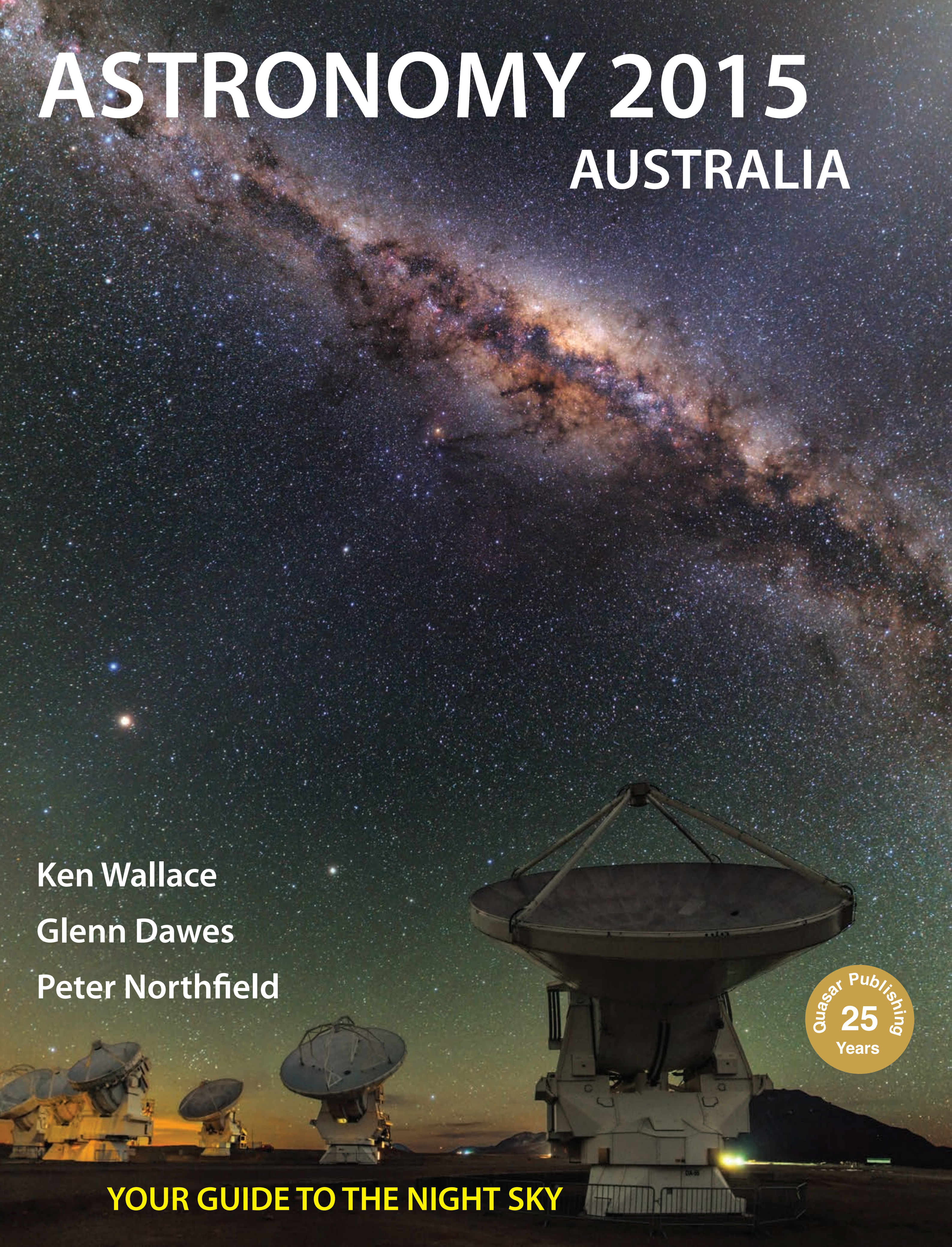
ASTRONOMY 2015
AUSTRALIA



Ken Wallace

Glenn Dawes

Peter Northfield

Quasar Publishing 25 Years

YOUR GUIDE TO THE NIGHT SKY

CALENDAR 2015

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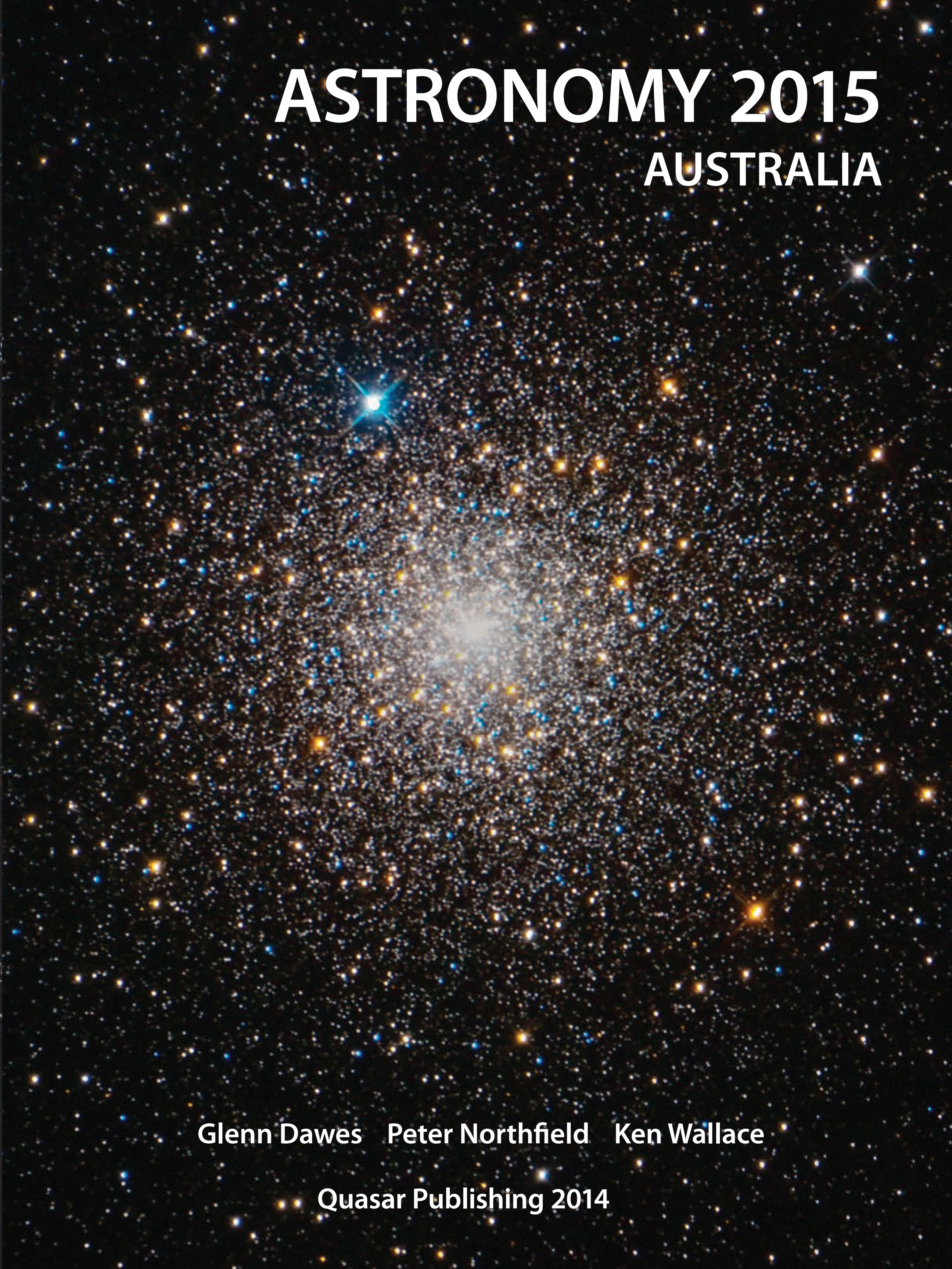

ASTRONOMY 2015
AUSTRALIA

Glenn Dawes Peter Northfield Ken Wallace

Quasar Publishing 2014

Acknowledgements 2015

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

- Astronomical Almanac for the Year 2015 (US Naval Observatory and UK Hydrographic Office)
- Astronomical Tables of the Sun, Moon and Planets (Meeus)
- Atlas of the Moon (Rukl)
- Comet orbital elements (International Astronomical Union)
- Uranometria 2000.0 Vol II (Tirion, Rappaport, Lovi)
- Exploring the Moon (Massey)
- International Astronomical Union
- International Meteor Organisation Calendar
- Mathematical Astronomy Morsels series, volumes 1 to 5 (Meeus)
- NASA/JPL websites
- Stars (Jim Kaler)
- The Moon a Biography (Whitehouse)
- Washington Double Star Catalog

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

- Multiyear Interactive Computer Almanac 1800–2050 version 2.22 (MICA) (US Naval Observatory)
- TheSky (Sofware Bisque)
- Occult version 4.1.1.4 (Herald)
- Voyager version 4.5 (Carina Software)
- Guide 9 (Project Pluto)
- Ephemeris Tool (Dings)

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We would like to acknowledge the following individuals for that vital job of proofreading. Our thanks go to Greg Bryant, Brenda McNamara, Chris Douglass and Jade Dawes.

Any remaining errors, we (the authors) are responsible, however such an incident is totally incomprehensible and denial isn't just a river in Egypt!

Illustrations

Front cover:	ALMA radio telescope array, Atacama desert of northern Chile by Babak A. Tafreshi. Using a Canon 6D (modified), stitched panorama by 24 mm lens, ISO 3200, exposure 30s, tracked on Polaris Star Tracker.
Page 1:	Globular Cluster NGC 6752 in Pavo. Joe Cauchi, taken with his 16" ƒ/4.5 Newtonian, 12 × 15 minute exposures.
Page 6 to 9:	Images supplied by Stepan Keller, see captions.
Page 10:	Dusty Heart by Phil Hart using Canon 6D with 50 mm lens at ƒ/3.5. 12 exp × 5 minutes at ISO800.
Page 10:	Marine Moonset by Phil Hart. Canon 6D with 300 mm lens and 1.4× converter at ~ƒ/8, 4 second exp, ISO200.
Page 10:	Mars 2014 by Stefan Buda. 404 mm Dall-Kirkham scope, DMK21AU04 camera, Astrodon RGB filters. 600 frames with 600 used for each colour channel.
Page 11:	Prominence by Paul Haese. Lunt 80 mm Ha scope with Point Grey Research camera. 700 frames taken.
Page 11:	Horsehead/Flame Nebulae by David Fitz-Henry. 12.5" astrograph/STL-11000M. Exp. Lum 16 × 12m, Ha 19 × 12m, Red 11 × 12m, Green 10 × 12m, Blue 10 × 12m.
Page 11:	Dust and Gas by Paul Haese. Equipment: TSA102 and QSI683-8.
Page 12:	Moonflowers by Bratislav Curcic, using a C11. Camera QHY5L-II
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Page 13:	Venus and Zodical glow by Grahame Kelaher. Canon 5DIII and 14 mm Lens @ ƒ2.8 – 20 second exposure.
Page 30:	Darwin woodcut of an australite, Wiki Commons.
Page 37:	Markarian's Chain by Packbj (own work), via Wiki Commons. Taken from Green Valley, Arizona..
Page 45:	New Horizons at Pluto, Credit: Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute (JHUAPL/SwRI)
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Page 68:	'Stargazing' by David Mariott taken at Wiruna SPSP 2014. Canon 7D, 10–22 mm @ 10 mm, ƒ/3.5, ISO320. 161 light shots and 4 dark shots x 30 seconds.
Page 86:	Partial Solar Eclipse series by Stephen Mudge. Canon 50D and 70–200 ƒ/4 telephoto lens with solar filter. Each exposure 1/100 second at ƒ/4, ISO 200.
Page 87:	Eclipse predictions by Fred Espenak, NASA/GSFC.
Page 98–99:	Texture maps of Moon, credit NASA/Naval Research.
Page 132	Comet McNaught (20/1/07) by Ted Dobosz. Canon 350D DSLR and 28 mm ƒ/3.5 lens at ISO 3200.

Inside front and back covers: Hubble Ultra Deep Field in Fornax. Credit: NASA, ESA, S. Beckwith (STScI) and the HUDF Team.

Back cover:	Convergence by Michael Goh. Canon 6D, Tokina 11–16 mm ƒ2.8, imaged at 26 × 16 mm ƒ2.8 37s exp.

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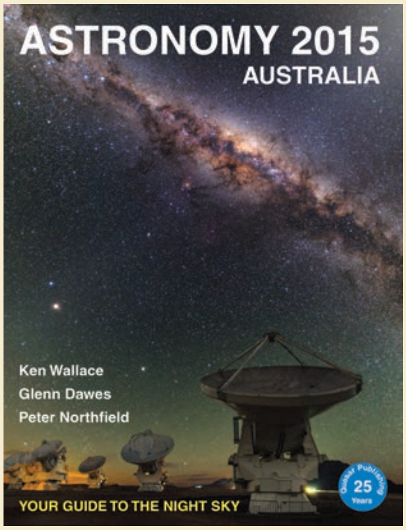


Where have all the Years Gone!

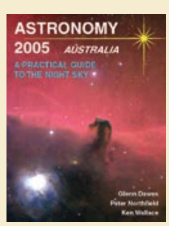
We know the title is somewhat of a cliché, but when the three of us started these yearbooks back in 1990 we had no idea we would still be doing it 25 years later! In fact for 10 years we did two editions. From 1993 to 2002 there was an Eastern Australian edition as well as one for Western Australia produced under contract for Perth Observatory. From 2003 we have published a single edition suitable for all Australia. I hope you can forgive us for being a little self indulgent while we take a brief trip down memory lane, especially seeing we won't be doing a 50th! We'll also reflect on the technical revolution that has made this longevity possible.

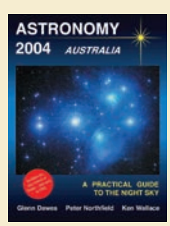
Back in the late 80s the concept of the yearbook was born in conversations around campfires, often while waiting for clouds to clear. The vision was an astronomy annual with the information we wished was at our finger tips when we were first getting into the hobby. At the time this data was only available through sometimes hard to obtain small print run astronomical society or professional publications. It also needed to be presented in a user-friendly manner such as the style of Astronomy and Sky & Telescope magazines. Also in the 80s, these Northern Hemisphere magazines were often out of date by the time they reached *down under* or were not tailored for the Southern Hemisphere. For example, back then not a lot was written about the Magellanic Clouds or the Eta Carinae region in overseas publications.

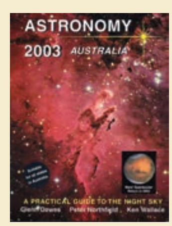
We took the plunge and printed 500 copies of our first edition in 1990. It was a moderate success although we only sold half of them. It took a few years, but it slowly dawned on us that even though Quasar may never be a full time job, it had to be more than just fun, we had to get commercially savvy. To make this book successful, it had to be attractive with astronomical images and lots of illustrations to explain the hard numbers. For three amateurs with little publishing or graphic design experience this was very confronting. Also, no artistic flare, which probably still shows! Fortunately the desktop publishing revolution had started and laser printers had come down in price considerably. Unfortunately in the early 90s the Internet didn't exist, but let's not dwell on the Stone Age! The power of modern day computers combined with advanced software makes looking professional so much easier these days.

This technological journey was yours as well. We have been observers for many years and the portable, low-cost light bucket revelation has been a real bonus with today's 400 mm (plus) Dobsonians giving breathtaking views. Advancement in astrophotography has been staggering. Watching amateurs go from film to quantum efficient electronic CCD cameras (including modern SLRs) and webcams has been amazing. For example, it's been fascinating watching our friend Joe Cauchi's progression into digital over the years, a gentleman whose brilliant work has graced many pages of the yearbooks (including this one). He has, along with many others, produced images professional astronomers would have envied back in the 70s.

Finally, we would like to acknowledge the many people who have supported the book by contributing articles, images and assisting us with proof reading and advice. They are too numerous to name. Also a special mention to Fred Watson for his on-going encouragement, our self appointed 'Number one fan!'. Last, but not least, the biggest thank you to you, our loyal readers. Without you there would be no yearbooks.



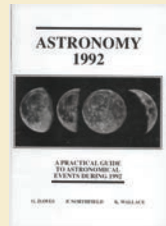




Introduction to the 2015 Edition

The author of our first article is Dr Stefan Kellar, He is the Operational Scientist at the Skymapper Telescope. Stefan gives us some insights into this installation on Siding Spring Mountain which is a world class sky survey instrument run by the Australian National University. His story of their discovery of a rare star makes fascinating reading.

The Central West Astronomical Society conducts the annual CWAS Astrophotography Awards which is judged by Australia's world renowned astrophotographer Dr David Malin. Starting on page ten we are pleased to showcase the winning images from the 2014 event, and several of the honourable mentions. Thanks to these people for allowing us to display their talents.

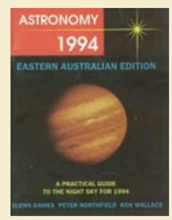


We still have the regular information you have come to expect, including our monthly features covering the usual diverse range of interests. In fact, it's hard to pick a single theme this year with such weird concepts as a 'Blood Moon', some observing hints and targets, up to pondering about life elsewhere in the Universe.

Other topics covered this year include:

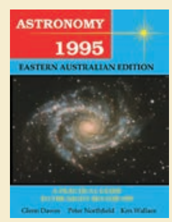
- Amateur comet hunting, a tribute to Bill Bradfield.
- Cepheid variables and how they help determine the size of the Universe.
- Impressive early attempts at measuring the speed of light.
- Double deep sky objects.
- Observing dark nebulae
- The importance of dark adaptation

Part I of Astronomy 2015 is intended as a general quick reference to finding and observing the planets. This section is ideal for those just starting to navigate the heavens. The All Sky Maps cover the entire Southern Hemisphere night sky in nine easy to use charts. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, include sections on astronomical objects such as the constellations, bright stars, deep sky objects, as well as places of interest and the amateur societies. You can also visit our website www.quasarastronomy.com.au where you will find links to all of the sites listed in Part III of this book.



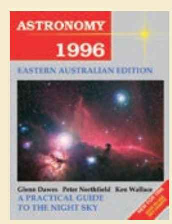
As stated in previous years, astronomy, like any science, may seem to be swamped in jargon. Unfortunately it is impossible to avoid such words. However, where necessary, astronomical terms are explained in the text or covered in the glossary.

It is amazing to watch amateur astronomers these days. The interests haven't changed that much over the years, just the way of doing them. For example the astrophotographer still looks to record every possible photon of light, but today often spending hours under dark skies hunched over a laptop instead of an eyepiece. Even many observers are busy instructing their GOTOs to slew to the next object. Whatever happened to the good old-fashioned astronomical equivalent of stopping and having their olfactory system stimulated by the scent of the *woody perennials of the genus Rosa*? Try sitting back, take in the Milky Way, perhaps watching for meteors, while discussing with fellow observers the sky conditions or reminiscing of past glorious nights. Learning the constellations and stars also has its own rewards. Finding bright deep sky objects without computer assistance can be very satisfying. Star hopping and seeing that bright globular drift into the field is magic! Being alone under the stars can be special too, try turning off the music and just enjoy being part of the cosmos.



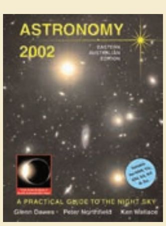
Public field nights can be very rewarding, we know it's not everyone's thing but showing people the planets and constellations might inspire them to undertake a voyage of discovery like yours. You might find yourself observing bright objects you haven't observing for years, a reminder of where the interest all started.

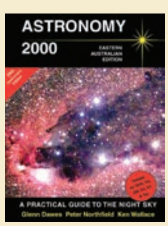
Don't misunderstand us, wherever your passion leads you it's still admirable. We love drooling over the images and yes, even own GOTOs. There's no quicker way to cover as many celestial gems as possible in those sometimes too few hours under dark country skies. Just remember to occasionally stop and smell the roses!

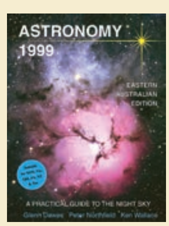


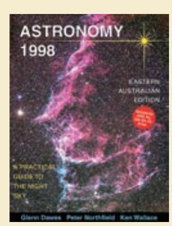
Wishing you clear skies and see you next year.

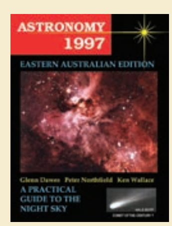
Glenn Dawes ***Peter Northfield*** ***Ken Wallace***

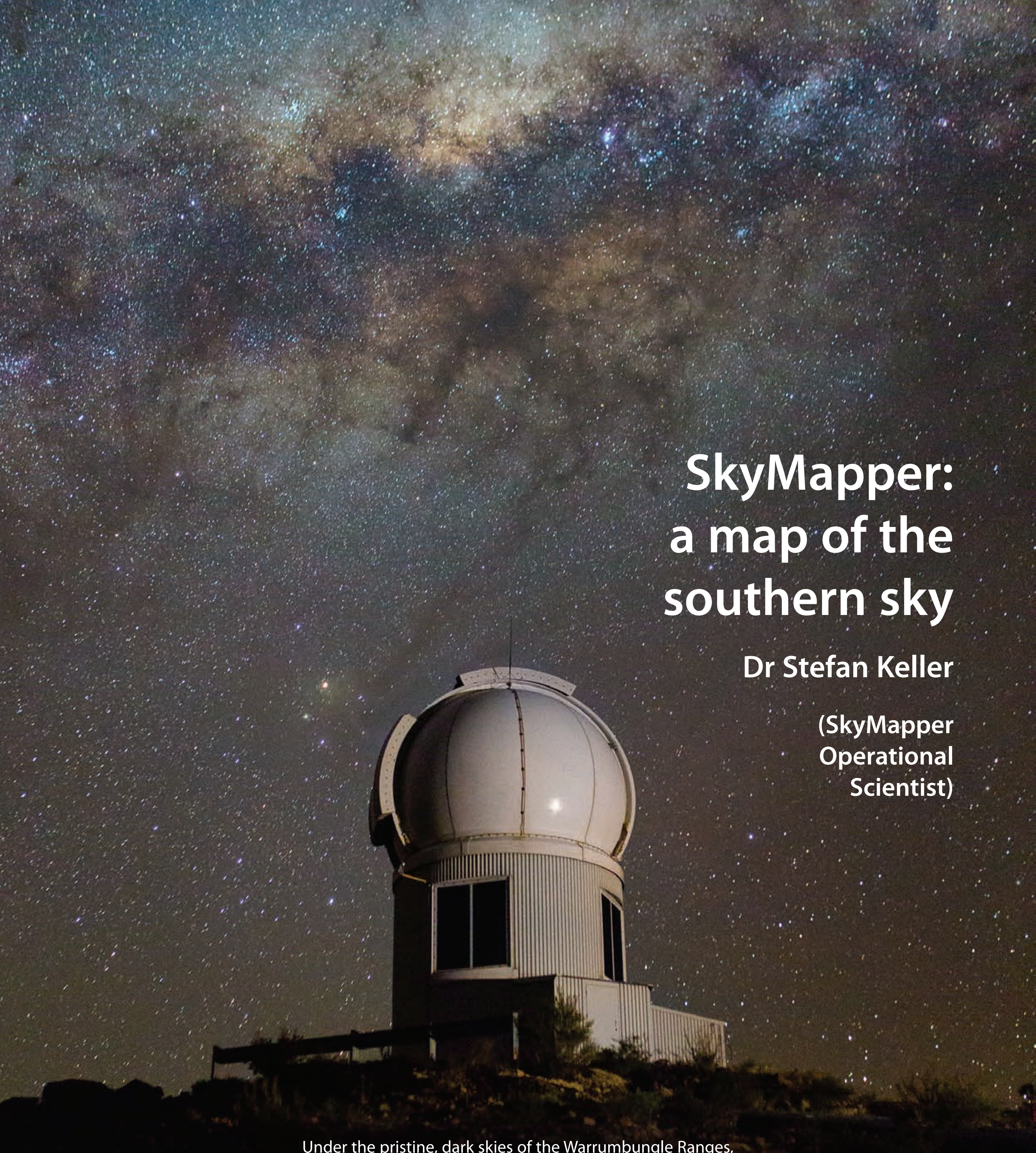












SkyMapper: a map of the southern sky

Dr Stefan Keller

(SkyMapper Operational Scientist)

Under the pristine, dark skies of the Warrumbungle Ranges, 50 km from Coonabarabran NSW, a team of astronomers from the Australian National University are piecing together the first digital map of the southern sky. We are using the purpose-built SkyMapper telescope that is able to record the details of 200,000 stars per hour.

The need for a detailed map of the southern sky is a long-standing one. In the 1980s there was a global effort to photograph the sky. In the Southern Hemisphere this effort was led by the Australian Astronomical Observatory's UK Schmidt telescope. The photographic atlas has been the basis of many scientific programs that have changed our view of the Universe. The 2dF Galaxy Redshift Survey showed us that the Universe is pervaded by cold dark matter. It did this through the study of the motion of galaxies identified from photographic plates.

However, there are a number of important limitations to photographic plates; they are limited in dynamic range and they are slow in their response to light. This sets a limit to the accuracy we can measure the brightness and position of stars and galaxies from a photograph. In the majority of cases this is simply not sufficient to enable our science. Digital imaging offers a dramatic improvement and lifts these limitations.

The last decade has seen the cost per pixel of digital imaging devices fall to a level where it is now feasible to construct a digital camera of size to rival a photographic plate — this was the genesis of SkyMapper. The other factor that enabled SkyMapper was, oddly enough, the firestorm that devastated the University's Mt. Stromlo Observatory in 2003. In the wake of the loss of our facilities at Mt Stromlo we had a rare opportunity to regroup and address the question: 'how can we do things better?'

Half of the one billion objects SkyMapper examines are stars; the remainder are mostly galaxies that are assemblies of stars. Stars have three fundamental parameters: temperature, density, and the amount of heavy elements they have within them. Once we understand these three qualities we are well on the way to understanding where, when, and how a star formed. So we asked 'how can we best determine these quantities from just the light SkyMapper receives?'

SkyMapper uses a set of glass filters that can be positioned in front of its camera to record the brightness of objects in different colours. Prof. Michael Bessell, a member of the SkyMapper team and acknowledged world expert in the design of astronomical filters, devised a unique solution – a series of filters that isolate regions of the stellar spectrum that contain information on the three fundamental qualities of stars. In this way, SkyMapper is not only generating a fundamental map of the sky, but also enables us to trace the evolution of the Milky Way.

Every clear night SkyMapper images the sky in its six filters. It returns to each point on the sky three times in each filter. This enables us to build a time-series view of the sky with which to see objects that are changing in brightness such as pulsating stars. To date, we have covered around 15% of the southern sky.

Our software delivers each night's data to the National Computing Infrastructure supercomputing centre in Canberra where these data are processed and the distilled positions and brightness of each object is recorded. The National Computing Infrastructure facility then makes these distilled data available to the world via the All-Sky Virtual Observatory.

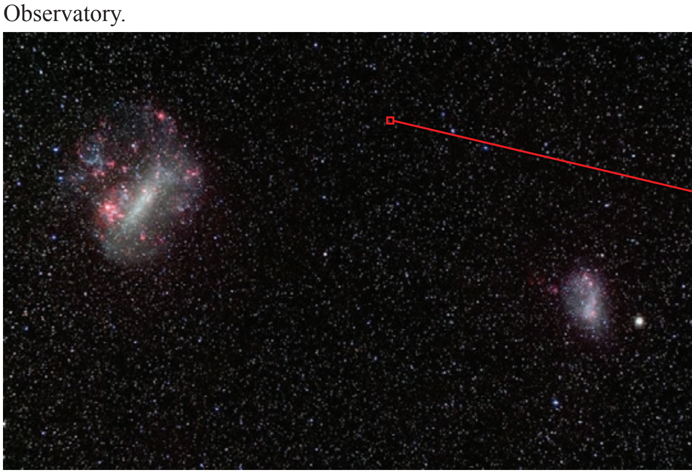
Big Survey = Big Questions

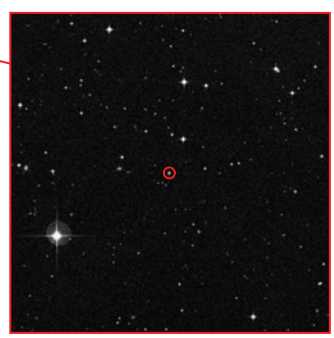
Astronomers are grappling with a big question. How did the gas in the aftermath of the Big Bang come together to form the galaxies we see today, some 13.8 billion years later? Looking at progressively more distant galaxies is like peering into a time machine; we see galaxies as they were when the light was emitted. The largest telescopes in the world have been able to see back to galaxies as they were when the Universe was only 1% of its current age. However, it turns out that the formative phase of a galaxy's life is earlier still – beyond the reach of modern telescopes. The phase in question is when the Universe's first stars were forming and rapidly dying in titanic supernova explosions.

We can't yet study these early times directly, but there is another way. Stars act as time capsules – they lock within them a sample of how the Universe was when the star formed. Even after 13 billion years an ancient star retains the chemistry of the early Universe. To understand the evolution of the early Universe we therefore need to find the oldest stars. Since inception in the Big Bang the Universe has become increasingly enriched in elements other than hydrogen and helium due to nuclear processes within each generation of stars. Massive stars develop a core of iron towards the end of their lives. When such a star undergoes a supernova explosion the iron, and a range of other elements formed over the star's lifetime are distributed into a reservoir of gas from which the next generation will form. In this way, the iron content of the Universe is constantly increasing. The oldest stars are, generally speaking, those with the lowest levels of iron. SkyMapper is unique in its ability to determine how much iron is in each star we observe.

Our team were able to use this technique to find a star with less than one ten-millionths the iron as the Sun. The star we estimate was formed between 100–400 million years after the Big Bang. The discovery of this ancient star is a defining success for the team. As one star out of 60 million imaged by SkyMapper we were able to pin-point it only through the special design of SkyMapper; it truly was a needle in a haystack search. This star is not pristine gas however. Although it contains no measurable iron, it does contain large quantities of carbon and magnesium, which indicate that the star formed in the wake of a supernova explosion. By studying the pattern of elements found in the star we understand that the star we have found formed after the explosion of a single first generation star.

The first stars have been a mystery to astronomers. Forming from the pristine hydrogen and helium of the Big Bang, such stars were expected to be extremely massive, hundreds of times more so than stars today, and undergo extremely explosive deaths. But the star we have found does not match this picture – it points to a first star that was 10–70 times the mass of the Sun that died in a low energy explosion. Although the first star was disintegrated in the explosion, much of the material fell back into the central black hole that formed in the supernova – vacuuming away the iron. This iron-poor gas was then mixed with the surrounding pristine gas and drawn together by gravity to form the star we have found. In this way, we have pieced together the forensic evidence that tells us, for the first time, what a first generation star was like. We continue to use SkyMapper to search for further such stars to describe the range of properties of the first stars.





The location of the early star is in a picturesque part of the southern sky between the Large and Small Magellanic Clouds. The right image is about five arcminutes square, the left about 30° across. (LMC/SMC image credit Michael Bessell, ANU)

Opposite page is SkyMapper Observatory under the Milky Way (credit James Gilbert - Australian Astronomical Observatory)

There is a broad range of science applications for SkyMapper's survey data ranging from the nearby Solar System to the limits of the optically observable Universe. For example, our images contain a multitude of asteroids. Due to their close proximity these objects appear as streaks in our survey images, from which it is possible to determine orbital motion. Beyond the orbit of Neptune is the realm of bodies like Pluto that no longer conform to the orbital plane in which all the major planets reside. Due to the disproportionately more intensive study of the northern sky it is possible that a body the size of Pluto may well be lurking in the southern sky and SkyMapper will be well placed to catch it.

SkyMapper scientist and Nobel Laureate Brian Schmidt will utilise the light grasp of SkyMapper to continue his work on supernovae. By repeatedly surveying a quarter of the sky Prof. Schmidt and his team will identify nearby supernovae in large numbers. It is the aim of this research to strengthen the basis behind the use of supernovae to measure cosmic distances and hence cosmic acceleration.

Rarely seen at the present epoch but progressively more common at early times in the Universe are galaxies that are hosting tremendous outpourings of radiation. These objects, termed Quasi-Stellar Objects, or QSOs, as the name suggests, look like starry points of light. They are however powered by a very different process than a star. At the core of each QSO resides a black hole many millions of times more massive than the Sun, which is consuming matter at a high rate. Much like a baby eating, only a fraction gets down! The rest is ejected in the form of a jet of energy and plasma. When it happens that this jet is aligned with us here on Earth we see the energy beamed towards us. The QSO-host galaxy pales in comparison to the jet and is lost in its glare leaving us with what appears as a star.

QSOs act as cosmic lighthouses, able to be seen at tremendous distances, and courtesy of their power they enable us to trace the material along the line of sight. QSOs can be used to great effect to trace the boundary of the Cosmic Dark Age – a boundary that marks the transition from a Universe pervaded by cold, dark gas to one bathed in hot, transparent gas we now inhabit. The Universe's first stars are thought to have forced this transition around 500 million years after the Big Bang. With SkyMapper, we aim to find around 100 new QSOs at vast distances. The timing of the transition can inform us about the formative processes of the early Universe – how the first stars and galaxy development led to the galaxies we see today.

2015 promises to be an exciting year for the SkyMapper project as we piece together the first digital map of the southern sky.

Stefan Keller is Senior Research Fellow at the Research School of Astronomy and Astrophysics, Australian National University. He joined the University in 2003 to construct the SkyMapper Southern Sky Survey program. Prior to this he was a post-doctoral fellow at the Lawrence Livermore National Laboratory in the USA where he conducted research on dark matter and pulsating stars.

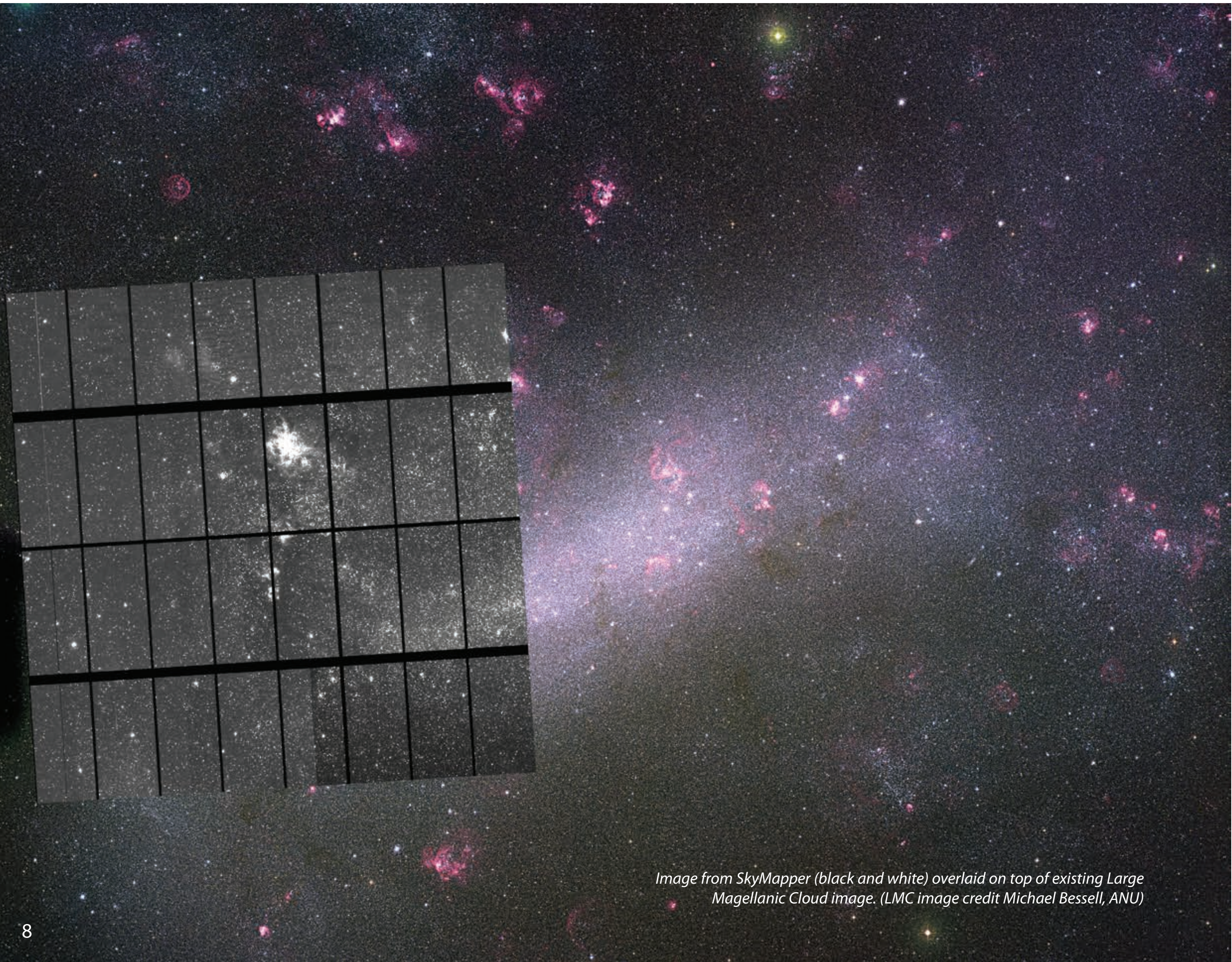


Image from SkyMapper (black and white) overlaid on top of existing Large Magellanic Cloud image. (LMC image credit Michael Bessell, ANU)

25 YEARS OF INCREDIBLE EXPLORATIONS!

We've already mentioned the yearbook has been going for 25 years; it's amazing to reflect on the numerous projects during that period that have added to our knowledge of the cosmos. Here's a brief snapshot of some of our favourite highlights, many of which we've shared with our readers over the years. We'll admit our bias to the imagination grabbing robotic probes and orbiting observatories.

Our Solar System

In 1989, the brief visit of Voyager II to Neptune finished mankind's preliminary reconnaissance of the Solar System (well... the big stuff). At that time the only visitors to Mercury and the outer gas/ice giants had been brief, but exciting flybys.

The Voyager spacecraft had in the 70s and 80s given us unprecedented explorations of Jupiter, Saturn, Uranus and Neptune, but one philosophical aspect was Carl Sagan's suggestion to turn Voyager I's camera back on the Solar System. So in 1990, an image of the Earth was taken at a record distance of six billion kilometres revealing a pale blue dot a fraction of a pixel in size. A reminder to us all how small the Earth is and how we need to look after the only lifeboat Mankind knows.

Sun. There have been numerous missions to improve our knowledge of our closest star, here are two. STEREO (Solar TErrestrial RElations Observatory) launched in 2006, gets the best acronym award consisting of duel spacecraft one in front of the Earth in orbit and the other behind creating stereo solar views. SOHO, since 1995, has continually monitored the Sun across a number of wavelengths. It's possibly best known for the large number of sungrazing comets discovered in its images (2,702 as of May 2014).

Mercury. Prior to the arrival of Messenger in 2008, this inner world had only received one visitor (Mariner 10 in 1974) so little was known until the 21st century. Messenger changed all this and is best known for its impressive imaging/mapping of its surface.

Venus is the most hostile planet with many short-lived landers being crushed by its high surface pressure and temperature. Venus hides its secrets well under a thick cloudy atmosphere. In 2006 Venus Express went into polar orbit and since then has been returning a stream of data including atmospheric chemical composition and recording the planet's bizarre weather patterns.

Mars. Numerous orbiters and landers have graced Mars but the highest profile missions recently have been the extraordinarily long lived landers Opportunity and Spirit with the latest, Curiosity, which since its nail-biting landing in 2012 has been exploring Gale Crater.

Jupiter. Beginning in 1995 the Galileo spacecraft spent eight years in orbit around Jupiter. It also released a probe, which descended towards the planet making measurements of its upper atmosphere. Galileo examined the planet, rings and satellites. This included Io's volcanism and an indication of oceans beneath Europa's icy surface.

Saturn. In 2004, Cassini became the first spacecraft to orbit Saturn and has been sending back data on the planet, rings and satellites since. A triumph was the successful delivery of the Huygens probe to the surface of Saturn's largest satellite, Titan. A further achievement was the discovery of a possible subsurface ocean on Enceladus, complete with geysers, the source of raw material for Saturn's E ring.

Dwarf Planets. 2015 is a busy year for spacecraft encounters. The New Horizons spacecraft flies by Pluto in July (see page 45) and Ceres has 'Dawn' go into orbit in March/April.

Asteroids. A number of minor planets have had robotic visitors; with the best known being Dawn going into orbit around 4 Vesta from July 2011 to September 2012, before heading off to Ceres (see above).

Comets. Like the asteroids, a number have had flybys over the years, with the most exciting being Rosetta that in 2014 went into orbit around Comet 67P/Churyumov-Gerasimenko. Also let's not forget the bonus Earth bound observers had when four of the best comets over the last 100 years graced our skies since 1990. Only your eyes were needed to feast upon the displays from Hyakutake in 1996, Hale-Bopp in 1997, McNaught in 2007 (see image p. 132) and Lovejoy in 2011. Additionally, only an amateur telescope was needed to see Comet Shoemaker-Levy 9 give Jupiter multiple black eyes as its fragments collided with the planet back in 1994.

Other Solar Systems

In 1990 there were no confirmed planets outside of the Solar System (the first was in 1992), now thousands have been revealed or suspected with the space-based observatory Kepler contributing significantly to this number.

The Biggest Picture!

The realisation that the Universe's expansion is accelerating was a major discovery, leading to the postulation of dark energy. This rocked some aspects of the traditional view of the Big Bang model of the creation of the Universe. However the cosmic microwave background radiation continues to be the best evidence for the Big Bang, outside of the expansion itself. Three probes have been involved in mapping this echo from 13.7 billion years ago, COBE launched in 1990, WMAP operating throughout the 90s and Planck 2009–2013, with each subsequent mission improving the resolution of the microwave map.

Another mystery has been dark matter, but its existence is widely accepted now. Although it's unseen, its gravitational effect on the mechanics and interaction of galaxies as well as the lensing of images of distant objects in the Universe is unmistakable.

In 1990 the Hubble Space Telescope had finally made it into space. Unfortunately, the optics were found to be flawed and it had to wait until 1994 to get its glasses (corrective optics) to lift the blurry haze to show its amazing view of our Universe. It took a further 10 years before the mind blowing 'Deep Field Images' were taken. The idea was simple. Point Hubble at a location in the sky where nothing had been seen before and take the equivalent of a two-week exposure. It revealed thousands of faint distant galaxies, many in their infant state. Remember it's taken their light billions of years to reach us. This successful experiment was repeated in a totally different part of the sky with the same results. The idea of there being as many galaxies in the Universe as stars in the Milky Way is awesome!

Comet 67P/Churyumov-Gerasimenko imaged by Rosetta's OSIRIS narrow-angle camera on 3 August 2014 from a distance of 285 km. The image resolution is 5.3 metres/pixel.

Credit ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

The 2014 CWAS

In July 2014, the Central West Astronomical Society's astrophotography competition was held again as part of the CWAS AstroFest. Amateur astronomers and photographers from around Australia were invited to take part in the exhibition and to submit their astrophotographs for consideration in the prestigious "David Malin Awards".

This year's competition had seven categories: Deep Sky, Wide-Field, Solar System Hires (< 30'), Solar System Wide-Field (> 30') and a themed Section – *The Moon.* Additional categories for animated sequences are not included here.

The photographs were judged by world-renowned astrophotographer, Dr David Malin, without David being aware of the identity of the photographers. The winners were presented with the "David Malin Awards" in the presence of invited dignitaries, during the CWAS AstroFest conference dinner on 19 July 2014.

Dusty Heart of the Milky Way

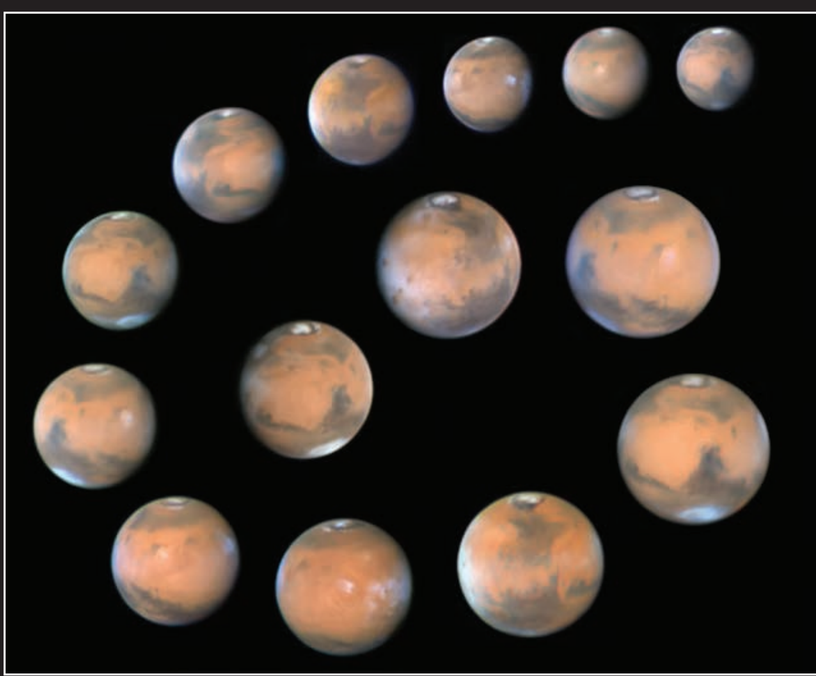
Phil Hart (Wide-Field)

"This is a perfectly simple rendition of the Milky Way using an off-the-shelf camera and a standard 50 mm lens. However, the quality of the result is outstanding, especially the colour balance and stunning detail. Beautiful!"

Marine Moonset

Phil Hart (Theme - The Moon)

"This is a striking image that has a quite painterly quality. The careful cropping and a soft and gentle light, makes the photograph look like an art work."



Mars 2014

Stefan Buda (Solar System - Hires)

"Intriguing composition of a series of excellent images of Mars over several months, all of them showing fine resolution and the obvious change in the diameter of the planet with distance. Excellent!"

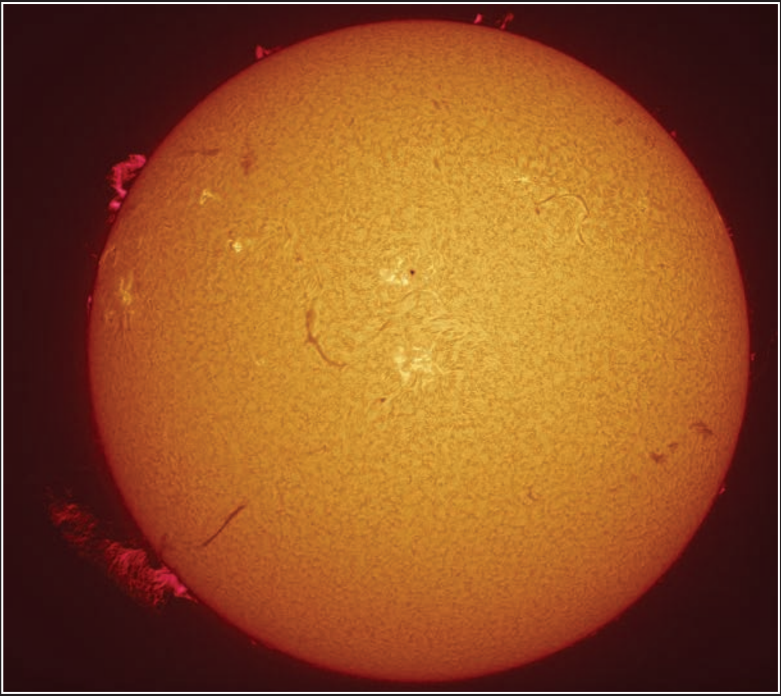
David Malin Awards

It was not just technical skill that was awarded. The prizes went to pictures that captured the beauty of the sky and the intrinsic interest of astronomy in an aesthetically pleasing manner.

Mr Steve Grove, the News Corp. Photographic Manager, judged the "Photo Editor's Choice" awards and gave his pick from each category. His overall winner was awarded the Photo Editor's Choice Award.

This year's permanent exhibition will be on show at the CSIRO Parkes Observatory's Visitor's Centre for one year from 20 July 2014. A second touring exhibition, organised by the Powerhouse Museum, will travel to selected venues, beginning with Sydney Observatory on 13 August 2014.

Shown here are the still image category winners with the judges citation.



Prominence

Paul Haese (Solar System - Wide-Field & Photo Editor's Pick)

"This is a stunning image in all respects, and shows the active Sun and large prominence on the limb. A lot of effort and specialised knowledge goes into making images of this quality, and this is a superb example of an arcane art."

The Horsehead and Flame Nebulas

David Fitz-Henry (Photo Editor's Choice)

"This image contains all the elements of an intriguing photograph - splendour, mystery and drama. It's one that takes the average observer into what is truly the beauty of deep space."

OVERALL WINNER

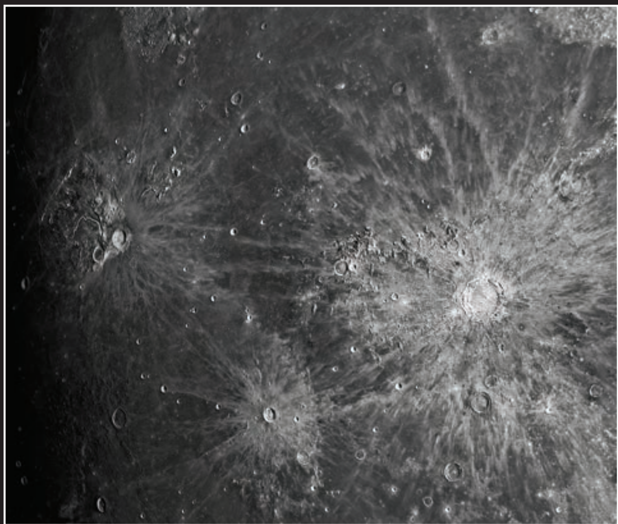
Dust and Gas

Paul Haese (Deep Sky)

"I think this is the best true-colour image of the Orion Nebula I have seen for a long time. It has everything. The basics are well covered by a realistic-looking colour balance and the dynamic range, which makes the heart of the nebula look brighter than everything else, which is as it should be. But the other things are right too, including the delicate, faint nebulosity that fills the field and the careful handling of the bright stars, which don't dominate the image. Fantastic!"

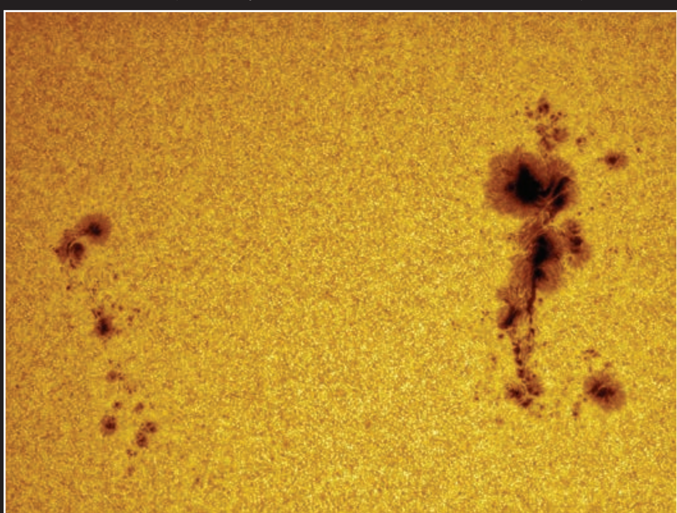
David Malin Awards

Below are three of the many honourable mentions from the competition. See www.parkes.atnf.csiro.au/news_events/astrofest/awards/ for the complete list and other details.



Moonflowers

Bratislav Curcic (Solar System - Hires, Photo Editor's Pick)



White Light Sunspot AR11967

David Hough (Solar System - Hires)

Partial Solar Eclipse Setting

Andrew Wall (Solar System - Wide-Field)

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Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the formidable worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, The magazine is produced specifically for Southern Hemisphere astronomers. Cost (October 2014) is $76 for one year (8 issues), $140 for two years (16 issues).

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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.

Designed for the Southern Hemisphere, the Night Sky planisphere is printed with dark stars on a light background for easy night time readability. The constellations are drawn simply, emphasising the brighter stars. A selection of deep sky objects for binocular viewing is included.

The map scale is larger than on similar-size planispheres because the whole sky does not have to be shown on a single map. The Night Sky's design corrects for distortion of the constellations around the horizon, inherent on single sided planispheres. Its plastic construction makes it durable and moisture resistant.

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

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. They come in two sizes: the large 22 cm version is $24.95, the small 13 cm one is $14.95, price includes postage within Australia.

We Are All Beginners

So you are uneasy being a novice — relax, we were all beginners once. One of the pleasures of astronomy is you don't need much to enjoy the wonder of the night sky. You don't need to know a lot either. You already have the important part, the interest. The knowledge (including the jargon) will come when it is required.

On this page we look at the attraction of naked eye astronomy. Some basic equipment will help — this book and a red light torch are a good start. The red light can be as simple as a few pieces of red cellophane wrapped around the end of the torch and secured with an elastic band. The red light is to help preserve your night vision when reading charts and books at night. Even if you can't escape the light polluted skies of the suburbs, it is still important to eliminate direct light in your eyes. If you have a neighbour with that annoying backyard light that seems to be always on, invite them over to enjoy the sky. They will soon get the message. Also, don't underestimate the importance of being comfortable. A reclining chair and warm clothing are soon appreciated.

Perhaps a good place to start is to become familiar with the constellations. This is where the All Sky Maps (starting on page 69) or a planisphere can come in handy. A planisphere, a good companion to this yearbook, shows all of the sky, except for the Sun, Moon and planets because they move with respect to the stars. You will see at a glance all of the constellations visible at the time you are observing. An example is shown opposite. Once you start to look around the sky using a planisphere or the All Sky Maps, you may be pleasantly surprised how easy it is to recognise some of the constellations. These star patterns will quickly become familiar and soon be like old friends. Learning the sky under light polluted city skies is easier than under dark rural skies because there are fewer faint stars visible to confuse the patterns. When it comes to the minor constellations, like those in the far south such as Octans or Mensa, you will need binoculars or dark country skies to view them.

Once you have a working knowledge of the prominent stars, the brighter planets can be much easier to recognise. Besides the Sun and Moon, five of the planets are easily seen with the naked eye: Mercury, Venus, Mars, Jupiter and Saturn. Venus, the Evening or Morning Star, is quickly recognised as it is by far the brightest *star* in the sky. Jupiter is also easy to find, for only the star Sirius can rival its brilliance. Mercury, Mars and Saturn can be a little less obvious and this is where the Sky Views, in the monthly section, can help.

The night sky regularly puts on displays for us called conjunctions. Since the planets, including Earth, are moving around 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 appears near another planet, the Moon or a star, it's called a conjunction. Those including the Moon can be a wonderful sight. The Sky View diagrams are designed to display the most spectacular conjunctions during the year. A great example is the one between the Moon, Aldebaran and Venus on 21 April (see Sky View p. 35). These objects are in the northwest sky in the evening twilight. 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 kilometres because the numbers would be so large. Instead, we use the time it takes for light to travel from these objects to us (at 300,000 km per second) to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over one second to reach us, Venus 9 minutes and Aldebaran 65 years. If you include the Pleiades open star cluster, we are out to 430 years! Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, Aldebaran is a close neighbour. Light takes some 100,000 years to cross from one side of the Milky Way to the other!

While on the subject of naked eye Solar System objects, here is a challenge. The planet Uranus can be glimpsed under ideal dark skies, but you will need a finder chart (p. 130) and All Sky Maps (Map 3).

The following are ideal for naked eye observations:

- Meteor showers (see Part I monthly section).
- Artificial satellites. These can be fun to look for up to a couple of hours before sunrise or after sunset (the Heavens Above website www.heavens-above.com will give you tailored predictions for your latitude and longitude).
- Aurorae, if you live far enough south.
- The phases of the Moon. Don't forget that the Moon can be followed into the daytime sky. For a brief period (up to three days) either side of a New Moon, it can be difficult to see in daylight.

While talking daytime viewing, if a Sky View shows Venus very close to the Moon, try finding the planet in the daytime sky (July 19 is a possibility). Venus and Jupiter are bright enough to see in broad daylight, provided they are not too close to the Sun. The challenge is knowing where to look in the featureless daytime sky and getting your eyes focused correctly. Having the Moon nearby helps in both these areas.

Don't miss getting out under dark country skies, preferably when the Moon is not around. Now you will see naked eye deep sky objects. Autumn and winter evening skies give us in the Southern Hemisphere a magnificent view of our home galaxy, the Milky Way. It is amazing the detail that can be seen with the unaided eye, such as the bright central bulge around Sagittarius and the numerous dark lanes running along its length. Have a look for the Aboriginal *emu* constellation. The head is the dark nebula, the Coal Sack, near the Southern Cross (complete with its faint 6th magnitude *eye* star). The neck is the dark nebulae running through Centaurus towards Scorpius and the body is the complex of dark lanes in the region of the galactic bulge. It is best seen sitting on the southwestern horizon in the early evening autumn sky. The dark lanes in the Milky Way are clouds of gas and dust silhouetted against the bright galactic carpet of stars.

The list of naked eye galaxies doesn't stop here. The Magellanic Clouds can be seen appearing like small detached sections of the Milky Way, in the far south. In the north we have M31, the Great Galaxy in Andromeda. There are also a number of open star clusters (such as M44 and M45) visible. When you see the obvious fuzzy patch we know as the globular cluster Omega (ω) Centauri, it can leave you wondering how it got a normal star name. There are a number of other naked eye objects and the All Sky Maps will help you identify them.

A final warning. By purchasing this book you may have started on a lifetime of frustration at the weather and having to train your family to organise events so they don't clash with New Moon weekends. The uncertainty of the weather can even add spice to the hobby. To pull up in your car, having driven through rain for the last hour, to see a magnificent winter's evening sky with the Milky Way stretching from horizon to horizon can be a fantastic adrenalin rush. Enjoy the buzz.

Venus and Zodiacal Glow – Grahame Kelaher
An honourable mention from the 2014 CWAS David Malin awards. See page 10.

A Word About Binoculars

Probably the most cost-effective accessory for the beginner are binoculars. A reasonable quality pair can be purchased for the same price as a cheap, sub-standard 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 low cost way of gauging your child's level of interest. This does not mean the quality of the binoculars should be poor. We suggest that binoculars should be purchased from a reputable optics or telescope dealer. These people appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. To observe detail on the Moon or look for Jupiter's moons, avoid just holding them in your hands. Try bracing yourself on the arms of a chair or the roof of a car. Telescope dealers can assist with mounts to hold the binoculars steady. There are also brackets designed to attach binoculars to a camera tripod. This is probably the cheapest option, especially if you already have a tripod. Keeping the binoculars steady is important if the power of the binoculars is more than 10 ×. A power of 7 × is 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 handhold and the budget; 7 × 50 binoculars (7 times magnification, 50 mm diameter front lens) are fairly popular with amateurs.

For the novice, finding your way around the sky is far easier with binoculars than with a telescope. Using a telescope is a bit like looking at the sky through a straw and the view is usually upside down and sometimes mirror-imaged! Even when using low power in a typical amateur telescope, the field of view is only about one degree. A pair of 7×50 binoculars can give a field about seven degrees in diameter (roughly the size of the Southern Cross), or if you like, 40 to 50 times the area visible through a small telescope. It is not unusual for the general public to ask when looking through a telescope, "where in the sky is that?" Looking at the star field doesn't make the location obvious. Having a larger field will help with knowing where you are looking. The field size in degrees is normally marked on the binoculars. To get a feel for how that translates to the sky, look at a Sky View diagram, each have a 10° line marked on them.

Even with binoculars you still need to practice pointing the instrument. There is a tendency to look too low, so if you don't see what you are after, the first thing to try is tilt the binoculars up. One method that may help is to find an obvious nearby bright star, or better still, a bright star pattern (called an asterism) and star hop across. If your object isn't too high in the sky you can try finding something on the horizon directly under it, like a distinctive tree outline, and move the binoculars up. Another method, that might take a little getting used to, is to stare intently at the area of the sky with your unaided eyes and then moving the binoculars into place without moving your eyes. Practice on bright stars first until you are comfortable. Talking of comfort, plan your observing as it can be very difficult to look directly up, especially if the binoculars are mounted on a tripod. This is where sitting back in a reclining chair and hand holding the binoculars makes it easier. If your seat doesn't recline, try leaning the tripod on two legs (or a monopod – single leg tripod).

Also, it is worth remembering that binoculars are prone to dewing just like a refracting telescope. A couple of cardboard tubes on the front, sticking out about 7 cm, can help prevent dew on the front lens and also minimise stray light. If you do strike dew, place the binoculars in a warm environment for a short time until they clear.

Taking your binoculars out under dark country skies at some stage is a must. It has been said that one of the joys of the Milky Way's satellite galaxies, the Magellanic Clouds, is that they show as much detail through a moderate size amateur telescope as that seen by large professional telescopes looking at distant galaxies (outside our Local Group). This argument can be extended to our own Milky Way, but in this case the humble binoculars are sufficient. The wide field of binoculars is ideal to show detail in the complex dark lanes and star clouds running through our galaxy, especially around the central galactic bulge region in Sagittarius. Some of these dark rifts and star cluster regions are sometimes barely visible to the unaided eye but quite obvious through binoculars. Their wide fields can also show some larger open star clusters such as the Beehive (M44) and the Pleiades (M45) better than they look through the narrow field of view of a telescope.

Buying your First Telescope

There will come a time when you will want to take the plunge and buy a telescope. Obviously you can only go so far with binoculars and the chance of seeing the Universe up close, live and personal has to be experienced. Those of you who have read our yearbooks in the past will be sick of hearing this advice, but it is still very true. Don't buy anything without spending some time evaluating the various telescopes available to establish what suits you best. This is where your local astronomical society can be a gold mine of information (see Part III). These people are more than willing to show off their scopes and discuss the various features available and their associated pros and cons. Learn from these experts. If you can look through their instruments under light polluted conditions as well as under dark, country skies, all the better. This gives you a realistic feel of what to expect. The telescope shops and public observatories also have many years of experience in this area, so draw on their advice as well.

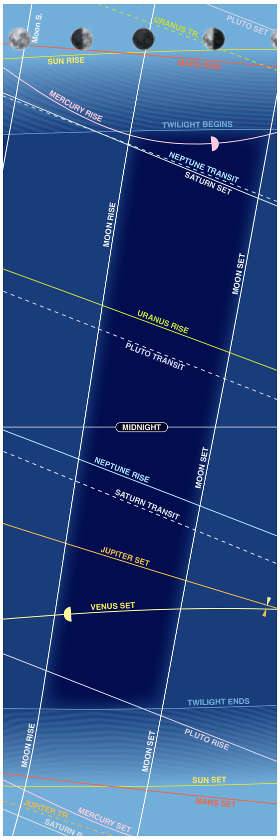
There are a multitude of uses for binoculars in amateur astronomy. Some of these include:

- Helping to find stars and planets in a bright twilight sky.
- Looking at the mares (seas), larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views, All Sky Maps and finder charts in this publication. Binoculars can help 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. Contrast the yellow of Alpha (α) Centauri with the blue of Beta (β) Centauri.
- Stars and planets close to the horizon.
- Looking at artificial satellites in the early evening sky. You might find them with the naked eye, but binoculars will help; sometimes they vary in brightness as they tumble. You can follow them further into the Earth's shadow before disappearing.
- Lunar occultations of some of the brighter stars (see Part II). Small binoculars are well suited for magnitude four or brighter events, preferably on a dark limb.
- Looking at bright, wide double stars.
- Observing bright comets.
- Searching out Uranus and Neptune, using the finder charts, see page 130 and All Sky Maps 3 and 8.
- Observing the moons of Jupiter as they oscillate across the planet from night to night, see the diagrams on pages 113 to 118. The magnification of the binoculars will dictate how close to Jupiter you can see these satellites.
- Some of the bright deep sky objects such as star clusters, Milky Way regions, and the Magellanic Clouds. The galaxies M33 in Triangulum and NGC 253 in Sculptor are worth going after with binoculars.
- 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 to see which *star* has moved. Taking the coordinates of a minor planet from Part II, and plotting that position on the All Sky Maps, will help you find the correct area.
- 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 (p. 149) or organisations such as Variable Stars South (www.variablestarssouth.org) or AAVSO (www.aavso.org).

A lot of the above can be done from a typical suburban backyard. It is not always necessary to drive for hours to reach dark skies.

Using this Book

The yearbook was never intended to be read from cover to cover. Instead think of it as a jigsaw puzzle offering pieces to enable you to assemble an observing plan for a night under the stars. This is not only fun but can help your time at the telescope be more productive. There's nothing worse than packing up early saying you ran out of things to look at. Here's a worked example.



It is 22 June, you live near Canberra and are looking to observe all evening and into the morning (23rd). A great place to start is the Visibility of the Planets diagram (p. 19). Looking in late June you see Venus, Jupiter and Saturn are in the evening sky with Mercury, Uranus, Neptune and Pluto in the morning. Pluto is near the midnight line showing it's close to opposition while Mars is near the Sun line and probably in conjunction (too close to the Sun to see). Our next port of call will be the Rise–Set chart for June, see page 40. Keep this page bookmarked, as we will often refer to it; the rise and set times below come from here. Note, being June there's no need to add an hour for daylight saving. Find the position for the 22nd across the bottom and draw a vertical line to the top of the diagram to the 23rd. Remember the times from this diagram are only approximate. In this case for Canberra, being a capital city, more accurate rise and set times can be obtained from the relevant tables in Part II. For example the diagram shows Jupiter setting around 9 pm, referring to page 111 it would be closer to 8:50 pm from Canberra (interpolating between times for the 20th and 27th). Now, let's take each object roughly in the order they are available tonight. It is best to start with those setting first.

Looking at Venus, Jupiter and the Moon on the Rise–Set Chart (p. 40) they all are setting within about two hours, 8:30 pm, 9:00 pm and 10:50 pm respectively. It's reasonable to assume a Sky View diagram would cover these naked eye objects. One does, on page 43, showing Venus with Jupiter above, then the Moon higher again in the northwest early evening sky. If you include the star Regulus, the four make a straight line. The previous two nights would have had closer conjunctions between the Moon and these planets.

The **Moon** section on page 41 (or the calendar on the inside front cover) tells us Luna is around five days old, two days before First Quarter Moon. The Observing the Moon section (p. 96) lists some prominent features to look for on the terminator on each phase of the Moon. Have a look at those listed for Day 5 (plus the day either side, as the terminator position used here is only approximate).

Lunar Occultations. Only two events are listed for 22 June, both involving the 5.1 magnitude star, 48 Leo. Looking at page 102, it disappears behind the dark limb at 20:01 (8:01 pm) and reappears from behind the bright limb at 20:57 (8:57 pm) for Canberra.

The Moon setting at 22:26 (p. 89) marks the beginning of deep sky observing time. The **Hours of Darkness** section for Canberra (p. 93) confirms this with dark skies expected between 22:26 (moonset) and 05:41 (start of dawn).

Venus, having just past maximum elongation (see 'half moon' symbol on the Rise–Set chart), can't be missed in the early evening sky, setting around 8:30 pm. It is a –4.4 magnitude beacon to the lower left of another unmistakable planet, Jupiter (see Sky View p. 43). The Appearance of the Planets diagrams (next to the Rise–Set charts each month) show it has been steadily growing in size (January was 10.6" to June 23.6") with the phase shrinking significantly (now around a First Quarter Moon shape) as it heads towards inferior conjunction (passing between the Sun and Earth) in August.

The gas giant **Jupiter** is setting around 9 pm and should be observed as soon as possible before it gets too low (even during twilight). Although you could work out Jupiter's location using the All Sky Charts and its finder, at magnitude –1.9 this brilliant *star* should be easily visible, only outshone by Venus. To find where its main satellites are tonight go to the diagram on page 116. Estimating the position in the early evening of the 22nd, Io (I) is on its own on the western side with the east showing Europa (II) closest to the gas giant, then Ganymede (III) and Callisto (IV). It's no surprise Europa is close for the Jupiter Satellite events (p. 116) sees that moon transit from Perth, starting 19:12 WST, after the planet has set from the east coast. The Great Red Spot (GRS) is transiting at 18:47 (6:47 pm) EST and best viewed from eastern Australia, see page 121. Another reason to get onto Jupiter early to watch this ancient storm.

Saturn on the Rise–Set is transiting around 10 pm (see the dashed line). This means it is due north, at a maximum altitude and the best time to observe. The sky View (p. 43) and all Sky Map No. 6 (p. 74) shows us the planet is not far from Antares in Scorpius. The Appearance Diagram (p. 40) shows how the rings appear this month. To find the position of Saturn's brightest satellite, Titan, you need pages 124 and 125. Titan's most recent greatest eastern elongation was on 8.779 UT (table 2). Let's look at the time tonight when it is highest in the sky at 10 pm or 12:00 UT and still the 22nd (using table 3, p. 125). Converting to decimal days equals 22.500 days so 13.721 days has passed since this eastern elongation. Finding this position on Titan's orbit on the diagram on page 124 shows the satellite in the northeast quadrant, only a couple of days away from its next maximum eastern elongation. See these pages for how to calculate the positions of the other major satellites for any date or time.

Neptune rises in the late evening (around 10:30 pm), transiting just before dawn. The text on page 42 tells us Neptune is in Aquarius and the constellation table (p. 138) directs you to All Sky Maps No. 8 (p. 76), then the finder (p. 130) completes the search.

Uranus rises around 2 am and best left to observe until the predawn. Use the same approach as Neptune to find this outer world. It is in Pisces and the constellation table directs you to All Sky Map No. 3 (p. 71) and the finder (p. 130).

A challenge with Uranus and Neptune is to observe their moons. Page 128 can be used to estimate the position of Uranus' major satellites and Neptune's brightest, Triton.

Mercury. The Rise–Set chart has this inner world rising around 5:30 am and near a maximum elongation from the Sun. By this inner world's standard it is well placed. The Appearance Diagram (p. 40) shows its size decreasing quickly and its phase growing as it moves away from inferior conjunction late in May. The Sky View diagram (p. 43) indicates Mercury is probably in the Hyades on the 23rd, close to Aldebaran.

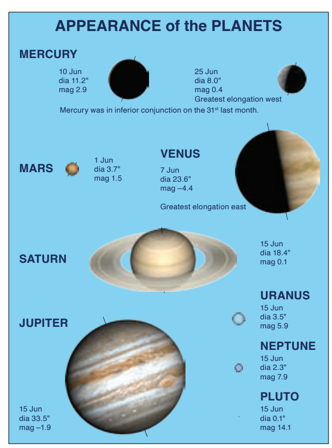
Lesser bodies of the Solar System. The monthly text also mentions the brightest dwarf and minor planets, the best comets (known at time of publication), and meteor showers for the month, if observable.

Dwarf Planet **Pluto** is in Sagittarius and at opposition next month (p. 42). It's up most of the night, transiting around 1 am (see Rise–Set). Its approximate position is marked on All Sky Map No 8 (p. 76). Then the pointer and finder charts, on pages 130 and 131 respectively, allow you to zoom in on its location. At least a 20 cm telescope is needed to glimpse this outer world.

Minor Planet **2 Pallas** is at opposition this month in Hercules (p. 42). Not all minor planets mentioned in this section have ephemerides in Part II. However, Pallas is one of the brightest asteroids and its position is included (p. 137). If you plot the position on All Sky Map 6 (p. 74) it is close to Lambda (λ) Herculis (within about two degrees) in the direction of Delta (δ).

Comet C/2013 US$_{10}$ (Catalina) is in Sculptor in June, rising in the late evening (see p. 42). Approaching 10th magnitude it has the potential of looking reasonable through a medium sized telescope (20+ cm). You can get an approximate position by plotting its coordinates from page 134 for 20 June and 27 June on an All Sky Map (in this case No. 2) and interpolating. At this time Catalina is heading due south and on the 22nd approximately 4° east of Mu (μ) Sculptoris. Looking at the text and diary (p. 42), the comet will make a very close approach to galaxy NGC 9993 the next day! Also looking at the comet's rise time, around 22:40 (interpolating, see p. 134), it's around the same time the Moon departs leaving the rest of the night to observe.

Any meteor showers that are favoured for the month are found at the end of the monthly text. Unfortunately, no known showers are favourable for June. In general most (but not all) meteors are seen in the morning hours and it's good the Moon will have set by then. Whenever you feel like a break, grab a warm drink and sit back and just look. Who knows when that next brilliant fireball will light up the heavens? Seeing one of them would keep you awake for a while!

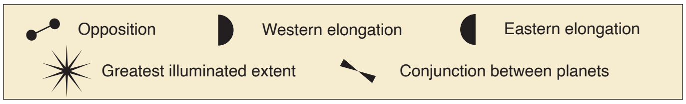


The Monthly Sections

Each monthly chapter in Part I contains the following:

Rise–Set Chart

This enables you 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 following morning sky above. The ideal time to observe an outer planet is at the time of transit (represented by dashed lines), which is when it is due north and has reached its maximum altitude. A number of events during the year have been shown with symbols.



These charts only give an approximate local standard time and you will see from the specific rise and set times in Part II that there is variation from city to city. If more accurate times are required, see the tables for the object of interest in Part II. For rural locations use the appendix on page 142.

Highlights

This lists a few interesting events during the month.

Constellations

A general discussion on the constellations and stars visible during the month, with an emphasis on the evenings when most people are out gazing at the night sky. This is for those armed with nothing more than their eyes and their curiosity. A diverse range of subjects is covered including times to observe, what to look for in the Milky Way and some of the legends and mythology surrounding the heavens.

Appearance of the Planets

This diagram provides the reader with a telescopic view of each planet at the same scale. To make them more attractive we use photographic images but you may be surprised how much of this detail can be viewed directly through a small telescope given good seeing. For example, the Great Red Spot (when visible) and cloud bands on Jupiter. Phases are also shown for Mercury, Venus and Mars and the approximate appearance of Saturn's rings. With each image are the date, the planet's angular diameter and magnitude. The top of the diagram is north.

The Moon

This provides information on major events relating to the Moon. Included are the Moon's phase, apogee, perigee, libration, occultation of planets, minor planets or bright stars and lunar and solar eclipses. An event does not have to be visible from Australia to be included. The description will indicate whether or not it can be seen.

The Planets

Presented are general notes on each planet, including location and best time to observe. Emphasis is placed on their suitability for observation and any interesting conjunctions and patterns between the Moon, other Solar System objects, stars and deep sky objects.

Dwarf Planets and Small Solar System Bodies

Minor Planets (or Asteroids) This section deals with the brightest asteroids that reach opposition each month (13.0 magnitude or brighter). An entry includes the date of opposition (when it is brightest), its magnitude and the constellation the asteroid is in at the time of opposition. The 15 brightest minor planets have ephemerides included in Part II.

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. **No adjustments are made for Daylight Saving** anywhere in this book. When Daylight Saving is in force you will need to add one hour to times given here. For example, any rise or set time from the charts will need to have one hour added 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 meridians of longitude 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from the EST times given. Any 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.

Comets. This section deals with the brightest comets expected to be visible during the year. Note, most of the known comets this year are relatively faint and will need a telescope. Comet C/2013 US$_{10}$ (Catalina) is worth following with its tour of the deep south from July to September, expecting to peak around 5th magnitude at year end. It is likely many other comets will be discovered during the year.

Meteor Showers

On any clear night we may 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 that are suitable for observation this year – those largely unaffected by moonlight in the mornings during their peak period. Information for other 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. In general, more meteors are seen after midnight.

Double Stars

Two impressive examples are presented each month, one suited for binoculars, the other for small telescopes.

Feature Article

This section concentrates on some topics in popular astronomy. It can include observation, events, history, profiles of astronomy enthusiasts, astronomical equipment and techniques.

Diary

This is a list of general phenomena associated with the planets, Moon, minor planets and comets. Included are:

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

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

Planet. Just like the Earth! A planet is a spheroid of rock or gas that orbits the Sun or another star. The diagram on page 82 gives a good overview. The Moon and planets we see in the sky do not glow in their own right. They are only visible due to reflected sunlight.

Minor Planet. These are minor rocky bodies in the Solar System that vary from a few metres to hundreds of kilometres in diameter. There are hundreds of thousands of known minor planets, mostly in the main belt between the orbits of Mars and Jupiter.

Star. Just like the Sun. Stars are enormous spheres of glowing gas that give off tremendous amounts of light and heat. They shine by their own light caused by nuclear reactions going on deep inside them.

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. The Moon is considered waxing between New and Full, 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 Last 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.

Twilight does not formally end until the Sun is 18° below the horizon; this is called astronomical twilight. This happens about 90 minutes after sunset (or before sunrise) but it does vary with latitude. Only when astronomical twilight has ended is the sky considered truly dark. There is also civil and nautical twilight, see the glossary.

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 outer planets, this is when they are transiting the meridian.

- 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. Minor differences sometimes can be found between the separation and times quoted and those found elsewhere in Part I. Some entries are geocentric (the theoretical view from the centre of the Earth), others may have times and separations given in the text or Sky Views as seen from Australia. For conjunctions involving the Moon, the distances given are measured from the centre of the Moon (which has a radius of about one quarter of a degree). Occultations with the planets or the brightest stars are also mentioned in the Moon text.

Abbreviations. These include:

G	galaxy (or sometimes SG for spiral, IG irregular, EG elliptical and LG lenticular)		
N	nebula (PN planetary, BN bright and DN dark nebula)		
OC	open cluster	GC	globular cluster
m.p.	minor planet	d.p.	dwarf planet
DS	double star		

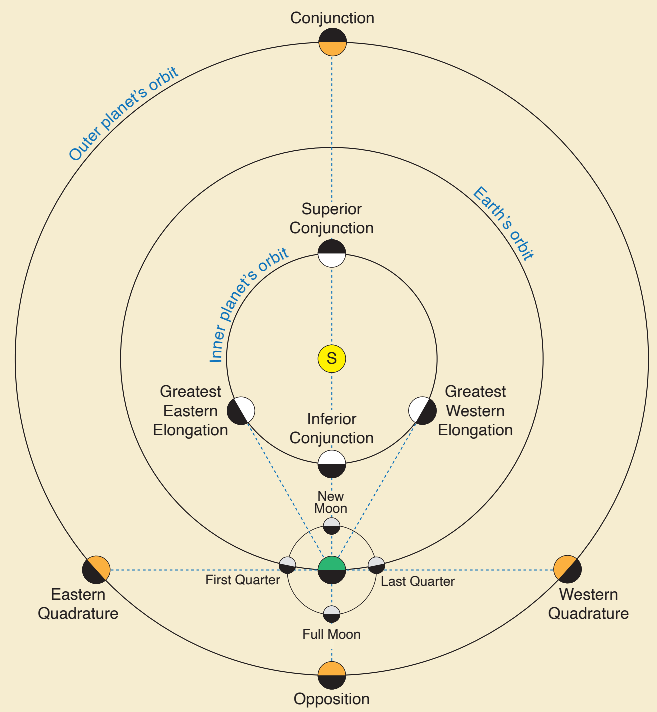
There are also some astronomical catalogues including NGC, IC and M for New General Catalogue, Index Catalogue or Messier Catalogue respectively.

Time. When times are given, both EST and WST are presented. With the exception of lunar phases (which are given to the nearest minute) 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 from 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 2 am) for EST, the WST conversion (subtracting two hours) takes them into the previous day and are shown as 'prev day'.

Sky Views

These diagrams are designed to help you find the naked eye planets. The date and time chosen give the most interesting patterns of the planets and Moon. Sometimes the times correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although this is twilight, it is sometimes necessary to catch a glimpse of the planets when 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*.

ORBITAL ASPECTS



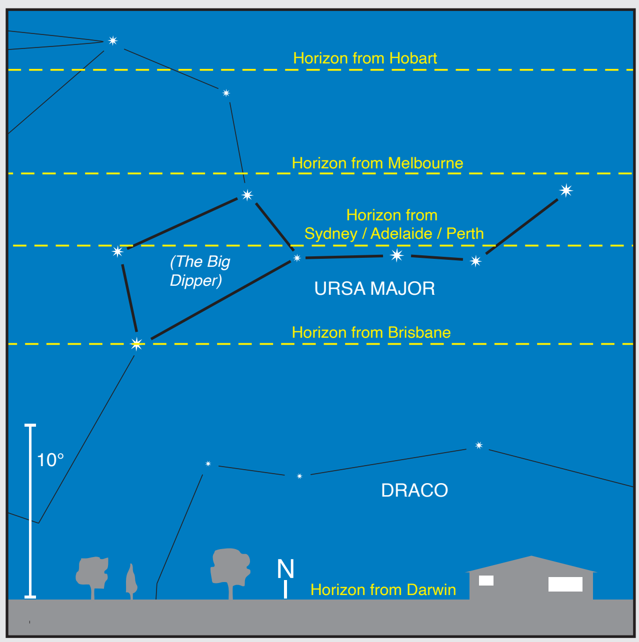
The Sky Views (see also the legend opposite) include:

- The Moon (approximate phase) and planets visible to the naked eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies. 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, to show the constellation's recognisable pattern.

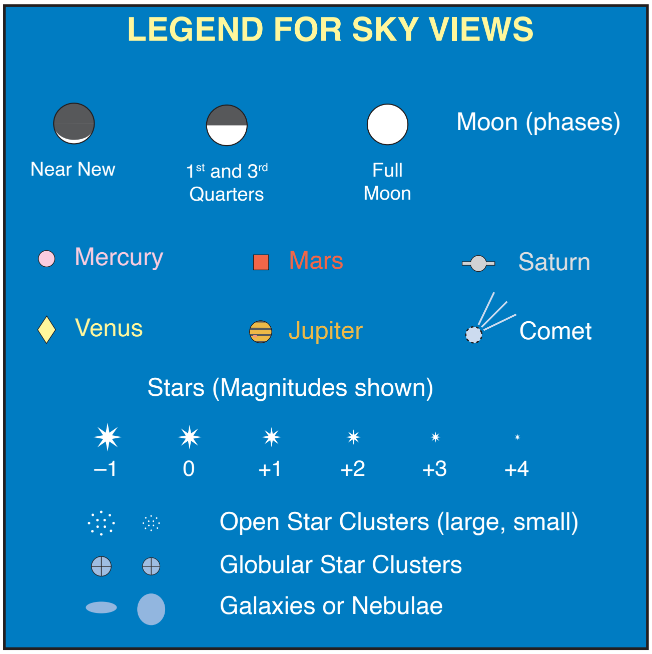
Saturn and Jupiter Satellites. Each planet has a monthly diagram for months close to their opposition. Only the brightest moons are included. There are key differences worth keeping in mind between these planets. The plane of the orbits of Jupiter's moons is close to the Earth's orbital plane, so we see them shuffle back and forth in straight lines, passing in front of and behind the planet and even in and out of its shadow (see p. 112). Saturn's moons orbit in the plane of the rings. As the rings spend most of the time inclined to our line of sight (hence our brilliant view), so the orbits of the satellites are in ellipses appearing to pass below, then half an orbit later over the planet. The further out the larger the ellipse. Except for Titan, Saturn's moons are considerably fainter than Jupiter's Galilean satellites. This results in them being swamped by the glow of the nearby rings, making the inner moons hard to see. Titan is a bright, pleasant exception and that's why we concentrate so much on its conjunctions.

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 20 cm telescope to glimpse this faint dwarf planet. In any case, because of the many faint stars of similar brightness close by, separate finder charts (see Part II) are needed to find these outer worlds. Their approximate positions are marked on the All Sky Maps to point you in the right position, then go to the finders.

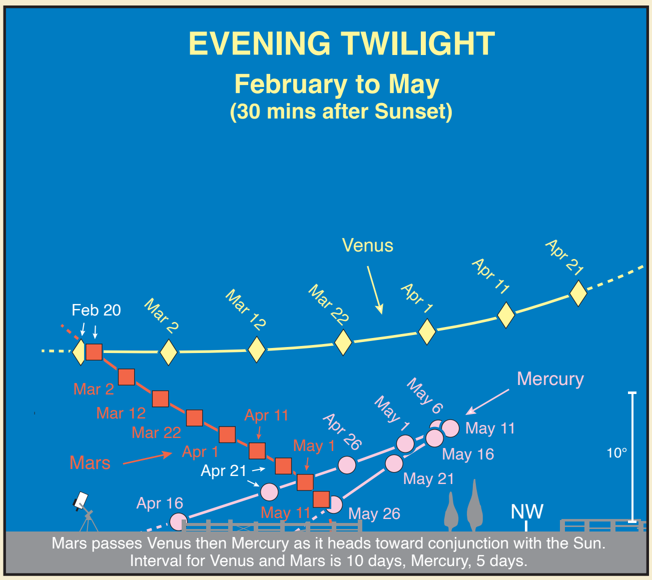
EFFECT OF LATITUDE

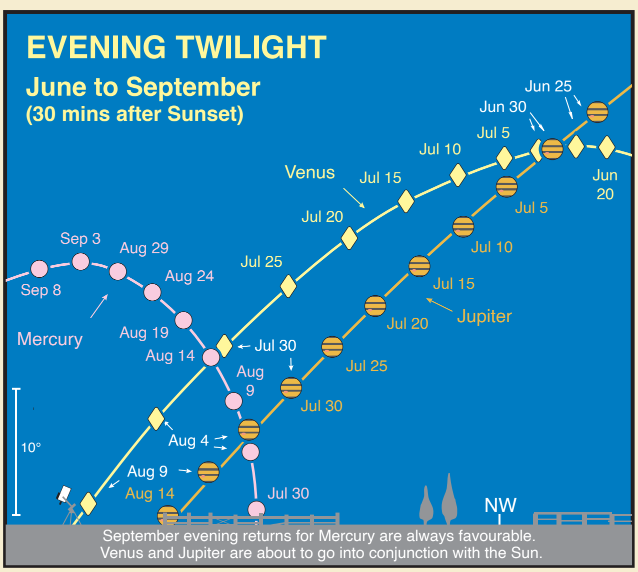


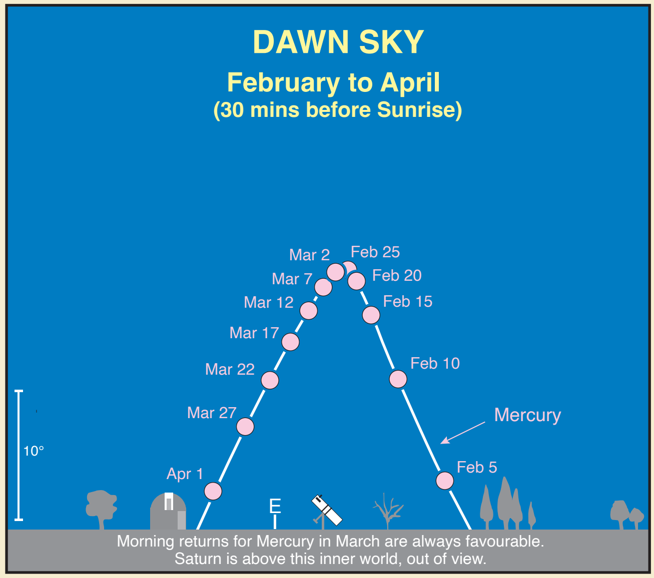
The Sky Views (see the monthly sections) have been drawn for a latitude of approximately 33° south of the equator. This is reasonably central for the population distribution of Australia. However, we live in a large continent which covers a wide range of latitudes. The further you go north the more stars you see familiar to our Northern Hemisphere friends. As an example, let's take the Big Dipper. This group of stars is part of the constellation Ursa Major, the Great Bear. From Darwin the group is clearly visible above the horizon. 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 9 pm (mid-June, 7 pm). Also from the south we see very little of the constellation Draco. The diagram is drawn to the same scale as a Sky View.

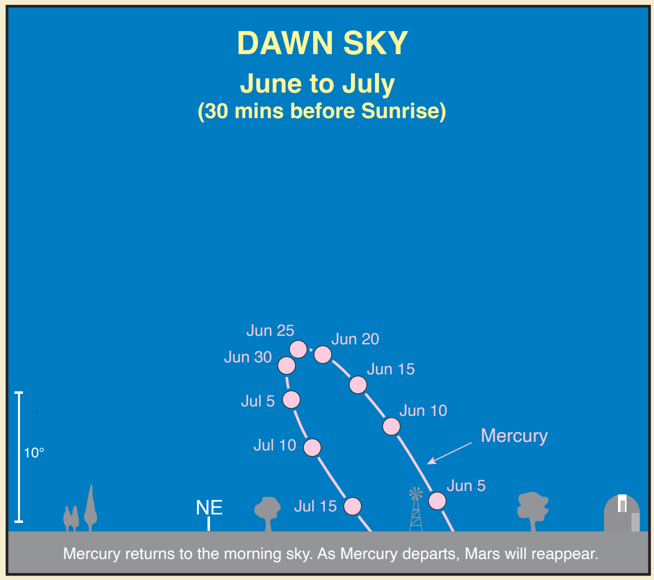


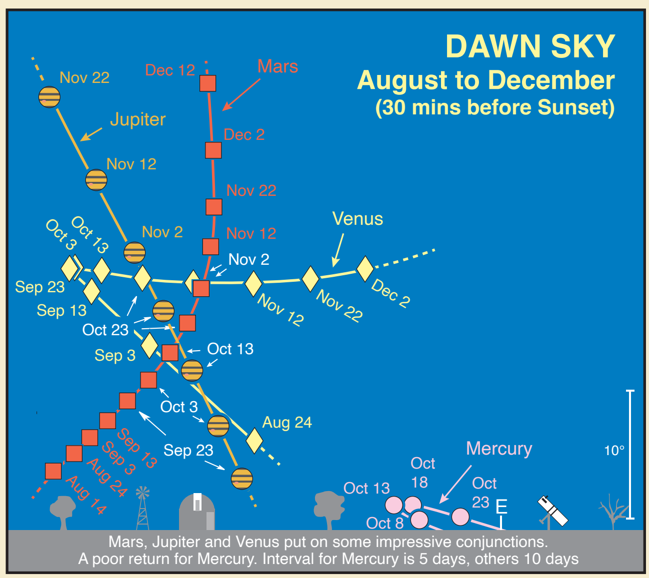
MOVEMENT OF THE PLANETS





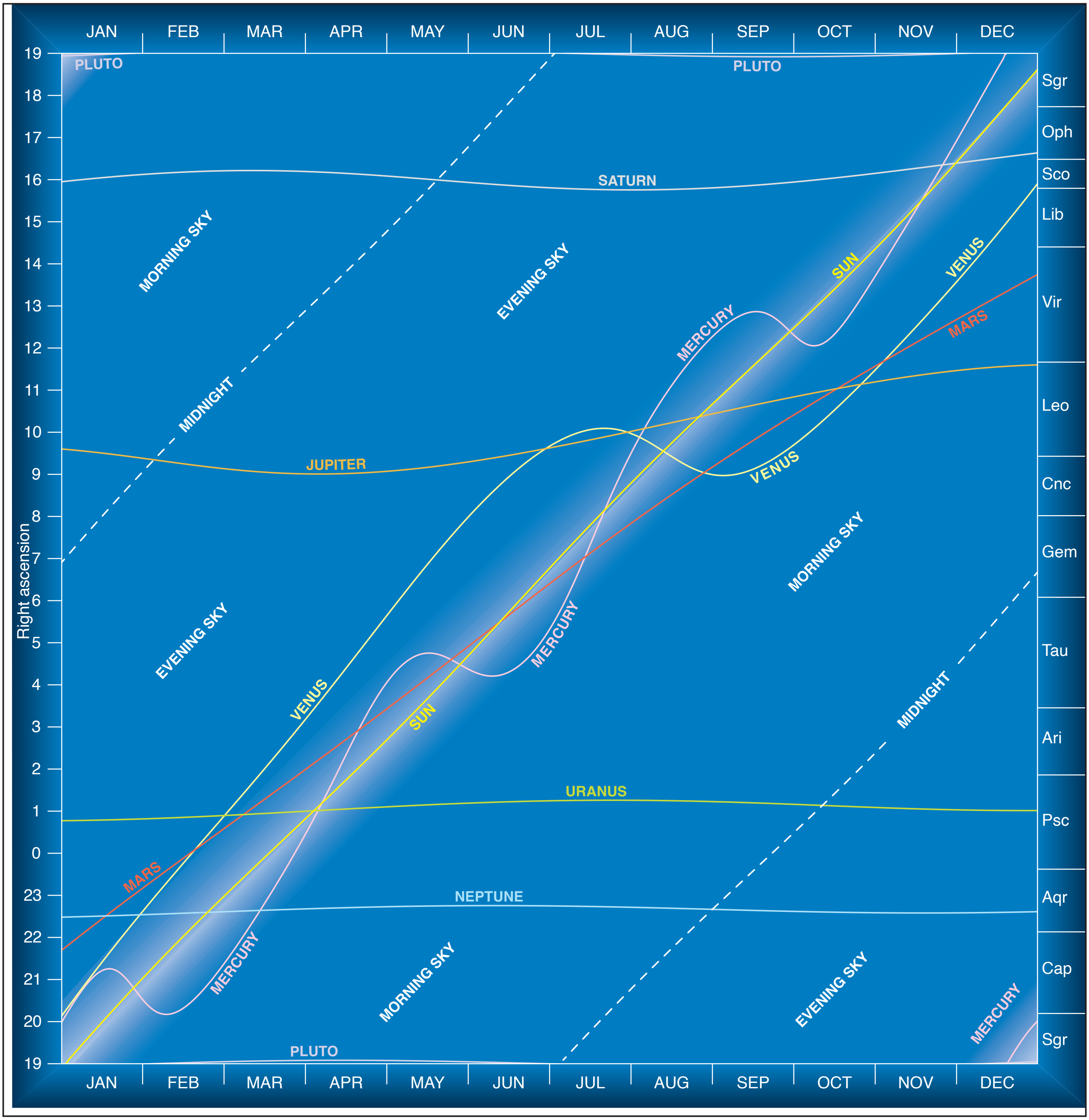






These diagrams are designed to help observers know when a planet first becomes observable after being in conjunction with the Sun, or is about to go into conjunction with our star. They are particularly useful as an observing guide for Mercury. Also the Visibility of the Planets diagram (opposite) allows you to see at a glance whether an object is in the morning or evening sky.

VISIBILITY of the PLANETS



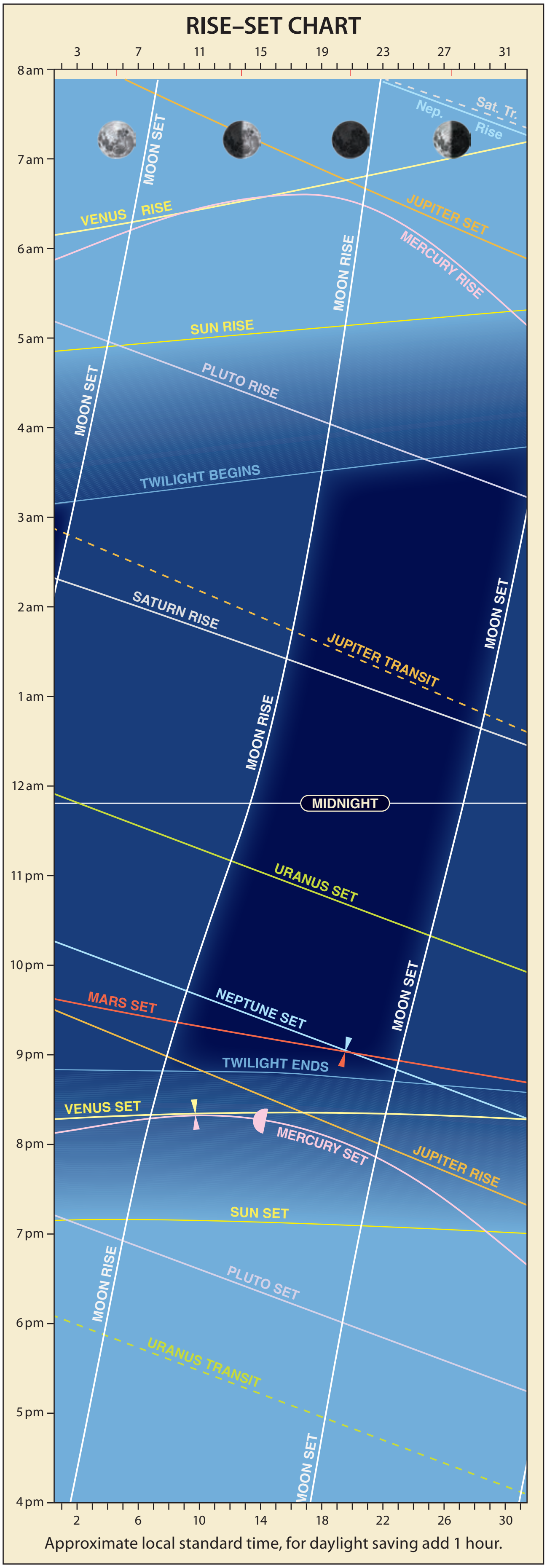
This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation 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 (Mars for example will be in Virgo in the December morning sky, also see All Sky Map No. 6).

Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best time to observe these inner planets is when their path extends beyond the twilight. For Mercury, the optimum period in the evening sky is from mid August to mid September – in the mornings from early February to mid March. Venus is visible from January until mid-August in the evening sky. It then becomes too close to the Sun for observation until September when it reappears in the morning sky.

When an outer planet crosses the midnight line, it is at opposition and is visible the entire night, and when crossing the Sun line it is in conjunction. 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 planet lines cross or are close, they will be near each other in the sky. A fine example this year is the appearance of Venus and Jupiter in the June and July evening sky. Another instance is shown when the Mars and Jupiter lines intersect in the October morning sky.

JANUARY



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

HIGHLIGHTS

- Mercury and Venus close.
- Mars and Neptune close.

CONSTELLATIONS

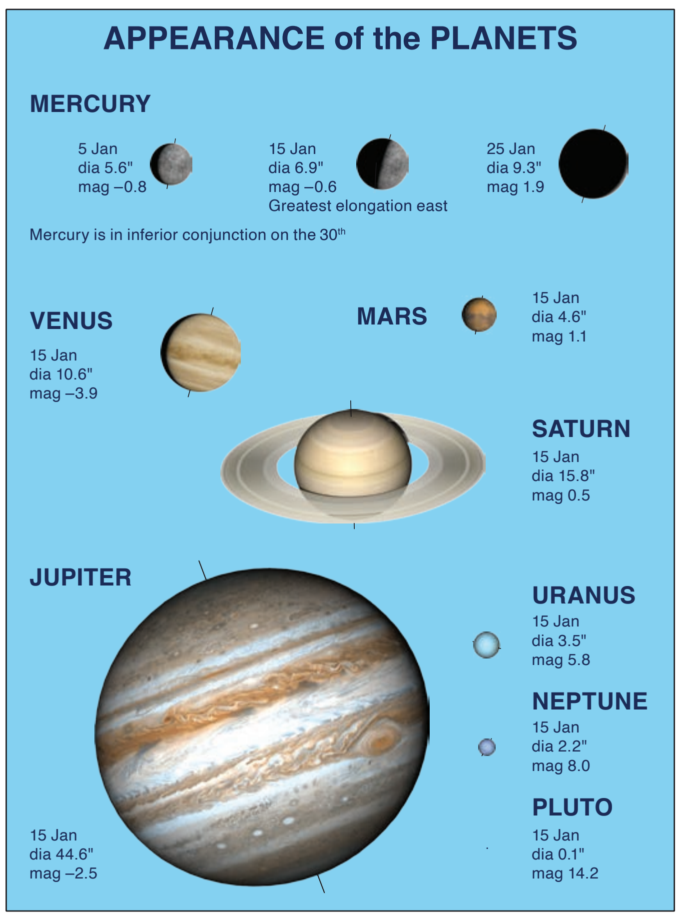
The summer evening zodiacal constellations are low on the northern horizon from mid-latitude Australia. Let's follow the ecliptic, the invisible annual path of the Sun. Near the west horizon you will find Pisces. Heading eastward are the three stars of Aries. Looking north and directly under Orion, the ecliptic bisects the Pleiades and Hyades in Taurus. Next, the 1st magnitude stars Castor and Pollux are obvious markers to the Gemini twins. In the northeast the ecliptic passes close to the Beehive open star cluster, the only obvious evidence for Cancer. Going further east it moves close to the first magnitude star Regulus. Not only is it the brightest star in Leo, it makes up the handle end of the Sickle asterism.

The Sun goes through 13 constellations each year, not just the traditional 12 signs of the zodiac (the extra one is Ophiuchus). However, astrologers also bring the planets into the same 12 signs, where in reality they can actually reside in up to 21 constellations. Two of the extras are Cetus and Hydra, visible in the evening sky this month. If you include the Moon though, there is one more, Auriga. During January evenings, this distinctive pentagon shaped constellation is found below Taurus, sitting on the northern horizon.

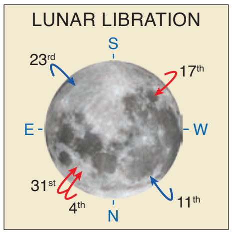
Turning to the stars, it is interesting that of the 20 closest to Earth, only four are considered bright (greater than magnitude 1). January is a great time to view them. The second brightest of the four, Sirius (Alpha Canis Major), located high in the northern evening sky, is 8.6 light-years away. Lower, further westward, lies the fourth brightest, Procyon (Alpha Canis Minor), 11.4 light years distant. The morning sees number three low in the southeast sky, Alpha Centauri, which is close at only 4.3 light years. You'll have to wait until daylight for the brightest and closest, only eight light minutes away, the Sun!

THE MOON

4th 11 am (9 am WST) Maximum Libration (7.9°), bright NE limb. The small dark Mare Humboldtianum visible on the limb, also the



129 km crater Endymion with its high walls and dark flooded floors seen to best advantage.



- 5th 3 pm (1 pm WST) Full Moon.
- 10th 4 am (2 am WST) Moon at apogee (furthest from Earth at 405,408 km).
- 11th 1 am (11 pm previous day WST) Minimum Libration (3.6°), bright NW limb.
- 13th 8 pm (6 pm WST) Last Quarter.
- 17th 5 pm (3 pm WST) Maximum Libration (9.0°), bright SW limb. The 300 km Mare Orientale is brought into view, it is only visible during favourable librations such as this.
- 20th 11 pm (9 pm WST) New Moon.
- 22nd 6 am (4 am WST) Moon at perigee (closest to Earth, 359,645 km).
- 23rd 10 pm (8 pm WST) Minimum Libration (4.2°), bright SE limb.
- 25th 10 pm (8 pm WST) Occultation of Uranus by the Moon, visible from northern half of Africa, southern Europe, Middle East, Russia and northern Asia.
- 27th 3 pm (1 pm WST) First Quarter.
- 30th 4 am (2 am WST) Occultation of Aldebaran by the Moon, visible from northernmost Canada.
- 31st 2 am (Midnight previous day WST) Maximum Libration (8.6°), bright NE limb. The 182 km walled plain Gauss favoured.

THE PLANETS

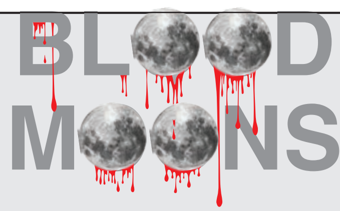
Mercury returns to the western twilight sky after superior conjunction (Earth and Mercury on opposite sides of the Sun) early last month. Reaching its greatest elongation east of the Sun (19°) on the 15th, the planet then rapidly returns sunward as it heads toward inferior conjunction (between the Earth and the Sun) at month end. During this rather poor apparition, Mercury makes a close approach to Venus on the 11th when it comes within 0.6° of the brilliant planet (see Sky View). If you have difficulty finding Mercury in the twilight, try offsetting from Venus. The fainter planet will be within three degrees (albeit low to the horizon) for a week either side of the 11th. As always, binoculars will help.

Venus is brilliant in the early western evening sky. It remains the Evening Star until early August when it gets too close to the Sun for observation. It will be interesting to watch Mercury head toward its brighter neighbour from the beginning of the month and then arc back toward the horizon (see Mercury). On the 22nd, the 2-day waxing Moon appears north (right) of Venus, not real close but it's always pleasant to see the brightest planet and the fingernail crescent Moon, illuminated with earthshine, in the twilight (see Sky View).

The **Earth** is at perihelion on the 4th, the closest point in its orbit to the Sun (147,096,146 km or 0.983277 au distant).

Mars, in the early western evening sky, is in Capricornus during the first week of January before it enters Aquarius. At 1st magnitude it is similar in brightness to star Fomalhaut in neighbouring Piscis Austrinus (see Sky View). Mars and Neptune have a relatively close encounter on the 19th at 0.5° apart and on the 20th a little closer at 0.4°. The pair will make an attractive colour contrast in a low power telescope field but they will be close to the western horizon in

The sun shall be turned into darkness, and the moon into blood, before the great and the terrible day of the lord come. Joel 2:31



There has been a lot of media publicity recently about Blood Moons and prophecy. Is there more to this than meets the eye? Or are we going through another *end time* scenario brought about by overzealous interpretations of biblical texts.

Currently we are half way through a *tetrad* – a sequence of four successive total lunar eclipses that happen at intervals of six lunations. The eclipses last year occurred on 15 April and 8 October, this year's are on 4 April and 28 September. Other tetrad examples are the eclipses of 1985/1986 and 2003/2004. Italian astronomer Giovanni Schiaparelli (1835–1910) found that over a period of 300 years about 17 tetrads occur, followed by a 300 year drought and then a new cycle.

The phrase *Blood Moon* (not an official astronomical term) has been adopted by the popular press and now seems to be in common usage (just like the cringe worthy *super moon* of astrological origins, that the media embrace for when Full Moon is at perigee). Aside from several biblical references to the Moon turning to blood (total lunar eclipse), it appears that the term Blood Moon to describe a lunar tetrad is of recent origin. Indeed we need look no further than two best selling books, Mark Biltz's '2013 Blood Moons – Decoding the Imminent Heavenly Signs', and John Hagee's '2014 Four Blood Moons – Something is About to Change', to get an inkling of its beginnings.

The main thrust of these two prophetic works is that God is controlling the Sun, Moon and stars to send us a signal that something big is about to happen. The authors compared previous tetrads (62 in all, since the 1st century) to the Jewish calendar and discovered that some coincided with feast days. They then looked at the historical record and found that several of these tetrads signalled events that affected 'Gods chosen people'. These Blood Moon tetrads have occurred eight times (including the current one) on feast days in the past 2,000 years.

The claimed connections between Jewish history and the Blood Moon tetrads are as follows: The tetrad of 1493/1494 – The Spanish Inquisition, when Jews were expelled if they did not convert to Catholicism. 1949/1950 – Israel becomes a nation. 1967/1968 – The Six-Day War.

Some of the associations seem tenuous at best. The Spanish Inquisition was established in 1478 and was disbanded in 1834 – even linking the royal decree of 1492 misses the first eclipse of the tetrad by over a year.

The tetrad associated with the Israeli war of independence (May 1948 to Mar 1949) began over a month after the end of the war. Lastly, a hit with the tetrad connected with the Six-Day War when it occurred between the first and second eclipse of that tetrad.

The focus is on the above three tetrads that have a tenuous link to major events in Jewish history (good or bad), and coincide with the feasts of Sukkot (Tabernacles) and Passover. What of the other tetrads that fell on feast days (162/163 CE., 795/796, 842/843 and 860/861), these are glossed over, why? Well, actually nothing much happened that corresponded to anything significant with Israel. If the Blood Moon tetrads are a sign from above or the fulfilment of biblical prophecy, why were there no tetrads on occasions such as the Exodus from Egypt, the birth or death of Jesus, the Roman siege of Jerusalem and the Holocaust?

The Jewish calendar is based on lunar cycles and because of this fact alone its inevitable that lunar eclipses will fall on feast days with some regularity. Lunar eclipses typically happen six months apart and roughly half of important Jewish holidays occur during Full Moons. The feasts of Sukkot and Passover are six months apart, so it's not a great stretch nor especially unique that this could happen.

Three of the four eclipses of the current tetrad (2014/2015) are not even visible from Israel and only a small portion of the last eclipse will be observable before moonset. It seems rather ironic that such a significant sign from above for the Israelites would be hidden from their view.

Will there be a big event during the current tetrad? Probably. The world is a volatile place where nature takes its toll on a daily basis with earthquakes, storms, volcanic eruptions and tsunamis. Humanity continuously wages war over race, religion, borders and territory – at the time of writing there is a major Israel-Gaza conflict. However, none of this has anything to do with the Moon's orbital motion, nor is it a sign of the *end time*s or the second coming of you know who.

The ancients believed that eclipses and other celestial events were omens from God of impending miracles and/or catastrophes. In this enlightened age you would think that if God wished to send us a sign he could communicate in a more effective way that modern day humans would comprehend and get the message immediately (Facebook or Twitter perhaps?).

We see these apocalyptic evangelists and others prophesying the *end times* all too often. There have been hundreds of predictions for the end of humankind in historical times, none of which have reached fruition.

twilight – the star visible in the same field is the 5th magnitude white giant Sigma Aquarii (the 29th brightest star of the constellation).

Jupiter, in Leo, can be seen rising in the east during twilight. With opposition early next month, the giant planet is unmistakable as it dominates the mid-evening sky. Its closest rival, Sirius (Alpha Canis Majoris), is over a magnitude fainter. On the 8th, the 18-day old waning gibbous Moon appears just south (right) of the planet (see Sky View). Jupiter has been in retrograde motion (see page 78) since early December and moving slowly back toward Cancer. Take advantage of the warm summer nights to observe this fascinating planet – even the smallest of telescopes will show detail on the disk and reveal the four largest satellites as they shuttle back and forth (see Sky View for some interesting configurations during the month). A pair of 7 × 50 binoculars (properly braced) will even show these moons that had a major impact on cosmology after their discovery by Galileo in the early 17th century.

Saturn is visible in the eastern morning sky rising around 1:30 am mid-month. The planet spends the first two thirds of January in Libra before crossing over into the claw region of Scorpius, where it remains until mid-May. During the last week of January, Saturn will be 1° from Beta Scorpii (Graffias – Arabic meaning 'claws'). Beta is a brilliant double star with both components bluish white – well suited to small telescopes, the 2.6 and 4.5 magnitude suns are separated by 14 arc-seconds. On the 17th, the 25-day old waning crescent Moon appears near the ringed planet (see Sky View). Since they were edge on in 2009, Saturn's rings have been gradually widening. This year begins with the rings tilted at 24.5°, and the planet's north pole angled towards Earth. Due to the orbital movement of our planet, the rings narrow a little from January to July then reopen to their widest this year at 26° in December. The rings will be at their most open with a tilt of 27° in 2017, they then begin to close again until the Earth next passes through the ring plane in March 2025.

Uranus can be located in the north-western sky at the end of evening dusk. The planet is in Pisces, close to the Cetus border and sets around 11 pm mid-month. On the 25th, the 6-day old waxing crescent Moon will be close to Uranus, from parts of the Northern Hemisphere there will be an occultation. From our southern location Uranus will be 1° from the lunar cusp – do not confuse Uranus with the double star HR 222 which is almost the same magnitude as the planet, but much closer to the Moon.

Neptune is low in the evening western sky in Aquarius. Early in the month, the planet is 0.6° from the 5th magnitude star Sigma Aquarii. On the 7th, the 11th magnitude asteroid 16 Psyche will pass directly between Neptune and Sigma. Psyche is one of the strangest objects in our Solar System; it is around 250 km wide and is composed mostly of iron and nickel. It is thought to be the exposed metallic core of a Vesta sized body that has been stripped of its outer layers by collisions with other asteroids. On the 19th and 20th Neptune has a visit by Mars (see Mars).

DIARY

Thu	1st		m.p. 44 Nysa 0.8°S of NGC 4179 (G) in Virgo
Thu	1st		Mars 0.6°E of m.p. 27 Euterpe
Fri	2nd		Neptune 0.5°NW of star Sigma Aquarii
Fri	2nd	10 pm	(8 pm WST) star Aldebaran 1.4°S of Moon
Sat	3rd		Venus 0.5°NE of M75 (GC) in Sagittarius
Sun	4th		Mars 1.5°N of star Delta Capricorni
Sun	4th		Mercury 0.3°S of M75 (GC) in Sagittarius
Sun	4th	10 am	(8 am WST) d.p. Pluto in conjunction with Sun
Sun	4th	5 pm	(3 pm WST) Earth at perihelion, 0.983277390 au
Mon	5th	2:53 pm	(12:53 pm WST) Full Moon (397,240 km)
Wed	7th	am	m.p. 44 Nysa 0.8°N of star Eta Virginis
Thu	8th		Neptune 0.2°N of m.p. 16 Psyche
Thu	8th	6 pm	(4 pm WST) Jupiter 5°N of Moon
Fri	9th	Noon	(10 am WST) star Regulus 4°N of Moon
Sat	10th	4 am	(2 am WST) Moon at apogee, 405,408 km
Sun	11th		Comet 88P/Howell 0.3°S of NGC 6235 (GC) in Ophiuchus
Sun	11th	3 am	(1 am WST) m.p. 532 Herculina 0.05°W of NGC 5792 (G) in Libra
Sun	11th	4 pm	(2 pm WST) m.p. 4 Vesta in conjunction with Sun
Mon	12th		Venus 0.7°SE of Mercury
Tue	13th	7:46 pm	(5:46 pm WST) Last Quarter Moon
Tue	13th	8 pm	(6 pm WST) star Spica 3°S of Moon
Thu	15th	5 am	(3 am WST) Comet 88P/Howell 0.2°SE of NGC 6287 (GC) in Ophiuchus
Thu	15th	7 am	(5 am WST) Mercury at greatest elongation East (18.9°)
Fri	16th	10 pm	(8 pm WST) Saturn 1.9°S of Moon
Sat	17th		Mercury at ascending node
Sat	17th	9 am	(7 am WST) star Antares 9°S of Moon
Sun	18th		Comet 88P/Howell 0.7°NW of NGC 6325 (GC) in Ophiuchus
Sun	18th		Venus at greatest latitude south
Mon	19th	5 am	(3 am WST) d.p. Ceres 6°S of Moon
Mon	19th	9 pm	(7 pm WST) d.p. Pluto 3°S of Moon
Tue	20th	7 am	(5 am WST) Neptune 0.2°N of Mars
Tue	20th	11:14 pm	(9:14 pm WST) New Moon
Wed	21st		Mercury at perihelion
Wed	21st		Venus 1.0°N of star Gamma Capricorni
Thu	22nd		Venus 1.0°NW of star Delta Capricorni
Thu	22nd	4 am	(2 am WST) Mercury 3°S of Moon
Thu	22nd	6 am	(4 am WST) Moon at perigee, 359,645 km
Thu	22nd	3 pm	(1 pm WST) Venus 6°S of Moon
Fri	23rd	11 am	(9 am WST) Neptune 4°S of Moon
Fri	23rd	3 pm	(1 pm WST) Mars 4°S of Moon
Sat	24th		d.p. Ceres 0.7°N of M28 (GC) in Sagittarius
Sat	24th	pm	m.p. 3 Juno 0.7°SW of star Sigma Hydrae
Sun	25th		Comet 88P/Howell 0.4°NE of NGC 6401 (GC) in Ophiuchus
Sun	25th		d.p. Ceres 1.2°N of star Lambda Sagittarii
Sun	25th	10 pm	(8 pm WST) Uranus 0.6°S of Moon; Occn.
Mon	26th		d.p. Ceres 1.2°N of NGC 6638 (GC) in Sagittarius
Mon	26th	am	m.p. 44 Nysa 0.6°S of NGC 4437 (G) in Virgo
Tue	27th		Mars 0.5°S of star Lambda Aquarii
Tue	27th	2:48 pm	(12:48 pm WST) First Quarter Moon
Wed	28th		d.p. Ceres 0.8°S of NGC 6642 (GC) in Sagittarius
Fri	30th	Midnight	(10 pm WST) Mercury in inferior conjunction
Fri	30th	4 am	(2 am WST) star Aldebaran 1.2°S of Moon; Occn.
Fri	30th	9 am	(7 am WST) m.p. 3 Juno at opposition
Sat	31st		d.p. Ceres 0.4°S of M22 (GC) in Sagittarius

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Pluto is in conjunction with the Sun on the 4th and will return to the morning skies in February. We eagerly await the arrival of the New Horizons spacecraft in July 2015, for our first close up view of this denizen of the outer Solar System, see page 45.

In late January, **Ceres** visits a number of deep sky objects near the Teapot of Sagittarius (see diary).

Minor Planets. Two of the brighter minor planets reach opposition this month in Gemini, 94 Aurora on 2nd at magnitude 11.7 and 346 Hermentaria on 3rd at magnitude 10.6. Others at opposition include; 69 Hesperia on 16th at magnitude 10.3 in Canis Minor, 3 Juno on 29th at magnitude 8.1 in Hydra and 42 Isis on 31st at magnitude 11.7 in Cancer.

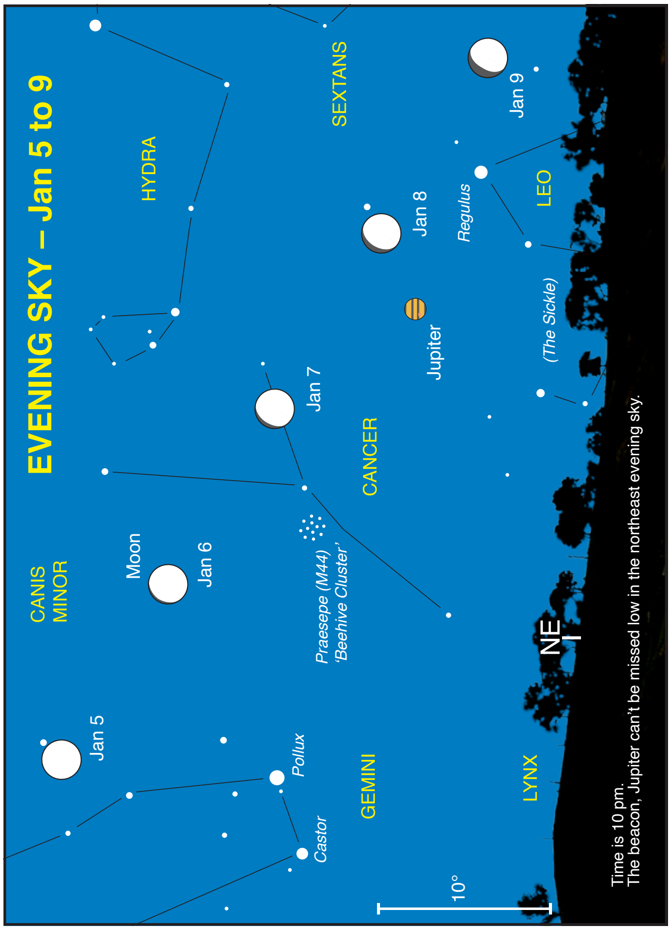
Comet 88P/Howell is in the morning sky, rising around an hour before the start of dawn. It visits a number of globular clusters in Ophiuchus this month (see diary).

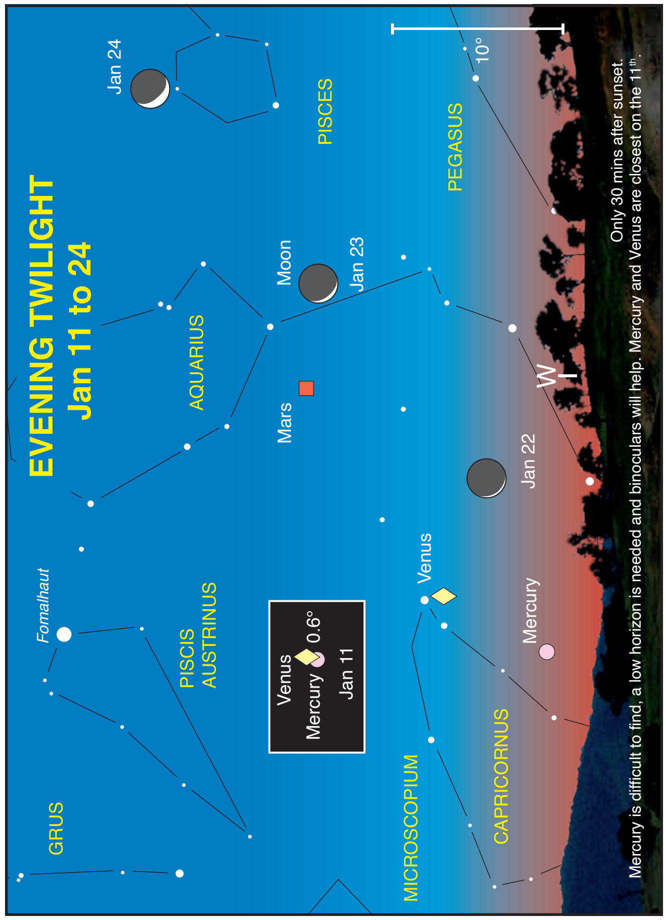
Comet C/2012 K1 (PANSTARRS) opens January at 10th magnitude in Sculptor in the evening sky. Having passed perihelion in August 2014 at a distance of 1.0 au from the Sun, and now moving away from both the Earth and the Sun, PANSTARRS should have faded to 11th magnitude by month's end. The best time to observe the comet is around mid month.

DOUBLE STARS

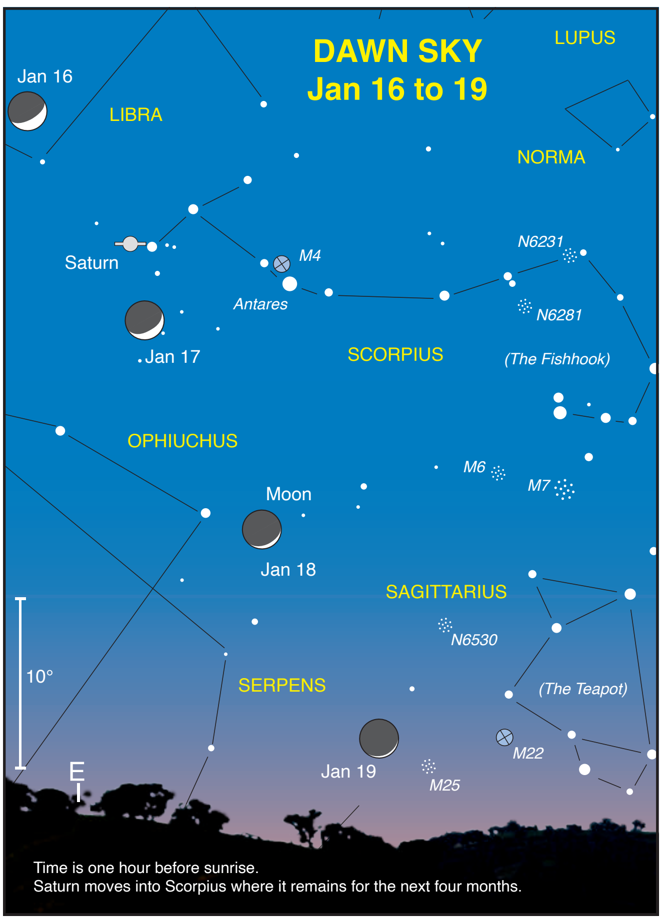
Located to the north of Betelgeuse (α Orionis) and Bellatrix (γ Orionis), **Meissa (λ Orionis)**, whose name means 'the shining one', is a brilliant and easy pair of bluish-white stars (magnitude 3.5 and 5.5) separated by 4.2 arcseconds. Located 900 light years away they are thought to form a long period binary. Photographs show that the pair is immersed in the faint emission nebulosity Sh2-264 also known as the 'Lambda Orionis molecular ring'. (Map 3, p. 71)

This month's binocular double is an Orion belt star. **δ Orionis (Mintaka)** is a lovely pair of magnitude 2.4 and 6.8 stars separated by 53 arcseconds. The stars look bluish and violet through 10 × 50 binoculars. The primary is an eclipsing spectroscopic binary and also a very close visual binary, thus making the system at least quadruple. (Map 3, p. 71)





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



Jupiter's Satellites for January

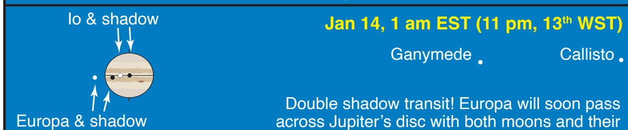
1 arc min.

Jupiter's Moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole up, east to the left.

Jan 7, 11 pm EST (9 pm WST)

Callisto transits are rare. Although this shadow transit is not visible from WA, the satellite will transit later in the night visible from anywhere in Australia.

