

ASTRONOMY



2005 *AUSTRALIA*

**A PRACTICAL GUIDE
TO THE NIGHT SKY**

**Glenn Dawes
Peter Northfield
Ken Wallace**

CALENDAR 2005

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ASTRONOMY 2005

AUSTRALIA

A Practical Guide to the Night Sky

**Glenn Dawes
Peter Northfield
Ken Wallace**

Quasar Publishing 2004

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- Fifty Year Canon of Solar Eclipses 1986 – 2035 (NASA RP1178)
- International Astronomical Union Web site
- Mathematical Astronomy Morsels (Meeus)
- More Mathematical Astronomy Morsels (Meeus)
- Atlas of the Moon (Rukl)
- International Meteor Organisation Calendar
- Moon Observers Handbook (Price)
- Gary Kronk's Cometography website
- NASA/JPL website
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Illustrations

- The front cover is the Horsehead Nebula in Orion, photographed by David Malin at the Anglo-Australian Observatory © Anglo-Australian Observatory/David Malin Images.
- Inside front cover is an image of Gassendi Crater on the Moon taken by Apollo 16, credit NASA archives.
- Page 1, Barnard 72 (dark nebula) in Ophiuchus, the Snake Nebula. A 40 min exposure using hypered Kodak 2415 through a 250mm (10") f4 Newtonian. J. Cauchi (Sydney, NSW).
- RAVE article images (pp. 5–7): fig 1, UK Schmidt Telescope building, courtesy Kristin Fiegert, Anglo-Australian Observatory, fig 2, NGC 2997, © Anglo-Australian Observatory/David Malin Images, fig 3, image of 6df robot, Courtesy Jonathan Pogson (c) Anglo-Australian Observatory.
- Page 9, Siding Spring Survey fig. 1, 2, 3 are © G. Garradd and fig. 4 is © ANU Research School of Astronomy & Astrophysics.
- Page 34, galaxy NGC 253 taken by J. Cauchi (Sydney, NSW)
- Page 37, photo of Comet LINEAR taken May 19 2004, a 5 min exposure. Photo of Comet NEAT, taken on May 12 2004 is a 2 X 20 min exposure, stacked, tracking on comet. Both images taken through a 300mm f4 lens on Fuji 400 by S. Quirk (Mudgee). For those wishing to see these images in colour see Steve's excellent website (www.hwy.com.au/~sjquirk/).
- Page 41, image of h4638 taken by Robert Price, Bethanga Victoria using an SBIG ST7 camera through a Celestron 11 at f/6.3. The exposure was only 5 seconds to avoid burning out this close multiple star.
- Page 45, photo of Faulkes Telescope, courtesy of Robert Hollow.
- Page 57, photo of Bill Bradfield supplied by Bill. Image of C/2003 T3 (Tabur) taken by Vello Tabur (10 X 20 sec exposures, taken with an SBIG ST6 CCD camera on a Celestron 11 at f5.8).
- Page 61, mosaic of lunar images taken by Robert Price, Bethanga Victoria using an SBIG ST7 camera through a Celestron 11.
- Page 142, Sir Thomas Brisbane Planetarium; Mark Rigby
- Page 143, Great Barrier Reef observatory; Ray Johnston
- Rear cover photo is a fish-eye lens (16mm) image of the Milky Way using Fuji 400 film (2 X 30 min. exposures, stacked). The field covers 125° and stretches from Sagitta to Crux. By S. Quirk (Mudgee, NSW).

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INTRODUCTION TO THE 2005 EDITION

Welcome to Astronomy 2005.

Two of our lead articles this year highlight some of the excellent work being done at Siding Spring Observatory, near Coonabarabran, NSW — the Mecca of optical astronomy in Australia.

Fred Watson makes a welcome return as he takes us RAVEing to understand the structure of our Milky Way, past, present and future. This is an ambitious project, which ultimately wishes to measure the spectra of 50 million stars in our galaxy.

Gordon Garradd, a well-known amateur, has now taken his talents into the professional arena as he contributes to what may be the most important insurance policy the Earth could have — searching for Near Earth Asteroids. It is amazing to think that some people consider these relatively inexpensive projects to be a waste of money. A project that, if it gave us sufficient warning of an asteroidal collision, could prevent us becoming the next dominant species on Earth to undergo mass extinction. As the tyre advertisement says “if it saves you once, it’s a good year!” We thank Gordon for giving us a glimpse into the Siding Spring Survey.

With regard to observing in 2005, the highlight will be the opposition of Mars. Although this is not as spectacular as the record breaking 2003 event, it is still a great opposition and certainly worthwhile observing. Part II has a comprehensive guide to observing the Red Planet at this time.

As usual, our monthly feature articles cover quite a diverse range of interests:

- A review of the performance of the various Solar System probes and what 2005 has in store
- Inviting you to observe an unusual multiple star in Centaurus
- Comet hunting ‘pays off’ for Australian observers
- The unusual April 8 solar eclipse that is both annular and total
- Finding the South Celestial Pole
- The early history of the telescope
- Exploring the Straight Wall region on the Moon
- A review of the performance of the naked eye comets of 2004
- The results of our website Olympics. Did your favourite site get a medal?
- Observing bright red stars — there are more than you think!
- Helping beginners to observe Earth satellites
- The Faulkes Telescope, on the verge of revolutionising Australian education in astronomy

Part I of Astronomy 2005 is intended as a general quick reference section for those wishing to see which planets are up tonight and when is the best time to observe them. This section is ideal for those just starting their exploration of the night sky. The Sky View diagrams are an easy way for you to find the brighter planets and constellations. The All Sky Maps cover the entire night sky we live under in the southern hemisphere. These pages compress the sky into nine, easy to use, maps. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, includes sections on astronomical places of interest and the amateur societies, ideal for the beginner. We also would like to recommend to readers our website www.quasarastronomy.com.au. There are links to all of the sites listed in Part III of this book, as well as monthly updates.

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

The night sky is like a giant National Park but no one can charge you admission. Neither do you need special equipment to go walking along its wondrous tracks — just your eyes. Get yourself a lifetime pass and keep looking up.

Glenn Dawes Peter Northfield Ken Wallace

RAVEing Mad!

Imagine for a moment that you're looking out into a night sky radiant with stars. Seen at face value, they're all the same. Some are brighter than others, of course, and there are subtle colour variations here and there, but apart from that, the only thing that differentiates one from another is position in the sky. And if we didn't have the good old join-the-dots constellations, even that would be tricky without an instrument of some kind.

At first sight, stars don't give away too many clues when it comes to trying to make sense of them. Little wonder the ancient watchers of the skies thought the stars were all stuck to the inside of a sphere, never changing or moving with respect to one another. In fact, one of the first big challenges of telescopic astronomy was to understand the three-dimensional distribution of stars in space. It was William Herschel who made the big breakthrough towards the end of the eighteenth century. He recognised that we live in a flattened disc of stars, though it was to be well over a hundred years before our modern picture of the Milky Way Galaxy emerged.

During the nineteenth century, astronomers realised they could detect the individual motions of stars, initially across the line-of-sight (known as 'proper motion') and, later, towards or away from us (the so-called 'radial velocity'). While proper motions are derived from accurate positional measurements over a period of time, radial velocities are measured by forming the rainbow spectrum of a star and measuring the minute shifts of its features resulting from the Doppler effect. The spectroscope thus becomes a kind of star speedometer.

For any one star, its speed is not particularly exciting, but when these data can be collected for thousands of stars, they start to reveal patterns and show up bulk motions within the Milky Way Galaxy. And that is much more interesting ...

Hi-fibre diet

When an experimental fibre-optics system for the 1.2-metre UK Schmidt Telescope in north-western New South Wales was proposed by yours truly more than twenty years ago, it was with surveys of star velocities in mind. The idea was to use optical fibres to carry light from a few dozen stars in the telescope's 6-degree field of view,

Fred Watson (for the international RAVE team)

and line them up in a spectrograph, where all the radial velocities could be measured simultaneously. That having been done, the fibres would then be laboriously rearranged by hand to suit the next set of stars, and the telescope moved on to the new field. Even with the tedious reconfiguration of fibres, it offered a speedy method of collecting radial velocities for large numbers of stars.

Fortunately, as soon as this primitive multi-star speedometer appeared in 1985, it was hijacked by the galaxy redshift brigade — who wanted to perform the same trick on galaxies rather than stars, in order to map the local Universe. That dastardly deed almost certainly saved it from oblivion. Star velocity surveys were very unglamorous in the 1980s, whereas mapping the Universe by measuring the redshifts of galaxies (and hence their three-dimensional positions in space) was just starting to become the cornerstone of observational cosmology.

The UK Schmidt is still observing galaxies today, most notably as part of the 6dF Galaxy Survey (6dFGS) being carried out with the telescope's fourth-generation multi-fibre system. That instrument (6dF — for 6-degree field) allows up to 150 objects to be observed at once, with fibre positioning being carried out by a friendly robot instead of a bored astronomer. By the time 6dFGS is completed in mid-2005, it will have produced three-dimensional positions for something like 150,000 galaxies over the whole southern sky.

Meanwhile, how many stellar radial velocities do you think the world's astronomers have in their data archives? Astonishingly, it is only about 40,000. Thanks to 6dFGS and other galaxy surveys, we now know far more about the geography of the local and middle-distance Universe than the internal motions of our own Galaxy. And with the Global Virtual Observatory threatening to bring all the world's astronomical archives to a computer near you very soon, this imbalance of data is quickly going to start looking pretty embarrassing.

It is not embarrassment that drives large-scale surveys, however, but scientific impetus. In contrast with the 1980s, there is growing awareness today that many clues to the fundamental problem of

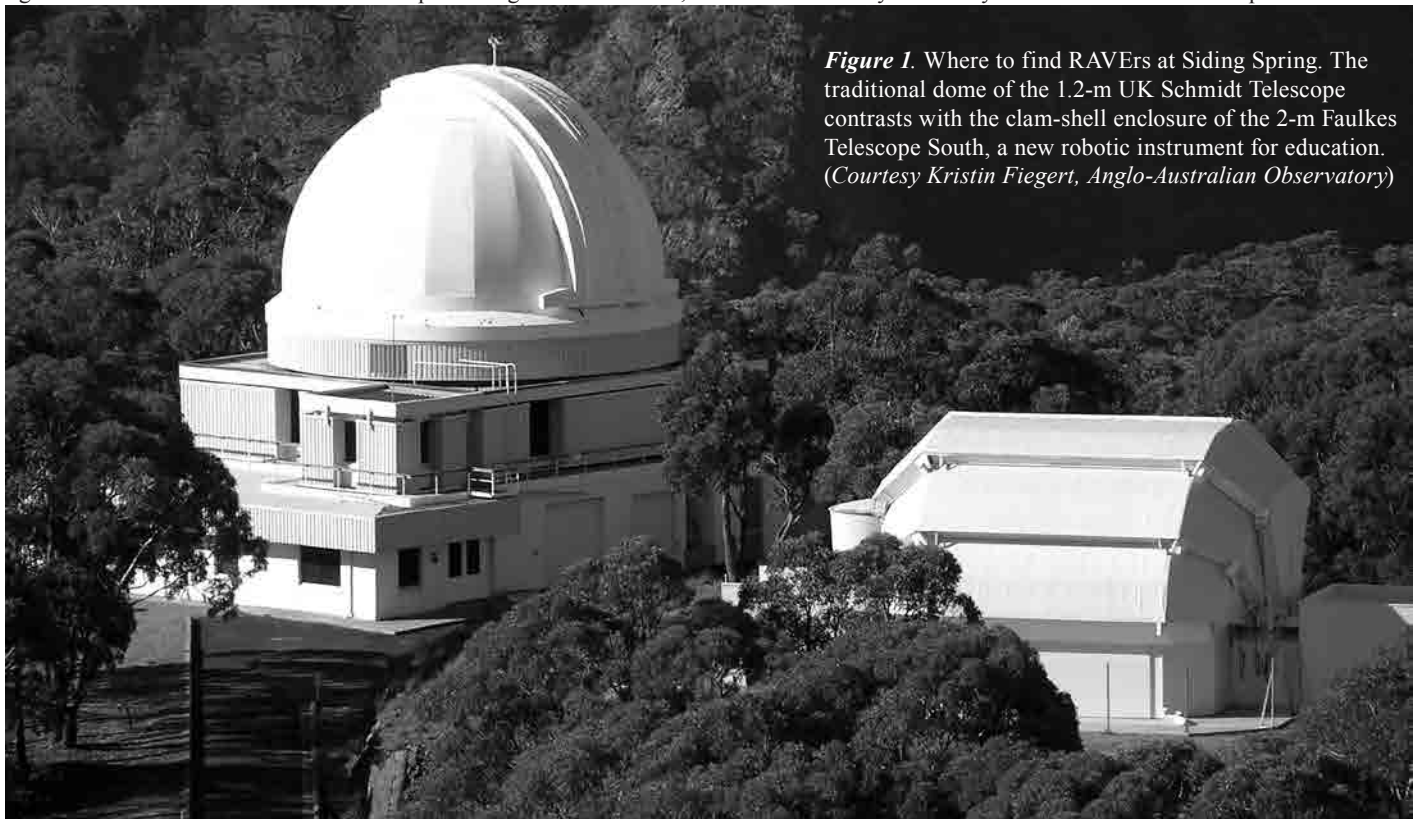


Figure 1. Where to find RAVers at Siding Spring. The traditional dome of the 1.2-m UK Schmidt Telescope contrasts with the clam-shell enclosure of the 2-m Faulkes Telescope South, a new robotic instrument for education. (Courtesy Kristin Fiegert, Anglo-Australian Observatory)

galaxy formation in the early Universe are locked up in the motions and chemical compositions of stars in our own Galaxy.

It is clear that there is a pressing need for stellar spectroscopy on an all-sky scale. In work such as this, field of view is more important than mirror diameter, because the stars are well spread out in the sky but are relatively bright. So it turns out that a large Schmidt telescope is the perfect tool for carrying it out. Especially one with a highly-effective multiple-object spectroscopy system that will complete its present task in mid-2005...

RAVErs gatecrash the party

It is this logic that has led to the idea of RAVE. Nice acronym, don't you think? It conjures up all sorts of feverish activity, and certainly matches the fervour with which the project is being conducted. In fact, RAVE stands for RADial Velocity Experiment, and it is a survey of the radial velocities and ages of a large number of stars over the whole sky. It is being carried out with the UK Schmidt Telescope, and was started back in April 2003 using nights around each Full Moon when the telescope is not scheduled for other work — the so-called BOM, or bright-of-moon period. From mid-2005, if all goes to plan, RAVE will use all observing time on the UK Schmidt, with completion of the survey expected around 2012.

Capable though the telescope is, it cannot observe beneath the horizon, and so a second instrument in the northern hemisphere will eventually be needed to complete the survey. Fortunately, about two-thirds of the sky can be observed from UK Schmidt's location at Siding Spring Observatory.

RAVE is a project of megalomaniac proportions. The survey currently under way will obtain spectra of about 80,000 southern-hemisphere stars by mid-2005, and is then expected to be extended to around 2007. By that date, well over a third of a million objects will have been observed. But RAVE's ultimate goal is far more ambitious — namely, to observe the brightest 50 million stars in the Galaxy, with completeness to an *I* magnitude (measured in the far red waveband) of 15. Little wonder the project team members are sometimes accused of being RAVEing mad...

These team members are drawn from eleven nations, including Australia and the UK. Large-scale surveys such as this do not happen without substantial resources being devoted to them, and it is expected that the science funding agencies of most of the participating countries will help to pay for it. The Anglo-Australian Observatory and the Australian Research Council have both contributed to get the project off the ground during 2003–5.

RAVE uses observations made in the far-red region of the spectrum. Observations so far indicate that velocity errors of less than 2 km s⁻¹ can be obtained from such data, a precision achieved largely because of the stability of 6dF's spectrograph. That is no accident — the spectrograph sits in its own private room in the dome, with an 11-metre long fibre cable connecting it to the telescope's focal surface.

With such high-precision radial velocities, and equivalent accuracy in the chemical signatures of stars, it has quickly become clear that RAVE has the potential to be an invaluable resource. In fact, the finished RAVE database looks set to revolutionise our understanding of the formation and evolution of all the major components of the Galaxy: the disk, the bulge and the halo.

What are the scientific questions that RAVE scientists want to address? Many of them centre on the dynamical history of our Galaxy — in other words, the way that large-scale motions of stars have evolved to become the way we see them today. Imagine for a moment our Galaxy as it was, say, ten billion years ago. We expect from simulations of galaxy formation that its structure would have been very different from what we see now. No elegantly-curving arms representing 'grand-design' spiral structure, but instead, an irregularly-shaped proto-galaxy surrounded by a rag-tag collection of smaller satellite galaxies. We have some faith in this model of galaxy

formation as there are hints of such untidy structures in the 'deep-field' images provided by Hubble and other telescopes, in which we look back in time perhaps ten billion years.

What we believe has happened to our Galaxy in the aeons since then is that the satellite galaxies have been gravitationally gobbled up to form various components of today's Milky Way. Most notably, we believe many of them disintegrated to form the halo of our Galaxy — that spheroidal mass of stars and globular clusters within which lurks the Galaxy's store of mysterious dark matter. But crucially, the stars that came from these devoured satellites still carry a memory of their origin with them — in their orbits through space. Thus, analysis of the velocities of very large numbers of stars allows a kind of galactic archaeology to be carried out. Stars with a common origin can be disentangled from the mass by their common velocities — and also their similar chemical signatures.

In the broadest sense, RAVE is designed to allow a comparison of what we see in our Galaxy today with what simulations of galaxy formation predict. Theoretical astronomers have provided sophisticated models involving millions of test particles — artificial stars — and naturally want to compare them with reality. The problem is that at this level of detail, we don't know what reality looks like — hence the need for RAVE.

Other questions the survey will address include the chemical history of the Galaxy, the origin of the so-called 'thick disk' (a rarefied layer of stars above and below the main disk), and the origin of the bulge at the Galaxy's nucleus — that blaze of stars glimpsed through intervening dust clouds on Australian winter nights. The idea of 'weighing a spiral arm' (by analysing the motions of stars within it) is also one that has caught the imagination of RAVErs, and no doubt it will be one of the first significant results to come from the survey.

RAVEing on

At present, the RAVE survey is being conducted with 6dF on the UK Schmidt telescope during seven nights per lunar month. By mid-2005, when the 6dF Galaxy Survey is completed, it is hoped that will increase to 25 nights per month, with RAVE taking up all the time on the telescope. But there is clearly a problem here. Using 6dF, about 700 stars can be observed on an average clear night, and it doesn't take a genius to work out that at this rate, the UK Schmidt's eventual share of RAVE (perhaps 30 million stars) will take something like 210 years to observe — with due allowance for cloudy weather. That is rather longer than most RAVErs expect to have available.

The solution to this problem could be waiting in the wings. It is a new instrument that might one day replace 6dF on the UK Schmidt,



Figure 3. The 6dF robot positioning optical fibres under the watchful eye of UK Schmidt Telescope observer Kristin Fiegert. The robot positions the fibres so that they will be in alignment with RAVE target stars when loaded into the telescope (Courtesy Jonathan Pogson, Anglo-Australian Observatory).

an instrument whose capabilities will make 6dF seem as crude as its manually-operated predecessor does today. This is *Ukidna* — the holy grail of wide-field multi-fibre spectroscopy.

The name is derived from the echidna, and this hedgehog-like creature provides rather a good illustration of the working of the instrument. Imagine something like an echidna held upside-down in the focus of the Schmidt Telescope's concave mirror. (Forget animal cruelty for a minute — this is just a thought experiment.) That position is where an image of the sky is formed, and if the spines of the echidna each have an optical fibre running down the centre and can be independently tilted to a predetermined position, then the obliging echidna would allow you to align many fibres with target objects on the sky.

Such an instrument — christened simply *Echidna* — is currently being built by the Anglo-Australian Observatory for the Japanese 8-m Subaru Telescope at Mauna Kea in Hawaii. Its robotic technology is reasonably well-established, and adaptable to the UK Schmidt. The main difference is one of scale: whereas *Echidna* on Subaru has 400 fibre-carrying spines, *Ukidna* on the Schmidt Telescope would have no less than 2250 — all of which have to be stirred into robotic action at the same time. This is challenging technology, but there is no reason to believe it cannot be brought to reality. And if it eventually is, the UK Schmidt Telescope will be able to record the spectra of some 22,000 stars per average clear night, allowing the more ambitious part of the RAVE survey to be completed in something like six years.

The bigger challenge at present — certainly for yours truly — is trying to work out how *Ukidna* could be funded in time to be operational by around 2007. For not only would the complex mechanical hedgehog have to be built, but also a new spectrograph

to record the results. And then the cost needs to be doubled, because the same thing would have to be built for RAVE's northern-hemisphere telescope. Add to that total the running costs of the two telescopes, and you are soon talking many millions of dollars, pounds, euros or yen. At present, RAVErs are optimistic about raising the appropriate funding, such is the scientific urgency of the project. But only time will tell.

By the middle of 2004, the RAVE survey in the capable hands of the UK Schmidt Telescope's observing team had already doubled the world's store of stellar radial velocities. Even if the survey proceeds no further, it is a remarkable achievement for one of the world's most unassuming telescopes. But if, as everyone hopes, the full RAVE survey proceeds beyond 2007, it will provide a spectacular finale to the UK Schmidt's long career. And the omens are good. A couple of years ago, when two Anglo-Australian Observatory astronomers were first hatching the idea of *Ukidna* during the long drive from Sydney to the telescopes, they rounded a bend in the road to come face to face with — an echidna. Screeching to a halt, they gently moved the animal out of harm's way, whereupon it scuttled off into the undergrowth. If you believe in good signs, they don't come any better than that!

See also the following internet sites:

RAVE: <http://www.aip.de/RAVE/>

6dF: <http://www.aao.gov.au/ukst/6df.html>

Ukidna: <http://www.aao.gov.au/local/www/schmechidna/>

About the Author

Fred Watson is Astronomer-in-Charge of the Anglo-Australian Observatory at Coonabarabran and a member of the international RAVE team. He is also the author of *Stargazer: The Life and Times of the Telescope*.



Figure 2. The spiral galaxy NGC 2997 is probably similar in structure to our own Milky Way Galaxy — we will never know for certain. But our position in the disk of our own Galaxy allows us to study its motions and history in great detail by analysing hundreds of thousands of stars — the aim of the RAVE survey. (Anglo-Australian Observatory/David Malin Images)

SIDING SPRING SURVEY

Gordon Garradd

Southern Hemisphere NEO Search Program

NASA has a program that, by 2008, will have identified all asteroids over 1km in diameter that may pose a threat of collision with the Earth. As part of this, they have funded a partnership between the University of Arizona's Lunar and Planetary Laboratory and the Australian National University's Research School of Astronomy and Astrophysics for a Near-Earth Object (NEO) survey in the southern hemisphere. Apart from the Anglo-Australian Near-Earth Asteroid Survey (AANEAS), which ran from 1990 to 1996, all previous professional NEO surveys have been conducted in the north, leaving a large part of the sky unsurveyed. Whilst all asteroids will cross the ecliptic in their orbits and be above the horizon for the northern NEO surveys, they may be either at low solar elongations or too distant and faint to be discovered except when in the southern skies.

Over the past few years the Uppsala Southern Schmidt telescope has been upgraded in preparation for NEO surveying, which commenced in March 2004. This telescope was built at the Uppsala Observatory in Sweden in 1956 and was then installed at Mt Stromlo Observatory, near Canberra, in 1957. It was relocated to Siding Spring Observatory in 1982, where it was used for various studies of the Milky Way, comets and asteroids, student projects and, in the early to mid-1990s, for NEO follow up of objects found on the UK Schmidt photographic plates as part of the AANEAS.

The drive system has been greatly improved, with computer controlled stepper motors now driving both axes, allowing high speed computer controlled slewing. Previously the telescope had to be slewed by releasing a magnetic RA clamp and a declination hand clutch and then manually pushing the telescope around to a new position.

The primary mirror is 0.6 metres in diameter, and the corrector plate 0.5 metres, with f/3.5 optics. The optics were cleaned up and the plate holder, which used to take sheets of photographic film, was removed. In its place went a flat secondary mirror which reflects light out to the side of the tube, where a 4K x 4K 15 micron Spectral Instruments CCD camera is now located. This CCD has a field of view of 123 arc minutes square, at an image scale of 1.8 arc seconds per pixel.

For cooling, this camera uses a Cryotiger, which is basically a remote refrigeration unit under the dome floor that pumps the refrigerant to the camera where it expands and cools the chip. A small heater unit regulates the temperature to approximately -94°C in winter and -85°C in summer. This is sufficiently cold to eliminate the need for dark frame subtraction from the images; only a bias and flat field are needed. It also eliminates the need for daily refilling of a Dewar with liquid Nitrogen, which must be done on most large professional CCD cameras.

The dome is now controlled by software to automatically rotate it in alignment with the telescope. The shutters are still manually opened as part of observing set up in the evenings, and manually closed when observing is finished for the night. An office has been constructed next to the dome to contain the bank of computers used to process images and detect moving objects. One computer is dedicated to controlling the telescope and dome, one controls the CCD, five are used for data processing and one for archiving.

Each image is over 32Mb in size, and each pre-programmed field of view is visited four times, with a typical exposure of 60 seconds, over the course of about an hour in a block of 10 – 12 fields, so the image processing requires quite a lot of computing power. In our regular survey mode we typically image 100 – 120 fields per night in the longer nights of winter, which can result in almost 20Gb of data being collected for the night, including the detection files, which may contain dozens of asteroids per field with four astrometric positions for each one. The images are compressed and archived onto DVD after each night of observing.

The image processing software has been developed by the Catalina Sky Survey (CSS) team at the University of Arizona, where they operate a NEO survey using the same software and a slightly larger Schmidt telescope at Mt Bigelow in the Santa Catalina Mountains, north of Tucson. They generally test out new software modifications at CSS before installing it on Siding Spring Survey (SSS) computers, and if problems are encountered here they are able to rapidly respond to keep us operational.

Each image has all the objects extracted into a file, and then the files from the four images of each field are compared. Various filters are applied to weed out most false detections, such as those due to cosmic rays and image flaws, and the results are presented to the observer who manually blinks each potential moving object detected to decide its validity. With the detection threshold set to just above the background noise levels we get quite a large number of false detections, but it enables us to detect moving objects fainter than 20th magnitude when the sky is dark.

A new mode of surveying implemented by Rob McNaught utilises 20-second exposures during bright Moon periods and enables us to cover approximately twice the area of sky per night at a limiting magnitude of about 19.5 under good seeing conditions. This enables a more complete available sky coverage each month, giving us a greater chance of discovering intrinsically bright objects when they are distant and slow moving. A deeper survey covering less sky could easily miss many of these objects. It should also give SSS a better chance of finding the very fast moving and relatively bright close asteroids that may escape detection when some of the northern surveys don't operate because the sky is too bright.

Full time surveying started in March 2004, and the first five months of operations saw about two NEO discoveries per month, plus a comet P/2004 K2 and a number of other interesting objects. This includes the extraordinary 2004 NN8, an apparently asteroidal object in a highly eccentric retrograde orbit with a period of almost 900 years.

Improvements to the hardware, plus software modifications by the CSS team, such as detection parameter optimisation and reduced dead time between exposures in August 2004, have enabled many more fields to be covered. This includes surveying into the outer edges of the Milky Way, a region that was previously avoided due to the star fields being so crowded.

This saw a large surge in the number of discoveries and SSS/CSS leapt into second place overall in year to date survey performance, behind the large US based LINEAR program, for discoveries of NEAs. Planned further modifications will allow detections when a moving object is apparent on only three out of the set of four images, due to involvement with a field star, or because it is too faint for the variable seeing conditions or rotational light curve variations.

The SSS home page is www.mso.anu.edu.au/~rmn

List of Uppsala NEO discoveries from March to August 2004

Atens	2004 QD14	2004 FJ29		
Apollos	2004 KT	2004 HW	2004 GD	2004 FH29
	2004 QT24	2004 QJ7	2004 QD3	2004 QY2
	2004 MQ1			2004 QB
Amors	2004 HE62	2004 OF6	2004 NM8	2004 LK
	2004 QE14	2004 QN5	2004 QA2	2004 PP97
	2004 PY27	2004 PX27	2004 PT42	

Gordon Garradd is employed as an NEO observer on the Siding Spring Survey for NEOs and has been an active amateur astronomer for 30 years. In between observing he spends a lot of time riding mountain bikes in the forests around Coonabarabran and the mountains near his home at Loomberah, NSW.



Fig 3 Uppsala tube with CCD camera in place.

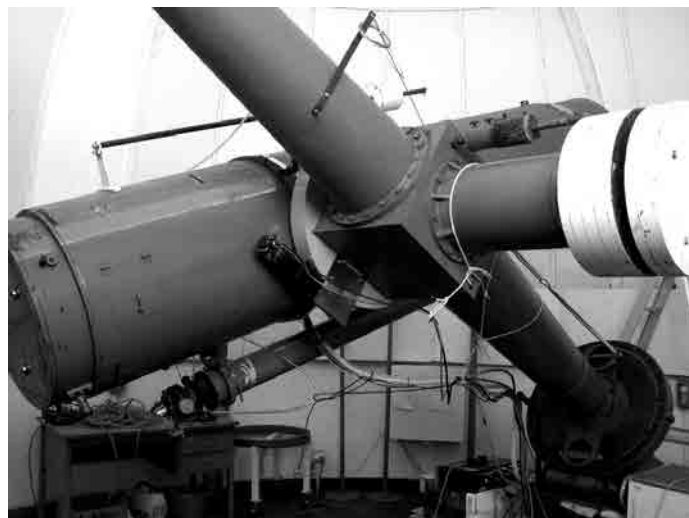


Fig 2 Uppsala Schmidt Tube and Mount.

Near Earth Asteroids. NEOs can be divided into three categories:

Atens: These are defined as those that have a semi major axis less than 1 AU with aphelion distances greater than 0.98 AU. By definition these asteroids orbit the Sun in less than a year. There are 232 such asteroids known as of August 30, 2004.

Apollo: Those that have a semi major axis greater than 1 AU and a perihelion distance less than 1.02 AU. There are 1407 Apollos known as of August 30, 2004.

Amors: These minor planets have a perihelion distance between 1.02 and 1.3 AU, which ensures they lie just outside the Earth's orbit with an orbital period greater than one year. There have been 1289 Amors discovered as of August 30, 2004.

The Earth's orbital eccentricity causes our distance from the Sun to vary from approximately 0.98 AU out to 1.02 AU; this makes all three categories potentially dangerous Earth orbit-crossing bodies. Even a few of the Amors can in theory approach within 0.05 AU and are considered a threat.

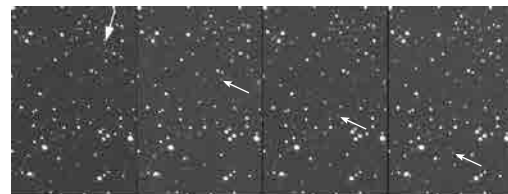


Fig 4 Images of asteroid 2004FH29 showing its motion over one hour (arrowed).



Fig 1 Uppsala Dome with star trails

Amateur Telescopes

In a previous yearbook we discussed the pros and cons of the classical 60mm refractor, the most common type of telescope found in camera and department stores. Even if you were lucky to get a good one, it still has the limitation of a relatively poor light collector. When looking at the surface area of a 60mm diameter lens it gathers less light than a pair of 7 X 50 binoculars! The telescope's advantage, of course, is the ability to have significantly greater magnification than your bird-watching 'binocs'. Assuming the optics in a telescope are of good quality, including your eyepieces, the aperture can become critical if you wish to go beyond the Moon, planets and bright deep sky objects. The diameter of the primary mirror or lens ultimately dictates how faint an object you can see, the amount of detail and how much colour can be glimpsed. Unfortunately, refractors grow in price exponentially with the lens diameter.

Refractor vs. Reflector. A good 60mm tube assembly can cost about \$200 — a 150mm refractor is thousands! And that's without the cost of the mount. The replacement of the traditional lens with a slightly concave mirror, in the shape of a paraboloid or a sphere, to focus the light revolutionised the design of telescopes. From a perspective of 'more bang for your buck' or dollars per square inch of light gathering power, reflectors are much more economic than refractors. For example a 150mm (6") Newtonian optical tube assembly would be only a few hundred dollars.

One type of reflector is called the Newtonian, after Sir Isaac Newton. They are very popular with amateurs and we will concentrate on this design (see diagram). It has some advantages over other reflector systems, being easier for amateurs to make, often having a wider field of view, straight-forward to collimate (align the optics) and the eyepiece is at the top of the tube placing it at a comfortable observing height.

The other most common reflectors are the Schmidt-Cassegrains, which have short tube assemblies, used with the often high-tech commercial equatorial fork mounts. Cassegrains use a convex secondary mirror to reflect and focus the light back down the tube through a hole in the centre of the primary mirror; Newtonians use an optically flat mirror that is tilted to direct the light out the side of the tube. It is worthwhile noting a distinction between Newtonian and the Cassegrain or refractor types. To get the eyepiece to a reasonable viewing position both Cassegrains and refractors use star diagonals, which is a small mirror placed just before the eyepiece to bend the light 90°. This gives them an odd number of reflecting surfaces (refractor = 1, Cassegrain = 3), which results in a reversed image (Newtonians have two reflections). If north is up the reverse image shows east to the right where the Newtonian shows east to the left, which is the normal sky view and how star atlases are drawn. Sometimes when using a Cassegrain the authors have had to turn a finder chart over and shine the torch through the paper to get the same view as the scope. The optical arrangement for the Schmidt-Cassegrain (SCT) is shown opposite. The main difference between the appearance of a Schmidt-Cassegrain and a classic Cassegrain is that the SCT uses a corrector plate at the front of the scope. The commercial Schmidt-Cassegrains also have a unique focusing system, which shifts the primary mirror instead of the eyepiece. Another subtle difference is

the shape of the reflecting surfaces on the mirrors, which we will not discuss here.

The Mount. Now we come to the topic of the mount, which is as critical as the optics. If you find your mount unstable or difficult to use, the telescope is likely to stay in the garage gathering dust. Before choosing your type of mount you need to think carefully about what you ultimately wish to do with the instrument. If you are looking towards photography or CCD imaging you need some way of tracking the stars, which normally requires an equatorial mount and drive. The equatorial mounts have an axis, which is tilted so it is parallel to the Earth's axis of rotation. Sometimes this axis is electrically driven very slowly, so it rotates once every 24 hours, and effectively tracks the stars. These costs can add up and if you just wish to basically observe and the budget is important, then you should look seriously at a Dobsonian Telescope.

John Dobson. The Dobsonian was named after an American amateur, John Dobson. He belonged to an order of monks who one day kicked him out because John spent too much time grinding astronomical mirrors! John was passionate about observing and showing the general public the Universe. He, along with two of his young students, established the now famous amateur society, the San Francisco Sidewalk Astronomers. His telescope design was simple and easy to transport to various public venues, not to mention being quick to set up. Amateurs quickly realised how easily and cheaply they could be constructed and a legend was born.

The Dobsonian. Unlike the more traditional equatorial mounts which require machined steel or cast aluminium parts, the Dobsonian is a simple altazimuth construction built primarily from plywood. The word 'altazimuth' is a contraction of the words 'altitude' and 'azimuth'. Or, if you like, their two axes move in altitude (up and down) and azimuth (along the horizon), like a gun turret. These days you no longer need to make such a telescope, although if you wish to have a go there is no shortage of books or experienced amateurs to give advice. The popularity of 'Dobs' has led to various commercially produced versions. There are extremely economic 'no name' units, manufactured in Asia, being sold through Australian telescope shops that have quite good optics and come with reasonable quality eyepieces. The 250mm (10") scope in the photograph, shown below, costs around \$1100. 200mm (8") and 300mm (12") versions cost around \$700 and \$1500 respectively.

'Dobs' use the basic Newtonian optical configuration, see the diagram, but the mirrors are thinner to reduce the weight and they are normally optically fast (low f ratio). For 200mm (8") and larger Dobsonians they are typically f/5 to f/6 to keep the tube as short as possible. The f ratio is the focal length of the primary mirror divided by its diameter — analogous to the speed of the lens for a camera.

A word on Star Hopping. The approach to star hopping can be quite different whether you have a Dobsonian or equatorial mount. With the altazimuth 'Dob' you need to rely on recognising star patterns. The equatorials have an added dimension, being able to move in the compass point directions in the sky. For example to find Centaurus A (the well-known galaxy NGC 5128) you can find the globular cluster Omega Centauri and swing the mount in declination about 5° towards the north, with the Right Ascension (RA) axis locked, to pick up this 'hamburger galaxy'. This works because these deep sky objects have similar RAs. If you wish to star



Fig. 1. A typical commercially manufactured 250mm (10") f/5 Dobsonian.

hop this way the RA and Dec. lines are marked on the All Sky Maps (see p. 68). This procedure is successful with an equatorial mount no matter where in the sky the objects are. However, the Dob has axes that operate only on an up/down and left/right basis and the star field rotates with time and you need to be able to recognise the star pattern, no matter what the orientation (one gets quite good at rotating star atlases).

This extra dimension that the equatorial offers does also add an extra dimension to setting them up. The polar axis needs to be aligned with the South Celestial Pole. Its altitude needs to be correct (hopefully this only has to be done once) and has to be pointing south (at least roughly) when the scope is set-up. As for your Dob, just drop it (well... gently) on fairly level ground and you're ready to go.

Going back to the challenges of finding celestial objects, there is an accessory that is extremely useful, no matter what type of telescope or mount — a Telrad type finder. This device, when you look through it, projects a luminous series of circles (like a bull's eye) onto the sky (their centre needs to be aligned with the main telescope beforehand). You are not looking through a lens so the image is neither upside down nor magnified. With experience and under dark country skies, where you can see lots of reference stars with the naked eye, you may not even need to use the traditional, lens based, finder but instead go directly from the Telrad to the telescope to enjoy your 'piece of the universe'.

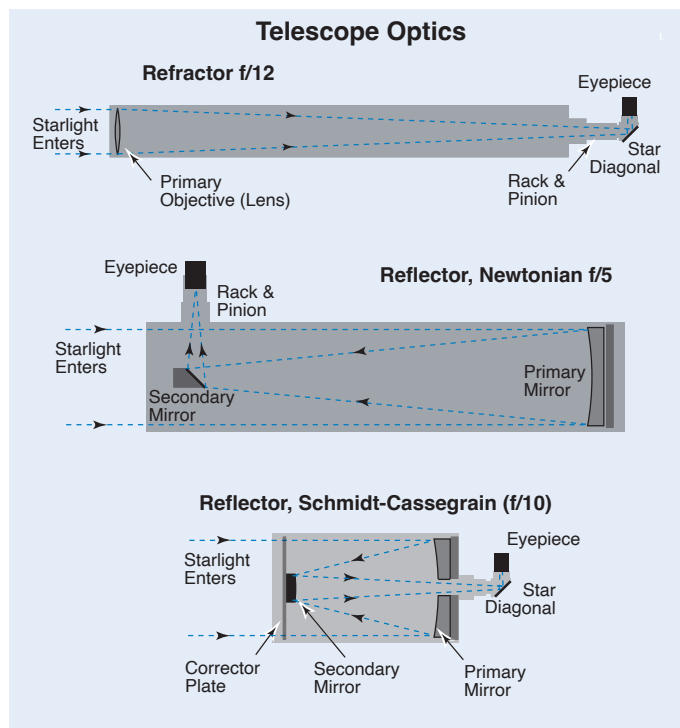
Tracking (the Earth's rotation stops for no one!) Once you have found your 'slice of heaven', keeping it in the eyepiece can be quite different depending on your type of mount. With an equatorial it is relatively easy to follow the stars even if you don't have a drive. It is handy being able to just nudge the scope in RA, especially if your mount has slow motion controls. With the Dob there is a lot of manual pushing/nudging of the mount on both axes and this can take a little practice. But this pushing does not require one to find slow-motion knobs in the dark either. The bottom line is it really comes down to what you are comfortable with or used to doing.

Checking out a Dobsonian. If you are considering making such a purchase here are a few things worth looking at:

- Ensure the Teflon bearings (on both altitude and azimuth) axes give a smooth motion and no backlash
- There must be a reasonable level of friction on the altitude bearing. This is important so the balance doesn't become a problem with different weight eyepieces or moderate wind.
- Check the main box doesn't rock on the base plate i.e., the azimuth bearing.
- Check the type of eyepieces that come with it. Short f ratio scopes, having a wide cone of light entering the eyepiece, can be prone to coma. 4 or 5 element Plossl eyepieces seem to work well and are reasonably priced. Coma is a slight fuzziness (or defocused region) towards the edge of the field. In general, the more elements the eyepiece has the better correction you get.
- A rack and pinion that can accommodate both 1.25" and 2" barrel eyepieces would be a nice touch. Be aware, if one day you can afford a 2" eyepiece you may need to modify your tube slightly so you can place weights near the bottom to balance these hefty eyepieces. Warning: once you see the deep sky view through a 2" eyepiece, under dark skies, you may be reluctant to ever go back to your 1.25ers!

Bonuses. With today's technology the Dobsonian can gain some of the features that were once considered the realm of the equatorial mounts only. For example, instead of having to star hop, there are now a number of systems that can help you point the telescope to the object of your choice. In fact there is a home-grown system called the Argo Navis, which has won a number of international awards. These aren't cheap but can be retro fitted at any time.

There are even tracking platforms which you sit the scope on which allows one to equatorially guide the scope for an hour or two. There



are only a few available commercially (and you would likely have to import one) but if you have the skills to make a Dobsonian mount, this wouldn't be much more difficult to manufacture.

The Ultimate Piece of Advice. In closing, many of the concepts discussed above may make more sense once you have gone and played with a Dob and an equatorially mounted telescope at night, under the guidance of an experienced user. There is a piece of John Dobson in all amateur astronomers. Go to an astronomical society's observing night and we are sure the people there will be very friendly and helpful. See Part III of this book or the Quasar Publishing website for contact details for societies. Our website also has links to telescope vendors.



Fig 2. A Celestron 8 tube (Schmidt Cassegrain) on a motorised German Equatorial mount. NB there are slow motion controls on both axes and a normal 35mm camera has been mounted piggy-back on the unit.

PART I – GETTING STARTED

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

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

Is this useful for where I live?

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

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

So what can this book help me see?

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

Conjunctions can be spectacular events. An example of a good conjunction this year is the one between the Moon, Mars and Antares on January 8 (see Sky View p. 23). These celestial dwellers all lie within a 5-degree circle in the eastern dawn sky. This is simply a chance alignment of these celestial bodies. They only look close together; in space they are still separated by enormous distances. When talking distances beyond the Earth, it is difficult to use normal scales such as metres or kilometres because the numbers would be so large. Instead, let's use the time it takes for light to travel from these objects to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over one second to reach us, Mars 18.3 minutes and Antares 490 years. If you include the globular cluster, M4, we are now out to 6,800 years. Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, these objects are just in our neighbourhood!

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

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

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

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

Part I is divided into months. At the beginning of each monthly section is a curious looking graph called a rise/set chart. This series of squiggly lines is your guide to knowing when the planets, Sun and Moon rise and set. To use the chart, simply look at the current date on the bottom of the chart and follow that line upward until it intersects the object of interest. The rise or set time of the object can now be read on the left-hand edge of the chart. For example, on January 31, the Moon and Jupiter rise together about 10:30pm. Incidentally, when you see objects rising or setting together, look for a Sky View on that date. There is a Sky View for this conjunction (see p. 23).

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

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

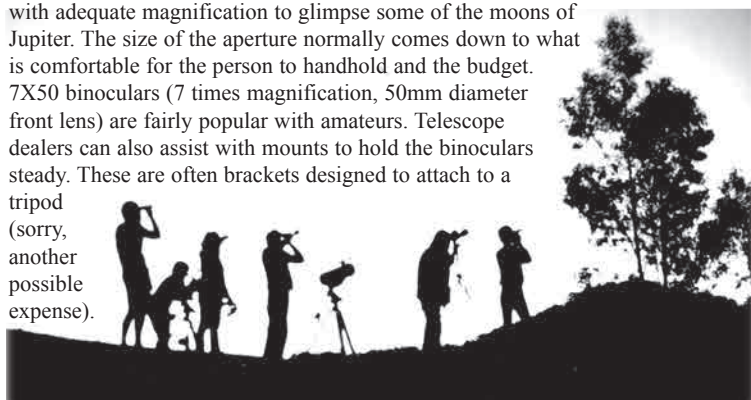
While on the subject of lights, make sure as many lights as possible near your observing site are turned off. The less glare around you, the easier it will be to enjoy the night sky. Encourage neighbours to turn off their outside lights and invite them to enjoy the night sky as well. A major modern threat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

The Sky Views don't show all the sky. By their very nature they mostly concentrate on the ecliptic or zodiac regions of the sky, where the planets and Moon wander. This is why we have the All Sky Maps. Also, a good companion to this publication would be a planisphere. This shows all of the sky, but not the Sun, Moon and planets because they move. The planisphere is useful by showing at a glance all of the constellations visible at the time you are observing. An example is shown on page 15. Once you start to look around the sky 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 will soon be like old friends.

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

A word about binoculars

Probably the most cost-effective accessory for the beginner are binoculars. Good quality binoculars can be purchased at the same cost as a cheap, low quality telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a cheap way of gauging their level of dedication. This does not mean we are suggesting the quality of the binoculars should be poor. It is recommended that even binoculars should be purchased from a reputable optics or telescope dealer (see the Quasar Publishing website). These people appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. To observe details on the Moon or look for Jupiter's moons, it is recommended that binoculars are not hand held. Sometimes you can brace yourself on the arms of a chair or the roof of a car. This can be important if the power of the binoculars is more than 10X. A power of 7X is 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. 7X50 binoculars (7 times magnification, 50mm diameter front lens) are fairly popular with amateurs. Telescope dealers can also assist with mounts to hold the binoculars steady. These are often brackets designed to attach to a tripod (sorry, another possible expense).



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 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. This can be important in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Contrast the yellow of Alpha Centauri with the blue of Beta Centauri (see also p. 53).
- The crescent phases of Venus.
- Stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky (see p. 65).
- 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.
- Looking at wide double stars.
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on pp. 114–115). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites as the moon passes into or out of the shadow of the planet. The magnification of the binoculars will dictate how close to Jupiter you can see such an event.
- Lunar occultations of some of the brighter stars (see also Part II). Small binoculars are well suited for magnitude 4 or brighter events, preferably on a dark limb. There is no reason why you should not time the event as described on page 92.
- Looking for bright comets (from dark skies).
- Some of the bright deep sky objects such as the star clusters, Milky Way regions and the Magellanic Clouds.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart and see which 'star' has moved. Taking the co-ordinates of a minor planet from Part II, pages 128–129, and plotting that position on the All Sky Maps will help you find the correct area.
- Searching out Uranus and Neptune, see finder charts, page 124.

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

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

Some astronomical terms to get you started

There are several astronomical terms you'll come across in *Astronomy 2005*, many of which are defined in the glossary at the end of the book. Here are a few of the more common ones, just to get you started.

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

Star. Just like the Sun. 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. It's a testament to the enormous distances between the stars when you realise that the Sun is a relatively average star, while some stars visible in the night sky are tens or hundreds of times larger and brighter, yet in our sky look so faint.

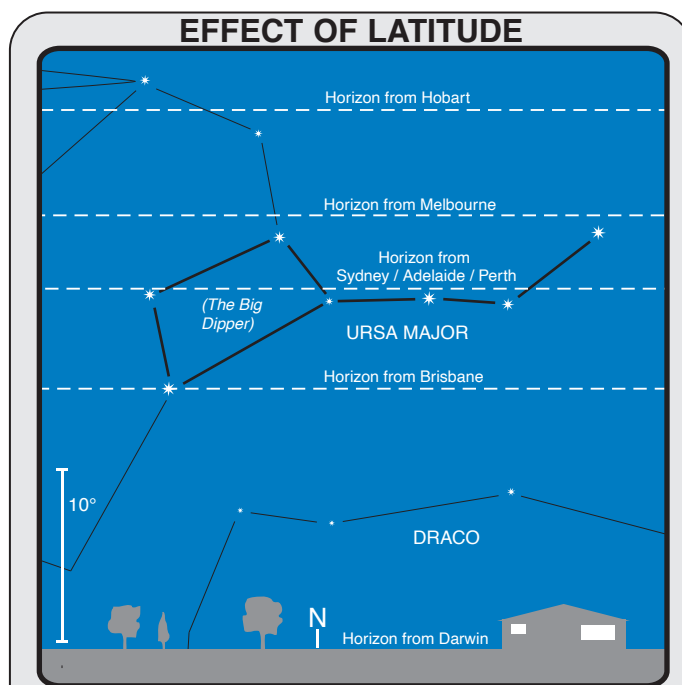
Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'magn.'). The numbers work backwards. The faintest star you're likely to see with the naked eye is about 6.0 magnitude (under country skies), while the brightest stars are –1.0 magnitude. Planets can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

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

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

Twilight does not really end until the Sun is 18° below the horizon; this is called astronomical twilight. This happens about 90 minutes after sunset (or before sunrise) and is different from what people normally call the end of twilight. This is civil twilight, which begins or ends when the Sun is 6° below the horizon (about 30 minutes before sunrise or after sunset). Only when astronomical twilight has ended is the sky considered truly dark (assuming the Moon isn't above the horizon!) Keep in mind that many celestial features can be seen even during twilight; binoculars can also help. The actual time between sunset and end of twilight (and the beginning of dawn and sunrise) does vary with latitude. The further south, the longer the time of twilight. Compare the twilight and rise/set times in Part II between Darwin and Hobart.

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



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

How do I use this book to plan my observing?

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

You live near Melbourne, Victoria, and are planning to go out and observe on the evening of January 6 and hoping to push on all night. Being in an eastern state you will use times in EST, when given, and **add one hour due to Victoria being on daylight saving in January**. A good place to start is the Visibility of the Planets chart (p. 18). Looking around early January, the diagram is showing Venus, Mercury, Pluto, Saturn and Jupiter in the morning sky, with Uranus and Neptune in the evening. Saturn is close to crossing the midnight line so you would expect it to be close to opposition and visible most of the night. A quick check of the Rise/Set Chart for January (p. 20) confirms Saturn rising close to sunset. On this same diagram, looking up in the top half (morning of the 7th) we see the Moon rising around 1:30am and on the following couple of days it rises with Mars, Venus, Mercury and Pluto. With these conjunctions you would expect a Sky View — which there is (see 'Jan 7 to 21' p. 23). This promises a spectacular late morning/dawn sky, but there is much to do in the evening first. Neptune is setting around the end of evening twilight and it is probably best to wait until it reappears in the morning sky in March. Uranus has a narrow window for observations available, setting about one hour after the end of twilight. If you have a large enough telescope you can work out the approximate positions of its brightest moons (see p. 122), but beware the brightest satellite, Titania, is only 13.5 magnitude.

The January monthly section, under Comets, says the following about C/2004 Q2 (Machholz):

... opens the year well up in the sky, due north at the end of evening twilight and possibly as bright as 4th–5th magnitude. It is in Taurus early in the month ...

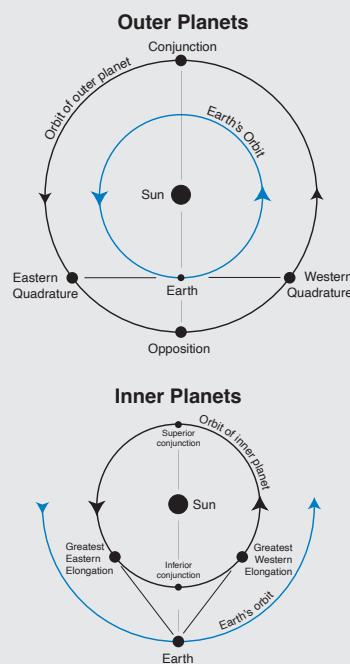
The comet section in Part II (p. 133), shows the comet near maximum brightness this month and assuming you are under dark skies, this could be impressive, even through binoculars. There is no position given for 'Machholz' for the 6th, but there is for the 1st and the 8th. Plotting these on the All Sky Map (No. 3, p. 71) and roughly interpolating we see the comet is indeed in Taurus and probably 4 – 5° south (above) the Pleiades on the 6th (on the 8th it will be only a couple of degrees west (left) of this spectacular open star cluster). This is a good night for comets, for Comet C/2003 K4 (LINEAR) is high in the southern evening sky in Pictor (as per the comet monthly text, p. 22). Going through the same exercise as with Machholz, we find a position approximately 3° from Gamma (γ) Pictoris (around 8° west and slightly south of Canopus), where the 'T' is in the word 'PICTOR' on All Sky Map No. 1 (p. 69). A quick check with a planisphere (see example p. 15) shows it is at its maximum altitude, due south, around 11pm so LINEAR is visible most of the night.

We have previously mentioned that Saturn is visible most of the night. The Sky View 'Jan 23 – 27' shows Saturn near the Gemini Twins this month. In fact, the diary (p. 22) tells us Saturn is close to Pollux on the same evening (7° S). Looking at the Appearance of the Planets diagram, shows that Saturn's rings are still relatively wide open (as they are for the whole year). If you can pull yourself away from the rings, Saturn, even through a small telescope, displays a sprinkling of satellites with five of the moons brighter than 12th magnitude. The satellite section in Part II (p. 118) explains how to calculate their relative positions and hence identify them.

Don't forget, while having a coffee break to sit back and enjoy the view. It could be worthwhile looking for meteors, take note of the direction they come from. The monthly text indicates that the delta Cancriids are active in January with the radiant in the constellation of Cancer. Although this is a minor shower you never know when you might catch one.

Switching to the morning sky, Jupiter is rising around midnight and visible until dawn. It is worth checking to see if there are any satellite events on that morning. The table on page 111 shows satellite II, Europa, disappearing into the shadow of Jupiter (being eclipsed) at 1:22am (the

ORBITAL ASPECTS



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

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

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

reappearance is after sunrise). The diagram on the bottom of page 110 indicates that this happens on the western side of Jupiter. The 'Jupiter's Moons' diagram, see page 114, shows you the remaining three Jovian satellites spend the morning on the eastern side in the order of I (Io), IV (Callisto), and III (Ganymede), from closest to Jupiter moving out. Satellites I and IV will get closer as the morning progresses.

While on the subject of Jupiter, you might wonder what are the chances of glimpsing the Great Red Spot? The longitude of central meridian for the GRS is now around 93° (generally considered observable up to one hour either side which translates to a longitude range of 57° to 129°, System II (see p. 116). A calculation for System II at 2am on the 7th (16hr UT on the 6th) shows the central meridian as 37.2°. Considering this longitude increases 36° for each hour, the central meridian will be 91.2°, an hour and a half later i.e., 3:30am. It looks like the GRS will be very close to the central meridian around the start of dawn.

Switching to the Moon, besides enjoying the waning crescent image (it is now two days past 3rd quarter), we have an occultation of 7th magnitude star, ZC2207. At 3:25am it reappears from behind the dark limb at a position angle of 12° (east from north) while the Moon is at an altitude of 20° (see Lunar Occultation table for Melbourne, p. 96).

Mars rises around 2:30am (see Rise/Set chart, p. 20) but unfortunately there is not much to see. It is still 10 months from opposition and presents a very small image of only about 4 arc seconds (see Appearance of the Planets diagram, p. 20). It is worthwhile waiting until October/November when it will present a much more impressive sight (see Opposition of Mars, pp. 105–107).

The Rise/Set diagram (p. 20) shows that Mercury and Venus rise together about 1.5 hours before sunrise; dawn has already started. The previously mentioned Sky View (Jan. 7 to 21) illustrates this quite well. Telling them apart is no problem with Venus considerably brighter than Mercury, about 4 magnitudes — see Appearance Diagram (p. 20). This same drawing shows them both to be quite full and gibbous. This is expected, as they are both approaching superior conjunction, on the opposite side of the Sun from Earth. Contrast this to the crescent-shaped, large sizes as they approach inferior conjunction, i.e., closer to us with more of the night

WHAT TIME IS IT?

Unless a time zone or a location is specifically mentioned, times given in the Monthly section will be approximate local standard time. There are no adjustments made for Daylight Saving (or Summer Time) anywhere in this book. When Daylight Saving is in force you will need to add one hour to times given here. For example, any rise/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 meridian of longitudes of 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from the EST times given. Any times specifically given for Darwin or Adelaide are CST.

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

side showing, just before passing between the Earth and the Sun. See December section for Venus or April for Mercury.

These are just a few examples of the way to apply the information within this book and how it can be a lot of fun planning an observing session.

THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

Rise/Set Chart

This will enable the reader to quickly determine when (or if) a planet or the Moon is visible in the night sky for any day in that month. Each chart has the midnight line centred, with the evening sky below this line and the morning sky above. The two bands of lighter shading show the times of morning and evening astronomical twilight. If you are using a telescope you'll soon learn to avoid trying to observe a planet near the horizon (close to rise or set times). Turbulence in the much thicker atmosphere (at low altitude) gives very poor 'boiling' images. The ideal time to observe an outer planet is at the time of transit, which is when it is due north and has reached its maximum altitude. Dashed lines, giving this time have been included this year. Also a number of events during the year have been shown using symbols, as per the following legend.

These charts only give an approximate local standard time and you will see from the specific rise/set times in Part II there is variation from city to city. This reflects the effects of position relative to the standard meridian and differing latitudes. The chart indicates the time to within plus/minus 30 minutes for all capital cities (except Darwin). Darwin, because of its extreme latitude compared to the more populated southern regions of the continent, can differ by up to 90 minutes. If more accurate rise/set times are required, you will need to refer to the specific tables for the object of interest in Part II of this publication. You can also adjust for rural locations using the appendix on page 138.



Greatest brilliancy



Opposition with Sun.



Conjunction between planets.



Eastern elongation



Western elongation

Highlights

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

Appearance Of The Planets

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

The Moon

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

Unlike 2004, there are a number of bright star occultations during 2005; these involve either Antares or Spica. There will be 31 occultations of bright stars, planets or major asteroids this year, somewhere in the world, plus the usual multitude of fainter star events (see Lunar Occultations in Part II).

The Planets

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

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, emphasizing 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 unique design corrects for distortion of the constellations around the horizon, inherent on single sided planispheres. Its plastic construction makes for a durable and moisture resistant product.

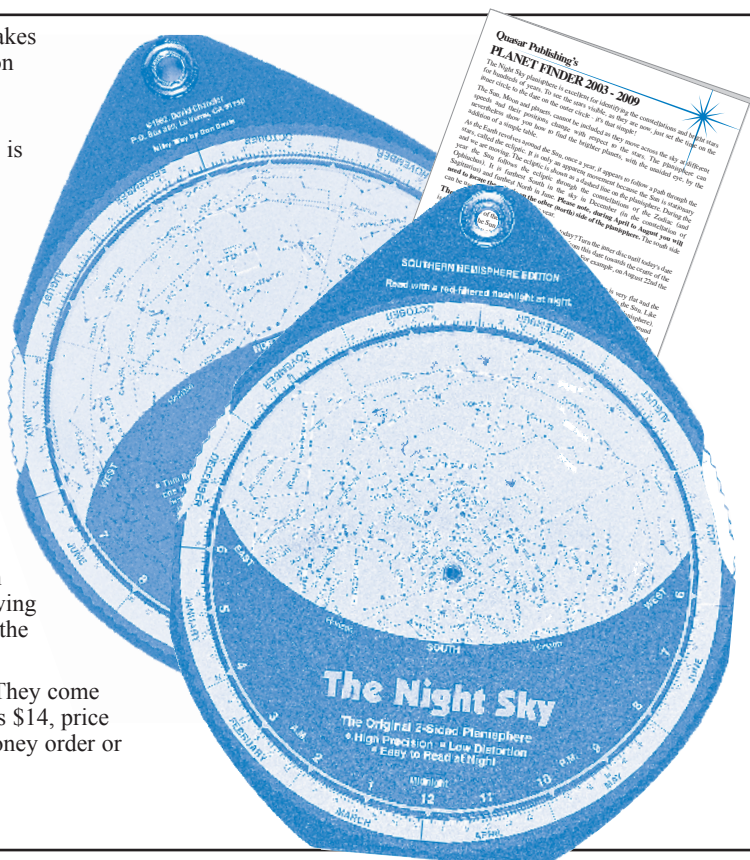
To use this planisphere is easy. Just turn the disk so the date lines up with the time and it will show you what the sky looks like now. It's that simple!

PLANET FINDER

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

These planispheres are available direct from Quasar Publishing. They come in two sizes: the large 22cm version is \$24, the small 13cm one is \$14, price includes postage within Australia. Payment can be by cheque, money order or credit card (VISA, MC or Bankcard). Orders should be sent to:

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



Minor Planets (or Asteroids)

This section deals with the brightest asteroids that reach opposition this year (approximately 11th magnitude or brighter). An entry includes the date of opposition (i.e., when it is brightest), its magnitude and the constellation the asteroid is in at the time of opposition. Ephemerides for the brightest 19 of these, plus 1 other that reaches opposition in January 2006, are included in Part II.

Comets

This section deals with the comets expected to be visible during the year. It points out those that are observable during the month and includes any interesting conjunctions. Note, with the possible exception of C/2004 Q2 (Machholz), most of the known comets this year are relatively faint and will need a telescope. It is likely that many other comets will be discovered during the year, so who knows what surprises are ahead!

Meteor Showers

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

Diary Of Events

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

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

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

Abbreviations. These include:

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

There are also some astronomical catalogues including:

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

Time. When times are given, both EST and WST are presented. As these times are rounded to the nearest hour, it is unnecessary to include a separate entry for CST seeing there is only a 30-minute difference to EST. The remaining entries are less time sensitive and either have no time (i.e., closest day) or a PM or AM designation for an evening or morning event

respectively. For 'timed' events that occur in the very early hours (before 2am) for EST, the WST conversion (subtracting 2 hours) takes it into the previous day — shown as 'prev. day'.

Feature Article

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

Sky Views

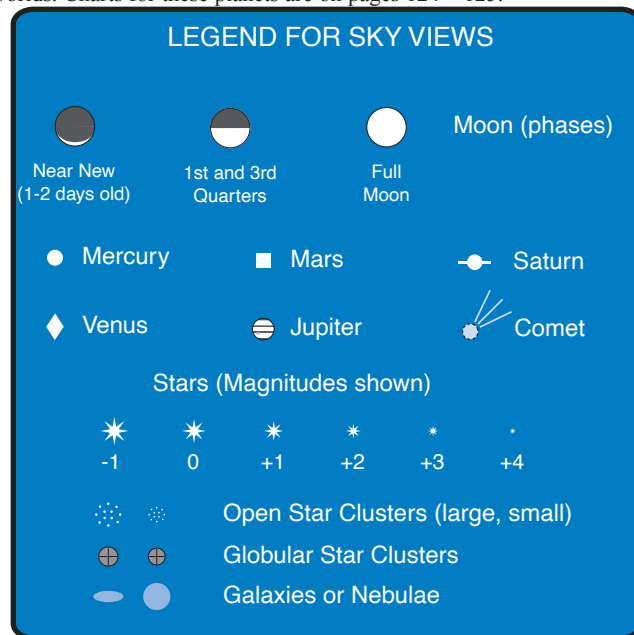
These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although,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

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

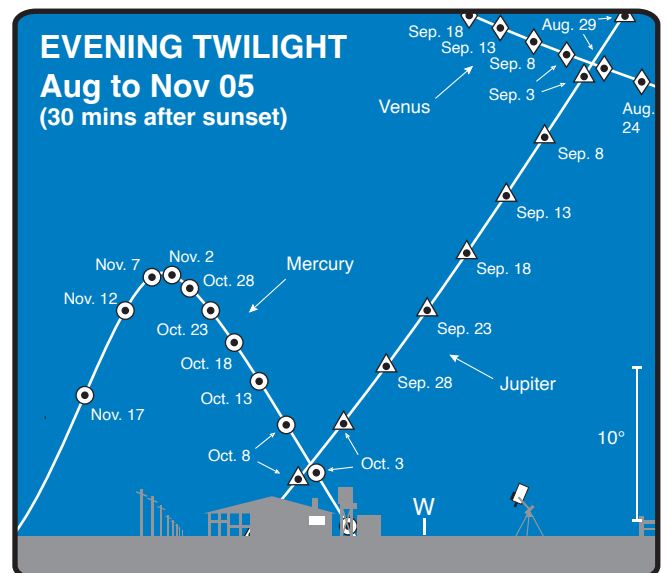
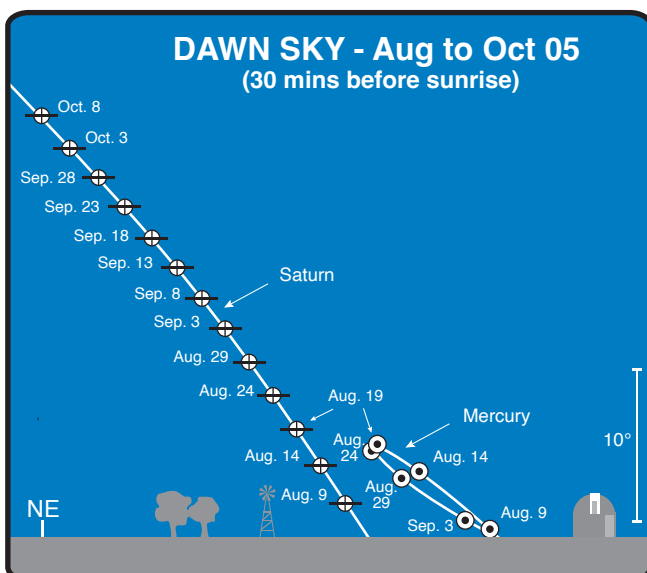
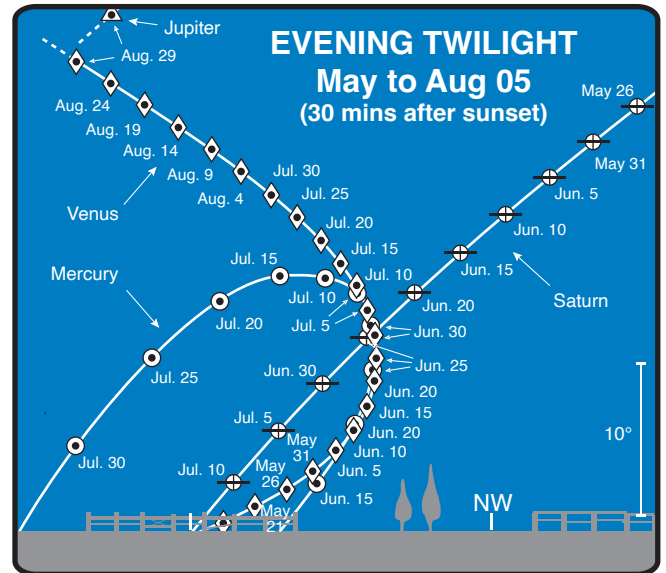
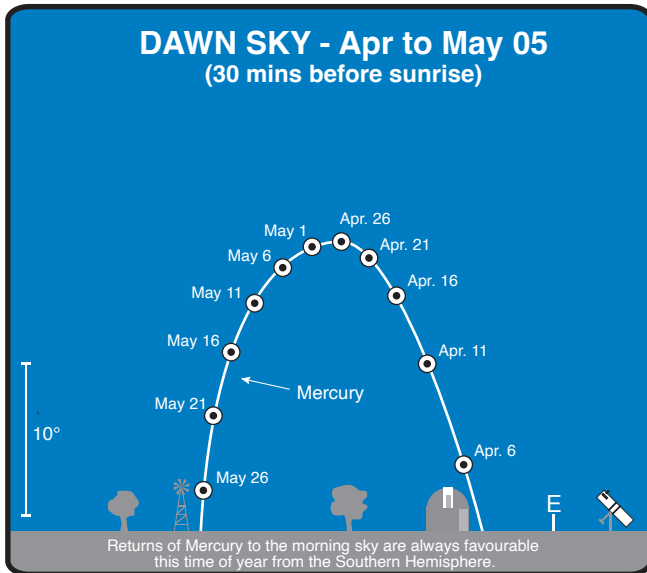
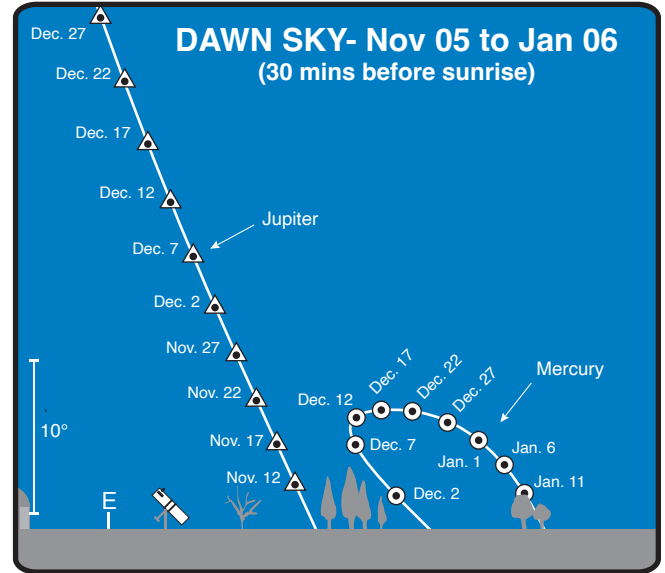
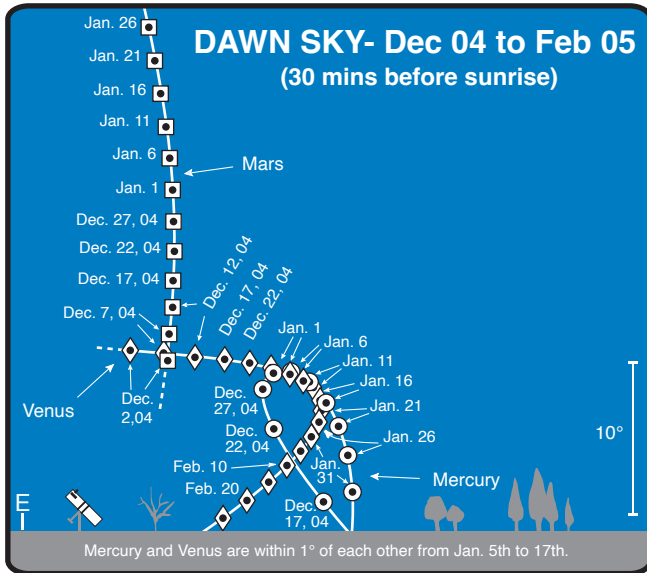
- The Moon (showing approximate phase) and the planets visible with the naked-eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies (down to approximately 5.5 magnitude). These objects are named using the following codes. A prefix of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

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

Uranus, Neptune and Pluto have been excluded from the Sky Views, as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. In any case, because of the many faint stars of similar brightness close-by, finder charts would be needed to identify these outer worlds. Charts for these planets are on pages 124 – 125.



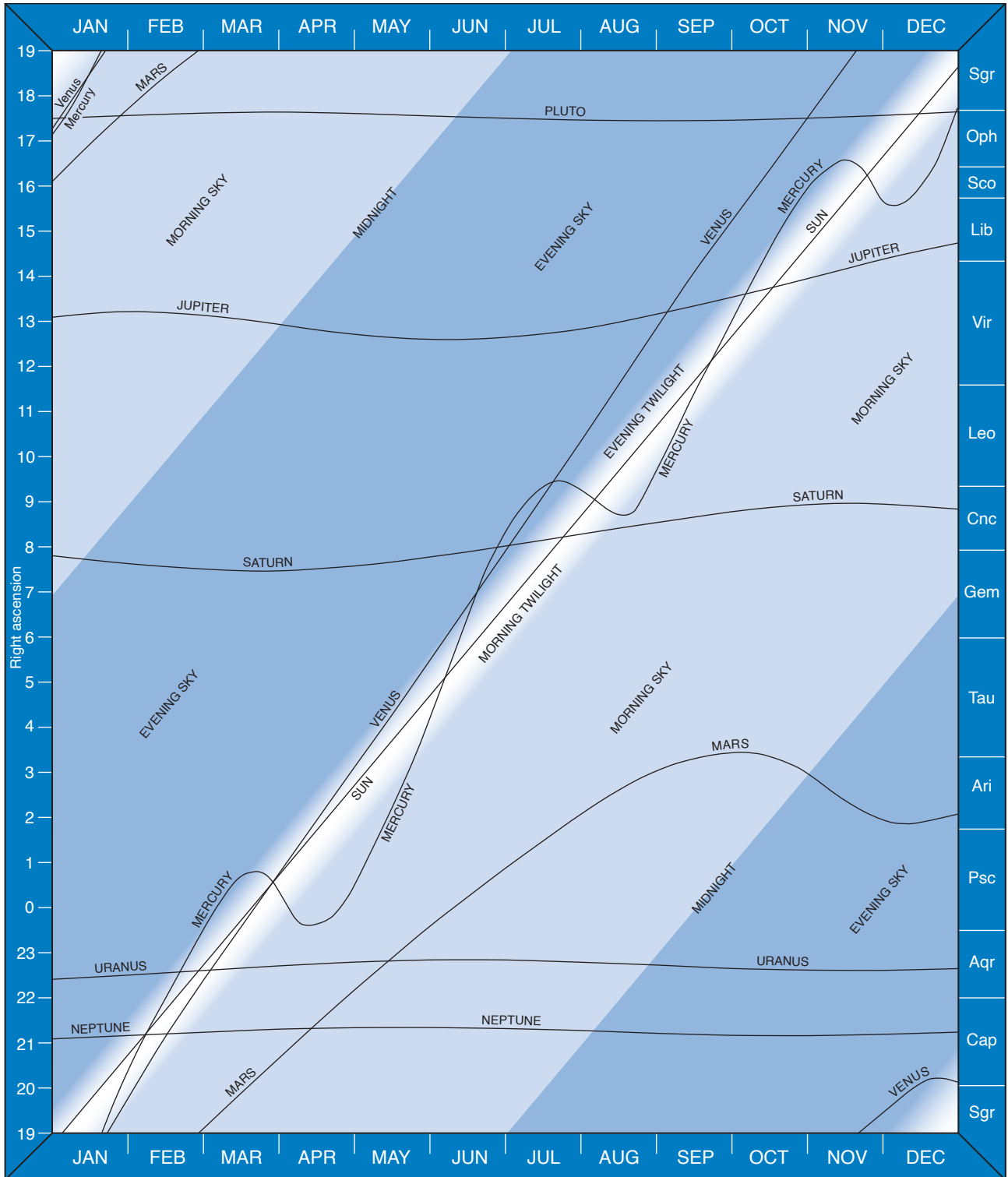
MOVEMENT OF THE PLANETS



These diagrams are designed to help observers know when the planets first become observable after being in conjunction with the Sun, or when they are about to go into conjunction with our star. The drawings are particularly useful

as an observing guide for Mercury. In addition, the Visibility of the Planets diagram (p. 18), allows you to see at a glance whether an object is in the morning or evening sky.

VISIBILITY OF THE PLANETS



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

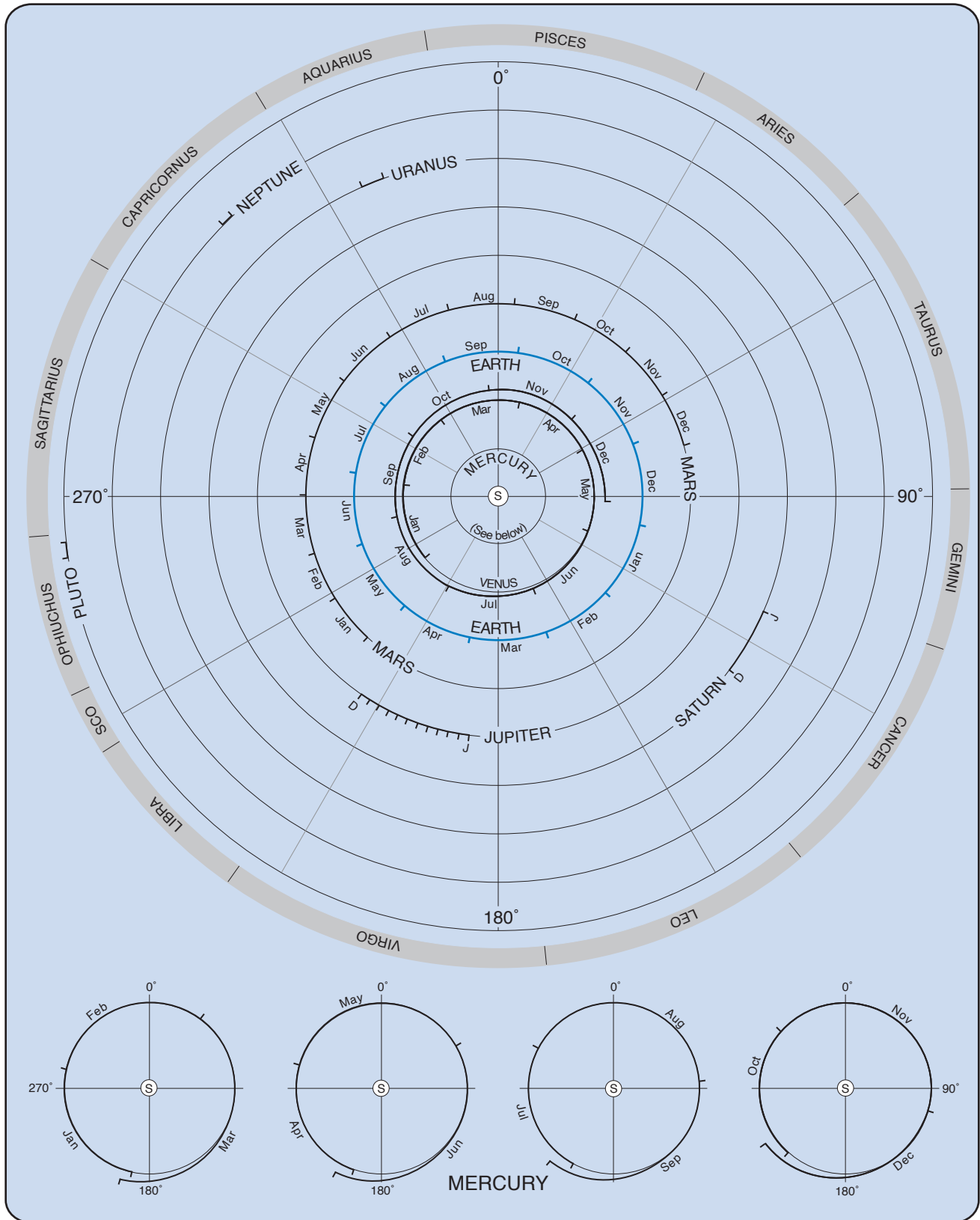
Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best times to observe Mercury are from mid-

April to mid-May for the morning sky, and from late June to mid-July and late October to early November in the evening, when its path extends beyond the twilight area.

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 lines cross, the planets will be close together in the sky. This year's conjunction between Venus and Jupiter is clearly shown where their paths cross in the early September evening sky.

PLANET POSITIONS



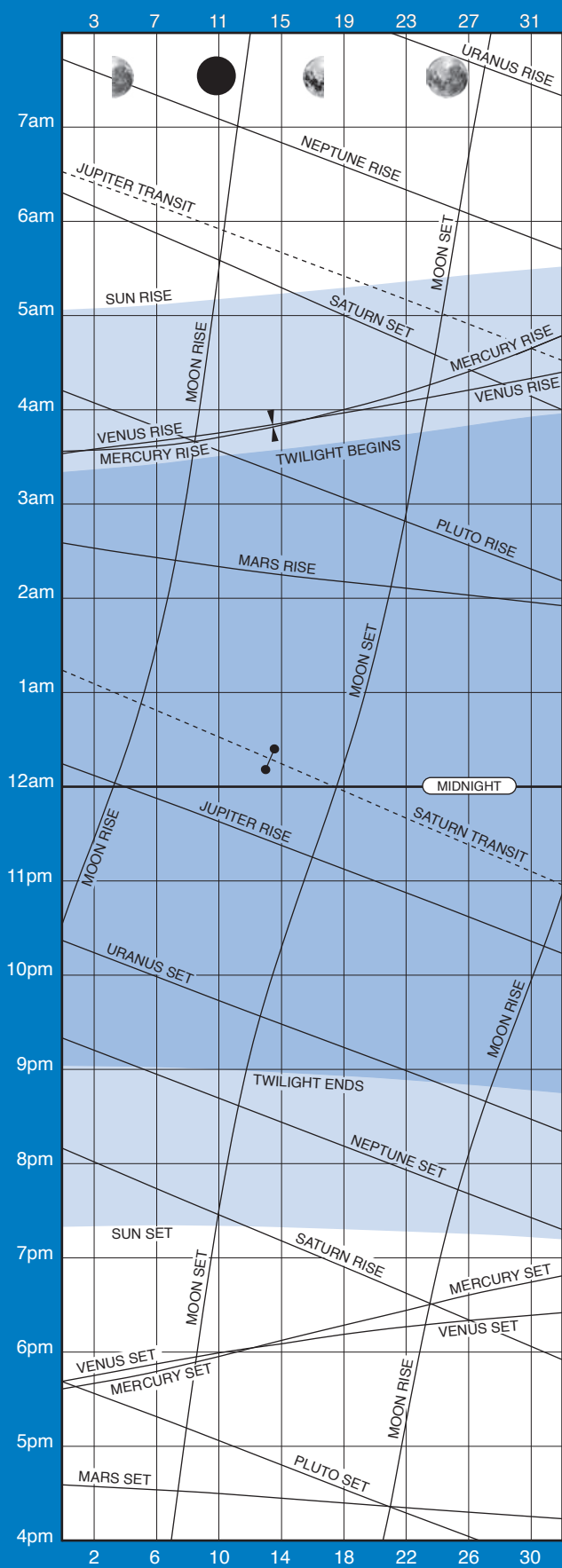
This diagram illustrates the relative positions of the planets during the course of their orbits in 2005. The relationships between the major Solar System bodies are clearly shown. For example, this year's opposition of Mars occurs early in November when the Earth appears closest. A line extended from Earth, through and beyond Mars shows that the planet is

located in Aries at this time. The diagram is drawn as viewed from below (south of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the Sun and planet distances are not drawn to scale. The thirteen constellations named are those that are situated on the ecliptic.

JANUARY

JANUARY

RISE/SET CHART



HIGHLIGHTS

- Daytime occultation of Jupiter by the Moon for Perth
- Mercury and Venus very close in the morning sky
- Mars and 1st magnitude star Antares close
- Saturn at opposition
- Comet C/2004 Q2 (Machholz) possibly 4th magnitude in the evening sky

THE MOON

- 4th Last Quarter.
- 4th Occultation of Jupiter by the Moon. This is a daytime event visible only from the far southwestern portion of Australia. From Perth, the planet will disappear behind the Moon's bright limb in the western sky at around 10:44am local time, and reappear from the dark limb about 11:05am. Jupiter is not easy for small telescopes in the daytime, however 20cm or larger instruments should have no trouble. This is the third in a series of eleven occultations of Jupiter that began in November 2004, and will end in August this year.
- 8th Occultation of Antares by the Moon, not visible from Australia. This is the first in a series of sixty nine occultations of Antares, which will conclude in February 2010; it is also the first occultation of this star since April 1991.
- 10th Moon at perigee (closest to Earth – 356,570 km distant, angular size 33.7')
- 10th New Moon.
- 17th First Quarter.
- 24th Moon at apogee (furthest from Earth – 406,445 km distant, angular size 29.5').
- 25th Full Moon.
- 31st Occultation of Jupiter by the Moon, not visible from Australia.

APPEARANCE of the PLANETS

MERCURY



5th Jan
dia 5.94"
mag -0.3



15th Jan
dia 5.28"
mag -0.3



25th Jan
dia 4.93"
mag -0.5

VENUS

15th Jan
dia 10.49"
mag -3.9



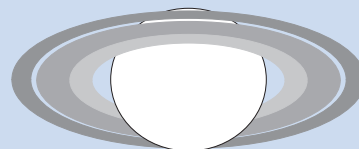
MARS

15th Jan
dia 4.35"
mag 1.5

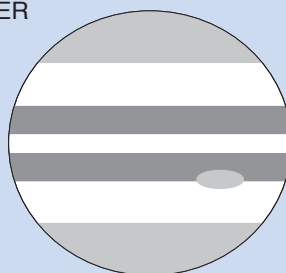


SATURN

14th Jan
Opposition
dia 20.58"
mag -0.4



JUPITER



15th Jan
dia 37.41"
mag -2.1

URANUS

15th Jan
dia 3.39"
mag 5.9



NEPTUNE

15th Jan
dia 2.20"
mag 8.0



PLUTO

15th Jan
dia 0.10"
mag 14.0



THE PLANETS

MERCURY and Venus feature prominently in the dawn morning sky. Both planets spend the first week of January in Ophiuchus and then cross over into Sagittarius for the rest of the month. Since late December the pair have been constant companions and will be closest on the 14th at 0.3° (see Sky View). On the 1st, Venus is directly south of the fainter planet at 1° separation, it then loops under Mercury and to the north for its closest approach, thereafter the pair rapidly separate as Mercury moves towards superior conjunction next month. On the 9th, the slender crescent Moon (just 4% illuminated) appears 5° above the two inner planets (see Sky View). On the 10th and 11th Mercury and Venus pass between the Trifid and Lagoon nebulae, difficult in the dawn sky.

VENUS' rendezvous with Mercury as detailed above, is an outstanding sight for early risers. On the 16th, both planets are situated near the top of the 'Teapot' in Sagittarius and very near to the fine globular cluster M22; the three objects forming a line. From the north Venus is 0.5° from Mercury which is then 0.5° from M22's centre.

The **EARTH** is at perihelion (the closest point in its orbit to the Sun) on the 2nd. The Earth/Sun distance is 0.983297 astronomical units, which is equivalent to about 147,096,000 km.

MARS rises a little after 2am near the head of Scorpius early in the month. The Red Planet will be within 5° of the 1st magnitude star Antares on the 7th. The name Antares came from the ancient Greek 'Anti Ares' meaning 'equal to Ares' or 'rival to Mars'. When the pair happen to be close in the sky it is easy to see where the name comes from, the two being very similar in colour although often with differing brightness (at this time, Antares is just 0.5 magnitude brighter than Mars). On the 8th the thin crescent Moon appears between Mars and Antares (see Sky View). After the first week of the month in Scorpius, Mars moves across

Ophiuchus and has close encounters with a number of globular clusters (see diary).

JUPITER rises before midnight in Virgo and is visible for more than half the night. The planet is visited by the Moon twice this month; on the 4th, the Last Quarter Moon appears close (See 'The Moon', above, for details of a daytime occultation from Perth, also see Sky View), and on the 31st, the 20-day old gibbous Moon is near (see Sky View). By month's end Jupiter will be located 6° from 1st magnitude Spica (Alpha Virginis).

SATURN is at opposition on the 14th, and the next month or so is the optimum period to observe this exquisite planet at its brightest and largest. Interestingly, a Saturnian looking towards the inner Solar System on the 14th would see a rare transit of the Earth across the Sun. Observers will note a gradual closing up of the planet's rings over the course of the year. This trend continues until the Earth passes through the ring plane in 2009, when they will appear edge on. Visible the entire night this month in Gemini, the best time to view the planet is late evening when it is high in the north sky above the Gemini Twins, Castor and Pollux. On the 24th, the near Full Moon appears close to Saturn (see Sky View).

On the nights of the 25th and 26th Saturn can be seen crossing the open star cluster NGC2420 in Gemini. Due to its retrograde loop Saturn will again visit this cluster on 14th May, this time missing its northern edge by around 3 arc minutes.

URANUS in Aquarius and **NEPTUNE** in Capricornus remain in their respective constellations during the year. Both planets are low in the western evening sky, moving into conjunction with the Sun next month.

PLUTO, in Serpens Cauda, returns to the morning sky after its solar conjunction in December. This year the planet spends a good deal of time close to the 3.5 magnitude star Xi Serpentis. From the end of this month through to May and all of December it remains within 1° of the star.

PROBING THE PLANETS – UPDATE

2004 Reviewed

On August 3 NASA launched its Messenger probe to Mercury. After two flybys of Venus and one of Mercury it will finally enter orbit in 2009. Messenger stands for **M**ercury Surface, **S**pace **E**Nvironment, **G**eochemistry and **R**anging mission.

The Cassini mission passed a major milestone on July 1, 2004, by becoming Saturn's first artificial satellite when it successfully fired its main rocket and entered orbit. It has already taken some spectacular images of the moon Phoebe and Saturn's storms and ring system. Cassini is expected to spend four years studying Saturn's rings and atmosphere, the moons and the magnetosphere.

After collecting particles from the solar wind for two years, the space probe Genesis returned them to Earth on September 9, 2004. Unfortunately, due to failure of the parachute to deploy, the probe returned somewhat faster than anticipated, crashing into the Utah desert at over 300 kph. Early reports indicate much of the scientific material has survived.

On January 2, 2004, the Stardust probe flew within 236 km of the Comet Wild 2 and its 'aerogel' collected samples of the dust and gas from its coma. It will return this material to Earth in 2006.

Mars. The highlight of 2004 was the successful landing of NASA's Spirit (MER-A) and Opportunity (MER-B) probes on Mars in January. It was hoped these two identical robotic field geologists would operate for three months but they have well and truly exceeded expectations and, as of September 2004, are still gathering a wealth of scientific data. Their primary mission was to examine a wide range of rocks to look for evidence of water activity in the past. Opportunity's site on 'Meridiani' used to be the shallow coastal waters of a saltwater ocean. The history of Spirit's location, on the opposite side of Mars from Opportunity, at Gusev Crater was not so clear-cut, but some rocks are showing evidence of water action.

Unfortunately the Beagle 2 Lander was lost shortly after separation from the European Space Agency's (ESA) Mars Express Orbiter. Although much was said about the failure of the lander, the orbiter is still performing well taking high-resolution images of Mars, determining

subsurface mineral compositions and studying the interactions of the atmosphere with the surface and the solar wind.

Another victim of the Mars 'hex' was the Japanese probe NOZOMI (or Planet B). In December 2003 ground controllers were unable to orientate the craft for its orbital insertion burn and the spacecraft flew past Mars, entering a two year orbit around the Sun.

The JPL Mars Global Surveyor spacecraft has continued its remarkable mapping mission around Mars, which started on April 1, 1999 and as of September 2004, has completed over 24,000 mapping orbits. It has returned more data about the surface and atmosphere than all previous missions combined.

