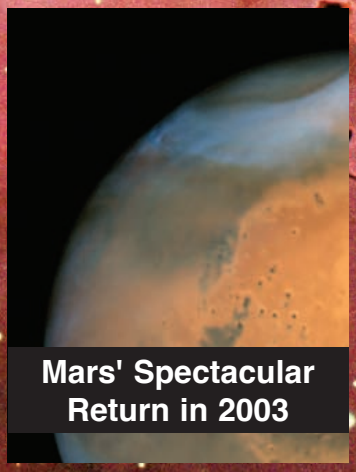
# ASTRONOMY

# 2003 AUSTRALIA

Suitable for all states in Australia.



Mars' Spectacular Return in 2003

## A PRACTICAL GUIDE TO THE NIGHT SKY

Glenn Dawes Peter Northfield Ken Wallace

# 2003

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● New Moon ◑ First Quarter ○ Full Moon ◐ Last Quarter

# ASTRONOMY 2003

## AUSTRALIA

## A PRACTICAL GUIDE TO THE NIGHT SKY

GLENN DAWES

PETER NORTHFIELD

KEN WALLACE

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# INTRODUCTION TO THE 2003 EDITION

Welcome to **Astronomy 2003 – *AUSTRALIA***. This is our 13th yearbook and for the first time we have combined what was traditionally the **Eastern and Western** editions. Western Australian editions had been produced for Perth Observatory since 1993. Traditional 'Eastern' readers should see very few changes from what they usually expect. We hope our friends in the west enjoy the colour and expanded articles this edition provides. Incorporating an additional time zone presented some unique challenges and we hope our readers appreciate our first national, single volume, astronomy yearbook. Your feedback is most welcome.

When it comes to lead articles this year we certainly offer a bit of variety. With Mars putting on its greatest display since before the time of Christ, it is only fitting we lead off with a brief overview of our exploration of the Red Planet. Geoff McNamara returns this year with 'Cryobots'. This is a fascinating insight into the next generation robotic probe which could give us our best opportunity of finding life elsewhere in the Solar System. When writing these books it is a delight to highlight the work of fellow Australian enthusiasts. Our lead articles wind up with a chat with Bill Bradfield – Australia's world famous comet discoverer. Like the Jedi's light-sabre, he is a "product of a more civilised time". A time when dedicated amateurs could make such discoveries, which is perhaps slipping away. We thank Bill for what must be his umpteenth interview over the years.

With regards to observing in 2003 we have a full, rich year:

- The opposition of Mars. There are updates throughout the monthly text as well as an expanded observers guide in Part II.
- A transit of Mercury across the Sun on the afternoon of May 7.
- Total Solar Eclipse in Antarctica offering Australians a partial view.
- The newly discovered Comet C/2002 O7 (LINEAR) could hold some surprises as it tours the southern skies.
- A 2003 guide to observing the variable star, RW Tauri. Watching it going into eclipse in real time is quite an experience!

Part I of **Astronomy 2003** is intended as a general quick reference section for those wishing to see which planets are up tonight and when, during the year, is the best time to observe them. This section, in particular, is ideal for those just starting their exploration of the night sky. The Sky View diagrams are an easy way for you to find your way around the night sky. The planets can be identified and followed throughout the year as these wanderers journey through the constellations. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, includes sections on astronomical places of interest and the amateur societies, ideal for the beginner. We also would like to recommend to readers our website www.quasarastronomy.com.au. There are links to all of the sites listed in Part III of this book as well as monthly updates.

As in previous editions of this yearbook, we would like to conclude this introduction with a brief word to the novice. Astronomy, like any science, may seem to be swamped in jargon. Unfortunately, it is impossible to avoid such words. However, where necessary, astronomical terms have been explained in the text or covered in the glossary. To a beginner, some of this information (especially the tables of numbers) may seem difficult to understand. It is important not to allow yourself to become overwhelmed. Understanding will come with experience and when there is a need to know.

It is easy to pick a dedicated observer in a crowd when they leave a building at night. He or she is the one who always looks up.

Wishing you a long lifetime of looking up.

*Glenn Dawes  Peter Northfield  K e n  W a l l a c e*

# ACKNOWLEDGEMENTS

Some of the information for this yearbook was adapted from the following sources:

- Astronomical Almanac for the Year 2003 (US Naval and Royal Greenwich Observatories)
- Astronomical Tables of the Sun, Moon and Planets (Jean Meeus)
- Comet orbital elements courtesy International Astronomical Union
- Fifty Year Canon of Lunar Eclipses 1986 – 2035 (NASA RP1216)
- Fifty Year Canon of Solar Eclipses 1986 – 2035 (NASA RP1178)
- Institut de Mecanique Celeste (IMCCE) – Paris Observatory for Jupiter satellite events
- Burnham's Celestial Handbook (Robert Burnham Jnr.)
- A Short History of Astronomy (Arthur Berry)
- Under the Southern Cross … (Bhathal & White)
- SEDS Web Page for La Caille Catalogue (Cozens et al).
- AAVSO Web site
- International Astronomical Union Web site
- Mathematical Astronomy Morsels (Meeus)
- More Mathematical Astronomy Morsels (Meeus)
- International Meteor Organisation Calendar

Data was also prepared with the assistance of the following software:

- MICA version 1.5 (US Naval Observatory)
- Occult version 4.2 (David Herald)
- Deep Space version 5.56 (David Chandler Company)
- Voyager II, the Interactive Desktop Planetarium version 2 (Carina Software)
- TheSky for Mac version 5 (Software Bisque)

Special thanks are extended to Bill Bradfield for the interview, Greg Bryant for the comet text in part II and monthly comet highlights, Martin George for the use of his Page Award speech and Geoff McNamara for 'Cryobots'. Rob McIntyre deserves a special mention for his efforts in compiling Places/Sources/Societies (in Part III) and his ongoing assistance with our website. Thanks also to David Frew for updating the nearest and brightest star tables.

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**Illustrations**

- The front cover is the Eagle Nebula (M16) in Serpens, photographed by David Malin at the Anglo-Australian Observatory © AAO / D. Malin (thanks for the ongoing support, David).
- Mars Image (front cover insert) taken by the Hubble Space Telescope on June 26, 2001, during the last opposition. NASA and the Hubble Heritage Team (STScI/AURA) Acknowledgment: J. Bell (Cornell U.), P. James (U. Toledo), M. Wolff (Space Science Institute), A. Lubenow (STScI) and J. Neubert (MIT/Cornell)
- Page 1 is a mosaic of a First Quarter Moon taken by Robert Price (Bethanga, Vic) using an SBIG ST7 camera through a Celestron 11 and assembled using Photoshop.
- Image of Mars on page 5 is of the Twin Peaks, taken by the Pathfinder lander, courtesy NASA/JPL/Caltech
- Cryobot illustrations (pp. 6-7). Copyright 1998-2001, Jet Propulsion Laboratory. All Rights Reserved. U.S. Government Sponsorship Acknowledged under NAS7-1260.
- Photo of Bill Bradfield (p. 8) supplied by Bill
- Photo of Comets Bradfield C/1974 C1 (p. 9) and C/1987 P1 (p. 11) taken by Joint Observatory for Cometary Research (Socorro, New Mexico) and Wafra Observatory (Kuwait) respectively.
- Globular cluster Omega Centauri photograph (p. 65) by Sydney amateur, Joe Cauchi.
- Image of Sydney Observatory (p. 133) courtesy Nick Lomb.
- Rear cover photo is the Orion Nebula by Perth amateur Vic Lewis (using a Meade 10" LX-200 – a compilation of 5 separate images).

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# MARS – FALLACIES, LEGENDS AND FACTS

Man has had a fascination with Mars as long as there have been telescopes. During a close approach to Earth in 1877, Italian astronomer Giovanni Schiaparelli scrutinised Mars and thought the dark markings (supposedly oceans) were the source of hundreds of fine, barely visible lines running across the bright 'continental' regions. He called these *canali*. The word was unfortunately translated incorrectly into canals, instead of the more correct channels, that suggested a natural origin.

These canals attracted the attention of Percival Lowell (1855-1916) a wealthy Boston businessman. With another favourable close approach of Mars coming in 1894, he constructed a well-equipped private observatory near Flagstaff, Arizona. Over many years, Lowell and his team mapped the Martian surface showing a vast network of canals, although he admitted that these features were at the very limits of the resolution of his telescopes. Lowell believed the canals were constructed by a race of Martians to carry water for irrigation on the dying planet. Although he was ultimately found to be wrong, his observatory went on to make some genuine contributions to science, including Clive Tombaugh's discovery of Pluto. Lowell did prove the worthiness of placing good instruments at carefully selected observing sites.

There was a strong interest in Mars long before the days of Lowell. As early as 1783, William Herschel had described it as "a most Earth-like planet". He noted it had a similar rotational period to the Earth, had white polar ice caps (which changed with the Martian seasons) and some permanent surface markings, which were identifiable in telescopic drawings as early as the 17th Century. It is likely the polar ice caps are made up of water and carbon dioxide $CO_2$ (dry ice). The $CO_2$ would seasonally sublimate or evaporate, shrinking the caps. In reality, a view of melted ice filling a global network of canals, holds about as much truth as H.G. Wells' 'War of the Worlds'. Mars remained mysterious and science fiction writers had a field day. It was, after all, the only planet which gave us a tantalising glimpse of its surface, even if only a jumble of brown and yellow details just beyond the limit of visibility.

Talking about myths, the more recent 'face on Mars' (which was actually imaged by the Viking Orbiter back in 1976) caused some controversy. However, this was just a mountain that resembled (vaguely) a humanoid face when lit by the Sun at just the right angle.

Man's knowledge of the Red Planet stagnated until July 1965 when the United State's unmanned probe, Mariner 4, flew past and took a handful of images of a dark southern region and shattered the Martian myths forever. Mars showed a dead Moon-like view, complete with craters. The canals had been an illusion. Two subsequent Mariner missions, which imaged the same southern region, seemed to confirm this observation and it was then felt that Mars had probably never gone through a period of running water or any form of life as we know it. Perhaps a view now thought of as being incorrect?

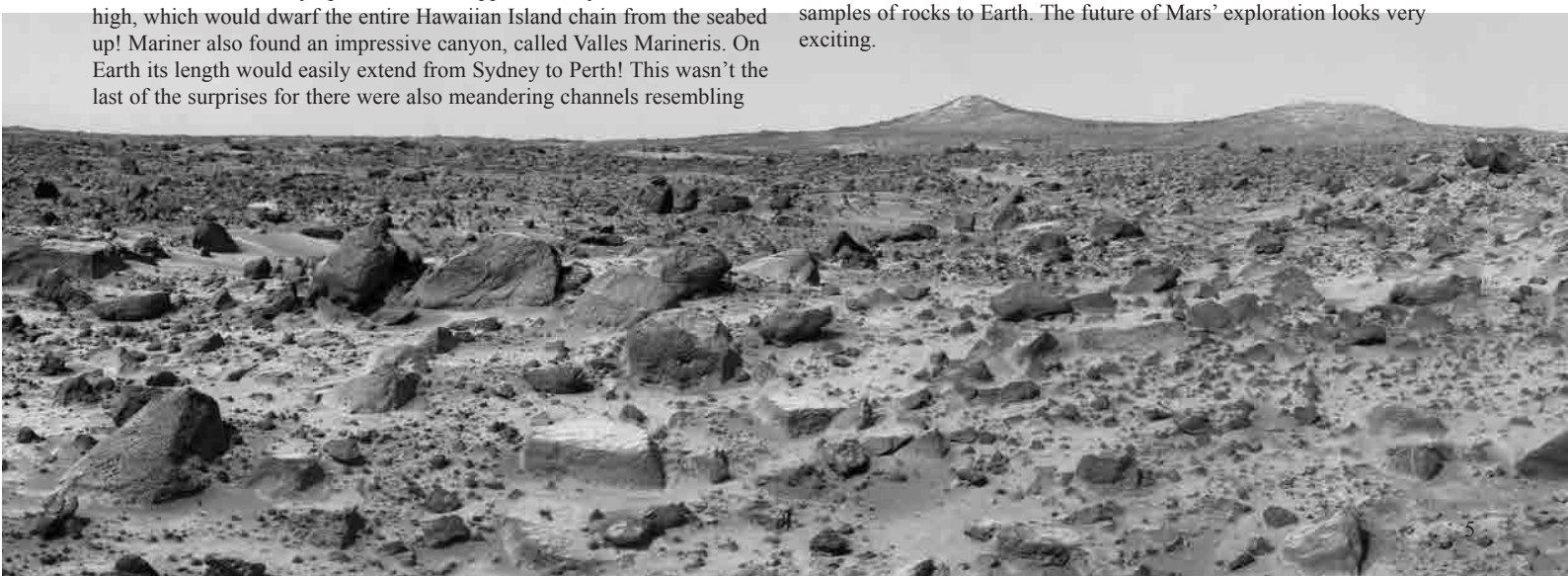
A more complete, global picture was made in 1971 when Mariner 9 became its first artificial satellite. It initially found Mars to be in the throes of a global dust storm. When the clouds cleared we were greeted with our first views of four enormous volcanoes – the first seen outside of the Earth. One of them, Olympus Mons, was approximately 24 kilometres high, which would dwarf the entire Hawaiian Island chain from the seabed up! Mariner also found an impressive canyon, called Valles Marineris. On Earth its length would easily extend from Sydney to Perth! This wasn't the last of the surprises for there were also meandering channels resembling riverbeds on Earth! Also the Northern Hemisphere was found to be smoother (less cratered) and at a generally lower altitude compared to the Southern Hemisphere. Suddenly an ancient ocean concept was born and with this the possibility of micro-organisms. In the mid 1970s the Viking landers sent back unprecedented clear views of the surface and conducted some experiments on nearby rocks, hoping to find signs of life. Unfortunately the results were inconclusive and the question of life remains unanswered.

To add to the intrigue of possible Martian life, in 1984 a meteorite was found in Antarctica called ALH84001. It was not at first recognised as possibly coming from Mars until it was found to match the unique chemical composition of the rocks found by the Viking landers. Within the specimen a NASA research team found mineral compounds, commonly associated with microscopic organisms, and a possible microscopic fossil structure. The scientific community is still divided on this interpretation.

In 1997 we saw the first mobile field geologist visit Mars. This was in the shape of the automated rover, Sojourner, which explored a few tens of metres of Martian terrain. It had arrived, piggybacked, on the Mars Pathfinder lander. Both the lander and rover took hundreds of images over a 3-month period, including the red sky with blue clouds and a Martian sunset. The Rover also conducted 20 chemical analyses on rocks and soil.

Over the years amateur astronomers have reported seeing bright flares on Mars, some dating back to 1894! On the morning of June 7, 2001, at the time of Mars' last opposition, a group of amateurs in Florida witnessed such an event in the Edom Promontorium region, not far from Mars' equator. It was suspected this could be caused by sunlight reflecting off ice sheets on the ground or ice crystals in the Martian atmosphere. In late 2001, the Mars Odyssey spacecraft went into orbit around Mars. It has been conducting a detailed geological and mineralogical survey of the surface of Mars using similar equipment as that used by orbiting satellites like Landsat for the same purpose on Earth. One of its instruments is a gamma-ray and neutron spectrometer, which can detect the hydrogen signature of water on or near the surface. It has found vast amounts of ice buried just under the surface at high Martian latitudes and a small patch corresponding to the flash area. It is still uncertain whether the water was on the surface or in the atmosphere but the Mars Global Surveyor probe has seen patches of surface frost in the area. Could the large bodies of water detected at high latitudes be the remains of a vast primordial ocean, now permanently locked-up in the form of deep permafrost?

NASA has made a long-term commitment to the exploration of Mars with an orbiter or lander expected every two years. In 2003 two identical lander/rover missions are expected to be launched. They will target regions found to be interesting by Odyssey. In 2005 we will see the Mars Reconnaissance Orbiter. This will have the ability to see objects as small as 20cm in size from orbit! In 2007 landers will be sent again to hopefully visit even more interesting sites found by Reconnaissance. This will be a new generation of landers, which will be able to detect boulders, unsafe landing sites and automatically adjust its final approach. The Rovers will be expected to live for 6 months and have a range of more than 80 kilometres. If all goes well, 2011 may see the first attempt to return samples of rocks to Earth. The future of Mars' exploration looks very exciting.



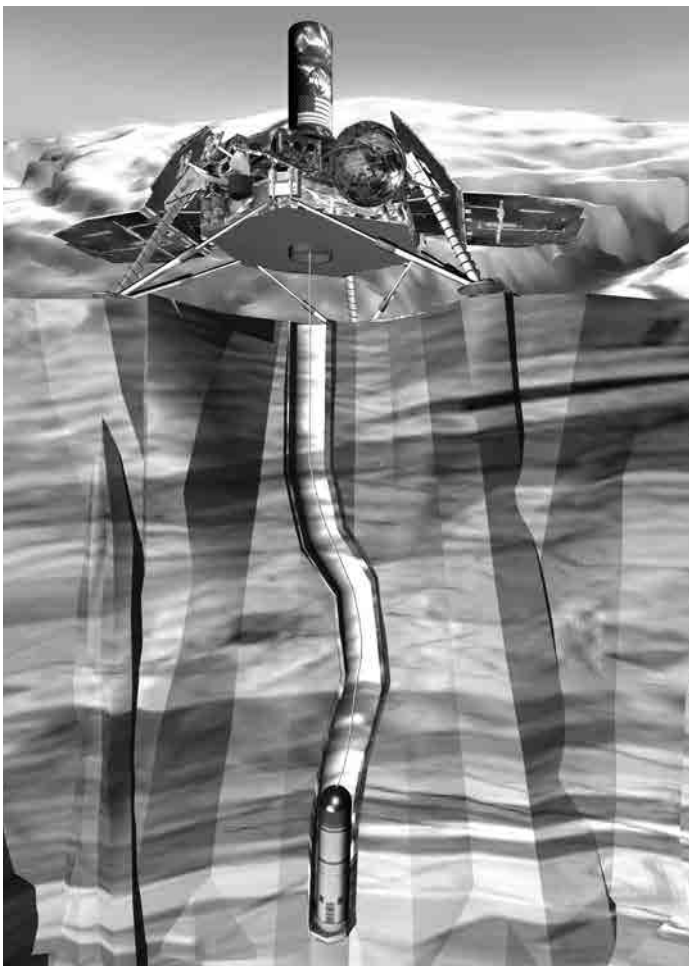
# CRYOBOTS

*Geoff McNamara*

Imagine the view from the surface of Europa, a frozen moon silently orbiting the planet Jupiter. In the pitch black sky hangs the giant planet, dazzling against the myriad stars. Also bright are the unmistakable sister moons Io, Ganymede and Callisto. Unexpectedly, a spacecraft approaches and lands on the ancient ice. For a time it seems motionless and then from beneath its belly protrudes a cylinder. Slowly the shiny torpedo descends to the ice. Frozen for millions of years, the ice now begins to melt. The probe sits silently in the shallow pool it has created, but as the pool becomes deeper, as more and more ice becomes liquid, the shiny metallic object begins to sink. As the ice continues to melt, the cylinder slowly penetrates the ice. The sluggish dive continues, deeper and deeper, until finally the probe disappears from view forever.

This is the scene scientists at NASA would like to see played out some time in the next decade. For the probe, this is a one-way trip. Its mission is to burrow down beneath the ice, deep below the surface, and see what's there. But this is more than just a mere scientific investigation into the ice of another world. This is the search for what may turn out to be the Solar System's largest ocean, and potentially the abode of extraterrestrial life. The most recent data beamed back from Europa suggest that the tiny world has a global ocean covered in a layer of ice. What's more, if the results coming in from similar experiments in Antarctica are any indication, Europa's ocean may be teeming with life.

The tiny probe is called a cryobot; a robot designed to penetrate and examine ice. Although the study of ice, called glaciology, and planetary exploration may seem an unusual partnership, the realisation of just how much ice there is out there has formed a unique partnership between these two sciences. Not only is glaciology essential in unveiling the Earth's climatic past, it is now known that it is the best way to reveal secrets of other ice-laden worlds, notably Europa and the red planet Mars. What's exciting is that large ice deposits on these worlds may hold valuable clues to the past. Enter the glaciologists.



*Cryobot Ice-Penetrating Probe*

Glaciology is a major branch of science simply because ice is such a good preservative of things past. Like their counterparts who study the history of the Earth in geological records, glaciologists study (among other things) the history of the Earth by retrieving samples of ice that have been buried for millions of years. Deep ice samples contain records of the Earth's early atmosphere, climatic conditions and early life. With the recent discovery that many places in the Solar System are frozen or near frozen environments, planetary scientists have also developed an interest in glaciology.

Ice is a well known constituent of the Solar System. Not only is there ice on Mars and Europa, but Saturn's rings, as well as the comets that frequently visit the inner Solar System, are mainly ice. Two of the coldest places to explore are Mars and Europa. It's been known for some time that Mars has polar ice caps. Even before spacecraft reached the red planet, astronomers were able to watch the ice caps expand and contract with each Martian winter and summer. While much of the ice caps was known to be in the form of frozen carbon dioxide, more commonly known as 'dry ice', vast quantities of frozen water have been discovered there as well. In early 2002, the Mars Odyssey spacecraft revealed huge deposits of water ice in a region surrounding Mars' south pole. In the top metre of soil, more than half of the volume is water ice, more like dirty ice than frozen mud. The presence of water on Mars is one of the reasons life there is suspected so strongly.

Europa, on the other hand, is completely covered in ice. When scientists first laid eyes on images of Europa, it showed all the surface relief of a billiard ball. No mountains, no valleys, just smooth all over. For astronomers used to seeing cratered terrains like the Moon and the huge volcanoes on Mars, the bald face of Europa came as quite a surprise. As it turned out, the reason Europa stays so smooth is because its surface is not rock or dirt, but ice. On a planetary scale, ice is not good stuff to make mountains from, anymore than sand is at the beach. While you can make sand castles and dunes a few metres high, beyond that height the sand collapses under its own weight. The same thing goes for Europa's icy surface, with a surface temperature hovering around -162° C, it never rains, it never snows. Europa is the last word in frozen desolation.

But what makes it such an intriguing place is that, despite its distance from the Sun, there may be a vast ocean sloshing about underneath a crust of ice several kilometres thick. How could an ocean exist if the moon is so cold as to freeze the surface solid? Being so far from the Sun, the amount of warmth it receives is negligible. But there are other ways to heat water, and one of them is to use gravity. Just as the Moon creates our tides with its gravity, so Europa is pulled this way and that, not only by the massive parent Jupiter, but also by its sibling moons Io, Ganymede and Callisto. All this gravitational tugging produces friction deep inside the moon, and this friction produces heat just as you can warm your hands on a winter's day by rubbing them together. But rather than heating the surface of the planet, it's the interior of Europa that's raised above the melting point of ice. In conjunction with possible volcanic-like heat sources deeper within Europa, the gravitational tugging is just enough to keep the water beneath the ice liquid.

Despite the heating of the interior of the moon, Europa is still an extremely cold place. Nonetheless, a global ocean may be just the beginning of the surprises Europa has in store. The reason scientists want to explore Europa's ocean comes from discoveries made not out there, but right here on Earth. In 1974, a group of scientists was conducting airborne research over the Russian Vostok station in eastern Antarctica. Quite by chance their sounding instruments detected a huge expanse of fresh water four kilometres beneath the ice. Rather than aiding the freezing of the water, the ice sheet acts as a blanket, shielding the lake from cold temperatures on the surface. It is also thought that geothermal heat helps keep the water liquid.

Twenty three years later, Russian and American scientists managed to drill down through the ice to within 100 metres of the surface of the submerged Lake Vostok. What they found surprised everyone – life. The samples, which date back 400,000 years, contained a wide range of living

organisms. The scientists recognised some of the organisms – bacteria, cyanobacteria, fungi, spores, pollen grains, and diatoms – but others were life forms they had never seen before.

Rather than being an inhospitable environment, it turns out that ice is a good place for bacteria to survive. Being so cold, the metabolism of bacteria and other living things slows right down and so they need less food, just like a bear hibernating for the winter. But what is puzzling is how did these organisms survive if they have been cut off from sunlight for so long? Even without answering that question, it prompts another, more intriguing one: if life can survive four kilometres beneath the Antarctic ice, why not elsewhere in the Solar System where conditions are similar? This is why scientists have now turned their thoughts to the icy moon Europa.

Getting to the bottom of the ice on Europa is a technological problem for scientists. Until now, the main way to study deep ice is to mechanically drill through it the way you might drill through a piece of wood. Core samples are then brought to the surface and analysed. The depths from which samples have been retrieved is staggering, in the case of Lake Vostok over four kilometres. But achieving such a feat on Europa is out of the question, and so another way had to be found.

This is where the cryobots come in. These devices are shaped like a torpedo and use a process known as passive drilling. Rather than drilling their way through the ice, cryobots melt the ice ahead of themselves and let gravity do the rest. As the ice melts, a cryobot simply sinks to the bottom of the hole, the melted ice flowing around the sides of the cryobot. Behind the cryobot, the once melted ice is allowed to refreeze, sealing it beneath the surface forever. This continuous process of melting and sinking allows the cryobots to slowly 'fall' through the ice, a process requiring far less energy than mechanical drilling. The probe would also be given semi-autonomous steering capability to help it avoid obstructions.

On their way down, cryobots will make use of an In Situ Chemical Laboratory, or ISiCL. This miniature laboratory will analyse the ice for things like composition, acidity and electrical conductivity. All this information will be transmitted to the lander on the surface. On Earth or Mars, the data can be transmitted using a cable strung out from the cryobot as it descends, avoiding the need to return the sample to the surface. On Europa, the descent is likely to be so long as to make a spooled cable impractical, and so a transceiver will transmit the data to the lander on the surface. The lander can then relay the information back to Earth.

A prototype cryobot measuring about a metre long and 10cm in diameter has now been built and tested. Scientists from NASA, the Norwegian Polar Institute and the Norwegian Space Centre conducted a test on a glacier on the island of Spitsbergen, far above the Arctic circle. Braving fading sunlight, snow, severe cold and migrating polar bears, the scientists watched as the probe descended 23 metres beneath the ice. The experiment was a success.

But such a mission will have a lot to contend with on Europa: high radiation levels, near vacuum, corrosive salts and a chilly -190° C. Not only that, but the evidence that Europa has a subsurface ocean at all is not conclusive. Studies of changes in the appearance of features on Europa are not obvious. Scientists have studied images sent back by Voyager 2 and Galileo spanning a 20 year interval without much success. There are plenty of features on Europa that suggest it has a dynamic surface: shifting and collapsing ice rafts, surface melts and cold water volcanoes could all have been active in the last 50 million years. The problem is that 50 million years is only 1% of Europa's age. The features may be geologically fresh, but a lot of freezing could have taken place since then. In the mean time, astronomers continue to pore over images looking for signs that the surface of Europa is simply a crust over a global ocean.

If such an ocean exists, penetration of ice is likely to be only part of the story. To explore the inner space of an outer world, the cryobot could release a hydrobot as soon as it penetrates the kilometres-thick ice shell. A hydrobot would be an automated submarine equipped with sensors and a camera to explore the frigid Europan ocean, and a sonar device could allow scientists to map the ocean floor. Although so much of this is still speculation, scientists may one day discover life in one of the most unexpected places in the Solar System.

*Geoff McNamara is a teacher and freelance science writer based in Canberra, Australia.*

***Hydrobot/Cryobot Under the Ice of Europa***

*This artist rendering shows a proposed ice-penetrating cryobot and a submersible hydrobot that could be used to explore the ice-covered ocean on Jupiter's large satellite, Europa.*

# BILL BRADFIELD – AN AUSTRALIAN COMET HUNTING LEGEND

*Glenn Dawes*

## INTRODUCTION

In last year's book we presented an interview with the extraordinary supernova hunter, Bob Evans. This year we are pleased to pay tribute to another legendary Australian amateur astronomer, William Bradfield. Bill is known worldwide as the most successful visual comet discoverer of the 20th Century. He was also the first amateur to discover a comet from South Australia. It is important to emphasis this 'visual' aspect of his work. The majority of comet discoveries, in recent years, have been made photographically or electronically by professional astronomers. Visual discoveries tend to be made by hobbyists, such as Bradfield, searching the heavens looking for these fuzzy patches through their relatively low cost, small aperture telescopes. In recent times this professional / amateur line has blurred as more amateurs embrace the CCD camera and automated telescope revolution.

Bill was born and raised in New Zealand and moved to South Australia in 1951 where he still resides. He initially came to work for the Australian Government on rocket propulsion. After 35 years in this field he decided to retire in 1986 having completed the last 10 years as the Principal Research Scientist in charge of the Rocket Propulsion Research Group. At the time of this interview, in early 2002, Bill is 74 years old. He is married with 3 daughters and has 2 grand children. When he moved to Australia he took up residence in the Salisbury / Elizabeth area but moved in 1970 to the Adelaide suburb of Dernancourt. In 1996 he moved to Yankalilla, a small country town about 65km SSW of Adelaide.

To date there have been 17 Comet Bradfields. The fact that they were all sole discoveries, with him not having to share the name with anyone else, must also be a record. Only two people have surpassed his visual record – both predating Bill. Pons, in Europe, discovered about 30 (or more) but only has 26 named credits. In America, in the late 1800's and early 1900's, Brooks had 21 named comets.

Bill is still looking and hopes to find another one soon.

For those wishing to learn what a comet is, and for an explanation of the naming convention, see page 122.

## THE INTERVIEW

(G is Glenn, B is Bill)

G: How and when did you first get interested in astronomy? Was there any connection with your day job?

B: I first became interested in astronomy at about the age of 14 as a result of being able to see dark night skies from my father's farm which was well removed from towns in the district. At age 17, in my first year at university, I became aware of the idea that some day a rocket would go to the Moon. Also in that year of 1944 I knew about the existence of V2 rockets being fired at England. However, in my subsequent employment in the rocket propulsion field, there was no real connection with astronomy. Although, reflecting back I think in my mind there was a slight similarity between the appearance of a rocket exhaust jet and a comet tail, despite the fact that the formation mechanisms were completely different.

G: How did your interest evolve into comet searching? Why not variable stars, novae?

B: I had a casual interest in comets having seen 2 bright ones, the 'Southern Comet' in 1947 and the other in 1965 'Ikeya-Seki' the sun-grazer comet (i). But it was Comet Bennett in early 1970 that increased my interest in the subject. I suppose in a way seeing them was some sort of inspiration, particularly for Bennett, for I realised he was an amateur and so were Ikeya and Seki for that matter.

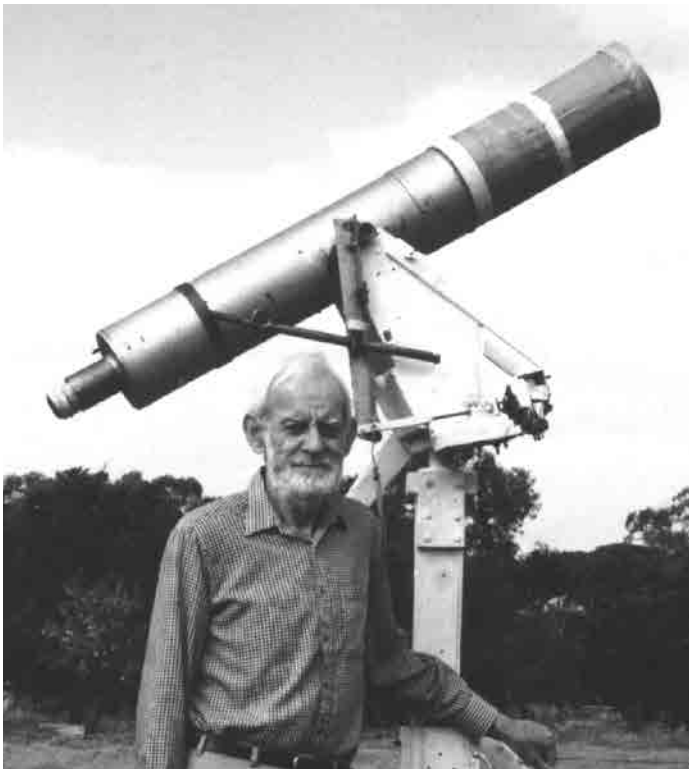


*Fig 1. Bill with his 6" Refractor, his main discovery instrument.*

When I bought a 150mm *f*5.5 refractor, from Ralph Sangster, I started a search for comets. I commenced searching on January 1 1971.

I was never interested in variable stars but I did have some ideas in the early 1990's to do some novae searching. Although I thought about it quite seriously I never really got started.

G: Was there someone who inspired you as a role model? Your hero if you like?

B: Not really.

G: Over the years what instruments have you used for your searches?

B: The 150mm refractor (see above) was used for most of the work and I discovered 14 of the named comets with that. But I did find one comet with 7 x 35 binoculars and two others were discovered with my 250mm *f*5.6 Newtonian reflector.

G: Where were your searches conducted?

B: My first discovery was made from my backyard at Dernancourt. At that time streetlights went off in all the suburbs of Adelaide at 1am so that meant the skies suddenly became quite dark after that time. All-night street lighting gradually came in from 1974 as a result of the Electricity Trust of South Australia persuading various councils to use all-night lighting at a cheap rate. All other discoveries were made away from home out in the country from various roadside sites. The locations being used over the years have moved further away because I became more concerned about light from Adelaide. Of course this was increasing because of the expansion in the outer suburbs so I felt it was best to travel in the end up to 80km from home to do my searches.

G: When observing on the roadside did you have any interesting encounters involving the public?

B: Well I have had many of those. The idea I had in my mind was to set up a site on little used side roads. One time in the early years, when I was barely out of the suburbs, I got caught up with some policemen who suddenly decided to investigate me because they saw

my vehicle in the dark on the side of the road. It was a bit suspicious to them and they were surprised when they found I was just a stargazer. Over the years various farmers, who owned properties near the sites I was using, would be driving home and stop to see what I was doing and ask questions. Sometimes they wanted to have a look, which wasn't exactly what I wanted, but I did let one or two look at some bright objects like Omega Centauri. The farmers were more concerned about the possible theft of farm implements or stock so their curiosity was understandable. Of course rabbit shooters disturbed me a bit because of the floodlights being directed all over the country side and with shots ringing out from time to time I wondered whether I would be on the receiving end of a bullet!

G: What was your search technique? I believe you tailored your approach taking the Japanese competition into account.

B: I was fully aware of the large numbers of comets discovered by the Japanese so invariably on the first possible night for searching, i.e., after the Full Moon, I would search the evening sky that was accessible to the Japanese before I started on more southern areas. I wouldn't follow this idea if I was delayed by cloudy weather for a week for I thought that the Japanese would have searched their areas anyway and it was possibly pointless for me to aim there first.

G: After so many years do you recognise all the deep sky objects without referring to atlases?

B: This is difficult to answer precisely. I think it would have been about 2 years before I could recognise most of the objects I could see easily. The objects of course that were difficult to remember and recognise readily were the fainter ones which I wouldn't necessarily see every time because of the variability of the clarity of the sky. And then of course where there were lots of these fainter objects (e.g., galaxy clusters – Ed) there were more difficulties in my remembering and I really had to check out the various objects one by one by looking at the star charts.

G: How much did you rely on detecting movement before seeking confirmation?

B: Detection of movement is essential to confirm the cometary nature and I would try to do that in the limited time available. For example if the Moon comes up reference stars might fade and I was unable to decide whether the comet was moving or not. There were all sorts of things like that so in some cases I might have to wait for the following day to get an indication of that. Also, the movement is essential so people who are going to confirm your comet know where to look, particularly if it is a day late or later. In the extreme case if people don't know where the comet is going it might be completely lost! I think on the occasions when I didn't bother giving an indication of motion was when it was a magnitude 5 or 6 comet with an obvious display of a tail. This being so anybody could find the comet without knowing where it was exactly.

G: We all associate the name Bradfield with comets but do you regularly observe other celestial bodies? Any interest in photography, CCDs?

B: I do not regularly observe other celestial bodies or undertake astrophotography, although in earlier years I did dabble a bit in astrophotography. I do not plan to take up CCD technology.

G: A question I like asking dedicated observers like yourself, did this work put a strain on your home life at times?

B: Yes, this strain probably increased over the years with my continued involvement in leaving home at night to go out into the country. Also I spent a lot of time making improvements to my comet hunting gear and analysing the comet hunting process to find the best method of searching. I seemed to be always facing up to the media and answering letters, mostly from overseas amateurs. So I guess one could understand my wife's concern in lots of cases.

G: What does your family think of your achievements?

B: My family doesn't get too excited about my achievements and I think over the years they have barely looked through my telescope.

G: When was your first discovery?

B: My first discovery was made in March 1972 after running up 260 hours (of searching) having started on 1st January 1971. It was made in the morning in my backyard in Dernancourt. At that time Adelaide street lighting was turned off at 1am (refer above). By 1974, all night street lighting was introduced, and from then on it was necessary for me to travel away from the Adelaide area for morning searches. Of course I had been going out to the country for evening searches right from the word go.

Back to my first discovery. I was very excited and so was Ralph Sangster, the person I bought the telescope from. Over the years the first person I would tell, apart from my family, when I made a discovery was Ralph and he was always very excited about them. This went on for time after time. It was a great experience I think for Ralph to realise that his telescope, the one he put together, was being used by me in such a good way.

G: What do you consider to be your most spectacular comet? Why?

B: This is a difficult question. A comet, as far as I'm concerned, is only spectacular if it displays a bright tail at least a degree long. There were a number of those I found and it was a pleasant shock to find them in that state. The first question that came to mind was 'how come they had escaped being detected earlier by somebody else?' I think the general answer was they had (just) moved away from the area of the Sun into the darker skies. Some of the comets I discovered were heading to the north and put on a spectacular display beyond my view. For example my second comet discovery in 1974 (see photograph below) put on a good performance and was considered by the northerners to be much better than the (infamous – Ed.) poor performer Comet Kohoutek. In 1987, another one of my comets (C/1987 P1 – Ed), again heading north, put on a good performance

*Fig 2. Comet Bradfield (C/1974 C1), Bill's second discovery.*

for Northern Hemisphere observers and was considered by some to be more impressive than Comet Halley in the previous year!

G: Were there any that bring back special memories?

B: I confess I did not dwell too much on following the behaviour of my discoveries. David Seargent, who runs the Australian Comet Section, was hoping that I might be able to make regular observation reports on the comets but I declined with the knowledge there were many other amateurs who were very happily making regular observations of comets.

G: Did any of your comets show promise and didn't deliver, such as rapidly fading or broke up?

B: I have no recollections about any non-performing comets that I discovered. Undoubtedly, some would have been less bright than originally expected.

G: When was your last discovery?

B: This was in August 1995 (C/1995 Q1 – Ed).

G: Are you aware of any of your comets contributing significantly to our understanding of these dirty snowballs?

B: I am not aware of any of my comets specifically contributing to the understanding of comet behaviour. I'm sure many of them did but I have no details.

G: Do you have any classic stories about the 'one that got away', a comet that should have been yours but wasn't for whatever reason?

B: Yes, all comet hunters have stories of the one that got away and I can quote one or two.

In January 1991 I discovered a comet in the evening sky but did not get my message to the Central Bureau (ii) quickly enough and on the following day I found out that Howard Brewington of New Mexico had already found the comet 8 hours before me. Alan Hale of Arizona apparently confirmed Howard's comet fairly quickly within one and a half hours of its discovery and it was announced as Comet Brewington. I also found out that Kiuchi of Japan had also found the comet just one hour before me. Two days later it was announced that the comet was (renamed) periodic Metcalf-Brewington. Periodic Metcalf was found in 1906 but had been lost all these years.

In 1996 there was a comet discovered by Japanese amateur Hyakutake (iii), the brightest comet seen for many, many years. I was very disappointed missing out on this for I must have been very close to finding it during my search a day earlier. I was using my larger telescope under perfect viewing conditions at Yankalilla. If only I had set the northern limit of my sweeps 5 degrees further to the north – I would have swept right over it! (5 degrees is about the distance between the 2 pointers Alpha and Beta Centauri, certainly a near miss – Ed) In March, when the newspapers and TV started to publicise the expected bright performance of Comet Hyakutake, I started to realise it was probably just as well I didn't find this particular comet. It would have lead to a fresh round, and probably more demanding round of interviews on radio and TV with requests for talks. All of which would have required a lot more of my time than with past discoveries.

G: Picking up on an earlier comment you made, which of your discoveries were so obvious that at the time you were absolutely certain someone else just had to have seen it before you? This question is to give the 'want-to-bes' some hope!

B: I think the last comet I found in 1995 in the evening sky would have been in the category of 'somebody would have found it before me; why wouldn't they have seen it?' Had it been in the morning sky of course things might have been slightly different I feel. (Bill's comet C/1995 Q1 was already 6th magnitude at discovery and possibly visible in small binoculars from dark skies – Ed).

G: What would be the shortest period of any of your comets? Have you ever seen one of them return on a subsequent orbit?

B: Two of my comets were rated as periodic, having periods of less than 200 years (P/1984 A1 and P/1989 A3 – Ed). Both were found with my 250mm reflector. The shortest of the two periods was around 73 years so I am not likely to be around for that one (to return) nor for the other with a period of around 153 years.

G: I'm sure there were periods of drought when you thought, 'why am I doing this?' How did you keep going?

B: I think there are two aspects here. One is a drought of comets that may be found by an amateur and the other drought being my inability to find them. There were periods when I wasn't doing very well, going for about 3 years or so before finding another, but there was one case where I found 2 comets in a fortnight!

G: The opposite to the previous question, was there a time when you had so much success it seemed the sky was raining Comet Bradfields?

B: I never got the impression the sky was raining comet Bradfields. But I did find 2 comets in the one year 5 times: 1975, 1976, 1978, 1979 and 1992.

G: Was there ever more than one of your comets visible in the sky at the same time?

B: If one was to interpret that as being observable on the same night the answer is yes, one was in the evening sky and one in the morning sky (these were his two comets in 1976 – Ed).

G: How often do you search for comets?

B: This is a variable quantity, directly related to the clear weather opportunity. My plans have always been to search twice every lunation, with the Moon as much as possible absent from the sky. In the evening I first search the areas a few days after Full Moon (perhaps having an hour or 2 before moonrise), and again two weeks later when the thin crescent Moon starts coming back into the evening sky. And the same in the morning sky searching once when the Moon is near the new phase and roughly a fortnight later when the Moon approaches Full Moon (say 3 days before).

G: How many hours would you observe per discovery?

B: Considering the period from my 1st to 17th discovery the average number of hours was 170 per comet. But since 1995 (to May 2002 – Ed) I haven't found any more but I have put in another 640 hours. Adding these in the average goes up to 206 hours.

G: Being such a successful comet hunter you must have attracted your fair share of media attention over the years. Do you have any memories, amusing or otherwise, of dealing with this often ill-informed establishment?

B: I accepted the questions put to me by the media but there were some occasions when it was obvious to me that the reporter knew nothing about comets. This was a bit irritating but I accepted what they asked and gave appropriate answers to get them back on the right track.

G: We have only recently had instant contact with the world via the Internet. For instance today we have the International Astronomical Unions Circulars on email. How did you get confirmation of suspected comets and how was it reported before the communication super-highway?

B: In those early days – 1972 to some time after that – I sent a telegram to the Central Bureau (ii) and they sent some back (e.g., announcement communications – Ed). The procedure then was the Bureau would inform other people to get confirmation. Quite often I got a confirmation from people such as Bruce Tregaskis in Victoria, David Herald in Canberra (both gentlemen are amateurs – Ed) and even people over in Perth Observatory made confirmations. There was a stage when it seemed to me the Bureau was accepting my reports of new discoveries as genuine articles. My credibility was established and my initial reports of the comet's position and motion were accepted without getting it checked.

G: I believe you had a friendship with the late Eugene Shoemaker (iv). Do you have any special memories you would like to share?

B: The two Shoemakers, Carolyn and Gene, made a yearly trip to Australia for many years, usually during the winter months, and they used Adelaide as a base. So there were plenty of opportunities to meet them but I must admit it wasn't every year that I did so. When they first came Gene gave a lecture at the University of Adelaide and I was there to listen. He thought I might be there and he was keen to meet me, as I was keen to meet him. There were also other occasions such as dinner functions and listening to further talks. So it was a contact through mutual interest I guess and there was no real social contact. We were all saddened by his accidental death in the outback.

*Fig. 3 Comet Bradfield (C/1987 P1), thought by some to be more impressive than Comet Halley!*

Gene and Carolyn were responsible for suggesting my name for asteroid 3430. That was a special surprise for me when Gene presented me with a copy of the announcement circular at the first dinner function I had with him.

G: What other famous comet hunters have you known over the years? Do you feel you share a bond with these kindred spirits?

B: There were a number of famous comet hunters I have known over the years, basically through correspondence. They include Jack Bennett, who of course found the comet that got me on the rails to finding comets and Don Machholz with whom I have had many communications, several each year, for all the years we were active. Don is not so active now for being a Northern Hemisphere observer in California he is being outdone a bit by LINEAR. Howard Brewington also communicated with me as well as a few others. Over the years many comet observers and would-be hunters wrote to me or sent photographs they had taken of 'Comet Bradfield'. These people lived in various parts of the world, China, a number of European countries and America. I have mountains and mountains of correspondence.

In 1990 I was invited to Japan to attend the 20th Japanese Comet Conference to present a paper on comet hunting. At the conference I was the only non-Japanese person there. In the following fortnight I was taken around Japan to meet other comet hunters such as Ikeya, Seki, Fujikawa, Terasako and others.

G: Putting your modesty aside for a moment, what recognition and awards have you received over the years?

B: I have received a number of awards:

- The Thomas Donovan Medal in 1972 (for Bill's first discovery – Comet 1972f)
- A cash award in 1976 which was given by I.P. Debono of the NSW Branch of the British Astronomical Association (BAA) for the first comet to be discovered by an Australian in 1975 (this was won for his discovery of Comet 1975d),
- The Berenice Page Medal in 1982 (from the Astronomical Society of Australia for excellence in Amateur Astronomy – also see article on page 41)
- I have already mentioned the naming of an asteroid 'Bradfield',
- On Australia Day in 1989 I was awarded an 'AM', a Member of the Order of Australia, for service to astronomy.
- Also my own society, the Astronomical Society of South Australia, and the Astronomical Society of Victoria have made me honorary life members.

G: Taking into account professional search programmes such as LINEAR (v) are the days of the visual comet hunter numbered?

B: The operation of automated search programmes, such as LINEAR, probably does mean the days of the visual comet hunter are numbered but not until a similar system with the same capability is located in the Southern Hemisphere. But even then I believe it will be possible to discover some comets which come from the general direction of the Sun (LINEAR cannot search as low in the twilight sky as an experienced visual observer can – Ed).

G: Considering the technology explosion do you feel your visual record will ever be surpassed?

B: It is unlikely my record of 17 will be exceeded by anyone else.

G: What advice would you offer a beginner hoping to get his/her name on a comet?

B: The answer is simple. The advice I would give is the same advice I was given by earlier comet hunters – the only way to find a comet is to keep looking. Certain people in recent years have spent a lot of time to find their comet, for example Don Machholz spent 1,700 hours for his first discovery.

G: Thank you for your time and effort.

B: Thank you for the opportunity to contribute.

## NOTES

(i) Comet Ikeya-Seki was without doubt the brightest comet of the 20th Century and would also be in the running for the most brilliant comet in recorded history. Near its perihelion this 'sun-grazer' and its tail was clearly visible to the naked eye in daylight only 0.5 degrees from the Sun! (0.5 degrees is about the diameter of the Moon)

(ii) The Central Bureau of Astronomical Telegrams is run by the International Astronomical Union (IAU) which acts as the central clearing house for receiving, confirming, announcing and naming new astronomical discoveries. This includes comets, novae, supernovae and minor planets.

(iii) Comet Hyakutake (1996 B2) was regarded by many as the most spectacular comet of the decade, reaching zero magnitude and having a tail stretching literally half way across the sky! Unfortunately Yuji Hyakutake passed away in early 2002 at the age of 51.

(iv) Eugene Shoemaker was a renowned geologist and astronomer. He was an expert on impact craters on the Earth in particular 'Meteor Crater' near Flagstaff, Arizona. He became well known as an 'astrogeologist' becoming an expert on lunar geology and helping to train the Apollo astronauts back in the 1960's. In more recent years his interests expanded to asteroids with him forming a successful photographic search team with his wife, Carolyn and David Levy using the 46cm Schmidt camera on Mt. Palomar. They discovered numerous asteroids and comets. A highlight of his career was his involvement with the discovery of Comet Shoemaker-Levy 9, whose fragments crashed into Jupiter in July 1994.

(v) LINEAR stands for Lincoln Near Earth Asteroid Research and is a joint cooperation between the American Air Force and MIT's Lincoln Laboratory. It operates 2 one metre aperture telescopes fitted with the latest CCD technology, to search for asteroids that may come close to the Earth. To date (April 2002) LINEAR has discovered some 157,000 new asteroids (of which 951 are confirmed Near Earth Asteroids) and 82 comets. www.ll.mit.edu/LINEAR/index.html
See also 'Flying Rocks' article on page 49.

# GETTING STARTED

If you are a beginner, this page is for you. If the tables of numbers in the back of this book seem a little daunting, forget them. You don't need them (yet). Nor do you need a telescope to discover the most spectacular show nature has to offer, the night sky. You just need this book to guide you along on your voyage of discovery of the Universe.

This page will concentrate on the first part of this book, the 'Monthly Sections', as this area has the most to offer the novice.

## IS THIS USEFUL FOR WHERE I LIVE?

Part I is designed as a quick reference section for anyone who wants a summary of tonight's sky – **no matter where you live in Australia.**

**No adjustment has been made for daylight saving time. When in force you will need to add one hour to get your local time.**

## SO WHAT CAN THIS BOOK HELP ME SEE?

The night sky regularly puts on displays for us called conjunctions. Since the planets, including Earth, are moving round the Sun, their positions change constantly with respect to the background stars. As seen in the sky, the planets seem to pass by each other and bright stars. When a planet is near another, the Moon or a star, it's called a conjunction. When the Moon is included, it's a wonderful sight.

Conjunctions can be spectacular events. An example of a good conjunction this year is the one between the Moon, Mars and Antares on January 28 (see Sky View p. 23). These celestial dwellers all lie within a 6-degree circle in the eastern morning sky. This is simply a chance alignment of these celestial bodies. They only look close together; in space they are still separated by enormous distances. When talking distances, beyond the Earth, it is difficult to use normal scales such as metres or kilometres because the numbers would be so large. Instead, let's use the time it takes for light to travel from these objects to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over 1 second to reach us, Mars 15 minutes and Antares 490 years. If you include the globular star cluster, M4, we are out to 6800 years. Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, this cluster is just in our neighbourhood!

Conjunctions are fun to watch, free, and entertaining. The equipment needed to see conjunctions? You guessed it… nothing!

The best times to see conjunctions are shown in the Sky View diagrams (there are 5 such drawings for each month). Each Sky View shows you an area of the sky that contains a conjunction or another interesting feature. The horizon is shown at the bottom of most Sky Views along with any useful notes. At the top of each is the date you should look. Since the planets move fairly slowly in the sky, many conjunctions occur over a number of days. This means you can often see the planets and stars starting to take their 'places' days before, and then drift apart for days after the event. The Moon is the only exception. It moves quite a bit each day against the background stars. This is why the Moon's position for more than one day is often shown on the same diagram. All the planets visible in a Sky View are labelled, as are the brighter stars.

To use a Sky View, simply go outside under the night sky at the time given and face the direction shown on the Sky View. What you see in the Sky View will be a temporary map of the sky in front of you. Incidentally, if you don't know the directions around your house, use a street directory to show you which way is north (it is always towards the top of the page).

There is more to the night sky than conjunctions. There are meteor showers, comets, minor planets (asteroids) and constellations. Not to mention the fascinating movements of the planets as they wander against the background stars. All are described in Part I.

Part I is divided into months. At the beginning of each monthly section is a curious looking graph called a rise/set chart. This series of squiggly lines is your guide to knowing when the planets, Sun and Moon rise and set. To use the chart, simply look at the current date on the bottom of the chart and follow that line upward until it intersects the object of interest. The rise or set time of the object can now be read on the left-hand edge of the chart. For example, on January 19, the Moon and Jupiter rise together during twilight, just after 8pm. Incidentally, when you see objects rising or setting together, look for a Sky View on that date. There is a Sky View for this conjunction for later that evening (see p. 23).

Each of these monthly sections also has a diagram showing the relative size and appearance of each planet, as seen through a telescope. There is also a description of celestial happenings and highlights – kind of like a celestial moviegoer's guide – and in plain English! Want to know what Venus is up to in March? The description will tell you. A diary of events is also included that summarises the month's features. To see a lot of these celestial events, you'll need a pair of binoculars or a telescope.

There is one piece of equipment that every sky watcher should have – a red tinted torch. Any torch will do. Simply tape some red cellophane over the end of the torch so that it gives off a dull red glow. The aim is to preserve your night vision, or 'dark adaptation'. When your eyes become used to the dark, they won't react to a red light and so you can use the charts and illustrations and still enjoy the night sky.

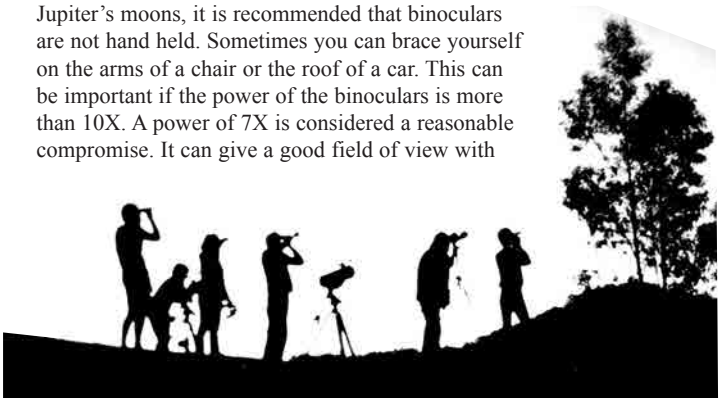
While on the subject of lights, make sure as many lights as possible near your observing site are turned off. The less glare around you, the easier it will be to enjoy the night sky. Encourage neighbours to turn off their outside lights and invite them to enjoy the night sky as well. A major modern threat to the night sky is light pollution; stray light scatters upward into the night sky where it drowns out the stars. So, the more lights we all turn off, the less light pollution, the more power we save and the less natural resources we consume. Perhaps it is time the environmentalists had a look at this. After all, it is the only form of pollution that costs less to fix!

The Sky Views don't show all the sky. By their very nature they mostly concentrate on the ecliptic or zodiac regions of the sky, where the planets and Moon wander. A good companion to this publication would be a basic star atlas or a planisphere. These will show all of the sky, but not the Sun, Moon and planets because they move. The planisphere is useful by showing at a glance all of the constellations visible at the time you are observing. An example is shown on page 15. Once you start to look around the sky with a planisphere, you may be pleasantly surprised how easy it is to recognise a few of the constellations. These star patterns will quickly become familiar and will soon be like old friends.

Part II of Astronomy 2003 contains specialised data designed for the experienced enthusiast. The novice however should not miss the appendices in Part III. If you wish to pursue the hobby further, we strongly recommend that beginners check out the local amateur community. Learn from these experts and look through their equipment, before spending hundreds or thousands of dollars on a telescope that may not suit your needs. The public observatories, planetariums and courses can also be great resources. Use them.

## A WORD ABOUT BINOCULARS

Probably the most cost-effective accessory for the beginner are binoculars. Good quality binoculars can be purchased at the same cost as a cheap, low quality telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a cheap way of gauging their level of dedication. This does not mean we are suggesting the quality of the binoculars should be poor. It is recommended that even binoculars should be purchased from a reputable optics or telescope dealer. They are people who appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. Such shops can also assist with mounts to hold the binoculars steady. These are often brackets designed to attach to a tripod (sorry, another possible expense). To observe details on the Moon or look for Jupiter's moons, it is recommended that binoculars are not hand held. Sometimes you can brace yourself on the arms of a chair or the roof of a car. This can be important if the power of the binoculars is more than 10X. A power of 7X is considered a reasonable compromise. It can give a good field of view with



adequate magnification to glimpse some of the moons of Jupiter. The size of the aperture normally comes down to what is comfortable for the person to hand hold and the budget. 7X50 binoculars (7 times magnification, 50mm diameter front lens) are fairly popular with amateurs.

There are a multitude of uses for binoculars in amateur astronomy. Some of these include:

- Helping to find stars and planets in the bright twilight sky.
- Looking at the larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views and finder charts in this publication. This can be important in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Also, the contrast between the yellow of Alpha Centauri and the blue of Beta Centauri is interesting.
- The crescent phases of Venus.
- Stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky.
- Monitoring the change in magnitude of some of the brighter variable stars. There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society.
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on pp. 106-107). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites as the moon passes into or out of the shadow of the planet. The magnification of the binoculars will dictate how close to Jupiter you can see such an event.
- Lunar occultations of some of the brighter stars (see also Part II). Small binoculars are well suited for magnitude 4 or brighter events, preferably on a dark limb. There is no reason why one should not time the event as described on page 82.
- Looking for bright comets (from dark skies).
- Some of the bright deep sky objects such as the star clusters, Milky Way regions and the Magellanic Clouds.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart and see which 'star' has moved.
- Searching out Uranus and Neptune, see finder charts, page 118.

A lot of the above can be done from a typical suburban backyard. It is not necessary to drive for hours to reach dark skies. Also scanning the skies for satellites can open up a whole new Universe of discovery as various star clusters and nebulae drift through your field of view.

Finally, it is worth remembering that a pair of binoculars is prone to dewing just like a refracting telescope. A couple of cardboard tubes on the front, sticking out about 75mm, can prevent dew and also help eliminate stray light.

**SOME ASTRONOMICAL TERMS TO GET YOU STARTED**

There are several astronomical terms you'll come across in Astronomy 2003, many of which are defined in the glossary at the end of the book. Here are a few of the more common ones, just to get you started.

**Planet**. Just like the Earth! A planet is a sphere of either rock or gas that orbits the Sun or another star. There are nine planets in our Solar System, and the Earth is the third from the Sun. The diagram on page 19 gives a good overview. There are also a number (actually hundreds of thousands) of 'minor planets' that move around the Sun, mostly between the orbits of Mars and Jupiter (see also p. 49). The Moon and all the planets we see in the sky do not glow in their own right. They are only visible because of reflected sunlight.

**Star**. Just like the Sun. A star is an enormous sphere of glowing gas that gives off tremendous amounts of light and heat. They shine by their own light caused by nuclear reactions going on deep inside them. It's a testament to the enormous distances between the stars when you realise that the Sun is a relatively average star, while some stars visible in the night sky are tens or hundreds of times larger and brighter, yet in our sky look so faint.

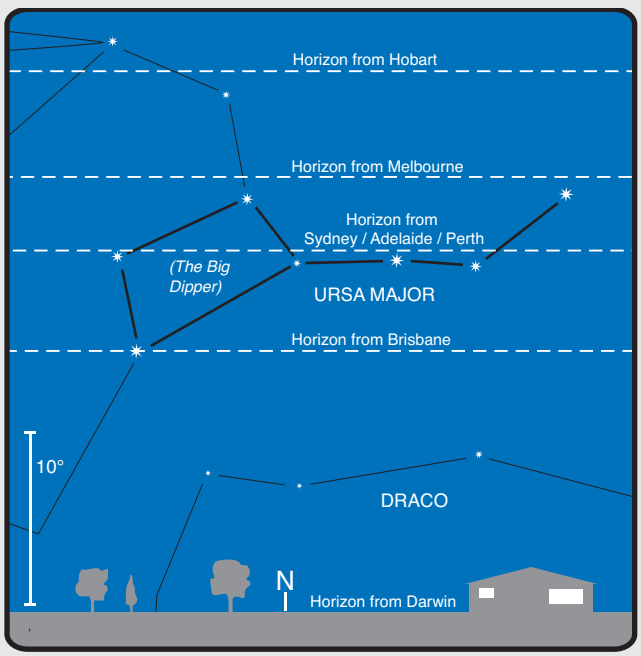
**Magnitude**. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'mag.'). The numbers work backwards. The faintest star you're likely to see with the naked eye is about 6.0 magnitude (under country skies), while the brightest stars are -1.0 magnitude. Planets can be much brighter. Venus, for example, can be as bright as -4.0 magnitude, the Full Moon, -12 magnitude!

**Waxing, Waning, Gibbous and Crescent**. These terms are normally used to describe the Moon. It is 'waxing' between New and Full Moon, after this time it is said to be 'waning'. The Moon is 'gibbous' when more than half is illuminated i.e., from after first quarter to just before third quarter. On either side of New Moon, when less than half is lit it is a 'crescent'. Gibbous and crescent are also sometimes used to describe the appearance of Mercury or Venus. Mars can also be gibbous.

**Angles in the sky** are measured in degrees. You'll see that the 'Sky Views' have a line showing what an angle of 10° looks like on the scale of these drawings. On the back cover is a scale that can help you measure angles. It is an interesting exercise to go out on nights when there are conjunctions and do your own measurements of the objects' separations and compare your results with the diagrams in this book. Always measure from the centres of the objects – the Moon in the Sky Views is not drawn to scale.

**Twilight** does not really end until the Sun is 18 degrees below the horizon; this is called 'astronomical twilight'. This happens about 90 minutes after sunset (or before sunrise) and is different from what people normally call the end of twilight. This is civil twilight, which begins or

**EFFECT OF LATITUDE**




The Sky Views (see the monthly sections) have been drawn for a latitude of approximately 33° south of the equator. This is reasonably central for the population distribution of Australia. However, we live in a large continent which covers a wide range of latitude. The further one goes north the more stars we see familiar to our northern hemisphere friends. As an example, let's take the 'Big Dipper'. You may have first heard about this in books written in England or America. This group of stars is part of a larger group known as the constellation Ursa Major, the Great Bear. From Darwin the group is clearly visible above the horizon (but upside down). However, from the southern states not all of it is visible. The Big Dipper is best placed in the northern sky in mid-May around 9pm (mid-June, 7pm). Also from the south we see very little of the constellation Draco. The diagram (above) is drawn to the same scale as a Sky View.

ends when the Sun is 6° below the horizon (about 30 minutes before sunrise or after sunset). Only when astronomical twilight has ended, is the sky considered truly dark (assuming the Moon isn't above the horizon!). But keep in mind that many celestial features can be seen even during twilight; binoculars can also help. The actual time between sunset and end of twilight (and the beginning of dawn and sunrise) does vary with latitude. The further south, the longer the time of twilight. Compare the twilight and rise/set times in Part II between Darwin and Hobart.

**Culmination.** When an object culminates it has reached its highest point in the sky and is generally considered to be the best time to observe it. For the planets, this is normally when they are due north.

## HOW DO I USE THIS BOOK TO PLAN MY OBSERVING?

This publication was never intended to be read from cover to cover (but we don't mind if you do!). It is a reference work, which, if you look closely enough, gives you a number of pieces of the picture. Also, the picture is quite different depending on whether you are using your eyes, binoculars, or a telescope. The data that an astrophotographer would find useful could again differ. To illustrate how to use the book we will work through an example.

You live near Melbourne, Victoria and are planning to go out and observe on the evening of **May 21** and hoping to push on all night (for once the infamous Melbourne weather is looking OK). Being in an eastern state you will use times in EST, when given. A good place to start is the 'Visibility of the Planets' chart (p. 18). Looking around mid May, the diagram is showing Jupiter and Saturn in the evening sky, with Mars, Mercury, Venus, Pluto, Uranus and Neptune in the morning. A quick check of the 'Rise/Set Chart' for May (p. 36) shows Mars and the Moon are rising close together (around 10.30pm) which would indicate a conjunction and there may be a sky view for this date. On p. 39 there is indeed a sky view with 'EVENING SKY – May 19 to 22' showing Mars and the Moon low in the eastern sky at midnight.

With the Moon between full and last quarter (the monthly Moon text shows this) a 'gibbous' or humped appearance is expected. With the Moon being up it is worthwhile checking for any occultations on this evening (or on the morning of the 22nd). The Melbourne table (p. 86) shows the reappearance of a 5th magnitude star ZC3089 from the dark limb of the Moon at 23:29, or 11.29pm. This is shortly after the Moon rises and you will see from the occultation table it has an altitude of only 12 degrees.

Before considering observing the Moon, there are other priorities earlier in the evening. The Rise/Set Chart shows Saturn setting not long after the end of twilight and this could be the first target for the evening. The 'Appearance of the Planets' diagram (p. 36) shows the rings wide open (as it remains for all of the year). A check of 'Satellites of Saturn' (p. 112) shows its brightest moon Titan to be approximately 6 days past an Eastern Elongation. Its position can be read directly off the diagram on page 112. Going back to the 'appearance' diagram this places the moon to the upper right (2 o'clock position) of Saturn, but a fair distance from the rings. Note this is on the opposite side as the appearance diagrams are drawn with north up, whereas the diagram on page 112 is drawn with south up. Titan can be seen in a small telescope.

Our next attraction could be Jupiter, for this giant world is setting around 10pm. Its satellites have an event for us. Early in the evening (twilight) the four Galilean moons can be seen with two on either side of the planet; Io (I) and Europa (II) to the east with Callisto (IV) and Ganymede (III) to the west (see p. 106). Ganymede is slowly closing the gap with Jupiter until at 8.23pm (20:23) when it will pass behind (get occulted) by Jupiter (see p. 104). You will see from this table it reappears just after midnight (12.02am) but Jupiter will be set by then. This reappearance is suitable (and recommended) for Western Australian observers.

The 3 hours prior to moonrise would be a good time to do some dark sky observing, assuming you can escape the suburban light polluted skies. An interesting exercise would be to find Comet 116P/Wild 4. At 12th magnitude it is faint and definitely for the more advanced amateur. The monthly text shows the comet to be in Libra moving towards the west. A planisphere (see example p. 15) shows Libra to be well up in the NE evening sky by 9pm. The 'Diary of Events' shows the comet was close to NGC5897 (a globular cluster) only 2 days before, so starting from this cluster you may pick it up by scanning. Otherwise the position (see p. 125) can be plotted on a star atlas.

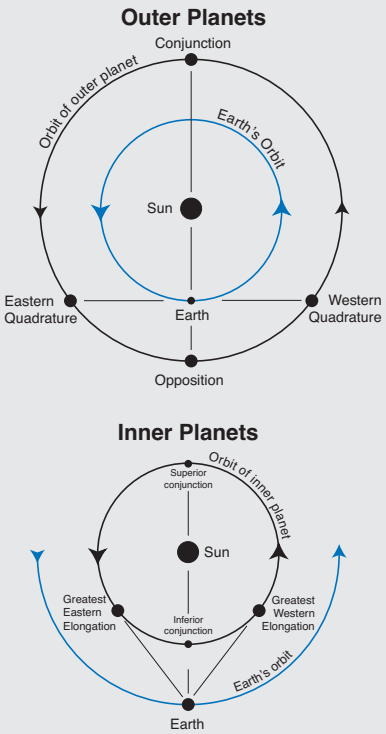
Returning to Mars, it is 3 months away from opposition and still presents a rather poor disk size of only 10.6 arc seconds (see Appearance Diagram p. 36).

The Rise/Set chart shows Neptune rising before 11pm with Uranus less than 2 hours behind. This confirms the Visibility Chart indicating these planets are best visible in the morning sky (allowing a couple of hours for them to get away from the horizon). Finder charts for these distant members of our Solar System can be found on page 118.

The pre-dawn sky sees Venus rising around 30 minutes before the start of twilight. Mercury rises just on the start of dawn. Mercury is rising up to meet Venus as it drops towards conjunction with the Sun in August. This is illustrated in the Movement of the Planets diagram, 'DAWN SKY – May to Aug. 03', (p. 17). This merger culminates in the Moon, Mercury and Venus conjunction on May 29 (see Sky View 'DAWN SKY – May 21 to 30', p. 39).

This is just one example of the way to apply the information within this book and how it can be a lot of fun planning an observing session.

## ORBITAL ASPECTS




A **conjunction** of a planet and the Sun is when they are closest together in the sky (not the best time to observe the planet). When an inner planet is between us and the Sun it is said to be at inferior conjunction, when on the far side of the Sun we have a superior conjunction. It is also common to hear this word referring to any two or more objects when they are closest to each other in the sky, that is their minimum angular separation.

**Opposition** refers to the time a planet is opposite the Sun in the sky. An object in opposition will rise around sunset and will be visible the entire night (like the Full Moon). The inner planets, Mercury and Venus, can never reach opposition. Their orbits are both inside Earth's. We need to pass between an object and the Sun for opposition to occur.

**Elongation** is often used in reference to the inner planets and their greatest angular distance from the Sun, that is greatest western elongation (in the eastern morning sky just before sunrise) and eastern elongation (a western evening sky object just after sunset). This is generally the best time to observe Mercury and Venus.

## THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

### RISE/SET CHART

This will enable the reader to quickly determine when (or if) a planet or the Moon is visible in the night sky for any day in that month. Each chart has the midnight line centred, with the evening sky below this line and the morning sky above. The two bands of 'lighter' shading show the times of morning and evening astronomical twilight. If you are using a telescope you'll soon learn to avoid trying to observe a planet near the

## WHAT TIME IS IT?

Unless a time zone or a location is specifically mentioned, times given in the Monthly section will be approximate local standard time. There are **no adjustments made for Daylight Saving** (or Summer Time) anywhere in this publication. When Daylight Saving is in force you will need to **add 1 hour** to times given here. For example, any rise/set time read off the charts will need to have one hour added to it to get daylight saving time.

When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST). They are the mean solar time on the meridian of longitudes of 150°E and 120°E respectively. For Central Standard Time (CST) subtract 30 minutes from the EST times given. Any times specifically given for Darwin or Adelaide are CST.

Queensland, NSW, ACT, Victoria and Tasmania use EST as their time zone. South Australia and the Northern Territory use CST and Western Australia uses WST.

horizon (close to rise or set times). Turbulence in the much thicker atmosphere (at low altitude) gives very poor 'boiling' images.

**These charts only give an approximate local standard time** and you will see from the specific rise/set times in Part II there is variation from city to city. This reflects the effects of position relative to the standard meridian and differing latitudes. The chart indicates the time to within plus/minus 30 minutes for all capital cities (except Darwin). Darwin, because of its extreme latitude compared to the more populated southern regions of the continent, can differ by up to 90 minutes. If more accurate rise/set times are required, you will need to refer to the specific tables for the object of interest in Part II of this publication. You can also adjust for rural locations using the appendix on page 130.

### APPEARANCE OF THE PLANETS

This diagram provides the reader with a telescopic view of each planet drawn to the same scale. Under each image is the date, the planet's angular diameter and magnitude. Phases are also shown for Mercury, Venus and Mars. Each planet is presented with the north pole to the top.

### MONTHLY HIGHLIGHTS

This lists a few of the more interesting events during the month.

### THE MOON

This provides information on major events relating to the Moon. The data includes the Moon's phases, apogee, perigee, occultations of planets or bright stars and lunar and solar eclipses. The event does not have to be visible from Australia to be included. The description will normally indicate whether or not it can be seen. Throughout the monthly section the Earth–Moon distance quoted is between the centres of the two bodies.

There will be no occultations of bright stars by the Moon during 2003, the next bright star occultation will be in January 2005 when the 1st magnitude star Antares passes behind the lunar limb. There will be eight planet and major asteroid occultations this year (somewhere in the world) plus the usual multitude of fainter star events (see Lunar Occultations in Part II for details). Interestingly, half of the eight events involve Mars.

### THE PLANETS

Presented are general notes on each planet. Emphasis is placed on their suitability for observation and any interesting conjunctions and patterns between the Moon, other planets and bright stars. Any times given for specific locations assumes local standard time.

### MINOR PLANETS (or Asteroids)

This section deals with the 38 brightest asteroids that reach opposition this year (approximately 11th magnitude or brighter). An entry includes the date of opposition (i.e., when it is brightest), its magnitude and the constellation the asteroid is in at the time of opposition. Ephemerides for the brightest 16 of these, plus 4 others that reach opposition in early 2004 are included in Part II.

### COMETS

This section deals with the comets expected to be visible during the year. It points out those that are observable during the month and includes any

# PLANISPHERE

A planisphere makes a great companion to our book. It is a hand held aid used to identify which stars and constellations are visible on any particular date and time. It is useful for many years.

The 'Night Sky' planisphere is a high precision, low distortion aid to the visual observer. It is double sided, designed for the southern hemisphere, and printed with a light background for easy night readability. Its plastic construction makes for a durable and moisture resistant product.

To use this planisphere is easy. Just turn the disk so the date lines up with the time and it will show you what the sky looks like now. It's that simple!

**PLANET FINDER**

Each planisphere comes in a reusable plastic sleeve and also with Quasar's **Planet Finder** card. This card includes information allowing you to easily locate the position of the five naked eye planets, on the planisphere.


*These planispheres are available direct from Quasar Publishing. They come in two sizes: the large 22cm version is $22.00, the small 13cm one is $13.20, price includes postage within Australia. Payment can be by cheque, money order or credit card (VISA, MC or Bankcard). Orders should be sent to:*

*PO Box 85, Georges Hall NSW 2198,*
*Fax: (02) 8814 5331 or*
*Email: sales@quasarastronomy.com.au*

interesting conjunctions. Note, most of the known comets this year are relatively faint and will need a telescope.

It is likely that many other comets will be discovered during the year. We have seen some spectacular comets in recent years, such as C/2001 A2 (LINEAR), and it is hoped that this trend continues with comets such as C/2001 Q4 (NEAT) and the newly discovered (at the time of publication) C/2002 O7 (LINEAR).

## METEOR SHOWERS

On any clear night we can sometimes see up to five shooting stars per hour, these are known as random or sporadic meteors. There are also annual 'showers' which return at the same time each year. Each shower seems to radiate from a focal point in the sky and is named after the constellation or a bright star the radiant lies near. For example, the radiant for the Leonids lies within the constellation of Leo. The monthly section lists the major showers for this year that are suitable for observation. These selected showers are those largely unaffected by moonlight during their peak period. Information for all the known showers is given in Part II. It takes great patience to watch for meteors but the occasional fireball makes it all worthwhile. It is best to do your searching on moonless nights, away from light polluted cities. As a general rule, more meteors are seen after midnight.

## DIARY OF EVENTS

This is a list of all general phenomena associated with the planets and Moon. The presentation is keyed to those people who would like to know 'what's happening tonight (astronomically speaking)?' Included are:

- Phase of the Moon.
- Key events in a planet's orbit.
- Selected conjunctions between the Sun, Moon, planets, comets, minor planets (asteroids), brighter stars and deep sky objects.

**Conjunctions**. Differences will be often found between the separation distances (and times quoted) and those found in the remainder of Part I. Conjunctions involving only the bright stars, the planets and the Moon are geocentric. This is how they would look from a position corresponding to the centre of the Earth. The exact time of closest approach may be in daylight from Australia, or the objects of interest may not be above the horizon for us. The planetary text and Sky Views have been tailor made to suit Australia. Hence the times and angles given in the Diary of Events could differ from those on a Sky View. Sometimes a lunar conjunction is followed by 'Occn'. This indicates that from somewhere in the world, the object will be occulted (covered) by the Moon. The distance given is measured from the centre of the Moon (remember, the Moon has a diameter of 0.5°). Occultations involving the planets or the brightest stars are also mentioned in the 'Moon' text.

**Abbreviations.** These include:

- G is galaxy (SG spiral, IG irregular, EG elliptical, LG lenticular)
- OC represents an open cluster
- GC is a globular cluster
- N is nebula (PN planetary, BN bright and DN dark nebula)
- m.p. refers to a minor planet

There are also some astronomical catalogues including:

- NGC – New General Catalogue
- IC – Index Catalogue
- M – Messier catalogue

**Time.** With the change to a single volume, the times of events have been streamlined. Specific times have been retained for time critical events such as conjunctions with the Moon. **When times are given both EST and WST are presented.** As these times are rounded to the nearest hour it is unnecessary to include a separate entry for CST seeing there is only a 30 minute difference to EST. The remaining entries are less time sensitive and either have no time (i.e., closest day) or a PM or AM designation for an evening or morning event respectively. For 'timed' events that occur in the very early hours (before 2am) for EST, the WST conversion (subtracting 2 hours) takes it into the previous day – shown as 'prev. day'.

## FEATURE ARTICLE

This section concentrates on some topics in popular astronomy. This can include: observational, historical, profiles of astronomy enthusiasts, astronomical equipment and techniques. Some of these are written specifically for beginners.

## SKY VIEWS

These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although, astronomically speaking, this would still be considered twilight, this is sometimes necessary to catch a glimpse of the planets when they are close to the Sun. This is especially needed for Mercury, because it never wanders more than 28° from the Sun. Sky Views which show a twilight view after sunset are called 'Evening Twilight' and morning twilights are 'Dawn Sky'. Those before midnight are 'Evening Sky' and after midnight, 'Morning Sky'.

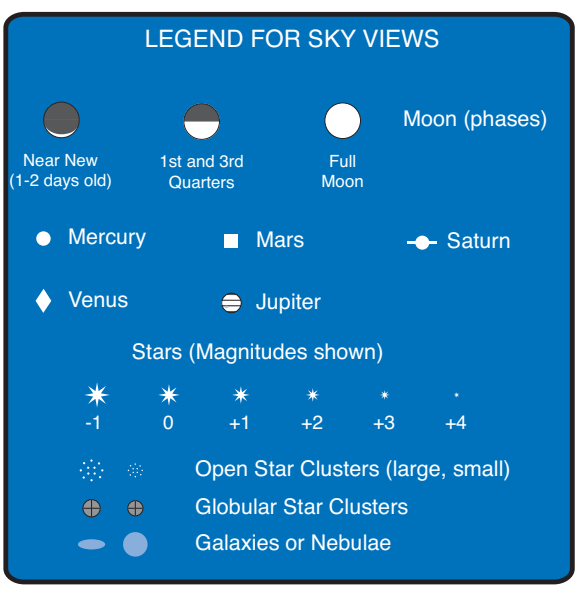
The 'Sky Views' (see also the legend below) include:

- The Moon (showing approximate phase) and the planets visible with the naked eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies (down to approximately 5.5 magnitude). These objects are named using the following codes. A prefix of 'N' means the object is in the New General Catalogue (NGC), an 'I' is the Index Catalogue (IC) and 'M' is a number in the Messier catalogue.
- Constellations are labelled (capital letters) and have black lines joining key stars.

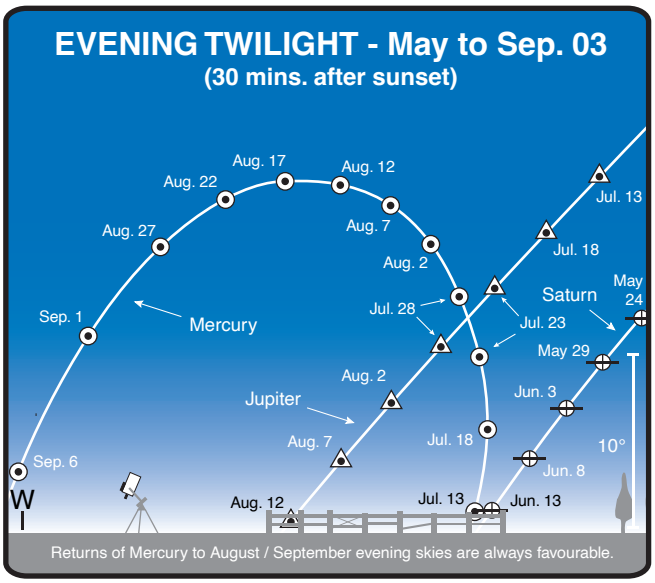
When using these 'windows to the sky' it is important to keep in mind that the horizon shown is theoretical, like looking out over the ocean. You will soon learn to make mental adjustments for local hills, trees and buildings etc. The scale has been kept constant and a 10° reference bar is marked. Sometimes the object of interest is so high, the field of view is not large enough to include the horizon.

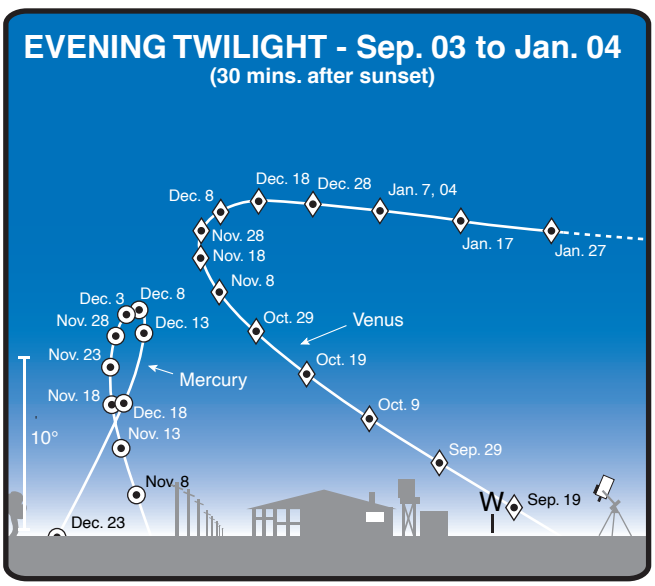
The Sky Views are useful for more than just the date and time shown. The pattern of stars relative to the horizon will appear the same one month later, but 2 hours earlier. Of course the planets and the Moon will have moved. Compare the Sky Views for Mar. 20 to 23 (10pm) on page 31, with Apr. 17 to 19 (8pm) on page 35. A few minutes playing with a planisphere (p. 15) will also show this yearly motion of the stars.

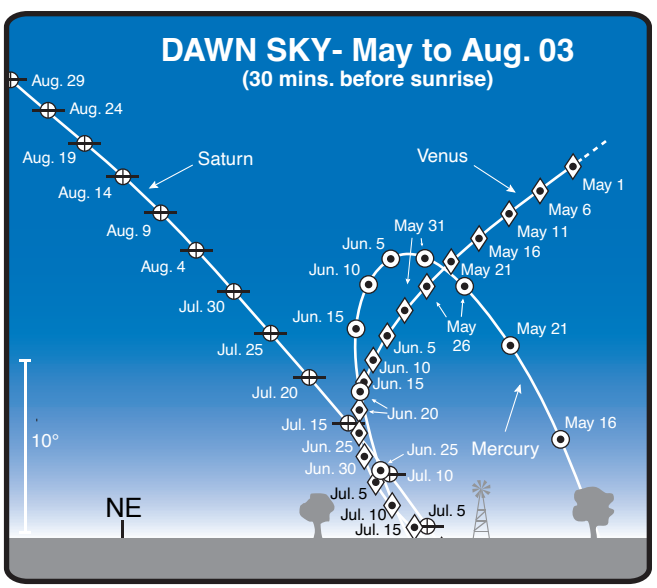
Uranus, Neptune and Pluto have been excluded from the Sky Views as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. In any case, because of the many faint stars of similar brightness close by, finder charts would be needed to identify these outer worlds. Charts for these planets are on pages 118-119.

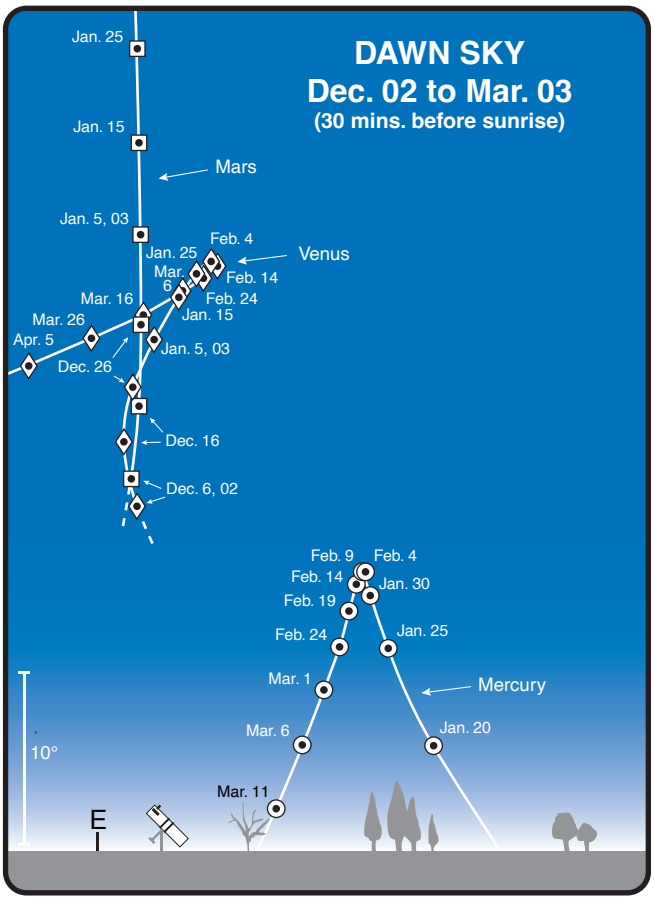


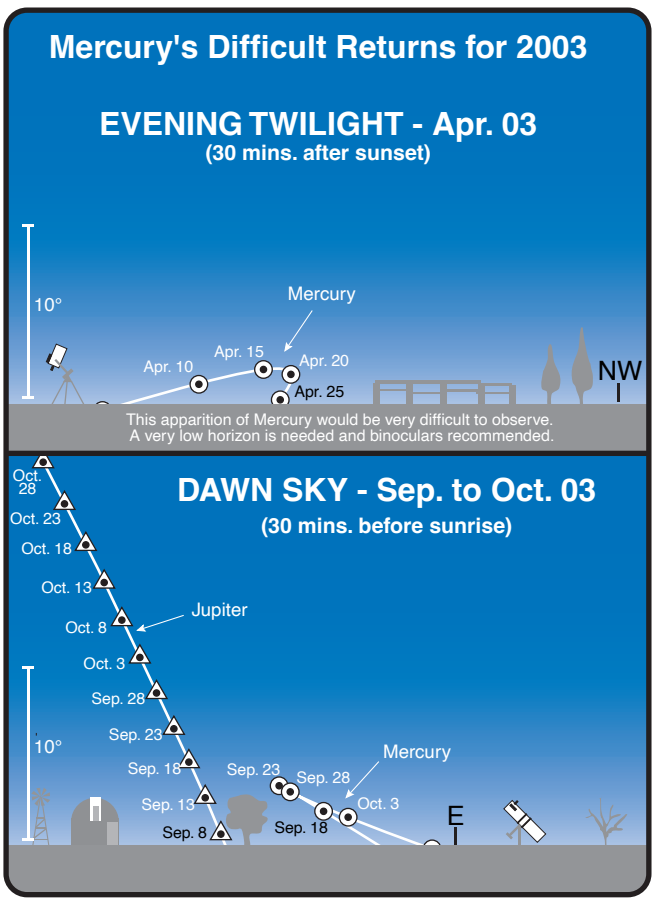
# MOVEMENT OF THE PLANETS



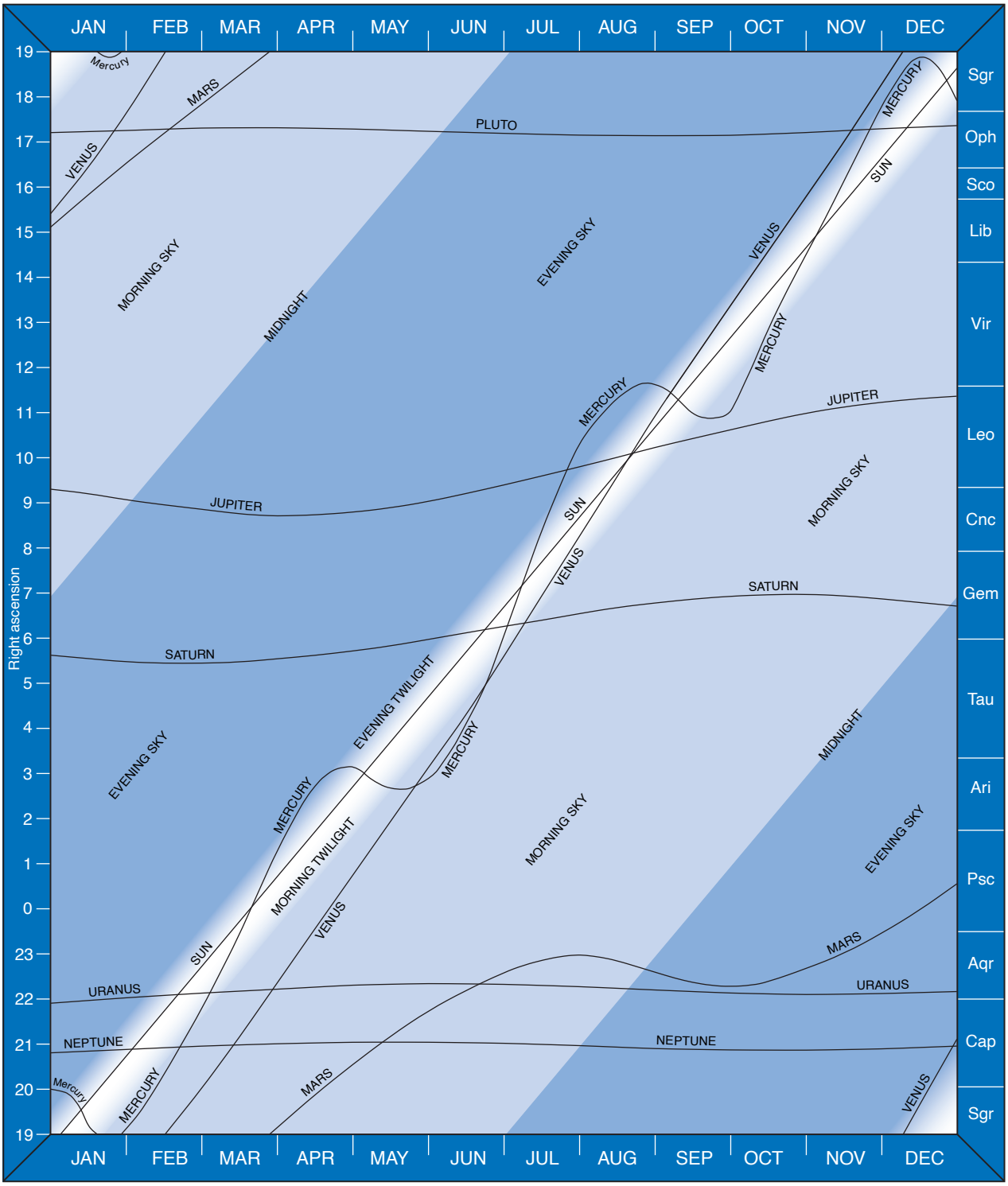




These diagrams are designed to help observers know when the planets first become observable after being in conjunction with the Sun, or when they are about to go into conjunction with our star. The drawings are particularly useful as an observing guide for Mercury. In addition, the Visibility of the Planets diagram (p. 18), allows you to see at a glance whether an object is in the morning or evening sky.

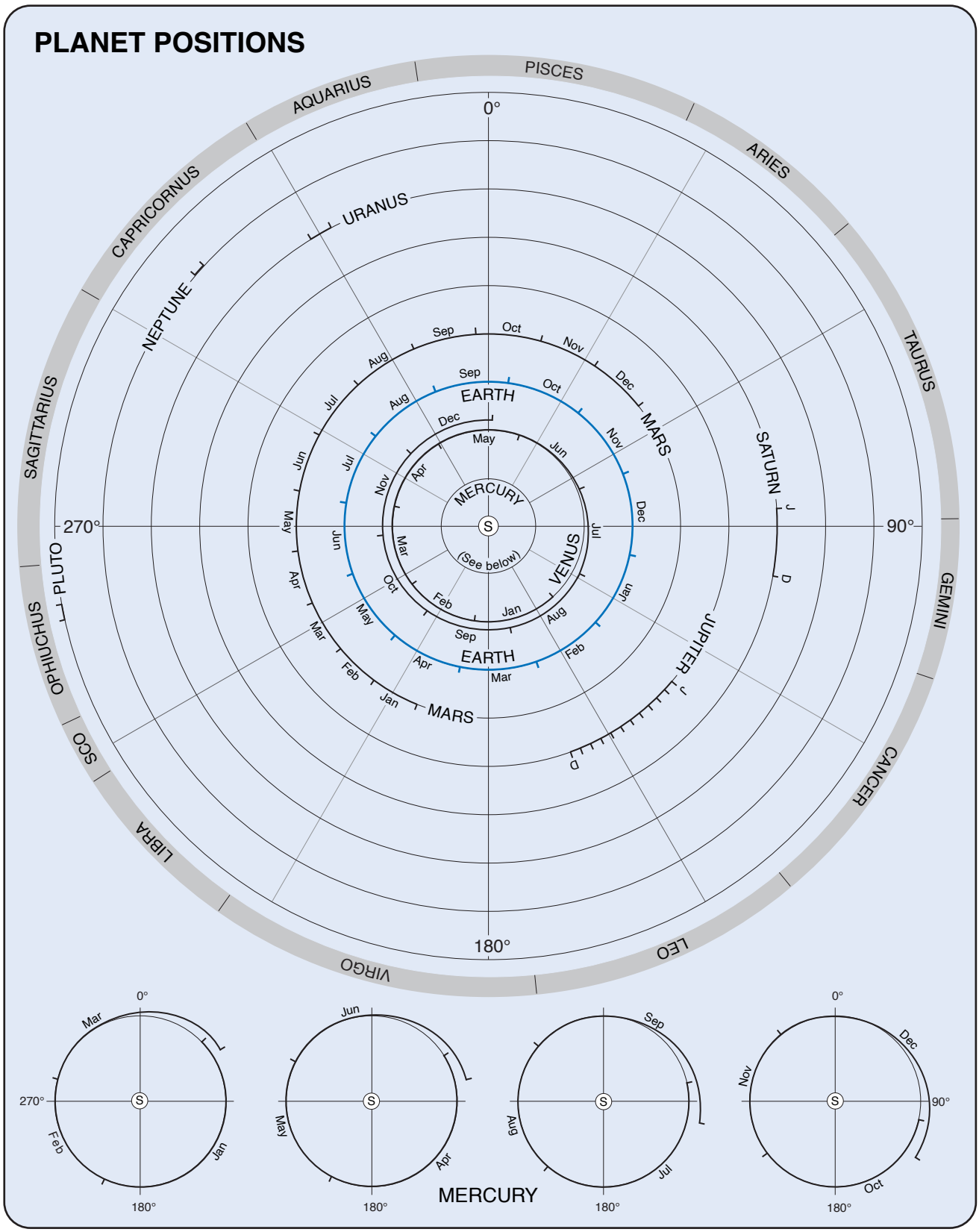
# VISIBILITY OF THE PLANETS




This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point a horizontal line to the right vertical axis will show which constellation the planet is in (Saturn, in the second half of the year, is visible in the morning sky in Gemini). To simplify the diagram the Moon has been omitted.

Mercury and Venus (and the rest of the planets) are in conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best times to observe Mercury are from mid-February to mid-March for the morning sky, and from mid-August to mid-September in the evening, when its path extends beyond twilight. When an outer planet crosses the midnight line, it is at opposition and is visible the entire night. Where an outer planet's line shows a downward slope, it is in retrograde motion.

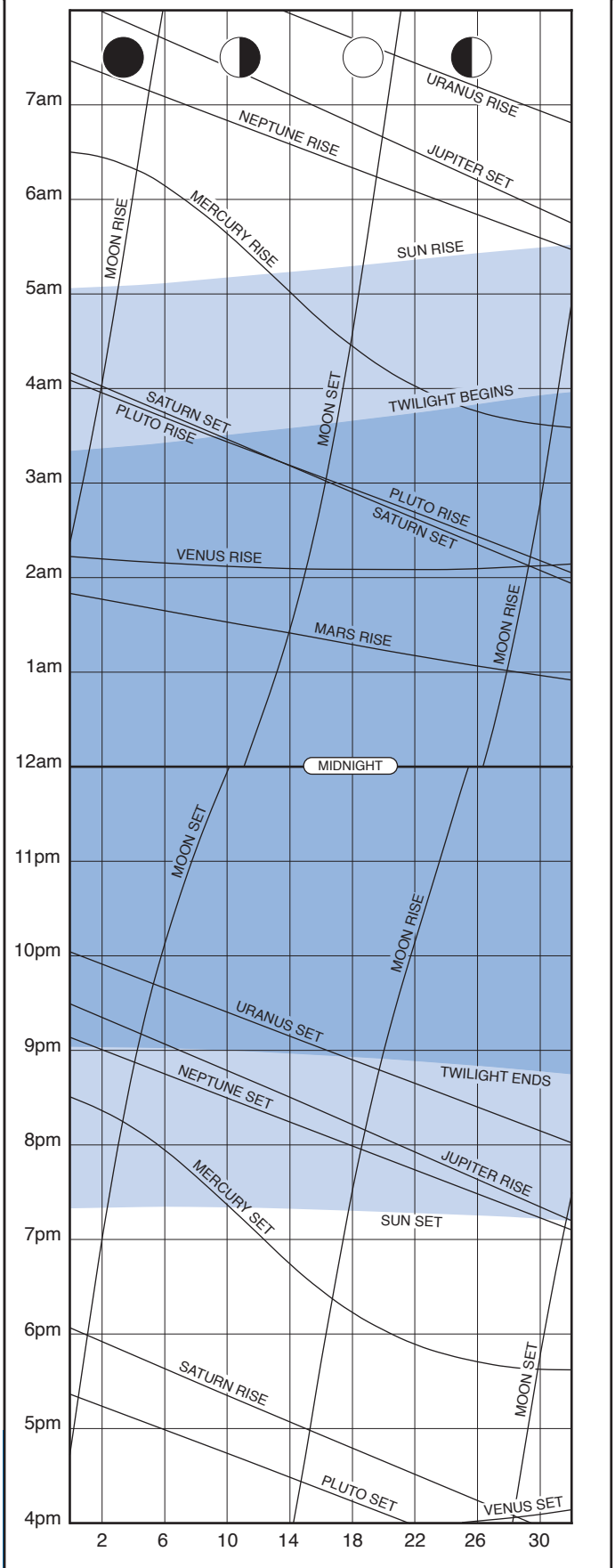
The diagram also shows when conjunctions between the planets occur. When two or more lines cross, the planets will be close together in the sky. This year's conjunction between Mercury and Jupiter is clearly shown where their paths cross in the July early evening sky (see also Sky View p. 47).




This diagram illustrates the relative positions of the planets during the course of their orbits in the year 2003. The relationships between the major Solar System bodies is clearly shown. For example, this year's opposition of Jupiter occurs early in February when the Earth appears closest. A line extended from Earth, through and beyond Jupiter shows that the planet is located in Cancer at this time. The diagram is drawn as viewed from below (south of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the Sun and planet distances are not drawn to scale. The thirteen constellations named are those that are situated on the ecliptic.

# JANUARY

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury returns to the morning sky late January.
- Venus at greatest elongation.
- Mars, the Moon and Antares close.
- Jupiter nearing opposition.
- Saturn passes over M1 (the Crab Nebula).

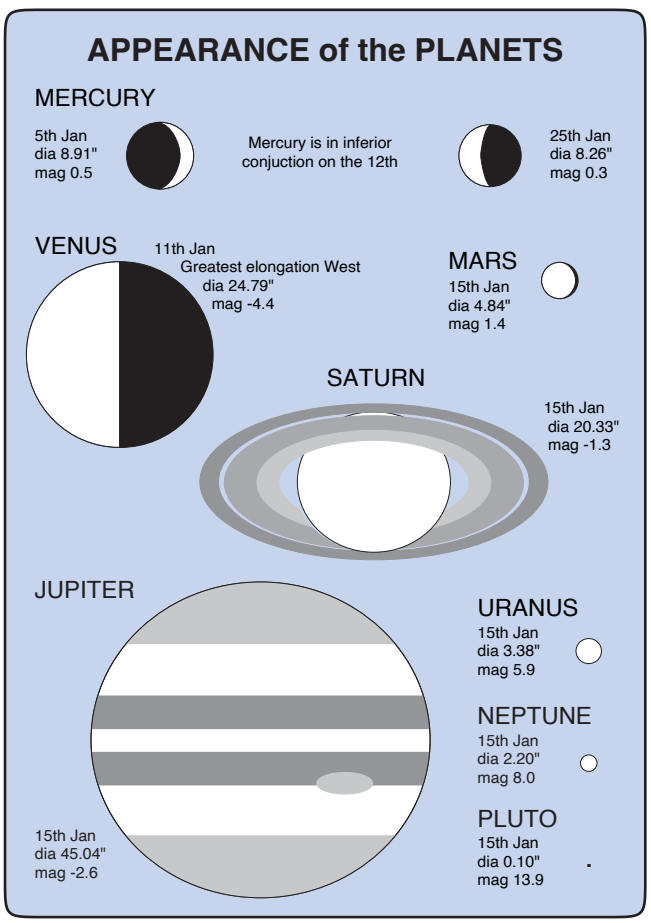
### THE MOON

| | |
|---|---|
| 3rd | New Moon |
| 10th | First Quarter |
| 11th | Moon at apogee (furthest from Earth – 404,343 km distant, angular size 29.4') |
| 18th | Full Moon |
| 24th | Moon at perigee (closest to Earth – 369,898 km distant, angular size 32.6') |
| 25th | Last Quarter |
| 28th | Occultation of Mars by the Moon, not visible from Australia |

### THE PLANETS

**MERCURY**, in Sagittarius, is located in the western evening twilight at the beginning of the month, but is soon lost in the Sun's glare as it moves into inferior conjunction (between Earth and Sun) on the 12th. Swinging west of the Sun the planet then reappears in the eastern dawn sky, where it remains until March. The planet appears as a slender crescent, visible in small telescopes at the beginning and end of the month.

## APPEARANCE of the PLANETS



**VENUS**, at its greatest elongation west of the Sun on the 11th (47°), shines at a dazzling magnitude -4.5 in the morning eastern sky. Only the Sun and Moon surpass Venus in the celestial brightness stakes. Venus will remain the Morning Star until September when it returns to the evening twilight sky. Since their close approach last December, the distance between Venus and Mars gradually increases as Venus moves from Libra into Scorpius and finally into Ophiuchus. On the 29th, the slim crescent 26–day old Moon is close to the planet (see Sky View). With an optical aid the waxing gibbous phase of the planet can be seen. Being nearly 25 arc seconds in diameter, this is the largest it will appear all year – when nearing inferior conjunction next year Venus will grow much larger than Jupiter in angular size!

The **EARTH** is at perihelion (the closest point in its orbit to the Sun) on the 4th. The Earth–Sun distance is 0.98332 astronomical units, which is equivalent to about 146,995,000 km.

**MARS**, located above Venus in the morning eastern sky (see Sky View), travels through Libra and Scorpius and lastly into Ophiuchus at month's end. Amateurs worldwide will be keenly waiting this year's opposition of Mars in August. As oppositions go this one is as good as they get and particularly favourable for the Southern Hemisphere (see Mars section in part II for full details). At the end of January, Mars will be within 5° of the 1st magnitude star Antares (see Sky View). The name Antares came from the ancient Greek 'Anti Ares' meaning 'equal to Ares' or 'rival to Mars'. When the pair happen to be close in the sky it is easy to see where the name comes from, the two being very similar in colour although often with differing brightness. This month they will not be so easy to distinguish as their magnitudes are almost evenly matched, the more northern of the pair being the planet. On the 28th, the 25–day old crescent Moon appears close to Mars (see Sky Views).

**JUPITER** comes to opposition early next month, and can be seen rising during evening twilight in the northeastern sky in Cancer. At the end of January, Jupiter will be situated between the Gemini twins, Caster and Pollux (to the north) and Regulus in Leo (to the south). On the 19th, the Moon, just past full, can be seen near the planet (see Sky View).

**SATURN** rises in the eastern evening sky in the 'horn' region of Taurus. Early in the month Saturn moves across the Crab Nebula. Ingress occurs on the evening of the 4th, moving off the nebula about 24 hours later. It will be a difficult event to observe, for even in a small telescope, the glare of this ringed world will be overwhelming compared to the Crab. First in Messier's catalogue, the Crab Nebula or M1 is the remnant of the supernova of 1054 AD. Saturn is currently in retrograde motion and will again pass very close to the Crab in April after the planet returns to its east to west motion across the sky. On the 15th, the 12–day old gibbous Moon appears near Saturn (see Sky View).

**URANUS** and **NEPTUNE** begin the month low in the western evening sky in Capricornus, with Neptune setting during twilight. Neptune will be in conjunction with the Sun on the 31st. This is the 4th in a series of 8 annual Neptunian conjunctions, where the planet is occulted by the Sun's disk (not exactly observable); the next series begins in the year 2080. On the 21st, Uranus moves from Capricornus into Aquarius, where it remains until March 2009.

**PLUTO** returns to the morning sky in Ophiuchus after solar conjunction late last year.

**MINOR PLANETS** at opposition this month include: 511 Davida on the 1st at magnitude 9.5 in Gemini, 704 Interamnia on the 18th at magnitude 10.4 near the border of Cancer and Canis Minor and 39 Laetitia on the 31st at magnitude 10.1 in Cancer. 4 Vesta takes us on a tour de force this year of Virgo, visiting a number of bright galaxies from January to July.

## THE MOON ILLUSION

You may have noticed that the Full Moon rising or setting just above the horizon looks much larger than when seen overhead. This is the famous 'Moon illusion', one of the most celebrated of all illusions. It is indeed an illusion, there is no physical or atmospheric reason that the horizon Moon should look any larger than the zenith Moon.

Not only does the Moon suffer from this horizon enlargement but also the Sun and surprisingly the familiar constellation patterns. On average people judge the horizon Moon to be 50% to 75% larger than the zenith Moon.

Instruments and cameras can prove that the angular size of the Moon is constant, at least over a single evening. As the Moon orbits the Earth in an elliptical path, its apparent size will vary during the month. When most distant (apogee) the Moon appears about seven-eighths the size it appears when nearest (perigee), but this orbital variance does not contribute to the illusion.

Knowledge of the Moon illusion no doubt predates recorded history, and there are references in Greek and Chinese literature going back to around 700 BC. The Arab mathematician Alhazen (965 – 1040 AD) concluded that when the Moon is near the horizon, it looks large as the brain compares it with terrestrial objects like trees and buildings. High in the sky, with no familiar objects nearby, it appears smaller as the eye tends to accept a wide-angle view.

While there are many theories attempting to explain the Moon illusion, it is interesting to note that the horizon Moon is slightly smaller in angular size than the zenith Moon (when overhead). When the Moon is seen on the horizon, it is about 6400 kilometres further away than when viewed later at the zenith. This is because the observer is further from the Moon by almost one Earth radius (see diagram), amounting to a 1.6% reduction in the Moon's size (not really noticeable to the eye).

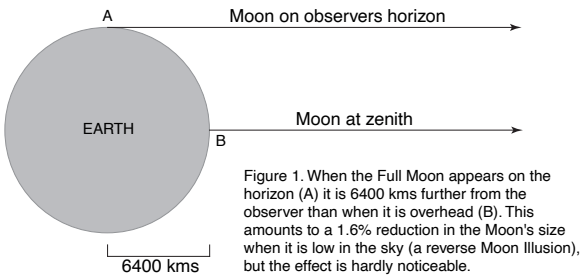



Figure 1. When the Full Moon appears on the horizon (A) it is 6400 kms further from the observer than when it is overhead (B). This amounts to a 1.6% reduction in the Moon's size when it is low in the sky (a reverse Moon Illusion), but the effect is hardly noticeable.

Effects such as atmospheric refraction have also been put forward to explain the phenomena, but refraction only reduces the vertical dimension, making the Moon (or Sun) appear oval. Some researchers believe that an effect called oculomotor micropsia (looking small) and oculomotor macropsia (looking large) causes the illusion. With this effect, the size of the Moon is altered by changes in the activity of eye muscles, depending on where the eyes are focused and converged.

Some problems with the various theories include the fact that you cannot see a horizon Moon and a zenith Moon at the same time, and therefore the observer cannot draw a comparison. About eighty five to ninety percent of the population perceives the illusion, but the rest do not. If you face 180° from the Moon, bend over and look at our celestial neighbour from between your legs, the illusion disappears! This is a fact, so please do not send any 'mooning the Moon' jokes to us (on second thoughts, maybe the best could be published in 'Astronomy 2004').

Whichever theory is correct, the Full Moon rising is always a stunning sight. In addition, it is a perfect photographic opportunity with a telephoto lens or small telescope, particularly if buildings or trees are in the foreground.

# JANUARY

## COMETS

**Comet 116P/Wild 4** is a morning object in Virgo and Libra, rising after midnight at the beginning of the year. During the month the comet should brighten from 13th to 12th magnitude. It is at perihelion on the 22nd, at 2.2 AU from the Sun. However, over the next few months, the distance between the comet and Earth will narrow and the comet should brighten slightly.

**Comet 154P/Brewington** can be found in the evening sky and towards the end of January it is setting before the end of astronomical twilight. Predicted to brighten from 11th to 10th magnitude as it heads towards perihelion next month, Comet Brewington is slowly moving through the constellations of Aquarius and Pisces.

**Comet C/2001 HT50 (LINEAR-NEAT)** rises early in the evening and is visible until dawn. The 12th magnitude comet moves through Hydra and Monoceros and in mid-January passes just north of the open cluster M48.

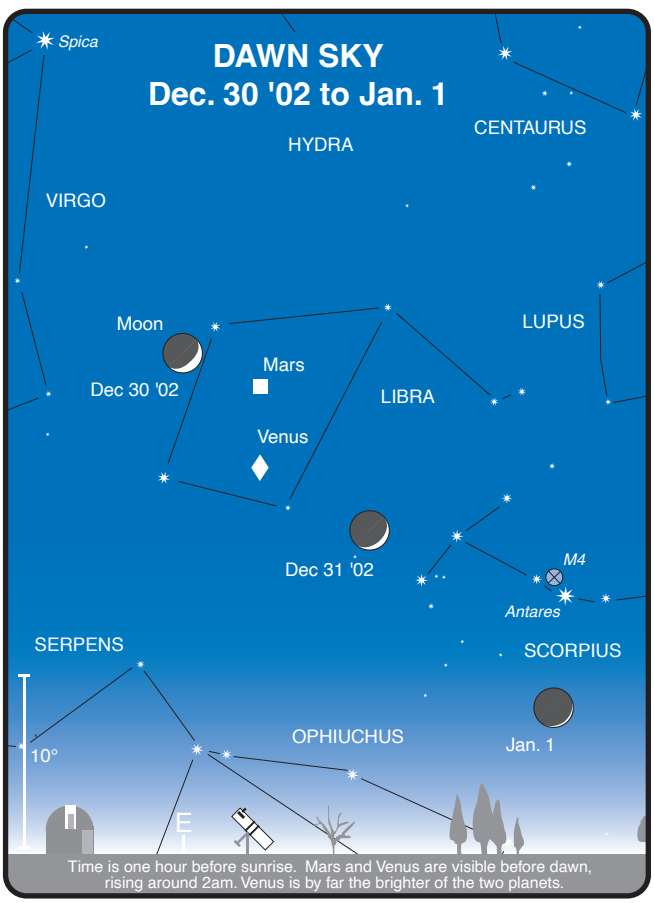
**Comet C/2001 RX14 (LINEAR)** is low in the northern sky this month and thus presents a challenge to observe. The 10th magnitude comet, at perihelion on the 19th, is moving through the constellations of Ursa Major and Canes Venatici and rises in the early hours of the morning. It is best observed at the beginning of astronomical twilight.

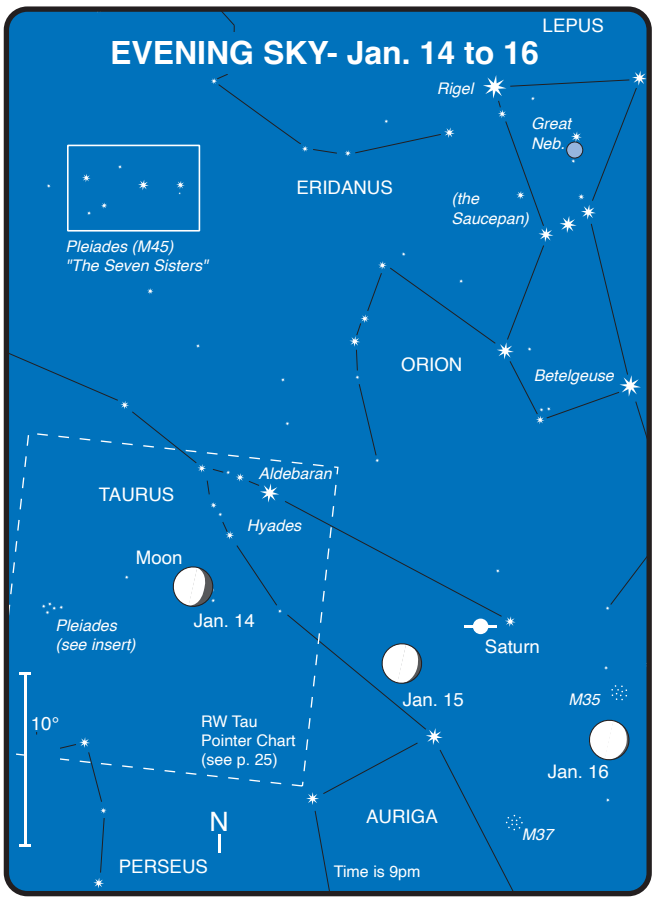
## METEOR SHOWERS

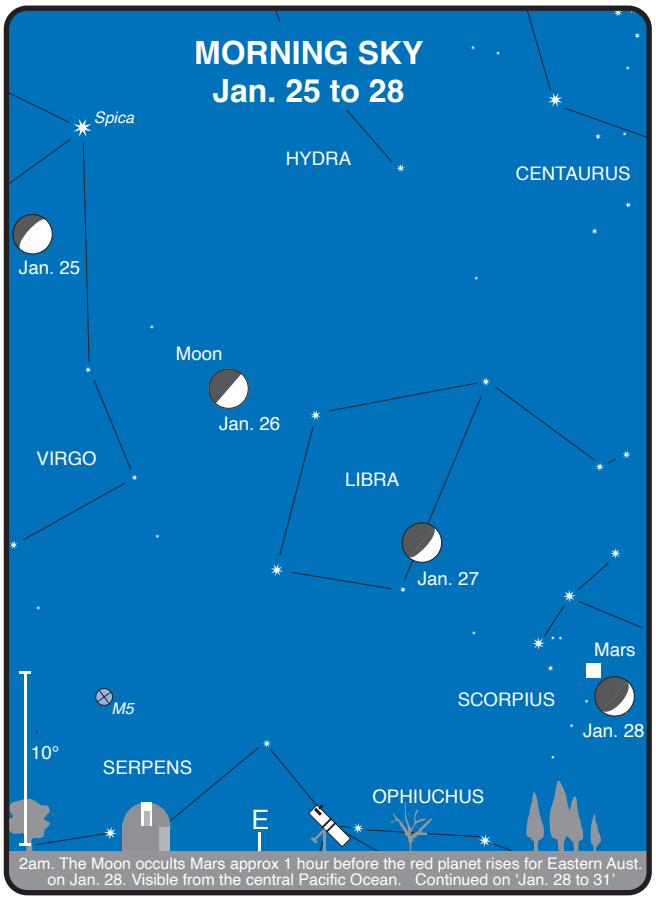
The **Quadrantids** are a strong and consistent northern shower. However, it is difficult for southern observers, with the radiant below the early morning northeastern horizon. If observing before dawn, the occasional long-pathed member may be glimpsed. The Quadrantids are active from January 1-5, and peak on the 4th, the zenith hourly rate is 120, but can vary from 60 to 200.

## DIARY EST (WST)

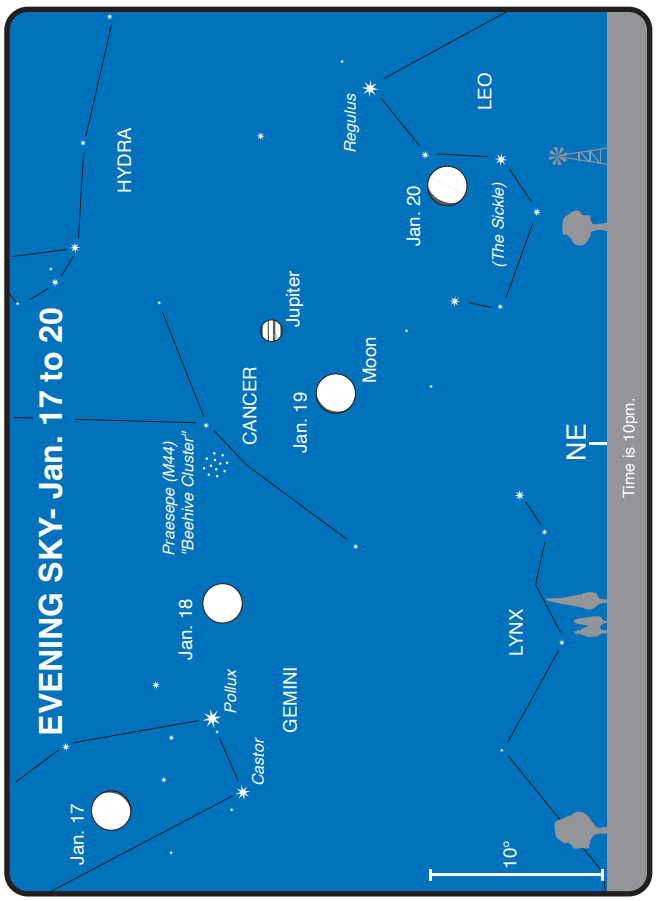
| | | |
|---|---|---|
| 1st | | m.p. 4 Vesta 0.7°E of NGC4496A (SG) in Virgo |
| 1st | | Mercury at ascending node |
| 2nd | am | Comet C/2002 O7 (LINEAR) 0.7°NE of star Alpha Coronae Borealis |
| 3rd | | Mercury stationary |
| 3rd | | m.p. 29 Amphitrite 1°NW of star Delta Capricorni |
| 3rd | | New Moon |
| 4th | | Earth at perihelion |
| 4th | 9 am | (7 am WST) Mercury 5°N of Moon |
| 4th | 11 pm | (9 pm WST) Saturn 0.02°NE of M1 (Crab Neb.) in Taurus |
| 5th | | m.p. 85 Io 1°SW of star Eta Ophiuchi |
| 5th | 5 am | (3 am WST) Neptune 5°N of Moon |
| 6th | | Comet 65P/Gunn 1.4°SW of m.p. 8 Flora |
| 6th | | Mercury at perihelion |
| 6th | 11 am | (9 am WST) Uranus 5°N of Moon |
| 10th | | First Quarter Moon |
| 10th | am | m.p. 4 Vesta 0.7°N of NGC4636 (EG) in Virgo |
| 11th | | Uranus 0.6°NW of m.p. 29 Amphitrite |
| 11th | | Moon at apogee |
| 11th | | Venus greatest elong. W (47°) |
| 12th | | Mercury in inferior conjunction |
| 12th | am | m.p. 4 Vesta 0.3°N of NGC4665 (SG) in Virgo |
| 13th | | Pluto 0.9°S of the Box Nebula (PN) in Ophiuchus |
| 15th | | m.p. 12 Victoria 0.6°SW of NGC5897 (GC) in Libra |
| 16th | | Venus 0.7°S of m.p. 8 Flora |
| 16th | | Mercury at greatest latitude north |
| 16th | 6 am | (4 am WST) Saturn 3°S of Moon |
| 16th | 8 am | (6 am WST) Venus 8°N of Antares |
| 18th | | Full Moon |
| 18th | pm | Comet C/2001 HT50 (LINEAR-NEAT) 1.7°N of M48 (OC) in Hydra |
| 19th | | Venus at greatest latitude north |
| 20th | 1 am | (11 pm WST, prev day) Jupiter 4°S of Moon |
| 22nd | | Mars 0.6°SW of star Beta 1 Scorpii |
| 23rd | | m.p. 23 Thalia 0.7°NE of NGC5634 (GC) in Virgo |
| 23rd | | Mercury stationary |
| 24th | | Moon at perigee |
| 25th | | Last Quarter Moon |
| 26th | 3 am | (1 am WST) m.p. 4 Vesta 0.05°SW of star Delta Virginis |
| 28th | | Venus 0.7°SE of NGC6342 (GC) in Ophiuchus |
| 28th | 1 am | (11 pm WST, prev day) Mars 0.4° of Moon Occn. |
| 29th | 5 am | (3 am WST) Venus 4°N of Moon |
| 29th | pm | m.p. 511 Davida 1°NE of star Mu Geminorum |
| 30th | 8 pm | (6 pm WST) Mercury 5°N of Moon |
| 31st | | Neptune in conjunction with Sun |
| 31st | 3 pm | (1 pm WST) Mars 5°N of Antares |

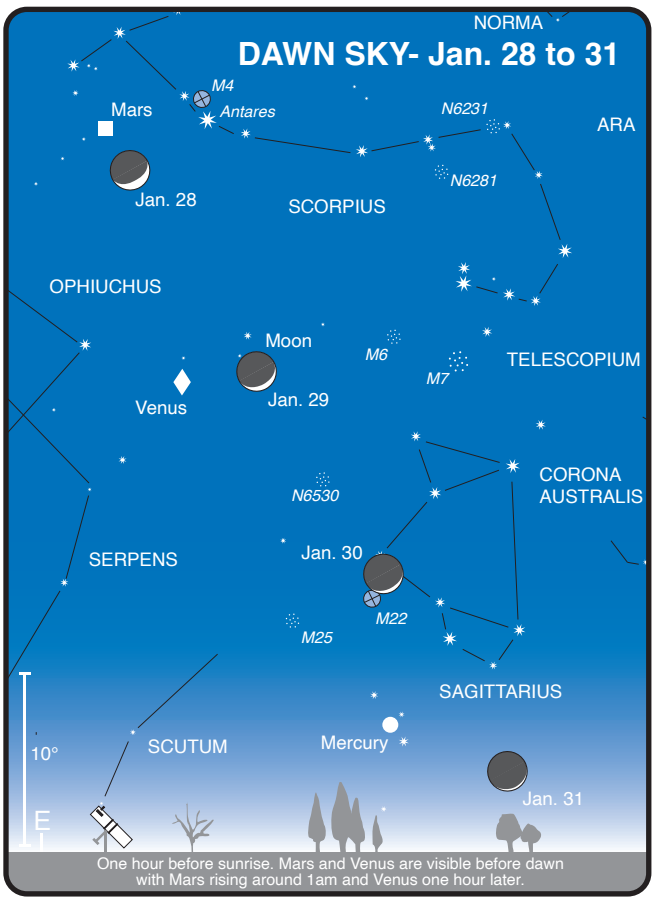




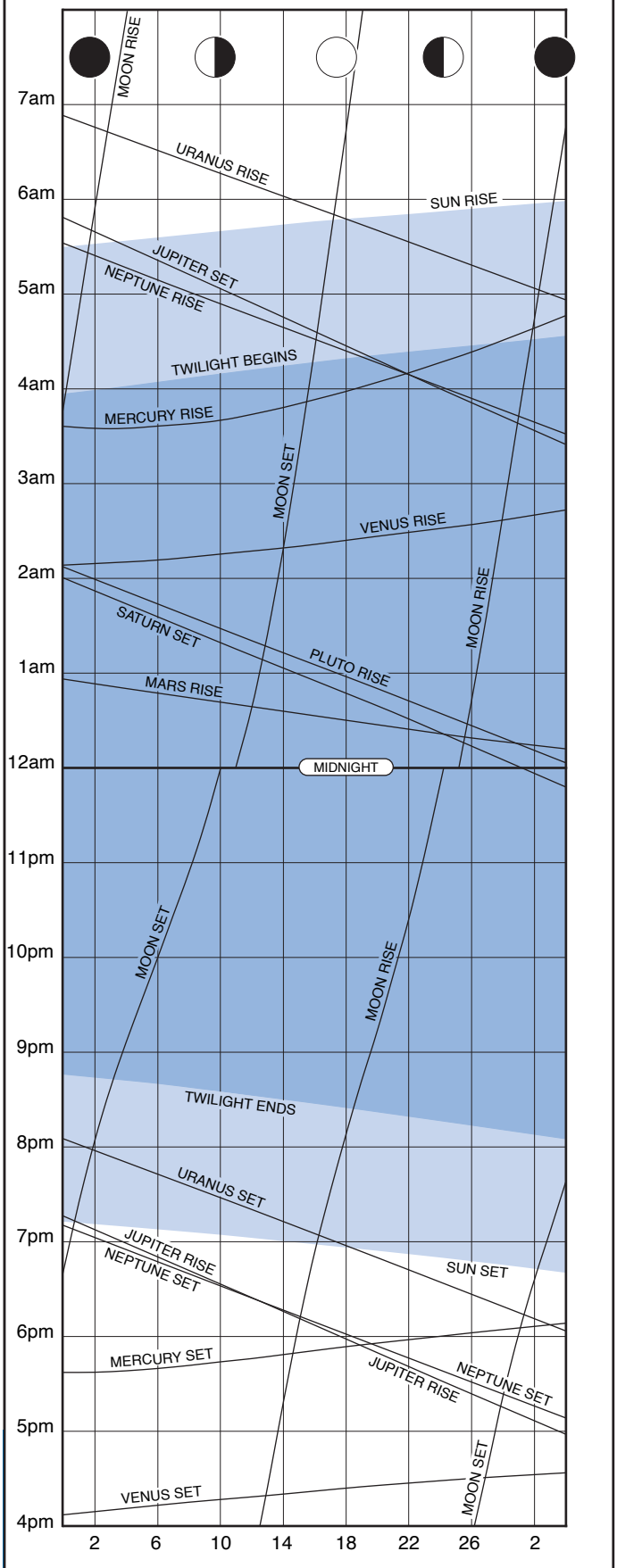

Approximate local standard time, for daylight saving add 1 hour.



# FEBRUARY

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury favourable for observation in the morning sky
- Jupiter at opposition

### THE MOON

| | |
|---|---|
| 1st | New Moon |
| 8th | Moon at apogee (furthest from Earth – 404,552 km distant, angular size 29.2') |
| 9th | First Quarter |
| 17th | Full Moon |
| 20th | Moon at perigee (closest to Earth – 364,845 km distant, angular size 33.2') |
| 24th | Last Quarter |

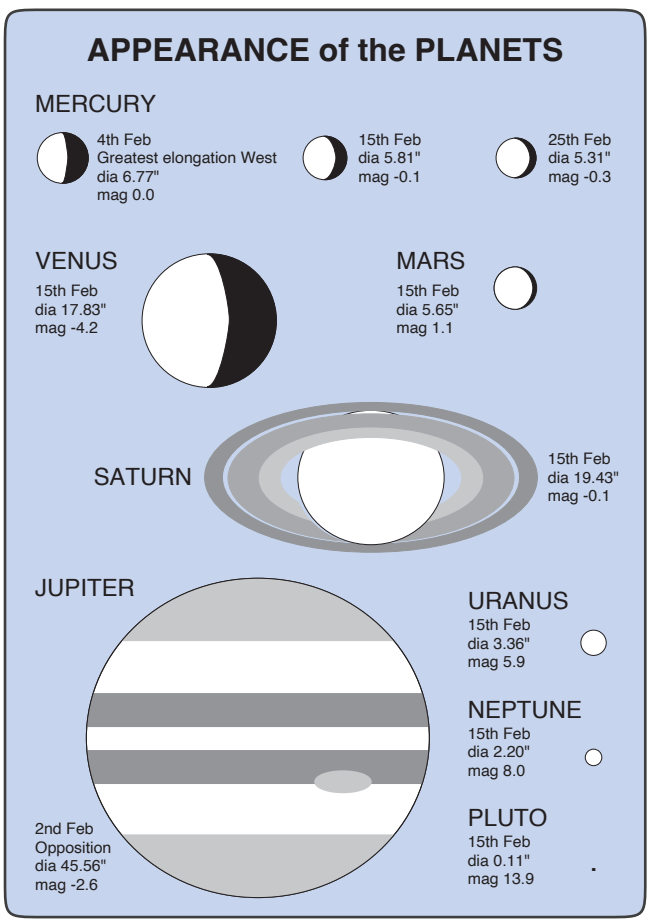
### THE PLANETS

**MERCURY** is in a favourable position to observe this month, reaching its greatest elongation west of the Sun on the 4th (25°), rising just before morning twilight in the east. As the planet slowly heads down toward the horizon, it moves from Sagittarius into Capricornus, passing very close to the Messier globular M75 and the outer planet Neptune. With optical aid, the waxing gibbous phase and diminishing globe will be apparent as the speedy little planet races ahead of the Earth in its orbit.

**VENUS** shines brilliantly high in the eastern morning sky throughout February. Moving across the Sagittarius Star Cloud, close to the galactic centre, Venus passes near some of the better known and impressive Messier objects this month, although the sheer brilliance of the planet will overwhelm and swamp these fine gems. On the 12th, Venus passes between the M22 and M25 star clusters. On the 28th, the 26–day old slender crescent Moon is located just south of the planet (see Sky View).

**MARS** is in Ophiuchus for all but the last day of February, when it moves into Sagittarius. Rising around 1am in the eastern morning sky, the Red Planet follows the path of Venus across the heart of the Milky Way.

## APPEARANCE of the PLANETS



On the 25th, the waning crescent Moon, now past Last Quarter, will be just above Mars, and on the following evening below (see Sky View).

**JUPITER** is at opposition on the 2nd, and can be seen in the constellation of Cancer mid-evening in the northeastern sky. As far as oppositions go this one is not particularly favourable with the diameter of the disc at 45.5 arc seconds. Perihelic or favourable oppositions occur every twelve years, when the disc is about 50 arc seconds in diameter, the next will occur in September 2010. In reality, there are really no bad oppositions of Jupiter. Its large angular size ensures even the smallest of telescopes can glimpse the cloud bands and polar flattening, and binoculars held steady will reveal the four Galilean satellites. Throughout the month the king of planets, approaches the famous Beehive cluster or Praesepe (M44), an open cluster of about 200 stars visible to the unaided eye from dark skies. By the end of the month Jupiter will be a little less than 3° from the Beehive's core, further than last September when the planet passed by the cluster's outer fringes. On the 15th, the near Full Moon appears to the north of Jupiter (see Sky View).

## A REAL TIME VARIABLE STAR

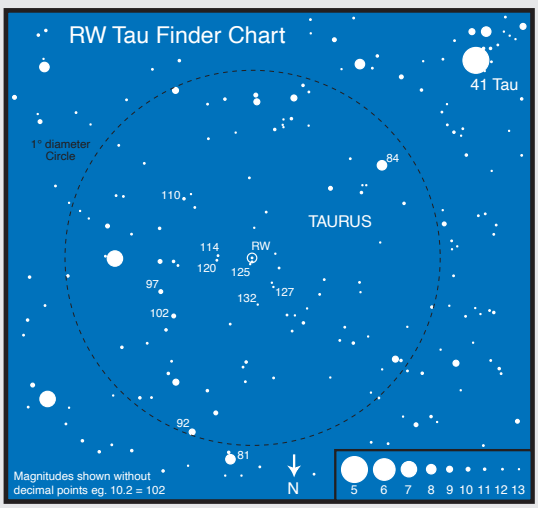
You don't have to be involved in this hobby long to learn that there is a select group of stars that vary in brightness. The most common 'variables' are the pulsating type that change brightness as the star expands and contracts while going through a relatively brief (millions of years) but unstable period in its life. The most famous example of these are the Mira variables (see article in Astronomy 2002) which typically change around 4 to 6 magnitudes, taking about 100 to 200 days to fade and then a similar period to recover. This oscillation, of which a plot of brightness versus time resembles a sine wave, continues to repeat year after year. There are also stars whose variability has nothing to do with such internal change. Their variation is due to a periodical covering of the star by a lower temperature, fainter companion. These are the 'Eclipsing Binaries'. Anyone who has looked at Alpha Centauri appreciates that stars can exist in pairs, gravitationally linked and orbiting each other. If the position of the Earth in space happens to lie close to or in the plane of such a pair we may see the stars occult each other. They may be so far away, or physically close together, that the only indication of its binary nature may be a periodic fluctuation in luminosity (or by shifts in the lines of its spectrum – another story). Many of these stars orbit so close to each other they take only a few days to complete an orbit. One such example is RW Tauri; a hot B8 type star orbiting with a cooler K0 star in only 66 hours. The cooler, fainter star takes approximately 10 hours to pass completely across its companion (see figure 1) with the brighter, but much smaller, star being completely blocked for approximately 80 minutes of this time (the bottom plateau). There is a total drop of 4.5 magnitudes. To get a feel for this relative change in luminosity, compare Sirius to Delta Crucis (the star in the 3 o'clock position in the Southern Cross). You will see from fig. 1, RW Tau fades quite quickly at times (when the line is steep). Most of the drop occurs in the last 2.5 hours before minimum. This is mirrored in the recovery phase. The authors once witnessed a drop of 3 magnitudes in 2 hours. That's what one would call a real time change! Who said we live in a static Universe (outside of the Solar System that is)? Some changes in colour have also been reported. The cooler star is certainly red compared to its hot blue friend. However, it would take a large telescope to see colour in a magnitude 12 star. With regards to observing the star almost any small telescope can be used during its bright phase at magnitude 8. A 15cm telescope at least, under dark country skies, is needed to follow it to minimum.

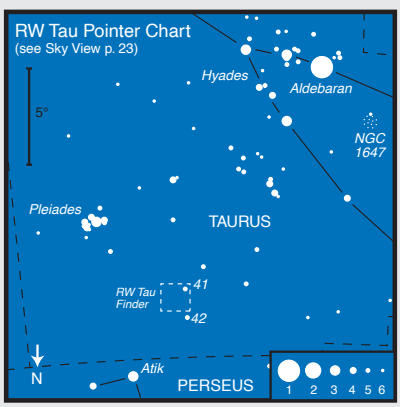
This table gives predictions for times of minimum for 'RW' from the end of 2002 to the end of 2003. This is the middle of the bottom plateau (fig. 1, time '0') so expect the star to remain at its faintest for 40 minutes either side of this time. It is easier, if you are a beginner, to watch the star fade. Plan to start your observing around 5 hours before the predicted times (if possible). The eclipses listed are those which generally favour Australia with times for Eastern (EST) and Western Australia (WST); a 'p' following the WST times indicates the previous evening. For CST time subtract 30 minutes from EST times.

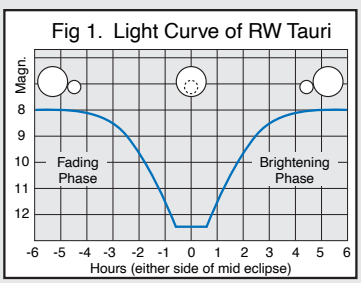
| DATE | EST Time | EST Obs | WST Time | WST Obs |
|---|---|---|---|---|
| 03.11.2002 | 3:39 AM | F | 1:39 AM | F |
| 05.11.2002 | 10:06 PM | B | 8:06 PM | B |
| 14.11.2002 | 5:27 AM | X | 3:27 AM | F |
| 16.11.2002 | 11:54 PM | W | 9:54 PM | B |
| 28.11.2002 | 1:43 AM | F | 11:43 PM p | W |
| 30.11.2002 | 8:10 PM | B | 6:10 PM | B |
| 09.12.2002 | 3:31 AM | F | 1:31 AM | F |
| 11.12.2002 | 9:59 PM | B | 7:59 PM | B |
| 22.12.2002 | 11:47 PM | W | 9:47 PM | B |
| 03.01.2003 | 1:36 AM | F | 11:36 PM p | W |
| 05.01.2003 | 8:03 PM | B | 6:03 PM | X |
| 16.01.2003 | 9:51 PM | B | 7:51 PM | B |
| 27.01.2003 | 11:40 PM | F | 9:40 PM | X |
| 10.02.2003 | 7:55 PM | B | 5:55 PM | X |
| 29.08.2003 | 4:28 AM | F | 2:28 AM | B |
| 09.09.2003 | 6:17 AM | X | 4:17 AM | F |
| 12.09.2003 | 12:44 AM | B | 10:44 PM p | X |
| 23.09.2003 | 2:32 AM | F | 12:32 AM | B |
| 04.10.2003 | 4:21 AM | F | 2:21 AM | F |
| 06.10.2003 | 10:48 PM | B | 8:48 PM | X |
| 15.10.2003 | 6:09 AM | X | 4:09 AM | F |
| 18.10.2003 | 12:36 AM | W | 10:36 PM p | B |
| 29.10.2003 | 2:25 AM | F | 12:25 AM | W |
| 31.10.2003 | 8:52 PM | B | 6:52 PM | X |
| 09.11.2003 | 4:13 AM | F | 2:13 AM | F |
| 11.11.2003 | 10:40 PM | B | 8:40 PM | B |
| 20.11.2003 | 6:02 AM | X | 4:02 AM | F |
| 23.11.2003 | 12:29 AM | W | 10:29 PM p | B |
| 04.12.2003 | 2:17 AM | F | 12:17 AM | W |
| 06.12.2003 | 8:45 PM | B | 6:45 PM | X |
| 15.12.2003 | 4:06 AM | X | 2:06 AM | F |
| 17.12.2003 | 10:33 PM | B | 8:33 PM | B |
| 29.12.2003 | 12:22 AM | F | 10:22 PM p | B |

Codes are given (under 'Obs') to indicate which part of the 'eclipse' is favoured for eastern or western Australia, taking into account the rise and set times of the star and the Sun (twilight) on the day. F is fading phase, B is brightening phase and W means both phases are visible during the night; X means not observable.

Although the orbit of RW is considered quite stable, when you extrapolate out hundreds (to over a thousand) orbits it doesn't take much variation to put the times out by an accumulated hour or two. Also predictions based on different publications of RW's period and time of minima haven't agreed. We would be interested in anyone's observations of this star and will post updates on the Quasar website from time to time.



# FEBRUARY

**SATURN**, in Taurus, appears high in the northern sky mid-evening. At this time last year, Saturn and the 1st magnitude star Aldebaran were quite close and consequently the familiar 'head of the bull' or Hyades appeared odd and distorted. Now the interloper has moved on (at this time 13° from Aldebaran), the Hyades have resumed their normal appearance. On the 11th and 12th the Moon, now past First Quarter, can be seen near the planet (see Sky View).

**URANUS** is in conjunction with the Sun on the 18th, and will remain lost in the Sun's glare until its return to the morning sky next month.

**NEPTUNE**, after conjunction with the Sun last month, moves out of the morning twilight towards the end of February. The planet can be observed low in the pre-dawn sky in Capricornus.

**PLUTO**, rising around 1am, moves into Serpens this month after a six year journey across Ophiuchus. Retrograde motion returns it to Ophiuchus in May, until it re-enters Serpens in December.

**MINOR PLANETS** at opposition this month include 41 Daphne on the 6th at magnitude 10.7 in Hydra and 89 Julia on the 22nd at magnitude 10.8 in Sextans. Two of the brighter minor planets are at opposition in Leo, 97 Klotho on the 21st at magnitude 10.5 and 37 Fides on the 26th at magnitude 10.4.

## COMETS

**Comet 116P/Wild 4** rises late in the evening during February but is best observed after midnight. The 12th magnitude comet is moving southeast through Libra and in late February is less than three degrees north of the globular cluster NGC5897.

**Comet 154P/Brewington** reaches perihelion this month on the 19th, at 1.6 AU from the Sun. It will not be easy to find as the 10th magnitude comet, located in Pisces, will be setting by the time evening twilight has ended.

**Comet C/2001 HT50 (LINEAR-NEAT)** is visible in the eastern sky at the end of evening twilight. The 11th magnitude comet is moving through the constellation of Monoceros and sets in the early hours of the morning.

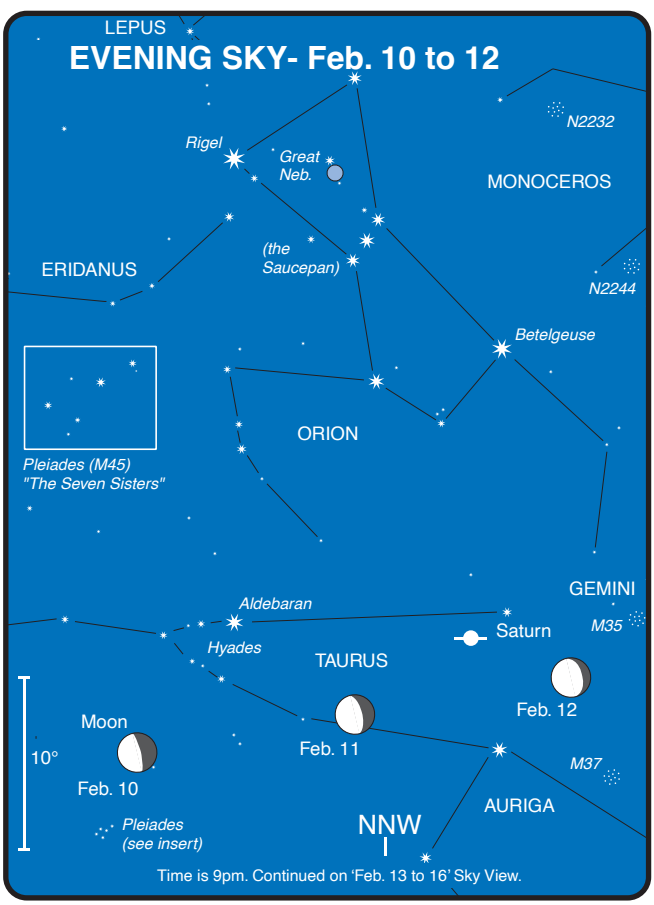
**Comet C/2001 RX14 (LINEAR)** should be steady at 10th magnitude in February, despite having passed perihelion last month, as it approaches to within 1.3 AU of Earth. Rising before midnight, the comet is moving southwest through Ursa Major, and is thus climbing higher in the northern sky from our perspective.

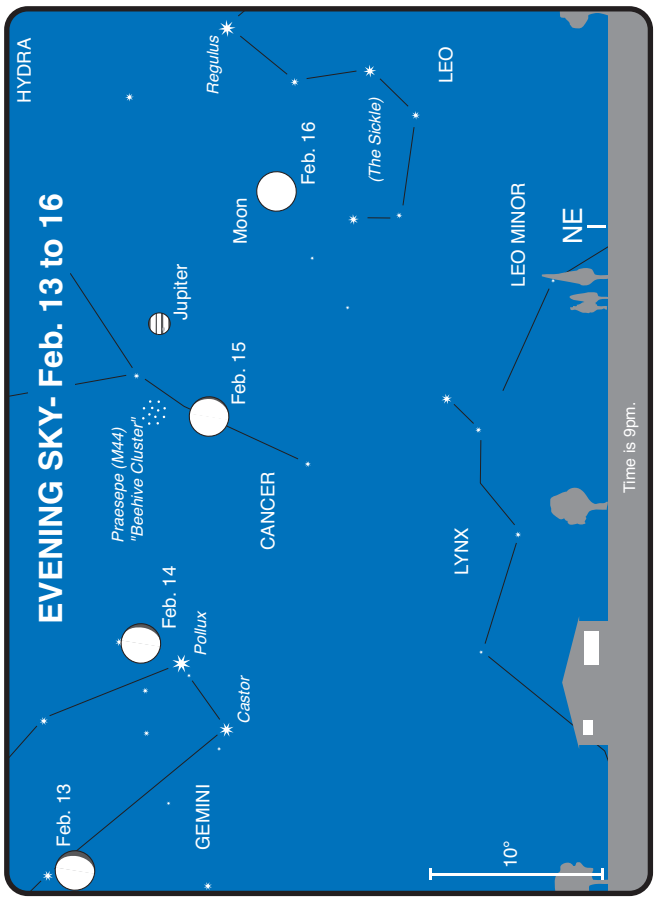
## METEOR SHOWERS

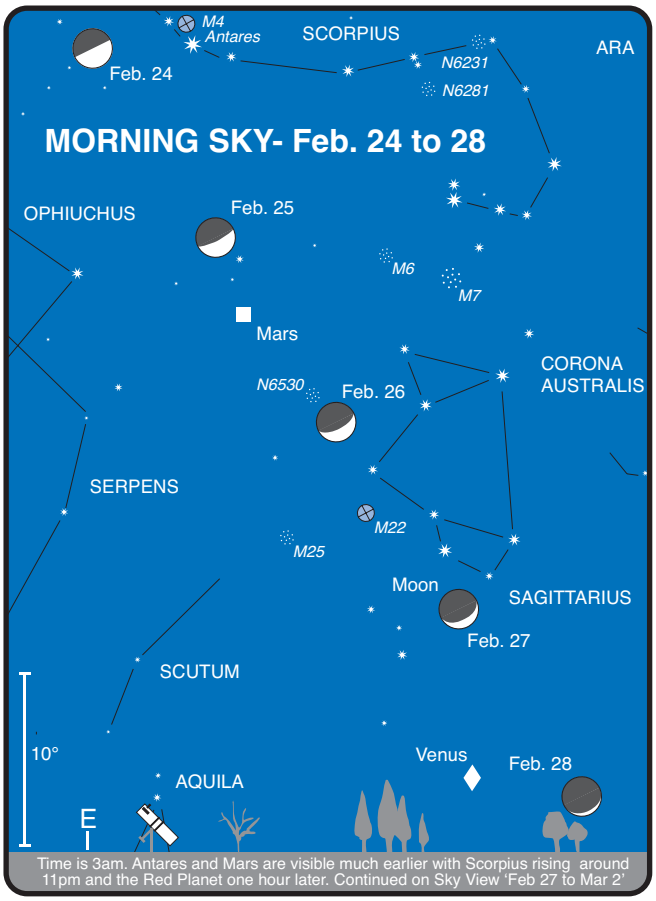
The **Alpha Centaurids** are active from 28th January through to 21st February, with maximum on the 8th. Their zenith hourly rate is unpredictable, around 5 to 10 per hour at best, but high rates sometimes occur every 4 to 6 years. Most recently, in 1974 and 1980 the rate was 20–30 per hour. This increase is always temporary, lasting no more than 2–3 hours. The shower is noted for its brightly coloured fireballs that often reach negative magnitudes (up to -3 or more). They are predominantly yellow or blue, but their range can cover the entire spectrum. The Alpha Centaurids are also well known for their long lasting trains (about 25 to 30 percent of the meteors) which may last from a few seconds to several minutes. Being circumpolar, the shower is visible throughout the night, but the Moon will begin to interfere after the first week.

## DIARY EST (WST)

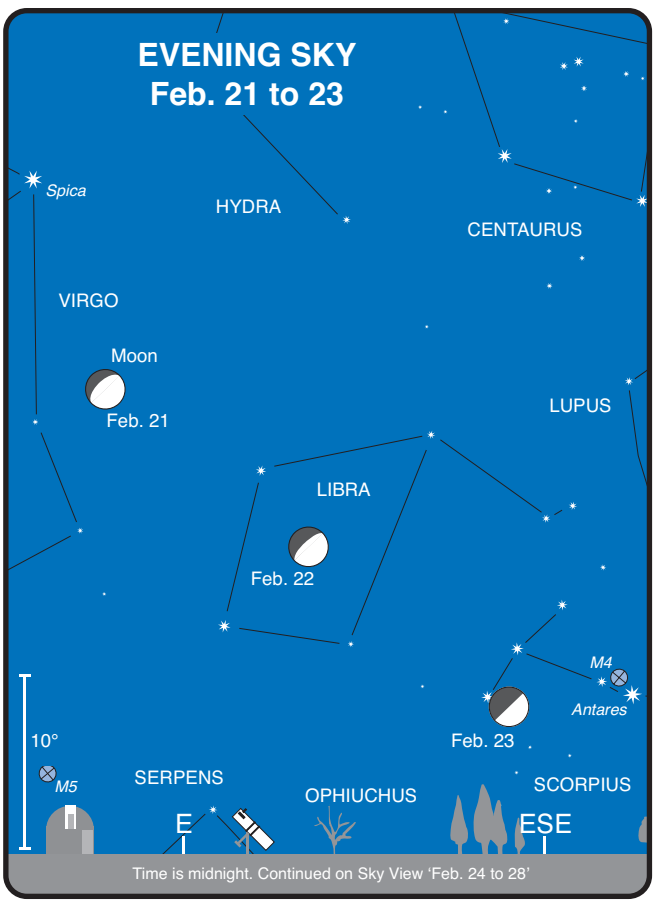
| | | |
|---|---|---|
| 1st | | Mercury 0.1°E of star Pi Sagittarii |
| 1st | | New Moon |
| 2nd | | Jupiter at opposition |
| 2nd | 3 am | (1 am WST) Comet 116P/Wild 4 0.1°SW of star Alpha Librae |
| 3rd | | Venus 0.7°SE of NGC6440 (GC) in Sagittarius |
| 4th | | Mercury greatest elong. W (25°) |
| 5th | | m.p. 1 Ceres 0.6°SE of NGC428 (SG) in Cetus |
| 7th | am | Comet C/2001 RX14 (LINEAR) 1°SE of NGC4051 (SG) in Ursa Major |
| 8th | | Venus 0.8°NE of NGC6568 (OC) in Sagittarius |
| 8th | | m.p. 12 Victoria 0.7°SW of star Delta Scorpii |
| 8th | | Moon at apogee |
| 9th | | Mars 0.1°W of NGC6235 (GC) in Ophiuchus |
| 9th | | m.p. 85 Io 0.7°S of NGC6605 (OC) in Serpens |
| 9th | | Mercury at descending node |
| 9th | | First Quarter Moon |
| 9th | am | Comet C/2001 RX14 (LINEAR) 0.5°NW of NGC4111 (LG) in Canes Venatici |
| 11th | | m.p. 85 Io 0.7°N of M17 (Omega Neb.) in Sagittarius |
| 12th | 1 pm | (11 am WST) Saturn 3°S of Moon |
| 13th | | Mercury 1.1°N of M75 (GC) in Sagittarius |
| 13th | | Mars 0.4°W of NGC6287 (GC) in Ophiuchus |
| 13th | pm | Comet C/2001 HT50 (LINEAR-NEAT) 0.8°SW of NGC2324 (OC) in Monoceros |
| 14th | am | m.p. 3 Juno 0.9°N of star Beta Librae |
| 16th | | m.p. 8 Flora 0.3°SW of M9 (GC) in Ophiuchus |
| 16th | | Vesta stationary |
| 16th | 4 am | (2 am WST) Jupiter 4°S of Moon |
| 17th | | Full Moon |
| 18th | | Mars 0.8°N of NGC6325 (GC) in Ophiuchus |
| 18th | | m.p. 8 Flora 0.7°N of NGC6342 (GC) in Ophiuchus |
| 18th | | m.p. 12 Victoria 0.7°S of M80 (GC) in Scorpius |
| 18th | | Uranus in conjunction with Sun |
| 19th | | Venus 0.2°N of star Pi Sagittarii |
| 19th | | Mercury at aphelion |
| 19th | 11 pm | (9 pm WST) Comet 155P/Shoemaker 3 0.1°SW of star Epsilon Leonis |
| 20th | | Moon at perigee |
| 21st | 10 am | (8 am WST) Mercury 1.6°S of Neptune |
| 22nd | | Saturn stationary |
| 24th | | Last Quarter Moon |
| 25th | 3 pm | (1 pm WST) Mars 1.9°N of Moon |
| 27th | 9 pm | (7 pm WST) Venus 5°N of Moon |
| 28th | | Mars at descending node |

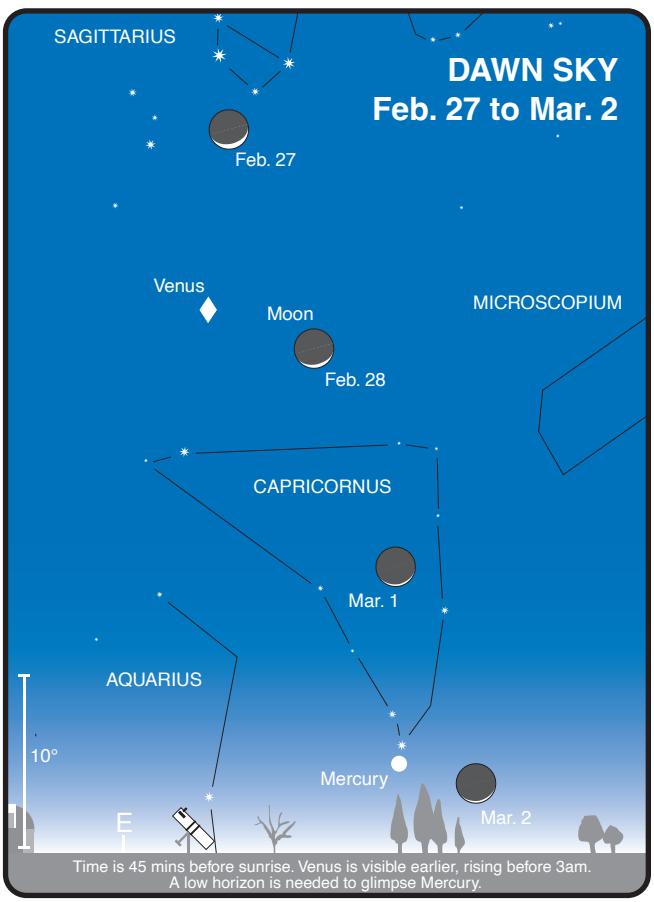




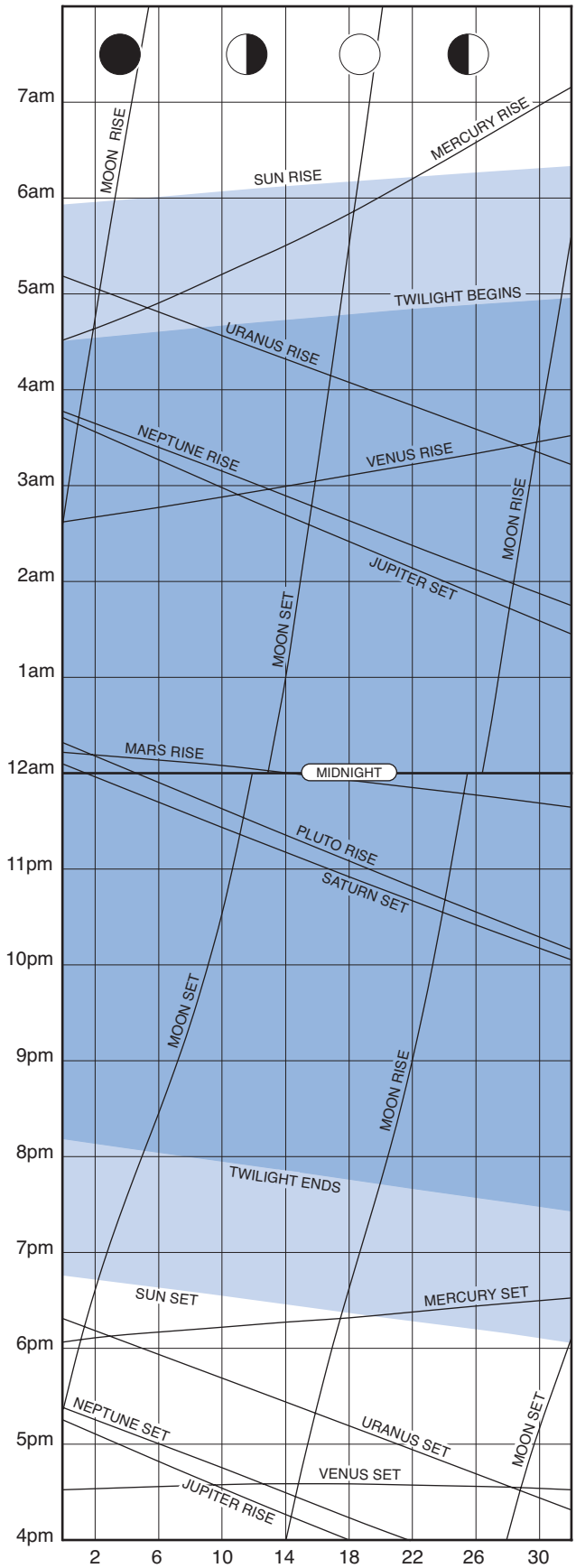

Approximate local standard time, for daylight saving add 1 hour.



# MARCH

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Venus comes close to Uranus and Neptune.
- Mars passes between the Trifid (M20) and the Lagoon (M8) nebulae and near the globular cluster M22.
- Jupiter just past opposition and close to the Beehive Cluster (M44).

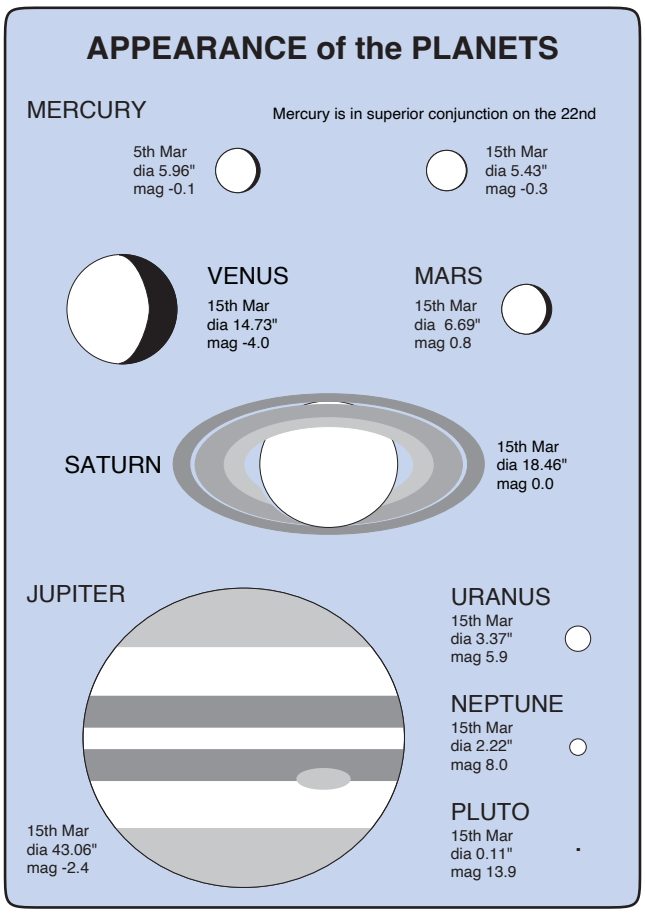
### THE MOON

| | |
|---|---|
| 3rd | New Moon |
| 8th | Moon at apogee (furthest from Earth – 405,382 km distant, angular size 29.1') |
| 11th | First Quarter |
| 18th | Full Moon |
| 20th | Moon at perigee (closest to Earth – 359,816 km distant, angular size 33.5') |
| 25th | Last Quarter |

### THE PLANETS

**MERCURY** is visible in the dawn sky early in March, the planet gradually moving down toward the eastern horizon and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 22nd. Mercury then moves east of the Sun, reappearing in the western evening twilight next month. Mercury passes 1.5° from Uranus on the 5th, but the fainter outer planet will be lost in the brightness of the dawn sky.

## APPEARANCE of the PLANETS



**VENUS**, very conspicuous in the pre-dawn eastern sky, begins the month in Sagittarius then moves through Capricornus and into Aquarius. The brightest of the planets has close encounters with two faint outer members of the Solar System this month; on the 13th, Venus and Neptune appear just 0.2° apart, and on the 29th, Venus and Uranus are 0.3° from each other. On the 30th, the slender waning crescent of the 27–day old Moon will be just below and south of the planet (see Sky View).

The **EARTH** is at its autumnal equinox on the 21st. The Sun rises and sets due east and west and day and night are equal.

**MARS**, rising around midnight, traverses the Sagittarius Star Cloud and passes by some renowned galactic showpieces. An ideal wide-angle photographic opportunity happens when Mars passes near the Trifid (M20) and the Lagoon (M8) nebulae between the 5th and 7th. These two wonders of the southern sky lie on either side of the ecliptic and Mars, moving close to ecliptic at this time, passes directly between the pair. On the 6th the distance between the planet and M20 is 0.5° and 1° from M8. On the 18th, Mars passes within 0.5° of the heart of M22, one of the finest of the globular clusters. M22 is only surpassed in brightness by Omega Centauri and 47 Tucanae. Only the fact that M22 (one of the nearest globulars) is being dimmed by interstellar dust prevents it from being the gem of the southern skies. On the 26th, the Last Quarter Moon will be close to the Red Planet (see Sky View).

**JUPITER**, now one month past opposition, stands prominent in the northern mid-evening sky in Cancer. Jupiter begins the month 3° from the famous Beehive cluster (known also as Praesepe, or the 44th object in Messier's catalogue, M44), and by month's end will be just 1° from the cluster's centre. M44 is an open cluster of about 200 stars visible to the unaided eye from dark skies; it lies at a distance of around 520 light years from our Solar System. On the 14th and 15th, the waxing gibbous near Full Moon appears near the planet (see Sky View).

**SATURN**, in Taurus, can be seen in the northwestern mid-evening sky. On the 11th, the First Quarter Moon will be close to and below the ringed planet (see Sky View).

**URANUS**, in Aquarius, emerges from its conjunction with the Sun last month into the dawn sky; by mid-month the planet will be visible in the night sky before the onset of dawn. On the 29th, Venus and Uranus are a mere 0.3° from each other. Their closest approach of 0.05° occurs on the previous day when the planets are below our horizon.

**NEPTUNE**, in Capricornus, is much higher in the morning sky than its sister gas giant Uranus. Like Uranus, Venus also pays this gas giant a visit this month. On the 13th the pair will be fairly near at just 0.2° apart in the morning sky.

**PLUTO**, in Serpens, rises just before midnight in the east. If you want to get a feel for where Pluto is, go out on the morning of the 1st or 2nd. Just as Mars is rising, track 12° directly northwards from the Red Planet, maintaining the same altitude (the scale on the rear cover of this book may help). It is in this region, devoid of bright stars, that this distant member of our Solar System lies.

**MINOR PLANETS** at opposition this month include: 11 Parthenope on the 3rd at magnitude 10.0 in Leo, 19 Fortuna on the 3rd at magnitude 10.5 near the border of Leo and Sextans, 24 Themis on the 23rd at magnitude 10.6 in Virgo, 22 Kalliope on the 24th at magnitude 10.9 in Coma Berenices and 4 Vesta on the 26th at magnitude 5.9 in Virgo.

On the morning of March 17, 8 Flora will be seen crossing over the open star cluster M23 in Sagittarius. It could be fun for observers to play 'hunt the new 11th magnitude star'. Dark skies and a 150mm telescope are recommended. 11 Parthenope visits the Leo galaxies, passing between M105 and NGC3384 on the 17th.

## COMETS

**Comet 65P/Gunn** is a morning object in the constellation of Sagittarius. The 13th magnitude comet is in conjunction with M20 (The Trifid Nebula) in mid-March and ends the month about a degree north of the globular cluster M28. In the months to come this slow moving comet will take us on an amazing tour of the 'Tea Pot' and the surrounding star clusters (keep an eye on the Diary of Events).

**Comet 116P/Wild 4** should be about 12th magnitude this month, rising in the evening while moving slowly through Libra, just south of the ecliptic.

**Comet C/2001 HT50 (LINEAR-NEAT)** begins the month near the Rosette Nebula in Monoceros. Within a few days, it crosses over into Orion. Late in the month it passes quite close to Betelgeuse (Alpha Orionis), and at month's end it is setting before midnight.

**Comet C/2001 RX14 (LINEAR)** continues to move southwest this month. The 10th magnitude comet is now moving away from both Earth and the Sun, and it will start to fade. LINEAR, now best observed around midnight, is in Ursa Major throughout the month, ending March on the border of Leo and Leo Minor.

## THE MAN WHO NAMED THE SOUTHERN SKIES
## Abbe Nicholas Louis de la Caille (1713 – 1762)

This French astronomer is best known for his work while heading up an astronomical expedition to the Cape of Good Hope from 1750-54. At that time the southern skies were nearly 'untouched' and he established the first southern catalogue composed of measurements of the positions of 9,766 stars, his "Caelum Australe Stelliferum".

La Caille was also responsible for the naming of a number of far southern constellations. Instead of using animals or mythical creatures he chose to use scientific instruments, with the exception of Mensa which he named after the mountain on which his observatory was located at Cape Town. The constellations were:

| | |
|---|---|
| Reticulum Rhomboidalis (the Reticle) | Horologium (the Clock) |
| Sculptor (the Sculptor's Apparatus) | Antlia (the Air Pump). |
| Microscopium (the Microscope) | Fornax (the Furnace) |
| Telescopium (the Telescope) | Octans (the Octant) |
| Mensa (the Table Mountain) | Pictor (the Easel) |
| Caelum (the Graving Tool) | Norma (the Level) |

and Circinus (the Compasses for drawing circles)

**La Caille's Deep Sky Catalogue**

He also catalogued 42 deep sky objects, being split into 3 categories:

Class I "Nebulosities not accompanied by stars"

Class II "Nebulosities due to clusters"

Class III "Stars accompanied by nebulosity"

Of these 25 were original discoveries including the Eta Carinae Nebula (NGC3372), globular cluster 47 Tucanae (NGC104) and the Tarantula Nebula (NGC2070) in the LMC. He also found the spiral galaxy M83, which would eventually be recognised as the first galaxy discovered beyond the Local Group. The fact that 47 Tuc is classed as a nebula without stars is indicative of the size of his telescope – a lowly 15mm refractor!

Continued next month when we take a closer look at his deep sky catalogue.

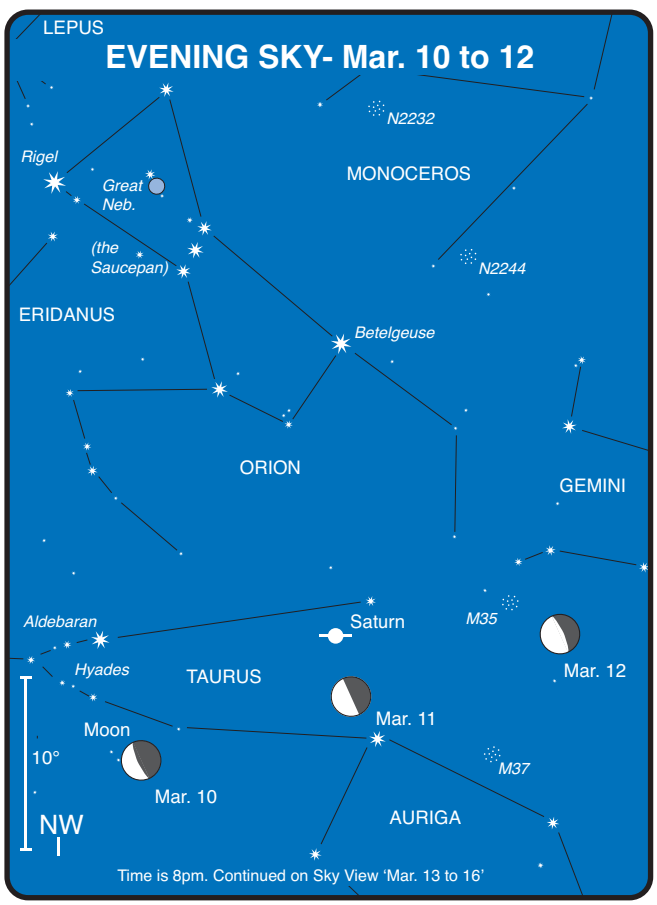
# MARCH

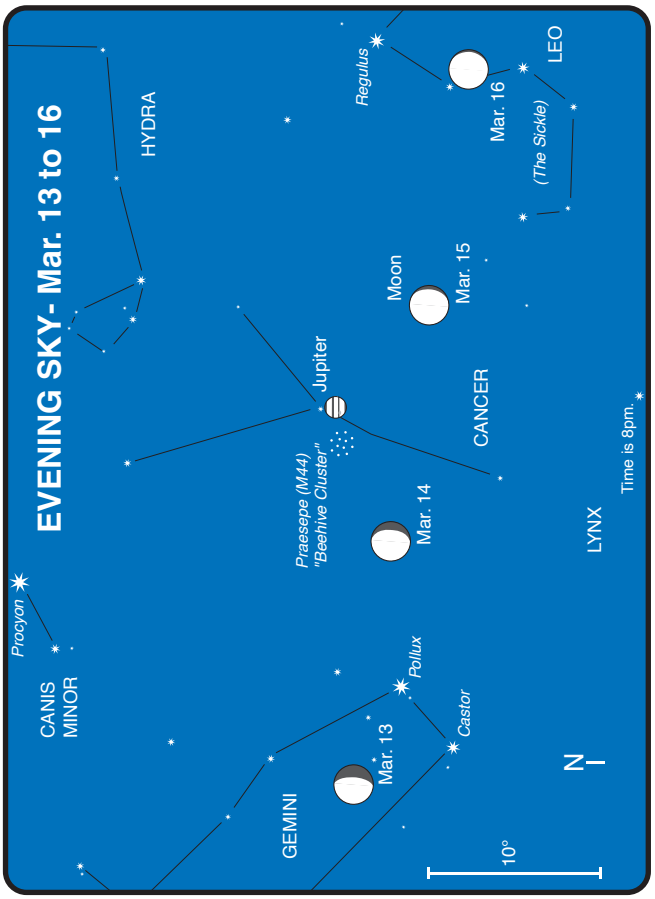
## METEOR SHOWERS

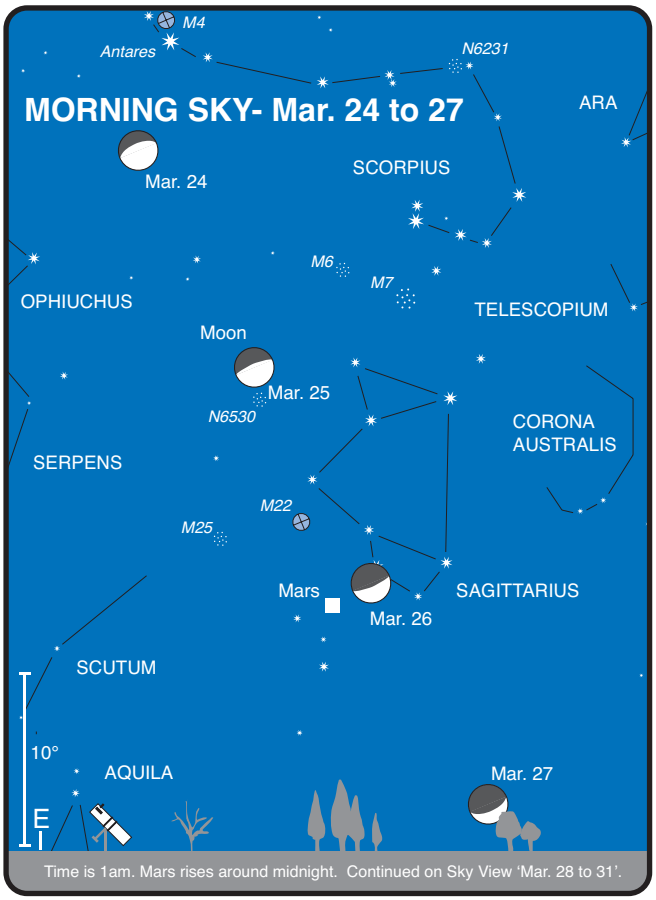
The **gamma Normids** are active between 25th February and 22nd March. For most of the period, the rate is low, and members are difficult to sort out from the background sporadic activity. The peak occurs on March 14, when rates can reach 3 to 8 per hour. Generally, the gamma Normids are bright and chiefly yellow, white or orange with about 15% leaving trains. Since the constellation Norma rises in the evening, the shower is best viewed after midnight when the radiant reaches a reasonable altitude and the Moon has set.