Jan 14, 1 am EST (11 pm, 13th WST)

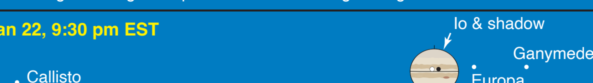


Double shadow transit! Europa will soon pass across Jupiter's disc with both moons and their shadows completing their transits during the night.

Jan 16, midnight EST (10 pm WST)

All four moons on the east side of Jupiter. It is interesting watching them pass each other during the night.

Jan 22, 9:30 pm EST



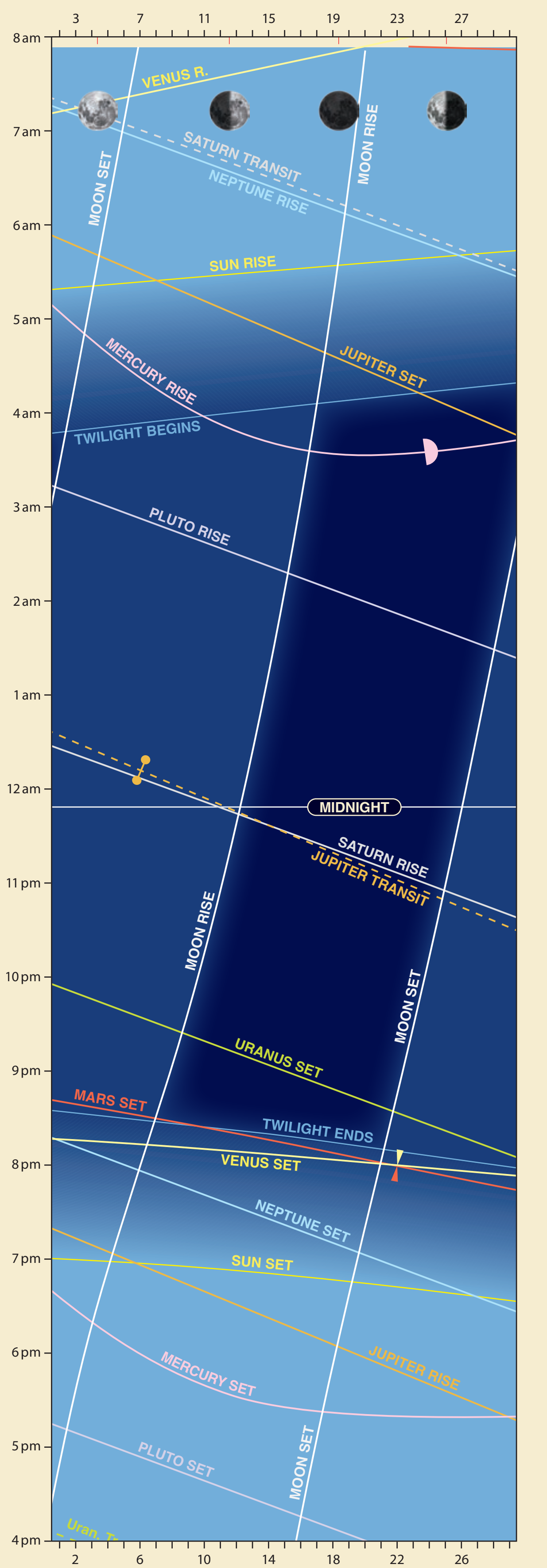
Io and its shadow are currently transiting. Europa is about to be eclipsed. Although these are eastern state events, Ganymede will be eclipsed later in the night visible from all of Australia.

Jan 29, midnight EST (10 pm WST)

Io and its shadow are currently transiting with Europa about to be eclipsed. This is soon followed by Io and its shadow egressing from transit.

FEBRUARY

RISE–SET CHART



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

HIGHLIGHTS

- Mercury at best in the second half of February.
- Venus and Mars close.
- Jupiter at opposition.
- Possible outburst of the alpha-Centaurids.

CONSTELLATIONS

The prominent constellation of Orion is obvious in the northwest evening sky. This Hunter is best known for the Saucepan asterism, its base formed by Orion's three belt stars, with its handle being the sword hanging up from this belt. Unfortunately, from *down under*, we see him standing on his head so the human shape is hard to see. Here's a lesser-known star pattern. Start at the red star, Betelgeuse, Orion's right armpit. To the left is his other armpit marked by blue Bellatrix. This left arm extends westward to 'Orion's Shield'. This curve of six 3rd to 4th magnitude stars, running north-south, is obvious under dark skies.

A hunter needs his dogs, which follow Orion faithfully across the sky. Canis Major (Greater Dog) is best known for the brightest star, Sirius or 'Dog Star', high in the north. The other canine, to the lower right, is Canis Minor (Lesser Dog), which is only recognised by the star Procyon. These stars form an approximate equilateral triangle with Betelgeuse.

To the lower right of the hunter lies the constellation of Gemini, the Twins. Its most distinctive feature is two 1st magnitude stars Castor and Pollux, which mark the twins' heads. Extending from each towards Orion are their bodies and legs consisting of lines of approximately six 2nd to 4th magnitude stars. It's easy to distinguish the 'twin' stars; Castor is always Closer to the horizon (so remember CC). Being 4.5° apart their separation is similar to the Pointers in Centaurus now rising in the southeast.

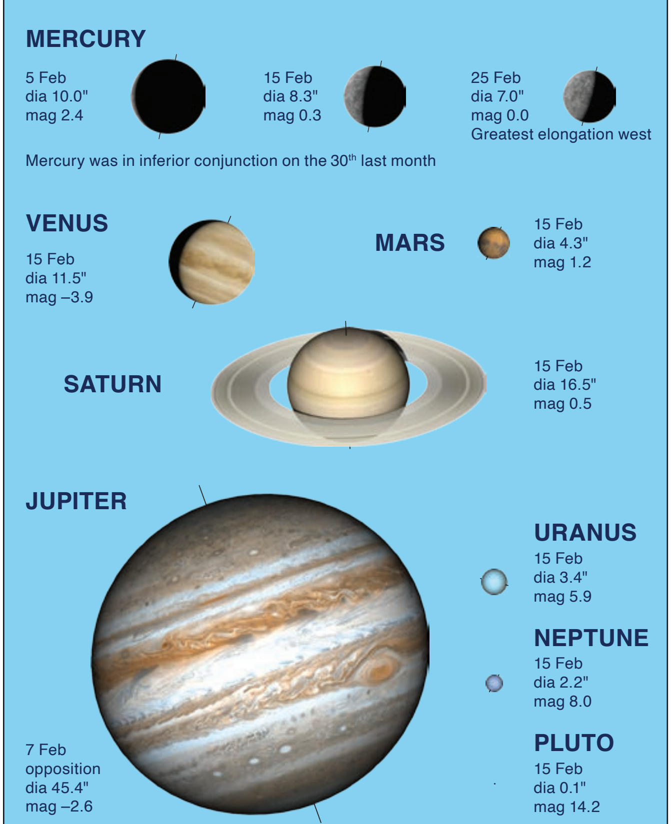
THE MOON

4th 9 am (7 am WST) Full Moon.

6th 4 pm (2 pm WST) Moon at apogee (furthest from Earth at 406,150 km).

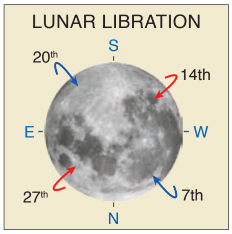
7th Noon (10 am WST). Minimum Libration (3.1°), bright NW limb.

APPEARANCE of the PLANETS



12th 2 pm (noon WST) Last Quarter.

14th 2 pm (midday WST) Maximum Libration (10.0°), bright SW limb. The 300 km Mare Orientale is brought into view and is only visible during favourable librations such as this.



19th 10 am (8 am WST) New Moon.

19th 5 pm (3 pm WST) Moon at perigee (closest to Earth at 356,995 km).

20th 5 pm (3 pm WST). Minimum Libration (3.1°), bright SE limb.

22nd 8 am (6 am WST) Occultation of Uranus by the Moon, visible from north Polynesia, USA except north west and Mexico.

26th 3 am (1 am WST) First Quarter.

26th 9 am (7 am WST) Occultation of Aldebaran by the Moon, visible from Alaska, NW Canada, northernmost Russia, Greenland, Iceland and Scandinavia.

27th 6 am (4 am WST) Maximum Libration (9.5°), bright NE limb. The 90 km crater Hayn and the small dark 165 km Mare Humboldtianum visible on the limb.

THE PLANETS

Mercury has changed to a morning object after moving between the Earth and Sun (inferior conjunction) late last month. Early February to mid-March marks the best period for Mercurian observation in the morning skies this year. The planet reaches its greatest elongation (27°) west of the Sun on the 24th – this, coupled with a near vertical ecliptic (the plane of the planetary orbits) also means that the planet is at its greatest altitude above the horizon prior to sunrise. The slender fingernail crescent of the 27-day old Moon appears a little above and northwest (left) of Mercury on the 17th.

Venus spends the first half of the month in Capricornus before moving into Aquarius. In its travels in the early western evening sky it passes less than 1° from Neptune on the 1st (not visible in the twilight) and 0.4° of Mars on the 22nd – this will be visible in binoculars or small telescope, if you wait a little after the end of civil twilight, and will show good colour contrast (see Sky View). On the 21st, the 3–day old waxing crescent Moon, bathed in earthshine, appears to the north (right) of Venus.

Mars is visible in the early western evening sky, briefly moving through Aquarius before crossing into Pisces above the Circlet (a grouping of six stars of 4th and 6th magnitude forming a ring). Venus has been gradually closing in on the Red Planet and appears within a degree from the 20th to 24th – with closest approach of 0.4° on the 22nd (see Sky View). On the

Cepheids – a Rung on the Cosmic Distance Ladder

Our Sun and about ninety percent of stars in the Universe are classified as main sequence stars. These stars fuse hydrogen into helium at their cores. The fusion process creates an outward pressure that balances the inward force of gravity. Once the hydrogen in the core is exhausted the star will move off the main sequence to become (depending on its size) a giant star, supergiant or a white dwarf. Some stars will change from the swollen red giant phase to a pulsating variable star before they finally die – these are the Cepheid variables.

Friends and neighbours, John Goodricke and Edward Pigott, worked together between 1781 and 1786 observing variable stars. They calculated the periods of Algol (Beta Persei) and Beta Lyrae, two eclipsing binaries. Goodricke was awarded the Copley Medal from the Royal Society for his work on Algol and he was the first to propose that the variability was due to a binary system. They then discovered the periodic variation of the first two known Cepheid variables, Eta Aquilae and Delta Cephei.

Delta Cephei is the 4th brightest star in the northern constellation of Cepheus, and the prototype for the Cepheid class variables. Its regular pulsations change its magnitude from 3.5 to 4.4 over a 5.4 day period and its spectral type changes from an F5 to G3. Delta's rise to maximum takes about 1.5 days, and then it dims steadily over the next 3 days back to minima (see light curve). Among the Cepheids, Delta's distance of 887 light-years (±26) is the most refined as measured by the Hipparcos Satellite.

Henrietta Leavitt (1868 – 1921), working for Edward Pickering at the Harvard College Observatory, discovered more than 2400 variable stars from photographic plates – more than half of the total known at the time. Leavitt became interested in the Cepheid variables and found many in the Small Magellanic Cloud. She established that the cycle of a Cepheid (maximum to maximum) and its luminosity are linked together – the brighter the Cepheid, the longer the period (the period-luminosity relationship).

If two Cepheids had the same period it could be assumed that they were equal in brightness. If one were one-quarter as bright as the other it could only be because it was twice the distance, one-ninth as bright would place it three times the distance (the brightness is inversely proportional to the square of the distance). If you know the distance to any one Cepheid, it is a simple matter to calculate the distance to all the rest. Leavitt realised this and dubbed the Cepheids 'standard candles'.

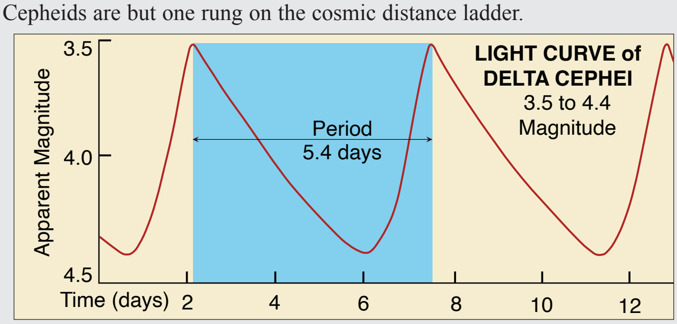
At the time the best method to determine stellar distances was to measure a star's parallax. This distance measuring technique uses the diameter of the Earth's orbit as a baseline for measuring the shift in a star's position relative to distant background stars. At distances of more than 100 light-years the parallax becomes too small to measure. Unfortunately the nearest Cepheid, Polaris (Alpha Ursae Minoris), is several times that distance.

Astronomers realised the importance of Leavitt's period-luminosity relationship and Harlow Shapley set about to study the size of our galaxy and the distances to the globular clusters. Since no Cepheids were close enough to be measured, Shapley relied on an estimated statistical technique to establish the distance and hence the luminosity of a typical Cepheid. Using Cepheids as distance markers to the globular clusters, Shapley realised that their distribution was lopsided relative to our Solar System. Many of the globulars formed a gigantic halo, the centre of which was the centre of our galaxy and therefore our Solar System was nowhere near that centre. Prior to Shapley's published results in 1918, it was generally assumed that our galaxy was the entire Universe with the Sun near the centre.

Shapley determined the size of our galaxy and its globulars to be around 300,000 light years across, yet still considered it to be the entire Universe – external galaxies were either part of our galaxy or satellites of it. The excessive size of our galaxy (now considered to be around 120,000 light years across) came from the fact that Shapley did not allow for the effects of interstellar dust. The dust dimmed the light from the globulars, making them appear much further away than they actually are.

In 1924, Edwin Hubble announced his discovery of 11 Cepheids in NGC 6822 (Barnard's Galaxy – part of the Local Group of galaxies), and determined its distance at more than 700,000 light years (current estimate 1.6 million ly), larger than Shapley's 'Universe'. Hubble went on to the Andromeda (M31) and Triangulum (M33) Nebulae, again observing Cepheids and proved beyond any doubt that these were island universes far outside our Milky Way Galaxy.

The extreme luminosity of the Cepheids means that they can be detected out as far as the Virgo Cluster of galaxies. No one technique can provide astronomers with a universal measuring stick or standard candle and the Cepheids are but one rung on the cosmic distance ladder.



21st, the 3–day old waxing crescent Moon is just north (right) of the pair (see Sky View).

Jupiter is at opposition on the 7th and at –2.6 magnitude is prominent in the early eastern evening sky after twilight ends. On the 4th, the Full Moon appears near the planet as it crosses the border from Leo into Cancer (see Sky View). Around opposition is always the best time to observe an outer planet, when they are at their largest and brightest. Over the course of Jupiter's 11.86-year orbit around the Sun its angular size varies at each opposition. The equatorial diameter at this opposition is a little over 45 arcseconds, compared to 50 when this occurs at perihelion, when the planet is closest to the Sun. Despite its lesser size, small telescopes will still reveal lots of detail. On its oblate (flattened) disk you will see the changing cloud bands known as belts (the dark ones) and zones (the light ones), plus a storm (the Great Red Spot) that has been raging since its discovery in 1664. Don't neglect the Galilean moons as they shuttle back and forth undergoing satellite transits, shadow transits, occultations and eclipses – just like a miniature solar system (see Sky View for some interesting configurations during the month). Incidentally, the GRS has, at least since the 1930s, been gradually shrinking and currently measures around 16,000 km across – big enough to fit 1.25 Earths inside. Predictions for the Great Red Spot and moon events are in Part II.

Saturn rises in the late eastern evening sky in Scorpius. On the 23rd the planet is at western quadrature where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 17). This means that when the Sun rises in the east, Saturn will be at its highest altitude in the sky. It is during quadrature that the maximum shadow of the planet is cast onto the back of the rings, giving a truly spectacular 3-D appearance. On the 13th, the 23-day old waning crescent Moon will be near Saturn (see Sky View).

Uranus, in Pisces, is low to the horizon in the early western evening sky during February. The constellation of the Fish will be the planet's home until 2018 when it moves into Aries.

Neptune is in conjunction with the Sun on the 26th and will not be observable until its reappearance in the morning eastern sky next month.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, returns to the predawn eastern sky after solar conjunction last month.

Minor Planets. Three of the brighter minor planets reach opposition this month in Cancer, 128 Nemesis on 1st at magnitude 11.4, 71 Niobe on 4th at magnitude 10.6 and 89 Julia on 5th at magnitude 10.4. Two others reach opposition in Leo, 8 Flora on 15th at magnitude 9.1 and 324 Bamberga on 19th at magnitude 11.1.

Comet 88P/Howell should become visible in the pre-dawn sky this month. The morning sky will be moonlight-free from mid-February through to the end of the month. Brightening to 10th magnitude, Howell can be found in the constellation Sagittarius. Touring the Milky Way's centre it passes close to a number of deep sky objects this month (see diary). On 1st it presents a brilliant imaging opportunity as it passes between the Trifid and Lagoon Nebulae.

Comet C/2012 K1 (PANSTARRS) is low in the western evening sky at the beginning of February. Fading from 11th to 12th magnitude this month, PANSTARRS will soon be too low by the end of astronomical twilight. The Moon will interfere with observing at the start of the month and again at the end.

METEOR SHOWERS

The **alpha-Centaurids**, one of the main southern summer showers, are active from 28 January to 21 February, with maximum on the 8th. Since 1988, activity has been quite low with an average zenith hourly rate of six per hour. The shower has yielded some surprises in the past and in 1974 and 1980 bursts of around 20 – 30 were produced over a few hours. The shower is noted for its brightly coloured fireballs that frequently reach negative magnitudes, and are predominantly yellow or blue. The alpha-Centaurids are also well known for their long lasting trains that may vary from a few seconds to several minutes. Unfortunately a bright waning gibbous Moon will hamper observational efforts for the alpha-Centaurids this year. However, the International Meteor Organization has predicted a possible outburst in activity and requested all observers to be on the alert just in case.

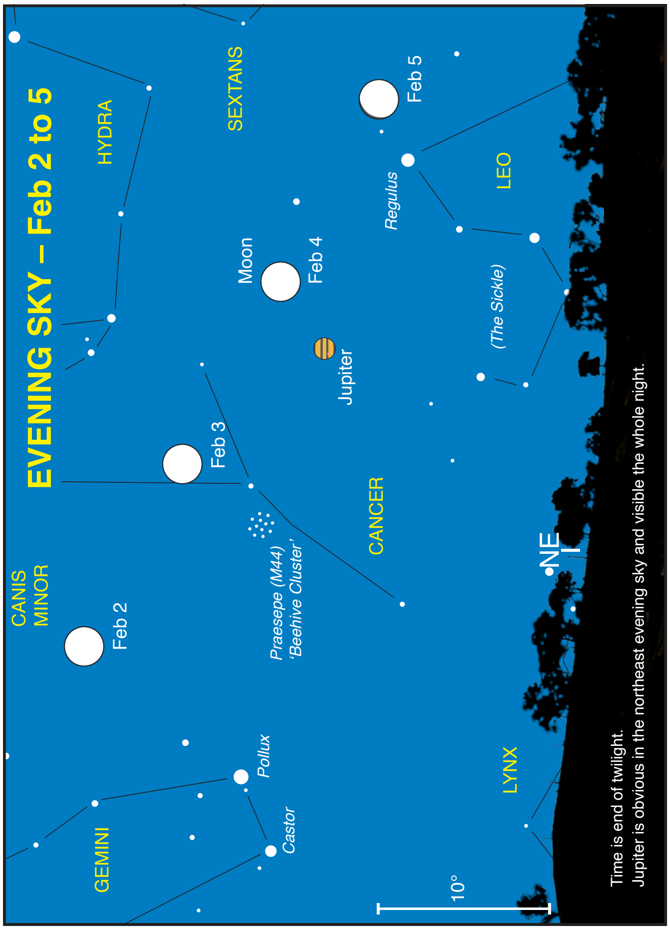
DOUBLE STARS

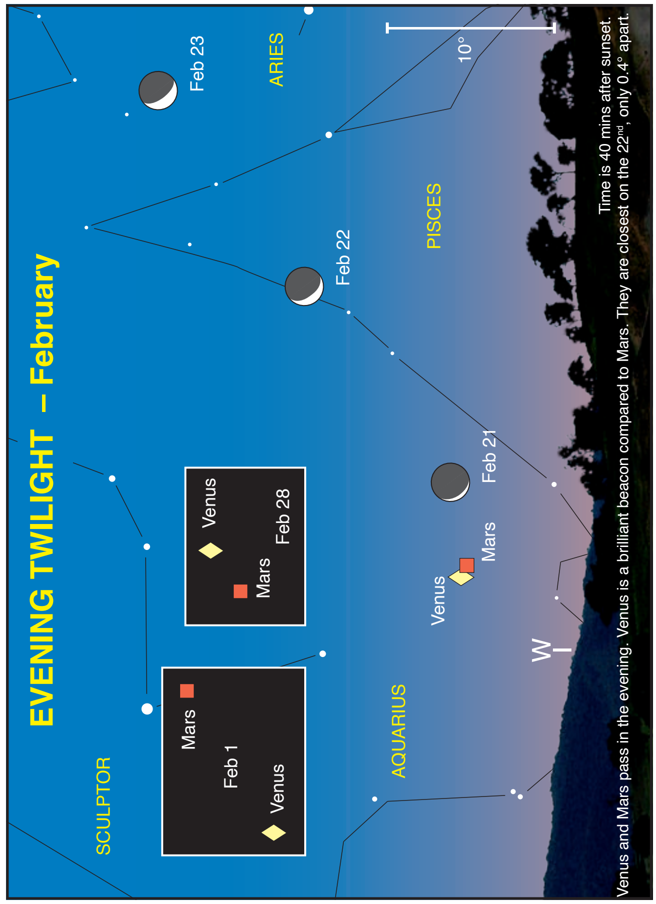
Located near Sirius (α Canis Majoris), **μ Canis Majoris** is a beautiful telescopic pair of orange stars (magnitude 5.3 and 7.1) separated by 2.8 arcseconds and probably is a long period binary. Whilst in Canis Major, if you up for a challenge then the following stars are recommended. Epsilon (ε) Canis Majoris (Adhara) is the second brightest star in Canis Major and is a very unequal telescopic pair of white and yellowish stars. The magnitude 1.5 and 7.5 components are separated by 7.9 arcseconds. It can just be split in a 15 cm *f*/8 reflector. This double star benefits from more aperture. Some have likened this pair to a fainter version of the much more difficult Sirius. If you have a telescope 250 mm or larger, it is worthwhile trying to observe the companion of Sirius called the 'Pup'. You will need high power and look for a speck of light (magnitude 8.5) located about 10 arcseconds roughly east of the dazzling primary. The pair is widening so if you are unsuccessful this year keep trying. (Map 4, p. 72)

Located in Gemini is the fine binocular pair ζ **Geminorum**. The unequal (magnitude 4.1 and 7.7) white and yellowish stars are separated by 101 arcseconds. In the Washington Double Star Catalogue there are three other much fainter stars linked with this pair. (Map 5, p. 73)

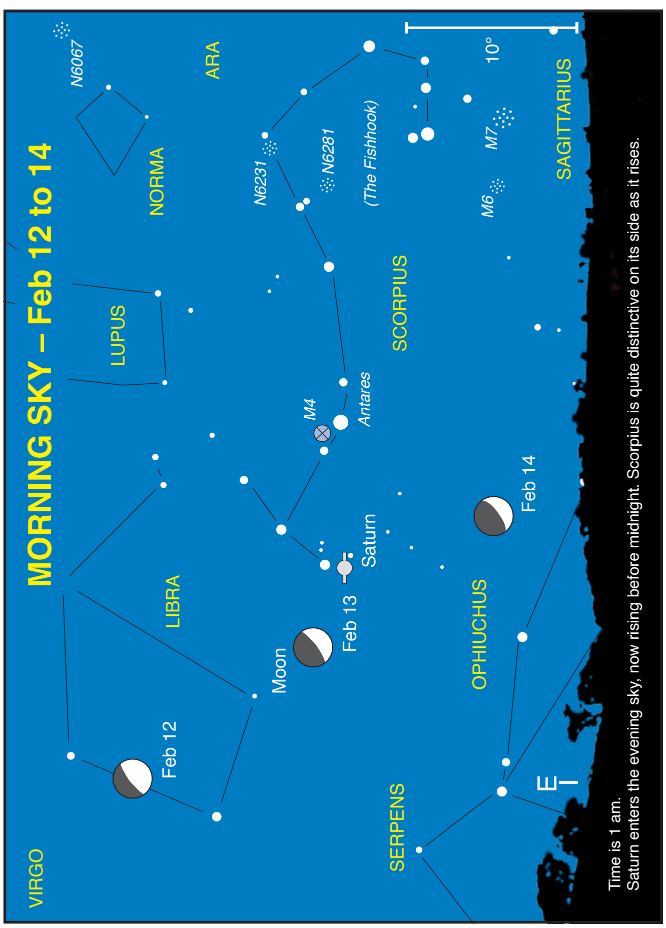
DIARY

Sun	1st		Comet 88P/Howell 0.4°N of M8 Lagoon Nebula (BN) in Sagittarius
Sun	1st		Comet 88P/Howell 1.0°SE of M20 Trifid Nebula (BN) in Sagittarius
Sun	1st		Mercury at greatest latitude north
Sun	1st	9 pm	(7 pm WST) Neptune 0.8°N of Venus
Mon	2nd		m.p. 129 Antigone 0.4°S of star Zeta Ophiuchi
Mon	2nd		Mars 0.3°N of m.p. 16 Psyche
Tue	3rd		Saturn 1.0°NE of star Beta Scorpii
Tue	3rd	4 pm	(2 pm WST) m.p. 3 Juno 10°S of Moon
Wed	4th		Comet C/2012 K1 (PANSTARRS) 0.4°E of NGC 24 (G) in Sculptor
Wed	4th	9:09 am	(7:09 am WST) Full Moon (404,341 km)
Wed	4th	7 pm	(5 pm WST) Jupiter 5°N of Moon
Thu	5th		Mars 0.6°S of NGC 7585 (G) in Aquarius
Thu	5th	7 pm	(5 pm WST) star Regulus 4°N of Moon
Fri	6th		Comet 88P/Howell 1.0°NW of M28 (GC) in Sagittarius
Fri	6th	4 pm	(2 pm WST) Moon at apogee, 406,150 km
Sat	7th	4 am	(2 am WST) Jupiter at opposition
Sun	8th		m.p. 8 Flora 0.9°NE of star Eta Leonis
Mon	9th		Comet 88P/Howell 0.6°SE of NGC 6642 (GC) in Sagittarius
Tue	10th	3 am	(1 am WST) star Spica 3°S of Moon
Tue	10th	4 am	(2 am WST) Comet 88P/Howell 0.1°SE of M22 (GC) in Sagittarius
Thu	12th	1:50 pm	(11:50 am WST) Last Quarter Moon
Fri	13th	10 am	(8 am WST) Saturn 2°S of Moon
Fri	13th	7 pm	(5 pm WST) star Antares 9°S of Moon
Sat	14th		Comet C/2012 K1 (PANSTARRS) 0.4°SE of NGC 45 (G) in Cetus
Sat	14th		Venus 0.4°E of m.p. 16 Psyche
Sat	14th	2 pm	(Noon WST) d.p. Ceres 4°S of d.p. Pluto
Mon	16th	10 am	(8 am WST) d.p. Pluto 3°S of Moon
Mon	16th	11 am	(9 am WST) d.p. Ceres 7°S of Moon
Tue	17th	4 pm	(2 pm WST) Mercury 4°S of Moon
Wed	18th	6 am	(4 am WST) m.p. 4 Vesta 6°S of Moon
Thu	19th	9:47 am	(7:47 am WST) New Moon
Thu	19th	5 pm	(3 pm WST) Moon at perigee, 356,995 km
Sat	21st	11 am	(9 am WST) Mars 1.5°S of Moon
Sat	21st	11 am	(9 am WST) Venus 2°S of Moon
Sun	22nd	6 am	(4 am WST) Mars 0.5°N of Venus
Sun	22nd	8 am	(6 am WST) Uranus 0.3°S of Moon; Occn.
Tue	24th		Mercury at descending node
Wed	25th	2 am	(Midnight WST, prev day) Mercury at greatest elongation West (26.7°)
Thu	26th	3:14 am	(1:14 am WST) First Quarter Moon
Thu	26th	9 am	(7 am WST) star Aldebaran 1.0°S of Moon; Occn.
Thu	26th	3 pm	(1 pm WST) Neptune in conjunction with Sun
Sat	28th		Saturn 0.4°N of star Nu Scorpii





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

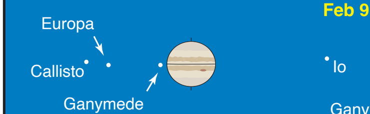


Jupiter's Satellites for February

1 arc min.

Jupiter's Moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole up, east to the left.

Feb 9, 10:30 pm EST (8:30 pm WST)

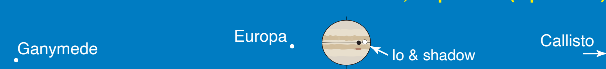


Ganymede and its shadow are about to commence their transit. Later, in the morning, they egress.

Feb 11, 10 pm EST (8 pm WST)

Interesting configuration. All four satellites are on the west side.

Feb 14, 10 pm EST (8 pm WST)



Io and its shadow have been in transit since earlier in the evening. They are about to egress. Later in the night Europa and its shadow will transit.

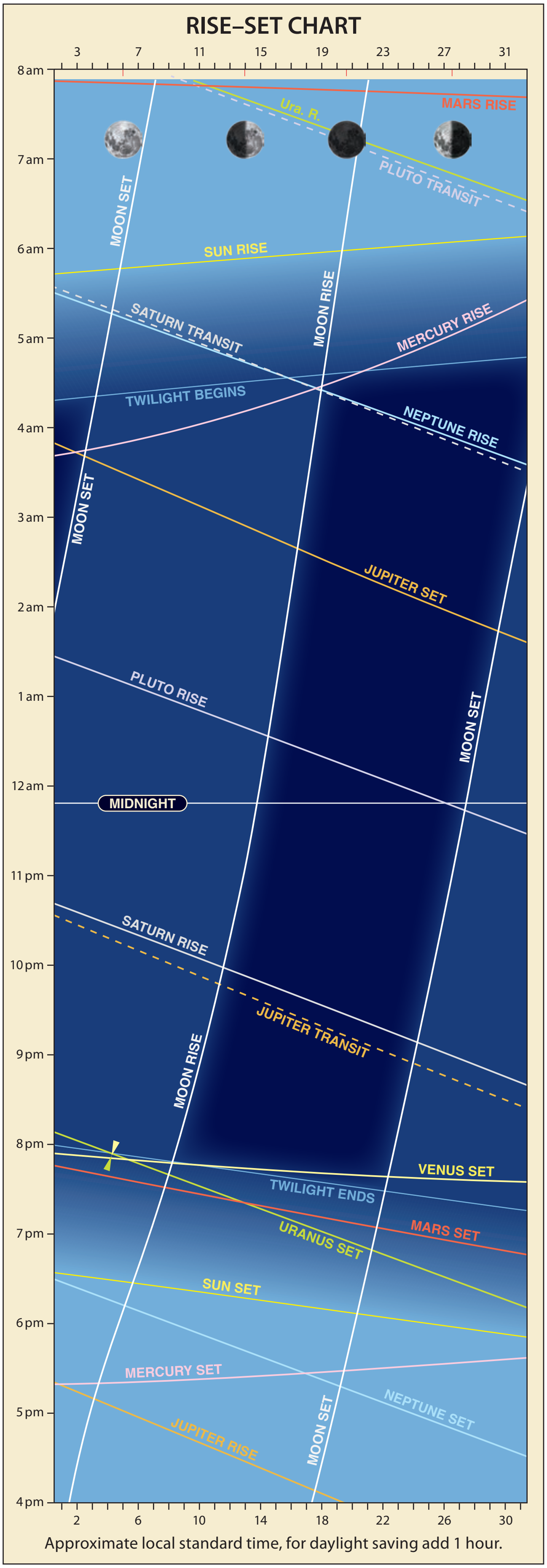
Feb 17, 1:30 am EST (11:30 pm, 16th WST)

Ganymede and its shadow are about to transit. The moon's egress is visible late in the morning from WA.

Feb 21, 9:30 am EST (7:30 pm WST)

All four moons are on the eastern side. Io and its shadow are about to make a complete transit to be followed by Europa.

MARCH



HIGHLIGHTS

- Mercury at best during first half of the month.
- Venus and Uranus close.

CONSTELLATIONS

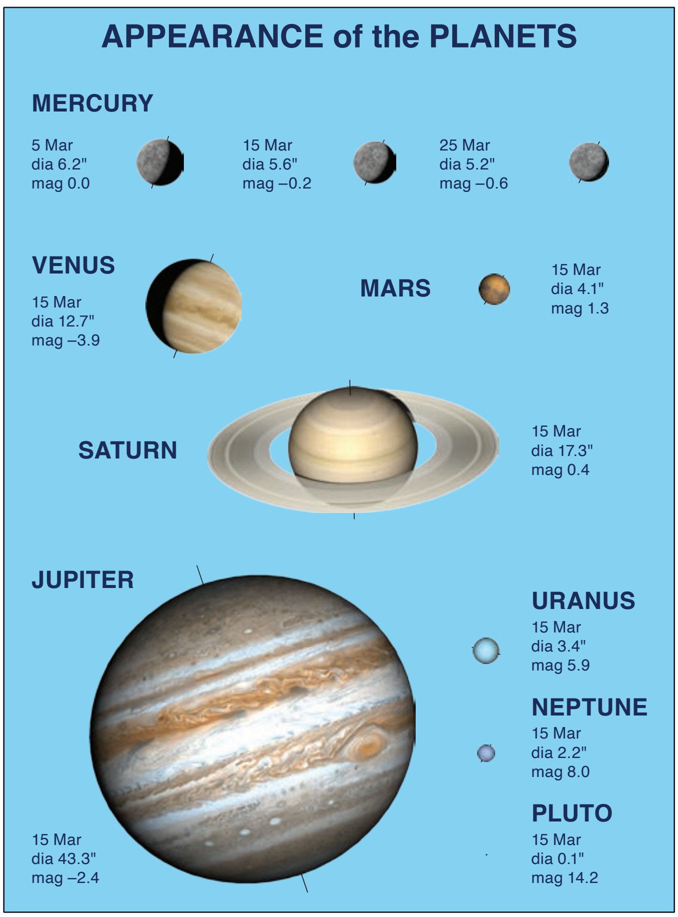
Seeing the ship Argo Navis, of Jason and the Argonauts fame, high in the southern sky is iconic to our early autumn evenings. This constellation was the only one of the 48 ancient Greek constellations *not* to survive. However, its origin is easy to understand with the ship appearing to sail along the southern horizon when seen from ancient Middle East latitudes. Today Argo has been fragmented into three constellations, while still retaining its history. The ship's most distinctive remnant is the False Cross. This asterism, immersed in the star rich region of the Milky Way between the Southern Cross (Crux) and the bright star Canopus (Alpha Carinae), consists of four 2nd magnitude stars. You could call it the home of Argo's mast with two stars residing in Carina (the Keel) and two in Vela (the Sail). Vela consists of a collection of about a dozen 2nd to 4th magnitude stars clearly showing the outline of the sails. The third constellation is Puppis the Stern.

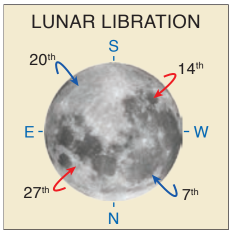
Seeing Orion low in the west and Leo above the northern horizon is also typical for autumn evenings. Virgo has returned to the early evening but this maiden is somewhat nondescript. Its most brilliant star, Spica, is close to the eastern horizon with the distorted square of Corvus above.

The northern evening sky this month contains one of the longest constellations, but it tends to go unnoticed! Hydra, the Water Serpent, is made up mainly of 4th magnitude stars and needs dark skies to observe. Its head is a tight circle of five stars, roughly half way between Regulus and Procyon. Hydra's body then slithers its way east passing other lesser-known constellations such as Sextans, Antlia and Crater. It then dives past Corvus to finish near 1st magnitude Spica. You can also glimpse its southern counterpart, Hydrus, a triangle of 3rd magnitude stars near the bright star, Achernar, low in the southwest.

THE MOON

5th 6 pm (4 pm WST) Moon at apogee (furthest from Earth, 406,385 km)
6th 4 am (2 am WST) Full Moon.





7th 2 am (midnight previous day WST) Minimum Libration (2.4°), bright NW limb.

14th 4 am (2 am WST) Last Quarter.

14th 1 pm (11 am WST) Maximum Libration (10.1°), bright SW limb. The 172 km crater Hausen with its high walls, terraces and central mountain, revealed at this libration.

20th 6 am (4 am WST) Moon at perigee (closest to Earth at 357,584 km).

20th 6 pm (4 pm WST) Minimum Libration (1.7°), too close to New Moon.

20th 8 pm (6 pm WST) New Moon, eclipse (p. 87).

21st 9 pm (7 pm WST) Occultation of Uranus by the Moon, visible from easternmost Brazil, central Africa, Middle East and western Asia.

22nd 8 am (6 am WST) Occultation of Mars by the Moon, visible from parts of western Antarctica and SW South America.

25th 5 pm (3 pm WST) Occultation of Aldebaran by the Moon, visible from Kazakhstan, Russia, NW Canada and Alaska.

27th 1 am (11 pm previous day WST) Maximum Libration (9.8°), bright NE limb. The 165 km Mare Humboldtianum revealed on the limb, and the 182 km walled plain Gauss with its internal craters and small central mountain favoured.

27th 6 pm (4 pm WST) First Quarter.

THE PLANETS

Mercury is in a prime position for observation in the eastern morning skies until mid-March. Thereafter the planet gets closer to the Sun as it moves towards superior conjunction (Earth and Mercury on opposite sides of the Sun). As a last farewell, the 28-day old Moon, just 3% illuminated, appears to the north (left) of the planet on the 19th.

Venus is brilliant in the early western evening sky, spending equal time in Pisces and Aries. On the 4th, the fainter outer planet Uranus will be 0.4° from Venus – although to observe them you will need a small telescope and wait until the sky darkens, placing the pair close to the horizon. The planet shares the twilight with the waxing crescent Moon on the 22nd and 23rd (see Sky View).

The **Earth** is at its autumnal equinox on the 21st. An observer on the equator will see the Sun rise due east and set due west. At this location, day and night are equal.

Mars, in the western evening twilight sky, spends most of March in Pisces before moving into Aries at month end. During the month the Red Planet can be seen a few degrees below and south (left) of Venus. On the 11th Mars will be just 0.3° from Uranus, although the pair will set by the time astronomical twilight ends.

Jupiter, now past opposition, is visible in the north-eastern evening sky after dusk in Cancer. The waxing gibbous Moon appears nearby the planet twice this month, on the 3rd (see Sky View) and 30th (see Sky View in April section). Even though the most favourable period for observation has passed, the planet still presents well in small telescopes. At –2.4 magnitude with an equatorial diameter of just over 43 arcseconds mid

Inkstones of the Thundergods

About 800,000 years ago there was a celestial event of unimaginable magnitude as thousands of tonnes of molten glass bombarded the Earth from the sky. To our distant ancestors, *Homo erectus*, the sight would have been terrifying and devastating as it rained a hail of fire and brimstone. The fall stretched from southern China over the Malay Archipelago to the Australian continent. It was the largest and most recent of the world's major tektite strewn fields, covering some 16 to 18 percent of the Earth's surface. It is also the world's richest source of tektites with thousands of specimens recovered. Other major strewn fields include North America (age 35 million years), Central European (15 million) and the Ivory Coast (1.1 million).

In 1900, Franz Suess coined the term tektite (from the Greek *tektos* meaning molten or melted) to describe these glassy objects. Tektites have been collected and valued as ornamental stones for many years. In fact, tektites were discovered at a site in Austria that Cro-Magnon Man used around 30,000 years ago. In the Philippines pre-Neolithic man shaped them into tools.

The first written account of tektites comes from China in the mid 10th century. In a book by Liu Sun he describes the *lei-gong-mo*, or 'inkstones of the thundergods' – black stones with a bright lustre that were collected in the fields after rain. The indigenous Australians of the South Australian desert regions called them *ooga* or 'staring eyes', and were sometimes named 'blackfellows buttons' by Europeans of the early 20th century.

In 1836, on the famous five-year voyage of HMS Beagle, the naturalist Charles Darwin was given a strangely shaped black glassy object by the explorer Major Sir Thomas Mitchell. Mitchell found the specimen during one of his inland exploratory trips on a sandy plain between the Darling and Murray rivers in New South Wales.

In what was to be the first scientific study of an australite (Australian tektite), Darwin thought that the *curious stone* was obsidian (a naturally occurring volcanic glass), with the flange developing due to rotation of the molten glass. Darwin surmised that since the specimen was found hundreds of kilometres from any known volcanic region it might have been transported either by aborigines or by natural means.

Although closely related, tektites should not be confused with Darwin Glass. This siliceous material is pale to dark green, white or black, irregularly shaped and slaggy. The impact site, Darwin Crater, is a 1.2 km diameter depression near Queenstown in Tasmania. Australites are found across much of the continent with the main concentration below 25 degrees latitude.

There have been many theories advanced to account for their origin including ejection from the Moon via volcanism or meteor impacts – both discounted after the samples returned by the Apollo missions in the 60s and 70s showed no compositional similarities to tektites. The idea that they could be meteorites arriving from deep space was also discounted since they had not been irradiated by cosmic rays.

Today, the majority of scientists agree that tektites were formed as the result of a large asteroid or comet striking the Earth. The Australasian strewn field appears to have originated from a very low angle impact somewhere in Indochina, although the source crater has not been discovered. The energy from the impact melted the local terrestrial rock and launched it up into the atmosphere and beyond.

The shape of typical tektites varies and their ultimate profile and size is dependant on factors including their velocity, rotation and distance travelled from the impact site. A dumbbell will form when the molten glass is spinning, driving material into the ends – if a dumbbell breaks in half during flight the result is two teardrops.

Australites are distinctive from their Asian counterparts even though originating from the same impact that produced the strewn field. It is thought that because of their higher velocity and smaller size, australites were ejected completely out of the atmosphere. Their re-entry caused a secondary melt of the glass creating the australites distinctive forms we see today. With some rare exceptions, it is only the australites that undergo this secondary melt.

… continued next page.


Tektites from Khorat Plateau, Nakhon Ratchasima Province,Thailand (from author's collection).

month, its slightly lesser presence since opposition will be minimal. For optimum viewing at this time wait until Jupiter transits the meridian (is due north) and at its highest altitude to lessen atmospheric affects. One thing to remember about Jupiter is its fast 9 hour 55 minute rotation, and after just an hour or so of observation you can see changes as new parts of the planet come into view. Even from night to night the clouds can change in dramatic fashion. See also the Sky View showing some interesting satellite configurations during the month.

Saturn rises in the mid-evening eastern sky near the head of Scorpius. The planet is stationary on the 15th and then begins 4.5 months of retrograde motion. Whilst Saturn is barely moving against the stellar backdrop this month it remains within 0.5° of the 4th magnitude quadruple star Nu Scorpii (Jabbah, the forehead of the Scorpion – not to be confused with the Star Wars character Jabba). Jabbah appears as a double double, two close pairs separated by 41 arcseconds and easily split with a small telescope. The main pair is a close 1.2 arcseconds apart and will require some magnification and steady seeing to divide these white stars. The secondary pair of yellow suns is less difficult at 2.2 arcseconds apart. See also double stars, page 47. On the 13th, the 21-day old waning gibbous Moon appears near the planet (see Sky View).

Uranus is only visible at the beginning of the month low in the western sky; it then becomes lost in the twilight as its angular distance from the Sun decreases. On the 4th, Venus will overwhelm the outer planet when it comes within 0.4° (see Venus).

Neptune, in Aquarius, reappears in the morning eastern sky mid-month after its conjunction with the Sun in February.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, rises around midnight in the eastern sky. On the 2nd **Ceres** passes through the wide, bright double star, Chi Sagittarii.

Minor Planets. Three of the brighter minor planets reach opposition this month in Virgo, 67 Asia on 19th at magnitude 11.7, 44 Nysa on 22nd at magnitude 9.4 and 85 Io on 31st at magnitude 11.6. Two reach opposition in Leo, 354 Eleonora on 5th at magnitude 9.6 and 17 Thetis on 7th at magnitude 10.8. Others include 216 Kleopatra on 13th at magnitude 11.9 in Crater, 511 Davida on 18th at magnitude 10.8 in Corona Borealis and 7 Iris on 6th at magnitude 8.9 near the Leo/Sextans border.

Comet 88P/Howell begins March in Sagittarius at 9th magnitude, rising two hours before the onset of dawn. Early in the month, Howell moves into Capricornus where it will remain until April. From early until mid-March, the Moon will hinder observing.

METEOR SHOWERS

The **gamma-Normids** are active between 25th February and 28th March, with maximum around the 15th. For most of the period, the rate is low, and members are difficult to sort out from the background sporadic activity. From 1988 to 2007 the shower has generated an average zenith hourly rate of six. Generally, the gamma-Normids are bright and chiefly yellow, white or orange with a few leaving trains. Since the constellation of Norma rises late in the evening, the shower is best viewed after midnight when the radiant reaches a reasonable altitude.

DOUBLE STARS

Castor (α Geminorum) is a brilliant blue-white binary with a period of about 445 years and is located 52 light years away. The pair (magnitude 1.9 and 3.0), now separated by 5.0 arcseconds, are each spectroscopic binaries. Also, look for the faint (magnitude 8.9 – 9.6) orange eclipsing star YY Geminorum, having a period of 20 hours, located 71 arcseconds away. One can only imagine what the view would be like from a planet orbiting one of the stars in this sextuple system. (Map 5, p. 73)

Easily identified within the main trapezium of Corvus, this month's binocular pair is **ζ Corvi** and the adjacent star HR 4691 (HD 107295). This pair of magnitude 5.2 and 5.9 white stars is widely spaced and a pleasing sight. ζ Corvi is located about 415 light years away, whilst the distance to the other star is uncertain and may also be similar. As the two share a common motion through space, they may be connected. Both stars are also binaries in their own right. (Map 6, p. 74)

DIARY

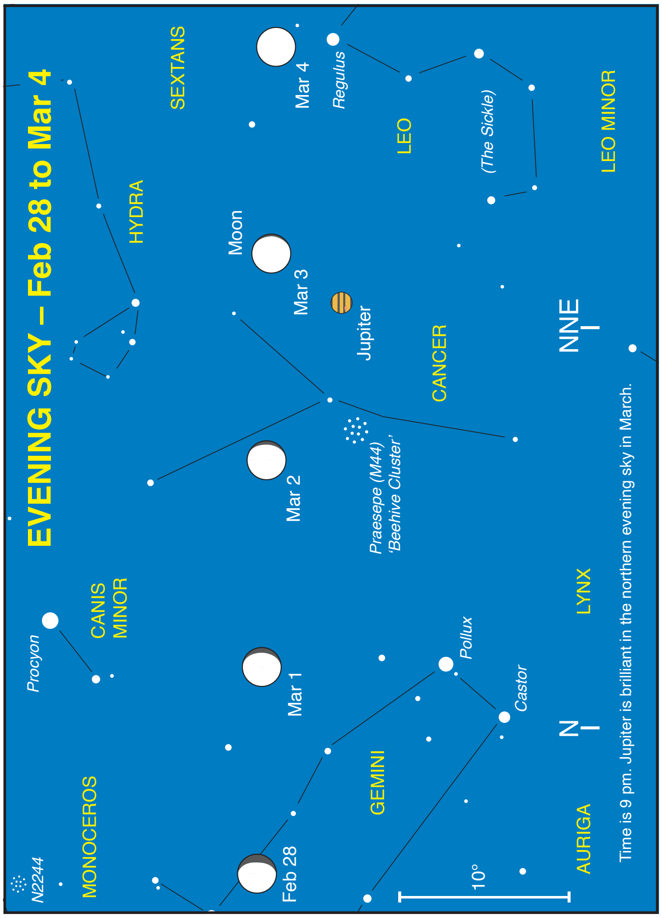
Mon	2nd		d.p. Ceres 0.4°E of star Chi 1 Sagittarii
Mon	2nd		Mars 0.2°S of NGC 128 (G) in Pisces
Mon	2nd	2 pm	(Noon WST) m.p. 3 Juno 6°S of Moon
Mon	2nd	pm	m.p. 354 Eleonora 0.5°W of NGC 3686 (G) in Leo
Tue	3rd	6 pm	(4 pm WST) Jupiter 5°N of Moon
Wed	4th		m.p. 3 Juno 0.9°W of star Beta Cancri
Thu	5th	1 am	(11 pm WST, prev day) star Regulus 4°N of Moon
Thu	5th	5 am	(3 am WST) m.p. 4 Vesta 0.9°S of Mercury
Thu	5th	6 am	(4 am WST) Uranus 0.1°S of Venus
Thu	5th	6 pm	(4 pm WST) Moon at apogee, 406,385 km
Fri	6th		Mercury at aphelion
Fri	6th	4 am	(2 am WST) Comet 88P/Howell 0.1°S of M75 (GC) in Sagittarius
Fri	6th	4:05 am	(2:05 am WST) Full Moon (406,323 km, furthest for this year)
Sun	8th	pm	m.p. 354 Eleonora 0.3°E of NGC 3626 (G) in Leo
Mon	9th		d.p. Ceres 0.8°N of star Nu Sagittarii
Mon	9th	9 am	(7 am WST) star Spica 3°S of Moon
Mon	9th	pm	m.p. 354 Eleonora 1.0°NE of NGC 3607 (G) in Leo
Thu	12th	6 am	(4 am WST) Uranus 0.3°S of Mars
Thu	12th	6 pm	(4 pm WST) Saturn 2°S of Moon
Fri	13th	2 am	(Midnight WST, prev day) star Antares 9°S of Moon
Sat	14th	3:48 am	(1:48 am WST) Last Quarter Moon
Sun	15th		Venus at ascending node
Sun	15th	8 pm	(6 pm WST) d.p. Pluto 3°S of Moon
Mon	16th	2 pm	(Noon WST) d.p. Ceres 8°S of Moon
Tue	17th	pm	Jupiter 0.7°SW of NGC 2749 (G) in Cancer
Wed	18th		Mercury 1.5°SE of Neptune
Wed	18th	4 pm	(2 pm WST) m.p. 4 Vesta 6°S of Moon
Wed	18th	11 pm	(9 pm WST) m.p. 354 Eleonora 0.15°S of star Delta Leonis
Thu	19th	Noon	(10 am WST) Neptune 4°S of Moon
Thu	19th	3 pm	(1 pm WST) Mercury 5°S of Moon
Fri	20th	6 am	(4 am WST) Moon at perigee, 357,584 km
Fri	20th	7:36 pm	(5:36 pm WST) New Moon; Eclipse
Sat	21st		Mercury 0.7°SE of m.p. 29 Amphitrite
Sat	21st	9 am	(7 am WST) Equinox
Sat	21st	9 pm	(7 pm WST) Uranus 0.1°S of Moon; Occn.
Sun	22nd	8 am	(6 am WST) Mars 1.0°N of Moon; Occn.
Mon	23rd	6 am	(4 am WST) Venus 3°N of Moon
Wed	25th	3 am	(1 am WST) m.p. 129 Antigone 0.4°W of star Nu Ophiuchi
Wed	25th	5 pm	(3 pm WST) star Aldebaran 0.9°S of Moon; Occn.
Fri	27th		Mercury at greatest latitude south
Fri	27th	5:43 pm	(3:43 pm WST) First Quarter Moon
Sun	29th		m.p. 21 Lutetia 0.9°N of M75 (GC) in Sagittarius
Sun	29th	am	m.p. 129 Antigone 0.7°S of NGC 6517 (GC) in Ophiuchus
Sun	29th	11 pm	(9 pm WST) m.p. 3 Juno 2°S of Moon
Mon	30th	8 pm	(6 pm WST) Jupiter 6°N of Moon
Mon	30th	pm	m.p. 8 Flora 0.2°S of NGC 2905 in Leo

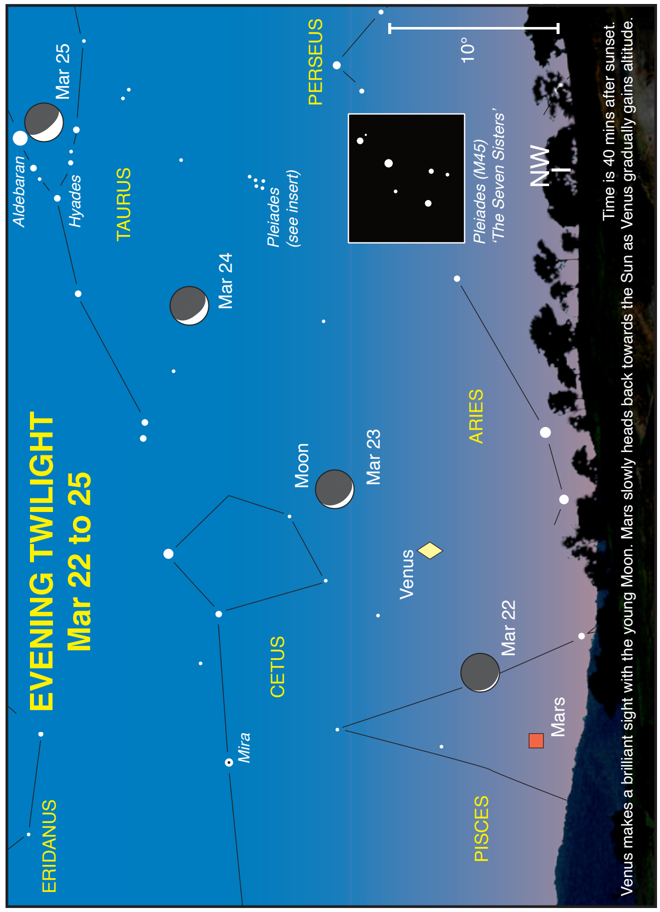
Inkstones of the Thundergods … continued

The Asian tektites, or indochinites, are termed *splash form* tektites and are usually larger than australites and characteristically shaped as spheres, ellipsoids, teardrops and dumbbells. The smaller australites can take the form of the much sought after 'flanged button' type or other aerodynamic shapes such as ovals, boats, canoes, cores (flange type stripped of its flange) and classic teardrops and dumbbells. The flanged button australites form as a spherical globule re-enters the atmosphere and the side facing the direction of travel begins to melt. The melt is forced toward the rear creating ridges and the flange.

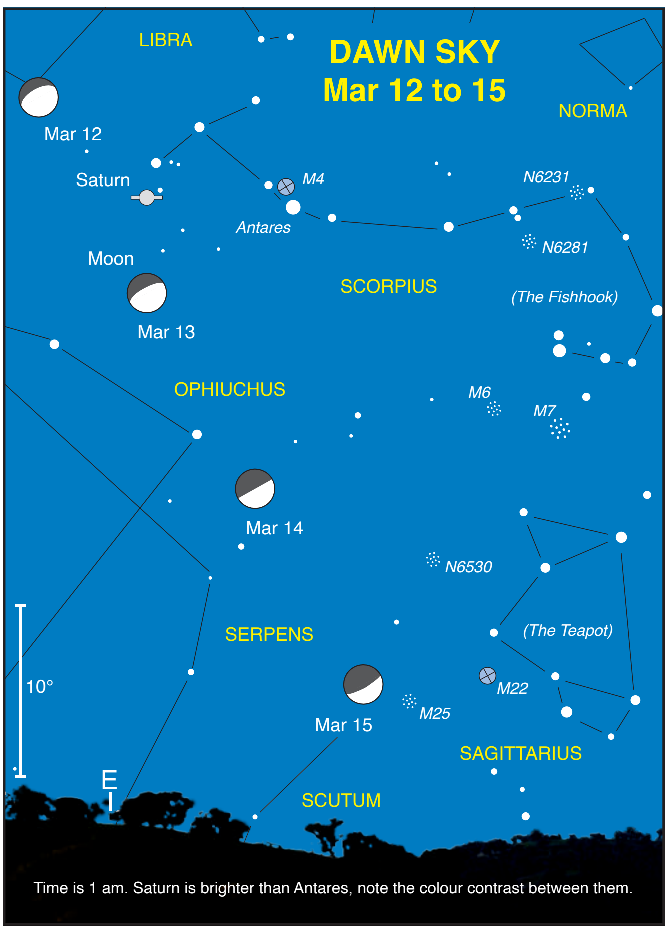
Darwin's woodcut of an australite

In all states of Australia it is illegal to collect and own meteorites, though there is no restriction on tektites. In the Northern Territory however, they come under the same classification as meteorites and it is against the law. Next time you wander in the outback try looking down for a small dark glassy fragment, you may find a piece of Earth that spent a little time in space.





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



Jupiter's Satellites for March

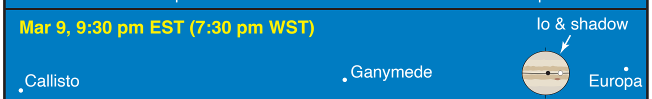
1 arc min.

Jupiter's Moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole up, east to the left.

Mar 7, 10 pm EST (8 pm WST)

Interesting configuration.
All four moons on the east side of Jupiter.
40 mins earlier Europa occulted Callisto and for a few mins were inseparable.

Mar 9, 9:30 pm EST (7:30 pm WST)

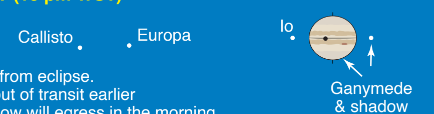


Io and its shadow are currently in transit and will egress shortly. Europa will be occulted later in the night.

Mar 14, 8 pm EST

All four moons on the east side of Jupiter, although to see them this close together requires observing early in the evening from the eastern states.

Mar 24, midnight EST (10 pm WST)

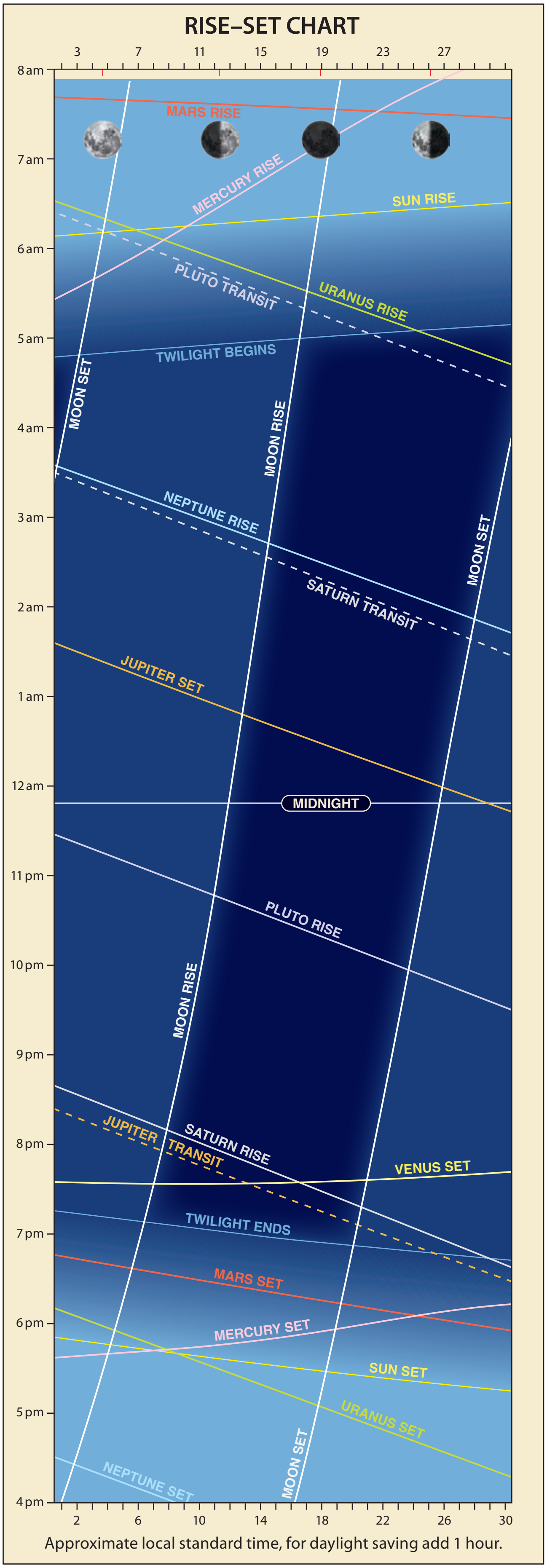


Io has just reappeared from eclipse.
Ganymede has come out of transit earlier in the evening. Its shadow will egress in the morning.

Mar 31, 10 pm EST (8 pm WST)

An interesting close configuration of the moons. In the next hour Io will go into occultation followed by Ganymede commencing a transit.

APRIL



HIGHLIGHTS

❍ Total lunar eclipse.

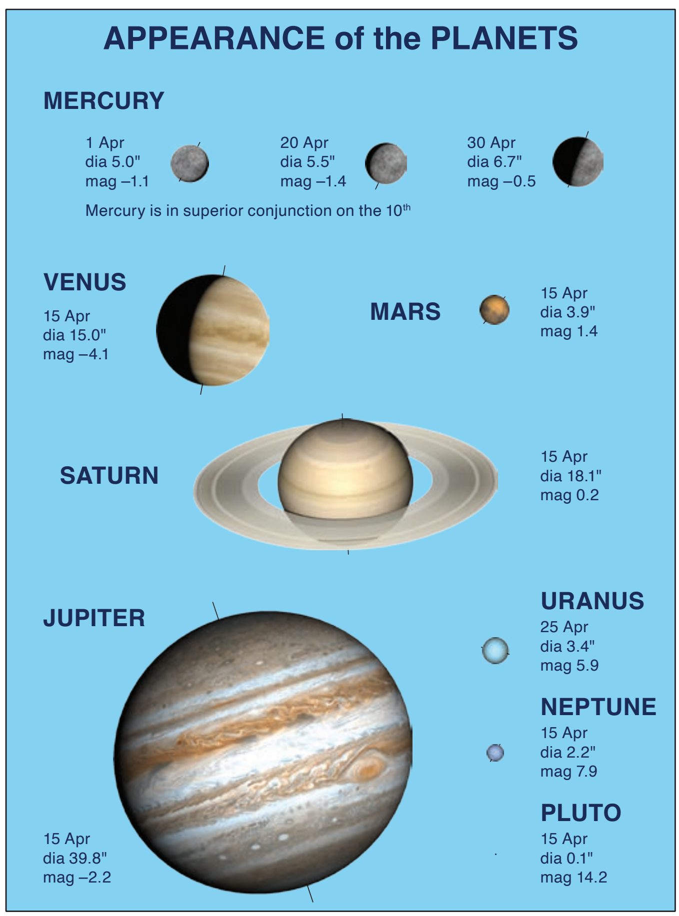
m Venus and crescent Moon make an impressive sight.

CONSTELLATIONS

Don't ever take the southern Milky Way for granted. This month look high in the southern evening sky and soak in the grandeur that is the envy of Northern Hemisphere observers. The Southern Cross (Crux) is the jewel in the crown! Extend your closed hand and see how easily it covers this smallest, brightest and most star dense constellation in the entire heavens. Opening your hand and moving to the right, it now spans the distance from Crux to the False Cross which encompasses the magnificent Carina nebulae and star cluster region. This section of our galaxy glows with bright naked-eye patches of nebulae and star clusters.

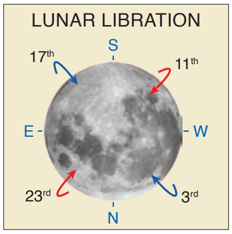
Crux isn't the only iconic constellation visible in April evenings. Looking to the west you will see the summer signature of Orion about to set. This hunter is lying on his side with his distinctive three belt stars pointing straight up. Talking about being close to the horizon, look towards the east and see the winter symbol of Scorpius commencing its return to the evening sky. To the north is Leo the Lion, one of the few constellations that looks like its namesake, well… to people in the Northern Hemisphere. From *down under* this regal beast sits low in the north, but upside down. Its head and shoulders are referred to as the sickle, with its top member Leo's brightest (alpha) star, Regulus, being Latin for 'Little King' – a fitting royal connection. To the east lie its hindquarters consisting of a conspicuous triangle of stars. This group's brightest star, Denebola (Beta Leonis), is short for an Arabic phrase meaning 'tail of the Lion'.

High in the northern evening sky lies the constellation of Corvus the Crow. These four distinctive 3rd magnitude stars, arranged in a trapezium shape, don't look anything like a bird. Only 15° right (east) of Corvus is the obvious, isolated 1st magnitude star Spica (alpha Virginis).



APRIL

THE MOON



1st 11 pm (9 pm WST) Moon at apogee (furthest from Earth at 406,012 km).

3rd 3 pm (1 pm WST) Minimum Libration (1.8°), dark NW limb.

4th 10 pm (8 pm WST) Full Moon. Total lunar eclipse visible across Australia (see Part II for details).

11th 4 am (2 am WST) Maximum Libration (9.5°), bright SW limb. This libration brings the south polar regions into view, the 311 km walled plain Bailly and 172 km crater Hausen also seen to good advantage.

12th 2 pm (noon WST) Last Quarter.

17th 2 pm (noon WST) Moon at perigee (closest to Earth at 361,023 km).

17th 4 pm (2 pm WST) Minimum Libration (0.6°), too close to New Moon.

19th 5 am (3 am WST) New Moon.

22nd 3 am (1 am WST) Occultation of Aldebaran by the Moon, visible from NW USA, Canada, Greenland, Iceland, Scandinavia and NW Russia.

23rd 10 pm (8 pm WST) Maximum Libration (9.4°), bright NE limb. North polar regions favoured including Mare Humboldtianum, the dark floor and high walls of the 129 km crater Endymion and walled plain Gauss

26th 10 am (8 am WST) First Quarter.

26th 5 pm (3 pm WST) Occultation of Juno by the Moon, visible from northern Papua New Guinea, Micronesia, north Melanesia and French Polynesia.

29th 2 pm (noon WST) Moon at apogee (furthest from Earth at 405,083 km).

THE PLANETS

Mercury is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 10th and thereafter moves into the western evening twilight.

Venus spends the first week of April in Aries before moving into Taurus where it travels between the Pleiades and Hyades clusters, finally ending up between Beta and Zeta Tauri – the stars marking the tip of the Bull's horns. The whole early evening western horizon is a joy to view at this time of year with Taurus, Orion and Gemini all poised to set – the dazzling Venus and the thin crescent Moon on the 21st and 22nd just adding to the ambience (see Sky View).

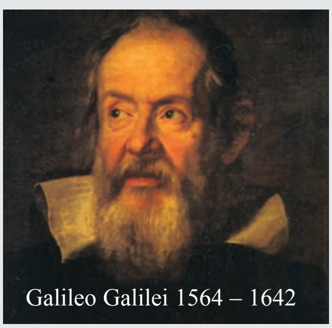
Mars, moving across Aries, becomes increasingly difficult to see as it is consumed in the western evening dusk (see Sky View). The planet then remains too close to the Sun for observation until its reappearance in the eastern dawn sky in August.

Jupiter, in Cancer, is visible in the north as the sky darkens after evening dusk. On the 26th, the First Quarter Moon will be seen close to the planet (see Sky View). On the 9th, Jupiter appears stationary as it comes to the end of its four-month retrograde loop as the Earth overtakes it – thereafter the planet moves from east to west across the sky. During the month Jupiter will be within 2° of one of the reddest stars in the sky, and we are not talking about Antares or Betelgeuse red here, but intensely *red*. The star, X Cancri, is a semi-regular variable carbon star with a magnitude range from 5.5 to 7.5 (typically sitting around 6.7 on average). Scanning around Jupiter with a pair of binoculars will aid in finding this remarkable star, then try looking through a telescope. Sir Patrick Moore once said, "It looks rather like a tiny glowing coal".

Saturn comes to opposition in May and can be seen rising in the east around 7:30 pm mid-month. The planet is currently in Scorpius with retrograde motion taking it back towards the border of Libra. On the 8th, the 19-day old waning gibbous Moon appears quite close to Saturn (see Sky View). The entire period from April through June is an ideal time to observe this gem of the Solar System. Aside from viewing the

Early Measures of the Speed of Light

Most scholars prior to the 17th century considered the velocity of light to be infinite, but then, along came Galileo. Around 1623, Galileo was also of the opinion that light was infinite and had "… an instantaneous motion, or rather an instantaneous expansion and diffusion …" Although by 1638 he appears to have changed his mind, describing an experiment to determine the speed of light in his 'Dialogues Concerning Two New Sciences'.


Galileo Galilei 1564 – 1642

He proposed that two assistants should take lanterns and stand facing each other separated by a distance of three miles (5 km). The first person would uncover his lantern and the instant his companion saw the light he would uncover his own. Galileo reasoned that a delay would easily be observable over the distance from one observer to the other and back again. He even suggested carrying out the experiment at a distance of eight or ten miles (13–18 km) and use telescopes to sight the light sources.

Galileo states that he tried the experiment over a short distance (less than one mile) and was unable to ascertain whether it was instantaneous or not, "… but if not instantaneous it is extraordinarily rapid – I should call it momentary …" He also presented an analogy to the transmission of light from lightning spreading to surrounding clouds, arguing that some time is required for its propagation. Of course light moves far too fast to be measured by such methods, but credit to Galileo as the first to attempt such an experiment.

It is interesting that one of Galileo's first discoveries with a telescope, the four main moons of Jupiter, would lead on to the next measurement.

The determination of longitude was a major problem for navigators until the 18th century when accurate clocks were developed. Galileo suggested that eclipses of the Jovian moons could be used as a celestial clock to enable calculation of the time of day and hence longitude. The idea proved unworkable for several reasons: Jupiter was only visible for part of the year, it could not be seen in the daytime, the skies had to be clear, and it was difficult to make observations from a moving deck. After Galileo's death the method was adopted by land based surveyors and cartographers who were now able to draw maps with greater accuracy.

In attempting to improve on his predecessor's tables of the Jovian satellite eclipses, the Danish astronomer Ole Roemer, working at the Paris Observatory in 1676, noted a discrepancy in the timing of the moon Io. This innermost Galilean moon orbits Jupiter in 1.769 days and the times it enters or egresses from eclipse could be accurately forecast.

Roemer noticed that when near opposition, with Jupiter closest to Earth, the timings were fine. However, as the Earth receded from Jupiter after opposition the eclipse times fell further and further behind schedule. When approaching Jupiter six months later the opposite occurred as the times began to catch up again. He correctly concluded that the discrepancy was due to the varying distance between the planets. When Jupiter was further from Earth, it took longer for the light to reach us. The extra distance that light had to travel was the diameter of the Earth's orbit. Roemer estimated that light would take about 22 minutes (correct value 16 minutes) to travel this distance, which gave a light speed of around 220,000 km/s. This figure, although short of the mark, was nonetheless remarkable since planetary distances were not accurately known at the time.


Ole Roemer 1644 – 1710

… continued next page.

planet with its glorious rings, it can be a lot of fun to track down some of Saturn's brighter moons. At 8.4 magnitude, Titan is the easiest and can even be seen in binoculars. The others are a bit more difficult, the task made all the tougher by the planet's inclination to our line of sight which effectively scatters the satellites all over the place – unlike the neat and orderly shuffling of Jupiter's moons from one side to the other. In May and June, some of the more interesting patterns formed by the brightest satellites are presented in the Sky View section. These will aid in their identification.

Uranus is in conjunction with the Sun on the 7th (the planet on the opposite side of the Sun from the Earth) and will not be observable until its reappearance in the morning eastern sky in early May.

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 3 am mid-April. This distant world ends the month around 2.5° from the 4th magnitude star Lambda Aquarii (Hydor).

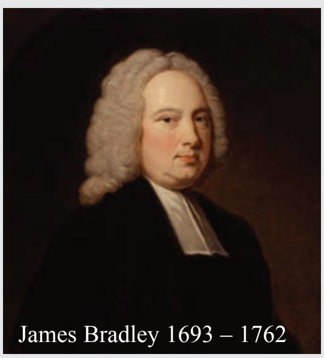
DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto rises in the late evening eastern sky in Sagittarius. It appears stationary on the 17th and thereafter will be in retrograde motion for the next five months. The brightest naked eye star near Pluto is 3rd magnitude Pi Sagittarii at a distance of 1.2°.

Minor Planets. Five of the brighter minor planets reach opposition this month in Virgo. They are: 87 Sylvia on 8th at magn 12.3, 20 Massalia on 20th at magn 9.3, 64 Angelina on 22nd at magn 10.9, 19 Fortuna on 23rd at magn 10.7 and 11 Parthenope on 23rd at magn 9.7. Also 704 Interamnia reaches opposition on 12th at magn 11.3 near the Centaurus/Hydra border.

Comet 88P/Howell reaches perihelion this month on the 6th, at a distance of 1.4 au from the Sun. Predicted to be 9th magnitude in brightness throughout April, Howell begins the month in Capricornus, moving into Aquarius early in April. With the comet visible in the morning sky, the second half of the month will be Moon-free for observing.

Measures of the Speed of Light … continued


James Bradley 1693 – 1762

The next substantial improvement came in 1728 by the English astronomer James Bradley. He was looking for stellar parallaxes and discovered the aberration of starlight – the apparent shift of the positions of stars (up to 20.5 arcseconds) due to the annual motion of the Earth around the Sun. All stars are affected equally in this way and it should not be confused with stellar parallax, which displaces nearby stars. Stellar aberration is caused by the Earth's motion at a given time in its orbit, not on its position. Bradley crunched the numbers and derived 301,000 km/s for the speed of light – accurate to within one percent!

Stellar aberration is not a simple concept to get across in a few short paragraphs – the following analogy will hopefully help. Imagine you are running in the rain, there is no wind, so you get wet in the front and not behind. Now if you were to carry an empty tube pointed vertically, rain would not fall all the way through the tube but hit the back wall. If you want the rain to fall all the way through you must angle the tube forwards, more or less according to your velocity forwards compared with that of the rain downwards. Now, substitute the rain for light and your running for the motion of the Earth and you have a rough idea what stellar aberration is.

Refinements continued using various methods and by 1970 the speed of light was known to within an error of plus or minus one metre per second. In 1983 the metre was redefined by international agreement as the distance travelled by light in a vacuum in 1/299,792,458 of a second. This defines the speed of light in a vacuum to be exactly 299,792,458 metres per second.

Please note; in our section on Jupiter's moons in Part II of this publication, there is no need to take into account the length of light travel time, we have already done that for you.

METEOR SHOWERS

Both showers this month are Moon free in the morning hours for their maxima, and the International Meteor Organization is predicting a possible strong return for the Lyrids this year.

The **Lyrids** are a Northern Hemisphere shower, but they are visible south of the equator. They are best seen well past midnight in the Southern Hemisphere from the 16th to 25th, with maximum predicted on the 22nd. Maximum rates may only last an hour or so, and typically the zenith hourly rate is around 18. The Lyrids have on occasion produced higher rates, and because of their erratic nature is a shower to be watched. In 1982, American observers noticed a short peak of 90 per hour.

The **pi-Puppids** are a young southern shower first observed in 1972, and produced by Comet 26P/Grigg-Skjellerup. Best seen from 15th to 28th, with maximum activity on the 24th. Leading up to and after maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil, occasionally three to four per hour or more (40 in 1977 and 1982, 13 in 1983). The pi-Puppids are noted for their very slow speed, brightness, persistent trains, large proportion of yellow meteors and occasional fireballs.

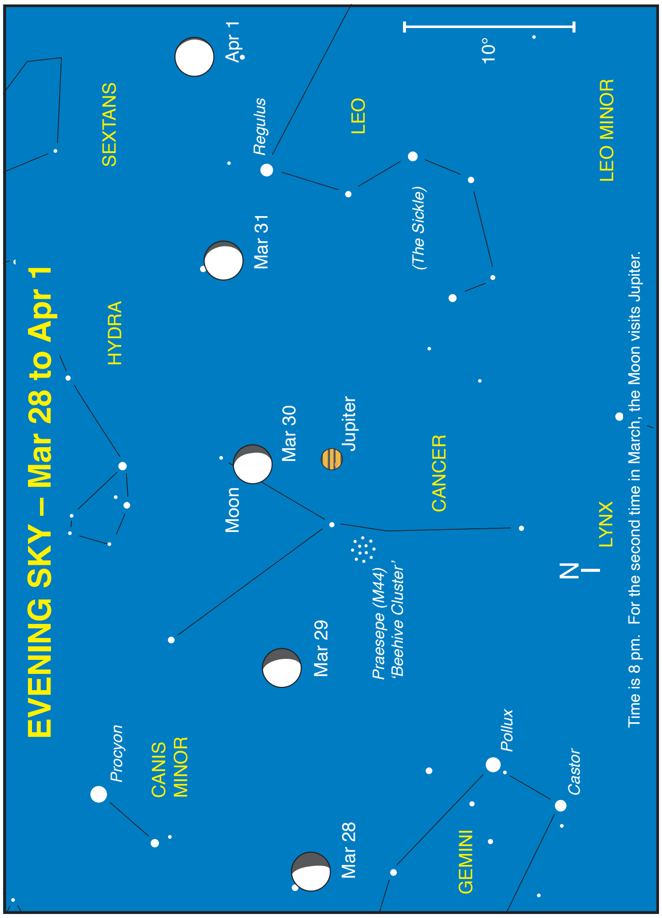
DOUBLE STARS

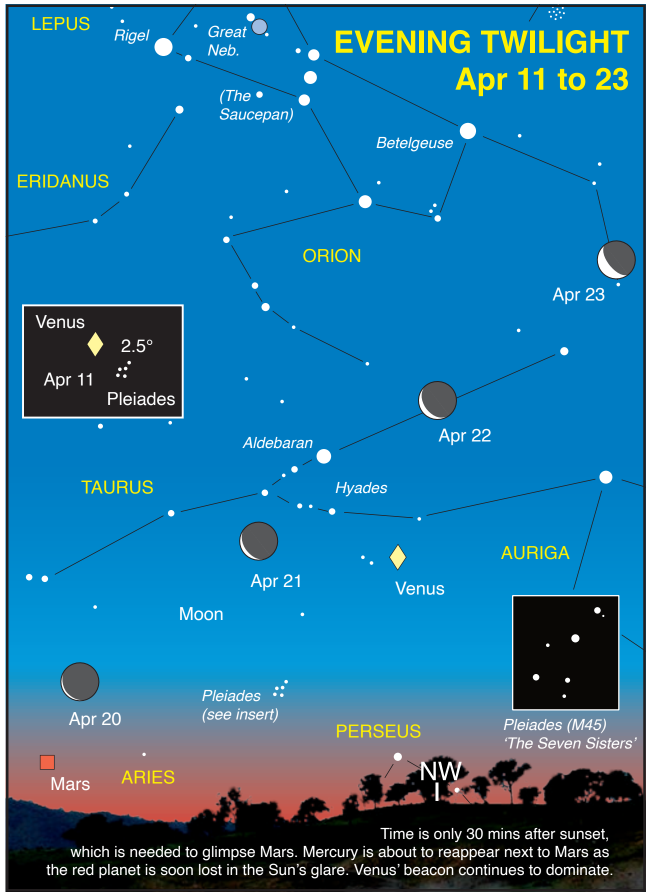
Located on the border between Leo and Leo Minor, **54 Leonis** is a delightful but little-known unequal binary composed of a white star and a bluish companion. Some see the pair as bluish-white and greenish-white. The stars, magnitude 4.5 and 6.3, separated by 6.6 arcseconds are located 150 light years away. The pair shows direct motion and common proper motion suggesting a long-period binary. (Map 5, p. 73)

Located near α Hydrae (Alphard) is the easy binocular double **27 Hydrae**. This pair of magnitude 4.9 and 7.0 stars is separated by 229 arcseconds and is about 222 light years distant. Through 10 × 50 binoculars they appear yellowish and white. (Map 4, p. 72)

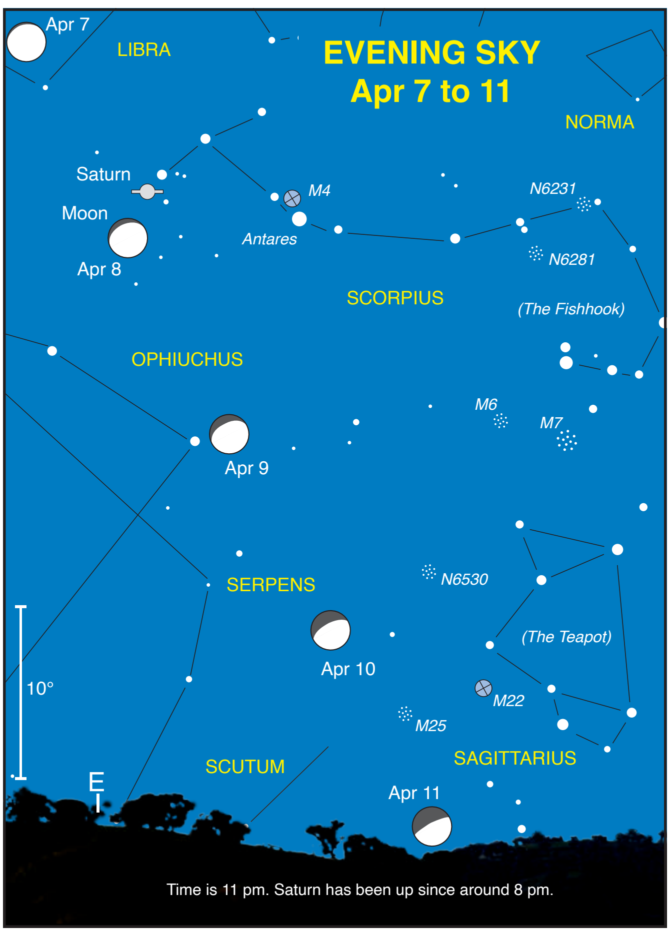
DIARY

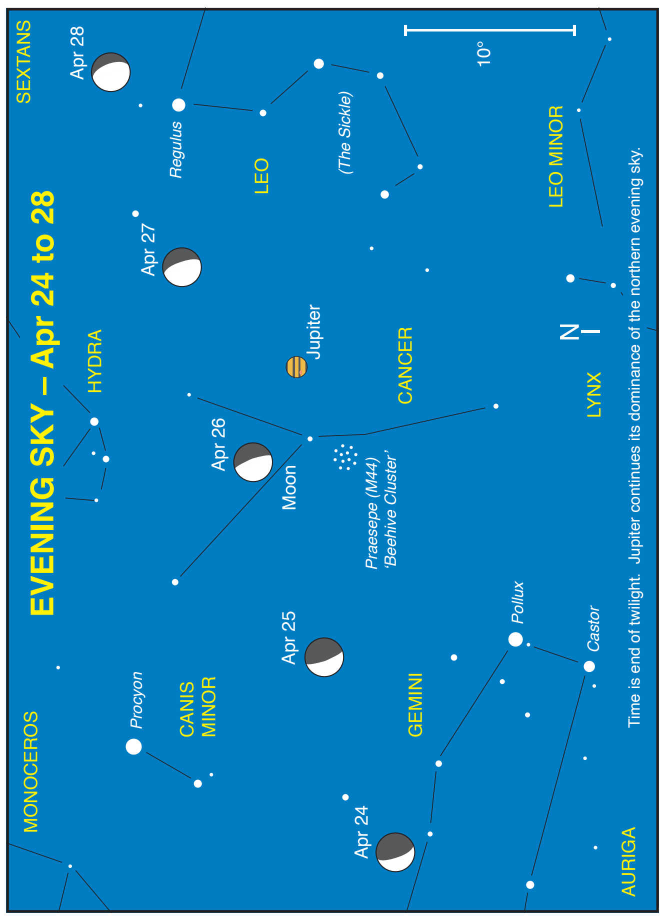
Wed	1st		Saturn 0.5°N of star Nu Scorpii
Wed	1st	4 am	(2 am WST) Comet 88P/Howell 0.05°SE of star Gamma Capricorni
Wed	1st	7 am	(5 am WST) star Regulus 4°N of Moon
Wed	1st	11 pm	(9 pm WST) Moon at apogee, 406,012 km
Fri	3rd		m.p. 29 Amphitrite 0.4°SE of star Phi Aquarii
Fri	3rd	4 am	(2 am WST) Comet 88P/Howell 0.1°S of star Delta Capricorni
Sat	4th	10:06 pm	(8:06 pm WST) Full Moon (402,834 km); Eclipse
Sun	5th		m.p. 11 Parthenope 1.0°S of NGC 5634 (GC) in Virgo
Sun	5th	3 pm	(1 pm WST) star Spica 3°S of Moon
Mon	6th	Midnight	(10 pm WST) Uranus in conjunction with Sun
Wed	8th	11 pm	(9 pm WST) Saturn 2°S of Moon
Thu	9th	7 am	(5 am WST) star Antares 9°S of Moon
Fri	10th		m.p. 15 Eunomia 1.0°N of star Theta Aquarii
Fri	10th	2 pm	(Noon WST) Mercury in superior conjunction
Sat	11th		Venus 2.5°S of M45 the Pleiades (OC) in Taurus
Sun	12th		Mars at ascending node
Sun	12th	3 am	(1 am WST) d.p. Pluto 3°S of Moon
Sun	12th	1:44 pm	(11:44 am WST) Last Quarter Moon
Mon	13th	Noon	(10 am WST) d.p. Ceres 9°S of Moon
Tue	14th	7 pm	(5 pm WST) m.p. 4 Vesta 3°S of Neptune
Wed	15th	Midnight	(10 pm WST) m.p. 4 Vesta 6°S of Moon
Wed	15th		Mercury at ascending node
Wed	15th	11 pm	(9 pm WST) Neptune 4°S of Moon
Fri	17th	2 pm	(Noon WST) Moon at perigee, 361,023 km
Sat	18th		Venus at perihelion
Sun	19th		Mercury at perihelion
Sun	19th	4:57 am	(2:57 am WST) New Moon
Mon	20th	5 am	(3 am WST) Mars 3°N of Moon
Tue	21st		m.p. 11 Parthenope 0.4°NE of star Iota Virginis
Tue	21st	2 pm	(Noon WST) Venus 8°N of star Aldebaran
Wed	22nd	3 am	(1 am WST) star Aldebaran 0.9°S of Moon; Occn.
Wed	22nd	4 am	(2 am WST) Venus 7°N of Moon
Sat	25th		Comet 88P/Howell 0.5°NW of m.p. 4 Vesta
Sun	26th		m.p. 11 Parthenope 0.1°E of NGC 5493 (G) in Virgo
Sun	26th		Venus 1.3°N of NGC 1746 (OC) in Taurus
Sun	26th	9:55 am	(7:55 am WST) First Quarter Moon
Sun	26th	5 pm	(3 pm WST) m.p. 3 Juno 0.1°N of Moon; Occn.
Mon	27th	4 am	(2 am WST) Jupiter 5°N of Moon
Tue	28th	2 pm	(Noon WST) star Regulus 4°N of Moon
Wed	29th	2 pm	(Noon WST) Moon at apogee, 405,083 km
Thu	30th		Mercury at greatest latitude north
Thu	30th	pm	Jupiter 0.7°SW of NGC 2749 (G) in Cancer





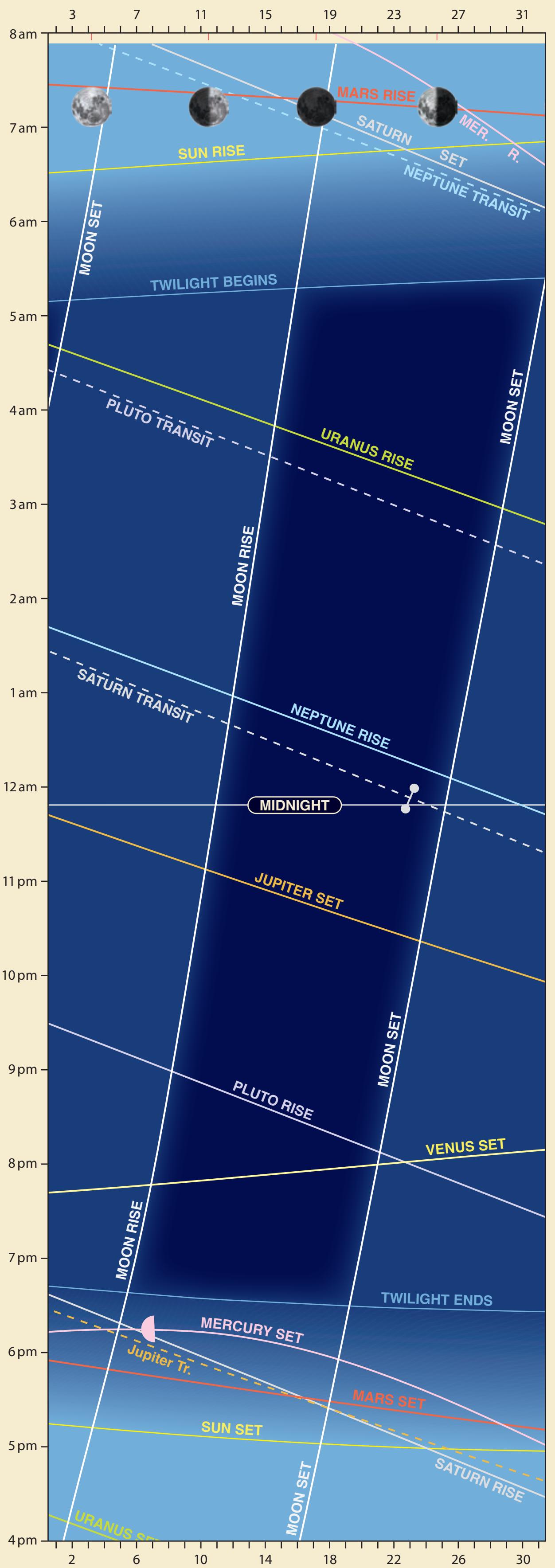
Approximate local standard time, for daylight saving add one hour.





MAY

RISE–SET CHART



Approximate local standard time.

HIGHLIGHT

- Saturn at opposition.

CONSTELLATIONS

High in the eastern evening sky are the distinctive constellations of Sagittarius and Scorpius. Following the Milky Way westward finds the equally impressive Pointers and the Southern Cross (Crux). But what about some lesser known, but also recognisable fringe dwellers, the constellations that skirt along our galaxy below and parallel to this group? Head south of Sagittarius, to the faint but obvious half circle of stars called Corona Australis. Then continue to the bow tie shaped Ara, followed by three-sided Triangulum Australe and finally the trapezium of Musca (below, south of Crux).

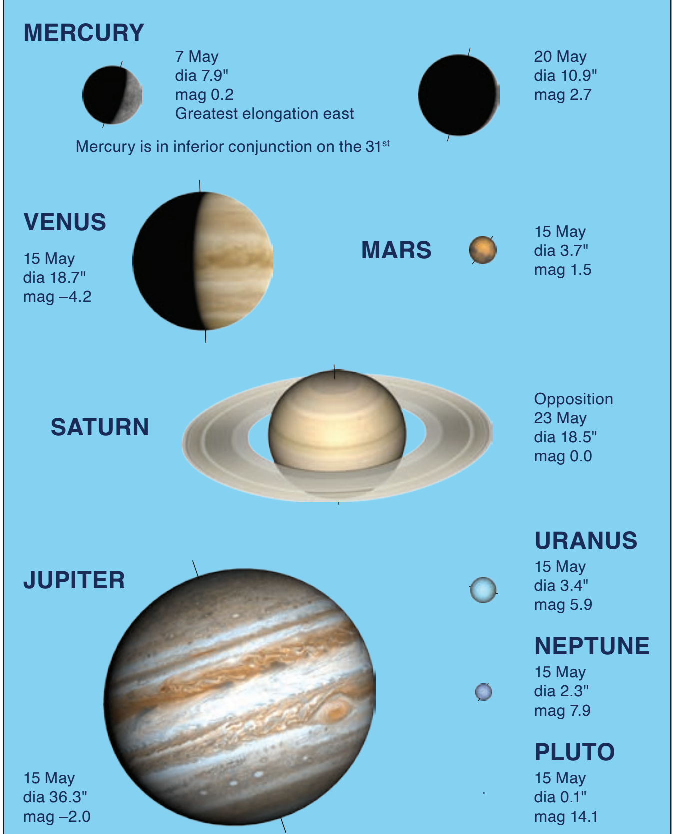
Return to the Pointers, can you see their colours? Alpha Centauri is an obvious yellow in contrast to the distinctive blue of Beta Centauri. Now observe Crux. See how blue the bottom star (Alpha) and Beta (9 o'clock position) are compared to the orange of the top star (Gamma). Next glance at red Antares, its translation to 'Rival to Mars' suits it well.

Look to the north this evening and find Virgo. It is one of the largest but most inconspicuous constellations with its brightest (1st magnitude) star Spica (Alpha Virginis) the only obvious marker. There is an asterism formed by four of Virgo's stars called the Diamond. Spica is the most southerly (top) member with the 9 o'clock position occupied by 3.5 magnitude double star Porrima (Gamma Virginis, p. 38). Magnitude 2.8 Vindemiatrix (Epsilon Virginis) is at 6 o'clock (23° below Spica) with magnitude 3.4 Heze (Zeta Virginis) completing the grouping at 3 o'clock.

THE MOON

1st	2 am (midnight previous day WST) Minimum Libration (1.5°), dark NW limb.
4th	2 pm (noon WST) Full Moon.
8th	7 am (5 am WST) Maximum Libration (8.6°), bright SW limb. The 311 km crater sprinkled, walled plain, Bailly and 172 km crater Hausen seen to good advantage.
11th	9 pm (7 pm WST) Last Quarter.
15th	3 am (1 am WST) Minimum Libration (0.2°), dark SE limb.

APPEARANCE of the PLANETS



15th 10 am (8 am WST) Moon at perigee (closest to Earth at 366,024 km).

15th 10 pm (8 pm WST) Occultation of Uranus by the Moon, visible from Central South America, West and Central Africa.

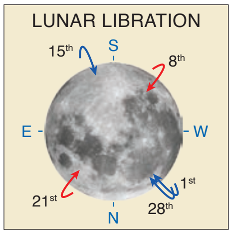
18th 2 pm (noon WST) New Moon.

21st 1 pm (11 am WST) Maximum Libration (8.8°), bright NE limb. With the Moon only a few days old this libration will showcase the 165 km Mare Humboldtianum and the crater-strewn floor of the 182 km crater Gauss.

26th 3 am (1 am WST) First Quarter.

27th 8 am (6 am WST) Moon at apogee (furthest from Earth at 404,244 km).

28th 8 am (6 am WST) Minimum Libration (1.3°), dark NW limb.



THE PLANETS

Mercury reaches its greatest elongation east of the Sun (21°) on the 7th, in the western dusk sky. At this time the planet will be just 6° above the horizon at civil twilight (when the Sun is 6° below) and difficult to spot in the twilight sky (see Sky View). The fast moving world then descends back toward the Sun and inferior conjunction (between the Earth and Sun) at month end.

Venus moves out of Taurus early in the month and traverses Gemini for the remainder. Brilliant in the early western evening sky, the planet is joined in the constellation of the Twins on the 21st and 22nd by the young waxing crescent Moon (see Sky Views)

Mars is too close to the Sun for observation this month. The Red Planet will be in conjunction with the Sun mid-June and will not be seen again until its reappearance in the morning dawn sky in August.

Jupiter is visible in the early northern evening sky in Cancer. As the planet transits the meridian (is due north) at 5:30 pm mid-month any observations should be made early before the planet loses too much altitude. On the 24th, the 6-day old waxing crescent Moon appears nearby (see Sky View). All in all a rather dull month for the king of planets, however, things begin to hot up next month.

Saturn is at opposition on the 23rd, and can be seen low in the eastern evening sky after the end of astronomical twilight – moving from Scorpius into Libra mid-month. Oppositions of the ringed planet have, since 2003, become favourable for southern hemisphere observers as its southern declination gradually increased. The planet reaches greatest declination south in 2018 before moving northwards again. Simply put, Saturn will be close to its highest altitude at meridian passage (due north) and suffering the least from atmospheric effects. Whilst planetary rings are not uncommon (Jupiter, Uranus and Neptune plus one asteroid has them), Saturn's must be considered the wonder of the Solar System. In general, telescopes in the 50 to 100 mm range will be able to see the rings and the small dark gap known as the Cassini Division. On the planet itself there is a light coloured band around the equator, and a noticeable darkening and flattening at the poles. Moving to 150 mm and larger should reveal the Encke Gap (a gap in the outermost ring) and the inner

Wow, Look at That!

The Quasar team have been observing the heavens over many years. We've lost count of the number of times we've drunk in spectacular views of star party favourites like the Eta Carinae, Tarantula and Orion nebulae. Why are they so popular? It's true they are bright and their appearance, across a wide range of apertures, is just like the electronic images. In fact sometimes small is good, with the views of Eta Carinae through a 150 mm rich field telescope still memorable some 20 years later. The same goes for binocular, *really* large field (5° plus), sights of the central and southern regions of the Milky Way. Part of the attraction is the combination of different types of deep sky objects. For example would the Lagoon Nebula be as appealing if it didn't combine an open cluster plus bright and dark nebulae? Or, would the Southern Cross be so attractive without the stark contrast between the bright star field and the dark 'coal sack' nebula nestled in the southeast corner? The purpose of this article is to point out combinations, call them double or multiple deep sky objects (DSO), close to each other that individually may be good, but together look fantastic! We've deliberately included lesser-known objects. There's no room for lengthy descriptions but we hope by pointing people in the right direction, even the seasoned observer might make a few new discoveries when next at the eyepiece. Well-known, often visited DSOs can still have surprises. For example while observing wide field views of the Eta Carinae region, don't forget the star itself. To see the planetary nebula doesn't take a large telescope just high power and good seeing. This is the famous Homunculus nebula created when the star went nova in the mid 19th century.

Galaxies are mostly visible away from the galactic plane so tend to be isolated from star clusters and nebulae. Most appear as faint fuzzes but when clustered can offer unique vistas. The Virgo/Coma Galaxy cluster is well known with hundreds of galaxies visible through mid size telescopes (200 mm). Markarian's Chain is the standout. A group of seven galaxies arranged in an arc 1.5° long. The western end is the impressive bright elliptical NGC 4374 or M84 with the next *link* only 16 arcminutes (16') east, another elliptical, NGC 4406 (M86). A further 22' finds the pair NGC 4435/38. The chain ends 50' northeast with the fainter NGC 4461, 4473 and 4477.

Let's head south to the triplet of galaxies in the constellation of Grus, NGC 7582, 7590 and 7599. These 11th magnitude spirals are arranged in a triangle 15' across. They resemble the Leo Triplet of M65, M66 and NGC 3628, however the Grus group is much fainter but more compact. If you go to a wider field (45') the Grus trio becomes a quartet with another spiral NGC 7552.

The famous barred spiral galaxy NGC 1365 in Fornax is impressive, but it's just one member of a cluster. Only 1° northeast is a small beehive of galactic treasures with 9 galaxies lying within a 1° circle. These are just the obvious members (11.5 magnitude and brighter) and there are many more fainter galaxies. Also worthy of mention are the three brightest examples of the Dorado cluster starting with NGC 1566, the face-on spiral galaxy, and only 1° southwest the close pair of NGC 1549 and 1553, both with bright nuclei.

… continued next page.

Markarian's Chain, part of the Virgo/Coma galaxy cluster.

translucent Crepe Ring. On the 5th, the Moon, just past Full, will be close to the planet (see Sky View). Saturn visits Beta Scorpii this month with closest approach on the 4th (see diary). Retrograde motion will cause them to come together again in October.

Uranus, after its solar conjunction last month, rises in the eastern sky prior to the morning dawn in Pisces.

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 1 am mid-May. The planet ends the month around 2° from the 4th magnitude star Lambda Aquarii (Hydor).

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, rises around 8:30 pm mid-month in the eastern evening sky.

Minor Planets. Three of the brighter minor planets reach opposition this month in Libra, 18 Melpomene on 2nd at magn 10.3, 349 Dembowska on 12th at magn 10.2 and 107 Camilla on 15th at magn 12.3. There are two at opposition in Serpens, 194 Prokne on 15th at magn 11.2 and 532 Herculina on 17th at magn 9.1. Also at opposition is 185 Eunike on 20th at magn 12.3 near the Hercules/Serpens border.

Wow, Look at That! … continued

Open Clusters. M46 (NGC 2437), the open star cluster in Puppis, is famous for the planetary nebula NGC 2438, 3' north northeast from the centre. Did you know the naked eye open cluster in Scorpius, M7 (NGC 6475), has a small globular star cluster NGC 6453 lying on its western edge? It's easy to miss for most people observe M7 under low power to see the whole cluster, where the globular needs around 100× to see this small 10th magnitude smudge.

The Galactic Hub. M7 is just one of many examples near the galactic centre. NGC 6723 is a globular cluster in Sagittarius close to the border with Corona Australis. Only 0.5° southeast is an impressive double-double star. One pair (WDS B 957, 7.3 and 9.4 magnitude, 57" apart) is 0.2° from the other (WDS BSO 14, matched 6th magnitude components separated by 13"). Together they form a nice triangle with the cluster. Each double lies in bright reflection nebulae and, commencing between these glowing gas clouds and extending to the southeast, is a dark nebula visible by an absence of stars in an otherwise rich field – breathtaking!

Starting at the Teapot's naked eye spout star Gamma (γ^2) Sagittarii, move 2.5° north to the open star cluster NGC 6520. It would be easy to miss this tight cluster if not for the dark nebula, Barnard 86 (only 7' west). This triangular shaped black cloud is so obvious it's called the 'ink spot' and stands out well against the bright Milky Way environs (see image p. 61).

Sagittarius contains the galactic core, with much of it hidden behind the vast dark clouds of gas and dust visible to the naked eye. There are two spectacular regions where this veil is partially lifted giving us a glimpse of the galaxy beyond. M24 is referred to as the Sagittarius Star Cloud. It is a naked-eye, 2° long, oval-shaped area packed with a number of deep sky objects including the open clusters of NGC 6603, Collinder 469 and Turner 2, 3 and 4. The dark nebulae of Barnard 92 and 93, side by side are a stark contrast to the rest of the bright *cloud*.

The other clearing is known as Baade's Window. Return to Gamma (γ^2) Sagittarii, about 0.5° northwest lies the globular clusters NGC 6522 and 6528, only 16' apart. They are at the centre of this window and together look stunning in the bright star field.

The Magellanic Clouds. It's not unusual to put the SMC and LMC in their own category (we are so lucky in the Southern Hemisphere!). Because of their distance from us, 190,000 and 160,000 light years respectively, the majority of the star clusters are small (typically 1' to 2' across) and their star members faint (13th to 14th magnitude). The numbers of clusters are amazing, hence combining with the general Magellanic star field to give the bright white clouds we see. Small telescopes (150 mm) still give great views but often only tantalising hints of the numerous clusters in the same field of view. This is where the large Dobsonians (300 mm and larger) in combination with wide field eyepieces come into their own. Brilliant regions like the Tarantula Nebula are in the minority. It alone is naked eye brightness and looks great through any aperture!

Whatever size telescope you are using, try to observe any of the objects mentioned here and if you have the opportunity compare the views with other people's scopes. Enjoy!

Comet 88P/Howell is rising in the early hours of the morning in May and is best observed just before the onset of dawn. Moving away from the Sun, after reaching perihelion last month, Howell is expected to fade from 9th to 10th magnitude this month. Mid-May sees the comet move from Aquarius into Pisces, before ending the month in Cetus. The Moon will interfere with observing until mid-month.

Comet C/2013 US$_{10}$ (Catalina) rises in the morning sky in May. Located in Aquarius for most of the month, when it then moves into Sculptor, Catalina is expected to brighten from 13th to 12th magnitude. The second half of the month will be Moon-free for observing.

Comet 22P/Kopff, currently only 13th magnitude, visits a number of galaxies in Virgo during May and June (see diary).

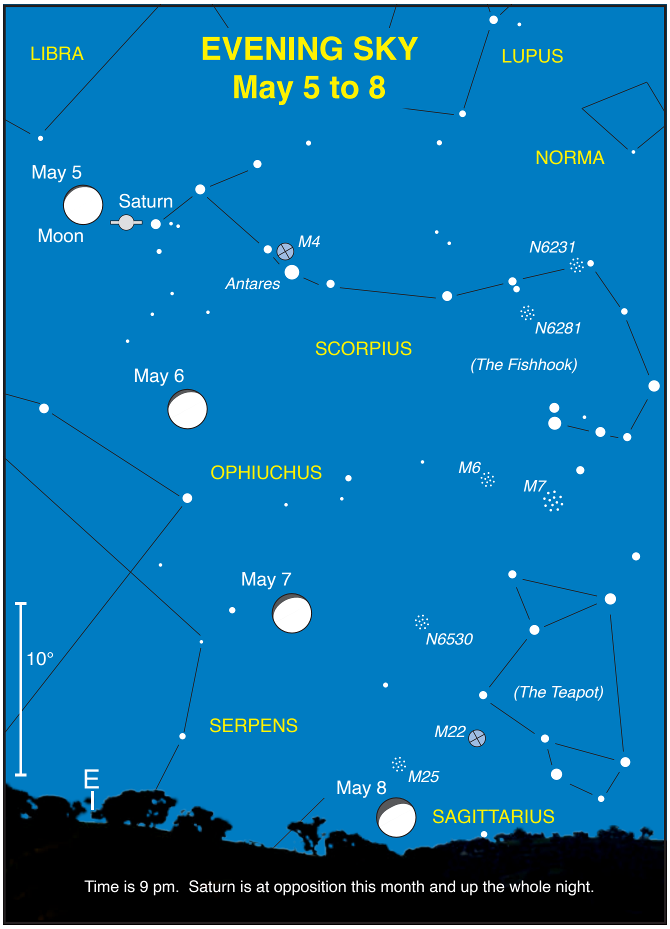
DOUBLE STARS

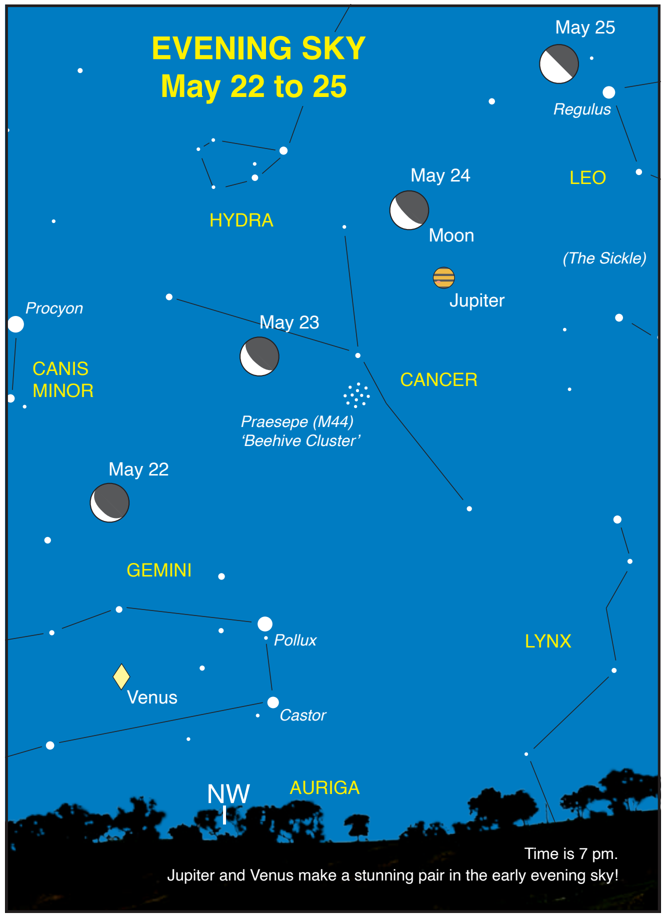
γ Virginis (Porrima) is a bright, very famous tight binary with a period of 169 years. The pair is now widening since their closest approach, in mid 2005. This brilliant, equal white pair of stars (magnitude 3.5 and 3.5) is now separated by 1.9 arcseconds. Under good seeing a 15 cm telescope can split them at high power. The pair is located 38 light years away and their separation varies from 5 to 81 astronomical units. (Map 6, p. 74)

Located conveniently in the Southern Cross, **α Crucis** is a close double through 10 × 50 binoculars. To steady the view try sitting in a chair and observe them when they are away from the zenith. The pair of bluish-white (magnitude 3.9 and 5.0) stars is separated by 36.6 arcseconds. This spacing has not changed significantly since James Dunlop's measures in 1826 and the pair probably forms a long-period binary. The brighter of these stars is a brilliant telescopic double. (Map 1, p. 69)

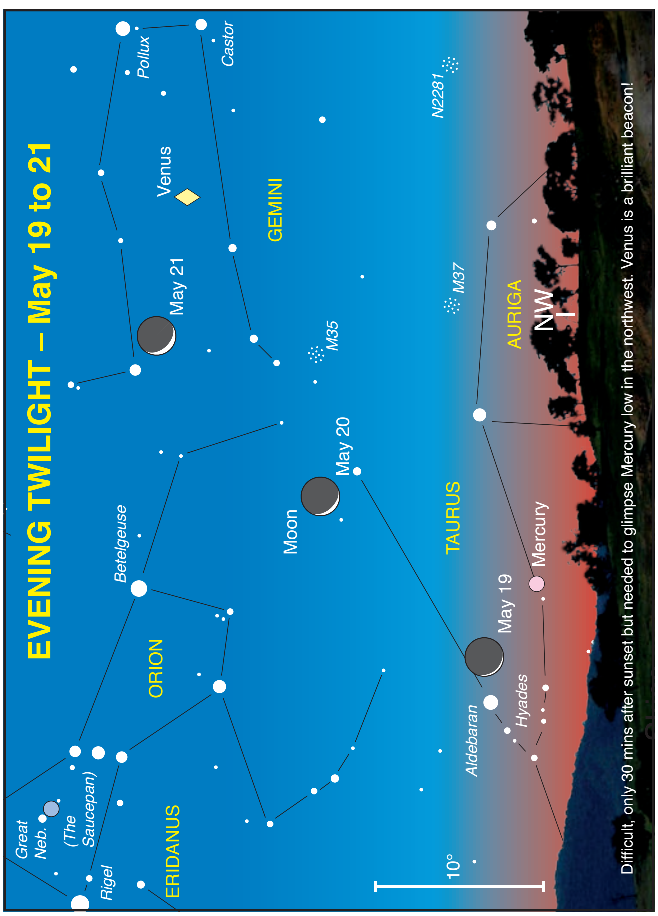
DIARY

Fri	1st		Comet 88P/Howell 0.6°NW of NGC 7606 (G) in Aquarius
Fri	1st		Mercury 1.5°S of M45 the Pleiades (OC) in Taurus
Sat	2nd	10 pm	(8 pm WST) star Spica 3°S of Moon
Mon	4th		Saturn 1.2°N of star Beta Scorpii
Mon	4th	1:42 pm	(11:42 am WST) Full Moon (394,986 km)
Wed	6th		m.p. 4 Vesta 0.4°S of NGC 7606 (G) in Aquarius
Wed	6th	2 am	(Midnight WST, prev day) Saturn 2°S of Moon
Wed	6th	1 pm	(11 am WST) star Antares 9°S of Moon
Thu	7th	am	m.p. 68 Leto 1.0°S of star Psi Capricorni
Thu	7th	3 pm	(1 pm WST) Mercury at greatest elongation East (21.2°)
Sat	9th	8 am	(6 am WST) d.p. Pluto 3°S of Moon
Sat	9th	pm	m.p. 44 Nysa 0.9°E of star Nu Virginis
Sun	10th		Venus at greatest latitude north
Mon	11th	8:36 pm	(6:36 pm WST) Last Quarter Moon
Tue	12th	am	m.p. 68 Leto 0.6°N of star Omega Capricorni
Tue	12th	11 am	(9 am WST) Mercury 8°N of star Aldebaran
Tue	12th	pm	Comet 22P/Kopff 0.6°S of NGC 4339 (G) in Virgo
Wed	13th	7 am	(5 am WST) Neptune 3°S of Moon
Thu	14th	4 am	(2 am WST) m.p. 4 Vesta 6°S of Moon
Fri	15th	10 am	(8 am WST) Moon at perigee, 366,024 km
Fri	15th	10 pm	(8 pm WST) Uranus 0.2°N of Moon; Occn.
Sat	16th	am	m.p. 2 Pallas 0.4°NE of NGC 6482 (G) in Hercules
Sun	17th		Venus 0.7°N of star Epsilon Geminorum
Mon	18th	2:13 pm	(12:13 pm WST) New Moon
Tue	19th	5 pm	(3 pm WST) Mercury 6°N of Moon
Wed	20th		m.p. 29 Amphitrite 0.4°S of NGC 128 (G) in Pisces
Thu	21st	pm	m.p. 354 Eleonora 0.5°SW of Leo II galaxy in Leo
Fri	22nd	5 am	(3 am WST) Venus 8°N of Moon
Sat	23rd		Mercury at descending node
Sat	23rd	2 am	(Midnight WST, prev day) m.p. 3 Juno 4°S of Jupiter
Sat	23rd	Noon	(10 am WST) Saturn at opposition
Sun	24th	5 pm	(3 pm WST) Jupiter 5°N of Moon
Sun	24th	6 pm	(4 pm WST) m.p. 3 Juno 1.6°N of Moon
Mon	25th	10 pm	(8 pm WST) star Regulus 4°N of Moon
Mon	25th	pm	Comet 22P/Kopff 0.2°SE of NGC 4281 (G) in Virgo
Tue	26th	3:19 am	(1:19 am WST) First Quarter Moon
Wed	27th		m.p. 354 Eleonora 0.8°NE of star Delta Leonis
Wed	27th		m.p. 8 Flora 0.5°NE of star Eta Leonis
Wed	27th	8 am	(6 am WST) Moon at apogee, 404,244 km
Fri	29th		m.p. 21 Lutetia 0.4°N of star Gamma Capricorni
Sat	30th		Venus 0.4°S of star Kappa Geminorum
Sat	30th	5 am	(3 am WST) star Spica 4°S of Moon
Sun	31st	3 am	(1 am WST) Mercury in inferior conjunction
Sun	31st	3 am	(1 am WST) Venus 4°S of star Pollux



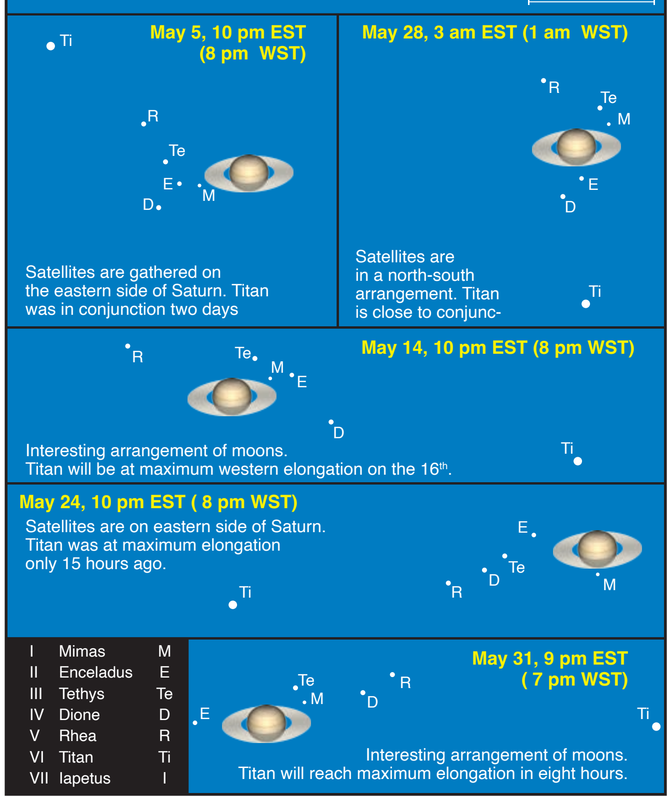


Approximate local standard time.



Saturn's Satellites for May

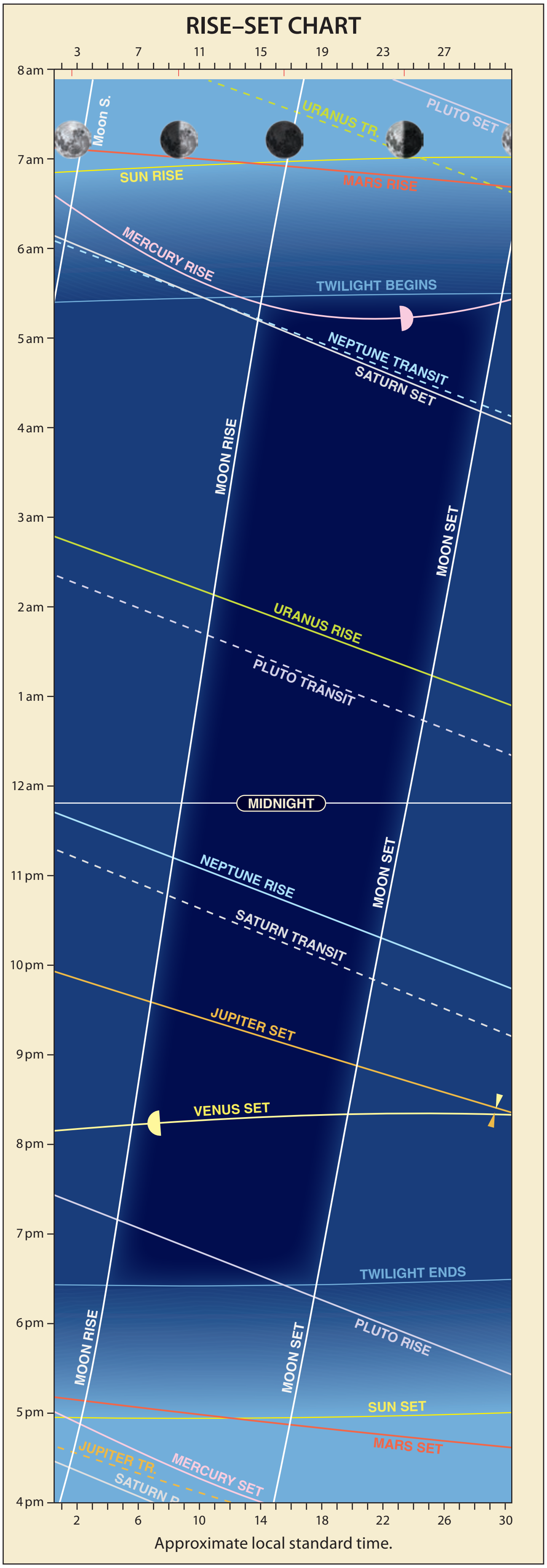
Below are a few interesting patterns of the brightest moons.
A good time to observe is when Titan is close to Saturn (conjunction), see also Introduction to Part I and Satellites of Saturn (Part II).



I	Mimas	M
II	Enceladus	E
III	Tethys	Te
IV	Dione	D
V	Rhea	R
VI	Titan	Ti
VII	Iapetus	I

MAY

JUNE



HIGHLIGHTS

- ❍ Mercury close to slender crescent Moon.
- m Mercury close to Aldebaran.
- m Venus and Jupiter very close.
- m Jupiter, Venus and Moon make a fine sight.
- m Occultation of Uranus by the Moon.

CONSTELLATIONS

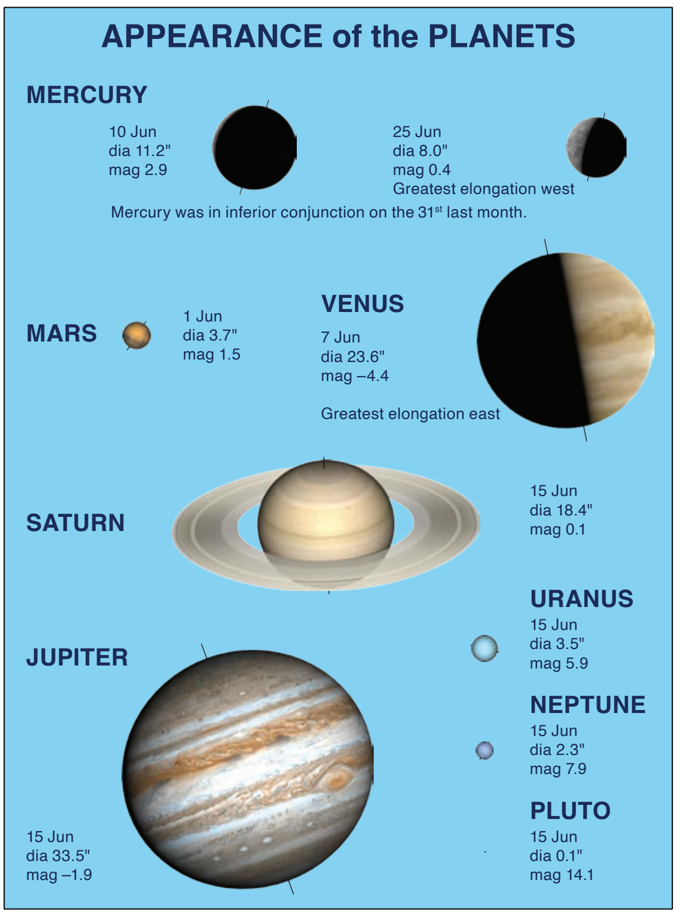
The view of our magnificent galaxy flowing from the eastern horizon, passing overhead and extending to the west is truly inspiring. Having the winter solstice on the 22nd means you have longer nights to enjoy it. This is a great time to see our star and nebulae rich Milky Way. Perched high in the eastern mid-evening sky is Scorpius and Sagittarius, which mark the galactic hub. The star pattern of Scorpius resembles a scorpion. Find Antares and follow the tail as it curves around ending at Shaula (see All Sky Map No 6). Under this lies Sagittarius, the famous Teapot asterism.

However there is a third, less conspicuous member of the galactic hub - Ophiuchus, the Serpent Bearer. Look to the left of the Teapot, and find six 2nd and 3rd magnitude stars arranged in a box shape, often referred to as the coffin. It can be a little foreboding, needing reasonably dark skies (fainter than 5th magnitude) to see any stars within this group with the unaided eye.

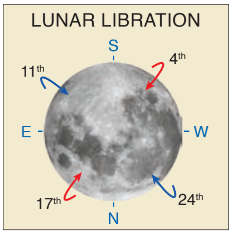
Returning to the Teapot, look left to the faint but distinctive constellation of the Southern Crown, Corona Australis. This consists of about a dozen 5th magnitude stars arranged in an 8° diameter semi-circular arc. Look low in the north to find the Crown's northern counterpart, Corona Borealis, showing a similar arc of stars. Two mythical gentlemen, who from the Southern Hemisphere are standing on their heads, flank this Northern Crown. To the left (west) is Bootes the Herdsman whose star pattern looks more like an inverted kite, topped by the bright star Arcturus. To the right (east) is Hercules, the Son of Zeus; his brightest stars forming the Keystone asterism.

THE MOON

3rd 2 am (midnight previous day WST) Full Moon.



4th 4 am (2 am WST) Maximum Libration (8.1°), bright SW limb. Just after Full Moon so there will not be any shadow relief. The dark floor of Mare Orientale will be visible on the limb.



10th 2 am (midnight previous day WST) Last Quarter.

10th 3 pm (1 pm WST) Moon at perigee (closest to Earth at 369,711 km).

11th 2 am (midnight previous day WST) Minimum Libration (0.7°), dark SE limb.

12th 6 am (4 am WST) Occultation of Uranus by the Moon, visible from south and east Australia, New Zealand, Fiji, Samoa and French Polynesia.

15th Noon (10 am WST) Occultation of Mercury by the Moon, visible from Sri Lanka, most of SE Asia and Micronesia.

15th 10 pm (8 pm WST) Occultation of Aldebaran by the Moon, visible from east and north Canada, Greenland, Iceland and north and central Russia.

16th Midnight (10 pm WST) New Moon.

17th 9 pm (7 pm WST) Maximum Libration (8.3°), too close to New Moon.

24th 3 am (1 am WST) Moon at apogee (furthest from Earth, 404,132 km).

24th Noon (10 am WST) Minimum Libration (1.2°), dark NW limb.

24th 9 pm (7 pm WST) First Quarter.