In May 2004, the probe '2001 Mars Odyssey' completed its 10,000th orbit. During this time it has discovered vast supplies of frozen water and mapped surface textures and minerals over the entire surface of Mars, plus other feats. Its mission was due to end but has now been extended to 2006 to, amongst other things, look for changes in the Martian climate and act as a communications relay station for the two MER landers.

So What Will 2005 bring?

December 2004 is a busy month for NASA. The Deep Impact probe will be launched with the mission of sending a 350 kg projectile into Comet Tempel 1 in July 2005. It is hoped the resulting cloud of debris will tell us a lot about the structure and composition of comets.

On Boxing Day 2004, the Huygens probe will separate from the Cassini spacecraft, currently orbiting Saturn. On January 14 it will enter the atmosphere of the moon, Titan, and parachute to the surface. It is anticipated that it will return to Earth a deluge of data during its two hour descent through the atmosphere and hopefully for four hours on the surface. This largest moon of Saturn is intriguing with its opaque atmosphere, which is believed to contain many organic compounds. Huygens could easily splash down on an ocean of ammonia! 2005 will be a busy year for Cassini with the following encounters: Saturn (18 times), Titan (6), Enceladus (3) and single flybys of Hyperion, Dione and Rhea.

In August 2005 the Mars Reconnaissance Orbiter is due for launch and will enter Mars' orbit in 2006. It will image the entire surface at a high resolution, generate mineral composition maps and subsurface radar profiles. It will contribute to the knowledge of water action and selection of landing sites for future missions.

MINOR PLANETS at opposition this month include: 216 Kleopatra on the 13th at magnitude 10.7 in Canis Minor, 8 Flora on the 14th at magnitude 8.4 in Gemini, 532 Herculina on the 16th at magnitude 8.9 in Gemini and 115 Thyra on the 27th at magnitude 9.8 in Cancer. At the time of its opposition 115 Thyra skims the edge of the Beehive Cluster.

COMETS

Comet C/2003 K4 (LINEAR) begins the year deep in the southern sky in Pictor and visible all night. Between 7th and 8th magnitude, and best observed in the evening, the comet will be moving northwest through Caelum, Horologium, Eridanus, and Fornax.

Comet 49P/Arend-Rigaux can be found in the constellation of Cetus this month and is mainly an evening object. At 13th magnitude, the comet has a history of showing little, if any, coma.

Comet 62P/Tsuchinshan is a morning object this month, rising around midnight. Between 12th and 13th magnitude, the comet will be moving along the borders of Leo, Virgo, and Coma Berenices. In mid-January, Tsuchinshan will traverse the Virgo Cluster of galaxies, passing quite close to M84 and M86, and will present some challenging viewing opportunities (see diary).

Comet C/2004 Q2 (Machholz) opens the year well up in the sky, due north at the end of evening twilight, and possibly as bright as 4th–5th magnitude. It is in Taurus early in the month, passing 3° west of the Pleiades, on the 7th. It quickly moves NNW, into Perseus, as it approaches perihelion (closest to the Sun) on the 24th. Around this time it drops below the northern horizon for mid-latitude Australian observers. The comet will return to the southern skies in May.

METEOR SHOWERS

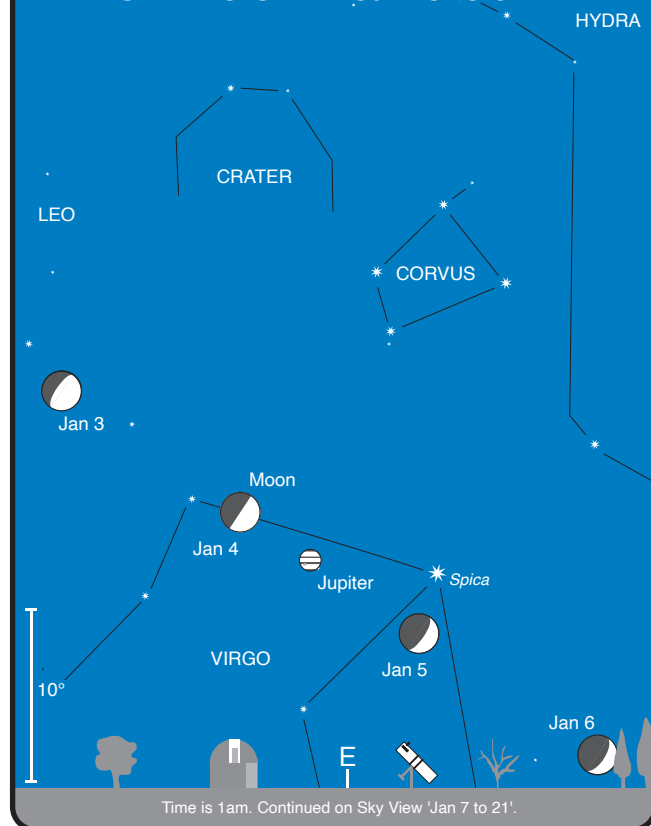
The **delta-Cancerids** are a minor meteor shower, with the radiant in Cancer above the horizon for most of the night. Typically faint, the zenith hourly rate is unlikely to rise above 3 to 4. The showers' duration is from the 1st to 24th January with maximum on the 17th. Some interference can be expected from the Moon in the evening hours.

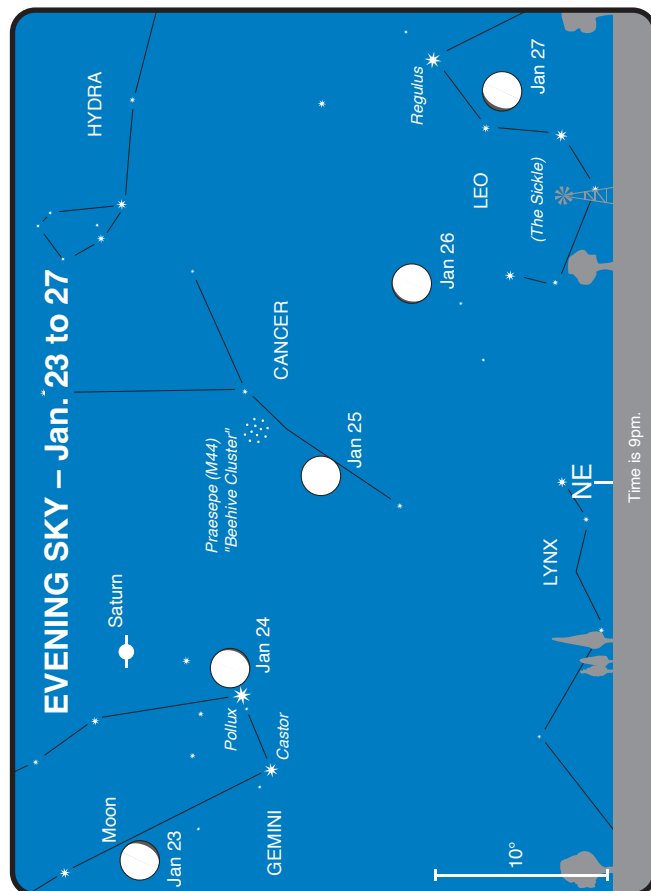
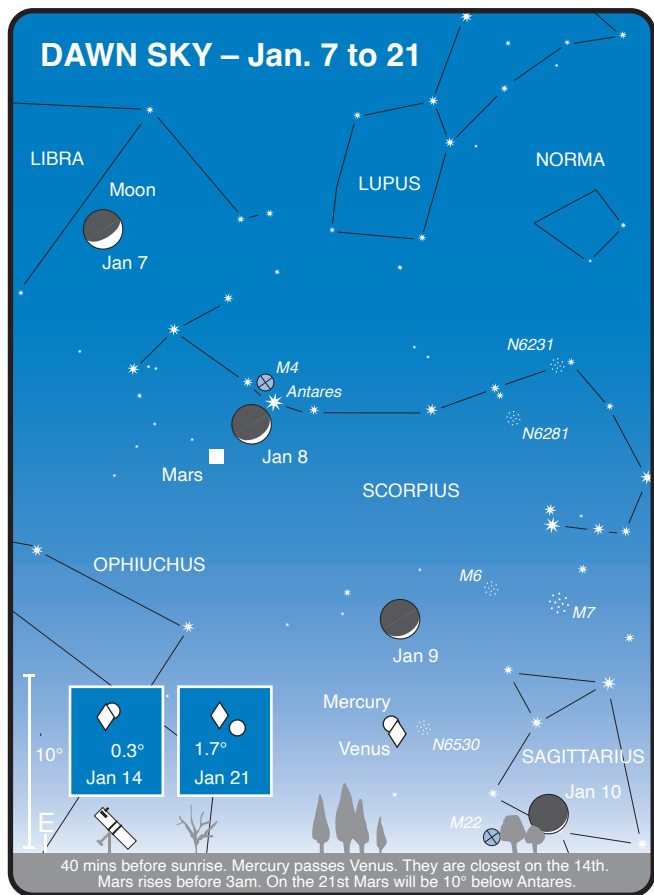
DIARY

1st		Pluto 0.4°NW of m.p. 39 Laetitia
2nd		m.p. 29 Amphitrite 1.0°SW of NGC 4691 (SG) in Virgo
2nd	11 am	(9 am WST) Earth at perihelion
4th	3:46 am	(1:46 am WST) Last Quarter Moon
4th	Noon	(10 am WST) Jupiter 0.4°N of Moon Occn.
6th	8 pm	(6 pm WST) Saturn 7°S of Pollux
7th	pm	Comet C/2004 Q2 (Machholz) 3.0°W of the Pleiades (M45) in Taurus
8th	5 am	(3 am WST) Mars 3°N of Moon
8th	6 am	(4 am WST) Antares 1.3°S of Moon Occn.
8th	7 am	(5 am WST) Mars 5°N of Antares
8th		Saturn at ascending node
8th	9 pm	(7 pm WST) Uranus 0.15°NW of m.p. 16 Psyche
9th		Mercury 0.7°SW of NGC 6469 (OC) in Sagittarius
9th		m.p. 1 Ceres 0.6°N of m.p. 14 Irene
9th	Noon	(10 am WST) Mercury 5°N of Moon
9th	1 pm	(11 am WST) Venus 5°N of Moon
10th		Venus 0.5°W of Trifid Nebula (BN) in Sagittarius
10th	8 pm	(6 pm WST) Moon at perigee
10th	10:03 pm	(8:03 pm WST) New Moon
11th	am	Comet 62P/Tsuchinshan 0.5°S of NGC 4216 (SG) in Virgo
11th		Mercury 0.2°SE of Trifid Nebula (BN) in Sagittarius
11th		Venus 0.5°W of NGC 6546 (OC) in Sagittarius
12th	am	m.p. 10 Hygiea 0.3°SW of NGC 4504 (SG) in Virgo
12th	9 am	(7 am WST) Neptune 5°N of Moon
12th		m.p. 7 Iris 0.5°S of star Delta Scorprii
12th		Mercury at descending node
13th	am	m.p. 10 Hygiea 0.3°NE of NGC 4487 (SG) in Virgo
13th	3 am	(1 am WST) Comet 62P/Tsuchinshan 0.05°S of NGC 4267 (LG) in Virgo
13th	6 pm	(4 pm WST) Uranus 4°N of Moon
14th	9 am	(7 am WST) Saturn at opposition
14th	11 am	(9 am WST) Mercury 0.3°S of Venus
15th		Mars at descending node
16th	3 am	(1 am WST) Comet 62P/Tsuchinshan 0.05°NW of M84 (EG) in Virgo
16th		Mercury 0.5°E of NGC 6642 (GC) in Sagittarius
16th		Mercury 0.6°NW of M22 (GC) in Sagittarius
16th		Venus 0.5°NE of NGC 6642 (GC) in Sagittarius
16th		Mars 0.4°SW of NGC 6235 (GC) in Ophiuchus

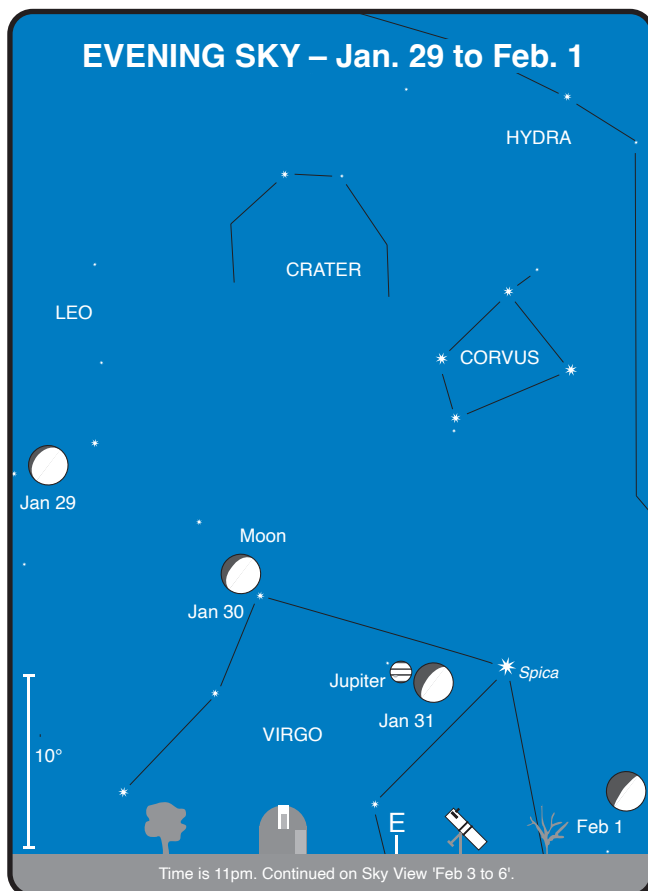
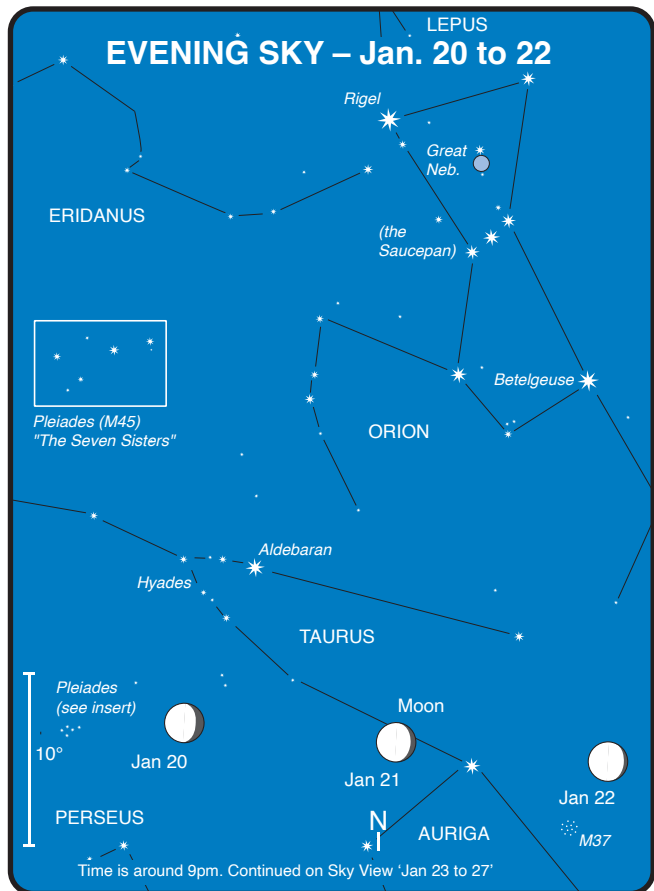
16th	pm	Comet C/2004 Q2 (Machholz) 1.5°E of star Algol
17th	3 am	(1 am WST) Comet 62P/Tsuchinshan 0.1°NE of M86 (EG) in Virgo
17th		Venus 0.9°NE of M22 (GC) in Sagittarius
17th		m.p. 18 Melpomene 0.5°SW of M107 (GC) in Ophiuchus
17th	4:57 pm	(2:57 pm WST) First Quarter Moon
18th	3 am	(1 am WST) Comet 62P/Tsuchinshan 0.1°NE of NGC 4438 (SG) in Virgo
18th		Venus at descending node
18th	pm	Saturn 0.9°S of m.p. 8 Flora
19th	am	Comet 62P/Tsuchinshan 0.3°S of NGC 4473 (EG) in Coma Berenices
19th	pm	m.p. 115 Thyra 0.3°N of NGC 2672 (EG) in Cancer
20th	am	Comet 62P/Tsuchinshan 0.9°N of M87 (EG) in Virgo
20th		Mars 0.2°SW of NGC 6287 (GC) in Ophiuchus
23rd	am	Comet 62P/Tsuchinshan 1.0°N of M89 (EG) in Virgo
23rd	am	Comet 62P/Tsuchinshan 0.9°S of M91 (SG) in Coma Berenices
23rd		Mercury at aphelion
24th	am	Comet 62P/Tsuchinshan 0.5°N of M90 (EG) in Virgo
24th	5 am	(3 am WST) Moon at apogee
24th		Mars 0.7°NW of NGC 6325 (GC) in Ophiuchus
24th		m.p. 7 Iris 0.8°S of M80 (GC) in Scorpius
24th	6 pm	(4 pm WST) Saturn 5°S of Moon
24th	pm	Comet C/2004 Q2 (Machholz) 0.5°NW of star Gamma Persei
25th		m.p. 2 Pallas 0.5°E of m.p. 10 Hygiea
25th	8:32 pm	(6:32 pm WST) Full Moon
25th	pm	Comet 49P/Arend-Rigaux 0.2°S of NGC 779 (SG) in Cetus
26th	9 pm	(7 pm WST) Saturn 0.02°SW of NGC 2420 (OC) in Gemini
26th	pm	m.p. 115 Thyra 0.8°S of Beehive Cluster M44 (OC) in Cancer
28th		Venus 1°S of m.p. 20 Massalia
29th	3 am	(1 am WST) m.p. 14 Irene 0.1°S of star Beta Librae
29th		m.p. 39 Laetitia 0.5°SW of NGC 6605 (OC) in Serpens
31st		Mars 0.4°NW of NGC 6401 (GC) in Ophiuchus
31st	9 pm	(7 pm WST) Jupiter 0.9°N of Moon Occn.
31st	pm	m.p. 532 Herculina 0.9°SW of star Pollux

MORNING SKY – Jan. 3 to 6





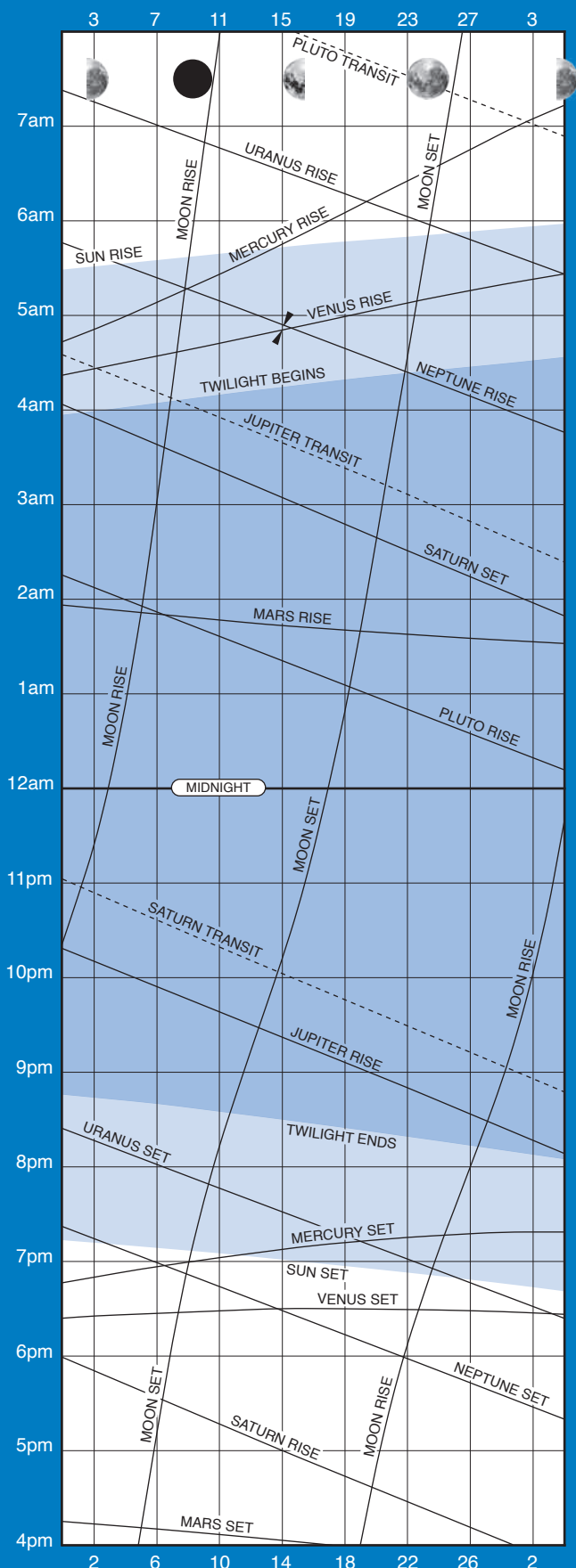
Approximate local standard time, for daylight saving add 1 hour.



FEBRUARY

FEBRUARY

RISE/SET CHART



HIGHLIGHTS

- Mars passes close to several deep sky objects in Sagittarius
- Jupiter and Moon very close (occultation in the far south of Australia)
- Saturn, just past opposition, is still excellent in small telescopes
- Comet C/2003 K4 (LINEAR) visits the Fornax group of galaxies
- Minor Planet, 2 Pallas, commences a tour of numerous galaxies in Virgo and Coma Berenices

THE MOON

- 2nd Last Quarter.
- 4th Occultation of Antares by the Moon. Visible only from parts of the northern hemisphere.
- 8th Moon at perigee (closest to Earth – 358,565 km distant, angular size 33.8').
- 9th New Moon.
- 16th First Quarter.
- 20th Moon at apogee (furthest from Earth – 405,805 km distant, angular size 29.3').
- 24th Full Moon.
- 27th Occultation of Jupiter by the Moon. Visible in the far south of Australia, see Jupiter below and the occultation tables in Part II.

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 14th

5th Feb
dia 4.79"
mag -0.9

25th Feb
dia 5.25"
mag -1.3

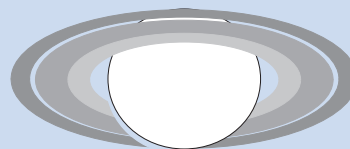
VENUS

15th Feb
dia 9.97"
mag -3.9

MARS

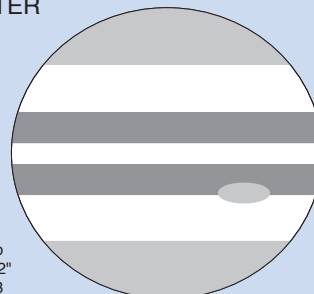
15th Feb
dia 4.85"
mag 1.3

SATURN



15th Feb
dia 20.18"
mag -0.2

JUPITER



15th Feb
dia 41.12"
mag -2.3

URANUS

15th Feb
dia 3.35"
mag 5.9

NEPTUNE

15th Feb
dia 2.20"
mag 8.0

PLUTO

15th Feb
dia 0.11"
mag 13.9

THE PLANETS

MERCURY is visible early in the month in the dawn sky. The planet then loses altitude as it moves toward the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 14th. Mercury thereafter moves east of the Sun to become an evening star for a short period from month's end to mid-March.

VENUS, like Mercury, gradually loses altitude as it moves towards superior conjunction late in March. On the 8th, the very thin crescent Moon appears above and south of the planet in the dawn sky (see Sky View). Venus will be 1° south of Neptune on the 15th, however the 8th magnitude outer planet will be lost in the morning twilight. Venus begins the month in Sagittarius, quickly moves across into Capricornus and finally into Aquarius at month's end.

MARS can be seen in the eastern morning sky, rising just before 2am, moving across the portion of Milky Way known as the Sagittarius Star Cloud. This area has an abundance of deep sky objects, and many of the southern hemisphere gems are found in this region. On the 6th, the 26-day waning crescent Moon appears just south of the Red Planet (see Sky View). On the 8th and 9th, Mars passes between two famous nebulae, the Lagoon (M8) and the Trifid (M20). Finally, an encounter with one of the best of the globular clusters, when the planet skims past the outer reaches of M22 on the 19th (also see diary for other objects).

JUPITER rises mid-evening and is visible for the rest of the night. It begins retrograde motion early in February, and will remain within 7° north of the 1st magnitude star Spica (Alpha Virginis) for the entire month. We have for many years suffered from a lack of occultations of the planets and bright stars by the Moon visible from our continent. The drought breaks this month with Jupiter on the 27th. The actual occultation is only visible from the far south of Australia, but the close approach from most other areas will be rewarding for all observers (see Sky View). Tasmania

and western Victoria across to the far south of South Australia will all see the occultation (see occultation tables in Part II for contact times for Adelaide, Melbourne, Perth and Hobart). Observers in Melbourne will see only a short occultation, with a graze nearby. From Perth the event begins below the horizon and ends with the Moon at just 3° altitude. The closest approach by Jupiter and the Moon from outside the occultation zone are detailed below for various locations, local times shown are approximate only and one hour must be added for daylight saving.

Location	Day	Time	Distance from limb	Altitude of Moon
Alice Springs	27	10:00pm CST	0° 04'	13°
Auckland	28	01:25am	0° 12'	52°
Brisbane	27	10:45pm EST	0° 07'	33°
Canberra	27	10:55pm EST	0° 02'	30°
Christchurch	28	01:30am	0° 08'	47°
Darwin	27	09:45pm CST	0° 10'	6°
Sydney	27	10:55pm EST	0° 04'	33°
Townsville	27	10:30pm EST	0° 10'	25°

SATURN transits the meridian around 10pm mid-month, visible above the stars Castor and Pollux in Gemini. Now past opposition, the planet is still well placed for observation during these warm summer evenings. On the 20th, the 11-day old Moon will be near the ringed planet (see Sky View).

URANUS is in conjunction with the Sun on the 25th, and will remain lost in the Sun's glare until its return to the morning sky mid-March.

NEPTUNE is in conjunction with the Sun on the 4th, and moves into the morning sky towards the end of February. While not observable, it is of interest to note that during this conjunction the planet is occulted by the Sun's disk. This is the 6th in a series of 8 annual Neptunian conjunctions where an occultation occurs; the next series begins in the year 2080.

WEBSITE OLYMPICS

In Australia we have some excellent astronomical websites. We would like to recognise some of these and, seeing at the time of writing the whole world seemed to be focused on Athens, we have chosen to use an Olympic theme. The judging was based on the following broad guidelines. The site had to be easy to use, reasonably attractive and up-to-date. This includes being not too slow for dialup and covering recent events with a minimum of broken links. The content was important but obviously that which was considered advantageous varied depending on the category (event). With possibly the exception of personal homepages, a common prerequisite was how well they explained their purpose, what they had to offer and did they attempt to educate the reader. Anything that was considered to have a high degree of originality was looked upon with favour.

Our distinguished er... distinguished panel of judges have indicated how difficult this task has been and no correspondence will be entered into, unless of course you agree with the decision or wish to make an 'under the table' donation with regards to future year's winners (all serious bribes will be considered). We have selected the following four categories. The websites considered were those covered under the relevant section on the Quasar Publishing site (www.quasarastronomy.com.au). Please let us know of any omissions.

PLACES OF ASTRONOMICAL INTEREST

- Gold** Melbourne Planetarium
www.museum.vic.gov.au/planetarium
- Silver** Canberra Deep Space Communication Complex (Tidbinbilla)
www.cdsc.nasa.gov/
- Bronze** Questacon (a brilliant 'Science for Kids' site)
www.questacon.edu.au/

There were twelve finalists in this category and very little separated any of them. The Melbourne Planetarium was considered very impressive with its simple and clear timetable and program details. The section explaining the universe, from the solar system out, was also effective.

COURSES AND SOURCES OF INFORMATION

- Gold** Australian Astronomy, Astronomical Society of Australia
www.astronomy.org.au/ngn/engine.php
- Silver** Starlore ching.apana.org.au/~paulc/
- Bronze** The Planetary Society – Australian Volunteers
www4.tpg.com.au/users/tps-seti/index.html

The Astronomical Society of Australia is a professional body and this web site is a well-structured links orientated site, with basic explanations. A wide cross-section of Australian websites is presented covering many diverse aspects of astronomy – all from a totally Australian perspective.

SOCIETIES

- Gold** Brisbane Astronomical Society
www.bas.asn.au
- Silver** The Astronomical Society of WA
aswa.info/
- Bronze** Astronomical Society of South Australia
www.assa.org.au/

It is an interesting split between Courses and Sources of Information and Societies. Along with useful local information about meetings and observatories, most of the Society sites also have excellent information on general and beginner astronomy. Even if they are not your local, their site is still worth a visit.

PERSONAL WEB PAGES

- Gold** Fraser Farrell
astronomy.trilobytes.com.au/scope.htm
- Silver** Steve Massey
members.optushome.com.au/ssmassey/
- Bronze** Ian Musgrave
home.mira.net/~reynella/skywatch/ssky.htm

Fraser's site is a great summary of buying your first telescope in Australia. It is a site that we have recommended to several people. He also has an accompanying site for fixing common telescope problems.

PLUTO rises around 1am in Serpens. At month's end the planet is 0.5° from the 3.5 magnitude star Xi Serpentis, a good starting point for star hopping to this distant planet.

MINOR PLANETS at opposition this month include: 52 Europa on the 2nd at magnitude 9.9 in Cancer, 69 Hesperia on the 21st at magnitude 10.4 in Sextans and 196 Philomela on the 21st at magnitude 11.0 in Leo.

February sees 2 Pallas commence a tour of numerous galaxies in Virgo and Coma Berenices. This will continue through until April (see the diary for details). Pallas will be near opposition and brighter than 8th magnitude during this time. One wonders who will be the first to report supernova Pallas!

COMETS

Comet C/2003 K4 (LINEAR) will be moving north through Fornax and Eridanus this month. The comet has some close encounters with members of the Fornax galaxy cluster (see diary). Expected to fade from 8th to 9th magnitude, LINEAR will be setting around midnight.

Comet 9P/Tempel should brighten from 13th to 12th magnitude this month. Visible late evening, comet Tempel will be slowly moving through Virgo.

Comet 49P/Arend-Rigaux, at perihelion this month, is an evening object of 13th magnitude. On 2nd February, Arend-Rigaux will be within a degree of the famous variable star Mira in Cetus.

Comet 62P/Tsuchinshan should be at 13th magnitude this month, slowly fading as it moves through Coma Berenices. The comet will be rising late evening but will be best observed when it is highest in the northern sky in the early hours of the morning.

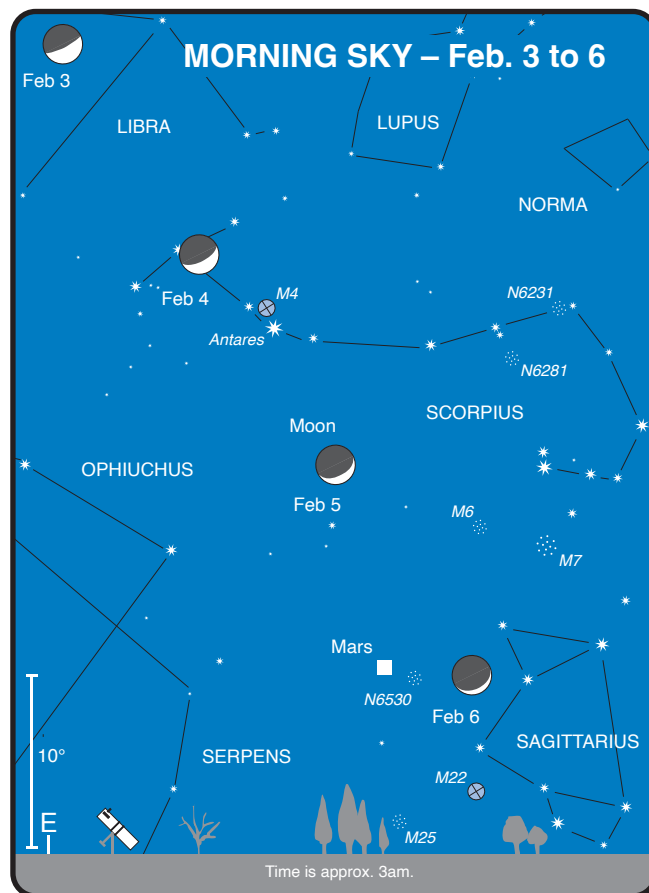
METEOR SHOWERS

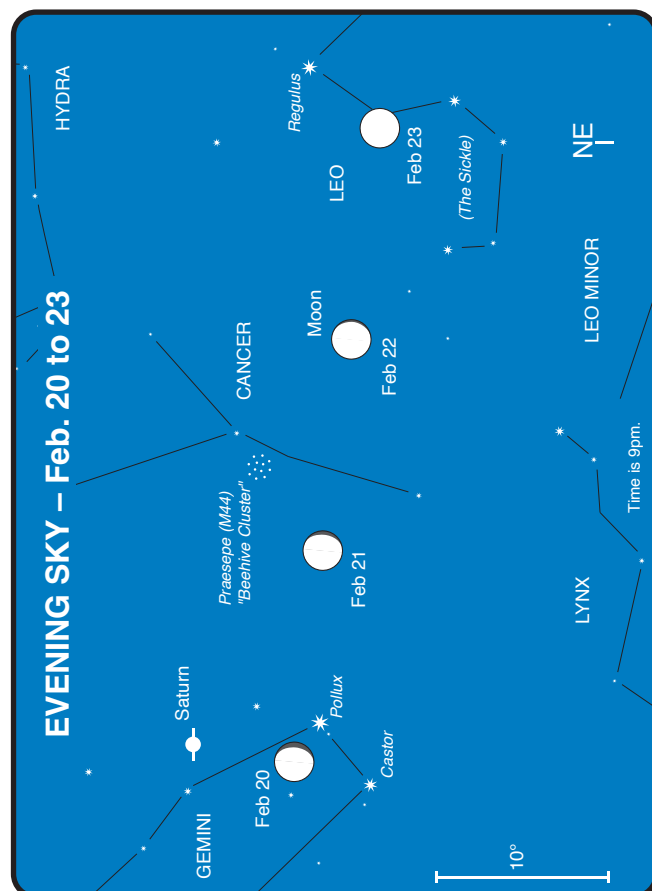
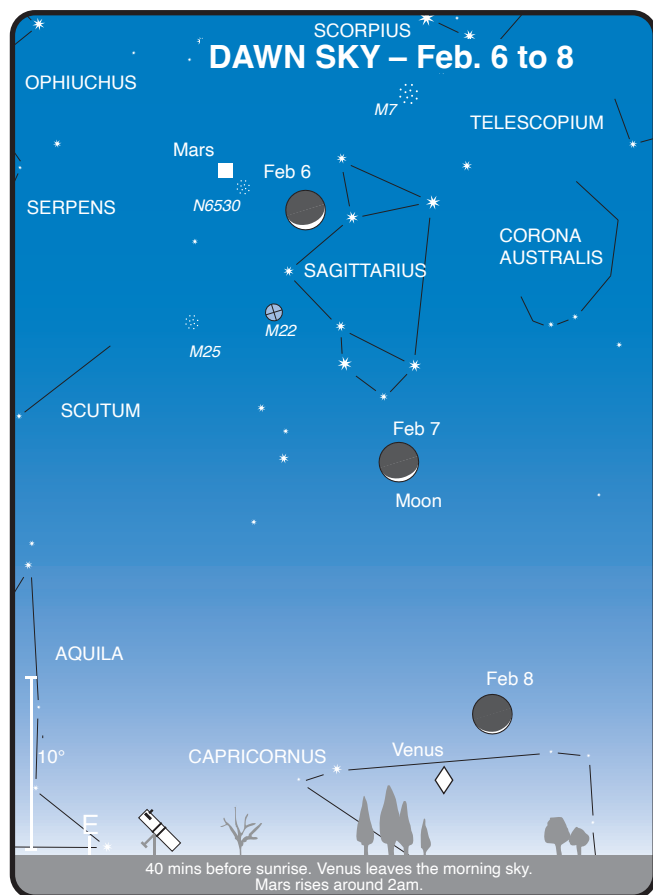
The **alpha-Centaurids** are active from 28th January through to 21st February, with maximum on the 8th. Their zenith hourly rate is unpredictable, around 5 to 10 per hour at best, but high rates sometimes occur every 4 to 6 years. Most recently, in 1974 and 1980 the rate was 20 – 30 per hour. This increase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

DIARY

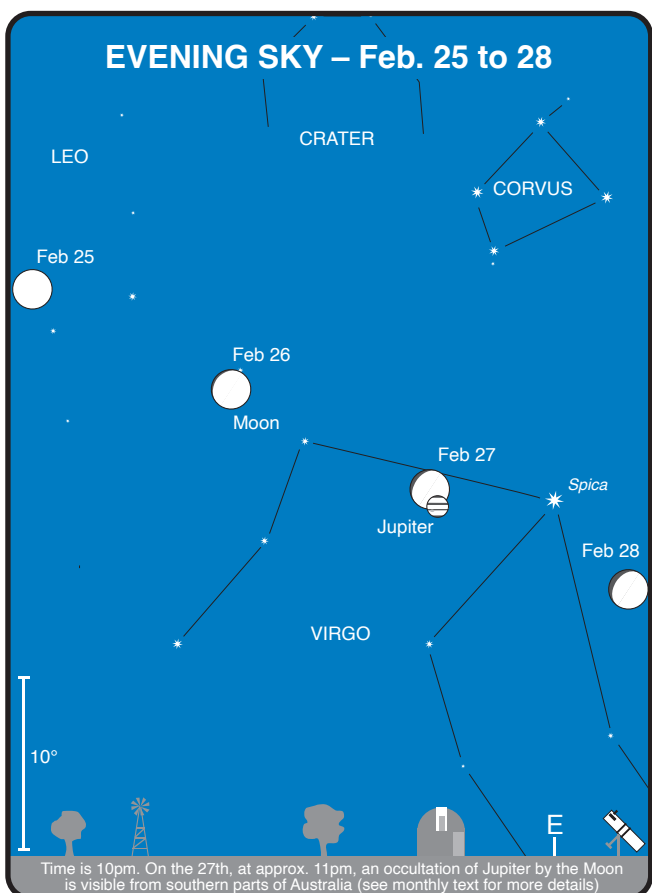
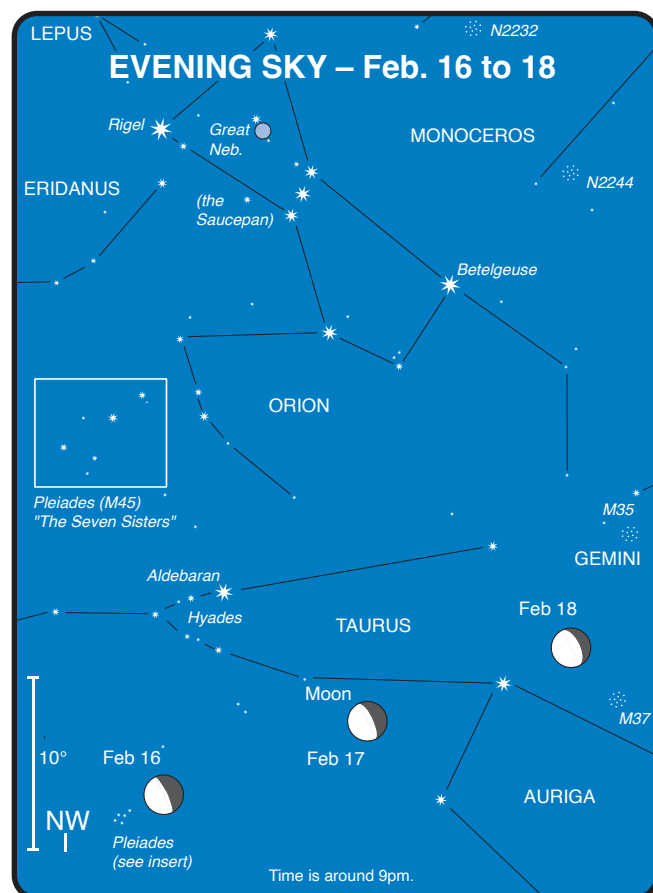
1st	am	Comet 62P/Tsuchinshan 1.0° NW of NGC 4689 (SG) in Coma Berenices
1st		m.p. 39 Laetitia 0.8° N of Omega Nebula M17 (OC BN) in Sagittarius
2nd		Venus 1° N of M75 (GC) in Sagittarius
2nd	5:27 pm	(3:27 pm WST) Last Quarter Moon
3rd	2 am	(Midnight WST, prev day) Jupiter stationary
4th	5 am	(3 am WST) Neptune in conjunction with Sun
4th	3 pm	(1 pm WST) Antares 1.1° S of Moon Occn.
5th		m.p. 42 Isis 0.6° SW of NGC 6342 (GC) in Ophiuchus
5th		Comet 49P/Arend-Rigaux 0.6° NW of NGC 936 (LG) in Cetus
5th	11 pm	(9 pm WST) Mars 4° N of Moon
6th	am	Comet 62P/Tsuchinshan 0.2° W of NGC 4710 (LG) in Coma Berenices
6th		m.p. 1 Ceres 0.6° N of star Beta Librae
6th	pm	Comet C/2003 K4 (LINEAR) 0.5° SW of NGC 1425 (SG) in Fornax
8th	8 am	(6 am WST) Moon at perigee
8th		Mars 0.4° SW of Trifid Nebula (BN) in Sagittarius
9th	8:28 am	(6:28 am WST) New Moon
9th		Mars 0.6° NE of Lagoon Nebula M8 (BN) in Sagittarius
9th	pm	m.p. 2 Pallas 1.0° W of NGC 4697 (EG) in Virgo
10th	pm	m.p. 2 Pallas 1.0° E of NGC 4593 (SG) in Virgo
12th		Mercury at greatest latitude south
13th		Comet 49P/Arend-Rigaux 0.8° SE of star Gamma Ceti
13th	pm	Comet C/2003 K4 (LINEAR) 0.9° W of NGC 1398 (SG) in Fornax
14th	5 pm	(3 pm WST) Pallas stationary
14th	9 pm	(7 pm WST) Mercury in superior conjunction
15th	5 am	(3 am WST) Venus 1.0° S of Neptune

15th		Mars 1.0° N of M28 (GC) in Sagittarius
15th	pm	Comet C/2003 K4 (LINEAR) 0.4° SW of NGC 1371 (SG) in Fornax
16th	10:16 am	(8:16 am WST) First Quarter Moon
17th		Jupiter at greatest latitude north
17th	pm	m.p. 2 Pallas 1.0° W of NGC 4691 (SG) in Virgo
18th		Mars 0.4° SE of NGC 6642 (GC) in Sagittarius
19th		Mars 0.3° N of M22 (GC) in Sagittarius
20th		m.p. 42 Isis 0.4° S of NGC 6440 (GC) in Sagittarius
20th	3 pm	(1 pm WST) Moon at apogee
20th	9 pm	(7 pm WST) Saturn 5° S of Moon
21st		m.p. 4 Vesta 1.0° SE of IC 1613 (IG) in Cetus
22nd		Venus at aphelion
23rd		m.p. 4 Vesta 0.9° NW of NGC 428 (SG) in Cetus
23rd		Comet P/1983 V1 (Hartley-IRAS) 0.7° E of NGC 45 (SG) in Cetus
23rd	pm	m.p. 2 Pallas 0.4° NE of star Gamma Virginis
24th	2:54 pm	(12:54 pm WST) Full Moon
25th	3 am	(1 am WST) Juno in conjunction with Sun
25th	5 pm	(3 pm WST) Uranus in conjunction with Sun
25th	pm	m.p. 2 Pallas 0.7° W of NGC 4666 (SG) in Virgo
28th	1 am	(11 pm WST, prev day) Jupiter 1.2° N of Moon Occn.



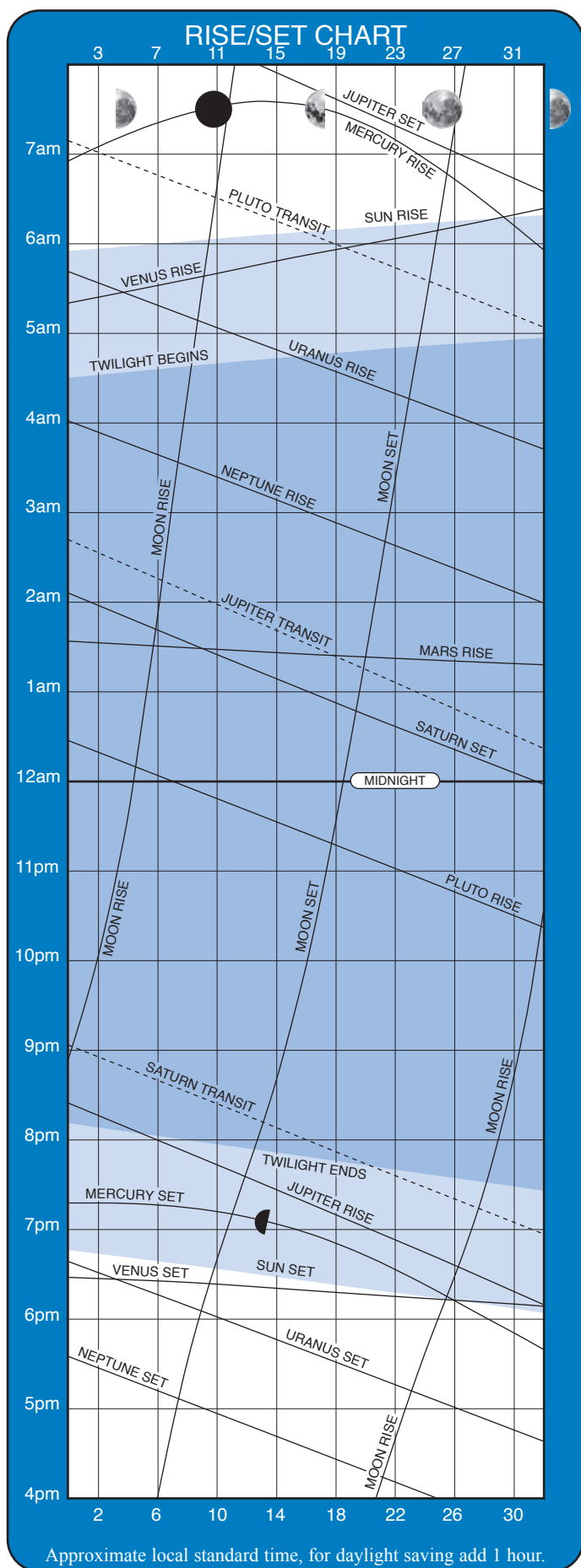


Approximate local standard time, for daylight saving add 1 hour.



MARCH

MARCH



HIGHLIGHTS

- Moon and Antares close twice this month
- Jupiter and Moon very close (occultation far south of WA)
- Jupiter nearing opposition
- Three of the brighter minor planets reach opposition this month in Virgo
- Comet C/2003 T4 (LINEAR) may be 7th magnitude in the pre-dawn sky

THE MOON

- 3rd Occultation of Antares by the Moon (not visible from Australia). However the 1st magnitude star appears just above the Last Quarter Moon as it rises late in the evening.
- 4th Last Quarter.
- 8th Moon at perigee (closest to Earth – 363,233 km distant, angular size 33.3').
- 10th New Moon.
- 18th First Quarter.
- 20th Moon at apogee (furthest from Earth – 404,847 km distant, angular size 29.1').
- 26th Full Moon.
- 27th Occultation of Jupiter by the Moon, visible from the southwest tip of Australia. See also Jupiter below.
- 31st Occultation of Antares by the Moon for the second time this month (not visible from Australia). Pre-dawn observers will see the star approximately 1° from the lunar limb.

THE PLANETS

MERCURY emerged from superior conjunction mid-February to appear in the evening twilight sky. The planet's greatest elongation east of

APPEARANCE of the PLANETS

MERCURY

Mercury is in inferior conjunction on the 30th



5th Mar
dia 6.00"
mag -1.0



13th Mar
Greatest elongation east
dia 7.21"
mag -0.4

VENUS

15th Mar
dia 9.73"
mag -3.9



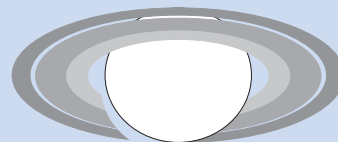
Venus is in superior conjunction on the 31st

MARS

15th Mar
dia 5.43"
mag 1.1

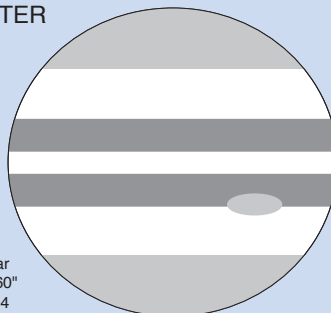


SATURN



15th Mar
dia 19.36"
mag 0.0

JUPITER



15th Mar
dia 43.60"
mag -2.4

URANUS

15th Mar
dia 3.35"
mag 5.9



NEPTUNE

15th Mar
dia 2.21"
mag 8.0



PLUTO

15th Mar
dia 0.11"
mag 13.9



the Sun (18°) occurs on the 13th. This is not a particularly favourable elongation, with the planet in the western twilight sky, setting less than three-quarters of an hour after the Sun (see Sky View). This short apparition ends with the planet again moving toward the Sun and inferior conjunction (between Earth and Sun) on the 30th.

VENUS is in superior conjunction on the 31st (Venus and Earth on opposite sides of the Sun). From early this month the planet will be too close to the Sun for observation. In May, Venus returns to grace the evening skies until late December.

The **EARTH** is at its autumnal equinox on the 20th. The Sun rises and sets due east and west and day and night are equal.

MARS leaves the Sagittarius Star Cloud and enters Capricornus mid-month. A morning object until September, it then moves into the evening sky and is at opposition in early November. Readers will recall the outstanding 2003 opposition when the planet attained an angular diameter of 25 arc seconds. On this coming apparition, the planet reaches 20 arc seconds, still a reasonable size for quality views of the Red Planet. After this, the oppositions (every 26 months) are not as good. The worst occurs in 2012 (diameter 14"), then things slowly improve until 2018 when the planet returns to a respectable 24.5".

JUPITER is at opposition early next month, and very noticeable rising in the eastern sky after the end of astronomical twilight, just north of 1st magnitude Spica (Alpha Virginis). An occultation of Jupiter by the Moon is visible in the evening of the 26th from the south west tip of Australia;

details for Perth observers are provided in the Lunar Occultation Tables in Part II. From the rest of Australia, the planet and the Moon appear very close (see Sky View). The closest approach from various locations are detailed below, local times shown are only approximate and one hour must be added for daylight saving.

Location	Time	Distance from limb
Adelaide	00:20am CST (27th)	$0^\circ 10'$
Brisbane	01:15am EST (27th)	$0^\circ 23'$
Canberra	01:20am EST (27th)	$0^\circ 15'$
Darwin	11:35pm CST (26th)	$0^\circ 18'$
Hobart	01:25am EST (27th)	$0^\circ 09'$
Melbourne	01:15am EST (27th)	$0^\circ 11'$
Sydney	01:25am EST (27th)	$0^\circ 18'$

SATURN can be seen in the northern sky in the early evening. Since late last year the ringed planet has been in retrograde motion, lingering nearby the Gemini Twins, Castor and Pollux. At month's end the planet reverses direction and moves away from the twins, crossing into the constellation of Cancer in July, where it meanders until August 2006. On the 19th, the 9-day old Moon will be seen below Saturn forming an irregular quadrilateral figure with Castor and Pollux (see Sky View).

URANUS, in Aquarius, is visible in the second half of March, rising in the east just before dawn begins.

NEPTUNE, in Capricornus, is visible in the eastern morning sky (rising around 3am mid-month) 20° above Uranus.

FINDING THE SOUTH CELESTIAL POLE

In the northern hemisphere, to find approximate north celestial pole (NCP) is relatively easy. It is located within the constellation of Ursa Minor and fortunately the 2nd magnitude star Polaris lies within 1° of the pole.

Down under, the south celestial pole (SCP) is located within the constellation of Octans, and the 5.5 magnitude Sigma Octans is the nearest visible star to the pole (about 1° away). It is not exactly a beacon that one would recognise, and impossible to see under suburban skies, unlike its northern hemisphere counterpart.

The celestial poles are an extension of the Earth's polar axis projected onto the celestial sphere; it is around these two points that the daily rotation of the 'star-dome' takes place. At any given location on the Earth the height of the celestial pole above the horizon is equal to your latitude. If you are at latitude 35°S for instance, the south celestial pole will be 35° above the southern horizon, on the other hand the north celestial pole will be depressed below the northern horizon by the same amount. Any stars within 35° of the SCP will never set for an observer and similarly all stars within 35° of the NCP will never rise. These stars that never set are known as circumpolar, which simply means *around the pole*. The further south you travel the higher the south celestial pole becomes, with more and more stars becoming circumpolar.

To extend the length of time that an object remains in the field of view of a telescope that is equatorially mounted and

motor driven, the telescope must be set up with the polar axis pointing reasonably accurately towards the SCP. To find the pole the following methods provide a good approximation for visual observing but are not suitable for long exposure astrophotography.

Some difficulty may be experienced from the northern regions of Australia, where our reference stars are not circumpolar and at times will dip below the horizon. If this is the case or if the south view is partially blocked by trees or buildings you may need to use more than one method, depending on the placement of the reference stars at the time of observation.

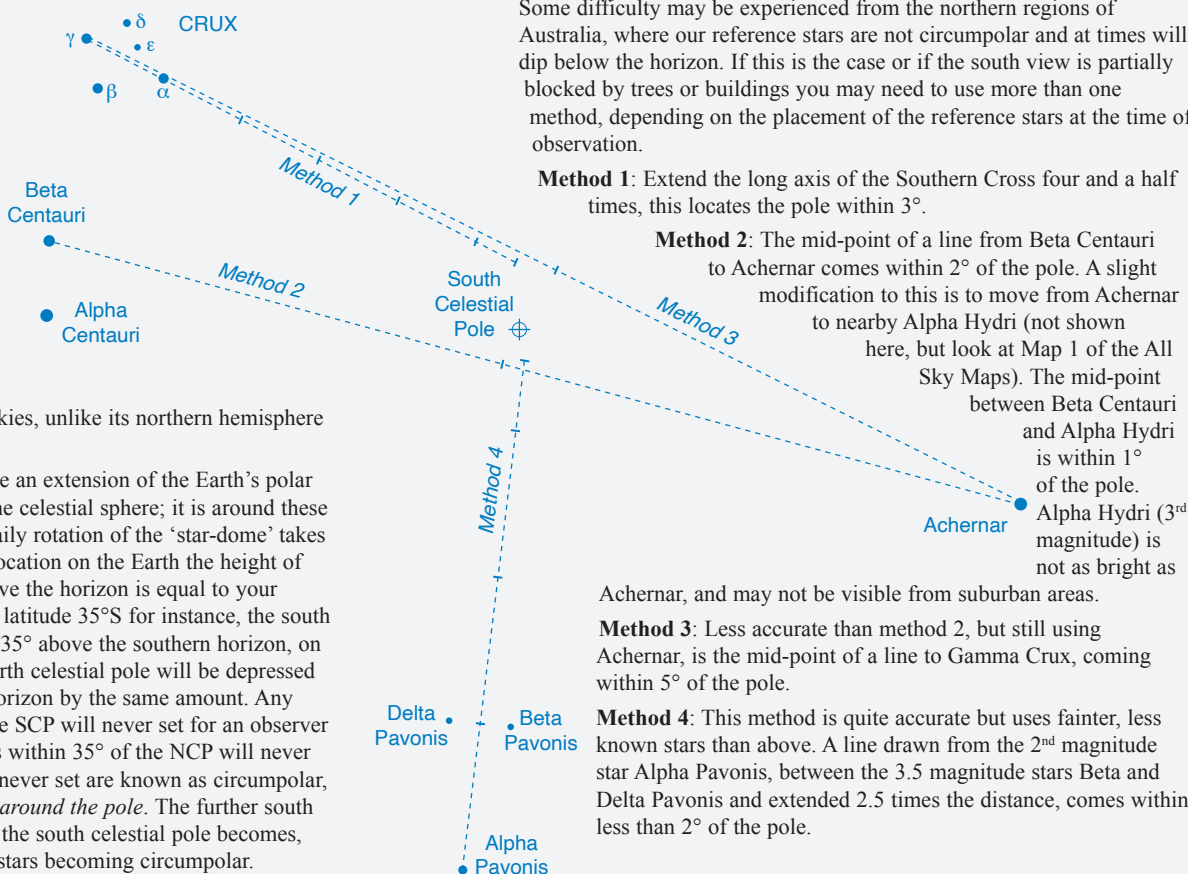
Method 1: Extend the long axis of the Southern Cross four and a half times, this locates the pole within 3° .

Method 2: The mid-point of a line from Beta Centauri to Achernar comes within 2° of the pole. A slight modification to this is to move from Achernar to nearby Alpha Hydri (not shown here, but look at Map 1 of the All Sky Maps). The mid-point between Beta Centauri and Alpha Hydri is within 1° of the pole. Alpha Hydri (3rd magnitude) is not as bright as

Achernar, and may not be visible from suburban areas.

Method 3: Less accurate than method 2, but still using Achernar, is the mid-point of a line to Gamma Crux, coming within 5° of the pole.

Method 4: This method is quite accurate but uses fainter, less known stars than above. A line drawn from the 2nd magnitude star Alpha Pavonis, between the 3.5 magnitude stars Beta and Delta Pavonis and extended 2.5 times the distance, comes within less than 2° of the pole.



PLUTO rises before midnight in Serpens. Pluto is stationary on the 27th and it is around this time and the preceding couple of weeks that this distant planet makes its closest approach to the 3.5 magnitude star Xi Serpentis. Being only 0.3° to the northwest of Xi, makes it relatively easy to find Pluto. Having our finder chart (see Part II), an adequate telescope (20cm or larger) and dark skies will help.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Virgo. They are: 2 Pallas on the 23rd at magnitude 7.1, 10 Hygiea on the 27th at magnitude 9.3 and 29 Amphitrite on the 30th at magnitude 9.2. 13 Egeria also reaches opposition on the 9th at magnitude 10.1 near the border of Leo and Coma Berenices.

29 Amphitrite commences a tour of a number of galaxies in Virgo this month. It continues in July and August.

COMETS

Comet C/2003 K4 (LINEAR) is likely to fade from 9th to 10th magnitude this month. Best observed early in the evening, LINEAR is moving north through Eridanus.

Comet C/2003 T4 (LINEAR) should be sighted in the morning sky this month. Predicted to be 7th magnitude in brightness, the comet will be moving through Delphinus, Equuleus, Aquarius, and Capricornus. On the 23rd, LINEAR will be approximately 3 degrees from the globular cluster M2.

Comet 9P/Tempel can be found in Virgo this month, near the border with Coma Berenices. Expected to brighten from 12th to 11th magnitude, Tempel will be visible for most of the night.

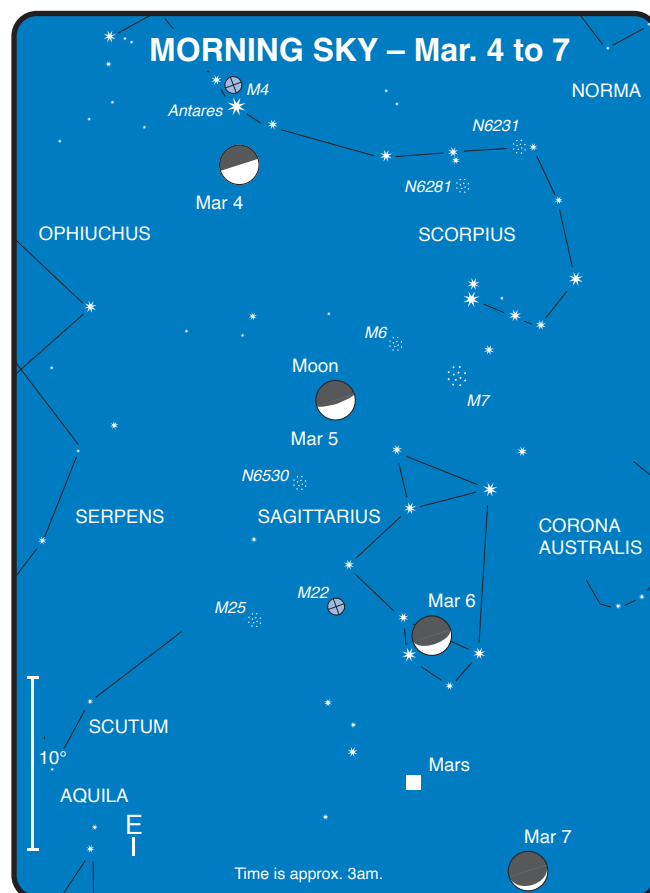
METEOR SHOWERS

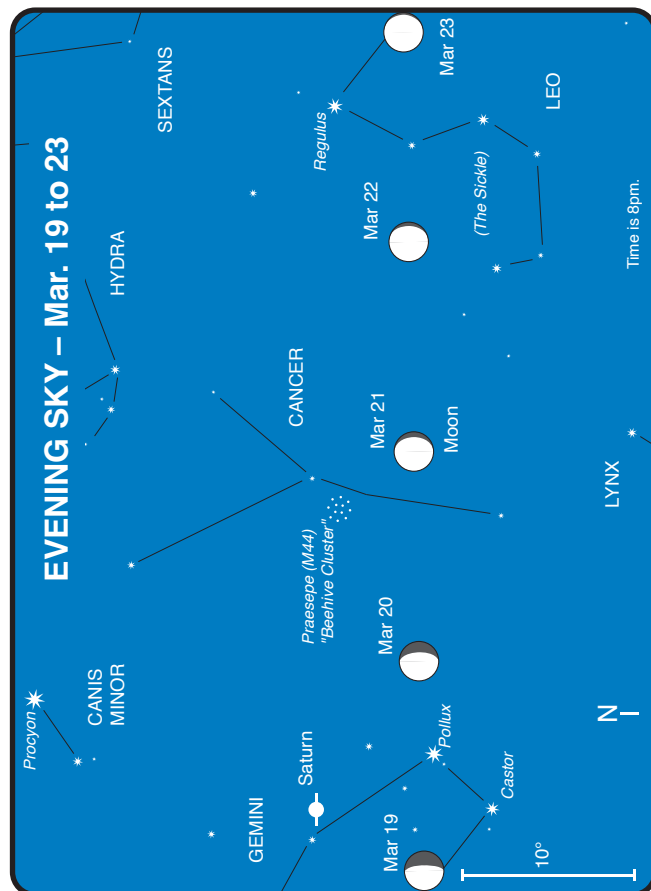
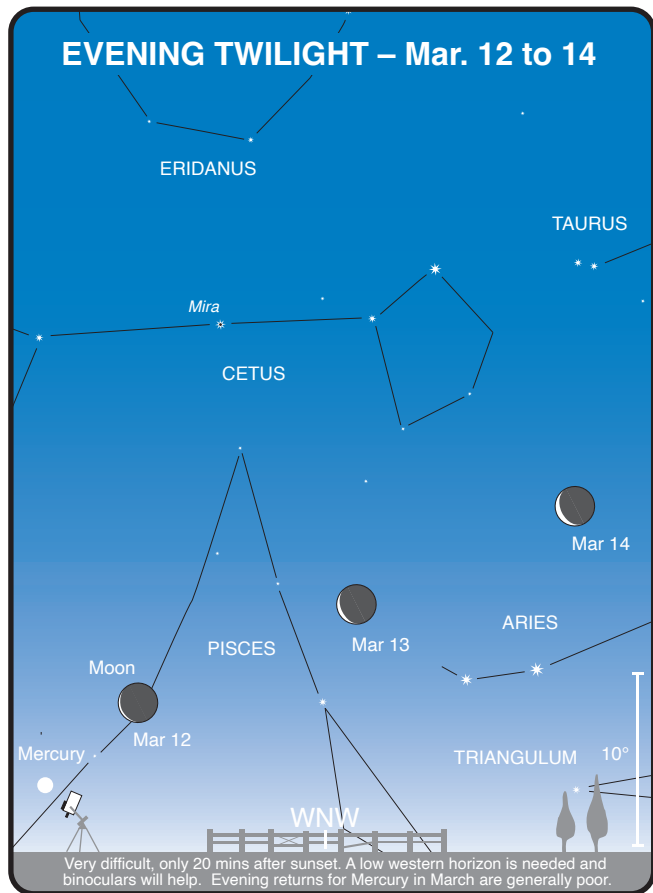
The **gamma-Normids** are active between 25th February and 22nd March. For most of this period, the rate is low, and members are difficult to sort out from the background sporadic activity. The peak occurs on March 13, when rates can reach 3 to 8 per hour. Generally, the gamma-Normids are bright and chiefly yellow, white or orange with about 15% leaving trains. Since the constellation Norma rises late in the evening, the shower is best viewed after midnight when the radiant reaches a reasonable altitude.

DIARY

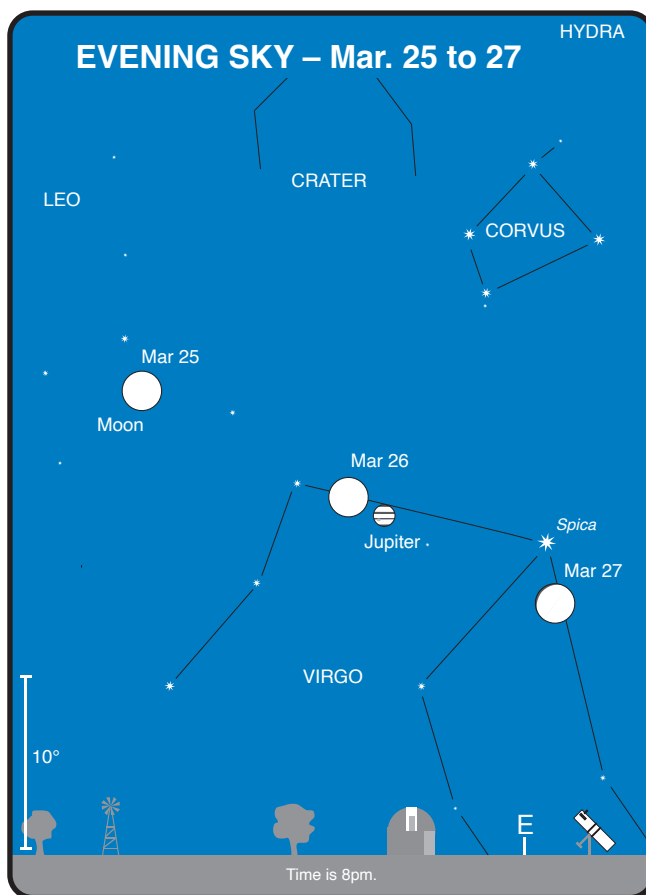
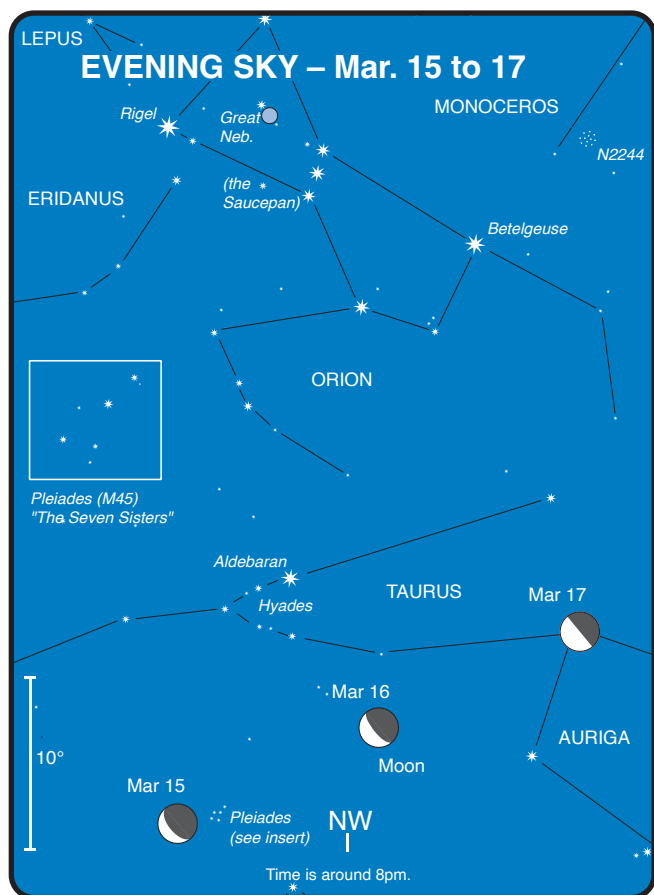
1st	Comet 78P/Gehrels 0.1°S of star Gamma Tauri
3rd	Mercury at ascending node
3rd 9 pm	(7 pm WST) Antares 0.8°S of Moon Occn.
3rd pm	m.p. 2 Pallas 0.8°W of NGC 4643 (SG) in Virgo
4th 3:36 am	(1:36 am WST) Last Quarter Moon
4th	m.p. 42 Isis 0.6°N of NGC 6568 (OC) in Sagittarius
5th pm	m.p. 2 Pallas 0.9°SW of NGC 4636 (EG) in Virgo
5th pm	m.p. 29 Amphitrite 0.5°S of NGC 4775 (SG) in Virgo
6th	Comet 78P/Gehrels 0.2°W of star Theta 2 Tauri
6th 4 pm	(2 pm WST) Mars 5°N of Moon
7th pm	m.p. 2 Pallas 1.0°NE of NGC 4527 (SG) in Virgo
8th am	m.p. 7 Iris 0.3°S of NGC 6284 (GC) in Ophiuchus
8th 10 am	(8 am WST) Neptune 5°N of Moon
8th	Mercury at perihelion
8th 2 pm	(Noon WST) Moon at perigee
10th 7:10 pm	(5:10 pm WST) New Moon
10th pm	m.p. 29 Amphitrite 0.6°SW of NGC 4731 (SG) in Virgo
11th	Comet 78P/Gehrels 0.3°S of star Aldebaran
12th 2 am	(Midnight WST, prev day) Mercury 3°N of Moon
13th 4 am	(2 am WST) Mercury greatest elongation east (18°)
16th	Venus at greatest latitude south
17th	Comet 49P/Arend-Rigaux 0.8°SE of star Delta 1 Tauri
18th 5:19 am	(3:19 am WST) First Quarter Moon
18th	Mercury at greatest latitude north
18th pm	m.p. 2 Pallas 0.7°W of NGC 4526 (LG) in Virgo
19th	m.p. 4 Vesta 0.2°W of NGC 676 (SG) in Pisces
19th pm	m.p. 2 Pallas 0.2°SE of M49 (EG) in Virgo
20th 2 am	(Midnight WST, prev day) Mercury stationary
20th 2 am	(Midnight WST, prev day) Saturn 5°S of Moon
20th 9 am	(7 am WST) Moon at apogee
20th	Mars 0.7°N of M75 (GC) in Sagittarius
20th 11 pm	(9 pm WST) Equinox
22nd 6 am	(4 am WST) Ceres stationary
22nd 10 am	(8 am WST) Saturn stationary
23rd	Pluto 0.3°NW of star Xi Serpentis
23rd	Comet 49P/Arend-Rigaux 0.8°NW of NGC 1647 (OC) in Taurus
23rd 5 pm	(3 pm WST) Pallas at opposition

24th pm	m.p. 2 Pallas 0.3°W of NGC 4442 (LG) in Virgo
24th pm	m.p. 29 Amphitrite 1.0°SW of NGC 4593 (SG) in Virgo
26th 6:58 am	(4:58 am WST) Full Moon
26th	m.p. 532 Herculina 0.9°S of star Castor
26th	Comet C/2003 T4 (LINEAR) 1.0°NE of star Beta Aquarii
27th 2 am	(Midnight WST, prev day) Jupiter 1.0°N of Moon Occn.
27th 6 pm	(4 pm WST) Pluto stationary
27th pm	m.p. 2 Pallas 0.7°W of NGC 4429 (LG) in Virgo
29th am	m.p. 42 Isis 0.2°S of star Xi 2 Sagittarii
29th	Neptune 0.7°SE of m.p. 20 Massalia
29th pm	m.p. 2 Pallas 0.4°SW of NGC 4371 (LG) in Virgo
30th 2 am	(Midnight WST, prev day) Mercury in inferior conjunction
31st 3 am	(1 am WST) Antares 0.7°S of Moon Occn.
31st 1 pm	(11 am WST) Venus in superior conjunction



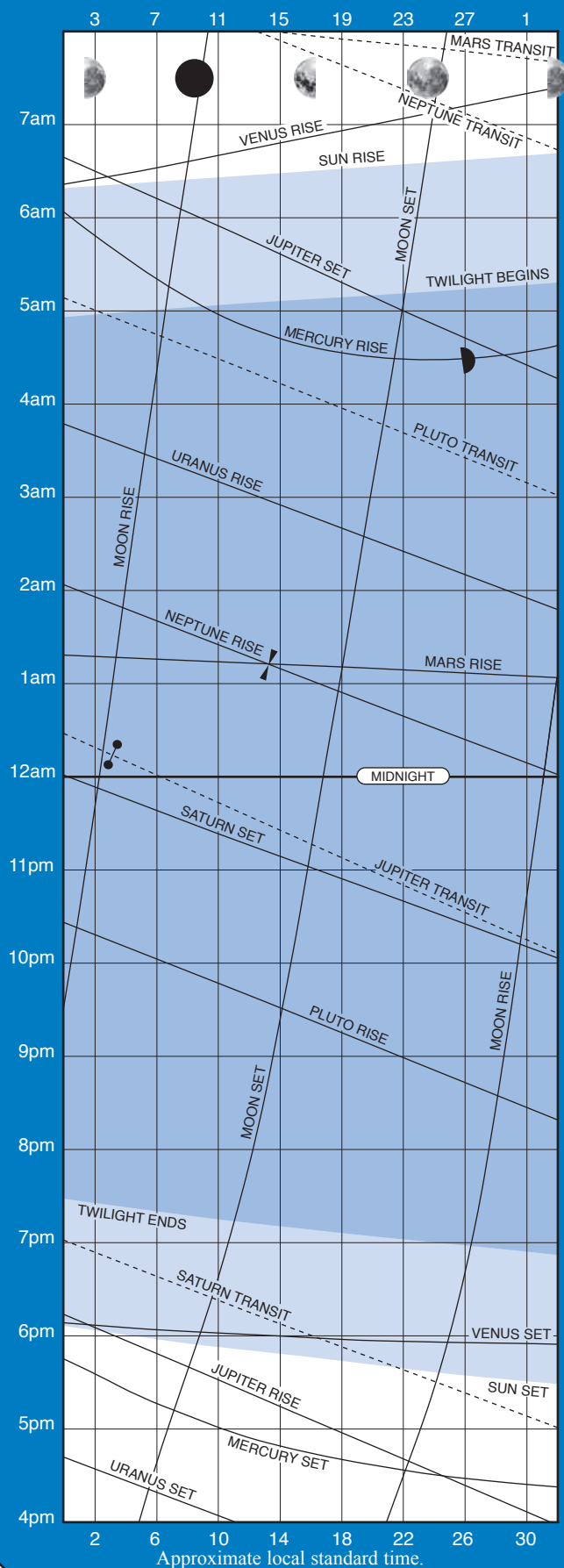


Approximate local standard time, for daylight saving add 1 hour.



APRIL

RISE/SET CHART



HIGHLIGHTS

- Mercury at best in morning sky
- Mars and Neptune have a close encounter
- Penumbral lunar eclipse for Australia's east coast and New Zealand, see Part II
- Jupiter at opposition
- Comet C/2003 T4 (LINEAR) at maximum brightness (6th magnitude) is well placed in the pre-dawn sky

THE MOON

- 2nd Last Quarter.
- 4th Moon at perigee (closest to Earth – 368,492 km distant, angular size 32.1').
- 9th New Moon. Eclipse, annular/total solar (a rare eclipse), not visible from Australia – see opposite and Part II.
- 17th First Quarter.
- 17th Moon at apogee (furthest from Earth – 404,304 km distant, angular size 29.1').
- 23rd Occultation of Jupiter by the Moon (not visible from Australia).
- 24th Full Moon (eclipse, penumbral lunar, visible from New Zealand and east coast of Australia - see Part II).
- 27th Occultation of Antares by the Moon (not visible from Australia).
- 29th Moon at perigee (closest to Earth – 369,029 km distant, angular size 32.3').

APPEARANCE of the PLANETS

MERCURY



15th Apr
dia 9.87"
mag 1.2



27th Apr
Greatest elongation west
dia 7.93"
mag 0.4

VENUS

15th Apr
dia 9.69"
mag -3.9



MARS

15th Apr
dia 6.25"
mag 0.8

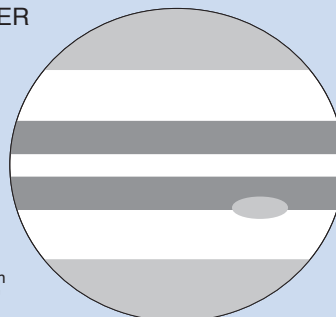


SATURN



15th Apr
dia 18.29"
mag 0.1

JUPITER



4th Apr
Opposition
dia 44.24"
mag -2.5

URANUS

15th Apr
dia 3.40"
mag 5.9



NEPTUNE

15th Apr
dia 2.24"
mag 7.9



PLUTO

15th Apr
dia 0.11"
mag 13.9



THE PLANETS

MERCURY moves to the west of the Sun and into the dawn sky early in the month. This return marks the beginning of the best period to observe the planet in the morning sky this year. From mid-April to mid-May Mercury rises two hours ahead of the Sun providing ample opportunity to view this sometimes elusive planet. Mercury reaches its greatest elongation west of the Sun (27°) on the 27th. On the 8th, Mercury appears above and north of the delicate and slender crescent of a 1-day old Moon. To some extent this is a difficult observation in the late dawn sky, but it's not impossible and worth the effort (see Sky View).

VENUS remains close to the Sun and sets very soon after sunset, making observation impossible during April. The planet will be better placed late next month in the western twilight sky.

MARS in Capricornus rises a little after 1am in the eastern morning sky. On the 4th, the waning crescent Moon is situated close to the planet (see Sky View). Moving through the constellation Mars encounters another temporary resident on the 13th (albeit a longer term one), when it appears 1.2° south of Neptune. Near month's end, Mars moves into Aquarius joining Uranus.

JUPITER is at opposition on the 4th, and very noticeable in the east as the sky begins to darken after sunset. With Jupiter reaching aphelion (the most distant point in its orbit from the Sun) on the 14th April, this opposition is not the most favourable. The diameter of the planet's disc reaches 44 arc seconds this month, compared with 50 arc seconds when Jupiter is at perihelion (closest to the Sun). Jupiter's distance from the Sun from perihelion to aphelion varies by around 0.5 a.u., equivalent to half the average distance from the Earth to the Sun. The next perihelic opposition occurs in five years time in 2010. Unlike Mars, there are really no bad or good oppositions of Jupiter, as its large angular size ensures even the smallest of telescopes can glimpse the cloud bands, polar flattening and Moons at any time. On the 22nd, the almost Full Moon will be just north of Jupiter (see Sky View).

SATURN transits the meridian at sunset. This month, and next, are the last opportunities for telescopic observation before too much altitude is lost. On the 16th, the First Quarter Moon is very close to the 1st magnitude star Pollux and below Saturn (see Sky View).

URANUS passes an uneventful month in the morning eastern sky, rising around 3am mid-month.

AN UNUSUAL ECLIPSE

A solar eclipse occurs when the Moon comes between the Earth and the Sun. For any given location on the Earth where the eclipse is visible it can be a partial, total or annular eclipse. On rare occasions when the circumstances are just right, you can also have a combined annular-total eclipse. These unusual hybrid eclipses vary in frequency, from one or two per century up to about twenty-five. From 2001 through to 2100 there are a total of 224 solar eclipses of all kinds, and just seven of these are annular-totals.

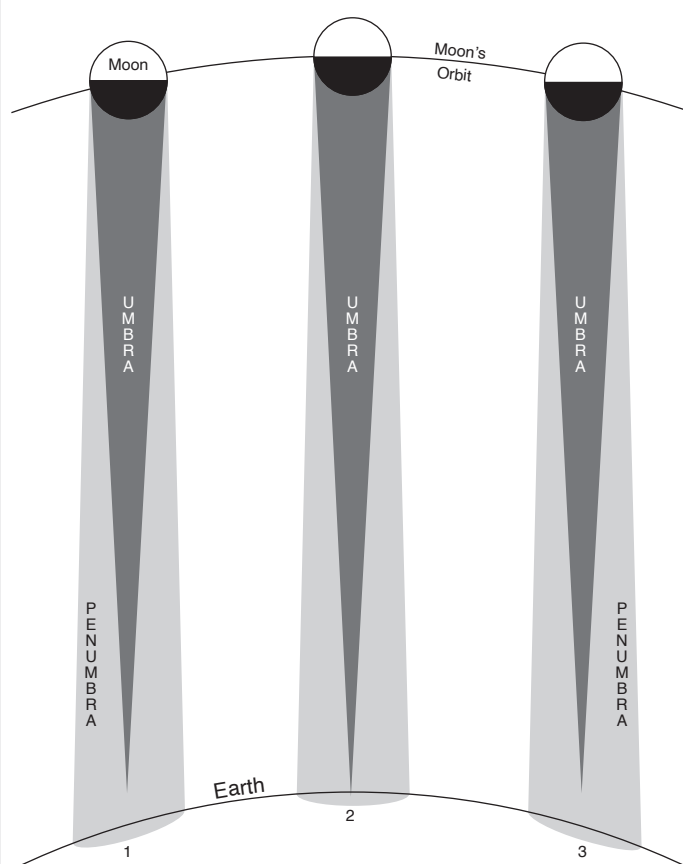
Neither the Sun nor the Moon is at a fixed distance from the Earth, and during the course of the month or year their angular size varies slightly. If a central eclipse occurs when the Moon is close to Earth, the Moon will appear larger than the Sun, and the Moon's umbral shadow will reach the Earth; observers under the umbral shadow will see a total eclipse, while those outside this zone will see a partial eclipse. On the other hand, when the Moon is a long way from Earth, and its angular diameter appears smaller than the Sun, we will experience an annular eclipse; the tip of the umbral shadow does not quite reach the Earth and a ring of sunlight will be seen surrounding the Moon.

When both the Sun and Moon are very close to the same size, it is possible for an eclipse to begin as an annular type, with the apex of the shadow cone above the Earth's surface. As the annular eclipse progresses the cone can graze land (or water) due to the curvature of the Earth, creating a period of totality. A return to the annular phase then occurs as the umbra again comes to a focus in the atmosphere as the land drops away.

This month, the first eclipse of the year is an annular-total type, the first of its kind since March 1986; the next occurs in May 2013. The path of this eclipse is for the most part over ocean, and not visible from Australia. The annular phase begins when the penumbral shadow meets the Earth southeast of New Zealand. Totality occurs half way across the Pacific when the umbral tip of the shadow cone reaches Earth. The maximum duration of total eclipse is 42 seconds, with the path width a narrow 27 km. Reverting to an annular eclipse, the first land is encountered when the path reaches Central America at Costa Rica; it then crosses Panama and Colombia, ending at sunset in Venezuela.

The most remarkable thing about eclipses is that we are very fortunate to have them. The Moon is unique: no other planet in the Solar System has a satellite that matches the angular size of the Sun so closely. The Sun's diameter is about 400 times that of the Moon, but since the Sun is about 400 times further away their diameters match neatly. We are indeed fortunate to be able to stand under the shadow of the Moon, and witness one of nature's most spectacular events.

AN ANNULAR-TOTAL SOLAR ECLIPSE



- 1 & 3 The apex of the umbral shadow cone does not reach the Earth. Observers directly under the umbra will see a bright ring or annulus of sunlight around the Moon, a partial eclipse is visible elsewhere under the penumbra.
- 2 Because of the Earth's curvature the tip of umbral shadow makes contact and the eclipse becomes total. Again a partial eclipse is visible elsewhere under the penumbra.

NEPTUNE, rising around 1am mid-month, is paid a visit by Mars on the 13th (see Mars).

PLUTO, approaching opposition in June, rises in the mid-evening eastern sky.

MINOR PLANETS at opposition this month include: 6 Hebe on the 13th at magnitude 9.9 in Bootes, 433 Eros on the 16th at magnitude 10.7 in Centaurus and 15 Eunomia on the 30th at magnitude 9.8 in Centaurus.

COMETS

Comet C/2003 K4 (LINEAR) sets early in the evening this month as it fades from 10th to 11th magnitude. Moving northeast through Eridanus, LINEAR will pass close to Delta Eridani on 8th April.

Comet C/2003 T4 (LINEAR) is expected to peak in brightness this month at 6th magnitude as it reaches both perihelion and perigee. Moving southeast through Aquarius and Sculptor, LINEAR will be best observed before the beginning of morning astronomical twilight.

Comet 9P/Tempel is visible most of the night. It continues to move through Virgo this month, near the Virgo Cluster of galaxies. By month's end, when the comet should have brightened to 10th magnitude, it will be just over a degree from Epsilon Virginis.

Comet 21P/Giacobini-Zinner should brighten to 13th magnitude this month as it moves through Equuleus and Pegasus in the late morning sky. It passes quite close to the 6th magnitude globular cluster M15 on 11th April.

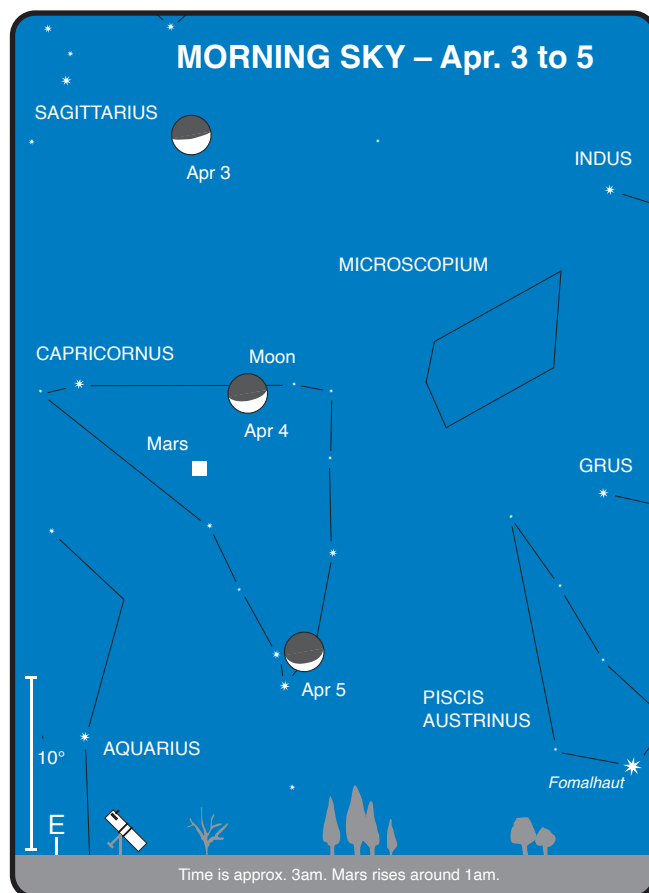
Comet 37P/Forbes will spend several months in the constellation of Lupus as it slowly brightens. April sees Forbes brighten to 13th magnitude and visible for most of the night.