## DIARY EST (WST)

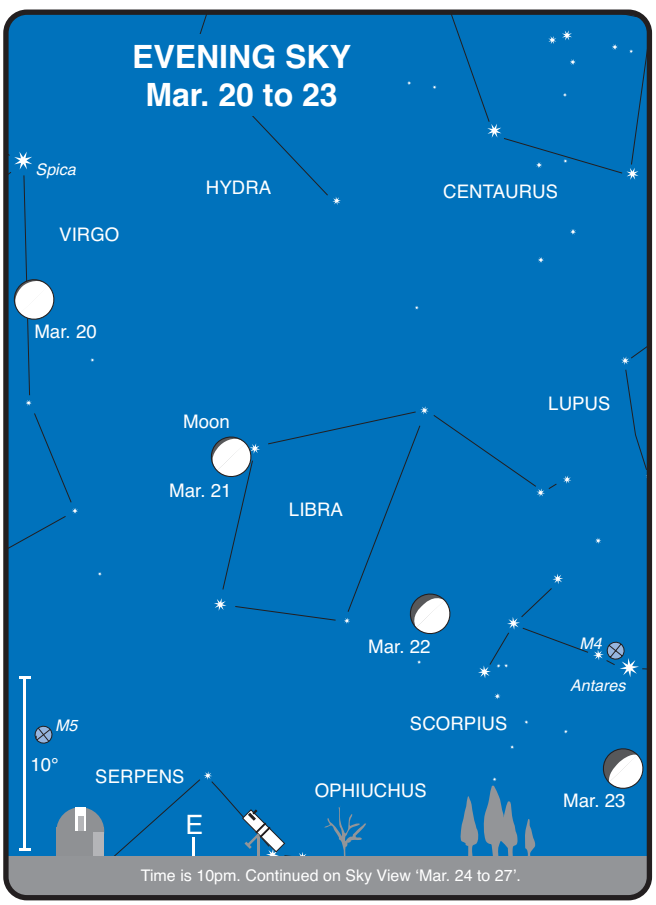
| | | |
|---|---|---|
| 1st | | Mercury 1°W of star Delta Capricorni |
| 1st | 1 am | (11 pm WST, prev day) Neptune 5°N of Moon |
| 2nd | 1 am | (11 pm WST, prev day) Mercury 3°N of Moon |
| 3rd | | Mercury 1.7°S of Comet 22P/Kopff |
| 3rd | | New Moon |
| 4th | 11 pm | (9 pm WST) Mercury 1.5°S of Uranus |
| 6th | | Mars 0.5°S of M20 (Trifid Neb.) in Sagittarius |
| 6th | | Mars 0.9°N of M8 (Lagoon Neb) in Sagittarius |
| 6th | 11 pm | (9 pm WST) Comet 155P/Shoemaker 3 0.05°N of Comet P/2001 YX127 (LINEAR) |
| 7th | | Mars 0.8°N of NGC6530 (OC) in Sagittarius |
| 7th | | Mars 1°S of M21 (OC) in Sagittarius |
| 7th | | m.p. 1 Ceres 0.6°SE of NGC676 (SG) in Pisces |
| 7th | | Pallas in conjunction with Sun |
| 8th | | Mars 0.2°S of NGC6546 (OC) in Sagittarius |
| 8th | | Moon at apogee |
| 9th | pm | Comet C/2001 HT50 (LINEAR-NEAT) 0.2°SW of NGC2186 (OC) in Orion |
| 11th | | Mercury at greatest latitude south |
| 11th | | First Quarter Moon |
| 11th | 10 pm | (8 pm WST) Saturn 3°S of Moon |
| 12th | | Juno stationary |
| 13th | am | Comet 65P/Gunn 0.3°S of M20 (Trifid Neb.) in Sagittarius |
| 13th | 6 am | (4 am WST) Venus 0.2°N of Neptune |
| 15th | am | Comet 65P/Gunn 1°N of M8 (Lagoon Neb.) in Sagittarius |
| 15th | 10 am | (8 am WST) Jupiter 4°S of Moon |
| 16th | | m.p. 11 Parthenope 0.8°NE of M96 (SG) in Leo |
| 16th | | Venus at descending node |
| 16th | 3 am | (1 am WST) Comet 65P/Gunn 0.1°W of NGC6546 (OC) in Sagittarius |
| 17th | | Mars 0.1°E of NGC6642 (GC) in Sagittarius |
| 17th | 3 am | (1 am WST) m.p. 8 Flora 0.05°NW of M23 (OC) in Sagittarius |
| 17th | 11 pm | (9 pm WST) m.p. 11 Parthenope 0.1°W of NGC3384 (LG) in Leo |
| 17th | 11 pm | (9 pm WST) m.p. 11 Parthenope 0.05°NE of M105 (EG) in Leo |
| 18th | | Mars 0.5°NW of M22 (GC) in Sagittarius |
| 18th | | Full Moon |
| 19th | pm | m.p. 4 Vesta 0.2°SW of NGC4698 (SG) in Virgo |
| 20th | | Moon at perigee |
| 21st | | Equinox |
| 21st | pm | m.p. 12 Victoria 0.9°N of NGC6284 (GC) in Ophiuchus |
| 22nd | | Mercury in superior conjunction |
| 22nd | 11 pm | (9 pm WST) Comet C/2001 HT50 (LINEAR-NEAT) 0.1°SW of star Betelgeuse |
| 24th | | Pluto stationary |
| 25th | | Last Quarter Moon |
| 26th | | m.p. 11 Parthenope 0.5°SW of NGC3338 (SG) in Leo |
| 26th | 4 am | (2 am WST) Mars 3°N of Moon |
| 27th | | Vesta at opposition |
| 28th | | m.p. 511 Davida 0.4°N of NGC2266 (OC) in Gemini |
| 28th | 8 am | (6 am WST) Neptune 5°N of Moon |
| 28th | 11 pm | (9 pm WST) Venus 0.05°N of Uranus |
| 29th | | m.p. 85 Io 0.2°S of NGC6814 (SG) in Aquila |
| 29th | am | Comet 65P/Gunn 0.9°N of M28 (GC) in Sagittarius |
| 29th | 6 pm | (4 pm WST) Uranus 5°N of Moon |
| 29th | 8 pm | (6 pm WST) Venus 5°N of Moon |
| 30th | | Mercury at ascending node |
| 30th | pm | m.p. 4 Vesta 0.7°SW of NGC4596 (LG) in Virgo |
| 30th | 11 pm | (9 pm WST) m.p. 4 Vesta 0.1°W of NGC4578 (LG) in Virgo |

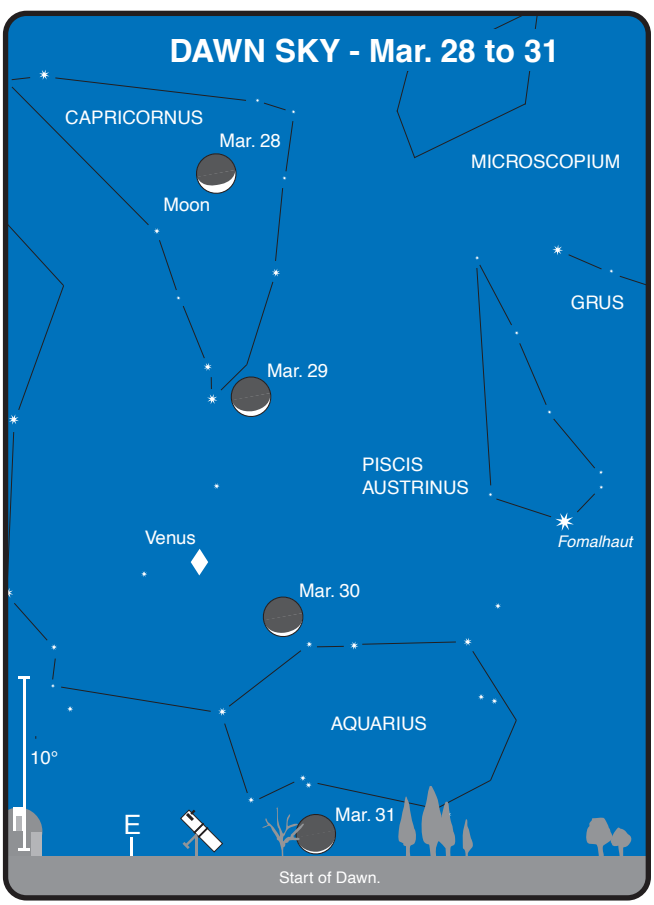




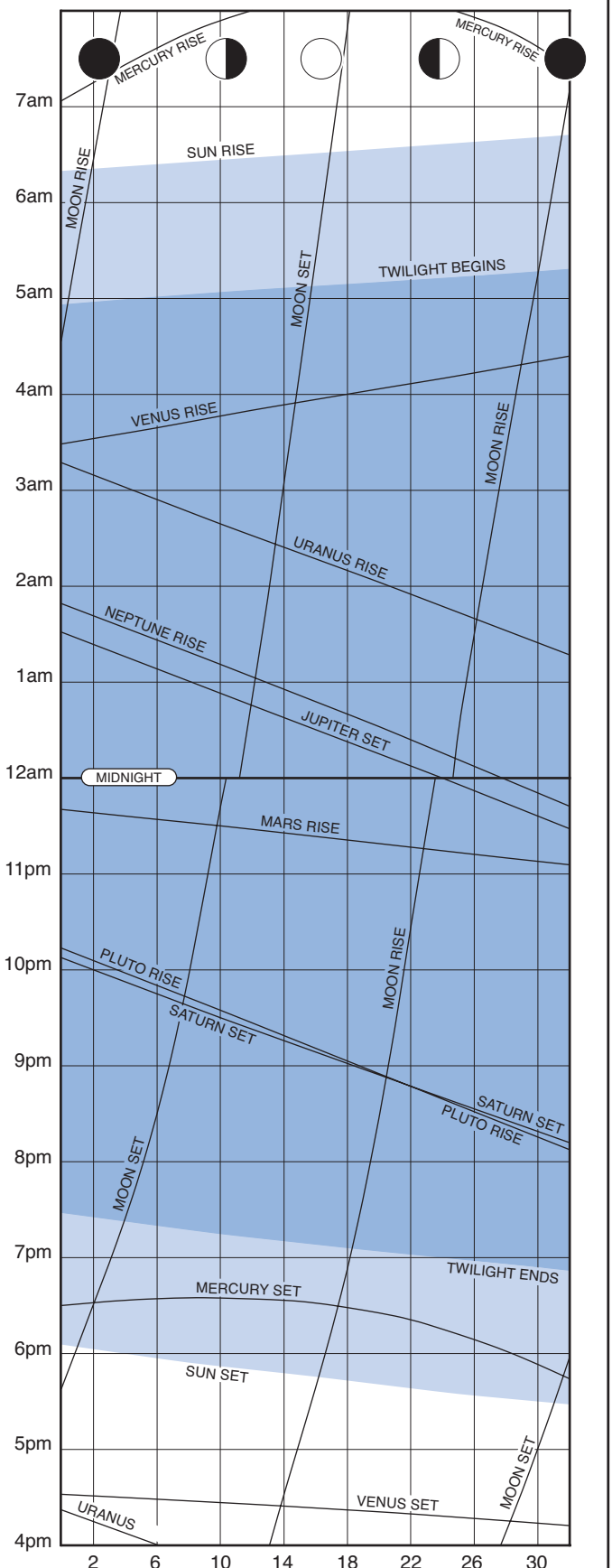

Approximate local standard time, for daylight saving add 1 hour.



# APRIL

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

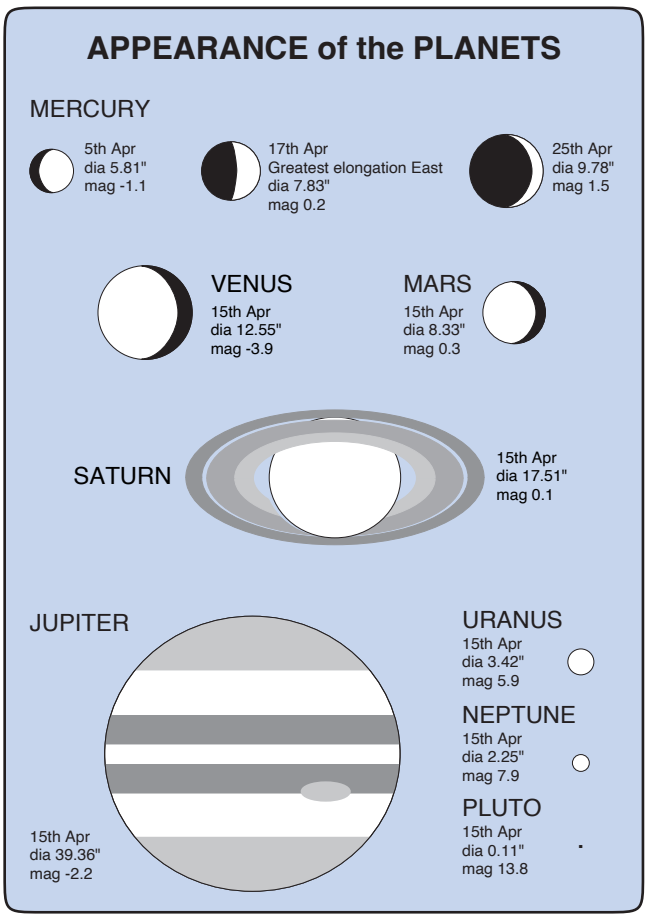
## HIGHLIGHTS

- Saturn's rings wide open.
- Venus near the asteroid Pallas.
- Jupiter closest to the open cluster M44 (the Beehive).

### THE MOON

| | |
|---|---|
| 2nd | New Moon |
| 4th | Moon at apogee (furthest from Earth – 406,209 km distant, angular size 29.7') |
| 10th | First Quarter |
| 17th | Full Moon |
| 17th | Moon at perigee (closest to Earth – 357,157 km distant, angular size 33.1') |
| 23rd | Last Quarter |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** reaches its greatest elongation east of the Sun (20°) on the 17th. This is not a particularly favourable elongation with the planet in the western twilight sky setting less than three-quarters of an hour after the Sun. After elongation, Mercury moves back toward the Sun and inferior conjunction (between Earth and Sun) early next month. Inferior conjunctions of Mercury are common, occurring three or four times each year. Due to the planet's 7° orbital tilt to the ecliptic, Mercury usually passes above or below the Sun, but next month a transit occurs and the planet can be seen in silhouette as is passes across the solar disc. These transits are relatively rare, happening around thirteen times each century.

**VENUS** rises about one hour before the start of dawn. It is in Aquarius until mid-month when it moves into Pisces and finally at month's end into Cetus. Of some interest, on the 24th Venus will be located 2° southeast of the minor planet Pallas (around 10th magnitude at this time). The German astronomer, Heinrich Olbers, discovered Pallas in 1802. This was a year after the first minor planet (Ceres) was found by the Italian Giuseppe Piazzi. On the 29th, the 27–day old thin crescent Moon appears just east of the planet (see Sky View).

**MARS**, rising just before midnight, moves from the rich Sagittarius Milky Way region into Capricornus towards month's end. With opposition three months away, the planet has now reached that part of its orbit known as quadrature, when the Sun-Earth-Mars angle is 90° (see diagram p. 14). Even with small telescopes, at this time the Martian disc appears distinctly gibbous (egg shaped) with the Sun illuminating just 87% of the planet's surface from our viewpoint on Earth. On the 23rd and 24th, the Last Quarter Moon will be near the planet (see Sky View).

**JUPITER** is located high in the northern evening sky in Cancer; it will remain in this constellation until the end of June when it moves into Leo. The planet begins the month just under 1° from M44 (the Beehive cluster or Praesepe), and remains close to the cluster for the entire month. M44 is an open cluster of about 200 stars visible to the unaided eye from dark skies; it lies at a distance of around 520 light years from our Solar System. On the 11th, the 9–day old Moon appears near the planet (see Sky View).

## La Caille's Deep Sky Catalogue

La Caille's work predated Messier by 16 years and has a wonderful southern bias, but few amateurs have heard of him.

There is no reason why we shouldn't be embracing 'La Caille Marathons' (like Messier's). Considering the size of his instrument (15mm) there is no telescope too small (binoculars?) to try and see all of these objects within one night. Under dark skies they should be all visible in the finder scope! It should be possible to cover them in only about 4–5 hours and is favoured for February to June.

Start with a sidereal time of around 9–10 hours (or earlier, but you need to reach 13 hours before running out of darkness). If you wish an evening run, starting around 8pm early April would be a good example. 47 Tuc (Lac I.1) would be your first object and then work your way up in RA. Your last object would be M55, which is up by midnight (better at 1am).

To see all 42 objects this exercise does come with some challenges, with 7 not being generally recognised as deep sky objects. Some entries appear to be just groups of a few stars. For the beginner I.13, II.1, II.2, II.11, III.1, III.9 and III.14 can be given a miss (see blue text in table).III.3 may be a star cluster and worthwhile checking out.

The La Caille system is not used in atlases so you will be looking, in most cases, for the corresponding NGC or Messier (M) labels. His three classes were: I, nebulae without stars, II nebulae due to clusters and III, nebulae with stars.

Good Luck.

| La Caille | NGC (IC) | Name | Type | RA (2000) | Dec | Con | Mag | Size |
|---|---|---|---|---|---|---|---|---|
| Lac I.1 | 104 | 47 Tuc | GC | 00 24.1 | -72 05 | Tuc | 4.0 | 31 |
| Lac I.2 | 2070 | 30 Dor | BN | 05 38.7 | -69 06 | Dor | 5.4 | 40x25 |
| Lac I.3 | 2477 | | OC | 07 52.3 | -38 33 | Pup | 5.8 | 27 |
| Lac I.4 | 4833 | | GC | 12 59.6 | -70 53 | Mus | 6.9 | 13 |
| Lac I.5 | 5139 | Omega Cen | GC | 13 26.8 | -47 29 | Cen | 3.7 | 36 |
| Lac I.6 | 5236 | M83 | SG | 13 37.0 | -29 52 | Hya | 7.6 | 11x10 |
| Lac I.7 | 5281 | | OC | 13 46.6 | -62 54 | Cen | 5.9 | 5 |
| Lac I.8 | 6124 | | OC | 16 25.6 | -40 40 | Sco | 5.8 | 29 |
| Lac I.9 | 6121 | M4 | GC | 16 23.6 | -26 32 | Sco | 5.9 | 26 |
| Lac I.10 | 6242 | | OC | 16 55.6 | -39 30 | Sco | 6.4 | 9 |
| Lac I.11 | 6637 | M69 | GC | 18 34.4 | -32 21 | Sgr | 7.7 | 7 |
| Lac I.12 | 6656 | M22 | GC | 18 36.4 | -29 54 | Sgr | 6.5 | 24 |
| Lac I.13 | 6777 | - | | 19 26.8 | -71 30 | Pav | (2 stars 8.0 & 8.3 mag) | |
| Lac I.14 | 6809 | M55 | GC | 19 40.0 | -30 58 | Sgr | 6.3 | 19 |
| | | | | | | | | |
| Lac II.1 | - | | | 04 03.7 | -44 27 | Hor | (12 stars mag 7.5 to 9.5) | |
| Lac II.2 | - | Cr 140? | OC? | 07 26.3 | -34 08 | Pup | (8 stars mag 5.9 to 8.9?) | |
| Lac II.3 | 2516 | | OC | 07 58.3 | -60 52 | Car | 3.8 | 30 |
| Lac II.4 | 2546 | | OC | 08 12.4 | -37 38 | Pup | 6.3 | 41 |
| Lac II.5 | (2391) | Omicron Vel | OC | 08 40.2 | -53 04 | Vel | 2.5 | 50 |
| Lac II.6 | - | Tr 10 | OC | 08 46.6 | -42 34 | Vel | 4.6 | 15 |
| Lac II.7 | 3228 | | OC | 10 21.8 | -51 43 | Vel | 6.0 | 18 |
| Lac II.8 | 3293 | | OC | 10 35.8 | -58 14 | Car | 4.7 | 6 |
| Lac II.9 | (2602) | Theta Car | OC | 10 43.2 | -64 24 | Car | 1.9 | 50 |
| Lac II.10 | 3532 | | OC | 11 06.4 | -58 40 | Car | 3.1 | 55 |
| Lac II.11 | - | | | 11 23.0 | -58 19 | Cen | (line of 8 stars mag 6.6 to 8.5) | |
| Lac II.12 | 4755 | Kappa Cru | OC | 12 53.6 | -60 20 | Cru | 4.2 | 10 |
| Lac II.13 | 6231 | | OC | 16 54.0 | -41 48 | Sco | 2.6 | 15 |
| Lac II.14 | 6475 | M7 | OC | 17 53.9 | -34 49 | Sco | 3.5 | 80 |
| | | | | | | | | |
| Lac III.1 | - | SAO 217150 | | 05 03.3 | -49 29 | Pic | (single star mag 7.1 ) | |
| Lac III.2 | 2547 | | OC | 08 10.7 | -49 16 | Vel | 4.7 | 20 |
| Lac III.3 | (2395) | | OC | 08 42.2 | -48 04 | Vel | 4.6 | 13 |
| Lac III.4 | (2488) | | OC | 09 27.6 | -56 59 | Vel | 6.5 | 15 |
| Lac III.5 | in 3372 | Cr 228? | OC? | 10 43.0 | -60 01 | Car | 4.4 | 5 |
| Lac III.6 | 3372 | Eta Car | BN | 10 43.8 | -59 52 | Car | 2.0 | 120x12 |
| Lac III.7 | 3766 | | OC | 11 36.1 | -61 37 | Cen | 5.3 | 12 |
| Lac III.8 | 5662 | | OC | 14 35.2 | -56 33 | Cen | 5.5 | 12 |
| Lac III.9 | - | | | 15 22.6 | -59 12 | Cir | (3 stars mag 8.1, 7.6, 7.9) | |
| Lac III.10 | 6025 | | OC | 16 03.7 | -60 30 | TrA | 5.1 | 12 |
| Lac III.11 | 6397 | | GC | 17 40.7 | -53 40 | Ara | 5.7 | 26 |
| Lac III.12 | 6405 | M6 | OC | 17 40.1 | -32 13 | Sco | 4.5 | 15 |
| Lac III.13 | 6523 | M8 | BN | 18 03.8 | -24 23 | Sgr | 3.0 | 60x35 |
| Lac III.14 | - | | | 21 31.4 | -58 35 | Ind | (3 stars mag 8.4, 8.2, 9.1) | |

Legend For Table

Columns: NGC (IC) = Catalogue, RA (2000) Dec = Coordinates (2000.0), Con = Constellation, Mag = Magnitude, Size = Dimensions (arc mins).

Other: OC = Open Cluster, GC = Globular Cluster, SG = Spiral Galaxy, BN = Bright Nebula, M = Messier catalogue, Tr = Trumper Catalogue.

# APRIL

**SATURN** spends the month near 3rd magnitude Zeta Tauri, the star marking the left horn of the bull. On the 7th, the 5–day old crescent Moon will be below the ringed planet, forming a triangle with the 1st magnitude star Aldebaran. On the following evening, the Moon is still close to Saturn but now northwards of the planet (see Sky View). On the 7th Saturn's rings will be fully open; the last time when they were like this was in September 1988. At that time, we saw the northern side of the rings, and since passing through the ring plane in 1996, we have been viewing the southern face. This aspect of the rings will remain visible until early 2010, when we again pass through the ring plane and our gaze returns to the northern side.

**URANUS** and **NEPTUNE**, in Aquarius and Capricornus respectively, pass an uneventful month in the morning eastern sky.

**PLUTO** rises in the mid-evening sky and transits the meridian around 3.30am. The inclination (or tilt) of Pluto's orbit to the plane of the ecliptic (the plane of the Earth's orbit) is 17.2°, much more than any other planet; currently Pluto is about 9° from the ecliptic.

**MINOR PLANETS** at opposition this month include 23 Thalia on the 28th at magnitude 10.1 in Virgo.

## COMETS

**Comet 65P/Gunn** spends April in Sagittarius, climbing in brightness from 13th to 12th magnitude. In early April Gunn is in conjunction with the globular cluster M22 and ends the month within a degree of Sigma Sagittarii.

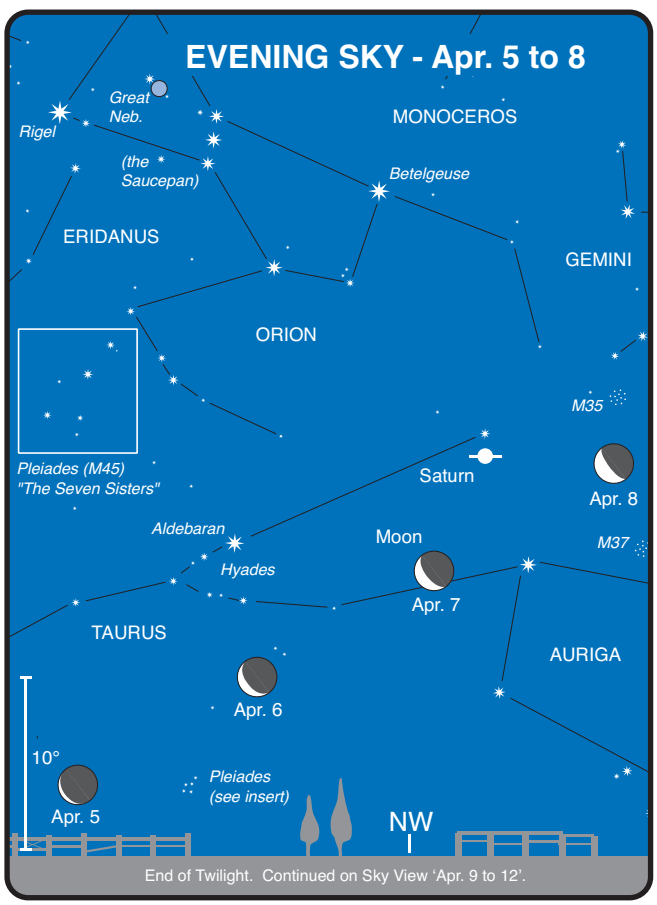
**Comet 116P/Wild 4**'s path across the sky changes this month from southeast to west. Located in Libra, 12th magnitude Wild 4 is rising early in the evening and will be visible for most of the night.

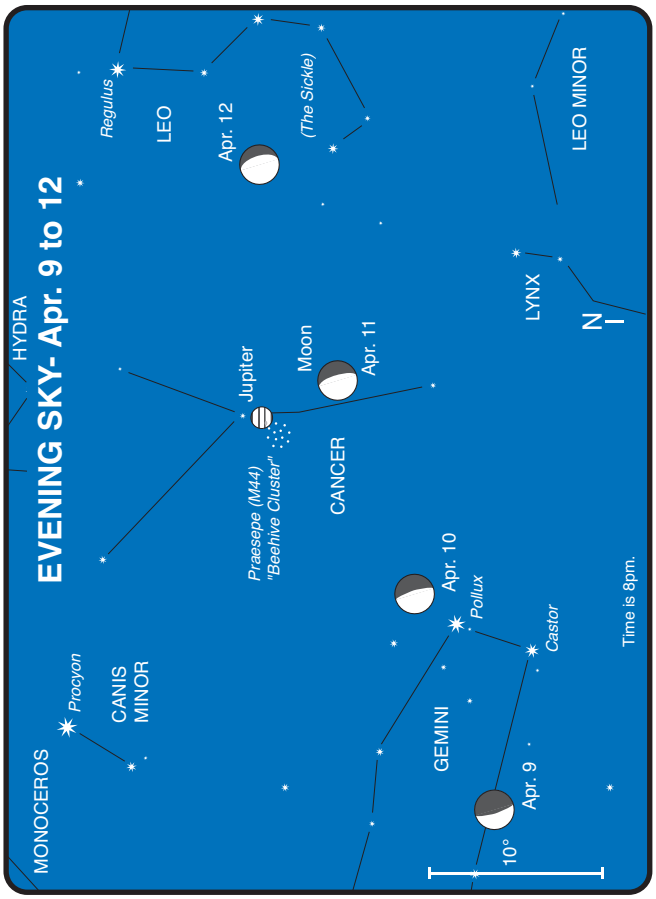
**Comet C/2002 O7 (LINEAR)** should brighten from 13th to 12th magnitude this month. April opens with LINEAR close to Beta Bootis. It moves through the northern sky constellations of Bootes and Canes Venatici and is best observed in the middle of the night.

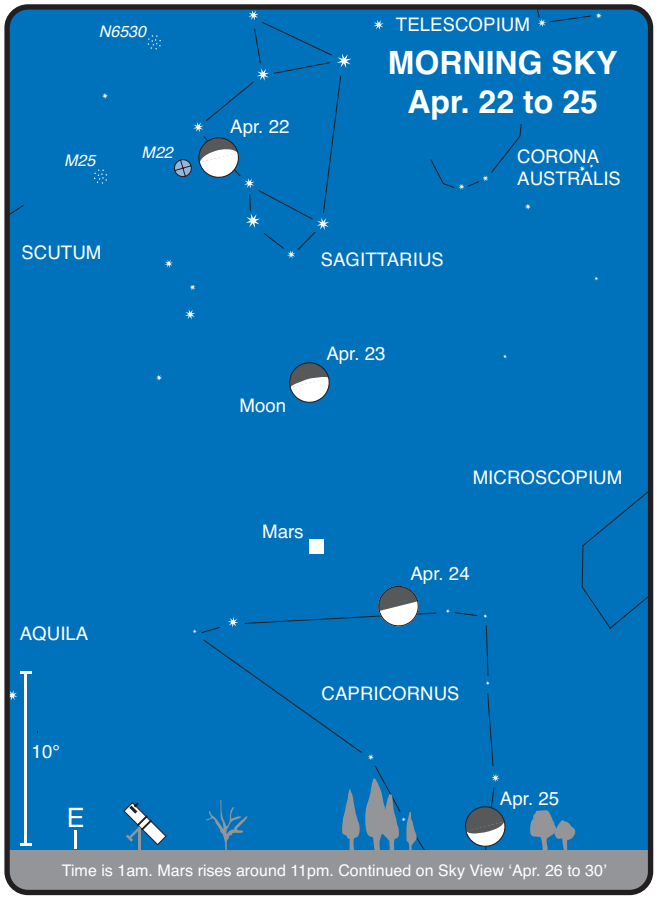
**Comet C/2001 RX14 (LINEAR)** is moving south through Leo Minor and Leo as it fades to 11th magnitude. By month's end, the comet is setting around 1am.

## DIARY EST (WST)

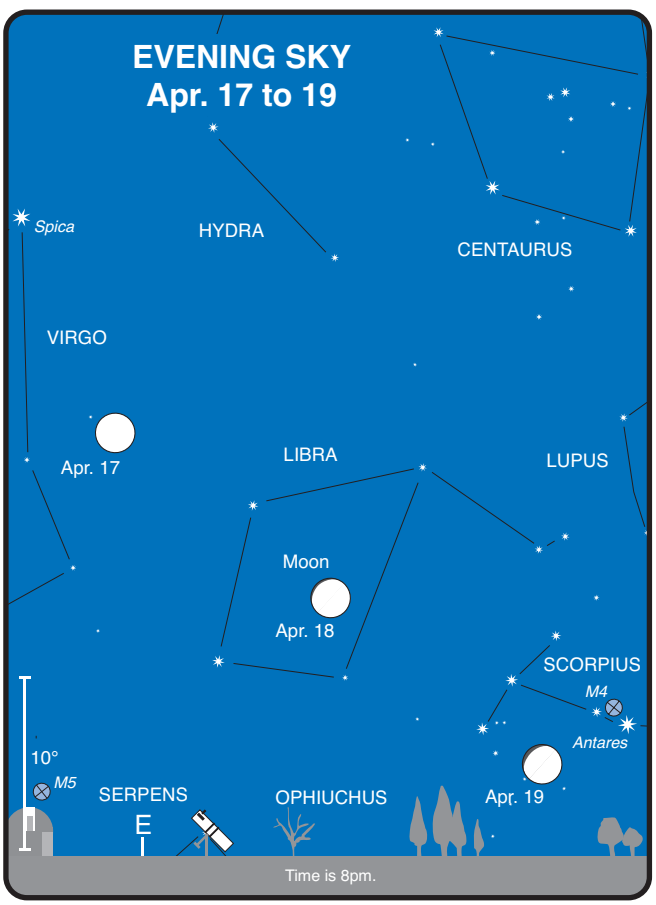
| | | |
|---|---|---|
| 2nd | | New Moon |
| 2nd | pm | m.p. 12 Victoria 0.3°N of NGC6325 (GC) in Ophiuchus |
| 3rd | pm | Comet C/2001 RX14 (LINEAR) 0.4°E of NGC3504 (SG) in Leo Minor |
| 4th | | Mercury at perihelion |
| 4th | | Moon at apogee |
| 4th | | Jupiter stationary |
| 5th | am | Comet C/2002 O7 (LINEAR) 0.8°NE of star Beta Bootis |
| 7th | | Jupiter 1°SE of M44 (Beehive Cluster) in Cancer |
| 8th | am | Comet 65P/Gunn 0.6°S of M22 (GC) in Sagittarius |
| 8th | 8 am | (6 am WST) Saturn 3°S of Moon |
| 8th | pm | m.p. 4 Vesta 0.7°SW of NGC4442 (LG) in Virgo |
| 9th | | m.p. 63 Ausonia 0.4°SE of star Delta Capricorni |
| 9th | pm | m.p. 8 Flora 0.3°S of M24 (OC) in Sagittarius |
| 10th | | Saturn 0.3°N of M1 (Crab Neb.) in Taurus |
| 10th | | First Quarter Moon |
| 11th | 6 pm | (4 pm WST) Jupiter 4°S of Moon |
| 12th | pm | m.p. 4 Vesta 0.5°SW of NGC4429 (LG) in Virgo |
| 14th | | Mercury at greatest latitude north |
| 15th | pm | m.p. 4 Vesta 0.9°S of NGC4371 (LG) in Virgo |
| 17th | | m.p. 511 Davida 0.4°N of NGC2331 (OC) in Gemini |
| 17th | | Mercury greatest elong. E (20°) |
| 17th | | Full Moon |
| 17th | | Moon at perigee |
| 19th | | Venus at aphelion |
| 21st | am | Mars 0.3°N of M75 (GC) in Sagittarius |
| 23rd | | Last Quarter Moon |
| 23rd | 5 pm | (3 pm WST) Mars 3°N of Moon |
| 24th | 2 pm | (Noon WST) Neptune 5°N of Moon |
| 26th | 2 am | (Midnight WST, prev day) Uranus 5°N of Moon |
| 27th | | Mercury stationary |
| 27th | pm | Comet C/2002 O7 (LINEAR) 0.5°SE of NGC5297 (SG) in Canes Venatici |
| 29th | 3 am | (1 am WST) Venus 3°N of Moon |
| 29th | pm | Comet 65P/Gunn 0.5°N of star Sigma Sagittarii |

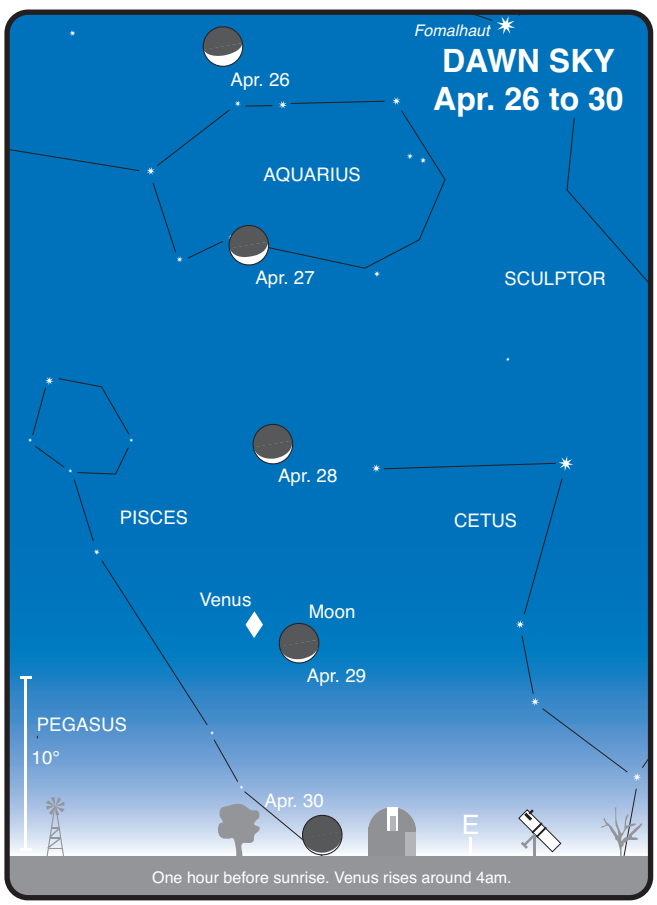




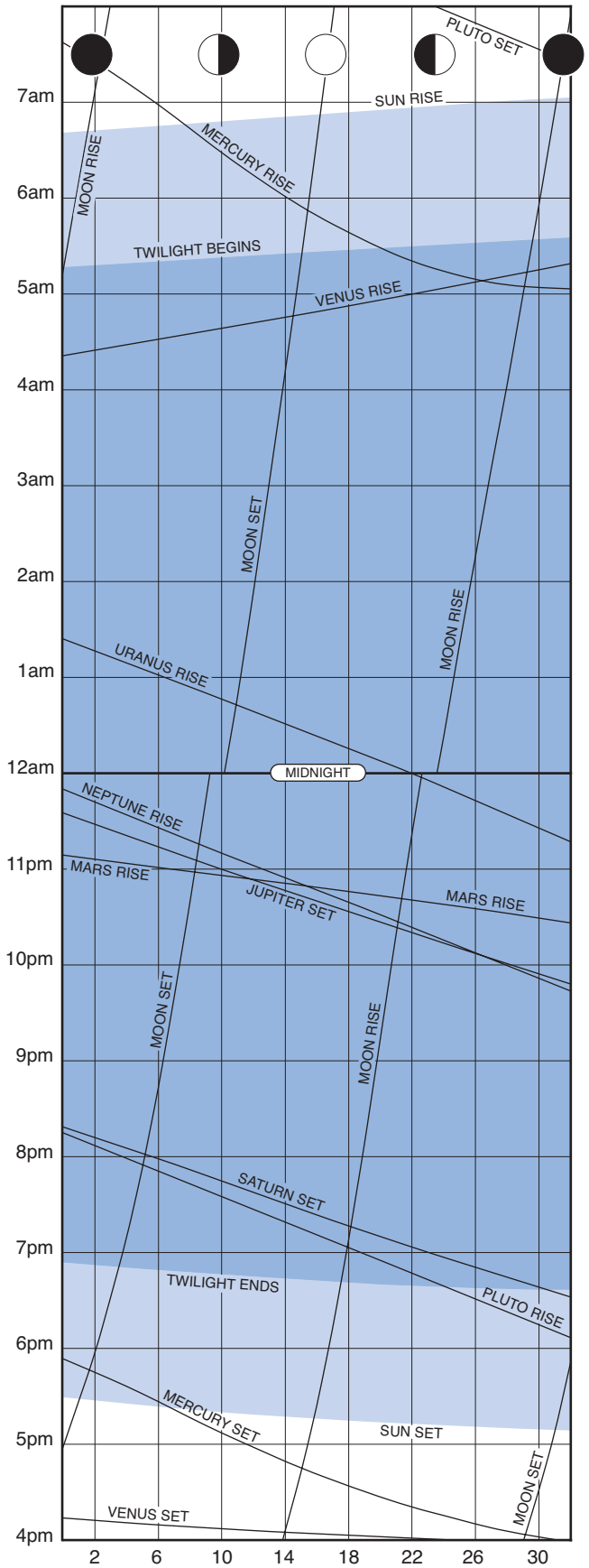

Approximate local standard time, for daylight saving add 1 hour.



# MAY

## RISE/SET CHART




Approximate local standard time.

## HIGHLIGHTS

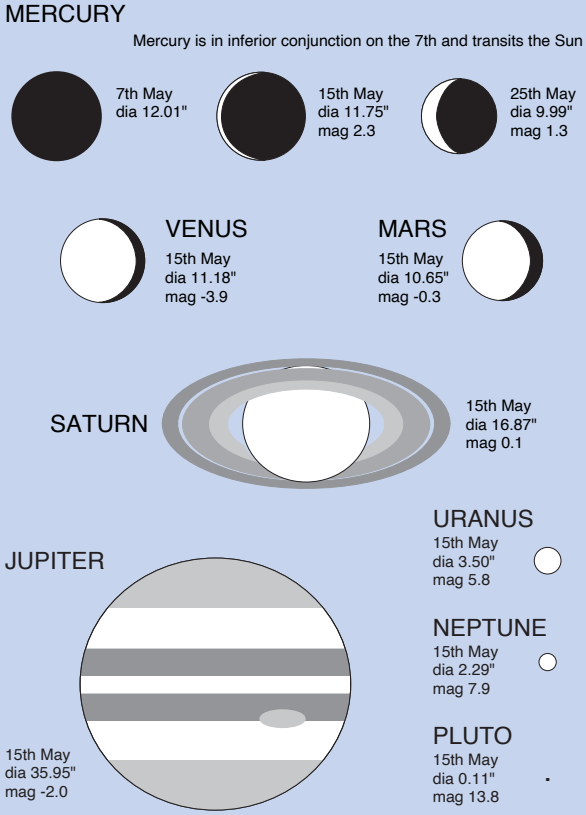
- Mercury transits the Sun.
- Mercury at its best for morning observation at the end of month.
- Venus and Mercury close.
- Five bright Minor Planets at Opposition in Libra

### THE MOON

This month has five lunar phases, two New Moons, as well as reaching apogee twice.

| | |
|---|---|
| 1st | Moon at apogee (furthest from Earth – 406,529 km distant, angular size 29.3') |
| 1st | New Moon |
| 9th | First Quarter |
| 16th | Moon at perigee (closest to Earth – 357,449 km distant, angular size 33.9') |
| 16th | Full Moon. Total Lunar Eclipse, not visible from Australia (see p. 76) |
| 23rd | Last Quarter |
| 28th | Moon at apogee (furthest from Earth – 406,168 km distant, angular size 29.0') |
| 29th | Occultation of Venus by the Moon, not visible from Australia |
| 31st | New Moon. An annular solar eclipse, not visible from Australia (see p. 76 for details). |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** is in inferior conjunction on the 7th and will transit over the Sun. The beginnings of the transit will be visible Australia wide. For those situated on the eastern seaboard, the Sun sets before Mercury has reached mid-transit. Observers from South Australia, Northern Territory and Western Australia will see at least until mid-transit, but the Sun sets before the planet's egress. **Warning, never look directly at the Sun with your eyes or without a suitability filtered instrument!** Viewing of the transit should be supervised by experienced solar observers. For more details of the transit see pages 92-93.

In Aries for the month, Mercury moves into the dawn sky after its passage across the solar disc. With the planet's greatest elongation west of the Sun early next month, the period from mid-month until mid June is the best opportunity to observe Mercury in the morning for the rest of the year. Late in the month Mercury and Venus are close together, with the Moon joining the pair on the 29th (see Sky View)

**VENUS**, at magnitude -3.9, is obvious in the pre-dawn eastern sky in Pisces, travelling into Aries mid-month as it gradually moves closer to the Sun. As Venus slowly loses altitude each morning, Mercury (after its transit) rapidly gains height above the horizon, with the two inner planets having a close encounter later in the month. Between the 25th and 29th, the two planets will be less than 2.6° apart, with closest approach on the 27th at 2.2° (see Sky View). On the 29th, the thin crescent Moon joins the pair, making a superb tight triangle in the dawn sky. At this time, the Moon appears as a slender crescent (just 5% illuminated by the Sun), Venus almost at full phase and Mercury a solid crescent approaching a first quarter appearance.

**MARS** rises late in the eastern evening sky in Capricornus. With opposition at the end of August the planet dramatically increases in brightness over the coming months, and at present is already outshining all but the very brightest stars. Telescopically Mars appears distinctly gibbous, and by the end of the month its angular size is larger than Venus, and will remain so until late November. Between the 14th and 16th, Mars will be 2° south of Neptune. The 21–day old Moon will be nearby Mars on the 21st (see Sky View). On the 31st, Mars will be a close 0.1° from the 3.7 magnitude star Gamma Capricorni.

**JUPITER** sets in the northeastern sky around 11pm, providing time for observations in the early evening before too much altitude is lost. In retrograde until last month, Jupiter has moved rather slowly (against the stellar background) remaining close to M44. This month Jupiter begins to distance itself from this famous open star cluster. The First Quarter Moon appears near the planet on the 8th and 9th (see Sky View).

**SATURN** sets soon after the end of astronomical twilight in the northwestern sky, the planet's low altitude not lending itself to telescopic scrutiny. On the 5th, the 3–day old thin crescent Moon will be near the planet (see Sky View). Saturn spends the first half of the month in Taurus before moving into neighbouring Orion.

**URANUS** in Aquarius and **NEPTUNE** in Capricornus spend an uneventful month in their respective constellations in the early morning eastern sky. Of some interest, Mars passes by Neptune mid-month (see Mars).

**PLUTO**, in Serpens, rises in the early evening eastern sky, heading towards opposition next month. Early in the month this distant planet moves into Ophiuchus, where it remains until December before returning to Serpens. The constellation of Serpens, the Serpent is unique in having two sections separated by Ophiuchus, the Serpent Holder. Pluto is in the the tail segment of Serpens, known as Serpens Cauda; the other part of the constellation being Serpens Caput, the serpent's head.

**MINOR PLANETS** at opposition this month includes 192 Nausikaa on the 30th at magnitude 10.7 near the border of Scorpius and Ophiuchus. May also sees 5 of the brighter minor planets at opposition in Libra. They are: 3 Juno on the 3rd at magnitude 10.1, 21 Lutetia on the 3rd at magnitude 10.4, 40 Harmonia on the 3rd at magnitude 9.8, 16 Psyche on the 9th at magnitude 10.4 and 9 Metis on the 21st at magnitude 9.6. 11 Parthenope, while still in Leo, visits M105 and M96 in the last few days of the month.

## HOW MANY CONSTELLATIONS IN THE ZODIAC?

If you look at the finder chart for Saturn (p. 110) you will notice that half way through May this ringed world enters the constellation of Orion briefly – exiting in early June. Likewise, Venus spends the last week of January 2014 in Scutum and Jupiter and Saturn visited Cetus in March 1999 and March 1997 respectively. In March 1798 Venus also made a short visit to Pegasus. The constellations Orion, Cetus, Pegasus or Scutum are not normally associated with the movement of the planets through the Zodiac. So you may ask what's going on?

We have all heard the astrologers refer to the 12 signs of the Zodiac. These signs have nothing to do with the official astronomical boundaries of the constellations but instead refer to arbitrary (well almost) rectangular spaces which are exactly 30 degrees wide in celestial longitude.* For example, when the Sun is close (in conjunction) to Aldebaran (Alpha Tauri), around May 30, it may be astronomically in Taurus but it is in the astrological star sign of Gemini, The Twins. It is not just the 'size' of the astrological 'constellation' that affects this, the Precession of the Equinoxes, due to the slow wobble of the Earth's axis over many thousands of years also has an influence. In reality the Sun actually passes through 13 constellations each year with Ophiuchus being the missing 'sign'. In fact the Sun stays in Ophiuchus each year longer than Scorpius (called Scorpio by astrologers).

We have covered the motion of the Sun but the astrologer's 'signs' are supposed to encompass the movement of the planets and Moon as well. When you include these astronomical bodies the field of constellations really opens up. Although the Solar System appears as a relatively flat disc, the planets all have their orbits slightly tilted with respect to the Earth's. So they can move a number of degrees above or below this 'plane of the Ecliptic'. The closer a planet can come to the Earth the further the apparent movement away from the ecliptic. For example, Venus' orbit is tilted (inclined) by about 3 degrees but from Earth but we can see it move up to nearly 9 degrees above and below the ecliptic. Similarly, Mars' inclination is just less than 2 degrees but it can move up to 4.5° north or nearly 7° south of the ecliptic.

In summary there are 21 constellations in which some of the planets from Mercury to Neptune can at times enter. The Moon adds Auriga to the list. Hence we have a total of 22 constellations. If you count Pluto's movement you can include Serpens, Eridanus, Coma Berenices and Bootes. These additions are due to the high inclination of this distant body.

The constellation boundaries used here are those as defined by the International Astronomical Union. Prior to this official IAU designation (circa 1930) these boundaries did vary between uranographers.

* It is interesting that the use of the 30 degree rectangles was not just for astrology. Up until the 19th century the astronomical almanacs defined the positions of the planets by their celestial longitudes expressed by their sign, degrees, minutes. For example, a position may have been Virgo 22° 14' which is the same as longitude 172° 14' (but try putting Virgo 22° 14' into your computer!).

**The 22 Zodiacal Constellations**

Aquarius *
Aries *
Auriga
Cancer *
Capricornus *
Cetus
Corvus
Crater
Gemini *
Hydra
Leo *
Libra *
Ophiuchus
Orion
Pegasus
Pisces *
Sagittarius *
Scorpius (Scorpio *)
Scutum
Sextans
Taurus *
Virgo *

* Traditional signs of the Zodiac

# MAY

## COMETS

**Comet 65P/Gunn** is at perihelion this month on the 12th at a distant 2.5 AU from the Sun, well beyond Mars' orbit and nearly half way out to Jupiter. The 12th magnitude comet begins the month near Sigma Sagittarii (a handle star of the teapot) and indeed only moves a few degrees from the star during May.

**Comet 116P/Wild 4** is at its closest to Earth this month – some 1.3 AU distant, nearly four months after perihelion. This is why the comet has been fairly constant in brightness at 12th magnitude since February. This month, Wild 4 continues its westward trek through Libra, visible all night, and in mid-May it is less than a degree south of the globular cluster NGC5897.

**Comet C/2002 O7 (LINEAR)** is moving southwest through Canes Venatici and Ursa Major this month. Early in the month, the comet passes near the galaxies M63 and M94. By month's end, LINEAR could have brightened to 11th magnitude and will be setting around midnight.

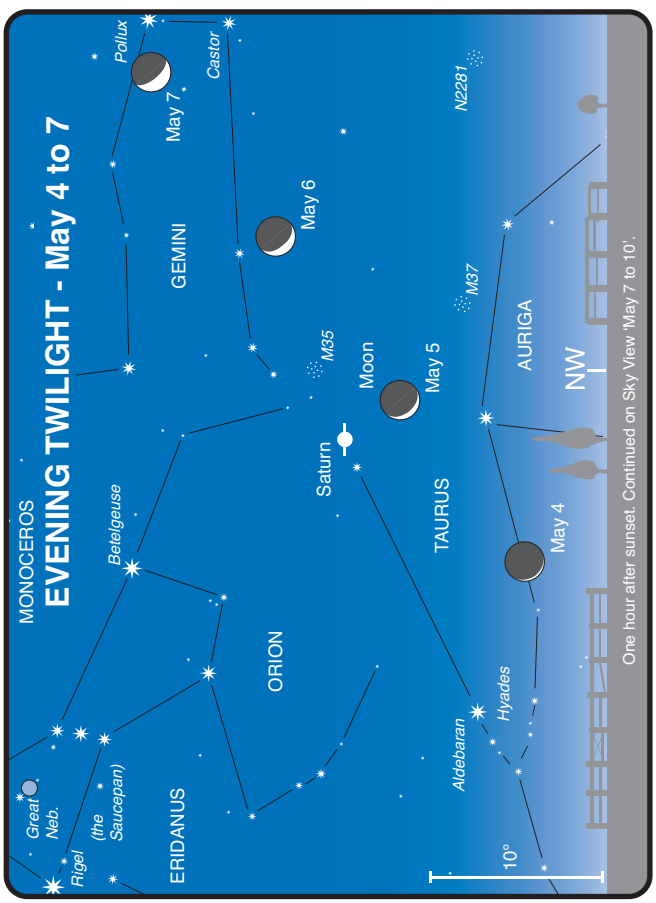
**Comet C/2001 RX14 (LINEAR)** continues its trek south through Leo this month. Mid-month, LINEAR passes several degrees west of the galaxies M65 and M66. By the end of May, the comet has faded to 12th magnitude and is setting around midnight.

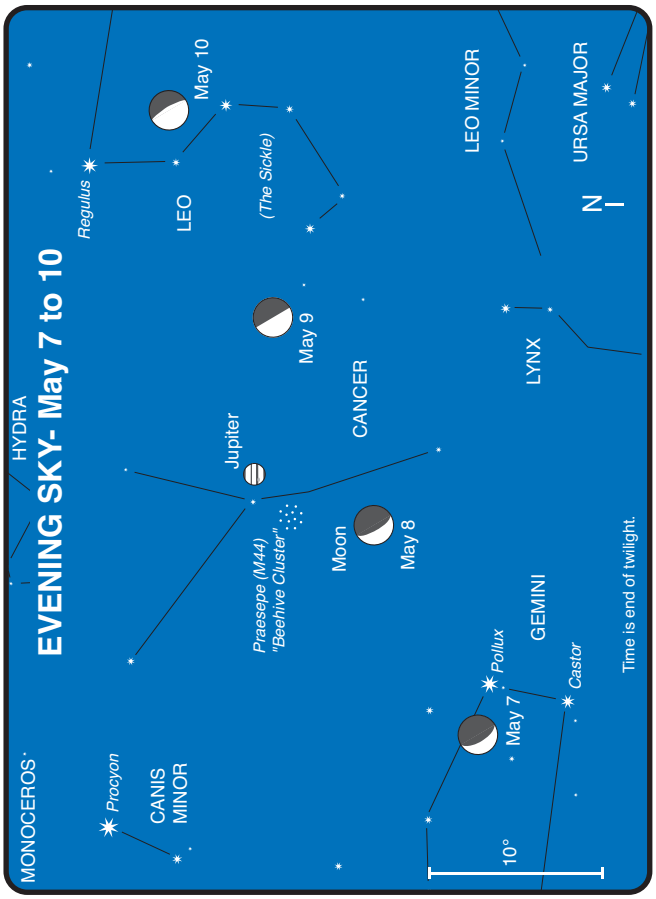
## METEOR SHOWERS

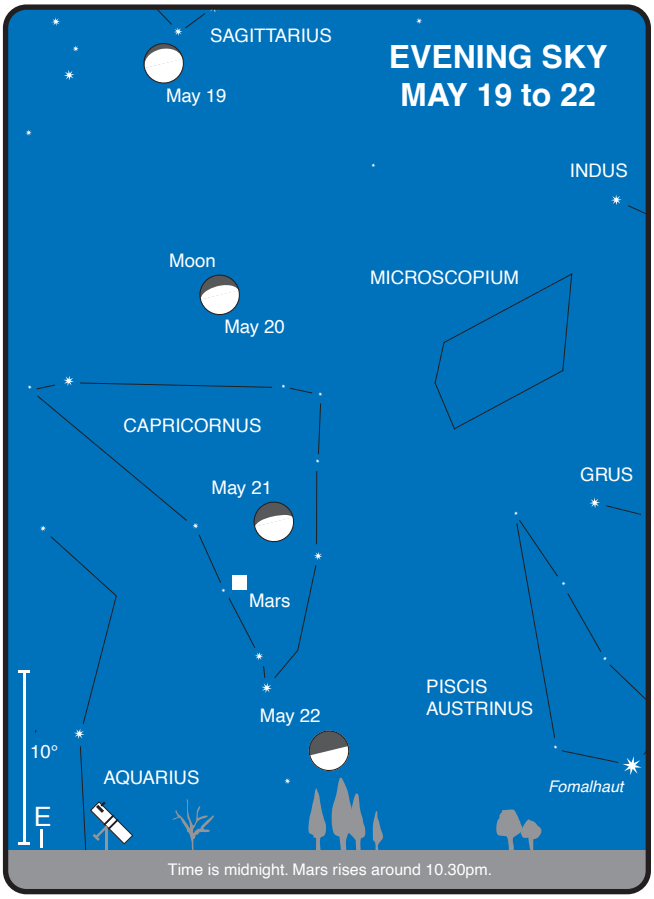
The **eta Aquarids** are linked with Halley's Comet and rank as one of the most popular of the Southern Hemisphere showers. They are visible for a few hours before dawn, from 19th April to 28th May. They peak this month on the 6th, but the rate is generally around 30 for 3 – 4 days either side of this day. The zenith hourly rate will often reach 50 or more meteors per hour (95 in 1975 and 110 in 1980). The Eta Aquarids are characterised by their high percentage of persistent trains (up to 25% of the meteors). They are very swift and are a striking yellow colour. The Moon has interfered with the shower over the past couple of years, but this year will be Moon free, at least until the peak is well over.

## DIARY EST (WST)

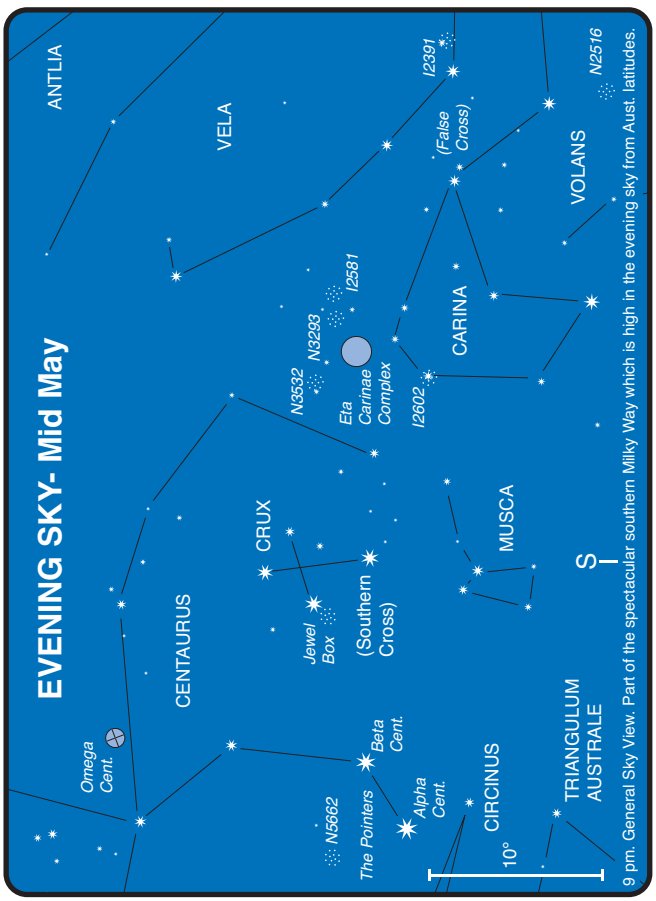
| | | |
|---|---|---|
| 1st | | Moon at apogee |
| 1st | | New Moon |
| 1st | 11 pm | (9 pm WST) m.p. 23 Thalia 0.1°SE of NGC5634 (GC) in Virgo |
| 3rd | | Saturn 0.4°N of Comet 81P/Wild 2 |
| 3rd | | Juno at opposition |
| 5th | 7 pm | (5 pm WST) Saturn 3°S of Moon |
| 5th | 11 pm | (9 pm WST) m.p. 4 Vesta 0.05°E of NGC4178 (SG) in Virgo |
| 6th | pm | Comet C/2002 O7 (LINEAR) 0.6°SE of M63 (SG) in Canes Venatici |
| 7th | | Mercury at descending node |
| 7th | 5 pm | (3 pm WST) Mercury in inferior conjunction, transit over Sun |
| 9th | | First Quarter Moon |
| 9th | 4 am | (2 am WST) Jupiter 4°S of Moon |
| 11th | | m.p. 9 Metis 0.7°N of star Beta Scorpii |
| 11th | pm | Comet C/2001 RX14 (LINEAR) 0.9°E of NGC3489 (LG) in Leo |
| 12th | | Venus at greatest latitude south |
| 12th | 11 pm | (9 pm WST) Comet C/2002 O7 (LINEAR) 0.05°S of M94 (SG) in Canes Venatici |
| 13th | | m.p. 511 Davida 0.6°S of star Pollux |
| 13th | Midnight | (10 pm WST) Mars 2°S of Neptune |
| 14th | pm | Comet C/2002 O7 (LINEAR) 0.7°SE of NGC4618 (SG) in Canes Venatici |
| 15th | | Vesta stationary |
| 16th | | Moon at perigee |
| 16th | | Neptune stationary |
| 16th | | Full Moon; eclipse |
| 17th | | Ceres in conjunction with Sun |
| 18th | | Mercury at aphelion |
| 19th | pm | Comet 116P/Wild 4 0.9°S of NGC5897 (GC) in Libra |
| 20th | | Mercury stationary |
| 21st | 10 pm | (8 pm WST) Neptune 5°N of Moon |
| 22nd | 6 am | (4 am WST) Mars 3°N of Moon |
| 22nd | pm | Comet C/2002 O7 (LINEAR) 0.2°S of NGC4244 (SG) in Canes Venatici |
| 23rd | | Last Quarter Moon |
| 23rd | 10 am | (8 am WST) Uranus 5°N of Moon |
| 27th | pm | m.p. 3 Juno 0.3°N of NGC5713 (SG) in Virgo |
| 28th | | Moon at apogee |
| 28th | 10 am | (8 am WST) Mercury 2°S of Venus |
| 28th | pm | m.p. 8 Flora 0.4°S of M24 (OC) in Sagittarius |
| 29th | | m.p. 11 Parthenope 0.5°SW of M105 (EG) in Leo |
| 29th | 1 pm | (11 am WST) Mercury 2°S of Moon |
| 29th | 2 pm | (Noon WST) Venus 0.1°S of Moon Occn. |
| 29th | pm | m.p. 12 Victoria 0.3°NE of NGC6356 (GC) in Ophiuchus |
| 31st | | m.p. 11 Parthenope 0.4°NE of M96 (SG) in Leo |
| 31st | | New Moon; eclipse |
| 31st | 3 am | (1 am WST) Mars 0.1°S of star Gamma Capricorni |
| 31st | pm | m.p. 23 Thalia 0.9°SE of NGC5427 (SG) in Virgo |

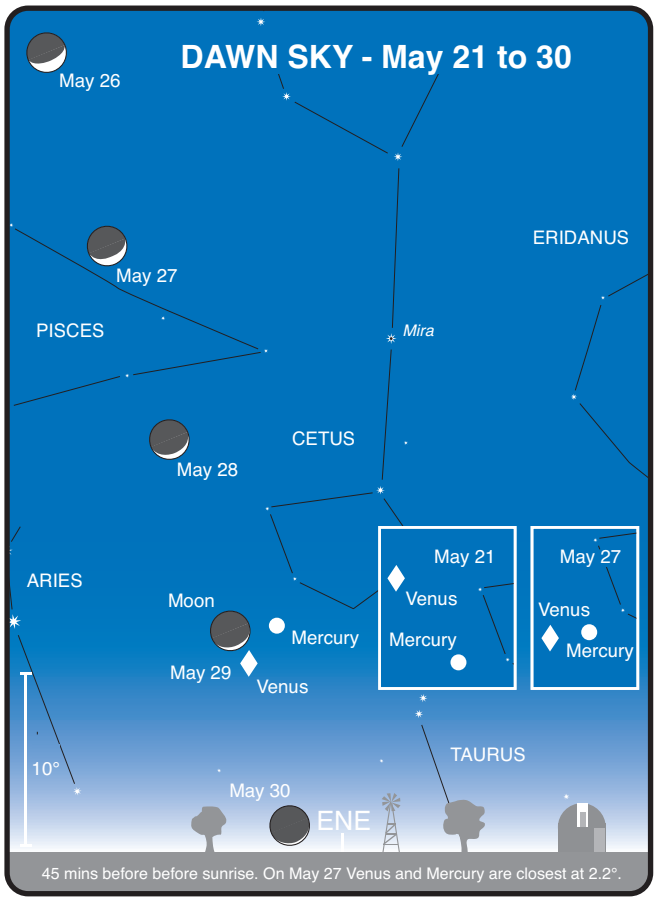




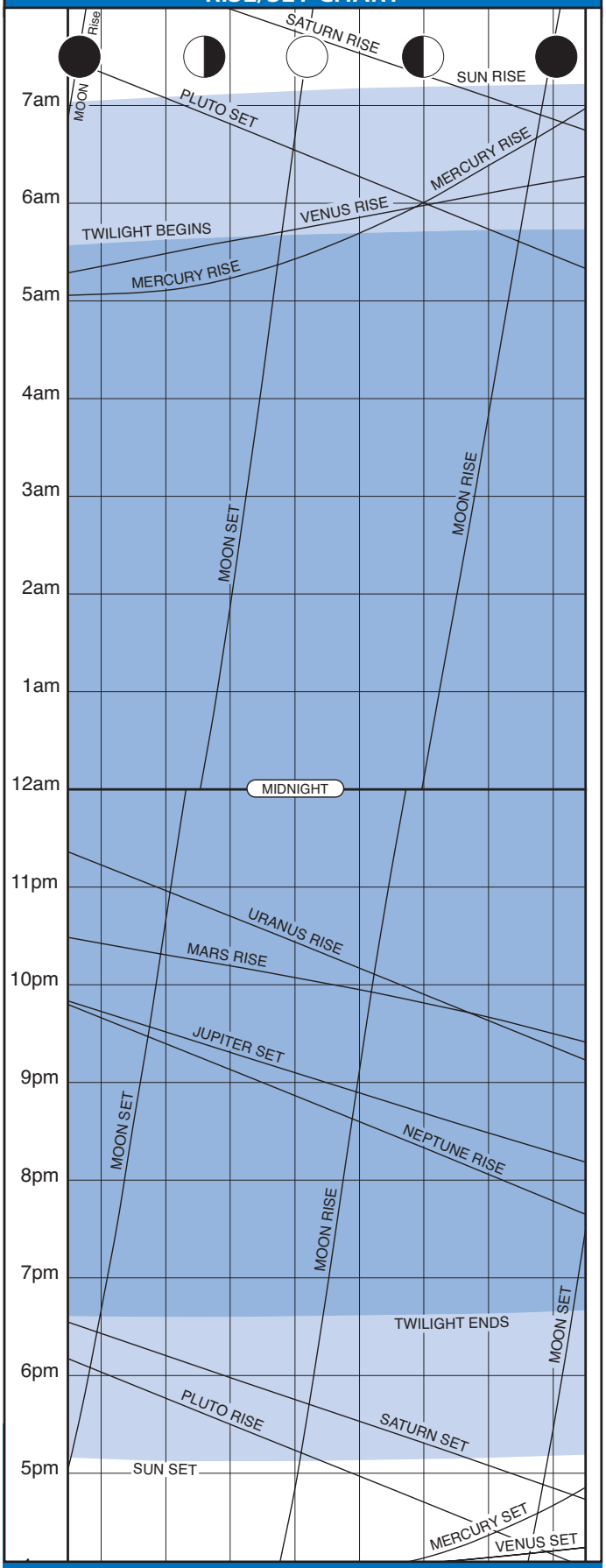

Approximate local standard time.



# JUNE

## RISE/SET CHART




Approximate local standard time.

## HIGHLIGHTS

- Mercury ideally suited for morning observation for the first three weeks of June.
- Mercury and Venus close.
- Mars' size now as large as at a poor opposition.
- Mars and Uranus close.
- Pluto at opposition

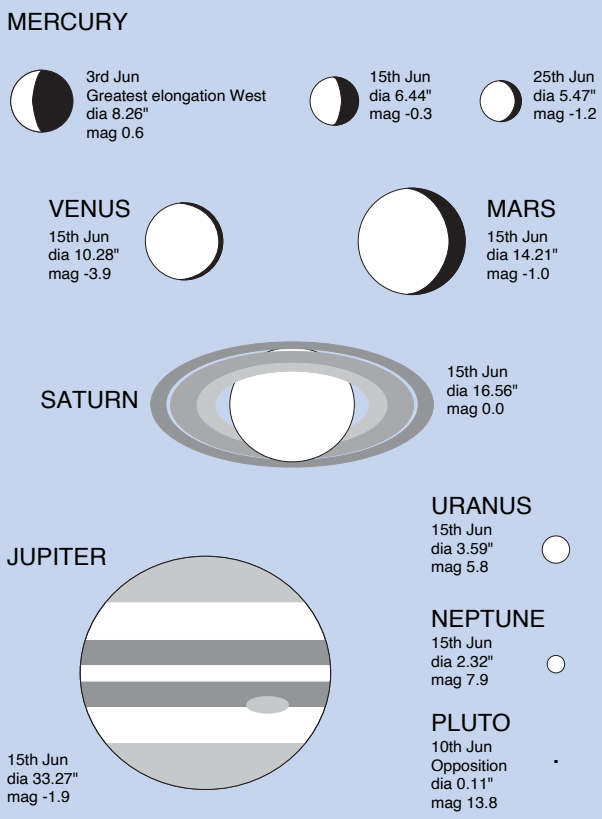
### THE MOON

| | |
|---|---|
| 8th | First Quarter |
| 13th | Moon at perigee (closest to Earth – 360,425 km distant, angular size 32.8') |
| 14th | Full Moon |
| 22nd | (EST, 21st WST) Last Quarter |
| 25th | Moon at apogee (furthest from Earth – 405,232 km distant, angular size 29.6') |
| 30th | New Moon |

### THE PLANETS

**MERCURY** is at its greatest elongation west of the Sun on the 3rd (24°), and for the first three weeks of June it is in an ideal position to observe in the morning sky. Mercury and Venus separate after their close conjunction in late May, only to come together again as Mercury heads back toward the Sun. On the 21st and 22nd, the pair will be just 0.5° apart (see Sky View). With both planets near the 1st magnitude star Aldebaran, early morning viewers will be treated to some interesting triangular configurations for the week leading up to the close planetary conjunction. By month's end, the speedy little planet will be lost in the Sun's glare as it races toward superior conjunction.

## APPEARANCE of the PLANETS



**VENUS** begins June in Aries about 4° below Mercury in the northeastern morning sky, rising around the start of dawn. As the planet slowly moves toward the Sun, it is followed and overtaken by the faster Mercury and on the 21st and 22nd, the pair will be just 0.5° apart; a spectacular sight with Venus at -3.9 and Mercury at -1.0 magnitude, separated by a Moon's width (see Sky View).

**EARTH** is at Solstice on the 22nd, when our days are shortest. On this day, the Sun is at its most northerly position with a declination of +23.5°.

**MARS**, rising around 10pm, spends the early part of the month in Capricornus before moving into Aquarius. On the 2nd and 3rd, the Red Planet will be just 0.3° from the 3rd magnitude star Deneb Algiedi (tail of the goat) or Delta Capricorni. Delta is an eclipsing binary system, but its main claim to fame is that it was within 3° of this star that the French mathematician, Le Verrier, calculated that the planet Neptune would be found. On the 19th, the 20–day old Moon will be nearby the planet (see Sky View). From mid-month onwards, Mars will be within 4° south of Uranus, with closest approach on the 20th at 3°. If you are gearing up for 'The Opposition' at the end of August, it is interesting to note that the size of Mars is the same this month as it is at a poor opposition. Compare the 'appearance' diagram on the preceding page with that of August, the planet's diameter increases from 14 to 25 arc seconds. This dramatic change in the planet's size is why observers keenly await each favourable perihelic opposition.

**JUPITER**, setting around 9pm, is in Cancer (home for the planet for the past six months) until the last day of the month when it moves into Leo. The planet is quite prominent in the early evening northwestern sky; telescope users would be well advised to view the planet early before it gets too close to the horizon. On the 5th, the 5–day old crescent Moon will be just north of Jupiter (see Sky View).

**SATURN** can only be seen in the evening twilight early in June. It then moves too close to the Sun to see. Saturn will be in conjunction with the Sun on the 25th, returning to grace the morning sky in mid-July.

## AMATEUR TEAM ACKNOWLEDGED

Every 2 years the Astronomical Society of Australia (ASA) awards the Berenice Page Medal. This is to recognise excellence in amateur astronomy in Australia and is judged on the basis of scientific contributions that have served to advance astronomy. Past winners are:

1973 Mr Sydney Elwin – photometric observations of the occultation of Beta Scorpii by Jupiter.

1975 Mr David Herald – Baily's Beads observations in the solar eclipse of 20 June 1974.

1982 Mr Bill Bradfield – discoveries of comets.

1984 Mr Byron Soulsby – umbral shadows, Lunar eclipses.

1986 Reverend Robert Evans – visual discoveries of supernovae.

1988 Mr Robert McNaught – photographic nova and supernova observations and discoveries.

1990 Mr Barry Adcock – telescope design and planetary observations.

1992 Dr Mal Wilkinson – design and construction of a radio telescope and subsequent observations of the Io–Jupiter system.

1994 Mr Paul Camilleri – discoveries of novae and Mira variables.

1996 Mr Peter Williams – visual observations of variable stars.

1998 Mr Gordon Garradd – contributions in the observation of asteroids, comets, novae and supernovae.

2000 Mr Andrew Robert Pearce – visual observations of comets, variable stars and novae.

The 2002 award departed from tradition and recognised the efforts of a group of dedicated amateurs rather than an individual – The Reynolds Amateur Photometry Team. This comprised members of the Canberra Astronomical Society using the 30 inch Reynolds Telescope at Mt Stromlo.

The following is an extract of a presentation speech made by Martin George, on behalf of the ASA, at the National Australian Amateur Astronomers Convention (NACAA), held over Easter 2002 in Adelaide.

"Between 1995 and 1999, the members of the group manned the telescope in sunset-to-midnight and midnight-to-dawn shifts seven days per week, on every night when weather permitted, during the long periods when observations were required. Many of them undertook their considerable efforts despite having family responsibilities and day jobs to go to.

In 1995, an X-ray nova in Scorpius, a suspected eclipsing binary system containing a black hole, was monitored for 5 months at the behest of Dr David Jauncey of the ATNF (CSIRO) and Duncan Campbell-Wilson (MOST). From about 900 images, a complete light curve was obtained. The eclipsing nature of the system was confirmed, and the accuracy of the orbital period was significantly improved. This was despite some data scattering caused by the object flickering with short outbursts on a time scale of several minutes.

It is especially notable that, for this project, the team provided its own ST6 camera and reduction software.

In 1996, the 30" was refurbished by Mt. Stromlo Observatory, and this included the installation of a liquid nitrogen-cooled, 2-arc-minute CCD, which enabled the monitoring of MACHO microlensing events in the Magellanic Clouds and the galactic bulge that had been found by Mount Stromlo's 50" telescope and an international collaboration. The latter groups did not have the ability to follow up every identification they made, so the data captured by our winning team would not otherwise have been obtained by anyone. The team obtained thousands of images with the aging Reynolds telescope until November 1999, when the last spare parts ran out along with funds for repairs. In addition to helping establish limits on the abundance of baryonic (normal matter, made up of atoms – Ed) dark matter and being a tool for studying galactic structure, 22 of the light curves partly deduced from their images pointed to microlensing by binary systems, at least one of which contained a possible exoplanet (The microlensing concept relies on the fact that gravity bends light, like a lens. If a massive enough dark object passes between the Earth and a distant star this results in a momentary brightening of this background object – Ed)

The team has also monitored long-distance supernovae, and the results have been used to extend accurate distance measurements far into the Universe, and refine the value of the Hubble Constant. This work had several side benefits including pre-discovery images of supernovae.

The team has also monitored a number of Cepheid variables in the Large Magellanic Cloud, and has observed two gamma ray bursts. In particular, for several months in 1998, the site of gamma ray burst GRB 980425 was intensively monitored, and for the first time by amateurs, images of an elusive optical counterpart to a burst were obtained. This particular gamma ray burst turned out to have a very different light curve to previous optical afterglows, giving support to the theories that different mechanisms can give rise to the bursts.

The list goes on. The team observed two Blazars in 1999 as part of an international programme, as well as an Active Galactic Nucleus in May of that year. And for six weeks in 2000, some members of the team manned Mount Stromlo's MSO 50" telescope just before it was fully automated, to assist in the sky survey searching for objects orbiting the Sun beyond Neptune. An impressive list indeed.

The team was led by Steve Ring at its inception in 1995. He was joined by Patrick Purcell, Vello Tabur, Brian Crook, Keith Ward, Denver Baines, Tim Leach and Igor Lucaszyk.

The following year, Steve could not continue as leader because of personal commitments, so Brian Crook assumed the leadership role from then on. All but two of the team continued on, with new members Eric Pozza, John Howard, Gavin Wyper, Albert Brakel, John Morland, Shirley McKeown, Geoff Mitchell and Stephen Jarrett joining them in 1996. Over the next three years further additions were Darren McDowell, Alan Salmon, Christoph Leach, Mark Dowling, Michael McDonald, Alex Gutierrez, Laeli Hogan, Gavin Veitch, Heather Crawford, Tony Hill and Gilbert Hughes."

# JUNE

**URANUS**, rising late evening, is in Aquarius. From mid-month onwards it will be within 4° and north of Mars, with closest approach on the 21st at 3°. Here is a good chance, using binoculars (say around 7 x 50), to see just how easy it is to locate this outer Solar System member even under city light pollution. Knowing the field size (marked on the binocular body), it is easy to use Mars as a marker at the edge of the field. A finder chart for Uranus is on page 118.

**NEPTUNE**, in Capricornus, rises in the eastern mid-evening sky. It is interesting to note that the planet, since its official discovery in 1846, has yet to complete a single orbit. It will however, in 2010, return to its original discovery point near the 3rd magnitude star Delta Capricorni. Early in the month Mars will be close to this star (see Mars).

**PLUTO** is at opposition on the 10th, and is visible the entire night. Our most distant planet is currently 4,436,000,000 km from Earth (29.6 AU), with its light taking 247 minutes to reach us (a little over 4 hours).

**MINOR PLANETS** at opposition this month include 12 Victoria on the 10th at magnitude 8.8 in Ophiuchus, 8 Flora on the 20th at magnitude 9.2 in Sagittarius and 346 Hermentaria on the 25th at magnitude 10.8 in Sagittarius.

## COMETS

**Comet 65P/Gunn** slowly moves southwest through Sagittarius this month. The 12th magnitude comet is visible for most of the night and is in conjunction with the globular cluster M54 in mid-June. This month Gunn is at its closest to Earth (1.5 AU) and being only a month after perihelion, makes this a favourable return.

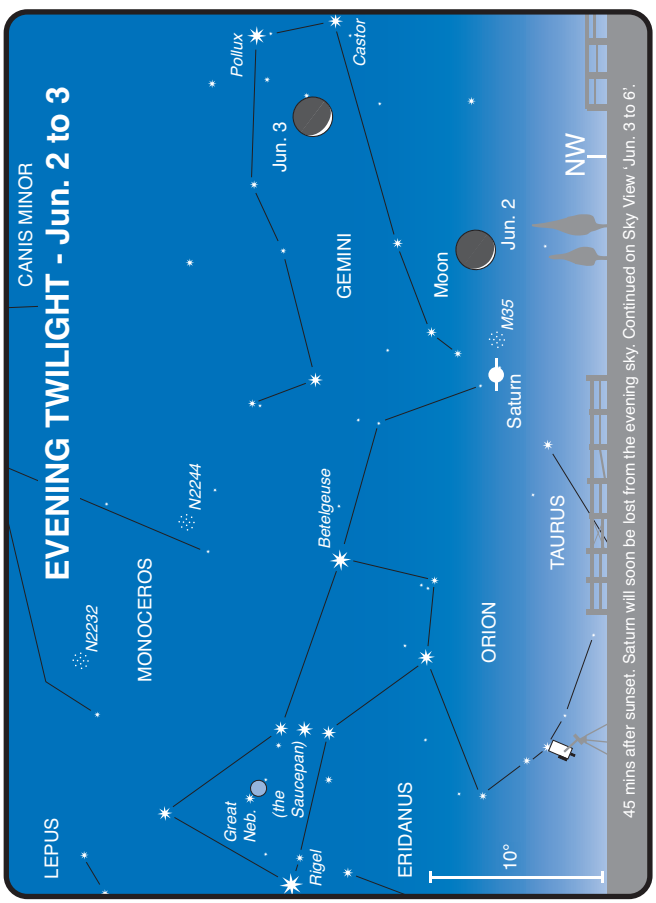
**Comet C/2002 O7 (LINEAR)** is best observed in the early evening this month, as it sets before midnight. Moving southwest through Ursa Major and Leo, LINEAR may have brightened to 10th magnitude by the end of June.

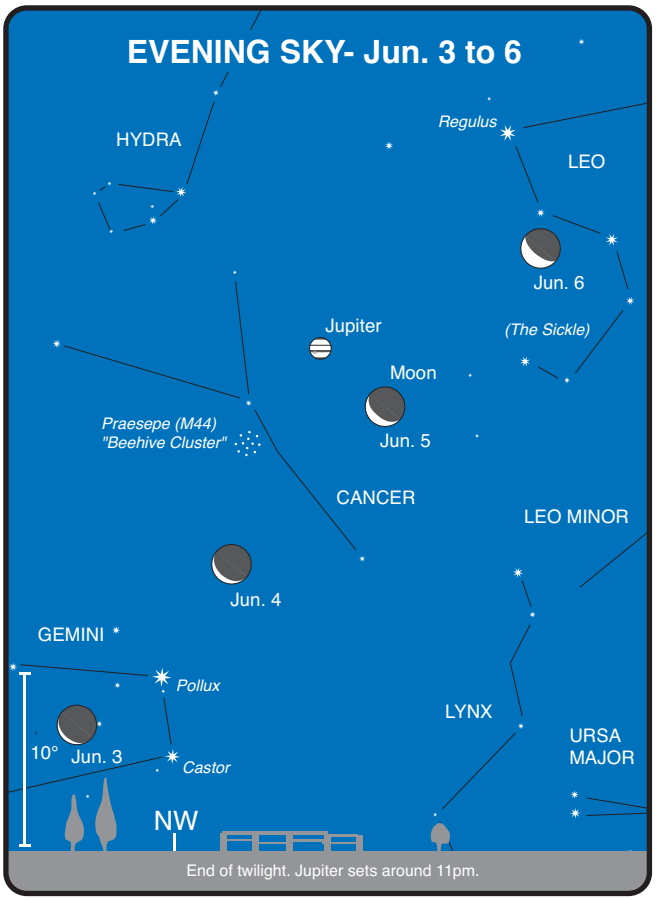
**Comet C/2001 Q4 (NEAT),** predicted to be naked eye in 2004, will hopefully have brightened to 13th magnitude by the end of this month. At the beginning of June, the comet is four degrees south of 4th magnitude Alpha Fornacis in the morning sky. During the month, NEAT slowly moves southeast, and will be near the galaxy NGC1365 as June draws to an end.

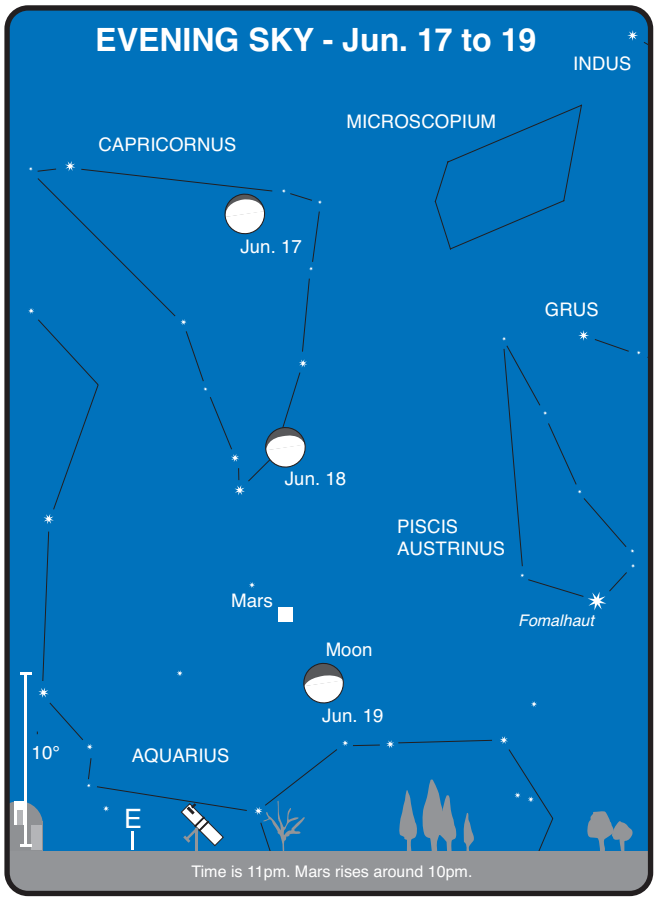
**Comet C/2001 RX14 (LINEAR)** fades from 12th to 13th magnitude this month. Setting before midnight by month's end, LINEAR moves through Leo into Virgo.

## DIARY EST (WST)

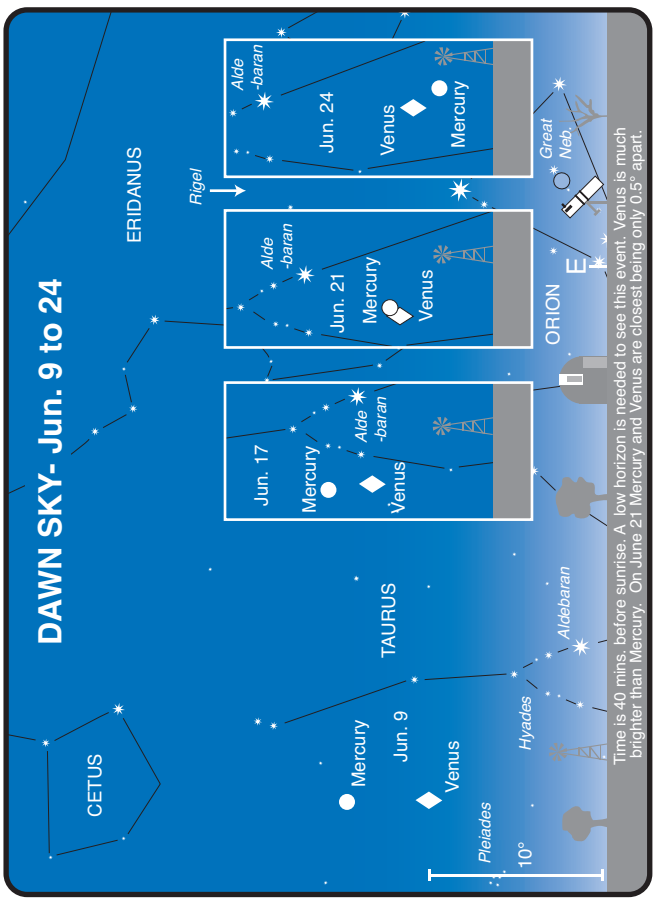
| | | |
|---|---|---|
| 2nd | 7 am | (5 am WST) Saturn 4°S of Moon |
| 3rd | | Mercury greatest elong. W (24°) |
| 3rd | pm | Mars 0.3°SE of star Delta Capricorni |
| 4th | | Pluto 0.5°S of the Box Nebula (PN) in Ophiuchus |
| 5th | 4 pm | (2 pm WST) Jupiter 4°S of Moon |
| 5th | pm | Comet 65P/Gunn 0.6°NW of star Zeta Sagittarii |
| 7th | | Mercury at greatest latitude south |
| 8th | | Uranus stationary |
| 8th | | First Quarter Moon |
| 10th | | Pluto at opposition |
| 12th | pm | m.p. 4 Vesta 0.6°SW of NGC4365 (EG) in Virgo |
| 13th | | Moon at perigee |
| 13th | 11 pm | (9 pm WST) m.p. 12 Victoria 0.2°NE of star Eta Ophiuchi |
| 14th | | Full Moon |
| 14th | pm | Comet 65P/Gunn 0.2°E of M54 (GC) in Sagittarius |
| 18th | 7 am | (5 am WST) Neptune 5°N of Moon |
| 19th | | Mercury 1°N of m.p. 1 Ceres |
| 19th | 5 am | (3 am WST) Venus 5°N of Aldebaran |
| 19th | 4 pm | (2 pm WST) Mars 1.7°N of Moon |
| 19th | 6 pm | (4 pm WST) Uranus 5°N of Moon |
| 19th | 10 pm | (8 pm WST) Mercury 4°N of Aldebaran |
| 19th | pm | m.p. 8 Flora 0.5°S of M23 (OC) in Sagittarius |
| 21st | | Mercury 2°N of NGC1647 (OC) in Taurus |
| 21st | | Comet 81P/Wild 2 0.5°NE of NGC2420 (OC) in Gemini |
| 21st | 9 am | (7 am WST) Mars 3°S of Uranus |
| 21st | Noon | (10 am WST) Mercury 0.4°S of Venus |
| 21st | pm | Comet C/2002 J4 (NEAT) 1°E of NGC6584 (GC) in Telescopium |
| 22nd | | Last Quarter Moon |
| 22nd | | Solstice |
| 24th | | Mercury 2°SE of NGC1746 (OC) in Taurus |
| 25th | | Saturn in conjunction with Sun |
| 25th | | Moon at apogee |
| 25th | | Comet C/2002 O7 (LINEAR) 0.7°NW of star Delta Leonis |
| 26th | | m.p. 4 Vesta 1°NE of NGC4496A (SG) in Virgo |
| 26th | | Mercury at ascending node |
| 26th | pm | m.p. 8 Flora 0.6°N of NGC6440 (GC) in Sagittarius |
| 27th | | Mercury 1.2°N of Crab. Neb. (BN) in Sagittarius |
| 28th | | m.p. 1 Ceres 1°N of NGC1647 (OC) in Taurus |
| 30th | | New Moon |

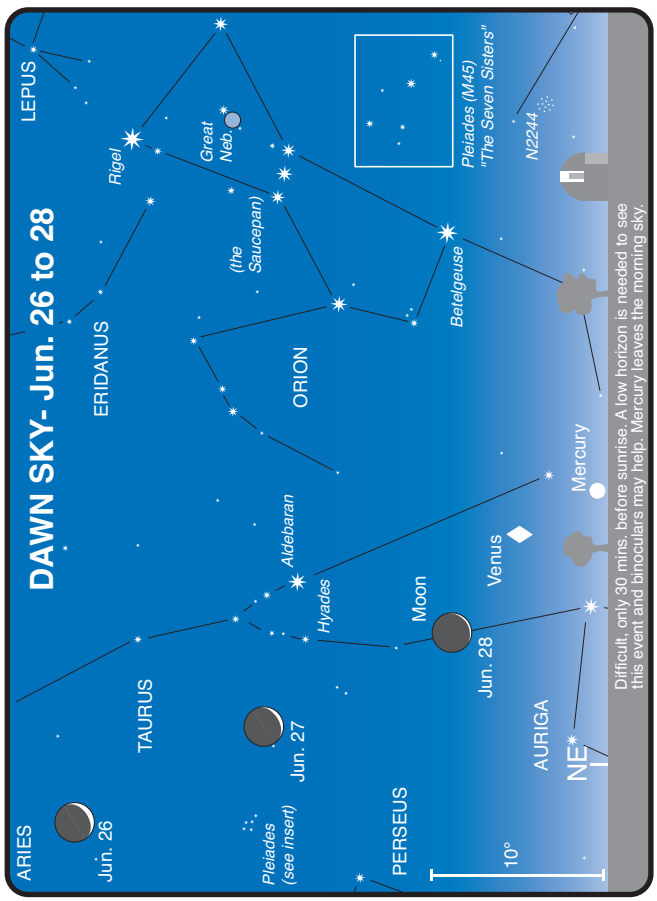




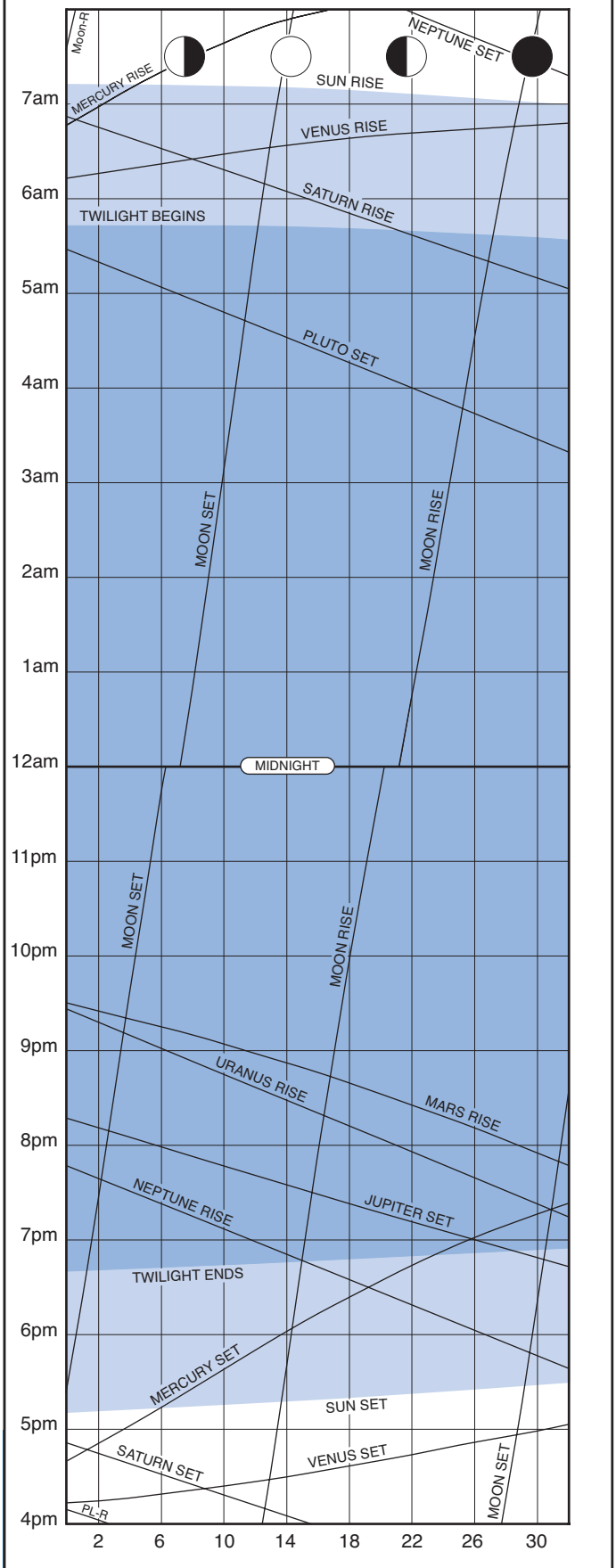

Approximate local standard time.



# JULY

## RISE/SET CHART




Approximate local standard time.

## HIGHLIGHTS

- Mercury returns to the evening sky at month's end.
- Mercury and Jupiter close.
- Mercury, Regulus and the Moon together.
- Mars is brilliant in the sky, just one month before opposition.
- Three bright minor planets at opposition in Sagittarius.
- The Southern delta-Aquarids meteor shower.

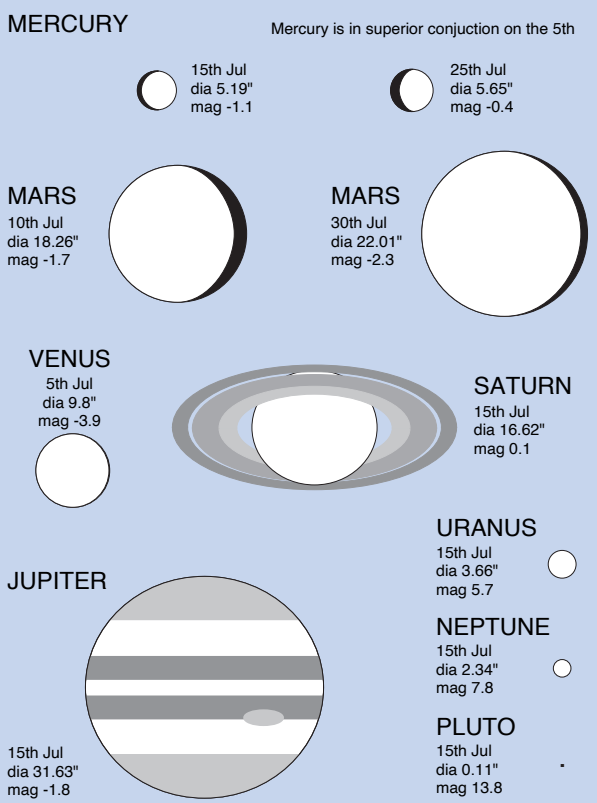
### THE MOON

| | |
|---|---|
| 7th | First Quarter |
| 11th | Moon at perigee (closest to Earth – 365,145 km distant, angular size 32.4') |
| 14th | Full Moon |
| 17th | Occultation of Mars by the Moon, not visible from Australia |
| 21st | Last Quarter |
| 23rd | Moon at apogee (furthest from Earth – 404,328 km distant, angular size 29.9') |
| 29th | New Moon |

### THE SUN

During July the barycentre (centre of gravity) of the Solar System will move back into the Sun having been outside the globe since October 1992. It will again leave the Sun in September 2006. The positions of the four gas giants of the Solar System (Jupiter, Saturn, Uranus and Neptune) are the major influence. In recent years, they have been together, pulling on the same side of the Sun.

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** is in superior conjunction on the 5th (Mercury and Earth on opposite sides of the Sun). The planet then moves east of the Sun and into the evening sky. The last week of this month and all of August provide the best viewing window for the planet in the evening sky this year. Mercury will be visible from mid-month, rising up to meet the setting Jupiter. Between the 25th and 27th the two planets will be around 1° apart, and half that on the 26th, making an excellent evening spectacle (see Sky View). Four days after the Jupiter rendezvous, Mercury continues to gain altitude, meeting up with the 1st magnitude star Regulus (Alpha Leonis). Again, we have another close encounter with the planet and star just 0.2° apart on the 30th; Mercury is below Regulus and is the brighter object. The 2–day old thin crescent Moon appears north of Mercury and Regulus on the 31st (see Sky View).

**VENUS** can only be seen very low in the northeastern dawn sky for the first week of July. The planet is then too close to the Sun for observation, as it moves toward superior conjunction next month. In late September the planet reappears in the evening sky where it stays until the end of the year.

The **EARTH** is at aphelion (the furthermost point in its orbit from the Sun) on the 4th. The Earth–Sun distance is 1.016728 astronomical units, which is equivalent to about 152,102,500 km. Some people believe that this should make winters in the Southern Hemisphere more severe compared to the north. However, the Southern Hemisphere land masses are relatively small compared to the large oceans of the south and these bodies of water have a tempering effect on our climate.

**MARS**, in Aquarius, rises in the early eastern evening sky. With *the* opposition occurring late in August, the Red Planet this month becomes the brightest object in the night sky besides the Moon. Even Jupiter (setting in the west) is slightly humbled by its brilliance. The motion of Mars against the background stars has been slowing, as it nears the stationary point in its orbit at the end of the month. Thereafter it begins its east to west (retrograde motion) direction across the sky until late September, when it again slows and reverses (see retrograde motion page 68 and the Mars finder chart on page 100). On the 17th, the 19–day old Moon appears close to Mars (see Sky View). During oppositions, most observers use only a narrow three or four week window on either side of the close approach to make their observations, when the disc is at its largest. Considering the size of the planet, even early in the month, this period could be extended to two months or more.

**JUPITER**, in Leo, sets in the early western evening sky. On the 3rd, Jupiter is near the slender crescent 4–day old Moon (see Sky View). The gas giant and little Mercury will appear just 0.5° from each other on the 26th (see Mercury). Two days later on the 28th, an interesting alignment occurs with Jupiter, Mercury and the 1st magnitude star Regulus all strung out in a straight line. We are about to lose Jupiter to the twilight sky early next month as it moves into conjunction with the Sun.

**SATURN** emerges into the morning dawn after its conjunction with the Sun last month. In Gemini, the planet will be difficult to pick out in the bright twilight until mid-month. On the 27th, the slender crescent of the 27–day old Moon appears northwards of the planet. On the 26th, Saturn will be at perihelion, or the point in its orbit that is closest to the Sun (9.0309 AU away). Since the orbital period of the ringed planet is just over 29 years, it follows that the last perihelion passage was in 1974 and the next will be in 2032 (at least dear old Terra Firma has one every year!).

**URANUS** and **NEPTUNE,** in Aquarius and Capricornus respectively, rise in the evening eastern sky. Both planets will be at opposition next month.

**PLUTO**, now past opposition, is visible throughout most of the night in Ophiuchus.

**MINOR PLANETS** at opposition this month include 230 Athamantis on the 12th at magnitude 10.3 in Aquila. July also sees three of the brighter minor planets at opposition in Sagittarius: 27 Euterpe on the 1st at magnitude 10.4, 30 Urania on the 9th at magnitude 10.3 and 115 Thyra on the 17th at magnitude 10.5.

## SHADOWS AND DUST – STUFF TO OBSERVE WITHOUT A TELESCOPE

There are many different phenomena triggered by the interaction of the light from the Sun or Moon with the Earth's atmosphere or lesser-known particles in the Solar System. Well-known solar effects include beautiful sunsets, rainbows and halos. There are also the rarer 'mock suns'. The Moon commonly produces halos and infrequently moonbows.

Most people would have seen some of the above, as they are relatively common. Other effects, while common, often go unnoticed or unrecognised for what they really are. Under the right conditions, they are plainly visible for anyone to see – a case in point is the Earth's shadow.

We are all familiar with the shadow of the Earth, cast by the Sun, as it passes across the Moon during a total or partial lunar eclipse. However, it is also possible to see the Earth's shadow twice every day, provided you have a clear or reasonably cloudless day.

As the Sun begins to set in the west, turn to the east (reverse for sunrise). You will notice a dark band rising slowly from the eastern horizon and gently tapering to both the north and south. This is the Earth's shadow projected through the atmosphere and into space.

The colour of the shadow can be striking with dark blue-purple and occasional grey and orange bands where it merges with the sunlit sky. After half to three-quarters of an hour, as the day gives way to night, the shadow fades as it merges into the darkening sky.

The shadow is most prominent in the east just after sunset, and in the west before sunrise. It should be observed where possible from a location with an unobstructed horizon; the effect is quite stunning from a mountain vantage-point with a 360° view.

After the Earth's shadow, another easy challenge is to observe the Zodiacal Light (so named because of its relationship with the Zodiac). This time face west after the Earth's shadow has gone, allowing time for the sky to darken a little more (reverse for sunrise).

The Zodiacal Light appears as a tenuous conical shaft of light soon after twilight in the western evening sky or before dawn in the eastern morning sky. Being brighter than the Milky Way it can provide an impressive naked eye spectacle, measuring up to 20° across at the base on the horizon, gradually tapering as its altitude increases.

The glow is the result of sunlight reflecting off small particles of dust that lie within the plane of the Solar System. The dust is believed to originate from comet fall out and collisions between asteroids, providing a continuous supply of fresh material to the ecliptic.

The optimum time to view the Zodiacal Light is when the ecliptic is close to being vertical to the horizon. In the Southern Hemisphere, the best period is August–September in the evening and March–April in the morning. While light pollution does not affect viewing of the Earth's shadow, you will definitely need to be well away from the city sky glow to successfully see the Zodiacal Light.

Difficult, but possible to be seen by the experienced observer, are the following two glows that are related to the Zodiacal Light. The Gegenschein or Counterglow, moves around the ecliptic 180° from the Sun (the anti-solar point); it is an elliptical glow that measures about 10° by 20° in diameter, and being much fainter than the Zodiacal Light, it definitely needs good dark skies. Very difficult to see is the Zodiacal Band, a parallel-sided band that extends from the apex of the Zodiacal Light connecting with the Gegenschein.

Most people do not notice these phenomena. To be fair, to see the Zodiacal Light you must go looking under country skies at the optimum time of the year. However, the Earth's shadow, once seen, will not be overlooked again and can become almost addictive.

# JULY

## COMETS

**Comet C/2002 O7 (LINEAR)** is moving south through Leo in July. By the end of the month 8th magnitude LINEAR is setting about an hour after the end of astronomical twilight.

**Comet C/2001 HT50 (LINEAR-NEAT)** emerges from the solar glare in the morning sky this month. Crossing over from Orion into Taurus, the comet reaches perihelion on the 9th at a distance of 2.8 AU from the Sun. By month's end, 12th magnitude LINEAR-NEAT is rising 3 hours before sunrise.

**Comet C/2001 Q4 (NEAT)** may be 13th magnitude this month, visible in the morning sky. It spends July slowly moving southeast through the constellations of Eridanus and Horologium and visits the Fornax cluster of galaxies.

## METEOR SHOWERS

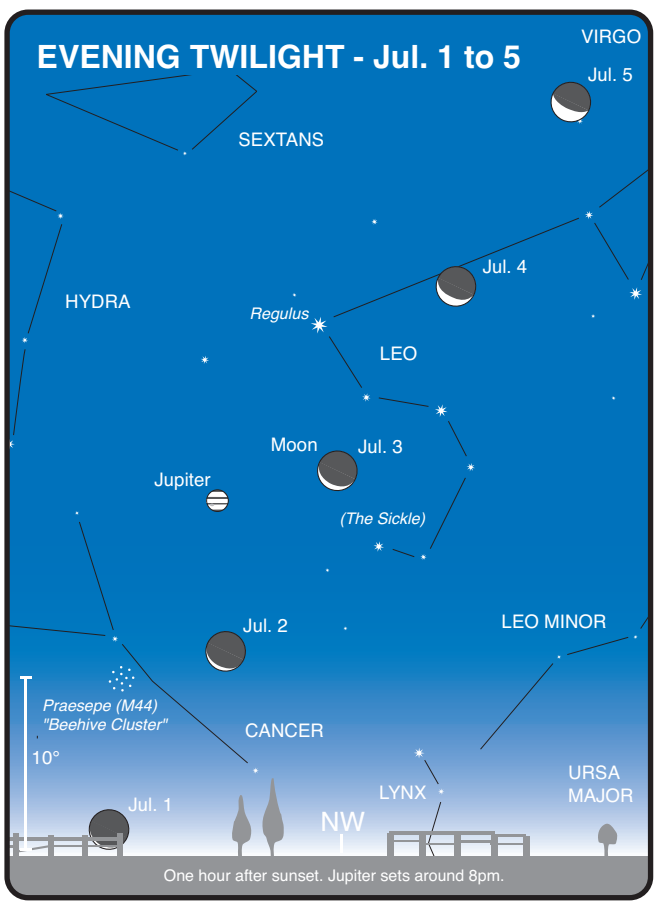
The **Piscis Austrinids** are visible from the 15th July to 10th August. The shower generally provides 1 or 2 meteors per hour and on occasion 3 or 4. The zenith hourly rate increases to 8 or 10 meteors on the 28th: however this can vary from as little as 5 to as many as 15 per hour. Visible from about 8pm to the beginning of morning twilight the Piscis Austrinids are generally blue, white or yellow in colour, with some leaving trains. Conditions are ideal this year for the peak with New Moon on the 29th.

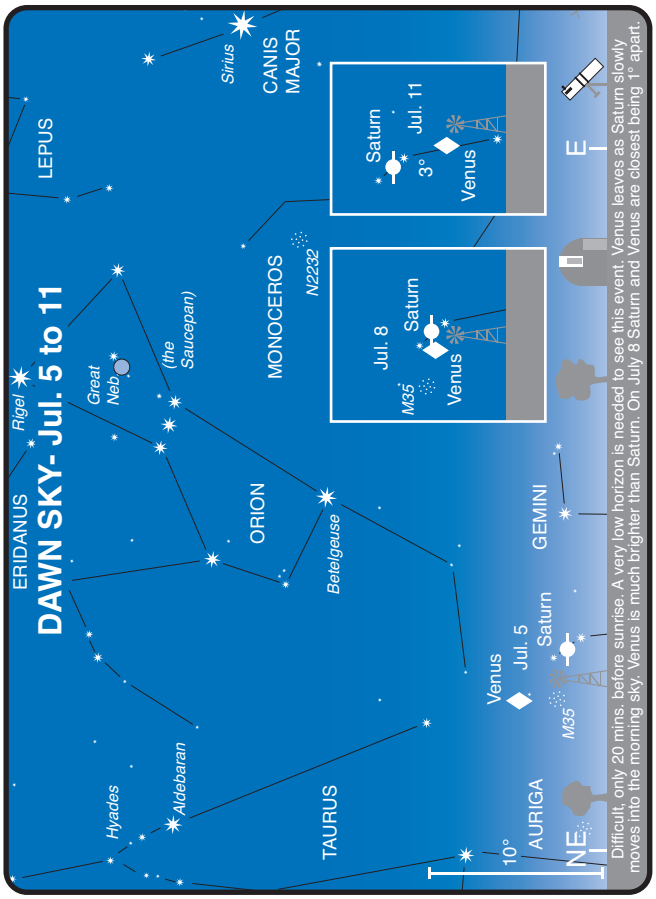
The **Southern delta-Aquarids** are one of the strongest and most consistent of the southern showers, visible late evening until dawn. The range of activity of these medium speed meteors extends from 12th July through to 19th August, with maximum this month on the 27th, with a zenith hourly rate of 20. The delta-Aquarids are generally faint (bright meteors are the exception), typically white with some blue members, and occasionally leaving trains. Like the Piscis Austrinids and the alpha-Capricornids this year, the Moon is perfect around the time of maximum activity.

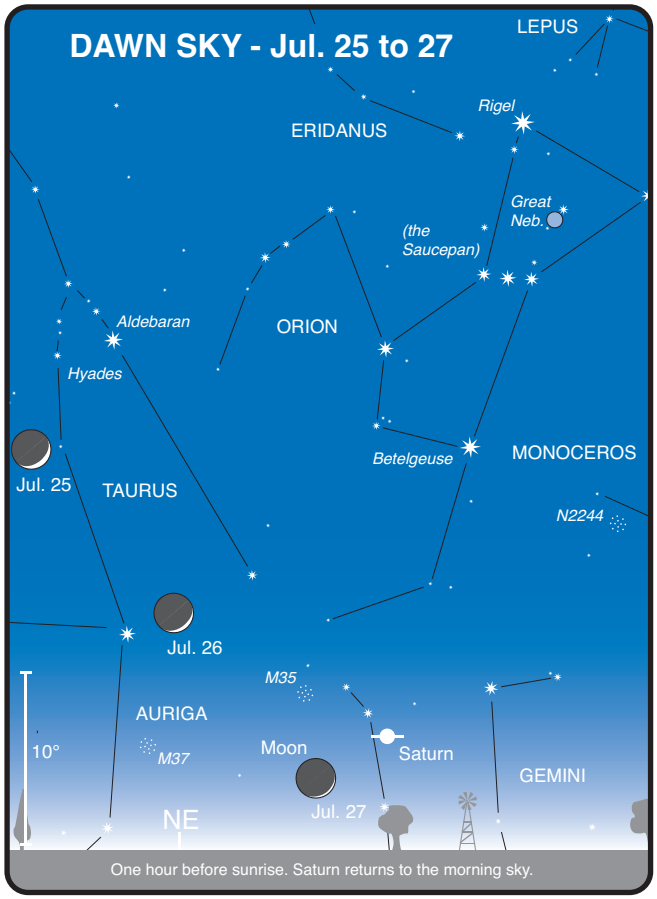
The **alpha-Capricornids** are noted for their bright, slow meteors with long paths and frequent fireballs. The shower is visible late evening until dawn, from 3rd July through to 15th August. Maximum activity occurs this month on the 30th, when a zenith hourly rate of 4 can be expected. Low hourly rates over the period are generally made up by the spectacular nature of the alpha-Capricornids.

## DIARY EST (WST)

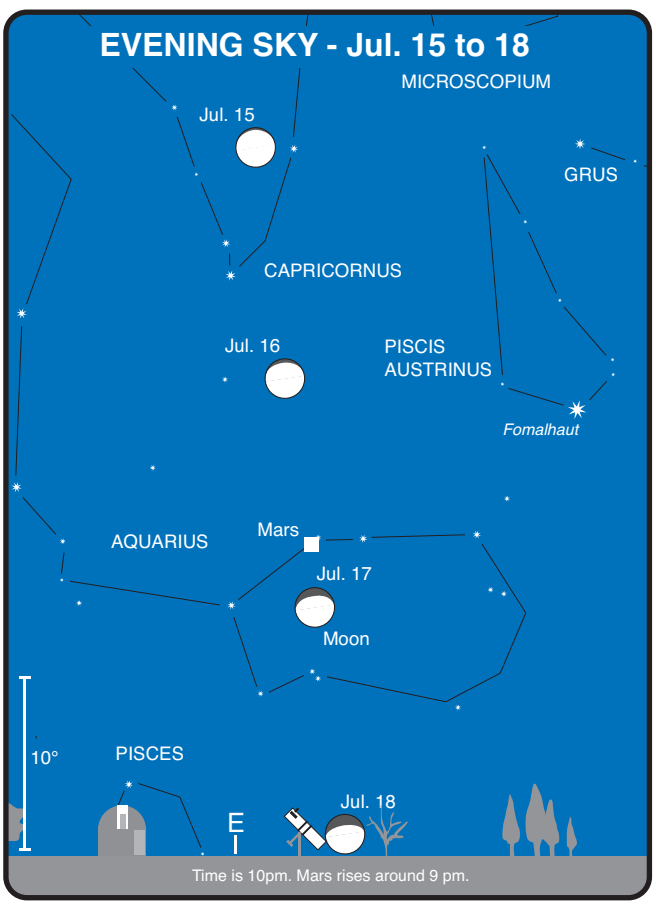
| | | |
|---|---|---|
| 1st | | Comet C/2001 Q4 (NEAT) 0.6°SW of NGC1374 (EG) in Fornax |
| 1st | | Mercury at perihelion |
| 1st | 11 pm | (9 pm WST) Comet 65P/Gunn 0.1°N of M70 (GC) in Sagittarius |
| 3rd | | Comet C/2001 Q4 (NEAT) 0.6°SW of NGC1387 (LG) in Fornax |
| 3rd | | Comet C/2001 Q4 (NEAT) 0.4°NE of NGC1365 (SG) in Fornax |
| 3rd | | Juno stationary |
| 3rd | 7 am | (5 am WST) Jupiter 4°S of Moon |
| 4th | | Earth at aphelion |
| 5th | | m.p. 4 Vesta 0.3°W of NGC4665 (SG) in Virgo |
| 5th | | m.p. 4 Vesta 0.5°NE of NGC4636 (EG) in Virgo |
| 5th | | Mercury in superior conjunction |
| 7th | | m.p. 4 Vesta 1°NE of NGC4643 (SG) in Virgo |
| 7th | | Venus at ascending node |
| 7th | | First Quarter Moon |
| 8th | 6 pm | (4 pm WST) Venus 0.8°N of Saturn |
| 10th | | Comet 66P/du Toit 0.7°NE of star Gamma Corvi |
| 10th | 6 am | (4 am WST) Comet C/2002 O7 (LINEAR) 0.2°SE of NGC3489 (LG) in Leo |
| 10th | 11 pm | (9 pm WST) Comet 65P/Gunn 0.1°NW of NGC6652 (GC) in Sagittarius |
| 11th | | Mercury at greatest latitude north |
| 11th | | Moon at perigee |
| 14th | | Full Moon |
| 15th | | m.p. 6 Hebe 0.4°NW of NGC1662 (OC) in Orion |
| 15th | 3 pm | (1 pm WST) Neptune 5°N of Moon |
| 17th | | m.p. 39 Laetitia 0.1°NW of star Regulus |
| 17th | 2 am | (Midnight WST, prev day) Uranus 5°N of Moon |
| 17th | 6 pm | (4 pm WST) Mars 0.3°S of Moon Occn. |
| 20th | | Glenn's Birthday |
| 21st | | Last Quarter Moon |
| 23rd | | Moon at apogee |
| 25th | | Comet C/2002 O7 (LINEAR) 0.8°E of NGC3423 (SG) in Sextans |
| 26th | | Saturn at perihelion |
| 26th | 11 am | (9 am WST) Mercury 0.4°N of Jupiter |
| 27th | | m.p. 1 Ceres 0.2°SE of M1 (crab Neb.) in Taurus |
| 27th | 10 am | (8 am WST) Saturn 4°S of Moon |
| 29th | | m.p. 1 Ceres 0.8°N of star Zeta Tauri |
| 29th | | New Moon |
| 30th | 9 pm | (7 pm WST) Mercury 0.2°N of Regulus |
| 30th | 11 pm | (9 pm WST) Jupiter 4°S of Moon |
| 31st | | Mars stationary |
| 31st | 11 am | (9 am WST) Mercury 5°S of Moon |

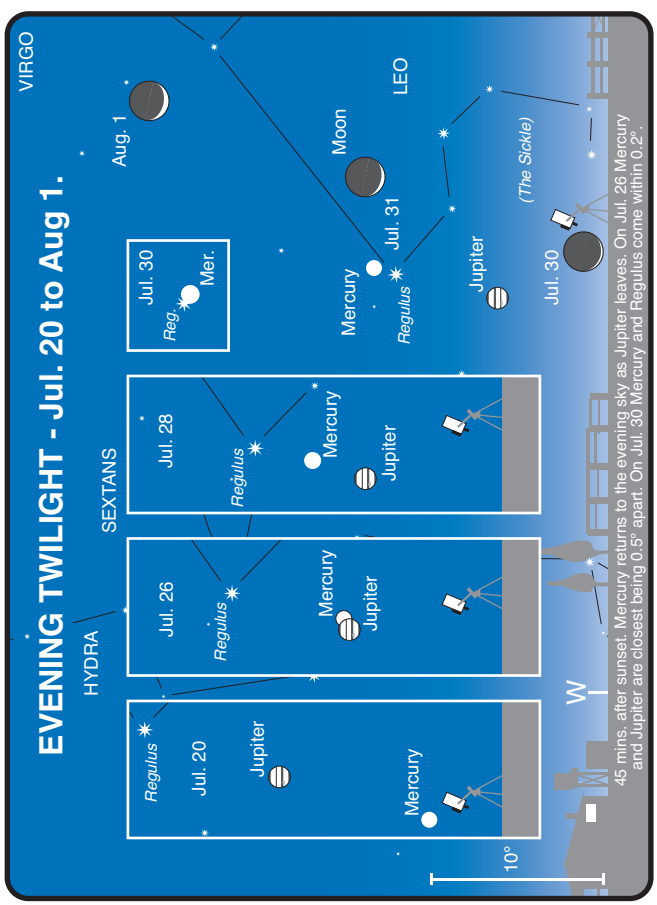




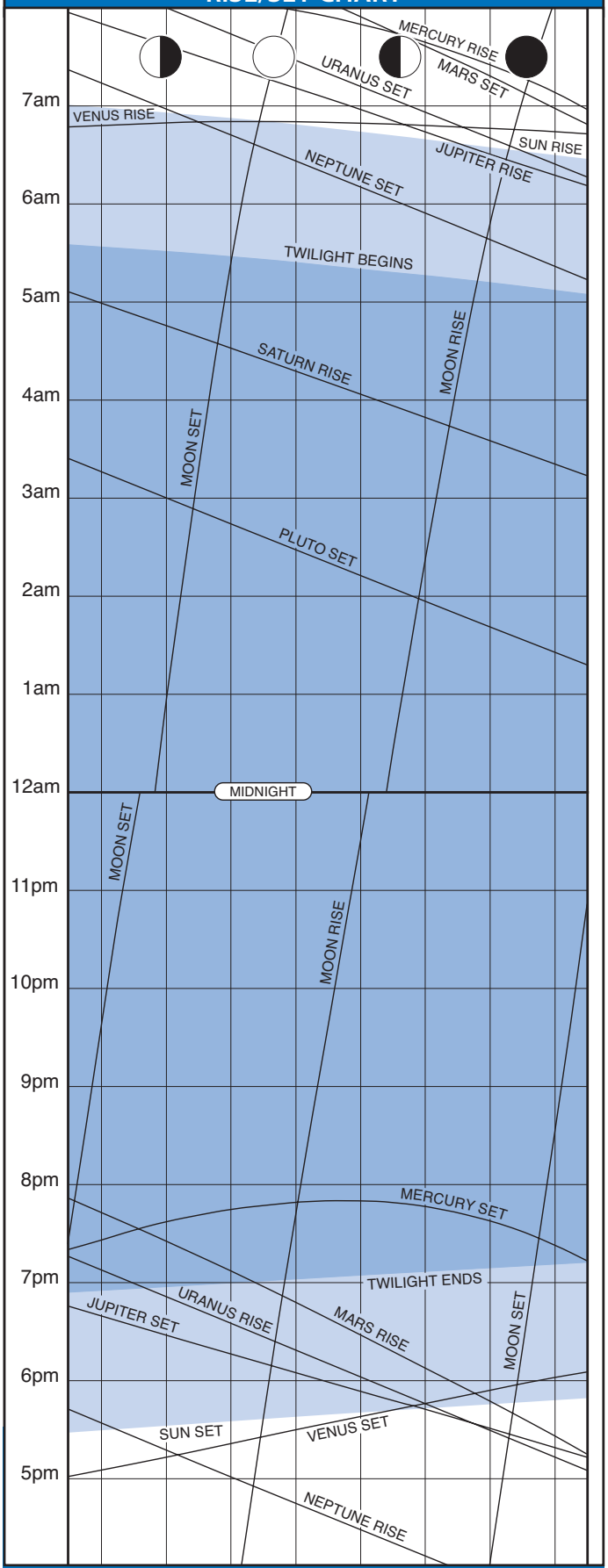

Approximate local standard time.



# AUGUST

## RISE/SET CHART




Approximate local standard time.

## HIGHLIGHTS

- Mars at opposition, the brightest object in the sky aside from the Sun and Moon.
- Uranus and Neptune at opposition this month.
- Mercury at its absolute best in the evening sky for the year.
- Earth transits the Sun (for Neptunian observers).

### THE MOON

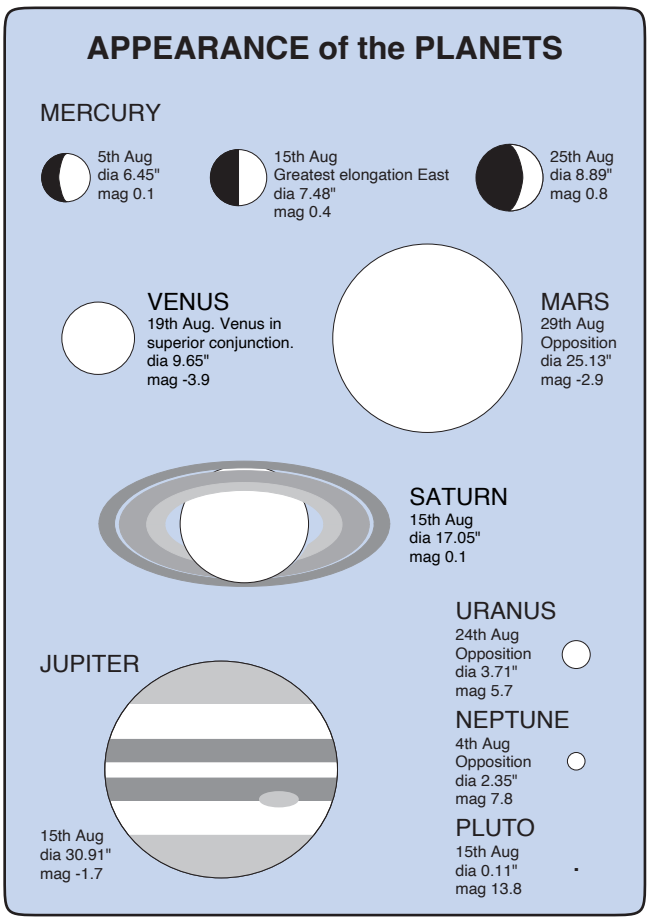
| | |
|---|---|
| 5th | First Quarter |
| 7th | Moon at perigee (closest to Earth – 369,433 km distant, angular size 32.6') |
| 12th | Full Moon |
| 20th | Moon at apogee (furthest from Earth – 404,102 km distant, angular size 29.5') |
| 20th | Last Quarter |
| 28th | New Moon |

### THE PLANETS

**MERCURY** is at its best in the evening sky this month, remaining high in the western sky after sunset. On the 15th, the planet is at its greatest elongation east of the Sun at an angular distance of 27°. This is the best possible separation. Due to the high eccentricity of Mercury's orbit a greatest elongation can be as close as 18°. Early in the month, Mercury can be seen above Regulus and Jupiter in Leo, the trio forming a line not quite vertical to the horizon (see also Sky View p. 47). Mercury soon distances itself from the other pair and at the end of the month moves into Virgo. Small telescopes will reveal Mercury as gibbous (egg-shaped) early in the month, at first quarter phase mid-month and as a slender crescent at month's end.

**VENUS** is in superior conjunction with the Sun on the 19th (Venus and Earth on opposite sides of the Sun). The planet will be too close

## APPEARANCE of the PLANETS



to the Sun for observation until late September when it returns to grace the evening skies for the rest of the year.

**MARS**. The red planet will be the focus of intense scrutiny though telescopes worldwide during August and September. It is at opposition on August 29 and reaches perihelion (its closest point in its orbit to the Sun) the following day. When the Earth and the planet line up in opposition at the same time as Mars' perihelion we get a particularly good view. With the planet's disk at its largest (25 arc seconds), even small telescopes will reveal detail, like surface markings and a polar cap. At this opposition Mars will come within 55.76 million kilometres of Earth, closer than it has been for thousands of years. It will not be close to this distance again until 2208 AD (55.77 Mkm) and will not be bettered until 2287 AD (55.69 Mkm). To be fair, not every opposition from now until 2208 AD will be a poor one and every 15 to 17 years we are treated to a good view. See pages 98–99 for full details of the opposition. On the 13th, the Moon, just past full, appears near the planet (see Sky View). It is interesting to note that Mars, at magnitude -2.9 is now the brightest object in the sky aside from the Sun and Moon (Venus, in superior conjunction, is currently out of the picture).

**JUPITER** can be seen very early in August in Leo, just below Regulus and Mercury low in the western evening twilight sky. Twilight soon extinguishes Jupiter's brightness as it moves into conjunction with the Sun on the 22nd, returning to the morning twilight late next month. As a matter of interest, but unobservable in the solar glare, is the close approach of Jupiter and Regulus on the

## FLYING ROCKS EVERYWHERE!

Everyone has heard of the threat that asteroids, sometimes referred to as minor planets, pose to the Earth. There is certainly strong evidence that such an impact resulted in the extinction of the dinosaurs. These potentially dangerous bodies are often referred to as Near Earth Objects (or NEOs). Even someone with a casual interest may also recall from school there is a main belt of asteroids, lying between the orbits of Mars and Jupiter. However there seems to be no shortage of such bodies in all sorts of orbits within the Solar System. Putting the Sun, planets, their moons and known comets aside for the moment, the following is an overview of the inventory of these 'oversized rocks'. Some may feel this term belittles these bodies. It is true some of these objects are more than 100 km in size but if all of the hundreds of thousands of asteroids known were pulled together they still couldn't make an object the size of our Moon!

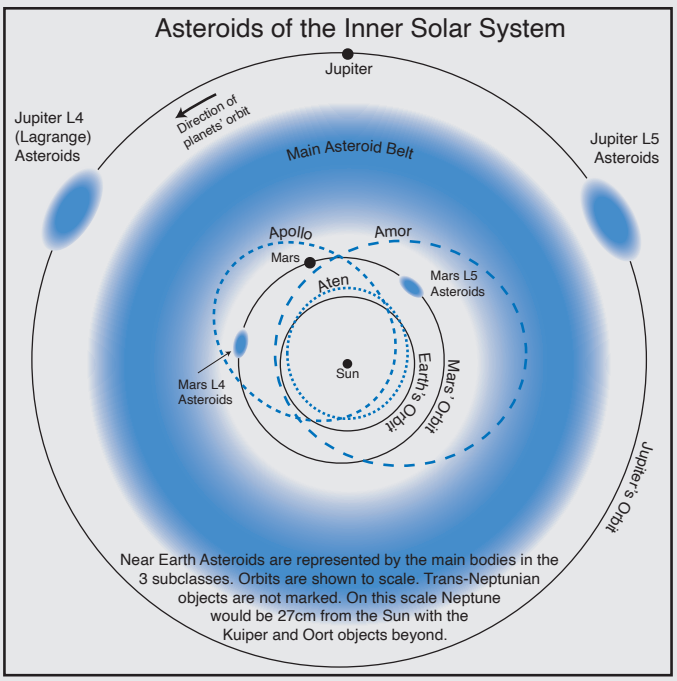
**Near Earth Asteroids**. If you have any doubt why mankind needs to closely monitor these objects, the case of 1994 XM1 is worth quoting. On December 9, 1994 this object came within 70,000 kilometres of the Earth, or only one fifth of the distance to the Moon! NEOs can be divided into 3 categories:

1. **Atens**: These are defined as those that have a semimajor axis less than 1 AU with aphelion distances greater than 0.98 AU. By definition these asteroids orbit the Sun in less than a year. There are approximately 150 such asteroids known (as of July 2002).
2. **Apollos**: Those that have a semimajor axis greater than 1 AU and a perihelion distance less than 1.02 AU. There are approximately 1,000 Apollos known.

   The Atens and Apollos are your classic, potentially dangerous, Earth crossing bodies.
3. **Amors**: These minor planets have a perihelion distance between 1.02 and 1.3 AU which ensures they lie just outside the Earth's orbit with an orbital period greater than 1 year. Like the Apollos there have been around 1,000 discovered.

**Main Belt Asteroids**. These lie between Mars and Jupiter at a distance of around 2 to 4 AU. The vast majority of the asteroids lie in this region of space. They are sometimes further subdivided into groups known as Hildas, Cybeles, Themis, Eos, Koronis, Hungarias, Phocaea and Floras (named after the main asteroid in each group). It was here that Sicilian astronomer, Giuseppe Piazzi, discovered the first minor planet 1 Ceres. This is the grand daddy of the main belt asteroids, with a diameter of nearly 1,000km.

**Trojan Asteroids**: In 1772, the French mathematician and astronomer, Joseph Louis Lagrange proposed that when a small body, a major planet and the Sun form an equilateral triangle they can share an orbit without catching up. L4 and L5 are the leading and following points respectively – 60 degrees along the orbit of the planet (there are also theoretical points L1, 2 and 3 but they are considered unstable). Trojans have been found with Jupiter (930 bodies in the L4, 558 in L5) and Mars (L4 has 1, L5 has 6).




**Centaurs**: Their orbits lie between Saturn and Uranus. Only a handful are known, with their orbits likely to be unstable. They could possibly be escaped Kuiper Belt objects and could be in reality comets (although being so distant from the Sun a few have still appeared fuzzy with a comet-like coma). Only a few Centaurs are known and their orbits are unstable being susceptible to perturbations from the gravitational pull of the planets.

There are also a few planet-crossing asteroids known such as 5335 Damocles, which ranges from near Mars to beyond Uranus, and 5145 Pholus, which orbits from Saturn to beyond Neptune. They are also considered to be in unstable orbits.

**Kuiper Belt Objects**. Over 500 of these trans-Neptunian objects are now known. They lie from 30 to 100 AU from the Sun. 'The Belt' contains many small icy bodies and is likely the source of short period comets. Pluto and its moon Charon may be the most famous members of this group and has fuelled the debate as to whether Pluto deserves to be called a planet in its own right.

**Oort Cloud**: To complete our tour of the outer Solar System, this is a vast region of space which lies well beyond the Kuiper Belt and may contain many thousands of icy bodies, as well as being the source of long period comets. Although for the moment it is speculation, some scientists believe it may make up a significant fraction of the mass of the Solar System.

# AUGUST

26th. The pair will be just 22 arc minutes apart, the closest since September 1991 when they were only 20 arc minutes apart.

**SATURN** rises in the early morning northeastern sky in Gemini. On the 24th, the slender crescent of the 26–day old Moon can be seen close to and below the planet (see Sky View).

**URANUS** is at opposition on the 24th and is visible the entire night. Interestingly, three planets are at opposition this month, Mars, Uranus and Neptune; no prizes for guessing which planet will receive the most attention!

**NEPTUNE** is at opposition on the 5th, and on this day, if any Neptunians happen to be looking our way, they will witness a transit of the Earth across the face of the Sun. This rare series of transits began in 2001, and will continue at each opposition until the year 2006.

**PLUTO**, now two months past opposition, transits the meridian around 7.30pm.

**MINOR PLANETS** at opposition this month include 85 Io on the 7th at magnitude 10.2 in Delphinus.

## COMETS

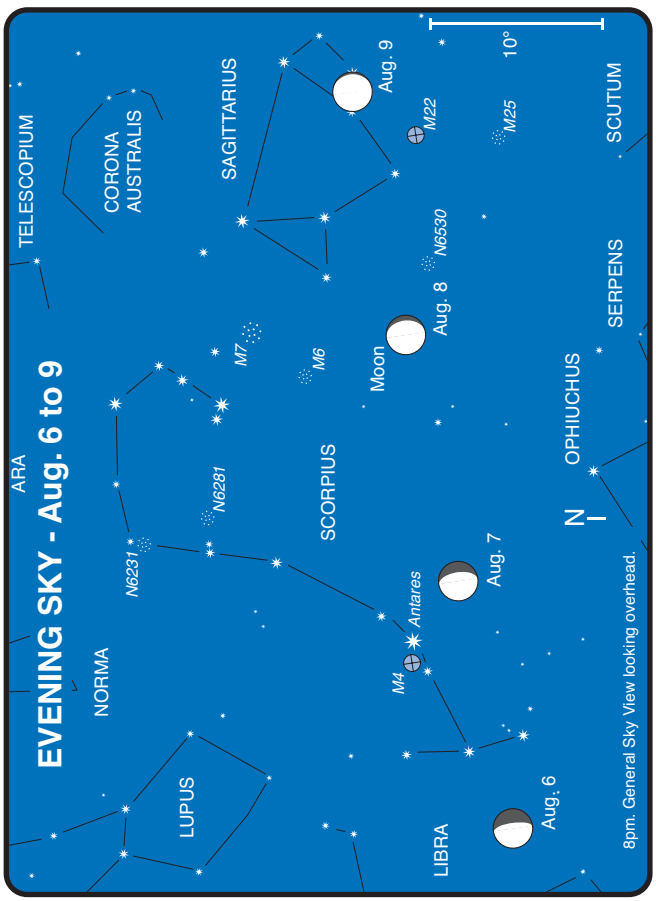
**Comet C/2002 O7 (LINEAR)** is moving south through Leo, Sextans and Hydra. By month's end, the 8th magnitude comet will be somewhat difficult to observe as it is immersed in both evening and morning twilight.

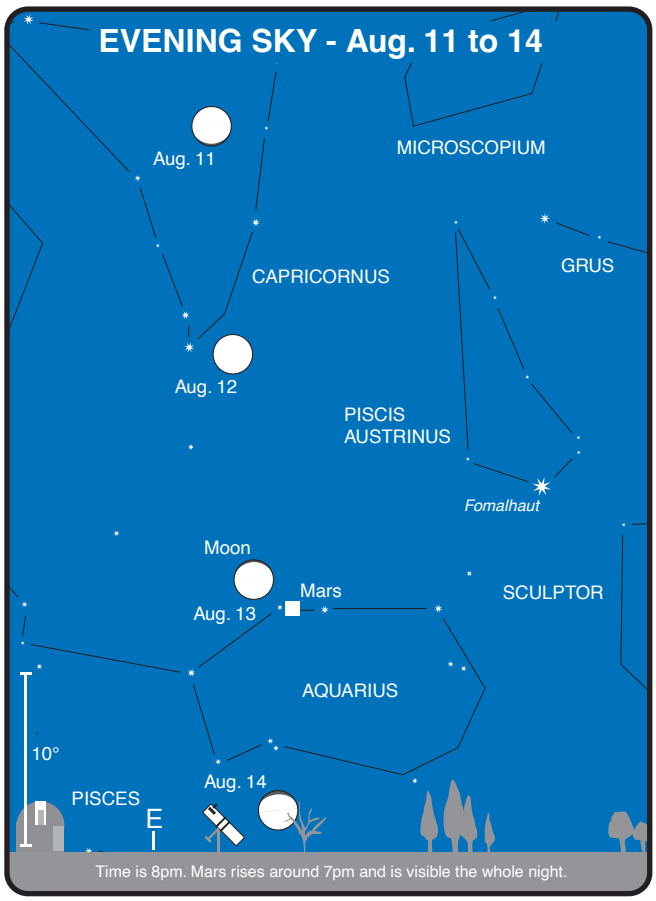
**Comet C/2001 HT50 (LINEAR-NEAT)** is slowly moving northwest through Taurus in the morning sky. The comet is gradually brightening again as it nears Earth, and could be close to 11th magnitude by month's end, rising in the early hours of the morning.

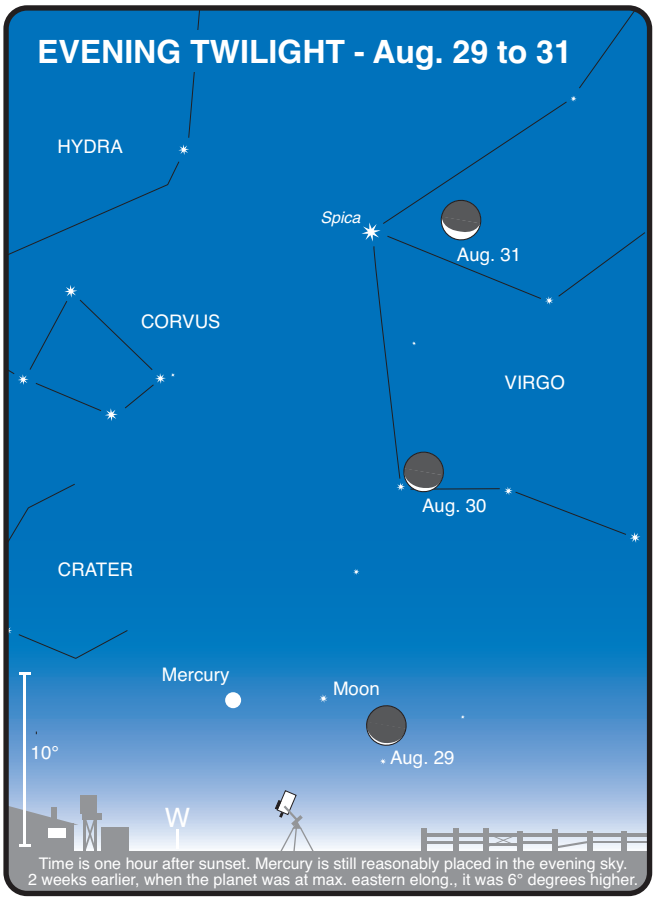
**Comet C/2001 Q4 (NEAT)** continues its trek south this month, hopefully brightening from 13th to 12th magnitude by the end of August. The beginning of the month sees Comet NEAT near Alpha and Delta Horologii. By the end of August, when the comet has moved through Caelum into Dorado, it will be above the horizon for most of the night.

## DIARY EST (WST)

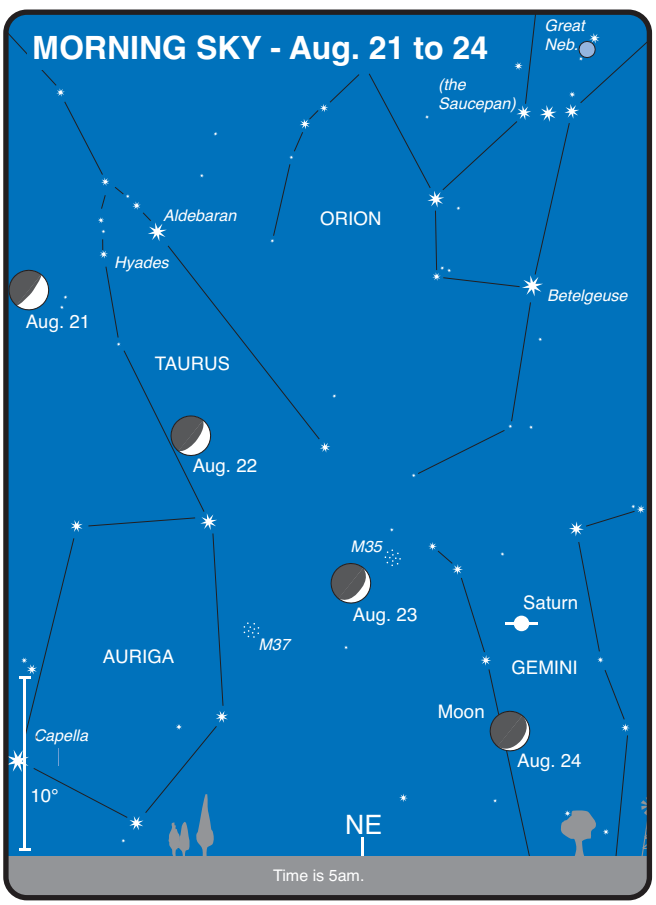
| | | |
|---|---|---|
| 2nd | | m.p. 14 Irene 0.8°N of star Aldebaran |
| 3rd | | Comet 65P/Gunn 0.6°NW of star Epsilon Sagittarii |
| 3rd | | Mercury at descending node |
| 4th | | Mars at greatest latitude south |
| 5th | | Neptune at opposition |
| 5th | | First Quarter Moon |
| 6th | am | Comet C/2001 Q4 (NEAT) 0.7°NE of NGC1512 (SG) in Horologium |
| 7th | | Moon at perigee |
| 7th | | m.p. 11 Parthenope 0.3°NW of NGC4123 (SG) in Virgo |
| 8th | | Mercury 0.6°N of NGC3423 (SG) in Sextans |
| 9th | | m.p. 29 Amphitrite 0.5°S of M45 (The Pleiades) in Taurus |
| 10th | | Venus at perihelion |
| 11th | | Neptune at descending node |
| 11th | 11 pm | (9 pm WST) Neptune 5°N of Moon |
| 12th | | Full Moon |
| 13th | | Comet 66P/du Toit 0.9°SW of M83 (SG) in Hydra |
| 13th | 10 am | (8 am WST) Uranus 5°N of Moon |
| 14th | | Mercury at aphelion |
| 14th | 3 am | (1 am WST) Mars 1.9°S of Moon |
| 15th | | Mercury 0.7°SW of NGC3630 (EG) in Leo |
| 15th | | Mercury greatest elong. E (27°) |
| 19th | | Pluto 0.9°S of m.p. 12 Victoria |
| 19th | | Venus in superior conjunction |
| 20th | | Moon at apogee |
| 20th | | m.p. 1 Ceres 0.2°NW of star Eta Geminorum |
| 20th | | Last Quarter Moon |
| 22nd | | Comet 66P/du Toit 0.3°S of NGC5419 (EG) in Centaurus |
| 22nd | | Jupiter in conjunction with Sun |
| 24th | | m.p. 11 Parthenope 0.2°N of NGC4517 (SG) in Virgo |
| 24th | | Uranus at opposition |
| 23rd | Midnight | (10 pm WST) Saturn 4°S of Moon |
| 25th | | m.p. 1 Ceres 0.3°NW of star Mu Geminorum |
| 27th | | Mars closest approach |
| 28th | | New Moon |
| 28th | | Mercury stationary |
| 29th | | m.p. 23 Thalia 0.1°N of star Alpha Librae |
| 29th | | Mars at opposition |
| 29th | 11 am | (9 am WST) Mercury 9°S of Moon |
| 30th | | Mars at perihelion |
| 30th | | Pluto stationary |
| 31st | | m.p. 11 Parthenope 0.7°SW of NGC4666 (SG) in Virgo |
| 31st | | m.p. 11 Parthenope 0.7°NE of star Gamma Virginis |
| 31st | | Venus at greatest latitude north |

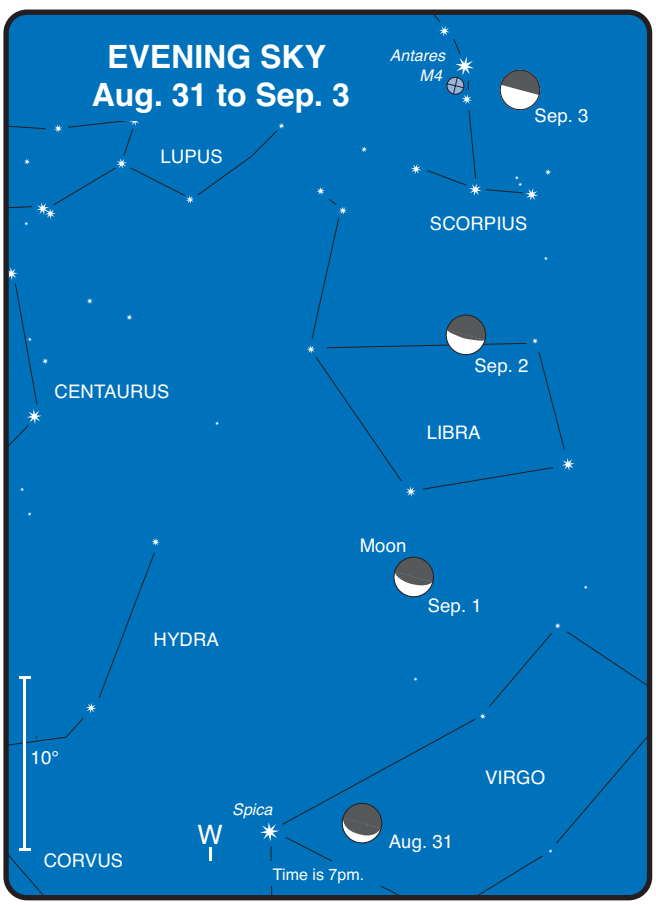




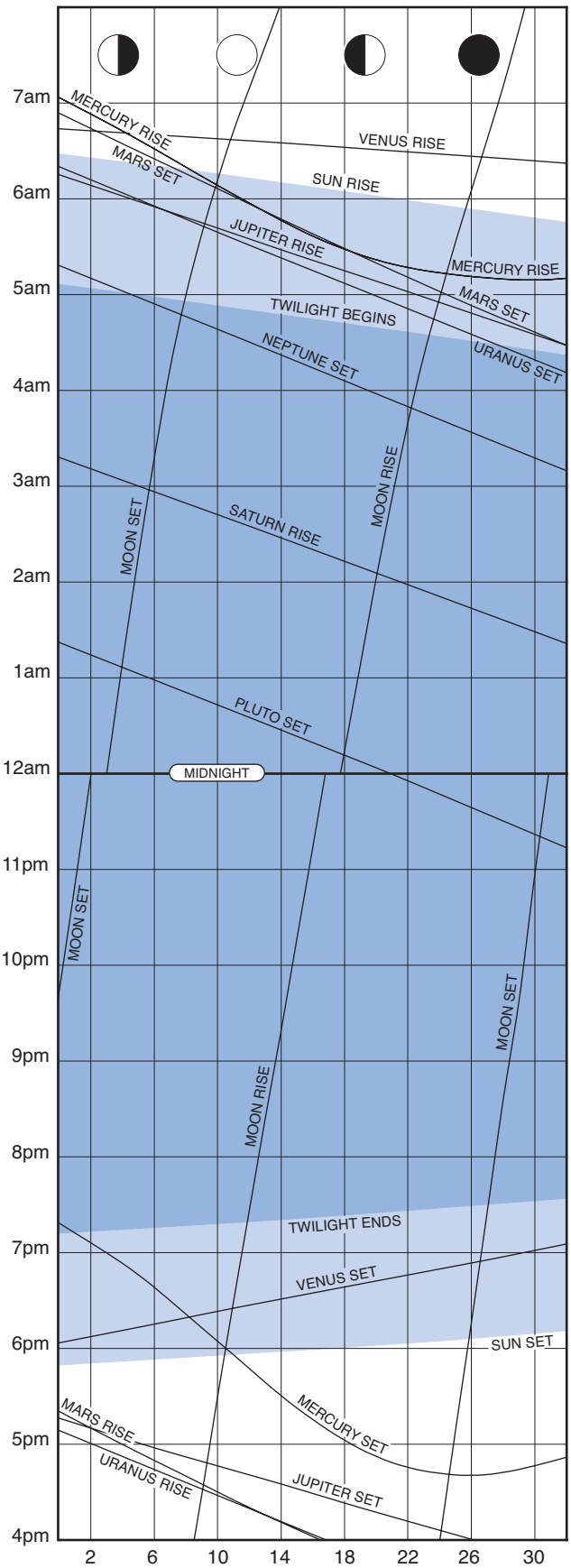

Approximate local standard time.



# SEPTEMBER

## RISE/SET CHART




Approximate local standard time.

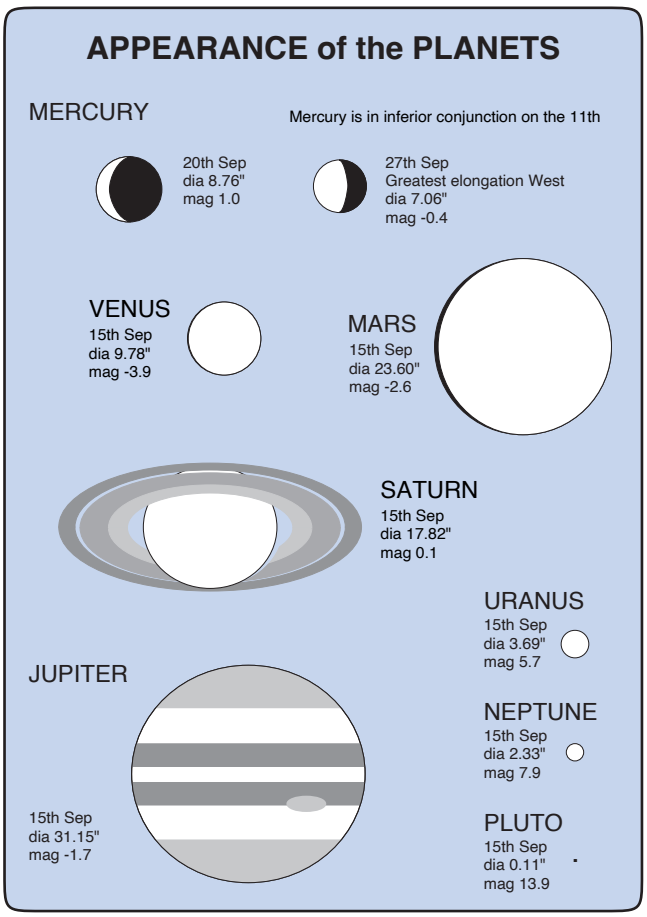
## HIGHLIGHTS

- Venus returns to the evening twilight.
- Mars, just past opposition, is still excellent in small telescopes.
- Mars and the Moon close.
- Jupiter returns to the dawn sky.
- Saturn and the asteroid Ceres together.
- Uranus and Mars close
- Comet C/2002 O7 (LINEAR) at 7th magnitude, moves into the morning sky.

### THE MOON

| | |
|---|---|
| 3rd | First Quarter |
| 9th | Occultation of Mars by the Moon, not visible from Australia |
| 11th | Full Moon |
| 16th | Moon at apogee (furthest from Earth – 404,714 km distant, angular size 29.2') |
| 19th | Last Quarter |
| 26th | New Moon |
| 28th | Moon at perigee (closest to Earth – 362,835 km distant, angular size 33.5') |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** makes a rapid descent in the western evening sky early in the month, moving into inferior conjunction (between Earth and the Sun) on the 11th. Moving into the dawn sky, on the 27th the planet is at its greatest elongation west of the Sun. The angular distance of 18° is the worst possible separation for an elongation. Due to the high eccentricity of Mercury's orbit, the angular distance of the planet from the Sun at a maximum elongation can be as close as 18° or as far as 27°. This is dramatically shown when comparing the rise/set chart this month, where Mercury's rise line remains well within the dawn band, with the August chart where Mercury's set line, in the evening sky, moves into the dark blue night area well away from the twilight band. With Mercury remaining close to the Sun, the next good opportunity to view the planet will be late November through to mid-December in the evening sky.

**VENUS**, after superior conjunction with the Sun in August, returns to the evening sky in Virgo late this month. The planet will remain visible as the Evening Star until June 2004, when it moves into the morning sky after inferior conjunction.

The **EARTH** is at its vernal (spring) equinox on the 23rd. The Sun rises and sets due east and west and day and night are equal.

**MARS**, just a few days past opposition, shines a brilliant orange/red in the mid-evening northeastern sky in Aquarius. Observers will not be disappointed with the Red Planet over the month with the disk diameter remaining above 20 arc seconds and the brightness over -2.0 magnitude. At opposition the Sun, Earth and Mars are all in line and as we look toward Mars, with the Sun behind, the Martian disk appears full. As the planetary alignment changes, the 'full' nature of the planet alters and around four weeks past opposition we see a slight gibbous phase with 95% of the planet illuminated. After being in retrograde motion since July, the planet appears stationary at the end of the month, reverting to its eastward movement against the background stars in October. Mars and the Full Moon appear close on the 9th (see Sky View).

**JUPITER**, after conjunction with the Sun late last month, returns to the morning dawn sky in Leo. By month's end the planet can be seen low in the east an hour before sunrise. The conjunction on the 24th between Jupiter, Mercury and the thin crescent Moon is a challenge (see Sky View).

**SATURN** can be seen in the morning northeastern sky above the Gemini twins, Castor and Pollux. Between the 10th and 15th, the largest Main Belt asteroid Ceres passes within 1° of the ringed planet. Using Saturn as a reference and its finder chart (p. 110) you may be able to track this asteroid down (presently at 9th magnitude) with a telescope; just note which 'star' moves over one or two nights observation. On the 20th, the Last Quarter Moon appears near this ringed world (see Sky View).

## NEPTUNE'S DISCOVERY

After the discovery of Uranus by William Herschel in 1781, it was soon realised that there were small discrepancies between the observed and calculated positions of the planet. This led to the search for another planet, a quest that occupied some of the greatest minds and egos of the nineteenth century (but that is another story).

On the 23rd September 1846, the planet Neptune was discovered by Johann Galle, an assistant at the Berlin Observatory, with the aid of a young student named Heinrich d'Arrest. The pair were using positions calculated and provided by the French mathematician Urbain Le Verrier.

The observatory director, Johann Encke, was off that night attending his birthday party. The party was cut short when Galle and d'Arrest interrupted to announce that, after just one hour of searching, they thought they had discovered the new planet. The trio then spent the night observing the suspect object, but they could not be sure if the object had moved or if it showed a disc.

On the following evening, they observed once more and in a few moments, they were able to confirm that the object had moved and that indeed it showed a disc. When Encke notified the scientific community, he credited the discovery to himself and Galle, omitting d'Arrest.

The claims and controversy surrounding Neptune's discovery could fill a good-sized book. At 8th magnitude, Neptune could not have been discovered until after the invention of the telescope, and the 1846 discovery is cemented rightly into history. However, as with many great discoveries somebody beat them to it and it may come as a surprise just who that person was, and when.

So, who was it that saw Neptune first? The answer to that question was not realised until 1980 when Charles Kowal and Stillman Drake were examining the orbit of Neptune with a view to more accurate calculations of its position. They had calculated that Neptune and Jupiter were very close to each other in the skies of December 1613. In 1613, there was not much telescopic astronomy going on; in fact, Galileo was probably the only person in the world who was making observations.

Jupiter fascinated Galileo, and he spent many hours plotting the positions of the planet's moons and other observations. When checking a notebook Galileo kept exclusively for the Jovian satellites, Kowal and Drake found a star marked at exactly the right position for Neptune for 28th December 1612. Thus, Galileo was the first person to see Neptune (234 years before its discovery), mistaking it for a star, see figure 1.

Kowal and Drake continued their search through Galileo's observations finding another dated 28th January 1613. In this observation, Galileo noted the position not only of Neptune, but also of a star (SAO 119234). Along with the drawing he made, Galileo wrote, "post stella fixa a. alia in eadem linea sequebat, ita ut est b que etia precedet nocte observata fuit; sed videbat remotiones inter se." (past the fixed star 'a' [SAO 119234] in a straight line, this is 'b' [Neptune] which was observed last night; but it seemed further from the other.) see figure 2.

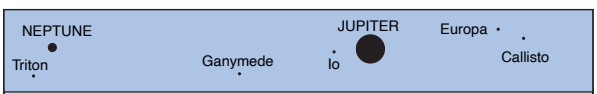



*Figure 1. The position of Neptune and Jupiter (at midnight 28th Dec 1612). The separation of the two planets was just 14.5 minutes of arc. Neptune's moon Triton, at 13.5 magnitude was way beyond the capabilities of Galileo's small telescope.*

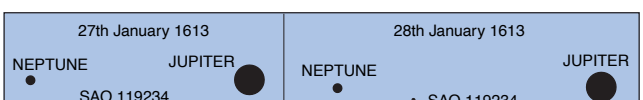



*Figure 2. The view that Galileo saw on consecutive evenings in January 1613. On the 27th the separation between Jupiter and Neptune was 8.5 arc minutes, and on the following evening 10.5 arc minutes. For clarity the planet's satellites have been omitted.*

So not only did Galileo observe Neptune once more; he noted that it had moved. Galileo also made a note in his book to follow up the observations over succeeding nights, but never did. What problems would this have caused in seventeenth century Europe had it been known? Already there was concern over Galileo's work and his dispute with the Church over the structure of the Universe. The existence of another planet, one hidden from view, would have really rocked the foundations.

# SEPTEMBER

**URANUS** in Aquarius and **NEPTUNE** in Capricornus are both now past opposition and are still visible for most of the night. During the last week of the month, Uranus and Mars will be around 4° apart and present a chance to dust off those old 7x50 binoculars and see the 'green' planet and the Red Planet in the same field. As a matter of interest, Neptune was officially discovered in September 1846 in Capricornus, but with an orbital period of 164.8 years it has yet to complete a single orbit since that time (see also the article on Neptune's pre-discovery on page 53).

**PLUTO** is only available to keen observers (with large enough telescopes and our finder chart on page 119), in the evening sky in Ophiuchus, setting around midnight.

**MINOR PLANETS** at opposition this month include 63 Ausonia on the 13th at magnitude 10.0 in Pisces and 354 Eleonora on the 15th near the border of Aquarius and Cetus. 15 Eunomia skirts the edge of the Beehive Cluster on the 20th. 29 Amphitrite visits the Pleiades on the 8th.

## COMETS

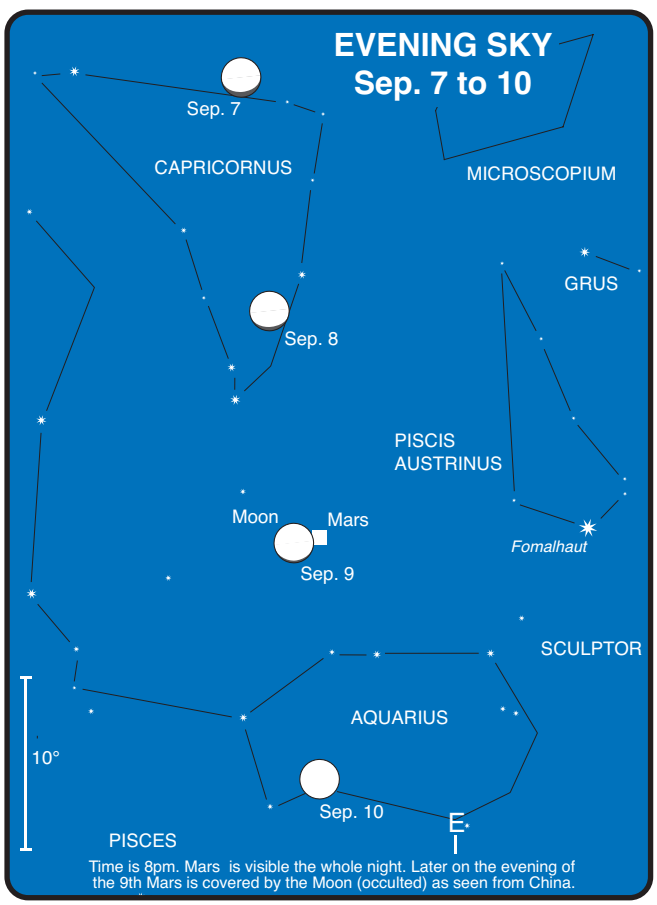
**Comet C/2002 O7 (LINEAR)** reaches perihelion this month on the 20th, 0.9 AU from the Sun. Brightening to 7th magnitude, the comet rapidly becomes a morning object as it moves south through Hydra and Antlia.

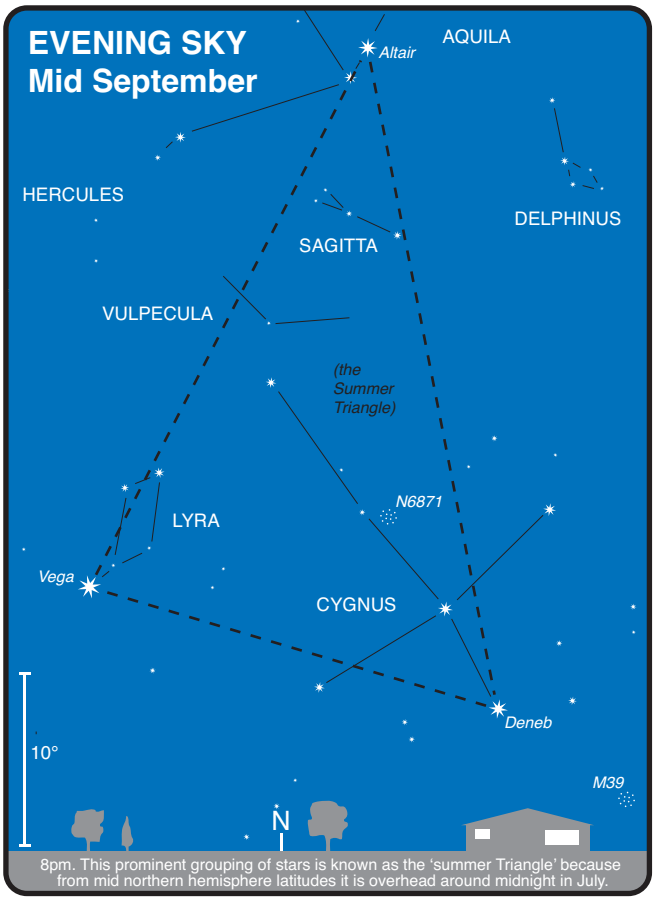
**Comet C/2001 HT50 (LINEAR-NEAT)** is moving westward through the constellation of Taurus, not far from the Hyades. The 11th magnitude comet is rising before midnight by the end of September.

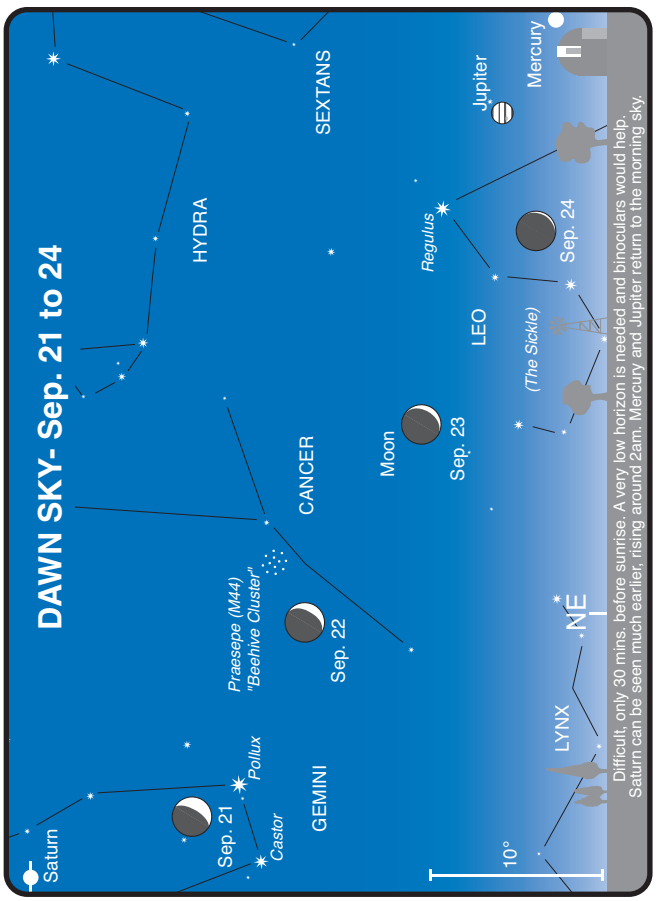
**Comet C/2001 Q4 (NEAT)** resides in the southern constellation of Dorado throughout September. For many readers, the comet (hopefully at 12th magnitude) will become circumpolar at some time this month, although viewing will still be best late in the night. Around mid-September, Comet NEAT will be very close to Alpha Doradus – unfortunately, observers will have to contend with a bright Moon at that time.

## DIARY EST (WST)

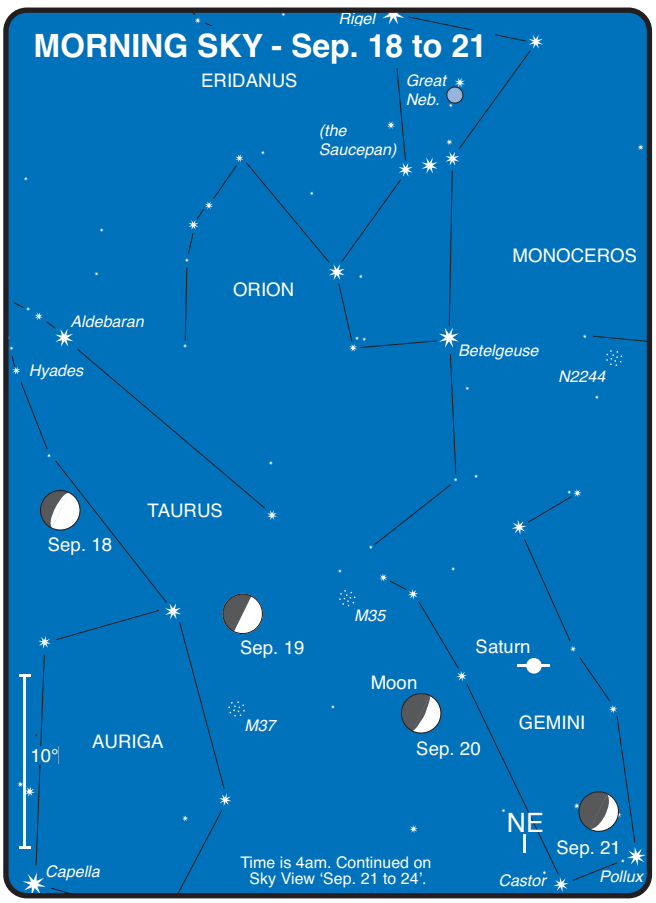
| | | |
|---|---|---|
| 1st | | Moon at perigee |
| 3rd | | Mercury at greatest latitude south |
| 3rd | | First Quarter Moon |
| 5th | | m.p. 11 Parthenope 0.6°SW of NGC4753 (SG) in Virgo |
| 6th | | Pallas stationary |
| 8th | 3 am | (1 am WST) m.p. 6 Hebe 0.1°SW of NGC2259 (OC) in Monoceros |
| 8th | 5 am | (3 am WST) Neptune 5°N of Moon |
| 9th | | m.p. 14 Irene 0.9°N of Comet C/2001 HT50 (LINEAR-NEAT) |
| 9th | 4 pm | (2 pm WST) Uranus 5°N of Moon |
| 9th | 11 pm | (9 pm WST) Mars 1.2°S of Moon Occn. |
| 10th | | m.p. 6 Hebe 0.8°N of NGC2264 (Cone Neb.) in Monoceros |
| 10th | | m.p. 9 Metis 0.6°N of star Delta Scorpii |
| 11th | | Full Moon |
| 11th | | Mercury in inferior conjunction |
| 11th | am | Comet C/2001 Q4 (NEAT) 0.4°E of NGC1617 (SG) in Dorado |
| 12th | | Saturn 0.9°S of m.p. 1 Ceres |
| 12th | | m.p. 8 Flora 0.5°N of NGC6401 (GC) in Sagittarius |
| 12th | | Comet 65P/Gunn 0.3°S of NGC6652 (GC) in Sagittarius |
| 12th | | Comet 66P/du Toit 0.3°S of star Gamma Lupi |
| 16th | | Moon at apogee |
| 19th | | Last Quarter Moon |
| 19th | | Mercury stationary |
| 20th | | m.p. 15 Eunomia 0.8°SW of M44 (Beehive Cluster) in Cancer |
| 20th | | Comet 65P/Gunn 0.7°S of M70 (GC) in Sagittarius |
| 20th | 1 pm | (11 am WST) Saturn 5°S of Moon |
| 22nd | | Mercury at ascending node |
| 23rd | | m.p. 9 Metis 0.1°NE of M80 (GC) in Scorpius |
| 23rd | | Comet C/2001 Q4 (NEAT) 0.8°W of NGC1672 (SG) in Dorado |
| 23rd | | Equinox |
| 24th | | Comet 66P/du Toit 0.2°N of NGC6192 (OC) in Scorpius |
| 24th | 2 pm | (Noon WST) Jupiter 4°S of Moon |
| 25th | 3 am | (1 am WST) Mercury 5°S of Moon |
| 26th | | New Moon |
| 27th | | Mercury at perihelion |
| 27th | | Mercury greatest elong. W (18°) |
| 28th | | Moon at perigee |
| 30th | | Mars stationary |
| 30th | | m.p. 40 Harmonia 0.5°SW of star Beta Scorpii |

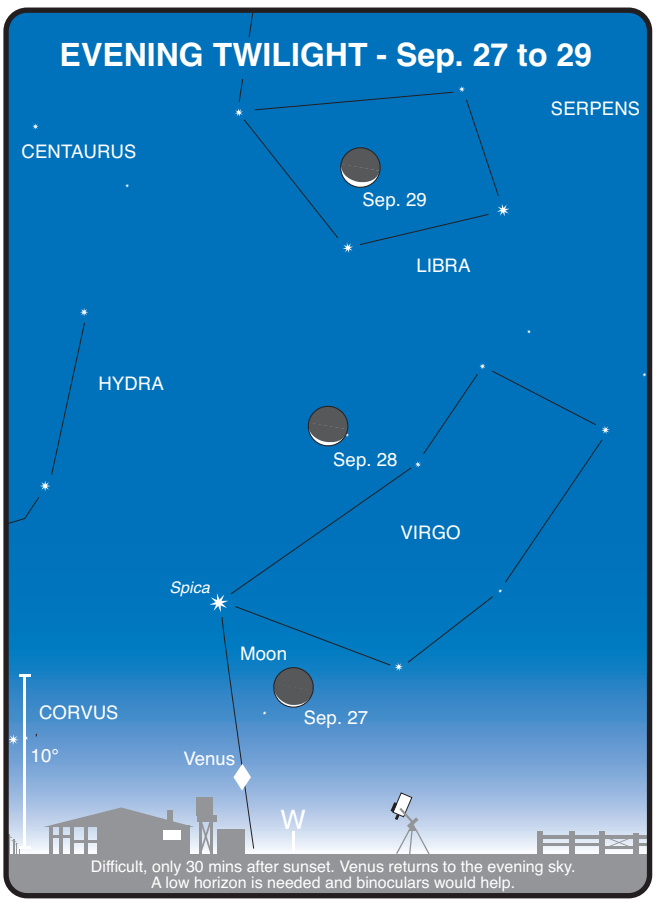




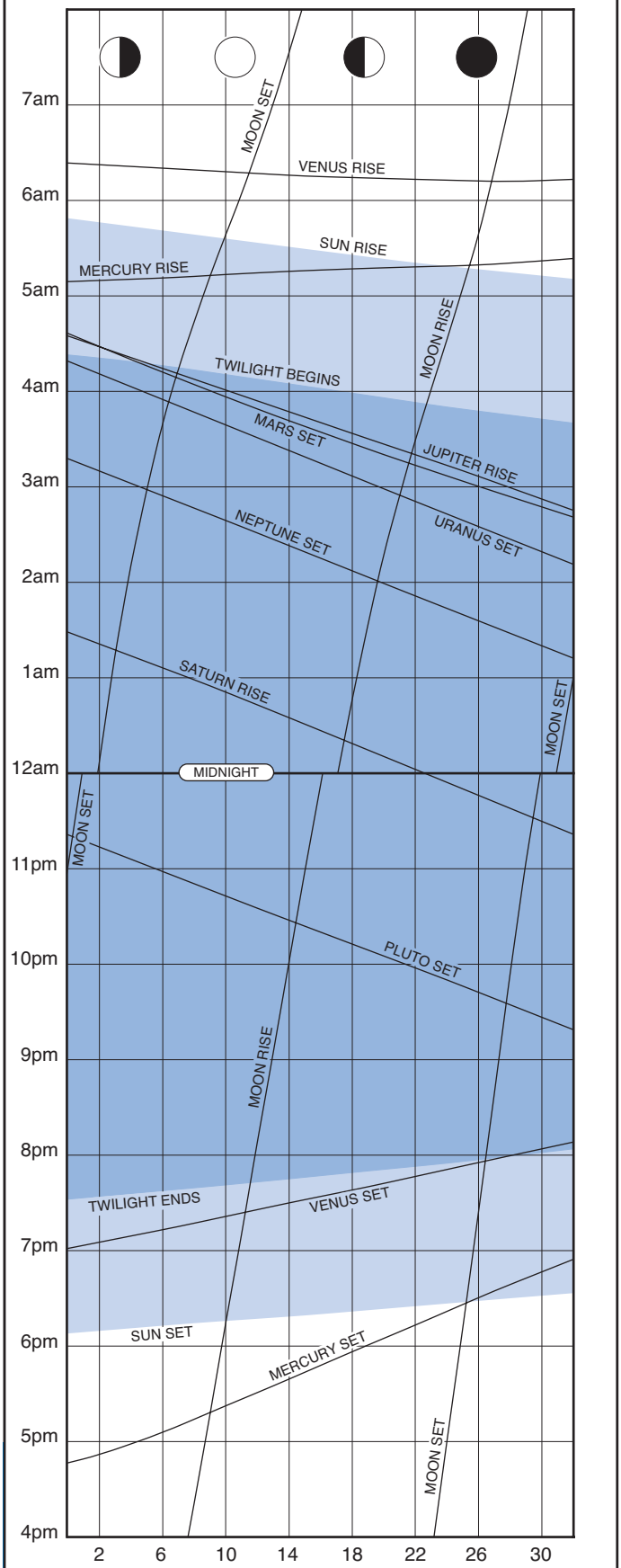

Approximate local standard time.



# OCTOBER

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Venus near Spica and Alpha $^2$ Librae.
- A final chance to view Mars while still close to Earth.
- Mars and Moon very close – an occultation visible from Tasmania.
- Five bright Minor Planets are at opposition in Cetus.
- Minor Planet 8 Flora crosses M8.
- Comet Encke visits M31.
- Comet C/2002 O7 (LINEAR) bright in the southern sky.

### THE MOON

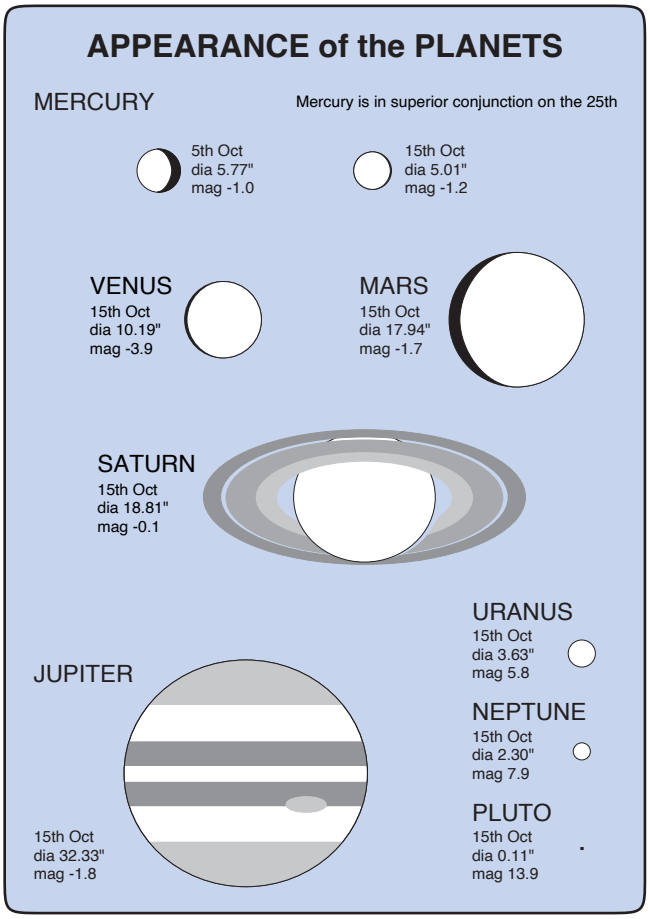
| | |
|---|---|
| 3rd | First Quarter |
| 7th | Occultation of Mars by the Moon, visible from parts of Australia (see Mars below) |
| 10th | Full Moon |
| 14th | Moon at apogee (furthest from Earth – 405,692 km distant, angular size 29.1') |
| 18th | Last Quarter |
| 25th | New Moon |
| 26th | Moon at perigee (closest to Earth – 358,547 km distant, angular size 33.0') |
| 27th | Occultation of Venus by the Moon, not visible from Australia |

### THE PLANETS

**MERCURY** is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 25th. During October, the planet remains close to the Sun, unobservable until its return to the evening sky later next month.

**VENUS** re-establishes itself as the 'Evening Star' this month as it moves away from the Sun, remaining visible after civil twilight ends (30 minutes after sunset). The planet spends the first half of October in Virgo and the

## APPEARANCE of the PLANETS



second in Libra, coming close to the principal star in each constellation. On the 4th and 5th, Venus will be 3° from 1st magnitude Alpha Virginis (Spica), and on the 21st and 22nd, 0.5° from 2.8 magnitude Alpha 2 Librae (Zuben Elgenubi). On the 27th, Venus is near the 2–day old slender crescent Moon (see Sky View); from Hawaii and South America an occultation will be visible.