THE PLANETS

Mercury climbs its way into the eastern morning sky this month after inferior conjunction. On the 15th, the planet appears quite close to the slender crescent of the Moon (see Sky View) and from parts of Asia an occultation occurs. Later in the month the planet moves through the Hyades star cluster, coming within 2° of the 1st magnitude star Aldebaran on the 23rd and 24th. Aldebaran's position south (right) of Mercury will identify which is which. On the 25th, the innermost world reaches its greatest elongation (22°) west of the Sun.

Venus spends a few days in Gemini before traversing Cancer and finally ending up in Leo towards month end. Its journey across the rather nondescript constellation of the Crab takes it close to M44 on the 14th. The Beehive or Praesepe is a large galactic cluster visible to the unaided eye away from city lights. Galileo was the first to realise the true nature of this little *cloud* and was delighted to count 36 stars in the group when he looked at it with his small telescope (the actual number of stars is around 350 down to 17th magnitude). Venus reaches its greatest elongation (45°) east of the Sun on the 7th and appears just like a little First Quarter Moon in a telescope. Those of you watching the early western sky during the month would have noticed the planet moving closer to Jupiter each evening. This culminates in a spectacular rendezvous at month end when the pair are just 0.5° apart (one Moon diameter), and just a little closer on 1 July (see Sky View). Also, don't miss the 4-day old crescent Moon, Venus and Jupiter when they form a neat right angle triangle on the 20th (see Sky View).

Life Finds a Way – Part 1

Going on bush walks is great. Occasionally getting away from the day-to-day hassles of life, family, school or work can be so refreshing. It can set your imagination free and if you're reading this it's likely you don't mind contemplating the Universe and your place in it. The possibility of life existing elsewhere is fascinating but have you ever wondered whether there might be someone just like you *out there* strolling along looking at trees, grass and a running river? Such a setting is pretty common on Earth, so why not elsewhere orbiting another star?

This article's inspiration came from the television show, 'Cosmos', both the original Sagan series and in recent times its worthy successor hosted by Neil Degrasse Tyson.

Our understanding of the Universe has come a long way since the dark ages. Up to around 400 years ago we were convinced mankind was unique, we had to be the centre of everything with even the Sun, stars and planets revolving around the Earth (the Ptolemaic System) – talk about the ultimate ego trip! The last hundred years has seen such an explosion of knowledge the pendulum has swung the other way. We have discovered our true place, on a planet in a solar system among many others in a galaxy, one of billions in a vast Universe. Taking this fact, combined with the discussion to follow, it's no surprise many people now speculate the Universe teems with living beings.

Because Mankind knows of only the life forms of Earth it's a good starting point to assume all living creatures elsewhere would also be based on the element carbon. Besides it's difficult to dismiss the incredible number and variety of functions performed by molecules with backbones of carbon chains – look at the organic compounds that come together to make DNA, the blueprint of all life we know. This rationale leads to another requirement, water, but in the correct state. Hence, the focus on the 'habitable zone' used in studying planets of other stars (exoplanets). This is the balance point between the temperature of the star and the distance of a planet for water to be liquid on its surface.

The glut of planets discovered orbiting other stars over the last decade, many in this goldilocks zone (not too hot and not too cold), amply fills the first requirement – extraterrestrials have lots of potential homes. Although most of these planets have turned out to be life-unfriendly gas giants like Jupiter, this more likely reflects the limitations of the detection methods and not the true ratio of rocky to gaseous worlds. Recently more terrestrial-like (lower mass) rocky planets have been discovered as our detection sensitivity improves. Also, having a large gas giant doesn't preclude a life-friendly moon, like the current speculations about life on Jupiter's satellite Europa. Evidence is growing that a liquid ocean exists below its frozen surface. Any exoplanet doesn't even have to be in the habitable zone for gravitational tidal friction to generate sufficient heat to keep water flowing. The possibilities then become endless! It isn't surprising scientists are keen to explore Europa and even Enceladus to search for life. Enceladus is a satellite of Saturn that appears to be covered in frozen water with erupting geysers, the source possibly from some inner layer of liquid water.

Let's look at the Earth's environment in space. What makes it conducive to life? How typical is it? To exist do we need a star like our Sun?

The Sun used to be considered pretty common, however it's now known around 60% of stars have binary companions, so a 'single' star isn't even in the majority. In general a solitary star offers long term orbital stability for planets, just what life needs to evolve. Admittedly a binary star system might have their components sufficiently separated for at least one of them to offer a stable habitable position for a planet, but it's an additional complication the Sun fortunately never had.

Whether you need stars like our Sun is still debatable but there are many that would be considered unlikely. It is believed life started some 3.8 billion (3,800 million) years ago as primitive bacteria in the oceans, less than a billion years after the formation of the Solar System's planets. It wasn't until around 600 million years ago that it finally found its way to dry land, but even then, mostly plants and insects. So if life needs these time frames to develop then we must have a star with a long stable life, not, for example, the hot O type stars whose existence is measured in only millions of years. The Sun is typical of a G2 type star and has a stable, relatively long life, currently middle aged having existed for five billion years. The most common stars are the M type, of which we see many in the solar neighbourhood. They have extremely long lives so meet this condition. Looking at stars of this type in our Nearest Stars table (see page 139), you'll see most have absolute magnitudes fainter than 10, showing how relatively cold they are. The habitable zones for these stars are much closer than the Sun's, hence having much shorter years (orbital periods) than Earth. Being close to its star eventually leads to tidal locking with the same side of the planet always baking in sunlight with the other side perpetually frozen. Not exactly the ideal environment for life to develop. Even if a G type star, like our Sun, is needed for life, it still leaves many billions of candidate stars, and that's just within our galaxy. The fact that we are out in the quiet galactic suburbs, well away from the million solar-mass Black Hole residing in its centre, is also a blessing.

… continued in Part 2 on page 49.

Earth is at Solstice on the 22nd, when our daylight hours are shortest. On this day, the Sun is at its most northerly declination of +23.5°.

Mars is in conjunction with the Sun on the 15th and remains hidden until August when it reappears in the morning sky in Gemini.

Jupiter, in the early north-western evening sky, is in Cancer for the first third of the month. During the month, Venus, rising from below, appears to chase the slower moving Jupiter into Leo (see Sky View), the pursuit ending at month end with the pair just 0.5° from each other, and a little closer on 1 July. One of the best conjunctions of the year occurs on the 20th, when the 4-day old waxing crescent Moon appears nearby Jupiter and Venus (see Sky View). Not that the trio are particularly close to one another – it's just that the two brightest planets and the crescent Moon with its night side immersed in earthshine make a fine sight when together.

Saturn, just past opposition, can be seen in the eastern evening sky after dusk in Libra. On the 1st, the 13-day old waxing gibbous Moon appears nearby the planet (see Sky View). Of interest at this time is an early evening occultation of the 4th magnitude star Gamma Librae by the Moon (twilight event in WA). Gamma, a double star, has an 11th magnitude companion 42 arcseconds away (see lunar occultations in Part II for details). Our satellite will again be near the planet on the 29th as a 12-day old waxing gibbous Moon (see Sky View in July section). One feature of Saturn that is not observable at opposition is the shadow of the planet on the back of the rings, which tends to enhance the 3-D effect when looking through the eyepiece. After opposition this shadow progressively grows, reaching its maximum in August this year.

Uranus, in Pisces, rises around 2 am mid month, and best observed in the late morning eastern sky. On the 12th, the planet will be occulted by the 25-day old waning crescent Moon. The event is visible roughly south of a line bisecting the continent from Townsville Qld to Geraldton WA. Uranus will disappear behind the Moon's bright limb and reappear from the dark limb, with twilight interfering with the egress along the NSW and Queensland coastal regions (see also Lunar Occultations in Part II). Towards mid-month Uranus moves toward two stars, one of similar magnitude (88 Piscium) and the other, a beautiful double star one magnitude brighter than the planet (more on this star next month). On 15th this distant world will be 3.5° north of Comet 88P/Howell.

Neptune rises around 11 pm mid-month in the evening eastern sky in Aquarius. The planet appears stationary in its course across the heavens on the 13th, and then begins over five months of retrograde motion ending in November.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, rises at the end of astronomical dusk mid-month and is at opposition in early July.

Minor Planets. Five of the brighter minor planets reach opposition this month in Ophiuchus. They are: 48 Doris on 1st at magn 11.6, 51 Nemausa on 9th at magn 10.4, 79 Eurynome on 9th at magn 11.7, 24 Themis on 11th at magn 11.5 and 92 Undina on 16th at magn 10.8. Also at opposition are 2 Pallas on 12th at magn 9.4 in Hercules, 129 Antigone on 23rd at magn 9.8 near the Serpens/Ophiuchus border. Two reach opposition near the Sagittarius/Ophiuchus border, 32 Pomona on 18th at magn 10.7 and 451 Patientia on 19th at magn 11.1. During June and July, 44 Nysa will visit some galaxies in Virgo.

Comet 22P/Kopff brightens from 13th to 12th magnitude this month. Located in Virgo, Kopff is setting around midnight. The evening sky will be Moon-free from around 9th to 18th.

Comet 88P/Howell opens June at 10th magnitude in Cetus. Rising in the early hours of the morning (around 2 am), Howell moves into Pisces mid-month where it remains until month's end, by which time the comet is expected to have faded to 11th magnitude. The morning sky will be Moon-free during the second half of June.

Comet C/2013 US_{10} (Catalina) is in Sculptor throughout June, rising in the late evening. Predicted to be 12th magnitude in brightness at the start of June, Catalina could be 10th magnitude by month's end. The Moon won't interfere with observing from mid-June onward. On the night of 23rd the comet will make a close approach to the bright (9.7 magnitude) spiral galaxy NGC 7793 in Sculptor (see diary) – a great imaging opportunity!

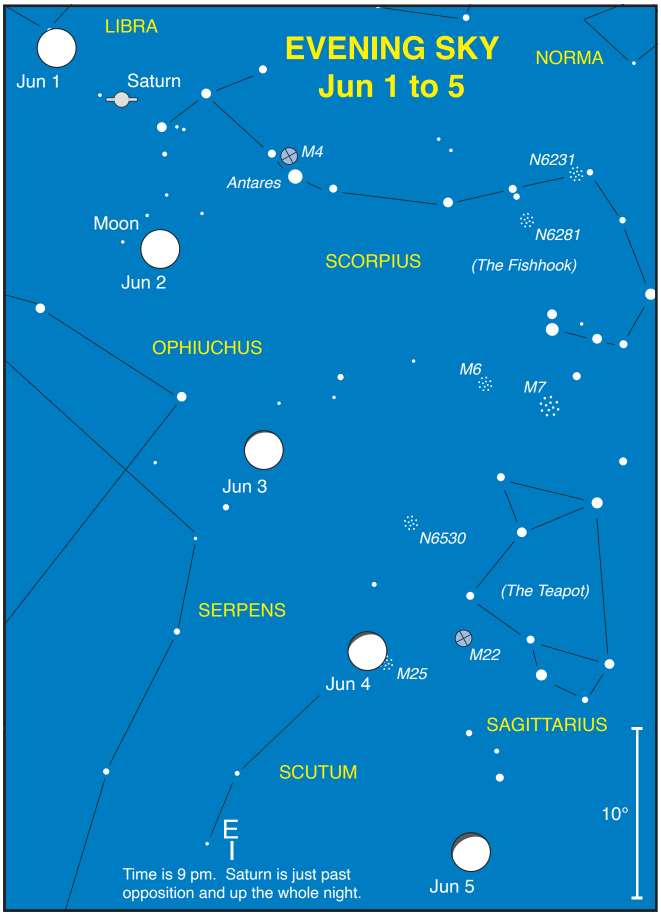
DOUBLE STARS

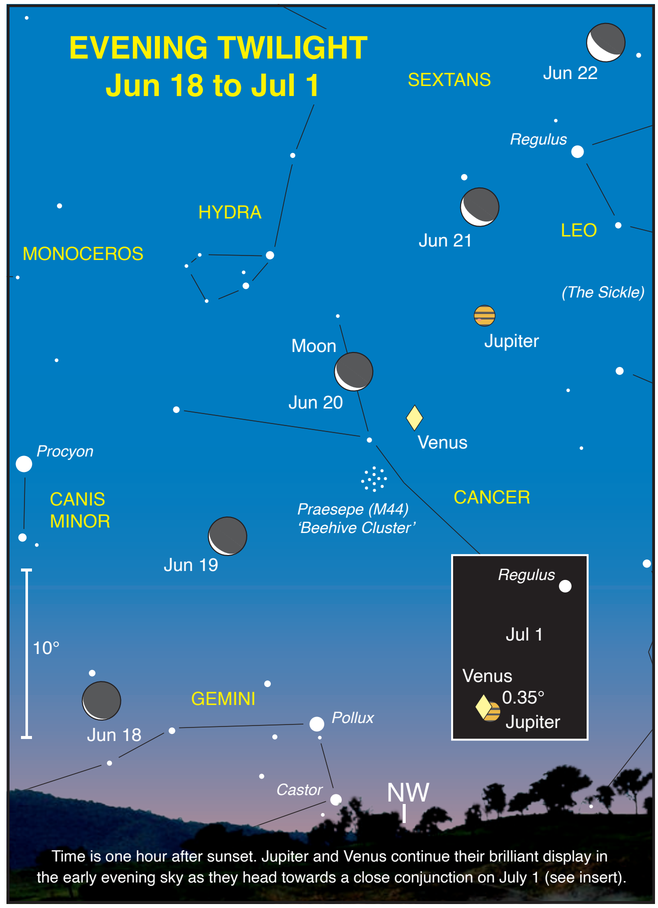
α Circini is a lovely colour contrasting pair located near α Centauri. The primary (magnitude 3.2) is bright yellow whilst the fainter companion (magnitude 8.5) appears red. The pair is separated by 15.7 arcseconds and forms a long period binary with an orbital period estimated to be at least 2,600 years. This is a lovely pair to show your friends. (Map 1, p. 69)

Located 88 light years away, **γ Crucis (Gacrux)** is the bright, magnitude 1.8 orange (spectral class M3.5III) star located at the top of the Southern Cross. It has about 1,500 times the luminosity of our Sun. Through binoculars it is a wide, easily seen double with a magnitude 6.5 bluish-white optical companion located 125 arcseconds to the north-east. Viewed from the companion star it would look as if Gacrux and the Sun were double. This pair is set in a rich field of fainter stars adding to the vista. (Map 1, p. 69)

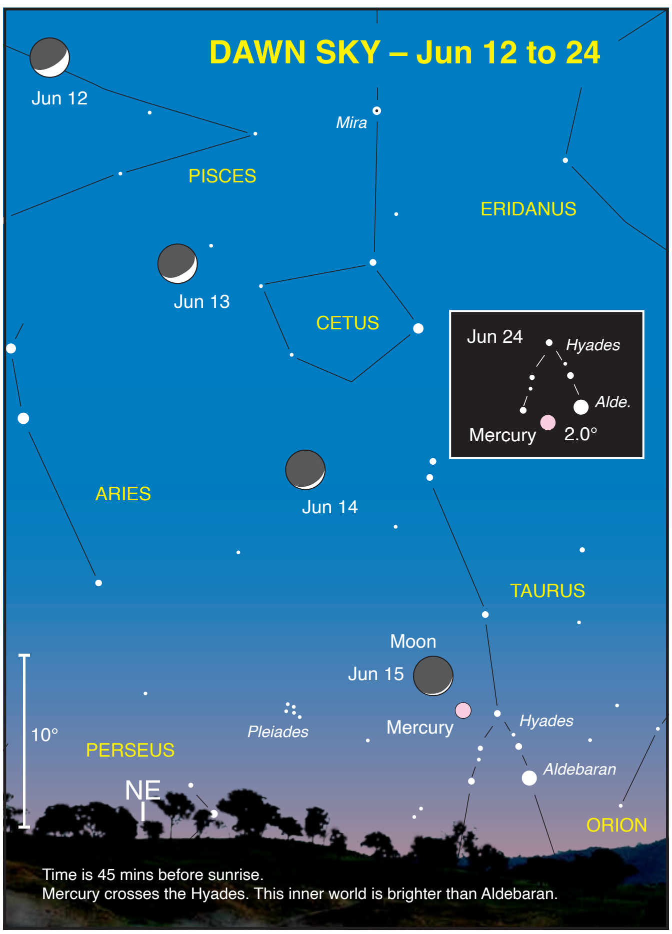
DIARY

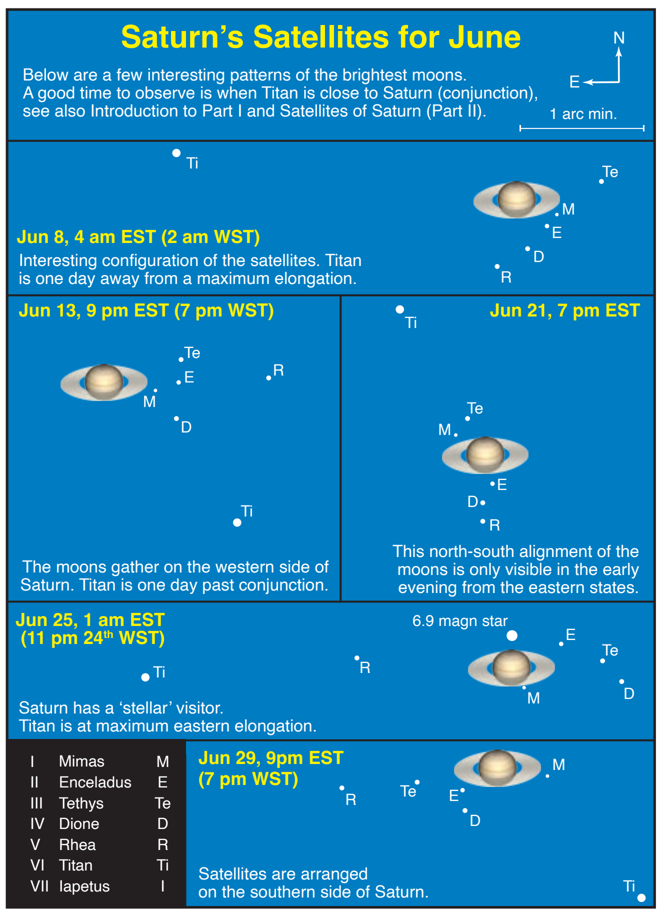
Tue	2nd		Mercury at aphelion
Tue	2nd	6 am	(4 am WST) Saturn 1.9°S of Moon
Tue	2nd	8 pm	(6 pm WST) star Antares 9°S of Moon
Wed	3rd		m.p. 354 Eleonora 0.3°NE of NGC 3646 (G) in Leo
Wed	3rd		m.p. 39 Laetitia 0.6°SE of NGC 488 (G) in Pisces
Wed	3rd	2:19 am	(12:19 am WST) Full Moon (384,744 km)
Wed	3rd	pm	Comet 22P/Kopff 0.3°NE of M61 (SG) in Virgo
Thu	4th		m.p. 21 Lutetia 0.2°NW of star Delta Capricorni
Fri	5th	2 pm	(Noon WST) d.p. Pluto 3°S of Moon
Sun	7th		m.p. 15 Eunomia 0.3°NW of star Iota Piscium
Sun	7th	4 am	(2 am WST) Venus at greatest elongation East (45.4°)
Tue	9th	1 pm	(11 am WST) Neptune 3°S of Moon
Wed	10th	1:42 am	(11:42 pm WST, prev day) Last Quarter Moon
Wed	10th	3 pm	(1 pm WST) Moon at perigee, 369,711 km
Thu	11th	4 am	(2 am WST) m.p. 4 Vesta 6°S of Moon
Fri	12th	6 am	(4 am WST) Uranus 0.5°N of Moon; Occn.
Fri	12th	11 am	(9 am WST) m.p. 2 Pallas at opposition
Sat	13th		m.p. 29 Amphitrite 0.5°SE of m.p. 192 Nausikaa
Sat	13th		Venus 0.9°N of M44 Beehive Cluster (OC) in Cancer
Mon	15th	2 am	(Midnight WST, prev day) Mars in conjunction with Sun
Mon	15th	Noon	(10 am WST) Mercury 0.04°N of Moon; Occn.
Mon	15th	10 pm	(8 pm WST) star Aldebaran 1.0°S of Moon; Occn.
Tue	16th	9 pm	(7 pm WST) Comet 22P/Kopff 0.1°S of NGC 4457 (G) in Virgo
Tue	16th	pm	m.p. 44 Nysa 0.7°NE of NGC 4123 (G) in Virgo
Wed	17th	12:05 am	(10:05 pm WST, prev day) New Moon
Fri	19th		Comet 88P/Howell 0.8°NW of NGC 520 (G) in Pisces
Fri	19th		Comet 88P/Howell 0.8°S of NGC 488 (G) in Pisces
Fri	19th		m.p. 39 Laetitia 0.5°N of NGC 676 (G) in Pisces
Fri	19th		Uranus 0.7°SE of m.p. 29 Amphitrite
Sat	20th	6 am	(4 am WST) Mercury 0.2°W of star Delta Tauri
Sat	20th	9 pm	(7 pm WST) Venus 6°N of Moon
Sun	21st	10 am	(8 am WST) Jupiter 5°N of Moon
Sun	21st	10 pm	(8 pm WST) m.p. 3 Juno 2°N of Moon
Mon	22nd	3 am	(1 am WST) Solstice
Mon	22nd	6 am	(4 am WST) star Regulus 4°N of Moon
Mon	22nd	9 pm	(7 pm WST) Comet 22P/Kopff 0.15°NW of NGC 4527 (G) in Virgo
Tue	23rd		Mercury at greatest latitude south
Tue	23rd	am	d.p. Ceres 0.2°NW of star Omega Capricorni
Tue	23rd	pm	m.p. 129 Antigone 0.8°SE of NGC 6539 (GC) in Serpens
Wed	24th		m.p. 192 Nausikaa 0.5°N of NGC 524 (G) in Pisces
Wed	24th	1 am	(11 pm WST, prev day) Comet C/2013 US_{10} (Catalina) 0.05°W of NGC 7793 (G) in Sculptor
Wed	24th	3 am	(1 am WST) Moon at apogee, 404,132 km
Wed	24th	6 pm	(4 pm WST) Mercury 2°N of star Aldebaran
Wed	24th	9:03 pm	(7:03 pm WST) First Quarter Moon
Wed	24th	pm	Comet 10P/Tempel 2 0.3°W of NGC 5364 (G) in Virgo
Wed	24th	pm	Comet 22P/Kopff 0.4°NE of NGC 4536 (G) in Virgo
Thu	25th		m.p. 7 Iris 0.4°NE of NGC 3521 (G) in Leo
Thu	25th	3 am	(1 am WST) Mercury at greatest elongation West (22.5°)
Fri	26th	1 pm	(11 am WST) star Spica 4°S of Moon
Sat	27th		m.p. 8 Flora 0.4°N of M105 (EG) in Leo
Sat	27th	6 am	(4 am WST) Mercury 0.2°N of NGC 1647 (OC) in Taurus
Sun	28th		m.p. 8 Flora 0.3°NE of NGC 3384 (G) in Leo
Mon	29th		Comet 22P/Kopff 1.2°SW of NGC 4636 (G) in Virgo
Mon	29th		m.p. 29 Amphitrite 0.2°S of NGC 524 (G) in Pisces
Mon	29th		m.p. 471 Papagena 0.4°NW of star Eta Ceti
Mon	29th	11 am	(9 am WST) Saturn 2°S of Moon
Tue	30th		Comet 22P/Kopff 0.7°SW of NGC 4643 (G) in Virgo
Tue	30th	5 am	(3 am WST) star Antares 9°S of Moon
Tue	30th	10 pm	(8 pm WST) m.p. 129 Antigone 0.2°NW of NGC 6517 (GC) in Ophiuchus





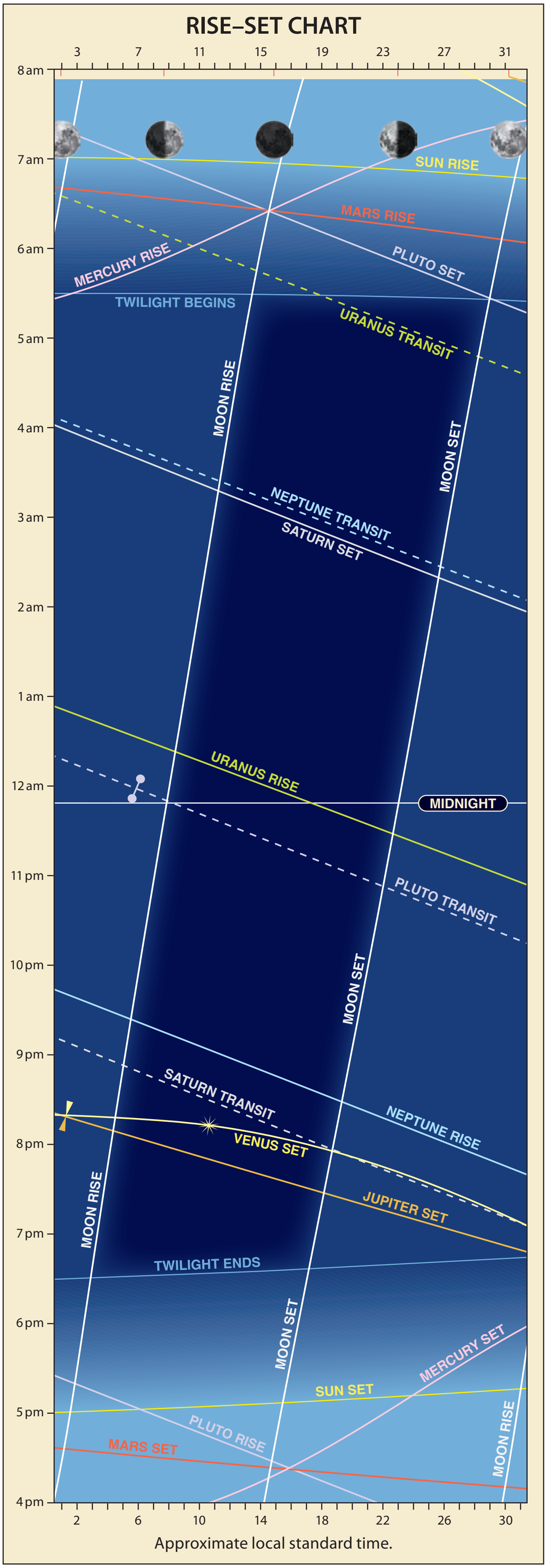
Approximate local standard time.





I	Mimas	M
II	Enceladus	E
III	Tethys	Te
IV	Dione	D
V	Rhea	R
VI	Titan	Ti
VII	Iapetus	I

JULY



HIGHLIGHTS

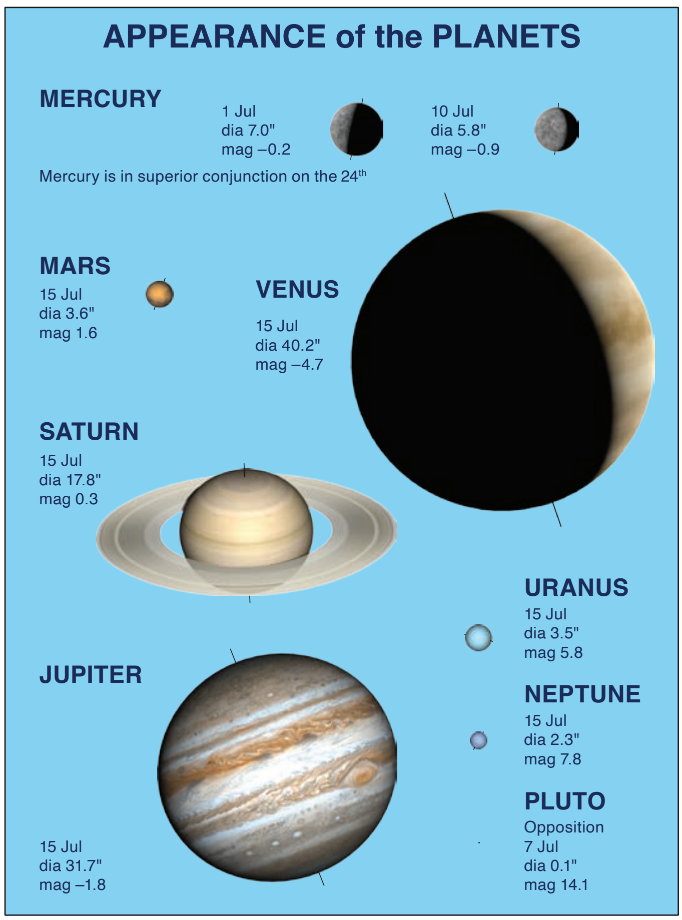
❍ Venus and Jupiter very close.

m Occultation of Venus by the Moon.

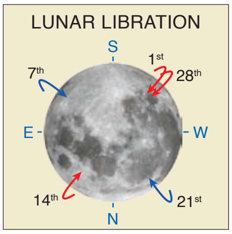
CONSTELLATIONS

Winter skies in the Southern Hemisphere are marvellous! Look overhead and imagine floating in space. Around 9 pm mid July, from mid-latitude Australia, Scorpius is at the zenith. An hour later sees not only the Teapot of Sagittarius in this position but the centre of the Milky Way is nearby as well! Find the Teapot's spout star Gamma Sagittarii, and move 4.5° towards Antares (or about the width of a medium power binocular field). That's the position of the centre. If it weren't for the dust and gas lying in the plane of the Milky Way blocking our view, the glow from the galactic nucleus would make it the most brilliant object in the night sky. Perhaps displaying the accretion disc surrounding the million solar-mass black hole that dwells within! We'll leave that part to your imagination. However, don't dismiss the attractive side of this complex of dark lanes crisscrossing the hub of our galaxy. Country skies, your eyes and perhaps a pair of binoculars are all that is needed. For example find the Pipe Nebula, complete with bowl and stem, close to the galactic centre.

July evenings are ideal for checking out the southern zodiacal constellations, those that lie on the annual path taken by the Sun (the ecliptic). High in the northeast evening sky you will see the brilliant star Spica, your only obvious marker to Virgo. Moving westward you will find the faint kite shaped Libra. Continuing this trek we return to the most southern members, Scorpius and Sagittarius. Nestled between these impressive constellations is an interloper, Ophiuchus. The only constellation on the ecliptic that isn't part of the zodiac! Next we find the faint 'smile' shaped Capricornus, followed by Aquarius in the northwest.



THE MOON



1st 3 am (1 am WST) Maximum Libration (8.4°), near Full Moon.

2nd Noon (10 am WST) Full Moon.

6th 5 am (3 am WST) Moon at perigee (closest to Earth at 367,093 km).

7th 7 pm (5 pm WST) Minimum Libration (1.7°), dark SE limb.

9th 6 am (4 am WST) Last Quarter.

9th 1 pm (11 am WST) Occultation of Uranus by the Moon, visible from westernmost Australia and southern Indian Ocean (daytime event).

13th 4 am (2 am WST) Occultation of Aldebaran by the Moon, visible from northern Japan, eastern Russia, Alaska, northern Canada, Greenland and Iceland.

14th 7 pm (5 pm WST) Maximum Libration (8.4°), too close to New Moon.

16th 11 am (9 am WST) New Moon.

19th 11 am (9 am WST) Occultation of Venus by the Moon, visible from New Guinea, NE Australia, Melanesia and French Polynesia. See Venus section.

21st 5 pm (3 pm WST). Minimum Libration (1.0°), dark NW limb.

21st 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 404,835 km).

24th 2 pm (noon WST) First Quarter.

28th Noon (10 am WST) Maximum Libration (9.2°), dark SW limb.

31st 9 pm (7 pm WST) Full Moon.

THE PLANETS

Mercury, in the eastern dawn sky, is only visible early this month as it descends toward the Sun and superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 24th. Subsequently this speedy little planet moves into the evening dusk sky joining the brightest planets Venus and Jupiter in early August.

Venus and Jupiter make a dazzling pair when they are just 0.4° apart on the 1st (see June Sky View). They quickly separate but remain within 6° of each other for July in the early western evening sky – all the while in the boundaries of Leo the Lion. The 2-day old Moon forms a triangle with the two brightest planets on the 18th (see Sky View). On the following evening the 3-day old Moon appears 3° above Venus with the cusps pointing away from the planet – a glance at the Moon at this time reveals the origin of the saying “the old Moon in the New Moon’s arms” as Earthshine (ashen glow) floods the unlit portion. Venus reaches its greatest brilliancy on the 10th at –4.7 magnitude – known as *greatest illuminated extent* by astronomers, it is defined as when the planet’s illuminated portion or day side covers the greatest square area of our sky. At this time we see Venus just one-quarter (25%) illuminated, just like a 3 or 4 day old Moon.

The **Earth** is at aphelion on the 7th, the furthest point in its orbit from the Sun (152,093,462 km or 1.016682 au distant).

Mars, now past conjunction, remains too close to the Sun for observation until next month.

Jupiter opens the month just 0.4° from the brighter Venus in the early western evening sky (see June Sky View) – a spectacular sight! At this time Jupiter is –1.8 magnitude compared to –4.6 for Venus. On the 18th, the 2-day old slender crescent Moon forms a triangle with Jupiter and Venus (see Sky View), or a quadrilateral if you include the 1st magnitude star Regulus (Alpha Leonis). Jupiter’s motion across Leo takes it directly toward Regulus and at month end the pair are 2.5° apart and even closer next month.

Saturn, in Libra, is visible high in the northeastern sky at the end of astronomical dusk. Early to mid evening is the best time for Saturnian observations this month while the planet remains at a decent elevation above the horizon. On the 26th, the 9-day old waxing gibbous Moon will be nearby the planet (see Sky View).

Uranus rises around midnight in Pisces mid-month. On the 27th, the planet appears stationary against the background stars and thereafter is in retrograde motion until late December. Whilst it is moving very slowly at this time it will be close to the 5th magnitude double star Zeta Piscium.

New Horizons – its Moment of Glory!

This month NASA’s New Horizons mission reaches a crescendo with its long anticipated flyby of Pluto. A lot can happen in a few years. When it launched on January 19, 2006 the mission was thought of as fulfilling the dream to finally visit the last *planet*. Since then, Pluto’s been demoted and the asteroid Ceres has been promoted, both to dwarf planet. This is not the only similarity between these worlds for Ceres should have received its first visitor by now, with the Dawn probe planned to enter orbit in late March/early April this year.

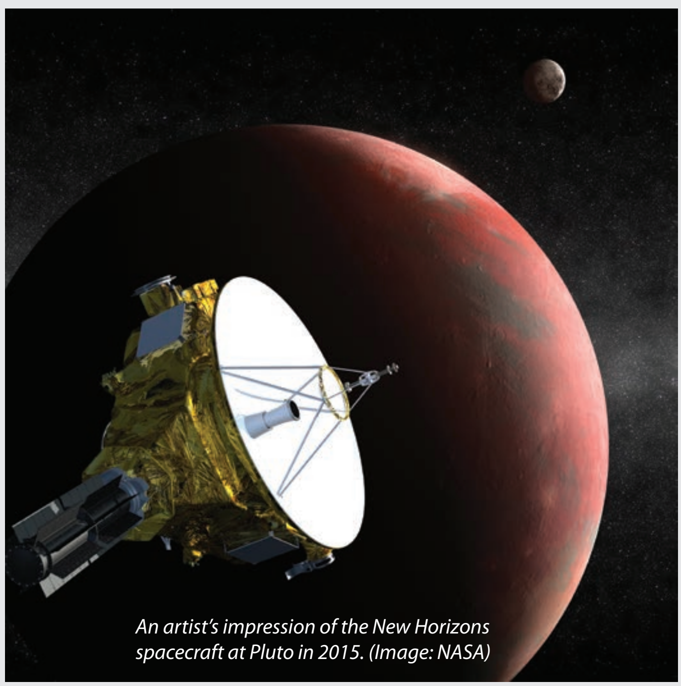
New Horizons had a lot of ground to cover with Pluto’s orbit some 40 times the distance between the Earth and Sun. Hence it was the fastest object ever to be launched, going straight to solar escape velocity; passing the Moon only nine hours after leaving the Earth! Even at this speed it still had to launch within a 23-day window to make its gravity assisted flyby of Jupiter possible. Any other launch would mean the Pluto encounter wouldn’t have happened before 2018.

The spacecraft’s instrumentation includes a high resolution visible imaging telescope, another scope with broadband spectroscopic capacity going into the near infrared and far/extreme UV, a particle and electron detector (solar wind), a dust counter and radio science experiments using the communication channels.

The Jupiter encounter was far from just a fuel free boost into the outer Solar System. Horizons’ instruments are superior to the Galileo probe’s, the last visitor to this gas giant whose mission was brought to an end in September 2003. New Horizons undertook an intensive study of Jupiter, its rings and moons from January to June 2007 with closest approach on February 28. It presented a great test bed for the instrumentation and manoeuvring needed at Pluto. Jupiter’s atmosphere is always undergoing changes and studies were made of the structure and composition of its clouds, storms and lightening bolts. Also the constantly changing face of Io was observed with 11 volcanic eruptions noted plus the infrared signatures of 36 volcanoes.

Post Jupiter the probe has spent most of its time in hibernation using its radioactive power source to keep critical instrumentation from

… continued next page.


An artist’s impression of the New Horizons spacecraft at Pluto in 2015. (Image: NASA)

In fact, Uranus remains within 0.5° of this star from mid-June through to early September. Zeta is a fine double and the best in the constellation for small telescopes. The 5th and 6th magnitude pair of suns is separated by a respectable 23 arcseconds, the primary is mostly described as white or bluish while observers seem to be in disagreement as to the secondary's colour – sometimes white, pink or greenish!

Neptune rises in the mid-evening eastern sky in Aquarius.

DIARY

Wed	1st	Midnight	(10 pm WST) Jupiter 0.4°N of Venus
Wed	1st		m.p. 3 Juno 1.0°S of star Regulus
Thu	2nd	12:20 pm	(10:20 am WST) Full Moon (374,185 km)
Thu	2nd	8 pm	(6 pm WST) d.p. Pluto 3°S of Moon
Fri	3rd		Uranus 0.5°SE of star Zeta Piscium
Fri	3rd	pm	m.p. 2 Pallas 0.2°S of star Delta Herculis
Sun	5th		Venus at descending node
Sun	5th	pm	m.p. 129 Antigone 0.5°NW of star Nu Ophiuchi
Mon	6th		Mercury 0.7°E of M1 Crab Nebula (PN) in Taurus
Mon	6th	5 am	(3 am WST) Moon at perigee, 367,093 km
Mon	6th	6 pm	(4 pm WST) Neptune 3°S of Moon
Tue	7th	2 am	(Midnight WST, prev day) d.p. Pluto at opposition
Tue	7th	6 am	(4 am WST) Earth at aphelion, 1.016682122 au
Wed	8th	11 pm	(9 pm WST) m.p. 4 Vesta 7°S of Moon
Thu	9th		m.p. 44 Nysa 0.4°NE of NGC 4437 (G) in Virgo
Thu	9th	6:24 am	(4:24 am WST) Last Quarter Moon
Thu	9th	1 pm	(11 am WST) Uranus 0.8°N of Moon; Occn.
Fri	10th	2 pm	(Noon WST) Venus greatest illuminated extent
Sat	11th		Comet 22P/Kopff 1.0°NE of NGC 4753 (G) in Virgo
Sat	11th		Mercury 0.6°NE of star Eta Geminorum
Sun	12th		Jupiter 0.5°NE of star Psi Leonis
Sun	12th		Mercury 0.8°NE of star Mu Geminorum
Sun	12th		Mercury at ascending node
Sun	12th	10 pm	(8 pm WST) Comet 10P/Tempel 2 0.1°N of star Tau Virginis
Mon	13th	4 am	(2 am WST) star Aldebaran 0.9°S of Moon; Occn.
Wed	15th		Venus 2.4°SW of star Regulus
Wed	15th	am	m.p. 15 Eunomia 1.5°SE of star Gamma Pegasi
Thu	16th		m.p. 354 Eleonora 0.8°SW of M98 (SG) in Coma Berenices
Thu	16th		m.p. 39 Laetitia 0.2°S of star Xi 2 Ceti
Thu	16th		Mercury at perihelion
Thu	16th	11:24 am	(9:24 am WST) New Moon
Sat	18th		m.p. 44 Nysa 0.4°SW of NGC 4666 (G) in Virgo
Sat	18th		m.p. 44 Nysa 0.9°NE of star Gamma Virginis
Sat	18th	7 pm	(5 pm WST) m.p. 3 Juno 0.15°W of star Rho Leonis
Sun	19th		m.p. 354 Eleonora 0.2°SW of NGC 4212 (G) in Coma Berenices
Sun	19th	4 am	(2 am WST) Jupiter 4°N of Moon
Sun	19th	11 am	(9 am WST) Venus 0.4°N of Moon; Occn.
Sun	19th	1 pm	(11 am WST) star Regulus 3°N of Moon
Mon	20th		m.p. 354 Eleonora 0.5°NE of NGC 4216 (G) in Virgo
Mon	20th		m.p. 354 Eleonora 0.9°SW of M99 (SG) in Coma Berenices
Mon	20th	3 am	(1 am WST) m.p. 3 Juno 2°N of Moon
Tue	21st	9 pm	(7 pm WST) Moon at apogee, 404,835 km
Thu	23rd		m.p. 354 Eleonora 0.4°NE of NGC 4267 (G) in Virgo
Thu	23rd		m.p. 44 Nysa 0.6°SW of NGC 4753 (G) in Virgo
Thu	23rd	9 pm	(7 pm WST) star Spica 4°S of Moon
Fri	24th	5 am	(3 am WST) Mercury in superior conjunction
Fri	24th	2:04 pm	(12:04 pm WST) First Quarter Moon
Sat	25th	am	m.p. 9 Metis 1.0°NW of NGC 7727 (G) in Aquarius
Sat	25th	6 pm	(4 pm WST) d.p. Ceres at opposition
Sun	26th		m.p. 354 Eleonora 0.2°W of NGC 4388 (G) in Virgo
Sun	26th		m.p. 354 Eleonora 0.3°S of M84 (EG) in Virgo
Sun	26th	6 pm	(4 pm WST) Saturn 2°S of Moon
Mon	27th		Mercury at greatest latitude north
Mon	27th	1 am	(11 pm WST, prev day) Comet C/2013 US_{10} (Catalina) 0.7°N of star Gamma Tucanae
Mon	27th	2 pm	(Noon WST) star Antares 9°S of Moon
Wed	29th		m.p. 354 Eleonora 0.2°N of IC 3408 (OC) in Virgo
Wed	29th		m.p. 354 Eleonora 0.5°SW of M87 Virgo A (EG) in Virgo
Thu	30th	5 am	(3 am WST) d.p. Pluto 3°S of Moon
Fri	31st	8:43 pm	(6:43 pm WST) Full Moon (365,117 km)

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto is at opposition on the 7th, and above the horizon the entire night. It is presently 4,770 million km (31.88 au) from Earth, with its light taking four hours and twenty-five minutes to reach us. If you have a need to add this distant 14th magnitude ice dwarf to your bucket list, you will need a moderate (200 – 250 mm) to large telescope. Your quest will also be aided by a good dark sky, our finder chart on page 131, and lots of luck! Remember that Pluto is currently in a region of our galaxy that has innumerable faint stars of similar brightness, making identification relatively difficult. Astrophotographers should try imaging the region over the span of a few days to sort out the wanderer from the fixed stars.

Ceres is at opposition on 25th at magnitude 7.5, near the border of Microscopium and Sagittarius.

Minor Planets. Three of the brighter minor planets reach opposition this month in Sagittarius, 287 Nephthys on 6th at magnitude 11.1, 135 Hertha on 11th at magnitude 9.9 and 60 Echo on 21st at magnitude 11.9. Also at opposition are 372 Palma on 4th at magnitude 13.0 in Telescopium, 68 Leto on 30th at magnitude 9.8 in Microscopium and 31 Euphrosyne on 9th at magnitude 12.6 near the Telescopium/Pavo border. In July and August, 11th magnitude 354 Eleonora passes through the Virgo/Coma cluster of galaxies, including a close approach this month to the western end of Markarian's Chain, M84 on 26th (see diary).

New Horizons … continued

freezing. It crossed the orbits of Saturn on June 8, 2008, Uranus on March 18, 2011 and at the time of writing (August 24, 2014) has just passed the orbit of Neptune.

The recent discovery of Pluto's 4th and 5th moons, Kerberos and Styx, raised concerns over what else might be in the vicinity of the planet that could damage New Horizons during the critical flyby. Some of the world's largest telescopes and Hubble have been imaging the Pluto family looking for any previously unknown moons or rings. New Horizons will start observing the system from about six months out with a similar goal in mind. Only 3.2 days before the encounter, the probe will take images of Pluto and Charon to cover the sides of these bodies that will be turned away from the spacecraft during closest approach.

On the day of Pluto flyby, the 14th this month, it will be racing along at 49,600 km/hr. The closest approach to this distant world is expected to be around 13,000 km at 11:47 UT (9:47 pm EST, 7:47 pm WST) with the flyby of the five satellites only 13 minutes later. At a distance of 31.9 au from the Earth communication delays will be approximately 4 hours 25 minutes each way. This means it will be on its own, under complete control of its internal programming and all NASA Deep Space Network will be able to do is wait for the probe to call home to confirm the mission has been successful. It may take months for New Horizons to download its images and data.

Post Pluto it is hoped sometime in the next five to six years the spacecraft may flyby one or two other Kuiper Belt Objects (KBO). These extremely faint distant asteroids are difficult to detect in the bright Milky Way star field near Pluto. Also New Horizons can only manoeuvre through a narrow angle so a search was launched in 2011 using the 8.2 m Subaru Telescope in Hawaii and the 6.5 m Magellan Telescopes in Chile. At the time of publishing this book no definite targets have been announced.

The Atacama Large Millimetre/submillimetre Array (ALMA), our cover image, has an important function in this mission. It's easy to think, 85 years since its discovery, the orbit of Pluto would be well known. But we have only been tracking it for around a third of its orbit and high precision is needed to place New Horizons exactly where it's required, a point inside the orbit of the closest moon, Charon. Even astrometry, measuring Pluto's position against known stars in large optical telescopes, wasn't precise enough, for the star's proper motions weren't known sufficiently well. ALMA eliminates this concern by using a distant quasar as a reference point which is very faint in optical, but very bright in ALMA's frequencies. Pluto and Charon are also good targets for ALMA as it monitors the radio emissions from their cold surfaces (around 45 K).

Comet 10P/Tempel 2 brightens from 13th to 12th magnitude this month in Virgo. Tempel 2 is setting around midnight and will be best observed during the 2nd and 3rd weeks of July when there is no moonlight interference.

Comet 22P/Kopff is, like comet Tempel 2, an evening object in Virgo during July and is best observed at the end of evening twilight. During July, Kopff should be around 12th magnitude. It is best to observe in the middle of the month when the Moon won't interfere.

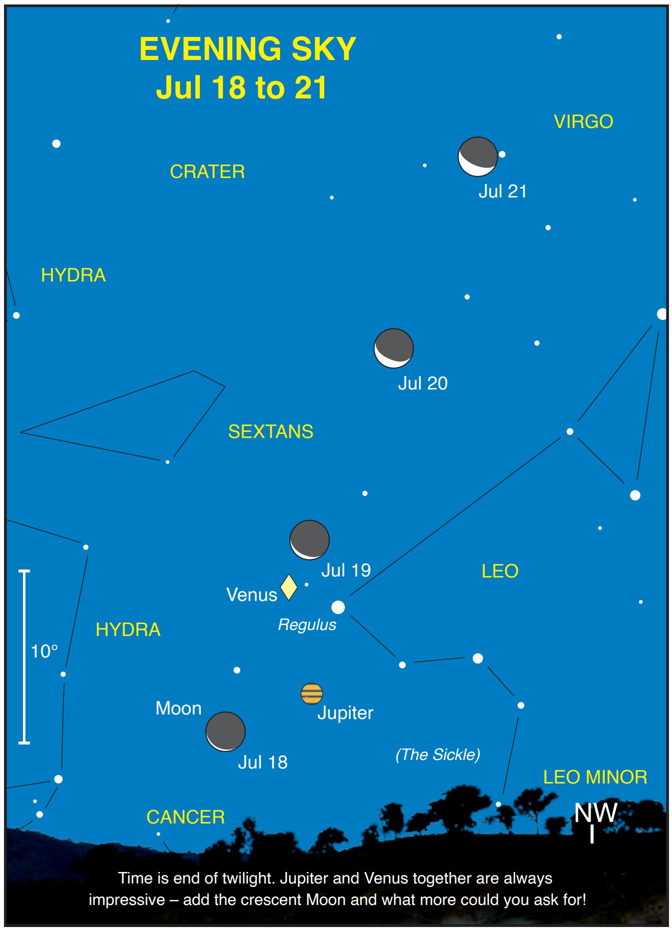
Comet 88P/Howell fades from 11th to 12th magnitude during July. Rising after midnight, Howell begins the month in Pisces before moving back into Cetus mid-month and then finally entering Aries at the end of July. The Moon will interfere with observing during much of the first half of July and again at the end.

Comet C/2013 US_{10} (Catalina) opens July in Sculptor at 10th magnitude, rising mid-evening. Early in the month, Catalina moves into Phoenix and then late in the month as it heads south, passes through Grus before finishing in Tucana when it might be 8th magnitude. Observers will need to contend with moonlight early in the month and again towards the end.

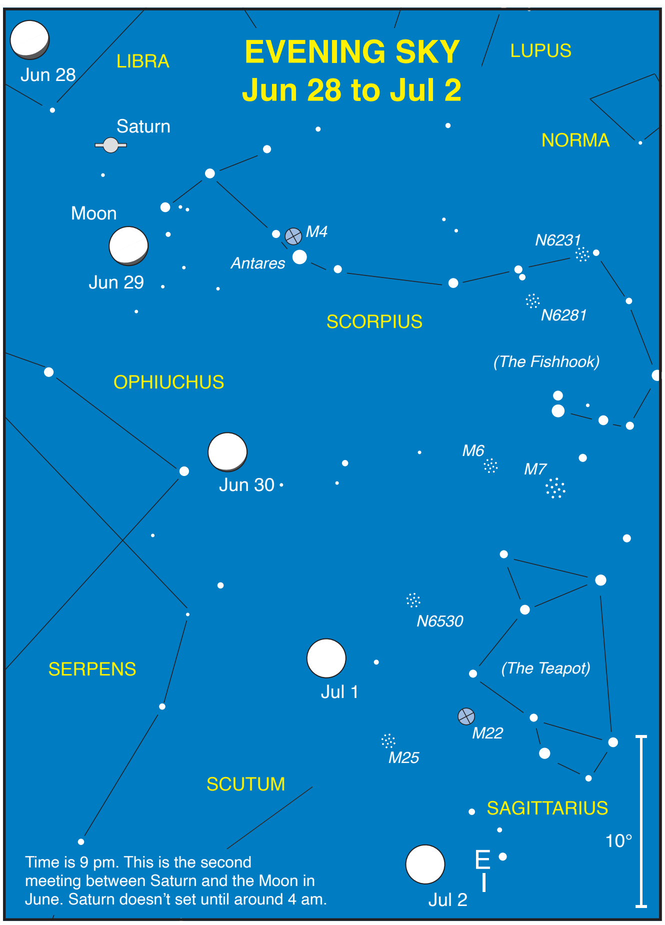
DOUBLE STARS

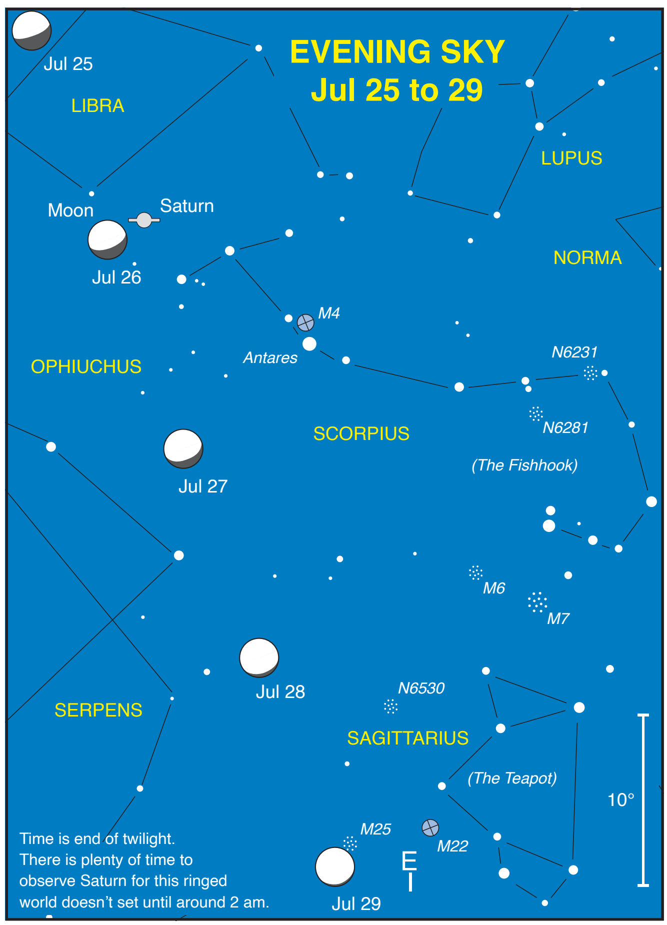
ν Scorpii (Jabbah) is a superb compact double-double star well situated for southern observers. This system of two connected close pairs has shown little change in position angle and separation, indicating a very long period. The two pairs are separated by about 41 arcseconds. The brighter pair consists of magnitude 4.4 and 5.3 stars separated by 1.2 arcseconds. The fainter easier pair, magnitude 6.6 and 7.2, is separated by 2.2 arcseconds. At high power a 15 cm telescope shows all four stars on nights of good seeing. (Map 6, p. 74)

Located not far from Antares, **Rho Ophiuchi** is a binocular triple set in a field of refection nebulosity, which obscures the Milky Way stars. The stars, magnitude 5.1 (A), 7.3 (C) and 6.8 (D), separated by 149 and 156 arcseconds respectively from A, form a lovely isosceles triangle in 10 × 50 binoculars. Through a small telescope the brightest star is also a close, slightly unequal double (magnitude 5.1 (A) and 5.7 (B), separation 3.3 arcseconds) and is located 395 light years away. (Map 6, p. 74)

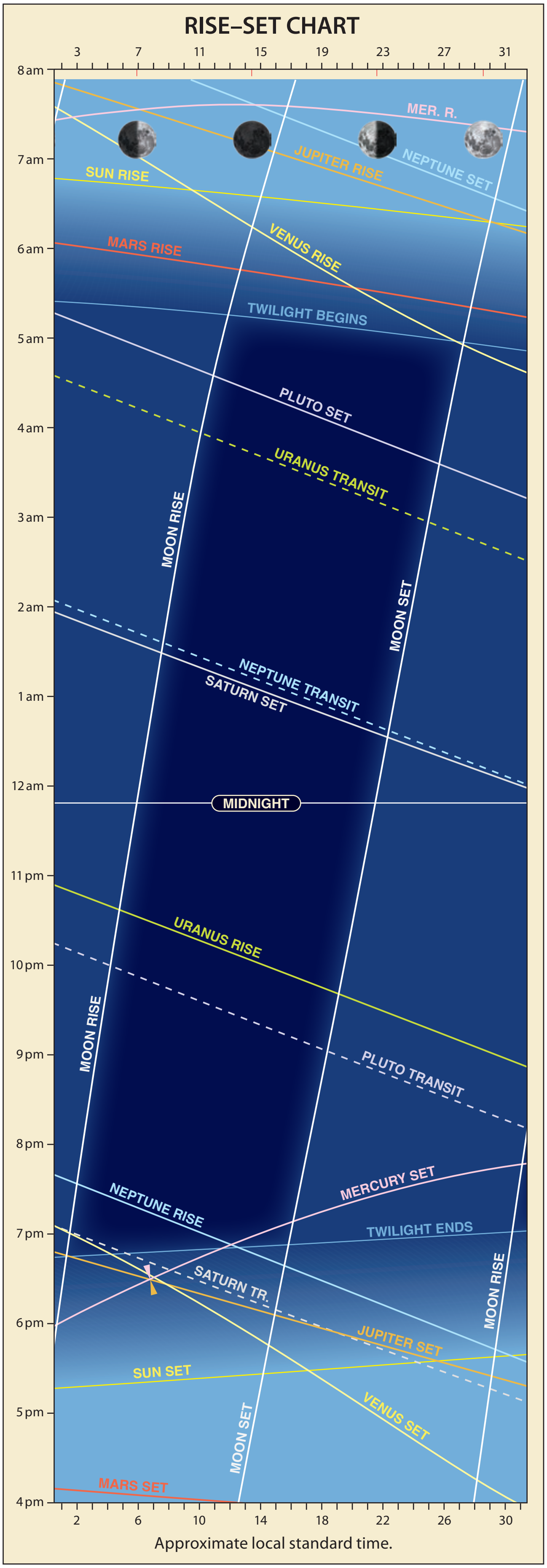


Approximate local standard time.





AUGUST



HIGHLIGHTS

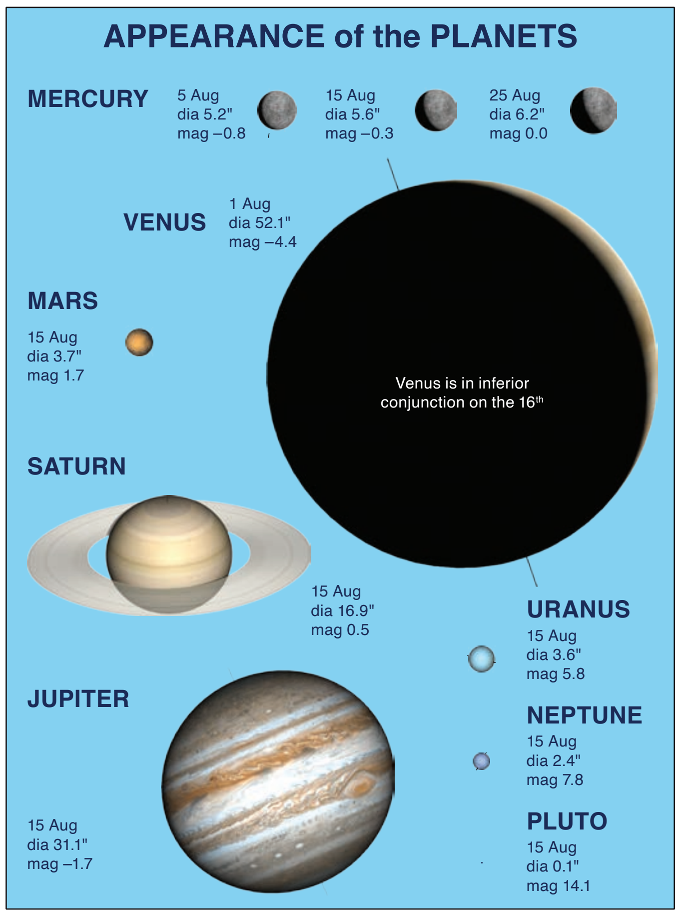
❍ Mercury close to Jupiter and Regulus.
m Mars crosses the Beehive cluster.
m Jupiter close to Regulus.
m Comet Catalina in the southern evening sky.

CONSTELLATIONS

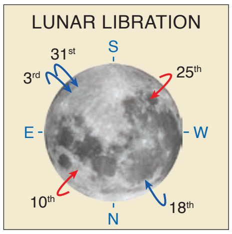
The Milky Way in the evenings is still stunning as it traverses the sky stretching from the northern to south-western horizons. As mentioned in July 'Constellations', overhead we see its central bulge with the Teapot of Sagittarius prominent. Below this *archer* is another obvious asterism, Ara, the Altar. The Southern Cross (Crux) is now on its side in the southwest with Achernar, rising in the southeast. This 0.5 magnitude star is the southern extremity of the river Eridanus. Achernar is opposite Crux in the sky, with the invisible South Celestial Pole half way between them. Unfortunately this point around which the stars revolve is obscure, not having a bright star, such as Polaris, which marks its northern counterpart.

Turning around, the northern evening August sky is home to four gentlemen constellations – Bootes, Hercules, Ophiuchus and Aquarius. However there was another, now lost in antiquity. Aquila the Eagle has the star Altair marking its head, with its eastward wing stretching out towards Theta Aquilae and the other westward to Zeta Aquilae. Its current body and tail, encompassing eta, kappa, lambda, sigma, theta, iota, nu and delta Aquilae, used to be the servant Antinous. He was immortalised in the heavens as a constellation for sacrificing himself in the hope of extending the life of his master and Roman Emperor, Hadrian. Good luck trying to find a human shape formed by these stars.

While looking at Aquila, Altair is one of four bright stars in the evening sky this month, which also lie quite close to us – in our Sun's celestial neighbourhood. Altair is 16.7 light years (ly) away. In the southwest is the nearest star, Alpha Centauri, only 4.4 ly away. This *pointer* is also the 3rd brightest star in the heavens. Next, shift to the east-southeast, and discover isolated Fomalhaut, 25.1 ly distant. Finally, low in the north finds Vega, 25.3 ly away.



THE MOON



- 2nd 8 pm (6 pm WST) Moon at perigee (closest to Earth at 362,139 km).
- 3rd 7 pm (5 pm WST) Minimum Libration (1.9°), dark SE limb.
- 5th 7 pm (5 pm WST) Occultation of Uranus by the Moon, visible from Antarctic Peninsula, southern South America and Falkland Islands.
- 7th Noon (10 am WST) Last Quarter.
- 9th 10 am (8 am WST) Occultation of Aldebaran by the Moon, visible from Middle East, Eastern Europe, NW Asia, Scandinavia, Russia, Alaska and NW Canada.
- 10th 5 pm (3 pm WST) Maximum Libration (9.1°), dark NE limb.
- 15th 1 am (11 pm previous day WST) New Moon.
- 18th 2 am (midnight previous day WST) Minimum Libration (0.6°), dark NW limb.
- 18th 1 pm (11 am WST) Moon at apogee (furthest from Earth at 405,848 km).
- 23rd 6 am (4 am WST) First Quarter.
- 25th 6 am (4 am WST) Maximum Libration (9.9°), dark SW limb. Although the features favoured by this libration are in darkness, it is interesting to see the effect on the opposite extremity where Mare Crisium has been pushed close to the eastern limb.
- 30th 5 am (3 am WST) Full Moon.
- 31st 1 am (11 pm previous day WST) Moon at perigee (closest to Earth at 358,290 km).
- 31st 9 am (7 am WST) Minimum Libration (1.1°), dark SE limb.

THE PLANETS

Mercury emerges into the western evening twilight this month, joining the two brightest planets, Venus and Jupiter (see Sky Views). The planet moves up toward Jupiter and on the 7th will be 0.6° north (right) of the gas giant, the view made more interesting with the 1st magnitude star Regulus 1° above the pair forming a triangle - binoculars and a good western horizon will help here (see Sky View). On the 16th, the young 2-day old slim crescent Moon appears near the planet (see Sky View) – this also marks the beginning of the best time to observe Mercury in the evening sky. For the next five weeks the elusive planet will be visible in the sky after the end of astronomical twilight.

Venus is visible in early August to the south (left) of Mercury and Jupiter (see Sky View), easily outshining both of them. It then yields to the Sun's glare as it approaches inferior conjunction (between the Earth and Sun) on the 16th. The planet reappears in the eastern dawn sky as the *Morning Star* in the last week of August.

Mars reappears in the eastern dawn this month, although it will not be visible in a truly dark sky until late next month. On the 13th, the slender crescent of the waning Moon appears above the planet (see Sky View). On the 20th and 21st Mars traverses M44, the Beehive Cluster. Visible to the unaided eye under dark skies, the Beehive has been known since antiquity and Hipparchus catalogued it as the *little cloud* or *cloudy star* in 130 BCE. Galileo was the first to realise its true nature when he observed over 40 stars in the cluster in 1609 – today a good pair of binoculars or small telescope will reveal at least 75 stars.

Jupiter follows Venus into solar conjunction this month but you can still catch a glimpse of this gas giant early in the month as it moves through Leo in the western evening twilight. On the 7th, Jupiter and Mercury appear 0.6° apart forming a triangle with the 1st magnitude star Regulus (Alpha Leonis) – the identification of Jupiter and Regulus is easy as the planet is the brighter of the two (see Sky View). After Mercury moves on, Jupiter heads toward Regulus and comes within 0.4° of the star on the 11th. Thereafter the planet gets lost in the dusk sky as it travels toward the Sun and conjunction on the 27th, reappearing in the morning sky late September.

Saturn, moving slowly through Libra, is visible in the early evening northern sky. The planet appears stationary on the 3rd as it comes to the end of its 4.5 month retrograde loop; it then resumes its west to east

Life Finds a Way – Part 2 (continued from Part 1, page 41)

The existence of the Moon also has assisted life evolve on Earth. Its constant tidal influence has helped stabilise the Earth's polar axis over billions of years, avoiding massive and rapid swings in its climate and weather.

Jupiter is an unexpected ally to Earth. Life has gone through at least five mass extinctions, well… since we've had fossil evidence, over the last 500 million years. Life continued to bounce back, hence the title of this article borrowed from Dr Malcolm in the movie, Jurassic Park. The last cataclysm was caused by a meteor impact, the famous K-T Extinction, which wiped out the dinosaurs some 65 million years ago paving the way for the rise of Man. Without super massive Jupiter there could have been more catastrophic collisions. Any wayward asteroids or comets that stroll too close to this gas giant have their orbits perturbed. They can be thrown into the inner Solar System, or directed out. The ones going outward are less likely to return, so over many millions of years Jupiter has gradually weeded out a lot of the potential Earth/life destroyers.

The chemistry of life is well known, but we had to wait for the 20th century to discover how widespread the essential 'life' elements were in the Universe. Spectroscopy has been Man's greatest forensic tool to discovering the cosmos. Atoms and molecules impose unmistakable fingerprint lines on the light (spectrum) of stars, gas clouds and galaxies. By spectrum we mean in the broadest sense from radio frequencies right up to gamma rays. The most common elements making up life are carbon, hydrogen, nitrogen, oxygen, phosphorous and sulphur. The spectral evidence is encouraging with five of these making the top 10 list of elements by mass found in the Milky Way (phosphorous is comparatively rare). Shortly after the Big Bang, when the Universe had cooled sufficiently to form atoms, only hydrogen, helium and some lithium existed. Every other element has since been forged either in the nuclear furnaces of stars or in their massive explosions called supernovae. As Carl Sagan so eloquently stated, "We are made of starstuff" and we see lots of this *stuff* everywhere. So the Sun and its planets have formed out of a nebula that had been enriched with debris from ancient supernovae.

Although the spark that brings organic molecules together as life remains unknown there is no doubt its precursors, such as amino acids, dwell in galactic gas clouds and even within comets. It's fascinating to speculate the comets that likely collided with the Earth, in the late heavy bombardment period (approximately 4 billion years ago), may have delivered much more than most of our planet's water! Asteroids from the same event also peppered the Earth, with the carbonaceous type delivering carbon, hydrogen, oxygen and nitrogen, further adding to the resources for the future living. Evidence of this ancient pounding has long gone from Earth with its active erosion and crustal motion but is still visible today having created the Moon's largest craters. So ponder this when you next look at our nearest neighbour.

Going to the other extreme, if we somehow discovered that Earth was the only home to life, the philosophical implications would be most profound (putting aside the difficulties of proving a negative). From the discussion above a Universe widespread with life is much more palatable.

So returning to where we started. Is there an alien just like you walking amongst grass and trees on a planet in another solar system? Who knows, maybe not. Even if the assumptions here are correct about the basis of life being carbon throughout the Universe, we have already seen the potential for its enormous diversity here on Earth. Just look around at the multitude of different living things, not to mention the millions of extinct species. Look into the river. I'm sure you don't think of that fish as an alien but any extra-terrestrial would likely be just as different from you. If first contact ever happens Mankind may be in for some surprises, finding both his knowledge and imagination somewhat lacking!

motion across the sky as it heads toward Scorpius. On the 22nd the planet is at a point in its orbit known as eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 17). This means that as the Sun sets in the west, Saturn will be at its highest altitude in the sky. It is during quadrature that the maximum shadow of the planet is cast onto the back of the rings giving Saturn a truly 3-D appearance. Also on the 22nd, the near First Quarter Moon appears close to the planet (see Sky View).

Uranus rises in the late evening eastern sky in Pisces. The planet remains close to the 5th magnitude double star, Zeta Piscium, an excellent pair for small telescopes. Do not confuse the yellowish star 88 Piscium with the planet; it is close to Uranus' magnitude and nearer than Zeta, although the greenish hue of Uranus should give it away.

Neptune rises in the east at the end of astronomical dusk mid-month. The planet is at opposition on 1 September and at its brightest over the next couple of months at 7.8 magnitude. Although Neptune is two magnitudes dimmer than Uranus it is still easily identified in a telescope and has a look that makes it stand out from the background stars. Its bluish disc is visible in telescopes over 100 mm with moderate magnification.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, now past opposition, transits the meridian (is due north) around 9 pm mid-month. On the 1st Pluto is between the 5th magnitude stars Chi^1 Sagittarii (0.2° away) and 4th magnitude Chi^2 Sagittarii (0.3°).

Minor Planets. Brighter minor planets reaching opposition this month include 21 Lutetia on 15th at magnitude 9.3 in Capricornus and 65 Cybele on 13th at magnitude 11.0 near the Aquarius/Capricornus border.

Comet 10P/Tempel 2 remains an evening object in August as it moves from Virgo into Libra. During the month, Tempel 2 is expected to brighten from 12th to 11th magnitude. The comet spends the month close to comet Kopff, with the separation ranging from 13° down to 10° at the close of August. The Moon will be out of the evening sky during the middle two weeks of the month.

Comet 22P/Kopff is in Virgo for all but the last few days of August, moving into Libra near the end of the month. Remaining around 12th magnitude, Kopff sets mid-evening. To avoid the Moon observe the comet around the middle of the month.

Comet 88P/Howell rises around midnight during August. Slowly moving through Aries, Howell is expected to fade from 12th to 13th magnitude this month. The first half of August will see moonlight hinder observing.

Comet C/2013 US$_{10}$ (Catalina) begins August deep in the south in Tucana at 8th magnitude. Visible throughout the night, Catalina rapidly moves through Indus, Pavo and Apus before finishing the month in Triangulum Australe when it could be 7th magnitude. The comet is easy to find on the evenings of 22nd and 23rd, being within 1° of 2nd magnitude Alpha Trianguli Australis. A similar conjunction occurs with Beta Trianguli Australis a few days later (28th and 29th). With New Moon on the 15th, the middle of the month is a good time to observe comet Catalina.

METEOR SHOWERS

New Moon favours the peak of the two showers listed below. Unfortunately, both are not easily observable and for many Australian observers the radiant will be below the horizon.

The famous **Perseids** are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17th July through to 24th August, with maxima predicted for the 13th. The zenith hourly rate is variable and has in the past been exceptional. The 2005 Perseids produced about 90 meteors per hour.

The **kappa-Cygnids** tend to be overshadowed by the more popular Perseids. Active from 3rd to 25th August, with it maxima predicted on the 18th, the zenith hourly rate is 25. The kappa-Cygnids meteors are infrequent and faint, although white/bluish fireballs are sometimes produced.

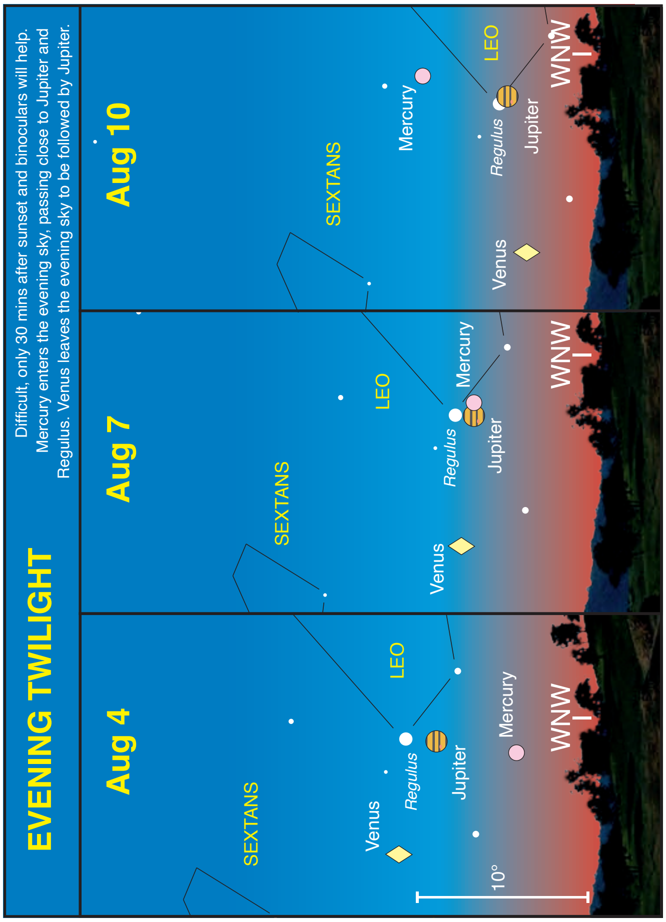
DOUBLE STARS

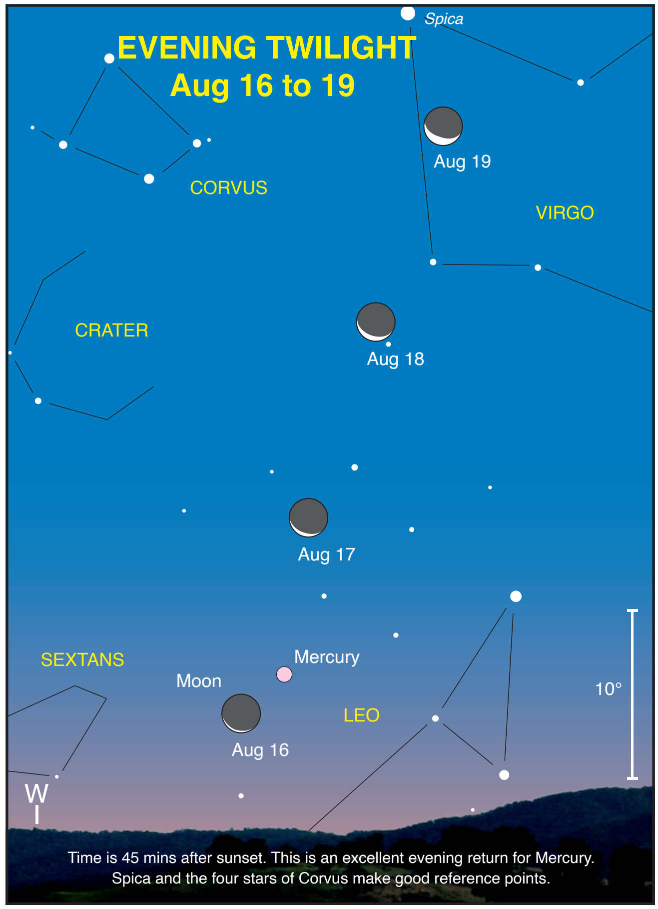
Located at a distance of 380 light years **β Cygni (Alberio)** is truly one of the gems of the night sky. This striking, colourful pair of bright deep yellow and pale bluish stars (magnitude 3.2 and 4.7) is separated by 34.7 arcseconds. The brighter star is also a very close binary visible only in very large telescopes. (Map 9, p. 77)

This month's binocular double is located in Lyra. Situated 200 light years away, **ε^1** and **ε^2 Lyrae** are a fine pair located near the brilliant star Vega. The magnitude 5.0 and 5.2 white stars are separated by a wide 209 arcseconds. This pair is also the famous double-double, which can be quite challenging for southern observers due to its low altitude. The companion of ε^1 is magnitude 6.1 with a separation of 2.2 arcseconds. The companion of ε^2 is magnitude 5.4 with a separation of 2.4 arcseconds. Many binocular doubles are optical doubles, however in this case both pairs may be very slowly orbiting each other (a binary). (Map 9, p. 77)

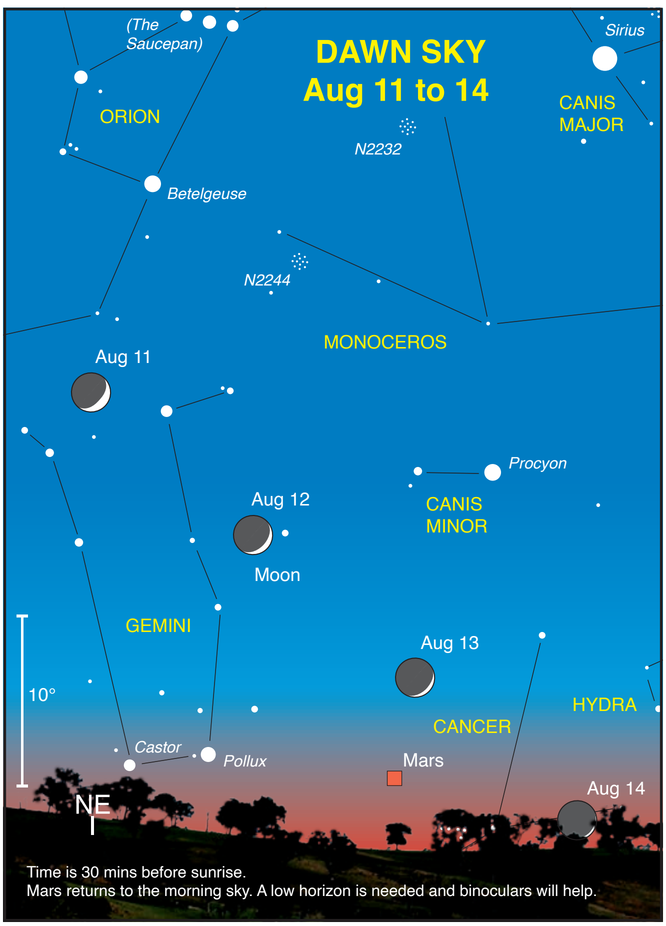
DIARY

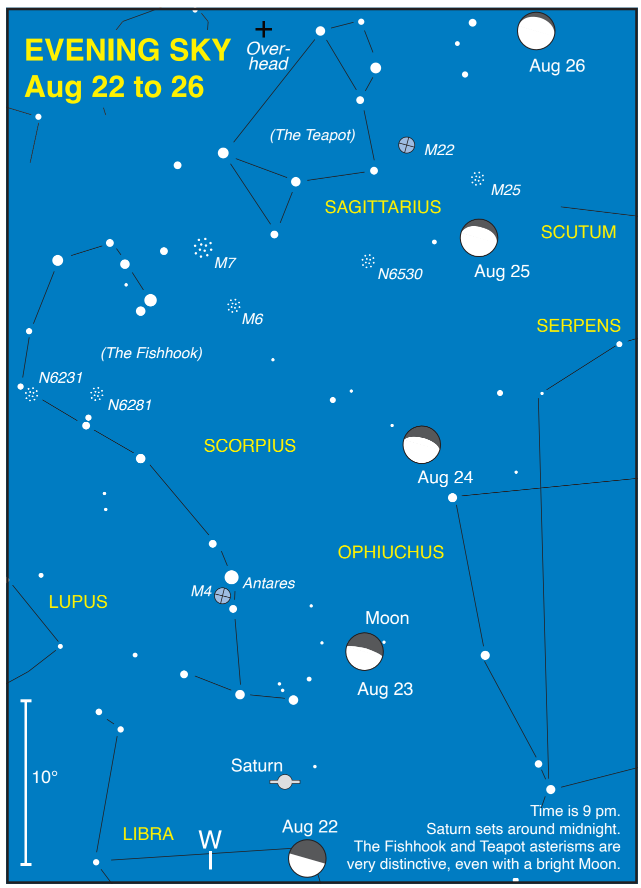
Sat	1st		d.p. Pluto 0.3°N of star Xi 2 Sagittarii
Sat	1st		m.p. 354 Eleonora 0.5°NE of NGC 4503 (G) in Virgo
Sat	1st	6 am	(4 am WST) Jupiter 6°N of Venus
Sun	2nd		m.p. 354 Eleonora 0.8°SW of M58 (SG) in Virgo
Sun	2nd	8 pm	(6 pm WST) Moon at perigee, 362,139 km
Mon	3rd		d.p. Pluto 0.2°S of star Xi 1 Sagittarii
Mon	3rd		m.p. 354 Eleonora 0.2°SW of NGC 4564 (G) in Virgo
Mon	3rd	1 am	(11 pm WST, prev day) Neptune 3°S of Moon
Mon	3rd	8 pm	(6 pm WST) m.p. 354 Eleonora 0.1°W of NGC 4567/68 Siamese Twin Galaxies in Virgo
Wed	5th	1 pm	(11 am WST) m.p. 4 Vesta 9°S of Moon
Wed	5th	7 pm	(5 pm WST) Uranus 1.0°N of Moon; Occn.
Thu	6th	am	m.p. 471 Papagena 0.7°N of star Zeta Ceti
Thu	6th	7 pm	(5 pm WST) m.p. 8 Flora 0.05°S of star Nu Virginis
Fri	7th	12:03 pm	(10:03 am WST) Last Quarter Moon
Fri	7th	2 pm	(Noon WST) Jupiter 0.6°S of Mercury
Sat	8th		Venus at aphelion
Sat	8th	1 am	(11 pm WST, prev day) Mercury 1.0°N of star Regulus
Sun	9th		m.p. 16 Psyche 0.2°S of star Epsilon Tauri
Sun	9th	10 am	(8 am WST) star Aldebaran 0.7°S of Moon; Occn.
Mon	10th		Comet 10P/Tempel 2 1.0°NE of NGC 5634 (GC) in Virgo
Wed	12th	10 pm	(8 pm WST) Comet C/2013 US$_{10}$ (Catalina) 0.6°S of star Epsilon Pavonis
Thu	13th	3 pm	(1 pm WST) Mars 6°N of Moon
Sat	15th		Comet 10P/Tempel 2 1.0°SW of star Mu Virginis
Sat	15th	12:53 am	(10:53 pm WST, prev day) New Moon
Sun	16th	5 am	(3 am WST) Venus in inferior conjunction
Mon	17th	1 am	(11 pm WST, prev day) Mercury 2°N of Moon
Mon	17th	7 am	(5 am WST) m.p. 3 Juno 2°N of Moon
Mon	17th	pm	m.p. 135 Hertha 1.0°NE of star Sigma Sagittarii
Tue	18th	1 pm	(11 am WST) Moon at apogee, 405,848 km
Tue	18th	pm	m.p. 68 Leto 0.7°S of NGC 6925 (G) in Microscopium
Wed	19th		m.p. 20 Massalia 0.2°W of star Lambda Virginis
Wed	19th		Mercury 1.0°SW of m.p. 3 Juno
Wed	19th		Mercury at descending node
Thu	20th		m.p. 3 Juno 0.6°S of star Sigma Leonis
Thu	20th		Uranus 0.5°SE of star Zeta Piscium
Thu	20th	4 am	(2 am WST) star Spica 4°S of Moon
Thu	20th	7 am	(5 am WST) m.p. 3 Juno 1.3°N of Mercury
Fri	21st		m.p. 16 Psyche 0.2°NW of NGC 1647 (OC) in Taurus
Fri	21st		Mars 0.2°S of M44 Beehive Cluster (OC) in Cancer
Sun	23rd	3 am	(1 am WST) Saturn 3°S of Moon
Sun	23rd	5:31 am	(3:31 am WST) First Quarter Moon
Sun	23rd	7 pm	(5 pm WST) Comet C/2013 US$_{10}$ (Catalina) 0.7°W of star Alpha Trianguli Australis
Sun	23rd	11 pm	(9 pm WST) star Antares 10°S of Moon
Wed	26th	2 pm	(Noon WST) d.p. Pluto 3°S of Moon
Thu	27th	8 am	(6 am WST) Jupiter in conjunction with Sun
Fri	28th		Mercury 0.6°W of NGC 4030 (G) in Virgo
Sat	29th		Mercury at aphelion
Sat	29th	3 pm	(1 pm WST) Mars 9°N of Venus
Sat	29th	7 pm	(5 pm WST) Comet C/2013 US$_{10}$ (Catalina) 0.8°W of star Beta Trianguli Australis
Sun	30th	4:35 am	(2:35 am WST) Full Moon (358,992 km)
Sun	30th	10 am	(8 am WST) Neptune 3°S of Moon
Mon	31st		Venus at greatest latitude south
Mon	31st	1 am	(11 pm WST, prev day) Moon at perigee, 358,290 km



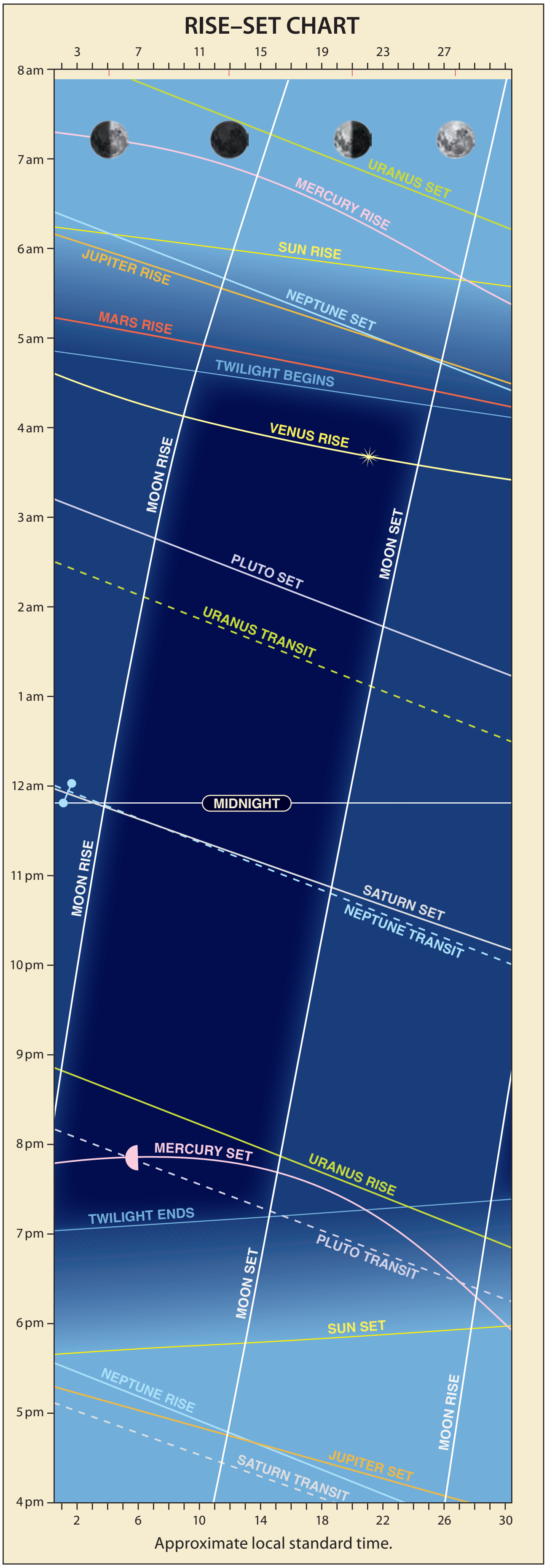


Approximate local standard time.





SEPTEMBER



HIGHLIGHTS

❍ Mercury at best for evening viewing.

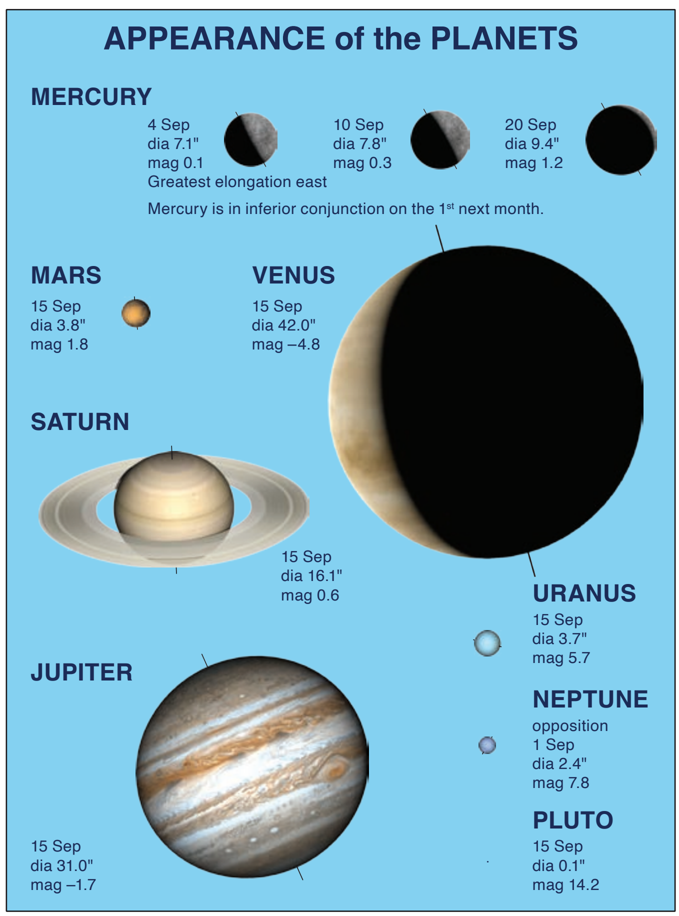
m Mars and Regulus close.

CONSTELLATIONS

September evening skies give Australians our most northerly view of the Milky Way. From mid latitudes this is marked by Cygnus the Swan, sitting on the northern horizon. It is often referred to as the Northern Cross, although upside down from our Southern Hemisphere perspective. Cygnus can be visualised as chasing another bird, Aquila the Eagle (directly above), also in the plane of our galaxy. Linking these feathered constellations is a dark rift, betraying the presence of unlit gas and dust clouds silhouetted against the Milky Way glow.

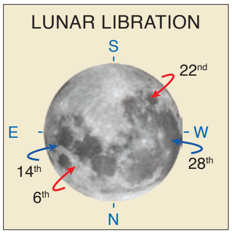
September evening skies offer some other excellent star patterns (asterisms). While looking in the direction of Cygnus, find the Summer Triangle consisting of the stars Altair (the top star, also known as Alpha Aquilae), Deneb (the lower right star – Alpha Cygni) and Vega (the bottom left star, Alpha Lyrae). Low in the northeast finds three bright stars from Pegasus and Alpha Andromedae that together make the Great Square of Pegasus (see All Sky Map No 9). Turning to the southwest, the Teapot of Sagittarius is tilting over as if pouring someone a celestial cuppa. It lies above the tail of Scorpius, as the scorpion prepares to dive head first below the western horizon.

Many of the far southern constellations are not visible from Europe and the Middle East and hence lack the rich Greek mythology of their famous northern brothers. Three of them, named after scientific instruments, are high in the southern evening sky during September. These constellations are quite faint and indistinct; so get away from the city lights to observe them. To the west of Grus lies Microscopium the Microscope. Move further west, past Corona Australis, to discover Telescopium the Telescope. Finally there is Octans the Octant where the South Celestial Pole currently resides.



SEPTEMBER

THE MOON



- 2nd 2 am (midnight, previous day WA) Occultation of Uranus by the Moon, visible from Wilkes Land, Victoria Land and most of New Zealand.
- 5th 4 pm (2 pm WST) Occultation of Aldebaran by the Moon, visible from eastern North America, Europe, western Russia and NW Asia.
- 5th 8 pm (6 pm WST) Last Quarter.
- 6th 9 pm (7 pm WST) Maximum Libration (10.1°), dark NE limb.
- 13th 5 pm (3 pm WST) New Moon.
- 14th 3 pm (1 pm WST) Minimum Libration (0.0°), too close to New Moon.
- 14th 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 406,464 km).
- 21st 7 pm (5 pm WST) First Quarter.
- 22nd 1 am (11 pm previous day WST) Maximum Libration (10.1°), dark SW limb. Features favoured by this libration are in darkness, but the effect is apparent when looking at the opposite side where it will be noted that Mare Crisium is now close to the limb.
- 28th 7 am (5 am WST) Minimum Libration (0.2°), near Full Moon.
- 28th Noon (10 am WST) Moon at perigee (closest to Earth at 356,877 km).
- 28th 1 pm (11 am WST) Full Moon.
- 29th 11 am (9 am WST) Occultation of Uranus by the Moon, visible from parts of Antarctica, South Africa and southern tip of Madagascar.

THE PLANETS

Mercury is at its best for observation in the western evening sky for the first three weeks of the month. Locating the planet at this time is relatively easy as it meanders in Virgo below the 1st magnitude star Spica (Alpha Virginis), and can be seen in a dark sky after the end of astronomical twilight. It reaches its greatest elongation east (27°) on the 4th – and then begins its journey back toward the Sun and inferior conjunction (1 October). On the 15th, the slender crescent of the 2-day old Moon appears to the north (right) of the planet (see Sky View).

Venus begins its job as the *Morning Star* this month, a position it will hold until June 2016 when it next goes into superior conjunction. Bright and bold in the morning dawn the planet spends most of the month in Cancer before moving into Leo. On the 10th, the 26-day old waning crescent Moon appears to the north (left) of Venus (see Sky View). The planet reaches its *greatest illuminated extent* (see July Venus section for definition) on the 22nd at –4.5 magnitude.

The **Earth** is at its vernal (spring) equinox on the 23rd. An observer on the equator will see the Sun rise due east and set due west. At this location, day and night are equal.

Mars is visible in the eastern dawn sky, moving through Cancer during the first week of the month before crossing into Leo. On the 11th, the 27-day old waning crescent Moon appears above and south (right) of the planet (see Sky View). From the 24th to 26th, Mars passes within 1° of Alpha Leonis (Regulus), the brightest star in the constellation of the Lion. Rotating in around 16 hours, this orange-red main sequence star is compressed into an oblate spheroid, much like a pumpkin, with its equatorial diameter 32% greater than its polar diameter.

Jupiter, after its solar conjunction, returns to the eastern dawn sky in Leo. By month end you will see Jupiter, Mars and Venus together in the constellation of the Lion.

Amateur Comet Hunting – The Legacy of Bill Bradfield

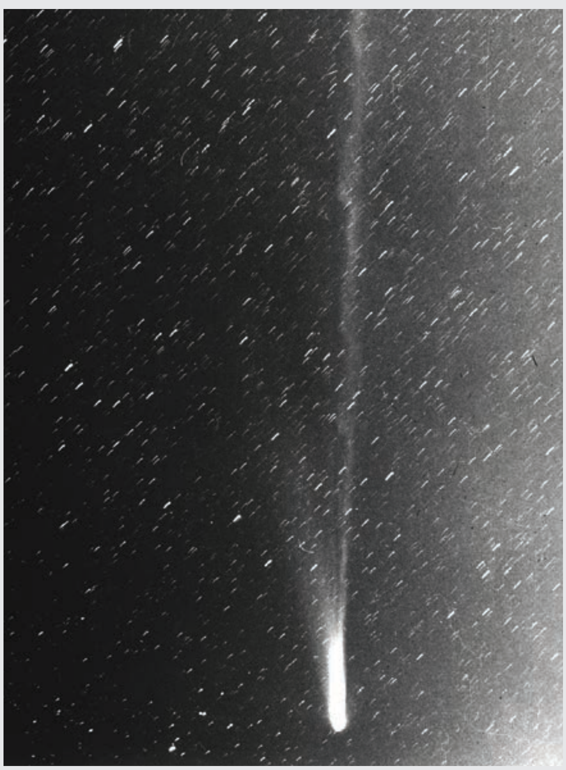
In June 2014, the amateur astronomy community lost a legend with the passing of William Bradfield. Bill, living near Adelaide in South Australia, was known worldwide as the most successful visual comet discover of the 20th century. He commenced his searching in 1971. After some 3,500 hours, stretching over 33 years, he discovered 18 comets. The fact that they were all sole discoveries, with him not having to share the name with anyone else, must also be a record. To put this remarkable achievement in perspective, only two people in history have surpassed his visual record – both predating Bradfield. Pons, in Europe, discovered about 30 (or more) but only had 26 named credits and in America, in the late 1800s and early 1900s, Brooks, who has 20 named comets. By visually we mean looking through an eyepiece while scanning across the sky looking for the appearance of fuzzy objects. Not all comets develop a tail or have obvious movement, especially when in the outer Solar System; so sorting them out from galaxies, globular star clusters, nebulae or previously know comets is an important part of the game.

What inspired him to look for comets?

He had some previous interest in comets but Ikeya-Seki in 1965 and Bennett in 1970 really sparked his interest. These were two of the brightest and most impressive comets of the century, both discovered visually by amateurs.

So how did Bradfield search?

Bill's equipment was pretty modest by today's amateur standards. He started out with a 150 mm refractor, which he used to discover the majority of his comets.



Comet Bradfield 1974b

He also used a 250 mm $f/5.6$ newtonian reflector and even made one discovery with 7 × 35 mm binoculars! As the light pollution increased in Adelaide he was forced to travel, setting up on the side of country roads. Does this sound like you? As a side note, he had many stories about being visited by farmers, the police and even had the occasional crack of gunshot blasts and searchlight beams from nearby rabbit shooters to keep him on his toes and fear for his life!

He would plan to sweep specific areas of the sky each night, finding it took him about two years to recognise most of the brighter deep sky objects, minimising constant referrals to star atlases. He didn't have the luxury of GOTO or pointing devices such as Argo Navis, which with a push of a button tells you what you are looking at. It was important to detect movement in any 'fuzzy' before reporting a find. Often spending hours going back to the object sometimes even after moonrise.

Why was he so successful?

Certainly determination was important. Bill had a number of droughts, sometimes going three years without any discoveries, but still pushed on. This is a virtue shared with American amateur Donald Machholz. It took Don four years (some 1,700 hours) to make his first discovery! Sometimes Bill's consistency paid off – for example once finding two comets in a fortnight! He also had the rare privilege of having two comet Bradfields observable at the same time, one in the evening, the other in the morning sky! These were his two discoveries in 1976. Also Bradfield had a strong competitive spirit. In his early days

… continued next page.

Saturn is visible in the early western evening sky after the end of dusk, setting prior to midnight. On the 19th, the 5-day old waxing crescent Moon appears nearby the planet (see Sky View). On the 20th, Comet Tempel 2 is only 2.3° north of Saturn.

Uranus rises a little after the end of astronomical dusk in the east and visible for the rest of the night as it heads towards opposition next month.

Amateur Comet Hunting … continued

Japanese amateurs were famous for their comet finding skills. He had a line drawn on his star maps, which marked the southern horizon as seen from Japan. He would always start his observing sessions by looking north to try and beat the Asians before heading into the south where there was less competition. Bill would search in the evenings within a few days after Full Moon and in the mornings a few days before Full Moon. Once again looking to get the jump on the competition. His commitment was truly remarkable having discovered the last Comet Bradfield in 2004 at the age of 76!

What are the chances for amateur visual discoveries today?

With the advent of professional automated imaging surveys such as PanSTARRS, Catalina, ISON and LINEAR, it is getting more difficult for visual amateurs to make new discoveries. The last was in November 2010, P/2010 V1 (Ikeya-Mirakami). The last four year's new comets have been found by electronic imaging (up to August 2014) – a long time since the last drink for the visual guys.

What Strategies to adopt?

If you are serious get competitive! Living in the Southern Hemisphere is a good start. The majority of the automated surveys are still located in the Northern Hemisphere, although Skymapper, near Coonabarabran, NSW (see page 6) has the potential to keep you on your toes. To detect a comet visually through amateur telescopes it needs to be bright. Comets are brightest during their perihelion (closest approach to the Sun). If the comet is passing inside the Earth's orbit it is likely to be near the Sun from our perspective. So don't hesitate to search low on the horizon, even when there is a hint of twilight around. The surveys won't take images that low and may not be working at all unless the sky is completely dark. This includes when the Moon is around, so take a leaf out of Bill's book and hunt when Luna is about to rise or just set. Search well south (high negative declinations), not only is there less competition but it's not unusual for comets to have high inclinations – they can come from anywhere! Also, if possible get someone else to confirm your discovery. Don't get a bad reputation with the IAU as the amateur who cries wolf. Finally, use today's technology effectively. See the comment above about GOTOs or have a planetarium programme, which uses the web to ensure it has the latest comets shown and if possible have it interfacing with your telescope. Such capability is not that expensive these days, so consult your local telescope dealer.

How have technological advancements revolutionised amateur comet hunting today?

Many amateurs have discovered comets by mining the daily images from the LASCO camera aboard the orbiting solar telescope SOHO, all from the comforts of home. This telescope takes images of the Sun 24 hours a day with them available to anyone through the net. SOHO has revolutionised our understanding of the population of sungrazing comets and since its launch in 1995, over 2,700 have been found!

Queenslander Terry Lovejoy epitomises the successful modern amateur comet hunter. He not only has discovered comets using SOHO but also has discovered five comets to date by directly imaging the sky using a CCD camera on a 20 cm Schmidt Cassegrain telescope. His most famous find was C/2011 W3 (Lovejoy). This was the first ground-based discovery of a Kreutz sungrazing comet in 40 years – made using amateur equipment! After surviving a passage through the Sun's corona it emerged to become the spectacular, naked-eye Christmas comet of 2011.

In conclusion, comet hunting is not for everyone but there is something we can all learn from these guys. Even if you just want to get out occasionally and enjoy the view of the Universe up close – *plan your nights*. For example, make a list of objects you'd like to observe. That way you won't fall into the trap of looking at the same half a dozen objects, getting bored and putting your telescope away.

The planet begins to move away from its companion stars of the past couple of months, Zeta and 88 Piscium. At 5.7 magnitude Uranus is visible to the unaided eye, but you will need a moonless night and keen eyesight away from light pollution.

Neptune is at opposition on the 1st, and is visible in the eastern sky after the end of astronomical twilight in Aquarius. Even at opposition, this distant outer world only appears as a bright *star* in small telescopes. Instruments larger than 100 mm and moderate magnification will resolve the planet into a small bluish disk.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, is an evening object crossing the meridian (due north) around 7 pm mid-month. It appears stationary on the 24th as it ends six months of retrograde motion, thereafter it returns to a west to east direction against the star field.

Minor Planets. Two of the brighter minor planets reach opposition this month in Aquarius, 9 Metis on 6th at magnitude 9.2 and 45 Eugenia on 16th at magnitude 11.2. Others at opposition include: 4 Vesta on 29th at

DIARY

Tue	1st	2 pm	(Noon WST) Neptune at opposition
Wed	2nd	2 am	(Midnight WST, prev day) Uranus 1.1°N of Moon; Occn.
Wed	2nd	7 pm	(5 pm WST) Comet C/2013 US_{10} (Catalina) 0.4°E of star Gamma Circini
Fri	4th	8 pm	(6 pm WST) Mercury at greatest elongation East (27.1°)
Sat	5th	4 pm	(2 pm WST) star Aldebaran 0.6°S of Moon; Occn.
Sat	5th	7:54 pm	(5:54 pm WST) Last Quarter Moon
Sun	6th	7 pm	(5 pm WST) Comet C/2013 US_{10} (Catalina) 0.9°E of NGC 5823 (OC) in Circinus
Sun	6th	9 pm	(7 pm WST) m.p. 129 Antigone 0.1°SW of NGC 6507 (C) in Sagittarius
Mon	7th		m.p. 2 Pallas 1.4°SW of star Alpha Herculis
Tue	8th	7 pm	(5 pm WST) Comet C/2013 US_{10} (Catalina) 0.6°NE of NGC 5822 (OC) in Lupus
Wed	9th	pm	m.p. 9 Metis 0.4°SE of NGC 7492 (GC) in Aquarius
Thu	10th	4 pm	(2 pm WST) Venus 3°S of Moon
Thu	10th	7 pm	(5 pm WST) Comet C/2013 US_{10} (Catalina) 1.6°W of star Zeta Lupi
Fri	11th	9 am	(7 am WST) Mars 5°N of Moon
Sat	12th		m.p. 20 Massalia 0.15°NW of star Alpha 2 Librae
Sat	12th		Mercury 0.5°W of NGC 4699 (G) in Virgo
Sat	12th	2 am	(Midnight WST, prev day) star Regulus 3°N of Moon
Sun	13th		Comet 10P/Tempel 2 0.8°NE of star Gamma Librae
Sun	13th	4:41 pm	(2:41 pm WST) New Moon; Eclipse
Mon	14th	9 pm	(7 pm WST) Moon at apogee, 406,464 km
Tue	15th		m.p. 11 Parthenope 0.4°SW of NGC 5878 (G) in Libra
Tue	15th	4 pm	(2 pm WST) Mercury 5°S of Moon
Wed	16th		m.p. 27 Euterpe 0.15°NE of M1 Crab Nebula (PN) in Taurus
Wed	16th	10 am	(8 am WST) star Spica 4°S of Moon
Wed	16th	7 pm	(5 pm WST) Comet C/2013 US_{10} (Catalina) 1.5°E of star Alpha Lupi
Thu	17th	7 pm	(5 pm WST) m.p. 44 Nysa 0.02°SW of star Kappa Virginis
Fri	18th	7 pm	(5 pm WST) m.p. 20 Massalia 0.1°W of NGC 5796 (G) in Libra
Sat	19th		Mercury at greatest latitude south
Sat	19th	1 pm	(11 am WST) Saturn 3°S of Moon
Sun	20th	6 am	(4 am WST) star Antares 10°S of Moon
Sun	20th	8 pm	(6 pm WST) m.p. 129 Antigone 0.1°NW of NGC 6567 (PN) in Sagittarius
Mon	21st	6:59 pm	(4:59 pm WST) First Quarter Moon
Tue	22nd	11 pm	(9 pm WST) d.p. Pluto 3°S of Moon
Wed	23rd	6 pm	(4 pm WST) Equinox
Wed	23rd	pm	m.p. 129 Antigone 0.9°SW of M24 Sagittarius Star Cloud (OC) in Sagittarius
Thu	24th	8 pm	(6 pm WST) Comet C/2013 US_{10} (Catalina) 1.3°E of star Eta Centauri
Thu	24th	pm	m.p. 9 Metis 1.0°S of star Delta Aquarii
Fri	25th		Mars 0.5°N of galaxy Leo 1 in Leo
Fri	25th	3 am	(1 am WST) Mars 0.8°N of star Regulus
Sat	26th	8 pm	(6 pm WST) Neptune 3°S of Moon
Sun	27th	2 pm	(Noon WST) m.p. 3 Juno in conjunction with Sun
Mon	28th	Noon	(10 am WST) Moon at perigee, 356,877 km
Mon	28th	12:51 pm	(10:51 am WST) Full Moon (356,879 km, closest for this year); Eclipse
Tue	29th	11 am	(9 am WST) Uranus 1.0°N of Moon; Occn.
Tue	29th	1 pm	(11 am WST) m.p. 4 Vesta at opposition

magnitude 6.2 in Cetus, 22 Kalliope on 8th at magnitude 10.5 near the Aquarius/Sculptor border and 13 Egeria on 13th at magnitude 10.7 near the Cetus/Aquarius border. During September and October 129 Antigone will have a number of close encounters with bright stars and star clusters in Sagittarius.

Comet 10P/Tempel 2 opens the month at 11th magnitude in Libra, where it remains until late September when it moves into Scorpius. Setting late in the evening, the first half of the month will see no moonlight interference in observing the comet. Tempel 2 remains approximately 9° from comet Kopff during September.

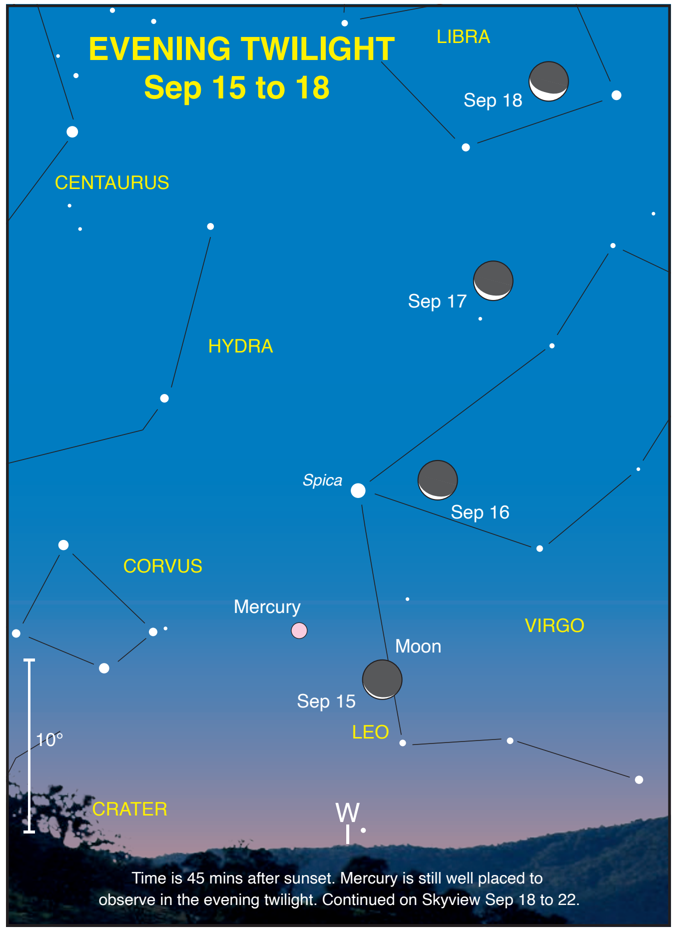
Comet 22P/Kopff remains at 12th magnitude and in Libra throughout September, setting mid-evening. Best observing will be in the first half of the month when the Moon is out of the sky.

Comet C/2013 US_{10} (Catalina) opens September in the constellation of Norma when it might be 7th magnitude in brightness. Quickly moving into Circinus and Lupus, Catalina is now best observed in the evening sky before it ends the month in Centaurus. Moonlight will interfere in the second half of the month.

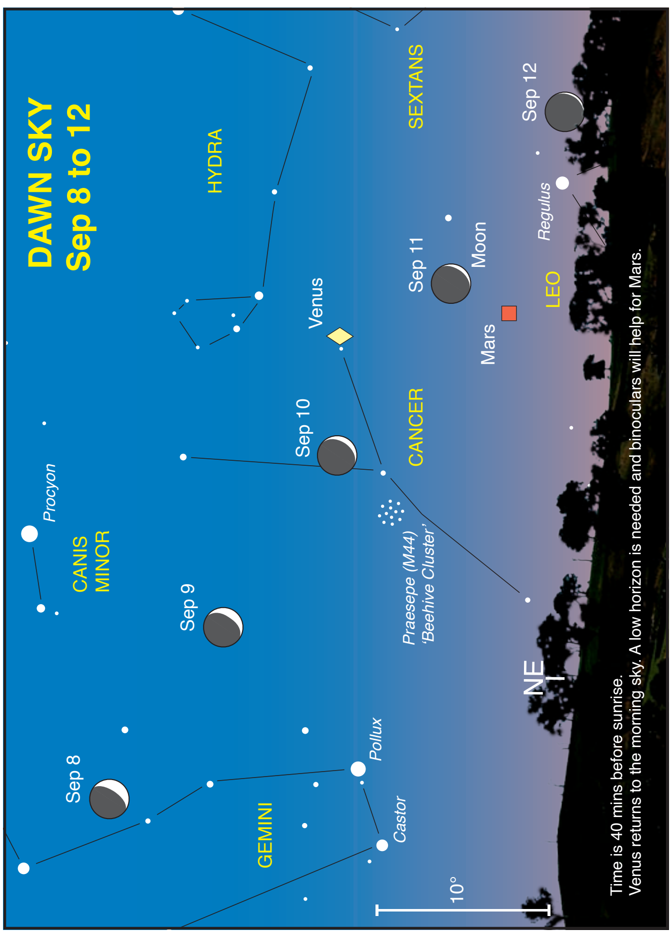
DOUBLE STARS

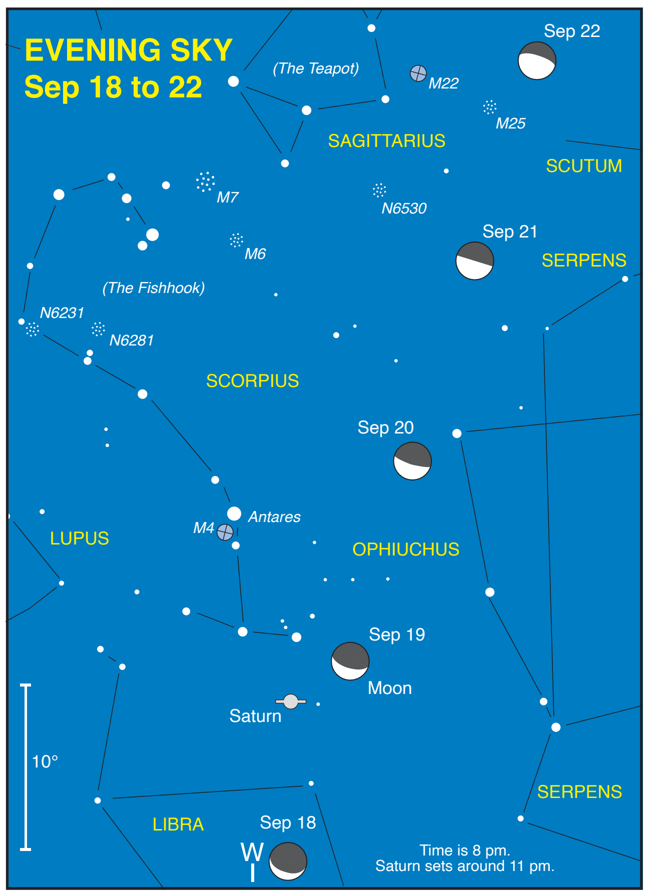
Located in the faint southern constellation of Indus, this month's telescopic double is **θ Indi**. This colourful unequal pair is composed of a magnitude 4.5 pale yellow primary and a magnitude 6.9 reddish companion separated by 7.3 arcseconds. The pair is physically connected and the separation has increased since the measurements of John Hershel in 1834. Theta is set in a field of scattered stars. (Map 8, p. 76)

Capricornus has a number of fine binocular doubles, one of which is **Rho Capricorni**. This pair of yellow and orange stars (magnitude 5.0 and 6.7), separated by 259 arcseconds, is an easy binocular target. They form part of a fine right angle triangle with ο and π Capricorni. The brighter star has a challenging fainter, close companion (magnitude 6.9, separation 1.5 arcseconds), which should be visible in telescopes over 20 cm in diameter in good seeing. (Map 8, p. 76)



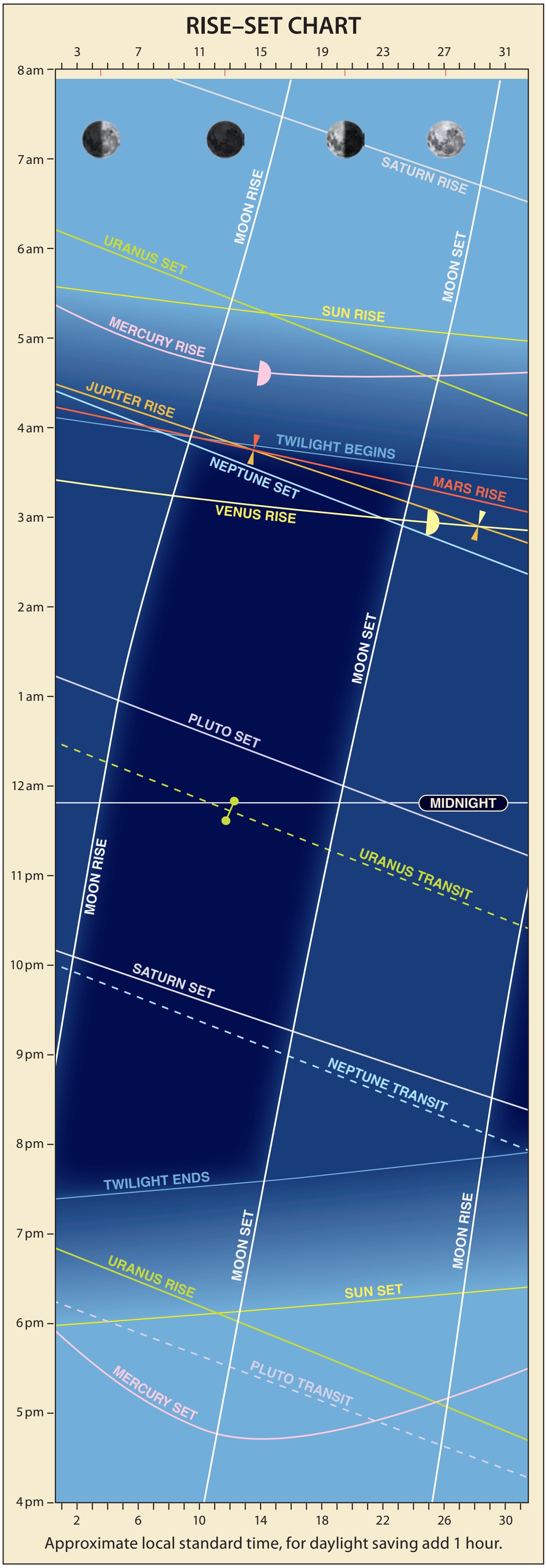
Approximate local standard time.





SEPTEMBER

OCTOBER



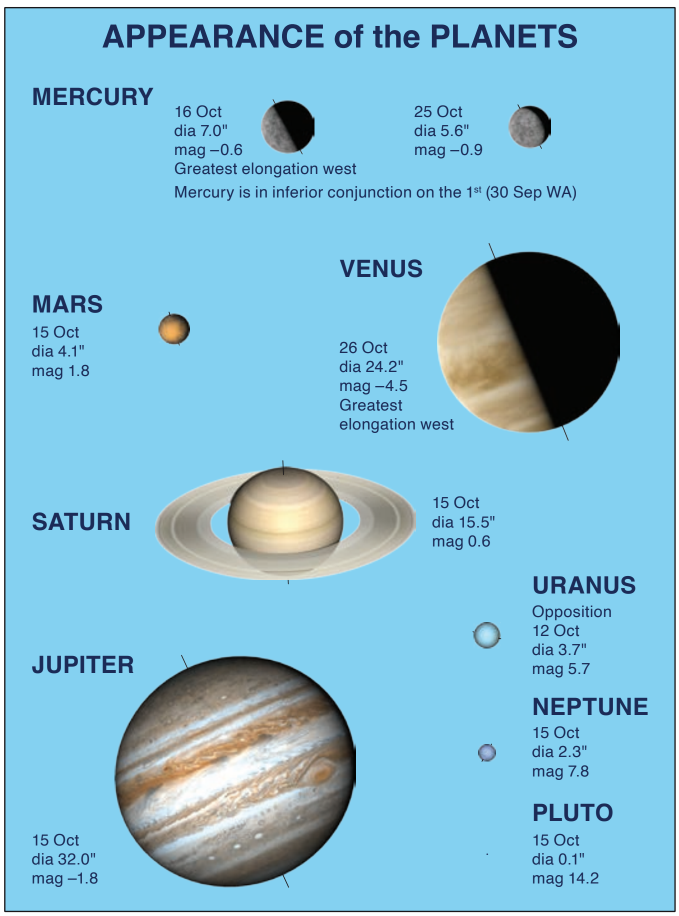
HIGHLIGHTS

- Occultation of Venus by the Moon.
- Venus close to Jupiter.
- Mars close to Jupiter.
- Venus close to Mars.
- Uranus at opposition.

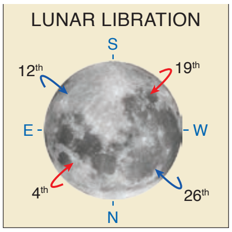
CONSTELLATIONS

The constellations of Piscis Austrinus (the Southern Fish) and Grus (the Crane) are high in the evening sky. They present quite a contrast. Piscis Austrinus is steeped in tradition dating back to the 2nd century. It is often shown with water from Aquarius' Water Jar flowing into the fish's mouth, marked by its only obvious feature, the 1st magnitude star Fomalhaut. The Water Jar is a 'Y' shaped asterism centred on Zeta Aquari (also see double star section on page 58 and All Sky Map No 8). Although Grus is much more distinctive, with its bow shaped arrangement of 2nd to 3rd magnitude stars, being further south it wasn't well known to the ancients and hence is a more modern constellation.

Water is certainly a theme amongst a number of constellations visible in October evening skies. Although Aquarius is known for his water jar, it's a challenge trying to find a human shape in its remaining faint (mostly 4th magnitude) stars. His neighbour to the west (or left when looking north) is Capricornus the Sea Goat. Its shape is more like a house roof or an inverted smile, but what does a sea goat look like anyway? Below (to the north) is a distinctive, compact group of five faint (4th magnitude) stars, Delphinus the Dolphin. Covering only 6° of sky this group makes a great target for low power binoculars under suburban lights. Four of the stars are arranged in a small distinctive diamond shape. On the other side of Aquarius is Pisces the Fish, best recognised by its not so fish-like 'circlet' marking the western fish. There is even a river, Eridanus, which ends at the bright star Achernar. The headwaters of this long meandering body of water lie near Orion. The entire river isn't visible until early morning.



THE MOON



- 2nd 11 pm (9 pm WST) Occultation of Aldebaran by the Moon, visible from Micronesia, Japan and North America.
- 4th 3 pm (1 pm WST) Maximum Libration (10.5°), dark NE limb.
- 5th 7 am (5 am WST) Last Quarter.
- 9th 7 am (5 am WST) Occultation of Venus by the Moon, visible from Australia except far west, eastern Melanesia, New Zealand and Victoria Land. See Venus section.
- 11th 10 pm (8 pm WST) Occultation of Mercury by the Moon, visible from south of South America, Falkland Islands and parts of Antarctica.
- 11th 11 pm (9 pm WST) Moon at apogee (furthest from Earth at 406,388 km).
- 12th 4 am (2 am WST) Minimum Libration (0.7°), too close to New Moon.
- 13th 10 am (8 am WST) New Moon.
- 19th 5 pm (3 pm WST) Maximum Libration (9.6°), dark SW limb.
- 21st 7 am (5 am WST) First Quarter.
- 26th 6 am (4 am WST) Minimum Libration (1.4°), dark NW limb
- 26th 8 pm (6 pm WST) Occultation of Uranus by the Moon, visible from New Zealand and southern French Polynesia.
- 26th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 358,463 km).
- 27th 10 pm (8 pm WST) Full Moon.
- 30th 9 am (7 am WST) Occultation of Aldebaran by the Moon, visible from NW Africa, Europe, Russia, northern Middle East and northern Asia.

THE PLANETS

Mercury begins the month in inferior conjunction (between the Earth and Sun) and then moves into the eastern dawn sky. The planet reaches its greatest elongation west (18°) of the Sun on the 16th. However, this is a poor apparition with Mercury barely above the horizon before sunrise – early risers would do better to view the interaction between Venus, Mars and Jupiter in Leo during the later half of October just before the end of astronomical dawn.