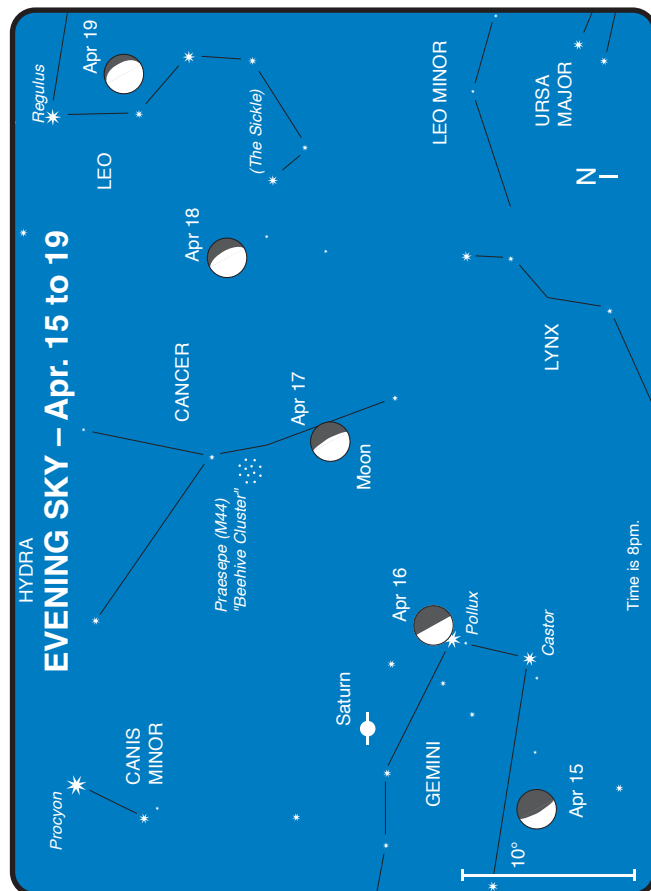
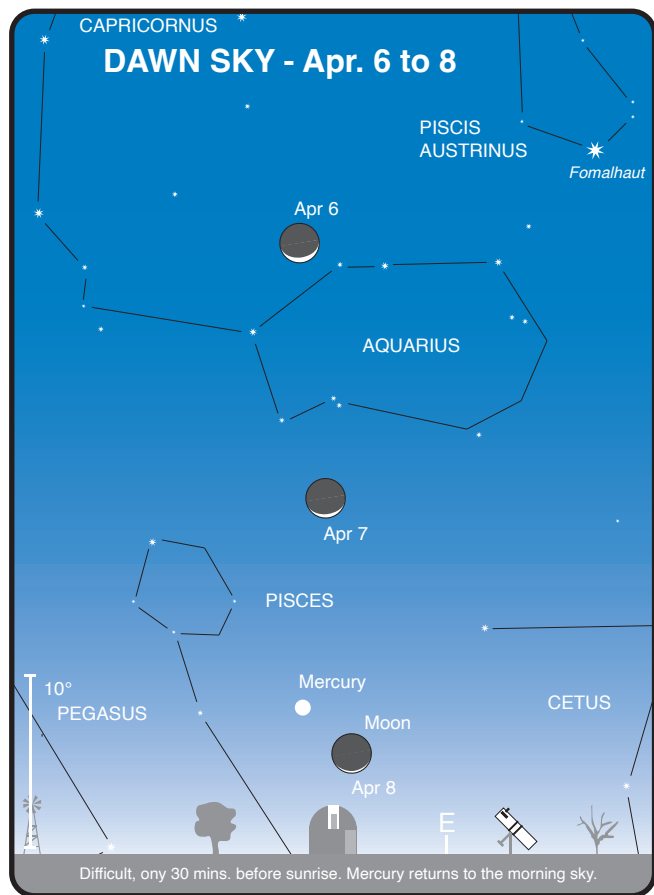
DIARY

2nd	10:50 am	(8:50 am WST) Last Quarter Moon
2nd	11 pm	(9 pm WST) m.p. 2 Pallas 0.2°NE of NGC 4267 (LG) in Virgo
4th	2 am	(Midnight WST, prev day) Jupiter at opposition
4th	8 am	(6 am WST) Mars 4°N of Moon
4th	7 pm	(5 pm WST) Neptune 5°N of Moon
4th	9 pm	(7 pm WST) Moon at perigee
4th	pm	m.p. 2 Pallas 0.9°NE of NGC 4216 (SG) in Virgo
5th	am	m.p. 42 Isis 0.3°S of star Pi Sagittarii
6th	8 am	(6 am WST) Uranus 3°N of Moon
6th	pm	m.p. 2 Pallas 0.6°NE of NGC 4212 (SG) in Virgo
6th	pm	m.p. 2 Pallas 0.3°SW of M99 (SG) in Coma Berenices
7th	Midnight	(10 pm WST) Mercury 3°N of Moon
9th	6:32 am	(4:32 am WST) New Moon; Eclipse
10th		Mercury at descending node
10th	pm	m.p. 2 Pallas 0.6°NE of M98 (SG) in Coma Berenices
11th	Noon	(10 am WST) Mercury stationary
13th	10 am	(8 am WST) Mars 1.2°S of Neptune
14th		Jupiter at aphelion
14th	pm	m.p. 7 Iris 0.4°W of star Theta Ophiuchi
15th		Comet 141P/Machholz 0.5°NW of star Gamma Tauri
15th	11 pm	(9 pm WST) Jupiter 0.1°SW of NGC 4691 (SG) in Virgo
16th	11 am	(9 am WST) Saturn 5°S of Moon
17th	12:37 am	(10:37 pm WST, prev day) First Quarter Moon
17th	5 am	(3 am WST) Moon at apogee
19th		Comet 141P/Machholz 0.7°SE of star Aldebaran
19th	pm	Comet 37P/Forbes 0.3°NE of star Eta Lupi
21st		Mercury at aphelion
23rd	4 am	(2 am WST) Jupiter 0.6°N of Moon Occn.
23rd		Mars 1.2°N of star Delta Capricorni
24th	8:06 pm	(6:06 pm WST) Full Moon; Penumbral Eclipse
25th	pm	m.p. 2 Pallas 0.3°W of NGC 4147 (GC) in Coma Berenices
25th	pm	m.p. 7 Iris 1.0°S of NGC 6325 (GC) in Ophiuchus
26th		Comet 49P/Arend-Rigaux 0.3°S of NGC 2266 (OC) in Gemini
27th	3 am	(1 am WST) Mercury greatest elongation west (27°)
27th	9 am	(7 am WST) Antares 0.7°S of Moon Occn.
27th		Comet C/2003 T4 (LINEAR) 0.7°S of NGC 134 (SG) in Sculptor
29th	8 pm	(6 pm WST) Moon at perigee

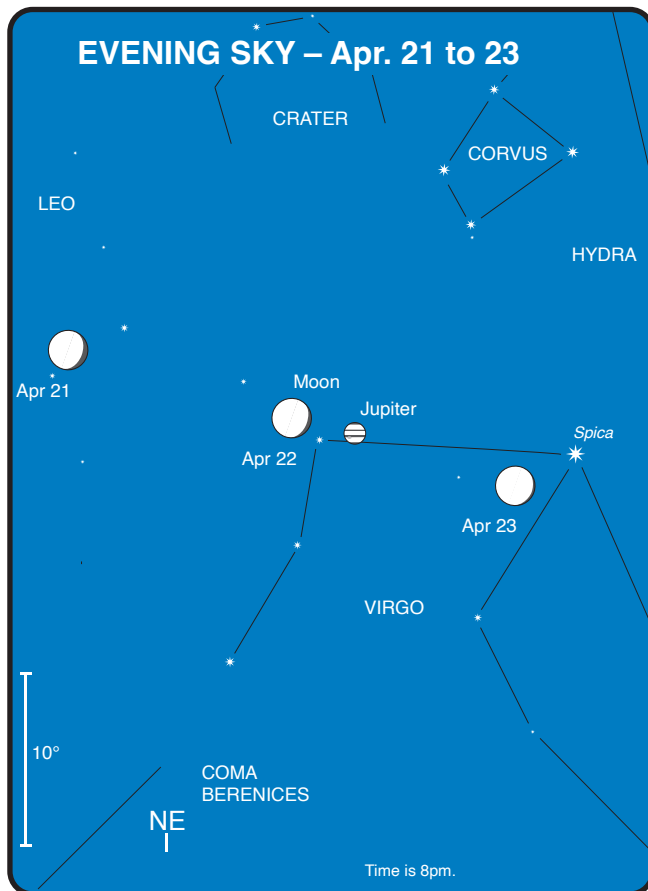
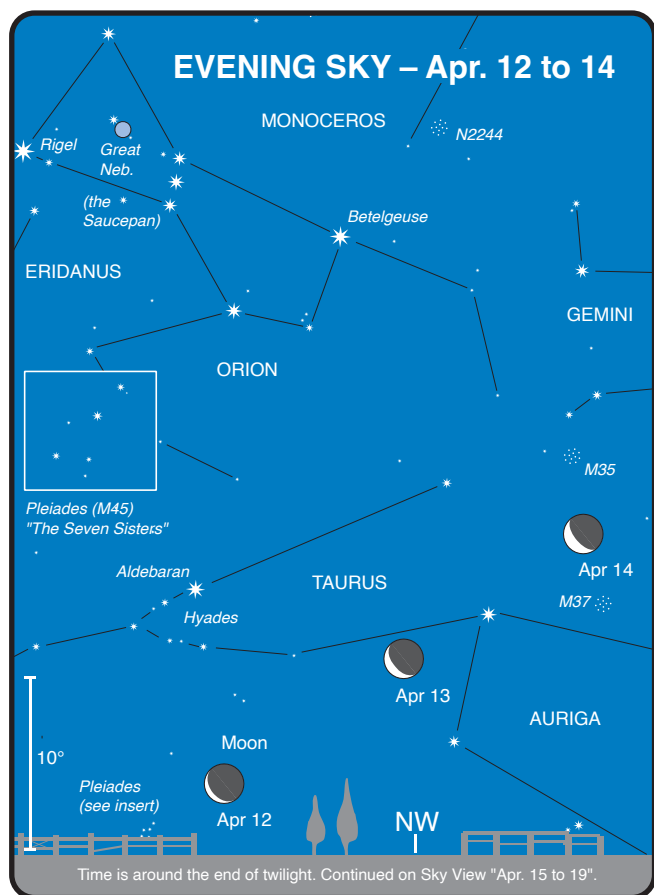


The spiral galaxy NGC 253 in the constellation of Sculptor. Dark lanes are clearly visible in the plane of this nearly edge on galaxy. 25 minute exposure using hypered Kodak 2415 film through a 250mm (10") Newtonian telescope. J. Cauchi (Sydney NSW).



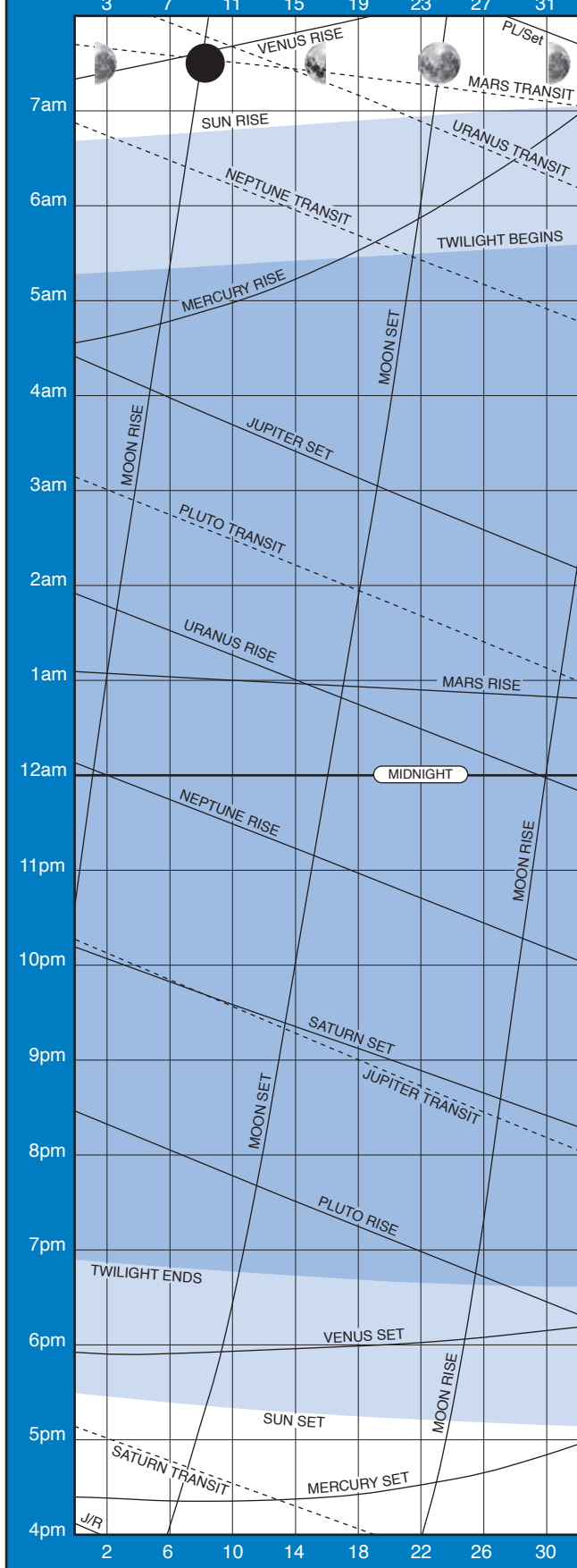


Approximate local standard time.



MAY

RISE/SET CHART



HIGHLIGHTS

- Mercury at best in the morning sky for first half of the month
- Venus returns to the evening sky
- Mars and Uranus have a close encounter
- Four of the brighter minor planets reach opposition in Libra
- Comet C/2003 T4 (LINEAR), still reasonably bright, is visible in the morning and evening skies
- eta-Aquarids meteor shower

THE MOON

- 1st Last Quarter.
- 6th Occultation of minor planet Juno by the Moon (not visible from Australia).
- 8th New Moon.
- 15th Moon at apogee (furthest from Earth – 404,600 km distant, angular size 29.3').
- 16th First Quarter.
- 20th Occultation of Jupiter by the Moon (not visible from Australia).
- 24th Full Moon.
- 24th Occultation of Antares by the Moon (not visible from Australia).
- 26th Moon at perigee (closest to Earth – 364,241 km distant, angular size 33.0').
- 30th Last Quarter.
- 31st Occultation of Mars by the Moon (not visible from Australia).

APPEARANCE of the PLANETS

MERCURY



5th May
dia 6.91"
mag 0.1



15th May
dia 5.94"
mag -0.4



25th May
dia 5.30"
mag -1.2

VENUS

15th May
dia 9.93"
mag -3.9

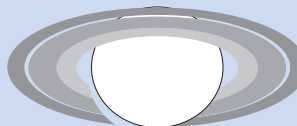


MARS

15th May
dia 7.24"
mag 0.5

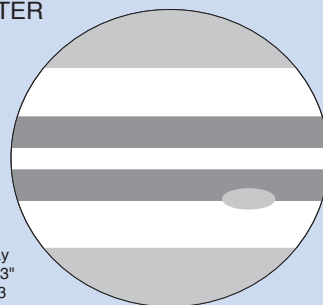


SATURN



15th May
dia 17.39"
mag 0.2

JUPITER



15th May
dia 42.03"
mag -2.3

URANUS

15th May
dia 3.47"
mag 5.9



NEPTUNE

15th May
dia 2.28"
mag 7.9



PLUTO

15th May
dia 0.11"
mag 13.8



THE PLANETS

MERCURY moves from Pisces to Aries mid-month and into Taurus at month's end. Since its greatest elongation west of the Sun (27°) late in April, the planet has been in an excellent position for observation in the morning sky. Rising two hours ahead of the Sun, Mercury is easily seen until mid-May when it begins to move toward the Sun. On the 6th, the planet is close to the 27-day old thin crescent Moon (see Sky View).

VENUS, hidden in the Sun's glare since March, returns to the evening twilight this month. The planet will be easier to see towards month's end when it remains in the twilight, setting an hour after sunset.

MARS in Aquarius rises around 1am in the eastern morning sky. On the 3rd, the 24-day old waning crescent Moon is situated close and south of the planet (see Sky View). In similar fashion to last month with Neptune, Mars moves through Aquarius and meets up with Uranus. From the 15th to the 17th the red and green planets will be within 1.2° of each other.

JUPITER, in Virgo, stands high in the northeastern evening sky at the end of astronomical twilight. Moving slowly in retrograde motion, the

planet remains within 2° of the 3.5 magnitude star Gamma Virginis. On the 19th and 20th, the waxing gibbous Moon appears nearby Jupiter (see Sky View).

SATURN is visible low in the northwestern evening sky. Setting around 9pm mid-month the planet's low altitude leaves little time for meaningful telescopic observation. On the 13th, the 5-day old Moon appears below Saturn (see Sky View). On the 14th, Saturn passes within 3 arc minutes of the northern edge of the open cluster NGC2420 in Gemini. In January, Saturn and its satellites passed across this cluster.

URANUS, rising around 1am is paid a visit by Mars mid-month (see Mars).

NEPTUNE, in Capricornus, rises around 11pm mid-month. From late this month until the end of October the planet will be in retrograde motion.

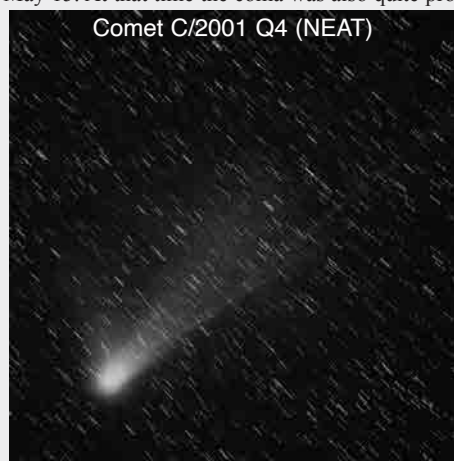
PLUTO, nearing opposition mid-June, rises in the early evening eastern sky.

THE BRILLIANT COMETS OF 2004

In May last year the world witnessed a rare event, two comets, C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR), clearly visible to the unaided eye in the evening sky, at the same time. The previous time this occurred was in 1911. By naked eye, we mean you needed to get out under dark skies, with dark-adapted eyes. It is probably just as well the media didn't strongly promote this event for it probably wouldn't have come up to the expectations of the general public, but for the experienced sky watcher it was magic!

C/2001 Q4 (NEAT)

NEAT came up from below the Earth's orbit, at a very steep angle to the plane of the Solar System, and made its closest approach to the Earth on May 7, at 0.32 AU. It passed through the ecliptic on May 14 and made its closest approach to the Sun a day later at 0.96 AU. The size of its coma and magnitude grew steadily in early 2004: mid-February being 8th magnitude with a 2 arc minute coma, March – 7th magnitude, 5 arc minute and April – 5th magnitude with a 15 arc minute coma. At its closest approach to Earth on May 7 the size of the coma had been reported from 20 to 30 arc minutes with the brightness around 3rd magnitude. The tail had been relatively short but in late April and early May it had developed quickly showing quite a degree of filamentary structure, probably most outstanding around the time of perihelion on May 15. At that time the coma was also quite prominent. Even under



Comet C/2001 Q4 (NEAT)

light polluted urban skies, through binoculars, the coma (sitting up next to M44 in Cancer) resembled the size and brightness of the globular cluster Omega Centauri. Following perihelion the comet faded relatively quickly and by the end of May was 5th magnitude with a reported coma of around 10 to 15 arc minutes.

Comet NEAT on May 12, 2004 (2 X 20 min exposures, tracking the Comet).

COMET C/2002 T7 (LINEAR)

From a brightness point-of-view LINEAR had everyone guessing as early as 2003. At the end of that year it suddenly brightened to 8th magnitude — possibly promising great things. However this glee turned to confusion when the comet, by February 2004, had failed to match the expected rate of increase in brightness. To keep the suspense going it disappeared during the second half of March while in conjunction, being too close to the Sun to observe. After reappearing in the dawn sky, Andrew Pearce (W.A.) was one of the first to observe LINEAR on April 9. He reported the comet at 4.6 magnitude with a 6 arc minute coma. In April/early May, LINEAR was heading directly towards the Earth but from above our orbit. On April 23 it made its closest approach to the Sun (perihelion) at 0.61au. At this time the comet was still in the late morning sky, rising about 4am or approximately 1 hour before the start of dawn. This was when the tail was first reported as being visible to the unaided eye. On May 1 it passes through the plane of the ecliptic at a distance of 0.63 AU from the Sun (a little inside the orbit of Venus). Now below (south) of the ecliptic it continued to brighten as it neared its closest approach to the Earth on the 19th at 0.26 AU. The comet then presented a surprise, up until then most observers had been reporting a tail length of up to 2° . However around the time of closest approach to Earth, reports were received like: on the 19th David Seargent (Cowra, NSW) saw a tail of 13° through binoculars, John Drummond (NZ) photographed a 43° tail through a 24mm lens on the 19th and Terry Lovejoy (Qld) on the 20th estimated the tail to be over 25° . Lovejoy pointed out that at the time of Drummond's image the end of the ion tail was less than 0.1 AU from Earth. With this close proximity of the tail to us, we were likely to be seeing an effect caused by perspective. LINEAR peaked in brightness at 3rd magnitude, towards the end of May, but by then the comet was getting very low for southern hemisphere observers.



Comet C/2002 T7 (LINEAR)

Comet LINEAR taken on May 19 (5 min. exposure).

Images by S. Quirk.

MINOR PLANETS. Four of the brighter minor planets reach opposition this month in Libra. They are: 68 Leto on the 7th at magnitude 10.7, 1 Ceres on the 8th at magnitude 7.0, 349 Dembowska on the 12th at magnitude 10.2 and 14 Irene on the 18th at magnitude 9.0. Others at opposition include: 129 Antigone on the 6th at magnitude 9.9 in Serpens, 409 Aspasia on the 25th at magnitude 10.3 near the border of Scorpius and Libra and 704 Interamnia on the 28th at magnitude 10.8 near the border of Scorpius and Lupus.

COMETS

Comet P/1983 V1 (Hartley-IRAS) may first be sighted this month in the pre-dawn sky. 11th magnitude in brightness, the comet will be moving north through Pisces.

Comet C/2003 K4 (LINEAR) will be difficult to view this month as it moves lower into the glow of the evening twilight.

Comet C/2003 T4 (LINEAR) is visible both early in the evening and again before dawn this month, fading from 7th to 8th magnitude. It moves through Sculptor, Fornax and Eridanus before ending the month in Caelum.

Comet 9P/Tempel should brighten from 10th to 9th magnitude this month. Moving south through Virgo, and visible until after midnight, Tempel will end the month near Delta Virginis. On the evening of the 31st Comet 9P/Tempel will be 0.1 degree from this 3rd magnitude star. At this time the comet should be close to its maximum brightness, at around 9th magnitude, and the star should make finding it quite easy.

Comet 21P/Giaconini-Zinner is a late morning object this month as it moves east through Pegasus and Andromeda. Expected to brighten from 12th to 11th magnitude, Giacobini-Zinner will spend just over half of the month within the Great Square of Pegasus.

Comet 37P/Forbes, visible all night in Lupus, reaches the southernmost point of its apparition this year and begins a trek north. By month's end, the comet may be nearing 12th magnitude.

Comet C/2004 Q2 (Machholz) reappears over the northwest evening horizon mid-month, in Ursa Major, at around 9th magnitude. It moves into Canes Venatici by the end of the month, setting around 11pm, now magnitude 10.

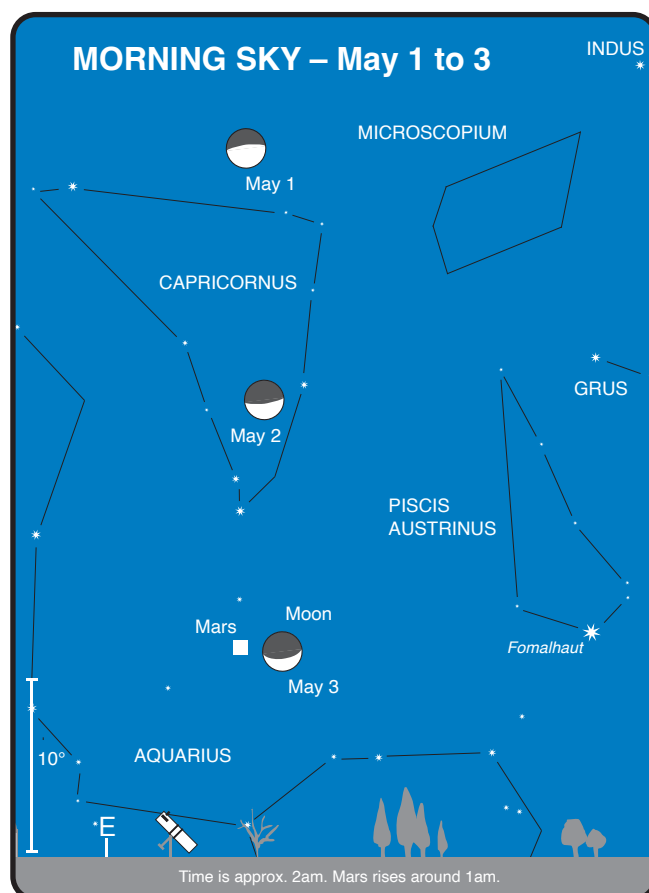
METEOR SHOWERS

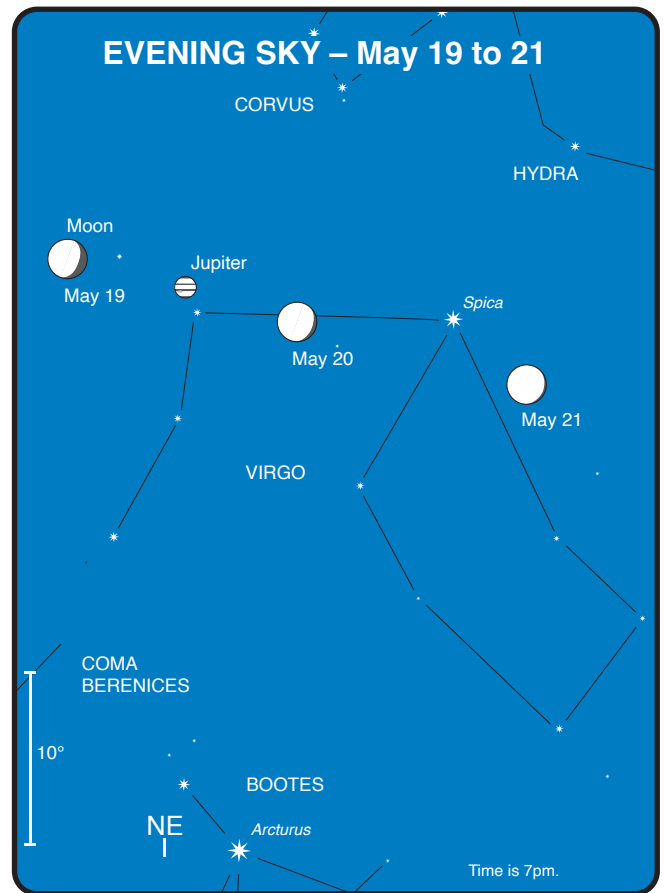
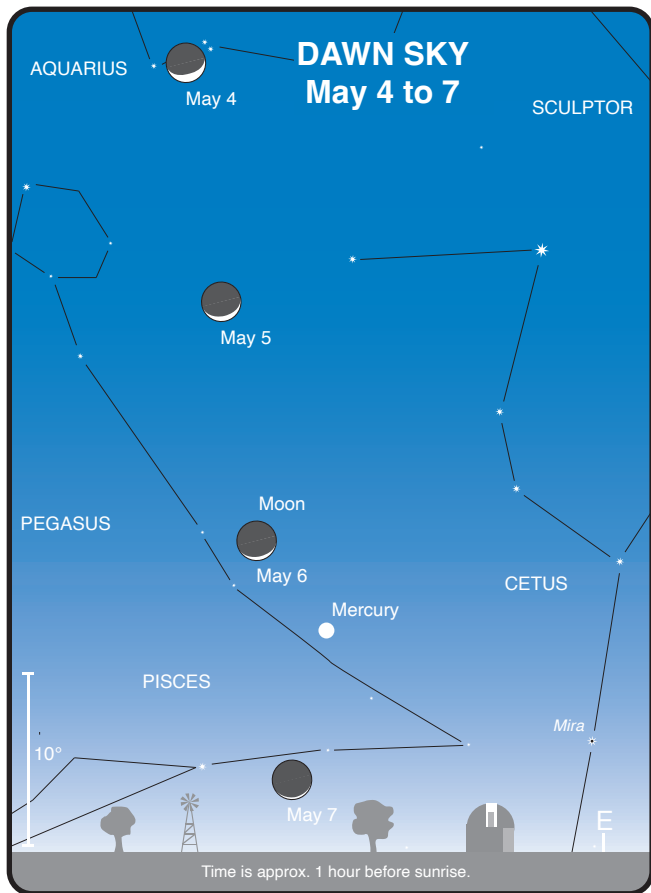
The **eta-Aquarids** are linked with Halley's Comet and rank as one of the most popular of the southern hemisphere showers. They are visible for a few hours before dawn, from 19th April to 28th May. They peak this month on the 5th, but the rate is generally around 30 for 3 – 4 days either side of this date. The zenith hourly rate will often reach 50 or more meteors per hour (95 in 1975 and 110 in 1980). The Eta Aquarids are characterised by their high percentage of persistent trains (up to 25% of the meteors). They are very swift and are a striking yellow colour.

DIARY

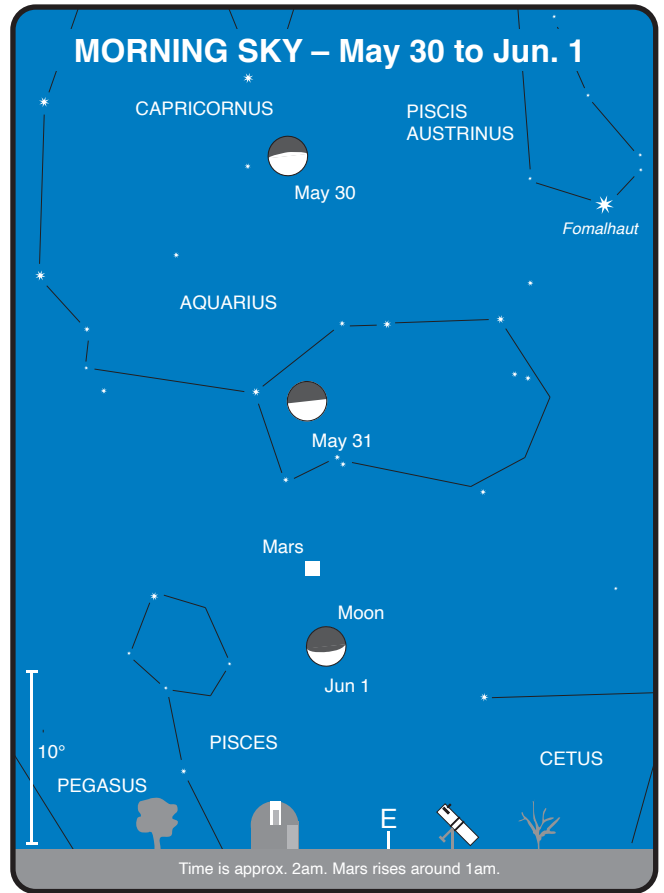
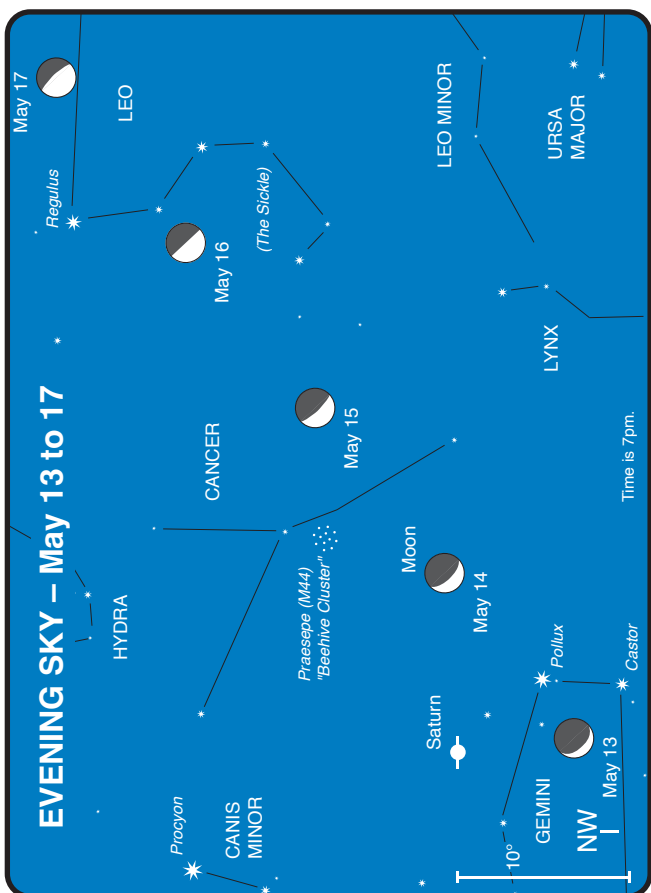
1st	4:24 pm	(2:24 pm WST) Last Quarter Moon
2nd	1 am	(11 pm WST, prev day) Neptune 5°N of Moon
3rd	1 am	(11 pm WST, prev day) Mars 3°N of Moon
3rd	4 pm	(2 pm WST) Uranus 3°N of Moon
3rd	pm	Comet 9P/Tempel 0.7°E of NGC 4762 (LG) in Virgo
4th		m.p. 1 Ceres 0.8°N of star Beta Librae
5th	Midnight	(10 pm WST) Juno 0.08°N of Moon Occn.
6th		Mercury 0.2°N of NGC 488 (SG) in Pisces
6th	8 pm	(6 pm WST) Mercury 3°S of Moon
7th	11 am	(9 am WST) Pallas stationary
9th	4 am	(2 am WST) Ceres at opposition
8th	6:45 pm	(4:45 pm WST) New Moon
11th		Mercury at greatest latitude south
11th		Venus at ascending node
11th	1 pm	(11 am WST) Vesta in conjunction with Sun
12th		Comet C/2003 T4 (LINEAR) 0.8°S of NGC 986 (SG) in Fornax
13th		Mercury 0.7°NW of m.p. 11 Parthenope
13th		m.p. 115 Thyra 0.4°NE of M67 (OC) in Cancer
13th	11 pm	(9 pm WST) Saturn 5°S of Moon
14th		Mercury 0.9°SE of m.p. 16 Psyche
14th	pm	Saturn 0.1°N of NGC 2420 (OC) in Gemini
14th	pm	Comet 9P/Tempel 0.9°E of NGC 4698 (SG) in Virgo
14th	Midnight	(10 pm WST) Moon at apogee

15th	6 am	(4 am WST) Mars 1.2°S of Uranus
16th		Comet C/2003 T4 (LINEAR) 0.6°E of star Theta Eridani
16th	6:56 pm	(4:56 pm WST) First Quarter Moon
16th	pm	m.p. 7 Iris 0.5°N of NGC 6284 (GC) in Ophiuchus
16th	pm	m.p. 42 Isis 0.2°S of M75 (GC) in Sagittarius
19th	7 am	(5 am WST) Venus 6°N of Aldebaran
20th	8 am	(6 am WST) Jupiter 0.4°N of Moon Occn.
20th	1 pm	(11 am WST) Neptune stationary
24th	6:18 am	(4:18 am WST) Full Moon
24th	6 pm	(4 pm WST) Antares 0.8°S of Moon Occn.
26th		m.p. 3 Juno 0.6°N of NGC 488 (SG) in Pisces
26th	9 pm	(7 pm WST) Moon at perigee
29th	7 am	(5 am WST) Neptune 5°N of Moon
30th		Mercury at ascending node
30th	9:47 pm	(7:47 pm WST) Last Quarter Moon
30th	10 pm	(8 pm WST) Uranus 3°N of Moon
31st	3 pm	(1 pm WST) Saturn 7°S of Pollux
31st	7 pm	(5 pm WST) Mars 0.5°N of Moon Occn.
31st	9 pm	(7 pm WST) Comet 9P/Tempel 0.1°E of star Delta Virginis



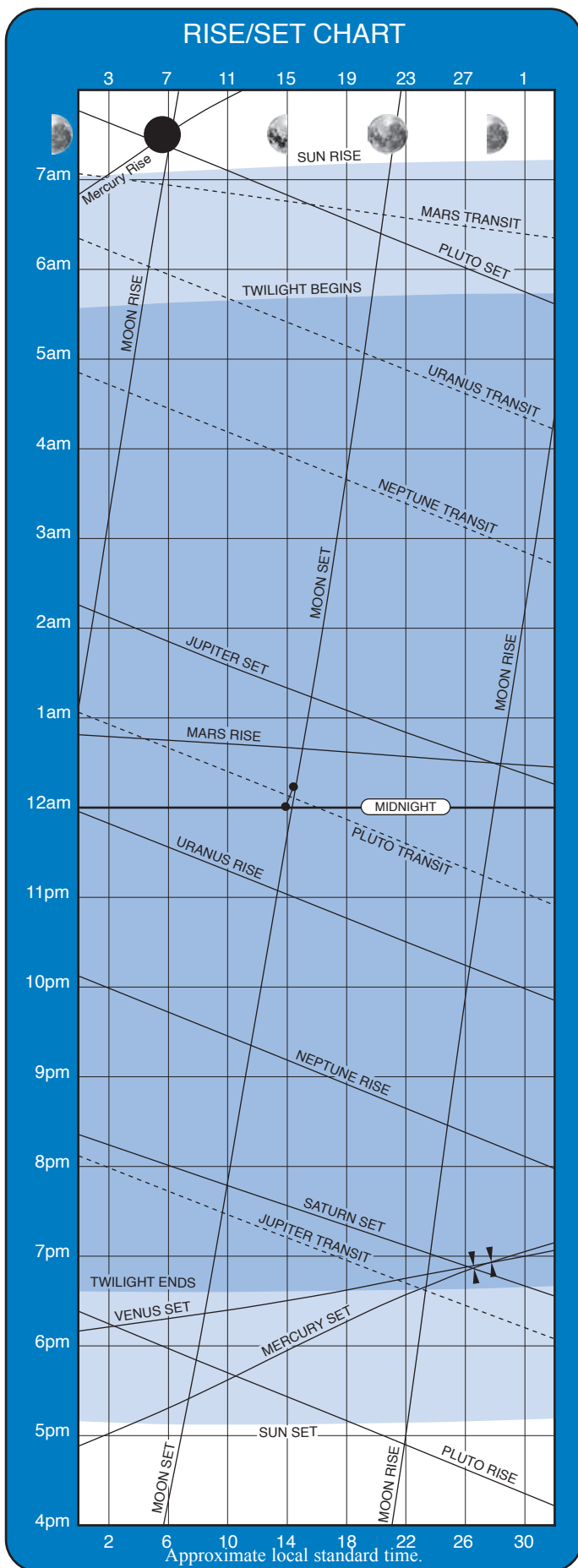


Approximate local standard time.



JUNE

RISE/SET CHART



HIGHLIGHTS

- Mercury, Venus and Saturn form a rare planetary grouping.
- Mercury and Venus very close.
- Jupiter and the Moon are very close with a daytime occultation from northern Australia.

THE MOON

- 7th New Moon.
- 11th Moon at apogee (furthest from Earth – 405,506 km distant, angular size 29.7').
- 15th First Quarter.
- 16th Occultation of Jupiter by the Moon, daytime event visible from northern parts of Australia and New Zealand except far south (see Jupiter below).
- 21st Occultation of Antares by the Moon, not visible from Australia. The Moon can be seen less than 2° from Antares around 5am low in the western sky.
- 22nd Full Moon.
- 23rd Moon at perigee (closest to Earth – 359,672 km distant, angular size 33.7').
- 29th Last Quarter.

THE PLANETS

MERCURY is in superior conjunction with the Sun (Mercury and Earth on opposite sides of the Sun) on the 3rd. Moving east of the Sun the planet rapidly moves into the evening sky where it remains until late next month. The period late June to late July is one of the best periods to observe Mercury in the evening sky this year. The next good window occurs from mid-October to mid-November. Mercury leaves Taurus early in June to join Venus and Saturn in Gemini.

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 3rd



5th Jun
dia 5.10"
mag -2.1



15th Jun
dia 5.47"
mag -1.0



25th Jun
dia 6.28"
mag -0.2

VENUS

15th Jun
dia 10.53"
mag -3.9



MARS

15th Jun
dia 8.52"
mag 0.1

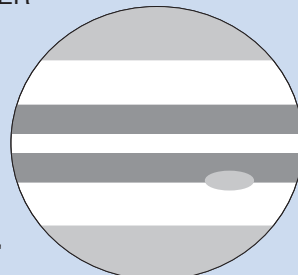


SATURN



15th Jun
dia 16.75"
mag 0.2

JUPITER



15th Jun
dia 38.64"
mag -2.1

URANUS

15th Jun
dia 3.56"
mag 5.8



NEPTUNE

15th Jun
dia 2.32"
mag 7.9



PLUTO

14th Jun
Opposition
dia 0.11"
mag 13.8



As the speedy planet gains altitude it appears to chase Venus across Gemini, catching up when the pair is very close to Saturn on the Gemini/Cancer border. From the 23rd to 30th, the three planets form a rare triple grouping fitting into a 5° circle, on the 26th the circle is a tight 1.3°, a splendid sight (see Sky View). Mercury and Venus themselves are at their closest on the 27th and 28th at around 0.2° apart, another superb treat.

VENUS moves from Taurus to Gemini and finally into Cancer. Setting around 1.5 hours after the Sun the planet, at -3.9 magnitude, is very prominent in the western early evening sky. Venus spends the month gradually approaching Saturn with Mercury in hot pursuit. At month's end the three form a neat planetary triple grouping, and Venus and Mercury get really close! (See Mercury, above, and Sky View).

Twelve months have now passed since the historical transit of Venus, we trust our readers had clear skies, and a reminder that it's just seven years until the next one on June 6th 2012.

EARTH is at Solstice on the 21st when our days are shortest. On this day, the Sun is at its most northerly position with a declination of +23.5°.

MARS in June rises soon after midnight and travels from Aquarius, across a small section of Pisces and into a corner of Cetus. Twice in the month the Moon appears nearby the planet, on the 1st a 23-day old Moon (see Sky View, in May section), and on the 29th the Last Quarter Moon (see Sky View).

JUPITER transits the meridian just after the end of astronomical twilight and can be seen high in the northern sky. On the evening of the 16th, the 9-day old Moon appears close to Jupiter (see Sky View), however the daytime view is much more interesting. From the northern parts of Australia an occultation occurs, from south of the occultation zone the planet appears significantly closer than the evening view. For a challenge try spotting Jupiter in the daytime, a good test for small instruments, but moderate size scopes (around 20cm) should have no difficulty. Venus, Jupiter and a few of the brighter stars are all visible during daylight hours; you just need a reference point. For Jupiter this month, we have the Moon as our guide and a good object to find focus on. Focusing a telescope to infinity can be tricky on a clear daytime sky. Sometimes a distant tree or telephone pole can help.

Occultation details for the northern regions are as follows; note times are approximate local time.

Location	Disappearance (Dark limb)	Reappearance (Bright Limb)
Darwin	2:25pm CST	2:56pm
Rockhampton	3:35pm EST	4:05pm
Townsville	3:20pm EST	3:55pm

AN UNUSUAL MULTIPLE STAR

This story started a number of years ago when the authors were observing the globular cluster Omega Centauri through a German equatorially mounted 8" Newtonian telescope. To examine this city of stars more closely, a reasonably high magnification was being used (200x). The telescope was left for a while and on returning the globular could no longer be seen in the eyepiece. The scope was moved in a roughly spiral pattern in an attempt to recover the cluster — instead, this interesting Y shaped multiple star passed into the field. It was soon realised that this accidental discovery had been assisted by a loss of power to the scope's motor drive, which therefore hadn't been tracking the cluster for a while. This find was a little serendipitous, for under a lower power this object can easily be overlooked. It is also easy to find being only about 3/4 degree east of naked eye (2.5 mag) Zeta (ζ) Centauri, which is in turn 5° east of Omega Centauri. See All Sky Map number 6.

On investigation we discovered that John Herschel had found this object long before us. It is known as h4638. The PA (position angle, as measured east from north), separations and magnitudes of the components are as follows:

Component	Magnitude	Position Angle from A	Separation from A
A	8.9	-	-
B	10.8	314°	8.0"
C	var	110°	9.3"
D	var	259°	9.4"

It is interesting that stars C and D are variable and have been allocated the designation of AA Cen (10.7 to 13.5 mag) and ZZ Cen (10.5 to 13.0 mag) respectively. The authors were unable to find out their variable types or periods.

The accompanying finder chart does not show all of the stars down to 11th magnitude but was designed only as an aid to identifying h4638.

Who was John Herschel?

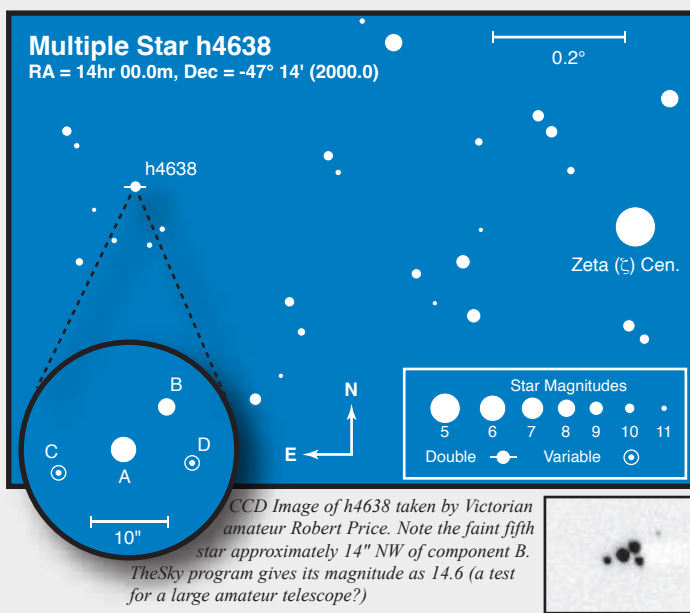
John Frederick William Herschel was born in 1792 in Slough, England. He was the only offspring to the famous astronomer William Herschel. William's claim to fame had been his discovery of the planet Uranus in 1781, the first planet found with a telescope and the first since antiquity. Up until then he had been little more than an unknown amateur astronomer but this work lead him to being appointed by King George III to the post of King's Astronomer. He and his sister/assistant Caroline went on to many other discoveries including two new moons for Uranus and two moons of Saturn. William also discovered infrared radiation in

the solar spectrum, did a lot of work on double stars and with the help of increasingly larger telescopes began to resolve many of the mysterious nebulae into collections of stars. Caroline, as well as helping to raise her nephew, John, went on to make a name for herself discovering comets.

After graduating from St John's College in Cambridge in 1816, John became an astronomer, at first concentrating on double stars. In 1834, John and his family moved to the Cape of Good Hope in South Africa. From 1834-38 he undertook an extensive observation program of stars, doubles, clusters and nebulae of the then little-known southern skies. He was the first and only astronomer to systematically survey the entire sky (both hemispheres) with a telescope. This eventually led to his publication General Catalogue of Nebulae and Clusters which was the precursor to the modern NGC catalogue.

Trivia Time...

Did you know the full name of retired astronaut John Glenn Jnr, the first American to orbit the earth, was John Herschel Glenn Jnr? A coincidence, or perhaps John wasn't the only member of his family interested in outer space?



From Brisbane a graze occurs at 4pm. Close approaches for other locations are as follows, again times are only approximate local time.

Location	Time	Distance from limb
Adelaide	03:20pm CST	0° 09'
Hobart	04:05pm EST	0° 09'
Melbourne	04:00pm EST	0° 08'
Perth	01:35pm WST	0° 11'
Sydney	04:00pm EST	0° 04'

SATURN is in conjunction with the Sun next month and June provides the last views of the planet before it is lost in the evening twilight. On the 10th, the 3-day old crescent Moon will be just north (to the right) of the planet (see Sky View). During the last week of the month Saturn, Mercury and Venus produce a grand display (see Mercury and Sky View). Close planetary groupings of a trio of planets (within a 5° circle) may occur several times a year, or even a few years apart. Particular close alignments between set groups of planets are not as common. The last Mercury, Venus and Saturn configuration was seen in 1985, the next occurs in 2008, and then again in 2041 (see Astronomy 2041).

URANUS, in Aquarius, rises around 11pm. From mid-month until mid-November the planet will be in retrograde motion.

NEPTUNE, in Capricornus, rises around 9pm mid-month.

PLUTO is at opposition on the 14th and is visible the entire night. This distant planet is currently 4,482,000,000 km from Earth (29.95 AU), with its light taking 250 minutes to reach us.

MINOR PLANETS at opposition this month include: 18 Melpomene on the 18th at magnitude 9.5 in Ophiuchus, 103 Hera on the 21st at magnitude 10.9 in Sagittarius and 54 Alexandra on the 22nd at magnitude 10.3 in Corona Australis.

COMETS

Comet P/1983 V1 (Hartley-IRAS) will be moving north in the pre-dawn sky this month. On 5th June, the 11th magnitude comet will pass in front of the galaxy M33. As June progresses, Hartley-IRAS will become more and more difficult to sight as it passes through Triangulum and Andromeda. By the end of the month it will be below the northern horizon for mid-latitude observers.

Comet C/2003 K4 (LINEAR) may be recovered by the end of the month as it emerges into the pre-dawn sky. Located in Eridanus, the 12th magnitude comet will be near Xi Eridani around 25th June.

Comet C/2003 T4 (LINEAR) should fade from 8th to 10th magnitude this month as it moves through Caelum and Columba. It will be visible in the early evening and again before morning twilight begins.

Comet 9P/Tempel begins June near Delta Virginis. Throughout the month, the 9th magnitude comet will move southeast through Virgo, and will be best observed early in the evening.

Comet 21P/Giacobini-Zinner makes its way through three constellations in the pre-dawn sky – Andromeda, Pisces, and Aries. On 16th June, less than a degree will separate 10th magnitude Giacobini-Zinner and 2nd magnitude Alpha Arietis (Hamal).

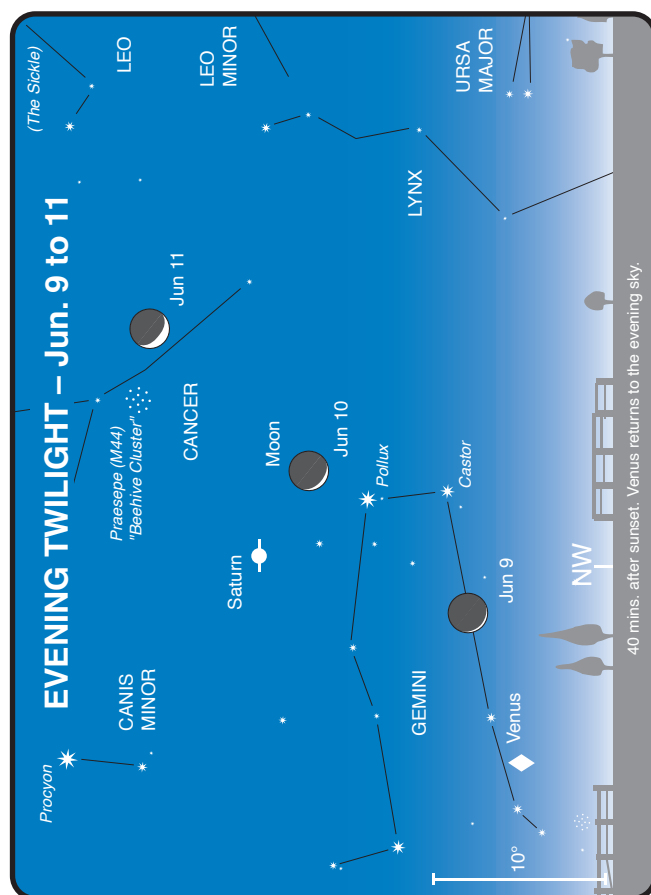
Comet 37P/Forbes should be at 12th magnitude this month. Visible virtually all night in Lupus, comet Forbes will pass close to the globular cluster NGC 5986 on June 25.

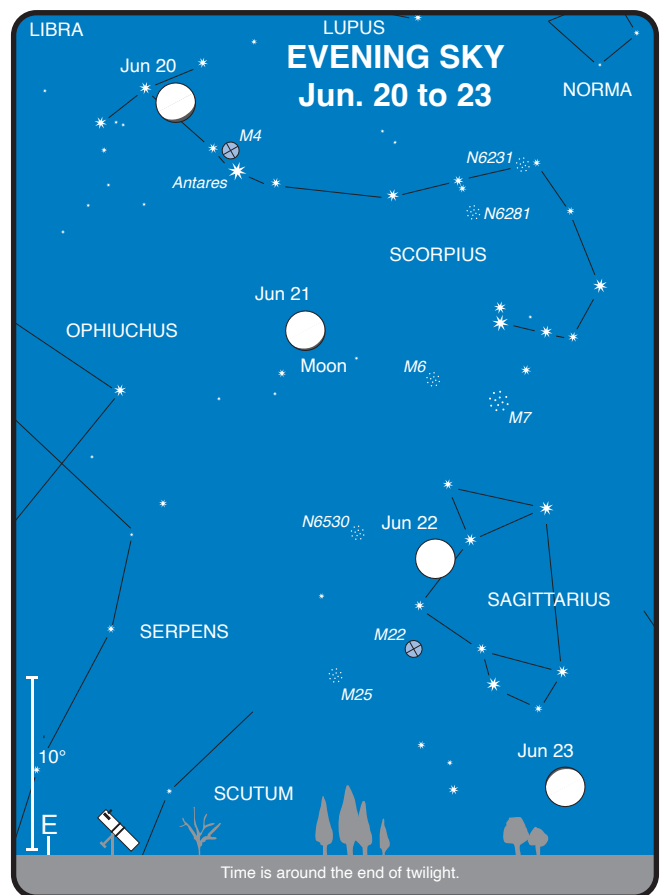
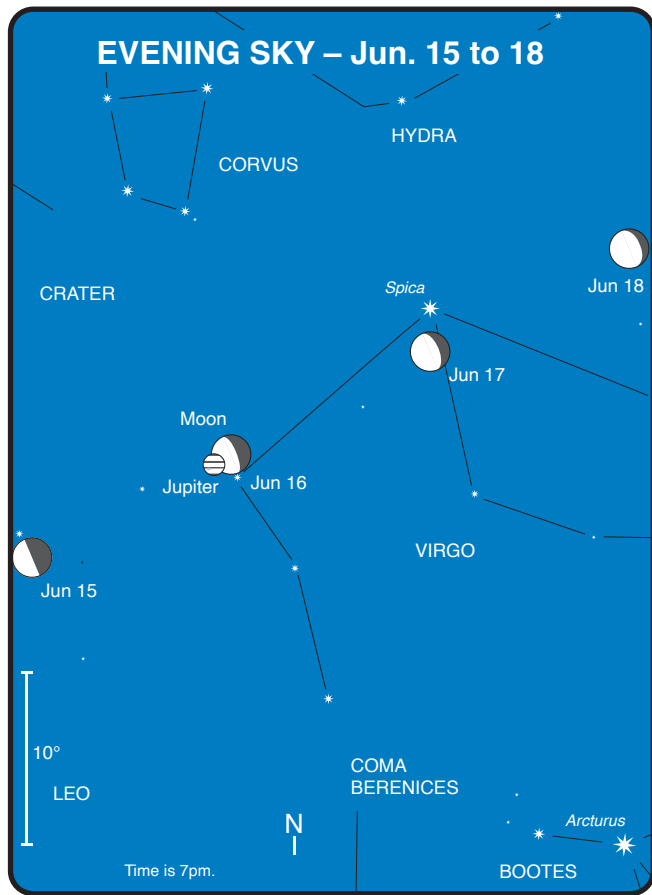
Comet C/2004 Q2 (Machholz) spends the month in the evening sky, in Canes Venatici, setting around 11pm. It has now faded to 11th magnitude.

DIARY

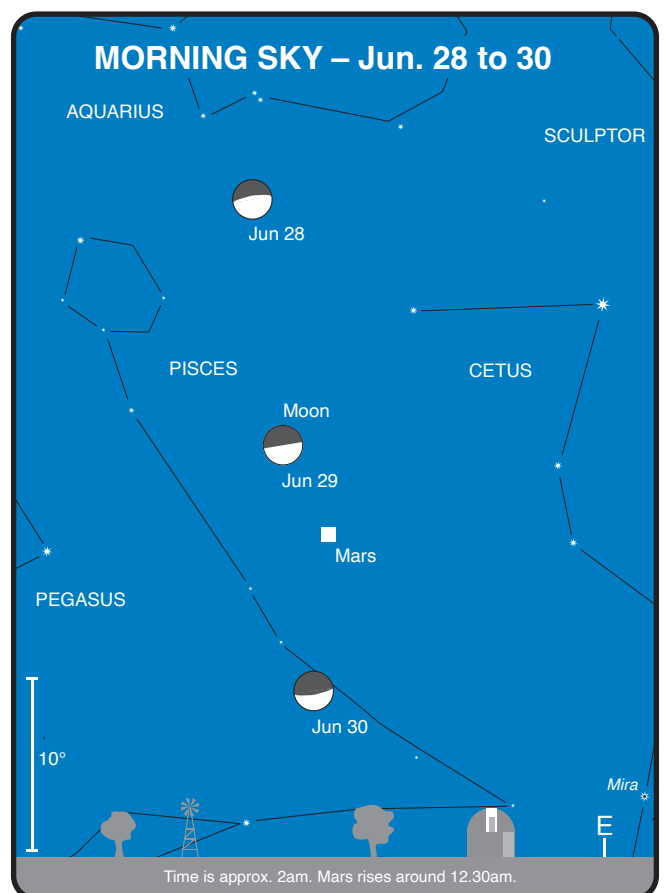
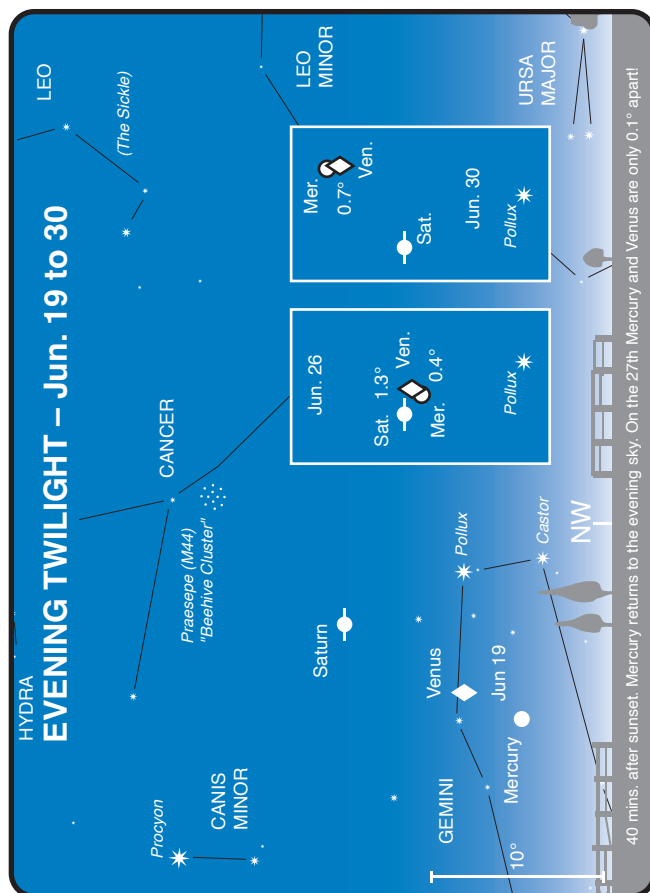
3rd		Venus 0.5°NW of IC 2157 (OC) in Gemini
3rd	7 pm	(5 pm WST) Mercury in superior conjunction
3rd	11 pm	(9 pm WST) m.p. 18 Melpomene 0.2°S of NGC 6539 (GC) in Serpens
4th		Venus 0.1°N of M35 (OC) in Gemini
4th		Mercury at perihelion
5th	am	Comet P/1983 V1 (Hartley-IRAS) 0.3°N of M33 (SG) in Triangulum
6th	8 am	(6 am WST) Jupiter stationary
7th	7:55 am	(5:55 am WST) New Moon
8th	10 pm	(8 pm WST) Venus 4°S of Moon
10th	Noon	(10 am WST) Saturn 5°S of Moon

10th	pm	Comet C/2004 Q2 (Machholz) 0.7°E of M94 (SG) in Canes Venatici
11th	4 pm	(2 pm WST) Moon at apogee
12th		Venus 1°SE of star Epsilon Geminorum
14th		Mercury at greatest latitude north
14th		Venus at perihelion
14th	1 pm	(11 am WST) Pluto at opposition
15th		m.p. 42 Isis 0.7°W of NGC 6907 (SG) in Capricornus
15th	11:22 am	(9:22 am WST) First Quarter Moon
15th	5 pm	(3 pm WST) Uranus stationary
16th		Comet 21P/Giacobini-Zinner 0.7°NW of star Alpha Arietis
16th	5 pm	(3 pm WST) Jupiter 0.4°N of Moon Occn.
16th	pm	Comet C/2004 Q2 (Machholz) 0.9°E of star Cor Caroli
21st	4 am	(2 am WST) Antares 0.7°S of Moon Occn.
21st		Mars at greatest latitude south
21st	5 pm	(3 pm WST) Solstice
22nd	2:14 pm	(12:14 pm WST) Full Moon
23rd		m.p. 532 Herculina 0.9°N of star Epsilon Leonis
23rd		Comet C/2003 T4 (LINEAR) 0.8°N of star Beta Columbae
23rd	10 pm	(8 pm WST) Moon at perigee
23rd	10 pm	(8 pm WST) Venus 5°S of Pollux
24th	6 pm	(4 pm WST) Mercury 5°S of Pollux
25th	10 am	(8 am WST) Neptune 5°N of Moon
25th	11 pm	(9 pm WST) Comet 37P/Forbes 0.1°E of NGC 5986 (GC) in Lupus
26th	7 am	(5 am WST) Venus 1.3°N of Saturn
26th	4 pm	(2 pm WST) Mercury 1.4°N of Saturn
27th	5 am	(3 am WST) Uranus 3°N of Moon
27th		m.p. 19 Fortuna 0.4°NW of NGC 524 (LG) in Pisces
28th	7 am	(5 am WST) Mercury 0.08°S of Venus
29th	4:23 am	(2:23 am WST) Last Quarter Moon
29th	2 pm	(Noon WST) Mars 2°S of Moon
30th	11 pm	(9 pm WST) Ceres stationary



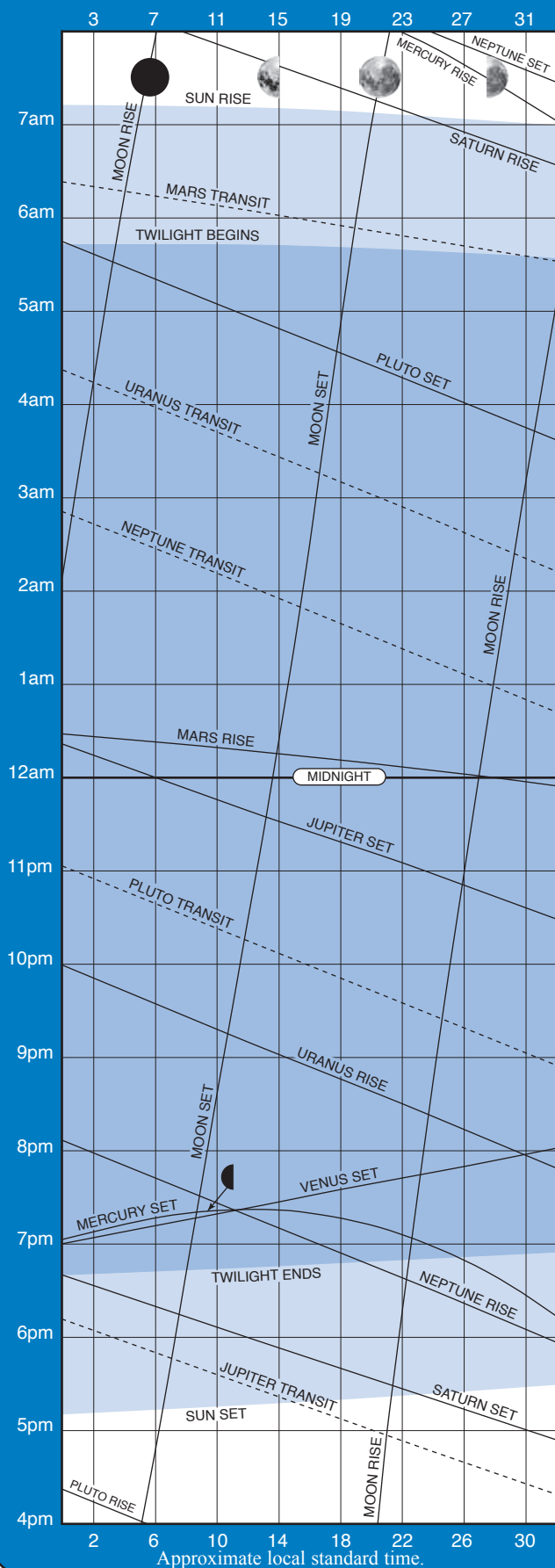


Approximate local standard time.



JULY

RISE/SET CHART



HIGHLIGHTS

- Mercury and Venus close together for first half of July.
- Mercury very close to open cluster M44.
- Venus goes directly over M44.
- Venus and Regulus close.
- Minor planet 8 Flora visits the galaxy trio of M95, M96 and M105
- Possible surge in brightness of Comet 9P/Tempel as a probe from 'Deep Impact' collides with it.

THE MOON

- 6th New Moon.
- 9th Moon at apogee (furthest from Earth – 406,363 km distant, angular size 29.0').
- 14th Occultation of Jupiter by the Moon (not visible from Australia).
- 15th First Quarter.
- 18th Occultation of Antares by the Moon (not visible from Australia). However the pair appear close together in the evening sky.
- 21st Full Moon.
- 22nd Moon at perigee (closest to Earth – 357,158 km distant, angular size 33.6').
- 28th Last Quarter.

THE PLANETS

MERCURY, paired with Venus, is prominent for most of the month in the western evening sky. Since their close approach to Saturn last month the duo moves toward the open star cluster M44 (the Beehive) in Cancer. On the 3rd, Mercury skims past the outer fringes of the cluster, with Venus moving directly across the centre on the following evening (see Sky View). Mercury and Venus remain close until mid-month when Mercury

APPEARANCE of the PLANETS

MERCURY



9th Jul
Greatest elongation east
dia 8.00"
mag 0.5



20th Jul
dia 9.78"
mag 1.3

VENUS

15th Jul
dia 11.57"
mag -3.9

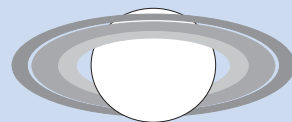


MARS

15th Jul
dia 10.14"
mag -0.2

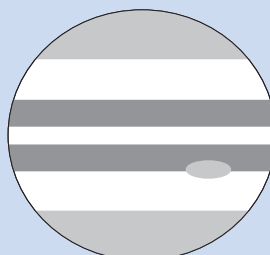


SATURN



15th Jul
dia 16.47"
mag 0.2

JUPITER



15th Jul
dia 35.43"
mag -1.9

URANUS

15th Jul
dia 3.64"
mag 5.8



NEPTUNE

15th Jul
dia 2.34"
mag 7.8



PLUTO

15th Jul
dia 0.11"
mag 13.8



begins its descent back toward the Sun. The planet reaches its greatest elongation east of the Sun (26°) on the 9th.

VENUS, in the early western evening sky, spends the first half of the month in Cancer close to Mercury. The pair separates as Mercury nears the end of its evening appearance, and Venus continues on into Leo. On the 4th, Venus passes directly over the centre of the Beehive Cluster; Mercury at this time is situated 1.2° above its brighter companion (see Sky View). The journey through Leo brings Venus within 1.2° of the 1st magnitude star Regulus (Alpha Leonis) on the 23rd (see Sky View). Known as the 'Little King' and sometimes the 'Lion's Heart', Regulus is located at the base of the asterism known as the Sickle.

The **EARTH** is at aphelion (the furthestmost point in its orbit from the Sun) on the 5th. The Earth/Sun distance is 1.016742 astronomical units, which is equivalent to about 152,104,000 km.

ONLINE ASTRONOMY THE FAULKES TELESCOPE

For some time now, professional astronomers have had the convenience of running some of their observing programmes online, from the comfort of their offices. That must be a relief considering the remoteness of some major astronomical observatories. The concept of using this approach for education has been in its infancy for a number of years with perhaps the US-based Telescopes in Education (TIE) project being the most successful (see below). Now this concept is on the verge of bringing to life astronomy for Australian, UK and Hawaiian students, thanks to the UK-based cosmologist turned businessman Dil Faulkes. He has made millions of dollars in software programming and has generously ploughed substantial funding into the Faulkes Telescopes (FT). They will be by far the largest instruments ever available for use by non-professional astronomers.

The FTs are a pair of altazimuthally mounted telescopes with 2 metre diameter mirrors, initially armed with CCD cameras with a full complement of filters (B, V, R, U, I, OIII narrowband and H-alpha). Future instrumentation will include the donation of a powerful infrared camera to Faulkes North, when it has finished its duty on the Gemini Telescope on Mauna Kea. This will allow observations to continue well into the local morning (daylight time). The University of Leicester is also developing spectrographs for the scopes, so the future has great potential.

The telescopes, which are designed to operate fully automatically via the web, are located at two sites — one on the mountain of Haleakala on Maui, Hawaii and the other at the Siding Spring Observatory near Coonabarabran, NSW. The Hawaiian site for 'Faulkes North' is situated at the existing University of Hawaii High Altitude Observatory. It is at an altitude of 3,000 metres and has the excellent seeing and transparency needed for high quality astronomical observations. With regards to the home of the 'Faulkes South' instrument, if you look in figure 1 in Fred Watson's article on RAVE (p. 5) you will see its enclosure next to the UK Schmidt building. The 'Faulkes North' is expected to come online in late 2004 and 'South' will be fully operational by early 2005. The Australian operations centre for the project is located at Swinburne University in Victoria.

Although at this stage the only people that will be invited to participate in Australia will be educational facilities, this presents a unique opportunity for amateur astronomers. Many of the societies already have close ties to the school system through lectures and field nights. Now Faulkes could add an extra dimension. The Faulkes people are encouraging amateurs to get involved with the project by suggesting and working with observational programmes through their local schools. Science teachers, like all teachers, are often overworked and so bogged down in their own curriculum something like this may not get off the ground without the knowledge of an experienced, enthusiastic amateur with the push to make it happen.

Faulkes Telescope Australia <http://astronomy.swin.edu.au/ Faulkes/>
Faulkes Telescope Project (UK HQ) www.faulkes-telescope.com/

Photo of Faulkes Telescope, courtesy Robert Hollow

MARS remains in Pisces during the month, rising around midnight. On the 28th, the Last Quarter Moon is near the planet (see Sky View). Mars is still a disappointing telescope target this month, but it is steadily growing in size and brightness as opposition approaches in November.

JUPITER can be seen high in the northwestern evening sky at the end of astronomical twilight. The Moon, near First Quarter, appears close to the planet on the 13th and 14th (see Sky View). Since April, Jupiter has been within 2° of the 3.6 magnitude star Gamma Virginis. Gamma is one of the finest of the binary star systems and is composed of a pair of 3.5 magnitude pale yellow suns with a 171-year period. In 1920 the pair were at their greatest separation of 6.2 arc seconds. This year they will be a close 1 arc second, and by 2007/8 they will appear virtually as a single star. Later in the month, Jupiter moves towards Spica.

Other Robotic Telescopes used in Education.

- **The Bradford Robotic Telescope**
<http://www.telescope.org/index.php>

This is a Celestron 14 located at Observatorio del Teide site of the Instituto De Astrofísica De Canarias, in Tenerife, Canary Islands, Spain. The Teide Observatory is the best in Europe and is situated at an altitude of 2,400 metres on the northern part of a volcanic caldera. Bradford had originally been based around a UK sited instrument. A combination of the poor UK weather and a lightning strike has resulted in this totally new complex. At the time of writing (September 2004), the Canary Islands telescope was beginning to test its instruments.

- **Micro-Observatory Online Telescopes**
<http://mo-www.harvard.edu/MicroObservatory/>

Micro-Observatory is a research and development project designed to improve high-school science education providing teachers and their students with access to a network of educational telescopes. They are 6" Maksutov instruments equipped with CCD cameras. There are two sites: one is at the Whipple Observatory, in Amado, Arizona and the other at the Harvard Smithsonian centre for Astrophysics in Cambridge MA.

- **Telescopes in Education (TIE)**
<http://tie.jpl.nasa.gov/tie/>

This is a NASA funded operation, which uses a dedicated research grade 600mm telescope at Mt Wilson. It is booked and accessed through the internet, primarily for schools in America, although trials have been conducted elsewhere, including Australia.



SATURN is lost in the twilight this month as it moves toward solar conjunction on the 24th. The planet returns to grace the dawn sky next month.

URANUS, in Aquarius, rises around 9pm.

NEPTUNE, in Capricornus, rises around 7pm and will be at opposition early in August.

PLUTO, now past opposition, is visible throughout most of the night, setting before dawn.

MINOR PLANETS at opposition this month include: 26 Proserpina on the 4th at magnitude 10.5 in Sagittarius, 42 Isis on the 19th at magnitude 9.2 in Sagittarius and 39 Laetitia on the 24th at magnitude 9.6 in Capricornus.

At the end of July 11th magnitude 8 Flora visits the galaxy trio of M95, M96 and M105 in Leo. It will be low in the early evening western sky at the time.

COMETS

Comet C/2003 K4 (LINEAR) slowly arcs southeast through Eridanus this month. Visible in the late morning sky, LINEAR should lie between 12th and 13th magnitude.

Comet C/2003 T4 (LINEAR) may fade from 10th to 11th magnitude this month as it moves through Columba and Puppis near the border with Canis Major. It will be best observed in the pre-dawn morning sky, although it may be seen early in the month near the end of evening twilight. On 7th July, LINEAR will be within a degree of Delta Columbae.

Comet 9P/Tempel, visible in the evening as it moves southeast through Virgo and Libra, will be the subject of much attention this month. If all goes according to plan, on 4th July, a day before perihelion, an impactor from the Deep Impact space probe will collide with the comet. While the impact is expected to create a large crater, the resulting release of dust and ice could see the 9th magnitude comet surge in brightness by several magnitudes, perhaps to 5th magnitude.

Comet 21P/Giacobini-Zinner is at perihelion this month and should peak in brightness at 10th magnitude. Visible only in the late morning sky, Giacobini-Zinner will be moving through Aries, Taurus, and Orion. Around 6th July, the comet will be less than 4 degrees from the Pleiades, and two weeks later, just one degree will separate it from 1st magnitude Aldebaran.

Comet 37P/Forbes moves through Lupus and Scorpius this month. At 12th magnitude, the comet will be visible for most of the night, setting before dawn.

Comet C/2004 Q2 (Machholz) opens the month in the evening sky, setting around 11pm. It commences July in Canes Venatici, moving slowly towards the southeast, and mid-month moves briefly into Coma Berenices and then a few days later into Boötes. It remains in this constellation until October, but by the close of July will be fainter than 12th magnitude.

METEOR SHOWERS

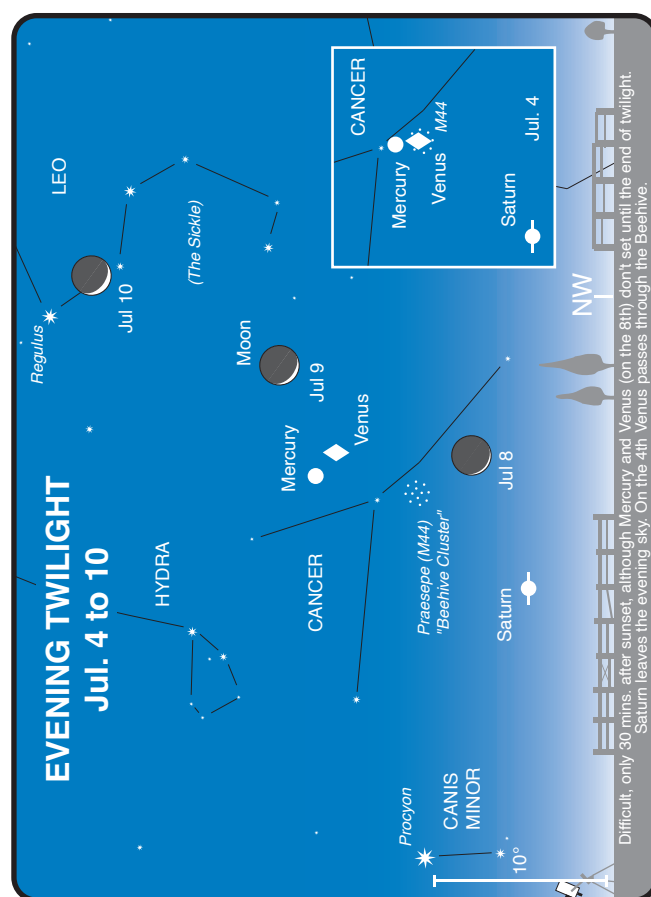
The **Pegasids** are a short-lived shower, lasting only from the 7th to 13th, with maximum on the 9th. The shower is best viewed during the second half of the night, and produces faint, swift meteors. The zenith hourly rate is low, and about 3 can be expected. The radiant is on the western side of the Great Square of Pegasus, near 3rd magnitude Alpha Pegasi.

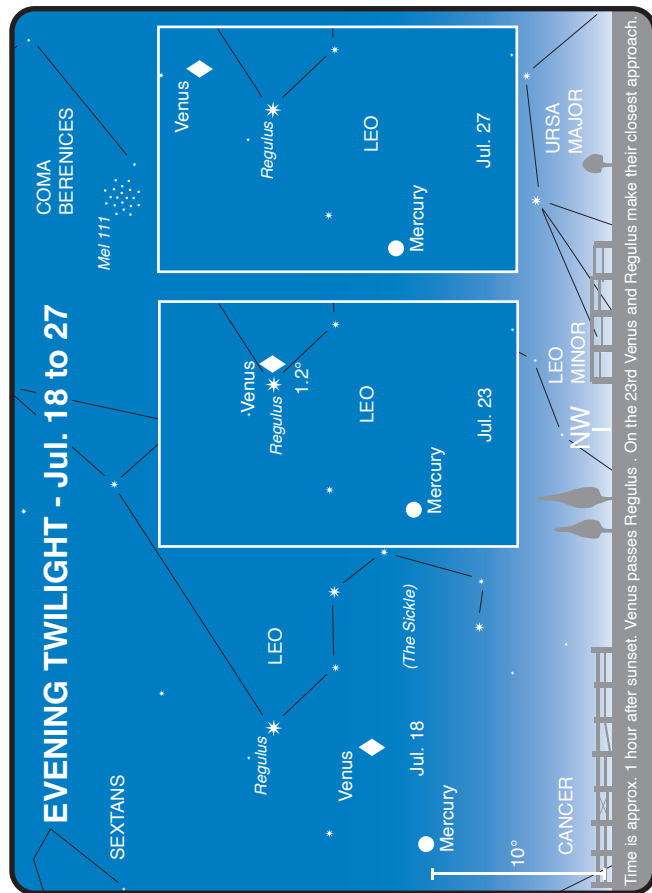
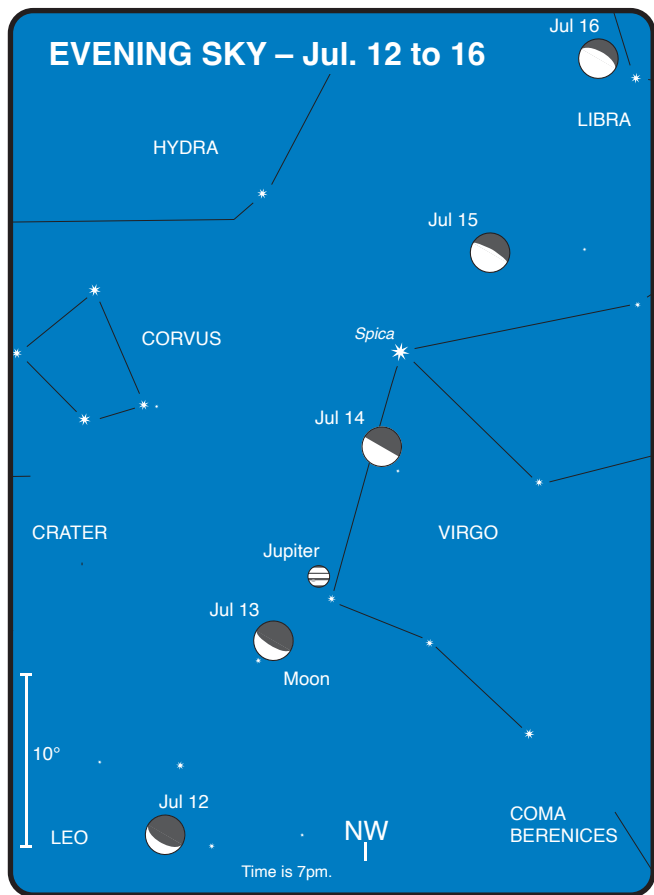
The **Phoenicids** (July) are a southern hemisphere shower, and are best seen after midnight when the radiant is at its highest altitude. The Phoenicids are active from the 10th to 16th, with maximum on the 13th. Activity is variable, but zenith hourly rates of 3 – 10 have been recorded, although in more recent years the rate has been less than 4 per hour.

DIARY

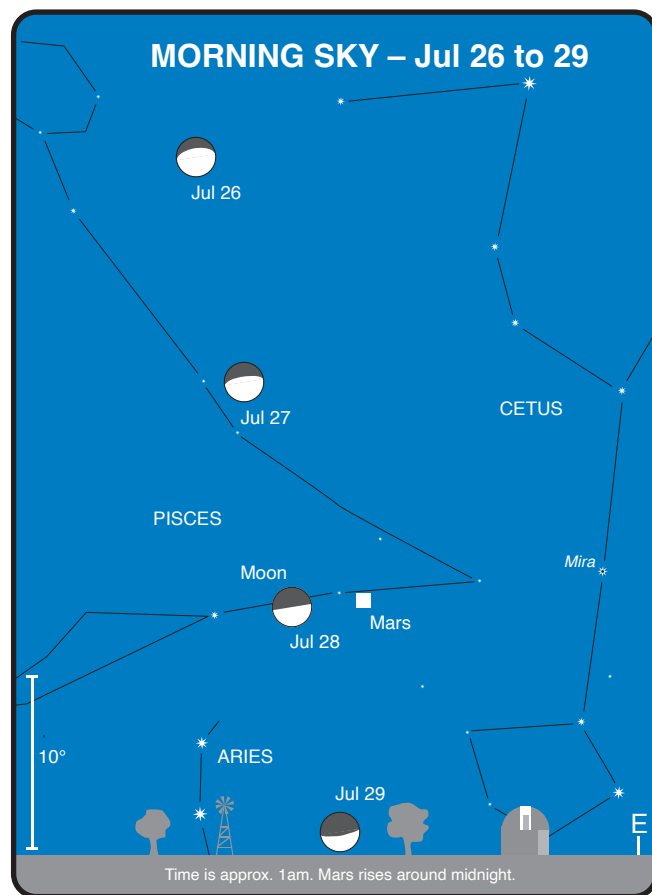
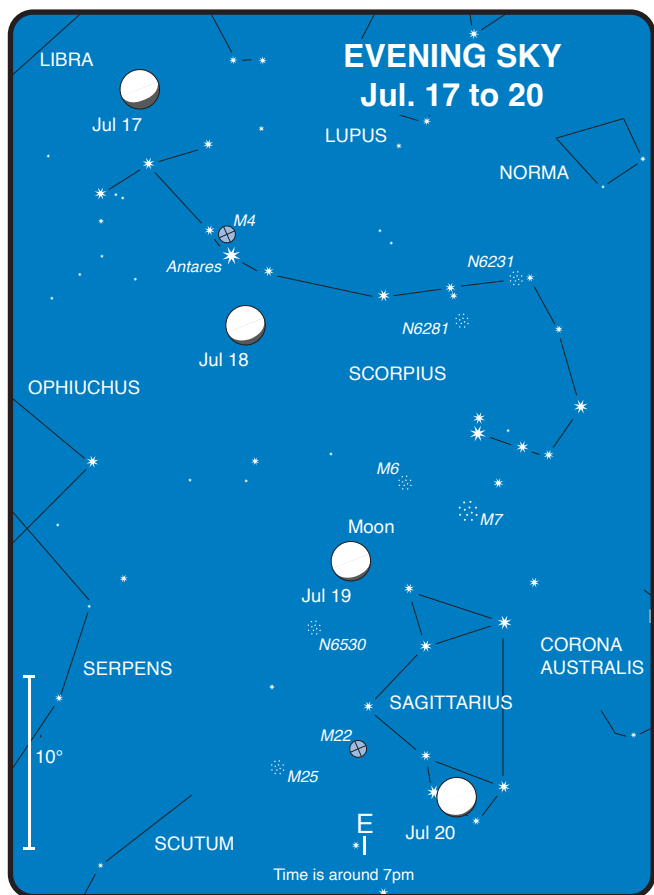
1st	m.p. 4 Vesta 0.3°S of NGC 1647 (OC) in Taurus
3rd	Mercury 1°SW of Beehive Cluster (OC) in Cancer
3rd	m.p. 115 Thyra 0.5°N of Sextans B (IG) in Sextans
4th	pm Venus 0.1°E of Beehive Cluster (OC) in Cancer
5th	Venus at greatest latitude north
5th	3 pm (1 pm WST) Earth at aphelion
6th	10:02 pm (8:02 pm WST) New Moon
7th	m.p. 8 Flora 1.0°SW of star Eta Leonis
7th	Mercury at descending node

7th	6 pm (4 pm WST) Mercury 1.6°S of Venus
9th	4 am (2 am WST) Mercury 5°S of Moon
9th	4 am (2 am WST) Moon at apogee
9th	5 am (3 am WST) Venus 3°S of Moon
9th	1 pm (11 am WST) Mercury greatest elongation east (26°)
10th	m.p. 532 Herculina 0.3°N of NGC 3190 (SG) in Leo
12th	m.p. 29 Amphitrite 0.2°E of NGC 4504 (SG) in Virgo
12th	m.p. 29 Amphitrite 0.7°NE of NGC 4487 (SG) in Virgo
14th	4 am (2 am WST) Jupiter 0.8°N of Moon Occn.
14th	Mars 0.5°N of NGC 488 (SG) in Pisces
14th	m.p. 115 Thyra 1.0°NE of NGC 3166 (SG) in Sextans
15th	1:20 am (11:20 pm WST, prev day) First Quarter Moon
17th	Mars at perihelion
18th	m.p. 10 Hygiea 0.2°NE of NGC 4504 (SG) in Virgo
18th	Mercury at aphelion
18th	2 pm (Noon WST) Antares 0.6°S of Moon Occn.
20th	Comet 21P/Giacobini-Zinner 0.9°NE of star Aldebaran
21st	9:00 pm (7:00 pm WST) Full Moon
22nd	6 am (4 am WST) Moon at perigee
22nd	3 pm (1 pm WST) Mercury stationary
22nd	11 pm (9 pm WST) Neptune 4°N of Moon
23rd	1 am (11 pm WST, prev day) Venus 1.2°N of Regulus
24th	3 am (1 am WST) Saturn in conjunction with Sun
24th	1 pm (11 am WST) Uranus 2°N of Moon
25th	Jupiter 0.5°SW of NGC 4691 (SG) in Virgo
26th	m.p. 29 Amphitrite 0.5°SW of NGC 4699 (SG) in Virgo
28th	6 am (4 am WST) Mars 4°S of Moon
28th	1:19 pm (11:19 am WST) Last Quarter Moon
30th	m.p. 8 Flora 0.4°N of M95 (SG) in Leo
31st	m.p. 4 Vesta 1.0°S of star Zeta Tauri
31st	m.p. 8 Flora 0.8°SW of M105 (EG) in Leo
31st	m.p. 8 Flora 0.2°W of M96 (SG) in Leo



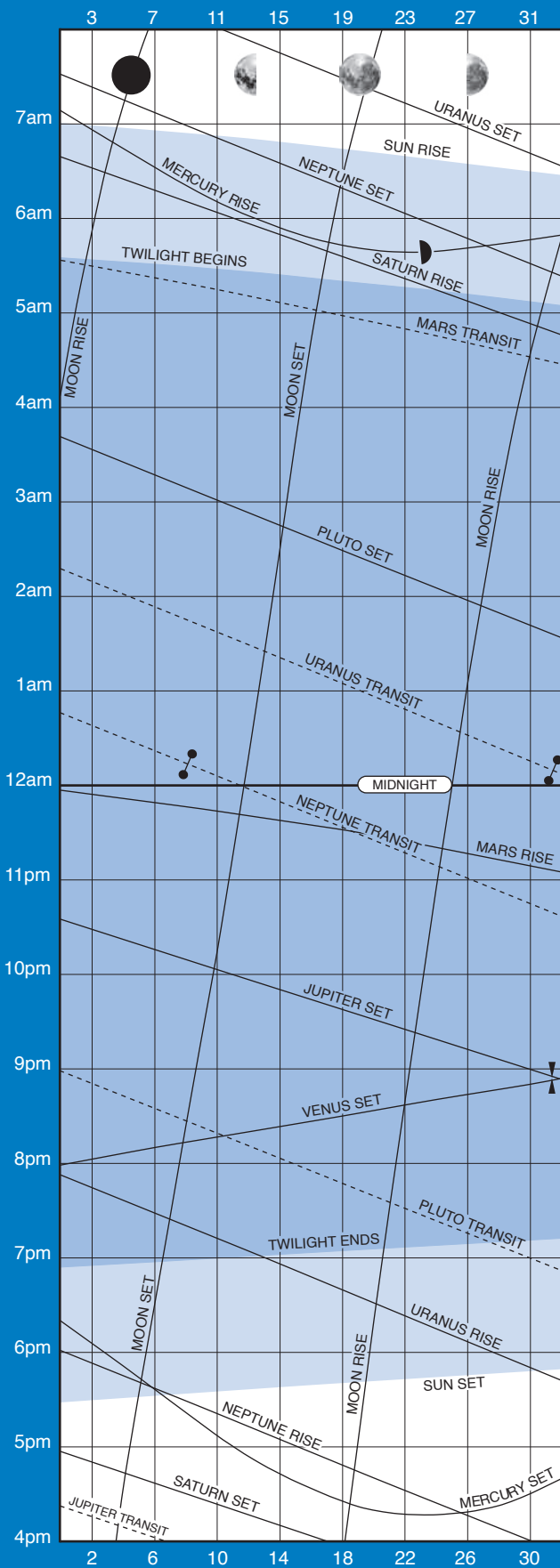


Approximate local standard time.



AUGUST

RISE/SET CHART



Approximate local standard time.

HIGHLIGHTS

- Antares and Moon close, occultation from far north Australia.
- Venus and Moon close.
- Venus and Jupiter close.
- Neptune at opposition.

THE MOON

- 5th Moon at apogee (furthest from Earth – 406,632 km distant, angular size 29.5').
- 5th New Moon.
- 8th Occultation of Venus by the Moon (not visible from Australia).
- 10th Occultation of Jupiter by the Moon (not visible from Australia).
- 13th First Quarter.
- 14th Occultation of Antares by the Moon. Only visible from extreme north of Australia (see Occultation Tables in Part II for times for Darwin), Antares and the Moon appear close for the rest of the continent (see Sky View).
- 19th Moon at perigee (closest to Earth – 357,393 km distant, angular size 33.3').
- 20th Full Moon.
- 27th Last Quarter.

THE PLANETS

MERCURY is in inferior conjunction (between Earth and Sun) on the 6th, and thereafter becomes a dawn star. The planet reaches its greatest elongation west of the Sun on the 24th (18°). Due to the high eccentricity of the planet's orbit, the angular distance between elongations varies from 18° to 28°. Therefore this month's elongation is far from favourable; nevertheless, observers should be able to spot the planet in the twilight without too much difficulty.

APPEARANCE of the PLANETS

MERCURY

Mercury is in inferior conjunction on the 6th



24th Aug
Greatest elongation west
dia 7.37"
mag -0.1



31st Aug
dia 6.11"
mag -0.9

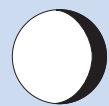
VENUS

15th Aug
dia 13.29"
mag -4.0

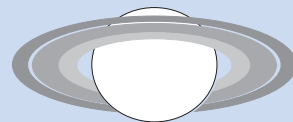


MARS

15th Aug
dia 12.45"
mag -0.7

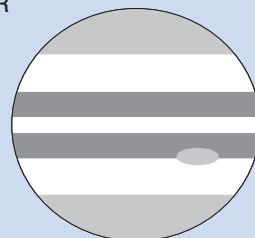


SATURN



15th Aug
dia 16.55"
mag 0.3

JUPITER



15th Aug
dia 32.87"
mag -1.8

URANUS

15th Aug
dia 3.69"
mag 5.7



NEPTUNE

9th Aug
Opposition
dia 2.35"
mag 7.8



PLUTO

15th Aug
dia 0.11"
mag 13.9



VENUS is prominent in the western evening sky, setting around 8pm. On the 8th, the 3-day old thin crescent Moon appears close to the brightest planet (see Sky View). Leaving Leo early in the month, Venus moves into Virgo and heads in the direction of Jupiter and Spica. We are in for a real treat this month and next as the two brightest planets (Venus and Jupiter), the Moon and Spica play out some interesting configurations and close approaches. At month's end Venus (at -3.9 magnitude) and Jupiter (at -1.9 magnitude) appear just 2° apart, with 1st magnitude Spica (Alpha Virginis) above the bright pair.