**MARS**, in Aquarius, is visible high in the northern sky around 9pm. Early in the month is the last good opportunity for telescope users to view the planet while it still presents a reasonable sized disk; around 20 arc seconds during the first week, compared with 15 arc seconds at month's end (not much better than at an unfavourable opposition). Telescopes will reveal a marked gibbous phase as the planet moves toward quadrature in December (see diagram page 14). Toward month's end just 90% of the Martian surface will be illuminated from our perspective. Observers with or without optical aid are in for a treat in the early morning hours of the 7th, when the Moon and Mars are very close together in the western sky (see Sky View). From Tasmania, New Zealand and Antarctica an occultation will occur, see Occultation Table, page 89, for timing of the event for Hobart. For the mainland (approximate local times) Mars will be closest to the lunar limb from: Brisbane at 2.55am, Canberra and Melbourne 2.40am, Sydney 2.45am, Adelaide 2.10am, and Perth 12.35am.

## AUSTRALIA'S SECOND OBSERVATORY

Australia's first observatory was constructed by William Dawes; an officer who had arrived on the First Fleet (see Astronomy 2002). With Dawes' return to England in 1791, his observatory soon fell into disrepair; the colony being without an observatory for the next 31 years.

In November 1821, Thomas Brisbane arrived in Sydney to take up the commission as NSW's sixth Governor General, replacing Lachlan Macquarie. Brisbane had had a distinguished military career, having been involved in the Peninsular and American wars, and was also an amateur astronomer and had a scientific reputation. For example he had built the second observatory in Scotland at Brisbane House in 1808. The Duke of Wellington (famous for his victory over Napoleon) in 1815 had approached Lord Bathurst and recommended Brisbane for the position as governor. Bathurst at the time had been Secretary of State to the Colonies. Bathurst, knowing about Brisbane's stellar interests had warned him "He wanted a man to govern not the heavens, but the earth".

Brisbane was also financially well off and had come to Australia with the intention of establishing a self-funded private observatory to take advantage of the still largely unexplored southern skies. With the exception of Halley's observations from St. Helena in 1677 and La Caille's work from the Cape of Good Hope (see page 29), there had been previously little systematic observations of the 'south'.

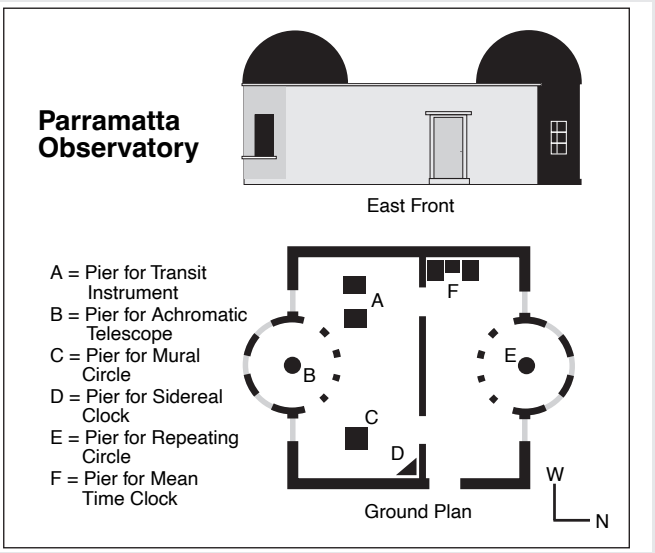
Brisbane had arrived in Australia complete with his own library and instruments which included a mural circle, a transit instrument, a repeating circle, astronomical clocks, a sextant, barometers and thermometers. He had also funded two assistant observers, Carl Rumker and James Dunlop, to come with him. Dunlop was an amateur astronomer from Scotland and Rumker an astronomer from Germany. The observatory was completed in early 1822 and immediately met with success when Comet Encke was found on its first predicted return. This was only the second such successful calculated recovery – after the famous Halley's Comet.

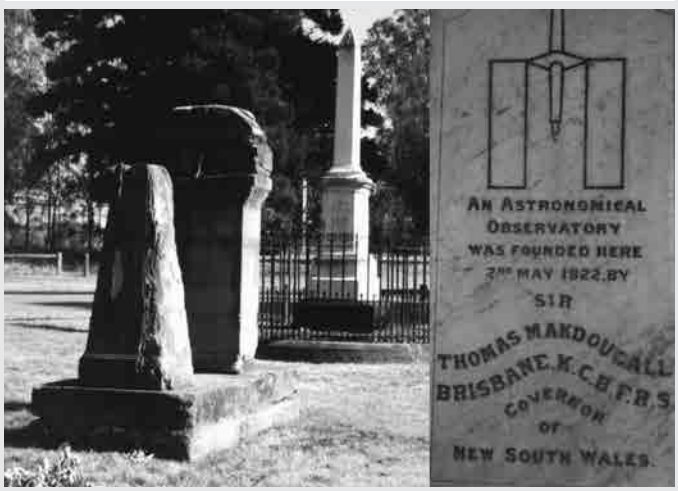
The duties of governor kept Brisbane occupied and the bulk of the observing fell to Dunlop and Rumker. His assistants were kept busy with discovering and observing double stars and clusters, many of which are still referred to by their Brisbane numbers. The main work for which the observatory is remembered is the cataloguing of bright stars in the southern sky. This was required for navigation and surveying for the colony. Dunlop and Rumker conducted over 40,000 observations of stars in just over 2 years. This eventually lead to the publication, 'Catalogue of 7,385 Stars Chiefly in the Southern Hemisphere' in 1835. Unfortunately, due to defects in the instruments it quickly lost its value. Rumker is also known for a small catalogue of double stars, which to this day are still referred to by their Rmk number. Dunlop published a catalogue of 621 nebulae. The Royal Astronomical Society subsequently honoured Brisbane, Rumker and Dunlop with its Gold Medal for contributions to astronomy.

Problems developed with Brisbane's administration of the colony and he was recalled to London, relinquishing his post, in December 1825. He came under attack with some claiming he spent too much time working at his observatory rather than governing the colony. He denied these accusations, stating he only went there at night after 8pm when the public no longer required his services.

Observations continued despite Brisbane's departure. In 1827 Rumker was appointed as the first Government Astronomer. He resigned 4 years later and returned to Hamburg where he became the director of the School of Navigation and later its Observatory. Dunlop took over the job but unfortunately, due to ill health, had trouble continuing its operation.

With Parramatta Observatory being the official timekeeper for the colony this presented a challenge for ship's captains. They had to make the long journey (in those days) inland to set their chronometers before setting sail from Sydney. Having accurate time was vital for navigation. In 1841 an unfortunate incident took place. When Captain James Ross came to check his chronometers he was insulted when an ill Dunlop called to his dog "to attend to the English gentleman". A government enquiry was set up, lead by Captain Phillip Parker King. He found the floor and walls of the observatory to be overrun with white ants and it would have to be rebuilt. This lead to its eventual closure in 1847 and Dunlop retiring to an estate on Brisbane Waters. The instruments were packed away and the building demolished.




*All that remains of the observatory are two piers used for the transit instrument ('A' on floor plan) and a commemorative obelisk. Located in Parramatta Park, Sydney, behind the still existing Old Government House.*

# OCTOBER

**JUPITER**, in Leo, can be seen rising in the eastern morning sky around two hours before the Sun. On the 22nd, the 25–day old waning crescent Moon will be close to Jupiter (see Sky View).

**SATURN** rises around midnight (mid-month) in Gemini above the twins Castor and Pollux. On the 18th, the 21–day old waning gibbous Moon appears near the planet (see Sky View).

**URANUS** in Aquarius and **NEPTUNE** in Capricornus, transit the meridian in the early evening. Uranus and Mars remain around 4° apart for the first half of the month before the pair begin to separate; last chance to see the 'green' planet and the Red Planet in the same binocular field.

**PLUTO**, moving toward conjunction in early December, sets in the evening around 10.30pm.

**MINOR PLANETS** at opposition this month include 69 Hesperia on the 24th at magnitude 10.9 in Pisces. October also sees 5 minor planets reach opposition all in the constellation of Cetus. They are: 194 Prokne on the 6th at magnitude 10.3, 2 Pallas on the 13th at magnitude 8.2, 532 Herculina on the 23rd at magnitude 10.6, 13 Egeria on the 26th at magnitude 10.0 and 52 Europa on the 28th at magnitude 10.6.

On the evening of October 2nd and 3rd, 8 Flora will be seen crossing over the Lagoon Nebula (M8) in Sagittarius. It could be fun for observers (or photographers) to look for the new 11th magnitude star. You may find a commercial photograph of M8 would be a good reference (if you don't have your own image) or a previous sketch of the field. Dark skies and a 150mm telescope are recommended.

## COMETS

**Comet C/2002 O7 (LINEAR)** should remain about 7th magnitude this month. Although it is moving away from the Sun after last month's perihelion, the distance between it and Earth narrows. Mid-month LINEAR passes just to the west of the Eta Carinae Nebula. By the end of October, the comet will be circumpolar on the border of Chamaeleon and Octans.

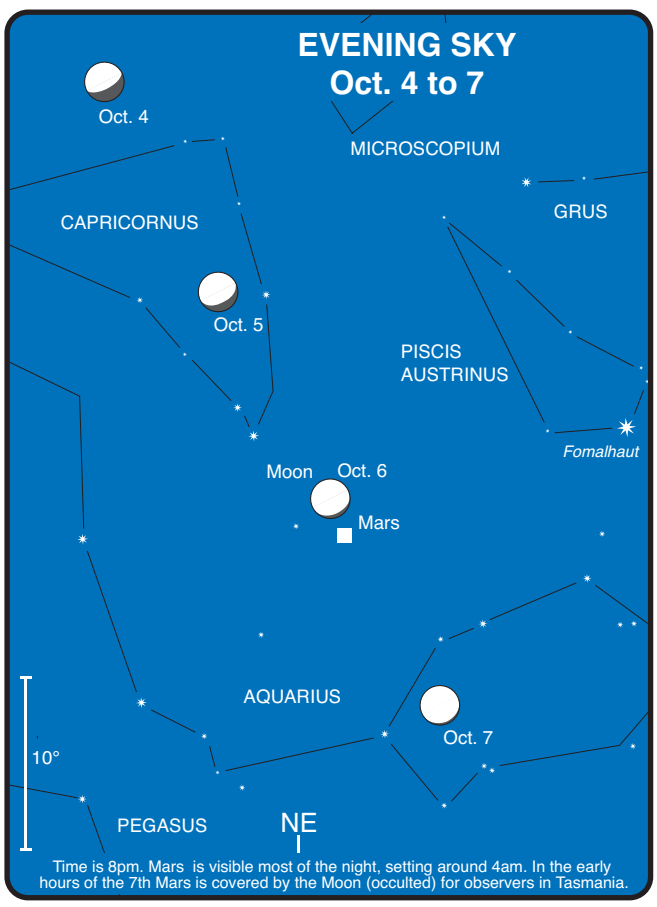
**Comet 2P/Encke** should brighten from 13th to 9th magnitude this month. Encke begins October in the northern constellation of Triangulum, rising mid-evening and visible until dawn, and can be found near 3rd magnitude Beta Trianguli during the first week before moving into neighbouring Andromeda. Towards the end of the month, with no Moon in the sky, Comet Encke will approach M31 – the Great Andromeda galaxy.

**Comet C/2001 HT50 (LINEAR-NEAT)** passes through the Hyades in the first week of this month. At 11th magnitude, LINEAR-NEAT is in Taurus for most of October, except at the end when it crosses over into neighbouring Aries.

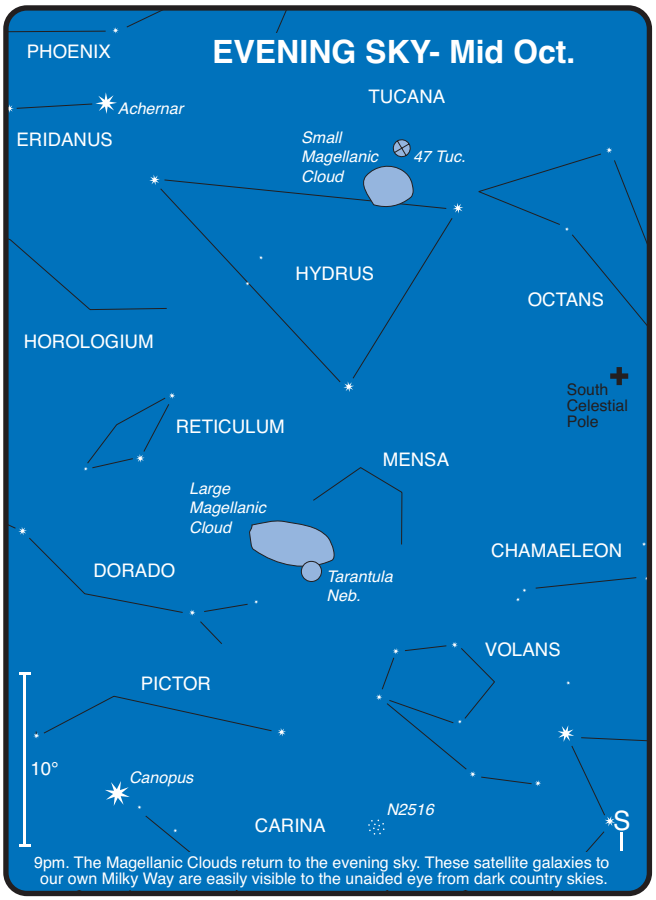
**Comet C/2001 Q4 (NEAT)** should hopefully brighten from 12th to 11th magnitude this month. Circumpolar for most readers, the comet skirts the edge of the Large Magellanic Cloud as it moves through the constellations of Dorado, Reticulum, and Hydrus.

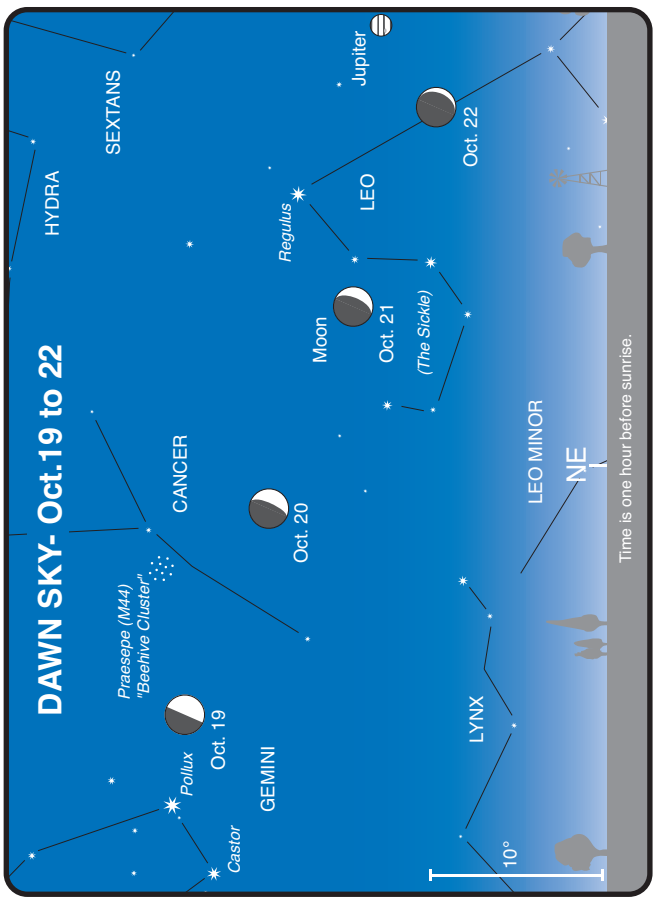
## DIARY EST (WST)

| | | |
|---|---|---|
| 1st | am | Comet C/2001 HT50 (LINEAR-NEAT) 0.9°S of NGC1647 (OC) in Taurus |
| 2nd | | m.p. 8 Flora 0.3°NW of Lagoon Neb. in Sagittarius |
| 3rd | | m.p. 12 Victoria 0.5°S of Eagle Nebula (M16) in Serpens |
| 3rd | | First Quarter Moon |
| 4th | 8 am | (6 am WST) Venus 3°N of Spica |
| 5th | 10 am | (8 am WST) Neptune 5°N of Moon |
| 6th | | m.p. 8 Flora 0.2°SW of NGC6559 (BN) in Sagittarius |
| 6th | am | Comet C/2001 HT50 (LINEAR-NEAT) 1.6°N of star Aldebaran |
| 6th | 8 pm | (6 pm WST) Uranus 5°N of Moon |
| 7th | | Mercury at greatest latitude north |
| 7th | 1 am | (11 pm WST, prev day) Mars 1.1°N of Moon Occn. |
| 9th | | Ken's Birthday |
| 10th | | m.p. 6 Hebe 0.4°N of star Beta Canis Minoris |
| 10th | | Full Moon |
| 10th | pm | Comet 2P/Encke 0.4°S of NGC752 (OC) in Andromeda |
| 13th | am | Comet C/2002 O7 (LINEAR) 1.3°W of star Mu Velorum |
| 14th | | Pallas at opposition |
| 14th | | Moon at apogee |
| 16th | | m.p. 8 Flora 0.5°N of M28 (GC) in Sagittarius |
| 17th | am | Comet C/2002 O7 (LINEAR) 0.5°S of NGC3330 (OC) in Vela |
| 17th | 11 pm | (9 pm WST) Saturn 5°S of Moon |
| 18th | | m.p. 8 Flora 1°N of star Lambda Sagittarii |
| 18th | | Last Quarter Moon |
| 19th | am | Comet C/2002 O7 (LINEAR) 0.7°S of NGC3293 (OC) in Carina |
| 19th | am | Comet C/2002 O7 (LINEAR) 1.2°NW of Eta Carinae Nebula (BN, DN) in Carina |
| 20th | | m.p. 23 Thalia 1°NE of star Delta Scorpii |
| 22nd | | Venus 0.5°SE of star Alpha 2 Librae |
| 22nd | | m.p. 8 Flora 0.5°SW of M22 (GC) in Sagittarius |
| 22nd | 9 am | (7 am WST) Jupiter 4°S of Moon |
| 23rd | | Neptune stationary |
| 23rd | am | Comet C/2002 O7 (LINEAR) 1.0°W of IC2602 (OC) in Carina |
| 24th | | m.p. 9 Metis 0.05°NW of NGC6284 (GC) in Ophiuchus |
| 25th | | Mercury in superior conjunction |
| 25th | | New Moon |
| 25th | pm | Comet 2P/Encke 1.7°N of M31 (Andromeda Galaxy) in Andromeda |
| 26th | | m.p. 40 Harmonia 0.2°S of NGC6235 (GC) in Ophiuchus |
| 26th | | Venus at descending node |
| 26th | | Saturn stationary |
| 26th | | Moon at perigee |
| 27th | 6 am | (4 am WST) Venus 0.08°N of Moon Occn. |
| 29th | | Peter's Birthday |
| 30th | | m.p. 23 Thalia 0.4°NE of M80 (GC) in Scorpius |
| 30th | | Mercury at descending node |

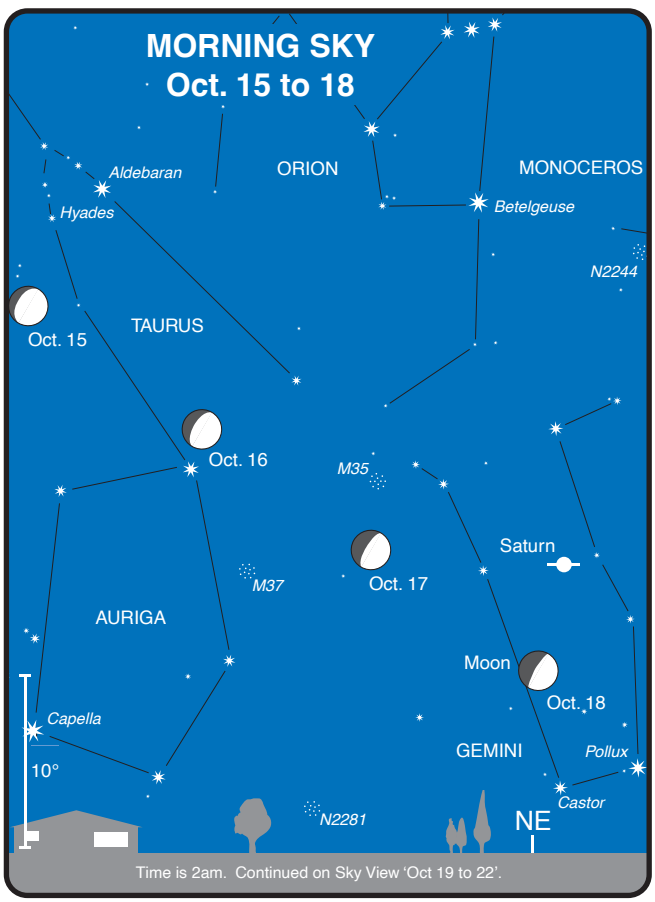


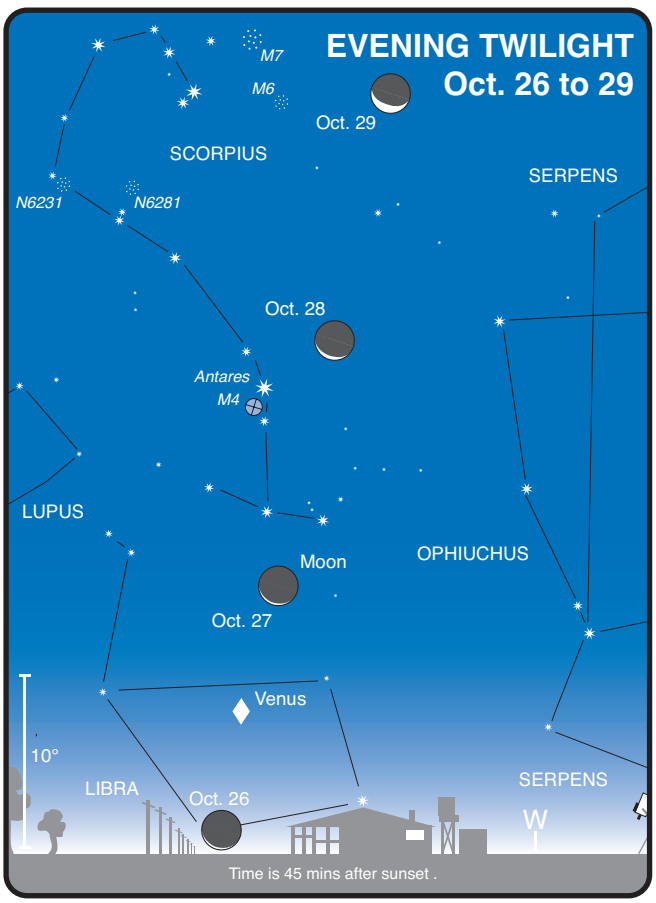
Time is 8pm. Mars is visible most of the night, setting around 4am. In the early hours of the 7th Mars is covered by the Moon (occulted) for observers in Tasmania.



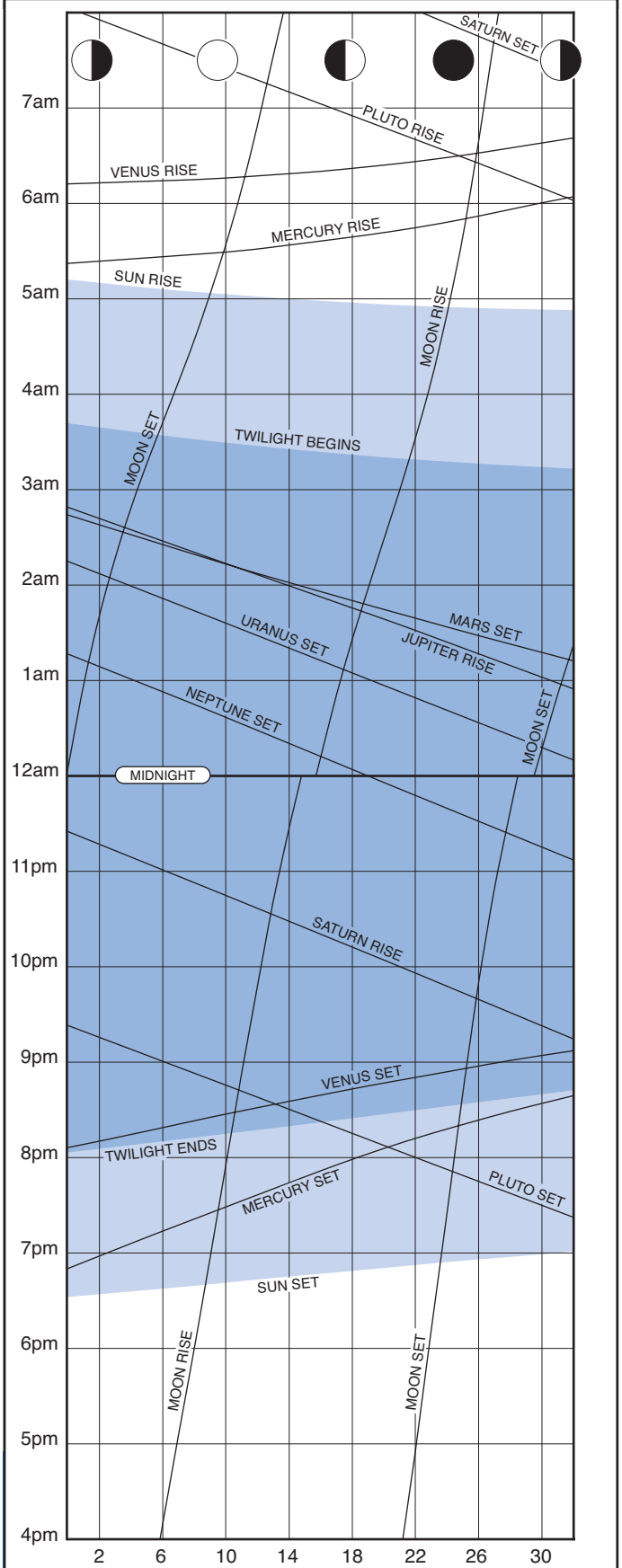

Approximate local standard time, for daylight saving add 1 hour.



# NOVEMBER

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury returns to the evening sky.
- Daytime occultation of Mercury by the Moon.
- Venus traverses the Sagittarius Star Cloud, passing by many excellent deep sky objects.
- Comet Encke makes its closest approach to Earth.

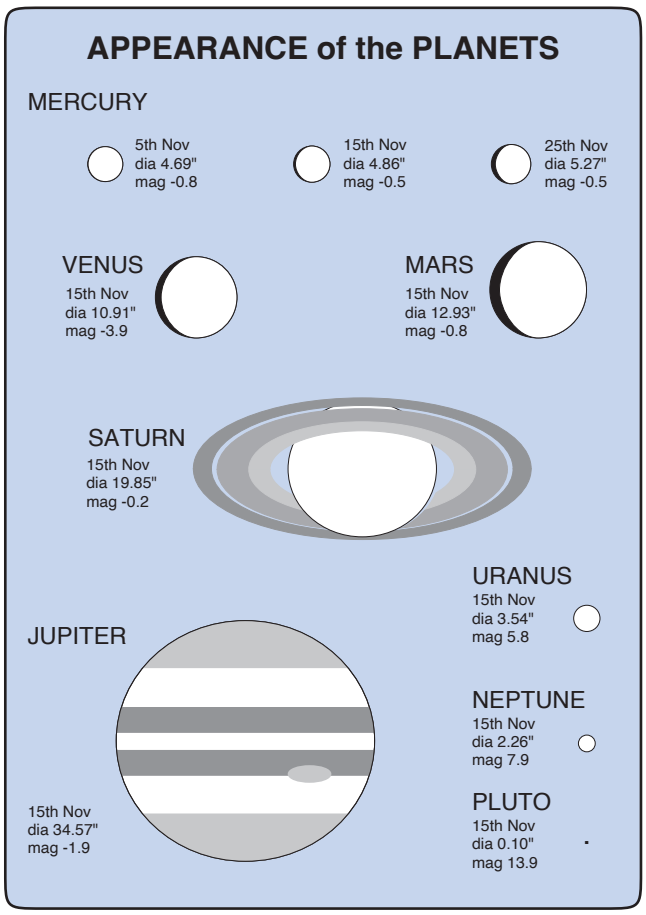
### THE MOON

| | |
|---|---|
| 1st | First Quarter |
| 9th | Full Moon. Total Lunar Eclipse, not visible from Australia (see p. 76) |
| 10th | Moon at apogee (furthest from Earth – 406,301 km distant, angular size 30.2') |
| 17th | Last Quarter |
| 24th | Moon at perigee (closest to Earth – 356,811 km distant, angular size 33.3') |
| 24th | New Moon. Total Solar Eclipse, partial phases visible across most of Australia (see p. 77) |
| 25th | Occultation of Mercury by the Moon, daytime event from Australia. |

### THE PLANETS

**MERCURY** returns to the western evening sky after being in superior conjunction (Mercury and Earth on opposite sides of the Sun) late last month. During the course of November, Mercury moves through Libra, Scorpius, Ophiuchus and finally joins Venus in Sagittarius at month's end. On the 18th and 19th, Mercury will be less than 3° north of the 1st magnitude star Antares (see Sky View). On the 25th, the slender crescent of the 2–day old Moon can be seen near Mercury in the evening twilight (see Sky View). Earlier in the daylight, the Moon occults the planet for observers in southern Australia (the top halves of Queensland and

### APPEARANCE of the PLANETS



Northern Territory miss out). Times for this event, for your location, can be found in Part II in the Lunar Occultation section. WARNING: this event is close to the Sun and should be attempted by experienced observers ONLY.

**VENUS** shines brilliantly in the early western evening sky throughout November and December. Setting after Mercury, the planet also travels through Libra, Scorpius, Ophiuchus and Sagittarius and at month's end the pair are around 7° apart. On the 11th, the planet will be located 4° north of the 1st magnitude star Antares (Alpha Scorpii). Moving across the Sagittarius Star Cloud close to the Galactic Centre, the planet passes near some excellent deep sky objects (and in so doing the sheer brilliance of the planet will overwhelm and swamp these fine gems). Of note, on the 28th, Venus passes very close to the Lagoon Nebula (Messier 8).

**MARS** in Aquarius, is visible high in the northern sky mid-evening. On the 3rd, the 10–day old waxing gibbous Moon appears near the planet (see Sky View). Now three months past opposition, the planet has lost all appeal for those seeking to see surface markings in any detail, with the globe shrinking from 15 arc minutes down to 11 at month's end. The gibbous phase of the planet however can be seen in telescopes. Even Galileo noted this in the pioneering days of telescope observations. The planet's magnitude also decreases noticeably from -1.2 at the beginning of the month to 0.2 at the end of the year.

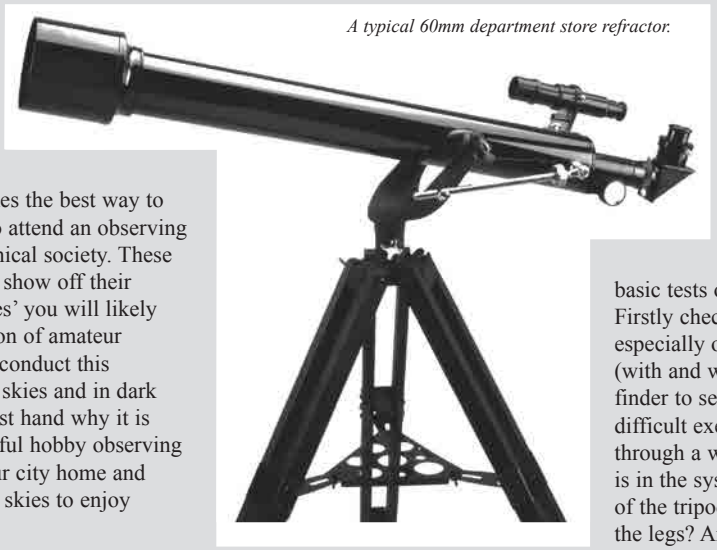
**JUPITER**, in Leo, rises in the eastern morning sky around 2am. Not a lot happens to the King of Planets this month. The next opposition occurs in early March 2004. The planet will steadily increase in brightness and size as the months pass. On the 19th, the 24–day old crescent Moon will be near the planet (see Sky View).

**SATURN** rises in the late evening northeastern sky, above the Gemini twins, Castor and Pollux. On the 13th, the 19–day old waning gibbous Moon will be seen near the planet (see Sky View).

**URANUS** and **NEPTUNE**, in Aquarius and Capricornus respectively, are high in the northwestern sky after the end of astronomical twilight.

**PLUTO**, in conjunction in early December, becomes lost in the evening twilight this month, returning to the morning sky in late January 2004.

## BEGINNERS PART 1 – BUYING YOUR FIRST TELESCOPE



*A typical 60mm department store refractor.*

Do you really want a telescope? What do you want to do with it? Will the view be what you expected? These may be bigger questions than you think (for the last question we refer you to page 65). Sometimes the best way to help define what you want is to attend an observing night with an amateur astronomical society. These experts are more than happy to show off their telescopes. At these 'Star Parties' you will likely come across a good cross section of amateur equipment. It would be best to conduct this exercise under suburban bright skies and in dark country conditions. Learn at first hand why it is possible to have a very successful hobby observing the Moon and planets from your city home and why you need to be under dark skies to enjoy nebulae and galaxies.

Until now, in these yearbooks, we have refrained from giving advice on buying telescopes because a lot of the decision making process is often limited by one's budget. Here we are going to 'zoom in' on the department store 60mm refractor. After all this is what we were brought up to expect a telescope should look like. Its price is also not so scary compared to some of the alternatives on offer from the specialised telescope shops. We are not saying cheap always means poor quality, and you shouldn't underestimate what can be seen through these low-end instruments (see p. 65). Unfortunately most of the time in department and camera stores, the sales person knows nothing about astronomy and it is impossible to get informed answers to your questions. The bottom line is, many perfectly good telescopes have been returned because of poor instructions or advice given in the store of purchase.

It is a shame that the manufacturers of these instruments sometimes shoot themselves in the foot by making silly marketing statements on the box like, "The telescope magnifies to 500 X power, allowing you to see further!" Firstly, what you see is dependent on how bright it is not how far away. For example, the faint star Proxima Centauri is only 4 light years away and is too faint to see through a 60mm telescope but the Andromeda Galaxy is 2 million light years away and it is visible, under dark skies, to the naked eye! Also the power or magnification is purely dependent on the focal length of the eyepiece. It is on rare occasions (if ever) that atmospheric turbulence would allow you to go anywhere near 500 times (200X sometimes). In addition, the cheaper short focal length eyepieces (needed for high magnification) have very poor eye relief. This is how close to the eyepiece you need to place your eye – an important factor, especially for people who have to wear glasses when using a telescope.

The 60mm refractors typically have a focal length around 700mm. The magnification is this number divided by the focal length of the eyepiece i.e., a 20mm eyepiece delivers 35X. Coupled with a 2X Barlow doubles this to 70X. You may find this combination will become your workhorse.

It is unfortunate that all 60mm refractors look similar because there are some 'lemons' around. Under store conditions you can't check the optics with the image of a star, but you may find it worthwhile conducting a few basic tests of your own on their display model. Firstly check all of the wing nuts are done up tightly especially on the tripod. Check all the eyepieces (with and without the Barlow lens, if supplied) and finder to see if they focus at infinity (this can be a difficult exercise – try seeing distant telephone lines through a window). Next, check how much flexure is in the system. Does the small platform on the top of the tripod rock when pressure is applied to one of the legs? Are the altitude and azimuth axes reasonably rigid in the locked position? This can also test the stability of the silver-coloured slow motion arm that is often present on the altitude axis. When the axes are unlocked does the scope move smoothly? Does the rack and pinion tube (where the eyepiece goes) flex when gentle pressure is applied? We recognise that a beginner may have trouble trying to evaluate what is or isn't acceptable, but an unstable mount can make your life miserable. If you have any doubt take it to a star party and have an experienced amateur check it out especially for the quality of the star images across the field. You may be able to return it or use it for bird watching (with the appropriate inverting prism).

It is interesting to note you will rarely see a 60mm refractor at a 'star party'. This is because these people have committed a lot more than just their time to the hobby. Even a Dobsonian in the 150-200mm size can represent an investment of $600 to $1000 – quite a jump from the $200 store special! We have mentioned a Dobsonian here because for the more experienced amateurs, who just wish to observe, look upon these as the best 'bang for your buck'. How faint you can see in a telescope is a function of the surface area of the mirror or lens. A 200mm mirror pulls in roughly 10 times as much light as a 60mm refractor. For simplicity we have avoided equatorially mounted or computer controlled scopes at this time – here we start talking money. If your finances are tight you might be better off buying a reasonable pair of binoculars. There is a lot one can do with these as well, see page 12.

In conclusion it doesn't matter what equipment you have, or don't have. If your heart quickens as the Sun goes down, with the anticipation of the Milky Way stretching magnificently across the heavens, then this hobby is for you. The joys of the night sky are available to every budget.

# NOVEMBER

**MINOR PLANETS** at opposition this month includes 29 Amphitrite on the 29th at magnitude 8.8 near the border of Taurus and Perseus. 40 Harmonia goes on a globular cluster and nebula 'crawl' in Ophiuchus in the early evening sky this month, passing between the Trifid and Lagoon nebulae at the end of November.

## COMETS

**Comet C/2002 O7 (LINEAR)** passes 0.9 AU from Earth early in November and should then fade from 7th to 9th magnitude by month's end. During the month, it moves rapidly through Octans, Indus, Tucana, and Grus. By the end of November, LINEAR is setting around the beginning of morning twilight.

**Comet 2P/Encke** is moving quickly through the northern sky this month as it makes its closest approach to Earth (0.26 AU) during this apparition. It is an evening object for most of November, but by month's end, when it could be 6th magnitude, it will be lost in the evening twilight glare.

**Comet C/2001 HT50 (LINEAR-NEAT)** is at its closest to Earth early this month – a very distant 2.1 AU. Moving through the zodiacal constellations of Aries and Pisces, the 11th magnitude comet sets in the early hours of the morning by month's end.

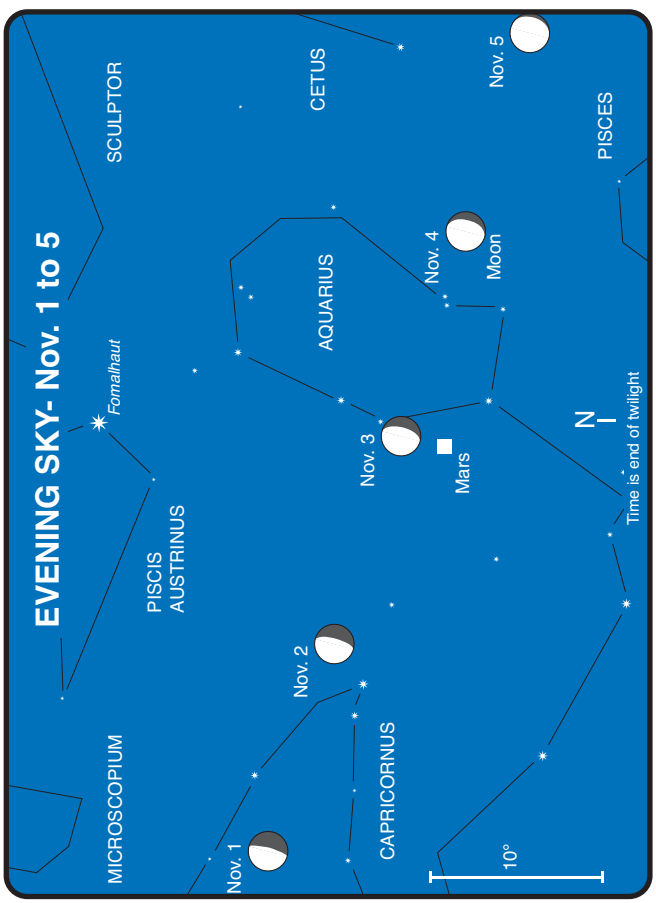
**Comet C/2001 Q4 (NEAT)** is visible all night as a circumpolar 11th magnitude object but is best observed in the later evening hours when it has gained further altitude. NEAT spends November moving through Hydrus, with a brief passage through Mensa, and ends the month south of the Small Magellanic Cloud, little more than ten degrees from the South Celestial Pole.

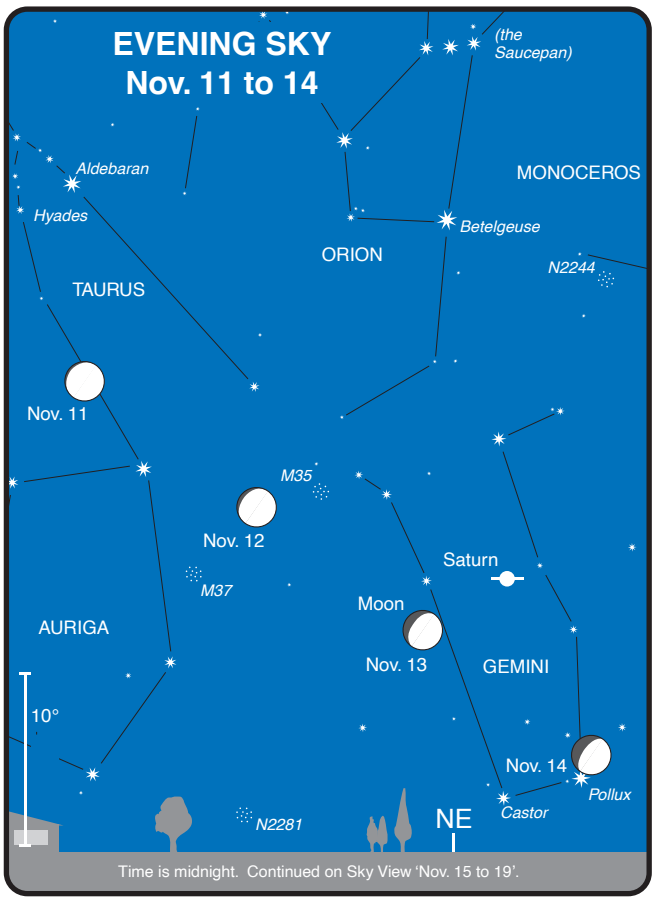
## METEOR SHOWERS

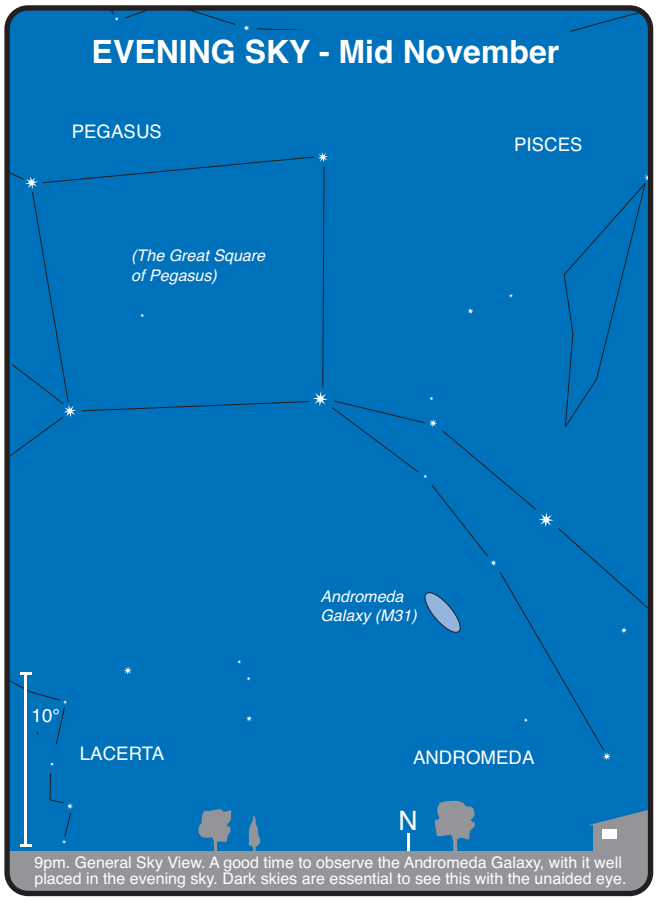
The **alpha-Monocerotids** is a minor shower, with unusual short-lived bursts of high rates. Active from 15th to 25th November, they peak on the 22nd and are best seen during the late evening. While the zenith hourly rate is normally around 5, high rates were seen in the years 1925, 1935, 1985 and 1995. The 1995 rate reached an estimated 420, and lasted just 5 minutes; the entire shower was over in 30 minutes. There is some speculation of a 10-year cycle, but who knows what this year has in store?

## DIARY EST (WST)

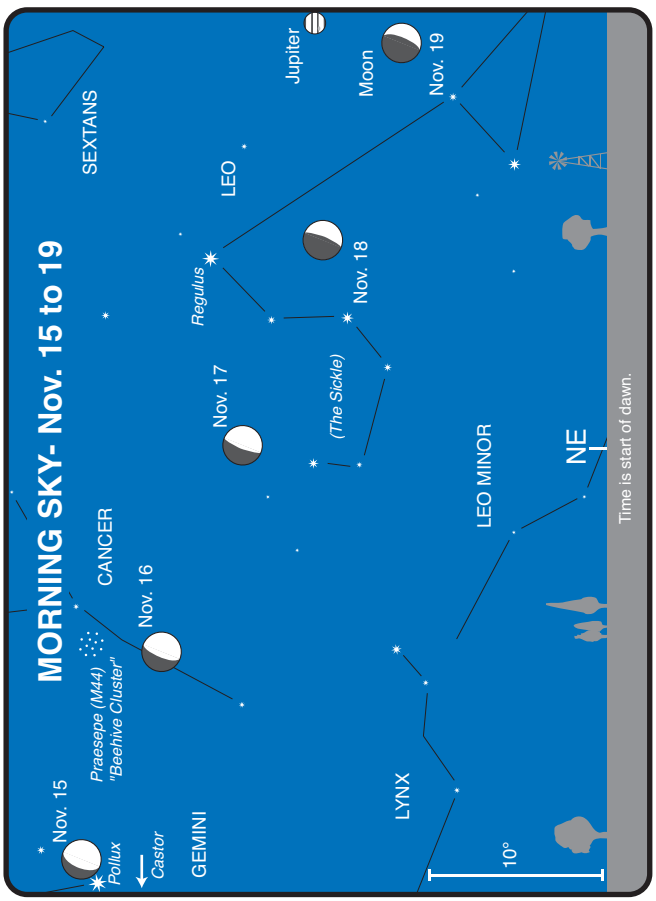
| | | |
|---|---|---|
| 1st | | m.p. 40 Harmonia 0.1°SE of NGC6287 (GC) in Ophiuchus |
| 1st | | First Quarter Moon |
| 1st | 4 pm | (2 pm WST) Neptune 5°N of Moon |
| 3rd | | m.p. 9 Metis 0.2°SW of star Theta Ophiuchi |
| 3rd | 1 am | (11 pm WST, prev day) Uranus 5°N of Moon |
| 3rd | 7 pm | (5 pm WST) Mars 3°N of Moon |
| 4th | | Comet C/2002 O7 (LINEAR) 1.5° from the South Celestial Pole |
| 7th | | m.p. 39 Laetitia 0.5°NE of star Gamma Virginis |
| 7th | | m.p. 40 Harmonia 0.6°S of NGC6325 (GC) in Ophiuchus |
| 8th | | Venus 1.1°N of M80 (GC) in Scorpius |
| 9th | | Uranus stationary |
| 9th | | Full Moon; eclipse |
| 10th | | Mercury at aphelion |
| 10th | | Moon at apogee |
| 10th | 5 pm | (3 pm WST) Venus 4°N of Antares |
| 12th | | Venus 0.9°N of m.p. 23 Thalia |
| 12th | pm | m.p. 2 Pallas 0.3°SE of NGC578 (SG) in Cetus |
| 13th | | m.p. 39 Laetitia 0.6°SW of NGC4753 (SG) in Virgo |
| 14th | | Mercury 0.7°NE of star Delta Scorpii |
| 14th | 5 am | (3 am WST) Saturn 5°S of Moon |
| 15th | | Comet 2P/Encke 1.5°NW of the Veil Nebula in Cygnus. |
| 16th | | Mercury 0.3°W of M80 (GC) in Scorpius |
| 17th | | m.p. 40 Harmonia 0.4°N of NGC6401 (GC) in Ophiuchus |
| 17th | | Last Quarter Moon |
| 18th | 10 pm | (8 pm WST) Mercury 3°N of Antares |
| 19th | | Venus 0.3°S of NGC6325 (GC) in Ophiuchus |
| 19th | 2 am | (Midnight WST, prev day) Jupiter 4°S of Moon |
| 21st | | m.p. 7 Iris 0.7°NE of NGC3521 (OC) in Leo |
| 21st | | m.p. 511 Davida 0.2°SW of NGC4698 (SG) in Virgo |
| 22nd | | Mercury 0.4°SW of m.p. 23 Thalia |
| 23rd | | Venus 0.6°S of NGC6401 (GC) in Ophiuchus |
| 24th | | New Moon; eclipse |
| 24th | | Moon at perigee |
| 25th | 1 pm | (11 am WST) Mercury 0.3°N of Moon Occn. |
| 26th | | Ceres stationary |
| 26th | 4 am | (2 am WST) Venus 2°N of Moon |
| 27th | | Venus 1°S of m.p. 40 Harmonia |
| 28th | | Venus 0.6°SE of Lagoon Neb (M8) in Sagittarius |
| 28th | | Venus 0.3°N of NGC6544 (GC) in Sagittarius |
| 28th | | m.p. 40 Harmonia 0.8°S of M20 (Trifid Nebula) in Ophiuchus |
| 29th | | m.p. 40 Harmonia 0.5°N of M8 (Lagoon Nebula) in Ophiuchus |
| 28th | Midnight | (10 pm WST) Neptune 5°N of Moon |
| 30th | | m.p. 9 Metis 0.3°NE of NGC6553 (GC) in Sagittarius |
| 30th | | Mercury at greatest latitude south |
| 30th | | Venus at aphelion |
| 30th | 8 am | (6 am WST) Uranus 5°N of Moon |
| 30th | am | Comet C/2002 O7 (LINEAR) 0.5°N of NGC7496 (SG) in Grus |

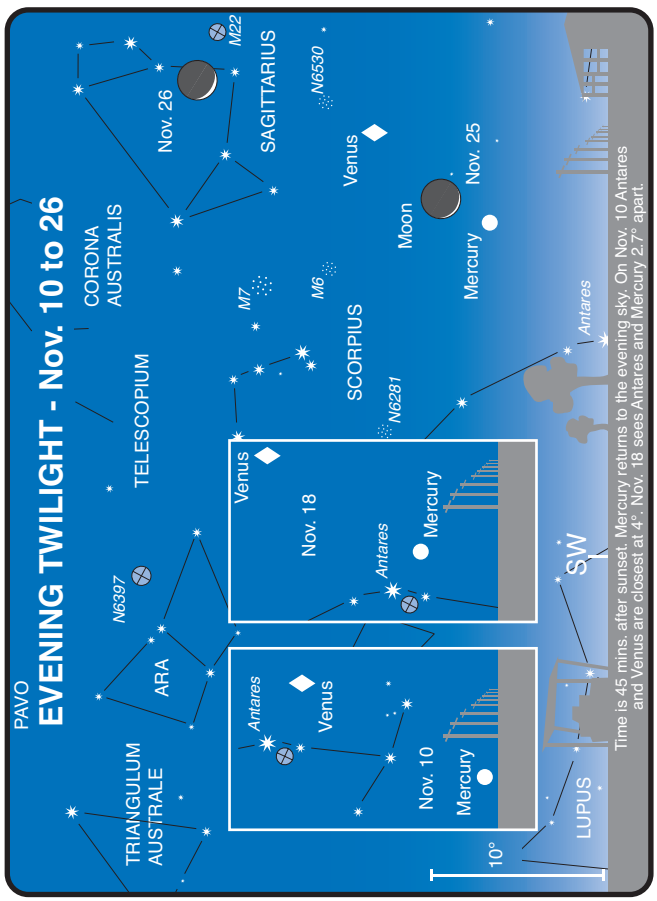




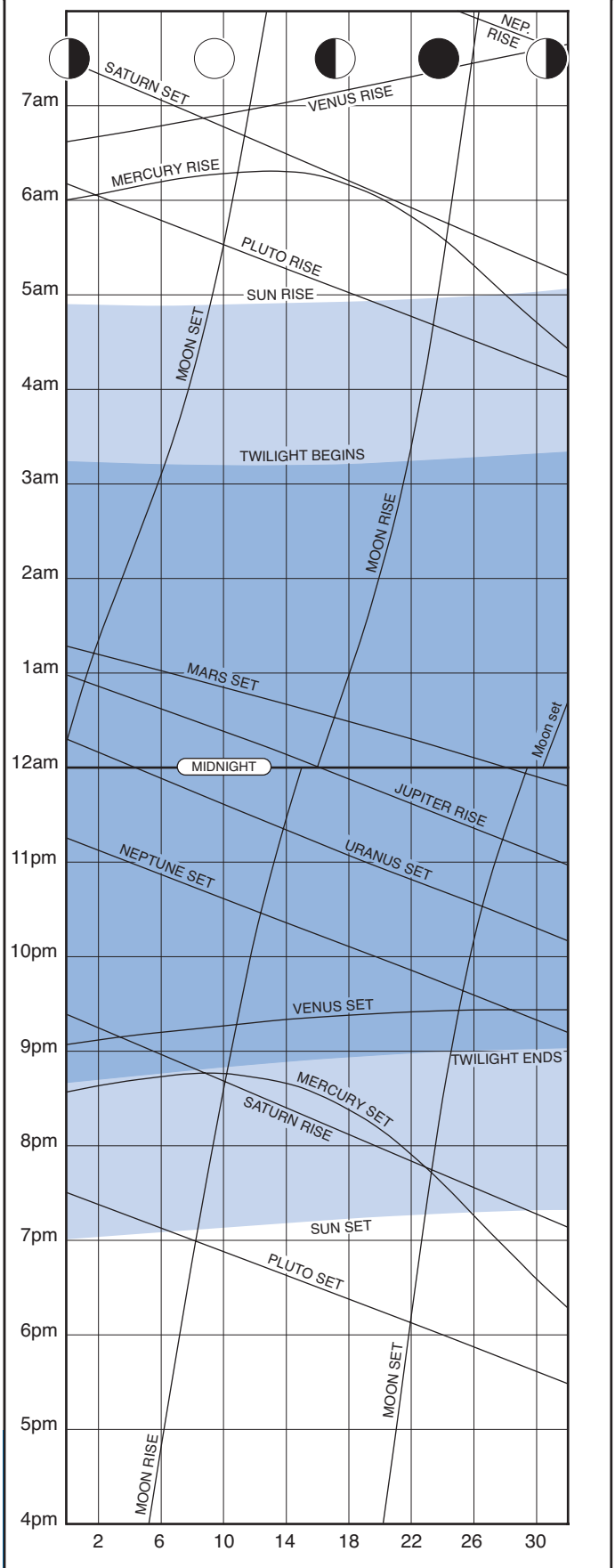

Approximate local standard time, for daylight saving add 1 hour.



# DECEMBER

## RISE/SET CHART




Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury in the evening sky in early December.
- Mercury and Venus encounter Messier globulars in Sagittarius.
- Saturn at opposition (1st January 2004).
- Comet Encke at perihelion in the Dawn Sky
- Comet C/2002 Q4 (NEAT) is in the far south and hopefully preparing for a spectacular 2004.

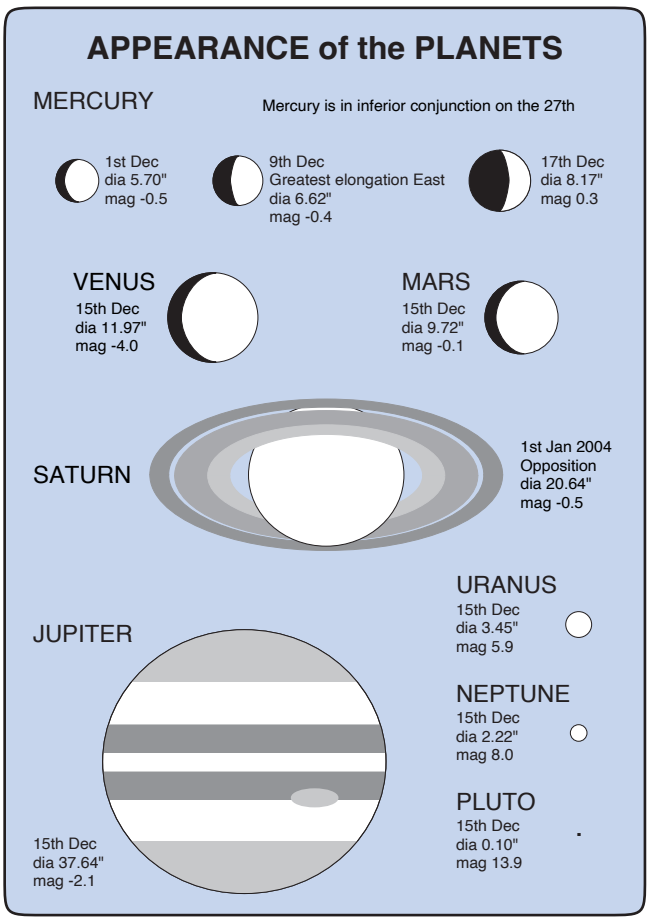
### THE MOON

This month is a little unusual in that it has five lunar phases (two First Quarters).

| | |
|---|---|
| 1st | First Quarter |
| 7th | Moon at apogee (furthest from Earth – 406,279 km distant, angular size 29.7') |
| 9th | Full Moon |
| 12th | Occultation of minor planet Ceres by the Moon (not visible from Australia) |
| 17th | Last Quarter |
| 22nd | Moon at perigee (closest to Earth – 358,338 km distant, angular size 33.1') |
| 23rd | New Moon |
| 30th | First Quarter |

### THE PLANETS

**MERCURY**, at least for the first two weeks of December, is in a good position to observe in the western evening sky. The planet will be at its greatest elongation (21°) from the Sun on the 9th, setting almost two hours after the Sun. Mercury then rapidly swings back toward the Sun and inferior conjunction (between Earth and Sun) on the 27th. Following Venus early in the month through the Sagittarius Star Cloud, Mercury has



close encounters with well known Messier objects such as M8 (the Lagoon Nebula) on the 3rd, M28 (a globular cluster) on the 7th, and M22 (one of the best of the globular clusters) on the 10th. Of course, this is not the best time to view these celestial showpieces, having to look at a low altitude (through more atmosphere) in a twilight sky.

**VENUS** begins the month close to the 3rd magnitude star Lambda Sagittarii (Kaus Borealis) in the early western evening sky. Lambda marks the lid of the well known asterism of the teapot; a much easier pattern of stars to see than Sagittarius, the mythical half-beast half-man with his arrow aimed directly at the heart of neighbouring Scorpius (the 1st magnitude star Antares). The presence of the brilliant planet will no doubt make the teapot look a little strange early in the month. Venus has close approaches to three Messier globular clusters this month, M28 on the 1st (at 0.3° from the heart of the cluster), M22 on the 3rd (at 0.9°), and M75 on the 20th (at 0.2°). Sadly, the planet's brightness will wipe out the delicate nature of these fine objects. The planet moves from Sagittarius into Capricornus, and on the 25th the 2–day old slender crescent Moon will be near Venus (see Sky View). On the 30th and 31st, Venus will be within 2° of the distant Solar System member, Neptune.

**EARTH** is at Solstice on the 22nd when the days are longest. On this day the Sun is at its most southerly position with a declination of -23.5°.

**MARS**, setting a little after midnight in the west, can be seen in Aquarius early in the month before moving into Pisces. On the 1st, an 8–day old Moon will be near the planet (see Sky View) and four weeks later on the 30th, the 7–day old First Quarter Moon will be similarly close (see Sky View). With opposition now three months past, the planet has reached

## BEGINNERS PART II – OBSERVING

When going to look through a telescope it is important to understand the limitation of your instrument to arrive at a realistic expectation. Amateur telescopes can't do everything. If they did the professionals wouldn't build multi-million dollar technical marvels like the 3.9 metre Anglo-Australian Telescope.

The following general comments apply to small to medium size (60 to 200mm) telescopes that one would normally consider a beginner's instrument. Any comments related to observing deep sky objects (see below) assumes you have successfully escaped the light polluted cities and have allowed sufficient time for your eyes to dark adapt (this can take up to 30 minutes). The use of a red light source (a torch covered in red cellophane) when making notes or reading atlases is then needed to help maintain this state.

**What Not to Expect!**

Firstly don't expect to see images that remind you of the latest Space Telescope images or something akin to a David Malin special. Although some objects, such as globular clusters like Omega Centauri, or some of the brighter nebulae (Orion, Eta Carinae, Tarantula, Lagoon and Trifid come to mind) look spectacular, even through the smallest of telescopes, you will not see the brilliant reds and galactic spiral arms associated with photographs or electronic CCD images. The light levels are mostly too low to activate the cone cells in your eyes which allow you to see colour. Stars are an exception with most of the brightest stars' hues being noticeable to even the unaided eye. Also the surface brightness in most galaxies is too low to perceive the photographic details. Even in reasonably sized amateur instruments, a galaxy will look like a white milky ghost, perhaps with a central brightening. Often the nature of the galaxy can be gleaned; for example an edge-on spiral may be noticeably cigar-shaped. Some of the brightest galaxies do show dark lanes and bright hydrogen cloud regions, looking almost stellar. Often there may be a special attraction such as a supernova which is of interest, not for how it looks (just another faint star) but for the cataclysmic event it represents. In fact the real appeal of observing galaxies can be for what they are, the faint smudge of light from a city of billions of stars dimmed by a voyage that has lasted millions of light years.

**What We Can See**

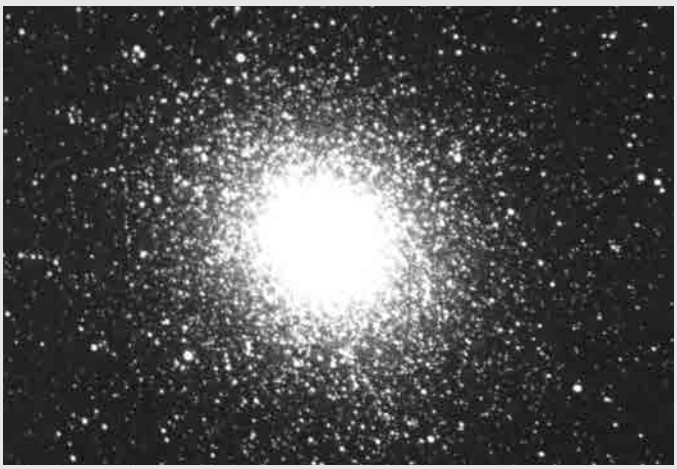
After the previous statements you may be surprised how much detail can be teased out of a faint deep sky object (such as a galaxy) by a practised observer using techniques such as averted vision. This is looking at the centre of the eyepiece field but perceiving detail at the edge (looking out of the corner of the eye if you like). It is often used so effectively, that with practice, it becomes an unconscious act. The reason for this is the least sensitive cones are in the central zone of the retina, in the centre of vision. The most sensitive, but colour blind, rod cells are in the outer regions. Also going to higher power (shorter focal length eyepieces) can help. Although the faint object gets larger, smearing the precious photons across a bigger area, the background gets darker increasing the contrast between the object and the sky. The use of filters can also have this effect. For example an Oxygen (OIII) filter is very effective on planetary nebulae, by allowing a selective wavelength of light, common to planetaries, to pass through and excluding other light such as background glow which can be atmospheric or man-made (light pollution).

The brighter members of the Solar System is an area where even the smallest amateur telescope (60mm) shines. The Moon is an object that can look better through a telescope than a photograph. It is probably best to avoid the Full Moon for it is not only extremely bright but also flat and lifeless, like a watercolour painting. Remember that when full it is 'high noon' on the surface of the Moon and there are few shadows to give the impression of depth. The best views are probably the few days either side of first and third quarter. The use of high power eyepieces can be very rewarding (it's the closest you'll get to orbiting the Moon) but is dependent on good 'seeing'. The turbulent atmosphere may only give you a momentary glimpse of a 'still' Moon but it is worth waiting for. An experienced observer will gaze at the Moon for many minutes waiting for these rare moments. This applies to any planet being observed.

Like the Moon, you will never forget your first views of Saturn and Jupiter. Saturn's ring system is easily visible in the smallest telescope. Likewise the swirling bands and Great Red Spot (GRS) of Jupiter and its four bright moons are easy targets. Atmospheric turbulence, as with our Moon, can cause havoc. You may find that settling for a small, low power, 'crisp' image is more acceptable than a large boiling blob.

As a general rule, when it comes to optimising the seeing, the higher in the sky the object, the less atmosphere you are looking through. This may not be possible if you are looking for Mercury or a very young Moon where they never stray too far from the Sun and are low on the horizon. You may also find it rewarding checking out the Moon and brighter planets during twilight. A slightly different perspective can be seen. For example the crescent Venus can in fact be easier to observe when it is not as brilliant.

No matter what size telescope you have the Universe has much to offer.



*The globular cluster Omega Centauri is an example of a deep sky object that looks more spectacular through a small telescope than a photograph. The central hub of stars quickly gets burnt out in a photo, where you can see the stars right into the centre with a telescope. In this case a 15cm instrument (or larger) is needed to resolve the faint individual stars.*

# DECEMBER

that part of its orbit known as quadrature, when the Sun-Earth-Mars angle is 90° (see diagram page 14). Even with small telescopes at this time the Martian disc appears distinctly gibbous (egg-shaped), the Sun illuminating just 87% of the planet's surface from our viewpoint.

**JUPITER** rises around midnight (mid-month) in Leo. Again, another dull month for Jupiter with little interaction with other Solar System bodies. The Moon at Last Quarter will be reasonably close to the planet on the 16th and 17th (see Sky View).

**SATURN** rises in the early evening eastern sky in Gemini. The ringed world reaches opposition on the 1st day of 2004 and the period from December through January is the optimum time for observing this most exquisite planet at its brightest and largest. Its rings are still well displayed, having reached maximum opening only last April. On the 10th and 11th, the Moon, just past full phase appears near the planet (see Sky View).

**URANUS** and **NEPTUNE**, moving toward solar conjunction early next year, are now both setting before midnight.

**PLUTO**, at conjunction on the 12th, returns to the morning sky in January.

**MINOR PLANETS** at opposition this month include 196 Philomela on the 10th at magnitude 10.8 and 14 Irene on the 11th at magnitude 9.6. Both are in Taurus at this time.

## COMETS

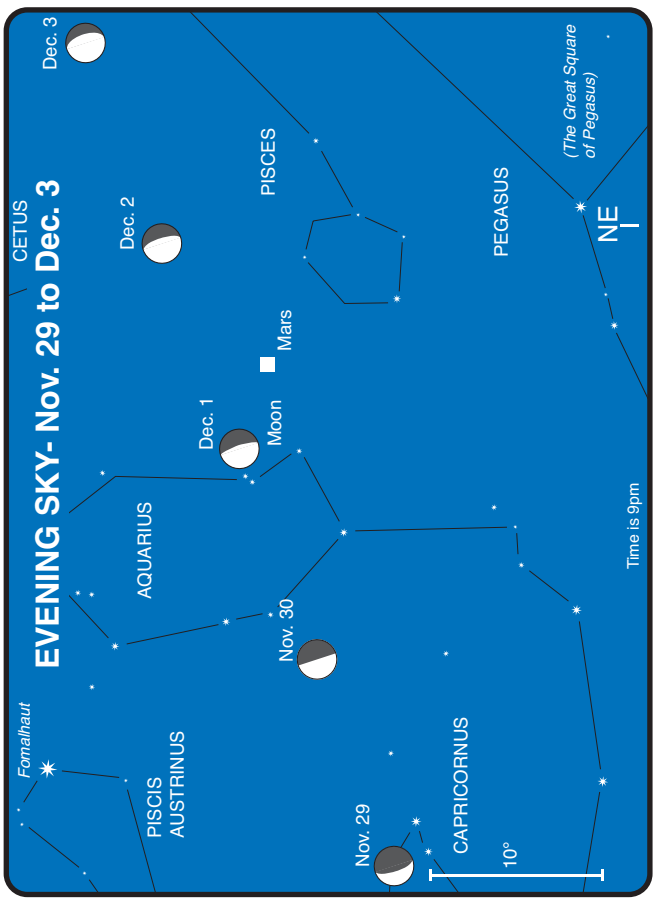
**Comet 2P/Encke** reaches perihelion this month on the 30th just 0.34 AU from the Sun. Normally, it would not be listed as an observing target from Australia. However, keen observers might like to try for the comet in the dawn sky at the end of the month and into early January 2004. At this time it is rising just after twilight commences and it would be interesting to see if it is brighter than 7th magnitude (see page 122 for a review of Encke's evolving lightcurve).

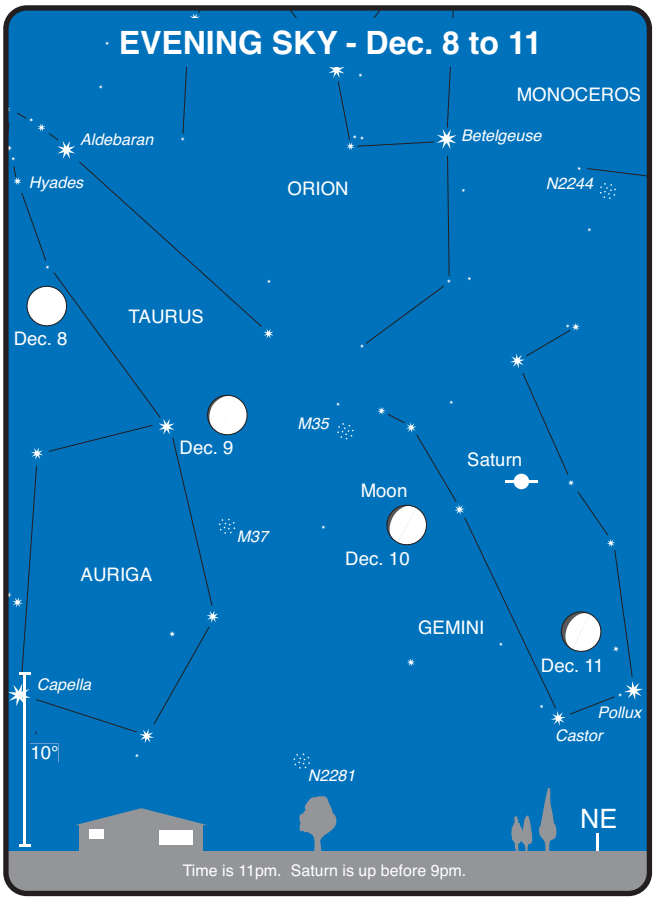
**Comet C/2002 O7 (LINEAR)** fades from 9th to 11th magnitude this month as it moves through the constellations of Grus, Sculptor, and Aquarius. The comet is best observed in the evening sky, and by month's end it is setting around midnight.

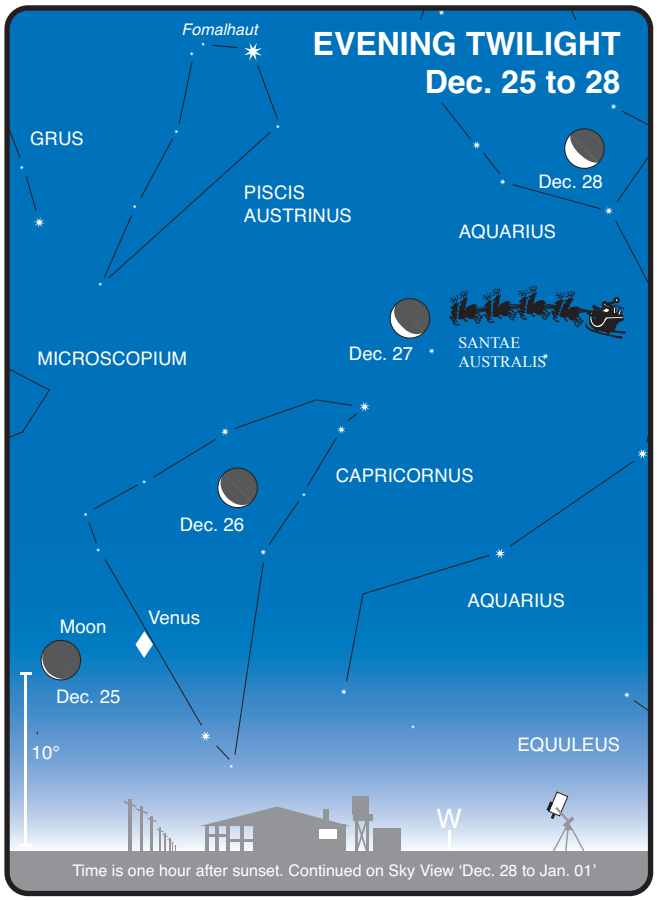
**Comet C/2001 Q4 (NEAT)** ends the year moving through the far southern constellations of Hydrus and Octans. The comet may have brightened to 10th magnitude by month's end, visible all night and setting the stage for an anticipated naked eye display in 2004.

## DIARY EST (WST)

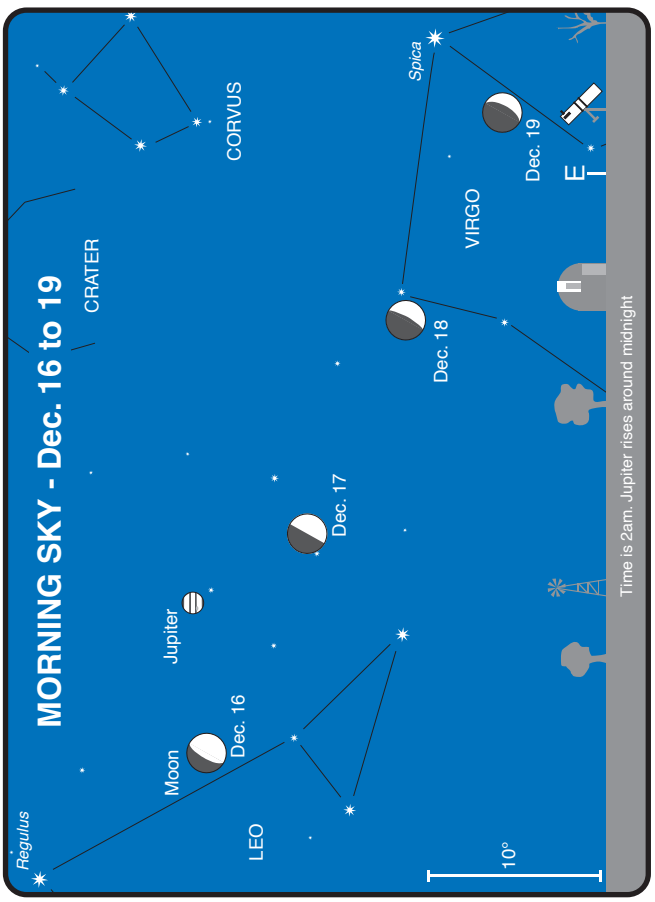
| | | |
|---|---|---|
| 1st | | Venus 0.3°NW of M28 (GC) in Sagittarius |
| 1st | | Comet 43P/Wolf-Harrington 0.5°NE of star Alpha Pegasi |
| 1st | | First Quarter Moon |
| 2nd | | Venus 0.7°N of Lambda Sagittarii |
| 2nd | 2 am | (Midnight WST, prev day) Mars 4°N of Moon |
| 3rd | | Venus 0.9°SW of M22 (GC) in Sagittarius |
| 3rd | | Mercury 1.5°S of Lagoon Neb. (M8) in Sagittarius |
| 4th | | Mercury 0.9°S of NGC6544 (GC) in Sagittarius |
| 4th | | Mercury 0.2°NW of NGC6553 (GC) in Sagittarius |
| 6th | | Mercury 0.4°W of m.p. 9 Metis |
| 6th | | Juno in conjunction with Sun |
| 7th | | m.p. 8 Flora 0.5°S of M75 (GC) in Sagittarius |
| 7th | | m.p. 9 Metis 0.8°S of M28 (GC) in Sagittarius |
| 7th | | Mercury 0.7°S of M28 (GC) in Sagittarius |
| 7th | | Moon at apogee |
| 8th | | Mercury 0.3°E of star Lambda Sagittarii |
| 8th | | Mercury 0.4°W of NGC6638 (GC) in Sagittarius |
| 9th | | Pallas stationary |
| 9th | | Full Moon |
| 9th | | Mercury greatest elong. E (21°) |
| 10th | | Mercury 1.2°S of M22 (GC) in Sagittarius |
| 10th | | m.p. 9 Metis 0.3°SE of star Lambda Sagittarii |
| 11th | | m.p. 9 Metis 0.1°SW of NGC6638 (GC) in Sagittarius |
| 11th | 8 am | (6 am WST) Saturn 5°S of Moon |
| 12th | | Pluto in conjunction with Sun |
| 12th | 11 am | (9 am WST) Ceres 1.1°N of Moon Occn. |
| 16th | 2 pm | (Noon WST) Jupiter 4°S of Moon |
| 17th | | Last Quarter Moon |
| 17th | | Mercury stationary |
| 19th | 11 pm | (9 pm WST) m.p. 1 Ceres 0.2°SW of star Pollux |
| 20th | | Venus 0.2°S of M75 (GC) in Sagittarius |
| 22nd | | Comet 81P/Wild 2 1°SW of m.p. 11 Parthenope |
| 22nd | | Venus at greatest latitude south |
| 22nd | | Solstice |
| 22nd | | Moon at perigee |
| 23rd | | New Moon |
| 24th | | Mercury at perihelion |
| 24th | | Vesta in conjunction with Sun |
| 26th | 2 am | (Midnight WST, prev day) Venus 3°N of Moon |
| 26th | 11 am | (9 am WST) Neptune 5°N of Moon |
| 27th | | Mercury in inferior conjunction |
| 27th | 6 pm | (4 pm WST) Uranus 5°N of Moon |
| 29th | | Mars at ascending node |
| 30th | | Venus 0.7°N of m.p. 8 Flora |
| 30th | | First Quarter Moon |
| 30th | 5 pm | (3 pm WST) Mars 4°N of Moon |
| 30th | 5 pm | (3 pm WST) Venus 1.9°S of Neptune |
| 1st Jan 2004 | | Saturn at opposition |

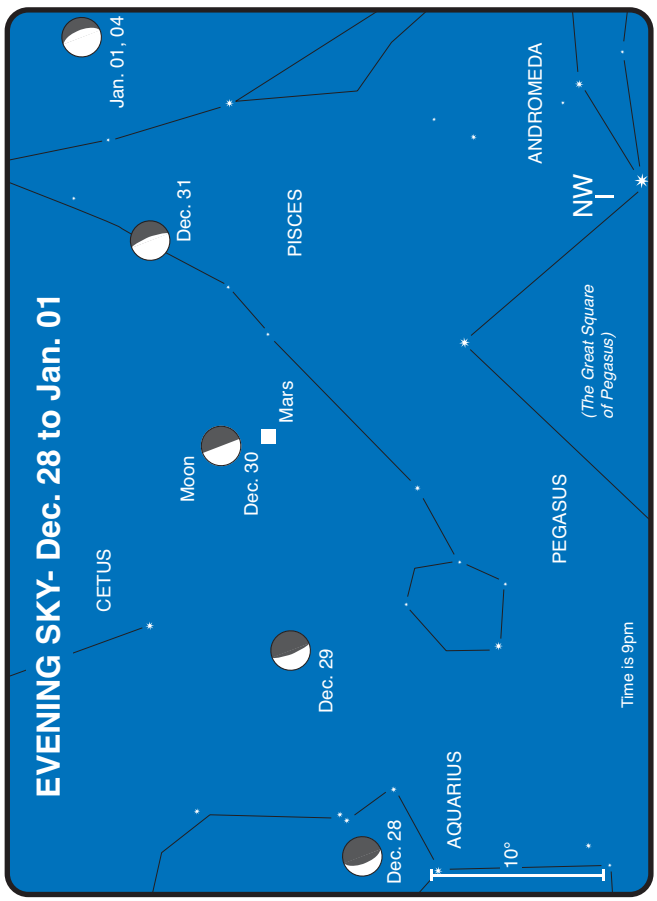





Approximate local standard time, for daylight saving add 1 hour.



# PART II

# THE SOLAR SYSTEM

## GENERAL COMMENTS

In previous editions a lot of the Part II explanations and worked examples had been consolidated in this introduction. Many of these have now been relocated to their relevant sections.

**Time**. With the creation of this 'National Edition' there have been some changes to time zones in Part II compared with our previous publications. There are four zones used in Part II, they are: Eastern Standard Time (EST), Central Standard Time (CST), Western Standard Time (WST) and Universal Time (UT).

**Time Zones.** The local Australian standard zones are used where ever they involve location specific data, such as rise/set times of the Sun, Moon and planets and lunar occultation tables. As in Part I, **no allowance has been made for Daylight Saving Time.** When in force you need to add one hour to the times given here.

All information related to Jupiter's moons is given in EST and WST (pp. 102-108). **All remaining data is in UT**. This is different from our previous Eastern and Western Editions, when lunar phase, distance (apogee/perigee) as well as the satellite data for Saturn, Uranus and Neptune were EST or WST – they are now in UT.

**Universal Time**, or UT, is the mean time for the meridian of Greenwich, England, reckoned from midnight. EST is 10 hours ahead of UT, CST is 9.5 hours ahead and WST is 8 hours ahead. For example, midnight UT, or 0 hr, is equal to 10:00hr (10:00am) EST, 9:30hr (9:30am) CST and 8:00hr (8:00am) WST.

**The 24 hr clock** is often used in astronomy e.g., 16:00 hr is the same as 4:00pm. This avoids having to distinguish between 'am' and 'pm'. The 24hr approach is used a lot in Part II of this book, e.g., for rise/set times. In some areas, it is convenient to use decimal hours. e.g., 5.3hr is the same as 5hr 18min or 5:18hr. The satellite data for Saturn, Uranus and Neptune use decimal hours.

**Locations**. Rise and set times and lunar occultation data are given for specific cities. The latitudes and longitudes used are:

| | | | |
|---|---|---|---|
| Adelaide | 34° 58' S 138° 38' E | Brisbane | 27° 30' S 153° 01' E |
| Canberra | 35° 15' S 149° 08' E | Darwin | 12° 23' S 130° 44' E |
| Hobart | 42° 48' S 147° 13' E | Melbourne | 37° 50' S 145° 00' E |
| Perth | 31° 57' S 115° 51' E | Sydney | 33° 54' S 151° 15' E |

**Astronomical Co-ordinates or Positions**. The astronomical positions are given in equatorial co-ordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations, south have negative (-).

The Earth's daily rotation on its polar axis causes the stars to appear to rotate around a point in the sky. From southern latitudes, including Australia, this point is called the South Celestial Pole and is at declination -90°. The Northern Celestial Pole, not visible from the southern hemisphere, is at +90°. The celestial equator and poles can be described as projections on the sky of their terrestrial counterparts.

**Position Tables**. Right Ascension and Declination have been calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. This means they have been calculated for a position at the centre of the Earth. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Except for the Moon, this slight shift is insignificant. Positions for the outer planets are given in weekly intervals and correspond to Saturdays; those for the Sun, Moon, Venus and Mercury are daily.

**Rise and Set Times**. Those given are when the upper limb of the object is coincident with the theoretical horizon. The data is adjusted for atmospheric refraction. The intervals used for rise/sets are weekly, the dates corresponding to Saturdays. The exception is the Moon which is presented for each day. Also see note on time zones (above).

**Use of Star Atlases**. As the Earth orbits the Sun, the polar axis remains fixed relative to the stars. The points, around which the stars appear to rotate (the celestial poles), appear to never change no matter what time of the year one is observing. However, the positions of the celestial poles do slowly move against the star field. This is called precession and is caused by the Earth's axis slowly wobbling, like a spinning top, over thousands of years. 'Epoch 2000.0' refers to an object's position relative to where the celestial poles (+ /-90° in declination) were in the year 2000.

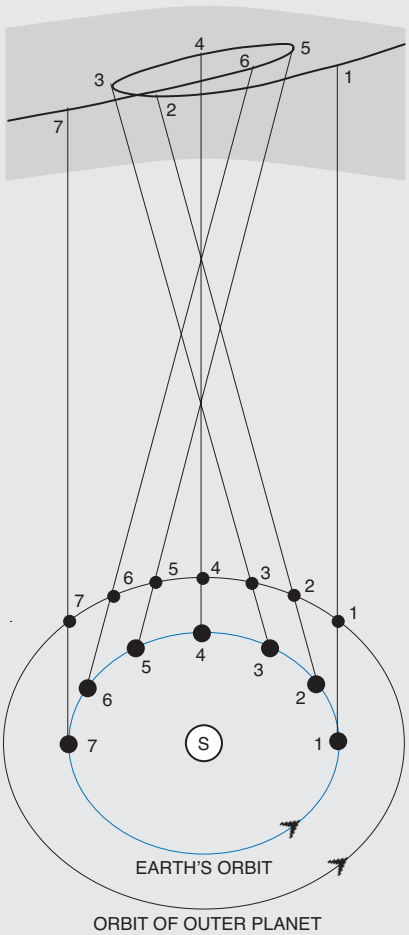
**Field of View in a Telescope**. All the satellite diagrams and finder charts in this book are drawn to correct or normal sky orientation, i.e., east to the left, and north to the top (in the sky, east and west are opposite to what is seen on terrestrial maps). Telescope systems that use an odd number of mirrors will reverse the image. The common use of star diagonals in Schmidt-Cassegrains or traditional refractors causes this reversal. Binoculars or straight Newtonians show 'normal' sky images (the Newtonian image will be upside down).

**Finder Charts**. No finder charts are presented for the Moon, Venus or Mercury. Their rapid motion during the year causes them to cover a very large section of the sky which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams (see Part I) should be sufficient to act as finders.

### RETROGRADE MOTION

The finder charts for the outer planets have one thing in common – an apparent motion with a loop shape. This only applies to the period during opposition. Note that Mars does not reach opposition every year. The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

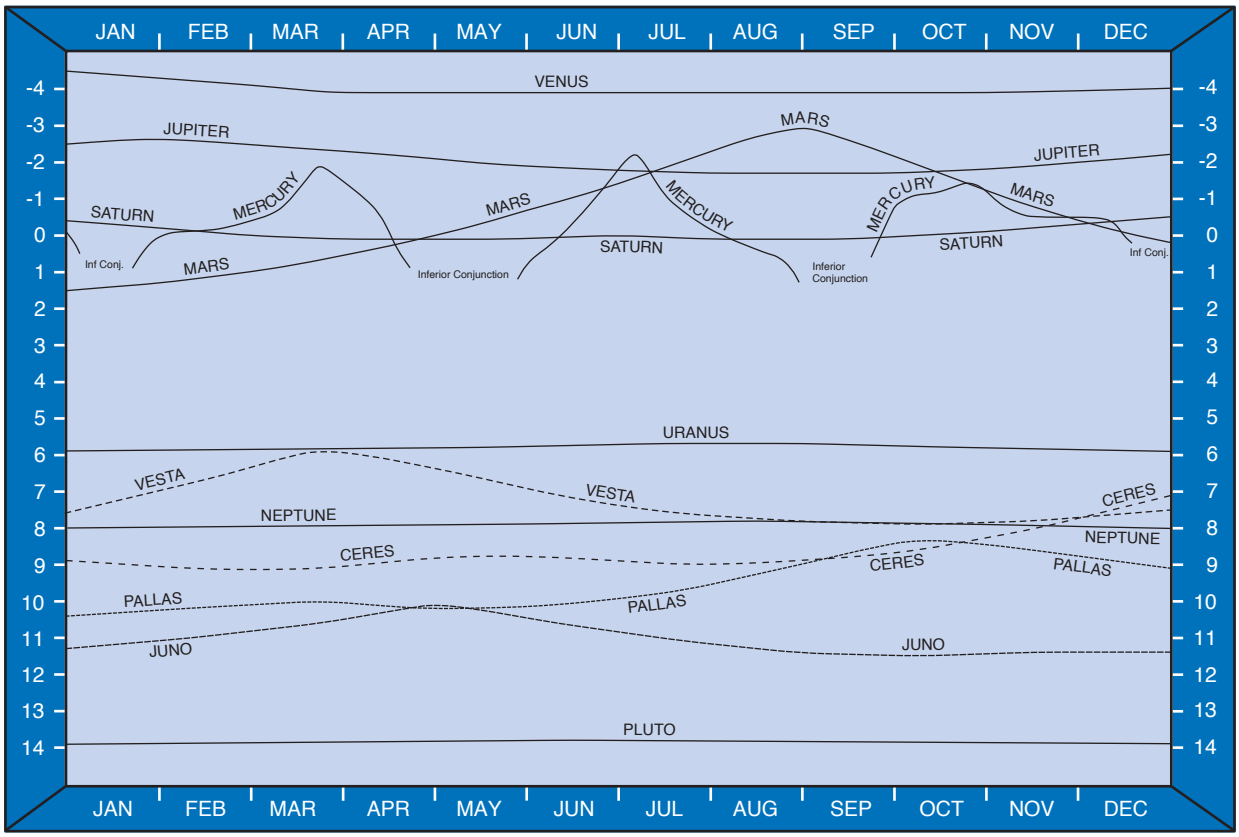
In the diagram, the shaded area represents the path of an outer planet against the celestial sphere. As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet moves from east to west instead of from west to east. At positions 1 and 2, Uranus continues its west to east path and begins to slow to position 3 as the Earth catches up. Between 3 and 5, Uranus is in retrograde motion (i.e., moving east to west) and it is at opposition (in line with the Earth and the Sun) at 4. At points 3 and 5, the planet is said to be stationary. After 5, as the Earth passes the slower planet, Uranus continues its west to east direction.



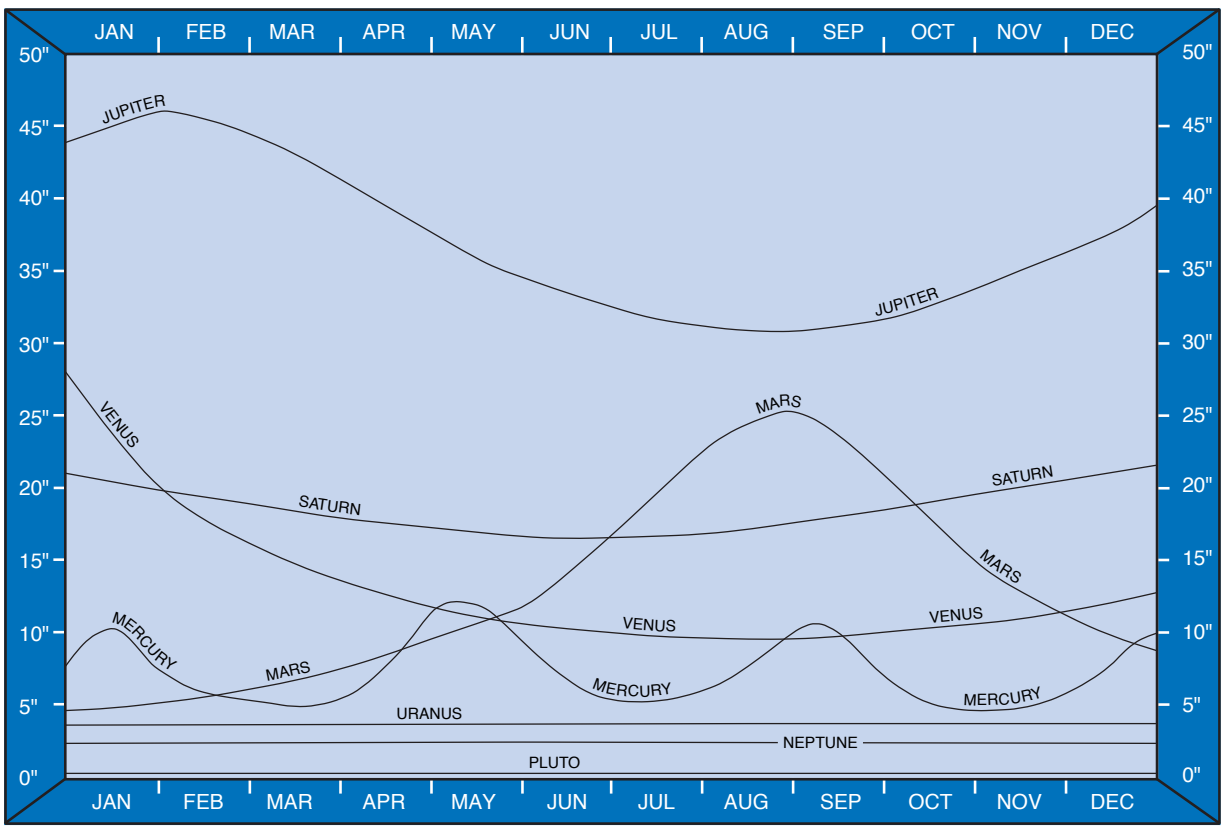

Because the orbits of the outer planets are inclined to that of the Earth's, the path can never be a straight line. It will always be a loop or an S-bend.

## MAGNITUDES of the PLANETS and MAJOR ASTEROIDS

The magnitude plot of Mercury is not shown when the planet is near inferior conjunction, as it is too close to the Sun and little of the bright side of the planet can be seen from Earth.




## PLANETARY ANGULAR SIZE



## GEOCENTRIC PHENOMENA (UT)

| Planet | Stationary | Inferior Conjunction | Stationary | Greatest Elongation West | Superior Conjunction | Greatest Elongation East |
|---|---|---|---|---|---|---|
| Mercury | Jan 2 10<br>Apr 26 22<br>Aug 28 00<br>Dec 17 13 | Jan 11 20<br>May 7 07<br>Sep 11 02<br>Dec 27 01 | Jan 22 23<br>May 19 14<br>Sep 19 13 | Feb 4 01<br>Jun 3 06<br>Sep 27 00 | Mar 22 00<br>Jul 5 10<br>Oct 25 10 | Apr 16 15<br>Aug 14 21<br>Dec 9 06 |
| Venus | | | | Jan 11 03 | Aug 18 18 | |

| Planet | Conjunction | Stationary | Opposition | Stationary | Conjunction |
|---|---|---|---|---|---|
| Mars | | Jul 30 22 | Aug 28 18 | Sep 29 14 | |
| Jupiter | | | Feb 2 09 | Apr 4 05 | Aug 22 10 |
| Saturn | | Feb 22 10 | Jun 24 14 | Oct 26 00 | Dec 31 21 |
| Uranus | Feb 17 22 | Jun 7 15 | Aug 24 10 | Nov 8 19 | |
| Neptune | Jan 31 00 | May 16 03 | Aug 4 14 | Oct 23 00 | |
| Pluto | | Mar 23 17 | Jun 9 21 | Aug 30 06 | Dec 12 05 |

| EARTH | |
|---|---|
| Perihelion | Jan 4 05 |
| Equinox | Mar 21 01:00 |
| Solstice | Jun 21 19:10 |
| Aphelion | Jul 4 06 |
| Equinox | Sep 23 10:07 |
| Solstice | Dec 22 07:04 |

## HELIOCENTRIC PHENOMENA (UT)

| Planet | Perihelion | Aphelion | Ascending Node | Greatest Latitude North | Descending Node | Greatest Latitude South |
|---|---|---|---|---|---|---|
| Mercury | Jan 6<br>Apr 4<br>Jul 1<br>Sep 27<br>Dec 24 | Feb 19<br>May 18<br>Aug 14<br>Nov 10 | Jan 1<br>Mar 30<br>Jun 26<br>Sep 22 | Jan 16<br>Apr 14<br>Jul 11<br>Oct 7 | Feb 9<br>May 7<br>Aug 3<br>Oct 30 | Mar 11<br>Jun 7<br>Sep 3<br>Nov 30 |
| Venus | Aug 10 | Apr 19<br>Nov 30 | Jul 7 | Jan 19<br>Aug 31 | Mar 16<br>Oct 26 | May 12<br>Dec 22 |
| Mars | Aug 30 | | Dec 29 | | Feb 28 | Aug 4 |
| Saturn | | | | Jul 26 | | |
| Neptune | | | | | | Aug 11 |

Jupiter, Uranus and Pluto have no events in 2003

## SOLAR SYSTEM DATA – THE PLANETS

| NAME | MEAN DISTANCE FROM SUN (x $10^3$ km) | (Earth = 1) | MAG at OPP | EQUATORIAL DIAMETER (km). | FLATTENING [1] | No of MOONS | MASS (x$10^{24}$ kg) | (Earth = 1) |
|---|---|---|---|---|---|---|---|---|
| Sun | - | | -26.8 | 1392530 | 0 | - | 1989085 | 332946 |
| Moon | - | | -12.74 [11] | 3475 | 0 | - | 0.073483 | 0.0123 |
| Mercury | 57856 | 0.387 | 0.16 [12] | 4879 | 0 | 0 | 0.33022 | 0.055 |
| Venus | 108132 | 0.723 | -4.07 [12] | 12104 | 0 | 0 | 4.8690 | 0.816 |
| Earth | 149492 | 1.000 | -3.5 [13] | 12756 | 0.00335364 | 1 | 5.9742 | 1.000 |
| Mars | 227780 | 1.524 | -2.01 | 6794 | 0.006476 | 2 | 0.64191 | 0.107 |
| Jupiter | 777776 | 5.203 | -2.70 | 142984 | 0.064874 | 39 | 1898.8 | 317.900 |
| Saturn | 1425983 | 9.540 | 0.67 | 120536 | 0.097962 | 30 | 568.50 | 95.200 |
| Uranus | 2867760 | 19.180 | 5.52 | 51118 | 0.022927 | 20 | 86.625 | 14.500 |
| Neptune | 4492800 | 30.700 | 7.84 | 49528 | 0.017081 | 8 | 102.78 | 17.400 |
| Pluto | 5745000 | 39.670 | 13.7 | 2302 | 0 | 1 | 0.015 | 0.003 |

| NAME | VOLUME (Earth = 1) | SIDEREAL PERIOD [2] | SYNODIC PERIOD (days) [3] | AXIAL ROTATION (days) [4] | ALBEDO [5] | ECCEN-TRICITY [6] | INCLINATION [7] | OBLIQUITY [8] |
|---|---|---|---|---|---|---|---|---|
| Sun | 1300000 | - | - | 25.38 [9] | - | - | - | 7° 15' [10] |
| Moon | 0.02 | 27.32 d | 29.4 | 27.32166 | 0.12 | 0.0549 | 5° 08' 40" | 6° 41' |
| Mercury | 0.06 | 87.97 d | 115.8 | 58.6462 | 0.106 | 0.20562 | 7° 00' 00" | 0° 00' |
| Venus | 0.86 | 224.7 d | 583.9 | -243.0187 | 0.65 | 0.00681 | 3° 23' 38" | 92° 00' |
| Earth | 1 | 365.256 d | - | 0.99726968 | 0.367 | 0.01681 | 0° 00' 00" | 23° 26' |
| Mars | 0.15 | 687 d | 779.8 | 1.02595675 | 0.150 | 0.09333 | 1° 51' 01" | 25° 10' |
| Jupiter | 1323 | 11.86 y | 398.8 | 0.41354 [14] | 0.52 | 0.04837 | 1° 18' 28" | 3° 07' |
| Saturn | 752 | 29.46 y | 378.0 | 0.44401 [14] | 0.47 | 0.05582 | 2° 29' 29" | 26° 45' |
| Uranus | 64 | 84.01 y | 369.7 | -0.71833 | 0.51 | 0.0471 | 0° 46' 22" | 98° 00' |
| Neptune | 54 | 164.8 y | 367.5 | 0.67125 | 0.41 | 0.00855 | 1° 46' 38" | 29° 00' |
| Pluto | 0.007 | 249.9 y | 366.7 | -6.3872 | 0.30 | 0.2486 | 17° 09' 00" | 118° 00' |

Notes:

1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
5 The ratio of the sunlight reflected to that received.
6 The measure of how long or thin the ellipse of the planet's orbit is.
7 The angle of the planet's orbit from the plane of the ecliptic.
8 The degree of inclination of the planet's equator to its orbit
9 Equatorial region (the polar areas of the Sun rotate in a period of 29 to 30 days).
10 To the ecliptic.
11 From the Earth.
12 At mean greatest elongation.
13 As seen from the Sun.
14 Based on System III rotation. Similar to systems I or II except a radio source within the planet is used as the reference point.

# SOLAR SYSTEM DATA – SATELLITES

| PLANET | SATELLITE | | ORBITAL PERIOD (days) (R=retrograde) [1] | MAX. ELONG AT MEAN OPPOSITION | SEMIMAJOR AXIS ($x10^3$ km) | ORBITAL ECCENTRICITY | INCLINATION TO PLANET'S EQUATOR (°) | MASS (1/PLANET) | RADIUS (km) | SIDEREAL PERIOD OF ROTATION (days) [4] | MAGNITUDE AT OPPOSITION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Earth | Moon | | 27.321661 | | 384.400 | 0.054900489 | 18.28-28.58 | 0.01230002 | 1737.4 | S | -12.74 |
| Mars | Phobos | I | 0.31891023 | 25" | 9.378 | 0.015 | 1.0 | $1.65x10^{-8}$ | 13.4x11.2x9.2 | S | 11.3 |
| | Deimos | II | 1.2624407 | 1' 02" | 23.459 | 0.0005 | 0.9-2.7 | $3.71x10^{-9}$ | 7.5x6.1x5.2 | S | 12.40 |
| Jupiter | Metis | XVI | 0.294780 | 0' 42" | 128 | | | $0.5x10^{-10}$ | 20 | S | 17.5 |
| | Adrastea | XV | 0.29826 | 0' 42" | 129 | | | $0.1x10^{-10}$ | 13x10x8 | S | 19.1 |
| | Amalthea | V | 0.49817905 | 0' 59" | 181 | 0.003 | 0.40 | $38x10^{-10}$ | 131x73x67 | S | 14.1 |
| | Thebe | XIV | 0.6745 | 1' 13" | 222 | 0.015 | 0.8 | $4x10^{-10}$ | 55x45 | S | 15.7 |
| | Io | I | 1.769137786 | 2' 18" | 422 | 0.004 | 0.04 | $4.70x10^{-5}$ | 1830x1819x1815 | S | 5.02 |
| | Europa | II | 3.551181041 | 3' 40" | 671 | 0.009 | 0.47 | $2.53x10^{-5}$ | 1565 | S | 5.29 |
| | Ganymede | III | 7.15455296 | 5' 51" | 1070 | 0.002 | 0.21 | $7.80x10^{-5}$ | 2634 | S | 4.61 |
| | Callisto | IV | 16.6890184 | 10' 18" | 1883 | 0.007 | 0.51 | $5.67x10^{-5}$ | 2403 | S | 5.65 |
| | Leda | XIII | 238.72 | 1° 00' 39" | 11094 | 0.14762 | 26.07 | $0.03x10^{-10}$ | 5 | | 20.2 |
| | Himalia | VI | 250.5662 | 1° 02' 46" | 11480 | 0.15798 | 27.63 | $50x10^{-10}$ | 85 | 0.4 | 14.84 |
| | Lysithea | X | 259.22 | 1° 04' 04" | 11720 | 0.107 | 29.02 | $0.4x10^{-10}$ | 12 | 0.533 | 18.4 |
| | Elara | VII | 259.6528 | 1° 04' 10" | 11737 | 0.20719 | 24.77 | $4x10^{-10}$ | 40 | | 16.77 |
| | Ananke | XII | 631. R | 1° 55' 52" | 21200 | 0.16870 | 147 | $0.2x10^{-10}$ | 10 | 0.35 | 18.9 |
| | Carme | XI | 692. R | 2° 03' 31" | 22600 | 0.20678 | 164 | $0.5x10^{-10}$ | 15 | 0.433 | 18.0 |
| | Pasiphae | VIII | 735. R | 2° 08' 26" | 23500 | 0.378 | 145 | $1x10^{-10}$ | 18 | | 17.03 |
| | Sinope | IX | 758. R | 2° 09' 31" | 23700 | 0.275 | 153 | $0.4x10^{-10}$ | 14 | 0.548 | 18.3 |
| Saturn | Pan | XVIII | 0.5750 | 0' 21" | 133.583 | | | | 10 | | |
| | Atlas | XV | 0.6019 | 0' 22" | 137.670 | 0.000 | 0.3 | | 18.5x17.2x13.5 | | 18 |
| | Prometheus | XVI | 0.6130 | 0' 23" | 139.353 | 0.003 | 0.0 | | 74x50x34 | | 16 |
| | Pandora | XVII | 0.6285 | 0' 23" | 141.700 | 0.004 | 0.0 | | 55x44x31 | | 16 |
| | Epimetheus | XI | 0.6942 | 0' 24" | 151.422 | 0.009 | 0.34 | $9.5x10^{-10}$ | 69x55x55 | S | 15 |
| | Janus | X | 0.6945 | 0' 24" | 151.472 | 0.007 | 0.14 | $3.38x10^{-9}$ | 97x95x77 | S | 14 |
| | Mimas | I | 0.942421813 | 0' 30" | 185.52 | 0.0202 | 1.53 | $6.60x10^{-8}$ | 209x196x191 | S | 12.9 |
| | Enceladus | II | 1.370217855 | 0' 38" | 238.02 | 0.00452 | 0.00 | $1x10^{-7}$ | 256x247x245 | S | 11.7 |
| | Telesto | XIII | 1.8878 | 0' 48" | 294.66 | | | | 15x12.5x7.5 | | 18.5 |
| | Tethys | III | 1.887802160 | 0' 48" | 294.66 | 0.00000 | 1.86 | $1.10x10^{-6}$ | 536x528x526 | S | 10.2 |
| | Calypso | XIV | 1.8878 | 0' 48" | 294.66 | | | | 15x8x8 | | 18.7 |
| | Helene | XII | 2.7369 | 1' 01" | 377.40 | 0.005 | 0.0 | | 18x16x15 | | 18 |
| | Dione | IV | 2.736914742 | 1' 01" | 377.40 | 0.002230 | 0.02 | $1.93x10^{-6}$ | 560 | S | 10.4 |
| | Rhea | V | 4.517500436 | 1' 25" | 527.04 | 0.00100 | 0.35 | $4.06x10^{-6}$ | 764 | S | 9.7 |
| | Titan | VI | 15.94542068 | 3' 17" | 1221.83 | 0.029192 | 0.33 | $2.37x10^{-4}$ | 2575 | S | 8.28 |
| | Hyperion | VII | 21.2766088 | 3' 59" | 1481.1 | 0.104 | 0.43 | $4x10^{-8}$ | 180x140x113 | | 14.19 |
| | Iapetus | VIII | 79.3301825 | 9' 35" | 3561.3 | 0.02828 | 14.72 | $2.8x10^{-6}$ | 718 | S | 11.1 |
| | Phoebe | IX | 550.48 R | 34' 51" | 12952 | 0.16326 | 177 [2] | $7x10^{-10}$ | 110 | 0.4 | 16.45 |
| Uranus | Cordelia | VI | 0.3350338 | 0' 04" | 49.77 | 0.00026 | 0.08 | | 13 | | 24.1 |
| | Ophelia | VII | 0.376400 | 0' 04" | 53.79 | 0.0099 | 0.10 | | 15 | | 23.8 |
| | Bianca | VIII | 0.43457899 | 0' 04" | 59.17 | 0.009 | 0.19 | | 21 | | 23.0 |
| | Cressida | IX | 0.46356960 | 0' 05" | 61.78 | 0.0004 | 0.01 | | 31 | | 22.2 |
| | Desdemona | X | 0.47364960 | 0' 05" | 62.68 | 0.00013 | 0.11 | | 27 | | 22.5 |
| | Juliet | XI | 0.49306549 | 0' 05" | 64.35 | 0.00066 | 0.07 | | 42 | | 21.5 |
| | Portia | XII | 0.51319592 | 0' 05" | 66.09 | 0.0000 | 0.06 | | 54 | | 21.0 |
| | Rosalind | XIII | 0.55845953 | 0' 05" | 69.94 | 0.0001 | 0.28 | | 27 | | 22.5 |
| | Belinda | XIV | 0.62352747 | 0' 06" | 75.26 | 0.00007 | 0.03 | | 33 | | 22.1 |
| | Puck | XV | 0.76183287 | 0' 07" | 86.01 | 0.00012 | 0.32 | | 77 | | 20.2 |
| | Miranda | V | 1.41347925 | 0' 10" | 129.39 | 0.0027 | 4.2 | $0.08x10^{-5}$ | 240x234x233 | S | 16.3 |
| | Ariel | I | 2.52037935 | 0' 14" | 191.02 | 0.0034 | 0.3 | $1.55x10^{-5}$ | 581x578x578 | S | 14.16 |
| | Umbriel | II | 4.1441772 | 0' 20" | 266.30 | 0.0050 | 0.36 | $1.35x10^{-5}$ | 585 | S | 14.81 |
| | Titania | III | 8.7058717 | 0' 33" | 435.91 | 0.0022 | 0.14 | $4.06x10^{-5}$ | 789 | S | 13.73 |
| | Oberon | IV | 13.4632389 | 0' 44" | 583.52 | 0.0008 | 0.10 | $3.47x10^{-5}$ | 761 | S | 13.94 |
| | Caliban | XVI | 579R | 8' 56" | 7,169 | 0.082 | 139.7 [2] | | 30 | | 22.4 |
| | Stephano | XX | | | 7,948 | | | | 10 | | |
| | Sycorax | XVII | 1289R | 15' 26" | 12,214 | 0.509 | 152.7 [2] | | 60 | | 20.9 |
| | Prospero | XVIII | | | 16,568 | | | | 15 | | |
| | Setebos | XIX | | | 17,681 | | | | 15 | | |
| Neptune | Naiad | III | 0.294396 | 0' 02" | 48.23 | 0.000 | 4.74 | | 29 | | 24.7 |
| | Thalassa | IV | 0.311485 | 0' 02" | 50.07 | 0.000 | 0.21 | | 40 | | 23.8 |
| | Despina | V | 0.334655 | 0' 02" | 52.53 | 0.000 | 0.07 | | 74 | | 22.6 |
| | Galatea | VI | 0.428745 | 0' 03" | 61.95 | 0.000 | 0.05 | | 79 | | 22.3 |
| | Larissa | VII | 0.554654 | 0' 03" | 73.55 | 0.00139 | 0.20 | | 104x89 | | 22.0 |
| | Proteus | VIII | 1.122315 | 0' 06" | 117.65 | 0.0004 | 0.55 | | 218x208x201 | S | 20.3 |
| | Triton | I | 5.8768541 R | 0' 17" | 354.76 | 0.000016 | 157.345 | $2.09x10^{-4}$ | 1353 | S | 13.47 |
| | Nereid | II | 360.13619 | 4' 21" | 5513.4 | 0.7512 | 27.6 [3] | $2x10^{-7}$ | 170 | | 18.7 |
| Pluto | Charon | I | 6.38725 | <1" | 19.6 | <0.001 | 99 [3] | 0.125 | 593 | S | 16.8 |

The table covers all the currently named satellites of the Solar System (as of Sep 02).
There are also a number of recently discovered, unnamed satellites.

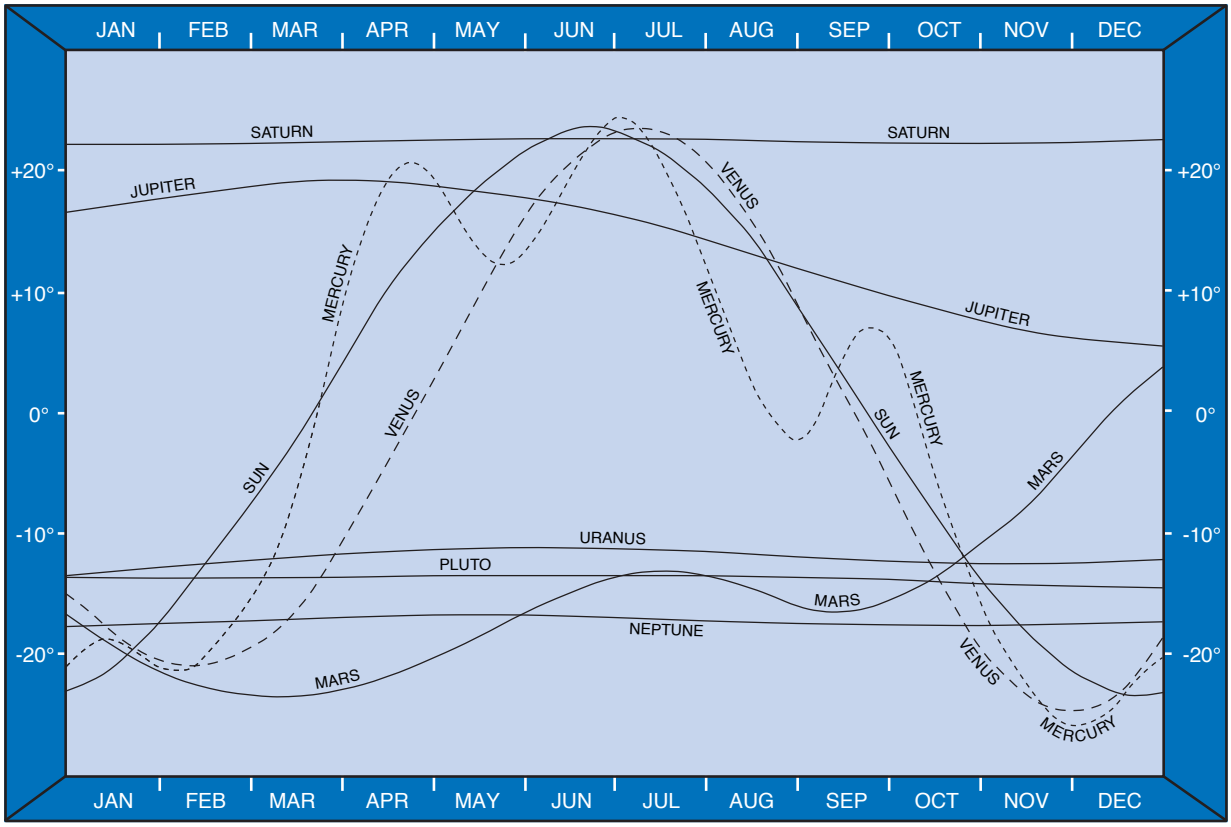
- Jupiter has an additional 23 satellites taking its total to 39.
  They are S/1975 J1, S/1999 J1, S/2000 J2 to J11 and S/2001 J1 to J11.
- Saturn has an additional 12 satellites (S/2000 S1 to S12) taking its total to 30.

These additions bring the total number of satellites for the Solar System to 101.

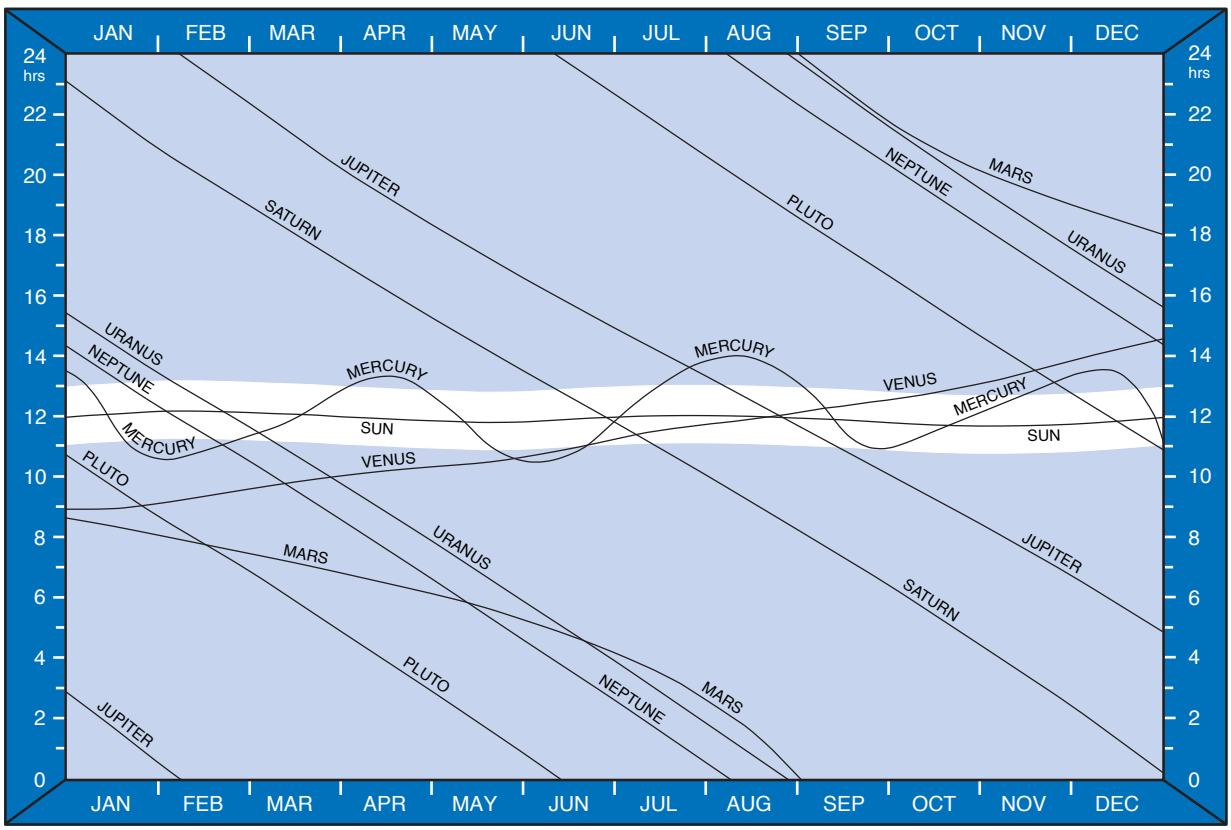
Notes:
**1** - Sidereal periods, except tropical periods are given for Saturn.
**2** - Relative to the ecliptic plane.
**3** - Referred to the equator of 1950.0
**4** - S = Synchronous, rotation period same as orbital period. i.e., keeps the same section of its surface facing its planet.

## DECLINATIONS of the SUN and PLANETS

In general, the further south a planet is (negative declination), the higher in the northern sky it is, as seen from most of Australia. The higher in the sky, the less atmosphere you have to look through and the more stable the image is (less prone to turbulence). This can be particularly relevant when trying to observe a planet under high magnification.




## MERIDIAN PASSAGE of the SUN and PLANETS




The time of meridian passage for a planet is when it is due north and at its highest point in the sky. For the outer planets this is certainly looked upon as the best time to observe when you are looking through the least amount of atmosphere. The time for the Sun is close to midday (12hrs). When a planet crosses from the bottom of the diagram (0 hours) to the top (24 hours) it is at opposition and visible the whole night.

# SUN

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " |
| 1 | 18 43 58 | - 23 03 15 | 20 56 30 | - 17 17 13 | 22 45 56 | - 07 50 22 | 00 39 47 | + 04 16 54 | 02 31 06 | + 14 52 22 | 04 33 47 | + 21 57 38 |
| 2 | 18 48 23 | - 22 58 23 | 21 00 35 | - 17 00 12 | 22 49 41 | - 07 27 35 | 00 43 25 | + 04 40 05 | 02 34 55 | + 15 10 34 | 04 37 53 | + 22 05 51 |
| 3 | 18 52 48 | - 22 53 03 | 21 04 39 | - 16 42 52 | 22 53 26 | - 07 04 41 | 00 47 04 | + 05 03 10 | 02 38 45 | + 15 28 31 | 04 41 59 | + 22 13 41 |
| 4 | 18 57 12 | - 22 47 16 | 21 08 42 | - 16 25 15 | 22 57 10 | - 06 41 42 | 00 50 43 | + 05 26 11 | 02 42 35 | + 15 46 12 | 04 46 05 | + 22 21 08 |
| 5 | 19 01 36 | - 22 41 02 | 21 12 44 | - 16 07 21 | 23 00 54 | - 06 18 36 | 00 54 22 | + 05 49 05 | 02 46 26 | + 16 03 38 | 04 50 12 | + 22 28 11 |
| 6 | 19 06 00 | - 22 34 21 | 21 16 46 | - 15 49 11 | 23 04 37 | - 05 55 26 | 00 58 02 | + 06 11 53 | 02 50 17 | + 16 20 48 | 04 54 19 | + 22 34 50 |
| 7 | 19 10 23 | - 22 27 13 | 21 20 47 | - 15 30 44 | 23 08 20 | - 05 32 10 | 01 01 41 | + 06 34 35 | 02 54 09 | + 16 37 42 | 04 58 26 | + 22 41 06 |
| 8 | 19 14 45 | - 22 19 38 | 21 24 46 | - 15 12 01 | 23 12 02 | - 05 08 51 | 01 05 21 | + 06 57 10 | 02 58 02 | + 16 54 19 | 05 02 34 | + 22 46 57 |
| 9 | 19 19 07 | - 22 11 37 | 21 28 46 | - 14 53 03 | 23 15 44 | - 04 45 27 | 01 09 01 | + 07 19 38 | 03 01 55 | + 17 10 38 | 05 06 42 | + 22 52 25 |
| 10 | 19 23 29 | - 22 03 10 | 21 32 44 | - 14 33 50 | 23 19 25 | - 04 21 59 | 01 12 41 | + 07 41 58 | 03 05 49 | + 17 26 41 | 05 10 50 | + 22 57 28 |
| 11 | 19 27 50 | - 21 54 18 | 21 36 41 | - 14 14 22 | 23 23 07 | - 03 58 29 | 01 16 21 | + 08 04 11 | 03 09 43 | + 17 42 26 | 05 14 58 | + 23 02 07 |
| 12 | 19 32 10 | - 21 44 59 | 21 40 38 | - 13 54 40 | 23 26 47 | - 03 34 55 | 01 20 02 | + 08 26 15 | 03 13 37 | + 17 57 53 | 05 19 07 | + 23 06 22 |
| 13 | 19 36 30 | - 21 35 15 | 21 44 34 | - 13 34 45 | 23 30 28 | - 03 11 19 | 01 23 43 | + 08 48 10 | 03 17 33 | + 18 13 01 | 05 23 16 | + 23 10 13 |
| 14 | 19 40 49 | - 21 25 07 | 21 48 29 | - 13 14 36 | 23 34 08 | - 02 47 41 | 01 27 24 | + 09 09 57 | 03 21 29 | + 18 27 52 | 05 27 25 | + 23 13 39 |
| 15 | 19 45 07 | - 21 14 33 | 21 52 24 | - 12 54 14 | 23 37 48 | - 02 24 02 | 01 31 05 | + 09 31 34 | 03 25 25 | + 18 42 23 | 05 31 34 | + 23 16 40 |
| 16 | 19 49 25 | - 21 03 35 | 21 56 17 | - 12 33 40 | 23 41 28 | - 02 00 21 | 01 34 47 | + 09 53 02 | 03 29 22 | + 18 56 36 | 05 35 43 | + 23 19 17 |
| 17 | 19 53 42 | - 20 52 13 | 22 00 10 | - 12 12 54 | 23 45 07 | - 01 36 39 | 01 38 29 | + 10 14 20 | 03 33 19 | + 19 10 29 | 05 39 52 | + 23 21 29 |
| 18 | 19 57 59 | - 20 40 27 | 22 04 03 | - 11 51 56 | 23 48 47 | - 01 12 57 | 01 42 12 | + 10 35 27 | 03 37 17 | + 19 24 03 | 05 44 02 | + 23 23 16 |
| 19 | 20 02 14 | - 20 28 18 | 22 07 54 | - 11 30 47 | 23 52 26 | - 00 49 14 | 01 45 55 | + 10 56 25 | 03 41 16 | + 19 37 17 | 05 48 11 | + 23 24 39 |
| 20 | 20 06 29 | - 20 15 45 | 22 11 45 | - 11 09 27 | 23 56 04 | - 00 25 31 | 01 49 38 | + 11 17 11 | 03 45 15 | + 19 50 12 | 05 52 21 | + 23 25 37 |
| 21 | 20 10 44 | - 20 02 50 | 22 15 35 | - 10 47 57 | 23 59 43 | - 00 01 49 | 01 53 22 | + 11 37 47 | 03 49 15 | + 20 02 46 | 05 56 30 | + 23 26 10 |
| 22 | 20 14 57 | - 19 49 32 | 22 19 25 | - 10 26 16 | 00 03 22 | + 00 21 53 | 01 57 06 | + 11 58 11 | 03 53 15 | + 20 14 59 | 06 00 40 | + 23 26 19 |
| 23 | 20 19 10 | - 19 35 52 | 22 23 14 | - 10 04 26 | 00 07 00 | + 00 45 33 | 02 00 51 | + 12 18 23 | 03 57 16 | + 20 26 52 | 06 04 50 | + 23 26 03 |
| 24 | 20 23 22 | - 19 21 50 | 22 27 03 | - 09 42 26 | 00 10 39 | + 01 09 13 | 02 04 36 | + 12 38 24 | 04 01 18 | + 20 38 24 | 06 08 59 | + 23 25 22 |
| 25 | 20 27 33 | - 19 07 27 | 22 30 50 | - 09 20 18 | 00 14 17 | + 01 32 50 | 02 08 22 | + 12 58 12 | 04 05 20 | + 20 49 35 | 06 13 09 | + 23 24 16 |
| 26 | 20 31 43 | - 18 52 42 | 22 34 38 | - 08 58 01 | 00 17 56 | + 01 56 26 | 02 12 08 | + 13 17 47 | 04 09 22 | + 21 00 25 | 06 17 18 | + 23 22 45 |
| 27 | 20 35 53 | - 18 37 37 | 22 38 24 | - 08 35 35 | 00 21 34 | + 02 19 59 | 02 15 54 | + 13 37 09 | 04 13 25 | + 21 10 52 | 06 21 27 | + 23 20 50 |
| 28 | 20 40 02 | - 18 22 12 | 22 42 10 | - 08 13 03 | 00 25 13 | + 02 43 29 | 02 19 41 | + 13 56 18 | 04 17 28 | + 21 20 58 | 06 25 36 | + 23 18 30 |
| 29 | 20 44 10 | - 18 06 26 | | | 00 28 51 | + 03 06 56 | 02 23 29 | + 14 15 14 | 04 21 32 | + 21 30 42 | 06 29 45 | + 23 15 46 |
| 30 | 20 48 17 | - 17 50 21 | | | 00 32 30 | + 03 30 19 | 02 27 17 | + 14 33 55 | 04 25 37 | + 21 40 03 | 06 33 54 | + 23 12 37 |
| 31 | 20 52 24 | - 17 33 57 | | | 00 36 08 | + 03 53 39 | | | 04 29 42 | + 21 49 02 | | |

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 06 38 03 | + 23 09 03 | 08 42 58 | + 18 11 03 | 10 39 06 | + 08 31 26 | 12 27 03 | - 02 55 22 | 14 22 56 | - 14 12 31 | 16 26 17 | - 21 41 33 |
| 2 | 06 42 11 | + 23 05 05 | 08 46 51 | + 17 56 00 | 10 42 44 | + 08 09 42 | 12 30 40 | - 03 18 39 | 14 26 51 | - 14 31 47 | 16 30 36 | - 21 50 58 |
| 3 | 06 46 19 | + 23 00 43 | 08 50 44 | + 17 40 39 | 10 46 21 | + 07 47 50 | 12 34 18 | - 03 41 54 | 14 30 46 | - 14 50 48 | 16 34 55 | - 21 59 57 |
| 4 | 06 50 27 | + 22 55 57 | 08 54 36 | + 17 25 02 | 10 49 58 | + 07 25 51 | 12 37 55 | - 04 05 06 | 14 34 43 | - 15 09 35 | 16 39 15 | - 22 08 31 |
| 5 | 06 54 34 | + 22 50 47 | 08 58 27 | + 17 09 07 | 10 53 35 | + 07 03 45 | 12 41 33 | - 04 28 15 | 14 38 40 | - 15 28 07 | 16 43 35 | - 22 16 39 |
| 6 | 06 58 41 | + 22 45 13 | 09 02 17 | + 16 52 56 | 10 57 11 | + 06 41 31 | 12 45 12 | - 04 51 20 | 14 42 38 | - 15 46 23 | 16 47 57 | - 22 24 21 |
| 7 | 07 02 48 | + 22 39 16 | 09 06 07 | + 16 36 28 | 11 00 48 | + 06 19 12 | 12 48 51 | - 05 14 22 | 14 46 36 | - 16 04 24 | 16 52 18 | - 22 31 37 |
| 8 | 07 06 54 | + 22 32 54 | 09 09 57 | + 16 19 45 | 11 04 24 | + 05 56 46 | 12 52 30 | - 05 37 20 | 14 50 36 | - 16 22 09 | 16 56 40 | - 22 38 27 |
| 9 | 07 11 00 | + 22 26 10 | 09 13 46 | + 16 02 45 | 11 08 00 | + 05 34 14 | 12 56 09 | - 06 00 13 | 14 54 36 | - 16 39 37 | 17 01 03 | - 22 44 50 |
| 10 | 07 15 05 | + 22 19 02 | 09 17 34 | + 15 45 31 | 11 11 35 | + 05 11 37 | 12 59 49 | - 06 23 02 | 14 58 38 | - 16 56 49 | 17 05 26 | - 22 50 46 |
| 11 | 07 19 10 | + 22 11 31 | 09 21 21 | + 15 28 01 | 11 15 11 | + 04 48 55 | 13 03 30 | - 06 45 45 | 15 02 40 | - 17 13 43 | 17 09 50 | - 22 56 16 |
| 12 | 07 23 15 | + 22 03 37 | 09 25 08 | + 15 10 17 | 11 18 46 | + 04 26 08 | 13 07 10 | - 07 08 23 | 15 06 43 | - 17 30 19 | 17 14 14 | - 23 01 18 |
| 13 | 07 27 19 | + 21 55 21 | 09 28 55 | + 14 52 18 | 11 22 22 | + 04 03 16 | 13 10 52 | - 07 30 55 | 15 10 46 | - 17 46 38 | 17 18 38 | - 23 05 53 |
| 14 | 07 31 23 | + 21 46 42 | 09 32 41 | + 14 34 05 | 11 25 57 | + 03 40 19 | 13 14 34 | - 07 53 22 | 15 14 51 | - 18 02 38 | 17 23 03 | - 23 10 00 |
| 15 | 07 35 26 | + 21 37 41 | 09 36 26 | + 14 15 38 | 11 29 32 | + 03 17 19 | 13 18 16 | - 08 15 41 | 15 18 57 | - 18 18 19 | 17 27 28 | - 23 13 40 |
| 16 | 07 39 29 | + 21 28 18 | 09 40 11 | + 13 56 57 | 11 33 07 | + 02 54 15 | 13 21 59 | - 08 37 54 | 15 23 03 | - 18 33 41 | 17 31 53 | - 23 16 53 |
| 17 | 07 43 31 | + 21 18 32 | 09 43 55 | + 13 38 03 | 11 36 42 | + 02 31 08 | 13 25 43 | - 09 00 00 | 15 27 10 | - 18 48 44 | 17 36 19 | - 23 19 37 |
| 18 | 07 47 33 | + 21 08 26 | 09 47 39 | + 13 18 56 | 11 40 17 | + 02 07 58 | 13 29 27 | - 09 21 58 | 15 31 18 | - 19 03 26 | 17 40 44 | - 23 21 53 |
| 19 | 07 51 34 | + 20 57 57 | 09 51 22 | + 12 59 37 | 11 43 53 | + 01 44 44 | 13 33 12 | - 09 43 48 | 15 35 27 | - 19 17 48 | 17 45 10 | - 23 23 42 |
| 20 | 07 55 34 | + 20 47 08 | 09 55 05 | + 12 40 05 | 11 47 28 | + 01 21 29 | 13 36 57 | - 10 05 30 | 15 39 37 | - 19 31 50 | 17 49 37 | - 23 25 02 |
| 21 | 07 59 34 | + 20 35 57 | 09 58 47 | + 12 20 20 | 11 51 03 | + 00 58 11 | 13 40 43 | - 10 27 03 | 15 43 48 | - 19 45 31 | 17 54 03 | - 23 25 54 |
| 22 | 08 03 34 | + 20 24 26 | 10 02 29 | + 12 00 24 | 11 54 38 | + 00 34 52 | 13 44 30 | - 10 48 27 | 15 47 59 | - 19 58 50 | 17 58 30 | - 23 26 18 |
| 23 | 08 07 33 | + 20 12 34 | 10 06 11 | + 11 40 17 | 11 58 14 | + 00 11 31 | 13 48 17 | - 11 09 41 | 15 52 11 | - 20 11 47 | 18 02 56 | - 23 26 14 |
| 24 | 08 11 32 | + 20 00 21 | 10 09 52 | + 11 19 58 | 12 01 49 | - 00 11 51 | 13 52 05 | - 11 30 46 | 15 56 25 | - 20 24 22 | 18 07 23 | - 23 25 41 |
| 25 | 08 15 29 | + 19 47 49 | 10 13 33 | + 10 59 29 | 12 05 25 | - 00 35 13 | 13 55 54 | - 11 51 40 | 16 00 38 | - 20 36 34 | 18 11 49 | - 23 24 40 |
| 26 | 08 19 27 | + 19 34 57 | 10 17 13 | + 10 38 49 | 12 09 01 | - 00 58 36 | 13 59 44 | - 12 12 23 | 16 04 53 | - 20 48 23 | 18 16 15 | - 23 23 11 |
| 27 | 08 23 23 | + 19 21 45 | 10 20 53 | + 10 17 58 | 12 12 37 | - 01 21 59 | 14 03 34 | - 12 32 55 | 16 09 08 | - 20 59 49 | 18 20 42 | - 23 21 13 |
| 28 | 08 27 20 | + 19 08 14 | 10 24 32 | + 09 56 58 | 12 16 13 | - 01 45 22 | 14 07 25 | - 12 53 15 | 16 13 24 | - 21 10 52 | 18 25 08 | - 23 18 47 |
| 29 | 08 31 15 | + 18 54 24 | 10 28 11 | + 09 35 49 | 12 19 50 | - 02 08 43 | 14 11 17 | - 13 13 23 | 16 17 41 | - 21 21 30 | 18 29 34 | - 23 15 54 |
| 30 | 08 35 10 | + 18 40 15 | 10 31 50 | + 09 14 30 | 12 23 26 | - 02 32 04 | 14 15 09 | - 13 33 19 | 16 21 59 | - 21 31 44 | 18 34 00 | - 23 12 32 |
| 31 | 08 39 04 | + 18 25 48 | 10 35 28 | + 08 53 02 | | | 14 19 02 | - 13 53 02 | | | 18 38 25 | - 23 08 42 |

# SUN RISE, SUN SET AND ASTRONOMICAL TWILIGHT

**Brisbane and Canberra EST  Adelaide and Darwin CST**

| | ADELAIDE | | | | BRISBANE | | | | CANBERRA | | | | DARWIN | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TWI | SUN | | TWI | TWI | SUN | | TWI | TWI | SUN | | TWI | TWI | SUN | | TWI | |
| | BEG | RISE | SET | END | BEG | RISE | SET | END | BEG | RISE | SET | END | BEG | RISE | SET | END | |
| | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | |
| Jan 4 | 03:21 | 05:07 | 19:33 | 21:19 | 03:26 | 04:58 | 18:47 | 20:19 | 03:08 | 04:54 | 19:22 | 21:08 | 05:08 | 06:26 | 19:16 | 20:35 | Jan 4 |
| 11 | 03:29 | 05:13 | 19:33 | 21:17 | 03:32 | 05:03 | 18:48 | 20:19 | 03:16 | 05:00 | 19:22 | 21:06 | 05:13 | 06:30 | 19:18 | 20:36 | 11 |
| 18 | 03:38 | 05:20 | 19:31 | 21:13 | 03:39 | 05:09 | 18:47 | 20:17 | 03:25 | 05:07 | 19:20 | 21:02 | 05:17 | 06:34 | 19:19 | 20:36 | 18 |
| 25 | 03:48 | 05:27 | 19:28 | 21:07 | 03:47 | 05:14 | 18:46 | 20:13 | 03:34 | 05:14 | 19:17 | 20:56 | 05:22 | 06:38 | 19:20 | 20:36 | 25 |
| Feb 1 | 03:58 | 05:34 | 19:23 | 20:59 | 03:54 | 05:20 | 18:42 | 20:08 | 03:44 | 05:22 | 19:12 | 20:49 | 05:26 | 06:41 | 19:19 | 20:34 | Feb 1 |
| 8 | 04:07 | 05:41 | 19:17 | 20:51 | 04:01 | 05:26 | 18:38 | 20:02 | 03:54 | 05:29 | 19:06 | 20:40 | 05:30 | 06:44 | 19:18 | 20:32 | 8 |
| 15 | 04:17 | 05:48 | 19:10 | 20:42 | 04:08 | 05:31 | 18:33 | 19:56 | 04:04 | 05:36 | 18:59 | 20:30 | 05:33 | 06:46 | 19:16 | 20:29 | 15 |
| 22 | 04:26 | 05:55 | 19:02 | 20:32 | 04:14 | 05:36 | 18:27 | 19:48 | 04:13 | 05:43 | 18:51 | 20:20 | 05:35 | 06:48 | 19:13 | 20:25 | 22 |
| Mar 1 | 04:34 | 06:02 | 18:54 | 20:21 | 04:20 | 05:40 | 18:20 | 19:40 | 04:21 | 05:49 | 18:42 | 20:10 | 05:37 | 06:49 | 19:09 | 20:21 | Mar 1 |
| 8 | 04:42 | 06:08 | 18:44 | 20:11 | 04:25 | 05:44 | 18:13 | 19:32 | 04:29 | 05:56 | 18:33 | 19:59 | 05:39 | 06:50 | 19:05 | 20:16 | 8 |
| 15 | 04:49 | 06:14 | 18:35 | 20:00 | 04:30 | 05:48 | 18:05 | 19:24 | 04:36 | 06:02 | 18:23 | 19:48 | 05:40 | 06:50 | 19:01 | 20:12 | 15 |
| 22 | 04:55 | 06:20 | 18:25 | 19:49 | 04:34 | 05:52 | 17:58 | 19:15 | 04:43 | 06:07 | 18:13 | 19:38 | 05:40 | 06:51 | 18:57 | 20:07 | 22 |
| 29 | 05:01 | 06:25 | 18:15 | 19:39 | 04:38 | 05:56 | 17:50 | 19:07 | 04:49 | 06:13 | 18:03 | 19:28 | 05:41 | 06:51 | 18:52 | 20:02 | 29 |
| Apr 5 | 05:07 | 06:31 | 18:06 | 19:30 | 04:42 | 05:59 | 17:42 | 19:00 | 04:54 | 06:19 | 17:54 | 19:18 | 05:41 | 06:51 | 18:48 | 19:58 | Apr 5 |
| 12 | 05:12 | 06:36 | 17:56 | 19:20 | 04:45 | 06:03 | 17:35 | 18:52 | 05:00 | 06:24 | 17:44 | 19:08 | 05:41 | 06:52 | 18:43 | 19:54 | 12 |
| 19 | 05:17 | 06:42 | 17:47 | 19:12 | 04:48 | 06:06 | 17:28 | 18:46 | 05:05 | 06:30 | 17:35 | 19:00 | 05:41 | 06:52 | 18:40 | 19:51 | 19 |
| 26 | 05:22 | 06:47 | 17:39 | 19:04 | 04:51 | 06:10 | 17:21 | 18:40 | 05:10 | 06:36 | 17:27 | 18:52 | 05:41 | 06:53 | 18:36 | 19:48 | 26 |
| May 3 | 05:27 | 06:53 | 17:32 | 18:58 | 04:55 | 06:14 | 17:15 | 18:35 | 05:15 | 06:41 | 17:19 | 18:46 | 05:42 | 06:54 | 18:33 | 19:46 | May 3 |
| 10 | 05:31 | 06:58 | 17:25 | 18:52 | 04:58 | 06:18 | 17:10 | 18:31 | 05:20 | 06:47 | 17:13 | 18:40 | 05:42 | 06:55 | 18:31 | 19:44 | 10 |
| 17 | 05:36 | 07:04 | 17:20 | 18:47 | 05:01 | 06:22 | 17:06 | 18:27 | 05:24 | 06:52 | 17:07 | 18:35 | 05:43 | 06:57 | 18:29 | 19:43 | 17 |
| 24 | 05:40 | 07:09 | 17:15 | 18:44 | 05:04 | 06:26 | 17:03 | 18:25 | 05:28 | 06:57 | 17:03 | 18:32 | 05:44 | 06:59 | 18:28 | 19:43 | 24 |
| 31 | 05:44 | 07:13 | 17:12 | 18:42 | 05:07 | 06:29 | 17:01 | 18:24 | 05:32 | 07:02 | 17:00 | 18:30 | 05:46 | 07:01 | 18:28 | 19:43 | 31 |
| Jun 7 | 05:47 | 07:18 | 17:11 | 18:41 | 05:10 | 06:33 | 17:00 | 18:23 | 05:36 | 07:06 | 16:58 | 18:28 | 05:47 | 07:03 | 18:28 | 19:44 | Jun 7 |
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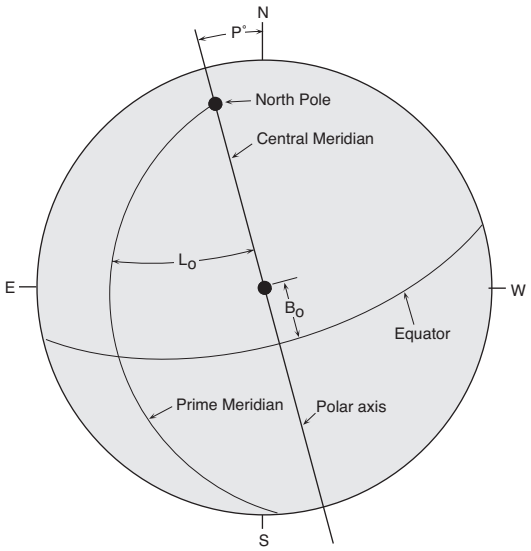
| 21 | 05:52 | 07:23 | 17:11 | 18:42 | 05:14 | 06:37 | 17:02 | 18:25 | 05:41 | 07:12 | 16:58 | 18:29 | 05:50 | 07:06 | 18:30 | 19:46 | 21 |
| 28 | 05:53 | 07:24 | 17:13 | 18:44 | 05:15 | 06:39 | 17:03 | 18:27 | 05:42 | 07:13 | 17:00 | 18:31 | 05:52 | 07:08 | 18:32 | 19:48 | 28 |
| Jul 5 | 05:54 | 07:24 | 17:16 | 18:46 | 05:16 | 06:39 | 17:06 | 18:29 | 05:42 | 07:13 | 17:03 | 18:34 | 05:53 | 07:09 | 18:34 | 19:49 | Jul 5 |
| 12 | 05:53 | 07:22 | 17:20 | 18:50 | 05:15 | 06:38 | 17:09 | 18:32 | 05:41 | 07:11 | 17:07 | 18:37 | 05:54 | 07:09 | 18:36 | 19:51 | 12 |
| 19 | 05:51 | 07:19 | 17:24 | 18:53 | 05:14 | 06:36 | 17:12 | 18:34 | 05:39 | 07:08 | 17:12 | 18:41 | 05:54 | 07:08 | 18:37 | 19:52 | 19 |
| 26 | 05:47 | 07:15 | 17:29 | 18:57 | 05:12 | 06:33 | 17:16 | 18:37 | 05:36 | 07:04 | 17:16 | 18:45 | 05:53 | 07:07 | 18:39 | 19:53 | 26 |
| Aug 2 | 05:43 | 07:10 | 17:34 | 19:01 | 05:09 | 06:29 | 17:20 | 18:40 | 05:31 | 06:58 | 17:22 | 18:49 | 05:52 | 07:06 | 18:40 | 19:54 | Aug 2 |
| 9 | 05:37 | 07:03 | 17:39 | 19:05 | 05:05 | 06:24 | 17:23 | 18:43 | 05:25 | 06:52 | 17:27 | 18:53 | 05:51 | 07:03 | 18:41 | 19:54 | 9 |
| 16 | 05:30 | 06:56 | 17:44 | 19:10 | 04:59 | 06:18 | 17:27 | 18:46 | 05:19 | 06:44 | 17:32 | 18:58 | 05:48 | 07:00 | 18:42 | 19:54 | 16 |
| 23 | 05:23 | 06:47 | 17:50 | 19:14 | 04:53 | 06:12 | 17:30 | 18:48 | 05:11 | 06:36 | 17:37 | 19:02 | 05:45 | 06:56 | 18:43 | 19:54 | 23 |
| 30 | 05:14 | 06:38 | 17:55 | 19:19 | 04:47 | 06:05 | 17:33 | 18:51 | 05:02 | 06:27 | 17:42 | 19:07 | 05:41 | 06:52 | 18:43 | 19:54 | 30 |
| Sep 6 | 05:05 | 06:29 | 18:00 | 19:24 | 04:39 | 05:57 | 17:37 | 18:54 | 04:53 | 06:17 | 17:47 | 19:12 | 05:37 | 06:48 | 18:43 | 19:53 | Sep 6 |
| 13 | 04:55 | 06:19 | 18:05 | 19:29 | 04:32 | 05:49 | 17:40 | 18:57 | 04:43 | 06:07 | 17:53 | 19:17 | 05:33 | 06:43 | 18:43 | 19:53 | 13 |
| 20 | 04:45 | 06:09 | 18:10 | 19:34 | 04:23 | 05:41 | 17:43 | 19:00 | 04:33 | 05:57 | 17:58 | 19:22 | 05:28 | 06:38 | 18:43 | 19:53 | 20 |
| 27 | 04:34 | 05:59 | 18:15 | 19:40 | 04:15 | 05:33 | 17:46 | 19:04 | 04:22 | 05:47 | 18:03 | 19:28 | 05:23 | 06:33 | 18:43 | 19:53 | 27 |
| Oct 4 | 04:23 | 05:49 | 18:20 | 19:46 | 04:06 | 05:25 | 17:49 | 19:08 | 04:11 | 05:37 | 18:08 | 19:35 | 05:18 | 06:29 | 18:43 | 19:53 | Oct 4 |
| 11 | 04:12 | 05:39 | 18:26 | 19:53 | 03:58 | 05:17 | 17:53 | 19:13 | 04:00 | 05:27 | 18:14 | 19:42 | 05:13 | 06:24 | 18:43 | 19:54 | 11 |
| 18 | 04:02 | 05:30 | 18:32 | 20:01 | 03:49 | 05:10 | 17:57 | 19:18 | 03:49 | 05:18 | 18:20 | 19:49 | 05:09 | 06:20 | 18:44 | 19:56 | 18 |
| 25 | 03:51 | 05:22 | 18:38 | 20:09 | 03:41 | 05:03 | 18:01 | 19:23 | 03:39 | 05:09 | 18:26 | 19:58 | 05:04 | 06:17 | 18:45 | 19:58 | 25 |
| Nov 1 | 03:41 | 05:14 | 18:45 | 20:18 | 03:34 | 04:57 | 18:06 | 19:30 | 03:29 | 05:02 | 18:33 | 20:07 | 05:01 | 06:14 | 18:47 | 20:00 | Nov 1 |
| 8 | 03:32 | 05:08 | 18:51 | 20:27 | 03:28 | 04:53 | 18:11 | 19:36 | 03:19 | 04:55 | 18:40 | 20:16 | 04:58 | 06:12 | 18:49 | 20:03 | 8 |
| 15 | 03:24 | 05:02 | 18:58 | 20:36 | 03:22 | 04:49 | 18:16 | 19:43 | 03:11 | 04:50 | 18:47 | 20:25 | 04:55 | 06:11 | 18:51 | 20:07 | 15 |
| 22 | 03:18 | 04:58 | 19:05 | 20:46 | 03:18 | 04:46 | 18:22 | 19:51 | 03:04 | 04:45 | 18:54 | 20:35 | 04:54 | 06:11 | 18:55 | 20:11 | 22 |
| 29 | 03:13 | 04:55 | 19:12 | 20:55 | 03:15 | 04:45 | 18:27 | 19:58 | 02:59 | 04:43 | 19:01 | 20:44 | 04:54 | 06:11 | 18:58 | 20:16 | 29 |
| Dec 6 | 03:10 | 04:54 | 19:18 | 21:03 | 03:14 | 04:45 | 18:33 | 20:04 | 02:56 | 04:42 | 19:07 | 20:53 | 04:55 | 06:13 | 19:02 | 20:20 | Dec 6 |
| 13 | 03:09 | 04:55 | 19:24 | 21:10 | 03:14 | 04:46 | 18:37 | 20:10 | 02:55 | 04:42 | 19:12 | 21:00 | 04:57 | 06:15 | 19:06 | 20:24 | 13 |
| 20 | 03:10 | 04:57 | 19:28 | 21:15 | 03:16 | 04:49 | 18:42 | 20:14 | 02:57 | 04:45 | 19:17 | 21:05 | 04:59 | 06:18 | 19:10 | 20:28 | 20 |
| 27 | 03:14 | 05:01 | 19:31 | 21:18 | 03:20 | 04:52 | 18:45 | 20:17 | 03:01 | 04:48 | 19:20 | 21:08 | 05:03 | 06:22 | 19:13 | 20:32 | 27 |

# SUN RISE, SUN SET AND ASTRONOMICAL TWILIGHT

**Hobart, Melbourne and Sydney EST  Perth WST**

| | HOBART | | | | MELBOURNE | | | | PERTH | | | | SYDNEY | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TWI | SUN | | TWI | TWI | SUN | | TWI | TWI | SUN | | TWI | TWI | SUN | | TWI | |
| | BEG | RISE | SET | END | BEG | RISE | SET | END | BEG | RISE | SET | END | BEG | RISE | SET | END | |
| | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | |
| Jan 4 | 02:24 | 04:39 | 19:53 | 22:06 | 03:10 | 05:03 | 19:46 | 21:39 | 03:37 | 05:16 | 19:26 | 21:05 | 03:06 | 04:49 | 19:10 | 20:53 | Jan 4 |
| 11 | 02:35 | 04:46 | 19:51 | 22:01 | 03:18 | 05:10 | 19:45 | 21:36 | 03:44 | 05:22 | 19:27 | 21:04 | 03:14 | 04:55 | 19:10 | 20:51 | 11 |
| 18 | 02:48 | 04:54 | 19:48 | 21:53 | 03:28 | 05:17 | 19:43 | 21:31 | 03:52 | 05:28 | 19:25 | 21:01 | 03:22 | 05:02 | 19:08 | 20:47 | 18 |
| 25 | 03:02 | 05:03 | 19:43 | 21:43 | 03:39 | 05:25 | 19:39 | 21:24 | 04:01 | 05:34 | 19:23 | 20:56 | 03:31 | 05:09 | 19:05 | 20:42 | 25 |
| Feb 1 | 03:17 | 05:12 | 19:36 | 21:31 | 03:51 | 05:33 | 19:34 | 21:15 | 04:09 | 05:41 | 19:19 | 20:50 | 03:41 | 05:16 | 19:01 | 20:35 | Feb 1 |
| 8 | 03:31 | 05:22 | 19:28 | 21:18 | 04:02 | 05:41 | 19:27 | 21:06 | 04:18 | 05:48 | 19:14 | 20:43 | 03:50 | 05:23 | 18:55 | 20:27 | 8 |
| 15 | 03:44 | 05:31 | 19:18 | 21:05 | 04:12 | 05:49 | 19:19 | 20:55 | 04:26 | 05:54 | 19:07 | 20:34 | 03:59 | 05:29 | 18:48 | 20:18 | 15 |
| 22 | 03:57 | 05:41 | 19:08 | 20:51 | 04:22 | 05:56 | 19:10 | 20:44 | 04:34 | 06:00 | 19:00 | 20:26 | 04:08 | 05:36 | 18:41 | 20:09 | 22 |
| Mar 1 | 04:09 | 05:50 | 18:57 | 20:37 | 04:32 | 06:04 | 19:01 | 20:32 | 04:41 | 06:05 | 18:52 | 20:16 | 04:16 | 05:42 | 18:32 | 19:59 | Mar 1 |
| 8 | 04:20 | 05:58 | 18:45 | 20:23 | 04:41 | 06:11 | 18:51 | 20:21 | 04:48 | 06:11 | 18:44 | 20:07 | 04:23 | 05:48 | 18:23 | 19:48 | 8 |
| 15 | 04:30 | 06:07 | 18:33 | 20:09 | 04:49 | 06:17 | 18:40 | 20:09 | 04:54 | 06:16 | 18:35 | 19:57 | 04:30 | 05:54 | 18:14 | 19:38 | 15 |
| 22 | 04:40 | 06:15 | 18:21 | 19:56 | 04:56 | 06:24 | 18:30 | 19:57 | 04:59 | 06:21 | 18:26 | 19:48 | 04:36 | 05:59 | 18:05 | 19:28 | 22 |
| 29 | 04:49 | 06:23 | 18:09 | 19:43 | 05:03 | 06:30 | 18:19 | 19:46 | 05:04 | 06:25 | 18:17 | 19:38 | 04:41 | 06:04 | 17:55 | 19:18 | 29 |
| Apr 5 | 04:57 | 06:31 | 17:56 | 19:30 | 05:10 | 06:37 | 18:09 | 19:36 | 05:09 | 06:30 | 18:08 | 19:29 | 04:47 | 06:10 | 17:46 | 19:09 | Apr 5 |
| 12 | 05:05 | 06:39 | 17:45 | 19:19 | 05:16 | 06:43 | 17:58 | 19:26 | 05:14 | 06:35 | 18:00 | 19:21 | 04:52 | 06:15 | 17:37 | 19:00 | 12 |
| 19 | 05:12 | 06:47 | 17:33 | 19:08 | 05:22 | 06:49 | 17:49 | 19:16 | 05:18 | 06:40 | 17:52 | 19:13 | 04:56 | 06:20 | 17:28 | 18:52 | 19 |
| 26 | 05:20 | 06:55 | 17:23 | 18:58 | 05:27 | 06:56 | 17:40 | 19:08 | 05:22 | 06:44 | 17:44 | 19:07 | 05:01 | 06:25 | 17:20 | 18:44 | 26 |
| May 3 | 05:26 | 07:03 | 17:13 | 18:49 | 05:33 | 07:02 | 17:31 | 19:01 | 05:26 | 06:49 | 17:38 | 19:01 | 05:06 | 06:31 | 17:13 | 18:38 | May 3 |
| 10 | 05:33 | 07:10 | 17:04 | 18:42 | 05:38 | 07:08 | 17:24 | 18:54 | 05:30 | 06:54 | 17:32 | 18:56 | 05:10 | 06:36 | 17:07 | 18:32 | 10 |
| 17 | 05:39 | 07:18 | 16:57 | 18:36 | 05:43 | 07:14 | 17:18 | 18:49 | 05:34 | 06:59 | 17:27 | 18:52 | 05:14 | 06:41 | 17:01 | 18:28 | 17 |
| 24 | 05:45 | 07:24 | 16:51 | 18:31 | 05:48 | 07:20 | 17:13 | 18:45 | 05:38 | 07:03 | 17:23 | 18:49 | 05:18 | 06:46 | 16:57 | 18:25 | 24 |
| 31 | 05:50 | 07:30 | 16:47 | 18:28 | 05:52 | 07:25 | 17:10 | 18:43 | 05:41 | 07:08 | 17:21 | 18:47 | 05:22 | 06:50 | 16:54 | 18:23 | 31 |
| Jun 7 | 05:54 | 07:36 | 16:44 | 18:26 | 05:56 | 07:30 | 17:08 | 18:41 | 05:44 | 07:11 | 17:19 | 18:46 | 05:25 | 06:54 | 16:53 | 18:22 | Jun 7 |
| 14 | 05:57 | 07:40 | 16:43 | 18:25 | 05:59 | 07:33 | 17:07 | 18:41 | 05:47 | 07:14 | 17:19 | 18:46 | 05:28 | 06:58 | 16:53 | 18:22 | 14 |
| 21 | 05:59 | 07:42 | 16:43 | 18:26 | 06:01 | 07:35 | 17:08 | 18:42 | 05:49 | 07:17 | 17:20 | 18:47 | 05:30 | 07:00 | 16:53 | 18:23 | 21 |
| 28 | 06:01 | 07:43 | 16:46 | 18:28 | 06:02 | 07:36 | 17:10 | 18:44 | 05:50 | 07:18 | 17:22 | 18:49 | 05:31 | 07:01 | 16:55 | 18:25 | 28 |
| Jul 5 | 06:00 | 07:42 | 16:49 | 18:31 | 06:02 | 07:36 | 17:13 | 18:47 | 05:51 | 07:18 | 17:25 | 18:52 | 05:32 | 07:01 | 16:58 | 18:27 | Jul 5 |
| 12 | 05:59 | 07:40 | 16:54 | 18:35 | 06:01 | 07:34 | 17:17 | 18:50 | 05:50 | 07:16 | 17:28 | 18:55 | 05:31 | 06:59 | 17:02 | 18:30 | 12 |
| 19 | 05:55 | 07:35 | 17:00 | 18:40 | 05:58 | 07:31 | 17:22 | 18:54 | 05:48 | 07:14 | 17:32 | 18:58 | 05:29 | 06:57 | 17:06 | 18:34 | 19 |
| 26 | 05:51 | 07:30 | 17:06 | 18:45 | 05:55 | 07:26 | 17:27 | 18:59 | 05:45 | 07:10 | 17:36 | 19:01 | 05:26 | 06:53 | 17:11 | 18:38 | 26 |
| Aug 2 | 05:45 | 07:22 | 17:13 | 18:51 | 05:50 | 07:20 | 17:33 | 19:03 | 05:41 | 07:05 | 17:41 | 19:05 | 05:21 | 06:47 | 17:16 | 18:42 | Aug 2 |
| 9 | 05:37 | 07:14 | 17:20 | 18:57 | 05:43 | 07:13 | 17:39 | 19:08 | 05:36 | 06:59 | 17:45 | 19:09 | 05:16 | 06:41 | 17:21 | 18:46 | 9 |
| 16 | 05:29 | 07:04 | 17:28 | 19:03 | 05:36 | 07:05 | 17:45 | 19:13 | 05:30 | 06:53 | 17:50 | 19:12 | 05:10 | 06:34 | 17:25 | 18:50 | 16 |
| 23 | 05:19 | 06:54 | 17:35 | 19:10 | 05:28 | 06:56 | 17:51 | 19:19 | 05:23 | 06:45 | 17:54 | 19:16 | 05:02 | 06:26 | 17:30 | 18:54 | 23 |
| 30 | 05:08 | 06:42 | 17:42 | 19:17 | 05:18 | 06:46 | 17:56 | 19:24 | 05:16 | 06:37 | 17:58 | 19:20 | 04:54 | 06:17 | 17:35 | 18:58 | 30 |
| Sep 6 | 04:57 | 06:30 | 17:50 | 19:24 | 05:08 | 06:35 | 18:02 | 19:30 | 05:07 | 06:28 | 18:03 | 19:24 | 04:45 | 06:08 | 17:40 | 19:03 | Sep 6 |
| 13 | 04:44 | 06:18 | 17:57 | 19:31 | 04:58 | 06:25 | 18:08 | 19:35 | 04:58 | 06:19 | 18:07 | 19:28 | 04:35 | 05:58 | 17:45 | 19:08 | 13 |
| 20 | 04:31 | 06:06 | 18:05 | 19:40 | 04:46 | 06:14 | 18:14 | 19:42 | 04:49 | 06:10 | 18:11 | 19:33 | 04:25 | 05:49 | 17:49 | 19:13 | 20 |
| 27 | 04:18 | 05:53 | 18:12 | 19:48 | 04:35 | 06:03 | 18:20 | 19:49 | 04:39 | 06:01 | 18:16 | 19:37 | 04:15 | 05:39 | 17:54 | 19:18 | 27 |
| Oct 4 | 04:04 | 05:41 | 18:20 | 19:58 | 04:23 | 05:52 | 18:26 | 19:56 | 04:29 | 05:52 | 18:20 | 19:43 | 04:05 | 05:29 | 17:59 | 19:24 | Oct 4 |
| 11 | 03:49 | 05:29 | 18:28 | 20:08 | 04:11 | 05:42 | 18:33 | 20:04 | 04:19 | 05:43 | 18:25 | 19:49 | 03:54 | 05:20 | 18:05 | 19:31 | 11 |
| 18 | 03:35 | 05:17 | 18:37 | 20:19 | 03:59 | 05:32 | 18:39 | 20:13 | 04:09 | 05:34 | 18:30 | 19:55 | 03:44 | 05:11 | 18:10 | 19:38 | 18 |
| 25 | 03:21 | 05:06 | 18:45 | 20:31 | 03:48 | 05:22 | 18:47 | 20:22 | 04:00 | 05:27 | 18:35 | 20:02 | 03:34 | 05:03 | 18:16 | 19:45 | 25 |
| Nov 1 | 03:07 | 04:56 | 18:54 | 20:44 | 03:36 | 05:14 | 18:54 | 20:32 | 03:51 | 05:20 | 18:41 | 20:10 | 03:24 | 04:55 | 18:22 | 19:54 | Nov 1 |
| 8 | 02:54 | 04:47 | 19:03 | 20:57 | 03:26 | 05:07 | 19:01 | 20:42 | 03:43 | 05:14 | 18:47 | 20:18 | 03:16 | 04:49 | 18:29 | 20:03 | 8 |
| 15 | 02:42 | 04:39 | 19:13 | 21:11 | 03:17 | 05:00 | 19:09 | 20:53 | 03:37 | 05:09 | 18:53 | 20:26 | 03:08 | 04:44 | 18:36 | 20:12 | 15 |
| 22 | 02:31 | 04:33 | 19:21 | 21:25 | 03:09 | 04:56 | 19:17 | 21:04 | 03:31 | 05:06 | 19:00 | 20:35 | 03:02 | 04:40 | 18:42 | 20:21 | 22 |
| 29 | 02:21 | 04:29 | 19:30 | 21:38 | 03:03 | 04:53 | 19:24 | 21:14 | 03:27 | 05:04 | 19:06 | 20:43 | 02:57 | 04:38 | 18:49 | 20:30 | 29 |
| Dec 6 | 02:15 | 04:27 | 19:37 | 21:50 | 02:59 | 04:51 | 19:31 | 21:23 | 03:25 | 05:03 | 19:12 | 20:50 | 02:54 | 04:37 | 18:55 | 20:37 | Dec 6 |
| 13 | 02:11 | 04:26 | 19:44 | 22:00 | 02:57 | 04:51 | 19:36 | 21:31 | 03:25 | 05:04 | 19:17 | 20:57 | 02:54 | 04:38 | 19:00 | 20:44 | 13 |
| 20 | 02:11 | 04:28 | 19:49 | 22:06 | 02:58 | 04:54 | 19:41 | 21:36 | 03:26 | 05:07 | 19:21 | 21:01 | 02:55 | 04:40 | 19:05 | 20:49 | 20 |
| 27 | 02:15 | 04:32 | 19:52 | 22:08 | 03:02 | 04:57 | 19:44 | 21:39 | 03:30 | 05:10 | 19:24 | 21:04 | 02:59 | 04:43 | 19:08 | 20:52 | 27 |

# ORIENTATION OF THE SUN




P ° Position angle of Polar Axis. (+ when pole east of north point, - if west)

$B_o$° Heliocentric Latitude of centre of Sun

$L_o$° Heliocentric Longitude of centre of Sun

At the date of commencement of each synodic rotation period the value of Lo is zero; that is, the prime meridian passes through the central point of the disk.

The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is 27.28 days.

**Example for Calculating Heliocentric Longitude**

You wish to calculate the Lo value for Jan. 24 at 2pm WST.
2pm WST is 6 hours UT (0 hr UT is 8am WST). From the table the value for Jan. 24 (0 hr UT) is the value for Jan. 18 (78.28°) plus 6 days which from the daily variation table is -79.10°. Then you add the value for 6 hours, which is -3.30°. The calculation becomes:

78.28° + (-79.10°) + (-3.30°) = -4.12°.

If negative you need to add 360° so the result is 355.88° for Jan. 24 @ 2pm WST.

| DATE (0hr UT) | | P° | $B_o$° | $L_o$° |
|---|---|---|---|---|
| Jan | 4 | + 0.79 | - 3.33 | 262.64 |
| | 11 | - 2.59 | - 4.10 | 170.45 |
| | 18 | - 5.88 | - 4.81 | 078.28 |
| | 25 | - 9.03 | - 5.45 | 346.11 |
| Feb | 1 | - 12.01 | - 6.00 | 253.95 |
| | 8 | - 14.76 | - 6.46 | 161.78 |
| | 15 | - 17.26 | - 6.82 | 069.61 |
| | 22 | - 19.49 | - 7.07 | 337.43 |
| Mar | 1 | - 21.43 | - 7.21 | 245.23 |
| | 8 | - 23.06 | - 7.25 | 153.02 |
| | 15 | - 24.36 | - 7.18 | 060.77 |
| | 22 | - 25.34 | - 7.00 | 328.49 |
| | 29 | - 25.98 | - 6.72 | 236.18 |
| Apr | 5 | - 26.27 | - 6.34 | 143.84 |
| | 12 | - 26.21 | - 5.87 | 051.45 |
| | 19 | - 25.79 | - 5.32 | 319.02 |
| | 26 | - 25.00 | - 4.70 | 226.56 |
| May | 3 | - 23.86 | - 4.01 | 134.06 |
| | 10 | - 22.37 | - 3.27 | 041.52 |
| | 17 | - 20.54 | - 2.49 | 308.95 |
| | 24 | - 18.40 | - 1.67 | 216.35 |
| | 31 | - 15.97 | - 0.84 | 123.73 |
| Jun | 7 | - 13.29 | + 0.01 | 031.09 |
| | 14 | - 10.41 | + 0.85 | 298.44 |
| | 21 | - 7.38 | + 1.68 | 205.78 |
| | 28 | - 4.25 | + 2.49 | 113.12 |
| Jul | 5 | - 1.08 | + 3.26 | 020.47 |
| | 12 | + 2.08 | + 3.99 | 287.82 |
| | 19 | + 5.19 | + 4.67 | 195.19 |
| | 26 | + 8.18 | + 5.28 | 102.58 |
| Aug | 2 | + 11.04 | + 5.82 | 009.99 |
| | 9 | + 13.71 | + 6.29 | 277.43 |
| | 16 | + 16.19 | + 6.67 | 184.88 |
| | 23 | + 18.43 | + 6.96 | 092.37 |
| | 30 | + 20.43 | + 7.15 | 359.88 |
| Sep | 6 | + 22.17 | + 7.24 | 267.42 |
| | 13 | + 23.62 | + 7.23 | 174.98 |
| | 20 | + 24.77 | + 7.12 | 082.57 |
| | 27 | + 25.61 | + 6.91 | 350.18 |
| Oct | 4 | + 26.13 | + 6.59 | 257.81 |
| | 11 | + 26.29 | + 6.18 | 165.45 |
| | 18 | + 26.10 | + 5.68 | 073.11 |
| | 25 | + 25.53 | + 5.09 | 340.79 |
| Nov | 1 | + 24.58 | + 4.42 | 248.48 |
| | 8 | + 23.25 | + 3.69 | 156.18 |
| | 15 | + 21.53 | + 2.90 | 063.89 |
| | 22 | + 19.45 | + 2.06 | 331.62 |
| | 29 | + 17.02 | + 1.19 | 239.36 |
| Dec | 6 | + 14.29 | + 0.30 | 147.11 |
| | 13 | + 11.30 | - 0.60 | 054.87 |
| | 20 | + 8.11 | - 1.49 | 322.64 |
| | 27 | + 4.78 | - 2.35 | 230.44 |

**VARIATION OF $L_o$**

DAILY

| | |
|---|---|
| 1 | - 13.18 |
| 2 | - 26.37 |
| 3 | - 39.55 |
| 4 | - 52.73 |
| 5 | - 65.91 |
| 6 | - 79.10 |

HOURLY

| | |
|---|---|
| 1 | - 0.55 |
| 2 | - 1.10 |
| 3 | - 1.65 |
| 4 | - 2.20 |
| 5 | - 2.75 |
| 6 | - 3.30 |
| 7 | - 3.84 |
| 8 | - 4.39 |
| 9 | - 4.94 |
| 10 | - 5.49 |
| 11 | - 6.04 |
| 12 | - 6.59 |
| 13 | - 7.14 |
| 14 | - 7.69 |
| 15 | - 8.24 |
| 16 | - 8.79 |
| 17 | - 9.34 |
| 18 | - 9.89 |
| 19 | - 10.43 |
| 20 | - 10.98 |
| 21 | - 11.53 |
| 22 | - 12.08 |
| 23 | - 12.63 |
| 24 | - 13.18 |

**SYNODIC 2003 ROTATION NUMBERS (UT)**

| | | d.dd |
|---|---|---|
| 1999 | Jan | 23.95 |
| 2000 | Feb | 20.29 |
| 2001 | Mar | 19.61 |
| 2002 | Apr | 15.90 |
| 2003 | May | 13.14 |
| 2004 | Jun | 9.35 |
| 2005 | Jul | 6.55 |
| 2006 | Aug | 2.76 |
| 2007 | Aug | 29.99 |
| 2008 | Sep | 26.26 |
| 2009 | Oct | 23.55 |
| 2010 | Nov | 19.85 |
| 2011 | Dec | 17.17 |

# SOLAR and LUNAR ECLIPSES

During 2003 there are four eclipses, two of the Sun and two of the Moon. One solar eclipse is annular and the other total. Both of the lunar eclipses are total.

Magnitudes quoted for lunar eclipses relate to the percentage of the lunar diameter that is either immersed in the Earth's umbral shadow (total and partial eclipses), or the penumbral shadow (penumbral eclipse). It is not a measure of brightness.

Please note, all times listed below are in UT.

**TOTAL LUNAR ECLIPSE – 16th May 2003**

The eclipse will be widely visible from the Americas, Europe, and Africa. The eastern half of North America will witness the entire event, while the partial phases will already be in progress at moonrise from the western portions of the continent. Similarly, the Moon sets in Europe during various stages of the eclipse. Observers in Ontario, Quebec, the Maritime Provinces and eastern U. S. will see all phases of the eclipse. Farther to the west, the eclipse begins before moonrise but totality will still be visible from the region except from Yukon and Alaska.

| | |
|---|---|
| Penumbral Eclipse Begins: | 01:05:16 UT |
| Partial Eclipse Begins: | 02:02:42 UT |
| Total Eclipse Begins: | 03:13:40 UT |
| Greatest Eclipse: | 03:40:01 UT |
| Total Eclipse Ends: | 04:06:22 UT |
| Partial Eclipse Ends: | 05:17:20 UT |
| Penumbral Eclipse Ends: | 06:14:47 UT |

**ANNULAR SOLAR ECLIPSE – 30th May 2003**

The eclipse begins in Scotland, the shadow moving northwest with the annularity being seen in all Iceland as well as a third of Greenland. Partial phases of the eclipse are visible from much of Europe (except Spain and Portugal) and the Middle East where the event occurs at sunrise, as well as from central and northern Asia. In the Western Hemisphere, the partial eclipse is visible from northern Canada and Alaska during the afternoon of May 30.

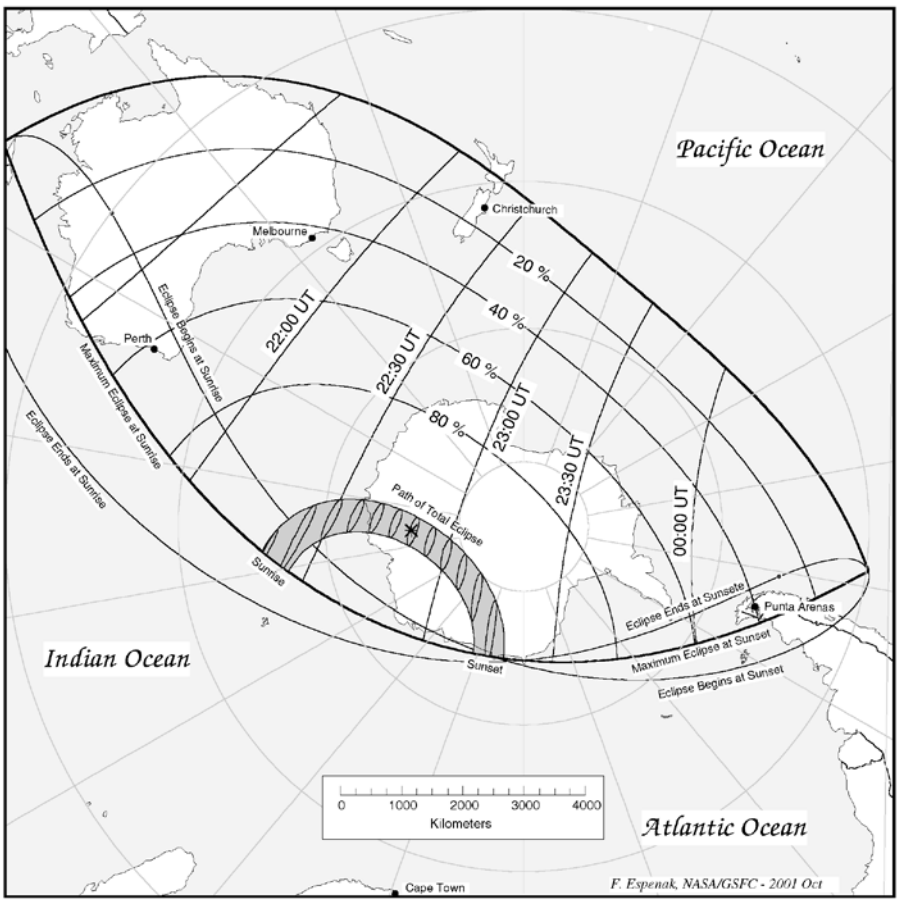
**TOTAL LUNAR ECLIPSE – 8th and 9th November 2003**

The entire eclipse will be visible from Europe and most of Africa as well as the eastern Americas. Various stages of the eclipse are in progress at moonset for observers throughout most of Asia. None of the total phase is visible from easternmost Asia, Japan, Indonesia or Australia. In the Western Hemisphere, the ingressing partial phases will already be in progress at moonrise for observers in western Canada and the USA.

| | |
|---|---|
| Penumbral Eclipse Begins: | 22:15:00 UT |
| Partial Eclipse Begins: | 23:32:21 UT |
| Total Eclipse Begins: | 01:06:07 UT |
| Greatest Eclipse: | 01:18:23 UT |
| Total Eclipse Ends: | 01:30:38 UT |
| Partial Eclipse Ends: | 03:04:24 UT |
| Penumbral Eclipse Ends: | 04:21:48 UT |

## TOTAL SOLAR ECLIPSE – 24th November 2003

The final event of 2003 is a total solar eclipse visible from the Southern Hemisphere. The path of the Moon's shadow begins in the southern Indian Ocean and reaches the coast of Antarctica on the 23rd at 22:35 UT. Greatest eclipse occurs in Wilkes Land at 22:49:17 UT, a duration of just under two minutes with the Sun just 15° above the Antarctic ice. The rest of Antarctica will see a partial eclipse as well as New Zealand, most of Australia, and southern South America. The maximum partial phase for each capital city in Australia, along with the times, is illustrated in the diagram below.