Venus has a busy month in the eastern dawn sky, firstly with a lunar occultation and then some interactions with Mars and Jupiter. The occultation occurs on the 9th (see Sky View and times for your location in Part II, Lunar Occultations) and is visible from the eastern and central states, Western Australia misses out with the event transpiring before Moon rise. Venus disappears on the bright lunar limb and reappears in the

Probing the Solar System

MERCURY

After three and a half years orbiting our Sun's closest planet, ***MESSENGER*** has completed over 3000 orbits. It is expected to make a final orbital correction in January 2015 leading to a termination of the mission with an impact into Mercury's northern hemisphere in late March. Meanwhile its instruments continue to gather data on the planet and its environment. messenger.jhuapl.edu/

VENUS

The ***Venus Express*** mission has been in orbit around our closest planetary neighbour gathering atmospheric information for eight years. It undertook a daring mission in May 2014 allowing Venus' gravity to drag it into a low orbit. For approximately a month it skimmed Venus' cloud tops coming within 140 km of the surface. This made possible measurements of the effect of atmospheric drag hence determining its density. The friction caused the spacecraft to exceed 100°C. It has since been returned to a safer altitude, however with little fuel remaining the mission is likely to end in December 2014 by burning up in the atmosphere. www.esa.int/esaMI/Venus_Express/

MARS

In August 2014 the ***Curiosity*** rover marked its two year anniversary on Mars and is currently driving towards its longer term science goals on the lower slopes of Mt Sharp. This terrain consists of a number of sand filled canyons. mars.jpl.nasa.gov/msl/

January 2014 marked the ten year anniversary of ***Opportunity*** on the surface of Mars. As of July 2014 it holds the off-Earth roving distance record having travelled 40 km since landing and currently exploring the west rim of Endeavour crater. www.nasa.gov/mission_pages/mer

Mars Odyssey, the longest-working spacecraft sent to the Red Planet, has been sending images since its arrival in 2002 using its THermal EMission Imaging System (THEMIS), a multi-band camera on the orbiter. In July 2014 the U.S. Geological Survey released a detailed global map of Mars using more than 20,000 THEMIS night time images. How quickly regions lose their heat after sunset tells much about the nature of the surface material. mars.jpl.nasa.gov/odyssey/

Mars Express was launched in June 2004. Eleven years later, it is still operating, and it will continue to return scientific data at least until the end of 2014. The spacecraft has been monitoring all aspects of the Martian environment, from the subsurface to the upper atmosphere and beyond to the two tiny moons. www.esa.int/esaMI/Mars_Express/

Mars Reconnaissance Orbiter has been in orbit since 2006. It continues to take detailed images of the ground using its High Resolution Imaging Science Experiment (HiRISE), This allows it to search for future landing sites for probes as well as find mineral deposits that may have formed in water. In December 2013 the orbiter imaged Curiosity and its tracks in Gale Crater. mars.jpl.nasa.gov/mro/

In November 2013, ***MAVEN*** (Mars Atmosphere and Volatile EvolutioN) was successfully launched, the first devoted space probe to understanding Mars' upper atmosphere. It is expected to enter orbit on September 22, 2014. www.nasa.gov/mission_pages/maven/

On October 19, 2014 **Comet Siding Spring (C/2013 A1)** will make its closest approach to Mars, at only 132 thousand kilometres. JPL is planning to make orbital adjustments to MRO, Mars Odyssey and the soon to arrive MAVEN. This not only optimises their positions to study the comet's nucleus, coma and tail but to minimise the risk of cometary debris striking the spacecraft. Curiosity and Opportunity on the ground will be looking for meteors in the atmosphere. mars.jpl.nasa.gov/comets/sidingspring/

JUPITER

The ***Juno*** probe is still on its way to Jupiter. On 5 August 2014 it celebrated three years since its launch with a further two years remaining, It did an Earth fly by in October 2013 for a gravity boast towards the gas giant. At closest approach more than 1,400 amateur radio operators around the world sent it the word 'hi' in morse code. At Jupiter its primary goal is to reveal the story of the formation and evolution of the planets while orbiting for a little over a year. www.nasa.gov/juno/

SATURN

In July 2014 ***Cassini*** celebrated ten years of observing Saturn, its moons and ring system. The spacecraft is still healthy, and since the end of its first extended mission in September 2010 it has been in its Solstice mission, now scheduled to end September 2017. In the coming years the most important targets will be Titan, Enceladus and some of Saturn's other icy moons. saturn.jpl.nasa.gov

DWARF PLANETS

The ***Dawn*** space probe, having completed its 14 month visit of minor planet Vesta in late 2012, has been en route to Ceres, with arrival due in April 2015. dawn.jpl.nasa.gov

New Horizons will make its much anticipated fly by of Pluto on 14 July 2015. See article on page 45. pluto.jhuapl.edu

COMETS

ESA's ***Rosetta*** spacecraft successfully arrived at Comet Churyumov-Gerasimenko on 6 August 2014. As of late August, Rosetta has drawn within 100 km of the surface and had found possible sites for the lander, Philae. Touchdown is expected in November 2014. www.esa.int/SPECIALS/Rosetta/

daytime from the dark limb. It is also the perfect opportunity to astound your friends and capture a glimpse of Venus in the daytime. After the occultation the planet does not stray more than a couple of degrees from the Moon up until noon (3° from WA). If you cannot see Venus with the unaided eye at first, try using binoculars – once found, lower the binoculars and look again, you will be amazed at how easy it is to see. The Moon and Venus will be west (left) of the Sun so for your comfort it is suggested to block the Sun with a building or tree. From the 22nd to month end Venus, Mars and Jupiter can be found within 5° of each other in the eastern morning sky in Leo (see Sky View), with Venus coming within 1° of Jupiter on the 26th – this is also the date of Venus' greatest elongation west of the Sun (46°).

Mars is visible in the eastern dawn sky together with Venus and Jupiter in Leo. On the 10th, the 27-day old waning crescent Moon appears to the south (right) of Mars with Jupiter below (see Sky View). Mars and Jupiter have a close rendezvous on the 18th when they're 0.4° apart (see Sky View), the low power telescope field made all the better with the presence of the 5th magnitude star Chi Leonis. Mars and Jupiter separate and the faster moving Venus glides past the gas giant and catches up with the Red Planet – at month end they will be 2° apart and even closer in early November.

Jupiter, in Leo, rises before the beginning of astronomical dawn in the eastern sky and the following events can be viewed (close to the horizon) in a dark sky. On the 10th, the waning crescent Moon, Jupiter and Mars form a triangle (see Sky View). On the 18th, Jupiter and Mars are a close 0.4° apart (see Sky View). Mars drops away from Jupiter and Venus comes closer until they are 1° apart on the 26th – the three planets remain close for the rest of the month (see Sky View).

Saturn is visible in the early western evening sky in Libra for the first half of the month then crosses back into Scorpius for the remainder. On the 16th, the slender crescent of the 3-day old waxing crescent Moon appears below the planet (see Sky View). At the end of October the planet will be within one degree of the brilliant double stars Beta and Nu Scorpii, detailed in the Saturn section in January and March respectively.

Uranus is at opposition on the 12th, rising in the early evening eastern sky in Pisces and visible the entire night. On the 26th, at astronomical dusk, the planet will be less than 0.3° from the limb of the 13-day old waxing gibbous Moon from the eastern states (0.5° from SA and just over 1° from WA) – our friends across the Tasman in New Zealand will witness an occultation. Uranus' magnitude at opposition is 5.7 and those with keen eyesight and dark skies should have no difficulty seeing this outer world from a dark sky location. Through the telescope, the planet is devoid of detail, but observers will note its blue/green colour. Even in a small telescope the planet looks different to stars of similar magnitude and by pushing up the magnification a few notches its planetary disc will be revealed.

Neptune, in Aquarius, transits the meridian (is due north) around 9 pm mid-month.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, transits the meridian (due north) around 6 pm mid-month.

Eris, in Cetus, is at opposition on the 16th. This 18.7 magnitude trans-Neptunian object, discovered in 2005, is three times the distance that Pluto is from the Sun. Apart from known long period comets and spacecraft, Eris and its moon are currently the most distant objects in the Solar System.

Minor Planets. Two of the brighter minor planets reach opposition this month in Cetus, 471 Papagena on 13th at magnitude 9.5 and 14 Irene on 29th at magnitude 10.4. Others include: 15 Eunomia on 3rd at magnitude 7.9 in Pegasus and 29 Amphitrite on 25th at magnitude 8.7 near the Aries/Pisces border.

Comet 10P/Tempel 2. As October opens it shines at 11th magnitude, setting late in the evening. The comet commences a tour of the hub of our galaxy starting with some encounters with deep sky objects in Ophiuchus early this month (see diary). By the end of the month, as Tempel 2 brightens to 10th magnitude, it will have moved into Sagittarius. The Moon will hinder observing in the second half of October. At the beginning of the month, the three comets mentioned here fit within a 30° circle.

Comet 22P/Kopff, setting in the mid evening, moves from Libra into Scorpius before spending the later half of October in Ophiuchus. This month sees Kopff reach perihelion, at a distance of 1.6 au from the Sun. It spends the month predicted to be around 11.5 magnitude. The Moon-free evenings of the first half of October will be best to sight Kopff. It follows comet 10P/Tempel 2 crossing the Milky Way's hub during October and November (see diary).

Comet C/2013 US_{10} (Catalina) is in Centaurus at the beginning of October, setting around 10 pm. Predicted to shine at 7th magnitude initially, Catalina should brighten to 6th by late October, by which time it will be hard to see in the evening twilight sky as it heads towards perihelion next month. Fortunately, there will be no interference from moonlight in the first half of October.

DIARY

Thu	1st	1 am	(11 pm WST, prev day) Mercury in inferior conjunction
Fri	2nd	11 pm	(9 pm WST) star Aldebaran 0.5°S of Moon; Occn.
Sun	4th		Comet 22P/Kopff 0.3°E of Saturn
Mon	5th		m.p. 27 Euterpe 0.9°S of star 1 Geminorum
Mon	5th		m.p. 4 Vesta 0.3°NW of NGC 153 in Cetus
Mon	5th	7:06 am	(5:06 am WST) Last Quarter Moon
Mon	5th	pm	m.p. 129 Antigone 0.9°S of M25 (OC) in Sagittarius
Wed	7th		Comet 22P/Kopff 0.8°SE of star Beta Scorpii
Thu	8th		m.p. 11 Parthenope 0.8°SW of star Theta Librae
Thu	8th		Mercury at ascending node
Fri	9th	7 am	(5 am WST) Venus 0.7°N of Moon; Occn.
Fri	9th	8 am	(6 am WST) star Regulus 3°N of Moon
Sat	10th	3 am	(1 am WST) Mars 3°N of Moon
Sat	10th	7 am	(5 am WST) Venus 3°S of star Regulus
Sat	10th	10 am	(8 am WST) Jupiter 3°N of Moon
Sun	11th	10 pm	(8 pm WST) Mercury 1.0°N of Moon; Occn.
Sun	11th	11 pm	(9 pm WST) Moon at apogee, 406,388 km
Mon	12th		Comet 10P/Tempel 2 1.0°NE of NGC 6235 (GC) in Ophiuchus
Mon	12th		Mercury at perihelion
Mon	12th	2 pm	(Noon WST) Uranus at opposition
Tue	13th		m.p. 27 Euterpe 0.2°SW of star Eta Geminorum
Tue	13th		Mars at greatest latitude north
Tue	13th	10:06 am	(8:06 am WST) New Moon
Wed	14th	pm	m.p. 29 Amphitrite 0.9°S of NGC 772 (G) in Aries
Thu	15th		Comet 10P/Tempel 2 0.8°N of NGC 6287 (GC) in Ophiuchus
Fri	16th		Mercury 0.6°NW of star Eta Virginis
Fri	16th	1 pm	(11 am WST) Mercury at greatest elongation West (18.1°)
Fri	16th	11 pm	(9 pm WST) Saturn 3°S of Moon
Sat	17th	Midnight	(10 pm WST) Jupiter 0.4°S of Mars
Sat	17th	Noon	(10 am WST) star Antares 10°S of Moon
Tue	20th		m.p. 11 Parthenope 1.0°NE of star Nu Scorpii
Tue	20th	6 am	(4 am WST) d.p. Pluto 3°S of Moon
Wed	21st		Jupiter 0.4°SW of star Chi Leonis
Wed	21st		m.p. 129 Antigone 0.8°S of NGC 6716 (OC) in Sagittarius
Wed	21st		m.p. 2 Pallas 0.7°NE of IC 4665 (OC) in Ophiuchus
Wed	21st		m.p. 27 Euterpe 0.2°S of star Mu Geminorum
Wed	21st		Mercury 0.9°S of star Gamma Virginis
Wed	21st	6:31 am	(4:31 am WST) First Quarter Moon
Thu	22nd		Comet 22P/Kopff 0.8°N of NGC 6235 (GC) in Ophiuchus
Thu	22nd		m.p. 129 Antigone 0.3°NW of star Xi 2 Sagittarii
Thu	22nd		Mercury at greatest latitude north
Fri	23rd		Comet 10P/Tempel 2 0.7°NE of NGC 6369 (PN) in Ophiuchus
Fri	23rd	pm	m.p. 135 Hertha 1.0°N of M75 (GC) in Sagittarius
Sat	24th		Saturn 0.7°N of star Beta Scorpii
Sat	24th	5 am	(3 am WST) Neptune 3°S of Moon
Sat	24th	pm	m.p. 192 Nausikaa 0.7°NE of star Zeta Persei
Sun	25th		Comet 10P/Tempel 2 0.4°N of NGC 6401 (GC) in Ophiuchus
Mon	26th		Comet 22P/Kopff 0.9°N of NGC 6287 (GC) in Ophiuchus
Mon	26th		Venus at ascending node
Mon	26th	5 pm	(3 pm WST) Venus at greatest elongation West (46.4°)
Mon	26th	6 pm	(4 pm WST) Jupiter 1.1°N of Venus
Mon	26th	8 pm	(6 pm WST) Uranus 0.9°N of Moon; Occn.
Mon	26th	11 pm	(9 pm WST) Moon at perigee, 358,463 km
Tue	27th		m.p. 129 Antigone 0.8°N of star Omicron Sagittarii
Tue	27th	10:05 pm	(8:05 pm WST) Full Moon (359,329 km)
Tue	27th	pm	m.p. 68 Leto 0.3°NW of star Omega Capricorni
Wed	28th		m.p. 532 Herculina 0.8°S of NGC 6342 (GC) in Ophiuchus
Thu	29th		m.p. 20 Massalia 0.6°S of star Beta Scorpii
Fri	30th		m.p. 20 Massalia 0.2°N of star Omega 1 Scorpii
Fri	30th	9 am	(7 am WST) star Aldebaran 0.6°S of Moon; Occn.
Fri	30th	9 pm	(7 pm WST) m.p. 129 Antigone 0.05°N of star Pi Sagittarii

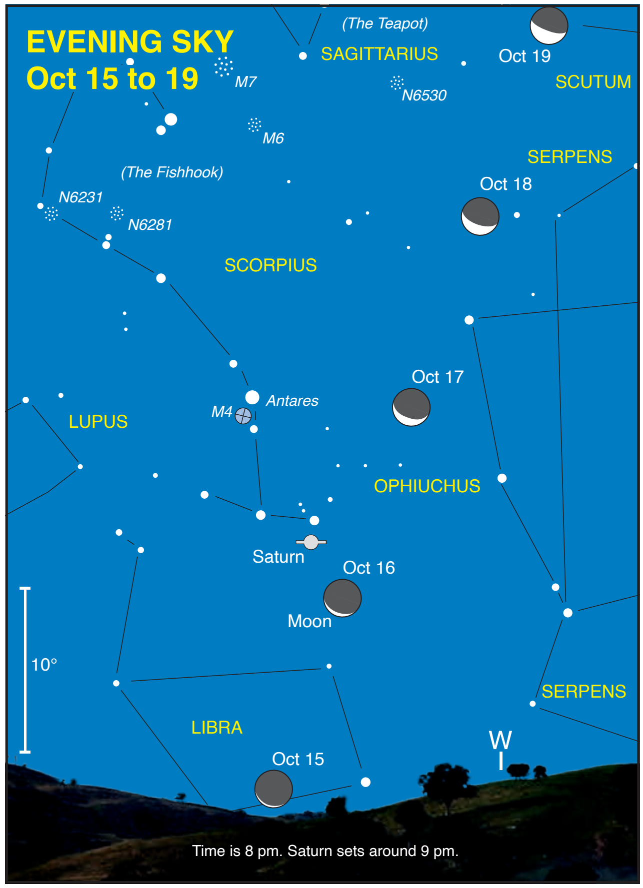
METEOR SHOWERS

The **Southern Taurids** are bright slow meteors from September to November, with the expected peak on October 10th. The shower is composed of two radiants of nearly equal activity ten degrees apart. The Southern Taurids peak around 10 October and the Northern Taurids next month on the 12th. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs, although not in every year. Their relative slowness and brightness makes them an ideal target for astrophotography. They are associated with Comet 2P/Encke, and can be seen from late evening to early morning.

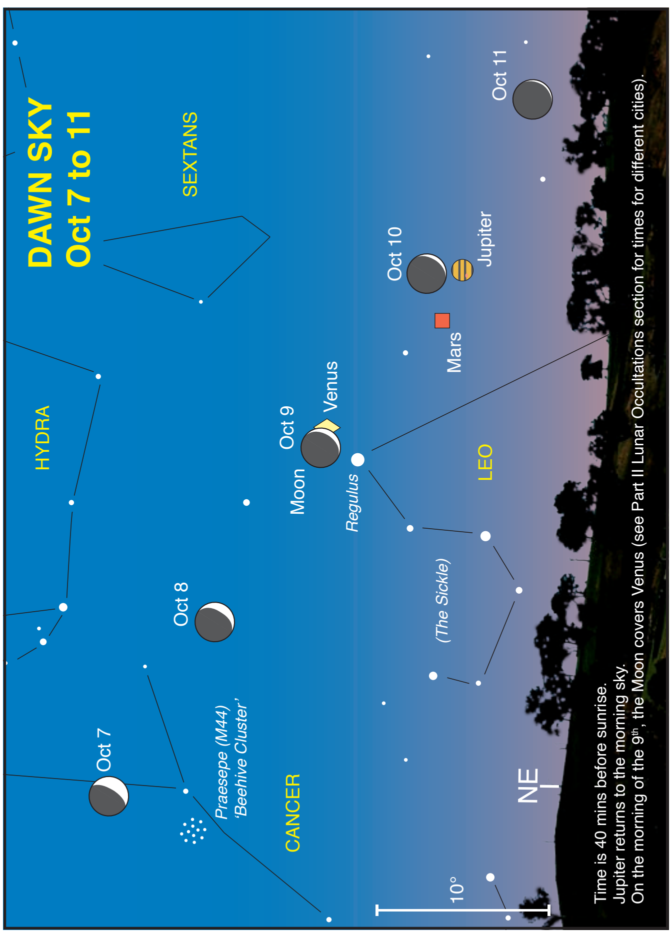
DOUBLE STARS

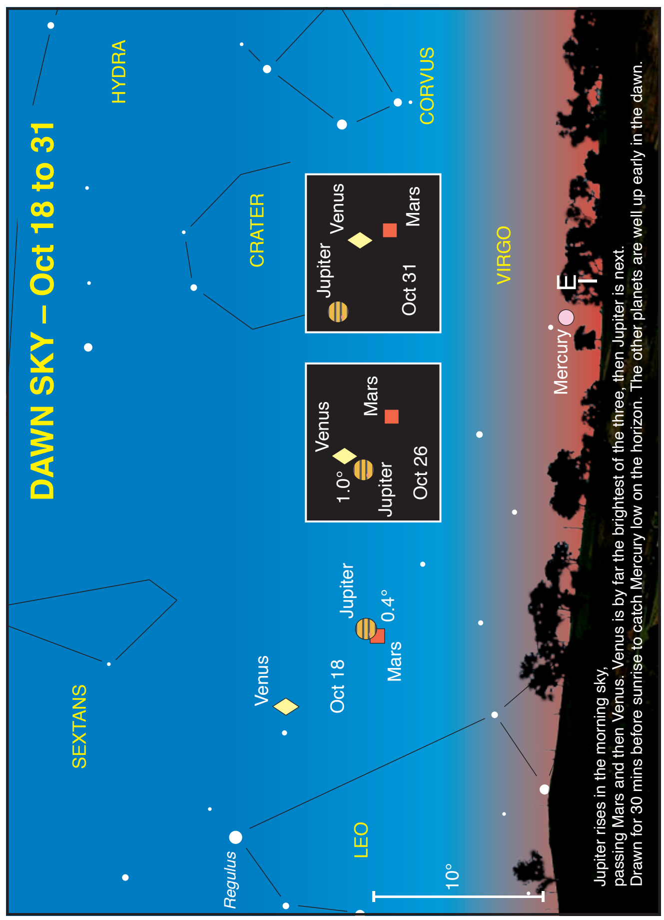
The asterism called the Water Jar is composed of the triangle formed by π, η and γ Aquarii, plus the central star, **ζ Aquarii**. Zeta is a beautiful close pair of bright yellow stars (magnitude 4.3 and 4.5) separated by 2.2 arcseconds and has an orbital period of 590 years. The primary is also a very close binary with a faint companion (magnitude 9.3, separation 0.5 arcseconds) and the whole system is located 76 light years away. (Map 8, p. 76)

Located in the distinctive southern constellation of Grus, the Crane, **δ¹ and δ² Gruis** are a naked eye pair and fine sight in binoculars. Although located at similar distances from us, this is an optical pair. The yellowish stars (magnitude 4.2 and 4.1) are separated by just over a quarter of a degree. Both stars have faint telescopic companions. (Map 8, p. 76)

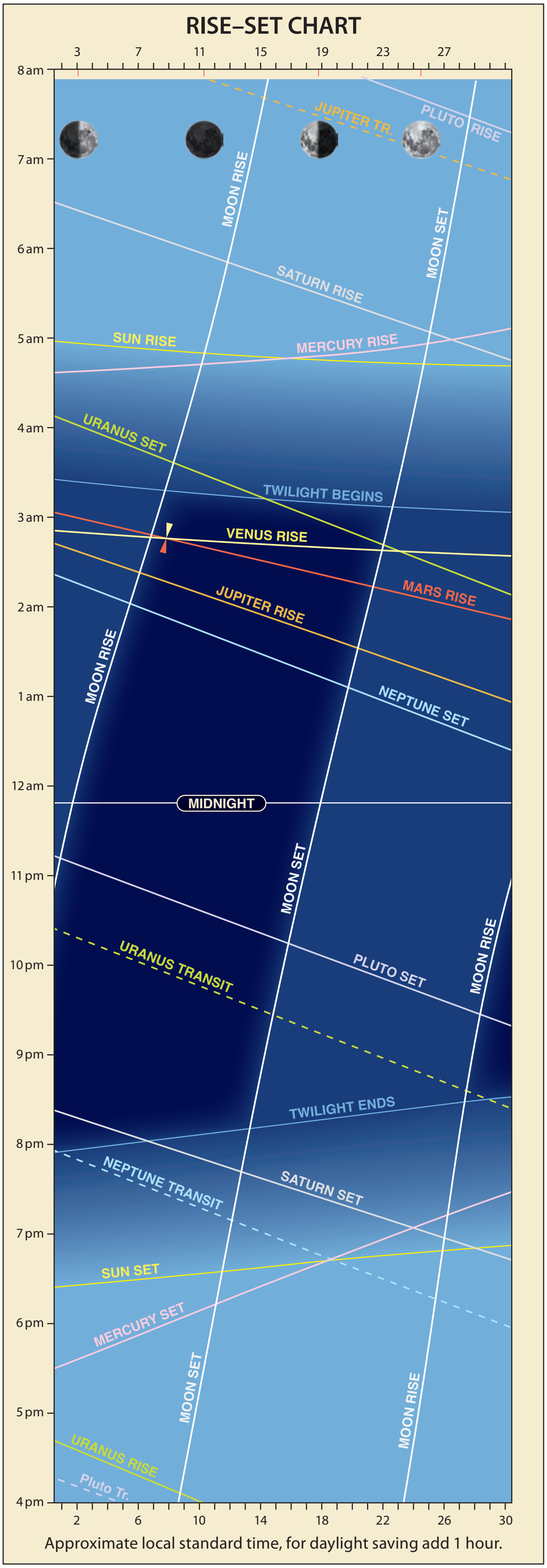


Approximate local standard time, for daylight saving add one hour.





NOVEMBER



HIGHLIGHTS

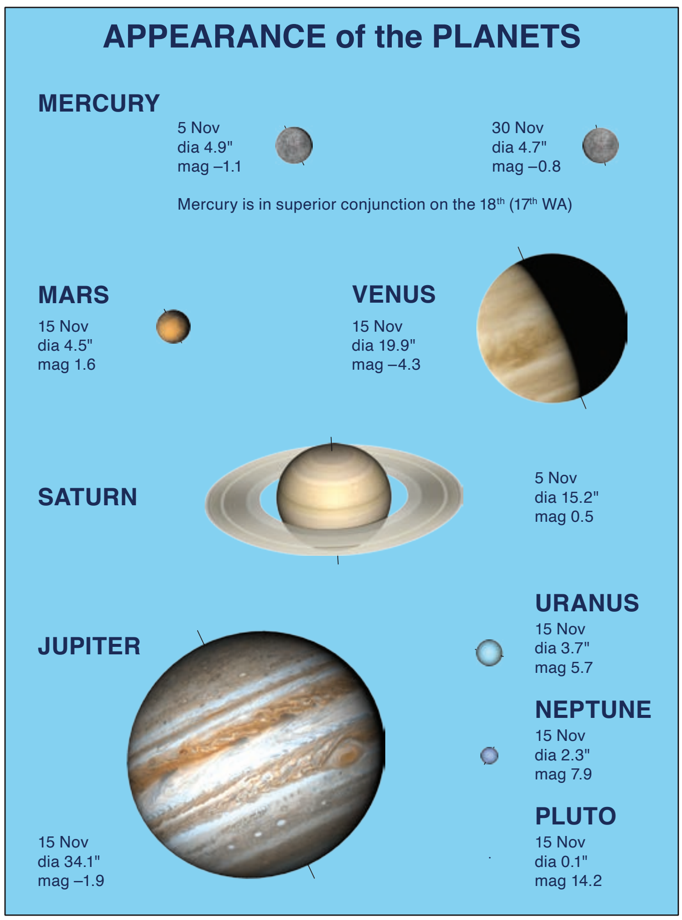
- Venus and Mars close.
- Jupiter and Moon close.
- Jupiter, Mars and Venus in dawn sky.
- Mars, Venus and the Moon together.
- Comet C/2013 US_{10} (Catalina) appears in the dawn sky.

CONSTELLATIONS

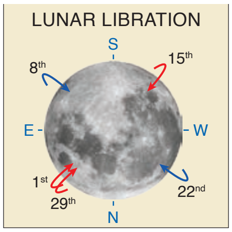
Experience the Milky Way skirting the horizon in the evening. Look up – and gaze below and out of the plane of our galaxy. The sky here is a complete contrast to the prominent constellations like Sagittarius (which is setting), the Southern Cross (now upside down hugging the southern horizon) and the low, but rising icons such as Orion and Canis Major. High in the south is zero magnitude Achernar (Alpha Eridani) burning in a relatively barren sky. Its isolation is interrupted to the south by the triangle of 3rd magnitude stars marking the water snake, Hydrus. Another southern icon is the obvious arc of stars forming Grus with nearby 1st magnitude star, Fomalhaut.

In the east Orion is returning to the evening sky. To its right is Sirius the brightest star in the night sky. Continue in this direction and higher to find the second brightest luminary, Canopus, in the southeast. Drawing a line between these stars and extending to the south finds the two Magellanic Clouds. First up is the Large (LMC) then continuing southward is the Small. Directly above the SMC is 0.5 magnitude Achernar (Alpha Eridani). Follow the numerous winding faint stars of this river, Eridanus, to go full circle, back to Orion.

Cetus the Whale is a large constellation, which is due north in November evening skies. Its most obvious feature, the ‘Head of Cetus’, is a group of six stars arranged in a pentagon shape, left (west) of Taurus. Its brightest member is Alpha Ceti (upper right) at magnitude 2.5, then Gamma (centre top) at magnitude 3.4 with the balance ranging from 4.2 down to 4.8. If you live in suburbia how many can you see? The remainder of Cetus is made up of scattered mostly faint stars, extending almost to the zenith from mid-latitude Australia.



THE MOON



- 1st 11 am (9 am WST) Maximum Libration (10.1°), dark NE limb.
- 3rd 10 pm (8 pm) Last Quarter.
- 8th 8 am (6 am WST) Moon at apogee (furthest from Earth at 405,721 km).
- 8th 3 pm (1 pm WST) Minimum Libration (1.1°), dark SE limb.
- 12th 4 am (2 am WST) New Moon.
- 15th 9 pm (7 pm WST) Maximum Libration (8.6°), dark SW limb. Features favoured by this libration are in darkness but nonetheless its effects are apparent on the opposite limb where prominent features like the crater Endymion and Mare Crisium are depressed toward the limb.
- 19th 4 pm (2 pm WST) First Quarter.
- 22nd 6 pm (4 pm WST) Minimum Libration (2.2°), dark NW limb.
- 23rd 5 am (3 am WST) Occultation of Uranus by the Moon, visible from Queen Maud Land, Enderby Land and southern Indian Ocean.
- 24th 6 am (4 am WST) Moon at perigee (closest to Earth, 362,817 km).
- 26th 9 am (7 am WST) Full Moon.
- 26th 8 pm (6 pm WST) Occultation of Aldebaran by the Moon, visible from Japan, Eastern Russia, northern USA, Canada and Greenland.
- 29th 4 am (2 am WST) Maximum Libration (9.1°), dark NE limb.

THE PLANETS

Mercury stays close to the Sun and unobservable during November. It moves from the morning sky, into superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 18th and into the western evening dusk sky. As a matter of interest the planet will be occulted by the Sun's disk at this conjunction. Like a transit across the face of the Sun these *eclipses* of Mercury are relatively infrequent, the next such occurrences being May 2020 and November 2022.

Venus begins the month close to Mars in the predawn eastern sky, the distance between the pair narrows to 0.7° on the 3rd and 4th (see Sky View) and then Venus drops away toward the Sun. A pleasant view occurs on the 8th when Venus is situated between Mars and the 26-day old waning crescent Moon (see Sky View).

Mars spends the first couple of days of November in Leo before crossing into Virgo. Rising just before astronomical dawn begins, it shares the eastern horizon with the brightest two planets, Venus and Jupiter. The Red Planet and Venus will be within 1° of each other between the 2nd

Voids in the Heavens

Edward Emerson (E. E.) Barnard (1857–1923) was one of the great American astronomers of the 19th century. With the exception of just two months of formal schooling, his widowed mother provided Edward's rudimentary education. When not quite nine years old be began an apprenticeship as a photographer's assistant – a trade that would serve him well in later life.

In his late teens he became so fascinated with a popular book on astronomy that he constructed his first telescope – a 2.5 cm lens mounted in a tube. From his small earnings at the photographic studio he scrimped and saved to purchase a 12.5 cm refracting telescope (costing two thirds of his annual salary). In 1881 he began to search for comets and found a total of 19 (including two co-discoveries) during his career. He was also the first person to discover a comet by photographic means (comet D/1892 T1).

Among his achievements was the discovery of the fifth moon of Jupiter, Almathea. It was the first visual detection of a satellite of the giant planet since Galileo – it would also be the last visual planetary moon discovery by any astronomer, the rest are the result of photography and spacecraft imagery. Whilst watching Saturn's moon Iapetus behind the planet's rings, he noticed a shadow pass over the satellite – believed to be the first observation of the 'spokes' in the rings seen by the Voyager and Cassini spacecraft.

After a careful and prolonged study of Nova Aurigae (1891), Barnard noticed the sharply defined nebula around the star and correctly deduced it to be the result of a high-energy explosion of some kind. In 1916, he discovered the large proper motion of a 10th magnitude red dwarf star now known as 'Barnard's Star'. Lying about six light-years from our solar system, it is the closest star after the three components of the Alpha Centauri system and has by far the greatest proper motion of any known star. He found a small faint galaxy, now called 'Barnard's Galaxy' (NGC 6822 – a member of the Local Group) – Edwin Hubble used this galaxy to show these were indeed island universes far outside the Milky Way.

B72 the 'Snake' or 'S' nebula – both images by Joe Cauchi

B86 the 'Ink Spot' nebula with open cluster NGC 6520

Barnard took an interest in wide-field astrophotography of the Milky Way and had a custom instrument constructed for this purpose. Consisting of a 12.5 cm guide telescope and two photographic doublets of 25 and 16.5 cm aperture the combined instrument was used to photograph the Milky Way. Each plate was exposed for two to five hours, while constantly guiding the instrument. His images were published (after his death) as A Photographic Atlas of Selected Regions of the Milky Way to great acclaim.

The beautiful panoramas presented in his book show starry fields containing dark lanes and voids. Astronomers at one stage regarded these patches as openings in the Milky Way through which one could look out into the darkness beyond the stars – Barnard eventually realised their true nature. The dark nebulae were in fact dense interstellar clouds of dust obscuring the background.

A classic example of a dark nebula is the Horsehead in Orion; it is silhouetted against a region of bright emission nebulae (see image page 11). The largest dark nebulae however, are visible to the unaided eye and best observed away from city lights. Around August, when the Milky Way is high, you can trace the thick dust clouds known as the Great Rift stretching from the constellation of Cygnus in the north to Sagittarius overhead.

… continued next page

and 5th, with closest approach of 0.7° on the 3rd and 4th (see Sky View). On the 30th, Mars will be a little over 1° from the second brightest star in Virgo, 3rd magnitude Porrima (Gamma Virginis). Porrima is a showcase double of some note, and appears as a stunning duo of equally bright yellowish suns (each 3.5 magnitude). They reached periastron (the point when the stars are closest) in 2005 and were impossible to split with anything but very large telescopes. They are now widening again in their 169-year orbit and within reach of a 150 mm telescope under good seeing conditions (separation 1.9 arcseconds, see also Double Stars p. 38).

Jupiter's close planetary companions of the past several weeks, Venus and Mars, take leave of the gas giant and move into Virgo. The planet is visible low in the eastern sky prior to the brightening dawn. On the 7th, the 25-day old waning crescent Moon appears 2.5° from Jupiter (see Sky View).

Saturn is only visible low to the western horizon for a short time after evening dusk and by mid-month will be absorbed into the twilight. On the 7th, the planet will be around four arcminutes from the 4th magnitude quadruple star Nu Scorpii, although the altitude and thick atmosphere are not exactly conducive for splitting double stars (see Double Stars p. 47). On the 13th the planet will be a little south (left) of the 2-day old Moon – a difficult observation in the twilight although binoculars will help. Saturn is in conjunction (on the opposite side of the Sun from Earth) on the 30th, and will be lost from view until its return to the morning sky in Ophiuchus late December.

Uranus, now past opposition, transits the meridian (is due north) around 9:30 pm mid-month in Pisces.

Neptune is high in the early north-western evening sky at the end of astronomical dusk in Aquarius. The planet appears stationary on the 19th after five months in retrograde, returning to a west to east direction against the star-field.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto, in Sagittarius, sets around 10:30 pm mid-month. Between the 16th and 18th the little world will be swamped by the brilliance of Chi^2 Sagittarii as it passes within two arcminutes of this 4th magnitude star.

Minor Planets. Three of the brighter minor planets reach opposition this month in Cetus, 121 Hermione on 4th at magnitude 11.5, 39 Laetitia on 7th at magnitude 9.5 and 103 Hera on 11th at magnitude 11.2. Two reach opposition in Perseus, 192 Nausikaa on 20th at magnitude 9.0 and 54 Alexandra on 24th at magnitude 11.9. Also at opposition are 26 Proserpina on 22nd at magnitude 11.3 in Taurus and 43 Ariadne on 18th at magnitude 10.8 near the Taurus/Aries border.

Voids in the Heavens … continued

The most famous and prominent of the southern hemisphere's dark nebulae is the Coal Sack. This 7 × 5 degree region of blackness cloaking the background Milky Way lies primarily in Crux. To the Australian aborigines it was the head and beak of the Emu and the 5th magnitude star BZ Crucis, the eye. The Emu is most easily recognised in the evening skies around March/April when its body can be traced by the dark lanes in the Milky Way going from Crux to the southeastern horizon. Nearby the Coal Sack, in Musca, is the Dark Doodad Nebula – a wonderful 3° long curving streak with the globular cluster NGC 4372 in the same field.

Dark nebulae can be fun to track down and observe however many will challenge even the most experienced amateur. The most important criteria are dark skies away from city lights. The smallest optical instrument you should use is your eye – just gaze at the Milky Way to appreciate the amount of obscuring matter blocking our view. Binoculars are the next best instrument – 7 × 50 or larger provide amazing views of our galaxy. Finally a telescope – since scores of dark nebulae are 30 arcminutes (Full Moon size) or larger in size, a nice wide field of view is essential.

A copy of Barnard's catalogue can be downloaded from the link below – it contains descriptions of all his 370 objects, however there are many dark nebulae in the southern skies that are not included. If you are prepared to do a little digging, an excellent source is the Uranometria Deep Sky Atlas, the size and scale of the dark nebulae is shown on the charts. www.dvaa.org/AData/Barnard.html

Comet C/2013 US_{10} (Catalina) after passing through perihelion on 15th, moves into the dawn sky in the later half of November. It is predicted to be at maximum brightness of approximately 5.5 magnitude. At month's end it is rising just after the beginning of astronomical dawn, about 12° to the lower right of Spica. Unfortunately the Moon will be in the morning sky at that time.

Comet 10P/Tempel 2 opens November in Sagittarius at 10th magnitude. Perihelion for Tempel 2's current apparition is this month on the 14th, at a distance of 1.4 au from the Sun. Low in the evening sky, it closes November with an altitude of about 20° at the end of astronomical twilight. Unfortunately the Moon will be in the evening sky during the second half of November. It continues its trip through the galactic centre calling on a number of deep sky objects in Sagittarius this month (see

DIARY

Sun	1st		Comet 10P/Tempel 2 0.5°W of M8 Lagoon Nebula (BN) in Sagittarius
Tue	3rd	10:24 pm	(8:24 pm WST) Last Quarter Moon
Wed	4th	2 am	(Midnight WST, prev day) Mars 0.7°N of Venus
Thu	5th	3 pm	(1 pm WST) star Regulus 3°N of Moon
Fri	6th		m.p. 21 Lutetia 1.1°SE of star Delta Capricorni
Fri	6th		Venus 0.5°NW of star Beta Virginis
Sat	7th		Comet 10P/Tempel 2 0.3°W of M28 (GC) in Sagittarius
Sat	7th	Midnight	(10 pm WST) Venus 1.2°N of Moon
Sat	7th	2 am	(Midnight WST, prev day) Jupiter 2°N of Moon
Sat	7th	7 pm	(5 pm WST) Saturn 0.05°NW of star Nu Scorpii
Sat	7th	8 pm	(6 pm WST) Mars 1.8°N of Moon
Sat	7th	pm	m.p. 192 Nausikaa 1.0°N of star Omicron Persei
Sat	7th	pm	m.p. 29 Amphitrite 1.0°N of M74 (SG) in Pisces
Sun	8th		Comet 10P/Tempel 2 0.4°NW of star Lambda Sagittarii
Sun	8th		Mars 0.9°N of star Beta Virginis
Sun	8th	8 am	(6 am WST) Moon at apogee, 405,721 km
Mon	9th		Comet 10P/Tempel 2 0.3°N of NGC 6638 (GC) in Sagittarius
Mon	9th		Comet 22P/Kopff 0.7°S of NGC 6469 (OC) in Sagittarius
Mon	9th	7 pm	(5 pm WST) m.p. 3 Juno 2°N of Moon
Mon	9th	11 pm	(9 pm WST) star Spica 4°S of Moon
Thu	12th	3:47 am	(1:47 am WST) New Moon
Thu	12th	8 pm	(6 pm WST) Comet 22P/Kopff 0.1°SE of M20 Trifid Nebula (BN) in Sagittarius
Fri	13th		Comet 22P/Kopff 0.3°NW of NGC 6546 (OC) in Sagittarius
Fri	13th		Venus 0.5°NW of star Eta Virginis
Fri	13th	11 am	(9 am WST) Saturn 3°S of Moon
Fri	13th	6 pm	(4 pm WST) star Antares 9°S of Moon
Sat	14th		Jupiter 0.7°SW of star Sigma Leonis
Sat	14th		Mars 0.7°SW of NGC 4073 (G) in Virgo
Sun	15th		Mercury at descending node
Sun	15th	10 am	(8 am WST) m.p. 3 Juno 6°N of star Spica
Mon	16th		Comet 10P/Tempel 2 0.8°N of star Sigma Sagittarii
Mon	16th		m.p. 532 Herculina 0.5°N of NGC 6469 (OC) in Sagittarius
Mon	16th	Noon	(10 am WST) d.p. Pluto 3°S of Moon
Tue	17th		d.p. Pluto 0.02°N of star Xi 2 Sagittarii
Tue	17th		Mars 1.0°SW of NGC 4179 (G) in Virgo
Wed	18th		Venus 1.0°SW of star Gamma Virginis
Wed	18th	1 am	(11 pm WST, prev day) Mercury in superior conjunction
Wed	18th	pm	m.p. 29 Amphitrite 1.2°NW of star Eta Piscium
Wed	18th	pm	m.p. 9 Metis 0.6°S of star Tau 2 Aquarii
Thu	19th	4:27 pm	(2:27 pm WST) First Quarter Moon
Fri	20th		Mars at aphelion
Fri	20th		Venus 0.4°NW of NGC 4691 (G) in Virgo
Fri	20th	Noon	(10 am WST) Neptune 3°S of Moon
Sat	21st		Comet 22P/Kopff 0.3°NE of NGC 6642 (GC) in Sagittarius
Sun	22nd		Comet 22P/Kopff 0.7°N of M22 (GC) in Sagittarius
Sun	22nd		Mars 0.2°E of star Eta Virginis
Sun	22nd	9 pm	(7 pm WST) m.p. 68 Leto 0.2°SW of star Zeta Capricorni
Mon	23rd		m.p. 135 Hertha 0.6°NW of star Theta Capricorni
Mon	23rd	5 am	(3 am WST) Uranus 0.9°N of Moon; Occn.
Tue	24th	6 am	(4 am WST) Moon at perigee, 362,817 km
Wed	25th		Mercury at aphelion
Thu	26th	8:44 am	(6:44 am WST) Full Moon (366,154 km)
Thu	26th	8 pm	(6 pm WST) star Aldebaran 0.7°S of Moon; Occn.
Fri	27th	pm	d.p. Ceres 0.3°NW of star Omega Capricorni
Sat	28th		Comet 22P/Kopff 0.4°SE of NGC 6717 (GC) in Sagittarius
Sun	29th		Venus at perihelion
Sun	29th	2 am	(Midnight WST, prev day) Venus 4°N of star Spica
Mon	30th		Mars 1.4°SW of star Gamma Virginis
Mon	30th	10 am	(8 am WST) Saturn in conjunction with Sun

diary). This includes passing close to the Teapot asterism. Tempel 2 spends the month approximately 9° above comet 22P/Kopff.

Comet 22P/Kopff is now close to 12th magnitude, setting around an hour after the end of twilight. It encounters a number of deep sky objects in Sagittarius this month including a close visit to the Trifid Nebula on 12th (see diary).

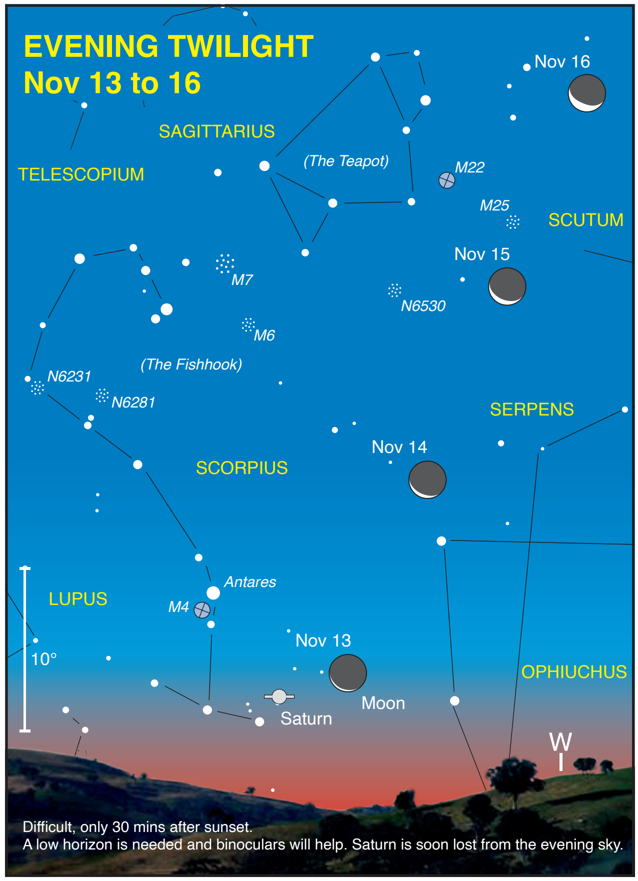
METEOR SHOWERS.

The **Northern Taurids** are bright slow meteors active during October and November. The shower is composed of two radiants of nearly equal activity ten degrees apart. The Northern Taurids peak around 12th November and the Southern Taurids in October. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs (although not in every year). Four of the last five Northern Taurids showers have displayed unusual and variable activity (the exception was 2012), so it may pay to keep a watch this year. Their relative slowness and brightness makes them an ideal target for astroimaging. They are associated with Comet 2P/Encke, and can be seen from late evening to early morning. There will be no lunar interference this year with New Moon occurring during the peak.

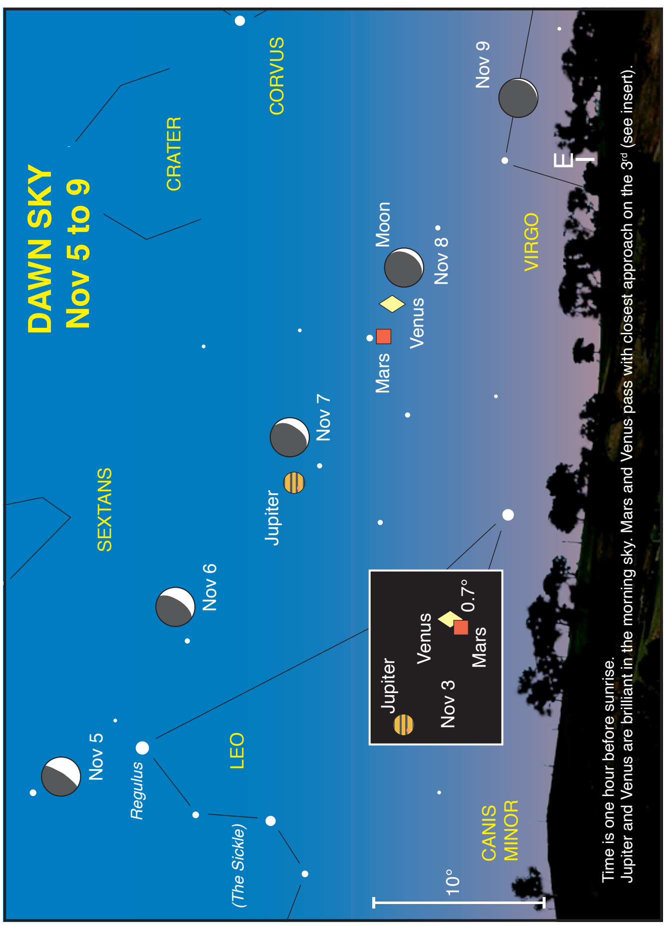
DOUBLE STARS

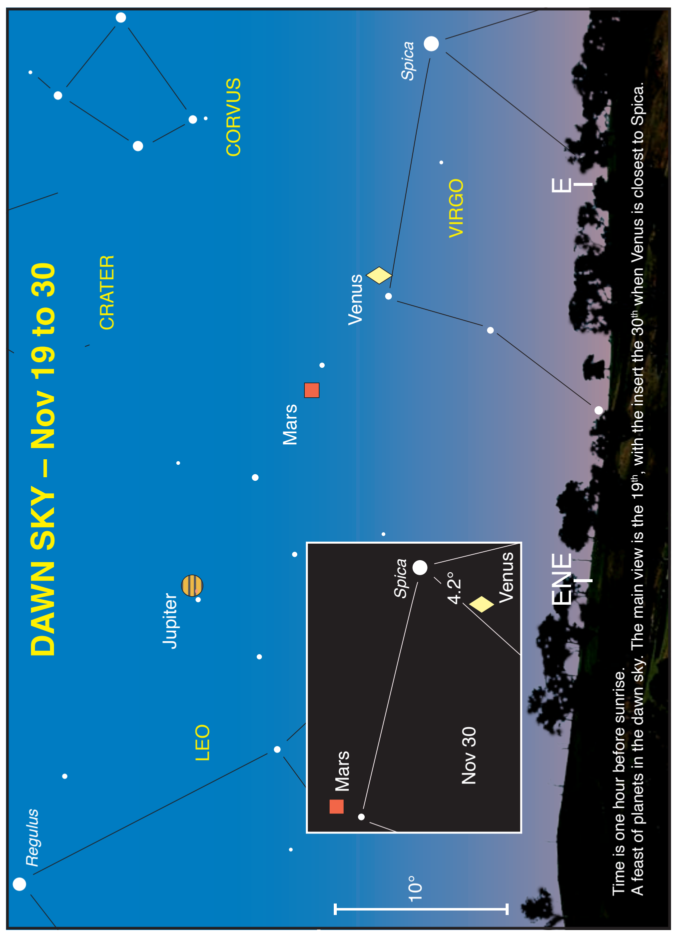
Located in the far northern sky, **γ Andromedae** (Almach) is one of the most colourful doubles in the night sky. This brilliant pair of orange and green gems (magnitude 2.3 and 5.0) is separated by 9.8 arcseconds. The secondary is also a tight binary (magnitude 6.3, separation 0.2 arcseconds). (Map 3, p. 71)

Located next to the very unequal telescopic double ζ Ceti, **χ Ceti** is a fine binocular double. This mismatched pair of white stars (magnitude 4.7 and 6.8) is separated by 193 arcseconds. Whilst in the region have a search for o Ceti (Mira) a famous long period pulsating variable star. This star varies from magnitude 2.0 to 10.1 over a period of 331.96 days and actually has a variable, white dwarf companion out of the reach of amateur telescopes. (Map 2, p. 70)

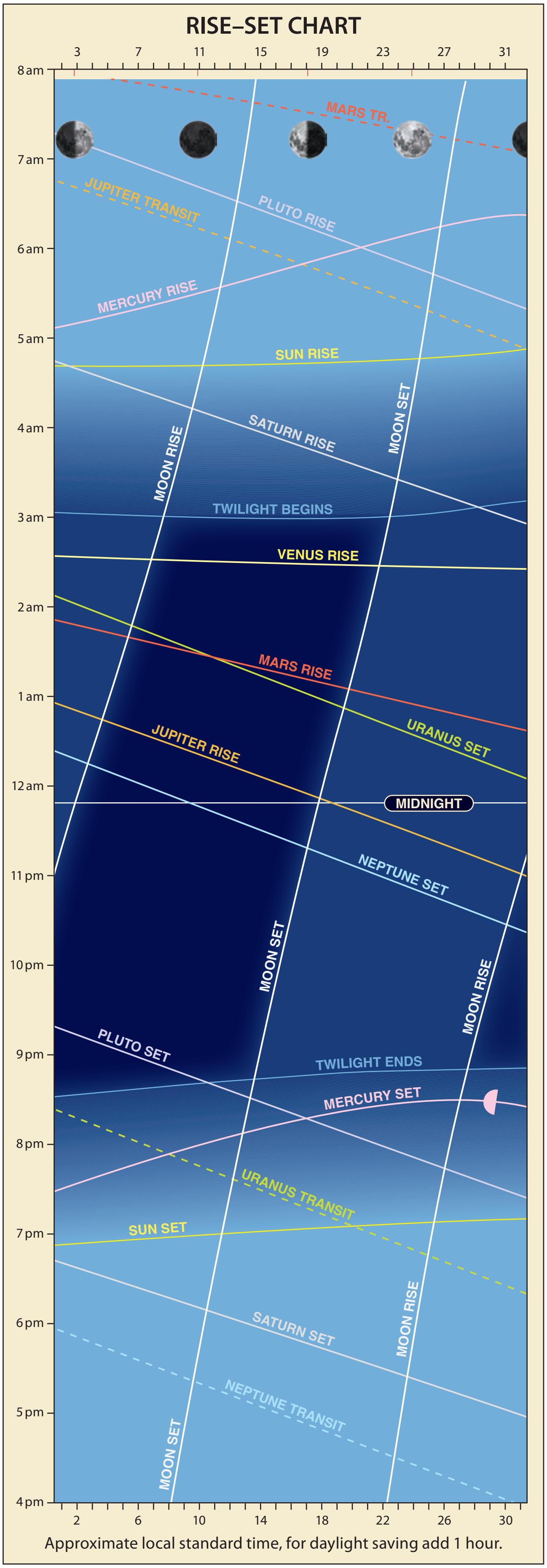


Approximate local standard time, for daylight saving add one hour.





DECEMBER



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

HIGHLIGHTS

❍ Venus, Comet Catalina and the Moon close.
m Comet C/2013 US_{10} (Catalina) in the dawn sky

CONSTELLATIONS

Having the two Magellanic Clouds and the isolated bright star Achernar (Alpha Eridani) high in the southern evening sky is typical of Southern Hemisphere summers. This otherwise barren stretch of the heavens is flanked by the distinctive constellation of Grus in the southwest and the star Canopus (Alpha Carinae) in the southeast.

Starting at Achernar move 5° south (below) to 2.8 magnitude Alpha Hydri, the top of the triangle of stars known as Hydrus, the Southern Sea Serpent. Continue south, over the Small Magellanic Cloud, to another member, 2.8 magnitude Beta Hydri, the closest obvious star to the South Celestial Pole (SCP). Travel eastward and just before the Large Magellanic Cloud is the 3rd component, Gamma Hydri.

Returning to Achernar, moving northward finds the obscure constellation of Phoenix, the mythical bird that rose from the ashes, high in the sky. Next, near the zenith, is another faint stellar collection, Fornax. The journey continues through Cetus, Aries and Triangulum, ending in Perseus, which from mid Australian latitudes sits on the northern horizon.

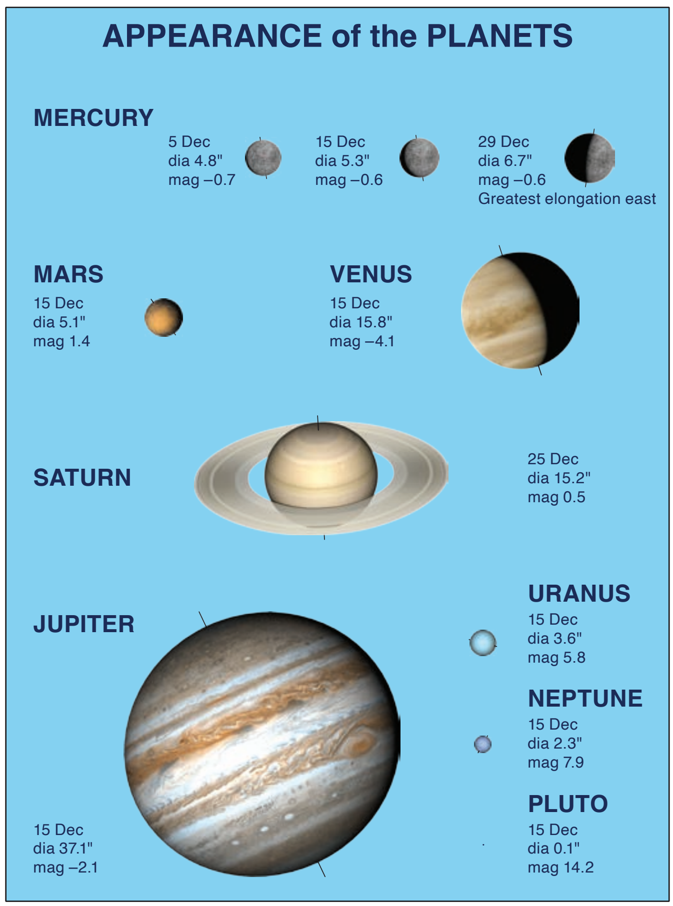
While looking north, here's some great trivia to use to show off to your friends. Point out the 2nd magnitude stars Hamel (Alpha Arietis), Gamma 1 Leonis and Pollux (Beta Geminorum). What do they have in common? They are three of the brightest stars known to have at least one planet (exoplanets). Although they are gas giants, like Jupiter, the first two stars' planets lie in their habitable zones – could they have life bearing moons? Other naked-eye stars with planets visible in December evenings include, Epsilon Tauri, Epsilon Eridani, 7 Canis Majoris and Upsilon Andromedae.

THE MOON

3rd 6 pm (4 pm WST) Last Quarter.

5th 11 pm (9 pm WST) Minimum Libration (1.5°), Dark SE limb.

6th 1 am (11 pm previous day WST) Moon at apogee (furthest from Earth at 404,799 km).



6th 1 pm (11 am WST) Occultation of Mars by the Moon, visible from Central and East Africa, Indonesia and Australia (daytime event).

8th 3 am (1 am WST) Occultation of Venus by the Moon, visible from North and Central America and Caribbean.

11th 8 pm (6 pm WST) New Moon.

12th 3 pm (1 pm WST) Maximum Libration (8.1°), too close to New Moon.

19th 1 am (11 pm previous day WST) First Quarter.

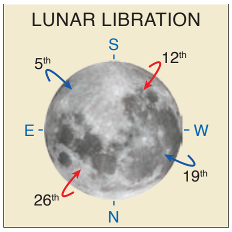
19th 1 pm (11 am WST) Minimum Libration (1.9°), dark NW limb.

20th 11 am (9 am WST) Occultation of Uranus by the Moon, visible from Antarctic Peninsula, southern tip of South America and Falkland Islands.

21st 7 pm (5 pm WST) Moon at perigee (closest to Earth at 368,417 km).

24th 6 am (4 am WST) Occultation of Aldebaran by the Moon, visible from NW Africa, Europe, Russia and northern Asia.

25th 9 pm (7 pm WST) Full Moon.



26th 11 am (9 am WST) Maximum Libration (8.2°), near Full Moon. Mare Humboldtianum favoured.

THE PLANETS

Mercury gradually climbs into the western evening twilight reaching its greatest elongation east (20°) of the Sun on the 29th. The best time to catch this sometimes-difficult planet would be after the end of civil twilight in the second half of the month (see Sky View). For a few days mid month Mercury passes through the lid of the Sagittarius Teapot, unfortunately it occurs quite low in the twilight sky.

Venus begins the month just below the 1st magnitude star Spica (Alpha Virginis) in the predawn eastern sky. On the 8th, the 26-day old waning crescent Moon appears about 1° below the planet (2° from WA) with Comet Catalina 3° below the Moon providing a really pleasant view for early risers (see Sky View).

The **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 spends the month moving through Virgo in the eastern predawn sky. On the 7th, the 25-day old waning crescent Moon appears just north (left) of the planet. On the 14th and 15th, the Red Planet will be 0.3° from the star Theta Virginis. The main star is a spectroscopic binary, but

Dark Adaptation

Long gone are the days when professional astronomers made discoveries by looking through the eyepiece of a telescope long into the cold night. Today, sensitive computerised devices like CCDs and IR arrays replace the eyepiece with the data stored for later analysis. More often than not, the astronomer will be *observing* in air-conditioned comfort many thousands of kilometres from the remote mountain top observatory.

Modern amateurs take advantage of current imaging and computer technology to enable them to emulate their professional counterparts. They tend to find niches that a grant-funded observatory could never justify spending time on, and contribute immensely to the advancement of the science of astronomy. Many amateurs specialise in astrophotography and images that we have published in our yearbooks attest to the dedication and commitment of these individuals.

Gradually over the years the authors have noted an increasing number of amateurs at dark sky sites using computers and other light producing gadgets. We wonder if the trend continues, will we ultimately lose the art of visual observing? It is nice occasionally to actually look through a telescope and see first hand the marvels that make up the Universe. We say this a bit tongue-in-cheek, but without dark adaptation and an understanding of how the eye works you may not be getting the most from your favourite dark sky site.

What is dark adaptation? If you walk outside at night from a brightly lit room at first it is difficult to see anything. After a few minutes your ability to see in the dark improves. This is called ‘dark adaptation’. Your stereotypical pirate is always depicted with a patch over one eye, and while there is no historical evidence, it has been speculated that in days of old sailors used these patches to enable them to see in the dim light below deck. They would simply switch the patch from one eye to the other to have instant dark adaptation.

The eye works by using millions of photoreceptors on the retina at the back of the eye. Known as rods and cones they make up the sensory layer that sees colour and light. The rods are by far the more numerous and responsive to light and detection of movement, although they are not sensitive to colour. The lesser population of cones provide the eye’s colour sensitivity and detail. Rods are mostly located at the outer edges of the retina, whereas the cones are concentrated in the central spot know as the macula and densest in the fovea centralis, the area of the most acute vision.

When outside at night the pupil automatically dilates and allows more light to fall on the periphery of the eye where the maximum amount of rods will be exposed. It takes less than a minute for the pupil to enlarge, but up to half an hour for the eye to attain full light sensitivity. The rods use a light sensitive pigment known as rhodopsin to see in the dark. Shine a bright light into the eyes and the chemical is bleached out, the pupils shrink and you have to start all over again. In the daytime rhodopsin is continuously bleached out.

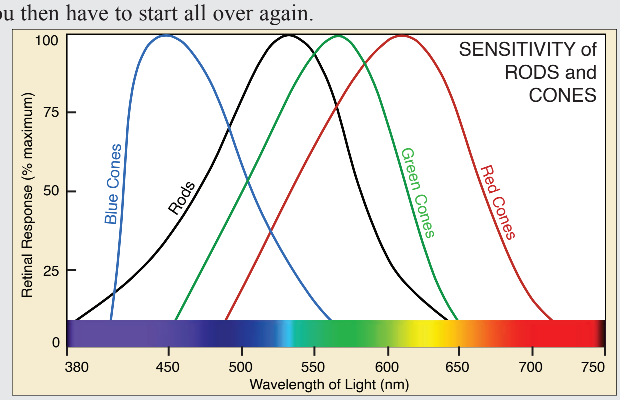
The rods are much more proficient than cones for seeing at lower light levels, that’s why colour vision is poor at night (and why you can’t see colour in faint objects through the telescope). There are three types of cones and they are sensitive to red, green and blue light, but the ability to see colour and detail comes at a sacrifice in sensitivity. When light levels decrease sufficiently the cones no longer respond and our monochromatic rod receptors take over and we only see in shades of grey at night.

When our eyes have reached full dark adaptation we can truly appreciate the night sky, with or without a telescope. However, a technique called averted vision will enable us to see more, even things not immediately apparent. Since the rods are predominantly away from the centre of vision it is here that the eye is much more sensitive to low light.

The trick is to not look directly at a faint object; this mainly uses the insensitive cones. Try looking off to one side so the light falls onto the rods – you will be surprised at how much detail pops out. It takes a little practice to perfect and there are a couple of rules. The blind spot where the optic nerve connects to the retina must be avoided for obvious reasons. To do this, shift your gaze to the right if that’s your eyepiece eye, or left if you use your left eye. The offset from the eye’s centre will vary with each individual but around 10 to 15 degrees ought to suffice. Once mastered, the art of averted vision can be used to tease out hidden detail in low contrast objects like nebulae, planetaries and galaxies.

Once dark-adapted you will want to preserve this state for the whole observing session. If you need to refer to a star chart or find your way in the dark use a dim red light – the light response of the rods peaks in the blue part of the spectrum with little reaction to red light. A regular torch with layers of red cellophane held in place by a rubber band works well. Alternatively, your local telescope store can supply a red LED torch with a variable brightness control. Remember, it must be a dull red so as not to destroy that hard earned night vision.

Just a fraction of a second of bright light (even observing the Moon through a telescope) is all it takes to ruin your night vision in an instant – you then have to start all over again.



DECEMBER

through a moderate sized telescope 4.4 magnitude Theta appears as a triple star system with components of 9.4 magnitude at a distance of 7 arcseconds and 10.4 magnitude at 70 arcseconds. As the month draws to a close Mars will be within a few degrees of Spica, the planet at this time only a little fainter than the star. Identification however is easy with orange Mars contrasting against the bluish Spica.

Jupiter in Leo, near the border of Virgo, rises around midnight mid-month. On two consecutive days the Moon appears near the planet – on the 4th the Last Quarter Moon will be north and on the 5th the waning crescent will be to the south (see Sky View). Of interest on the 5th (for occultation enthusiasts), there will be the occultation of the 4th magnitude star Beta Virginis. The star will disappear behind the bright lunar limb and pop out from behind the dark (see Lunar Occultations in Part II for full details). Beta is actually the fifth star in order of brightness in Virgo, not the second as you would expect.

Saturn, after being in conjunction with the Sun at the end of November, reappears in the eastern morning dawn sky late in the month in Ophiuchus (see Sky View).

Uranus appears stationary on the 26th having come to the end of its retrograde loop, it then resumes its west to east direction across the sky. The planet is located in the north-western evening sky after the end of astronomical dusk in Pisces. During the month the planet will be within 2° of the 4th magnitude star Epsilon Piscium.

Neptune can only be seen in the western evening sky in Aquarius, setting around 11:30 pm mid month.

DWARF PLANETS AND SMALL SOLAR SYSTEM BODIES

Pluto is in conjunction with the Sun on January 6th 2016, and will be lost from view this month until its return to the morning skies in February.

Minor Planets. Three of the brighter minor planets reach opposition this month in Taurus, 409 Aspasia on 9th at magnitude 11.2, 16 Psyche on 9th at magnitude 9.4 and 230 Athamantis on 11th at magnitude 10.0. Also at opposition are 41 Daphne on 5th at magnitude 12.2 in Orion, 63 Ausonia on 22nd at magnitude 11.2 in Auriga and 27 Euterpe on 25th at magnitude 8.4 in Gemini. Magnitude 10 minor planet 39 Laetitia visits the Cetus group of galaxies this month, including a close approach to M77 on 12th (see diary).

Comet C/2013 US_{10} (Catalina) emerged from the solar glare in late November after passing through perihelion. Perhaps 6th magnitude in brightness, Catalina will be in the morning dawn sky in December, rising around 2:30 am mid month. It is in Virgo, moving into Bootes for the last week of the month. To avoid moonlight the best observing period is 9th to 22nd. On 8th the comet has a close meeting with the thin crescent Moon and Venus (see Venus section and Sky View).

Comet 10P/Tempel 2 spends the first week of December in Sagittarius moving into Capricornus for the rest of the month. Having faded to around 11th magnitude, it is low in the early western evening sky, setting approximately one hour after the end of astronomical twilight. The evenings are Moon free for the first half of December.

METEOR SHOWERS

The following showers will be relatively Moon free around their peak.

The **Phoenicids** are a southern shower discovered in 1956, during its only known major outburst when rates of around 100 plus were observed. There have been three minor bursts in activity since then, but in recent years the shower seems non-existent. There is a possibility that this may be a periodic shower, so observations should still be carried out in case of a return. The period of activity appears to be 28th November through 9th December, with maxima on the 6th. The Phoenicids' radiant culminates at dusk and sets in the early morning hours. The very low velocity of the Phoenicids will help in identification from the sporadics.

The **Puppid-Velids** complex contains a series of radiants located in the constellations of Carina, Puppis, Pyxis and Vela. Some of the showers are thought to be visible from late October to early January, but have been so poorly observed that the International Meteor Organization can only confirm high activity from early to mid December, with a possible peak zenith hourly rate of 10 around the 7th. Most of the Puppid-Velids are faint but occasional bright fireballs, particularly around the maximum, have been observed.

The **sigma-Hydrids** are active from the 3rd to 15th, reaching their peak on the 12th. A low rate of three swift and faint meteors can be expected. The radiant is about ten degrees east of Procyon (Alpha Canis Minoris) and will be best viewed after midnight.

The **Geminids** are one of the finest and most reliable of the major annual showers. Visible from the 4th to 17th, with maximum predicted on the 14th, the Geminids often produce bright, medium-speed meteors. The zenith hourly rate is variable but around 120 are possible. Even though our northern counterparts will see the best of the Geminids, they can still provide a spectacular display for us *down under*.

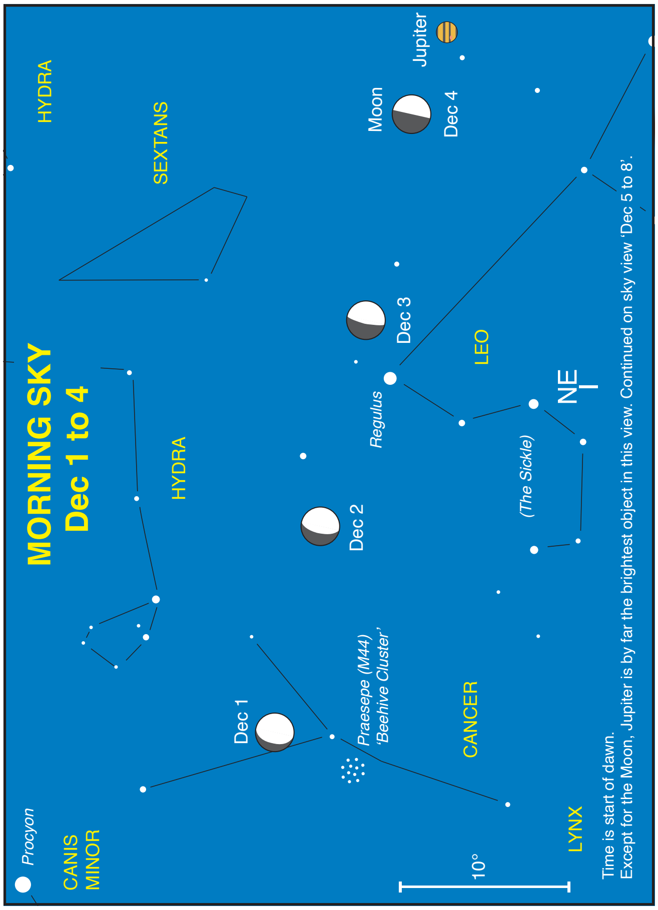
DOUBLE STARS

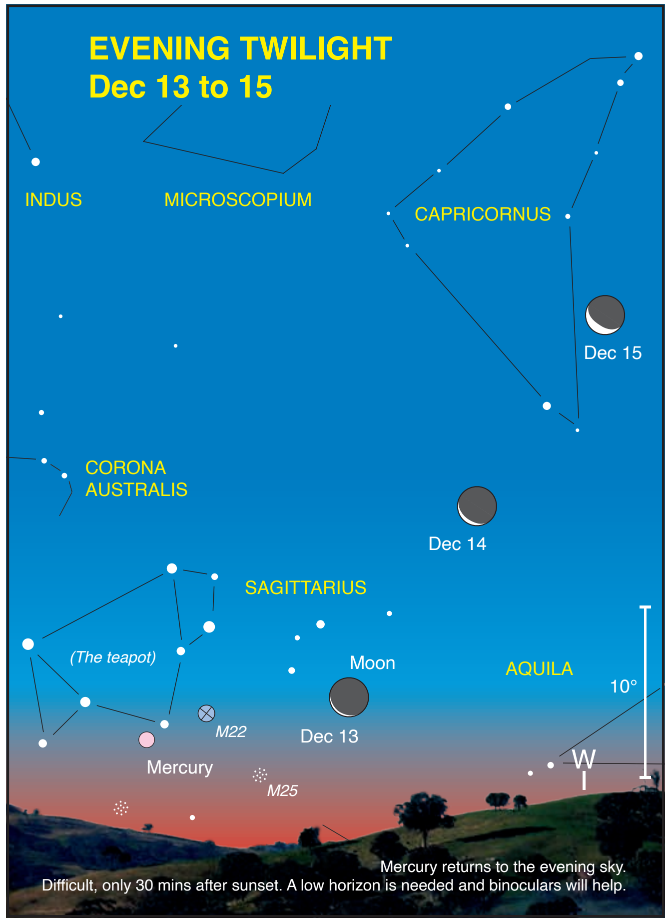
Located near the bright star Achernar, **p Eridani** is an excellent pair for small telescopes. The stars (magnitude 5.8 and 5.9) are both yellow-orange and are separated by 11.6 arcseconds. Both stars are main sequence dwarfs of spectral type K and are fainter and cooler than the Sun. This pair has been well studied and the orbit is known with reasonable accuracy. Because of this, they are a suitable reference pair for those interested in measuring the separations and position angles of double stars. (Map 2, p. 70)

Located about midway between α Tauri (Aldebaran) and γ Tauri, **θ^1 and θ^2 Tauri** are a bright, slightly unequal pair of yellow and white stars, which along with the surrounding Hyades form a pleasing sight in low-power binoculars. The magnitude 3.8 and 3.4 stars are separated by a generous 337 arcseconds. (Map 3, p. 71)

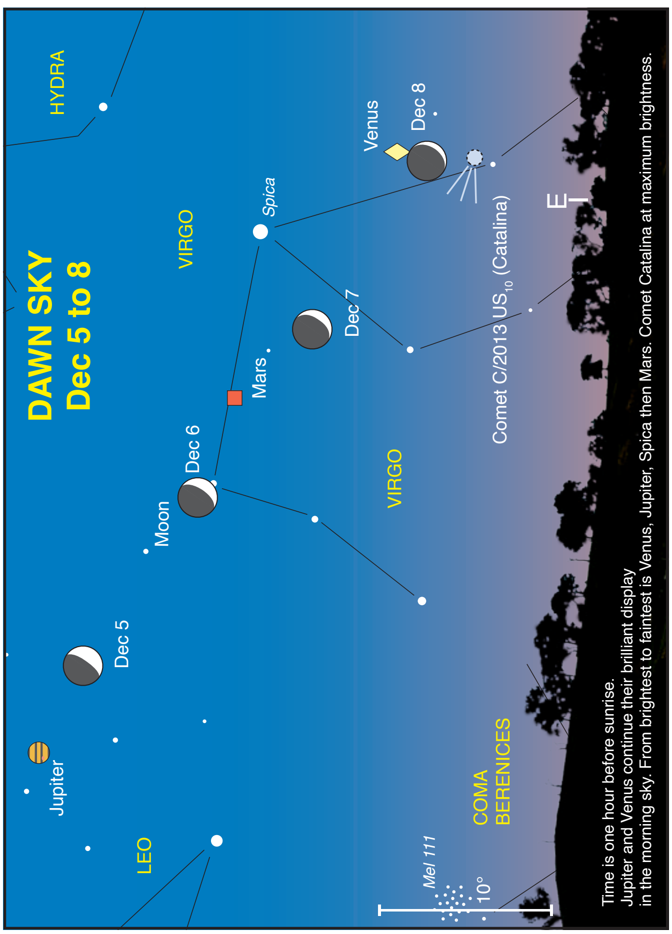
DIARY

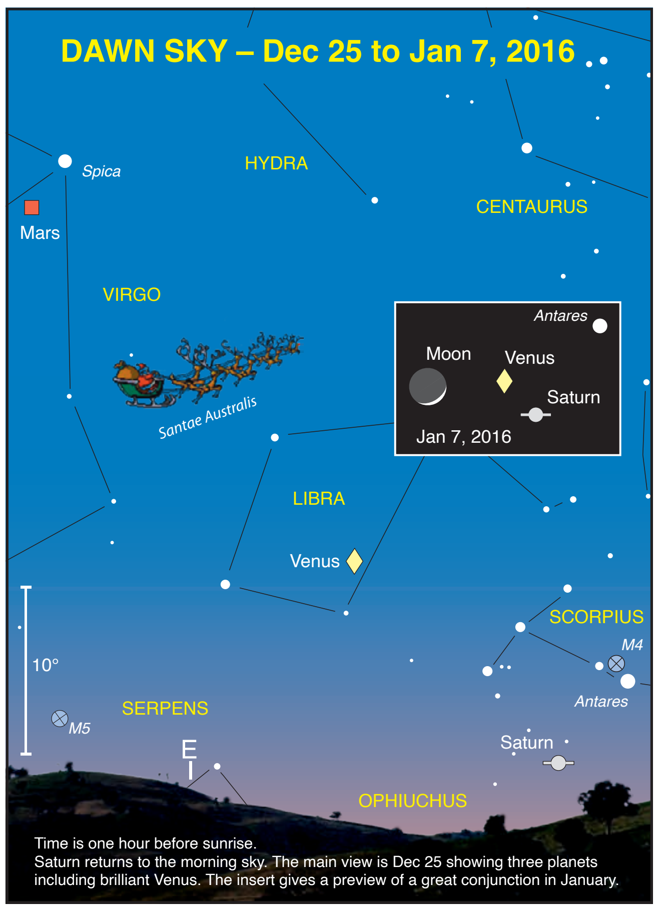
Wed	2nd	10 pm	(8 pm WST) star Regulus 3°N of Moon
Thu	3rd	5:40 pm	(3:40 pm WST) Last Quarter Moon
Thu	3rd	pm	m.p. 39 Laetitia 0.5°N of NGC 1087 (G) in Cetus
Fri	4th		Mars 0.3°W of NGC 4691 (G) in Virgo
Fri	4th	4 pm	(2 pm WST) Jupiter 1.8°N of Moon
Fri	4th	7 pm	(5 pm WST) m.p. 3 Juno 3°N of Venus
Sun	6th	1 am	(11 pm WST, prev day) Moon at apogee, 404,799 km
Sun	6th	1 pm	(11 am WST) Mars 0.1°N of Moon; Occn.
Mon	7th	6 am	(4 am WST) star Spica 4°S of Moon
Mon	7th	9 pm	(7 pm WST) m.p. 3 Juno 2°N of Moon
Tue	8th	3 am	(1 am WST) Venus 0.7°S of Moon; Occn.
Thu	10th		Comet 10P/Tempel 2 0.5°NW of NGC 6907 (G) in Capricornus
Thu	10th		d.p. Ceres 0.4°S of star 24 Capricorni
Thu	10th	pm	m.p. 39 Laetitia 0.1°N of M77 (SG) in Cetus
Fri	11th		Mercury 0.4°NW of NGC 6553 (GC) in Sagittarius
Fri	11th	8:29 pm	(6:29 pm WST) New Moon
Sat	12th		m.p. 15 Eunomia 0.7°N of NGC 7814 (G) in Pegasus
Sat	12th		Mars 0.3°N of NGC 4941 (G) in Virgo
Sat	12th	Midnight	(10 pm WST) Mercury 7°S of Moon
Sun	13th	8 pm	(6 pm WST) d.p. Pluto 3°S of Moon
Mon	14th	7 pm	(5 pm WST) Mercury 0.1°S of star Lambda Sagittarii
Tue	15th		Mercury at greatest latitude south
Tue	15th	pm	m.p. 27 Euterpe 0.5°N of star Mu Geminorum
Thu	17th	6 pm	(4 pm WST) Neptune 3°S of Moon
Fri	18th		Mercury 1.0°N of star Sigma Sagittarii
Fri	18th	pm	m.p. 39 Laetitia 0.3°E of star Delta Ceti
Fri	18th	pm	m.p. 39 Laetitia 0.3°W of NGC 1055 (G) in Cetus
Sat	19th		Comet 22P/Kopff 0.7°NW of M75 (GC) in Sagittarius
Sat	19th	1:14 am	(11:14 pm WST, prev day) First Quarter Moon
Sat	19th	5 pm	(3 pm WST) m.p. 4 Vesta 8°S of Moon
Sat	19th	10 pm	(8 pm WST) d.p. Pluto 4°N of Mercury
Sun	20th		m.p. 9 Metis 1.0°SE of NGC 7606 (G) in Aquarius
Sun	20th		Venus at greatest latitude north
Sun	20th	11 am	(9 am WST) Uranus 1.2°N of Moon; Occn.
Mon	21st	7 pm	(5 pm WST) Moon at perigee, 368,417 km
Mon	21st	10 pm	(8 pm WST) Mars 4°N of star Spica
Tue	22nd	3 pm	(1 pm WST) Solstice
Wed	23rd		m.p. 15 Eunomia 0.5°S of NGC 57 (G) in Pisces
Wed	23rd	pm	m.p. 27 Euterpe 0.8°N of star Eta Geminorum
Thu	24th	6 am	(4 am WST) star Aldebaran 0.7°S of Moon; Occn.
Fri	25th	9:11 pm	(7:11 pm WST) Full Moon (376,266 km)
Mon	28th	pm	m.p. 27 Euterpe 0.9°S of M35 (OC) in Gemini
Mon	28th	pm	m.p. 39 Laetitia 0.2°E of NGC 1032 (G) in Cetus
Tue	29th	1 pm	(11 am WST) Mercury at greatest elongation East (19.7°)
Tue	29th	pm	m.p. 27 Euterpe 0.7°S of NGC 2158 (OC) in Gemini
Wed	30th	7 am	(5 am WST) star Regulus 3°N of Moon
Thu	31st		d.p. Ceres 0.7°NW of M30 (GC) in Capricornus
Thu	31st		m.p. 16 Psyche 1.0°S of NGC 1647 (OC) in Taurus
Thu	31st		Mercury 0.8°NW of M75 (GC) in Sagittarius





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





ALL SKY MAPS

Introduction

These maps have been created to show you the entire night sky at any time of the year from anywhere in Australia. It is more accurate to say they are useful for anywhere in the Southern Hemisphere with latitudes similar to Australia. This includes New Zealand, South Africa and parts of South America.

Who can use them?

Anyone, and you don't need binoculars or a telescope to be at ease finding your way around the sky and recognising all of the constellations.

The limiting magnitude of the stars is 5.5. If you live in a suburban area, you will not see the fainter stars marked on the maps. Some of the obscure constellations may not be visible at all; a pair of binoculars will help. Under dark, country skies, where you can see the Milky Way, you will be able to see all these stars plus numerous fainter ones not included on the maps.

How Do I Use Them?

There are nine maps. Map 1 *Looking South* covers the far southern sky. Then there are four pairs of maps, one pair for each season i.e., a Centre and a North map.

To use the Looking South map, face south and rotate the chart to get the correct orientation. Use a distinctive star pattern like the Pointers and Southern Cross (Crux) to help. From mid-Australian latitudes, and further south, Crux is circumpolar and never sets.

The rest of the maps are used as follows. Turn to the relevant season and rotate the book onto its side so the right hand North page is on the bottom and look towards the north. The northern sky, directly above the horizon, is represented on the North map and as you progress up the sky towards the overhead point (or zenith) you will cross over onto the Centre map.

The seasonal views are a little arbitrary. As you will see in the Notes section on the maps, an evening view around the relevant time of the year was chosen. However, if you are willing to stay up all night there is only a small part of the entire sky not available to you, especially in winter. For example, suppose it is around mid-to-late June. At 9 pm the sky will look like the Winter pair. By 3 am the sky will be showing the Spring view. Around dawn, the Earth will have rotated further, where the sky is now half Spring (to the left or west if you are facing north and half Summer (towards the right or east). A planisphere illustrates this quite well (p. 12).

What does the fine black grid represent?

These are the right ascension (RA) and declination (Dec.) lines. The RA line, which starts on the due north point (N on the North charts) and runs vertically up the page, crossing through the point directly overhead and heading down to the southern horizon, is called the local central meridian. When objects cross this meridian they are said to be culminating and they have reached their highest point in the sky. Looking at the Spring (North) chart, the RA of the central meridian at 11 pm on 20 August is approximately 21 hours (as an aside this is also the definition of the local sidereal time, see page 142). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1 am) the star Alpha (α) Pegasi (Markab), with an RA close to 23 hours, will culminate.

The declination indicates which areas of the charts will pass directly overhead. This is when an object has the same declination as your latitude. For example, the latitude of Hobart is nearly 43° S. Looking at the Autumn (Centre) map on 20 March at 9 pm the star Suhail, with a declination close to –43°, will be very close to the overhead point (or zenith) as seen from Hobart.

What do the dashed lines, labelled with city names, on the North maps mean?

Australia is a large country and your latitude dictates how far north in the sky you can see. These lines represent the declination furthest north you can see from each of the cities. If a star is very close, but still above your dashed line, it will be visible if only briefly, assuming you have a low flat horizon. To see all the sky, as depicted in the North maps, you would need to be at a latitude similar to Darwin.

What are the planet lines?

Lines are shown to indicate the approximate path in the sky for Mars, Jupiter, Saturn, Uranus, Neptune and Pluto for the year. With the exception of Mars, once you have found the general area you can go to the relevant finder chart. The path for Mars has the position marked for each month and thus replaces a separate finder chart. The Moon, Mercury and Venus are not shown. The Sky View diagrams (see Part I) show the location and optimum time to observe these objects.

What else is shown on the maps?

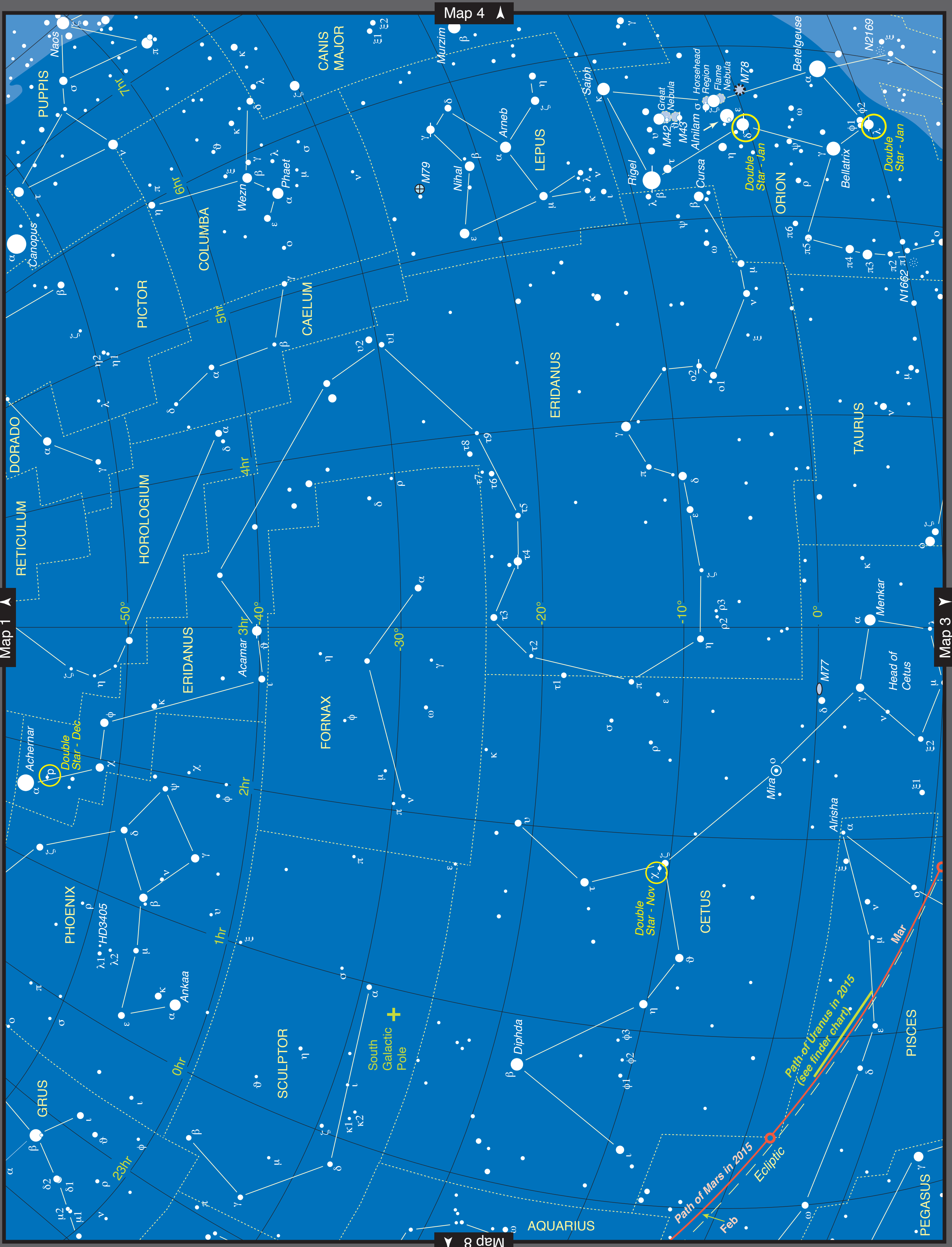
- Deep sky objects down to magnitude 7 and all of the Messier objects (see the legend). These objects are identified by their common names (such as asterisms), Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope. There are occasionally fainter objects included when referred to elsewhere in the book.
- Constellation lines. The yellow dotted lines are the boundaries and the solid lines joining some of the brighter stars help recognise the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A few of the brighter variable and double Stars. The specific doubles mentioned in the Part 1 monthly sections, are labelled with the month and circled.
- A light blue shading shows the Milky Way and Magellanic Clouds.

'Stargazing' by David Mariott, taken at ASNSW South Pacific Star Party 2014.

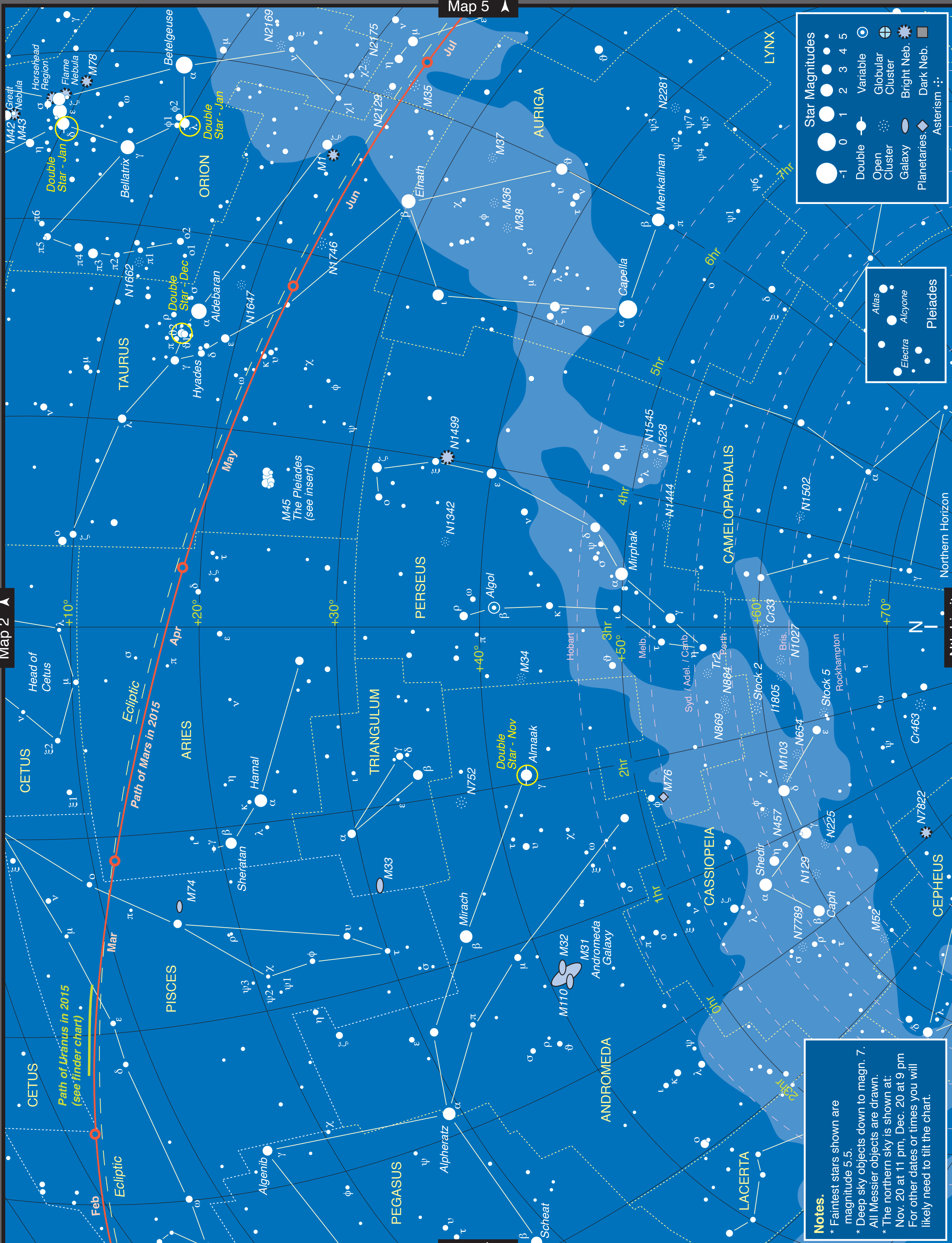
Map 1 - Looking South

Notes.
* Faintest stars shown are magnitude 5.5.
* Deep sky objects down to magn. 7. All Messier objects are drawn.
* This covers the far southern sky for all of the year. The stars revolve around the South Celestial Pole. You may need to rotate the page to get the correct orientation.

Map 2 - Summer (Centre)

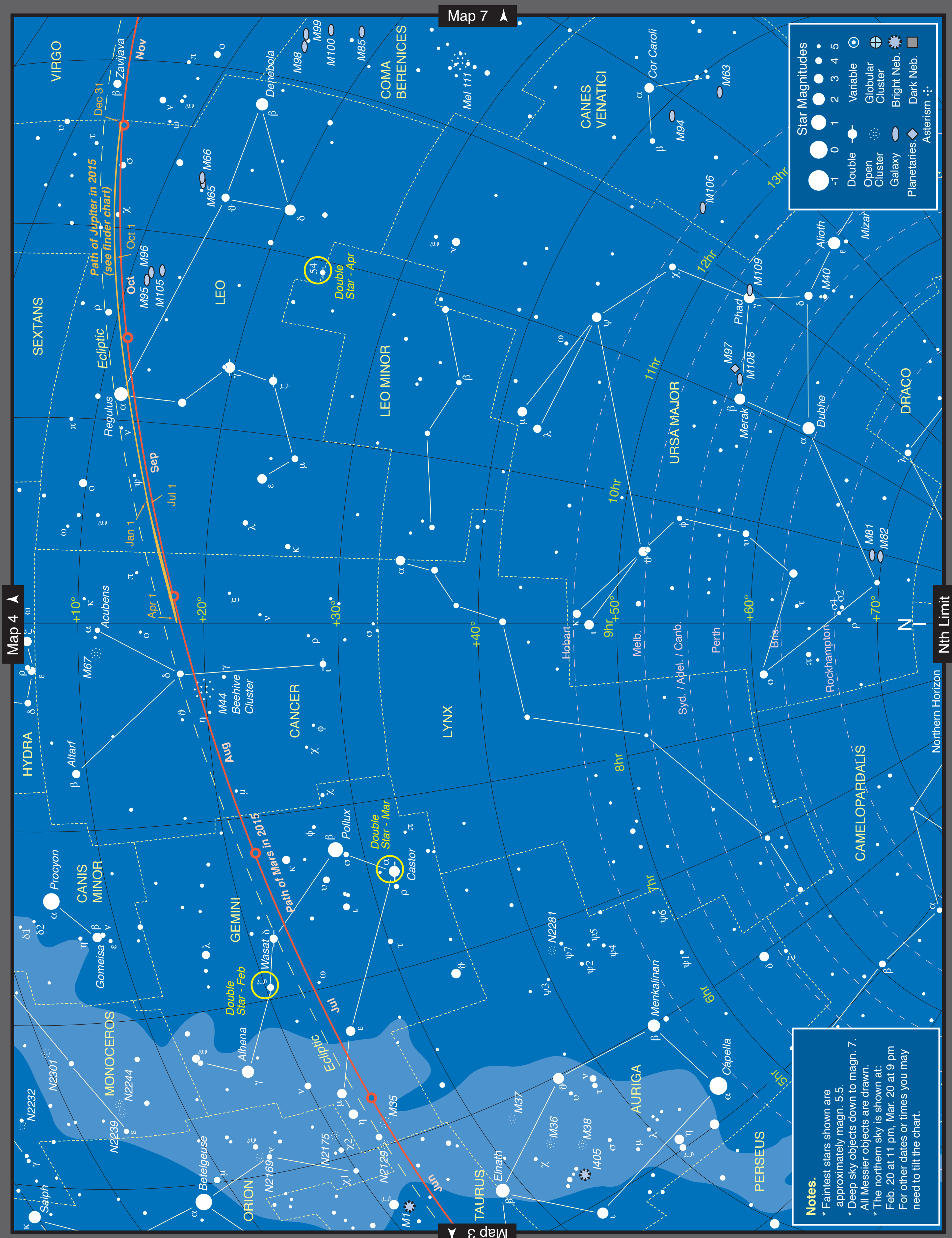


Map 3 - Summer (North)

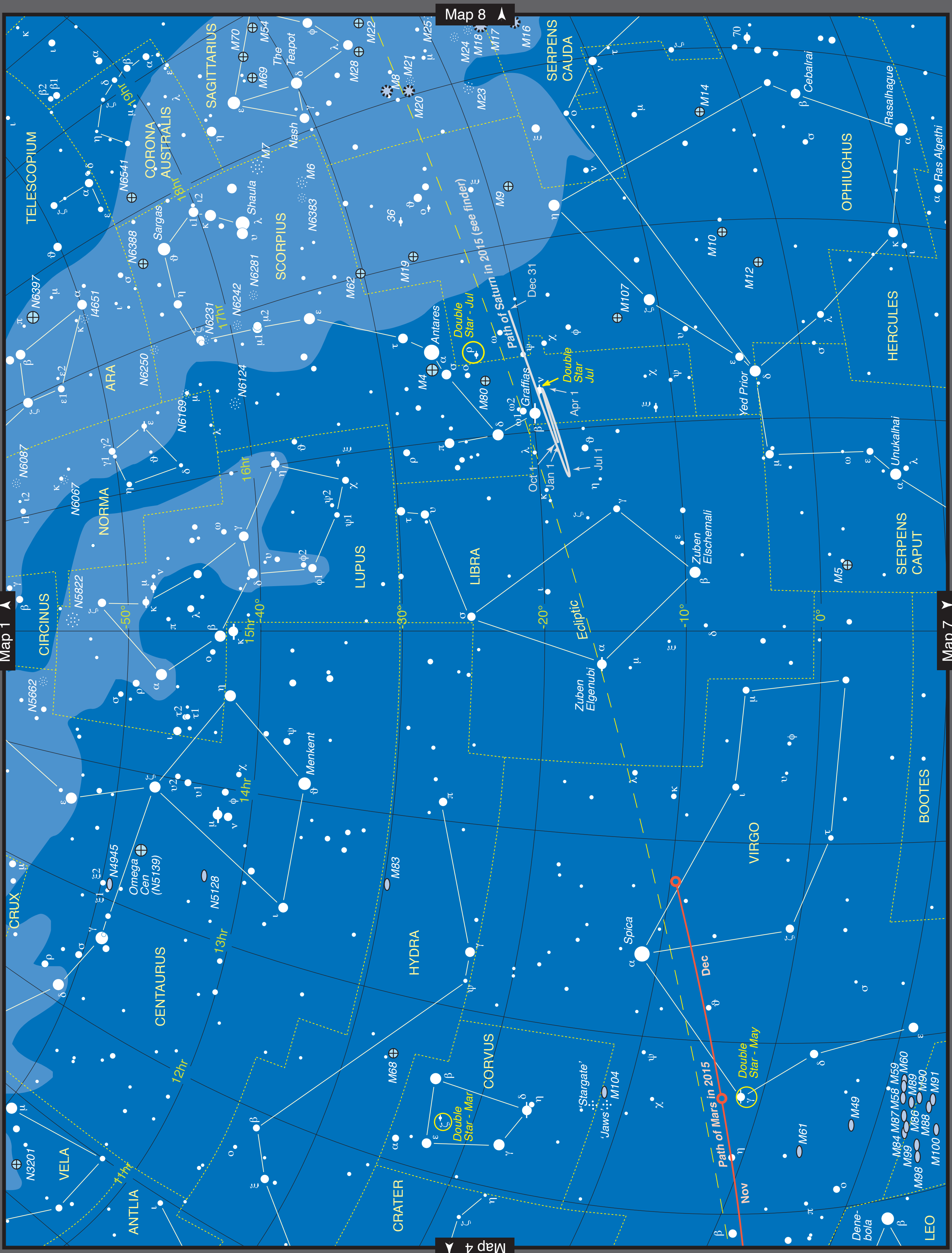


Map 4 - Autumn (Centre)

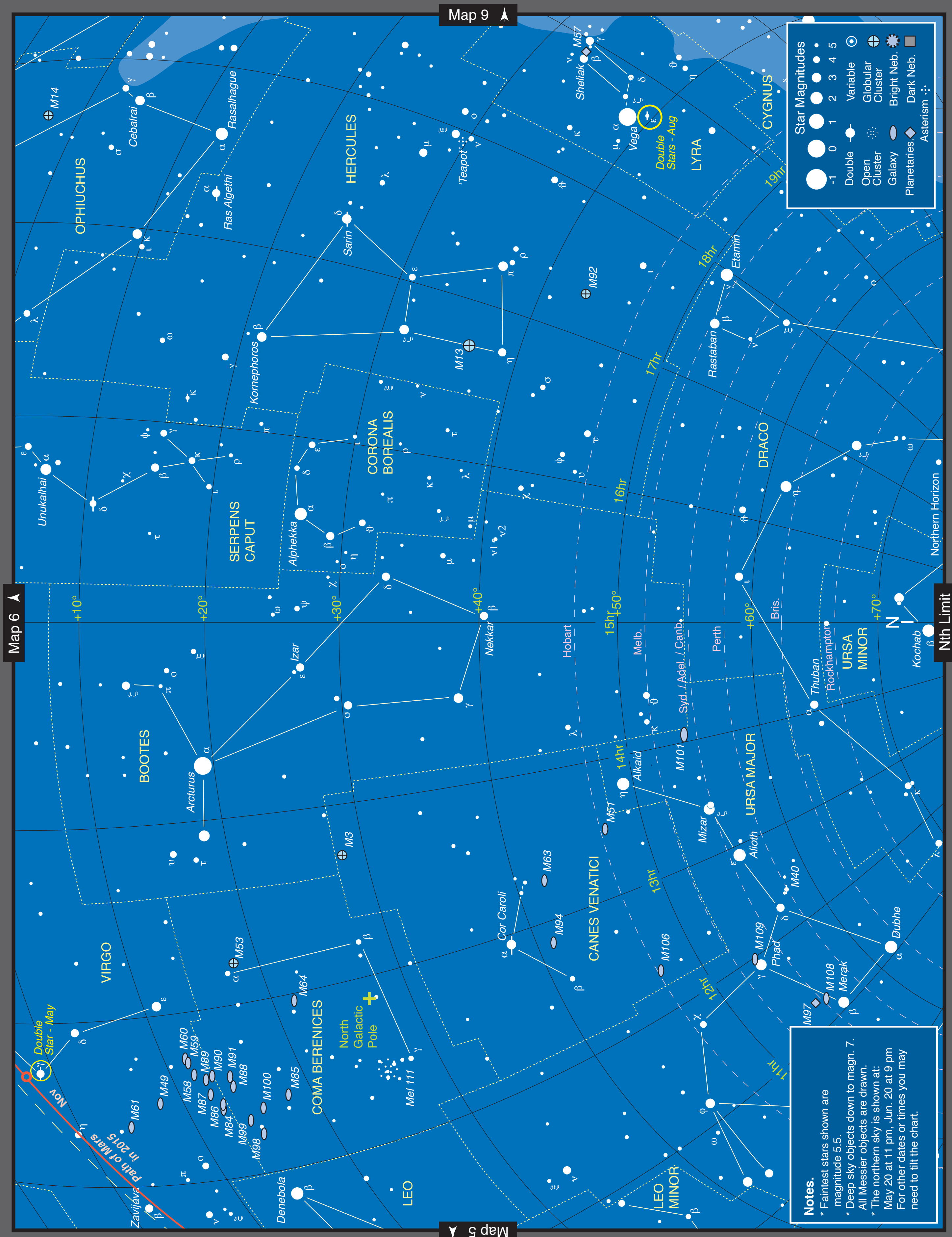
Map 5 - Autumn (North)



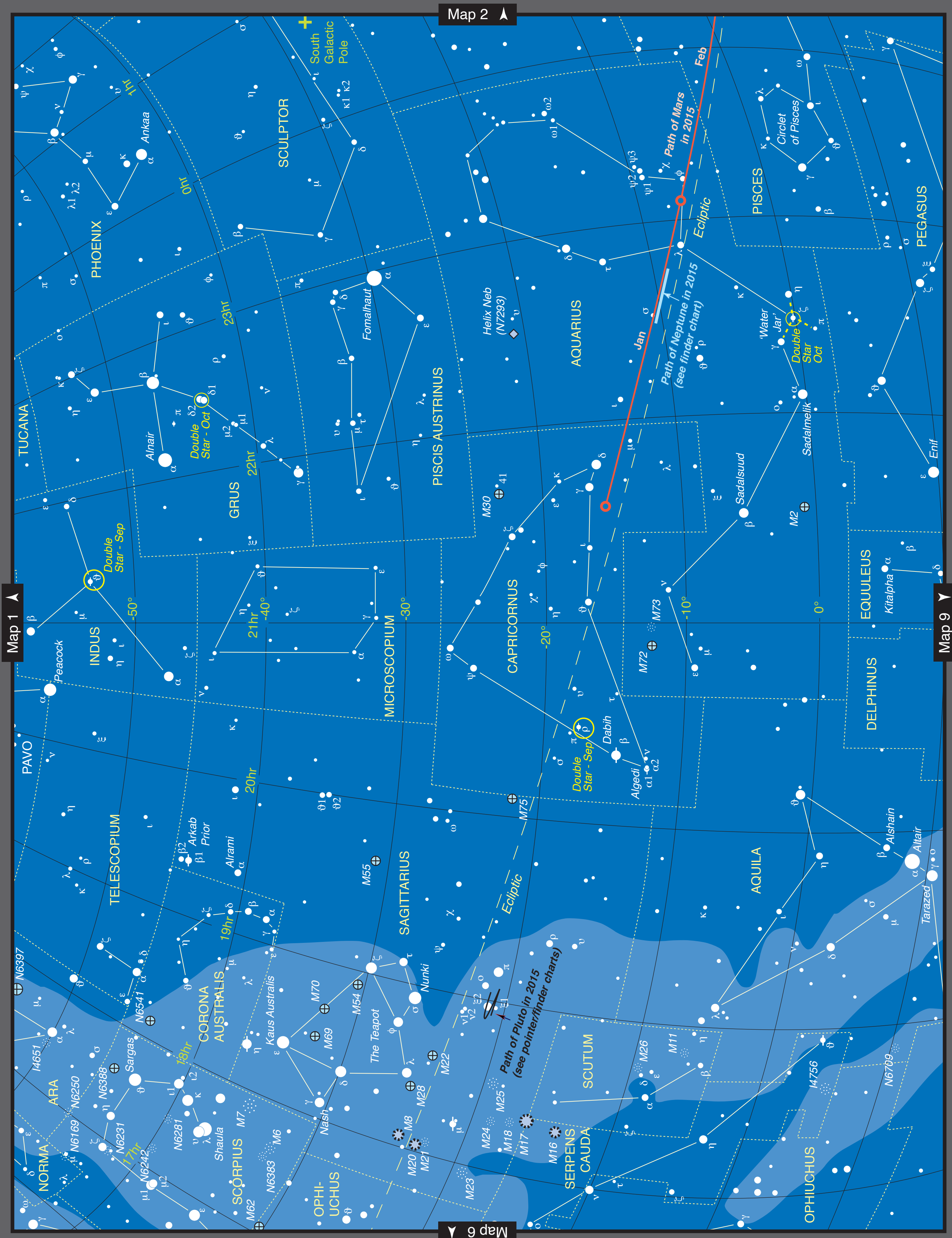
Map 6 - Winter (Centre)



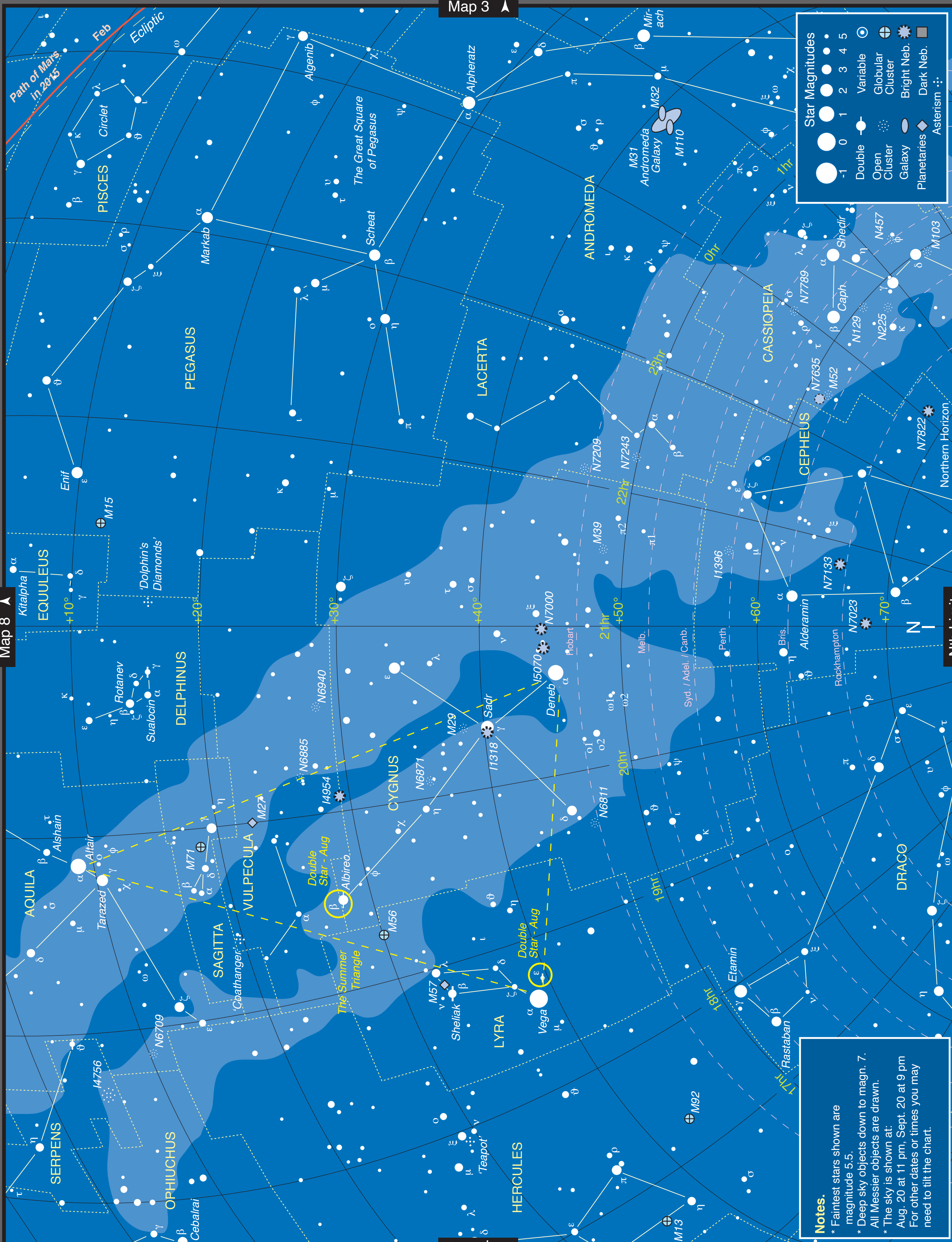
Map 7 - Winter (North)



Map 8 - Spring (Centre)



Map 9 - Spring (North)



PART II — THE SOLAR SYSTEM

This introduction is only brief, as many specific explanations are located in the relevant sections.

Time. 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 wherever they involve location specific data, such as rise and set times of the Sun, Moon and planets, darkness hours 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.

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 10:00 hr (10:00 am) EST, 9:30 hr (9:30 am) CST and 8:00 hr (8:00 am) WST.

The 24 hour clock is often used in astronomy e.g., 16:00 is the same as 4:00 pm. This avoids the need to distinguish between 'am' and 'pm'. The 24 hour approach is frequently used in Part II of this book e.g., for rise and set times.

The satellite data for Saturn, Uranus and Neptune use decimal days. There are worked examples on these pages to further explain this.

Locations. Rise and set times, hours of darkness and lunar occultation data are given for specific cities. The latitudes and longitudes used are:

Adelaide	34° 54' S	138° 36' 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 Coordinates or Positions. The astronomical positions are given in equatorial coordinates. 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, those south have negative (–). The Right Ascension and Declination grid has been marked on the All Sky Maps (see previous pages). The RA has a line for each hour and the Declination has a line every 10°. The finders also have them marked.

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° (see Map 1 in the All Sky Maps). The North 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 are calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. 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 times are adjusted for atmospheric refraction. The intervals used for rise and sets are weekly. They correspond 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 you are 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. The All Sky Maps are Epoch 2000.0.

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 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).

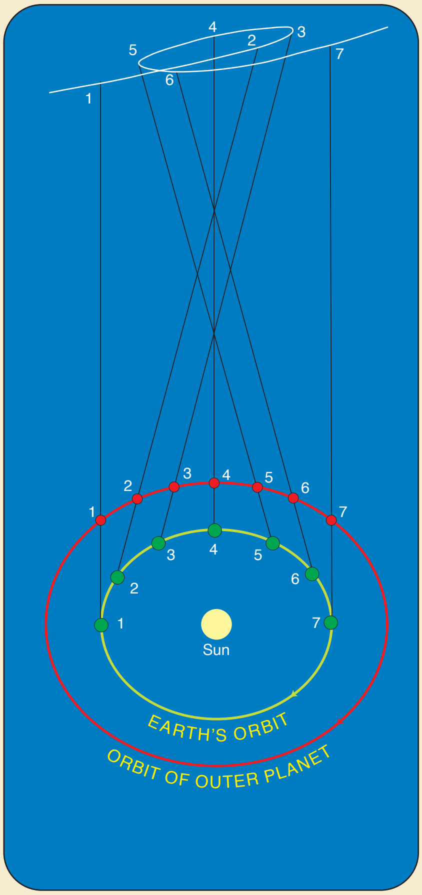
Finder Charts. No finder charts are presented for the Moon, Mercury, Venus or Mars. Their rapid motion during the year causes them to cover a very large section of the sky which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams (see Part I) should be sufficient to act as finders. With regard to Mars, the All Sky Maps give adequate detail to easily find the Red Planet, so its traditional finder has been included on these maps. Although there are separate finder charts for Jupiter, Saturn, Uranus, Neptune and Pluto, the approximate track for each is also shown on the All Sky Maps. This acts as a pointer to help you find the smaller field of the finder charts.

Hours of Darkness. People who seek out dark skies to view deep sky objects choose to observe at times outside of twilight and when the Moon is not in the sky. These tables present the times of the day when these dark hours commence (either end of evening twilight or moonset) and end (either start of dawn or moonrise). Daily figures are presented for all capital cities. **Note all times that are in the morning hours** (after midnight) **refer to the previous day** (the evening). For example, Adelaide (p. 92) on 30 January shows a start on 02:11 (moonset) and end 03:57 (start of dawn). These times are after midnight and refer technically to the morning of 31st. Looking at the relevant Moon and Sun rise and set tables, where the day changes at midnight, confirms this.

RETROGRADE MOTION

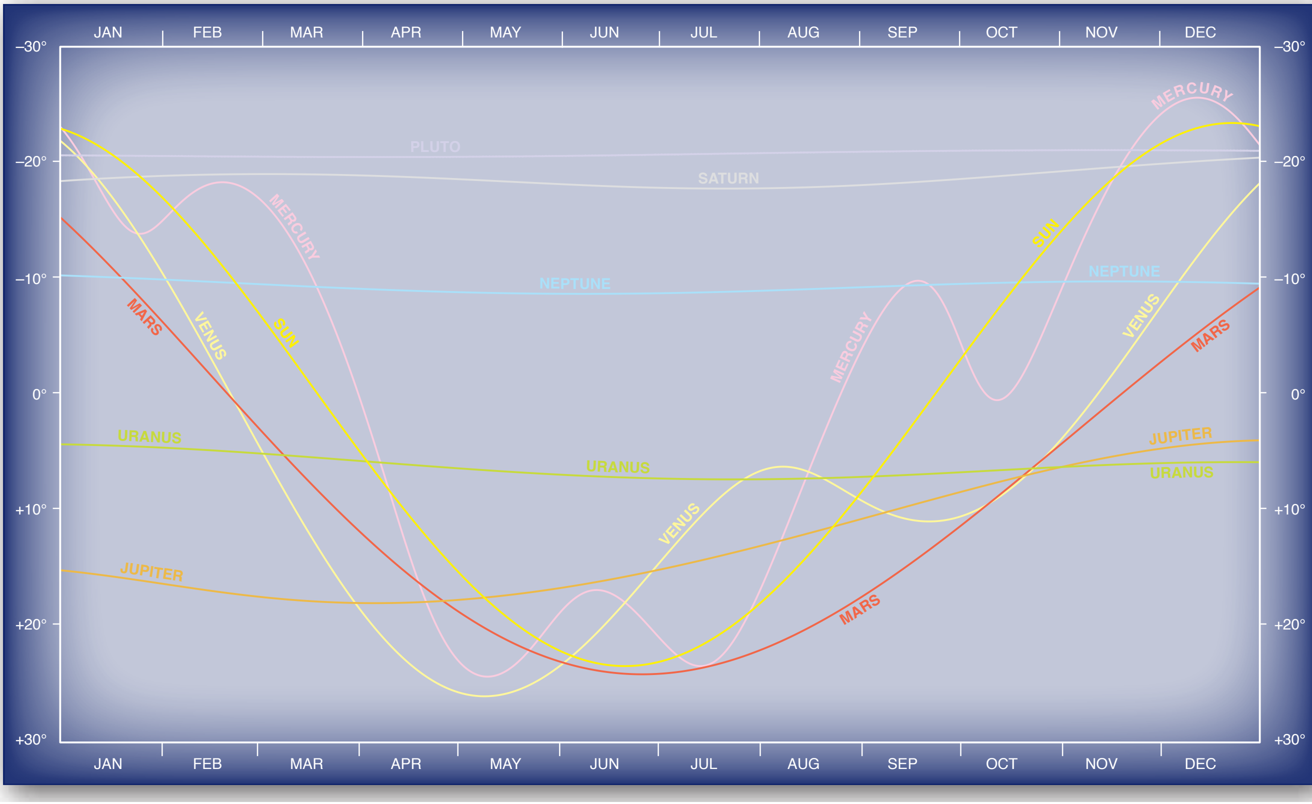
The finder charts for the outer planets have one thing in common, an apparent motion with a loop or 'S' shape. This only applies to the period during opposition. See the All Sky Maps or the Finder Charts for examples. The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

In the diagram, the top section represents the path of an outer planet against the celestial sphere viewed from the south (below the ecliptic). 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 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 appears to move from east to west, instead of 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.



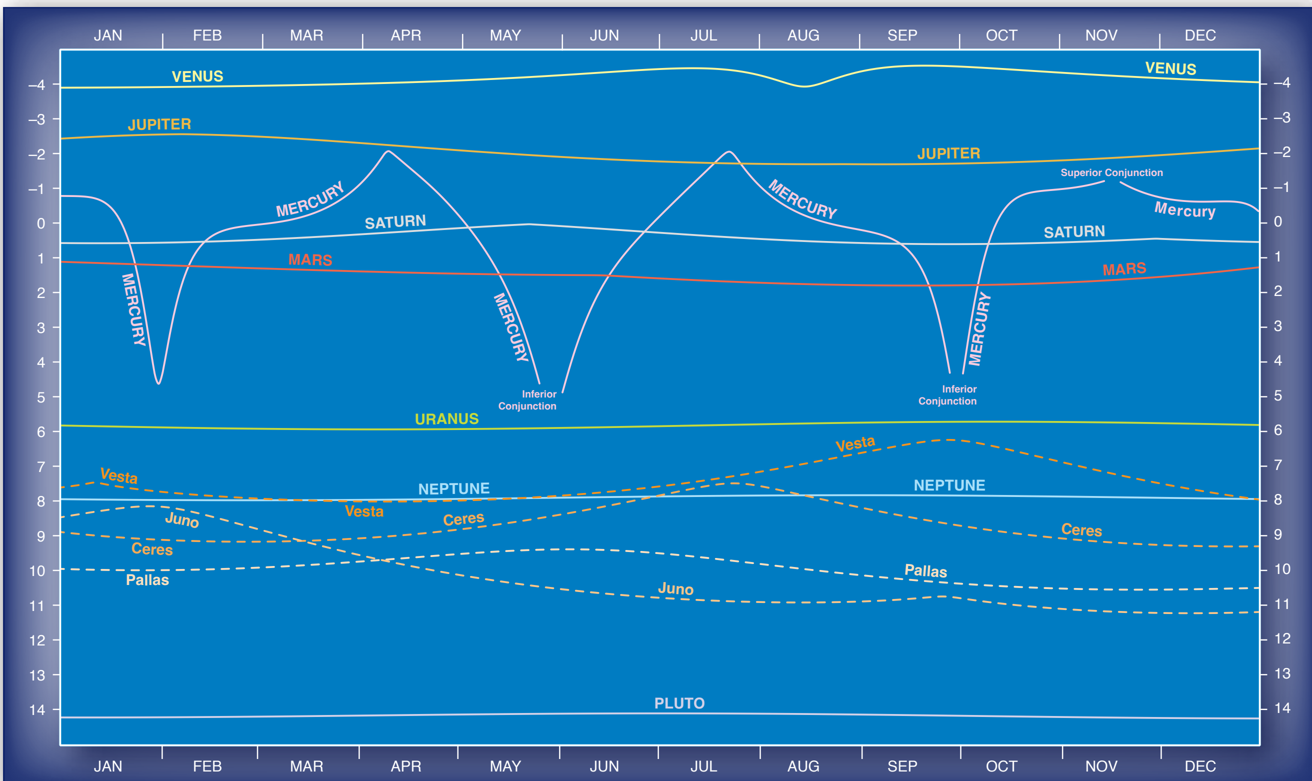
Because the orbits of the outer planets are inclined to that of the Earth's, the path can never be a straight line. It will always be a loop or an S-bend.

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 as it is less prone to turbulence. This can be particularly relevant when trying to observe a planet under high magnification.