MARS, rising just prior to midnight, moves from Pisces into Cetus in the first week of the month, then into Aries where it remains until late September. This month the Sun-Earth-Mars angle is 90°, and Mars is at quadrature (see Orbital Aspects diagram on p. 14). In telescopes the Martian disc appears distinctly gibbous (egg-shaped) at this time, the Sun illuminating 87% of the planet's surface from our viewpoint on Earth. The November opposition is eagerly awaited following the spectacular August 2003 view. Alas, the angular size this year is smaller, but they do not get any better until 2018/2020. To get a feel for a poor opposition, try viewing the planet with your telescope from late August to early September when the disc will be around 14 arc seconds (this is how the 2012 opposition will look). This will provide a sobering reminder as to why we look forward so much to the favourable perihelic oppositions. On the 24th and 25th, the gibbous Moon appears near Mars (see Sky View).

JUPITER, in Virgo, sets around 10pm mid-month. The planet moves toward the 1st magnitude star Spica during the month, and has a close approach with Venus (see left). On the 10th, the crescent Moon appears close to Jupiter (see Sky View).

SATURN makes its debut in the eastern dawn sky this month, rising just above the open star cluster M44, the Beehive (see Sky View).

URANUS, rising around 7pm, is visible for most of the night. The planet reaches opposition early next month.

NEPTUNE is in opposition on the 9th and is visible the entire night. A special treat for any Neptunians that may be looking our way on the 9th; they will witness a transit of the Earth across the face of the Sun. This rare series of transits began in 2001, and will end with next year's opposition.

PLUTO, now two months past opposition, transits the meridian (due north, at its highest) around 8pm.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Capricornus. They are: 5 Astraea on the 2nd at magnitude 10.9, 44 Nysa on the 14th at magnitude 10.4 and 37 Fides on the 17th at magnitude 10.7. Also 20 Massalia reaches opposition on the 24th at magnitude 9.7 in Aquarius and 22 Kalliope on the 30th at magnitude 10.6 on the border of Piscis Austrinus and Sculptor.

On the morning of the 24th, 11th magnitude 16 Psyche will be transiting the open star cluster NGC 1647 in Taurus. It will be seen on the edge of NGC 1647 as it enters on the 23rd and leaves the cluster on the 25th.

LENTILS OF GLASS

The old geocentric view of the Earth at the centre of the Universe collapsed overnight when Galileo aimed his small telescope at Jupiter, discovering four satellites in orbit. This observation implied that everything in the Universe did not have to revolve around the Earth. The long held ideas of Aristotle and Ptolemy were soon replaced by the heliocentric view (the Solar System revolving around the Sun) proposed by Copernicus in the 16th century.

The telescope ranks as one of the greatest technological advances of mankind, although its origins are rather obscure. The Phoenicians discovered glass around 3500 BC, and very crude lenses have been found in Crete and Asia Minor, dating around 2000 BC. We know from writers in classical times that refraction, reflection and magnification were well understood. Thus it is rather surprising that the actual invention of the telescope was so long coming, considering the basic theory and ingredients for its construction had been around for a very long time.

There are tantalising references to the magnifying effects of lenses in the literature from the Middle Ages through to the Renaissance, although there is no evidence that a telescope was actually constructed in this period. The famous Franciscan friar, Roger Bacon in his *Opus Maius* (published in 1266 AD) proposes a telescope in this way:

"For we can so shape transparent bodies, and arrange them in such a way with respect to our sight and objects of vision, that the rays will be reflected and bent in any direction we desire, and under any angle we wish, we may see the object near or at a distance ... So we might also cause the Sun, Moon and stars in appearance to descend here below..."

At the end of the 13th century, glass of reasonable quality and price was being manufactured. Craftsmen in Venice and Florence had developed skills in grinding and polishing glass, and hand-held magnifying lenses were common. These lenses overcome the inability of the eye to focus on text and small items at close range, an affliction (presbyopia) common in people over forty.

By 1350 AD, the craftsmen began mounting small disks of glass, convex on both sides, into a frame — the first spectacles. Shaped like a lentil (a flattened biconvex seed of the annual plant *Lens culinaris*), they became known as *lenticils of glass*. Obviously there was a demand by older literate folk for these spectacles, and they soon became symbols of learning. About a century later, concave lenses first appeared correcting near-sightedness (myopia).

In 1538, Giambattista della Porta wrote of the properties of convex and concave lenses in his *Magia Naturalis*:

"If you know how to combine them exactly you will see both distant and near objects larger than otherwise appear and very distinct."

Now Porta had no problem with his imagination and often borrowed ideas from others, but by the sound of his writings telescope theory was well known.

Was the first telescope just an accident? The result of an early spectacle maker tinkering around with different shaped lenses, perhaps holding them to the light to check on clarity? Was the telescope around for years but suppressed due to superstitious beliefs, or the risk of being burned at the stake as a heretic? It is difficult to imagine that after several hundred years of lens making, and many references attesting to the remarkable magnifying properties of lenses by the likes of Bacon and Porta, that the early opticians did not have the knowledge and ability to build a telescope; the real puzzle is that there is no record or evidence that it actually happened. Instead, the telescope virtually materialised out of the ether in the early 17th century.

Many historians credit the Dutch spectacle maker Hans Lippershey (1570 – 1619) as the inventor of the telescope. His application for a patent in October 1608 is one of the first documented pieces of evidence of such an instrument and he was certainly the first to make the new device widely known. The patent was eventually denied as it was considered that too many people had knowledge of the invention. Indeed, toy telescopes were being sold in Paris around this time.

News of Lippershey's 'far looker' soon reached Galileo and he set about constructing his own improved *perspicillum* (the name telescope was not coined until 1611). The military and commercial use of the telescope was not lost on Lippershey or Galileo and both saw an opportunity to make money on the invention. In the autumn of 1609, Galileo turned one of his new instruments towards the Moon, thus beginning a series of discoveries that revolutionised astronomy of the day. There is evidence that Galileo was not the first to use a telescope on the heavens, but he was certainly the first with the intellect to understand the implications of what he was seeing.

Typically Galileo's instruments were tiny; the 50 mm objective (stopped down to around 25mm) had a focal length of about 1,000 mm. The field of view was around 15 arc minutes and the magnification about 15 to 20; the glass used had a green tinge (caused by iron content) and was full of little bubbles. With this, Galileo discovered the moons of Jupiter, lunar craters, phases of Venus, sunspots, and the rings of Saturn. He also realised that the Milky Way is composed of millions of stars. Imagine Galileo's joy if he could have viewed the Universe through an average amateur telescope of today's standards.

COMETS

Comet C/2003 K4 (LINEAR) continues to move southwest through Eridanus. This 13th magnitude comet is best observed in the morning sky.

Comet C/2003 T4 (LINEAR) is visible in the morning sky as it slowly moves southeast through Puppis. During August, the comet is expected to be between 11th and 12th magnitude.

Comet 9P/Tempel's brightness should be returning to normal this month following the Deep Impact event last month. Therefore, the comet should be between 10th and 11th magnitude in August's evening sky as it moves southeast through Libra and Scorpius.

Comet 21P/Giacobini-Zinner should fade from 11th to 12th magnitude this month as it moves away from both the Sun and Earth. A morning sky object, Giacobini-Zinner will be moving through Orion and Monoceros. It tours a number of open star clusters in Monoceros this month. This includes the Rosette Nebula and cluster on the 22nd.

Comet 37P/Forbes is at perihelion this month and should fade from 12th to 13th magnitude. Moving through Scorpius and Ophiuchus, the comet is best observed in the evening. In the second half of August, comet Forbes will pass near several globular clusters.

METEOR SHOWERS

The **Piscis Austrinids** and **Aquarid/Capricornid** complex is a conglomerate of many individual meteor showers. In 2005, only two of the less active are favourable moon wise, and are summarised below.

Southern iota-Aquarids

active 25th Jul to 15th August, maximum 4th August, ZHR = 2.

Northern delta-Aquarids

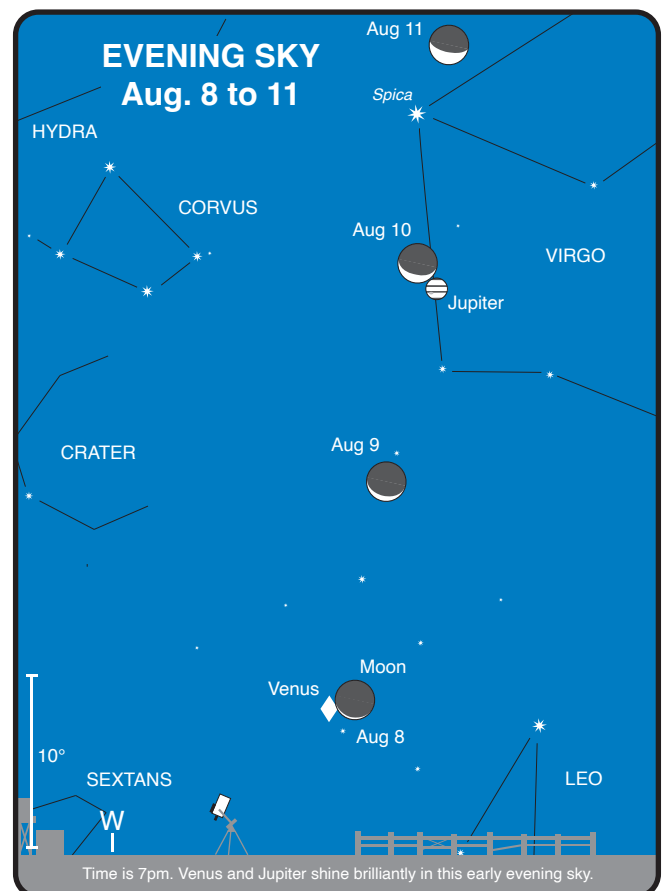
active 15th July to 25th August, maximum 8th August, ZHR = 4.

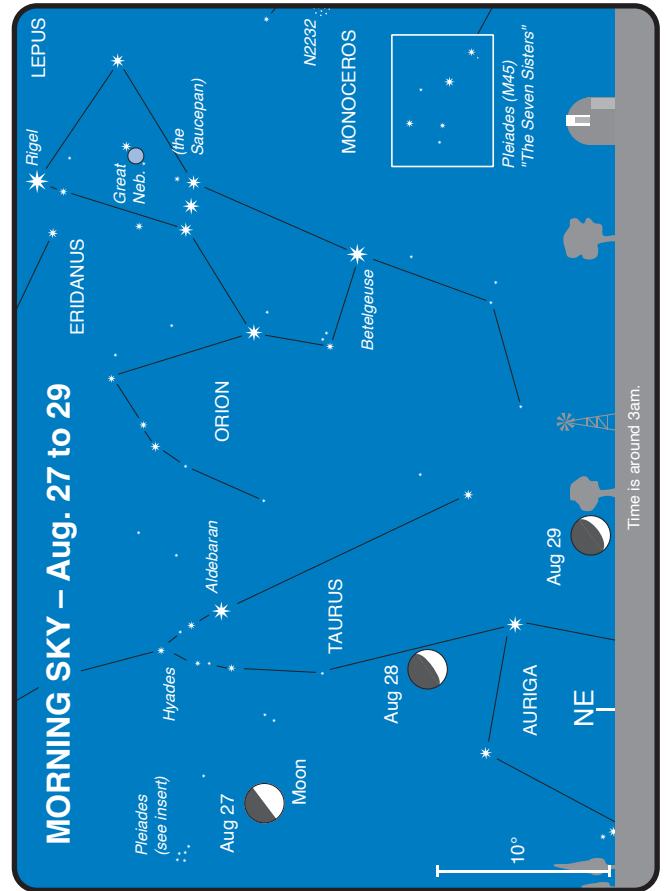
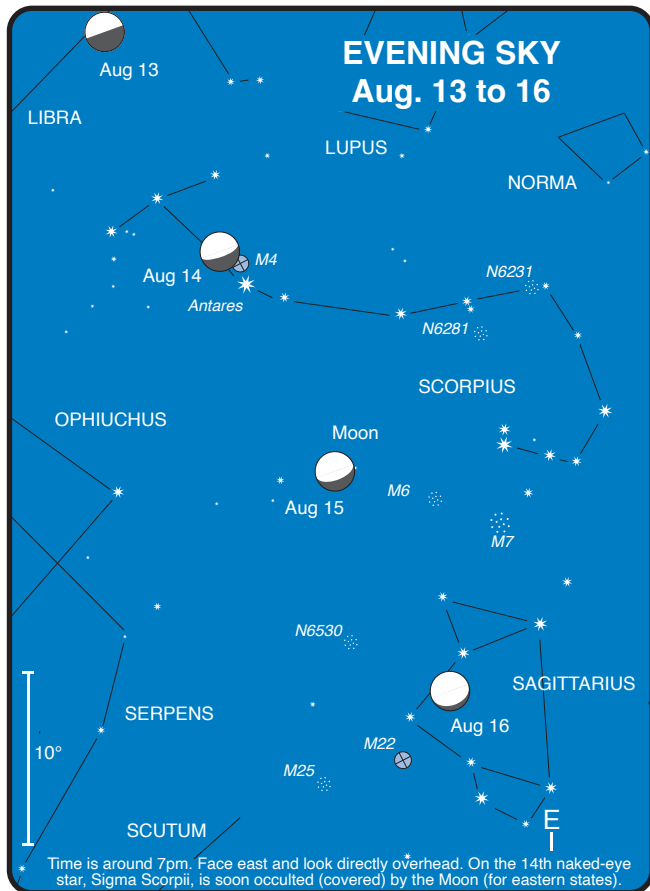
The **Perseids** unfortunately are not easily seen, for most southern observers the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17th July through to 24th August, with maximum on the 12th. The zenith hourly rate is variable and has in the past been exceptional, over 400 in 1991/1992 and down to 100 – 120 by the late 1990s. Since 2000, the peak has failed to appear; this was not unanticipated as the parent comet 109P/Swift-Tuttle passed perihelion in 1992 and is now moving back into the outer solar system.

DIARY

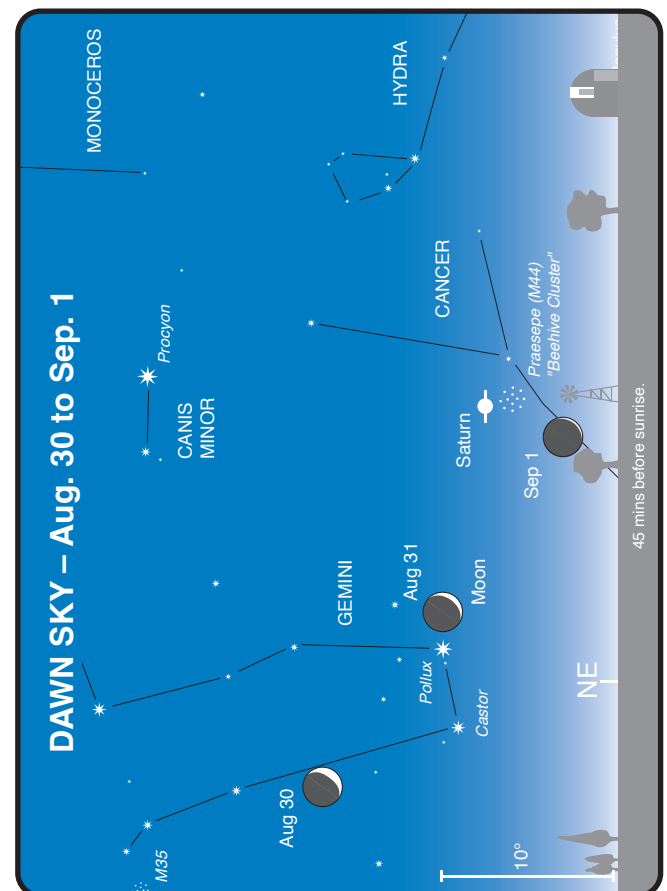
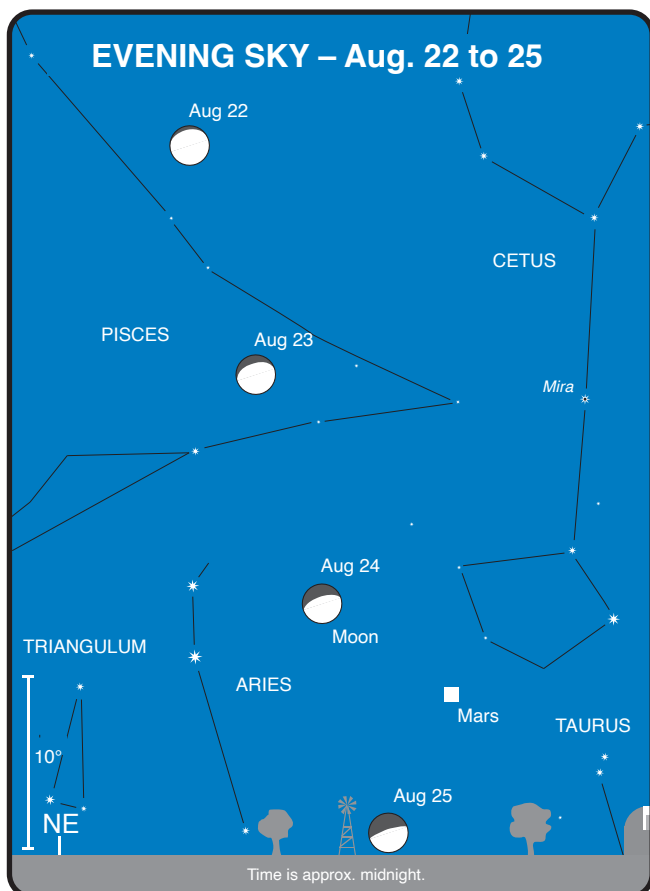
1st	8 pm	(6 pm WST) m.p. 10 Hygiea 0.1°S of NGC 4699 (SG) in Virgo
3rd	4 am	(2 am WST) m.p. 11 Parthenope 0.1°S of star Delta 1 Tauri
3rd		m.p. 29 Amphitrite 0.8°NE of NGC 4781 (SG) in Virgo
5th	8 am	(6 am WST) Moon at apogee
5th	1:05 pm	(11:05 am WST) New Moon
6th	10 am	(8 am WST) Mercury in inferior conjunction
7th		Mercury at greatest latitude south
8th		m.p. 29 Amphitrite 0.4°SW of NGC 4939 (SG) in Virgo
8th	2 pm	(Noon WST) Venus 1.2°S of Moon Occn.
9th	2 am	(Midnight WST, prev day) Neptune at opposition
10th	6 pm	(4 pm WST) Jupiter 1.3°N of Moon Occn.
11th		m.p. 11 Parthenope 1.0°N of star Aldebaran
11th		m.p. 16 Psyche 0.2°S of star Epsilon Tauri
13th		m.p. 10 Hygiea 0.15°N of NGC 4939 (SG) in Virgo
13th	12:38 pm	(10:38 am WST) First Quarter Moon
14th	11 pm	(9 pm WST) Antares 0.4°S of Moon Occn.
15th	11 pm	(9 pm WST) Mercury stationary
19th	9 am	(7 am WST) Neptune 5°N of Moon
19th		m.p. 11 Parthenope 1.0°S of NGC 1647 (OC) in Taurus
19th	4 pm	(2 pm WST) Moon at perigee
20th	3:53 am	(1:53 am WST) Full Moon
20th	5 am	(3 am WST) m.p. 4 Vesta 0.03°NW of NGC 2175 (OC) in Orion
20th		Comet 21P/Giacobini-Zinner 0.5°NE of NGC 2236 (OC) in Monoceros
20th	10 pm	(8 pm WST) Uranus 2°N of Moon
21st	11 pm	(9 pm WST) Comet 37P/Forbes 0.05°N of NGC 6316 (GC) in Ophiuchus
22nd		Comet 21P/Giacobini-Zinner 1.0°NE of Rosette Nebula NGC 2244 (BN OC) in Monoceros

22nd		Comet 21P/Giacobini-Zinner 0.5°NW of NGC 2252 (OC) in Monoceros
24th	9 am	(7 am WST) Mercury greatest elongation west (18°)
24th		m.p. 16 Psyche 0.2°N of NGC 1647 (OC) in Taurus
25th		Venus 0.3°N of NGC 4546 (LG) in Virgo
25th		Comet 21P/Giacobini-Zinner 0.4°NW of NGC 2269 (OC) in Monoceros
25th	5 pm	(3 pm WST) Mars 6°S of Moon
26th		Mercury at ascending node
27th	1:18 am	(11:18 pm WST, prev day) Last Quarter Moon
27th		m.p. 10 Hygiea 0.8°SW of star Spica
28th		Venus 0.7°N of NGC 4697 (EG) in Virgo
29th		Venus 1°N of NGC 4731 (SG) in Virgo
30th		Venus 1°NE of NGC 4775 (SG) in Virgo
31st		Mercury at perihelion
31st		Venus at descending node



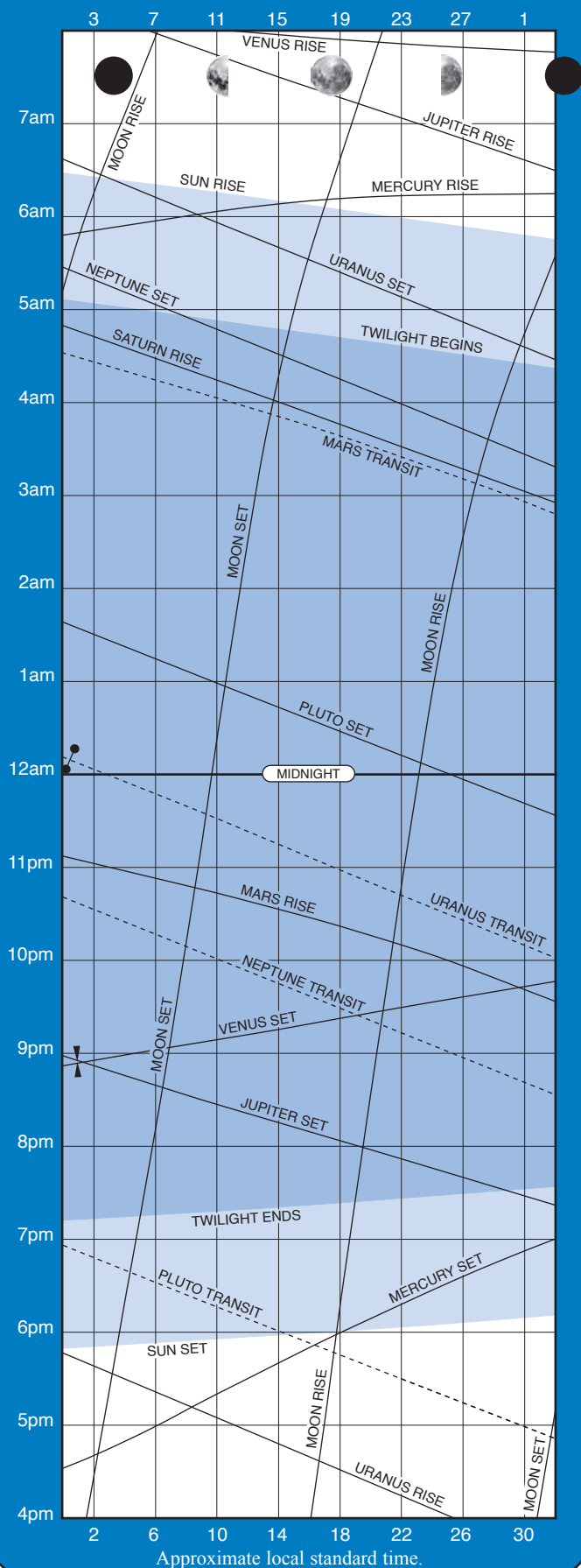


Approximate local standard time.



SEPTEMBER

RISE/SET CHART



HIGHLIGHTS

- Spica, Moon, Venus and Jupiter close in the evening sky.
- Occultation of the Pleiades star cluster by the Moon.
- Saturn close to M44, the Beehive Star Cluster.
- Uranus at opposition.
- Comet 37P/Forbes has some interesting encounters with globular clusters in Sagittarius.
- Minor planet 18 Melpomene has a brief meeting with Pluto.

THE MOON

- 1st Moon at apogee (furthest from Earth – 406,213 km distant, angular size 29.6').
- 4th New Moon.
- 7th Occultation of Spica by the Moon, not visible from Australia. Although we miss the actual occultation, this is not one to be ignored. We see an exquisite display in the evening sky between the Moon, two planets and this bright star (see Venus below).
- 7th Occultation of Venus by the Moon, not visible from Australia.
- 11th Occultation of Antares by the Moon, not visible from Australia.
- 11th First Quarter.
- 17th Moon at perigee (closest to Earth – 360,405 km distant, angular size 33.7').
- 18th Full Moon.
- 23rd Occultation of the Pleiades (M45) by the Moon
- 25th Last Quarter.
- 29th Moon at apogee (furthest from Earth – 405,308 km distant, angular size 29.4').

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 18th



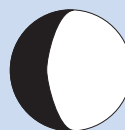
5th Sep
dia 5.52"
mag -1.2



25th Sep
dia 4.79"
mag -1.1

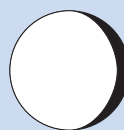
VENUS

15th Sep
dia 16.03"
mag -4.1

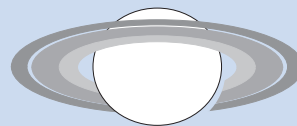


MARS

15th Sep
dia 15.78"
mag -1.3

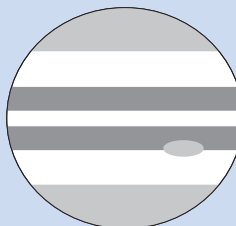


SATURN



15th Sep
dia 17.00"
mag 0.3

JUPITER



15th Sep
dia 31.25"
mag -1.7

URANUS

1st Sep
Opposition
dia 3.70"
mag 5.7



NEPTUNE

15th Sep
dia 2.33"
mag 7.9



PLUTO

15th Sep
dia 0.11"
mag 13.9



THE PLANETS

MERCURY is in a somewhat poor position for observation this month. The planet moves through the morning twilight close to the Sun until superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 18th. Mercury then swings back into the evening sky, but will not reach its evening best until next month.

VENUS begins the month just 1.3° from Jupiter, the pair situated just 6° below Spica in Virgo in the western evening sky. Venus separates from Jupiter and moves toward Spica, and by the 6th will be 1.7° north (to the right) of the 1st magnitude star, with Jupiter and the thin crescent Moon below. On the following evening, and it doesn't get much better than this, the 3-day old Moon appears directly between Spica and Venus (the star and planet just 2° apart), with Jupiter about 5° nearer to the horizon (see

Sky View). After the close encounters in Virgo, Venus distances itself and moves into Libra later in the month.

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

MARS rises around 10:30pm in the eastern evening sky in Aries, moving into Taurus in the last week of September. The Red Planet will be at opposition on 7th November, and observers will note the Martian disc becoming tantalizingly larger and brighter over the coming weeks. The optimum time for observations is from mid-October to mid-November, but this can be extended a few weeks either side of this period. On the 23rd, the gibbous 20 day old Moon is about 9° below the planet (see Sky View); in this case it is not the distance between the planet and Moon that is interesting, but the fact that the Moon is occulting members of

SEEING RED

With a title like this you can be forgiven for thinking this article is about a dark adapted amateur being confronted by a pair of zillion watt car headlights on high beam – but it's nothing like this.

The casual sky watcher might think the heavens are very much a black and white proposition. The observant person may see coloured hues in some of the brightest stars like Alpha Centauri (yellow) and Beta Centauri (blue). These are well known bright naked eye stars but there are numerous others only limited by the size of your binoculars or telescope. However, one does not hear of many red stars, particularly naked eye examples. The obvious exceptions are Antares (Alpha Scorpii) and Betelgeuse (Alpha Orionis). Another one is Gamma Crucis (the top star in the Southern Cross), whose orange colour is obvious when compared to the blue-white colour of the other three main stars of the cross.

So what of other bright red stars? Well for starters, they are not so easy to identify. The logical place to begin is the spectrum of the stars. The main spectral classes are O, B, A, F, G, K and M. Unfortunately there is not, strictly speaking, a 'red' class, however this list is broadly in order of temperature, O being the hottest and M the coolest. But the colour can also be inferred, for stars tend to follow the classic black-body radiation sequence, the highest temperature being blue, and the coolest, red. Think of an iron bar as an example. When you first start to heat it we see it as red, as the temperature increases we eventually see blue-white.

The best place to start is to look at all 'M' class stars. The table here gives all stars that fit into this category brighter than 4th magnitude, visible from Australian latitudes. You will notice that Antares, Betelgeuse and Gamma Crucis appear on the list. You might say, "why not go to 6th magnitude, i.e., the approximate naked eye limit under dark skies?" The 4th magnitude cut off was a little arbitrary, however we need to remember the structure of our eyes. The rods are the most sensitive but only see in shades of grey. The cones, which detect colour, need a certain brightness, or number of photons, before they kick in. So you may need some optical aid (binoculars can be a great help) to detect colour in even the 3rd or 4th magnitude stars, especially if you are stuck under light polluted skies. Making comparisons with other nearby bright stars of similar magnitude may help in detecting a difference, like that mentioned above for Gamma Crucis.

The number following the class is a subclass, from 0 to 9. The difference in colour within a spectral class can be subtle. In general early type 'M' stars, such as M0 or M1, have been reported as yellow-orange. They can then progress through orange and finally red as the number increases. The roman numerals following the subclass is the luminosity class.

Ultimately the colour seen comes down to personal perception, the sky conditions and the equipment being used for the observation.

Have fun — we at Quasar would be interested in your observations of these stars, so please drop us an email.

M Class Stars (down to magnitude 4.0)

Constellation	Designation	RA (2000.0) hh mm.m	Dec. dd mm	Magn.	Spectral Class	All Sky Map No.	Notes
Andromeda	β	01 09.7	+35 37	2.1	M0 III	3	
Aquarius	λ	22 52.6	-07 34	3.8	M2 III	8	
Cetus	α	03 02.2	+04 05	2.8	M2 III	2	
Cetus	ο	02 19.3	-02 59	2 – 10	M5 IIIe	2	(i)
Crux	γ	12 31.2	-57 07	1.6	M4 III	1	
Eridanus	γ	03 58.0	-13 30	3	M1 III	2	
Gemini	η	06 14.9	+22 30	3.2 – 3.9	M3 III	5	(ii)
Grus	β	22 42.7	-46 53	2.1	M5 III	8	
Hercules	α	17 14.6	+14 23	3.0 – 4.0	M5 II	7	(iii)
Hydrus	γ	03 47.2	-74 14	3.2	M2 III	1	
Libra	σ	15 04.1	-25 17	3.4	M4 III	6	(ii)
Lynx	α	09 21.1	+34 23	3.3	M0 III	5	
Musca	ε	12 17.6	-67 58	4	M6 III	1	
Ophiuchus	δ	16 14.3	-03 42	2.7	M1 III	6	
Orion	α	05 55.2	+07 24	0.4 – 1.3	M2 Ia	3	(iv)
Pegasus	β	23 03.8	+28 05	2.3 – 2.8	M2 II	9	(ii)
Sagitta	δ	19 47.4	+18 32	3.7	M2 III + B6v	9	
Sagittarius	η	18 17.6	-36 46	3.1	M2 III	8	
Scorpius	α	16 29.4	-26 26	0.9 – 1. ?	M1 Iab	6	(v)
Virgo	δ	12 55.6	+03 24	3.4	M3 III	6	

Notes

- (i) Mira, the prototype of this type of long period variable. The period is 330 days.
- (ii) Variable star
- (iii) Alpha Herculis is variable and has a close companion (5" away) at magnitude 5.4. A telescope is needed to split the pair. They have been described as orange and emerald green.
- (iv) Betelgeuse, a semi-regular variable
- (v) Antares, a semi regular variable and double star

the Pleiades star cluster (M45), from about midnight until 3:30am (see occultation tables in Part II).

JUPITER begins the month just 1.3° from Venus and during the first week is involved in a series of conjunctions and alignments with Spica, the Moon and Venus (see Venus and Sky View). During the last week of September Jupiter will be around 3° from Spica. By month's end Jupiter will set by the end of astronomical twilight, moving towards solar conjunction next month.

SATURN rises around 4am mid-month in Cancer, just above the open cluster M44 (also known as the Beehive or Praesepe). Never more than 2° from the heart of M44 all month, the planet skims just 0.5° from the cluster's outer fringes on the 12th. M44 has been known since antiquity, being visible to the unaided eye as a nebulous patch under dark skies. Galileo was the first to understand the true nature of Praesepe when he turned the newly invented telescope onto the object in 1610, revealing 36 stars. In all, several hundred stars are members of the cluster, which is over a degree across, making it a good binocular or low power telescope object. On the 28th and 29th, the crescent Moon appears near Saturn in Cancer (see Sky View).

URANUS is at opposition on the 1st, and is visible the entire night.

NEPTUNE, now one month past opposition, transits the meridian (due north) around 10pm.

PLUTO, in the evening sky in Serpens, sets around 1am and is only visible to keen observers with large (> 20 cm) telescopes (see finder chart p. 125).

MINOR PLANETS. 471 Papagena reaches opposition on the 9th at magnitude 9.9 in Sculptor. On the 4th, 10.5 magnitude minor planet 18 Melpomene passes 0.5 degrees to the northeast of Pluto.

COMETS

Comet C/2003 K4 (LINEAR) remains at 13th magnitude this month. Visible from late evening onwards, the comet is moving through Eridanus.

Comet C/2003 T4 (LINEAR) moves south through Puppis during September. The comet is 12th magnitude and in the morning sky. During mid-September, LINEAR will be near the open cluster NGC 2451.

Comet 9P/Tempel is an evening object in Scorpius this month. Fading from 11th to 12th magnitude, the comet passes near the globular cluster M4 during the first week, and ends September near M6.

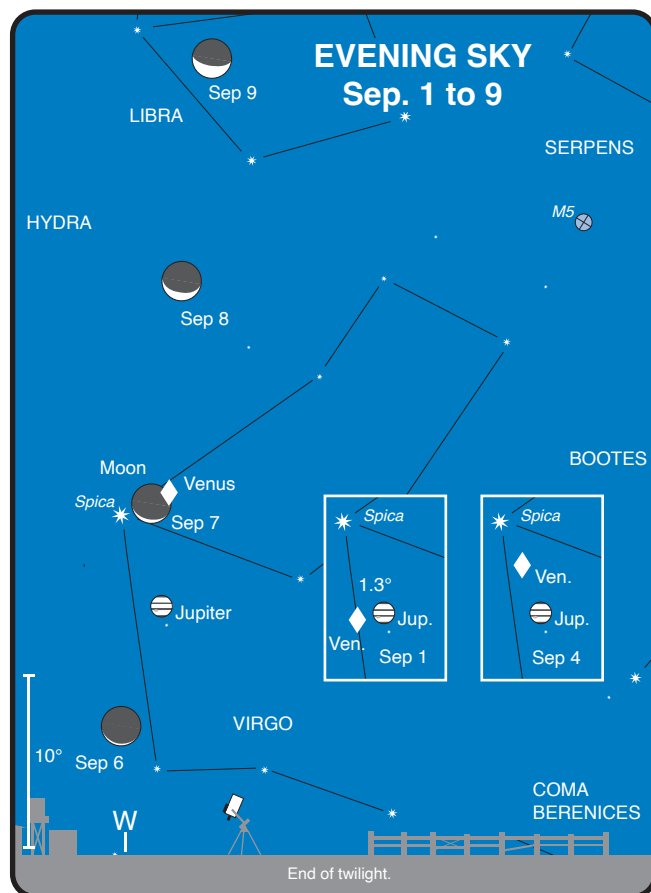
Comet 21P/Giacobini-Zinner resides in Monoceros this month. Between 12th and 13th magnitude, this comet will best be observed before the beginning of dawn.

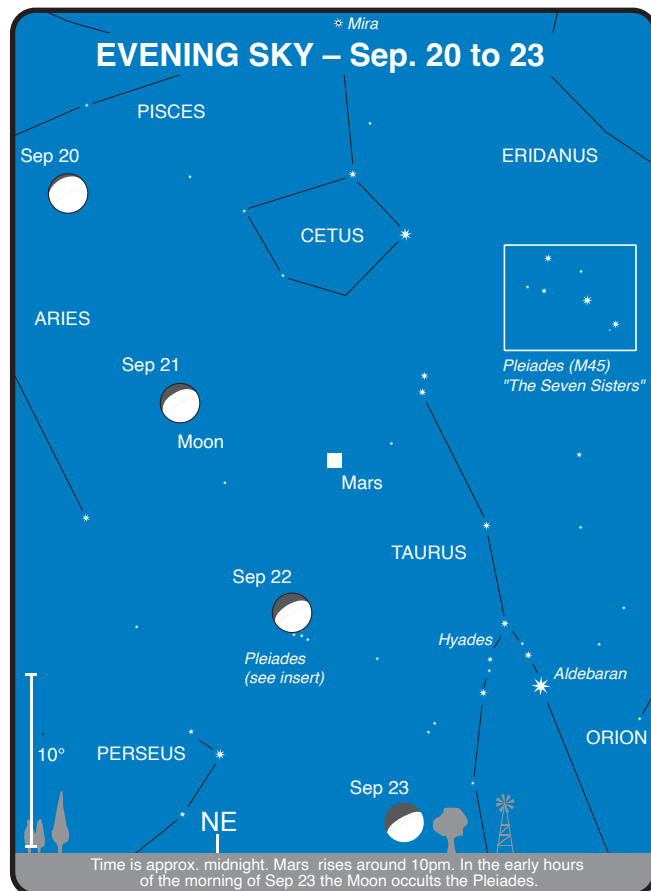
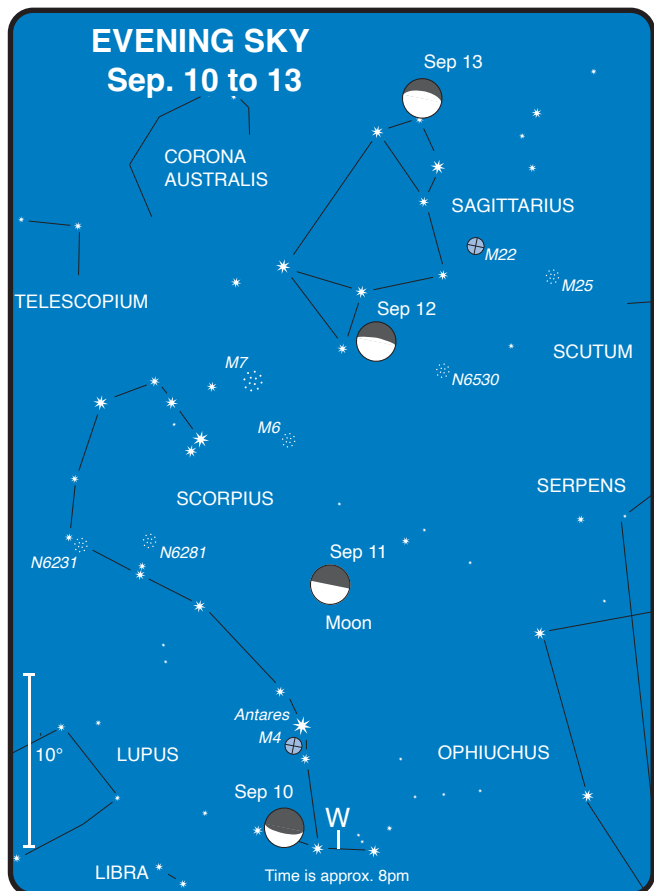
Comet 37P/Forbes opens September in Ophiuchus but moves quickly into Sagittarius. Although fading from 13th magnitude, Forbes will be involved in some interesting conjunctions as it passes near M8, M20, M28, and M22.

DIARY

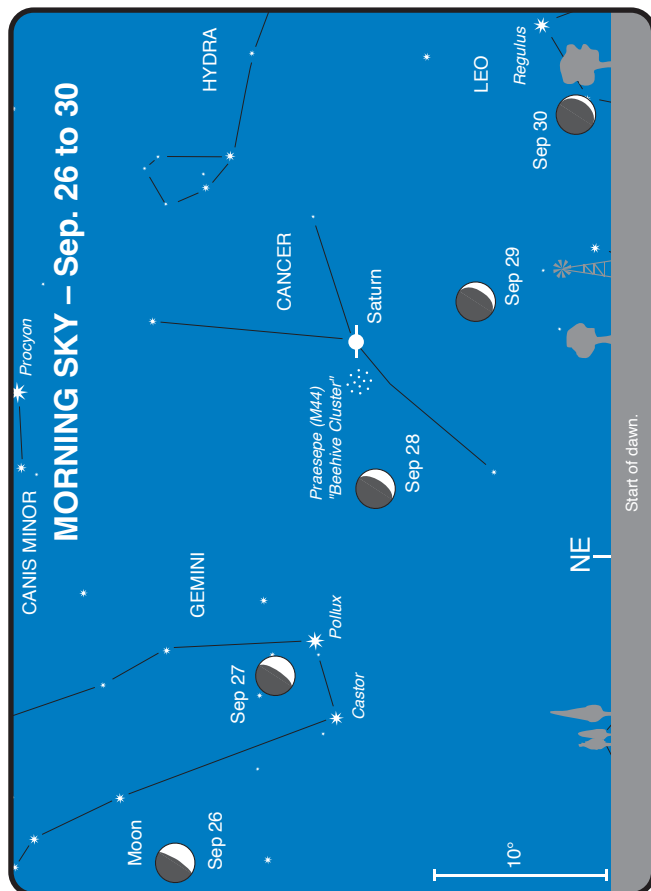
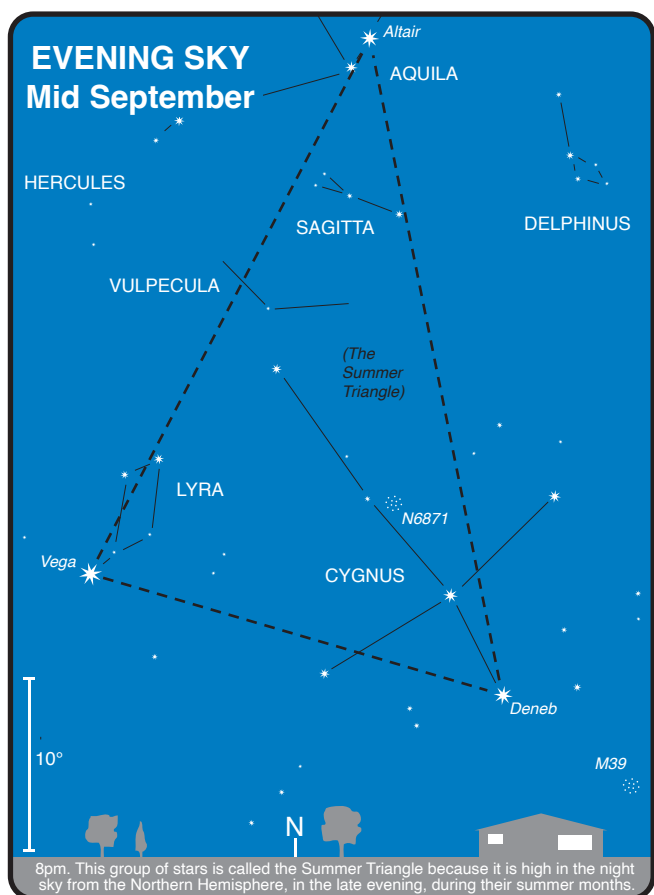
1st	3 am	(1 am WST) Saturn 5°S of Moon
1st		Venus 1°N of NGC 4958 (LG) in Virgo
1st	1 pm	(11 am WST) Moon at apogee
1st	1 pm	(11 am WST) Uranus at opposition
2nd		Venus 0.2°N of NGC 49995 (SG) in Virgo
2nd	10 pm	(8 pm WST) Venus 1.4°S of Jupiter
3rd		m.p. 14 Irene 1.0°S of star Beta Scorpii
3rd		Comet 21P/Giacobini-Zinner 0.7°NE of NGC 2324 (OC) in Monoceros
3rd	1 pm	(11 am WST) Pluto stationary
4th	4:45 am	(2:45 am WST) New Moon
4th		Pluto 0.5°SW of m.p. 18 Melpomene
4th	9 pm	(7 pm WST) Mercury 1.1°N of Regulus
4th	pm	m.p. 39 Laetitia 0.3°W of Barnard's Galaxy NGC 6822 (IG) in Sagittarius
6th	7 am	(5 am WST) Venus 1.8°N of Spica
7th	10 am	(8 am WST) Jupiter 1.8°N of Moon
7th	4 pm	(2 pm WST) Spica 1.3°S of Moon Occn.
7th	7 pm	(5 pm WST) Venus 0.6°N of Moon Occn.
9th		m.p. 3 Juno 1.0°SW of NGC 1662 (OC) in Orion
9th	pm	Comet 37P/Forbes 0.8°S of Lagoon Nebula M8 (BN OC) in Sagittarius
10th		Mercury at greatest latitude north

10th	10 pm	(8 pm WST) Comet 37P/Forbes 0.15°W of NGC 6544 (GC) in Sagittarius
11th	6 am	(4 am WST) Antares 0.2°S of Moon Occn.
11th	9:37 pm	(7:37 pm WST) First Quarter Moon
12th		Saturn 1°SW of the Beehive Cluster M44 (OC) in Cancer
15th	6 pm	(4 pm WST) Neptune 5°N of Moon
16th	pm	Comet 37P/Forbes 1.0°NW of M28 (GC) in Sagittarius
16th	Midnight	(10 pm WST) Moon at perigee
17th	7 am	(5 am WST) Uranus 2°N of Moon
18th	1 pm	(11 am WST) Mercury in superior conjunction
18th	12:01 pm	(10:01 am WST) Full Moon
19th	pm	Comet 9P/Tempel 1.0°S of M62 (GC) in Ophiuchus
20th	10 pm	(8 pm WST) Comet 37P/Forbes 0.1°NE of NGC 6642 (GC) in Sagittarius
21st	pm	Comet 37P/Forbes 0.7°NW of M22 (GC) in Sagittarius
22nd	8 am	(6 am WST) Jupiter 3°N of Spica
22nd	5 pm	(3 pm WST) Mars 6°S of Moon
23rd	8 am	(6 am WST) Equinox
25th	4:41 pm	(2:41 pm WST) Last Quarter Moon
26th		m.p. 7 Iris 1.0°N of NGC 6235 (GC) in Ophiuchus
26th		m.p. 15 Eunomia 0.3°N of star Sigma Librae
28th	3 pm	(1 pm WST) Saturn 5°S of Moon
29th	1 am	(11 pm WST, prev day) Moon at apogee
30th	pm	Comet 9P/Tempel 0.9°NE of NGC 6374 (OC) in Scorpius



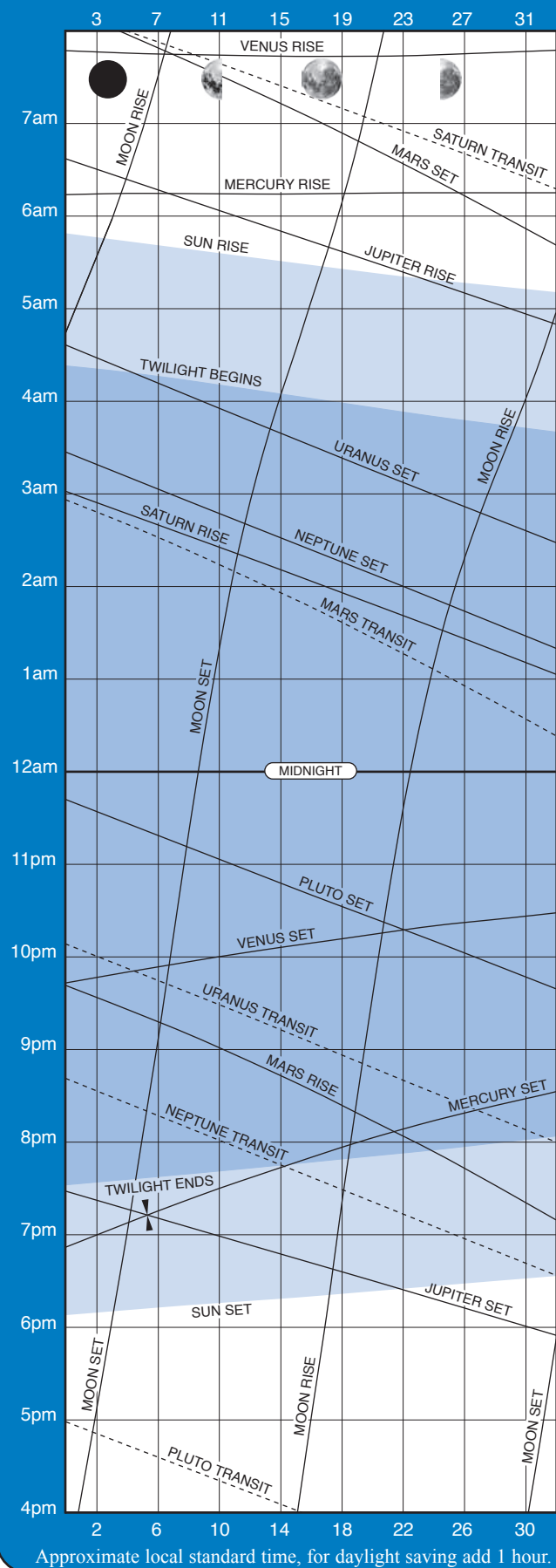


Approximate local standard time.



OCTOBER

RISE/SET CHART



HIGHLIGHTS

- Partial lunar eclipse.
- Mercury in favourable evening position for observation.
- Mercury, Jupiter and Spica close.
- Venus close to Antares.
- Closest approach to Earth by Mars.
- Minor planets, 14 Irene and 18 Melpomene, encounters a number of star clusters near the Milky Way's centre.
- Comet 9P/Tempel tours star clusters in Scorpius and Sagittarius.

THE MOON

- 3rd New Moon (annular solar eclipse, not visible from Australia – see Part II).
- 8th Occultation of Antares by the Moon, not visible from Australia.
- 11th First Quarter.
- 15th Moon at perigee (closest to Earth – 365,449 km distant, angular size 33.1').
- 17th Full Moon (partial lunar eclipse, visible from Australia – see Part II).
- 25th Last Quarter.
- 26th Moon at apogee (furthest from Earth – 404,494 km distant, angular size 29.1').

THE PLANETS

MERCURY climbs out of the western evening twilight and enters an excellent period for observation from mid-October through to mid-November. The planet spends half the month in Virgo, crosses into Libra and ends up near the head of Scorpius. From the 4th to the 7th, Mercury, Jupiter and Spica make for interesting companions in the early evening twilight (see Sky View). On the 5th, Mercury will be between Jupiter (1.5°

APPEARANCE of the PLANETS

MERCURY



5th Oct
dia 4.88''
mag -0.5



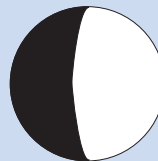
15th Oct
dia 5.16''
mag -0.3



25th Oct
dia 5.69''
mag -0.2

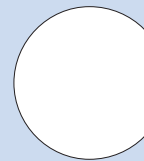
VENUS

15th Oct
dia 20.41''
mag -4.3

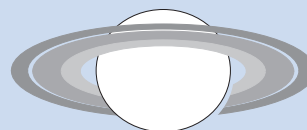


MARS

Closest approach
30th Oct
dia 20.19''
mag -2.3

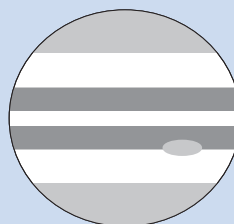


SATURN



15th Oct
dia 17.76''
mag 0.3

JUPITER



15th Oct
dia 30.62''
mag -1.7

URANUS

15th Oct
dia 3.64''
mag 5.8



NEPTUNE

15th Oct
dia 2.30''
mag 7.9



PLUTO

15th Oct
dia 0.10''
mag 13.9



to the north) and the 1st magnitude star Spica (2° south), the trio forming a straight line. A difficult observation due to the twilight but not impossible. Binoculars and a good western horizon will help and a thin crescent Moon directly above the trio enhances the view.

VENUS shines brilliantly high in the western evening sky, spending a little time in Libra, Scorpius and Ophiuchus this month. On the 7th, the 4-day old crescent Moon will appear close to Venus (see Sky View). On the 16th and 17th, the planet will be 1.7° from the 1st magnitude star Antares, Alpha Scorpii – the heart of Scorpius (see Sky View). While touring in Ophiuchus, Venus passes by several globular clusters. On the 23rd the planet is within 0.5° of the globular cluster M19 (one of the most

oblate globulars known), on the 25th within 0.3° of NGC6293 and 0.3° from NGC6355 on the 28th.

MARS, rising in the evening, spends the first week of the month in Taurus before moving into Aries. On the 19th the 17-day old Moon will be near Mars (see Sky View). The Red Planet comes to opposition next month on the 7th. It is interesting to note that the actual time of opposition does not necessarily coincide with the time of closest approach between the Earth and Mars. This year the closest approach occurs 8.2 days earlier on 30th October; the variation can be as short as 10 minutes or as long as 8.5 days. In fact, it is slightly more advantageous to view Mars at closest approach on the 30th when the disc diameter is 20.19 arc seconds,

AUSSIE AMATEURS HONOURED

In 1998 the International Astronomical Union announced the establishment of an annual award for amateurs who discover comets. This is a cash prize from the Smithsonian Astrophysical Observatory from the will of American businessman, Edgar Wilson. This award was to be shared amongst amateurs, using privately owned amateur equipment, who have been officially recognized as discoverers. This 'Edgar Wilson Award' is worth \$20,000 (US) and is open to observers worldwide. There were only two eligible candidates for the 2004 award and it was pleasing to see that both were Australians — Vello Tabur, from the ACT, and veteran comet hunter Bill Bradfield from South Australia.

Bill Bradfield discovered his 18th comet on the evening of March 23, 2004, using his 250mm Newtonian, in Cetus. The comet's designation was C/2004 F4 (Bradfield) (see Part II Comet section for an explanation of the naming convention). Like all Bill's other triumphs, this was discovered using the traditional visual method and he maintained his incredible record of not having to share any of his discoveries with other observers. It had been the end of quite a drought for Bill, having discovered his previous (No.17) back in 1995. C/2004 F4 just adds to his legendary performance which had previously been recognised with: an asteroid named after him (nominated by none other than the late Gene Shoemaker), the Berenice Page Medal in 1982 (the highest honour an amateur can receive from the Australian professional community) and receiving an Order of Australia (AM) in 1989 for service to astronomy. For those wishing to know more about Bill, Astronomy 2003 has a comprehensive interview or you can visit (www.assa.org.au/sig/comets/).

By 'traditional visual means' we refer to looking through a telescope and systematically scanning the sky. Any nebulous (cloudy) patches encountered are investigated to ensure they are not known comets or deep sky objects such as galaxies. This low-tech approach is also the low cost, most easily understood method for beginners wishing to enter the comet-hunting arena. Bill is 76 years old so don't think you are too old to start!

Vello Tabur is a much more recent edition to the Australian honour role of amateur discoverers, but has already left an indelible mark. Vello found his third comet on the evening of October 14, 2003 in Pavo — called C/2003 T3 (Tabur). His first two, C/1996 Q1 and C/1997 N1, were discovered by the traditional visual means (with some computer assistance) but C/2003 T3 was his first cometary success with his high technology, automated search technique. Although this might have been his first comet by this means, in only a few years he has already proved his technique's success by an independent discovery of Nova Centauri 2001, the discovery of Nova Sagittarii 2002 No.4 and hundreds of variable stars, many of which were previously unknown. He uses an SBIG ST6 CCD camera coupled to a normal 100mm f3.5 telephoto lens which is mounted piggy-back on a Celestron 11 tube on a Losmandy G11 German equatorial mount. You might wonder about the telephoto lens, but this is necessary to give him a reasonable field of view (4.7° X 3.6°). He already works with 334 predefined areas (with some overlap) so he doesn't need a narrower field. Anyone wishing to learn more should visit his comprehensive web site (www.tip.net.au/~vello/).

Other Australian Success Stories. Over the years there have been many comets discovered by Aussie amateurs — both deliberate and some accidental. The following Australians have also been fortunate to share in a piece of the 'Edgar Wilson' pie: Peter Williams (Sydney), Justin Tilbrook (South Australia), Steven Lee (Coonabarabran, NSW) and

Daniel Lynn (Kingslake West, Vic.). In fact, Peter Williams' discovery of C/1998 P1 made him the first person to qualify for the award. Counting Bill and Vello, we have six Aussies out of a total of 24 (to date) recipients throughout the world i.e., we account for 25%. Not bad for a country of only 20 million people!

The Future of Amateur Comet Hunting. Although it is true that the fully automated professional search programs such as LINEAR and NEAT will continue to expand and discover more and more comets — for the moment there is still a place for the amateur. We just need to act smarter and Bill and Vello make excellent role models. Bill looks as low as possible in the twilight sky, where the automated searches can't go. Vello, besides his ability to bulk survey the sky, concentrates south of declination -50° where the LINEAR's and NEAT's can't reach. At the moment these programs are primarily in the northern hemisphere.

As this article was being written, the authors became aware that American amateur Donald Machholz had just discovered his 10th comet, all achieved visually. It was on the morning of August 27, 2004 and the comet was already at an altitude of 30° at the start of dawn, sitting up in a fairly empty region in Eridanus. He was using a modest 150mm f/8 reflector, so you see a dedicated amateur with humble equipment (and a slice of luck) can still beat the 'big boys'.



Bill Bradfield with his 6" (150mm) refractor in the background.



Comet C/2003 T3 (Tabur) taken by Vello on October 18, 2003 as the comet was passing 13th magnitude galaxy NGC 6848 in Telescopium.

compared to 19.95 arc seconds at opposition. Visual observers will note a half magnitude brightening of the planet from -1.7 to -2.3 during the month. An enlargement of the disc from $17.7''$ to $20.19''$ during October will also be evident to telescope users. Obviously this opposition is not as favourable as the notable 2003 event, but the smaller planetary size this year will still afford reasonable views. See also 'Opposition of Mars' in Part II.

JUPITER makes an appearance with Mercury and Spica in the evening twilight sky early in the month (see Mercury above and Sky View). On the 22nd, the planet will be in conjunction with the Sun, reappearing in the morning sky late next month.

SATURN, rising around 2am, is just 0.3° from the 4th magnitude star Delta Cancri on the morning of the 1st. On the 26th, the 23-day old Moon appears near Saturn (see Sky View).

URANUS, in Aquarius, is high in the northern sky as it transits the meridian at 9pm mid-month.

NEPTUNE, in retrograde motion since May, returns to its west to east motion against the star field. The planet is high in the northern sky in Capricornus at the end of astronomical twilight.

PLUTO, moving toward conjunction in mid-December, sets in the evening around 10:30pm mid-month.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Cetus. They are: 51 Nemausa on the 4th at magnitude 10.5, 23 Thalia on the 4th at magnitude 10.8 and 92 Undina on the 29th at magnitude 10.9. Also 89 Julia reaches opposition on the 25th at magnitude 9.4 in Andromeda and 43 Ariadne on the 25th at magnitude 10.5 near the border of Aries and Pisces.

Over the next 2 months 14 Irene has a tour of a number of globular clusters in Ophiuchus and Sagittarius before being lost in the western twilight sky. 18 Melpomene has close encounters with some open star clusters in Sagittarius in October.

COMETS

Comet C/2003 K4 (LINEAR) is slowly moving southeast through Eridanus and is 13th magnitude in brightness. LINEAR, rising in the early evening, is visible most of the night. Around 20th October, LINEAR is within a degree of Pi Eridani.

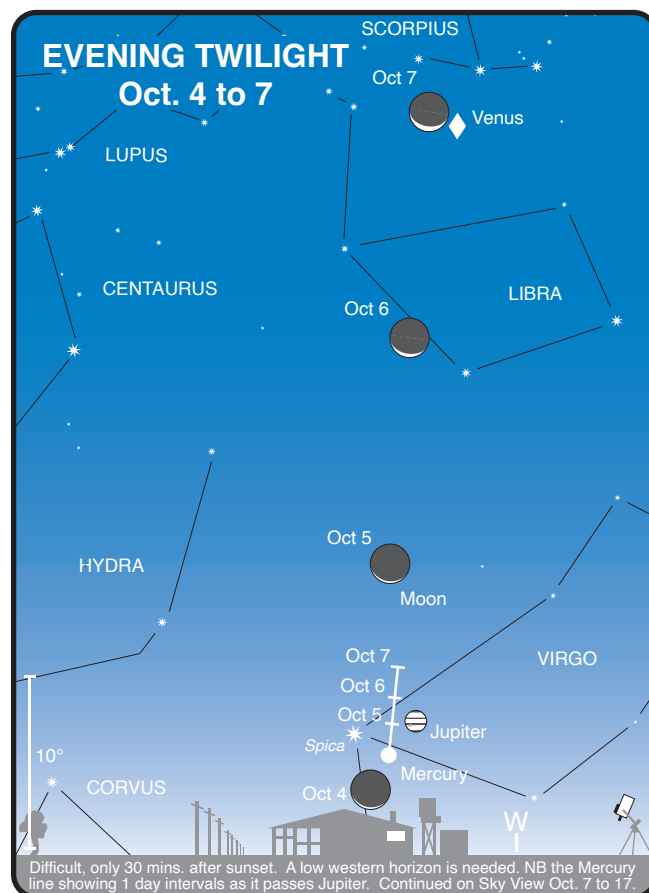
Comet C/2003 T4 (LINEAR) remains at 13th magnitude this month. Visible from late evening onwards, LINEAR is moving southwest through Puppis. On 20th October the comet will be 0.3° from Sigma Puppis.

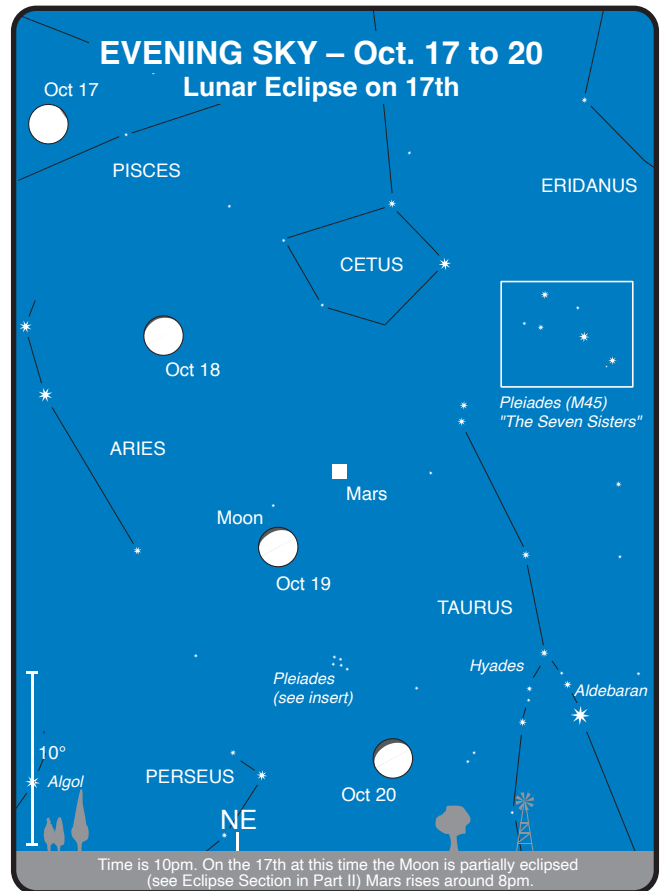
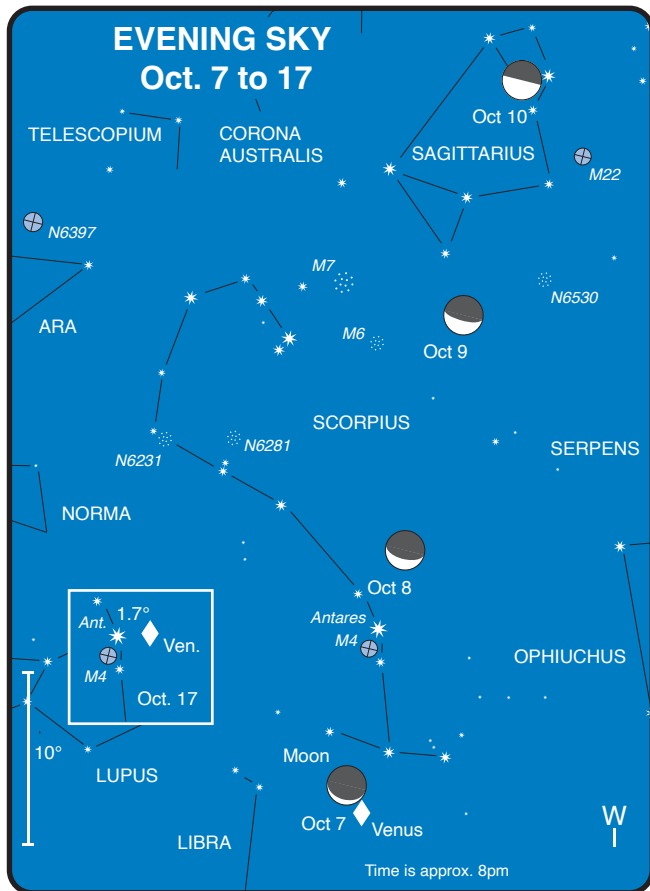
Comet 9P/Tempel is an evening object, setting around midnight. It begins October near M6 in Scorpius. A now faint (magnitude 12 – 13) object, Tempel has a number of encounters with star clusters in Scorpius and Sagittarius this month; this includes passing through the Teapot.

DIARY

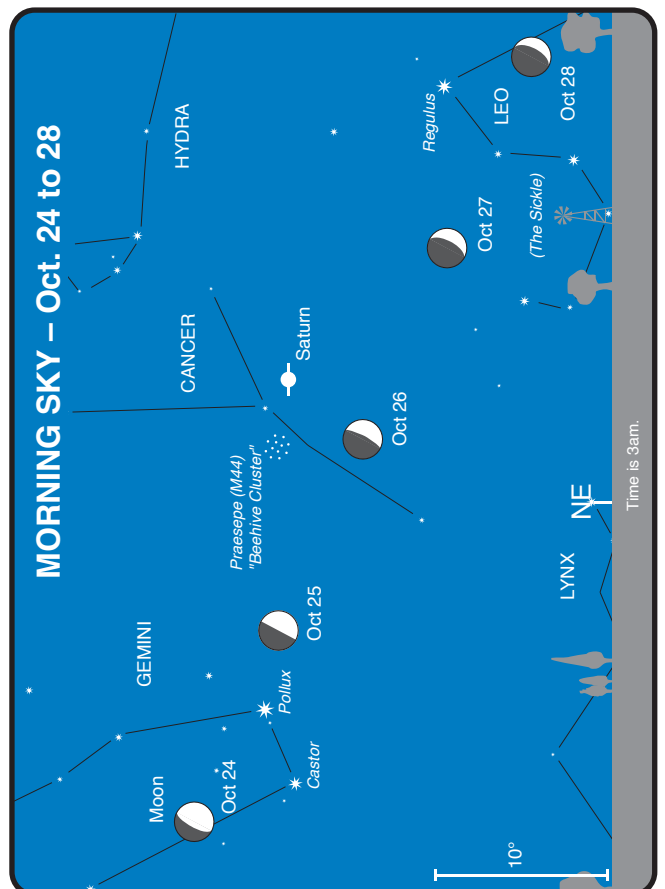
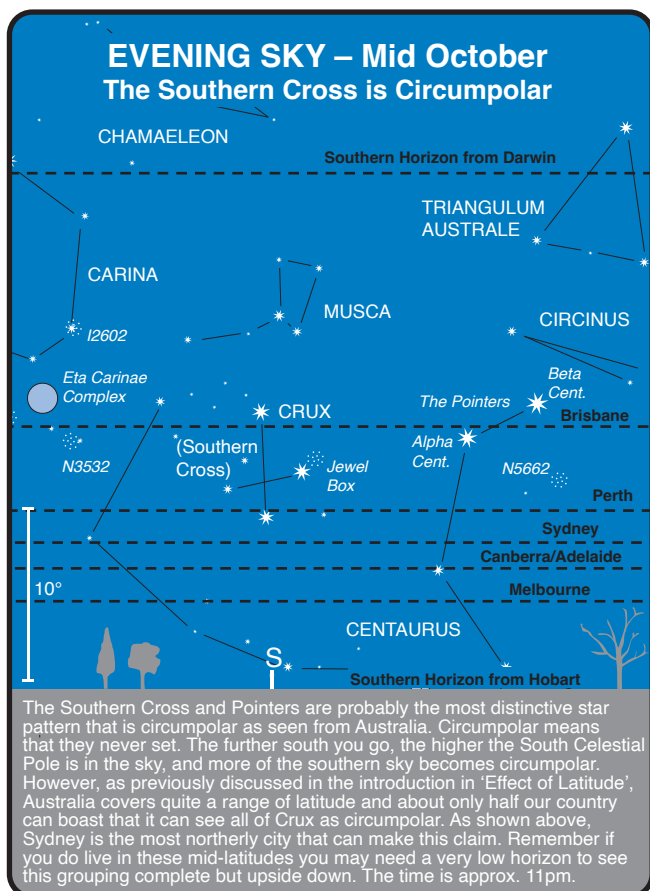
1st	Venus 0.7° N of NGC 5897 (GC) in Libra
1st	m.p. 18 Melpomene 0.3° SW of NGC 6507 (OC) in Sagittarius
1st	8 pm (6 pm WST) Mars stationary
2nd	pm Comet 9P/Tempel 0.3° NE of M6 (OC) in Scorpius
3rd	m.p. 1 Ceres 0.9° S of star Beta Scorpii
3rd	Mercury at descending node
3rd	8:28 pm (6:28 pm WST) New Moon; Eclipse
3rd	pm Comet 9P/Tempel 0.4° NW of NGC 6416 (OC) in Scorpius
4th	Venus at aphelion
4th	6 pm (4 pm WST) Mercury 2° N of Spica
4th	pm Comet 9P/Tempel 0.5° S of NGC 6425 (OC) in Scorpius
6th	5 pm (3 pm WST) Mercury 1.5° S of Jupiter
7th	4 pm (2 pm WST) Venus 1.4° N of Moon
8th	11 am (9 am WST) Antares 0.2° S of Moon Occn.
10th	Venus 0.6° SW of star Delta Scorpii
10th	Saturn 0.8° SW of NGC 2672 (EG) in Cancer
11th	am m.p. 3 Juno 0.7° SW of star Gamma Orionis
11th	5:01 am (3:01 am WST) First Quarter Moon
13th	1 am (11 pm WST, prev day) Neptune 5° N of Moon
13th	m.p. 14 Irene 0.5° N of NGC 6284 (GC) in Ophiuchus
13th	9 pm (7 pm WST) m.p. 18 Melpomene 0.15° SW of M24 (OC) in Sagittarius
13th	pm Comet 9P/Tempel 0.3° S of NGC 6569 (GC) in Sagittarius
14th	Mercury at aphelion
14th	3 pm (1 pm WST) Uranus 3° N of Moon

14th	Midnight (10 pm WST) Moon at perigee
15th	Venus 1.2° N of star Sigma Scorpii
17th	4 am (2 am WST) Venus 1.6° N of Antares
17th	10:14 pm (8:14 pm WST) Full Moon; Eclipse
19th	Mercury 0.7° NE of m.p. 10 Hygiea
19th	pm Comet 9P/Tempel 0.3° N of M69 (GC) in Sagittarius
19th	11 pm (9 pm WST) Mars 5° S of Moon
20th	m.p. 14 Irene 0.9° S of NGC 6325 (GC) in Ophiuchus
20th	pm Comet C/2003 T4 (LINEAR) 0.3° NW of star Sigma Puppis
21st	pm m.p. 18 Melpomene 0.25° N of M25 (OC) in Sagittarius
22nd	11 pm (9 pm WST) Jupiter in conjunction with Sun
23rd	Venus 0.5° NW of M19 (GC) in Ophiuchus
23rd	pm Comet 9P/Tempel 0.4° N of M70 (GC) in Sagittarius
24th	Mercury 0.5° N of NGC 5897 (GC) in Libra
25th	Venus 0.3° N of NGC 6293 (GC) in Ophiuchus
25th	11:17 am (9:17 am WST) Last Quarter Moon
26th	3 am (1 am WST) Saturn 4° S of Moon
26th	Venus at greatest latitude south
26th	8 pm (6 pm WST) Moon at apogee
27th	8 am (6 am WST) Neptune stationary
28th	Venus 0.3° S of NGC 6355 (GC) in Ophiuchus
30th	1 pm (11 am WST) Mars closest approach
31st	m.p. 15 Eunomia 0.7° S of star Pi Scorpii
31st	m.p. 115 Thyra 0.4° SW of NGC 4902 (SG) in Virgo
31st	m.p. 115 Thyra 0.2° NE of NGC 4856 (SG) in Virgo



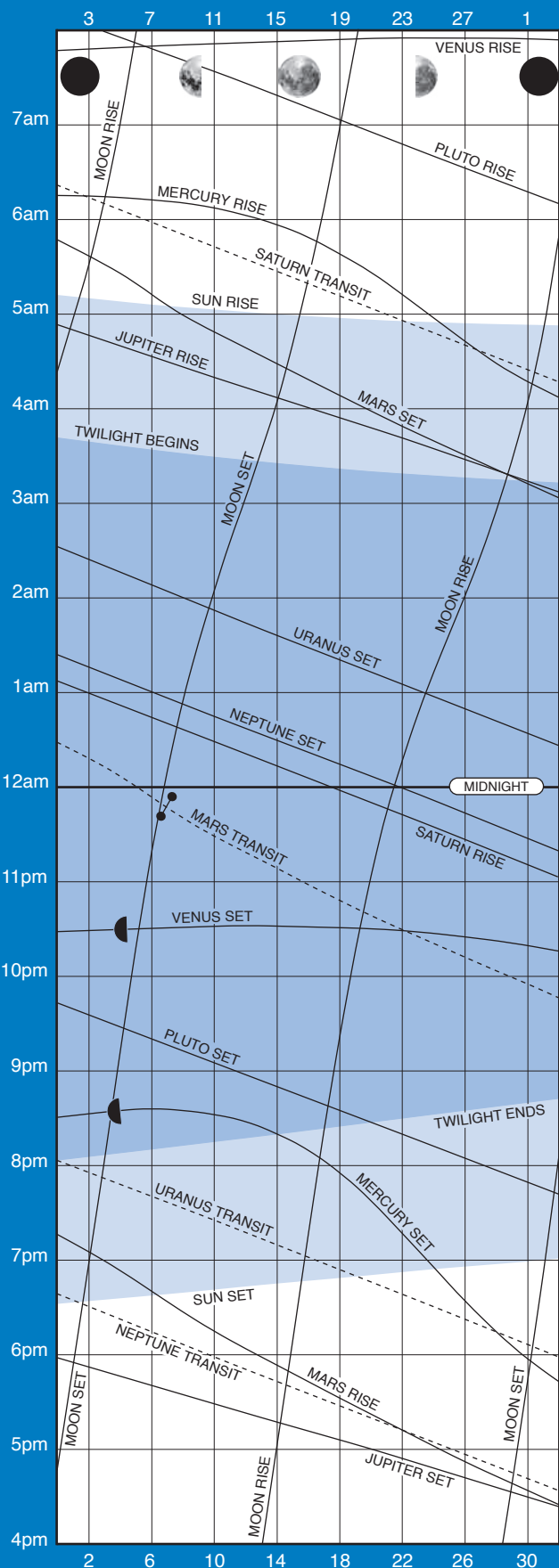


Approximate local standard time, for daylight saving add 1 hour.



NOVEMBER

RISE/SET CHART



HIGHLIGHTS

- Antares and Moon very close in the evening sky.
- Mercury in an excellent position for evening observations.
- Venus forms a temporary brilliant addition to the Teapot of Sagittarius in the evening sky.
- Mars at opposition.
- Taurids meteor shower.

THE MOON

- 1st Occultation of Spica by the Moon, not visible from Australia.
- 2nd New Moon.
- 4th Occultation of Antares by the Moon, visible from northern Australia, a daytime event close to the Sun. We will see them very close in the early western evening sky (see Sky View).
- 9th First Quarter.
- 10th Moon at perigee (closest to Earth – 370,010 km distant, angular size 32.1').
- 16th Full Moon.
- 23rd Moon at apogee (furthest from Earth – 404,370 km distant, angular size 29.1').
- 24th Last Quarter.
- 28th Occultation of Spica by the Moon, not visible from Australia.

THE PLANETS

MERCURY is in an excellent position for observation in the western evening sky for the first half of November. The rapidly moving planet will be at its greatest elongation east of the Sun on the 4th (24°), and three weeks later it will be in inferior conjunction (between Earth and Sun).

APPEARANCE of the PLANETS

MERCURY

Mercury is in inferior conjunction on the 25th



4th Nov
Greatest elongation east
dia 6.79"
mag -0.1

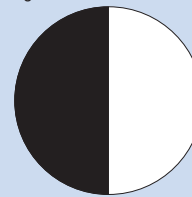


15th Nov
dia 8.57"
mag 0.6

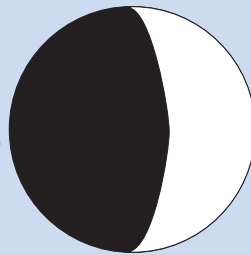
VENUS

Greatest elongation east

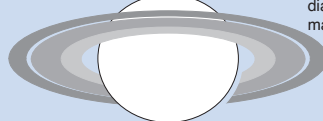
4th Nov
dia 25.08"
mag -4.4



25th Nov
dia 32.87"
mag -4.6

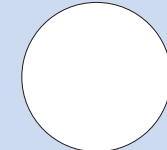


SATURN



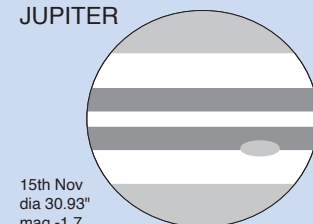
15th Nov
dia 18.77"
mag 0.2

MARS



7th Nov
Opposition
dia 19.95"
mag -2.3

JUPITER



15th Nov
dia 30.93"
mag -1.7

URANUS

15th Nov
dia 3.56"
mag 5.8

NEPTUNE

15th Nov
dia 2.26"
mag 7.9

PLUTO

15th Nov
dia 0.10"
mag 14.0

On the 4th, the slender crescent Moon (close to Antares) appears just above the planet (see Sky View). Mercury begins its journey this month a little less than 1° from the 2nd magnitude star Delta Scorpii. It then moves into Ophiuchus on the 7th where it remains for the next fortnight, then returns to Scorpius and its engagement with the Sun. After inferior conjunction Mercury returns to the morning dawn sky in December.

VENUS, high and brilliant in the western evening sky, moves into Sagittarius early in November where it remains all month. The thin crescent Moon appears near the planet on the 5th and 6th (see Sky View). On the 11th, Venus will be close to the 3rd magnitude star Lambda Sagittarii. Lambda marks the lid of the well-known asterism of the Teapot, an easier pattern of stars to see than the total constellation of Sagittarius. By the 18th, Venus will be 0.2° from the 2nd magnitude Sigma Sagittarii (Nunki), one of the stars marking the handle of the Teapot.

MARS, at opposition on the 7th, stands high and bright above the northeastern horizon at the end of astronomical twilight. Observers will get good views of the Red Planet throughout the month, although its brightness and angular size diminishes slightly each day. The actual brightness range over the month is from -2.3 to -1.6 magnitude and angular size from 20.17 to 17.10 arc minutes. This opposition will not quite be the spectacle of the 2003 return, and will undoubtedly stir little media or public interest. The 2001 opposition, if readers recall, was more or less identical to this one except it occurred in the colder month of June. Don't write the less favourable oppositions off too lightly, there will be

rewarding views; just enjoy the show, it only takes place every 26 months. On the 14th and 15th, the Full Moon appears in the vicinity of Mars.

JUPITER, moving east of the Sun after conjunction, returns to the morning sky late this month. On the 29th, the thin crescent Moon will be seen rising above the planet (see Sky View).

SATURN rises at midnight mid-month in the northeastern sky. The gibbous Moon appears in Cancer together with Saturn on the 22nd and 23rd (see Sky View).

URANUS, in retrograde motion since June, returns to its west to east motion against the star field. The planet is high in the northern sky in Aquarius at the end of astronomical twilight.

NEPTUNE, in Capricornus, is in the northwestern sky at the end of astronomical twilight.

PLUTO, in conjunction in mid-December, becomes lost in the evening twilight late in the month, returning to the morning sky in the New Year.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Aries. They are: 67 Asia on the 4th at magnitude 11.0, 19 Fortuna on the 4th at magnitude 8.9 and 88 Thisbe on the 11th at magnitude 10.7. Also 28 Bellona reaches opposition on the 26th at magnitude 10.6 in Taurus.

During November, 1 Ceres visits a number of globular clusters in Ophiuchus but unfortunately it is getting low in the early evening western sky. 14 Irene tours some globular clusters in Sagittarius before being lost

MOON WATCHER

SUNRISE OVER THE STRAIGHT WALL

This image was taken around First Quarter Moon and the features mentioned below should be visible through a small amateur telescope. As usual, a terminator region (where day and night time meet) has been highlighted because of the relief that the long shadows offer the features. The area shown runs from almost the centre of the lunar disc (below Herschel) towards the south and comes within 30° latitude of the pole (centre top). The following identifies some of the obvious features.

The **Straight Wall** is quite distinctive and seen here near the terminator. Its best view is around one day past first quarter, or third quarter. This 110 km long scar, running across the eastern side of Mare Nubium, is not a sheer cliff as was once thought. It is now known to be a relatively gentle slope of approximately 7° with a width of 2.5km and a height of around 300m.

Thebit is a quite distinctive triple crater with the centre, high walled, 'Thebit A' being the most obvious at this sun angle.

Arzachel, Alphonsus and Ptolemaeus. These three walled plains make an obvious group running roughly north to south.

Arzachel has quite a prominent central peak rising 1,500m above the floor with an adjacent crater to the east.

Alphonsus' claim to fame is the final resting place of the 1960's NASA probe, Ranger 9. The Ranger series was the first successful landings on the Moon by the United States, with number 9 being the last — sending back some 5,800 images. However, they were not exactly designed to be soft landings, but more a test of NASA's ability to navigate. Up until then the rockets either blew up or the probes had missed the Moon totally! Alphonsus is also the site of several reports of transient lunar phenomena, which show gaseous emission spectra, as obtained in November 1958 by Kozurev.

Ptolemaeus is named after Claudius Ptolemaeus, the Greek astronomer who introduced the geocentric model of the Universe in his *Almagest*. On first impression, the plain appears relatively featureless but contains numerous ghost craters (crater-like depressions) and low hills. To give some scale, the small crater on its floor, Ammonius, is 9 km in diameter.

Alpetragius. This crater has very high walled terraces with a prominent central massif.

Hell. An interesting, distinctive, isolated crater near the southwest wall of Deslandres. It has steep slopes and an off-centre mountain (still in shadow in this image).

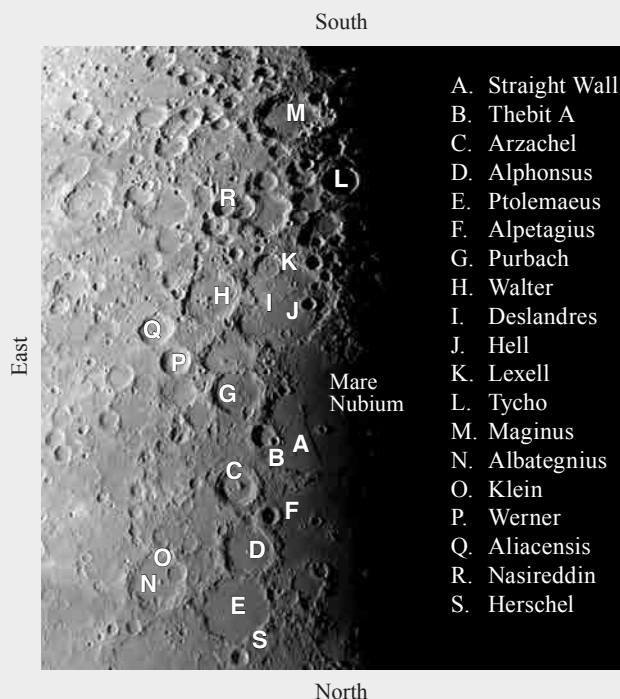
Lexell. Interesting crater with relatively high walls, except for the northeast section which has been destroyed by lava flows from Deslandres.

Tycho. This very young crater is named after the famous 16th century Danish astronomer, Tycho Brahe. It has very steep, tormented slopes and supports a 1,500m central mountain with three distinct peaks. In this image none of the internal structure is visible as yet with the sun's rays having just illuminated the western rim. Tycho is the source of the most prominent ray system on the Moon.

Albategnius. The combination of this walled plain with the crater Klein, just inside the western edge, makes this pair very recognisable.

Werner and Aliacensis. These two craters form a remarkable pair. Aliacensis has a flat floor with an off-centre mountain.

Nasireddin. This crater forms an easily recognised trio with crater Huggins to the west (right and partly covered) and Millar to the north and slightly east (below with central peak and touching Nasireddin).



in the western twilight sky in December. 7 Iris has close encounters with a number of star clusters in Sagittarius this month. On the evening of the 24th, 42 Isis will be transiting the globular cluster M30 in Capricornus. Whether you can see this 11th magnitude object against this city of stars is another matter!

COMETS

Comet C/2003 K4 (LINEAR) is approximately 13th magnitude this month. Visible all night, the comet is moving westward through Eridanus.

Comet C/2003 T4 (LINEAR) is visible all night throughout November. Fading from 13th magnitude, LINEAR can be found in Puppis as it moves towards the border with Pictor.

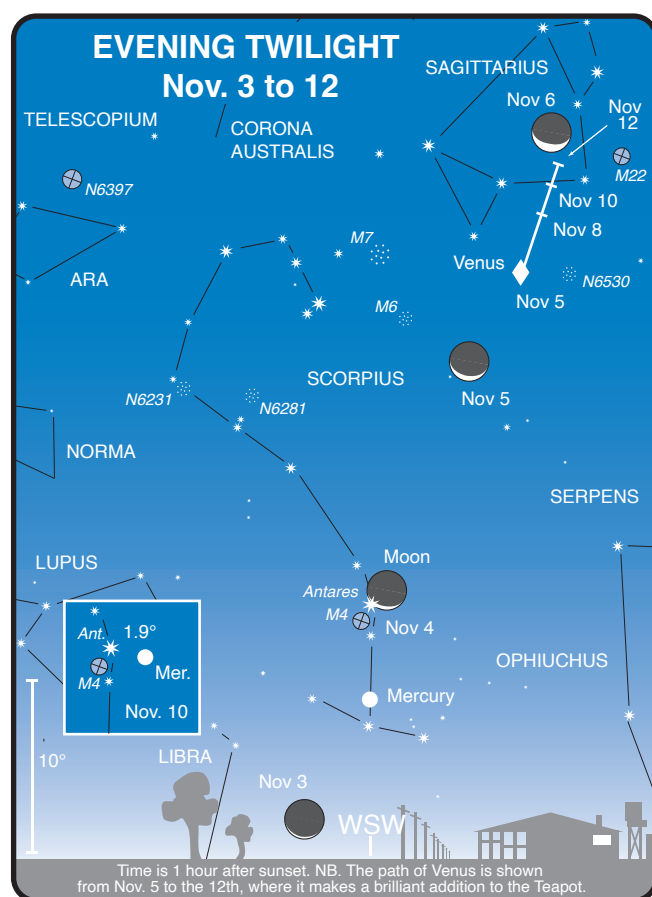
METEOR SHOWERS

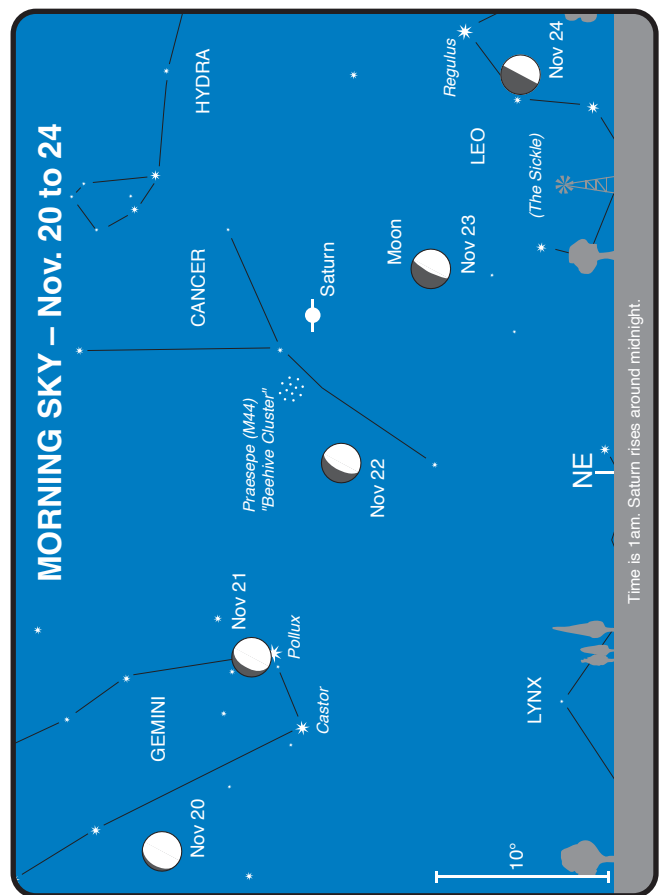
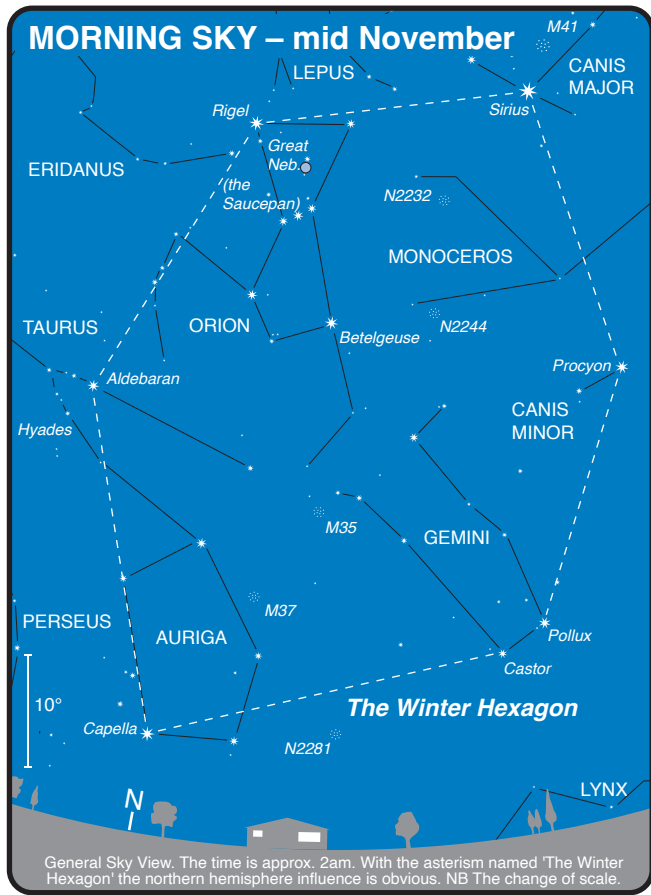
The **Taurids** (North and South) are associated with Comet 2P/Encke, and can be seen from late evening to early morning. The shower is composed of a main double radiant which is visible from 1st October through to 25th November. The Taurids do not have a well-defined sharp peak in activity, but rather plateau for about ten days in early November. Maxima occur on the 5th November for the Taurids South (ZHR of 5) and on the 12th November for the Taurids North (ZHR of 5). Both maxima last for about a week and provide nearly constant rates. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs. The International Meteor Organisation recommends the Taurids to newcomers as their slow speed allows them to practice their visual meteor plotting techniques. The Taurids brightness also makes them an ideal target for astrophotography.