The Sun can be extremely dangerous unless you are experienced and familiar with safe solar observing techniques. The Sun requires special filters to observe with the unaided eye or optical equipment. Its visible surface, the photosphere, not only radiates normal white light but also invisible ultraviolet (UV) and infrared (IR) radiation. Even when the Moon covers a substantial portion of the Sun, and the brightness is reduced to a comfortable level, UV and IR are still being radiated at dangerous levels. It is these invisible components of sunlight that damage the eye's retina. Directly looking at the Sun, even for a few seconds, can cause irreparable damage or blindness.

Avoid the use of photographic neutral density filters (of any density), smoked glass and exposed photographic film; these can transmit UV and IR radiation. Perfectly safe for the partial phases are purpose made, hand held aluminium coated Mylar filters, which can be purchased already supported in a cardboard frame, and even 'spectacles' are available. A number 14 welder's filter also will work. These products are useful for checking the Sun at any time for large sunspots.

A very simple and safe method to watch the partial progress of the eclipse is to project the Sun's image through a small hole onto a screen. A hole 1 to 5 millimeters in diameter should be made in a piece of stiff paper or card (alternately drill a hole in a piece of thin metal sheet). The image of the Sun is then projected through this hole and viewed against a screen of white paper or board. The screen should be held about 20 cm behind a 1 mm hole, and about 1 to 1.5 meters behind a 5 mm hole.

Along the same theme, but with a magnified and clearer image, is the eyepiece projection method with a telescope. The projection method is low-cost and easy (providing you have a telescope to start with), and enables more than one observer to monitor the progress of the eclipse. It is preferable to use a Ramsden or Huygenian eyepiece or any old cheap unwanted eyepiece. The intense heat at the focal point can damage eyepieces with cemented elements. We suggest that telescopes larger than 15cm should be stopped down. Detail in sunspots can be discerned with this method, and a projected image around twice the diameter of the objective provides excellent results.

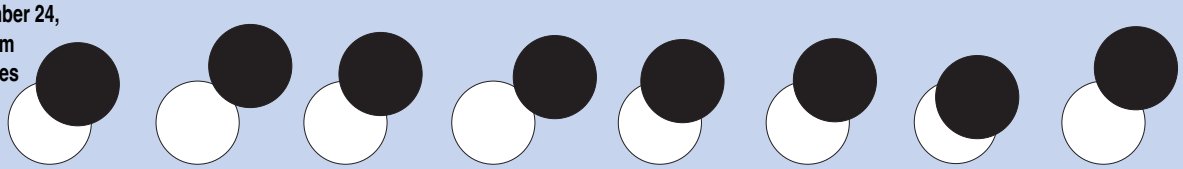
Direct observation through an instrument using filters is quite safe, provided the filters are specifically designed for this purpose. These filters are fitted to the front of the telescope, and are usually either aluminium coated Mylar or nickel chromium coated glass. The economical Mylar filters do show the Sun in an unusual blue light, whereas the expensive glass filters provide a pleasant yellow/orange image.

If you intend watching the evolution of sunspots across the solar disk as a future long-term interest, the nickel chromium coated glass filters are recommended. NEVER use filters that go over the eyepiece, they can crack with the now focussed intense heat, allowing the highly magnified Sun's heat through. Ensure any filter is fastened securely, and do not forget to cap the objective lens of the finderscope, a likely source of a nasty burn!

If you have any doubts on how to view the Sun in perfect safety, do not take any chances, it is simply not worth any loss of vision. Contact your local astronomical society (p. 138) as they may be having an eclipse viewing party.

*Eclipse predictions (maps) courtesy of Fred Espenak, NASA/GSFC*

**Appearance of November 24, 2003 Solar Eclipse from Australian Capital Cities**



| Location (zone) | Adelaide (CST) | Brisbane (EST) | Canberra (EST) | Darwin (CST) | Hobart (EST) | Melbourne (EST) | Perth (WST) | Sydney (EST) |
|---|---|---|---|---|---|---|---|---|
| Eclipse begins | 6:25am | 7:04am | 7:01am | 6:23am | 7:08am | 7:01am | ** | 7:02am |
| Mid Eclipse (Alt) | 7:11am (26°) | 7:32am (35°) | 7:44am (35°) | 6:41am (6°) | 8:00am (37°) | 7:47am (33°) | 5:40am (7°) | 7:42am (36°) |
| Eclipse End | 8:00am | 8:01am | 8:30am | 7:00am | 8:51am | 8:37am | 6.28am | 8:25am |

*Drawings are for mid-eclipse in local horizon view. Times are local standard and do not include Daylight Saving. You will need to add one hour to convert to Daylight Saving. ** From Perth the eclipse begins before sunrise at 5:05am.*

# MOON RISE AND SET

## ADELAIDE — CST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 3 12 | 18 07 | 4 51 | 19 37 | 3 44 | 18 13 | 5 37 | 18 11 |
| 2 | 4 03 | 19 13 | 5 56 | 20 14 | 4 47 | 18 47 | 6 33 | 18 36 |
| 3 | 5 00 | 20 11 | 6 58 | 20 47 | 5 48 | 19 16 | 7 29 | 19 01 |
| 4 | 6 03 | 21 01 | 7 59 | 21 15 | 6 47 | 19 43 | 8 25 | 19 28 |
| 5 | 7 08 | 21 43 | 8 57 | 21 41 | 7 44 | 20 08 | 9 22 | 19 57 |
| 6 | 8 12 | 22 18 | 9 54 | 22 06 | 8 40 | 20 33 | 10 20 | 20 31 |
| 7 | 9 13 | 22 48 | 10 49 | 22 31 | 9 36 | 20 58 | 11 18 | 21 10 |
| 8 | 10 12 | 23 15 | 11 45 | 22 58 | 10 32 | 21 26 | 12 16 | 21 56 |
| 9 | 11 09 | 23 40 | 12 42 | 23 27 | 11 29 | 21 57 | 13 11 | 22 48 |
| 10 | 12 05 | DNS | 13 40 | DNS | 12 28 | 22 33 | 14 02 | 23 47 |
| 11 | 13 00 | 0 05 | 14 39 | 0 00 | 13 26 | 23 15 | 14 48 | DNS |
| 12 | 13 56 | 0 31 | 15 39 | 0 39 | 14 24 | DNS | 15 29 | 0 52 |
| 13 | 14 54 | 0 58 | 16 37 | 1 25 | 15 19 | 0 04 | 16 06 | 1 59 |
| 14 | 15 53 | 1 29 | 17 31 | 2 18 | 16 10 | 1 01 | 16 39 | 3 09 |
| 15 | 16 53 | 2 05 | 18 20 | 3 20 | 16 55 | 2 04 | 17 12 | 4 20 |
| 16 | 17 53 | 2 47 | 19 04 | 4 26 | 17 35 | 3 12 | 17 44 | 5 31 |
| 17 | 18 51 | 3 37 | 19 42 | 5 36 | 18 11 | 4 23 | 18 18 | 6 45 |
| 18 | 19 43 | 4 35 | 20 16 | 6 47 | 18 45 | 5 34 | 18 55 | 7 59 |
| 19 | 20 29 | 5 39 | 20 49 | 7 58 | 19 17 | 6 46 | 19 38 | 9 15 |
| 20 | 21 10 | 6 46 | 21 20 | 9 08 | 19 50 | 7 58 | 20 27 | 10 30 |
| 21 | 21 45 | 7 55 | 21 52 | 10 17 | 20 24 | 9 11 | 21 24 | 11 39 |
| 22 | 22 18 | 9 04 | 22 27 | 11 27 | 21 03 | 10 24 | 22 25 | 12 41 |
| 23 | 22 48 | 10 12 | 23 06 | 12 38 | 21 47 | 11 36 | 23 29 | 13 33 |
| 24 | 23 19 | 11 19 | 23 51 | 13 47 | 22 37 | 12 46 | DNR | 14 17 |
| 25 | 23 51 | 12 27 | DNR | 14 54 | 23 34 | 13 50 | 0 32 | 14 53 |
| 26 | DNR | 13 36 | 0 42 | 15 55 | DNR | 14 47 | 1 34 | 15 24 |
| 27 | 0 27 | 14 45 | 1 39 | 16 48 | 0 34 | 15 35 | 2 34 | 15 51 |
| 28 | 1 07 | 15 54 | 2 41 | 17 34 | 1 37 | 16 15 | 3 31 | 16 16 |
| 29 | 1 54 | 17 00 | | | 2 40 | 16 50 | 4 27 | 16 41 |
| 30 | 2 48 | 18 00 | | | 3 40 | 17 19 | 5 23 | 17 05 |
| 31 | 3 48 | 18 52 | | | 4 39 | 17 46 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 19 | 17 31 | 8 04 | 17 50 | 8 41 | 18 26 | 9 14 | 20 37 |
| 2 | 7 15 | 18 00 | 9 01 | 18 38 | 9 26 | 19 29 | 9 44 | 21 43 |
| 3 | 8 13 | 18 32 | 9 55 | 19 33 | 10 05 | 20 34 | 10 13 | 22 50 |
| 4 | 9 12 | 19 09 | 10 43 | 20 33 | 10 40 | 21 39 | 10 43 | 23 57 |
| 5 | 10 10 | 19 52 | 11 26 | 21 36 | 11 11 | 22 44 | 11 15 | DNS |
| 6 | 11 06 | 20 42 | 12 04 | 22 41 | 11 41 | 23 50 | 11 51 | 1 07 |
| 7 | 11 58 | 21 38 | 12 38 | 23 46 | 12 10 | DNS | 12 32 | 2 18 |
| 8 | 12 45 | 22 39 | 13 09 | DNS | 12 41 | 0 57 | 13 22 | 3 29 |
| 9 | 13 26 | 23 44 | 13 39 | 0 52 | 13 14 | 2 06 | 14 19 | 4 36 |
| 10 | 14 03 | DNS | 14 09 | 2 00 | 13 52 | 3 17 | 15 23 | 5 37 |
| 11 | 14 37 | 0 51 | 14 41 | 3 09 | 14 38 | 4 30 | 16 31 | 6 30 |
| 12 | 15 08 | 1 58 | 15 17 | 4 21 | 15 31 | 5 42 | 17 38 | 7 14 |
| 13 | 15 39 | 3 07 | 16 00 | 5 36 | 16 33 | 6 50 | 18 44 | 7 50 |
| 14 | 16 11 | 4 18 | 16 50 | 6 51 | 17 40 | 7 49 | 19 47 | 8 22 |
| 15 | 16 46 | 5 31 | 17 49 | 8 03 | 18 49 | 8 38 | 20 46 | 8 50 |
| 16 | 17 26 | 6 47 | 18 54 | 9 08 | 19 56 | 9 19 | 21 44 | 9 15 |
| 17 | 18 13 | 8 03 | 20 02 | 10 03 | 21 00 | 9 54 | 22 42 | 9 40 |
| 18 | 19 07 | 9 18 | 21 09 | 10 48 | 22 01 | 10 23 | 23 39 | 10 06 |
| 19 | 20 09 | 10 26 | 22 14 | 11 25 | 22 59 | 10 50 | DNR | 10 33 |
| 20 | 21 14 | 11 24 | 23 15 | 11 56 | 23 56 | 11 15 | 0 36 | 11 04 |
| 21 | 22 20 | 12 13 | DNR | 12 23 | DNR | 11 40 | 1 35 | 11 39 |
| 22 | 23 25 | 12 53 | 0 13 | 12 49 | 0 52 | 12 06 | 2 33 | 12 19 |
| 23 | DNR | 13 26 | 1 10 | 13 13 | 1 49 | 12 34 | 3 30 | 13 07 |
| 24 | 0 26 | 13 55 | 2 05 | 13 38 | 2 47 | 13 06 | 4 25 | 14 02 |
| 25 | 1 25 | 14 21 | 3 02 | 14 05 | 3 46 | 13 43 | 5 15 | 15 03 |
| 26 | 2 22 | 14 45 | 3 59 | 14 34 | 4 44 | 14 27 | 5 59 | 16 08 |
| 27 | 3 17 | 15 10 | 4 57 | 15 08 | 5 41 | 15 18 | 6 38 | 17 15 |
| 28 | 4 13 | 15 35 | 5 56 | 15 48 | 6 34 | 16 16 | 7 13 | 18 23 |
| 29 | 5 09 | 16 02 | 6 54 | 16 34 | 7 22 | 17 18 | 7 45 | 19 31 |
| 30 | 6 07 | 16 33 | 7 50 | 17 27 | 8 04 | 18 24 | 8 15 | 20 40 |
| 31 | 7 05 | 17 09 | | | 8 41 | 19 31 | 8 45 | 21 48 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 16 | 22 59 | 9 13 | DNS | 11 08 | 1 10 | 12 12 | 1 00 |
| 2 | 9 51 | DNS | 10 06 | 0 22 | 12 14 | 1 53 | 13 12 | 1 28 |
| 3 | 10 31 | 0 10 | 11 06 | 1 27 | 13 18 | 2 28 | 14 09 | 1 54 |
| 4 | 11 17 | 1 21 | 12 10 | 2 24 | 14 19 | 2 58 | 15 06 | 2 18 |
| 5 | 12 12 | 2 29 | 13 16 | 3 11 | 15 18 | 3 24 | 16 03 | 2 43 |
| 6 | 13 13 | 3 31 | 14 21 | 3 51 | 16 15 | 3 49 | 17 00 | 3 09 |
| 7 | 14 18 | 4 25 | 15 24 | 4 24 | 17 12 | 4 14 | 17 59 | 3 37 |
| 8 | 15 25 | 5 11 | 16 25 | 4 53 | 18 09 | 4 39 | 18 57 | 4 10 |
| 9 | 16 30 | 5 49 | 17 24 | 5 20 | 19 07 | 5 05 | 19 55 | 4 47 |
| 10 | 17 33 | 6 22 | 18 22 | 5 45 | 20 06 | 5 35 | 20 49 | 5 31 |
| 11 | 18 34 | 6 50 | 19 19 | 6 09 | 21 04 | 6 09 | 21 40 | 6 21 |
| 12 | 19 33 | 7 16 | 20 16 | 6 35 | 22 01 | 6 48 | 22 24 | 7 17 |
| 13 | 20 31 | 7 42 | 21 15 | 7 03 | 22 54 | 7 34 | 23 03 | 8 16 |
| 14 | 21 28 | 8 07 | 22 13 | 7 34 | 23 42 | 8 25 | 23 38 | 9 18 |
| 15 | 22 26 | 8 33 | 23 11 | 8 10 | DNR | 9 22 | DNR | 10 21 |
| 16 | 23 24 | 9 02 | DNR | 8 51 | 0 25 | 10 23 | 0 08 | 11 24 |
| 17 | DNR | 9 35 | 0 07 | 9 39 | 1 03 | 11 26 | 0 37 | 12 27 |
| 18 | 0 22 | 10 13 | 0 59 | 10 33 | 1 37 | 12 30 | 1 05 | 13 33 |
| 19 | 1 20 | 10 57 | 1 46 | 11 32 | 2 07 | 13 36 | 1 34 | 14 41 |
| 20 | 2 15 | 11 48 | 2 28 | 12 36 | 2 36 | 14 43 | 2 05 | 15 52 |
| 21 | 3 06 | 12 46 | 3 05 | 13 42 | 3 06 | 15 52 | 2 41 | 17 08 |
| 22 | 3 52 | 13 49 | 3 38 | 14 49 | 3 37 | 17 04 | 3 24 | 18 24 |
| 23 | 4 33 | 14 55 | 4 09 | 15 57 | 4 11 | 18 20 | 4 17 | 19 37 |
| 24 | 5 09 | 16 03 | 4 40 | 17 07 | 4 52 | 19 38 | 5 19 | 20 43 |
| 25 | 5 42 | 17 12 | 5 10 | 18 19 | 5 40 | 20 54 | 6 28 | 21 38 |
| 26 | 6 13 | 18 21 | 5 44 | 19 34 | 6 38 | 22 03 | 7 40 | 22 22 |
| 27 | 6 43 | 19 32 | 6 21 | 20 50 | 7 43 | 23 01 | 8 51 | 22 58 |
| 28 | 7 15 | 20 44 | 7 05 | 22 06 | 8 52 | 23 49 | 9 58 | 23 29 |
| 29 | 7 49 | 21 57 | 7 56 | 23 16 | 10 02 | DNS | 11 01 | 23 56 |
| 30 | 8 28 | 23 11 | 8 56 | DNS | 11 09 | 0 28 | 12 01 | DNS |
| 31 | | | 10 01 | 0 18 | | | 12 59 | 0 21 |

Note:

## BRISBANE — EST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 3 00 | 17 17 | 4 41 | 18 50 | 3 32 | 17 29 | 5 10 | 17 42 |
| 2 | 3 54 | 18 21 | 5 42 | 19 32 | 4 31 | 18 06 | 6 02 | 18 10 |
| 3 | 4 52 | 19 21 | 6 41 | 20 08 | 5 28 | 18 40 | 6 54 | 18 39 |
| 4 | 5 54 | 20 13 | 7 37 | 20 40 | 6 23 | 19 10 | 7 46 | 19 10 |
| 5 | 6 56 | 20 58 | 8 32 | 21 10 | 7 16 | 19 39 | 8 39 | 19 43 |
| 6 | 7 56 | 21 37 | 9 24 | 21 39 | 8 08 | 20 08 | 9 33 | 20 20 |
| 7 | 8 54 | 22 11 | 10 16 | 22 08 | 9 00 | 20 38 | 10 29 | 21 01 |
| 8 | 9 49 | 22 42 | 11 08 | 22 38 | 9 52 | 21 09 | 11 24 | 21 48 |
| 9 | 10 42 | 23 11 | 12 00 | 23 11 | 10 46 | 21 44 | 12 19 | 22 41 |
| 10 | 11 34 | 23 40 | 12 55 | 23 47 | 11 40 | 22 22 | 13 11 | 23 38 |
| 11 | 12 25 | DNS | 13 51 | DNS | 12 36 | 23 06 | 13 59 | DNS |
| 12 | 13 17 | 0 09 | 14 48 | 0 29 | 13 33 | 23 56 | 14 44 | 0 40 |
| 13 | 14 11 | 0 40 | 15 45 | 1 16 | 14 28 | DNS | 15 25 | 1 43 |
| 14 | 15 07 | 1 15 | 16 40 | 2 10 | 15 20 | 0 52 | 16 04 | 2 48 |
| 15 | 16 04 | 1 54 | 17 32 | 3 10 | 16 08 | 1 54 | 16 41 | 3 54 |
| 16 | 17 02 | 2 38 | 18 19 | 4 14 | 16 52 | 2 58 | 17 18 | 5 00 |
| 17 | 17 59 | 3 29 | 19 02 | 5 20 | 17 33 | 4 04 | 17 57 | 6 08 |
| 18 | 18 53 | 4 26 | 19 41 | 6 26 | 18 11 | 5 11 | 18 39 | 7 18 |
| 19 | 19 42 | 5 28 | 20 18 | 7 32 | 18 49 | 6 18 | 19 26 | 8 29 |
| 20 | 20 27 | 6 32 | 20 54 | 8 37 | 19 26 | 7 24 | 20 18 | 9 40 |
| 21 | 21 07 | 7 37 | 21 31 | 9 42 | 20 06 | 8 32 | 21 16 | 10 47 |
| 22 | 21 44 | 8 41 | 22 10 | 10 47 | 20 49 | 9 40 | 22 17 | 11 49 |
| 23 | 22 19 | 9 44 | 22 53 | 11 53 | 21 36 | 10 49 | 23 18 | 12 43 |
| 24 | 22 55 | 10 47 | 23 41 | 12 58 | 22 29 | 11 55 | DNR | 13 30 |
| 25 | 23 31 | 11 50 | DNR | 14 03 | 23 26 | 12 59 | 0 19 | 14 10 |
| 26 | DNR | 12 54 | 0 34 | 15 03 | DNR | 13 56 | 1 17 | 14 45 |
| 27 | 0 11 | 13 59 | 1 31 | 15 58 | 0 25 | 14 46 | 2 12 | 15 16 |
| 28 | 0 55 | 15 05 | 2 31 | 16 47 | 1 26 | 15 30 | 3 06 | 15 45 |
| 29 | 1 45 | 16 09 | | | 2 25 | 16 08 | 3 58 | 16 14 |
| 30 | 2 40 | 17 09 | | | 3 22 | 16 42 | 4 49 | 16 42 |
| 31 | 3 39 | 18 03 | | | 4 17 | 17 13 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 5 41 | 17 12 | 7 14 | 17 42 | 7 50 | 18 17 | 8 36 | 20 14 |
| 2 | 6 34 | 17 44 | 8 09 | 18 31 | 8 37 | 19 17 | 9 11 | 21 15 |
| 3 | 7 28 | 18 19 | 9 03 | 19 25 | 9 20 | 20 18 | 9 45 | 22 17 |
| 4 | 8 23 | 18 59 | 9 53 | 20 23 | 9 59 | 21 19 | 10 19 | 23 19 |
| 5 | 9 19 | 19 44 | 10 39 | 21 23 | 10 35 | 22 20 | 10 56 | DNS |
| 6 | 10 14 | 20 35 | 11 20 | 22 24 | 11 09 | 23 21 | 11 36 | 0 24 |
| 7 | 11 06 | 21 30 | 11 58 | 23 25 | 11 43 | DNS | 12 21 | 1 31 |
| 8 | 11 55 | 22 29 | 12 34 | DNS | 12 18 | 0 23 | 13 13 | 2 38 |
| 9 | 12 40 | 23 30 | 13 08 | 0 26 | 12 56 | 1 26 | 14 11 | 3 44 |
| 10 | 13 21 | DNS | 13 43 | 1 29 | 13 39 | 2 33 | 15 14 | 4 46 |
| 11 | 13 59 | 0 32 | 14 20 | 2 33 | 14 27 | 3 41 | 16 19 | 5 40 |
| 12 | 14 35 | 1 35 | 15 01 | 3 40 | 15 23 | 4 51 | 17 24 | 6 28 |
| 13 | 15 11 | 2 39 | 15 47 | 4 50 | 16 25 | 5 57 | 18 25 | 7 09 |
| 14 | 15 48 | 3 45 | 16 41 | 6 01 | 17 31 | 6 58 | 19 23 | 7 44 |
| 15 | 16 28 | 4 52 | 17 41 | 7 11 | 18 36 | 7 50 | 20 19 | 8 17 |
| 16 | 17 12 | 6 03 | 18 45 | 8 16 | 19 40 | 8 35 | 21 13 | 8 47 |
| 17 | 18 02 | 7 15 | 19 51 | 9 13 | 20 39 | 9 14 | 22 06 | 9 16 |
| 18 | 18 59 | 8 26 | 20 55 | 10 01 | 21 36 | 9 48 | 22 59 | 9 45 |
| 19 | 20 01 | 9 33 | 21 55 | 10 42 | 22 30 | 10 18 | 23 52 | 10 16 |
| 20 | 21 05 | 10 33 | 22 52 | 11 18 | 23 23 | 10 48 | DNR | 10 50 |
| 21 | 22 08 | 11 25 | 23 47 | 11 50 | DNR | 11 16 | 0 47 | 11 28 |
| 22 | 23 09 | 12 08 | DNR | 12 19 | 0 15 | 11 46 | 1 43 | 12 11 |
| 23 | DNR | 12 46 | 0 39 | 12 47 | 1 08 | 12 18 | 2 39 | 13 00 |
| 24 | 0 06 | 13 19 | 1 31 | 13 16 | 2 02 | 12 54 | 3 33 | 13 54 |
| 25 | 1 01 | 13 49 | 2 23 | 13 47 | 2 57 | 13 34 | 4 24 | 14 53 |
| 26 | 1 54 | 14 17 | 3 16 | 14 20 | 3 54 | 14 19 | 5 11 | 15 55 |
| 27 | 2 45 | 14 45 | 4 11 | 14 57 | 4 49 | 15 10 | 5 54 | 16 59 |
| 28 | 3 37 | 15 15 | 5 07 | 15 39 | 5 43 | 16 07 | 6 34 | 18 02 |
| 29 | 4 29 | 15 46 | 6 03 | 16 26 | 6 33 | 17 07 | 7 10 | 19 05 |
| 30 | 5 23 | 16 20 | 6 58 | 17 19 | 7 18 | 18 10 | 7 45 | 20 08 |
| 31 | 6 18 | 16 58 | | | 7 59 | 19 12 | 8 20 | 21 12 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 8 56 | 22 17 | 9 04 | 23 30 | 10 57 | 0 20 | 11 50 | 0 21 |
| 2 | 9 35 | 23 24 | 9 58 | DNS | 12 00 | 1 06 | 12 46 | 0 54 |
| 3 | 10 19 | DNS | 10 58 | 0 34 | 12 59 | 1 46 | 13 39 | 1 24 |
| 4 | 11 08 | 0 31 | 12 01 | 1 32 | 13 56 | 2 20 | 14 32 | 1 52 |
| 5 | 12 04 | 1 37 | 13 04 | 2 23 | 14 51 | 2 51 | 15 25 | 2 21 |
| 6 | 13 05 | 2 39 | 14 06 | 3 06 | 15 44 | 3 20 | 16 18 | 2 50 |
| 7 | 14 08 | 3 35 | 15 05 | 3 44 | 16 36 | 3 49 | 17 12 | 3 23 |
| 8 | 15 12 | 4 24 | 16 01 | 4 17 | 17 29 | 4 18 | 18 08 | 3 58 |
| 9 | 16 13 | 5 06 | 16 55 | 4 48 | 18 23 | 4 48 | 19 03 | 4 39 |
| 10 | 17 12 | 5 43 | 17 49 | 5 17 | 19 18 | 5 22 | 19 57 | 5 24 |
| 11 | 18 08 | 6 16 | 18 42 | 5 46 | 20 14 | 5 59 | 20 48 | 6 14 |
| 12 | 19 03 | 6 46 | 19 35 | 6 15 | 21 08 | 6 40 | 21 35 | 7 09 |
| 13 | 19 56 | 7 15 | 20 30 | 6 47 | 22 01 | 7 27 | 22 17 | 8 06 |
| 14 | 20 50 | 7 45 | 21 25 | 7 22 | 22 51 | 8 19 | 22 55 | 9 04 |
| 15 | 21 43 | 8 15 | 22 20 | 8 00 | 23 36 | 9 14 | 23 30 | 10 03 |
| 16 | 22 38 | 8 48 | 23 14 | 8 44 | DNR | 10 12 | DNR | 11 01 |
| 17 | 23 33 | 9 24 | DNR | 9 32 | 0 18 | 11 11 | 0 03 | 12 00 |
| 18 | DNR | 10 04 | 0 07 | 10 26 | 0 55 | 12 11 | 0 35 | 13 01 |
| 19 | 0 28 | 10 50 | 0 55 | 11 23 | 1 30 | 13 12 | 1 09 | 14 04 |
| 20 | 1 23 | 11 41 | 1 40 | 12 23 | 2 04 | 14 14 | 1 45 | 15 10 |
| 21 | 2 14 | 12 38 | 2 21 | 13 25 | 2 38 | 15 18 | 2 26 | 16 20 |
| 22 | 3 03 | 13 38 | 2 59 | 14 27 | 3 14 | 16 25 | 3 13 | 17 33 |
| 23 | 3 47 | 14 40 | 3 35 | 15 30 | 3 54 | 17 35 | 4 08 | 18 44 |
| 24 | 4 28 | 15 44 | 4 10 | 16 35 | 4 39 | 18 48 | 5 11 | 19 51 |
| 25 | 5 05 | 16 48 | 4 46 | 17 42 | 5 31 | 20 01 | 6 20 | 20 48 |
| 26 | 5 41 | 17 52 | 5 24 | 18 51 | 6 30 | 21 10 | 7 29 | 21 37 |
| 27 | 6 16 | 18 57 | 6 06 | 20 03 | 7 35 | 22 10 | 8 35 | 22 17 |
| 28 | 6 53 | 20 04 | 6 54 | 21 15 | 8 43 | 23 01 | 9 38 | 22 53 |
| 29 | 7 32 | 21 12 | 7 48 | 22 23 | 9 49 | 23 45 | 10 37 | 23 24 |
| 30 | 8 15 | 22 22 | 8 48 | 23 26 | 10 51 | DNS | 11 32 | 23 54 |
| 31 | | | 9 52 | DNS | | | 12 26 | 0 22 |

# MOON RISE AND SET

## CANBERRA — EST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 2 58 | 17 54 | 4 37 | 19 24 | 3 30 | 18 01 | 5 23 | 17 59 |
| 2 | 3 48 | 19 00 | 5 41 | 20 02 | 4 32 | 18 34 | 6 19 | 18 23 |
| 3 | 4 46 | 19 59 | 6 44 | 20 34 | 5 34 | 19 03 | 7 15 | 18 48 |
| 4 | 5 49 | 20 49 | 7 45 | 21 02 | 6 33 | 19 30 | 8 11 | 19 15 |
| 5 | 6 53 | 21 30 | 8 43 | 21 28 | 7 30 | 19 55 | 9 09 | 19 44 |
| 6 | 7 57 | 22 05 | 9 40 | 21 53 | 8 26 | 20 20 | 10 07 | 20 17 |
| 7 | 8 59 | 22 36 | 10 36 | 22 18 | 9 22 | 20 45 | 11 05 | 20 56 |
| 8 | 9 58 | 23 02 | 11 32 | 22 45 | 10 19 | 21 13 | 12 03 | 21 41 |
| 9 | 10 55 | 23 28 | 12 29 | 23 13 | 11 16 | 21 44 | 12 58 | 22 34 |
| 10 | 11 51 | 23 52 | 13 27 | 23 46 | 12 15 | 22 19 | 13 49 | 23 33 |
| 11 | 12 47 | DNS | 14 26 | DNS | 13 13 | 23 01 | 14 35 | DNS |
| 12 | 13 43 | 0 18 | 15 26 | 0 25 | 14 11 | 23 50 | 15 16 | 0 37 |
| 13 | 14 41 | 0 45 | 16 24 | 1 10 | 15 06 | DNS | 15 53 | 1 45 |
| 14 | 15 40 | 1 16 | 17 18 | 2 04 | 15 57 | 0 46 | 16 27 | 2 54 |
| 15 | 16 40 | 1 51 | 18 08 | 3 05 | 16 42 | 1 49 | 16 59 | 4 05 |
| 16 | 17 41 | 2 33 | 18 51 | 4 12 | 17 23 | 2 57 | 17 31 | 5 17 |
| 17 | 18 38 | 3 23 | 19 29 | 5 22 | 17 59 | 4 08 | 18 04 | 6 31 |
| 18 | 19 30 | 4 20 | 20 04 | 6 33 | 18 32 | 5 20 | 18 42 | 7 46 |
| 19 | 20 17 | 5 24 | 20 36 | 7 43 | 19 04 | 6 32 | 19 24 | 9 02 |
| 20 | 20 57 | 6 32 | 21 07 | 8 54 | 19 36 | 7 44 | 20 13 | 10 16 |
| 21 | 21 33 | 7 41 | 21 39 | 10 04 | 20 11 | 8 57 | 21 09 | 11 26 |
| 22 | 22 05 | 8 50 | 22 14 | 11 14 | 20 49 | 10 10 | 22 10 | 12 28 |
| 23 | 22 36 | 9 58 | 22 52 | 12 24 | 21 33 | 11 23 | 23 14 | 13 21 |
| 24 | 23 06 | 11 05 | 23 37 | 13 34 | 22 23 | 12 33 | DNR | 14 04 |
| 25 | 23 38 | 12 13 | DNR | 14 41 | 23 19 | 13 38 | 0 18 | 14 40 |
| 26 | DNR | 13 22 | 0 28 | 15 42 | DNR | 14 34 | 1 20 | 15 11 |
| 27 | 0 13 | 14 32 | 1 25 | 16 36 | 0 20 | 15 22 | 2 20 | 15 39 |
| 28 | 0 53 | 15 41 | 2 26 | 17 22 | 1 22 | 16 03 | 3 17 | 16 04 |
| 29 | 1 40 | 16 47 | | | 2 25 | 16 37 | 4 14 | 16 28 |
| 30 | 2 33 | 17 47 | | | 3 26 | 17 07 | 5 09 | 16 52 |
| 31 | 3 33 | 18 40 | | | 4 25 | 17 34 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 05 | 17 18 | 7 51 | 17 36 | 8 28 | 18 11 | 9 01 | 20 23 |
| 2 | 7 02 | 17 46 | 8 48 | 18 24 | 9 13 | 19 14 | 9 31 | 21 29 |
| 3 | 8 00 | 18 18 | 9 42 | 19 18 | 9 53 | 20 19 | 10 00 | 22 36 |
| 4 | 8 59 | 18 55 | 10 31 | 20 18 | 10 28 | 21 25 | 10 30 | 23 44 |
| 5 | 9 57 | 19 38 | 11 14 | 21 21 | 10 59 | 22 30 | 11 01 | DNS |
| 6 | 10 53 | 20 27 | 11 52 | 22 26 | 11 28 | 23 36 | 11 37 | 0 53 |
| 7 | 11 45 | 21 24 | 12 25 | 23 32 | 11 57 | DNS | 12 18 | 2 04 |
| 8 | 12 32 | 22 25 | 12 56 | DNS | 12 27 | 0 43 | 13 07 | 3 15 |
| 9 | 13 14 | 23 29 | 13 26 | 0 38 | 13 00 | 1 52 | 14 04 | 4 23 |
| 10 | 13 51 | DNS | 13 56 | 1 46 | 13 38 | 3 03 | 15 08 | 5 25 |
| 11 | 14 24 | 0 36 | 14 28 | 2 55 | 14 23 | 4 17 | 16 16 | 6 17 |
| 12 | 14 56 | 1 44 | 15 04 | 4 07 | 15 17 | 5 29 | 17 24 | 7 01 |
| 13 | 15 26 | 2 53 | 15 46 | 5 22 | 16 18 | 6 37 | 18 30 | 7 38 |
| 14 | 15 58 | 4 04 | 16 36 | 6 38 | 17 26 | 7 36 | 19 32 | 8 09 |
| 15 | 16 33 | 5 17 | 17 34 | 7 50 | 18 34 | 8 26 | 20 33 | 8 37 |
| 16 | 17 12 | 6 33 | 18 39 | 8 55 | 19 42 | 9 07 | 21 31 | 9 03 |
| 17 | 17 59 | 7 50 | 19 47 | 9 50 | 20 46 | 9 41 | 22 28 | 9 27 |
| 18 | 18 53 | 9 04 | 20 55 | 10 35 | 21 47 | 10 11 | 23 25 | 9 53 |
| 19 | 19 54 | 10 13 | 21 59 | 11 12 | 22 45 | 10 37 | DNR | 10 20 |
| 20 | 20 59 | 11 12 | 23 01 | 11 43 | 23 42 | 11 02 | 0 23 | 10 50 |
| 21 | 22 06 | 12 00 | 23 59 | 12 11 | DNR | 11 27 | 1 22 | 11 25 |
| 22 | 23 10 | 12 40 | DNR | 12 36 | 0 39 | 11 53 | 2 20 | 12 05 |
| 23 | DNR | 13 14 | 0 56 | 13 00 | 1 36 | 12 21 | 3 18 | 12 52 |
| 24 | 0 12 | 13 42 | 1 52 | 13 25 | 2 34 | 12 52 | 4 12 | 13 47 |
| 25 | 1 11 | 14 08 | 2 48 | 13 51 | 3 33 | 13 29 | 5 02 | 14 48 |
| 26 | 2 08 | 14 33 | 3 46 | 14 21 | 4 32 | 14 13 | 5 47 | 15 53 |
| 27 | 3 04 | 14 57 | 4 44 | 14 54 | 5 29 | 15 03 | 6 26 | 17 01 |
| 28 | 3 59 | 15 22 | 5 43 | 15 34 | 6 22 | 16 01 | 7 00 | 18 09 |
| 29 | 4 56 | 15 49 | 6 41 | 16 19 | 7 10 | 17 04 | 7 32 | 19 17 |
| 30 | 5 54 | 16 20 | 7 37 | 17 12 | 7 52 | 18 09 | 8 02 | 20 26 |
| 31 | 6 52 | 16 55 | | | 8 28 | 19 16 | 8 32 | 21 35 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 03 | 22 45 | 8 59 | DNS | 10 53 | 0 58 | 11 58 | 0 48 |
| 2 | 9 37 | 23 56 | 9 51 | 0 09 | 12 00 | 1 40 | 12 58 | 1 16 |
| 3 | 10 17 | DNS | 10 51 | 1 14 | 13 04 | 2 15 | 13 56 | 1 41 |
| 4 | 11 03 | 1 08 | 11 55 | 2 11 | 14 05 | 2 45 | 14 53 | 2 06 |
| 5 | 11 57 | 2 16 | 13 02 | 2 59 | 15 04 | 3 12 | 15 50 | 2 30 |
| 6 | 12 58 | 3 19 | 14 07 | 3 38 | 16 01 | 3 37 | 16 47 | 2 56 |
| 7 | 14 03 | 4 13 | 15 10 | 4 12 | 16 58 | 4 01 | 17 45 | 3 24 |
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| 11 | 18 20 | 6 38 | 19 05 | 5 56 | 20 51 | 5 55 | 21 27 | 6 06 |
| 12 | 19 19 | 7 04 | 20 03 | 6 22 | 21 48 | 6 34 | 22 12 | 7 02 |
| 13 | 20 17 | 7 29 | 21 02 | 6 50 | 22 41 | 7 19 | 22 51 | 8 01 |
| 14 | 21 15 | 7 54 | 22 00 | 7 20 | 23 30 | 8 11 | 23 25 | 9 03 |
| 15 | 22 13 | 8 20 | 22 58 | 7 56 | DNR | 9 08 | 23 56 | 10 06 |
| 16 | 23 11 | 8 49 | 23 54 | 8 37 | 0 13 | 10 09 | DNR | 11 09 |
| 17 | DNR | 9 21 | DNR | 9 24 | 0 51 | 11 12 | 0 24 | 12 13 |
| 18 | 0 09 | 9 59 | 0 46 | 10 18 | 1 24 | 12 16 | 0 52 | 13 19 |
| 19 | 1 07 | 10 43 | 1 34 | 11 18 | 1 55 | 13 22 | 1 21 | 14 27 |
| 20 | 2 02 | 11 34 | 2 15 | 12 21 | 2 24 | 14 29 | 1 52 | 15 39 |
| 21 | 2 54 | 12 31 | 2 53 | 13 27 | 2 53 | 15 38 | 2 27 | 16 54 |
| 22 | 3 40 | 13 34 | 3 26 | 14 34 | 3 24 | 16 51 | 3 10 | 18 11 |
| 23 | 4 21 | 14 40 | 3 57 | 15 43 | 3 58 | 18 07 | 4 02 | 19 24 |
| 24 | 4 57 | 15 49 | 4 27 | 16 53 | 4 38 | 19 24 | 5 04 | 20 30 |
| 25 | 5 30 | 16 58 | 4 57 | 18 05 | 5 26 | 20 41 | 6 13 | 21 25 |
| 26 | 6 00 | 18 07 | 5 30 | 19 20 | 6 23 | 21 50 | 7 25 | 22 10 |
| 27 | 6 30 | 19 18 | 6 07 | 20 37 | 7 28 | 22 49 | 8 36 | 22 46 |
| 28 | 7 02 | 20 30 | 6 51 | 21 52 | 8 38 | 23 37 | 9 44 | 23 17 |
| 29 | 7 36 | 21 44 | 7 42 | 23 03 | 9 47 | DNS | 10 47 | 23 44 |
| 30 | 8 14 | 22 57 | 8 41 | DNS | 10 54 | 0 16 | 11 47 | DNS |
| 31 | | | 9 46 | 0 06 | | | 12 45 | 0 09 |

**Note:** DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

## DARWIN — CST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 4 33 | 17 46 | 6 14 | 19 23 | 5 02 | 18 05 | 6 17 | 18 41 |
| 2 | 5 30 | 18 49 | 7 11 | 20 10 | 5 56 | 18 48 | 7 02 | 19 16 |
| 3 | 6 30 | 19 48 | 8 03 | 20 52 | 6 46 | 19 28 | 7 47 | 19 52 |
| 4 | 7 30 | 20 43 | 8 53 | 21 31 | 7 34 | 20 05 | 8 33 | 20 29 |
| 5 | 8 28 | 21 33 | 9 40 | 22 08 | 8 20 | 20 41 | 9 19 | 21 08 |
| 6 | 9 23 | 22 17 | 10 26 | 22 43 | 9 05 | 21 16 | 10 08 | 21 50 |
| 7 | 10 14 | 22 58 | 11 11 | 23 19 | 9 51 | 21 52 | 10 59 | 22 36 |
| 8 | 11 02 | 23 35 | 11 56 | 23 55 | 10 37 | 22 30 | 11 51 | 23 26 |
| 9 | 11 48 | DNS | 12 43 | DNS | 11 24 | 23 10 | 12 45 | DNS |
| 10 | 12 33 | 0 11 | 13 32 | 0 34 | 12 14 | 23 54 | 13 38 | 0 19 |
| 11 | 13 18 | 0 46 | 14 23 | 1 16 | 13 06 | DNS | 14 30 | 1 15 |
| 12 | 14 04 | 1 22 | 15 16 | 2 02 | 13 59 | 0 42 | 15 19 | 2 12 |
| 13 | 14 51 | 2 00 | 16 12 | 2 53 | 14 54 | 1 34 | 16 07 | 3 09 |
| 14 | 15 41 | 2 40 | 17 08 | 3 48 | 15 48 | 2 30 | 16 53 | 4 07 |
| 15 | 16 35 | 3 24 | 18 02 | 4 46 | 16 41 | 3 28 | 17 39 | 5 04 |
| 16 | 17 30 | 4 13 | 18 55 | 5 46 | 17 31 | 4 27 | 18 25 | 6 02 |
| 17 | 18 26 | 5 07 | 19 44 | 6 46 | 18 19 | 5 27 | 19 12 | 7 01 |
| 18 | 19 22 | 6 04 | 20 31 | 7 45 | 19 06 | 6 25 | 20 03 | 8 02 |
| 19 | 20 15 | 7 03 | 21 16 | 8 42 | 19 51 | 7 23 | 20 57 | 9 05 |
| 20 | 21 05 | 8 02 | 22 00 | 9 38 | 20 37 | 8 21 | 21 55 | 10 10 |
| 21 | 21 52 | 9 00 | 22 45 | 10 35 | 21 25 | 9 20 | 22 54 | 11 14 |
| 22 | 22 37 | 9 56 | 23 32 | 11 32 | 22 16 | 10 21 | 23 55 | 12 15 |
| 23 | 23 20 | 10 51 | DNR | 12 31 | 23 09 | 11 22 | DNR | 13 11 |
| 24 | DNR | 11 46 | 0 22 | 13 30 | DNR | 12 24 | 0 53 | 14 02 |
| 25 | 0 03 | 12 41 | 1 15 | 14 31 | 0 06 | 13 25 | 1 48 | 14 47 |
| 26 | 0 48 | 13 37 | 2 11 | 15 30 | 1 04 | 14 23 | 2 40 | 15 28 |
| 27 | 1 35 | 14 36 | 3 09 | 16 26 | 2 02 | 15 16 | 3 29 | 16 06 |
| 28 | 2 25 | 15 36 | 4 07 | 17 18 | 2 58 | 16 04 | 4 15 | 16 42 |
| 29 | 3 20 | 16 36 | | | 3 52 | 16 48 | 5 00 | 17 17 |
| 30 | 4 17 | 17 36 | | | 4 42 | 17 28 | 5 45 | 17 52 |
| 31 | 5 16 | 18 32 | | | 5 31 | 18 05 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 30 | 18 29 | 7 42 | 19 18 | 8 16 | 19 53 | 9 23 | 21 27 |
| 2 | 7 16 | 19 07 | 8 35 | 20 09 | 9 07 | 20 49 | 10 05 | 22 21 |
| 3 | 8 05 | 19 48 | 9 29 | 21 03 | 9 56 | 21 44 | 10 47 | 23 14 |
| 4 | 8 55 | 20 33 | 10 21 | 21 58 | 10 41 | 22 38 | 11 29 | DNS |
| 5 | 9 47 | 21 21 | 11 10 | 22 53 | 11 24 | 23 31 | 12 14 | 0 09 |
| 6 | 10 40 | 22 13 | 11 57 | 23 48 | 12 05 | DNS | 13 01 | 1 06 |
| 7 | 11 32 | 23 07 | 12 42 | DNS | 12 47 | 0 24 | 13 53 | 2 05 |
| 8 | 12 24 | DNS | 13 24 | 0 42 | 13 30 | 1 18 | 14 50 | 3 07 |
| 9 | 13 13 | 0 03 | 14 07 | 1 35 | 14 16 | 2 14 | 15 50 | 4 10 |
| 10 | 14 00 | 0 59 | 14 50 | 2 29 | 15 06 | 3 12 | 16 52 | 5 12 |
| 11 | 14 45 | 1 54 | 15 35 | 3 25 | 16 02 | 4 14 | 17 53 | 6 09 |
| 12 | 15 29 | 2 49 | 16 24 | 4 24 | 17 01 | 5 19 | 18 51 | 7 02 |
| 13 | 16 13 | 3 45 | 17 18 | 5 27 | 18 04 | 6 23 | 19 45 | 7 49 |
| 14 | 16 58 | 4 42 | 18 17 | 6 32 | 19 07 | 7 25 | 20 36 | 8 31 |
| 15 | 17 47 | 5 41 | 19 20 | 7 38 | 20 08 | 8 21 | 21 25 | 9 10 |
| 16 | 18 39 | 6 43 | 20 23 | 8 42 | 21 04 | 9 12 | 22 11 | 9 47 |
| 17 | 19 37 | 7 48 | 21 25 | 9 41 | 21 57 | 9 57 | 22 57 | 10 23 |
| 18 | 20 37 | 8 54 | 22 23 | 10 34 | 22 46 | 10 37 | 23 43 | 10 59 |
| 19 | 21 40 | 9 59 | 23 17 | 11 21 | 23 33 | 11 15 | DNR | 11 37 |
| 20 | 22 41 | 11 00 | DNR | 12 03 | DNR | 11 51 | 0 31 | 12 17 |
| 21 | 23 40 | 11 55 | 0 07 | 12 42 | 0 18 | 12 26 | 1 20 | 13 00 |
| 22 | DNR | 12 44 | 0 54 | 13 18 | 1 04 | 13 03 | 2 12 | 13 47 |
| 23 | 0 34 | 13 27 | 1 39 | 13 53 | 1 50 | 13 41 | 3 05 | 14 38 |
| 24 | 1 25 | 14 07 | 2 24 | 14 29 | 2 39 | 14 22 | 3 58 | 15 33 |
| 25 | 2 12 | 14 43 | 3 09 | 15 05 | 3 29 | 15 07 | 4 51 | 16 29 |
| 26 | 2 58 | 15 18 | 3 56 | 15 45 | 4 21 | 15 56 | 5 43 | 17 26 |
| 27 | 3 43 | 15 53 | 4 45 | 16 27 | 5 15 | 16 49 | 6 31 | 18 23 |
| 28 | 4 28 | 16 29 | 5 37 | 17 14 | 6 09 | 17 45 | 7 17 | 19 18 |
| 29 | 5 13 | 17 07 | 6 30 | 18 04 | 7 01 | 18 41 | 8 01 | 20 13 |
| 30 | 6 01 | 17 47 | 7 23 | 18 58 | 7 51 | 19 38 | 8 44 | 21 08 |
| 31 | 6 51 | 18 31 | | | 8 38 | 20 33 | 9 27 | 22 04 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 12 | 23 01 | 10 39 | 23 57 | 12 31 | 0 49 | 13 06 | 1 05 |
| 2 | 10 59 | DNS | 11 37 | DNS | 13 28 | 1 40 | 13 55 | 1 44 |
| 3 | 11 50 | 0 00 | 12 38 | 0 59 | 14 20 | 2 25 | 14 41 | 2 21 |
| 4 | 12 45 | 1 01 | 13 38 | 1 58 | 15 10 | 3 06 | 15 26 | 2 57 |
| 5 | 13 43 | 2 04 | 14 36 | 2 52 | 15 57 | 3 44 | 16 12 | 3 32 |
| 6 | 14 44 | 3 05 | 15 31 | 3 41 | 16 43 | 4 20 | 16 59 | 4 09 |
| 7 | 15 44 | 4 02 | 16 23 | 4 25 | 17 28 | 4 55 | 17 47 | 4 47 |
| 8 | 16 42 | 4 55 | 17 12 | 5 05 | 18 15 | 5 31 | 18 38 | 5 29 |
| 9 | 17 36 | 5 43 | 17 59 | 5 43 | 19 02 | 6 09 | 19 29 | 6 14 |
| 10 | 18 28 | 6 27 | 18 45 | 6 19 | 19 51 | 6 48 | 20 22 | 7 02 |
| 11 | 19 17 | 7 06 | 19 31 | 6 55 | 20 42 | 7 31 | 21 13 | 7 54 |
| 12 | 20 04 | 7 44 | 20 18 | 7 31 | 21 34 | 8 17 | 22 02 | 8 47 |
| 13 | 20 50 | 8 20 | 21 06 | 8 10 | 22 26 | 9 06 | 22 49 | 9 40 |
| 14 | 21 37 | 8 56 | 21 56 | 8 50 | 23 17 | 9 58 | 23 33 | 10 33 |
| 15 | 22 24 | 9 33 | 22 47 | 9 34 | DNR | 10 51 | DNR | 11 25 |
| 16 | 23 12 | 10 12 | 23 39 | 10 21 | 0 05 | 11 45 | 0 15 | 12 16 |
| 17 | DNR | 10 54 | DNR | 11 11 | 0 52 | 12 38 | 0 55 | 13 08 |
| 18 | 0 03 | 11 39 | 0 31 | 12 04 | 1 36 | 13 31 | 1 36 | 14 00 |
| 19 | 0 55 | 12 28 | 1 22 | 12 59 | 2 18 | 14 24 | 2 17 | 14 55 |
| 20 | 1 48 | 13 20 | 2 11 | 13 54 | 3 00 | 15 18 | 3 02 | 15 53 |
| 21 | 2 40 | 14 15 | 2 58 | 14 49 | 3 42 | 16 13 | 3 51 | 16 56 |
| 22 | 3 32 | 15 11 | 3 43 | 15 44 | 4 27 | 17 12 | 4 46 | 18 02 |
| 23 | 4 21 | 16 08 | 4 26 | 16 39 | 5 15 | 18 14 | 5 46 | 19 10 |
| 24 | 5 08 | 17 04 | 5 09 | 17 35 | 6 08 | 19 20 | 6 52 | 20 16 |
| 25 | 5 53 | 18 00 | 5 54 | 18 33 | 7 07 | 20 28 | 7 58 | 21 17 |
| 26 | 6 37 | 18 56 | 6 41 | 19 34 | 8 10 | 21 35 | 9 03 | 22 11 |
| 27 | 7 20 | 19 52 | 7 31 | 20 37 | 9 15 | 22 37 | 10 02 | 22 59 |
| 28 | 8 05 | 20 50 | 8 27 | 21 43 | 10 19 | 23 33 | 10 57 | 23 41 |
| 29 | 8 53 | 21 51 | 9 26 | 22 49 | 11 19 | DNS | 11 48 | DNS |
| 30 | 9 44 | 22 54 | 10 29 | 23 51 | 12 15 | 0 22 | 12 36 | 0 19 |
| 31 | | | 11 31 | DNS | | | 13 22 | 0 56 |

# MOON RISE AND SET

## HOBART — EST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 2 43 | 18 27 | 4 20 | 19 54 | 3 16 | 18 28 | 5 27 | 18 08 |
| 2 | 3 30 | 19 35 | 5 29 | 20 27 | 4 23 | 18 56 | 6 28 | 18 27 |
| 3 | 4 26 | 20 33 | 6 37 | 20 54 | 5 29 | 19 20 | 7 29 | 18 47 |
| 4 | 5 30 | 21 20 | 7 43 | 21 18 | 6 34 | 19 42 | 8 31 | 19 09 |
| 5 | 6 39 | 21 58 | 8 46 | 21 39 | 7 36 | 20 02 | 9 33 | 19 34 |
| 6 | 7 47 | 22 28 | 9 48 | 21 59 | 8 37 | 20 22 | 10 35 | 20 03 |
| 7 | 8 54 | 22 54 | 10 49 | 22 19 | 9 38 | 20 43 | 11 38 | 20 38 |
| 8 | 9 58 | 23 16 | 11 49 | 22 41 | 10 40 | 21 06 | 12 38 | 21 21 |
| 9 | 11 00 | 23 36 | 12 51 | 23 05 | 11 42 | 21 32 | 13 34 | 22 13 |
| 10 | 12 01 | 23 56 | 13 54 | 23 34 | 12 45 | 22 04 | 14 24 | 23 14 |
| 11 | 13 01 | DNS | 14 57 | DNS | 13 47 | 22 42 | 15 07 | DNS |
| 12 | 14 02 | 0 17 | 16 00 | 0 08 | 14 47 | 23 29 | 15 44 | 0 22 |
| 13 | 15 05 | 0 40 | 17 00 | 0 51 | 15 42 | DNS | 16 15 | 1 35 |
| 14 | 16 09 | 1 06 | 17 53 | 1 44 | 16 31 | 0 26 | 16 43 | 2 50 |
| 15 | 17 13 | 1 37 | 18 40 | 2 46 | 17 12 | 1 32 | 17 09 | 4 08 |
| 16 | 18 16 | 2 16 | 19 18 | 3 57 | 17 47 | 2 45 | 17 35 | 5 26 |
| 17 | 19 13 | 3 03 | 19 51 | 5 12 | 18 18 | 4 01 | 18 02 | 6 46 |
| 18 | 20 04 | 4 01 | 20 20 | 6 29 | 18 45 | 5 19 | 18 33 | 8 08 |
| 19 | 20 46 | 5 07 | 20 46 | 7 46 | 19 11 | 6 37 | 19 10 | 9 30 |
| 20 | 21 22 | 6 19 | 21 11 | 9 02 | 19 37 | 7 56 | 19 55 | 10 49 |
| 21 | 21 52 | 7 34 | 21 38 | 10 18 | 20 06 | 9 16 | 20 49 | 12 02 |
| 22 | 22 19 | 8 48 | 22 07 | 11 35 | 20 38 | 10 35 | 21 50 | 13 04 |
| 23 | 22 44 | 10 02 | 22 40 | 12 51 | 21 17 | 11 53 | 22 57 | 13 54 |
| 24 | 23 09 | 11 16 | 23 20 | 14 05 | 22 04 | 13 07 | DNR | 14 34 |
| 25 | 23 35 | 12 30 | DNR | 15 15 | 22 59 | 14 14 | 0 05 | 15 06 |
| 26 | DNR | 13 44 | 0 09 | 16 18 | DNR | 15 09 | 1 12 | 15 32 |
| 27 | 0 05 | 14 59 | 1 05 | 17 10 | 0 01 | 15 55 | 2 17 | 15 54 |
| 28 | 0 40 | 16 13 | 2 09 | 17 53 | 1 07 | 16 31 | 3 20 | 16 14 |
| 29 | 1 23 | 17 22 | | | 2 14 | 17 01 | 4 21 | 16 34 |
| 30 | 2 14 | 18 22 | | | 3 20 | 17 26 | 5 22 | 16 53 |
| 31 | 3 14 | 19 13 | | | 4 24 | 17 47 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 23 | 17 14 | 8 25 | 17 17 | 9 03 | 17 53 | 9 20 | 20 22 |
| 2 | 7 25 | 17 38 | 9 25 | 18 03 | 9 45 | 18 59 | 9 44 | 21 35 |
| 3 | 8 28 | 18 05 | 10 19 | 18 58 | 10 20 | 20 09 | 10 08 | 22 47 |
| 4 | 9 30 | 18 38 | 11 05 | 20 00 | 10 50 | 21 20 | 10 31 | DNS |
| 5 | 10 32 | 19 18 | 11 45 | 21 08 | 11 16 | 22 32 | 10 57 | 0 01 |
| 6 | 11 30 | 20 07 | 12 18 | 22 18 | 11 40 | 23 43 | 11 27 | 1 17 |
| 7 | 12 21 | 21 04 | 12 46 | 23 29 | 12 03 | DNS | 12 03 | 2 34 |
| 8 | 13 06 | 22 08 | 13 12 | DNS | 12 27 | 0 56 | 12 48 | 3 49 |
| 9 | 13 43 | 23 17 | 13 35 | 0 41 | 12 55 | 2 11 | 13 44 | 5 00 |
| 10 | 14 15 | DNS | 14 00 | 1 55 | 13 27 | 3 29 | 14 49 | 6 01 |
| 11 | 14 43 | 0 29 | 14 26 | 3 10 | 14 07 | 4 47 | 16 00 | 6 50 |
| 12 | 15 09 | 1 43 | 14 56 | 4 29 | 14 57 | 6 04 | 17 13 | 7 30 |
| 13 | 15 34 | 2 59 | 15 32 | 5 50 | 15 58 | 7 13 | 18 24 | 8 01 |
| 14 | 15 59 | 4 16 | 16 17 | 7 11 | 17 07 | 8 11 | 19 32 | 8 27 |
| 15 | 16 28 | 5 36 | 17 13 | 8 26 | 18 20 | 8 57 | 20 38 | 8 50 |
| 16 | 17 02 | 6 58 | 18 19 | 9 31 | 19 33 | 9 33 | 21 41 | 9 11 |
| 17 | 17 43 | 8 20 | 19 31 | 10 24 | 20 43 | 10 02 | 22 44 | 9 30 |
| 18 | 18 33 | 9 39 | 20 43 | 11 04 | 21 49 | 10 27 | 23 46 | 9 51 |
| 19 | 19 34 | 10 49 | 21 53 | 11 36 | 22 53 | 10 48 | DNR | 10 13 |
| 20 | 20 41 | 11 47 | 23 00 | 12 02 | 23 55 | 11 08 | 0 49 | 10 39 |
| 21 | 21 51 | 12 32 | DNR | 12 25 | DNR | 11 28 | 1 52 | 11 09 |
| 22 | 23 01 | 13 08 | 0 03 | 12 45 | 0 56 | 11 49 | 2 54 | 11 46 |
| 23 | DNR | 13 36 | 1 05 | 13 05 | 1 58 | 12 12 | 3 54 | 12 32 |
| 24 | 0 08 | 14 00 | 2 06 | 13 24 | 3 01 | 12 40 | 4 49 | 13 27 |
| 25 | 1 12 | 14 20 | 3 08 | 13 46 | 4 04 | 13 13 | 5 37 | 14 30 |
| 26 | 2 14 | 14 40 | 4 10 | 14 11 | 5 06 | 13 53 | 6 18 | 15 39 |
| 27 | 3 15 | 14 59 | 5 13 | 14 40 | 6 05 | 14 43 | 6 52 | 16 52 |
| 28 | 4 15 | 15 20 | 6 16 | 15 16 | 6 58 | 15 41 | 7 21 | 18 06 |
| 29 | 5 17 | 15 42 | 7 17 | 15 59 | 7 43 | 16 47 | 7 47 | 19 21 |
| 30 | 6 19 | 16 08 | 8 14 | 16 52 | 8 21 | 17 58 | 8 11 | 20 35 |
| 31 | 7 23 | 16 39 | | | 8 52 | 19 10 | 8 35 | 21 51 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 00 | 23 07 | 8 42 | DNS | 10 36 | 1 31 | 11 55 | 1 08 |
| 2 | 9 29 | DNS | 9 31 | 0 44 | 11 48 | 2 09 | 13 01 | 1 31 |
| 3 | 10 03 | 0 24 | 10 30 | 1 51 | 12 57 | 2 39 | 14 04 | 1 51 |
| 4 | 10 45 | 1 41 | 11 36 | 2 47 | 14 04 | 3 04 | 15 06 | 2 11 |
| 5 | 11 36 | 2 52 | 12 47 | 3 31 | 15 08 | 3 25 | 16 08 | 2 30 |
| 6 | 12 37 | 3 55 | 13 57 | 4 06 | 16 11 | 3 45 | 17 11 | 2 51 |
| 7 | 13 46 | 4 47 | 15 06 | 4 34 | 17 14 | 4 04 | 18 14 | 3 14 |
| 8 | 14 57 | 5 29 | 16 12 | 4 58 | 18 16 | 4 24 | 19 17 | 3 42 |
| 9 | 16 08 | 6 02 | 17 17 | 5 19 | 19 19 | 4 46 | 20 18 | 4 15 |
| 10 | 17 17 | 6 30 | 18 20 | 5 39 | 20 23 | 5 10 | 21 14 | 4 56 |
| 11 | 18 23 | 6 53 | 19 22 | 5 58 | 21 25 | 5 40 | 22 04 | 5 45 |
| 12 | 19 28 | 7 14 | 20 25 | 6 19 | 22 25 | 6 15 | 22 46 | 6 42 |
| 13 | 20 31 | 7 34 | 21 29 | 6 41 | 23 19 | 6 58 | 23 21 | 7 45 |
| 14 | 21 34 | 7 54 | 22 32 | 7 08 | DNR | 7 50 | 23 50 | 8 51 |
| 15 | 22 36 | 8 15 | 23 33 | 7 39 | 0 06 | 8 48 | DNR | 9 59 |
| 16 | 23 40 | 8 39 | DNR | 8 17 | 0 46 | 9 53 | 0 15 | 11 08 |
| 17 | DNR | 9 07 | 0 31 | 9 03 | 1 19 | 11 01 | 0 38 | 12 18 |
| 18 | 0 42 | 9 41 | 1 23 | 9 58 | 1 47 | 12 11 | 1 01 | 13 29 |
| 19 | 1 43 | 10 22 | 2 08 | 11 00 | 2 12 | 13 22 | 1 23 | 14 43 |
| 20 | 2 39 | 11 13 | 2 47 | 12 07 | 2 36 | 14 35 | 1 49 | 16 02 |
| 21 | 3 30 | 12 12 | 3 19 | 13 18 | 2 59 | 15 51 | 2 18 | 17 23 |
| 22 | 4 13 | 13 18 | 3 47 | 14 32 | 3 24 | 17 10 | 2 55 | 18 45 |
| 23 | 4 49 | 14 29 | 4 12 | 15 46 | 3 52 | 18 33 | 3 43 | 20 02 |
| 24 | 5 20 | 15 43 | 4 36 | 17 03 | 4 26 | 19 57 | 4 42 | 21 07 |
| 25 | 5 47 | 16 58 | 5 00 | 18 22 | 5 08 | 21 17 | 5 53 | 21 58 |
| 26 | 6 12 | 18 14 | 5 27 | 19 43 | 6 02 | 22 27 | 7 09 | 22 38 |
| 27 | 6 36 | 19 31 | 5 58 | 21 06 | 7 07 | 23 24 | 8 26 | 23 09 |
| 28 | 7 01 | 20 50 | 6 35 | 22 27 | 8 19 | DNS | 9 39 | 23 34 |
| 29 | 7 29 | 22 10 | 7 22 | 23 41 | 9 34 | 0 08 | 10 48 | 23 55 |
| 30 | 8 02 | 23 29 | 8 19 | DNS | 10 46 | 0 42 | 11 54 | DNS |
| 31 | | | 9 25 | 0 42 | | | 12 57 | 0 15 |

**Note:** DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

## MELBOURNE — EST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 3 08 | 18 19 | 4 46 | 19 48 | 3 40 | 18 24 | 5 39 | 18 16 |
| 2 | 3 57 | 19 26 | 5 52 | 20 24 | 4 44 | 18 56 | 6 37 | 18 39 |
| 3 | 4 54 | 20 24 | 6 57 | 20 55 | 5 47 | 19 23 | 7 34 | 19 02 |
| 4 | 5 58 | 21 13 | 7 59 | 21 22 | 6 48 | 19 48 | 8 32 | 19 27 |
| 5 | 7 04 | 21 54 | 8 59 | 21 46 | 7 47 | 20 12 | 9 31 | 19 55 |
| 6 | 8 09 | 22 27 | 9 57 | 22 09 | 8 45 | 20 35 | 10 30 | 20 27 |
| 7 | 9 12 | 22 56 | 10 55 | 22 33 | 9 42 | 20 59 | 11 30 | 21 05 |
| 8 | 10 13 | 23 21 | 11 52 | 22 58 | 10 40 | 21 25 | 12 29 | 21 50 |
| 9 | 11 12 | 23 45 | 12 50 | 23 25 | 11 39 | 21 54 | 13 24 | 22 42 |
| 10 | 12 09 | DNS | 13 50 | 23 57 | 12 39 | 22 29 | 14 15 | 23 42 |
| 11 | 13 06 | 0 08 | 14 51 | DNS | 13 39 | 23 09 | 15 00 | DNS |
| 12 | 14 04 | 0 32 | 15 51 | 0 34 | 14 37 | 23 58 | 15 40 | 0 47 |
| 13 | 15 03 | 0 58 | 16 50 | 1 19 | 15 32 | DNS | 16 15 | 1 56 |
| 14 | 16 04 | 1 27 | 17 44 | 2 12 | 16 22 | 0 55 | 16 46 | 3 08 |
| 15 | 17 05 | 2 01 | 18 32 | 3 14 | 17 06 | 1 59 | 17 16 | 4 21 |
| 16 | 18 06 | 2 42 | 19 14 | 4 22 | 17 45 | 3 08 | 17 46 | 5 35 |
| 17 | 19 04 | 3 31 | 19 51 | 5 34 | 18 19 | 4 21 | 18 18 | 6 50 |
| 18 | 19 55 | 4 29 | 20 23 | 6 46 | 18 50 | 5 34 | 18 53 | 8 08 |
| 19 | 20 41 | 5 34 | 20 53 | 7 59 | 19 21 | 6 48 | 19 34 | 9 25 |
| 20 | 21 19 | 6 43 | 21 23 | 9 11 | 19 51 | 8 03 | 20 22 | 10 41 |
| 21 | 21 53 | 7 53 | 21 53 | 10 23 | 20 24 | 9 18 | 21 17 | 11 52 |
| 22 | 22 24 | 9 04 | 22 26 | 11 35 | 21 00 | 10 33 | 22 19 | 12 54 |
| 23 | 22 53 | 10 14 | 23 03 | 12 47 | 21 42 | 11 47 | 23 24 | 13 46 |
| 24 | 23 21 | 11 24 | 23 46 | 13 58 | 22 31 | 12 59 | DNR | 14 28 |
| 25 | 23 51 | 12 33 | DNR | 15 06 | 23 27 | 14 04 | 0 29 | 15 03 |
| 26 | DNR | 13 44 | 0 36 | 16 08 | DNR | 15 00 | 1 32 | 15 32 |
| 27 | 0 25 | 14 55 | 1 33 | 17 01 | 0 28 | 15 47 | 2 34 | 15 58 |
| 28 | 1 04 | 16 06 | 2 36 | 17 46 | 1 32 | 16 26 | 3 33 | 16 21 |
| 29 | 1 49 | 17 13 | | | 2 36 | 16 59 | 4 31 | 16 44 |
| 30 | 2 42 | 18 13 | | | 3 39 | 17 27 | 5 28 | 17 07 |
| 31 | 3 42 | 19 05 | | | 4 40 | 17 52 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 26 | 17 31 | 8 16 | 17 45 | 8 54 | 18 20 | 9 21 | 20 37 |
| 2 | 7 24 | 17 58 | 9 14 | 18 32 | 9 38 | 19 24 | 9 50 | 21 46 |
| 3 | 8 24 | 18 28 | 10 08 | 19 27 | 10 16 | 20 31 | 10 17 | 22 54 |
| 4 | 9 23 | 19 04 | 10 56 | 20 27 | 10 49 | 21 38 | 10 45 | DNS |
| 5 | 10 23 | 19 46 | 11 38 | 21 32 | 11 19 | 22 45 | 11 15 | 0 04 |
| 6 | 11 19 | 20 36 | 12 14 | 22 38 | 11 46 | 23 53 | 11 48 | 1 16 |
| 7 | 12 11 | 21 32 | 12 46 | 23 46 | 12 13 | DNS | 12 28 | 2 28 |
| 8 | 12 57 | 22 34 | 13 15 | DNS | 12 42 | 1 02 | 13 16 | 3 41 |
| 9 | 13 38 | 23 40 | 13 43 | 0 54 | 13 13 | 2 13 | 14 13 | 4 49 |
| 10 | 14 13 | DNS | 14 11 | 2 03 | 13 49 | 3 26 | 15 17 | 5 51 |
| 11 | 14 45 | 0 49 | 14 41 | 3 15 | 14 33 | 4 41 | 16 26 | 6 42 |
| 12 | 15 14 | 1 59 | 15 16 | 4 29 | 15 25 | 5 55 | 17 35 | 7 25 |
| 13 | 15 43 | 3 10 | 15 56 | 5 46 | 16 27 | 7 03 | 18 43 | 8 00 |
| 14 | 16 13 | 4 23 | 16 44 | 7 03 | 17 35 | 8 02 | 19 47 | 8 29 |
| 15 | 16 46 | 5 38 | 17 42 | 8 16 | 18 45 | 8 50 | 20 49 | 8 55 |
| 16 | 17 23 | 6 56 | 18 47 | 9 21 | 19 54 | 9 30 | 21 49 | 9 19 |
| 17 | 18 08 | 8 14 | 19 57 | 10 15 | 21 00 | 10 02 | 22 48 | 9 43 |
| 18 | 19 01 | 9 30 | 21 06 | 10 59 | 22 02 | 10 30 | 23 47 | 10 07 |
| 19 | 20 02 | 10 39 | 22 12 | 11 34 | 23 02 | 10 55 | DNR | 10 32 |
| 20 | 21 08 | 11 37 | 23 15 | 12 04 | DNR | 11 18 | 0 46 | 11 01 |
| 21 | 22 16 | 12 25 | DNR | 12 29 | 0 01 | 11 41 | 1 46 | 11 34 |
| 22 | 23 22 | 13 03 | 0 15 | 12 53 | 0 59 | 12 06 | 2 46 | 12 14 |
| 23 | DNR | 13 35 | 1 14 | 13 16 | 1 58 | 12 32 | 3 44 | 13 01 |
| 24 | 0 25 | 14 02 | 2 11 | 13 39 | 2 57 | 13 03 | 4 38 | 13 55 |
| 25 | 1 26 | 14 26 | 3 09 | 14 04 | 3 57 | 13 39 | 5 28 | 14 57 |
| 26 | 2 24 | 14 49 | 4 08 | 14 32 | 4 57 | 14 21 | 6 11 | 16 04 |
| 27 | 3 22 | 15 12 | 5 08 | 15 04 | 5 55 | 15 12 | 6 49 | 17 13 |
| 28 | 4 19 | 15 36 | 6 08 | 15 42 | 6 48 | 16 09 | 7 21 | 18 23 |
| 29 | 5 17 | 16 01 | 7 07 | 16 28 | 7 35 | 17 13 | 7 51 | 19 33 |
| 30 | 6 16 | 16 31 | 8 03 | 17 21 | 8 15 | 18 20 | 8 19 | 20 44 |
| 31 | 7 17 | 17 05 | | | 8 50 | 19 29 | 8 47 | 21 55 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 16 | 23 07 | 9 08 | DNS | 11 03 | 1 23 | 12 11 | 1 09 |
| 2 | 9 49 | DNS | 10 00 | 0 35 | 12 11 | 2 04 | 13 13 | 1 35 |
| 3 | 10 27 | 0 20 | 10 59 | 1 40 | 13 16 | 2 37 | 14 13 | 1 59 |
| 4 | 11 12 | 1 33 | 12 04 | 2 37 | 14 19 | 3 06 | 15 12 | 2 21 |
| 5 | 12 05 | 2 42 | 13 12 | 3 23 | 15 20 | 3 30 | 16 10 | 2 44 |
| 6 | 13 06 | 3 45 | 14 19 | 4 02 | 16 19 | 3 54 | 17 09 | 3 09 |
| 7 | 14 13 | 4 38 | 15 24 | 4 33 | 17 18 | 4 16 | 18 09 | 3 35 |
| 8 | 15 21 | 5 23 | 16 26 | 5 01 | 18 17 | 4 39 | 19 09 | 4 06 |
| 9 | 16 28 | 5 59 | 17 27 | 5 25 | 19 17 | 5 04 | 20 08 | 4 42 |
| 10 | 17 33 | 6 30 | 18 26 | 5 48 | 20 17 | 5 33 | 21 03 | 5 25 |
| 11 | 18 36 | 6 57 | 19 26 | 6 11 | 21 16 | 6 05 | 21 53 | 6 14 |
| 12 | 19 37 | 7 21 | 20 25 | 6 35 | 22 14 | 6 43 | 22 37 | 7 10 |
| 13 | 20 36 | 7 45 | 21 25 | 7 01 | 23 08 | 7 27 | 23 15 | 8 11 |
| 14 | 21 35 | 8 08 | 22 25 | 7 31 | 23 56 | 8 19 | 23 47 | 9 14 |
| 15 | 22 35 | 8 33 | 23 24 | 8 05 | DNR | 9 16 | DNR | 10 19 |
| 16 | 23 35 | 9 00 | DNR | 8 45 | 0 38 | 10 18 | 0 16 | 11 24 |
| 17 | DNR | 9 31 | 0 20 | 9 32 | 1 14 | 11 23 | 0 43 | 12 29 |
| 18 | 0 34 | 10 08 | 1 13 | 10 27 | 1 46 | 12 29 | 1 09 | 13 37 |
| 19 | 1 33 | 10 51 | 1 59 | 11 27 | 2 15 | 13 37 | 1 36 | 14 47 |
| 20 | 2 29 | 11 42 | 2 40 | 12 32 | 2 42 | 14 45 | 2 05 | 16 01 |
| 21 | 3 20 | 12 40 | 3 15 | 13 39 | 3 09 | 15 57 | 2 39 | 17 18 |
| 22 | 4 05 | 13 44 | 3 47 | 14 48 | 3 38 | 17 12 | 3 20 | 18 36 |
| 23 | 4 44 | 14 52 | 4 16 | 15 59 | 4 10 | 18 30 | 4 11 | 19 51 |
| 24 | 5 19 | 16 02 | 4 44 | 17 11 | 4 49 | 19 49 | 5 12 | 20 56 |
| 25 | 5 50 | 17 13 | 5 13 | 18 25 | 5 35 | 21 07 | 6 22 | 21 50 |
| 26 | 6 18 | 18 24 | 5 43 | 19 42 | 6 31 | 22 16 | 7 35 | 22 33 |
| 27 | 6 47 | 19 37 | 6 19 | 21 01 | 7 36 | 23 14 | 8 48 | 23 08 |
| 28 | 7 16 | 20 51 | 7 00 | 22 18 | 8 47 | DNS | 9 57 | 23 36 |
| 29 | 7 48 | 22 07 | 7 50 | 23 30 | 9 58 | 0 01 | 11 02 | DNS |
| 30 | 8 25 | 23 22 | 8 49 | DNS | 11 06 | 0 38 | 12 04 | 0 02 |
| 31 | | | 9 54 | 0 32 | | | 13 04 | 0 25 |

# MOON RISE AND SET

## PERTH — WST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 3 24 | 18 04 | 5 05 | 19 33 | 3 57 | 18 10 | 5 42 | 18 14 |
| 2 | 4 16 | 19 09 | 6 08 | 20 12 | 4 58 | 18 45 | 6 37 | 18 40 |
| 3 | 5 15 | 20 07 | 7 09 | 20 45 | 5 57 | 19 16 | 7 31 | 19 07 |
| 4 | 6 17 | 20 57 | 8 07 | 21 15 | 6 54 | 19 44 | 8 25 | 19 35 |
| 5 | 7 21 | 21 40 | 9 04 | 21 43 | 7 49 | 20 11 | 9 21 | 20 07 |
| 6 | 8 23 | 22 16 | 9 58 | 22 10 | 8 43 | 20 37 | 10 17 | 20 42 |
| 7 | 9 23 | 22 48 | 10 52 | 22 36 | 9 38 | 21 05 | 11 14 | 21 23 |
| 8 | 10 20 | 23 16 | 11 46 | 23 05 | 10 32 | 21 34 | 12 11 | 22 09 |
| 9 | 11 15 | 23 43 | 12 41 | 23 36 | 11 28 | 22 07 | 13 06 | 23 02 |
| 10 | 12 09 | DNS | 13 38 | DNS | 12 25 | 22 44 | 13 57 | DNS |
| 11 | 13 02 | 0 09 | 14 36 | 0 10 | 13 22 | 23 28 | 14 44 | 0 01 |
| 12 | 13 57 | 0 37 | 15 35 | 0 51 | 14 19 | DNS | 15 26 | 1 05 |
| 13 | 14 53 | 1 06 | 16 32 | 1 38 | 15 14 | 0 18 | 16 04 | 2 11 |
| 14 | 15 51 | 1 39 | 17 27 | 2 32 | 16 05 | 1 15 | 16 40 | 3 18 |
| 15 | 16 50 | 2 16 | 18 16 | 3 33 | 16 51 | 2 18 | 17 14 | 4 27 |
| 16 | 17 49 | 3 00 | 19 01 | 4 39 | 17 33 | 3 24 | 17 48 | 5 37 |
| 17 | 18 46 | 3 51 | 19 41 | 5 48 | 18 11 | 4 33 | 18 25 | 6 48 |
| 18 | 19 39 | 4 49 | 20 17 | 6 57 | 18 46 | 5 43 | 19 05 | 8 01 |
| 19 | 20 26 | 5 52 | 20 51 | 8 05 | 19 20 | 6 52 | 19 50 | 9 14 |
| 20 | 21 07 | 6 59 | 21 25 | 9 13 | 19 55 | 8 02 | 20 41 | 10 27 |
| 21 | 21 45 | 8 06 | 21 59 | 10 20 | 20 32 | 9 13 | 21 38 | 11 35 |
| 22 | 22 19 | 9 12 | 22 36 | 11 28 | 21 13 | 10 24 | 22 39 | 12 36 |
| 23 | 22 52 | 10 18 | 23 17 | 12 37 | 21 59 | 11 34 | 23 42 | 13 29 |
| 24 | 23 24 | 11 24 | DNR | 13 44 | 22 51 | 12 43 | DNR | 14 13 |
| 25 | 23 59 | 12 29 | 0 04 | 14 50 | 23 48 | 13 46 | 0 44 | 14 50 |
| 26 | DNR | 13 36 | 0 56 | 15 50 | DNR | 14 42 | 1 44 | 15 22 |
| 27 | 0 36 | 14 44 | 1 54 | 16 44 | 0 48 | 15 31 | 2 42 | 15 51 |
| 28 | 1 19 | 15 51 | 2 55 | 17 31 | 1 50 | 16 12 | 3 38 | 16 18 |
| 29 | 2 07 | 16 56 | | | 2 51 | 16 47 | 4 32 | 16 44 |
| 30 | 3 02 | 17 56 | | | 3 50 | 17 19 | 5 26 | 17 10 |
| 31 | 4 02 | 18 48 | | | 4 47 | 17 47 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 20 | 17 38 | 8 00 | 18 03 | 8 36 | 18 40 | 9 13 | 20 45 |
| 2 | 7 15 | 18 08 | 8 56 | 18 52 | 9 22 | 19 42 | 9 45 | 21 49 |
| 3 | 8 11 | 18 42 | 9 50 | 19 47 | 10 02 | 20 45 | 10 17 | 22 54 |
| 4 | 9 09 | 19 21 | 10 39 | 20 46 | 10 38 | 21 49 | 10 48 | 23 59 |
| 5 | 10 06 | 20 05 | 11 22 | 21 48 | 11 12 | 22 52 | 11 22 | DNS |
| 6 | 11 01 | 20 56 | 12 01 | 22 51 | 11 43 | 23 56 | 12 00 | 1 07 |
| 7 | 11 53 | 21 52 | 12 37 | 23 55 | 12 14 | DNS | 12 44 | 2 16 |
| 8 | 12 40 | 22 53 | 13 09 | DNS | 12 47 | 1 00 | 13 35 | 3 25 |
| 9 | 13 23 | 23 56 | 13 41 | 0 59 | 13 22 | 2 07 | 14 34 | 4 32 |
| 10 | 14 01 | DNS | 14 13 | 2 05 | 14 03 | 3 17 | 15 38 | 5 33 |
| 11 | 14 36 | 1 01 | 14 48 | 3 12 | 14 50 | 4 28 | 16 44 | 6 26 |
| 12 | 15 10 | 2 07 | 15 27 | 4 22 | 15 46 | 5 39 | 17 50 | 7 10 |
| 13 | 15 43 | 3 14 | 16 11 | 5 35 | 16 48 | 6 45 | 18 54 | 7 48 |
| 14 | 16 17 | 4 22 | 17 03 | 6 49 | 17 55 | 7 44 | 19 54 | 8 21 |
| 15 | 16 54 | 5 33 | 18 03 | 7 59 | 19 02 | 8 35 | 20 52 | 8 51 |
| 16 | 17 37 | 6 47 | 19 08 | 9 03 | 20 07 | 9 17 | 21 48 | 9 18 |
| 17 | 18 26 | 8 01 | 20 15 | 9 58 | 21 09 | 9 52 | 22 44 | 9 45 |
| 18 | 19 22 | 9 14 | 21 21 | 10 44 | 22 08 | 10 23 | 23 39 | 10 12 |
| 19 | 20 23 | 10 21 | 22 24 | 11 22 | 23 04 | 10 51 | DNR | 10 41 |
| 20 | 21 28 | 11 20 | 23 23 | 11 55 | 23 59 | 11 18 | 0 35 | 11 14 |
| 21 | 22 33 | 12 09 | DNR | 12 24 | DNR | 11 45 | 1 32 | 11 50 |
| 22 | 23 36 | 12 50 | 0 19 | 12 51 | 0 54 | 12 13 | 2 29 | 12 32 |
| 23 | DNR | 13 24 | 1 14 | 13 17 | 1 49 | 12 43 | 3 26 | 13 21 |
| 24 | 0 35 | 13 55 | 2 08 | 13 44 | 2 45 | 13 17 | 4 20 | 14 16 |
| 25 | 1 32 | 14 22 | 3 02 | 14 12 | 3 43 | 13 55 | 5 10 | 15 17 |
| 26 | 2 27 | 14 48 | 3 58 | 14 44 | 4 40 | 14 40 | 5 55 | 16 21 |
| 27 | 3 21 | 15 14 | 4 55 | 15 19 | 5 36 | 15 32 | 6 36 | 17 26 |
| 28 | 4 15 | 15 41 | 5 52 | 16 00 | 6 29 | 16 30 | 7 12 | 18 32 |
| 29 | 5 09 | 16 11 | 6 50 | 16 47 | 7 18 | 17 32 | 7 45 | 19 38 |
| 30 | 6 05 | 16 43 | 7 45 | 17 41 | 8 01 | 18 36 | 8 17 | 20 44 |
| 31 | 7 02 | 17 20 | | | 8 39 | 19 41 | 8 49 | 21 51 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 23 | 22 59 | 9 26 | DNS | 11 21 | 1 06 | 12 20 | 0 59 |
| 2 | 10 00 | DNS | 10 20 | 0 18 | 12 26 | 1 49 | 13 18 | 1 29 |
| 3 | 10 42 | 0 09 | 11 20 | 1 22 | 13 28 | 2 25 | 14 14 | 1 56 |
| 4 | 11 31 | 1 18 | 12 24 | 2 19 | 14 27 | 2 57 | 15 09 | 2 22 |
| 5 | 12 26 | 2 25 | 13 29 | 3 07 | 15 23 | 3 25 | 16 04 | 2 48 |
| 6 | 13 27 | 3 27 | 14 33 | 3 48 | 16 19 | 3 52 | 17 00 | 3 16 |
| 7 | 14 32 | 4 21 | 15 34 | 4 23 | 17 14 | 4 18 | 17 56 | 3 47 |
| 8 | 15 37 | 5 07 | 16 32 | 4 53 | 18 09 | 4 45 | 18 53 | 4 21 |
| 9 | 16 41 | 5 47 | 17 29 | 5 21 | 19 06 | 5 13 | 19 50 | 5 00 |
| 10 | 17 42 | 6 21 | 18 25 | 5 48 | 20 03 | 5 45 | 20 44 | 5 45 |
| 11 | 18 41 | 6 51 | 19 20 | 6 14 | 21 00 | 6 21 | 21 34 | 6 35 |
| 12 | 19 37 | 7 19 | 20 16 | 6 42 | 21 56 | 7 01 | 22 19 | 7 31 |
| 13 | 20 33 | 7 45 | 21 13 | 7 11 | 22 48 | 7 48 | 22 59 | 8 29 |
| 14 | 21 29 | 8 12 | 22 10 | 7 44 | 23 37 | 8 40 | 23 35 | 9 30 |
| 15 | 22 25 | 8 41 | 23 07 | 8 22 | DNR | 9 36 | DNR | 10 31 |
| 16 | 23 22 | 9 12 | DNR | 9 04 | 0 21 | 10 36 | 0 07 | 11 32 |
| 17 | DNR | 9 46 | 0 02 | 9 53 | 0 59 | 11 38 | 0 38 | 12 34 |
| 18 | 0 19 | 10 25 | 0 53 | 10 47 | 1 35 | 12 40 | 1 08 | 13 37 |
| 19 | 1 15 | 11 11 | 1 41 | 11 46 | 2 07 | 13 43 | 1 39 | 14 43 |
| 20 | 2 10 | 12 03 | 2 24 | 12 48 | 2 38 | 14 48 | 2 12 | 15 53 |
| 21 | 3 01 | 13 00 | 3 02 | 13 52 | 3 10 | 15 56 | 2 51 | 17 06 |
| 22 | 3 48 | 14 02 | 3 37 | 14 58 | 3 43 | 17 06 | 3 36 | 18 21 |
| 23 | 4 30 | 15 07 | 4 10 | 16 04 | 4 20 | 18 20 | 4 31 | 19 33 |
| 24 | 5 07 | 16 13 | 4 42 | 17 12 | 5 03 | 19 36 | 5 34 | 20 38 |
| 25 | 5 42 | 17 20 | 5 15 | 18 22 | 5 54 | 20 50 | 6 43 | 21 34 |
| 26 | 6 15 | 18 27 | 5 51 | 19 34 | 6 52 | 21 58 | 7 54 | 22 19 |
| 27 | 6 47 | 19 35 | 6 31 | 20 49 | 7 58 | 22 57 | 9 03 | 22 57 |
| 28 | 7 21 | 20 45 | 7 17 | 22 03 | 9 07 | 23 45 | 10 07 | 23 29 |
| 29 | 7 58 | 21 57 | 8 10 | 23 12 | 10 14 | DNS | 11 08 | 23 58 |
| 30 | 8 39 | 23 08 | 9 10 | DNS | 11 19 | 0 25 | 12 06 | DNS |
| 31 | | | 10 15 | 0 13 | | | 13 02 | 0 25 |

**Note:** DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

## SYDNEY — EST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | |
|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 2 52 | 17 41 | 4 32 | 19 12 | 3 24 | 17 49 | 5 15 | 17 50 |
| 2 | 3 43 | 18 47 | 5 35 | 19 51 | 4 26 | 18 23 | 6 10 | 18 15 |
| 3 | 4 41 | 19 46 | 6 38 | 20 23 | 5 27 | 18 53 | 7 05 | 18 41 |
| 4 | 5 44 | 20 36 | 7 38 | 20 53 | 6 25 | 19 21 | 8 01 | 19 08 |
| 5 | 6 48 | 21 19 | 8 35 | 21 19 | 7 22 | 19 46 | 8 57 | 19 38 |
| 6 | 7 52 | 21 54 | 9 31 | 21 45 | 8 17 | 20 12 | 9 55 | 20 12 |
| 7 | 8 53 | 22 25 | 10 26 | 22 11 | 9 12 | 20 38 | 10 52 | 20 51 |
| 8 | 9 51 | 22 53 | 11 22 | 22 38 | 10 08 | 21 06 | 11 50 | 21 37 |
| 9 | 10 47 | 23 19 | 12 18 | 23 07 | 11 05 | 21 38 | 12 45 | 22 29 |
| 10 | 11 42 | 23 44 | 13 15 | 23 41 | 12 02 | 22 14 | 13 36 | 23 28 |
| 11 | 12 37 | DNS | 14 14 | DNS | 13 01 | 22 56 | 14 23 | DNS |
| 12 | 13 32 | 0 11 | 15 13 | 0 20 | 13 58 | 23 45 | 15 05 | 0 32 |
| 13 | 14 29 | 0 39 | 16 11 | 1 06 | 14 53 | DNS | 15 42 | 1 39 |
| 14 | 15 28 | 1 10 | 17 06 | 1 59 | 15 44 | 0 42 | 16 17 | 2 47 |
| 15 | 16 28 | 1 46 | 17 55 | 3 00 | 16 30 | 1 44 | 16 50 | 3 57 |
| 16 | 17 28 | 2 28 | 18 39 | 4 06 | 17 11 | 2 52 | 17 23 | 5 08 |
| 17 | 18 25 | 3 18 | 19 19 | 5 16 | 17 48 | 4 02 | 17 57 | 6 21 |
| 18 | 19 18 | 4 16 | 19 54 | 6 26 | 18 22 | 5 12 | 18 35 | 7 35 |
| 19 | 20 05 | 5 19 | 20 27 | 7 35 | 18 55 | 6 23 | 19 19 | 8 50 |
| 20 | 20 46 | 6 26 | 20 59 | 8 45 | 19 29 | 7 35 | 20 08 | 10 03 |
| 21 | 21 22 | 7 34 | 21 32 | 9 54 | 20 04 | 8 46 | 21 04 | 11 13 |
| 22 | 21 55 | 8 42 | 22 07 | 11 03 | 20 43 | 9 59 | 22 06 | 12 15 |
| 23 | 22 27 | 9 49 | 22 47 | 12 12 | 21 28 | 11 11 | 23 09 | 13 08 |
| 24 | 22 58 | 10 56 | 23 32 | 13 21 | 22 18 | 12 20 | DNR | 13 52 |
| 25 | 23 31 | 12 03 | DNR | 14 28 | 23 14 | 13 24 | 0 12 | 14 29 |
| 26 | DNR | 13 11 | 0 23 | 15 29 | DNR | 14 21 | 1 14 | 15 01 |
| 27 | 0 07 | 14 20 | 1 20 | 16 23 | 0 15 | 15 10 | 2 13 | 15 29 |
| 28 | 0 48 | 15 28 | 2 21 | 17 10 | 1 17 | 15 51 | 3 09 | 15 55 |
| 29 | 1 35 | 16 34 | | | 2 19 | 16 26 | 4 05 | 16 20 |
| 30 | 2 29 | 17 34 | | | 3 20 | 16 57 | 5 00 | 16 45 |
| 31 | 3 29 | 18 27 | | | 4 18 | 17 24 | | |

| | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|
| 1 | 5 55 | 17 11 | 7 38 | 17 32 | 8 15 | 18 07 | 8 51 | 20 15 |
| 2 | 6 51 | 17 40 | 8 35 | 18 20 | 9 01 | 19 09 | 9 22 | 21 21 |
| 3 | 7 48 | 18 13 | 9 29 | 19 14 | 9 41 | 20 13 | 9 52 | 22 26 |
| 4 | 8 46 | 18 50 | 10 18 | 20 13 | 10 17 | 21 18 | 10 22 | 23 33 |
| 5 | 9 44 | 19 33 | 11 02 | 21 16 | 10 49 | 22 23 | 10 55 | DNS |
| 6 | 10 40 | 20 23 | 11 40 | 22 20 | 11 19 | 23 27 | 11 31 | 0 42 |
| 7 | 11 32 | 21 19 | 12 15 | 23 25 | 11 49 | DNS | 12 13 | 1 52 |
| 8 | 12 20 | 22 20 | 12 46 | DNS | 12 20 | 0 33 | 13 03 | 3 03 |
| 9 | 13 02 | 23 24 | 13 17 | 0 30 | 12 54 | 1 41 | 14 00 | 4 10 |
| 10 | 13 40 | DNS | 13 48 | 1 37 | 13 33 | 2 52 | 15 04 | 5 11 |
| 11 | 14 14 | 0 30 | 14 21 | 2 45 | 14 18 | 4 04 | 16 11 | 6 05 |
| 12 | 14 46 | 1 37 | 14 57 | 3 56 | 15 12 | 5 16 | 17 18 | 6 49 |
| 13 | 15 18 | 2 45 | 15 40 | 5 10 | 16 14 | 6 23 | 18 23 | 7 27 |
| 14 | 15 50 | 3 55 | 16 31 | 6 25 | 17 21 | 7 23 | 19 25 | 7 59 |
| 15 | 16 26 | 5 07 | 17 29 | 7 37 | 18 29 | 8 13 | 20 24 | 8 27 |
| 16 | 17 07 | 6 21 | 18 34 | 8 42 | 19 36 | 8 55 | 21 22 | 8 54 |
| 17 | 17 54 | 7 37 | 19 42 | 9 37 | 20 39 | 9 30 | 22 18 | 9 20 |
| 18 | 18 48 | 8 51 | 20 49 | 10 23 | 21 39 | 10 01 | 23 15 | 9 46 |
| 19 | 19 49 | 9 59 | 21 53 | 11 01 | 22 37 | 10 28 | DNR | 10 14 |
| 20 | 20 55 | 10 59 | 22 53 | 11 33 | 23 33 | 10 54 | 0 12 | 10 44 |
| 21 | 22 00 | 11 48 | 23 51 | 12 01 | DNR | 11 19 | 1 09 | 11 20 |
| 22 | 23 04 | 12 29 | DNR | 12 27 | 0 29 | 11 46 | 2 07 | 12 01 |
| 23 | DNR | 13 03 | 0 47 | 12 52 | 1 25 | 12 15 | 3 05 | 12 48 |
| 24 | 0 05 | 13 32 | 1 42 | 13 18 | 2 22 | 12 47 | 3 59 | 13 43 |
| 25 | 1 03 | 13 59 | 2 38 | 13 45 | 3 20 | 13 24 | 4 49 | 14 43 |
| 26 | 1 59 | 14 24 | 3 34 | 14 15 | 4 19 | 14 08 | 5 34 | 15 48 |
| 27 | 2 54 | 14 49 | 4 32 | 14 49 | 5 15 | 14 59 | 6 14 | 16 55 |
| 28 | 3 49 | 15 15 | 5 30 | 15 29 | 6 09 | 15 56 | 6 50 | 18 02 |
| 29 | 4 45 | 15 43 | 6 28 | 16 15 | 6 57 | 16 59 | 7 22 | 19 09 |
| 30 | 5 42 | 16 14 | 7 24 | 17 08 | 7 40 | 18 04 | 7 53 | 20 17 |
| 31 | 6 40 | 16 50 | | | 8 17 | 19 10 | 8 24 | 21 25 |

| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 8 56 | 22 34 | 8 54 | 23 56 | 10 48 | 0 45 | 11 50 | 0 37 |
| 2 | 9 31 | 23 44 | 9 47 | DNS | 11 54 | 1 28 | 12 50 | 1 06 |
| 3 | 10 11 | DNS | 10 47 | 1 01 | 12 57 | 2 04 | 13 47 | 1 32 |
| 4 | 10 58 | 0 55 | 11 51 | 1 58 | 13 57 | 2 35 | 14 43 | 1 57 |
| 5 | 11 53 | 2 03 | 12 56 | 2 46 | 14 56 | 3 02 | 15 39 | 2 23 |
| 6 | 12 53 | 3 05 | 14 01 | 3 27 | 15 52 | 3 28 | 16 36 | 2 49 |
| 7 | 13 58 | 4 00 | 15 03 | 4 01 | 16 49 | 3 53 | 17 33 | 3 18 |
| 8 | 15 05 | 4 46 | 16 03 | 4 31 | 17 45 | 4 18 | 18 32 | 3 51 |
| 9 | 16 10 | 5 25 | 17 02 | 4 58 | 18 42 | 4 46 | 19 29 | 4 29 |
| 10 | 17 12 | 5 59 | 17 59 | 5 23 | 19 40 | 5 16 | 20 24 | 5 12 |
| 11 | 18 12 | 6 28 | 18 55 | 5 49 | 20 38 | 5 50 | 21 14 | 6 02 |
| 12 | 19 10 | 6 55 | 19 52 | 6 15 | 21 35 | 6 30 | 21 59 | 6 57 |
| 13 | 20 07 | 7 21 | 20 50 | 6 43 | 22 28 | 7 15 | 22 39 | 7 57 |
| 14 | 21 04 | 7 46 | 21 48 | 7 15 | 23 17 | 8 07 | 23 14 | 8 58 |
| 15 | 22 01 | 8 14 | 22 45 | 7 51 | DNR | 9 03 | 23 45 | 10 00 |
| 16 | 22 59 | 8 43 | 23 41 | 8 32 | 0 00 | 10 03 | DNR | 11 02 |
| 17 | 23 57 | 9 16 | DNR | 9 20 | 0 39 | 11 06 | 0 15 | 12 05 |
| 18 | DNR | 9 54 | 0 33 | 10 14 | 1 13 | 12 09 | 0 43 | 13 10 |
| 19 | 0 54 | 10 38 | 1 21 | 11 13 | 1 44 | 13 14 | 1 13 | 14 17 |
| 20 | 1 49 | 11 29 | 2 03 | 12 16 | 2 14 | 14 20 | 1 45 | 15 28 |
| 21 | 2 41 | 12 27 | 2 41 | 13 21 | 2 45 | 15 28 | 2 21 | 16 42 |
| 22 | 3 27 | 13 29 | 3 15 | 14 27 | 3 16 | 16 40 | 3 05 | 17 58 |
| 23 | 4 09 | 14 35 | 3 47 | 15 35 | 3 51 | 17 55 | 3 57 | 19 11 |
| 24 | 4 46 | 15 42 | 4 18 | 16 44 | 4 32 | 19 12 | 4 59 | 20 17 |
| 25 | 5 19 | 16 50 | 4 49 | 17 55 | 5 21 | 20 27 | 6 08 | 21 12 |
| 26 | 5 51 | 17 58 | 5 23 | 19 09 | 6 19 | 21 36 | 7 20 | 21 58 |
| 27 | 6 22 | 19 08 | 6 01 | 20 24 | 7 24 | 22 36 | 8 30 | 22 35 |
| 28 | 6 54 | 20 19 | 6 45 | 21 39 | 8 33 | 23 24 | 9 37 | 23 06 |
| 29 | 7 29 | 21 32 | 7 37 | 22 50 | 9 42 | DNS | 10 39 | 23 34 |
| 30 | 8 09 | 22 45 | 8 36 | 23 52 | 10 48 | 0 04 | 11 39 | DNS |
| 31 | | | 9 41 | DNS | | | 12 36 | 0 00 |

# LUNAR OCCULTATIONS 2003

## INTRODUCTION

An occultation is when a body passes in front of a more distant astronomical object. As viewed from Earth, no Solar System body occults more stars, more often, than our own Moon. The reasons for this are:

1. Its large angular size. Although the Moon is small in comparison to the planets, it appears large (0.5° wide) because of its proximity. The Moon travels along a 0.5° wide path across the sky, as does the Sun.
2. The rapid motion of the Moon across the sky. It completes one orbit about every 28 days.
3. With it moving approximately in the plane of the ecliptic, as do most Solar System bodies, each month the Moon crosses the heavily star populated Milky Way. It also occasionally occults the Sun and the planets. An eclipse of the Sun is indeed the most spectacular lunar occultation!

From month to month the Moon does not occult the same stars. In fact over a number of years it drifts in declination between plus and minus 28°. The brighter stars the Moon occults are listed in the Zodiacal Catalogue (ZC). There are about 3500 stars in the ZC.

The Moon moves from west to east, so it rises and sets later from day to day. From just after New Moon to just before Full Moon, stars being occulted will disappear behind part of the dark limb and reappear from the bright limb. The limb is another way of saying the edge of the Moon. After Full Moon a star will disappear on the bright limb and reappear on the dark limb. There is no dark limb at the time of Full Moon.

Dark limb events, in particular disappearances, are the easiest to observe. Following a star until it 'winks out' is much easier than scanning the lunar limb, waiting for it to suddenly reappear. The brighter the star, the more spectacular the event. The following tables present the easier to observe occultations for 2003 as predicted for **Adelaide**, **Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth** and **Sydney**. Both events, the disappearance and reappearance, are not necessarily included. An event may not be present because:

1. The Moon is in daylight
2. The Moon is too close to or below the horizon.
3. For faint stars, events on a bright limb (in particular reappearances) are difficult to observe and have been omitted.

## THE TIMING OF OCCULTATIONS.

Besides being a spectacular event, occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

**TIMING EQUIPMENT**. For a single event, such as a normal occultation, a stop-watch and the telephone time signal as a reference are required. For multiple events, the amateur may tape record simultaneously a shortwave radio time signal with his own voice calling out the events (e.g., star gone … now!). The tape would be later played back (often at a slower speed) and the precise times determined. An accuracy of within 0.2 seconds is not unusual for the experienced observer.

**TELESCOPE REQUIREMENTS**. These vary greatly with the brightness of the star being observed, the brightness of the Moon (how close to Full Moon) and whether the event is on a bright or dark limb. Disappearances of first magnitude stars on the dark limb can be observed with the naked eye!

For further information on timing methods for occultations it would be worth contacting your local astronomical society (p. 138).

## LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 7th magnitude. The criteria for selection are complex involving the Sun and Moon altitude, star magnitude and whether it is a bright or dark limb event.

## EXPLANATION

**EST** the date and time of the occultation, hr and min are in EST except Adelaide and Darwin using CST and Perth using WST.

**OBJECT**
- n, nn, nnn, nnnn — ZC catalogue number
- nnnnn or nnnnnn — SAO catalogue number
- X nnnnn — USNO XZ catalogue number
- name of planet, satellite or Messier (Mnnn) object.

**PD** event, consisting of two letters.
The first letter is the type of Event: 'D' = Disappearance and 'R' = Reappearance. The second letter represents: 'D' = Dark limb, 'B' = a bright limb event. A 'G' indicates a graze at or near the location.

**Mag** magnitude of the star.

**Elg** elongation or separation of the Moon from the Sun as measured in degrees.

**Alt.** altitude of the Moon during the occultation.

**P.A.** position angle is the position the event occurs on the limb of the Moon (measured as degrees east of north).

**A** coefficient of longitude (see below)

**B** coefficient of latitude (see below)

**** NB. For some stars, close to 'grazing', A and B values become useless, and no values are recorded.

## CALCULATING EVENT TIME FOR OTHER LOCATIONS

Unless the event is close to a 'graze' (PA is close to 0° or 180°) this method will give a good approximation for any location within about 500km from the city's table you are working from. The formula is:

Predicted Time at your location

= Time from Table + ( A x n ) + ( B x p )

where 'n' and 'p' are the **change** in longitude and latitude respectively (in decimal degrees).

'n' is positive (+) if east, negative (-) if west

'p' is positive (+) if north, negative (-) if south.

The values for A and B are taken from the tables.

It is best to use data for the city which you are closest to.

## WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the disappearance of ZC3425 on December 1st for their location in Albury NSW (146° 55' E, 36° 05' S), see page 130. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

= 149°.13 - 146°.92 = –2°.21 — 'n' (-)

The change in latitude from Canberra (decimal degrees)

= 35°.25 - 36°.08 = –0°.83 — 'p' (–)

From the Canberra table, the time of the event is 20:15 EST and the values of A and B are +1.4 and +1.9 respectively.

Therefore the equation becomes:

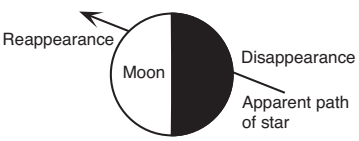
20:15 + (1.4 * -2°.21) + (1.9 * -0°.83)

= 20:15 + ( -3.1 ) + ( -1.6 )

= 20:15 + ( -4.7 ) = 20:10

The event will be visible from Albury approximately 5 minutes earlier than Canberra, i.e., about 8:10pm (EST) on December 1st.

Lunar occultation predictions were calculated using Occult version 4 by D. Herald,
PO Box 254
Woden ACT 2606.
heraldd@canberra.DIALix.oz.au



LUNAR OCCULTATION TABLE

# ADELAIDE (34° 58' S, 138° 38'E)

| CST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 06 21:01 | 3265 | DD | 6.5 | 44 | 14 | 123 | +0.7 | +0.2 |
| Jan 08 20:58 | 146908 | DD | 7.6 | 67 | 27 | 37 | +0.4 | +2.3 |
| Jan 09 22:10 | 128823 | DD | 7.2 | 78 | 17 | 100 | +0.8 | +1.1 |
| Jan 15 00:23 | 656 | DD | 4.2 | 134 | 16 | 129 | +1.1 | -0.2 |
| Jan 17 22:07 | 1089 | DD | 6.7 | 168 | 25 | 103 | +2.2 | -0.9 |
| Jan 17 22:48 | 79164 | DD | 7.4 | 168 | 27 | 68 | +2.2 | +0.2 |
| Jan 18 01:44 | 79243 | DD | 7.3 | 169 | 23 | 84 | +2.0 | +0.9 |
| Jan 18 02:06 | 79253 | DD | 7.6 | 169 | 20 | 84 | +1.9 | +1.0 |
| Jan 19 23:18 | 1363 | RD | 5.2 | 165 | 25 | 267 | +1.8 | -0.8 |
| Jan 19 23:55 | 1365 | RD | 6.0 | 164 | 29 | 272 | +2.1 | -0.7 |
| | | | | | | | | |
| Jan 26 03:48 | 2088 | RD | 6.2 | 84 | 46 | 301 | +1.1 | -1.7 |
| Jan 27 01:40 | 2209 | RD | 5.6 | 72 | 13 | 334 | -0.4 | -2.2 |
| Jan 28 04:01 | 2376 | DB | 4.5 | 58 | 32 | 78 | +1.0 | -0.8 |
| Jan 28 04:53 | 2376 | RD | 4.5 | 58 | 43 | 331 | +0.1 | -2.7 |
| Jan 29 04:01 | 2523 | DB | 4.8 | 45 | 22 | 41 | +1.6 | +1.1 |
| Jan 29 04:25 | 2523 | RD | 4.8 | 45 | 27 | 353 | -1.3 | -4.1 |
| Feb 10 20:56 | 76373 | DD | 7.6 | 101 | 27 | 17 | +1.7 | +3.2 |
| Feb 11 21:48 | 76810 | DD | 7.6 | 112 | 24 | 85 | +2.0 | +1.0 |
| Feb 11 22:39 | 76820 | DD | 7.5 | 113 | 18 | 143 | +0.9 | -1.2 |
| Feb 12 20:20 | 77523 | DD | 7.7 | 123 | 29 | 117 | +2.8 | -1.0 |
| | | | | | | | | |
| Feb 12 23:27 | 77622 | DD | 7.6 | 124 | 17 | 103 | +1.4 | +0.7 |
| Feb 14 21:20 | 1169 | DD | 5.3 | 148 | 28 | 134 | +2.2 | -1.6 |
| Feb 14 22:03 | 79672 | DD | 7.5 | 148 | 29 | 77 | +2.4 | +0.2 |
| Feb 19 01:47 | 1689 | RD | 5.2 | 157 | 47 | 276 | +2.4 | -0.3 |
| Feb 21 00:56 | 1923 | RD | 7.0 | 130 | 41 | 318 | +0.9 | -2.0 |
| Feb 21 00:58 | 139316 | RD | 7.7 | 130 | 42 | 267 | +1.8 | -0.9 |
| Feb 22 04:35 | 2060 | RD | 6.2 | 115 | 67 | 240 | +4.3 | +2.8 |
| Feb 23 00:31 | 159096 | RD | 7.6 | 103 | 24 | 324 | 0.0 | -2.1 |
| Feb 24 03:15 | 2330 | RD | 6.4 | 89 | 48 | 233 | +3.0 | +1.2 |
| Feb 24 04:52 | 2337 | RD | 6.6 | 88 | 66 | 261 | +2.4 | -0.2 |
| | | | | | | | | |
| Feb 25 04:32 | 2490 | DB | 5.2 | 76 | 53 | 123 | +1.0 | -2.0 |
| Feb 27 03:22 | 2809 | DB | 4.9 | 51 | 17 | 66 | +0.4 | -0.5 |
| Feb 27 04:15 | 2809 | RD | 4.9 | 51 | 28 | 305 | 0.0 | -2.1 |
| Mar 10 19:51 | 76636 | DD | 7.1 | 80 | 24 | 76 | +2.0 | +1.3 |
| Mar 13 20:00 | 1105 | DD | 6.5 | 114 | 28 | 98 | +2.4 | -0.3 |
| Mar 13 21:52 | 1108 | DD | 7.0 | 115 | 24 | 39 | +3.6 | +3.2 |
| Mar 14 21:27 | 80070 | DD | 7.5 | 127 | 30 | 125 | +1.9 | -0.7 |
| Mar 17 22:35 | 1621 | DD | 7.2 | 166 | 41 | 149 | +1.2 | -1.9 |
| Mar 19 21:18 | 1856 | RD | 6.8 | 164 | 23 | 312 | +0.6 | -1.9 |
| Mar 20 21:08 | 139581 | RD | 7.3 | 151 | 15 | 279 | +0.3 | -1.3 |
| | | | | | | | | |
| Mar 20 21:14 | 1985 | RD | 6.9 | 150 | 16 | 247 | +0.7 | -0.5 |
| Mar 20 23:17 | 1994 | RD | 6.6 | 150 | 40 | 319 | +0.7 | -2.0 |
| Mar 21 05:22 | 139704 | RD | 7.3 | 147 | 43 | 296 | +1.3 | -0.1 |
| Mar 21 22:23 | 2114 | RD | 5.3 | 136 | 23 | 240 | +1.2 | -0.2 |
| Mar 24 02:05 | 2430 | RD | 6.8 | 107 | 49 | 263 | +1.5 | -0.8 |
| Mar 28 04:56 | 3062 | RD | 7.5 | 56 | 37 | 265 | +1.0 | -1.0 |
| Mar 29 04:09 | 3191 | RD | 7.4 | 45 | 16 | 313 | -0.3 | -3.4 |
| Mar 29 05:06 | 164674 | RD | 7.6 | 44 | 27 | 246 | +0.8 | -0.3 |
| Mar 30 05:05 | 3323 | RD | 7.5 | 33 | 16 | 204 | +0.7 | +1.6 |
| Apr 06 19:08 | 625 | DD | 7.0 | 49 | 13 | 96 | +1.2 | +1.1 |
| | | | | | | | | |
| Apr 09 19:54 | 1056 | DD | 7.2 | 83 | 22 | 46 | +3.0 | +2.6 |
| Apr 14 21:58 | 1689 | DD | 5.2 | 147 | 47 | 147 | +1.2 | -1.7 |
| Apr 14 23:10 | 1689 | RB | 5.2 | 148 | 46 | 288 | +1.9 | -0.3 |
| Apr 15 02:20 | 119030 | DD | 7.1 | 149 | 22 | 117 | +0.7 | +0.1 |
| Apr 15 02:43 | 119038 | DD | 6.9 | 149 | 17 | 61 | +1.5 | +3.3 |
| Apr 17 01:25 | 1941 | DD | 4.7 | 176 | 56 | 202 | -2.6 | -8.5 |
| Apr 17 01:43 | 1941 | RD | 4.7 | 176 | 54 | 230 | +5.3 | +7.1 |
| Apr 17 22:14 | 2060 | RD | 6.2 | 169 | 46 | 246 | +2.5 | +0.1 |
| Apr 17 22:57 | 2064 | RD | 6.3 | 169 | 54 | 298 | +1.3 | -1.5 |
| Apr 19 23:56 | 2362 | RD | 7.7 | 140 | 49 | 279 | +1.2 | -1.2 |
| | | | | | | | | |
| Apr 25 04:08 | 3164 | DB | 4.5 | 74 | 40 | 61 | +1.3 | +0.1 |
| Apr 25 05:28 | 3164 | RD | 4.5 | 74 | 56 | 262 | +2.0 | -0.5 |
| Apr 25 05:39 | 164528 | RD | 7.5 | 74 | 58 | 313 | +2.7 | -5.5 |
| May 08 21:05 | 1279 | DD | 6.3 | 77 | 14 | 166 | -0.5 | -1.8 |
| May 12 21:24 | 119227 | DD | 7.5 | 128 | 50 | 164 | +0.6 | -2.2 |
| May 12 23:47 | 1755 | DD | 6.9 | 129 | 36 | 104 | +1.5 | +0.4 |
| May 14 20:19 | 1994 | DD | 6.6 | 156 | 47 | 69 | +2.6 | 0.0 |
| May 15 02:08 | 139704 | DD | 7.3 | 158 | 39 | 99 | +1.3 | +0.7 |
| May 15 18:54 | 2114 | DD | 5.3 | 170 | 24 | 138 | +0.1 | -1.9 |
| May 16 04:28 | 2159 | DD | 5.2 | 174 | 26 | 100 | +0.6 | +0.7 |
| May 16 04:46 | 2160 | DD | 6.4 | 174 | 22 | 144 | +0.7 | -0.8 |
| May 17 20:37 | 2430 | RD | 6.8 | 161 | 26 | 268 | +0.5 | -1.0 |
| May 18 00:53 | 184964 | RD | 7.3 | 159 | 75 | 273 | +2.1 | -0.5 |
| May 18 01:23 | 184991 | RD | 7.3 | 159 | 79 | 287 | +2.0 | -0.9 |
| May 18 22:27 | 186235 | RD | 7.2 | 146 | 36 | 325 | -0.1 | -2.7 |
| May 19 00:53 | 2623 | RD | 7.7 | 145 | 65 | 264 | +1.9 | -0.4 |
| May 19 01:33 | 186403 | RD | 7.7 | 145 | 73 | 292 | +1.8 | -1.4 |
| May 19 21:57 | 187710 | RD | 7.4 | 133 | 18 | 320 | -0.6 | -2.4 |
| May 20 00:26 | 2804 | RD | 5.8 | 131 | 47 | 298 | +0.9 | -2.0 |
| May 20 05:01 | 2824 | RD | 7.3 | 130 | 72 | 215 | +1.3 | +3.3 |
| | | | | | | | | |
| May 22 05:57 | 190252 | RD | 7.2 | 104 | 75 | 216 | +1.5 | +2.5 |
| May 25 05:51 | 3506 | DB | 6.1 | 69 | 50 | 105 | +2.9 | -2.2 |
| May 26 05:30 | 62 | RD | 7.5 | 58 | 36 | 249 | +1.4 | -0.2 |
| Jun 05 18:42 | 1363 | DD | 5.2 | 59 | 25 | 175 | -0.5 | -2.5 |
| Jun 05 19:05 | 1365 | DD | 6.0 | 59 | 23 | 154 | +0.3 | -1.1 |
| Jun 05 19:23 | 1363 | RB | 5.2 | 59 | 20 | 241 | +2.7 | +2.7 |
| Jun 08 18:46 | 119038 | DD | 6.9 | 97 | 48 | 162 | +0.8 | -2.2 |
| Jun 11 18:24 | 2060 | DD | 6.2 | 137 | 44 | 164 | +0.1 | -2.7 |
| Jun 11 18:44 | 2064 | DD | 6.3 | 137 | 47 | 117 | +1.1 | -1.6 |
| Jun 13 20:18 | 2362 | DD | 7.7 | 166 | 49 | 104 | +1.1 | -1.3 |
| | | | | | | | | |
| Jun 14 02:29 | 2388 | DD | 7.6 | 169 | 49 | 71 | +1.2 | +1.8 |
| Jun 14 05:25 | 2407 | DD | 7.0 | 170 | 15 | 93 | +0.1 | +0.9 |
| Jun 16 05:22 | 2750 | DB | 2.0 | 162 | 41 | 134 | +2.0 | -1.0 |
| Jun 16 05:58 | 2750 | RD | 2.0 | 161 | 34 | 203 | -0.6 | +3.4 |
| Jun 17 23:58 | 3037 | RD | 7.3 | 137 | 44 | 257 | +1.3 | -0.5 |
| Jun 18 05:19 | 3062 | RD | 7.5 | 135 | 63 | 270 | +2.0 | +0.7 |
| Jun 18 23:06 | 3175 | RD | 4.7 | 125 | 21 | 288 | +0.2 | -1.9 |
| Jun 19 03:10 | 164674 | RD | 7.6 | 123 | 67 | 274 | +2.5 | -0.7 |
| Jun 20 01:40 | 3323 | RD | 7.5 | 112 | 40 | 238 | +1.3 | +0.2 |
| Jun 22 01:52 | 20 | RD | 6.7 | 88 | 19 | 275 | +0.8 | -1.6 |
| | | | | | | | | |
| Jun 22 02:43 | 128642 | RD | 7.4 | 88 | 29 | 209 | +0.7 | +1.4 |
| Jun 22 04:19 | 128661 | RD | 6.6 | 88 | 46 | 211 | +1.1 | +1.6 |
| Jun 23 05:29 | 137 | RD | 7.6 | 76 | 45 | 196 | +0.6 | +2.3 |
| Jul 04 18:52 | 99249 | DD | 7.6 | 55 | 28 | 177 | -0.3 | -2.5 |
| Jul 06 20:41 | 1783 | DD | 7.3 | 81 | 35 | 105 | +1.4 | +0.4 |
| Jul 08 20:36 | 2028 | DD | 6.5 | 107 | 60 | 94 | +2.3 | +0.4 |
| Jul 09 22:08 | 2159 | DD | 5.2 | 122 | 58 | 78 | +2.2 | +1.4 |
| Jul 09 22:19 | 2160 | DD | 6.4 | 122 | 56 | 119 | +1.7 | -0.5 |
| Jul 09 23:09 | 2159 | RB | 5.2 | 122 | 47 | 331 | +1.3 | -1.8 |
| Jul 11 02:21 | 2327 | DD | 6.7 | 137 | 23 | 63 | +0.1 | +2.1 |
| | | | | | | | | |
| Jul 11 19:30 | 184964 | DD | 7.3 | 148 | 55 | 127 | +0.9 | -2.0 |
| Jul 11 19:55 | 184991 | DD | 7.3 | 148 | 60 | 111 | +1.4 | -1.5 |
| Jul 12 20:01 | 2623 | DD | 7.7 | 162 | 50 | 124 | +0.8 | -2.1 |
| Jul 12 20:34 | 186403 | DD | 7.7 | 162 | 56 | 93 | +1.5 | -1.0 |
| Jul 13 02:21 | 2657 | DD | 6.9 | 164 | 50 | 77 | +1.1 | +1.4 |
| Jul 13 19:30 | 2804 | DD | 5.8 | 174 | 31 | 91 | +0.6 | -1.1 |
| Jul 15 20:52 | 3106 | RD | 5.2 | 157 | 22 | 312 | -0.2 | -3.2 |
| Jul 15 23:28 | 190252 | RD | 7.2 | 156 | 53 | 196 | +1.6 | +3.7 |
| Jul 17 01:20 | 164984 | RD | 7.1 | 143 | 61 | 227 | +1.7 | +1.3 |
| Jul 17 05:50 | 3284 | RD | 7.0 | 141 | 47 | 245 | +1.2 | +1.7 |
| | | | | | | | | |
| Jul 18 06:07 | 3409 | RD | 7.0 | 129 | 49 | 275 | +2.2 | +0.8 |
| Jul 23 05:41 | 434 | RD | 6.9 | 73 | 35 | 219 | +1.2 | +1.0 |
| Aug 02 20:03 | 119272 | DD | 7.6 | 52 | 19 | 107 | +0.7 | +0.6 |
| Aug 03 20:53 | 139130 | DD | 7.6 | 65 | 22 | 142 | +0.5 | -0.8 |
| Aug 04 21:26 | 1996 | DD | 6.7 | 78 | 29 | 166 | +0.7 | -2.3 |
| Aug 05 21:56 | 158842 | DD | 7.2 | 92 | 36 | 73 | +1.1 | +2.1 |
| Aug 06 18:33 | 2241 | DD | 4.8 | 104 | 74 | 144 | +1.3 | -2.3 |
| Aug 06 19:46 | 2241 | RB | 4.8 | 105 | 71 | 270 | +2.3 | +0.3 |
| Aug 07 00:46 | 2267 | DD | 5.0 | 107 | 16 | 53 | -0.3 | +2.6 |
| Aug 09 22:21 | 2750 | DD | 2.0 | 145 | 80 | 79 | +2.2 | +0.7 |
| | | | | | | | | |
| Aug 09 23:44 | 2750 | RB | 2.0 | 146 | 66 | 267 | +1.9 | +0.8 |
| Aug 10 19:01 | X27622 | DD | 7.5 | 157 | 39 | 19 | +2.7 | +4.2 |
| Aug 11 21:58 | 3062 | DD | 7.5 | 171 | 62 | 45 | +1.8 | +1.4 |
| Aug 12 05:38 | 3092 | DD | 6.2 | 173 | 17 | 22 | -0.6 | +2.3 |
| Aug 14 05:51 | 3356 | RD | 5.8 | 160 | 29 | 235 | +0.5 | +1.9 |
| Aug 15 00:48 | 3478 | RD | 6.4 | 150 | 55 | 196 | +0.8 | +2.6 |
| Aug 15 23:00 | 37 | RD | 7.2 | 139 | 26 | 268 | +1.1 | -1.2 |
| Aug 19 04:29 | X 3541 | RD | 7.3 | 103 | 39 | 230 | +1.7 | +1.0 |
| Aug 21 03:05 | 621 | RD | 6.1 | 82 | 14 | 211 | +0.1 | +0.8 |
| Sep 02 20:38 | 159309 | DD | 7.7 | 75 | 40 | 60 | +1.0 | +2.8 |
| Sep 08 01:31 | 189613 | DD | 7.2 | 142 | 41 | 14 | -0.4 | +3.3 |
| Sep 08 02:59 | 189680 | DD | 7.3 | 143 | 24 | 22 | -0.5 | +2.5 |
| Sep 09 00:10 | 164528 | DD | 7.5 | 154 | 65 | 96 | +2.5 | +0.4 |
| Sep 09 02:11 | 164567 | DD | 7.3 | 155 | 42 | 121 | +2.5 | -0.3 |
| Sep 10 23:39 | 3425 | DD | 4.4 | 176 | 63 | 62 | +2.0 | +0.9 |
| Sep 11 01:02 | 3425 | RB | 4.4 | 176 | 62 | 220 | +1.3 | +2.1 |
| Sep 12 04:11 | 12 | RD | 6.4 | 167 | 35 | 283 | +2.0 | +0.8 |
| Sep 12 04:30 | 13 | RD | 6.2 | 167 | 32 | 288 | +1.9 | +0.6 |
| Sep 12 05:19 | 128618 | RD | 6.8 | 167 | 23 | 205 | +0.3 | +2.5 |
| Sep 13 02:59 | 109506 | RD | 7.6 | 156 | 48 | 266 | +2.6 | +0.8 |
| | | | | | | | | |
| Sep 15 01:32 | 340 | RD | 6.9 | 134 | 38 | 253 | +2.1 | 0.0 |
| Sep 16 03:29 | 455 | RD | 6.1 | 123 | 37 | 225 | +1.7 | +1.2 |
| Sep 19 02:38 | 844 | RD | 5.8 | 90 | 12 | 316 | +3.2 | -4.1 |
| Sep 19 03:32 | 849 | RD | 6.5 | 90 | 19 | 201 | +0.1 | +1.5 |
| Sep 29 20:47 | 2182 | DD | 6.2 | 45 | 12 | 107 | +0.2 | +0.6 |
| Sep 30 21:12 | 2333 | DD | 7.4 | 59 | 21 | 117 | +0.6 | +0.3 |
| Oct 01 21:00 | 2483 | DD | 7.1 | 72 | 36 | 91 | +0.8 | +1.0 |
| Oct 02 23:06 | 186770 | DD | 7.6 | 86 | 24 | 73 | +0.1 | +1.5 |
| Oct 03 20:52 | 2824 | DD | 7.3 | 98 | 62 | 63 | +1.4 | +1.8 |
| Oct 04 01:17 | 2852 | DD | 7.3 | 100 | 11 | 98 | 0.0 | +0.8 |
| | | | | | | | | |
| Oct 06 19:32 | 3243 | DD | 7.3 | 135 | 59 | 12 | +1.1 | +3.6 |
| Oct 06 23:45 | 3265 | DD | 6.5 | 137 | 54 | 61 | +1.3 | +1.8 |
| Oct 08 01:28 | 3392 | DD | 7.3 | 149 | 40 | 96 | +1.7 | +1.0 |
| Oct 08 21:32 | 146908 | DD | 7.6 | 159 | 55 | 88 | +2.6 | -0.6 |
| Oct 11 22:03 | 293 | RD | 7.6 | 166 | 29 | 199 | +0.3 | +1.7 |
| Oct 14 03:33 | 525 | RD | 6.5 | 142 | 32 | 251 | +2.3 | +1.0 |
| Oct 19 03:04 | 1213 | RD | 7.1 | 87 | 12 | 308 | +1.8 | -2.2 |
| Oct 22 04:45 | 1570 | RD | 5.5 | 50 | 12 | 304 | +0.9 | -1.8 |
| Nov 01 23:29 | 3089 | DD | 5.3 | 94 | 27 | 57 | +0.1 | +1.8 |
| Nov 02 20:02 | 3214 | DD | 6.8 | 105 | 71 | 89 | +2.6 | +0.3 |
| | | | | | | | | |
| Nov 02 23:53 | 164829 | DD | 7.1 | 107 | 30 | 77 | +0.6 | +1.5 |
| Nov 02 23:53 | 3228 | DD | 7.2 | 107 | 30 | 77 | +0.6 | +1.5 |
| Nov 04 01:07 | 3356 | DD | 5.8 | 119 | 21 | 56 | +0.2 | +1.8 |
| Nov 05 19:48 | 37 | DD | 7.2 | 140 | 49 | 83 | +2.3 | -0.5 |
| Nov 07 19:42 | 257 | DD | 4.3 | 163 | 27 | 32 | +0.5 | +1.1 |
| Nov 07 20:55 | 257 | RB | 4.3 | 163 | 38 | 252 | +1.8 | -0.1 |
| Nov 08 02:50 | 92688 | DD | 6.8 | 165 | 20 | 58 | +1.1 | +2.0 |
| Nov 10 03:05 | 489 | RD | 6.8 | 173 | 23 | 284 | +1.9 | +0.7 |
| Nov 10 23:56 | 612 | RD | 7.6 | 163 | 30 | 281 | +2.9 | -1.0 |
| Nov 10 23:56 | 76475 | RD | 7.7 | 163 | 30 | 280 | +2.9 | -1.0 |
| | | | | | | | | |
| Nov 11 02:29 | 76499 | RD | 7.3 | 162 | 29 | 319 | +3.5 | -2.3 |
| Nov 11 04:02 | 624 | RD | 6.8 | 162 | 19 | 313 | +1.4 | -0.5 |
| Nov 13 01:47 | 77724 | RD | 7.0 | 140 | 26 | 316 | +3.5 | -2.5 |
| Nov 13 02:17 | 77753 | RD | 7.2 | 140 | 27 | 182 | -0.3 | +7.2 |
| Nov 25 11:47 | Mercury | DD | -0.5 | 17 | 69 | 95 | +2.2 | -0.8 |
| Nov 25 13:15 | Mercury | RB | -0.5 | 17 | 80 | 301 | +2.2 | -1.5 |
| Nov 29 20:24 | 164567 | DD | 7.3 | 74 | 47 | 56 | +0.9 | +1.9 |
| Nov 29 21:32 | 3175 | DD | 4.7 | 75 | 34 | 111 | +1.4 | +0.5 |
| Nov 29 22:12 | 3175 | RB | 4.7 | 75 | 25 | 191 | -0.6 | +2.8 |
| Dec 01 20:39 | 3434 | DD | 7.5 | 99 | 55 | 58 | +1.6 | +1.8 |
| | | | | | | | | |
| Dec 01 22:35 | 3446 | DD | 7.2 | 99 | 34 | 121 | +2.5 | -0.2 |
| Dec 02 22:23 | 12 | DD | 6.4 | 111 | 40 | 350 | -0.7 | +4.0 |
| Dec 02 22:50 | 13 | DD | 6.2 | 111 | 35 | 345 | -1.2 | +4.7 |
| Dec 02 23:10 | 128618 | DD | 6.8 | 111 | 32 | 79 | +1.2 | +1.6 |
| Dec 03 21:10 | 109506 | DD | 7.6 | 122 | 51 | 32 | +1.2 | +2.2 |
| Dec 04 21:22 | 109990 | DD | 7.0 | 133 | 46 | 23 | +1.0 | +2.2 |
| Dec 05 01:43 | 247 | DD | 6.3 | 134 | 11 | 132 | +0.8 | -0.8 |
| Dec 05 20:28 | 340 | DD | 6.9 | 144 | 39 | 90 | +2.8 | -0.6 |
| Dec 07 21:48 | 76311 | DD | 7.2 | 166 | 30 | 69 | +1.9 | +0.1 |
| Dec 08 00:33 | 582 | DD | 5.6 | 166 | 29 | 25 | +1.8 | +2.4 |
| | | | | | | | | |
| Dec 09 23:21 | 844 | RD | 5.8 | 171 | 25 | 232 | +1.7 | +0.5 |
| Dec 11 00:43 | 78480 | RD | 7.5 | 160 | 26 | 263 | +2.4 | -0.2 |
| Dec 11 01:05 | 78496 | RD | 7.5 | 160 | 27 | 298 | +2.7 | -1.0 |
| Dec 11 02:05 | 1008 | RD | 5.3 | 160 | 27 | 310 | +2.3 | -0.9 |
| Dec 12 00:44 | 79402 | RD | 7.3 | 149 | 24 | 284 | +2.3 | -1.1 |
| Dec 13 00:00 | 1252 | RD | 7.3 | 138 | 15 | 267 | +1.4 | -1.0 |
| Dec 17 02:02 | 119030 | RD | 7.1 | 90 | 16 | 258 | +0.9 | -1.0 |
| Dec 17 02:21 | 119038 | RD | 6.9 | 90 | 20 | 307 | +0.8 | -1.9 |
| Dec 26 20:21 | 3106 | RB | 5.2 | 41 | 22 | 239 | 0.0 | +1.6 |
| Dec 26 20:41 | 3116 | DD | 6.6 | 41 | 18 | 69 | 0.0 | +1.4 |

LUNAR OCCULTATION TABLE

# BRISBANE (27° 30' S, 153° 01'E)

| EST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 08 21:48 | 146908 | DD | 7.6 | 67 | 11 | 34 | 0.0 | +2.2 |
| Jan 09 20:33 | 62 | DD | 7.5 | 78 | 33 | 86 | +1.5 | +1.2 |
| Jan 15 01:09 | 656 | DD | 4.2 | 134 | 8 | 96 | +0.7 | +0.8 |
| Jan 15 01:15 | 657 | DD | 5.3 | 134 | 7 | 120 | +0.3 | 0.0 |
| Jan 17 21:59 | 79122 | DD | 7.6 | 168 | 33 | 68 | +2.3 | +0.3 |
| Jan 17 23:09 | 1089 | DD | 6.7 | 168 | 36 | 91 | +2.7 | -0.1 |
| Jan 20 00:14 | 1363 | RD | 5.2 | 165 | 39 | 289 | +2.4 | -0.9 |
| Jan 20 00:44 | 80677 | RD | 7.6 | 164 | 41 | 216 | +6.5 | +6.7 |
| Jan 20 00:52 | 1365 | RD | 6.0 | 164 | 41 | 298 | +2.2 | -0.9 |
| Jan 22 22:59 | 1714 | RD | 7.6 | 126 | 15 | 259 | +0.8 | -0.7 |
| Jan 24 23:32 | 1950 | RD | 5.7 | 100 | 8 | 295 | +0.1 | -1.4 |
| Jan 26 04:13 | 2088 | RD | 6.2 | 84 | 60 | 346 | +0.3 | -3.1 |
| Jan 27 03:08 | 2211 | RD | 6.7 | 72 | 37 | 255 | +1.6 | -0.4 |
| Jan 29 03:08 | 2513 | RD | 4.2 | 46 | 16 | 258 | +0.4 | -0.5 |
| Jan 30 03:33 | 2672 | RD | 2.8 | 33 | 10 | 255 | +0.1 | -0.5 |
| Jan 30 04:02 | 2678 | RD | 6.6 | 33 | 15 | 305 | -0.3 | -1.7 |
| Feb 11 22:55 | 76810 | DD | 7.6 | 112 | 16 | 60 | +1.7 | +1.9 |
| Feb 11 23:21 | 76820 | DD | 7.5 | 112 | 12 | 105 | +0.8 | +0.5 |
| Feb 14 22:15 | 1169 | DD | 5.3 | 147 | 37 | 112 | +2.4 | -0.6 |
| Feb 14 23:27 | 79672 | DD | 7.5 | 148 | 32 | 36 | +5.1 | +5.1 |
| Feb 19 01:20 | 1689 | DB | 5.2 | 157 | 54 | 114 | +2.1 | -1.0 |
| Feb 19 02:37 | 1689 | RD | 5.2 | 157 | 51 | 324 | +1.2 | -1.5 |
| Feb 21 01:13 | 1923 | RD | 7.0 | 130 | 54 | 6 | -0.5 | -4.0 |
| Feb 21 01:42 | 139316 | RD | 7.7 | 130 | 59 | 310 | +1.5 | -1.8 |
| Feb 21 02:17 | 139325 | RD | 7.4 | 130 | 64 | 261 | +3.3 | +0.1 |
| Feb 21 22:40 | 2032 | RD | 7.2 | 118 | 14 | 293 | +0.2 | -1.4 |
| Feb 23 01:00 | 2170 | RD | 6.7 | 103 | 36 | 257 | +1.5 | -0.5 |
| Feb 24 04:12 | 2330 | RD | 6.4 | 89 | 67 | 290 | +1.9 | -1.3 |
| Feb 26 01:43 | 2622 | RD | 6.7 | 64 | 13 | 245 | +0.4 | -0.2 |
| Mar 10 19:36 | 664 | RB | 5.5 | 80 | 28 | 242 | +2.2 | +1.7 |
| Mar 10 21:00 | 76636 | DD | 7.1 | 80 | 14 | 53 | +1.6 | +2.2 |
| Mar 13 21:10 | 1105 | DD | 6.5 | 114 | 32 | 72 | +2.8 | +1.2 |
| Mar 13 21:35 | 79243 | DD | 7.3 | 115 | 30 | 145 | +1.1 | -1.4 |
| Mar 13 21:59 | 79253 | DD | 7.6 | 115 | 27 | 143 | +0.9 | -1.2 |
| Mar 14 22:26 | 80070 | DD | 7.5 | 127 | 32 | 89 | +2.3 | +0.6 |
| Mar 15 19:28 | 1363 | RB | 5.2 | 139 | 33 | 252 | +2.3 | 0.0 |
| Mar 17 23:20 | 1621 | DD | 7.2 | 166 | 51 | 108 | +2.3 | -0.7 |
| Mar 18 01:50 | 99505 | DD | 7.5 | 167 | 38 | 168 | +0.2 | -2.2 |
| Mar 19 21:40 | 1856 | RD | 6.8 | 164 | 36 | 343 | +0.4 | -2.6 |
| Mar 20 21:33 | 139581 | RD | 7.3 | 151 | 27 | 306 | +0.5 | -1.7 |
| Mar 20 21:49 | 1985 | RD | 6.9 | 150 | 30 | 282 | +0.9 | -1.2 |
| Mar 20 23:37 | 139607 | RD | 7.7 | 150 | 53 | 244 | +3.5 | +0.9 |
| Mar 21 23:02 | 2114 | RD | 5.3 | 136 | 37 | 283 | +1.0 | -1.3 |
| Mar 22 22:05 | 159480 | RD | 7.5 | 123 | 15 | 247 | +0.6 | -0.2 |
| Mar 23 01:42 | 2267 | DB | 5.0 | 121 | 62 | 187 | -1.6 | -5.8 |
| Mar 23 02:12 | 2267 | RD | 5.0 | 121 | 68 | 233 | +4.7 | +2.9 |
| Mar 24 02:45 | 2430 | RD | 6.8 | 107 | 64 | 309 | +1.3 | -2.1 |
| Apr 06 19:06 | 621 | DD | 6.1 | 49 | 13 | 62 | +1.4 | +1.8 |
| Apr 07 19:00 | 753 | DD | 7.4 | 60 | 21 | 101 | +1.5 | +0.6 |
| Apr 10 18:56 | 1181 | DD | 7.0 | 94 | 36 | 54 | +3.6 | +1.9 |
| Apr 14 22:46 | 1689 | DD | 5.2 | 147 | 53 | 101 | +2.4 | -0.2 |
| Apr 14 23:52 | 1689 | RB | 5.2 | 147 | 45 | 338 | +0.6 | -1.8 |
| Apr 16 20:48 | 139325 | DD | 7.4 | 174 | 44 | 154 | +0.6 | -2.3 |
| Apr 17 01:44 | 1941 | DD | 4.7 | 176 | 54 | 136 | +1.4 | -1.2 |
| Apr 17 02:53 | 1941 | RB | 4.7 | 176 | 40 | 291 | +1.3 | 0.0 |
| Apr 17 23:06 | 2060 | RD | 6.2 | 169 | 65 | 299 | +1.7 | -1.4 |
| Apr 17 23:27 | 2064 | RD | 6.3 | 169 | 68 | 346 | +0.5 | -3.0 |
| Apr 19 21:19 | 2348 | RD | 6.8 | 142 | 22 | 225 | +2.0 | +1.5 |
| Apr 20 00:29 | 2362 | RD | 7.7 | 140 | 63 | 325 | +0.9 | -2.5 |
| Apr 25 05:11 | 3164 | DB | 4.5 | 74 | 60 | 32 | +1.9 | +2.5 |
| May 06 18:37 | 1013 | DD | 7.0 | 53 | 19 | 52 | +2.6 | +2.6 |
| May 08 19:43 | 80209 | DD | 7.0 | 76 | 27 | 132 | +1.0 | -0.6 |
| May 08 20:59 | 1274 | DD | 5.7 | 77 | 16 | 148 | 0.0 | -1.0 |
| May 08 21:34 | 1279 | DD | 6.3 | 77 | 10 | 114 | +0.5 | +0.2 |
| May 11 19:12 | 1621 | DD | 7.2 | 114 | 51 | 159 | +1.1 | -2.4 |
| May 12 19:08 | 1739 | DD | 6.4 | 127 | 51 | 59 | +5.0 | +2.1 |
| May 12 19:59 | 119200 | DD | 7.1 | 127 | 57 | 158 | +1.0 | -2.4 |
| May 12 22:03 | 119227 | DD | 7.5 | 128 | 52 | 114 | +1.9 | -0.5 |
| May 13 18:46 | 1856 | DD | 6.8 | 141 | 44 | 65 | +3.1 | +0.6 |
| May 14 18:24 | 139581 | DD | 7.3 | 155 | 33 | 91 | +1.1 | -1.0 |
| May 14 18:38 | 1985 | DD | 6.9 | 155 | 36 | 116 | +0.9 | -1.5 |
| May 14 20:44 | 139607 | DD | 7.7 | 156 | 62 | 138 | +1.2 | -2.0 |
| May 15 03:04 | 139704 | DD | 7.3 | 158 | 22 | 59 | +0.6 | +2.9 |
| May 15 19:18 | 2114 | DD | 5.3 | 170 | 35 | 105 | +0.9 | -1.3 |
| May 16 05:10 | 2159 | DD | 5.2 | 174 | 10 | 83 | 0.0 | +1.1 |
| May 16 22:25 | 2267 | RD | 5.0 | 174 | 66 | 270 | +2.2 | -0.6 |
| May 17 01:32 | 183983 | RD | 7.3 | 173 | 70 | 243 | +2.7 | +2.3 |
| May 17 21:03 | 2430 | RD | 6.8 | 161 | 36 | 308 | +0.3 | -1.8 |
| May 18 01:44 | 184964 | RD | 7.3 | 159 | 82 | 314 | +2.1 | -2.0 |
| May 18 02:10 | 184991 | RD | 7.3 | 159 | 76 | 328 | +2.0 | -2.9 |
| May 19 01:44 | 2623 | RD | 7.7 | 145 | 83 | 304 | +2.2 | -1.9 |
| May 19 02:10 | 186403 | RD | 7.7 | 145 | 87 | 338 | +2.0 | -5.6 |
| May 19 21:26 | 2781 | RD | 7.4 | 133 | 16 | 247 | +0.5 | -0.2 |
| May 28 04:27 | 283 | RD | 6.6 | 36 | 10 | 192 | -0.2 | +2.3 |
| Jun 03 17:59 | 1105 | DD | 6.5 | 35 | 14 | 108 | +0.9 | +0.4 |
| Jun 05 19:11 | 1363 | DD | 5.2 | 59 | 23 | 121 | +0.9 | -0.2 |
| Jun 05 19:43 | 1365 | DD | 6.0 | 59 | 18 | 106 | +1.0 | +0.4 |
| Jun 05 20:21 | 80677 | DD | 7.6 | 59 | 11 | 175 | -1.0 | -2.7 |
| Jun 08 19:25 | 119030 | DD | 7.1 | 96 | 53 | 163 | +0.7 | -2.3 |
| Jun 08 19:27 | 119038 | DD | 6.9 | 97 | 53 | 113 | +2.1 | -0.6 |
| Jun 10 21:32 | 1941 | DD | 4.7 | 124 | 61 | 149 | +1.2 | -1.9 |
| Jun 10 22:43 | 1941 | RB | 4.7 | 125 | 47 | 283 | +1.7 | +0.2 |
| Jun 11 18:49 | 2060 | DD | 6.2 | 137 | 57 | 120 | +1.4 | -1.6 |
| Jun 11 19:39 | 2064 | DD | 6.3 | 137 | 66 | 62 | +4.6 | +1.9 |
| Jun 13 18:04 | 2348 | DD | 6.8 | 165 | 27 | 144 | -0.1 | -2.0 |
| Jun 14 03:26 | 2388 | DD | 7.6 | 169 | 30 | 52 | +0.2 | +2.5 |
| Jun 18 00:44 | 3037 | RD | 7.3 | 137 | 60 | 290 | +2.1 | -1.8 |
| Jun 19 04:18 | 164674 | RD | 7.6 | 123 | 79 | 277 | +3.2 | -0.2 |
| Jun 20 02:35 | 3323 | RD | 7.5 | 112 | 59 | 255 | +2.2 | 0.0 |
| Jun 22 02:22 | 20 | RD | 6.7 | 88 | 33 | 303 | +2.4 | -4.7 |
| Jun 22 03:37 | 128642 | RD | 7.4 | 88 | 48 | 219 | +1.3 | +1.5 |
| Jun 22 05:21 | 128661 | RD | 6.6 | 88 | 63 | 206 | +1.2 | +2.4 |
| Jun 27 05:36 | 76373 | RD | 7.6 | 32 | 15 | 283 | +1.6 | -1.6 |
| Jul 04 19:19 | 99249 | DD | 7.6 | 55 | 23 | 123 | +0.7 | -0.3 |
| Jul 09 23:15 | 2160 | DD | 6.4 | 122 | 41 | 86 | +1.4 | +1.1 |
| Jul 10 19:27 | 183983 | DD | 7.3 | 134 | 73 | 186 | -1.2 | -6.4 |
| Jul 10 20:53 | 2293 | DD | 7.1 | 135 | 82 | 167 | +1.0 | -4.2 |
| Jul 11 20:15 | 184964 | DD | 7.3 | 148 | 72 | 81 | +2.5 | 0.0 |
| Jul 11 20:55 | 184991 | DD | 7.3 | 148 | 80 | 61 | +3.2 | +1.6 |
| Jul 12 20:43 | 2623 | DD | 7.7 | 162 | 64 | 81 | +2.2 | -0.2 |
| Jul 12 21:40 | 186403 | DD | 7.7 | 162 | 77 | 44 | +3.2 | +3.0 |
| Jul 13 03:13 | 2657 | DD | 6.9 | 164 | 32 | 74 | +0.5 | +1.3 |
| Jul 13 20:18 | 2804 | DD | 5.8 | 174 | 46 | 41 | +2.3 | +1.8 |
| Jul 16 00:42 | 190252 | RD | 7.2 | 156 | 76 | 221 | +2.0 | +2.1 |
| Jul 17 02:28 | 164984 | RD | 7.1 | 143 | 78 | 231 | +1.9 | +1.8 |
| Jul 19 23:35 | 76 | RD | 5.9 | 108 | 13 | 215 | +0.3 | +1.1 |
| Jul 21 01:17 | 109832 | RD | 7.5 | 96 | 23 | 176 | -0.4 | +4.0 |
| Jul 23 05:06 | 93185 | RD | 7.4 | 73 | 40 | 295 | +4.8 | -3.0 |
| Jul 25 04:17 | 76636 | RD | 7.1 | 51 | 14 | 258 | +0.9 | -0.5 |
| Aug 03 21:28 | 139130 | DD | 7.6 | 65 | 10 | 110 | +0.3 | +0.2 |
| Aug 04 21:57 | 1996 | DD | 6.7 | 78 | 17 | 132 | +0.5 | -0.6 |
| Aug 04 22:28 | 1997 | DD | 6.8 | 79 | 10 | 188 | +1.0 | -6.9 |
| Aug 06 18:35 | 2236 | DD | 6.9 | 104 | 82 | 169 | +0.8 | -4.1 |
| Aug 06 18:36 | 2233 | RB | 5.5 | 104 | 82 | 317 | +1.8 | -2.0 |
| Aug 06 19:22 | 2241 | DD | 4.8 | 104 | 76 | 99 | +2.5 | -0.1 |
| Aug 06 20:43 | 2241 | RB | 4.8 | 104 | 59 | 309 | +1.9 | -1.1 |
| Aug 09 21:53 | 2740 | DD | 6.3 | 145 | 84 | 125 | +2.8 | -2.0 |
| Aug 09 23:30 | 2750 | DD | 2.0 | 145 | 64 | 64 | +1.7 | +1.7 |
| Aug 10 00:44 | 2750 | RB | 2.0 | 146 | 47 | 273 | +1.5 | +0.7 |
| Aug 11 23:13 | 3062 | DD | 7.5 | 171 | 83 | 25 | +1.5 | +3.4 |
| Aug 15 01:51 | 3478 | RD | 6.4 | 150 | 70 | 189 | +0.5 | +3.4 |
| Aug 15 23:43 | 37 | RD | 7.2 | 139 | 42 | 282 | +2.5 | -1.9 |
| Aug 17 01:42 | 109664 | DD | 7.3 | 127 | 51 | 332 | -4.7 | +9.7 |
| Aug 17 02:03 | 109664 | RD | 7.3 | 126 | 54 | 304 | +8.4 | -6.9 |
| Aug 21 03:48 | 621 | RD | 6.1 | 82 | 30 | 203 | +0.4 | +1.7 |
| Aug 22 03:17 | 753 | RD | 7.4 | 71 | 16 | 180 | -1.8 | +4.1 |
| Aug 24 05:18 | 1056 | RD | 7.2 | 48 | 17 | 288 | +1.8 | -1.5 |
| Aug 31 19:57 | 1951 | DD | 7.1 | 48 | 15 | 184 | +0.6 | -5.0 |
| Sep 02 18:38 | 2205 | DD | 7.7 | 74 | 59 | 55 | +2.6 | +3.8 |
| Sep 04 19:22 | 2514 | DD | 6.4 | 101 | 76 | 167 | +2.3 | -7.4 |
| Sep 04 20:05 | 185433 | DD | 7.2 | 101 | 67 | 43 | +1.9 | +3.9 |
| Sep 06 19:15 | 188263 | DD | 7.7 | 127 | 75 | 83 | +2.5 | 0.0 |
| Sep 08 02:16 | 189613 | DD | 7.2 | 142 | 25 | 23 | -0.5 | +2.6 |
| Sep 09 01:17 | 164528 | DD | 7.5 | 154 | 48 | 108 | +2.4 | +0.1 |
| Sep 11 00:49 | 3425 | DD | 4.4 | 176 | 67 | 73 | +2.4 | +1.2 |
| Sep 11 02:05 | 3425 | RB | 4.4 | 176 | 53 | 207 | +0.7 | +2.6 |
| Sep 13 04:09 | 109506 | RD | 7.6 | 156 | 38 | 255 | +1.7 | +1.4 |
| Sep 14 03:33 | 109990 | RD | 7.0 | 145 | 47 | 297 | +4.8 | -1.4 |
| Sep 15 02:39 | 340 | RD | 6.9 | 134 | 50 | 240 | +2.3 | +1.2 |
| Sep 16 04:38 | 455 | RD | 6.1 | 123 | 41 | 216 | +1.9 | +2.3 |
| Sep 17 03:31 | 76311 | RD | 7.2 | 112 | 40 | 306 | +5.8 | -3.4 |
| Sep 19 03:33 | 844 | RD | 5.8 | 90 | 28 | 306 | +3.6 | -2.7 |
| Sep 19 04:23 | 849 | RD | 6.5 | 90 | 33 | 194 | +0.5 | +3.4 |
| Sep 30 19:52 | 2319 | DD | 7.0 | 58 | 29 | 93 | +0.8 | +0.8 |
| Oct 01 19:50 | 2469 | DD | 6.5 | 71 | 43 | 78 | +1.1 | +1.3 |
| Oct 01 21:45 | 2483 | DD | 7.1 | 72 | 20 | 86 | +0.2 | +1.0 |
| Oct 03 21:52 | 2824 | DD | 7.3 | 98 | 44 | 62 | +0.8 | +1.7 |
| Oct 06 20:45 | 3243 | DD | 7.3 | 135 | 79 | 4 | +0.4 | +4.5 |
| Oct 07 00:44 | 3265 | DD | 6.5 | 137 | 38 | 71 | +0.9 | +1.5 |
| Oct 08 02:25 | 3392 | DD | 7.3 | 149 | 24 | 104 | +1.0 | +0.6 |
| Oct 08 22:45 | 146908 | DD | 7.6 | 159 | 68 | 100 | +4.1 | -0.6 |
| Oct 11 22:53 | 293 | RD | 7.6 | 166 | 45 | 191 | +0.3 | +2.6 |
| Oct 12 21:56 | 403 | RD | 5.8 | 155 | 27 | 195 | -0.1 | +2.0 |
| Oct 19 03:49 | 1213 | RD | 7.1 | 87 | 27 | 314 | +2.5 | -2.3 |
| Oct 28 19:06 | 184652 | DD | 7.1 | 39 | 24 | 132 | +1.1 | -0.6 |
| Oct 28 20:00 | 2417 | DD | 6.7 | 40 | 14 | 171 | +3.4 | -6.6 |
| Nov 02 00:09 | 3089 | DD | 5.3 | 94 | 11 | 60 | -0.3 | +1.4 |
| Nov 02 21:13 | 3214 | DD | 6.8 | 105 | 58 | 101 | +2.7 | +0.2 |
| Nov 03 00:38 | 164829 | DD | 7.1 | 107 | 13 | 80 | +0.1 | +1.1 |
| Nov 03 00:38 | 3228 | DD | 7.2 | 107 | 13 | 80 | +0.1 | +1.1 |
| Nov 04 01:50 | 3356 | DD | 5.8 | 119 | 6 | 54 | -0.2 | +1.6 |
| Nov 05 20:46 | 36 | DD | 7.1 | 140 | 64 | 44 | +1.8 | +1.8 |
| Nov 05 20:58 | 37 | DD | 7.2 | 140 | 64 | 94 | +3.7 | -0.3 |
| Nov 07 20:33 | 257 | DD | 4.3 | 163 | 44 | 35 | +1.1 | +1.5 |
| Nov 07 21:58 | 257 | RB | 4.3 | 163 | 53 | 240 | +2.2 | +1.0 |
| Nov 11 01:08 | 612 | RD | 7.6 | 163 | 39 | 272 | +3.2 | +0.1 |
| Nov 12 00:35 | 745 | RD | 7.3 | 152 | 35 | 315 | +5.3 | -3.9 |
| Nov 13 00:26 | 890 | DB | 4.6 | 141 | 29 | 9 | -0.5 | +4.0 |
| Nov 13 01:04 | 890 | RD | 4.6 | 141 | 32 | 321 | +4.7 | -4.1 |
| Nov 13 02:46 | 77724 | RD | 7.0 | 140 | 34 | 329 | +3.1 | -3.5 |
| Nov 13 03:54 | 77753 | RD | 7.2 | 140 | 31 | 216 | +3.3 | +3.2 |
| Nov 14 00:01 | 1035 | RD | 6.7 | 130 | 20 | 258 | +1.4 | -0.5 |
| Nov 20 03:38 | 119200 | RD | 7.1 | 58 | 19 | 302 | +0.7 | -1.7 |
| Nov 25 13:12 | Mercury | DD | -0.5 | 17 | 83 | 38 | +4.0 | +6.3 |
| Nov 25 13:54 | Mercury | RB | -0.5 | 17 | 74 | 347 | +2.3 | -7.1 |
| Nov 29 19:38 | 164528 | DD | 7.5 | 74 | 52 | 48 | +0.9 | +2.1 |
| Nov 29 20:15 | 3164 | RB | 4.5 | 74 | 43 | 220 | +0.4 | +2.2 |
| Nov 29 21:16 | 164567 | DD | 7.3 | 74 | 30 | 64 | +0.5 | +1.6 |
| Nov 29 22:21 | 3175 | DD | 4.7 | 75 | 17 | 119 | +0.9 | -0.1 |
| Nov 30 19:39 | 3304 | DD | 6.4 | 86 | 60 | 84 | +2.3 | +1.0 |
| Dec 01 20:35 | 3425 | RB | 4.4 | 98 | 54 | 238 | +1.6 | +1.8 |
| Dec 01 21:43 | 3434 | DD | 7.5 | 99 | 41 | 70 | +1.3 | +1.6 |
| Dec 01 23:30 | 3446 | DD | 7.2 | 99 | 17 | 128 | +1.5 | -1.1 |
| Dec 02 23:17 | 12 | DD | 6.4 | 111 | 27 | 360 | -0.1 | +3.6 |
| Dec 02 23:43 | 13 | DD | 6.2 | 111 | 21 | 350 | -0.5 | +4.5 |
| Dec 03 00:04 | 128618 | DD | 6.8 | 111 | 17 | 79 | +0.6 | +1.3 |
| Dec 03 22:16 | 109506 | DD | 7.6 | 122 | 44 | 44 | +1.4 | +2.2 |
| Dec 04 22:29 | 109990 | DD | 7.0 | 133 | 44 | 35 | +1.5 | +2.4 |
| Dec 05 21:45 | 340 | DD | 6.9 | 144 | 49 | 109 | +4.7 | -1.1 |
| Dec 07 22:55 | 76311 | DD | 7.2 | 166 | 40 | 78 | +2.9 | +0.6 |
| Dec 09 22:59 | 77272 | RD | 7.6 | 172 | 33 | 271 | +2.7 | -0.5 |
| Dec 10 00:29 | 844 | RD | 5.8 | 171 | 36 | 234 | +2.7 | +1.4 |
| Dec 11 01:51 | 78480 | RD | 7.5 | 160 | 34 | 277 | +2.8 | +0.1 |
| Dec 11 02:04 | 78496 | RD | 7.5 | 160 | 33 | 319 | +2.2 | -1.6 |
| Dec 12 01:44 | 79402 | RD | 7.3 | 149 | 35 | 298 | +2.7 | -1.0 |
| Dec 13 00:50 | 1252 | RD | 7.3 | 138 | 31 | 275 | +2.4 | -0.8 |
| Dec 17 02:42 | 119030 | RD | 7.1 | 90 | 32 | 283 | +1.5 | -1.3 |
| Dec 17 02:49 | 119038 | RD | 6.9 | 90 | 33 | 332 | +1.0 | -2.5 |
| Dec 19 02:15 | 1924 | RD | 5.8 | 65 | 14 | 345 | -0.1 | -2.5 |
| Dec 26 20:07 | 3106 | DD | 5.2 | 41 | 17 | 73 | +0.1 | +1.2 |

LUNAR OCCULTATION TABLE

# CANBERRA (35° 15' S, 149° 08'E)

| EST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 08 21:31 | 146908 | DD | 7.6 | 67 | 17 | 46 | +0.3 | +2.1 |
| Jan 15 01:02 | 656 | DD | 4.2 | 134 | 8 | 120 | +0.6 | +0.3 |
| Jan 17 21:51 | 79122 | DD | 7.6 | 168 | 24 | 82 | +2.0 | -0.4 |
| Jan 17 23:02 | 1089 | DD | 6.7 | 168 | 28 | 107 | +2.3 | -0.6 |
| Jan 17 23:42 | 79164 | DD | 7.4 | 168 | 28 | 67 | +2.5 | +0.7 |
| Jan 20 00:10 | 1363 | RD | 5.2 | 165 | 31 | 271 | +2.2 | -0.5 |
| Jan 20 00:49 | 1365 | RD | 6.0 | 164 | 32 | 279 | +2.2 | -0.4 |
| Jan 24 23:42 | 1950 | RD | 5.7 | 100 | 7 | 279 | +0.1 | -1.3 |
| Jan 27 02:06 | 2209 | RD | 5.6 | 72 | 21 | 348 | -0.5 | -2.7 |
| Jan 29 02:42 | 2513 | DB | 4.2 | 46 | 10 | 167 | -1.2 | -2.9 |
| Jan 29 03:08 | 2513 | RD | 4.2 | 46 | 15 | 225 | +0.9 | +0.4 |
| Jan 30 03:04 | 2672 | DB | 2.8 | 33 | 4 | 156 | -1.1 | -2.5 |
| Jan 30 03:33 | 2672 | RD | 2.8 | 33 | 10 | 224 | +0.6 | +0.4 |
| Jan 30 03:52 | 186864 | RD | 7.6 | 33 | 13 | 326 | -0.8 | -2.3 |
| Jan 30 04:14 | 2678 | RD | 6.6 | 33 | 17 | 280 | 0.0 | -1.2 |
| Feb 10 21:44 | 76373 | DD | 7.6 | 101 | 19 | 19 | +1.9 | +3.4 |
| Feb 11 22:37 | 76810 | DD | 7.6 | 112 | 16 | 81 | +1.6 | +1.3 |
| Feb 14 22:13 | 1169 | DD | 5.3 | 147 | 29 | 131 | +2.0 | -1.0 |
| Feb 14 22:59 | 79672 | DD | 7.5 | 148 | 28 | 70 | +2.6 | +0.9 |
| Feb 19 01:23 | 1689 | DB | 5.2 | 157 | 46 | 138 | +1.4 | -1.5 |
| Feb 19 02:38 | 1689 | RD | 5.2 | 157 | 45 | 296 | +1.7 | -0.5 |
| Feb 21 01:35 | 1923 | RD | 7.0 | 130 | 50 | 335 | +0.7 | -2.4 |
| Feb 21 22:50 | 2032 | RD | 7.2 | 118 | 13 | 275 | +0.2 | -1.2 |
| Feb 23 01:01 | 159096 | RD | 7.6 | 103 | 32 | 339 | -0.1 | -2.5 |
| Feb 23 23:28 | 2303 | RD | 4.8 | 91 | 6 | 326 | -0.6 | -1.8 |
| Feb 23 23:29 | 2302 | RD | 2.6 | 91 | 6 | 325 | -0.5 | -1.8 |
| Feb 24 04:11 | 2330 | RD | 6.4 | 89 | 61 | 259 | +2.2 | -0.3 |
| Feb 27 04:00 | 2809 | DB | 4.9 | 51 | 27 | 50 | +1.1 | +0.3 |
| Feb 27 04:45 | 2809 | RD | 4.9 | 51 | 36 | 321 | 0.0 | -3.1 |
| Mar 01 04:49 | 3089 | RD | 5.3 | 27 | 14 | 223 | +0.6 | +0.4 |
| Mar 10 20:40 | 76636 | DD | 7.1 | 80 | 15 | 73 | +1.5 | +1.6 |
| Mar 13 20:55 | 1105 | DD | 6.5 | 114 | 27 | 93 | +2.3 | +0.3 |
| Mar 14 22:16 | 80070 | DD | 7.5 | 127 | 27 | 113 | +1.8 | 0.0 |
| Mar 17 23:20 | 1621 | DD | 7.2 | 166 | 43 | 132 | +1.5 | -1.2 |
| Mar 18 23:47 | 119200 | RD | 7.1 | 175 | 49 | 256 | +3.1 | +0.4 |
| Mar 19 21:55 | 1856 | RD | 6.8 | 164 | 33 | 322 | +0.7 | -2.0 |
| Mar 20 21:43 | 139581 | RD | 7.3 | 151 | 25 | 288 | +0.6 | -1.5 |
| Mar 20 21:54 | 1985 | RD | 6.9 | 150 | 27 | 260 | +1.0 | -0.9 |
| Mar 20 23:54 | 1994 | RD | 6.6 | 150 | 49 | 336 | +0.6 | -2.4 |
| Mar 21 23:06 | 2114 | RD | 5.3 | 136 | 34 | 259 | +1.2 | -0.8 |
| Mar 24 02:52 | 2430 | RD | 6.8 | 107 | 61 | 280 | +1.6 | -1.1 |
| Mar 29 04:36 | 3191 | RD | 7.4 | 45 | 24 | 328 | -0.6 | -7.1 |
| Apr 06 18:48 | 621 | DD | 6.1 | 49 | 14 | 81 | +1.4 | +1.4 |
| Apr 07 18:52 | 753 | DD | 7.4 | 60 | 18 | 123 | +1.4 | 0.0 |
| Apr 12 18:54 | 1432 | DD | 6.7 | 119 | 31 | 64 | +2.6 | +0.2 |
| Apr 14 22:43 | 1689 | DD | 5.2 | 147 | 46 | 128 | +1.5 | -1.0 |
| Apr 14 23:57 | 1689 | RB | 5.2 | 148 | 40 | 308 | +1.3 | -0.6 |
| Apr 15 02:56 | 119030 | DD | 7.1 | 149 | 12 | 108 | +0.5 | +0.5 |
| Apr 16 21:08 | 139325 | DD | 7.4 | 174 | 42 | 181 | -0.2 | -3.2 |
| Apr 17 01:54 | 1941 | DD | 4.7 | 176 | 51 | 171 | +0.5 | -2.7 |
| Apr 17 02:42 | 1941 | RB | 4.7 | 176 | 43 | 256 | +1.9 | +1.8 |
| Apr 17 23:07 | 2060 | RD | 6.2 | 169 | 58 | 271 | +2.0 | -0.7 |
| Apr 17 23:41 | 2064 | RD | 6.3 | 169 | 62 | 317 | +1.2 | -1.8 |
| Apr 25 04:54 | 3164 | DB | 4.5 | 74 | 52 | 62 | +1.7 | +0.3 |
| May 06 18:15 | 1013 | DD | 7.0 | 53 | 18 | 80 | +1.9 | +1.2 |
| May 08 19:49 | 80209 | DD | 7.0 | 76 | 22 | 164 | 0.0 | -1.7 |
| May 11 19:34 | 1621 | DD | 7.2 | 114 | 43 | 194 | -1.3 | -4.5 |
| May 12 18:57 | 1739 | DD | 6.4 | 127 | 42 | 93 | +2.1 | -0.9 |
| May 12 20:22 | 119200 | DD | 7.1 | 128 | 49 | 194 | -1.1 | -4.3 |
| May 12 22:05 | 119227 | DD | 7.5 | 128 | 47 | 143 | +1.1 | -1.3 |
| May 13 00:31 | 1755 | DD | 6.9 | 129 | 26 | 89 | +1.2 | +1.2 |
| May 13 18:42 | 1856 | DD | 6.8 | 141 | 37 | 94 | +1.5 | -1.1 |
| May 14 18:30 | 139581 | DD | 7.3 | 155 | 29 | 112 | +0.7 | -1.5 |
| May 14 18:49 | 1985 | DD | 6.9 | 155 | 33 | 135 | +0.6 | -1.9 |
| May 15 02:48 | 139704 | DD | 7.3 | 158 | 28 | 96 | +0.8 | +0.9 |
| May 15 19:27 | 2114 | DD | 5.3 | 170 | 34 | 125 | +0.5 | -1.7 |
| May 16 05:03 | 2159 | DD | 5.2 | 174 | 16 | 107 | +0.3 | +0.6 |
| May 16 22:11 | 2267 | RD | 5.0 | 175 | 58 | 226 | +4.5 | +3.1 |
| May 17 05:01 | 2310 | DB | 4.3 | 172 | 31 | 37 | -0.1 | +4.6 |
| May 17 05:28 | 2310 | RD | 4.3 | 172 | 25 | 345 | +1.5 | -2.9 |
| May 17 21:13 | 2430 | RD | 6.8 | 161 | 36 | 283 | +0.6 | -1.4 |
| May 18 01:45 | 184964 | RD | 7.3 | 159 | 78 | 283 | +2.1 | -0.4 |
| May 18 02:15 | 184991 | RD | 7.3 | 159 | 75 | 294 | +2.0 | -0.8 |
| May 18 22:54 | 186235 | RD | 7.2 | 146 | 44 | 350 | -1.0 | -5.1 |
| May 19 21:20 | 2781 | RD | 7.4 | 133 | 14 | 208 | +1.5 | +1.8 |
| May 19 22:20 | 187710 | RD | 7.4 | 133 | 25 | 343 | -1.3 | -4.5 |
| May 20 01:07 | 2804 | RD | 5.8 | 131 | 58 | 309 | +1.2 | -2.6 |
| May 20 05:38 | 2824 | RD | 7.3 | 130 | 62 | 194 | 0.0 | +5.4 |
| May 21 23:17 | 3089 | RD | 5.3 | 107 | 12 | 329 | -1.2 | -4.6 |
| Jun 05 19:13 | 1363 | DD | 5.2 | 59 | 20 | 150 | +0.3 | -0.9 |
| Jun 05 19:40 | 1365 | DD | 6.0 | 59 | 16 | 135 | +0.5 | -0.3 |
| Jun 08 19:28 | 119038 | DD | 6.9 | 97 | 46 | 141 | +1.3 | -1.3 |
| Jun 10 21:52 | 1941 | DD | 4.7 | 124 | 54 | 190 | -0.6 | -5.0 |
| Jun 10 22:24 | 1941 | RB | 4.7 | 125 | 50 | 241 | +3.2 | +3.7 |
| Jun 11 18:59 | 2060 | DD | 6.2 | 137 | 52 | 145 | +0.8 | -2.2 |
| Jun 11 19:30 | 2064 | DD | 6.3 | 137 | 57 | 99 | +1.9 | -1.0 |
| Jun 14 03:09 | 2388 | DD | 7.6 | 169 | 38 | 79 | +0.8 | +1.5 |
| Jun 18 00:44 | 3037 | RD | 7.3 | 137 | 56 | 259 | +1.7 | -0.4 |
| Jun 18 06:05 | 3062 | RD | 7.5 | 135 | 51 | 251 | +1.2 | +1.5 |
| Jun 18 22:25 | 164567 | RD | 7.3 | 125 | 16 | 329 | -1.1 | -6.0 |
| Jun 18 22:50 | 3175 | DB | 4.7 | 125 | 21 | 37 | +0.8 | +0.8 |
| Jun 18 23:41 | 3175 | RD | 4.7 | 125 | 31 | 295 | +0.6 | -2.4 |
| Jun 19 04:06 | 164674 | RD | 7.6 | 123 | 73 | 258 | +2.3 | +0.6 |
| Jun 20 02:25 | 3323 | RD | 7.5 | 112 | 51 | 232 | +1.6 | +0.8 |
| Jun 22 02:33 | 20 | RD | 6.7 | 88 | 29 | 267 | +1.2 | -1.2 |
| Jun 22 03:20 | 128642 | RD | 7.4 | 88 | 38 | 196 | +0.6 | +2.3 |
| Jun 22 04:57 | 128661 | RD | 6.6 | 88 | 53 | 190 | +0.5 | +2.9 |
| Jun 23 05:57 | 137 | RD | 7.6 | 76 | 49 | 164 | -1.5 | +5.3 |
| Jul 04 19:22 | 99249 | DD | 7.6 | 55 | 21 | 155 | +0.2 | -1.2 |
| Jul 06 21:24 | 1783 | DD | 7.3 | 81 | 25 | 93 | +1.1 | +1.1 |
| Jul 08 18:05 | 139704 | DD | 7.3 | 106 | 61 | 133 | +1.4 | -1.8 |
| Jul 08 21:29 | 2028 | DD | 6.5 | 107 | 49 | 79 | +2.1 | +1.6 |
| Jul 09 22:57 | 2159 | DD | 5.2 | 122 | 47 | 72 | +1.6 | +2.0 |
| Jul 09 23:05 | 2160 | DD | 6.4 | 122 | 45 | 115 | +1.4 | 0.0 |
| Jul 09 23:52 | 2159 | RB | 5.2 | 122 | 36 | 331 | +1.1 | -1.5 |
| Jul 11 02:50 | 2327 | DD | 6.7 | 137 | 15 | 76 | -0.1 | +1.5 |
| Jul 11 20:14 | 184964 | DD | 7.3 | 148 | 66 | 112 | +1.6 | -1.4 |
| Jul 11 20:43 | 184991 | DD | 7.3 | 148 | 71 | 97 | +2.0 | -0.7 |
| Jul 12 18:42 | 186235 | DD | 7.2 | 161 | 37 | 45 | +1.9 | +1.0 |
| Jul 13 03:01 | 2657 | DD | 6.9 | 164 | 39 | 91 | +0.9 | +1.0 |
| Jul 13 20:10 | 2804 | DD | 5.8 | 174 | 42 | 78 | +1.2 | -0.6 |
| Jul 15 21:21 | 3106 | RD | 5.2 | 157 | 31 | 328 | -0.3 | -6.1 |
| Jul 16 00:12 | 190252 | RD | 7.2 | 156 | 64 | 188 | +1.2 | +5.1 |
| Jul 17 02:06 | 164984 | RD | 7.1 | 143 | 69 | 213 | +1.4 | +2.2 |
| Jul 19 23:19 | 76 | RD | 5.9 | 108 | 6 | 174 | 0.0 | +4.8 |
| Jul 23 05:06 | 93185 | RD | 7.4 | 73 | 32 | 276 | +2.6 | -1.2 |
| Aug 03 21:28 | 139130 | DD | 7.6 | 65 | 13 | 140 | +0.3 | -0.6 |
| Aug 04 22:03 | 1996 | DD | 6.7 | 78 | 19 | 167 | +0.6 | -2.2 |
| Aug 05 22:34 | 158842 | DD | 7.2 | 92 | 26 | 76 | +0.6 | +1.8 |
| Aug 06 18:39 | 2233 | RB | 5.5 | 104 | 74 | 286 | +2.1 | -0.8 |
| Aug 06 19:20 | 2241 | DD | 4.8 | 104 | 73 | 130 | +1.8 | -1.5 |
| Aug 06 20:38 | 2241 | RB | 4.8 | 104 | 61 | 278 | +1.9 | +0.3 |
| Aug 07 01:13 | 2267 | DD | 5.0 | 107 | 8 | 68 | -0.3 | +1.7 |
| Aug 09 23:13 | 2750 | DD | 2.0 | 145 | 70 | 87 | +2.0 | +0.7 |
| Aug 10 00:31 | 2750 | RB | 2.0 | 146 | 54 | 254 | +1.3 | +1.5 |
| Aug 11 22:48 | 3062 | DD | 7.5 | 171 | 72 | 52 | +1.9 | +1.4 |
| Aug 12 20:44 | 3191 | RD | 7.4 | 174 | 38 | 313 | +0.9 | -4.4 |
| Aug 15 23:44 | 37 | RD | 7.2 | 138 | 36 | 256 | +1.5 | -0.5 |
| Aug 17 02:06 | 109664 | RD | 7.3 | 126 | 46 | 277 | +3.0 | -1.2 |
| Aug 19 05:15 | X 3541 | RD | 7.3 | 103 | 40 | 210 | +1.4 | +1.9 |
| Aug 21 03:33 | 621 | RD | 6.1 | 82 | 20 | 184 | -0.8 | +2.6 |
| Aug 24 05:22 | 1056 | RD | 7.2 | 48 | 10 | 274 | +1.3 | -1.2 |
| Sep 04 19:40 | 185433 | DD | 7.2 | 101 | 74 | 78 | +2.2 | +1.0 |
| Sep 08 01:59 | 189613 | DD | 7.2 | 142 | 33 | 36 | 0.0 | +2.3 |
| Sep 08 03:24 | 189680 | DD | 7.3 | 143 | 16 | 39 | -0.4 | +2.0 |
| Sep 09 01:10 | 164528 | DD | 7.5 | 154 | 52 | 129 | +4.0 | -1.9 |
| Sep 09 01:28 | 164516 | DD | 6.9 | 154 | 48 | 346 | -2.5 | +6.2 |
| Sep 09 21:06 | 3284 | DD | 7.0 | 165 | 55 | 353 | +0.2 | +7.0 |
| Sep 11 00:01 | 3419 | DD | 4.2 | 176 | 64 | 341 | -2.1 | +6.9 |
| Sep 11 00:29 | 3419 | RD | 4.2 | 176 | 63 | 301 | +5.6 | -3.3 |
| Sep 11 00:33 | 3425 | DB | 4.4 | 176 | 63 | 84 | +2.6 | +0.5 |
| Sep 11 01:41 | 3425 | RB | 4.4 | 176 | 56 | 198 | +0.5 | +2.8 |
| Sep 12 04:55 | 12 | RD | 6.4 | 167 | 24 | 268 | +1.0 | +1.4 |
| Sep 13 03:50 | 109506 | RD | 7.6 | 156 | 40 | 247 | +1.7 | +1.6 |
| Sep 14 03:21 | 109990 | RD | 7.0 | 145 | 43 | 283 | +3.3 | 0.0 |
| Sep 15 02:22 | 340 | RD | 6.9 | 134 | 41 | 232 | +1.8 | +1.0 |
| Sep 16 04:15 | 455 | RD | 6.1 | 123 | 36 | 206 | +1.4 | +2.1 |
| Sep 17 03:29 | 76311 | RD | 7.2 | 112 | 32 | 289 | +3.4 | -1.3 |
| Sep 19 03:37 | 844 | RD | 5.8 | 90 | 20 | 289 | +2.4 | -1.6 |
| Sep 20 04:05 | 78480 | RD | 7.5 | 79 | 17 | 329 | +3.9 | -4.6 |
| Sep 28 19:33 | 2036 | DD | 7.0 | 30 | 10 | 133 | +0.3 | -0.3 |
| Sep 30 19:45 | 2319 | DD | 7.0 | 58 | 35 | 117 | +1.1 | +0.1 |
| Sep 30 21:47 | 2333 | DD | 7.4 | 59 | 12 | 131 | +0.4 | -0.1 |
| Oct 01 19:38 | 2469 | DD | 6.5 | 71 | 50 | 101 | +1.5 | +0.5 |
| Oct 01 21:37 | 2483 | DD | 7.1 | 72 | 27 | 104 | +0.6 | +0.7 |
| Oct 02 23:37 | 186770 | DD | 7.6 | 86 | 16 | 88 | 0.0 | +1.1 |
| Oct 03 21:36 | 2824 | DD | 7.3 | 98 | 51 | 78 | +1.2 | +1.4 |
| Oct 06 20:15 | 3243 | DD | 7.3 | 135 | 67 | 29 | +1.4 | +2.4 |
| Oct 07 00:29 | 3265 | DD | 6.5 | 137 | 43 | 80 | +1.3 | +1.4 |
| Oct 08 02:16 | 3392 | DD | 7.3 | 149 | 28 | 120 | +1.8 | +0.1 |
| Oct 08 22:41 | 146908 | DD | 7.6 | 160 | 61 | 124 | +7.0 | -5.1 |
| Oct 14 04:25 | 525 | RD | 6.5 | 142 | 26 | 243 | +2.0 | +1.6 |
| Oct 19 03:55 | 1213 | RD | 7.1 | 87 | 20 | 298 | +2.0 | -1.6 |
| Oct 30 22:15 | 2781 | DD | 7.4 | 68 | 18 | 24 | -0.9 | +2.8 |
| Nov 01 23:59 | 3089 | DD | 5.3 | 94 | 18 | 70 | 0.0 | +1.5 |
| Nov 02 21:03 | 3214 | DD | 6.8 | 105 | 60 | 119 | +3.8 | -1.2 |
| Nov 03 00:28 | 164829 | DD | 7.1 | 107 | 20 | 91 | +0.4 | +1.2 |
| Nov 03 00:28 | 3228 | DD | 7.2 | 107 | 20 | 91 | +0.4 | +1.2 |
| Nov 04 01:38 | 3356 | DD | 5.8 | 119 | 12 | 65 | 0.0 | +1.6 |
| Nov 05 20:28 | 36 | DD | 7.1 | 140 | 54 | 56 | +1.8 | +1.0 |
| Nov 05 20:51 | 37 | DD | 7.2 | 141 | 56 | 113 | +4.8 | -2.6 |
| Nov 07 01:07 | 109667 | DD | 7.3 | 153 | 32 | 354 | -0.1 | +3.8 |
| Nov 07 01:07 | 155 | DD | 6.3 | 153 | 32 | 352 | -0.2 | +4.0 |
| Nov 07 20:20 | 257 | DD | 4.3 | 163 | 34 | 50 | +1.2 | +0.5 |
| Nov 07 21:43 | 257 | RB | 4.3 | 163 | 43 | 230 | +1.6 | +0.9 |
| Nov 11 00:55 | 612 | RD | 7.6 | 163 | 32 | 262 | +2.6 | +0.2 |
| Nov 11 03:26 | 76499 | RD | 7.3 | 162 | 22 | 313 | +1.8 | -0.7 |
| Nov 12 00:38 | 745 | RD | 7.3 | 152 | 27 | 296 | +3.2 | -1.6 |
| Nov 13 00:08 | 890 | DB | 4.6 | 141 | 19 | 29 | +0.5 | +1.1 |
| Nov 13 01:09 | 890 | RD | 4.6 | 141 | 24 | 302 | +3.0 | -1.8 |
| Nov 13 02:49 | 77724 | RD | 7.0 | 140 | 27 | 306 | +2.7 | -1.0 |
| Nov 14 00:00 | 1035 | RD | 6.7 | 130 | 11 | 245 | +0.9 | -0.4 |
| Nov 25 12:43 | Mercury | DD | -0.5 | 17 | 79 | 82 | +2.6 | +0.3 |
| Nov 25 14:09 | Mercury | RB | -0.5 | 17 | 72 | 305 | +2.3 | -1.4 |
| Nov 29 19:55 | 3164 | RB | 4.5 | 74 | 50 | 209 | +0.4 | +2.6 |
| Nov 29 21:02 | 164567 | DD | 7.3 | 74 | 37 | 74 | +0.8 | +1.5 |
| Dec 01 20:15 | 3425 | RB | 4.4 | 98 | 56 | 230 | +1.4 | +1.9 |
| Dec 01 21:25 | 3434 | DD | 7.5 | 99 | 45 | 78 | +1.6 | +1.5 |
| Dec 02 22:52 | 12 | DD | 6.4 | 111 | 32 | 13 | +0.3 | +2.8 |
| Dec 02 23:16 | 13 | DD | 6.2 | 111 | 28 | 8 | +0.1 | +3.0 |
| Dec 02 23:51 | 128618 | DD | 6.8 | 111 | 21 | 91 | +0.9 | +1.3 |
| Dec 03 21:54 | 109506 | DD | 7.6 | 122 | 44 | 51 | +1.6 | +1.9 |
| Dec 04 21:32 | 226 | DD | 6.5 | 133 | 45 | 344 | -1.3 | +4.6 |
| Dec 04 22:06 | 109990 | DD | 7.0 | 133 | 43 | 43 | +1.6 | +1.9 |
| Dec 05 21:41 | 340 | DD | 6.9 | 144 | 42 | 130 | +8.3 | -5.3 |
| Dec 07 22:43 | 76311 | DD | 7.2 | 166 | 33 | 87 | +2.7 | 0.0 |
| Dec 08 01:22 | 582 | DD | 5.6 | 166 | 23 | 31 | +1.9 | +2.6 |
| Dec 09 22:53 | 77272 | RD | 7.6 | 171 | 24 | 260 | +2.1 | -0.4 |
| Dec 10 00:10 | 844 | RD | 5.8 | 171 | 28 | 219 | +1.9 | +1.3 |
| Dec 11 01:39 | 78480 | RD | 7.5 | 160 | 27 | 261 | +2.5 | +0.4 |
| Dec 11 02:02 | 78496 | RD | 7.5 | 160 | 26 | 299 | +2.3 | -0.4 |
| Dec 11 02:55 | 1008 | RD | 5.3 | 160 | 23 | 318 | +1.5 | -0.8 |
| Dec 12 01:39 | 79402 | RD | 7.3 | 149 | 27 | 282 | +2.5 | -0.5 |
| Dec 13 00:48 | 1252 | RD | 7.3 | 138 | 22 | 261 | +1.9 | -0.7 |
| Dec 17 02:45 | 119030 | RD | 7.1 | 90 | 26 | 264 | +1.5 | -1.1 |
| Dec 17 03:02 | 119038 | RD | 6.9 | 90 | 29 | 314 | +1.1 | -2.0 |
| Dec 19 02:32 | 1924 | RD | 5.8 | 65 | 14 | 325 | +0.1 | -2.0 |
| Dec 26 20:49 | 3106 | RB | 5.2 | 41 | 14 | 226 | -0.3 | +1.7 |
| Dec 26 20:54 | 190191 | DD | 7.6 | 41 | 13 | 360 | -1.2 | +3.3 |
| Dec 26 21:10 | 3116 | DD | 6.6 | 41 | 10 | 81 | -0.1 | +1.2 |