MAGNITUDES of the PLANETS and MAJOR ASTEROIDS



GEOCENTRIC PHENOMENA (UT)

Planet	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary	Greatest Elongation West	Superior Conjunction
Mercury	14 Jan, 21h (18.9°)	21 Jan, 4h	30 Jan, 14h	11 Feb, 7h	24 Feb, 16h (26.7°)	10 Apr, 4h
	7 May, 5h (21.2°)	19 May, 11h	30 May, 17h	11 Jun, 20h	24 Jun, 17h (22.5°)	23 Jul, 19h
	4 Sep, 10h (27.1°)	17 Sep, 13h	30 Sep, 15h	8 Oct, 22h	16 Oct, 3h (18.1°)	17 Nov, 15h
	29 Dec, 3h (19.7°)					
Venus	6 Jun, 18h (45.4°)	23 Jul, 6h	15 Aug, 19h	5 Sep, 9h	26 Oct, 7h (46.4°)	

Planet	Conjunction	Stationary	Opposition	Stationary	Conjunction
Mars	14 Jun, 16h				
Jupiter			6 Feb, 18h	8 Apr, 20h	26 Aug, 22h
Saturn		14 Mar, 22h	23 May, 2h	2 Aug, 20h	30 Nov, 0h
Uranus	6 Apr, 14h	26 Jul, 16h	12 Oct, 4h	26 Dec, 11h	
Neptune	26 Feb, 5h	12 Jun, 20h	1 Sep, 4h	18 Nov, 21h	
Pluto	4 Jan, 0h	17 Apr, 7h	6 Jul, 16h	24 Sep, 17h	

EARTH	
Perihelion	4 Jan, 7h
Equinox	20 Mar, 23h
Solstice	21 Jun, 17h
Aphelion	6 Jul, 20h
Equinox	23 Sep, 8h
Solstice	22 Dec, 5h

HELIOCENTRIC PHENOMENA (UT)

Planet	Perihelion	Aphelion	Ascending Node	Greatest Latitude North	Descending Node	Greatest Latitude South
Mercury	Jan 21	Mar 6	Jan 17	Feb 1	Feb 24	Mar 27
	Apr 19	Jun 2	Apr 15	Apr 30	May 23	Jun 23
	Jul 16	Aug 29	Jul 12	Jul 27	Aug 19	Sep 19
	Oct 12	Nov 25	Oct 8	Oct 22	Nov 15	Dec 15
Venus	Apr 18	Aug 8	Mar 15	May 10	Jul 5	Jan 18
	Nov 29		Oct 26	Dec 20		Aug 31
Mars		Nov 20	Apr 12	Oct 13		
Jupiter, Saturn, Uranus, and Neptune have no events in 2015						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS and PLUTO

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun ($\times 10^3$ km)	-	-	57856	108132	149492	227780	777776	1425983	2867760	4492800	5745000
Mean Distance from Sun (Earth = 1)	-	-	0.387	0.723	1.000	1.524	5.203	9.540	19.180	30.700	39.670
Magnitude at Opposition	–26.8	–12.74 [11]	0.16 [12]	–4.07 [12]	–3.5 [13]	–2.01	–2.70	0.67	5.52	7.84	13.7
Equatorial Diameter (km)	1392530	3474.8	4879.4	12103.6	12756.3	6792.4	142984	120536	51118	49528	2390
Flattening [1]	0	0	0	0	0.00335281	0.005886	0.064874	0.097962	0.022927	0.017081	0
No of Moons	-	-	0	0	1	2	67	62	27	14	5
Mass ($\times 10^{24}$ kg)	1.9884×10^{30}	0.073458	0.3301	4.8673	5.9721986	0.64169	1898.1	568.31	86.809	102.41	0.013041
Mass (Earth = 1)	332946	0.012300	0.0553	0.8150	1.0000000	0.10745	317.8	95.16	14.536	17.148	0.002184
Volume (Earth = 1)	1300000	0.02	0.06	0.86	1	0.15	1323	752	64	54	0.007
Sidereal Period [2]	-	27.32 d	87.97 d	224.7 d	365.256 d	687 d	11.86 y	29.46 y	84.01 y	164.8 y	249.9 y
Synodic Period (Days) [3]	-	29.4	115.8	583.9	-	779.8	398.8	378.0	369.7	367.5	366.7
Axial Rotation (Days) [4]	25.38 [9]	27.32166	58.6462	–243.0185	0.99726963	1.02595676	0.41354 [14]	0.44401 [14]	–0.71833	0.67125	–6.3872
Albedo [5]	-	0.12	0.106	0.65	0.367	0.150	0.52	0.47	0.51	0.41	0.3
Eccentricity [6]	-	0.0549	0.20562	0.00681	0.01681	0.09333	0.04837	0.05582	0.0471	0.00855	0.2486
Inclination [7]	-	5° 08' 40"	7° 00' 00"	3° 23' 38"	0° 00' 00"	1° 51' 01"	1° 18' 28"	2° 29' 29"	0° 46' 22"	1° 46' 38"	17° 09' 00"
Obliquity [8]	7° 15' [10]	6° 41'	0° 01'	2° 38'	23° 26'	25° 11'	3° 07'	26° 45'	82° 14'	28° 20'	60° 25'

Notes:

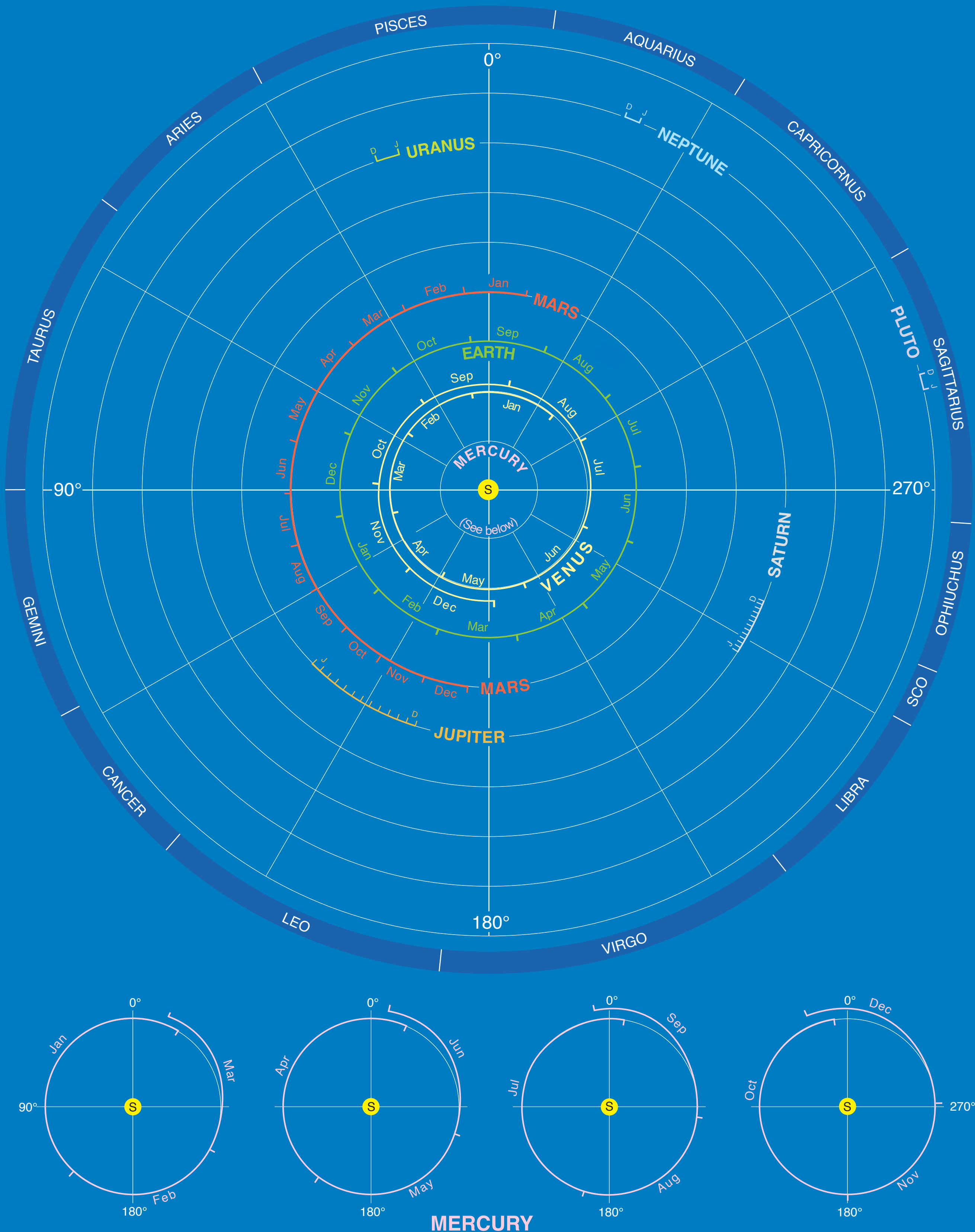
1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
5 The ratio of the sunlight reflected 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 (polar areas of the Sun rotate in 29–30 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 the reference point.
15 Value is uncertain.
16 Retrograde

The satellite table (right) covers those currently known (as of August 2014). Some are not yet named, instead they have a preliminary designation such as S/2007 S3.

SOLAR SYSTEM DATA — SATELLITES

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (× 10³ km)	RADIUS (km)	MAG AT OPP
Earth	Moon	27.321661		384.400	1,737.4	–12.74
Mars	Phobos	0.31891023	25"	9.380	13.4 × 11.2 × 9.2	11.9
	Deimos	1.2624407	1' 02"	23.460	7.5 × 6.1 × 5.2	13.0
Jupiter	Metis	0.295	42"	127.98	22	17.5
	Adrastea	0.298	42"	128.98	10 × 8 × 7	18.7
	Amalthea	0.49817905	59"	181.20	125 × 73 × 64	14.1
	Thebe	0.675	1' 13"	221.90	58 × 49 × 42	16.0
	Io	1.769137786	2' 18"	422.0	1829 × 1819 × 1816	5.0
	Europa	3.551181041	3' 40"	671.0	1,562	5.3
	Ganymede	7.15455296	5' 51"	1,070.0	2,632	4.6
	Callisto	16.6890184	10' 18"	1,883.0	2,409	5.7
	Themisto	130.0	40' 44"	7,450.00	2 [15]	20.3
	Leda	240.5	1° 00' 58"	11,150.00	10 [15]	19.0
	Himalia	250.1	1° 02' 34"	11,443.00	85	14.6
	Lysithea	258.5	1° 03' 58"	11,700.00	18 [15]	18.3
	Elara	259.1	1° 04' 03"	11,716.00	43 [15]	16.3
	S/2000 J11	287		12,555	2	22.4
	Carpo	455.07	1° 33' 14"	17,056.04	1.5 [15]	23.0
	S/2003 J3	505	1° 44' 24"	18,290.718	0.5	23.6
	S/2003 J12	533	1° 49' 12"	18,951.537	0.7	23.8
	Euporie	555.2 [16]	1° 46' 38"	19,509.12	1 [15]	23.1
	S/2011 J1	580.7 [16]		20,155.29	1	23.6
	Chaldene	591.7 [16]	1° 50' 57"	20,299.46	1.5 [15]	22.5
	S/2010 J2	588.1		20,307.15	1	23.9
	S/2003 J16	596.76	1° 58' 48"	20,434.426	0.8	23.0
	Mneme	599.65 [16]	1° 52' 03"	20,500.28	1 [15]	23.3
	Helike	601.40 [16]	1° 52' 16"	20,540.27	2 [15]	22.6
	Iocaste	606.3 [16]	1° 52' 50"	20,642.86	2 [15]	22.5
	S/2003 J18	607.68	2°	20,682.998	1	23.0
	Thyone	610.0 [16]	1° 53' 31"	20,769.90	1.5 [15]	22.3
	Orthosie	613.6 [16]	1° 53' 58"	20,849.89	1 [15]	23.1
	Harpalyke	617.3 [16]	1° 54' 20"	20,917.72	1.5 [15]	23.0
	Euanthe	620.9 [16]	1° 54' 41"	20,983.14	1.5 [15]	22.8
	Hermippe	624.6 [16]	1° 55' 26"	21,047.99	2 [15]	22.1
	Ananke	624.1 [16]	1° 55' 03"	21,048.00	14 [15]	18.8
	Praxidike	624.6 [16]	1° 55' 19"	21,098.10	2.5 [15]	22.5
	Thelxinoe	635.82 [16]	1° 56' 31"	21,316.68	1 [15]	23.5
	Taygete	650.1 [16]	1° 58' 27"	21,671.85	2 [15]	22.9
	Erinome	661.1 [16]	1° 59' 31"	21,867.75	1.5 [15]	22.8
	S/2003 J15	667.17	2° 7' 48"	22,011.816	0.7	23.3
	Aitne	679.3 [16]	2° 01' 44"	22,274.41	1.5 [15]	22.7
	Kale	679.4 [16]	2° 01' 53"	22,300.64	1 [15]	23.0
	Kallichore	681.94 [16]	2° 02' 04"	22,335.35	1 [15]	23.7
	S/2003 J9	684	2° 9' 36"	22,381.517	0.7	23.6
	Herse	689.98	2° 10' 12"	22,510.605	1	23.0
	Sponde	690.3 [16]	2° 03' 14"	22,548.24	1 [15]	23.0
	S/2003 J19	700.83	2° 12' 0"	22,745.922	0.8	23.5
	Isonoe	704.9 [16]	2° 04' 38"	22,804.70	1.5 [15]	22.5
	Hegemone	715 [16]	2° 05' 44"	23,006.33	1.5 [15]	22.8
	S/2003 J4	722	2° 14' 24"	23,195.569	1	22.7
	Carme	726.3 [16]	2° 07' 14"	23,280.00	23 [15]	17.6
	S/2010 J1	723.2		23,314.335	2	22.3
	S/2011 J2	726.8 [16]		23,329.71	1	23.6
	Megaclite	734.1 [16]	2° 08' 06"	23,439.08	2 [15]	22.1
	Eukelade	735.27 [16]	2° 08' 21"	23,485.28	2 [15]	22.6
	Cyllene	737.80 [16]	2° 08' 41"	23,544.84	1 [15]	23.2
	Pasiphae	744.2 [16]	2° 09' 18"	23,658.00	30 [15]	17.0
	Aoede	747 [16]	2° 09' 46"	23,743.83	2 [15]	22.5
	Arche	748.7 [16]	2° 09' 53"	23,765.12	1.5 [15]	22.8
	Pasithee	748.76 [16]	2° 09' 58"	23,780.14	1 [15]	23.2
	Eurydome	752.4 [16]	2° 10' 14"	23,830.94	1.5 [15]	22.7
	Sinope	753.2 [16]	2° 10' 20"	23,848.00	19 [15]	18.1
	S/2003 J23	759.15	2° 19' 12"	23,991.011	0.7	23.6
	S/2003 J5	761	2° 19' 12"	24,019.614	1.8	22.0
	Kalyke	767 [16]	2° 11' 54"	24,135.61	2 [15]	21.8
	S/2003 J10	768.4	2° 19' 48"	24,184.59	0.9	23.6
	Autonoe	778.0 [16]	2° 13' 25"	24,413.09	1.5 [15]	22.0
	Callirrhoe	736 [16]	2° 14' 25"	24,596.24	3.5 [15]	20.7
	Kore	807.20 [16]	2° 16' 29"	24,974.03	1 [15]	23.6
	S/2003 J2	983	2° 42' 36"	28,493.817	1	23.2
Saturn	S/2009 S1	0.4715	19"	117	0.15	
	Pan	0.575	22"	133.58	14.2	19.4
	Daphnis	0.594	22"	136.50	3.9	23.4
	Atlas	0.602	22"	137.67	20.9 × 18.1 × 8.9	19.0
	Prometheus	0.613	22"	139.38	66.3 × 39.5 × 30.7	15.8
	Pandora	0.629	23"	141.72	51.6 × 39.8 × 32.0	16.4
	Epimetheus	0.694	24"	151.41	58.0 × 58.7 × 53.2	15.6
	Janus	0.695	24"	151.46	97.4 × 96.9 × 77.2	14.4
	Aegaeon	0.8081	27" [15]	167.5	0.25	27R
	Mimas	0.942421813	30"	185.54	207 × 197 × 191	12.8
	Methone	1.01	31"	194.44	1.6	25.1
	Anthe	1.037	32"	197.70	1 [15]	26 [15]
	Pallene	1.14	34"	212.28	2.2	24.5
	Enceladus	1.370217855	38"	238.20	257 × 251 × 248	11.8
	Calypso	1.888	48"	294.71	15.0 × 11.5 × 7	18.7
	Telesto	1.888	48"	294.71	15.7 × 11.7 × 10.4	18.5
	Tethys	1.887802160	48"	294.99	540 × 531 × 528	10.3
	Polydeuces	2.74	1' 01"	377.20	1.3	24.8
	Helene	2.737	1' 01"	377.42	16.5	18.4
	Dione	2.736914742	1' 01"	377.65	562	10.4
	Rhea	4.517500436	1' 25"	527.37	764	9.7
	Titan	15.94542068	3' 17"	1,221.80	2,575	8.4
	Hyperion	21.2766088	3' 59"	1,481.10	164 × 130 × 107	14.4
	Iapetus	79.3301825	9' 35"	3,561.85	736	11.0
	Kiviuq	449.2	30' 27"	11,319.01	8 [15]	22.7
	Ijiraq	451.4	30' 33"	11,359.25	6 [15]	22.6
	Phoebe	548.2 [16]	34' 41"	12,893.24	110	16.7
	Paaliaq	686.9	40' 18"	14,985.05	13 [15]	21.0
	Skathi	728.2 [16]	41' 37"	15,471.94	4 [15]	23.6
	Albiorix	783.5	44' 22"	16,495.93	16 [15]	20.5
	S/2007 S2	799.8975	0° 46' 48"	16,560	3	24.4
	Bebhionn	834.8	45' 36"	16,950.00	3 [15]	24.1
	Skoll	878.3 [16]	47' 22"	17,610.00	3 [15]	24.5
	Erriapus	871.2	47' 54"	17,807.71	5 [15]	23.9
	Tarqeq	887.5	48' 12"	17,920.00	3.5 [15]	23.9
	Tarvos	926.2	48' 21"	17,977.24	7 [15]	22.3
	Greip	921.2 [16]	48' 42"	18,105.00	3 [15]	24.4
	Siarnaq	895.6	48' 57"	18,201.44	21 [15]	20.4
	Hyrrokkin	931.8 [16]	49' 00"	18,217.13	4 [15]	23.5
	Mundilfari	952.6 [16]	49' 32"	18,412.67	3 [15]	23.8
	S/2004 S13	905.82	0° 52' 48"	18,450	3	24.5
	S/2004 S17	913.125	0° 53' 24"	18,600	2	25.2
	Bergelmir	1,005.9 [16]	50' 26"	18,750.00	3 [15]	24.2
	S/2006 S1	971.565	0° 54' 0"	18,981.135	3	24.6
	Narvi	1,003.9 [16]	51' 29"	19,140.48	2.5 [15]	23.8
	Suttungr	1,016.7 [16]	51' 36"	19,185.70	4 [15]	23.9
	Aegir	1,116.5 [16]	52' 03"	19,350.00	3 [15]	24.4
	S/2004 S12	1,048.2675	0° 57' 0"	19,650	2.5	24.8
	Bestla	1,083.6 [16]	52' 51"	19,650.00	3.5 [15]	23.8
	S/2004 S7	1,103.055	0° 57' 0"	19,800	3	24.5
	Farbauti	1,086.1 [16]	53' 15"	19,800.00	2.5 [15]	24.7
	Hati	1,038.7 [16]	53' 40"	19,950.00	3 [15]	24.4
	Thrymr	1,094.3 [16]	53' 41"	19,957.54	4 [15]	23.9
	S/2007 S3	1,099.4025	0° 58' 48"	20,578	2.5	24.9
	S/2006 S3	1,143.2325	1° 0' 0"	21,132	3	24.6
	Fenrir	1,260.3 [16]	59' 43"	22,200.00	2 [15]	25.0
	Fornjot	1,490.9 [16]	59' 43"	22,200.00	3 [15]	24.6
	Surtur	1,297.7 [16]	59' 57"	22,290.00	3 [15]	24.8
	Kari	1,233.6 [16]	1° 00' 07"	22,350.00	3.5 [15]	23.9
	Jarnsaxa	964.7 [16]	1° 02' 22"	23,190.00	3 [15]	24.7
	Loge	1,312.0 [16]	1° 02' 22"	23,190.00	3 [15]	24.6
	Ymir	1,315.4 [16]	1° 02' 41"	23,305.87	10 [15]	22.4
Uranus	Cordelia	0.335	4"	49.75	25 × 18 × 18	23.1
	Ophelia	0.376	4"	53.76	27 × 19 × 19	22.8
	Bianca	0.435	4"	59.17	27	22.0
	Cressida	0.46356960	5"	61.77	41	21.1
	Desdemona	0.47364960	5"	62.66	35	21.5
	Juliet	0.49306549	5"	64.36	53	20.6
	Portia	0.51319592	5"	66.10	70	19.9
	Rosalind	0.55845953	5"	69.93	36	21.3
	Cupid	0.616	6"	74.80	8.9	25.9
	Belinda	0.62352747	6"	75.26	45	21.0
	Perdita	0.638	6"	76.42	13.3	24.0
	Puck	0.76183287	7"	86.00	81	19.2
	Mab	0.923	7"	97.73	12.4	25.4
	Miranda	1.41347925	10"	129.87	240 × 234 × 233	15.3
	Ariel	2.52037935	14"	190.95	581 × 578 × 578	13.2
	Umbriel	4.1441772	20"	266.00	585	14.0
	Titania	8.7058717	33"	436.30	789	13.0
	Oberon	13.4632389	44"	583.52	761	13.2
	Francisco	266.6 [16]	5' 24"	4,276.00	7 [15]	25.0
	Caliban	579.6 [16]	9' 03"	7,170.00	49	22.4
	Stephano	675.7 [16]	10' 19"	7,942.00	10 [15]	24.1
	Trinculo	759.7 [16]	10' 50"	8,571.02	7 [15]	25.4
	Sycorax	1,289.0 [16]	15' 24"	12,216.00	95	20.8
	Margaret	1,694.8	18' 07"	14,345.00	7.5 [15]	25.2
	Prospero	1,948.1 [16]	20' 19"	16,089.00	15 [15]	23.2
	Setebos	2,303.1 [16]	22' 43"	17,988.00	17.5 [15]	23.3
	Ferdinand	2,823.4 [16]	26' 24"	20,901.00	8 [15]	25.1
Neptune	Naiad	0.294	2"	48.227	33	23.9
	Thalassa	0.311	2"	50.075	41	23.3
	Despina	0.334655	2"	52.526	75	22.0
	Galatea	0.428745	3"	61.953	88	21.9
	Larissa	0.554654	3"	73.548	97	21.5
	S/2004 N1	0.950	5"	105.284	9	26.5
	Proteus	1.122315	6"	117.647	210	19.8
	Triton	5.8768541 [16]	17"	354.759	1,353	13.0
	Nereid	360.13	4' 22"	5,513.4	170	19.7
	Halimede	1,881.00	12' 26"	15,728.00	25 [15]	24.5
	Sao	2,914.63	17' 44"	22,422.00	13.5 [15]	25.4
	Laomedeia	3,166.65	18' 38"	23,571.00	16.5 [15]	25.4
	Psamathe	9,116.45	36' 55"	46,695.00	18 [15]	25.6
	Neso	9,737.36	38' 15"	48,387.00	21.5 [15]	24.6
Pluto	Charon	6.38723	1"	19.571	604	17.3
	Styx	20.16	2"	42.393	10	27.0
	Nix	24.8562	2"	48.671	13	23.4
	Kerberos	32.17	2"	57.729	14	26.1
	Hydra	38.2065	2"	64.698	30.5	22.9

PLANET POSITIONS



This diagram illustrates the relative positions of the planets during the course of their orbits in 2015. The relationships between the major Solar System bodies are clearly shown. The diagram is drawn as viewed from above (north 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 named constellations are those situated on the ecliptic.

SUN

GEOCENTRIC POSITION

(0 hr UT, Epoch 2000.0)

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

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

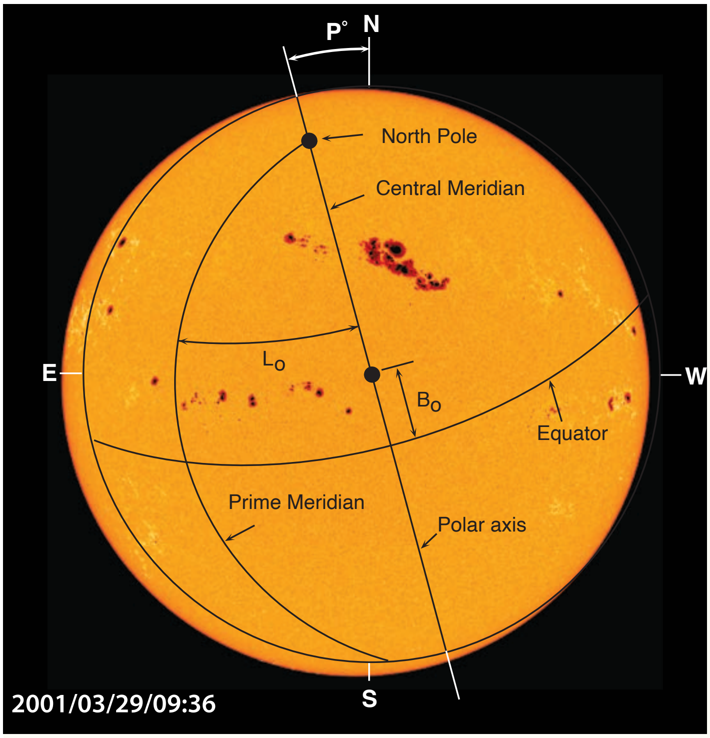
SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

ORIENTATION OF THE SUN



Sun image shows active region 9393, hosting a large sunspot group. On 30 March 2001, the sunspot area within the group spanned an area more than 13 times the entire surface of the Earth! It was the source of numerous flares and coronal mass ejections, including the largest flare recorded (at the time) in 25 years on 2 April 2001. Caused by intense magnetic fields emerging from the interior, a sunspot appears to be dark only when contrasted against the rest of the solar surface, because it is slightly cooler than the unmarked regions. Courtesy of SOHO/[MDI] consortium. SOHO is a project of international cooperation between ESA and NASA.

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 L_o is zero; that is, the prime meridian passes through the central point of the disc. 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 L_o value for 19 June at 2 pm WST.

2 pm WST is 6 hours UT (0 hr UT is 8 am WST). To get the value for 19 June (0 hr UT) start with the value from the main table for 13 June (61.4°) plus 6 days which from the daily variation table is –79.1°. Then you add the value for 6 hours, which is –3.3°. The calculation becomes:

61.4° + (–79.1°) + (–3.3°) = –21.0°

(If result negative, add 360°, if greater than 360, subtract 360) so

–21.0° + 360° = 339.0°

VARIATION OF L_o	
DAILY	
1	– 13.2
2	– 26.4
3	– 39.6
4	– 52.7
5	– 65.9
6	– 79.1
HOURLY	
1	– 0.6
2	– 1.1
3	– 1.7
4	– 2.2
5	– 2.8
6	– 3.3
7	– 3.8
8	– 4.4
9	– 4.9
10	– 5.5
11	– 6.0
12	– 6.6
13	– 7.1
14	– 7.7
15	– 8.2
16	– 8.8
17	– 9.3
18	– 9.9
19	– 10.4
20	– 11.0
21	– 11.5
22	– 12.1
23	– 12.6
24	– 13.2

SYNODIC ROTATION NUMBERS (UT)

Rotation	Month	d.dd
2159	Jan	4.94
2160	Feb	1.28
2161	Feb	28.62
2162	Mar	27.93
2163	Apr	24.21
2164	May	21.43
2165	Jun	17.64
2166	Jul	14.84
2167	Aug	11.05
2168	Sep	7.30
2169	Oct	4.57
2170	Oct	31.86
2171	Nov	28.17
2172	Dec	25.49

Date		P°	B_o°	L_o°
Jan	3	+ 1.3	– 3.2	025.5
	10	– 2.1	– 4.0	293.3
	17	– 5.4	– 4.7	201.1
	24	– 8.6	– 5.4	109.0
	31	– 11.6	– 5.9	016.8
Feb	7	– 14.4	– 6.4	284.6
	14	– 16.9	– 6.8	192.5
	21	– 19.2	– 7.0	100.3
	28	– 21.2	– 7.2	008.1
Mar	7	– 22.8	– 7.3	275.9
	14	– 24.2	– 7.2	183.6
	21	– 25.2	– 7.0	091.4
	28	– 25.9	– 6.8	359.1
Apr	4	– 26.2	– 6.4	266.7
	11	– 26.2	– 6.0	174.4
	18	– 25.8	– 5.4	081.9
	25	– 25.1	– 4.8	349.5
May	2	– 24.0	– 4.1	257.0
	9	– 22.6	– 3.4	164.4
	16	– 20.8	– 2.6	071.9
	23	– 18.7	– 1.8	339.3
	30	– 16.3	– 1.0	246.7
Jun	6	– 13.7	– 0.1	154.0
	13	– 10.8	+ 0.7	061.4
	20	– 7.8	+ 1.6	328.7
	27	– 4.7	+ 2.4	236.1
Jul	4	– 1.5	+ 3.2	143.4
	11	+ 1.7	+ 3.9	050.8
	18	+ 4.8	+ 4.6	318.1
	25	+ 7.8	+ 5.2	225.5
Aug	1	+ 10.7	+ 5.8	132.9
	8	+ 13.4	+ 6.2	040.4
	15	+ 15.9	+ 6.6	307.8
	22	+ 18.1	+ 6.9	215.3
	29	+ 20.2	+ 7.1	122.8
Sep	5	+ 21.9	+ 7.2	030.3
	12	+ 23.4	+ 7.2	297.9
	19	+ 24.6	+ 7.2	205.5
	26	+ 25.5	+ 7.0	113.1
Oct	3	+ 26.1	+ 6.7	020.7
	10	+ 26.3	+ 6.3	288.3
	17	+ 26.1	+ 5.8	196.0
	24	+ 25.6	+ 5.2	103.7
	31	+ 24.7	+ 4.5	011.4
Nov	7	+ 23.4	+ 3.8	279.1
	14	+ 21.8	+ 3.0	186.8
	21	+ 19.7	+ 2.2	094.5
	28	+ 17.4	+ 1.3	002.2
Dec	5	+ 14.7	+ 0.4	270.0
	12	+ 11.7	– 0.5	177.7
	19	+ 8.5	– 1.4	085.5
	26	+ 5.2	– 2.2	353.3

Partial Solar Eclipse Sunset Series

Stephen Mudge (Solar System - Wide-Field)

An honourable mention from the 2014 CWAS David Malin awards. See page 10.

SOLAR AND LUNAR ECLIPSES

During 2015 there are four eclipses, two of the Sun and two of the Moon. The two lunar eclipses are total and there is a total and partial eclipse of the Sun. The only eclipse visible from Australasia is the April total lunar eclipse.

To cater for all observers we use four time zones in the eclipse section, UT, EST, CST and WST **and no account is made for daylight saving time (add one hour if applicable)**. Carefully check the data you are using when planning your observing.

20 March — Total eclipse of the Sun

The first solar eclipse of the year is total and occurs mostly over water in the northern hemisphere. The path of totality begins off the southern coast of Greenland and heads northeast between Iceland and the United Kingdom. First landfall is the Danish owned Faeroe Islands where the capitol Torshavn will enjoy 2 minutes and 5 seconds of totality. The path continues across the Norwegian Sea with the next touchdown being the Norwegian archipelago Svalbard, where the few inhabitants will witness 2 minutes and 30 seconds of daytime darkness – the path then leaves the Earth near the North Pole. Greatest eclipse of 2 minutes and 47 seconds occurs over the Norwegian Sea.

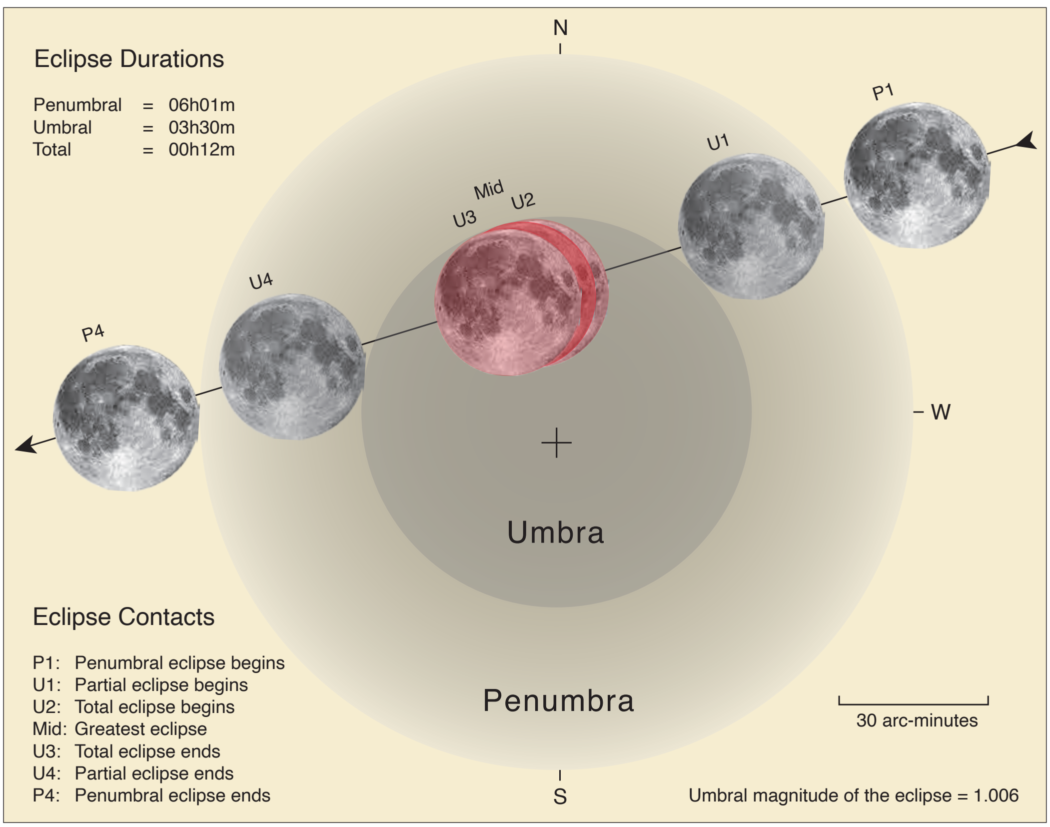
13 September — Partial eclipse of the Sun

The year's second solar eclipse is partial and will not attract a lot of attention. The shadow begins in the southern portion of Africa (south of latitude –15°) and heads across the south-western Indian Ocean making landfall over Antarctica. At Cape Town, South Africa, the eclipse magnitude (fraction of the Sun's diameter occulted by the Moon) is 0.42 and the eclipse obscuration (fraction of the Sun's area occulted by the Moon) is 30%.

28 September — Total eclipse of the Moon

The last of this year's eclipses is visible from North America, South America, Europe, Africa, Antarctica, the eastern Pacific Ocean, the Atlantic Ocean and the western Indian Ocean. With a magnitude of 1.282 the Moon traverses a much deeper path through the umbral shadow than the April total lunar eclipse.

4 April — Total eclipse of the Moon



The year's first lunar eclipse is total and visible across Australia. From the eastern states the eclipse is visible in its entirety. From Western Australia greatest eclipse occurs 30 minutes after the end of astronomical twilight. Essentially if you cut the continent in half (down the 133° degree longitude line) those to the east will see the full eclipse, those to the west will suffer from some degree of daylight or twilight interference during the early stages.

This is a very short eclipse with the totality phase lasting just 12 minutes. The figures presented here are based on predictions from the Nautical Almanac Office of the US Naval Observatory, however some published data varies from this. The NASA eclipse site has a totality length of just 4.7 minutes – the shortest duration since the eclipse of 17th October 1529 (1.7 minutes), over 485 years ago! The next shortest (2.6 minutes) occurs 140 years hence on 11th September 2155. By comparison the length of the totality phase of a *typical* eclipse is often 60 to 90 minutes, with an upper limit of a little over 100 minutes – one of the longest occurred as recently as 16th July 2000 when it lasted for 106.4 minutes. The variation in time stems from different methods of calculating the eclipse geometry to allow for the Earth's atmosphere.

The magnitude of this eclipse, or the fraction of the Moon's diameter immersed in the umbral shadow is 1.006 (during a partial eclipse the magnitude is between 0.0 and 1.0, and when total the magnitude will be larger than 1.0).

The shallow incursion of the Moon into the northern edge of the Earth's umbra might also make this the brightest total lunar eclipse in recent history, although there are other factors that contribute to the darkness and redness of each and every eclipse.

		UT	EST	CST	WST
Penumbral eclipse begins	P1	08:59.6	7:00 pm	6:30 pm	5:00 pm
Partial eclipse begins	U1	10:15.4	8:15 pm	7:45 pm	6:15 pm
Total eclipse begins	U2	11:54.1	9:54 pm	9:24 pm	7:54 pm
Greatest eclipse	Mid	12:00.2	10:00 pm	9:30 pm	8:00 pm
Total eclipse ends	U3	12:06.4	10:06 pm	9:36 pm	8:06 pm
Partial eclipse ends	U4	13:45.1	11:45 pm	11:15 pm	9:45 pm
Penumbral eclipse ends	P4	15:00.8	1:01 am	12:31 am	11:01 pm

ADELAIDE (CST) MOON RISE AND SET BRISBANE (EST)

ADELAIDE (CST)

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

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

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

Note: DNR or DNS means Moon does not rise or 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.

BRISBANE (EST)

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

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

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

CANBERRA (EST) MOON RISE AND SET DARWIN (CST)

CANBERRA (EST)

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

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

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

DARWIN (CST)

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

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

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

Note: DNR or DNS means Moon does not rise or 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.

HOBART (EST) MOON RISE AND SET MELBOURNE (EST)

HOBART (EST)

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

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

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

Note: DNR or DNS means Moon does not rise or 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 Rise	JANUARY Set	FEBRUARY Rise	FEBRUARY Set	MARCH Rise	MARCH Set	APRIL Rise	APRIL Set
1	15:58	01:52	17:26	02:59	16:08	01:48	16:31	03:20
2	16:57	02:35	18:09	03:52	16:48	02:42	17:01	04:15
3	17:52	03:21	18:47	04:46	17:24	03:36	17:32	05:09
4	18:43	04:11	19:23	05:42	17:57	04:31	18:02	06:04
5	19:29	05:04	19:55	06:37	18:29	05:26	18:35	07:00
6	20:10	05:58	20:26	07:31	18:59	06:20	19:09	07:56
7	20:48	06:54	20:56	08:26	19:29	07:15	19:47	08:53
8	21:22	07:49	21:26	09:21	20:00	08:10	20:28	09:50
9	21:53	08:44	21:58	10:16	20:33	09:05	21:15	10:46
10	22:24	09:39	22:31	11:11	21:08	10:01	22:06	11:41
11	22:54	10:33	23:07	12:08	21:46	10:58	23:03	12:34
12	23:24	11:28	23:48	13:05	22:29	11:55	DNR	13:23
13	23:56	12:24	DNR	14:03	23:18	12:51	00:04	14:09
14	DNR	13:21	00:34	15:01	DNR	13:46	01:09	14:52
15	00:31	14:19	01:27	15:57	00:12	14:39	02:17	15:33
16	01:10	15:19	02:26	16:51	01:12	15:29	03:26	16:13
17	01:55	16:19	03:31	17:41	02:18	16:15	04:37	16:52
18	02:46	17:18	04:41	18:27	03:26	16:59	05:47	17:32
19	03:44	18:15	05:53	19:10	04:37	17:41	06:58	18:14
20	04:48	19:07	07:05	19:51	05:50	18:21	08:06	18:59
21	05:57	19:55	08:17	20:31	07:02	19:01	09:12	19:47
22	07:08	20:39	09:28	21:10	08:13	19:43	10:14	20:38
23	08:19	21:19	10:36	21:51	09:22	20:26	11:10	21:32
24	09:29	21:58	11:41	22:33	10:28	21:11	12:00	22:27
25	10:38	22:35	12:44	23:18	11:30	21:59	12:44	23:22
26	11:45	23:14	13:42	DNS	12:28	22:50	13:23	DNS
27	12:50	23:53	14:35	00:06	13:19	23:43	13:59	00:17
28	13:52	DNS	15:24	00:56	14:06	DNS	14:32	01:12
29	14:51	00:35			14:47	00:36	15:03	02:07
30	15:47	01:20			15:24	01:31	15:33	03:02
31	16:39	02:08			15:59	02:25		

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

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

PERTH (WST) — MOON RISE AND SET — SYDNEY (EST)

PERTH (WST)

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

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

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

Note: DNR or DNS means Moon does not rise or 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 Rise	JANUARY Set	FEBRUARY Rise	FEBRUARY Set	MARCH Rise	MARCH Set	APRIL Rise	APRIL Set
1	15:25	01:32	16:52	02:42	15:35	01:30	16:02	02:58
2	16:23	02:17	17:36	03:34	16:15	02:23	16:35	03:51
3	17:18	03:04	18:15	04:28	16:53	03:17	17:06	04:44
4	18:08	03:54	18:52	05:21	17:28	04:10	17:39	05:37
5	18:55	04:46	19:26	06:15	18:01	05:03	18:13	06:31
6	19:38	05:40	19:59	07:08	18:33	05:56	18:48	07:25
7	20:16	06:34	20:31	08:01	19:05	06:49	19:27	08:21
8	20:52	07:28	21:02	08:54	19:37	07:42	20:10	09:17
9	21:25	08:22	21:35	09:47	20:11	08:36	20:57	10:12
10	21:57	09:15	22:10	10:41	20:48	09:30	21:49	11:07
11	22:29	10:08	22:47	11:36	21:27	10:26	22:45	11:59
12	23:01	11:01	23:29	12:32	22:11	11:21	23:45	12:50
13	23:34	11:55	DNR	13:29	23:00	12:17	DNR	13:37
14	DNR	12:50	00:16	14:27	23:55	13:12	00:49	14:22
15	00:11	13:47	01:09	15:23	DNR	14:05	01:55	15:05
16	00:51	14:46	02:08	16:17	00:54	14:56	03:02	15:46
17	01:37	15:45	03:12	17:09	01:58	15:44	04:10	16:28
18	02:28	16:44	04:20	17:57	03:05	16:29	05:19	17:10
19	03:26	17:40	05:30	18:42	04:14	17:13	06:27	17:54
20	04:30	18:34	06:41	19:25	05:24	17:56	07:34	18:40
21	05:37	19:23	07:51	20:06	06:34	18:38	08:39	19:29
22	06:47	20:09	08:59	20:48	07:43	19:21	09:39	20:21
23	07:56	20:52	10:05	21:30	08:51	20:06	10:35	21:14
24	09:04	21:32	11:09	22:14	09:55	20:53	11:26	22:09
25	10:11	22:12	12:10	23:00	10:57	21:42	12:11	23:03
26	11:15	22:52	13:08	23:48	11:53	22:32	12:51	23:57
27	12:18	23:33	14:01	DNS	12:45	23:25	13:28	DNS
28	13:19	DNS	14:50	00:39	13:32	DNS	14:03	00:51
29	14:18	00:17			14:14	00:18	14:35	01:44
30	15:13	01:02			14:53	01:11	15:07	02:37
31	16:05	01:51			15:29	02:05		

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

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

ADELAIDE (CST) HOURS of DARKNESS BRISBANE (EST)

Note: For the Hours of Darkness tables, any time after midnight refers to the following morning. An entry of None means the Moon is up the entire time between evening and morning twilight. For the notes after each time: (e) dark starts at end of evening twilight, (s) dark starts at Moon set, (r) dark ends with Moon rise and (m) dark ends with morning twilight.

ADELAIDE (CST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:37 (s)	03:20 (m)	03:55 (s)	03:59 (m)	02:44 (s)	04:35 (m)	04:13 (s)	05:04 (m)
2	None		None		03:38 (s)	04:36 (m)	None	
3	None		None		04:31 (s)	04:38 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		None		None		19:27 (e)	19:48 (r)
8	None		20:51 (e)	21:24 (r)	None		19:25 (e)	20:30 (r)
9	21:17 (e)	21:47 (r)	20:49 (e)	21:56 (r)	20:09 (e)	20:32 (r)	19:24 (e)	21:17 (r)
10	21:17 (e)	22:19 (r)	20:48 (e)	22:30 (r)	20:07 (e)	21:08 (r)	19:23 (e)	22:09 (r)
11	21:16 (e)	22:50 (r)	20:47 (e)	23:08 (r)	20:06 (e)	21:48 (r)	19:22 (e)	23:06 (r)
12	21:16 (e)	23:22 (r)	20:45 (e)	23:50 (r)	20:04 (e)	22:32 (r)	19:20 (e)	00:06 (r)
13	21:15 (e)	23:55 (r)	20:44 (e)	00:37 (r)	20:03 (e)	23:21 (r)	19:19 (e)	01:10 (r)
14	21:15 (e)	00:32 (r)	20:43 (e)	01:30 (r)	20:01 (e)	00:15 (r)	19:18 (e)	02:17 (r)
15	21:14 (e)	01:12 (r)	20:41 (e)	02:29 (r)	20:00 (e)	01:15 (r)	19:17 (e)	03:25 (r)
16	21:14 (e)	01:57 (r)	20:40 (e)	03:33 (r)	19:58 (e)	02:19 (r)	19:15 (e)	04:33 (r)
17	21:13 (e)	02:49 (r)	20:39 (e)	04:21 (m)	19:57 (e)	03:27 (r)	19:14 (e)	05:17 (m)
18	21:12 (e)	03:40 (m)	20:37 (e)	04:22 (m)	19:55 (e)	04:37 (r)	19:13 (e)	05:17 (m)
19	21:12 (e)	03:41 (m)	20:36 (e)	04:24 (m)	19:54 (e)	04:53 (m)	19:12 (e)	05:18 (m)
20	21:11 (e)	03:43 (m)	20:34 (e)	04:25 (m)	19:52 (e)	04:54 (m)	19:11 (e)	05:19 (m)
21	21:10 (e)	03:44 (m)	20:33 (e)	04:26 (m)	19:51 (e)	04:55 (m)	19:50 (s)	05:19 (m)
22	21:09 (e)	03:45 (m)	21:09 (s)	04:27 (m)	19:49 (e)	04:56 (m)	20:41 (s)	05:20 (m)
23	21:14 (s)	03:47 (m)	21:51 (s)	04:28 (m)	20:27 (s)	04:57 (m)	21:35 (s)	05:21 (m)
24	21:54 (s)	03:48 (m)	22:35 (s)	04:30 (m)	21:13 (s)	04:58 (m)	22:29 (s)	05:21 (m)
25	22:33 (s)	03:50 (m)	23:21 (s)	04:31 (m)	22:02 (s)	04:59 (m)	23:24 (s)	05:22 (m)
26	23:13 (s)	03:51 (m)	00:09 (s)	04:32 (m)	22:53 (s)	05:00 (m)	00:18 (s)	05:23 (m)
27	23:54 (s)	03:52 (m)	00:59 (s)	04:33 (m)	23:45 (s)	05:00 (m)	01:12 (s)	05:24 (m)
28	00:37 (s)	03:54 (m)	01:51 (s)	04:34 (m)	00:39 (s)	05:01 (m)	02:06 (s)	05:24 (m)
29	01:23 (s)	03:55 (m)			01:32 (s)	05:02 (m)	02:59 (s)	05:25 (m)
30	02:11 (s)	03:57 (m)			02:26 (s)	05:03 (m)	03:53 (s)	05:26 (m)
31	03:02 (s)	03:58 (m)			03:19 (s)	05:04 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:47 (s)	05:26 (m)	None		None		None	
2	None		None		None		19:01 (e)	19:47 (r)
3	None		None		None		19:02 (e)	20:55 (r)
4	None		18:41 (e)	18:53 (r)	18:46 (e)	19:48 (r)	19:03 (e)	22:03 (r)
5	None		18:41 (e)	19:53 (r)	18:47 (e)	20:55 (r)	19:03 (e)	23:09 (r)
6	18:55 (e)	19:14 (r)	18:41 (e)	20:55 (r)	18:47 (e)	22:02 (r)	19:04 (e)	00:14 (r)
7	18:54 (e)	20:05 (r)	18:41 (e)	21:59 (r)	18:48 (e)	23:08 (r)	19:04 (e)	01:18 (r)
8	18:54 (e)	21:01 (r)	18:41 (e)	23:04 (r)	18:48 (e)	00:13 (r)	19:05 (e)	02:18 (r)
9	18:53 (e)	22:00 (r)	18:41 (e)	00:09 (r)	18:48 (e)	01:18 (r)	19:06 (e)	03:15 (r)
10	18:52 (e)	23:02 (r)	18:41 (e)	01:15 (r)	18:49 (e)	02:21 (r)	19:06 (e)	04:08 (r)
11	18:51 (e)	00:06 (r)	18:41 (e)	02:20 (r)	18:49 (e)	03:24 (r)	19:07 (e)	04:57 (r)
12	18:51 (e)	01:12 (r)	18:41 (e)	03:25 (r)	18:50 (e)	04:24 (r)	19:08 (e)	05:33 (m)
13	18:50 (e)	02:18 (r)	18:41 (e)	04:30 (r)	18:50 (e)	05:20 (r)	19:08 (e)	05:32 (m)
14	18:49 (e)	03:24 (r)	18:41 (e)	05:33 (r)	18:51 (e)	05:52 (m)	19:09 (e)	05:31 (m)
15	18:49 (e)	04:31 (r)	18:41 (e)	05:51 (m)	18:51 (e)	05:52 (m)	19:09 (e)	05:30 (m)
16	18:48 (e)	05:36 (m)	18:41 (e)	05:51 (m)	18:52 (e)	05:51 (m)	19:17 (s)	05:29 (m)
17	18:48 (e)	05:37 (m)	18:41 (e)	05:52 (m)	18:52 (e)	05:51 (m)	20:11 (s)	05:28 (m)
18	18:47 (e)	05:37 (m)	18:59 (s)	05:52 (m)	19:36 (s)	05:51 (m)	21:04 (s)	05:27 (m)
19	18:47 (e)	05:38 (m)	19:55 (s)	05:52 (m)	20:31 (s)	05:50 (m)	21:57 (s)	05:26 (m)
20	19:21 (s)	05:38 (m)	20:51 (s)	05:52 (m)	21:25 (s)	05:50 (m)	22:51 (s)	05:25 (m)
21	20:16 (s)	05:39 (m)	21:46 (s)	05:53 (m)	22:18 (s)	05:49 (m)	23:45 (s)	05:24 (m)
22	21:12 (s)	05:40 (m)	22:40 (s)	05:53 (m)	23:12 (s)	05:49 (m)	00:40 (s)	05:23 (m)
23	22:08 (s)	05:40 (m)	23:34 (s)	05:53 (m)	00:05 (s)	05:48 (m)	01:36 (s)	05:22 (m)
24	23:02 (s)	05:41 (m)	00:27 (s)	05:53 (m)	01:00 (s)	05:48 (m)	02:31 (s)	05:20 (m)
25	23:57 (s)	05:41 (m)	01:21 (s)	05:53 (m)	01:55 (s)	05:47 (m)	03:25 (s)	05:19 (m)
26	00:50 (s)	05:42 (m)	02:16 (s)	05:53 (m)	02:52 (s)	05:47 (m)	04:17 (s)	05:18 (m)
27	01:44 (s)	05:42 (m)	03:12 (s)	05:54 (m)	03:49 (s)	05:46 (m)	05:06 (s)	05:17 (m)
28	02:37 (s)	05:43 (m)	04:09 (s)	05:54 (m)	04:45 (s)	05:45 (m)	None	
29	03:32 (s)	05:44 (m)	05:06 (s)	05:54 (m)	05:39 (s)	05:45 (m)	None	
30	04:28 (s)	05:44 (m)	None		None		None	
31	05:25 (s)	05:45 (m)			None		19:20 (e)	19:44 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:20 (e)	20:54 (r)	19:44 (e)	21:56 (r)	20:18 (e)	23:32 (r)	20:57 (e)	23:34 (r)
2	19:21 (e)	22:02 (r)	19:45 (e)	23:00 (r)	20:19 (e)	00:18 (r)	20:58 (e)	00:10 (r)
3	19:22 (e)	23:08 (r)	19:45 (e)	23:58 (r)	20:20 (e)	00:59 (r)	21:00 (e)	00:43 (r)
4	19:22 (e)	00:11 (r)	19:46 (e)	00:51 (r)	20:22 (e)	01:36 (r)	21:01 (e)	01:14 (r)
5	19:23 (e)	01:10 (r)	19:47 (e)	01:38 (r)	20:23 (e)	02:10 (r)	21:02 (e)	01:46 (r)
6	19:24 (e)	02:05 (r)	19:48 (e)	02:21 (r)	20:24 (e)	02:42 (r)	21:03 (e)	02:17 (r)
7	19:25 (e)	02:55 (r)	19:49 (e)	02:59 (r)	20:26 (e)	03:13 (r)	21:04 (e)	02:51 (r)
8	19:25 (e)	03:40 (r)	19:50 (e)	03:35 (r)	20:27 (e)	03:31 (m)	21:05 (e)	03:09 (m)
9	19:26 (e)	04:21 (r)	19:51 (e)	04:08 (r)	20:28 (e)	03:30 (m)	21:06 (e)	03:09 (m)
10	19:27 (e)	04:58 (m)	19:52 (e)	04:13 (m)	20:30 (e)	03:29 (m)	21:07 (e)	03:09 (m)
11	19:27 (e)	04:57 (m)	19:53 (e)	04:11 (m)	20:31 (e)	03:28 (m)	21:08 (e)	03:09 (m)
12	19:28 (e)	04:55 (m)	19:54 (e)	04:10 (m)	20:32 (e)	03:27 (m)	21:09 (e)	03:09 (m)
13	19:29 (e)	04:54 (m)	19:55 (e)	04:08 (m)	20:34 (e)	03:26 (m)	21:10 (e)	03:09 (m)
14	19:30 (e)	04:52 (m)	19:56 (e)	04:06 (m)	21:07 (s)	03:25 (m)	21:33 (s)	03:10 (m)
15	19:52 (s)	04:51 (m)	20:29 (s)	04:05 (m)	21:58 (s)	03:24 (m)	22:18 (s)	03:10 (m)
16	20:45 (s)	04:49 (m)	21:23 (s)	04:03 (m)	22:47 (s)	03:23 (m)	22:59 (s)	03:10 (m)
17	21:39 (s)	04:48 (m)	22:17 (s)	04:02 (m)	23:33 (s)	03:22 (m)	23:39 (s)	03:10 (m)
18	22:33 (s)	04:46 (m)	23:09 (s)	04:00 (m)	00:17 (s)	03:21 (m)	00:17 (s)	03:10 (m)
19	23:27 (s)	04:45 (m)	00:00 (s)	03:59 (m)	00:58 (s)	03:20 (m)	00:56 (s)	03:11 (m)
20	00:21 (s)	04:43 (m)	00:49 (s)	03:57 (m)	01:37 (s)	03:19 (m)	01:35 (s)	03:11 (m)
21	01:14 (s)	04:42 (m)	01:34 (s)	03:56 (m)	02:16 (s)	03:18 (m)	02:17 (s)	03:12 (m)
22	02:05 (s)	04:40 (m)	02:18 (s)	03:54 (m)	02:56 (s)	03:17 (m)	03:02 (s)	03:12 (m)
23	02:55 (s)	04:39 (m)	03:00 (s)	03:53 (m)	None		None	
24	03:41 (s)	04:37 (m)	03:41 (s)	03:52 (m)	None		None	
25	04:26 (s)	04:36 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		20:54 (e)	21:21 (r)	21:18 (e)	21:29 (r)
29	None		20:14 (e)	20:41 (r)	20:55 (e)	22:11 (r)	21:18 (e)	22:07 (r)
30	19:43 (e)	20:49 (r)	20:15 (e)	21:43 (r)	20:56 (e)	22:55 (r)	21:18 (e)	22:42 (r)
31			20:16 (e)	22:41 (r)			21:18 (e)	23:15 (r)

BRISBANE (EST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:20 (s)	03:24 (m)	03:38 (s)	03:55 (m)	02:26 (s)	04:21 (m)	03:47 (s)	04:40 (m)
2	03:08 (s)	03:25 (m)	None		03:18 (s)	04:22 (m)	04:37 (s)	04:41 (m)
3	None		None		04:09 (s)	04:22 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		20:03 (e)	20:23 (r)	None		18:57 (e)	19:29 (r)
8	20:19 (e)	20:38 (r)	20:02 (e)	20:57 (r)	19:32 (e)	19:34 (r)	18:56 (e)	20:13 (r)
9	20:19 (e)	21:14 (r)	20:01 (e)	21:32 (r)	19:31 (e)	20:10 (r)	18:55 (e)	21:01 (r)
10	20:19 (e)	21:48 (r)	20:00 (e)	22:09 (r)	19:29 (e)	20:48 (r)	18:54 (e)	21:53 (r)
11	20:18 (e)	22:22 (r)	19:59 (e)	22:49 (r)	19:28 (e)	21:30 (r)	18:53 (e)	22:49 (r)
12	20:18 (e)	22:57 (r)	19:58 (e)	23:32 (r)	19:27 (e)	22:15 (r)	18:52 (e)	23:48 (r)
13	20:18 (e)	23:33 (r)	19:57 (e)	00:21 (r)	19:26 (e)	23:05 (r)	18:51 (e)	00:50 (r)
14	20:18 (e)	00:11 (r)	19:56 (e)	01:14 (r)	19:25 (e)	23:59 (r)	18:50 (e)	01:53 (r)
15	20:18 (e)	00:54 (r)	19:55 (e)	02:13 (r)	19:23 (e)	00:58 (r)	18:49 (e)	02:57 (r)
16	20:17 (e)	01:41 (r)	19:54 (e)	03:16 (r)	19:22 (e)	02:00 (r)	18:48 (e)	04:03 (r)
17	20:17 (e)	02:33 (r)	19:53 (e)	04:11 (m)	19:21 (e)	03:05 (r)	18:48 (e)	04:48 (m)
18	20:16 (e)	03:31 (r)	19:52 (e)	04:12 (m)	19:20 (e)	04:11 (r)	18:47 (e)	04:48 (m)
19	20:16 (e)	03:41 (m)	19:51 (e)	04:13 (m)	19:19 (e)	04:33 (m)	18:46 (e)	04:49 (m)
20	20:16 (e)	03:42 (m)	19:50 (e)	04:14 (m)	19:18 (e)	04:34 (m)	18:45 (e)	04:49 (m)
21	20:15 (e)	03:43 (m)	20:01 (s)	04:14 (m)	19:16 (e)	04:34 (m)	19:33 (s)	04:50 (m)
22	20:15 (e)	03:45 (m)	20:46 (s)	04:15 (m)	19:20 (s)	04:35 (m)	20:26 (s)	04:50 (m)
23	20:42 (s)	03:46 (m)	21:30 (s)	04:16 (m)	20:07 (s)	04:35 (m)	21:19 (s)	04:51 (m)
24	21:26 (s)	03:47 (m)	22:16 (s)	04:17 (m)	20:56 (s)	04:36 (m)	22:13 (s)	04:51 (m)
25	22:08 (s)	03:48 (m)	23:04 (s)	04:18 (m)	21:46 (s)	04:37 (m)	23:06 (s)	04:52 (m)
26	22:51 (s)	03:49 (m)	23:53 (s)	04:19 (m)	22:37 (s)	04:37 (m)	23:58 (s)	04:52 (m)
27	23:34 (s)	03:50 (m)	00:43 (s)	04:19 (m)	23:29 (s)	04:38 (m)	00:50 (s)	04:52 (m)
28	00:20 (s)	03:51 (m)	01:35 (s)	04:20 (m)	00:22 (s)	04:38 (m)	01:41 (s)	04:53 (m)
29	01:07 (s)	03:52 (m)			01:13 (s)	04:39 (m)	02:31 (s)	04:53 (m)
30	01:56 (s)	03:53 (m)			02:05 (s)	04:39 (m)	03:22 (s)	04:54 (m)
31	02:46 (s)	03:54 (m)			02:56 (s)	04:40 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:13 (s)	04:54 (m)	None		None		None	
2	None		None		None		18:40 (e)	19:22 (r)
3	None		None		None		18:40 (e)	20:27 (r)
4	None		18:24 (e)	18:38 (r)	18:29 (e)	19:28 (r)	18:41 (e)	21:31 (r)
5	None		18:23 (e)	19:36 (r)	18:29 (e)	20:32 (r)	18:41 (e)	22:34 (r)
6	18:33 (e)	18:58 (r)	18:23 (e)	20:36 (r)	18:29 (e)	21:35 (r)	18:42 (e)	23:36 (r)
7	18:32 (e)	19:49 (r)	18:23 (e)	21:38 (r)	18:30 (e)	22:38 (r)	18:42 (e)	00:36 (r)
8	18:32 (e)	20:44 (r)	18:23 (e)	22:40 (r)	18:30 (e)	23:39 (r)	18:43 (e)	01:35 (r)
9	18:31 (e)	21:42 (r)	18:23 (e)	23:42 (r)	18:30 (e)	00:41 (r)	18:43 (e)	02:31 (r)
10	18:31 (e)	22:43 (r)	18:24 (e)	00:43 (r)	18:31 (e)	01:42 (r)	18:43 (e)	03:24 (r)
11	18:30 (e)	23:44 (r)	18:24 (e)	01:45 (r)	18:31 (e)	02:42 (r)	18:44 (e)	04:14 (r)
12	18:30 (e)	00:46 (r)	18:24 (e)	02:47 (r)	18:32 (e)	03:40 (r)	18:44 (e)	05:00 (r)
13	18:29 (e)	01:49 (r)	18:24 (e)	03:49 (r)	18:32 (e)	04:36 (r)	18:45 (e)	05:01 (m)
14	18:29 (e)	02:52 (r)	18:24 (e)	04:50 (r)	18:32 (e)	05:15 (m)	18:45 (e)	05:00 (m)
15	18:28 (e)	03:55 (r)	18:24 (e)	05:13 (m)	18:33 (e)	05:15 (m)	18:45 (e)	04:59 (m)
16	18:28 (e)	04:59 (r)	18:24 (e)	05:13 (m)	18:33 (e)	05:15 (m)	18:52 (s)	04:59 (m)
17	18:27 (e)	05:01 (m)	18:24 (e)	05:13 (m)	18:34 (e)	05:14 (m)	19:42 (s)	04:58 (m)
18	18:27 (e)	05:02 (m)	18:42 (s)	05:14 (m)	19:15 (s)	05:14 (m)	20:33 (s)	04:57 (m)
19	18:27 (e)	05:02 (m)	19:37 (s)	05:14 (m)	20:07 (s)	05:14 (m)	21:23 (s)	04:56 (m)
20	19:05 (s)	05:03 (m)	20:31 (s)	05:14 (m)	20:58 (s)	05:14 (m)	22:14 (s)	04:55 (m)
21	20:00 (s)	05:03 (m)	21:23 (s)	05:14 (m)	21:48 (s)	05:13 (m)	23:06 (s)	04:54 (m)
22	20:55 (s)	05:04 (m)	22:15 (s)	05:14 (m)	22:39 (s)	05:13 (m)	23:59 (s)	04:53 (m)
23	21:48 (s)	05:04 (m)	23:06 (s)	05:15 (m)	23:30 (s)	05:13 (m)	00:52 (s)	04:52 (m)
24	22:41 (s)	05:05 (m)	23:56 (s)	05:15 (m)	00:22 (s)	05:12 (m)	01:47 (s)	04:52 (m)
25	23:33 (s)	05:05 (m)	00:47 (s)	05:15 (m)	01:15 (s)	05:12 (m)	02:41 (s)	04:51 (m)
26	00:24 (s)	05:05 (m)	01:39 (s)	05:15 (m)	02:09 (s)	05:12 (m)	03:34 (s)	04:50 (m)
27	01:14 (s)	05:06 (m)	02:32 (s)	05:15 (m)	03:05 (s)	05:11 (m)	04:26 (s)	04:49 (m)
28	02:05 (s)	05:06 (m)	03:27 (s)	05:15 (m)	04:01 (s)	05:11 (m)	None	
29	02:57 (s)	05:07 (m)	04:23 (s)	05:16 (m)	04:56 (s)	05:10 (m)	None	
30	03:50 (s)	05:07 (m)	None		None		None	
31	04:44 (s)	05:07 (m)			None		18:52 (e)	19:14 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	18:52 (e)	20:20 (r)	19:06 (e)	21:15 (r)	19:30 (e)	22:49 (r)	19:59 (e)	22:56 (r)
2	18:53 (e)	21:24 (r)	19:07 (e)	22:16 (r)	19:31 (e)	23:37 (r)	20:00 (e)	23:34 (r)
3	18:53 (e)	22:28 (r)	19:08 (e)	23:14 (r)	19:32 (e)	00:19 (r)	20:01 (e)	00:10 (r)
4	18:53 (e)	23:28 (r)	19:08 (e)	00:07 (r)	19:33 (e)	00:59 (r)	20:02 (e)	00:44 (r)
5	18:54 (e)	00:27 (r)	19:09 (e)	00:56 (r)	19:33 (e)	01:35 (r)	20:03 (e)	01:18 (r)
6	18:54 (e)	01:21 (r)	19:09 (e)	01:40 (r)	19:34 (e)	02:10 (r)	20:04 (e)	01:53 (r)
7	18:55 (e)	02:12 (r)	19:10 (e)	02:21 (r)	19:35 (e)	02:44 (r)	20:05 (e)	02:29 (r)
8	18:55 (e)	02:58 (r)	19:11 (e)	02:59 (r)	19:36 (e)	03:18 (r)	20:06 (e)	03:07 (r)
9	18:55 (e)	03:41 (r)	19:11 (e)	03:35 (r)	19:37 (e)	03:26 (m)	20:07 (e)	03:14 (m)
10	18:56 (e)	04:21 (r)	19:12 (e)	03:58 (m)	19:38 (e)	03:25 (m)	20:07 (e)	03:14 (m)
11	18:56 (e)	04:33 (m)	19:13 (e)	03:56 (m)	19:39 (e)	03:24 (m)	20:08 (e)	03:14 (m)
12	18:57 (e)	04:31 (m)	19:13 (e)	03:55 (m)	19:40 (e)	03:23 (m)	20:09 (e)	03:14 (m)
13	18:57 (e)	04:30 (m)	19:14 (e)	03:54 (m)	19:41 (e)	03:23 (m)	20:10 (e)	03:14 (m)
14	18:58 (e)	04:29 (m)	19:15 (e)	03:53 (m)	20:23 (s)	03:22 (m)	20:51 (s)	03:14 (m)
15	19:19 (s)	04:28 (m)	19:49 (s)	03:52 (m)	21:15 (s)	03:21 (m)	21:38 (s)	03:15 (m)
16	20:09 (s)	04:27 (m)	20:41 (s)	03:50 (m)	22:05 (s)	03:21 (m)	22:23 (s)	03:15 (m)
17	21:01 (s)	04:26 (m)	21:34 (s)	03:49 (m)	22:52 (s)	03:20 (m)	23:05 (s)	03:15 (m)
18	21:53 (s)	04:24 (m)	22:26 (s)	03:48 (m)	23:38 (s)	03:19 (m)	23:47 (s)	03:16 (m)
19	22:45 (s)	04:23 (m)	23:17 (s)	03:47 (m)	00:22 (s)	03:19 (m)	00:28 (s)	03:16 (m)
20	23:38 (s)	04:22 (m)	00:06 (s)	03:46 (m)	01:05 (s)	03:18 (m)	01:11 (s)	03:16 (m)
21	00:30 (s)	04:21 (m)	00:54 (s)	03:45 (m)	01:47 (s)	03:18 (m)	01:56 (s)	03:17 (m)
22	01:22 (s)	04:20 (m)	01:40 (s)	03:44 (m)	02:31 (s)	03:17 (m)	02:44 (s)	03:17 (m)
23	02:13 (s)	04:18 (m)	02:25 (s)	03:42 (m)	03:16 (s)	03:17 (m)	None	
24	03:02 (s)	04:17 (m)	03:10 (s)	03:41 (m)	None		None	
25	03:50 (s)	04:16 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		19:57 (e)	20:37 (r)	20:18 (e)	20:50 (r)
29	None		19:27 (e)	19:58 (r)	19:58 (e)	21:28 (r)	20:18 (e)	21:30 (r)
30	19:06 (e)	20:10 (r)	19:28 (e)	20:59 (r)	19:59 (e)	22:14 (r)	20:18 (e)	22:08 (r)
31			19:29 (e)	21:57 (r)			20:18 (e)	22:43 (r)

HOURS of DARKNESS

CANBERRA (EST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:23 (s)	03:06 (m)	03:40 (s)	03:46 (m)	02:30 (s)	04:22 (m)	03:59 (s)	04:52 (m)
2	None		None		03:23 (s)	04:24 (m)	04:52 (s)	04:53 (m)
3	None		None		04:17 (s)	04:25 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		None		None		19:15 (e)	19:34 (r)
8	None		20:40 (e)	21:10 (r)	None		19:14 (e)	20:16 (r)
9	21:07 (e)	21:35 (r)	20:38 (e)	21:43 (r)	19:57 (e)	20:19 (r)	19:12 (e)	21:03 (r)
10	21:06 (e)	22:06 (r)	20:37 (e)	22:17 (r)	19:56 (e)	20:54 (r)	19:11 (e)	21:55 (r)
11	21:06 (e)	22:37 (r)	20:36 (e)	22:54 (r)	19:54 (e)	21:34 (r)	19:10 (e)	22:51 (r)
12	21:05 (e)	23:09 (r)	20:34 (e)	23:36 (r)	19:53 (e)	22:17 (r)	19:08 (e)	23:52 (r)
13	21:05 (e)	23:42 (r)	20:33 (e)	00:22 (r)	19:51 (e)	23:06 (r)	19:07 (e)	00:56 (r)
14	21:04 (e)	00:18 (r)	20:32 (e)	01:15 (r)	19:50 (e)	00:01 (r)	19:06 (e)	02:02 (r)
15	21:04 (e)	00:58 (r)	20:30 (e)	02:14 (r)	19:48 (e)	01:00 (r)	19:05 (e)	03:10 (r)
16	21:03 (e)	01:43 (r)	20:29 (e)	03:19 (r)	19:47 (e)	02:05 (r)	19:03 (e)	04:19 (r)
17	21:02 (e)	02:34 (r)	20:27 (e)	04:08 (m)	19:45 (e)	03:12 (r)	19:02 (e)	05:04 (m)
18	21:02 (e)	03:26 (m)	20:26 (e)	04:09 (m)	19:44 (e)	04:22 (r)	19:01 (e)	05:05 (m)
19	21:01 (e)	03:28 (m)	20:25 (e)	04:10 (m)	19:42 (e)	04:41 (m)	19:00 (e)	05:06 (m)
20	21:00 (e)	03:29 (m)	20:23 (e)	04:12 (m)	19:41 (e)	04:42 (m)	18:59 (e)	05:07 (m)
21	20:59 (e)	03:30 (m)	20:22 (e)	04:13 (m)	19:39 (e)	04:43 (m)	19:35 (s)	05:07 (m)
22	20:59 (e)	03:32 (m)	20:56 (s)	04:14 (m)	19:38 (e)	04:44 (m)	20:27 (s)	05:08 (m)
23	21:01 (s)	03:33 (m)	21:37 (s)	04:15 (m)	20:13 (s)	04:45 (m)	21:20 (s)	05:09 (m)
24	21:41 (s)	03:35 (m)	22:21 (s)	04:17 (m)	20:59 (s)	04:45 (m)	22:15 (s)	05:09 (m)
25	22:20 (s)	03:36 (m)	23:06 (s)	04:18 (m)	21:48 (s)	04:46 (m)	23:10 (s)	05:10 (m)
26	22:59 (s)	03:37 (m)	23:54 (s)	04:19 (m)	22:38 (s)	04:47 (m)	00:04 (s)	05:11 (m)
27	23:40 (s)	03:39 (m)	00:45 (s)	04:20 (m)	23:31 (s)	04:48 (m)	00:58 (s)	05:12 (m)
28	00:23 (s)	03:40 (m)	01:37 (s)	04:21 (m)	00:24 (s)	04:49 (m)	01:52 (s)	05:12 (m)
29	01:08 (s)	03:42 (m)			01:18 (s)	04:50 (m)	02:45 (s)	05:13 (m)
30	01:57 (s)	03:43 (m)			02:12 (s)	04:51 (m)	03:39 (s)	05:14 (m)
31	02:47 (s)	03:45 (m)			03:05 (s)	04:51 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:33 (s)	05:14 (m)	None		None		None	
2	None		None		None		18:49 (e)	19:32 (r)
3	None		None		None		18:50 (e)	20:41 (r)
4	None		18:29 (e)	18:39 (r)	18:34 (e)	19:34 (r)	18:50 (e)	21:49 (r)
5	None		18:29 (e)	19:38 (r)	18:34 (e)	20:41 (r)	18:51 (e)	22:56 (r)
6	18:43 (e)	19:00 (r)	18:29 (e)	20:40 (r)	18:34 (e)	21:47 (r)	18:51 (e)	00:01 (r)
7	18:42 (e)	19:51 (r)	18:28 (e)	21:45 (r)	18:35 (e)	22:54 (r)	18:52 (e)	01:04 (r)
8	18:41 (e)	20:46 (r)	18:28 (e)	22:50 (r)	18:35 (e)	23:59 (r)	18:53 (e)	02:05 (r)
9	18:40 (e)	21:45 (r)	18:28 (e)	23:55 (r)	18:36 (e)	01:04 (r)	18:53 (e)	03:02 (r)
10	18:40 (e)	22:48 (r)	18:28 (e)	01:01 (r)	18:36 (e)	02:08 (r)	18:54 (e)	03:55 (r)
11	18:39 (e)	23:52 (r)	18:28 (e)	02:06 (r)	18:37 (e)	03:10 (r)	18:55 (e)	04:44 (r)
12	18:38 (e)	00:57 (r)	18:28 (e)	03:11 (r)	18:37 (e)	04:11 (r)	18:55 (e)	05:21 (m)
13	18:38 (e)	02:04 (r)	18:28 (e)	04:16 (r)	18:38 (e)	05:07 (r)	18:56 (e)	05:21 (m)
14	18:37 (e)	03:10 (r)	18:28 (e)	05:19 (r)	18:38 (e)	05:40 (m)	18:57 (e)	05:20 (m)
15	18:36 (e)	04:18 (r)	18:29 (e)	05:39 (m)	18:39 (e)	05:40 (m)	18:57 (e)	05:18 (m)
16	18:36 (e)	05:24 (m)	18:29 (e)	05:40 (m)	18:39 (e)	05:40 (m)	19:04 (s)	05:17 (m)
17	18:35 (e)	05:25 (m)	18:29 (e)	05:40 (m)	18:40 (e)	05:39 (m)	19:57 (s)	05:16 (m)
18	18:35 (e)	05:25 (m)	18:44 (s)	05:40 (m)	19:22 (s)	05:39 (m)	20:51 (s)	05:15 (m)
19	18:34 (e)	05:26 (m)	19:41 (s)	05:40 (m)	20:17 (s)	05:38 (m)	21:44 (s)	05:14 (m)
20	19:06 (s)	05:27 (m)	20:37 (s)	05:41 (m)	21:11 (s)	05:38 (m)	22:38 (s)	05:13 (m)
21	20:01 (s)	05:27 (m)	21:32 (s)	05:41 (m)	22:05 (s)	05:38 (m)	23:32 (s)	05:12 (m)
22	20:57 (s)	05:28 (m)	22:26 (s)	05:41 (m)	22:58 (s)	05:37 (m)	00:27 (s)	05:11 (m)
23	21:53 (s)	05:28 (m)	23:20 (s)	05:41 (m)	23:52 (s)	05:37 (m)	01:22 (s)	05:10 (m)
24	22:48 (s)	05:29 (m)	00:14 (s)	05:41 (m)	00:46 (s)	05:36 (m)	02:18 (s)	05:08 (m)
25	23:43 (s)	05:30 (m)	01:08 (s)	05:42 (m)	01:42 (s)	05:35 (m)	03:12 (s)	05:07 (m)
26	00:36 (s)	05:30 (m)	02:02 (s)	05:42 (m)	02:39 (s)	05:35 (m)	04:04 (s)	05:06 (m)
27	01:30 (s)	05:31 (m)	02:58 (s)	05:42 (m)	03:36 (s)	05:34 (m)	04:53 (s)	05:05 (m)
28	02:24 (s)	05:31 (m)	03:56 (s)	05:42 (m)	04:32 (s)	05:34 (m)	None	
29	03:18 (s)	05:32 (m)	04:53 (s)	05:42 (m)	05:26 (s)	05:33 (m)	None	
30	04:14 (s)	05:32 (m)	None		None		None	
31	05:11 (s)	05:33 (m)			None		19:08 (e)	19:30 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:08 (e)	20:40 (r)	19:32 (e)	21:43 (r)	20:07 (e)	23:20 (r)	20:47 (e)	23:21 (r)
2	19:09 (e)	21:48 (r)	19:33 (e)	22:46 (r)	20:08 (e)	00:05 (r)	20:48 (e)	23:57 (r)
3	19:10 (e)	22:54 (r)	19:34 (e)	23:45 (r)	20:09 (e)	00:46 (r)	20:49 (e)	00:30 (r)
4	19:10 (e)	23:58 (r)	19:35 (e)	00:38 (r)	20:11 (e)	01:23 (r)	20:50 (e)	01:01 (r)
5	19:11 (e)	00:57 (r)	19:36 (e)	01:26 (r)	20:12 (e)	01:57 (r)	20:52 (e)	01:33 (r)
6	19:12 (e)	01:52 (r)	19:37 (e)	02:08 (r)	20:13 (e)	02:29 (r)	20:53 (e)	02:04 (r)
7	19:13 (e)	02:42 (r)	19:38 (e)	02:47 (r)	20:15 (e)	03:00 (r)	20:54 (e)	02:37 (r)
8	19:13 (e)	03:27 (r)	19:39 (e)	03:22 (r)	20:16 (e)	03:18 (m)	20:55 (e)	02:56 (m)
9	19:14 (e)	04:08 (r)	19:40 (e)	03:55 (r)	20:17 (e)	03:17 (m)	20:56 (e)	02:56 (m)
10	19:15 (e)	04:46 (m)	19:41 (e)	04:00 (m)	20:19 (e)	03:16 (m)	20:57 (e)	02:55 (m)
11	19:15 (e)	04:44 (m)	19:42 (e)	03:58 (m)	20:20 (e)	03:14 (m)	20:58 (e)	02:55 (m)
12	19:16 (e)	04:43 (m)	19:43 (e)	03:57 (m)	20:21 (e)	03:13 (m)	20:59 (e)	02:55 (m)
13	19:17 (e)	04:42 (m)	19:44 (e)	03:55 (m)	20:23 (e)	03:12 (m)	21:00 (e)	02:55 (m)
14	19:18 (e)	04:40 (m)	19:45 (e)	03:54 (m)	20:54 (s)	03:11 (m)	21:20 (s)	02:56 (m)
15	19:38 (s)	04:39 (m)	20:16 (s)	03:52 (m)	21:45 (s)	03:10 (m)	22:05 (s)	02:56 (m)
16	20:32 (s)	04:37 (m)	21:10 (s)	03:51 (m)	22:35 (s)	03:09 (m)	22:46 (s)	02:56 (m)
17	21:26 (s)	04:36 (m)	22:04 (s)	03:49 (m)	23:21 (s)	03:08 (m)	23:26 (s)	02:56 (m)
18	22:20 (s)	04:34 (m)	22:57 (s)	03:47 (m)	00:04 (s)	03:07 (m)	00:04 (s)	02:57 (m)
19	23:14 (s)	04:33 (m)	23:47 (s)	03:46 (m)	00:45 (s)	03:06 (m)	00:42 (s)	02:57 (m)
20	00:08 (s)	04:31 (m)	00:36 (s)	03:44 (m)	01:24 (s)	03:05 (m)	01:21 (s)	02:57 (m)
21	01:01 (s)	04:29 (m)	01:22 (s)	03:43 (m)	02:03 (s)	03:04 (m)	02:03 (s)	02:58 (m)
22	01:53 (s)	04:28 (m)	02:05 (s)	03:41 (m)	02:43 (s)	03:04 (m)	02:48 (s)	02:58 (m)
23	02:42 (s)	04:26 (m)	02:47 (s)	03:40 (m)	None		None	
24	03:28 (s)	04:25 (m)	03:28 (s)	03:38 (m)	None		None	
25	04:13 (s)	04:23 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		20:43 (e)	21:08 (r)	21:08 (e)	21:16 (r)
29	None		20:03 (e)	20:27 (r)	20:44 (e)	21:58 (r)	21:08 (e)	21:54 (r)
30	19:31 (e)	20:36 (r)	20:04 (e)	21:30 (r)	20:46 (e)	22:42 (r)	21:08 (e)	22:29 (r)
31			20:05 (e)	22:28 (r)			21:08 (e)	23:02 (r)

Note: For the Hours of Darkness tables, any time after midnight refers to the following morning. An entry of None means the Moon is up the entire time between evening and morning twilight. For the notes after each time: (e) dark starts at end of evening twilight, (s) dark starts at Moon set, (r) dark ends with Moon rise and (m) dark ends with morning twilight.

DARWIN (CST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	03:44 (s)	05:07 (m)	05:03 (s)	05:27 (m)	03:49 (s)	05:38 (m)	04:55 (s)	05:41 (m)
2	04:34 (s)	05:08 (m)	None		04:38 (s)	05:38 (m)	05:40 (s)	05:41 (m)
3	None		None		05:25 (s)	05:38 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		20:33 (e)	20:45 (r)	None		19:58 (e)	20:05 (r)
7	20:36 (e)	20:46 (r)	20:33 (e)	21:24 (r)	None		19:57 (e)	20:49 (r)
8	20:36 (e)	21:27 (r)	20:32 (e)	22:03 (r)	20:17 (e)	20:42 (r)	19:57 (e)	21:37 (r)
9	20:36 (e)	22:07 (r)	20:32 (e)	22:43 (r)	20:16 (e)	21:23 (r)	19:56 (e)	22:27 (r)
10	20:36 (e)	22:46 (r)	20:31 (e)	23:24 (r)	20:15 (e)	22:06 (r)	19:56 (e)	23:20 (r)
11	20:36 (e)	23:25 (r)	20:31 (e)	00:08 (r)	20:15 (e)	22:51 (r)	19:55 (e)	00:15 (r)
12	20:36 (e)	00:04 (r)	20:30 (e)	00:55 (r)	20:14 (e)	23:39 (r)	19:55 (e)	01:11 (r)
13	20:37 (e)	00:45 (r)	20:30 (e)	01:46 (r)	20:13 (e)	00:31 (r)	19:54 (e)	02:09 (r)
14	20:37 (e)	01:28 (r)	20:29 (e)	02:41 (r)	20:13 (e)	01:25 (r)	19:54 (e)	03:07 (r)
15	20:37 (e)	02:15 (r)	20:29 (e)	03:39 (r)	20:12 (e)	02:23 (r)	19:53 (e)	04:06 (r)
16	20:37 (e)	03:05 (r)	20:28 (e)	04:39 (r)	20:11 (e)	03:22 (r)	19:53 (e)	05:05 (r)
17	20:37 (e)	04:00 (r)	20:28 (e)	05:34 (m)	20:11 (e)	04:22 (r)	19:52 (e)	05:41 (m)
18	20:37 (e)	04:58 (r)	20:27 (e)	05:35 (m)	20:10 (e)	05:23 (r)	19:52 (e)	05:41 (m)
19	20:37 (e)	05:19 (m)	20:27 (e)	05:35 (m)	20:09 (e)	05:41 (m)	19:51 (e)	05:41 (m)
20	20:37 (e)	05:20 (m)	20:26 (e)	05:35 (m)	20:09 (e)	05:41 (m)	20:04 (s)	05:41 (m)
21	20:37 (e)	05:20 (m)	21:07 (s)	05:36 (m)	20:08 (e)	05:41 (m)	20:58 (s)	05:41 (m)
22	20:48 (s)	05:21 (m)	21:57 (s)	05:36 (m)	20:34 (s)	05:41 (m)	21:52 (s)	05:42 (m)
23	21:39 (s)	05:21 (m)	22:47 (s)	05:36 (m)	21:26 (s)	05:41 (m)	22:45 (s)	05:42 (m)
24	22:28 (s)	05:22 (m)	23:38 (s)	05:37 (m)	22:19 (s)	05:41 (m)	23:37 (s)	05:42 (m)
25	23:17 (s)	05:23 (m)	00:28 (s)	05:37 (m)	23:11 (s)	05:41 (m)	00:28 (s)	05:42 (m)
26	00:05 (s)	05:23 (m)	01:19 (s)	05:37 (m)	00:03 (s)	05:41 (m)	01:17 (s)	05:42 (m)
27	00:53 (s)	05:24 (m)	02:10 (s)	05:37 (m)	00:55 (s)	05:41 (m)	02:04 (s)	05:42 (m)
28	01:42 (s)	05:25 (m)	03:00 (s)	05:38 (m)	01:45 (s)	05:41 (m)	02:50 (s)	05:42 (m)
29	02:32 (s)	05:25 (m)			02:34 (s)	05:41 (m)	03:36 (s)	05:42 (m)
30	03:22 (s)	05:26 (m)			03:22 (s)	05:41 (m)	04:22 (s)	05:42 (m)
31	04:13 (s)	05:26 (m)			04:09 (s)	05:41 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	05:09 (s)	05:42 (m)	None		None		None	
2	None		None		None		19:54 (e)	20:33 (r)
3	None		None		None		19:54 (e)	21:32 (r)
4	None		19:44 (e)	20:04 (r)	19:50 (e)	20:48 (r)	19:54 (e)	22:30 (r)
5	None		19:44 (e)	21:01 (r)	19:50 (e)	21:46 (r)	19:54 (e)	23:28 (r)
6	19:45 (e)	20:23 (r)	19:44 (e)	21:58 (r)	19:50 (e)	22:44 (r)	19:54 (e)	00:24 (r)
7	19:45 (e)	21:16 (r)	19:44 (e)	22:56 (r)	19:50 (e)	23:41 (r)	19:54 (e)	01:21 (r)
8	19:45 (e)	22:10 (r)	19:44 (e)	23:52 (r)	19:50 (e)	00:37 (r)	19:54 (e)	02:16 (r)
9	19:44 (e)	23:06 (r)	19:44 (e)	00:49 (r)	19:51 (e)	01:33 (r)	19:54 (e)	03:10 (r)
10	19:44 (e)	00:03 (r)	19:44 (e)	01:44 (r)	19:51 (e)	02:29 (r)	19:54 (e)	04:03 (r)
11	19:44 (e)	01:00 (r)	19:45 (e)	02:41 (r)	19:51 (e)	03:25 (r)	19:54 (e)	04:53 (r)
12	19:44 (e)	01:57 (r)	19:45 (e)	03:37 (r)	19:51 (e)	04:20 (r)	19:55 (e)	05:41 (r)
13	19:44 (e)	02:53 (r)	19:45 (e)	04:34 (r)	19:51 (e)	05:15 (r)	19:55 (e)	05:49 (m)
14	19:44 (e)	03:51 (r)	19:45 (e)	05:31 (r)	19:52 (e)	05:54 (m)	19:55 (e)	05:49 (m)
15	19:44 (e)	04:49 (r)	19:45 (e)	05:50 (m)	19:52 (e)	05:54 (m)	19:55 (e)	05:49 (m)
16	19:43 (e)	05:43 (m)	19:46 (e)	05:50 (m)	19:52 (e)	05:54 (m)	20:00 (s)	05:48 (m)
17	19:43 (e)	05:44 (m)	19:46 (e)	05:50 (m)	19:52 (e)	05:54 (m)	20:46 (s)	05:48 (m)
18	19:43 (e)	05:44 (m)	20:07 (s)	05:50 (m)	20:31 (s)	05:54 (m)	21:32 (s)	05:47 (m)
19	19:43 (e)	05:44 (m)	20:59 (s)	05:51 (m)	21:18 (s)	05:54 (m)	22:18 (s)	05:47 (m)
20	20:32 (s)	05:44 (m)	21:49 (s)	05:51 (m)	22:05 (s)	05:54 (m)	23:04 (s)	05:46 (m)
21	21:26 (s)	05:44 (m)	22:37 (s)	05:51 (m)	22:50 (s)	05:54 (m)	23:52 (s)	05:46 (m)
22	22:18 (s)	05:44 (m)	23:24 (s)	05:51 (m)	23:36 (s)	05:54 (m)	00:42 (s)	05:45 (m)
23	23:09 (s)	05:45 (m)	00:10 (s)	05:51 (m)	00:23 (s)	05:54 (m)	01:33 (s)	05:45 (m)
24	23:57 (s)	05:45 (m)	00:56 (s)	05:52 (m)	01:10 (s)	05:54 (m)	02:26 (s)	05:44 (m)
25	00:45 (s)	05:45 (m)	01:42 (s)	05:52 (m)	01:59 (s)	05:54 (m)	03:20 (s)	05:44 (m)
26	01:31 (s)	05:45 (m)	02:30 (s)	05:52 (m)	02:51 (s)	05:54 (m)	04:15 (s)	05:43 (m)
27	02:16 (s)	05:45 (m)	03:19 (s)	05:52 (m)	03:44 (s)	05:54 (m)	05:10 (s)	05:43 (m)
28	03:03 (s)	05:46 (m)	04:10 (s)	05:52 (m)	04:40 (s)	05:53 (m)	None	
29	03:50 (s)	05:46 (m)	05:03 (s)	05:53 (m)	05:35 (s)	05:53 (m)	None	
30	04:38 (s)	05:46 (m)	None		None		None	
31	05:29 (s)	05:46 (m)			None		19:54 (e)	20:16 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:54 (e)	21:16 (r)	19:54 (e)	21:58 (r)	20:01 (e)	23:29 (r)	20:17 (e)	23:42 (r)
2	19:54 (e)	22:15 (r)	19:54 (e)	22:57 (r)	20:01 (e)	00:18 (r)	20:18 (e)	00:25 (r)
3	19:54 (e)	23:13 (r)	19:54 (e)	23:53 (r)	20:02 (e)	01:04 (r)	20:19 (e)	01:05 (r)
4	19:54 (e)	00:11 (r)	19:54 (e)	00:46 (r)	20:02 (e)	01:47 (r)	20:19 (e)	01:44 (r)
5	19:54 (e)	01:06 (r)	19:54 (e)	01:36 (r)	20:02 (e)	02:28 (r)	20:20 (e)	02:23 (r)
6	19:54 (e)	02:00 (r)	19:54 (e)	02:23 (r)	20:03 (e)	03:07 (r)	20:21 (e)	03:02 (r)
7	19:54 (e)	02:51 (r)	19:54 (e)	03:07 (r)	20:03 (e)	03:46 (r)	20:21 (e)	03:43 (r)
8	19:54 (e)	03:39 (r)	19:54 (e)	03:49 (r)	20:04 (e)	04:25 (r)	20:22 (e)	04:25 (r)
9	19:54 (e)	04:25 (r)	19:54 (e)	04:29 (r)	20:04 (e)	04:57 (m)	20:22 (e)	04:56 (m)
10	19:54 (e)	05:08 (r)	19:55 (e)	05:08 (r)	20:05 (e)	04:57 (m)	20:23 (e)	04:56 (m)
11	19:54 (e)	05:34 (m)	19:55 (e)	05:13 (m)	20:05 (e)	04:57 (m)	20:24 (e)	04:57 (m)
12	19:54 (e)	05:33 (m)	19:55 (e)	05:12 (m)	20:06 (e)	04:56 (m)	20:24 (e)	04:57 (m)
13	19:54 (e)	05:32 (m)	19:55 (e)	05:11 (m)	20:10 (s)	04:56 (m)	20:41 (s)	04:57 (m)
14	19:53 (e)	05:32 (m)	19:55 (e)	05:11 (m)	21:01 (s)	04:56 (m)	21:33 (s)	04:58 (m)
15	20:15 (s)	05:31 (m)	20:34 (s)	05:10 (m)	21:53 (s)	04:56 (m)	22:23 (s)	04:58 (m)
16	21:01 (s)	05:30 (m)	21:23 (s)	05:09 (m)	22:44 (s)	04:55 (m)	23:12 (s)	04:59 (m)
17	21:48 (s)	05:30 (m)	22:13 (s)	05:09 (m)	23:35 (s)	04:55 (m)	00:00 (s)	04:59 (m)
18	22:36 (s)	05:29 (m)	23:04 (s)	05:08 (m)	00:24 (s)	04:55 (m)	00:47 (s)	04:59 (m)
19	23:26 (s)	05:28 (m)	23:56 (s)	05:08 (m)	01:13 (s)	04:55 (m)	01:34 (s)	05:00 (m)
20	00:17 (s)	05:28 (m)	00:47 (s)	05:07 (m)	02:01 (s)	04:55 (m)	02:23 (s)	05:00 (m)
21	01:09 (s)	05:27 (m)	01:38 (s)	05:06 (m)	02:50 (s)	04:55 (m)	03:13 (s)	05:01 (m)
22	02:02 (s)	05:26 (m)	02:29 (s)	05:06 (m)	03:39 (s)	04:54 (m)	04:05 (s)	05:01 (m)
23	02:55 (s)	05:25 (m)	03:19 (s)	05:05 (m)	04:30 (s)	04:54 (m)	05:00 (s)	05:02 (m)
24	03:48 (s)	05:25 (m)	04:09 (s)	05:05 (m)	None		None	
25	04:40 (s)	05:24 (m)	05:00 (s)	05:04 (m)	None		None	
26	None		None		None		None	
27	None		None		20:15 (e)	20:19 (r)	20:32 (e)	20:46 (r)
28	None		None		20:15 (e)	21:15 (r)	20:33 (e)	21:34 (r)
29	19:54 (e)	19:58 (r)	20:00 (e)	20:40 (r)	20:16 (e)	22:08 (r)	20:33 (e)	22:19 (r)
30	19:54 (e)	20:58 (r)	20:00 (e)	21:39 (r)	20:17 (e)	22:57 (r)	20:33 (e)	23:01 (r)
31			20:00 (e)	22:36 (r)			20:34 (e)	23:41 (r)

HOBART (EST) — HOURS of DARKNESS — MELBOURNE (EST)

HOBART (EST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:15 (s)	02:22 (m)	None		02:22 (s)	04:11 (m)	04:02 (s)	04:54 (m)
2	None		None		03:18 (s)	04:12 (m)	None	
3	None		None		None		None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		None		None		19:27 (e)	19:28 (r)
8	None		None		None		19:25 (e)	20:08 (r)
9	None		21:16 (e)	21:44 (r)	None		19:23 (e)	20:54 (r)
10	22:02 (e)	22:16 (r)	21:14 (e)	22:15 (r)	20:19 (e)	20:51 (r)	19:22 (e)	21:45 (r)
11	22:01 (e)	22:44 (r)	21:12 (e)	22:49 (r)	20:17 (e)	21:27 (r)	19:20 (e)	22:42 (r)
12	22:00 (e)	23:12 (r)	21:10 (e)	23:28 (r)	20:15 (e)	22:09 (r)	19:18 (e)	23:45 (r)
13	21:59 (e)	23:42 (r)	21:08 (e)	00:13 (r)	20:13 (e)	22:57 (r)	19:17 (e)	00:52 (r)
14	21:58 (e)	00:15 (r)	21:06 (e)	01:05 (r)	20:11 (e)	23:51 (r)	19:15 (e)	02:02 (r)
15	21:57 (e)	00:52 (r)	21:05 (e)	02:05 (r)	20:09 (e)	00:52 (r)	19:14 (e)	03:14 (r)
16	21:55 (e)	01:34 (r)	21:03 (e)	03:11 (r)	20:07 (e)	01:59 (r)	19:12 (e)	04:28 (r)
17	21:54 (e)	02:24 (r)	21:01 (e)	03:50 (m)	20:05 (e)	03:10 (r)	19:11 (e)	05:11 (m)
18	21:53 (e)	02:51 (m)	20:59 (e)	03:52 (m)	20:03 (e)	04:24 (r)	19:09 (e)	05:12 (m)
19	21:51 (e)	02:53 (m)	20:57 (e)	03:54 (m)	20:01 (e)	04:37 (m)	19:08 (e)	05:14 (m)
20	21:50 (e)	02:55 (m)	20:55 (e)	03:56 (m)	19:59 (e)	04:39 (m)	19:06 (e)	05:15 (m)
21	21:49 (e)	02:57 (m)	20:53 (e)	03:57 (m)	19:57 (e)	04:40 (m)	19:27 (s)	05:16 (m)
22	21:47 (e)	02:59 (m)	20:56 (s)	03:59 (m)	19:55 (e)	04:41 (m)	20:17 (s)	05:17 (m)
23	21:46 (e)	03:01 (m)	21:34 (s)	04:01 (m)	20:08 (s)	04:43 (m)	21:10 (s)	05:18 (m)
24	21:48 (s)	03:03 (m)	22:15 (s)	04:03 (m)	20:51 (s)	04:44 (m)	22:06 (s)	05:19 (m)
25	22:23 (s)	03:05 (m)	22:58 (s)	04:04 (m)	21:38 (s)	04:45 (m)	23:03 (s)	05:20 (m)
26	22:58 (s)	03:07 (m)	23:45 (s)	04:06 (m)	22:28 (s)	04:46 (m)	00:00 (s)	05:21 (m)
27	23:36 (s)	03:09 (m)	00:35 (s)	04:08 (m)	23:21 (s)	04:48 (m)	00:57 (s)	05:22 (m)
28	00:16 (s)	03:11 (m)	01:27 (s)	04:09 (m)	00:16 (s)	04:49 (m)	01:54 (s)	05:23 (m)
29	00:59 (s)	03:13 (m)			01:12 (s)	04:50 (m)	02:51 (s)	05:24 (m)
30	01:47 (s)	03:15 (m)			02:09 (s)	04:51 (m)	03:48 (s)	05:25 (m)
31	02:37 (s)	03:17 (m)			03:05 (s)	04:53 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:46 (s)	05:25 (m)	None		None		None	
2	None		None		None		18:51 (e)	19:34 (r)
3	None		None		None		18:52 (e)	20:47 (r)
4	None		18:26 (e)	18:29 (r)	18:31 (e)	19:29 (r)	18:52 (e)	21:59 (r)
5	None		18:26 (e)	19:29 (r)	18:31 (e)	20:40 (r)	18:53 (e)	23:10 (r)
6	18:46 (e)	18:51 (r)	18:26 (e)	20:34 (r)	18:32 (e)	21:51 (r)	18:54 (e)	00:19 (r)
7	18:45 (e)	19:41 (r)	18:26 (e)	21:42 (r)	18:32 (e)	23:01 (r)	18:55 (e)	01:26 (r)
8	18:44 (e)	20:37 (r)	18:25 (e)	22:51 (r)	18:33 (e)	00:11 (r)	18:56 (e)	02:29 (r)
9	18:43 (e)	21:37 (r)	18:25 (e)	00:00 (r)	18:33 (e)	01:20 (r)	18:57 (e)	03:28 (r)
10	18:42 (e)	22:42 (r)	18:25 (e)	01:10 (r)	18:34 (e)	02:28 (r)	18:58 (e)	04:21 (r)
11	18:41 (e)	23:50 (r)	18:25 (e)	02:20 (r)	18:35 (e)	03:33 (r)	18:59 (e)	05:09 (r)
12	18:40 (e)	01:00 (r)	18:25 (e)	03:29 (r)	18:35 (e)	04:36 (r)	19:00 (e)	05:32 (m)
13	18:39 (e)	02:10 (r)	18:25 (e)	04:37 (r)	18:36 (e)	05:33 (r)	19:00 (e)	05:31 (m)
14	18:38 (e)	03:21 (r)	18:25 (e)	05:43 (r)	18:36 (e)	05:57 (m)	19:01 (e)	05:30 (m)
15	18:37 (e)	04:33 (r)	18:25 (e)	05:58 (m)	18:37 (e)	05:57 (m)	19:02 (e)	05:29 (m)
16	18:36 (e)	05:39 (m)	18:25 (e)	05:58 (m)	18:38 (e)	05:56 (m)	19:07 (s)	05:27 (m)
17	18:36 (e)	05:40 (m)	18:25 (e)	05:59 (m)	18:38 (e)	05:56 (m)	20:04 (s)	05:26 (m)
18	18:35 (e)	05:41 (m)	18:35 (s)	05:59 (m)	19:20 (s)	05:55 (m)	21:01 (s)	05:25 (m)
19	18:34 (e)	05:41 (m)	19:34 (s)	05:59 (m)	20:18 (s)	05:55 (m)	21:57 (s)	05:23 (m)
20	18:56 (s)	05:42 (m)	20:33 (s)	06:00 (m)	21:15 (s)	05:54 (m)	22:54 (s)	05:22 (m)
21	19:52 (s)	05:43 (m)	21:31 (s)	06:00 (m)	22:12 (s)	05:54 (m)	23:52 (s)	05:20 (m)
22	20:49 (s)	05:44 (m)	22:29 (s)	06:00 (m)	23:09 (s)	05:53 (m)	00:50 (s)	05:19 (m)
23	21:48 (s)	05:45 (m)	23:26 (s)	06:00 (m)	00:07 (s)	05:52 (m)	01:47 (s)	05:17 (m)
24	22:46 (s)	05:45 (m)	00:23 (s)	06:00 (m)	01:05 (s)	05:51 (m)	02:43 (s)	05:16 (m)
25	23:43 (s)	05:46 (m)	01:21 (s)	06:00 (m)	02:03 (s)	05:51 (m)	03:37 (s)	05:14 (m)
26	00:41 (s)	05:47 (m)	02:19 (s)	06:00 (m)	03:02 (s)	05:50 (m)	04:28 (s)	05:13 (m)
27	01:38 (s)	05:48 (m)	03:18 (s)	06:01 (m)	04:01 (s)	05:49 (m)	None	
28	02:35 (s)	05:48 (m)	04:18 (s)	06:01 (m)	04:58 (s)	05:48 (m)	None	
29	03:33 (s)	05:49 (m)	05:18 (s)	06:01 (m)	None		None	
30	04:32 (s)	05:50 (m)	None		None		None	
31	05:32 (s)	05:50 (m)			None		19:18 (e)	19:39 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:19 (e)	20:53 (r)	19:54 (e)	22:05 (r)	20:44 (e)	23:45 (r)	21:42 (e)	23:40 (r)
2	19:20 (e)	22:05 (r)	19:55 (e)	23:11 (r)	20:46 (e)	00:28 (r)	21:44 (e)	00:13 (r)
3	19:21 (e)	23:15 (r)	19:56 (e)	00:11 (r)	20:48 (e)	01:07 (r)	21:45 (e)	00:42 (r)
4	19:22 (e)	00:21 (r)	19:58 (e)	01:03 (r)	20:49 (e)	01:40 (r)	21:47 (e)	01:10 (r)
5	19:23 (e)	01:22 (r)	19:59 (e)	01:50 (r)	20:51 (e)	02:11 (r)	21:49 (e)	01:38 (r)
6	19:24 (e)	02:18 (r)	20:01 (e)	02:30 (r)	20:53 (e)	02:40 (r)	21:50 (e)	02:06 (r)
7	19:25 (e)	03:07 (r)	20:02 (e)	03:06 (r)	20:55 (e)	02:54 (m)	21:52 (e)	02:13 (m)
8	19:26 (e)	03:51 (r)	20:04 (e)	03:38 (r)	20:57 (e)	02:52 (m)	21:53 (e)	02:13 (m)
9	19:27 (e)	04:30 (r)	20:05 (e)	03:51 (m)	20:59 (e)	02:50 (m)	21:55 (e)	02:12 (m)
10	19:28 (e)	04:48 (m)	20:06 (e)	03:49 (m)	21:01 (e)	02:49 (m)	21:56 (e)	02:12 (m)
11	19:29 (e)	04:46 (m)	20:08 (e)	03:47 (m)	21:03 (e)	02:47 (m)	21:57 (e)	02:11 (m)
12	19:30 (e)	04:44 (m)	20:10 (e)	03:45 (m)	21:05 (e)	02:45 (m)	21:58 (e)	02:11 (m)
13	19:32 (e)	04:42 (m)	20:11 (e)	03:43 (m)	21:07 (e)	02:43 (m)	22:00 (e)	02:11 (m)
14	19:33 (e)	04:40 (m)	20:13 (e)	03:41 (m)	21:19 (s)	02:42 (m)	22:01 (e)	02:10 (m)
15	19:51 (s)	04:38 (m)	20:36 (s)	03:39 (m)	22:11 (s)	02:40 (m)	22:25 (s)	02:10 (m)
16	20:48 (s)	04:37 (m)	21:33 (s)	03:37 (m)	22:59 (s)	02:38 (m)	23:04 (s)	02:10 (m)
17	21:45 (s)	04:35 (m)	22:29 (s)	03:35 (m)	23:43 (s)	02:37 (m)	23:39 (s)	02:11 (m)
18	22:42 (s)	04:33 (m)	23:22 (s)	03:33 (m)	00:23 (s)	02:35 (m)	00:13 (s)	02:11 (m)
19	23:38 (s)	04:31 (m)	00:13 (s)	03:31 (m)	01:00 (s)	02:34 (m)	00:47 (s)	02:11 (m)
20	00:33 (s)	04:29 (m)	00:59 (s)	03:29 (m)	01:36 (s)	02:32 (m)	01:23 (s)	02:11 (m)
21	01:27 (s)	04:27 (m)	01:43 (s)	03:27 (m)	02:11 (s)	02:31 (m)	02:00 (s)	02:12 (m)
22	02:17 (s)	04:25 (m)	02:23 (s)	03:25 (m)	None		None	
23	03:04 (s)	04:23 (m)	03:01 (s)	03:23 (m)	None		None	
24	03:48 (s)	04:21 (m)	None		None		None	
25	None		None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		None		None	
29	None		20:38 (e)	20:51 (r)	21:38 (e)	22:22 (r)	22:08 (e)	22:12 (r)
30	19:52 (e)	20:55 (r)	20:40 (e)	21:56 (r)	21:40 (e)	23:04 (r)	22:08 (e)	22:43 (r)
31			20:42 (e)	22:54 (r)			22:08 (e)	23:12 (r)

Note: For the Hours of Darkness tables, any time after midnight refers to the following morning. An entry of None means the Moon is up the entire time between evening and morning twilight. For the notes after each time: (e) dark starts at end of evening twilight, (s) dark starts at Moon set, (r) dark ends with Moon rise and (m) dark ends with morning twilight.

MELBOURNE (EST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:35 (s)	03:08 (m)	None		02:42 (s)	04:33 (m)	04:15 (s)	05:07 (m)
2	None		None		03:36 (s)	04:34 (m)	None	
3	None		None		04:31 (s)	04:36 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		None		None		19:32 (e)	19:47 (r)
8	None		21:05 (e)	21:26 (r)	None		19:31 (e)	20:28 (r)
9	21:37 (e)	21:53 (r)	21:04 (e)	21:58 (r)	20:19 (e)	20:33 (r)	19:30 (e)	21:15 (r)
10	21:37 (e)	22:24 (r)	21:02 (e)	22:31 (r)	20:17 (e)	21:08 (r)	19:28 (e)	22:06 (r)
11	21:36 (e)	22:54 (r)	21:01 (e)	23:07 (r)	20:15 (e)	21:46 (r)	19:27 (e)	23:03 (r)
12	21:35 (e)	23:24 (r)	20:59 (e)	23:48 (r)	20:14 (e)	22:29 (r)	19:25 (e)	00:04 (r)
13	21:35 (e)	23:56 (r)	20:58 (e)	00:34 (r)	20:12 (e)	23:18 (r)	19:24 (e)	01:09 (r)
14	21:34 (e)	00:31 (r)	20:56 (e)	01:27 (r)	20:10 (e)	00:12 (r)	19:23 (e)	02:17 (r)
15	21:33 (e)	01:10 (r)	20:55 (e)	02:26 (r)	20:09 (e)	01:12 (r)	19:21 (e)	03:26 (r)
16	21:33 (e)	01:55 (r)	20:53 (e)	03:31 (r)	20:07 (e)	02:18 (r)	19:20 (e)	04:37 (r)
17	21:32 (e)	02:46 (r)	20:52 (e)	04:17 (m)	20:05 (e)	03:26 (r)	19:19 (e)	05:21 (m)
18	21:31 (e)	03:30 (m)	20:50 (e)	04:18 (m)	20:04 (e)	04:37 (r)	19:17 (e)	05:22 (m)
19	21:30 (e)	03:32 (m)	20:48 (e)	04:20 (m)	20:02 (e)	04:54 (m)	19:16 (e)	05:23 (m)
20	21:29 (e)	03:33 (m)	20:47 (e)	04:21 (m)	20:00 (e)	04:55 (m)	19:15 (e)	05:23 (m)
21	21:28 (e)	03:35 (m)	20:45 (e)	04:22 (m)	19:59 (e)	04:56 (m)	19:47 (s)	05:24 (m)
22	21:27 (e)	03:36 (m)	21:10 (s)	04:24 (m)	19:57 (e)	04:57 (m)	20:38 (s)	05:25 (m)
23	21:26 (e)	03:38 (m)	21:51 (s)	04:25 (m)	20:26 (s)	04:58 (m)	21:32 (s)	05:26 (m)
24	21:58 (s)	03:39 (m)	22:33 (s)	04:27 (m)	21:11 (s)	04:59 (m)	22:27 (s)	05:27 (m)
25	22:35 (s)	03:41 (m)	23:18 (s)	04:28 (m)	21:59 (s)	05:00 (m)	23:22 (s)	05:27 (m)
26	23:14 (s)	03:43 (m)	00:06 (s)	04:29 (m)	22:50 (s)	05:01 (m)	00:17 (s)	05:28 (m)
27	23:53 (s)	03:44 (m)	00:56 (s)	04:31 (m)	23:43 (s)	05:02 (m)	01:12 (s)	05:29 (m)
28	00:35 (s)	03:46 (m)	01:48 (s)	04:32 (m)	00:36 (s)	05:03 (m)	02:07 (s)	05:30 (m)
29	01:20 (s)	03:47 (m)			01:31 (s)	05:04 (m)	03:02 (s)	05:31 (m)
30	02:08 (s)	03:49 (m)			02:25 (s)	05:05 (m)	03:56 (s)	05:31 (m)
31	02:59 (s)	03:51 (m)			03:20 (s)	05:06 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:52 (s)	05:32 (m)	None		None		None	
2	None		None		None		19:03 (e)	19:48 (r)
3	None		None		None		19:04 (e)	20:58 (r)
4	None		18:42 (e)	18:50 (r)	18:47 (e)	19:47 (r)	19:05 (e)	22:07 (r)
5	None		18:42 (e)	19:50 (r)	18:47 (e)	20:55 (r)	19:06 (e)	23:15 (r)
6	18:58 (e)	19:12 (r)	18:42 (e)	20:53 (r)	18:47 (e)	22:03 (r)	19:06 (e)	00:22 (r)
7	18:57 (e)	20:02 (r)	18:41 (e)	21:59 (r)	18:48 (e)	23:11 (r)	19:07 (e)	01:26 (r)
8	18:56 (e)	20:58 (r)	18:41 (e)	23:05 (r)	18:48 (e)	00:18 (r)	19:08 (e)	02:27 (r)
9	18:55 (e)	21:58 (r)	18:41 (e)	00:12 (r)	18:49 (e)	01:24 (r)	19:08 (e)	03:25 (r)
10	18:54 (e)	23:01 (r)	18:41 (e)	01:18 (r)	18:49 (e)	02:29 (r)	19:09 (e)	04:18 (r)
11	18:53 (e)	00:06 (r)	18:41 (e)	02:25 (r)	18:50 (e)	03:32 (r)	19:10 (e)	05:07 (r)
12	18:53 (e)	01:13 (r)	18:41 (e)	03:32 (r)	18:50 (e)	04:33 (r)	19:10 (e)	05:39 (m)
13	18:52 (e)	02:20 (r)	18:41 (e)	04:38 (r)	18:51 (e)	05:30 (r)	19:11 (e)	05:38 (m)
14	18:51 (e)	03:29 (r)	18:41 (e)	05:42 (r)	18:52 (e)	06:00 (m)	19:12 (e)	05:37 (m)
15	18:51 (e)	04:37 (r)	18:41 (e)	06:00 (m)	18:52 (e)	06:00 (m)	19:13 (e)	05:36 (m)
16	18:50 (e)	05:43 (m)	18:42 (e)	06:00 (m)	18:53 (e)	05:59 (m)	19:19 (s)	05:35 (m)
17	18:49 (e)	05:44 (m)	18:42 (e)	06:00 (m)	18:53 (e)	05:59 (m)	20:14 (s)	05:34 (m)
18	18:49 (e)	05:45 (m)	18:56 (s)	06:00 (m)	19:36 (s)	05:58 (m)	21:08 (s)	05:33 (m)
19	18:48 (e)	05:45 (m)	19:53 (s)	06:01 (m)	20:32 (s)	05:58 (m)	22:03 (s)	05:31 (m)
20	19:18 (s)	05:46 (m)	20:50 (s)	06:01 (m)	21:27 (s)	05:57 (m)	22:58 (s)	05:30 (m)
21	20:13 (s)	05:47 (m)	21:46 (s)	06:01 (m)	22:22 (s)	05:57 (m)	23:53 (s)	05:29 (m)
22	21:10 (s)	05:47 (m)	22:42 (s)	06:01 (m)	23:16 (s)	05:56 (m)	00:49 (s)	05:28 (m)
23	22:06 (s)	05:48 (m)	23:37 (s)	06:02 (m)	00:11 (s)	05:56 (m)	01:45 (s)	05:26 (m)
24	23:02 (s)	05:49 (m)	00:31 (s)	06:02 (m)	01:07 (s)	05:55 (m)	02:40 (s)	05:25 (m)
25	23:58 (s)	05:49 (m)	01:26 (s)	06:02 (m)	02:03 (s)	05:55 (m)	03:34 (s)	05:24 (m)
26	00:52 (s)	05:50 (m)	02:22 (s)	06:02 (m)	03:01 (s)	05:54 (m)	04:26 (s)	05:22 (m)
27	01:47 (s)	05:50 (m)	03:19 (s)	06:02 (m)	03:58 (s)	05:53 (m)	05:15 (s)	05:21 (m)
28	02:42 (s)	05:51 (m)	04:17 (s)	06:02 (m)	04:55 (s)	05:53 (m)	None	
29	03:38 (s)	05:52 (m)	05:16 (s)	06:02 (m)	05:49 (s)	05:52 (m)	None	
30	04:35 (s)	05:52 (m)	None		None		None	
31	05:33 (s)	05:53 (m)			None		19:25 (e)	19:48 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:26 (e)	20:59 (r)	19:53 (e)	22:05 (r)	20:32 (e)	23:42 (r)	21:17 (e)	23:42 (r)
2	19:26 (e)	22:08 (r)	19:54 (e)	23:09 (r)	20:33 (e)	00:27 (r)	21:18 (e)	00:16 (r)
3	19:27 (e)	23:16 (r)	19:55 (e)	00:08 (r)	20:35 (e)	01:07 (r)	21:20 (e)	00:48 (r)
4	19:28 (e)	00:20 (r)	19:56 (e)	01:01 (r)	20:36 (e)	01:43 (r)	21:21 (e)	01:19 (r)
5	19:29 (e)	01:20 (r)	19:57 (e)	01:48 (r)	20:38 (e)	02:16 (r)	21:22 (e)	01:49 (r)
6	19:30 (e)	02:15 (r)	19:58 (e)	02:30 (r)	20:39 (e)	02:47 (r)	21:23 (e)	02:19 (r)
7	19:30 (e)	03:05 (r)	19:59 (e)	03:07 (r)	20:41 (e)	03:17 (r)	21:25 (e)	02:51 (r)
8	19:31 (e)	03:49 (r)	20:00 (e)	03:42 (r)	20:43 (e)	03:25 (m)	21:26 (e)	02:58 (m)
9	19:32 (e)	04:29 (r)	20:02 (e)	04:13 (m)	20:44 (e)	03:23 (m)	21:27 (e)	02:57 (m)
10	19:33 (e)	05:01 (m)	20:03 (e)	04:11 (m)	20:46 (e)	03:22 (m)	21:28 (e)	02:57 (m)
11	19:34 (e)	04:59 (m)	20:04 (e)	04:09 (m)	20:47 (e)	03:20 (m)	21:29 (e)	02:57 (m)
12	19:35 (e)	04:58 (m)	20:05 (e)	04:07 (m)	20:49 (e)	03:19 (m)	21:30 (e)	02:57 (m)
13	19:36 (e)	04:56 (m)	20:06 (e)	04:06 (m)	20:50 (e)	03:18 (m)	21:31 (e)	02:57 (m)
14	19:36 (e)	04:54 (m)	20:08 (e)	04:04 (m)	21:16 (s)	03:17 (m)	21:42 (s)	02:57 (m)
15	19:57 (s)	04:53 (m)	20:37 (s)	04:02 (m)	22:08 (s)	03:15 (m)	22:26 (s)	02:57 (m)
16	20:52 (s)	04:51 (m)	21:32 (s)	04:01 (m)	22:57 (s)	03:14 (m)	23:06 (s)	02:57 (m)
17	21:46 (s)	04:50 (m)	22:26 (s)	03:59 (m)	23:42 (s)	03:13 (m)	23:45 (s)	02:58 (m)
18	22:41 (s)	04:48 (m)	23:19 (s)	03:57 (m)	00:24 (s)	03:12 (m)	00:21 (s)	02:58 (m)
19	23:36 (s)	04:46 (m)	00:10 (s)	03:56 (m)	01:04 (s)	03:11 (m)	00:58 (s)	02:58 (m)
20	00:31 (s)	04:45 (m)	00:58 (s)	03:54 (m)	01:42 (s)	03:10 (m)	01:36 (s)	02:59 (m)
21	01:24 (s)	04:43 (m)	01:43 (s)	03:52 (m)	02:20 (s)	03:09 (m)	02:17 (s)	02:59 (m)
22	02:15 (s)	04:41 (m)	02:25 (s)	03:51 (m)	02:58 (s)	03:08 (m)	None	
23	03:03 (s)	04:40 (m)	03:06 (s)	03:49 (m)	None		None	
24	03:49 (s)	04:38 (m)	03:45 (s)	03:47 (m)	None		None	
25	04:32 (s)	04:36 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		21:13 (e)	21:30 (r)	None	
29	None		20:28 (e)	20:49 (r)	21:14 (e)	22:20 (r)	21:39 (e)	22:14 (r)
30	19:52 (e)	20:57 (r)	20:29 (e)	21:53 (r)	21:16 (e)	23:03 (r)	21:39 (e)	22:48 (r)
31			20:31 (e)	22:51 (r)			21:39 (e)	23:20 (r)

PERTH (WST) HOURS of DARKNESS

PERTH (WST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:46 (s)	03:35 (m)	04:04 (s)	04:11 (m)	02:53 (s)	04:42 (m)	04:18 (s)	05:07 (m)
2	03:34 (s)	03:36 (m)	None		03:46 (s)	04:43 (m)	None	
3	None		None		04:39 (s)	04:44 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		20:44 (e)	20:55 (r)	None		19:27 (e)	19:56 (r)
8	21:05 (e)	21:15 (r)	20:43 (e)	21:28 (r)	None		19:26 (e)	20:39 (r)
9	21:05 (e)	21:49 (r)	20:41 (e)	22:01 (r)	20:05 (e)	20:38 (r)	19:24 (e)	21:27 (r)
10	21:04 (e)	22:21 (r)	20:40 (e)	22:37 (r)	20:04 (e)	21:16 (r)	19:23 (e)	22:19 (r)
11	21:04 (e)	22:54 (r)	20:39 (e)	23:16 (r)	20:02 (e)	21:56 (r)	19:22 (e)	23:16 (r)
12	21:04 (e)	23:27 (r)	20:38 (e)	23:59 (r)	20:01 (e)	22:41 (r)	19:21 (e)	00:16 (r)
13	21:03 (e)	00:01 (r)	20:37 (e)	00:47 (r)	20:00 (e)	23:31 (r)	19:20 (e)	01:20 (r)
14	21:03 (e)	00:39 (r)	20:36 (e)	01:40 (r)	19:58 (e)	00:26 (r)	19:19 (e)	02:25 (r)
15	21:02 (e)	01:20 (r)	20:34 (e)	02:40 (r)	19:57 (e)	01:25 (r)	19:18 (e)	03:31 (r)
16	21:02 (e)	02:07 (r)	20:33 (e)	03:44 (r)	19:56 (e)	02:29 (r)	19:16 (e)	04:38 (r)
17	21:01 (e)	02:59 (r)	20:32 (e)	04:30 (m)	19:54 (e)	03:36 (r)	19:15 (e)	05:17 (m)
18	21:01 (e)	03:53 (m)	20:31 (e)	04:31 (m)	19:53 (e)	04:44 (r)	19:14 (e)	05:18 (m)
19	21:00 (e)	03:55 (m)	20:29 (e)	04:32 (m)	19:51 (e)	04:58 (m)	19:13 (e)	05:19 (m)
20	21:00 (e)	03:56 (m)	20:28 (e)	04:33 (m)	19:50 (e)	04:59 (m)	19:12 (e)	05:19 (m)
21	20:59 (e)	03:57 (m)	20:33 (e)	04:34 (m)	19:49 (e)	04:59 (m)	19:59 (s)	05:20 (m)
22	20:58 (e)	03:58 (m)	21:15 (s)	04:35 (m)	19:49 (s)	05:00 (m)	20:52 (s)	05:20 (m)
23	21:17 (s)	03:59 (m)	21:59 (s)	04:36 (m)	20:35 (s)	05:01 (m)	21:45 (s)	05:21 (m)
24	21:58 (s)	04:01 (m)	22:43 (s)	04:37 (m)	21:22 (s)	05:02 (m)	22:39 (s)	05:22 (m)
25	22:39 (s)	04:02 (m)	23:30 (s)	04:38 (m)	22:12 (s)	05:02 (m)	23:33 (s)	05:22 (m)
26	23:20 (s)	04:03 (m)	00:19 (s)	04:39 (m)	23:03 (s)	05:03 (m)	00:27 (s)	05:23 (m)
27	00:02 (s)	04:04 (m)	01:09 (s)	04:40 (m)	23:55 (s)	05:04 (m)	01:20 (s)	05:23 (m)
28	00:46 (s)	04:06 (m)	02:01 (s)	04:41 (m)	00:48 (s)	05:04 (m)	02:12 (s)	05:24 (m)
29	01:32 (s)	04:07 (m)			01:41 (s)	05:05 (m)	03:04 (s)	05:24 (m)
30	02:21 (s)	04:08 (m)			02:34 (s)	05:06 (m)	03:56 (s)	05:25 (m)
31	03:12 (s)	04:09 (m)			03:26 (s)	05:06 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:50 (s)	05:26 (m)	None		None		None	
2	None		None		None		19:05 (e)	19:54 (r)
3	None		None		18:51 (e)	18:53 (r)	19:05 (e)	21:01 (r)
4	None		18:46 (e)	19:04 (r)	18:51 (e)	19:58 (r)	19:06 (e)	22:07 (r)
5	None		18:46 (e)	20:03 (r)	18:52 (e)	21:03 (r)	19:06 (e)	23:12 (r)
6	18:58 (e)	19:24 (r)	18:46 (e)	21:05 (r)	18:52 (e)	22:08 (r)	19:07 (e)	00:16 (r)
7	18:57 (e)	20:15 (r)	18:46 (e)	22:08 (r)	18:52 (e)	23:13 (r)	19:08 (e)	01:18 (r)
8	18:57 (e)	21:11 (r)	18:46 (e)	23:12 (r)	18:53 (e)	00:17 (r)	19:08 (e)	02:17 (r)
9	18:56 (e)	22:10 (r)	18:46 (e)	00:16 (r)	18:53 (e)	01:20 (r)	19:09 (e)	03:14 (r)
10	18:55 (e)	23:11 (r)	18:46 (e)	01:19 (r)	18:54 (e)	02:22 (r)	19:09 (e)	04:07 (r)
11	18:55 (e)	00:15 (r)	18:46 (e)	02:23 (r)	18:54 (e)	03:24 (r)	19:10 (e)	04:55 (r)
12	18:54 (e)	01:19 (r)	18:46 (e)	03:27 (r)	18:55 (e)	04:23 (r)	19:10 (e)	05:33 (m)
13	18:54 (e)	02:23 (r)	18:46 (e)	04:30 (r)	18:55 (e)	05:19 (r)	19:11 (e)	05:32 (m)
14	18:53 (e)	03:29 (r)	18:46 (e)	05:32 (r)	18:56 (e)	05:49 (m)	19:11 (e)	05:31 (m)
15	18:53 (e)	04:34 (r)	18:46 (e)	05:48 (m)	18:56 (e)	05:49 (m)	19:12 (e)	05:30 (m)
16	18:52 (e)	05:34 (m)	18:47 (e)	05:48 (m)	18:56 (e)	05:49 (m)	19:23 (s)	05:29 (m)
17	18:52 (e)	05:35 (m)	18:47 (e)	05:48 (m)	18:57 (e)	05:48 (m)	20:16 (s)	05:28 (m)
18	18:51 (e)	05:35 (m)	19:09 (s)	05:49 (m)	19:44 (s)	05:48 (m)	21:08 (s)	05:27 (m)
19	18:51 (e)	05:36 (m)	20:05 (s)	05:49 (m)	20:38 (s)	05:48 (m)	22:00 (s)	05:26 (m)
20	19:31 (s)	05:36 (m)	21:00 (s)	05:49 (m)	21:30 (s)	05:47 (m)	22:52 (s)	05:25 (m)
21	20:26 (s)	05:37 (m)	21:53 (s)	05:49 (m)	22:22 (s)	05:47 (m)	23:46 (s)	05:24 (m)
22	21:22 (s)	05:37 (m)	22:46 (s)	05:50 (m)	23:15 (s)	05:47 (m)	00:40 (s)	05:23 (m)
23	22:16 (s)	05:38 (m)	23:39 (s)	05:50 (m)	00:07 (s)	05:46 (m)	01:34 (s)	05:22 (m)
24	23:10 (s)	05:38 (m)	00:31 (s)	05:50 (m)	01:01 (s)	05:46 (m)	02:29 (s)	05:21 (m)
25	00:03 (s)	05:39 (m)	01:24 (s)	05:50 (m)	01:55 (s)	05:45 (m)	03:23 (s)	05:20 (m)
26	00:56 (s)	05:39 (m)	02:17 (s)	05:50 (m)	02:51 (s)	05:45 (m)	04:16 (s)	05:19 (m)
27	01:48 (s)	05:40 (m)	03:12 (s)	05:50 (m)	03:47 (s)	05:44 (m)	05:06 (s)	05:18 (m)
28	02:41 (s)	05:40 (m)	04:08 (s)	05:50 (m)	04:43 (s)	05:44 (m)	None	
29	03:34 (s)	05:41 (m)	05:06 (s)	05:50 (m)	05:38 (s)	05:43 (m)	None	
30	04:29 (s)	05:41 (m)	None		None		None	
31	05:25 (s)	05:42 (m)			None		19:20 (e)	19:50 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:21 (e)	20:57 (r)	19:40 (e)	21:57 (r)	20:10 (e)	23:31 (r)	20:45 (e)	23:34 (r)
2	19:22 (e)	22:04 (r)	19:41 (e)	22:59 (r)	20:11 (e)	00:17 (r)	20:46 (e)	00:10 (r)
3	19:22 (e)	23:09 (r)	19:42 (e)	23:56 (r)	20:12 (e)	00:58 (r)	20:47 (e)	00:44 (r)
4	19:23 (e)	00:11 (r)	19:43 (e)	00:49 (r)	20:13 (e)	01:36 (r)	20:48 (e)	01:17 (r)
5	19:23 (e)	01:09 (r)	19:44 (e)	01:37 (r)	20:14 (e)	02:11 (r)	20:49 (e)	01:49 (r)
6	19:24 (e)	02:03 (r)	19:44 (e)	02:20 (r)	20:16 (e)	02:44 (r)	20:50 (e)	02:22 (r)
7	19:24 (e)	02:53 (r)	19:45 (e)	02:59 (r)	20:17 (e)	03:16 (r)	20:51 (e)	02:57 (r)
8	19:25 (e)	03:39 (r)	19:46 (e)	03:35 (r)	20:18 (e)	03:42 (m)	20:52 (e)	03:18 (r)
9	19:26 (e)	04:20 (r)	19:47 (e)	04:09 (r)	20:19 (e)	03:41 (m)	20:53 (e)	03:24 (m)
10	19:26 (e)	04:58 (r)	19:48 (e)	04:19 (m)	20:20 (e)	03:40 (m)	20:54 (e)	03:24 (m)
11	19:27 (e)	04:59 (m)	19:49 (e)	04:18 (m)	20:22 (e)	03:39 (m)	20:55 (e)	03:24 (m)
12	19:27 (e)	04:58 (m)	19:50 (e)	04:16 (m)	20:23 (e)	03:38 (m)	20:56 (e)	03:25 (m)
13	19:28 (e)	04:57 (m)	19:51 (e)	04:15 (m)	20:24 (e)	03:37 (m)	20:57 (e)	03:25 (m)
14	19:29 (e)	04:55 (m)	19:51 (e)	04:13 (m)	21:05 (s)	03:37 (m)	21:32 (s)	03:25 (m)
15	19:55 (s)	04:54 (m)	20:29 (s)	04:12 (m)	21:57 (s)	03:36 (m)	22:17 (s)	03:25 (m)
16	20:47 (s)	04:53 (m)	21:22 (s)	04:11 (m)	22:46 (s)	03:35 (m)	23:00 (s)	03:25 (m)
17	21:40 (s)	04:51 (m)	22:15 (s)	04:09 (m)	23:32 (s)	03:34 (m)	23:41 (s)	03:26 (m)
18	22:33 (s)	04:50 (m)	23:08 (s)	04:08 (m)	00:17 (s)	03:33 (m)	00:20 (s)	03:26 (m)
19	23:26 (s)	04:49 (m)	23:59 (s)	04:07 (m)	00:59 (s)	03:32 (m)	01:00 (s)	03:26 (m)
20	00:20 (s)	04:47 (m)	00:47 (s)	04:05 (m)	01:39 (s)	03:32 (m)	01:41 (s)	03:27 (m)
21	01:13 (s)	04:46 (m)	01:34 (s)	04:04 (m)	02:20 (s)	03:31 (m)	02:24 (s)	03:27 (m)
22	02:04 (s)	04:44 (m)	02:18 (s)	04:03 (m)	03:02 (s)	03:30 (m)	03:11 (s)	03:28 (m)
23	02:54 (s)	04:43 (m)	03:02 (s)	04:01 (m)	None		None	
24	03:41 (s)	04:42 (m)	03:44 (s)	04:00 (m)	None		None	
25	04:27 (s)	04:40 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		20:42 (e)	21:19 (r)	21:05 (e)	21:29 (r)
29	19:39 (e)	19:43 (r)	20:07 (e)	20:40 (r)	20:43 (e)	22:09 (r)	21:05 (e)	22:07 (r)
30	19:40 (e)	20:51 (r)	20:08 (e)	21:42 (r)	20:44 (e)	22:54 (r)	21:05 (e)	22:43 (r)
31			20:09 (e)	22:39 (r)			21:05 (e)	23:17 (r)

Note: For the Hours of Darkness tables, any time after midnight refers to the following morning. An entry of None means the Moon is up the entire time between evening and morning twilight. For the notes after each time: (e) dark starts at end of evening twilight, (s) dark starts at Moon set, (r) dark ends with Moon rise and (m) dark ends with morning twilight.