DIARY

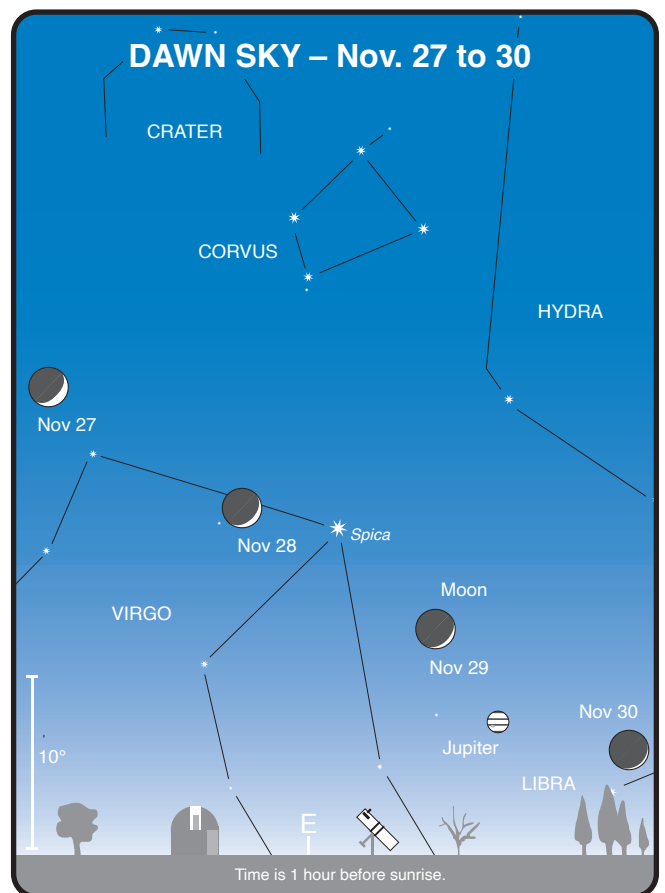
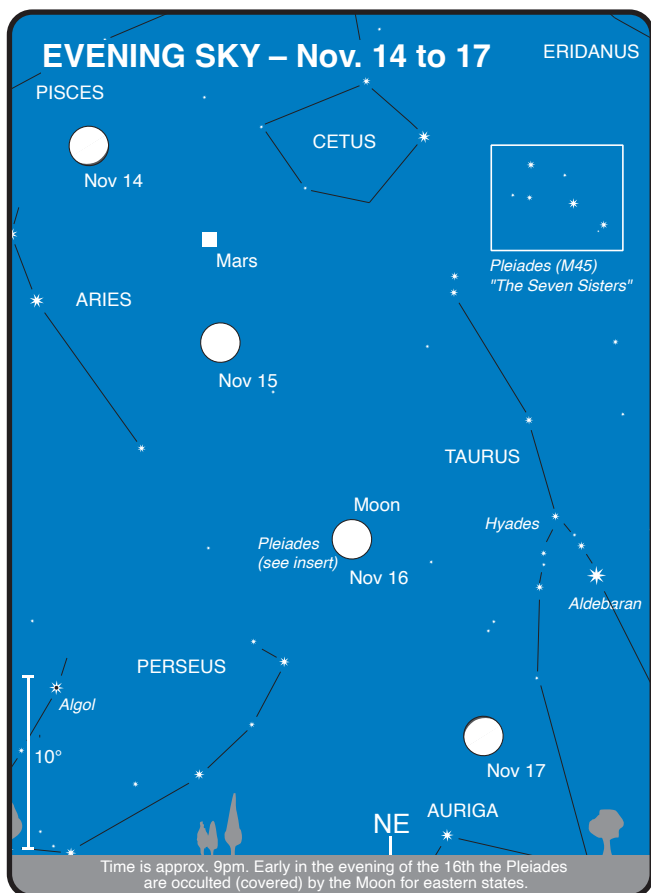
1st	5 am	(3 am WST) Spica 1.2°S of Moon Occn.
1st		Mercury 1°SW of star Beta Scorpii
2nd		m.p. 18 Melpomene 0.4°N of NGC 6716 (OC) in Sagittarius
2nd	11:24 am	(9:24 am WST) New Moon
3rd	6 am	(4 am WST) Juno stationary
3rd		m.p. 1 Ceres 1.0°S of NGC 6235 (GC) in Ophiuchus
3rd		Mercury at greatest latitude south
4th	2 am	(Midnight WST, prev day) Mercury greatest elongation east (24°)
4th	5 am	(3 am WST) Venus greatest elongation east (47°)
4th	9 am	(7 am WST) Mercury 1.3°N of Moon
4th	5 pm	(3 pm WST) Antares 0.2°S of Moon Occn.
5th		m.p. 7 Iris 0.8°N of NGC 6469 (OC) in Sagittarius
6th	5 am	(3 am WST) Venus 1.4°N of Moon
6th		Venus 0.8°N of NGC 6520 (OC) in Sagittarius
6th		m.p. 115 Thyra 0.4°N of NGC 4984 (SG) in Virgo
7th		Mercury 1.2°N of star Sigma Scorpii
7th	6 pm	(4 pm WST) Mars at opposition
9th	6 am	(4 am WST) Neptune 5°N of Moon
9th	11:57 am	(9:57 am WST) First Quarter Moon
10th	2 am	(Midnight WST, prev day) Mercury 1.9°N of Antares
10th	10 am	(8 am WST) Moon at perigee
10th		m.p. 1 Ceres 0.9°N of NGC 6284 (GC) in Ophiuchus
10th		m.p. 1 Ceres 1.0°S of NGC 6287 (GC) in Ophiuchus
10th		m.p. 115 Thyra 0.3°SW of NGC 5044 (EG) in Virgo
10th	8 pm	(6 pm WST) Uranus 3°N of Moon
11th		Venus 1.6°S of star Lambda Sagittarii
11th		m.p. 115 Thyra 0.2°SW of NGC 5054 (SG) in Virgo
12th		m.p. 7 Iris 1.0°N of M21 (OC) in Sagittarius
14th	7 pm	(5 pm WST) Mercury stationary
14th	pm	m.p. 3 Juno 0.5°NW of star Delta Orionis
15th		Mars at ascending node
15th	4 pm	(2 pm WST) Mars 3°S of Moon
16th		m.p. 14 Irene 0.7°S of NGC 6544 (GC) in Sagittarius
16th	10:57 am	(8:57 am WST) Full Moon
16th	5 pm	(3 pm WST) Uranus stationary
16th	pm	Venus 0.4°NE of star Phi Sagittarii
17th		m.p. 1 Ceres 0.5°S of NGC 6325 (GC) in Ophiuchus
17th		m.p. 7 Iris 0.3°NE of NGC 6568 (OC) in Sagittarius
17th		m.p. 14 Irene 0.3°NW of NGC 6553 (GC) in Sagittarius
18th		m.p. 7 Iris 0.7°N of NGC 6583 (OC) in Sagittarius
18th	Noon	(10 am WST) Pallas in conjunction with Sun
18th	9 pm	(7 pm WST) Venus 0.2°SW of star Sigma Sagittarii
19th	2 am	(Midnight WST, prev day) Mercury 3°N of Antares
20th	2 am	(Midnight WST, prev day) Vesta stationary
22nd		Mercury at ascending node
22nd	1 pm	(11 am WST) Saturn 4°S of Moon
23rd	4 am	(2 am WST) Saturn stationary

23rd	4 pm	(2 pm WST) Moon at apogee
24th	8:11 am	(6:11 am WST) Last Quarter Moon
24th	10 pm	(8 pm WST) m.p. 42 Isis 0.05°N of M30 (GC) in Capricornus
25th	2 am	(Midnight WST, prev day) Mercury in inferior conjunction
26th		m.p. 14 Irene 0.9°S of M28 (GC) in Sagittarius
27th		m.p. 14 Irene 0.4°SW of star Lambda Sagittarii
27th		Mercury at perihelion
28th	2 pm	(Noon WST) Spica 1.1°S of Moon Occn.
29th		m.p. 1 Ceres 0.9°S of NGC 6401 (GC) in Ophiuchus
29th		m.p. 14 Irene 0.3°S of NGC 6638 (GC) in Sagittarius
29th	6 pm	(4 pm WST) Jupiter 3°N of Moon



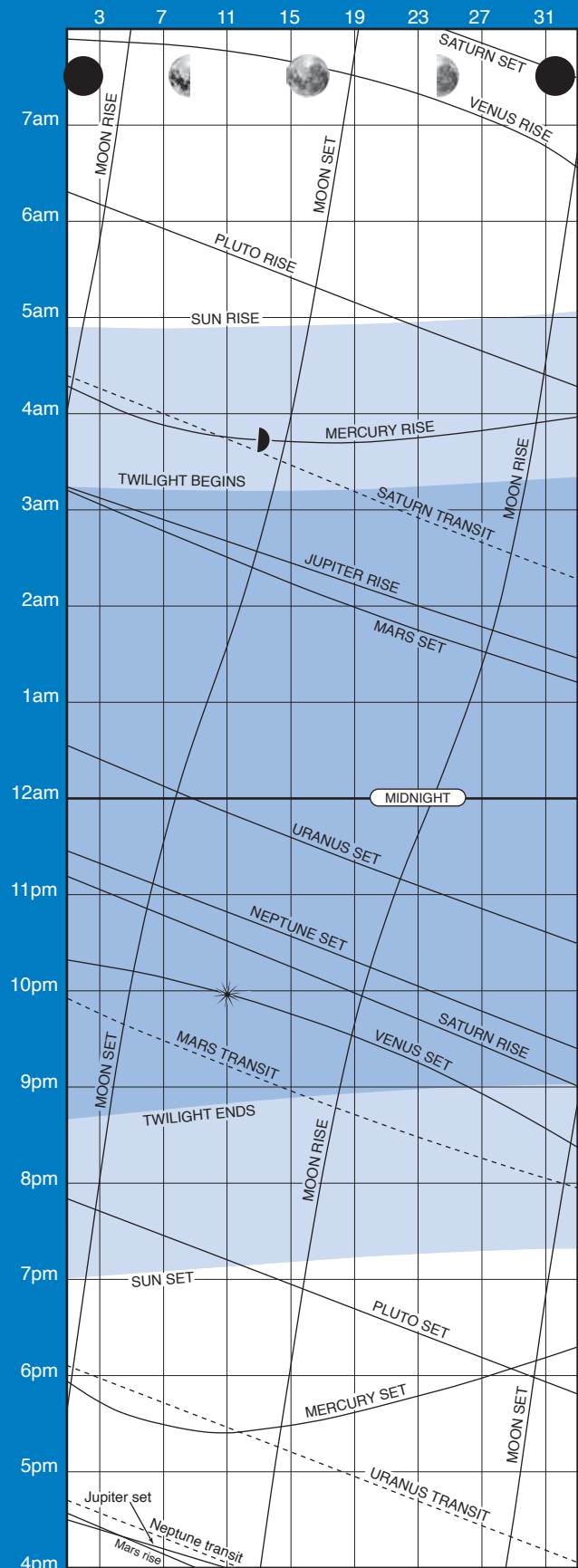


Approximate local standard time, for daylight saving add 1 hour.



DECEMBER

RISE/SET CHART



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

HIGHLIGHTS

- Spica and Moon close.
- Venus at greatest brilliancy.
- Three of the brighter minor planets reach opposition in Taurus.

THE MOON

- 2nd New Moon.
- 5th Moon at perigee (closest to Earth – 367,365 km distant, angular size 33.1').
- 8th First Quarter.
- 12th Occultation of Mars by the Moon. Not visible from Australia.
- 16th Full Moon.
- 21st Moon at apogee (furthest from Earth – 405,014 km distant, angular size 29.2').
- 24th Last Quarter.
- 25th Occultation of Spica by the Moon. Not visible from Australia, although the pair will be close together at moonrise (see Sky View).
- 29th Occultation of Antares by the Moon. Daytime event, visible from parts of northern Australia (see Sky View for dawn appearance).
- 31st New Moon.

THE PLANETS

MERCURY returns to the dawn sky after being in inferior conjunction (between Earth and Sun) late last month. The planet's greatest elongation west of the Sun (21°) occurs on the 12th. Although not the best of elongations, Mercury rises an hour before the Sun, affording an opportunity to see the planet in the twilight sky. On the 30th, a very thin lunar crescent can be seen above and south of the planet.

APPEARANCE of the PLANETS

MERCURY



5th Dec
dia 8.07"
mag 0.2



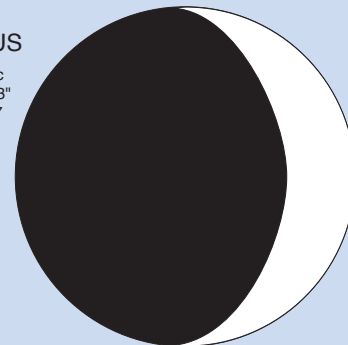
12th Dec
Greatest elongation west
dia 6.73"
mag -0.4



25th Dec
dia 5.40"
mag -0.4

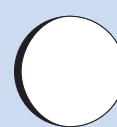
VENUS

15th Dec
dia 44.93"
mag -4.7



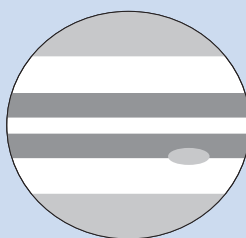
MARS

15th Dec
dia 14.60"
mag -1.2



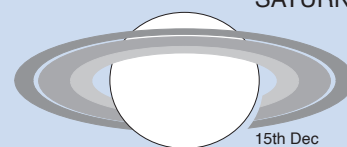
JUPITER

15th Dec
dia 32.19"
mag -1.8



SATURN

15th Dec
dia 19.75"
mag 0.1



URANUS

15th Dec
dia 3.47"
mag 5.9



NEPTUNE

15th Dec
dia 2.23"
mag 8.0



PLUTO

15th Dec
dia 0.10"
mag 14.0



VENUS is at its greatest brilliancy this year at -4.7 magnitude, and very conspicuous in the western evening sky for the first three weeks of the month. Spending the first half of December in Sagittarius the planet then moves into Capricornus where Neptune resides. The splendid evening display comes to a close as the planet moves toward the Sun and inferior conjunction mid-January. On the 4th, the slender crescent Moon will be seen nearby Venus (see Sky View).

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 transits the meridian around 9pm mid-month, and is high in the northern sky meandering around Aries throughout December. On the 11th Mars is stationary and thereafter resumes its normal west to east movement after being in retrograde motion since the beginning of October. On the 12th, the near full gibbous Moon is close to the planet (see Sky View). Now one month past opposition the Red Planet begins to lose

OBSERVING SATELLITES

A BEGINNER'S GUIDE

If you are middle aged or younger you would have no memory of a time when the Earth only had one satellite — the Moon. Your earliest memory of an artificial satellite is probably that mysterious, silent moving star seen in the twilight sky. If you took the time to watch you might have been lucky enough to see it suddenly brighten, flicker, or fade into nothing while still well above the horizon.

What are they? Most people when they refer to satellites are thinking mainly of communication or weather devices in orbit. Of course they have many applications, including scientific and military. The most famous scientific satellite has been the orbiting Hubble telescope. Also we need to include the high profile manned spacecraft such as the ISS (International Space Station) or the shuttles (when they fly again). But this is only the tip of the iceberg. Since the time of Sputnik in 1957 there have been approximately 4,500 satellite launches. A launch would often deliver more than just the payload into orbit. They can also leave secondary objects such as third or fourth stage rockets, shrouds, payload platforms or boosters. General debris also makes up a significant portion of the population (see below).

How many satellites are there? Since 1957, approximately 30,000 objects have had their orbits determined. Most of these have re-entered the atmosphere and burnt up. There are currently around 10,000 satellites being followed. Some of these objects are quite small, as our methods of finding and tracking them, by radar or optical means, becomes more sensitive. It is interesting to note that less than 10% of these 10,000 objects are operational spacecraft; around 50% are decommissioned satellites and their associated launch vehicles and the balance is debris from various in-orbit explosions or breakups. These fragmentations are believed to have also generated tens of thousands of smaller objects, which are unable to be tracked. These are considered a major threat to other satellites or manned missions.

Where are they? There are two main factors to consider, one is their altitude, the majority of which are in low Earth orbits (say, 300 to 500km), and the other is their orbital inclination. This is the tilt of the orbit with respect to the equator. If a satellite's inclination is 30 degrees then its orbit oscillates between latitude 30 degrees north and 30 degrees south in the course of its trip around the Earth. This is important when looking for satellites, for a 'low Earth' one wouldn't be visible at higher latitudes. The high inclination satellites (90 degrees plus or minus 10) are said to be in polar orbits and over many orbits will pass over the entire Earth's surface.

There is also a special category called 'Geosynchronous' or 'Geostationary' satellites. Simple orbital mechanics dictate that the higher the altitude the longer it takes to complete an orbit. Once you reach an altitude of around 36,000 km, the orbital period is 24 hours so the satellite will appear to be parked permanently above the same point on the Earth. Although this is directly above the equator, their high orbit means they are visible over much of the Earth and are ideal for communication systems such as pay television.

How many can I see? To the naked eye there are only a few dozen visible. The ISS can reach magnitude -4 , or about as bright as Venus. A shuttle can get to -2 or slightly brighter than Sirius. If you are using binoculars the number of satellites jumps to several hundred. You may soon find that your humble binocs are your most useful observing aid. In theory, an amateur telescope can see thousands of satellites, but being able to find and track them in such a narrow field of view can be a challenge. You will not see any geostationary satellites for they are faint and require a telescope to find and look like any other star.

When do I look? Like the Moon, satellites do not generate light but can only be seen by reflected sunlight. Therefore they are visible during the twilight time — up to one hour after sunset or before sunrise, while they are still bathed in sunlight. It is worthwhile keeping in mind that the satellite may pass into the Earth's shadow, so expect to see it fade and disappear, especially if it is moving towards the eastern sky in the evening twilight. Likewise, they can suddenly appear well up in the sky as they pass out of the shadow. In a lot of cases the brightness is not constant, with different surfaces on the spacecraft having differing levels of reflectivity. A satellite at an altitude of 300km takes only 90 minutes to complete an orbit of the Earth so it is little wonder it takes only a few minutes to pass over.

Iridium satellites. Solar cells on satellites can be brilliant reflectors and when the Sun-craft-observer angle is just right they can jump dramatically in brightness. Well-known examples are the Iridium communication satellites. If you happen to be at the right place and time they can outshine even Venus for a number of seconds and are gone just as quickly.

What resources are available? The internet has revolutionised observing satellites. The Heavens Above website (www.heavens-above.com) is an invaluable tool for beginners. It has many nice features and allows you to get predictions for the appearances of the Iridiums, Hubble, ISS and the brighter satellites, all tailored for your location. Another useful site is the Visual Satellite Observers Home Page (www.satobs.org/satintro.html). There are also various satellite interest groups such as *sci.astro.satellites.visual-observe* and the *SeeSat L* mailing list.



An Iridium satellite flare, taken by the authors.

appeal in telescopes for observers, its angular diameter dropping from 17 to 12 arc seconds over the course of December. Visually the planet is still bright, although it dims by a full magnitude over the month, and by early January it is -0.5 magnitude.

JUPITER is prominent in the northeastern morning sky at the beginning of twilight. Having just moved into Libra, this constellation will now be Jupiter's home for the next twelve months. On the 27th, the 25-day old crescent Moon will be close to the planet (see Sky View).

SATURN, within a few degrees of M44, the Beehive cluster in Cancer, rises around 10pm mid-month in the northeastern sky. On the 19th, the waning gibbous Moon is a little below the planet (see Sky View). The ringed planet reaches opposition on the 28th of January next year. The period from December through February is the optimum period for observation of this exquisite planet at its brightest and largest.

URANUS and **NEPTUNE** are setting in the evening with both planets moving toward solar conjunction early next year. On the 6th, the minor planet 39 Laetitia passes north of Neptune at a distance of 0.4° at 11th magnitude. 39 Laetitia was discovered by Chacornac at the Paris Observatory in 1856.

PLUTO, at conjunction on the 16th, returns to the morning sky in the New Year.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Taurus. They are: 16 Psyche on the 7th at magnitude 9.4, 11 Parthenope on the 9th at magnitude 9.8 and 60 Echo on the 21st at magnitude 9.9. Also 3 Juno reaches opposition on the 9th at magnitude 7.6 in Orion.

METEOR SHOWERS

The **chi-Orionids** are active from 26th November through to 15th December. Their peak is on December 2nd, with a low zenith hourly rate of 3. While generally a weak stream visually, a number of bright meteors have been recorded.

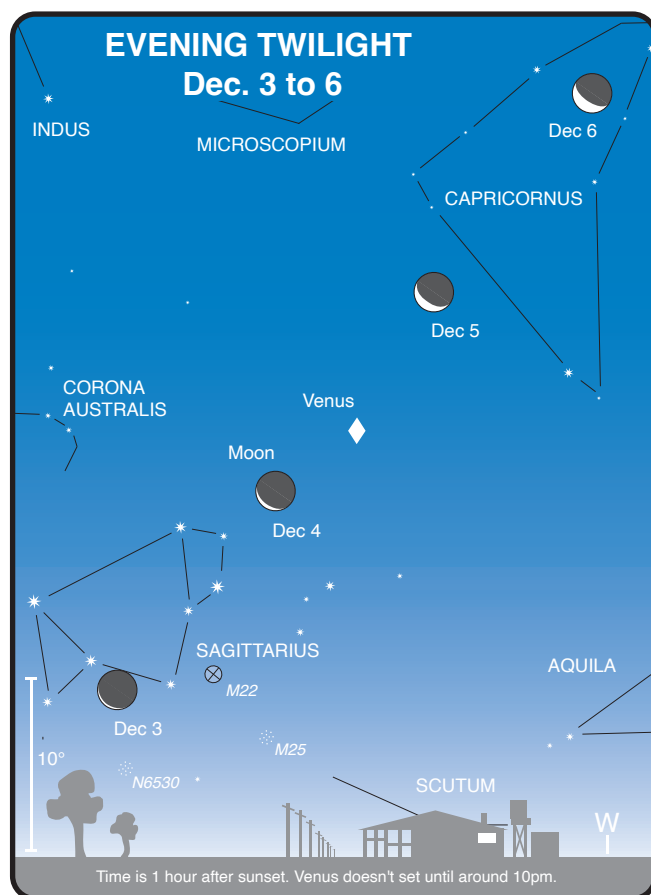
The **Phoenicids** are a southern shower that was discovered in 1956, when a zenith hourly rate of around 100 was observed. There have been three minor bursts in activity since 1956, but in recent years the shower seems nonexistent. There is a possibility that this may be a periodic shower, so observations should still be carried out in case of a return. The period of activity appears to be 28th November through 9th December, with the 6th being the maximum. There will be some interference from the Moon in the evening.

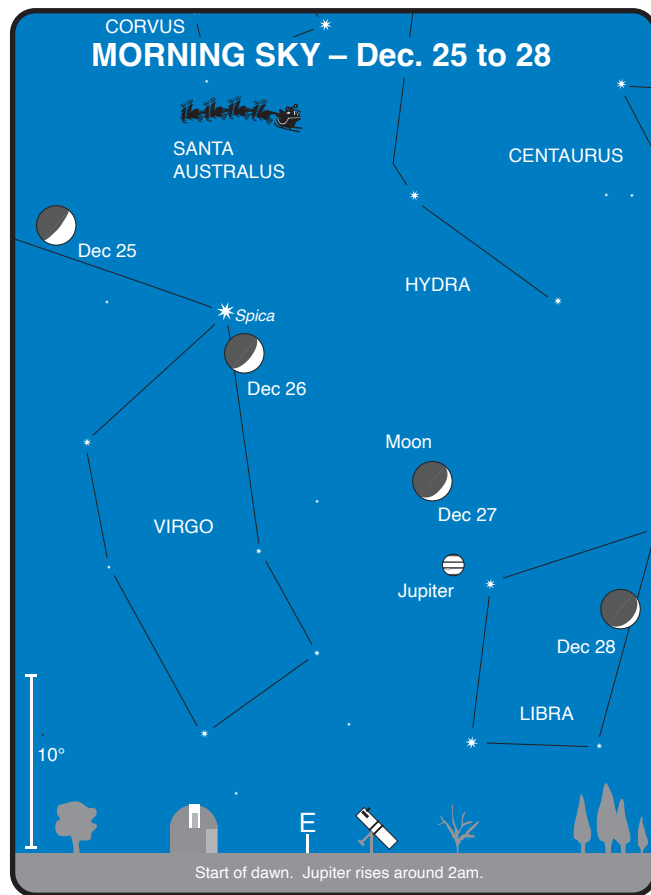
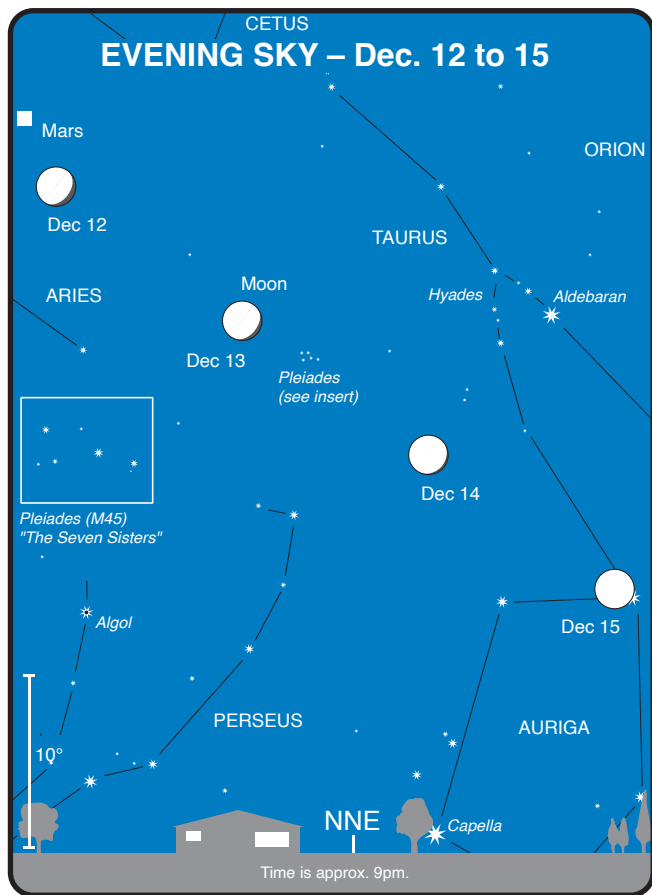
The **Puppид-Velids** are a very complex system of around ten showers, with each radiant so close that visual observation cannot easily separate them. Some of the showers are thought to be visible from late October to early January, but have been so poorly observed (a reflection on the number of southern meteor observers perhaps?) that the International Meteor Organisation can only confirm high activity from December 1st to 15th, with a peak zenith hourly rate of 10 on the 6th. Most of the Puppид-Velids are faint but occasional bright fireballs, particularly around the maximum, have been observed.

DIARY

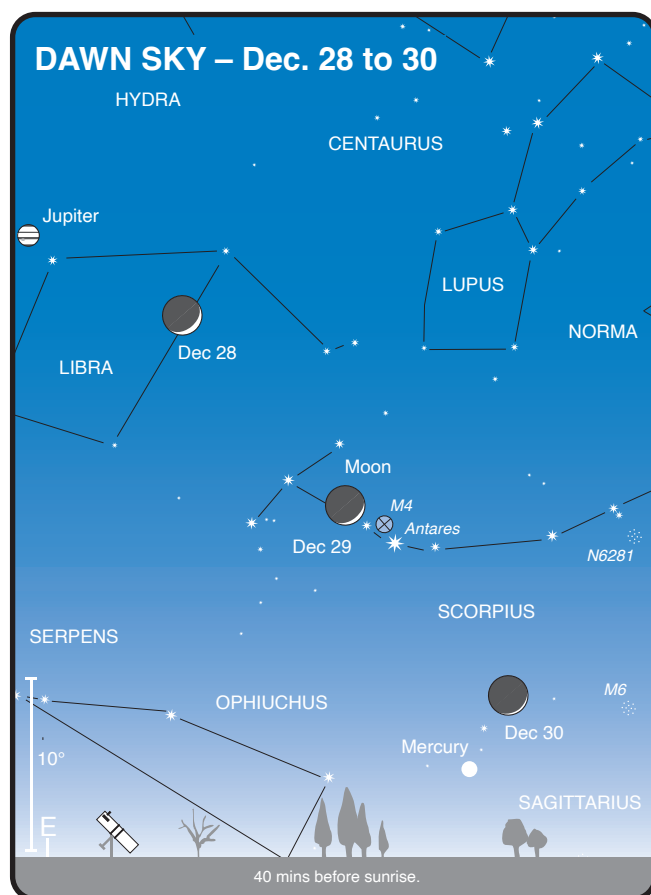
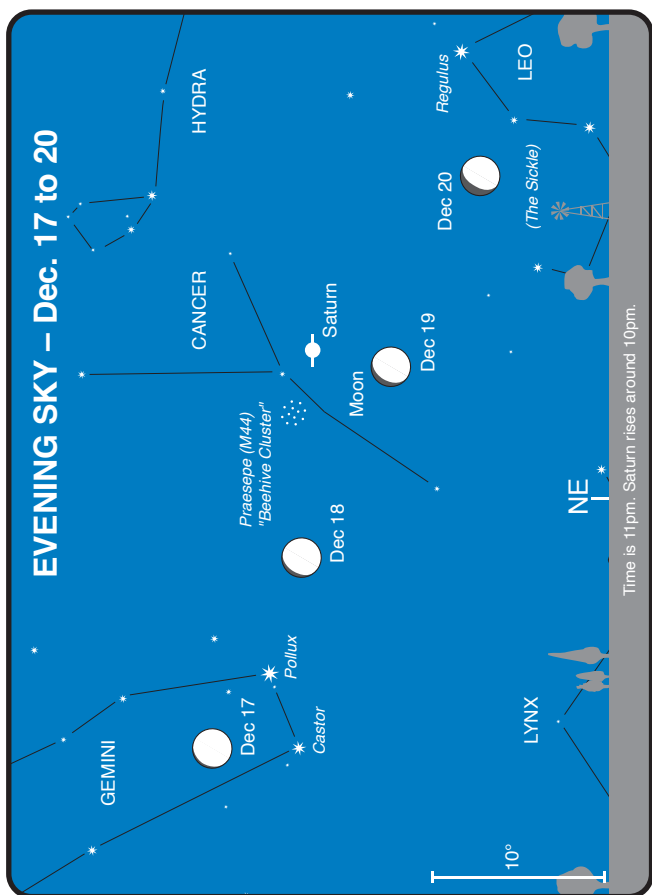
2nd	1:01 am	(11:01 pm WST, prev day) New Moon
3rd	pm	m.p. 11 Parthenope 0.5° N of NGC 1817 (OC) in Taurus
4th	11 am	(9 am WST) Mercury stationary
4th	pm	m.p. 11 Parthenope 0.6° N of NGC 1807 (OC) in Taurus
5th	4 am	(2 am WST) Venus 2° N of Moon
5th	3 pm	(1 pm WST) Moon at perigee
5th	11 pm	(9 pm WST) m.p. 42 Isis 0.1° W of NGC 7184 (SG) in Aquarius
6th		Neptune 0.4° S of m.p. 39 Laetitia
6th	1 pm	(11 am WST) Neptune 4° N of Moon
7th		Mercury at greatest latitude north
8th	2 am	(Midnight WST, prev day) Uranus 2° N of Moon
8th	7:36 pm	(5:36 pm WST) First Quarter Moon
9th	6 pm	(4 pm WST) Juno at opposition
9th	11 pm	(9 pm WST) Venus greatest brilliancy
11th	9 am	(7 am WST) Mars stationary
12th	3 pm	(1 pm WST) Mars 1.3° S of Moon Occn.
12th	11 pm	(9 pm WST) Mercury greatest elongation west (21°)
13th	9 pm	(7 pm WST) Venus 0.1° NE of M75 (GC) in Sagittarius
16th	2:15 am	(12:15 am WST) Full Moon

16th	2 pm	(Noon WST) Pluto in conjunction with Sun
19th		Uranus 1.0° SE of m.p. 20 Massalia
19th	7 pm	(5 pm WST) Saturn 4° S of Moon
20th	5 pm	(3 pm WST) Mercury 6° N of Antares
21st	1 pm	(11 am WST) Moon at apogee
22nd	5 am	(3 am WST) Solstice
22nd		Venus at ascending node
23rd	3 pm	(1 pm WST) Venus stationary
24th	5:36 am	(3:36 am WST) Last Quarter Moon
24th	11 pm	(9 pm WST) m.p. 4 Vesta 0.1° S of star Delta Geminorum
25th		Mercury 0.5° NE of NGC 6235 (GC) in Ophiuchus
25th	Midnight	(10 pm WST) Spica 0.9° S of Moon Occn.
27th		Mercury 0.5° NE of NGC 6287 (GC) in Ophiuchus
27th	2 pm	(Noon WST) Jupiter 4° N of Moon
28th	10 pm	(8 pm WST) Ceres in conjunction with Sun
29th	Noon	(10 am WST) Antares 0.2° S of Moon Occn.
30th	10 am	(8 am WST) Mercury 5° N of Moon
30th		m.p. 42 Isis 1.0° NW of star Delta Aquarii
30th		Mercury at descending node
31st	1:12 pm	(11:12 am WST) New Moon





Approximate local standard time, for daylight saving add 1 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 probably more accurate to say they are useful for anywhere in the southern hemisphere with latitudes similar to Australia. This includes most of New Zealand, South Africa and parts of South America.

Who can use them?

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

The limiting magnitude of the charts is 5.5. If you live in a suburban area, you will not see the faintest stars marked on the maps. Some of the less conspicuous 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 numerous fainter stars that are not marked on the maps.

How Do I Use Them?

There are nine maps. Map 1 is the far southern sky called 'Looking South'. 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 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. For example, suppose it is around mid to late June. At 9pm the sky will look like the 'Winter' pair. By 3am 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 towards the west) and half 'Summer' (towards the right or east). Using a planisphere illustrates this quite well.

What does the fine black grid represent?

These are the right ascension (RA) and declination (Dec.) lines, see explanation on page 78. 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 August 20 is approximately 21 hours (as an aside this is also the definition of the local sidereal time, see page 139). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1am) the star Alpha 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 March 20 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 black 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 may only be above the northern horizon briefly. 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, you can then go to the relevant finder chart. The path for Mars has the position marked for each month and thus replacing 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.

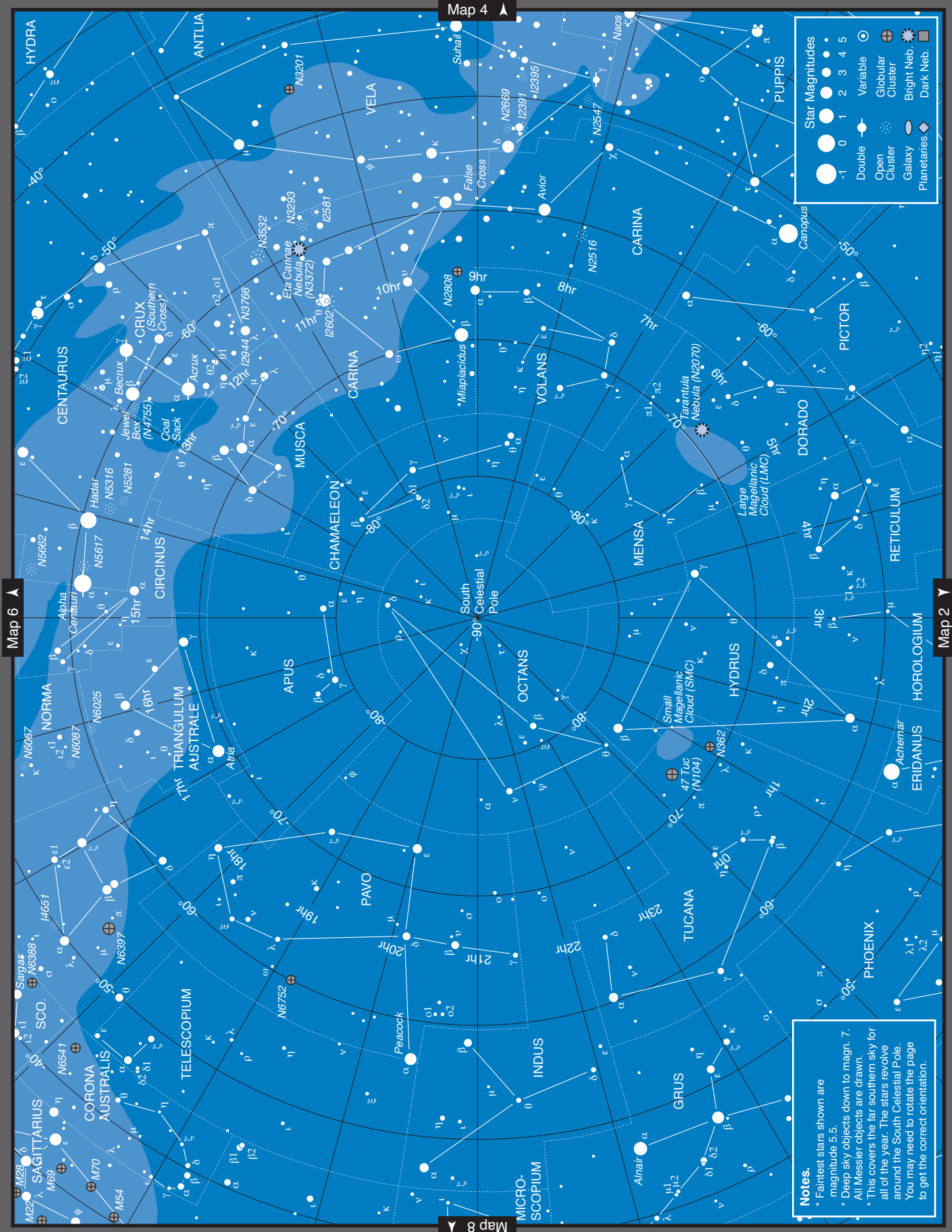
What else is shown on the maps?

- Deep sky objects down to magnitude 7 and all of the Messier objects (see the legend). Most of these objects are identified by their common names, 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.
- Constellation lines. The white dotted lines are the boundaries and the solid white lines join some of the brighter stars to help in recognising the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A few of the brighter Double Stars and Variables.
- A light blue shading shows the Milky Way and Magellanic Clouds.

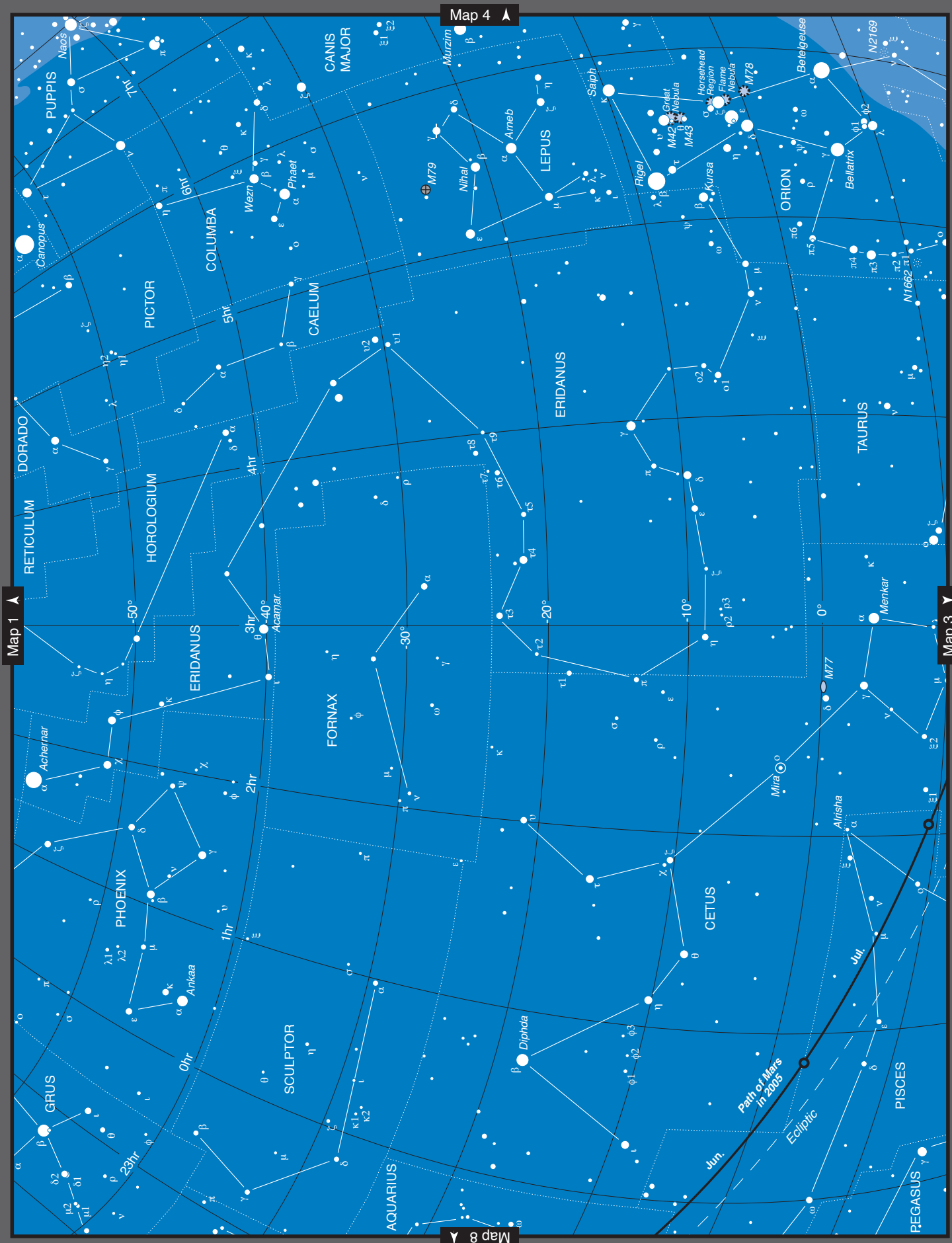


Southern Cross and Pointers Note the dark lanes shown here against the bright band of the Milky Way. The most prominent of these is the Coal Sack which the Aborigines called the head of the emu (seen on its side here). In the sky the entire bird can be seen with its body consisting of the dark nebulae near the centre of the Milky Way in Scorpius and Sagittarius (see back cover). Taken on Kodak T Max (400 ASA) for 5 minutes (piggy-backed on an equatorially tracking telescope) through a 35mm camera (55mm lens).

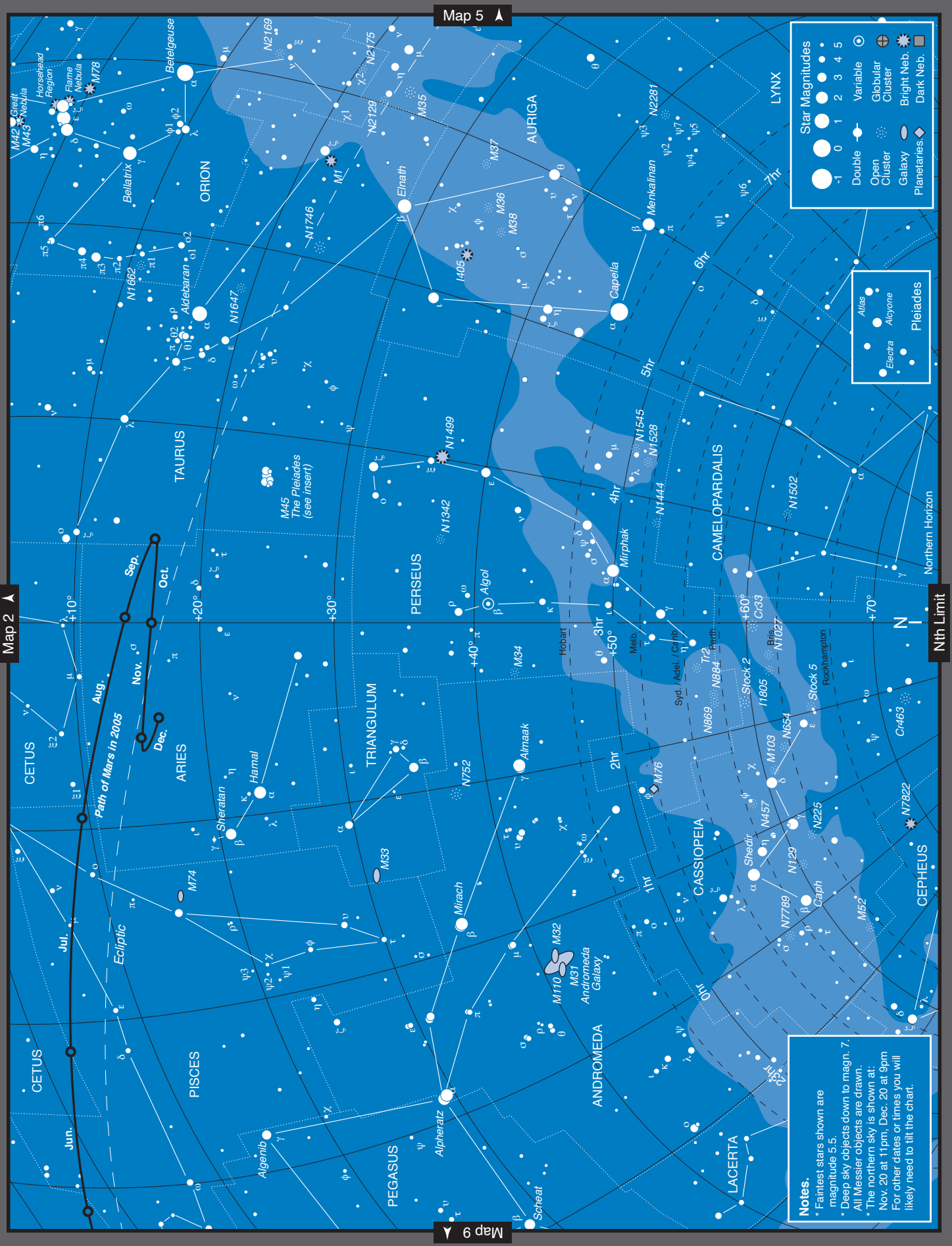
Map 1 - Looking South



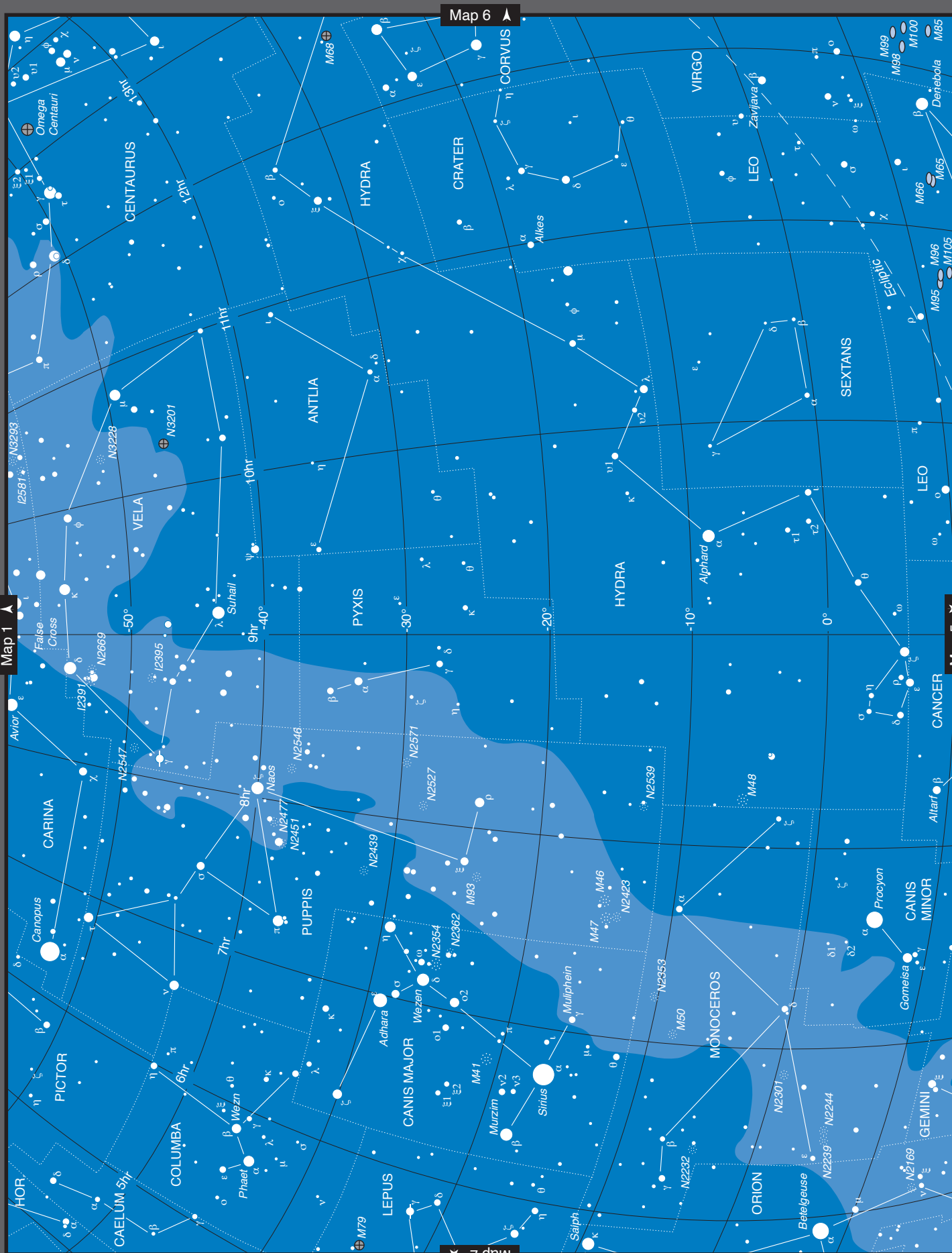
Map 2 - Summer (Centre)



Map 3 - Summer (North)



Map 4 - Autumn (Centre)



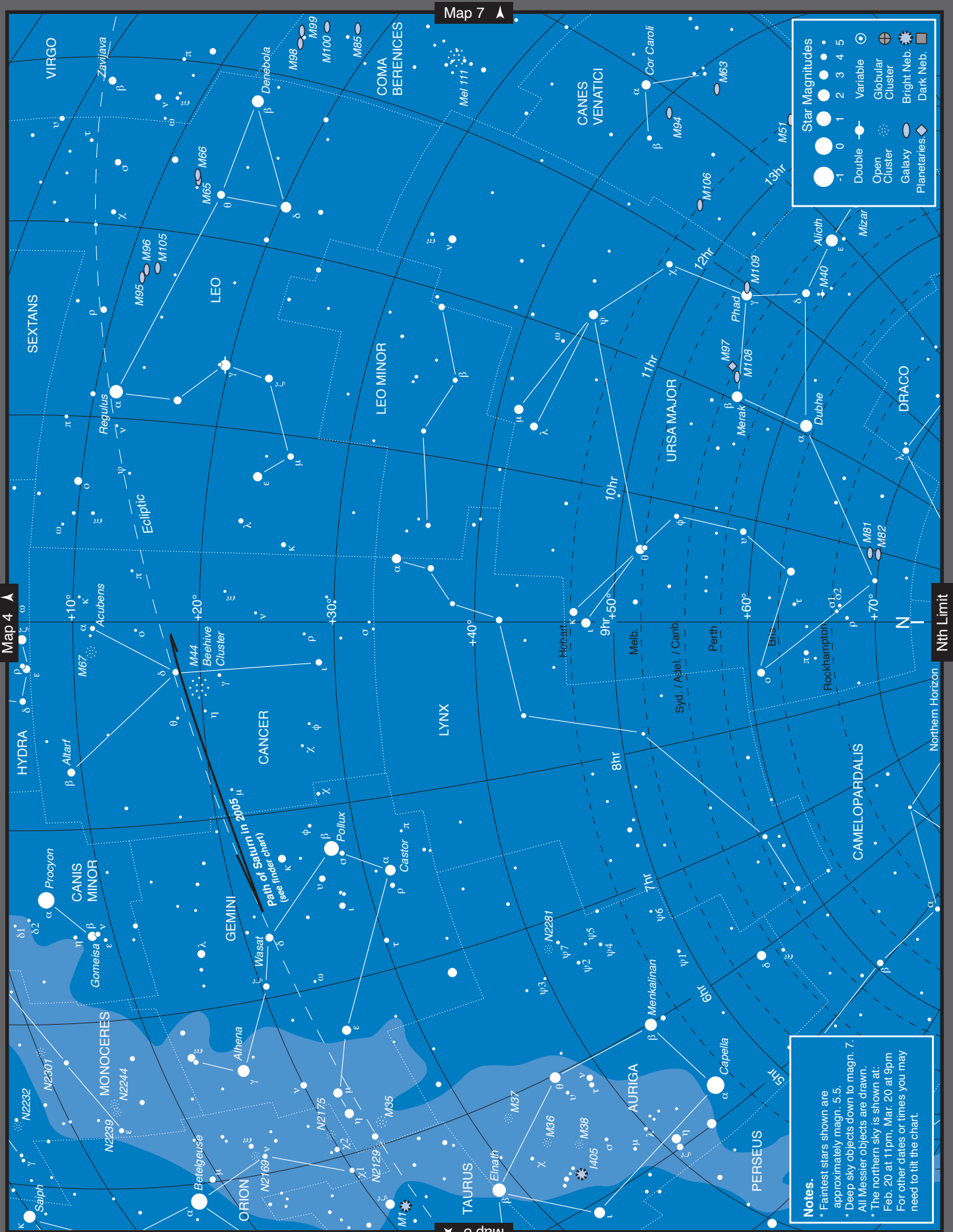
Map 1 ▲

Map 6 ▲

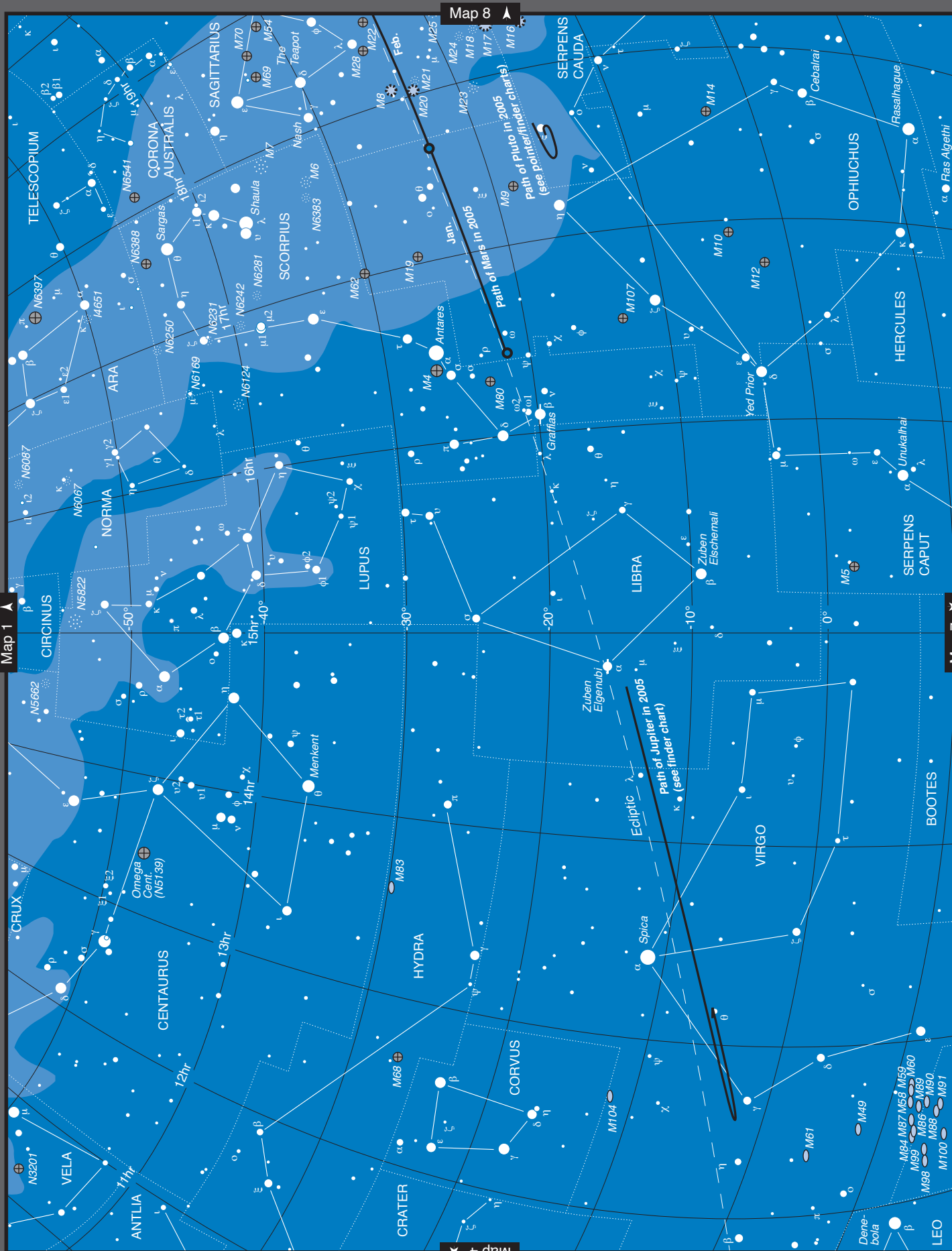
Map 5 ▼

Map 2 ▼

Map 5 - Autumn (North)



Map 6 - Winter (Centre)

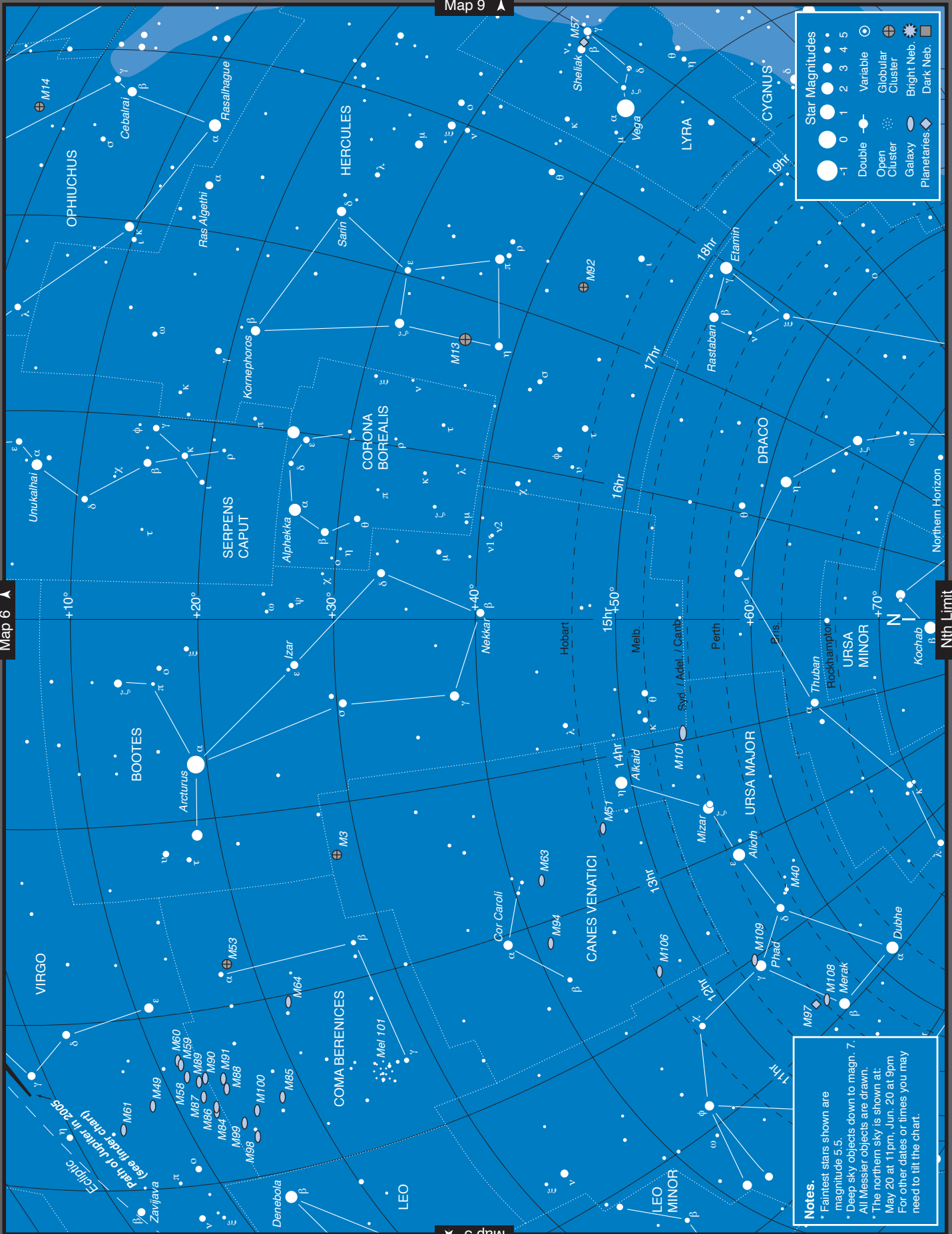


Map 7 - Winter (North)

Map 9

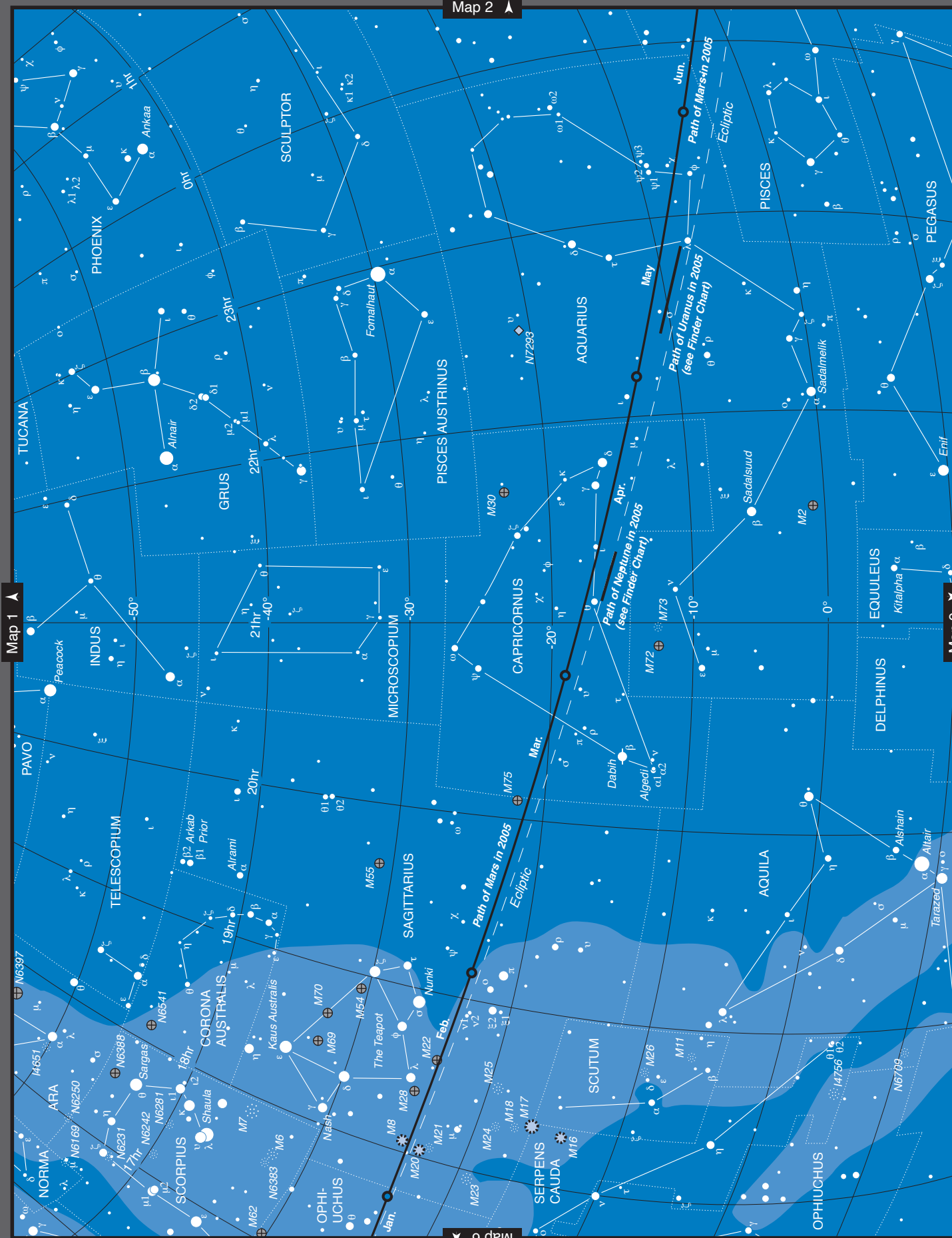
Map 6

Map 5



Map 8 - Spring (Centre)

Map 2

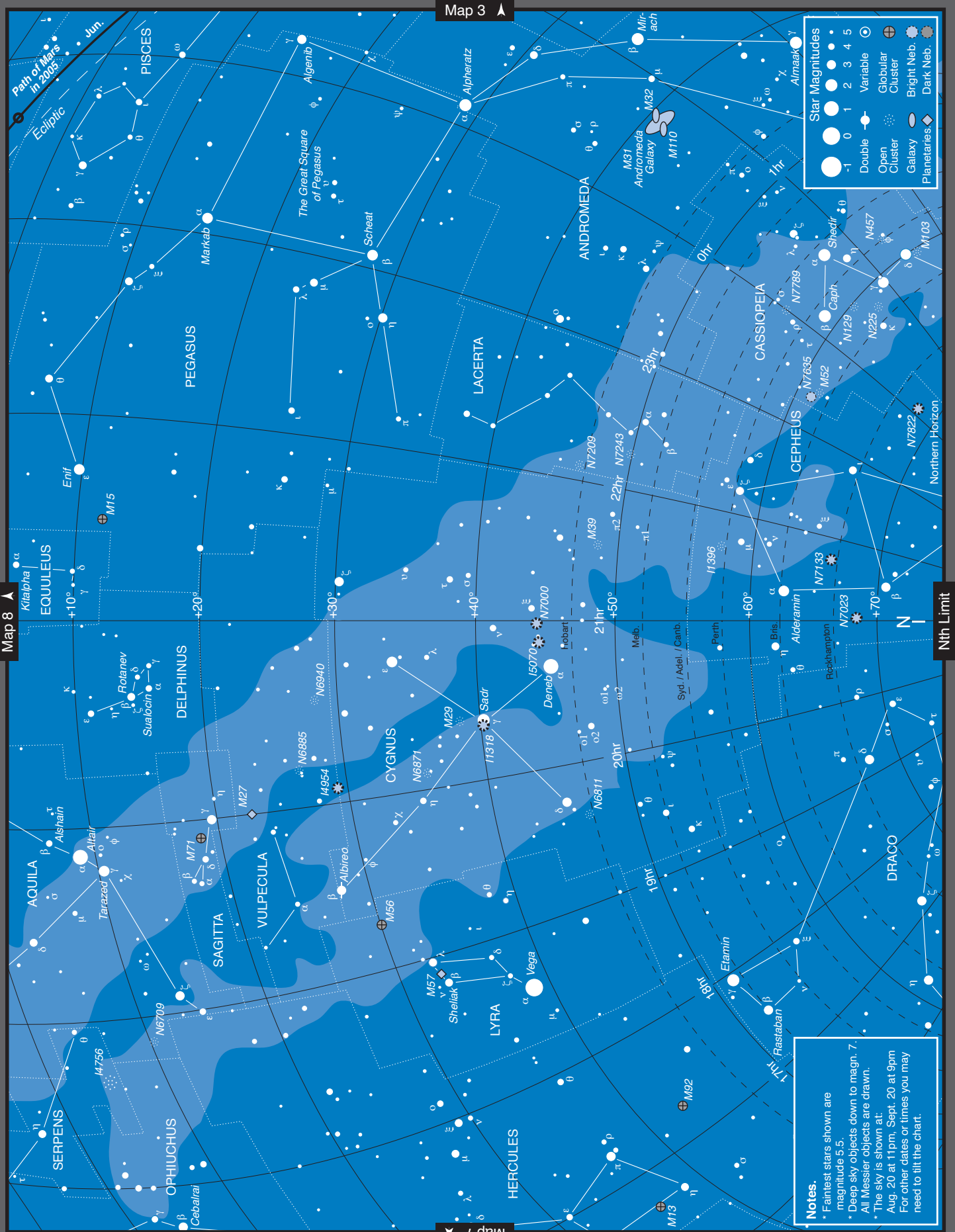


Map 1

Map 9

Map 6

Map 9 - Spring (North)



PART II THE SOLAR SYSTEM

This introduction is only brief, as many of the 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 where ever they involve location specific data, such as rise and set times of the Sun, Moon and planets and lunar occultation tables. As in Part I, no allowance has been made for Daylight Saving Time. When in force you need to add one hour to the times given here. Information related to Jupiter's moons (pp. 111 – 113) is given in EST and WST. Remaining data in Part II is presented in UT.

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

The 24 hr clock is often used in astronomy e.g., 16:00 hr is the same as 4:00pm. This avoids having to distinguish between 'am' and 'pm'. The 24hr approach is frequently used in Part II of this book e.g., for rise/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 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 Co-ordinates or Positions. The astronomical positions are given in equatorial co-ordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one-hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations, 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 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 have been calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. This means they have been calculated for a position at the centre of the Earth. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Except for the Moon, this slight shift is insignificant. Positions for the outer planets are given in weekly intervals and correspond to Saturdays; those for the Sun, Moon, Venus and Mercury are daily.

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

Use of Star Atlases. As the Earth orbits the Sun, the polar axis remains fixed relative to the stars. The points, around which the stars appear to rotate (the celestial poles), appear to never change no matter what time of the year one is observing. However, the positions of the celestial poles do slowly move against the star field. This is called precession and is caused

by the Earth's axis slowly wobbling, like a spinning top, over thousands of years. 'Epoch 2000.0' refers to an object's position relative to where the celestial poles (+/-90° in declination) were in the year 2000. 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 what is seen on terrestrial maps). Telescope systems that use an odd number of mirrors will reverse the image. The common use of star diagonals in Schmidt-Cassegrains or traditional refractors causes this reversal. Binoculars or straight Newtonians show 'normal' sky images (the Newtonian image will be upside down).

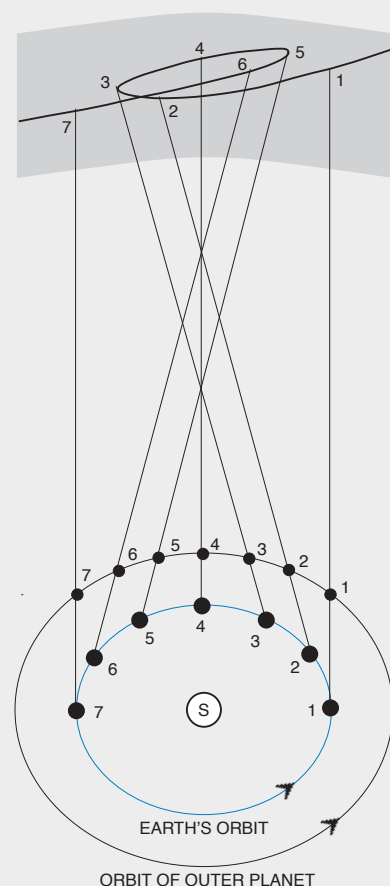
Finder Charts. No finder charts are presented for the Moon, Mercury, Venus or Mars. Their rapid motion during the year causes them to cover a very large section of the sky which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams (see Part I) should be sufficient to act as finders. With regard to Mars it was decided that the All Sky Maps gave adequate detail to easily find the red planet, so its traditional finder has been included on the All Sky 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 much narrower field finders.

RETROGRADE MOTION

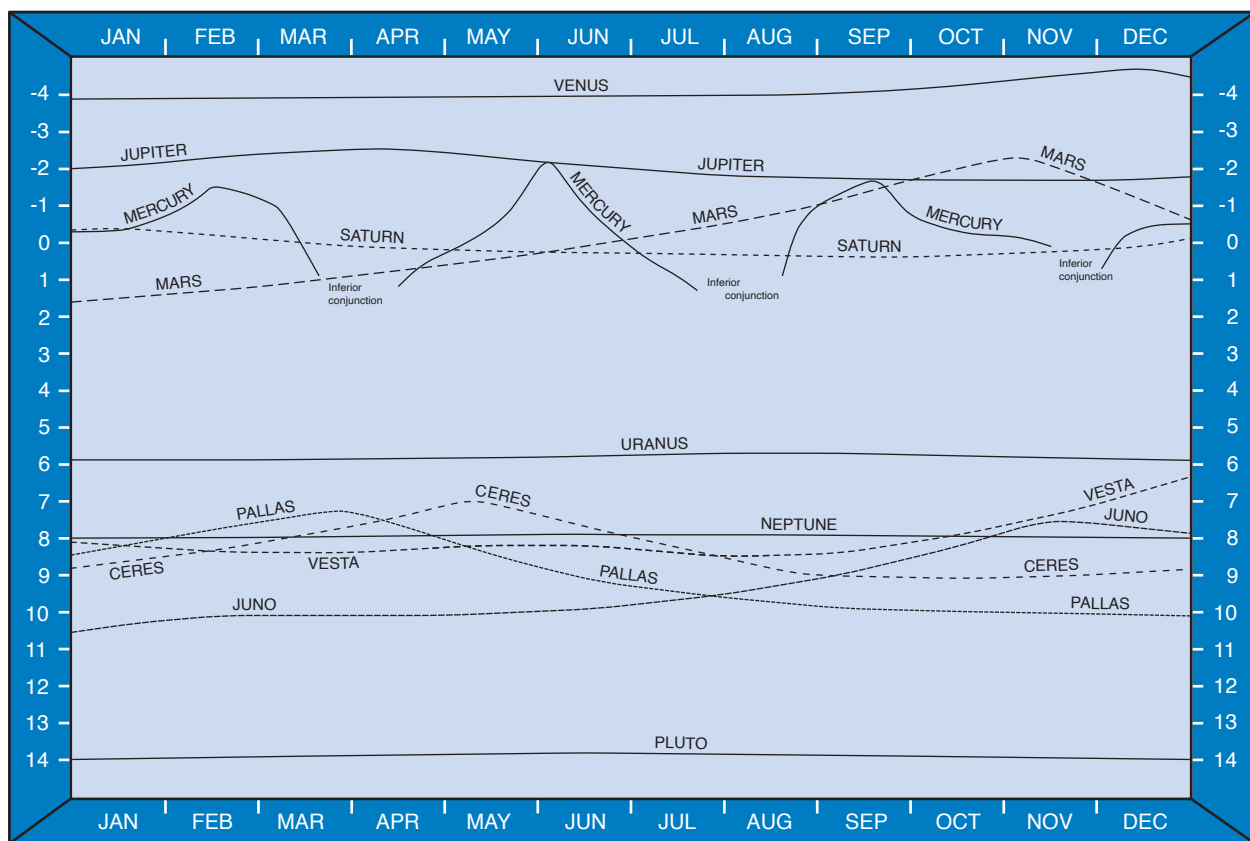
The finder charts for the outer planets have one thing in common — an apparent motion with a loop or 'S' shape. This only applies to the period during opposition. Note that Mars does not reach opposition every year, but it does in November this year and the All Sky Map showing Mars towards the end of 2005 displays a prominent 'S' shape. The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

In the diagram, the shaded area represents the path of an outer planet against the celestial sphere. As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet 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.

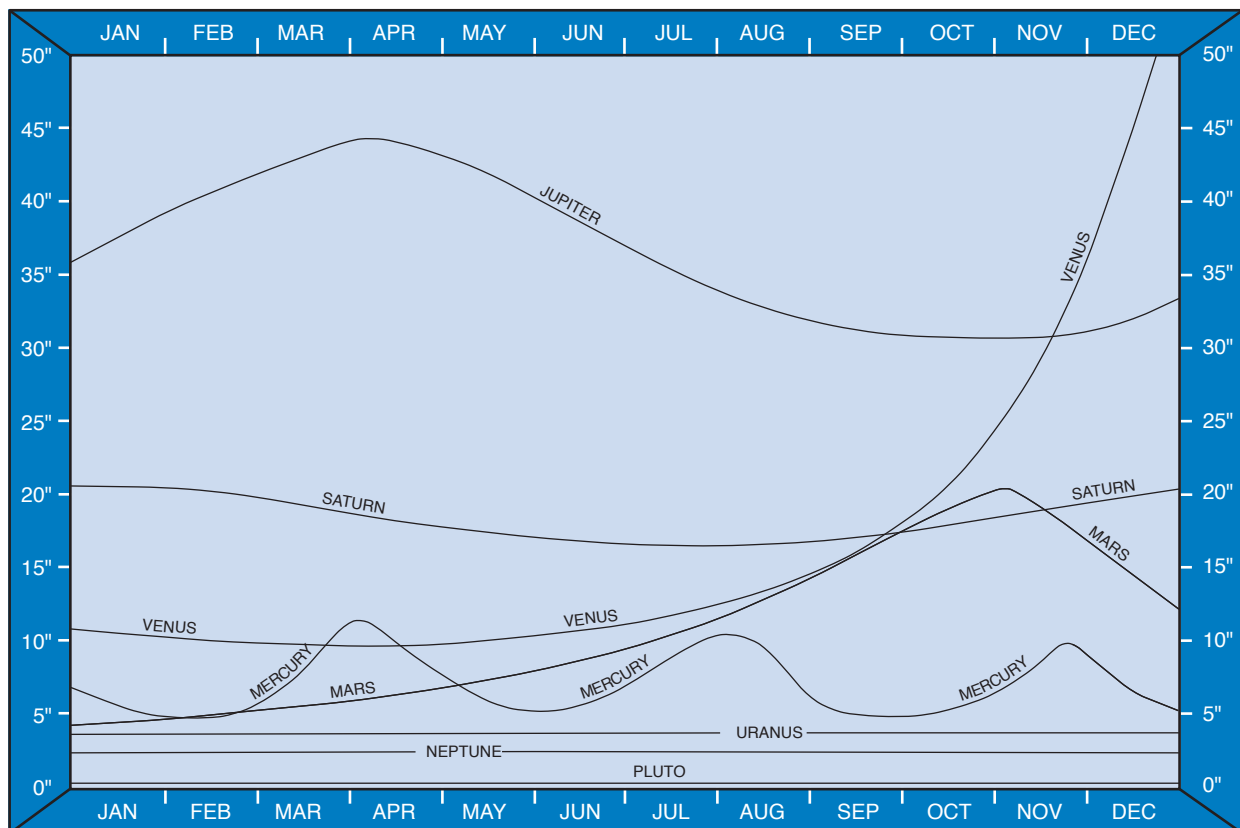


MAGNITUDES of the PLANETS and MAJOR ASTEROIDS



The magnitude plot for Mercury is not shown when the planet is near inferior conjunction, as it is too close to the Sun for observation.

PLANETARY ANGULAR SIZE



GEOCENTRIC PHENOMENA (UT)

Planet	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary	Greatest Elongation West
Mercury	14 Feb, 11h 3 Jun, 9h 18 Sep, 3h	12 Mar, 18h (18°) 9 Jul, 3h (26°) 3 Nov, 16h (24°)	19 Mar, 16h 22 Jul, 5h 14 Nov, 9h	29 Mar, 16h 6 Aug, 0h 24 Nov, 16h	11 Apr, 2h 15 Aug, 13h 4 Dec, 1h	26 Apr, 17h (27°) 23 Aug, 23h (18°) 12 Dec, 13h (21°)
Venus	31 Mar, 3h	3 Nov, 19h (47°)	23 Dec, 5h			
Planet	Conjunction	Stationary	Opposition	Stationary	EARTH	
Mars		1 Oct, 10h	7 Nov, 8h	10 Dec, 23h	Perihelion	2 Jan, 1h
Jupiter	22 Oct, 13h	2 Feb, 16h	3 Apr, 16h	5 Jun, 22h	Equinox	20 Mar, 13h
Saturn	23 Jul, 17h	22 Nov, 18h	13 Jan, 23h	22 Mar, 0h	Solstice	21 Jun, 7h
Uranus	25 Feb, 7h	15 Jun, 7h	1 Sep, 3h	16 Nov, 7h	Aphelion	5 Jul, 5h
Neptune	3 Feb, 19h	20 May, 3h	8 Aug, 16h	26 Oct, 22h	Equinox	22 Sep, 22h
Pluto	16 Dec, 4h	27 Mar, 8h	14 Jun, 3h	3 Sep, 3h	Solstice	21 Dec, 19h

HELIOCENTRIC PHENOMENA (UT)

Planet	Aphelion	Perihelion	Descending Node	Greatest Latitude South	Ascending Node	Greatest Latitude North
Mercury	23 Jan 21 Apr 18 Jul 14 Oct	8 Mar 4 Jun 31 Aug 27 Nov	12 Jan 10 Apr 7 Jul 3 Oct 30 Dec	12 Feb 11 May 7 Aug 3 Nov	3 Mar 30 May 26 Aug 22 Nov	18 Mar 14 Jun 10 Sep 7 Dec
Venus	22 Feb 4 Oct	14 Jun	18 Jan 31 Aug	16 Mar 26 Oct	11 May 22 Dec	5 Jul
Mars		17 Jul	15 Jan	21 Jun	15 Nov	
Jupiter	14 Apr					17 Feb
Saturn		Uranus, Neptune and Pluto have no events in 2005				8 Jan

SOLAR SYSTEM DATA – SUN, MOON AND THE PLANETS

NAME	MEAN DISTANCE FROM SUN (x 10 ³ km) (Earth = 1)		MAG at OPP	EQUATORIAL DIAMETER (km.)	FLATTENING ¹	No of MOONS	MASS (x10 ²⁴ kg) (Earth = 1)	
Sun	-		-26.8	1392530	0	-	1989085	332946
Moon	-		-12.74 ¹¹	3475	0	-	0.073483	0.0123
Mercury	57856	0.387	0.16 ¹²	4879	0	0	0.33022	0.055
Venus	108132	0.723	-4.07 ¹²	12104	0	0	4.8690	0.816
Earth	149492	1.000	-3.5 ¹³	12756	0.00335364	1	5.9742	1.000
Mars	227780	1.524	-2.01	6794	0.006476	2	0.64191	0.107
Jupiter	777776	5.203	-2.70	142984	0.064874	63	1898.8	317.900
Saturn	1425983	9.540	0.67	120536	0.097962	35	568.50	95.200
Uranus	2867760	19.180	5.52	51118	0.022927	27	86.625	14.500
Neptune	4492800	30.700	7.84	49528	0.017081	13	102.78	17.400
Pluto	5745000	39.670	13.7	2302	0	1	0.015	0.003
NAME	VOLUME (Earth = 1)	SIDEREAL PERIOD ²	SYNODIC PERIOD (days) ³	AXIAL ROTATION (days) ⁴	ALBEDO ⁵	ECCENTRICITY ⁶	INCLINATION ⁷	OBLIQUITY ⁸
Sun	1300000	-	-	25.38 ⁹	-	-	-	7° 15' 10
Moon	0.02	27.32 d	29.4	27.32166	0.12	0.0549	5° 08' 40"	6° 41'
Mercury	0.06	87.97 d	115.8	58.6462	0.106	0.20562	7° 00' 00"	0° 00'
Venus	0.86	224.7 d	583.9	-243.0187	0.65	0.00681	3° 23' 38"	92° 00'
Earth	1	365.256 d	-	0.99726968	0.367	0.01681	0° 00' 00"	23° 26'
Mars	0.15	687 d	779.8	1.02595675	0.150	0.09333	1° 51' 01"	25° 10'
Jupiter	1323	11.86 y	398.8	0.41354 ¹⁴	0.52	0.04837	1° 18' 28"	3° 07'
Saturn	752	29.46 y	378.0	0.44401 ¹⁴	0.47	0.05582	2° 29' 29"	26° 45'
Uranus	64	84.01 y	369.7	-0.71833	0.51	0.0471	0° 46' 22"	98° 00'
Neptune	54	164.8 y	367.5	0.67125	0.41	0.00855	1° 46' 38"	29° 00'
Pluto	0.007	249.9 y	366.7	-6.3872	0.30	0.2486	17° 09' 00"	118° 00'

Notes:

- The ratio of the difference of equatorial and polar radii to equatorial radius.
- The planet's year.
- The period of the planet's orbit with respect to the Earth.
- The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
- The ratio of the sunlight reflected to that received.

- The measure of how long or thin the ellipse of the planet's orbit is.
- The angle of the planet's orbit from the plane of the ecliptic.
- The degree of inclination of the planet's equator to its orbit
- Equatorial region (the polar areas of the Sun rotate in a period of 29 to 30 days).
- To the ecliptic.

- From the Earth.
- At mean greatest elongation.
- As seen from the Sun.
- Based on System III rotation. Similar to systems I or II except a radio source within the planet is used as the reference point.