LUNAR OCCULTATION TABLE

# MELBOURNE (37° 50' S, 145° 00'E)

| EST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 08 21:25 | 146908 | DD | 7.6 | 67 | 22 | 47 | +0.4 | +2.1 |
| Jan 09 22:42 | 128823 | DD | 7.2 | 78 | 11 | 110 | +0.6 | +0.9 |
| Jan 15 00:59 | 656 | DD | 4.2 | 134 | 10 | 132 | +0.6 | -0.1 |
| Jan 17 21:45 | 79122 | DD | 7.6 | 168 | 20 | 84 | +1.7 | -0.6 |
| Jan 17 22:54 | 1089 | DD | 6.7 | 168 | 25 | 111 | +2.2 | -0.8 |
| Jan 17 23:31 | 79164 | DD | 7.4 | 168 | 26 | 73 | +2.2 | +0.3 |
| Jan 18 02:22 | 79243 | DD | 7.3 | 169 | 17 | 82 | +1.7 | +1.2 |
| Jan 20 00:03 | 1363 | RD | 5.2 | 165 | 26 | 264 | +2.0 | -0.5 |
| Jan 20 00:41 | 1365 | RD | 6.0 | 164 | 29 | 271 | +2.2 | -0.4 |
| Jan 27 02:15 | 2209 | RD | 5.6 | 72 | 20 | 336 | -0.3 | -2.3 |
| Jan 30 04:00 | 186864 | RD | 7.6 | 33 | 12 | 313 | -0.5 | -1.9 |
| Jan 30 04:17 | 2678 | RD | 6.6 | 33 | 15 | 269 | 0.0 | -1.1 |
| Feb 10 21:29 | 76373 | DD | 7.6 | 101 | 21 | 26 | +1.7 | +2.7 |
| Feb 11 22:27 | 76810 | DD | 7.6 | 112 | 18 | 88 | +1.7 | +1.1 |
| Feb 14 22:07 | 1169 | DD | 5.3 | 148 | 26 | 138 | +2.0 | -1.3 |
| Feb 14 22:47 | 79672 | DD | 7.5 | 148 | 26 | 79 | +2.3 | +0.4 |
| Feb 19 02:31 | 1689 | RD | 5.2 | 157 | 44 | 282 | +2.0 | -0.2 |
| Feb 21 01:37 | 1923 | RD | 7.0 | 130 | 46 | 323 | +0.9 | -2.0 |
| Feb 21 01:42 | 139316 | RD | 7.7 | 130 | 47 | 273 | +1.9 | -1.0 |
| Feb 21 22:52 | 2032 | RD | 7.2 | 118 | 11 | 268 | +0.2 | -1.2 |
| Feb 23 01:08 | 159096 | RD | 7.6 | 103 | 30 | 327 | +0.1 | -2.2 |
| Feb 23 23:35 | 2302 | RD | 2.6 | 91 | 5 | 316 | -0.5 | -1.7 |
| Feb 24 04:00 | 2330 | RD | 6.4 | 89 | 55 | 240 | +2.7 | +0.7 |
| Feb 27 03:57 | 2809 | DB | 4.9 | 51 | 24 | 65 | +0.6 | -0.5 |
| Feb 27 04:52 | 2809 | RD | 4.9 | 51 | 34 | 305 | +0.3 | -2.3 |
| Mar 01 04:44 | 3089 | RD | 5.3 | 27 | 11 | 205 | +0.8 | +1.4 |
| Mar 10 20:29 | 76636 | DD | 7.1 | 80 | 17 | 80 | +1.7 | +1.4 |
| Mar 13 20:45 | 1105 | DD | 6.5 | 114 | 25 | 100 | +2.2 | 0.0 |
| Mar 13 22:35 | 1108 | DD | 7.0 | 115 | 18 | 34 | +3.8 | +4.3 |
| Mar 14 22:10 | 80070 | DD | 7.5 | 127 | 26 | 123 | +1.6 | -0.3 |
| Mar 17 23:18 | 1621 | DD | 7.2 | 166 | 40 | 144 | +1.2 | -1.5 |
| Mar 18 23:15 | 119200 | DD | 7.1 | 175 | 43 | 207 | -4.5 | -8.1 |
| Mar 18 23:27 | 119200 | RD | 7.1 | 175 | 44 | 226 | +7.6 | +5.5 |
| Mar 19 21:57 | 1856 | RD | 6.8 | 164 | 29 | 313 | +0.7 | -1.9 |
| Mar 20 21:44 | 139581 | RD | 7.3 | 151 | 21 | 280 | +0.5 | -1.4 |
| Mar 20 21:52 | 1985 | RD | 6.9 | 151 | 23 | 248 | +1.0 | -0.7 |
| Mar 20 23:57 | 1994 | RD | 6.6 | 150 | 46 | 324 | +0.7 | -2.1 |
| Mar 21 23:02 | 2114 | RD | 5.3 | 136 | 30 | 244 | +1.4 | -0.4 |
| Mar 24 02:47 | 2430 | RD | 6.8 | 107 | 56 | 266 | +1.7 | -0.8 |
| Mar 29 04:48 | 3191 | RD | 7.4 | 45 | 23 | 305 | +0.1 | -3.0 |
| Apr 09 20:35 | 1056 | DD | 7.2 | 83 | 16 | 43 | +2.9 | +3.0 |
| Apr 14 22:40 | 1689 | DD | 5.2 | 147 | 44 | 142 | +1.2 | -1.3 |
| Apr 14 23:52 | 1689 | RB | 5.2 | 148 | 40 | 293 | +1.6 | -0.2 |
| Apr 15 02:53 | 119030 | DD | 7.1 | 149 | 15 | 120 | +0.5 | +0.2 |
| Apr 15 03:13 | 119038 | DD | 6.9 | 149 | 12 | 69 | +0.9 | +2.5 |
| Apr 17 02:05 | 1941 | DD | 4.7 | 176 | 50 | 200 | -1.8 | -8.1 |
| Apr 17 02:23 | 1941 | RD | 4.7 | 176 | 47 | 228 | +4.2 | +7.2 |
| Apr 17 22:59 | 2060 | RD | 6.2 | 169 | 52 | 254 | +2.3 | -0.2 |
| Apr 17 23:40 | 2064 | RD | 6.3 | 169 | 58 | 303 | +1.3 | -1.5 |
| Apr 20 00:38 | 2362 | RD | 7.7 | 140 | 56 | 282 | +1.4 | -1.2 |
| Apr 25 04:47 | 3164 | DB | 4.5 | 74 | 47 | 71 | +1.5 | -0.3 |
| May 12 18:52 | 1739 | DD | 6.4 | 127 | 37 | 104 | +1.6 | -1.2 |
| May 12 22:05 | 119227 | DD | 7.5 | 128 | 46 | 158 | +0.7 | -1.8 |
| May 13 00:24 | 1755 | DD | 6.9 | 129 | 29 | 104 | +1.1 | +0.6 |
| May 13 18:40 | 1856 | DD | 6.8 | 141 | 32 | 104 | +1.2 | -1.4 |
| May 14 18:32 | 139581 | DD | 7.3 | 155 | 26 | 120 | +0.5 | -1.7 |
| May 14 18:52 | 1985 | DD | 6.9 | 155 | 30 | 145 | +0.4 | -2.1 |
| May 14 21:06 | 139607 | DD | 7.7 | 156 | 53 | 183 | -0.3 | -3.5 |
| May 14 21:07 | 1994 | DD | 6.6 | 156 | 53 | 58 | +3.9 | +1.5 |
| May 15 02:43 | 139704 | DD | 7.3 | 158 | 32 | 107 | +0.9 | +0.5 |
| May 15 19:30 | 2114 | DD | 5.3 | 170 | 31 | 135 | +0.3 | -1.9 |
| May 16 05:00 | 2159 | DD | 5.2 | 174 | 20 | 113 | +0.5 | +0.4 |
| May 17 04:50 | 2310 | DB | 4.3 | 172 | 36 | 49 | +0.5 | +3.3 |
| May 17 05:28 | 2310 | RD | 4.3 | 171 | 29 | 334 | +1.2 | -1.6 |
| May 17 21:14 | 2430 | RD | 6.8 | 161 | 33 | 271 | +0.6 | -1.1 |
| May 18 01:37 | 184964 | RD | 7.3 | 159 | 76 | 270 | +2.1 | -0.1 |
| May 18 02:08 | 184991 | RD | 7.3 | 159 | 75 | 282 | +2.0 | -0.4 |
| May 18 23:05 | 186235 | RD | 7.2 | 146 | 43 | 328 | 0.0 | -2.9 |
| May 19 01:36 | 2623 | RD | 7.7 | 145 | 71 | 261 | +2.0 | -0.1 |
| May 19 02:18 | 186403 | RD | 7.7 | 145 | 77 | 286 | +2.0 | -0.9 |
| May 19 22:31 | 187710 | RD | 7.4 | 133 | 25 | 321 | -0.4 | -2.6 |
| May 20 01:08 | 2804 | RD | 5.8 | 131 | 55 | 295 | +1.2 | -1.9 |
| May 20 05:22 | 2824 | RD | 7.3 | 130 | 68 | 184 | -0.8 | +9.3 |
| May 21 23:29 | 3089 | RD | 5.3 | 107 | 12 | 307 | -0.5 | -2.5 |
| May 24 01:42 | 3358 | RD | 6.9 | 82 | 14 | 305 | 0.0 | -3.4 |
| May 26 06:08 | 62 | RD | 7.5 | 58 | 40 | 231 | +1.3 | +0.6 |
| Jun 05 19:15 | 1363 | DD | 5.2 | 59 | 19 | 169 | -0.3 | -1.8 |
| Jun 05 19:40 | 1365 | DD | 6.0 | 59 | 16 | 150 | +0.2 | -0.8 |
| Jun 05 20:00 | 1363 | RB | 5.2 | 59 | 13 | 246 | +1.9 | +2.4 |
| Jun 07 18:39 | 99343 | DD | 7.7 | 83 | 39 | 188 | -0.7 | -3.5 |
| Jun 08 19:27 | 119038 | DD | 6.9 | 97 | 45 | 155 | +0.9 | -1.7 |
| Jun 11 19:03 | 2060 | DD | 6.2 | 137 | 49 | 158 | +0.4 | -2.5 |
| Jun 11 19:26 | 2064 | DD | 6.3 | 137 | 52 | 112 | +1.4 | -1.4 |
| Jun 13 21:00 | 2362 | DD | 7.7 | 166 | 56 | 100 | +1.4 | -1.2 |
| Jun 14 03:02 | 2388 | DD | 7.6 | 169 | 43 | 85 | +1.0 | +1.2 |
| Jun 18 00:38 | 3037 | RD | 7.3 | 137 | 51 | 249 | +1.5 | -0.2 |
| Jun 18 05:56 | 3062 | RD | 7.5 | 135 | 56 | 251 | +1.3 | +1.5 |
| Jun 18 22:37 | 164567 | RD | 7.3 | 125 | 16 | 305 | -0.2 | -2.7 |
| Jun 18 22:46 | 3175 | DB | 4.7 | 125 | 17 | 51 | +0.5 | 0.0 |
| Jun 18 23:44 | 3175 | RD | 4.7 | 125 | 28 | 282 | +0.6 | -1.7 |
| Jun 19 03:55 | 164674 | RD | 7.6 | 123 | 70 | 255 | +2.2 | +0.5 |
| Jun 20 02:16 | 3323 | RD | 7.5 | 112 | 45 | 225 | +1.3 | +0.9 |
| Jun 22 02:31 | 20 | RD | 6.7 | 88 | 25 | 260 | +1.0 | -0.9 |
| Jun 22 03:11 | 128642 | RD | 7.4 | 88 | 32 | 189 | +0.4 | +2.6 |
| Jun 22 04:48 | 128661 | RD | 6.6 | 88 | 47 | 189 | +0.5 | +2.8 |
| Jun 23 05:49 | 137 | RD | 7.6 | 76 | 45 | 166 | -1.2 | +4.9 |
| Jul 04 19:26 | 99249 | DD | 7.6 | 55 | 21 | 174 | -0.3 | -2.1 |
| Jul 06 21:17 | 1783 | DD | 7.3 | 81 | 28 | 107 | +1.0 | +0.5 |
| Jul 07 18:57 | 139229 | DD | 7.3 | 93 | 55 | 78 | +3.0 | +0.9 |
| Jul 08 21:18 | 2028 | DD | 6.5 | 107 | 53 | 95 | +1.9 | +0.6 |
| Jul 09 22:46 | 2159 | DD | 5.2 | 122 | 51 | 85 | +1.7 | +1.2 |
| Jul 09 23:01 | 2160 | DD | 6.4 | 122 | 49 | 126 | +1.4 | -0.5 |
| Jul 09 23:50 | 2159 | RB | 5.2 | 122 | 39 | 320 | +1.1 | -0.9 |
| Jul 11 02:46 | 2327 | DD | 6.7 | 137 | 19 | 80 | +0.1 | +1.4 |
| Jul 11 20:12 | 184964 | DD | 7.3 | 148 | 62 | 126 | +1.2 | -1.9 |
| Jul 11 20:39 | 184991 | DD | 7.3 | 148 | 66 | 110 | +1.6 | -1.3 |
| Jul 12 18:36 | 186235 | DD | 7.2 | 161 | 33 | 64 | +1.0 | -0.4 |
| Jul 12 20:43 | 2623 | DD | 7.7 | 162 | 57 | 125 | +1.0 | -2.1 |
| Jul 12 21:17 | 186403 | DD | 7.7 | 162 | 63 | 95 | +1.7 | -0.9 |
| Jul 13 02:54 | 2657 | DD | 6.9 | 164 | 44 | 93 | +1.1 | +1.0 |
| Jul 13 20:08 | 2804 | DD | 5.8 | 174 | 38 | 91 | +0.8 | -1.1 |
| Jul 15 21:31 | 3106 | RD | 5.2 | 157 | 29 | 306 | +0.3 | -2.9 |
| Jul 17 01:54 | 164984 | RD | 7.1 | 143 | 64 | 209 | +1.3 | +2.2 |
| Jul 17 06:21 | 3284 | RD | 7.0 | 141 | 41 | 230 | +0.7 | +2.0 |
| Jul 23 05:00 | 93185 | RD | 7.4 | 73 | 27 | 277 | +2.3 | -1.4 |
| Jul 23 06:13 | 434 | RD | 6.9 | 73 | 34 | 199 | +0.6 | +1.8 |
| Aug 02 20:35 | 119272 | DD | 7.6 | 52 | 12 | 112 | +0.4 | +0.5 |
| Aug 03 21:29 | 139130 | DD | 7.6 | 65 | 15 | 151 | +0.3 | -1.0 |
| Aug 04 22:09 | 1996 | DD | 6.7 | 79 | 21 | 186 | +0.6 | -5.4 |
| Aug 05 22:27 | 158842 | DD | 7.2 | 92 | 31 | 85 | +0.8 | +1.4 |
| Aug 06 19:18 | 2241 | DD | 4.8 | 104 | 72 | 144 | +1.4 | -2.2 |
| Aug 06 20:29 | 2241 | RB | 4.8 | 104 | 64 | 266 | +2.1 | +0.8 |
| Aug 07 01:09 | 2267 | DD | 5.0 | 107 | 13 | 72 | -0.1 | +1.7 |
| Aug 09 23:03 | 2750 | DD | 2.0 | 145 | 73 | 92 | +2.0 | +0.3 |
| Aug 10 00:21 | 2750 | RB | 2.0 | 146 | 59 | 251 | +1.4 | +1.5 |
| Aug 10 19:37 | X27622 | DD | 7.5 | 157 | 46 | 27 | +2.2 | +2.7 |
| Aug 11 04:40 | 2934 | DD | 7.5 | 161 | 20 | 6 | -1.3 | +3.5 |
| Aug 11 22:37 | 3062 | DD | 7.5 | 171 | 66 | 59 | +1.9 | +0.9 |
| Aug 12 05:59 | 3092 | DD | 6.2 | 173 | 14 | 37 | -0.4 | +1.9 |
| Aug 12 20:49 | 3191 | RD | 7.4 | 174 | 35 | 296 | +0.8 | -2.6 |
| Aug 15 23:40 | 37 | RD | 7.2 | 138 | 31 | 251 | +1.2 | -0.5 |
| Aug 17 01:58 | 109664 | RD | 7.3 | 126 | 41 | 277 | +2.6 | -1.4 |
| Aug 19 05:05 | X 3541 | RD | 7.3 | 103 | 37 | 213 | +1.3 | +1.5 |
| Aug 21 03:29 | 621 | RD | 6.1 | 82 | 15 | 185 | -0.8 | +2.4 |
| Sep 02 21:08 | 159309 | DD | 7.7 | 75 | 34 | 76 | +0.8 | +1.8 |
| Sep 04 19:29 | 185433 | DD | 7.2 | 101 | 76 | 88 | +2.1 | +0.3 |
| Sep 06 19:10 | 188263 | DD | 7.7 | 127 | 65 | 125 | +1.7 | -2.6 |
| Sep 08 01:53 | 189613 | DD | 7.2 | 142 | 38 | 35 | +0.1 | +2.4 |
| Sep 08 03:20 | 189680 | DD | 7.3 | 143 | 21 | 39 | -0.3 | +2.0 |
| Sep 09 00:58 | 164528 | DD | 7.5 | 154 | 56 | 125 | +3.7 | -1.5 |
| Sep 09 20:50 | 3284 | DD | 7.0 | 165 | 48 | 7 | +0.9 | +3.9 |
| Sep 10 03:11 | 165149 | DD | 7.7 | 167 | 37 | 13 | -0.1 | +2.9 |
| Sep 10 23:51 | 3419 | DD | 4.2 | 176 | 61 | 339 | -2.5 | +7.9 |
| Sep 11 00:15 | 3419 | RD | 4.2 | 176 | 61 | 305 | +6.0 | -4.8 |
| Sep 11 00:21 | 3425 | DB | 4.4 | 176 | 61 | 83 | +2.4 | +0.3 |
| Sep 11 01:32 | 3425 | RB | 4.4 | 176 | 57 | 200 | +0.7 | +2.7 |
| Sep 12 04:47 | 12 | RD | 6.4 | 167 | 28 | 268 | +1.2 | +1.4 |
| Sep 12 05:06 | 13 | RD | 6.2 | 167 | 25 | 273 | +1.1 | +1.3 |
| Sep 13 03:39 | 109506 | RD | 7.6 | 156 | 42 | 249 | +1.8 | +1.5 |
| Sep 14 03:07 | 109990 | RD | 7.0 | 145 | 43 | 288 | +3.7 | -0.5 |
| Sep 15 02:13 | 340 | RD | 6.9 | 134 | 38 | 234 | +1.6 | +0.7 |
| Sep 16 04:04 | 455 | RD | 6.1 | 123 | 34 | 208 | +1.3 | +1.7 |
| Sep 17 03:19 | 76311 | RD | 7.2 | 112 | 28 | 292 | +3.3 | -1.7 |
| Sep 19 03:31 | 844 | RD | 5.8 | 90 | 16 | 290 | +2.1 | -1.7 |
| Sep 20 04:02 | 78480 | RD | 7.5 | 79 | 12 | 329 | +3.6 | -4.6 |
| Sep 28 19:32 | 2036 | DD | 7.0 | 30 | 14 | 141 | +0.4 | -0.5 |
| Sep 30 19:40 | 2319 | DD | 7.0 | 58 | 40 | 124 | +1.2 | -0.1 |
| Sep 30 21:45 | 2333 | DD | 7.4 | 59 | 16 | 135 | +0.6 | -0.2 |
| Oct 01 19:30 | 2469 | DD | 6.5 | 71 | 54 | 107 | +1.6 | +0.2 |
| Oct 01 21:32 | 2483 | DD | 7.1 | 72 | 31 | 107 | +0.8 | +0.6 |
| Oct 01 23:56 | 2500 | DD | 3.3 | 73 | 5 | 31 | -1.2 | +2.8 |
| Oct 02 23:34 | 186770 | DD | 7.6 | 86 | 21 | 89 | +0.2 | +1.1 |
| Oct 03 21:27 | 2824 | DD | 7.3 | 98 | 56 | 80 | +1.4 | +1.3 |
| Oct 06 20:03 | 3243 | DD | 7.3 | 135 | 61 | 33 | +1.4 | +2.0 |
| Oct 07 00:19 | 3265 | DD | 6.5 | 137 | 48 | 78 | +1.4 | +1.4 |
| Oct 08 02:08 | 3392 | DD | 7.3 | 149 | 33 | 118 | +2.0 | +0.3 |
| Oct 08 22:27 | 146908 | DD | 7.6 | 160 | 57 | 120 | +5.2 | -3.8 |
| Oct 14 04:13 | 525 | RD | 6.5 | 142 | 27 | 241 | +2.0 | +1.4 |
| Oct 19 03:51 | 1213 | RD | 7.1 | 87 | 15 | 296 | +1.8 | -1.7 |
| Oct 30 22:11 | 2781 | DD | 7.4 | 68 | 23 | 24 | -0.8 | +2.9 |
| Nov 01 23:55 | 3089 | DD | 5.3 | 94 | 23 | 70 | +0.1 | +1.6 |
| Nov 02 20:51 | 3214 | DD | 6.8 | 105 | 63 | 116 | +3.6 | -1.1 |
| Nov 03 00:22 | 164829 | DD | 7.1 | 107 | 25 | 91 | +0.6 | +1.3 |
| Nov 03 00:23 | 3228 | DD | 7.2 | 107 | 25 | 91 | +0.6 | +1.3 |
| Nov 04 01:33 | 3356 | DD | 5.8 | 119 | 17 | 66 | +0.2 | +1.7 |
| Nov 05 20:19 | 36 | DD | 7.1 | 140 | 50 | 55 | +1.6 | +0.8 |
| Nov 05 20:40 | 37 | DD | 7.2 | 141 | 52 | 111 | +4.0 | -2.4 |
| Nov 07 00:58 | 109667 | DD | 7.3 | 153 | 34 | 352 | -0.3 | +3.8 |
| Nov 07 00:58 | 155 | DD | 6.3 | 153 | 34 | 350 | -0.4 | +4.0 |
| Nov 07 20:15 | 257 | DD | 4.3 | 163 | 29 | 51 | +1.0 | +0.3 |
| Nov 07 21:34 | 257 | RB | 4.3 | 163 | 39 | 232 | +1.5 | +0.7 |
| Nov 08 03:20 | 92688 | DD | 6.8 | 165 | 14 | 64 | +0.9 | +1.9 |
| Nov 11 00:44 | 612 | RD | 7.6 | 163 | 29 | 263 | +2.4 | 0.0 |
| Nov 11 03:19 | 76499 | RD | 7.3 | 162 | 22 | 306 | +2.1 | -0.2 |
| Nov 12 00:29 | 745 | RD | 7.3 | 152 | 23 | 298 | +3.0 | -1.8 |
| Nov 13 01:02 | 890 | RD | 4.6 | 141 | 20 | 302 | +2.8 | -1.9 |
| Nov 13 02:40 | 77724 | RD | 7.0 | 140 | 25 | 302 | +2.7 | -1.0 |
| Nov 20 03:49 | 119200 | RD | 7.1 | 58 | 12 | 280 | +0.6 | -1.5 |
| Nov 25 12:33 | Mercury | DD | -0.5 | 17 | 74 | 96 | +2.2 | -0.6 |
| Nov 25 14:03 | Mercury | RB | -0.5 | 17 | 74 | 294 | +2.2 | -0.9 |
| Nov 29 20:54 | 164567 | DD | 7.3 | 74 | 42 | 72 | +0.9 | +1.6 |
| Dec 01 21:15 | 3434 | DD | 7.5 | 99 | 48 | 75 | +1.7 | +1.5 |
| Dec 02 22:43 | 12 | DD | 6.4 | 111 | 36 | 12 | +0.3 | +2.8 |
| Dec 02 23:08 | 13 | DD | 6.2 | 111 | 32 | 7 | +0.1 | +3.0 |
| Dec 02 23:43 | 128618 | DD | 6.8 | 111 | 25 | 91 | +1.1 | +1.4 |
| Dec 03 21:43 | 109506 | DD | 7.6 | 122 | 45 | 49 | +1.5 | +1.8 |
| Dec 04 21:55 | 109990 | DD | 7.0 | 133 | 42 | 40 | +1.5 | +1.8 |
| Dec 05 21:25 | 340 | DD | 6.9 | 144 | 39 | 121 | +5.3 | -2.8 |
| Dec 07 22:32 | 76311 | DD | 7.2 | 166 | 30 | 86 | +2.4 | -0.2 |
| Dec 08 01:08 | 582 | DD | 5.6 | 166 | 24 | 35 | +1.8 | +2.1 |
| Dec 10 00:00 | 844 | RD | 5.8 | 171 | 25 | 218 | +1.6 | +1.0 |
| Dec 11 01:28 | 78480 | RD | 7.5 | 160 | 24 | 256 | +2.4 | +0.2 |
| Dec 11 01:53 | 78496 | RD | 7.5 | 160 | 24 | 293 | +2.3 | -0.4 |
| Dec 11 02:50 | 1008 | RD | 5.3 | 160 | 22 | 308 | +1.8 | -0.4 |
| Dec 12 01:31 | 79402 | RD | 7.3 | 149 | 24 | 278 | +2.3 | -0.6 |
| Dec 13 00:42 | 1252 | RD | 7.3 | 138 | 17 | 258 | +1.6 | -0.8 |
| Dec 17 02:42 | 119030 | RD | 7.1 | 90 | 22 | 256 | +1.3 | -1.0 |
| Dec 17 03:03 | 119038 | RD | 6.9 | 90 | 25 | 307 | +1.0 | -1.9 |
| Dec 19 02:37 | 1924 | RD | 5.8 | 65 | 11 | 319 | +0.1 | -1.9 |
| Dec 26 21:07 | 3116 | DD | 6.6 | 41 | 15 | 81 | 0.0 | +1.3 |

LUNAR OCCULTATION TABLE

# PERTH (31° 57' S, 115° 51'E)

| WST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 07 21:31 | 3392 | DD | 7.3 | 57 | 15 | 30 | -0.1 | +2.3 |
| Jan 13 22:19 | 519 | DD | 7.6 | 123 | 32 | 90 | +2.3 | +0.8 |
| Jan 14 22:04 | 656 | DD | 4.2 | 134 | 34 | 118 | +3.1 | -0.7 |
| Jan 14 23:10 | 656 | RB | 4.2 | 134 | 28 | 207 | +2.1 | +2.9 |
| Jan 17 23:22 | 79243 | DD | 7.3 | 169 | 32 | 94 | +2.5 | -0.3 |
| Jan 17 23:48 | 79253 | DD | 7.6 | 169 | 32 | 98 | +2.5 | -0.2 |
| Jan 18 02:07 | 79316 | DD | 7.5 | 170 | 24 | 104 | +1.6 | +0.4 |
| Jan 19 21:45 | 1365 | RD | 6.0 | 164 | 14 | 281 | +1.2 | -1.3 |
| Jan 22 03:49 | 1621 | RD | 7.2 | 137 | 46 | 271 | +2.7 | +0.1 |
| Jan 23 03:46 | 1739 | RD | 6.4 | 123 | 52 | 329 | +1.2 | -1.9 |
| Jan 25 03:22 | 1976 | RD | 7.0 | 97 | 48 | 352 | +0.1 | -3.1 |
| Jan 25 03:53 | 1978 | RD | 6.6 | 97 | 53 | 360 | -0.2 | -3.6 |
| Jan 26 01:54 | 2088 | RD | 6.2 | 84 | 23 | 274 | +0.6 | -1.2 |
| Jan 28 02:20 | 2376 | DB | 4.5 | 58 | 11 | 102 | -0.1 | -1.2 |
| Jan 28 03:14 | 2376 | RD | 4.5 | 58 | 22 | 302 | 0.0 | -1.6 |
| Jan 29 03:04 | 2523 | RD | 4.8 | 45 | 10 | 318 | -0.6 | -1.8 |
| Feb 09 22:28 | 93370 | DD | 7.4 | 91 | 12 | 107 | +0.9 | +0.7 |
| Feb 11 20:13 | 76820 | DD | 7.5 | 113 | 34 | 130 | +3.5 | -1.8 |
| Feb 12 21:12 | 77622 | DD | 7.6 | 124 | 32 | 108 | +2.6 | -0.3 |
| Feb 18 23:14 | 1689 | RD | 5.2 | 157 | 33 | 232 | +2.9 | +1.3 |
| Feb 19 04:20 | 119030 | RD | 7.1 | 155 | 40 | 279 | +1.8 | +0.4 |
| Feb 19 04:29 | 119038 | RD | 6.9 | 155 | 39 | 326 | +0.8 | -1.2 |
| Feb 19 04:36 | 119034 | RD | 7.7 | 155 | 38 | 276 | +1.7 | +0.6 |
| Feb 20 23:04 | 1923 | RD | 7.0 | 130 | 20 | 298 | +0.5 | -1.6 |
| Feb 22 03:06 | 2064 | RD | 6.3 | 115 | 61 | 259 | +2.8 | -0.1 |
| Feb 25 02:49 | 2490 | DB | 5.2 | 75 | 31 | 155 | -0.4 | -2.8 |
| Feb 25 03:35 | 2490 | RD | 5.2 | 75 | 41 | 245 | +1.7 | 0.0 |
| Feb 25 03:35 | 185237 | RD | 6.7 | 75 | 41 | 246 | +1.7 | -0.1 |
| Feb 25 03:38 | 2491 | RD | 6.6 | 75 | 41 | 294 | +0.7 | -1.7 |
| Feb 26 03:53 | 2652 | RD | 6.5 | 62 | 33 | 264 | +0.9 | -0.8 |
| Mar 01 05:08 | 3106 | DB | 5.2 | 25 | 13 | 74 | +0.2 | -0.5 |
| Mar 08 20:04 | 434 | DD | 6.9 | 59 | 16 | 57 | +1.2 | +2.0 |
| Mar 10 21:30 | 693 | DD | 6.0 | 81 | 12 | 141 | +0.3 | -1.2 |
| Mar 12 20:52 | 78309 | DD | 7.4 | 104 | 27 | 16 | +4.9 | +7.9 |
| Mar 17 20:36 | 1621 | DD | 7.2 | 166 | 27 | 173 | +0.8 | -3.2 |
| Mar 20 21:29 | 1994 | RD | 6.6 | 149 | 19 | 298 | +0.3 | -1.6 |
| Mar 21 03:10 | 139704 | RD | 7.3 | 147 | 66 | 277 | +2.4 | 0.0 |
| Mar 22 05:27 | 2159 | DB | 5.2 | 132 | 59 | 118 | +1.8 | -0.5 |
| Mar 23 23:59 | 2430 | RD | 6.8 | 107 | 22 | 218 | +2.3 | +2.1 |
| Mar 24 00:36 | 2434 | RD | 5.6 | 107 | 29 | 354 | -1.1 | -3.8 |
| Mar 24 04:46 | 184964 | RD | 7.3 | 105 | 80 | 239 | +3.1 | +1.8 |
| Mar 24 05:27 | 184991 | RD | 7.3 | 105 | 82 | 257 | +2.6 | +0.8 |
| Mar 25 04:21 | 186235 | RD | 7.2 | 93 | 65 | 324 | +1.1 | -3.3 |
| Mar 26 04:08 | 2781 | RD | 7.4 | 80 | 50 | 223 | +2.4 | +1.7 |
| Mar 28 03:09 | 3062 | RD | 7.5 | 56 | 14 | 253 | +0.3 | -0.5 |
| Apr 09 20:22 | 78957 | DD | 7.5 | 84 | 23 | 126 | +1.3 | -0.3 |
| Apr 09 20:51 | 1067 | DD | 7.1 | 84 | 19 | 49 | +2.9 | +2.8 |
| Apr 10 22:44 | 1206 | DD | 5.9 | 97 | 12 | 130 | +0.4 | -0.2 |
| Apr 13 20:53 | 1570 | DD | 5.5 | 134 | 43 | 97 | +2.4 | -0.6 |
| Apr 13 22:04 | 1570 | RB | 5.5 | 134 | 44 | 333 | +1.0 | -1.7 |
| Apr 14 20:05 | 1689 | DD | 5.2 | 147 | 38 | 187 | -0.1 | -4.0 |
| Apr 14 20:39 | 1689 | RB | 5.2 | 147 | 43 | 241 | +3.6 | +0.9 |
| Apr 15 00:27 | 119030 | DD | 7.1 | 149 | 42 | 142 | +1.0 | -1.1 |
| Apr 15 00:39 | 119038 | DD | 6.9 | 149 | 41 | 95 | +2.0 | +0.6 |
| Apr 15 00:45 | 119034 | DD | 7.7 | 149 | 40 | 144 | +0.9 | -1.1 |
| Apr 17 20:56 | 2064 | RD | 6.3 | 169 | 31 | 267 | +1.0 | -1.0 |
| Apr 19 05:38 | 2233 | RD | 5.5 | 151 | 42 | 254 | +1.2 | +1.7 |
| Apr 20 03:49 | 2388 | RD | 7.6 | 138 | 77 | 318 | +1.9 | -2.0 |
| Apr 25 02:17 | 3164 | DB | 4.5 | 74 | 17 | 66 | +0.5 | -0.3 |
| Apr 25 03:23 | 3164 | RD | 4.5 | 74 | 31 | 270 | +0.8 | -1.1 |
| Apr 25 04:03 | 164544 | RD | 7.2 | 74 | 39 | 206 | +1.6 | +2.3 |
| May 06 18:41 | 1028 | DD | 7.5 | 54 | 20 | 118 | +1.3 | +0.1 |
| May 08 20:33 | 1283 | DD | 7.0 | 78 | 22 | 133 | +0.8 | -0.4 |
| May 10 22:55 | 1533 | DD | 7.3 | 103 | 22 | 83 | +1.6 | +1.4 |
| May 11 21:18 | 99548 | DD | 7.7 | 116 | 45 | 91 | +2.6 | +0.4 |
| May 12 21:41 | 1755 | DD | 6.9 | 129 | 53 | 137 | +1.4 | -1.4 |
| May 15 00:00 | 139704 | DD | 7.3 | 158 | 63 | 115 | +1.9 | -0.6 |
| May 15 03:00 | 2028 | DD | 6.5 | 160 | 30 | 87 | +1.0 | +1.2 |
| May 16 02:36 | 2159 | DD | 5.2 | 174 | 49 | 88 | +1.6 | +1.0 |
| May 16 02:51 | 2160 | DD | 6.4 | 174 | 47 | 127 | +1.4 | -0.6 |
| May 17 22:35 | 184964 | RD | 7.3 | 159 | 49 | 244 | +2.1 | +0.2 |
| May 17 23:08 | 184991 | RD | 7.3 | 159 | 56 | 265 | +1.7 | -0.6 |
| May 18 20:54 | 186235 | RD | 7.2 | 146 | 16 | 297 | -0.2 | -1.5 |
| May 18 22:43 | 2623 | RD | 7.7 | 145 | 38 | 238 | +1.6 | +0.3 |
| May 18 23:14 | 2627 | RD | 6.7 | 145 | 44 | 346 | -0.7 | -4.6 |
| May 18 23:25 | 186403 | RD | 7.7 | 145 | 47 | 274 | +1.2 | -1.0 |
| May 19 05:02 | 2657 | RD | 6.9 | 142 | 61 | 318 | +2.6 | -2.2 |
| May 19 22:38 | 2804 | RD | 5.8 | 131 | 24 | 276 | +0.3 | -1.1 |
| May 20 02:52 | 2824 | RD | 7.3 | 130 | 76 | 241 | +2.4 | +1.1 |
| May 22 03:46 | 190252 | RD | 7.2 | 104 | 62 | 250 | +2.1 | +0.2 |
| May 25 04:56 | 3506 | RD | 6.1 | 68 | 41 | 229 | +1.3 | +0.8 |
| May 26 03:33 | 62 | RD | 7.5 | 58 | 13 | 280 | +0.6 | -1.8 |
| Jun 04 18:17 | 80070 | DD | 7.5 | 48 | 23 | 162 | 0.0 | -1.8 |
| Jun 11 02:06 | 1969 | DD | 7.1 | 127 | 13 | 95 | +0.3 | +0.9 |
| Jun 12 02:37 | 2092 | DD | 7.0 | 141 | 20 | 153 | +0.7 | -1.4 |
| Jun 13 02:18 | 2233 | DD | 5.5 | 155 | 38 | 138 | +1.3 | -1.0 |
| Jun 14 00:23 | 2388 | DD | 7.6 | 169 | 75 | 58 | +2.6 | +2.5 |
| Jun 14 03:55 | 2407 | DD | 7.0 | 170 | 32 | 55 | +0.3 | +2.4 |
| Jun 16 03:09 | 2750 | DB | 2.0 | 162 | 69 | 88 | +2.0 | +0.6 |
| Jun 16 04:26 | 2750 | RD | 2.0 | 161 | 53 | 252 | +1.2 | +1.5 |
| Jun 17 22:05 | 3037 | RD | 7.3 | 137 | 20 | 246 | +0.6 | -0.3 |
| Jun 19 00:48 | 164674 | RD | 7.6 | 123 | 41 | 300 | +1.2 | -3.0 |
| Jun 19 01:53 | 3202 | RD | 6.2 | 123 | 54 | 196 | +1.5 | +3.5 |
| Jun 19 05:50 | 3214 | RD | 6.8 | 122 | 66 | 211 | +1.0 | +2.7 |
| Jun 19 23:49 | 3323 | RD | 7.5 | 112 | 17 | 246 | +0.5 | -0.2 |
| Jun 22 02:26 | 128661 | RD | 6.6 | 87 | 25 | 246 | +0.9 | -0.2 |
| Jun 22 05:34 | 128698 | RD | 7.0 | 86 | 57 | 168 | -0.9 | +5.1 |
| Jun 23 03:39 | 137 | RD | 7.6 | 76 | 29 | 242 | +1.0 | +0.1 |
| Jun 24 05:06 | 258 | DD | 6.5 | 64 | 33 | 336 | -3.3 | +8.7 |
| Jun 24 05:26 | 258 | RD | 6.5 | 64 | 36 | 307 | +6.1 | -7.5 |
| Jul 06 18:35 | 1783 | DD | 7.3 | 81 | 54 | 135 | +1.5 | -1.3 |
| Jul 06 22:03 | 1796 | DD | 7.6 | 82 | 22 | 88 | +1.0 | +1.2 |
| Jul 07 23:47 | 1924 | DD | 5.8 | 96 | 14 | 42 | +0.5 | +7.2 |
| Jul 09 19:44 | 2159 | DD | 5.2 | 122 | 73 | 103 | +2.2 | -0.8 |
| Jul 09 20:07 | 2160 | DD | 6.4 | 122 | 74 | 138 | +1.5 | -2.0 |
| Jul 09 21:01 | 2159 | RB | 5.2 | 122 | 71 | 321 | +1.6 | -1.9 |
| Jul 12 02:58 | 2499 | DD | 6.4 | 152 | 30 | 95 | +0.7 | +0.8 |
| Jul 12 03:09 | 2500 | DD | 3.3 | 152 | 27 | 115 | +0.8 | +0.2 |
| Jul 12 03:46 | 185346 | DD | 7.3 | 152 | 20 | 142 | +1.1 | -1.0 |
| Jul 12 04:02 | 2500 | RB | 3.3 | 153 | 17 | 244 | -0.2 | +1.6 |
| Jul 12 18:57 | 2627 | DD | 6.7 | 162 | 36 | 49 | +1.8 | +0.7 |
| Jul 13 00:24 | 2657 | DD | 6.9 | 164 | 74 | 43 | +1.8 | +3.2 |
| Jul 13 02:00 | 186770 | DD | 7.6 | 165 | 55 | 138 | +2.5 | -1.9 |
| Jul 15 21:30 | 190252 | RD | 7.2 | 156 | 28 | 198 | +1.6 | +2.9 |
| Jul 16 23:15 | 164984 | RD | 7.1 | 143 | 37 | 250 | +1.2 | -0.2 |
| Jul 18 05:01 | 146587 | RD | 7.5 | 129 | 62 | 241 | +1.9 | +1.6 |
| Jul 18 06:08 | 3425 | DB | 4.4 | 128 | 51 | 64 | +1.5 | +1.7 |
| Jul 23 03:40 | 434 | RD | 6.9 | 73 | 20 | 271 | +1.4 | -1.2 |
| Aug 03 19:03 | 139130 | DD | 7.6 | 65 | 45 | 154 | +0.9 | -1.7 |
| Aug 04 19:31 | 1996 | DD | 6.7 | 79 | 53 | 175 | +0.5 | -3.6 |
| Aug 05 19:50 | 158842 | DD | 7.2 | 92 | 62 | 75 | +2.6 | +1.7 |
| Aug 05 20:49 | 2122 | DD | 7.7 | 92 | 51 | 111 | +1.7 | -0.1 |
| Aug 06 22:16 | 183864 | DD | 7.7 | 106 | 47 | 143 | +1.6 | -1.5 |
| Aug 09 20:01 | 2750 | DD | 2.0 | 146 | 63 | 75 | +2.1 | 0.0 |
| Aug 09 21:22 | 2750 | RB | 2.0 | 146 | 80 | 289 | +2.3 | -1.2 |
| Aug 10 01:39 | 2781 | DD | 7.4 | 148 | 44 | 92 | +1.2 | +0.9 |
| Aug 10 03:12 | 187710 | DD | 7.4 | 148 | 25 | 26 | -0.7 | +2.9 |
| Aug 11 19:54 | 3062 | DD | 7.5 | 171 | 36 | 40 | +1.4 | +1.1 |
| Aug 12 03:01 | 3089 | DD | 5.3 | 173 | 50 | 89 | +1.6 | +1.0 |
| Aug 13 03:39 | 164829 | RD | 7.1 | 171 | 50 | 225 | +0.8 | +2.1 |
| Aug 13 03:39 | 3228 | RD | 7.2 | 171 | 50 | 225 | +0.8 | +2.1 |
| Aug 14 03:56 | 3356 | RD | 5.8 | 160 | 53 | 280 | +2.6 | +0.5 |
| Aug 14 22:19 | 146786 | RD | 7.4 | 150 | 29 | 204 | +0.8 | +1.7 |
| Aug 14 22:55 | 3478 | RD | 6.4 | 149 | 36 | 235 | +1.2 | +0.4 |
| Aug 15 04:22 | 146849 | RD | 7.7 | 148 | 53 | 291 | +3.7 | -0.4 |
| Aug 17 05:36 | 109743 | RD | 7.7 | 124 | 45 | 203 | +1.0 | +2.6 |
| Aug 19 02:09 | X 3541 | RD | 7.3 | 103 | 27 | 291 | +2.7 | -2.7 |
| Aug 19 05:26 | 403 | DB | 5.8 | 102 | 43 | 127 | +6.9 | -4.0 |
| Aug 19 05:55 | 403 | RD | 5.8 | 102 | 42 | 162 | -2.3 | +6.5 |
| Aug 24 05:25 | 1067 | RD | 7.1 | 47 | 10 | 265 | +1.1 | -0.9 |
| Sep 02 22:49 | X39791 | DD | 7.6 | 77 | 15 | 125 | +0.5 | -0.1 |
| Sep 02 23:11 | 2236 | DD | 6.9 | 77 | 10 | 124 | +0.3 | 0.0 |
| Sep 07 02:30 | X27622 | DD | 7.5 | 131 | 20 | 63 | -0.1 | +1.5 |
| Sep 08 21:18 | 3164 | DD | 4.5 | 154 | 67 | 83 | +2.3 | -0.2 |
| Sep 08 21:53 | 164528 | DD | 7.5 | 154 | 73 | 49 | +1.9 | +1.6 |
| Sep 08 22:40 | 3164 | RB | 4.5 | 154 | 77 | 222 | +1.7 | +2.1 |
| Sep 08 23:58 | 164567 | DD | 7.3 | 155 | 69 | 62 | +1.8 | +1.6 |
| Sep 09 01:32 | 3175 | DD | 4.7 | 156 | 51 | 134 | +5.8 | -3.9 |
| Sep 09 01:50 | 3175 | RB | 4.7 | 156 | 48 | 162 | -3.5 | +7.3 |
| Sep 09 03:49 | 164637 | DD | 7.5 | 157 | 23 | 35 | -0.2 | +2.1 |
| Sep 09 22:06 | 3304 | DD | 6.4 | 166 | 63 | 75 | +2.2 | +0.2 |
| Sep 10 21:41 | 3425 | DD | 4.4 | 175 | 47 | 17 | +0.9 | +2.6 |
| Sep 10 22:46 | 3425 | RD | 4.4 | 176 | 59 | 274 | +2.8 | -0.9 |
| Sep 12 03:38 | 128618 | RD | 6.8 | 167 | 44 | 238 | +1.4 | +1.8 |
| Sep 14 00:07 | 235 | RD | 7.6 | 145 | 39 | 193 | +0.3 | +2.3 |
| Sep 14 00:07 | X 2226 | RD | 7.7 | 145 | 39 | 193 | +0.3 | +2.3 |
| Sep 14 00:51 | 238 | RD | 6.4 | 145 | 45 | 202 | +0.8 | +1.9 |
| Sep 14 04:49 | 247 | RD | 6.3 | 144 | 37 | 228 | +1.5 | +2.0 |
| Sep 16 01:13 | 455 | RD | 6.1 | 123 | 28 | 279 | +2.4 | -1.5 |
| Sep 20 03:12 | 1013 | RD | 7.0 | 78 | 10 | 206 | -0.3 | +1.4 |
| Sep 20 04:48 | 78580 | RD | 7.3 | 78 | 22 | 321 | +3.4 | -3.4 |
| Sep 21 04:21 | 1149 | DB | 4.1 | 66 | 12 | 76 | +1.0 | -0.7 |
| Sep 29 19:09 | 2182 | DD | 6.2 | 45 | 32 | 81 | +0.8 | +1.4 |
| Sep 30 19:25 | 2333 | DD | 7.4 | 59 | 43 | 87 | +1.2 | +1.1 |
| Oct 02 21:42 | 186770 | DD | 7.6 | 86 | 41 | 23 | -0.4 | +4.2 |
| Oct 02 23:00 | 2669 | DD | 6.4 | 87 | 26 | 98 | +0.6 | +0.8 |
| Oct 02 23:17 | 2673 | DD | 6.3 | 87 | 22 | 134 | +1.2 | -0.6 |
| Oct 02 23:30 | 2676 | DD | 6.7 | 87 | 20 | 96 | +0.3 | +0.8 |
| Oct 03 23:50 | 2852 | DD | 7.3 | 100 | 27 | 60 | +0.1 | +1.7 |
| Oct 04 23:01 | 2985 | DD | 6.8 | 112 | 48 | 130 | +3.3 | -1.6 |
| Oct 05 20:19 | 190252 | DD | 7.2 | 124 | 78 | 88 | +2.7 | -0.1 |
| Oct 06 22:00 | 3265 | DD | 6.5 | 137 | 73 | 5 | +0.2 | +4.1 |
| Oct 07 03:12 | 3284 | DD | 7.0 | 139 | 14 | 118 | +0.6 | +0.2 |
| Oct 07 23:25 | 3392 | DD | 7.3 | 149 | 64 | 45 | +1.5 | +2.1 |
| Oct 08 19:24 | 146908 | DD | 7.6 | 159 | 34 | 48 | +1.0 | +0.7 |
| Oct 11 22:10 | 301 | RD | 6.5 | 165 | 31 | 230 | +1.0 | +0.5 |
| Oct 13 01:29 | 423 | RD | 6.3 | 153 | 41 | 176 | -0.4 | +3.6 |
| Oct 14 00:52 | 525 | RD | 6.5 | 142 | 32 | 306 | +5.5 | -4.2 |
| Oct 29 21:00 | 2605 | DD | 7.3 | 55 | 24 | 45 | -0.3 | +2.3 |
| Nov 01 22:06 | 3089 | DD | 5.3 | 94 | 44 | 8 | -0.6 | +3.6 |
| Nov 01 22:46 | 3089 | RB | 5.3 | 95 | 35 | 296 | +1.7 | +0.1 |
| Nov 02 22:13 | 164829 | DD | 7.1 | 107 | 51 | 34 | +0.6 | +2.5 |
| Nov 02 22:13 | 3228 | DD | 7.2 | 107 | 51 | 34 | +0.6 | +2.5 |
| Nov 03 23:37 | 3356 | DD | 5.8 | 119 | 41 | 19 | +0.2 | +2.8 |
| Nov 06 20:35 | 109664 | DD | 7.3 | 153 | 46 | 54 | +1.6 | +0.8 |
| Nov 08 00:55 | 92688 | DD | 6.8 | 165 | 40 | 32 | +1.4 | +2.3 |
| Nov 12 03:31 | 76970 | RD | 7.6 | 150 | 28 | 297 | +2.5 | -0.3 |
| Nov 13 00:27 | 77753 | RD | 7.2 | 140 | 22 | 233 | +1.2 | +0.3 |
| Nov 13 02:02 | 77804 | RD | 7.3 | 140 | 30 | 265 | +2.6 | -0.2 |
| Nov 13 03:26 | 909 | RD | 6.0 | 139 | 30 | 255 | +2.7 | +0.7 |
| Nov 18 03:50 | 1533 | RD | 7.3 | 82 | 24 | 230 | +2.0 | +1.0 |
| Nov 25 09:41 | Mercury | DD | -0.5 | 17 | 43 | 123 | +0.6 | -2.0 |
| Nov 25 10:56 | Mercury | RB | -0.5 | 17 | 59 | 281 | +1.7 | -1.3 |
| Nov 28 20:45 | 3037 | DD | 7.3 | 62 | 35 | 89 | +0.9 | +1.1 |
| Nov 29 20:47 | 3175 | RB | 4.7 | 75 | 43 | 236 | +0.7 | +1.9 |
| Nov 29 22:30 | 3191 | DD | 7.4 | 76 | 22 | 72 | +0.3 | +1.4 |
| Dec 01 20:21 | 3446 | DD | 7.2 | 99 | 60 | 61 | +1.8 | +1.6 |
| Dec 02 21:14 | 128618 | DD | 6.8 | 111 | 54 | 37 | +1.3 | +2.3 |
| Dec 04 23:34 | 247 | DD | 6.3 | 134 | 36 | 99 | +2.5 | +0.7 |
| Dec 05 00:20 | 110063 | DD | 7.3 | 134 | 28 | 61 | +1.4 | +1.9 |
| Dec 06 20:20 | 455 | DD | 6.1 | 155 | 32 | 84 | +2.2 | -0.6 |
| Dec 06 23:54 | 93319 | DD | 7.6 | 156 | 35 | 15 | +1.3 | +2.9 |
| Dec 07 02:01 | 467 | DD | 6.5 | 157 | 18 | 44 | +1.5 | +2.3 |
| Dec 09 21:15 | 844 | RD | 5.8 | 171 | 13 | 274 | +1.4 | -1.2 |
| Dec 11 02:28 | 78580 | RD | 7.3 | 159 | 29 | 265 | +2.6 | +0.5 |
| Dec 12 01:25 | 79479 | RD | 7.2 | 148 | 29 | 274 | +2.5 | -0.6 |
| Dec 12 02:39 | 1149 | DB | 4.1 | 148 | 31 | 127 | +2.3 | -1.0 |
| Dec 14 03:44 | 1389 | RD | 7.7 | 125 | 36 | 253 | +3.3 | +0.5 |
| Dec 19 02:47 | 1933 | RD | 7.1 | 63 | 14 | 285 | +0.3 | -1.4 |
| Dec 19 03:14 | 1941 | DB | 4.7 | 63 | 19 | 113 | +0.4 | -1.5 |

LUNAR OCCULTATION TABLE

# SYDNEY (33° 54' S, 151° 15'E)

| EST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 08 21:35 | 146908 | DD | 7.6 | 67 | 15 | 45 | +0.2 | +2.1 |
| Jan 09 20:23 | 62 | DD | 7.5 | 78 | 34 | 98 | +1.9 | +1.0 |
| Jan 15 01:04 | 656 | DD | 4.2 | 134 | 7 | 114 | +0.6 | +0.5 |
| Jan 17 21:55 | 79122 | DD | 7.6 | 168 | 27 | 80 | +2.1 | -0.3 |
| Jan 17 23:06 | 1089 | DD | 6.7 | 168 | 30 | 104 | +2.4 | -0.5 |
| Jan 20 00:14 | 1363 | RD | 5.2 | 165 | 33 | 275 | +2.3 | -0.5 |
| Jan 20 00:52 | 1365 | RD | 6.0 | 164 | 34 | 284 | +2.2 | -0.5 |
| Jan 24 23:41 | 1950 | RD | 5.7 | 100 | 8 | 282 | +0.1 | -1.3 |
| Jan 27 02:01 | 2209 | RD | 5.6 | 72 | 21 | 357 | -0.8 | -3.2 |
| Jan 27 02:47 | 2211 | DD | 6.7 | 72 | 31 | 195 | -2.7 | -6.1 |
| Jan 27 03:02 | 2211 | RD | 6.7 | 72 | 34 | 222 | +3.9 | +2.9 |
| Jan 29 02:36 | 2513 | DB | 4.2 | 46 | 10 | 158 | -0.9 | -2.4 |
| Jan 29 03:09 | 2513 | RD | 4.2 | 46 | 17 | 235 | +0.7 | 0.0 |
| Jan 30 03:34 | 2672 | RD | 2.8 | 33 | 11 | 233 | +0.4 | 0.0 |
| Jan 30 03:46 | 186864 | RD | 7.6 | 33 | 13 | 336 | -1.0 | -2.8 |
| Jan 30 04:12 | 2678 | RD | 6.6 | 33 | 18 | 286 | 0.0 | -1.3 |
| Feb 10 21:53 | 76373 | DD | 7.6 | 101 | 17 | 13 | +2.0 | +4.2 |
| Feb 11 22:42 | 76810 | DD | 7.6 | 112 | 15 | 77 | +1.5 | +1.4 |
| Feb 14 22:15 | 1169 | DD | 5.3 | 147 | 30 | 126 | +2.1 | -0.9 |
| Feb 14 23:06 | 79672 | DD | 7.5 | 148 | 29 | 64 | +2.8 | +1.3 |
| Feb 19 02:41 | 1689 | RD | 5.2 | 157 | 46 | 304 | +1.6 | -0.7 |
| Feb 21 01:33 | 1923 | RD | 7.0 | 130 | 52 | 342 | +0.6 | -2.6 |
| Feb 21 01:49 | 139316 | RD | 7.7 | 130 | 54 | 293 | +1.7 | -1.3 |
| Feb 21 22:49 | 2032 | RD | 7.2 | 118 | 15 | 279 | +0.3 | -1.3 |
| Feb 23 00:56 | 2170 | RD | 6.7 | 103 | 33 | 227 | +3.0 | +1.7 |
| Feb 23 00:57 | 159096 | RD | 7.6 | 103 | 33 | 346 | -0.3 | -2.8 |
| Feb 23 23:25 | 2303 | RD | 4.8 | 91 | 6 | 331 | -0.6 | -2.0 |
| Feb 23 23:25 | 2302 | RD | 2.6 | 91 | 6 | 330 | -0.6 | -1.9 |
| Feb 24 04:14 | 2330 | RD | 6.4 | 89 | 64 | 268 | +2.2 | -0.6 |
| Feb 26 01:40 | 2622 | RD | 6.7 | 64 | 13 | 216 | +1.2 | +1.2 |
| Feb 27 04:04 | 2809 | DB | 4.9 | 51 | 29 | 39 | +1.6 | +1.2 |
| Feb 27 04:40 | 2809 | RD | 4.9 | 51 | 37 | 332 | -0.3 | -4.0 |
| Mar 10 19:20 | 664 | RB | 5.5 | 80 | 26 | 229 | +2.1 | +2.0 |
| Mar 10 20:45 | 76636 | DD | 7.1 | 80 | 14 | 69 | +1.5 | +1.7 |
| Mar 13 21:00 | 1105 | DD | 6.5 | 114 | 27 | 89 | +2.3 | +0.5 |
| Mar 13 21:49 | 79243 | DD | 7.3 | 115 | 24 | 176 | -1.2 | -4.6 |
| Mar 13 22:11 | 79253 | DD | 7.6 | 115 | 21 | 173 | -0.9 | -3.7 |
| Mar 14 22:20 | 80070 | DD | 7.5 | 127 | 27 | 107 | +1.8 | +0.2 |
| Mar 17 23:22 | 1621 | DD | 7.2 | 166 | 45 | 125 | +1.7 | -1.0 |
| Mar 19 21:54 | 1856 | RD | 6.8 | 164 | 35 | 327 | +0.7 | -2.1 |
| Mar 20 21:42 | 139581 | RD | 7.3 | 151 | 26 | 292 | +0.6 | -1.5 |
| Mar 20 21:54 | 1985 | RD | 6.9 | 150 | 29 | 266 | +1.0 | -1.0 |
| Mar 20 23:52 | 1994 | RD | 6.6 | 150 | 51 | 343 | +0.4 | -2.7 |
| Mar 21 23:07 | 2114 | RD | 5.3 | 136 | 36 | 266 | +1.2 | -1.0 |
| Mar 24 02:53 | 2430 | RD | 6.8 | 107 | 63 | 288 | +1.6 | -1.3 |
| Apr 06 18:53 | 621 | DD | 6.1 | 49 | 13 | 77 | +1.3 | +1.5 |
| Apr 07 18:55 | 753 | DD | 7.4 | 60 | 18 | 118 | +1.3 | +0.2 |
| Apr 10 18:43 | 1181 | DD | 7.0 | 94 | 30 | 73 | +2.7 | +0.6 |
| Apr 12 19:00 | 1432 | DD | 6.7 | 119 | 33 | 57 | +3.1 | +0.9 |
| Apr 14 22:45 | 1689 | DD | 5.2 | 147 | 47 | 121 | +1.7 | -0.7 |
| Apr 17 01:52 | 1941 | DD | 4.7 | 176 | 50 | 162 | +0.8 | -2.2 |
| Apr 17 23:10 | 2060 | RD | 6.2 | 169 | 60 | 279 | +1.9 | -0.9 |
| Apr 17 23:41 | 2064 | RD | 6.3 | 169 | 64 | 324 | +1.1 | -2.1 |
| Apr 20 00:41 | 2362 | RD | 7.7 | 140 | 63 | 303 | +1.3 | -1.8 |
| Apr 25 04:58 | 3164 | DB | 4.5 | 74 | 55 | 57 | +1.8 | +0.7 |
| May 06 18:21 | 1013 | DD | 7.0 | 53 | 18 | 74 | +1.9 | +1.5 |
| May 08 19:48 | 80209 | DD | 7.0 | 76 | 22 | 155 | +0.3 | -1.2 |
| May 08 21:11 | 1274 | DD | 5.7 | 77 | 11 | 181 | -1.7 | -3.8 |
| May 11 19:28 | 1621 | DD | 7.2 | 114 | 45 | 181 | 0.0 | -3.2 |
| May 12 19:00 | 1739 | DD | 6.4 | 127 | 44 | 86 | +2.4 | -0.6 |
| May 12 20:16 | 119200 | DD | 7.1 | 127 | 51 | 181 | 0.0 | -3.2 |
| May 12 22:06 | 119227 | DD | 7.5 | 128 | 47 | 136 | +1.3 | -1.0 |
| May 13 00:36 | 1755 | DD | 6.9 | 129 | 24 | 80 | +1.3 | +1.7 |
| May 13 18:44 | 1856 | DD | 6.8 | 141 | 40 | 87 | +1.8 | -0.9 |
| May 14 18:30 | 139581 | DD | 7.3 | 155 | 31 | 107 | +0.8 | -1.4 |
| May 14 18:47 | 1985 | DD | 6.9 | 155 | 35 | 130 | +0.7 | -1.8 |
| May 14 20:56 | 139607 | DD | 7.7 | 156 | 58 | 156 | +0.7 | -2.4 |
| May 15 02:51 | 139704 | DD | 7.3 | 158 | 26 | 90 | +0.8 | +1.1 |
| May 15 19:26 | 2114 | DD | 5.3 | 170 | 35 | 120 | +0.6 | -1.6 |
| May 16 05:04 | 2159 | DD | 5.2 | 174 | 14 | 104 | +0.3 | +0.6 |
| May 16 22:21 | 2267 | RD | 5.0 | 174 | 62 | 243 | +3.0 | +0.9 |
| May 17 05:07 | 2310 | DB | 4.3 | 172 | 27 | 29 | -0.7 | +6.3 |
| May 17 05:26 | 2310 | RD | 4.3 | 172 | 23 | 352 | +1.9 | -4.6 |
| May 17 21:13 | 2430 | RD | 6.8 | 161 | 37 | 290 | +0.6 | -1.5 |
| May 18 01:48 | 184964 | RD | 7.3 | 159 | 78 | 289 | +2.1 | -0.7 |
| May 18 02:18 | 184991 | RD | 7.3 | 159 | 74 | 300 | +2.0 | -1.0 |
| May 19 01:48 | 2623 | RD | 7.7 | 145 | 79 | 279 | +2.1 | -0.6 |
| May 19 02:26 | 186403 | RD | 7.7 | 145 | 82 | 304 | +2.1 | -1.7 |
| May 19 21:24 | 2781 | RD | 7.4 | 133 | 16 | 221 | +1.0 | +0.7 |
| May 20 01:06 | 2804 | RD | 5.8 | 131 | 60 | 317 | +1.2 | -3.2 |
| May 20 05:45 | 2824 | RD | 7.3 | 130 | 59 | 197 | 0.0 | +4.7 |
| Jun 03 17:57 | 1105 | DD | 6.5 | 35 | 12 | 128 | +0.6 | 0.0 |
| Jun 05 19:12 | 1363 | DD | 5.2 | 59 | 19 | 142 | +0.5 | -0.6 |
| Jun 05 19:41 | 1365 | DD | 6.0 | 59 | 15 | 127 | +0.6 | -0.1 |
| Jun 07 18:31 | 99343 | DD | 7.7 | 83 | 42 | 158 | +0.8 | -1.8 |
| Jun 08 19:29 | 119038 | DD | 6.9 | 97 | 47 | 133 | +1.5 | -1.1 |
| Jun 08 19:44 | 119030 | DD | 7.1 | 97 | 46 | 192 | -1.1 | -4.3 |
| Jun 08 20:05 | 119034 | DD | 7.7 | 97 | 44 | 194 | -1.4 | -4.7 |
| Jun 10 21:46 | 1941 | DD | 4.7 | 124 | 55 | 177 | +0.3 | -3.3 |
| Jun 10 22:33 | 1941 | RB | 4.7 | 125 | 47 | 254 | +2.4 | +2.0 |
| Jun 11 18:58 | 2060 | DD | 6.2 | 137 | 54 | 138 | +1.0 | -2.0 |
| Jun 11 19:33 | 2064 | DD | 6.3 | 137 | 60 | 91 | +2.2 | -0.7 |
| Jun 13 18:19 | 2348 | DD | 6.8 | 165 | 30 | 165 | -0.6 | -2.8 |
| Jun 13 21:08 | 2362 | DD | 7.7 | 166 | 63 | 78 | +2.2 | -0.1 |
| Jun 14 03:13 | 2388 | DD | 7.6 | 169 | 36 | 76 | +0.7 | +1.5 |
| Jun 18 00:47 | 3037 | RD | 7.3 | 137 | 59 | 265 | +1.9 | -0.6 |
| Jun 18 22:53 | 3175 | DB | 4.7 | 125 | 23 | 28 | +1.0 | +1.5 |
| Jun 18 23:39 | 3175 | RD | 4.7 | 125 | 32 | 304 | +0.6 | -3.0 |
| Jun 19 04:11 | 164674 | RD | 7.6 | 123 | 74 | 259 | +2.4 | +0.6 |
| Jun 20 02:29 | 3323 | RD | 7.5 | 112 | 54 | 235 | +1.7 | +0.7 |
| Jun 22 02:34 | 20 | RD | 6.7 | 88 | 32 | 270 | +1.4 | -1.3 |
| Jun 22 03:24 | 128642 | RD | 7.4 | 88 | 41 | 199 | +0.7 | +2.2 |
| Jun 22 05:02 | 128661 | RD | 6.6 | 88 | 55 | 190 | +0.6 | +2.9 |
| Jun 27 05:41 | 76373 | RD | 7.6 | 32 | 12 | 263 | +1.0 | -0.9 |
| Jul 04 19:21 | 99249 | DD | 7.6 | 55 | 20 | 147 | +0.3 | -0.9 |
| Jul 06 21:28 | 1783 | DD | 7.3 | 81 | 23 | 85 | +1.1 | +1.5 |
| Jul 08 18:05 | 139704 | DD | 7.3 | 106 | 63 | 126 | +1.6 | -1.6 |
| Jul 08 21:36 | 2028 | DD | 6.5 | 108 | 47 | 69 | +2.2 | +2.5 |
| Jul 09 23:03 | 2159 | DD | 5.2 | 122 | 44 | 64 | +1.5 | +2.6 |
| Jul 09 23:08 | 2160 | DD | 6.4 | 122 | 43 | 110 | +1.3 | +0.2 |
| Jul 09 23:52 | 2159 | RB | 5.2 | 122 | 34 | 338 | +1.1 | -2.0 |
| Jul 11 02:52 | 2327 | DD | 6.7 | 137 | 12 | 73 | -0.1 | +1.5 |
| Jul 11 20:15 | 184964 | DD | 7.3 | 148 | 69 | 105 | +1.8 | -1.1 |
| Jul 11 20:47 | 184991 | DD | 7.3 | 148 | 74 | 89 | +2.2 | -0.3 |
| Jul 12 18:51 | 186235 | DD | 7.2 | 161 | 40 | 26 | +4.5 | +5.6 |
| Jul 12 20:44 | 2623 | DD | 7.7 | 162 | 63 | 104 | +1.6 | -1.2 |
| Jul 12 21:27 | 186403 | DD | 7.7 | 162 | 71 | 75 | +2.2 | +0.2 |
| Jul 13 03:04 | 2657 | DD | 6.9 | 164 | 36 | 90 | +0.8 | +1.0 |
| Jul 13 20:12 | 2804 | DD | 5.8 | 174 | 44 | 71 | +1.4 | -0.3 |
| Jul 16 00:21 | 190252 | RD | 7.2 | 156 | 68 | 195 | +1.4 | +4.0 |
| Jul 17 02:12 | 164984 | RD | 7.1 | 143 | 71 | 214 | +1.4 | +2.3 |
| Jul 19 23:24 | 76 | RD | 5.9 | 108 | 9 | 184 | +0.1 | +3.0 |
| Jul 23 05:10 | 93185 | RD | 7.4 | 73 | 35 | 275 | +2.8 | -1.1 |
| Aug 03 21:28 | 139130 | DD | 7.6 | 65 | 11 | 134 | +0.3 | -0.4 |
| Aug 04 22:02 | 1996 | DD | 6.7 | 78 | 17 | 159 | +0.6 | -1.7 |
| Aug 05 22:38 | 158842 | DD | 7.2 | 92 | 23 | 71 | +0.5 | +2.0 |
| Aug 06 18:42 | 2233 | RB | 5.5 | 104 | 75 | 294 | +2.0 | -1.0 |
| Aug 06 19:22 | 2241 | DD | 4.8 | 104 | 73 | 123 | +1.9 | -1.2 |
| Aug 06 20:43 | 2241 | RB | 4.8 | 104 | 59 | 285 | +1.9 | +0.1 |
| Aug 07 01:14 | 2267 | DD | 5.0 | 107 | 6 | 65 | -0.4 | +1.7 |
| Aug 09 23:18 | 2750 | DD | 2.0 | 145 | 67 | 84 | +1.9 | +0.9 |
| Aug 10 00:35 | 2750 | RB | 2.0 | 146 | 51 | 256 | +1.2 | +1.4 |
| Aug 11 22:54 | 3062 | DD | 7.5 | 171 | 75 | 49 | +1.9 | +1.7 |
| Aug 15 23:46 | 37 | RD | 7.2 | 139 | 39 | 259 | +1.6 | -0.6 |
| Aug 17 02:11 | 109664 | RD | 7.3 | 126 | 48 | 276 | +3.2 | -1.0 |
| Aug 19 05:20 | X 3541 | RD | 7.3 | 103 | 41 | 209 | +1.4 | +2.0 |
| Aug 21 03:35 | 621 | RD | 6.1 | 82 | 22 | 184 | -0.7 | +2.7 |
| Aug 24 05:23 | 1056 | RD | 7.2 | 48 | 13 | 274 | +1.4 | -1.2 |
| Sep 04 19:46 | 185433 | DD | 7.2 | 101 | 72 | 72 | +2.1 | +1.4 |
| Sep 06 18:36 | 2852 | DD | 7.3 | 127 | 65 | 31 | +2.5 | +3.4 |
| Sep 06 19:15 | 188263 | DD | 7.7 | 127 | 72 | 107 | +2.2 | -1.3 |
| Sep 08 02:02 | 189613 | DD | 7.2 | 142 | 31 | 37 | -0.1 | +2.2 |
| Sep 09 01:16 | 164528 | DD | 7.5 | 154 | 49 | 130 | +4.2 | -2.2 |
| Sep 09 01:32 | 164516 | DD | 6.9 | 154 | 45 | 348 | -2.2 | +5.7 |
| Sep 11 00:06 | 3419 | DD | 4.2 | 176 | 65 | 342 | -1.9 | +6.4 |
| Sep 11 00:36 | 3419 | RD | 4.2 | 176 | 63 | 299 | +5.3 | -2.6 |
| Sep 11 00:39 | 3425 | DB | 4.4 | 176 | 63 | 85 | +2.6 | +0.6 |
| Sep 11 01:46 | 3425 | RB | 4.4 | 176 | 55 | 196 | +0.5 | +2.9 |
| Sep 12 04:59 | 12 | RD | 6.4 | 167 | 22 | 268 | +0.9 | +1.3 |
| Sep 13 03:56 | 109506 | RD | 7.6 | 156 | 38 | 246 | +1.6 | +1.7 |
| Sep 14 03:28 | 109990 | RD | 7.0 | 145 | 43 | 281 | +3.2 | +0.2 |
| Sep 15 02:27 | 340 | RD | 6.9 | 134 | 43 | 230 | +1.8 | +1.2 |
| Sep 16 04:21 | 455 | RD | 6.1 | 123 | 37 | 206 | +1.5 | +2.2 |
| Sep 17 03:35 | 76311 | RD | 7.2 | 112 | 34 | 288 | +3.5 | -1.1 |
| Sep 19 03:39 | 844 | RD | 5.8 | 90 | 23 | 289 | +2.6 | -1.5 |
| Sep 20 04:07 | 78480 | RD | 7.5 | 79 | 19 | 330 | +4.2 | -4.9 |
| Sep 30 19:47 | 2319 | DD | 7.0 | 58 | 33 | 114 | +1.0 | +0.2 |
| Sep 30 21:47 | 2333 | DD | 7.4 | 59 | 10 | 129 | +0.3 | -0.1 |
| Oct 01 19:42 | 2469 | DD | 6.5 | 71 | 47 | 98 | +1.4 | +0.7 |
| Oct 01 21:39 | 2483 | DD | 7.1 | 72 | 24 | 103 | +0.5 | +0.7 |
| Oct 02 23:38 | 186770 | DD | 7.6 | 86 | 14 | 88 | 0.0 | +1.0 |
| Oct 03 21:40 | 2824 | DD | 7.3 | 98 | 48 | 77 | +1.1 | +1.4 |
| Oct 06 20:21 | 3243 | DD | 7.3 | 135 | 70 | 27 | +1.3 | +2.6 |
| Oct 07 00:33 | 3265 | DD | 6.5 | 137 | 41 | 81 | +1.2 | +1.4 |
| Oct 08 02:20 | 3392 | DD | 7.3 | 149 | 26 | 120 | +1.7 | 0.0 |
| Oct 19 03:57 | 1213 | RD | 7.1 | 87 | 22 | 300 | +2.2 | -1.6 |
| Oct 30 22:17 | 2781 | DD | 7.4 | 68 | 16 | 23 | -1.0 | +2.7 |
| Nov 02 00:01 | 3089 | DD | 5.3 | 94 | 16 | 70 | -0.1 | +1.4 |
| Nov 02 21:10 | 3214 | DD | 6.8 | 105 | 58 | 120 | +3.9 | -1.3 |
| Nov 03 00:30 | 164829 | DD | 7.1 | 107 | 18 | 91 | +0.3 | +1.1 |
| Nov 03 00:30 | 3228 | DD | 7.2 | 107 | 18 | 91 | +0.3 | +1.1 |
| Nov 04 01:40 | 3356 | DD | 5.8 | 119 | 10 | 64 | 0.0 | +1.6 |
| Nov 05 20:34 | 36 | DD | 7.1 | 140 | 57 | 56 | +1.9 | +1.1 |
| Nov 05 20:58 | 37 | DD | 7.2 | 141 | 58 | 115 | +5.4 | -2.8 |
| Nov 07 01:12 | 109667 | DD | 7.3 | 153 | 30 | 354 | 0.0 | +4.0 |
| Nov 07 01:12 | 155 | DD | 6.3 | 153 | 30 | 352 | -0.2 | +4.2 |
| Nov 07 20:24 | 257 | DD | 4.3 | 163 | 37 | 50 | +1.3 | +0.7 |
| Nov 07 21:48 | 257 | RB | 4.3 | 163 | 46 | 229 | +1.7 | +1.1 |
| Nov 11 01:01 | 76475 | RD | 7.7 | 163 | 33 | 262 | +2.6 | +0.4 |
| Nov 11 01:01 | 612 | RD | 7.6 | 163 | 33 | 262 | +2.6 | +0.4 |
| Nov 12 00:43 | 745 | RD | 7.3 | 152 | 29 | 296 | +3.3 | -1.5 |
| Nov 13 00:11 | 890 | DB | 4.6 | 141 | 21 | 29 | +0.6 | +1.2 |
| Nov 13 01:13 | 890 | RD | 4.6 | 141 | 26 | 302 | +3.1 | -1.7 |
| Nov 13 02:54 | 77724 | RD | 7.0 | 140 | 28 | 309 | +2.7 | -1.1 |
| Nov 14 00:01 | 1035 | RD | 6.7 | 130 | 14 | 245 | +1.0 | -0.4 |
| Nov 25 12:49 | Mercury | DD | -0.5 | 17 | 81 | 75 | +2.8 | +0.9 |
| Nov 25 14:12 | Mercury | RB | -0.5 | 17 | 71 | 311 | +2.3 | -1.7 |
| Nov 29 20:00 | 3164 | RB | 4.5 | 74 | 48 | 208 | +0.3 | +2.6 |
| Nov 29 21:06 | 164567 | DD | 7.3 | 74 | 35 | 74 | +0.7 | +1.5 |
| Dec 01 20:20 | 3425 | RB | 4.4 | 98 | 55 | 229 | +1.3 | +2.0 |
| Dec 01 21:31 | 3434 | DD | 7.5 | 99 | 43 | 79 | +1.5 | +1.4 |
| Dec 02 22:56 | 12 | DD | 6.4 | 111 | 31 | 14 | +0.3 | +2.9 |
| Dec 02 23:20 | 13 | DD | 6.2 | 111 | 26 | 8 | +0.1 | +3.0 |
| Dec 02 23:54 | 128618 | DD | 6.8 | 111 | 19 | 90 | +0.8 | +1.3 |
| Dec 03 22:00 | 109506 | DD | 7.6 | 122 | 44 | 52 | +1.6 | +1.9 |
| Dec 04 21:35 | 226 | DD | 6.5 | 133 | 46 | 347 | -0.9 | +4.4 |
| Dec 04 22:12 | 109990 | DD | 7.0 | 133 | 42 | 44 | +1.6 | +2.0 |
| Dec 07 22:48 | 76311 | DD | 7.2 | 166 | 34 | 88 | +2.8 | +0.1 |
| Dec 08 01:30 | 582 | DD | 5.6 | 166 | 22 | 27 | +1.9 | +2.9 |
| Dec 10 00:16 | 844 | RD | 5.8 | 171 | 29 | 220 | +2.1 | +1.5 |
| Dec 11 01:45 | 78480 | RD | 7.5 | 160 | 28 | 264 | +2.6 | +0.4 |
| Dec 11 02:06 | 78496 | RD | 7.5 | 160 | 27 | 302 | +2.2 | -0.5 |
| Dec 11 02:57 | 1008 | RD | 5.3 | 160 | 24 | 324 | +1.3 | -1.1 |
| Dec 12 01:44 | 79402 | RD | 7.3 | 149 | 29 | 285 | +2.5 | -0.5 |
| Dec 13 00:51 | 1252 | RD | 7.3 | 138 | 24 | 263 | +2.1 | -0.6 |
| Dec 17 02:47 | 119030 | RD | 7.1 | 90 | 29 | 269 | +1.6 | -1.1 |
| Dec 17 03:01 | 119038 | RD | 6.9 | 90 | 31 | 318 | +1.1 | -2.1 |
| Dec 19 01:44 | 1921 | RD | 5.9 | 65 | 6 | 344 | -0.1 | -2.4 |
| Dec 19 02:29 | 1924 | RD | 5.8 | 65 | 15 | 329 | +0.1 | -2.1 |
| Dec 26 20:56 | 190191 | DD | 7.6 | 41 | 10 | 359 | -1.3 | +3.4 |

LUNAR OCCULTATION TABLE

# DARWIN (12° 23' S, 130° 44' E)

| CST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 09 23:45 | 76 | DD | 5.9 | 79 | 6 | 80 | +0.2 | +0.8 |
| Jan 14 21:15 | 634 | RB | 5.3 | 133 | 56 | 243 | +2.8 | +1.2 |
| Jan 15 00:19 | 657 | DD | 5.3 | 134 | 37 | 92 | +2.2 | +0.3 |
| Jan 15 00:20 | 656 | DD | 4.2 | 134 | 37 | 71 | +2.3 | +1.2 |
| Jan 15 01:43 | 656 | RB | 4.2 | 134 | 20 | 270 | +1.2 | +0.5 |
| Jan 19 22:30 | 1363 | RD | 5.2 | 165 | 28 | 329 | +2.1 | -3.0 |
| Jan 19 23:05 | 1365 | RD | 6.0 | 164 | 35 | 328 | +2.2 | -3.0 |
| Jan 26 02:57 | 2088 | RD | 6.2 | 84 | 29 | 342 | -0.1 | -2.6 |
| Feb 12 00:42 | 742 | DD | 5.8 | 113 | 16 | 109 | +0.7 | -0.2 |
| Feb 14 20:40 | 1169 | DD | 5.3 | 148 | 40 | 73 | +2.1 | +0.4 |
| Feb 14 22:09 | 1169 | RB | 5.3 | 148 | 50 | 295 | +3.0 | -1.2 |
| Feb 19 01:04 | 1689 | RD | 5.2 | 157 | 60 | 314 | +1.8 | -1.9 |
| Feb 19 05:37 | 1702 | DB | 4.0 | 155 | 42 | 137 | +1.0 | -1.4 |
| Feb 21 05:08 | 1941 | DB | 4.7 | 128 | 76 | 149 | +1.4 | -2.4 |
| Feb 22 04:09 | 2060 | RD | 6.2 | 115 | 76 | 300 | +2.2 | -1.4 |
| Feb 22 04:31 | 2064 | RD | 6.3 | 115 | 81 | 351 | +0.5 | -3.6 |
| Feb 24 02:53 | 2330 | RD | 6.4 | 89 | 33 | 288 | +0.8 | -1.0 |
| Feb 25 04:01 | 2490 | DB | 5.2 | 76 | 35 | 70 | +1.9 | +0.5 |
| Feb 25 04:54 | 2490 | RD | 5.2 | 75 | 47 | 335 | +0.1 | -3.1 |
| Mar 09 20:31 | 531 | DD | 5.7 | 69 | 34 | 110 | +2.0 | -0.6 |
| Mar 13 19:53 | 1105 | DD | 6.5 | 115 | 49 | 38 | +2.9 | +3.3 |
| Mar 21 22:05 | 2114 | RD | 5.3 | 136 | 8 | 291 | 0.0 | -0.9 |
| Mar 23 00:34 | 2267 | DD | 5.0 | 121 | 30 | 198 | -4.5 | -8.9 |
| Mar 23 00:46 | 2267 | RD | 5.0 | 121 | 33 | 221 | +5.9 | +6.5 |
| Mar 29 05:59 | 3202 | RD | 6.2 | 44 | 28 | 238 | +1.3 | +0.9 |
| Apr 14 21:08 | 1689 | DD | 5.2 | 147 | 56 | 111 | +2.2 | -1.2 |
| Apr 14 22:27 | 1689 | RB | 5.2 | 148 | 68 | 327 | +1.5 | -2.2 |
| Apr 15 02:47 | 1702 | DD | 4.0 | 149 | 31 | 125 | +0.8 | -0.8 |
| Apr 15 03:49 | 1702 | RB | 4.0 | 150 | 16 | 302 | +0.4 | -0.7 |
| Apr 17 00:13 | 1941 | DD | 4.7 | 176 | 81 | 137 | +1.7 | -1.9 |
| Apr 17 01:33 | 1941 | RB | 4.7 | 176 | 76 | 305 | +2.0 | -1.4 |
| Apr 17 21:46 | 2060 | RD | 6.2 | 169 | 35 | 293 | +0.9 | -1.1 |
| Apr 17 22:07 | 2064 | RD | 6.3 | 169 | 40 | 337 | +0.2 | -2.4 |
| Apr 25 03:29 | 3158 | RD | 5.7 | 74 | 22 | 240 | +1.0 | +0.7 |
| Apr 27 05:27 | 3413 | RD | 6.1 | 51 | 27 | 225 | +1.1 | +1.4 |
| May 08 19:54 | 1274 | DD | 5.7 | 77 | 46 | 148 | +1.1 | -2.2 |
| May 08 20:38 | 1279 | DD | 6.3 | 77 | 40 | 112 | +1.8 | -0.5 |
| May 08 21:06 | 1274 | RB | 5.7 | 77 | 34 | 266 | +2.2 | +0.6 |
| May 16 21:08 | 2267 | RD | 5.0 | 174 | 33 | 267 | +1.2 | -0.3 |
| May 18 05:22 | 2469 | RD | 6.5 | 157 | 45 | 216 | +0.7 | +3.9 |
| May 25 05:57 | 3506 | DB | 6.1 | 69 | 52 | 9 | +0.7 | +3.8 |
| Jun 05 19:24 | 1363 | RB | 5.2 | 59 | 41 | 298 | +1.6 | -0.7 |
| Jun 05 19:57 | 1365 | RB | 6.0 | 59 | 35 | 315 | +0.8 | -1.3 |
| Jun 05 21:15 | 1373 | DD | 6.5 | 60 | 20 | 160 | -0.4 | -2.1 |
| Jun 07 22:28 | 1598 | DD | 6.5 | 85 | 30 | 186 | -0.9 | -4.1 |
| Jun 10 20:00 | 1941 | DD | 4.7 | 124 | 73 | 157 | +1.0 | -2.7 |
| Jun 10 21:15 | 1941 | RB | 4.7 | 125 | 83 | 288 | +2.7 | -0.9 |
| Jun 13 04:04 | 2233 | DD | 5.5 | 155 | 18 | 75 | +0.3 | +1.0 |
| Jun 16 05:04 | 2740 | RD | 6.3 | 162 | 46 | 247 | +1.3 | +1.2 |
| Jun 16 05:30 | 2750 | DB | 2.0 | 162 | 40 | 42 | +0.5 | +2.2 |
| Jun 16 06:26 | 2750 | RD | 2.0 | 161 | 28 | 290 | +1.3 | -0.3 |
| Jun 19 04:29 | 3202 | RD | 6.2 | 123 | 82 | 253 | +3.0 | +0.9 |
| Jul 12 00:28 | 2469 | DD | 6.5 | 150 | 62 | 142 | +2.7 | -2.8 |
| Jul 16 01:23 | 3130 | RD | 5.4 | 155 | 70 | 227 | +2.4 | +2.0 |
| Jul 24 03:38 | 531 | RD | 5.7 | 62 | 13 | 250 | +0.4 | +0.3 |
| Jul 24 04:08 | 533 | RD | 6.1 | 62 | 19 | 199 | -0.4 | +2.2 |
| Jul 25 06:09 | 693 | RD | 6.0 | 50 | 32 | 214 | +0.4 | +1.8 |
| Aug 09 20:15 | 2740 | DD | 6.3 | 145 | 55 | 79 | +2.4 | +0.2 |
| Aug 12 05:07 | 3089 | DD | 5.3 | 173 | 25 | 66 | +0.4 | +1.1 |
| Aug 15 00:47 | 3478 | RD | 6.4 | 149 | 59 | 293 | +4.3 | -2.8 |
| Aug 21 02:46 | 621 | RD | 6.1 | 82 | 18 | 309 | +3.2 | -4.2 |
| Sep 02 21:40 | 2217 | DD | 5.5 | 76 | 31 | 128 | +1.3 | -1.1 |
| Sep 04 20:42 | 2524 | DD | 6.0 | 102 | 67 | 138 | +2.9 | -2.7 |
| Sep 08 21:41 | 3158 | DD | 5.7 | 153 | 67 | 105 | +3.3 | -1.3 |
| Sep 08 23:47 | 3164 | DD | 4.5 | 154 | 79 | 41 | +1.8 | +2.3 |
| Sep 09 01:12 | 3164 | RB | 4.5 | 154 | 61 | 249 | +2.0 | +1.2 |
| Sep 09 03:28 | 3175 | DD | 4.7 | 155 | 30 | 97 | +1.3 | +0.2 |
| Sep 10 00:36 | 3304 | DD | 6.4 | 166 | 82 | 43 | +1.9 | +2.2 |
| Sep 10 23:59 | 3428 | DB | 5.0 | 175 | 77 | 96 | +4.1 | -0.7 |
| Sep 11 01:00 | 3428 | RB | 5.0 | 175 | 86 | 179 | -0.1 | +4.4 |
| Sep 14 03:24 | 238 | RD | 6.4 | 145 | 69 | 216 | +1.8 | +2.4 |
| Sep 18 01:17 | 714 | RD | 6.2 | 102 | 15 | 228 | +0.1 | +1.0 |
| Oct 02 20:08 | 2650 | DD | 4.7 | 85 | 61 | 76 | +2.3 | +0.9 |
| Oct 02 21:31 | 2650 | RB | 4.7 | 85 | 43 | 269 | +1.6 | +0.4 |
| Oct 12 00:19 | 301 | RD | 6.5 | 165 | 61 | 253 | +2.9 | +0.7 |
| Oct 12 21:16 | 403 | RD | 5.8 | 155 | 12 | 289 | +1.1 | -1.6 |
| Oct 13 04:20 | 423 | RD | 6.3 | 153 | 48 | 203 | +1.8 | +3.3 |
| Nov 04 21:30 | 3478 | DD | 6.4 | 129 | 85 | 55 | +2.4 | +1.7 |
| Nov 10 20:34 | 599 | RD | 4.4 | 164 | 9 | 264 | +0.5 | -0.2 |
| Nov 10 20:49 | 601 | RD | 5.9 | 164 | 12 | 232 | +0.1 | +0.8 |
| Nov 11 22:10 | 743 | RD | 5.8 | 152 | 18 | 229 | +0.2 | +1.0 |
| Nov 29 21:53 | 3175 | DD | 4.7 | 75 | 33 | 40 | +0.3 | +1.9 |
| Nov 29 22:53 | 3175 | RB | 4.7 | 75 | 19 | 258 | +0.4 | +0.8 |
| Dec 05 01:51 | 247 | DD | 6.3 | 134 | 23 | 65 | +1.1 | +1.4 |
| Dec 06 22:33 | 455 | DD | 6.1 | 155 | 59 | 66 | +2.9 | +1.1 |
| Dec 09 22:48 | 844 | RD | 5.8 | 171 | 37 | 310 | +4.6 | -3.7 |
| Dec 12 04:57 | 1149 | DB | 4.1 | 148 | 42 | 53 | +4.5 | +3.1 |
| Dec 12 05:45 | 1149 | RD | 4.1 | 148 | 34 | 349 | -0.7 | -3.8 |
| Dec 19 05:01 | 1937 | RD | 6.1 | 63 | 38 | 292 | +1.2 | -1.2 |
| Dec 21 04:51 | 2192 | RD | 6.2 | 36 | 13 | 295 | 0.0 | -1.0 |

LUNAR OCCULTATION TABLE

# HOBART (42° 48' S, 147° 13'E)

| EST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 17 23:03 | 1089 | DD | 6.7 | 168 | 21 | 119 | +2.0 | -0.8 |
| Jan 20 00:09 | 1363 | RD | 5.2 | 165 | 23 | 257 | +2.0 | -0.4 |
| Jan 20 00:47 | 1365 | RD | 6.0 | 164 | 25 | 265 | +2.0 | -0.2 |
| Jan 27 02:25 | 2209 | RD | 5.6 | 72 | 24 | 329 | -0.1 | -2.2 |
| Jan 29 02:29 | 2507 | RD | 6.7 | 46 | 10 | 257 | -0.1 | -0.9 |
| Feb 14 22:18 | 1169 | DD | 5.3 | 148 | 22 | 147 | +1.6 | -1.2 |
| Feb 19 02:36 | 1689 | RD | 5.2 | 157 | 38 | 274 | +2.0 | +0.2 |
| Feb 23 23:43 | 2302 | RD | 2.6 | 91 | 9 | 310 | -0.4 | -1.7 |
| Feb 24 03:43 | 2330 | DD | 6.4 | 89 | 52 | 193 | -3.0 | -8.1 |
| Feb 24 03:58 | 2330 | RD | 6.4 | 89 | 55 | 218 | +5.3 | +5.1 |
| Feb 27 04:02 | 2809 | DB | 4.9 | 51 | 27 | 76 | +0.5 | -1.0 |
| Mar 13 20:50 | 1105 | DD | 6.5 | 114 | 20 | 107 | +1.9 | +0.1 |
| Mar 21 00:09 | 1994 | RD | 6.6 | 150 | 46 | 318 | +0.8 | -1.9 |
| Mar 21 23:07 | 2114 | RD | 5.3 | 136 | 32 | 234 | +1.9 | 0.0 |
| Apr 12 18:52 | 1432 | DD | 6.7 | 119 | 23 | 80 | +1.9 | -0.6 |
| Apr 14 00:07 | 1570 | DD | 5.5 | 134 | 23 | 50 | +3.8 | +5.2 |
| Apr 14 22:49 | 1689 | DD | 5.2 | 147 | 39 | 148 | +0.9 | -1.3 |
| Apr 14 23:56 | 1689 | RB | 5.2 | 148 | 35 | 284 | +1.6 | +0.3 |
| Apr 17 23:04 | 2060 | RD | 6.2 | 169 | 51 | 243 | +2.7 | +0.5 |
| Apr 17 23:50 | 2064 | RD | 6.3 | 169 | 56 | 296 | +1.4 | -1.2 |
| Apr 20 21:59 | 2510 | RD | 6.2 | 128 | 19 | 347 | -1.0 | -3.0 |
| Apr 25 04:54 | 3164 | DB | 4.5 | 74 | 48 | 89 | +1.5 | -1.1 |
| May 12 19:01 | 1739 | DD | 6.4 | 127 | 35 | 108 | +1.5 | -1.2 |
| May 14 21:11 | 1994 | DD | 6.6 | 156 | 50 | 70 | +2.6 | +0.1 |
| May 15 19:40 | 2114 | DD | 5.3 | 170 | 33 | 141 | +0.3 | -2.0 |
| May 16 05:00 | 2159 | DD | 5.2 | 174 | 19 | 132 | +0.5 | 0.0 |
| May 17 04:39 | 2310 | DB | 4.3 | 172 | 36 | 73 | +0.7 | +1.9 |
| May 17 05:33 | 2310 | RD | 4.3 | 171 | 26 | 310 | +0.7 | 0.0 |
| May 19 02:15 | 2627 | RD | 6.7 | 145 | 72 | 342 | +1.2 | -5.6 |
| May 20 01:19 | 2804 | RD | 5.8 | 131 | 57 | 279 | +1.4 | -1.3 |
| May 21 23:39 | 3089 | RD | 5.3 | 107 | 17 | 291 | -0.1 | -2.0 |
| Jun 05 19:26 | 1363 | DD | 5.2 | 59 | 13 | 186 | -1.7 | -3.7 |
| Jun 05 19:44 | 1365 | DD | 6.0 | 59 | 11 | 162 | -0.2 | -1.1 |
| Jun 11 19:16 | 2060 | DD | 6.2 | 137 | 49 | 165 | +0.3 | -2.6 |
| Jun 11 19:36 | 2064 | DD | 6.3 | 137 | 52 | 119 | +1.2 | -1.5 |
| Jun 18 22:49 | 3175 | DB | 4.7 | 125 | 20 | 66 | +0.4 | -0.6 |
| Jun 18 23:53 | 3175 | RD | 4.7 | 125 | 32 | 265 | +0.8 | -1.2 |
| Jun 22 02:36 | 20 | RD | 6.7 | 88 | 26 | 241 | +0.8 | -0.3 |
| Jul 06 18:01 | 1773 | RB | 5.0 | 80 | 44 | 0 | 0.0 | -2.8 |
| Jul 08 21:20 | 2028 | DD | 6.5 | 107 | 48 | 109 | +1.5 | +0.1 |
| Jul 09 22:45 | 2159 | DD | 5.2 | 122 | 48 | 103 | +1.4 | +0.5 |
| Jul 09 23:07 | 2160 | DD | 6.4 | 122 | 44 | 144 | +1.1 | -1.1 |
| Jul 09 23:54 | 2159 | RB | 5.2 | 122 | 36 | 301 | +1.0 | +0.1 |
| Jul 10 23:58 | 2310 | DD | 4.3 | 136 | 48 | 40 | +1.1 | +5.1 |
| Jul 11 00:28 | 2310 | RB | 4.3 | 136 | 43 | 349 | +1.5 | -3.7 |
| Jul 11 02:41 | 2327 | DD | 6.7 | 137 | 20 | 97 | +0.2 | +1.1 |
| Jul 12 03:47 | 2490 | DD | 5.2 | 151 | 21 | 19 | -1.5 | +5.2 |
| Jul 12 03:47 | 185237 | DD | 6.7 | 151 | 20 | 17 | -1.7 | +5.8 |
| Jul 15 21:44 | 3106 | RD | 5.2 | 157 | 34 | 286 | +0.6 | -2.0 |
| Jul 16 06:06 | 3150 | RD | 6.6 | 154 | 35 | 315 | +2.6 | -1.0 |
| Jul 17 00:23 | 3265 | RD | 6.5 | 143 | 49 | 300 | +1.9 | -3.4 |
| Aug 06 18:36 | 2233 | RB | 5.5 | 104 | 66 | 258 | +2.3 | +0.5 |
| Aug 06 19:33 | 2241 | DD | 4.8 | 104 | 65 | 161 | +1.0 | -3.0 |
| Aug 06 20:26 | 2241 | RB | 4.8 | 104 | 60 | 246 | +2.1 | +2.1 |
| Aug 07 01:02 | 2267 | DD | 5.0 | 107 | 14 | 90 | 0.0 | +1.2 |
| Aug 09 23:08 | 2750 | DD | 2.0 | 146 | 68 | 112 | +2.0 | -0.4 |
| Aug 10 00:14 | 2750 | RB | 2.0 | 146 | 57 | 232 | +1.0 | +2.3 |
| Aug 12 05:49 | 3092 | DD | 6.2 | 173 | 16 | 47 | -0.3 | +1.8 |
| Aug 23 05:23 | 906 | RD | 6.6 | 59 | 10 | 306 | +2.2 | -2.3 |
| Sep 10 23:30 | 3419 | DD | 4.2 | 176 | 55 | 12 | +0.6 | +2.8 |
| Sep 11 00:28 | 3425 | DB | 4.4 | 176 | 56 | 104 | +2.9 | -0.6 |
| Sep 11 00:30 | 3419 | RD | 4.2 | 176 | 56 | 275 | +2.5 | -0.1 |
| Sep 11 01:18 | 3425 | RB | 4.4 | 176 | 53 | 182 | 0.0 | +3.3 |
| Sep 12 04:42 | 12 | RD | 6.4 | 167 | 26 | 258 | +0.9 | +1.7 |
| Sep 12 05:01 | 13 | RD | 6.2 | 167 | 23 | 264 | +0.8 | +1.6 |
| Sep 13 22:18 | 215 | RD | 6.5 | 147 | 17 | 309 | +2.6 | -6.5 |
| Sep 16 03:58 | 455 | RD | 6.1 | 123 | 29 | 194 | +0.8 | +1.9 |
| Sep 19 03:43 | 844 | RD | 5.8 | 90 | 14 | 275 | +1.7 | -1.2 |
| Oct 01 19:34 | 2469 | DD | 6.5 | 71 | 51 | 127 | +1.5 | -0.4 |
| Oct 01 23:43 | 2500 | DD | 3.3 | 73 | 8 | 52 | -0.7 | +1.9 |
| Oct 05 22:30 | 3116 | DD | 6.6 | 124 | 57 | 354 | -1.2 | +5.5 |
| Oct 07 00:16 | 3265 | DD | 6.5 | 137 | 45 | 92 | +1.5 | +1.2 |
| Oct 07 02:12 | Mars | DD | -1.9 | 137 | 24 | 3 | -0.6 | +3.0 |
| Oct 07 02:44 | Mars | RB | -1.9 | 138 | 18 | 300 | +0.8 | +0.7 |
| Oct 14 04:10 | 525 | RD | 6.5 | 142 | 22 | 233 | +1.7 | +1.5 |
| Nov 01 23:47 | 3089 | DD | 5.3 | 94 | 23 | 80 | +0.2 | +1.5 |
| Nov 04 01:25 | 3356 | DD | 5.8 | 119 | 17 | 74 | +0.2 | +1.7 |
| Nov 07 00:42 | 155 | DD | 6.3 | 153 | 32 | 6 | +0.4 | +2.8 |
| Nov 07 20:18 | 257 | DD | 4.3 | 163 | 27 | 69 | +1.3 | -0.4 |
| Nov 07 21:33 | 257 | RB | 4.3 | 163 | 35 | 216 | +1.0 | +1.0 |
| Nov 13 01:15 | 890 | RD | 4.6 | 141 | 17 | 288 | +2.2 | -1.1 |
| Nov 25 12:42 | Mercury | DD | -0.5 | 17 | 72 | 110 | +1.9 | -1.1 |
| Nov 25 14:09 | Mercury | RB | -0.5 | 17 | 68 | 277 | +2.0 | +0.2 |
| Dec 02 22:31 | 12 | DD | 6.4 | 111 | 34 | 23 | +0.5 | +2.4 |
| Dec 02 22:55 | 13 | DD | 6.2 | 111 | 30 | 19 | +0.4 | +2.5 |
| Dec 04 21:06 | 226 | DD | 6.5 | 133 | 39 | 3 | +0.2 | +2.6 |
| Dec 08 01:03 | 582 | DD | 5.6 | 166 | 19 | 43 | +1.7 | +1.8 |
| Dec 09 23:57 | 844 | RD | 5.8 | 171 | 20 | 205 | +1.2 | +1.3 |
| Dec 11 02:54 | 1008 | RD | 5.3 | 160 | 17 | 301 | +1.6 | +0.1 |
| Dec 19 02:47 | 1924 | RD | 5.8 | 65 | 14 | 313 | +0.2 | -1.9 |

# MOON

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | | JULY | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " |
| 1 | 16 58 54 | - 23 23 13 | 20 38 59 | - 22 56 27 | 21 17 27 | - 20 45 14 | 00 14 04 | - 03 13 48 | 02 12 36 | + 10 59 48 | 05 12 04 | + 24 46 08 | 07 42 07 | + 25 36 44 |
| 2 | 18 00 37 | - 25 22 08 | 21 33 14 | - 19 36 23 | 22 08 29 | - 16 46 44 | 00 57 07 | + 02 04 49 | 02 57 22 | + 15 37 29 | 06 05 35 | + 26 13 12 | 08 37 32 | + 23 25 58 |
| 3 | 19 02 34 | - 25 42 55 | 22 23 57 | - 15 23 46 | 22 56 30 | - 12 07 40 | 01 40 07 | + 07 16 55 | 03 44 09 | + 19 40 14 | 07 00 33 | + 26 24 26 | 09 31 32 | + 20 00 57 |
| 4 | 20 02 46 | - 24 28 36 | 23 11 32 | - 10 36 09 | 23 42 07 | - 07 03 20 | 02 23 53 | + 12 12 13 | 04 33 19 | + 22 56 21 | 07 55 51 | + 25 15 54 | 10 23 45 | + 15 32 46 |
| 5 | 20 59 44 | - 21 52 18 | 23 56 40 | - 05 28 49 | 00 26 04 | - 01 47 09 | 03 09 06 | + 16 40 22 | 05 24 55 | + 25 14 11 | 08 50 27 | + 22 49 15 | 11 14 23 | + 10 15 12 |
| 6 | 21 52 48 | - 18 12 31 | 00 40 16 | - 00 14 21 | 01 09 14 | + 03 29 14 | 03 56 22 | + 20 30 37 | 06 18 34 | + 26 23 15 | 09 43 43 | + 19 11 05 | 12 04 05 | + 04 23 20 |
| 7 | 22 42 07 | - 13 48 14 | 01 23 17 | + 04 56 47 | 01 52 27 | + 08 35 29 | 04 46 05 | + 23 31 45 | 07 13 31 | + 26 15 57 | 10 35 30 | + 14 31 39 | 12 53 50 | - 01 46 45 |
| 8 | 23 28 23 | - 08 56 02 | 02 06 38 | + 09 55 23 | 02 36 33 | + 13 21 56 | 05 38 18 | + 25 32 26 | 08 08 46 | + 24 48 53 | 11 26 11 | + 09 03 26 | 13 44 43 | - 07 57 35 |
| 9 | 00 12 30 | - 03 49 13 | 02 51 14 | + 14 32 28 | 03 22 19 | + 17 38 46 | 06 32 39 | + 26 22 19 | 09 03 29 | + 22 03 29 | 12 16 32 | + 03 00 49 | 14 37 54 | - 13 49 22 |
| 10 | 00 55 29 | + 01 21 34 | 03 37 56 | + 18 38 12 | 04 10 23 | + 21 15 32 | 07 28 26 | + 25 53 25 | 09 57 09 | + 18 05 45 | 13 07 34 | - 03 19 39 | 15 34 18 | - 18 59 26 |
| 11 | 01 38 20 | + 06 27 20 | 04 27 24 | + 22 01 14 | 05 01 12 | + 24 00 42 | 08 24 40 | + 24 01 54 | 10 49 46 | + 13 05 29 | 14 00 27 | - 09 38 11 | 16 34 19 | - 23 03 17 |
| 12 | 02 22 02 | + 11 19 30 | 05 19 59 | + 24 28 33 | 05 54 47 | + 25 42 09 | 09 20 32 | + 20 49 03 | 11 41 45 | + 07 15 44 | 14 56 13 | - 15 31 10 | 17 37 24 | - 25 37 57 |
| 13 | 03 07 32 | + 15 48 38 | 06 15 33 | + 25 46 26 | 06 50 45 | + 26 08 24 | 10 15 31 | + 16 21 39 | 12 33 54 | + 00 52 58 | 15 55 35 | - 20 31 32 | 18 41 53 | - 26 27 53 |
| 14 | 03 55 36 | + 19 43 40 | 07 13 22 | + 25 42 48 | 07 48 10 | + 25 10 52 | 11 09 36 | + 10 51 44 | 13 27 13 | - 05 42 21 | 16 58 26 | - 24 11 57 | 19 45 26 | - 25 30 33 |
| 15 | 04 46 48 | + 22 51 25 | 08 12 10 | + 24 10 32 | 08 45 56 | + 22 46 16 | 12 03 12 | + 04 36 14 | 14 22 45 | - 12 05 26 | 18 03 30 | - 26 10 41 | 20 45 55 | - 22 57 16 |
| 16 | 05 41 12 | + 24 57 17 | 09 10 35 | + 21 10 11 | 09 43 04 | + 18 58 16 | 12 57 06 | - 02 03 20 | 15 21 17 | - 17 47 53 | 19 08 30 | - 26 18 28 | 21 42 11 | - 19 08 37 |
| 17 | 06 38 16 | + 25 47 18 | 10 07 36 | + 16 50 55 | 10 39 00 | + 13 57 48 | 13 52 12 | - 08 41 23 | 16 23 02 | - 22 20 36 | 20 11 02 | - 24 41 29 | 22 34 08 | - 14 27 45 |
| 18 | 07 36 51 | + 25 11 31 | 11 02 49 | + 11 29 04 | 11 33 45 | + 08 02 07 | 14 49 18 | - 14 49 46 | 17 27 11 | - 25 19 00 | 21 09 25 | - 21 37 58 | 23 22 24 | - 09 15 40 |
| 19 | 08 35 26 | + 23 07 16 | 11 56 27 | + 05 25 30 | 12 27 47 | + 01 33 14 | 15 48 53 | - 20 00 15 | 18 31 58 | - 26 29 17 | 22 03 12 | - 17 31 00 | 00 07 57 | - 03 49 18 |
| 20 | 09 32 43 | + 19 40 32 | 12 49 10 | - 00 56 53 | 13 21 52 | - 05 03 50 | 16 50 43 | - 23 48 22 | 19 35 04 | - 25 52 09 | 22 52 46 | - 12 42 29 | 00 51 52 | + 01 38 15 |
| 21 | 10 27 59 | + 15 04 43 | 13 41 53 | - 07 15 03 | 14 16 52 | - 11 22 54 | 17 53 40 | - 25 57 49 | 20 34 39 | - 23 41 09 | 23 39 04 | - 07 30 20 | 01 35 14 | + 06 56 33 |
| 22 | 11 21 13 | + 09 37 46 | 14 35 29 | - 13 06 50 | 15 13 29 | - 16 58 32 | 18 56 02 | - 26 23 44 | 21 29 49 | - 20 16 39 | 00 23 11 | - 02 08 22 | 02 19 03 | + 11 56 27 |
| 23 | 12 12 56 | + 03 39 22 | 15 30 45 | - 18 11 36 | 16 12 02 | - 21 28 05 | 19 56 01 | - 25 12 48 | 22 20 41 | - 15 59 44 | 01 06 14 | + 03 12 36 | 03 04 13 | + 16 28 53 |
| 24 | 13 04 02 | - 02 30 38 | 16 28 01 | - 22 10 49 | 17 12 12 | - 24 33 53 | 20 52 25 | - 22 39 56 | 23 07 58 | - 11 08 36 | 01 49 14 | + 08 23 20 | 03 51 30 | + 20 23 51 |
| 25 | 13 55 33 | - 08 32 44 | 17 27 01 | - 24 49 29 | 18 12 58 | - 26 05 42 | 21 44 53 | - 19 03 15 | 23 52 40 | - 05 57 48 | 02 33 10 | + 13 14 51 | 04 41 24 | + 23 30 06 |
| 26 | 14 48 29 | - 14 07 40 | 18 26 48 | - 25 58 13 | 19 12 55 | - 26 02 06 | 22 33 44 | - 14 40 23 | 00 35 49 | - 00 38 59 | 03 18 51 | + 17 37 26 | 05 34 01 | + 25 35 28 |
| 27 | 15 43 36 | - 18 56 02 | 19 25 59 | - 25 35 13 | 20 10 39 | - 24 30 12 | 23 19 41 | - 09 46 42 | 01 18 26 | + 04 37 59 | 04 06 56 | + 21 20 00 | 06 28 55 | + 26 28 32 |
| 28 | 16 41 14 | - 22 39 05 | 20 23 11 | - 23 46 42 | 21 05 14 | - 21 43 07 | 00 03 39 | - 04 35 05 | 02 01 29 | + 09 43 46 | 04 57 43 | + 24 10 19 | 07 25 08 | + 26 00 57 |
| 29 | 17 40 57 | - 25 00 32 | | | 21 56 27 | - 17 56 41 | 00 46 32 | + 00 43 18 | 02 45 47 | + 14 28 39 | 05 51 03 | + 25 56 04 | 08 21 25 | + 24 10 03 |
| 30 | 18 41 34 | - 25 50 01 | | | 22 44 32 | - 13 26 51 | 01 29 14 | + 05 58 16 | 03 32 03 | + 18 41 58 | 06 46 13 | + 26 26 51 | 09 16 40 | + 20 59 55 |
| 31 | 19 41 26 | - 25 06 00 | | | 23 30 09 | - 08 28 13 | | | 04 20 46 | + 22 11 54 | | | 10 10 12 | + 16 40 50 |

| | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 01 57 | + 11 27 18 | 14 12 02 | - 11 34 13 | 16 48 41 | - 24 25 54 | 20 38 10 | - 23 46 20 | 22 59 54 | - 11 44 20 |
| 2 | 11 52 24 | + 05 36 08 | 15 06 37 | - 17 05 49 | 17 51 02 | - 26 31 27 | 21 33 19 | - 20 05 34 | 23 46 01 | - 06 17 10 |
| 3 | 12 42 20 | - 00 34 53 | 16 03 51 | - 21 38 23 | 18 53 26 | - 26 53 43 | 22 24 18 | - 15 31 45 | 00 30 08 | - 00 43 00 |
| 4 | 13 32 47 | - 06 47 20 | 17 03 42 | - 24 52 16 | 19 54 03 | - 25 36 32 | 23 11 53 | - 10 23 25 | 01 13 24 | + 04 46 57 |
| 5 | 14 24 50 | - 12 41 57 | 18 05 20 | - 26 32 31 | 20 51 32 | - 22 52 43 | 23 57 02 | - 04 55 59 | 01 56 48 | + 10 02 48 |
| 6 | 15 19 28 | - 17 58 13 | 19 07 08 | - 26 32 22 | 21 45 16 | - 19 00 06 | 00 40 47 | + 00 37 38 | 02 41 15 | + 14 54 40 |
| 7 | 16 17 13 | - 22 14 37 | 20 07 20 | - 24 55 14 | 22 35 26 | - 14 17 32 | 01 24 06 | + 06 06 02 | 03 27 28 | + 19 12 08 |
| 8 | 17 17 59 | - 25 10 27 | 21 04 33 | - 21 53 37 | 23 22 41 | - 09 02 33 | 02 07 53 | + 11 18 30 | 04 15 54 | + 22 43 59 |
| 9 | 18 20 41 | - 26 29 42 | 21 58 09 | - 17 45 35 | 00 07 50 | - 03 30 35 | 02 52 54 | + 16 04 12 | 05 06 39 | + 25 18 49 |
| 10 | 19 23 24 | - 26 05 42 | 22 48 18 | - 12 50 43 | 00 51 50 | + 02 04 51 | 03 39 44 | + 20 12 04 | 05 59 21 | + 26 46 23 |
| 11 | 20 24 08 | - 24 03 44 | 23 35 35 | - 07 27 29 | 01 35 34 | + 07 31 38 | 04 28 44 | + 23 30 47 | 06 53 11 | + 26 59 24 |
| 12 | 21 21 26 | - 20 39 19 | 00 20 51 | - 01 52 00 | 02 19 51 | + 12 38 33 | 05 19 53 | + 25 49 35 | 07 47 06 | + 25 55 08 |
| 13 | 22 14 47 | - 16 13 17 | 01 05 00 | + 03 41 58 | 03 05 25 | + 17 14 45 | 06 12 43 | + 26 59 21 | 08 40 08 | + 23 35 59 |
| 14 | 23 04 29 | - 11 06 59 | 01 48 59 | + 09 02 39 | 03 52 49 | + 21 09 30 | 07 06 29 | + 26 54 06 | 09 31 39 | + 20 08 34 |
| 15 | 23 51 16 | - 05 39 13 | 02 33 36 | + 13 59 28 | 04 42 21 | + 24 12 09 | 08 00 14 | + 25 31 55 | 10 21 35 | + 15 42 22 |
| 16 | 00 36 07 | - 00 05 28 | 03 19 37 | + 18 22 21 | 05 33 59 | + 26 12 40 | 08 53 12 | + 22 55 09 | 11 10 18 | + 10 28 18 |
| 17 | 01 20 00 | + 05 21 52 | 04 07 37 | + 22 01 13 | 06 27 20 | + 27 02 25 | 09 44 56 | + 19 09 42 | 11 58 34 | + 04 38 17 |
| 18 | 02 03 55 | + 10 32 22 | 04 57 56 | + 24 45 41 | 07 21 39 | + 26 35 31 | 10 35 29 | + 14 24 09 | 12 47 23 | - 01 34 17 |
| 19 | 02 48 45 | + 15 16 35 | 05 50 33 | + 26 25 29 | 08 16 04 | + 24 49 44 | 11 25 22 | + 08 49 06 | 13 38 00 | - 07 53 17 |
| 20 | 03 35 18 | + 19 25 00 | 06 44 59 | + 26 51 31 | 09 09 52 | + 21 47 06 | 12 15 22 | + 02 37 35 | 14 31 38 | - 13 58 21 |
| 21 | 04 24 10 | + 22 47 22 | 07 40 26 | + 25 57 28 | 10 02 40 | + 17 33 39 | 13 06 33 | - 03 54 01 | 15 29 20 | - 19 23 56 |
| 22 | 05 15 38 | + 25 12 33 | 08 35 56 | + 23 41 27 | 10 54 33 | + 12 19 06 | 14 00 05 | - 10 24 40 | 16 31 34 | - 23 40 26 |
| 23 | 06 09 31 | + 26 29 24 | 09 30 41 | + 20 06 53 | 11 46 01 | + 06 16 49 | 14 57 02 | - 16 27 57 | 17 37 32 | - 26 19 14 |
| 24 | 07 05 10 | + 26 28 29 | 10 24 17 | + 15 22 29 | 12 37 50 | - 00 15 55 | 15 58 02 | - 21 33 18 | 18 45 05 | - 27 01 17 |
| 25 | 08 01 32 | + 25 04 22 | 11 16 49 | + 09 41 51 | 13 31 00 | - 06 57 28 | 17 02 44 | - 25 10 21 | 19 51 13 | - 25 44 55 |
| 26 | 08 57 28 | + 22 17 33 | 12 08 48 | + 03 22 39 | 14 26 31 | - 13 21 53 | 18 09 30 | - 26 56 30 | 20 53 28 | - 22 45 59 |
| 27 | 09 52 10 | + 18 15 03 | 13 01 02 | - 03 13 58 | 15 25 07 | - 19 00 17 | 19 15 42 | - 26 44 34 | 21 50 40 | - 18 30 30 |
| 28 | 10 45 19 | + 13 09 34 | 13 54 27 | - 09 44 13 | 16 26 57 | - 23 24 01 | 20 18 45 | - 24 44 34 | 22 43 01 | - 13 25 31 |
| 29 | 11 37 08 | + 07 17 54 | 14 49 55 | - 15 42 42 | 17 31 07 | - 26 09 51 | 21 17 08 | - 21 18 15 | 23 31 23 | - 07 53 56 |
| 30 | 12 28 14 | + 00 59 23 | 15 48 01 | - 20 44 08 | 18 35 48 | - 27 05 34 | 22 10 38 | - 16 50 41 | 00 16 59 | - 02 13 10 |
| 31 | 13 19 33 | - 05 25 11 | | | 19 38 45 | - 26 13 05 | | | 01 01 03 | + 03 23 44 |

### MOON PHASES (UT)

| Lunation | New Moon d | h:m | First Quarter d | h:m |
|---|---|---|---|---|
| 990 | Jan 02 | 20:23 | Jan 10 | 13:15 |
| 991 | Feb 01 | 10:48 | Feb 09 | 11:11 |
| 992 | Mar 03 | 02:35 | Mar 11 | 07:15 |
| 993 | Apr 01 | 19:19 | Apr 09 | 23:40 |
| 994 | May 01 | 12:15 | May 09 | 11:53 |
| 995 | May 31 | 04:20 | Jun 07 | 20:28 |
| 996 | Jun 29 | 18:39 | Jul 07 | 02:32 |
| 997 | Jul 29 | 06:53 | Aug 05 | 07:28 |
| 998 | Aug 27 | 17:26 | Sep 03 | 12:34 |
| 999 | Sep 26 | 03:09 | Oct 02 | 19:09 |
| 1000 | Oct 25 | 12:50 | Nov 01 | 04:25 |
| 1001 | Nov 23 | 22:59 | Nov 30 | 17:16 |
| 1002 | Dec 23 | 09:43 | Dec 30 | 10:03 |
| | Full Moon d | h:m | Last Quarter d | h:m |
| 990 | Jan 18 | 10:48 | Jan 25 | 08:33 |
| 991 | Feb 16 | 23:51 | Feb 23 | 16:46 |
| 992 | Mar 18 | 10:35 | Mar 25 | 01:51 |
| 993 | Apr 16 | 19:36 | Apr 23 | 12:18 |
| 994 | May 16 | 03:36 | May 23 | 00:31 |
| 995 | Jun 14 | 11:16 | Jun 21 | 14:45 |
| 996 | Jul 13 | 19:21 | Jul 21 | 07:01 |
| 997 | Aug 12 | 04:48 | Aug 20 | 00:48 |
| 998 | Sep 10 | 16:36 | Sep 18 | 19:03 |
| 999 | Oct 10 | 07:27 | Oct 18 | 12:31 |
| 1000 | Nov 09 | 01:13 | Nov 17 | 04:15 |
| 1001 | Dec 08 | 20:37 | Dec 16 | 17:42 |
| 1002 | | | | |

### MOON APOGEE AND PERIGEE (UT)

| APOGEE | d hh | | d hh | PERIGEE | d hh | | d hh |
|---|---|---|---|---|---|---|---|
| Jan | 11 01 | Jul | 22 20 | Jan | 23 22 | Aug | 6 14 |
| Feb | 7 22 | Aug | 19 14 | Feb | 19 16 | Aug | 31 19 |
| Mar | 7 17 | Sep | 16 09 | Mar | 19 19 | Sep | 28 06 |
| Apr | 4 04 | Oct | 14 02 | Apr | 17 05 | Oct | 26 12 |
| May | 1 08 | Nov | 10 12 | May | 15 16 | Nov | 23 23 |
| May | 28 13 | Dec | 7 12 | Jun | 12 23 | Dec | 22 12 |
| Jun | 25 02 | | | Jul | 10 22 | | |

# MERCURY

## RISE AND SET TIMES EST, Adelaide and Darwin CST, Perth WST

| | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | |
| Jan 4 | 06:23 | 20:23 | 06:11 | 19:40 | 06:10 | 20:11 | 07:35 | 20:13 | 05:59 | 20:38 | 06:21 | 20:34 | 06:30 | 20:17 | 06:05 | 20:00 | Jan 4 |
| 11 | 05:33 | 19:24 | 05:20 | 18:42 | 05:20 | 19:13 | 06:42 | 19:16 | 05:10 | 19:39 | 05:31 | 19:35 | 05:39 | 19:18 | 05:15 | 19:01 | 11 |
| 18 | 04:29 | 18:25 | 04:17 | 17:43 | 04:17 | 18:14 | 05:40 | 18:16 | 04:06 | 18:40 | 04:28 | 18:36 | 04:36 | 18:19 | 04:12 | 18:02 | 18 |
| 25 | 03:51 | 17:56 | 03:40 | 17:12 | 03:39 | 17:44 | 05:04 | 17:45 | 03:26 | 18:12 | 03:49 | 18:07 | 03:59 | 17:50 | 03:33 | 17:33 | 25 |
| Feb 1 | 03:38 | 17:49 | 03:27 | 17:05 | 03:25 | 17:38 | 04:53 | 17:37 | 03:12 | 18:07 | 03:35 | 18:01 | 03:46 | 17:43 | 03:20 | 17:26 | Feb 1 |
| 8 | 03:41 | 17:53 | 03:30 | 17:09 | 03:28 | 17:42 | 04:56 | 17:41 | 03:15 | 18:11 | 03:38 | 18:05 | 03:49 | 17:48 | 03:23 | 17:30 | 8 |
| 15 | 03:54 | 18:01 | 03:42 | 17:18 | 03:41 | 17:50 | 05:07 | 17:50 | 03:28 | 18:17 | 03:51 | 18:13 | 04:02 | 17:56 | 03:36 | 17:38 | 15 |
| 22 | 04:13 | 18:09 | 04:00 | 17:27 | 04:01 | 17:58 | 05:23 | 18:02 | 03:50 | 18:23 | 04:11 | 18:20 | 04:21 | 18:04 | 03:55 | 17:46 | 22 |
| Mar 1 | 04:38 | 18:16 | 04:23 | 17:36 | 04:26 | 18:04 | 05:42 | 18:16 | 04:18 | 18:27 | 04:38 | 18:25 | 04:45 | 18:12 | 04:20 | 17:53 | Mar 1 |
| 8 | 05:08 | 18:21 | 04:49 | 17:45 | 04:55 | 18:10 | 06:03 | 18:29 | 04:52 | 18:28 | 05:08 | 18:30 | 05:13 | 18:19 | 04:48 | 17:59 | 8 |
| 15 | 05:41 | 18:26 | 05:19 | 17:53 | 05:29 | 18:14 | 06:26 | 18:44 | 05:30 | 18:28 | 05:43 | 18:33 | 05:45 | 18:25 | 05:21 | 18:05 | 15 |
| 22 | 06:19 | 18:30 | 05:52 | 18:02 | 06:07 | 18:18 | 06:53 | 19:00 | 06:13 | 18:27 | 06:23 | 18:35 | 06:21 | 18:31 | 05:58 | 18:10 | 22 |
| 29 | 07:00 | 18:35 | 06:29 | 18:11 | 06:48 | 18:23 | 07:21 | 19:17 | 07:00 | 18:25 | 07:06 | 18:38 | 07:00 | 18:38 | 06:39 | 18:15 | 29 |
| Apr 5 | 07:41 | 18:39 | 07:05 | 18:20 | 07:29 | 18:26 | 07:49 | 19:34 | 07:47 | 18:23 | 07:49 | 18:39 | 07:39 | 18:43 | 07:19 | 18:19 | Apr 5 |
| 12 | 08:12 | 18:38 | 07:31 | 18:24 | 08:00 | 18:26 | 08:09 | 19:44 | 08:23 | 18:18 | 08:21 | 18:37 | 08:08 | 18:45 | 07:49 | 18:20 | 12 |
| 19 | 08:22 | 18:30 | 07:40 | 18:18 | 08:11 | 18:18 | 08:14 | 19:42 | 08:37 | 18:07 | 08:33 | 18:28 | 08:17 | 18:38 | 08:00 | 18:12 | 19 |
| 26 | 08:08 | 18:12 | 07:25 | 18:00 | 07:57 | 17:59 | 07:58 | 19:24 | 08:24 | 17:48 | 08:19 | 18:10 | 08:03 | 18:19 | 07:45 | 17:54 | 26 |
| May 3 | 07:30 | 17:44 | 06:49 | 17:30 | 07:19 | 17:31 | 07:24 | 18:52 | 07:44 | 17:22 | 07:41 | 17:43 | 07:25 | 17:51 | 07:07 | 17:26 | May 3 |
| 10 | 06:39 | 17:12 | 06:00 | 16:56 | 06:27 | 16:59 | 06:39 | 18:13 | 06:49 | 16:53 | 06:48 | 17:11 | 06:35 | 17:17 | 06:17 | 16:53 | 10 |
| 17 | 05:53 | 16:42 | 05:16 | 16:24 | 05:42 | 16:30 | 05:59 | 17:38 | 06:01 | 16:26 | 06:02 | 16:43 | 05:50 | 16:47 | 05:31 | 16:23 | 17 |
| 24 | 05:24 | 16:20 | 04:48 | 16:01 | 05:12 | 16:07 | 05:32 | 17:14 | 05:30 | 16:05 | 05:32 | 16:21 | 05:21 | 16:24 | 05:02 | 16:01 | 24 |
| 31 | 05:13 | 16:05 | 04:36 | 15:46 | 05:01 | 15:52 | 05:19 | 17:01 | 05:20 | 15:48 | 05:22 | 16:05 | 05:10 | 16:09 | 04:51 | 15:46 | 31 |
| Jun 7 | 05:18 | 15:57 | 04:39 | 15:40 | 05:06 | 15:44 | 05:20 | 16:58 | 05:27 | 15:38 | 05:27 | 15:56 | 05:15 | 16:03 | 04:56 | 15:38 | Jun 7 |
| 14 | 05:36 | 15:57 | 04:55 | 15:43 | 05:25 | 15:45 | 05:32 | 17:05 | 05:49 | 15:35 | 05:47 | 15:56 | 05:32 | 16:04 | 05:14 | 15:39 | 14 |
| 21 | 06:07 | 16:08 | 05:23 | 15:57 | 05:56 | 15:55 | 05:55 | 17:23 | 06:24 | 15:43 | 06:19 | 16:06 | 06:02 | 16:16 | 05:44 | 15:50 | 21 |
| 28 | 06:47 | 16:33 | 06:01 | 16:23 | 06:36 | 16:20 | 06:30 | 17:53 | 07:06 | 16:04 | 07:00 | 16:29 | 06:41 | 16:42 | 06:24 | 16:15 | 28 |
| Jul 5 | 07:28 | 17:10 | 06:41 | 17:01 | 07:16 | 16:57 | 07:09 | 18:31 | 07:48 | 16:41 | 07:40 | 17:06 | 07:21 | 17:20 | 07:04 | 16:52 | Jul 5 |
| 12 | 07:59 | 17:53 | 07:14 | 17:42 | 07:48 | 17:40 | 07:44 | 19:10 | 08:17 | 17:26 | 08:11 | 17:50 | 07:53 | 18:02 | 07:36 | 17:35 | 12 |
| 19 | 08:18 | 18:33 | 07:36 | 18:19 | 08:06 | 18:20 | 08:10 | 19:42 | 08:32 | 18:10 | 08:28 | 18:31 | 08:13 | 18:40 | 07:55 | 18:14 | 19 |
| 26 | 08:25 | 19:06 | 07:46 | 18:49 | 08:13 | 18:53 | 08:27 | 20:06 | 08:35 | 18:48 | 08:34 | 19:06 | 08:21 | 19:12 | 08:03 | 18:47 | 26 |
| Aug 2 | 08:24 | 19:31 | 07:49 | 19:11 | 08:12 | 19:19 | 08:35 | 20:22 | 08:29 | 19:18 | 08:32 | 19:33 | 08:22 | 19:36 | 08:02 | 19:12 | Aug 2 |
| 9 | 08:16 | 19:49 | 07:45 | 19:25 | 08:05 | 19:37 | 08:36 | 20:31 | 08:17 | 19:39 | 08:23 | 19:52 | 08:16 | 19:52 | 07:55 | 19:29 | 9 |
| 16 | 08:03 | 19:57 | 07:34 | 19:31 | 07:51 | 19:45 | 08:31 | 20:31 | 08:00 | 19:51 | 08:08 | 20:01 | 08:03 | 19:59 | 07:42 | 19:37 | 16 |
| 23 | 07:43 | 19:53 | 07:16 | 19:25 | 07:31 | 19:41 | 08:16 | 20:22 | 07:38 | 19:50 | 07:47 | 19:58 | 07:44 | 19:54 | 07:23 | 19:33 | 23 |
| 30 | 07:15 | 19:31 | 06:49 | 19:02 | 07:03 | 19:19 | 07:51 | 19:57 | 07:08 | 19:30 | 07:19 | 19:37 | 07:17 | 19:31 | 06:55 | 19:11 | 30 |
| Sep 6 | 06:38 | 18:46 | 06:12 | 18:18 | 06:26 | 18:34 | 07:12 | 19:15 | 06:33 | 18:43 | 06:42 | 18:51 | 06:39 | 18:46 | 06:18 | 18:26 | Sep 6 |
| 13 | 05:59 | 17:45 | 05:30 | 17:20 | 05:47 | 17:34 | 06:25 | 18:22 | 05:57 | 17:39 | 06:04 | 17:49 | 05:59 | 17:47 | 05:38 | 17:26 | 13 |
| 20 | 05:30 | 16:59 | 04:58 | 16:36 | 05:18 | 16:47 | 05:50 | 17:41 | 05:31 | 16:49 | 05:36 | 17:01 | 05:29 | 17:01 | 05:09 | 16:39 | 20 |
| 27 | 05:19 | 16:47 | 04:47 | 16:24 | 05:07 | 16:35 | 05:37 | 17:31 | 05:20 | 16:37 | 05:25 | 16:50 | 05:18 | 16:50 | 04:58 | 16:27 | 27 |
| Oct 4 | 05:18 | 17:04 | 04:48 | 16:39 | 05:06 | 16:52 | 05:43 | 17:42 | 05:17 | 16:57 | 05:24 | 17:08 | 05:19 | 17:07 | 04:58 | 16:44 | Oct 4 |
| 11 | 05:21 | 17:34 | 04:54 | 17:05 | 05:09 | 17:22 | 05:54 | 18:02 | 05:16 | 17:31 | 05:25 | 17:39 | 05:23 | 17:35 | 05:01 | 17:13 | 11 |
| 18 | 05:23 | 18:05 | 05:00 | 17:33 | 05:11 | 17:53 | 06:07 | 18:23 | 05:13 | 18:07 | 05:26 | 18:12 | 05:26 | 18:04 | 05:03 | 17:44 | 18 |
| 25 | 05:25 | 18:36 | 05:06 | 17:59 | 05:13 | 18:24 | 06:18 | 18:44 | 05:10 | 18:42 | 05:26 | 18:44 | 05:30 | 18:33 | 05:06 | 18:14 | 25 |
| Nov 1 | 05:27 | 19:05 | 05:11 | 18:25 | 05:15 | 18:53 | 06:30 | 19:04 | 05:08 | 19:16 | 05:27 | 19:15 | 05:33 | 19:01 | 05:08 | 18:43 | Nov 1 |
| 8 | 05:31 | 19:33 | 05:18 | 18:50 | 05:18 | 19:22 | 06:42 | 19:24 | 05:07 | 19:49 | 05:29 | 19:44 | 05:39 | 19:28 | 05:13 | 19:10 | 8 |
| 15 | 05:37 | 20:00 | 05:28 | 19:14 | 05:25 | 19:49 | 06:56 | 19:44 | 05:10 | 20:19 | 05:34 | 20:13 | 05:46 | 19:54 | 05:20 | 19:37 | 15 |
| 22 | 05:47 | 20:25 | 05:39 | 19:37 | 05:34 | 20:14 | 07:11 | 20:03 | 05:16 | 20:47 | 05:43 | 20:38 | 05:57 | 20:18 | 05:29 | 20:01 | 22 |
| 29 | 06:00 | 20:45 | 05:53 | 19:57 | 05:47 | 20:34 | 07:26 | 20:21 | 05:27 | 21:09 | 05:55 | 20:59 | 06:10 | 20:38 | 05:42 | 20:21 | 29 |
| Dec 6 | 06:13 | 20:58 | 06:07 | 20:09 | 06:00 | 20:47 | 07:40 | 20:34 | 05:41 | 21:21 | 06:08 | 21:12 | 06:24 | 20:50 | 05:56 | 20:34 | Dec 6 |
| 13 | 06:20 | 20:55 | 06:13 | 20:08 | 06:08 | 20:44 | 07:44 | 20:34 | 05:50 | 21:17 | 06:16 | 21:08 | 06:30 | 20:48 | 06:03 | 20:32 | 13 |
| 20 | 06:04 | 20:23 | 05:55 | 19:38 | 05:52 | 20:12 | 07:23 | 20:07 | 05:37 | 20:43 | 06:01 | 20:36 | 06:13 | 20:16 | 05:47 | 20:00 | 20 |
| 27 | 05:12 | 19:17 | 05:02 | 18:34 | 05:00 | 19:06 | 06:27 | 19:05 | 04:47 | 19:35 | 05:10 | 19:29 | 05:20 | 19:11 | 04:55 | 18:55 | 27 |

# TRANSIT OF MERCURY 7th May 2003

From the Earth's position in the Solar System, only the inner (inferior) planets, Mercury and Venus, can ever pass across the face of the Sun. This event only occurs when the inner planet is at inferior conjunction (between the Earth and the Sun), and when the planetary orbits line up at just the right place and time.

Mercury transits the Sun on the 7th May 2003, the first time since 1999. Transits of Mercury occur on average thirteen or fourteen times each century (fourteen this current century), at intervals of about three, seven, ten or thirteen years (see table 1). The Venus transits are even rarer than those of Mercury. They occur in pairs separated eight years apart at intervals of more than a century (see table 2). Since the invention of the telescope, only six Venusian transits have been observed; the next in 2004 is eagerly awaited – 121.5 years since the last.

Observers can see the entire transit of Mercury from most of Europe, Africa and Asia. Japan, Australia and New Zealand will see the beginning, with the Sun setting before the completion of the transit (see diagram 3). Western Africa, eastern North America and eastern South America will only witness the end of the transit after sunrise.

Transits of Mercury (or Venus) are only possible when the planet crosses the ecliptic, or the nodes of its orbit (the intersection points of a planet's orbit with the plane of the Earth's orbit) at inferior conjunction (Diagram 1). Because of Mercury's 7° orbital inclination

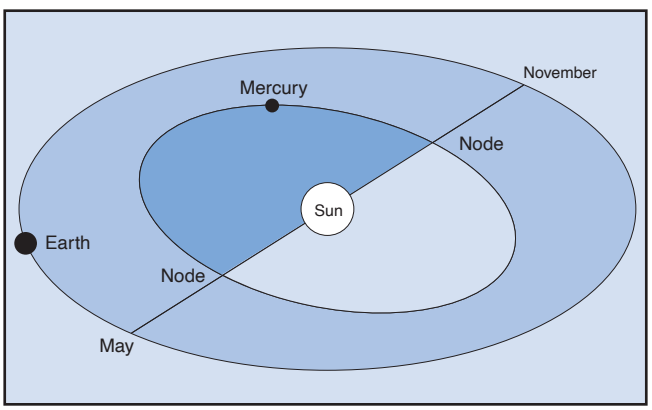



*DIAGRAM 1. A transit of Mercury is only possible if inferior conjunction occurs when the planet is at one of the nodes of its orbit. Mercury crosses the nodes only in May and November.*

to the plane of the ecliptic, (Diagram 2) transits are not frequent, as the planet usually passes above or below the Sun, as seen from Earth. The innermost planet's large orbital tilt is only exceeded by the furthermost planet, Pluto with an inclination of 17°. Transits of Mercury always occur in May or November, with November transits being about twice as frequent as those in May.

The progress of the transit may be monitored with a telescope using normal safe solar observing techniques and a magnification of between about 60 to 100x. The two most widely used and recommended methods for viewing are the projection method, or by use of a full aperture filter that reduces most of the light before it enters the telescope (do not forget to cover the objective of the finder scope, to prevent any nasty burns). Warning! Do not risk blindness, the Sun is an intense radiator of infrared and ultraviolet radiation and will cause permanent eye damage. Under no circumstances should any other type of device be used, particularly tinted glass eyepiece filters, or smoked glass etc. We would strongly recommend that anyone wishing to see the event, with no previous solar observing experience, observe the event with experienced amateurs more familiar with this field.

Table 1. TRANSITS of MERCURY from 2001 to 2100

Note the frequency of the November transits

| | | |
|---|---|---|
| 2003 | 7th | May |
| 2006 | 8th | November |
| 2016 | 9th | May |
| 2019 | 11th | November |
| 2032 | 13th | November |
| 2039 | 7th | November |
| 2049 | 7th | May |
| 2052 | 9th | November |
| 2062 | 10th | May |
| 2065 | 11th | November |
| 2078 | 14th | November |
| 2085 | 7th | November |
| 2095 | 8th | May |
| 2098 | 10th | November |

Unfortunately, the time of this transit is late in the day for all but Western Australia, and the atmosphere may not be steady. Poor seeing can be reduced by avoiding viewing over nearby buildings and large concrete areas. Minimise internal currents within the telescope by preventing direct sunlight from falling on the tube (a cardboard shield near the top end works fine), and give the telescope time to reach ambient temperature if it was stored indoors. If you are mobile, find a location looking over a large body of water or an expanse of grass. These areas tend to have steadier seeing.

What can an observer expect to see at this transit? All of Australia will see the beginning of the transit, but the Sun will set for much of the eastern states before mid-transit. From Adelaide and Hobart, the Sun sets just on mid-transit. From Darwin and Perth, observers will see the event beyond mid-transit but the Sun will set before the end of the transit. Like an annular solar eclipse there are certain events, or contacts, that will occur in the course of a transit as follows (see diagram 4). Local times of contact are shown in Table 3.

| | |
|---|---|
| Contact 1 (ingress) | When the planet makes first exterior contact with the limb. |
| Contact 2 (ingress) | Interior contact when the entire disc of the planet can be seen. |
| Greatest transit | When the planet is at its least angular distance from the Sun's centre |
| Contact 3 (egress) | Interior contact when the entire disc is still visible. |
| Contact 4 (egress) | When the planet makes last exterior contact with the limb. |

In reality contacts 1 and 4 are not visible in normal white light, but may be visible in Hydrogen-alpha light if the planet is silhouetted against a prominence. For a short time before contact 2, the 'black drop effect' (diagram 5) can be seen, and looks like a trail or drop joining the planet to the Sun's limb. When the drop breaks, sunlight will be seen surrounding the planet and this is the true instant of contact 2; contact 3 occurs in precisely the opposite order.

The next transit of Mercury occurs in 3.5 years. It is a little better suited for Australia with the eastern states seeing the entire event with ingress very close to sunrise. From central and Western Australia the Sun rises after the start of the transit.

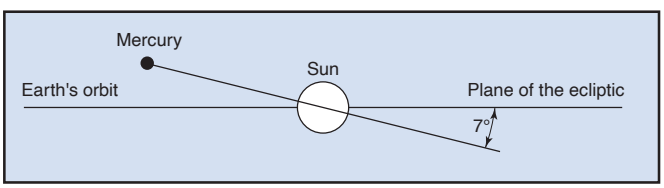



*DIAGRAM 2. Mercury's orbital tilt to the plane of the ecliptic. Transits are not very frequent as the planet generally passes above or below the Sun, when at inferior conjunction.*

Table 2. TRANSITS of VENUS from 1801 to 2300

The rare transits of Venus are separated by 8, 121.5, 8 and 105.5 years

| | | |
|---|---|---|
| 1874 | 9th | December |
| 1882 | 6th | December |
| 2004 | 8th | June |
| 2012 | 6th | June |
| 2117 | 11th | December |
| 2125 | 8th | December |
| 2247 | 11th | June |
| 2255 | 9th | June |

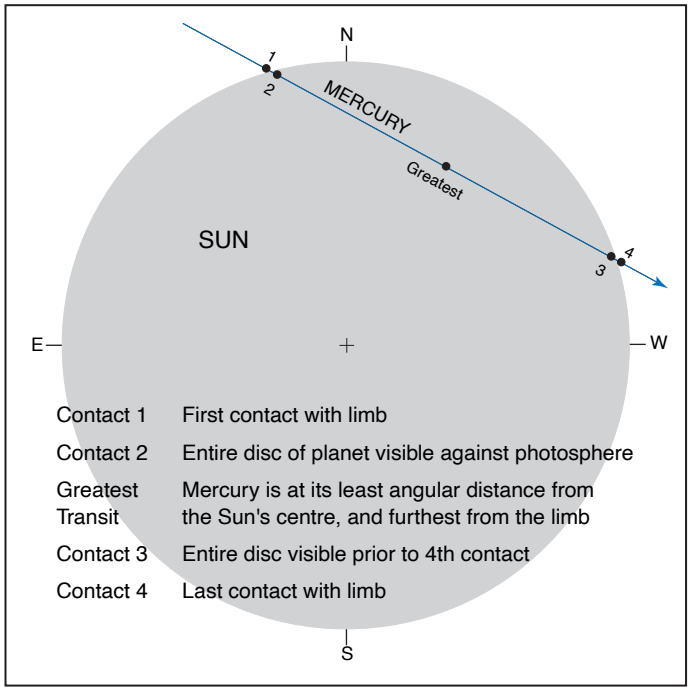



*DIAGRAM 4. Path and events of Mercury's transit on 7th May 2003. At best Australian observers will witness the event just beyond 'Greatest Transit' from the west, contacts 3 and 4 will not be visible as the Sun will be below the horizon.*

Table 3. LOCAL TIME of TRANSIT from CAPITAL CITIES

| Location | Time Zone | Ingress Exterior (Contact 1) | Ingress Interior (Contact 2) |
|---|---|---|---|
| Adelaide | CST | 2.44 pm | 2.49 pm |
| Brisbane | EST | 3.14 pm | 3.19 pm |
| Canberra | EST | 3.14 pm | 3.19 pm |
| Darwin | CST | 2.44 pm | 2.48 pm |
| Hobart | EST | 3.15 pm | 3.19 pm |
| Melbourne | EST | 3.14 pm | 3.19 pm |
| Perth | WST | 1.15 pm | 1.19 pm |
| Sydney | EST | 3.14 pm | 3.19 pm |

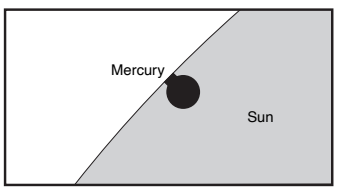



*DIAGRAM 5. The black drop effect.*

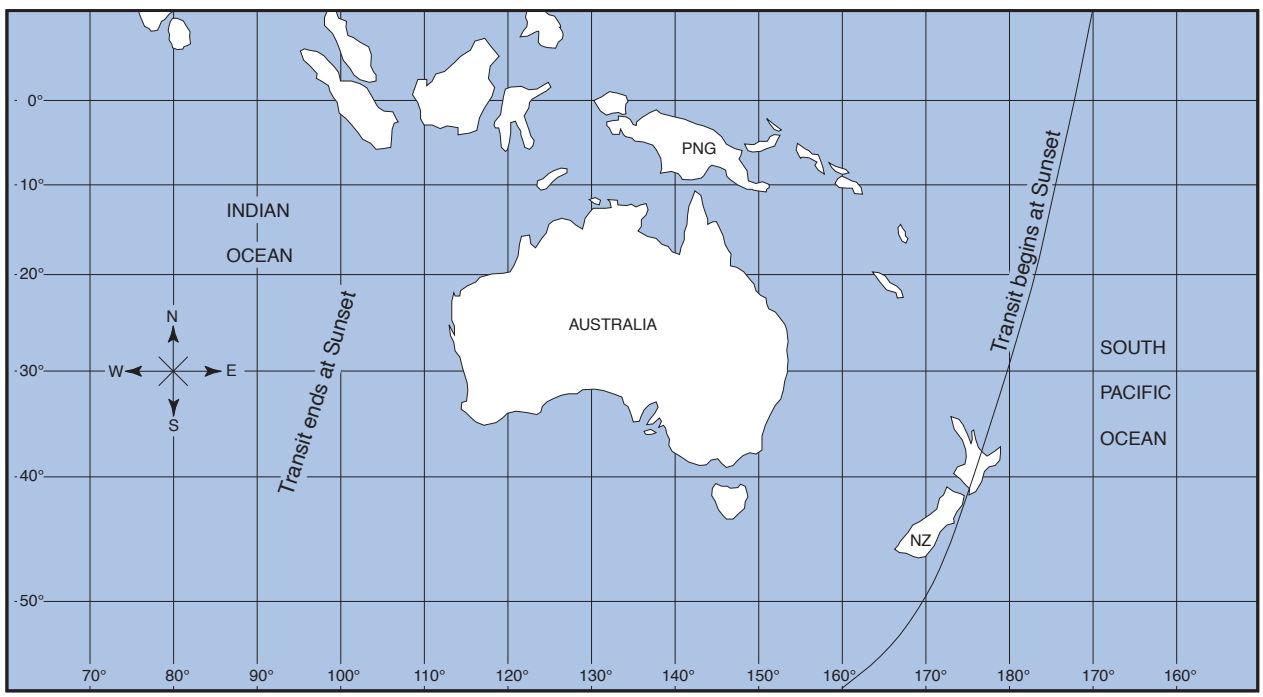



*DIAGRAM 3. Observers throughout Australia, most of New Zealand, Papua New Guinea and parts of Indonesia will witness a transit of Mercury. The further west of the 'Transit begins at Sunset' line the more will be seen of the transit before Sunset. Only observers west of the 'Transit ends at Sunset' can see the entire event.*

# MERCURY

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " |
| 1 | 20 01 10 | - 20 43 45 | 19 11 12 | - 21 05 31 | 21 45 12 | - 15 40 20 | 01 17 43 | + 08 28 05 | 03 06 40 | + 19 24 17 | 02 58 43 | + 13 07 32 |
| 2 | 20 01 53 | - 20 24 45 | 19 15 01 | - 21 09 25 | 21 51 33 | - 15 10 27 | 01 24 52 | + 09 23 02 | 03 05 17 | + 19 04 49 | 03 02 01 | + 13 23 58 |
| 3 | 20 01 50 | - 20 06 58 | 19 19 06 | - 21 12 24 | 21 57 56 | - 14 39 17 | 01 31 56 | + 10 16 57 | 03 03 40 | + 18 43 21 | 03 05 32 | + 13 41 55 |
| 4 | 20 00 59 | - 19 50 41 | 19 23 22 | - 21 14 25 | 22 04 21 | - 14 06 50 | 01 38 54 | + 11 09 37 | 03 01 52 | + 18 20 07 | 03 09 17 | + 14 01 15 |
| 5 | 19 59 19 | - 19 36 08 | 19 27 51 | - 21 15 25 | 22 10 47 | - 13 33 05 | 01 45 46 | + 12 00 49 | 02 59 55 | + 17 55 22 | 03 13 15 | + 14 21 53 |
| 6 | 19 56 49 | - 19 23 33 | 19 32 30 | - 21 15 22 | 22 17 15 | - 12 58 03 | 01 52 29 | + 12 50 19 | 02 57 52 | + 17 29 26 | 03 17 26 | + 14 43 42 |
| 7 | 19 53 32 | - 19 13 03 | 19 37 19 | - 21 14 14 | 22 23 46 | - 12 21 45 | 01 59 02 | + 13 37 56 | 02 55 45 | + 17 02 37 | 03 21 51 | + 15 06 37 |
| 8 | 19 49 31 | - 19 04 42 | 19 42 17 | - 21 11 59 | 22 30 17 | - 11 44 10 | 02 05 25 | + 14 23 28 | 02 53 37 | + 16 35 17 | 03 26 29 | + 15 30 30 |
| 9 | 19 44 53 | - 18 58 30 | 19 47 23 | - 21 08 35 | 22 36 51 | - 11 05 20 | 02 11 35 | + 15 06 45 | 02 51 30 | + 16 07 47 | 03 31 20 | + 15 55 16 |
| 10 | 19 39 44 | - 18 54 24 | 19 52 36 | - 21 04 01 | 22 43 27 | - 10 25 14 | 02 17 31 | + 15 47 39 | 02 49 26 | + 15 40 27 | 03 36 24 | + 16 20 49 |
| 11 | 19 34 15 | - 18 52 16 | 19 57 55 | - 20 58 17 | 22 50 05 | - 09 43 53 | 02 23 13 | + 16 26 03 | 02 47 28 | + 15 13 39 | 03 41 42 | + 16 47 01 |
| 12 | 19 28 35 | - 18 51 57 | 20 03 21 | - 20 51 20 | 22 56 45 | - 09 01 18 | 02 28 38 | + 17 01 49 | 02 45 37 | + 14 47 42 | 03 47 12 | + 17 13 45 |
| 13 | 19 22 56 | - 18 53 16 | 20 08 52 | - 20 43 11 | 23 03 27 | - 08 17 29 | 02 33 47 | + 17 34 55 | 02 43 56 | + 14 22 56 | 03 52 57 | + 17 40 55 |
| 14 | 19 17 28 | - 18 56 02 | 20 14 28 | - 20 33 47 | 23 10 11 | - 07 32 28 | 02 38 37 | + 18 05 15 | 02 42 26 | + 13 59 35 | 03 58 55 | + 18 08 24 |
| 15 | 19 12 18 | - 19 00 05 | 20 20 09 | - 20 23 09 | 23 16 58 | - 06 46 16 | 02 43 09 | + 18 32 46 | 02 41 09 | + 13 37 57 | 04 05 06 | + 18 36 02 |
| 16 | 19 07 37 | - 19 05 16 | 20 25 54 | - 20 11 16 | 23 23 47 | - 05 58 53 | 02 47 20 | + 18 57 27 | 02 40 06 | + 13 18 12 | 04 11 32 | + 19 03 43 |
| 17 | 19 03 28 | - 19 11 24 | 20 31 43 | - 19 58 07 | 23 30 38 | - 05 10 23 | 02 51 12 | + 19 19 16 | 02 39 17 | + 13 00 31 | 04 18 12 | + 19 31 18 |
| 18 | 18 59 56 | - 19 18 20 | 20 37 36 | - 19 43 43 | 23 37 33 | - 04 20 46 | 02 54 42 | + 19 38 12 | 02 38 43 | + 12 45 02 | 04 25 06 | + 19 58 37 |
| 19 | 18 57 04 | - 19 25 57 | 20 43 32 | - 19 28 02 | 23 44 29 | - 03 30 05 | 02 57 50 | + 19 54 14 | 02 38 26 | + 12 31 51 | 04 32 14 | + 20 25 31 |
| 20 | 18 54 52 | - 19 34 05 | 20 49 31 | - 19 11 04 | 23 51 29 | - 02 38 23 | 03 00 36 | + 20 07 22 | 02 38 24 | + 12 21 01 | 04 39 36 | + 20 51 50 |
| 21 | 18 53 20 | - 19 42 37 | 20 55 33 | - 18 52 49 | 23 58 30 | - 01 45 44 | 03 03 00 | + 20 17 36 | 02 38 39 | + 12 12 35 | 04 47 13 | + 21 17 24 |
| 22 | 18 52 27 | - 19 51 23 | 21 01 37 | - 18 33 17 | 00 05 35 | - 00 52 11 | 03 05 01 | + 20 24 55 | 02 39 10 | + 12 06 34 | 04 55 04 | + 21 42 00 |
| 23 | 18 52 11 | - 20 00 15 | 21 07 44 | - 18 12 27 | 00 12 42 | + 00 02 11 | 03 06 39 | + 20 29 20 | 02 39 57 | + 12 02 55 | 05 03 08 | + 22 05 28 |
| 24 | 18 52 30 | - 20 09 06 | 21 13 54 | - 17 50 20 | 00 19 51 | + 00 57 17 | 03 07 54 | + 20 30 52 | 02 41 01 | + 12 01 37 | 05 11 26 | + 22 27 35 |
| 25 | 18 53 21 | - 20 17 48 | 21 20 05 | - 17 26 56 | 00 27 02 | + 01 53 00 | 03 08 46 | + 20 29 31 | 02 42 21 | + 12 02 38 | 05 19 57 | + 22 48 10 |
| 26 | 18 54 42 | - 20 26 13 | 21 26 19 | - 17 02 13 | 00 34 16 | + 02 49 12 | 03 09 16 | + 20 25 21 | 02 43 56 | + 12 05 52 | 05 28 39 | + 23 07 01 |
| 27 | 18 56 31 | - 20 34 16 | 21 32 35 | - 16 36 13 | 00 41 30 | + 03 45 46 | 03 09 24 | + 20 18 24 | 02 45 47 | + 12 11 15 | 05 37 33 | + 23 23 55 |
| 28 | 18 58 45 | - 20 41 50 | 21 38 52 | - 16 08 56 | 00 48 46 | + 04 42 33 | 03 09 12 | + 20 08 42 | 02 47 53 | + 12 18 44 | 05 46 37 | + 23 38 43 |
| 29 | 19 01 22 | - 20 48 49 | | | 00 56 01 | + 05 39 22 | 03 08 39 | + 19 56 23 | 02 50 14 | + 12 28 11 | 05 55 50 | + 23 51 12 |
| 30 | 19 04 20 | - 20 55 09 | | | 01 03 17 | + 06 36 02 | 03 07 48 | + 19 41 32 | 02 52 49 | + 12 39 32 | 06 05 11 | + 24 01 15 |
| 31 | 19 07 37 | - 21 00 44 | | | 01 10 31 | + 07 32 20 | | | 02 55 39 | + 12 52 41 | | |

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 06 14 37 | + 24 08 43 | 10 16 48 | + 11 09 08 | 11 37 17 | - 02 17 23 | 11 27 25 | + 05 16 41 | 14 39 09 | - 15 37 56 | 17 48 30 | - 25 50 16 |
| 2 | 06 24 08 | + 24 13 30 | 10 22 04 | + 10 30 01 | 11 35 46 | - 02 10 27 | 11 32 52 | + 04 48 03 | 14 45 22 | - 16 13 21 | 17 54 30 | - 25 51 19 |
| 3 | 06 33 41 | + 24 15 31 | 10 27 11 | + 09 51 02 | 11 33 54 | - 01 59 48 | 11 38 30 | + 04 16 40 | 14 51 34 | - 16 47 56 | 18 00 23 | - 25 50 57 |
| 4 | 06 43 15 | + 24 14 45 | 10 32 10 | + 09 12 13 | 11 31 43 | - 01 45 25 | 11 44 20 | + 03 42 50 | 14 57 47 | - 17 21 40 | 18 06 09 | - 25 49 09 |
| 5 | 06 52 48 | + 24 11 10 | 10 37 00 | + 08 33 38 | 11 29 13 | - 01 27 16 | 11 50 17 | + 03 06 52 | 15 04 01 | - 17 54 31 | 18 11 46 | - 25 45 57 |
| 6 | 07 02 19 | + 24 04 49 | 10 41 41 | + 07 55 21 | 11 26 27 | - 01 05 26 | 11 56 22 | + 02 29 03 | 15 10 15 | - 18 26 29 | 18 17 13 | - 25 41 22 |
| 7 | 07 11 46 | + 23 55 43 | 10 46 13 | + 07 17 27 | 11 23 27 | - 00 40 07 | 12 02 32 | + 01 49 39 | 15 16 30 | - 18 57 31 | 18 22 27 | - 25 35 25 |
| 8 | 07 21 07 | + 23 43 58 | 10 50 37 | + 06 39 58 | 11 20 16 | - 00 11 34 | 12 08 46 | + 01 08 55 | 15 22 46 | - 19 27 37 | 18 27 27 | - 25 28 09 |
| 9 | 07 30 22 | + 23 29 39 | 10 54 51 | + 06 02 59 | 11 16 58 | + 00 19 51 | 12 15 03 | + 00 27 05 | 15 29 02 | - 19 56 45 | 18 32 10 | - 25 19 36 |
| 10 | 07 39 29 | + 23 12 54 | 10 58 57 | + 05 26 33 | 11 13 35 | + 00 53 37 | 12 21 22 | - 00 15 37 | 15 35 20 | - 20 24 55 | 18 36 35 | - 25 09 49 |
| 11 | 07 48 27 | + 22 53 49 | 11 02 53 | + 04 50 46 | 11 10 14 | + 01 29 12 | 12 27 42 | - 00 59 01 | 15 41 38 | - 20 52 04 | 18 40 39 | - 24 58 54 |
| 12 | 07 57 16 | + 22 32 33 | 11 06 40 | + 04 15 41 | 11 06 58 | + 02 05 55 | 12 34 03 | - 01 42 56 | 15 47 57 | - 21 18 12 | 18 44 18 | - 24 46 55 |
| 13 | 08 05 55 | + 22 09 15 | 11 10 17 | + 03 41 23 | 11 03 53 | + 02 43 03 | 12 40 24 | - 02 27 13 | 15 54 18 | - 21 43 17 | 18 47 30 | - 24 33 57 |
| 14 | 08 14 23 | + 21 44 04 | 11 13 45 | + 03 07 56 | 11 01 03 | + 03 19 53 | 12 46 45 | - 03 11 42 | 16 00 39 | - 22 07 19 | 18 50 11 | - 24 20 09 |
| 15 | 08 22 41 | + 21 17 07 | 11 17 01 | + 02 35 26 | 10 58 33 | + 03 55 38 | 12 53 06 | - 03 56 18 | 16 07 01 | - 22 30 14 | 18 52 18 | - 24 05 36 |
| 16 | 08 30 48 | + 20 48 34 | 11 20 08 | + 02 03 58 | 10 56 26 | + 04 29 38 | 12 59 26 | - 04 40 53 | 16 13 23 | - 22 52 03 | 18 53 46 | - 23 50 27 |
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| 19 | 08 54 02 | + 19 14 36 | 11 28 17 | + 00 36 44 | 10 53 03 | + 05 54 42 | 13 18 20 | - 06 53 39 | 16 32 35 | - 23 50 36 | 18 53 46 | - 23 02 47 |
| 20 | 09 01 25 | + 18 40 57 | 11 30 36 | + 00 10 25 | 10 53 02 | + 06 15 45 | 13 24 37 | - 07 37 19 | 16 39 00 | - 24 07 44 | 18 52 10 | - 22 46 37 |
| 21 | 09 08 37 | + 18 06 19 | 11 32 40 | - 00 14 19 | 10 53 35 | + 06 32 33 | 13 30 52 | - 08 20 35 | 16 45 25 | - 24 23 38 | 18 49 43 | - 22 30 29 |
| 22 | 09 15 39 | + 17 30 50 | 11 34 31 | - 00 37 21 | 10 54 43 | + 06 44 53 | 13 37 07 | - 09 03 24 | 16 51 50 | - 24 38 17 | 18 46 26 | - 22 14 33 |
| 23 | 09 22 30 | + 16 54 35 | 11 36 07 | - 00 58 31 | 10 56 27 | + 06 52 36 | 13 43 21 | - 09 45 43 | 16 58 15 | - 24 51 39 | 18 42 24 | - 21 58 53 |
| 24 | 09 29 10 | + 16 17 41 | 11 37 28 | - 01 17 41 | 10 58 43 | + 06 55 41 | 13 49 34 | - 10 27 30 | 17 04 39 | - 25 03 44 | 18 37 40 | - 21 43 38 |
| 25 | 09 35 41 | + 15 40 13 | 11 38 32 | - 01 34 40 | 11 01 31 | + 06 54 08 | 13 55 47 | - 11 08 41 | 17 11 02 | - 25 14 29 | 18 32 23 | - 21 28 54 |
| 26 | 09 42 02 | + 15 02 17 | 11 39 18 | - 01 49 18 | 11 04 50 | + 06 48 04 | 14 01 59 | - 11 49 15 | 17 17 23 | - 25 23 54 | 18 26 43 | - 21 14 53 |
| 27 | 09 48 13 | + 14 23 57 | 11 39 47 | - 02 01 24 | 11 08 36 | + 06 37 37 | 14 08 11 | - 12 29 10 | 17 23 43 | - 25 31 58 | 18 20 51 | - 21 01 45 |
| 28 | 09 54 14 | + 13 45 19 | 11 39 57 | - 02 10 47 | 11 12 47 | + 06 23 01 | 14 14 23 | - 13 08 24 | 17 30 00 | - 25 38 38 | 18 14 57 | - 20 49 46 |
| 29 | 10 00 06 | + 13 06 26 | 11 39 48 | - 02 17 15 | 11 17 21 | + 06 04 28 | 14 20 34 | - 13 46 55 | 17 36 14 | - 25 43 56 | 18 09 14 | - 20 39 08 |
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| 31 | 10 11 23 | + 11 48 17 | 11 38 28 | - 02 20 44 | | | 14 32 58 | - 15 01 43 | | | 17 59 00 | - 20 22 56 |

# VENUS

## RISE AND SET TIMES EST, Adelaide and Darwin CST, Perth WST

| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | | |
| Jan | 4 | 02:14 | 15:52 | 01:59 | 15:12 | 02:02 | 15:41 | 03:18 | 15:51 | 01:55 | 16:03 | 02:14 | 16:02 | 02:21 | 15:48 | 01:56 | 15:30 | Jan | 4 |
| | 11 | 02:10 | 15:58 | 01:56 | 15:17 | 01:58 | 15:46 | 03:17 | 15:53 | 01:49 | 16:10 | 02:09 | 16:08 | 02:17 | 15:53 | 01:52 | 15:35 | | 11 |
| | 18 | 02:08 | 16:04 | 01:55 | 15:22 | 01:56 | 15:53 | 03:18 | 15:57 | 01:45 | 16:19 | 02:07 | 16:15 | 02:16 | 15:59 | 01:50 | 15:42 | | 18 |
| | 25 | 02:09 | 16:12 | 01:56 | 15:29 | 01:56 | 16:01 | 03:21 | 16:02 | 01:44 | 16:28 | 02:06 | 16:23 | 02:16 | 16:07 | 01:50 | 15:49 | | 25 |
| Feb | 1 | 02:11 | 16:20 | 02:00 | 15:36 | 01:58 | 16:08 | 03:25 | 16:08 | 01:46 | 16:36 | 02:08 | 16:31 | 02:19 | 16:14 | 01:53 | 15:57 | Feb | 1 |
| | 8 | 02:16 | 16:27 | 02:05 | 15:43 | 02:03 | 16:16 | 03:31 | 16:15 | 01:50 | 16:44 | 02:13 | 16:39 | 02:24 | 16:21 | 01:58 | 16:04 | | 8 |
| | 15 | 02:22 | 16:34 | 02:11 | 15:50 | 02:10 | 16:22 | 03:37 | 16:21 | 01:57 | 16:51 | 02:20 | 16:46 | 02:31 | 16:28 | 02:04 | 16:11 | | 15 |
| | 22 | 02:31 | 16:39 | 02:20 | 15:56 | 02:18 | 16:28 | 03:45 | 16:28 | 02:06 | 16:56 | 02:29 | 16:51 | 02:39 | 16:34 | 02:13 | 16:16 | | 22 |
| Mar | 1 | 02:41 | 16:43 | 02:29 | 16:00 | 02:29 | 16:32 | 03:53 | 16:34 | 02:17 | 16:58 | 02:39 | 16:54 | 02:49 | 16:38 | 02:23 | 16:20 | Mar | 1 |
| | 8 | 02:53 | 16:45 | 02:39 | 16:04 | 02:40 | 16:34 | 04:01 | 16:39 | 02:30 | 16:59 | 02:51 | 16:56 | 03:00 | 16:40 | 02:34 | 16:23 | | 8 |
| | 15 | 03:05 | 16:46 | 02:50 | 16:06 | 02:52 | 16:34 | 04:09 | 16:44 | 02:44 | 16:57 | 03:04 | 16:56 | 03:11 | 16:42 | 02:46 | 16:23 | | 15 |
| | 22 | 03:17 | 16:45 | 03:01 | 16:07 | 03:05 | 16:33 | 04:17 | 16:48 | 02:59 | 16:54 | 03:17 | 16:54 | 03:23 | 16:41 | 02:59 | 16:23 | | 22 |
| | 29 | 03:30 | 16:42 | 03:11 | 16:06 | 03:18 | 16:31 | 04:25 | 16:51 | 03:15 | 16:49 | 03:31 | 16:51 | 03:35 | 16:40 | 03:11 | 16:21 | | 29 |
| Apr | 5 | 03:43 | 16:39 | 03:22 | 16:05 | 03:31 | 16:27 | 04:32 | 16:53 | 03:30 | 16:43 | 03:45 | 16:46 | 03:47 | 16:37 | 03:24 | 16:17 | Apr | 5 |
| | 12 | 03:56 | 16:34 | 03:33 | 16:02 | 03:44 | 16:22 | 04:39 | 16:54 | 03:46 | 16:35 | 03:58 | 16:41 | 03:59 | 16:33 | 03:36 | 16:13 | | 12 |
| | 19 | 04:09 | 16:29 | 03:43 | 16:00 | 03:57 | 16:17 | 04:46 | 16:55 | 04:01 | 16:27 | 04:12 | 16:35 | 04:11 | 16:29 | 03:48 | 16:08 | | 19 |
| | 26 | 04:21 | 16:24 | 03:54 | 15:57 | 04:09 | 16:12 | 04:52 | 16:56 | 04:17 | 16:19 | 04:26 | 16:28 | 04:23 | 16:25 | 04:01 | 16:03 | | 26 |
| May | 3 | 04:34 | 16:18 | 04:04 | 15:53 | 04:22 | 16:06 | 04:59 | 16:57 | 04:33 | 16:11 | 04:40 | 16:22 | 04:34 | 16:20 | 04:13 | 15:58 | May | 3 |
| | 10 | 04:47 | 16:13 | 04:15 | 15:51 | 04:35 | 16:01 | 05:05 | 16:58 | 04:49 | 16:03 | 04:54 | 16:16 | 04:46 | 16:16 | 04:26 | 15:53 | | 10 |
| | 17 | 05:00 | 16:09 | 04:26 | 15:48 | 04:49 | 15:56 | 05:12 | 16:59 | 05:05 | 15:55 | 05:08 | 16:10 | 04:59 | 16:13 | 04:39 | 15:49 | | 17 |
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| Jun | 7 | 05:42 | 16:02 | 05:01 | 15:48 | 05:30 | 15:49 | 05:37 | 17:10 | 05:55 | 15:40 | 05:52 | 16:01 | 05:37 | 16:09 | 05:19 | 15:44 | Jun | 7 |
| | 14 | 05:56 | 16:03 | 05:13 | 15:51 | 05:44 | 15:51 | 05:47 | 17:15 | 06:11 | 15:39 | 06:07 | 16:01 | 05:51 | 16:11 | 05:33 | 15:45 | | 14 |
| | 21 | 06:09 | 16:06 | 05:25 | 15:56 | 05:58 | 15:54 | 05:56 | 17:22 | 06:26 | 15:41 | 06:21 | 16:04 | 06:04 | 16:15 | 05:46 | 15:49 | | 21 |
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| Jul | 5 | 06:33 | 16:20 | 05:48 | 16:10 | 06:22 | 16:07 | 06:17 | 17:39 | 06:53 | 15:52 | 06:46 | 16:16 | 06:27 | 16:29 | 06:10 | 16:02 | Jul | 5 |
| | 12 | 06:43 | 16:30 | 05:58 | 16:20 | 06:32 | 16:17 | 06:26 | 17:49 | 07:02 | 16:02 | 06:56 | 16:26 | 06:37 | 16:39 | 06:20 | 16:12 | | 12 |
| | 19 | 06:51 | 16:41 | 06:06 | 16:31 | 06:40 | 16:29 | 06:36 | 17:59 | 07:09 | 16:14 | 07:03 | 16:38 | 06:45 | 16:50 | 06:28 | 16:24 | | 19 |
| | 26 | 06:57 | 16:55 | 06:12 | 16:43 | 06:45 | 16:42 | 06:44 | 18:10 | 07:14 | 16:29 | 07:08 | 16:52 | 06:51 | 17:03 | 06:33 | 16:37 | | 26 |
| Aug | 2 | 07:00 | 17:09 | 06:17 | 16:56 | 06:48 | 16:56 | 06:51 | 18:20 | 07:15 | 16:45 | 07:11 | 17:07 | 06:55 | 17:16 | 06:37 | 16:50 | Aug | 2 |
| | 9 | 07:01 | 17:23 | 06:20 | 17:09 | 06:49 | 17:11 | 06:57 | 18:30 | 07:14 | 17:02 | 07:11 | 17:22 | 06:56 | 17:30 | 06:38 | 17:05 | | 9 |
| | 16 | 07:00 | 17:38 | 06:21 | 17:21 | 06:49 | 17:25 | 07:01 | 18:39 | 07:10 | 17:19 | 07:10 | 17:38 | 06:57 | 17:44 | 06:38 | 17:19 | | 16 |
| | 23 | 06:58 | 17:53 | 06:21 | 17:34 | 06:46 | 17:40 | 07:05 | 18:48 | 07:05 | 17:37 | 07:06 | 17:53 | 06:55 | 17:58 | 06:36 | 17:33 | | 23 |
| | 30 | 06:54 | 18:07 | 06:20 | 17:46 | 06:42 | 17:55 | 07:07 | 18:56 | 06:58 | 17:55 | 07:01 | 18:09 | 06:52 | 18:11 | 06:32 | 17:48 | | 30 |
| Sep | 6 | 06:49 | 18:21 | 06:17 | 17:58 | 06:37 | 18:09 | 07:09 | 19:04 | 06:50 | 18:12 | 06:55 | 18:24 | 06:48 | 18:24 | 06:28 | 18:01 | Sep | 6 |
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| | 20 | 06:38 | 18:50 | 06:11 | 18:21 | 06:26 | 18:38 | 07:11 | 19:18 | 06:32 | 18:47 | 06:42 | 18:55 | 06:39 | 18:50 | 06:18 | 18:29 | | 20 |
| | 27 | 06:32 | 19:04 | 06:08 | 18:33 | 06:20 | 18:52 | 07:12 | 19:26 | 06:23 | 19:04 | 06:35 | 19:10 | 06:35 | 19:04 | 06:12 | 18:43 | | 27 |
| Oct | 4 | 06:27 | 19:18 | 06:05 | 18:45 | 06:14 | 19:07 | 07:14 | 19:33 | 06:15 | 19:22 | 06:29 | 19:26 | 06:30 | 19:17 | 06:07 | 18:57 | Oct | 4 |
| | 11 | 06:22 | 19:33 | 06:03 | 18:57 | 06:10 | 19:22 | 07:16 | 19:41 | 06:07 | 19:40 | 06:23 | 19:42 | 06:27 | 19:31 | 06:03 | 19:11 | | 11 |
| | 18 | 06:18 | 19:49 | 06:02 | 19:10 | 06:06 | 19:37 | 07:19 | 19:50 | 06:00 | 19:58 | 06:18 | 19:58 | 06:24 | 19:45 | 05:59 | 19:26 | | 18 |
| | 25 | 06:16 | 20:04 | 06:02 | 19:23 | 06:04 | 19:53 | 07:23 | 19:59 | 05:55 | 20:17 | 06:15 | 20:14 | 06:23 | 20:00 | 05:58 | 19:41 | | 25 |
| Nov | 1 | 06:16 | 20:20 | 06:04 | 19:37 | 06:03 | 20:08 | 07:28 | 20:10 | 05:51 | 20:36 | 06:13 | 20:31 | 06:23 | 20:14 | 05:58 | 19:57 | Nov | 1 |
| | 8 | 06:17 | 20:35 | 06:07 | 19:50 | 06:05 | 20:24 | 07:34 | 20:20 | 05:51 | 20:54 | 06:14 | 20:47 | 06:26 | 20:29 | 06:00 | 20:12 | | 8 |
| | 15 | 06:22 | 20:50 | 06:13 | 20:04 | 06:09 | 20:39 | 07:42 | 20:32 | 05:53 | 21:10 | 06:18 | 21:03 | 06:31 | 20:43 | 06:04 | 20:27 | | 15 |
| | 22 | 06:28 | 21:04 | 06:20 | 20:16 | 06:16 | 20:52 | 07:51 | 20:43 | 05:58 | 21:25 | 06:24 | 21:17 | 06:38 | 20:56 | 06:11 | 20:40 | | 22 |
| | 29 | 06:38 | 21:15 | 06:30 | 20:28 | 06:25 | 21:04 | 08:02 | 20:54 | 06:07 | 21:38 | 06:33 | 21:29 | 06:47 | 21:08 | 06:20 | 20:52 | | 29 |
| Dec | 6 | 06:49 | 21:25 | 06:41 | 20:38 | 06:36 | 21:14 | 08:13 | 21:04 | 06:19 | 21:47 | 06:45 | 21:38 | 06:59 | 21:18 | 06:32 | 21:01 | Dec | 6 |
| | 13 | 07:02 | 21:32 | 06:54 | 20:46 | 06:49 | 21:21 | 08:24 | 21:13 | 06:33 | 21:52 | 06:58 | 21:45 | 07:12 | 21:25 | 06:45 | 21:09 | | 13 |
| | 20 | 07:17 | 21:36 | 07:07 | 20:51 | 07:04 | 21:25 | 08:35 | 21:21 | 06:49 | 21:55 | 07:14 | 21:49 | 07:26 | 21:30 | 06:59 | 21:13 | | 20 |
| | 27 | 07:32 | 21:38 | 07:20 | 20:55 | 07:19 | 21:27 | 08:45 | 21:28 | 07:07 | 21:54 | 07:29 | 21:49 | 07:40 | 21:33 | 07:14 | 21:15 | | 27 |