SYDNEY (EST)

	JANUARY Begin	JANUARY End	FEBRUARY Begin	FEBRUARY End	MARCH Begin	MARCH End	APRIL Begin	APRIL End
1	02:17 (s)	03:04 (m)	03:34 (s)	03:42 (m)	02:23 (s)	04:17 (m)	03:51 (s)	04:44 (m)
2	03:04 (s)	03:05 (m)	None		03:17 (s)	04:18 (m)	04:44 (s)	04:45 (m)
3	None		None		04:10 (s)	04:19 (m)	None	
4	None		None		None		None	
5	None		None		None		None	
6	None		None		None		None	
7	None		20:28 (e)	20:31 (r)	None		19:06 (e)	19:27 (r)
8	None		20:27 (e)	21:02 (r)	None		19:05 (e)	20:10 (r)
9	20:52 (e)	21:25 (r)	20:26 (e)	21:35 (r)	19:47 (e)	20:11 (r)	19:03 (e)	20:57 (r)
10	20:51 (e)	21:57 (r)	20:24 (e)	22:10 (r)	19:45 (e)	20:48 (r)	19:02 (e)	21:49 (r)
11	20:51 (e)	22:29 (r)	20:23 (e)	22:47 (r)	19:44 (e)	21:27 (r)	19:01 (e)	22:45 (r)
12	20:51 (e)	23:01 (r)	20:22 (e)	23:29 (r)	19:42 (e)	22:11 (r)	19:00 (e)	23:45 (r)
13	20:50 (e)	23:34 (r)	20:21 (e)	00:16 (r)	19:41 (e)	23:00 (r)	18:58 (e)	00:49 (r)
14	20:50 (e)	00:11 (r)	20:19 (e)	01:09 (r)	19:39 (e)	23:55 (r)	18:57 (e)	01:55 (r)
15	20:49 (e)	00:51 (r)	20:18 (e)	02:08 (r)	19:38 (e)	00:54 (r)	18:56 (e)	03:02 (r)
16	20:49 (e)	01:37 (r)	20:17 (e)	03:12 (r)	19:36 (e)	01:58 (r)	18:55 (e)	04:10 (r)
17	20:48 (e)	02:28 (r)	20:15 (e)	04:03 (m)	19:35 (e)	03:05 (r)	18:54 (e)	04:56 (m)
18	20:47 (e)	03:24 (m)	20:14 (e)	04:04 (m)	19:34 (e)	04:14 (r)	18:53 (e)	04:57 (m)
19	20:47 (e)	03:25 (m)	20:13 (e)	04:05 (m)	19:32 (e)	04:34 (m)	18:52 (e)	04:57 (m)
20	20:46 (e)	03:26 (m)	20:11 (e)	04:07 (m)	19:31 (e)	04:35 (m)	18:50 (e)	04:58 (m)
21	20:45 (e)	03:28 (m)	20:10 (e)	04:08 (m)	19:29 (e)	04:36 (m)	19:29 (s)	04:59 (m)
22	20:44 (e)	03:29 (m)	20:48 (s)	04:09 (m)	19:28 (e)	04:37 (m)	20:21 (s)	04:59 (m)
23	20:52 (s)	03:30 (m)	21:30 (s)	04:10 (m)	20:06 (s)	04:37 (m)	21:14 (s)	05:00 (m)
24	21:32 (s)	03:32 (m)	22:13 (s)	04:11 (m)	20:53 (s)	04:38 (m)	22:09 (s)	05:01 (m)
25	22:12 (s)	03:33 (m)	23:00 (s)	04:12 (m)	21:42 (s)	04:39 (m)	23:03 (s)	05:01 (m)
26	22:52 (s)	03:34 (m)	23:48 (s)	04:13 (m)	22:32 (s)	04:40 (m)	23:57 (s)	05:02 (m)
27	23:33 (s)	03:36 (m)	00:39 (s)	04:15 (m)	23:25 (s)	04:41 (m)	00:51 (s)	05:03 (m)
28	00:17 (s)	03:37 (m)	01:30 (s)	04:16 (m)	00:18 (s)	04:41 (m)	01:44 (s)	05:03 (m)
29	01:02 (s)	03:38 (m)			01:11 (s)	04:42 (m)	02:37 (s)	05:04 (m)
30	01:51 (s)	03:40 (m)			02:05 (s)	04:43 (m)	03:30 (s)	05:04 (m)
31	02:42 (s)	03:41 (m)			02:58 (s)	04:44 (m)		

	MAY Begin	MAY End	JUNE Begin	JUNE End	JULY Begin	JULY End	AUGUST Begin	AUGUST End
1	04:24 (s)	05:05 (m)	None		None		None	
2	None		None		None		18:42 (e)	19:25 (r)
3	None		None		None		18:42 (e)	20:33 (r)
4	None		18:22 (e)	18:33 (r)	18:27 (e)	19:27 (r)	18:43 (e)	21:40 (r)
5	None		18:22 (e)	19:32 (r)	18:27 (e)	20:33 (r)	18:43 (e)	22:46 (r)
6	18:35 (e)	18:54 (r)	18:22 (e)	20:34 (r)	18:28 (e)	21:39 (r)	18:44 (e)	23:50 (r)
7	18:35 (e)	19:45 (r)	18:22 (e)	21:38 (r)	18:28 (e)	22:45 (r)	18:45 (e)	00:53 (r)
8	18:34 (e)	20:40 (r)	18:22 (e)	22:42 (r)	18:29 (e)	23:50 (r)	18:45 (e)	01:54 (r)
9	18:33 (e)	21:39 (r)	18:22 (e)	23:47 (r)	18:29 (e)	00:54 (r)	18:46 (e)	02:51 (r)
10	18:32 (e)	22:41 (r)	18:22 (e)	00:52 (r)	18:30 (e)	01:57 (r)	18:46 (e)	03:44 (r)
11	18:32 (e)	23:45 (r)	18:22 (e)	01:56 (r)	18:30 (e)	02:59 (r)	18:47 (e)	04:33 (r)
12	18:31 (e)	00:49 (r)	18:22 (e)	03:01 (r)	18:30 (e)	03:59 (r)	18:47 (e)	05:12 (m)
13	18:30 (e)	01:55 (r)	18:22 (e)	04:05 (r)	18:31 (e)	04:56 (r)	18:48 (e)	05:11 (m)
14	18:30 (e)	03:01 (r)	18:22 (e)	05:08 (r)	18:31 (e)	05:30 (m)	18:49 (e)	05:10 (m)
15	18:29 (e)	04:08 (r)	18:22 (e)	05:29 (m)	18:32 (e)	05:30 (m)	18:49 (e)	05:09 (m)
16	18:29 (e)	05:14 (m)	18:22 (e)	05:29 (m)	18:32 (e)	05:29 (m)	18:56 (s)	05:08 (m)
17	18:28 (e)	05:15 (m)	18:22 (e)	05:30 (m)	18:33 (e)	05:29 (m)	19:49 (s)	05:07 (m)
18	18:28 (e)	05:16 (m)	18:38 (s)	05:30 (m)	19:15 (s)	05:29 (m)	20:41 (s)	05:06 (m)
19	18:27 (e)	05:16 (m)	19:34 (s)	05:30 (m)	20:09 (s)	05:28 (m)	21:34 (s)	05:05 (m)
20	19:00 (s)	05:17 (m)	20:30 (s)	05:30 (m)	21:03 (s)	05:28 (m)	22:28 (s)	05:04 (m)
21	19:55 (s)	05:17 (m)	21:25 (s)	05:31 (m)	21:56 (s)	05:28 (m)	23:21 (s)	05:03 (m)
22	20:51 (s)	05:18 (m)	22:18 (s)	05:31 (m)	22:49 (s)	05:27 (m)	00:16 (s)	05:02 (m)
23	21:47 (s)	05:18 (m)	23:12 (s)	05:31 (m)	23:42 (s)	05:27 (m)	01:11 (s)	05:01 (m)
24	22:41 (s)	05:19 (m)	00:05 (s)	05:31 (m)	00:36 (s)	05:26 (m)	02:06 (s)	05:00 (m)
25	23:35 (s)	05:20 (m)	00:58 (s)	05:31 (m)	01:31 (s)	05:26 (m)	03:00 (s)	04:59 (m)
26	00:28 (s)	05:20 (m)	01:52 (s)	05:31 (m)	02:27 (s)	05:25 (m)	03:53 (s)	04:57 (m)
27	01:21 (s)	05:21 (m)	02:48 (s)	05:31 (m)	03:24 (s)	05:25 (m)	04:42 (s)	04:56 (m)
28	02:14 (s)	05:21 (m)	03:44 (s)	05:32 (m)	04:20 (s)	05:24 (m)	None	
29	03:09 (s)	05:22 (m)	04:42 (s)	05:32 (m)	05:15 (s)	05:23 (m)	None	
30	04:04 (s)	05:22 (m)	None		None		None	
31	05:00 (s)	05:23 (m)			None		18:59 (e)	19:21 (r)

	SEPTEMBER Begin	SEPTEMBER End	OCTOBER Begin	OCTOBER End	NOVEMBER Begin	NOVEMBER End	DECEMBER Begin	DECEMBER End
1	19:00 (e)	20:30 (r)	19:21 (e)	21:32 (r)	19:54 (e)	23:08 (r)	20:32 (e)	23:11 (r)
2	19:00 (e)	21:38 (r)	19:22 (e)	22:35 (r)	19:55 (e)	23:54 (r)	20:33 (e)	23:47 (r)
3	19:01 (e)	22:44 (r)	19:23 (e)	23:33 (r)	19:56 (e)	00:35 (r)	20:34 (e)	00:20 (r)
4	19:02 (e)	23:46 (r)	19:24 (e)	00:26 (r)	19:58 (e)	01:13 (r)	20:35 (e)	00:53 (r)
5	19:02 (e)	00:46 (r)	19:25 (e)	01:14 (r)	19:59 (e)	01:47 (r)	20:36 (e)	01:24 (r)
6	19:03 (e)	01:40 (r)	19:26 (e)	01:57 (r)	20:00 (e)	02:20 (r)	20:38 (e)	01:56 (r)
7	19:04 (e)	02:31 (r)	19:27 (e)	02:36 (r)	20:01 (e)	02:51 (r)	20:39 (e)	02:30 (r)
8	19:04 (e)	03:16 (r)	19:28 (e)	03:12 (r)	20:03 (e)	03:14 (m)	20:40 (e)	02:54 (m)
9	19:05 (e)	03:57 (r)	19:29 (e)	03:45 (r)	20:04 (e)	03:13 (m)	20:41 (e)	02:54 (m)
10	19:06 (e)	04:35 (r)	19:30 (e)	03:54 (m)	20:05 (e)	03:12 (m)	20:42 (e)	02:54 (m)
11	19:06 (e)	04:37 (m)	19:31 (e)	03:53 (m)	20:07 (e)	03:11 (m)	20:42 (e)	02:54 (m)
12	19:07 (e)	04:35 (m)	19:32 (e)	03:51 (m)	20:08 (e)	03:10 (m)	20:43 (e)	02:54 (m)
13	19:08 (e)	04:34 (m)	19:33 (e)	03:50 (m)	20:09 (e)	03:09 (m)	20:44 (e)	02:54 (m)
14	19:08 (e)	04:33 (m)	19:34 (e)	03:48 (m)	20:42 (s)	03:08 (m)	21:09 (s)	02:54 (m)
15	19:29 (s)	04:31 (m)	20:05 (s)	03:47 (m)	21:34 (s)	03:07 (m)	21:54 (s)	02:54 (m)
16	20:22 (s)	04:30 (m)	20:59 (s)	03:45 (m)	22:23 (s)	03:06 (m)	22:36 (s)	02:55 (m)
17	21:15 (s)	04:28 (m)	21:52 (s)	03:44 (m)	23:10 (s)	03:05 (m)	23:16 (s)	02:55 (m)
18	22:09 (s)	04:27 (m)	22:45 (s)	03:42 (m)	23:53 (s)	03:04 (m)	23:55 (s)	02:55 (m)
19	23:03 (s)	04:25 (m)	23:36 (s)	03:41 (m)	00:35 (s)	03:03 (m)	00:34 (s)	02:55 (m)
20	23:57 (s)	04:24 (m)	00:24 (s)	03:39 (m)	01:15 (s)	03:03 (m)	01:14 (s)	02:56 (m)
21	00:50 (s)	04:22 (m)	01:11 (s)	03:38 (m)	01:54 (s)	03:02 (m)	01:56 (s)	02:56 (m)
22	01:41 (s)	04:21 (m)	01:55 (s)	03:36 (m)	02:35 (s)	03:01 (m)	02:41 (s)	02:57 (m)
23	02:31 (s)	04:19 (m)	02:37 (s)	03:35 (m)	None		None	
24	03:18 (s)	04:18 (m)	03:19 (s)	03:34 (m)	None		None	
25	04:03 (s)	04:17 (m)	None		None		None	
26	None		None		None		None	
27	None		None		None		None	
28	None		None		20:28 (e)	20:56 (r)	20:52 (e)	21:06 (r)
29	None		19:50 (e)	20:16 (r)	20:30 (e)	21:46 (r)	20:53 (e)	21:44 (r)
30	19:21 (e)	20:25 (r)	19:51 (e)	21:19 (r)	20:31 (e)	22:31 (r)	20:53 (e)	22:20 (r)
31			19:53 (e)	22:16 (r)			20:53 (e)	22:53 (r)

OBSERVING THE MOON

The Moon map has something for everyone, whether you are using binoculars or a telescope, in fact many features are visible to the naked eye. The so called *Man in the Moon* is a pattern formed by a number of prominent seas, although in the south more people report seeing a *rabbit*.

The Moon maps are drawn with south to the top giving a correct view as we see it from the Southern Hemisphere. After New Moon the phase grows (or waxes) from a thin phase on the eastern limb (left edge of page 98) toward the right. After Full Moon the bright limb starts to wane or shrink away from the eastern limb. Approximately 14 to 15 days after a feature has been on the terminator it is there again but this time illuminated from the opposite direction with shadows going the other way (it is sunrise before Full Moon and sunset after). This is why the table below goes only a few days beyond Full Moon, for the features would be repeated. If you are able to view well into the morning, beyond Third Quarter, you will be treated to a whole new perspective. For the first 1 to 2 days after being *New* the Moon is too close to the Sun and the horizon to give good views. It is better to wait until a couple of days beyond Full Moon (e.g. 17 days) to see these features return to the terminator under dark, night skies.

The Table

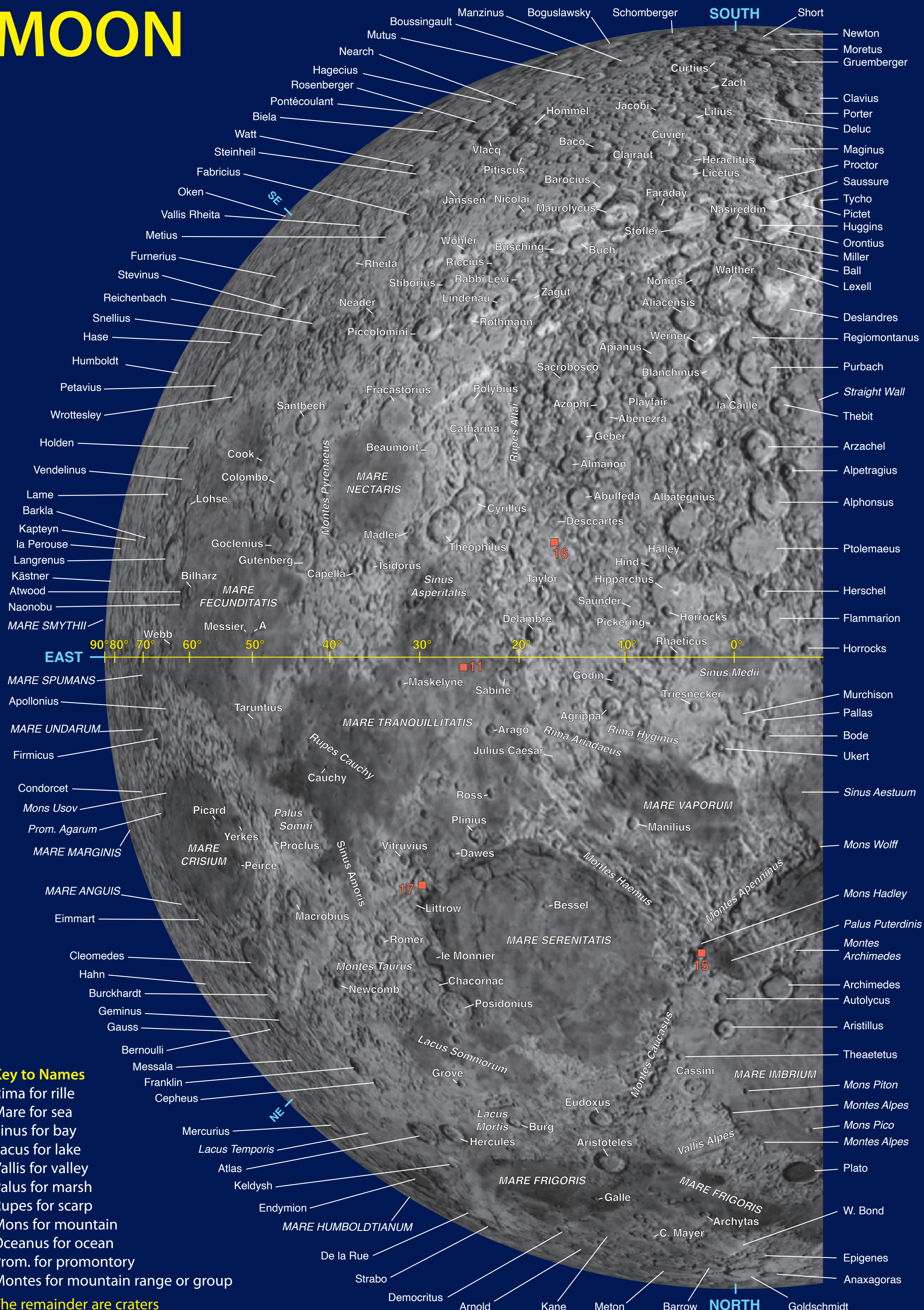
The lunar features listed are those on the terminator (the day–night line) for the age of the Moon, i.e., number of days after New Moon. The presumed position of the terminator is only approximate for this can vary depending on the libration or even the time of day. Objects on the terminator give a true 3D effect with the low Sun angle sometimes resulting in complex, interesting shadows from peaks, crater walls, ridges and mountains. Seeing a *star* suspended in an otherwise dark crater as the sunlight touches the peak of its central mountain is impressive! For each day the features are listed starting in the south (top of the page) and moving north (down) along the terminator. The list covers prominent objects or those that present an observing challenge, such as ridges on the crater floor. The majority are craters unless otherwise named such as Mare for seas (see key list on the maps). The number following a crater's name is its diameter in kilometres. Note, there are numerous features that give great views over a number of lunar days (such as seas), but may not be listed on subsequent days.

FEATURE	NOTES
Day 3 (48° E)	
Biela (76 km)	three central peaks
Furnerius, Petavius, Vendelinus and Langrenus	easily recognised row of four craters
Furnerius (130 km)	look for small crater on floor
Petavius (177 km)	central mountain and rille
Vendelinus (150 km) and Lame (84 km)	merged craters (Lame was a later impact)
Langrenus (132 km)	terraced walls, double central peak
Mare Fecunditatis	Sea of Fertility, note ridges on floor
Picard (24 km) and Peirce (19 km)	prominent on floor of Mare Crisium
Mare Crisium	one of the most prominent features on the Moon (Sea of Crises)
Cleomedes (132 km)	look for rille on floor
Geminus (87 km)	terraced walls, central peak
Endymion (124 km)	smooth, dark floored crater
Day 4 (40° E)	
Vlacq (89 km)	has prominent central peak, paired with Rosenberger
Janssen (24 km)	old, northern wall destroyed by heavy cratering
Vallis Rheita	crater chain, next to Rheita
Rheita (70 km)	has nice central peak, forms a line with Metius and Fabricius
Neander (52 km)	contains small central peak and crater
Mare Fecunditatis	Sea of Fertility
Taruntius (57 km)	prominent on Mare Fecunditatis
Messier (13 km)	pair of small craters with two prominent rays running west (on Mare Fecunditatis)
Macrobius (64 km)	a good landmark
Franklin (54 km) and Cepheus (39 km)	pair, Franklin has central peak
Atlas (87 km)	prominent on terminator
Day 5 (28° E)	
Mare Nectaris	Sea of Nectar in full view
Fracastorius (120 km)	on northern edge of Mare Nectaris, has a lava flooded floor with the northern rim destroyed
Capella (64 km) and Isidorus (41 km)	distinctive pair on northern edge of Mare Nectaris. Capella has a central peak with a valley cutting through the crater
Mare Tranquillitatis	Sea of Tranquility, partly revealed
Maskelyne (24 km)	small prominent crater in southern region of Mare Tranquillitatis
Rupes Cauchy	a scarp casting shadows on Mare Tranquillitatis

FEATURE	NOTES
Posidonius (101 km)	impressive, circular walled plain
Lacus Somniorum	Lake of Dreams
Atlas (87 km) and Hercules (67 km)	prominent pair of craters near Mare Frigoris
Mare Frigoris	Sea of Cold
Day 6 (20° E)	
Manzinus (97 km)	deep crater with small craters on floor
Mutus (76 km)	paired with Manzinus with three small craters nearby
Hommel (120 km)	south of Pitiscus, with two obvious internal craters
Pitiscus (82 km)	prominent crater with central peak
Maurolycus (116km)	old, heavily cratered floor
Catharina (101 km), Cyrillus (93 km) and Theophilus (104 km)	Theophilus and Cyrillus are overlapping craters, these three make a very distinctive group
Delambre (46 km)	near equator
Arago (26 km), Ross (27 km) and Plinius (43 km)	three distinctive, isolated craters on western Mare Tranquillitatis
Bessel (16 km)	small isolated crater on Mare Serenitatis
Mare Serenitatis	Sea of Serenity
Eudoxus (67 km) and Aristoteles (88 km)	an impressive pair of craters near Mare Frigoris
Day 7 (4° E) — First Quarter	
Curtius (95 km)	contains three small mountain peaks
Lilius (62 km)	prominent central peak (casts a long spire shadow at low Sun angles)
Cuvier (78 km), Heraclitus (97 km) and Licetus (76 km)	three craters in obvious triangle
Stofler (126 km)	large flat floored crater with smaller crater Faraday crushing its eastern wall
Aliacensis (81 km) and Werner (71 km)	pair of striking craters
Azophi (48 km), Abenezra (42 km) and Gerber (46 km)	obvious group of three craters
Albategnius (134 km)	has a distinctive central mountain with flat plain, the western wall contains Klein
Hipparchus (153 km)	eroded crater
Horrocks (30 km)	sits on northern edge of Hipparchus
Godin (36 km) and Agrippa (46 km)	nice isolated pair, Agrippa has an obvious central peak
Mare Vaporum	Sea of Vapours, has series of ridges and Hyginus Rille
Manilius (39 km)	prominent, isolated crater in eastern Mare Vaporum
Mare Serenitatis	now in full view
Montes Caucasus	eastern edge of Mare Imbrium, casting large shadows

FEATURE	NOTES
Day 8 (4° W)	
Purbach (124 km)	damaged, containing slopes and ridges
Arzachel, Alphonsus and Ptolemaeus	possibly the most recognisable line of three craters on the Moon
Arzachel (97 km)	terraced walls with the floor having a central peak, small craters and a rille
Alphonsus (117 km)	central peak with two rilles running along the floor
Ptolemaeus (160 km)	a vast flat floor with degraded walls, note the small crater Ammonius (northeast of centre)
Herschel (41 km)	obvious crater close to Ptolemaeus (north side)
Ptolemaeus to Walther (132 km)	extending the Ptolemaeus group of three south to Walther, line of six large craters
Sinus Medii	bay of the centre (marking the Centre of the Moon)
Triesnecker (28 km)	prominent crater isolated in Sinus Medii
Mones Apennine	eastern end of this mountain range, on southeast edge of Mare Imbrium
Mare Imbrium	Sea of Rains, eastern part in view
Autolycus (39 km)	makes a distinctive pair with Aristillus to the north
Aristillus (56 km)	three central mountain peaks
Cassini (57 km)	crater in northern Mare Imbrium, with two smaller craters on floor
Vallis Alpes (Alpine Valley)	cuts through Montes Alpes
Montes Alpes	northern edge of Mare Imbrium
Day 9 (15° W)	
Moretus (117 km)	not far from the south pole, another distinctive crater with a central mountain that casts eye-catching shadows
Clavius (232 km)	a number of smaller craters are on the floor (location of Clavius Base, from where TMA-1 was discovered – for those Sci-Fi fans)
Rays extending to the east from Tycho	these develop as the Moon gets closer to full
Tycho (87 km)	prominent crater in the southern uplands, at low Sun angles its central peak casts a *witch's hat* shadow (location of TMA-1, see Clavius above)
Hell (35 km)	well defined crater in flat plain of Deslandres
Pitatus (88 km)	on southern edge of Mare Nubium, a flat lava filled crater with central peak
Mare Nubium	Sea of Clouds, eastern portion
Nicollet	small distinctive crater in the middle of Mare Nubium
Rupes Recta (Straight Wall)	running north-south (120 km) on eastern edge of Mare Nubium, small crater Birt is just west
Eratosthenes (58 km)	at the western end of the Apennines, has terraced walls and a central peak
Mones Apennine	the mountain range is now in full sunlight
Archimedes (80 km)	distinctive, flat floored crater in Mare Imbrium
Mons Piton and Mons Pico	two obvious isolated mountains in northern Mare Imbrium, both cast long shadows at low Sun angles
Plato (101 km)	at the northern end of Mare Imbrium, casts interesting shadows from its jagged crater walls and has challenging 1 km diameter craters on its floor
Day 10 (27° W)	
Longomontanus (149 km)	a walled plain with several craters around the edge of the floor plus some peaks
Mare Nubium	now in full sunlight
Bullialdus A, B and Konig (23 km)	a group of three craters, just south of Bullialdus, standing out well against the dark floor of Mare Nubium
Bullialdus (60 km)	prominent crater in Mare Nubium with terraced walls and multiple peaked central mountain
Lansberg (39 km)	isolated crater with central peak in Mare Insularum
Reinhold (45 km)	distinctive crater, near Lansberg in Mare Insularum
Copernicus (91 km)	possibly the most recognisable crater on the Moon. It has terraced walls and a prominent central peak with surrounding ejector rays, standing out well against the dark floored mare. Located on the border of Mare Insularum and Mare Imbrium
Crater chain	a challenge, this string of craters (4–7 km) is between Copernicus and Eratosthenes, running roughly towards the southeast
Day 11 (40° W)	
Scheiner (115 km)	west of Clavius, this crater has four small craters on its floor. Makes a good pair with Blancanus.
Schiller (180 km)	this prominent elongated crater has an obvious ridge running along its floor visible at low Sun angles
Hainzel (73 km)	has an odd shape showing signs of multiple impacts in the past
Vitello (42 km)	on southern edge of Mare Humorum is a steep walled crater with central mountain
Gassendi (110 km)	contains a double mountain peak and several rills and hills on the floor
Kepler (33 km)	in eastern part of Oceanus Procellarum is this well known *rayed* crater. These develop as the Moon gets closer to full.
Sinus Iridum	this obvious bay in northwest Mare Imbrium is probably a lava filled remnant of an old impact
Day 12 (55° W)	
Schickard (216 km)	has a dark floor with white stripe
Aristarchus (39 km)	the brightest feature on the near side of the Moon. This is even visible when lit only by earthshine (near New Moon). It sits on a smooth, dark plateau.
Herodotus (36 km)	next to Aristarchus. The prominent winding valley, Schroter's, extends from Herodotus towards the north.
Day 13 and 14 (about 70°–80° W)	
Bailly (295 km)	a large, foreshortened crater near the south pole limb, presents great views with favourable librations
Wargentin (84 km)	was once a crater but now filled with lava to the brim forming a plateau, that appears to stand above the surface with the right Sun angle
Mersenius (84 km)	west of Mare Humorum, has a lava flooded floor with small crater pits
Billy (46 km)	prominent crater with a dark floor
Grimaldi (228 km)	large, foreshortened, dark floored crater is an obvious signpost
Hevelius (109 km) and Cavalerius (60 km)	a distinctive pair near western limb. Hevelius is a walled plain with a small central peak and crisscross pattern of rilles
Cardanus (51 km) and Krafft (53 km)	impressive pair near limb against backdrop of dark plain of Oceanus Procellarum
Struve (175 km) and Russell (105 km)	both are extremely foreshortened limb features, appearing to merge
Mons Rumker	a well known lunar dome (mound-like), isolated in Sinus Roris
Pythagoras (129 km)	very close to the northern pole limb, is extremely foreshortened but displays good terraced walls and twin central peaks
Day 15 — Full Moon	
Bright Rays from craters	the most prominent example is Tycho (dominates the southern hemisphere). The rays of Copernicus, Aristarchus and Kepler form a triangle. Also worthwhile looking at are Stevinus, Proclus (fan shaped ejecta) and Anaxagoras
Bright craters	there are a number of these which include Dionysius, Byrgius, and Censorinus
Dark features	all the seas and walled plains of Grimaldi, Endymion and Plato
Day 16 to 17 (about 70°–80° E)	
Furnerius, Petavius, Vendelinus and Langrenus	seen at best (better view than day 3)
Mare Crisium	best phase to see the wrinkled ridges on floor

MOON



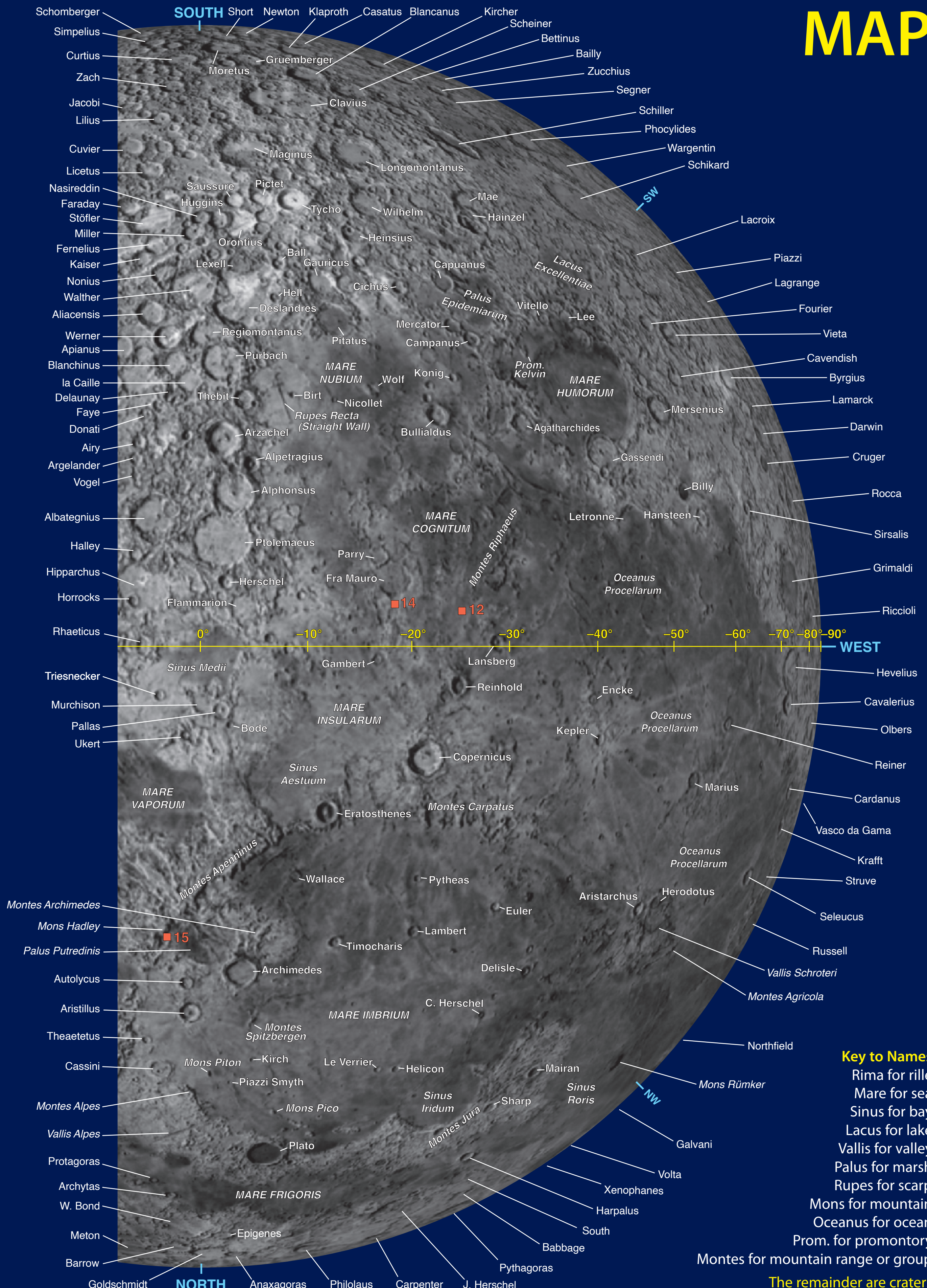
Key to Names

Rima for rille
Mare for sea
Sinus for bay
Lacus for lake
Vallis for valley
Palus for marsh
Rupes for scarp
Mons for mountain
Oceanus for ocean
Prom. for promontory
Montes for mountain range or group

The remainder are craters

Orange squares are Apollo landing sites

MAP



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The remainder are craters
Orange squares are Apollo landing sites

LUNAR OCCULTATIONS

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 each day. From just after New Moon to just before Full Moon, stars being occulted 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 disappears on the bright limb and reappears on the dark limb. There is no dark limb at 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 this year 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.

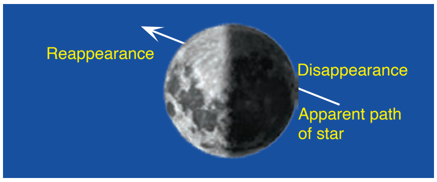
Besides being a spectacular event, occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

TIMING EQUIPMENT. Historically, amateurs timed these events by recording a radio time signal along with their voice calling out the events. With the demise of time signal services, such as Australia's VNG, beeper boxes are now being used instead of shortwave radios, especially for multiple timing events. The boxes are electronically synchronised to a time standard before the event. In addition, many observers are now using a combination of video and a GPS signal to record an occultation. See links below for more information.

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 (see Part III) or the International Occultation Timing Association.

www.lunar-occultations.com/iota/iotandx.htm
www.occultations.org.nz



LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 6.5 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
	ggg ccc	Greek letter and constellation abbreviation
	n ccc	Flamsteed number and constellation
	name of planet, satellite or deep sky 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. G indicates a graze at or near the location. M means a miss with a graze nearby.	
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.	
PA	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 would be useless, and no values are shown.	

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 500 km from the city's table you are working from. The formula is:

Predicted Time at your location

= Time from Table + (A × n) + (B × 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 reappearance of Phi Oph on March 13th for their location in Albury NSW (146° 55' E, 36° 05' S), see page 142. 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 01:24 EST and the values of A and B are + 0.1 and – 3.3 respectively.

Therefore the equation becomes:

01:24 + (+0.1 × –2.21°) + (–3.3 × –0.83°)

= 01:24 + (–0.2) + (+2.7)

= 01:24 + (+2.5) = 01:27

The event will be visible from Albury approximately three minutes later than Canberra, i.e., about 1:27 am (EST) on March 13th.

Lunar occultation predictions calculated using Occult version 4.1.1.4 by D. Herald.

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 01:48	82 Vir	DB	5.0	86	22	132	0.3	–2.1
Jan 14 02:54	82 Vir	RD	5.0	86	35	274	1.2	–1.3
Jan 24 20:24	21 Psc	DD	5.8	54	17	73	0.6	1.5
Jan 29 23:09	68 Tau	DD	4.3	118	22	153	0.6	–2.4
Jan 29 23:42	68 Tau	RB	4.3	118	17	204	2.2	4.5
Feb 01 00:18	71 Ori	DD	5.2	142	26	69	2.1	1.7
Feb 03 00:50	1198	DD	6.1	164	35	57	3.2	2.4
Feb 04 23:08	Xi Leo	RD	5.0	173	38	290	2.1	–1.4
Feb 11 00:40	Kap Vir	DB	4.2	107	25	45	1.7	1.2
Feb 11 01:07	Kap Vir	RD	4.2	107	30	358	–0.6	–4.9
Feb 25 21:11	610	DD	6.1	87	22	110	1.3	0.4
Mar 11 23:28	Gam Lib	RD	3.9	115	19	289	0.2	–1.6
Mar 12 03:59	Eta Lib	DB	5.4	113	69	162	1.1	–4.8
Mar 12 04:50	Eta Lib	RD	5.4	113	71	229	3.3	3.3
Mar 13 00:01	Phi Oph	DB	4.3	103	16	68	0.4	–0.5
Mar 13 00:52	Phi Oph	RD	4.3	103	26	317	0.1	–2.5
Mar 15 03:30	2674	RD	6.2	77	37	232	1.4	0.5
Apr 01 01:46	1458	DD	5.9	138	17	174	–0.3	–3.4
Apr 09 23:08	2460	RD	6.0	121	21	244	0.7	–0.3
Apr 10 04:58	2495	DB	6.0	119	72	73	2.4	1.1
Apr 27 18:49	Xi Leo	RB	5.0	105	43	305	2.1	–1.5
May 03 19:01	Kap Vir	DD	4.2	171	21	88	0.6	–1.1
May 03 20:03	Kap Vir	RB	4.2	172	34	315	0.6	–2.4
May 11 04:38	3045	DB	5.9	98	62	358	0.3	9.3
May 11 05:01	3045	RD	5.9	98	65	326	4.2	–8.6
May 12 03:43	47 Cap	DB	6.0	85	41	60	1.3	0.2
May 12 04:58	47 Cap	RD	6.0	85	55	262	1.9	–0.3
May 14 02:59	14 Psc	RD	5.9	59	7	187	0.1	3.1
Jun 01 17:54	Gam Lib	DD	3.9	164	16	88	0.3	–1.1
Jun 01 18:53	Gam Lib	RB	3.9	164	29	306	0.4	–2.0
Jun 01 23:24	Eta Lib	DD	5.4	166	71	138	1.9	–2.4
Jun 02 00:39	Eta Lib	RB	5.4	166	64	249	2.4	1.7

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 02 19:03	Phi Oph	DB	4.3	174	21	33	1.7	2.2
Jun 02 19:24	Phi Oph	RB	4.3	174	25	353	–1.1	–5.3
Jun 04 21:39	2674	RD	6.2	156	31	277	0.7	–1.3
Jun 06 05:16	54 Sgr	DB	5.3	140	55	127	2.6	–1.3
Jun 06 06:00	54 Sgr	RD	5.3	140	46	199	0.2	3.9
Jun 06 06:14	55 Sgr	DB	5.1	140	44	115	1.7	0.0
Jun 07 03:52	3002	RD	6.1	128	69	288	2.6	–1.0
Jun 12 04:19	Uranus	DB	5.9	61	21	54	0.7	0.1
Jun 12 05:13	88 Psc	DB	6.0	61	31	105	1.7	–1.7
Jun 12 05:27	Uranus	RD	5.9	61	33	256	1.4	–0.4
Jun 12 06:09	88 Psc	RD	6.0	60	39	204	0.8	1.8
Jun 22 19:12	48 Leo	DD	5.1	67	37	88	2.1	1.1
Jun 22 20:22	48 Leo	RB	5.1	67	25	324	0.6	–1.0
Jun 30 19:56	2460	DD	6.0	159	47	70	1.7	–0.2
Jul 01 03:06	2495	DD	6.0	161	34	65	0.6	1.9
Jul 24 21:55	Kap Vir	DD	4.2	93	36	113	1.3	0.2
Jul 24 23:07	Kap Vir	RB	4.2	94	21	275	0.6	1.0
Jul 30 20:24	54 Sgr	DD	5.3	166	45	77	1.4	–0.5
Jul 30 21:32	55 Sgr	DD	5.1	167	58	50	1.9	1.2
Jul 30 21:40	54 Sgr	RB	5.3	167	60	270	1.9	–0.6
Jul 30 22:42	55 Sgr	RB	5.1	167	69	292	2.3	–1.4
Jul 31 05:46	61 Sgr	DD	5.0	170	8	120	0.2	0.2
Aug 01 21:02	3169	RD	6.1	165	27	200	0.9	2.3
Aug 07 04:28	31 Ara	DB	5.6	93	39	99	2.3	–1.0
Aug 07 05:38	31 Ara	RD	5.6	93	43	215	1.5	1.7
Aug 09 02:33	Del 1 Tau	RD	3.8	69	2	320	1.5	–4.2
Aug 09 03:19	64 Tau	RD	4.8	68	10	271	0.8	–1.1
Aug 19 20:44	The Vir	DD	4.4	52	14	120	0.4	0.1
Aug 22 22:19	Gam Lib	DD	3.9	86	27	137	1.1	–0.8
Aug 22 23:10	Gam Lib	RB	3.9	86	16	235	0.0	2.5
Aug 24 00:11	Phi Oph	DD	4.3	98	15	104	0.3	0.7
Aug 24 21:06	2495	DD	6.0	109	62	110	2.2	–0.3

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 24 22:23	2495	RB	6.0	110	47	248	1.3	1.9
Aug 28 01:25	Bet 1 Cap	MD	3.1	150	43	161	9.9	9.9
Aug 29 22:53	The Aqr	DD	4.2	176	58	97	2.2	–0.8
Aug 30 00:00	The Aqr	RB	4.2	176	63	215	1.4	2.1
Sep 01 21:42	80 Psc	RD	5.5	141	9	173	–0.8	6.7
Sep 05 05:22	620	RD	6.1	97	38	301	2.8	–1.4
Sep 06 03:31	104 Tau	DB	4.9	85	22	16	–0.1	2.7
Sep 06 04:06	104 Tau	RD	4.9	85	27	322	3.0	–3.9
Sep 30 00:01	Omi Psc	DB	4.3	158	41	26	0.9	1.7
Sep 30 01:01	Omi Psc	RD	4.3	158	46	284	2.6	–0.8
Oct 09 03:55	Venus	DB	–4.7	45	3	118	0.4	–2.0
Oct 09 05:08	Venus	RD	–4.7	45	17	272	1.1	–1.4
Oct 21 19:06	Bet 1 Cap	RB	3.1	97	69	230	1.8	2.0
Oct 23 19:40	The Aqr	DD	4.2	124	61	93	2.3	–0.5
Oct 23 20:52	The Aqr	RB	4.2	124	62	217	1.4	2.2
Oct 26 23:16	88 Psc	DD	6.0	167	48	14	0.8	2.8
Oct 30 03:23	Del 1 Tau	DB	3.8	149	35	82	2.1	0.7
Oct 30 04:07	64 Tau	DB	4.8	149	31	111	1.8	0.1
Oct 30 04:42	Del 1 Tau	RD	3.8	148	26	265	1.6	1.0
Nov 20 20:37	3362	DD	5.9	105	55	118	3.1	–1.0
Nov 20 21:22	3362	RB	5.9	106	48	189	0.3	3.8
Nov 21 23:19	3520	DD	5.8	120	34	100	1.5	0.7
Nov 23 21:50	Omi Psc	DD	4.3	147	46	36	1.4	1.7
Nov 23 22:59	Omi Psc	RB	4.3	147	43	275	2.2	0.3
Dec 05 02:20	Bet Vir	RD	3.6	75	12	296	0.5	–1.8
Dec 06 13:33	Mars	DB	1.5	60	10	150	0.3	–1.3
Dec 14 20:55	61 Sgr	DD	5.0	37	6	39	–0.4	2.1
Dec 23 23:42	Del 1 Tau	DD	3.8	155	35	86	2.1	0.6
Dec 24 00:28	64 Tau	DD	4.8	155	31	117	1.8	–0.1
Dec 24 01:02	Del 1 Tau	RB	3.8	156	27	259	1.7	1.1
Dec 24 01:33	64 Tau	RB	4.8	156	23	232	1.6	2.1
Dec 27 23:31	1238	RD	6.0	153	27	264	1.7	–0.8

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 01 20:27	527	DD	6.2	136	46	141	4.5	–4.6
Jan 14 02:15	82 Vir	DB	5.0	86	34	100	1.1	–1.3
Jan 14 03:30	82 Vir	RD	5.0	86	50	311	1.3	–2.3
Jan 29 23:46	68 Tau	DD	4.3	118	15	111	0.8	0.2
Feb 04 22:32	Xi Leo	DB	5.0	173	43	83	2.6	–0.4
Feb 04 23:56	Xi Leo	RD	5.0	173	51	323	2.0	–2.4
Feb 13 05:02	49 Lib	DB	5.5	82	69	164	0.8	–5.3
Feb 22 19:16	Zet Psc A	RB	5.2	47	18	240	0.8	1.7
Feb 25 22:03	610	DD	6.1	87	12	80	0.9	1.2
Mar 11 22:54	Gam Lib	DB	3.9	115	17	70	0.6	–0.3
Mar 11 23:46	Gam Lib	RD	3.9	115	28	325	0.1	–2.7
Mar 12 04:38	Eta Lib	DB	5.4	113	77	116	2.6	–1.2
Mar 15 03:05	2674	DB	6.2	77	38	94	1.1	–1.0
Apr 01 02:08	1458	DD	5.9	137	9	125	0.3	–0.3
Apr 07 02:41	2088	DB	6.2	156	67	109	2.5	–0.5
Apr 07 04:12	2088	RD	6.2	155	49	285	1.9	0.1
Apr 09 23:43	2460	RD	6.0	121	33	283	0.8	–1.3
Apr 24 19:22	1072	DD	6.0	71	31	146	0.8	–1.5
Apr 24 20:22	1072	RB	6.0	71	20	245	1.7	2.1
Apr 25 21:32	1 Cnc	DD	5.8	83	18	185	–2.5	–8.1
Apr 27 18:28	Xi Leo	DD	5.0	105	51	62	4.0	1.7
Apr 27 19:27	Xi Leo	RB	5.0	105	51	350	0.7	–4.0
May 03 19:53	Kap Vir	DB	4.2	172	39	35	5.1	6.5
May 03 20:08	Kap Vir	RB	4.2	172	42	13	9.9	9.9
May 09 23:18	55 Sgr	RD	5.1	113	19	242	0.7	0.0
May 12 04:42	47 Cap	DB	6.0	85	61	41	1.7	1.8
May 14 03:46	14 Psc	RD	5.9	59	24	220	0.6	1.0
May 22 18:31	1141	RB	5.5	52	26	248	2.0	1.9
Jun 01 18:35	Gam Lib	DD	3.9	164	31	43	2.2	2.1
Jun 01 19:03	Gam Lib	RB	3.9	164	37	355	–0.8	–5.3
Jun 02 00:18	Eta Lib	DD	5.4	166	67	102	2.4	–0.1
Jun 02 01:46	Eta Lib	RB	5.4	166	48	277	1.7	0.5

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 06 21:03	Bet 1 Cap	RD	3.1	131	5	212	0.5	1.4
Jun 07 03:58	3002	DB	6.1	128	74	21	1.2	3.9
Jun 07 04:56	3002	RD	6.1	128	64	296	3.0	–1.1
Jun 09 01:33	3285	DB	5.9	102	36	120	1.5	–2.7
Jun 09 02:20	3285	RD	5.9	102	46	199	1.1	2.9
Jun 12 05:06	Uranus	DB	5.9	61	39	47	1.1	0.9
Jun 12 06:22	Uranus	RD	5.9	61	50	259	2.2	0.0
Jul 01 03:54	2495	DD	6.0	161	17	55	0.0	1.9
Jul 07 23:54	3520	RD	5.8	106	16	247	0.5	–0.1
Jul 19 09:31	Venus	DD	–4.7	34	14	178	1.2	–7.4
Jul 19 09:52	Venus	RB	–4.7	34	18	210	0.8	4.7
Jul 24 22:43	Kap Vir	DD	4.2	93	20	89	0.6	1.0
Jul 30 21:25	54 Sgr	DD	5.3	166	66	46	2.2	1.8
Jul 30 22:36	54 Sgr	RB	5.3	167	78	294	2.8	–1.5
Jul 30 22:51	55 Sgr	DD	5.1	167	79	18	1.6	5.0
Jul 30 23:37	55 Sgr	RB	5.1	167	76	314	3.5	–3.4
Aug 01 21:58	3169	RD	6.1	164	46	233	1.5	0.8
Aug 07 05:32	31 Ara	DB	5.6	93	50	99	2.9	–0.4
Aug 09 02:52	64 Tau	DB	4.8	69	14	52	0.4	0.4
Aug 09 02:53	Del 1 Tau	MD	3.8	69	14	344	9.9	9.9
Aug 09 03:58	64 Tau	RD	4.8	68	26	276	1.6	–1.1
Aug 22 22:58	Gam Lib	DD	3.9	86	12	120	0.4	–0.1
Aug 24 22:06	2495	DD	6.0	109	46	93	1.6	0.7
Aug 24 23:19	2495	RB	6.0	110	30	259	0.7	1.3
Aug 28 02:17	Bet 1 Cap	MD	3.1	150	27	162	9.9	9.9
Aug 29 23:56	The Aqr	DD	4.2	176	70	91	2.6	0.1
Aug 30 01:06	The Aqr	RB	4.2	176	61	216	1.3	2.4
Sep 01 21:09	73 Psc	RD	6.0	141	10	279	0.5	–1.2
Sep 01 22:33	80 Psc	RD	5.5	140	27	202	0.4	1.9
Sep 06 04:32	104 Tau	DB	4.9	85	39	3	–0.7	8.3
Sep 06 04:53	104 Tau	RD	4.9	85	41	337	5.0	–8.5
Sep 23 18:10	54 Sgr	RB	5.3	115	70	267	2.4	–0.3

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 23 19:22	55 Sgr	RB	5.1	115	79	286	2.8	–0.9
Sep 25 19:18	3169	RB	6.1	142	58	221	1.7	1.7
Sep 30 01:02	Omi Psc	DB	4.3	158	53	26	1.3	2.4
Sep 30 02:06	Omi Psc	RD	4.3	158	50	284	2.7	–0.3
Oct 09 04:21	Venus	DB	–4.7	45	16	103	1.0	–1.5
Oct 09 05:47	Venus	RD	–4.7	45	33	292	1.9	–1.8
Oct 19 19:13	2674	RB	6.2	72	51	271	1.8	0.7
Oct 21 18:53	Bet 1 Cap	DD	3.1	96	74	85	2.6	0.5
Oct 21 20:08	Bet 2 Cap	RB	6.1	97	60	239	1.6	1.8
Oct 21 20:16	Bet 1 Cap	RB	3.1	97	59	236	1.5	2.0
Oct 23 20:46	The Aqr	DD	4.2	123	68	89	2.6	0.3
Oct 23 21:58	The Aqr	RB	4.2	124	56	217	1.2	2.4
Oct 24 00:59	3285	DD	5.9	125	18	143	1.7	–3.2
Oct 26 20:04	80 Psc	DD	5.5	165	40	149	9.9	9.9
Oct 26 20:11	80 Psc	RB	5.5	165	41	159	9.9	9.9
Oct 27 00:22	88 Psc	DD	6.0	167	48	14	1.0	3.5
Oct 30 04:30	Del 1 Tau	DB	3.8	149	29	61	1.8	1.7
Nov 20 21:41	3362	DD	5.9	105	43	119	2.4	–0.7
Nov 20 22:23	3362	RB	5.9	106	34	191	0.1	3.7
Nov 22 00:11	3520	DD	5.8	120	20	91	0.8	0.9
Nov 23 22:57	Omi Psc	DD	4.3	147	47	35	1.6	2.3
Nov 24 00:02	Omi Psc	RB	4.3	147	37	281	1.9	0.3
Nov 29 22:47	74 Gem	RD	5.0	133	15	325	1.6	–3.3
Dec 05 01:41	Bet Vir	DB	3.6	75	11	83	0.5	–0.8
Dec 05 02:44	Bet Vir	RD	3.6	75	25	319	0.8	–2.5
Dec 24 00:48	Del 1 Tau	DD	3.8	155	30	67	1.8	1.5
Dec 24 01:24	64 Tau	DD	4.8	155	24	92	1.3	0.8
Dec 24 01:57	Del 1 Tau	RB	3.8	156	18	286	0.9	0.4
Dec 25 21:34	71 Ori	RD	5.2	176	33	284	2.1	–1.1
Dec 28 00:26	1238	RD	6.0	153	43	283	2.5	–0.9
Jan 01 01:44	89 Leo	DB	5.8	107	37	156	1.0	–3.3
Jan 01 02:51	89 Leo	RD	5.8	106	49	256	3.0	0.0

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 22:17	697	DD	6.5	148	36	116	2.5	–0.7
Jan 14 02:24	82 Vir	DB	5.0	86	31	123	0.7	–2.0
Jan 14 03:39	82 Vir	RD	5.0	86	46	286	1.5	–1.5
Jan 24 20:58	21 Psc	DD	5.8	54	8	76	0.3	1.4
Jan 29 23:45	68 Tau	DD	4.3	118	14	141	0.4	–0.8
Feb 01 01:08	71 Ori	DD	5.2	142	16	56	1.8	2.5
Feb 04 22:30	Xi Leo	DB	5.0	173	35	104	2.0	–1.3
Feb 05 00:01	Xi Leo	RD	5.0	173	43	299	2.2	–1.3
Feb 25 21:52	610	DD	6.1	87	13	104	0.8	0.7
Mar 11 02:02	2110	RD	6.3	126	59	240	3.1	1.1
Mar 11 22:59	Gam Lib	DB	3.9	115	16	95	0.2	–1.3
Mar 12 00:02	Gam Lib	RD	3.9	115	28	298	0.5	–1.9
Mar 12 04:46	Eta Lib	DB	5.4	113	70	150	1.8	–3.4
Mar 13 00:39	Phi Oph	DB	4.3	103	26	56	1.1	0.1
Mar 13 01:24	Phi Oph	RD	4.3	103	36	331	0.1	–3.3
Mar 15 03:14	2674	DB	6.2	77	36	124	0.6	–2.3
Mar 15 04:16	2674	RD	6.2	77	49	241	1.8	0.3
Apr 01 02:15	1458	DD	5.9	137	9	161	–0.1	–1.8
Apr 07 03:57	2088	RD	6.2	155	52	255	2.0	1.7
Apr 09 23:47	2460	RD	6.0	121	31	256	1.0	–0.7
Apr 27 18:14	Xi Leo	DD	5.0	105	41	90	2.6	–0.5
Apr 27 19:41	Xi Leo	RB	5.0	105	43	318	1.7	–1.5
May 03 19:41	Kap Vir	DD	4.2	171	32	78	1.2	–0.8
May 03 20:41	Kap Vir	RB	4.2	172	44	328	0.7	–2.9
May 04 04:26	2064	DD	6.3	174	22	158	1.0	–2.2
May 05 21:57	2280	RD	6.5	163	43	231	2.2	0.9
May 09 23:09	55 Sgr	RD	5.1	113	15	202	1.1	2.3
May 11 05:16	3045	DB	5.9	98	67	19	1.2	3.7
May 11 06:09	3045	RD	5.9	98	67	301	3.1	–1.8
May 12 04:28	47 Cap	DB	6.0	85	51	66	1.7	0.2
May 12 05:49	47 Cap	RD	6.0	85	62	251	2.0	0.5
May 14 03:29	14 Psc	RD	5.9	59	16	179	0.1	5.0
May 31 21:28	2110	DD	6.3	154	65	140	1.6	–2.5
Jun 01 18:30	Gam Lib	DD	3.9	164	26	79	0.8	–0.8
Jun 01 19:29	Gam Lib	RB	3.9	164	38	317	0.5	–2.5
Jun 02 00:16	Eta Lib	DD	5.4	166	66	132	2.1	–1.7
Jun 04 22:19	2674	RD	6.2	156	42	285	1.1	–1.5
Jun 07 04:48	3002	RD	6.1	128	64	274	2.2	0.3
Jun 12 04:59	Uranus	DB	5.9	61	30	67	1.1	–0.2
Jun 12 06:13	Uranus	RD	5.9	61	41	242	1.6	0.3
Jun 22 20:01	48 Leo	DD	5.1	67	26	74	1.7	2.1
Jun 22 20:57	48 Leo	RB	5.1	67	16	334	0.2	–1.4
Jun 30 20:48	2460	DD	6.0	159	60	58	2.4	0.9
Jul 01 03:40	2495	DD	6.0	161	24	76	0.4	1.5
Jul 07 23:51	3520	RD	5.8	106	11	219	0.3	0.6
Jul 24 22:35	Kap Vir	DD	4.2	93	25	116	0.8	0.3
Jul 24 23:41	Kap Vir	RB	4.2	94	12	270	0.2	1.2
Jul 30 21:11	54 Sgr	DD	5.3	166	57	76	1.8	–0.1
Jul 30 22:22	55 Sgr	DD	5.1	167	68	53	2.0	1.4
Jul 30 22:32	54 Sgr	RB	5.3	167	69	267	2.2	–0.1
Jul 30 23:38	55 Sgr	RB	5.1	167	70	283	2.4	–0.5
Aug 01 21:41	3169	RD	6.1	165	38	199	1.1	2.7
Aug 02 04:36	3199	RD	6.5	162	37	314	2.4	–1.6
Aug 06 01:53	226	RD	6.5	108	31	275	1.6	–1.2
Aug 07 05:27	31 Ara	DB	5.6	93	42	118	3.0	–1.5
Aug 07 06:22	31 Ara	RD	5.6	93	41	200	1.3	2.8
Aug 09 03:18	Del 1 Tau	RD	3.8	69	12	298	1.4	–2.3
Aug 09 04:00	64 Tau	RD	4.8	68	19	258	1.1	–0.7
Aug 22 22:59	Gam Lib	DD	3.9	86	16	148	0.8	–1.3
Aug 22 23:36	Gam Lib	RB	3.9	86	9	222	–0.5	3.1
Aug 24 00:43	Phi Oph	DD	4.3	98	7	114	0.1	0.4
Aug 24 21:57	2495	DD	6.0	109	50	117	1.8	–0.2
Aug 27 18:39	2936	DD	6.5	147	42	41	1.5	1.2
Aug 29 23:49	The Aqr	DD	4.2	176	63	114	2.8	–1.4
Aug 30 00:41	The Aqr	RD	4.2	176	60	196	0.7	3.3
Sep 02 02:41	88 Psc	RD	6.0	139	48	307	3.7	–2.5
Sep 06 04:06	104 Tau	DB	4.9	85	28	36	1.1	1.2
Sep 06 05:07	104 Tau	RD	4.9	85	34	305	2.6	–1.8
Sep 23 19:14	55 Sgr	RB	5.1	115	70	260	2.2	0.3
Sep 26 01:15	3199	DD	6.5	144	34	25	0.3	2.8
Sep 29 22:50	247	RD	6.3	159	35	306	2.7	–3.3
Sep 30 00:43	Omi Psc	DB	4.3	158	45	43	1.5	1.2
Sep 30 01:56	Omi Psc	RD	4.3	158	45	268	2.2	0.3
Oct 09 04:32	Venus	DB	–4.7	45	13	121	0.9	–2.2
Oct 09 05:53	Venus	RD	–4.7	45	27	273	1.7	–1.3
Oct 21 18:44	Bet 1 Cap	DD	3.1	96	69	109	2.7	–0.9
Oct 21 19:45	Bet 2 Cap	RB	6.1	97	63	219	1.4	2.6
Oct 21 19:52	Bet 1 Cap	RB	3.1	97	62	215	1.2	2.9
Oct 23 20:37	The Aqr	DD	4.2	124	62	110	2.8	–1.0
Oct 23 21:33	The Aqr	RB	4.2	124	57	199	0.8	3.2
Oct 26 23:57	88 Psc	DD	6.0	167	46	33	1.3	2.1
Oct 29 23:10	620	RD	6.1	151	26	315	2.7	–3.5
Oct 30 04:13	Del 1 Tau	DB	3.8	149	28	82	1.7	1.0
Nov 01 00:32	71 Ori	DB	5.2	124	20	27	0.4	1.7
Nov 01 01:13	71 Ori	RD	5.2	124	25	324	2.5	–3.4
Nov 22 00:02	3520	DD	5.8	120	23	109	1.0	0.6
Nov 23 22:36	Omi Psc	DD	4.3	147	44	51	1.7	1.5
Nov 23 23:50	Omi Psc	RB	4.3	147	36	265	1.7	0.9
Nov 29 23:01	74 Gem	RD	5.0	133	11	301	1.1	–2.0
Dec 01 00:52	1284	RD	6.3	120	22	273	1.4	–1.2
Dec 05 01:49	Bet Vir	DB	3.6	75	9	103	0.3	–1.5
Dec 05 02:57	Bet Vir	RD	3.6	75	22	298	0.8	–2.0
Dec 24 00:32	Del 1 Tau	DD	3.8	155	29	87	1.7	0.9
Dec 24 01:15	64 Tau	DD	4.8	155	23	115	1.3	0.2
Dec 24 01:47	Del 1 Tau	RB	3.8	156	18	263	1.2	1.2
Dec 28 00:22	1238	RD	6.0	153	34	264	2.1	–0.4

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 02:10	82 Vir	RD	5.0	86	19	327	0.1	–2.4
Jan 14 05:28	1973	DB	6.2	85	67	154	1.2	–3.4
Jan 29 21:31	Del 1 Tau	MB	3.8	118	57	172	9.9	9.9
Jan 29 22:46	68 Tau	DD	4.3	118	47	81	2.6	0.7
Jan 30 00:12	68 Tau	RB	4.3	119	29	276	1.4	0.2
Feb 05 05:11	Omi Leo	DB	3.5	171	31	131	0.8	–1.3
Feb 05 06:20	Omi Leo	RD	3.5	170	15	277	0.6	0.2
Feb 13 02:27	2280	RD	6.5	83	20	310	0.1	–1.7
Feb 13 03:24	49 Lib	DB	5.5	82	33	141	0.4	–2.3
Feb 13 04:30	49 Lib	RD	5.5	82	49	257	2.3	0.3
Feb 17 05:35	61 Sgr	DB	5.0	30	12	41	0.8	1.5
Feb 17 06:18	61 Sgr	RD	5.0	29	22	311	0.2	–2.2
Feb 25 21:22	610	DD	6.1	87	39	48	2.4	2.4
Mar 11 00:44	2110	RD	6.3	126	37	287	1.2	–1.1
Mar 12 02:56	Eta Lib	DB	5.4	113	56	93	2.3	–0.5
Mar 12 04:27	Eta Lib	RD	5.4	113	78	307	2.5	–2.2
Mar 13 06:09	24 Oph	DB	4.9	101	85	122	3.0	–1.9
Mar 15 03:07	2674	RD	6.2	77	22	303	0.3	–1.6
Apr 01 01:16	1458	DD	5.9	137	39	98	1.8	0.1
Apr 05 21:28	82 Vir	RD	5.0	168	29	241	1.8	1.2
Apr 07 02:27	2088	RD	6.2	155	90	323	2.2	–3.0
Apr 25 20:04	1 Cnc	DD	5.8	83	54	155	1.3	–3.3
Apr 25 21:11	1 Cnc	RB	5.8	84	42	248	2.9	1.8
Apr 28 00:39	Omi Leo	DD	3.5	107	19	115	0.6	–0.5
May 04 02:33	2 Lib	DD	6.2	174	59	95	2.6	0.1
May 31 19:47	2110	DD	6.3	154	43	98	1.6	–0.8
Jun 01 22:46	Eta Lib	DD	5.4	166	73	66	3.8	1.5
Jun 02 00:00	Eta Lib	RB	5.4	166	86	331	2.2	–4.0
Jun 03 00:47	24 Oph	DD	4.9	176	85	98	3.1	–0.4
Jun 03 02:26	24 Oph	RD	4.9	176	65	275	2.7	0.0
Jun 04 22:12	2686	DB	5.1	155	28	153	–0.2	–3.9
Jun 04 22:49	2686	RD	5.1	155	37	216	2.4	3.0
Jun 06 05:21	54 Sgr	DB	5.3	140	64	36	1.4	3.0
Jun 06 06:28	54 Sgr	RB	5.3	140	48	287	2.2	–0.4
Jun 06 06:34	55 Sgr	DB	5.1	140	46	29	0.6	3.1
Jun 09 01:37	3285	RD	5.9	102	24	268	0.8	–0.4
Jun 09 05:15	3308	DB	6.2	101	75	77	2.8	0.5
Jun 12 05:17	88 Psc	DB	6.0	61	35	9	0.0	3.7
Jun 12 06:00	88 Psc	RD	6.0	60	45	298	3.0	–2.5
Jun 26 21:30	82 Vir	DD	5.0	112	71	129	2.5	–1.9
Jun 26 23:02	82 Vir	RB	5.0	113	48	278	2.1	0.0
Jun 28 02:03	2088	DD	6.2	125	17	95	0.6	0.3
Jul 02 01:44	2640	DD	6.1	172	70	139	3.7	–3.8
Jul 04 05:45	Bet 1 Cap	DB	3.1	157	41	73	1.2	1.0
Jul 04 06:52	Bet 1 Cap	RD	3.1	157	25	246	0.5	1.1
Jul 06 05:53	The Aqr	DB	4.2	130	64	96	2.8	0.0
Jul 06 23:36	3380	RD	5.9	119	12	214	0.4	1.7
Jul 18 19:36	Xi Leo	DD	5.0	26	12	57	1.1	2.5
Aug 01 20:58	3169	RD	6.1	165	19	289	0.5	–1.2
Aug 05 00:30	81	RD	6.4	122	27	235	0.8	0.9
Aug 06 02:29	238	RD	6.4	107	41	224	1.0	1.5
Aug 07 04:34	31 Ara	DB	5.6	93	53	12	0.3	3.9
Aug 07 05:28	31 Ara	RD	5.6	93	61	297	4.1	–2.2
Aug 22 22:32	Gam Lib	DD	3.9	86	29	42	0.6	3.4
Aug 22 23:15	Gam Lib	RB	3.9	86	19	328	1.3	–2.6
Aug 28 00:59	Bet 2 Cap	DD	6.1	150	58	56	1.6	1.7
Aug 28 01:07	Bet 1 Cap	DD	3.1	150	56	60	1.6	1.5
Aug 28 02:20	Bet 1 Cap	RB	3.1	150	38	258	1.2	0.8
Aug 29 23:17	The Aqr	DB	4.2	177	70	350	9.9	9.9
Aug 29 23:40	The Aqr	RB	4.2	177	76	319	6.2	–8.1
Aug 30 00:43	Rho Aqr	DD	5.4	177	85	92	3.1	–0.1
Aug 30 23:39	3416	RD	5.6	168	61	258	2.3	0.3
Sep 01 02:09	35	RD	6.2	153	75	237	2.2	1.4
Sep 01 21:56	80 Psc	RD	5.5	140	9	279	0.4	–0.8
Sep 11 05:39	Xi Leo	RD	5.0	26	6	200	9.9	9.9
Sep 24 02:09	61 Sgr	DD	5.0	118	10	67	0.0	1.0
Sep 28 04:11	3520	DD	5.8	174	31	79	1.1	0.8
Sep 30 23:23	38 Ara	DB	5.2	144	31	65	1.0	0.5
Oct 01 00:35	38 Ara	RD	5.2	144	47	248	1.7	0.6
Oct 09 04:10	Venus	RD	–4.7	45	4	349	1.0	–5.5
Oct 23 20:16	The Aqr	DD	4.2	124	79	341	9.9	9.9
Oct 23 20:28	The Aqr	RB	4.2	124	81	325	9.9	9.9
Oct 23 21:41	Rho Aqr	DD	5.4	124	79	94	3.2	–0.1
Oct 23 22:53	Rho Aqr	RB	5.4	125	62	209	1.1	2.9
Oct 24 00:06	3285	DD	5.9	125	45	58	1.3	1.6
Oct 24 20:26	3416	DD	5.6	138	67	65	2.2	0.9
Oct 24 21:51	3416	RB	5.6	138	81	237	2.3	1.5
Oct 25 23:35	35	DD	6.2	153	72	99	3.3	–0.4
Oct 30 04:02	Del 1 Tau	MD	3.8	149	54	352	9.9	9.9
Oct 30 04:08	64 Tau	DB	4.8	149	53	48	2.6	2.3
Oct 30 05:17	64 Tau	RD	4.8	148	41	301	1.8	–1.1
Nov 20 20:41	3362	DD	5.9	105	75	32	1.6	2.8
Nov 20 21:55	3362	RB	5.9	106	57	269	2.4	0.4
Nov 20 22:00	3367	DD	6.3	106	57	55	1.7	1.7
Nov 21 23:43	3520	DD	5.8	120	43	30	1.0	2.7
Nov 24 21:34	38 Ara	DD	5.2	160	54	100	2.8	–0.8
Nov 24 22:43	38 Ara	RB	5.2	161	64	210	1.6	2.6
Dec 06 13:37	Mars	DB	1.5	60	17	60	0.7	2.4
Dec 06 14:23	Mars	RD	1.5	60	5	335	0.3	–2.5
Dec 24 00:11	Del 1 Tau	DD	3.8	155	56	4	9.9	9.9
Dec 24 00:24	64 Tau	DD	4.8	155	54	54	2.6	1.9
Dec 24 00:32	Del 1 Tau	RB	3.8	155	53	338	2.9	–9.6
Dec 24 01:40	64 Tau	RB	4.8	156	41	293	1.9	–0.7
Dec 25 05:05	119 Tau	DD	4.3	170	11	87	0.6	0.5
Dec 27 22:32	1238	RD	6.0	153	23	349	2.9	–8.1
Jan 01 01:29	89 Leo	RD	5.8	106	25	281	1.1	–0.9

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 22:20	697	DD	6.5	149	29	135	2.3	–1.4
Jan 14 02:40	82 Vir	DB	5.0	86	31	141	0.5	–2.5
Jan 14 03:46	82 Vir	RD	5.0	86	42	266	1.6	–1.0
Jan 24 20:47	21 Psc	DD	5.8	54	10	90	0.4	1.3
Feb 01 00:50	71 Ori	DD	5.2	142	15	80	1.4	1.5
Feb 03 01:27	1198	DD	6.1	164	24	70	2.1	1.7
Feb 05 00:04	Xi Leo	RD	5.0	173	35	282	2.1	–0.7
Feb 11 01:22	Kap Vir	DB	4.2	107	32	61	1.5	–0.4
Feb 11 02:08	Kap Vir	RD	4.2	107	40	343	0.3	–3.5
Feb 25 21:46	610	DD	6.1	87	11	125	0.6	0.4
Mar 11 23:11	Gam Lib	DB	3.9	115	17	113	0.1	–1.8
Mar 12 00:14	Gam Lib	RD	3.9	115	29	279	0.6	–1.6
Mar 13 00:42	Phi Oph	DB	4.3	103	25	80	0.6	–1.1
Mar 13 01:44	Phi Oph	RD	4.3	103	37	305	0.6	–2.2
Mar 15 03:40	2674	DB	6.2	77	39	163	–0.3	–6.6
Mar 15 04:02	2674	RD	6.2	77	43	200	2.3	4.5
Apr 01 19:58	48 Leo	DD	5.1	146	32	46	2.8	1.4
Apr 01 20:30	48 Leo	RB	5.1	147	36	1	0.2	–4.6
Apr 07 03:25	2088	RD	6.2	155	53	208	9.9	9.9
Apr 09 23:47	2460	RD	6.0	121	29	228	1.2	0.2
Apr 27 18:16	Xi Leo	DD	5.0	105	34	107	2.0	–1.0
Apr 27 19:45	Xi Leo	RB	5.0	105	36	298	1.8	–0.6
May 03 19:48	Kap Vir	DD	4.2	171	30	97	0.8	–1.5
May 03 20:58	Kap Vir	RB	4.2	172	42	307	1.0	–2.1
May 11 04:56	3045	DB	5.9	98	58	48	1.6	1.3
May 11 06:10	3045	RD	5.9	98	60	274	2.1	0.0
May 12 04:05	46 Cap	DB	5.1	85	42	26	1.1	1.8
May 12 04:28	47 Cap	DB	6.0	85	46	91	1.6	–1.0
May 12 04:59	46 Cap	RD	5.1	85	50	295	2.0	–2.2
May 12 05:40	47 Cap	RD	6.0	85	54	229	1.5	1.1
May 13 05:51	3328	RD	6.4	71	46	230	1.3	0.7
May 31 21:53	2110	DD	6.3	154	59	175	0.3	–5.6
Jun 01 18:38	Gam Lib	DD	3.9	164	26	98	0.5	–1.5
Jun 01 19:44	Gam Lib	RB	3.9	164	38	296	0.8	–1.9
Jun 02 00:38	Eta Lib	DD	5.4	166	58	177	1.2	–9.3
Jun 02 19:38	Phi Oph	DB	4.3	174	29	54	1.1	–0.1
Jun 02 20:22	Phi Oph	RB	4.3	174	37	332	0.2	–3.3
Jun 04 22:26	2674	RD	6.2	156	40	260	1.1	–0.8
Jun 07 04:39	3002	RD	6.1	128	59	253	1.7	1.0
Jun 12 05:01	Uranus	DB	5.9	61	25	88	1.2	–1.1
Jun 12 06:07	Uranus	RD	5.9	61	33	223	1.0	0.7
Jun 22 19:48	48 Leo	DD	5.1	67	25	103	1.2	0.8
Jun 22 21:00	48 Leo	RB	5.1	67	14	305	0.5	0.2
Jun 30 20:44	2460	DD	6.0	159	54	87	1.6	–0.7
Jul 01 03:29	2495	DD	6.0	161	28	96	0.6	1.1
Jul 03 19:08	61 Sgr	RD	5.0	162	7	252	0.0	–0.8
Jul 04 00:18	2936	RD	6.5	159	58	281	1.8	–1.1
Jul 07 23:37	3520	RD	5.8	106	6	175	–0.1	5.7
Jul 24 22:35	Kap Vir	DD	4.2	93	26	144	0.8	–0.8
Jul 24 23:27	Kap Vir	RB	4.2	94	16	243	0.2	2.5
Jul 30 21:14	54 Sgr	DD	5.3	166	52	102	1.5	–1.3
Jul 30 22:14	55 Sgr	DD	5.1	167	60	79	1.8	–0.1
Jul 30 22:26	54 Sgr	RB	5.3	167	61	241	1.7	0.8
Jul 30 23:33	55 Sgr	RB	5.1	167	63	259	1.8	0.5
Aug 02 04:34	3199	RD	6.5	162	36	290	1.4	0.6
Aug 03 21:51	14 Psc	RD	5.9	137	10	319	0.5	–5.0
Aug 06 01:56	226	RD	6.5	108	26	253	1.1	–0.6
Aug 06 06:05	247	RD	6.3	106	36	201	1.0	2.4
Aug 09 03:29	Del 1 Tau	RD	3.8	69	9	276	0.9	–1.5
Aug 09 04:02	64 Tau	RD	4.8	68	13	239	0.7	–0.4
Aug 17 18:37	1676	RB	6.5	29	14	292	0.5	0.7
Aug 19 21:20	The Vir	DD	4.4	52	6	153	0.2	–1.0
Aug 22 23:10	Gam Lib	MD	3.9	86	16	186	9.9	9.9
Aug 24 00:41	Phi Oph	DD	4.3	98	10	138	0.4	–0.2
Aug 24 22:02	2495	DD	6.0	109	48	150	2.1	–2.7
Aug 24 22:38	2495	RB	6.0	110	42	207	0.3	4.7
Sep 02 02:45	88 Psc	RD	6.0	139	40	284	2.2	–0.5
Sep 06 04:01	104 Tau	DB	4.9	85	21	54	1.1	0.0
Sep 06 05:12	104 Tau	RD	4.9	85	27	287	2.0	–1.0
Sep 23 19:05	55 Sgr	RB	5.1	115	62	235	1.8	1.2
Sep 25 00:23	3045	DD	5.9	130	35	10	–0.2	3.9
Sep 25 22:54	47 Cap	DD	6.0	143	53	3	0.0	4.7
Sep 29 23:01	247	RD	6.3	159	29	278	1.6	–1.2
Sep 30 00:34	Omi Psc	DB	4.3	158	37	60	1.4	0.4
Sep 30 01:48	Omi Psc	RD	4.3	158	38	254	1.7	0.6
Oct 09 04:49	Venus	DB	–4.7	45	11	137	0.8	–2.6
Oct 09 05:59	Venus	RD	–4.7	45	22	257	1.5	–1.1
Oct 21 18:57	Bet 1 Cap	DD	3.1	97	62	148	3.8	–6.7
Oct 21 19:19	Bet 1 Cap	RB	3.1	97	61	179	–0.4	8.3
Oct 26 23:42	88 Psc	DD	6.0	167	40	48	1.4	1.3
Oct 29 23:24	620	RD	6.1	151	21	290	1.6	–1.6
Oct 30 04:04	Del 1 Tau	DB	3.8	149	24	98	1.5	0.7
Nov 01 01:27	71 Ori	RD	5.2	124	20	302	1.7	–1.8
Nov 21 23:58	3520	DD	5.8	120	23	131	1.3	–0.2
Nov 23 22:24	Omi Psc	DD	4.3	147	38	65	1.6	0.9
Nov 23 23:39	Omi Psc	RB	4.3	147	32	252	1.5	1.2
Nov 29 23:12	74 Gem	RD	5.0	133	7	284	0.9	–1.6
Dec 01 00:57	1284	RD	6.3	120	17	258	1.2	–1.0
Dec 05 02:02	Bet Vir	DB	3.6	75	8	117	0.3	–1.9
Dec 05 03:10	Bet Vir	RD	3.6	75	20	284	0.8	–1.7
Dec 20 23:45	214	DD	6.2	115	16	14	0.7	3.2
Dec 24 00:24	Del 1 Tau	DD	3.8	155	24	102	1.6	0.5
Dec 24 01:12	64 Tau	DD	4.8	155	19	136	1.0	–0.3
Dec 24 01:33	Del 1 Tau	RB	3.8	156	16	246	1.3	1.6
Dec 24 02:09	68 Tau	DD	4.3	156	11	19	1.8	4.2
Dec 28 00:20	1238	RD	6.0	153	26	247	1.8	–0.2

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 02:27	82 Vir	DB	5.0	86	28	132	0.5	–2.2
Jan 14 03:37	82 Vir	RD	5.0	86	41	275	1.5	–1.3
Jan 24 20:53	21 Psc	DD	5.8	54	12	80	0.4	1.4
Jan 29 23:48	68 Tau	DD	4.3	118	15	160	–0.2	–3.3
Jan 30 00:12	68 Tau	RB	4.3	118	11	198	2.3	5.6
Feb 01 00:55	71 Ori	DD	5.2	142	19	70	1.7	1.8
Feb 03 01:32	1198	DD	6.1	164	29	57	2.8	2.6
Feb 04 23:55	Xi Leo	RD	5.0	173	39	289	2.2	–1.1
Feb 11 01:19	Kap Vir	DB	4.2	107	31	46	2.1	1.2
Feb 11 01:48	Kap Vir	RD	4.2	107	37	359	–0.6	–5.0
Feb 25 21:47	610	DD	6.1	87	15	114	0.9	0.5
Mar 11 01:38	2110	RD	6.3	126	50	208	9.9	9.9
Mar 11 23:02	Gam Lib	DB	3.9	115	13	104	0.0	–1.5
Mar 12 00:04	Gam Lib	RD	3.9	115	25	288	0.4	–1.7
Mar 12 04:52	Eta Lib	DB	5.4	113	68	171	0.9	–6.6
Mar 12 05:28	Eta Lib	RD	5.4	113	66	217	3.1	5.8
Mar 13 00:36	Phi Oph	DB	4.3	103	22	70	0.7	–0.6
Mar 13 01:31	Phi Oph	RD	4.3	103	33	316	0.3	–2.6
Mar 15 03:19	2674	DB	6.2	77	34	138	0.3	–3.0
Mar 15 04:08	2674	RD	6.2	77	44	227	1.7	0.9
Apr 01 02:24	1458	DD	5.9	138	10	186	–1.1	–6.3
Apr 07 03:43	2088	RD	6.2	155	56	242	2.4	2.6
Apr 09 23:44	2460	RD	6.0	121	27	243	0.9	–0.3
Apr 10 05:40	2495	DB	6.0	119	65	85	2.1	0.7
Apr 27 19:36	Xi Leo	RB	5.0	105	41	306	1.9	–1.1
May 03 19:39	Kap Vir	DD	4.2	171	28	89	0.9	–1.2
May 03 20:45	Kap Vir	RB	4.2	172	40	316	0.8	–2.4
May 04 04:30	2064	DD	6.3	174	25	175	1.3	–5.7
May 11 05:02	3045	DB	5.9	98	62	27	1.4	2.8
May 11 06:01	3045	RD	5.9	98	65	295	2.7	–1.4
May 12 04:22	47 Cap	DB	6.0	85	46	72	1.5	–0.2
May 12 05:40	47 Cap	RD	6.0	85	57	246	1.8	0.5
May 13 05:49	3328	RD	6.4	71	49	247	1.6	0.1
May 31 21:30	2110	DD	6.3	154	61	155	1.1	–3.4
Jun 01 18:30	Gam Lib	DD	3.9	164	23	89	0.5	–1.2
Jun 01 19:33	Gam Lib	RB	3.9	164	35	305	0.6	–2.1
Jun 02 00:14	Eta Lib	DD	5.4	166	66	145	1.8	–2.6
Jun 02 19:38	Phi Oph	DB	4.3	174	27	36	1.9	1.8
Jun 02 20:03	Phi Oph	RB	4.3	174	32	351	–0.8	–5.1
Jun 04 22:18	2674	RD	6.2	156	38	273	1.0	–1.2
Jun 07 04:38	3002	RD	6.1	128	64	270	2.2	0.3
Jun 12 04:55	Uranus	DB	5.9	61	26	70	1.0	–0.4
Jun 12 06:06	Uranus	RD	5.9	61	36	240	1.3	0.2
Jun 12 06:06	88 Psc	DB	6.0	61	36	134	3.5	–5.1
Jun 22 19:50	48 Leo	DD	5.1	67	30	89	1.6	1.2
Jun 22 20:58	48 Leo	RB	5.1	67	18	320	0.5	–0.6
Jun 30 20:38	2460	DD	6.0	159	54	73	1.9	–0.2
Jul 01 03:35	2495	DD	6.0	161	29	80	0.6	1.5
Jul 07 23:48	3520	RD	5.8	106	6	209	0.1	1.0
Jul 24 22:31	Kap Vir	DD	4.2	93	29	124	1.0	–0.1
Jul 24 23:36	Kap Vir	RB	4.2	94	16	262	0.3	1.6
Jul 30 21:05	54 Sgr	DD	5.3	166	52	85	1.6	–0.7
Jul 30 22:12	55 Sgr	DD	5.1	167	62	62	1.9	0.7
Jul 30 22:24	54 Sgr	RB	5.3	167	64	259	2.0	0.0
Jul 30 23:29	55 Sgr	RB	5.1	167	68	277	2.2	–0.3
Aug 01 21:25	3169	RD	6.1	165	31	174	9.9	9.9
Aug 02 04:29	3199	RD	6.5	162	41	311	2.4	–1.2
Aug 06 06:13	247	RD	6.3	106	41	216	1.4	2.0
Aug 07 05:18	31 Ara	DB	5.6	93	39	120	2.9	–1.7
Aug 07 06:10	31 Ara	RD	5.6	93	40	197	1.0	2.7
Aug 09 03:19	Del 1 Tau	RD	3.8	69	8	295	1.1	–2.1
Aug 09 03:57	64 Tau	RD	4.8	68	14	255	0.9	–0.7
Aug 19 21:16	The Vir	DD	4.4	52	8	132	0.3	–0.2
Aug 22 23:00	Gam Lib	DD	3.9	86	20	158	1.1	–2.4
Aug 22 23:29	Gam Lib	RB	3.9	86	14	213	–0.5	4.3
Aug 24 00:41	Phi Oph	RB	4.3	98	11	118	0.3	0.4
Aug 24 21:51	2495	DD	6.0	109	54	124	2.0	–0.7
Aug 24 22:54	2495	RB	6.0	110	42	232	0.8	2.6
Aug 29 23:42	The Aqr	DD	4.2	176	59	118	2.8	–1.9
Aug 30 00:29	The Aqr	RD	4.2	176	60	193	0.7	3.4
Sep 02 02:33	88 Psc	RD	6.0	139	45	305	3.3	–2.4
Sep 06 04:00	104 Tau	DB	4.9	85	23	38	0.9	0.8
Sep 06 05:01	104 Tau	RD	4.9	85	30	301	2.4	–1.7
Sep 23 19:05	55 Sgr	RB	5.1	115	66	253	2.0	0.4
Sep 29 22:48	247	RD	6.3	159	30	301	2.1	–2.7
Sep 30 00:34	Omi Psc	DB	4.3	158	41	45	1.3	1.0
Sep 30 01:46	Omi Psc	RD	4.3	158	43	267	2.1	0.2
Oct 09 04:35	Venus	DB	–4.7	45	9	126	0.7	–2.3
Oct 09 05:50	Venus	RD	–4.7	45	22	266	1.4	–1.3
Oct 21 19:39	Bet 1 Cap	RB	3.1	97	64	211	1.3	3.0
Oct 23 20:29	The Aqr	DD	4.2	124	60	114	2.8	–1.4
Oct 23 21:21	The Aqr	RB	4.2	124	58	197	0.8	3.3
Oct 26 23:46	88 Psc	DD	6.0	167	45	34	1.3	1.8
Oct 29 23:09	620	RD	6.1	151	21	311	2.2	–3.0
Oct 30 04:03	Del 1 Tau	DB	3.8	149	29	88	1.8	0.8
Nov 01 01:11	71 Ori	RD	5.2	124	21	319	2.1	–2.9
Nov 21 23:56	3520	DD	5.8	120	27	113	1.3	0.5
Nov 23 22:26	Omi Psc	DD	4.3	147	43	52	1.6	1.2
Nov 23 23:40	Omi Psc	RB	4.3	147	37	262	1.8	0.9
Nov 29 23:02	74 Gem	RD	5.0	133	7	298	0.9	–1.9
Dec 01 00:49	1284	RD	6.3	120	18	268	1.2	–1.1
Dec 05 02:59	Bet Vir	RD	3.6	75	19	292	0.7	–1.8
Dec 24 00:23	Del 1 Tau	DD	3.8	155	29	93	1.8	0.6
Dec 24 01:09	64 Tau	DD	4.8	155	24	123	1.4	–0.1
Dec 24 01:38	Del 1 Tau	RB	3.8	156	20	255	1.4	1.4
Dec 28 00:15	1238	RD	6.0	153	29	257	1.9	–0.5

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 01:54	577	DD	6.0	139	9	80	0.8	1.3
Jan 03 01:08	718	DD	6.0	150	25	99	1.5	0.6
Jan 07 02:29	1246	RD	6.4	162	41	5	–1.4	–7.5
Jan 14 01:03	82 Vir	RD	5.0	86	12	260	0.3	–0.8
Jan 29 20:52	68 Tau	DD	4.3	118	39	149	3.0	–3.8
Jan 29 21:30	68 Tau	RB	4.3	118	37	197	2.4	5.0
Jan 31 21:56	71 Ori	DD	5.2	142	39	78	2.7	0.5
Jan 31 23:25	71 Ori	RB	5.2	142	34	295	2.0	–0.2
Feb 02 22:16	1198	DD	6.1	164	39	75	2.6	0.1
Feb 04 20:56	Xi Leo	RD	5.0	173	19	290	1.1	–1.7
Feb 10 23:34	Kap Vir	RD	4.2	107	11	336	–0.3	–2.8
Feb 13 01:06	2280	RD	6.5	83	13	230	0.7	0.4
Feb 17 04:53	61 Sgr	RD	5.0	29	13	224	0.5	0.6
Feb 25 22:15	620	DD	6.1	88	13	163	–0.8	–4.8
Feb 26 22:07	104 Tau	DD	4.9	100	23	108	1.3	0.4
Mar 12 23:18	Phi Oph	RD	4.3	103	7	302	–0.3	–1.6
Mar 15 01:36	2674	RD	6.2	77	13	212	1.0	1.6
Mar 17 05:01	3002	DB	6.1	49	30	96	0.8	–1.2
Mar 28 23:22	1141	DD	5.5	104	15	79	1.2	1.5
Apr 07 00:17	2088	RD	6.2	155	60	216	6.6	8.0
Apr 10 02:34	2495	DB	6.0	119	61	73	2.3	0.1
Apr 10 03:57	2495	RD	6.0	119	74	300	2.3	–1.8
Apr 13 02:49	2936	RD	6.5	81	30	218	1.2	1.2
May 03 05:02	82 Vir	DD	5.0	164	8	121	0.2	0.0
May 04 01:34	2064	DD	6.3	174	60	145	1.8	–2.3
May 07 05:45	2460	RD	6.0	148	43	315	1.9	–1.3
May 10 04:06	61 Sgr	DB	5.0	110	69	91	2.4	–0.4
May 10 05:32	61 Sgr	RD	5.0	110	73	240	2.1	1.5
May 12 02:50	47 Cap	RD	6.0	85	31	282	1.0	–1.6
May 13 03:07	3328	RD	6.4	71	21	286	0.7	–1.7
May 31 02:11	96 Vir	DD	6.5	145	27	77	0.9	1.7
Jun 01 21:14	Eta Lib	DD	5.4	166	57	158	0.6	–4.0

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 01 22:09	Eta Lib	RB	5.4	166	67	238	3.1	1.5
Jun 02 05:07	2280	DD	6.5	169	14	109	0.3	0.5
Jun 06 02:49	54 Sgr	DB	5.3	140	74	89	2.4	0.0
Jun 06 04:01	55 Sgr	DB	5.1	140	70	76	2.1	1.0
Jun 06 04:13	54 Sgr	RD	5.3	140	68	242	1.9	1.6
Jun 06 05:23	55 Sgr	RD	5.1	139	55	251	1.5	1.5
Jun 07 01:15	3002	RD	6.1	128	50	325	1.8	–6.3
Jun 12 03:28	Uranus	RD	5.9	61	12	293	0.8	–2.2
Jun 12 04:22	88 Psc	RD	6.0	60	23	243	0.8	–0.1
Jun 22 18:22	48 Leo	RB	5.1	67	46	303	1.8	–0.7
Jul 04 03:38	Bet 1 Cap	DB	3.1	157	60	116	2.6	–0.7
Jul 04 04:26	Bet 2 Cap	RD	6.1	157	51	209	0.6	3.0
Jul 04 04:32	Bet 1 Cap	RD	3.1	157	50	205	0.5	3.3
Jul 18 18:45	Xi Leo	RB	5.0	27	11	254	0.9	1.9
Jul 21 19:27	1716	DD	6.3	60	35	106	1.4	0.4
Jul 24 19:44	Kap Vir	DD	4.2	93	62	114	2.3	–0.6
Jul 24 21:13	Kap Vir	RB	4.2	94	45	286	1.7	0.3
Jul 26 22:33	2280	DD	6.5	117	52	163	2.2	–5.0
Jul 30 18:30	54 Sgr	DD	5.3	166	22	82	0.5	–0.7
Jul 30 19:29	55 Sgr	DD	5.1	167	34	48	1.2	0.7
Jul 30 20:25	55 Sgr	RB	5.1	167	45	303	1.2	–2.5
Jul 31 04:08	61 Sgr	DD	5.0	170	28	87	0.7	1.1
Aug 06 03:24	247	RD	6.3	106	43	270	2.2	–0.6
Aug 06 05:13	Omi Psc	DB	4.3	105	49	74	2.2	0.6
Aug 07 02:22	31 Ara	DB	5.6	93	23	59	0.8	0.1
Aug 07 03:34	31 Ara	RD	5.6	93	34	255	1.6	–0.2
Aug 09 05:49	684	DB	6.2	67	33	26	0.9	2.0
Aug 19 18:55	The Vir	DD	4.4	52	37	114	1.4	0.0
Aug 19 20:10	The Vir	RB	4.4	53	21	285	0.7	0.6
Aug 22 20:15	Gam Lib	DD	3.9	86	53	116	2.0	–0.4
Aug 22 21:33	Gam Lib	RB	3.9	86	37	261	1.1	1.4
Aug 23 22:30	Phi Oph	DD	4.3	98	36	76	1.0	1.6

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 23 23:37	Phi Oph	RB	4.3	99	22	286	0.6	0.5
Aug 24 20:13	2495	RB	6.0	110	73	269	2.5	0.4
Aug 26 01:39	2674	DD	6.2	124	20	135	1.0	–0.8
Aug 27 22:40	Bet 2 Cap	DD	6.1	150	72	102	2.5	–0.4
Aug 27 22:50	Bet 1 Cap	DD	3.1	150	71	105	2.6	–0.5
Aug 27 23:58	Bet 1 Cap	RB	3.1	150	61	218	1.2	2.6
Aug 29 20:43	The Aqr	DD	4.2	176	37	70	1.2	–0.2
Aug 29 21:55	The Aqr	RB	4.2	177	52	250	1.7	0.1
Aug 30 21:28	3416	RD	5.6	168	33	197	0.7	2.4
Aug 31 23:41	35	RD	6.2	153	43	192	0.5	2.9
Sep 24 00:16	61 Sgr	DD	5.0	118	31	108	1.1	0.4
Sep 24 01:07	61 Sgr	RB	5.0	118	20	219	–0.1	2.3
Sep 30 22:33	38 Ara	RD	5.2	144	19	200	0.0	1.8
Oct 21 23:46	3002	DD	6.1	99	21	64	0.3	1.6
Oct 23 21:47	3285	DD	5.9	125	60	92	2.3	0.4
Oct 24 19:16	3416	RB	5.6	138	49	186	0.5	3.9
Oct 25 02:50	11 Psc	DD	6.4	141	11	101	0.4	0.7
Oct 30 01:07	Del 1 Tau	DB	3.8	149	38	63	1.9	0.5
Oct 30 01:45	64 Tau	DB	4.8	149	40	97	2.4	–0.4
Oct 30 02:28	Del 1 Tau	RD	3.8	148	40	273	2.4	0.0
Oct 30 03:07	64 Tau	RD	4.8	148	39	242	2.2	1.2
Nov 20 19:32	3362	RB	5.9	106	63	236	1.9	1.4
Nov 21 21:11	3520	DD	5.8	120	55	65	1.9	1.3
Nov 21 22:30	3520	RB	5.8	120	44	241	1.5	1.6
Dec 06 11:44	Mars	DB	1.5	60	33	143	1.1	–1.4
Dec 06 12:50	Mars	RD	1.5	60	19	258	0.8	1.8
Dec 23 21:24	Del 1 Tau	DD	3.8	155	38	65	1.9	0.4
Dec 23 22:05	64 Tau	DD	4.8	155	40	101	2.5	–0.6
Dec 23 22:47	Del 1 Tau	RB	3.8	156	41	268	2.4	0.1
Dec 23 23:24	64 Tau	RB	4.8	156	39	236	2.2	1.4
Dec 27 21:31	1238	RD	6.0	153	8	283	0.7	–1.4
Dec 30 04:23	31 Leo	DB	4.4	127	48	83	3.0	0.6

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 02:23	82 Vir	DB	5.0	86	33	117	0.9	–1.9
Jan 14 03:40	82 Vir	RD	5.0	86	48	292	1.6	–1.7
Jan 24 21:00	21 Psc	DD	5.8	54	6	73	0.2	1.4
Jan 29 23:45	68 Tau	DD	4.3	118	13	133	0.5	–0.4
Feb 01 01:15	71 Ori	DD	5.2	142	14	46	2.0	3.2
Feb 04 22:33	Xi Leo	DB	5.0	173	37	100	2.1	–1.1
Feb 05 00:04	Xi Leo	RD	5.0	173	45	304	2.1	–1.4
Feb 25 21:55	610	DD	6.1	87	11	99	0.8	0.8
Mar 11 22:58	Gam Lib	DB	3.9	115	17	90	0.3	–1.1
Mar 12 00:00	Gam Lib	RD	3.9	115	30	304	0.4	–2.0
Mar 12 04:46	Eta Lib	DB	5.4	113	71	142	2.0	–2.7
Mar 13 00:42	Phi Oph	DB	4.3	103	29	47	1.5	0.9
Mar 13 01:19	Phi Oph	RD	4.3	103	36	341	–0.2	–4.1
Mar 15 03:12	2674	DB	6.2	77	38	117	0.8	–2.0
Apr 01 02:12	1458	DD	5.9	137	8	152	0.0	–1.3
Apr 07 02:44	2088	DB	6.2	156	63	133	2.0	–1.6
Apr 09 23:48	2460	RD	6.0	121	33	262	1.0	–0.8
Apr 27 18:19	Xi Leo	DD	5.0	105	44	84	2.8	–0.2
Apr 27 19:42	Xi Leo	RB	5.0	105	44	324	1.6	–1.8
May 03 19:43	Kap Vir	DD	4.2	171	34	71	1.5	–0.5
May 03 20:38	Kap Vir	RB	4.2	172	45	335	0.6	–3.2
May 09 23:14	55 Sgr	RD	5.1	113	18	214	0.9	1.2
May 11 05:24	3045	DB	5.9	98	69	15	1.1	4.3
May 12 04:32	47 Cap	DB	6.0	85	54	63	1.8	0.5
May 14 03:34	14 Psc	RD	5.9	59	19	189	0.3	3.0
May 22 17:49	1141	DD	5.5	51	29	189	9.9	9.9
May 22 18:02	1141	RB	5.5	51	28	205	9.9	9.9
Jun 01 18:31	Gam Lib	DD	3.9	164	28	72	1.0	–0.6
Jun 01 19:27	Gam Lib	RB	3.9	164	40	324	0.5	–2.8
Jun 02 00:19	Eta Lib	DD	5.4	166	65	126	2.1	–1.3
Jun 02 01:36	Eta Lib	RB	5.4	166	51	254	1.7	1.7
Jun 06 20:52	Bet 1 Cap	MD	3.1	131	3	174	9.9	9.9

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 07 03:37	3002	DB	6.1	128	70	45	1.8	2.0
Jun 07 04:53	3002	RD	6.1	128	63	275	2.3	0.3
Jun 12 05:01	Uranus	DB	5.9	61	33	65	1.2	0.0
Jun 12 06:17	Uranus	RD	5.9	61	44	243	1.7	0.4
Jun 22 20:08	48 Leo	DD	5.1	67	24	65	1.8	2.8
Jun 22 20:55	48 Leo	RB	5.1	67	15	343	0.0	–2.1
Jun 30 20:55	2460	DD	6.0	159	63	50	2.7	1.8
Jun 30 21:52	2460	RB	6.0	159	72	327	1.8	–3.7
Jul 01 03:43	2495	DD	6.0	161	22	74	0.3	1.5
Jul 03 18:59	61 Sgr	RD	5.0	162	6	281	–0.1	–1.2
Jul 07 23:52	3520	RD	5.8	106	13	224	0.3	0.5
Jul 24 22:37	Kap Vir	DD	4.2	93	23	111	0.7	0.4
Jul 24 23:43	Kap Vir	RB	4.2	94	9	273	0.2	1.0
Jul 30 21:15	54 Sgr	DD	5.3	166	60	71	1.9	0.2
Jul 30 22:29	55 Sgr	DD	5.1	167	70	49	2.0	1.7
Jul 30 22:36	54 Sgr	RB	5.3	167	71	270	2.3	–0.2
Jul 30 23:42	55 Sgr	RB	5.1	167	71	286	2.5	–0.6
Aug 01 21:47	3169	RD	6.1	165	41	206	1.2	2.1
Aug 07 05:31	31 Ara	DB	5.6	93	44	117	3.1	–1.3
Aug 09 02:32	Del 1 Tau	DB	3.8	69	6	29	–0.2	1.1
Aug 09 02:52	64 Tau	DB	4.8	69	10	70	0.5	–0.5
Aug 09 03:18	Del 1 Tau	RD	3.8	69	14	301	1.5	–2.4
Aug 09 04:01	64 Tau	RD	4.8	68	21	259	1.2	–0.6
Aug 22 22:59	Gam Lib	DD	3.9	86	14	144	0.7	–1.0
Aug 22 23:39	Gam Lib	RB	3.9	86	6	226	–0.5	2.7
Aug 24 22:01	2495	DD	6.0	109	48	114	1.7	0.0
Aug 24 23:07	2495	RB	6.0	110	34	240	0.6	2.1
Aug 29 23:54	The Aqr	DD	4.2	176	64	112	2.9	–1.2
Aug 30 00:47	The Aqr	RD	4.2	176	60	197	0.8	3.3
Sep 01 21:13	73 Psc	RD	6.0	141	8	256	0.3	–0.6
Sep 02 02:11	88 Psc	DB	6.0	139	49	359	–0.1	4.5
Sep 02 02:45	88 Psc	RD	6.0	139	49	309	3.8	–2.6

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 05 05:13	620	DB	6.1	98	39	42	1.9	1.6
Sep 06 04:10	104 Tau	DB	4.9	85	31	34	1.1	1.4
Sep 06 05:10	104 Tau	RD	4.9	85	36	307	2.8	–1.9
Sep 23 19:20	55 Sgr	RB	5.1	115	72	264	2.3	0.2
Sep 25 18:58	3169	RB	6.1	142	50	189	1.0	4.5
Sep 30 00:48	Omi Psc	DB	4.3	158	47	43	1.5	1.4
Sep 30 02:01	Omi Psc	RD	4.3	158	45	269	2.2	0.4
Oct 09 04:31	Venus	DB	–4.7	45	15	118	0.9	–2.1
Oct 09 05:54	Venus	RD	–4.7	45	30	276	1.8	–1.4
Oct 21 18:48	Bet 1 Cap	DD	3.1	96	70	106	2.7	–0.6
Oct 21 19:51	Bet 2 Cap	RB	6.1	97	62	221	1.3	2.6
Oct 21 19:58	Bet 1 Cap	RB	3.1	97	61	217	1.2	2.8
Oct 23 20:42	The Aqr	DD	4.2	124	63	109	2.9	–0.8
Oct 23 21:39	The Aqr	RB	4.2	124	56	200	0.8	3.2
Oct 27 00:02	88 Psc	DD	6.0	167	46	32	1.3	2.2
Oct 29 23:12	620	RD	6.1	151	28	318	3.0	–3.8
Oct 30 04:18	Del 1 Tau	DB	3.8	149	27	78	1.7	1.1
Nov 01 00:36	71 Ori	DB	5.2	124	22	24	0.4	2.2
Nov 01 01:13	71 Ori	RD	5.2	124	28	327	2.7	–3.7
Nov 22 00:05	3520	DD	5.8	120	21	107	0.9	0.6
Nov 23 22:42	Omi Psc	DD	4.3	147	44	50	1.7	1.6
Nov 23 23:55	Omi Psc	RB	4.3	147	35	266	1.7	0.9
Nov 29 23:00	74 Gem	RD	5.0	133	13	304	1.2	–2.1
Dec 05 01:48	Bet Vir	DB	3.6	75	10	99	0.4	–1.4
Dec 05 02:57	Bet Vir	RD	3.6	75	24	302	0.9	–2.0
Dec 24 00:37	Del 1 Tau	DD	3.8	155	28	83	1.7	1.0
Dec 24 01:18	64 Tau	DD	4.8	155	22	110	1.2	0.4
Dec 24 01:50	Del 1 Tau	RB	3.8	156	17	268	1.1	1.1
Dec 25 21:36	71 Ori	RD	5.2	176	28	268	1.7	–0.8
Dec 28 00:26	1238	RD	6.0	153	36	267	2.3	–0.5
Jan 01 02:09	89 Leo	DB	5.8	107	37	185	–0.2	–6.0
Jan 01 02:40	89 Leo	RD	5.8	106	42	226	3.9	2.7

GEOCENTRIC POSITION of the MOON

(0 hr UT, Epoch 2000.0)

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

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

MOON PHASE (UT)

Lunation	New Moon		First Quarter		Full Moon		Last Quarter	
1138					Jan 5	04:53	Jan 13	09:46
1139	Jan 20	13:14	Jan 27	04:48	Feb 3	23:09	Feb 12	03:50
1140	Feb 18	23:47	Feb 25	17:14	Mar 5	18:05	Mar 13	17:48
1141	Mar 20	09:36	Mar 27	07:43	Apr 4	12:06	Apr 12	03:44
1142	Apr 18	18:57	Apr 25	23:55	May 4	03:42	May 11	10:36
1143	May 18	04:13	May 25	17:19	Jun 2	16:19	Jun 9	15:42
1144	Jun 16	14:05	Jun 24	11:03	Jul 2	02:20	Jul 8	20:24
1145	Jul 16	01:24	Jul 24	04:04	Jul 31	10:43	Aug 7	02:03
1146	Aug 14	14:53	Aug 22	19:31	Aug 29	18:35	Sep 5	09:54
1147	Sep 13	06:41	Sep 21	08:59	Sep 28	02:51	Oct 4	21:06
1148	Oct 13	00:06	Oct 20	20:31	Oct 27	12:05	Nov 3	12:24
1149	Nov 11	17:47	Nov 19	06:27	Nov 25	22:44	Dec 3	07:40
1150	Dec 11	10:29	Dec 18	15:14	Dec 25	11:11		

PERIGEE AND APOGEE (UT)

Date	Time	Event	Distance (km)
Jan 9	18:18	Apogee	405,408
Jan 21	20:07	Perigee	359,645
Feb 6	06:26	Apogee	406,150
Feb 19	07:28	Perigee	356,995
Mar 5	07:33	Apogee	406,385
Mar 19	19:38	Perigee	357,584
Apr 1	13:01	Apogee	406,012
Apr 17	03:48	Perigee	361,023
Apr 29	03:55	Apogee	405,083
May 15	00:18	Perigee	366,024
May 26	22:12	Apogee	404,244
Jun 10	04:44	Perigee	369,711
Jun 23	17:00	Apogee	404,132
Jul 5	18:52	Perigee	367,093
Jul 21	11:02	Apogee	404,835
Aug 2	10:03	Perigee	362,139
Aug 18	02:33	Apogee	405,848
Aug 30	15:21	Perigee	358,290
Sep 14	11:27	Apogee	406,464
Sep 28	01:46	Perigee	356,877
Oct 11	13:18	Apogee	406,388
Oct 26	13:01	Perigee	358,463
Nov 7	21:50	Apogee	405,721
Nov 23	20:07	Perigee	362,817
Dec 5	14:56	Apogee	404,799
Dec 21	09:00	Perigee	368,417

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

MERCURY

GEOCENTRIC POSITION

(0 hr UT, Epoch 2000.0)

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

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

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

VENUS

GEOCENTRIC POSITION

(0 hr UT, Epoch 2000.0)

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

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

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

JUPITER

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

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

JUPITER'S MOONS

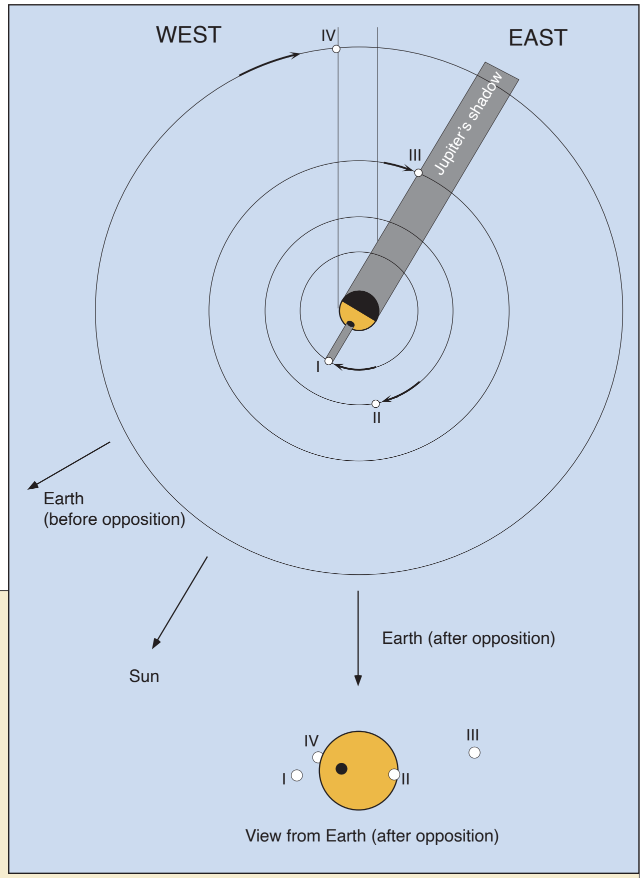
Jupiter, with its many moons orbiting the planet, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are currently 67 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after 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 *Jupiter Moon Events* on the following pages. All the moons orbit in roughly the same plane, which is very close to the plane of 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. Note, Jupiter's opposition date in 2015 is 7 February.
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. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7× 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 approximately every eight days; an example would be January 3.

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.



This diagram 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):

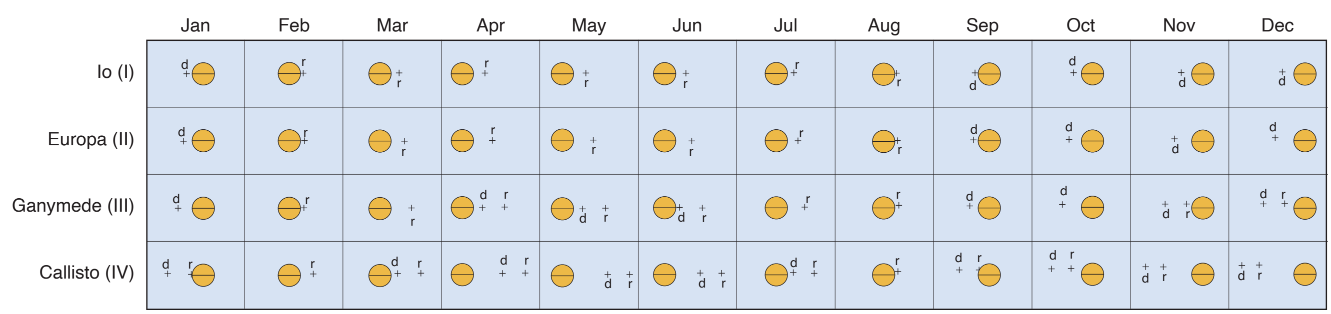
Satellite I	(Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.
Satellite II	(Europa) has just commenced a satellite transit (ingress).
Satellite III	(Ganymede) is about to be eclipsed (disappear).
Satellite IV	(Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

JUPITER'S MOON EVENTS Legend (following pages)

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 Western Australia. 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. Events near conjunction i.e., with Jupiter closer than 18° to the Sun, have been omitted.

ECLIPSE POSITIONS



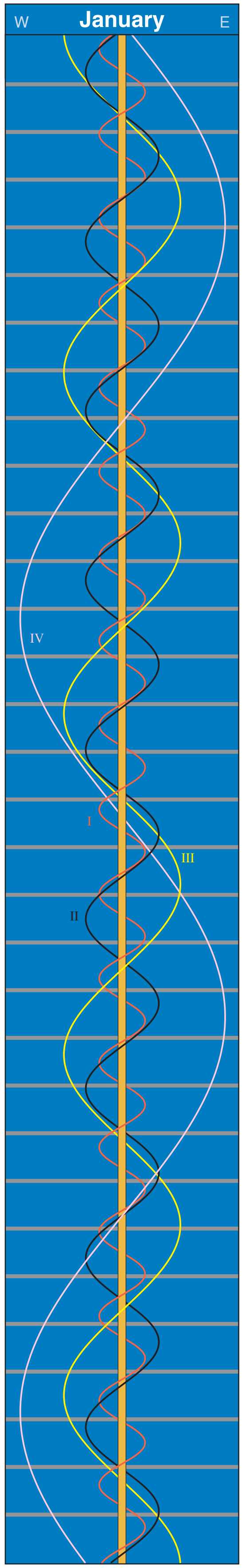
These diagrams show the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse is when the moon passes into (disappearance or d) or out of (reappearance or r) Jupiter's shadow; west to the left, east to the right.

JUPITER MOON EVENTS

The diagrams here show the patterns the four major moons of Jupiter make as they shuffle back and forth. 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 (14 hr UT), the bottom edge of the line is midnight WST (16 hr 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. 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.