SOLAR SYSTEM DATA — SATELLITES

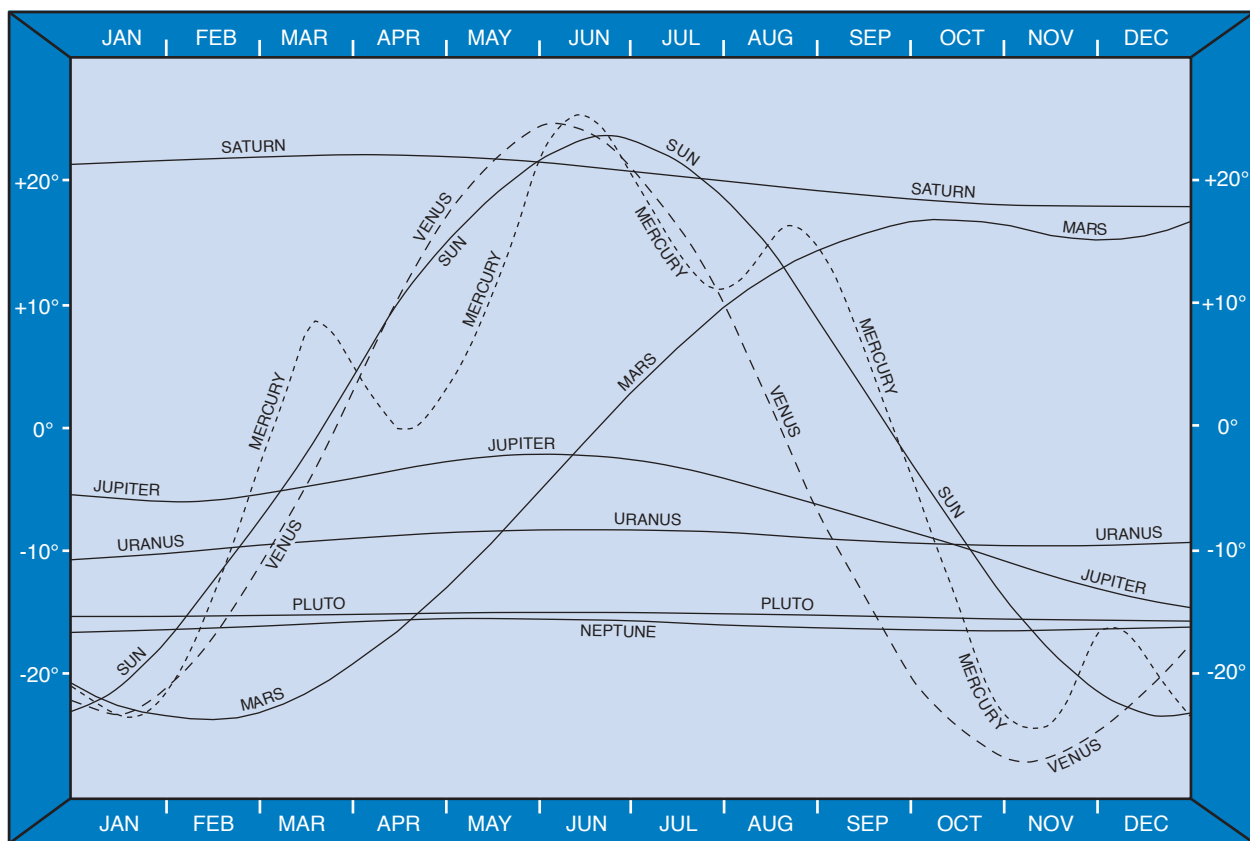
PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMI-MAJOR AXIS (x10 ³ km)	DIAMETER (km)	MAGNITUDE AT OPPOSITION
Earth	Moon	27.321661		384.400	3,475	-12.74
Mars	Phobos	0.31891023	25"	9.378	26.8x21x18.4	11.3
	Deimos	1.2624407	1' 02"	23.459	15.0x12x10.4	12.40
Jupiter	Metis	0.30	0' 42"	128	43	17.5
	Adrastea	0.30	0' 42"	129	16	18.7
	Amalthea	0.50	0' 59"	181	167	14.1
	Thebe	0.68	1' 13"	222	99	16.0
	Io	1.77	2' 18"	422	3,643	5.1
	Europa	3.55	3' 40"	671	3,122	5.3
	Ganymede	7.16	5' 51"	1,070	5,262	4.6
	Callisto	16.69	10' 18"	1,883	4,821	5.7
	Themisto	130.02		7,507	8	21.0
	Leda	240.92	1° 00' 39"	11,094	20	19.5
	Himalia	250.56	1° 02' 46"	11,480	170	14.6
	Lysithea	259.20	1° 04' 04"	11,720	36	18.3
	Elara	259.64	1° 04' 10"	11,737	86	16.3
	S/2000 J 11	286.95		12,555	4	22.4R
	S/2003 J 20	454.13		17,033	3	23.0R
	S/2003 J 3	490.45		17,929	2	23.4R
	S/2003 J 18	511.75		18,445	2	23.4R
	S/2003 J 12	536.23		19,028	1	23.9R
	S/2003 J 4	547.50		19,294	2	23.0R
	Euporie	550.67		19,302	2	23.1R
	S/2003 J 16	598.04		20,464	2	23.3R
	S/2003 J 22	601.0		20,700	2	23.5
	Orthosie	622.58		20,721	2	23.1R
	Euanthe	620.55		20,799	3	22.8R
	S/2003 J 21	613.40		20,813	2	23.3R
	S/2003 J 6	616.82		20,890	4	22.6R
	Thyone	627.26		20,940	4	22.3R
	S/2003 J 8	623.39		21,038	3	22.9R
	S/2003 J 10	625.16		21,078	2	23.6R
	Harpalyke	623.34		21,105	4	22.2
	Hermippe	633.91		21,131	4	22.1R
	Praxidike	625.30		21,147	7	21.2
	Ananke	629.77	1° 55' 52"	21,200	28	18.8
	Iocaste	631.49		21,269	5	21.8
	S/2003 J 15	678.19		22,253	2	23.5R
	Carne	734.17	2° 03' 31"	22,600	46	17.6
	S/2003 J 11	702.95		22,792	2	23.7R
	Eurydome	717.31		22,865	3	22.7R
	S/2003 J 17	708.81		22,918	2	23.4R
	S/2002 J 1	723.90		22,931	3	22.8R
	S/2003 J 9	713.51		23,020	1	23.7R
	S/2003 J 7	714.00		23,030	4	22.5R
	Autonoe	762.70		23,039	4	22.0R
	Pasithee	719.48		23,096	2	23.2R
	Chaldene	723.78		23,179	4	22.5
	Isonoe	725.52		23,217	4	22.5
	Kale	729.47		23,217	2	23.0R
	Aitne	730.22		23,231	3	22.7R
	Erinome	728.26		23,279	3	22.8
	S/2003 J 19	728.84		23,348	2	23.7R
	Taygete	732.24		23,360	5	21.9
	Sponde	748.33		23,487	2	23.0R
	Pasiphae	743.63	2° 08' 26"	23,500	60	17.0
	Kalyke	742.98		23,583	5	21.8
	S/2003 J 13	742.93		23,648	2	23.2R
	Sinope	758.90	2° 09' 31"	23,700	38	18.1
	S/2003 J 1	747.70		23,749	4	22.6R
	Megaclite	752.82		23,806	5	21.7
	S/2003 J 14	761.45		24,039	2	23.6R
	S/2003 J 23	759.7		24,056	2	23.6
	Callirrhoe	758.77		24,102	9	20.7
	S/2003 J 5	781.03		24,450	4	22.4R
	S/2003 J 2	889.20		26,658	2	23.2R
Saturn	Pan	0.58	0' 21"	134	20	19.4
	Atlas	0.60	0' 22"	138	32	19.0
	Prometheus	0.61	0' 23"	139	100	15.8
	S/2004 S 4			140	4	
	S/2004 S 3			141	4	
Saturn	Pandora	0.63	0' 23"	142	84	16.4
	Epimetheus	0.69	0' 24"	151	119	15.6
	Janus	0.70	0' 24"	152	178	14.4
	Mimas	0.94	0' 30"	186	397	12.8
	S/2004 S 1	1.01		194	3	23
	S/2004 S 2	1.14		211	4	23
	Enceladus	1.37	0' 38"	238	499	11.8
	Calypso	1.89	0' 48"	295	19	18.7
	Telesto	1.89	0' 48"	295	24	18.5
	Tethys	1.89	0' 48"	295	1,060	10.2
	Dione	2.74	1' 01"	377	1,118	10.4
	Helene	2.74	1' 01"	377	32	18.4
	Rhea	4.52	1' 25"	527	1,528	9.6
	Titan	15.95	3' 17"	1,222	5,150	8.4
	Hyperion	21.28	3' 59"	1,464	266	14.4
	Iapetus	79.33	9' 35"	3,561	1,436	11.0
	Kiviuq	449.22		11,365	14	22.0R
	Ijiraq	451.47		11,442	10	22.6R
	Phoebe	548.21	34' 51"	12,944	220	16.4
	Paaliaq	686.94		15,198	19	21.3R
	Skadi	728.18		15,641	6	23.6R
	Albiorix	783.47		16,394	26	20.5R
	Erriapo	871.25		17,604	9	23.0R
	Siarnaq	895.55		18,195	32	20.1R
	Tarvos	926.13		18,239	13	22.1R
	S/2003 S 1	956.19		18,719	7	24.0
	Mundilfari	951.56		18,722	6	23.8R
	Suttung	1,016.51		19,465	6	23.9R
	Thrym	1,091.76		20,219	6	23.9R
	Ymir	1,315.33		23,130	16	21.7R
Uranus	Cordelia	0.34	0' 04"	50	40	23.6
	Ophelia	0.38	0' 04"	54	43	23.3
	Bianca	0.44	0' 04"	59	51	22.5
	Cressida	0.46	0' 05"	62	80	21.6
	Desdemona	0.47	0' 05"	63	64	22.0
	Juliet	0.49	0' 05"	64	94	21.1
	Portia	0.51	0' 05"	66	135	20.4
	Rosalind	0.56	0' 05"	70	72	21.8
	S/2003 U 2			75	10	26
	Belinda	0.62	0' 06"	75	81	21.5
	S/1986 U 10	0.64		76	20	24
	Puck	0.76	0' 07"	86	162	19.8
	S/2003 U 1			98	20	26
	Miranda	1.41	0' 10"	130	472	15.8
	Ariel	2.52	0' 14"	191	1,158	13.7
	Umbriel	4.14	0' 20"	266	1,097	14.5
	Titania	8.71	0' 33"	436	1,578	13.5
	Oberon	13.46	0' 44"	584	1,523	13.7
	S/2001 U 3	266.6		4,276	22	25
	Caliban	579.73	8' 56"	7,231	98	22.4
	Stephano	677.37		8,004	20	24.1
	Trinculo	759.03		8,578	18	25.4R
	Sycorax	1,288.28	15' 26"	12,179	190	20.8
	S/2003 U 3	1,694.8		14,345	20	25.2R
	Prospero	1,977.29		16,243	30	23.2
	Setebos	2,234.77		17,501	30	23.3
	S/2001 U 2	2,823.40		20,901	21	25.1
Neptune	Naiad	0.29	0' 02"	48	66	23.9
	Thalassa	0.31	0' 02"	50	82	23.3
	Despina	0.34	0' 02"	53	150	22.0
	Galatea	0.43	0' 03"	62	176	21.9
	Larissa	0.56	0' 03"	74	194	21.5
	Proteus	1.12	0' 06"	118	420	19.8
	Triton	5.88	0' 17"	355	2,707	13.5
	Nereid	360.14	4' 21"	5,513	340	19.7
	S/2002 N 1	1,874.83		15,686	48	25.0R
	S/2002 N 2	2,405.98		19,345	48	25.0R
	S/2002 N 3	2,674.87		20,723	48	25.0R
	S/2003 N 1	9,136.11		46,738	28	26.0R
	S/2002 N 4	9,007.10		47,280	120	
Pluto	Charon	6.39	<1"	19	1,186	17.3

The table covers the currently known satellites of the Solar System (as of September 2004). Note a number of the satellites above are recent discoveries and have not yet been named. Instead they have a

preliminary designation such as S/2003 J 2.
Note: magnitudes followed by R are red magnitudes.

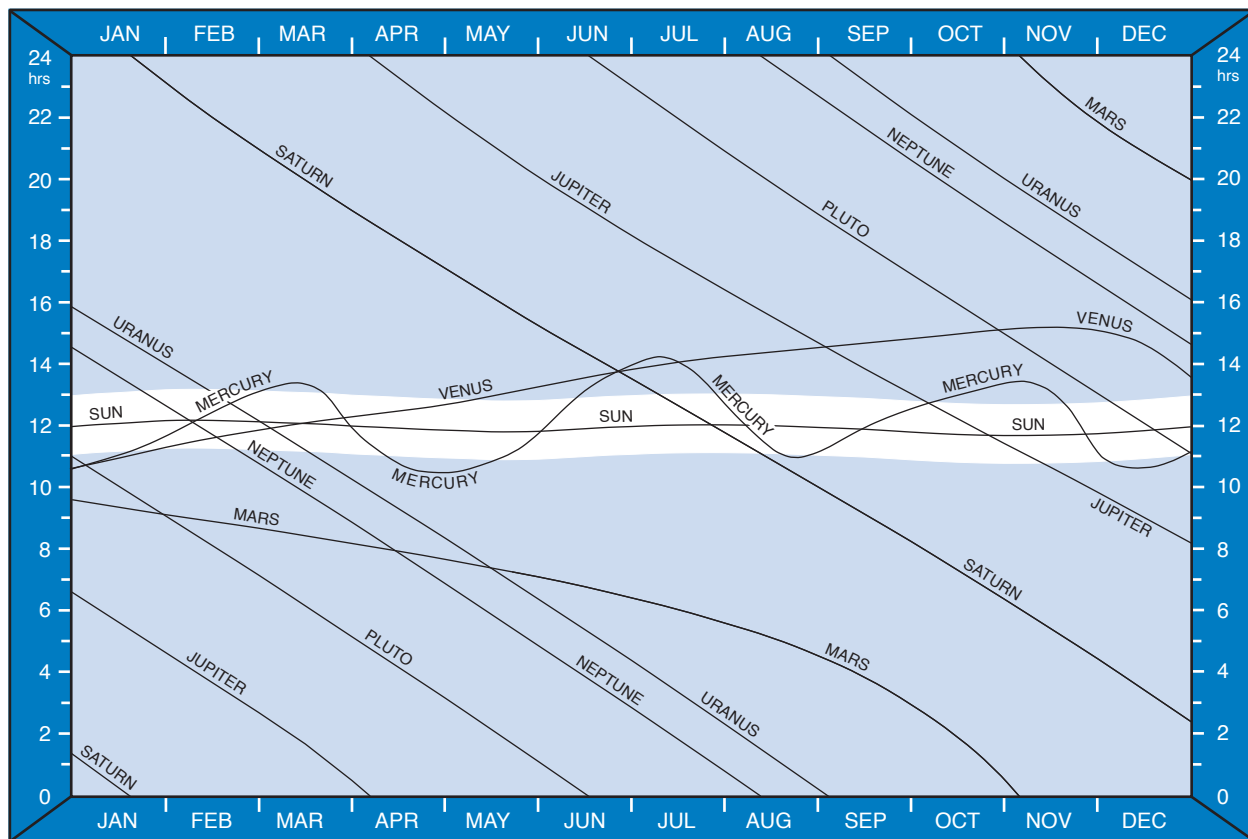
In general, the further south a planet is (negative declination), the higher in the northern sky it is, as seen from most of Australia. The higher in the sky, the less atmosphere you have to look through and the more stable the image is (less prone to turbulence). This can be particularly relevant when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

DECLINATIONS of the SUN and PLANETS



MERIDIAN PASSAGE of the SUN and PLANETS

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



GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

SUN

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

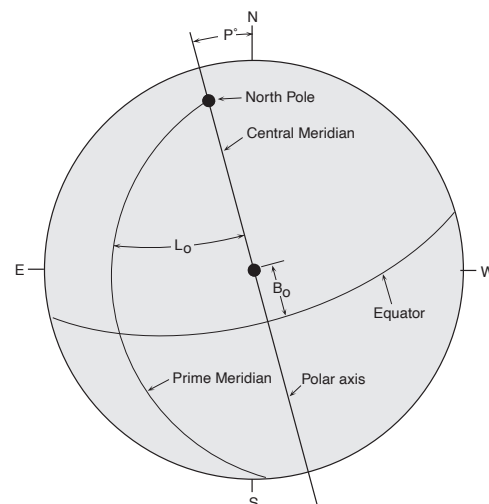
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		Twilight		Sun		Twilight		Sun		Twilight		Sun		Twilight		Sun		Twilight	
		Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End		
Jan	1	2:21	4:36	19:53	22:08	3:07	5:01	19:45	21:39	3:35	5:14	19:26	21:05	3:04	4:47	19:09	20:53	Jan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

ORIENTATION OF THE SUN

SUN

Date	P°	B ₀ °	L ₀ °
Jan 1	+ 2.0	- 3.0	013.8
8	- 1.4	- 3.8	281.7
15	- 4.7	- 4.6	189.5
22	- 7.9	- 5.2	097.3
29	- 11.0	- 5.8	005.1
Feb 5	- 13.8	- 6.3	273.0
12	- 16.4	- 6.7	180.8
19	- 18.7	- 7.0	088.6
26	- 20.8	- 7.2	356.4
Mar 5	- 22.5	- 7.3	264.2
12	- 23.9	- 7.2	172.0
19	- 25.0	- 7.1	079.7
26	- 25.8	- 6.8	347.4
Apr 2	- 26.2	- 6.5	255.1
9	- 26.3	- 6.1	162.7
16	- 26.0	- 5.5	070.3
23	- 25.3	- 4.9	337.9
30	- 24.3	- 4.3	245.4
May 7	- 22.9	- 3.5	152.9
14	- 21.2	- 2.8	060.3
21	- 19.2	- 2.0	327.7
28	- 16.9	- 1.1	235.1
Jun 4	- 14.3	- 0.3	142.5
11	- 11.5	+ 0.6	049.8
18	- 8.5	+ 1.4	317.2
25	- 5.4	+ 2.2	224.5

Date	P°	B ₀ °	L ₀ °
Jul 2	- 2.2	+ 3.0	131.8
9	+ 1.0	+ 3.7	039.2
16	+ 4.1	+ 4.4	306.6
23	+ 7.1	+ 5.1	213.9
30	+ 10.0	+ 5.6	121.3
Aug 6	+ 12.8	+ 6.1	028.8
13	+ 15.3	+ 6.5	296.2
20	+ 17.7	+ 6.9	203.7
27	+ 19.8	+ 7.1	111.2
Sep 3	+ 21.6	+ 7.2	018.7
10	+ 23.1	+ 7.3	286.3
17	+ 24.4	+ 7.2	193.9
24	+ 25.4	+ 7.0	101.5
Oct 1	+ 26.0	+ 6.7	009.1
8	+ 26.3	+ 6.3	276.7
15	+ 26.2	+ 5.9	184.4
22	+ 25.8	+ 5.3	092.0
29	+ 25.0	+ 4.7	359.7
Nov 5	+ 23.8	+ 4.0	267.4
12	+ 22.2	+ 3.2	175.1
19	+ 20.2	+ 2.4	082.9
26	+ 17.9	+ 1.5	350.6
Dec 3	+ 15.3	+ 0.6	258.3
10	+ 12.4	- 0.3	166.1
17	+ 9.3	- 1.2	073.9
24	+ 6.0	- 2.1	341.7
31	+ 2.6	- 2.9	249.5



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

B₀° Heliocentric Latitude of centre of Sun

L₀° Heliocentric Longitude of centre of Sun

At the date of commencement of each synodic rotation period the value of L₀ is zero; that is, the prime meridian passes through the central point of the disk.

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

Example for Calculating Heliocentric Longitude

You wish to calculate the L₀ value for Aug 19 at 2pm WST.

2pm WST is 6 hours UT (0 hr UT is 8am WST). From the table the value for Aug 19 (0 hr UT) is the value for Aug 13 (296.2°) 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:

$$296.2^\circ + (-79.1^\circ) + (-3.3^\circ) = 213.8^\circ$$

(If negative you need to add 360°)

SOLAR AND LUNAR ECLIPSES

During 2005 there are four eclipses, two of the Sun and two of the Moon. One solar eclipse is a hybrid annular/total and the other annular. One lunar eclipse is penumbral and the other partial. Of the four eclipses, only the lunar eclipses will be visible from Australia, although not in their entirety across the whole continent.

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

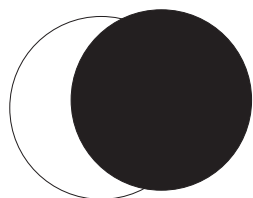
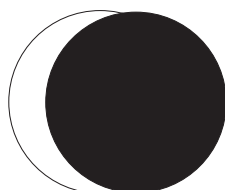
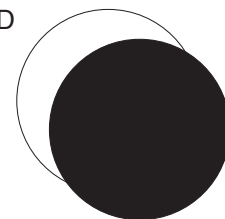
April 8th Annular/total eclipse of the Sun

The path of the first eclipse of the year, an uncommon annular/total event (see also p.33), is for the most part over water. The annular

phase begins when the shadow meets the Earth southeast of New Zealand. Greatest total eclipse of 42 seconds occurs half way across the Pacific near the equator. Land is first encountered when the path reaches Central America at Costa Rica; it then crosses Panama and Colombia, ending at sunset in Venezuela. New Zealanders will see the Sun rise in partial eclipse (see diagram).

	Time (UT)	Longitude	Latitude
Eclipse begins	17h51.2m	-170°55.5'	-40°41.5'
Central eclipse	20h15.6m	-123°28.3'	-15°47.3'
Eclipse ends	23h20.4m	-77°40.0'	+14°55.5'

PARTIAL ECLIPSE of the SUN from NEW ZEALAND

Auckland
6:50amWellington
6:55amChristchurch
7:05am

Each view is just after sunrise at local time on the 9th April 2005

April 24th

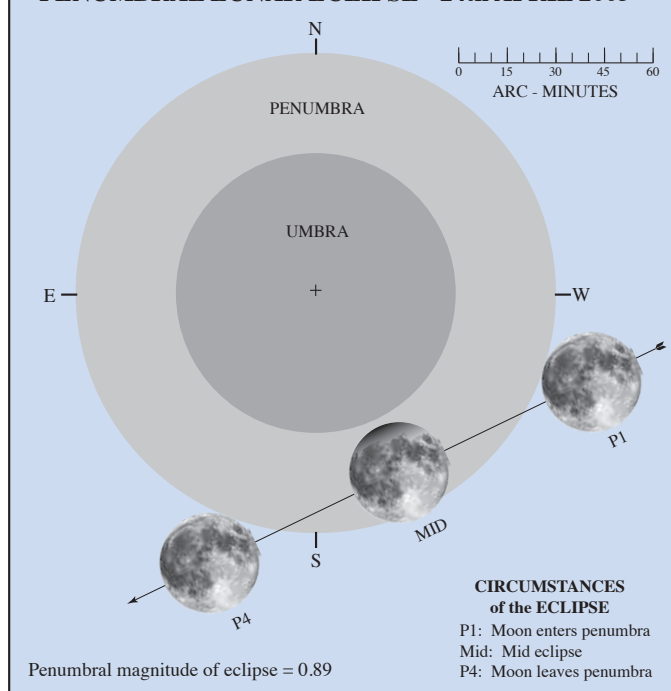
Penumbral eclipse of the Moon

The first lunar eclipse of 2005 is visible from the western parts of North America, New Zealand and eastern Australia. The penumbral magnitude of the eclipse is 0.89, which places the Moon deep within the penumbral shadow. At mid-eclipse, the Moon's northern limb will be just 4.4 arc minutes from the umbra, while the southern limb remains outside the penumbra throughout the eclipse. Penumbral eclipses are sometimes difficult to see, and certainly any eclipse with a penumbral magnitude of 0.7 or less is generally considered too difficult to observe. This eclipse should display a subtle darkening across the northern half of the Moon, best seen around mid-eclipse.

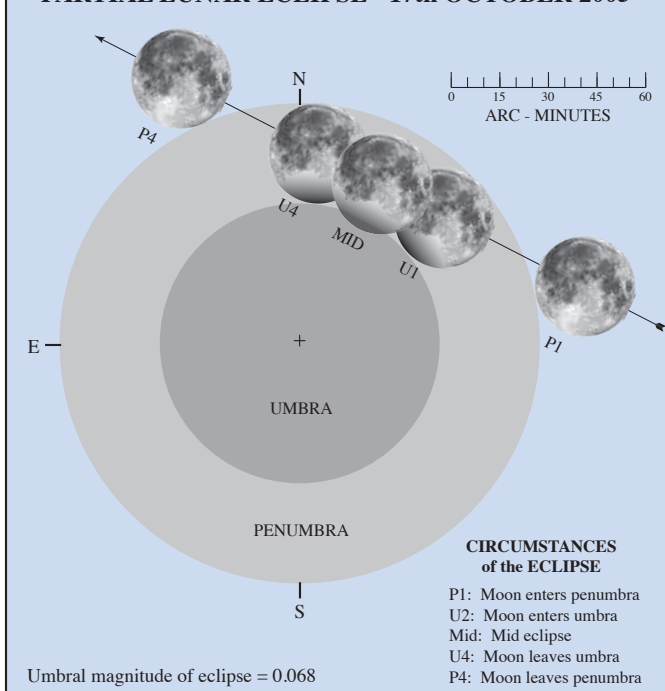
From the eastern half of Australia the eclipse begins around sunset, and consequently it will not be visible until the end of astronomical twilight: this is fortuitously well before the time of mid-eclipse. Unfortunately the western half of Australia will fail to notice the event due to the evening twilight.

	Time (UT)	Time (EST)	Time (CST)
Moon enters penumbra	07h 49.8m	17h 49.8m	17h 19.8m
Middle of eclipse	09h 54.8m	19h 54.8m	19h 24.8m
Moon leaves penumbra	11h 59.8m	21h 59.8m	21h 29.8m

PENUMBRAL LUNAR ECLIPSE - 24th APRIL 2005



PARTIAL LUNAR ECLIPSE - 17th OCTOBER 2005



October 3rd

Annular eclipse of the Sun

The second solar eclipse of the year is a northern hemisphere event. The Moon's shadow begins in the North Atlantic Ocean and first landfall is near the Portuguese / Spanish border. Crossing the Mediterranean, the path then moves across the African continent, beginning with Algeria and followed by Tunisia, Libya, Chad, Sudan, Ethiopia, Kenya and Somalia before ending over the Indian Ocean. The safest and easiest place to go for eclipse chasers would be Madrid, Spain where annularity can be enjoyed for 4 minutes and 11 seconds.

	Time (UT)	Longitude	Latitude
Eclipse begins	07h35.5m	-23°05.0'	+41°07.7'
Central eclipse	10h10.7m	+24°35.3'	+18°12.6'
Eclipse ends	13h27.8m	+66°31.1'	-16°40.9'

October 17th

Partial eclipse of the Moon

The final eclipse of 2005 is a shallow partial eclipse. The umbral magnitude is 0.068, which places the Moon just within the umbral shadow. At mid-eclipse, the Moon's southern limb will only be 2.2 arc minutes within the umbra. The eclipse is visible across Australia but twilight and the Moon being below the horizon will interfere in the early stages from the west. The umbral stage is quite lengthy at this eclipse, and observers will see the dark notch on the lunar limb for an hour.

	Time (UT)	Time (EST)	Time (CST)	Time (WST)
Moon enters penumbra	09h51.4m	19h51.4m	19h21.4m	17h51.4m
Moon enters umbra	11h34.0m	21h34.0m	21h04.0m	19h34.0m
Middle of eclipse	12h03.3m	22h03.3m	21h33.3m	20h03.3m
Moon leaves umbra	12h32.5m	22h32.5m	22h02.5m	20h32.5m
Moon leaves penumbra	14h15.1m	00h15.1m (18th)	23h45.1m	22h15.1m

ADELAIDE (CST)

MOON RISE AND SET

BRISBANE (EST)

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

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

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

CANBERRA (EST)

MOON RISE AND SET

DARWIN (CST)

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

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

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

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

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

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

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

PERTH (WST)

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

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

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

MOON RISE AND SET

SYDNEY (EST)

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

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

LUNAR OCCULTATIONS 2005

INTRODUCTION

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

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

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

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

Dark limb events, in particular disappearances, are the easiest to observe. Following a star until it 'winks out' is much easier than scanning the lunar limb, waiting for it to suddenly reappear. The brighter the star, the more spectacular the event. The following tables present the easier to observe occultations for 2005 as predicted for **Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney**. Both events, the disappearance and reappearance, are not necessarily included. An event may not be present because:

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

THE TIMING OF OCCULTATIONS.

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

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

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

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

LUNAR OCCULTATION TABLES

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

EXPLANATION

EST	the date and time of the occultation, hr and min are in EST except Adelaide and Darwin using CST and Perth using WST.	
OBJECT	n, nn, nnn, nnnn	ZC catalogue number
	nnnnn or nnnnnn	SAO catalogue number
	X nnnnn	USNO XZ catalogue number
	name of planet, satellite or 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. A 'G' indicates a graze at or near the location.	
Mag	magnitude of the star.	
Elg	elongation or separation of the Moon from the Sun as measured in degrees.	
Alt.	altitude of the Moon during the occultation.	
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 become useless, and no values are recorded.	

CALCULATING EVENT TIME FOR OTHER LOCATIONS

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

Predicted Time at your location

$$= \text{Time from Table} + (A \times n) + (B \times p)$$

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

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

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

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

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

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the disappearance of ZC810 on March 17th for their location in Albury NSW ($146^\circ 55' \text{ E}$, $36^\circ 05' \text{ S}$), see page 138. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

$$= 149.13 - 146.92 = -2.21 \quad \text{--- 'n' (-)}$$

The change in latitude from Canberra (decimal degrees)

$$= 35.25 - 36.08 = -0.83 \quad \text{--- 'p' (-)}$$

From the Canberra table, the time of the event is 20:26 EST and the values of A and B are +2.1 and +1.7 respectively.

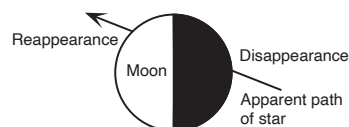
Therefore the equation becomes:

$$\begin{aligned} & 20:26 + (2.1 \times -2.21) + (1.7 \times -0.83) \\ & = 20:26 + (-4.64) + (-1.41) \\ & = 20:26 + (-6.1) = 20:20 \end{aligned}$$

The event will be visible from Albury approximately 6 minutes earlier than Canberra, i.e., about 8:20pm (EST) on March 17th.

Lunar occultation predictions were calculated using Win Occult version 3.1 by D. Herald, PO Box 254 Woden ACT 2606.

heraldd@canberra.DIALix.oz.au



LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 03:41	1849	RD	6.1	90	43	294	+1.4	-1.7	May 14 18:30	1252	DD	7.3	68	27	139	+1.3	-0.8	Sep 19 01:46	24	RD	6.8	172	50	278	+2.8	+0.2
Jan 04 12:15	Jupiter	DB	-2.0	86	6	66	0.0	+2.5	May 15 18:57	1363	RB	5.2	79	31	273	+2.6	+0.4	Sep 19 02:12	26	RD	7.0	172	48	231	+1.4	+1.6
Jan 06 02:50	2074	RD	7.1	65	22	254	+0.8	-0.8	May 15 21:26	1373	DD	6.5	80	15	186	-1.5	-3.6	Sep 19 03:44	32	RD	7.0	171	34	255	+1.3	+1.4
Jan 07 02:54	2207	RD	7.0	52	15	5	-1.4	-3.5	May 22 02:08	2104	DD	7.3	163	69	109	+1.9	-1.1	Sep 19 03:53	35	RD	6.2	171	32	188	+0.3	+2.7
Jan 16 22:27	148	DD	7.1	81	10	58	+0.5	+1.8	May 23 02:10	2120	DD	6.3	164	46	75	+1.5	+1.9	Sep 20 02:17	162	RD	6.9	158	45	251	+2.0	+0.9
Jan 19 20:40	493	DD	6.9	115	32	9	+1.0	+2.9	May 25 20:43	2554	DB	4.5	157	26	144	-0.5	-2.3	Sep 21 04:10	297	RD	6.5	144	33	220	+1.4	+1.8
Jan 21 21:22	773	DD	7.0	137	28	112	+2.9	-0.7	May 25 21:28	2554	RD	4.5	156	35	243	+1.2	-0.2	Sep 21 23:05	411	RD	7.0	133	12	239	+0.5	-0.1
Jan 24 22:47	1189	DD	5.0	169	27	102	+2.4	-0.8	May 26 02:05	2583	RD	5.8	155	83	273	+2.2	-0.1	Sep 22 03:46	75633	RD	7.0	131	34	209	+1.4	+1.7
Jan 26 22:28	80882	RD	7.3	167	21	267	+1.7	-1.1	May 26 05:08	2601	RD	6.8	153	50	313	+2.1	-1.1	Sep 22 03:47	425	RD	7.1	131	34	261	+2.3	+0.6
Jan 28 01:25	99091	RD	7.3	155	39	323	+1.6	-1.7	May 27 02:15	2784	DB	3.3	141	77	106	+2.1	-1.1	Sep 23 00:20	541	DB	3.9	120	12	49	+0.4	+0.1
Jan 29 00:39	1612	RD	7.3	144	35	322	+1.4	-2.1	May 27 03:30	2784	RD	3.3	140	81	237	+1.9	+1.7	Sep 23 00:24	539	DB	4.3	120	13	7	-0.8	+2.0
Jan 30 23:35	1802	RD	7.1	122	18	255	+0.9	-0.9	May 29 00:48	3089	RD	5.3	114	34	270	+0.8	-1.1	Sep 23 00:46	537	RD	3.7	120	16	227	+0.6	+0.2
Feb 02 02:42	2034	RD	6.8	97	45	261	+1.9	-0.8	May 29 03:31	3106	DB	5.2	113	65	59	+1.8	+0.8	Sep 23 00:54	536	RD	5.5	120	17	263	+1.4	-0.8
Feb 04 04:33	2305	RD	5.9	71	51	295	+1.0	-1.6	May 29 04:52	3106	RD	5.2	112	75	247	+2.0	+0.9	Sep 23 01:06	539	RD	4.3	120	19	294	+2.6	-2.3
Feb 05 03:51	2458	RD	6.3	58	32	261	+0.8	-0.8	May 30 06:05	164948	RD	7.2	98	70	193	+0.6	+3.1	Sep 23 01:23	76152	RD	7.2	120	21	251	+1.3	-0.4
Feb 06 04:18	2634	RD	7.2	44	25	300	0.0	-1.7	Jun 01 03:28	3514	RD	5.9	73	25	196	+0.4	+1.9	Sep 23 01:31	541	RD	3.9	120	22	252	+1.4	-0.4
Feb 15 20:57	459	DD	6.4	84	18	96	+1.5	+1.0	Jun 10 18:13	1213	DD	7.1	38	14	67	+2.3	+2.3	Sep 23 01:32	542	RD	5.8	120	22	293	+2.8	-2.1
Feb 17 22:37	76841	DD	7.3	107	13	128	+0.9	0.0	Jun 16 22:22	1830	DD	7.3	106	38	126	+1.2	-0.4	Sep 23 01:37	546	RD	7.3	120	23	214	+0.6	+0.8
Feb 23 22:50	1484	DD	3.5	171	35	137	+1.7	-1.8	Jun 17 23:16	1945	DD	5.2	119	40	148	+1.0	-1.4	Sep 23 01:40	543	RD	6.4	120	23	281	+2.3	-1.3
Feb 24 00:17	1484	RB	3.5	172	38	294	+2.2	-0.7	Jun 19 00:00	2063	DD	6.7	131	44	168	+1.1	-3.1	Sep 23 02:00	553	RD	6.8	119	25	190	-0.2	+2.0
Feb 25 22:35	1684	RD	6.8	164	32	263	+2.0	-1.0	Jun 20 03:14	2206	DD	7.0	146	19	88	+0.2	+1.2	Sep 23 02:16	548	RD	6.8	119	26	253	+1.8	-0.2
Feb 25 22:52	118952	RD	7.1	164	34	321	+1.1	-2.2	Jun 20 20:08	2328	DD	6.4	156	57	86	+1.8	-0.7	Sep 25 02:54	77381	RD	7.0	96	15	240	+1.1	-0.2
Feb 27 22:09	Jupiter	DB	-2.3	141	19	49	+1.8	+1.0	Jun 21 03:58	2364	DD	7.0	159	24	121	+0.7	+0.1	Sep 25 04:47	864	RD	6.6	95	25	260	+2.3	-0.2
Feb 27 22:20	Callisto	RD	6.0	141	21	15	-1.0	-4.3	Jun 21 04:53	2371	DD	4.8	160	13	33	-1.1	+3.3	Sep 26 03:53	1018	RD	5.8	84	16	225	+0.9	+0.3
Feb 27 22:24	Europa	RD	5.6	141	22	16	-1.0	-4.4	Jun 21 18:24	2476	DD	6.6	169	25	124	-0.1	-1.7	Oct 07 20:44	2270	DD	5.4	47	17	91	+0.1	+1.1
Feb 27 22:26	Jupiter	RD	-2.3	141	22	17	-1.2	-4.7	Jun 21 21:27	185295	DD	7.4	170	61	116	+1.3	-1.7	Oct 09 22:01	2583	DD	5.8	73	27	64	+0.1	+1.7
Mar 01 00:52	2000	RD	7.0	128	46	344	+0.2	-2.8	Jun 25 01:20	3037	RD	7.3	144	67	233	+1.8	+1.1	Oct 13 01:20	3092	DD	6.3	114	19	108	+0.6	+0.7
Mar 02 00:31	2111	RD	6.9	116	35	344	-0.2	-2.7	Jun 27 02:47	3339	RD	6.7	116	55	239	+1.6	+0.6	Oct 13 01:28	3090	DD	6.7	114	18	27	-0.4	+2.1
Mar 02 02:20	2119	RD	6.6	115	57	354	-0.2	-3.5	Jun 27 04:32	3347	RD	6.2	115	66	274	+2.8	-0.3	Oct 13 22:44	3225	DD	7.2	126	58	55	+1.2	+1.7
Mar 02 03:09	2120	RD	6.3	115	66	247	+3.6	+1.0	Jun 29 01:45	50	RD	5.8	90	17	302	+1.4	-4.2	Oct 14 01:23	3236	DD	7.1	128	27	67	+0.4	+1.5
Mar 03 02:16	2249	RD	6.7	103	48	226	+4.4	+2.6	Jul 03 05:35	559	RD	6.5	41	11	251	+0.8	-0.5	Oct 14 02:17	3240	DD	6.7	128	16	30	-0.2	+2.0
Mar 05 01:46	2554	DB	4.5	77	22	176	-2.2	-4.8	Jul 03 05:39	564	RD	6.2	41	11	199	-0.3	+1.3	Oct 14 20:09	3355	DD	6.7	139	58	77	+2.0	0.0
Mar 05 02:03	2554	RD	4.5	77	25	211	+2.6	+2.4	Jul 03 05:43	560	RD	3.6	41	12	291	+1.9	-2.2	Oct 15 19:45	3496	DD	7.3	153	41	47	+1.1	0.7
Mar 08 05:08	3089	DB	5.3	35	21	46	+0.7	+0.4	Jul 03 06:02	567	RD	6.8	40	15	224	+0.4	+0.3	Oct 15 22:02	3505	DD	5.5	154	57	101	+3.2	-0.9
Mar 17 19:32	810	DD	1.7	86	23	70	+2.4	+1.2	Jul 11 19:25	1596	DD	7.2	53	24	109	+1.1	+0.5	Oct 18 22:06	348	RD	6.8	166	25	212	+0.5	+0.9
Mar 17 20:56	810	RB	1.7	86	14	290	+1.3	+0.5	Jul 19 20:57	2583	DD	5.8	152	70	94	+1.9	-0.7	Oct 22 02:10	788	RD	6.8	127	23	309	+3.3	-2.2
Mar 19 22:58	79295	DD	7.2	108	13	75	+1.8	+1.7	Jul 20 00:35	2601	DD	6.8	153	62	28	+0.7	+4.3	Oct 22 03:00	77089	RD	7.3	127	26	264	+2.4	-0.1
Mar 20 21:59	1232	DD	6.4	119	26	188	-2.3	-5.1	Jul 20 02:53	X150546	DD	7.2	154	35	78	+0.5	+1.3	Oct 23 01:32	948	DB	4.3	116	14	42	+0.6	+0.4
Mar 26 22:57	1850	RD	6.5	172	49	297	+1.6	-1.6	Jul 20 03:14	186361	DD	7.2	154	31	56	+0.1	+1.9	Oct 23 02:37	948	RD	4.3	116	21	302	+2.6	-1.7
Mar 27 00:15	139039	RD	7.3	171	58	315	+1.5	-1.8	Jul 20 21:49	2784	DD	3.3	166	67	130	+1.6	-2.8	Oct 24 04:22	79185	RD	7.0	104	25	281	+2.5	-0.7
Mar 27 01:16	1855	RD	7.2	171	60	288	+2.2	-0.7	Jul 20 22:44	2784	RB	3.3	166	78	219	+2.0	+2.5	Oct 27 03:43	1435	RD	6.5	71	13	306	+1.2	-2.1
Mar 30 00:25	183495	RD	7.2	134	50	312	+0.7	-2.1	Jul 20 23:39	2796	DD	6.9	167	82	12	+1.1	+6.4	Nov 05 20:38	185573	DD	6.8	42	19	131	+0.8	-0.2
Mar 30 03:08	2216	RD	7.2	133	77	269	+2.5	0.0	Jul 21 01:51	2805	DD	7.1	167	60	12	-0.3	+4.7	Nov 06 22:22	2723	DD	6.6	56	11	55	-0.5	+1.5
Mar 31 01:25	2364	RD	7.0	120	53	246	+2.3	+0.1	Jul 22 22:33	3116	RD	6.6	163	48	218	+1.4	+1.2	Nov 08 19:54	189613	DD	7.2	81	60	16	+0.1	+3.3
Mar 31 01:50	184425	RD	7.3	120	58	356	-0.8	-4.9	Jul 23 21:56	3271	RD	7.2	150	26	192	+0.9	+2.6	Nov 10 20:42	3318	DD	7.3	108	62	96	+2.7	+0.2
Apr 04 05:17	3037	RD	7.3	66	50	313	+1.3	-4.2	Jul 24 02:37	3288	RD	5.8	148	69	203	+0.9	+2.4	Nov 11 21:56	3461	DD	6.3	122	53	13	+0.4	+2.6
Apr 06 05:32	3327	RD	6.8	39	26	245	+0.7	-0.2	Jul 25 01:18	3422	RD	6.7	134	50	222	+1.2	+1.1	Nov 11 23:27	3465	DD	6.5	123	38	5	0.0	+2.8
Apr 13 19:26	756	DD	6.6	54	10	156	-0.5	-2.0	Jul 25 04:35	146658	RD	7.3	133	57	234	+1.5	+1.5	Nov 12 01:07	146789	DD	7.2	123	19	86	+0.6	+1.3
Apr 16 22:18	1189	DD	5.0	88	8	102	+0.9	+0.8	Jul 26 06:12	26	RD	7.0	119	45	275	+2.4	+0.7	Nov 12 20:00	35	DD	6.2	134	50	31	+1.0	+1.6
Apr 18 20:56	80882	DD	7.3	110	33	122	+1.8	-0.5	Jul 27 02:03	136	RD	6.1	107	32	200	+0.4	+1.5	Nov 14 01:34	186	DD	7.3	150	23	50	+1.0	+1.9
Apr 18 21:41	1408	DD	7.4	110	30	171	0.0	-2.1	Jul 30 05:58	521	RD	6.7	69	29	175	-1.2	+3.5	Nov 14 21:45	297	DD	6.5	161	38	40	+1.2	+1.0
Apr 19 23:35	1514	DD	6.2	122	26	122	+1.1	-0.1	Aug 01 06:14	810	DB	1.7	47	15	62	+1.1	-0.2	Nov 15 01:58	313	DD	7.1	172	22	93	+1.5	-0.1
Apr 22 19:54																										

LUNAR OCCULTATION TABLE

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 01:52	2069	RD	7.3	66	15	286	+0.1	-1.3	May 29 00:39	3089	DB	5.3	114	37	15	+1.7	+3.6	Sep 19 21:11	132	RD	6.7	160	26	297	+2.3	-3.4
Jan 06 03:23	2074	RD	7.1	65	35	292	+0.8	-1.5	May 29 01:17	3089	RD	5.3	114	45	312	+1.3	-4.3	Sep 20 03:23	162	RD	6.9	158	40	240	+1.6	+1.6
Jan 19 21:58	493	DD	6.9	115	27	0	+1.9	+5.9	May 29 04:38	3106	DB	5.2	113	83	52	+1.9	+1.6	Sep 21 23:46	411	RD	7.0	133	28	235	+1.0	+0.4
Jan 21 22:30	773	DD	7.0	137	30	100	+2.5	+0.2	Jun 01 04:20	3514	RD	5.9	73	44	208	+0.9	+1.7	Sep 23 00:20	537	DB	3.7	120	22	81	+1.4	-0.5
Jan 24 23:57	1189	DD	5.0	169	35	76	+3.4	+0.8	Jun 02 03:21	109348	RD	7.3	61	20	238	+0.6	+0.2	Sep 23 01:02	539	DB	4.3	120	27	19	+0.1	+1.7
Jan 26 23:20	80882	RD	7.3	167	37	289	+2.5	-1.2	Jun 14 21:20	1625	DD	5.8	83	24	139	+0.5	-0.9	Sep 23 01:03	541	DB	3.9	120	28	57	+1.2	+0.3
Jan 28 02:14	1514	RD	6.2	155	47	264	+3.7	+0.6	Jun 15 23:05	1732	DD	6.8	95	14	192	-0.5	-5.8	Sep 23 01:31	537	RD	3.7	120	32	217	+0.9	+1.1
Jan 29 01:02	1612	RD	7.3	145	48	6	-0.1	-4.0	Jun 16 16:00	Jupiter	GB	-2.1	104	43	220	+1.2	-0.4	Sep 23 01:45	536	RD	5.5	120	33	253	+2.0	0.0
Jan 31 00:12	1802	RD	7.1	122	33	286	+1.3	-1.5	Jun 16 23:12	1830	DD	7.3	106	24	85	+1.0	+1.4	Sep 23 02:04	539	RD	4.3	120	34	279	+3.0	-0.9
Feb 02 03:26	2034	RD	6.8	97	62	309	+1.4	-1.9	Jun 17 23:56	1945	DD	5.2	119	27	113	+0.9	0.0	Sep 23 02:16	76152	RD	7.2	120	36	241	+1.9	+0.5
Feb 04 04:06	2305	DB	5.9	71	51	71	+2.3	0.0	Jun 19 00:35	2063	DD	6.7	131	31	133	+1.1	-0.8	Sep 23 02:25	541	RD	3.9	120	36	242	+2.0	+0.5
Feb 05 04:22	2458	RD	6.3	58	43	304	+0.6	-1.8	Jun 20 19:18	2317	DD	6.6	156	53	150	+0.3	-2.6	Sep 23 02:27	546	RD	7.3	120	36	202	+0.8	+1.9
Feb 06 02:56	186361	RD	7.2	45	13	249	+0.3	-0.3	Jun 21 18:04	2468	DD	6.8	168	25	125	-0.1	-1.6	Sep 23 02:34	542	RD	5.8	120	37	278	+3.1	-0.7
Feb 16 19:57	587	DD	6.2	94	31	67	+2.4	+1.4	Jun 21 18:50	2476	DD	6.6	169	34	82	+1.0	-0.6	Sep 23 02:41	543	RD	6.4	120	37	268	+2.8	-0.2
Feb 19 19:58	1018	DD	5.8	127	33	46	+2.8	+1.6	Jun 21 22:20	185295	DD	7.4	170	79	72	+2.7	+0.7	Sep 23 02:43	553	RD	6.8	120	37	168	-2.6	+6.3
Feb 23 23:44	1484	DD	3.5	171	46	98	+3.0	-0.3	Jun 25 02:27	3037	RD	7.3	144	85	243	+2.1	+1.2	Sep 23 03:18	548	RD	6.8	119	38	243	+2.3	+0.8
Feb 24 01:00	1484	RB	3.5	172	42	341	+0.6	-2.0	Jun 26 23:55	3329	RD	6.8	118	29	179	+0.8	+4.5	Sep 24 00:15	701	RD	6.6	108	11	226	+0.2	+0.4
Feb 24 23:10	1578	RD	6.9	174	47	235	+7.3	+3.7	Jun 27 03:50	3337	RD	6.7	116	73	238	+0.0	+1.2	Sep 25 02:51	850	RD	6.0	96	24	312	+3.6	-3.1
Feb 25 23:25	1684	RD	6.8	164	49	301	+2.0	-1.7	Jun 27 05:43	3347	RD	6.2	115	63	259	+2.3	+1.0	Sep 25 03:46	77381	RD	7.0	96	30	235	+1.9	+0.6
Feb 26 04:37	119000	RD	7.3	163	30	287	+1.2	+0.2	Jul 03 05:17	76189	RD	7.0	41	17	264	+1.2	-0.7	Sep 27 02:57	1137	RD	5.0	74	11	304	+1.7	-2.1
Mar 02 04:13	2120	RD	6.3	115	80	304	+2.1	-1.5	Jul 03 05:20	550	RD	7.0	41	18	279	+1.7	-1.4	Sep 27 03:28	1139	RD	7.1	73	16	302	+2.0	-2.0
Mar 03 03:17	2249	RD	6.7	103	68	290	+1.9	-1.4	Jul 03 05:34	560	DB	3.6	41	20	18	-0.3	+1.7	Oct 07 18:51	2257	DD	6.7	46	32	90	+0.9	+1.0
Mar 05 01:49	2554	DB	4.5	77	26	119	0.0	-1.6	Jul 14 20:05	1890	DD	7.3	87	48	160	+1.0	-2.4	Oct 09 22:40	2583	DD	5.8	73	11	67	-0.3	+1.3
Mar 05 02:50	2554	RD	4.5	77	38	271	+1.0	-0.9	Jul 18 01:35	2270	DD	5.4	126	16	176	+3.6	-7.8	Oct 13 23:42	3225	DD	7.2	126	42	67	+1.0	+1.5
Mar 15 19:27	521	DD	6.7	62	18	73	+1.5	+1.4	Jul 18 19:43	2409	DD	7.0	137	75	141	+1.4	-2.6	Oct 14 21:15	3355	DD	6.7	139	72	84	+2.8	+0.3
Mar 17 20:54	810	DD	1.7	86	16	32	+3.2	+4.1	Jul 19 18:23	2554	RB	4.5	150	45	297	+0.8	-1.6	Oct 15 20:41	3496	DD	7.3	153	60	48	+1.6	+1.2
Mar 17 21:31	810	RB	1.7	86	10	337	-0.8	-2.4	Jul 19 22:04	2583	DD	5.8	152	87	58	+2.5	+1.8	Oct 18 22:53	348	RD	6.8	166	41	202	+0.6	+1.7
Mar 19 19:38	79185	RD	7.0	107	34	54	+3.8	+1.9	Jul 20 01:38	2601	DD	6.8	153	42	18	-0.8	+4.7	Oct 20 23:56	76514	RD	7.2	140	28	295	+3.2	-2.0
Mar 19 21:46	1103	DD	5.8	108	24	174	-1.1	-3.5	Jul 20 03:36	X150546	DD	7.2	154	18	81	+0.1	+1.0	Oct 22 03:15	788	RD	6.8	127	34	311	+3.2	-1.7
Mar 20 22:23	1232	DD	6.4	119	27	128	+1.2	-0.5	Jul 20 22:38	2784	DD	3.3	166	84	98	+2.4	-0.5	Oct 22 04:09	77089	RD	7.3	127	32	272	+2.6	+0.3
Mar 23 18:50	1544	DD	5.4	151	25	135	+1.4	-2.2	Jul 20 23:57	2784	RB	3.3	166	77	240	+1.9	+1.6	Oct 23 02:23	948	DB	4.3	116	29	45	+1.7	+1.0
Mar 26 23:30	1850	RD	6.5	172	63	342	+0.8	-2.7	Jul 21 02:44	2805	DD	7.1	167	42	17	-0.6	+3.5	Oct 23 03:36	948	RD	4.3	116	33	308	+3.0	-1.5
Mar 27 01:59	1855	RD	7.2	171	59	339	+1.0	-2.4	Jul 22 21:55	3106	RD	5.2	164	47	232	+1.5	+0.8	Oct 25 02:29	1213	RD	7.1	94	20	256	+1.5	-0.5
Mar 29 01:43	158642	RD	7.2	146	79	269	+3.1	0.0	Jul 22 23:34	3116	RD	6.6	163	68	239	+2.0	+0.9	Nov 08 20:47	189613	DD	7.2	81	43	28	+0.1	+2.5
Mar 30 00:02	2206	RD	7.0	134	52	263	+2.1	-0.6	Jul 23 22:53	3271	RD	7.2	149	45	223	+1.3	+1.1	Nov 09 22:01	164583	DD	7.2	95	37	341	-2.9	+5.9
Mar 30 04:04	2216	RD	7.2	133	72	313	+2.0	-1.7	Jul 24 03:36	3288	RD	5.8	148	65	190	+0.2	+3.1	Nov 10 21:57	3318	DD	7.3	108	47	122	+4.1	-1.5
Mar 31 02:17	2364	RD	7.0	120	71	297	+1.8	-1.6	Jul 25 02:19	3422	RD	6.7	134	68	218	+1.4	+1.8	Nov 11 22:52	3461	DD	6.3	122	42	27	+0.6	+2.4
Apr 05 02:51	164567	RD	7.3	54	12	220	+0.6	+0.8	Jul 25 05:02	3432	DD	6.2	133	54	334	-3.6	+6.8	Nov 12 00:19	3465	DD	6.5	122	23	12	+0.1	+2.7
Apr 05 03:08	3175	DB	4.7	54	15	144	-0.9	-5.4	Jul 25 05:19	3432	RD	6.2	133	50	305	+5.7	-2.9	Nov 12 21:01	35	DD	6.2	134	60	44	+1.6	+1.7
Apr 05 03:29	3175	RD	4.7	53	19	183	+1.7	+4.9	Jul 25 05:36	146658	RD	7.3	133	47	221	+0.9	+2.0	Nov 14 22:47	297	DD	6.5	161	47	54	+2.0	+1.3
Apr 18 22:07	80882	DD	7.3	110	29	62	+4.2	+3.5	Jul 27 02:53	136	RD	6.1	107	49	194	+0.5	+2.3	Nov 15 22:24	75633	DD	7.0	173	41	63	+2.1	+0.6
Apr 19 18:19	1499	DD	7.1	120	39	121	+2.1	-1.7	Aug 14 19:33	2349	DD	2.9	106	77	92	+2.6	+0.2	Nov 16 00:46	435	DD	5.8	173	36	99	+2.7	+0.3
Apr 20 00:32	1514	DD	6.2	122	15	64	+2.0	+3.3	Aug 14 20:59	2349	RB	2.9	106	58	294	+2.1	-0.4	Nov 16 20:09	Pleiades	DB	3.0	173	16	86	+1.1	-0.8
Apr 22 23:25	1808	DD	7.0	157	61	100	+2.7	-0.1	Aug 15 19:37	2505	DD	5.3	119	88	158	+1.9	-5.1	Nov 16 20:12	541	DB	3.9	173	16	357	-1.6	+3.4
Apr 26 23:35	184104	RD	7.3	152	63	274	+2.0	-0.8	Aug 15 20:21	2505	RB	5.3	119	80	217	+2.5	+4.7	Nov 16 20:16	537	RD	3.7	173	17	268	+1.3	-0.8
Apr 27 01:02	2311	RD	6.3	151	81	279	+2.4	-0.7	Aug 18 22:17	3037	DD	7.3	162	81	90	+2.6	-0.2	Nov 16 20:29	552	DB	2.9	173	19	105	+1.9	-1.6
Apr 27 02:27	2317	RD	6.6	151	79	299	+2.3	-1.1	Aug 20 22:14	3339	RD	6.7	168	52	209	+1.2	+1.8	Nov 16 20:37	545	RD	4.1	173	20	194	-0.4	+1.9
Apr 28 21:47	X150546	RD	7.2	126	16	291	-0.2	-1.3	Aug 21 00:07	3347	RD	6.2	168	71	240	+1.9	+1.1	Nov 16 20:43	541	RD	3.9	173	21	303	+3.3	-3.3
Apr 28 21:51	186361	RD	7.2	126	16	329	-0.8	-2.4	Aug 22 01:25	3496	RD	7.3	153	66	234	+1.8	+1.3	Nov 16 21:13	Pleiades	RD	3.0	173	26	214	+0.5	+1.0
Apr 29 01:55	2644	RD	6.4	124	67	279	+2.0	-0.9	Aug 22 03:10	3505	RD	5.5	152	57	166	-1.0	+4.2	Nov 16 21:20	552	RD	2.9	173	27	195	-0.1	+1.9
Apr 29 04:35	2660	RD	6.2	123	78	254	+2.3	+1.1	Aug 24 00:08	209	RD	7.2	127	33	298	+3.5	-3.9	Nov 16 21:20	549	RD	6.3	173	27	202	+0.2	+1.5
Apr 30 04:51	2848	DB	5.6	110	88	48	+2.1	+2.1	Aug 25 03:41	348	RD	6.8	113	46	200	+0.9	+2.1	Nov 16 21:44	553	RD	6					

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 02:00	2069	RD	7.3	66	15	268	+0.2	-1.1	May 27 03:51	187672	RD	7.4	140	75	325	+3.5	-4.7	Sep 19 02:53	26	RD	7.0	172	40	213	+0.9	+2.0
Jan 06 03:30	2074	RD	7.1	65	33	270	+1.0	-1.2	May 27 04:17	2784	RD	3.3	140	70	225	+1.3	+2.5	Sep 19 04:25	32	RD	7.0	171	24	244	+0.8	+1.6
Jan 13 20:39	3303	DD	6.4	41	12	79	+0.1	+1.3	May 27 05:44	2796	RD	6.9	140	53	312	+2.6	-1.4	Sep 19 21:19	132	RD	6.7	160	22	265	+1.0	-1.0
Jan 16 21:15	136	DD	6.1	80	21	356	+0.2	+3.6	May 29 01:29	3089	RD	5.3	114	45	274	+1.3	-1.2	Sep 19 23:51	146	DB	4.3	159	43	345	-1.2	+4.0
Jan 19 21:24	493	DD	6.9	115	27	23	+1.7	+2.5	May 29 04:21	3106	DB	5.2	113	74	71	+2.1	+0.6	Sep 20 00:25	146	RD	4.3	159	46	292	+4.0	-2.1
Jan 21 22:21	773	DD	7.0	137	25	117	+2.4	-0.2	May 29 05:40	3106	RD	5.2	112	72	229	+1.4	+1.8	Sep 20 03:05	162	RD	6.9	158	39	232	+1.5	+1.6
Jan 24 23:44	1189	DD	5.0	169	28	96	+2.5	-0.1	Jun 01 04:00	3514	RD	5.9	73	34	181	+0.2	+3.2	Sep 21 04:54	297	RD	6.5	144	26	209	+1.2	+2.2
Jan 26 23:19	80882	RD	7.3	167	29	272	+2.3	-0.9	Jun 02 03:16	109348	RD	7.3	61	13	213	+0.2	+0.8	Sep 21 23:40	411	RD	7.0	133	20	220	+0.5	+0.5
Jan 28 02:09	99091	RD	7.3	155	39	343	+0.8	-2.1	Jun 14 21:30	1625	DD	5.8	83	22	175	-0.2	-2.5	Sep 22 04:28	75633	RD	7.0	131	30	192	+1.1	+2.6
Jan 29 01:22	1612	RD	7.3	144	41	338	+1.1	-2.3	Jun 16 23:03	1830	DD	7.3	106	28	118	+0.9	+0.1	Sep 22 04:40	425	RD	7.1	131	29	248	+1.9	+1.2
Jan 31 00:18	1802	RD	7.1	122	29	266	+1.4	-1.2	Jun 17 23:56	1945	DD	5.2	119	30	143	+0.8	-1.0	Sep 23 00:22	537	DB	3.7	120	14	97	+1.5	-1.4
Feb 02 03:32	2034	RD	6.8	97	56	284	+1.8	-1.3	Jun 19 00:43	2063	DD	6.7	131	33	168	+1.1	-2.9	Sep 23 00:52	539	DB	4.3	120	18	34	+0.4	+0.7
Feb 04 04:05	2305	DB	5.9	71	48	101	+1.1	-1.3	Jun 20 21:02	2328	DD	6.4	156	70	65	+2.8	+0.9	Sep 23 00:59	541	DB	3.9	120	19	69	+1.2	-0.4
Feb 06 02:52	186361	RD	7.2	45	12	211	+1.3	+1.4	Jun 21 04:35	2364	DD	7.0	159	14	139	+0.7	-0.5	Sep 23 01:21	537	RD	3.7	120	22	205	+0.3	+1.1
Feb 23 23:40	1484	DD	3.5	171	38	122	+2.0	-1.0	Jun 21 05:14	2371	DD	4.8	160	7	55	-0.6	+1.8	Sep 23 01:39	536	RD	5.5	120	24	242	+1.4	0.0
Feb 24 01:06	1484	RB	3.5	172	36	313	+1.4	-0.8	Jun 21 18:56	2476	DD	6.6	169	34	108	+0.4	-1.5	Sep 23 02:00	539	RD	4.3	120	26	267	+2.1	-0.6
Feb 25 23:28	1684	RD	6.8	164	41	280	+2.2	-1.2	Jun 21 22:14	185295	DD	7.4	170	73	104	+1.8	-1.0	Sep 23 02:07	76152	RD	7.2	120	26	231	+1.3	+0.4
Feb 25 23:34	118952	RD	7.1	164	42	337	+1.0	-2.4	Jun 25 02:08	3037	RD	7.3	144	76	222	+1.6	+1.9	Sep 23 02:11	546	RD	7.3	120	27	188	-0.1	+2.1
Feb 26 04:19	119000	RD	7.3	163	33	244	+3.1	+3.9	Jun 27 03:33	3339	RD	6.7	116	63	223	+1.4	+1.5	Sep 23 02:15	541	RD	3.9	120	27	232	+1.4	+0.4
Feb 28 23:15	158223	RD	7.4	129	29	284	+0.7	-1.5	Jun 27 05:27	3347	RD	6.2	115	62	249	+1.9	+1.2	Sep 23 02:28	542	RD	5.8	120	28	267	+2.3	-0.5
Mar 01 01:20	2000	RD	7.0	128	53	12	-1.3	-4.4	Jun 29 02:31	50	RD	5.8	90	29	282	+1.6	-2.0	Sep 23 02:33	543	RD	6.4	120	28	258	+2.1	-0.2
Mar 02 00:55	2111	RD	6.9	116	43	12	-1.7	-4.6	Jul 03 05:23	550	RD	7.0	41	11	262	+1.0	-0.9	Sep 23 03:05	548	RD	6.8	119	30	234	+1.7	+0.6
Mar 02 04:10	2120	RD	6.3	115	73	273	+2.6	-0.2	Jul 03 05:24	551	RD	7.3	41	11	287	+1.6	-2.0	Sep 25 02:57	850	RD	6.0	96	16	295	+2.4	-1.8
Mar 03 03:15	2249	RD	6.7	103	63	259	+2.4	-0.3	Jul 03 05:26	560	DB	3.6	41	11	36	+0.1	+0.5	Sep 25 03:36	77381	RD	7.0	96	21	223	+1.2	+0.5
Mar 05 02:06	2554	DB	4.5	77	28	148	-0.5	-2.5	Jul 03 05:39	561	DB	5.1	41	13	16	-0.4	+1.4	Sep 26 04:34	1018	RD	5.8	84	21	208	+1.0	+1.7
Mar 05 02:50	2554	RD	4.5	77	37	240	+1.4	-0.1	Jul 03 06:31	560	RD	3.6	41	20	266	+1.7	-0.9	Oct 07 21:14	2270	DD	5.4	47	9	104	0.0	+0.7
Mar 17 20:26	810	DD	1.7	85	16	63	+2.1	+1.7	Jul 11 20:05	1596	DD	7.2	53	14	95	+0.8	+1.1	Oct 09 22:31	2583	DD	5.8	73	19	81	0.0	+1.2
Mar 17 21:36	810	RB	1.7	86	7	303	+0.6	+0.3	Jul 19 18:29	2554	RB	4.5	151	45	268	+1.1	-0.9	Oct 13 23:27	3225	DD	7.2	126	47	76	+1.3	+1.4
Mar 19 19:18	79185	DD	7.0	107	26	75	+2.7	+0.3	Jul 19 21:48	2583	DD	5.8	152	81	89	+2.1	-0.1	Oct 14 01:55	3236	DD	7.1	128	18	80	+0.2	+1.3
Mar 20 22:27	1232	DD	6.4	119	22	157	+0.4	-1.3	Jul 20 01:11	2601	DD	6.8	153	52	47	+0.7	+2.6	Oct 14 21:06	3355	DD	6.7	139	64	102	+3.1	-0.9
Mar 26 23:43	1850	RD	6.5	172	56	317	+1.4	-1.9	Jul 20 03:28	X150546	DD	7.2	154	26	95	+0.4	+0.9	Oct 15 20:29	3496	DD	7.3	153	50	64	+1.6	+0.4
Mar 27 00:59	139039	RD	7.3	171	59	336	+1.0	-2.2	Jul 20 03:44	186361	DD	7.2	154	23	73	0.0	+1.4	Oct 18 22:38	348	RD	6.8	166	31	188	-0.1	+2.0
Mar 27 02:06	1855	RD	7.2	171	54	308	+1.6	-1.0	Jul 20 22:25	187672	DD	7.4	166	76	41	+2.0	+2.3	Oct 20 23:58	76514	RD	7.2	140	20	280	+2.1	-1.3
Mar 30 01:03	183495	RD	7.2	134	60	332	+0.6	-2.7	Jul 20 22:40	2784	DD	3.3	166	79	130	+2.2	-2.7	Oct 22 03:12	788	RD	6.8	127	26	295	+2.7	-0.7
Mar 30 04:03	2216	RD	7.2	133	72	282	+2.2	-0.2	Jul 20 23:32	2784	RB	3.3	166	81	211	+1.5	+3.3	Oct 22 03:55	77089	RD	7.3	127	26	258	+2.4	+0.5
Mar 31 02:18	2364	RD	7.0	120	66	267	+2.1	-0.5	Jul 21 00:20	2796	DD	6.9	167	75	30	+1.1	+3.3	Oct 23 02:13	948	DB	4.3	116	19	58	+1.5	0.0
Apr 18 21:46	80882	DD	7.3	110	28	101	+1.9	+0.5	Jul 21 02:21	2805	DD	7.1	167	51	37	+0.4	+2.6	Oct 23 03:34	948	RD	4.3	116	25	293	+2.6	-0.9
Apr 18 22:15	1408	DD	7.4	110	25	148	+0.6	-0.9	Jul 22 19:16	3092	RD	6.3	165	12	305	-0.4	-2.4	Oct 25 02:28	1213	RD	7.1	94	12	241	+1.0	-0.4
Apr 20 00:16	1514	DD	6.2	122	17	105	+1.0	+0.6	Jul 22 21:38	3106	RD	5.2	164	40	195	+1.4	+2.9	Nov 08 20:27	189613	DD	7.2	81	51	39	+0.5	+2.3
Apr 22 20:48	1802	DD	7.1	156	48	73	+3.3	0.0	Jul 22 23:18	3116	RD	6.6	163	59	213	+1.5	+1.8	Nov 08 21:55	189680	DD	7.4	82	33	58	+0.3	+1.7
Apr 22 23:23	1808	DD	7.0	157	56	130	+1.6	-1.2	Jul 23 22:35	3271	RD	7.2	150	37	189	+0.9	+2.9	Nov 09 21:34	164583	DD	7.2	95	45	1	-0.6	+3.4
Apr 26 23:27	184104	RD	7.3	152	57	236	+3.1	+1.2	Jul 24 03:10	3288	RD	5.8	148	66	174	-0.6	+4.1	Nov 11 22:32	3461	DD	6.3	122	45	34	+0.8	+2.1
Apr 27 00:51	2311	RD	6.3	151	73	242	+3.1	+1.3	Jul 24 22:19	3404	RD	7.3	136	20	284	+0.6	-1.9	Nov 11 23:59	3465	DD	6.5	122	29	23	+0.3	+2.3
Apr 27 02:22	2317	RD	6.6	151	78	268	+2.4	+0.3	Jul 25 02:00	3422	RD	6.7	134	58	203	+0.9	+2.0	Nov 12 20:44	35	DD	6.2	134	53	53	+1.6	+1.2
Apr 27 22:32	2458	RD	6.3	139	35	359	-1.8	-4.9	Jul 25 05:11	3432	RD	6.2	133	50	287	+2.9	+0.1	Nov 13 20:15	162	DD	6.9	147	42	2	-0.1	+2.6
Apr 28 01:40	2468	RD	6.8	138	72	315	+1.4	-2.4	Jul 25 05:16	146658	RD	7.3	133	50	214	+0.8	+2.1	Nov 14 22:31	297	DD	6.5	161	40	61	+1.9	+0.8
Apr 28 21:56	X150546	RD	7.2	126	18	266	+0.1	-0.9	Jul 25 23:57	4	RD	6.3	122	25	298	+1.6	-3.6	Nov 15 22:14	75633	DD	7.0	173	32	72	+1.9	+0.1
Apr 28 22:08	186361	RD	7.2	126	20	300	-0.2	-1.6	Jul 27 02:33	136	RD	6.1	107	38	175	-0.5	+3.2	Nov 16 00:35	435	DD	5.8	173	32	112	+2.9	-0.2
Apr 28 23:14	186461	RD	7.4	125	32	202	+4.7	+5.9	Jul 30 05:02	75987	RD	7.2	70	24	307	+4.4	-3.8	Nov 16 20:14	Pleiades	DB	3.0	173	9	105	+1.4	-1.8
Apr 29 01:50	2644	RD	6.4	124	63	247	+2.1	+0.3	Aug 10 20:56	1865	DD	7.3	58	14	77	+0.4	+2.0	Nov 16 20:18	537	RD	3.7	173	10	251	+0.7	-0.6
Apr 29 04:13	2660	RD	6.2	123	82	223	+2.1	+2.8	Aug 14 19:29	2349	DD	2.9	106	77	123	+2.0	-1.3	Nov 16 20:40	552	DD	2.9	173	13	132	+3.5	-4.7
Apr 30 04:32	2848	DB	5.6	110	79	75	+2.2	+0.5	Aug 14 20:49	2349	RB	2.9	106	63	267	+1.9	+0.9	Nov 16 20:51	541	RD	2.9	173	15			

LUNAR OCCULTATION TABLE

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 02:02	2069	RD	7.3	66	12	259	+0.2	-1.0	May 27 03:03	2784	DB	3.3	141	80	120	+2.3	-1.7	Sep 19 02:28	24	RD	6.8	172	44	257	+1.8	+1.1
Jan 06 03:29	2074	RD	7.1	65	29	258	+1.0	-1.0	May 27 03:48	187672	RD	7.4	140	76	314	+2.7	-2.7	Sep 19 02:44	26	RD	7.0	172	42	216	+1.0	+1.9
Jan 07 03:25	2207	RD	7.0	52	20	12	-2.0	-4.5	May 27 04:04	2784	RD	3.3	140	74	220	+1.4	+2.7	Sep 19 04:17	32	RD	7.0	171	27	244	+0.9	+1.7
Jan 16 21:06	136	DD	6.1	80	24	358	+0.2	+3.3	May 27 05:37	2796	RD	6.9	140	58	309	+2.5	-1.2	Sep 19 21:17	132	RD	6.7	160	17	261	+0.8	-0.9
Jan 19 21:12	493	DD	6.9	115	27	24	+1.5	+2.1	May 29 01:27	3089	RD	5.3	114	41	263	+1.1	-0.9	Sep 19 23:46	146	DB	4.3	159	38	343	-1.5	+4.5
Jan 21 22:11	773	DD	7.0	137	24	122	+2.5	-0.5	May 29 04:12	3106	DB	5.2	113	69	75	+2.0	+0.3	Sep 20 00:14	146	RD	4.3	159	41	297	+4.2	-3.0
Jan 24 23:34	1189	DD	5.0	169	25	104	+2.3	-0.5	May 29 05:29	3106	RD	5.2	112	72	228	+1.5	+1.7	Sep 20 02:55	162	RD	6.9	158	40	235	+1.5	+1.4
Jan 26 23:13	80882	RD	7.3	167	24	265	+2.0	-0.9	Jun 01 03:50	3514	RD	5.9	73	28	170	-0.2	+4.8	Sep 21 04:43	297	RD	6.5	144	28	208	+1.2	+2.1
Jan 28 02:09	99091	RD	7.3	155	37	329	+1.2	-1.6	Jun 16 23:00	1830	DD	7.3	106	31	130	-0.9	-0.3	Sep 21 23:37	411	RD	7.0	133	15	220	+0.3	+0.4
Jan 29 01:23	1612	RD	7.3	144	38	327	+1.3	-2.0	Jun 17 23:56	1945	DD	5.2	119	32	156	+0.8	-1.6	Sep 22 04:18	75633	RD	7.0	131	30	193	+1.0	+2.3
Jan 31 00:15	1802	RD	7.1	122	24	256	+1.3	-1.0	Jun 19 00:51	2063	DD	6.7	132	34	191	+1.1	-9.6	Sep 22 04:29	425	RD	7.1	131	29	248	+1.9	+1.0
Feb 02 03:27	2034	RD	6.8	97	51	269	+2.0	-1.0	Jun 20 03:42	2206	DD	7.0	146	15	104	+0.2	+0.8	Sep 23 00:20	537	DB	3.7	120	10	97	+1.3	-1.5
Feb 04 04:06	2305	DB	5.9	71	44	114	+0.7	-1.7	Jun 20 20:52	2328	DD	6.4	156	64	83	+2.0	-0.4	Sep 23 00:49	539	DB	4.3	120	14	33	+0.2	-0.5
Feb 05 04:29	2458	RD	6.3	58	39	264	+1.0	-1.0	Jun 21 04:33	2364	DD	7.0	159	19	142	+0.8	-0.6	Sep 23 00:55	541	DB	3.9	120	14	68	+1.0	-0.5
Feb 15 21:32	459	DD	6.4	84	11	100	+1.1	+1.1	Jun 21 05:11	2371	DD	4.8	160	12	57	-0.5	+1.9	Sep 23 01:17	537	RD	3.7	120	18	206	+0.2	+0.9
Feb 23 23:35	1484	DD	3.5	171	35	133	+1.7	-1.3	Jun 21 18:59	2476	DD	6.6	169	32	121	+0.1	-1.7	Sep 23 01:34	536	RD	5.5	120	19	244	+1.2	-0.2
Feb 24 01:01	1484	RB	3.5	172	34	300	+1.8	-0.5	Jun 21 22:10	185295	DD	7.4	170	68	117	+1.5	-1.6	Sep 23 01:54	539	RD	4.3	120	21	269	+1.9	-0.9
Feb 25 23:22	1684	RD	6.8	164	36	268	+2.2	-1.0	Jun 25 01:57	3037	RD	7.3	144	70	217	+1.5	+2.3	Sep 23 02:01	76152	RD	7.2	120	22	233	+1.1	+0.2
Feb 25 23:36	118952	RD	7.1	164	38	326	+1.1	-2.1	Jun 27 03:23	3339	RD	6.7	116	58	221	+1.3	+1.3	Sep 23 02:06	546	RD	7.3	120	23	191	-0.1	+1.7
Feb 27 22:51	Jupiter	DB	-2.3	141	26	43	+4.5	+3.6	Jun 27 05:16	3347	RD	6.2	115	62	251	+1.9	+0.9	Sep 23 02:09	541	RD	3.9	120	23	234	+1.2	+0.2
Feb 27 23:00	Jupiter	RB	-2.3	141	27	27	-3.6	-7.5	Jun 29 02:30	50	RD	5.8	90	24	276	+1.2	-1.6	Sep 23 02:21	542	RD	5.8	120	24	269	+2.1	-0.7
Mar 01 01:31	2000	RD	7.0	128	51	351	0.0	-3.0	Jul 03 05:24	560	DB	3.6	41	6	36	0.0	+0.4	Sep 23 02:26	543	RD	6.4	120	24	260	+1.9	-0.4
Mar 02 01:08	2111	RD	6.9	116	41	350	-0.3	-3.0	Jul 03 06:11	559	RD	6.5	41	13	232	+0.6	0.0	Sep 23 02:57	548	RD	6.8	119	26	236	+1.5	+0.3
Mar 02 02:58	2119	RD	6.6	115	61	2	-0.6	-4.3	Jul 03 06:27	561	RD	5.1	41	15	286	+2.0	-1.9	Sep 25 02:53	850	RD	6.0	96	12	296	+2.1	-1.9
Mar 02 03:58	2120	RD	6.3	115	69	254	+3.1	+0.7	Jul 03 06:27	560	RD	3.6	41	15	267	+1.4	-1.0	Sep 25 03:31	77381	RD	7.0	96	16	224	+0.9	+0.3
Mar 03 03:04	2249	RD	6.7	103	57	238	+3.1	+0.9	Jul 03 06:32	567	RD	6.8	40	16	202	0.0	+1.0	Sep 26 04:26	1018	RD	5.8	84	16	206	+0.6	+1.4
Mar 05 02:17	2554	DB	4.5	77	28	169	-1.4	-3.9	Jul 11 19:59	1596	DD	7.2	53	17	110	+0.8	+0.6	Oct 07 21:12	2270	DD	5.4	47	14	107	+0.2	+0.7
Mar 05 02:42	2554	RD	4.5	77	33	219	+2.1	+1.3	Jul 18 02:39	2283	DD	6.8	127	13	52	-0.5	+2.4	Oct 09 22:27	2583	DD	5.8	73	23	81	+0.1	+1.3
Mar 17 20:13	810	DD	1.7	85	17	71	+2.1	+1.3	Jul 19 18:27	2554	RB	4.5	151	41	254	+1.1	-0.6	Oct 13 01:50	3090	DD	6.7	114	15	40	-0.3	+1.8
Mar 17 21:31	810	RB	1.7	86	8	291	+0.9	+0.7	Jul 19 21:41	2583	DD	5.8	152	76	100	+1.9	-0.7	Oct 13 01:53	3092	DD	6.3	114	14	129	+0.8	0.0
Mar 20 22:31	1232	DD	6.4	119	21	176	-0.7	-2.6	Jul 20 01:02	2601	DD	6.8	153	57	51	+1.0	+2.4	Oct 13 23:18	3225	DD	7.2	126	51	73	+1.3	+1.4
Mar 26 23:41	1850	RD	6.5	172	52	304	+1.6	-1.6	Jul 20 03:23	X150546	DD	7.2	154	31	95	+0.6	+1.0	Oct 14 01:51	3236	DD	7.1	128	22	79	+0.4	+1.4
Mar 27 00:59	139039	RD	7.3	171	57	321	+1.3	-1.7	Jul 20 03:40	186361	DD	7.2	154	27	74	+0.2	+1.5	Oct 14 02:40	3240	DD	6.7	128	12	40	-0.2	+1.8
Mar 27 02:01	1855	RD	7.2	171	54	293	+1.9	-0.5	Jul 20 22:12	187672	DD	7.4	166	70	53	+2.0	+1.2	Oct 14 20:56	3355	DD	6.7	139	61	101	+2.8	-1.1
Mar 30 01:06	183495	RD	7.2	134	57	317	+0.8	-2.2	Jul 20 22:40	2784	DD	3.3	166	75	146	+2.0	-4.8	Oct 15 20:22	3496	DD	7.3	153	45	65	+1.5	+0.1
Mar 30 03:53	2216	RD	7.2	133	73	268	+2.4	+0.3	Jul 20 23:16	2784	RB	3.3	166	79	199	+1.5	+5.0	Oct 18 22:34	348	RD	6.8	166	26	189	-0.1	+1.8
Mar 31 02:10	2364	RD	7.0	120	61	250	+2.3	+0.1	Jul 21 00:06	2796	DD	6.9	167	77	37	+1.4	+2.7	Oct 20 23:53	76514	RD	7.2	140	15	281	+1.8	-1.8
Mar 31 02:29	184425	RD	7.3	120	64	2	-1.2	-6.4	Jul 21 02:13	2805	DD	7.1	167	56	39	+0.6	+2.6	Oct 22 03:03	788	RD	6.8	127	23	293	+2.6	-0.4
Apr 18 21:38	80882	DD	7.3	110	28	116	+1.6	0.0	Jul 22 19:22	3092	RD	6.3	165	11	289	-0.2	-1.7	Oct 22 03:44	77089	RD	7.3	127	24	255	+2.2	+0.4
Apr 20 00:11	1514	DD	6.2	122	19	120	+0.8	+0.2	Jul 22 23:07	3116	RD	6.6	163	53	204	+1.3	+2.2	Oct 23 02:08	948	DB	4.3	116	15	58	+1.2	-0.2
Apr 22 20:39	1802	DD	7.1	156	43	90	+2.1	-1.0	Jul 24 03:01	3288	RD	5.8	148	65	176	-0.3	+3.9	Oct 23 03:26	948	RD	4.3	116	21	290	+2.4	-0.9
Apr 22 23:21	1808	DD	7.0	157	54	145	+1.2	-1.7	Jul 24 22:21	3404	RD	7.3	136	17	273	+0.4	-1.4	Nov 08 20:19	189613	DD	7.2	81	55	38	+0.6	+2.3
Apr 27 02:10	2317	RD	6.6	151	77	253	+2.5	+1.0	Jul 25 01:51	3422	RD	6.7	134	52	202	+0.8	+1.9	Nov 09 21:28	164583	DD	7.2	95	49	357	-0.8	+3.7
Apr 27 03:37	2328	RD	6.4	150	68	2	+1.0	-9.8	Jul 25 04:58	3432	RD	6.2	133	52	293	+3.5	-0.6	Nov 11 22:23	3461	DD	6.3	122	47	32	+0.8	+2.1
Apr 27 22:45	2458	RD	6.3	139	35	335	-0.4	-2.8	Jul 25 05:07	146658	RD	7.3	133	52	217	+1.0	+2.0	Nov 11 23:51	3465	DD	6.5	122	33	22	+0.4	+2.3
Apr 28 01:40	2468	RD	6.8	138	68	301	+1.4	-1.8	Jul 25 23:59	4	RD	6.3	121	21	287	+1.1	-2.4	Nov 12 01:36	146789	DD	7.2	123	13	96	+0.5	+1.2
Apr 28 02:20	2476	RD	6.6	137	75	350	+0.4	-6.3	Jul 27 02:26	136	RD	6.1	107	33	174	-0.5	+3.3	Nov 12 20:35	35	DD	6.2	134	50	51	+1.5	+1.0
Apr 28 21:58	X150546	RD	7.2	126	16	254	+0.2	-0.8	Jul 30 04:54	75987	RD	7.2	70	20	311	+4.6	-4.8	Nov 14 02:04	186	DD	7.3	150	17	57	+0.8	+1.8
Apr 28 22:13	186361	RD	7.2	126	18	288	-0.1	-1.4	Aug 01 06:54	810	DB	1.7	47	17	78	+1.6	-0.6	Nov 14 22:22	297	DD	6.5	161	37	58	+1.7	+0.7
Apr 29 01:39	2644	RD	6.4	124	57	231	+2.2	+1.0	Aug 10 20:50	1865	DD	7.3	58	18	89	+0.6	+1.4	Nov 15 02:33	313	DD	7.1	162	15	100	+1.1	+1.0
Apr 29 03:55	2660	RD	6.2	123	80	208	+2.3	+4.9	Aug 14 19:25	2349	DD	2.9	106	77	136	+1.7	-2.1	Nov 16 00:23	435	DD	5.8	173	31	111	+2.9	-0.3
Apr 30 04:23	2848	DB	5.6	110	74	83	+2.0	-0.1	Aug 14 20:38	2349	RB	2.9	106	67	256	+2.0	+1.5	Nov 16 20:17	537	RD	3					

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	WST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	WST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 01:40	1849	RD	6.1	90	20	270	+0.8	-1.2	May 22 20:06	2104	DD	7.3	163	48	146	+0.5	-2.3	Aug 20 23:34	3355	RD	6.7	166	58	238	+1.7	+0.7
Jan 04 10:44	Jupiter	DB	-2.0	86	25	49	+1.6	+6.7	May 22 23:53	2120	DD	6.3	164	73	85	+2.7	+0.6	Aug 21 22:12	3496	RD	7.3	153	29	292	+1.5	-2.7
Jan 04 11:05	Jupiter	RD	-2.0	86	20	12	+0.1	-6.6	May 25 23:47	2583	RD	5.8	155	61	266	+1.8	-0.5	Aug 22 00:25	3505	RD	5.5	152	53	244	+1.7	+0.4
Jan 07 03:27	2212	RD	6.2	51	20	274	+0.3	-1.1	May 26 04:47	186286	RD	7.1	153	56	201	0.0	+4.9	Aug 24 00:53	222	RD	7.0	125	32	227	+0.9	+0.6
Jan 15 21:45	109126	DD	7.2	69	14	78	+0.5	+1.4	May 26 05:50	2621	RD	7.5	152	43	335	+3.9	-5.0	Aug 24 05:15	240	RD	5.5	124	41	251	+2.1	+1.2
Jan 16 20:44	148	DD	7.1	81	31	41	+1.1	+2.1	May 26 05:54	X150546	RD	7.2	152	42	307	+1.8	-0.6	Aug 24 05:27	241	RD	6.8	123	40	222	+1.5	+1.8
Jan 17 22:13	279	DD	7.1	93	19	95	+1.2	+1.0	May 27 00:03	2784	DB	3.3	141	50	109	+1.1	-1.6	Aug 25 00:51	348	RD	6.8	112	19	267	+1.2	-1.0
Jan 20 22:50	647	DD	5.4	127	25	87	+2.2	+0.9	May 27 01:15	2784	RD	3.3	140	65	251	+2.1	+0.2	Aug 27 04:30	76514	RD	7.2	87	27	311	+4.9	-3.8
Jan 24 01:32	1081	DD	6.5	160	21	82	+2.2	+1.2	May 28 00:07	2939	RD	7.5	127	38	234	+1.3	+0.4	Aug 28 04:00	768	RD	7.0	76	16	278	+1.8	-1.3
Jan 24 20:28	1189	DD	5.0	169	14	87	+1.4	-1.0	May 28 23:05	3089	RD	5.3	114	12	261	+0.1	-0.7	Aug 28 04:15	771	RD	6.1	76	18	198	-0.2	+1.8
Jan 26 23:16	1416	RD	7.0	166	29	313	+1.9	-2.0	May 29 01:28	3106	DB	5.2	113	40	43	+1.3	+1.0	Sep 11 21:35	2470	DD	6.1	90	45	123	+1.7	-0.4
Jan 27 23:11	99091	RD	7.3	155	26	302	+1.6	-1.9	May 29 02:33	3106	RD	5.2	112	54	279	+1.8	-1.3	Sep 11 22:28	2474	DD	6.7	91	34	138	+1.7	-1.0
Jan 28 04:21	1535	RD	6.9	154	35	319	+1.0	-0.9	May 29 04:19	3116	RD	6.6	111	74	282	+2.8	-1.1	Sep 12 19:59	186461	DD	7.4	103	77	24	+1.4	+5.5
Jan 28 22:35	1612	RD	7.3	144	16	310	+0.9	-2.1	May 30 04:08	164948	RD	7.2	98	59	241	+1.8	+0.6	Sep 12 21:13	186536	DD	7.5	103	62	133	+2.8	-1.8
Jan 30 03:29	1728	RD	6.7	132	55	353	+0.4	-2.9	May 30 05:53	3271	RD	7.2	97	73	250	+2.2	+0.8	Sep 12 22:12	2644	DD	6.4	104	50	76	+1.2	+1.4
Feb 02 04:22	158493	RD	7.4	96	64	331	+0.9	-2.5	Jun 01 01:53	3514	RD	5.9	73	6	217	+0.2	+0.7	Sep 14 23:26	2985	DD	6.8	131	59	114	+2.7	-0.4
Feb 03 03:33	2172	DB	4.5	83	47	144	+0.4	-2.3	Jun 05 06:18	472	RD	4.9	22	8	252	+0.5	-0.5	Sep 15 23:22	3150	DD	6.6	145	69	105	+2.9	-0.3
Feb 03 04:41	2172	RD	4.5	83	62	283	+1.8	-1.2	Jun 12 19:12	1436	DD	6.8	61	28	61	+4.1	+3.7	Sep 16 20:55	3288	DD	5.8	159	56	70	+1.8	+0.2
Feb 04 02:40	2305	RD	5.9	71	27	262	+0.7	-0.8	Jun 16 20:19	1830	DD	7.3	106	59	154	+1.1	-2.2	Sep 17 19:24	3422	DD	6.7	172	24	77	+0.7	-0.6
Feb 04 03:51	2314	RD	5.9	70	42	304	+0.5	-1.8	Jun 17 21:16	1945	DD	5.2	119	63	170	+0.7	-3.2	Sep 17 22:19	146658	DD	7.3	173	57	36	+1.2	+1.5
Feb 06 03:44	186606	RD	7.2	43	17	349	-1.8	-4.1	Jun 17 22:17	1945	RB	5.2	119	53	265	+2.4	+1.3	Sep 18 23:45	26	RD	7.0	172	54	303	+6.6	-5.3
Feb 06 03:45	2643	RD	6.7	43	17	251	+0.4	-0.5	Jun 18 22:01	2063	DD	6.7	132	68	187	-0.1	-5.7	Sep 19 02:10	35	RD	6.2	171	51	231	+1.5	+1.6
Feb 17 20:28	76841	DD	7.3	107	29	136	+2.8	-1.6	Jun 19 17:53	2172	RB	4.5	143	39	334	0.0	-2.4	Sep 21 02:00	297	RD	6.5	144	43	263	+2.6	+0.1
Feb 19 21:07	1032	DD	5.4	129	29	39	+3.2	+2.3	Jun 20 01:38	2206	DD	7.0	146	38	56	+0.8	+3.1	Sep 22 01:40	75633	RD	7.0	131	34	256	+2.0	-0.1
Feb 22 01:48	1283	DD	7.0	152	19	167	-0.4	-1.9	Jun 21 02:08	2364	DD	7.0	159	46	87	+1.2	+1.1	Sep 22 03:46	435	RD	5.8	130	37	217	+1.6	+1.6
Feb 23 20:38	1484	DD	3.5	171	20	150	+1.3	-2.6	Jun 23 04:45	2723	RD	6.6	170	41	308	+1.9	-0.7	Sep 22 23:56	Pleiades	RD	3.0	119	10	225	+0.2	+0.3
Feb 23 21:48	1484	RB	3.5	172	31	263	+2.3	-0.8	Jun 24 23:15	3037	RD	7.3	144	41	244	+1.3	0.0	Sep 23 00:03	549	RD	6.3	119	11	215	0.0	+0.7
Feb 27 20:56	Jupiter	RD	-2.3	141	3	357	-0.3	-2.9	Jun 25 04:05	3062	RD	7.5	142	72	229	+1.4	+1.9	Sep 23 00:04	552	RD	2.9	119	11	208	-0.1	-0.9
Feb 28 23:08	2000	RD	7.0	128	25	313	+0.2	-1.9	Jun 27 00:43	3339	RD	6.7	116	31	269	+1.0	-1.0	Sep 23 00:21	553	RD	6.8	119	14	245	+0.7	-0.3
Mar 01 22:58	2111	RD	6.9	116	15	317	-0.2	-1.8	Jun 27 05:15	3355	RD	6.7	114	67	263	+2.5	+0.5	Sep 23 00:51	557	RD	7.0	119	18	232	+0.7	+0.2
Mar 02 00:36	2119	RD	6.6	115	36	314	+0.4	-2.0	Jun 29 05:47	69	RD	7.5	88	54	279	+3.5	-0.9	Sep 23 01:15	562	RD	6.6	119	21	216	+0.5	+0.7
Mar 05 03:33	2583	DB	5.8	75	41	135	+0.2	-2.3	Jun 30 05:21	205	RD	7.4	76	42	162	-1.9	+5.1	Sep 23 01:53	76259	RD	7.4	119	26	210	+0.6	+1.1
Mar 05 04:33	2583	RD	5.8	75	53	251	+1.9	-0.1	Jul 01 05:46	326	DB	5.7	63	34	87	+2.2	-0.7	Sep 25 02:24	864	RD	6.6	95	13	301	+2.2	-2.3
Mar 06 05:38	2784	DB	3.3	61	53	103	+1.3	-1.4	Jul 02 04:40	439	RD	7.3	52	13	281	+1.4	-1.7	Sep 25 03:45	77506	RD	7.4	95	22	295	+2.7	-1.6
Mar 08 04:21	3089	RD	5.3	34	11	275	-0.1	-1.1	Jul 11 20:16	1603	DD	7.2	54	17	172	-0.2	-2.3	Oct 07 20:00	2270	RB	5.4	47	26	325	+1.3	-1.2
Mar 17 18:40	810	RB	1.7	86	29	282	+2.7	-0.1	Jul 14 22:57	1911	DD	7.3	89	19	179	+0.6	-3.8	Oct 10 23:13	187672	DD	7.4	87	24	55	-0.1	+1.7
Mar 19 20:43	79295	DD	7.2	108	29	106	+2.4	-0.1	Jul 15 23:10	2021	DD	6.6	101	28	92	+0.9	+1.1	Oct 12 23:39	3092	DD	6.3	114	40	65	+0.7	+1.6
Mar 19 23:45	1119	DD	5.8	109	9	140	+0.1	-0.5	Jul 17 20:21	2262	DD	7.5	125	81	50	+4.2	+4.0	Oct 13 21:05	3225	DD	7.2	127	73	354	-0.5	+4.7
Mar 20 00:11	1122	DD	3.8	110	4	81	+1.0	+1.4	Jul 17 22:38	2270	DD	5.4	126	60	149	+1.9	-2.4	Oct 13 23:48	3236	DD	7.1	128	47	27	+0.3	+2.4
Mar 22 01:10	1363	DD	5.2	132	15	72	+1.9	+2.2	Jul 18 02:12	184027	DD	7.2	128	17	147	+1.0	-1.1	Oct 14 02:44	3256	DD	6.1	129	11	77	0.0	+1.2
Mar 26 20:49	1850	RD	6.5	172	27	265	+1.2	-1.1	Jul 18 19:12	2420	DD	7.5	138	61	166	-0.1	-4.2	Oct 14 23:15	3375	DD	6.8	141	59	90	+2.4	+0.7
Mar 26 22:02	139039	RD	7.3	171	41	275	+1.7	-1.2	Jul 18 20:08	184724	DD	7.5	139	73	164	+0.5	-4.5	Oct 15 02:29	3389	DD	7.1	143	21	58	+0.4	+1.7
Mar 26 22:10	Jupiter	DB	-2.5	171	42	55	+4.7	+1.9	Jul 19 01:48	2449	DD	7.4	141	35	125	+1.3	-0.3	Oct 15 02:30	3388	DD	5.5	143	21	43	+0.2	+1.9
Mar 26 22:29	Jupiter	RB	-2.5	171	46	24	-2.8	-5.9	Jul 19 18:52	2583	DD	5.8	152	44	115	+0.7	-1.7	Oct 15 02:44	3391	DD	6.7	143	18	115	+0.9	+0.3
Mar 29 22:36	183495	RD	7.2	134	27	280	+0.5	-1.3	Jul 20 00:16	186286	DD	7.1	154	67	139	+2.7	-2.5	Oct 15 19:49	3505	DD	5.5	154	43	46	+1.1	+0.8
Mar 30 03:42	2226	RD	7.0	132	79	349	+0.8	-4.3	Jul 20 01:16	X150546	DD	7.2	154	55	32	+0.4	+3.6	Oct 22 00:32	77089	RD	7.3	127	16	309	+2.9	-2.9
Mar 30 23:20	2371	DB	4.8	120	26	82	+0.6	-0.8	Jul 20 02:27	186434	DD	7.5	155	41	94	+1.0	+0.8	Oct 22 04:01	801	RD	6.5	126	29	273	+2.6	+0.1
Mar 31 00:11	184425	RD	7.3	120	37	313	+0.2	-2.0	Jul 20 04:32	2643	DD	6.7	156	16	72	-0.1	+1.3	Oct 23 03:58	968	RD	6.4	114	28	317	+2.9	-1.9
Mar 31 00:12	2371	RD	4.8	120	37	325	0.0	-2.4	Jul 20 19:24	187672	DD	7.4	166	37	59	+1.3	+0.1	Oct 23 04:08	967	RD	7.0	114	29	274	+2.6	-0.3
Apr 01 03:20	185573	RD	6.8	106	64	235	+2.8	+1.3	Jul 20 19:50	2784	DD	3.3	166	43	145	0.0	-3.5	Oct 24 01:58	79185	RD	7.0	104	13	302	+1.9	-2.0
Apr 04 03:24	3037	RD	7.3	66	26	306	0.0	-2.7	Jul 20 20:31	2784	RB	3.3	166	51	217	+2.3	+2.0	Oct 25 03:51	1232	RD	6.4	92	23	221	+1.8	+1.4
Apr 05 03:56	3191	RD	7.4	52	19	210	+0.8	+1.3	Jul 22 20:40	3116	RD	6.6	163	24	220	+0.9	+0.8	Nov 05 21:02	2545	DD	6.4	93	14	78		