# VENUS

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " | R.A. hh mm ss | Dec. ° ' " |
| 1 | 15 28 41 | - 15 14 11 | 17 42 48 | - 20 37 51 | 20 00 15 | - 19 34 23 | 22 28 48 | - 10 26 22 | 00 43 55 | + 02 55 10 | 03 07 03 | + 16 08 28 |
| 2 | 15 32 29 | - 15 27 14 | 17 47 34 | - 20 42 49 | 20 05 11 | - 19 23 58 | 22 33 24 | - 10 02 20 | 00 48 23 | + 03 23 04 | 03 11 53 | + 16 29 41 |
| 3 | 15 36 19 | - 15 40 17 | 17 52 21 | - 20 47 19 | 20 10 07 | - 19 13 01 | 22 38 00 | - 09 38 01 | 00 52 52 | + 03 50 55 | 03 16 45 | + 16 50 29 |
| 4 | 15 40 12 | - 15 53 20 | 17 57 09 | - 20 51 19 | 20 15 03 | - 19 01 31 | 22 42 35 | - 09 13 26 | 00 57 21 | + 04 18 43 | 03 21 38 | + 17 10 53 |
| 5 | 15 44 07 | - 16 06 20 | 18 01 58 | - 20 54 49 | 20 19 58 | - 18 49 29 | 22 47 09 | - 08 48 34 | 01 01 51 | + 04 46 27 | 03 26 33 | + 17 30 51 |
| 6 | 15 48 05 | - 16 19 18 | 18 06 48 | - 20 57 48 | 20 24 53 | - 18 36 54 | 22 51 43 | - 08 23 28 | 01 06 20 | + 05 14 07 | 03 31 28 | + 17 50 23 |
| 7 | 15 52 05 | - 16 32 10 | 18 11 39 | - 21 00 16 | 20 29 48 | - 18 23 48 | 22 56 16 | - 07 58 06 | 01 10 50 | + 05 41 40 | 03 36 24 | + 18 09 28 |
| 8 | 15 56 08 | - 16 44 58 | 18 16 31 | - 21 02 12 | 20 34 41 | - 18 10 10 | 23 00 49 | - 07 32 31 | 01 15 21 | + 06 09 08 | 03 41 22 | + 18 28 05 |
| 9 | 16 00 12 | - 16 57 38 | 18 21 24 | - 21 03 37 | 20 39 35 | - 17 56 01 | 23 05 21 | - 07 06 43 | 01 19 52 | + 06 36 29 | 03 46 20 | + 18 46 14 |
| 10 | 16 04 19 | - 17 10 10 | 18 26 17 | - 21 04 29 | 20 44 27 | - 17 41 22 | 23 09 53 | - 06 40 42 | 01 24 23 | + 07 03 43 | 03 51 20 | + 19 03 54 |
| 11 | 16 08 28 | - 17 22 34 | 18 31 11 | - 21 04 49 | 20 49 19 | - 17 26 12 | 23 14 24 | - 06 14 28 | 01 28 55 | + 07 30 49 | 03 56 20 | + 19 21 04 |
| 12 | 16 12 39 | - 17 34 46 | 18 36 05 | - 21 04 36 | 20 54 10 | - 17 10 33 | 23 18 54 | - 05 48 04 | 01 33 28 | + 07 57 46 | 04 01 22 | + 19 37 44 |
| 13 | 16 16 53 | - 17 46 48 | 18 41 01 | - 21 03 49 | 20 59 01 | - 16 54 25 | 23 23 25 | - 05 21 29 | 01 38 01 | + 08 24 33 | 04 06 25 | + 19 53 53 |
| 14 | 16 21 08 | - 17 58 37 | 18 45 56 | - 21 02 29 | 21 03 51 | - 16 37 47 | 23 27 55 | - 04 54 44 | 01 42 34 | + 08 51 10 | 04 11 29 | + 20 09 31 |
| 15 | 16 25 25 | - 18 10 13 | 18 50 52 | - 21 00 36 | 21 08 40 | - 16 20 41 | 23 32 24 | - 04 27 49 | 01 47 09 | + 09 17 37 | 04 16 34 | + 20 24 37 |
| 16 | 16 29 45 | - 18 21 34 | 18 55 49 | - 20 58 09 | 21 13 29 | - 16 03 08 | 23 36 53 | - 04 00 46 | 01 51 44 | + 09 43 52 | 04 21 40 | + 20 39 09 |
| 17 | 16 34 06 | - 18 32 40 | 19 00 45 | - 20 55 07 | 21 18 17 | - 15 45 07 | 23 41 22 | - 03 33 35 | 01 56 20 | + 10 09 55 | 04 26 47 | + 20 53 09 |
| 18 | 16 38 29 | - 18 43 30 | 19 05 42 | - 20 51 32 | 21 23 04 | - 15 26 39 | 23 45 51 | - 03 06 16 | 02 00 56 | + 10 35 45 | 04 31 55 | + 21 06 34 |
| 19 | 16 42 54 | - 18 54 02 | 19 10 40 | - 20 47 22 | 21 27 50 | - 15 07 45 | 23 50 19 | - 02 38 50 | 02 05 34 | + 11 01 22 | 04 37 04 | + 21 19 26 |
| 20 | 16 47 21 | - 19 04 15 | 19 15 37 | - 20 42 38 | 21 32 36 | - 14 48 25 | 23 54 48 | - 02 11 18 | 02 10 12 | + 11 26 44 | 04 42 14 | + 21 31 42 |
| 21 | 16 51 49 | - 19 14 10 | 19 20 35 | - 20 37 20 | 21 37 21 | - 14 28 40 | 23 59 16 | - 01 43 41 | 02 14 51 | + 11 51 52 | 04 47 25 | + 21 43 22 |
| 22 | 16 56 20 | - 19 23 44 | 19 25 33 | - 20 31 27 | 21 42 05 | - 14 08 30 | 00 03 44 | - 01 15 59 | 02 19 31 | + 12 16 44 | 04 52 37 | + 21 54 27 |
| 23 | 17 00 52 | - 19 32 57 | 19 30 30 | - 20 25 00 | 21 46 49 | - 13 47 56 | 00 08 11 | - 00 48 12 | 02 24 11 | + 12 41 20 | 04 57 50 | + 22 04 55 |
| 24 | 17 05 26 | - 19 41 48 | 19 35 28 | - 20 17 59 | 21 51 32 | - 13 26 58 | 00 12 39 | - 00 20 22 | 02 28 53 | + 13 05 38 | 05 03 03 | + 22 14 46 |
| 25 | 17 10 01 | - 19 50 16 | 19 40 26 | - 20 10 24 | 21 56 14 | - 13 05 37 | 00 17 07 | + 00 07 31 | 02 33 36 | + 13 29 39 | 05 08 18 | + 22 24 00 |
| 26 | 17 14 38 | - 19 58 21 | 19 45 23 | - 20 02 14 | 22 00 55 | - 12 43 54 | 00 21 35 | + 00 35 26 | 02 38 19 | + 13 53 21 | 05 13 33 | + 22 32 36 |
| 27 | 17 19 16 | - 20 06 01 | 19 50 21 | - 19 53 31 | 22 05 35 | - 12 21 50 | 00 26 03 | + 01 03 23 | 02 43 04 | + 14 16 45 | 05 18 48 | + 22 40 33 |
| 28 | 17 23 56 | - 20 13 16 | 19 55 18 | - 19 44 13 | 22 10 15 | - 11 59 24 | 00 30 30 | + 01 31 20 | 02 47 50 | + 14 39 48 | 05 24 05 | + 22 47 52 |
| 29 | 17 28 37 | - 20 20 06 | | | 22 14 54 | - 11 36 38 | 00 34 58 | + 01 59 18 | 02 52 36 | + 15 02 31 | 05 29 22 | + 22 54 31 |
| 30 | 17 33 19 | - 20 26 28 | | | 22 19 33 | - 11 13 31 | 00 39 27 | + 02 27 15 | 02 57 24 | + 15 24 52 | 05 34 40 | + 23 00 31 |
| 31 | 17 38 03 | - 20 32 23 | | | 22 24 10 | - 10 50 06 | | | 03 02 13 | + 15 46 51 | | |

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 05 39 58 | + 23 05 51 | 08 23 50 | + 20 16 14 | 10 54 52 | + 08 27 51 | 13 11 42 | - 06 33 12 | 15 41 03 | - 19 50 02 | 18 21 24 | - 24 44 34 |
| 2 | 05 45 16 | + 23 10 32 | 08 28 57 | + 20 00 26 | 10 59 29 | + 07 59 21 | 13 16 18 | - 07 03 00 | 15 46 10 | - 20 09 12 | 18 26 52 | - 24 43 16 |
| 3 | 05 50 35 | + 23 14 31 | 08 34 04 | + 19 44 04 | 11 04 07 | + 07 30 39 | 13 20 54 | - 07 32 39 | 15 51 19 | - 20 27 49 | 18 32 20 | - 24 41 13 |
| 4 | 05 55 55 | + 23 17 51 | 08 39 10 | + 19 27 09 | 11 08 43 | + 07 01 44 | 13 25 31 | - 08 02 09 | 15 56 28 | - 20 45 53 | 18 37 47 | - 24 38 25 |
| 5 | 06 01 14 | + 23 20 29 | 08 44 15 | + 19 09 40 | 11 13 19 | + 06 32 38 | 13 30 08 | - 08 31 28 | 16 01 39 | - 21 03 21 | 18 43 14 | - 24 34 52 |
| 6 | 06 06 34 | + 23 22 27 | 08 49 18 | + 18 51 38 | 11 17 54 | + 06 03 20 | 13 34 46 | - 09 00 36 | 16 06 51 | - 21 20 15 | 18 48 40 | - 24 30 34 |
| 7 | 06 11 54 | + 23 23 44 | 08 54 21 | + 18 33 05 | 11 22 29 | + 05 33 52 | 13 39 25 | - 09 29 31 | 16 12 04 | - 21 36 33 | 18 54 06 | - 24 25 32 |
| 8 | 06 17 15 | + 23 24 19 | 08 59 22 | + 18 14 00 | 11 27 04 | + 05 04 15 | 13 44 05 | - 09 58 15 | 16 17 18 | - 21 52 14 | 18 59 32 | - 24 19 45 |
| 9 | 06 22 35 | + 23 24 13 | 09 04 23 | + 17 54 24 | 11 31 38 | + 04 34 29 | 13 48 45 | - 10 26 44 | 16 22 34 | - 22 07 18 | 19 04 56 | - 24 13 14 |
| 10 | 06 27 55 | + 23 23 26 | 09 09 22 | + 17 34 18 | 11 36 11 | + 04 04 35 | 13 53 27 | - 10 54 59 | 16 27 50 | - 22 21 44 | 19 10 20 | - 24 05 59 |
| 11 | 06 33 16 | + 23 21 58 | 09 14 20 | + 17 13 42 | 11 40 45 | + 03 34 34 | 13 58 09 | - 11 23 00 | 16 33 07 | - 22 35 32 | 19 15 44 | - 23 58 00 |
| 12 | 06 38 36 | + 23 19 48 | 09 19 17 | + 16 52 38 | 11 45 17 | + 03 04 25 | 14 02 52 | - 11 50 44 | 16 38 26 | - 22 48 40 | 19 21 06 | - 23 49 18 |
| 13 | 06 43 56 | + 23 16 57 | 09 24 14 | + 16 31 05 | 11 49 50 | + 02 34 11 | 14 07 36 | - 12 18 12 | 16 43 45 | - 23 01 09 | 19 26 28 | - 23 39 54 |
| 14 | 06 49 16 | + 23 13 25 | 09 29 09 | + 16 09 05 | 11 54 23 | + 02 03 52 | 14 12 21 | - 12 45 22 | 16 49 05 | - 23 12 58 | 19 31 49 | - 23 29 47 |
| 15 | 06 54 36 | + 23 09 12 | 09 34 03 | + 15 46 38 | 11 58 55 | + 01 33 28 | 14 17 07 | - 13 12 15 | 16 54 27 | - 23 24 06 | 19 37 09 | - 23 18 58 |
| 16 | 06 59 55 | + 23 04 18 | 09 38 55 | + 15 23 45 | 12 03 27 | + 01 03 01 | 14 21 54 | - 13 38 48 | 16 59 49 | - 23 34 33 | 19 42 28 | - 23 07 27 |
| 17 | 07 05 14 | + 22 58 43 | 09 43 47 | + 15 00 27 | 12 07 59 | + 00 32 30 | 14 26 42 | - 14 05 02 | 17 05 12 | - 23 44 19 | 19 47 46 | - 22 55 15 |
| 18 | 07 10 33 | + 22 52 27 | 09 48 38 | + 14 36 43 | 12 12 31 | + 00 01 57 | 14 31 31 | - 14 30 55 | 17 10 35 | - 23 53 22 | 19 53 02 | - 22 42 23 |
| 19 | 07 15 51 | + 22 45 30 | 09 53 28 | + 14 12 36 | 12 17 03 | - 00 28 38 | 14 36 21 | - 14 56 27 | 17 16 00 | - 24 01 42 | 19 58 18 | - 22 28 51 |
| 20 | 07 21 09 | + 22 37 54 | 09 58 17 | + 13 48 05 | 12 21 35 | - 00 59 13 | 14 41 13 | - 15 21 37 | 17 21 25 | - 24 09 20 | 20 03 32 | - 22 14 39 |
| 21 | 07 26 27 | + 22 29 37 | 10 03 05 | + 13 23 11 | 12 26 07 | - 01 29 49 | 14 46 05 | - 15 46 24 | 17 26 50 | - 24 16 14 | 20 08 46 | - 21 59 49 |
| 22 | 07 31 43 | + 22 20 41 | 10 07 51 | + 12 57 56 | 12 30 39 | - 02 00 24 | 14 50 59 | - 16 10 47 | 17 32 16 | - 24 22 25 | 20 13 58 | - 21 44 20 |
| 23 | 07 36 59 | + 22 11 05 | 10 12 37 | + 12 32 19 | 12 35 12 | - 02 30 58 | 14 55 54 | - 16 34 46 | 17 37 43 | - 24 27 52 | 20 19 08 | - 21 28 13 |
| 24 | 07 42 15 | + 22 00 50 | 10 17 22 | + 12 06 22 | 12 39 44 | - 03 01 30 | 15 00 50 | - 16 58 20 | 17 43 10 | - 24 32 34 | 20 24 18 | - 21 11 30 |
| 25 | 07 47 30 | + 21 49 57 | 10 22 06 | + 11 40 04 | 12 44 17 | - 03 31 59 | 15 05 47 | - 17 21 27 | 17 48 37 | - 24 36 32 | 20 29 26 | - 20 54 10 |
| 26 | 07 52 44 | + 21 38 25 | 10 26 50 | + 11 13 28 | 12 48 51 | - 04 02 25 | 15 10 46 | - 17 44 08 | 17 54 05 | - 24 39 45 | 20 34 33 | - 20 36 14 |
| 27 | 07 57 57 | + 21 26 15 | 10 31 32 | + 10 46 33 | 12 53 24 | - 04 32 46 | 15 15 46 | - 18 06 21 | 17 59 33 | - 24 42 13 | 20 39 38 | - 20 17 44 |
| 28 | 08 03 09 | + 21 13 28 | 10 36 13 | + 10 19 21 | 12 57 58 | - 05 03 02 | 15 20 47 | - 18 28 05 | 18 05 01 | - 24 43 56 | 20 44 42 | - 19 58 39 |
| 29 | 08 08 21 | + 21 00 04 | 10 40 54 | + 09 51 52 | 13 02 32 | - 05 33 12 | 15 25 49 | - 18 49 20 | 18 10 29 | - 24 44 54 | 20 49 45 | - 19 39 01 |
| 30 | 08 13 31 | + 20 46 03 | 10 45 34 | + 09 24 07 | 13 07 07 | - 06 03 16 | 15 30 53 | - 19 10 05 | 18 15 57 | - 24 45 07 | 20 54 46 | - 19 18 50 |
| 31 | 08 18 41 | + 20 31 26 | 10 50 13 | + 08 56 06 | | | 15 35 57 | - 19 30 19 | | | 20 59 46 | - 18 58 06 |

# MARS

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| Jan | 4 | 01:46 | 15:33 | 01:32 | 14:53 | 01:34 | 15:22 | 02:53 | 15:29 | 01:25 | 15:47 | 01:45 | 15:44 | 01:53 | 15:29 | 01:28 | 15:11 |
| | 11 | 01:33 | 15:28 | 01:20 | 14:46 | 01:21 | 15:17 | 02:43 | 15:21 | 01:10 | 15:42 | 01:32 | 15:39 | 01:41 | 15:23 | 01:15 | 15:05 |
| | 18 | 01:21 | 15:22 | 01:09 | 14:40 | 01:08 | 15:11 | 02:33 | 15:13 | 00:57 | 15:38 | 01:19 | 15:34 | 01:28 | 15:17 | 01:03 | 15:00 |
| | 25 | 01:09 | 15:17 | 00:58 | 14:33 | 00:56 | 15:05 | 02:23 | 15:05 | 00:44 | 15:34 | 01:06 | 15:28 | 01:17 | 15:11 | 00:51 | 14:54 |
| Feb | 1 | 00:58 | 15:11 | 00:47 | 14:27 | 00:45 | 15:00 | 02:13 | 14:57 | 00:31 | 15:29 | 00:55 | 15:23 | 01:06 | 15:05 | 00:40 | 14:48 |
| | 8 | 00:47 | 15:05 | 00:37 | 14:20 | 00:34 | 14:54 | 02:04 | 14:50 | 00:20 | 15:24 | 00:44 | 15:17 | 00:55 | 14:58 | 00:29 | 14:42 |
| | 15 | 00:37 | 14:59 | 00:27 | 14:13 | 00:24 | 14:47 | 01:55 | 14:42 | 00:09 | 15:18 | 00:33 | 15:11 | 00:45 | 14:52 | 00:19 | 14:35 |
| | 22 | 00:27 | 14:52 | 00:18 | 14:06 | 00:14 | 14:41 | 01:47 | 14:34 | 23:57 | 15:12 | 00:23 | 15:04 | 00:36 | 14:45 | 00:09 | 14:29 |
| Mar | 1 | 00:18 | 14:45 | 00:09 | 13:58 | 00:05 | 14:33 | 01:38 | 14:26 | 23:48 | 15:05 | 00:14 | 14:57 | 00:27 | 14:38 | 23:59 | 14:21 |
| | 8 | 00:09 | 14:37 | 23:59 | 13:51 | 23:55 | 14:26 | 01:30 | 14:18 | 23:39 | 14:57 | 00:06 | 14:50 | 00:18 | 14:30 | 23:51 | 14:14 |
| | 15 | 00:01 | 14:29 | 23:51 | 13:42 | 23:47 | 14:18 | 01:22 | 14:10 | 23:31 | 14:49 | 23:56 | 14:42 | 00:10 | 14:22 | 23:42 | 14:05 |
| | 22 | 23:52 | 14:20 | 23:43 | 13:34 | 23:39 | 14:09 | 01:14 | 14:02 | 23:23 | 14:40 | 23:49 | 14:33 | 00:02 | 14:13 | 23:35 | 13:57 |
| | 29 | 23:45 | 14:10 | 23:36 | 13:24 | 23:32 | 13:59 | 01:06 | 13:53 | 23:16 | 14:30 | 23:41 | 14:23 | 23:54 | 14:04 | 23:27 | 13:47 |
| Apr | 5 | 23:37 | 14:00 | 23:28 | 13:15 | 23:25 | 13:49 | 00:57 | 13:44 | 23:09 | 14:20 | 23:34 | 14:13 | 23:46 | 13:54 | 23:20 | 13:37 |
| | 12 | 23:30 | 13:49 | 23:20 | 13:04 | 23:17 | 13:38 | 00:49 | 13:34 | 23:03 | 14:08 | 23:27 | 14:02 | 23:39 | 13:43 | 23:12 | 13:26 |
| | 19 | 23:23 | 13:38 | 23:12 | 12:54 | 23:10 | 13:27 | 00:40 | 13:24 | 22:56 | 13:56 | 23:20 | 13:50 | 23:31 | 13:32 | 23:05 | 13:15 |
| | 26 | 23:15 | 13:26 | 23:04 | 12:42 | 23:03 | 13:15 | 00:31 | 13:14 | 22:50 | 13:43 | 23:13 | 13:38 | 23:23 | 13:20 | 22:58 | 13:03 |
| May | 3 | 23:08 | 13:13 | 22:56 | 12:30 | 22:55 | 13:02 | 00:22 | 13:03 | 22:43 | 13:29 | 23:05 | 13:25 | 23:15 | 13:07 | 22:50 | 12:50 |
| | 10 | 23:00 | 13:00 | 22:47 | 12:17 | 22:47 | 12:48 | 00:12 | 12:51 | 22:36 | 13:15 | 22:58 | 13:11 | 23:07 | 12:54 | 22:42 | 12:37 |
| | 17 | 22:51 | 12:46 | 22:38 | 12:04 | 22:39 | 12:34 | 00:01 | 12:39 | 22:28 | 13:00 | 22:49 | 12:56 | 22:58 | 12:41 | 22:33 | 12:23 |
| | 24 | 22:42 | 12:31 | 22:28 | 11:50 | 22:29 | 12:19 | 23:49 | 12:26 | 22:20 | 12:44 | 22:41 | 12:41 | 22:49 | 12:26 | 22:24 | 12:08 |
| | 31 | 22:32 | 12:15 | 22:17 | 11:35 | 22:19 | 12:04 | 23:37 | 12:13 | 22:11 | 12:27 | 22:31 | 12:25 | 22:38 | 12:11 | 22:13 | 11:53 |
| Jun | 7 | 22:21 | 11:59 | 22:05 | 11:20 | 22:08 | 11:48 | 23:24 | 11:58 | 22:01 | 12:10 | 22:20 | 12:09 | 22:27 | 11:55 | 22:02 | 11:37 |
| | 14 | 22:09 | 11:42 | 21:53 | 11:03 | 21:56 | 11:31 | 23:10 | 11:43 | 21:50 | 11:53 | 22:08 | 11:52 | 22:14 | 11:38 | 21:50 | 11:20 |
| | 21 | 21:55 | 11:24 | 21:38 | 10:46 | 21:43 | 11:13 | 22:55 | 11:27 | 21:37 | 11:34 | 21:55 | 11:34 | 22:01 | 11:21 | 21:36 | 11:02 |
| | 28 | 21:40 | 11:06 | 21:23 | 10:28 | 21:27 | 10:54 | 22:39 | 11:09 | 21:22 | 11:15 | 21:40 | 11:15 | 21:45 | 11:02 | 21:21 | 10:44 |
| Jul | 5 | 21:22 | 10:46 | 21:05 | 10:08 | 21:10 | 10:34 | 22:20 | 10:50 | 21:05 | 10:55 | 21:23 | 10:55 | 21:28 | 10:43 | 21:04 | 10:24 |
| | 12 | 21:03 | 10:25 | 20:45 | 09:48 | 20:50 | 10:13 | 22:00 | 10:30 | 20:46 | 10:33 | 21:03 | 10:34 | 21:08 | 10:22 | 20:44 | 10:03 |
| | 19 | 20:41 | 10:02 | 20:23 | 09:25 | 20:28 | 09:51 | 21:38 | 10:07 | 20:24 | 10:11 | 20:41 | 10:11 | 20:46 | 09:59 | 20:22 | 09:41 |
| | 26 | 20:15 | 09:38 | 19:58 | 09:01 | 20:03 | 09:27 | 21:13 | 09:43 | 19:58 | 09:47 | 20:16 | 09:47 | 20:21 | 09:35 | 19:57 | 09:16 |
| Aug | 2 | 19:47 | 09:12 | 19:30 | 08:35 | 19:35 | 09:01 | 20:45 | 09:16 | 19:30 | 09:21 | 19:47 | 09:21 | 19:52 | 09:09 | 19:28 | 08:50 |
| | 9 | 19:16 | 08:44 | 18:59 | 08:06 | 19:04 | 08:33 | 20:15 | 08:47 | 18:58 | 08:54 | 19:16 | 08:54 | 19:21 | 08:41 | 18:57 | 08:22 |
| | 16 | 18:42 | 08:14 | 18:26 | 07:36 | 18:30 | 08:03 | 19:43 | 08:16 | 18:24 | 08:24 | 18:42 | 08:24 | 18:48 | 08:11 | 18:24 | 07:52 |
| | 23 | 18:06 | 07:43 | 17:51 | 07:04 | 17:54 | 07:31 | 19:08 | 07:43 | 17:47 | 07:54 | 18:06 | 07:52 | 18:12 | 07:39 | 17:48 | 07:21 |
| | 30 | 17:30 | 07:10 | 17:15 | 06:30 | 17:18 | 06:59 | 18:33 | 07:09 | 17:10 | 07:21 | 17:29 | 07:20 | 17:36 | 07:06 | 17:11 | 06:48 |
| Sep | 6 | 16:54 | 06:36 | 16:39 | 05:57 | 16:42 | 06:25 | 17:58 | 06:35 | 16:34 | 06:48 | 16:53 | 06:46 | 17:00 | 06:32 | 16:36 | 06:14 |
| | 13 | 16:20 | 06:03 | 16:05 | 05:23 | 16:07 | 05:52 | 17:24 | 06:01 | 15:59 | 06:15 | 16:19 | 06:13 | 16:26 | 05:59 | 16:01 | 05:41 |
| | 20 | 15:48 | 05:31 | 15:33 | 04:51 | 15:36 | 05:19 | 16:52 | 05:29 | 15:28 | 05:43 | 15:47 | 05:41 | 15:54 | 05:26 | 15:30 | 05:09 |
| | 27 | 15:20 | 05:00 | 15:05 | 04:20 | 15:07 | 04:49 | 16:23 | 04:59 | 15:00 | 05:11 | 15:19 | 05:10 | 15:26 | 04:56 | 15:01 | 04:38 |
| Oct | 4 | 14:55 | 04:31 | 14:39 | 03:52 | 14:42 | 04:19 | 15:57 | 04:31 | 14:35 | 04:42 | 14:54 | 04:40 | 15:01 | 04:27 | 14:36 | 04:09 |
| | 11 | 14:33 | 04:03 | 14:16 | 03:25 | 14:20 | 03:52 | 15:33 | 04:05 | 14:14 | 04:13 | 14:32 | 04:13 | 14:38 | 04:00 | 14:14 | 03:41 |
| | 18 | 14:13 | 03:38 | 13:56 | 03:00 | 14:01 | 03:26 | 15:11 | 03:42 | 13:56 | 03:47 | 14:13 | 03:47 | 14:18 | 03:34 | 13:54 | 03:16 |
| | 25 | 13:56 | 03:13 | 13:38 | 02:37 | 13:44 | 03:02 | 14:52 | 03:20 | 13:40 | 03:21 | 13:57 | 03:22 | 14:01 | 03:10 | 13:37 | 02:52 |
| Nov | 1 | 13:41 | 02:51 | 13:22 | 02:15 | 13:29 | 02:39 | 14:34 | 03:00 | 13:26 | 02:57 | 13:42 | 02:59 | 13:46 | 02:48 | 13:22 | 02:29 |
| | 8 | 13:28 | 02:29 | 13:07 | 01:54 | 13:16 | 02:17 | 14:18 | 02:41 | 13:14 | 02:34 | 13:29 | 02:36 | 13:32 | 02:27 | 13:08 | 02:07 |
| | 15 | 13:16 | 02:08 | 12:54 | 01:34 | 13:04 | 01:56 | 14:03 | 02:23 | 13:04 | 02:11 | 13:18 | 02:15 | 13:19 | 02:06 | 12:56 | 01:47 |
| | 22 | 13:05 | 01:48 | 12:42 | 01:15 | 12:53 | 01:36 | 13:49 | 02:06 | 12:54 | 01:50 | 13:07 | 01:54 | 13:08 | 01:47 | 12:45 | 01:27 |
| | 29 | 12:55 | 01:28 | 12:31 | 00:57 | 12:43 | 01:16 | 13:36 | 01:50 | 12:46 | 01:29 | 12:58 | 01:34 | 12:58 | 01:28 | 12:35 | 01:07 |
| Dec | 6 | 12:46 | 01:09 | 12:21 | 00:39 | 12:34 | 00:57 | 13:23 | 01:34 | 12:38 | 01:08 | 12:49 | 01:15 | 12:48 | 01:09 | 12:26 | 00:49 |
| | 13 | 12:37 | 00:51 | 12:11 | 00:22 | 12:25 | 00:39 | 13:11 | 01:19 | 12:32 | 00:48 | 12:41 | 00:56 | 12:39 | 00:51 | 12:17 | 00:30 |
| | 20 | 12:29 | 00:33 | 12:02 | 00:05 | 12:17 | 00:21 | 13:00 | 01:04 | 12:25 | 00:28 | 12:34 | 00:37 | 12:30 | 00:34 | 12:09 | 00:12 |
| | 27 | 12:22 | 00:15 | 11:53 | 23:47 | 12:10 | 00:03 | 12:49 | 00:50 | 12:19 | 00:09 | 12:27 | 00:19 | 12:22 | 00:17 | 12:01 | 23:52 |

## POSITION

(0hrs UT Epoch 2000.0)

| | RA | DEC |
|---|---|---|
| | h m s | ° ' " |
| Jan 4 | 15 16 54 | - 17 29 29 |
| 11 | 15 35 14 | - 18 40 03 |
| 18 | 15 53 48 | - 19 43 57 |
| 25 | 16 12 36 | - 20 40 46 |
| Feb 1 | 16 31 37 | - 21 30 03 |
| 8 | 16 50 48 | - 22 11 24 |
| 15 | 17 10 07 | - 22 44 34 |
| 22 | 17 29 32 | - 23 09 22 |
| Mar 1 | 17 49 01 | - 23 25 42 |
| 8 | 18 08 29 | - 23 33 32 |
| 15 | 18 27 53 | - 23 33 01 |
| 22 | 18 47 10 | - 23 24 22 |
| 29 | 19 06 17 | - 23 07 56 |
| Apr 5 | 19 25 09 | - 22 44 10 |
| 12 | 19 43 44 | - 22 13 41 |
| 19 | 20 01 58 | - 21 37 11 |
| 26 | 20 19 48 | - 20 55 23 |
| May 3 | 20 37 11 | - 20 09 16 |
| 10 | 20 54 02 | - 19 19 53 |
| 17 | 21 10 18 | - 18 28 20 |
| 24 | 21 25 56 | - 17 35 45 |
| 31 | 21 40 48 | - 16 43 34 |
| Jun 7 | 21 54 49 | - 15 53 20 |
| 14 | 22 07 52 | - 15 06 32 |
| 21 | 22 19 49 | - 14 24 43 |
| 28 | 22 30 26 | - 13 49 48 |
| Jul 5 | 22 39 32 | - 13 23 39 |
| 12 | 22 46 51 | - 13 07 47 |
| 19 | 22 52 09 | - 13 03 28 |
| 26 | 22 55 10 | - 13 11 41 |
| Aug 2 | 22 55 41 | - 13 32 22 |
| 9 | 22 53 41 | - 14 03 29 |
| 16 | 22 49 22 | - 14 41 20 |
| 23 | 22 43 12 | - 15 20 53 |
| 30 | 22 35 56 | - 15 55 57 |
| Sep 6 | 22 28 40 | - 16 20 22 |
| 13 | 22 22 25 | - 16 30 01 |
| 20 | 22 17 56 | - 16 23 27 |
| 27 | 22 15 45 | - 16 00 49 |
| Oct 4 | 22 16 05 | - 15 23 16 |
| 11 | 22 18 52 | - 14 32 41 |
| 18 | 22 23 51 | - 13 31 09 |
| 25 | 22 30 47 | - 12 20 16 |
| Nov 1 | 22 39 24 | - 11 01 14 |
| 8 | 22 49 24 | - 09 35 13 |
| 15 | 23 00 32 | - 08 03 26 |
| 22 | 23 12 36 | - 06 26 48 |
| 29 | 23 25 28 | - 04 46 00 |
| Dec 6 | 23 38 59 | - 03 01 52 |
| 13 | 23 53 02 | - 01 15 20 |
| 20 | 00 07 33 | + 00 32 48 |
| 27 | 00 22 30 | + 02 21 56 |

# OPPOSITION OF MARS 2003

On the 29th August 2003, Mars will be at opposition, providing the best view of the planet since the opposition of September 1988. Oppositions of Mars are not all favourable, some giving a better perspective than others. When the Earth passes Mars in its orbit every 26 months, we get a close view of the planet (fig. 3). When Mars is at also at perihelion, we get a particularly good view. The reason for this is the elliptical orbit of Mars. On average, the planet is 228 million km (Mkm) from the Sun, but this varies by a considerable 42 Mkm. At an aphelic opposition (Mars furthest from the Sun) the planet is 99 Mkm from the Earth. When at a perihelic opposition, it will average around 57 Mkm from us.

The favourable perihelic oppositions are rare, occurring only once every 15 to 17 years. This year's opposition can be considered the 'best ever', not only is it a perihelic opposition, but the planet will be closer (55.76 Mkm) to Earth than it has been for thousands of years. Similar oppositions occur in 2208 AD (55.77 Mkm), and 2287 AD (55.76 Mkm), although any opposition around perihelion will provide good views of the planet.

Oppositions in the early months of the year are always unfavourable as Mars is at aphelion. Perihelic oppositions occur around August, and fortunately for Southern Hemisphere observers, Mars is at its greatest southerly declination at that time. When Mars is in conjunction with the Sun its disc is only 3.5 arc seconds (") in diameter, smaller than distant Uranus. At an aphelic opposition, the diameter is 14", increasing to 25" at a perihelic opposition (fig. 4). During 2003 the disc steadily grows from 4.6" at the beginning of the year to 25.1" at opposition, then decreases to 8.5" by year's end (fig. 1).

Since the Martian day is about 40 minutes longer than Earth's, surface features cross the central meridian 40 minutes later each night (fig. 2). As this delay is about 9° of longitude per day, observations made at the same time each night will see all surface features cross the central meridian in under six weeks. The Martian dust storms which can be global and last for months may well obscure some surface features or even create a total block-out, but the study of these storms is still important to our understanding of the mechanics of the planet's atmosphere.

The iron-rich soils of Mars (which give the 'Red Planet' its colour) were shown by the Viking landers to be much lighter in colour than the rocks underneath. Depending on the season, high velocity winds can lift the soil and transport it around the planet. Sometimes the rocky surface is uncovered, showing a darker area; conversely dark areas can be covered by lighter dust as storms deposit millions of tonnes of material over the landscape. Observers noted during the opposition of 1988 that there were a number of new features, including four darker areas that had not been seen since last century.

Even with the constant movement of dust around the planet, several easily recognisable regions can be seen and identified from opposition to opposition. It will be interesting to compare this year's observable features with the ALPO map (fig. 5). The most prominent of the dark areas is Syrtis Major, a wedge shaped region just north of the equator. Directly below Syrtis Major in the south is a light contrasting area known as Hellas, a depression that when covered in light dust is very conspicuous. The mysterious 'Eye of Mars' or Solis Lacus (Lake of the Sun) is also located in the southern hemisphere, a small dark region ringed by lighter material. At some oppositions the 'Eye' is outstanding, and at others it is difficult because of the shifting sands of Mars.

Mars can certainly be enjoyed at any opposition through a telescope, however the view can be enhanced dramatically by the use of filters. The improvement in contrast by using various coloured filters brings hard to detect areas into prominence. A red or orange filter will highlight dark features; green or red filters are best for detecting the projections and boundaries of the polar caps. Yellow and green filters can distinguish surface frost and fog from lower level cloud, and blue or violet filters will show the higher level clouds. Dust storms are best seen through yellow, orange and red filters.

There are many unsolved mysteries of the Red Planet and in a scientific light the amateur can still contribute. Monitoring the Martian atmosphere and surface features will assist in our understanding of the geological and atmospheric mechanics of this strange planet. An example of an amateur contribution is the monitoring of Martian flares. These have been suspected to be sunlight reflecting off possible ground frost. They have been seen in the Titonius Lacus and Edom Promontorium regions.

For Internet users, we recommend the Association of Lunar and Planetary Observers (ALPO) home page at www.lpl.arizona.edu/alpo. This site is an excellent resource, providing up to date news and observations, and on how the amateur can contribute.

## Ephemeris for Physical Observations

**Calculating longitude of central meridian** for a particular observation date and time. First convert your local time to UT correcting the date if needed. Next, from the main table, select the central meridian figure for the date. If the date is not in the table, use the longitude for the previous date and add 350.9° to it. Now take the hour and minute values from the 'Increase in Longitude' table. Add these three numbers. If the result is greater than 360° subtract 360 from it, more than once if needed.

For example an observation at 2:20am EST on July 21st, converts to 16:20 UT on July 20th. There is no entry for the 20th so use the 19th and add 350.9 as above i.e., 329.4 + 350.9 = 680.3. From the tables below our calculation is 680.3 + 233.9 + 4.9 = 919.1 Subtract multiples of 360 until the result is less than 360 gives us a longitude of central meridian of 199.1°. The longitudes are shown on the map (fig. 5)

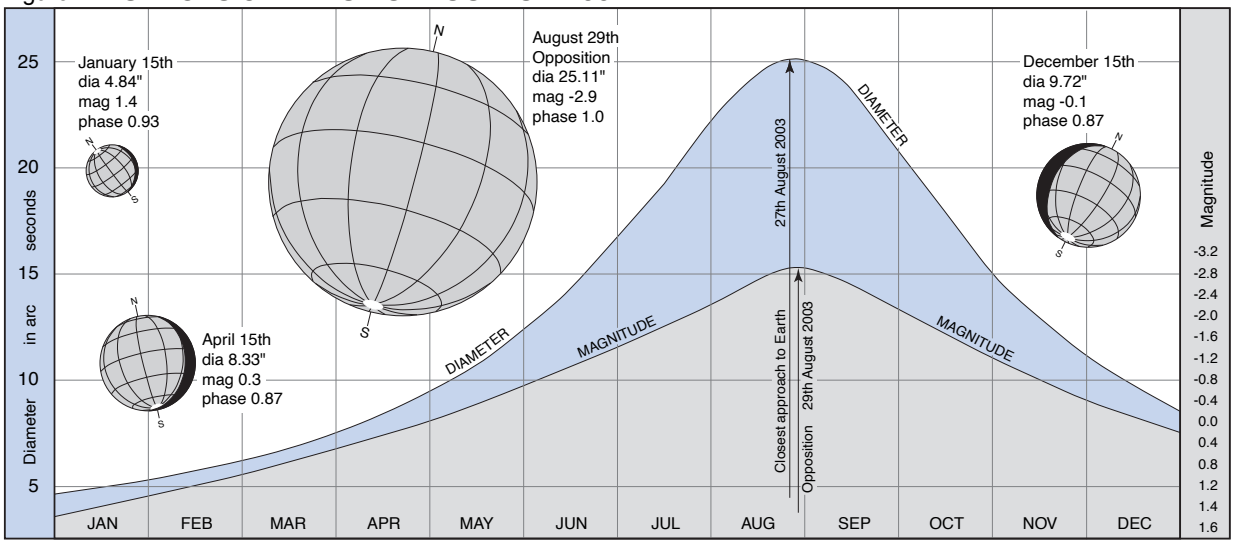
Central Meridian – Increase in Longitude

| hr | deg° | hr | deg° | hr | deg° | min | deg° |
|---|---|---|---|---|---|---|---|
| 01 | 014.6 | 09 | 131.6 | 17 | 248.6 | 10 | 002.4 |
| 02 | 029.2 | 10 | 146.2 | 18 | 263.2 | 20 | 004.9 |
| 03 | 043.9 | 11 | 160.8 | 19 | 277.8 | 30 | 007.3 |
| 04 | 058.5 | 12 | 175.5 | 20 | 292.4 | 40 | 009.7 |
| 05 | 073.1 | 13 | 190.1 | 21 | 307.0 | 50 | 012.2 |
| 06 | 087.7 | 14 | 204.7 | 22 | 321.7 | | |
| 07 | 102.3 | 15 | 219.3 | 23 | 336.3 | | |
| 08 | 117.0 | 16 | 233.9 | 24 | 350.9 | | |

**PHYSICAL EPHEMERIS 2003, 0 hr UT**

| Date | Cent Mer° | Tilt° | Phase | Phase Angle | P.A.° | Date | Cent Mer° | Tilt° | Phase | Phase Angle | P.A.° |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul 1 | 137.8 | -21.3 | 0.899 | 37.1 | 346.6 | Sep 1 | 294.2 | -19.0 | 0.998 | 5.6 | 346.9 |
| Jul 3 | 118.9 | -21.3 | 0.902 | 36.5 | 346.2 | Sep 3 | 276.6 | -19.0 | 0.997 | 6.6 | 347.3 |
| Jul 5 | 100.1 | -21.3 | 0.905 | 35.9 | 345.9 | Sep 5 | 258.9 | -19.0 | 0.995 | 8.0 | 347.6 |
| Jul 7 | 081.3 | -21.2 | 0.909 | 35.2 | 345.5 | Sep 7 | 241.2 | -19.0 | 0.993 | 9.4 | 347.9 |
| Jul 9 | 062.5 | -21.2 | 0.912 | 34.5 | 345.2 | Sep 9 | 223.4 | -19.0 | 0.991 | 10.9 | 348.2 |
| Jul 11 | 043.8 | -21.1 | 0.916 | 33.7 | 344.9 | Sep 11 | 205.6 | -19.1 | 0.988 | 12.4 | 348.4 |
| Jul 13 | 025.2 | -21.0 | 0.920 | 32.9 | 344.6 | Sep 13 | 187.8 | -19.1 | 0.985 | 13.9 | 348.7 |
| Jul 15 | 006.5 | -21.0 | 0.924 | 32.1 | 344.4 | Sep 15 | 170.0 | -19.2 | 0.982 | 15.4 | 348.9 |
| Jul 17 | 348.0 | -20.9 | 0.928 | 31.2 | 344.2 | Sep 17 | 152.1 | -19.3 | 0.978 | 16.9 | 349.1 |
| Jul 19 | 329.4 | -20.8 | 0.932 | 30.3 | 344.0 | Sep 19 | 134.1 | -19.4 | 0.975 | 18.3 | 349.3 |
| Jul 21 | 311.0 | -20.7 | 0.936 | 29.3 | 343.8 | Sep 21 | 116.1 | -19.5 | 0.971 | 19.7 | 349.4 |
| Jul 23 | 292.6 | -20.6 | 0.940 | 28.3 | 343.7 | Sep 23 | 098.1 | -19.6 | 0.967 | 21.1 | 349.5 |
| Jul 25 | 274.2 | -20.5 | 0.945 | 27.2 | 343.6 | Sep 25 | 080.0 | -19.8 | 0.962 | 22.4 | 349.6 |
| Jul 27 | 255.9 | -20.4 | 0.949 | 26.0 | 343.5 | Sep 27 | 061.8 | -19.9 | 0.958 | 23.6 | 349.7 |
| Jul 29 | 237.6 | -20.3 | 0.954 | 24.9 | 343.5 | Sep 29 | 043.6 | -20.1 | 0.954 | 24.8 | 349.7 |
| Jul 31 | 219.4 | -20.2 | 0.958 | 23.6 | 343.5 | Oct 1 | 025.3 | -20.3 | 0.949 | 26.0 | 349.7 |
| Aug 2 | 201.3 | -20.1 | 0.963 | 22.3 | 343.5 | Oct 3 | 007.0 | -20.4 | 0.945 | 27.1 | 349.6 |
| Aug 4 | 183.2 | -20.0 | 0.967 | 21.0 | 343.6 | Oct 5 | 348.6 | -20.6 | 0.941 | 28.2 | 349.5 |
| Aug 6 | 165.2 | -19.9 | 0.971 | 19.6 | 343.7 | Oct 7 | 330.1 | -20.8 | 0.937 | 29.2 | 349.4 |
| Aug 8 | 147.2 | -19.8 | 0.975 | 18.2 | 343.8 | Oct 9 | 311.6 | -21.0 | 0.932 | 30.1 | 349.3 |
| Aug 10 | 129.3 | -19.7 | 0.979 | 16.7 | 343.9 | Oct 11 | 293.1 | -21.2 | 0.928 | 31.0 | 349.1 |
| Aug 12 | 111.4 | -19.6 | 0.982 | 15.2 | 344.1 | Oct 13 | 274.5 | -21.5 | 0.924 | 31.9 | 348.9 |
| Aug 14 | 093.6 | -19.5 | 0.986 | 13.7 | 344.3 | Oct 15 | 255.8 | -21.7 | 0.921 | 32.7 | 348.6 |
| Aug 16 | 075.8 | -19.4 | 0.989 | 12.2 | 344.5 | Oct 17 | 237.1 | -21.9 | 0.917 | 33.5 | 348.4 |
| Aug 18 | 058.0 | -19.3 | 0.991 | 10.7 | 344.8 | Oct 19 | 218.4 | -22.1 | 0.913 | 34.2 | 348.1 |
| Aug 20 | 040.3 | -19.2 | 0.994 | 9.2 | 345.1 | Oct 21 | 199.6 | -22.4 | 0.910 | 34.9 | 347.8 |
| Aug 22 | 022.6 | -19.2 | 0.995 | 7.8 | 345.3 | Oct 23 | 180.7 | -22.6 | 0.907 | 35.6 | 347.4 |
| Aug 24 | 004.9 | -19.1 | 0.997 | 6.5 | 345.6 | Oct 25 | 161.9 | -22.8 | 0.904 | 36.2 | 347.1 |
| Aug 26 | 347.2 | -19.1 | 0.998 | 5.5 | 346.0 | Oct 27 | 142.9 | -23.0 | 0.901 | 36.7 | 346.7 |
| Aug 28 | 329.6 | -19.0 | 0.998 | 4.9 | 346.3 | Oct 29 | 124.0 | -23.3 | 0.898 | 37.3 | 346.3 |
| Aug 30 | 311.9 | -19.0 | 0.998 | 4.9 | 346.6 | Oct 31 | 105.0 | -23.5 | 0.895 | 37.8 | 345.9 |

Figure 1. **ASPECTS of MARS - OPPOSITION 2001**




**Cent. Mer.:** Longitude of central meridian is the longitude that is centred on the disc.

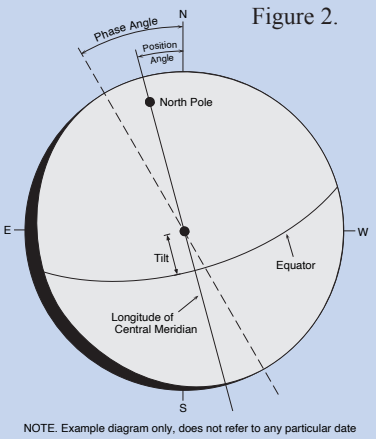
**Tilt:** (or Sub-Earth latitude) is the number of degrees that Mars' north pole is tilted towards (positive value) or away (negative value) as seen from the Earth. It is also equal to the latitude of the centre of the disc.

**Phase:** The fraction of the disc of Mars illuminated by the Sun, 1.0 would be the entire disc. At opposition the phase is at maximum.

**Phase Angle:** The number of degrees (east of north) the phase is rotated.

**P.A.:** Position Angle is the number of degrees (east of north) that Mars' north pole is rotated from north.

Figure 2.




NOTE. Example diagram only, does not refer to any particular date

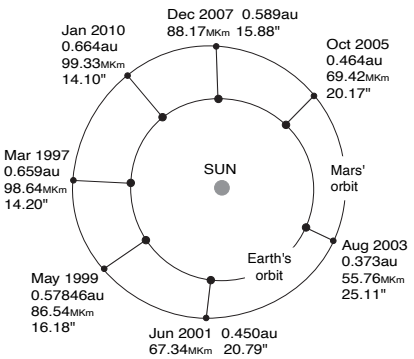



*Figure 3:* ***Oppositions from 1997 to 2010*** *Shown under each date is the Earth/Mars distance in astronomical units and millions of kilometres (Mkm), plus the angular diameter in seconds of arc*

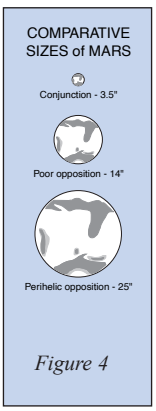



*Figure 4*

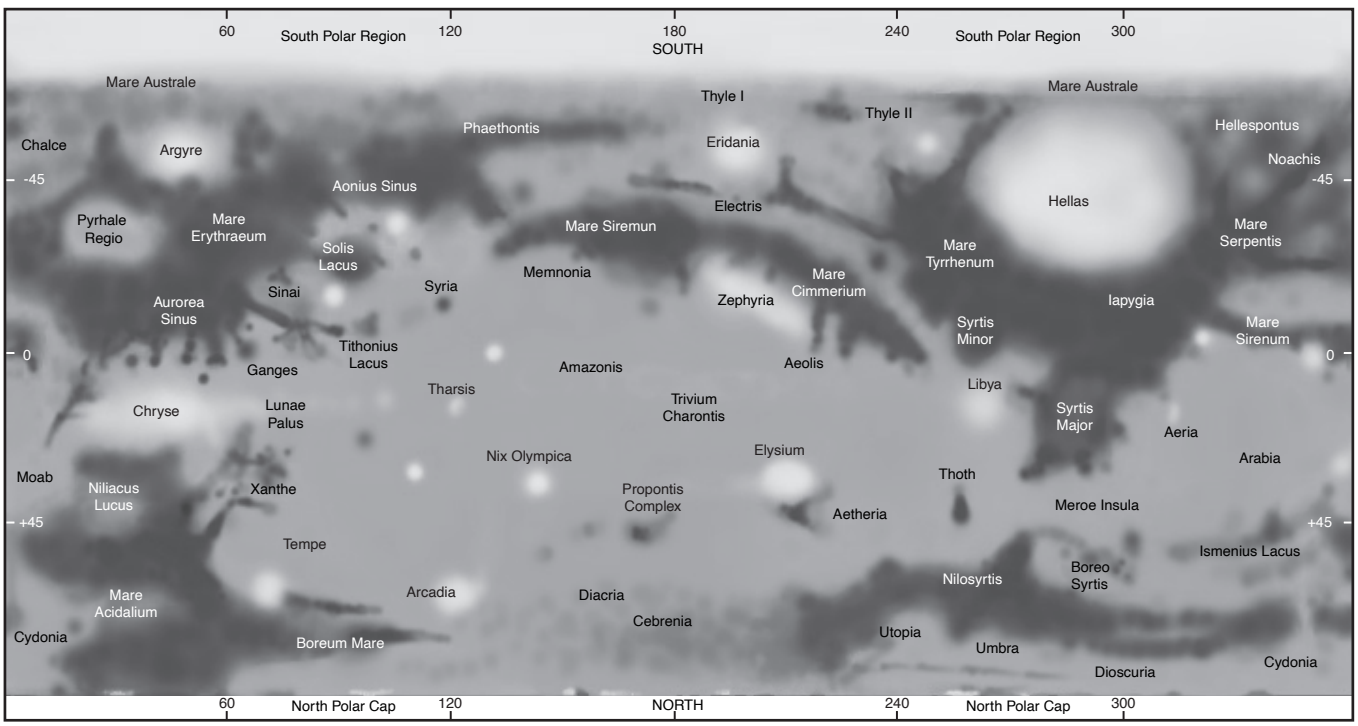
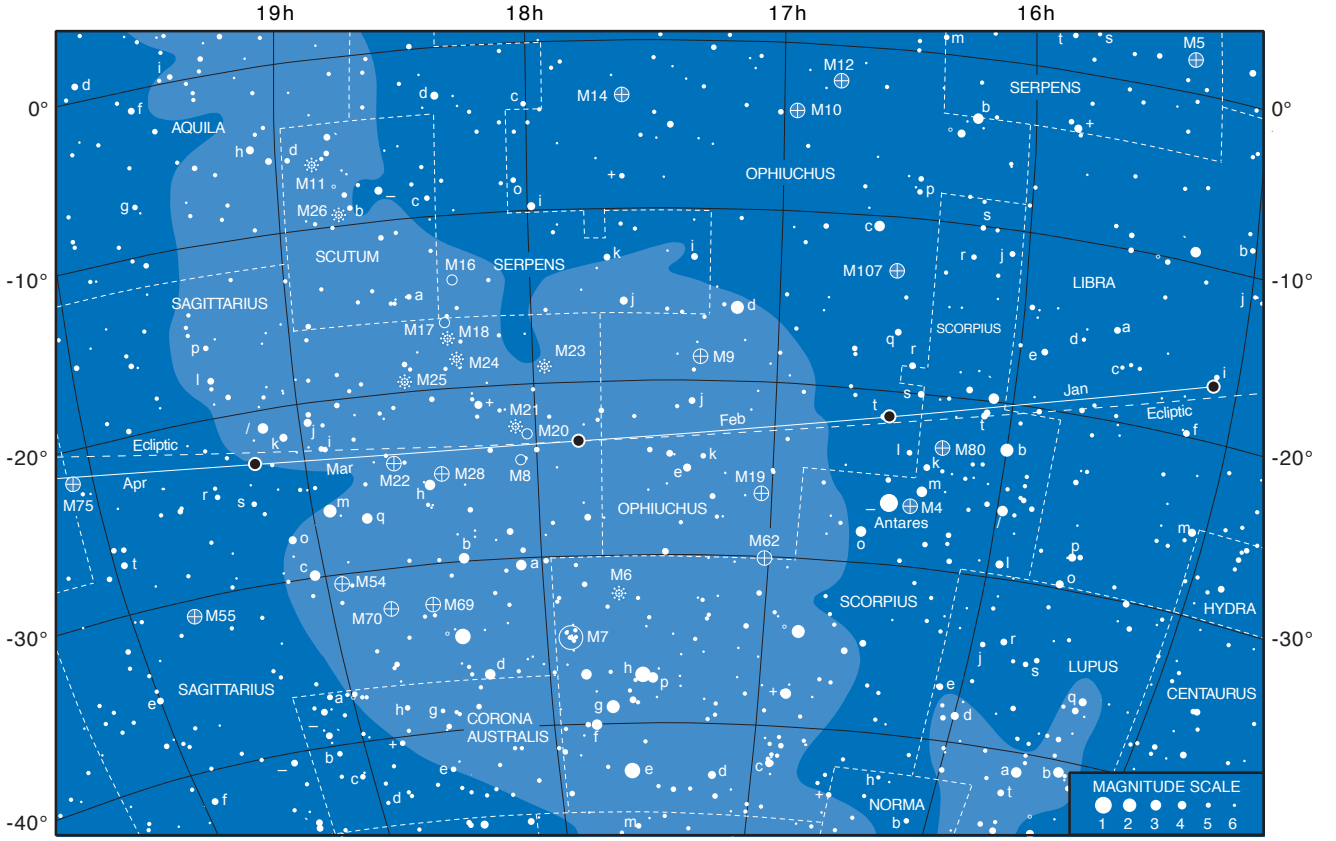
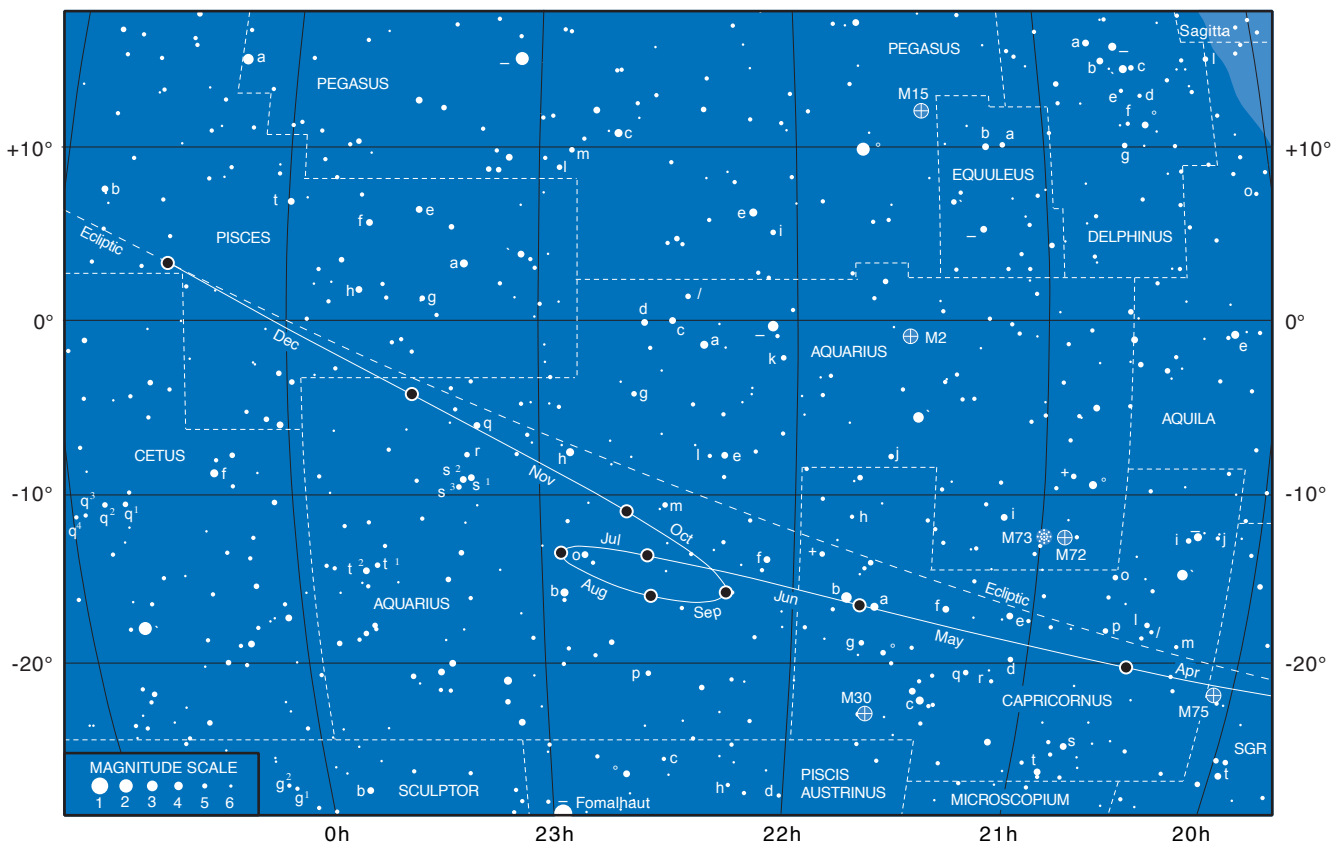



*Figure 5. Mars map courtesy of Dan Troiani, Association of Lunar and Planetary Observers, Mars Section Head Coordinator. The map was assembled using CCD images, videos, drawings and photographs taken during the 1997 apparition by observers of the ALPO International Mars Patrol and MarsWatch '97. Dan used over 1,700 observations to create the map. The white areas are where clouds are frequently observed.*

# MARS FINDER CHART




Stationary 31st July, Opposition 29th August, Stationary 30th September.



# JUPITER

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

## POSITION

(0hrs UT Epoch 2000.0)

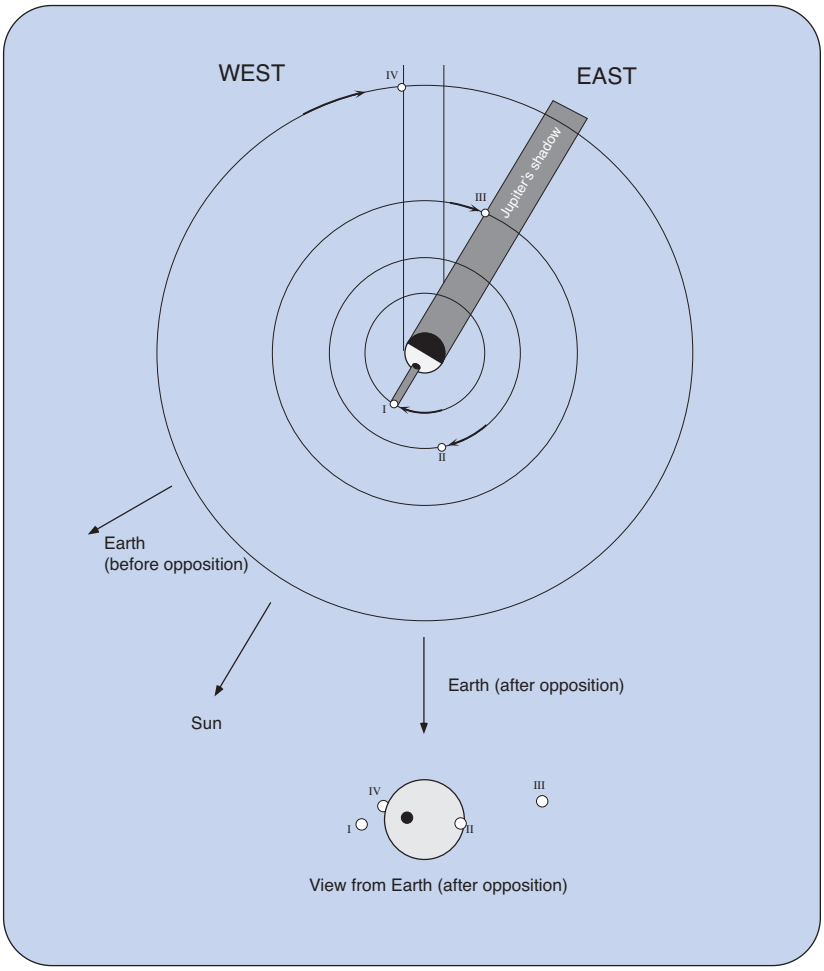
| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | | RA | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | h m s | ° ' " |
| Jan | 4 | 21:23 | 07:55 | 20:44 | 07:40 | 21:12 | 07:43 | 21:22 | 08:59 | 21:34 | 07:35 | 21:33 | 07:54 | 21:19 | 08:01 | 21:01 | 07:37 | 09 17 06 | + 16 36 46 |
| | 11 | 20:53 | 07:24 | 20:14 | 07:09 | 20:42 | 07:12 | 20:51 | 08:28 | 21:05 | 07:04 | 21:03 | 07:23 | 20:49 | 07:30 | 20:31 | 07:06 | 09 14 17 | + 16 50 56 |
| | 18 | 20:24 | 06:53 | 19:44 | 06:38 | 20:12 | 06:40 | 20:21 | 07:57 | 20:35 | 06:32 | 20:34 | 06:52 | 20:19 | 06:59 | 20:01 | 06:34 | 09 11 04 | + 17 06 36 |
| | 25 | 19:53 | 06:21 | 19:13 | 06:06 | 19:42 | 06:08 | 19:50 | 07:26 | 20:05 | 06:00 | 20:03 | 06:20 | 19:49 | 06:27 | 19:31 | 06:02 | 09 07 33 | + 17 23 09 |
| Feb | 1 | 19:23 | 05:49 | 18:43 | 05:34 | 19:12 | 05:36 | 19:19 | 06:55 | 19:35 | 05:28 | 19:33 | 05:48 | 19:18 | 05:55 | 19:01 | 05:30 | 09 03 51 | + 17 40 02 |
| | 8 | 18:53 | 05:17 | 18:12 | 05:02 | 18:41 | 05:04 | 18:48 | 06:23 | 19:05 | 04:55 | 19:03 | 05:15 | 18:48 | 05:23 | 18:30 | 04:58 | 09 00 07 | + 17 56 35 |
| | 15 | 18:22 | 04:45 | 17:41 | 04:31 | 18:11 | 04:32 | 18:17 | 05:52 | 18:35 | 04:23 | 18:33 | 04:43 | 18:17 | 04:51 | 18:00 | 04:26 | 08 56 29 | + 18 12 14 |
| | 22 | 17:52 | 04:13 | 17:11 | 03:59 | 17:41 | 04:00 | 17:47 | 05:21 | 18:05 | 03:51 | 18:03 | 04:12 | 17:47 | 04:20 | 17:30 | 03:55 | 08 53 05 | + 18 26 28 |
| Mar | 1 | 17:22 | 03:42 | 16:41 | 03:28 | 17:11 | 03:29 | 17:16 | 04:50 | 17:36 | 03:20 | 17:33 | 03:40 | 17:17 | 03:48 | 17:00 | 03:23 | 08 50 01 | + 18 38 53 |
| | 8 | 16:53 | 03:11 | 16:11 | 02:58 | 16:41 | 02:59 | 16:46 | 04:19 | 17:06 | 02:49 | 17:03 | 03:10 | 16:48 | 03:18 | 16:30 | 02:53 | 08 47 24 | + 18 49 11 |
| | 15 | 16:24 | 02:41 | 15:42 | 02:28 | 16:12 | 02:28 | 16:17 | 03:50 | 16:37 | 02:19 | 16:34 | 02:39 | 16:18 | 02:48 | 16:01 | 02:23 | 08 45 19 | + 18 57 09 |
| | 22 | 15:55 | 02:12 | 15:13 | 01:58 | 15:44 | 01:59 | 15:48 | 03:21 | 16:09 | 01:49 | 16:06 | 02:10 | 15:50 | 02:18 | 15:32 | 01:53 | 08 43 49 | + 19 02 39 |
| | 29 | 15:27 | 01:43 | 14:45 | 01:30 | 15:15 | 01:31 | 15:20 | 02:52 | 15:41 | 01:21 | 15:37 | 01:41 | 15:21 | 01:50 | 15:04 | 01:25 | 08 42 56 | + 19 05 40 |
| Apr | 5 | 14:59 | 01:15 | 14:17 | 01:02 | 14:48 | 01:03 | 14:52 | 02:24 | 15:13 | 00:53 | 15:10 | 01:14 | 14:54 | 01:22 | 14:36 | 00:57 | 08 42 41 | + 19 06 11 |
| | 12 | 14:32 | 00:48 | 13:50 | 00:35 | 14:20 | 00:36 | 14:25 | 01:57 | 14:46 | 00:26 | 14:42 | 00:47 | 14:27 | 00:55 | 14:09 | 00:30 | 08 43 05 | + 19 04 14 |
| | 19 | 14:05 | 00:22 | 13:23 | 00:08 | 13:54 | 00:09 | 13:58 | 01:31 | 14:19 | 23:56 | 14:16 | 00:20 | 14:00 | 00:29 | 13:42 | 00:04 | 08 44 05 | + 18 59 54 |
| | 26 | 13:39 | 23:53 | 12:57 | 23:39 | 13:27 | 23:40 | 13:32 | 01:05 | 13:52 | 23:30 | 13:49 | 23:51 | 13:34 | 23:59 | 13:16 | 23:34 | 08 45 41 | + 18 53 16 |
| May | 3 | 13:13 | 23:28 | 12:32 | 23:14 | 13:01 | 23:15 | 13:07 | 00:40 | 13:26 | 23:06 | 13:23 | 23:26 | 13:08 | 23:34 | 12:50 | 23:09 | 08 47 50 | + 18 44 25 |
| | 10 | 12:47 | 23:03 | 12:06 | 22:50 | 12:36 | 22:51 | 12:42 | 00:15 | 13:01 | 22:42 | 12:58 | 23:02 | 12:42 | 23:10 | 12:25 | 22:45 | 08 50 30 | + 18 33 25 |
| | 17 | 12:22 | 22:40 | 11:41 | 22:26 | 12:11 | 22:27 | 12:17 | 23:47 | 12:35 | 22:18 | 12:33 | 22:38 | 12:17 | 22:46 | 12:00 | 22:21 | 08 53 38 | + 18 20 22 |
| | 24 | 11:58 | 22:17 | 11:17 | 22:03 | 11:46 | 22:04 | 11:53 | 23:23 | 12:10 | 21:55 | 12:08 | 22:15 | 11:53 | 22:23 | 11:35 | 21:58 | 08 57 13 | + 18 05 22 |
| | 31 | 11:33 | 21:54 | 10:53 | 21:40 | 11:22 | 21:41 | 11:29 | 23:00 | 11:46 | 21:33 | 11:43 | 21:53 | 11:28 | 22:00 | 11:11 | 21:36 | 09 01 11 | + 17 48 30 |
| Jun | 7 | 11:09 | 21:32 | 10:29 | 21:17 | 10:58 | 21:19 | 11:06 | 22:37 | 11:21 | 21:11 | 11:19 | 21:31 | 11:04 | 21:38 | 10:47 | 21:13 | 09 05 30 | + 17 29 51 |
| | 14 | 10:45 | 21:10 | 10:05 | 20:55 | 10:34 | 20:57 | 10:42 | 22:15 | 10:57 | 20:50 | 10:55 | 21:09 | 10:40 | 21:16 | 10:23 | 20:51 | 09 10 07 | + 17 09 30 |
| | 21 | 10:21 | 20:48 | 09:41 | 20:33 | 10:10 | 20:36 | 10:19 | 21:52 | 10:33 | 20:28 | 10:31 | 20:48 | 10:17 | 20:55 | 09:59 | 20:30 | 09 15 00 | + 16 47 33 |
| | 28 | 09:57 | 20:27 | 09:18 | 20:12 | 09:46 | 20:15 | 09:56 | 21:30 | 10:09 | 20:08 | 10:07 | 20:27 | 09:53 | 20:33 | 09:35 | 20:09 | 09 20 07 | + 16 24 06 |
| Jul | 5 | 09:34 | 20:06 | 08:55 | 19:50 | 09:23 | 19:54 | 09:34 | 21:09 | 09:45 | 19:47 | 09:44 | 20:06 | 09:30 | 20:12 | 09:12 | 19:48 | 09 25 27 | + 15 59 13 |
| | 12 | 09:11 | 19:45 | 08:32 | 19:29 | 08:59 | 19:33 | 09:11 | 20:47 | 09:21 | 19:27 | 09:20 | 19:45 | 09:07 | 19:51 | 08:49 | 19:27 | 09 30 56 | + 15 33 03 |
| | 19 | 08:47 | 19:25 | 08:09 | 19:08 | 08:36 | 19:13 | 08:49 | 20:25 | 08:57 | 19:07 | 08:57 | 19:25 | 08:44 | 19:31 | 08:25 | 19:06 | 09 36 33 | + 15 05 42 |
| | 26 | 08:24 | 19:05 | 07:46 | 18:48 | 08:13 | 18:52 | 08:27 | 20:04 | 08:33 | 18:47 | 08:33 | 19:05 | 08:20 | 19:10 | 08:02 | 18:46 | 09 42 17 | + 14 37 17 |
| Aug | 2 | 08:01 | 18:44 | 07:23 | 18:27 | 07:49 | 18:32 | 08:05 | 19:43 | 08:10 | 18:27 | 08:10 | 18:44 | 07:57 | 18:50 | 07:39 | 18:25 | 09 48 05 | + 14 07 53 |
| | 9 | 07:38 | 18:24 | 07:00 | 18:06 | 07:26 | 18:12 | 07:42 | 19:21 | 07:46 | 18:07 | 07:46 | 18:24 | 07:34 | 18:29 | 07:16 | 18:05 | 09 53 57 | + 13 37 42 |
| | 16 | 07:14 | 18:04 | 06:38 | 17:46 | 07:03 | 17:52 | 07:20 | 19:00 | 07:22 | 17:48 | 07:23 | 18:04 | 07:11 | 18:09 | 06:53 | 17:45 | 09 59 49 | + 13 06 50 |
| | 23 | 06:51 | 17:44 | 06:15 | 17:25 | 06:40 | 17:32 | 06:58 | 18:39 | 06:58 | 17:28 | 07:00 | 17:45 | 06:48 | 17:49 | 06:29 | 17:25 | 10 05 42 | + 12 35 27 |
| | 30 | 06:28 | 17:24 | 05:52 | 17:05 | 06:16 | 17:11 | 06:36 | 18:18 | 06:35 | 17:09 | 06:36 | 17:25 | 06:25 | 17:28 | 06:06 | 17:05 | 10 11 34 | + 12 03 42 |
| Sep | 6 | 06:05 | 17:04 | 05:29 | 16:44 | 05:53 | 16:51 | 06:14 | 17:57 | 06:11 | 16:49 | 06:13 | 17:05 | 06:02 | 17:08 | 05:43 | 16:44 | 10 17 22 | + 11 31 46 |
| | 13 | 05:41 | 16:43 | 05:06 | 16:24 | 05:30 | 16:31 | 05:51 | 17:35 | 05:47 | 16:29 | 05:49 | 16:44 | 05:39 | 16:47 | 05:20 | 16:24 | 10 23 06 | + 10 59 49 |
| | 20 | 05:18 | 16:23 | 04:43 | 16:03 | 05:06 | 16:11 | 05:29 | 17:14 | 05:23 | 16:09 | 05:26 | 16:24 | 05:16 | 16:27 | 04:56 | 16:04 | 10 28 44 | + 10 28 03 |
| | 27 | 04:54 | 16:02 | 04:20 | 15:42 | 04:43 | 15:50 | 05:07 | 16:52 | 04:59 | 15:49 | 05:02 | 16:04 | 04:52 | 16:06 | 04:33 | 15:43 | 10 34 15 | + 09 56 39 |
| Oct | 4 | 04:31 | 15:42 | 03:57 | 15:21 | 04:19 | 15:29 | 04:44 | 16:31 | 04:35 | 15:29 | 04:38 | 15:43 | 04:29 | 15:45 | 04:09 | 15:22 | 10 39 37 | + 09 25 51 |
| | 11 | 04:07 | 15:21 | 03:33 | 14:59 | 03:55 | 15:08 | 04:21 | 16:09 | 04:10 | 15:09 | 04:14 | 15:23 | 04:05 | 15:24 | 03:46 | 15:01 | 10 44 47 | + 08 55 52 |
| | 18 | 03:43 | 14:59 | 03:10 | 14:38 | 03:31 | 14:47 | 03:58 | 15:46 | 03:46 | 14:48 | 03:50 | 15:02 | 03:41 | 15:03 | 03:22 | 14:40 | 10 49 45 | + 08 26 57 |
| | 25 | 03:19 | 14:38 | 02:46 | 14:16 | 03:07 | 14:26 | 03:35 | 15:24 | 03:22 | 14:27 | 03:26 | 14:40 | 03:17 | 14:41 | 02:58 | 14:18 | 10 54 29 | + 07 59 19 |
| Nov | 1 | 02:54 | 14:16 | 02:22 | 13:54 | 02:43 | 14:04 | 03:11 | 15:01 | 02:57 | 14:05 | 03:01 | 14:18 | 02:53 | 14:19 | 02:33 | 13:57 | 10 58 56 | + 07 33 15 |
| | 8 | 02:30 | 13:54 | 01:58 | 13:31 | 02:18 | 13:42 | 02:48 | 14:38 | 02:32 | 13:43 | 02:37 | 13:56 | 02:29 | 13:57 | 02:09 | 13:34 | 11 03 05 | + 07 09 01 |
| | 15 | 02:05 | 13:31 | 01:33 | 13:08 | 01:53 | 13:19 | 02:24 | 14:15 | 02:07 | 13:21 | 02:12 | 13:34 | 02:04 | 13:34 | 01:44 | 13:11 | 11 06 53 | + 06 46 52 |
| | 22 | 01:40 | 13:08 | 01:08 | 12:45 | 01:28 | 12:56 | 01:59 | 13:51 | 01:41 | 12:58 | 01:47 | 13:11 | 01:39 | 13:11 | 01:19 | 12:48 | 11 10 19 | + 06 27 04 |
| | 29 | 01:15 | 12:44 | 00:43 | 12:21 | 01:03 | 12:32 | 01:35 | 13:27 | 01:16 | 12:35 | 01:21 | 12:47 | 01:14 | 12:47 | 00:54 | 12:24 | 11 13 20 | + 06 09 54 |
| Dec | 6 | 00:49 | 12:20 | 00:18 | 11:56 | 00:37 | 12:08 | 01:09 | 13:02 | 00:50 | 12:11 | 00:56 | 12:23 | 00:48 | 12:22 | 00:28 | 12:00 | 11 15 53 | + 05 55 39 |
| | 13 | 00:23 | 11:55 | 23:48 | 11:31 | 00:11 | 11:43 | 00:44 | 12:37 | 00:24 | 11:46 | 00:29 | 11:58 | 00:22 | 11:57 | 23:59 | 11:35 | 11 17 57 | + 05 44 32 |
| | 20 | 23:53 | 11:29 | 23:22 | 11:06 | 23:41 | 11:17 | 00:18 | 12:11 | 23:54 | 11:20 | 23:59 | 11:32 | 23:52 | 11:32 | 23:32 | 11:10 | 11 19 29 | + 05 36 46 |
| | 27 | 23:26 | 11:03 | 22:55 | 10:39 | 23:15 | 10:51 | 23:47 | 11:44 | 23:27 | 10:54 | 23:33 | 11:06 | 23:26 | 11:05 | 23:05 | 10:43 | 11 20 29 | + 05 32 33 |

# JUPITER'S MOONS 2003

Jupiter and its moons can be likened to a miniature solar system with its many moons orbiting the planet. Also, like the planets, these moons all lie in a similar plane. Although there are currently 39 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo (who suggested calling them the 'Medicean Stars'), are bright enough to be visible in small telescopes (or moderate sized binoculars). The dance of these moons, as they pass back and forth across Jupiter, is illustrated in the monthly 'Jupiter's Moons' on pages 106-107. All the moons orbit in roughly the same plane, which is very close to the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From our perspective on Earth, we see four types of events. They are:

1 The satellite passes in front of Jupiter. This is called a **Satellite Transit**.
2 The shadow of a satellite can move across the 'surface' of the planet. This is called a **Satellite Shadow Transit.** The start of a satellite or shadow transit is called its ingress, the finish, its egress.
Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter's opposition date in 2003 is February 2nd.
3 A satellite can go into **occultation** i.e., pass behind the disc of Jupiter.
4 A satellite can be **eclipsed** as it passes into Jupiter's shadow. The closer Jupiter is to opposition (or conjunction), the more likely the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. In fact, Io is so close to Jupiter, it is impossible to see both the disappearance and reappearance for the same eclipse. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram opposite.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7X power or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation). This happens every 8 days approximately; an example would be the evening of January 5th. To see the moons, with binoculars, may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.




The diagram above illustrates all of the Jupiter satellite events. It is only an example and does not represent any particular date. Viewed from the Earth (after opposition):

**Satellite I**'s (Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.

**Satellite II** (Europa) has just commenced a satellite transit (ingress).

**Satellite III** (Ganymede) is about to be eclipsed (disappear).

**Satellite IV** (Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

**JUPITER'S MOON EVENTS Legend (pp. 103-105)**

Column 1 Date (only appears for the first event each day).
Column 2 Time in EST.
Column 3 Time in WST, a (p) after the time means it is on the previous day.
Column 4 I = Io, II = Europa, III = Ganymede, IV = Callisto
Column 5 OC = Occultation, SH = Shadow Transit, TR = Satellite Transit, EC = Eclipse
Column 6 I = Ingress, E = Egress, D = Disappearance, R = Reappearance
Column 7 Visibility where 'E' indicates the event is more suitable for the eastern states, 'W' is for events more suitable for observation from the western states. A blank here means the event is suitable for most of Australia.

**Note:** In these tables, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia.

# JUPITER MOON EVENTS

## January

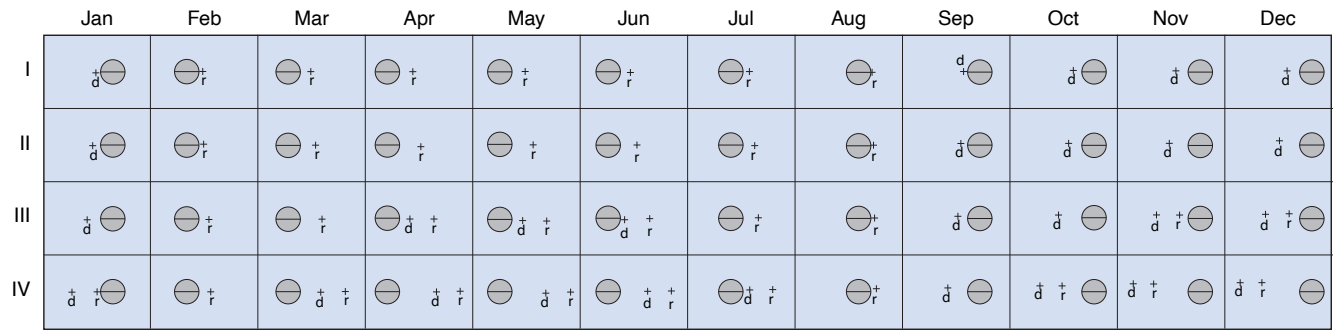
| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 03:52 | 01:52 | II | Sh | I | |
| | 04:44 | 02:44 | I | Sh | I | |
| | 05:17 | 03:17 | II | Tr | I | |
| | 05:25 | 03:25 | I | Tr | I | W |
| | 06:47 | 04:47 | II | Sh | E | W |
| | 07:01 | 05:01 | I | Sh | E | W |
| 5 | 01:57 | 23:57(p) | I | Ec | D | |
| | 04:56 | 02:56 | I | Oc | R | |
| | 21:31 | 19:31 | III | Ec | D | E |
| | 22:35 | 20:35 | II | Ec | D | |
| | 23:12 | 21:12 | I | Sh | I | |
| | 23:51 | 21:51 | I | Tr | I | |
| 6 | 01:29 | 23:29(p) | I | Sh | E | |
| | 02:09 | 00:09 | I | Tr | E | |
| | 02:45 | 00:45 | II | Oc | R | |
| | 03:50 | 01:50 | III | Oc | R | |
| | 23:23 | 21:23 | I | Oc | R | |
| 7 | 21:22 | 19:22 | II | Tr | E | E |
| 9 | 21:35 | 19:35 | IV | Ec | R | E |
| | 22:12 | 20:12 | IV | Oc | D | |
| 10 | 03:03 | 01:03 | IV | Oc | R | |
| 11 | 06:29 | 04:29 | II | Sh | I | W |
| | 06:37 | 04:37 | I | Sh | I | W |
| 12 | 03:51 | 01:51 | I | Ec | D | |
| | 06:41 | 04:41 | I | Oc | R | W |
| 13 | 01:06 | 23:06(p) | I | Sh | I | |
| | 01:09 | 23:09(p) | II | Ec | D | |
| | 01:30 | 23:30(p) | III | Ec | D | |
| | 01:36 | 23:36(p) | I | Tr | I | |
| | 03:23 | 01:23 | I | Sh | E | |
| | 03:53 | 01:53 | I | Tr | E | |
| | 05:00 | 03:00 | II | Oc | R | |
| | 22:20 | 20:20 | I | Ec | D | |
| 14 | 01:07 | 23:07(p) | I | Oc | R | |
| | 20:44 | 18:44 | II | Tr | I | E |
| | 21:51 | 19:51 | I | Sh | E | |
| | 22:19 | 20:19 | I | Tr | E | |
| | 22:42 | 20:42 | II | Sh | E | |
| | 23:39 | 21:39 | II | Tr | E | |
| 16 | 20:43 | 18:43 | III | Tr | E | E |
| 18 | 03:03 | 01:03 | IV | Sh | I | |
| | 06:37 | 04:37 | IV | Tr | I | W |
| 19 | 05:45 | 03:45 | I | Ec | D | W |
| 20 | 02:59 | 00:59 | I | Sh | I | |
| | 03:19 | 01:19 | I | Tr | I | |
| | 03:42 | 01:42 | II | Ec | D | |
| | 05:17 | 03:17 | I | Sh | E | |
| | 05:29 | 03:29 | III | Ec | D | |
| | 05:37 | 03:37 | I | Tr | E | W |
| | 07:14 | 05:14 | II | Oc | R | W |
| 21 | 00:14 | 22:14(p) | I | Ec | D | |
| | 02:52 | 00:52 | I | Oc | R | |
| | 21:28 | 19:28 | I | Sh | I | |
| | 21:45 | 19:45 | I | Tr | I | |
| | 22:24 | 20:24 | II | Sh | I | |
| | 23:00 | 21:00 | II | Tr | I | |
| | 23:45 | 21:45 | I | Sh | E | |
| 22 | 00:02 | 22:02(p) | I | Tr | E | |
| | 01:19 | 23:19(p) | II | Sh | E | |
| | 01:55 | 23:55(p) | II | Tr | E | |
| | 21:18 | 19:18 | I | Oc | R | E |
| 23 | 20:21 | 18:21 | II | Oc | R | E |
| | 20:22 | 18:22 | III | Tr | I | E |
| | 23:00 | 21:00 | III | Sh | E | |
| | 23:59 | 21:59 | III | Tr | E | |
| 27 | 04:53 | 02:53 | I | Sh | I | |
| | 05:03 | 03:03 | I | Tr | I | |
| | 06:16 | 04:16 | II | Ec | D | W |
| | 07:10 | 05:10 | I | Sh | E | W |
| | 07:20 | 05:20 | I | Tr | E | W |
| 28 | 02:08 | 00:08 | I | Ec | D | |
| | 04:35 | 02:35 | I | Oc | R | |
| | 23:21 | 21:21 | I | Sh | I | |
| | 23:29 | 21:29 | I | Tr | I | |
| 29 | 01:01 | 23:01(p) | II | Sh | I | |
| | 01:15 | 23:15(p) | II | Tr | I | |
| | 01:39 | 23:39(p) | I | Sh | E | |
| | 01:46 | 23:46(p) | I | Tr | E | |
| | 03:56 | 01:56 | II | Sh | E | |
| | 04:10 | 02:10 | II | Tr | E | |
| | 20:37 | 18:37 | I | Ec | D | E |
| | 23:01 | 21:01 | I | Oc | R | |
| 30 | 19:33 | 17:33 | II | Ec | D | E |
| | 20:07 | 18:07 | I | Sh | E | E |
| | 20:12 | 18:12 | I | Tr | E | E |
| | 22:34 | 20:34 | II | Oc | R | |
| | 23:22 | 21:22 | III | Sh | I | |
| | 23:38 | 21:38 | III | Tr | I | |
| 31 | 02:59 | 00:59 | III | Sh | E | |
| | 03:15 | 01:15 | III | Tr | E | |

## February

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 06:46 | 04:46 | I | Tr | I | W |
| | 06:47 | 04:47 | I | Sh | I | W |
| | 20:47 | 18:47 | IV | Tr | I | E |
| | 21:03 | 19:03 | IV | Sh | I | E |
| 4 | 01:33 | 23:33(p) | IV | Tr | E | |
| | 01:51 | 23:51(p) | IV | Sh | E | |
| | 04:01 | 02:01 | I | Oc | D | |
| | 06:21 | 04:21 | I | Ec | R | W |
| 5 | 01:12 | 23:12(p) | I | Tr | I | |
| | 01:15 | 23:15(p) | I | Sh | I | |
| | 03:29 | 01:29 | I | Tr | E | |
| | 03:30 | 01:30 | II | Tr | I | |
| | 03:33 | 01:33 | I | Sh | E | |
| | 03:38 | 01:38 | II | Sh | I | |
| | 06:25 | 04:25 | II | Tr | E | W |
| | 06:33 | 04:33 | II | Sh | E | W |
| | 22:27 | 20:27 | I | Oc | D | |
| 6 | 00:50 | 22:50(p) | I | Ec | R | |
| | 19:38 | 17:38 | I | Tr | I | E |
| | 19:44 | 17:44 | I | Sh | I | E |
| | 21:55 | 19:55 | II | Oc | D | |
| | 21:55 | 19:55 | I | Tr | E | |
| | 22:01 | 20:01 | I | Sh | E | |
| 7 | 00:59 | 22:59(p) | II | Ec | R | |
| | 02:54 | 00:54 | III | Tr | I | |
| | 03:21 | 01:21 | III | Sh | I | |
| | 06:31 | 04:31 | III | Tr | E | W |
| | 06:58 | 04:58 | III | Sh | E | W |
| | 19:19 | 17:19 | I | Ec | R | E |
| 8 | 19:32 | 17:32 | II | Tr | E | E |
| | 19:51 | 17:51 | II | Sh | E | E |
| 10 | 21:04 | 19:04 | III | Ec | R | |
| 11 | 05:45 | 03:45 | I | Oc | D | W |
| 12 | 02:33 | 00:33 | IV | Oc | D | |
| | 02:55 | 00:55 | I | Tr | I | |
| | 03:09 | 01:09 | I | Sh | I | |
| | 05:13 | 03:13 | I | Tr | E | W |
| | 05:27 | 03:27 | I | Sh | E | W |
| | 05:46 | 03:46 | II | Tr | I | W |
| | 06:15 | 04:15 | II | Sh | I | W |
| 13 | 00:11 | 22:11(p) | I | Oc | D | |
| | 02:45 | 00:45 | I | Ec | R | |
| | 21:21 | 19:21 | I | Tr | I | |
| | 21:38 | 19:38 | I | Sh | I | |
| | 23:39 | 21:39 | I | Tr | E | |
| | 23:55 | 21:55 | I | Sh | E | |
| 14 | 00:08 | 22:08(p) | II | Oc | D | |
| | 03:33 | 01:33 | II | Ec | R | |
| | 06:10 | 04:10 | III | Tr | I | W |
| | 18:37 | 16:37 | I | Oc | D | E |
| | 21:13 | 19:13 | I | Ec | R | |
| 15 | 18:53 | 16:53 | II | Tr | I | E |
| | 19:33 | 17:33 | II | Sh | I | E |
| | 21:48 | 19:48 | II | Tr | E | |
| | 22:27 | 20:27 | II | Sh | E | |
| 17 | 19:53 | 17:53 | III | Oc | D | E |
| 18 | 01:03 | 23:03(p) | III | Ec | R | |
| 19 | 04:39 | 02:39 | I | Tr | I | W |
| | 05:03 | 03:03 | I | Sh | I | W |
| 20 | 01:55 | 23:55(p) | I | Oc | D | |
| | 04:40 | 02:40 | I | Ec | R | W |
| | 19:51 | 17:51 | IV | Sh | E | E |
| | 23:06 | 21:06 | I | Tr | I | |
| | 23:32 | 21:32 | I | Sh | I | |
| 21 | 01:23 | 23:23(p) | I | Tr | E | |
| | 01:49 | 23:49(p) | I | Sh | E | |
| | 02:22 | 00:22 | II | Oc | D | |
| | 20:22 | 18:22 | I | Oc | D | E |
| | 23:08 | 21:08 | I | Ec | R | |
| 22 | 19:49 | 17:49 | I | Tr | E | E |
| | 20:18 | 18:18 | I | Sh | E | E |
| | 21:10 | 19:10 | II | Tr | I | |
| | 22:10 | 20:10 | II | Sh | I | |
| 23 | 00:04 | 22:04(p) | II | Tr | E | |
| | 01:04 | 23:04(p) | II | Sh | E | |
| 24 | 19:25 | 17:25 | II | Ec | R | E |
| | 23:13 | 21:13 | III | Oc | D | |
| 25 | 05:03 | 03:03 | III | Ec | R | W |
| 27 | 03:41 | 01:41 | I | Oc | D | W |
| 28 | 00:50 | 22:50(p) | I | Tr | I | |
| | 01:26 | 23:26(p) | I | Sh | I | |
| | 03:08 | 01:08 | I | Tr | E | |
| | 03:44 | 01:44 | I | Sh | E | W |
| | 04:38 | 02:38 | II | Oc | D | W |
| | 18:54 | 16:54 | III | Sh | E | E |
| | 21:45 | 19:45 | IV | Oc | R | |
| | 22:07 | 20:07 | I | Oc | D | |
| | 22:49 | 20:49 | IV | Ec | D | |

continued on p. 104

# ECLIPSE POSITIONS OF JUPITER'S MOONS




These diagrams shows the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse is when the moon passes into (disappearance or 'd') or out of (reappearance or 'r') Jupiter's shadow. West to the left, east to the right.

# JUPITER MOON EVENTS

## March

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 01:03 | 23:03(p) | I | Ec | R | |
| | 03:43 | 01:43 | IV | Ec | R | W |
| | 19:17 | 17:17 | I | Tr | I | E |
| | 19:55 | 17:55 | I | Sh | I | E |
| | 21:34 | 19:34 | I | Tr | E | |
| | 22:12 | 20:12 | I | Sh | E | |
| | 23:28 | 21:28 | II | Tr | I | |
| 2 | 00:47 | 22:47(p) | II | Sh | I | |
| | 02:22 | 00:22 | II | Tr | E | |
| | 03:41 | 01:41 | II | Sh | E | W |
| | 19:32 | 17:32 | I | Ec | R | E |
| 3 | 22:00 | 20:00 | II | Ec | R | |
| 4 | 02:36 | 00:36 | III | Oc | D | |
| 7 | 02:36 | 00:36 | I | Tr | I | |
| | 03:21 | 01:21 | I | Sh | I | W |
| | 04:54 | 02:54 | I | Tr | E | W |
| | 19:16 | 17:16 | III | Sh | I | E |
| | 19:49 | 17:49 | III | Tr | E | E |
| | 22:53 | 20:53 | III | Sh | E | |
| | 23:53 | 21:53 | I | Oc | D | |
| 8 | 02:58 | 00:58 | I | Ec | R | W |
| | 21:03 | 19:03 | I | Tr | I | |
| | 21:49 | 19:49 | I | Sh | I | |
| | 23:20 | 21:20 | I | Tr | E | |
| 9 | 00:07 | 22:07(p) | I | Sh | E | |
| | 01:42 | 23:42(p) | IV | Tr | I | |
| | 01:48 | 23:48(p) | II | Tr | I | |
| | 03:24 | 01:24 | II | Sh | I | W |
| | 04:42 | 02:42 | II | Tr | E | W |
| | 18:20 | 16:20 | I | Oc | D | E |
| | 21:27 | 19:27 | I | Ec | R | |
| 10 | 18:36 | 16:36 | I | Sh | E | E |
| | 20:05 | 18:05 | II | Oc | D | E |
| 11 | 00:35 | 22:35(p) | II | Ec | R | |
| 12 | 19:37 | 17:37 | II | Sh | E | E |
| 14 | 04:23 | 02:23 | I | Tr | I | W |
| | 19:40 | 17:40 | III | Tr | I | E |
| | 23:15 | 21:15 | III | Sh | I | |
| | 23:16 | 21:16 | III | Tr | E | |
| 15 | 01:41 | 23:41(p) | I | Oc | D | |
| | 02:53 | 00:53 | III | Sh | E | W |
| | 22:50 | 20:50 | I | Tr | I | |
| | 23:44 | 21:44 | I | Sh | I | |
| 16 | 01:07 | 23:07(p) | I | Tr | E | |
| | 02:02 | 00:02 | I | Sh | E | |
| | 04:09 | 02:09 | II | Tr | I | W |
| | 20:08 | 18:08 | I | Oc | D | E |
| | 23:22 | 21:22 | I | Ec | R | |
| 17 | 18:13 | 16:13 | I | Sh | I | E |
| | 19:34 | 17:34 | I | Tr | E | E |
| | 20:30 | 18:30 | I | Sh | E | |
| | 21:46 | 19:46 | IV | Ec | R | |
| | 22:25 | 20:25 | II | Oc | D | |
| 18 | 03:10 | 01:10 | II | Ec | R | W |
| 19 | 19:20 | 17:20 | II | Sh | I | E |
| | 20:16 | 18:16 | II | Tr | E | |
| | 22:14 | 20:14 | II | Sh | E | |
| 21 | 23:12 | 21:12 | III | Tr | I | |
| 22 | 02:49 | 00:49 | III | Tr | E | W |
| | 03:14 | 01:14 | III | Sh | I | W |
| | 03:29 | 01:29 | I | Oc | D | W |
| 23 | 00:38 | 22:38(p) | I | Tr | I | |
| | 01:39 | 23:39(p) | I | Sh | I | |
| | 02:56 | 00:56 | I | Tr | E | W |
| | 21:57 | 19:57 | I | Oc | D | |
| 24 | 01:17 | 23:17(p) | I | Ec | R | |
| | 19:05 | 17:05 | I | Tr | I | E |
| | 20:07 | 18:07 | I | Sh | I | |
| | 21:23 | 19:23 | I | Tr | E | |
| | 22:25 | 20:25 | I | Sh | E | |
| 25 | 00:48 | 22:48(p) | II | Oc | D | |
| | 19:46 | 17:46 | I | Ec | R | E |
| | 21:01 | 19:01 | III | Ec | R | |
| | 22:01 | 20:01 | IV | Tr | E | |
| 26 | 03:05 | 01:05 | IV | Sh | I | W |
| | 19:47 | 17:47 | II | Tr | I | E |
| | 21:57 | 19:57 | II | Sh | I | |
| | 22:41 | 20:41 | II | Tr | E | |
| 27 | 00:51 | 22:51(p) | II | Sh | E | |
| 28 | 19:03 | 17:03 | II | Ec | R | E |
| 29 | 02:49 | 00:49 | III | Tr | I | W |
| 30 | 02:28 | 00:28 | I | Tr | I | W |
| | 23:47 | 21:47 | I | Oc | D | |
| 31 | 03:12 | 01:12 | I | Ec | R | W |
| | 20:55 | 18:55 | I | Tr | I | |
| | 22:02 | 20:02 | I | Sh | I | |
| | 23:13 | 21:13 | I | Tr | E | |

## April

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 00:20 | 22:20(p) | I | Sh | E | |
| | 03:13 | 01:13 | II | Oc | D | W |
| | 18:14 | 16:14 | I | Oc | D | E |
| | 20:23 | 18:23 | III | Oc | R | |
| | 21:21 | 19:21 | III | Ec | D | |
| | 21:41 | 19:41 | I | Ec | R | |
| 2 | 01:01 | 23:01(p) | III | Ec | R | W |
| | 17:40 | 15:40 | I | Tr | E | E |
| | 18:49 | 16:49 | I | Sh | E | E |
| | 22:14 | 20:14 | II | Tr | I | |
| | 23:57 | 21:57 | IV | Oc | D | |
| 3 | 00:33 | 22:33(p) | II | Sh | I | |
| | 01:08 | 23:08(p) | II | Tr | E | W |
| 4 | 21:39 | 19:39 | II | Ec | R | |
| 7 | 01:38 | 23:38(p) | I | Oc | D | W |
| | 22:46 | 20:46 | I | Tr | I | |
| | 23:57 | 21:57 | I | Sh | I | |
| 8 | 01:03 | 23:03(p) | I | Tr | E | W |
| | 02:15 | 00:15 | I | Sh | E | W |
| | 20:06 | 18:06 | I | Oc | D | |
| | 20:29 | 18:29 | III | Oc | D | |
| | 23:36 | 21:36 | I | Ec | R | |
| 9 | 00:07 | 22:07(p) | III | Oc | R | |
| | 01:21 | 23:21(p) | III | Ec | D | W |
| | 18:26 | 16:26 | I | Sh | I | E |
| | 19:31 | 17:31 | I | Tr | E | E |
| | 20:44 | 18:44 | I | Sh | E | |
| 10 | 00:44 | 22:44(p) | II | Tr | I | W |
| | 18:05 | 16:05 | I | Ec | R | E |
| 11 | 18:55 | 16:55 | II | Oc | D | E |
| | 21:07 | 19:07 | IV | Sh | I | |
| 12 | 00:14 | 22:14(p) | II | Ec | R | |
| | 01:55 | 23:55(p) | IV | Sh | E | W |
| | 18:52 | 16:52 | III | Sh | E | E |
| 13 | 19:22 | 17:22 | II | Sh | E | E |
| 15 | 00:38 | 22:38(p) | I | Tr | I | W |
| | 01:52 | 23:52(p) | I | Sh | I | W |
| | 21:58 | 19:58 | I | Oc | D | |
| 16 | 00:18 | 22:18(p) | III | Oc | D | W |
| | 01:31 | 23:31(p) | I | Ec | R | W |
| | 19:06 | 17:06 | I | Tr | I | E |
| | 20:21 | 18:21 | I | Sh | I | |
| | 21:24 | 19:24 | I | Tr | E | |
| | 22:39 | 20:39 | I | Sh | E | |
| 17 | 20:00 | 18:00 | I | Ec | R | |
| 18 | 21:26 | 19:26 | II | Oc | D | |
| 19 | 17:45 | 15:45 | III | Tr | E | E |
| | 19:12 | 17:12 | III | Sh | I | E |
| | 21:47 | 19:47 | IV | Oc | R | |
| | 22:51 | 20:51 | III | Sh | E | |
| 20 | 19:05 | 17:05 | II | Sh | I | E |
| | 19:26 | 17:26 | II | Tr | E | |
| | 21:58 | 19:58 | II | Sh | E | |
| 22 | 23:52 | 21:52 | I | Oc | D | W |
| 23 | 21:00 | 19:00 | I | Tr | I | |
| | 22:16 | 20:16 | I | Sh | I | |
| | 23:17 | 21:17 | I | Tr | E | |
| 24 | 00:34 | 22:34(p) | I | Sh | E | W |
| | 18:20 | 16:20 | I | Oc | D | E |
| | 21:55 | 19:55 | I | Ec | R | |
| 25 | 17:46 | 15:46 | I | Tr | E | E |
| | 19:03 | 17:03 | I | Sh | E | E |
| | 23:59 | 21:59 | II | Oc | D | W |
| 26 | 18:02 | 16:02 | III | Tr | I | E |
| | 21:39 | 19:39 | III | Tr | E | |
| | 23:11 | 21:11 | III | Sh | I | |
| 27 | 19:07 | 17:07 | II | Tr | I | E |
| | 21:41 | 19:41 | II | Sh | I | |
| | 22:00 | 20:00 | II | Tr | E | |
| 28 | 00:35 | 22:35(p) | II | Sh | E | W |
| | 19:56 | 17:56 | IV | Sh | E | |
| 29 | 18:45 | 16:45 | II | Ec | R | E |
| 30 | 17:01 | 15:01 | III | Ec | R | E |
| | 22:54 | 20:54 | I | Tr | I | |

## May

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 00:11 | 22:11(p) | I | Sh | I | W |
| | 01:12 | 23:12(p) | I | Tr | E | W |
| | 20:15 | 18:15 | I | Oc | D | |
| | 23:50 | 21:50 | I | Ec | R | W |
| 2 | 17:23 | 15:23 | I | Tr | I | E |
| | 18:40 | 16:40 | I | Sh | I | E |
| | 19:41 | 17:41 | I | Tr | E | |
| | 20:58 | 18:58 | I | Sh | E | |
| 3 | 18:19 | 16:19 | I | Ec | R | E |
| | 22:01 | 20:01 | III | Tr | I | |
| 4 | 21:43 | 19:43 | II | Tr | I | |
| 5 | 00:18 | 22:18(p) | II | Sh | I | W |
| | 00:37 | 22:37(p) | II | Tr | E | W |
| 6 | 21:21 | 19:21 | II | Ec | R | |
| | 23:03 | 21:03 | IV | Ec | D | W |
| 7 | 17:20 | 15:20 | III | Ec | D | E |
| | 21:00 | 19:00 | III | Ec | R | |
| 8 | 00:50 | 22:50(p) | I | Tr | I | W |
| | 22:11 | 20:11 | I | Oc | D | |
| 9 | 19:19 | 17:19 | I | Tr | I | |
| | 20:35 | 18:35 | I | Sh | I | |
| | 21:37 | 19:37 | I | Tr | E | |
| | 22:53 | 20:53 | I | Sh | E | W |
| 10 | 20:14 | 18:14 | I | Ec | R | |
| 11 | 17:22 | 15:22 | I | Sh | E | E |
| 12 | 00:22 | 22:22(p) | II | Tr | I | W |
| 13 | 18:32 | 16:32 | II | Oc | D | E |
| | 23:58 | 21:58 | II | Ec | R | W |
| 14 | 19:54 | 17:54 | III | Oc | R | |
| | 21:19 | 19:19 | III | Ec | D | |
| | 21:26 | 19:26 | IV | Tr | I | |
| 15 | 19:05 | 17:05 | II | Sh | E | |
| 16 | 00:07 | 22:07(p) | I | Oc | D | W |
| | 21:15 | 19:15 | I | Tr | I | |
| | 22:30 | 20:30 | I | Sh | I | W |
| | 23:33 | 21:33 | I | Tr | E | W |
| 17 | 18:37 | 16:37 | I | Oc | D | E |
| | 22:09 | 20:09 | I | Ec | R | |
| 18 | 16:59 | 14:59 | I | Sh | I | E |
| | 18:03 | 16:03 | I | Tr | E | E |
| | 19:17 | 17:17 | I | Sh | E | |
| 20 | 21:12 | 19:12 | II | Oc | D | |
| 21 | 20:23 | 18:23 | III | Oc | D | |
| 22 | 00:02 | 22:02(p) | III | Oc | R | W |
| | 18:48 | 16:48 | II | Sh | I | E |
| | 19:15 | 17:15 | II | Tr | E | |
| | 21:41 | 19:41 | II | Sh | E | |
| 23 | 17:07 | 15:07 | IV | Ec | D | E |
| | 21:58 | 19:58 | IV | Ec | R | W |
| | 23:13 | 21:13 | I | Tr | I | W |
| 24 | 20:34 | 18:34 | I | Oc | D | |
| 25 | 17:42 | 15:42 | I | Tr | I | E |
| | 18:49 | 16:49 | III | Sh | E | E |
| | 18:54 | 16:54 | I | Sh | I | E |
| | 20:00 | 18:00 | I | Tr | E | |
| | 21:12 | 19:12 | I | Sh | E | |
| 26 | 18:33 | 16:33 | I | Ec | R | E |
| 29 | 19:04 | 17:04 | II | Tr | I | |
| | 21:24 | 19:24 | II | Sh | I | |
| | 21:57 | 19:57 | II | Tr | E | W |
| 31 | 18:30 | 16:30 | II | Ec | R | E |
| | 21:15 | 19:15 | IV | Tr | E | |
| | 22:32 | 20:32 | I | Oc | D | W |

## June

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 18:12 | 16:12 | III | Tr | E | E |
| | 19:10 | 17:10 | III | Sh | I | |
| | 19:41 | 17:41 | I | Tr | I | |
| | 20:49 | 18:49 | I | Sh | I | |
| | 21:59 | 19:59 | I | Tr | E | W |
| | 22:48 | 20:48 | III | Sh | E | W |
| | 23:07 | 21:07 | I | Sh | E | W |
| 2 | 17:02 | 15:02 | I | Oc | D | E |
| | 20:27 | 18:27 | I | Ec | R | |
| 3 | 17:36 | 15:36 | I | Sh | E | E |
| 5 | 21:47 | 19:47 | II | Tr | I | W |
| 7 | 21:07 | 19:07 | II | Ec | R | W |
| 8 | 18:48 | 16:48 | III | Tr | I | E |
| | 21:40 | 19:40 | I | Tr | I | W |
| | 22:27 | 20:27 | III | Tr | E | W |
| | 22:44 | 20:44 | I | Sh | I | W |
| | 23:09 | 21:09 | III | Sh | I | W |

# JUPITER MOON EVENTS

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | 19:01 | 17:01 | I | Oc | D | |
| | 22:22 | 20:22 | I | Ec | R | W |
| 10 | 17:13 | 15:13 | I | Sh | I | E |
| | 18:28 | 16:28 | I | Tr | E | E |
| | 19:31 | 17:31 | I | Sh | E | |
| 11 | 16:51 | 14:51 | I | Ec | R | E |
| 12 | 16:57 | 14:57 | III | Ec | R | E |
| 14 | 18:45 | 16:45 | II | Oc | D | E |
| 16 | 16:46 | 14:46 | II | Tr | E | E |
| | 18:44 | 16:44 | II | Sh | E | E |
| | 21:00 | 19:00 | I | Oc | D | W |
| 17 | 16:49 | 14:49 | IV | Tr | E | E |
| | 18:09 | 16:09 | I | Tr | I | E |
| | 19:08 | 17:08 | I | Sh | I | |
| | 20:27 | 18:27 | I | Tr | E | |
| | 21:14 | 19:14 | IV | Sh | I | W |
| | 21:26 | 19:26 | I | Sh | E | W |
| 18 | 18:46 | 16:46 | I | Ec | R | E |
| 19 | 17:04 | 15:04 | III | Oc | R | E |
| | 17:18 | 15:18 | III | Ec | D | E |
| | 20:57 | 18:57 | III | Ec | R | W |
| 21 | 21:32 | 19:32 | II | Oc | D | W |
| 23 | 16:38 | 14:38 | II | Tr | I | E |
| | 18:27 | 16:27 | II | Sh | I | E |
| | 19:31 | 17:31 | II | Tr | E | |
| | 21:19 | 19:19 | II | Sh | E | W |
| 24 | 20:09 | 18:09 | I | Tr | I | |
| | 21:03 | 19:03 | I | Sh | I | W |
| 25 | 17:30 | 15:30 | I | Oc | D | E |
| | 20:40 | 18:40 | I | Ec | R | W |
| | 20:43 | 18:43 | IV | Oc | D | W |
| 26 | 16:58 | 14:58 | I | Tr | E | E |
| | 17:44 | 15:44 | III | Oc | D | E |
| | 17:50 | 15:50 | I | Sh | E | E |
| 30 | 19:24 | 17:24 | II | Tr | I | |
| | 21:02 | 19:02 | II | Sh | I | W |

## July

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 18:17 | 16:17 | II | Ec | R | E |
| | 19:30 | 17:30 | I | Oc | D | |
| 3 | 16:40 | 14:40 | I | Tr | I | E |
| | 17:27 | 15:27 | I | Sh | I | E |
| | 18:58 | 16:58 | I | Tr | E | E |
| | 19:45 | 17:45 | I | Sh | E | W |
| 4 | 17:03 | 15:03 | I | Ec | R | E |
| | 19:56 | 17:56 | IV | Sh | E | W |
| 7 | 18:45 | 16:45 | III | Sh | E | E |
| 9 | 20:54 | 18:54 | II | Ec | R | W |
| | 21:30 | 19:30 | I | Oc | D | W |
| 10 | 18:41 | 16:41 | I | Tr | I | E |
| | 19:22 | 17:22 | I | Sh | I | |
| | 20:59 | 18:59 | I | Tr | E | W |
| 11 | 18:58 | 16:58 | I | Ec | R | E |
| 12 | 16:58 | 14:58 | IV | Oc | D | E |
| 14 | 19:06 | 17:06 | III | Sh | I | |
| | 20:14 | 18:14 | III | Tr | E | W |
| 16 | 19:23 | 17:23 | II | Oc | D | W |
| 17 | 20:42 | 18:42 | I | Tr | I | W |
| 18 | 17:13 | 15:13 | II | Tr | E | E |
| | 18:01 | 16:01 | I | Oc | D | E |
| | 18:20 | 16:20 | II | Sh | E | E |
| | 20:52 | 18:52 | I | Ec | R | W |
| 19 | 17:31 | 15:31 | I | Tr | E | E |
| | 18:04 | 16:04 | I | Sh | E | E |
| 21 | 21:00 | 19:00 | III | Tr | I | W |
| 25 | 17:09 | 15:09 | II | Tr | I | E |
| | 18:03 | 16:03 | II | Sh | I | E |
| | 20:01 | 18:01 | II | Tr | E | W |
| | 20:02 | 18:02 | I | Oc | D | W |
| 26 | 17:14 | 15:14 | I | Tr | I | E |
| | 17:40 | 15:40 | I | Sh | I | E |
| | 19:32 | 17:32 | I | Tr | E | W |
| | 19:59 | 17:59 | I | Sh | E | W |
| 27 | 17:15 | 15:15 | I | Ec | R | E |

## August

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 19:56 | 17:56 | II | Tr | I | W |
| 2 | 19:15 | 17:15 | I | Tr | I | E |
| | 19:35 | 17:35 | I | Sh | I | W |
| 3 | 18:03 | 16:03 | II | Ec | R | E |
| | 19:09 | 17:09 | I | Ec | R | E |

## September

| | | | | | | |
|---|---|---|---|---|---|---|
| 22 | 06:07 | 04:07 | I | Ec | D | E |
| 23 | 05:42 | 03:42 | I | Sh | E | E |
| | 06:13 | 04:13 | I | Tr | E | W |
| 24 | 04:52 | 02:52 | II | Tr | I | E |
| | 06:41 | 04:41 | II | Sh | E | W |
| 28 | 06:57 | 04:57 | III | Oc | R | W |
| 30 | 05:18 | 03:18 | I | Sh | I | E |
| | 05:56 | 03:56 | I | Tr | I | |
| | 07:36 | 05:36 | I | Sh | E | W |

## October

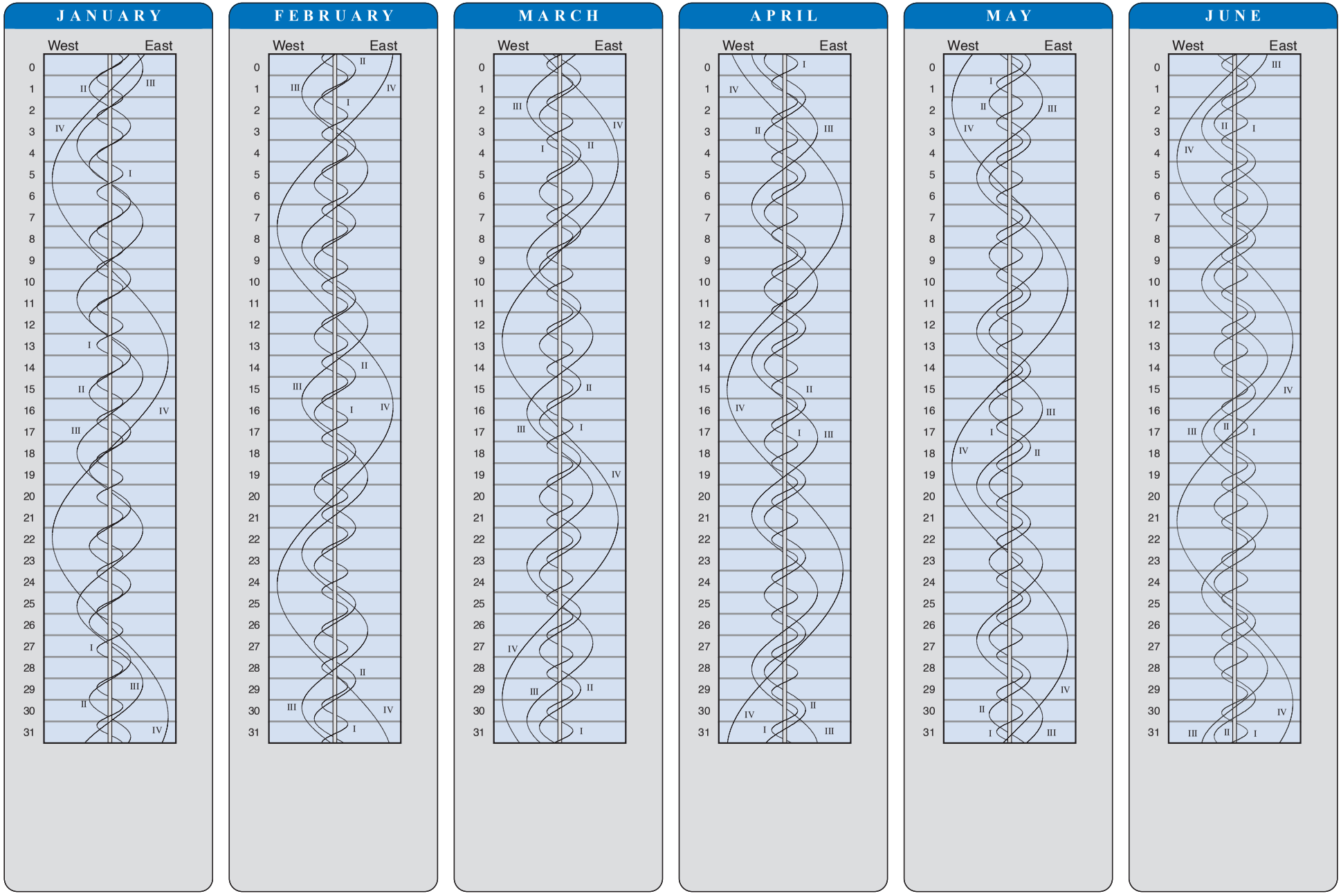
| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 05:24 | 03:24 | I | Oc | R | E |
| | 06:24 | 04:24 | II | Sh | I | W |
| 3 | 05:35 | 03:35 | II | Oc | R | |
| 5 | 04:26 | 02:26 | IV | Oc | R | E |
| | 04:56 | 02:56 | III | Ec | D | E |
| 7 | 07:12 | 05:12 | I | Sh | I | W |
| 8 | 04:23 | 02:23 | I | Ec | D | E |
| | 07:23 | 05:23 | I | Oc | R | W |
| 9 | 03:59 | 01:59 | I | Sh | E | E |
| | 04:43 | 02:43 | I | Tr | E | E |
| 10 | 03:57 | 01:57 | II | Ec | D | E |
| 15 | 06:16 | 04:16 | I | Ec | D | W |
| 16 | 03:35 | 01:35 | I | Sh | I | E |
| | 04:25 | 02:25 | I | Tr | I | E |
| | 05:46 | 03:46 | III | Tr | E | W |
| | 05:52 | 03:52 | I | Sh | E | W |
| | 06:43 | 04:43 | I | Tr | E | W |
| 17 | 03:52 | 01:52 | I | Oc | R | E |
| | 06:33 | 04:33 | II | Ec | D | W |
| 19 | 03:39 | 01:39 | II | Sh | E | E |
| | 05:23 | 03:23 | II | Tr | E | |
| 23 | 05:28 | 03:28 | I | Sh | I | |
| | 06:22 | 04:22 | III | Sh | E | W |
| | 06:24 | 04:24 | I | Tr | I | W |
| | 06:32 | 04:32 | III | Tr | I | W |
| 24 | 05:50 | 03:50 | I | Oc | R | W |
| 25 | 03:11 | 01:11 | I | Tr | E | E |
| 26 | 03:21 | 01:21 | II | Sh | I | E |
| | 05:16 | 03:16 | II | Tr | I | |
| | 06:13 | 04:13 | II | Sh | E | W |
| 28 | 03:17 | 01:17 | II | Oc | R | E |
| 30 | 06:40 | 04:40 | IV | Tr | I | W |
| | 06:45 | 04:45 | III | Sh | I | W |
| 31 | 04:31 | 02:31 | I | Ec | D | |

## November

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 02:52 | 00:52 | I | Tr | I | E |
| | 04:08 | 02:08 | I | Sh | E | |
| | 05:09 | 03:09 | I | Tr | E | |
| 2 | 05:55 | 03:55 | II | Sh | I | W |
| 3 | 04:34 | 02:34 | III | Oc | R | |
| 4 | 06:01 | 04:01 | II | Oc | R | W |
| 7 | 05:27 | 03:27 | IV | Ec | D | W |
| | 06:24 | 04:24 | I | Ec | D | W |
| 8 | 03:44 | 01:44 | I | Sh | I | |
| | 04:50 | 02:50 | I | Tr | I | |
| | 06:01 | 04:01 | I | Sh | E | W |
| 9 | 04:15 | 02:15 | I | Oc | R | |
| 10 | 04:19 | 02:19 | III | Ec | R | |
| | 05:16 | 03:16 | III | Oc | D | |
| 11 | 03:36 | 01:36 | II | Ec | D | |
| 13 | 02:52 | 00:52 | II | Tr | E | E |
| 15 | 05:37 | 03:37 | I | Sh | I | W |
| | 06:46 | 04:46 | I | Tr | I | W |
| 16 | 02:06 | 00:06 | IV | Tr | I | E |
| | 02:45 | 00:45 | I | Ec | D | E |
| | 05:51 | 03:51 | IV | Tr | E | W |
| | 06:11 | 04:11 | I | Oc | R | W |
| 17 | 02:23 | 00:23 | I | Sh | E | E |
| | 03:32 | 01:32 | I | Tr | E | |
| | 04:43 | 02:43 | III | Ec | D | |
| 18 | 06:11 | 04:11 | II | Ec | D | W |
| 20 | 02:42 | 00:42 | II | Tr | I | E |
| | 03:11 | 01:11 | II | Sh | E | |
| | 05:32 | 03:32 | II | Tr | E | W |
| 21 | 02:54 | 00:54 | III | Tr | E | |
| 23 | 04:38 | 02:38 | I | Ec | D | |
| 24 | 01:59 | 23:59(p) | I | Sh | I | E |
| | 03:11 | 01:11 | I | Tr | I | |
| | 03:41 | 01:41 | IV | Ec | R | |
| | 04:16 | 02:16 | I | Sh | E | |
| | 05:28 | 03:28 | I | Tr | E | W |
| 25 | 02:36 | 00:36 | I | Oc | R | |
| 27 | 02:54 | 00:54 | II | Sh | I | |
| | 05:20 | 03:20 | II | Tr | I | W |
| | 05:45 | 03:45 | II | Sh | E | W |
| 28 | 02:08 | 00:08 | III | Sh | E | E |
| | 03:34 | 01:34 | III | Tr | I | |
| 29 | 03:21 | 01:21 | II | Oc | R | |
| 30 | 06:31 | 04:31 | I | Ec | D | W |

## December

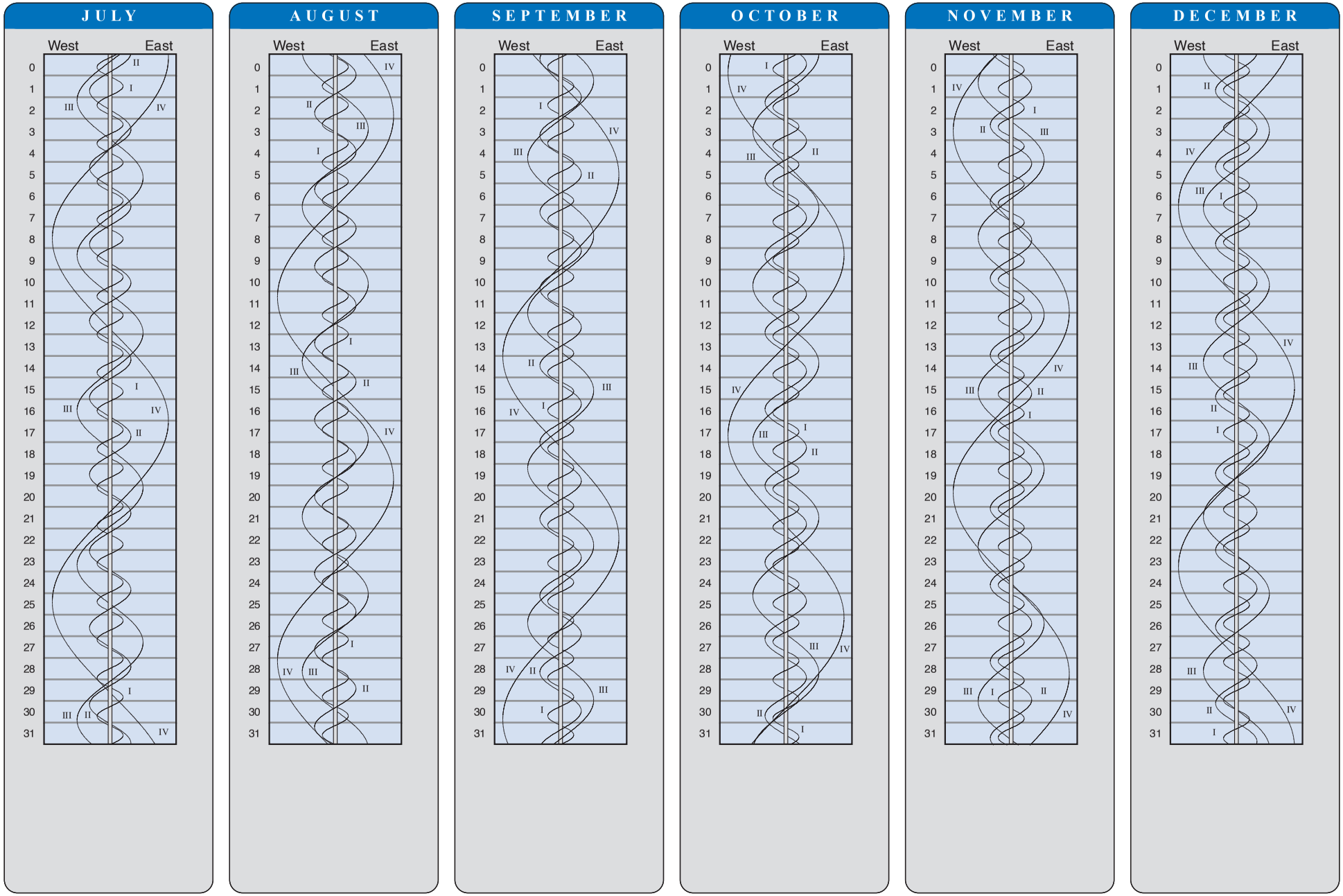
| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 03:52 | 01:52 | I | Sh | I | |
| | 05:06 | 03:06 | I | Tr | I | |
| | 06:09 | 04:09 | I | Sh | E | W |
| 2 | 01:00 | 23:00(p) | I | Ec | D | E |
| | 04:30 | 02:30 | I | Oc | R | |
| 3 | 00:38 | 22:38(p) | I | Sh | E | E |
| | 01:51 | 23:51(p) | I | Tr | E | E |
| 4 | 05:28 | 03:28 | II | Sh | I | W |
| 5 | 02:33 | 00:33 | III | Sh | I | |
| | 06:05 | 04:05 | III | Sh | E | W |
| 6 | 00:38 | 22:38(p) | II | Ec | D | E |
| | 05:57 | 03:57 | II | Oc | R | W |
| 8 | 05:45 | 03:45 | I | Sh | I | W |
| 9 | 01:05 | 23:05(p) | III | Oc | R | E |
| | 02:53 | 00:53 | I | Ec | D | |
| | 06:24 | 04:24 | I | Oc | R | W |
| 10 | 00:14 | 22:14(p) | I | Sh | I | E |
| | 01:28 | 23:28(p) | I | Tr | I | E |
| | 02:31 | 00:31 | I | Sh | E | |
| | 03:44 | 01:44 | I | Tr | E | |
| 11 | 00:52 | 22:52(p) | I | Oc | R | E |
| | 05:45 | 03:45 | IV | Oc | D | W |
| 12 | 06:31 | 04:31 | III | Sh | I | W |
| 13 | 03:12 | 01:12 | II | Ec | D | |
| 14 | 23:49 | 21:49 | II | Tr | I | E |
| 15 | 00:11 | 22:11(p) | II | Sh | E | E |
| | 02:39 | 00:39 | II | Tr | E | |
| 16 | 00:05 | 22:05(p) | III | Ec | R | E |
| | 01:37 | 23:37(p) | III | Oc | D | |
| | 04:46 | 02:46 | I | Ec | D | |
| | 05:00 | 03:00 | III | Oc | R | |
| 17 | 02:07 | 00:07 | I | Sh | I | |
| | 03:21 | 01:21 | I | Tr | I | |
| | 04:24 | 02:24 | I | Sh | E | |
| | 05:37 | 03:37 | I | Tr | E | W |
| 18 | 02:45 | 00:45 | I | Oc | R | |
| 19 | 00:05 | 22:05(p) | I | Tr | E | E |
| | 03:03 | 01:03 | IV | Sh | I | |
| 20 | 05:46 | 03:46 | II | Ec | D | W |
| 21 | 23:54 | 21:54 | II | Sh | I | E |
| 22 | 02:22 | 00:22 | II | Tr | I | |
| | 02:45 | 00:45 | II | Sh | E | |
| | 05:11 | 03:11 | II | Tr | E | |
| 23 | 00:31 | 22:31(p) | III | Ec | D | E |
| | 04:03 | 02:03 | III | Ec | R | |
| | 05:30 | 03:30 | III | Oc | D | W |
| | 06:39 | 04:39 | I | Ec | D | W |
| 24 | 00:17 | 22:17(p) | II | Oc | R | E |
| | 04:00 | 02:00 | I | Sh | I | |
| | 05:13 | 03:13 | I | Tr | I | |
| | 06:17 | 04:17 | I | Sh | E | W |
| 25 | 01:07 | 23:07(p) | I | Ec | D | |
| | 04:36 | 02:36 | I | Oc | R | |
| | 23:40 | 21:40 | I | Tr | I | E |
| 26 | 00:45 | 22:45(p) | I | Sh | E | |
| | 01:56 | 23:56(p) | I | Tr | E | |
| | 23:04 | 21:04 | I | Oc | R | E |
| 27 | 23:19 | 21:19 | IV | Oc | D | E |
| 28 | 02:22 | 00:22 | IV | Oc | R | |
| 29 | 02:28 | 00:28 | II | Sh | I | |
| | 04:52 | 02:52 | II | Tr | I | |
| | 05:20 | 03:20 | II | Sh | E | W |
| 30 | 04:28 | 02:28 | III | Ec | D | |
| 31 | 02:46 | 00:46 | II | Oc | R | |
| | 05:53 | 03:53 | I | Sh | I | W |




## JUPITER'S MOONS

Jupiter is like a miniature solar system with many moons orbiting the planet. As seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing in front of or behind the planet. The diagrams here show the patterns the four major moons of Jupiter make as they move from side-to-side. Each complete period represents one orbit of the satellite. Each horizontal grey date

line represents midnight; the top edge of the line is midnight EST (14hr UT), the bottom edge of the line is midnight WST (16hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times (pp.103–105). The same can be done with the occultation times, that is when the line disappears behind Jupiter. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.



# JUPITER'S MOONS – Mutual Events

| Date | EST Start | EST End | WST Start | WST End | Event | Type | Mag Drop | Jup Dist | Sat Sep |
|---|---|---|---|---|---|---|---|---|---|
| Jan 02 | 01:09 | 01:13 | 23:09(p) | 23:17 | III Oc I | P | 0.08 | 5.9 | 1.1 |
| Jan 02 | 23:07 | 23:11 | | | III Oc I | P | 0.06 | 5.9 | 1.1 |
| Jan 08 | 05:00 | 05:04 | 03:00 | 03:08 | II Oc I | P | 0.05 | 5.9 | 0.8 |
| Jan 09 | 04:46 | 04:54 | 02:46 | 03:02 | III Oc I | P | 0.08 | 5.7 | 1.0 |
| Jan 10 | 02:08 | 02:11 | 00:08 | 00:14 | III Oc I | P | 0.05 | 5.7 | 1.1 |
| Jan 10 | 22:54 | 23:03 | 20:54 | 21:12 | II Ec I | P | 0.40 | 5.8 | 10.9 |
| Jan 11 | 05:03 | 05:21 | 03:03 | 03:39 | II Oc I | P | 0.14 | 2.5 | 0.6 |
| Jan 13 | 21:27 | 21:38 | | | II Ec III | P | 0.22 | 8.4 | 16.7 |
| Jan 13 | 23:42 | 23:50 | 21:42 | 21:59 | II Oc III | P | 0.17 | 9.4 | 0.6 |
| Jan 15 | | | 05:24 | 05:30 | II Oc I | P | 0.04 | 5.9 | 0.9 |
| Jan 17 | 04:54 | 04:56 | 02:54 | 02:59 | III Oc I | P | 0.03 | 5.4 | 1.2 |
| Jan 17 | 20:16 | 20:20 | | | IV Oc I | P | 0.27 | 5.3 | 0.8 |
| Jan 18 | 02:33 | 02:55 | 00:33 | 01:16 | II Ec I | P | 0.32 | 5.1 | 6.4 |
| Jan 18 | | | 03:17 | 04:29 | II Ec I | P | 0.45 | 3.4 | 5.2 |
| Jan 18 | 20:32 | 20:35 | | | II Oc I | P | 0.04 | 5.9 | 0.9 |
| Jan 18 | 22:30 | 22:36 | 20:30 | 20:41 | IV Oc I | T | 0.67 | 5.7 | 0.2 |
| Jan 19 | 02:25 | 02:57 | 00:25 | 01:28 | IV Ec II | P | 0.53 | 8.6 | 25.7 |
| Jan 21 | 01:45 | 01:54 | 23:45(p) | 00:04 | II Ec III | P | 0.25 | 8.8 | 12.1 |
| Jan 21 | 03:05 | 03:12 | 01:05 | 01:20 | II Oc III | P | 0.19 | 9.4 | 0.5 |
| Jan 25 | 04:28 | 04:34 | 02:28 | 02:41 | III Oc IV | P | 0.17 | 13.5 | 0.4 |
| Jan 25 | 22:28 | 22:38 | 20:28 | 20:47 | I Ec IV | Q | 0.03 | 6.6 | 16.6 |
| Jan 25 | 23:29 | 23:32 | 21:29 | 21:36 | II Oc IV | A | 0.15 | 6.3 | 0.2 |
| Jan 26 | 04:09 | 04:23 | 02:09 | 02:36 | I Ec IV | Q | 0.14 | 4.3 | 13.7 |
| Jan 27 | 00:54 | 00:57 | 22:54(p) | 23:01 | I Oc IV | A | 0.19 | 4.1 | 0.1 |
| Jan 28 | | | 03:43 | 04:00 | II Ec III | A | 0.28 | 9.2 | 5.8 |
| Jan 28 | | | 04:17 | 04:31 | II Oc III | P | 0.21 | 9.4 | 0.5 |
| Feb 04 | 03:08 | 03:11 | 01:08 | 01:14 | IV Oc I | T | 0.67 | 1.7 | 0.1 |
| Feb 19 | 03:46 | 03:53 | 01:46 | 02:00 | IV Oc III | P | 0.47 | 13.4 | 0.4 |
| Feb 20 | 22:15 | 22:18 | 20:15 | 20:21 | IV Oc II | T | 0.63 | 3.7 | 0.1 |
| Feb 21 | 00:22 | 00:27 | 22:22(p) | 22:31 | IV Ec II | Q | 0.54 | 2.3 | 51.8 |
| Feb 25 | 18:30 | 18:35 | | | II Oc III | A | 0.23 | 9.0 | 0.1 |
| Feb 25 | 20:21 | 20:27 | 18:21 | 18:33 | II Ec III | A | 0.41 | 9.8 | 28.6 |
| Feb 28 | | | 01:45 | 01:49 | I Oc II | P | 0.35 | 1.6 | 0.3 |
| Mar 04 | 21:31 | 21:36 | 19:31 | 19:41 | II Oc III | A | 0.23 | 8.8 | 0.3 |
| Mar 04 | 23:50 | 23:56 | 21:50 | 22:02 | II Ec III | A | 0.44 | 9.8 | 37.5 |
| Mar 10 | 02:30 | 02:36 | 00:30 | 00:43 | IV Oc II | P | 0.63 | 9.2 | 0.3 |
| Mar 10 | 18:46 | 18:48 | | | I Oc II | P | 0.28 | 1.9 | 0.4 |
| Mar 12 | 00:34 | 00:38 | 22:34(p) | 22:43 | II Oc III | P | 0.19 | 8.6 | 0.5 |
| Mar 12 | | | 01:16 | 01:28 | II Ec III | A | 0.40 | 9.8 | 45.8 |
| Mar 16 | 22:22 | 22:29 | 20:22 | 20:35 | II Ec IV | Q | 0.27 | 4.9 | 85.5 |
| Mar 17 | 20:48 | 20:50 | 18:48 | 18:52 | I Oc II | P | 0.25 | 2.1 | 0.4 |
| Mar 18 | | | 02:17 | 02:26 | I Ec III | Q | 0.07 | 3.8 | 45.4 |
| Mar 18 | 19:09 | 19:20 | | | I Ec III | P | 0.08 | 4.3 | 28.1 |
| Mar 19 | 01:56 | 02:05 | 23:56(p) | 00:14 | I Ec III | Q | 0.08 | 7.7 | 25.4 |
| Mar 19 | | | 01:38 | 01:46 | II Oc III | P | 0.14 | 8.4 | 0.7 |
| Mar 20 | | | 02:20 | 02:25 | II Ec I | Q | 0.09 | 4.5 | 34.2 |
| Mar 24 | 22:52 | 22:54 | 20:52 | 20:56 | I Oc II | P | 0.22 | 2.3 | 0.5 |
| Mar 25 | 22:09 | 22:13 | 20:09 | 20:17 | IV Ec I | Q | 0.34 | 3.8 | 4.4 |
| Mar 25 | 23:31 | 23:38 | 21:31 | 21:45 | IV Ec III | Q | 0.55 | 4.7 | 2.3 |
| Mar 30 | 19:46 | 19:49 | 17:46 | 17:51 | II Ec I | P | 0.23 | 4.0 | 39.8 |
| Apr 01 | 00:58 | 01:00 | 22:58(p) | 23:02 | I Oc II | P | 0.21 | 2.5 | 0.5 |
| Apr 04 | | | 01:14 | 01:29 | I Ec IV | Q | 0.27 | 10.0 | 62.8 |
| Apr 06 | 22:03 | 22:06 | 20:03 | 20:08 | II Ec I | P | 0.35 | 3.8 | 42.5 |
| Apr 08 | | | 01:06 | 01:09 | I Oc II | P | 0.21 | 2.7 | 0.5 |
| Apr 11 | 17:57 | 17:59 | | | I Ec II | Q | 0.11 | 1.6 | 16.3 |
| Apr 14 | | | 22:19(p) | 22:25 | II Ec I | P | 0.47 | 3.5 | 44.5 |
| Apr 16 | 20:06 | 20:10 | 18:06 | 18:14 | II Ec III | P | 0.15 | 9.2 | 71.5 |
| Apr 18 | 18:21 | 18:23 | | | I Oc II | P | 0.24 | 3.1 | 0.4 |
| Apr 20 | | | 23:22(p) | 23:32 | III Ec IV | Q | 0.10 | 2.5 | 55.7 |
| Apr 23 | 18:24 | 18:28 | | | I Ec III | A | 0.44 | 6.6 | 19.8 |
| Apr 23 | 23:25 | 23:28 | 21:25 | 21:32 | II Ec III | Q | 0.07 | 8.9 | 73.1 |
| Apr 25 | 20:33 | 20:35 | 18:33 | 18:37 | I Oc II | P | 0.28 | 3.3 | 0.3 |
| Apr 26 | 19:03 | 19:07 | | | III Ec I | A | 0.96 | 4.1 | 95.5 |
| Apr 29 | | | 22:55(p) | 23:03 | IV Oc II | P | 0.45 | 7.9 | 0.5 |
| Apr 29 | 18:35 | 18:41 | | | IV Ec III | Q | 0.15 | 7.9 | 44.6 |
| Apr 30 | 21:13 | 21:17 | 19:13 | 19:21 | I Ec III | A | 0.52 | 6.0 | 28.2 |
| May 01 | 17:58 | 18:00 | | | II Ec I | A | 0.64 | 2.8 | 46.3 |
| May 02 | 22:47 | 22:49 | 20:47 | 20:51 | I Oc II | P | 0.33 | 3.5 | 0.3 |
| May 03 | 16:47 | 16:51 | | | III Ec II | P | 0.46 | 7.6 | 71.6 |
| May 03 | 21:52 | 21:56 | 19:52 | 20:00 | III Ec I | P | 0.95 | 4.6 | 66.3 |
| May 08 | | | 22:00(p) | 22:08 | I Ec III | A | 0.41 | 5.4 | 38.0 |
| May 08 | 20:13 | 20:15 | 18:13 | 18:18 | II Ec I | A | 0.51 | 2.6 | 45.9 |
| May 10 | | | 23:03(p) | 23:07 | I Oc II | P | 0.40 | 3.7 | 0.2 |
| May 10 | 20:05 | 20:09 | 18:05 | 18:14 | III Ec II | P | 0.59 | 7.9 | 67.7 |
| May 11 | | | 22:44(p) | 22:52 | III Ec I | P | 0.87 | 5.1 | 61.6 |
| May 15 | | | 20:27 | 20:32 | II Ec I | P | 0.40 | 2.4 | 44.9 |
| May 17 | | | 21:24 | 21:33 | III Ec II | P | 0.72 | 8.1 | 63.2 |
| May 20 | 16:29 | 16:32 | | | I Oc II | T | 0.46 | 4.1 | 0.0 |
| May 22 | 17:13 | 17:25 | | | I Oc IV | P | 0.16 | 5.9 | 0.3 |
| May 22 | | | 20:04 | 20:33 | I Oc IV | A | 0.19 | 3.9 | 0.1 |
| May 27 | 18:49 | 18:51 | | | I Oc II | P | 0.43 | 4.3 | 0.1 |
| Jun 01 | | | 21:27 | 21:55 | III Ec I | T | 1.00 | 2.4 | 26.4 |
| Jun 03 | 21:11 | 21:13 | 19:11 | 19:15 | I Oc II | P | 0.33 | 4.5 | 0.2 |
| Jun 09 | 16:44 | 16:45 | | | II Oc I | P | 0.03 | 2.9 | 0.7 |
| Jun 12 | 19:12 | 19:14 | 17:12 | 17:17 | II Oc III | P | 0.11 | 4.5 | 0.6 |
| Jun 16 | 19:03 | 19:05 | 17:03 | 17:06 | II Oc I | P | 0.11 | 2.6 | 0.5 |
| Jun 18 | 17:08 | 17:13 | | | IV Oc III | P | 0.18 | 10.8 | 0.7 |
| Jun 19 | | | 20:39 | 20:45 | II Oc III | P | 0.18 | 4.0 | 0.4 |
| Jun 22 | 19:18 | 19:45 | 17:18 | 18:12 | III Oc I | P | 0.11 | 5.1 | 0.7 |
| Jun 22 | | | 18:30 | 18:30 | III Oc I | P | 0.05 | 4.7 | 0.8 |
| Jun 22 | | | 18:30 | 20:02 | III Oc I | P | 0.11 | 4.3 | 0.7 |
| Jun 23 | | | 19:23 | 19:27 | II Oc I | P | 0.22 | 2.3 | 0.3 |
| Jun 29 | 19:45 | 19:51 | 17:45 | 17:57 | III Ec II | T | 1.00 | 9.1 | 31.3 |
| Jun 30 | 19:03 | 19:06 | 17:03 | 17:09 | III Oc I | P | 0.19 | 5.1 | 0.6 |
| Jul 03 | | | 18:08 | 18:13 | I Oc III | P | 0.19 | 2.0 | 0.4 |
| Jul 13 | | | 19:29 | 19:37 | III Oc IV | P | 0.05 | 10.3 | 0.8 |
| Aug 11 | 17:32 | 17:39 | | | III Oc II | P | 0.14 | 9.4 | 0.6 |
| Aug 12 | 17:34 | 17:52 | | | III Ec II | P | 0.14 | 3.0 | 2.3 |
| Aug 14 | 17:06 | 17:18 | | | I Ec II | P | 0.92 | 5.8 | 1.8 |
| Aug 18 | 06:42 | 06:52 | | | I Ec II | P | 0.81 | 5.8 | 1.1 |

It has already been stated on page 102 that the plane of Jupiter's moons is close to that of the Earth's orbit. About every 6 years the two planes cross and for a brief period we can see the moons eclipse and occult each other. The drop in brightness does not just depend on the relative magnitudes of the satellites. It also varies depending on whether the event is complete e.g., how much of the shadow (eclipse) or the moon (occultation) covers the other moon during an event.

The mutual events table above has the following information

**Date** of the event (month and day).

**Start** and **end** times of the events (hh:mm) in EST and/or WST. If an EST time is not given, that event is likely not visible from the eastern part of Australia. Similarly for the WST zone columns. Where both are given the event is likely suitable for all Australia.

**Event** description e.g., II Oc I. This means satellite II occults (passes in front of) satellite I. For event II Ec I, this means satellite I passes into satellite II's shadow. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.

Event **type** where 'P' is partial, 'A' is annular, 'T' is total and 'Q' is penumbral.

**Mag Drop** is the maximum drop in magnitude at mid event.

**Jup Dist** is the distance from Jupiter's centre (in Jupiter radii).

**Sat Sep** is the separation between the two satellites in arc seconds at closest approach.

# JUPITER – LONGITUDE OF CENTRAL MERIDIAN

## SYSTEM I (0hr UT)

| DATE | JAN ° | FEB ° | MAR ° | APR ° | MAY ° | JUN ° | JUL ° | AUG ° | SEP ° | OCT ° | NOV ° | DEC ° | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 265.9 | 125.2 | 229.3 | 084.1 | 137.7 | 346.6 | 036.5 | 244.0 | 091.9 | 143.4 | 354.2 | 049.4 | 1 |
| 2 | 064.0 | 283.2 | 027.2 | 242.0 | 295.4 | 144.2 | 194.2 | 041.6 | 249.6 | 301.1 | 152.0 | 207.3 | 2 |
| 3 | 222.0 | 081.3 | 185.2 | 039.8 | 093.2 | 301.9 | 351.8 | 199.3 | 047.3 | 098.8 | 309.8 | 005.1 | 3 |
| 4 | 020.0 | 239.3 | 343.1 | 197.6 | 250.9 | 099.6 | 149.5 | 356.9 | 205.0 | 256.6 | 107.6 | 163.0 | 4 |
| 5 | 178.1 | 037.3 | 141.1 | 355.4 | 048.6 | 257.3 | 307.2 | 154.6 | 002.7 | 054.3 | 265.4 | 320.9 | 5 |
| 6 | 336.1 | 195.4 | 299.0 | 153.3 | 206.3 | 054.9 | 104.8 | 312.3 | 160.4 | 212.1 | 063.2 | 118.8 | 6 |
| 7 | 134.1 | 353.4 | 096.9 | 311.1 | 004.1 | 212.6 | 262.5 | 109.9 | 318.1 | 009.8 | 221.1 | 276.7 | 7 |
| 8 | 292.2 | 151.4 | 254.9 | 108.9 | 161.8 | 010.3 | 060.1 | 267.6 | 115.8 | 167.6 | 018.9 | 074.6 | 8 |
| 9 | 090.2 | 309.4 | 052.8 | 266.7 | 319.5 | 168.0 | 217.8 | 065.3 | 273.5 | 325.3 | 176.7 | 232.5 | 9 |
| 10 | 248.3 | 107.4 | 210.7 | 064.5 | 117.2 | 325.6 | 015.4 | 223.0 | 071.2 | 123.1 | 334.5 | 030.4 | 10 |
| 11 | 046.3 | 265.5 | 008.7 | 222.3 | 275.0 | 123.3 | 173.1 | 020.6 | 228.9 | 280.8 | 132.3 | 188.3 | 11 |
| 12 | 204.3 | 063.5 | 166.6 | 020.1 | 072.7 | 281.0 | 330.8 | 178.3 | 026.6 | 078.6 | 290.2 | 346.2 | 12 |
| 13 | 002.4 | 221.5 | 324.5 | 177.9 | 230.4 | 078.6 | 128.4 | 336.0 | 184.3 | 236.4 | 088.0 | 144.1 | 13 |
| 14 | 160.4 | 019.5 | 122.4 | 335.7 | 028.1 | 236.3 | 286.1 | 133.6 | 342.1 | 034.1 | 245.8 | 302.0 | 14 |
| 15 | 318.5 | 177.5 | 280.3 | 133.5 | 185.8 | 034.0 | 083.7 | 291.3 | 139.8 | 191.9 | 043.7 | 100.0 | 15 |
| 16 | 116.5 | 335.5 | 078.2 | 291.3 | 343.5 | 191.6 | 241.4 | 089.0 | 297.5 | 349.6 | 201.5 | 257.9 | 16 |
| 17 | 274.6 | 133.5 | 236.1 | 089.1 | 141.2 | 349.3 | 039.0 | 246.7 | 095.2 | 147.4 | 359.3 | 055.8 | 17 |
| 18 | 072.6 | 291.5 | 034.0 | 246.8 | 298.9 | 147.0 | 196.7 | 044.3 | 252.9 | 305.2 | 157.2 | 213.7 | 18 |
| 19 | 230.7 | 089.5 | 191.9 | 044.6 | 096.6 | 304.6 | 354.4 | 202.0 | 050.6 | 103.0 | 315.0 | 011.7 | 19 |
| 20 | 028.7 | 247.5 | 349.8 | 202.4 | 254.3 | 102.3 | 152.0 | 359.7 | 208.3 | 260.7 | 112.9 | 169.6 | 20 |
| 21 | 186.8 | 045.5 | 147.7 | 000.2 | 052.0 | 259.9 | 309.7 | 157.4 | 006.1 | 058.5 | 270.7 | 327.5 | 21 |
| 22 | 344.8 | 203.5 | 305.5 | 157.9 | 209.7 | 057.6 | 107.3 | 315.1 | 163.8 | 216.3 | 068.6 | 125.5 | 22 |
| 23 | 142.8 | 001.4 | 103.4 | 315.7 | 007.4 | 215.3 | 265.0 | 112.7 | 321.5 | 014.1 | 226.4 | 283.4 | 23 |
| 24 | 300.9 | 159.4 | 261.3 | 113.4 | 165.1 | 012.9 | 062.7 | 270.4 | 119.2 | 171.8 | 024.3 | 081.3 | 24 |
| 25 | 098.9 | 317.4 | 059.2 | 271.2 | 322.8 | 170.6 | 220.3 | 068.1 | 277.0 | 329.6 | 182.2 | 239.3 | 25 |
| 26 | 257.0 | 115.4 | 217.0 | 069.0 | 120.5 | 328.2 | 018.0 | 225.8 | 074.7 | 127.4 | 340.0 | 037.2 | 26 |
| 27 | 055.0 | 273.3 | 014.9 | 226.7 | 278.1 | 125.9 | 175.6 | 023.5 | 232.4 | 285.2 | 137.9 | 195.2 | 27 |
| 28 | 213.1 | 071.3 | 172.7 | 024.5 | 075.8 | 283.6 | 333.3 | 181.2 | 030.2 | 083.0 | 295.8 | 353.1 | 28 |
| 29 | 011.1 | | 330.6 | 182.2 | 233.5 | 081.2 | 131.0 | 338.9 | 187.9 | 240.8 | 093.6 | 151.1 | 29 |
| 30 | 169.1 | | 128.4 | 339.9 | 031.2 | 238.9 | 288.6 | 136.5 | 345.6 | 038.6 | 251.5 | 309.1 | 30 |
| 31 | 327.2 | | 286.3 | | 188.9 | | 086.3 | 294.2 | | 196.4 | | 107.0 | 31 |

## SYSTEM II (0hr UT)

| DATE | JAN ° | FEB ° | MAR ° | APR ° | MAY ° | JUN ° | JUL ° | AUG ° | SEP ° | OCT ° | NOV ° | DEC ° | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 163.6 | 146.4 | 036.8 | 015.2 | 199.8 | 172.2 | 353.3 | 324.2 | 295.7 | 118.2 | 092.5 | 278.7 | 1 |
| 2 | 314.0 | 296.8 | 187.1 | 165.4 | 350.0 | 322.3 | 143.3 | 114.2 | 085.7 | 268.3 | 242.6 | 069.0 | 2 |
| 3 | 104.5 | 087.2 | 337.5 | 315.6 | 140.1 | 112.3 | 293.4 | 264.3 | 235.8 | 058.4 | 032.8 | 219.2 | 3 |
| 4 | 254.9 | 237.6 | 127.8 | 105.8 | 290.2 | 262.4 | 083.4 | 054.3 | 025.8 | 208.5 | 183.0 | 009.5 | 4 |
| 5 | 045.3 | 028.0 | 278.1 | 256.0 | 080.3 | 052.4 | 233.4 | 204.3 | 175.9 | 358.6 | 333.2 | 159.8 | 5 |
| 6 | 195.7 | 178.4 | 068.4 | 046.2 | 230.4 | 202.4 | 023.4 | 354.4 | 326.0 | 148.7 | 123.4 | 310.0 | 6 |
| 7 | 346.1 | 328.8 | 218.7 | 196.3 | 020.5 | 352.5 | 173.5 | 144.4 | 116.1 | 298.9 | 273.5 | 100.3 | 7 |
| 8 | 136.5 | 119.2 | 009.0 | 346.5 | 170.6 | 142.5 | 323.5 | 294.5 | 266.1 | 089.0 | 063.7 | 250.5 | 8 |
| 9 | 286.9 | 269.6 | 159.3 | 136.7 | 320.6 | 292.6 | 113.5 | 084.5 | 056.2 | 239.1 | 213.9 | 040.8 | 9 |
| 10 | 077.3 | 060.0 | 309.6 | 286.9 | 110.7 | 082.6 | 263.5 | 234.5 | 206.3 | 029.2 | 004.1 | 191.1 | 10 |
| 11 | 227.7 | 210.3 | 099.9 | 077.1 | 260.8 | 232.7 | 053.6 | 024.6 | 356.3 | 179.3 | 154.3 | 341.4 | 11 |
| 12 | 018.1 | 000.7 | 250.2 | 227.2 | 050.9 | 022.7 | 203.6 | 174.6 | 146.4 | 329.5 | 304.5 | 131.6 | 12 |
| 13 | 168.6 | 151.1 | 040.5 | 017.4 | 201.0 | 172.7 | 353.6 | 324.7 | 296.5 | 119.6 | 094.7 | 281.9 | 13 |
| 14 | 319.0 | 301.5 | 190.8 | 167.6 | 351.1 | 322.8 | 143.7 | 114.7 | 086.6 | 269.7 | 244.9 | 072.2 | 14 |
| 15 | 109.4 | 091.9 | 341.1 | 317.7 | 141.1 | 112.8 | 293.7 | 264.7 | 236.7 | 059.9 | 035.1 | 222.5 | 15 |
| 16 | 259.8 | 242.2 | 131.3 | 107.9 | 291.2 | 262.8 | 083.7 | 054.8 | 026.7 | 210.0 | 185.3 | 012.8 | 16 |
| 17 | 050.2 | 032.6 | 281.6 | 258.0 | 081.3 | 052.9 | 233.7 | 204.8 | 176.8 | 000.1 | 335.5 | 163.1 | 17 |
| 18 | 200.6 | 183.0 | 071.9 | 048.2 | 231.4 | 202.9 | 023.8 | 354.9 | 326.9 | 150.3 | 125.7 | 313.4 | 18 |
| 19 | 351.0 | 333.3 | 222.1 | 198.3 | 021.4 | 352.9 | 173.8 | 144.9 | 117.0 | 300.4 | 275.9 | 103.7 | 19 |
| 20 | 141.5 | 123.7 | 012.4 | 348.5 | 171.5 | 143.0 | 323.8 | 295.0 | 267.1 | 090.6 | 066.2 | 254.0 | 20 |
| 21 | 291.9 | 274.1 | 162.6 | 138.6 | 321.6 | 293.0 | 113.9 | 085.0 | 057.2 | 240.7 | 216.4 | 044.3 | 21 |
| 22 | 082.3 | 064.4 | 312.9 | 288.7 | 111.6 | 083.0 | 263.9 | 235.1 | 207.3 | 030.9 | 006.6 | 194.6 | 22 |
| 23 | 232.7 | 214.8 | 103.1 | 078.9 | 261.7 | 233.1 | 053.9 | 025.1 | 357.4 | 181.0 | 156.8 | 344.9 | 23 |
| 24 | 023.1 | 005.1 | 253.4 | 229.0 | 051.8 | 023.1 | 203.9 | 175.2 | 147.5 | 331.2 | 307.1 | 135.2 | 24 |
| 25 | 173.5 | 155.5 | 043.6 | 019.1 | 201.8 | 173.1 | 354.0 | 325.2 | 297.6 | 121.3 | 097.3 | 285.5 | 25 |
| 26 | 323.9 | 305.8 | 193.8 | 169.3 | 351.9 | 323.2 | 144.0 | 115.3 | 087.7 | 271.5 | 247.5 | 075.8 | 26 |
| 27 | 114.4 | 096.1 | 344.1 | 319.4 | 141.9 | 113.2 | 294.0 | 265.4 | 237.8 | 061.6 | 037.8 | 226.1 | 27 |
| 28 | 264.8 | 246.5 | 134.3 | 109.5 | 292.0 | 263.2 | 084.1 | 055.4 | 027.9 | 211.8 | 188.0 | 016.5 | 28 |
| 29 | 055.2 | | 284.5 | 259.6 | 082.1 | 053.2 | 234.1 | 205.5 | 178.0 | 002.0 | 338.2 | 166.8 | 29 |
| 30 | 205.6 | | 074.7 | 049.7 | 232.1 | 203.3 | 024.1 | 355.5 | 328.1 | 152.1 | 128.5 | 317.1 | 30 |
| 31 | 356.0 | | 224.9 | | 022.2 | | 174.2 | 145.6 | | 302.3 | | 107.5 | 31 |

Unlike Mars, Jupiter (and Saturn) are gas giants and they only allow us to view their upper atmospheric features. Only a small telescope (even a 50mm instrument) is required to view the equatorial belts and the Great Red Spot. When seeing is good, numerous breaks can be glimpsed in the bands as well as many minor spots. There is no single correct rotation period for the features of Jupiter. The speed of movement of any feature on the 'surface' depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs often measure the time a feature crosses the central meridian of the planet.

The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0hrs UT (10:00am EST) of date. You will need to add multiple hours and minutes from the small 'Increase in Longitude' tables below. For example the longitude of central meridian for Jupiter (system I) for January 31 at 2:20am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on January 30. From the table, the longitude on January 30 is 169.1°. To this add an adjustment for the 16 hours, which is 225.3°, and finally for the 20 minutes add 12.2°. These add up to 406.6°; less 360° gives a final answer of 46.6°.

**Finding the Great Red Spot (GRS)**

At the time of publication (Sep. 02) the GRS was located at 76° longitude using System II (it slowly drifts over the years, e.g., at the end of 1999 its longitude was 66°). For all features visible on Jupiter they are best observed from about 1 hour before crossing the central meridian to one hour after. Based on System II this results in plus/minus about 36° (see correction table below) or in the case of the GRS about 40° to 112°.

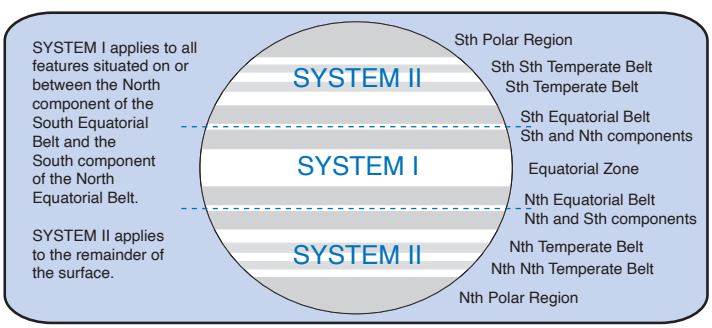
Repeating the calculation for the example above i.e., January 31 at 2:20am but using the data and correction tables for System II gives a value of 437.7°. Subtracting 360° gives a final result of 77.9°. The GRS should be transiting at this time. The Great Red Spot in recent years has lost a lot of its red colouration and now looks more pale orange – tan.

The longitude of the GRS was obtained from the website below, as calculated by John W. McAnally of the Association of Lunar and Planetary Observers (ALPO). Updates for its Longitude and predicted times (in UT) for the GRS crossing the central meridian can be found at:
http://ncastro.org/juptrans.html

SYSTEM I
Rotation: 9h 50m 30.003s

| hr | deg° | hr | deg° | min | deg° |
|---|---|---|---|---|---|
| 01 | 036.6 | 13 | 115.5 | 05 | 03.0 |
| 02 | 073.2 | 14 | 152.1 | 10 | 06.1 |
| 03 | 109.7 | 15 | 188.7 | 15 | 09.1 |
| 04 | 146.3 | 16 | 225.3 | 20 | 12.2 |
| 05 | 182.9 | 17 | 261.8 | 25 | 15.2 |
| 06 | 219.5 | 18 | 298.4 | 30 | 18.3 |
| 07 | 256.1 | 19 | 335.0 | 35 | 21.3 |
| 08 | 292.6 | 20 | 011.6 | 40 | 24.4 |
| 09 | 329.2 | 21 | 048.2 | 45 | 27.4 |
| 10 | 005.8 | 22 | 084.7 | 50 | 30.5 |
| 11 | 042.4 | 23 | 121.3 | 55 | 33.5 |
| 12 | 079.0 | 24 | 157.9 | 60 | 36.6 |

Increase in longitude

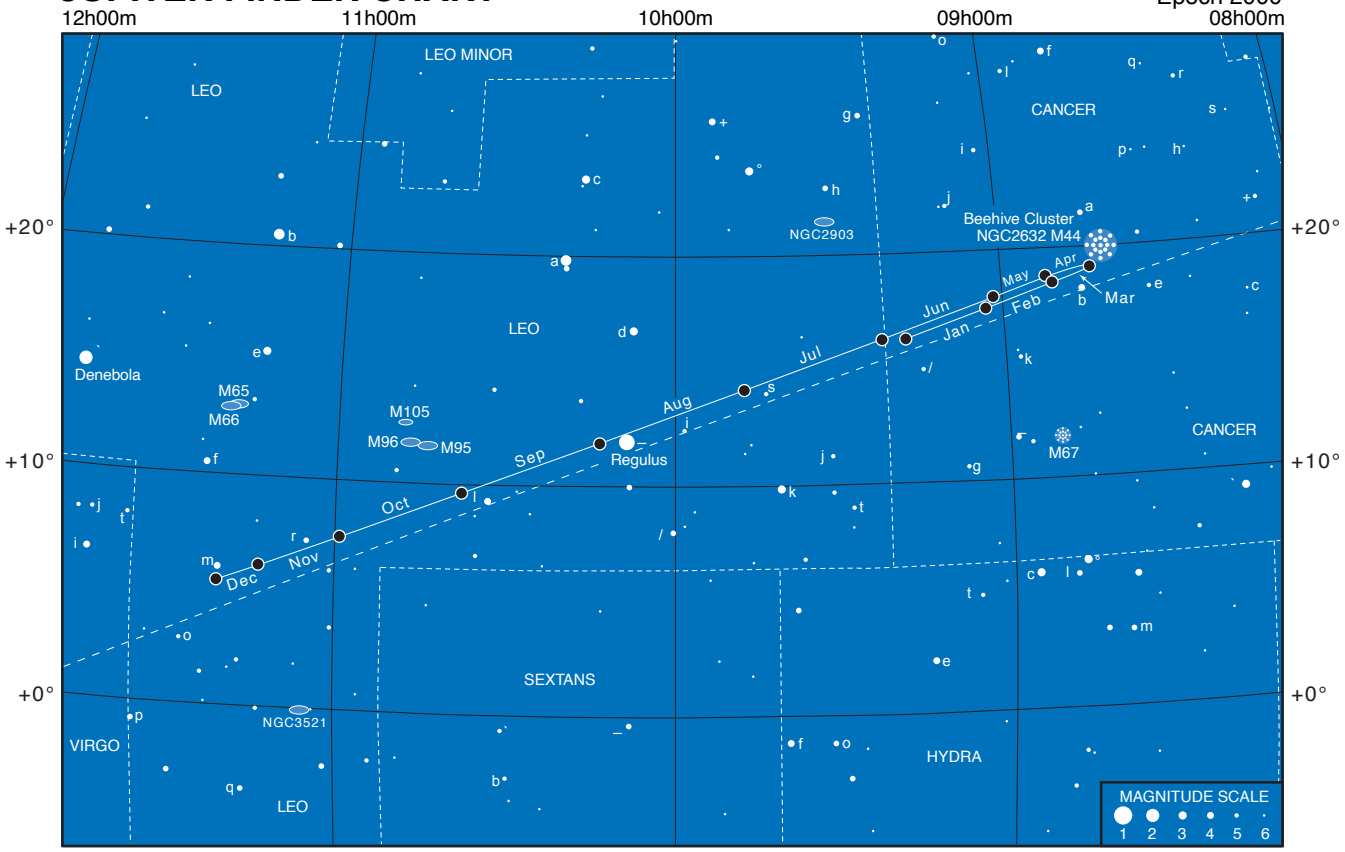



SYSTEM II
Rotation: 9h 55m 40.062s

| hr | deg° | hr | deg° | min | deg° |
|---|---|---|---|---|---|
| 01 | 036.3 | 13 | 111.4 | 05 | 03.0 |
| 02 | 072.5 | 14 | 147.7 | 10 | 06.0 |
| 03 | 108.8 | 15 | 183.9 | 15 | 09.1 |
| 04 | 145.0 | 16 | 220.2 | 20 | 12.1 |
| 05 | 181.3 | 17 | 256.5 | 25 | 15.1 |
| 06 | 217.6 | 18 | 292.7 | 30 | 18.1 |
| 07 | 253.8 | 19 | 329.0 | 35 | 21.2 |
| 08 | 290.1 | 20 | 005.2 | 40 | 24.2 |
| 09 | 326.4 | 21 | 041.5 | 45 | 27.2 |
| 10 | 002.6 | 22 | 077.8 | 50 | 30.2 |
| 11 | 038.9 | 23 | 114.0 | 55 | 33.2 |
| 12 | 075.1 | 24 | 150.3 | 60 | 36.3 |

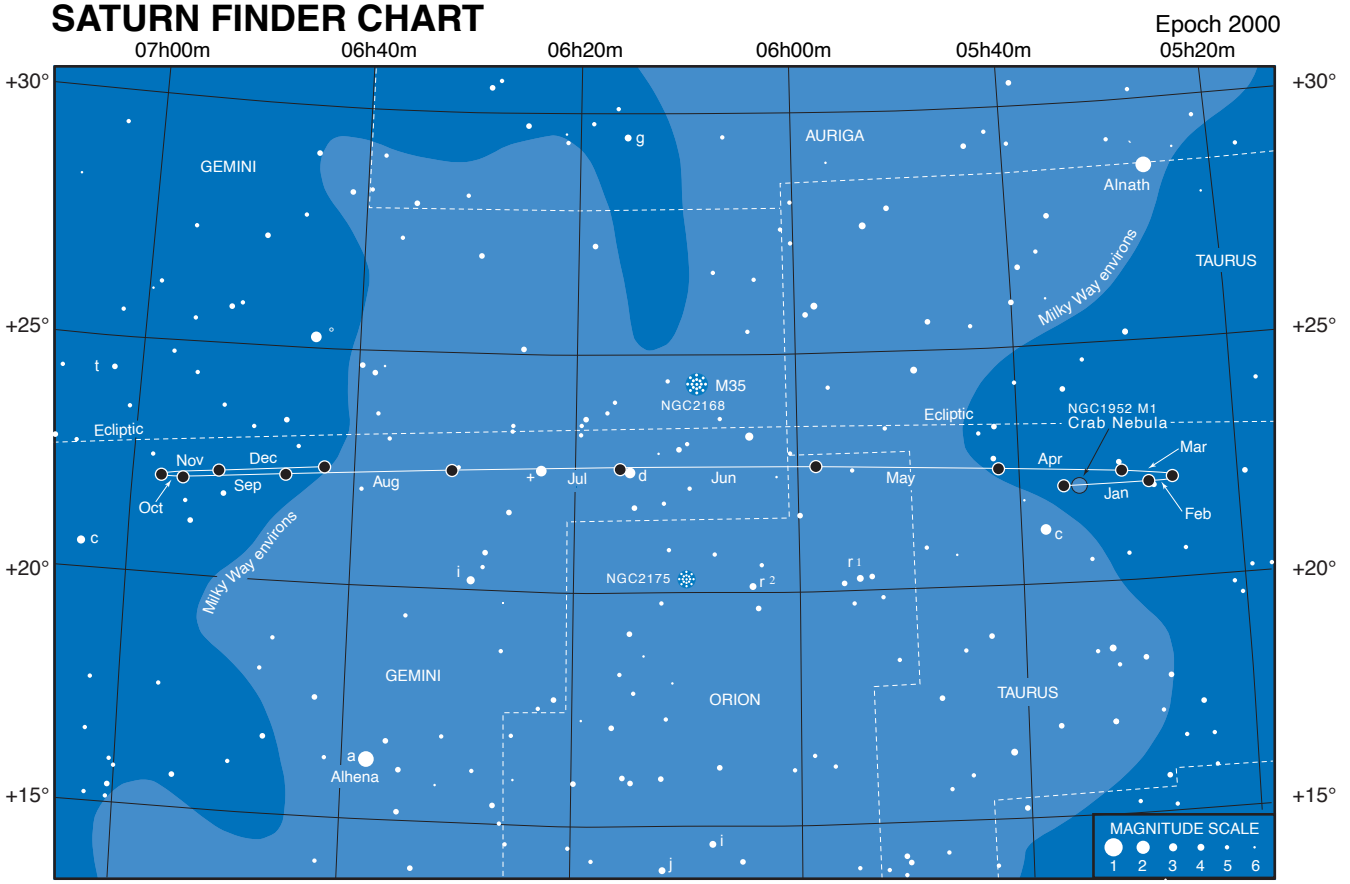
Increase in longitude

# JUPITER FINDER CHART




Opposition 2nd February, Stationary 4th April, Conjunction 22nd August.