January

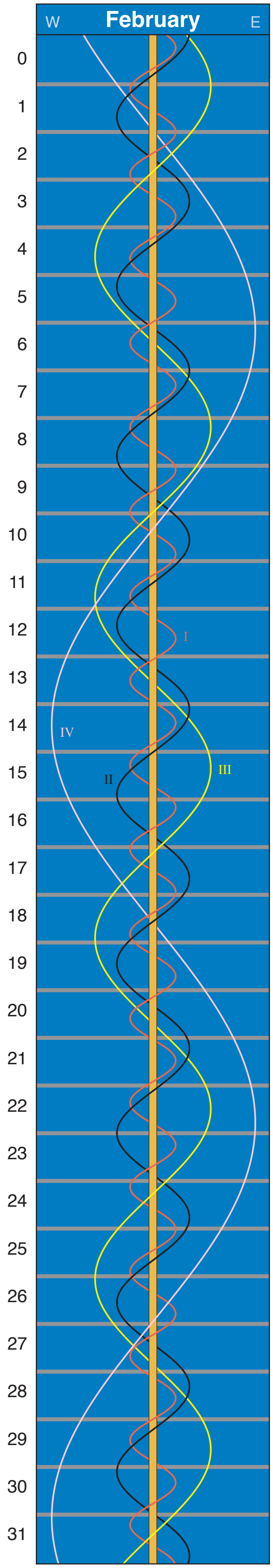
Day	EST	WST	Sat	Event	Vis
4	06:08	04:08	I	Ec D	W
5	03:17	01:17	II	Ec D	
	03:18	01:18	III	Sh I	
	03:23	01:23	I	Sh I	
	04:08	02:08	I	Tr I	
	05:40	03:40	I	Sh E	W
	06:21	04:21	III	Tr I	W
	06:25	04:25	I	Tr E	W
	06:56	04:56	III	Sh E	W
6	00:37	22:37(p)	I	Ec D	
	03:40	01:40	I	Oc R	
	21:51	19:51	I	Sh I	E
	21:56	19:56	II	Sh I	E
	22:34	20:34	I	Tr I	E
	23:24	21:24	II	Tr I	E
7	00:08	22:08(p)	I	Sh E	
	00:50	22:50(p)	II	Sh E	
	00:51	22:51(p)	I	Tr E	
	02:19	00:19	II	Tr E	
	22:06	20:06	I	Oc R	E
8	00:02	22:02(p)	IV	Sh E	
	01:49	23:49(p)	IV	Tr I	
	06:32	04:32	IV	Tr E	W
	23:44	21:44	III	Oc R	
12	05:16	03:16	I	Sh I	W
	05:51	03:51	II	Ec D	W
	05:53	03:53	I	Tr I	W
	07:16	05:16	III	Sh I	W
13	02:31	00:31	I	Ec D	
	05:25	03:25	I	Oc R	W
	23:44	21:44	I	Sh I	
14	00:19	22:19(p)	I	Tr I	
	00:32	22:32(p)	II	Sh I	
	01:43	23:43(p)	II	Tr I	
	02:02	00:02	I	Sh E	
	02:36	00:36	I	Tr E	
	03:27	01:27	II	Sh E	
	04:37	02:37	II	Tr E	
	20:59	18:59	I	Ec D	E
	23:51	21:51	I	Oc R	
15	21:02	19:02	I	Tr E	E
	21:16	19:16	III	Ec D	E
	23:03	21:03	II	Oc R	
16	02:48	00:48	IV	Ec D	
	03:05	01:05	III	Oc R	
19	07:10	05:10	I	Sh I	W
20	04:25	02:25	I	Ec D	
	07:10	05:10	I	Oc R	W
21	01:38	23:38(p)	I	Sh I	
	02:03	00:03	I	Tr I	
	03:09	01:09	II	Sh I	
	03:55	01:55	I	Sh E	
	03:59	01:59	II	Tr I	
	04:20	02:20	I	Tr E	
	06:03	04:03	II	Sh E	W
	06:54	04:54	II	Tr E	W
	22:53	20:53	I	Ec D	
22	01:36	23:36(p)	I	Oc R	
	20:06	18:06	I	Sh I	E
	20:29	18:29	I	Tr I	E
	21:41	19:41	II	Ec D	E
	22:24	20:24	I	Sh E	E
	22:46	20:46	I	Tr E	
23	01:14	23:14(p)	III	Ec D	
	01:17	23:17(p)	II	Oc R	
	06:23	04:23	III	Oc R	W
	20:02	18:02	I	Oc R	E
24	20:02	18:02	II	Tr E	E
	21:02	19:02	IV	Tr E	E
26	19:59	17:59	III	Tr E	E
27	06:19	04:19	I	Ec D	W
28	03:32	01:32	I	Sh I	
	03:46	01:46	I	Tr I	
	05:45	03:45	II	Sh I	W
	05:49	03:49	I	Sh E	W
	06:04	04:04	I	Tr E	W
	06:15	04:15	II	Tr I	W
29	00:48	22:48(p)	I	Ec D	
	03:20	01:20	I	Oc R	
	22:00	20:00	I	Sh I	
	22:12	20:12	I	Tr I	
30	00:14	22:14(p)	II	Ec D	
	00:17	22:17(p)	I	Sh E	
	00:29	22:29(p)	I	Tr E	
	03:30	01:30	II	Oc R	
	05:13	03:13	III	Ec D	
	21:46	19:46	I	Oc R	E
31	21:58	19:58	II	Sh E	
	22:17	20:17	II	Tr E	



February

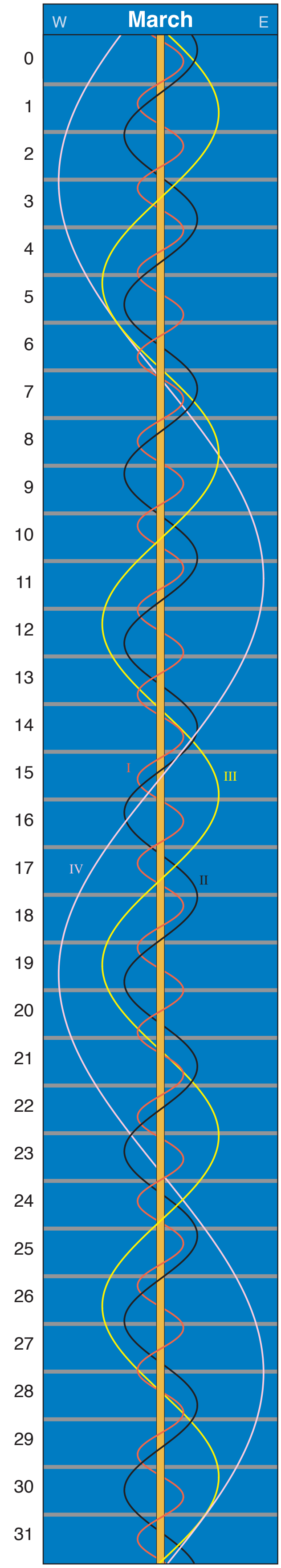
Day	EST	WST	Sat	Event	Vis
1	20:49	18:49	IV	Ec D	E
2	02:53	00:53	IV	Oc R	
	19:37	17:37	III	Tr I	E
	22:49	20:49	III	Sh E	
	23:15	21:15	III	Tr E	
4	05:25	03:25	I	Sh I	W
	05:30	03:30	I	Tr I	W
	07:43	05:43	I	Sh E	W
5	02:42	00:42	I	Ec D	
	05:04	03:04	I	Oc R	
	23:54	21:54	I	Sh I	
	23:56	21:56	I	Tr I	
6	02:11	00:11	I	Sh E	
	02:13	00:13	I	Tr E	
	02:48	00:48	II	Ec D	
	05:43	03:43	II	Oc R	W
	21:11	19:11	I	Ec D	E
	23:29	21:29	I	Oc R	
7	20:39	18:39	I	Tr E	E
	20:40	18:40	I	Sh E	E
	21:38	19:38	II	Tr I	
	21:40	19:40	II	Sh I	
8	00:32	22:32(p)	II	Tr E	
	00:35	22:35(p)	II	Sh E	
9	22:52	20:52	III	Tr I	
	23:09	21:09	III	Sh I	
10	02:30	00:30	III	Tr E	
	02:48	00:48	III	Sh E	
	06:29	04:29	IV	Tr I	W
	07:11	05:11	IV	Sh I	W
11	07:13	05:13	I	Tr I	W
	07:19	05:19	I	Sh I	W
12	04:29	02:29	I	Oc D	
	06:55	04:55	I	Ec R	W
13	01:39	23:39(p)	I	Tr I	
	01:48	23:48(p)	I	Sh I	
	03:56	01:56	I	Tr E	
	04:05	02:05	I	Sh E	
	05:04	03:04	II	Oc D	
	22:55	20:55	I	Oc D	
14	01:24	23:24(p)	I	Ec R	
	20:05	18:05	I	Tr I	E
	20:16	18:16	I	Sh I	E
	22:22	20:22	I	Tr E	
	22:34	20:34	I	Sh E	
	23:53	21:53	II	Tr I	
15	00:17	22:17(p)	II	Sh I	
	02:47	00:47	II	Tr E	
	03:12	01:12	II	Sh E	
	19:52	17:52	I	Ec R	E
16	21:31	19:31	II	Ec R	
17	02:08	00:08	III	Tr I	
	03:07	01:07	III	Sh I	
	05:45	03:45	III	Tr E	W
	06:46	04:46	III	Sh E	W
18	19:43	17:43	IV	Ec R	E
19	06:13	04:13	I	Oc D	W

JUPITER MOON EVENTS



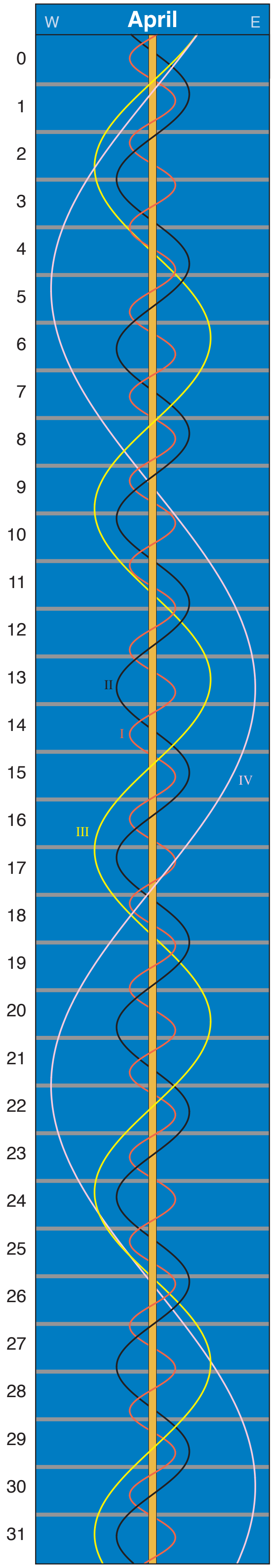
Day	EST	WST	Sat	Event	Vis
20	03:23	01:23	I	Tr I	
	03:42	01:42	I	Sh I	
	05:40	03:40	I	Tr E	W
	05:59	03:59	I	Sh E	W
	20:51	18:51	III	Ec R	E
21	00:39	22:39(p)	I	Oc D	
	03:18	01:18	I	Ec R	
	21:49	19:49	I	Tr I	
	22:10	20:10	I	Sh I	
22	00:06	22:06(p)	I	Tr E	
	00:28	22:28(p)	I	Sh E	
	02:09	00:09	II	Tr I	
	02:54	00:54	II	Sh I	
	05:03	03:03	II	Tr E	W
	05:48	03:48	II	Sh E	W
	19:05	17:05	I	Oc D	E
	21:47	19:47	I	Ec R	
23	18:56	16:56	I	Sh E	E
	20:25	18:25	II	Oc D	E
24	00:06	22:06(p)	II	Ec R	
	05:25	03:25	III	Tr I	W
25	19:06	17:06	II	Sh E	E
26	20:43	18:43	IV	Tr I	E
27	01:12	23:12(p)	IV	Sh I	
	01:28	23:28(p)	IV	Tr E	
	05:07	03:07	I	Tr I	W
	05:36	03:36	I	Sh I	W
	05:59	03:59	IV	Sh E	W
	19:08	17:08	III	Oc D	E
28	00:50	22:50(p)	III	Ec R	
	02:24	00:24	I	Oc D	
	05:13	03:13	I	Ec R	W
	23:33	21:33	I	Tr I	
March					
1	00:05	22:05(p)	I	Sh I	
	01:51	23:51(p)	I	Tr E	
	02:22	00:22	I	Sh E	
	04:26	02:26	II	Tr I	W
	05:31	03:31	II	Sh I	W
	20:50	18:50	I	Oc D	E
	23:42	21:42	I	Ec R	
2	20:17	18:17	I	Tr E	E
	20:51	18:51	I	Sh E	E
	22:40	20:40	II	Oc D	
3	02:41	00:41	II	Ec R	
4	18:49	16:49	II	Sh I	E
	20:29	18:29	II	Tr E	E
	21:43	19:43	II	Sh E	
6	22:29	20:29	III	Oc D	
7	02:36	00:36	IV	Oc D	
	04:10	02:10	I	Oc D	W
	04:49	02:49	III	Ec R	W
8	01:19	23:19(p)	I	Tr I	
	01:59	23:59(p)	I	Sh I	
	03:36	01:36	I	Tr E	W
	04:17	02:17	I	Sh E	W
	22:36	20:36	I	Oc D	

Day	EST	WST	Sat	Event	Vis
9	01:37	23:37(p)	I	Ec R	
	19:45	17:45	I	Tr I	E
	20:28	18:28	I	Sh I	E
	22:02	20:02	I	Tr E	
	22:45	20:45	I	Sh E	
10	00:57	22:57(p)	II	Oc D	
	05:15	03:15	II	Ec R	W
	18:44	16:44	III	Sh E	E
	20:05	18:05	I	Ec R	E
11	19:54	17:54	II	Tr I	E
	21:25	19:25	II	Sh I	
	22:48	20:48	II	Tr E	
12	00:20	22:20(p)	II	Sh E	
13	18:33	16:33	II	Ec R	E
14	01:54	23:54(p)	III	Oc D	
15	03:05	01:05	I	Tr I	W
	03:54	01:54	I	Sh I	W
	19:12	17:12	IV	Sh I	E
	23:59	21:59	IV	Sh E	
16	00:23	22:23(p)	I	Oc D	
	03:32	01:32	I	Ec R	W
	21:32	19:32	I	Tr I	
	22:22	20:22	I	Sh I	
	23:49	21:49	I	Tr E	
17	00:40	22:40(p)	I	Sh E	
	03:16	01:16	II	Oc D	W
	18:50	16:50	I	Oc D	E
	19:04	17:04	III	Sh I	E
	19:14	17:14	III	Tr E	E
	22:00	20:00	I	Ec R	
	22:43	20:43	III	Sh E	
18	18:16	16:16	I	Tr E	E
	19:08	17:08	I	Sh E	E
	22:15	20:15	II	Tr I	
19	00:02	22:02(p)	II	Sh I	
	01:09	23:09(p)	II	Tr E	
	02:56	00:56	II	Sh E	W
20	21:08	19:08	II	Ec R	
23	02:11	00:11	I	Oc D	
	22:36	20:36	IV	Oc R	
	23:19	21:19	I	Tr I	
24	00:17	22:17(p)	I	Sh I	
	01:37	23:37(p)	I	Tr E	
	02:34	00:34	I	Sh E	W
	02:56	00:56	IV	Ec D	W
	19:08	17:08	III	Tr I	E
	20:38	18:38	I	Oc D	
	22:45	20:45	III	Tr E	
	23:03	21:03	III	Sh I	
	23:55	21:55	I	Ec R	
25	02:42	00:42	III	Sh E	W
	18:46	16:46	I	Sh I	E
	20:04	18:04	I	Tr E	E
	21:03	19:03	I	Sh E	
26	00:38	22:38(p)	II	Tr I	
	02:39	00:39	II	Sh I	W
	03:32	01:32	II	Tr E	W
	18:24	16:24	I	Ec R	E

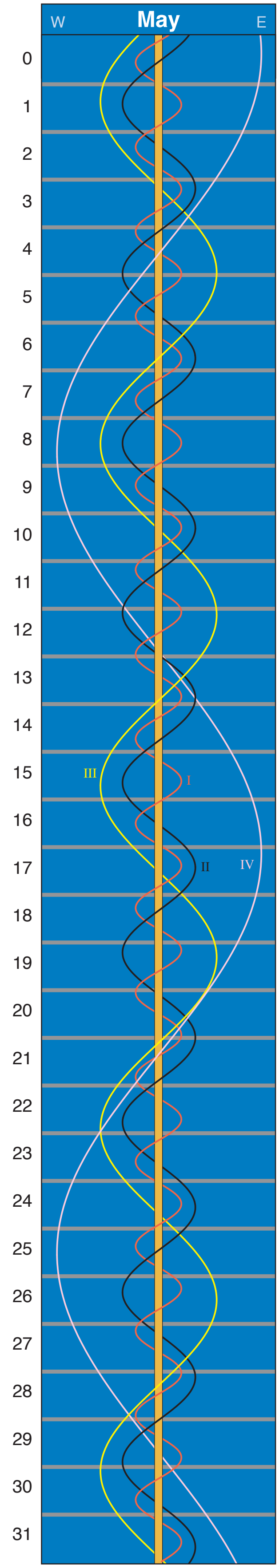


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
27	18:49	16:49	II	Oc D	E
	23:44	21:44	II	Ec R	
29	18:51	16:51	II	Sh E	E
30	04:00	02:00	I	Oc D	W
31	01:08	23:08(p)	I	Tr I	
	02:12	00:12	I	Sh I	W
	03:26	01:26	I	Tr E	W
	22:27	20:27	I	Oc D	
	22:43	20:43	III	Tr I	
April					
1	01:50	23:50(p)	I	Ec R	W
	02:21	00:21	III	Tr E	W
	03:02	01:02	III	Sh I	W
	03:08	01:08	IV	Tr I	W
	17:59	15:59	IV	Sh E	E
	19:36	17:36	I	Tr I	E
	20:40	18:40	I	Sh I	
	21:53	19:53	I	Tr E	
	22:58	20:58	I	Sh E	
2	03:04	01:04	II	Tr I	W
	20:19	18:19	I	Ec R	
3	21:14	19:14	II	Oc D	
4	02:19	00:19	II	Ec R	W
	20:48	18:48	III	Ec R	
5	18:34	16:34	II	Sh I	E
	19:11	17:11	II	Tr E	E
	21:28	19:28	II	Sh E	
7	02:58	00:58	I	Tr I	W
8	00:18	22:18(p)	I	Oc D	
	02:23	00:23	III	Tr I	W
	21:26	19:26	I	Tr I	
	22:35	20:35	I	Sh I	
	23:44	21:44	I	Tr E	
9	00:53	22:53(p)	I	Sh E	
	18:46	16:46	I	Oc D	E
	21:00	19:00	IV	Ec D	
	22:14	20:14	I	Ec R	
10	01:48	23:48(p)	IV	Ec R	W
	18:11	16:11	I	Tr E	E
	19:22	17:22	I	Sh E	E
	23:41	21:41	II	Oc D	
11	19:58	17:58	III	Oc R	E
	21:07	19:07	III	Ec D	
12	00:47	22:47(p)	III	Ec R	
	18:46	16:46	II	Tr I	E
	21:11	19:11	II	Sh I	
	21:40	19:40	II	Tr E	
13	00:04	22:04(p)	II	Sh E	
14	18:13	16:13	II	Ec R	E
15	02:10	00:10	I	Oc D	W
	23:17	21:17	I	Tr I	
16	00:30	22:30(p)	I	Sh I	
	01:35	23:35(p)	I	Tr E	W
	02:48	00:48	I	Sh E	W
	20:38	18:38	I	Oc D	

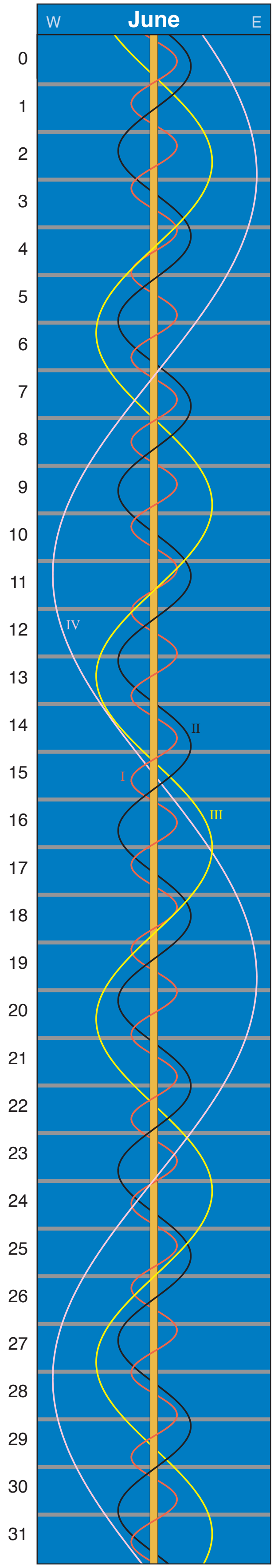


Day	EST	WST	Sat	Event	Vis
17	00:09	22:09(p)	I	Ec R	
	17:45	15:45	I	Tr I	E
	18:59	16:59	I	Sh I	E
	19:43	17:43	IV	Tr I	E
	20:03	18:03	I	Tr E	
	21:17	19:17	I	Sh E	
18	00:31	22:31(p)	IV	Tr E	
	02:10	00:10	II	Oc D	W
	18:38	16:38	I	Ec R	E
	20:06	18:06	III	Oc D	
	23:46	21:46	III	Oc R	
19	01:07	23:07(p)	III	Ec D	W
	21:17	19:17	II	Tr I	
	23:47	21:47	II	Sh I	
20	00:11	22:11(p)	II	Tr E	
	02:40	00:40	II	Sh E	W
21	20:49	18:49	II	Ec R	
22	18:39	16:39	III	Sh E	E
23	01:10	23:10(p)	I	Tr I	W
	02:25	00:25	I	Sh I	W
	22:31	20:31	I	Oc D	
24	02:04	00:04	I	Ec R	W
	19:38	17:38	I	Tr I	E
	20:54	18:54	I	Sh I	
	21:56	19:56	I	Tr E	
	23:12	21:12	I	Sh E	
25	20:33	18:33	I	Ec R	
	23:58	21:58	III	Oc D	
26	17:41	15:41	I	Sh E	E
	19:51	17:51	IV	Ec R	
	23:51	21:51	II	Tr I	
28	17:59	15:59	II	Oc D	E
	23:26	21:26	II	Ec R	
29	17:31	15:31	III	Tr E	E
	19:01	17:01	III	Sh I	E
	22:39	20:39	III	Sh E	
30	18:34	16:34	II	Sh E	E
May					
1	00:25	22:25(p)	I	Oc D	W
	21:32	19:32	I	Tr I	
	22:49	20:49	I	Sh I	
	23:50	21:50	I	Tr E	W
2	01:07	23:07(p)	I	Sh E	W
	18:53	16:53	I	Oc D	E
	22:28	20:28	I	Ec R	
3	17:18	15:18	I	Sh I	E
	18:19	16:19	I	Tr E	E
	19:36	17:36	I	Sh E	E
4	18:04	16:04	IV	Tr E	E
5	01:17	23:17(p)	IV	Sh I	W
	20:34	18:34	II	Oc D	
6	17:51	15:51	III	Tr I	E
	21:29	19:29	III	Tr E	
	23:00	21:00	III	Sh I	
7	18:17	16:17	II	Sh I	E
	18:37	16:37	II	Tr E	E
	21:10	19:10	II	Sh E	
8	23:27	21:27	I	Tr I	W

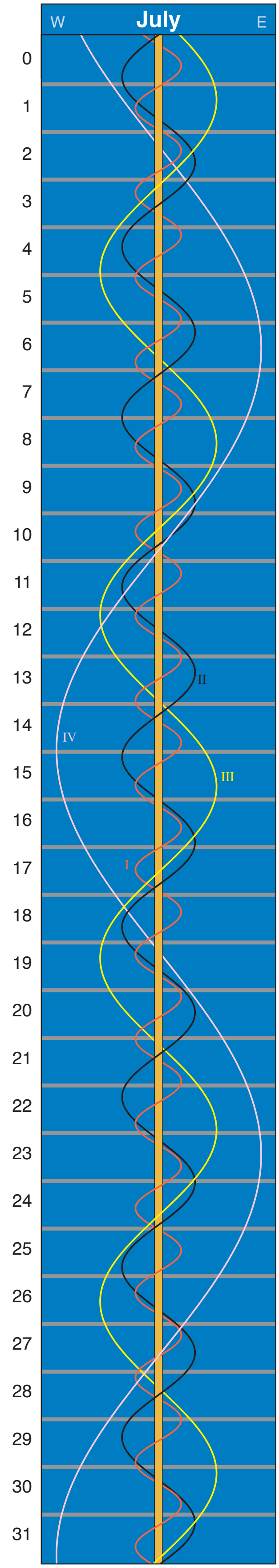


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
9	00:44	22:44(p)	I	Sh I	W
	20:49	18:49	I	Oc D	
10	00:23	22:23(p)	I	Ec R	W
	17:56	15:56	I	Tr I	E
	19:13	17:13	I	Sh I	E
	20:14	18:14	I	Tr E	
	21:31	19:31	I	Sh E	
11	18:52	16:52	I	Ec R	E
12	20:54	18:54	IV	Oc D	
	23:11	21:11	II	Oc D	W
13	21:53	19:53	III	Tr I	
14	18:21	16:21	II	Tr I	E
	20:53	18:53	II	Sh I	
	21:14	19:14	II	Tr E	
	23:46	21:46	II	Sh E	W
16	17:57	15:57	II	Ec R	E
	22:45	20:45	I	Oc D	
17	19:53	17:53	I	Tr I	
	20:44	18:44	III	Ec R	
	21:08	19:08	I	Sh I	
	22:11	20:11	I	Tr E	
	23:26	21:26	I	Sh E	W
18	17:14	15:14	I	Oc D	E
	20:47	18:47	I	Ec R	
19	17:55	15:55	I	Sh E	E
21	19:20	17:20	IV	Sh I	E
	21:00	19:00	II	Tr I	
	23:29	21:29	II	Sh I	W
	23:53	21:53	II	Tr E	W
	23:58	21:58	IV	Sh E	W
23	20:34	18:34	II	Ec R	
24	00:42	22:42(p)	I	Oc D	W
	19:46	17:46	III	Oc R	
	21:05	19:05	III	Ec D	
	21:50	19:50	I	Tr I	
	23:03	21:03	I	Sh I	W
25	00:08	22:08(p)	I	Tr E	W
	19:11	17:11	I	Oc D	E
	22:42	20:42	I	Ec R	W
26	17:32	15:32	I	Sh I	E
	18:37	16:37	I	Tr E	E
	19:50	17:50	I	Sh E	
27	17:10	15:10	I	Ec R	E
28	23:41	21:41	II	Tr I	W
29	20:33	18:33	IV	Oc R	
30	17:52	15:52	II	Oc D	E
	23:11	21:11	II	Ec R	W
31	20:16	18:16	III	Oc D	
	23:47	21:47	I	Tr I	W
	23:57	21:57	III	Oc R	W
June					
1	18:15	16:15	II	Sh E	E
	21:09	19:09	I	Oc D	
2	18:17	16:17	I	Tr I	E
	19:27	17:27	I	Sh I	
	20:35	18:35	I	Tr E	
	21:45	19:45	I	Sh E	

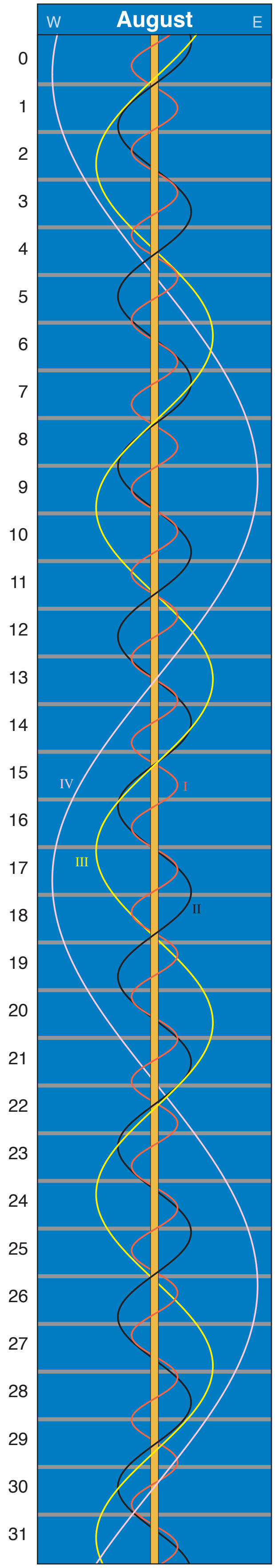


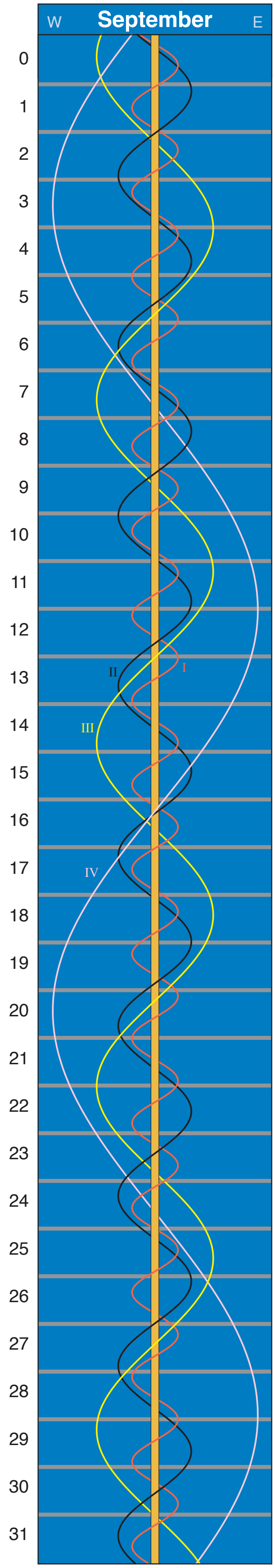
Day	EST	WST	Sat	Event	Vis
3	19:05	17:05	I	Ec R	E
4	18:35	16:35	III	Sh E	E
6	20:36	18:36	II	Oc D	
7	17:58	15:58	IV	Sh E	E
8	17:57	15:57	II	Sh I	E
	18:37	16:37	II	Tr E	E
	20:50	18:50	II	Sh E	
	23:07	21:07	I	Oc D	W
9	20:16	18:16	I	Tr I	
	21:22	19:22	I	Sh I	
	22:34	20:34	I	Tr E	W
	23:40	21:40	I	Sh E	W
10	17:37	15:37	I	Oc D	E
	21:00	19:00	I	Ec R	
11	17:04	15:04	I	Tr E	E
	18:09	16:09	I	Sh E	E
	18:12	16:12	III	Tr E	E
	18:57	16:57	III	Sh I	E
	22:35	20:35	III	Sh E	W
13	23:20	21:20	II	Oc D	W
15	18:28	16:28	II	Tr I	E
	20:33	18:33	II	Sh I	
	21:15	19:15	IV	Ec D	W
	21:20	19:20	II	Tr E	W
	23:25	21:25	II	Sh E	W
16	22:15	20:15	I	Tr I	W
	23:18	21:18	I	Sh I	W
17	17:43	15:43	II	Ec R	E
	19:35	17:35	I	Oc D	
	22:54	20:54	I	Ec R	W
18	17:46	15:46	I	Sh I	E
	18:50	16:50	III	Tr I	E
	19:03	17:03	I	Tr E	E
	20:04	18:04	I	Sh E	
	22:29	20:29	III	Tr E	W
	22:58	20:58	III	Sh I	W
19	17:23	15:23	I	Ec R	E
22	21:12	19:12	II	Tr I	W
	23:08	21:08	II	Sh I	W
23	22:17	20:17	IV	Tr I	W
24	20:21	18:21	II	Ec R	
	21:35	19:35	I	Oc D	W
25	18:45	16:45	I	Tr I	E
	19:41	17:41	I	Sh I	
	21:03	19:03	I	Tr E	W
	21:59	19:59	I	Sh E	W
26	19:18	17:18	I	Ec R	E
29	20:39	18:39	III	Ec R	W
July					
1	18:17	16:17	II	Oc D	E
2	19:54	17:54	IV	Ec R	
	20:45	18:45	I	Tr I	W
	21:36	19:36	I	Sh I	W
3	17:51	15:51	II	Sh E	E
	18:05	16:05	I	Oc D	E
	21:12	19:12	I	Ec R	W

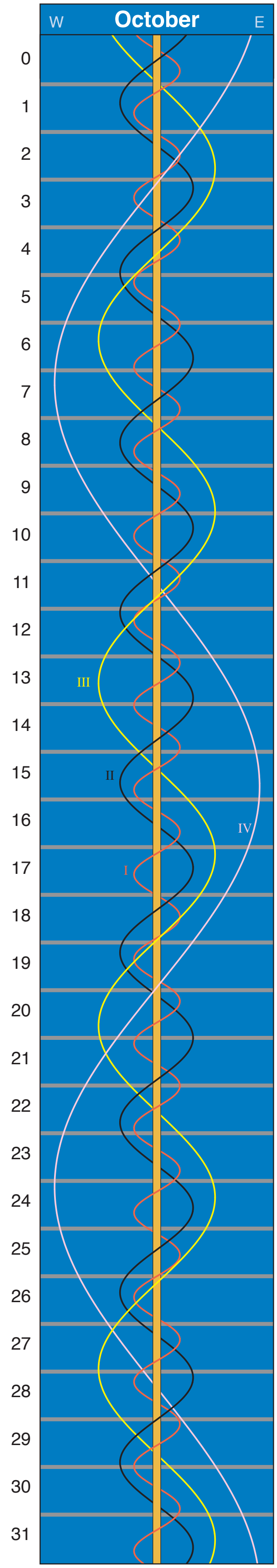


JUPITER MOON EVENTS

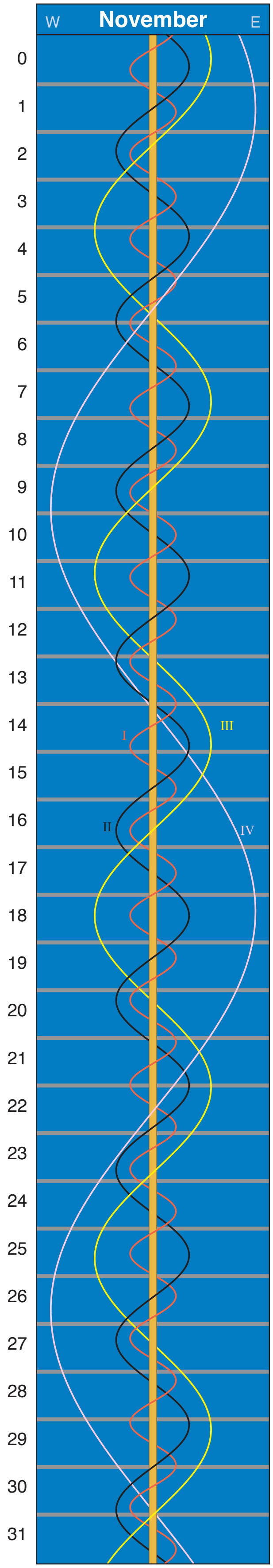
Day	EST	WST	Sat	Event	Vis
4	17:33	15:33	I	Tr E	E
	18:23	16:23	I	Sh E	E
6	17:44	15:44	III	Oc D	E
8	21:06	19:06	II	Oc D	W
10	17:34	15:34	II	Sh I	E
	18:19	16:19	IV	Tr I	E
	18:58	16:58	II	Tr E	E
	20:05	18:05	I	Oc D	W
	20:26	18:26	II	Sh E	W
11	17:16	15:16	I	Tr I	E
	18:00	16:00	I	Sh I	E
	19:34	17:34	I	Tr E	
	20:18	18:18	I	Sh E	W
12	17:35	15:35	I	Ec R	E
17	18:30	16:30	III	Sh E	E
	18:52	16:52	II	Tr I	E
	20:09	18:09	II	Sh I	W
	21:45	19:45	II	Tr E	W
18	19:17	17:17	I	Tr I	E
	19:55	17:55	I	Sh I	W
	21:35	19:35	I	Tr E	W
19	17:31	15:31	II	Ec R	E
24	18:53	16:53	III	Sh I	E
	20:20	18:20	III	Tr E	W
25	21:18	19:18	I	Tr I	W
26	18:36	16:36	I	Oc D	E
	20:08	18:08	II	Ec R	W
	21:23	19:23	I	Ec R	W
27	18:07	16:07	I	Tr E	E
	18:37	16:37	I	Sh E	E
31	21:07	19:07	III	Tr I	W
August					
2	20:37	18:37	I	Oc D	W
September					
22	07:34	05:34	I	Sh I	W
	08:00	06:00	I	Tr I	W
23	07:28	05:28	I	Oc R	W
October					
3	05:01	03:01	IV	Tr E	E
8	06:54	04:54	III	Oc R	W
11	04:20	02:20	II	Tr I	E
	07:10	05:10	II	Tr E	W
	07:40	05:40	IV	Ec R	W
15	04:38	02:38	III	Ec D	E
16	04:54	02:54	I	Ec D	E
17	04:30	02:30	I	Sh E	E
	05:18	03:18	I	Tr E	E
18	07:06	05:06	II	Tr I	W
20	05:05	03:05	II	Oc R	E
23	06:47	04:47	I	Ec D	W
24	04:07	02:07	I	Sh I	E
	05:00	03:00	I	Tr I	E
	06:24	04:24	I	Sh E	W
	07:17	05:17	I	Tr E	W





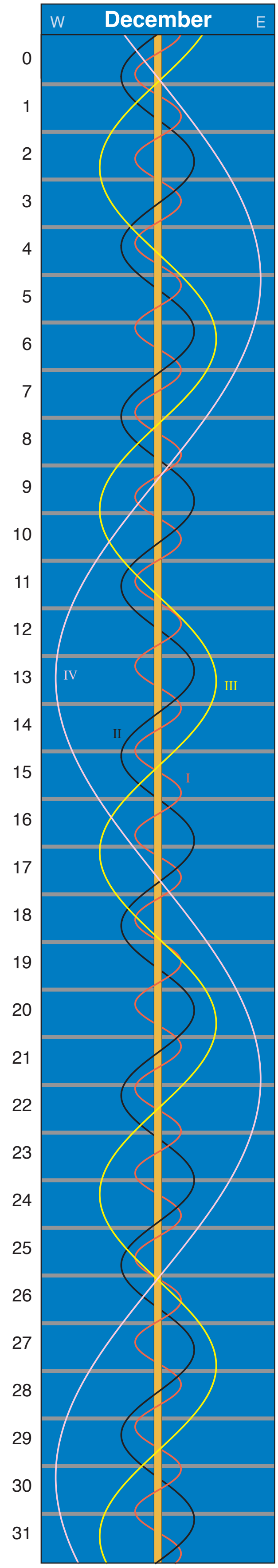


JUPITER MOON EVENTS



Day	EST	WST	Sat	Event	Vis
25	04:25	02:25	I	Oc R	E
26	05:41	03:41	III	Tr E	W
28	06:34	04:34	IV	Oc D	W
31	06:01	04:01	I	Sh I	W
	06:59	04:59	I	Tr I	W
November					
1	03:09	01:09	I	Ec D	E
	06:24	04:24	I	Oc R	W
2	03:45	01:45	I	Tr E	E
	06:02	04:02	III	Sh E	W
	06:33	04:33	III	Tr I	W
3	05:43	03:43	II	Ec D	W
5	02:44	00:44	II	Sh E	E
	04:45	02:45	II	Tr E	E
8	05:02	03:02	I	Ec D	W
9	03:26	01:26	I	Tr I	E
	04:39	02:39	I	Sh E	E
	05:42	03:42	I	Tr E	W
	06:30	04:30	III	Sh I	W
10	02:51	00:51	I	Oc R	E
12	02:28	00:28	II	Sh I	E
	04:39	02:39	II	Tr I	
	05:18	03:18	II	Sh E	W
13	04:22	02:22	III	Oc R	E
14	02:20	00:20	IV	Oc D	E
	02:38	00:38	II	Oc R	E
	05:47	03:47	IV	Oc R	W
15	06:55	04:55	I	Ec D	W
16	04:16	02:16	I	Sh I	E
	05:23	03:23	I	Tr I	W
	06:33	04:33	I	Sh E	W
17	04:47	02:47	I	Oc R	
18	02:08	00:08	I	Tr E	E
19	05:02	03:02	II	Sh I	W
20	03:56	01:56	III	Ec R	E
	05:10	03:10	III	Oc D	W
21	05:19	03:19	II	Oc R	W
22	05:09	03:09	IV	Sh E	W
23	06:09	04:09	I	Sh I	W
24	03:17	01:17	I	Ec D	E
	06:43	04:43	I	Oc R	W
25	01:48	23:48(p)	I	Tr I	E
	02:54	00:54	I	Sh E	E
	04:04	02:04	I	Tr E	
27	04:25	02:25	III	Ec D	
28	02:45	00:45	II	Ec D	E
30	02:07	00:07	II	Tr E	E
December					
1	02:38	00:38	III	Tr E	E
	05:10	03:10	I	Ec D	W
2	02:31	00:31	I	Sh I	E
	03:44	01:44	I	Tr I	
	04:47	02:47	I	Sh E	W
	05:59	03:59	I	Tr E	W

Day	EST	WST	Sat	Event	Vis
3	03:07	01:07	I	Oc R	E
5	05:19	03:19	II	Ec D	W
7	01:58	23:58(p)	II	Tr I	E
	02:18	00:18	II	Sh E	E
	04:44	02:44	II	Tr E	W
8	01:47	23:47(p)	III	Sh E	E
	03:23	01:23	III	Tr I	
	06:40	04:40	III	Tr E	W
9	04:24	02:24	I	Sh I	
	05:38	03:38	I	Tr I	W
	06:40	04:40	I	Sh E	W
10	01:31	23:31(p)	I	Ec D	E
	05:02	03:02	I	Oc R	W
11	01:08	23:08(p)	I	Sh E	E
	02:22	00:22	I	Tr E	E
14	02:02	00:02	II	Sh I	E
	04:34	02:34	II	Tr I	
	04:52	02:52	II	Sh E	W
15	02:17	00:17	III	Sh I	E
	05:44	03:44	III	Sh E	W
16	02:26	00:26	II	Oc R	E
	06:17	04:17	I	Sh I	W
17	03:24	01:24	I	Ec D	
	03:32	01:32	IV	Ec D	
	06:55	04:55	I	Oc R	W
18	00:45	22:45(p)	I	Sh I	E
	02:00	00:00	I	Tr I	E
	03:01	01:01	I	Sh E	
	04:15	02:15	I	Tr E	
19	00:40	22:40(p)	III	Oc R	E
	01:23	23:23(p)	I	Oc R	E
21	04:37	02:37	II	Sh I	
22	06:15	04:15	III	Sh I	W
	23:45	21:45	II	Ec D	E
23	04:58	02:58	II	Oc R	W
24	05:18	03:18	I	Ec D	W
25	02:38	00:38	I	Sh I	
	03:52	01:52	I	Tr I	
	04:54	02:54	I	Sh E	W
	06:06	04:06	I	Tr E	W
	23:43	21:43	III	Ec R	E
	23:46	21:46	I	Ec D	E
26	01:07	23:07(p)	IV	Tr I	E
	01:18	23:18(p)	III	Oc D	E
	03:15	01:15	I	Oc R	
	03:36	01:36	IV	Tr E	
	04:32	02:32	III	Oc R	
27	00:34	22:34(p)	I	Tr E	E
30	02:18	00:18	II	Ec D	
31	23:18	21:18	II	Sh E	E



JUPITER MOON MUTUAL EVENTS

Date	EST		WST		Vis	Event	Type	DL	Jup Dist	Sat Sep
	Start	End	Start	End						
1 Nov 14	00:40	02:52	22:40(p)	00:52	E	IV Ec III	P	0.7	2.6	0.50
11 Nov 14	03:43	03:49	01:43	01:49		I Oc IV	P	0.1	1.1	0.71
19 Nov 14	02:11	02:22	00:11	00:22	E	II Oc III	P	0.2	2.3	0.51
20 Nov 14	01:54	01:59	23:54(p)	23:59(p)	E	I Oc III	A	0.4	0.7	0.10
23 Nov 14	02:31	02:37	00:31	00:37		III Oc I	T	0.4	1.1	0.04
26 Nov 14	05:11	06:35	03:11	04:35	W	III Ec IV	P	0.3	2.9	0.92
26 Nov 14	05:47	05:56	03:47	03:56	W	II Oc III	P	0.1	2.3	0.80
27 Nov 14	04:34	04:40	02:34	02:40		I Oc III	A	0.4	0.6	0.19
29 Nov 14	00:51	01:08	22:51(p)	23:08(p)	E	III Oc IV	P	0.4	3.7	0.39
30 Nov 14	05:20	05:27	03:20	03:27	W	III Oc I	T	0.4	1.2	0.17
15 Dec 14	04:22	05:22	02:22	03:22	W	III Oc I	T	0.4	1.0	0.03
17 Dec 14	01:48	02:16	23:48(p)	00:16		II Oc I	A	0.6	1.3	0.06
19 Dec 14	04:14	04:46	02:14	02:46		II Oc III	P	0.2	2.2	0.54
24 Dec 14	04:59	05:15	02:59	03:15	W	II Oc I	P	0.4	1.4	0.25
29 Dec 14	01:13	01:38	23:13(p)	23:38(p)		III Oc I	T	0.4	0.5	0.04
8 Jan 15	01:53	02:35	23:53(p)	00:35		II Ec III	A	0.4	2.5	0.37
10 Jan 15	21:51	22:02	19:51	20:02	E	II Ec I	P	0.2	1.5	0.58
10 Jan 15	23:13	23:22	21:13	21:22		II Oc I	P	0.3	1.5	0.47
12 Jan 15	21:01	21:07	19:01	19:07	E	III Oc I	P	0.1	1.3	0.87
18 Jan 15	00:30	00:40	22:30(p)	22:40(p)		II Ec I	P	0.4	1.5	0.49
18 Jan 15	01:29	01:37	23:29(p)	23:37(p)		II Oc I	P	0.3	1.5	0.49
19 Jan 15	23:36	23:41	21:36	21:41		III Oc I	P	0.1	1.2	0.89
23 Jan 15	00:17	00:21	22:17(p)	22:21(p)		I Oc III	P	0.1	0.6	1.06
23 Jan 15	22:52	23:02	20:52	21:02		II Oc III	P	0.1	2.3	0.82
25 Jan 15	03:03	03:12	01:03	01:12		II Ec I	P	0.5	1.5	0.41
25 Jan 15	03:40	03:47	01:40	01:47		II Oc I	P	0.3	1.5	0.47
25 Jan 15	04:48	05:01	02:48	03:01		IV Ec I	A	0.3	1.4	0.14
27 Jan 15	01:24	01:31	23:24(p)	23:31(p)		III Ec I	P	0.4	1.2	0.82
27 Jan 15	02:06	02:11	00:06	00:11		III Oc I	P	0.1	1.1	0.86
30 Jan 15	02:10	02:16	00:10	00:16		I Ec III	P	0.2	0.8	0.76
30 Jan 15	02:38	02:42	00:38	00:42		I Oc III	P	0.1	0.7	0.92
31 Jan 15	01:57	02:06	23:57(p)	00:06		II Oc III	P	0.1	2.3	0.92
1 Feb 15	05:31	05:40	03:31	03:40	W	II Ec I	P	0.7	1.5	0.31
1 Feb 15	05:48	05:55	03:48	03:55	W	II Oc I	P	0.3	1.4	0.42
3 Feb 15	04:17	04:24	02:17	02:24		III Ec I	P	0.7	1.0	0.64
3 Feb 15	04:32	04:37	02:32	02:37		III Oc I	P	0.2	1.0	0.78
6 Feb 15	04:55	05:02	02:55	03:02		I Ec III	P	0.4	0.8	0.57
6 Feb 15	05:00	05:04	03:00	03:04		I Oc III	P	0.2	0.8	0.74
7 Feb 15	04:58	05:05	02:58	03:05		II Oc III	P	0.1	2.3	1.04
9 Feb 15	20:34	20:39	18:34	18:39	E	III Oc II	T	0.3	0.6	0.10
10 Feb 15	06:56	07:01	04:56	05:01	W	III Oc I	P	0.2	0.9	0.65
10 Feb 15	07:05	07:12	05:05	05:12	W	III Ec I	P	0.9	0.8	0.44
11 Feb 15	20:57	21:03	18:57	19:03	E	II Oc I	P	0.4	1.4	0.30
11 Feb 15	21:08	21:16	19:08	19:16	E	II Ec I	A	0.9	1.4	0.17
11 Feb 15	22:29	22:44	20:29	20:44		IV Oc III	P	0.1	3.7	1.12
11 Feb 15	23:25	23:50	21:25	21:50		IV Ec III	A	0.6	3.7	0.22
13 Feb 15	07:23	07:28	05:23	05:28	W	I Oc III	P	0.3	0.9	0.54
16 Feb 15	23:15	23:20	21:15	21:20		III Oc II	T	0.3	0.6	0.30
18 Feb 15	23:02	23:08	21:02	21:08		II Oc I	P	0.5	1.4	0.19
18 Feb 15	23:30	23:38	21:30	21:38		II Ec I	A	0.5	1.3	0.06
20 Feb 15	06:21	06:24	04:21	04:24	W	I Oc II	P	0.2	0.4	0.58
23 Feb 15	19:20	19:23	17:20	17:23	E	I Oc II	P	0.1	0.4	0.67
24 Feb 15	01:58	02:03	23:58(p)	00:03		III Oc II	P	0.3	0.7	0.51
24 Feb 15	03:09	03:16	01:09	01:16		III Ec II	P	0.7	0.9	0.67
26 Feb 15	01:06	01:12	23:06(p)	23:12(p)		II Oc I	A	0.6	1.4	0.07

Date	EST		WST		Vis	Event	Type	DL	Jup Dist	Sat Sep
	Start	End	Start	End						
26 Feb 15	01:51	01:58	23:51(p)	23:58(p)		II Ec I	A	0.4	1.3	0.05
2 Mar 15	21:19	21:21	19:19	19:21		I Oc II	P	0.1	0.5	0.85
3 Mar 15	04:43	04:47	02:43	02:47	W	III Oc II	P	0.2	0.8	0.71
5 Mar 15	03:12	03:17	01:12	01:17		II Oc I	A	0.6	1.3	0.06
5 Mar 15	04:11	04:17	02:11	02:17	W	II Ec I	A	0.9	1.2	0.16
7 Mar 15	21:21	21:28	19:21	19:28		II Oc IV	A	0.4	1.7	0.02
8 Mar 15	19:27	19:49	17:27	17:49	E	III Oc IV	P	0.4	3.7	0.48
9 Mar 15	01:37	02:01	23:37(p)	00:01		III Ec IV	P	0.8	4.3	0.54
12 Mar 15	05:17	05:23	03:17	03:23	W	II Oc I	P	0.5	1.3	0.18
13 Mar 15	19:52	20:05	17:52	18:05	E	I Ec III	A	0.3	1.0	0.14
15 Mar 15	18:21	18:26	16:21	16:26	E	II Oc I	P	0.5	1.3	0.24
15 Mar 15	19:39	19:44	17:39	17:44	E	II Ec I	P	0.6	1.1	0.34
20 Mar 15	20:22	20:32	18:22	18:32	E	I Oc III	P	0.3	1.4	0.43
20 Mar 15	23:40	00:01	21:40	22:01(p)		I Ec III	A	0.3	1.0	0.16
21 Mar 15	21:40	21:53	19:40	19:53		I Ec III	A	0.5	1.9	0.38
22 Mar 15	20:28	20:33	18:28	18:33		II Oc I	P	0.4	1.2	0.35
22 Mar 15	21:56	22:01	19:56	20:01		II Ec I	P	0.4	1.0	0.47
27 Mar 15	23:32	23:44	21:32	21:44		I Oc III	P	0.3	1.5	0.55
28 Mar 15	21:41	21:53	19:41	19:53		I Oc III	P	0.3	1.5	0.59
29 Mar 15	00:59	01:08	22:59(p)	23:08(p)		I Ec III	P	0.3	1.9	0.63
29 Mar 15	22:37	22:41	20:37	20:41		II Oc I	P	0.3	1.2	0.44
30 Mar 15	00:13	00:18	22:13(p)	22:18(p)		II Ec I	P	0.2	1.0	0.60
2 Apr 15	19:37	20:00	17:37	18:00	E	IV Oc III	A	0.7	3.7	0.06
3 Apr 15	20:07	20:12	18:07	18:12	E	I Ec II	A	0.4	0.4	0.10
4 Apr 15	03:31	03:53	01:31	01:53	W	I Oc III	P	0.2	1.4	0.65
5 Apr 15	00:56	01:04	22:56(p)	23:04(p)		I Oc III	P	0.2	1.4	0.63
6 Apr 15	00:46	00:50	22:46(p)	22:50(p)		II Oc I	P	0.2	1.2	0.51
8 Apr 15	18:05	18:11	16:05	16:11	E	III Oc IV	P	0.1	1.8	1.07
13 Apr 15	02:57	03:01	00:57	01:01	W	II Oc I	P	0.2	1.1	0.56
18 Apr 15	00:35	00:40	22:35(p)	22:40(p)	W	I Ec II	A	0.4	0.5	0.09
26 Apr 15	18:16	18:24	16:16	16:24	E	II Ec III	A	0.4	2.1	0.37
3 May 15	20:36	20:43	18:36	18:43		IV Oc III	P	0.1	1.9	0.96
3 May 15	21:32	21:40	19:32	19:40		II Ec III	P	0.2	2.0	0.64
5 May 15	18:13	18:18	16:13	16:18	E	I Ec II	P	1.2	0.6	0.30
7 May 15	22:45	22:48	20:45	20:48		II Oc I	P	0.2	0.9	0.53
12 May 15	20:29	20:34	18:29	18:34		I Ec II	P	0.9	0.7	0.37
13 May 15	22:55	23:07	20:55	21:07	W	II Oc IV	P	0.2	2.4	0.60
15 May 15	01:00	01:04	23:00(p)	23:04(p)	W	II Oc I	P	0.2	0.9	0.47
19 May 15	22:45	22:51	20:45	20:51	W	I Ec II	P	0.7	0.8	0.43
1 Jun 15	18:44	18:48	16:44	16:48	E	II Oc I	P	0.4	0.7	0.23
3 Jun 15	21:28	21:36	19:28	19:36		III Oc II	T	0.3	1.9	0.12
4 Jun 15	17:04	17:33	15:04	15:33	E	III Oc I	P	0.3	0.7	0.40
4 Jun 15	22:37	23:02	20:37	21:02	W	III Oc I	P	0.4	1.4	0.24
8 Jun 15	21:02	21:06	19:02	19:06		II Oc I	P	0.6	0.7	0.10
13 Jun 15	18:49	18:54	16:49	16:54	E	I Ec II	P	0.4	1.0	0.56
15 Jun 15	23:22	23:25	21:22	21:25	W	II Oc I	A	0.6	0.6	0.06
20 Jun 15	21:08	21:14	19:08	19:14	W	I Ec II	P	0.4	1.1	0.57
22 Jun 15	17:22	17:27	15:22	15:27	E	II Oc III	P	0.2	0.9	0.51
27 Jun 15	22:01	22:05	20:01	20:05	W	I Oc II	P	0.1	1.3	0.60
29 Jun 15	20:50	20:56	18:50	18:56	W	II Oc III	A	0.3	0.8	0.15
3 Jul 15	17:12	17:15	15:12	15:15	E	II Oc I	P	0.1	0.4	0.50
15 Jul 15	17:30	17:38	15:30	15:38	E	I Ec II	P	0.5	1.3	0.51
22 Jul 15	18:56	19:04	16:56	17:04	E	I Oc II	P	0.3	1.5	0.29
22 Jul 15	20:00	20:09	18:00	18:09	W	I Ec II	P	0.6	1.3	0.46
8 Aug 15	19:30	20:14	17:30	18:14	W	III Oc II	T	0.3	2.1	0.16

The plane of Jupiter's moons is close to that of the Earth's orbit. About every six years the two planes cross and for a few months 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.
Vis where E indicates the event is more suitable for eastern states, W is for events more suitable for observation from Western Australia. A blank means the event is suitable for most of Australia.
Event description e.g., II Oc I means satellite II occults (passes in front of) satellite I. Event II Ec I, 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 and 'T' is total.
DL is the relative intensity drop 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 arcseconds at closest approach.

JUPITER – LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	056.6	275.9	020.2	235.6	289.6	138.8	188.9	036.4	244.2	295.5	146.1	201.0	1
2	214.6	073.9	178.2	033.5	087.4	296.5	346.6	194.0	041.9	093.2	303.9	358.8	2
3	012.7	231.9	336.2	191.3	245.1	094.2	144.3	351.7	199.6	251.0	101.7	156.7	3
4	170.7	030.0	134.1	349.2	042.9	251.9	301.9	149.4	357.3	048.7	259.5	314.6	4
5	328.7	188.0	292.1	147.0	200.6	049.6	099.6	307.0	155.0	206.4	057.3	112.5	5
6	126.8	346.0	090.0	304.8	358.4	207.2	257.2	104.7	312.7	004.2	215.1	270.3	6
7	284.8	144.1	248.0	102.7	156.1	004.9	054.9	262.4	110.4	161.9	012.9	068.2	7
8	082.8	302.1	045.9	260.5	313.8	162.6	212.6	060.0	268.1	319.7	170.7	226.1	8
9	240.9	100.1	203.9	058.3	111.6	320.3	010.2	217.7	065.8	117.4	328.5	024.0	9
10	038.9	258.2	001.8	216.2	269.3	118.0	167.9	015.4	223.5	275.1	126.3	181.9	10
11	196.9	056.2	159.8	014.0	067.0	275.6	325.5	173.0	021.2	072.9	284.1	339.8	11
12	355.0	214.2	317.7	171.8	224.8	073.3	123.2	330.7	178.9	230.6	081.9	137.7	12
13	153.0	012.2	115.6	329.6	022.5	231.0	280.8	128.4	336.6	028.4	239.8	295.6	13
14	311.1	170.2	273.6	127.4	180.2	028.6	078.5	286.0	134.3	186.2	037.6	093.5	14
15	109.1	328.3	071.5	285.2	337.9	186.3	236.2	083.7	292.0	343.9	195.4	251.4	15
16	267.2	126.3	229.4	083.0	135.6	344.0	033.8	241.4	089.7	141.7	353.2	049.3	16
17	065.2	284.3	027.3	240.8	293.4	141.7	191.5	039.0	247.4	299.4	151.1	207.2	17
18	223.2	082.3	185.3	038.6	091.1	299.3	349.1	196.7	045.1	097.2	308.9	005.1	18
19	021.3	240.3	343.2	196.4	248.8	097.0	146.8	354.4	202.8	255.0	106.7	163.0	19
20	179.3	038.3	141.1	354.2	046.5	254.7	304.4	152.1	000.6	052.7	264.6	321.0	20
21	337.4	196.3	299.0	152.0	204.2	052.3	102.1	309.7	158.3	210.5	062.4	118.9	21
22	135.4	354.3	096.9	309.8	001.9	210.0	259.8	107.4	316.0	008.3	220.3	276.8	22
23	293.5	152.3	254.8	107.5	159.6	007.7	057.4	265.1	113.7	166.0	018.1	074.7	23
24	091.5	310.3	052.6	265.3	317.3	165.3	215.1	062.8	271.4	323.8	176.0	232.7	24
25	249.6	108.3	210.5	063.1	115.0	323.0	012.7	220.5	069.1	121.6	333.8	030.6	25
26	047.6	266.3	008.4	220.9	272.7	120.6	170.4	018.1	226.9	279.4	131.7	188.5	26
27	205.6	064.3	166.3	018.6	070.4	278.3	328.1	175.8	024.6	077.1	289.5	346.5	27
28	003.7	222.2	324.2	176.4	228.1	076.0	125.7	333.5	182.3	234.9	087.4	144.4	28
29	161.7		122.0	334.1	025.8	233.6	283.4	131.2	340.0	032.7	245.2	302.4	29
30	319.8		279.9	131.9	183.5	031.3	081.0	288.9	137.8	190.5	043.1	100.3	30
31	117.8		077.8		341.1		238.7	086.6		348.3		258.3	31

SYSTEM II (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	352.0	334.8	225.5	204.4	029.5	002.2	183.4	154.3	125.7	308.0	282.1	108.0	1
2	142.4	125.2	015.8	354.6	179.6	152.3	333.4	304.4	275.7	098.1	072.2	258.3	2
3	292.8	275.6	166.2	144.8	329.8	302.3	123.5	094.4	065.8	248.2	222.4	048.5	3
4	083.2	066.0	316.5	295.0	119.9	092.4	273.5	244.4	215.9	038.3	012.6	198.7	4
5	233.6	216.4	106.8	085.2	270.0	242.4	063.5	034.5	005.9	188.4	162.7	349.0	5
6	024.0	006.8	257.2	235.4	060.1	032.5	213.6	184.5	156.0	338.5	312.9	139.2	6
7	174.4	157.2	047.5	025.6	210.2	182.5	003.6	334.5	306.0	128.7	103.1	289.5	7
8	324.9	307.6	197.8	175.9	000.3	332.6	153.6	124.6	096.1	278.8	253.3	079.8	8
9	115.3	098.0	348.1	326.0	150.4	122.6	303.7	274.6	246.2	068.9	043.4	230.0	9
10	265.7	248.4	138.4	116.2	300.5	272.7	093.7	064.6	036.2	219.0	193.6	020.3	10
11	056.1	038.8	288.7	266.4	090.6	062.7	243.7	214.7	186.3	009.1	343.8	170.5	11
12	206.5	189.2	079.1	056.6	240.7	212.7	033.7	004.7	336.4	159.2	134.0	320.8	12
13	356.9	339.6	229.4	206.8	030.8	002.8	183.8	154.8	126.5	309.4	284.2	111.1	13
14	147.3	130.0	019.7	357.0	180.9	152.8	333.8	304.8	276.5	099.5	074.4	261.3	14
15	297.7	280.3	170.0	147.2	331.0	302.9	123.8	094.8	066.6	249.6	224.6	051.6	15
16	088.1	070.7	320.2	297.3	121.1	092.9	273.8	244.9	216.7	039.7	014.8	201.9	16
17	238.5	221.1	110.5	087.5	271.2	242.9	063.9	034.9	006.8	189.9	165.0	352.2	17
18	029.0	011.5	260.8	237.7	061.2	033.0	213.9	185.0	156.8	340.0	315.2	142.5	18
19	179.4	161.9	051.1	027.8	211.3	183.0	003.9	335.0	306.9	130.1	105.4	292.7	19
20	329.8	312.2	201.4	178.0	001.4	333.1	154.0	125.1	097.0	280.3	255.6	083.0	20
21	120.2	102.6	351.6	328.1	151.5	123.1	304.0	275.1	247.1	070.4	045.8	233.3	21
22	270.6	253.0	141.9	118.3	301.5	273.1	094.0	065.1	037.2	220.5	196.0	023.6	22
23	061.0	043.4	292.2	268.4	091.6	063.2	244.0	215.2	187.3	010.7	346.2	173.9	23
24	211.5	193.7	082.4	058.6	241.7	213.2	034.1	005.2	337.4	160.8	136.4	324.2	24
25	001.9	344.1	232.7	208.7	031.8	003.2	184.1	155.3	127.4	311.0	286.6	114.5	25
26	152.3	134.4	022.9	358.9	181.8	153.3	334.1	305.3	277.5	101.1	076.9	264.8	26
27	302.7	284.8	173.2	149.0	331.9	303.3	124.2	095.4	067.6	251.3	227.1	055.1	27
28	093.1	075.1	323.4	299.1	122.0	093.3	274.2	245.5	217.7	041.4	017.3	205.4	28
29	243.5		113.7	089.3	272.0	243.4	064.2	035.5	007.8	191.6	167.6	355.8	29
30	033.9		263.9	239.4	062.1	033.4	214.3	185.6	157.9	341.7	317.8	146.1	30
31	184.3		054.1		212.1		004.3	335.6		131.9		296.4	31

Jupiter is a gas giant and we can only view the upper atmospheric features. Just a small telescope (even a 60 mm instrument) is required to view the equatorial belts and the Great Red Spot. When the 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 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 record the time a feature crosses the central meridian of the planet. This central meridian is an imaginary line drawn from the north to south pole of Jupiter which passes through the centre of the disc.

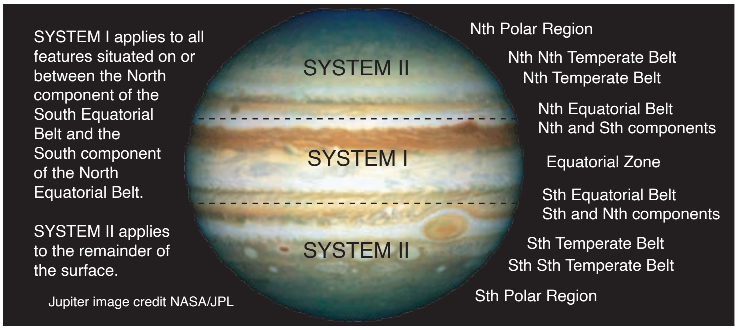
The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0 hr UT of date. You will need to add multiple hours and minutes from the small Increase in Longitude tables below. For example, the longitude of central meridian for Jupiter (System I) for 28 June at 2:20 am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on June 27. From the table, the longitude on 27 June is 278.3°. 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 515.8°, less 360° gives a final answer of 155.8°.

GREAT RED SPOT TRANSIT TIME

The GRS can best be seen from about one hour before transiting the central meridian to one hour after. During this two-hour period it will move approximately 70% of the diameter of Jupiter at its latitude. It can be seen a further 30 minutes either side of this period, but it tends to appear foreshortened and merging with the limb. The longitude of the GRS (System II) does drift over the years. In recent times it shows an average increase of about 14° to 17° per annum. The following are some actual values for June: 2009 = 136°, 2010 = 152°, 2011 = 167°, 2012 = 180°, 2013 = 197° and 2014 about 214°. The table data (opposite) has been based on 232°. For every degree of longitude greater than 232° it will transit 1.6 minutes later than shown (for every degree less than 232°, transit is 1.6 minutes earlier). If this trend continues the value could range from about 10 minutes earlier than shown here as the year opens to 10 minutes later by the end of 2015. This is an estimated mid-point of the GRS. The spot is about 15° in diameter, so it takes around 24 minutes to transit. The longitude of the GRS was obtained from the JUPOS website. jupos.privat.t-online.de/

Increase In Longitude
SYSTEM I
Rotation: 9 h 50 m 30.003 s

hr	deg°	hr	deg°	min	deg°
1	036.6	13	115.5	5	03.0
2	073.2	14	152.1	10	06.1
3	109.7	15	188.7	15	09.1
4	146.3	16	225.3	20	12.2
5	182.9	17	261.8	25	15.2
6	219.5	18	298.4	30	18.3
7	256.1	19	335.0	35	21.3
8	292.6	20	011.6	40	24.4
9	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



Jupiter image credit NASA/JPL

Increase In Longitude
SYSTEM II
Rotation: 9 h 55 m 40.062 s

hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	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

JUPITER – GREAT RED SPOT

Date	1st	2nd	3rd
Jan 1	(4:41)		
Jan 2	2:32 *		22:23
Jan 4	4:10 *		(22:01)
Jan 5	0:01		
Jan 6	(3:48)		(23:39)
Jan 7	1:39		21:30
Jan 8	(5:26)		
Jan 9	3:17 *		23:08
Jan 11	4:55 *		(22:46)
Jan 12	0:46		
Jan 13	(4:33)		
Jan 14	2:24 *		22:15
Jan 16	4:02 *		23:53 *
Jan 18	(3:40)		(23:31)
Jan 19	1:31		21:22
Jan 20	(5:18)		
Jan 21	3:09 *		23:00 *
Jan 23	4:47 *		(22:38)
Jan 24	0:38		20:29
Jan 25	(4:25)		
Jan 26	2:16 *		22:07 *
Jan 27	(6:02)		
Jan 28	3:54 *		23:45 *
Jan 29		19:36	
Jan 30	5:32 *		(23:23)
Jan 31	1:23		21:14
Feb 1	(5:09)		
Feb 2	3:01 *		22:52 *
Feb 4	4:38 *		(22:30)
Feb 5	0:30		20:21
Feb 6	(4:16)		
Feb 7	2:08 *		21:59 *
Feb 9	3:46 *		23:37 *
Feb 10		19:28	
Feb 11	(3:23)		(23:15)
Feb 12	1:15	(19:06)	21:06
Feb 13	(5:01)		
Feb 14	2:53 *		22:44 *

Date	1st	2nd	3rd
Feb 15		18:35	
Feb 16	4:31 *		(22:22)
Feb 17	0:22		20:13
Feb 18	(4:09)		
Feb 19	2:00 *		21:51 *
Feb 21	3:38 *		23:29 *
Feb 22		19:20	
Feb 23	(3:16)		(23:07)
Feb 24	1:07	(18:59)	20:59
Feb 26	2:45 *		22:37 *
Feb 27		18:28	
Feb 28	(2:23)		(22:15)
Mar 1	0:15		20:06
Mar 2	(4:01)		(23:53)
Mar 3	1:53	(19:44)	21:44
Mar 5	(1:31)		23:22 *
Mar 6		19:14	
Mar 7	(3:09)		(23:01)
Mar 8	1:00	(18:52)	20:52
Mar 10	2:39 *		22:30 *
Mar 11		18:21	
Mar 12	(2:17)		(22:08)
Mar 13	0:08		20:00
Mar 14			(23:47)
Mar 15	1:46	(19:38)	21:38
Mar 17	(1:25)		23:16 *
Mar 18		19:08	
Mar 19			(22:55)
Mar 20	0:54	(18:46)	20:46
Mar 22	(0:33)		22:24 *
Mar 23		18:16	
Mar 24	(2:11)		(22:03)
Mar 25	0:03	(17:54)	19:54
Mar 26			(23:41)
Mar 27	1:41	(19:33)	21:33
Mar 29	(1:20)		23:11 *
Mar 30		19:02	
Mar 31			(22:50)

Date	1st	2nd	3rd
Apr 1	0:49	(18:41)	20:41
Apr 3	(0:28)		22:19 *
Apr 4		18:11	
Apr 5			23:58 *
Apr 6		19:50 *	
Apr 7			(23:37)
Apr 8		(19:28)	21:28
Apr 9		17:20	
Apr 10	(1:15)		23:07 *
Apr 11		18:58	
Apr 12			(22:45)
Apr 13	0:45	(18:37)	20:37
Apr 15	(0:24)		22:16 *
Apr 16		18:07	
Apr 17			23:54 *
Apr 18		19:46 *	
Apr 19			(23:33)
Apr 20		(19:25)	21:25
Apr 21		17:16	
Apr 22			23:03 *
Apr 23		18:55	
Apr 24			(22:42)
Apr 25		(18:34)	20:34
Apr 27			22:13 *
Apr 28		18:04	
Apr 29			(21:51)
Apr 30		19:43 *	
May 1			(23:30)
May 2		(19:22)	21:22
May 3		17:13	
May 4			23:01 *
May 5		18:52	
May 6			(22:40)
May 7		(18:31)	20:31
May 9			22:10 *
May 10		18:02	
May 11			(21:49)
May 12		19:41 *	

Date	1st	2nd	3rd
May 14		(19:20)	21:20
May 15		17:11	
May 16			(20:59)
May 17		18:50	
May 18			(22:38)
May 19		(18:29)	20:29
May 21			22:08 *
May 22		18:00	
May 23			(21:48)
May 24		19:39 *	
May 26		(19:18)	21:18
May 27		17:10	
May 28			(20:57)
May 29		18:49	
May 31		(18:28)	20:28
Jun 2			(20:07)
Jun 3		17:59	
Jun 4			(21:46)
Jun 5		19:38 *	
Jun 7		(19:17)	21:17
Jun 8		17:09	
Jun 9			(20:56)
Jun 10		18:48	
Jun 12		(18:27)	20:27
Jun 14			(20:06)
Jun 15		17:58	
Jun 17		19:37 *	
Jun 19		(19:16)	
Jun 20		17:08	
Jun 21			(20:55)
Jun 22		18:47	
Jun 24		(18:26)	20:26
Jun 26			(20:06)
Jun 27		17:57	
Jun 29		19:36 *	
Jul 1		(19:16)	
Jul 2		17:07	
Jul 4		18:47	

Date	1st	2nd	3rd
Jul 6		(18:26)	
Jul 8			(20:05)
Jul 9		17:57	
Jul 11		19:36 *	
Jul 13		(19:15)	
Jul 14		17:07	
Jul 16		18:46	
Jul 18		(18:25)	
Jul 21		17:56	
Jul 23		(17:35)	
Jul 25		(19:14)	
Jul 26		17:06	
Jul 28		18:45	
Jul 30		(18:25)	
Aug 2		17:55	
Sep 22	5:26		
Oct 1	(5:54)		
Oct 4	5:24		
Oct 6	(5:03)		
Oct 9	4:34		
Oct 13	(5:51)		
Oct 16	5:22		
Oct 18	(5:01)		
Oct 21	4:31		
Oct 23	(4:10)		
Oct 25	(5:49)		
Oct 26	3:40		
Oct 28	5:19 *		
Oct 30	(4:58)		
Oct 31	2:49		
Nov 2	4:28		
Nov 4	(4:07)		
Nov 7	3:37		
Nov 9	5:16 *		
Nov 11	(4:54)		
Nov 12	2:46		
Nov 14	4:25 *		
Nov 16	(4:03)		

Date	1st	2nd	3rd
Nov 17	1:55		
Nov 19	3:33		
Nov 21	(3:12)		
Nov 23	(4:50)		
Nov 24	2:42		
Nov 26	4:20 *		
Nov 28	(3:59)		
Nov 29	1:50		
Dec 1	3:29 *		
Dec 3	(3:07)		
Dec 4	0:59		
Dec 5	(4:46)		
Dec 6	2:37		
Dec 8	4:16 *		
Dec 10	(3:54)		
Dec 11	1:45		
Dec 12	(5:33)		
Dec 13	3:24 *		
Dec 15	5:02 *		
Dec 16	0:54		
Dec 17	(4:41)		
Dec 18	2:32 *		
Dec 20	4:10 *		
Dec 21	0:02		
Dec 22	(3:49)		
Dec 23	1:40		
Dec 24	(5:27)		
Dec 25	3:18 *		
Dec 27	4:56 *		
Dec 28	0:48		
Dec 29	(4:35)		
Dec 30	2:26 *		

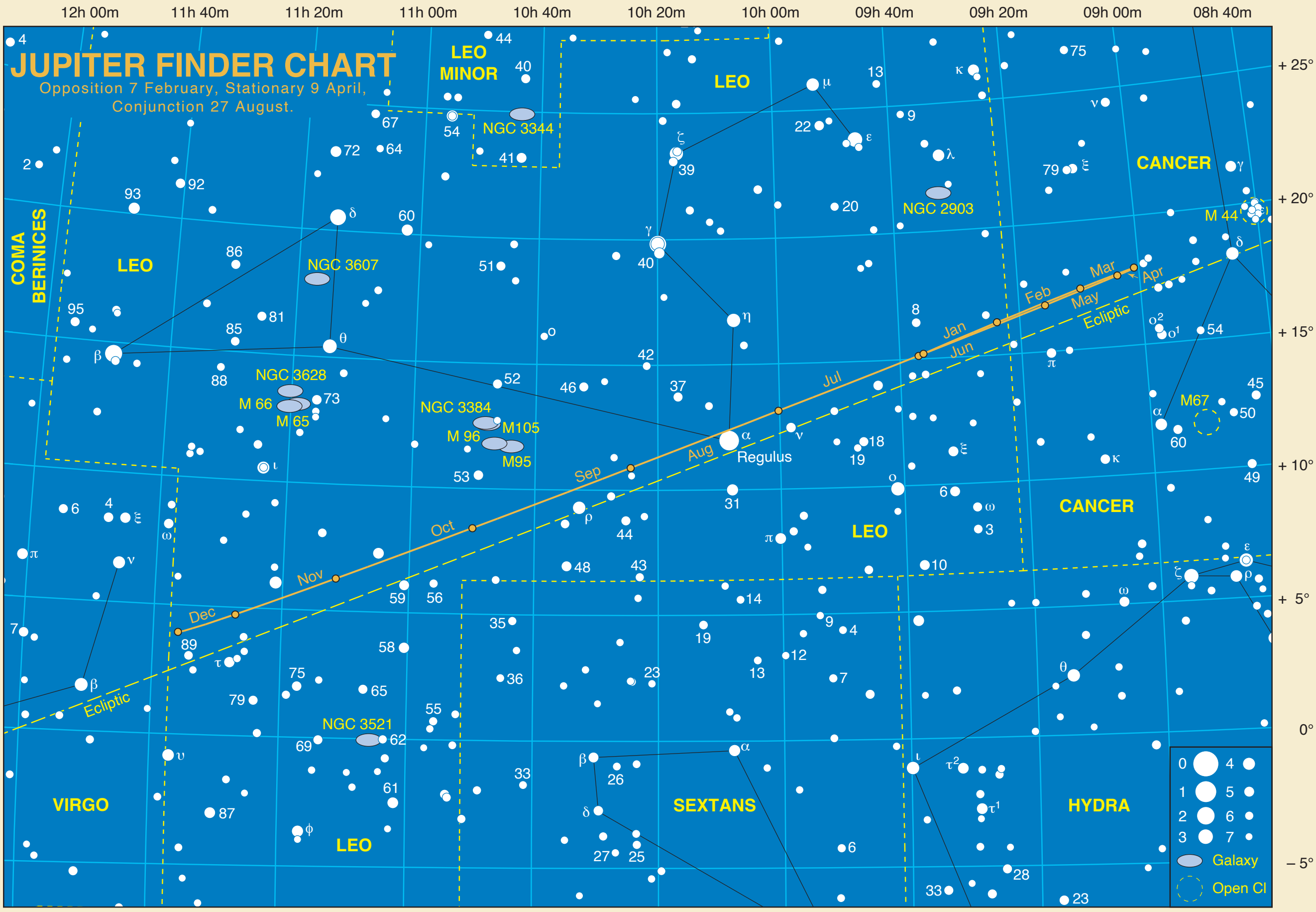
1st, 2nd or 3rd GRS

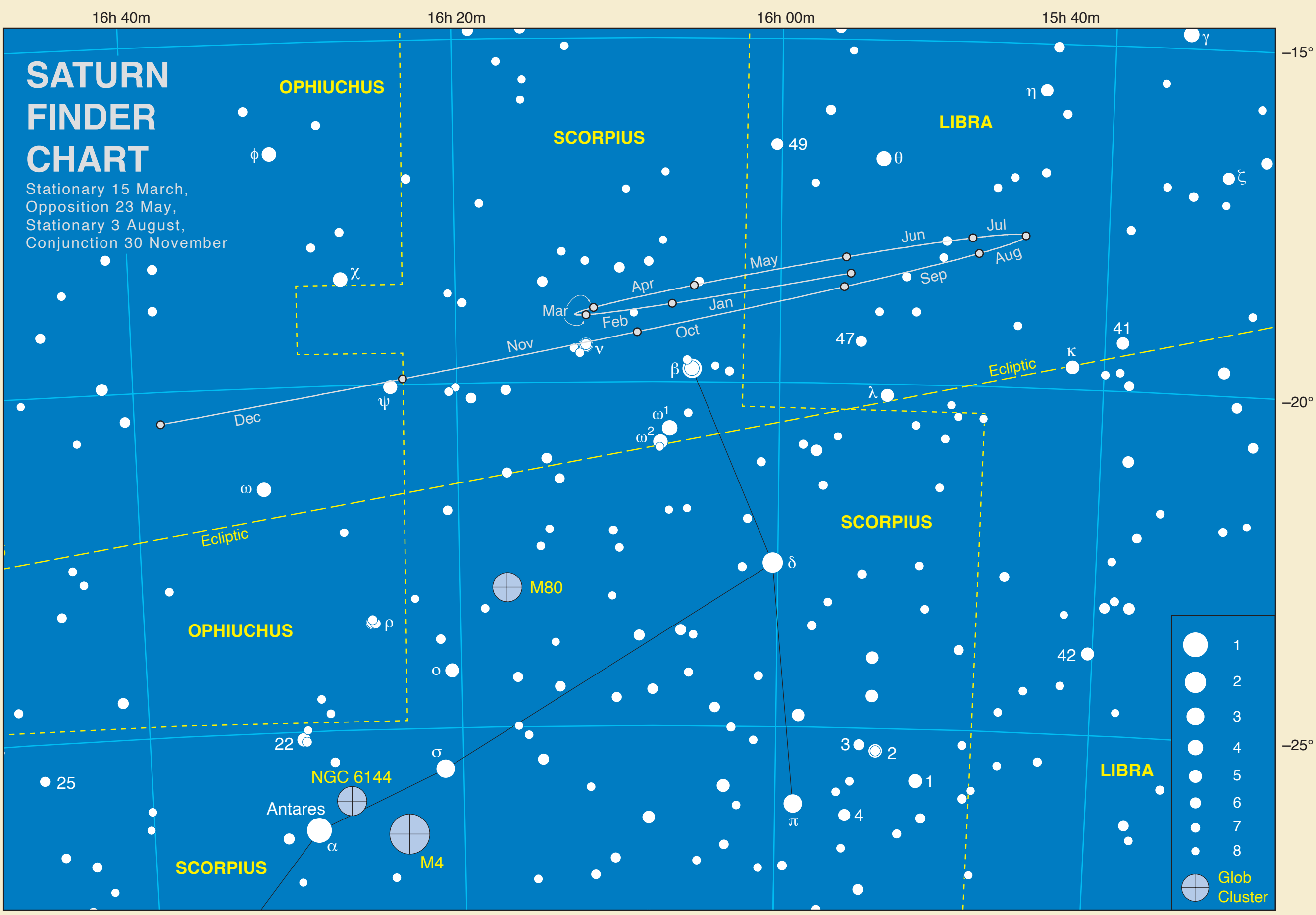
h:mm EST (Eastern only)
h:mm* EST (All States)
(h:mm) WST (WA only)

Predictions are shown for transit times for Sydney and Perth (giving a reasonable indication for eastern and western Australia). Times have been excluded when Jupiter is at conjunction (within 18° of the Sun) or below the horizon. If a transit is predicted when Jupiter is close to the horizon, the GRS may still be seen at least one hour before or after the time (allowing it to have some altitude). Predictions during daylight hours have also been omitted, except for those within 30 minutes after sunrise or 30 minutes before sunset. Even if there is a transit close to sunrise or sunset, the GRS can be seen well into the twilight period. For places that have extreme latitudes (such as Darwin or Hobart) you may need to check times against your local rise and set times for the Sun and Jupiter.

With a transit occurring every 9 hours 55 min 40 secs, two or three transits will occur every day, but a maximum of two are visible from most places. The three columns represent the 1st, 2nd and 3rd (when applicable) transits for each day for the relevant time zone. Note if the first transit for the day in EST is before 2 am, the event will be the last transit (3rd) for the previous day in WST (assuming Jupiter is visible). When the same numbered transit is visible accross the country, only the EST time is given followed by an asterisk (*). To get the WST time subtract two hours from the EST. For CST subtract 30 minutes from EST. For an event only visible from WA the time is given in brackets (WST). Daylight Saving is not allowed for and you will need to add one hour to the times in the table when in effect.

For example, on 5 March the first transit is only visible from WA at 1:31 am WST. The 3rd transit for the day is visible Australia wide at 23:22 EST or 11:22 pm EST (9:22 pm WST).


JUPITER FINDER CHART
Opposition 7 February, Stationary 9 April,
Conjunction 27 August.
12h 00m
11h 40m
11h 20m
11h 00m
10h 40m
10h 20m
10h 00m
09h 40m
09h 20m
09h 00m
08h 40m
+ 25°
+ 20°
+ 15°
+ 10°
+ 5°
0°
– 5°
LEO MINOR
LEO
COMA BERINICES
CANCER
VIRGO
SEXTANS
HYDRA
NGC 3344
NGC 3607
NGC 2903
NGC 3628
M 66
M 65
NGC 3384
M105
M 96
M95
NGC 3521
M 44
M67
Regulus
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Galaxy
Open Cl


SATURN FINDER CHART
Stationary 15 March,
Opposition 23 May,
Stationary 3 August,
Conjunction 30 November
16h 40m
16h 20m
16h 00m
15h 40m
–15°
–20°
–25°
OPHIUCHUS
SCORPIUS
LIBRA
M80
NGC 6144
Antares
M4
Ecliptic
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Glob Cluster

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

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

SATELLITES OF SATURN

These pages are designed to help you find the position of Saturn's major satellites. Note, dates and times on these two pages are given in day and fractions in UT. You will need to convert your local time to this format first. Table 3 will help.

On these pages we will use worked examples based on a diagram of the satellites configuration for 31 May 9 pm EST, see page 39.

Rhea and Dione

Table 1 presents the times of the first greatest elongation to the east for each month. This location is the day 0 (zero) point on the Apparent Orbits diagram. The procedure is to work out how many orbits have elapsed since the first elongation of the month, then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram below. You wish to determine the position of **Rhea** for the date above.

1. Convert to UT as a fractional day (table 3) = 31.458 UT.
2. Subtract the date of the greatest elongation east for Rhea for May, i.e., 31.458 – 1.613 = 29.845
3. Express this as the number of orbits by dividing by the period i.e., 29.845 / 4.518 = 6.606
4. Discard any completed orbits (6 in this case) leaves 0.606.
5. Multiply by the period, 0.606 × 4.518 = 2.737 days or about 2 days 18 hr.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is approximately half way between the 2d12h and 3h00m marker, in the northwest quadrant.

Table 1: **Saturn Satellites – Time of Greatest Elongation East** (dd.ddd UT)

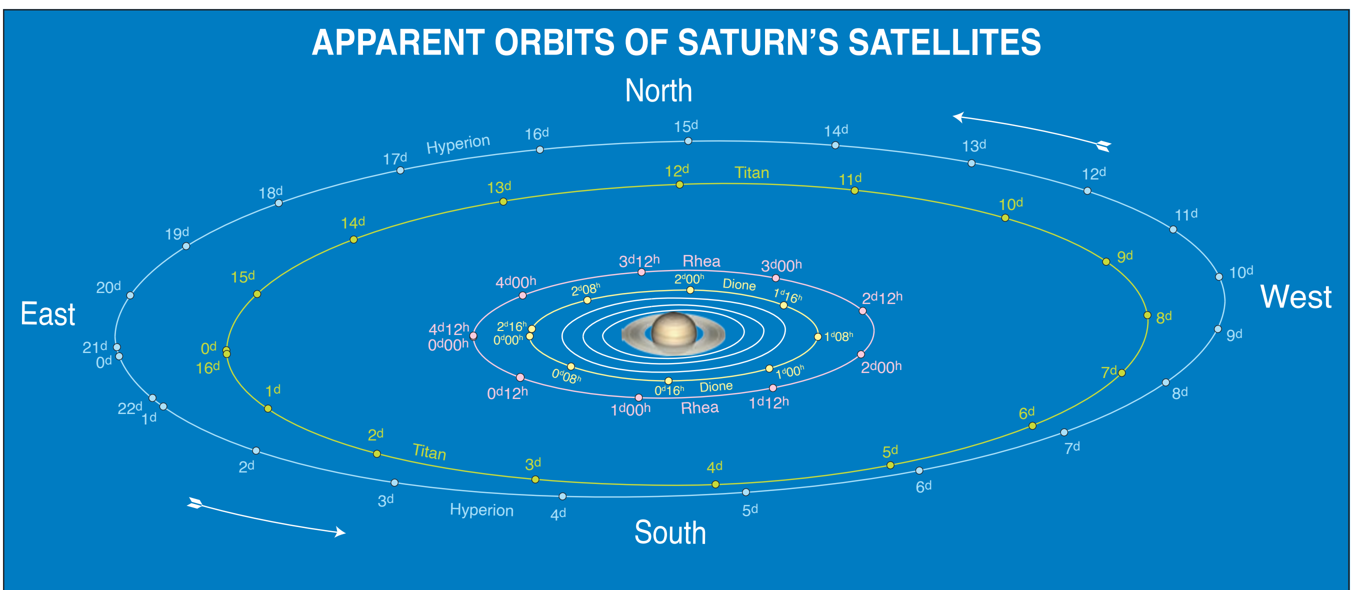
Moon	Mimas	Enceladus	Tethys	Dione	Rhea
Magnitude [1]	12.8	11.8	10.2	10.4	9.6
Max Elong. [1]	0' 30"	0' 38"	0' 48"	1' 01"	1' 25"
Period (days) [2]	0.942	1.370	1.888	2.737	4.518
Month	**Elongation East (d.ddd)**				
January	1.029	2.129	1.017	2.038	4.142
February	1.138	1.283	2.121	1.163	4.796
March	1.413	2.058	2.442	3.275	3.913
April	1.513	1.200	1.642	2.379	4.529
May	1.663	1.338	1.838	2.471	1.613
June	1.758	1.842	1.029	1.558	2.204
July	1.908	1.983	1.225	1.650	3.800
August	1.067	1.125	2.317	3.488	4.417
September	1.171	1.646	1.525	2.604	5.054
October	1.338	1.804	1.746	2.729	2.188
November	1.446	2.333	2.858	1.863	2.854
December	1.617	1.121	1.192	1.996	4.529

Notes 1. When at opposition 2. Mean Synodic Period

Mimas, Enceladus and Tethys

The procedure is similar to Rhea and Dione above with the times of the first greatest elongation east for each month also being listed in Table 1. However, these inner moons are so close to Saturn that while the orbits are represented on the diagram, it is difficult to put the day markers on and still have it readable. As above we calculate the fraction of the orbit and then estimate its position. Like the other major moons, these moons still orbit in the same direction (since the ring plane crossing, now moving anticlockwise), so three quarters of an orbit (0.75) would place it north of Saturn.

Estimate the position for Enceladus using the same date, May 31.458 UT; 21.985 orbits have elapsed since the first greatest elongation east for May on 1.338 UT. Discarding the 21 orbits leaves 0.985. This is very close to 1 so Enceladus has effectively returned to a maximum eastern elongation, i.e., due east.



Apparent orbits of the satellites on 23 May at 0hrs UT. Only the inner satellites are shown. Note the three inner orbits (shown in white) are for Mimas, Enceladus and Tethys (from inner to outer). The orbits of Iapetus and Phoebe are too large to show on the above diagram.

Titan and Hyperion

Because of their long orbital periods, compared to the moons shown opposite, it is possible to list all of their greatest elongations for the year (see Table 2). Therefore, all you need to do is work out the number of days that have elapsed since the most recent elongation and read this position directly off the diagram.

Using our previous example 31 May 9 pm EST (31.458 UT), Titan is 7.57 days past its most recent greatest elongation east (May 23.888 UT) which puts it due west of Saturn, near its maximum western elongation. The diagram on page 39 shows this very well.

Table 3
Converting Time in Australia to Universal Time (UT) *

EST	WST	Fraction of day (UT)
6 pm	4 pm	0.333
7 pm	5 pm	0.375
8 pm	6 pm	0.417
9 pm	7 pm	0.458
10 pm	8 pm	0.500
11 pm	9 pm	0.542
midnight	10 pm	0.583
1 am	11 pm	0.625
2 am	midnight	0.667
3 am	1 am	0.708
4 am	2 am	0.750
5 am	3 am	0.792
6 am	4 am	0.833
7 am	5 am	0.875
8 am	6 am	0.917

*After midnight it is still the previous day in UT, for example 1 am (EST) on the 21st = 20.625 days UT

Table 2
Time of Greatest Elongation East (UT)

Moon	Titan	Hyperion
Magnitude [1]	8.4	14.4
Max. Elong. [1]	3' 17"	3' 59"
Period (days) [2]	15.945	21.277
	Elongation (d.ddd)	
January	16.379	7.379
		28.700
February	1.379	18.954
	17.367	
March	5.333	12.167
	21.279	
April	6.204	2.308
	22.108	23.396
May	8.004	14.492
	23.888	
June	8.779	4.550
	24.675	25.629
July	10.583	16.808
	26.513	
August	11.458	7.008
	27.425	28.263
September	12.413	18.650
	28.413	
October	14.429	10.050
	30.458	31.488
November	15.492	22.025
December	1.529	13.542
	17.567	

Notes 1. When at opposition
2. Mean Synodic Period

Table 4: **Iapetus**

Magnitude [1] 11.0
Max Elong. [1] 9' 35"
Period (days) [2] 79.331

Elongation East		**Inferior Conjunction**		**Elongation West**		**Superior Conjunction**	
						Jan	2.221
Jan	22.338	Feb	10.404	Mar	3.083	Mar	23.438
Apr	11.967	Apr	30.546	May	20.413	Jun	9.725
Jun	28.800	Jul	17.858	Aug	6.621	Aug	27.717
Sep	16.213	Oct	5.850	Oct	26.325	Nov	16.713
Dec	6.675	Dec	26.163				

Notes 1. When at opposition 2. Mean Synodic Period

Iapetus

This moon's orbit is too large to place on the Apparent Orbits diagram. The shape of its orbit is similar to the others but more inclined and over twice the diameter of Hyperion's. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from stars of similar brightness. Table 4 shows this moon's greatest elongations east, inferior conjunctions (due south of Saturn), greatest elongations west and superior conjunctions (north of Saturn) for the year. Taking the same example date and time as above 31 May 9 pm EST (31.458 UT). The most recent event was a western elongation on May 20.413 UT. Iapetus is 11.045 days past this time, heading towards a superior conjunction, so it's in the northwest quadrant.

SATURN'S RINGS

Date	Major "	Minor "	U °	B °
Jan 2	35.30	14.67	108.70	24.55
Jan 10	35.61	14.86	109.54	24.67
Jan 18	35.97	15.07	110.31	24.77
Jan 26	36.36	15.28	111.00	24.85
Feb 3	36.80	15.50	111.61	24.91
Feb 11	37.26	15.72	112.11	24.95
Feb 19	37.75	15.95	112.52	24.98
Feb 27	38.26	16.17	112.80	25.00
Mar 7	38.78	16.39	112.98	25.00
Mar 15	39.30	16.60	113.03	24.98
Mar 23	39.81	16.80	112.97	24.95
Mar 31	40.30	16.97	112.79	24.91
Apr 8	40.75	17.13	112.51	24.86
Apr 16	41.15	17.26	112.12	24.80
Apr 24	41.49	17.35	111.65	24.72
May 2	41.75	17.41	111.10	24.64
May 10	41.94	17.43	110.50	24.56
May 18	42.05	17.41	109.87	24.47
May 26	42.06	17.36	109.22	24.38
Jun 3	41.98	17.27	108.58	24.29
Jun 11	41.82	17.15	107.97	24.21
Jun 19	41.57	17.00	107.40	24.14
Jun 27	41.26	16.84	106.90	24.08
Jul 5	40.88	16.65	106.49	24.04
Jul 13	40.45	16.46	106.16	24.01
Jul 21	39.98	16.26	105.93	24.00
Jul 29	39.48	16.07	105.81	24.02
Aug 6	38.97	15.88	105.80	24.05
Aug 14	38.45	15.70	105.90	24.10
Aug 22	37.94	15.53	106.11	24.17
Aug 30	37.44	15.38	106.43	24.26
Sep 7	36.96	15.24	106.85	24.36
Sep 15	36.51	15.13	107.37	24.47
Sep 23	36.10	15.03	107.98	24.60
Oct 1	35.71	14.94	108.68	24.73
Oct 9	35.37	14.88	109.45	24.87
Oct 17	35.08	14.83	110.29	25.02
Oct 25	34.83	14.81	111.19	25.16
Nov 2	34.63	14.80	112.14	25.30
Nov 10	34.47	14.81	113.13	25.44
Nov 18	34.37	14.83	114.15	25.57
Nov 26	34.32	14.88	115.18	25.69
Dec 4	34.32	14.94	116.23	25.80
Dec 12	34.37	15.01	117.27	25.90
Dec 20	34.48	15.11	118.30	25.99
Dec 28	34.63	15.22	119.30	26.07

The Appearance of the Planets diagrams in Part I show how open the rings are for 2015. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn'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 seven 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 last edge-on during 2009. During 2015 they are continuing to open up, by year's end reaching 26°.

Major and minor axes (in arcseconds) 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.

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr 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 3	12:23	00:06	11:53	23:37	12:11	23:50	12:46	00:45	12:22	23:54	12:29	00:09	12:22	00:08	12:02	23:42	00 46 44	+ 04 17 59
10	11:56	23:35	11:25	23:10	11:44	23:23	12:19	00:18	11:55	23:27	12:02	23:38	11:55	23:37	11:35	23:15	00 47 04	+ 04 20 26
17	11:29	23:08	10:59	22:43	11:17	22:55	11:52	23:47	11:28	22:59	11:35	23:11	11:29	23:10	11:08	22:48	00 47 34	+ 04 23 50
24	11:02	22:41	10:32	22:16	10:50	22:28	11:25	23:20	11:02	22:32	11:08	22:44	11:02	22:43	10:41	22:20	00 48 12	+ 04 28 08
31	10:36	22:14	10:05	21:49	10:24	22:01	10:59	22:53	10:35	22:05	10:42	22:17	10:35	22:16	10:15	21:54	00 48 59	+ 04 33 19
Feb 7	10:09	21:47	09:39	21:22	09:58	21:34	10:32	22:27	10:09	21:38	10:15	21:50	10:09	21:49	09:49	21:27	00 49 53	+ 04 39 16
14	09:43	21:20	09:12	20:56	09:31	21:08	10:06	22:00	09:43	21:11	09:49	21:23	09:43	21:22	09:22	21:00	00 50 55	+ 04 45 56
21	09:17	20:53	08:46	20:29	09:05	20:41	09:40	21:34	09:17	20:44	09:23	20:56	09:17	20:55	08:56	20:33	00 52 02	+ 04 53 15
28	08:51	20:26	08:20	20:02	08:39	20:14	09:13	21:07	08:51	20:18	08:57	20:29	08:51	20:29	08:30	20:06	00 53 16	+ 05 01 07
Mar 7	08:25	20:00	07:54	19:36	08:14	19:48	08:47	20:41	08:25	19:51	08:31	20:03	08:25	20:02	08:04	19:40	00 54 34	+ 05 09 27
14	08:00	19:33	07:29	19:09	07:48	19:21	08:21	20:14	08:00	19:24	08:06	19:36	07:59	19:36	07:39	19:13	00 55 56	+ 05 18 08
21	07:34	19:07	07:03	18:43	07:22	18:55	07:55	19:48	07:34	18:58	07:40	19:10	07:33	19:09	07:13	18:47	00 57 21	+ 05 27 07
28	07:08	18:40	06:37	18:17	06:56	18:28	07:29	19:22	07:09	18:31	07:14	18:43	07:07	18:43	06:47	18:20	00 58 49	+ 05 36 16
Apr 4	06:43	18:14	06:11	17:50	06:31	18:02	07:03	18:56	06:43	18:04	06:49	18:16	06:42	18:16	06:22	17:54	01 00 17	+ 05 45 31
11	06:17	17:47	05:46	17:24	06:05	17:35	06:37	18:30	06:18	17:38	06:23	17:50	06:16	17:50	05:56	17:27	01 01 46	+ 05 54 45
18	05:51	17:21	05:20	16:57	05:40	17:09	06:12	18:03	05:52	17:11	05:58	17:23	05:50	17:23	05:30	17:01	01 03 15	+ 06 03 53
25	05:26	16:54	04:54	16:31	05:14	16:42	05:46	17:37	05:27	16:44	05:32	16:57	05:25	16:57	05:05	16:34	01 04 42	+ 06 12 51
May 2	05:00	16:28	04:28	16:05	04:48	16:16	05:20	17:11	05:01	16:18	05:06	16:30	04:59	16:30	04:39	16:08	01 06 07	+ 06 21 32
9	04:34	16:01	04:02	15:38	04:23	15:49	04:54	16:45	04:36	15:51	04:41	16:04	04:33	16:04	04:13	15:41	01 07 29	+ 06 29 51
16	04:08	15:35	03:36	15:12	03:57	15:22	04:27	16:18	04:10	15:24	04:15	15:37	04:07	15:37	03:47	15:15	01 08 47	+ 06 37 45
23	03:43	15:08	03:10	14:45	03:31	14:56	04:01	15:52	03:44	14:58	03:49	15:10	03:41	15:11	03:21	14:48	01 10 01	+ 06 45 09
30	03:16	14:41	02:44	14:18	03:05	14:29	03:35	15:26	03:18	14:31	03:23	14:44	03:15	14:44	02:55	14:21	01 11 09	+ 06 51 58
Jun 6	02:50	14:14	02:18	13:52	02:39	14:02	03:09	14:59	02:52	14:04	02:57	14:17	02:49	14:17	02:29	13:55	01 12 11	+ 06 58 08
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20	01:57	13:21	01:25	12:58	01:46	13:08	02:15	14:05	01:59	13:10	02:04	13:23	01:56	13:23	01:36	13:01	01 13 56	+ 07 08 20
27	01:31	12:54	00:58	12:31	01:19	12:41	01:49	13:39	01:33	12:43	01:37	12:56	01:29	12:56	01:10	12:34	01 14 36	+ 07 12 16
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11	00:37	11:59	00:04	11:37	00:25	11:47	00:55	12:44	00:39	11:48	00:44	12:02	00:36	12:02	00:16	11:40	01 15 33	+ 07 17 34
18	00:10	11:32	23:33	11:09	23:54	11:20	00:27	12:17	00:12	11:21	00:16	11:34	00:08	11:35	23:45	11:12	01 15 48	+ 07 18 54
25	23:38	11:05	23:06	10:42	23:27	10:52	23:56	11:50	23:41	10:54	23:45	11:07	23:37	11:07	23:17	10:45	01 15 55	+ 07 19 20
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NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		RA	Dec
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10	08:58	21:59	08:38	21:24	08:46	21:47	09:50	22:10	08:44	22:04	08:59	22:07	09:02	21:57	08:39	21:38	22 30 01	– 10 12 20
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24	08:05	21:05	07:45	20:30	07:53	20:54	08:56	21:17	07:51	21:10	08:06	21:13	08:09	21:03	07:46	20:44	22 31 39	– 10 02 42
31	07:39	20:38	07:19	20:03	07:26	20:27	08:30	20:50	07:25	20:43	07:40	20:46	07:43	20:36	07:19	20:17	22 32 33	– 09 57 24
Feb 7	07:13	20:11	06:52	19:37	07:00	20:00	08:03	20:23	06:59	20:16	07:14	20:19	07:16	20:09	06:53	19:50	22 33 29	– 09 51 51
14	06:46	19:45	06:26	19:10	06:34	19:33	07:37	19:57	06:33	19:50	06:48	19:52	06:50	19:42	06:27	19:23	22 34 28	– 09 46 09
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Jul 4	21:46	10:42	21:25	10:08	21:33	10:30	22:34	10:56	21:33	10:46	21:47	10:49	21:49	10:40	21:26	10:21	22 45 22	– 08 45 04
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28	11:55	00:57	11:35	00:22	11:43	00:45	12:46	01:09	11:41	01:02	11:56	01:05	11:59	00:55	11:36	00:36	22 35 25	– 09 45 11
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12	11:01	23:58	10:40	23:24	10:48	23:47	11:51	00:15	10:47	00:07	11:02	00:10	11:04	23:56	10:41	23:37	22 35 55	– 09 42 01
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26	10:07	23:04	09:46	22:29	09:54	22:52	10:57	23:17	09:53	23:09	10:08	23:12	10:10	23:02	09:47	22:43	22 36 49	– 09 36 29

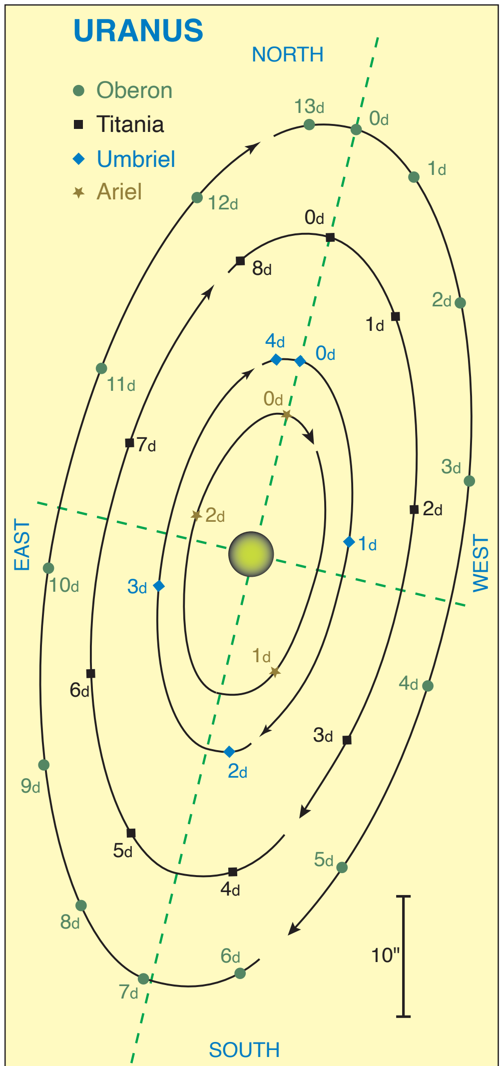
SATELLITES OF URANUS AND NEPTUNE

This page helps you find the position of Uranus' major satellites and Neptune's moon Triton. All dates and times are given in day and fractions of a day in UT. You will need to convert your local time to this format first. Table 1 will help.

URANUS

Table 2 presents the times of the first greatest elongation to the *north* for each month for **Ariel**, **Umbriel**, **Titania and Oberon**. This location is the day 0 (zero) point on the Apparent Orbits diagram. As with Saturn's satellites, the procedure is to work out how many orbits have elapsed since the first elongation of the month. Then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of **Umbriel** for 26 October at 1 am WST.

1. Convert to UT as a fractional day. 26 October at 1 am (WST) = 25.708 UT
2. Subtract the date of the greatest elongation north for October, i.e. 25.708 – 4.025 = 21.683 days
3. Divide by the period to get the number of orbits, i.e. 21.683 / 4.144 = 5.232
4. Discard any completed orbits leaves 0.232 (about a quarter of the way around its orbit)
5. Multiply by the period, 0.232 × 4.144 = 0.963 days (or 0 days 23.1 hours)
6. Looking at the orbital path for Umbriel (see Apparent Orbits diagram), the satellite is very close to the 1 day marker, that is nearly due west of Uranus.



Apparent orbits of Uranus' satellites I–IV as at the date of opposition, 12 October.

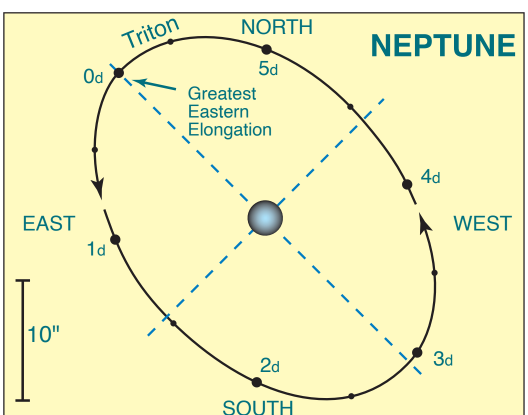
NEPTUNE

Table 1: **Converting Time in Australia to Universal Time (UT) ***		
EST	WST	Fraction of day (UT)
6 pm	4 pm	0.333
7 pm	5 pm	0.375
8 pm	6 pm	0.417
9 pm	7 pm	0.458
10 pm	8 pm	0.500
11 pm	9 pm	0.542
midnight	10 pm	0.583
1 am	11 pm	0.625
2 am	midnight	0.667
3 am	1 am	0.708
4 am	2 am	0.750
5 am	3 am	0.792
6 am	4 am	0.833
7 am	5 am	0.875
8 am	6 am	0.917

* After midnight it is still the previous day in UT, for example 1 am (EST) on the 21st = 20.625 days UT

The procedure for finding Neptune's major satellite **Triton** is identical to above, except the times of the first greatest elongation *east* for each month is listed in Table 2. The orientation of Triton's orbit places this day 0 (zero) point closer to northeast of Neptune (see diagram).

An example. Estimate the position for Triton for September 19 at 10 pm EST. 2.510 orbits have elapsed since its greatest elongation east on Sep 4.746 UT. Discarding the two orbits leaves 0.510. Multiplying by 5.877 (its period) gives 3.00 days. From the diagram the moon is southwest of Neptune on the 3 day mark, diagonally opposite the greatest eastern elongation point in the orbit.



Apparent orbit of Triton at date of opposition, 1 September.

Table 2: **Time of Greatest Elongation North or East** (UT)					
Planet	**Uranus**				**Neptune**
Moon	**Ariel**	**Umbriel**	**Titania**	**Oberon**	**Triton**
Magnitude [1]	13.7	14.5	13.5	13.7	13.5
Max Elong. [1]	0' 14"	0' 20"	0' 33"	0' 44"	0' 17"
Period (days) [2]	2.520	4.144	8.706	13.463	5.877
Month	**Elongation North (d.ddd)**				**East** (d.ddd)
January	1.142	3.525	2.729	5.871	6.854
February	2.908	1.538	6.554	1.796	5.221
March	2.633	2.546	4.667	14.179	6.583
April	1.879	4.696	8.483	10.100	4.950
May	2.121	3.704	4.596	7.017	4.317
June	1.363	1.708	8.413	2.933	2.692
July	1.600	4.858	4.525	13.317	2.075
August	3.363	2.863	8.346	9.238	6.346
September	2.608	5.017	3.463	5.167	4.746
October	2.850	4.025	8.288	2.096	4.142
November	2.096	2.038	3.413	11.492	2.538
December	2.346	1.050	8.238	8.425	1.925

Notes 1. When at opposition 2. Sidereal Period

PLUTO

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

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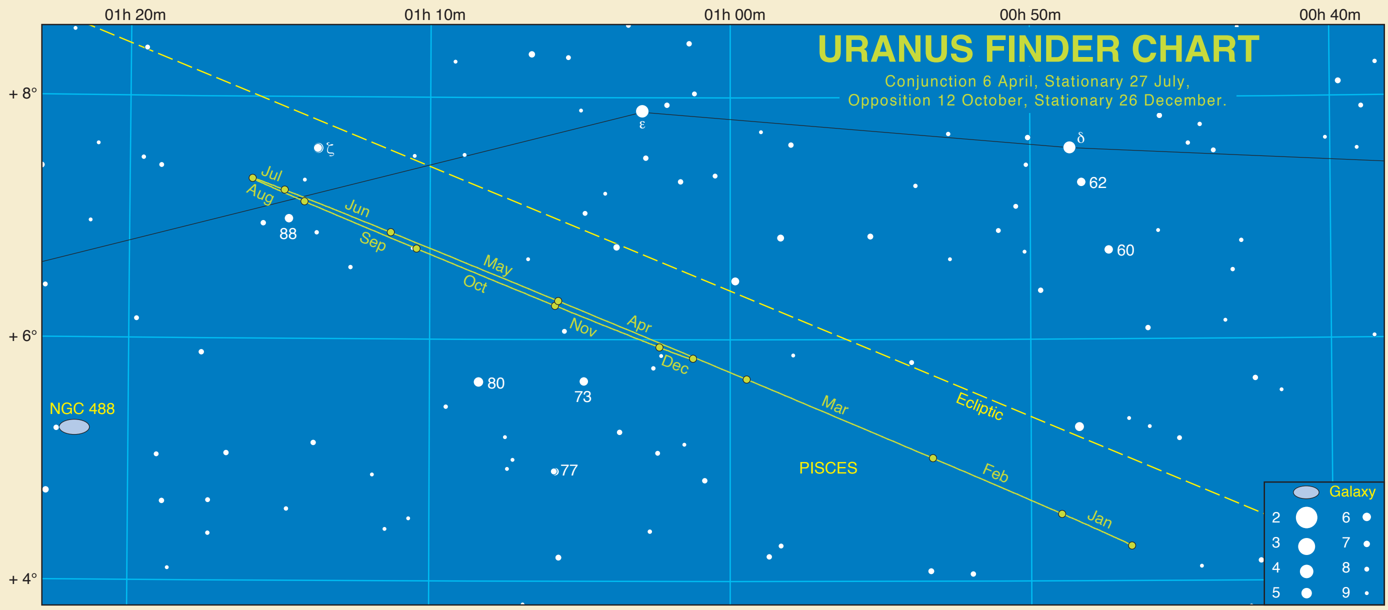
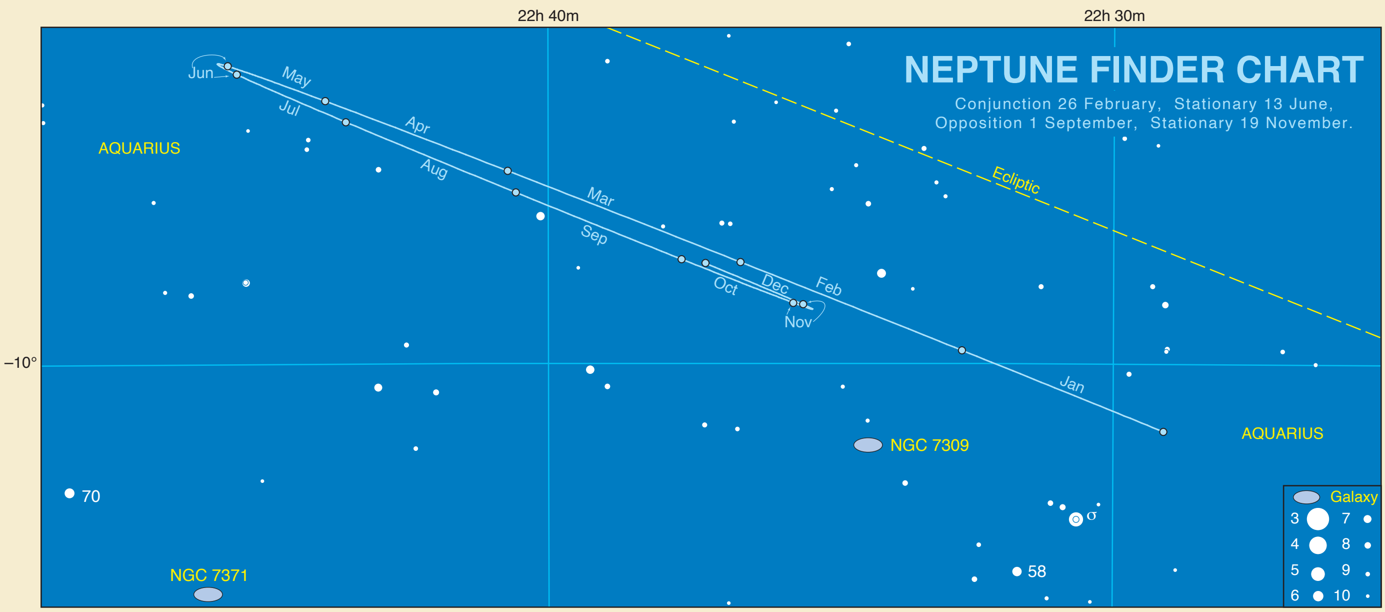
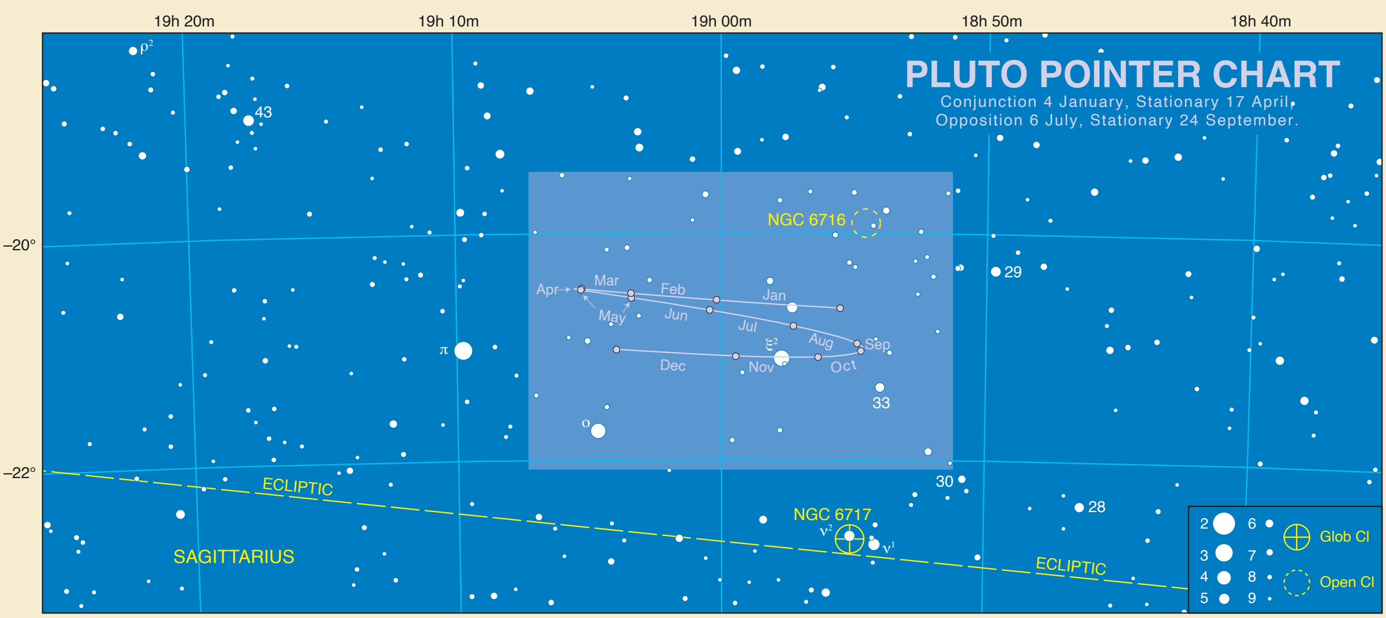
Jul 4	17:25	07:35	17:13	06:51	17:12	07:23	18:39	07:23	16:59	07:51	17:22	07:46	17:32	07:29	17:07	07:12	19 00 22	– 20 42 45
11	16:56	07:06	16:45	06:23	16:43	06:55	18:10	06:55	16:31	07:23	16:54	07:18	17:04	07:01	16:38	06:44	18 59 38	– 20 44 33
18	16:28	06:38	16:16	05:55	16:15	06:27	17:42	06:27	16:02	06:55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

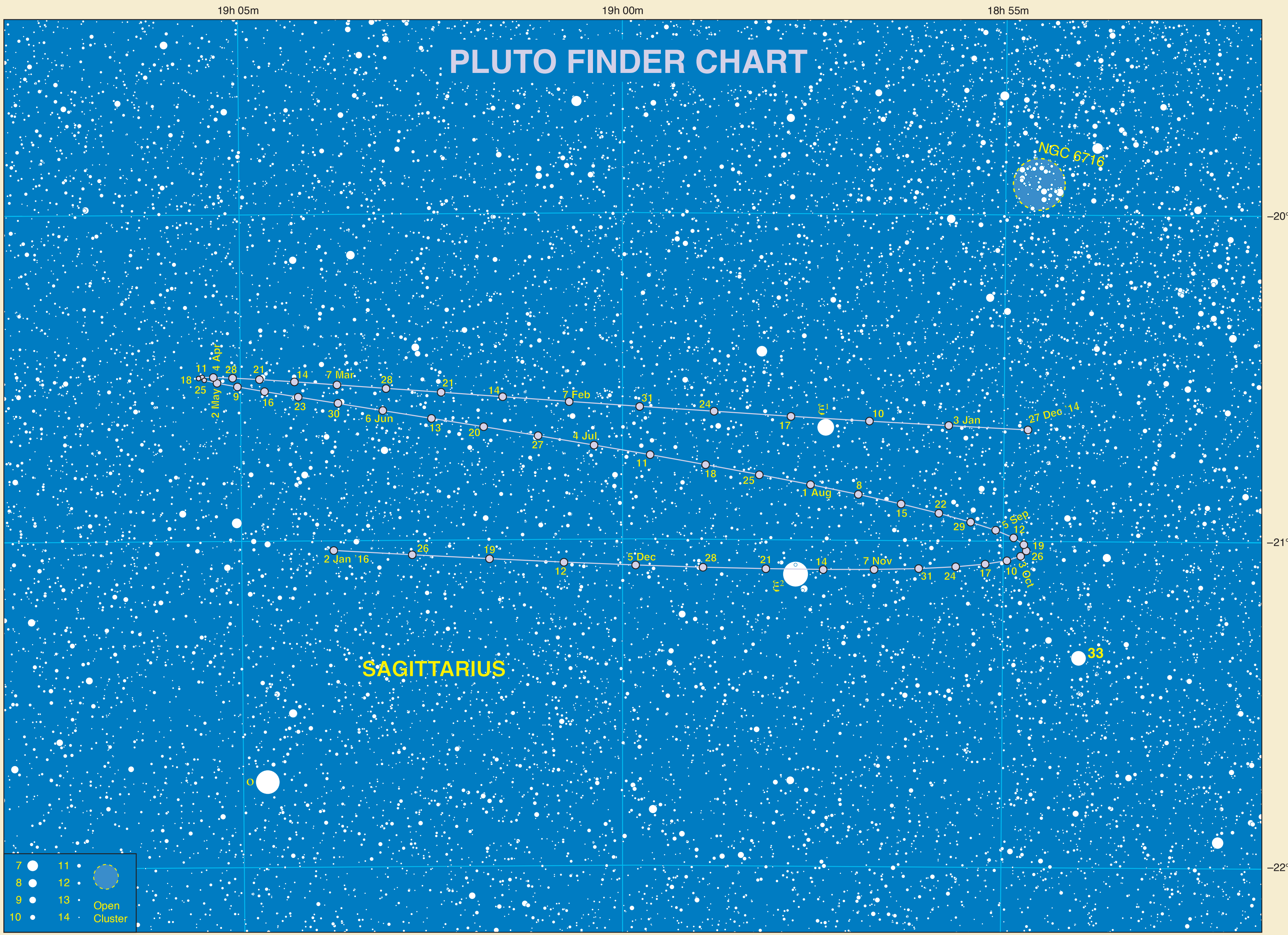

URANUS FINDER CHART
Conjunction 6 April, Stationary 27 July,
Opposition 12 October, Stationary 26 December.
01h 20m
01h 10m
01h 00m
00h 50m
00h 40m
+ 8°
+ 6°
+ 4°
ζ
ε
δ
62
60
88
80
73
77
Jul
Aug
Jun
Sep
May
Oct
Apr
Nov
Dec
Mar
Feb
Jan
Ecliptic
NGC 488
PISCES
Galaxy
2
3
4
5
6
7
8
9


NEPTUNE FINDER CHART
Conjunction 26 February, Stationary 13 June,
Opposition 1 September, Stationary 19 November.
22h 40m
22h 30m
−10°
AQUARIUS
Jun
May
Jul
Apr
Aug
Mar
Sep
Dec
Feb
Oct
Nov
Jan
Ecliptic
NGC 7309
NGC 7371
70
58
σ
AQUARIUS
Galaxy
3
4
5
6
7
8
9
10


PLUTO POINTER CHART
Conjunction 4 January, Stationary 17 April,
Opposition 6 July, Stationary 24 September.
19h 20m
19h 10m
19h 00m
18h 50m
18h 40m
−20°
−22°
ρ²
43
NGC 6716
29
Apr
Mar
Feb
Jan
May
Jun
Jul
Aug
Sep
Dec
Nov
Oct
ξ²
π
33
ο
30
28
ECLIPTIC
NGC 6717
ν²
ν¹
SAGITTARIUS
ECLIPTIC
2
3
4
5
6
7
8
9
Glob Cl
Open Cl

PLUTO

PLUTO FINDER CHART



COMETS FOR 2015

WHAT IS A COMET? It is a member of the Solar System, which is normally in a highly elongated orbit around the Sun. The orbits of periodic or regularly reappearing comets, are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive, containing significant quantities 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, 2P/Encke, takes just over three 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 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 ionised 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 dust grains that trail behind the comet along the path it has travelled. The lost material from the coma will continue to be replenished from the nucleus while 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/’ means the comet is periodic. The number before the ‘P’ indicates the number of the periodic comet. For example Comet 88P/Howell indicates Howell was the 88th comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. You will also see references to another naming system, best explained with an example. Comet PANSTARRS is referred to as ‘C/2012 K1’. 2012 refers to the year of the discovery, K is the 10th half-month period (‘I’ is not used) during the year and 1 shows it was the first discovery in this half month. Therefore C/2012 K1 (PANSTARRS) was the first comet discovered in the second half of May 2012.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbit, overall brightness, size of the coma and tail can vary dramatically from comet to comet and even from 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 brightest comets that are expected to be observable during 2015, most of them passing through perihelion – closest approach to the Sun – during this year. The table opposite lists the comets along with their orbital elements that are expected to brighten to at least 13th magnitude sometime during 2015. This is the data required to calculate their locations in the sky. The elements are followed by *ephemerides* (a list of expected positions in the sky and magnitude estimates for different dates). These positions can be plotted on the All Sky Maps to get an idea of where they are in the sky. 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 be considered unfavourable.

There are many other comets, not listed here that are expected in 2015, but they are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

Comet McNaught by Ted Dobosz. Taken from Woodford (Blue Mountains) Jan 20 2007.

NOTES ON SELECTED COMETS FOR 2015

Greg Bryant

10P/Tempel 2: This comet was discovered by Ernst Wilhelm Liebrecht Tempel (Marseille, France) in July 1873. At this time, the comet was probably close to maximum brightness, thereafter fading as it moved away from both the Sun and Earth. Quickly recognised as a new short period comet, it was successfully recovered by Tempel himself in July 1878. The comet has been observed on most returns, having been missed five times due to a poor placement at the time of perihelion. It was last missed in 1941.

Comet Tempel 2’s most favourable return was in 1925, when the comet’s perihelion nearly coincided with its closest approach to Earth of 0.35 au, leading to the comet reaching magnitude 6.5. In the past, occasional jumps in brightness have occurred, typically within a week or two following perihelion, and in the order of 2 to 3 magnitudes.

2015’s return of comet Tempel 2 will see it brighten to 12th magnitude by July and peak at 10th magnitude in November, finishing the year low in the early western evening sky. It reaches perihelion on November 14 at a distance of 1.4 au from the Sun.

22P/Kopff: German astronomer August Kopff discovered this comet on photographs taken in August 1906. The 12th magnitude comet was revealed to be periodic within a few weeks, although the subsequent return of 1912–13 was too unfavourable for recovery. 1919 saw the comet recovered by Max Wolf quite close to the predicted position.

Since 1919, Kopff has been seen at every apparition. Its return in 1996 was extremely favourable, with the comet's closest approach to Earth (0.57 au) occurring just days after perihelion. As a result, the comet rose to better than 8th magnitude in brightness.

In 2015, comet Kopff returns to perihelion on October 25 but is only expected to be 12th magnitude during the second half of the year.

88P/Howell: Ellen Howell discovered this comet on photographic plates taken in August 1981 with the 0.46-metre Schmidt telescope at Palomar. Within a fortnight, the periodic nature of the comet was confirmed. Three close approaches to Jupiter during the 20th century have progressively brought the comet closer to the Sun, from a minimum distance of 2 au to the current 1.4 au. Jupiter will play a role again later this century, pushing the comet out again. This is the 7th observed apparition of comet Howell and this year it is expected to reach 9th magnitude in autumn. Perihelion is on April 6th.

C/2012 K1 (PANSTARRS): The Panoramic Survey Telescope And Rapid Response System (PanSTARRs) in Hawaii has discovered 53 comets as at the time of writing. PANSTARRS was found on May 19, 2012. Reaching perihelion in August 2014, it was predicted to brighten to 6th magnitude in Spring 2014. In 2015, the comet should be 10th magnitude as the year opens, fading to 12th magnitude by the end of February.

C/2013 US_{10} (Catalina): The Catalina Sky Survey, operating from Arizona, has 123 comets named after it as of June 2014. On October 31, 2013, it discovered an apparently asteroidal object. Subsequent observations revealed it to be a long-period comet, reaching perihelion two years after discovery on November 15, 2015 at a distance of 0.8 au from the Sun. 2015 should see comet Catalina brighten to 12th magnitude by May, and then perhaps reach 6th magnitude in October before it is lost in the evening twilight. At the end of 2015, it may be sighted post-perihelion at around 6th magnitude again in the dawn sky.

BIOGRAPHICAL NOTE – *Greg Bryant* is Editor of *Australian Sky & Telescope* magazine and can be reached at greg@skyandtelescope.com.au. He enjoys noting each year's new comet discoveries.

BRIGHT COMETS FOR 2015 – ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
C/2012 K1 (PANSTARRS)	2014 08 27.6556	1.054530	1.000210		203.1078	317.7380	142.4283	4.5	10.0
88P/Howell	2015 04 06.2611	1.358852	0.562913	5.5	235.9086	56.7020	4.3824	3.5	30.0
C/2013 US_{10} (Catalina)	2015 11 15.7474	0.822917	1.000292		340.3628	186.1440	148.8770	5.0	10.0
22P/Kopff	2015 10 25.1074	1.561519	0.547341	6.4	162.7618	120.8726	4.7369	7.0	15.0
10P/Tempel 2	2015 11 14.3941	1.418763	0.536983	5.4	195.5242	117.8087	12.0292	5.0	25.0

COMET ELEMENTS (above)

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 or greater than one indicates: an open orbit (a once only visitor to the Solar System), it has a very long period (thousands of years) or it is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period (time taken for one orbit of the Sun) in years.

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. A value greater than 90° means the comet's orbit direction is retrograde (moves 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' opposite for further details).

Calculation of ephemerides from these elements is complex (but not difficult, with the power of home computers) but beyond the scope of this book.

COMET EPHEMERIDES (next page)

Date at 0 hr UT (10 am EST, 9:30 am CST and 8 am WST).

RA, 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.

Rise, Transit, Set Times given are approximate and will vary between locations. Where no rise or set time is given, the comet is circumpolar.