LUNAR OCCULTATION TABLE
SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 01:59	2069	RD	7.3	66	16	272	+0.3	-1.2	May 29 00:27	3089	DB	5.3	114	34	48	+1.1	+0.5	Sep 20 00:31	146	RD	4.3	159	48	289	+3.9	-1.6
Jan 06 03:30	2074	RD	7.1	65	35	276	+1.0	-1.3	May 29 01:30	3089	RD	5.3	114	47	279	+1.4	-1.5	Sep 20 03:10	162	RD	6.9	158	39	231	+1.4	+1.7
Jan 16 21:21	136	DD	6.1	80	18	353	+0.2	+3.9	May 29 04:26	3106	DB	5.2	113	76	70	+2.1	+0.8	Sep 21 23:42	411	RD	7.0	133	22	220	+0.5	+0.6
Jan 19 21:31	493	DD	6.9	115	26	22	+1.7	+2.8	May 29 05:45	3106	RD	5.2	112	71	229	+1.4	+1.9	Sep 22 04:35	75633	RD	7.0	131	30	193	+1.2	+2.7
Jan 21 22:25	773	DD	7.0	137	26	114	+2.3	-0.1	Jun 01 04:05	3514	RD	5.9	73	37	184	+0.3	+2.9	Sep 22 04:45	425	RD	7.1	131	29	249	+1.9	+1.3
Jan 24 23:49	1189	DD	5.0	169	29	92	+2.7	+0.1	Jun 14 21:27	1625	DD	5.8	83	21	166	0.0	-1.8	Sep 23 00:24	537	DB	3.7	120	17	97	+1.6	-1.3
Jan 26 23:23	80882	RD	7.3	167	31	276	+2.4	-0.9	Jun 16 23:05	1830	DD	7.3	106	26	111	+0.9	+0.3	Sep 23 00:54	539	DB	4.3	120	20	34	+0.5	+0.7
Jan 28 02:07	99091	RD	7.3	155	41	352	+0.4	-2.5	Jun 17 23:57	1945	DD	5.2	119	28	138	+0.8	-0.7	Sep 23 01:01	541	DB	3.9	120	21	70	+1.3	-0.3
Jan 29 01:21	1612	RD	7.3	144	43	345	+0.9	-2.6	Jun 19 00:42	2063	DD	6.7	131	31	161	+1.1	-2.2	Sep 23 01:23	537	RD	3.7	120	24	204	+0.3	+1.2
Jan 31 00:19	1802	RD	7.1	122	31	272	+1.4	-1.3	Jun 20 21:11	2328	DD	6.4	156	73	52	+3.7	+2.7	Sep 23 01:42	536	RD	5.5	120	26	241	+1.4	+0.1
Feb 02 03:34	2034	RD	6.8	97	59	291	+1.7	-1.5	Jun 21 05:15	2371	DD	4.8	160	5	54	-0.7	+1.8	Sep 23 02:04	539	RD	4.3	120	28	266	+2.2	-0.5
Feb 04 04:06	2305	DB	5.9	71	50	94	+1.4	-1.1	Jun 21 18:55	2476	DD	6.6	169	35	102	+0.6	-1.3	Sep 23 02:10	76152	RD	7.2	120	29	230	+1.4	+0.5
Feb 06 02:55	186361	RD	7.2	45	14	224	+0.8	+0.4	Jun 25 02:14	3037	RD	7.3	144	78	224	+1.6	+1.8	Sep 23 02:13	546	RD	7.3	120	29	187	-0.1	+2.3
Feb 11 19:35	3505	DD	5.5	33	10	6	-0.1	+2.7	Jun 27 03:38	3339	RD	6.7	116	65	223	+1.5	+1.5	Sep 23 02:19	541	RD	3.9	120	29	231	+1.5	+0.5
Feb 16 19:45	587	DD	6.2	94	27	78	+2.3	+1.0	Jun 27 05:32	3347	RD	6.2	115	62	248	+1.8	+1.3	Sep 23 02:33	542	RD	5.8	120	30	266	+2.4	-0.3
Feb 19 19:47	1018	DD	5.8	127	26	61	+2.4	+0.5	Jun 29 02:32	50	RD	5.8	90	31	285	+1.9	-2.2	Sep 23 02:38	543	RD	6.4	120	30	257	+2.2	0.0
Feb 23 23:43	1484	DD	3.5	171	39	115	+2.2	-0.8	Jul 03 05:19	76189	RD	7.0	41	12	248	+0.8	-0.4	Sep 23 03:09	548	RD	6.8	119	31	234	+1.8	+0.7
Feb 24 01:08	1484	RB	3.5	172	36	321	+1.2	-1.0	Jul 03 05:24	550	RD	7.0	41	13	262	+1.1	-0.8	Sep 25 03:00	850	RD	6.0	96	19	295	+2.5	-1.7
Feb 25 23:31	1684	RD	6.8	164	44	286	+2.1	-1.3	Jul 03 05:27	560	DB	3.6	41	13	36	+0.2	+0.6	Sep 25 03:40	77381	RD	7.0	96	23	223	+1.3	+0.7
Feb 25 23:33	118952	RD	7.1	164	44	343	+0.8	-2.6	Jul 03 05:40	561	DB	5.1	41	15	16	-0.3	+1.5	Sep 26 04:38	1018	RD	5.8	84	23	210	+1.3	+1.8
Feb 26 04:28	119000	RD	7.3	163	30	258	+2.0	+2.1	Jul 03 06:34	560	RD	3.6	41	23	265	+1.8	-0.8	Sep 27 03:06	1137	RD	5.0	74	7	289	+1.3	-1.7
Mar 02 04:15	2120	RD	6.3	115	74	281	+2.4	-0.5	Jul 11 20:08	1596	DD	7.2	53	12	87	+0.9	+1.5	Sep 27 03:36	1139	RD	7.1	73	11	288	+1.6	-1.6
Mar 03 03:20	2249	RD	6.7	103	66	268	+2.2	-0.6	Jul 18 20:07	2409	DD	7.0	137	77	178	-0.3	-7.3	Oct 07 21:15	2270	DD	5.4	47	7	103	-0.1	+0.7
Mar 05 02:02	2554	DB	4.5	77	29	139	-0.3	-2.3	Jul 19 18:30	2554	RB	4.5	151	46	275	+1.1	-1.1	Oct 09 22:32	2583	DD	5.8	73	16	81	-0.1	+1.2
Mar 05 02:53	2554	RD	4.5	77	39	249	+1.3	-0.4	Jul 19 21:53	2583	DD	5.8	152	83	83	+2.2	+0.2	Oct 13 23:31	3225	DD	7.2	126	45	77	+1.2	+1.4
Mar 15 19:16	521	DD	6.7	62	16	87	+1.5	+1.2	Jul 20 01:16	2601	DD	6.8	153	49	45	+0.6	+2.6	Oct 14 01:58	3236	DD	7.1	128	15	80	+0.2	+1.3
Mar 17 20:33	810	DD	1.7	86	16	57	+2.2	+2.0	Jul 20 03:30	X150546	DD	7.2	154	23	95	+0.3	+0.9	Oct 14 21:11	3355	DD	6.7	139	66	102	+3.3	-0.8
Mar 17 21:37	810	RB	1.7	86	6	310	+0.3	0.0	Jul 20 03:46	186361	DD	7.2	154	20	73	0.0	+1.3	Oct 15 20:33	3496	DD	7.3	153	53	64	+1.7	+0.5
Mar 19 19:25	79185	DD	7.0	107	28	71	+2.9	+0.6	Jul 20 22:41	2784	DD	3.3	166	81	124	+2.3	-2.1	Oct 18 22:41	348	RD	6.8	166	33	186	-0.1	+2.1
Mar 20 22:26	1232	DD	6.4	119	22	148	+0.6	-1.0	Jul 20 23:40	2784	RB	3.3	166	81	216	+1.5	+2.9	Oct 21 00:01	76514	RD	7.2	140	22	279	+2.2	-1.2
Mar 23 19:03	1544	DD	5.4	151	22	148	+1.2	-2.4	Jul 21 00:26	2796	DD	6.9	167	72	27	+0.9	+3.6	Oct 22 03:17	788	RD	6.8	127	27	296	+2.7	-0.7
Mar 26 23:43	1850	RD	6.5	172	58	324	+1.3	-2.0	Jul 21 02:26	2805	DD	7.1	167	49	37	+0.3	+2.5	Oct 22 04:01	77089	RD	7.3	127	26	260	+2.4	+0.6
Mar 27 02:08	1855	RD	7.2	171	54	316	+1.4	-1.2	Jul 22 19:11	3092	RD	6.3	165	13	316	-0.6	-3.2	Oct 23 02:17	948	DB	4.3	116	22	58	+1.7	+0.1
Mar 29 01:26	158642	RD	7.2	146	71	228	+8.2	+7.2	Jul 22 21:44	3106	RD	5.2	164	43	204	+1.4	+2.1	Oct 23 03:39	948	RD	4.3	116	26	294	+2.6	-0.8
Mar 29 23:57	2206	RD	7.0	134	49	233	+3.7	+1.5	Jul 22 23:23	3116	RD	6.6	163	62	217	+1.5	+1.7	Oct 25 02:30	1213	RD	7.1	94	14	242	+1.2	-0.3
Mar 30 01:00	183495	RD	7.2	134	62	340	+0.3	-3.1	Jul 23 22:40	3271	RD	7.2	150	40	196	+1.0	+2.4	Nov 08 20:31	189613	DD	7.2	81	48	40	+0.5	+2.2
Mar 30 04:07	2216	RD	7.2	133	71	289	+2.1	-0.4	Jul 24 03:14	3288	RD	5.8	148	65	172	-0.8	+3.3	Nov 09 21:37	164583	DD	7.2	95	43	3	-0.6	+3.3
Mar 31 02:22	2364	RD	7.0	120	69	275	+2.0	-0.8	Jul 24 22:17	3404	RD	7.3	136	21	290	+0.7	-2.4	Nov 11 22:37	3461	DD	6.3	122	43	36	+0.8	+2.1
Apr 18 21:51	80882	DD	7.3	110	28	93	+2.1	+0.8	Jul 25 02:04	3422	RD	6.7	134	60	203	+0.9	+2.1	Nov 12 00:02	3465	DD	6.5	122	27	23	+0.3	+2.3
Apr 19 18:27	1499	DD	7.1	120	33	134	+1.8	-1.9	Jul 25 05:17	3432	RD	6.2	133	49	285	+2.7	+0.3	Nov 12 20:49	35	DD	6.2	134	54	54	+1.7	+1.2
Apr 20 00:19	1514	DD	6.2	122	16	97	+1.0	+0.9	Jul 25 05:21	146658	RD	7.3	133	48	212	+0.8	+2.2	Nov 13 20:18	162	DD	6.9	147	44	3	0.0	+2.6
Apr 22 20:59	1802	DD	7.1	156	52	58	+6.3	+2.7	Jul 25 23:55	4	RD	6.3	122	27	304	+2.1	-5.0	Nov 14 22:36	297	DD	6.5	161	41	62	+2.0	+0.9
Apr 22 23:25	1808	DD	7.0	157	56	122	+1.8	-0.9	Jul 27 02:36	136	RD	6.1	107	41	175	-0.5	+3.3	Nov 15 22:18	75633	DD	7.0	173	34	74	+2.1	+0.1
Apr 26 23:34	184104	RD	7.3	152	60	249	+2.6	+0.3	Jul 30 05:07	75987	RD	7.2	70	27	304	+4.4	-3.4	Nov 16 00:40	435	DD	5.8	173	32	112	+2.8	-0.1
Apr 27 00:58	2311	RD	6.3	151	76	253	+2.8	+0.6	Aug 14 19:32	2349	DD	2.9	106	77	117	+2.1	-1.0	Nov 16 20:15	Pleiades	DB	3.0	173	11	104	+1.5	-1.7
Apr 27 02:27	2317	RD	6.6	151	77	275	+2.3	0.0	Aug 14 20:55	2349	RB	2.9	106	61	271	+1.9	+0.7	Nov 16 20:19	545	RD	4.1	173	12	161	-5.2	+9.2
Apr 28 01:40	2468	RD	6.8	138	74	323	+1.3	-2.9	Aug 17 02:59	2723	DD	6.6	136	15	70	-0.2	-1.3	Nov 16 20:19	537	RD	3.7	173	12	252	+0.8	-0.5
Apr 28 21:55	X150546	RD	7.2	126	18	273	+0.1	-1.0	Aug 18 22:18	3037	DD	7.3	162	76	115	+2.8	-2.0	Nov 16 20:41	552	DD	2.9	173	15	132	+3.8	-4.8
Apr 28 22:05	186361	RD	7.2	126	20	306	-0.3	-1.8	Aug 19 22:51	3197	DD	6.4	175	68	11	+0.8	+3.3	Nov 16 20:52	541	RD	3.9	173	17	281	+1.8	-1.5
Apr 29 01:54	2644	RD	6.4	124	65	255	+2.1	0.0	Aug 20 23:56	3347	RD	6.2	168	64	225	+1.4	+1.4	Nov 16 21:04	552	RD	2.9	173	19	170	-2.3	+4.5
Apr 29 04:21	2660	RD	6.2	123	81	229	+2.0	+2.4	Aug 22 01:13	3496	RD	7.3	153	59	222	+1.4	+1.4	Nov 16 21:05	Pleiades	RD	3.0	173	19	198	-0.1	+1.4
Apr 30 04:38	2848	DB	5.6	110	82	71	+2.2	+0.8	Aug 24 00:16	209	RD	7.2	126	29	270	+1.7	-1.1	Nov 16 21:08	549	RD	6.3					

LUNAR OCCULTATION TABLE

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B	CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 04:54	1749	RD	6.0	101	67	309	+2.1	-1.9	Jun 17 23:47	1945	RB	5.2	119	43	358	+0.7	-4.4	Sep 23 00:34	Pleiades	DB	3.0	120	22	44	+0.3	+1.1
Jan 04 02:49	1849	RD	6.1	90	31	328	+0.5	-2.2	Jun 21 00:22	2349	DD	2.9	158	69	112	+2.7	-0.9	Sep 23 00:45	552	DB	2.9	120	24	60	+0.7	+0.6
Jan 07 04:26	2212	RD	6.2	51	21	345	-0.6	-2.6	Jun 21 01:48	2349	RB	2.9	158	51	274	+2.1	+0.2	Sep 23 01:14	545	RD	4.1	120	30	237	+0.9	+0.7
Jan 28 00:21	1514	RD	6.2	155	46	253	+3.4	+0.7	Jul 03 05:34	564	RD	6.2	40	17	291	+1.8	-1.7	Sep 23 01:43	Pleiades	RD	3.0	119	36	252	+1.6	+0.3
Feb 04 03:45	2305	RD	5.9	71	29	339	-0.5	-2.5	Jul 18 00:28	2270	DD	5.4	126	39	78	+1.4	+1.0	Sep 23 01:44	561	DB	5.1	119	36	105	+2.8	-1.3
Feb 05 03:25	2458	RD	6.3	58	12	306	-0.3	-1.3	Jul 20 02:52	2617	DD	4.6	154	35	117	+1.8	-0.7	Sep 23 01:55	549	RD	6.3	119	38	241	+1.4	+0.7
Feb 07 06:15	2848	DB	5.6	29	20	82	+0.7	-0.2	Jul 20 03:42	2617	RB	4.6	154	24	220	-0.3	+2.0	Sep 23 01:58	552	RD	2.9	119	38	235	+1.3	+0.9
Feb 15 21:15	459	DD	6.4	84	35	45	+2.1	+2.2	Jul 20 21:22	2784	DD	3.3	166	50	50	+2.5	+1.6	Sep 23 02:39	561	RD	5.1	119	45	190	-0.1	+3.2
Feb 22 01:43	1279	DD	6.4	151	38	155	+0.3	-2.2	Jul 20 22:26	2784	RB	3.3	166	63	308	+2.2	-2.4	Sep 26 03:30	1018	RD	5.8	84	23	299	+2.3	-1.8
Feb 23 21:57	1484	DD	3.5	171	40	99	+2.4	-0.9	Jul 22 21:00	3106	RD	5.2	164	18	275	+0.4	-0.6	Oct 07 21:06	2269	DD	5.4	47	12	131	+0.9	-1.0
Feb 23 23:25	1484	RB	3.5	172	56	326	+2.0	-2.6	Jul 24 02:38	3288	RD	5.8	148	83	298	+5.9	-3.4	Oct 11 19:09	2910	RB	4.7	98	76	255	+2.9	+0.7
Mar 02 02:36	2120	RD	6.3	115	55	295	+1.6	-1.4	Jul 24 06:10	3303	RD	6.4	146	46	193	0.0	+2.7	Oct 11 19:39	2914	DD	4.8	98	76	97	+3.3	-0.4
Mar 05 01:58	2554	RD	4.5	77	9	275	0.0	-0.5	Jul 24 23:33	3421	DB	4.9	135	26	80	+0.9	-0.1	Oct 11 20:54	2914	RB	4.8	99	65	213	+1.1	+2.7
Mar 05 05:20	2583	DB	5.8	75	51	29	+6.2	+7.6	Jul 25 00:37	3421	RD	4.9	134	41	215	+1.1	+1.8	Oct 13 01:43	3092	DD	6.3	114	15	45	-0.2	+1.5
Mar 05 05:42	2583	RD	5.8	75	56	358	-2.4	-9.9	Jul 27 01:52	136	RD	6.1	107	33	303	+3.7	-4.6	Oct 15 22:11	3505	DD	5.5	154	75	15	+0.8	+2.8
Mar 19 20:05	1103	DD	5.8	108	50	162	+2.3	-5.2	Jul 30 12:23	Pleiades	DB	3.0	67	17	60	+1.4	+1.5	Nov 04 17:28	Antares	DD	1.1	28	44	99	+1.9	0.0
Mar 20 20:51	1232	DD	6.4	119	52	131	+2.8	-2.0	Aug 11 21:27	1971	DD	5.5	70	28	89	+1.2	+0.5	Nov 04 18:43	Antares	RB	1.1	28	27	268	+0.9	+0.5
Apr 19 23:36	1514	DD	6.2	122	46	56	+8.2	+6.5	Aug 14 19:04	2349	RB	2.9	106	75	341	+1.1	-4.1	Nov 16 19:58	552	DB	2.9	173	10	5	-1.2	+2.9
Apr 19 23:56	1514	RD	6.2	122	42	28	-5.2	-9.1	Aug 14 23:38	Antares	DD	1.1	108	34	146	+2.3	-2.6	Nov 16 20:21	560	DB	3.6	173	14	64	+0.3	+0.4
Apr 24 04:36	1945	DD	5.2	171	25	101	+1.0	0.0	Aug 15 00:19	Antares	RB	1.1	108	24	218	-0.4	+3.0	Nov 16 20:32	552	RD	2.9	173	17	297	+2.0	-2.1
Apr 26 23:33	2311	RD	6.3	151	45	278	+1.5	-0.7	Aug 15 19:08	2505	RB	5.3	119	64	264	+2.8	0.0	Nov 16 21:26	560	RD	3.6	172	28	236	+0.7	+0.7
Apr 27 06:37	2349	DB	2.9	149	35	122	+1.7	-0.9	Aug 22 02:40	3505	RD	5.5	152	80	267	+3.4	+0.2	Nov 16 21:32	561	RD	5.1	172	29	251	+1.1	+0.3
Apr 29 00:37	2644	RD	6.4	124	32	294	+0.6	-1.2	Aug 22 23:41	81	RD	6.4	140	33	166	-1.0	+5.2	Nov 18 01:34	731	RD	6.0	159	50	305	+4.4	-2.4
Apr 29 02:59	2660	RD	6.2	123	61	305	+1.9	-2.0	Aug 31 05:32	1189	DB	5.0	43	13	37	-0.4	+2.2	Dec 09 00:05	3432	DD	6.2	92	14	106	+0.7	-0.2
May 20 00:02	1772	DD	3.9	126	48	135	+1.4	-1.5	Aug 31 06:18	1189	RD	5.0	42	23	326	+2.7	-3.5	Dec 15 22:08	810	DB	1.7	175	36	50	+1.2	+1.2
May 20 01:18	1772	RB	3.9	126	29	301	+1.0	-0.8	Sep 11 23:28	2470	DD	6.1	90	21	80	+0.4	+0.7	Dec 15 23:34	810	RB	1.7	175	46	276	+3.2	-0.5
May 25 21:08	2554	RD	4.5	156	16	294	0.0	-1.0	Sep 13 00:16	2645	DD	6.2	104	24	122	+1.5	-0.9	Dec 18 01:52	1122	DB	3.8	156	49	43	+4.2	+3.8
Jun 01 03:26	3514	RD	5.9	73	21	291	+1.1	-1.9	Sep 13 00:22	2644	DD	6.4	104	22	40	-0.3	+2.0	Dec 18 02:26	1119	RD	5.8	156	50	285	+3.2	-0.7
Jun 14 20:07	1625	DD	5.8	83	58	138	+1.6	-1.8	Sep 16 23:18	3288	RD	5.8	159	87	35	+1.5	+2.2	Dec 18 02:40	1122	RD	3.8	156	50	349	+1.1	-5.2
Jun 16 14:25	Jupiter	DD	-2.1	104	10	182	-0.2	-4.0	Sep 19 04:32	35	RD	6.2	171	39	247	+1.4	+1.2	Dec 29 05:55	2349	DB	2.9	30	22	104	+0.4	-0.8
Jun 16 14:56	Jupiter	RB	-2.1	104	18	242	+1.2	+1.2	Sep 19 21:02	136	RD	6.1	160	15	255	+0.5	+0.1	Dec 29 10:43	Antares	DB	1.1	28	76	96	+3.0	-0.3
Jun 17 22:58	1945	DD	5.2	119	55	72	+3.5	+2.0	Sep 23 00:05	545	DB	4.1	120	17	60	+0.4	+0.5	Dec 29 12:16	Antares	RD	1.1	28	64	295	+2.7	-1.0

HOBART (42° 48' S, 147° 13' E)

EST									Object									EST									OBJECT								
PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B		
Jan 24	23:41	1189	DD	5.0	169	21	109	+2.0	-0.4	May 23	02:41	2120	DD	6.3	164	38	106	+1.0	+0.7	Sep 15	19:34	3116	DD	6.6	143	53	127	+1.9	-3.9						
Feb 23	23:45	1484	DD	3.5	171	30	137	+1.4	-1.1	May 25	21:30	2554	DB	4.5	157	37	152	-0.4	-3.0	Sep 18	00:59	3432	DD	6.2	173	50	56	+1.3	+1.4						
Feb 24	01:07	1484	RB	3.5	172	29	294	+1.7	-0.1	May 25	22:11	2554	RD	4.5	156	44	233	+1.6	+0.2	Sep 18	20:24	4	RD	6.3	174	22	219	+0.5	+0.4						
Feb 27	22:54	Jupiter	DB	-2.3	141	26	57	+1.9	-0.4	May 26	02:46	2583	RD	5.8	155	72	242	+1.7	+1.6	Sep 19	23:32	146	DB	4.3	159	34	11	+0.2	+1.7						
Feb 27	23:12	Callisto	RD	6.0	141	30	10	-0.7	-3.4	May 27	03:24	2784	DB	3.3	140	74	153	+3.1	-6.9	Sep 20	00:27	146	RD	4.3	159	38	270	+2.2	-0.5						
Feb 27	23:16	Europa	RD	5.6	141	30	11	-0.7	-3.4	May 27	03:46	2784	RD	3.3	140	72	186	+0.1	+8.0	Sep 21	04:35	297	RD	6.5	144	24	199	+0.9	+2.1						
Feb 27	23:19	Jupiter	RD	-2.3	141	31	13	-0.9	-3.6	May 29	01:32	3089	RD	5.3	114	43	246	+1.1	-0.3	Sep 23	00:34	537	DB	3.7	120	9	121	+2.2	-2.9						
Feb 27	23:19	Io	RD	5.3	141	31	15	-1.1	-3.8	May 29	04:17	3106	DB	5.2	113	66	95	+2.1	-0.6	Sep 23	01:01	541	DB	3.9	120	12	84	+1.3	-1.0						
Feb 27	23:20	Ganymede	RB	4.9	141	31	23	-2.2	-5.0	May 29	05:22	3106	RD	5.2	112	67	209	+1.0	+2.4	Sep 23	01:11	537	RD	3.7	120	14	184	-0.7	+1.9						
Mar 02	03:17	2119	RD	6.6	115	61	350	+0.2	-3.3	Jun 18	00:10	1945	DD	5.2	119	27	183	+0.5	-4.2	Sep 23	01:37	536	RD	5.5	120	16	229	+0.9	0.0						
Mar 02	03:58	2120	RD	6.3	115	65	235	+4.0	+3.0	Jun 20	20:59	2328	DD	6.4	156	64	94	+1.7	-0.8	Sep 23	02:01	539	RD	4.3	120	18	255	+1.5	-0.5						
Mar 17	20:11	810	DD	1.7	85	12	77	+1.8	+1.2	Jun 21	05:02	2371	DD	4.8	160	14	75	-0.2	+1.5	Sep 23	02:10	541	RD	3.9	120	19	220	+0.9	+0.4						
Mar 17	21:29	810	RB	1.7	86	4	284	+0.9	+1.0	Jun 21	19:09	2476	DD	6.6	169	36	129	+0.1	-2.0	Sep 23	02:28	542	RD	5.8	120	20	256	+1.7	-0.3						
Mar 23	19:21	1544	DD	5.4	151	17	166	+0.9	-2.6	Jun 27	05:14	3347	RD	6.2	115	57	236	+1.4	+1.3	Sep 23	02:31	543	RD	6.4	120	20	247	+1.5	-0.1						
Mar 26	23:52	1850	RD	6.5	172	50	299	+1.6	-1.3	Jun 29	02:38	50	RD	5.8	90	25	254	+1.0	-0.7	Sep 23	03:48	555	RD	6.4	119	22	304	+3.1	-1.2						
Mar 31	02:18	2371	DB	4.8	120	61	43	+3.7	+3.1	Jul 03	06:11	559	RD	6.5	41	11	215	+0.3	+0.3	Oct 07	21:10	2270	DD	5.4	47	14	124	+0.3	+0.4						
Mar 31	02:46	2371	RD	4.8	120	65	0	-0.8	-6.4	Jul 03	06:34	560	RD	3.6	41	14	251	+1.1	-0.6	Oct 09	22:21	2583	DD	5.8	73	24	96	+0.3	+1.1						
Apr 20	00:12	1514	DD	6.2	122	15	131	+0.5	0.0	Jul 19	18:32	2554	RB	4.5	150	44	242	+1.4	-0.2	Oct 23	02:13	948	DB	4.3	116	12	69	+1.4	-0.6						
Apr 27	02:07	2317	RD	6.6	151	72	231	+2.9	+3.0	Jul 19	21:50	2583	DD	5.8	152	74	117	+1.7	-1.4	Oct 23	03:35	948	RD	4.3	116	17	282	+2.1	-0.6						
Apr 27	04:01	2328	RD	6.4	150	60	328	+1.6	-2.0	Jul 22	19:29	3092	RD	6.3	165	15	274	0.0	-1.3	Nov 11	22:16	3461	DD	6.3	122	44	43	+1.0	+1.8						
Apr 27	22:58	2458	RD	6.3	139	40	325	0.0	-2.5	Jul 25	05:03	3432	RD	6.2	133	47	273	+2.0	+0.8	Nov 11	23:41	3465	DD	6.5	122	31	32	+0.5	+2.1						
Apr 28	02:43	2476	RD	6.6	137	74	324	+1.4	-2.8	Jul 26	00:09	4	RD	6.3	121	23	263	+0.9	-1.1	Nov 12	20:34	35	DD	6.2	134	45	66	+1.7	+0.5						
Apr 29	01:34	2644	RD	6.4	124	57	205	+3.3	+5.0	Aug 01	07:02	810	DB	1.7	47	14	89	+1.7	-0.9	Nov 14	22:23	297	DD	6.5	161	32	71	+1.8	+0.3						
Apr 30	04:30	2848	DB	5.6	110	72	102	+1.9	-0.8	Aug 14	19:41	2349	DD	2.9	106	71	156	+1.4	-3.3	Nov 16	00:33	435	DD	5.8	173	25	128	+3.1	-0.8						
Apr 30	05:42	2848	RD	5.6	109	73	234	+1.5	+1.8	Aug 14	20:32	2349	RB	2.9	106	64	234	+1.9	+3.0	Nov 16	20:49	Pleiades	RD	3.0	173	8	166	-3.2	+5.7						
May 04	04:14	3421	DB	4.9	57	22	69	+0.6	-0.6	Aug 17	02:47	2723	DD	6.6	136	23	83	+0.1	+1.3	Nov 16	20:58	541	RD	3.9	173	9	262	+1.0	-1.0						
May 04	05:20	3421	RD	4.9	56	34	231	+0.9	+0.2	Aug 19	22:28	3197	DD	6.4	175	56	41	+1.2	+1.2	Nov 18	02:39	731	RD	6.0	159	17	232	+1.9	+1.3						
May 13	17:41	1122	DD	3.8	56	17	160	+0.5	-1.1	Aug 20	23:38	3347	RD	6.2	168	53	203	+0.8	+1.8	Dec 08	21:16	3412	DD	4.2	91	36	355	-0.4	+3.0						
May 13	18:33	1122	RB	3.8	57	12	236	+2.6	+2.3	Sep 10	19:31	2299	DD	6.2	76	54	129	+1.6	-0.6	Dec 08	21:49	3412	RB	4.2	91	30	293	+1.7	+0.8						
May 15	18:28	1363	DD	5.2	79	25	150	+1.0	-1.0	Sep 10	22:42	2317	DD	6.6	77	20	38	-0.7	+3.4	Dec 15	23:58	810	MD	1.7	174	19	173	+2.4	-1.3						
May 15	19:02	1365	DD	6.0	79	23	132	+1.3	-0.4	Sep 12	20:09	2617	DD	4.6	102	69	127	+2.1	-1.4	Dec 18	02:49	1122	DB	3.8	156	18	101	+1.9	+0.3						
May 15	19:41	1363	RB	5.2	79	20	272	+1.9	+0.9	Sep 12	21:06	2617	RB	4.6	102	59	222	+0.9	+3.0	Dec 26	02:49	1945	RD	5.2	68	22	328	+0.1	-2.2						

MOON

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

MOON

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

	AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			MOON PHASES (UT)				

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

MERCURY

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

MERCURY

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

VENUS

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

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

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

VENUS

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

OPPOSITION OF MARS 2005

On the 7th November 2005, Mars will be at opposition, providing the best views of the planet since August 2003.

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

The favourable perihelic oppositions occur only once every 15 to 17 years. At this year's opposition, Mars comes within 69.42 Mkm of Earth (compared with 55.77 Mkm in 2003); close enough for good viewing in small to medium telescopes. Although Mars is now past perihelion, this apparition is still considered a perihelic opposition.

Oppositions in the early months of the year are always unfavourable as Mars is at aphelion. Perihelic oppositions occur around August, and fortunately for southern hemisphere observers, Mars is at its greatest southerly declination at that time. When Mars is at conjunction its disc is only 3.5 arc seconds (") in diameter, smaller than distant Uranus. At a poor opposition, the diameter is 14", increasing to 25" at a perihelic opposition (fig 1). During the 2005 opposition the disc steadily grows from 4" at the beginning of the year to 20" at opposition, decreasing to 12" by year's end (fig 4). For northern hemisphere observers

Mars is better positioned in the sky than in 2003, and conversely a little poorer for us (transiting the meridian about 40 degrees above the horizon).

Since the Martian day is about 40 minutes longer than Earth's day, surface features cross the central meridian 40 minutes later

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

The iron-rich soils of Mars (which give the Red Planet its colour) were shown by the Viking landers to be much lighter in colour than the rocks underneath. Depending on the season, high velocity winds can lift the soil and transport it around the planet. Sometimes the rocky surface is uncovered, showing a darker area; and at other times, dark areas can be covered by lighter dust as storms deposit millions

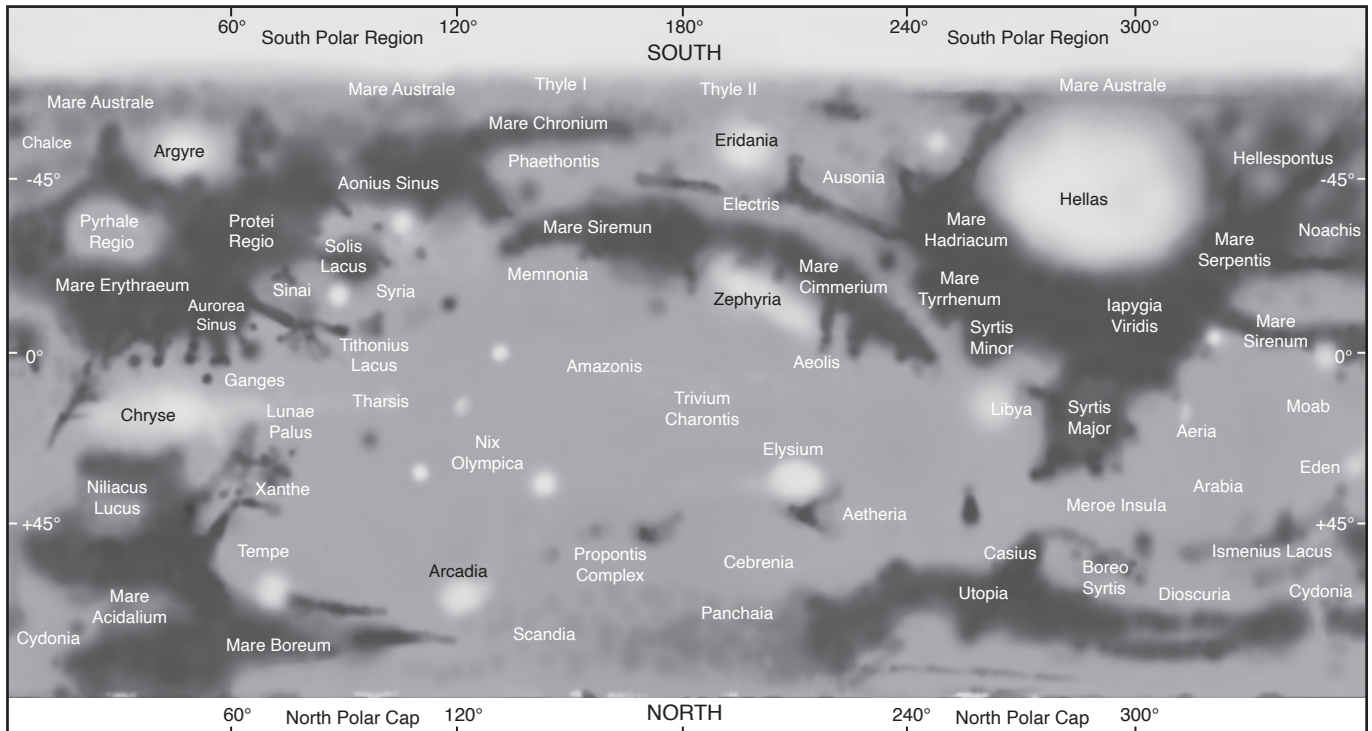
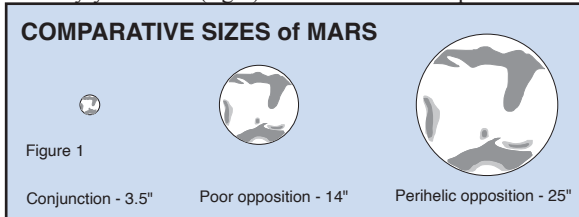
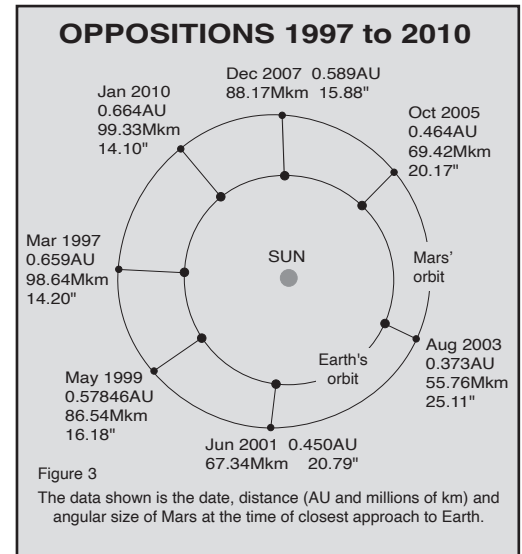


Figure 2. Mars map courtesy of Dan Troiani, Association of Lunar and Planetary Observers, Mars Section Head Coordinator. The map was assembled using CCD images, videos, drawings and photographs made during the 1997 apparition by observers of the ALPO International Mars Patrol and Mars Watch '97. Over 1,700 observations were used to create the map. The white areas are where clouds are frequently observed.

of tonnes of material over the landscape. Observers noted during the opposition of 1988 that there were a number of new features, including four darker areas that had not been seen since last century.

Even with the constant movement of dust around the planet, several easily recognisable regions can be seen and identified from opposition to opposition. It will be interesting to compare this year's observable features with the Association of Lunar and Planetary Observers' (ALPO) map (fig 2). The most prominent of the dark areas is Syrtis Major, a wedge shaped region just north of the equator. Directly below Syrtis Major in the south is a light contrasting area known as Hellas, a depression that when covered in light dust is very conspicuous. The mysterious Eye of Mars or Solis Lacus (Lake of the Sun) is also located in the southern hemisphere, a small dark region ringed by lighter material. At some oppositions the Eye is outstanding, and at others it is difficult because of the shifting sands of Mars.

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

A phenomenon known as the *violet clearing* is a rather puzzling event that has been noted by observers for many years, and as yet there is no generally accepted explanation. When viewing Mars through a violet filter, sometimes a *clearing* in transparency occurs. Under normal circumstances the violet filter reveals the high level clouds, and very little else. When the clearing occurs, the surface features become very pronounced for a day or two.

There are many unsolved mysteries of the Red Planet and in a scientific light the amateur can still contribute. Monitoring the Martian atmosphere and surface features will assist in our understanding of the geological and atmospheric mechanics of this strange planet. Even with centuries of Earth based telescope scrutiny, and years of surveillance by orbiting spacecraft, Mars still has many secrets. Only by the dedication and enthusiasm of astronomers (mostly amateurs) will some of the mysteries be solved.

The ALPO are looking for observers to keep an eye on the planet for at least a six-month period centred on opposition. Because of the limited resolution of smaller telescopes (around 100mm) the

ORIENTATION of MARS

NOTES on the Physical Ephemeris Table.

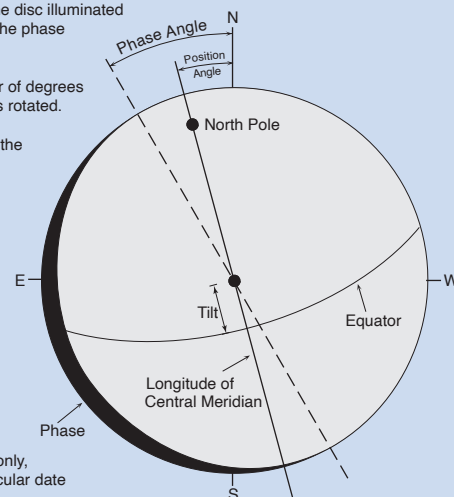
Cent Mer: Longitude of Central Meridian, is the longitude that is centred on the disc.

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

Phase: Is the fraction of the disc illuminated by the Sun. At opposition the phase is at maximum.

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

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



observing window will be limited to around eight or ten weeks on either side of opposition when the disc is largest. If you would like to see the shrinking southern polar cap, great yellow dust storms, cloud forming downwind from the largest volcanoes in the Solar System and other Martian features, why not put pen to paper and document your observations. Visual observers with telescopes in the 100mm to 200mm range or even larger are asked to sketch their observations. CCD, web-cam and photographic images are also welcome.

You can visit the ALPO home page at (www.lpl.arizona.edu/aplo). This site is an excellent resource, providing up to date news and observations, and information on how the amateur can contribute. Of special interest is the calendar of events to look out for during the period March 2005 through to March 2006.

ASPECTS of MARS - OPPOSITION 2005 Figure 4

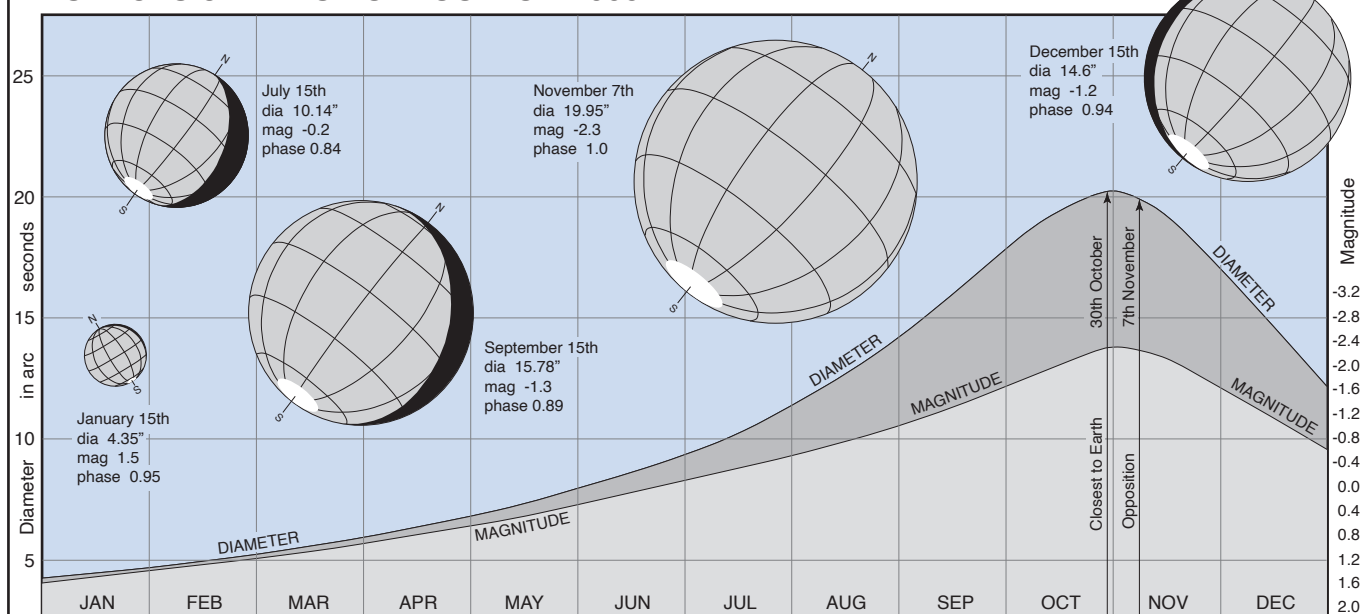


Table 1 **PHYSICAL EPHEMERIS 2005, 0hr UT**

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°	Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°	Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°		
Sep 1	039.9	-12.9	0.870	42.3	321.8	Oct 22	292.1	-12.9	0.983	14.9	321.8	Dec 12	198.1	-19.7	0.950	25.9	321.3		
Sep 2	030.4	-12.8	0.871	42.0	321.9	Oct 23	283.2	-13.0	0.985	14.0	321.8	Dec 13	189.0	-19.8	0.948	26.4	321.3		
Sep 3	021.0	-12.6	0.873	41.8	321.9	Oct 24	274.3	-13.2	0.987	13.1	321.8	Dec 14	179.8	-19.8	0.946	26.8	321.3		
Sep 4	011.5	-12.5	0.875	41.5	321.9	Oct 25	265.5	-13.4	0.989	12.2	321.7	Dec 15	170.6	-19.8	0.944	27.3	321.3		
Sep 5	002.1	-12.4	0.876	41.2	321.9	Oct 26	256.7	-13.6	0.990	11.3	321.7	Dec 16	161.4	-19.8	0.942	27.8	321.3		
Sep 6	352.7	-12.3	0.878	40.9	321.9	Oct 27	247.8	-13.7	0.992	10.4	321.7	Dec 17	152.2	-19.8	0.941	28.2	321.2		
Sep 7	343.3	-12.2	0.880	40.6	321.9	Oct 28	239.0	-13.9	0.993	09.5	321.6	Dec 18	143.0	-19.8	0.939	28.7	321.2		
Sep 8	333.9	-12.0	0.881	40.3	322.0	Oct 29	230.2	-14.1	0.994	08.6	321.6	Dec 19	133.7	-19.8	0.937	29.1	321.2		
Sep 9	324.5	-11.9	0.883	40.0	322.0	Oct 30	221.4	-14.3	0.995	07.7	321.6	Dec 20	124.5	-19.7	0.935	29.5	321.2		
Sep 10	315.2	-11.8	0.885	39.7	322.0	Oct 31	212.6	-14.5	0.996	06.8	321.6	Dec 21	115.2	-19.7	0.933	29.9	321.2		
Sep 11	305.8	-11.7	0.887	39.3	322.0	Nov 1	203.8	-14.6	0.997	05.9	321.5	Dec 22	105.9	-19.7	0.932	30.3	321.2		
Sep 12	296.4	-11.7	0.889	39.0	322.0	Nov 2	195.0	-14.8	0.998	05.0	321.5	Dec 23	096.7	-19.6	0.930	30.7	321.2		
Sep 13	287.1	-11.6	0.891	38.6	322.0	Nov 3	186.2	-15.0	0.999	04.0	321.5	Dec 24	087.4	-19.6	0.928	31.0	321.2		
Sep 14	277.8	-11.5	0.893	38.3	322.1	Nov 4	177.4	-15.2	0.999	03.1	321.5	Dec 25	078.1	-19.6	0.927	31.4	321.1		
Sep 15	268.4	-11.4	0.895	37.9	322.1	Nov 5	168.6	-15.4	1.000	02.2	321.4	Dec 26	068.8	-19.5	0.925	31.7	321.1		
Sep 16	259.1	-11.3	0.897	37.5	322.1	Nov 6	159.9	-15.6	1.000	01.3	321.4	Dec 27	059.4	-19.5	0.924	32.1	321.1		
Sep 17	249.8	-11.3	0.899	37.1	322.1	Nov 7	151.1	-15.8	1.000	00.4	321.4	Dec 28	050.1	-19.4	0.922	32.4	321.1		
Sep 18	240.5	-11.2	0.901	36.7	322.1	Nov 8	142.3	-16.0	1.000	00.7	321.4	Dec 29	040.8	-19.4	0.921	32.7	321.1		
Sep 19	231.2	-11.1	0.903	36.3	322.1	Nov 9	133.5	-16.1	1.000	01.6	321.4	Dec 30	031.4	-19.3	0.919	33.0	321.1		
Sep 20	222.0	-11.1	0.905	35.8	322.2	Nov 10	124.7	-16.3	1.000	02.5	321.4	Dec 31	022.1	-19.2	0.918	33.3	321.1		
Sep 21	212.7	-11.0	0.908	35.4	322.2	Nov 11	115.9	-16.5	0.999	03.4	321.4	Jan 1	012.7	-19.2	0.917	33.5	321.1		
Sep 22	203.5	-11.0	0.910	34.9	322.2	Nov 12	107.1	-16.7	0.999	04.2	321.4	Jan 2	003.3	-19.1	0.915	33.8	321.0		
Sep 23	194.2	-11.0	0.912	34.4	322.2	Nov 13	098.3	-16.8	0.998	05.1	321.3	Jan 3	353.9	-19.0	0.914	34.1	321.0		
Sep 24	185.0	-10.9	0.915	34.0	322.2	Nov 14	089.4	-17.0	0.997	06.0	321.3	Jan 4	344.5	-18.9	0.913	34.3	321.0		
Sep 25	175.8	-10.9	0.917	33.5	322.2	Nov 15	080.6	-17.2	0.996	06.9	321.3	Jan 5	335.1	-18.8	0.912	34.5	321.0		
Sep 26	166.6	-10.9	0.920	32.9	322.2	Nov 16	071.8	-17.3	0.995	07.8	321.3	Jan 6	325.7	-18.7	0.911	34.8	321.0		
Sep 27	157.4	-10.9	0.922	32.4	322.2	Nov 17	062.9	-17.5	0.994	08.6	321.3	Jan 7	316.3	-18.6	0.910	35.0	321.0		
Sep 28	148.3	-10.9	0.925	31.9	322.2	Nov 18	054.1	-17.7	0.993	09.5	321.3	Jan 8	306.9	-18.5	0.909	35.2	321.0		
Sep 29	139.1	-10.9	0.927	31.3	322.2	Nov 19	045.2	-17.8	0.992	10.3	321.3	Jan 9	297.5	-18.4	0.907	35.4	321.0		
Sep 30	129.9	-10.9	0.930	30.8	322.2	Nov 20	036.3	-18.0	0.991	11.1	321.3	Jan 10	288.0	-18.3	0.907	35.6	321.0		
Oct 1	120.8	-10.9	0.932	30.2	322.2	Nov 21	027.5	-18.1	0.989	11.9	321.3	Jan 11	278.6	-18.2	0.906	35.8	321.0		
Oct 2	111.7	-11.0	0.935	29.6	322.2	Nov 22	018.6	-18.2	0.988	12.7	321.3	Jan 12	269.1	-18.1	0.905	36.0	321.0		
Oct 3	102.6	-11.0	0.937	29.0	322.2	Nov 23	009.7	-18.4	0.986	13.5	321.3	Jan 13	259.7	-18.0	0.904	36.1	321.0		
Oct 4	093.5	-11.0	0.940	28.4	322.2	Nov 24	000.8	-18.5	0.984	14.3	321.3	Jan 14	250.2	-17.9	0.903	36.3	321.0		
Oct 5	084.4	-11.1	0.943	27.7	322.2	Nov 25	351.8	-18.6	0.983	15.1	321.3	Jan 15	240.7	-17.7	0.902	36.5	321.0		
Oct 6	075.4	-11.1	0.945	27.1	322.2	Nov 26	342.9	-18.7	0.981	15.8	321.3	Jan 16	231.3	-17.6	0.901	36.6	321.0		
Oct 7	066.3	-11.2	0.948	26.4	322.2	Nov 27	334.0	-18.8	0.979	16.6	321.3	Jan 17	221.8	-17.5	0.901	36.8	321.0		
Oct 8	057.3	-11.3	0.950	25.7	322.2	Nov 28	325.0	-18.9	0.977	17.3	321.3	Jan 18	212.3	-17.4	0.900	36.9	321.0		
Oct 9	048.2	-11.3	0.953	25.0	322.1	Nov 29	316.0	-19.0	0.976	18.0	321.3	Jan 19	202.8	-17.2	0.899	37.0	321.0		
Oct 10	039.2	-11.4	0.956	24.3	322.1	Nov 30	307.0	-19.1	0.974	18.7	321.3	Jan 20	193.3	-17.1	0.899	37.1	321.0		
Oct 11	030.2	-11.5	0.958	23.6	322.1	Dec 1	298.0	-19.2	0.972	19.4	321.3	Central Meridian - Increase in Longitude							
Oct 12	021.2	-11.6	0.961	22.9	322.1	Dec 2	289.0	-19.3	0.970	20.0	321.3	hr	deg°	hr	deg°	hr	deg°	min	deg°
Oct 13	012.3	-11.7	0.963	22.1	322.1	Dec 3	280.0	-19.3	0.968	20.7	321.3	1	14.6	9	131.6	17	248.6	10	2.4
Oct 14	003.3	-11.8	0.966	21.4	322.0	Dec 4	270.9	-19.4	0.966	21.3	321.3	2	29.2	10	146.2	18	263.2	20	4.9
Oct 15	354.4	-11.9	0.968	20.6	322.0	Dec 5	261.9	-19.5	0.964	21.9	321.3	3	43.9	11	160.8	19	277.8	30	7.3
Oct 16	345.4	-12.0	0.970	19.8	322.0	Dec 6	252.8	-19.5	0.962	22.5	321.3	4	58.5	12	175.5	20	292.4	40	9.7
Oct 17	336.5	-12.2	0.973	19.0	322.0	Dec 7	243.7	-19.6	0.960	23.1	321.3	5	73.1	13	190.1	21	307.0	50	12.2
Oct 18	327.6	-12.3	0.975	18.2	321.9	Dec 8	234.6	-19.6	0.958	23.7	321.3	6	87.7	14	204.7	22	321.7	Table 2	
Oct 19	318.7	-12.4	0.977	17.4	321.9	Dec 9	225.5	-19.7	0.956	24.3	321.3	7	102.3	15	219.3	23	336.3		
Oct 20	309.8	-12.6	0.979	16.6	321.9	Dec 10	216.4	-19.7	0.954	24.8	321.3	8	117.0	16	233.9	24	350.9		
Oct 21	300.9	-12.7	0.981	15.7	321.8	Dec 11	207.3	-19.7	0.952	25.3	321.3								

Calculating longitude of central meridian for a particular observation date and time. First convert your local time to UT correcting the date if needed. Next, from table 1, select the central meridian figure for the date. Now take the hour and minute values from the 'Increase in Longitude' (table 2). Add these three numbers. If the result is greater than 360° subtract 360 from it.

For example an observation at 2:20am EST on Nov. 1st, converts to 16:20 UT on Oct. 31st. From the tables above our calculation is 212.6 + 233.9 + 4.9 = 451.4 Subtracting 360 to get a result less than 360 gives us a longitude of central meridian of 91.4°. The longitudes are shown on the map (fig. 2). Around this time Solis Lacus will be crossing the central meridian.

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hr UT Epoch 2000.0

MARS

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

JUPITER

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

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

JUPITER'S MOONS 2005

Jupiter, with its many moons orbiting the planet, can be likened to a miniature solar system. Also, like the planets, these moons all lie in a similar plane. Although there are currently 63 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's Moons' on pages 114 – 115. All the moons orbit in roughly the same plane, which is very close to the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From our perspective on Earth, we see four types of events. They are:

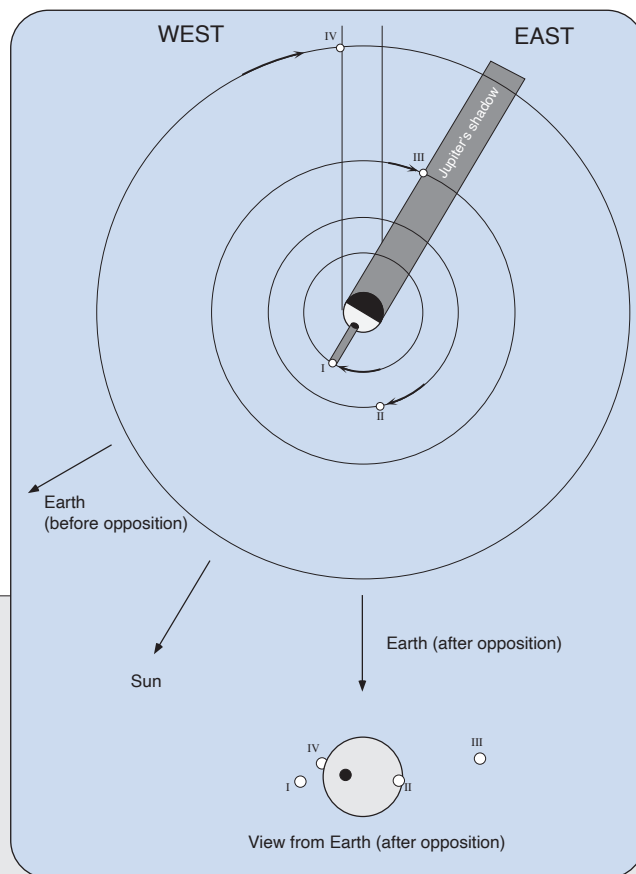
- 1 The satellite passes in front of Jupiter. This is called a Satellite Transit.
- 2 The shadow of a satellite can move across the 'surface' of the planet. This is called a Satellite Shadow Transit. The start of a satellite or shadow transit is called its ingress; the finish, its egress.

Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter's opposition date in 2005 is April 4.

- 3 A satellite can go into occultation i.e., pass behind the disc of Jupiter.
- 4 A satellite can be eclipsed as it passes into Jupiter's shadow. The closer Jupiter is to opposition (or conjunction), the more likely the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. In fact, Io is so close to Jupiter, it is impossible to see both the disappearance and reappearance for the same eclipse. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7X power or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation). This happens every eight days approximately; an example would be the morning of 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.

ECLIPSE POSITIONS



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 (pp. 111-113)

- 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.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Io (I)	d	d	d	r	r	r	r	r	r	r	d	d
Europa (II)	d	d	d	r	r	r	r	r	r	r	d	d
Ganymede (III)	d	d	d	r	r	r	r	r	r	r	d	d
Callisto (IV)	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse

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

JUPITER

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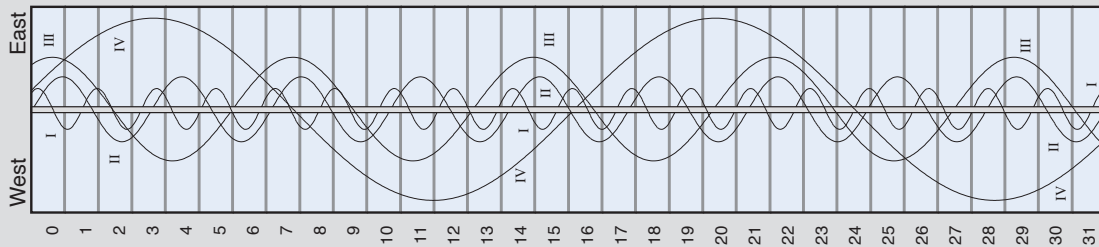
JUPITER

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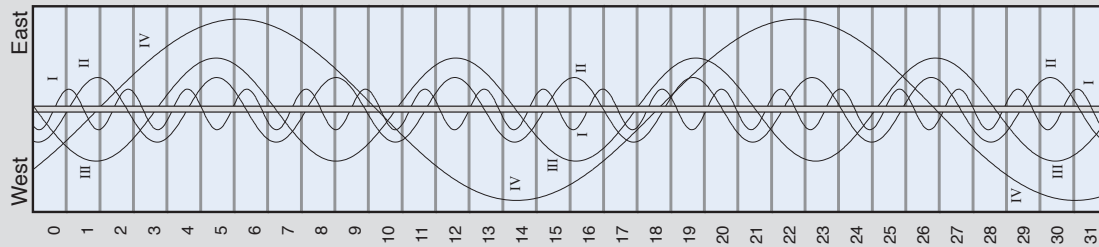
JUPITER MOON EVENTS

17	17:23	15:23	I Sh I E	11	00:12	22:12(p)	III Oc R W	11	17:48	15:48	II Oc D E	21	18:52	16:52	II Tr E E
	17:57	15:57	II Sh I E		17:04	15:04	I Ec R E		22:32	20:32	II Ec R W		19:52	17:52	II Sh E W
	18:07	16:07	II Tr E E	12	17:48	15:48	II Sh E E	13	17:34	15:34	II Sh E E	24	19:38	17:38	I Tr I W
	18:21	16:21	I Tr E E										20:07	18:07	I Sh I W
	19:34	17:34	I Sh E	14	18:52	16:52	III Sh E E	15	18:24	16:24	III Oc D E	25	19:38	17:38	I Ec R E
	20:37	18:37	II Sh E						21:07	19:07	III Oc R				
18	16:50	14:50	I Ec R E	15	23:47	21:47	I Tr I W		22:41	20:41	III Ec D W	27	20:44	18:44	III Oc D W
					16	01:01	23:01(p)	I Sh I W	23:27	21:27	I Oc D W	28	19:00	17:00	II Tr I E
19	17:10	15:10	III Ec R E			21:03	19:03	I Oc D				November			
22	02:19	00:19	I Oc D W	17	00:30	22:30(p)	I Ec R W	16	20:37	18:37	I Tr I	21	04:05	02:05	II Tr I E
	23:18	21:18	III Tr I		18:16	16:16	I Tr I E		21:37	19:37	I Sh I W		05:44	03:44	II Sh E W
	23:22	21:22	II Oc D		19:30	17:30	I Sh I		22:49	20:49	I Tr E W		06:42	04:42	II Tr E W
	23:33	21:33	I Tr I		20:25	18:25	II Oc D	17	17:57	15:57	I Oc D E	22	05:48	03:48	I Sh I W
23	00:49	22:49(p)	I Sh I W		20:28	18:28	I Tr E		21:08	19:08	I Ec R		06:18	04:18	I Tr I W
	01:46	23:46(p)	I Tr E W		21:41	19:41	I Sh E	18	17:19	15:19	I Tr E E	23	05:48	03:48	I Oc R W
	02:02	00:02	III Tr E W	18	18:59	16:59	I Ec R E		18:16	16:16	I Sh E E	24	06:23	04:23	III Ec D W
	20:47	18:47	I Oc D						20:32	18:32	II Oc D	28	05:42	03:42	II Sh I W
24	00:16	22:16(p)	I Ec R	19	17:46	15:46	II Sh I E	20	17:32	15:32	II Sh I E	30	03:55	01:55	II Oc R E
	17:58	15:58	II Tr I E		17:58	15:58	II Tr E E		18:17	16:17	II Tr E E		05:01	03:01	I Ec D
	18:02	16:02	I Tr I E		20:25	18:25	II Sh E	22	22:43	20:43	III Oc D W	December			
	19:17	17:17	I Sh I	21	18:09	16:09	III Tr E E	23	22:36	20:36	I Tr I W	1	04:21	02:21	I Sh E
	20:14	18:14	I Tr E		20:30	18:30	III Sh I	24	19:57	17:57	I Oc D		04:59	02:59	I Tr E
	20:35	18:35	II Sh I		22:51	20:51	III Sh E W		23:03	21:03	I Ec R W	5	02:54	00:54	III Tr I E
	20:42	18:42	II Tr E	23	23:01	21:01	I Oc D W	25	18:00	16:00	I Sh I E		04:59	02:59	III Tr E
	21:28	19:28	I Sh E	24	20:13	18:13	I Tr I		19:19	17:19	I Tr E E	7	02:38	00:38	II Ec D E
	23:15	21:15	II Sh E		21:25	19:25	I Sh I	26	17:32	15:32	I Ec R E		06:43	04:43	II Oc R W
25	18:45	16:45	I Ec R E		22:25	20:25	I Tr E		18:41	16:41	III Sh E E	8	04:04	02:04	I Sh I
26	17:47	15:47	II Ec R E		23:04	21:04	II Oc D W	27	18:21	16:21	II Tr I E		04:49	02:49	I Tr I
	18:43	16:43	III Ec D E		23:35	21:35	I Sh E W		20:08	18:08	II Sh I		06:15	04:15	I Sh E W
	21:09	19:09	III Ec R	25	17:30	15:30	I Oc D E	31	21:57	19:57	I Oc D W	9	04:17	02:17	I Oc R
30	01:27	23:27(p)	I Tr I W		20:54	18:54	I Ec R	September				12	04:04	02:04	III Sh I
	01:55	23:55(p)	II Oc D W	26	16:54	14:54	I Tr E E	1	19:06	17:06	I Tr I E		06:07	04:07	III Sh E W
	22:42	20:42	I Oc D		17:56	15:56	II Tr I E		19:55	17:55	I Sh I	14	05:14	03:14	II Ec D W
July					18:04	16:04	I Sh E E		21:18	19:18	I Tr E W	15	05:58	03:58	I Sh I W
1	19:56	17:56	I Tr I		20:23	18:23	II Sh I		22:05	20:05	I Sh E W		06:48	04:48	I Tr I W
	20:35	18:35	II Tr I	28	17:23	15:23	II Ec R E	2	19:26	17:26	I Ec R E	16	02:40	00:40	II Sh E E
	21:12	19:12	I Sh I		19:33	17:33	III Tr I		19:41	17:41	III Tr E		03:16	01:16	I Ec D E
	22:08	20:08	I Tr E		22:18	20:18	III Tr E		20:24	18:24	III Sh I		04:19	02:19	II Tr E
	23:12	21:12	II Sh I	29	00:29	22:29(p)	III Sh I W		22:40	20:40	III Sh E W		06:16	04:16	I Oc R W
	23:18	21:18	II Tr E		31	22:10	20:10	I Tr I				17	02:37	00:37	I Sh E E
	23:23	21:23	I Sh E			23:19	21:19	I Sh I W	3	21:09	19:09		03:29	01:29	I Tr E
2	01:52	23:52(p)	II Sh E W	August				5	19:34	17:34	II Ec R E	23	02:00	00:00	III Oc D E
	17:11	15:11	I Oc D E	1	17:02	15:02	III Ec R E						02:39	00:39	II Sh I E
	20:40	18:40	I Ec R		19:28	17:28	I Oc D	8	21:07	19:07	I Tr I W		03:58	01:58	III Oc R
3	17:24	15:24	III Oc D E		22:49	20:49	I Ec R W		21:49	19:49	I Sh I W		04:29	02:29	II Tr I
	17:51	15:51	I Sh E E	2	17:48	15:48	I Sh I E	9	18:28	16:28	I Oc D E		05:09	03:09	I Ec D
	20:10	18:10	III Oc R		18:52	16:52	I Tr E E		21:21	19:21	I Ec R W		05:13	03:13	II Sh E
	20:22	18:22	II Ec R		19:59	17:59	I Sh E		21:26	19:26	III Tr I W	24	02:20	00:20	I Sh I E
	22:43	20:43	III Ec D		20:40	18:40	II Tr I	10	17:49	15:49	I Tr E E		03:17	01:17	I Tr I
4	01:08	23:08(p)	III Ec R W		23:00	21:00	II Sh I W		18:28	16:28	I Sh E E		04:30	02:30	I Sh E
8	00:37	22:37(p)	I Oc D W		23:24	21:24	II Tr E W	12	18:13	16:13	II Oc D E		05:27	03:27	I Tr E W
	21:51	19:51	I Tr I	3	17:18	15:18	I Ec R E		22:09	20:09	II Ec R W	25	01:40	23:40(p)	II Oc R E
	23:07	21:07	I Sh I					16	20:29	18:29	I Oc D W		02:43	00:43	I Oc R E
	23:13	21:13	II Tr I	4	19:57	17:57	II Ec R					30	02:10	00:10	III Ec D E
9	00:03	22:03(p)	I Tr E W		23:46	21:46	III Tr I W	17	17:37	15:37	I Tr I E		04:12	02:12	III Ec R
	01:17	23:17(p)	I Sh E W	8	18:40	16:40	III Ec D E		18:12	16:12	I Sh I E		05:12	03:12	II Sh I
	19:06	17:06	I Oc D		21:00	19:00	III Ec R		19:49	17:49	I Tr E W		06:19	04:19	III Oc D W
	22:35	20:35	I Ec R		21:27	19:27	I Oc D	18	20:23	18:23	I Sh E W	31	04:14	02:14	I Sh I
10	17:35	15:35	I Sh I E	9	18:38	16:38	I Tr I E						05:16	03:16	I Tr I
	17:48	15:48	II Oc D E		19:43	17:43	I Sh I	20	20:49	18:49	III Ec R W		06:24	04:24	I Sh E W
	18:32	16:32	I Tr E E		20:50	18:50	I Tr E								
	19:46	17:46	I Sh E		21:53	19:53	I Sh E W								
	21:26	19:26	III Oc D		23:25	21:25	II Tr I W								
	22:56	20:56	II Ec R	10	19:13	17:13	I Ec R E								

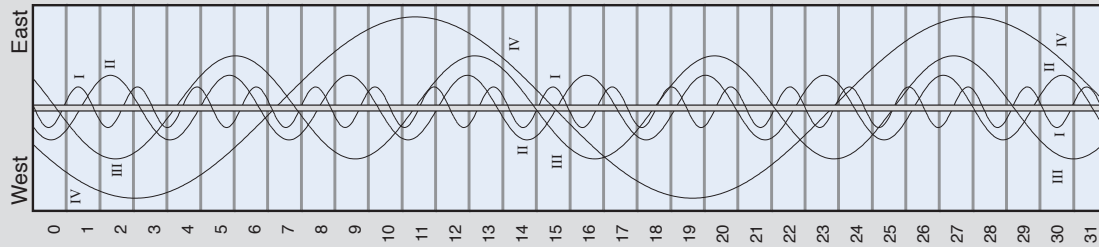
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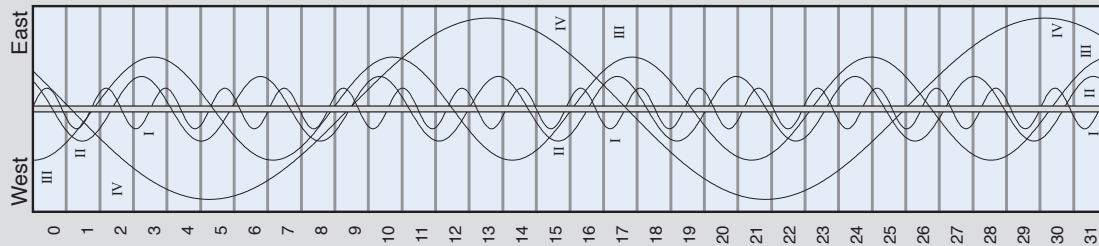
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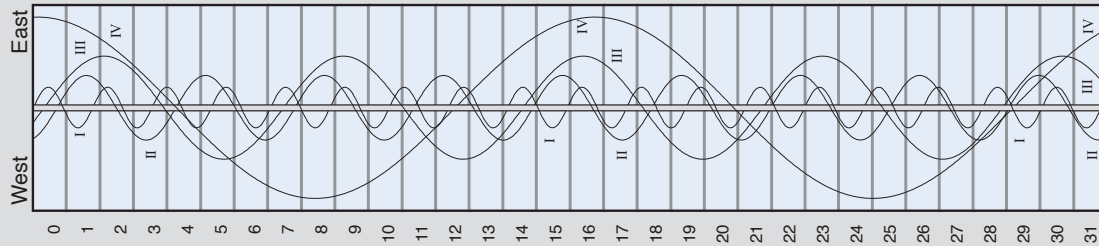
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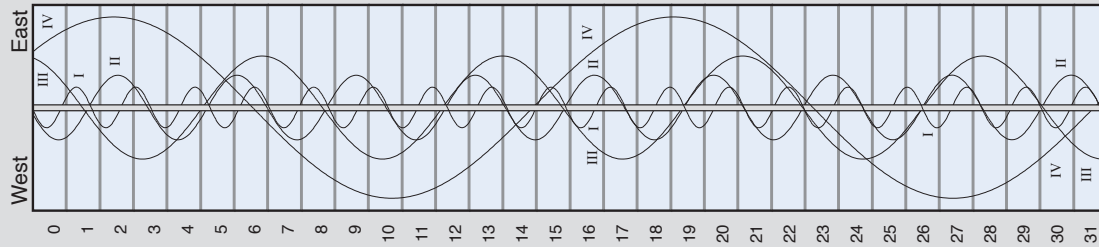
APRIL



MAY



JUNE



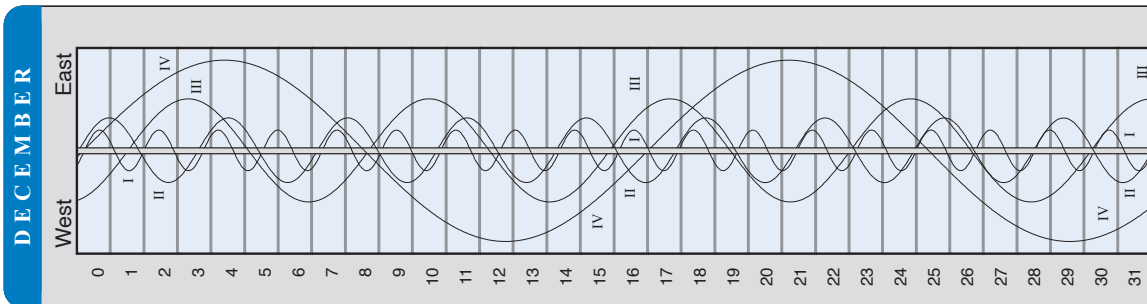
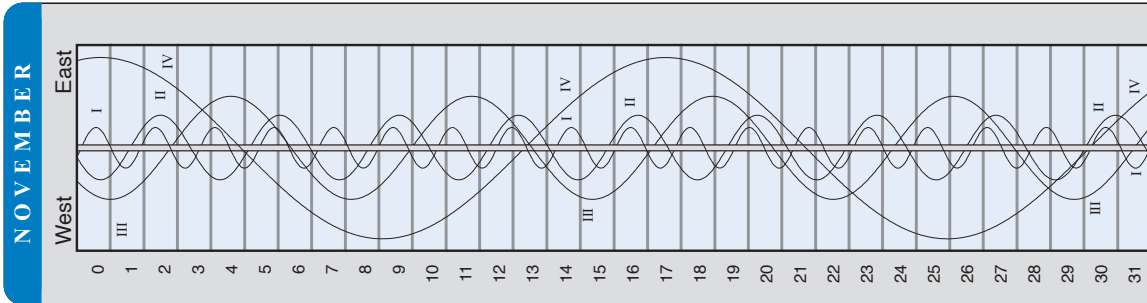
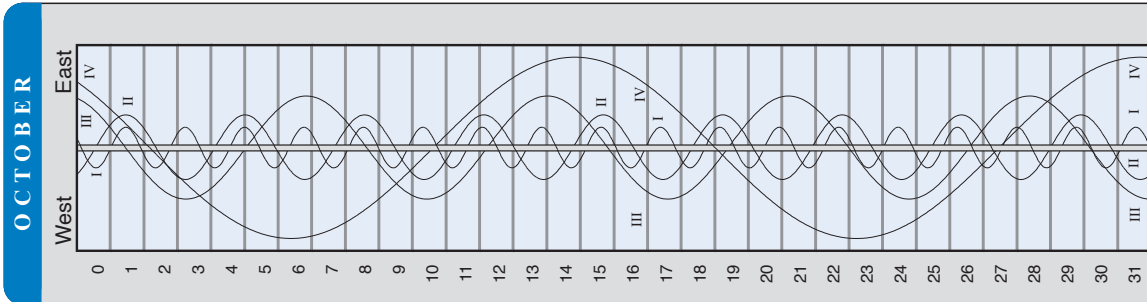
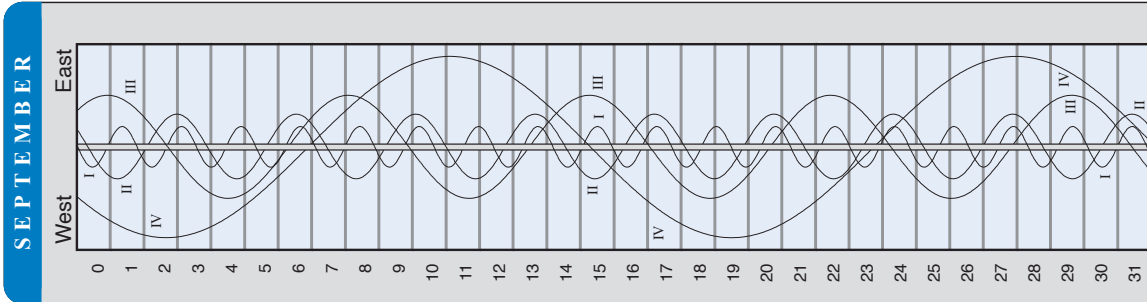
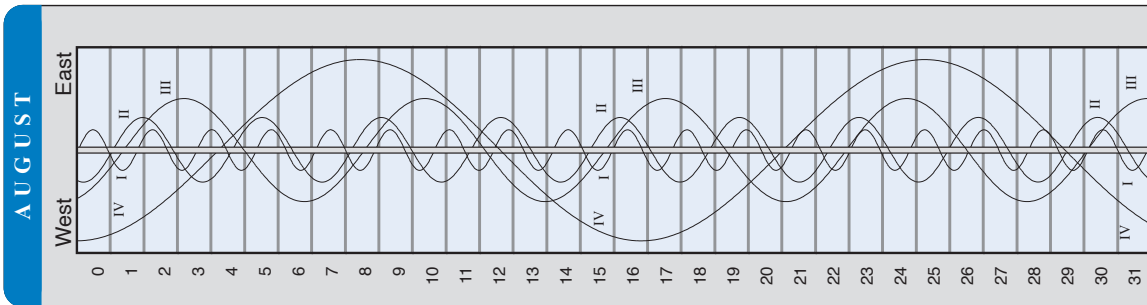
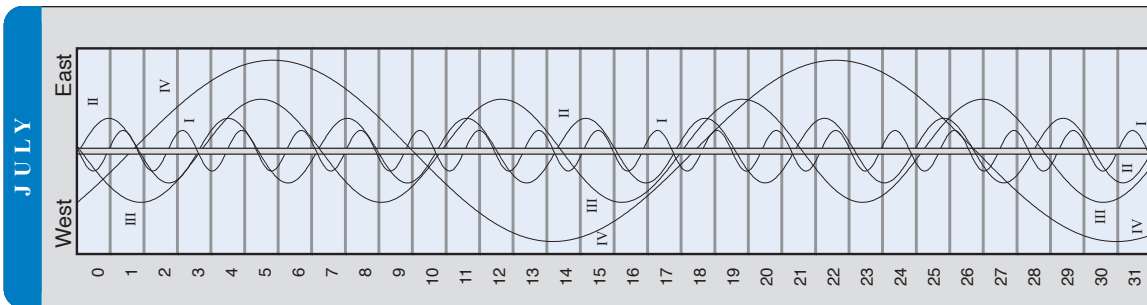
Jupiter is like a miniature solar system with many moons orbiting the planet. As seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing in front of or behind

the planet. The diagrams here show the patterns the four major moons of Jupiter make as they move from side-to-side. Each complete period represents one orbit of the satellite. Each horizontal grey date line

JUPITER'S MOONS

represents midnight; the top edge of the line is midnight EST (14hr UT), the bottom edge of the line is midnight WST (16hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each

moon passes over these lines, with the satellite's transit times (pp. 111-113). The same can be done with the occultation times, that is when the line disappears behind Jupiter. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.



JUPITER – LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	065.5	281.3	025.4	244.6	304.7	159.6	213.4	062.5	270.4	320.2	168.3	219.8	1
2	223.3	079.2	183.4	042.7	102.6	317.5	011.2	220.2	068.0	117.9	325.9	017.2	2
3	021.2	237.2	341.5	200.7	260.6	115.3	168.9	017.9	225.7	175.5	123.6	175.3	3
4	179.1	035.2	139.5	358.7	058.5	273.1	326.7	175.6	023.3	073.2	281.3	333.0	4
5	337.0	193.2	297.5	156.7	216.5	071.0	124.4	333.3	181.0	230.9	079.0	130.7	5
6	134.9	351.2	095.6	314.8	014.4	228.8	282.1	131.0	338.7	028.5	236.7	288.5	6
7	292.8	149.2	253.6	112.8	172.4	026.6	079.9	288.6	136.3	186.2	034.4	086.3	7
8	090.7	307.1	051.6	270.8	330.3	184.4	237.6	086.3	294.0	343.9	192.1	244.0	8
9	248.6	105.1	209.7	068.8	128.2	342.3	035.3	244.0	091.6	141.6	349.9	041.8	9
10	046.5	263.1	007.7	226.9	286.2	140.1	193.1	041.7	249.3	299.2	147.6	199.5	10
11	204.5	061.1	165.8	024.9	084.1	297.9	350.8	199.3	047.0	096.9	305.3	357.3	11
12	002.4	219.1	323.8	182.9	242.0	095.7	148.5	357.0	204.6	254.6	103.0	155.0	12
13	160.3	017.1	121.8	340.9	039.9	253.5	306.2	154.7	002.3	052.2	260.7	312.8	13
14	318.2	175.1	279.9	138.9	197.8	051.3	103.9	312.4	159.9	209.9	058.4	110.6	14
15	116.1	333.1	077.9	296.9	355.7	209.1	261.7	110.0	317.6	007.6	216.1	268.3	15
16	274.1	131.1	236.0	094.9	153.7	006.9	059.4	267.7	115.3	165.3	013.8	066.1	16
17	072.0	289.1	034.0	252.9	311.6	164.7	217.1	065.4	272.9	323.0	171.5	223.9	17
18	229.9	087.2	192.1	050.9	109.5	322.5	014.8	223.0	070.6	120.6	329.3	021.7	18
19	027.9	245.2	350.1	208.9	267.3	120.2	172.5	020.7	228.2	278.3	127.0	179.4	19
20	185.8	043.2	148.1	006.9	065.2	278.0	330.2	178.4	025.9	076.0	284.7	337.2	20
21	343.7	201.2	306.2	164.9	223.1	075.8	127.9	336.1	183.6	233.7	082.4	135.0	21
22	141.7	359.2	104.2	322.9	021.0	233.6	285.6	133.7	341.2	031.4	240.2	292.8	22
23	299.6	157.2	262.3	120.9	178.9	031.4	083.3	291.4	138.9	189.0	037.9	090.6	23
24	097.6	315.3	060.3	278.9	336.8	189.1	241.0	089.0	296.6	346.7	195.6	248.4	24
25	255.5	113.3	218.4	076.9	134.6	346.9	038.7	246.7	094.2	144.4	353.3	046.2	25
26	053.5	271.3	016.4	234.8	292.5	144.7	196.4	044.4	251.9	302.1	151.1	203.9	26
27	211.4	069.3	174.4	032.8	090.4	302.4	354.1	202.0	049.5	099.8	308.8	001.7	27
28	009.4	227.4	332.5	190.8	248.2	100.2	151.8	359.7	207.2	257.5	106.5	159.5	28
29	167.4		130.5	348.8	046.1	257.9	309.5	157.4	004.9	055.2	264.3	317.3	29
30	325.3		288.6	146.7	203.9	055.7	107.2	315.0	162.5	212.9	062.0	115.1	30
31	123.3		086.6		001.8		264.9	112.7		010.6		272.9	31

SYSTEM II (° at 0hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	145.7	125.0	015.4	358.1	189.3	167.7	352.6	325.2	296.5	117.5	089.0	271.6	1
2	296.0	275.3	165.8	148.5	339.6	317.9	142.7	115.3	086.6	267.5	239.1	061.7	2
3	086.2	065.6	316.2	298.9	129.9	108.1	292.9	265.4	236.6	057.6	029.1	211.8	3
4	236.5	216.0	106.6	089.3	280.2	258.3	083.0	055.4	026.6	207.6	179.2	002.0	4
5	026.7	006.3	257.0	239.7	070.6	048.5	233.1	205.5	176.7	357.6	329.3	152.1	5
6	177.0	156.7	047.4	030.1	220.9	198.7	023.2	355.5	326.7	147.7	119.4	302.2	6
7	327.3	307.1	197.9	180.5	011.2	348.9	173.3	145.6	116.7	297.7	269.4	092.3	7
8	117.6	097.4	348.3	330.9	161.5	139.1	323.4	295.6	266.8	087.8	059.5	242.4	8
9	267.8	247.8	138.7	121.3	311.8	289.3	113.5	085.7	056.8	237.8	209.6	032.6	9
10	058.1	038.1	289.1	271.7	102.1	079.5	263.6	235.7	206.8	027.9	359.7	182.7	10
11	208.4	188.5	079.5	062.1	252.4	229.7	053.7	025.7	356.8	177.9	149.7	332.8	11
12	358.7	338.9	229.9	212.5	042.7	019.9	203.8	175.8	146.9	327.9	299.8	123.0	12
13	149.0	129.2	020.3	002.8	193.0	170.0	353.9	325.8	296.9	118.0	089.9	273.1	13
14	299.3	279.6	170.7	153.2	343.3	320.2	144.0	115.9	086.9	268.0	240.0	062.2	14
15	089.5	070.0	321.1	303.6	133.5	110.4	294.0	265.9	237.0	058.1	030.1	213.4	15
16	239.8	220.4	111.6	094.0	283.8	260.5	084.1	056.0	027.0	208.1	180.1	003.5	16
17	030.1	010.7	262.0	244.4	074.1	050.7	234.2	206.0	177.0	358.2	330.2	153.7	17
18	180.4	161.1	052.4	034.7	224.4	200.9	024.3	356.0	327.1	148.2	120.3	303.8	18
19	330.8	311.5	202.8	185.1	014.6	351.0	174.4	146.1	117.1	298.3	270.4	093.9	19
20	121.1	101.9	353.2	335.5	164.9	141.2	324.5	296.1	267.1	088.3	060.5	244.1	20
21	271.4	252.3	143.6	125.8	315.1	291.3	114.5	086.2	057.2	238.4	210.6	034.2	21
22	061.7	042.7	294.0	276.2	105.4	081.5	264.6	236.2	207.2	028.4	000.7	184.4	22
23	212.0	193.1	084.4	066.5	255.6	231.6	054.7	026.2	357.2	178.5	150.8	334.6	23
24	002.3	343.4	234.9	216.9	045.9	021.7	204.7	176.3	147.3	328.5	300.9	124.7	24
25	152.6	133.8	025.3	007.2	196.1	171.9	354.8	326.3	297.3	118.6	091.0	274.9	25
26	303.0	284.2	175.7	157.6	346.4	322.0	144.9	116.3	087.3	268.6	241.1	065.0	26
27	093.3	074.6	326.1	307.9	136.6	112.1	294.9	266.4	237.4	058.7	031.2	215.2	27
28	243.6	225.0	116.5	098.3	286.8	262.3	085.0	056.4	027.4	208.8	181.3	005.4	28
29	033.9		266.9	248.6	077.1	052.4	235.1	206.4	177.4	358.8	331.4	155.5	29
30	184.3		057.3	038.9	227.3	202.5		356.5	327.5	148.9	121.5	305.7	30
31	334.6		207.7		017.5		175.2	146.5		298.9		095.9	31

Unlike Mars, Jupiter (and Saturn) are gas giants and we can only view their upper atmospheric features. Only a small telescope (even a 60mm instrument) is required to view the equatorial belts and the Great Red Spot. When seeing is good, numerous breaks can be glimpsed in the bands, as well as many minor spots. There is no single correct rotation period for the features of Jupiter. The speed of movement of any feature on the 'surface' depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs often measure the time a feature crosses the central meridian of the planet.

The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0hr 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 June 27 at 2:20am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on June 26. From the table, the longitude on June 26 is 144.7°. 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 382.2°; less 360° gives a final answer of 22.2°.