# SATURN FINDER CHART




Stationary 22nd February, Conjunction 25th June, Stationary 26th October, Opposition 1st January 2004

# SATURN

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| Jan | 4 | 17:59 | 03:56 | 17:15 | 03:46 | 17:48 | 03:44 | 17:45 | 05:12 | 18:16 | 03:30 | 18:11 | 03:53 | 17:53 | 04:04 | 17:36 | 03:38 |
| | 11 | 17:29 | 03:26 | 16:45 | 03:16 | 17:18 | 03:14 | 17:16 | 04:42 | 17:47 | 03:00 | 17:41 | 03:24 | 17:23 | 03:34 | 17:06 | 03:09 |
| | 18 | 17:00 | 02:57 | 16:16 | 02:46 | 16:49 | 02:44 | 16:46 | 04:13 | 17:17 | 02:31 | 17:12 | 02:54 | 16:53 | 03:05 | 16:37 | 02:39 |
| | 25 | 16:31 | 02:28 | 15:46 | 02:17 | 16:19 | 02:15 | 16:17 | 03:44 | 16:48 | 02:02 | 16:43 | 02:25 | 16:24 | 02:36 | 16:08 | 02:10 |
| Feb | 1 | 16:02 | 01:59 | 15:18 | 01:48 | 15:51 | 01:46 | 15:48 | 03:15 | 16:19 | 01:33 | 16:14 | 01:56 | 15:55 | 02:07 | 15:39 | 01:41 |
| | 8 | 15:33 | 01:30 | 14:49 | 01:20 | 15:22 | 01:18 | 15:20 | 02:46 | 15:51 | 01:04 | 15:45 | 01:28 | 15:27 | 01:38 | 15:10 | 01:13 |
| | 15 | 15:05 | 01:02 | 14:21 | 00:51 | 14:54 | 00:49 | 14:52 | 02:18 | 15:23 | 00:36 | 15:17 | 00:59 | 14:59 | 01:10 | 14:42 | 00:44 |
| | 22 | 14:38 | 00:34 | 13:53 | 00:24 | 14:26 | 00:22 | 14:24 | 01:50 | 14:55 | 00:08 | 14:50 | 00:31 | 14:31 | 00:42 | 14:15 | 00:16 |
| Mar | 1 | 14:10 | 00:07 | 13:26 | 23:52 | 13:59 | 23:50 | 13:56 | 01:23 | 14:28 | 23:37 | 14:22 | 00:04 | 14:04 | 00:15 | 13:47 | 23:45 |
| | 8 | 13:43 | 23:36 | 12:59 | 23:25 | 13:32 | 23:23 | 13:30 | 00:56 | 14:01 | 23:10 | 13:55 | 23:33 | 13:37 | 23:44 | 13:21 | 23:18 |
| | 15 | 13:17 | 23:09 | 12:33 | 22:59 | 13:06 | 22:57 | 13:03 | 00:29 | 13:35 | 22:43 | 13:29 | 23:06 | 13:11 | 23:17 | 12:54 | 22:51 |
| | 22 | 12:51 | 22:43 | 12:07 | 22:32 | 12:40 | 22:30 | 12:37 | 23:59 | 13:09 | 22:17 | 13:03 | 22:40 | 12:45 | 22:51 | 12:28 | 22:25 |
| | 29 | 12:25 | 22:17 | 11:41 | 22:07 | 12:14 | 22:04 | 12:11 | 23:33 | 12:43 | 21:51 | 12:37 | 22:14 | 12:19 | 22:25 | 12:02 | 21:59 |
| Apr | 5 | 12:00 | 21:51 | 11:15 | 21:41 | 11:49 | 21:39 | 11:46 | 23:08 | 12:18 | 21:25 | 12:12 | 21:48 | 11:54 | 21:59 | 11:37 | 21:34 |
| | 12 | 11:35 | 21:26 | 10:50 | 21:16 | 11:24 | 21:13 | 11:20 | 22:43 | 11:53 | 21:00 | 11:47 | 21:23 | 11:29 | 21:34 | 11:12 | 21:08 |
| | 19 | 11:10 | 21:01 | 10:26 | 20:51 | 10:59 | 20:48 | 10:56 | 22:18 | 11:28 | 20:34 | 11:22 | 20:58 | 11:04 | 21:09 | 10:47 | 20:43 |
| | 26 | 10:46 | 20:36 | 10:01 | 20:26 | 10:34 | 20:23 | 10:31 | 21:53 | 11:04 | 20:10 | 10:58 | 20:33 | 10:39 | 20:44 | 10:23 | 20:18 |
| May | 3 | 10:21 | 20:11 | 09:37 | 20:01 | 10:10 | 19:59 | 10:07 | 21:28 | 10:39 | 19:45 | 10:33 | 20:09 | 10:15 | 20:20 | 09:58 | 19:54 |
| | 10 | 09:57 | 19:47 | 09:13 | 19:37 | 09:46 | 19:35 | 09:42 | 21:04 | 10:15 | 19:21 | 10:09 | 19:44 | 09:51 | 19:55 | 09:34 | 19:29 |
| | 17 | 09:33 | 19:23 | 08:49 | 19:13 | 09:22 | 19:10 | 09:18 | 20:40 | 09:51 | 18:56 | 09:45 | 19:20 | 09:27 | 19:31 | 09:10 | 19:05 |
| | 24 | 09:09 | 18:59 | 08:25 | 18:49 | 08:58 | 18:46 | 08:54 | 20:16 | 09:28 | 18:32 | 09:21 | 18:56 | 09:03 | 19:07 | 08:46 | 18:41 |
| | 31 | 08:46 | 18:35 | 08:01 | 18:25 | 08:34 | 18:22 | 08:31 | 19:52 | 09:04 | 18:08 | 08:58 | 18:32 | 08:39 | 18:43 | 08:23 | 18:17 |
| Jun | 7 | 08:22 | 18:11 | 07:37 | 18:01 | 08:11 | 17:59 | 08:07 | 19:29 | 08:40 | 17:45 | 08:34 | 18:08 | 08:15 | 18:20 | 07:59 | 17:54 |
| | 14 | 07:58 | 17:48 | 07:14 | 17:38 | 07:47 | 17:35 | 07:43 | 19:05 | 08:17 | 17:21 | 08:10 | 17:45 | 07:52 | 17:56 | 07:35 | 17:30 |
| | 21 | 07:35 | 17:24 | 06:50 | 17:14 | 07:24 | 17:11 | 07:20 | 18:41 | 07:53 | 16:57 | 07:47 | 17:21 | 07:28 | 17:32 | 07:12 | 17:06 |
| | 28 | 07:11 | 17:01 | 06:26 | 16:50 | 07:00 | 16:48 | 06:56 | 18:18 | 07:29 | 16:34 | 07:23 | 16:58 | 07:05 | 17:09 | 06:48 | 16:43 |
| Jul | 5 | 06:47 | 16:37 | 06:03 | 16:27 | 06:36 | 16:24 | 06:32 | 17:54 | 07:06 | 16:10 | 07:00 | 16:34 | 06:41 | 16:45 | 06:24 | 16:19 |
| | 12 | 06:24 | 16:13 | 05:39 | 16:03 | 06:12 | 16:01 | 06:09 | 17:31 | 06:42 | 15:47 | 06:36 | 16:10 | 06:17 | 16:22 | 06:01 | 15:56 |
| | 19 | 06:00 | 15:50 | 05:15 | 15:40 | 05:49 | 15:37 | 05:45 | 17:07 | 06:18 | 15:23 | 06:12 | 15:47 | 05:53 | 15:58 | 05:37 | 15:32 |
| | 26 | 05:36 | 15:26 | 04:51 | 15:16 | 05:25 | 15:13 | 05:21 | 16:43 | 05:54 | 14:59 | 05:48 | 15:23 | 05:30 | 15:34 | 05:13 | 15:08 |
| Aug | 2 | 05:12 | 15:02 | 04:27 | 14:52 | 05:01 | 14:50 | 04:57 | 16:19 | 05:30 | 14:36 | 05:24 | 14:59 | 05:05 | 15:10 | 04:49 | 14:45 |
| | 9 | 04:48 | 14:38 | 04:03 | 14:28 | 04:36 | 14:26 | 04:33 | 15:55 | 05:06 | 14:12 | 05:00 | 14:35 | 04:41 | 14:47 | 04:25 | 14:21 |
| | 16 | 04:23 | 14:14 | 03:39 | 14:04 | 04:12 | 14:02 | 04:09 | 15:31 | 04:41 | 13:48 | 04:35 | 14:11 | 04:17 | 14:22 | 04:00 | 13:57 |
| | 23 | 03:59 | 13:50 | 03:14 | 13:40 | 03:48 | 13:37 | 03:44 | 15:07 | 04:17 | 13:24 | 04:11 | 13:47 | 03:52 | 13:58 | 03:36 | 13:32 |
| | 30 | 03:34 | 13:25 | 02:49 | 13:15 | 03:23 | 13:13 | 03:20 | 14:42 | 03:52 | 12:59 | 03:46 | 13:23 | 03:28 | 13:34 | 03:11 | 13:08 |
| Sep | 6 | 03:09 | 13:01 | 02:24 | 12:50 | 02:58 | 12:48 | 02:55 | 14:17 | 03:27 | 12:34 | 03:21 | 12:58 | 03:03 | 13:09 | 02:46 | 12:43 |
| | 13 | 02:44 | 12:36 | 01:59 | 12:25 | 02:32 | 12:23 | 02:30 | 13:52 | 03:01 | 12:09 | 02:56 | 12:33 | 02:37 | 12:44 | 02:21 | 12:18 |
| | 20 | 02:18 | 12:10 | 01:34 | 12:00 | 02:07 | 11:58 | 02:04 | 13:26 | 02:36 | 11:44 | 02:30 | 12:08 | 02:12 | 12:18 | 01:55 | 11:53 |
| | 27 | 01:52 | 11:45 | 01:08 | 11:34 | 01:41 | 11:32 | 01:38 | 13:01 | 02:10 | 11:19 | 02:04 | 11:42 | 01:46 | 11:53 | 01:29 | 11:27 |
| Oct | 4 | 01:26 | 11:19 | 00:42 | 11:08 | 01:15 | 11:06 | 01:12 | 12:35 | 01:43 | 10:53 | 01:38 | 11:16 | 01:20 | 11:27 | 01:03 | 11:01 |
| | 11 | 00:59 | 10:52 | 00:15 | 10:42 | 00:48 | 10:40 | 00:46 | 12:08 | 01:17 | 10:26 | 01:11 | 10:49 | 00:53 | 11:00 | 00:36 | 10:34 |
| | 18 | 00:32 | 10:25 | 23:44 | 10:15 | 00:21 | 10:13 | 00:19 | 11:41 | 00:50 | 09:59 | 00:44 | 10:23 | 00:26 | 10:33 | 00:09 | 10:08 |
| | 25 | 00:05 | 09:58 | 23:17 | 09:47 | 23:50 | 09:45 | 23:47 | 11:14 | 00:23 | 09:32 | 00:17 | 09:55 | 23:55 | 10:06 | 23:38 | 09:40 |
| Nov | 1 | 23:33 | 09:30 | 22:49 | 09:20 | 23:22 | 09:18 | 23:20 | 10:46 | 23:51 | 09:04 | 23:45 | 09:28 | 23:27 | 09:38 | 23:11 | 09:13 |
| | 8 | 23:05 | 09:02 | 22:21 | 08:52 | 22:54 | 08:50 | 22:52 | 10:18 | 23:23 | 08:36 | 23:17 | 09:00 | 22:59 | 09:10 | 22:43 | 08:45 |
| | 15 | 22:37 | 08:34 | 21:53 | 08:23 | 22:26 | 08:21 | 22:23 | 09:50 | 22:55 | 08:08 | 22:49 | 08:31 | 22:31 | 08:42 | 22:14 | 08:16 |
| | 22 | 22:08 | 08:05 | 21:24 | 07:54 | 21:57 | 07:52 | 21:55 | 09:21 | 22:26 | 07:39 | 22:20 | 08:02 | 22:02 | 08:13 | 21:45 | 07:47 |
| | 29 | 21:39 | 07:36 | 20:55 | 07:25 | 21:28 | 07:23 | 21:25 | 08:52 | 21:57 | 07:09 | 21:51 | 07:33 | 21:33 | 07:44 | 21:16 | 07:18 |
| Dec | 6 | 21:10 | 07:06 | 20:26 | 06:56 | 20:59 | 06:53 | 20:56 | 08:22 | 21:28 | 06:40 | 21:22 | 07:03 | 21:04 | 07:14 | 20:47 | 06:48 |
| | 13 | 20:41 | 06:36 | 19:56 | 06:26 | 20:29 | 06:24 | 20:26 | 07:53 | 20:58 | 06:10 | 20:53 | 06:33 | 20:34 | 06:44 | 20:18 | 06:19 |
| | 20 | 20:11 | 06:06 | 19:27 | 05:56 | 20:00 | 05:54 | 19:57 | 07:23 | 20:29 | 05:40 | 20:23 | 06:03 | 20:05 | 06:14 | 19:48 | 05:49 |
| | 27 | 19:41 | 05:36 | 18:57 | 05:26 | 19:30 | 05:24 | 19:27 | 06:53 | 19:59 | 05:10 | 19:53 | 05:33 | 19:35 | 05:44 | 19:18 | 05:18 |

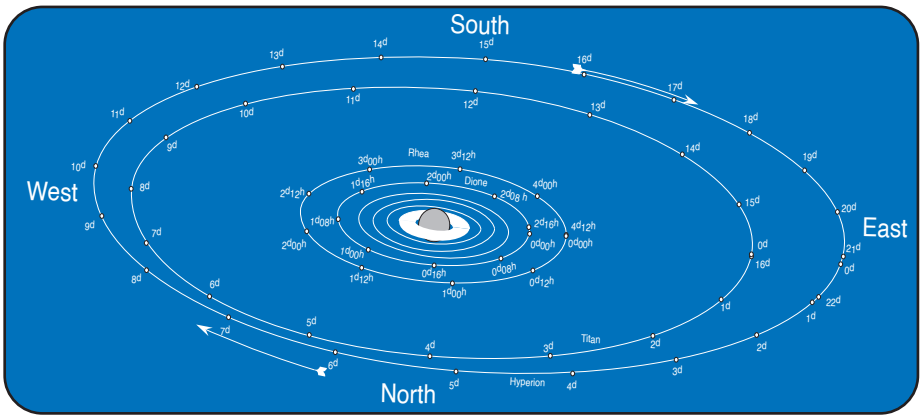
## POSITION

(0hrs UT Epoch 2000.0)

| RA | | | DEC | | |
|---|---|---|---|---|---|
| h | m | s | ° | ' | " |
| 05 | 34 | 51 | + 22 | 02 | 04 |
| 05 | 32 | 40 | + 22 | 01 | 47 |
| 05 | 30 | 43 | + 22 | 01 | 40 |
| 05 | 29 | 02 | + 22 | 01 | 46 |
| 05 | 27 | 41 | + 22 | 02 | 07 |
| 05 | 26 | 41 | + 22 | 02 | 47 |
| 05 | 26 | 05 | + 22 | 03 | 46 |
| 05 | 25 | 52 | + 22 | 05 | 04 |
| 05 | 26 | 02 | + 22 | 06 | 43 |
| 05 | 26 | 37 | + 22 | 08 | 40 |
| 05 | 27 | 34 | + 22 | 10 | 52 |
| 05 | 28 | 54 | + 22 | 13 | 18 |
| 05 | 30 | 35 | + 22 | 15 | 54 |
| 05 | 32 | 36 | + 22 | 18 | 36 |
| 05 | 34 | 56 | + 22 | 21 | 19 |
| 05 | 37 | 33 | + 22 | 24 | 00 |
| 05 | 40 | 25 | + 22 | 26 | 35 |
| 05 | 43 | 30 | + 22 | 28 | 59 |
| 05 | 46 | 48 | + 22 | 31 | 10 |
| 05 | 50 | 16 | + 22 | 33 | 04 |
| 05 | 53 | 53 | + 22 | 34 | 37 |
| 05 | 57 | 37 | + 22 | 35 | 49 |
| 06 | 01 | 27 | + 22 | 36 | 36 |
| 06 | 05 | 21 | + 22 | 36 | 58 |
| 06 | 09 | 16 | + 22 | 36 | 54 |
| 06 | 13 | 13 | + 22 | 36 | 25 |
| 06 | 17 | 09 | + 22 | 35 | 30 |
| 06 | 21 | 02 | + 22 | 34 | 11 |
| 06 | 24 | 52 | + 22 | 32 | 30 |
| 06 | 28 | 36 | + 22 | 30 | 28 |
| 06 | 32 | 12 | + 22 | 28 | 09 |
| 06 | 35 | 41 | + 22 | 25 | 37 |
| 06 | 38 | 59 | + 22 | 22 | 54 |
| 06 | 42 | 05 | + 22 | 20 | 05 |
| 06 | 44 | 57 | + 22 | 17 | 16 |
| 06 | 47 | 35 | + 22 | 14 | 29 |
| 06 | 49 | 56 | + 22 | 11 | 52 |
| 06 | 51 | 59 | + 22 | 09 | 27 |
| 06 | 53 | 43 | + 22 | 07 | 21 |
| 06 | 55 | 05 | + 22 | 05 | 38 |
| 06 | 56 | 06 | + 22 | 04 | 22 |
| 06 | 56 | 45 | + 22 | 03 | 36 |
| 06 | 57 | 00 | + 22 | 03 | 22 |
| 06 | 56 | 51 | + 22 | 03 | 42 |
| 06 | 56 | 19 | + 22 | 04 | 35 |
| 06 | 55 | 24 | + 22 | 06 | 02 |
| 06 | 54 | 08 | + 22 | 07 | 58 |
| 06 | 52 | 32 | + 22 | 10 | 21 |
| 06 | 50 | 38 | + 22 | 13 | 06 |
| 06 | 48 | 30 | + 22 | 16 | 08 |
| 06 | 46 | 11 | + 22 | 19 | 19 |
| 06 | 43 | 45 | + 22 | 22 | 36 |

# SATELLITES OF SATURN

To estimate the configuration or positions of the satellites, the Apparent Orbits diagram and the times of Greatest Eastern Elongation are needed. For each satellite, take the previous (most recent) date of greatest eastern elongation and work out the period that has elapsed (in days and hours) since this time. Locate this time on the relevant orbit on the diagram and that gives the moon's position directly.




*Apparent orbits of the satellites on July 1. Only the inner satellites are shown. The orbits of Iapetus and Phoebe are too large to show on the above diagram.*

## TITAN (UT) Mean Synodic Period 15d 23.3h

| Greatest Eastern Elongation | | Inferior Conjunction | | Greatest Western Elongation | | Superior Conjunction | |
|---|---|---|---|---|---|---|---|
| | | | | | | Jan 3 | 07.8 |
| Jan 7 | 11.6 | Jan 11 | 12.9 | Jan 15 | 08.0 | Jan 19 | 05.2 |
| Jan 23 | 09.0 | Jan 27 | 10.6 | Jan 31 | 05.8 | Feb 4 | 03.0 |
| Feb 8 | 06.9 | Feb 12 | 08.7 | Feb 16 | 04.0 | Feb 20 | 01.3 |
| Feb 24 | 05.4 | Feb 28 | 07.4 | Mar 4 | 02.8 | Mar 8 | 00.3 |
| Mar 12 | 04.5 | Mar 16 | 06.6 | Mar 20 | 02.1 | Mar 23 | 23.8 |
| Mar 28 | 04.2 | Apr 1 | 06.3 | Apr 5 | 02.0 | Apr 8 | 23.8 |
| Apr 13 | 04.4 | Apr 17 | 06.5 | Apr 21 | 02.2 | Apr 25 | 00.2 |
| Apr 29 | 05.0 | May 3 | 07.0 | May 7 | 02.7 | May 11 | 01.0 |
| May 15 | 05.9 | May 19 | 07.9 | May 23 | 03.6 | May 27 | 02.0 |
| May 31 | 07.0 | Jun 4 | 08.8 | Jun 8 | 04.5 | Jun 12 | 03.2 |
| Jun 16 | 08.2 | Jun 20 | 09.9 | Jun 24 | 05.5 | Jun 28 | 04.4 |
| Jul 2 | 09.5 | Jul 6 | 11.0 | Jul 10 | 06.6 | Jul 14 | 05.6 |
| Jul 18 | 10.7 | Jul 22 | 12.0 | Jul 26 | 07.5 | Jul 30 | 06.7 |
| Aug 3 | 11.8 | Aug 7 | 12.8 | Aug 11 | 08.2 | Aug 15 | 07.5 |
| Aug 19 | 12.6 | Aug 23 | 13.4 | Aug 27 | 08.7 | Aug 31 | 08.1 |
| Sep 4 | 13.1 | Sep 8 | 13.6 | Sep 12 | 08.9 | Sep 16 | 08.2 |
| Sep 20 | 13.2 | Sep 24 | 13.5 | Sep 28 | 08.6 | Oct 2 | 08.0 |
| Oct 6 | 12.8 | Oct 10 | 12.9 | Oct 14 | 07.9 | Oct 18 | 07.2 |
| Oct 22 | 11.8 | Oct 26 | 11.8 | Oct 30 | 06.7 | Nov 3 | 05.8 |
| Nov 7 | 10.3 | Nov 11 | 10.2 | Nov 15 | 04.9 | Nov 19 | 03.9 |
| Nov 23 | 08.3 | Nov 27 | 08.1 | Dec 1 | 02.7 | Dec 5 | 01.5 |
| Dec 9 | 05.8 | Dec 13 | 05.6 | Dec 17 | 00.2 | Dec 20 | 22.8 |
| Dec 25 | 03.0 | Dec 29 | 02.9 | | | | |

## IAPETUS (UT) Mean Synodic Period 79d 22.1h

| Greatest Eastern Elongation | | Inferior Conjunction | | Greatest Western Elongation | | Superior Conjunction | |
|---|---|---|---|---|---|---|---|
| Jan 6 | 14.6 | Jan 27 | 01.1 | Feb 15 | 06.4 | Mar 6 | 05.7 |
| Mar 26 | 17.7 | Apr 16 | 19.6 | May 6 | 13.1 | May 26 | 00.8 |
| Jun 16 | 01.4 | Jul 7 | 07.4 | Jul 27 | 00.0 | Aug 15 | 13.9 |
| Sep 5 | 14.0 | Sep 26 | 09.9 | Oct 15 | 15.3 | Nov 3 | 19.4 |
| Nov 24 | 05.7 | Dec 14 | 11.1 | | | | |

## HYPERION (UT) Mean Synodic Period 21d 7.6h

| Greatest Eastern Elongation | | Inferior Conjunction | | Greatest Western Elongation | | Superior Conjunction | |
|---|---|---|---|---|---|---|---|
| | | Jan 3 | 10.1 | Jan 7 | 15.1 | Jan 12 | 17.8 |
| Jan 19 | 05.2 | Jan 24 | 12.0 | Jan 28 | 17.3 | Feb 2 | 20.0 |
| Feb 9 | 07.8 | Feb 14 | 15.0 | Feb 18 | 20.4 | Feb 23 | 23.7 |
| Mar 2 | 12.2 | Mar 7 | 19.3 | Mar 12 | 00.8 | Mar 17 | 05.2 |
| Mar 23 | 18.4 | Mar 29 | 01.1 | Apr 2 | 06.7 | Apr 7 | 12.5 |
| Apr 14 | 02.4 | Apr 19 | 07.9 | Apr 23 | 13.9 | Apr 28 | 21.4 |
| May 5 | 11.6 | May 10 | 16.0 | May 14 | 22.1 | May 20 | 07.7 |
| May 26 | 22.3 | Jun 1 | 01.2 | Jun 5 | 07.4 | Jun 10 | 19.1 |
| Jun 17 | 09.7 | Jun 22 | 10.8 | Jun 26 | 17.5 | Jul 2 | 07.3 |
| Jul 8 | 21.8 | Jul 13 | 21.2 | Jul 18 | 04.0 | Jul 23 | 20.1 |
| Jul 30 | 09.9 | Aug 4 | 07.7 | Aug 8 | 15.1 | Aug 14 | 08.9 |
| Aug 20 | 22.1 | Aug 25 | 18.3 | Aug 30 | 01.8 | Sep 4 | 21.4 |
| Sep 11 | 09.7 | Sep 16 | 04.7 | Sep 20 | 12.7 | Sep 26 | 09.2 |
| Oct 2 | 20.7 | Oct 7 | 14.6 | Oct 11 | 22.7 | Oct 17 | 19.9 |
| Oct 24 | 06.6 | Oct 28 | 23.9 | Nov 2 | 08.0 | Nov 8 | 05.2 |
| Nov 14 | 15.2 | Nov 19 | 08.2 | Nov 23 | 16.3 | Nov 29 | 13.1 |
| Dec 5 | 22.9 | Dec 10 | 15.7 | Dec 14 | 23.5 | Dec 20 | 19.8 |
| Dec 27 | 05.5 | Dec 31 | 22.7 | | | | |

# SATURN'S RINGS

The 'Appearance of the Planets' diagrams in Part I show how open the rings are for 2003. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. The planet's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every 7 years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were edge-on during 1995. During 2003 the rings are wide open.

Major and minor axes (in arc seconds) are for the outer edge of the outer ring. To work out the size of the other rings, multiply by the following factors.

| | |
|---|---|
| Inner edge of outer ring | 0.8932 |
| Outer edge of inner ring | 0.8596 |
| Inner edge of inner ring | 0.6726 |
| Inner edge of dusky ring | 0.5477 |

'U' and 'B' are the geocentric longitude and the tilt of the rings respectively.

| Date | Major " | Minor " | U ° | B ° |
|---|---|---|---|---|
| Jan 1 | 46.7 | 20.9 | 315.3 | -26.7 |
| Jan 9 | 46.4 | 20.9 | 314.6 | -26.7 |
| Jan 17 | 46.0 | 20.7 | 314.0 | -26.8 |
| Jan 25 | 45.6 | 20.6 | 313.5 | -26.8 |
| Feb 2 | 45.1 | 20.3 | 313.1 | -26.8 |
| Feb 10 | 44.5 | 20.1 | 312.8 | -26.9 |
| Feb 18 | 43.9 | 19.9 | 312.7 | -26.9 |
| Feb 26 | 43.2 | 19.6 | 312.7 | -26.9 |
| Mar 6 | 42.6 | 19.3 | 312.8 | -27.0 |
| Mar 14 | 42.0 | 19.0 | 313.1 | -27.0 |
| Mar 22 | 41.4 | 18.8 | 313.5 | -27.0 |
| Mar 30 | 40.8 | 18.5 | 314.0 | -27.0 |
| Apr 7 | 40.2 | 18.3 | 314.6 | -27.0 |
| Apr 15 | 39.7 | 18.0 | 315.3 | -27.0 |
| Apr 23 | 39.3 | 17.8 | 316.1 | -27.0 |
| May 1 | 38.9 | 17.6 | 317.0 | -27.0 |
| May 9 | 38.5 | 17.4 | 318.0 | -26.9 |
| May 17 | 38.2 | 17.3 | 319.0 | -26.9 |
| May 25 | 38.0 | 17.1 | 320.1 | -26.8 |
| Jun 2 | 37.8 | 17.0 | 321.2 | -26.8 |
| Jun 10 | 37.6 | 16.9 | 322.3 | -26.7 |
| Jun 18 | 37.6 | 16.8 | 323.5 | -26.6 |
| Jun 26 | 37.5 | 16.7 | 324.6 | -26.5 |
| Jul 4 | 37.6 | 16.7 | 325.8 | -26.3 |
| Jul 12 | 37.7 | 16.6 | 326.9 | -26.2 |
| Jul 20 | 37.8 | 16.6 | 328.0 | -26.1 |
| Jul 28 | 38.0 | 16.6 | 329.1 | -25.9 |
| Aug 5 | 38.3 | 16.7 | 330.1 | -25.8 |
| Aug 13 | 38.6 | 16.7 | 331.1 | -25.6 |
| Aug 21 | 39.0 | 16.8 | 332.0 | -25.5 |
| Aug 29 | 39.4 | 16.9 | 332.9 | -25.4 |
| Sep 6 | 39.9 | 17.0 | 333.6 | -25.2 |
| Sep 14 | 40.4 | 17.1 | 334.3 | -25.1 |
| Sep 22 | 40.9 | 17.3 | 334.9 | -25.0 |
| Sep 30 | 41.5 | 17.5 | 335.3 | -24.9 |
| Oct 8 | 42.1 | 17.7 | 335.7 | -24.9 |
| Oct 16 | 42.8 | 18.0 | 335.9 | -24.8 |
| Oct 24 | 43.4 | 18.2 | 336.0 | -24.8 |
| Nov 1 | 44.0 | 18.5 | 336.0 | -24.8 |
| Nov 9 | 44.6 | 18.8 | 335.8 | -24.9 |
| Nov 17 | 45.2 | 19.0 | 335.5 | -24.9 |
| Nov 25 | 45.7 | 19.3 | 335.1 | -25.0 |
| Dec 3 | 46.1 | 19.6 | 334.6 | -25.1 |
| Dec 11 | 46.5 | 19.8 | 334.0 | -25.2 |
| Dec 19 | 46.7 | 20.0 | 333.4 | -25.3 |
| Dec 27 | 46.8 | 20.1 | 332.7 | -25.5 |

## TIMES OF GREATEST EASTERN ELONGATION (UT)

### RHEA Mean Synodic Period 4d 12.5h

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h |
| 3 05.0 | 3 19.4 | 2 21.9 | 3 13.4 | 5 05.3 | 1 09.0 | 3 01.3 | 3 17.5 | 4 09.5 | 1 12.5 | 2 03.5 | 3 18.0 |
| 7 17.3 | 8 07.8 | 7 10.3 | 8 01.9 | 9 17.9 | 5 21.6 | 7 13.9 | 8 06.1 | 8 22.0 | 6 01.0 | 6 15.9 | 8 06.3 |
| 12 05.7 | 12 20.2 | 11 22.8 | 12 14.5 | 14 06.5 | 10 10.2 | 12 02.5 | 12 18.7 | 13 10.5 | 10 13.4 | 11 04.3 | 12 18.6 |
| 16 18.0 | 17 08.6 | 16 11.3 | 17 03.0 | 18 19.1 | 14 22.8 | 16 15.1 | 17 07.2 | 17 23.0 | 15 01.9 | 15 16.6 | 17 06.9 |
| 21 06.3 | 21 21.0 | 20 23.8 | 21 15.6 | 23 07.7 | 19 11.4 | 21 03.7 | 21 19.8 | 22 11.5 | 19 14.3 | 20 05.0 | 21 19.2 |
| 25 18.7 | 26 09.4 | 25 12.3 | 26 04.2 | 27 20.4 | 24 00.0 | 25 16.3 | 26 08.4 | 27 00.0 | 24 02.7 | 24 17.3 | 26 07.5 |
| 30 07.0 | | 30 00.8 | 30 16.7 | | 28 12.7 | 30 04.9 | 30 20.9 | | 28 15.1 | 29 05.7 | 30 19.9 |

### DIONE Mean Synodic Period 2d 17.7h

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h |
| 2 01.0 | 1 03.2 | 3 05.8 | 2 08.6 | 2 11.8 | 1 15.1 | 1 18.4 | 3 15.5 | 2 18.6 | 2 21.4 | 2 00.0 | 2 02.3 |
| 4 18.7 | 3 20.9 | 5 23.5 | 5 02.4 | 5 05.5 | 4 08.8 | 4 12.2 | 6 09.2 | 5 12.3 | 5 15.1 | 4 17.7 | 4 19.9 |
| 7 12.3 | 6 14.6 | 8 17.2 | 7 20.1 | 7 23.3 | 7 02.6 | 7 05.9 | 9 03.0 | 8 06.0 | 8 08.8 | 7 11.4 | 7 13.6 |
| 10 05.9 | 9 08.2 | 11 10.9 | 10 13.8 | 10 17.0 | 9 20.4 | 9 23.7 | 11 20.7 | 10 23.7 | 11 02.5 | 10 05.0 | 10 07.2 |
| 12 23.6 | 12 01.9 | 14 04.6 | 13 07.6 | 13 10.8 | 12 14.1 | 12 17.5 | 14 14.4 | 13 17.5 | 13 20.2 | 12 22.7 | 13 00.9 |
| 15 17.3 | 14 19.6 | 16 22.3 | 16 01.3 | 16 04.5 | 15 07.9 | 15 11.2 | 17 08.2 | 16 11.2 | 16 13.9 | 15 16.3 | 15 18.5 |
| 18 10.9 | 17 13.3 | 19 16.0 | 18 19.1 | 18 22.3 | 18 01.6 | 18 05.0 | 20 01.9 | 19 04.9 | 19 07.6 | 18 10.0 | 18 12.1 |
| 21 04.6 | 20 07.0 | 22 09.7 | 21 12.8 | 21 16.1 | 20 19.4 | 20 22.7 | 22 19.6 | 21 22.6 | 22 01.3 | 21 03.7 | 21 05.8 |
| 23 22.2 | 23 00.7 | 25 03.5 | 24 06.5 | 24 09.8 | 23 13.2 | 23 16.5 | 25 13.4 | 24 16.3 | 24 19.0 | 23 21.3 | 23 23.4 |
| 26 15.9 | 25 18.4 | 27 21.2 | 27 00.3 | 27 03.6 | 26 06.9 | 26 10.2 | 28 07.1 | 27 10.0 | 27 12.7 | 26 15.0 | 26 17.1 |
| 29 09.6 | 28 12.1 | 30 14.9 | 29 18.0 | 29 21.3 | 29 00.7 | 29 04.0 | 31 00.8 | 30 03.7 | 30 06.3 | 29 08.6 | 29 10.7 |
| | | | | | | 31 21.7 | | | | | |

### TETHYS Mean Synodic Period 1d 21.3h

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h |
| 1 14.8 | 2 16.8 | 1 03.1 | 2 05.5 | 2 10.9 | 1 16.3 | 1 21.8 | 1 03.2 | 2 05.9 | 2 11.0 | 1 15.9 | 1 20.6 |
| 3 12.0 | 4 14.1 | 3 00.4 | 4 02.9 | 4 08.2 | 3 13.7 | 3 19.2 | 3 00.6 | 4 03.2 | 4 08.3 | 3 13.2 | 3 17.9 |
| 5 09.3 | 6 11.4 | 4 21.7 | 6 00.2 | 6 05.6 | 5 11.0 | 5 16.5 | 4 21.9 | 6 00.5 | 6 05.6 | 5 10.5 | 5 15.2 |
| 7 06.6 | 8 08.7 | 6 19.0 | 7 21.5 | 8 02.9 | 7 08.4 | 7 13.8 | 6 19.2 | 7 21.8 | 8 02.9 | 7 07.8 | 7 12.5 |
| 9 03.9 | 10 06.0 | 8 16.3 | 9 18.9 | 10 00.3 | 9 05.7 | 9 11.2 | 8 16.6 | 9 19.2 | 10 00.2 | 9 05.1 | 9 09.8 |
| 11 01.2 | 12 03.3 | 10 13.7 | 11 16.2 | 11 21.6 | 11 03.1 | 11 08.5 | 10 13.9 | 11 16.5 | 11 21.5 | 11 02.4 | 11 07.0 |
| 12 22.5 | 14 00.6 | 12 11.0 | 13 13.5 | 13 18.9 | 13 00.4 | 13 05.9 | 12 11.2 | 13 13.8 | 13 18.9 | 12 23.7 | 13 04.3 |
| 14 19.8 | 15 21.9 | 14 08.3 | 15 10.9 | 15 16.3 | 14 21.7 | 15 03.2 | 14 08.6 | 15 11.1 | 15 16.2 | 14 21.0 | 15 01.6 |
| 16 17.1 | 17 19.2 | 16 05.6 | 17 08.2 | 17 13.6 | 16 19.1 | 17 00.5 | 16 05.9 | 17 08.4 | 17 13.5 | 16 18.3 | 16 22.9 |
| 18 14.4 | 19 16.5 | 18 02.9 | 19 05.5 | 19 11.0 | 18 16.4 | 18 21.9 | 18 03.2 | 19 05.8 | 19 10.8 | 18 15.6 | 18 20.2 |
| 20 11.7 | 21 13.8 | 20 00.3 | 21 02.9 | 21 08.3 | 20 13.8 | 20 19.2 | 20 00.6 | 21 03.1 | 21 08.1 | 20 12.9 | 20 17.5 |
| 22 09.0 | 23 11.1 | 21 21.6 | 23 00.2 | 23 05.6 | 22 11.1 | 22 16.5 | 21 21.9 | 23 00.4 | 23 05.4 | 22 10.1 | 22 14.8 |
| 24 06.3 | 25 08.4 | 23 18.9 | 24 21.5 | 25 03.0 | 24 08.4 | 24 13.9 | 23 19.2 | 24 21.7 | 25 02.7 | 24 07.4 | 24 12.0 |
| 26 03.6 | 27 05.8 | 25 16.2 | 26 18.9 | 27 00.3 | 26 05.8 | 26 11.2 | 25 16.6 | 26 19.0 | 26 24.0 | 26 04.7 | 26 09.3 |
| 28 00.9 | | 27 13.6 | 28 16.2 | 28 21.7 | 28 03.1 | 28 08.6 | 27 13.9 | 28 16.4 | 28 21.3 | 28 02.0 | 28 06.6 |
| 29 22.2 | | 29 10.9 | 30 13.6 | 30 19.0 | 30 00.5 | 30 05.9 | 29 11.2 | 30 13.7 | 30 18.6 | 29 23.3 | 30 03.9 |
| 31 19.5 | | 31 08.2 | | | | | 31 08.5 | | | | |

### ENCELADUS Mean Synodic Period 1d 8.9h

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h | d hh.h |
| 1 04.8 | 1 17.0 | 1 02.7 | 1 15.3 | 1 19.1 | 2 07.9 | 1 02.8 | 1 15.6 | 2 04.2 | 2 07.8 | 1 11.3 | 1 14.6 |
| 2 13.7 | 3 01.9 | 2 11.6 | 3 00.2 | 3 04.0 | 3 16.8 | 2 11.7 | 3 00.5 | 3 13.1 | 3 16.7 | 2 20.2 | 2 23.5 |
| 3 22.6 | 4 10.8 | 3 20.5 | 4 09.1 | 4 12.9 | 5 01.7 | 3 20.6 | 4 09.4 | 4 22.0 | 5 01.6 | 4 05.1 | 4 08.4 |
| 5 07.5 | 5 19.7 | 5 05.4 | 5 18.0 | 5 21.8 | 6 10.6 | 5 05.5 | 5 18.3 | 6 06.9 | 6 10.5 | 5 14.0 | 5 17.3 |
| 6 16.4 | 7 04.6 | 6 14.3 | 7 02.9 | 7 06.7 | 7 19.5 | 6 14.4 | 7 03.2 | 7 15.8 | 7 19.4 | 6 22.9 | 7 02.2 |
| 8 01.2 | 8 13.4 | 7 23.2 | 8 11.8 | 8 15.6 | 9 04.4 | 7 23.3 | 8 12.1 | 9 00.7 | 9 04.2 | 8 07.7 | 8 10.9 |
| 9 10.1 | 9 22.3 | 9 08.1 | 9 20.7 | 10 00.5 | 10 13.3 | 9 08.2 | 9 21.0 | 10 09.6 | 10 13.1 | 9 16.6 | 9 19.8 |
| 10 19.0 | 11 07.2 | 10 17.0 | 11 05.6 | 11 09.4 | 11 22.2 | 10 17.1 | 11 05.9 | 11 18.5 | 11 22.0 | 11 01.5 | 11 04.7 |
| 12 03.9 | 12 16.1 | 12 01.9 | 12 14.5 | 12 18.3 | 13 07.1 | 12 02.0 | 12 14.8 | 13 03.4 | 13 06.9 | 12 10.4 | 12 13.6 |
| 13 12.8 | 14 01.0 | 13 10.8 | 13 23.4 | 14 03.2 | 14 16.0 | 13 10.9 | 13 23.7 | 14 12.3 | 14 15.8 | 13 19.3 | 13 22.5 |
| 14 21.5 | 15 09.8 | 14 19.6 | 15 08.3 | 15 12.1 | 16 00.9 | 14 19.9 | 15 08.6 | 15 21.1 | 16 00.7 | 15 04.0 | 15 07.3 |
| 16 06.4 | 16 18.7 | 16 04.5 | 16 17.2 | 16 21.0 | 17 09.8 | 16 04.8 | 16 17.5 | 17 06.0 | 17 09.6 | 16 12.9 | 16 16.2 |
| 17 15.3 | 18 03.6 | 17 13.4 | 18 02.1 | 18 05.9 | 18 18.7 | 17 13.7 | 18 02.4 | 18 14.9 | 18 18.5 | 17 21.8 | 18 01.1 |
| 19 00.2 | 19 12.5 | 18 22.3 | 19 11.0 | 19 14.8 | 20 03.6 | 18 22.6 | 19 11.3 | 19 23.8 | 20 03.4 | 19 06.7 | 19 10.0 |
| 20 09.1 | 20 21.4 | 20 07.2 | 20 19.9 | 20 23.7 | 21 12.5 | 20 07.5 | 20 20.2 | 21 08.7 | 21 12.3 | 20 15.6 | 20 18.9 |
| 21 17.9 | 22 06.3 | 21 16.1 | 22 04.8 | 22 08.6 | 22 21.4 | 21 16.4 | 22 05.0 | 22 17.6 | 22 21.1 | 22 00.4 | 22 03.7 |
| 23 02.8 | 23 15.2 | 23 01.0 | 23 13.7 | 23 17.5 | 24 06.3 | 23 01.3 | 23 13.9 | 24 02.5 | 24 06.0 | 23 09.3 | 23 12.6 |
| 24 11.7 | 25 00.1 | 24 09.9 | 24 22.6 | 25 02.4 | 25 15.2 | 24 10.2 | 24 22.8 | 25 11.4 | 25 14.9 | 24 18.2 | 24 21.5 |
| 25 20.6 | 26 09.0 | 25 18.8 | 26 07.5 | 26 11.3 | 27 00.1 | 25 19.1 | 26 07.7 | 26 20.3 | 26 23.8 | 26 03.1 | 26 06.4 |
| 27 05.5 | 27 17.9 | 27 03.7 | 27 16.4 | 27 20.2 | 28 09.0 | 27 04.0 | 27 16.6 | 28 05.2 | 28 08.7 | 27 12.0 | 27 15.3 |
| 28 14.4 | | 28 12.6 | 29 01.3 | 29 05.1 | 29 17.9 | 28 12.9 | 29 01.5 | 29 14.1 | 29 17.6 | 28 20.9 | 29 00.2 |
| 29 23.3 | | 29 21.5 | 30 10.2 | 30 14.0 | | 29 21.8 | 30 10.4 | 30 23.0 | 31 02.5 | 30 05.8 | 30 09.1 |
| 31 08.2 | | 31 06.4 | | 31 22.9 | | 31 06.7 | 31 19.3 | | | | 31 18.0 |

# URANUS

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

## POSITION

(0hrs UT Epoch 2000.0)

| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | | RA | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | h m s | ° ' " |
| Jan | 4 | 08:37 | 21:57 | 08:20 | 21:20 | 08:25 | 21:46 | 09:35 | 22:02 | 08:20 | 22:06 | 08:37 | 22:06 | 08:42 | 21:54 | 08:18 | 21:36 | 21 55 24 | - 13 24 15 |
| | 11 | 08:11 | 21:31 | 07:54 | 20:54 | 07:59 | 21:19 | 09:09 | 21:35 | 07:54 | 21:39 | 08:11 | 21:40 | 08:16 | 21:28 | 07:52 | 21:09 | 21 56 41 | - 13 17 20 |
| | 18 | 07:45 | 21:04 | 07:28 | 20:27 | 07:33 | 20:53 | 08:43 | 21:09 | 07:28 | 21:13 | 07:46 | 21:13 | 07:51 | 21:01 | 07:27 | 20:43 | 21 58 03 | - 13 09 57 |
| | 25 | 07:20 | 20:38 | 07:02 | 20:01 | 07:07 | 20:26 | 08:17 | 20:43 | 07:03 | 20:46 | 07:20 | 20:47 | 07:25 | 20:35 | 07:01 | 20:16 | 21 59 29 | - 13 02 12 |
| Feb | 1 | 06:54 | 20:11 | 06:36 | 19:34 | 06:42 | 20:00 | 07:51 | 20:17 | 06:37 | 20:20 | 06:54 | 20:20 | 06:59 | 20:08 | 06:35 | 19:50 | 22 00 58 | - 12 54 09 |
| | 8 | 06:29 | 19:45 | 06:11 | 19:08 | 06:16 | 19:34 | 07:25 | 19:51 | 06:12 | 19:53 | 06:29 | 19:54 | 06:33 | 19:42 | 06:10 | 19:23 | 22 02 29 | - 12 45 52 |
| | 15 | 06:03 | 19:19 | 05:45 | 18:42 | 05:51 | 19:07 | 06:59 | 19:25 | 05:47 | 19:27 | 06:03 | 19:27 | 06:08 | 19:16 | 05:44 | 18:57 | 22 04 02 | - 12 37 29 |
| | 22 | 05:37 | 18:52 | 05:19 | 18:15 | 05:25 | 18:41 | 06:33 | 18:58 | 05:21 | 19:00 | 05:38 | 19:01 | 05:42 | 18:49 | 05:18 | 18:30 | 22 05 35 | - 12 29 03 |
| Mar | 1 | 05:12 | 18:26 | 04:54 | 17:49 | 05:00 | 18:14 | 06:08 | 18:32 | 04:56 | 18:33 | 05:12 | 18:34 | 05:17 | 18:23 | 04:53 | 18:04 | 22 07 07 | - 12 20 40 |
| | 8 | 04:46 | 17:59 | 04:28 | 17:23 | 04:34 | 17:48 | 05:42 | 18:06 | 04:30 | 18:07 | 04:47 | 18:08 | 04:51 | 17:56 | 04:27 | 17:38 | 22 08 38 | - 12 12 25 |
| | 15 | 04:21 | 17:33 | 04:02 | 16:57 | 04:08 | 17:21 | 05:16 | 17:40 | 04:05 | 17:40 | 04:21 | 17:41 | 04:25 | 17:30 | 04:02 | 17:11 | 22 10 07 | - 12 04 23 |
| | 22 | 03:55 | 17:06 | 03:36 | 16:30 | 03:43 | 16:55 | 04:50 | 17:14 | 03:39 | 17:14 | 03:56 | 17:15 | 04:00 | 17:04 | 03:36 | 16:45 | 22 11 32 | - 11 56 40 |
| | 29 | 03:29 | 16:40 | 03:10 | 16:04 | 03:17 | 16:28 | 04:24 | 16:47 | 03:13 | 16:47 | 03:30 | 16:48 | 03:34 | 16:37 | 03:10 | 16:18 | 22 12 52 | - 11 49 20 |
| Apr | 5 | 03:03 | 16:13 | 02:44 | 15:37 | 02:51 | 16:02 | 03:58 | 16:21 | 02:48 | 16:20 | 03:04 | 16:22 | 03:08 | 16:10 | 02:44 | 15:52 | 22 14 08 | - 11 42 27 |
| | 12 | 02:37 | 15:47 | 02:18 | 15:11 | 02:25 | 15:35 | 03:31 | 15:55 | 02:22 | 15:54 | 02:38 | 15:55 | 02:42 | 15:44 | 02:18 | 15:25 | 22 15 18 | - 11 36 07 |
| | 19 | 02:11 | 15:20 | 01:52 | 14:44 | 01:59 | 15:08 | 03:05 | 15:28 | 01:56 | 15:27 | 02:12 | 15:28 | 02:15 | 15:17 | 01:52 | 14:58 | 22 16 22 | - 11 30 24 |
| | 26 | 01:45 | 14:53 | 01:26 | 14:17 | 01:32 | 14:42 | 02:38 | 15:01 | 01:29 | 15:00 | 01:45 | 15:01 | 01:49 | 14:50 | 01:25 | 14:31 | 22 17 18 | - 11 25 21 |
| May | 3 | 01:18 | 14:26 | 00:59 | 13:50 | 01:06 | 14:15 | 02:12 | 14:35 | 01:03 | 14:33 | 01:19 | 14:34 | 01:23 | 14:23 | 00:59 | 14:04 | 22 18 07 | - 11 21 01 |
| | 10 | 00:51 | 13:59 | 00:32 | 13:23 | 00:39 | 13:48 | 01:45 | 14:08 | 00:36 | 14:06 | 00:52 | 14:07 | 00:56 | 13:56 | 00:32 | 13:37 | 22 18 48 | - 11 17 27 |
| | 17 | 00:25 | 13:32 | 00:06 | 12:56 | 00:12 | 13:20 | 01:18 | 13:41 | 00:10 | 13:38 | 00:25 | 13:40 | 00:29 | 13:29 | 00:05 | 13:10 | 22 19 20 | - 11 14 43 |
| | 24 | 23:54 | 13:05 | 23:35 | 12:29 | 23:41 | 12:53 | 00:51 | 13:14 | 23:39 | 13:11 | 23:55 | 13:13 | 23:58 | 13:02 | 23:35 | 12:43 | 22 19 43 | - 11 12 48 |
| | 31 | 23:26 | 12:37 | 23:07 | 12:02 | 23:14 | 12:26 | 00:24 | 12:46 | 23:11 | 12:44 | 23:27 | 12:46 | 23:31 | 12:35 | 23:07 | 12:16 | 22 19 57 | - 11 11 45 |
| Jun | 7 | 22:59 | 12:10 | 22:40 | 11:34 | 22:47 | 11:58 | 23:52 | 12:19 | 22:44 | 12:16 | 23:00 | 12:18 | 23:03 | 12:07 | 22:40 | 11:48 | 22 20 02 | - 11 11 34 |
| | 14 | 22:31 | 11:42 | 22:12 | 11:07 | 22:19 | 11:31 | 23:25 | 11:51 | 22:16 | 11:49 | 22:32 | 11:51 | 22:36 | 11:40 | 22:12 | 11:21 | 22 19 59 | - 11 12 14 |
| | 21 | 22:03 | 11:15 | 21:45 | 10:39 | 21:51 | 11:03 | 22:57 | 11:23 | 21:48 | 11:21 | 22:04 | 11:23 | 22:08 | 11:12 | 21:44 | 10:53 | 22 19 46 | - 11 13 43 |
| | 28 | 21:35 | 10:47 | 21:17 | 10:11 | 21:23 | 10:35 | 22:29 | 10:56 | 21:20 | 10:54 | 21:36 | 10:55 | 21:40 | 10:44 | 21:16 | 10:25 | 22 19 24 | - 11 16 01 |
| Jul | 5 | 21:07 | 10:19 | 20:48 | 09:43 | 20:55 | 10:08 | 22:01 | 10:28 | 20:52 | 10:26 | 21:08 | 10:27 | 21:12 | 10:16 | 20:48 | 09:57 | 22 18 55 | - 11 19 05 |
| | 12 | 20:39 | 09:51 | 20:20 | 09:15 | 20:27 | 09:40 | 21:33 | 10:00 | 20:24 | 09:58 | 20:40 | 09:59 | 20:43 | 09:48 | 20:20 | 09:30 | 22 18 18 | - 11 22 49 |
| | 19 | 20:11 | 09:23 | 19:52 | 08:47 | 19:58 | 09:12 | 21:04 | 09:31 | 19:55 | 09:30 | 20:11 | 09:31 | 20:15 | 09:20 | 19:52 | 09:01 | 22 17 34 | - 11 27 11 |
| | 26 | 19:42 | 08:55 | 19:23 | 08:19 | 19:30 | 08:43 | 20:36 | 09:03 | 19:27 | 09:02 | 19:43 | 09:03 | 19:46 | 08:52 | 19:23 | 08:33 | 22 16 44 | - 11 32 04 |
| Aug | 2 | 19:13 | 08:27 | 18:55 | 07:51 | 19:01 | 08:15 | 20:07 | 08:35 | 18:58 | 08:34 | 19:14 | 08:35 | 19:18 | 08:24 | 18:54 | 08:05 | 22 15 48 | - 11 37 24 |
| | 9 | 18:44 | 07:59 | 18:26 | 07:22 | 18:32 | 07:47 | 19:39 | 08:06 | 18:29 | 08:06 | 18:45 | 08:07 | 18:49 | 07:56 | 18:25 | 07:37 | 22 14 49 | - 11 43 03 |
| | 16 | 18:16 | 07:30 | 17:57 | 06:54 | 18:03 | 07:19 | 19:10 | 07:38 | 18:00 | 07:37 | 18:16 | 07:39 | 18:20 | 07:27 | 17:57 | 07:09 | 22 13 47 | - 11 48 55 |
| | 23 | 17:47 | 07:02 | 17:28 | 06:26 | 17:34 | 06:51 | 18:42 | 07:09 | 17:31 | 07:09 | 17:47 | 07:11 | 17:51 | 06:59 | 17:28 | 06:40 | 22 12 43 | - 11 54 53 |
| | 30 | 17:18 | 06:34 | 16:59 | 05:57 | 17:06 | 06:22 | 18:13 | 06:41 | 17:02 | 06:41 | 17:19 | 06:42 | 17:23 | 06:31 | 16:59 | 06:12 | 22 11 39 | - 12 00 49 |
| Sep | 6 | 16:49 | 06:05 | 16:31 | 05:29 | 16:37 | 05:54 | 17:44 | 06:12 | 16:33 | 06:13 | 16:50 | 06:14 | 16:54 | 06:03 | 16:30 | 05:44 | 22 10 36 | - 12 06 37 |
| | 13 | 16:20 | 05:37 | 16:02 | 05:01 | 16:08 | 05:26 | 17:16 | 05:44 | 16:04 | 05:45 | 16:21 | 05:46 | 16:25 | 05:34 | 16:01 | 05:16 | 22 09 35 | - 12 12 09 |
| | 20 | 15:51 | 05:09 | 15:33 | 04:32 | 15:39 | 04:58 | 16:47 | 05:16 | 15:35 | 05:17 | 15:52 | 05:18 | 15:56 | 05:06 | 15:33 | 04:47 | 22 08 38 | - 12 17 18 |
| | 27 | 15:23 | 04:41 | 15:05 | 04:04 | 15:11 | 04:29 | 16:19 | 04:47 | 15:07 | 04:48 | 15:23 | 04:49 | 15:28 | 04:38 | 15:04 | 04:19 | 22 07 46 | - 12 21 59 |
| Oct | 4 | 14:54 | 04:13 | 14:36 | 03:36 | 14:42 | 04:01 | 15:50 | 04:19 | 14:38 | 04:20 | 14:55 | 04:21 | 14:59 | 04:10 | 14:35 | 03:51 | 22 06 59 | - 12 26 05 |
| | 11 | 14:26 | 03:45 | 14:08 | 03:08 | 14:14 | 03:33 | 15:22 | 03:51 | 14:10 | 03:53 | 14:27 | 03:53 | 14:31 | 03:42 | 14:07 | 03:23 | 22 06 19 | - 12 29 32 |
| | 18 | 13:58 | 03:17 | 13:40 | 02:40 | 13:46 | 03:05 | 14:54 | 03:23 | 13:42 | 03:25 | 13:58 | 03:25 | 14:03 | 03:14 | 13:39 | 02:55 | 22 05 46 | - 12 32 15 |
| | 25 | 13:30 | 02:49 | 13:12 | 02:12 | 13:18 | 02:37 | 14:26 | 02:55 | 13:13 | 02:57 | 13:30 | 02:58 | 13:35 | 02:46 | 13:11 | 02:27 | 22 05 22 | - 12 34 11 |
| Nov | 1 | 13:02 | 02:21 | 12:44 | 01:44 | 12:50 | 02:10 | 13:58 | 02:27 | 12:46 | 02:29 | 13:02 | 02:30 | 13:07 | 02:18 | 12:43 | 01:59 | 22 05 07 | - 12 35 18 |
| | 8 | 12:34 | 01:54 | 12:16 | 01:17 | 12:22 | 01:42 | 13:31 | 02:00 | 12:18 | 02:02 | 12:35 | 02:02 | 12:39 | 01:51 | 12:15 | 01:32 | 22 05 01 | - 12 35 32 |
| | 15 | 12:07 | 01:26 | 11:49 | 00:49 | 11:55 | 01:15 | 13:03 | 01:32 | 11:51 | 01:34 | 12:07 | 01:35 | 12:12 | 01:23 | 11:48 | 01:04 | 22 05 05 | - 12 34 55 |
| | 22 | 11:40 | 00:59 | 11:22 | 00:22 | 11:27 | 00:47 | 12:36 | 01:05 | 11:23 | 01:07 | 11:40 | 01:07 | 11:45 | 00:56 | 11:21 | 00:37 | 22 05 19 | - 12 33 25 |
| | 29 | 11:13 | 00:31 | 10:55 | 23:51 | 11:00 | 00:20 | 12:09 | 00:38 | 10:56 | 00:39 | 11:13 | 00:40 | 11:18 | 00:28 | 10:54 | 00:10 | 22 05 42 | - 12 31 03 |
| Dec | 6 | 10:46 | 00:04 | 10:28 | 23:24 | 10:34 | 23:49 | 11:42 | 00:11 | 10:30 | 00:12 | 10:46 | 00:13 | 10:51 | 23:57 | 10:27 | 23:39 | 22 06 14 | - 12 27 50 |
| | 13 | 10:19 | 23:33 | 10:01 | 22:57 | 10:07 | 23:22 | 11:15 | 23:40 | 10:03 | 23:41 | 10:20 | 23:42 | 10:24 | 23:30 | 10:00 | 23:12 | 22 06 55 | - 12 23 48 |
| | 20 | 09:53 | 23:07 | 09:35 | 22:30 | 09:40 | 22:55 | 10:48 | 23:13 | 09:37 | 23:14 | 09:53 | 23:15 | 09:58 | 23:03 | 09:34 | 22:45 | 22 07 45 | - 12 19 00 |
| | 27 | 09:26 | 22:40 | 09:08 | 22:03 | 09:14 | 22:28 | 10:22 | 22:46 | 09:10 | 22:47 | 09:27 | 22:48 | 09:31 | 22:37 | 09:08 | 22:18 | 22 08 43 | - 12 13 29 |

# SATELLITES OF URANUS – Greatest Northern Elongation (UT)

Titania (III) and Oberon (IV) are the easiest to observe visually. However, at least a 20cm telescope, under dark skies, is needed to glimpse these distant bodies. The inner satellites, Ariel and Umbriel, are harder to observe and they would be a real test for a 40cm telescope. The orbits of the satellites are only partly open as seen from Earth. The orbits' apparent minor axis (running east/west) is 29% of the apparent major axis (north/south). For example, Oberon, at opposition, has a maximum elongation of 44" (p. 71). Its minimum elongation would be 29% of this or 13". To locate the approximate position angle (degrees east of north) for a satellite, at your time of observation:

1. Work out how long since the satellite's most recent greatest northern elongation.
2. Express this as a fraction of the sidereal orbital period. Satellites I, II, III, and IV have periods of 2.52, 4.14, 8.71 and 13.46 days respectively.
3. Multiply the result by 360°.

**ARIEL** Mean Sidereal Period 2d 12.489h

| JAN | | FEB | | MAR | | APR | | MAY | | JUN | | JUL | | AUG | | SEP | | OCT | | NOV | | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h | d | hh.h |
| 1 | 6.1 | 3 | 0.5 | 2 | 17.8 | 1 | 23.6 | 2 | 5.4 | 1 | 11.2 | 1 | 17.0 | 3 | 11.3 | 2 | 17.2 | 2 | 23.1 | 2 | 5.1 | 2 | 11.0 |
| 3 | 18.6 | 5 | 13.0 | 5 | 6.3 | 4 | 12.1 | 4 | 17.9 | 3 | 23.7 | 4 | 5.5 | 5 | 23.8 | 5 | 5.7 | 5 | 11.6 | 4 | 17.6 | 4 | 23.5 |
| 6 | 7.1 | 8 | 1.5 | 7 | 18.8 | 7 | 0.6 | 7 | 6.4 | 6 | 12.2 | 6 | 18.0 | 8 | 12.3 | 7 | 18.2 | 8 | 0.1 | 7 | 6.1 | 7 | 12.0 |
| 8 | 19.6 | 10 | 14.0 | 10 | 7.3 | 9 | 13.1 | 9 | 18.9 | 9 | 0.7 | 9 | 6.5 | 11 | 0.8 | 10 | 6.7 | 10 | 12.6 | 9 | 18.6 | 10 | 0.5 |
| 11 | 8.0 | 13 | 2.5 | 12 | 19.8 | 12 | 1.6 | 12 | 7.4 | 11 | 13.2 | 11 | 19.0 | 13 | 13.3 | 12 | 19.2 | 13 | 1.1 | 12 | 7.1 | 12 | 13.0 |
| 13 | 20.5 | 15 | 14.9 | 15 | 8.2 | 14 | 14.0 | 14 | 19.8 | 14 | 1.6 | 14 | 7.4 | 16 | 1.8 | 15 | 7.7 | 15 | 13.6 | 14 | 19.6 | 15 | 1.5 |
| 16 | 9.0 | 18 | 3.4 | 17 | 20.7 | 17 | 2.5 | 17 | 8.3 | 16 | 14.1 | 16 | 19.9 | 18 | 14.3 | 17 | 20.2 | 18 | 2.1 | 17 | 8.1 | 17 | 14.0 |
| 18 | 21.5 | 20 | 15.9 | 20 | 9.2 | 19 | 15.0 | 19 | 20.8 | 19 | 2.6 | 19 | 8.4 | 21 | 2.8 | 20 | 8.7 | 20 | 14.6 | 19 | 20.6 | 20 | 2.5 |
| 21 | 10.0 | 23 | 4.4 | 22 | 21.7 | 22 | 3.5 | 22 | 9.3 | 21 | 15.1 | 21 | 20.9 | 23 | 15.3 | 22 | 21.2 | 23 | 3.1 | 22 | 9.1 | 22 | 15.0 |
| 14 | 21.5 | 25 | 16.9 | 25 | 10.2 | 24 | 16.0 | 24 | 21.8 | 24 | 3.6 | 24 | 9.4 | 26 | 3.8 | 25 | 9.7 | 25 | 15.6 | 24 | 21.6 | 25 | 3.5 |
| 26 | 10.9 | 28 | 5.4 | 27 | 22.7 | 27 | 4.5 | 27 | 10.3 | 26 | 16.1 | 26 | 21.9 | 28 | 16.3 | 27 | 22.2 | 28 | 4.1 | 27 | 10.1 | 27 | 16.0 |
| 28 | 23.4 | | | 30 | 11.1 | 29 | 16.9 | 29 | 22.7 | 29 | 4.5 | 29 | 10.3 | 31 | 4.7 | 30 | 10.6 | 30 | 16.5 | 29 | 22.5 | 30 | 4.4 |
| 31 | 11.9 | | | | | | | | | | | 31 | 22.8 | | | | | | | | | | |

**UMBRIEL** Mean Sidereal Period 4d 3.460h

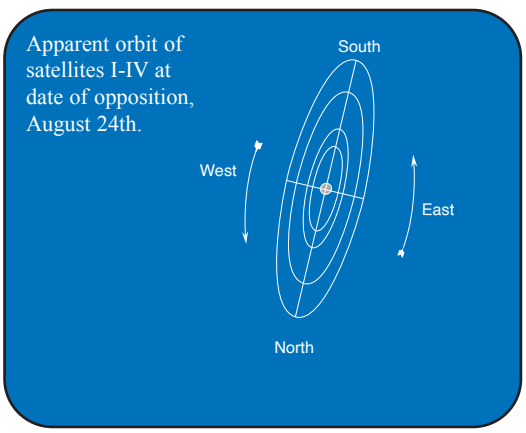
| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.6 | 4 | 5.2 | 1 | 2.1 | 3 | 5.7 | 2 | 5.8 | 4 | 9.2 | 3 | 9.5 | 1 | 9.8 | 3 | 13.5 | 2 | 13.6 | 4 | 17.5 | 3 | 17.9 |
| 6 | 5.1 | 8 | 8.7 | 5 | 5.6 | 7 | 9.2 | 6 | 9.3 | 8 | 12.7 | 7 | 13.0 | 5 | 13.3 | 7 | 17.0 | 6 | 17.1 | 8 | 21.0 | 7 | 21.4 |
| 10 | 8.5 | 12 | 12.1 | 9 | 9.0 | 11 | 12.6 | 10 | 12.7 | 12 | 16.1 | 11 | 16.4 | 9 | 16.7 | 11 | 20.4 | 10 | 20.5 | 13 | 0.4 | 12 | 0.8 |
| 14 | 12.0 | 16 | 15.6 | 13 | 12.5 | 15 | 16.1 | 14 | 16.2 | 16 | 19.6 | 15 | 19.9 | 13 | 20.2 | 15 | 23.9 | 14 | 24.0 | 17 | 3.9 | 16 | 4.3 |
| 18 | 15.4 | 20 | 19.0 | 17 | 15.9 | 19 | 19.5 | 18 | 19.6 | 20 | 23.0 | 19 | 23.3 | 17 | 23.6 | 20 | 3.3 | 19 | 3.4 | 21 | 7.3 | 20 | 7.7 |
| 22 | 18.9 | 24 | 22.5 | 21 | 19.4 | 23 | 23.0 | 22 | 23.1 | 25 | 2.5 | 24 | 2.8 | 22 | 3.1 | 24 | 6.8 | 23 | 6.9 | 25 | 10.8 | 24 | 11.2 |
| 26 | 22.3 | | | 25 | 22.8 | 28 | 2.4 | 27 | 2.5 | 29 | 5.9 | 28 | 6.2 | 26 | 6.5 | 28 | 10.2 | 27 | 10.3 | 29 | 14.2 | 28 | 14.6 |
| 31 | 1.8 | | | 30 | 2.3 | | | 31 | 6.0 | | | | | 30 | 10.0 | | | 31 | 13.8 | | | | |

**TITANIA** Mean Sidereal Period 8d 16.941h

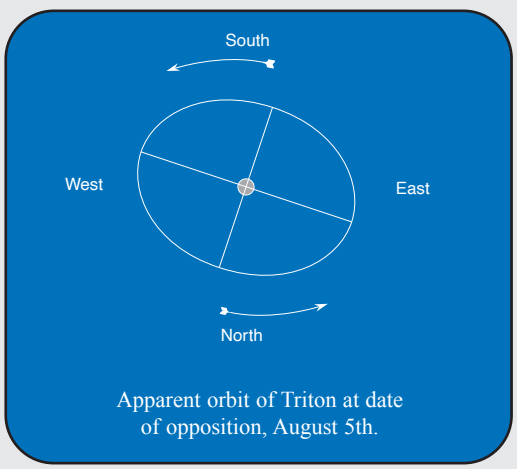
| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 20.3 | 1 | 23.1 | 8 | 18.7 | 3 | 21.3 | 8 | 16.8 | 3 | 19.6 | 8 | 15.4 | 3 | 18.2 | 7 | 14.1 | 3 | 16.9 | 7 | 12.8 | 3 | 15.6 |
| 15 | 13.3 | 10 | 16.1 | 17 | 11.7 | 12 | 14.3 | 17 | 9.8 | 12 | 12.6 | 17 | 8.4 | 12 | 11.2 | 16 | 7.1 | 12 | 9.8 | 16 | 5.8 | 12 | 8.6 |
| 24 | 6.2 | 19 | 9.0 | 26 | 4.6 | 21 | 7.2 | 26 | 2.7 | 21 | 5.5 | 26 | 1.3 | 21 | 4.1 | 25 | 0.0 | 21 | 2.8 | 24 | 22.7 | 21 | 1.5 |
| | | 28 | 2.0 | | | 30 | 0.2 | | | 29 | 22.5 | | | 29 | 21.1 | | | 29 | 19.8 | | | 29 | 18.5 |

**OBERON** Mean Sidereal Period 13d 11.118h

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 14.0 | 9 | 11.9 | 8 | 9.9 | 4 | 8.1 | 1 | 6.2 | 10 | 15.4 | 7 | 13.5 | 3 | 11.7 | 12 | 21.4 | 9 | 19.8 | 5 | 18.1 | 2 | 16.2 |
| 27 | 1.1 | 22 | 22.9 | 21 | 20.9 | 17 | 19.1 | 14 | 17.2 | 24 | 2.4 | 21 | 0.5 | 16 | 22.7 | 26 | 8.4 | 23 | 6.8 | 19 | 5.1 | 16 | 3.2 |
| | | | | | | | | 28 | 4.3 | | | | | 30 | 9.8 | | | | | | | 29 | 14.3 |




## SATELLITE OF NEPTUNE




With typical amateur telescopes, Triton (I) is the only observable moon. To find Triton, use the approach as described above for the satellites of Uranus. Note that in this case, the apparent major axis is in the east/west direction. The orbits of the Neptunian satellites are currently relatively open. In 2003, Triton's apparent orbit as seen from Earth is an ellipse with the minor axis being 74% of the major axis. Therefore Triton, at opposition, varies from 17" (p. 71) down to 13". To find the approximate position angle of Triton, the same approach is used as above for Uranus. The sidereal orbital period for Triton is 5.88 days and after step 3 add 90° to get the position angle from north. If greater than 360°, subtract 360°.

**Greatest Eastern Elongation (UT)**

**TRITON Mean Sidereal Period 5d 21.044h**

| JAN | | FEB | | MAR | | APR | | MAY | | JUN | | JUL | | AUG | | SEP | | OCT | | NOV | | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 7.0 | 4 | 15.6 | 6 | 0.2 | 4 | 8.9 | 3 | 17.8 | 2 | 3.0 | 1 | 12.4 | 5 | 19.2 | 4 | 4.9 | 3 | 14.5 | 1 | 23.8 | 1 | 8.9 |
| 12 | 4.0 | 10 | 12.5 | 11 | 21.1 | 10 | 5.8 | 9 | 14.7 | 7 | 23.9 | 7 | 9.3 | 11 | 16.1 | 10 | 1.8 | 9 | 11.4 | 7 | 20.7 | 7 | 5.8 |
| 18 | 0.9 | 16 | 9.5 | 17 | 18.1 | 16 | 2.8 | 15 | 11.7 | 13 | 20.9 | 13 | 6.3 | 17 | 13.1 | 15 | 22.8 | 15 | 8.4 | 13 | 17.7 | 13 | 2.8 |
| 23 | 21.9 | 22 | 6.4 | 23 | 15.0 | 21 | 23.7 | 21 | 8.6 | 19 | 17.8 | 19 | 3.2 | 23 | 10.0 | 21 | 19.7 | 21 | 5.3 | 19 | 14.6 | 18 | 23.7 |
| 29 | 18.8 | 28 | 3.4 | 29 | 12.0 | 27 | 20.7 | 27 | 5.6 | 25 | 14.8 | 25 | 0.2 | 29 | 7.0 | 27 | 16.7 | 27 | 2.3 | 25 | 11.6 | 24 | 20.7 |
| | | | | | | | | | | | | 30 | 21.1 | | | | | | | | | 30 | 17.6 |

# NEPTUNE

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

## POSITION

(0hrs UT Epoch 2000.0)

| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| Jan | 4 | 07:17 | 21:04 | 07:03 | 20:23 | 07:04 | 20:53 | 08:24 | 20:59 | 06:55 | 21:18 | 07:15 | 21:15 | 07:23 | 20:59 | 06:58 | 20:42 |
| | 11 | 06:50 | 20:37 | 06:36 | 19:56 | 06:38 | 20:26 | 07:57 | 20:32 | 06:28 | 20:51 | 06:49 | 20:48 | 06:57 | 20:33 | 06:32 | 20:15 |
| | 18 | 06:24 | 20:11 | 06:10 | 19:30 | 06:12 | 19:59 | 07:31 | 20:06 | 06:02 | 20:24 | 06:23 | 20:21 | 06:31 | 20:06 | 06:06 | 19:48 |
| | 25 | 05:58 | 19:44 | 05:44 | 19:03 | 05:45 | 19:33 | 07:05 | 19:39 | 05:36 | 19:57 | 05:56 | 19:54 | 06:04 | 19:39 | 05:40 | 19:22 |
| Feb | 1 | 05:32 | 19:17 | 05:18 | 18:37 | 05:19 | 19:06 | 06:38 | 19:13 | 05:10 | 19:30 | 05:30 | 19:28 | 05:38 | 19:13 | 05:13 | 18:55 |
| | 8 | 05:05 | 18:51 | 04:51 | 18:10 | 04:53 | 18:39 | 06:12 | 18:46 | 04:44 | 19:04 | 05:04 | 19:01 | 05:12 | 18:46 | 04:47 | 18:28 |
| | 15 | 04:39 | 18:24 | 04:25 | 17:43 | 04:27 | 18:13 | 05:45 | 18:20 | 04:18 | 18:37 | 04:38 | 18:34 | 04:46 | 18:19 | 04:21 | 18:02 |
| | 22 | 04:13 | 17:57 | 03:59 | 17:17 | 04:00 | 17:46 | 05:19 | 17:53 | 03:51 | 18:10 | 04:12 | 18:08 | 04:19 | 17:53 | 03:54 | 17:35 |
| Mar | 1 | 03:46 | 17:30 | 03:32 | 16:50 | 03:34 | 17:19 | 04:53 | 17:27 | 03:25 | 17:43 | 03:45 | 17:41 | 03:53 | 17:26 | 03:28 | 17:08 |
| | 8 | 03:20 | 17:04 | 03:06 | 16:23 | 03:08 | 16:52 | 04:26 | 17:00 | 02:59 | 17:16 | 03:19 | 17:14 | 03:27 | 16:59 | 03:02 | 16:41 |
| | 15 | 02:54 | 16:37 | 02:39 | 15:56 | 02:41 | 16:26 | 03:59 | 16:33 | 02:32 | 16:50 | 02:53 | 16:47 | 03:00 | 16:32 | 02:35 | 16:15 |
| | 22 | 02:27 | 16:10 | 02:13 | 15:30 | 02:15 | 15:59 | 03:33 | 16:06 | 02:06 | 16:23 | 02:26 | 16:20 | 02:34 | 16:05 | 02:09 | 15:48 |
| | 29 | 02:00 | 15:43 | 01:46 | 15:03 | 01:48 | 15:32 | 03:06 | 15:40 | 01:39 | 15:56 | 01:59 | 15:53 | 02:07 | 15:38 | 01:42 | 15:21 |
| Apr | 5 | 01:34 | 15:16 | 01:19 | 14:36 | 01:21 | 15:05 | 02:39 | 15:13 | 01:13 | 15:28 | 01:33 | 15:26 | 01:40 | 15:11 | 01:15 | 14:54 |
| | 12 | 01:07 | 14:49 | 00:52 | 14:09 | 00:54 | 14:38 | 02:12 | 14:46 | 00:46 | 15:01 | 01:06 | 14:59 | 01:13 | 14:44 | 00:49 | 14:27 |
| | 19 | 00:40 | 14:22 | 00:25 | 13:41 | 00:28 | 14:10 | 01:45 | 14:19 | 00:19 | 14:34 | 00:39 | 14:32 | 00:46 | 14:17 | 00:22 | 13:59 |
| | 26 | 00:13 | 13:55 | 23:54 | 13:14 | 23:57 | 13:43 | 01:18 | 13:51 | 23:48 | 14:07 | 00:12 | 14:05 | 00:19 | 13:50 | 23:51 | 13:32 |
| May | 3 | 23:42 | 13:27 | 23:27 | 12:47 | 23:29 | 13:16 | 00:51 | 13:24 | 23:21 | 13:40 | 23:41 | 13:37 | 23:48 | 13:23 | 23:23 | 13:05 |
| | 10 | 23:14 | 13:00 | 23:00 | 12:20 | 23:02 | 12:48 | 00:24 | 12:57 | 22:54 | 13:12 | 23:13 | 13:10 | 23:21 | 12:55 | 22:56 | 12:37 |
| | 17 | 22:47 | 12:32 | 22:32 | 11:52 | 22:34 | 12:21 | 23:52 | 12:29 | 22:26 | 12:45 | 22:46 | 12:43 | 22:53 | 12:28 | 22:29 | 12:10 |
| | 24 | 22:19 | 12:05 | 22:05 | 11:24 | 22:07 | 11:53 | 23:25 | 12:02 | 21:58 | 12:17 | 22:18 | 12:15 | 22:26 | 12:00 | 22:01 | 11:42 |
| | 31 | 21:52 | 11:37 | 21:37 | 10:57 | 21:39 | 11:26 | 22:57 | 11:34 | 21:31 | 11:49 | 21:51 | 11:47 | 21:58 | 11:32 | 21:33 | 11:15 |
| Jun | 7 | 21:24 | 11:09 | 21:09 | 10:29 | 21:11 | 10:58 | 22:29 | 11:06 | 21:03 | 11:22 | 21:23 | 11:20 | 21:30 | 11:05 | 21:05 | 10:47 |
| | 14 | 20:56 | 10:42 | 20:41 | 10:01 | 20:43 | 10:30 | 22:01 | 10:38 | 20:35 | 10:54 | 20:55 | 10:52 | 21:02 | 10:37 | 20:37 | 10:19 |
| | 21 | 20:28 | 10:14 | 20:13 | 09:33 | 20:15 | 10:02 | 21:33 | 10:10 | 20:07 | 10:26 | 20:27 | 10:24 | 20:34 | 10:09 | 20:09 | 09:51 |
| | 28 | 19:59 | 09:46 | 19:45 | 09:05 | 19:47 | 09:34 | 21:05 | 09:42 | 19:38 | 09:58 | 19:58 | 09:56 | 20:06 | 09:41 | 19:41 | 09:23 |
| Jul | 5 | 19:31 | 09:18 | 19:17 | 08:37 | 19:19 | 09:06 | 20:37 | 09:14 | 19:10 | 09:30 | 19:30 | 09:28 | 19:38 | 09:13 | 19:13 | 08:55 |
| | 12 | 19:03 | 08:50 | 18:49 | 08:09 | 18:50 | 08:38 | 20:09 | 08:46 | 18:42 | 09:02 | 19:02 | 09:00 | 19:09 | 08:45 | 18:45 | 08:27 |
| | 19 | 18:34 | 08:22 | 18:20 | 07:41 | 18:22 | 08:10 | 19:40 | 08:18 | 18:13 | 08:34 | 18:33 | 08:32 | 18:41 | 08:17 | 18:16 | 07:59 |
| | 26 | 18:06 | 07:54 | 17:52 | 07:13 | 17:54 | 07:42 | 19:12 | 07:50 | 17:45 | 08:06 | 18:05 | 08:04 | 18:12 | 07:49 | 17:48 | 07:31 |
| Aug | 2 | 17:38 | 07:25 | 17:23 | 06:45 | 17:25 | 07:14 | 18:44 | 07:22 | 17:16 | 07:38 | 17:36 | 07:36 | 17:44 | 07:21 | 17:19 | 07:03 |
| | 9 | 17:09 | 06:57 | 16:55 | 06:17 | 16:57 | 06:46 | 18:15 | 06:53 | 16:48 | 07:10 | 17:08 | 07:08 | 17:16 | 06:53 | 16:51 | 06:35 |
| | 16 | 16:41 | 06:29 | 16:27 | 05:49 | 16:28 | 06:18 | 17:47 | 06:25 | 16:19 | 06:42 | 16:39 | 06:40 | 16:47 | 06:24 | 16:22 | 06:07 |
| | 23 | 16:12 | 06:01 | 15:58 | 05:20 | 16:00 | 05:50 | 17:19 | 05:57 | 15:51 | 06:14 | 16:11 | 06:12 | 16:19 | 05:56 | 15:54 | 05:39 |
| | 30 | 15:44 | 05:33 | 15:30 | 04:52 | 15:31 | 05:22 | 16:50 | 05:29 | 15:22 | 05:46 | 15:43 | 05:44 | 15:50 | 05:28 | 15:26 | 05:11 |
| Sep | 6 | 15:16 | 05:05 | 15:02 | 04:24 | 15:03 | 04:54 | 16:22 | 05:01 | 14:54 | 05:18 | 15:14 | 05:16 | 15:22 | 05:00 | 14:57 | 04:43 |
| | 13 | 14:47 | 04:37 | 14:33 | 03:56 | 14:35 | 04:26 | 15:54 | 04:33 | 14:26 | 04:50 | 14:46 | 04:48 | 14:54 | 04:32 | 14:29 | 04:15 |
| | 20 | 14:19 | 04:09 | 14:05 | 03:28 | 14:07 | 03:58 | 15:26 | 04:05 | 13:58 | 04:22 | 14:18 | 04:20 | 14:26 | 04:04 | 14:01 | 03:47 |
| | 27 | 13:51 | 03:41 | 13:37 | 03:00 | 13:39 | 03:30 | 14:58 | 03:37 | 13:30 | 03:54 | 13:50 | 03:52 | 13:58 | 03:36 | 13:33 | 03:19 |
| Oct | 4 | 13:23 | 03:14 | 13:09 | 02:33 | 13:11 | 03:02 | 14:30 | 03:09 | 13:02 | 03:27 | 13:22 | 03:24 | 13:30 | 03:09 | 13:05 | 02:51 |
| | 11 | 12:55 | 02:46 | 12:42 | 02:05 | 12:43 | 02:35 | 14:02 | 02:41 | 12:34 | 02:59 | 12:54 | 02:56 | 13:02 | 02:41 | 12:37 | 02:23 |
| | 18 | 12:28 | 02:18 | 12:14 | 01:37 | 12:15 | 02:07 | 13:35 | 02:13 | 12:06 | 02:31 | 12:26 | 02:29 | 12:34 | 02:13 | 12:10 | 01:56 |
| | 25 | 12:00 | 01:51 | 11:46 | 01:10 | 11:48 | 01:39 | 13:07 | 01:46 | 11:38 | 02:04 | 11:59 | 02:01 | 12:07 | 01:46 | 11:42 | 01:28 |
| Nov | 1 | 11:33 | 01:23 | 11:19 | 00:42 | 11:20 | 01:12 | 12:40 | 01:18 | 11:11 | 01:36 | 11:31 | 01:34 | 11:39 | 01:18 | 11:15 | 01:01 |
| | 8 | 11:06 | 00:56 | 10:52 | 00:15 | 10:53 | 00:45 | 12:12 | 00:51 | 10:44 | 01:09 | 11:04 | 01:06 | 11:12 | 00:51 | 10:47 | 00:33 |
| | 15 | 10:38 | 00:29 | 10:24 | 23:44 | 10:26 | 00:17 | 11:45 | 00:24 | 10:17 | 00:42 | 10:37 | 00:39 | 10:45 | 00:24 | 10:20 | 00:06 |
| | 22 | 10:11 | 23:57 | 09:57 | 23:17 | 09:59 | 23:46 | 11:18 | 23:53 | 09:50 | 00:15 | 10:10 | 00:12 | 10:18 | 23:53 | 09:53 | 23:35 |
| | 29 | 09:44 | 23:30 | 09:30 | 22:50 | 09:32 | 23:19 | 10:51 | 23:26 | 09:23 | 23:44 | 09:43 | 23:41 | 09:51 | 23:26 | 09:26 | 23:08 |
| Dec | 6 | 09:18 | 23:03 | 09:04 | 22:23 | 09:05 | 22:52 | 10:24 | 22:59 | 08:56 | 23:16 | 09:16 | 23:14 | 09:24 | 22:59 | 08:59 | 22:41 |
| | 13 | 08:51 | 22:36 | 08:37 | 21:56 | 08:39 | 22:25 | 09:58 | 22:32 | 08:29 | 22:49 | 08:50 | 22:47 | 08:58 | 22:32 | 08:33 | 22:14 |
| | 20 | 08:24 | 22:10 | 08:10 | 21:29 | 08:12 | 21:58 | 09:31 | 22:05 | 08:03 | 22:22 | 08:23 | 22:20 | 08:31 | 22:05 | 08:06 | 21:47 |
| | 27 | 07:58 | 21:43 | 07:44 | 21:02 | 07:46 | 21:31 | 09:04 | 21:39 | 07:37 | 21:56 | 07:57 | 21:53 | 08:04 | 21:38 | 07:40 | 21:20 |

| RA | DEC |
|---|---|
| h m s | ° ' " |
| 20 48 15 | - 17 48 02 |
| 20 49 16 | - 17 44 07 |
| 20 50 18 | - 17 40 03 |
| 20 51 22 | - 17 35 53 |
| 20 52 27 | - 17 31 38 |
| 20 53 31 | - 17 27 22 |
| 20 54 34 | - 17 23 08 |
| 20 55 36 | - 17 19 00 |
| 20 56 35 | - 17 15 00 |
| 20 57 32 | - 17 11 10 |
| 20 58 25 | - 17 07 34 |
| 20 59 14 | - 17 04 15 |
| 20 59 58 | - 17 01 15 |
| 21 00 37 | - 16 58 35 |
| 21 01 10 | - 16 56 18 |
| 21 01 38 | - 16 54 26 |
| 21 01 59 | - 16 53 00 |
| 21 02 14 | - 16 52 01 |
| 21 02 23 | - 16 51 29 |
| 21 02 25 | - 16 51 24 |
| 21 02 21 | - 16 51 47 |
| 21 02 10 | - 16 52 36 |
| 21 01 54 | - 16 53 51 |
| 21 01 32 | - 16 55 29 |
| 21 01 04 | - 16 57 30 |
| 21 00 32 | - 16 59 50 |
| 20 59 56 | - 17 02 27 |
| 20 59 16 | - 17 05 19 |
| 20 58 34 | - 17 08 21 |
| 20 57 49 | - 17 11 31 |
| 20 57 04 | - 17 14 45 |
| 20 56 18 | - 17 18 00 |
| 20 55 33 | - 17 21 12 |
| 20 54 48 | - 17 24 17 |
| 20 54 07 | - 17 27 13 |
| 20 53 28 | - 17 29 56 |
| 20 52 53 | - 17 32 24 |
| 20 52 22 | - 17 34 33 |
| 20 51 56 | - 17 36 21 |
| 20 51 36 | - 17 37 47 |
| 20 51 22 | - 17 38 49 |
| 20 51 14 | - 17 39 25 |
| 20 51 13 | - 17 39 34 |
| 20 51 18 | - 17 39 17 |
| 20 51 30 | - 17 38 33 |
| 20 51 49 | - 17 37 21 |
| 20 52 15 | - 17 35 44 |
| 20 52 46 | - 17 33 41 |
| 20 53 24 | - 17 31 14 |
| 20 54 06 | - 17 28 25 |
| 20 54 54 | - 17 25 14 |
| 20 55 46 | - 17 21 45 |

# PLUTO

## RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

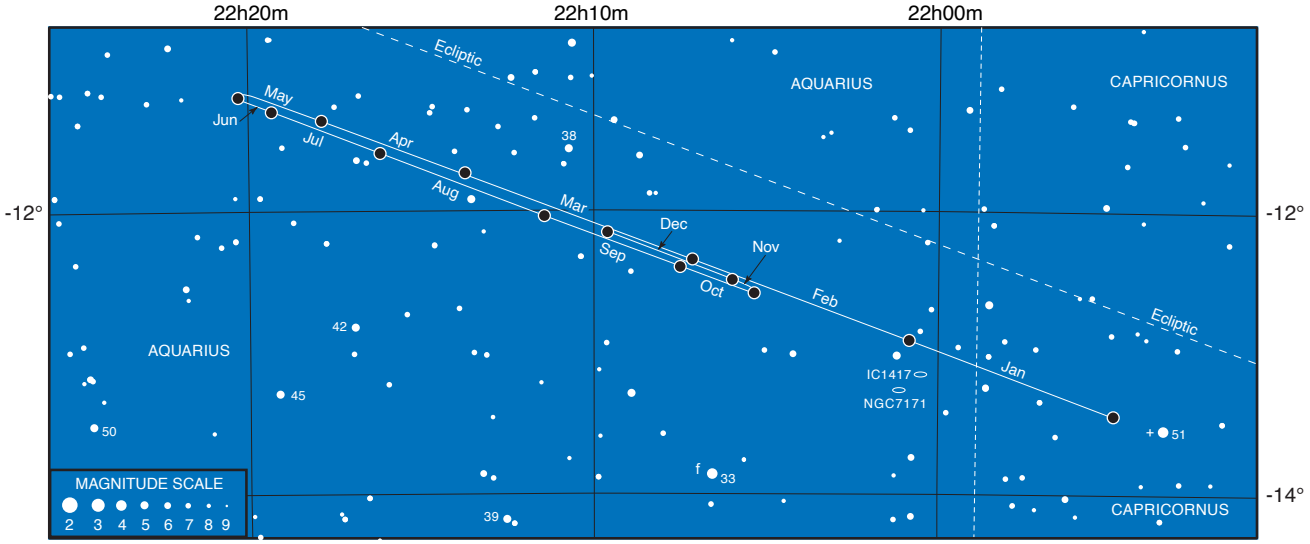
| | | Adelaide | | Brisbane | | Canberra | | Darwin | | Hobart | | Melbourne | | Perth | | Sydney | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| Jan | 4 | 03:54 | 17:17 | 03:37 | 16:39 | 03:42 | 17:05 | 04:53 | 17:20 | 03:36 | 17:26 | 03:54 | 17:26 | 03:59 | 17:13 | 03:35 | 16:55 |
| | 11 | 03:27 | 16:50 | 03:10 | 16:12 | 03:15 | 16:39 | 04:26 | 16:54 | 03:10 | 16:59 | 03:28 | 16:59 | 03:33 | 16:47 | 03:09 | 16:28 |
| | 18 | 03:01 | 16:24 | 02:44 | 15:46 | 02:49 | 16:12 | 04:00 | 16:27 | 02:43 | 16:33 | 03:01 | 16:33 | 03:06 | 16:20 | 02:42 | 16:02 |
| | 25 | 02:34 | 15:57 | 02:17 | 15:19 | 02:22 | 15:45 | 03:33 | 16:00 | 02:17 | 16:06 | 02:34 | 16:06 | 02:39 | 15:53 | 02:15 | 15:35 |
| Feb | 1 | 02:07 | 15:30 | 01:50 | 14:52 | 01:55 | 15:19 | 03:06 | 15:34 | 01:50 | 15:39 | 02:07 | 15:39 | 02:13 | 15:27 | 01:49 | 15:08 |
| | 8 | 01:41 | 15:03 | 01:24 | 14:26 | 01:28 | 14:52 | 02:39 | 15:07 | 01:23 | 15:12 | 01:41 | 15:12 | 01:46 | 15:00 | 01:22 | 14:41 |
| | 15 | 01:14 | 14:36 | 00:57 | 13:59 | 01:01 | 14:25 | 02:12 | 14:40 | 00:56 | 14:45 | 01:14 | 14:45 | 01:19 | 14:33 | 00:55 | 14:14 |
| | 22 | 00:47 | 14:09 | 00:30 | 13:32 | 00:34 | 13:58 | 01:45 | 14:13 | 00:29 | 14:18 | 00:47 | 14:18 | 00:52 | 14:06 | 00:28 | 13:47 |
| Mar | 1 | 00:20 | 13:42 | 23:59 | 13:04 | 00:07 | 13:31 | 01:18 | 13:46 | 23:58 | 13:51 | 00:20 | 13:51 | 00:25 | 13:39 | 23:57 | 13:20 |
| | 8 | 23:49 | 13:15 | 23:32 | 12:37 | 23:36 | 13:03 | 00:51 | 13:18 | 23:31 | 13:24 | 23:49 | 13:24 | 23:54 | 13:11 | 23:30 | 12:53 |
| | 15 | 23:21 | 12:47 | 23:04 | 12:10 | 23:09 | 12:36 | 00:24 | 12:51 | 23:04 | 12:56 | 23:22 | 12:57 | 23:27 | 12:44 | 23:03 | 12:26 |
| | 22 | 22:54 | 12:20 | 22:37 | 11:42 | 22:42 | 12:08 | 23:53 | 12:24 | 22:37 | 12:29 | 22:54 | 12:29 | 22:59 | 12:16 | 22:35 | 11:58 |
| | 29 | 22:27 | 11:52 | 22:09 | 11:15 | 22:14 | 11:41 | 23:25 | 11:56 | 22:09 | 12:01 | 22:27 | 12:01 | 22:32 | 11:49 | 22:08 | 11:30 |
| Apr | 5 | 21:59 | 11:25 | 21:42 | 10:47 | 21:47 | 11:13 | 22:57 | 11:28 | 21:42 | 11:34 | 21:59 | 11:34 | 22:04 | 11:21 | 21:40 | 11:03 |
| | 12 | 21:31 | 10:57 | 21:14 | 10:19 | 21:19 | 10:45 | 22:30 | 11:01 | 21:14 | 11:06 | 21:31 | 11:06 | 21:36 | 10:53 | 21:13 | 10:35 |
| | 19 | 21:03 | 10:29 | 20:46 | 09:51 | 20:51 | 10:17 | 22:02 | 10:33 | 20:46 | 10:38 | 21:04 | 10:38 | 21:09 | 10:25 | 20:45 | 10:07 |
| | 26 | 20:36 | 10:01 | 20:18 | 09:23 | 20:23 | 09:49 | 21:34 | 10:05 | 20:18 | 10:10 | 20:36 | 10:10 | 20:41 | 09:57 | 20:17 | 09:39 |
| May | 3 | 20:08 | 09:33 | 19:50 | 08:55 | 19:55 | 09:21 | 21:06 | 09:37 | 19:50 | 09:41 | 20:08 | 09:42 | 20:13 | 09:29 | 19:49 | 09:11 |
| | 10 | 19:40 | 09:04 | 19:22 | 08:27 | 19:27 | 08:53 | 20:38 | 09:09 | 19:22 | 09:13 | 19:40 | 09:14 | 19:45 | 09:01 | 19:21 | 08:43 |
| | 17 | 19:11 | 08:36 | 18:54 | 07:59 | 18:59 | 08:25 | 20:10 | 08:40 | 18:54 | 08:45 | 19:12 | 08:45 | 19:17 | 08:33 | 18:53 | 08:14 |
| | 24 | 18:43 | 08:08 | 18:26 | 07:30 | 18:31 | 07:57 | 19:41 | 08:12 | 18:26 | 08:17 | 18:43 | 08:17 | 18:48 | 08:05 | 18:25 | 07:46 |
| | 31 | 18:15 | 07:40 | 17:58 | 07:02 | 18:03 | 07:28 | 19:13 | 07:44 | 17:58 | 07:49 | 18:15 | 07:49 | 18:20 | 07:36 | 17:56 | 07:18 |
| Jun | 7 | 17:47 | 07:11 | 17:30 | 06:34 | 17:35 | 07:00 | 18:45 | 07:16 | 17:30 | 07:20 | 17:47 | 07:20 | 17:52 | 07:08 | 17:28 | 06:50 |
| | 14 | 17:19 | 06:43 | 17:01 | 06:06 | 17:06 | 06:32 | 18:17 | 06:47 | 17:01 | 06:52 | 17:19 | 06:52 | 17:24 | 06:40 | 17:00 | 06:21 |
| | 21 | 16:50 | 06:15 | 16:33 | 05:37 | 16:38 | 06:03 | 17:48 | 06:19 | 16:33 | 06:24 | 16:50 | 06:24 | 16:55 | 06:11 | 16:32 | 05:53 |
| | 28 | 16:22 | 05:47 | 16:05 | 05:09 | 16:10 | 05:35 | 17:20 | 05:51 | 16:05 | 05:55 | 16:22 | 05:56 | 16:27 | 05:43 | 16:03 | 05:25 |
| Jul | 5 | 15:54 | 05:18 | 15:37 | 04:41 | 15:41 | 05:07 | 16:52 | 05:23 | 15:37 | 05:27 | 15:54 | 05:27 | 15:59 | 05:15 | 15:35 | 04:57 |
| | 12 | 15:26 | 04:50 | 15:08 | 04:13 | 15:13 | 04:39 | 16:24 | 04:54 | 15:08 | 04:59 | 15:26 | 04:59 | 15:31 | 04:47 | 15:07 | 04:28 |
| | 19 | 14:57 | 04:22 | 14:40 | 03:45 | 14:45 | 04:11 | 15:56 | 04:26 | 14:40 | 04:31 | 14:58 | 04:31 | 15:03 | 04:19 | 14:39 | 04:00 |
| | 26 | 14:29 | 03:54 | 14:12 | 03:17 | 14:17 | 03:43 | 15:27 | 03:58 | 14:12 | 04:03 | 14:29 | 04:03 | 14:34 | 03:51 | 14:11 | 03:32 |
| Aug | 2 | 14:01 | 03:26 | 13:44 | 02:49 | 13:49 | 03:15 | 15:00 | 03:30 | 13:44 | 03:35 | 14:01 | 03:35 | 14:06 | 03:23 | 13:42 | 03:05 |
| | 9 | 13:33 | 02:59 | 13:16 | 02:21 | 13:21 | 02:47 | 14:32 | 03:03 | 13:16 | 03:08 | 13:33 | 03:08 | 13:38 | 02:55 | 13:14 | 02:37 |
| | 16 | 13:05 | 02:31 | 12:48 | 01:53 | 12:53 | 02:20 | 14:04 | 02:35 | 12:48 | 02:40 | 13:05 | 02:40 | 13:11 | 02:28 | 12:47 | 02:09 |
| | 23 | 12:38 | 02:03 | 12:20 | 01:26 | 12:25 | 01:52 | 13:36 | 02:07 | 12:20 | 02:12 | 12:38 | 02:13 | 12:43 | 02:00 | 12:19 | 01:42 |
| | 30 | 12:10 | 01:36 | 11:53 | 00:58 | 11:58 | 01:25 | 13:08 | 01:40 | 11:52 | 01:45 | 12:10 | 01:45 | 12:15 | 01:32 | 11:51 | 01:14 |
| Sep | 6 | 11:42 | 01:09 | 11:25 | 00:31 | 11:30 | 00:57 | 12:41 | 01:12 | 11:25 | 01:18 | 11:42 | 01:18 | 11:47 | 01:05 | 11:23 | 00:47 |
| | 13 | 11:15 | 00:41 | 10:58 | 00:04 | 11:02 | 00:30 | 12:14 | 00:45 | 10:57 | 00:51 | 11:15 | 00:51 | 11:20 | 00:38 | 10:56 | 00:19 |
| | 20 | 10:47 | 00:14 | 10:30 | 23:33 | 10:35 | 23:59 | 11:46 | 00:18 | 10:30 | 00:23 | 10:47 | 00:23 | 10:53 | 00:11 | 10:29 | 23:49 |
| | 27 | 10:20 | 23:43 | 10:03 | 23:06 | 10:08 | 23:32 | 11:19 | 23:47 | 10:02 | 23:53 | 10:20 | 23:53 | 10:25 | 23:40 | 10:01 | 23:22 |
| Oct | 4 | 09:53 | 23:17 | 09:36 | 22:39 | 09:40 | 23:05 | 10:52 | 23:20 | 09:35 | 23:26 | 09:53 | 23:26 | 09:58 | 23:13 | 09:34 | 22:55 |
| | 11 | 09:26 | 22:50 | 09:09 | 22:12 | 09:13 | 22:38 | 10:25 | 22:53 | 09:08 | 22:59 | 09:26 | 22:59 | 09:31 | 22:46 | 09:07 | 22:28 |
| | 18 | 08:59 | 22:23 | 08:42 | 21:45 | 08:46 | 22:12 | 09:58 | 22:26 | 08:41 | 22:33 | 08:59 | 22:32 | 09:04 | 22:19 | 08:40 | 22:01 |
| | 25 | 08:32 | 21:56 | 08:15 | 21:18 | 08:19 | 21:45 | 09:31 | 21:59 | 08:14 | 22:06 | 08:32 | 22:06 | 08:37 | 21:53 | 08:13 | 21:35 |
| Nov | 1 | 08:05 | 21:30 | 07:48 | 20:52 | 07:53 | 21:19 | 09:04 | 21:33 | 07:47 | 21:39 | 08:05 | 21:39 | 08:10 | 21:26 | 07:46 | 21:08 |
| | 8 | 07:38 | 21:03 | 07:21 | 20:25 | 07:26 | 20:52 | 08:38 | 21:06 | 07:20 | 21:13 | 07:38 | 21:13 | 07:44 | 21:00 | 07:19 | 20:41 |
| | 15 | 07:11 | 20:37 | 06:55 | 19:59 | 06:59 | 20:26 | 08:11 | 20:39 | 06:53 | 20:47 | 07:11 | 20:46 | 07:17 | 20:33 | 06:53 | 20:15 |
| | 22 | 06:45 | 20:11 | 06:28 | 19:32 | 06:32 | 19:59 | 07:45 | 20:13 | 06:27 | 20:20 | 06:45 | 20:20 | 06:50 | 20:07 | 06:26 | 19:49 |
| | 29 | 06:18 | 19:44 | 06:02 | 19:06 | 06:06 | 19:33 | 07:18 | 19:47 | 06:00 | 19:54 | 06:18 | 19:54 | 06:24 | 19:41 | 05:59 | 19:22 |
| Dec | 6 | 05:52 | 19:18 | 05:35 | 18:40 | 05:39 | 19:06 | 06:52 | 19:20 | 05:33 | 19:28 | 05:51 | 19:27 | 05:57 | 19:14 | 05:33 | 18:56 |
| | 13 | 05:25 | 18:52 | 05:08 | 18:13 | 05:13 | 18:40 | 06:25 | 18:54 | 05:07 | 19:01 | 05:25 | 19:01 | 05:30 | 18:48 | 05:06 | 18:30 |
| | 20 | 04:58 | 18:25 | 04:42 | 17:47 | 04:46 | 18:14 | 05:59 | 18:27 | 04:40 | 18:35 | 04:58 | 18:35 | 05:04 | 18:21 | 04:40 | 18:03 |
| | 27 | 04:32 | 17:59 | 04:15 | 17:21 | 04:20 | 17:47 | 05:32 | 18:01 | 04:14 | 18:09 | 04:32 | 18:08 | 04:37 | 17:55 | 04:13 | 17:37 |

## POSITION

(0hrs UT Epoch 2000.0)

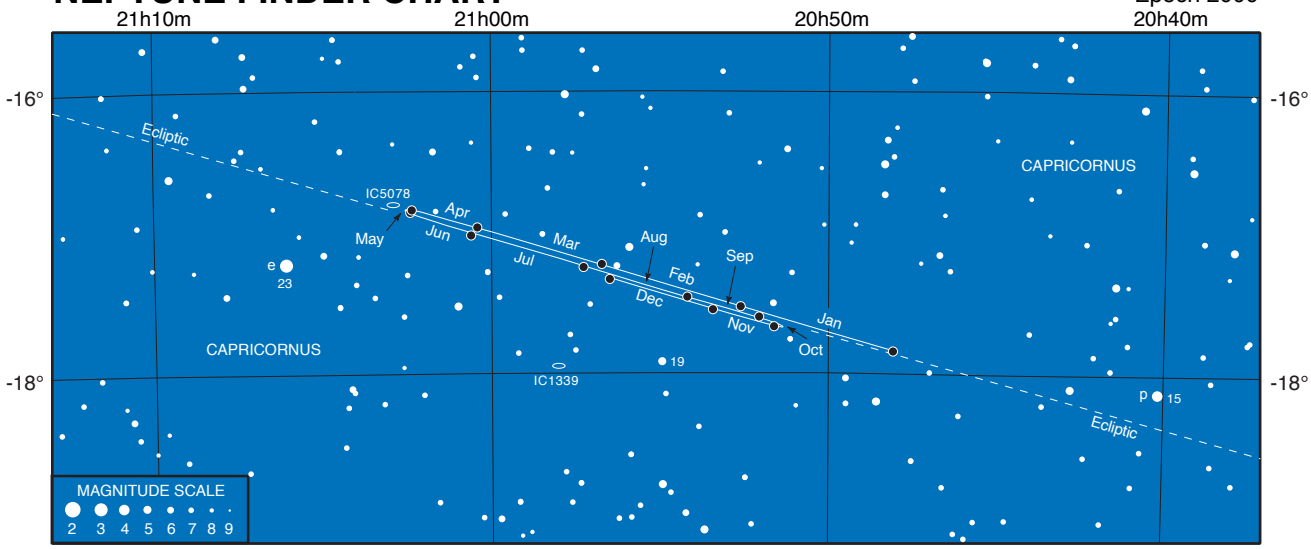
| RA | | | DEC | | |
|---|---|---|---|---|---|
| h | m | s | ° | ' | " |
| 17 | 12 | 39 | - 13 | 45 | 39 |
| 17 | 13 | 37 | - 13 | 46 | 28 |
| 17 | 14 | 33 | - 13 | 46 | 58 |
| 17 | 15 | 25 | - 13 | 47 | 12 |
| 17 | 16 | 12 | - 13 | 47 | 08 |
| 17 | 16 | 54 | - 13 | 46 | 47 |
| 17 | 17 | 31 | - 13 | 46 | 12 |
| 17 | 18 | 02 | - 13 | 45 | 23 |
| 17 | 18 | 26 | - 13 | 44 | 22 |
| 17 | 18 | 44 | - 13 | 43 | 10 |
| 17 | 18 | 56 | - 13 | 41 | 50 |
| 17 | 19 | 00 | - 13 | 40 | 23 |
| 17 | 18 | 58 | - 13 | 38 | 52 |
| 17 | 18 | 50 | - 13 | 37 | 18 |
| 17 | 18 | 35 | - 13 | 35 | 44 |
| 17 | 18 | 15 | - 13 | 34 | 12 |
| 17 | 17 | 48 | - 13 | 32 | 43 |
| 17 | 17 | 17 | - 13 | 31 | 21 |
| 17 | 16 | 42 | - 13 | 30 | 06 |
| 17 | 16 | 03 | - 13 | 29 | 01 |
| 17 | 15 | 21 | - 13 | 28 | 07 |
| 17 | 14 | 38 | - 13 | 27 | 26 |
| 17 | 13 | 52 | - 13 | 26 | 59 |
| 17 | 13 | 07 | - 13 | 26 | 47 |
| 17 | 12 | 22 | - 13 | 26 | 52 |
| 17 | 11 | 38 | - 13 | 27 | 13 |
| 17 | 10 | 56 | - 13 | 27 | 52 |
| 17 | 10 | 17 | - 13 | 28 | 47 |
| 17 | 09 | 41 | - 13 | 30 | 00 |
| 17 | 09 | 10 | - 13 | 31 | 30 |
| 17 | 08 | 43 | - 13 | 33 | 17 |
| 17 | 08 | 22 | - 13 | 35 | 19 |
| 17 | 08 | 07 | - 13 | 37 | 35 |
| 17 | 07 | 57 | - 13 | 40 | 05 |
| 17 | 07 | 54 | - 13 | 42 | 46 |
| 17 | 07 | 57 | - 13 | 45 | 38 |
| 17 | 08 | 07 | - 13 | 48 | 38 |
| 17 | 08 | 23 | - 13 | 51 | 44 |
| 17 | 08 | 45 | - 13 | 54 | 55 |
| 17 | 09 | 14 | - 13 | 58 | 09 |
| 17 | 09 | 48 | - 14 | 01 | 23 |
| 17 | 10 | 28 | - 14 | 04 | 36 |
| 17 | 11 | 13 | - 14 | 07 | 44 |
| 17 | 12 | 03 | - 14 | 10 | 48 |
| 17 | 12 | 57 | - 14 | 13 | 43 |
| 17 | 13 | 54 | - 14 | 16 | 29 |
| 17 | 14 | 55 | - 14 | 19 | 04 |
| 17 | 15 | 57 | - 14 | 21 | 27 |
| 17 | 17 | 01 | - 14 | 23 | 36 |
| 17 | 18 | 05 | - 14 | 25 | 29 |
| 17 | 19 | 10 | - 14 | 27 | 08 |
| 17 | 20 | 14 | - 14 | 28 | 29 |

## URANUS FINDER CHART



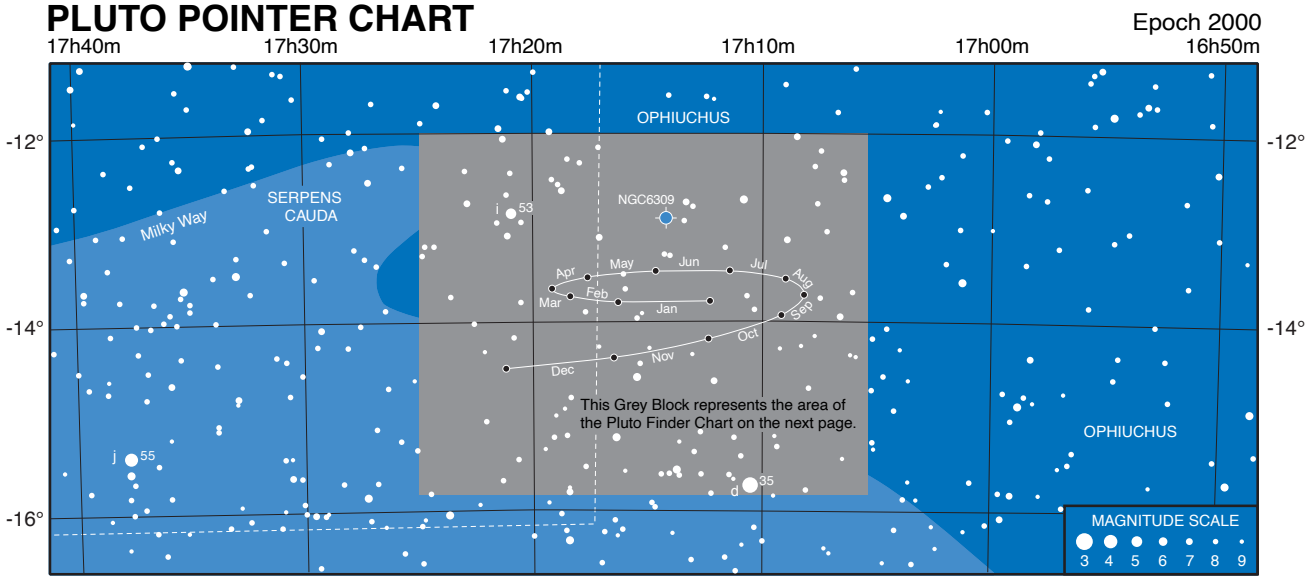

Conjunction 18th February, Stationary 8th Jun, Opposition 25th August, Stationary 9th November.

## NEPTUNE FINDER CHART



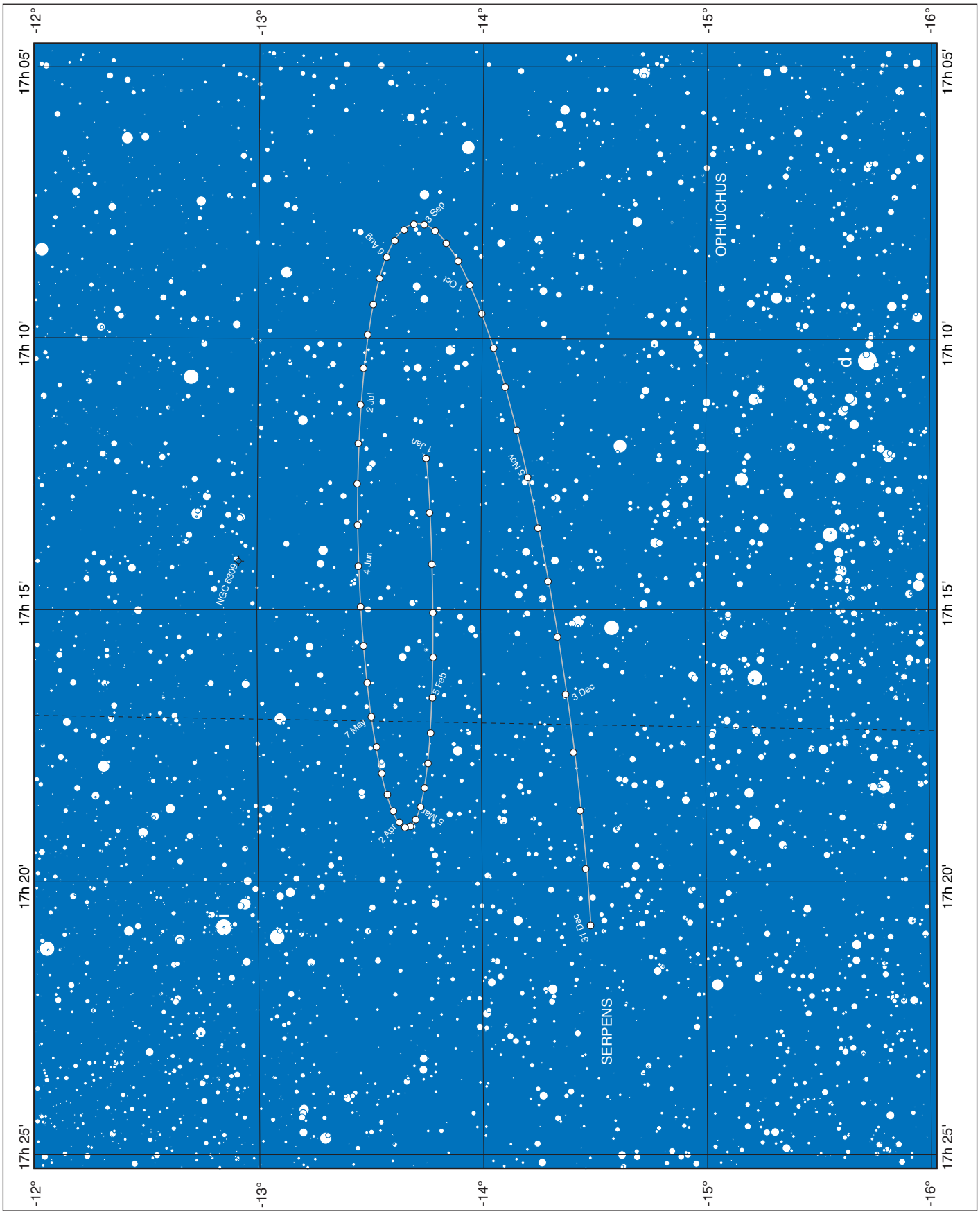

Conjunction 31st January, Stationary 16th May, Opposition 5th August, Stationary 23rd October.

## PLUTO POINTER CHART




Stationary 24th March, Opposition 10th June, Stationary 30th August, Conjunction 12th December.

# PLUTO FINDER CHART Epoch 2000.0




The pointer chart (left) is designed to help people find the general area for Pluto. The main finder chart above shows stars down to approximately magnitude 14.5. This is necessary to pick out the faint star-like image of Pluto (magnitude 13.9) from other numerous faint stars in the field. Commonly available star atlases do not include stars down to anywhere near this magnitude.

# MINOR PLANET POSITIONS (0hr UT, Epoch 2000.0)

| | 1 CERES | | | 2 PALLAS | | | 3 JUNO | | | 4 VESTA | | | 6 HEBE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. |
| Jan 4 | 00 45.2 | - 04 32 | 8.9 | 21 41.2 | - 04 43 | 10.4 | 14 43.1 | - 08 41 | 11.3 | 12 37.7 | + 03 36 | 7.5 | 21 32.9 | - 18 09 | 10.2 |
| 11 | 00 50.4 | - 03 29 | 9.0 | 21 49.8 | - 04 38 | 10.4 | 14 50.3 | - 08 51 | 11.2 | 12 44.4 | + 03 23 | 7.4 | 21 48.6 | - 17 16 | 10.2 |
| 18 | 00 56.3 | - 02 24 | 9.0 | 21 58.7 | - 04 28 | 10.4 | 14 57.0 | - 08 56 | 11.2 | 12 50.2 | + 03 18 | 7.3 | 22 04.3 | - 16 18 | 10.2 |
| 25 | 01 02.7 | - 01 18 | 9.1 | 22 07.7 | - 04 14 | 10.3 | 15 03.1 | - 08 57 | 11.2 | 12 55.0 | + 03 22 | 7.1 | 22 20.1 | - 15 16 | 10.1 |
| Feb 1 | 01 09.8 | - 00 10 | 9.1 | 22 16.8 | - 03 58 | 10.3 | 15 08.6 | - 08 52 | 11.1 | 12 58.6 | + 03 35 | 7.0 | 22 35.9 | - 14 09 | 10.1 |
| 8 | 01 17.3 | + 01 00 | 9.1 | 22 26.0 | - 03 38 | 10.2 | 15 13.3 | - 08 42 | 11.1 | 13 00.9 | + 03 57 | 6.8 | 22 51.8 | - 12 57 | 10.1 |
| 15 | 01 25.3 | + 02 09 | 9.1 | 22 35.3 | - 03 16 | 10.2 | 15 17.3 | - 08 27 | 11.0 | 13 01.9 | + 04 28 | 6.7 | 23 07.7 | - 11 43 | 10.0 |
| 22 | 01 33.7 | + 03 19 | 9.1 | 22 44.7 | - 02 51 | 10.1 | 15 20.4 | - 08 07 | 10.9 | 13 01.4 | + 05 08 | 6.5 | 23 23.5 | - 10 25 | 10.0 |
| Mar 1 | 01 42.4 | + 04 29 | 9.1 | 22 54.2 | - 02 25 | 10.0 | 15 22.6 | - 07 42 | 10.8 | 12 59.5 | + 05 55 | 6.4 | 23 39.4 | - 09 05 | 9.9 |
| 8 | 01 51.6 | + 05 39 | 9.1 | 23 03.6 | - 01 57 | 9.9 | 15 23.8 | - 07 11 | 10.8 | 12 56.1 | + 06 47 | 6.2 | 23 55.2 | - 07 44 | 9.9 |
| 15 | 02 01.0 | + 06 48 | 9.1 | 23 13.1 | - 01 29 | 10.0 | 15 23.9 | - 06 36 | 10.7 | 12 51.4 | + 07 42 | 6.0 | 00 11.1 | - 06 21 | 9.8 |
| 22 | 02 10.7 | + 07 56 | 9.1 | 23 22.6 | - 01 00 | 10.0 | 15 23.0 | - 05 57 | 10.6 | 12 45.8 | + 08 36 | 5.9 | 00 27.0 | - 04 58 | 9.8 |
| 29 | 02 20.7 | + 09 03 | 9.1 | 23 32.0 | - 00 30 | 10.1 | 15 21.0 | - 05 14 | 10.5 | 12 39.6 | + 09 26 | 5.9 | 00 42.9 | - 03 35 | 9.8 |
| Apr 5 | 02 30.9 | + 10 08 | 9.0 | 23 41.4 | - 00 01 | 10.1 | 15 18.0 | - 04 29 | 10.4 | 12 33.1 | + 10 07 | 5.9 | 00 58.8 | - 02 12 | 9.8 |
| 12 | 02 41.4 | + 11 12 | 9.0 | 23 50.8 | + 00 28 | 10.2 | 15 14.1 | - 03 42 | 10.3 | 12 26.9 | + 10 39 | 6.0 | 01 14.7 | - 00 51 | 9.8 |
| 19 | 02 52.0 | + 12 14 | 8.9 | 00 00.1 | + 00 55 | 10.2 | 15 09.5 | - 02 56 | 10.2 | 12 21.5 | + 10 58 | 6.2 | 01 30.7 | + 00 28 | 9.9 |
| 26 | 03 02.9 | + 13 13 | 8.9 | 00 09.4 | + 01 22 | 10.2 | 15 04.3 | - 02 12 | 10.1 | 12 17.0 | + 11 03 | 6.3 | 01 46.6 | + 01 45 | 9.9 |
| May 3 | 03 13.9 | + 14 11 | 8.8 | 00 18.5 | + 01 46 | 10.2 | 14 58.7 | - 01 31 | 10.1 | 12 13.8 | + 10 56 | 6.4 | 02 02.6 | + 03 00 | 10.0 |
| 10 | 03 25.1 | + 15 06 | 8.7 | 00 27.6 | + 02 08 | 10.2 | 14 53.0 | - 00 56 | 10.1 | 12 12.0 | + 10 37 | 6.6 | 02 18.7 | + 04 10 | 10.0 |
| 17 | 03 36.5 | + 15 58 | 8.6 | 00 36.5 | + 02 28 | 10.2 | 14 47.5 | - 00 26 | 10.2 | 12 11.7 | + 10 07 | 6.7 | 02 34.7 | + 05 17 | 10.0 |
| 24 | 03 48.0 | + 16 47 | 8.7 | 00 45.3 | + 02 44 | 10.2 | 14 42.4 | - 00 03 | 10.3 | 12 12.7 | + 09 27 | 6.8 | 02 50.8 | + 06 20 | 10.1 |
| 31 | 03 59.6 | + 17 34 | 8.8 | 00 53.9 | + 02 56 | 10.2 | 14 37.8 | + 00 12 | 10.4 | 12 15.1 | + 08 39 | 6.9 | 03 06.8 | + 07 17 | 10.1 |
| Jun 7 | 04 11.2 | + 18 17 | 8.8 | 01 02.4 | + 03 04 | 10.1 | 14 34.0 | + 00 19 | 10.5 | 12 18.7 | + 07 43 | 7.1 | 03 22.9 | + 08 10 | 10.1 |
| 14 | 04 23.0 | + 18 57 | 8.9 | 01 10.6 | + 03 08 | 10.1 | 14 31.1 | + 00 19 | 10.6 | 12 23.5 | + 06 42 | 7.2 | 03 38.9 | + 08 57 | 10.1 |
| 21 | 04 34.8 | + 19 34 | 8.9 | 01 18.5 | + 03 06 | 10.0 | 14 29.1 | + 00 12 | 10.7 | 12 29.2 | + 05 35 | 7.2 | 03 54.8 | + 09 39 | 10.2 |
| 28 | 04 46.7 | + 20 08 | 9.0 | 01 26.1 | + 02 57 | 10.0 | 14 28.0 | - 00 02 | 10.8 | 12 35.9 | + 04 24 | 7.3 | 04 10.6 | + 10 14 | 10.2 |
| Jul 5 | 04 58.6 | + 20 38 | 9.0 | 01 33.3 | + 02 42 | 9.9 | 14 27.8 | - 00 21 | 10.9 | 12 43.3 | + 03 09 | 7.4 | 04 26.3 | + 10 44 | 10.2 |
| 12 | 05 10.4 | + 21 05 | 9.0 | 01 40.1 | + 02 20 | 9.8 | 14 28.6 | - 00 45 | 11.0 | 12 51.5 | + 01 52 | 7.5 | 04 41.9 | + 11 08 | 10.2 |
| 19 | 05 22.2 | + 21 29 | 9.0 | 01 46.5 | + 01 49 | 9.7 | 14 30.2 | - 01 14 | 11.1 | 13 00.4 | + 00 32 | 7.5 | 04 57.2 | + 11 25 | 10.2 |
| 26 | 05 33.9 | + 21 50 | 9.0 | 01 52.2 | + 01 09 | 9.6 | 14 32.7 | - 01 46 | 11.2 | 13 09.8 | - 00 49 | 7.6 | 05 12.3 | + 11 37 | 10.2 |
| Aug 2 | 05 45.5 | + 22 08 | 9.0 | 01 57.4 | + 00 20 | 9.5 | 14 35.9 | - 02 20 | 11.2 | 13 19.8 | - 02 12 | 7.6 | 05 27.1 | + 11 42 | 10.2 |
| 9 | 05 57.0 | + 22 22 | 9.0 | 02 01.7 | - 00 40 | 9.4 | 14 39.8 | - 02 57 | 11.3 | 13 30.3 | - 03 36 | 7.7 | 05 41.6 | + 11 42 | 10.2 |
| 16 | 06 08.2 | + 22 35 | 9.0 | 02 05.3 | - 01 51 | 9.2 | 14 44.3 | - 03 36 | 11.4 | 13 41.3 | - 04 59 | 7.7 | 05 55.7 | + 11 37 | 10.2 |
| 23 | 06 19.2 | + 22 45 | 9.0 | 02 07.9 | - 03 13 | 9.1 | 14 49.5 | - 04 16 | 11.4 | 13 52.7 | - 06 23 | 7.8 | 06 09.3 | + 11 27 | 10.2 |
| 30 | 06 30.0 | + 22 52 | 8.9 | 02 09.6 | - 04 46 | 9.0 | 14 55.2 | - 04 57 | 11.4 | 14 04.5 | - 07 46 | 7.8 | 06 22.5 | + 11 12 | 10.2 |
| Sep 6 | 06 40.4 | + 22 59 | 8.9 | 02 10.1 | - 06 29 | 8.8 | 15 01.4 | - 05 38 | 11.5 | 14 16.8 | - 09 07 | 7.8 | 06 35.2 | + 10 53 | 10.2 |
| 13 | 06 50.4 | + 23 04 | 8.8 | 02 09.5 | - 08 22 | 8.7 | 15 08.1 | - 06 18 | 11.5 | 14 29.4 | - 10 27 | 7.8 | 06 47.3 | + 10 30 | 10.1 |
| 20 | 07 00.0 | + 23 08 | 8.8 | 02 07.8 | - 10 21 | 8.5 | 15 15.2 | - 06 59 | 11.5 | 14 42.4 | - 11 45 | 7.8 | 06 58.7 | + 10 05 | 10.1 |
| 27 | 07 09.0 | + 23 13 | 8.7 | 02 04.9 | - 12 24 | 8.4 | 15 22.7 | - 07 39 | 11.5 | 14 55.8 | - 13 01 | 7.8 | 07 09.4 | + 09 37 | 10.1 |
| Oct 4 | 07 17.5 | + 23 18 | 8.7 | 02 01.0 | - 14 27 | 8.3 | 15 30.6 | - 08 17 | 11.5 | 15 09.5 | - 14 13 | 7.9 | 07 19.3 | + 09 08 | 10.0 |
| 11 | 07 25.3 | + 23 24 | 8.6 | 01 56.3 | - 16 25 | 8.2 | 15 38.8 | - 08 54 | 11.5 | 15 23.6 | - 15 22 | 7.8 | 07 28.4 | + 08 38 | 10.0 |
| 18 | 07 32.3 | + 23 32 | 8.5 | 01 51.0 | - 18 15 | 8.2 | 15 47.2 | - 09 30 | 11.5 | 15 38.0 | - 16 27 | 7.8 | 07 36.5 | + 08 09 | 9.9 |
| 25 | 07 38.5 | + 23 43 | 8.4 | 01 45.4 | - 19 52 | 8.3 | 15 56.0 | - 10 03 | 11.5 | 15 52.7 | - 17 28 | 7.8 | 07 43.5 | + 07 40 | 9.8 |
| Nov 1 | 07 43.7 | + 23 57 | 8.3 | 01 39.8 | - 21 13 | 8.4 | 16 04.9 | - 10 35 | 11.5 | 16 07.7 | - 18 24 | 7.8 | 07 49.4 | + 07 15 | 9.8 |
| 8 | 07 47.8 | + 24 16 | 8.1 | 01 34.7 | - 22 16 | 8.5 | 16 14.1 | - 11 04 | 11.5 | 16 23.0 | - 19 15 | 7.8 | 07 54.0 | + 06 53 | 9.7 |
| 15 | 07 50.7 | + 24 40 | 8.0 | 01 30.3 | - 23 01 | 8.6 | 16 23.5 | - 11 30 | 11.4 | 16 38.5 | - 20 01 | 7.8 | 07 57.2 | + 06 36 | 9.6 |
| 22 | 07 52.3 | + 25 09 | 7.9 | 01 26.8 | - 23 28 | 8.7 | 16 33.0 | - 11 54 | 11.4 | 16 54.3 | - 20 40 | 7.7 | 07 58.9 | + 06 26 | 9.5 |
| 29 | 07 52.5 | + 25 43 | 7.7 | 01 24.4 | - 23 39 | 8.7 | 16 42.7 | - 12 14 | 11.4 | 17 10.2 | - 21 14 | 7.7 | 07 59.1 | + 06 23 | 9.3 |
| Dec 6 | 07 51.2 | + 26 23 | 7.6 | 01 23.3 | - 23 35 | 8.8 | 16 52.4 | - 12 31 | 11.3 | 17 26.3 | - 21 42 | 7.6 | 07 57.7 | + 06 31 | 9.2 |
| 13 | 07 48.4 | + 27 06 | 7.4 | 01 23.4 | - 23 17 | 8.9 | 17 02.2 | - 12 45 | 11.3 | 17 42.5 | - 22 04 | 7.6 | 07 54.7 | + 06 48 | 9.1 |
| 20 | 07 44.2 | + 27 53 | 7.2 | 01 24.8 | - 22 49 | 9.0 | 17 12.1 | - 12 56 | 11.4 | 17 58.8 | - 22 19 | 7.5 | 07 50.2 | + 07 17 | 9.0 |
| 27 | 07 38.7 | + 28 41 | 7.1 | 01 27.4 | - 22 11 | 9.1 | 17 21.9 | - 13 03 | 11.4 | 18 15.2 | - 22 27 | 7.5 | 07 44.5 | + 07 56 | 8.8 |

| | 7 IRIS | | | 8 FLORA | | | 9 METIS | | | 11 PARTHENOPE | | | 12 VICTORIA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. | RA(h mm) | Dec(° ') | Mag. |
| Jan 4 | 23 31.0 | + 01 40 | 9.6 | 16 09.4 | - 16 50 | 11.7 | 15 07.6 | - 14 28 | 11.6 | 11 24.2 | + 06 27 | 11.3 | 14 56.1 | - 20 21 | 12.1 |
| 11 | 23 44.9 | + 02 50 | 9.6 | 16 21.2 | - 17 19 | 11.7 | 15 17.7 | - 15 10 | 11.6 | 11 25.6 | + 06 34 | 11.2 | 15 09.0 | - 21 06 | 12.1 |
| 18 | 23 59.2 | + 04 04 | 9.7 | 16 32.9 | - 17 45 | 11.7 | 15 27.4 | - 15 48 | 11.6 | 11 25.8 | + 06 49 | 11.1 | 15 21.9 | - 21 46 | 12.0 |
| 25 | 00 13.9 | + 05 20 | 9.7 | 16 44.4 | - 18 06 | 11.7 | 15 36.7 | - 16 23 | 11.6 | 11 24.7 | + 07 13 | 10.9 | 15 34.7 | - 22 22 | 11.9 |
| Feb 1 | 00 28.9 | + 06 39 | 9.7 | 16 55.7 | - 18 24 | 11.6 | 15 45.6 | - 16 54 | 11.5 | 11 22.4 | + 07 45 | 10.8 | 15 47.3 | - 22 53 | 11.9 |
| 8 | 00 44.2 | + 07 59 | 9.8 | 17 06.6 | - 18 37 | 11.6 | 15 53.8 | - 17 21 | 11.5 | 11 18.8 | + 08 24 | 10.6 | 15 59.7 | - 23 18 | 11.8 |
| 15 | 00 59.9 | + 09 20 | 9.8 | 17 17.2 | - 18 48 | 11.6 | 16 01.3 | - 17 45 | 11.4 | 11 14.2 | + 09 09 | 10.4 | 16 11.8 | - 23 38 | 11.7 |
| 22 | 01 15.8 | + 10 40 | 9.8 | 17 27.4 | - 18 55 | 11.5 | 16 08.1 | - 18 06 | 11.3 | 11 08.7 | + 09 58 | 10.2 | 16 23.5 | - 23 53 | 11.6 |
| Mar 1 | 01 32.0 | + 12 00 | 9.8 | 17 37.1 | - 18 59 | 11.4 | 16 14.1 | - 18 24 | 11.3 | 11 02.6 | + 10 49 | 10.1 | 16 34.8 | - 24 02 | 11.5 |
| 8 | 01 48.4 | + 13 18 | 9.8 | 17 46.2 | - 19 00 | 11.4 | 16 19.0 | - 18 39 | 11.2 | 10 56.3 | + 11 37 | 10.1 | 16 45.6 | - 24 05 | 11.3 |
| 15 | 02 05.1 | + 14 33 | 9.8 | 17 54.6 | - 18 59 | 11.3 | 16 22.9 | - 18 51 | 11.1 | 10 50.1 | + 12 22 | 10.3 | 16 55.6 | - 24 02 | 11.2 |
| 22 | 02 22.0 | + 15 45 | 9.8 | 18 02.4 | - 18 56 | 11.2 | 16 25.5 | - 19 01 | 11.0 | 10 44.4 | + 13 01 | 10.5 | 17 04.8 | - 23 53 | 11.0 |
| 29 | 02 39.2 | + 16 53 | 9.8 | 18 09.3 | - 18 52 | 11.1 | 16 26.9 | - 19 09 | 10.8 | 10 39.5 | + 13 32 | 10.6 | 17 13.1 | - 23 39 | 10.9 |
| Apr 5 | 02 56.6 | + 17 57 | 9.8 | 18 15.3 | - 18 47 | 11.0 | 16 26.8 | - 19 14 | 10.7 | 10 35.7 | + 13 54 | 10.8 | 17 20.3 | - 23 19 | 10.7 |
| 12 | 03 14.1 | + 18 55 | 9.8 | 18 20.2 | - 18 42 | 10.8 | 16 25.4 | - 19 17 | 10.6 | 10 33.0 | + 14 08 | 10.9 | 17 26.2 | - 22 53 | 10.5 |
| 19 | 03 31.8 | + 19 48 | 9.8 | 18 23.9 | - 18 38 | 10.7 | 16 22.5 | - 19 18 | 10.4 | 10 31.6 | + 14 13 | 11.0 | 17 30.7 | - 22 21 | 10.3 |
| 26 | 03 49.7 | + 20 34 | 9.8 | 18 26.4 | - 18 35 | 10.6 | 16 18.3 | - 19 17 | 10.3 | 10 31.5 | + 14 09 | 11.2 | 17 33.7 | - 21 44 | 10.1 |
| May 3 | 04 07.7 | + 21 14 | 9.8 | 18 27.5 | - 18 33 | 10.4 | 16 12.8 | - 19 13 | 10.1 | 10 32.6 | + 13 58 | 11.3 | 17 34.9 | - 21 01 | 9.9 |
| 10 | 04 25.7 | + 21 46 | 9.8 | 18 27.1 | - 18 34 | 10.3 | 16 06.4 | - 19 08 | 10.0 | 10 34.9 | + 13 40 | 11.4 | 17 34.4 | - 20 13 | 9.7 |
| 17 | 04 43.7 | + 22 12 | 9.8 | 18 25.2 | - 18 37 | 10.1 | 15 59.4 | - 19 01 | 9.8 | 10 38.2 | + 13 15 | 11.5 | 17 32.2 | - 19 20 | 9.5 |
| 24 | 05 01.8 | + 22 30 | 9.8 | 18 21.7 | - 18 44 | 9.9 | 15 52.0 | - 18 53 | 9.7 | 10 42.5 | + 12 44 | 11.6 | 17 28.4 | - 18 23 | 9.3 |
| 31 | 05 19.8 | + 22 40 | 9.7 | 18 16.8 | - 18 53 | 9.7 | 15 44.8 | - 18 45 | 9.9 | 10 47.6 | + 12 08 | 11.7 | 17 23.2 | - 17 24 | 9.0 |
| Jun 7 | 05 37.7 | + 22 43 | 9.7 | 18 10.5 | - 19 05 | 9.6 | 15 38.1 | - 18 38 | 10.1 | 10 53.6 | + 11 28 | 11.7 | 17 17.1 | - 16 25 | 8.8 |
| 14 | 05 55.4 | + 22 39 | 9.7 | 18 03.3 | - 19 18 | 9.4 | 15 32.2 | - 18 32 | 10.2 | 11 00.1 | + 10 42 | 11.8 | 17 10.5 | - 15 27 | 8.8 |
| 21 | 06 13.0 | + 22 27 | 9.6 | 17 55.5 | - 19 34 | 9.2 | 15 27.4 | - 18 29 | 10.4 | 11 07.3 | + 09 53 | 11.8 | 17 04.2 | - 14 34 | 8.9 |
| 28 | 06 30.3 | + 22 08 | 9.5 | 17 47.5 | - 19 51 | 9.3 | 15 23.9 | - 18 30 | 10.5 | 11 15.1 | + 09 01 | 11.9 | 16 58.6 | - 13 48 | 9.1 |
| Jul 5 | 06 47.4 | + 21 43 | 9.6 | 17 39.9 | - 20 08 | 9.5 | 15 21.7 | - 18 35 | 10.7 | 11 23.3 | + 08 05 | 11.9 | 16 54.1 | - 13 11 | 9.3 |
| 12 | 07 04.2 | + 21 10 | 9.7 | 17 33.1 | - 20 27 | 9.6 | 15 20.9 | - 18 43 | 10.8 | 11 31.9 | + 07 06 | 12.0 | 16 51.3 | - 12 44 | 9.4 |
| 19 | 07 20.7 | + 20 32 | 9.8 | 17 27.5 | - 20 45 | 9.7 | 15 21.3 | - 18 56 | 11.0 | 11 40.9 | + 06 05 | 12.0 | 16 50.2 | - 12 26 | 9.6 |
| 26 | 07 36.8 | + 19 48 | 9.9 | 17 23.3 | - 21 05 | 9.9 | 15 23.1 | - 19 12 | 11.1 | 11 50.2 | + 05 01 | 12.0 | 16 50.9 | - 12 18 | 9.7 |
| Aug 2 | 07 52.6 | + 18 59 | 10.0 | 17 20.7 | - 21 24 | 10.0 | 15 26.0 | - 19 32 | 11.2 | 11 59.8 | + 03 56 | 12.0 | 16 53.5 | - 12 18 | 9.9 |
| 9 | 08 08.0 | + 18 05 | 10.1 | 17 19.8 | - 21 45 | 10.1 | 15 30.0 | - 19 55 | 11.3 | 12 09.7 | + 02 49 | 12.0 | 16 57.9 | - 12 25 | 10.0 |
| 16 | 08 23.1 | + 17 07 | 10.1 | 17 20.6 | - 22 06 | 10.3 | 15 35.0 | - 20 20 | 11.4 | 12 19.9 | + 01 40 | 12.0 | 17 03.8 | - 12 37 | 10.1 |
| 23 | 08 37.7 | + 16 05 | 10.2 | 17 23.0 | - 22 27 | 10.4 | 15 40.9 | - 20 46 | 11.5 | 12 30.3 | + 00 31 | 12.0 | 17 11.3 | - 12 53 | 10.3 |
| 30 | 08 52.0 | + 14 59 | 10.2 | 17 26.9 | - 22 48 | 10.5 | 15 47.7 | - 21 14 | 11.5 | 12 41.0 | - 00 40 | 11.9 | 17 20.1 | - 13 10 | 10.4 |
| Sep 6 | 09 05.8 | + 13 50 | 10.3 | 17 32.2 | - 23 08 | 10.6 | 15 55.3 | - 21 43 | 11.6 | 12 51.9 | - 01 51 | 11.9 | 17 30.2 | - 13 28 | 10.5 |
| 13 | 09 19.2 | + 12 40 | 10.3 | 17 38.8 | - 23 27 | 10.7 | 16 03.6 | - 22 12 | 11.6 | 13 02.9 | - 03 02 | 11.9 | 17 41.3 | - 13 45 | 10.6 |
| 20 | 09 32.3 | + 11 27 | 10.4 | 17 46.6 | - 23 44 | 10.7 | 16 12.5 | - 22 41 | 11.7 | 13 14.2 | - 04 13 | 11.8 | 17 53.4 | - 14 00 | 10.7 |
| 27 | 09 44.9 | + 10 12 | 10.4 | 17 55.5 | - 23 58 | 10.8 | 16 22.0 | - 23 09 | 11.7 | 13 25.7 | - 05 23 | 11.8 | 18 06.4 | - 14 12 | 10.8 |
| Oct 4 | 09 57.0 | + 08 57 | 10.4 | 18 05.3 | - 24 10 | 10.9 | 16 32.1 | - 23 36 | 11.8 | 13 37.4 | - 06 33 | 11.7 | 18 20.1 | - 14 20 | 10.9 |
| 11 | 10 08.8 | + 07 41 | 10.5 | 18 16.0 | - 24 19 | 10.9 | 16 42.7 | - 24 01 | 11.8 | 13 49.3 | - 07 42 | 11.6 | 18 34.4 | - 14 23 | 10.9 |
| 18 | 10 20.1 | + 06 25 | 10.5 | 18 27.5 | - 24 23 | 10.9 | 16 53.7 | - 24 24 | 11.8 | 14 01.3 | - 08 49 | 11.6 | 18 49.3 | - 14 21 | 11.0 |
| 25 | 10 30.9 | + 05 10 | 10.5 | 18 39.7 | - 24 23 | 11.0 | 17 05.1 | - 24 44 | 11.8 | 14 13.6 | - 09 55 | 11.5 | 19 04.6 | - 14 13 | 11.1 |
| Nov 1 | 10 41.2 | + 03 55 | 10.5 | 18 52.5 | - 24 19 | 11.0 | 17 16.9 | - 25 02 | 11.8 | 14 26.0 | - 10 59 | 11.4 | 19 20.3 | - 13 58 | 11.1 |
| 8 | 10 51.0 | + 02 41 | 10.5 | 19 05.8 | - 24 09 | 11.0 | 17 29.1 | - 25 16 | 11.8 | 14 38.6 | - 12 00 | 11.5 | 19 36.2 | - 13 37 | 11.2 |
| 15 | 11 00.3 | + 01 29 | 10.5 | 19 19.6 | - 23 54 | 11.0 | 17 41.5 | - 25 28 | 11.8 | 14 51.4 | - 12 59 | 11.5 | 19 52.4 | - 13 09 | 11.3 |
| 22 | 11 08.9 | + 00 20 | 10.4 | 19 33.8 | - 23 33 | 11.0 | 17 54.2 | - 25 35 | 11.7 | 15 04.3 | - 13 54 | 11.6 | 20 08.7 | - 12 35 | 11.3 |
| 29 | 11 16.8 | - 00 47 | 10.4 | 19 48.4 | - 23 06 | 11.0 | 18 07.1 | - 25 39 | 11.7 | 15 17.3 | - 14 47 | 11.6 | 20 25.0 | - 11 54 | 11.4 |
| Dec 6 | 11 24.1 | - 01 51 | 10.4 | 20 03.2 | - 22 33 | 11.0 | 18 20.2 | - 25 39 | 11.7 | 15 30.5 | - 15 36 | 11.7 | 20 41.5 | - 11 07 | 11.4 |
| 13 | 11 30.5 | - 02 50 | 10.3 | 20 18.3 | - 21 54 | 11.0 | 18 33.5 | - 25 35 | 11.6 | 15 43.8 | - 16 21 | 11.7 | 20 57.8 | - 10 14 | 11.5 |
| 20 | 11 36.0 | - 03 45 | 10.2 | 20 33.5 | - 21 09 | 11.0 | 18 46.8 | - 25 27 | 11.5 | 15 57.1 | - 17 02 | 11.7 | 21 14.2 | - 09 16 | 11.5 |
| 27 | 11 40.5 | - 04 35 | 10.2 | 20 48.9 | - 20 18 | 11.0 | 19 00.2 | - 25 14 | 11.5 | 16 10.5 | - 17 39 | 11.7 | 21 30.4 | - 08 13 | 11.5 |

As well as the nine planets, their moons and the comets, the Solar System contains numerous smaller bodies known as the minor planets or asteroids. There are now hundreds of thousands of such bodies catalogued! Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe. Many can be found by photographing the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which star has moved. Be sure you have the right field of view! Only about 60 of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition. The ephemerides are for the 20 brightest minor planets for 2003. Sixteen of these reach opposition in 2003, four early in 2004. These selected asteroids all get brighter than, or close to, 10th magnitude around the time of opposition.

# MINOR PLANET POSITIONS (0hr UT, Epoch 2000.0)

| | 13 EGERIA | | | 14 IRENE | | | 15 EUNOMIA | | | 23 THALIA | | | 29 AMPHITRITE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R.A. hr min | Dec. ° ' | Mag. | R.A. hr min | Dec. ° ' | Mag. | R.A. hr min | Dec. ° ' | Mag. | R.A. hr min | Dec. ° ' | Mag. | R.A. hr min | Dec. ° ' | Mag. |
| Jan 4 | 21 33.0 | - 27 49 | 12.4 | 23 55.9 | - 09 30 | 12.1 | 23 46.9 | + 11 34 | 9.7 | 14 06.9 | - 03 41 | 11.6 | 21 46.0 | - 15 03 | 11.1 |
| 11 | 21 44.4 | - 26 38 | 12.4 | 00 02.2 | - 08 29 | 12.2 | 23 58.5 | + 12 18 | 9.7 | 14 16.8 | - 04 26 | 11.6 | 21 57.5 | - 13 53 | 11.1 |
| 18 | 21 55.9 | - 25 26 | 12.4 | 00 09.0 | - 07 27 | 12.2 | 00 10.5 | + 13 06 | 9.8 | 14 26.1 | - 05 05 | 11.6 | 22 09.1 | - 12 40 | 11.1 |
| 25 | 22 07.3 | - 24 13 | 12.3 | 00 16.2 | - 06 23 | 12.2 | 00 23.0 | + 13 58 | 9.8 | 14 34.6 | - 05 39 | 11.5 | 22 20.7 | - 11 25 | 11.1 |
| Feb 1 | 22 18.7 | - 22 58 | 12.3 | 00 23.8 | - 05 18 | 12.2 | 00 35.9 | + 14 52 | 9.9 | 14 42.2 | - 06 08 | 11.4 | 22 32.4 | - 10 08 | 11.0 |
| 8 | 22 30.1 | - 21 42 | 12.2 | 00 31.8 | - 04 12 | 12.2 | 00 49.1 | + 15 49 | 9.9 | 14 48.9 | - 06 31 | 11.4 | 22 44.2 | - 08 48 | 11.0 |
| 15 | 22 41.4 | - 20 26 | 12.2 | 00 40.1 | - 03 05 | 12.2 | 01 02.7 | + 16 47 | 10.0 | 14 54.4 | - 06 48 | 11.3 | 22 56.0 | - 07 27 | 11.0 |
| 22 | 22 52.7 | - 19 09 | 12.2 | 00 48.7 | - 01 58 | 12.2 | 01 16.6 | + 17 46 | 10.0 | 14 58.7 | - 07 00 | 11.2 | 23 07.9 | - 06 04 | 10.9 |
| Mar 1 | 23 03.9 | - 17 51 | 12.1 | 00 57.4 | - 00 51 | 12.2 | 01 30.8 | + 18 45 | 10.0 | 15 01.7 | - 07 07 | 11.1 | 23 19.7 | - 04 40 | 10.8 |
| 8 | 23 15.0 | - 16 33 | 12.2 | 01 06.5 | + 00 16 | 12.2 | 01 45.2 | + 19 43 | 10.0 | 15 03.3 | - 07 09 | 11.0 | 23 31.6 | - 03 16 | 10.7 |
| 15 | 23 26.0 | - 15 16 | 12.2 | 01 15.7 | + 01 23 | 12.2 | 01 59.9 | + 20 40 | 10.1 | 15 03.3 | - 07 06 | 10.9 | 23 43.4 | - 01 50 | 10.6 |
| 22 | 23 36.9 | - 13 58 | 12.2 | 01 25.1 | + 02 29 | 12.1 | 02 14.8 | + 21 35 | 10.1 | 15 01.8 | - 07 00 | 10.8 | 23 55.3 | - 00 24 | 10.6 |
| 29 | 23 47.7 | - 12 42 | 12.2 | 01 34.6 | + 03 34 | 12.1 | 02 29.9 | + 22 28 | 10.1 | 14 58.9 | - 06 52 | 10.6 | 00 07.2 | + 01 02 | 10.7 |
| Apr 5 | 23 58.3 | - 11 26 | 12.3 | 01 44.3 | + 04 38 | 12.0 | 02 45.3 | + 23 18 | 10.1 | 14 54.5 | - 06 41 | 10.5 | 00 19.1 | + 02 29 | 10.8 |
| 12 | 00 08.9 | - 10 11 | 12.3 | 01 54.1 | + 05 41 | 11.9 | 03 00.8 | + 24 05 | 10.1 | 14 48.9 | - 06 30 | 10.4 | 00 31.0 | + 03 55 | 10.9 |
| 19 | 00 19.4 | - 08 57 | 12.3 | 02 04.1 | + 06 42 | 11.9 | 03 16.5 | + 24 47 | 10.1 | 14 42.4 | - 06 20 | 10.2 | 00 42.9 | + 05 20 | 10.9 |
| 26 | 00 29.7 | - 07 44 | 12.3 | 02 14.1 | + 07 42 | 11.8 | 03 32.3 | + 25 26 | 10.1 | 14 35.5 | - 06 12 | 10.1 | 00 54.8 | + 06 44 | 10.9 |
| May 3 | 00 39.9 | - 06 34 | 12.4 | 02 24.2 | + 08 40 | 11.9 | 03 48.2 | + 26 00 | 10.0 | 14 28.4 | - 06 07 | 10.2 | 01 06.7 | + 08 08 | 11.0 |
| 10 | 00 49.9 | - 05 25 | 12.4 | 02 34.4 | + 09 35 | 11.9 | 04 04.2 | + 26 28 | 10.0 | 14 21.6 | - 06 07 | 10.4 | 01 18.6 | + 09 30 | 11.0 |
| 17 | 00 59.8 | - 04 18 | 12.3 | 02 44.7 | + 10 29 | 12.0 | 04 20.2 | + 26 52 | 10.0 | 14 15.5 | - 06 13 | 10.6 | 01 30.5 | + 10 50 | 11.0 |
| 24 | 01 09.4 | - 03 13 | 12.3 | 02 55.0 | + 11 20 | 12.0 | 04 36.3 | + 27 10 | 10.0 | 14 10.3 | - 06 24 | 10.8 | 01 42.4 | + 12 09 | 11.0 |
| 31 | 01 18.9 | - 02 11 | 12.3 | 03 05.3 | + 12 09 | 12.1 | 04 52.3 | + 27 22 | 9.9 | 14 06.3 | - 06 42 | 10.9 | 01 54.3 | + 13 25 | 11.0 |
| Jun 7 | 01 28.1 | - 01 11 | 12.3 | 03 15.6 | + 12 55 | 12.1 | 05 08.3 | + 27 29 | 9.9 | 14 03.6 | - 07 05 | 11.1 | 02 06.1 | + 14 40 | 11.0 |
| 14 | 01 37.1 | - 00 14 | 12.3 | 03 26.0 | + 13 39 | 12.1 | 05 24.2 | + 27 30 | 9.9 | 14 02.1 | - 07 34 | 11.3 | 02 17.9 | + 15 52 | 11.0 |
| 21 | 01 45.8 | + 00 39 | 12.2 | 03 36.3 | + 14 19 | 12.1 | 05 40.0 | + 27 26 | 9.9 | 14 01.8 | - 08 07 | 11.5 | 02 29.7 | + 17 01 | 11.0 |
| 28 | 01 54.1 | + 01 30 | 12.2 | 03 46.5 | + 14 57 | 12.1 | 05 55.6 | + 27 15 | 10.0 | 14 02.8 | - 08 45 | 11.6 | 02 41.3 | + 18 08 | 11.0 |
| Jul 5 | 02 02.1 | + 02 18 | 12.1 | 03 56.7 | + 15 32 | 12.1 | 06 11.0 | + 27 00 | 10.1 | 14 04.9 | - 09 26 | 11.8 | 02 52.8 | + 19 12 | 10.9 |
| 12 | 02 09.6 | + 03 02 | 12.1 | 04 06.7 | + 16 04 | 12.1 | 06 26.1 | + 26 39 | 10.1 | 14 08.0 | - 10 10 | 11.9 | 03 04.2 | + 20 13 | 10.9 |
| 19 | 02 16.5 | + 03 43 | 12.0 | 04 16.6 | + 16 33 | 12.1 | 06 41.0 | + 26 12 | 10.2 | 14 12.1 | - 10 57 | 12.0 | 03 15.4 | + 21 12 | 10.9 |
| 26 | 02 22.9 | + 04 21 | 11.9 | 04 26.3 | + 16 59 | 12.1 | 06 55.6 | + 25 41 | 10.2 | 14 16.9 | - 11 45 | 12.1 | 03 26.3 | + 22 07 | 10.8 |
| Aug 2 | 02 28.6 | + 04 54 | 11.8 | 04 35.7 | + 17 23 | 12.0 | 07 09.9 | + 25 05 | 10.3 | 14 22.6 | - 12 36 | 12.2 | 03 36.9 | + 22 59 | 10.8 |
| 9 | 02 33.5 | + 05 25 | 11.7 | 04 44.9 | + 17 43 | 12.0 | 07 23.8 | + 24 26 | 10.3 | 14 28.9 | - 13 27 | 12.3 | 03 47.1 | + 23 49 | 10.7 |
| 16 | 02 37.6 | + 05 51 | 11.6 | 04 53.7 | + 18 01 | 11.9 | 07 37.3 | + 23 42 | 10.4 | 14 35.9 | - 14 18 | 12.4 | 03 56.9 | + 24 36 | 10.6 |
| 23 | 02 40.6 | + 06 15 | 11.5 | 05 02.1 | + 18 17 | 11.9 | 07 50.5 | + 22 54 | 10.4 | 14 43.4 | - 15 10 | 12.5 | 04 06.1 | + 25 21 | 10.6 |
| 30 | 02 42.6 | + 06 34 | 11.4 | 05 10.1 | + 18 30 | 11.8 | 08 03.2 | + 22 03 | 10.4 | 14 51.5 | - 16 02 | 12.6 | 04 14.6 | + 26 03 | 10.5 |
| Sep 6 | 02 43.2 | + 06 51 | 11.2 | 05 17.4 | + 18 41 | 11.7 | 08 15.5 | + 21 10 | 10.4 | 15 00.0 | - 16 53 | 12.6 | 04 22.3 | + 26 43 | 10.4 |
| 13 | 02 42.6 | + 07 04 | 11.1 | 05 24.2 | + 18 51 | 11.6 | 08 27.3 | + 20 14 | 10.5 | 15 08.9 | - 17 43 | 12.7 | 04 29.2 | + 27 21 | 10.3 |
| 20 | 02 40.6 | + 07 15 | 10.9 | 05 30.2 | + 19 00 | 11.5 | 08 38.6 | + 19 16 | 10.5 | 15 18.2 | - 18 32 | 12.7 | 04 34.9 | + 27 57 | 10.2 |
| 27 | 02 37.2 | + 07 24 | 10.8 | 05 35.3 | + 19 08 | 11.4 | 08 49.4 | + 18 16 | 10.5 | 15 27.9 | - 19 20 | 12.7 | 04 39.5 | + 28 32 | 10.1 |
| Oct 4 | 02 32.4 | + 07 30 | 10.6 | 05 39.5 | + 19 15 | 11.3 | 08 59.6 | + 17 16 | 10.4 | 15 37.9 | - 20 06 | 12.8 | 04 42.7 | + 29 05 | 9.9 |
| 11 | 02 26.5 | + 07 36 | 10.4 | 05 42.6 | + 19 22 | 11.2 | 09 09.3 | + 16 14 | 10.4 | 15 48.2 | - 20 50 | 12.8 | 04 44.4 | + 29 36 | 9.8 |
| 18 | 02 19.5 | + 07 41 | 10.2 | 05 44.6 | + 19 30 | 11.0 | 09 18.3 | + 15 13 | 10.4 | 15 58.8 | - 21 32 | 12.8 | 04 44.4 | + 30 04 | 9.7 |
| 25 | 02 11.9 | + 07 47 | 10.0 | 05 45.2 | + 19 39 | 10.9 | 09 26.7 | + 14 11 | 10.4 | 16 09.6 | - 22 12 | 12.8 | 04 42.7 | + 30 29 | 9.5 |
| Nov 1 | 02 04.1 | + 07 54 | 10.1 | 05 44.4 | + 19 49 | 10.7 | 09 34.3 | + 13 11 | 10.3 | 16 20.6 | - 22 49 | 12.8 | 04 39.3 | + 30 50 | 9.3 |
| 8 | 01 56.5 | + 08 05 | 10.2 | 05 42.2 | + 20 00 | 10.6 | 09 41.2 | + 12 12 | 10.3 | 16 31.8 | - 23 23 | 12.8 | 04 34.3 | + 31 06 | 9.2 |
| 15 | 01 49.5 | + 08 18 | 10.4 | 05 38.6 | + 20 13 | 10.4 | 09 47.2 | + 11 14 | 10.2 | 16 43.2 | - 23 54 | 12.7 | 04 27.9 | + 31 14 | 9.0 |
| 22 | 01 43.4 | + 08 37 | 10.6 | 05 33.5 | + 20 27 | 10.2 | 09 52.2 | + 10 19 | 10.2 | 16 54.7 | - 24 23 | 12.7 | 04 20.5 | + 31 14 | 8.9 |
| 29 | 01 38.6 | + 09 00 | 10.7 | 05 27.4 | + 20 42 | 10.0 | 09 56.3 | + 09 27 | 10.1 | 17 06.3 | - 24 48 | 12.7 | 04 12.7 | + 31 07 | 8.8 |
| Dec 6 | 01 35.2 | + 09 28 | 10.9 | 05 20.3 | + 20 57 | 9.8 | 09 59.2 | + 08 39 | 10.0 | 17 18.0 | - 25 10 | 12.6 | 04 05.0 | + 30 51 | 8.9 |
| 13 | 01 33.3 | + 10 02 | 11.0 | 05 12.7 | + 21 12 | 9.6 | 10 00.9 | + 07 55 | 9.9 | 17 29.7 | - 25 29 | 12.5 | 03 57.9 | + 30 30 | 9.0 |
| 20 | 01 32.8 | + 10 41 | 11.1 | 05 05.0 | + 21 28 | 9.8 | 10 01.4 | + 07 17 | 9.8 | 17 41.4 | - 25 45 | 12.5 | 03 51.9 | + 30 06 | 9.2 |
| 27 | 01 33.7 | + 11 24 | 11.3 | 04 57.8 | + 21 43 | 10.0 | 10 00.5 | + 06 43 | 9.7 | 17 53.1 | - 25 58 | 12.6 | 03 47.4 | + 29 39 | 9.4 |

| | 39 LAETITIA | | | 40 HARMONIA | | | 63 AUSONIA | | | 85 IO | | | 511 DAVIDA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan 4 | 09 05.5 | + 08 26 | 10.6 | 14 12.2 | - 09 06 | 12.0 | 18 14.1 | - 27 07 | 11.9 | 17 07.6 | - 16 40 | 12.8 | 06 45.2 | + 20 11 | 9.5 |
| 11 | 09 01.1 | + 08 54 | 10.5 | 14 22.0 | - 09 49 | 11.9 | 18 31.7 | - 26 55 | 12.0 | 17 21.4 | - 16 39 | 12.8 | 06 38.9 | + 21 06 | 9.7 |
| 18 | 08 55.9 | + 09 28 | 10.3 | 14 31.3 | - 10 27 | 11.9 | 18 49.1 | - 26 36 | 12.0 | 17 35.2 | - 16 32 | 12.8 | 06 33.1 | + 21 59 | 9.9 |
| 25 | 08 50.1 | + 10 08 | 10.2 | 14 40.0 | - 11 01 | 11.8 | 19 06.3 | - 26 10 | 12.1 | 17 48.9 | - 16 21 | 12.8 | 06 28.2 | + 22 49 | 10.1 |
| Feb 1 | 08 44.1 | + 10 52 | 10.1 | 14 48.1 | - 11 29 | 11.7 | 19 23.3 | - 25 38 | 12.1 | 18 02.5 | - 16 03 | 12.8 | 06 24.4 | + 23 36 | 10.3 |
| 8 | 08 38.2 | + 11 38 | 10.2 | 14 55.5 | - 11 53 | 11.6 | 19 40.1 | - 24 59 | 12.1 | 18 16.0 | - 15 40 | 12.8 | 06 22.0 | + 24 19 | 10.4 |
| 15 | 08 32.8 | + 12 24 | 10.4 | 15 02.0 | - 12 11 | 11.5 | 19 56.6 | - 24 14 | 12.1 | 18 29.4 | - 15 11 | 12.7 | 06 21.0 | + 24 57 | 10.6 |
| 22 | 08 28.0 | + 13 09 | 10.6 | 15 07.5 | - 12 24 | 11.4 | 20 12.7 | - 23 24 | 12.2 | 18 42.5 | - 14 37 | 12.7 | 06 21.6 | + 25 32 | 10.7 |
| Mar 1 | 08 24.2 | + 13 50 | 10.7 | 15 11.9 | - 12 31 | 11.3 | 20 28.5 | - 22 29 | 12.2 | 18 55.3 | - 13 58 | 12.7 | 06 23.5 | + 26 02 | 10.9 |
| 8 | 08 21.5 | + 14 28 | 10.9 | 15 15.0 | - 12 33 | 11.1 | 20 43.8 | - 21 30 | 12.2 | 19 07.9 | - 13 13 | 12.6 | 06 26.8 | + 26 28 | 11.0 |
| 15 | 08 19.9 | + 15 01 | 11.0 | 15 16.8 | - 12 30 | 11.0 | 20 58.8 | - 20 27 | 12.2 | 19 20.1 | - 12 24 | 12.6 | 06 31.4 | + 26 51 | 11.1 |
| 22 | 08 19.6 | + 15 30 | 11.2 | 15 17.1 | - 12 21 | 10.8 | 21 13.3 | - 19 21 | 12.2 | 19 32.0 | - 11 30 | 12.5 | 06 37.1 | + 27 09 | 11.2 |
| 29 | 08 20.4 | + 15 53 | 11.3 | 15 15.9 | - 12 08 | 10.7 | 21 27.4 | - 18 12 | 12.2 | 19 43.4 | - 10 32 | 12.4 | 06 43.8 | + 27 24 | 11.3 |
| Apr 5 | 08 22.4 | + 16 10 | 11.4 | 15 13.2 | - 11 50 | 10.5 | 21 41.1 | - 17 01 | 12.2 | 19 54.3 | - 09 30 | 12.4 | 06 51.4 | + 27 35 | 11.4 |
| 12 | 08 25.4 | + 16 23 | 11.5 | 15 09.0 | - 11 28 | 10.3 | 21 54.3 | - 15 48 | 12.1 | 20 04.7 | - 08 25 | 12.3 | 06 59.8 | + 27 42 | 11.5 |
| 19 | 08 29.4 | + 16 31 | 11.6 | 15 03.5 | - 11 04 | 10.1 | 22 06.9 | - 14 35 | 12.1 | 20 14.5 | - 07 17 | 12.2 | 07 08.9 | + 27 44 | 11.6 |
| 26 | 08 34.2 | + 16 33 | 11.7 | 14 57.1 | - 10 39 | 9.9 | 22 19.1 | - 13 21 | 12.1 | 20 23.6 | - 06 07 | 12.1 | 07 18.6 | + 27 43 | 11.6 |
| May 3 | 08 39.7 | + 16 31 | 11.8 | 14 50.1 | - 10 13 | 9.8 | 22 30.8 | - 12 07 | 12.1 | 20 32.1 | - 04 55 | 12.0 | 07 28.8 | + 27 38 | 11.7 |
| 10 | 08 46.0 | + 16 25 | 11.9 | 14 42.9 | - 09 50 | 9.9 | 22 42.0 | - 10 55 | 12.0 | 20 39.8 | - 03 43 | 11.9 | 07 39.4 | + 27 28 | 11.7 |
| 17 | 08 52.8 | + 16 14 | 11.9 | 14 36.0 | - 09 32 | 10.0 | 22 52.5 | - 09 43 | 12.0 | 20 46.6 | - 02 31 | 11.8 | 07 50.3 | + 27 15 | 11.8 |
| 24 | 09 00.2 | + 15 59 | 12.0 | 14 29.9 | - 09 19 | 10.2 | 23 02.4 | - 08 34 | 11.9 | 20 52.4 | - 01 20 | 11.7 | 08 01.6 | + 26 57 | 11.8 |
| 31 | 09 07.9 | + 15 40 | 12.0 | 14 24.8 | - 09 12 | 10.4 | 23 11.7 | - 07 27 | 11.9 | 20 57.2 | - 00 12 | 11.5 | 08 13.0 | + 26 36 | 11.9 |
| Jun 7 | 09 16.1 | + 15 18 | 12.1 | 14 20.9 | - 09 13 | 10.5 | 23 20.2 | - 06 23 | 11.8 | 21 00.9 | + 00 53 | 11.4 | 08 24.6 | + 26 11 | 11.9 |
| 14 | 09 24.6 | + 14 51 | 12.1 | 14 18.5 | - 09 22 | 10.7 | 23 27.9 | - 05 22 | 11.7 | 21 03.3 | + 01 53 | 11.3 | 08 36.4 | + 25 42 | 11.9 |
| 21 | 09 33.3 | + 14 22 | 12.1 | 14 17.5 | - 09 38 | 10.9 | 23 34.8 | - 04 26 | 11.6 | 21 04.5 | + 02 46 | 11.1 | 08 48.2 | + 25 10 | 11.9 |
| 28 | 09 42.3 | + 13 49 | 12.1 | 14 18.0 | - 10 01 | 11.0 | 23 40.7 | - 03 35 | 11.5 | 21 04.3 | + 03 30 | 11.0 | 09 00.0 | + 24 35 | 11.9 |
| Jul 5 | 09 51.5 | + 13 14 | 12.1 | 14 19.8 | - 10 30 | 11.1 | 23 45.5 | - 02 49 | 11.4 | 21 02.8 | + 04 03 | 10.8 | 09 11.9 | + 23 57 | 11.9 |
| 12 | 10 00.8 | + 12 36 | 12.1 | 14 22.9 | - 11 05 | 11.2 | 23 49.1 | - 02 09 | 11.3 | 21 00.1 | + 04 23 | 10.6 | 09 23.8 | + 23 16 | 11.9 |
| 19 | 10 10.2 | + 11 55 | 12.1 | 14 27.2 | - 11 44 | 11.4 | 23 51.5 | - 01 36 | 11.2 | 20 56.3 | + 04 29 | 10.5 | 09 35.6 | + 22 32 | 11.9 |
| 26 | 10 19.8 | + 11 12 | 12.1 | 14 32.6 | - 12 27 | 11.5 | 23 52.5 | - 01 11 | 11.1 | 20 51.7 | + 04 20 | 10.4 | 09 47.4 | + 21 46 | 11.9 |
| Aug 2 | 10 29.4 | + 10 27 | 12.1 | 14 39.1 | - 13 13 | 11.5 | 23 52.0 | - 00 53 | 10.9 | 20 46.5 | + 03 56 | 10.3 | 09 59.2 | + 20 58 | 11.8 |
| 9 | 10 39.1 | + 09 40 | 12.0 | 14 46.4 | - 14 01 | 11.6 | 23 50.0 | - 00 43 | 10.8 | 20 41.3 | + 03 17 | 10.2 | 10 10.8 | + 20 09 | 11.8 |
| 16 | 10 48.9 | + 08 52 | 12.0 | 14 54.5 | - 14 51 | 11.7 | 23 46.5 | - 00 41 | 10.7 | 20 36.4 | + 02 26 | 10.3 | 10 22.4 | + 19 18 | 11.8 |
| 23 | 10 58.6 | + 08 02 | 11.9 | 15 03.4 | - 15 41 | 11.8 | 23 41.8 | - 00 48 | 10.5 | 20 32.3 | + 01 26 | 10.4 | 10 33.8 | + 18 26 | 11.8 |
| 30 | 11 08.4 | + 07 12 | 11.9 | 15 13.1 | - 16 32 | 11.8 | 23 35.9 | - 01 00 | 10.4 | 20 29.2 | + 00 20 | 10.5 | 10 45.2 | + 17 33 | 11.8 |
| Sep 6 | 11 18.2 | + 06 20 | 11.8 | 15 23.4 | - 17 22 | 11.9 | 23 29.2 | - 01 19 | 10.2 | 20 27.5 | - 00 49 | 10.6 | 10 56.4 | + 16 40 | 11.8 |
| 13 | 11 28.0 | + 05 28 | 11.7 | 15 34.3 | - 18 12 | 11.9 | 23 22.2 | - 01 40 | 10.0 | 20 27.2 | - 01 57 | 10.8 | 11 07.5 | + 15 47 | 11.9 |
| 20 | 11 37.8 | + 04 36 | 11.8 | 15 45.7 | - 18 59 | 11.9 | 23 15.4 | - 02 02 | 10.2 | 20 28.5 | - 03 02 | 10.9 | 11 18.5 | + 14 54 | 11.9 |
| 27 | 11 47.6 | + 03 43 | 11.9 | 15 57.7 | - 19 45 | 12.0 | 23 09.0 | - 02 23 | 10.4 | 20 31.2 | - 04 01 | 11.1 | 11 29.3 | + 14 02 | 12.0 |
| Oct 4 | 11 57.3 | + 02 51 | 11.9 | 16 10.2 | - 20 28 | 12.0 | 23 03.6 | - 02 41 | 10.6 | 20 35.4 | - 04 54 | 11.2 | 11 40.0 | + 13 11 | 12.0 |
| 11 | 12 06.9 | + 02 00 | 12.0 | 16 23.2 | - 21 09 | 12.0 | 22 59.5 | - 02 54 | 10.8 | 20 40.9 | - 05 38 | 11.4 | 11 50.5 | + 12 21 | 12.1 |
| 18 | 12 16.5 | + 01 09 | 12.0 | 16 36.6 | - 21 45 | 12.0 | 22 56.7 | - 03 01 | 11.0 | 20 47.7 | - 06 14 | 11.5 | 12 00.9 | + 11 33 | 12.1 |
| 25 | 12 26.0 | + 00 20 | 12.1 | 16 50.4 | - 22 18 | 12.0 | 22 55.3 | - 03 01 | 11.2 | 20 55.4 | - 06 41 | 11.6 | 12 11.0 | + 10 47 | 12.1 |
| Nov 1 | 12 35.5 | - 00 28 | 12.1 | 17 04.5 | - 22 46 | 12.0 | 22 55.4 | - 02 55 | 11.4 | 21 04.1 | - 06 59 | 11.7 | 12 21.0 | + 10 04 | 12.2 |
| 8 | 12 44.7 | - 01 14 | 12.1 | 17 19.0 | - 23 10 | 12.0 | 22 56.8 | - 02 41 | 11.5 | 21 13.7 | - 07 08 | 11.9 | 12 30.7 | + 09 23 | 12.2 |
| 15 | 12 53.9 | - 01 58 | 12.1 | 17 33.7 | - 23 28 | 12.0 | 22 59.6 | - 02 21 | 11.7 | 21 23.9 | - 07 09 | 12.0 | 12 40.2 | + 08 46 | 12.2 |
| 22 | 13 02.9 | - 02 39 | 12.2 | 17 48.7 | - 23 41 | 11.9 | 23 03.5 | - 01 54 | 11.8 | 21 34.7 | - 07 02 | 12.0 | 12 49.4 | + 08 13 | 12.2 |
| 29 | 13 11.6 | - 03 18 | 12.1 | 18 03.9 | - 23 49 | 11.9 | 23 08.4 | - 01 22 | 11.9 | 21 46.0 | - 06 47 | 12.1 | 12 58.2 | + 07 43 | 12.2 |
| Dec 6 | 13 20.1 | - 03 53 | 12.1 | 18 19.3 | - 23 51 | 11.8 | 23 14.2 | - 00 44 | 12.1 | 21 57.7 | - 06 25 | 12.2 | 13 06.7 | + 07 19 | 12.2 |
| 13 | 13 28.4 | - 04 25 | 12.1 | 18 34.8 | - 23 47 | 11.8 | 23 20.9 | - 00 02 | 12.2 | 22 09.8 | - 05 57 | 12.3 | 13 14.8 | + 06 59 | 12.2 |
| 20 | 13 36.3 | - 04 53 | 12.1 | 18 50.4 | - 23 38 | 11.7 | 23 28.2 | + 00 45 | 12.3 | 22 22.1 | - 05 22 | 12.3 | 13 22.5 | + 06 45 | 12.1 |
| 27 | 13 43.8 | - 05 17 | 12.0 | 19 06.1 | - 23 22 | 11.7 | 23 36.1 | + 01 36 | 12.4 | 22 34.6 | - 04 42 | 12.4 | 13 29.6 | + 06 36 | 12.1 |

# COMETS FOR 2003

**WHAT IS A COMET?**

It is a member of the Solar System which is normally in a very eccentric orbit around the Sun. The orbits of periodic, or regularly reappearing comets are quite elongated or 'egg-shaped' compared to those of the planets. Comets also differ from the planets by being far less massive and mainly composed of water in the form of ice and dust. A common analogy is a 'dirty snowball' (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, Encke, takes just over 3 years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of a number of new comets that have not been recorded before. The majority of these have either open-ended orbits (they are believed to be making their only visit to the Solar System and are not expected to return) or have extremely long orbital periods measured in thousands of years.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a 'coma' around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionized particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of heavier particles that trail behind the comet along the direction of its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails. In fact some may only show the coma.

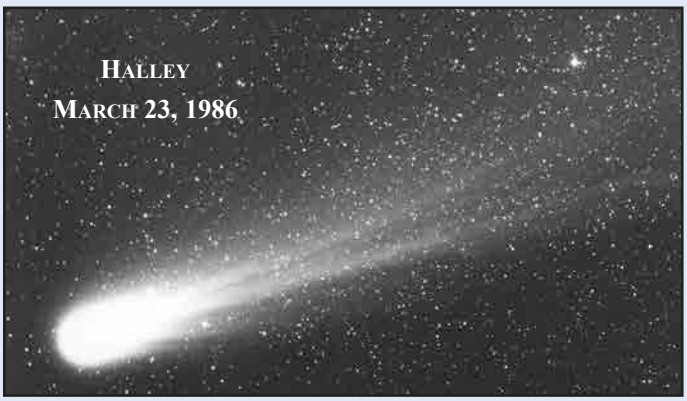
Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' refers to the fact the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 6P/d'Arrest indicates d'Arrest was the 6th comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. Interestingly, Halley's Comet's prefix is 1P/ because it was the first comet shown to be periodic. In fact Halley did not find the comet. It was named after him after he successfully predicted its return. You will also see references to another naming system. It is best to explain this with an example. You will notice one of the Comet LINEARs is referred to as 'C/2002 J5'. 2002 refers to the year, J refers to the 9th half month period ('I' is not used) during the year and 5 shows it was the fifth discovery in this half of the month. Therefore LINEAR was the fifth comet discovered in the first half of May 2002.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbits, the overall brightness, the size of the coma and the tail can vary dramatically from comet to comet and from even return to return. To watch one brighten, develop a tail and then fade away over a period of a few weeks, can be a fascinating experience.

This section is devoted to the comets that are expected to be observable during 2003. The table (p. 123) lists these objects as well as their orbital elements. This is the data required to calculate their locations in the sky. It lists all the known comets expected to be visible that reach perihelion (closest approach to the Sun) during 2003. There are also a few included that are bright during 2003 but have a perihelion date in 2002 or 2004. The elements are followed by 'ephemerides' (a list of expected positions in the sky and magnitude estimates for different dates) for some of the brighter comets. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could have it too close to the Sun or on the opposite side of the Sun from Earth. This would likely be considered unfavourable.

Many of the comets expected in 2003 are extremely faint and would require professional size telescopes or long exposure astrophotographs to detect them. But who knows what new discoveries lie in the future! Comet C/2002 O7 (LINEAR) shows promise for the later half of 2003.