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: $\text{Mag} = H1 + 5 \log(\Delta) + K1 \log R$

See the table of elements for the values of H1 and K1, above. For many comets the K1 value is equal to 10. For newly discovered comets the value of K1 is mostly 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. In fact, it is now believed that comets making their first visit to the Sun have an average K1 value of approximately 7.5. 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/2013 US_{10} (Catalina)

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
2015 May 2	23 34.0	−22 18	3.534	3.118	01:46	08:52	15:57	58.0°	12.7
2015 May 9	23 38.4	−22 47	3.344	3.035	01:22	08:29	15:36	63.7°	12.4
2015 May 16	23 42.7	−23 26	3.148	2.951	00:56	08:06	15:15	69.6°	12.2
2015 May 23	23 46.7	−24 18	2.947	2.867	00:29	07:43	14:54	75.5°	11.9
2015 May 30	23 50.3	−25 27	2.742	2.781	00:01	07:19	14:34	81.6°	11.6
2015 Jun 6	23 53.4	−26 54	2.535	2.695	23:28	06:54	14:15	87.9°	11.3
2015 Jun 13	23 55.8	−28 46	2.329	2.609	22:56	06:29	13:57	94.2°	11.0
2015 Jun 20	23 57.3	−31 08	2.124	2.521	22:20	06:03	13:40	100.8°	10.7
2015 Jun 27	23 57.5	−34 07	1.925	2.432	21:41	05:36	13:26	107.5°	10.3
2015 Jul 4	23 55.8	−37 55	1.735	2.343	20:53	05:06	13:14	114.2°	9.9
2015 Jul 11	23 51.1	−42 40	1.558	2.253	19:54	04:34	13:09	120.7°	9.5
2015 Jul 18	23 41.4	−48 34	1.399	2.162	18:30	03:57	13:19	126.3°	9.1
2015 Jul 25	23 22.7	−55 39	1.266	2.071		03:11		130.0°	8.7
2015 Aug 1	22 45.5	−63 31	1.166	1.979		02:06		130.1°	8.3
2015 Aug 8	21 27.7	−70 46	1.106	1.886		00:27		125.5°	8.0
2015 Aug 15	19 08.1	−73 48	1.090	1.792		21:31		116.9°	7.7
2015 Aug 22	16 58.2	−70 16	1.114	1.699		18:54		106.0°	7.5
2015 Aug 29	15 50.0	−63 38	1.171	1.605		17:18		94.5°	7.4
2015 Sep 5	15 16.4	−56 52	1.252	1.511		16:16		83.2°	7.3
2015 Sep 12	14 58.3	−50 52	1.347	1.418	05:41	15:32	01:25	72.5°	7.2
2015 Sep 19	14 47.8	−45 45	1.446	1.326	05:54	14:53	23:52	62.5°	7.0
2015 Sep 26	14 41.2	−41 25	1.544	1.236	05:50	14:19	22:47	53.1°	6.9
2015 Oct 3	14 36.8	−37 41	1.633	1.149	05:39	13:47	21:55	44.1°	6.7
2015 Oct 10	14 33.6	−34 23	1.710	1.067	05:24	13:16	21:08	35.4°	6.4
2015 Oct 17	14 31.0	−31 22	1.770	0.992	05:07	12:46	20:25	27.1°	6.2
2015 Oct 24	14 28.7	−28 31	1.808	0.927	04:48	12:16	19:44	19.1°	6.0
2015 Oct 31	14 26.6	−25 43	1.822	0.875	04:28	11:47	19:04	12.0°	5.7
2015 Nov 7	14 24.5	−22 52	1.807	0.839	04:08	11:17	18:24	8.5°	5.5
2015 Nov 14	14 22.5	−19 53	1.762	0.824	03:49	10:47	17:46	12.4°	5.4
2015 Nov 21	14 20.8	−16 41	1.687	0.829	03:30	10:18	17:06	19.9°	5.3
2015 Nov 28	14 19.5	−13 09	1.585	0.855	03:11	09:50	16:27	28.2°	5.3
2015 Dec 5	14 18.6	−09 06	1.461	0.899	02:54	09:21	15:47	37.1°	5.4
2015 Dec 12	14 18.0	−04 18	1.319	0.958	02:39	08:53	15:06	46.4°	5.4
2015 Dec 19	14 17.3	+01 41	1.169	1.029	02:27	08:24	14:21	56.3°	5.5
2015 Dec 26	14 16.2	+09 30	1.018	1.108	02:19	07:56	13:32	67.2°	5.5
2016 Jan 2	14 13.5	+20 03	0.880	1.192	02:20	07:26	12:31	79.3°	5.5
2016 Jan 9	14 07.5	+34 12	0.775	1.281	02:37	06:52	11:06	92.7°	5.5

Comet 88P/Howell

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
2015 Jan 3	16 28.9	− 21 27	2.419	1.684	02:32	09:36	16:39	33.2°	12.2
2015 Jan 10	16 50.8	− 22 20	2.347	1.644	02:24	09:30	16:36	35.2°	11.8
2015 Jan 17	17 13.6	− 23 04	2.277	1.605	02:16	09:25	16:33	37.0°	11.4
2015 Jan 24	17 37.2	− 23 36	2.210	1.568	02:11	09:21	16:31	38.7°	11.1
2015 Jan 31	18 01.6	− 23 56	2.147	1.533	02:07	09:18	16:29	40.2°	10.7
2015 Feb 7	18 26.6	− 24 02	2.087	1.500	02:04	09:16	16:27	41.6°	10.4
2015 Feb 14	18 52.3	− 23 53	2.032	1.470	02:02	09:14	16:24	42.8°	10.1
2015 Feb 21	19 18.2	− 23 28	1.982	1.443	02:02	09:12	16:21	43.9°	9.8
2015 Feb 28	19 44.4	− 22 48	1.936	1.419	02:03	09:11	16:18	45.0°	9.5
2015 Mar 7	20 10.5	− 21 51	1.896	1.399	02:05	09:09	16:13	45.9°	9.3
2015 Mar 14	20 36.5	− 20 40	1.860	1.383	02:07	09:07	16:08	46.7°	9.1
2015 Mar 21	21 02.0	− 19 15	1.830	1.371	02:09	09:05	16:01	47.5°	8.9
2015 Mar 28	21 27.0	− 17 38	1.805	1.363	02:11	09:03	15:54	48.3°	8.8
2015 Apr 4	21 51.4	− 15 52	1.784	1.359	02:14	09:00	15:45	49.1°	8.8
2015 Apr 11	22 15.0	− 13 58	1.766	1.360	02:15	08:56	15:36	50.0°	8.7
2015 Apr 18	22 37.8	− 11 59	1.753	1.365	02:16	08:51	15:25	51.0°	8.8
2015 Apr 25	22 59.8	− 09 57	1.742	1.375	02:16	08:46	15:14	52.0°	8.8
2015 May 2	23 20.9	− 07 54	1.733	1.388	02:15	08:39	15:01	53.2°	9.0
2015 May 9	23 41.2	− 05 52	1.725	1.406	02:14	08:32	14:48	54.6°	9.1
2015 May 16	00 00.6	− 03 53	1.718	1.427	02:11	08:23	14:35	56.1°	9.3
2015 May 23	00 19.2	− 01 59	1.712	1.452	02:07	08:14	14:21	57.8°	9.5
2015 May 30	00 36.9	− 00 09	1.704	1.480	02:02	08:04	14:06	59.8°	9.8
2015 Jun 6	00 53.7	+ 01 35	1.696	1.511	01:56	07:54	13:51	61.9°	10.0
2015 Jun 13	01 09.7	+ 03 11	1.686	1.545	01:49	07:42	13:35	64.3°	10.3
2015 Jun 20	01 24.8	+ 04 41	1.674	1.581	01:41	07:30	13:19	66.9°	10.6
2015 Jun 27	01 39.1	+ 06 03	1.659	1.618	01:31	07:16	13:01	69.7°	10.9
2015 Jul 4	01 52.3	+ 07 17	1.643	1.658	01:20	07:02	12:44	72.9°	11.2
2015 Jul 11	02 04.6	+ 08 24	1.623	1.699	01:08	06:47	12:25	76.3°	11.5
2015 Jul 18	02 15.8	+ 09 22	1.601	1.741	00:54	06:30	12:06	80.0°	11.7
2015 Jul 25	02 25.9	+ 10 13	1.576	1.784	00:39	06:13	11:47	84.1°	12.0
2015 Aug 1	02 34.7	+ 10 57	1.549	1.829	00:22	05:55	11:26	88.5°	12.3
2015 Aug 8	02 42.2	+ 11 32	1.520	1.873	00:04	05:34	11:04	93.2°	12.6
2015 Aug 15	02 48.3	+ 12 01	1.489	1.919	23:40	05:13	10:41	98.3°	12.9
2015 Aug 22	02 52.7	+ 12 22	1.459	1.965	23:18	04:50	10:17	103.9°	13.1
2015 Aug 29	02 55.6	+ 12 36	1.428	2.011	22:54	04:25	09:52	109.9°	13.4

Comet 22P/Kopff

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
2015 May 2	12 29.0	+ 05 10	1.394	2.280	15:56	21:46	03:37	142.8°	13.1
2015 May 9	12 25.0	+ 05 26	1.405	2.237	15:26	21:14	03:04	135.2°	13.0
2015 May 16	12 22.3	+ 05 30	1.424	2.196	14:56	20:44	02:34	128.0°	12.9
2015 May 23	12 21.2	+ 05 22	1.449	2.154	14:26	20:15	02:05	121.1°	12.8
2015 May 30	12 21.5	+ 05 03	1.479	2.113	13:59	19:48	01:40	114.7°	12.7
2015 Jun 6	12 23.4	+ 04 33	1.511	2.072	13:32	19:22	01:15	108.6°	12.6
2015 Jun 13	12 26.8	+ 03 53	1.546	2.032	13:06	18:58	00:53	103.0°	12.6
2015 Jun 20	12 31.6	+ 03 03	1.581	1.993	12:40	18:35	00:32	97.8°	12.5
2015 Jun 27	12 37.8	+ 02 06	1.617	1.954	12:16	18:14	00:13	93.0°	12.4
2015 Jul 4	12 45.2	+ 01 00	1.652	1.916	11:54	17:53	23:52	88.5°	12.3
2015 Jul 11	12 53.8	– 00 12	1.686	1.880	11:32	17:34	23:37	84.3°	12.2
2015 Jul 18	13 03.5	– 01 30	1.718	1.844	11:10	17:16	23:22	80.4°	12.2
2015 Jul 25	13 14.2	– 02 54	1.749	1.810	10:49	17:00	23:09	76.7°	12.1
2015 Aug 1	13 26.0	– 04 22	1.779	1.777	10:30	16:44	22:57	73.3°	12.0
2015 Aug 8	13 38.8	– 05 54	1.807	1.746	10:11	16:29	22:47	70.2°	11.9
2015 Aug 15	13 52.5	– 07 29	1.833	1.717	09:53	16:15	22:37	67.2°	11.8
2015 Aug 22	14 07.2	– 09 06	1.858	1.689	09:36	16:02	22:28	64.4°	11.8
2015 Aug 29	14 22.8	– 10 44	1.882	1.664	09:19	15:51	22:21	61.9°	11.7
2015 Sep 5	14 39.3	– 12 21	1.906	1.642	09:03	15:39	22:15	59.4°	11.6
2015 Sep 12	14 56.7	– 13 57	1.929	1.621	08:48	15:29	22:09	57.2°	11.6
2015 Sep 19	15 15.1	– 15 30	1.952	1.604	08:35	15:20	22:05	55.0°	11.5
2015 Sep 26	15 34.3	– 16 58	1.976	1.589	08:22	15:12	22:01	53.0°	11.5
2015 Oct 3	15 54.3	– 18 20	2.000	1.578	08:10	15:04	21:57	51.1°	11.5
2015 Oct 10	16 15.1	– 19 35	2.026	1.569	08:00	14:57	21:54	49.3°	11.5
2015 Oct 17	16 36.7	– 20 41	2.054	1.564	07:51	14:51	21:52	47.5°	11.5
2015 Oct 24	16 58.9	– 21 36	2.083	1.562	07:42	14:46	21:50	45.8°	11.5
2015 Oct 31	17 21.6	– 22 19	2.115	1.563	07:35	14:41	21:47	44.1°	11.5

Comet 10P/Tempel 2

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
2015 Aug 1	14 20.3	– 02 50	1.539	1.777	11:28	17:38	23:47	85.6°	12.2
2015 Aug 8	14 29.5	– 04 37	1.565	1.738	11:05	17:20	23:34	81.7°	12.0
2015 Aug 15	14 40.1	– 06 27	1.589	1.700	10:43	17:03	23:22	78.1°	11.8
2015 Aug 22	14 51.9	– 08 19	1.612	1.664	10:22	16:47	23:11	74.8°	11.6
2015 Aug 29	15 05.0	– 10 12	1.633	1.629	10:02	16:32	23:02	71.7°	11.4
2015 Sep 5	15 19.3	– 12 06	1.653	1.596	09:44	16:19	22:54	68.8°	11.2
2015 Sep 12	15 34.8	– 13 58	1.672	1.565	09:27	16:07	22:47	66.2°	11.0
2015 Sep 19	15 51.6	– 15 48	1.690	1.536	09:11	15:57	22:42	63.7°	10.8
2015 Sep 26	16 09.6	– 17 34	1.707	1.510	08:56	15:47	22:37	61.4°	10.6
2015 Oct 3	16 28.9	– 19 14	1.723	1.487	08:42	15:39	22:34	59.3°	10.5
2015 Oct 10	16 49.3	– 20 46	1.740	1.467	08:30	15:32	22:32	57.4°	10.4
2015 Oct 17	17 10.9	– 22 09	1.758	1.450	08:20	15:26	22:30	55.6°	10.3
2015 Oct 24	17 33.7	– 23 20	1.777	1.437	08:11	15:21	22:30	53.9°	10.2
2015 Oct 31	17 57.3	– 24 17	1.797	1.427	08:04	15:17	22:29	52.4°	10.1
2015 Nov 7	18 21.9	– 25 00	1.819	1.421	07:59	15:14	22:28	50.9°	10.1
2015 Nov 14	18 47.0	– 25 25	1.844	1.419	07:55	15:11	22:27	49.6°	10.1
2015 Nov 21	19 12.6	– 25 34	1.871	1.421	07:52	15:09	22:26	48.3°	10.2
2015 Nov 28	19 38.4	– 25 24	1.902	1.426	07:51	15:07	22:23	47.1°	10.2
2015 Dec 5	20 04.1	– 24 57	1.936	1.435	07:51	15:06	22:20	45.8°	10.4
2015 Dec 12	20 29.6	– 24 13	1.973	1.448	07:51	15:03	22:15	44.6°	10.5
2015 Dec 19	20 54.7	– 23 14	2.015	1.465	07:52	15:01	22:09	43.4°	10.7
2015 Dec 26	21 19.1	– 22 00	2.060	1.485	07:53	14:58	22:02	42.1°	10.9

Comet C/2012 K1 (PANSTARRS)

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
2015 Jan 3	00 08.6	– 33 00	2.378	2.223	09:29	17:14	01:03	69.0°	9.9
2015 Jan 10	00 07.2	– 30 54	2.577	2.306	09:08	16:45	00:25	63.2°	10.2
2015 Jan 17	00 07.2	– 29 02	2.769	2.389	08:48	16:17	23:47	57.5°	10.5
2015 Jan 24	00 08.2	– 27 23	2.954	2.471	08:27	15:51	23:14	51.9°	10.8
2015 Jan 31	00 10.0	– 25 55	3.130	2.553	08:07	15:26	22:43	46.4°	11.0
2015 Feb 7	00 12.3	– 24 36	3.295	2.634	07:47	15:00	22:13	41.2°	11.3
2015 Feb 14	00 15.0	– 23 24	3.449	2.715	07:26	14:35	21:45	36.2°	11.5
2015 Feb 21	00 18.1	– 22 20	3.591	2.796	07:05	14:11	21:17	31.5°	11.7
2015 Feb 28	00 21.3	– 21 22	3.720	2.876	06:44	13:47	20:49	27.3°	11.9
2015 Mar 7	00 24.7	– 20 30	3.836	2.956	06:22	13:23	20:22	23.9°	12.1
2015 Mar 14	00 28.1	– 19 43	3.938	3.035	06:01	12:58	19:56	21.5°	12.3
2015 Mar 21	00 31.6	– 19 02	4.027	3.114	05:39	12:34	19:30	20.5°	12.5
2015 Mar 28	00 35.0	– 18 26	4.101	3.192	05:17	12:10	19:03	21.3°	12.6

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a *dirty snowball*' a conglomerate of ice, gas, 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 solar wind to form the classic 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 tug 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 visual meteor 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 meteors, at 71 km/s, are the fastest of the showers.

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Δ24Quadrantids (QUA)	FM	Dec 28 – Jan 12	Jan 04	230˚	+49˚	41	120
alpha-Centaurids (ACE)	FM	Jan 28 – Feb 21	Feb 08	210˚	–59˚	56	6
gamma-Normids (GNO)	LQ	Feb 25 – Mar 28	Mar 15	239˚	–50˚	56	6
Lyrids (LYR)	NM	Apr 16 – Apr 25	Apr 22	271˚	+34˚	49	18
pi-Puppids (PPU)*	NM	Apr 15 – Apr 28	Apr 24	110˚	–45˚	18	var
eta-Aquarids (ETA)	FM	Apr 19 – May 28	May 06	338˚	–01˚	66	40
eta-Lyrids (ELY)	LQ	May 03 – May 14	May 09	287˚	+44˚	43	3
June Bootids (JBO)*	FQ	Jun 22 – Jul 02	Jun 27	224˚	+48˚	18	var
Pisces Austrinids (PAU)	FM	Jul 15 – Aug 10	Jul 28	341˚	–30˚	35	5
Southern delta-Aquarids (SDA)	FM	Jul 12 – Aug 23	Jul 30	340˚	–16˚	41	16
alpha-Capricornids (CAP)	FM	Jul 03 – Aug 15	Jul 30	307˚	–10˚	23	5
Perseids (PER)	NM	Jul 17 – Aug 24	Aug 13	048˚	+58˚	59	100
kappa-Cygnids (KCG)	NM	Aug 03 – Aug 25	Aug 18	286˚	+59˚	25	3
Aurigids (AUR)	FM	Aug 28 – Sep 05	Sep 01	091˚	+39˚	66	6
September Perseids (SPE)	LQ	Sep 05 – Sep 21	Sep 09	048˚	+40˚	64	5
Draconids (DRA)*	NM	Oct 06 – Oct 10	Oct 09	262˚	+54˚	20	var
Southern Taurids (STA)	NM	Sep 10 – Nov 20	Oct 10	032˚	+09˚	27	5
delta-Aurigids (DAU)	NM	Oct 10 – Oct 18	Oct 11	084˚	+44˚	64	2
epsilon-Geminids (EGE)	FQ	Oct 14 – Oct 27	Oct 18	102˚	+27˚	70	3
Orionids (ORI)	FQ	Oct 02 – Nov 07	Oct 21	095˚	+16˚	66	15
Leo Minorids (LMI)	FQ	Oct 19 – Oct 27	Oct 24	162˚	+37˚	62	2
Northern Taurids (NTA)	NM	Oct 20 – Dec 10	Nov 12	058˚	+22˚	29	5
Leonids (LEO)	FQ	Nov 06 – Nov 30	Nov 18	152˚	+22˚	71	15
alpha-Monocerotids (AMO)	FM	Nov 15 – Nov 25	Nov 22	117˚	+01˚	65	Var
Phoenicids (PHO)	LQ	Nov 28 – Dec 09	Dec 06	018˚	–53˚	18	Var
Puppid-Velids (PUP)	NM	Dec 01 – Dec 15	Dec 07	123˚	–45˚	40	10
Monocerotids (MON)	NM	Nov 27 – Dec 17	Dec 09	100˚	+08˚	42	2
sigma-Hydrids (HYD)	NM	Dec 03 – Dec 15	Dec 12	127˚	+02˚	58	3
Geminids (GEM)	NM	Dec 04 – Dec 17	Dec 14	112˚	+33˚	35	120
Coma Berenicids (COM)	NM	Dec 12 – Dec 23	Dec 16	175˚	+18˚	65	3
Dec. Leonis Minorids (DLM)	FQ	Dec 05 – Feb 04	Dec 20	161˚	+30˚	64	5
Ursids (URS)	FM	Dec 17 – Dec 26	Dec 23	217˚	+75˚	33	10

Incredible velocities such as these (a bullet from a rifle travels at about one kilometre 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 often named after the constellation in which the meteors appear. The particles of meteoroid streams travel though space in parallel paths. The apparent divergence from the radiant is only an illusion, due 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 Organization (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 each monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic or random meteors 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 Organization. www.imo.net/

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 The position of the shower radiant in right ascension and declination (RA is expressed in degrees). These coordinates refer to the radiant position on the date of maximum activity.

Vel The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11 km/s (very slow) to 71 km/s (very fast), medium speed is about 40 km/s.

ZHR Zenith Hourly Rate at peak period. A theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

MINOR PLANET POSITIONS (0 HR UT, EPOCH 2000.0)

As well as the 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 imaging 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 sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

Included are ephemerides for the 15 brightest minor or dwarf planets for 2015 that reach magnitude 9.5 or brighter during the year. They all get to opposition this year. As only the 15 brightest are considered here, 1 Ceres is the only dwarf planet that makes the grade. A total of 23 reach magnitude brighter than 10.1 and have had selected conjunctions included in the diary in Part I.

1 Ceres

Date	RA h mm	Dec ° ′	Mag
May 2	20 39.3	−23 39	8.8
9	20 44.3	−23 48	8.7
16	20 48.4	−24 02	8.6
23	20 51.4	−24 21	8.5
30	20 53.3	−24 46	8.4
Jun 6	20 54.1	−25 16	8.3
13	20 53.6	−25 51	8.2
20	20 51.9	−26 32	8.1
27	20 48.9	−27 15	7.9
Jul 4	20 44.8	−28 01	7.8
11	20 39.8	−28 47	7.7
18	20 33.9	−29 31	7.5
25	20 27.5	−30 12	7.5
Aug 1	20 21.0	−30 47	7.5
8	20 14.7	−31 14	7.7
15	20 08.9	−31 35	7.8
22	20 04.0	−31 48	8.0
29	20 00.1	−31 53	8.1
Sep 5	19 57.5	−31 53	8.2
12	19 56.2	−31 46	8.4
19	19 56.1	−31 34	8.5
26	19 57.4	−31 19	8.6
Oct 3	19 59.8	−30 59	8.7
10	20 03.4	−30 36	8.8
17	20 08.0	−30 11	8.9

2 Pallas

Date	RA h mm	Dec ° ′	Mag
Mar 21	17 50.7	+12 43	9.8
28	17 54.7	+14 07	9.8
Apr 4	17 57.8	+15 33	9.7
11	17 59.7	+16 59	9.7
18	18 00.7	+18 25	9.6
25	18 00.4	+19 49	9.6
May 2	17 59.0	+21 08	9.5
9	17 56.5	+22 20	9.5
16	17 53.0	+23 24	9.4
23	17 48.5	+24 17	9.4
30	17 43.4	+24 57	9.4
Jun 6	17 37.6	+25 23	9.4
13	17 31.7	+25 33	9.4
20	17 25.7	+25 28	9.4
27	17 20.0	+25 08	9.4
Jul 4	17 14.8	+24 34	9.5
11	17 10.4	+23 48	9.6
18	17 06.8	+22 50	9.6
25	17 04.1	+21 44	9.7
Aug 1	17 02.5	+20 32	9.8
8	17 01.9	+19 15	9.9
15	17 02.4	+17 55	9.9
22	17 03.8	+16 33	10.0
29	17 06.1	+15 12	10.1
Sep 5	17 09.3	+13 51	10.1

3 Juno

Date	RA h mm	Dec ° ′	Mag
Jan 3	08 53.4	+00 40	8.4
10	08 48.9	+01 08	8.3
17	08 43.4	+01 50	8.2
24	08 37.4	+02 44	8.2
31	08 31.2	+03 47	8.2
Feb 7	08 25.4	+04 57	8.2
14	08 20.4	+06 10	8.4
21	08 16.4	+07 23	8.6
28	08 13.7	+08 32	8.8
Mar 7	08 12.5	+09 37	8.9
14	08 12.7	+10 35	9.1
21	08 14.2	+11 25	9.3
28	08 17.1	+12 08	9.4
Apr 4	08 21.1	+12 43	9.6
11	08 26.2	+13 10	9.7
18	08 32.2	+13 30	9.9
25	08 39.0	+13 43	10.0
May 2	08 46.5	+13 48	10.1
9	08 54.6	+13 48	10.2
16	09 03.2	+13 41	10.3
23	09 12.2	+13 29	10.4
30	09 21.5	+13 12	10.5
Jun 6	09 31.0	+12 50	10.6
13	09 40.8	+12 24	10.6
20	09 50.8	+11 54	10.7

4 Vesta

Date	RA h mm	Dec ° ′	Mag
Jul 4	00 40.2	−03 14	7.5
11	00 46.8	−03 01	7.4
18	00 52.4	−02 55	7.4
25	00 57.0	−02 58	7.3
Aug 1	01 00.5	−03 08	7.1
8	01 02.8	−03 27	7.0
15	01 03.8	−03 55	6.9
22	01 03.3	−04 30	6.8
29	01 01.4	−05 13	6.7
Sep 5	00 58.2	−06 00	6.5
12	00 53.7	−06 51	6.4
19	00 48.2	−07 43	6.3
26	00 42.1	−08 31	6.2
Oct 3	00 35.6	−09 14	6.3
10	00 29.2	−09 48	6.4
17	00 23.3	−10 12	6.5
24	00 18.2	−10 25	6.7
31	00 14.3	−10 26	6.8
Nov 7	00 11.6	−10 16	7.0
14	00 10.2	−09 56	7.1
21	00 10.2	−09 26	7.3
28	00 11.4	−08 48	7.4
Dec 5	00 13.9	−08 04	7.5
12	00 17.4	−07 13	7.6
19	00 21.9	−06 18	7.8

7 Iris

Date	RA h mm	Dec ° ′	Mag
Jan 3	11 24.5	−03 21	9.9
10	11 25.8	−03 53	9.8
17	11 25.7	−04 17	9.7
24	11 24.2	−04 31	9.6
31	11 21.3	−04 35	9.4
Feb 7	11 17.1	−04 29	9.3
14	11 11.8	−04 12	9.2
21	11 05.6	−03 45	9.0
28	10 58.9	−03 10	8.9
Mar 7	10 52.0	−02 29	8.9
14	10 45.4	−01 45	9.0
21	10 39.5	−01 00	9.2
28	10 34.5	−00 16	9.4
Apr 4	10 30.7	+00 24	9.6
11	10 28.1	+00 58	9.7
18	10 26.8	+01 26	9.9
25	10 26.8	+01 47	10.1
May 2	10 28.0	+02 00	10.2
9	10 30.3	+02 07	10.4
16	10 33.6	+02 06	10.5
23	10 37.8	+01 59	10.6
30	10 42.8	+01 46	10.7
Jun 6	10 48.5	+01 27	10.8
13	10 54.8	+01 04	10.9
20	11 01.6	+00 35	11.0

8 Flora

Date	RA h mm	Dec ° ′	Mag
Jan 3	10 30.5	+13 05	9.9
10	10 29.7	+13 39	9.7
17	10 27.3	+14 24	9.6
24	10 23.2	+15 16	9.4
31	10 17.7	+16 15	9.3
Feb 7	10 11.1	+17 15	9.2
14	10 03.9	+18 15	9.1
21	09 56.5	+19 10	9.2
28	09 49.5	+19 57	9.4
Mar 7	09 43.3	+20 34	9.5
14	09 38.3	+21 00	9.7
21	09 34.8	+21 15	9.9
28	09 32.8	+21 20	10.1
Apr 4	09 32.4	+21 16	10.3
11	09 33.4	+21 04	10.4
18	09 35.9	+20 45	10.6
25	09 39.6	+20 18	10.7
May 2	09 44.3	+19 47	10.8
9	09 50.0	+19 10	11.0
16	09 56.6	+18 28	11.1
23	10 03.8	+17 42	11.2
30	10 11.7	+16 53	11.3
Jun 6	10 20.0	+16 00	11.3
13	10 28.7	+15 03	11.4
20	10 37.9	+14 04	11.5

9 Metis

Date	RA h mm	Dec ° ′	Mag
Jun 13	23 14.6	−11 31	11.0
20	23 20.6	−11 14	10.9
27	23 25.8	−11 03	10.8
Jul 4	23 30.0	−10 59	10.6
11	23 33.2	−11 03	10.5
18	23 35.2	−11 15	10.3
25	23 36.0	−11 34	10.2
Aug 1	23 35.4	−12 02	10.0
8	23 33.4	−12 36	9.8
15	23 30.1	−13 17	9.7
22	23 25.5	−14 01	9.5
29	23 19.9	−14 46	9.3
Sep 5	23 13.6	−15 30	9.2
12	23 06.9	−16 09	9.2
19	23 00.3	−16 40	9.3
26	22 54.3	−17 01	9.5
Oct 3	22 49.2	−17 12	9.6
10	22 45.3	−17 11	9.8
17	22 42.8	−17 00	9.9
24	22 41.8	−16 39	10.1
31	22 42.3	−16 08	10.2
Nov 7	22 44.2	−15 30	10.3
14	22 47.5	−14 44	10.4
21	22 52.0	−13 51	10.5
28	22 57.6	−12 53	10.6

15 Eunomia

Date	RA h mm	Dec ° ′	Mag
Jul 11	00 15.0	+13 26	9.5
18	00 20.3	+14 55	9.4
25	00 24.6	+16 20	9.2
Aug 1	00 27.9	+17 42	9.1
8	00 29.9	+18 59	9.0
15	00 30.7	+20 09	8.8
22	00 30.0	+21 12	8.7
29	00 27.9	+22 04	8.5
Sep 5	00 24.4	+22 44	8.4
12	00 19.6	+23 11	8.2
19	00 13.9	+23 22	8.1
26	00 07.6	+23 18	8.0
Oct 3	00 01.1	+22 58	7.9
10	23 55.0	+22 25	8.0
17	23 49.8	+21 42	8.0
24	23 45.9	+20 53	8.1
31	23 43.5	+20 03	8.3
Nov 7	23 42.7	+19 14	8.4
14	23 43.5	+18 29	8.6
21	23 46.0	+17 52	8.7
28	23 50.1	+17 23	8.8
Dec 5	23 55.5	+17 02	9.0
12	00 02.1	+16 51	9.1
19	00 09.9	+16 48	9.2
26	00 18.7	+16 53	9.3

16 Psyche

Date	RA h mm	Dec ° ′	Mag
Jul 11	03 43.7	+17 17	11.2
18	03 55.1	+17 48	11.2
25	04 06.2	+18 14	11.2
Aug 1	04 17.0	+18 37	11.2
8	04 27.4	+18 56	11.1
15	04 37.4	+19 11	11.1
22	04 46.9	+19 22	11.1
29	04 55.7	+19 30	11.0
Sep 5	05 03.9	+19 34	10.9
12	05 11.3	+19 36	10.9
19	05 17.8	+19 35	10.8
26	05 23.2	+19 32	10.7
Oct 3	05 27.7	+19 26	10.6
10	05 30.9	+19 20	10.5
17	05 32.8	+19 12	10.4
24	05 33.3	+19 04	10.3
31	05 32.4	+18 55	10.2
Nov 7	05 30.1	+18 45	10.0
14	05 26.4	+18 36	9.9
21	05 21.6	+18 28	9.8
28	05 15.9	+18 19	9.6
Dec 5	05 09.5	+18 12	9.5
12	05 03.0	+18 06	9.4
19	04 56.6	+18 02	9.6
26	04 50.9	+18 00	9.8

20 Massalia

Date	RA h mm	Dec ° ′	Mag
Jan 24	13 58.9	−12 25	10.9
31	14 05.3	−12 58	10.9
Feb 7	14 10.7	−13 25	10.8
14	14 14.9	−13 45	10.7
21	14 17.9	−13 59	10.6
28	14 19.5	−14 06	10.4
Mar 7	14 19.6	−14 05	10.3
14	14 18.3	−13 56	10.2
21	14 15.4	−13 40	10.1
28	14 11.3	−13 16	9.9
Apr 4	14 06.0	−12 46	9.8
11	13 59.8	−12 11	9.6
18	13 53.3	−11 33	9.4
25	13 46.6	−10 54	9.5
May 2	13 40.4	−10 17	9.7
9	13 34.9	−09 43	9.9
16	13 30.3	−09 15	10.1
23	13 27.0	−08 54	10.3
30	13 25.0	−08 40	10.4
Jun 6	13 24.2	−08 34	10.6
13	13 24.7	−08 36	10.8
20	13 26.4	−08 45	10.9
27	13 29.2	−09 01	11.0
Jul 4	13 33.1	−09 23	11.1
11	13 37.8	−09 50	11.3

21 Lutetia

Date	RA h mm	Dec ° ′	Mag
May 23	21 33.5	−16 38	11.4
30	21 41.5	−16 13	11.2
Jun 6	21 48.6	−15 54	11.1
13	21 54.6	−15 41	10.9
20	21 59.4	−15 34	10.8
27	22 02.8	−15 36	10.6
Jul 4	22 04.7	−15 46	10.4
11	22 05.1	−16 05	10.2
18	22 04.0	−16 32	10.0
25	22 01.3	−17 06	9.8
Aug 1	21 57.2	−17 44	9.6
8	21 52.0	−18 25	9.4
15	21 46.2	−19 06	9.3
22	21 40.1	−19 42	9.4
29	21 34.5	−20 11	9.6
Sep 5	21 29.6	−20 32	9.8
12	21 26.0	−20 43	10.0
19	21 23.9	−20 45	10.2
26	21 23.4	−20 36	10.4
Oct 3	21 24.6	−20 19	10.6
10	21 27.4	−19 54	10.7
17	21 31.6	−19 21	10.9
24	21 37.2	−18 41	11.0
31	21 44.0	−17 55	11.2
Nov 7	21 51.8	−17 03	11.3

27 Euterpe

Date	RA h mm	Dec ° ′	Mag
Jul 11	03 26.2	+17 31	11.7
18	03 40.3	+18 20	11.7
25	03 54.4	+19 05	11.6
Aug 1	04 08.5	+19 45	11.6
8	04 22.4	+20 20	11.5
15	04 36.2	+20 50	11.4
22	04 49.8	+21 15	11.4
29	05 03.1	+21 36	11.3
Sep 5	05 16.0	+21 52	11.2
12	05 28.4	+22 04	11.1
19	05 40.3	+22 12	11.0
26	05 51.4	+22 16	10.9
Oct 3	06 01.8	+22 18	10.8
10	06 11.1	+22 19	10.6
17	06 19.4	+22 18	10.5
24	06 26.3	+22 16	10.3
31	06 31.7	+22 16	10.2
Nov 7	06 35.4	+22 16	10.0
14	06 37.4	+22 19	9.8
21	06 37.3	+22 25	9.6
28	06 35.3	+22 33	9.4
Dec 5	06 31.4	+22 43	9.2
12	06 25.8	+22 55	9.0
19	06 19.0	+23 07	8.7
26	06 11.6	+23 19	8.5

44 Nysa

Date	RA h mm	Dec ° ′	Mag
Jan 3	12 16.1	+00 19	10.7
10	12 22.7	−00 06	10.6
17	12 28.1	−00 23	10.5
24	12 32.3	−00 30	10.4
31	12 35.1	−00 27	10.3
Feb 7	12 36.4	−00 15	10.1
14	12 36.2	+00 09	10.0
21	12 34.4	+00 41	9.9
28	12 31.1	+01 23	9.8
Mar 7	12 26.6	+02 11	9.6
14	12 21.1	+03 02	9.5
21	12 15.1	+03 54	9.4
28	12 08.9	+04 43	9.5
Apr 4	12 03.0	+05 25	9.7
11	11 57.9	+05 59	9.8
18	11 53.8	+06 23	10.0
25	11 51.0	+06 36	10.2
May 2	11 49.5	+06 39	10.3
9	11 49.4	+06 31	10.5
16	11 50.6	+06 14	10.6
23	11 53.1	+05 49	10.8
30	11 56.6	+05 17	10.9
Jun 6	12 01.1	+04 38	11.1
13	12 06.6	+03 53	11.2
20	12 12.8	+03 04	11.3

192 Nausikaa

Date	RA h mm	Dec ° ′	Mag
Jul 11	01 59.0	+14 17	11.3
18	02 12.6	+15 56	11.2
25	02 25.9	+17 32	11.2
Aug 1	02 38.9	+19 05	11.1
8	02 51.5	+20 34	11.0
15	03 03.5	+21 59	10.9
22	03 14.9	+23 21	10.8
29	03 25.4	+24 39	10.7
Sep 5	03 34.9	+25 54	10.6
12	03 43.3	+27 04	10.5
19	03 50.2	+28 11	10.3
26	03 55.4	+29 14	10.2
Oct 3	03 58.8	+30 13	10.0
10	04 00.1	+31 05	9.9
17	03 59.2	+31 51	9.7
24	03 56.1	+32 27	9.5
31	03 51.0	+32 52	9.3
Nov 7	03 44.2	+33 04	9.2
14	03 36.5	+33 02	9.1
21	03 28.6	+32 46	9.0
28	03 21.2	+32 18	9.2
Dec 5	03 15.0	+31 43	9.4
12	03 10.5	+31 04	9.6
19	03 07.9	+30 25	9.9
26	03 07.4	+29 49	10.1

532 Herculina

Date	RA h mm	Dec ° ′	Mag
Feb 21	15 56.4	−01 44	10.2
28	16 03.5	−01 31	10.1
Mar 7	16 09.6	−01 13	10.0
14	16 14.6	−00 51	9.9
21	16 18.2	−00 25	9.8
28	16 20.5	+00 02	9.7
Apr 4	16 21.3	+00 31	9.6
11	16 20.6	+00 58	9.5
18	16 18.4	+01 22	9.4
25	16 14.9	+01 42	9.3
May 2	16 10.1	+01 54	9.2
9	16 04.5	+01 58	9.1
16	15 58.2	+01 52	9.1
23	15 51.7	+01 34	9.1
30	15 45.3	+01 06	9.2
Jun 6	15 39.6	+00 27	9.3
13	15 34.6	−00 22	9.4
20	15 30.8	−01 18	9.6
27	15 28.1	−02 21	9.7
Jul 4	15 26.8	−03 28	9.8
11	15 26.7	−04 38	10.0
18	15 27.8	−05 51	10.1
25	15 30.2	−07 04	10.3
Aug 1	15 33.6	−08 17	10.4
8	15 38.1	−09 30	10.5

CONSTELLATIONS – Abbreviations and Culmination at 9 pm

Name	Genitive	Abr.	Map	Cul.
Andromeda	Andromedae	And	3, 9	Nov 23
Antlia	Antliae	Ant	4, 6	Apr 10
Apus	Apodis	Aps	1	Jul 5
Aquarius	Aquarii	Aqr	8	Oct 9
Aquila	Aquilae	Aql	8, 9	Aug 30
Ara	Arae	Ara	1, 6	Jul 25
Aries	Arietis	Ari	3	Dec 14
Auriga	Aurigae	Aur	3, 5	Feb 4
Bootes	Bootis	Boo	7	Jun 16
Caelum	Caeli	Cae	2, 4	Jan 15
Camelopardalis	Camelopardalis	Cam	3, 5	Feb 6
Cancer	Cancri	Cnc	5, 4	Mar 16
Canes Venatici	Canum Venaticorum	CVn	5, 7	May 22
Canis Major	Canis Majoris	CMa	4, 2	Feb 16
Canis Minor	Canis Minoris	CMi	5, 4	Feb 28
Capricornus	Capricorni	Cap	8	Sep 22
Carina	Carinae	Car	1, 4	Mar 17
Cassiopeia	Cassiopeiae	Cas	3, 9	Nov 23
Centaurus	Centauri	Cen	1, 6	May 14
Cepheus	Cephei	Cep	9, 3	Nov 13
Cetus	Ceti	Cet	2, 3	Nov 29
Chamaeleon	Chamaeleontis	Cha	1	Apr 15
Circinus	Circini	Cir	1, 6	Jun 14
Columba	Columbae	Col	4, 2	Feb 1
Coma Berenices	Comae Berenices	Com	7, 5	May 17
Corona Australis	Coronae Australis	CrA	8, 6	Aug 14
Corona Borealis	Coronae Borealis	CrB	7	Jul 3
Corvus	Corvi	Crv	6, 4	May 12

Name	Genitive	Abr.	Map	Cul.
Crater	Crateris	Crt	4, 6	Apr 26
Crux	Crucis	Cru	1	May 12
Cygnus	Cygni	Cyg	9	Sep 13
Delphinus	Delphini	Del	9, 8	Sep 14
Dorado	Doradus	Dor	2, 1	Jan 31
Draco	Draconis	Dra	7, 9	Jul 8
Equuleus	Equulei	Equ	9, 8	Sep 22
Eridanus	Eridani	Eri	2, 1	Dec 25
Fornax	Fornacis	For	2	Dec 17
Gemini	Geminorum	Gem	5, 4	Feb 19
Grus	Gruis	Gru	8, 1	Oct 12
Hercules	Herculis	Her	7, 9	Jul 28
Horologium	Horologii	Hor	2, 1	Dec 25
Hydra	Hydrae	Hya	4, 6	Apr 29
Hydrus	Hydri	Hyi	1	Dec 10
Indus	Indi	Ind	1, 8	Sep 26
Lacerta	Lacertae	Lac	9	Oct 12
Leo	Leonis	Leo	5, 7	Apr 15
Leo Minor	Leonis Minoris	LMi	5, 7	Apr 9
Lepus	Leporis	Lep	2, 4	Jan 28
Libra	Librae	Lib	6	Jun 23
Lupus	Lupi	Lup	6	Jun 23
Lynx	Lyncis	Lyn	5, 3	Mar 5
Lyra	Lyrae	Lyr	9, 7	Aug 18
Mensa	Mensae	Men	1	Jan 28
Microscopium	Microscopii	Mic	8	Sep 18
Monoceros	Monocerotis	Mon	4, 5	Feb 19
Musca	Muscae	Mus	1	May 14
Norma	Normae	Nor	6, 1	Jul 3
Octans	Octantis	Oct	1	Circum
Ophiuchus	Ophiuchi	Oph	6, 7	Jul 26

Name	Genitive	Abr.	Map	Cul.
Orion	Orionis	Ori	2, 3	Jan 27
Pavo	Pavonis	Pav	1, 8	Aug 29
Pegasus	Pegasi	Peg	9, 3	Oct 16
Perseus	Persei	Per	3	Dec 22
Phoenix	Phoenicis	Phe	2, 8	Nov 18
Pictor	Pictoris	Pic	1, 2	Jan 30
Pisces	Piscium	Psc	3, 9	Nov 11
Piscis Austrinus	Piscis Austrini	PsA	8	Oct 9
Puppis	Puppis	Pup	4, 2	Feb 22
Pyxis	Pyxidis	Pyx	4	Mar 21
Reticulum	Reticuli	Ret	1	Jan 3
Sagitta	Sagittae	Sge	9	Aug 30
Sagittarius	Sagittarii	Sgr	8, 6	Aug 21
Scorpius	Scorpii	Sco	6, 8	Jul 18
Sculptor	Sculptoris	Scl	2, 8	Nov 10
Scutum	Scuti	Sct	8	Aug 15
Serpens	Serpentis	Ser	6, 7	Jul 21
Sextans	Sextantis	Sex	4	Apr 8
Taurus	Tauri	Tau	3, 5	Jan 14
Telescopium	Telescopii	Tel	8, 1	Aug 24
Triangulum	Trianguli	Tri	3	Dec 7
Triangulum Australe	Trianguli Australis	TrA	1	Jul 7
Tucana	Tucanae	Tuc	1	Nov 1
Ursa Major	Ursae Majoris	UMa	5, 7	Apr 25
Ursa Minor	Ursae Minoris	UMi	7	Jun 27
Vela	Velorum	Vel	4, 1	Mar 30
Virgo	Virginis	Vir	6, 7	May 26
Volans	Volantis	Vol	1	Mar 4
Vulpecula	Vulpeculae	Vul	9	Sep 8

BRIGHTEST and NEAREST STARS (opposite)

The column descriptions are:

Designation The name of the star in the system created by Bayer, who numbered the stars in the constellations using Greek letters (p. 152). They were usually ordered by their brightness, Alpha being the brightest in most cases.

Name Common name for each star.
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.
Proper Motion see glossary.
Distance, 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.
(v) indicates the star is variable.

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 the *colder* star classes **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this 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, and the Sun).
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise 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 imaged simply. Mount a camera on a tripod and take a time exposure of several minutes. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., piggy-backed 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 can saturate the detector. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation		Name	Constellation	RA (2000.0)	Dec (2000.0)	Magnitude App	Magnitude Abs	Spectral Type	Parallax	Distance pc	Distance 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	v
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	–2.7	B2 III	0.0134	75	243	
27	β Tau	El Nath	Taurus	05 26.3	+28 36	1.65	–1.4	B7 III	0.0249	40.2	131	
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

Note, this list does not include some recently discovered brown dwarf stars.

No	Star Name		Constellation	RA 2000.0 hh mm.m	Dec ° '	Magnitude Apparent	Magnitude Absolute	Spect Type	Parallax "	Proper Motion "/yr	Distance pc	Distance ly
--	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	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	–60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		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	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	–16 43	–1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		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	2.68	8.73
		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	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	–09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	–35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	–15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		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	3.50	11.40
		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	3.50	11.40
		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	3.53	11.53
		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	3.56	11.63
		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	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	–15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	–44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	–17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten's Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

DEEP SKY OBJECTS

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 55	G	Scl	7.9	31.2	00 14.9	–39 11	10		A bright galaxy in the Sculptor Group
NGC 104	GC	Tuc	4.0	30	00 24.1	–72 05	10	1	47 Tucanae
NGC 205	G	And	8.1	19.5	00 40.4	+41 41	10	3,9	M110
NGC 221	G	And	8.1	8.5	00 42.7	+40 52	10	3,9	M32
NGC 224	G	And	3.4	189	00 42.7	+41 16	10	3,9	M31, Andromeda Galaxy
NGC 253	G	Scl	7.2	26.4	00 47.6	–25 18	10		Silver Coin galaxy. Large, bright edge-on spiral
SMC	G	Tuc	2.3	319	00 52.6	–72 48	10	1	Small Magellanic Cloud
NGC 288	GC	Scl	8.1	13.8	00 52.8	–26 35	10		Near galaxy NGC 253
NGC 346	BN	Tuc	10.3	5.2	00 59.1	–72 11	10		Nebula in the SMC
NGC 362	GC	Tuc	6.8	12.9	01 03.2	–70 51	11	1	
NGC 598	G	Tri	5.7	68.7	01 33.9	+30 39	11	3	M33, Triangulum Galaxy
NGC 628	G	Psc	9.4	10	01 36.7	+15 47	11	3	M74
NGC 891	G	And	9.9	13.1	02 22.6	+42 21	11		
NGC 1039	OC	Per	5.2	35	02 42.1	+42 47	11	3	M34
NGC 1068	G	Cet	8.9	7.3	02 42.7	–00 01	11	2	M77, Cetus A
NGC 1097	G	For	9.5	9.4	02 46.3	–30 17	11		
NGC 1261	GC	Hor	8.4	6.9	03 12.3	–55 13	12		
NGC 1269	G	Eri	8.5	9.7	03 17.3	–41 06	12		
NGC 1313	G	Ret	8.7	9.2	03 18.3	–66 30	12		
NGC 1316	G	For	8.5	11.2	03 22.7	–37 13	12		
NGC 1360	PN	For	9.4	360	03 33.2	–25 52	12		
NGC 1365	G	For	9.6	11	03 33.6	–36 08	12		
NGC 1399	G	For	9.6	6.6	03 38.5	–35 27	12		In Fornax galaxy group
Pleiades	OC	Tau	1.2	100	03 47.0	+24 07	12	3	M45, Contains Merope Nebula
NGC 1532	G	Eri	9.9	11.6	04 12.1	–32 52	12		
NGC 1535	PN	Eri	9.4	20	04 14.3	–12 44	12		
NGC 1553	G	Dor	9.4	5	04 16.2	–55 47	12		Near galaxy NGC 1549
NGC 1566	G	Dor	9.7	8.2	04 20.0	–54 56	12		
NGC 1808	G	Col	9.9	6.3	05 07.7	–37 31	1		Near galaxy NGC 1792
NGC 1851	GC	Col	7.1	11	05 14.1	–40 03	1		
LMC	G	Dor	0.4	550	05 23.6	–69 45	1	1	Large Magellanic Cloud
NGC 1904	GC	Lep	7.7	7.8	05 24.2	–24 31	1	2	M79, Rich and compressed, well resolved
NGC 1912	OC	Aur	6.4	21	05 28.7	+35 51	1	3,5	M38, 100 stars, magnitude 9.5 in splendid field
NGC 1952	BN	Tau	8.4	8	05 34.5	+22 01	1	5,3	M1, Crab Nebula
NGC 1976	BN	Ori	4.0	90	05 35.3	–05 23	1	2	M42, Orion Nebula
NGC 1982	BN	Ori	7.0	20	05 35.5	–05 16	1	2	M43, de Mairan's Nebula; part of Orion Nebula
NGC 1960	OC	Aur	6.0	12	05 36.3	+34 08	1	3,5	M36, 60 stars, magnitude 9 to 14
NGC 2070	BN	Dor	8.3	20	05 38.6	–69 06	1	1	Tarantula Nebula
NGC 2068	BN	Ori	8.0	8	05 46.8	+00 05	1	2,3	M78, Brightest and largest in group of four nebulae
NGC 2099	OC	Aur	5.6	24	05 52.3	+32 33	1	3,5	M37, 150 stars, magnitude 9 to 12.5
NGC 2168	OC	Gem	5.1	28	06 08.9	+24 21	1	3,5	M35, 200 stars, magnitude 9 to 16
NGC 2174	BN	Ori		40	06 09.4	+20 40	1		Near open cluster M35
NGC 2237	BN	Mon	5.5	80	06 30.9	+05 03	1		Rosette Nebula
NGC 2287	OC	CMa	4.5	38	06 46.0	–20 45	1	4	M41, 80 stars, magnitude 7 and fainter, with magnitude 6.9 red star near centre
NGC 2323	OC	Mon	5.9	16	07 02.5	–08 23	2	4	M50, Rich cluster, 80 stars magnitude 8 to 12
NGC 2362	OC	CMa	4.1	8	07 18.7	–24 57	2	4	Tau Canis Majoris
NGC 2392	PN	Gem	8.6	47	07 29.2	+20 55	2		Eskimo Nebula
NGC 2422	OC	Pup	4.4	30	07 36.6	–14 29	2	4	M47, Large coarse cluster with 30 stars

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 2438	PN	Pup	11.0	65	07 41.8	–14 44	2		In M46
NGC 2437	OC	Pup	6.1	27	07 41.8	–14 49	2	4	M46, Rich open cluster, 100 stars, planetary nebula NGC 2438 in same field
NGC 2440	PN	Pup	9.3	54	07 41.9	–18 13	2		
NGC 2447	OC	Pup	6.2	22	07 44.5	–23 51	2	4	M93, 80 stars magnitude 8 to 13
NGC 2477	OC	Pup	5.8	27	07 52.2	–38 32	2	4	160 stars, magnitude 10 to 12, central concentration
NGC 2467	BN	Pup	7.1	15	07 52.5	–26 26	2		Near open cluster M93
NGC 2516	OC	Car	3.8	21	07 58.1	–60 45	2	1	80 stars 6th mag. and fainter, central concentration
NGC 2547	OC	Vel	4.7	20	08 10.2	–49 12	2	4	Rich in stars with strong central concentration
NGC 2548	OC	Hya	5.8	54	08 13.7	–05 45	2	4	M48, Large cluster of 80 stars magnitude 8 to 13
NGC 2632	OC	Cnc	3.1	95	08 40.0	+19 40	2	5	M44, Beehive Cluster
NGC 2682	OC	Cnc	6.9	30	08 51.4	+11 49	2	5	M67, 200 stars magnitude 10 to 15, large and rich
NGC 2808	GC	Car	6.3	13.8	09 12.0	–64 52	3	1	Large and rich, compressed centre, mag. 13 to 15
NGC 2903	G	Leo	9.0	12	09 32.2	+21 30	3		
NGC 2997	G	Ant	9.4	9.2	09 45.6	–31 11	3		
NGC 3114	OC	Car	4.2	35	10 02.5	–60 08	3		Rich cluster, stars magnitude 9 to 14
NGC 3115	G	Sex	8.9	7.3	10 05.2	–07 43	3		
NGC 3132	PN	Vel	8.2	84	10 07.0	–40 26	3	4	Eight-burst Nebula
NGC 3201	GC	Vel	6.8	18.2	10 17.6	–46 25	3	4	
NGC 3242	PN	Hya	8.6	40	10 24.8	–18 39	3		Ghost of Jupiter
NGC 3293	OC	Car	4.7	40	10 35.8	–58 13	3	1	
NGC 3351	G	Leo	9.7	7.3	10 44.0	+11 42	3	5	M95
NGC 3372	BN	Car	3.0	120	10 45.1	–59 52	3	1	Eta Carinae
NGC 3368	G	Leo	9.3	7.8	10 46.8	+11 49	3	5	M96
NGC 3379	G	Leo	9.3	5.3	10 47.8	+12 35	3	5	M105, Three galaxies
NGC 3532	OC	Car	3.0	50	11 05.2	–58 44	4	1	Rich and large, 150 stars magnitude 7 to 12
NGC 3521	G	Leo	9.0	11.2	11 05.8	–00 02	4		
NGC 3623	G	Leo	9.3	9	11 18.9	+13 05	4	5	M65
NGC 3627	G	Leo	8.9	9.1	11 20.2	+13 00	4	5	M66
NGC 3628	G	Leo	9.5	13.1	11 20.3	+13 35	4		Near galaxies M65/66
NGC 3766	OC	Cen	5.3	12	11 36.2	–61 37	4	1	Rich cluster, 100 stars magnitude 7 to 12
IC 2948	BN	Cen	7.0	75	11 39.4	–63 28	4		Running Chicken Nebula
NGC 3918	PN	Cen	8.4	12	11 50.3	–57 11	4		
NGC 4192	G	Com	10.1	9.4	12 13.8	+14 54	4	7	M98
NGC 4216	G	Vir	10.0	7.8	12 15.9	+13 09	4		Edge on galaxy
NGC 4254	G	Com	9.9	5.3	12 18.8	+14 25	4	7	M99
NGC 4258	G	CVn	8.4	17.4	12 19.0	+47 18	4	5,7	M106
NGC 4303	G	Vir	9.6	6.5	12 21.9	+04 28	4	6,7	M61
NGC 4321	G	Com	9.4	7.5	12 22.9	+15 49	4	7	M100
NGC 4361	PN	Crv	10.9	80	12 24.5	–18 47	4		
NGC 4374	G	Vir	9.1	6.7	12 25.1	+12 53	4	7	M84, Bright centre, in same field as M86
NGC 4382	G	Com	9.1	7.4	12 25.4	+18 11	4	7	M85
NGC 4406	G	Vir	8.9	9.8	12 26.2	+12 57	4	7	M86
NGC 4472	G	Vir	8.4	9.8	12 29.8	+08 00	4	7	M49
NGC 4486	G	Vir	8.6	8.7	12 30.8	+12 23	4	7	M87, Virgo A
NGC 4501	G	Com	9.6	6.8	12 32.0	+14 25	4	7	M88
NGC 4548	G	Com	10.1	5.2	12 35.4	+14 30	4	7	M91
NGC 4552	G	Vir	9.8	5.3	12 35.7	+12 33	4	7	M89
NGC 4565	G	Com	9.6	14.9	12 36.3	+25 59	4		

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 4569	G	Vir	9.5	9.9	12 36.8	+13 10	4	7	M90
NGC 4579	G	Vir	9.7	6	12 37.7	+11 49	4	7	M58, Bright diffuse nucleus, dark lanes
NGC 4590	GC	Hya	7.3	9.8	12 39.5	–26 45	4	6	M68, Rich and compressed
NGC 4594	G	Vir	8.0	8.6	12 40.0	–11 37	4	6	M104, Sombrero Galaxy
NGC 4621	G	Vir	9.6	5.3	12 42.0	+11 39	4	7	M59
NGC 4631	G	CVn	9.2	15.2	12 42.1	+32 32	4		Whale Galaxy
NGC 4649	G	Vir	8.8	7.6	12 43.7	+11 33	4	7	M60
NGC 4736	G	CVn	8.2	12.3	12 50.9	+41 07	4	5,7	M94
NGC 4755	OC	Cru	4.2	10	12 53.6	–60 21	4	1	Jewel Box
NGC 4826	G	Com	8.5	10.3	12 56.7	+21 41	4	7	M64, Black Eye Galaxy
NGC 4833	GC	Mus	8.4	13.5	12 59.6	–70 52	4		Near globular cluster NGC 4372
NGC 4945	G	Cen	8.6	19.8	13 05.4	–49 28	5	6	Big edge on spiral, small galaxy in same field
NGC 5024	GC	Com	7.7	14.4	13 12.9	+18 10	5	7	M53, Bright centre region, very compressed
NGC 5055	G	CVn	8.6	12.6	13 15.8	+42 02	5	5,7	M63, Sunflower Galaxy
NGC 5128	G	Cen	6.8	27.6	13 25.5	–43 01	5		Centaurus A (radio source)
NGC 5139	GC	Cen	3.9	36.3	13 26.8	–47 29	5	6	Omega Centauri
NGC 5194	G	CVn	8.4	10.8	13 29.9	+47 12	5	7	M51, Whirlpool Galaxy
NGC 5189	PN	Mus	10.3	140	13 33.5	–65 58	5	1	Dunlop’s best planetary nebula
NGC 5236	G	Hya	7.5	13.1	13 37.0	–29 52	5	6	M83, Lacaille’s galaxy
NGC 5272	GC	CVn	6.3	18.6	13 42.2	+28 23	5	7	M3, Large bright globular, brightens suddenly towards the middle
NGC 5286	GC	Cen	7.4	9.1	13 46.4	–51 22	5		
IC 4406	PN	Lup	11.0	46	14 22.4	–44 09	5		Retina Nebula
NGC 5904	GC	Ser	5.7	19.9	15 18.6	+02 05	6	6	M5, Bright, large very compressed in middle, slightly oval in shape
NGC 5986	GC	Lup	7.6	9.8	15 46.1	–37 47	6		
NGC 6067	OC	Nor	5.6	13	16 13.2	–54 13	6	6	100 stars, large brightness range, central conc.
NGC 6093	GC	Sco	7.3	5.1	16 17.0	–22 59	6	6	M80, Strong central concentration, bright & large
NGC 6121	GC	Sco	5.4	26.3	16 23.6	–26 32	6	6	M4, Near Antares
NGC 6124	OC	Sco	5.8	29.0	16 25.3	–40 39	6	6	Near planetary nebula NGC 6153
NGC 6171	GC	Oph	7.8	3.3	16 32.5	–13 03	6	6	M107
NGC 6193	OC	Ara	5.2	15	16 41.3	–48 46	6		In nebula NGC 6188
NGC 6205	GC	Her	5.8	23.2	16 41.7	+36 28	6	7	M13, Great Hercules Cluster
NGC 6218	GC	Oph	6.1	14.5	16 47.2	–01 57	6	6	M12
NGC 6231	OC	Sco	2.6	15	16 54.2	–41 49	6	6	A few stars with strong central concentration
IC 4628	BN	Sco		90	16 57.0	–40 27	6		Prawn Nebula
NGC 6254	GC	Oph	6.6	12.2	16 57.1	–04 06	6	6	M10
NGC 6266	GC	Oph	6.4	14.1	17 01.2	–30 07	7	6	M62
NGC 6273	GC	Oph	6.8	5.3	17 02.6	–26 16	7	6	M19
NGC 6302	PN	Sco	9.7	72	17 13.7	–37 06	7		Bug Nebula
NGC 6341	GC	Her	6.5	11.2	17 17.1	+43 08	7	7,9	M92
NGC 6333	GC	Oph	7.9	5.5	17 19.2	–18 31	7	6	M9
NGC 6402	GC	Oph	7.6	6.7	17 37.6	–03 15	7	6,7	M14
NGC 6405	OC	Sco	4.2	20	17 40.3	–32 15	7	6,8	M6, Butterfly Cluster
NGC 6397	GC	Ara	5.3	25.7	17 40.7	–53 40	7	1,6	Loose structure, possibly the nearest globular
NGC 6441	GC	Sco	7.4	7.8	17 50.2	–37 03	7		
NGC 6475	OC	Sco	3.3	80	17 53.9	–34 48	7	6,8	M7, Ptolemy’s Cluster
NGC 6494	OC	Sgr	5.5	27	17 57.1	–18 59	7	6,8	M23, 150 stars, moderate brightness range, lies in good star field
NGC 6514	BN	Sgr	6.3	28	18 02.7	–22 58	7	6,8	M20, Trifid Nebula
NGC 6520	OC	Sgr	7.6	6	18 03.4	–27 53	7		Near Barnard 86
NGC 6523	BN	Sgr	5.0	45	18 03.7	–24 23	7	6,8	M8, Lagoon Nebula

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 6531	OC	Sgr	5.9	13	18 04.2	–22 29	7	6,8	M21
NGC 6541	GC	Cra	6.3	13.1	18 08.0	–43 42	7	8	
NGC 6572	PN	Oph	8.0	15	18 12.1	+06 51	7		
NGC 6611	BN	Ser	6.0	7	18 18.8	–13 47	7	8	M16, Eagle Nebula
NGC 6613	OC	Sgr	6.9	9	18 19.9	–17 08	7	8	M18
NGC 6618	BN	Sgr	6.0	11	18 20.8	–16 11	7	8	M17, Swan Nebula
NGC 6626	GC	Sgr	6.9	15	18 24.5	–24 52	7	6,8	M28, Large, round, increasingly compressed in the middle
		Sgr	3	95	18 19	–18 10	7	6,8	M24, Small Sagittarius Star Cloud
NGC 6633	OC	Oph	4.6	27	18 27.3	+06 31	7		Near open cluster IC 4756
NGC 6637	GC	Sgr	7.7	7.1	18 31.4	–32 21	7	1,6,8	M69
IC 4725	OC	Sgr	4.6	29	18 31.8	–19 07	7	8	M25, 30 stars loosely scattered
NGC 6656	GC	Sgr	5.2	24	18 36.4	–23 54	7	8	M22, Fine globular, only Omega Centauri and 47 Tucanae are brighter
NGC 6681	GC	Sgr	7.8	7.8	18 43.2	–32 18	7	1,6,8	M70
NGC 6694	OC	Sct	8.0	15	18 45.2	–09 24	7	8	M26
NGC 6705	OC	Sct	5.8	14	18 51.1	–06 16	7	8	M11, Wild Duck Cluster
NGC 6720	PN	Lyr	9.4	86	18 53.6	+33 02	7	7,9	M57, Ring Nebula
NGC 6715	GC	Sgr	7.7	9.1	18 55.1	–30 29	7	8	M54
NGC 6723	GC	Sgr	6.8	11	18 59.6	–36 38	7		
NGC 6726	BN	CrA		2	19 01.7	–36 53	8		
NGC 6744	G	Pav	8.3	20.2	19 09.8	–63 51	8	1	
NGC 6752	GC	Pav	5.4	20.4	19 10.9	–59 59	8	1	Starfish Cluster
NGC 6779	GC	Lyr	8.3	5	19 16.6	+30 11	8	9	M56, Irregularly round, compressed in the middle
NGC 6809	GC	Sgr	6.3	19	19 40.0	–30 58	8	8	M55
NGC 6818	PN	Sgr	10.0	22	19 44.0	–14 09	8		Near galaxy NGC 6822
NGC 6838	GC	Sge	8.3	6.1	19 53.8	+18 47	8	9	M71
NGC 6853	PN	Vul	7.3	480	19 59.6	+22 43	8	9	M27, Dumbbell Nebula
NGC 6864	GC	Sgr	8.6	6	20 06.1	–21 55	8	8	M75
NGC 6913	OC	Cyg	6.6	7	20 23.9	+38 32	8	9	M29
NGC 6981	GC	Aqr	9.2	5.9	20 53.5	–12 32	8	8	M72
NGC 6992	BN	Cyg	7.0	60	20 56.4	+31 43	8		Part of Veil Nebula
NGC 7000	BN	Cyg	4.0	120	21 01.8	+44 12	9	9	North American Nebula
NGC 7009	PN	Aqr	8.3	28	21 04.2	–11 22	9		Saturn Nebula
NGC 7078	GC	Peg	6.4	12.3	21 30.0	+12 10	9	9	M15, Bright, irregularly round, well resolved into faint stars
NGC 7092	OC	Cyg	4.6	32	21 32.2	+48 26	9	9	M39, Northern limit
NGC 7089	GC	Aqr	6.5	11.7	21 33.5	–00 49	9	8	M2
NGC 7099	GC	Cap	6.9	8.9	21 40.4	–23 11	9	8	M30
NGC 7293	PN	Aqr	6.3	960	22 29.6	–20 50	9	8	Helix Nebula
NGC 7662	PN	And	8.6	17	23 25.9	+42 32	10		Snowball Nebula
NGC 7793	G	Scl	9.1	9.6	23 57.8	–32 36	10		

LEGEND

Catalog Catalogue number (NGC New General Catalogue, IC Index Catalogue)

Type Object type:
- G Galaxy
- GC Globular Cluster
- OC Open Cluster
- BN Bright Nebula
- PN Planetary Nebula

Con Constellation
Mag Magnitude of object
Size In arcminutes (PN in arcseconds)
RA Right Ascension (hh mm.m, Epoch 2000.0)
Dec Declination (° ', Epoch 2000.0)
Mth 10 pm Month the object is highest at 10 pm.
Map All Sky Map number
Notes Common name and/or description

RISE & SET TIME ADJUSTMENTS FOR OTHER LOCATIONS

The rise and set tables for the Sun, Moon and planets in Part II are given for our capital cities. Here we help people who live outside these cities make adjustments to determine the rise and set times for their specific location. There are two adjustments needed.

1. Adjust 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**. Adjustments for various towns and cities are given in Table 1.
2. Adjust for the difference in latitude, that also requires the declination for the object of interest. Table 2 presents these adjustments (southern latitudes are negative). Note, **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 and set times for Sydney are used, irrespective of which town in Australia the calculations are for, when using these tables. If your local time is CST, **subtract** 30 minutes, if WST, **subtract** 2 hours. If daylight saving, **add** 60 minutes. In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example Calculate the rise and set times for the Sun on 3 January for Albury (36° 05'S, 146° 55'E)	**Rise**	**Set**
Rise and set values for Sydney (p. 85):	4:49	19:10
Adjust for longitude (Table 1) positive as Albury is west of Sydney.	+ :17	+ :17
Adjust for latitude and declination of the Sun from Table 2. Sun's declination is −22° 53' (p. 83)	− :06	+ :06
Rise and set times for Albury are:	5:00	19:33

Location	Lat. (° ' S)	Longitude (° ' E)	Long. dif (dec. °)	correct. (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	31 57	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
Uluru	25 11	130 58	20.3	81
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
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
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
Warrnambool	38 27	142 30	8.8	35
WESTERN 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
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
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
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
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

Table 1 **Longitude adjustments for some places relative to Sydney**

Declination	South Latitude (negative)																
	−12°	−14°	−16°	−18°	−20°	−22°	−24°	−26°	−28°	−30°	−32°	−34°	−36°	−38°	−40°	−42°	−44°
30°	−63	−58	−53	−48	−43	−37	−32	−26	−20	−13	−7	0	8	16	25	34	44
25°	−50	−46	−42	−38	−34	−30	−25	−20	−16	−11	−5	0	6	12	19	26	34
20°	−39	−36	−33	−29	−26	−23	−19	−16	−12	−8	−4	0	5	9	15	20	26
15°	−28	−26	−24	−22	−19	−17	−14	−11	−9	−6	−3	0	3	7	10	14	18
10°	−19	−17	−16	−14	−13	−11	−9	−7	−6	−4	−2	0	2	4	7	9	12
5°	−9	−8	−8	−7	−6	−5	−5	−4	−3	−2	−1	0	1	2	3	5	6
0°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
−5°	9	8	8	7	6	5	5	4	3	2	1	0	−1	−2	−3	−5	−6
−10°	19	17	16	14	13	11	9	7	6	4	2	0	−2	−4	−7	−9	−12
−15°	28	26	24	22	19	17	14	11	9	6	3	0	−3	−7	−10	−14	−18
−20°	39	36	33	29	26	23	19	16	12	8	4	0	−5	−9	−15	−20	−26
−25°	50	46	42	38	34	30	25	20	16	11	5	0	−6	−12	−19	−26	−34
−30°	63	58	53	48	43	37	32	26	20	13	7	0	−8	−16	−25	−34	−44

Table 2 **Rise and set corrections for latitude and declination (from Sydney)**

JULIAN DATE

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 0 hr 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 need the Julian date at 23:00 EST on 17 July 2015. Subtract 10 hours to get UT.

23 – 10 = 13:00 hrs UT

From the table the JD for July 0 is 2457203.5

Add the day of month, 17 gives us 2457220.5

Now add the hours as a fraction of a day from the 2nd table. 13 hr is 0.542. Thus JD at 23:00 17 July 2015 EST is 2457221.042

Julian Date (0 hr UT)		
Month		Julian Date
Jan	0	2457022.5
Feb	0	2457053.5
Mar	0	2457081.5
Apr	0	2457112.5
May	0	2457142.5
Jun	0	2457173.5
Jul	0	2457203.5
Aug	0	2457234.5
Sep	0	2457265.5
Oct	0	2457295.5
Nov	0	2457326.5
Dec	0	2457356.5

Hours as decimal of a day.			
1	0.042	13	0.542
2	0.083	14	0.583
3	0.125	15	0.625
4	0.167	16	0.667
5	0.208	17	0.708
6	0.250	18	0.750
7	0.292	19	0.792
8	0.333	20	0.833
9	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

Jan	0	6.6229	Jul	0	18.5164
Feb	0	8.6599	Aug	0	20.5534
Mar	0	10.4998	Sep	0	22.5904
Apr	0	12.5368	Oct	0	0.5617
May	0	14.5081	Nov	0	2.5987
Jun	0	16.5451	Dec	0	4.5700

Greenwich mean sidereal time (GMST) at 0 hr UT

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 0 hr UT (from table above) + 0.06571 d + 1.00274 t

To convert to local mean sidereal time (LMST)

LMST = GMST + east longitude (or – west)

where longitude is expressed in HOURS (not degrees!) To convert to hours, just divide by 15.

Example: Find LMST at 23 hours Sydney time (EST) on 17th July 2015.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5164 hours.

$$\text{GMST} = 18.5164 + (0.06571 \times 17) + (1.00274 \times 13) = 32.6691$$

Sydney's longitude (151.25°) is 10.0833 hrs so

$$\text{LMST} = 32.6691 + 10.0833 = 42.7524$$

Subtract from this multiples of 24 until it is in the range of 0 to 24

42.7524 – 24 = 18.7524 hrs or 18 h 45 m 09 s

PLACES OF ASTRONOMICAL INTEREST

Following is a list of places of astronomical interest. These facilities cater to the public with tours and/or displays. Information is subject to change. Links to the websites here can be found on the Quasar site: www.quasarastronomy.com.au

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY RESEARCH FACILITY

They operate their 'Open Nights' public observatory tours on a regular basis. School groups and general public tours a speciality. They are also dedicated to meteorite research, and the meteorite collection is open by request. Information on tour dates and times can be found on the web site. They also have a Facebook page.

Address	624 Limekilns Road, Bathurst NSW 2795
Times	See website for latest tour dates and times.
Cost	See website for details.
Contact	Bathurst Observatory Research Facility (02) 6337 3988
Email	info@bathurstobservatory.com.au
Web	www.bathurstobservatory.com.au

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The complex is located 35 km southwest of Canberra (Tourist Drive 5) and 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 and beyond. The centrepiece is the 70-metre antenna, the largest in Australia. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is an actual Moon rock. The MoonRock Cafe and gift shop is available for meals and souvenirs.

Address	Discovery Drive (off Paddy's River Rd), Tidbinbilla
Times	9 am to 5 pm, 7 days per week (except Dec 25)
Cost	Free.
Contact	Korinne McDonnell (02) 6201 7809 / 7838 < pr@cdscc.nasa.gov>
Web	www.cdscc.nasa.gov/

CRAGO OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (northwest of Sydney). It houses a 40 cm Dobsonian telescope. Due to a lack of local light pollution, the observatory enjoys the darkest sky in the Sydney region and is open on Saturday nights nearest to Last Quarter Moon. Visitors most welcome.

Address	Burralow Fire Trail, Bowen Mountain
Times	8 pm till late
Cost	Donation
Contact	Carlos Orue 0422 300 649 <VP_Crago@asnsw.com>
Web	www.asnsw.com/crago/index.html

CSIRO PARKES RADIO TELESCOPE

The famous Parkes Observatory, 'The Dish', is located 20 km north of Parkes (just off the Newell Highway). This landmark radio telescope is over 50 years old, but still considered to be one of the best single dish radio telescopes in the world. As well as a great view of the telescope, the visitors centre has displays and a 3D Theatre. There is also the Dish Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available.

Address	CSIRO Parkes radio telescope, Newell Hwy (PO Box 276), Parkes NSW 2870
Times	8:30 am to 4:15 pm – daily except Christmas and Boxing Day. Extended visiting hours during NSW school holidays.
Cost	Admission to the visitor's centre is free although there is a modest charge for the 3D Theatre.
Contact	(02) 6861 1777 <VCStaff-PA@csiro.au>
Web	www.csiro.au/parkes

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra.

Address	23 Observatory Road, Darbys Falls, NSW 2793
Times	Winter 7–10 pm; Summer (DST) 8:30–11 pm, bookings essential.
Cost	Adults $15; seniors $13; children (under 15) $10; family (2 adults, 2 children) $40; extra children $7 each; Groups 10+ POA
Contact	Mark Monk (02) 6345 1900 <darbysob@harboursat.com.au>

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. An entertaining audio visual is followed by viewing through up to five Schmidt telescopes (10" and 12"). There is a gift shop and and an 18 hole themed mini golf course including Stonehenge and Dr Who's Tardis.

Address	17L Camp Rd (PO Box 308) Dubbo NSW 2830
Times	Mini Golf: Weekends/public holidays and by appointment. Observatory sessions: These vary over the year please check website.
Contact	Peter Neilson (02) 6885 3022
Email	enquiries@dubboobservatory.com.au
Web	www.dubboobservatory.com.au

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The building houses 41 cm and 35 cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also run regular open nights for the general public.

Address	Cnr Green Point & Caravan Head Roads, Oyster Bay (PO Box 31, Sutherland NSW 1499)
Times	from 7:30 pm
Cost	Gold coin donation appreciated
Contact	Secretary 0408 832 408 (voicemail) <info@sasi.net.au>
Web	www.sasi.net.au

KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE

Located on the border of the Central Coast and Lower Hunter, the centre is no more than two hours from most Sydney and Newcastle suburbs. Bookings are essential. Koolang staff have also developed curriculum and theme based presentations to cover all school levels K–12. The preferred method of contacting the observatory is via phone on the number below.

Address	Great North Road, Bucketty NSW
Times	Group bookings 7 days and nights. Individuals and families Friday and Saturday nights. Night shows start about an hour after sunset. Starting times 8 pm for 8:30 or by arrangement. Prefer bookings by phone.
Cost	Public night shows: adults $20, concession $17, child $14; group discounts available; special prices and hours for schools (subject to change without notice).
Contact	(02) 4998 8216 <staff@koolang.com.au>
Web	www.koolang.com.au

LINDEN OBSERVATORY

WSAAG (Western Sydney Amateur Astronomy Group) holds observing Nights at Linden Observatory. These are usually held on Saturdays closest to the New Moon. Visits by members of the public are welcome but strictly by appointment only.

Address	105 Glossop Road, Linden NSW 2778
Times	See website.
Cost	See website <enquiry@wsaag.org>
Web	wsaag.org

MACQUARIE UNIVERSITY ASTRONOMICAL OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on Friday nights unless raining from March to November inclusive. Astronomy students will guide you with a range of telescopes.

Address	Macquarie University via Culloden Rd
Times	Observatory sessions run on every Friday night from March to November inclusive (excluding public holidays). Sessions run from 8–9:30 pm during daylight savings, and 7–8:30 pm during the rest of the year. Bookings are now essential online or by email.
Cost	$11 adult, $8 child/student/senior, $32 family, children < 5 free.
Email	starinfo@mq.edu.au
Web	physics.mq.edu.au/community/observatory/

MUDGEE OBSERVATORY

Mudgee Observatory is located just outside the small town of Mudgee NSW. A private observatory for the past ten years, it is now open to the general public, catering for school groups, organised tours and any member of the general public who wishes to attend. The observatory is situated 15 minutes drive to the west of Mudgee in a location of extremely dark skies away from the town lights and the lights of Ulan mines. The theatre and flat screen planetarium runs several features on the night sky and the Sun as well. A variety of telescopes and binoculars are available for visitors to use as well as conducted tours of the night sky. Bookings are essential.

Address	961 Old Grattai Rd Mudgee NSW 2850
Times	See web site for costs and times.
Contact	(02) 6373 3431 or 0428 560 039
Email	john@mudgeeobservatory.com.au
Web	www.mudgeeobservatory.com.au

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association Inc, is situated in Rotary Park (opposite Town Beach) Port Macquarie.

Address	PO Box 1453, Port Macquarie NSW 2444
Times	7:15 pm EST and 8:15 pm EDT
Cost	Adult $8, child $5, family $22 (2+2), under 5 free.
Contact	Kevin Gallagher 0498 690 802 <pmobs50@gmail.com>
Web	www.pmobs.org.au

SIDING SPRING OBSERVATORY

Siding Spring Observatory is Australia's premier optical astronomy research facility and is home to telescopes from many organisations within Australia and around the world. These include Australia's two largest optical telescopes, the 3.9 metre Anglo-Australian Telescope and the 2.3 metre Advanced Technology Telescope. Organisations currently operating telescopes at Siding Spring include the Australian National University, the Australian Astronomical Observatory, the University of New South Wales, the University of North Carolina, Polish Academy of Sciences, Princeton University, iTelescope.Net, Korean Astronomy and Space Science Institute and the Las Cumbres Optical Global Telescope Network. LCOGTN now have three telescopes operating at Siding Spring, a 2 metre, and two advanced 1 metre telescopes, all of which are available for web based education and research work. iTelescope.Net have 17 telescopes housed at Siding Spring, and they operate a global network of telescopes available online to the public. The Australian National University's robotic survey telescope SkyMapper sits on the top of the Mountain, surveying the Southern Sky, while the remotely operated and robotic telescopes of the HAT-South network and Project Solaris search for planets around other stars. PROMPT, operated by UNC as part of SKYNET, searches the sky for Gamma Ray Bursts, the most powerful explosions in the Universe, while the Korean Microlensing Telescope observes the faint flicker of objects moving between us and a faraway star, and there are still more telescopes to come over the next 12 months.

Siding Spring nestles into the Warrumbungle mountains at the entrance to the Warrumbungle National Park, 30 minutes west of Coonabarabran. The Visitor's Centre includes a café serving light meals, morning and afternoon teas, souvenir shop and an astronomy exhibit with hands on displays, videos and much more. From the Visitor's Centre, there is access to the viewing gallery of the 3.9 m Anglo-Australian Telescope and special tours of the site can be organised on request for school and other groups.

StarFest, a celebration of astronomy and the observatory is held on the long weekend in October in conjunction with the Warrumbungle Festival of the Stars. More information can be found at www.starfest.org.au

Address	Observatory Rd, Coonabarabran NSW 2357
Times	9:30 am to 4 pm Monday to Friday, 10 am to 4 pm Saturday, Sunday and public holidays.
Cost	Varies by type of tour.
Contact	Public enquiries and tour information, Amanda Wherrett (Outreach Officer) (02) 6842 6363
Email	amanda.wherrett@anu.edu.au
Web	rsaa.anu.edu.au/observatories/siding-spring-observatory

SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a 3-D Space Theatre, Digital planetarium and telescope tours, fascinating historic and interactive displays and night telescope tours (which include stargazing through the observatory's telescopes). The planetarium is also used during wet weather at night. Reconstruction of the astrographic third dome with fully accessible DFM telescope commenced in late 2014. Day tours are either the 3-D Space theatre or a planetarium show with a dome tour and solar viewing (weather permitting). Sydney Observatory is part of the Museum of Applied Arts and Sciences.

Address	1003 Upper Fort St, Millers Point NSW 2000
Times	10 am to 5 pm. Tours run at 2:30 pm, 3:30 pm and 4 pm weekdays, 11 am, 12 noon, 1 pm, 2:30 pm, 3:30 pm and 4 pm weekends.
Cost	See their website for prices, special events and on-line bookings.
Contact	(02) 9921 3485 <observatory@phm.gov.au>
Web	www.sydneyobservatory.com.au

THE AUSTRALIA TELESCOPE COMPACT ARRAY – NARRABRI

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22 m dishes, five of which are spaced along a 3 km 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	1828 Yarrie Lake Road, Narrabri NSW 2390
Times	8 am to 4 pm daily; unstaffed, except by request for groups (15+).
Cost	No charge to visit the centre. For groups requesting a staff guide there is a charge of $3 weekdays, $5 weekends per person and three weeks notice required.
Contact	Outreach staff (02) 6790 4070 <atnf-narrabri-outreach@csiro.au>
Web	www.narrabri.atnf.csiro.au

THE UNIVERSITY OF WESTERN SYDNEY PENRITH OBSERVATORY

The UWS Penrith Observatory is open to the public and runs public astronomy evenings, school and group programs. A visit can include listening to fascinating lectures on various aspects of astronomy, a 3D astronomy movie and viewing through fully computerised telescopes. You can also come and listen to special lectures given by some of Australia's eminent and internationally recognised astronomers, physicists and engineers.

Address	University of Western Sydney, Great Western Highway, Werrington North (Building AO)
Times	See web site for details of costs and times.
Web	www.uws.edu.au/observatory

WARRUMBUNGLE OBSERVATORY

The observatory is located at Coonabarabran and is open to the public for night viewing through a number of telescopes. Visitors are encouraged to bring DSLR cameras (Canon, Nikon, Pentax) to take astrophotographs of star clusters, nebulae and galaxies. The observatory can be hired by the more serious amateur astronomer to take advantage of the 51 cm telescope and CCD for astrophotography and photometry. There are piers available for Meade and Celestron telescopes if amateurs wish to bring them along. The site also hosts remote observatories utilised by our Northern Hemisphere cousins and is part of the Sierra Stars Observatory Network providing quality data for customers around the world.

Address	841 Timor Rd, Coonabarabran NSW 2357
Times	90 minute night sky and telescope viewing times vary depending on the time of year and bookings are essential.
Cost	Adults $20, school age children $10
Contact	Peter Starr 0488 425 112 <starr_peter@hotmail.com>
Web	www.tenbyobservatory.com

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes the BlueScope Steel Planetarium, observatory, laser light shows, extensive interactive exhibits, demonstration theatre (Illawarra Coal Science Theatre), and a gift and resource shop. The Planetarium has a Zeiss ZKP3 star projector, laser projector and a state of the art full-dome projection system. The observatory houses a high quality computer controlled telescope which is used to observe the Sun and stars. The Science Shop has one of the most extensive ranges of science educational materials in Australia, including telescopes.

Address	Science Centre & Planetarium, Innovation Campus, 60 Squires Way, North Wollongong 2500
Times	10 am to 4 pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Cost	Child $9, concession $11, adult $13; discount on planetarium show tickets when purchased with general entry.
Contact	(02) 4286 5000 (option 2) fax (02) 4283 6665
Email	science_centre@uow.edu.au
Web	sciencecentre.uow.edu.au

QUEENSLAND

ALLOWAY OBSERVATORY

The observatory, situated approximately 6 km south of Bundaberg, is operated by the Bundaberg Astronomical Society. The 6 metre dome houses a 480 mm Newtonian telescope and a 12 inch Meade ACF telescope with CCD imaging using various astronomical cameras. The observatory opens to the public on Friday nights. Midweek opening also arranged for large groups.

Address	PO Box 4221, South Bundaberg Qld 4670
Times	Open to the public 2nd Friday each month, other nights by appointment.
Cost	$20 family; $8 adult; $5 child, discounts for groups.
Contact	Lonnie Smilas 0468 857 309 or 0418 868 695
Email	lonnie37@me.com
Web	alloway-observatory-bundaberg.webs.com

COSMOS CENTRE AND OBSERVATORY CHARLEVILLE

The public observatory is located on Cunnamulla Rd, near the Charleville airport. The Centre includes an observatory for night viewing of the stars and planets. During the day the Sun Viewing sessions operate, using a solar telescope, Astronomy by Day includes a theatre presentation, seven interactive displays and two mini-talks – an update on dwarf planets and a meteorite talk where the collection is taken out of the cabinet for you to hold. Special programmes arranged for groups and schools. Bookings are essential for the Observatory and Sun Viewing Sessions.

Address PO Box 681, Charleville 4470
Times Contact them or see web site for times and costs
Contact (07) 4654 7771 <obguides@bigpond.com>
Web www.cosmoscentre.com

MAIDENWELL ASTRONOMICAL OBSERVATORY

Established in 2004 this is Queensland's largest, self-funded Astro-Tourism business and bookings are essential. Their night shows include a registered green laser guided tour of the night skies, before viewing the Moon, planets and stars using one of three Meade LX200 GPS 14 inch telescopes on the observation deck which can seat up to 45 persons. One hour day shows in the 77 seat Star Theatre are generally held at 2 pm subject to a minimum booked number of six persons. On sunny days you can sit in comfort and watch, on a big theatre screen, an instant colour video image of the Sun projected from a colour Stellacam II video camera attached to a Coronado Solarmax 60 telescope outside. They also show you audio/visual clips of the Solar System and Universe. The observatory is also setup for schools and social groups. The facility also has an on-site camp kitchen available for hire to schools and community groups and gold coin operated hot showers. Located on a disused sports field in the heart of Maidenwell, the observatory is three hours drive northwest of Brisbane and 40 minutes from Kingaroy and Nanango.

Address Main Rd, Maidenwell Qld 4615
Times Spring/Summer: Night sessions start at 7:30 pm;
Autumn/Winter: Night sessions start at 7 pm.
Cost See website for shows and bookings.
Contact Bookings by phone or email are essential for Day and Night sessions, phone (07) 4164 6194 or 0427 961 391
Email mao123@bigpond.com
Web www.maidenwellobservatory.com

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs presented in the Cosmic Skydome have various themes and are projected onto the interior of a 12.5 m dome. All shows include a current night sky tour recreated in the Skydome. During 2013, the Planetarium became one of the most advanced and versatile planetariums in the Southern Hemisphere with major upgrades to its Cosmic Skydome with a new projection dome, furnishings, optical star projector and new digital full dome projectors. The updated display areas contain astronomical and space items, while short videos and space news updates run in two small theatres. The shop has a wide range of astronomical and educational products, as well as souvenirs. The Planetarium observatory has a variety of telescopes and sessions must be pre-booked. School shows are also available during weekdays and are available to the public on a space-available basis.

Address Brisbane Botanic Gardens Mt Coot-tha,
Mt Coot-tha Rd, Toowong Qld 4066
Times Tuesday – Friday: school shows and one afternoon public show. Public of at least school age may attend school shows if space permits.
Saturday/Sunday: multiple general audience and children's shows.
School shows are on a booking basis only. Additional weekday shows run during Queensland school holidays.
Cost Show charges apply
Contact (07) 3403 2578 <bop@brisbane.qld.gov.au>
www.brisbane.qld.gov.au/planetarium/ www.facebook.com/BrisbanePlanetarium

SOUTH AUSTRALIA

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

Located in the heart of the northern Flinders Ranges, Arkaroola have a total of eleven Advanced Ecotourism accredited products including Ridgetop, Astronomy and Waterholes tours. There are also many guided and unguided bushwalks. They have three astronomical observatories offering two Celestron 360 mm and three Meade Maksutov-Cassegrain computer assisted telescopes. There are also spare piers and wedges suitable for BYO telescopes and astrophotography/CCD equipment.

Address Private Bag 106, Port Augusta SA 5710
Times Tours run nightly on demand and weather permitting.
Cost Cost is $40 (up to 1.5 hours per tour)
Contact (08) 8648 4848 fax (08) 8648 4846 <res@arkaroola.com.au>
Web www.arkaroola.com.au

STOCKPORT OBSERVATORY

Owned and operated by the Astronomical Society of South Australia (ASSA), the observatory is located in the small town of Stockport (6 km north-east of Hamley Bridge) approximately 80 km north of Adelaide. It provides a convenient astronomical facility away from the light pollution which surrounds Adelaide. Public star parties are held at Stockport in February, May, August and November. See web site for details.

Address Observatory Road, Stockport SA 5410
Times Public star parties 8 pm to 11 pm. Private bookings for groups and schools also available.
Cost $10 per person.
Contact ASSA Info Line (08) 8338 1231 <observatories@assa.org.au>
Web www.assa.org.au/facilities/stockport/

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury Heights, Adelaide. There are two main telescopes, 14" LX200ACF and research quality 12.5" RC OGS plus 60 mm and 40 mm Coronado solar scopes. Private bookings are accepted, (08) 8263 6244.

Address Brunel Drive, Modbury Heights
Times Evening
Cost Adults $10, U15 $3, groups min. $100 includes up to 10 people.
Contact Andrew Cool <andrew@cool.id.au>
Web www.theheights.sa.edu.au/observatory.html

UNIVERSITY OF SOUTH AUSTRALIA, ADELAIDE PLANETARIUM

Adelaide Planetarium is open seven days a week by appointment for group and private bookings. Adult education courses are held throughout the year along with school holiday programs. General public sessions are held on the 1st and 3rd Saturday of the month at 1 pm that combines a full dome movie with a condensed Night Sky session and a 2.45 pm one hour Night Sky Presentation session.

Address University of South Australia, Building P, Mawson Lakes Campus
Times 1 pm & 2:45 pm 1st and 3rd Saturday of the month or by appointment seven days a week.
Cost $9 adults, $7 children and concession
Contact (08) 8302 3138 (bookings essential)
Email adelaide.planetarium@unisa.edu.au
Web www.unisa.edu.au/planetarium/

TASMANIA

LAUNCESTON PLANETARIUM

The Launceston Planetarium is at the Queen Victoria Museum's Inveresk site. See their web site for details of shows.

Address Queen Victoria Museum, 2 Invermay Road Launceston Tas 7250
Contact (03) 6323 3777
Web www.qvmag.tas.gov.au

VICTORIA

ASTROTOURS

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 school holidays. AstroTour sessions can also be booked for school groups (Years 3–12) throughout the year.

Address The Virtual Reality theatre is located on the ground floor of the AR building in room AR104, Hawthorn campus, Swinburne University of Technology.
Cost $10 (school holiday shows) $7.70 (primary school groups) $8.80 (secondary school groups)
Contact Dr Christopher Fluke (03) 9214 5828 (school group enquiries)
Elizabeth Thackray (03) 9214 5569 (bookings).
Email astrotour@swin.edu.au
Web astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The observatory has several historic telescopes including the Jelbart (a 125 mm refractor), the Oddie (a 220 mm Newtonian), the Baker Great Equatorial Telescope (a 650 mm Newtonian, commissioned in 1886) and a 300 mm Newtonian. The Adcock-Federation telescope (406 mm Cassegrain-Springfield) has disabled-access. Observatory open Tuesday to Saturday. Bookings essential. See website for open times and calendar of events. Astrotour 3D Movies are available in conjunction with Swinburne University of Technology.

Address Cnr of Magpie and Cobden Street, Mount Pleasant, Ballarat East
PO Box 284 Ballarat 3353

Times As per website Tue – Sat, bookings taken for other times & days.

Cost Various, see web site

Contact (03) 5332 7526 Open hours 0429 199 312 After hours for bookings.

Email bas@cbl.com.au

Web observatory.ballarat.net

BENDIGO PLANETARIUM @ DISCOVERY

Part of the Discovery Science and Technology Centre, shows are presented at 1.30 pm daily and 11.30 am and 1.30 pm on weekends and holidays, school or group booking on request. The seven metre dome uses a Mirrordome system and has beanbags you can sink into! During school holidays we look at a different aspect of astronomy, whether it be an upcoming event or an object that is visible in the night sky at the time.

Address Discovery Science and Technology Centre
7 Railway Place Bendigo

Times 1:30 pm daily, 11:30 am and 1:30 pm weekends and holidays.

Cost Included in general admission price

Contact (03) 5444 4400 <planetarium@discovery.asn.au>

Web www.discovery.asn.au

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 150 and produces shows for all ages. The planetarium is open seven days a week from 10 am and runs special evening sessions in March and August.

Address 2 Booker St, Spotswood Vic 3015

Times See web site for costs and times.

Contact 131 102

Web museumvictoria.com.au/planetarium/

WESTERN AUSTRALIA

GINGIN OBSERVATORY – THE SPACE PLACE!

The observatory is situated in the Shire of Gingin, an hour north of Perth. Their main instrument is the 25 inch Brodie-Hall telescope. They have five other telescopes ranging from 11" to 16" as well as four pairs of binoculars. They specialise in school programs and community groups.
Stargazing evenings and a variety of special events that feature astronomical highlights are held throughout the year. Stargaze through telescopes to see planets, stars, galaxies and more. Chat with expert astronomers and discover more about the wonders of space!

Address 1098 Military Road, Gingin

Times See web site for costs and times.

Contact Office (08) 9575 7740 <stars@ginginobservatory.com>

Web www.ginginobservatory.com

PERTH OBSERVATORY

Situated in the Darling Ranges about 25 km east of Perth CBD, the Perth Observatory is WA's State Government observatory. As a major part of its education and outreach commitment, Perth Observatory hosts public star viewing sessions which run from October to April/May. To be sure of obtaining a booking you should phone or email well ahead. Places are limited. If you want to know what objects are visible on a certain date, you can ask to speak with a member of the astronomical staff — e.g. "Can I see the Moon? A planet? The Southern Cross?". Daytime guided tours of the Observatory facilities are also available by appointment. These cater mainly to excursion groups such as school children and seniors. The school tours are aligned with the national curriculum.

Address 337 Walnut Road, Bickley WA 6076
End of Walnut Road in Bickley, 15 minutes east of Kalamunda.

Times Bookings (essential) 8 am – 3:30 pm Monday to Friday
Daytime guided tours 10 am and 12:30 pm Monday to Friday, duration approx. 90 min., prices $15 adult, $11 per child or senior.
Star Viewing Nights - most weekends, from October to April or early May. Starting time varies with sunset time e.g. 7:30 pm in October, 8:30 pm in January. Duration approx. 90 min., $38 adult $28 concession (kids, students, pensioners). Booking essential.

Contact (08) 9293 8255, fax (08) 9293 8138

Email perth.observatory@dpaw.wa.gov.au

Web www.perthobservatory.wa.gov.au

EVENTS AND RESOURCES

The following are astronomy courses, events, magazines, websites and radio programs for this year. This list is by no means 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 with lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change. Links to the websites here can be found on the Quasar site: www.quasarastronomy.com.au

GENERAL

AUSTRALIAN SKY & TELESCOPE MAGAZINE

Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the formidable worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, Australian Sky & Telescope is a magazine produced specifically for the Southern Hemisphere's astronomers.

Consistently delivering the latest news and developments in astronomy 8 times a year, Australian Sky & Telescope caters for everyone with an interest in space and astronomy, from the absolute beginner looking to buy their first telescope to the seasoned observer wanting to expand their collection of equipment or acquire new skills.

With its thorough equipment reviews, detailed sky maps, up-to-date news, and knowledgeable advice on observing the southern skies, Australian Sky & Telescope is a powerful source of inspiration to get out and see the wonders of the Universe.

Address PO Box 81 St Leonards NSW 1590

Fees $9.50 in newsagencies or $76 for one year (8 issues).

Contact (02) 9439 1955 fax (02) 9439 1977

Email info@skyandtelescope.com.au

Web www.skyandtelescope.com.au

ICEINSPACE

IceInSpace is a community Web site dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers from around the world discover, discuss and enjoy the beauty of our night sky. IceInSpace is free to join and use, all you need is a valid email address.
By registering you will be able to post topics on the IceInSpace Forum, communicate privately with other members (PM), respond to polls, upload content and images and access many other special features. IceInSpace is eight years old and is the largest and most active astronomy community in the southern hemisphere, with over 13,500 members.

Address PO Box 9127, Wyoming NSW 2250

Fees Free to join, Free to use!

Contact Mike Salway <mike@iceinspace.com.au>

Web www.iceinspace.com.au

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

Fees See web site.

Contact Reg R. Wilson (Liaison Officer Asia/Pacific) phone/fax (02) 9488 7078

Email regrw@tpg.com.au

Web www.darksky.org

NATIONAL SCIENCE WEEK

Held in August each year, the aim of this week is a nationwide celebration of Australian science and has the objective to increase public awareness of the role that science, engineering, mathematics, innovation and technology play in our daily lives and to encourage younger people to become fascinated by the world we live in. Astronomy is always a key component, and amateur societies are ideally placed for such outreach. It runs from August 15–23, 2015. Support is available for event holders in each state and territory. See the web site for more information.

Web www.scienceweek.net.au

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia is the society of professional astronomers in Australia. It has a Society website and a second Australian Astronomy site providing links, both professional and amateur, and including links to educational material.

Contact A/Prof. John O'Byrne <john.obyrne@sydney.edu.au>

Web asa.astronomy.org.au (ASA site)
www.astronomy.org.au (Australian Astronomy site)

VARIABLE STARS SOUTH

VSS is an international association of astronomers, amateur and professional, interested in researching the rich and under-explored realm of southern variable stars. VSS covers most techniques of variable star research: visual observing with binoculars or telescopes, imaging with DSLRs and astronomical CCD cameras, and even spectrography. Its research work is project-oriented, often involving professional/amateur collaboration. VSS is directed by Dr Tom Richards of Melbourne, but its 'home' is its website, visit it for further information and contacts.

Email director@variablestarssouth.org
Web www.variablestarssouth.org

EVENTS

ASTROFEST (PARKES, NSW)

The CWAS AstroFest is sponsored by the Central West Astronomical Society and was first held in July 2004. The AstroFest incorporates a two day conference and related activities including the David Malin Astrophotography Exhibition and Competition which is open to all amateur astrophotographers. World-renowned professional and amateur astronomers share their knowledge and experience in an exciting amateur astronomy festival. The CWAS AstroFest is held annually in July, with the 2015 festival scheduled for the weekend of 18–19 July.

Address CWAS AstroFest, PO Box 819 Parkes NSW 2870
Fees To be determined.
Contact John Sarkissian (of the Local Organising Committee)
Email astrofest@cwas.org.au
Web www.cwas.org.au/astrofest/

BORDER STARGAZE

The Astronomical Society of Albury Wodonga will host the Border Stargaze 23–26 October 2014. An annual gathering of amateurs for observing under country skies. This major event combines public outreach activities with that of the star party format. Guest speakers, mobile planetarium (Cosmodome), workshops, astronomical activities and so much more. See the society web site for more details.

Address ASAW (Border Stargaze), PO Box 1500, Lavington NSW 2641
Fees Registration $30.00 (accommodation fee separate)
Contact David Chandler 0421 816 007 < borderstargaze@iprimus.com.au>
Web www.asaw.org.au

ICEINSPACE ASTRO CAMP

The IceInSpace AstroCamp is held at Lostock, in the beautiful clear dark skies of the Hunter Valley. Features include very dark skies, bunkhouse or camping accommodation, fully equipped kitchen and toilets/showers, 240V power, swimming hole, guest speakers, workshops and a lucky door prize competition. The 2015 camp is 19–21 March. Contact Mike or checkout IceInSpace for more information.

Address Lostock, Hunter Valley NSW
Contact Mike Salway <mike@iceinspace.com.au>
Web www.iceinspace.com.au/iisac

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, telescopes operated by local amateurs and commercial stands. They are now held once a year, normally in April – May (a Saturday night around First Quarter Moon). The venue is Macquarie University (off Epping Rd, North Ryde, Sydney), commencing around 6:30 pm.

Address Dept of Physics, Macquarie Uni NSW 2109
Fees Children/Students/Seniors: $5, Adults: $13, Families: $30, Association for Astronomy Members: Free.
Contact Macquarie University Switchboard (02) 9850 7111
Email starinfo@mq.edu.au
Web physics.mq.edu.au/community-schools/afa/opennight/

NACAA

The National Australian Convention of Amateur Astronomers Inc was started in 1967 and since has become a regular national forum at which amateur astronomers can exchange experiences, stay abreast of the latest trends, foster co-operative activities between individuals, societies and the professional sphere, and network amongst their peers throughout Australia and beyond. They are held over Easter every two years. The 27th NACAA will be held in southern Sydney, 25–28 March 2016, hosted by the Sutherland Astronomical Society.

Web www.nacaa.org.au

QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The Queensland Astrofest, rated in the Top Ten of the world's best astrocamps (BBC Sky at Night 2007), is held annually at the Lions Club Camp Duckadang, at Linville, 160 km northwest of Brisbane. It has a dark sky with bunk house accommodation. They have rooms for families with young children and plenty of room for camping and caravans. There is 240 volt power available for telescopes. Catered meals are available twice a day (about $8 per meal) from the camp managers; self-catering facilities will be available.

Queensland Astrofest boasts a nine day format, Friday August 7 to Sunday 16 2015. Each Saturday will have vendor sales and talks from major speakers. Workshops will be run each day covering various topics such as how to polar align, and colour balancing in Photoshop. The renowned Astro-Feast is held on the last Saturday night of the camp.

Entries for the Erwin van der Velden Photography Awards can be lodged any time, but if it is after the start of the camp, you will lose votes from earlier visitors. More details are on the Web site. Qld Astrofest is a great environment for exchanging ideas and techniques.

Registration opens April/May, early registration and payment is recommended. Cancellations with 100% refund at least two weeks before the start, after that there is a cancellation fee of $5.

Address Lions Camp Duckadang, Avoca Creek Rd, Linville Qld 4306
Fees Prices are estimated to start at $22 per night for adults, with an early bird discount of $2. (applies to all accommodation styles)
Contact Registrar by email <registrar@qldastrofest.org.au>
Web www.qldastrofest.org.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 300 people. See the society web site for more details.

Email president@asnsw.com
Web www.asnsw.com/spsp/index.asp

VASTROC (VIC)

VASTROC 2015 will be hosted by Bendigo District Astronomical Society at Discovery Science & Technology Centre, Bendigo on the weekend of 17 – 19 April 2015. This is an event for amateur astronomers by amateur astronomers for socialisation, speakers, poster displays, observing & convention dinner. See web site for more information.

Web vastroc.net

VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party is an annual weekend of astronomy, held at the Little Desert Nature Lodge about 16 km south of the town of Nhill in western Victoria. Jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, it offers a great weekend of social, astronomical and observing activities. VicSouth 2014 is planned for October 24 to 27 while VicSouth 2015 is scheduled to occur from Friday November 6 to Monday November 9, 2015. See website for more details.

Web www.vicsouth.info

NEW SOUTH WALES

MACQUARIE UNI. ASSOCIATION FOR ASTRONOMY

The AFA acts as a support group for astronomy activities at Macquarie University. Through its activities it supports community education in astronomy.

Address Department of Physics and Astronomy, Macquarie Uni NSW 2109
Fees see web site.
Email starinfo@mq.edu.au
Web physics.mq.edu.au/community/AFA/

MACQUARIE UNIVERSITY PLANETARIUM

Their Digitarium Epsilon planetarium projector system and portable 7 m GoDome is available, by arrangement, for groups of up to 45 people per session. The planetarium simulates the night sky, including special events such as the transit of Venus or an eclipse of the Sun. It allows an up-close look at the motions of celestial objects, the surfaces of planets, deep sky objects, and constellations. You can take a tour of the local Solar System, peer into the depths of the galaxy, or watch amazing new planetarium movies. Presentations can be tailored to the interests and age of your groups.

Address Dept of Physics, Macquarie Uni NSW 2109
Fees On application or see web site.
Email starinfo@mq.edu.au
Web physics.mq.edu.au/community/planetarium/

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is a nine week course conducted by Sutherland Astronomical Society Inc (SASI). Each lecture is followed by observations with the society's equipment (weather permitting). Refer to website for course dates.

Address Green Point Observatory (Sutherland, Sydney)
Fees $140 per student subject to change
Contact The Education Officer 0422 902 730 <info@sasi.net.au>
Web www.sasi.net.au

SKYWORKS PLANETARIUM

Skyworks Planetarium is a multi-award winning travelling educational resource using a STARLAB Portable Planetarium to visit schools and youth groups. Since starting in 2000, Skyworks has become the most active planetarium in greater Sydney. Programs are curriculum based to suit years K–12.

Contact Geoff & Diana Zenner (02) 9610 2899, 0427 112 899, fax (02) 9753 1898 <info@skyworks.net.au>
Web www.skyworks.net.au

SYDNEY OBSERVATORY ASTRONOMY COURSES

Adult continuing education evening courses are held at historic Sydney Observatory. Presented by Dr Paul Payne using unique 3D stereo graphics, without the aid of mathematics.

Address Watson Road, Observatory Hill, The Rocks
Contact (02) 9921 3485 <paulpayne@relativity.net.au>
Web www.sydneyobservatory.com.au/education/courses.asp
relativity.net.au/courses/index.php

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY INC.

Since 1998 SOLIS has been working at protecting the view of the night sky by promoting better outdoor lighting.

Address The Secretary, 6 Warwick Parade, Castle Hill NSW 2154
Fees $20 per year.
Contact Ken Petersen (02) 9634 1736 <solis@solis.org.au>
Web www.solis.org.au

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. See website for more information.

Web www.physics.usyd.edu.au/about/cep.shtml

QUEENSLAND

BAS MOON & PLANET TELESCOPE VIEWING NIGHTS

The Brisbane Astronomical Society (BAS) holds regular free public viewing nights at Mt Coot-tha Lookout on certain Saturdays nearest First Quarter Moon from 7–9 pm, check website for dates.

Address BAS PO Box 15892, City East Qld 4002
Email info@bas.asn.au
Web www.bas.asn.au

STARLAB EDUCATION

Starlab Education provides astronomy and earth science presentations throughout Queensland. Fully trained presenters visit your school or venue with a 'Cosmodome Science Theatre & Planetarium' or a 'Starlab Planetarium' to provide educational programs tailored to suit your level of interest and understanding.

Address PO Box 1656, Noosaville BC QLD 4566
Fees See website for details.
Contact Paul Tickner 0417 394 354 <info@starlab.net.au>
Web www.starlab.net.au

URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at the Barrett Street Reserve, Bracken Ridge (entry off Jude St) on the 1st and 3rd Sunday each month except January. All welcome.

Address SEQAS, PO Box 60, Everton Park Qld 4053
Contact Julie Straayer (07) 3325 2479 <urbanobs@seqas.org>
Web www.seqas.org

SOUTH AUSTRALIA

ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

A variety of astronomy themed courses are conducted at the Adelaide Planetarium during the year. See their web site for details.

Address University of South Australia, Building P, Mawson Lakes Campus
Web www.unisa.edu.au/Business-community/Arts-and-culture/Planetarium/Events-and-courses1/

TASMANIA

INTRODUCTION TO ASTRONOMY (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at Rosny LINC and at the University of Tasmania's Mt. Pleasant site, usually twice a year in March/April and October/November; six hours total (two by three hour sessions).

Address Rosny LINC and Mt. Pleasant
Fees $50
Contact 0419 305 722
Email joroco@trump.net.au
Web ast.n3.net

VICTORIA

ASTRONOMY PUBLIC LECTURES

The Centre for Astrophysics & Supercomputing have free public lectures on astronomy at the Hawthorn campus of Swinburne University of Technology. See web site for details.

Web astronomy.swin.edu.au/outreach/?topic=freelectures

ASTRONOMY, SECRETS OF THE NIGHT SKY

Look to the heavens and understand the mysteries of the stars. Learn about star formation, solar systems, galaxies, deep space, and big bang theory. Become familiar with major observatories, modern equipment and accessories under the passionate tutelage of an experienced astronomy specialist. Suitable for absolute beginners and amateur stargazers alike, this highly entertaining overview includes weekly on-campus viewings with telescopes provided.

Contact (03) 9564 1546 <shortcourses@holmesglen.edu.au>
Web www.holmesglen.edu.au search Night Sky

LEON MOW RADIO OBSERVATORY

The observatory is operated by the Radio Astronomy Section of the Astronomical Society of Victoria and situated at the their dark sky site in central Victoria. The website is designed to display the output from the various experiments running at the LMRO site in the form of a graph or chart with brief descriptions.

Address Astronomical Society of Victoria GPO Box 1059 Melbourne, Victoria. 3001
Contact Clint Jeffrey <vk3ekh@bigpond.com>
Web www.lmro.org.au

ASV AMATEUR RADIO STATION (VK3EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. The net is conducted by Clint Jeffrey and Russell Ward and commences each Friday at 10 pm EST on 3.541 MHz (LSB). New stations and shortwave listeners are welcome. See website for more information.

Email vk3ekh@bigpond.com
Web www.qrz.com/db/vk3ekh

WESTERN AUSTRALIA

ASTRO TOURS OF THE KIMBERLEY

Broome's Astronomy Experience is a 2-hour educational and entertaining mind bender using big telescopes and lasers at an open bush site under dark skies. They operate in Broome from April to December running shows for the general public, schools, community and corporate groups six nights a week. 'Greg Quicke's Astro Tours' is also a Facebook Page.

Address PO Box 2537 Broome WA 6725
Contact Greg Quicke 0417 949 958 <info@astrotours.net>
Web www.astrotours.net

ASTRONOMY EDUCATION SERVICES

AES grew out of ten years experience heading up the Public Outreach and Education at the Perth Observatory and lecturing at universities and other education institutions. Their activities include day presentations with safe viewing of the Sun (for students of any age) and Astronomy Field Nights with telescopes. AES also conduct public astronomy and astrophotography courses at various institutions. See their web site and FaceBook Page for more details.

Address PO Box 271, Dianella WA 6059
Fees Contact them for costs
Contact Richard Tonello 0417 961 357 <richard@astro-ed-services.com>
Web www.astro-ed-services.com

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, as are visitors to most meetings. Most societies now have websites, links to these can be found on the Quasar website: www.quasarastronomy.com.au/society.htm

NEW SOUTH WALES & ACT

ASTRONOMICAL SOCIETY OF ALBURY WODONGA meets regularly on the first Wednesday of each month (except January) at Charles Sturt University, Thurgoona Campus, off Elizabeth Mitchell Drive at 7 pm. Contact David Thurley (02) 6040 3704 <enquiries@asaw.org.au>.
PO Box 1500, Lavington NSW 2641 www.asaw.org.au

ASTRONOMICAL SOCIETY OF COONABARABRAN meets on the third Wednesday each month at 7:30 pm at Room EG01, Coonabarabran TAFE campus, Robertson Street, Coonabarabran.
Contact Michael Deep 0418 473 099 <secretary@coona-astro.org.au>.
PO Box 90, Coonabarabran NSW 2357 www.coona-astro.org.au

ASTRONOMICAL SOCIETY OF NSW holds meetings twice per month, see their website for details. Contact <president@asnsw.com>.
PO Box 870, Epping NSW 1710 www.asnsw.com

ASTRONOMICAL SOCIETY OF THE HUNTER meets at The Billabong Restaurant, East Maitland Bowling Club on the 1st Friday each odd month at 6:30 PM. Contact Col Maybury (02) 4937 4664 or 0427 889 653 <cma45714@bigpond.net.au>.
21 Brooks St, Kurri Kurri NSW 2327

CANBERRA ASTRONOMICAL SOCIETY meetings are held on the 3rd Thursday of each month except June and December starting at 8 pm. An Introductory meeting begins one hour before the main meeting. The venue is usually the Duffield Lecture Theatre, Mt. Stromlo Observatory, Weston, ACT. Contact Fay Neil (02) 6231 0851 <casadmin@gmail.com>.
PO Box 1338, Woden ACT 2606 www.mso.anu.edu.au/cas/

CENTRAL WEST ASTRONOMICAL SOCIETY INC meetings are held on the 1st Friday each month except January, at the Parkes Observatory Visitors Centre, at 7:30 pm, visitors welcome. Contact <secretary@cwas.org.au>.
PO Box 819, Parkes NSW 2870 www.cwas.org.au

CLARENCE VALLEY ASTRONOMICAL SOCIETY Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>.
97 Skinner St, South Grafton NSW 2460

COFFS HARBOUR ASTRONOMICAL SOCIETY INC meets on the first Monday of each month (except January) at 7 pm at the Boambee East Community Centre, cnr. Bruce King Drive and Pacific Highway, Boambee East. Contact Win Howard (02) 6653 2742 <winhoward@iprimus.com.au>.
11 Yarad Place, Boambee NSW 2450

ILLAWARRA ASTRONOMICAL SOCIETY
illawarraastronomicalsociety.hostoi.com

MACARTHUR ASTRONOMICAL SOCIETY meet in Campbelltown, NSW, on the 3rd Monday of the month (Jan-Nov), with guest speakers and workshops. They also schedule three dark-sky observing nights per month. Contact <contact@macastro.org.au>.
PO Box 17, Minto NSW 2566 www.macastro.org.au

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC meets at St Ignatius College at Lane Cove third Tuesday of every month and conducts regular observing nights at North Turramurra Golf Club. Contact Society mobile 0423 971 374 <nsas@nsas.org.au>.
PO Box 56, Lane Cove NSW 1595 www.nsas.org.au

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC members meetings are held once a month, contact them for dates. Contact Kevin Gallagher (President) 0498 690 802 <pmobs50@gmail.com>.
PO Box 1453, Port Macquarie NSW 2444 www.pmobs.org.au

SHOALHAVEN ASTRONOMERS meet at the University Of Wollongong, ShoalHaven Campus, Library and Resources Centre, Seminar Room LG.25 on the third Friday of the month at 7 for 7:30 pm.
Contact Jack Apfelbaum (Pres.) (02) 4423 2255
PO Box 1053, Nowra NSW 2541 www.shoalhavenastronomers.asn.au

SUTHERLAND ASTRONOMICAL SOCIETY meets every Thursday at 7:30 pm at the Green Point Observatory near Sutherland, with the main meeting and guest speaker on the 1st and 4th Thursdays. Junior Section meets 1st Thursdays Feb – Nov at 6:30 pm.
Contact Secretary 0408 832 408 (voicemail) <info@sasi.net.au>.
PO Box 31, Sutherland NSW 1499 www.sasi.net.au

SYDNEY CITY SKYWATCHERS meet at Sydney Observatory on the first Monday of the month (except January) at 6:30 pm. Contact Secretary, Elizabeth (02) 9398 9705 <president@sydneycityskywatchers.asn.au>.
Sydney Observatory, 1003 Upper Fort St, Millers Point NSW 2000
www.sydneycityskywatchers.asn.au

SYDNEY NORTHWEST ASTRONOMY GROUP (SNAG) does not have meetings, but observe on Friday nights under clear skies at Kenthurst. Contact Ken Petersen (02) 9634 1736 <solissydney@telstra.com>.
60.242.153.180/SNAG/

THE NEWCASTLE ASTRONOMICAL SOCIETY meetings are held on the first Friday each month (except January), at the University of Newcastle, Lecture Theatre GP 2.1 (room 1, 2nd floor) of Linguistics Building at 7:30 pm. Contact Pres. Ghul Hussain 0408 806 179 <moreinfo@nas.org.au>.
c/- Dept. Physics, University of Newcastle Callaghan NSW 2308
www.nas.org.au

UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY meetings are held once per month at the Kirby Observatory on Wednesday evenings close to New Moon at 7 for 7:30 pm.
Contact Anne Parnell (02) 6772 1958 <parnellansw@gmail.com>.
Ms Anne Parnell, 81 Perrott St Armidale NSW 2350
www.unentas.org.au

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC meets at 7:30 pm on the 3rd Wednesday of the month at Penrith Observatory, University of Western Sydney, Werrington Campus. Hear interesting guest speakers and attend Astronomy Workshops. Contact <enquiry@wsaag.org>.
PO Box 400, Kingswood NSW 2747 wsaag.org

WOLLONGONG AMATEUR ASTRONOMY CLUB has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra. Visitors are most welcome to attend. Contact Jeff Pountney (02) 4283 4486 or Warren Norrie (02) 4234 2371 <specsprinter@hotmail.com>. waacers.createmybb3.com

NORTHERN TERRITORY

GOVE AMATEUR ASTRONOMERS meets as advised for viewing nights on a Saturday close to the New Moon at a local dark sky site. Their nights are announced on their Facebook page, or on local radio stationon 106.9 GoveFM.
Contact Neal Baulch 08 8987 2069 <goveastronomers@yahoo.com.au>.
PO Box 178, Nhulunbuy NT 0881 www.facebook.com/GoveAstronomers

QUEENSLAND

ASTRONOMICAL ASSOCIATION OF QUEENSLAND meetings in 2015 will be on nominated Saturdays each month from February to December. The normal venue is Lecture Theatre 222, the Parnell Building (School of Maths and Physics), located on the south side of the Great Court, The University of Queensland, St Lucia Campus. Meetings generally commence at 4 pm. Dates of meetings and further details are published on their website.
PO Box 6101, St Lucia Qld 4067 www.aaq.org.au

BRISBANE ASTRONOMICAL SOCIETY hold meetings each month except January, see their web site for meeting night details. Contact Chris Landman 0419 861 689 <President@bas.asn.au> or Andy Polichronis 0423 532 679 <info@bas.asn.au>.
PO Box 15892, City East Qld 4002 www.bas.asn.au

BUNDABERG ASTRONOMICAL SOCIETY meetings are held at Alloway Observatory every Friday at 7:30 pm. The second Friday of the month are general meetings and are not held in January.
Contact Lonnie Smilas 0416 857 309 <lonnie37@me.com>.
PO Box 4221, South Bundaberg Qld 4670
alloway-observatory-bundaberg.webs.com

HERVEY BAY ASTRONOMICAL SOCIETY meets at 7 pm Wednesday nights two weeks after viewing nights (see website) at the University of Southern Queensland in Pialba. Contact Joe Mather (07) 4194 6005 or Mob 0419 461 532 <president@hbastro.net>.
Hervey Bay Astronomical Society
Unit 88 34–56 Elizabeth Street, Urangan Qld 4655 www.hbastro.net

MOUNT ISA ASTRONOMY GROUP meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17 km outside of Mount Isa). Meetings are held monthly, usually the Saturday preceding New Moon. Contact Len Fulham (07) 4743 5385 (AH), (07) 4743 2955 (W), fax (07) 4743 3381 <lfulham@tpgi.com.au>.
PO Box 1556, Mount Isa Qld 4825

REDLANDS ASTRONOMICAL SOCIETY meets on the second Tuesday of the month at Ormiston College, Ormiston (27 km SE of Brisbane), see web site for details. Contact President: Mike Hayes 0412 320 346 <redlandsastronomicalsociety@gmail.com>.
PO Box 2048, Wellington Point Qld 4160 www.ras.org.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY meets third Tuesday of the month at Chermside Library from January to November. Meetings commence at 7:30 pm.
Contact Julie Straayer (07) 3325 2479 <juliestraayer@hotmail.com>.
PO Box 60, Everton Park Qld 4053 www.seqas.org

SOUTHERN ASTRONOMICAL SOCIETY has monthly meetings at Ormeau Progress Hall, Maccreadie Road, Ormeau Qld.
Contact Joe Zerafa 0421 866 376
PO Box 867, Beenleigh Qld 4207 www.sas.org.au

FNQ ASTRONOMERS GROUP meet periodically in the Cairns region (Far North Qld) in conjunction with astronomical events as advised on their FaceBook page. Contact Ian Maclean 0417 601490.
www.facebook.com/FNQAstronomers

TOWNSVILLE ASTRONOMY GROUP INC observe on the Saturday closest to New Moon or the following Saturday if conditions are not suitable. Viewing sites change and details are on the website under events. Contact (07) 4788 8853 <President@astronomytsv.org.au> or <projects@astronomytsv.org.au>.
80 Gibraltar Road, Rangewood Qld 4817 www.astronomytsv.org.au

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA meetings are held on the 1st Wednesday each month (except January) at the University of Adelaide, North Terrace Campus. Contact <secretary@assa.org.au>.
GPO Box 199, Adelaide SA 5001 www.assa.org.au

TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA has general meetings at the Rosny LINC, Bligh St, Rosny Park on the last Tuesday each month except December. Contact Hobart 0419 305 722, Launceston – Michael Booth 0408 240 576, Devonport – Peter Sayers (03) 6424 2588 or secretary, Joy Coghlan <joroco@trump.net.au>.
GPO Box 1654, Hobart Tas 7001 ast.n3.net

VICTORIA

ASTRONOMICAL SOCIETY OF GEELONG meets every Friday at 7:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong. Contact Frank Baker 0407 345 070
PO Box 1799, Geelong Vic 3220 www.asog.org.au

ASTRONOMICAL SOCIETY OF MELBOURNE has monthly club nights and viewing sessions in southeast metropolitan Melbourne.
Contact Chris Ellis 0412 318 125 <sales@astronomyalive.com.au>.
PO Box 92, Bentleigh Vic 3204 www.astromelb.i.net.au

ASTRONOMICAL SOCIETY OF VICTORIA has monthly meetings, held at 8 pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. ASV has 18 specialist sections that also hold regular meetings.
Contact Linda Mockridge (Public Relations Officer) (03) 9888 7130
GPO Box 1059, Melbourne Vic 3001 www.asv.org.au

ASTRONOMY BENALLA meets on the third Wednesday of each month at 7:30 pm at Benalla Hockey Club Room, Churchill Park, Waller St Benalla. Contact Rupe Cheetham (President) (03) 5762 1523
61 Benson St, Benalla Vic 3672 www.astronomybenalla.org.au

BALLAARAT ASTRONOMICAL SOCIETY holds bi-monthly general meetings, 2nd Friday of the month, beginning in February.
Contact 0429 199 312 <bas@cbl.com.au>.
PO Box 284, Ballarat Vic 3353 observatory.ballarat.net

BENDIGO DISTRICT ASTRONOMICAL SOCIETY arranges Astronomy and Science Presentations at the Discovery Centre, Bendigo, 7:30 pm, on the first Wednesday of each month.
Contact President Joy Vinnicombe, 0407 058 279, secretary,
Ian Blume (03) 5435 3193 < president@bdas.net; secretary@bdas.net>.
PO Box 164, Bendigo Vic 3552 www.bdas.net

BRIGHT ASTRONOMY CLUB INC is a small group who meet at the Porepunkah airfield once a month or on special astronomical events and outreach works. Contact Zachary (president) 0438 863 739 or Sean (secretary) 0411 797 714 <brightastronomyclub@gmail.com>.
PO Box 350, Bright Vic 3741
brightastronomy.webs.com/
www.facebook.com/groups/brightastronomy/

LATROBE VALLEY ASTRONOMICAL SOCIETY meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers; call for details.
Contact John Sunderland (03) 5122 3014 <lvastro@ymail.com>.
PO Box 459, Moe Vic 3825 www.LVastro.org

MORNINGTON PENINSULA ASTRONOMICAL SOCIETY meetings are held on the 3rd Wednesday of each month (except December) at 8 pm, at the modern senior school theatrette, Building T, Peninsula School, Wooralla Drive, Mt Eliza.
Contact Peter Skilton 0419 253 252 <welcome@mpas.asn.au>.
PO Box 596, Frankston Vic 3199 www.mpas.asn.au

SNAKE VALLEY ASTRONOMICAL ASSOCIATION meet and observe at the SVAA Clubroom at 825 Linton-Carngham Rd Snake Valley on the closest Friday to the New Moon each month.
c/o Snake Valley Post Office, Snake Valley Vic 3351
ballaratman.wix.com/svaa

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND meetings are held at Bairnsdale, Perry Bridge, and Lakes Entrance. Dark sky site near Bairnsdale airport. Contact Mike Finn (03) 5153 2802, 0422 904 238 <mikef1@iprimus.com.au>.
53 Riley St, Bairnsdale Vic 3875

WEST AUSTRALIA

ASTRONOMICAL SOCIETY OF THE SOUTH WEST has observing nights at their observatory south of Bunbury on the two Fridays before the New Moon.
Contact Phil Smith (08) 9721 1586 <jpainter@iinet.com.au>.
PO Box 1100, Bunbury WA 6231

ASTRONOMICAL SOCIETY OF WESTERN AUSTRALIA meets at 8 pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como. Visitors most welcome. Contact <aswa@aswa.info>.
PO Box 421, Subiaco WA 6904 aswa.info

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. A perfectly reflecting body has an albedo of 1.0 or 100%. The average lunar albedo is 0.12 or 12%.

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 coordinates 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.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a body 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.***

Arcminute An angular measure (each degree is divided into 60 arcminutes).

Arcsecond An angular measure. Each degree contains 3600 arcseconds, and each ***arcminute*** contains 60 arcseconds.

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 coordinate 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 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 a coma and often 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 an ***inferior planet*** (Mercury or Venus) passes between the Sun and the Earth.

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 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 observer's horizon.

Declination (Dec) One part of the equatorial coordinate 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 analogous 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 in front of or into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow 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. It is 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 elongations of Mercury and Venus occur when the planets are at their largest 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 coordinate 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 21, and autumnal equinox about March 22.

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 disc 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 are seen in 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 in reference to 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 1 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 2.5. 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 eye are magnitude 6 (under dark skies).

Magnitude — absolute The apparent magnitude a star would have if it were viewed from 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 in 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 (***Asteroid***) Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

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.

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 from Earth.

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 arcsecond.

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. It is opposite to ***apogee.***

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 the latter stages of its 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 When 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. This occurs near ***opposition*** for the outer planets and near ***inferior conjunction*** for the inner planets.

Right ascension (RA) Part of the equatorial coordinate 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 analogous to lines of longitude on the Earth but is measured in hours (24 hrs = 360°).

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23 hrs 56 m 4 s.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way, 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 21 June marks the shortest day of the year, and around 21 December 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 time that it takes for an object to reappear at the same point in the sky, relative to the Sun, as observed from 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

Α, α	Alpha	Ε, ε	Epsilon	Ι, ι	Iota	Ν, ν	Nu	Ρ, ρ	Rho	Φ, φ	Phi
Β, β	Beta	Ζ, ζ	Zeta	Κ, κ	Kappa	Ξ, ξ	Xi	Σ, σ	Sigma	Χ, χ	Chi
Γ, γ	Gamma	Η, η	Eta	Λ, λ	Lambda	Ο, ο	Omicron	Τ, τ	Tau	Ψ, ψ	Psi
Δ, δ	Delta	Q, J	Theta	Μ, μ	Mu	Π, π	Pi	Υ, υ	Upsilon	Ω, ω	Omega

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We are fortunate to live in Australia for the stars of the Southern Hemisphere are indeed spectacular! Have you ever gazed at the beauty of the night sky and wondered:

What is that bright star? Which constellation is that?

Why do some *stars* move from night to night?

Which planet is that? Where is the Moon?

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Fred Watson, Astronomer-in-Charge
Australian Astronomical Observatory

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ESTIMATING ANGLES IN THE SKY When 0.5m (20 inches) from the eye, each division on this scale corresponds to 1° of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°

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