## NOTES ON SELECTED COMETS FOR 2003 – *by Greg Bryant*

**Comet 2P/Encke**: After Halley, Hale-Bopp, and Hyakutake, one of the most well known comets is Encke. This visitor enters our neighbourhood every 3.3 years, making it the shortest period of any known comet.

In January 1786, the comet was first sighted by the famous French comet hunter Pierre Mechain. He notified fellow comet hunter Charles Messier of his discovery and both astronomers observed the comet two nights later. However, the comet was not sighted again during that apparition.

Nearly ten years were to pass before the comet was seen again. English astronomer Caroline Herschel came across it in November 1795. Her brother, William Herschel, noted that it was visible to the naked-eye, whilst Alexis Bouvard compared its brightness to M31, the Andromeda Galaxy. During this apparition, the comet was observed for three weeks and an orbit calculation was attempted. The only conclusion reached was that the orbit was not parabolic.

Yet another ten years were to pass before the comet was 'discovered' again. This time, the comet was seen in October 1805 by European astronomers Jeans Pons, Johann Huth, and Bouvard. Huth estimated it to be 5th magnitude with a tail three degrees in length.

At this time German astronomer, Johann Encke, entered the picture. Encke studied the positions that had been reported, and suggested that they fitted an elliptical orbit with a period of 12.1 years. This was incorrect, but much closer than other astronomers, who were still trying to derive parabolic orbits.

It wasn't until 1818 that the comet was sighted again. Pons found the comet in November, and it brightened to display a similar appearance to its 1786 apparition. The comet remained observable for nearly seven weeks, enabling a good set of positions to be determined. Olbers was the first to suggest that this comet was the same as those observed in 1786, 1795, and 1805. However, it was Encke who proved mathematically that it was the same comet returning, with a period of 3.3 years. Encke then proceeded to predict the next return of the comet, with a perihelion date of 24th May 1822. On 2nd June 1822, Carl Rumker recovered the comet whilst observing at the observatory of Sir Thomas Brisbane in Parramatta, New South Wales. This was only the second comet whose return had been successfully predicted, the first being Halley. In a similar fashion to Halley, the comet was named after Encke (i.e., not the discoverer).

In 2003, Encke is making its 59th observed return. It was a target of the CONTOUR spacecraft, but contact was lost with the probe in August 2002.

Since Encke's discovery and recognition as a periodic comet, it has only been missed once (in 1944 due to unfavourable observing conditions and World War II). Although Encke is no longer as bright as it was in the 19th Century (when it was seen naked-eye on several returns), it did reach magnitude 5.8 in 1997 after perihelion, which supports recent studies that the comet's post-perihelion appearance may be brightening, whilst its pre-perihelion appearance declines. Ongoing observations of the comet will be important to ascertain any changing intrinsic brightness behaviour – it is conceivable that Encke could become a regular post-perihelion naked-eye comet in the 21st Century.

**Comet 65P/Gunn**: Whilst examining a Palomar Schmidt photographic plate taken on 27th October 1970 of the galaxy cluster Abell 194 in Cetus, astronomer James Gunn discovered a 16th magnitude comet. Confirmation

came the following month from additional photographs, though it wasn't until December that the comet discovery was announced.

With positions already spanning a month, Brian Marsden was able to immediately determine that the comet was short-period in nature, orbiting the Sun in just under seven years.

**Comet 116P/Wild 4**: This comet was discovered by Paul Wild on 21st January 1990. The 14th magnitude object was found on a photographic plate and it was soon revealed that the comet was periodic in nature. Calculations in early February of that year revealed that the comet had previously been in a low-eccentricity orbit, with a perihelion distance of 3.8 AU, before a close approach to Jupiter in July 1987 moved the comet much closer to the Sun.

At both its discovery apparition and its subsequent return in 1996, observers have seen the comet peak in brightness at 12th magnitude. A similar performance is expected for this return during which it should be visible through large amateur telescopes for the first half of the year.

**Comet 154P/Brewington**: On 28th August 1992, American amateur Howard Brewington discovered his fourth comet in the space of less than three years. Located in the constellation of Auriga at the time, observers estimated the new comet to be 11th magnitude in brightness. By the end of September, it became apparent that it was a new periodic comet. Whilst the comet does cross the orbit of Jupiter, there have been no close approaches in recent revolutions.

This is the first return of comet Brewington since its discovery, so there is an element of uncertainty in its predicted brightness.

**Comet C/2001 HT50 (LINEAR-NEAT)**: The NEAT asteroid survey program reported their discovery of an 18th magnitude comet on 14th May 2001. The comet was immediately identified as being identical to an apparent asteroid discovered by LINEAR several weeks earlier. Whereas an orbit was calculated quite quickly for this new comet, it took more than two months for the IAU Committee on Small Bodies Nomenclature to agree on assigning the name LINEAR-NEAT.

**Comet C/2001 Q4 (NEAT)**: Little more than three months after their above co-discovery, the NEAT program reported another comet discovery (it's worth noting that NEAT discovered an additional five comets in this time period!). A somewhat uncertain orbit announced several days after the 24th August 2001 discovery, suggested that the comet would reach perihelion in 2005.

In early September, word began to circulate that revised calculations indicated a much more promising set of orbital circumstances. On 10th September, it was officially announced that the comet would reach perihelion in May 2004 (still with an uncertainty of a few weeks) and much closer to both the Sun and Earth. Within a week, additional measurements of the comet's movement had narrowed down the uncertainty in our favour.

Whilst it is still more than a year before the comet reaches perihelion and maximum brightness, prospects look good for the comet to be visible to the naked-eye in Autumn of 2004, well placed in the southern sky. Astronomers will be watching the comet's slow climb in brightness over the next year. A better guide to Comet NEAT's 2004 prospects will be in next year's book.

**Comet C/2002 O7 (LINEAR)**: Discovered by the LINEAR program as an apparent asteroid on 29th July 2002, its true nature as a comet was revealed three days later on images taken with other telescopes in response to initial calculations that suggested a cometary orbit. The comet, LINEAR's 89th such discovery, could reach 7th magnitude or better in Spring 2003, when it will be circumpolar for some time.

*BIOGRAPHICAL NOTE – Greg Bryant has been an active member of the Australian amateur community since the 1980s and is a Contributing Editor for Sky & Telescope magazine.*

## COMETS FOR 2003 – ORBITAL ELEMENTS (EQUINOX 2000.0)

| Comet Name | Perihelion Date | q | e | Period | ω | Ω | i | H1 | K1 |
|---|---|---|---|---|---|---|---|---|---|
| | yy mm d.dd | A.U. | | years | deg | deg | deg | | |
| 67P/Churyumov-Gerasimenko | 2002 08 18.3101 | 1.292339 | 0.631528 | 6.6 | 011.4520 | 050.9685 | 007.1204 | 9.5 | 10.0 |
| 22P/Kopff | 2002 12 12.0763 | 1.583608 | 0.543307 | 6.5 | 162.7536 | 120.9290 | 004.7185 | 3.0 | 26.0 |
| 155P/Shoemaker 3 | 2002 12 15.0206 | 1.813723 | 0.726794 | 17.1 | 014.9411 | 097.2704 | 006.3862 | 10.5 | 10.0 |
| C/2001 RX14 (LINEAR) | 2003 01 18.7245 | 2.057576 | 1.001628 | | 121.4845 | 014.1723 | 030.5780 | 6.5 | 10.0 |
| 116P/Wild 4 | 2003 01 21.7803 | 2.169793 | 0.375570 | 6.5 | 173.4160 | 021.0752 | 003.6160 | 2.5 | 25.0 |
| 79P/du Toit-Hartley | 2003 02 15.3161 | 1.229971 | 0.594100 | 5.3 | 253.0673 | 307.9713 | 002.8945 | 16.0 | 10.0 |
| 154P/Brewington | 2003 02 18.8430 | 1.590355 | 0.671624 | 10.7 | 048.0058 | 343.6435 | 018.0596 | 2.5 | 30.0 |
| P/2001 YX127 (LINEAR) | 2003 03 11.8981 | 3.420300 | 0.180900 | 8.5 | 116.4486 | 031.4645 | 007.9075 | | |
| 65P/Gunn | 2003 05 11.9079 | 2.446265 | 0.318341 | 6.8 | 196.3748 | 068.4160 | 010.3847 | 5.0 | 15.0 |
| 127P/Holt-Olmstead | 2003 06 12.4654 | 2.159093 | 0.369592 | 6.3 | 006.4976 | 014.0080 | 014.3961 | 11.0 | 15.0 |
| 36P/Whipple | 2003 07 06.6516 | 3.088262 | 0.259041 | 8.5 | 202.2129 | 182.3993 | 009.9329 | 8.5 | 15.0 |
| C/2001 HT50 (LINEAR-NEAT) | 2003 07 09.0541 | 2.792217 | 0.997540 | | 324.0706 | 042.9154 | 163.2125 | 4.5 | 10.0 |
| 118P/Shoemaker-Levy 4 | 2003 07 16.8268 | 2.011056 | 0.422220 | 6.5 | 302.0912 | 152.0393 | 008.4822 | 10.0 | 12.0 |
| 100P/Hartley 1 | 2003 08 18.0346 | 1.979739 | 0.419139 | 6.3 | 181.5340 | 037.8919 | 025.6637 | 9.0 | 20.0 |
| 66P/du Toit | 2003 08 28.2336 | 1.274280 | 0.787683 | 14.7 | 257.2521 | 022.2142 | 018.7009 | 12.0 | 9.0 |
| 94P/Russell 4 | 2003 08 29.2329 | 2.231147 | 0.364843 | 6.6 | 092.9411 | 070.9380 | 006.1848 | 11.5 | 10.0 |
| C/2002 J5 (LINEAR) | 2003 09 19.2623 | 5.727863 | 1.001041 | | 074.8180 | 314.1097 | 117.2266 | | |
| C/2002 O7 (LINEAR) | 2003 09 20.3220 | 0.885212 | 1.0 | | 252.5301 | 012.7147 | 098.8174 | 6.5 | 10.0 |
| 81P/Wild 2 | 2003 09 25.9333 | 1.590363 | 0.538789 | 6.4 | 041.7516 | 136.1412 | 003.2403 | 7.0 | 15.0 |
| C/2002 J4 (NEAT) | 2003 09 30.8458 | 3.625572 | 1.0 | | 230.5755 | 071.0164 | 046.2871 | 5.5 | 10.0 |
| 53P/Van Biesbroeck | 2003 10 09.5579 | 2.415625 | 0.551513 | 12.5 | 134.1082 | 149.0062 | 006.6103 | 7.7 | 12.0 |
| 123P/West-Hartley | 2003 12 09.1217 | 2.128695 | 0.448505 | 7.6 | 102.9160 | 046.6200 | 015.3467 | 4.0 | 25.0 |
| 2P/Encke | 2003 12 29.8763 | 0.338461 | 0.847339 | 3.3 | 186.4987 | 334.5875 | 011.7696 | 9.8 | * |
| 43P/Wolf-Harrington | 2004 03 17.8640 | 1.578638 | 0.544597 | 6.5 | 187.2771 | 254.6943 | 018.5204 | 6.5 | 21.0 |
| C/2001 Q4 (NEAT) | 2004 05 16.0028 | 0.961930 | 1.000738 | | 001.2087 | 210.2819 | 099.6471 | 5.0 | 8.0 |

**Perihelion Date** Date of closest approach to the Sun.

**q** The perihelion distance, in AU (Astronomical Units)

**e** The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to one would indicate an open orbit which means it is a once only visitor to the Solar System, or it has a very long period (thousands of years) or the comet is newly discovered and astronomers have not clearly defined its orbit.

**Period** The comet's period in years. The time it takes to complete one orbit of the Sun.

ω Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).

Ω Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (Ecliptic) as the comet moves north.

**i** Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. If the value is greater than 90°, the comets direction of orbit is retrograde i.e., moving in the opposite direction to the planets.

**H1** The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it was one AU from the Sun and the Earth.

**K1** A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' for further details)

The maths used to calculate ephemerides from these elements is complex (but not difficult, with the power of home computers) but is beyond the scope of this publication.

## Comet 154P/Brewington

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Nov 2 | 20 24.7 | -23 10 | 1.827 | 1.980 | 84 | 12.7 |
| 2002 Nov 9 | 20 34.3 | -21 30 | 1.862 | 1.938 | 79 | 12.5 |
| 2002 Nov 16 | 20 44.9 | -19 46 | 1.896 | 1.897 | 75 | 12.2 |
| 2002 Nov 23 | 20 56.4 | -17 57 | 1.928 | 1.858 | 71 | 12.0 |
| 2002 Nov 30 | 21 08.7 | -16 03 | 1.959 | 1.821 | 67 | 11.8 |
| 2002 Dec 7 | 21 21.8 | -14 04 | 1.988 | 1.786 | 64 | 11.5 |
| 2002 Dec 14 | 21 35.4 | -12 00 | 2.015 | 1.753 | 61 | 11.3 |
| 2002 Dec 21 | 21 49.7 | -09 50 | 2.040 | 1.723 | 57 | 11.1 |
| 2002 Dec 28 | 22 04.5 | -07 35 | 2.064 | 1.695 | 55 | 10.9 |
| 2003 Jan 4 | 22 19.8 | -05 14 | 2.087 | 1.670 | 52 | 10.8 |
| 2003 Jan 11 | 22 35.6 | -02 49 | 2.110 | 1.648 | 49 | 10.6 |
| 2003 Jan 18 | 22 51.8 | -00 19 | 2.132 | 1.629 | 47 | 10.5 |
| 2003 Jan 25 | 23 08.5 | +02 15 | 2.154 | 1.614 | 45 | 10.4 |
| 2003 Feb 1 | 23 25.7 | +04 50 | 2.176 | 1.603 | 43 | 10.3 |
| 2003 Feb 8 | 23 43.4 | +07 28 | 2.200 | 1.595 | 41 | 10.3 |
| 2003 Feb 15 | 00 01.5 | +10 06 | 2.225 | 1.591 | 39 | 10.3 |
| 2003 Feb 22 | 00 20.1 | +12 42 | 2.251 | 1.591 | 38 | 10.3 |
| 2003 Mar 1 | 00 39.2 | +15 16 | 2.280 | 1.594 | 36 | 10.4 |
| 2003 Mar 8 | 00 58.8 | +17 46 | 2.311 | 1.602 | 35 | 10.5 |
| 2003 Mar 15 | 01 19.0 | +20 11 | 2.345 | 1.613 | 34 | 10.6 |
| 2003 Mar 22 | 01 39.6 | +22 27 | 2.382 | 1.628 | 32 | 10.7 |
| 2003 Mar 29 | 02 00.7 | +24 36 | 2.422 | 1.646 | 31 | 10.9 |
| 2003 Apr 5 | 02 22.2 | +26 34 | 2.464 | 1.668 | 30 | 11.1 |
| 2003 Apr 12 | 02 44.2 | +28 21 | 2.509 | 1.692 | 28 | 11.4 |
| 2003 Apr 19 | 03 06.4 | +29 55 | 2.557 | 1.720 | 27 | 11.6 |
| 2003 Apr 26 | 03 28.8 | +31 17 | 2.607 | 1.750 | 25 | 11.9 |
| 2003 May 3 | 03 51.3 | +32 26 | 2.660 | 1.783 | 24 | 12.2 |
| 2003 May 10 | 04 13.8 | +33 21 | 2.713 | 1.817 | 22 | 12.5 |
| 2003 May 17 | 04 36.1 | +34 02 | 2.768 | 1.854 | 20 | 12.8 |

## Comet C/2001 Q4 (NEAT)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2003 Jul 5 | 03 37.4 | -36 15 | 4.494 | 4.348 | 75 | 13.4 |
| 2003 Jul 12 | 03 44.1 | -37 23 | 4.357 | 4.275 | 79 | 13.2 |
| 2003 Jul 19 | 03 50.9 | -38 42 | 4.221 | 4.203 | 82 | 13.1 |
| 2003 Jul 26 | 03 57.6 | -40 10 | 4.087 | 4.129 | 85 | 13.0 |
| 2003 Aug 2 | 04 04.1 | -41 50 | 3.956 | 4.056 | 88 | 12.9 |
| 2003 Aug 9 | 04 10.4 | -43 40 | 3.829 | 3.981 | 91 | 12.7 |
| 2003 Aug 16 | 04 16.4 | -45 40 | 3.707 | 3.907 | 94 | 12.6 |
| 2003 Aug 23 | 04 22.1 | -47 52 | 3.592 | 3.832 | 96 | 12.4 |
| 2003 Aug 30 | 04 27.3 | -50 13 | 3.483 | 3.756 | 98 | 12.3 |
| 2003 Sep 6 | 04 31.9 | -52 44 | 3.383 | 3.680 | 99 | 12.2 |
| 2003 Sep 13 | 04 35.7 | -55 22 | 3.290 | 3.603 | 100 | 12.0 |
| 2003 Sep 20 | 04 38.5 | -58 07 | 3.207 | 3.526 | 100 | 11.9 |
| 2003 Sep 27 | 04 39.8 | -60 56 | 3.133 | 3.449 | 100 | 11.8 |
| 2003 Oct 4 | 04 39.3 | -63 48 | 3.068 | 3.370 | 99 | 11.7 |
| 2003 Oct 11 | 04 36.3 | -66 38 | 3.011 | 3.292 | 97 | 11.5 |
| 2003 Oct 18 | 04 30.0 | -69 25 | 2.963 | 3.212 | 95 | 11.4 |
| 2003 Oct 25 | 04 19.0 | -72 03 | 2.922 | 3.132 | 93 | 11.3 |
| 2003 Nov 1 | 04 01.9 | -74 27 | 2.886 | 3.052 | 90 | 11.2 |
| 2003 Nov 8 | 03 36.6 | -76 32 | 2.856 | 2.971 | 87 | 11.1 |
| 2003 Nov 15 | 03 01.9 | -78 09 | 2.829 | 2.889 | 84 | 10.9 |
| 2003 Nov 22 | 02 18.4 | -79 10 | 2.803 | 2.807 | 80 | 10.8 |
| 2003 Nov 29 | 01 30.7 | -79 30 | 2.778 | 2.724 | 77 | 10.7 |
| 2003 Dec 6 | 00 46.1 | -79 11 | 2.751 | 2.641 | 73 | 10.6 |
| 2003 Dec 13 | 00 09.8 | -78 22 | 2.722 | 2.557 | 70 | 10.4 |
| 2003 Dec 20 | 23 43.1 | -77 14 | 2.688 | 2.473 | 67 | 10.3 |
| 2003 Dec 27 | 23 25.0 | -75 55 | 2.649 | 2.388 | 64 | 10.1 |

## Comet C/2001 HT50 (LINEAR-NEAT)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Nov 2 | 10 02.0 | -04 26 | 4.030 | 3.740 | 66 | 13.3 |
| 2002 Nov 9 | 10 00.1 | -04 50 | 3.858 | 3.696 | 73 | 13.1 |
| 2002 Nov 16 | 09 57.1 | -05 13 | 3.682 | 3.652 | 81 | 13.0 |
| 2002 Nov 23 | 09 53.0 | -05 34 | 3.504 | 3.610 | 88 | 12.8 |
| 2002 Nov 30 | 09 47.5 | -05 51 | 3.326 | 3.567 | 96 | 12.6 |
| 2002 Dec 7 | 09 40.4 | -06 04 | 3.150 | 3.526 | 104 | 12.5 |
| 2002 Dec 14 | 09 31.5 | -06 11 | 2.982 | 3.485 | 113 | 12.3 |
| 2002 Dec 21 | 09 20.6 | -06 10 | 2.823 | 3.444 | 122 | 12.1 |
| 2002 Dec 28 | 09 07.5 | -06 00 | 2.679 | 3.405 | 131 | 12.0 |
| 2003 Jan 4 | 08 52.3 | -05 38 | 2.553 | 3.366 | 140 | 11.8 |
| 2003 Jan 11 | 08 35.1 | -05 03 | 2.451 | 3.328 | 148 | 11.7 |
| 2003 Jan 18 | 08 16.3 | -04 13 | 2.375 | 3.291 | 155 | 11.6 |
| 2003 Jan 25 | 07 56.4 | -03 11 | 2.329 | 3.255 | 156 | 11.5 |
| 2003 Feb 1 | 07 36.2 | -01 56 | 2.315 | 3.220 | 152 | 11.4 |
| 2003 Feb 8 | 07 16.5 | -00 34 | 2.331 | 3.186 | 145 | 11.4 |
| 2003 Feb 15 | 06 58.1 | +00 52 | 2.375 | 3.153 | 135 | 11.4 |
| 2003 Feb 22 | 06 41.4 | +02 17 | 2.444 | 3.121 | 125 | 11.4 |
| 2003 Mar 1 | 06 26.8 | +03 40 | 2.533 | 3.091 | 116 | 11.4 |
| 2003 Mar 8 | 06 14.3 | +04 58 | 2.637 | 3.061 | 106 | 11.5 |
| 2003 Mar 15 | 06 03.9 | +06 11 | 2.751 | 3.033 | 97 | 11.5 |
| 2003 Mar 22 | 05 55.4 | +07 17 | 2.872 | 3.006 | 88 | 11.6 |
| 2003 Mar 29 | 05 48.7 | +08 18 | 2.994 | 2.981 | 80 | 11.6 |
| 2003 Apr 5 | 05 43.5 | +09 13 | 3.115 | 2.957 | 72 | 11.7 |
| 2003 Apr 12 | 05 39.6 | +10 03 | 3.232 | 2.934 | 64 | 11.7 |
| 2003 Apr 19 | 05 36.8 | +10 48 | 3.343 | 2.913 | 57 | 11.8 |
| 2003 Apr 26 | 05 35.0 | +11 30 | 3.444 | 2.894 | 50 | 11.8 |
| 2003 May 3 | 05 33.9 | +12 07 | 3.536 | 2.876 | 43 | 11.8 |
| 2003 May 10 | 05 33.5 | +12 42 | 3.615 | 2.859 | 36 | 11.9 |
| 2003 May 17 | 05 33.6 | +13 13 | 3.682 | 2.845 | 29 | 11.9 |
| 2003 May 24 | 05 34.1 | +13 42 | 3.735 | 2.832 | 23 | 11.9 |
| 2003 May 31 | 05 34.9 | +14 09 | 3.773 | 2.821 | 17 | 11.9 |
| 2003 Jun 7 | 05 35.9 | +14 33 | 3.796 | 2.812 | 12 | 11.9 |
| 2003 Jun 14 | 05 37.0 | +14 55 | 3.804 | 2.804 | 9 | 11.9 |
| 2003 Jun 21 | 05 38.1 | +15 16 | 3.797 | 2.798 | 9 | 11.9 |
| 2003 Jun 28 | 05 39.2 | +15 34 | 3.774 | 2.795 | 13 | 11.8 |
| 2003 Jul 5 | 05 40.2 | +15 52 | 3.735 | 2.793 | 19 | 11.8 |
| 2003 Jul 12 | 05 41.0 | +16 08 | 3.682 | 2.792 | 25 | 11.8 |
| 2003 Jul 19 | 05 41.4 | +16 23 | 3.614 | 2.794 | 31 | 11.8 |
| 2003 Jul 26 | 05 41.3 | +16 38 | 3.533 | 2.798 | 38 | 11.7 |
| 2003 Aug 2 | 05 40.8 | +16 51 | 3.438 | 2.803 | 44 | 11.7 |
| 2003 Aug 9 | 05 39.5 | +17 04 | 3.332 | 2.810 | 51 | 11.6 |
| 2003 Aug 16 | 05 37.3 | +17 16 | 3.216 | 2.819 | 58 | 11.5 |
| 2003 Aug 23 | 05 34.1 | +17 28 | 3.091 | 2.830 | 66 | 11.5 |
| 2003 Aug 30 | 05 29.6 | +17 39 | 2.959 | 2.843 | 74 | 11.4 |
| 2003 Sep 6 | 05 23.6 | +17 49 | 2.823 | 2.857 | 82 | 11.3 |
| 2003 Sep 13 | 05 15.7 | +17 58 | 2.685 | 2.873 | 90 | 11.2 |
| 2003 Sep 20 | 05 05.7 | +18 05 | 2.550 | 2.891 | 100 | 11.1 |
| 2003 Sep 27 | 04 53.3 | +18 09 | 2.421 | 2.910 | 109 | 11.1 |
| 2003 Oct 4 | 04 38.1 | +18 07 | 2.303 | 2.931 | 120 | 11.0 |
| 2003 Oct 11 | 04 20.1 | +17 58 | 2.202 | 2.953 | 131 | 10.9 |
| 2003 Oct 18 | 03 59.5 | +17 38 | 2.122 | 2.977 | 143 | 10.9 |
| 2003 Oct 25 | 03 36.6 | +17 06 | 2.071 | 3.002 | 155 | 10.9 |
| 2003 Nov 1 | 03 12.5 | +16 22 | 2.051 | 3.029 | 168 | 10.9 |
| 2003 Nov 8 | 02 48.1 | +15 26 | 2.066 | 3.057 | 179 | 10.9 |
| 2003 Nov 15 | 02 24.7 | +14 22 | 2.116 | 3.086 | 166 | 11.0 |
| 2003 Nov 22 | 02 03.3 | +13 17 | 2.198 | 3.116 | 154 | 11.1 |
| 2003 Nov 29 | 01 44.5 | +12 14 | 2.309 | 3.148 | 142 | 11.3 |
| 2003 Dec 6 | 01 28.5 | +11 18 | 2.444 | 3.181 | 131 | 11.5 |
| 2003 Dec 13 | 01 15.3 | +10 30 | 2.597 | 3.215 | 121 | 11.6 |
| 2003 Dec 20 | 01 04.6 | +09 52 | 2.764 | 3.250 | 111 | 11.8 |
| 2003 Dec 27 | 00 56.2 | +09 23 | 2.940 | 3.285 | 102 | 12.0 |

## Comet 2P/Encke

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2003 Oct 4 | 02 12.8 | +35 00 | 0.733 | 1.641 | 142 | 12.7 |
| 2003 Oct 11 | 01 57.3 | +37 27 | 0.616 | 1.551 | 147 | 11.8 |
| 2003 Oct 18 | 01 31.8 | +40 08 | 0.510 | 1.458 | 149 | 10.8 |
| 2003 Oct 25 | 00 51.0 | +42 41 | 0.417 | 1.361 | 146 | 9.8 |
| 2003 Nov 1 | 23 47.9 | +44 00 | 0.341 | 1.259 | 136 | 8.7 |
| 2003 Nov 8 | 22 21.8 | +41 44 | 0.287 | 1.153 | 118 | 7.8 |
| 2003 Nov 15 | 20 49.6 | +33 42 | 0.262 | 1.042 | 94 | 7.1 |
| 2003 Nov 22 | 19 32.8 | +21 28 | 0.268 | 0.925 | 69 | 6.6 |
| 2003 Nov 29 | 18 35.6 | +09 06 | 0.304 | 0.803 | 46 | 6.4 |
| 2003 Dec 6 | 17 52.5 | -01 18 | 0.366 | 0.677 | 26 | 6.4 |
| 2003 Dec 13 | 17 20.2 | -09 35 | 0.460 | 0.548 | 14 | 6.5 |
| 2003 Dec 20 | 17 00.2 | -16 13 | 0.597 | 0.428 | 14 | 6.7 |
| 2003 Dec 27 | 16 59.4 | -21 34 | 0.791 | 0.347 | 19 | 7.2 |

## EXPLANATION OF COMET EPHEMERIDES

**Date** is for 0 hr UT (10am EST, 9:30am CST and 8am WST ) of date.

**R.A., Dec** Right Ascension and Declination are for equinox 2000.0

**Δ (delta)** Geocentric distance (distance from the Earth) in AU.

**R** Heliocentric distance (distance from the Sun) in AU.

**Elg** Elongation; angular distance of the comet from the Sun.

**Mag** This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is invariably based on the behaviour of its brightness during previous return(s).

The estimate of total magnitude is normally calculated using the formula:
Mag. = H1 + 5 log (Δ) + K1 log R.

* The brightness of Comet Encke behaves a little differently from the standard formula. Its magnitude estimate has been calculated using the following:

$$\text{Mag.} = 9.8 + 5 \log (\Delta) + 2.5 (R^{1.8} - 1)$$

See the table of elements for the values of H1 and K1. For many comets the K1 value is equal to 10. For newly discovered comets the value of K1 is nearly always assumed to be equal to 10 until its light curve can be studied in detail. The brightness of a comet is often very uncertain, especially for those newly discovered. Comets have also been known to suddenly flare up or fade away and some have even shown a different behaviour in their light curve (changed values for H1 and K1) after perihelion compared to before. There are also constants of H2 and K2 used by astronomers which refer to the absolute magnitude and the K constant for the nucleus of the comet. These are not used in this publication.

## Comet C/2002 O7 (LINEAR)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2003 Mar 1 | 15 49.8 | +33 22 | 2.735 | 3.155 | 106 | 13.7 |
| 2003 Mar 8 | 15 45.7 | +34 49 | 2.580 | 3.073 | 111 | 13.4 |
| 2003 Mar 15 | 15 39.3 | +36 24 | 2.432 | 2.991 | 115 | 13.2 |
| 2003 Mar 22 | 15 30.3 | +38 03 | 2.292 | 2.908 | 119 | 12.9 |
| 2003 Mar 29 | 15 18.1 | +39 42 | 2.163 | 2.824 | 122 | 12.7 |
| 2003 Apr 5 | 15 02.4 | +41 14 | 2.046 | 2.740 | 125 | 12.4 |
| 2003 Apr 12 | 14 43.1 | +42 30 | 1.943 | 2.655 | 126 | 12.2 |
| 2003 Apr 19 | 14 20.2 | +43 21 | 1.856 | 2.569 | 125 | 11.9 |
| 2003 Apr 26 | 13 54.5 | +43 35 | 1.787 | 2.483 | 123 | 11.7 |
| 2003 May 3 | 13 27.3 | +43 04 | 1.737 | 2.396 | 119 | 11.5 |
| 2003 May 10 | 13 00.4 | +41 45 | 1.704 | 2.308 | 114 | 11.3 |
| 2003 May 17 | 12 35.2 | +39 41 | 1.689 | 2.220 | 108 | 11.1 |
| 2003 May 24 | 12 12.9 | +37 00 | 1.689 | 2.131 | 101 | 10.9 |
| 2003 May 31 | 11 54.1 | +33 52 | 1.702 | 2.042 | 94 | 10.8 |
| 2003 Jun 7 | 11 38.6 | +30 27 | 1.726 | 1.952 | 87 | 10.6 |
| 2003 Jun 14 | 11 26.3 | +26 53 | 1.756 | 1.861 | 80 | 10.4 |
| 2003 Jun 21 | 11 16.7 | +23 16 | 1.790 | 1.771 | 72 | 10.2 |
| 2003 Jun 28 | 11 09.3 | +19 39 | 1.826 | 1.680 | 65 | 10.1 |
| 2003 Jul 5 | 11 03.7 | +16 03 | 1.860 | 1.590 | 59 | 9.9 |
| 2003 Jul 12 | 10 59.5 | +12 30 | 1.890 | 1.501 | 52 | 9.6 |
| 2003 Jul 19 | 10 56.4 | +08 58 | 1.913 | 1.412 | 46 | 9.4 |
| 2003 Jul 26 | 10 54.2 | +05 27 | 1.928 | 1.326 | 40 | 9.2 |
| 2003 Aug 2 | 10 52.6 | +01 54 | 1.933 | 1.242 | 35 | 8.9 |
| 2003 Aug 9 | 10 51.3 | -01 43 | 1.925 | 1.163 | 30 | 8.6 |
| 2003 Aug 16 | 10 50.2 | -05 25 | 1.904 | 1.089 | 26 | 8.3 |
| 2003 Aug 23 | 10 49.2 | -09 16 | 1.867 | 1.022 | 24 | 8.0 |
| 2003 Aug 30 | 10 48.2 | -13 19 | 1.813 | 0.966 | 23 | 7.6 |
| 2003 Sep 6 | 10 47.0 | -17 38 | 1.741 | 0.923 | 25 | 7.4 |
| 2003 Sep 13 | 10 45.6 | -22 18 | 1.652 | 0.895 | 28 | 7.1 |
| 2003 Sep 20 | 10 44.2 | -27 28 | 1.547 | 0.885 | 33 | 6.9 |
| 2003 Sep 27 | 10 42.6 | -33 18 | 1.430 | 0.894 | 38 | 6.8 |
| 2003 Oct 4 | 10 41.1 | -40 06 | 1.305 | 0.920 | 45 | 6.7 |
| 2003 Oct 11 | 10 39.2 | -48 14 | 1.181 | 0.961 | 52 | 6.7 |
| 2003 Oct 18 | 10 36.3 | -58 09 | 1.069 | 1.016 | 59 | 6.7 |
| 2003 Oct 25 | 10 29.1 | -70 08 | 0.980 | 1.082 | 67 | 6.8 |
| 2003 Nov 1 | 09 41.5 | -83 55 | 0.929 | 1.155 | 74 | 7.0 |
| 2003 Nov 8 | 23 38.3 | -80 39 | 0.929 | 1.235 | 80 | 7.3 |
| 2003 Nov 15 | 23 13.2 | -66 23 | 0.982 | 1.318 | 84 | 7.7 |
| 2003 Nov 22 | 23 09.8 | -53 53 | 1.083 | 1.404 | 85 | 8.1 |
| 2003 Nov 29 | 23 10.5 | -43 38 | 1.220 | 1.492 | 84 | 8.7 |
| 2003 Dec 6 | 23 12.9 | -35 26 | 1.382 | 1.582 | 82 | 9.2 |
| 2003 Dec 13 | 23 16.2 | -28 53 | 1.560 | 1.672 | 79 | 9.7 |
| 2003 Dec 20 | 23 20.0 | -23 33 | 1.748 | 1.762 | 75 | 10.2 |
| 2003 Dec 27 | 23 24.3 | -19 10 | 1.942 | 1.853 | 70 | 10.6 |

## Comet 116P/Wild 4

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Nov 9 | 12 21.9 | -00 43 | 2.882 | 2.232 | 41 | 13.5 |
| 2002 Nov 16 | 12 35.1 | -02 13 | 2.816 | 2.221 | 45 | 13.4 |
| 2002 Nov 23 | 12 48.3 | -03 42 | 2.748 | 2.211 | 48 | 13.3 |
| 2002 Nov 30 | 13 01.4 | -05 10 | 2.678 | 2.202 | 51 | 13.2 |
| 2002 Dec 7 | 13 14.5 | -06 36 | 2.606 | 2.194 | 55 | 13.1 |
| 2002 Dec 14 | 13 27.4 | -07 59 | 2.532 | 2.187 | 59 | 13.0 |
| 2002 Dec 21 | 13 40.2 | -09 20 | 2.458 | 2.182 | 62 | 12.9 |
| 2002 Dec 28 | 13 52.8 | -10 38 | 2.382 | 2.177 | 66 | 12.8 |
| 2003 Jan 4 | 14 05.1 | -11 52 | 2.305 | 2.174 | 70 | 12.7 |
| 2003 Jan 11 | 14 17.2 | -13 03 | 2.228 | 2.171 | 74 | 12.7 |
| 2003 Jan 18 | 14 28.9 | -14 10 | 2.150 | 2.170 | 78 | 12.6 |
| 2003 Jan 25 | 14 40.2 | -15 13 | 2.072 | 2.170 | 82 | 12.5 |
| 2003 Feb 1 | 14 50.9 | -16 11 | 1.995 | 2.171 | 87 | 12.4 |
| 2003 Feb 8 | 15 01.0 | -17 05 | 1.918 | 2.173 | 91 | 12.3 |
| 2003 Feb 15 | 15 10.3 | -17 55 | 1.843 | 2.177 | 96 | 12.3 |
| 2003 Feb 22 | 15 18.7 | -18 40 | 1.769 | 2.181 | 101 | 12.2 |
| 2003 Mar 1 | 15 26.1 | -19 21 | 1.697 | 2.187 | 106 | 12.1 |
| 2003 Mar 8 | 15 32.4 | -19 58 | 1.628 | 2.194 | 111 | 12.1 |
| 2003 Mar 15 | 15 37.3 | -20 30 | 1.563 | 2.202 | 117 | 12.0 |
| 2003 Mar 22 | 15 40.8 | -20 58 | 1.503 | 2.210 | 123 | 12.0 |
| 2003 Mar 29 | 15 42.8 | -21 22 | 1.448 | 2.220 | 130 | 12.0 |
| 2003 Apr 5 | 15 43.2 | -21 42 | 1.399 | 2.231 | 136 | 11.9 |
| 2003 Apr 12 | 15 42.0 | -21 56 | 1.358 | 2.243 | 143 | 11.9 |
| 2003 Apr 19 | 15 39.4 | -22 06 | 1.326 | 2.256 | 151 | 11.9 |
| 2003 Apr 26 | 15 35.5 | -22 11 | 1.305 | 2.270 | 158 | 12.0 |
| 2003 May 3 | 15 30.6 | -22 11 | 1.294 | 2.285 | 166 | 12.0 |
| 2003 May 10 | 15 25.1 | -22 07 | 1.294 | 2.300 | 174 | 12.1 |
| 2003 May 17 | 15 19.5 | -21 59 | 1.307 | 2.317 | 176 | 12.2 |
| 2003 May 24 | 15 14.3 | -21 49 | 1.332 | 2.334 | 169 | 12.3 |
| 2003 May 31 | 15 09.7 | -21 39 | 1.368 | 2.352 | 161 | 12.5 |
| 2003 Jun 7 | 15 06.1 | -21 29 | 1.416 | 2.370 | 154 | 12.6 |
| 2003 Jun 14 | 15 03.7 | -21 22 | 1.474 | 2.390 | 147 | 12.8 |
| 2003 Jun 21 | 15 02.6 | -21 19 | 1.542 | 2.410 | 140 | 13.0 |
| 2003 Jun 28 | 15 02.9 | -21 19 | 1.617 | 2.430 | 133 | 13.2 |
| 2003 Jul 5 | 15 04.4 | -21 23 | 1.701 | 2.451 | 127 | 13.4 |
| 2003 Jul 12 | 15 07.2 | -21 31 | 1.790 | 2.473 | 121 | 13.6 |
| 2003 Jul 19 | 15 11.2 | -21 43 | 1.885 | 2.495 | 115 | 13.8 |
| 2003 Jul 26 | 15 16.2 | -21 58 | 1.984 | 2.517 | 110 | 14.0 |

## Comet 65P/Gunn

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2003 Jan 4 | 16 05.5 | -17 57 | 3.237 | 2.569 | 40 | 13.7 |
| 2003 Jan 11 | 16 18.3 | -18 43 | 3.165 | 2.556 | 44 | 13.6 |
| 2003 Jan 18 | 16 31.0 | -19 26 | 3.088 | 2.544 | 48 | 13.5 |
| 2003 Jan 25 | 16 43.6 | -20 05 | 3.009 | 2.533 | 53 | 13.4 |
| 2003 Feb 1 | 16 56.2 | -20 41 | 2.927 | 2.522 | 57 | 13.4 |
| 2003 Feb 8 | 17 08.5 | -21 13 | 2.842 | 2.512 | 61 | 13.3 |
| 2003 Feb 15 | 17 20.6 | -21 43 | 2.755 | 2.503 | 65 | 13.2 |
| 2003 Feb 22 | 17 32.5 | -22 10 | 2.666 | 2.494 | 69 | 13.1 |
| 2003 Mar 1 | 17 44.0 | -22 35 | 2.576 | 2.486 | 74 | 13.0 |
| 2003 Mar 8 | 17 55.1 | -22 57 | 2.486 | 2.479 | 78 | 12.9 |
| 2003 Mar 15 | 18 05.7 | -23 19 | 2.394 | 2.472 | 83 | 12.8 |
| 2003 Mar 22 | 18 15.7 | -23 40 | 2.303 | 2.467 | 87 | 12.7 |
| 2003 Mar 29 | 18 25.0 | -24 00 | 2.213 | 2.461 | 92 | 12.6 |
| 2003 Apr 5 | 18 33.6 | -24 22 | 2.124 | 2.457 | 97 | 12.5 |
| 2003 Apr 12 | 18 41.3 | -24 44 | 2.036 | 2.453 | 102 | 12.4 |
| 2003 Apr 19 | 18 48.0 | -25 09 | 1.952 | 2.450 | 108 | 12.3 |
| 2003 Apr 26 | 18 53.7 | -25 37 | 1.871 | 2.448 | 113 | 12.2 |
| 2003 May 3 | 18 58.2 | -26 08 | 1.794 | 2.447 | 119 | 12.1 |
| 2003 May 10 | 19 01.4 | -26 43 | 1.722 | 2.446 | 125 | 12.0 |
| 2003 May 17 | 19 03.2 | -27 22 | 1.657 | 2.446 | 131 | 11.9 |
| 2003 May 24 | 19 03.6 | -28 04 | 1.599 | 2.447 | 138 | 11.8 |
| 2003 May 31 | 19 02.5 | -28 50 | 1.549 | 2.449 | 145 | 11.8 |
| 2003 Jun 7 | 19 00.1 | -29 37 | 1.509 | 2.452 | 152 | 11.7 |
| 2003 Jun 14 | 18 56.4 | -30 25 | 1.480 | 2.455 | 159 | 11.7 |
| 2003 Jun 21 | 18 51.6 | -31 11 | 1.462 | 2.459 | 166 | 11.7 |
| 2003 Jun 28 | 18 46.2 | -31 53 | 1.456 | 2.464 | 170 | 11.7 |
| 2003 Jul 5 | 18 40.5 | -32 30 | 1.462 | 2.469 | 170 | 11.7 |
| 2003 Jul 12 | 18 35.0 | -32 60 | 1.480 | 2.475 | 165 | 11.8 |
| 2003 Jul 19 | 18 30.1 | -33 23 | 1.510 | 2.482 | 158 | 11.8 |
| 2003 Jul 26 | 18 26.1 | -33 39 | 1.551 | 2.490 | 151 | 11.9 |
| 2003 Aug 2 | 18 23.3 | -33 49 | 1.603 | 2.498 | 144 | 12.0 |
| 2003 Aug 9 | 18 21.9 | -33 53 | 1.664 | 2.507 | 138 | 12.1 |
| 2003 Aug 16 | 18 22.0 | -33 53 | 1.733 | 2.517 | 131 | 12.2 |
| 2003 Aug 23 | 18 23.6 | -33 49 | 1.809 | 2.527 | 125 | 12.3 |
| 2003 Aug 30 | 18 26.5 | -33 41 | 1.891 | 2.538 | 119 | 12.5 |
| 2003 Sep 6 | 18 30.9 | -33 31 | 1.978 | 2.550 | 113 | 12.6 |
| 2003 Sep 13 | 18 36.4 | -33 19 | 2.070 | 2.562 | 108 | 12.7 |
| 2003 Sep 20 | 18 43.1 | -33 04 | 2.165 | 2.574 | 102 | 12.8 |
| 2003 Sep 27 | 18 50.7 | -32 46 | 2.262 | 2.588 | 97 | 13.0 |
| 2003 Oct 4 | 18 59.2 | -32 26 | 2.362 | 2.601 | 92 | 13.1 |
| 2003 Oct 11 | 19 08.4 | -32 03 | 2.462 | 2.616 | 88 | 13.2 |
| 2003 Oct 18 | 19 18.3 | -31 38 | 2.564 | 2.631 | 83 | 13.3 |
| 2003 Oct 25 | 19 28.7 | -31 09 | 2.665 | 2.646 | 78 | 13.5 |

## Comet C/2001 RX14 (LINEAR)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Nov 2 | 09 49.9 | +49 25 | 2.055 | 2.256 | 88 | 11.6 |
| 2002 Nov 9 | 10 09.7 | +49 09 | 1.972 | 2.224 | 91 | 11.4 |
| 2002 Nov 16 | 10 28.8 | +48 48 | 1.893 | 2.194 | 94 | 11.3 |
| 2002 Nov 23 | 10 46.8 | +48 25 | 1.818 | 2.166 | 97 | 11.2 |
| 2002 Nov 30 | 11 03.6 | +47 59 | 1.747 | 2.142 | 99 | 11.0 |
| 2002 Dec 7 | 11 19.0 | +47 33 | 1.679 | 2.120 | 102 | 10.9 |
| 2002 Dec 14 | 11 32.8 | +47 07 | 1.614 | 2.102 | 105 | 10.8 |
| 2002 Dec 21 | 11 44.9 | +46 41 | 1.553 | 2.086 | 109 | 10.7 |
| 2002 Dec 28 | 11 55.0 | +46 17 | 1.496 | 2.074 | 112 | 10.5 |
| 2003 Jan 4 | 12 02.9 | +45 55 | 1.443 | 2.065 | 115 | 10.4 |
| 2003 Jan 11 | 12 08.4 | +45 32 | 1.393 | 2.060 | 119 | 10.4 |
| 2003 Jan 18 | 12 11.5 | +45 09 | 1.348 | 2.058 | 123 | 10.3 |
| 2003 Jan 25 | 12 12.0 | +44 42 | 1.308 | 2.059 | 127 | 10.2 |
| 2003 Feb 1 | 12 09.9 | +44 09 | 1.275 | 2.064 | 132 | 10.2 |
| 2003 Feb 8 | 12 05.3 | +43 25 | 1.248 | 2.072 | 136 | 10.1 |
| 2003 Feb 15 | 11 58.6 | +42 27 | 1.229 | 2.083 | 140 | 10.1 |
| 2003 Feb 22 | 11 50.4 | +41 11 | 1.220 | 2.098 | 143 | 10.2 |
| 2003 Mar 1 | 11 41.1 | +39 34 | 1.221 | 2.116 | 146 | 10.2 |
| 2003 Mar 8 | 11 31.7 | +37 38 | 1.234 | 2.137 | 147 | 10.3 |
| 2003 Mar 15 | 11 22.9 | +35 22 | 1.259 | 2.161 | 147 | 10.3 |
| 2003 Mar 22 | 11 15.1 | +32 52 | 1.297 | 2.188 | 145 | 10.5 |
| 2003 Mar 29 | 11 08.8 | +30 13 | 1.347 | 2.217 | 142 | 10.6 |
| 2003 Apr 5 | 11 04.1 | +27 28 | 1.409 | 2.249 | 137 | 10.8 |
| 2003 Apr 12 | 11 01.1 | +24 43 | 1.483 | 2.283 | 133 | 10.9 |
| 2003 Apr 19 | 10 59.7 | +22 01 | 1.567 | 2.320 | 128 | 11.1 |
| 2003 Apr 26 | 10 59.7 | +19 24 | 1.661 | 2.359 | 123 | 11.3 |
| 2003 May 3 | 11 01.0 | +16 53 | 1.763 | 2.399 | 117 | 11.5 |
| 2003 May 10 | 11 03.5 | +14 30 | 1.873 | 2.442 | 112 | 11.7 |
| 2003 May 17 | 11 06.9 | +12 13 | 1.990 | 2.486 | 107 | 11.9 |
| 2003 May 24 | 11 11.2 | +10 02 | 2.112 | 2.531 | 102 | 12.2 |
| 2003 May 31 | 11 16.1 | +07 58 | 2.239 | 2.578 | 98 | 12.4 |
| 2003 Jun 7 | 11 21.7 | +06 00 | 2.370 | 2.627 | 93 | 12.6 |
| 2003 Jun 14 | 11 27.7 | +04 07 | 2.504 | 2.676 | 88 | 12.8 |
| 2003 Jun 21 | 11 34.2 | +02 18 | 2.640 | 2.727 | 84 | 13.0 |
| 2003 Jun 28 | 11 41.0 | +00 34 | 2.777 | 2.778 | 80 | 13.2 |
| 2003 Jul 5 | 11 48.1 | -01 07 | 2.915 | 2.831 | 75 | 13.3 |
| 2003 Jul 12 | 11 55.4 | -02 45 | 3.053 | 2.884 | 71 | 13.5 |
| 2003 Jul 19 | 12 03.0 | -04 19 | 3.191 | 2.938 | 67 | 13.7 |
| 2003 Jul 26 | 12 10.7 | -05 51 | 3.327 | 2.993 | 62 | 13.9 |

# METEOR SHOWERS

## WHAT is a METEOR SHOWER?

A meteor shower is no more than the leftover debris from comets. A comet has been best described as a 'dirty snowball', a conglomerate of ice, frozen gases, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or wind to form the classical dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical shaped donut. The effects of solar radiation and the slight gravity tugs from the planets will over time break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical meteor of visual magnitude may be as small as a grain of sand up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid stream, at 71 km/s, makes it the fastest of the showers.

Incredible velocities such as these (a bullet from a rifle travels at about 1 km per second) result in the meteor's kinetic energy being converted to heat when it strikes the atmosphere at an altitude of about 100 km. The surrounding air is heated to incandescence by friction and as a consequence we can observe these tiny bodies as they self-destruct in our atmosphere.

Individual meteors during a shower appear to originate from a common point in the sky known as the radiant. This focal point is named after the constellation in which the meteors appear or the comet that is associated with the shower. Members of meteoroid streams travel though space in parallel paths. The apparent divergence from the radiant is only an illusion, due simply to the effect of perspective. The way that trees and buildings converge on either side of a long straight road, is the same effect that is seen when a meteor shower occurs far above an observer.

The table of Meteor Showers has been compiled from the 'Meteor Shower Calendar' produced by the International Meteor Organisation (IMO). It is the most accurate listing for naked-eye meteor observing available today. The table is complete in that both northern and southern showers are listed. Serious meteor observing should be carried out under dark skies, and preferably without the Moon. The best showers for this year, taking into consideration the lunar phase, are summarised in the monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic meteors (originating from random points in the sky) are visible per hour under dark sky conditions. More meteors are seen in the morning sky than in the evening; as the morning sky is facing the Earth's motion in space we tend to 'run into' and 'sweep up' meteors, whereas evening meteors must have sufficient velocity to catch up to the speeding Earth. Amateurs wishing to follow up an interest in meteors, and even make a contribution to meteor science, should contact the International Meteor Organisation. They can be reached on the Web: www.imo.net/ or by writing to Ina Rendtel, IMO Treasurer, Mehlbeerenweg 5, D-14469 Potsdam, Germany. You can also email to treasurer@imo.net for details on IMO membership. Please enclose return postage if writing. International Reply Coupons are available from Australia Post outlets.

| SHOWER NAME | MOON PHASE | ACTIVITY DURATION | MAX ACT | RADIANT | | DIA | VEL km/s | ZHR |
|---|---|---|---|---|---|---|---|---|
| | | | | R.A. | Dec | | | |
| Quadrantids | NM | Jan 01-Jan 05 | Jan 04 | 230° | +49° | 5° | 41 | 120 |
| delta-Cancrids | FM | Jan 01-Jan 24 | Jan 17 | 130° | +20° | 10°-5° | 28 | 4 |
| alpha-Centaurids | FQ | Jan 28-Feb 21 | Feb 08 | 210° | -59° | 4° | 56 | 6 |
| delta-Leonids | LQ | Feb 15-Mar 10 | Feb 24 | 168° | +16° | 5° | 23 | 2 |
| gamma-Normids | FQ | Feb 25-Mar 22 | Mar 14 | 249° | -51° | 5° | 56 | 8 |
| Virginids | LQ | Jan 25-Apr 15 | Mar 25 | 195° | -04° | 15°-10° | 30 | 5 |
| Lyrids | LQ | Apr 16-Apr 25 | Apr 22 | 271° | +34° | 5° | 49 | 18 |
| pi-Puppids* | LQ | Apr 15-Apr 28 | Apr 24 | 110° | -45° | 5° | 18 | * |
| eta-Aquarids | NM | Apr 19-May 28 | May 06 | 338° | -01° | 4° | 66 | 60 |
| Sagittarids | FM | Apr 15-Jul 15 | May 20 | 247° | -22° | 15°-10° | 30 | 5 |
| Bootids (June)* | NM | Jun 26-Jul 02 | Jun 27 | 224° | +48° | 5° | 18 | * |
| Pegasids | FQ | Jul 07-Jul 13 | Jul 10 | 340° | +15° | 5° | 70 | 3 |
| Phoenicids (July)* | FM | Jul 10-Jul 16 | Jul 13 | 032° | -48° | 7° | 47 | * |
| Piscis Austrinids | NM | Jul 15-Aug 10 | Jul 28 | 341° | -30° | 15°-10° | 35 | 5 |
| Southern delta-Aquarids | NM | Jul 12-Aug 19 | Jul 28 | 339° | -16° | 5° | 41 | 20 |
| alpha-Capricornids | NM | Jul 03-Aug 15 | Jul 30 | 307° | -10° | 8° | 23 | 4 |
| Southern iota-Aquarids | FQ | Jul 25-Aug 15 | Aug 04 | 334° | -15° | 5° | 34 | 2 |
| Northern delta-Aquarids | FQ | Jul 15-Aug 25 | Aug 09 | 335° | -05° | 5° | 42 | 4 |
| Perseids | FM | Jul 17-Aug 24 | Aug 13 | 046° | +58° | 5° | 59 | 110 |
| kappa-Cygnids | LQ | Aug 03-Aug 25 | Aug 18 | 286° | +59° | 6° | 25 | 3 |
| Northern iota-Aquarids | LQ | Aug 11-Aug 31 | Aug 20 | 327° | -06° | 5° | 31 | 3 |
| alpha-Aurigids | FQ | Aug 25-Sep 05 | Sep 01 | 084° | +42° | 5° | 66 | 7 |
| delta-Aurigids | FM | Sep 05-Oct 10 | Sep 09 | 060° | +47° | 5° | 64 | 6 |
| Piscids | LQ | Sep 01-Sep 30 | Sep 20 | 005° | -01° | 5° | 26 | 3 |
| Draconids* | FM | Oct 06-Oct 10 | Oct 09 | 262° | +54° | 2° | 20 | * |
| epsilon Geminids | LQ | Oct 14-Oct 27 | Oct 18 | 102° | +27° | 5° | 70 | 2 |
| Orionids | LQ | Oct 02-Nov 07 | Oct 21 | 095° | +16° | 10° | 66 | 20 |
| Southern Taurids | FM | Oct 01-Nov 25 | Nov 05 | 052° | +13° | 10°-5° | 27 | 5 |
| Northern Taurids | FM | Oct 01-Nov 25 | Nov 12 | 058° | +22° | 10°-5° | 29 | 5 |
| Leonids | LQ | Nov 14-Nov 21 | Nov 18 | 153° | +22° | 5° | 71 | 100+ |
| alpha-Monocerotids | NM | Nov 15-Nov 25 | Nov 22 | 117° | +01° | 5° | 65 | Var |
| chi-Orionids | FQ | Nov 26-Dec 15 | Dec 02 | 082° | +23° | 8° | 28 | 3 |
| Phoenicids (Dec) | FM | Nov 28-Dec 09 | Dec 06 | 018° | -53° | 5° | 18 | Var |
| Puppid-Velids | FM | Dec 01-Dec 15 | Dec 07 | 123° | -45° | 10° | 40 | 10 |
| Monocerotids (Dec) | FM | Nov 27-Dec 17 | Dec 09 | 100° | +08° | 5° | 42 | 3 |
| sigma-Hydrids | FM | Dec 03-Dec 15 | Dec 12 | 127° | +02° | 5° | 58 | 2 |
| Geminids | LQ | Dec 07-Dec 17 | Dec 14 | 112° | +33° | 5° | 35 | 120 |
| Coma Berenicids | LQ | Dec 12-Jan 23 | Dec 20 | 175° | +25° | 5° | 65 | 5 |
| Ursids | NM | Dec 17-Dec 26 | Dec 23 | 217° | +76° | 5° | 33 | 10 |

### NOTES ON THE TABLE ABOVE

**SHOWER NAME** The shower is named after the constellation that the radiant appears in or a bright star near that point. A shower marked with an asterisk (*) is only occasionally active.

**MOON PHASE** The phase of the Moon nearest the date of maximum activity. If a Full Moon occurs near a shower's maximum period, only the very brightest of meteors will be seen.

**ACTIVITY DURATION** The approximate dates when the shower is active.

**MAX ACT** The date when maximum activity can be expected.

**RADIANT, R.A. and Dec:** The position of the shower radiant in right ascension and declination (R.A. is expressed in degrees). These co-ordinates refer to the radiant position on the date of maximum activity.

**DIA** The radiant diameter. When two figures are given, the first is the spread in R.A. and the second the spread in Dec.

**VEL km/s** The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11km/s (very slow) to 71km/s (very fast), medium speed is about 40km/s.

**ZHR** Zenith Hourly Rate, a theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

# PART III – APPENDICES

## JULIAN DATE – 2003

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 10 hrs from EST, 9.5 hrs from CST or 8 hrs from WST, correcting the date if necessary. Next find the Julian date given in the table (below left) for the month you are interested in. Now add the day of the month. This will give you JD for 0hrs UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you wish to know the Julian date at 23:00 EST on July 17th 2003. Subtract 10 hours to get UT.

23 - 10 = 13:00 hrs UT

From the table the JD for July is 2452820.5
Add the day of month, 17 gives us 2452837.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 23:00hr 17 July 2003 EST is 2452838.042

| JULIAN DATE at 0hrs UT | |
|---|---|
| Month | Julian Date |
| Jan 0 | 2452639.5 |
| Feb 0 | 2452670.5 |
| Mar 0 | 2452698.5 |
| Apr 0 | 2452729.5 |
| May 0 | 2452759.5 |
| Jun 0 | 2452790.5 |
| Jul 0 | 2452820.5 |
| Aug 0 | 2452851.5 |
| Sep 0 | 2452882.5 |
| Oct 0 | 2452912.5 |
| Nov 0 | 2452943.5 |
| Dec 0 | 2452973.5 |

| Hours as decimal of a day. | | | |
|---|---|---|---|
| 01 | 0.042 | 13 | 0.542 |
| 02 | 0.083 | 14 | 0.583 |
| 03 | 0.125 | 15 | 0.625 |
| 04 | 0.167 | 16 | 0.667 |
| 05 | 0.208 | 17 | 0.708 |
| 06 | 0.250 | 18 | 0.750 |
| 07 | 0.292 | 19 | 0.792 |
| 08 | 0.333 | 20 | 0.833 |
| 09 | 0.375 | 21 | 0.875 |
| 10 | 0.417 | 22 | 0.917 |
| 11 | 0.458 | 23 | 0.958 |
| 12 | 0.500 | 24 | 1.000 |

## SIDEREAL TIME – 2003

| | | |
|---|---|---|
| Jan 0 6.6168 | May 0 14.5020 | Sep 0 22.5843 |
| Feb 0 8.6538 | Jun 0 16.5390 | Oct 0 0.5556 |
| Mar 0 10.4937 | Jul 0 18.5103 | Nov 0 2.5926 |
| Apr 0 12.5307 | Aug 0 20.5473 | Dec 0 4.5639 |
| *Greenwich mean sidereal time (GMST) at 0hrs UT* | | |

You can use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to UT. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day *d* of month at hour *t* UT

= GMST at 0h UT (from table above) + 0.06571 *d* + 1.00274 *t*

To convert this to local mean sidereal time (LMST) we use

LMST = GMST + east longitude (or - west longitude)

where longitude is expressed in HOURS (not degrees!)

To convert longitude from degrees to hours, just divide by 15.

**Example**:

Find LMST at 23 hours Sydney time (EST) on 17th July 2003.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5103 hours.

GMST = 18.5103 + (0.06571 x 17) + (1.00274 x 13) = 32.6630

Sydney's longitude is 151.25° which is 10.0833 hrs so

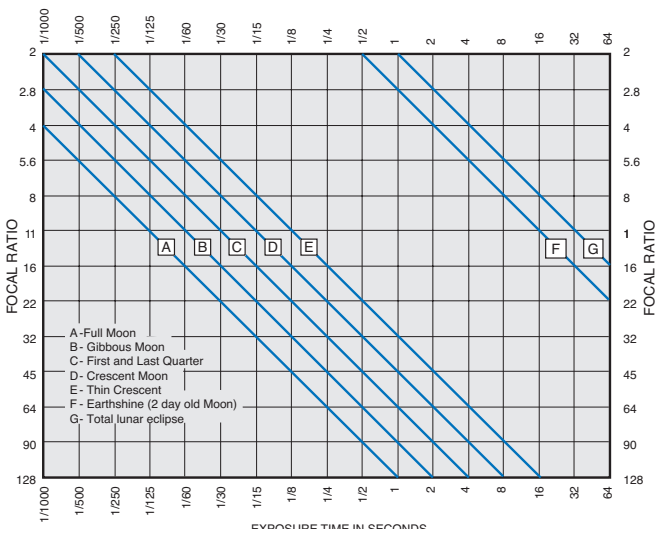
LMST = 32.6630 + 10.0833 = 42.7463

Subtract from this multiples of 24 until it is in the range of 0 to 24

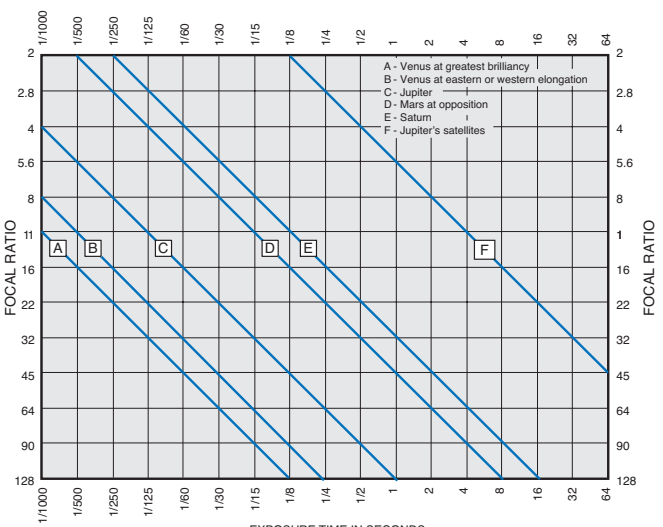
42.7463 - 24 = 18.7463 hrs or 18h 44m 46s

# PHOTOGRAPHIC EXPOSURE GUIDES

### MOON




### PLANETS




These charts provide recommended photographic exposures for the Moon (left) and selected planets (right) using 100 ISO film. The charts should only be treated as a guide as many factors will influence the exposure time.

Follow a horizontal line nearest to your systems focal ratio to the oblique line that represents the Moon aspect or planet required, then follow the intersecting vertical line down to find the correct exposure.

For the best result always take one photo at the recommended speed and follow up with one at half and one at twice the exposure (bracketing). This will help smooth out variables and should provide at least one image at the required density.

| Film Speed | Multiply By | Film Speed | Divide By |
|---|---|---|---|
| 32 ISO | 4 | 200 ISO | 2 |
| 64 ISO | 2 | 400 ISO | 4 |

*For ISO values other than 100 the above factors should be applied to the exposure time.*

# CONSTELLATIONS – Abbreviations and Culmination at 9pm.

| Name | Genitive | Abr. | Cul. |
|---|---|---|---|
| Andromeda | Andromedae | And | Nov 23 |
| Antlia | Antliae | Ant | Apr 10 |
| Apus | Apodis | Aps | Jul 05 |
| Aquarius | Aquarii | Aqr | Oct 09 |
| Aquila | Aquilae | Aql | Aug 30 |
| Ara | Arae | Ara | Jul 25 |
| Aries | Arietis | Ari | Dec 14 |
| Auriga | Aurigae | Aur | Feb 04 |
| Bootes | Bootis | Boo | Jun 16 |
| Caelum | Caeli | Cae | Jan 15 |
| Camelopardus | Camelopardi | Cam | Feb 06 |
| Cancer | Cancri | Cnc | Mar 16 |
| Canes Venatici | Canum Venaticorum | CVn | May 22 |
| Canis Major | Canis Majoris | CMa | Feb 16 |
| Canis Minor | Canis Minoris | CMi | Feb 28 |
| Capricornus | Capricorni | Cap | Sep 22 |
| Carina | Carinae | Car | Mar 17 |
| Cassiopeia | Cassiopeiae | Cas | Nov 23 |
| Centaurus | Centauri | Cen | May 14 |
| Cepheus | Cephei | Cep | Nov 13 |
| Cetus | Ceti | Cet | Nov 29 |
| Chamaeleon | Chamaeleontis | Cha | Apr 15 |
| Circinus | Circini | Cir | Jun 14 |
| Columba | Columbae | Col | Feb 01 |
| Coma Berenices | Comae Berenices | Com | May 17 |
| Corona Australis | Coronae Australis | CrA | Aug 14 |
| Corona Borealis | Coronae Borealis | CrB | Jul 03 |
| Corvus | Corvi | Crv | May 12 |
| Crater | Crateris | Crt | Apr 26 |
| Crux | Crucis | Cru | May 12 |
| Cygnus | Cygni | Cyg | Sep 13 |
| Delphinus | Delphini | Del | Sep 14 |
| Dorado | Doradus | Dor | Jan 31 |
| Draco | Draconis | Dra | Jul 08 |
| Equuleus | Equulei | Equ | Sep 22 |
| Eridanus | Eridani | Eri | Dec 25 |
| Fornax | Fornacis | For | Dec 17 |
| Gemini | Geminorum | Gem | Feb 19 |
| Grus | Gruis | Gru | Oct 12 |
| Hercules | Herculis | Her | Jul 28 |
| Horologium | Horologii | Hor | Dec 25 |
| Hydra | Hydrae | Hya | Apr 29 |
| Hydrus | Hydri | Hyi | Dec 10 |
| Indus | Indi | Ind | Sep 26 |
| Lacerta | Lacertae | Lac | Oct 12 |
| Leo | Leonis | Leo | Apr 15 |
| Leo Minor | Leonis Minoris | LMi | Apr 09 |
| Lepus | Leporis | Lep | Jan 28 |
| Libra | Librae | Lib | Jun 23 |
| Lupus | Lupi | Lup | Jun 23 |
| Lynx | Lyncis | Lyn | Mar 05 |
| Lyra | Lyrae | Lyr | Aug 18 |
| Mensa | Mensae | Men | Jan 28 |
| Microscopium | Microscopii | Mic | Sep 18 |
| Monoceros | Monocerotis | Mon | Feb 19 |
| Musca | Muscae | Mus | May 14 |
| Norma | Normae | Nor | Jul 03 |
| Octans | Octantis | Oct | Circum |
| Ophiuchus | Ophiuchi | Oph | Jul 26 |
| Orion | Orionis | Ori | Jan 27 |
| Pavo | Pavonis | Pav | Aug 29 |
| Pegasus | Pegasi | Peg | Oct 16 |
| Perseus | Persei | Per | Dec 22 |
| Phoenix | Phoenicis | Phe | Nov 18 |
| Pictor | Pictoris | Pic | Jan 30 |
| Pisces | Piscium | Psc | Nov 11 |
| Piscis Austrinus | Piscis Austrini | PsA | Oct 09 |
| Puppis | Puppis | Pup | Feb 22 |
| Pyxis | Pyxidis | Pyx | Mar 21 |
| Reticulum | Reticuli | Ret | Jan 03 |
| Sagitta | Sagittae | Sge | Aug 30 |
| Sagittarius | Sagittarii | Sgr | Aug 21 |
| Scorpius | Scorpii | Sco | Jul 18 |
| Sculptor | Sculptoris | Scl | Nov 10 |
| Scutum | Scuti | Sct | Aug 15 |
| Serpens | Serpentis | Ser | Jul 21 |
| Sextans | Sextantis | Sex | Apr 08 |
| Taurus | Tauri | Tau | Jan 14 |
| Telescopium | Telescopii | Tel | Aug 24 |
| Triangulum | Trianguli | Tri | Dec 07 |
| Triangulum Australe | Trianguli Australis | TrA | Jul 07 |
| Tucana | Tucanae | Tuc | Nov 01 |
| Ursa Major | Ursae Majoris | UMa | Apr 25 |
| Ursa Minor | Ursae Minoris | UMi | Jun 27 |
| Vela | Velorum | Vel | Mar 30 |
| Virgo | Virginis | Vir | May 26 |
| Volans | Volantis | Vol | Mar 04 |
| Vulpecula | Vulpeculae | Vul | Sep 08 |

# BRIGHTEST and NEAREST STARS

The column descriptions are:

**Designation** The name of the star in the system created by Bayer. He numbered the stars in the constellations using Greek letters (p. 144). They were usually ordered by their brightness, alpha being the brightest in most cases.

**Name** Common names for the stars.
**Constellation** The star's constellation.
**RA and Dec.** The position of the star, epoch 2000.0.
**Magnitude App.** The apparent magnitude as seen in the sky.
**Magnitude Abs.** The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light years) from Earth.
**Spectral Type** The spectral classification of the star (see below).
**Parallax** see glossary.
**ly** is light year and **pc** is parsec (see glossary).
**Note** (d) is a visual double star
(sb) is a spectroscopic binary,
(eb) is an eclipsing binary and
(v) is another type of variable star.

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O**, **B**, **A**, **F**, **G**, **K** and **M**, remembered by the mnemonic **O**h **B**e **A** **F**ine **G**irl(Guy) **K**iss **M**e.

There are also now the 'colder' star classes, **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and then even further subdivided into I, II, III, IV, etc. A discussion of these is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel)
- **F** and **G** are yellow (e.g., Capella, the Sun and Arcturus)
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is interesting trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only in shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (i.e., no colour).

The colours of stars can be photographed simply. Mount your normal 35mm camera on a tripod and take a time exposure (some minutes) using a fast film. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., piggybacked on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images burn out on the negative. All such photography should be conducted in country areas, away from city lights.

## THE BRIGHTEST STARS

| | Designation | Name | Constellation | R.A. (2000.0) | Dec (2000.0) | Magnitude App | Abs | Spectral Type | Parallax | Distance pc | ly | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | α CMa | Sirius | Canis Major | 06 45.1 | -16 43 | -1.44 | 1.5 | A1 V | 0.3800 | 2.63 | 8.58 | d |
| 2 | α Car | Canopus | Carina | 06 23.9 | -52 42 | -0.74 | -5.6 | F0 Ib | 0.0104 | 96 | 310 | |
| 3 | α Cen | Rigil Kent | Centaurus | 14 39.6 | -60 50 | -0.28 | 4.1 | G2V + K0V | 0.7472 | 1.34 | 4.37 | d |
| 4 | α Boo | Arcturus | Bootes | 14 15.7 | +19 11 | -0.05 | -0.3 | K2 III | 0.0889 | 11.3 | 36.7 | |
| 5 | α Lyr | Vega | Lyra | 18 36.9 | +38 47 | 0.03 | 0.6 | A0 V | 0.1289 | 7.76 | 25.3 | v |
| 6 | α Aur | Capella | Auriga | 05 16.7 | +46 00 | 0.08 | -0.5 | G8III + G0III | 0.0773 | 12.9 | 42.2 | sb, v |
| 7 | β Ori | Rigel | Orion | 05 14.5 | -08 12 | 0.15 | -6.8 | B8 Ia | 0.0042 | 240 | 780 | d, v |
| 8 | α CMi | Procyon | Canis Minor | 07 39.3 | +05 14 | 0.38 | 2.7 | F5 IV-V | 0.2861 | 3.50 | 11.4 | d |
| 9 | α Eri | Achernar | Eridanus | 01 37.7 | -57 14 | 0.45 | -2.8 | B5 IV | 0.0227 | 44.1 | 144 | v |
| 10 | α Ori | Betelgeuse | Orion | 05 55.2 | +07 24 | 0.50 | -5.2 | M2 Iab | 0.0076 | 131 | 430 | v |
| 11 | β Cen | Hadar | Centaurus | 14 03.8 | -60 22 | 0.61 | -5.4 | B1 II + B | 0.0062 | 161 | 525 | d, v |
| 12 | α Cru | Acrux | Crux | 12 26.6 | -63 06 | 0.74 | -4.2 | B0.5IV + B0.5V | 0.0102 | 98 | 320 | d |
| 13 | α Aql | Altair | Aquila | 19 50.8 | +08 52 | 0.76 | 2.2 | A7 IV-V | 0.1950 | 5.13 | 16.7 | |
| 14 | α Tau | Aldebaran | Taurus | 04 35.9 | +16 31 | 0.87 | -0.6 | K5 III | 0.0501 | 20.0 | 65 | |
| 15 | α Sco | Antares | Scorpius | 16 29.4 | -26 26 | 0.96 | -5.1 | M1.5Iab + B4V | 0.0067 | 150 | 490 | d, v |
| 16 | α Vir | Spica | Virgo | 13 25.2 | -11 10 | 0.98 | -3.5 | B1III-IV + B2V | 0.0124 | 80 | 262 | sb, v |
| 17 | β Gem | Pollux | Gemini | 07 45.3 | +28 02 | 1.15 | 1.1 | K0 III | 0.0967 | 10.3 | 33.7 | |
| 18 | α PsA | Fomalhaut | Piscis Austrinus | 22 57.7 | -29 37 | 1.16 | 1.7 | A3 V | 0.1301 | 7.69 | 25.1 | |
| 19 | α Cyg | Deneb | Cygnus | 20 41.4 | +45 17 | 1.25 | -7.2 | A2 Ia | 0.0020 | 500 | 1600 | v |
| 20 | β Cru | Mimosa | Crux | 12 47.7 | -59 41 | 1.26 | -3.9 | B0.5 III | 0.0093 | 108 | 353 | v |
| 21 | α Leo | Regulus | Leo | 10 08.4 | +11 58 | 1.36 | -0.5 | B7 V | 0.0421 | 23.8 | 78 | d |
| 22 | ε CMa | Adhara | Canis Major | 06 58.6 | -28 58 | 1.50 | -4.1 | B2 II | 0.0076 | 132 | 430 | d |
| 23 | α Gem | Castor | Gemini | 07 34.6 | +31 53 | 1.58 | 0.6 | A1V + Am | 0.0633 | 15.8 | 52 | d,sb |
| 24 | λ Sco | Shaula | Scorpius | 17 33.6 | -37 06 | 1.62 | -5.0 | B1.5 III | 0.0046 | 215 | 700 | sb, v |
| 25 | γ Cru | Gacrux | Crux | 12 31.2 | -57 07 | 1.63 | -0.5 | M3 III | 0.0371 | 27.0 | 88 | v |
| 26 | γ Ori | Bellatrix | Orion | 05 25.1 | +06 21 | 1.64 | -1.4 | B2 III | 0.0243 | 41.2 | 134 | |
| 27 | β Tau | El Nath | Taurus | 05 26.3 | +28 36 | 1.65 | -2.7 | B7 III | 0.0134 | 75 | 243 | |
| 28 | β Car | Miaplacidus | Carina | 09 13.2 | -69 43 | 1.67 | -1.0 | A0 III | 0.0293 | 34.1 | 111 | |
| 29 | ε Ori | Alnilam | Orion | 05 36.2 | -01 12 | 1.69 | -6.4 | B0 Ia | 0.0024 | 410 | 1340 | |
| 30 | γ Vel | Regor | Vela | 08 09.5 | -47 20 | 1.70 | -5.4 | O9Ib + WC8 | 0.0039 | 258 | 840 | sb, v |

## THE NEAREST STARS

| No | Star Name | | Constellation | R.A. 2000 hh mm.m | Dec ° ' | Magnitude Apparent | Absolute | Spect Type | Parallax " | Proper Motion | Distance ly | pc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -- | Sun | | | | | -26.72 | 4.85 | G2 V | | | | |
| 1 | Proxima Centauri | | Centaurus | 14 29.7 | -62 40 | 11.09 | 15.53 | M5.5 V | 0.7720 | 3.85 | 4.23 | 1.30 |
| | Alpha Centauri | A | Centaurus | 14 39.6 | -60 50 | 0.01 | 4.38 | G2 V | 0.7472 | 3.71 | 4.37 | 1.34 |
| | | B | | | | 1.34 | 5.71 | K0 V | | | | |
| 2 | Barnard's Star | | Ophiuchus | 17 57.8 | +04 41 | 9.53 | 13.22 | M4.0 V | 0.5470 | 10.36 | 5.96 | 1.83 |
| 3 | Wolf 359 | | Leo | 10 56.5 | +07 00 | 13.44 | 16.55 | M6.0 V | 0.4191 | 4.70 | 7.78 | 2.39 |
| 4 | Lalande 21185 | | Ursa Major | 11 03.3 | +35 58 | 7.47 | 10.44 | M2.0 V | 0.3934 | 4.80 | 8.29 | 2.54 |
| 5 | Sirius | A | Canis Major | 06 45.1 | -16 43 | -1.44 | 1.46 | A1 V | 0.3800 | 1.34 | 8.58 | 2.63 |
| | | B | | | | 8.44 | 11.34 | DA2 | | | | |
| 6 | L 726-8 (UV Ceti) | A | Cetus | 01 39.0 | -17 57 | 12.54 | 15.40 | M5.5 V | 0.3737 | 3.37 | 8.73 | 2.68 |
| | | B | | | | 12.99 | 15.85 | M6.0 V | | | | |
| 7 | Ross 154 | | Sagittarius | 18 49.8 | -23 50 | 10.43 | 13.07 | M3.5 V | 0.3369 | 0.67 | 9.68 | 2.97 |
| 8 | Ross 248 | | Andromeda | 23 41.9 | +44 10 | 12.29 | 14.79 | M5.5 V | 0.3160 | 1.62 | 10.32 | 3.16 |
| 9 | Epsilon Eridani | | Eridanus | 03 32.9 | -09 27 | 3.73 | 6.19 | K2 V | 0.3100 | 0.98 | 10.52 | 3.23 |
| 10 | Lacaille 9352 | | Piscis Austrinus | 23 05.9 | -35 51 | 7.34 | 9.75 | M1.5 V | 0.3036 | 6.90 | 10.74 | 3.29 |
| 11 | Ross 128 | | Virgo | 11 47.7 | +00 48 | 11.13 | 13.51 | M4.0 V | 0.2987 | 1.36 | 10.92 | 3.35 |
| 12 | L 789-6 (EZ Aquarii) | A | Aquarius | 22 38.6 | -15 18 | 13.33 | 15.64 | M5.0 V | 0.2895 | 3.25 | 11.27 | 3.45 |
| | | B | | | | 13.27 | 15.58 | M | | | | |
| | | C | | | | 14.03 | 16.34 | M | | | | |
| 13 | Procyon | A | Canis Minor | 07 39.3 | +05 14 | 0.38 | 2.66 | F5 IV-V | 0.2861 | 1.26 | 11.40 | 3.50 |
| | | B | | | | 10.70 | 12.98 | DA | | | | |
| 14 | 61 Cygni | A | Cygnus | 21 06.9 | +38 45 | 5.21 | 7.49 | K5.0 V | 0.2860 | 5.28 | 11.40 | 3.50 |
| | | B | | | | 6.03 | 8.31 | K7.0 V | | | | |
| 15 | Σ 2398 | A | Draco | 18 42.8 | +59 38 | 8.90 | 11.16 | M3.0 V | 0.2830 | 2.24 | 11.53 | 3.53 |
| | | B | | | | 9.69 | 11.95 | M3.5 V | | | | |
| 16 | Groombridge 34 | A | Andromeda | 00 18.4 | +44 01 | 8.08 | 10.32 | M1.5 V | 0.2806 | 2.92 | 11.63 | 3.56 |
| | | B | | | | 11.06 | 13.30 | M3.5 V | | | | |
| 17 | Epsilon Indi | | Indus | 22 03.4 | -56 47 | 4.69 | 6.89 | K5 Ve | 0.2758 | 4.70 | 11.83 | 3.63 |
| 18 | DX Cancri | | Cancer | 08 29.8 | +26 47 | 14.78 | 16.98 | M6.5 V | 0.2758 | 1.29 | 11.83 | 3.63 |
| 19 | Tau Ceti | | Cetus | 01 44.1 | -15 56 | 3.49 | 5.68 | G8 Vp | 0.2744 | 1.92 | 11.89 | 3.64 |
| 20 | GJ 1061 | | Horologium | 03 36.0 | -44 31 | 13.03 | 15.21 | M5.5 V | 0.2720 | 0.81 | 11.99 | 3.68 |
| 21 | YZ Ceti | | Cetus | 01 12.5 | -17 00 | 12.02 | 14.17 | M4.5 V | 0.2688 | 1.37 | 12.13 | 3.72 |
| 22 | Luyten's Star | | Canis Minor | 07 27.4 | +05 14 | 9.86 | 11.97 | M3.5 V | 0.2638 | 3.74 | 12.37 | 3.79 |

# RISE/SET TIME CORRECTIONS FOR OTHER LOCATIONS

As mentioned previously in this book, the rise/set tables for the Sun, Moon and planets, in Part II, are calculated for Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney.

This page is designed to help people, who live outside of these cities, to make corrections to determine the rise/set times for their specific location. There are two corrections needed, they are:

1. An adjustment for the difference in longitude. **For every degree of longitude east or west of SYDNEY, subtract or add respectively 4 minutes to both the rise and set times**. Examples of corrections for various towns and cities are given in table 1.

2. An adjustment for the difference in latitude also requires the declination for the object of interest. Table 2 presents these corrections (southern latitudes are negative). NB. **for rise times you add these values, for set you subtract**. For your specific latitude it is normally sufficient to interpolate these figures.

**It is IMPORTANT that Rise/Set times for SYDNEY are used, IRRESPECTIVE of which town in Australia the calculations are for, when using these tables.**

In all these calculations it is easier to first convert all latitudes and longitudes to decimal degrees.

**Example of rise/set time corrections.**

Calculate the rise/set times for the Sun on January 18 for Albury (36° 05'S, 146° 55'E)

| | Rise | Set |
|---|---|---|
| From p.75 the rise/set values for Sydney are: | 5:02 | 19:08 |
| Adjust for longitude (151.25-146.92) x 4 (table 1) | + :17 | + :17 |
| (value is positive due to Albury being west of Sydney) | | |
| Adjust for latitude and declination of the Sun from table 2. Sun's declination is -20° 40' ( p. 73) | - :05 | + :05 |
| Rise/Set times for Albury are: | 5:14 | 19:30 |

If your local time is Central Standard Time, **subtract** 30 minutes, if your local time is Western Standard Time, **subtract** 2 hours

If daylight saving is in force, **add** 60 minutes.

## TABLE 2 – RISE/SET CORRECTIONS FOR LATITUDE/ DECLINATION (from Sydney)

| South Latitude (negative) | Declination 30° | 25° | 20° | 15° | 10° | 5° | 0° | -5° | -10° | -15° | -20° | -25° | -30° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -12° | -63 | -50 | -39 | -28 | -19 | -9 | 0 | 9 | 19 | 28 | 39 | 50 | 63 |
| -14° | -58 | -46 | -36 | -26 | -17 | -8 | 0 | 8 | 17 | 26 | 36 | 46 | 58 |
| -16° | -53 | -42 | -33 | -24 | -16 | -8 | 0 | 8 | 16 | 24 | 33 | 42 | 53 |
| -18° | -48 | -38 | -29 | -22 | -14 | -7 | 0 | 7 | 14 | 22 | 29 | 38 | 48 |
| -20° | -43 | -34 | -26 | -19 | -13 | -6 | 0 | 6 | 13 | 19 | 26 | 34 | 43 |
| -22° | -37 | -30 | -23 | -17 | -11 | -5 | 0 | 5 | 11 | 17 | 23 | 30 | 37 |
| -24° | -32 | -25 | -19 | -14 | -9 | -5 | 0 | 5 | 9 | 14 | 19 | 25 | 32 |
| -26° | -26 | -20 | -16 | -11 | -7 | -4 | 0 | 4 | 7 | 11 | 16 | 20 | 26 |
| -28° | -20 | -16 | -12 | -9 | -6 | -3 | 0 | 3 | 6 | 9 | 12 | 16 | 20 |
| -30° | -13 | -11 | -8 | -6 | -4 | -2 | 0 | 2 | 4 | 6 | 8 | 11 | 13 |
| -32° | -7 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 7 |
| -34° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -36° | 8 | 6 | 5 | 3 | 2 | 1 | 0 | -1 | -2 | -3 | -5 | -6 | -8 |
| -38° | 16 | 12 | 9 | 7 | 4 | 2 | 0 | -2 | -4 | -7 | -9 | -12 | -16 |
| -40° | 25 | 19 | 15 | 10 | 7 | 3 | 0 | -3 | -7 | -10 | -15 | -19 | -25 |
| -42° | 34 | 26 | 20 | 14 | 9 | 5 | 0 | -5 | -9 | -14 | -20 | -26 | -34 |
| -44° | 44 | 34 | 26 | 18 | 12 | 6 | 0 | -6 | -12 | -18 | -26 | -34 | -44 |

Table 1 **LONGITUDE ADJUSTMENTS FOR SOME TOWNS AND CITIES RELATIVE TO SYDNEY**

| Location | Latitude (° ' S) | Longitude ° ' E) | Change in Longitude (decimal °) | correction (mins.) |
|---|---|---|---|---|
| **NEW SOUTH WALES** | | | | |
| Albury | 36 05 | 146 55 | 4.3 | 17 |
| Bathurst | 33 25 | 149 34 | 1.7 | 7 |
| Broken Hill | 32 0 | 141 27 | 9.8 | 39 |
| Coffs Harbour | 30 13 | 153 08 | -1.9 | -8 |
| Dubbo | 32 15 | 148 37 | 2.6 | 11 |
| Goulburn | 34 45 | 149 43 | 1.5 | 6 |
| Katoomba | 33 42 | 150 18 | 0.9 | 4 |
| Newcastle | 32 55 | 151 45 | -0.5 | -2 |
| Parkes | 33 05 | 148 10 | 3.1 | 12 |
| Tamworth | 31 03 | 151 02 | 0.2 | 1 |
| Wagga Wagga | 35 05 | 147 20 | 3.9 | 16 |
| Wollongong | 34 25 | 150 52 | 0.4 | 2 |
| **NORTHERN TERRITORY** | | | | |
| Alice Springs | 23 42 | 133 56 | 17.3 | 69 |
| Ayers Rock | 25 11 | 130 58 | 20.3 | 8 |
| **QUEENSLAND** | | | | |
| Bundaberg | 24 52 | 152 21 | -1.1 | -4 |
| Cairns | 16 55 | 145 49 | 5.4 | 22 |
| Longreach | 23 22 | 144 09 | 7.1 | 28 |
| Mackay | 21 08 | 149 10 | 2.1 | 8 |
| Mount Isa | 20 38 | 139 28 | 11.8 | 47 |
| Rockhampton | 23 21 | 150 28 | 0.8 | 3 |
| Surfers Paradise | 28 00 | 153 26 | -2.2 | -9 |
| Toowoomba | 27 33 | 151 58 | -0.7 | -3 |
| Townsville | 19 10 | 146 49 | 4.4 | 18 |
| **TASMANIA** | | | | |
| Launceston | 41 20 | 147 08 | 4.1 | 16 |
| Stanley | 40 40 | 145 08 | 6.1 | 24 |
| **VICTORIA** | | | | |
| Ballarat | 37 25 | 143 55 | 7.3 | 29 |
| Benalla | 36 30 | 146 01 | 5.2 | 21 |
| Bendigo | 36 46 | 144 17 | 7.1 | 28 |
| Geelong | 38 09 | 144 10 | 7.1 | 28 |
| Morwell | 38 12 | 146 21 | 4.9 | 20 |
| Shepparton | 36 13 | 145 25 | 5.8 | 23 |
| Swan Hill | 35 13 | 143 30 | 7.8 | 31 |
| Wangaratta | 36 17 | 146 13 | 5.0 | 20 |
| Warnambool | 38 27 | 142 30 | 8.8 | 35 |
| **SOUTH AUSTRALIA** | | | | |
| Port Augusta | 32 30 | 137 52 | 13.4 | 54 |
| Port Lincoln | 34 42 | 135 59 | 15.3 | 61 |
| Mount Gambier | 37 41 | 140 49 | 10.4 | 42 |
| Whyalla | 33 02 | 137 34 | 13.7 | 55 |
| **WEST AUSTRALIA** | | | | |
| Albany | 35 01 | 117 53 | 33.37 | 133 |
| Broome | 17 58 | 122 14 | 29.02 | 116 |
| Bunbury | 33 20 | 115 38 | 35.62 | 142 |
| Carnarvon | 24 53 | 113 40 | 37.58 | 150 |
| Denmark | 34 58 | 117 21 | 33.90 | 136 |
| Derby | 17 19 | 123 38 | 27.62 | 110 |
| Esperance | 33 52 | 121 54 | 29.35 | 117 |
| Eucla | 31 41 | 128 53 | 22.37 | 89 |
| Fitzroy Crossing | 18 11 | 125 36 | 25.65 | 103 |
| Geraldton | 28 46 | 114 37 | 36.63 | 147 |
| Kalgoorlie | 30 45 | 121 28 | 29.78 | 119 |
| Kellerberrin | 31 38 | 117 43 | 33.53 | 134 |
| Lake Grace | 33 06 | 118 28 | 32.78 | 131 |
| Marble Bar | 21 10 | 119 45 | 31.50 | 126 |
| Meekatharra | 26 36 | 118 28 | 32.78 | 131 |
| Mount Barker | 34 38 | 117 40 | 33.58 | 134 |
| Mount Magnet | 28 04 | 117 51 | 33.40 | 134 |
| Mount Newman | 23 19 | 119 45 | 31.50 | 126 |
| Mount Tom Price | 22 41 | 117 47 | 33.47 | 134 |
| Norseman | 32 12 | 121 47 | 29.47 | 118 |
| Northam | 31 39 | 116 40 | 34.58 | 138 |
| Onslow | 21 38 | 115 07 | 36.13 | 145 |
| Port Hedland | 20 18 | 118 35 | 32.67 | 131 |
| Rawlinna | 31 01 | 125 20 | 25.92 | 104 |
| Southern Cross | 31 14 | 119 19 | 31.93 | 128 |
| Wagin | 33 19 | 117 20 | 33.92 | 136 |
| Wiluna | 26 35 | 120 14 | 31.02 | 124 |
| Wyndham | 15 28 | 128 06 | 23.15 | 93 |
| Yampi Sound | 16 08 | 123 36 | 27.65 | 111 |

# Places of Astronomical Interest

Following is a list of places of astronomical interest. These facilities cater to the public in regards to tours and/or displays. Prices are subject to change. Links to all of the web sites listed in the following Places, Courses and Societies sections can be found on the Quasar Publishing site (www.quasarastronomy.com.au)

## NEW SOUTH WALES and ACT

### THE AUSTRALIA TELESCOPE – NARRABRI ARRAY

The Australia Telescope operates in the radio region of the spectrum. It essentially uses high technology to combine the signals from a number of dishes, or elements, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array, located at the CSIRO's Paul Wild Observatory near Narrabri, is the heart of the telescope. It consists of six 22m dishes, five of which are spaced along a 3km track with the sixth a further 3 km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations.

Address: Locked Bag 194 Narrabri, NSW 2390
Hours: 8am to 4pm daily (not staffed weekends, except school holidays).
Cost: No charge to visit, bookings appreciated for groups.
Contact: Tim Kennedy (02) 6790-4070.
Email: Tim.Kennedy@csiro.au
Web: www.nar.atnf.csiro.au/

### GROVE CREEK OBSERVATORY

This observatory is located 60km south of Bathurst. The facility caters for amateur astronomers who are looking to use large aperture telescopes under very dark skies. The facility boasts a C-14, two 12.5 inch Newtonians and a Meade 10 inch LX-200 with astrophotography and CCD equipment. The observatory has on-site accommodation, sleeping up to 10 people.

Cost: $120 per person/per night all-inclusive (conditions apply).
Contact: Steven Williams on (02) 6368-8611 or (02) 9438-1757
Email: info@gco.org.au
Web: www.gco.org.au/

### BOWEN MOUNTAIN OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (NW of Sydney). It houses a 40cm Dobsonian telescope. The observatory is open on Friday and Saturday nights (not every week). Visitors are welcome.

Contact: Adrian Saw (02) 4572-1568
Email: secretary@asnsw.com

### DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. It offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments, a 6-inch refractor and a flat screen planetarium.

Hours: Winter: 7-10pm, Summer: 8.30-11pm, or by appointment. Coaches and schools welcome.
Contact: Mark Monk (02) 6345-1900 or fax (02) 6345-1920
Email: darbysob@tpg.com.au

### LINDEN OBSERVATORY

WSAAG (Western Sydney Astronomy Group) holds two observing nights a month, where anyone can drop in and look through their telescopes. Observing nights are usually held on Saturdays closest to the New Moon. Dates can be obtained by contacting Brett White or by visiting the WSAAG website.

Address: 105 Glossop Road, Linden, 2778
Cost: Donation to Linden Trust @ $5.00 per person.
Contact: Brett White (bwhite@acay.com.au)
Web: www4.tpgi.com.au/users/wsaag/FindUs.html

### GILGANDRA OBSERVATORY

The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It provides a 31cm Newtonian reflector for public use. Tours of the night sky are held each night except Sundays (also during school holidays Sunday nights and during the day, noon till 4pm). Booking is advised.

Address: Willie Street, Gilgandra, 2827
Hours: 7pm to 10pm (daylight saving 8:30pm to 10pm)
Cost: Adults $8, pensioners $6, children $5, family $20.
Contact: (02) 6847-2646 fax: (02) 6847-2845
Email: mail@gilobs.com.au
Web: www.gilobs.com.au/

### GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two buildings house 41cm and 35cm telescopes. Visitors are welcome any Thursday nights, with guest speakers on the 1st Thursday. The society also runs regular open nights for the general public. In 2003, open nights are tentatively scheduled for the First Quarter Moon weekend in August.

Address: Cnr. Green Point & Caravan Head Roads, Oyster Bay
PO Box 31 Sutherland 1499
Cost: no charge for visitors
Contact: Secretary (02) 9589-1014 (voicemail phone/fax)
Email: sasi@ozemail.com.au
Web: members.ozemail.com.au/~sasi/

### THE CANBERRA SPACE DOME AND OBSERVATORY (ACT)

The Canberra Space Dome (Planetarium) is a virtual reality star theatre. Experience night sky simulations, interplanetary space flight, and explore the night sky. The Observatory features research-grade telescopes under domes.

Address: Hawdon Place, Dickson (off Antil Street)
Hours: Tuesday to Saturday evenings (phone for session times), bookings essential.
Cost: per facility: $8.50-adult, $6.00-child/student/senior, $24.00-family (2 adults + 2 children, extra child $4 each)
Contact: Phone: (02) 6248-5333 Fax: (02) 6249-7238
Email: planetarium@ctuc.asn.au
Web: www.ctuc.asn.au/planetarium/

### KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE

Located on the border of the Central Coast and Lower Hunter; the centre is no more than 2 hours from most Sydney and Newcastle suburbs. Koolang's telescopes operate 7 days and nights a week. Bookings are essential. Koolang staff have also developed curriculum and theme based presentations to cover all school levels.

Address: Koolang Observatory, George Downes Dr. Bucketty
Hours: Daytime solar viewing shows and display centre visits 6 days (closed Wednesday), 10am to 1pm and 3pm to 5pm. Night shows (2 hours) – Friday and Saturday nights (7 nights for groups.) Night shows start about an hour after sunset. Starting times vary, and booking is essential.
Cost: Public night shows: adults $11; concession; $9.50; child $8. Day shows: adults $5; concession $4; children $3; group discounts(15+) available. Special prices/hours for schools.
Contact: (02) 4998 8216, fax (02) 4998 8580
Email: staff@koolang.com.au
Web: koolang.com.au/

### NEPEAN OBSERVATORY

The Nepean Observatory of the University of Western Sydney is open to both the public and school groups. The hands-on programs cover space, astronomy, model rocketry and general science. Located at Werrington North on the Penrith Campus, it has a computer controlled 0.6m research telescope as well as smaller telescopes for public viewing.

Cost: $10 adult; $5 child/concession; $20 family (2 adults + 2 children)
Contact: Phone Roslyn McCourt (02) 4736 0135
Email: r.mccourt@uws.edu.au
Web: www.uws.edu.au/observatory/

### SKYWATCH OBSERVATORY AND ASTRO GOLF

This public observatory is in Coonabarabran, which is also the home of the Siding Spring Observatory. It is on Timor Rd, 2km west of the clock tower. During the day the exhibition features hands-on activities, a theatrette, computers and displays. At night there is guided telescope viewing. There is also Astro Golf, an 18 hole mini-golf course and light refreshments are available

Hours: 2pm to 5pm (closed during the day in February) Night-time hours vary. Bookings not required, but appreciated. Groups welcome but please book ahead. Open every day except Christmas day.
Cost: Adult $12.10, child/pensioner $7.15, family $33.00
Contact: Karl Rafferty (02) 6842-3303 fax: (02) 6842-2978
Email: astro@skywatchobservatory.com
Web: www.lisp.com.au/~skywatch

### PARKES RADIO TELESCOPE

The observatory is located on the western plains of NSW, 20km north of Parkes (just off the Newell Highway). This landmark radio telescope is just over 40 years old, but still considered to be one of the best single dish radio telescopes in the world. It also functions as part of the CSIRO Australia Telescope Array. As well as a great view of the telescope, its visitor's centre has upgraded its displays and audiovisual presentations. There is also a freely available public picnic area, with a large shelter and gas barbecue facility. Souvenirs and educational material are available.

Address: Visitors Centre, Radio Telescope, Newell Hwy.
Hours: 8:30am to 4:30pm – daily except Christmas & Boxing Day
Cost: Admission to the visitor's centre is free. A modest charge is made for the audiovisual presentation.
Contact: (02) 6861-1777
Email: rtwardy@atnf.csiro.au
Web: www.parkes.atnf.csiro.au/visitors_centre/

### DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. Stage one of the observatory is running, which includes viewing the night sky through 3 x 300 mm Schmidt Cassegrain telescopes and large binoculars. Slides of the Universe, displays, videos and a well stocked gift shop are available.

Address: 13L Camp Rd (PO Box 308) Dubbo NSW 2830
Hours: Open daily (except Christmas) from 10am until late. Bookings essential for night sessions.
Cost: Adults $13.50; family of four $38.50. Concession, school and tour groups welcome
Contact: Peter Neilson (manager) (02) 6885 3022 Fax (02) 6885 3012
Email: dubbobs@hwy.com.au
Web: www.hwy.com.au/~dubbobs/

### BIG BADJA OBSERVATORY

Situated on a dark site 20km east of Cooma, the 3.4m domed observatory houses a 25cm telescope. Small groups are welcome by appointment and asked to make a donation direct to the Fred Hollows Foundation. Open most suitable evenings during the year.

Address: Numeralla Street, Numeralla, NSW
Contact: Robert McDonald (02) 6453-3221
Email: bigbadja@ozemail.com.au

### MAGELLAN OBSERVATORY

This facility is at Lake Bathurst, 30km south of Goulburn. This well equipped observatory has accommodation and a variety of telescopes, which includes a computerised 46cm telescope (NGT18) in a dome. It also has some CCD equipment and a Hydrogen Alpha filter for viewing the Sun. An astrophotography rig is available for hire. For those travelling by train, your hosts will even pick you up from Goulburn station.

Address: Lot 48 Covan Creek Rd Lake Bathurst 2580
Contact: Zane and Fiona Hammond (02) 4849-4489
Email: magellan@goulburn.net.au
Web: www.goulburn.net.au/~magellan/

### CANBERRA DEEP SPACE COMPLEX (TIDBINBILLA)

The Complex is located 40km southwest of Canberra (Tourist Drive 5). It is a major link in NASA's Deep Space Network. Tidbinbilla sends and receives radio signals from distant spacecraft as they explore our Solar System. The centrepiece is the 70-metre antenna. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is a Moon rock. There is also the Moon Rock Cafe and Giftshop, where meals and souvenirs are available.

Address: Tourist Drive 5, Discovery Drive (off Paddy's River Rd), Tidbinbilla
Hours: 9am to 5pm, 7 days per week (8pm daylight saving time).
Cost: Entry to the Canberra Space Centre is free.
Contact: (02) 6201-7880
Email: cdscc-prc@anbe.cdscc.nasa.gov
Web: www.cdscc.nasa.gov/

### WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive exhibits, demonstration theatre, and a gift and resource shop. The BHP Star Theatre has a state of the art Zeiss ZKP3 star projector. The Duke Energy Observatory houses a computer controlled telescope under a dome which is used to observe the Sun and stars.

Address: Science Centre, Squires Way, Wollongong NSW 2522
Hours: 10am to 4pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Cost: Child $6, concession $8, adult $9.50. Discount on planetarium show tickets when purchased with general entry
Contact: (02) 4286-5000, fax: (02) 4283-6665
Email: Kim_Noble@uow.edu.au
Web: www.uow.edu.au/science_centre/

### KINGS TABLELAND OBSERVATORY

The observatory is located in the Blue Mountains at Wentworth Falls. It offers dark skies while still close to Sydney. It is open to any interested people or groups. There is a flat screen planetarium and two modern telescopes, housed in a dome. Classes for the Nepean Community College are also conducted including workshops on the night sky, use of star charts, astrophotography and telescopes. It is also open on Saturday and Sunday from 10am to 4pm for Solar Observing.

Hours: Flexible to meet demand
Contact: Roger North, Sybil Barber (02) 4757-2954
Email: north.barber@bigpond.com

### SIDING SPRING OBSERVATORY

Siding Spring is home to 8 telescopes, including the Anglo-Australian Telescope with a 3.9 metre mirror – the largest in Australia. Siding Spring nestles into the Warrumbungles at the entrance to the national park, 30 minutes west of Coonabarabran. The Exploratory at Siding Spring offers scale models, videos and interactive computers and much more. Guided tours are available most school holidays. Bus tours are available on booking. An open day is generally held in October.

Hours: 9:30am to 4:00pm daily except Christmas Day.
Cost: Exploratory: Adult $5.50, Child/Pensioners $3.50, Family $13.50
Tours: Adult $11.00, Child/Pensioner $9.00, Family $27.00
Contact: Ph (02) 6842 6211, Fax (02) 6842 6226
Email: juls@mso.anu.edu.com.au
Web: www.sidingspringexploratory.com.au/

### MACQUARIE UNIVERSITY OBSERVATORY

Located on the Macquarie University Campus at North Ryde, this observatory is open to the public every Friday night. Astronomy students will guide you with a range of telescopes. On cloudy nights their program includes slide shows and Solar System demonstrations.

Hours: 8.30pm to 10pm (Nov – Mar); 7.00pm to 8.30pm (Apr – Oct)
Cost: $5 per person (subject to variation)
Contact: Lesa Moore (Mob) 0427 4333 88
Email: StarryLady@hotmail.com
Web: members.ozemail.com.au/~starrylady/

### SYDNEY OBSERVATORY

This is Australia's oldest existing observatory – being used to view the southern sky for over 140 years. Situated on Observatory Hill, and overlooking Sydney Harbour, the observatory is an important site in the nation's early scientific history. It is now part of the Powerhouse Museum. There are interactive displays and films on astronomy as well as the exhibition 'By the light of the Southern Stars'. Night tours include exhibitions, lectures, films and stargazing through the observatory's telescopes. On weekends, visitors can observe the Sun through a safely filtered telescope (weather permitting).

Address: Watson Road, Observatory Hill, The Rocks, Sydney
Hours: 10am to 5pm, except Christmas Day. Night sessions are held every night of the week. Bookings required for evening tours.
Cost: Daytime entry free. Night-time entry – $10 adults, $5 students/concession, $25 families.
Contact: (02) 9217-0485
Email: observatory@phm.gov.au
Web: www.phm.gov.au/observe/

### BATHURST OBSERVATORY

This observatory is a new facility located 10km from Bathurst. Their dome houses a 14-inch telescope to view the dark rural skies. They also have a radio telescope for listening to signals from the Milky Way. Accommodation for individuals or groups is available at the adjacent Rossmore Park. The local Centaurus Astronomical Society has regular meetings at the observatory as well.

Address: Rossmore Park, 624 Limekilns Road, Bathurst 2795
Hours: The observatory is open every clear night of the year (except Christmas Eve, Christmas Day and Boxing Day) with tour time varying depending on the season.
Contact: Ray and Cindy Pickard on (02) 6337 3988
Email: info@bathurstobservatory.com.au
Web: bathurstobservatory.com.au/

### THE UNIVERSITY OF NSW OBSERVATORY

The university opens its observatory to the general public on most Friday nights for viewing sessions, regular astronomy talks and a visit to the university's Mini-Planetarium. Bookings are also available for school groups on other nights and group discounts apply. Holiday programs are also organised. It is possible to join SUNS, the 'Science at UNSW' society. Activities are suitable for all ages.

Contact: Outreach Manager (02) 9385-2942
Email: outreach@science.unsw.edu.au
Web: www.science.unsw.edu.au/school/student/events.asp

### CHESLEIGH HOMESTEAD

The homestead offers accommodation for couples to large groups. 'Chesleigh' offers observing to its patrons through its 12-inch reflector telescope taking full advantage of its clean, dark sky site.

Address: Chesleigh Homestead, Hill End Road, Sofala, NSW 2795
Contact: Mike and Jan Cody Ph: (02)6337 7077 Fax: (02)6337 7092
Email: cody@ix.net.au
Web: www.sofala.net.au/astronomy.html

### MT. STROMLO OBSERVATORY (ACT)

This is the oldest fully operational research observatory in Australia. The Visitors' Centre is full of interactive exhibits for all ages. A heliostat allows visitors to safely view sunspots. Professional astronomers and explainers conduct hourly slide shows and tours of the massive 74-inch reflector. Mt Stromlo is also home to a number of other telescopes dating back to 1868. Astronomers run regular public observing nights (phone for details). School or special interest groups of 10 or more can visit at night by appointment. There is also 'Star Wares', an astronomy-related gift shop and the Red Belly Black Café which offers a unique setting for meals, and special functions. Visitors can enjoy the views from the sundial garden and outdoor BBQ area. To assist its education programs, Mt Stromlo maintains a tax-deductible 'Adopt-a-Star' program.

Address: 15 minutes from Canberra City, Mt Stromlo Observatory, off Cotter Road, Weston Creek, ACT (On Tourist Drive 5)
Hours: Mt Stromlo Observatory Visitors' Centre is open every day (except Christmas) 9:30am-4:30pm.
Cost: Different tour packages, $6-$12 adult, $5-10 concession, $3.50-$7 child, $15-$25 family.
Contact: Visitors' Centre (02) 6125-0232; Fax (02) 6125-8045
Star Wares Gifts (02) 6125-8903
Red Belly Black Cafe (02) 6287-1518
Email: msovc@mso.anu.edu.au
Web: www.mso.anu.edu.au/msovc/

### PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association, is situated in Rotary Park (opposite Town Beach) Port Macquarie. It is open to the public on Wednesday and Sunday evenings at 7.30 pm (8.15pm, daylight saving). Lectures are given plus viewing of celestial objects. Special nights can be arranged for groups. They own 2 Celestron telescopes. Adult Education Classes are also held (contact Dave Reneke (02) 6585-2260).

Address: Port Macquarie Astronomical Association Inc
PO Box 1453, Port Macquarie NSW 2444
Contact: Jim Daniel (02) 6583-1933 or Peter Hall (02) 6586-1095
Email: jaidanl@bigpond.com.au

### CAMPBELLTOWN ROTARY OBSERVATORY

The Observatory is a research and teaching observatory. It is the home of the Australian Optical SETI Project (or OZ OSETI for short). It is the only dedicated optical SETI project in the southern hemisphere. It is searching for ETI in sun-like stars, globular clusters and some galaxies. It uses state of the art coincidence circuits to eliminate any false alarms. The Project Director is Dr Ragbir Bhathal.

The observatory is also used for teaching undergraduate astronomy and is opened to the public on Astronomy Nights held four times a year in conjunction with the Macarthur Astronomical Society.

Contact: Dr Ragbir Bhathal
Email: r.bhathal@uws.edu.au

## QUEENSLAND

### THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Mt. Coot-tha Botanic Gardens in Brisbane. Regular 45-minute programmes are presented. The 'Cosmic Skydome' has an artificial sky projected onto the interior of a 12.5m dome. The foyer and gallery areas contain interesting astronomical displays. The planetarium also has an observatory with 15cm and 41cm telescopes. Observatory sessions must be pre-booked.

Hours: Public shows are presented from Wednesday to Sunday. For bookings phone (07) 3403 2578, 12 noon to 7pm, Wed-Sun. Not recommended for children under 6. School shows are on a booking basis only. Display areas are free, but admission charges apply to shows.
Contact: (07) 3403-2578
Email: ACBP@brisbane.qld.gov.au
www.brisbane.qld.gov.au/community_facilities/leisure/planetarium/index.shtml

### SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is only a 45-minute drive from Surfers Paradise. The Observatory is open to the general public, astronomical

groups, schools, and researchers by appointment. This facility has a C14, C11, 4.5-inch refractor, CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing. There is also a fully licensed restaurant.

Address: 2319 Springbrook Road, Springbrook, 4213.
Cost: by donation
Contact: Andre Clayden (07) 5533-5200, fax (07) 5533-5457
Email: springbrook@iprimus.com.au
Web: www.maguires.com/astronomy/

### THE GREAT BARRIER REEF OBSERVATORY

Situated on Hamilton Island, the observatory is open to the public during the dry months from April to November. Sessions are held on Tuesday, Thursday and Sunday evenings, special openings on request. The observatory enjoys dark skies, operates five telescopes, and is staffed by members of the island's astronomical group. Viewing is complimentary.

Address: PO Box 40, Hamilton Island Qld 4803
Contact: Ray Johnston (07) 4946-8686
Email: star@whitsunday.net.au

### OUTBACK QUEENSLAND SKYWATCH

This public observatory is located in Charleville on Cunnamulla Road, near the airport. By early 2003 it should become the 'Charleville Cosmos Centre'. They have a telescope garden and 'Galactic Theatre'. Booking is essential.

Address: PO Box 63, Charleville, 4470
Contact: Visitor Information Centre (07) 4654-3057
Email: murweh@bigpond.com
Web: www.action-graphics.com.au/matilda_country/html_pages/charleville/charlevilleskywatch.html

### SUNDOWN OBSERVATORY

The Observatory is approximately 250km southwest of Brisbane, on a dark sky site 4 km off the New England Highway. The main instrument is a 46-cm telescope. The visitor's centre has space for visitor telescopes. There is on site accommodation for up to 8 people (ring for charges). Bookings are essential.

Address: Sundown Road, Ballandean, Qld, 4382.
Hours: Open nightly from 8pm (subject to weather)
Cost: Adults $8 each; groups of 10 or more $7 each, School children (primary and high) $5 each.
Contact: phone/fax (07) 4684 1192
Email: observatory@flexi.net.au
Web: www.flexi.net.au/~kxelay/

### ALLOWAY OBSERVATORY

The observatory, which is 6 km outside of Bundaberg, is operated by the Bundaberg Astronomical Society. The dome houses a 480mm telescope. A recent update has included computerised CCD imaging technology. As well as regular Friday night viewing and information evenings, interested persons or groups can visit any suitable night by prior arrangement.

Address: PO Box 4221, South Bundaberg Qld 4670
Contact: Don Gray: (07) 4152-3801 or Peter Rehbein: phone/fax (07) 4159-3230 or answering service (07) 4159-7232
Email: iluka@widebay.net.au
Web: www.angelfire.com/al/AstronDirectory/

## SOUTH AUSTRALIA

### UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM

The planetarium has sessions for primary and secondary schools and the general public, by appointment only. A public open session is on the first Saturday of the month at 3pm. Live concerts are also held in the planetarium (see ching.apana.org.au/~oliri/planet.html)

Address: University of SA, Building P, Mowson Lakes Campus
Cost: $4.40 adults, $3.30 students and concession
Contact: (08) 8302-3138
Email: Christine.Moore@unisa.edu.au
Web: www.unisa.edu.au/planetarium/

### INTERNATIONAL CANGAROO PROJECT (WOOMERA)

The Cangaroo III telescopes are used for high-energy astrophysical studies of pulsars, supernovae, gamma ray bursts and black holes. The telescopes are located inside the Woomera Security Area. There is a display in the Woomera Heritage Centre. An idea of the activities, including a picture gallery, is available on the web site.

Contact: Dr Roger Clay, University of Adelaide (08) 8303 5113 Fax (08) 8303 4380
Email: rclay@physics.adelaide.edu.au
Web: www.physics.adelaide.edu.au/astrophysics/cangaroo.html

### THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury (Adelaide). It was formed primarily for students of the school with an interest in astronomy, but anyone interested in astronomy is encouraged to join. There are two main telescopes and a classroom. During the day solar observations are made.

Email rperkins@theheights.sa.edu.au
Web: www.theheights.sa.edu.au/

## TASMANIA

### LAUNCESTON PLANETARIUM

The planetarium is in the Queen Victoria Museum, Wellington St.

Address: Queen Victoria Museum, Wellington St, Launceston, 7250
Hours: Tuesday to Friday 3pm, Saturday 2pm and 3pm. During government school holidays, shows run Monday to Saturday 2pm and 3pm. Group bookings by arrangement.
Cost: $3 Children (under 15), $5 adults and $12 family (children under 5 years old are not admitted). 50% discounts available to Museum admission ticket holders.
Contact: (03) 6323-3777
Email: martin@qvmag.tas.gov.au
Web: www.qvmag.tas.gov.au/planetarium.html

### PLANETARIUM IN HOBART

This planetarium is in Antarctic Adventure, Salamanca Square, Hobart. It consists of a 6-metre geodesic dome, seating 30 people. There is no age limit on entry. Shows run hourly 6 times per day. Antarctic Adventure offers educational and astronomical presentations for school groups. Also the Antarctic Gift Shop sells astronomy-related items.

Address: 2 Salamanca Square, Hobart Tas 7000
Hours: Open every day (except Christmas Day) from 10am to 5pm. Shows are hourly and run for about 40 minutes.
Cost: Entry (to Centre) Adult $16, Concession $13, Child $8 (4 and under free), and Family $40
Contact: 1800 350 028
Email: sales@antarctic.com.au
Web: www.antarctic.com.au/

### KING ISLAND OBSERVATORY

Take advantage of King Island's beautiful dark nights to enjoy a guided tour of the heavens. A 6-inch refracting telescope is used for observing.

Address: Rifle Range Road, Currie, King Island, 7256
Hours: Shows are nightly (except Wednesdays) when the sky is clear and run for about 60 minutes.
Contact: Phone: (03) 6462 1319
Email: kiobservarory@bigpond.com.au

## VICTORIA

### MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages. The planetarium is open 7 days a week from 10am and runs a special evening session every Thursday at 8pm. Bookings are essential.

Address: 2 Booker St, Spotswood, Victoria
Cost: see web site
Contact: (03) 9392-4800
Email: mvplanet@museum.vic.gov.au
Web: www.museum.vic.gov.au/planetarium/index.html

### BALLARAT MUNICIPAL OBSERVATORY

The observatory contains three historic telescopes: The Jelbart – a 125mm refractor; the Oddie – a 220 mm Newtonian and the Baker Great Equatorial Telescope – a 650 mm Newtonian, which was commissioned

in 1886. There are a number of other telescopes including a computer enhanced, disabled-access 406mm Cassegrain. The observatory is open most Friday and some Saturday nights. Daytime tours can also be arranged by appointment.

Contact: John Hastie (03) 5332-7526.
Email: bas@cbl.com.au
Web: observatory.ballarat.net/

### MELBOURNE OBSERVATORY

The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. There is a self-guided tour available from Friday to Monday. There are also Tuesday evening presentations 'The Night Sky Experience'. Bookings are essential for both programs (03) 9252-2429. The Royal Botanic Gardens Melbourne also has a visitor centre, function rooms, Observatory Cafe and a Gardens' Shop.

Address: Birdwood Avenue, South Yarra, 3141
Cost: $15.40 adult, $11 conc., $37.40 family (2 adults + 2 children)
Contact: Visitor Centre, Observatory Gate (03) 9252-2300
Email: rbg@rbg.vic.gov.au
Web: www.rbg.vic.gov.au/visinfo/whatson/index.html

### ASTROTOURS (MELB.)

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during the school holidays.

Address: Room AS406 on the fourth floor of the Applied Science building, enter from Burwood Road.
Contact: Asha Rawlings, phone (03) 9214 5569, fax (03) 9214 8797
Email: astrotour@swin.edu.au
Web: astronomy.swin.edu.au/astrotour/

## WESTERN AUSTRALIA

### PINGELLY HEIGHTS OBSERVATORY (ASTRO VENTURES)

An educational facility specialising in the presentation of astronomical information and the viewing of the night sky. They provide a wide range of talks and observing experiences through their telescopes. The observatory is one and a half hours drive from the Perth metropolitan area. The property is 'Sunarise' Lot 11 Pingelly Heights (off Aldersyde Road), Pingelly. 'Astro Ventures' caters especially for primary and secondary schools, youth groups, scout and guide units, recreational and sporting groups, community organisations, private parties and others on request.

Address: PO Box 512, Pingelly WA 6308
Hours: Night Programme starts Summer: 7.30 pm; Winter: 7.00pm Fri, Sat and Sun, other nights by appointment.
Cost: Adults: $20, Children/Pensioner/Concession: $10, Family (2 adults + 2 children): $50
Contact: For further information and reservations ring Susie or Trevor on (08) 9887 0088, 0407 380 922 or write to Astro Ventures.
Email: astroventures@westnet.com.au
Web: www.westnet.com.au/astroventures/

### SOUTHERN CROSS COSMOS CENTRE

Astro Nights (formerly of the Golden Grove Observatory) is a recently launched facility called the Southern Cross Cosmos Centre (SCCC), situated in the Shire of Gingin, an hour north of Perth. Each evening session starts with a short presentation, followed by an hour of viewing through a number of different telescopes.

Hours: The observatory is open each Friday and Saturday from October to April, (inclusive) with the evenings running from 7:30pm to 10:00pm. Other evenings are available on request but minimum charges apply. Bookings are essential and can be made by contacting 'Astro Nights'
Contact: (08) 9246-5782
Email: sccc@bigpond.net.au
Web: www.gravity.uwa.edu.au/SCCC/sccc.htm

### PERTH OBSERVATORY

Situated in the Darling Ranges, 40km inland from the West Coast, Perth Observatory conducts astronomical research and educational activities. As part of the observatory public education program, several telescopes from 10" to 16" are available for use by visitors. Astronomers also take telescopes to conduct Field Nights at various locations. A portable display is often used at public libraries and schools. There is a museum displaying instruments, from the old observatory (founded in 1896), paintings and current photographs.

Hours: Normal office hours: 8am – 5pm
Star Viewing Nights: Times vary during the year. No tours May – Sep. inclusive. Bookings essential. Tour lasts 1.5 hours approx.
Daytime Guided Tours: 10am, 12:30pm, or by appointment – bookings essential. 1st Sunday of the month 2pm, no booking needed.
Cost: Contact the observatory for details.
Contact: Phone: (08) 9293-8255 Fax: (08) 9293-8138 Info Line: (08) 9293-8109
Email: perthobs@iinet.net.au
Web: www.wa.gov.au/perthobs/

# ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following lists astronomy courses, events, magazines and radio programs for 2003. This list is by no means intended to be exhaustive. Across the country there are no doubt many other evening courses held at various universities and colleges. Enquiries from the general public are most welcome. A number of the amateur astronomical societies also provide an invaluable service to public education by their lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change.

## GENERAL

### INTERNATIONAL DARK-SKY ASSOCIATION

IDA's goal is to preserve and protect the night-time environment and our heritage of dark skies through quality outdoor lighting.

Address: 32 Carina Road, Turramurra, NSW 2074
Contact: Reg. R. Wilson (Director, Australian Representative) Phone/Fax:61 (02) 9488 7078
Email: regrw@acay.com.au
Web: www.Darksky.org/

### SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY

SOLIS is an active group with the aim of bringing the increasing sky glow to a standstill.

Address: PO Box 3002, North Turramurra NSW 2074
Contact: Ken Petersen (02) 9634-1736
Email: solissydney@telstra.com
Web: solissydney.tripod.com/

## FESTIVAL OF ASTRONOMY JULY 2003

Australia will be the centre of world astronomy in July, as up to 2000 research astronomers descend on Sydney to take part in the International Astronomical Union's General Assembly. A Festival of Astronomy with lots of public events will ensure that astronomy is at the focus of public attention in Sydney and other places in Australia at the same time.

Events planned for Sydney include a repeat of the phenomenally successful public observing night held at North Sydney Oval in June 2002. This year it will be on Saturday 19 July. In other events the world's best known astronomers will be giving public lectures in Sydney and, if possible, in Melbourne, Perth and other cities around the country. There will also be astronomy exhibitions, a weekend astronomy expo and maybe cultural and musical events. A conference for amateur astronomers is to be held on the weekend of 12–13 July and a Teacher's Professional Day on Saturday 26 July.

Some of the events will not be finalised until close to the date. For updated information please contact Sydney Observatory on (02) 9217 0485 or see www.mso.anu.edu.au/~iauxxv/events.shtml as well as the Quasar website.

### FUNDING FOR ASTRONOMICAL RESEARCH

The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateur astronomers and students. Funds are made available annually. An amount of $3,500 has been made available for grants in 2003. Application forms and further information concerning eligibility of applicants and obligations of successful applicants are available from the contact below.

Contact: The General Secretary
Astronomical Association of Queensland
Address: PO Box 6101, St. Lucia Qld 4067

### NACAA 2004

The National Australian Convention of Amateur Astronomers is a biennial meeting normally held over Easter. The 2004 gathering will be in Hobart, hosted by the Astronomical Society of Tasmania. Contact the society for details.

Web: www.southcom.com.au/~shevillm/ast/

### U3A ONLINE – INTRODUCTION TO ASTRONOMY

University of the third age (U3A) now offer an astronomy course online. For extra details contact Byron at jump.to/lunar-eclipse/

Contact: Byron Soulsby
Email: info@u3aonline.org.au
Web: u3aonline.edna.edu.au/course_summaries/astronomy_summ.html

### TUTORIALFIND – ASTRONOMY TUTORIALS

Web page that is a search engine for tutorials – in this case Astronomical tutorials. www.find.com.au/tutorials/education/astronomy/

### LABNOTES - TIPS FOR TEACHERS, ASTRONOMY & SPACE

Articles are listed and tips have been written for these articles. These tips will help you run learning activities, set homework, and guide student research. For educational purposes, you may print off pages, photocopy them and hand them to your students.

Web: www.abc.net.au/labnotes/tips/topics/astronomy.htm

## PUBLICATIONS

### SKY AND SPACE MAGAZINE

This astronomy and space exploration magazine is produced for Australia and New Zealand. This full-colour magazine is bimonthly and available through newsagencies or by subscription. Sky & Space also produce a magazine called 'Southern Astronomy'. It is available only by subscription.

Address: Sky and Space Publishing
PO Box 1690, Bondi Junction NSW 1355
Contact: (02) 9369-3344, fax (02) 9369-3366
Email: info@skyandspace.com.au
Web: www.skyandspace.com.au

### ASTROCARDS

The Astronomical Society of NSW runs an information service called 'Astrocards'. This service alerts subscribers to new observable discoveries such as comets, novae, supernovae, bright near-Earth asteroids, or unusual planetary phenomena. The service is available via email or letter and is open to all amateurs.

Cost: $10 for 10 'cards', subscriptions payable to the ASNSW
Contact: Greg Bryant, 7 Richards Close, Berowra NSW 2081
Email: gchbryant@hotmail.com
Web: gchbryant.tripod.com/

### COMET TALES

This quarterly publication covers a variety of topics including the latest information on comets. Deep-sky observing, monthly sky highlights, and Australian astronomy news (including amateur) are broadly covered.

Cost: $14 per year (payable to Greg Bryant, credit card accepted)
Contact: Greg Bryant, 7 Richards Close, Berowra NSW 2081
Email: gchbryant@hotmail.com
Web: gchbryant.tripod.com/

### PERIHELION COMET QUARTERLY

This bulletin, for comet observers, is published by David Seargent. It is a 16-page newsletter that carries articles of interest to the comet enthusiast, plus new discoveries and ephemerides of comets appropriate to southern hemisphere observers. There are also special bulletins which give discovery details for bright comets, visible from Australia.

Cost: $12 (for 4 issues per year), $15 also includes special bulletins (cheques payable to Karagi Publication).
Address: PO Box 204, The Entrance NSW 2261
Contact: David Seargent
Email: seargent@ozemail.com.au

## NEW SOUTH WALES and ACT

### ASTROFEST – COONABARABRAN

Activities on this weekend include: observing, lectures, tour of Siding Spring and Skywatch Observatories, and Science in the Pub (subject to availability). This event is hosted by the Warrumbungle Mountain Motel. Dates for 2003 were uncertain at time of publication. The 2002 Astrofest was held in early November.

Contact: Mark Boyd (02) 6842-1832
Email: warrumbunglelodge@bigpond.com.au

### ASTRONOMY COURSES – COONABARABRAN

At the time of publication, it was unknown whether these courses would be held in 2003 (they are dependent on the level of interest). Contact Mark for details (see Astrofest above). They are organised by the Warrumbungle Mountain Motel.

### VOYAGER PLANETARIUM

This is an Astronomy Science Education service. The planetarium visits schools and community groups in the Sydney metropolitan area. Programs are available for K to 12 or customised to suit. The service also provides astronomical activities for teachers and students. Authorised by the NSW Department of Education.

Contact: Don Whiteman (02) 9642-1574, mobile 0414 642 157
Email: mwtscope@optusnet.com.au

### MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include: a guest speaker, telescopes operated by local amateurs and commercial stands. They are held twice each year, normally in March-April and September-October (a Saturday night around First Quarter Moon) at Macquarie University (off Epping Rd, North Ryde, Sydney) and commences around 6.30pm.

Fees: Adults $8, Children $4, Family $20
Address: Dept of Physics, Macquarie University NSW 2109
Contact: Dr Alan Vaughan
Email: alanv@ics.mq.edu.au
Web: www.ics.mq.edu.au/~alanv/mqastro.htm

### MACQUARIE UNIVERSITY FOUNDATION FOR ASTRONOMY

The FFA acts as a support group for astronomy activities at Macquarie University. Through its activities it supports community education in astronomy.

Fees: $20 ($10 students)
Address: Dept of Physics, Macquarie University NSW 2109
Contact: Dr Alan Vaughan
Email: alanv@ics.mq.edu.au
Web: www.ics.mq.edu.au/~alanv/ffa.htm

### MACQUARIE UNIVERSITY PLANETARIUM

Macquarie University now operates a mobile planetarium. This simulates the appearance of the stars in the night sky. It can be set up on campus or can be taken to schools. The planetarium seats a maximum of 20 adults.

Address: Dept of Physics, Macquarie University NSW 2109
Contact: Dr Alan Vaughan (02) 9850 8904
Email: alanv@ics.mq.edu.au

### SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. This is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 400 people. The 2003 SPSP will be held March 28–30. Contact the ASNSW for details.

Email: secretary@asnsw.com
Web: www.asnsw.com/

### PRACTICAL ASTRONOMY (SASPAC) (SYDNEY)

A practical astronomy course for beginners and interested amateurs. This is an 8 week course conducted by Sutherland Astronomical Society (SAS) during Spring. Each lecture is followed by observations with the society's equipment (weather permitting).

Fees: $110 per student
Address: Green Point Observatory (Sutherland, Sydney)
Contact: Education Officer. (02) 9589-1014 (voicemail phone/fax)
Email: sasi@ozemail.com.au
Web: members.ozemail.com.au/~sasi/

### BASIC ASTRONOMY COURSE (CENTRAL COAST)

Starry Lady Astronomy Services offer courses in Basic Astronomy which will run in Jan/Feb 2003.

Fees: $98 for 8-week course, including field trip to Koolang Observatory at Bucketty
Address: Kariong, NSW
Contact: Lesa Moore (02) 4340 1253
Email: StarryLady@hotmail.com
Web: members.ozemail.com.au/~starrylady/

### W.E.A. – SYDNEY OBSERVATORY COURSE

Sydney Observatory and the WEA are likely to run some beginner astronomy courses, based at the observatory, during 2003.

Contact: WEA (02) 9264-2781 for cost and timetable details.
Web: www.weasydney.com.au/

### PRACTICAL AMATEUR ASTRONOMY COURSE

Run by the Wollongong Amateur Astronomy Club, this is an 8 week beginners course. Each class consists of a one hour tutorial followed by viewing through members' telescopes.

Web: www.users.bigpond.com/paul.b/index.htm

### SKYWORKS PLANETARIUM (SYDNEY)

Skyworks is a travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. It is authorised by the Dept. of Education and was recently presented with the Frater Award. Programs are curriculum based to suit years K-12.

Contact: Geoff Zenner / Diana Zenner (02) 9610 2899, 0427 112 899, Fax (02) 9753 1898
Email: sky-works@bigpond.com
Web: www.users.bigpond.com/sky-works/

### QUESTACON STARLAB (ACT)

Starlab is an inflatible planetarium which can accommodate up to 30 students. Starlab presentations are available in Sydney, Melbourne, Brisbane and Wollongong in collaboration with other science centres.

Address: National Science and Technology Centre, Canberra 2600
Contact: Outreach Programs Bookings Coordinator (02) 6270-2800 Fax: 1800 641 171
Email: gsmith@questacon.edu.au
Web: www.questacon.edu.au/

### STAR CLASS – ASTRONOMY EDUCATION (ACT)

This part-time, home-based business offers 'Star Kids', an astronomy and space club for upper-primary aged children and includes a membership kit. Star Class also provides free regular online astronomy chats, a free email based astronomy discussion forum, and is the Australian National Centre for the 'Red Rover Goes to Mars' project.

Address: GPO Box 271 Canberra ACT 2601
Contact: Michael and Leonie MacDonald (02) 6161 0471
Email: info@starclass.com.au
Web: www.starclass.com.au/

### ASTRONOMY – THE NIGHT SKY (ACT)

The aim of this course is to help people with a casual interest in astronomy develop this interest a little further. It will balance actual observing with classroom discussions, covering a wide range of topics. A telescope is not required. The course takes 6 nights.

Address: The Brain Gym, Canberra College, Woden Campus, Launceston St, Phillip 2606
Contact: fax: (02) 6205 5776
Web: www.canberrac.act.edu.au/BGWoden/special/Astronomy.html

### NEPEAN COMMUNITY COLLEGE COURSES

Run at the Kings Tableland Observatory in Wentworth Falls (Blue Mountains). Contact the college on (02) 4721-5368.

### SYDNEY UNIVERSITY ASTRONOMY COURSES

The University of Sydney Centre for Continuing Education runs regular astronomy courses on the main Sydney University campus, with occasional bus tours to NSW observatories. Contact the university's Centre for Continuing Education on (02) 9351 2907 to enroll.

Email: j.obyrne@physics.usyd.edu.au
Web: www.physics.usyd.edu.au/~obyrne/cep/cep.html

## QUEENSLAND

### ASTROFEST – QUEENSLAND

The Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours northwest of Brisbane. It has a dark sky with accommodation and a C14 telescope (Stewart Observatory). Activities include: presentations from professional astronomers, awards, swap and sell, barbecue, slide shows and light sports. Astrofest 2003 (10th anniversary) will be held over the New Moon period August 23 to 31.

Contact: Mark Harvey (07) 3260 6241
Email: info@aaq.org.au
Web: members.optushome.com.au/earthlight/astrofest.htm

### BRISBANE FIELD NIGHTS

The Brisbane Astronomical Society (BAS) holds a free public field night on the Saturday nearest to the First Quarter Moon (weather permitting) at Mt Coot-tha Lookout, from 7pm to 9pm.

Address: Bris. Astro. Society, PO Box 204, Morningside Qld 4170
Contact: BAS Infoline (07) 3321-8511 (recorded information)
Email: basmail@bas.asn.au
Web: www.bas.asn.au/

### INTRODUCTION TO THE NIGHT SKY COURSE

Run by the Bundy Skywatchers several times a year as required.

Fees: $25 (Notes included)
Address: 534 Moorlands Road, Bundaberg Qld 4670
Contact: Karlene Galway (07) 4159-9674
Email: karlene@interworx.com.au
Web: www.interworx.com.au/users/karlene/

### STARGAZERS WEEK 2003

O'Reilly's Rainforest Guesthouses will likely run its annual Stargazers Week towards the end of July. Program includes telescopic views of the winter Milky Way under dark skies and solar observing.

Contact: Tony Surma-Hawes (07) 3274 5073
Email: firstlight@optushome.com.au
Web: members.optushome.com.au/firstlight/stargazers/stargazers.htm

## SOUTH AUSTRALIA

### W.E.A. COURSES

Astronomy courses will run in March, May, August and October.

Address: 223 Angas Street, Adelaide 5000
Contact: (08) 8223-1272
Email: enrolments@wea-sa.com.au
Web: www.wea-sa.com.au/

### STARLORE AND SOLAR SYSTEM ASTRONOMY

This is a one night course conducted at the Adelaide Planetarium around 5-6 times a year. The course emphasises how other cultures see the night sky including indigenous Australians and their constellations.

Contact: Paul Curnow
Email: paulc@ching.apana.org.au
Web: ching.apana.org.au/~paulc/index.html

## TASMANIA

### INTRODUCTION TO ASTRONOMY (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Canopus Hill Optical Observatory, usually twice a year in April/May and October/November.

Fees: $40 per participant
Address: Canopus Hill Observatory
Contact: Greg Burns (03) 6278-2184
Email: joroco@trump.net.au
Web: www.southcom.com.au/~shevillm/ast/

## VICTORIA

### INTRODUCTION TO ASTRONOMY (MELBOURNE)

This course is a hands-on introduction to the sky and various astronomy related subjects. Viewing sessions are included every week (equipment supplied). Held at Chisholm and Holmesglen TAFE Institutes.

Contact: The TAFEs or Chris Ellis 0412 318 125
Email: ngc4755@i.net.au

### VASTROC – Victorian Amateur Astronomical Societys' Conventions

VASTROC's are held every second year (alternating years with NACAA Conventions). Activities include speakers, workshops, poster displays, observing and the convention dinner. For information regarding the 2003 event contact a Melbourne based amateur society.

### SKYLINE

A pre-recorded information service, run by the Astronomical Society of Victoria, to cover the latest astronomical discoveries. Cost is only the phone call. (03) 9888-7130. Updated weekly or as required.

### THE SPACE SHOW (MELBOURNE)

This show is broadcast on radio station 88.3 Southern FM (88.3 MHz) 7–8 pm every Wednesday. Presented by Andrew Rennie.

Email: webmaster@southernfm.org.au
Web: www.southernfm.org.au/index.html

### C.A.E. COURSES

Beginners and advanced courses are run each semester. Contact the C.A.E. for costs and dates. See website for fees.

Address: 253 Flinders Lane, Melbourne 3000
Contact: Phone (03) 9652-0611
Email: heleng@cae.edu.au
Web: www.cae.edu.au/dept/science.htm

### AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. The net, conducted by Russell Ward, commences each Friday evening at 10pm EST on 3.543 MHz (LSB). New stations and shortwave listeners are most welcome.

### ASTRONOMY SHOW ON RADIO KLFM

The Bendigo District Astronomical Society has a monthly segment on Radio KLFM. This goes to air at 5:30pm on the Saturday before each meeting (4th Wednesday of the month). KLFM can be found on 96.5 FM Bendigo and 106.3 FM Castlemaine (Victoria, Australia). The segment can be accessed online at: www.klfm.com.au/audiovault.html

## WESTERN AUSTRALIA

### ASTRO TOURS OF THE KIMBERLEY (BROOME)

Astro Tours runs a 2 hour astronomy show in Broome during winter (April to Dec) and on Rottnest Island during summer (Jan to March). The shows are run for the general public, schools, community and private groups using a selection of telescopes and binoculars. They also run 'Outback Stargazing Adventures' which are adventure tours in more remote areas.

Address: PO Box 2537, Broome WA 6725
Contact: Greg Quicke Ph: 0500 831 111 Fax (08) 6210 1468
Email: info@astrotours.net
Web: www.astrotours.net/

### ASTRO GUIDES

Astro Guides run regular courses for beginners in Perth, telescopic viewing nights for Schools, groups and parties, packages for schools (including a 114mm telescope and instructions) and directions to build a home for your telescope. All services available outside the metro area by arrangement.

Contact: Keith Galbraith Phone/Fax (08) 9307 1353
Email: kgalbraith@optusnet.com.au

### PERTH ASTRONOMICAL RESEARCH GROUP

Web: www.parg.asn.au/

# ASTRONOMICAL SOCIETIES

The following is a list of amateur societies in Australia. A common philosophy within these organisations is the emphasis they place on public education. Enquires from anyone are most welcome. Where given, annual fees are subject to change. We are keen to keep the information in this section 'evergreen'. It would be appreciated if you could keep us informed of any changes (see p. 2 for contact details). The deadline for Astronomy 2004 will be July 1, 2003.

Please note that many societies now have web sites. Links to these can be found on the Quasar web site: www.quasarastronomy.com.au

## NEW SOUTH WALES and ACT

### ASTRONOMICAL SOCIETY OF NSW

The society holds meetings twice per month at the CSIRO, Division of Radio Physics, Pembroke Rd. (cnr. Vimera Rd), Marsfield. At ordinary meetings, professional astronomers are invited to talk. The technical meetings are less formal, where members often run discussions. The society runs two observing sites. One, an observatory at Bowen Mountain, near Richmond, west of Sydney (housing a 16 inch telescope). The other is their dark sky property Wiruna, near Ilford. This site includes accommodation, amenities and a 17.5 inch telescope. A monthly magazine Universe is also published.

Fees: $43 full, $10 junior (under 18) and $32 student (over 18), $12 for each additional family member.
Address: GPO Box 1123, Sydney, NSW, 2001
Contact: Monte Wilson (President) (02) 9913 8305
Email: secretary@asnsw.com
Web: www.asnsw.com/

### ASTRONOMICAL SOCIETY OF COONABARABRAN

Meets on the third Thursday of each month at 7:30pm at the Coonabarabran High School. The club's 15cm Dobsonian reflector is available for members to hire.

Fees: $1 joining fee plus $20 annual subscription
Address: c/- AAO Private Bag, Coonabarabran NSW 2357
Contact: Paul Cass (02) 6842-2994
Email: cpc@aaocbn.aao.gov.au

### ASTRONOMICAL SOCIETY OF THE HUNTER

The society meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday of each month at 7:30pm. The observatory houses a 16 inch telescope. They also have a club 6 inch refractor and a portable telescope which is used in the field and 'Meet The Astronomers' nights. The observatory at Altair (Mt Olive) is also available. (Phone Technical Officer Ken Charlwood (02) 6577 3220)

Fees: $20 adult, $25 family
Address: PO Box 69, Kurri Kurri NSW 2327
Contact: Col Maybury (02) 4937-4664 (ph/fax)
Email: colmay@acay.com.au

### THE NEWCASTLE ASTRONOMICAL SOCIETY

Meetings are held on the last Friday of each month (except December), at the University of Newcastle, Lecture Theatre GP, first floor of Linguistics Building at 7:30pm. Most meetings consist of a general summary of astronomy news, followed by a variety of short talks. Observing nights are organised during the year.

Fees: Family $20, single $15, student/child $8, guests $2
Address: c/- Dept. Physics,
University of Newcastle Callaghan NSW 2308
Contact: Ghul Hussain (02) 4963 4529; or
George Barnes (02) 4967 1057
Email: ggbarnes@idl.net.au
Web: www.newcastle.edu.au/nas/

### BRITISH ASTRONOMICAL ASSOCIATION – NSW BRANCH

The BAA meets at Sydney Observatory on the third Wednesday of each month, commencing at 7:30pm. At these meetings, professional astronomers are often invited as guest speakers. Regular practical workshops are also held on weekends. The BAA also publish a regular newsletter called The Astronomer's Bulletin.

Fees: $40 full, $20 junior/concession and there are family concessions for $60. There is a joining fee.
Address: Sydney Observatory, Watson Rd, The Rocks, Sydney 2000
Contact: Elizabeth Cocking (02) 9398-9705

### CANBERRA ASTRONOMICAL SOCIETY (ACT)

CAS meetings are held on the 3rd Thursday of every month (except July and December) starting at 8pm at the Duffield Building, Mt Stromlo. Meetings regularly feature guest speakers from both the amateur and professional communities. The society has a broad range of programs to support the beginner through to the very experienced amateur astronomer. Membership includes the CAS monthly newsletter 'Southern Cross'.

Address: PO Box 1338, Woden ACT 2606
Contact: John Howard (02) 6248-0552
Email: cas@enzerink.net
Web: www.mso.anu.edu.au/cas/

### HAWKESBURY ASTRONOMICAL ASSOCIATION

Meetings are held once a month on the 2nd Wednesday, commencing 7:45pm, in the Tebbutt Rooms at the Windsor Library, Dight St. Windsor. They also observe on Third Quarter and New Moon weekends. The club organises several public field nights per year and presents a basic introduction to astronomy. The HAA aims to cater for the newcomer at a basic level.

Fees: $20 adult, $30 family and $10 junior
Address: PO Box 670 Windsor NSW 2756
Contact: Adrian Saw (02) 4572-1568
Email: haa@panthers.net.au
Web: jigsaw.panthers.net.au/haa.html

### SHOALHAVEN ASTRONOMERS

Meet at the Nowra Hill School on the third Friday of each month at 7:30pm. The first Saturday of each month is a viewing night. They also have a monthly journal called – The Astroflyer.

Fees: $25 full membership.
Address: PO Box 1053, Nowra NSW 2541
Contact: Jack Apfelbaum (president) (02) 4423-2255
Email: editor@shoalhavenastronomers.asn.au
Web: www.shoalhavenastronomers.asn.au/index.html

### ILLAWARRA ASTRONOMICAL SOCIETY

Meetings are held at the Wollongong Science Centre and Planetarium on the second Tuesday of each month at 8pm. There are regular observing nights held at various sites near Wollongong.

Address: PO Box 1814, Wollongong NSW 2500
Contact: Dave Wheeler (02) 4226-3584
Email: smr@cse.unsw.edu.au
Web: members.optusnet.com.au/~smr/

### MACARTHUR ASTRONOMICAL SOCIETY

The MAS holds meetings, with guest speakers and workshops, every 3rd Monday of the month at 7.30pm at the University of Western Sydney – Macarthur, Building 22, Room 5. The society also publishes a monthly journal, Prime Focus, and offers dark sky observing on members' sites. The MAS encourages members from novice to expert. They provide Full, Student, Pensioner and Family levels of membership.

Address: c/- Secretary, PO Box 17, Minto NSW 2566
Contact: Ian Cook 0415 915 771 Mobile
Email: skyview@zipworld.com.au

### NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC

Meetings are held at the Sports Pavilion, St. Ignatius College, Lane Cove on the 3rd Tuesday of each month at 7:30pm. The society has a quarterly journal, Reflections. Monthly observing nights are held at North Turramurra golf course.

Fees: $40 adult, $20 student/pensioner and $60 family
Address: PO Box 3002, North Turramurra NSW 2074
Contact: Ron Washington (President) (02) 9949-3544
Email info@nsas.ozau.net
Web: www.nsas.ozau.net/

### WOLLONGONG AMATEUR ASTRONOMY CLUB

Holds monthly meetings on the first Thursday of each month, at 7:30pm, at the Unanderra Community Centre, Princess Highway, Unanderra. Visitors are welcome. New Moon and Last Quarter observing nights are held. A monthly newsletter, 'Wollongong Observer' is produced.

Fees: Membership is $10 per year
Address: PO Box 398, Unanderra NSW 2526
Contact: Andrew Wood (02) 4272-4505
Email: bandawood@bigpond.com
Web: www.users.bigpond.com/paul.b/index.htm

### WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC

The society meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus. There are also regular observing nights at the Beames Observatory at Linden and a monthly newsletter.

Fees: $30 full, $20 student/concession, $40 family/school groups and $10 for newsletter only.
Address: PO Box 400, Kingswood NSW 2747
Contact: Dave Gault (02) 4754-4351
Ted Dobosz (President) (02) 9708-3163
Email: daveg@tpg.com.au
Web: www4.tpgi.com.au/users/wsaag/

### PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC.

Meets at the Port Macquarie Observatory (in Rotary Park, opposite Town Beach) on the last Monday of each month at 6.30pm.

Address: PO Box 1453, Port Macquarie NSW 2444
Contact: Jim Daniel (02) 6583-1933
Email: jaidanl@bigpond.com.au

### SUTHERLAND ASTRONOMICAL SOCIETY

The Society operates from Green Point Observatory, near Sutherland in Sydney. The observatory houses a 41cm reflecting telescope, 35cm C14, a library and meeting hall. The SAS meets every Thursday at 8pm (visitors welcome), with the main meeting and guest speaker on the 1st Thursday. The society also publishes a regular journal and star nights are available for interested groups. There is also a public open night and astronomy course held annually.

Fees: $40 full, $30 student/associate, $15 junior/pensioners and $50 for families plus joining fee – full/family $25, others $10
Address: PO Box 31, Sutherland NSW 1499
Contact: Secretary (02) 9589-1014 (voicemail phone/fax)
Email: sasi@ozemail.com.au
Web: members.ozemail.com.au/~sasi/

### UNIVERSITY OF NEW ENGLAND AND NTH. TABLELANDS AS

Meetings are held once per month at the Kirby Observatory on Thursday evenings close to New Moon. Meetings commence 6.30pm; Dec. and Jan. 8 pm. A second meeting is sometimes held at Margaret Sharpe's place. The society has access to the UNE Physics Department astronomy and observing facilities, and caters for all levels. Meetings usually include a talk with viewing.

Fees: Uncertain at time of publication, approx. $10.
Address: Dr Margaret Sharpe, 33A Brown St, Armidale 2350, or UNE internal mail to M. C. Sharpe, LCL, UNE.
Contact: Dr Margaret Sharpe, (02) 6771-1123 (ph/fax), 0428 711 123
Email: msharpe@metz.une.edu.au

### THE CENTRAL WEST ASTRONOMICAL SOCIETY (PARKES)

Meetings are held on the first Friday of the month at the Parkes Observatory Discovery Centre, commencing 7:30pm. Visitors welcome. Public viewing nights are organised and regular observing nights are held at their Orana site (10 km south of Parkes).

Fees: $30 adults, $20 students
Address: PO Box 819, Parkes NSW 2870
Contact: John Sarkissian (President) John.Sarkissian@csiro.au
Discovery Centre (02) 6861 1777

### CENTAURUS ASTRONOMICAL SOCIETY

The Centaurus Astronomical Society is located in Bathurst. It was established in November 2000 and now boasts a membership of around forty. They hold regular meetings at the Bathurst Observatory and publish a newsletter bimonthly.

Fees: Full Single: $20/year; Family: $30/year;
Concession and Student: $15/year
Contact: Ray Pickard (Bathurst Observatory) (02) 6337 3988
Email: info@bathurstobservatory.com.au
Web: centaurus.freeservers.com/

## NORTHERN TERRITORY

### ALICE SPRINGS ASTRONOMICAL SOCIETY

The society holds meetings on the 2nd Monday of each month at the Motor Registry Office, METEL Centre, Nth Stuart Hwy. Two viewing nights are held each month at their dark sky site 6km east of Alice Springs, on Saturdays closest to New Moon.

Fees: $25
Address: Box 739, Alice Springs NT 0871
Contact: Matt Pearce, President (08) 8953-8888;
Bob Oostergaard, Secretary (08) 8953-0811
Email: matt@ecotours.com.au
Web: members.ozemail.com.au/~asasinc/

### DARWIN ASTRONOMY GROUP

Monthly viewing nights are held during the dry season plus special astronomical events. Astronomy nights can be organised for schools and clubs as well as amateur telescope making.

Contact: Phillip Smith (08) 8945-9450
Email: hapchap@bigpond.com
Web: members.ozemail.com.au/~hapchap/

## QUEENSLAND

### ASTRONOMICAL ASSOCIATION OF QUEENSLAND

Meetings are held on the afternoon of the second Saturday of the month at 2.30pm in the lecture theatre of the Sir Thomas Brisbane Planetarium, Mt Coot-tha Botanic Gardens. The club also holds regular observing nights, astrocamps, public field nights and publishes a monthly journal and Annual Proceedings.

Fees: $35 adult, $50 family, $23 student and pensioner.
Address: PO Box 6101, St. Lucia Qld 4067
Contact: Bill Oliver (07) 3391-4587
Email: info@aaq.org.au
Web: www.aaq.org.au/

### TROPICAL STARGAZERS

(Formerly Ast. 20 S) Tropical Stargazers now has two branches. The Hamilton Island based group meets April – December on the last Wednesday and operates the Great Barrier Reef Observatory. The Mackay section holds regular meetings and viewing nights.

Contact: Mackay section, Margie Zinn (07) 4954 7487.
Hamilton Island, Ray Johnston (07) 4946-8686
Email: star@whitsunday.net.au
Address: PO Box 40 Hamilton Island Qld 4803

### BUNDABERG ASTRONOMICAL SOCIETY

Meetings are held at Alloway Observatory every Friday at 7:30pm. The first Friday of the month (except January) are general meetings. They also publish a bimonthly paper. Regular field nights are held.

Fees: $30 adult, $15 junior and $20 country.
Address: PO box 4221 South Bundaberg Qld 4670
Contact: Bill Fielding, Don Gray or Peter Rehbein (07) 4159-7232
Email: iluka@widebay.net.au
Web: www.angelfire.com/al/AstronDirectory/

### BUNDY SKYWATCHERS (BUNDABERG)

They meet every Friday night at 7pm, and have two field nights and one training night each month.

Fees: $10 per year
Address: 534 Moorlands Road, Bundaberg Qld 4670
Contact: Karlene Galway (07) 4159-9674
Email: karlene@interworx.com.au
Web: www.interworx.com.au/users/karlene/

### BRISBANE ASTRONOMICAL SOCIETY

Meets on the second Friday of each month at 7:30pm at Kelvin Grove State High School Library. There is a bimonthly newsletter. Regular field nights are held for members and the public, as well as astrocamps. Also public observing nights on the Saturday nearest First Quarter Moon, at the Mt. Coot-tha Lookout, from 7pm to 9pm, all welcome. They have a lending library, and telescopes for loan to members.

Fees: $25 adult, $30 family, $15 junior (<18 yrs) and pensioner, $22 country member, $27 family country members, also a $5 joining fee.
Address: PO Box 204, Morningside Qld 4170
Contact: BAS Infoline (07) 3321-8511 (recorded message)
Email: basmail@bas.asn.au
Web: www.bas.asn.au/

### SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY

The Society meets on the third Monday of the month at Kedron High School, from February to November. Meetings commence at 7.30pm and visitors are welcome. They have a quarterly newsletter Universal Times and a library. Telescopes are available to members, including assistance in constructing their own. Public field nights are held at Indooroopilly High School, on the first Sunday of each month. Dark sky visits and residential weekends are organised monthly.

Fees: $25 for adults and $15 concession
Address: PO Box 60, Everton Park Qld 4053
Contact: David Larkin (07) 3844-7904, Eric Rumbo (07) 3300-4904
Email: mcerlean@powerup.com.au
Web: homepage.powerup.com.au/~mcerlean/index.html

### SOUTHERN ASTRONOMICAL SOCIETY

Monthly meetings are held at Pimpama State School, Hotham Creek Road, Pimpama, on Saturdays (date varies with Moon phase), at 7pm. Meetings include observing through telescopes. They hold monthly astrocamps at a dark sky location and have a bimonthly newsletter.

Fees: $28 adult and $21 student, discount for family members
Address: PO Box 867, Beenleigh Qld 4207
Contact: Kevin Dixon (07) 5537-3852
Email: renato@odyssey.com.au
Web: www.sas.org.au/

### CAIRNS ASTRONOMY GROUP

Hold monthly meetings from June to November, on the first Saturday of the month, at Bob's place, 18 Yurongi St, Caravonica Qld 4878, starting at 7:30pm. A monthly newsletter is produced from June to November.

Fees: $12 per year
Address: 18 Yurongi St, Caravonica 4878
Contact: Bob Dollery (07) 4058-1180
Email: jamesbak@bigpond.com
Web: www.users.bigpond.com/jamesbak.htm

### MT. ISA ASTRONOMY GROUP

The society meets monthly at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17km outside of Mount Isa), usually near New Moon. They have an observatory at the camp with 250mm and 150mm telescopes. Contact Len Fulham for observing dates.

Fees: $40 per year
Address: PO Box 1556, Mount Isa Qld 4825
Contact: Len Fulham AH: (07) 4743 5385, Fax (07) 4743 3381
Email: lfulham@tpgi.com.au

### REDLANDS ASTRONOMICAL SOCIETY

This is a small society in the Brisbane area. They meet at Ormiston College, Ormiston (27km SE of Brisbane) on the 2nd Tuesday of the month, and another Tuesday for skywatching.

Fees: $25 single, $40 Family
Address: PO Box 2048, Wellington Point Qld 4160
Contact: Ross Spence (President) (07) 3822-5545
Email: r.a.l.spence@uq.net.au

### SUN COAST ASTRONOMICAL SOCIETY

Meetings are held on the third Friday of each month at 7pm. The venue is the Beerwah Field Study Centre, Roys Road, Beerwah.

Address: PO Box 961, Caloundra Qld 4551
Contact: Glen Lang (07) 5496-0310
Email: langfamily@itconnect.net.au
Web: suncoastastronomy.homestead.com/News.html

### TOWNSVILLE ASTRONOMY GROUP

Observe on the Saturday closest to New Moon at Alligator Creek (20km south of Townsville) or at Kelso Dam. There is a quarterly newsletter.

Address: 21 Gladys St, Kelso Qld 4815
Contact: Richard Free (07) 4789-2214
Email: mgib@tpg.com.au

## SOUTH AUSTRALIA

### ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA

Meetings are held on the 1st Wednesday of each month (except January) at the University of Adelaide, North Terrace Campus. The society maintains three sites. The Heights Observatory at Heights School, Modbury, houses a 300mm telescope. A northern country site is at Stockport, 80km north of Adelaide (houses 0.5m, 0.48m and 0.45m telescopes). The southern observing site is located at Douglas Scrub, McLaren Flat (a 0.45m telescope). Public education is important to the ASSA with various lectures and observing nights. The society publishes a monthly newsletter. Monthly public field nights are held at Heights and Douglas Scrub. The Stockport Observatory hosts a quarterly star party.

Fees: Full $45, country or concession $35, spouse $25
Address: GPO Box 199, Adelaide SA 5001
Contact: (08) 8338-1231
Email: info@assa.org.au
Web: www.assa.org.au/

## TASMANIA

### ASTRONOMICAL SOCIETY OF TASMANIA (AST)

General meetings are held at either the Canopus Observatory site at Cambridge or the Hutchins School, Sandy Bay, on the last Tuesday of each month except December. An annual meeting is held in Launceston at the Queen Victoria Museum Planetarium. The AST is active in public education and runs various public nights in Hobart (Canopus Hill Observatory) and in Launceston Planetarium. Presentations are made to school and community groups. Regular monthly observing nights are held for members and visitors are welcome.

Fees: $45 Family, $40 Full Adult Member, Town and Country and $20 Junior (up to age 18 years.)
Address: Sec. Mr. Laurie Priest, PO Box 1654, Hobart Tas 7001
Contact: Hobart (03) 6244-3476
Northern Tas. Laun. – Karenne Barnes (03) 6344-7100
Northwest Tas. Devonport – Peter Sayers (03) 6424-2588
Email: shevillm@southcom.com.au
Web: www.southcom.com.au/~shevillm/ast

## VICTORIA

### THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND

This is a small group which operates in Bairnsdale and the surrounding districts. Meetings and dark sky observations are held at 10 Waterholes Rd, Bairnsdale Vic 3875.

Contact: Mike Finn (03) 5156-0676
Email: mikef1@hotkey.net.au

### ASTRONOMICAL SOCIETY OF MELBOURNE

The society has regular club nights in Melbourne and also a dark sky site. The ASM also has an active Amateur Telescope Making team which has produced over forty instruments in the last four years (includes refractors and reflectors of various sizes). The ASM caters for beginners, with introductory sessions at each event, while still addressing the needs of the more experienced amateur.

Address: PO Box 92, Bentleigh, Vic 3204
Contact: Chris Ellis 0412 318 125, recorded info (03) 9517-9250
Email: ngc4755@i.net.au
Web: www.astromelb.i.net.au/

### ASTRONOMICAL SOCIETY OF VICTORIA

Visitors are welcome at the society's general meetings, held at 8pm on the 2nd Wednesday of each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. Also ASV specialist sections hold regular meetings. The society holds beginner courses in astronomy and in telescope making. The ASV has 2 properties, their Burwood premises (housing a 0.5m telescope) and a dark sky site near Heathcote. Heathcote is the venue for the annual Star Party and Star-Be-Cue events. Membership advantages include: bimonthly newsletter Crux, yearbook, email news, members' nights at Melbourne Observatory, Skyline phone info service, loan scopes, library and computer facilities.

Fees: Metropolitan $42 (family $47); junior (under 19) $26; country/interstate $26 (family $32); seniors $26 (family $32). A joining fee of $20 applies to all categories except Juniors.
Address: GPO Box 1059J, Melbourne, Vic 3001
Contact: Linda Mockridge (Public Rel. Officer) (03) 9888-7130
Email: mockrdge@alphalink.com.au
Web: www.asv.org.au/

### ASTRONOMICAL SOCIETY OF ALBURY WODONGA

The society meets regularly on the first Wednesday of each month (except January) at Victory Primary School, Drages Road, Wodonga at 8pm. Viewing nights are arranged including the Wodonga High School Observatory. There is also a grazing occultation programme.

Fees: $25 Single, $30 Family and $15 Student/Concession
Address: 1 Poplar St, Wodonga Vic 3690
Contact: John Hills (02) 6024-7255, fax (02) 6024 4540
Email: jhills@tpgi.com.au
Web: www.asaw.tripod.com/

### ASTRONOMICAL SOCIETY OF GEELONG

Meets every Friday at 8:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong. The society holds regular viewing nights for schools and community groups as required.

Fees: $50 adult, $25 junior/concession.
Address: PO Box 1799, Geelong Vic 3220
Contact: Frank Baker (Secretary) 0407 345 070
Email: robmarineowl@bigpond.com

### LATROBE VALLEY ASTRONOMICAL SOCIETY

The society meets each month (except December and January). They have a bimonthly newsletter, Nebulous News. The LVAS is active in education, viewing nights in Gippsland and is developing an observatory near the township of Tyers.

Fees: $25 adult, $13 associate (more than 50km from Morwell)
Address: PO Box 80, Glengarry Vic 3854
Contact: Rob Read (03) 5176-1560 fax (03) 5176-1571
Email: lvas@rajacomputers.com.au

### OASIS STARGAZERS CLUB MILDURA INC

Oasis conduct regular viewing nights, which are open to the public, and once a month have a public activity night. They are also available for community and school groups for star nights.

Address: PO Box 378CP, Mildura Vic 3500
Contact: Kerry Needs (03) 5021-1330
Email: kerryn@mvcitrus.org.au

### ASTRONOMICAL SOCIETY OF FRANKSTON (ASF)

Meetings are held on the 3rd Wednesday of each month (except December) at 8pm, at The Peninsula School, Wooralla Drive, Mt. Eliza. Visitors are welcome. The ASF have: a bimonthly newsletter, an email newsgroup, a library, videos, CD ROMs, telescopes, binoculars and computers, specialist sections, regular social events, and regular viewing nights at the society's dark sky Briars property on the Mornington Peninsula (an observatory is under construction). The ASF caters for all ages and levels of experience. Public viewing nights are held on the first Friday of each month at 8pm at the Briars site, Mt. Martha. The society is renowned for its 'Astronomy on the Move' viewing nights and presentations for schools and community groups. They also run the southern Australian aurora telephone alert service.

Fees: $35 adult, $30 concession, $25 student, $45 family, $40 family concession, $16 newsletter only, $50 international.
Address: PO Box 596, Frankston Vic 3199
Contact: Peter Skilton (mobile) 0419 253 252
Email: alphacent@iprimus.com.au
Web: www.ASFnet.20m.com/

### BALLARAT ASTRONOMICAL SOCIETY

The BAS holds a general meeting on the second Friday of each month. Membership is open to anyone over the age of 10 years. They have a quarterly Bulletin and run 'Introduction to Astronomy Courses' in Autumn and Spring. The Society is also the custodian of the Ballarat Municipal Observatory (see Places section).

Fees: $30 full, $50 family, $20 associate, junior and pensioner, $10 subscriber (joining fee $5 junior, $10 associate).
Address: PO Box 284, Ballarat Vic 3353
Contact: (03) 5332-7526 (society information)
Email: bas@cbl.com.au
Web: observatory.ballarat.net/

### THE BENDIGO DISTRICT ASTRONOMICAL SOCIETY

The society meets at the BRiT (3rd Floor of McCrae St Campus) at 7:30pm on the 4th Wednesday each month (except December). A monthly newsletter is published and regular field nights are held locally.

Fees: $28 adult, $15 concession and $40 family.
Address: PO Box 164, Bendigo Central, Bendigo Vic 3550
Contact: Neil Linton 03 5448-8352
Email: bdas@winmail.com.au
Web: www.bendigo.net.au/~rbath/bdas/index.html

### SPACE ASSOCIATION OF AUSTRALIA, INC.

Activities include monthly free public meetings, public displays, radio programme and newsletter to promote understanding of astronautics.

Address: PO Box 351, Mulgrave North, Vic 3170
Contact: Andrew Rennie
Email: info@space.asn.au
Web: www.space.asn.au

## WESTERN AUSTRALIA

### THE ASTRONOMICAL SOCIETY OF WA

The society meets at 8pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr. Brittain Street and Barker Avenue, Como. The ASWA conducts regular astro-camps at locations with accommodation and dark skies. They also hold regular observing nights and offer viewing/speakers to school and community groups. The society offers members the use of its library and equipment. They have a bimonthly journal, 'The Sidereal Times'.

Fees: Ordinary Member: $20 Nomination $50 Subscription, Associate Member: $15 Nomination $30 Subscription, Junior Member (<18): $15 Nomination $20 Subscription, Approx. 20% discount for Country Members
Address: PO Box 421, Subiaco WA 6008
Contact: (08) 9299 6347
Email: aswa@cleo.murdoch.edu.au
Web: cleo.murdoch.edu.au/gen/aswa/

### ASTRONOMICAL GROUP OF WA

The AGWA was formed to meet the needs of amateur astronomers and people interested in the night sky, with or without their own telescopes. Activities include: field trips, seminars by astronomers, workshops and special events and an annual AstroFest. The group meets at 7pm on the first Tuesday of every month (see address below). Visitors are welcome. AGWA is sponsored by the Binocular, Telescope and Optical World.

Address: 159A Scarborough Beach Rd Mount Hawthorn WA 6016
Contact: (08) 9201-0895
Email: btow@iinet.net.au

### THE MURDOCH ASTRONOMICAL SOCIETY

The MAS is an active body based at Murdoch University. Membership is open to the general public and no knowledge of astronomy is required. Meetings are conducted each month at the University and consist of informal talks, guest speakers, slide shows and observation reports. A library is available to members. There is dark sky viewing and activities at the Murdoch Observatory during the warmer months. Other activities include: star parties with the ASSW, an annual public viewing night around February/March and observing nights on request from school and community groups. The society owns 440mm, 300mm, 200mm and 150mm telescopes for members use.

Fees: $30 per year
Address: c/- Murdoch Uni. Physics and Energy Studies, Murdoch WA 6150
Email: mas@science.murdoch.edu.au
Web: www.science.murdoch.edu.au/interest/mas/

### ASTRONOMICAL SOCIETY OF THE SOUTH WEST (ASSW)

Membership is open to anyone. Observing nights are held at their observatory south of Bunbury on the two Fridays before the New Moon. There is an active junior group which meets twice monthly. Astronomy camps (and more informal evenings) are held during the year at dark sky sites. A six evening astronomy course for beginners is conducted each year in March/April. Nights for the general public are held during school holidays. Community groups are welcome to book for special nights.

Fees: Ordinary $25, Junior/Concession $10, Family $40.
Address: PO Box 1100, Bunbury, WA 6231
Contact: Phil Smith (08) 9721 1586
Email: dodong@ozzienetnet

# GLOSSARY

***Albedo*** The ratio of the amount of light reflected from a Solar System object to that received by it. (A complete reflection gives an albedo of 1.0 or 100%).

***Algol*** A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

***Almanac*** A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an ***Ephemeris***.

***Altazimuth co-ordinates*** The angular height (***altitude***) of an object above or below the horizon and its angular direction (***azimuth***) from north measured towards the east.

***Altitude*** The angular elevation of an object above or below the horizon.

***Angular diameter*** The apparent diameter of an object measured in degrees or radians.

***Angular separation*** The angular distance between two celestial bodies measured in degrees.

***Aphelion*** The point in an orbit of a comet, planet or minor planet most distant from the Sun. It is the opposite to ***perihelion***.

***Apogee*** The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to ***perigee***

***Asterism*** A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

***Asteroid*** See ***Minor Planet***.

***Astronomical unit*** The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 AU.

***Azimuth*** Horizontal co-ordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

***Celestial equator*** A projection of the Earth's equator onto the ***celestial sphere***.

***Celestial poles*** Points on the ***celestial sphere*** directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

***Celestial sphere*** Imaginary sphere of infinite size surrounding the Earth and to which celestial bodies seem to be attached.

***Circumpolar*** Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** it must have to be considered circumpolar.

***Colour index*** The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

***Coma*** The head of a ***comet***, usually the brightest part.

***Comet*** Small icy body that orbits the Sun and produces tails of gas and dust when approaching the Sun.

***Conjunction*** An alignment of two bodies; their least ***angular separation*** as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

***Conjunction – Inferior*** When the Earth, an ***inferior planet*** (Mercury or Venus) and the Sun are in a line in that order.

***Conjunction – Superior*** When the Earth and an ***inferior planet*** (Mercury or Venus) are situated on opposite sides of the Sun.

***Constellation*** A pattern of stars identified by name, usually of mythological gods, people, animals, or objects.

***Cosmology*** The study of the large-scale structure and evolution of the whole Universe.

***CST*** Central Standard Time.

***Culmination*** The instant when a celestial body crosses the ***meridian***; an object culminates when it reaches its highest point above the observers horizon.

***Declination (Dec)*** One part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (-) of the ***celestial equator*** and is similar to lines of latitude on the Earth.

***Diurnal motion*** The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

***Eccentricity*** A measure of how 'long or thin' an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

***Eclipse*** When one object passes into the shadow of another.

***Eclipse of the Moon*** When the Moon passes into the shadow cone of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the ***umbra***, and penumbral if the Moon passes only through the ***penumbra*** of the Earth's shadow.

***Eclipse of the Sun*** When the Moon passes in front of the Sun. Total when the Moon has a larger ***angular diameter*** than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

***Ecliptic*** The plane of the Earth's orbit projected onto the ***celestial sphere***. It can also be defined as the Sun's path against the stars.

***Ellipse*** An oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

***Elongation*** The ***angular separation*** of two bodies. The greatest elongation of Mercury and Venus occur when the planets are at their most angular distance from the Sun, as viewed from the Earth.

***Emission nebula*** A cloud of glowing gas excited by ultraviolet radiation from hot stars.

***Ephemeris (plural ephemerides)*** A tabulated list of positions for an object calculated from its orbital elements.

***Epoch*** A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all co-ordinate data and is compatible with modern star atlases.

***Equation of Time*** The difference between apparent and mean solar time.

***Equinox*** The two times of the year when the Sun crosses the ***celestial equator***; vernal or spring equinox occurs about September 21st, and autumnal or fall equinox about March 22nd.

***EST*** Eastern Standard Time.

***Galactic equator*** The great circle along the line of the Milky Way, marking the central plane of our ***galaxy***.

***Galaxy*** A large disk or ball of billions of stars and ***nebulae***. They are the largest individual structures in the Universe.

***Galilean satellites*** Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto, (also known as the Jovian satellites).

***Geocentric*** As viewed or measured from the centre of the Earth.

***Gibbous*** Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between first and last quarter.

***Globular Cluster*** A huge sphere containing thousands of stars. They surround our ***galaxy*** and other nearby galaxies.

***Heliocentric*** As viewed or measured from the centre of the Sun.

***Hour Angle*** The angular measure of the distance of an object from the local ***meridian***.

***Inclination*** The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually the reference is the ***ecliptic***.

***Inferior planet*** A planet orbiting the Sun inside Earth's orbit. That is Mercury and Venus.

***Julian date*** The number of days since noon on 1st January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

***Large Magellanic Cloud*** (LMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the ***constellation*** of Dorado. From mid-southern latitudes the LMC is ***circumpolar***.

***Light year*** The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

***Lunation*** The period of time between two consecutive New Moons.

***Magnitude*** Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.512. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude -1 (except for the Sun which is -26.7). The faintest visible to the unaided are magnitude 6 (under dark skies).

***Magnitude – absolute*** The apparent magnitude a star would have if it were placed at a distance of 10 ***parsecs*** (32.6 ***light years***).

***Meridian*** The local meridian is an imaginary line running directly overhead from north to south. The ***right ascension*** on the meridian equals local ***sidereal*** time.

***Meteor (***also Shooting or Falling Star***)*** A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

***Meteor shower*** A group of ***meteors*** that appear to originate from a small region of the sky (the radiant).

***Meteor swarm (or stream) Meteoroids*** grouped in a localised region of an orbit around the Sun (the source of ***meteor showers***).

***Meteorite*** A ***meteor*** that survives its trip through the atmosphere and reaches the ground.

***Meteoroid*** A small solid particle moving in orbit about the Sun.

***Minor planet*** Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

***Minute of arc*** An angular measure (each degree is divided in 60 minutes of arc).

***Mira*** A variable star in the ***constellation*** of Cetus, with a range in brightness from 2nd to 10th ***magnitude***, and a mean period of 331 days. Known as Mira the Wonderful, it is the brightest and most famous of the long period pulsating variables.

***Nadir*** The point on the ***celestial sphere*** directly opposite the ***zenith.***

***Nebula*** A cloud of interstellar gas and dust. See also ***emission, reflection*** and ***planetary nebula.***

***Node*** One of two points at which an orbit passes through a reference plane (usually the ***ecliptic***).

***Oblateness*** The ratio of a planet's polar to its equatorial diameter.

***Obliquity*** The degree of inclination (or tilt) of a planet's equator to its orbital plane.

***Occultation*** The disappearance of one celestial body behind another.

***Omega Centauri*** A globular star cluster in the ***constellation*** of Centaurus. Globulars are made up of tens of thousands of stars and form a shell around our galaxy. Omega Centauri and 47 Tucanae are two of the finest examples of these objects.

***Open star cluster*** A loose grouping of stars numbering from a few dozen to hundreds.

***Opposition*** When a celestial body is opposite the Sun in the sky.

***Orbit*** The path followed by one body as it moves around another.

***Parallax*** An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

***Parsec*** A unit of distance used by astronomers which is equal to 3.26 ***light years***. A parsec is defined as the distance to a celestial body whose ***parallax*** is one arc second.

***Penumbra*** Area of partial illumination in the shadow of a planet surrounding the ***Umbra***. Also zone of intermediate brightness between a sunspot and the solar photosphere.

***Perigee*** The point at which a body in orbit around the Earth most closely approaches the Earth.

***Perihelion*** The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to ***aphelion***.

***Perturbation*** Small changes in the motion of a body caused by the gravitational effects of another body.

***Planetary nebula*** An expanding shell of gas ejected from a star. Thought to be the outer layers of a red giant during its latter stages of evolution, the core of which becomes a white dwarf.

***Planisphere*** A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

***Polar axis*** The axis around which a celestial body rotates.

***Proper motion*** The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

***Quadrature*** A configuration that two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

***Reflection nebula***. A gas cloud illuminated by a nearby star.

***Retrograde motion*** 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.

2. Apparent retrograde motion is the westward motion of a planet with respect to the stars which occurs near opposition (outer planets) or near inferior conjunction (inner planets).

***Right ascension (R.A.)*** Part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is similar to lines of longitude on the Earth but is measured in hours (24hrs = 360°).

***Second of arc*** An angular measure. Each degree contains 3600 seconds of arc, and each ***minute of arc*** contains 60 seconds.

***Sidereal time*** A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23hrs56m4s of normal solar time.

***Small Magellanic Cloud*** (SMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is ***circumpolar***.

***Solstice*** The time when the Sun is farthest from the ***celestial equator***. In the southern hemisphere around June 21st marks the shortest day of the year, and around December 21st marks the longest day.

***Spectral type*** A star's spectral classification determined by its ***spectrum***.

***Spectrum*** The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

***Superior planet*** A planet orbiting the Sun outside Earth's orbit.

***Synodic period*** The period of a planet's orbit with respect to the Earth.

***Transit*** The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

***Transit the meridian or meridian passage*** The passage of a heavenly body across the ***meridian***.

***Twilight*** The short period of time before sunrise and after sunset during which there is not complete darkness.

***Twilight – astronomical*** Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

***Twilight – civil*** Civil twilight ends or begins when the Sun is 6° below the horizon.

***Twilight – nautical*** Nautical twilight ends or begins when the Sun is 12° below the horizon.

***Umbra*** Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

***Universal time (UT)*** A time system measured from the Meridian of Greenwich in England.

***WST*** Western Standard Time.

***Zenith*** The point directly overhead (90° in altitude).

***Zenith Hourly Rate*** A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the ***zenith*** with a sky limiting magnitude of 6.5.

***Zodiac*** The traditional twelve constellations that lie across the ***ecliptic*** (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

## GREEK ALPHABET

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A, α | Alpha | Z, ζ | Zeta | Λ, λ | Lambda | Π, π | Pi | Φ,φ | Phi | | |
| B, β | Beta | H, η | Eta | M, μ | Mu | P, ρ | Rho | Χ, χ | Chi | | |
| Γ, γ | Gamma | Θ,θ, ϑ | Theta | N, ν | Nu | Σ, σ | Sigma | | | | |
| Δ, δ | Delta | I, ι | Iota | Ξ, ξ | Xi | T, τ | Tau | Ψ, ψ | Psi | | |
| E, ε | Epsilon | K, κ | Kappa | O, ο | Omicron | Y, υ | Upsilon | Ω, ω | Omega | | |

# INDEX

Entries which refer to diagrams or tables are in **bold** type.

There is no one who has not gazed on the beauty of the night sky and wondered:

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Why do some “stars” move from night to night ?
Which planet is that ?

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- Guide to the best times to observe the planets
- When to see Shooting Stars (Meteor showers)
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- Public observatories in Australia
- Amateur astronomical societies
- Comets
- and much more …

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*Fred Watson*
*Anglo-Australian Observatory*

Quasar Publishing has been producing yearbooks since 1991 and ASTRONOMY 2003 continues with the high standard established over the years. The authors have had many years experience in observational astronomy, astronomical publications, public education and the amateur astronomical community.

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ESTIMATING ANGLES IN THE SKY. When held 0.5m(20 inches) from the eye, each division on this scale corresponds to 1of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°