Finding the Great Red Spot (GRS)

At the time of publication the GRS was located at 93° longitude using System II (it slowly drifts over the years e.g., at the end of 1999 its longitude was 66°). For all features visible on Jupiter they are best observed from about one hour before crossing the central meridian to one hour after. Based on System II this results in plus or minus about 36° (see correction table below) or in the case of the GRS about 57° to 129°.

For example calculating the System II value for March 30 at 1:10am EST, gives a value of 456.8°. Subtracting 360° gives a final result of 96.8°. The GRS has just transited. The GRS in recent years has lost a lot of its red colouration and now looks more pale orange or tan and can be difficult to observe.

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

Increase In Longitude

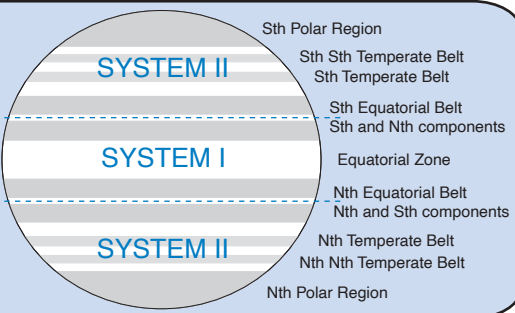
SYSTEM I

Rotation: 9h 50m 30.003s

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

SYSTEM I applies to all features situated on or between the North component of the South Equatorial Belt and the South component of the North Equatorial Belt.

SYSTEM II applies to the remainder of the surface.



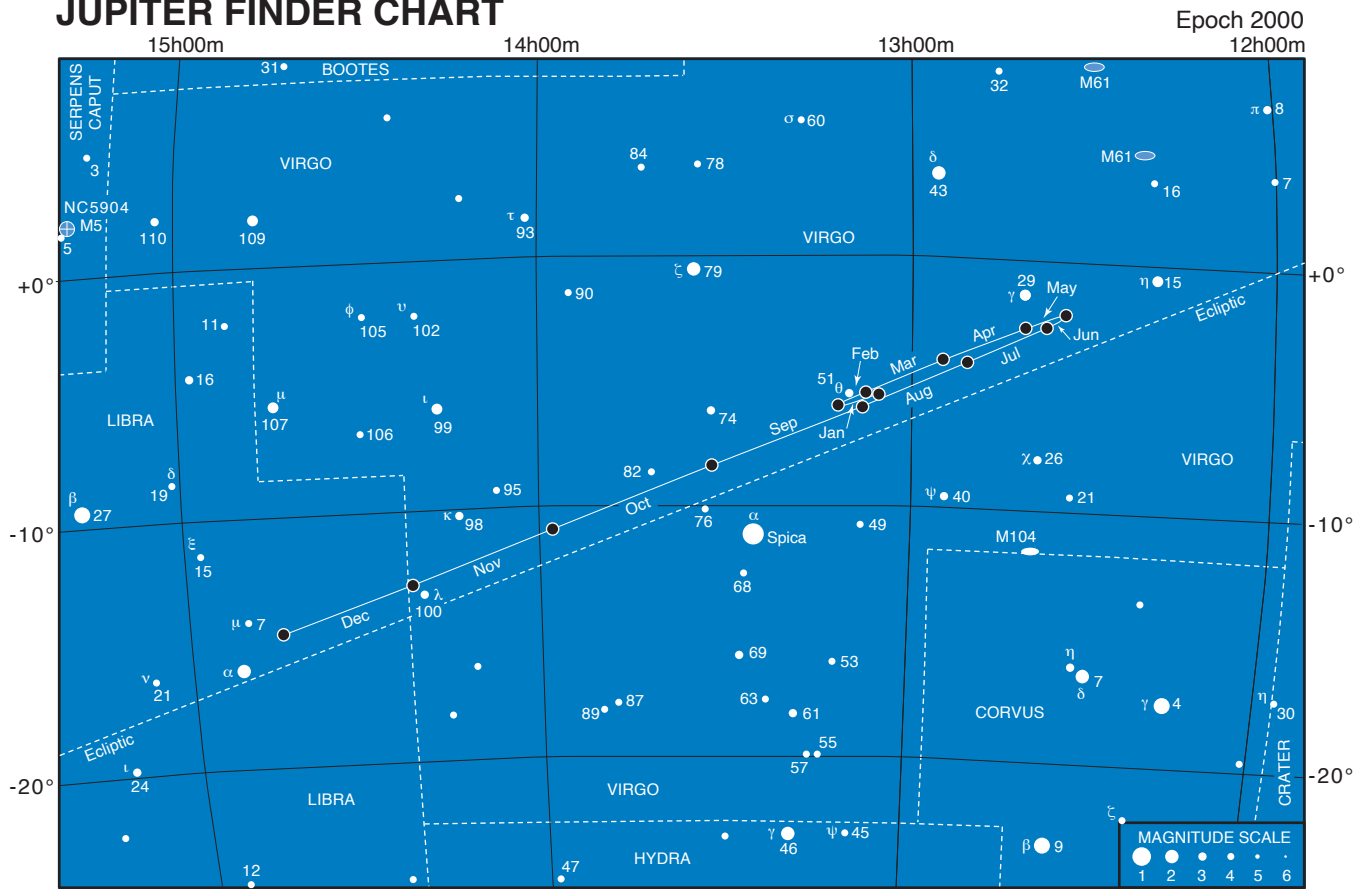
Increase In Longitude

SYSTEM II

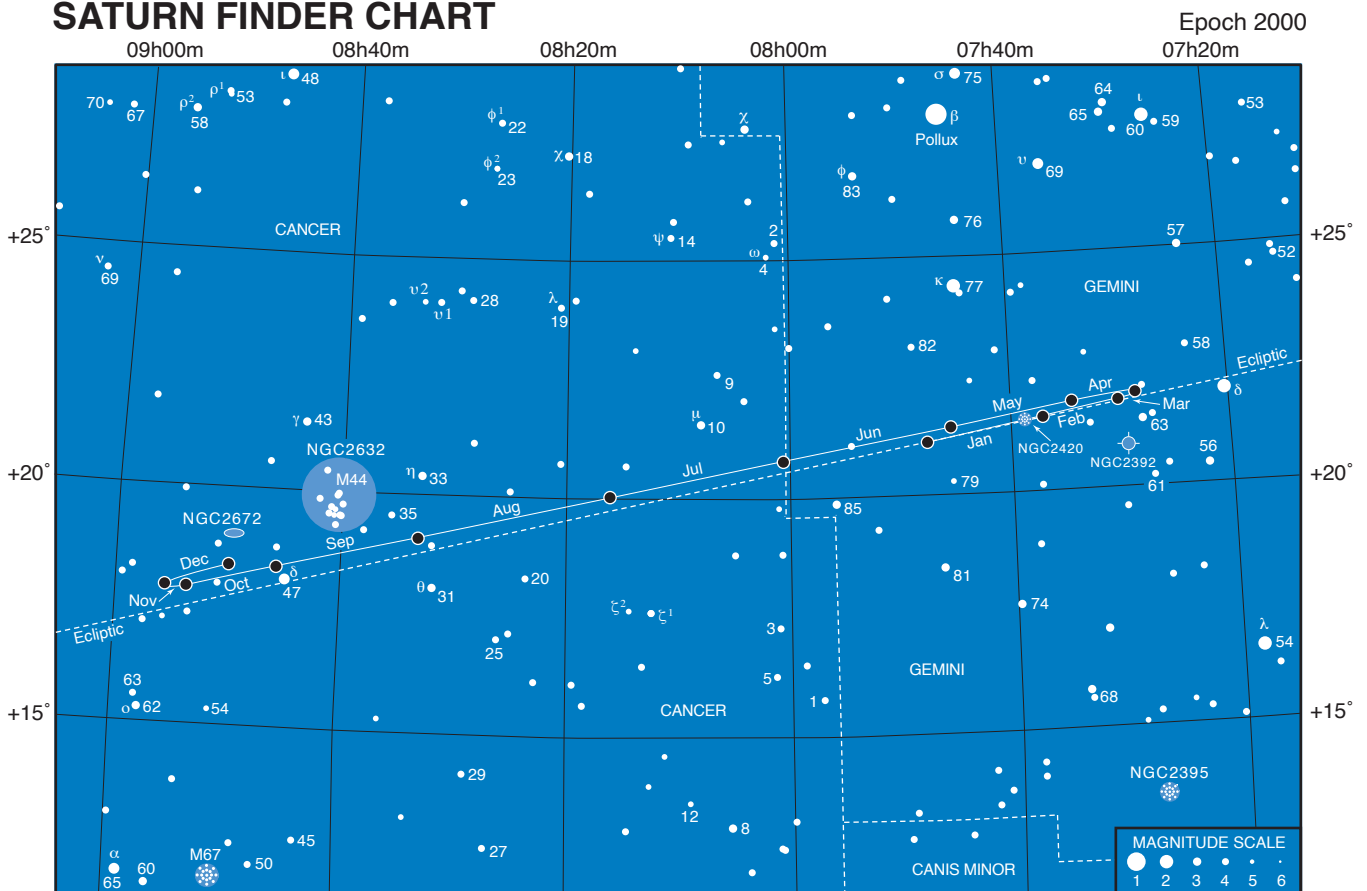
Rotation: 9h 55m 40.062s

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 FINDER CHART



SATURN FINDER CHART



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/fractions in UT. You will need to convert your local time to this format first. Table 3 will help.

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. This is best illustrated with an example. You wish to determine the position of Rhea for January 20 at 1am (EST).

1. Convert to UT as a fractional day.
Jan 20 at 1am EST is 15hr UT on the 19th = 19.625 UT.
2. Subtract the date of the greatest elongation east for Jan, i.e. $19.625 - 4.467 = 15.158$.
3. Express this as the number of orbits by dividing by the period i.e. $15.158 / 4.521 = 3.353$.
4. Discard the 3 completed orbits leaves 0.353 (i.e., it is a little over a third of the way around its orbit)
5. Multiply by the period, $0.353 \times 4.521 = 1.595$ days or 1 day 14.3 hr.
6. Looking at the orbital path for Rhea (see 'Apparent Orbit' diagram), the satellite is NW of Saturn – a little past (or west) of the 1d 12h mark.

Table 1: Saturn Satellites – Time of Greatest Elongation East (dd.ddd UT)

Moon	Mimas	Enceladus	Tethys	Dione	Rhea
Magnitude ¹	12.800	11.800	10.200	10.4	9.600
Max Elong. ¹	0' 30"	0' 38"	0' 48"	1' 01"	1' 25"
Period (days) ²	0.942	1.371	1.888	2.738	4.521
Month	Elongation (d.ddd)				
January	1.663	2.025	1.367	2.058	4.467
February	1.754	1.158	2.446	1.146	5.058
March	1.083	1.929	2.754	3.242	4.146
April	1.188	1.075	1.963	2.346	4.767
May	1.350	1.229	2.175	2.467	1.892
June	1.463	1.758	1.400	1.596	2.554
July	1.629	1.917	1.625	1.733	4.229
August	1.742	1.079	2.738	3.608	4.904
September	1.850	1.608	1.963	2.742	1.050
October	1.075	1.763	2.179	2.871	2.708
November	1.175	2.279	1.392	1.988	3.354
December	1.333	1.054	1.596	2.092	4.975

Notes 1. When at opposition

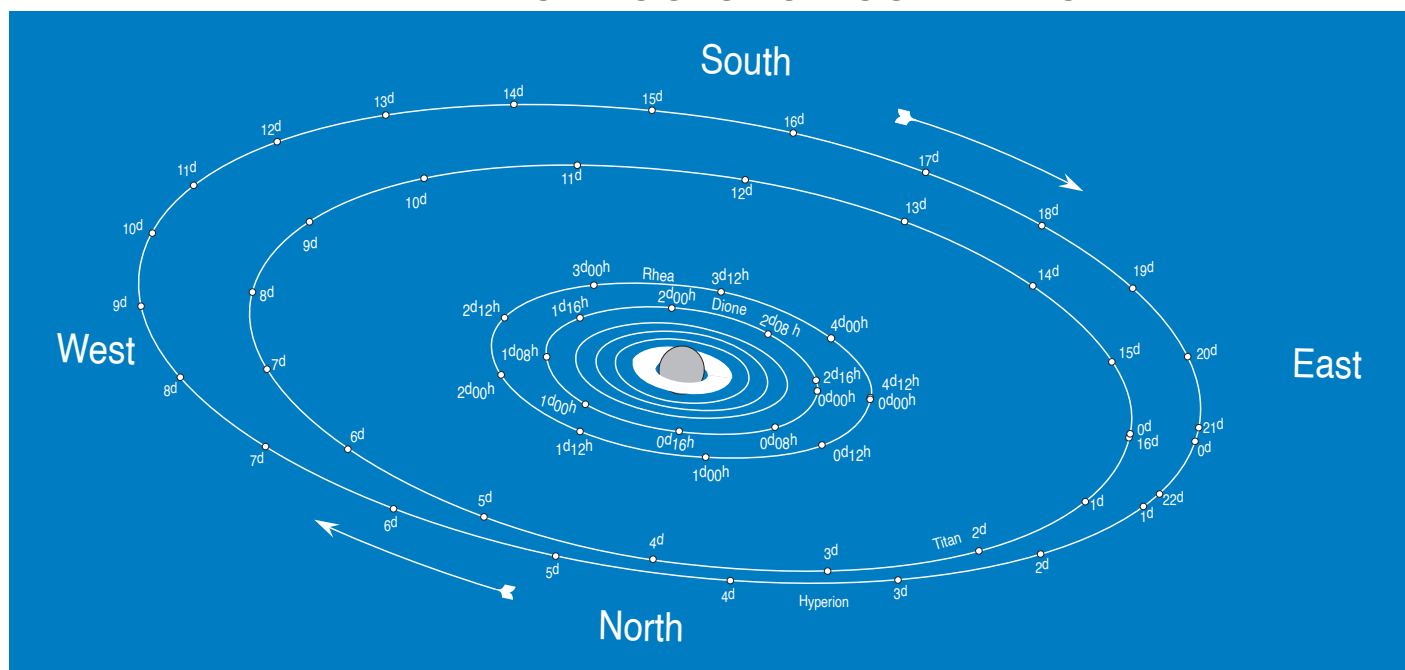
2. Mean Synodic Period

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 the orbits are represented on the diagram but 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, they still orbit clockwise, so a quarter of an orbit (0.25) would place a satellite north of Saturn.

An example. Estimate the position for Tethys for February 26 at 10pm EST (26.500 UT). 12.740 orbits have elapsed since its greatest elongation east on Feb 2.446 UT). Discarding the 12 orbits leaves 0.74. Tethys has completed almost three quarters of an orbit and should be close to due south of Saturn.

APPARENT ORBITS OF SATURN'S SATELLITES



Apparent orbits of the satellites on January 13. Only the inner satellites are shown. The orbits of Iapetus and Phoebe are too large to show on the above diagram.

Titan and Hyperion

Because of their long periods, compared to the moons listed above, 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. For example on January 15 at 10pm EST (15.500 UT), Hyperion is 2.533 days past a greatest elongation east which puts it northeast of Saturn.

EST	WST	Fraction of day (UT)
6pm	4pm	0.333
7pm	5pm	0.375
8pm	6pm	0.417
9pm	7pm	0.458
10pm	8pm	0.500
11pm	9pm	0.542
midnight	10pm	0.583
1am	11pm	0.625
2am	midnight	0.667
3am	1am	0.708
4am	2am	0.750
5am	3am	0.792
6am	4am	0.833
7am	5am	0.875
8am	6am	0.917

* After midnight it is still the previous day in UT, for example 1am (EST) on the 21st = 20.625 days UT

Moon	Titan	Hyperion
Magnitude ¹	8.4	14.4
Max. Elong. ¹	3' 17"	3' 59"
Period (days) ²	15.971	21.317
Elongation (d.ddd)		
January	11.433 27.317	12.967
February	12.204 28.108	3.108 24.254
March	16.033 31.983	17.446
April	16.954	7.788 29.158
May	2.946 18.958	20.571
June	3.983 20.017	11.096
July	6.058 22.100	2.621 24.142
August	7.142 23.179	14.708
September	8.213 24.229	5.254 26.733
October	10.238 26.225	18.213
November	11.196 27.142	8.654 29.971
December	13.071 28.979	21.263

Notes 1. When at opposition
2. Mean Synodic Period

Magnitude ¹		11.0					
Max Elong. ¹		9' 35"					
Period (days) ²		79.921					
Elongation East		Inferior Conjunction		Elongation West		Superior Conjunction	
		Jan	16.846	Feb	4.450	Feb	23.579
Mar	15.796	Apr	5.567	Apr	24.492	May	14.333
Jun	4.221	Jun	25.329	Jul	14.813	Aug	3.738
Aug	25.096	Sep	14.729	Oct	4.350	Oct	23.838
Nov	13.971	Dec	3.846	Dec	22.892		
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 and also orbits clockwise, however its orbit is over twice the diameter of Hyperion. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from similar brightness background stars. Table 4 shows all the moon's greatest elongations east, inferior conjunctions, greatest elongation west and superior conjunctions for the year. These roughly correspond to the east, north, west and south positions respectively. For example, on February 14 Iapetus will be approximately half way between a greatest elongation west and a superior conjunction, placing the satellite southwest of Saturn.

Date	Major "	Minor "	U °	B °
Jan 2	46.4	17.8	348.4	-22.6
Jan 10	46.5	18.0	347.8	-22.8
Jan 18	46.5	18.1	347.1	-23.0
Jan 26	46.4	18.2	346.4	-23.2
Feb 3	46.1	18.3	345.8	-23.4
Feb 11	45.8	18.3	345.2	-23.5
Feb 19	45.4	18.2	344.7	-23.7
Feb 27	44.9	18.1	344.3	-23.8
Mar 7	44.3	17.9	344.0	-23.9
Mar 15	43.7	17.7	343.9	-23.9
Mar 23	43.1	17.5	343.8	-24.0
Mar 31	42.5	17.2	343.9	-24.0
Apr 8	41.8	16.9	344.1	-23.9
Apr 16	41.2	16.6	344.4	-23.8
Apr 24	40.7	16.3	344.8	-23.7
May 2	40.1	16.0	345.4	-23.6
May 10	39.6	15.7	346.0	-23.5
May 18	39.1	15.4	346.7	-23.3
May 26	38.7	15.1	347.5	-23.1
Jun 3	38.3	14.8	348.4	-22.8
Jun 11	38.0	14.6	349.3	-22.6
Jun 19	37.7	14.3	350.3	-22.3
Jun 27	37.5	14.0	351.3	-22.0
Jul 5	37.3	13.8	352.3	-21.7
Jul 13	37.2	13.6	353.3	-21.4
Jul 21	37.2	13.3	354.4	-21.1
Jul 29	37.2	13.1	355.4	-20.7
Aug 6	37.3	13.0	356.4	-20.4
Aug 14	37.4	12.8	357.5	-20.1
Aug 22	37.6	12.7	358.4	-19.7
Aug 30	37.8	12.5	359.4	-19.4
Sep 7	38.1	12.4	0.3	-19.1
Sep 15	38.4	12.3	1.2	-18.8
Sep 23	38.8	12.3	1.9	-18.5
Oct 1	39.2	12.3	2.7	-18.2
Oct 9	39.7	12.3	3.3	-18.0
Oct 17	40.3	12.3	3.9	-17.8
Oct 25	40.8	12.4	4.3	-17.7
Nov 2	41.4	12.5	4.7	-17.5
Nov 10	42.0	12.6	4.9	-17.5
Nov 18	42.7	12.8	5.0	-17.4
Nov 26	43.3	13.0	5.0	-17.5
Dec 4	43.9	13.2	4.9	-17.5
Dec 12	44.4	13.4	4.7	-17.6
Dec 20	44.9	13.7	4.4	-17.8
Dec 28	45.4	14.0	4.0	-18.0

The 'Appearance of the Planets' diagrams in Part I show how open the rings are for 2005. 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 7 years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were edge-on during 1995 and will be again in 2009. During 2005 they are still fairly open at around 20°.

Major and minor axes (in arc seconds) are for the outer edge of the outer ring. To work out the size of the other rings, multiply by the following factors.

Inner edge of outer ring	0.8932
Outer edge of inner ring	0.8596
Inner edge of inner ring	0.6726
Inner edge of dusky ring	0.5477

'U' and 'B' are the geocentric longitude and the tilt of the rings respectively.

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hr 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	Set	
Jan	1	20:18	06:21	19:34	06:10	20:06	06:08	20:06	07:35	20:34	05:56	20:29	06:19	20:12	06:29	19:55	06:03	07 47 09		+ 21 08 34		
	8	19:48	05:51	19:05	05:39	19:37	05:38	19:36	07:05	20:05	05:26	20:00	05:48	19:42	05:58	19:25	05:33	07 44 47		+ 21 15 18		
	15	19:19	05:21	18:35	05:09	19:07	05:08	19:07	06:35	19:35	04:55	19:30	05:18	19:13	05:28	18:56	05:03	07 42 22		+ 21 22 03		
	22	18:49	04:50	18:05	04:39	18:38	04:38	18:37	06:05	19:06	04:25	19:01	04:48	18:43	04:58	18:26	04:32	07 39 57		+ 21 28 38		
	29	18:20	04:20	17:36	04:09	18:08	04:07	18:07	05:35	18:37	03:54	18:31	04:17	18:13	04:28	17:57	04:02	07 37 36		+ 21 34 54		
Feb	5	17:50	03:50	17:06	03:39	17:39	03:37	17:37	05:05	18:07	03:24	18:02	03:47	17:44	03:58	17:27	03:32	07 35 24		+ 21 40 42		
	12	17:21	03:20	16:37	03:09	17:10	03:07	17:08	04:35	17:38	02:54	17:33	03:17	17:15	03:28	16:58	03:02	07 33 24		+ 21 45 56		
	19	16:52	02:51	16:08	02:40	16:41	02:38	16:39	04:06	17:09	02:25	17:04	02:48	16:46	02:58	16:29	02:33	07 31 40		+ 21 50 29		
	26	16:23	02:22	15:39	02:11	16:12	02:09	16:10	03:37	16:41	01:56	16:35	02:19	16:17	02:29	16:00	02:04	07 30 14		+ 21 54 18		
Mar	5	15:55	01:53	15:11	01:42	15:44	01:40	15:41	03:08	16:12	01:27	16:07	01:50	15:49	02:00	15:32	01:35	07 29 08		+ 21 57 19		
	12	15:27	01:24	14:43	01:13	15:16	01:12	15:13	02:40	15:44	00:58	15:39	01:21	15:20	01:32	15:04	01:06	07 28 24		+ 21 59 33		
	19	14:59	00:56	14:15	00:46	14:48	00:44	14:45	02:12	15:16	00:30	15:11	00:53	14:53	01:04	14:36	00:38	07 28 02		+ 22 00 56		
	26	14:31	00:29	13:47	00:18	14:20	00:16	14:18	01:44	14:49	23:59	14:43	00:26	14:25	00:37	14:09	00:11	07 28 04		+ 22 01 29		
Apr	2	14:04	23:58	13:20	23:47	13:53	23:45	13:51	01:17	14:22	23:32	14:16	23:55	13:58	00:09	13:41	23:40	07 28 29		+ 22 01 13		
	9	13:38	23:31	12:53	23:20	13:26	23:18	13:24	00:51	13:55	23:05	13:49	23:28	13:31	23:39	13:15	23:13	07 29 16		+ 22 00 07		
	16	13:11	23:05	12:27	22:54	13:00	22:52	12:58	00:24	13:28	22:39	13:23	23:02	13:05	23:13	12:48	22:47	07 30 26		+ 21 58 12		
	23	12:45	22:39	12:01	22:28	12:34	22:26	12:32	23:54	13:02	22:13	12:57	22:36	12:39	22:47	12:22	22:21	07 31 57		+ 21 55 29		
	30	12:19	22:14	11:35	22:03	12:08	22:01	12:06	23:29	12:36	21:48	12:31	22:11	12:13	22:21	11:56	21:56	07 33 47		+ 21 51 58		
May	7	11:53	21:49	11:09	21:37	11:42	21:36	11:40	23:04	12:11	21:23	12:05	21:46	11:47	21:56	11:31	21:31	07 35 55		+ 21 47 40		
	14	11:28	21:24	10:44	21:13	11:17	21:11	11:15	22:39	11:45	20:58	11:40	21:21	11:22	21:31	11:05	21:06	07 38 21		+ 21 42 36		
	21	11:03	20:59	10:19	20:48	10:52	20:46	10:50	22:14	11:20	20:34	11:15	20:56	10:57	21:07	10:40	20:41	07 41 01		+ 21 36 46		
	28	10:38	20:35	09:54	20:24	10:27	20:22	10:25	21:49	10:55	20:09	10:50	20:32	10:32	20:43	10:15	20:17	07 43 56		+ 21 30 13		
Jun	4	10:13	20:11	09:29	19:59	10:02	19:58	10:01	21:25	10:30	19:46	10:25	20:08	10:07	20:19	09:50	19:53	07 47 02		+ 21 22 58		
	11	09:48	19:47	09:05	19:36	09:37	19:34	09:37	21:01	10:05	19:22	10:00	19:44	09:42	19:55	09:25	19:29	07 50 19		+ 21 15 02		
	18	09:24	19:24	08:40	19:12	09:12	19:11	09:12	20:37	09:40	18:58	09:35	19:21	09:18	19:31	09:01	19:05	07 53 44		+ 21 06 27		
	25	08:59	19:00	08:16	18:48	08:48	18:47	08:48	20:13	09:15	18:35	09:11	18:57	08:53	19:07	08:36	18:42	07 57 17		+ 20 57 16		
Jul	2	08:35	18:37	07:52	18:25	08:24	18:24	08:24	19:49	08:51	18:12	08:46	18:34	08:29	18:44	08:12	18:18	08 00 56		+ 20 47 33		
	9	08:10	18:13	07:27	18:01	07:59	18:01	08:00	19:26	08:26	17:49	08:22	18:11	08:05	18:21	07:48	17:55	08 04 38		+ 20 37 19		
	16	07:46	17:50	07:03	17:38	07:35	17:37	07:36	19:02	08:02	17:26	07:57	17:48	07:40	17:57	07:23	17:32	08 08 24		+ 20 26 39		
	23	07:22	17:27	06:39	17:15	07:10	17:14	07:12	18:39	07:37	17:03	07:33	17:25	07:16	17:34	06:59	17:09	08 12 10		+ 20 15 37		
	30	06:57	17:04	06:15	16:51	06:46	16:51	06:48	18:15	07:12	16:40	07:08	17:02	06:52	17:11	06:35	16:46	08 15 56		+ 20 04 19		
Aug	6	06:33	16:41	05:51	16:28	06:22	16:28	06:24	17:51	06:48	16:17	06:44	16:39	06:27	16:48	06:10	16:22	08 19 40		+ 19 52 47		
	13	06:08	16:17	05:26	16:04	05:57	16:05	06:00	17:28	06:23	15:54	06:19	16:15	06:03	16:24	05:46	15:59	08 23 21		+ 19 41 10		
	20	05:44	15:54	05:02	15:41	05:33	15:41	05:36	17:04	05:58	15:31	05:55	15:52	05:39	16:01	05:21	15:36	08 26 57		+ 19 29 33		
	27	05:19	15:31	04:37	15:17	05:08	15:18	05:12	16:40	05:33	15:08	05:30	15:29	05:14	15:37	04:57	15:12	08 30 27		+ 19 18 02		
Sep	3	04:54	15:07	04:13	14:54	04:43	14:54	04:47	16:16	05:08	14:44	05:05	15:05	04:49	15:14	04:32	14:49	08 33 48		+ 19 06 45		
	10	04:29	14:43	03:48	14:30	04:18	14:31	04:23	15:52	04:43	14:21	04:40	14:42	04:24	14:50	04:07	14:25	08 37 01		+ 18 55 48		
	17	04:04	14:19	03:23	14:06	03:53	14:07	03:58	15:28	04:18	13:57	04:15	14:18	03:59	14:26	03:42	14:01	08 40 03		+ 18 45 21		
	24	03:39	13:55	02:58	13:41	03:28	13:42	03:33	15:03	03:53	13:33	03:50	13:54	03:34	14:02	03:17	13:37	08 42 52		+ 18 35 31		
Oct	1	03:14	13:31	02:33	13:17	03:02	13:18	03:08	14:38	03:27	13:09	03:24	13:29	03:09	13:37	02:51	13:12	08 45 28		+ 18 26 25		
	8	02:48	13:06	02:07	12:52	02:37	12:53	02:43	14:13	03:01	12:44	02:59	13:04	02:43	13:12	02:26	12:47	08 47 48		+ 18 18 13		
	15	02:22	12:41	01:42	12:27	02:11	12:28	02:17	13:48	02:35	12:19	02:33	12:39	02:18	12:47	02:00	12:22	08 49 52		+ 18 11 03		
	22	01:56	12:15	01:16	12:01	01:45	12:03	01:52	13:22	02:09	11:54	02:07	12:14	01:51	12:22	01:34	11:57	08 51 38		+ 18 05 01		
	29	01:30	11:50	00:49	11:35	01:19	11:37	01:25	12:56	01:43	11:28	01:40	11:48	01:25	11:56	01:08	11:31	08 53 04		+ 18 00 15		
Nov	5	01:03	11:23	00:23	11:09	00:52	11:11	00:59	12:30	01:16	11:02	01:14	11:22	00:59	11:30	00:41	11:05	08 54 10		+ 17 56 51		
	12	00:36	10:57	23:52	10:42	00:25	10:44	00:32	12:03	00:49	10:35	00:47	10:55	00:32	11:03	00:14	10:38	08 54 55		+ 17 54 54		
	19	00:09	10:30	23:25	10:15	23:54	10:17	00:05	11:36	00:22	10:08	00:20	10:28	00:05	10:36	23:43	10:11	08 55 18		+ 17 54 28		
	26	23:38	10:02	22:57	09:48	23:27	09:49	23:34	11:08	23:51	09:41	23:48	10:01	23:33	10:08	23:16	09:43	08 55 18		+ 17 55 33		
Dec	3	23:10	09:34	22:30	09:20	22:59	09:21	23:06	10:40	23:23	09:12	23:21	09:33	23:05	09:40	22:48	09:15	08 54 57		+ 17 58 10		
	10	22:42	09:06	22:01	08:51	22:31	08:53	22														

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hr 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		Set
Jan	1	09:24	22:28	09:04	21:53	09:11	22:17	10:16	22:38	09:09	22:34	09:25	22:36	09:28	22:26	09:04	22:07	22	24	05	-	10 47 25
	8	08:58	22:01	08:38	21:26	08:45	21:50	09:50	22:11	08:43	22:07	08:58	22:09	09:02	21:59	08:38	21:40	22	25	11	-	10 40 53
	15	08:32	21:35	08:12	21:00	08:19	21:23	09:23	21:45	08:17	21:41	08:33	21:43	08:36	21:32	08:12	21:13	22	26	24	-	10 33 45
	22	08:06	21:08	07:46	20:33	07:53	20:57	08:57	21:19	07:51	21:14	08:07	21:16	08:10	21:06	07:46	20:47	22	27	41	-	10 26 06
Feb	29	07:40	20:42	07:20	20:07	07:27	20:30	08:31	20:52	07:26	20:47	07:41	20:50	07:44	20:39	07:21	20:20	22	29	03	-	10 18 02
	5	07:14	20:15	06:54	19:40	07:02	20:04	08:05	20:26	07:00	20:21	07:15	20:23	07:18	20:13	06:55	19:54	22	30	29	-	10 09 36
	12	06:49	19:49	06:28	19:14	06:36	19:37	07:39	20:00	06:35	19:54	06:50	19:56	06:52	19:46	06:29	19:27	22	31	57	-	10 00 54
	19	06:23	19:22	06:03	18:47	06:11	19:11	07:14	19:34	06:09	19:27	06:24	19:30	06:27	19:20	06:04	19:01	22	33	28	-	09 52 03
Mar	26	05:57	18:56	05:37	18:21	05:45	18:44	06:48	19:08	05:44	19:01	05:59	19:03	06:01	18:54	05:38	18:34	22	34	58	-	09 43 07
	5	05:32	18:29	05:11	17:55	05:19	18:18	06:22	18:41	05:18	18:34	05:33	18:37	05:36	18:27	05:12	18:08	22	36	29	-	09 34 12
	12	05:06	18:03	04:46	17:28	04:54	17:51	05:56	18:15	04:53	18:08	05:08	18:10	05:10	18:01	04:47	17:41	22	37	59	-	09 25 23
	19	04:41	17:36	04:20	17:02	04:28	17:25	05:30	17:49	04:27	17:41	04:42	17:44	04:44	17:34	04:21	17:15	22	39	27	-	09 16 45
Apr	26	04:15	17:10	03:54	16:36	04:02	16:58	05:04	17:23	04:02	17:14	04:16	17:17	04:18	17:08	03:55	16:48	22	40	52	-	09 08 26
	2	03:49	16:43	03:28	16:09	03:37	16:32	04:38	16:56	03:36	16:48	03:51	16:51	03:53	16:41	03:30	16:22	22	42	13	-	09 00 28
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	16	02:57	15:50	02:36	15:16	02:45	15:38	03:46	16:04	02:44	15:54	02:59	15:57	03:01	15:48	02:38	15:29	22	44	41	-	08 45 59
May	23	02:31	15:23	02:10	14:49	02:19	15:12	03:19	15:37	02:18	15:27	02:33	15:31	02:34	15:21	02:12	15:02	22	45	46	-	08 39 37
	30	02:05	14:56	01:44	14:23	01:52	14:45	02:53	15:11	01:52	15:00	02:06	15:04	02:08	14:55	01:45	14:35	22	46	45	-	08 33 56
	7	01:38	14:30	01:17	13:56	01:26	14:18	02:26	14:44	01:26	14:33	01:40	14:37	01:42	14:28	01:19	14:08	22	47	37	-	08 28 58
	14	01:12	14:03	00:50	13:29	00:59	13:51	01:59	14:17	00:59	14:06	01:13	14:10	01:15	14:01	00:52	13:41	22	48	21	-	08 24 48
Jun	21	00:45	13:35	00:24	13:02	00:33	13:24	01:33	13:50	00:33	13:39	00:47	13:43	00:48	13:34	00:25	13:14	22	48	57	-	08 21 27
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Aug	16	21:00	09:55	20:39	09:21	20:48	09:43	21:48	10:09	20:48	09:59	21:02	10:02	21:04	09:53	20:41	09:34	22	48	31	-	08 26 18
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Oct	10	17:11	06:10	16:50	05:36	16:58	05:58	18:00	06:23	16:57	06:14	17:12	06:17	17:14	06:08	16:51	05:48	22	41	10	-	09 11 25
	17	16:42	05:42	16:21	05:07	16:29	05:30	17:31	05:54	16:28	05:46	16:43	05:49	16:45	05:39	16:22	05:20	22	40	09	-	09 17 26
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Nov	8	15:16	04:17	14:55	03:43	15:03	04:05	16:06	04:29	15:02	04:22	15:17	04:25	15:19	04:15	14:56	03:56	22	37	27	-	09 33 02
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Dec	5	13:23	02:25	13:03	01:51	13:11	02:14	14:13	02:37	13:09	02:30	13:24	02:33	13:27	02:23	13:04	02:04	22	35	22	-	09 44 29
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	19	12:28	01:30	12:08	00:55	12:15	01:19	13:18	01:42	12:14	01:35	12:29	01:38	12:32	01:28	12:08	01:09	22	35	10	-	09 45 01
	26	12:01	01:03	11:40	00:28	11:48	00:51	12:51	01:14	11:47	01:08	12:02	01:10	12:04	01:00	11:41	00:41	22	35	19	-	09 43 54
Dec	3	11:33	00:35	11:13	23:57	11:21	00:24	12:24	00:47	11:20	00:40	11:35	00:43	11:37	00:33	11:14	00:14	22	35	36	-	09 41 51
	10	11:06	00:08	10:46	23:30	10:54	23:53	11:57	00:20	10:53	00:13	11:08	00:16	11:10	00:06	10:47	23:43	22	36	04	-	09 38 53
	17	10:40	23:37	10:19	23:03	10:27	23:26	11:30	23:49	10:26	23:42	10:41	23:45	10:43	23:35	10:20	23:16	22	36	40	-	09 35 02
	24	10:13	23:10	09:53	22:36	10:01	22:59	11:03	23:22	10:00	23:15	10:14	23:18	10:17	23:08	09:54	22:49	22	37	25	-	09 30 20
	31	09:47	22:43	09:26	22:09	09:34	22:32	10:36	22:56	09:33	22:48	09:48	22:51	09:50	22:41	09:27	22:22	22	38	17	-	09 24 52

SATELLITES OF URANUS AND NEPTUNE

This page is designed to help you find the position of Uranus' major satellites and Neptune's moon, Triton.

NB. All dates/times are given in day/fractions 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. Like 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 Sep. 17 at 11pm EST.

1. Convert to UT as a fractional day. September 17 at 11pm (EST) = 17.542 UT
2. Subtract the date of the greatest elongation north for September, i.e. $17.542 - 1.921 = 15.621$
3. Express this as the number of orbits by dividing by the period, i.e. $15.621 / 4.1442 = 3.769$
4. Discard the 3 completed orbits leaves 0.769 (i.e., it is a little over three quarters of the way around its orbit)
5. Multiply by the period, $0.769 \times 4.1442 = 3.188$ days
6. Looking at the orbital path for Umbriel (see 'Apparent Orbit' diagram), the satellite is approximately due west of Uranus and making a close approach of around 2". This is not the best time to try and observe this 14.5 magnitude object when it is so close to 6th magnitude Uranus! The next evening (18th) at the same time is much more favourable. If you do the calculation, or just look at the diagram by adding one day, the moon will be very close to a greatest elongation north.

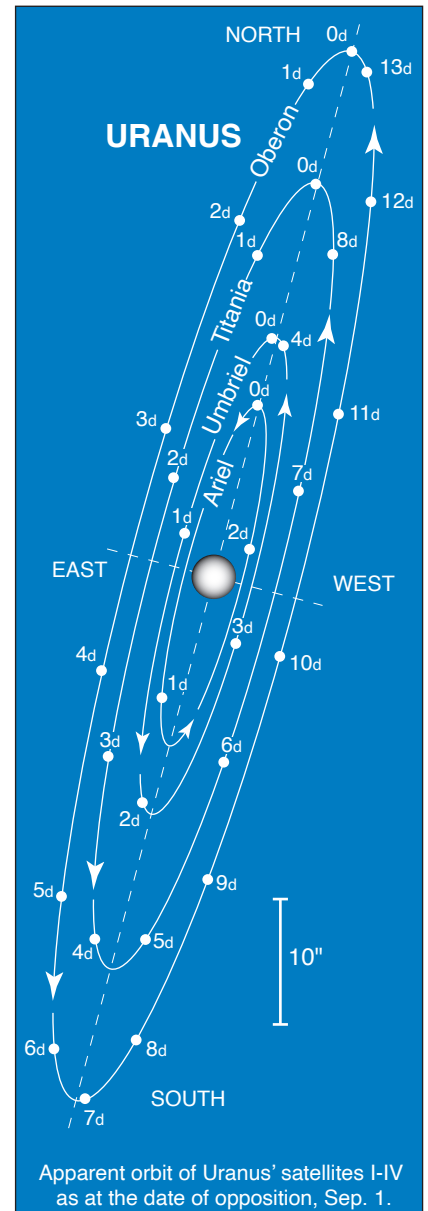
EST	WST	Fraction of day (UT)
6pm	4pm	0.333
7pm	5pm	0.375
8pm	6pm	0.417
9pm	7pm	0.458
10pm	8pm	0.500
11pm	9pm	0.542
midnight	10pm	0.583
1am	11pm	0.625
2am	midnight	0.667
3am	1am	0.708
4am	2am	0.750
5am	3am	0.792
6am	4am	0.833
7am	5am	0.875
8am	6am	0.917

* After midnight it is still the previous day in UT, for example 1am (EST) on the 21st = 20.625 days UT

making a close approach of around 2". This is not the best time to try and observe this 14.5 magnitude object when it is so close to 6th magnitude Uranus! The next evening (18th) at the same time is much more favourable. If you do the calculation, or just look at the diagram by adding one day, the moon will be very close to a greatest elongation north.

Neptune. The procedure for finding Triton is identical to above with the times of the first greatest elongation east for each month also being listed in Table 2. The orientation of Triton's orbit places this day 0 (zero) point closer to northeast of Neptune (see diagram)

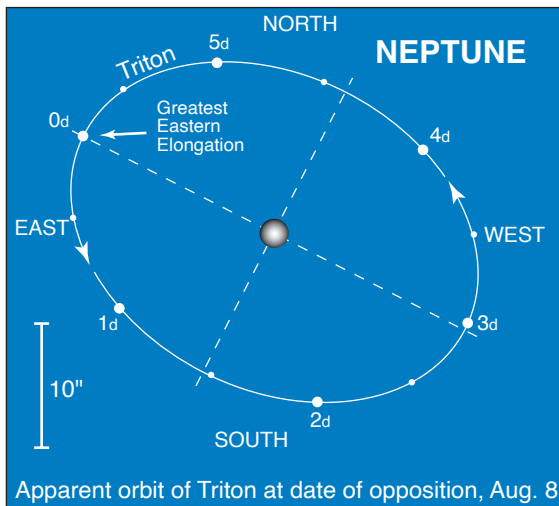
An example. Estimate the position for Triton for July 18 at 10pm EST (18.500 UT). 2.295 orbits have elapsed since its greatest elongation east on July 5.013 UT. Discarding the 2 orbits leaves 0.295. Multiplying by 5.8768 (its period) gives 1.73 days. From the diagram the moon is due south of Neptune.



Apparent orbit of Uranus' satellites I-IV as at the date of opposition, Sep. 1.

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	2.5204	4.1442	8.7059	13.4633	5.8768
Month	Elongation North (d.ddd)				East (d.ddd)
January	1.158	4.575	7.113	9.550	3.913
February	2.921	2.583	2.225	5.471	2.271
March	2.646	3.592	9.042	4.392	3.629
April	1.888	1.596	4.154	13.771	1.992
May	2.129	4.746	8.975	10.692	1.363
June	1.371	2.750	4.088	6.613	5.621
July	1.613	1.758	8.908	3.538	5.013
August	3.375	3.908	4.025	12.929	3.413
September	2.621	1.921	7.854	8.863	1.817
October	2.867	5.075	3.975	5.792	1.217
November	2.113	3.088	7.800	1.721	5.483
December	2.363	2.100	3.921	12.113	4.863

Notes 1. When at opposition
2. Mean Synodic Period



Apparent orbit of Triton at date of opposition, Aug. 8

NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

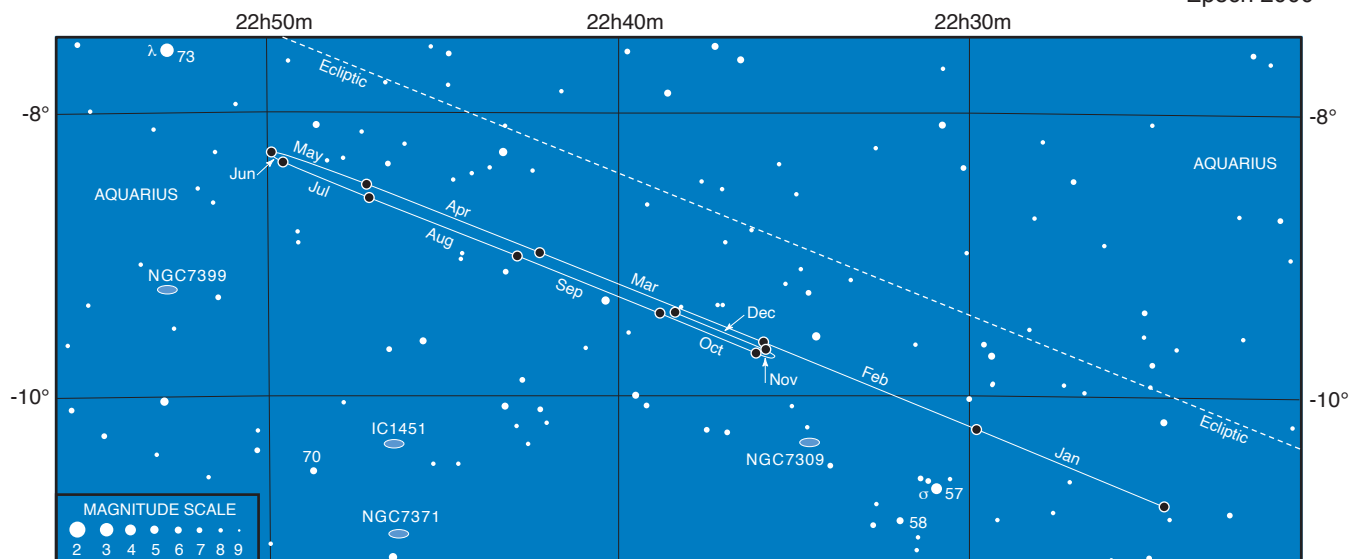
POSITION

0hr 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	Set	
Jan	1	07:47	21:28	07:32	20:47	07:34	21:16	08:52	21:25	07:26	21:40	07:46	21:38	07:53	21:23	07:28	21:05	21	05	07	- 16 46 34	
	8	07:20	21:01	07:06	20:21	07:08	20:49	08:25	20:58	07:00	21:13	07:19	21:11	07:26	20:56	07:02	20:38	21	06	04	- 16 42 32	
	15	06:54	20:34	06:39	19:54	06:41	20:23	07:59	20:31	06:33	20:46	06:53	20:44	07:00	20:30	06:35	20:12	21	07	04	- 16 38 16	
	22	06:28	20:07	06:13	19:27	06:15	19:56	07:32	20:05	06:07	20:19	06:27	20:17	06:34	20:03	06:09	19:45	21	08	05	- 16 33 51	
	29	06:02	19:41	05:47	19:01	05:49	19:29	07:06	19:38	05:41	19:52	06:00	19:51	06:08	19:36	05:43	19:18	21	09	08	- 16 29 19	
Feb	5	05:35	19:14	05:20	18:34	05:23	19:02	06:39	19:12	05:15	19:26	05:34	19:24	05:41	19:09	05:17	18:52	21	10	12	- 16 24 43	
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	19	04:43	18:20	04:28	17:41	04:30	18:09	05:47	18:19	04:22	18:32	04:42	18:30	04:49	18:16	04:24	17:58	21	12	18	- 16 15 33	
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May	7	23:46	13:23	23:30	12:44	23:33	13:12	00:52	13:23	23:26	13:35	23:45	13:33	23:51	13:19	23:27	13:01	21	19	52	- 15 42 17	
	14	23:18	12:56	23:02	12:17	23:06	12:45	00:25	12:56	22:58	13:07	23:17	13:06	23:24	12:52	22:59	12:34	21	20	01	- 15 41 44	
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	28	22:23	12:01	22:07	11:22	22:10	11:50	23:26	12:00	22:03	12:12	22:22	12:11	22:29	11:57	22:04	11:39	21	19	59	- 15 42 06	
Jun	4	21:55	11:33	21:40	10:54	21:43	11:22	22:58	11:33	21:36	11:44	21:55	11:43	22:01	11:29	21:37	11:11	21	19	49	- 15 43 00	
	11	21:28	11:06	21:12	10:26	21:15	10:54	22:30	11:05	21:08	11:17	21:27	11:15	21:33	11:01	21:09	10:43	21	19	33	- 15 44 21	
	18	21:00	10:38	20:44	09:59	20:47	10:26	22:02	10:37	20:40	10:49	20:59	10:48	21:05	10:34	20:41	10:16	21	19	11	- 15 46 08	
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	30	18:10	07:50	17:54	07:10	17:57	07:39	19:13	07:49	17:50	08:01	18:09	08:00	18:16	07:46	17:51	07:28	21	15	32	- 16 03 24	
Aug	6	17:41	07:22	17:26	06:42	17:29	07:11	18:45	07:21	17:21	07:33	17:40	07:32	17:47	07:18	17:23	07:00	21	14	47	- 16 06 53	
	13	17:13	06:54	16:58	06:14	17:00	06:42	18:16	06:52	16:53	07:05	17:12	07:04	17:19	06:49	16:54	06:32	21	14	01	- 16 10 22	
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Sep	3	15:48	05:30	15:33	04:50	15:35	05:18	16:52	05:28	15:27	05:41	15:47	05:40	15:54	05:25	15:29	05:07	21	11	51	- 16 20 17	
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	22	12:32	02:15	12:17	01:35	12:19	02:03	13:36	02:12	12:11	02:27	12:30	02:25	12:38	02:10	12:13	01:53	21	09	01	- 16 33 14	
	29	12:04	01:47	11:49	01:07	11:51	01:36	13:08	01:45	11:43	01:59	12:03	01:57	12:10	01:43	11:45	01:25	21	09	00	- 16 33 22	
Nov	5	11:37	01:20	11:22	00:40	11:24	01:08	12:41	01:17	11:16	01:32	11:35	01:30	11:43	01:15	11:18	00:58	21	09	05	- 16 33 01	
	12	11:09	00:52	10:54	00:12	10:57	00:41	12:14	00:50	10:49	01:04	11:08	01:03	11:15	00:48	10:51	00:30	21	09	17	- 16 32 10	
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	31	08:02	21:39	07:47	20:59	07:49	21:28	09:05	21:37	07:41	21:51	08:01	21:49	08:08	21:35	07:43	21:17	21	13	30	- 16 13 46	

URANUS FINDER CHART

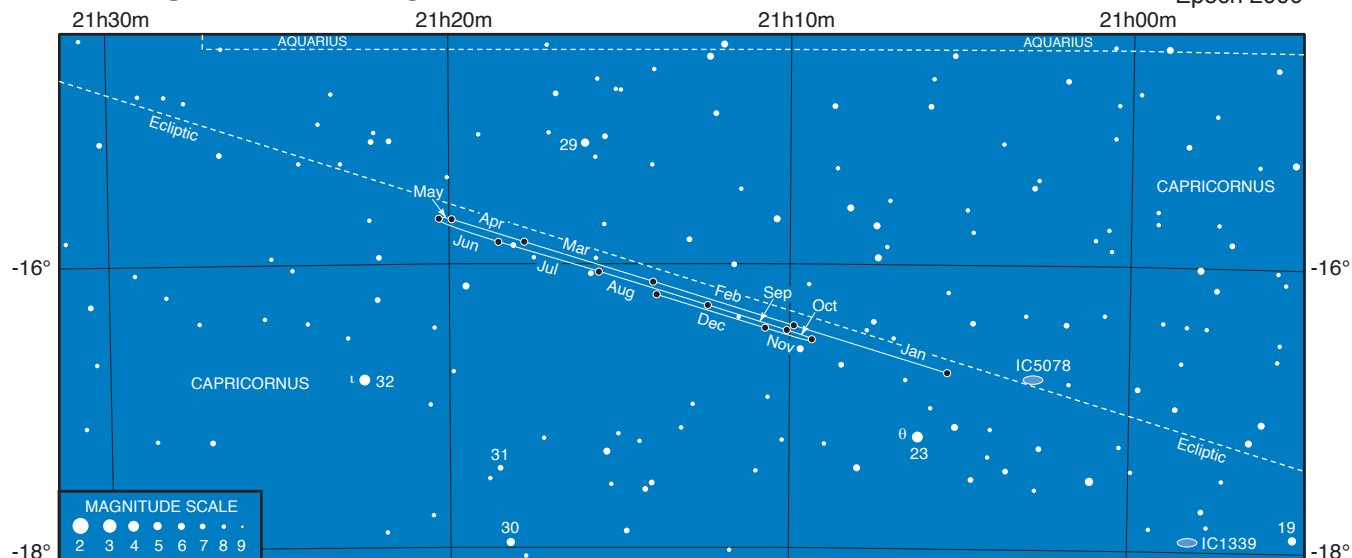
Epoch 2000



Conjunction 25th February, Stationary 15th June, Opposition 1st September, Stationary 16th November.

NEPTUNE FINDER CHART

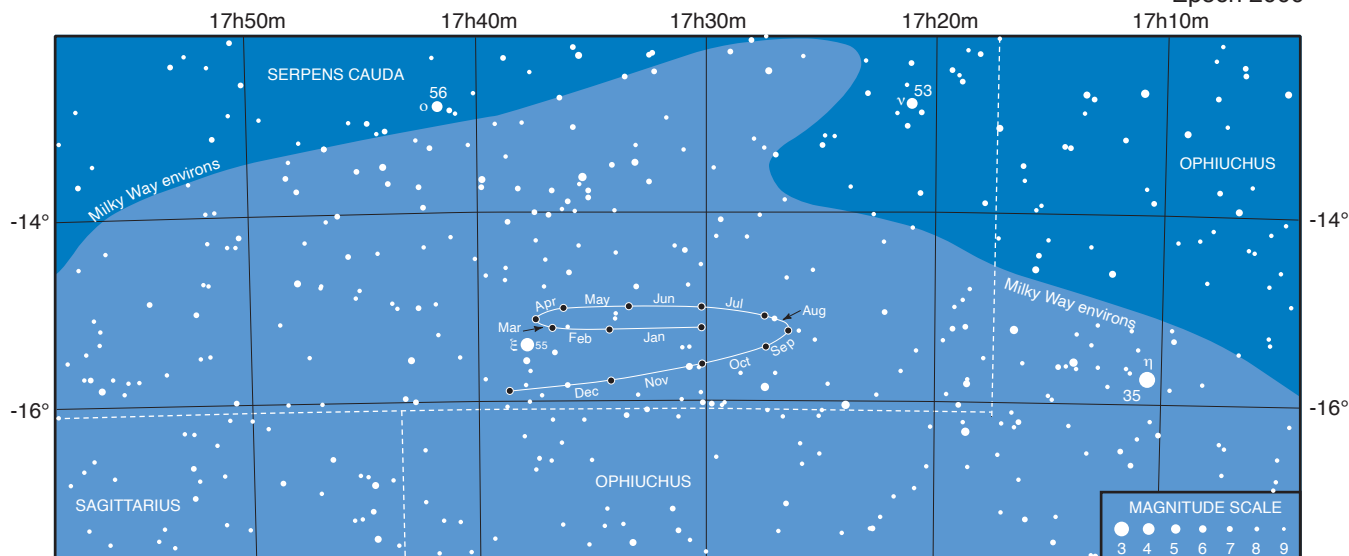
Epoch 2000



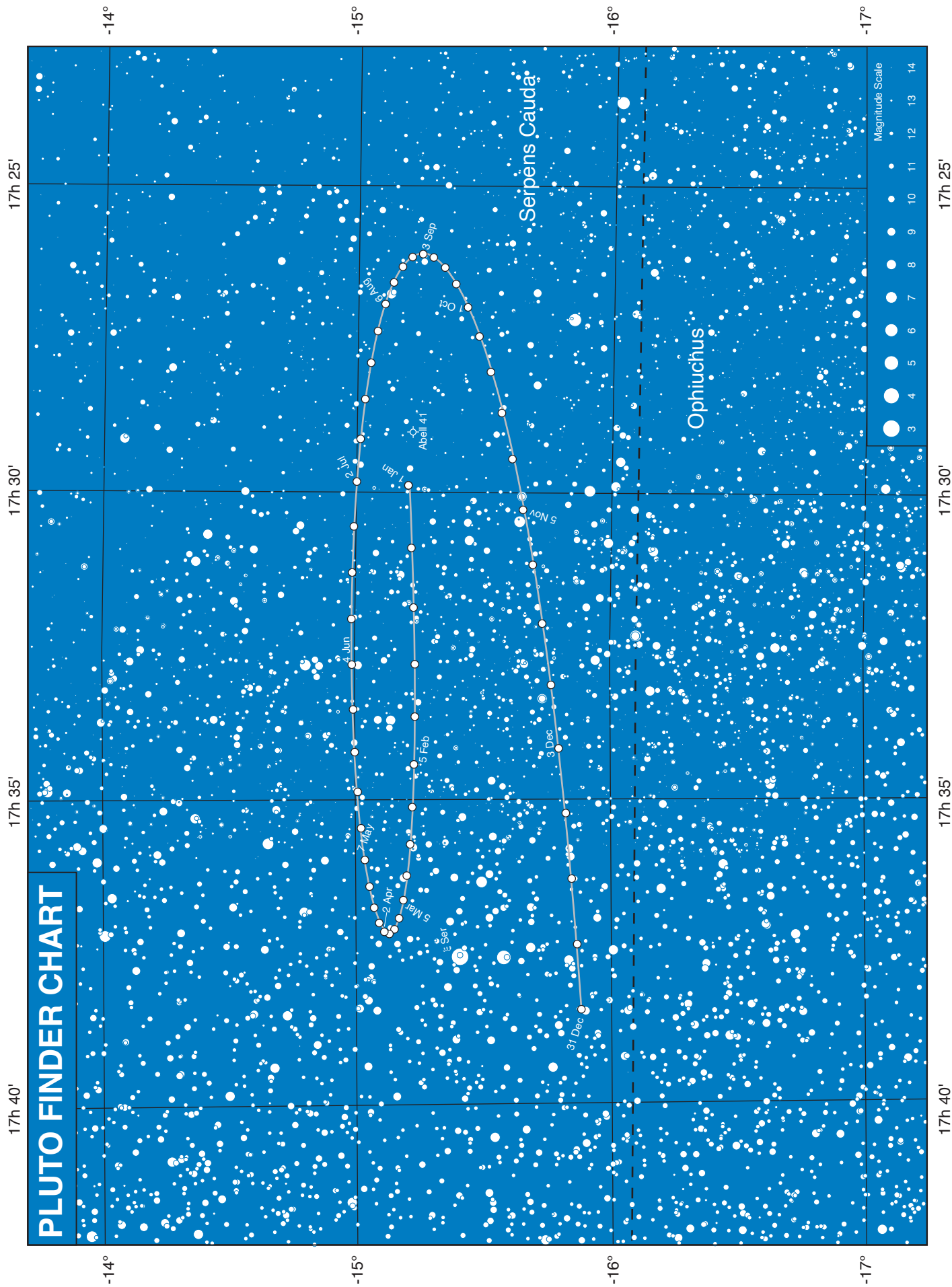
Conjunction 3rd February, Stationary 20th May, Opposition 8th August, Stationary 26th October.

PLUTO POINTER CHART

Epoch 2000



Stationary 27th March, Opposition 14th June, Stationary 3rd September, Conjunction 16th December.



PLUTO

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hr 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	Set	
Jan	1	04:17	17:48	04:01	17:09	04:04	17:37	05:18	17:49	03:58	17:59	04:16	17:58	04:22	17:44	03:58	17:26	17	29	52	- 15	11 53
	8	03:50	17:22	03:34	16:43	03:38	17:10	04:52	17:22	03:31	17:32	03:50	17:31	03:56	17:18	03:32	16:59	17	30	54	- 15	12 39
	15	03:24	16:55	03:08	16:16	03:11	16:44	04:25	16:56	03:05	17:06	03:23	17:05	03:29	16:51	03:05	16:33	17	31	52	- 15	13 09
	22	02:57	16:28	02:41	15:50	02:45	16:17	03:59	16:29	02:38	16:39	02:57	16:38	03:03	16:24	02:38	16:06	17	32	48	- 15	13 25
Feb	29	02:31	16:02	02:14	15:23	02:18	15:50	03:32	16:02	02:11	16:12	02:30	16:11	02:36	15:58	02:12	15:40	17	33	39	- 15	13 26
	5	02:04	15:35	01:48	14:56	01:51	15:24	03:05	15:35	01:44	15:46	02:03	15:45	02:09	15:31	01:45	15:13	17	34	26	- 15	13 13
	12	01:37	15:08	01:21	14:29	01:24	14:57	02:39	15:09	01:18	15:19	01:36	15:18	01:43	15:04	01:18	14:46	17	35	08	- 15	12 49
	19	01:10	14:41	00:54	14:02	00:58	14:30	02:12	14:42	00:51	14:52	01:09	14:51	01:16	14:37	00:51	14:19	17	35	44	- 15	12 13
Mar	26	00:43	14:14	00:27	13:35	00:31	14:03	01:45	14:15	00:24	14:25	00:43	14:24	00:49	14:10	00:24	13:52	17	36	15	- 15	11 27
	5	00:16	13:47	23:56	13:08	00:04	13:36	01:18	13:48	23:53	13:58	00:15	13:57	00:22	13:43	23:53	13:25	17	36	39	- 15	10 32
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	19	23:18	12:52	23:02	12:14	23:05	12:41	00:23	12:53	22:59	13:03	23:17	13:02	23:23	12:48	22:59	12:30	17	37	08	- 15	08 24
Apr	26	22:50	12:25	22:34	11:46	22:38	12:13	23:52	12:25	22:31	12:35	22:50	12:34	22:56	12:21	22:32	12:03	17	37	12	- 15	07 14
	2	22:23	11:57	22:07	11:18	22:10	11:46	23:24	11:58	22:04	12:08	22:22	12:07	22:28	11:53	22:04	11:35	17	37	10	- 15	06 03
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May	23	21:00	10:34	20:43	09:55	20:47	10:22	22:01	10:35	20:41	10:44	20:59	10:43	21:05	10:30	20:41	10:12	17	36	25	- 15	02 35
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	7	20:04	09:38	19:48	08:59	19:51	09:26	21:05	09:39	19:45	09:48	20:03	09:47	20:09	09:34	19:45	09:16	17	35	28	- 15	00 39
	14	19:36	09:10	19:19	08:31	19:23	08:58	20:37	09:10	19:17	09:20	19:35	09:19	19:41	09:06	19:17	08:47	17	34	53	- 14	59 52
Jun	21	19:08	08:41	18:51	08:03	18:55	08:30	20:09	08:42	18:49	08:52	19:07	08:51	19:13	08:37	18:49	08:19	17	34	14	- 14	59 15
	28	18:39	08:13	18:23	07:34	18:27	08:02	19:40	08:14	18:20	08:23	18:39	08:23	18:45	08:09	18:21	07:51	17	33	32	- 14	58 48
	4	18:11	07:45	17:55	07:06	17:59	07:33	19:12	07:46	17:52	07:55	18:11	07:54	18:17	07:41	17:52	07:23	17	32	48	- 14	58 33
	11	17:43	07:17	17:27	06:38	17:30	07:05	18:44	07:18	17:24	07:27	17:42	07:26	17:48	07:13	17:24	06:54	17	32	03	- 14	58 30
Jul	18	17:15	06:48	16:58	06:10	17:02	06:37	18:16	06:49	16:56	06:59	17:14	06:58	17:20	06:44	16:56	06:26	17	31	18	- 14	58 41
	25	16:46	06:20	16:30	05:41	16:34	06:09	17:47	06:21	16:27	06:30	16:46	06:30	16:52	06:16	16:28	05:58	17	30	33	- 14	59 05
	2	16:18	05:52	16:02	05:13	16:05	05:40	17:19	05:53	15:59	06:02	16:17	06:01	16:24	05:48	15:59	05:30	17	29	49	- 14	59 42
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Aug	16	15:22	04:56	15:05	04:17	15:09	04:44	16:23	04:56	15:02	05:06	15:21	05:05	15:27	04:52	15:03	04:33	17	28	28	- 15	01 40
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	6	13:57	03:32	13:41	02:53	13:45	03:20	14:59	03:32	13:38	03:42	13:57	03:41	14:03	03:28	13:38	03:10	17	26	55	- 15	06 19
Sep	13	13:29	03:04	13:13	02:25	13:17	02:52	14:31	03:04	13:10	03:14	13:29	03:13	13:35	03:00	13:10	02:42	17	26	34	- 15	08 16
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Oct	10	11:38	01:14	11:22	00:35	11:26	01:02	12:40	01:14	11:19	01:25	11:38	01:23	11:44	01:10	11:19	00:52	17	26	09	- 15	17 42
	17	11:11	00:47	10:55	00:08	10:58	00:35	12:13	00:47	10:51	00:57	11:10	00:56	11:16	00:43	10:52	00:24	17	26	19	- 15	20 21
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	1	10:16	23:49	10:00	23:10	10:03	23:37	11:18	23:49	09:57	23:59	10:15	23:58	10:22	23:45	09:57	23:26	17	26	57	- 15	25 48
Nov	8	09:49	23:22	09:33	22:43	09:36	23:10	10:51	23:22	09:29	23:33	09:48	23:31	09:55	23:18	09:30	23:00	17	27	26	- 15	28 33
	15	09:22	22:55	09:06	22:16	09:09	22:44	10:24	22:55	09:02	23:06	09:21	23:05	09:27	22:51	09:03	22:33	17	28	01	- 15	31 16
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Dec	5	08:01	21:35	07:45	20:56	07:48	21:24	09:04	21:35	07:41	21:46	08:00	21:45	08:07	21:31	07:42	21:13	17	30	16	- 15	39 02
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	19	07:08	20:42	06:52	20:03	06:55	20:31	08:10	20:41	06:48	20:53	07:07	20:52	07:13	20:38	06:49	20:20	17	32	08	- 15	43 35
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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, gases, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classical dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical shaped donut. The effects of solar radiation and the slight gravity tugs from the planets will over time break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical 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.

Incredible velocities such as these (a bullet from a rifle travels at about 1 km per second) result in the meteor's kinetic energy being converted to heat when it strikes the atmosphere at an altitude of about 100 km. The surrounding air is heated to incandescence by friction and as a consequence we can observe these tiny bodies as they self-destruct in our atmosphere.

Individual meteors during a shower appear to originate from a common point in the sky known as the radiant. This focal point is named after the constellation in which the meteors appear or the comet that is associated with the shower. Individual particles of meteoroid streams travel through space in parallel paths. The apparent divergence from the radiant is only an illusion, due simply to the effect of perspective. The way that trees and buildings converge on either side of a long straight road, is the same effect that is seen when a meteor shower occurs far above an observer.

The table of Meteor Showers has been compiled from the Meteor Shower Calendar produced by the International Meteor Organisation (IMO). It is the most accurate listing for naked-eye meteor observing available today. The table is complete in that both northern and southern showers are listed. Serious meteor observing should be carried out under dark skies, and preferably without the Moon. The best showers for this year, taking into consideration the lunar phase, are summarised in the monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic meteors (originating from random points in the sky) are visible per hour under dark sky conditions. More meteors are seen in the morning sky than in the evening; as the morning sky is facing the Earth's motion in space we tend to 'run into' and 'sweep up' meteors, whereas evening meteors must have sufficient velocity to catch up to the speeding Earth. Amateurs wishing to follow up an interest in meteors, and even make a contribution to meteor science, should contact the International Meteor Organisation (www.imo.net/).

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		DIA	VEL km/s	ZHR
				R.A.	Dec			
Quadrantids	LQ	Jan 01 – Jan 05	Jan 04	230°	+49°	5°	41	120
delta-Cancerids	FQ	Jan 01 – Jan 24	Jan 17	130°	+20°	10° – 5°	28	4
alpha-Centaurids	NM	Jan 28 – Feb 21	Feb 08	210°	–59°	4°	56	6
delta-Leonids	FM	Feb 15 – Mar 10	Feb 25	168°	+16°	5°	23	2
gamma-Normids	NM	Feb 25 – Mar 22	Mar 13	249°	–51°	5°	56	8
Virginids	FM	Jan 25 – Apr 15	Mar 24	195°	–04°	15° – 10°	30	5
Lyrids	FM	Apr 16 – Apr 25	Apr 23	271°	+34°	5°	49	18
pi-Puppids*	FM	Apr 15 – Apr 28	Apr 24	110°	–45°	5°	18	var
eta-Aquarids	NM	Apr 19 – May 28	May 05	338°	–01°	4°	66	60
Sagittarids	FQ	Apr 15 – Jul 15	May 19	247°	–22°	15° – 10°	30	5
Bootids (June)*	LQ	Jun 26 – Jul 02	Jun 27	224°	+48°	5°	18	var
Pegasids	NM	Jul 07 – Jul 13	Jul 09	340°	+15°	5°	70	3
Phoenicids (July)*	FQ	Jul 10 – Jul 16	Jul 13	032°	–48°	7°	47	var
Pisces Austrinids	LQ	Jul 15 – Aug 10	Jul 27	341°	–30°	15° – 10°	35	5
Southern delta-Aquarids	LQ	Jul 12 – Aug 19	Jul 27	339°	–16°	5°	41	20
alpha-Capricornids	LQ	Jul 03 – Aug 15	Jul 29	307°	–10°	8°	23	4
Southern iota-Aquarids	NM	Jul 25 – Aug 15	Aug 04	334°	–15°	5°	34	2
Northern delta-Aquarids	NM	Jul 15 – Aug 25	Aug 08	335°	–05°	5°	42	4
Perseids	FQ	Jul 17 – Aug 24	Aug 12	046°	+58°	5°	59	110
kappa-Cygnids	FM	Aug 03 – Aug 25	Aug 17	286°	+59°	6°	25	3
Northern iota-Aquarids	FM	Aug 11 – Aug 31	Aug 19	327°	–06°	5°	31	3
alpha-Aurigids	NM	Aug 25 – Sep 08	Aug 31	084°	+42°	5°	66	7
delta-Aurigids	FQ	Sep 05 – Oct 10	Sep 09	060°	+47°	5°	64	5
Piscids	FM	Sep 01 – Sep 30	Sep 19	005°	–01°	5°	26	3
Draconids*	FQ	Oct 06 – Oct 10	Oct 08	262°	+54°	2°	20	var
Epsilon Geminids	FM	Oct 14 – Oct 27	Oct 18	102°	+27°	5°	70	2
Orionids	FM	Oct 02 – Nov 07	Oct 21	095°	+16°	10°	66	23
Southern Taurids	NM	Oct 01 – Nov 25	Nov 05	052°	+13°	10° – 5°	27	5
Northern Taurids	FQ	Oct 01 – Nov 25	Nov 12	058°	+22°	10° – 5°	29	5
Leonids	FM	Nov 14 – Nov 21	Nov 17	153°	+22°	5°	71	50+
alpha-Monocerotids	LQ	Nov 15 – Nov 25	Nov 21	117°	+01°	5°	65	Var
chi-Orionids	NM	Nov 26 – Dec 15	Dec 01	082°	+23°	8°	28	3
Phoenicids	FQ	Nov 28 – Dec 09	Dec 06	018°	–53°	5°	22	Var
Puppids-Velids	FQ	Dec 01 – Dec 15	Dec 06	123°	–45°	10°	40	10
Monocerotids (Dec)	FQ	Nov 27 – Dec 17	Dec 08	100°	+08°	5°	42	3
sigma-Hydrids	FQ	Dec 03 – Dec 15	Dec 11	127°	+02°	5°	58	2
Geminids	FM	Dec 07 – Dec 17	Dec 13	112°	+33°	5°	35	120
Coma Berenicids	FM	Dec 12 – Jan 23	Dec 19	175°	+25°	5°	65	5
Ursids	LQ	Dec 17 – Dec 26	Dec 22	217°	+76°	5°	33	10

Notes On The Table Above

Shower Name The shower is named after the constellation that the radiant appears in or a bright star near that point. A shower marked with an asterisk (*) is only occasionally active.

Moon Phase The phase of the Moon nearest the date of maximum activity. If a Full Moon occurs near a shower's maximum period, only the very brightest of meteors will be seen.

Activity Duration The approximate dates when the shower is active.

Max Act The date when maximum activity can be expected.

Radiant: The position of the shower radiant in right ascension and declination (R.A. is expressed in degrees). These co-ordinates refer to the radiant position on the date of maximum activity.

Dia The radiant diameter. When two figures are given, the first is the spread in R.A. and the second the spread in Dec.

Vel The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11km/s (very slow) to 71km/s (very fast), medium speed is about 40km/s.

ZHR Zenith Hourly Rate, a theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

MINOR PLANET POSITIONS

(0HR UT, EPOCH 2000.0)

As well as the nine planets, their moons and the comets, the Solar System contains numerous smaller bodies known as the minor planets or asteroids. There are now hundreds of thousands of such bodies catalogued! Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe.

Many can be found by photographing the area, at least twice, over several days and detecting them as they move against the distant star field.

The same can be achieved by observing the field and making drawings over several days to detect which 'star' has moved. Be sure you have the right field of view! Only about sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

The ephemerides are for the twenty brightest minor planets for 2005. Nineteen of these reach opposition in 2005, and one early in 2006. These selected asteroids all get brighter than 10th magnitude around the time of opposition.

1 CERES				2 PALLAS				3 JUNO			
		R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag		
Jan	1	14 33.8	-06 13	8.8	12 18.2	-11 23	8.6	20 49.5	-12 57	10.6	
	8	14 43.3	-06 52	8.7	12 25.3	-10 56	8.5	21 01.6	-12 26	10.5	
	15	14 52.4	-07 27	8.7	12 31.5	-10 16	8.4	21 14.0	-11 50	10.5	
	22	15 00.9	-07 57	8.6	12 36.6	-09 21	8.2	21 26.5	-11 11	10.4	
	29	15 08.9	-08 22	8.6	12 40.4	-08 09	8.1	21 39.1	-10 27	10.3	
Feb	5	15 16.2	-08 43	8.5	12 43.0	-06 39	8.0	21 51.9	-09 40	10.3	
	12	15 22.7	-09 00	8.4	12 44.1	-04 50	7.8	22 04.7	-08 49	10.2	
	19	15 28.4	-09 12	8.3	12 43.9	-02 44	7.7	22 17.6	-07 56	10.1	
	26	15 33.0	-09 20	8.3	12 42.3	-00 21	7.5	22 30.6	-06 59	10.0	
Mar	5	15 36.7	-09 25	8.2	12 39.5	+02 14	7.4	22 43.7	-06 00	10.0	
	12	15 39.1	-09 25	8.0	12 35.6	+04 57	7.2	22 56.8	-05 00	10.1	
	19	15 40.3	-09 22	7.9	12 31.0	+07 41	7.1	23 10.0	-03 57	10.1	
	26	15 40.1	-09 17	7.8	12 26.0	+10 19	7.2	23 23.3	-02 53	10.1	
Apr	2	15 38.7	-09 10	7.7	12 21.0	+12 44	7.3	23 36.6	-01 48	10.1	
	9	15 35.9	-09 01	7.5	12 16.4	+14 52	7.6	23 49.9	-00 43	10.1	
	16	15 31.9	-08 51	7.4	12 12.6	+16 40	7.8	00 03.4	+00 22	10.1	
	23	15 26.8	-08 42	7.2	12 09.7	+18 07	8.0	00 16.9	+01 27	10.1	
	30	15 21.0	-08 35	7.1	12 07.9	+19 13	8.2	00 30.5	+02 31	10.1	
May	7	15 14.6	-08 30	7.0	12 07.3	+20 00	8.3	00 44.2	+03 34	10.1	
	14	15 08.1	-08 28	7.0	12 07.9	+20 29	8.5	00 58.0	+04 36	10.1	
	21	15 01.8	-08 32	7.2	12 09.6	+20 44	8.7	01 11.8	+05 35	10.0	
	28	14 56.1	-08 40	7.3	12 12.5	+20 45	8.8	01 25.7	+06 31	10.0	
Jun	4	14 51.2	-08 53	7.5	12 16.2	+20 36	8.9	01 39.8	+07 24	10.0	
	11	14 47.3	-09 11	7.6	12 20.9	+20 17	9.1	01 53.8	+08 13	9.9	
	18	14 44.5	-09 35	7.8	12 26.3	+19 51	9.2	02 08.0	+08 59	9.9	
	25	14 43.0	-10 04	7.9	12 32.5	+19 18	9.3	02 22.1	+09 39	9.8	
Jul	2	14 42.6	-10 37	8.1	12 39.2	+18 41	9.4	02 36.3	+10 14	9.8	
	9	14 43.5	-11 14	8.2	12 46.5	+17 58	9.5	02 50.5	+10 44	9.7	
	16	14 45.4	-11 54	8.3	12 54.3	+17 13	9.5	03 04.6	+11 07	9.6	
	23	14 48.5	-12 37	8.5	13 02.5	+16 24	9.6	03 18.5	+11 24	9.6	
	30	14 52.4	-13 22	8.6	13 11.0	+15 34	9.7	03 32.4	+11 34	9.5	
Aug	6	14 57.3	-14 09	8.6	13 19.9	+14 42	9.7	03 45.9	+11 36	9.4	
	13	15 03.1	-14 56	8.7	13 29.1	+13 49	9.7	03 59.2	+11 31	9.3	
	20	15 09.5	-15 45	8.8	13 38.6	+12 56	9.8	04 12.1	+11 18	9.2	
	27	15 16.7	-16 34	8.9	13 48.3	+12 03	9.8	04 24.5	+10 57	9.2	
Sep	3	15 24.5	-17 22	8.9	13 58.3	+11 11	9.8	04 36.2	+10 28	9.1	
	10	15 32.9	-18 10	9.0	14 08.4	+10 19	9.9	04 47.3	+09 51	8.9	
	17	15 41.8	-18 57	9.0	14 18.7	+09 29	9.9	04 57.5	+09 06	8.8	
	24	15 51.2	-19 42	9.1	14 29.2	+08 41	9.9	05 06.7	+08 14	8.7	
Oct	1	16 01.1	-20 26	9.1	14 39.9	+07 55	9.9	05 14.8	+07 15	8.6	
	8	16 11.4	-21 07	9.1	14 50.7	+07 11	9.9	05 21.6	+06 11	8.5	
	15	16 22.0	-21 47	9.1	15 01.6	+06 30	9.9	05 26.9	+05 03	8.3	
	22	16 33.0	-22 24	9.1	15 12.6	+05 52	9.9	05 30.7	+03 51	8.2	
	29	16 44.3	-22 58	9.1	15 23.7	+05 18	9.9	05 32.7	+02 39	8.1	
Nov	5	16 55.9	-23 29	9.1	15 34.8	+04 48	9.9	05 33.1	+01 29	7.9	
	12	17 07.7	-23 56	9.1	15 46.0	+04 22	9.9	05 31.7	+00 24	7.8	
	19	17 19.8	-24 21	9.1	15 57.3	+04 00	10.0	05 28.7	-00 32	7.7	
	26	17 32.0	-24 42	9.0	16 08.5	+03 43	10.0	05 24.4	-01 17	7.6	
Dec	3	17 44.4	-24 59	9.0	16 19.7	+03 31	10.0	05 19.1	-01 47	7.6	
	10	17 56.9	-25 12	8.9	16 30.8	+03 23	10.0	05 13.3	-02 00	7.6	
	17	18 09.4	-25 22	8.8	16 41.9	+03 22	10.1	05 07.5	-01 54	7.6	
	24	18 22.0	-25 29	8.7	16 52.8	+03 25	10.1	05 02.3	-01 32	7.7	
	31	18 34.6	-25 31	8.7	17 03.6	+03 34	10.1	04 58.0	-00 54	7.8	

		4 VESTA			7 IRIS			8 FLORA			10 HYGIEA			11 PARTHENOPE		
Jan	1	23 57.7	-07 50	8.0	15 45.1	-22 23	11.4	08 00.9	+20 19	8.7	12 25.1	-06 48	11.0	21 49.9	-15 26	11.5
	8	00 06.1	-06 39	8.1	15 55.2	-22 52	11.4	07 53.4	+21 08	8.6	12 29.4	-07 28	10.9	22 03.5	-14 18	11.5
	15	00 14.9	-05 26	8.2	16 05.1	-23 18	11.4	07 45.4	+21 56	8.4	12 33.0	-08 03	10.8	22 17.0	-13 08	11.5
	22	00 24.0	-04 12	8.2	16 14.7	-23 41	11.4	07 37.5	+22 42	8.7	12 35.6	-08 33	10.7	22 30.6	-11 54	11.5
	29	00 33.6	-02 57	8.3	16 23.9	-24 01	11.3	07 30.3	+23 22	8.9	12 37.3	-08 57	10.5	22 44.1	-10 38	11.5
Feb	5	00 43.4	-01 41	8.3	16 32.7	-24 18	11.3	07 24.4	+23 56	9.1	12 37.9	-09 14	10.4	22 57.5	-09 20	11.4
	12	00 53.5	-00 25	8.3	16 41.0	-24 33	11.2	07 20.1	+24 23	9.3	12 37.4	-09 25	10.3	23 11.0	-08 00	11.4
	19	01 03.9	+00 52	8.4	16 48.8	-24 44	11.2	07 17.7	+24 44	9.5	12 35.8	-09 28	10.1	23 24.4	-06 39	11.4
	26	01 14.5	+02 07	8.4	16 55.9	-24 54	11.1	07 17.1	+24 58	9.7	12 33.2	-09 24	10.0	23 37.7	-05 17	11.3
Mar	5	01 25.3	+03 23	8.4	17 02.3	-25 01	11.1	07 18.3	+25 07	9.9	12 29.6	-09 12	9.8	23 51.0	-03 54	11.3
	12	01 36.3	+04 37	8.4	17 07.9	-25 06	11.0	07 21.2	+25 11	10.1	12 25.2	-08 53	9.7	00 04.3	-02 31	11.2
	19	01 47.4	+05 50	8.4	17 12.6	-25 09	10.9	07 25.5	+25 09	10.2	12 20.2	-08 28	9.5	00 17.5	-01 09	11.2
	26	01 58.7	+07 01	8.4	17 16.2	-25 11	10.8	07 31.3	+25 04	10.4	12 14.9	-07 58	9.3	00 30.7	+00 13	11.1
Apr	2	02 10.2	+08 11	8.4	17 18.7	-25 10	10.7	07 38.1	+24 54	10.5	12 09.6	-07 25	9.4	00 43.9	+01 34	11.1
	9	02 21.8	+09 18	8.3	17 20.0	-25 08	10.5	07 46.0	+24 39	10.7	12 04.6	-06 50	9.6	00 57.0	+02 53	11.2
	16	02 33.6	+10 23	8.3	17 20.0	-25 03	10.4	07 54.6	+24 20	10.8	12 00.2	-06 16	9.7	01 10.1	+04 11	11.3
	23	02 45.4	+11 26	8.3	17 18.7	-24 57	10.3	08 04.0	+23 57	10.9	11 56.5	-05 45	9.8	01 23.1	+05 27	11.4
	30	02 57.4	+12 25	8.2	17 16.0	-24 48	10.1	08 14.0	+23 30	11.0	11 53.8	-05 19	10.0	01 36.2	+06 40	11.4
May	7	03 09.5	+13 22	8.2	17 12.0	-24 36	10.0	08 24.4	+22 58	11.1	11 52.2	-04 57	10.1	01 49.2	+07 51	11.5
	14	03 21.6	+14 16	8.2	17 06.8	-24 22	9.8	08 35.2	+22 22	11.2	11 51.7	-04 43	10.2	02 02.1	+08 59	11.5
	21	03 33.9	+15 06	8.2	17 00.6	-24 04	9.6	08 46.3	+21 43	11.2	11 52.3	-04 34	10.3	02 15.0	+10 03	11.6
	28	03 46.2	+15 52	8.3	16 53.7	-23 44	9.4	08 57.7	+20 59	11.3	11 54.0	-04 33	10.4	02 27.9	+11 05	11.6
Jun	4	03 58.5	+16 35	8.3	16 46.4	-23 21	9.2	09 09.2	+20 12	11.4	11 56.7	-04 38	10.5	02 40.7	+12 02	11.6
	11	04 10.8	+17 15	8.4	16 39.0	-22 55	9.4	09 20.9	+19 22	11.4	12 00.3	-04 50	10.6	02 53.4	+12 56	11.7
	18	04 23.2	+17 50	8.4	16 32.0	-22 29	9.5	09 32.6	+18 28	11.4	12 04.8	-05 07	10.7	03 05.9	+13 45	11.7
	25	04 35.5	+18 22	8.4	16 25.7	-22 04	9.7	09 44.5	+17 31	11.5	12 10.1	-05 31	10.8	03 18.4	+14 31	11.7
Jul	2	04 47.8	+18 50	8.5	16 20.4	-21 39	9.8	09 56.3	+16 31	11.5	12 16.1	-05 59	10.9	03 30.7	+15 12	11.7
	9	05 00.0	+19 13	8.5	16 16.3	-21 18	10.0	10 08.2	+15 29	11.5	12 22.7	-06 32	10.9	03 42.8	+15 49	11.7
	16	05 12.2	+19 34	8.5	16 13.4	-21 00	10.1	10 20.1	+14 24	11.6	12 30.0	-07 09	11.0	03 54.6	+16 22	11.7
	23	05 24.1	+19 50	8.5	16 11.9	-20 46	10.2	10 31.9	+13 17	11.6	12 37.7	-07 49	11.0	04 06.2	+16 50	11.7
	30	05 36.0	+20 02	8.5	16 11.7	-20 36	10.3	10 43.8	+12 09	11.6	12 46.0	-08 33	11.0	04 17.4	+17 14	11.7
Aug	6	05 47.6	+20 12	8.5	16 12.8	-20 30	10.4	10 55.6	+10 59	11.6	12 54.7	-09 20	11.1	04 28.2	+17 34	11.6
	13	05 59.0	+20 18	8.4	16 15.2	-20 28	10.5	11 07.4	+09 47	11.6	13 03.8	-10 09	11.1	04 38.6	+17 50	11.6
	20	06 10.1	+20 20	8.4	16 18.7	-20 29	10.6	11 19.2	+08 35	11.5	13 13.3	-10 59	11.1	04 48.5	+18 02	11.6
	27	06 20.8	+20 21	8.4	16 23.3	-20 33	10.7	11 31.0	+07 22	11.5	13 23.1	-11 51	11.1	04 57.7	+18 10	11.6
Sep	3	06 31.1	+20 18	8.3	16 28.8	-20 39	10.7	11 42.7	+06 08	11.5	13 33.3	-12 44	11.1	05 06.3	+18 15	11.5
	10	06 41.1	+20 14	8.3	16 35.3	-20 46	10.8	11 54.4	+04 54	11.4	13 43.8	-13 38	11.1	05 14.1	+18 16	11.4
	17	06 50.5	+20 09	8.2	16 42.7	-20 55	10.8	12 06.1	+03 40	11.4	13 54.5	-14 31	11.1	05 21.0	+18 15	11.3
	24	06 59.4	+20 02	8.2	16 50.7	-21 04	10.9	12 17.8	+02 27	11.4	14 05.6	-15 25	11.1	05 26.8	+18 12	11.2
Oct	1	07 07.6	+19 55	8.1	16 59.5	-21 13	10.9	12 29.4	+01 14	11.4	14 16.9	-16 18	11.1	05 31.6	+18 07	11.1
	8	07 15.0	+19 48	8.0	17 08.9	-21 21	10.9	12 41.0	+00 02	11.4	14 28.4	-17 10	11.1	05 35.1	+18 01	11.0
	15	07 21.7	+19 42	8.0	17 18.9	-21 27	10.9	12 52.6	-01 09	11.5	14 40.2	-18 00	11.0	05 37.3	+17 53	10.9
	22	07 27.4	+19 37	7.9	17 29.5	-21 32	10.9	13 04.2	-02 18	11.5	14 52.2	-18 49	11.0	05 38.0	+17 46	10.8
	29	07 32.0	+19 35	7.7	17 40.5	-21 34	10.9	13 15.7	-03 26	11.6	15 04.4	-19 36	10.9	05 37.1	+17 38	10.6
Nov	5	07 35.5	+19 36	7.6	17 52.0	-21 34	10.9	13 27.2	-04 32	11.6	15 16.8	-20 21	10.8	05 34.8	+17 31	10.5
	12	07 37.8	+19 41	7.5	18 03.9	-21 30	10.9	13 38.7	-05 35	11.7	15 29.3	-21 03	10.8	05 30.9	+17 24	10.4
	19	07 38.6	+19 51	7.4	18 16.1	-21 23	10.9	13 50.1	-06 36	11.7	15 42.0	-21 42	10.7	05 25.6	+17 18	10.2
	26	07 38.0	+20 06	7.2	18 28.6	-21 12	10.8	14 01.4	-07 33	11.7	15 54.8	-22 18	10.7	05 19.3	+17 14	10.0
Dec	3	07 35.9	+20 25	7.1	18 41.4	-20 57	10.8	14 12.6	-08 28	11.7	16 07.7	-22 51	10.8	05 12.2	+17 11	9.9
	10	07 32.2	+20 50	6.9	18 54.4	-20 37	10.7	14 23.7	-09 20	11.7	16 20.7	-23 20	10.9	05 04.7	+17 09	9.8
	17	07 27.1	+21 18	6.8	19 07.6	-20 13	10.7	14 34.6	-10 08	11.7	16 33.7	-23 45	10.9	04 57.4	+17 10	10.0
	24	07 20.8	+21 50	6.6	19 21.0	-19 45	10.6	14 45.4	-10 52	11.7	16 46.7	-24 07	11.0	04 50.6	+17 13	10.1
	31	07 13.5	+22 23	6.4	19 34.5	-19 12	10.5	14 55.9	-11 33	11.7	16 59.6	-24 24	11.0	04 44.7	+17 19	10.3

14 IRENE							15 EUNOMIA							16 PSYCHE							18 MELPOMENE							19 FORTUNA							20 MASSALIA						
		R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag			R.A. h mm	Dec ° ' "	Mag							
Jan	1	14 30.8	-06 37	11.0			14 04.1	-23 57	11.2			22 14.0	-11 48	11.2			16 07.0	-12 53	12.0			19 50.2	-19 53	12.1			18 51.6	-22 24	11.7												
	8	14 43.0	-07 28	11.0			14 11.2	-24 52	11.2			22 25.1	-10 49	11.2			16 18.2	-13 12	12.0			20 04.2	-19 14	12.1			19 04.1	-22 07	11.7												
	15	14 54.9	-08 14	10.9			14 17.7	-25 45	11.1			22 36.4	-09 47	11.2			16 29.2	-13 26	11.9			20 18.2	-18 30	12.0			19 16.5	-21 45	11.8												
	22	15 06.4	-08 55	10.9			14 23.7	-26 36	11.1			22 47.8	-08 42	11.1			16 40.1	-13 37	11.9			20 32.3	-17 42	11.8			19 28.9	-21 21	11.9												
	29	15 17.3	-09 30	10.8			14 28.9	-27 24	11.0			22 59.4	-07 34	11.2			16 50.7	-13 43	11.9			20 46.3	-16 50	11.7			19 41.0	-20 53	11.9												
Feb	5	15 27.7	-10 01	10.7			14 33.4	-28 10	11.0			23 11.1	-06 25	11.2			17 01.1	-13 44	11.8			21 00.3	-15 53	11.8			19 53.1	-20 22	12.0												
	12	15 37.3	-10 27	10.7			14 37.1	-28 53	10.9			23 22.9	-05 13	11.2			17 11.1	-13 42	11.8			21 14.3	-14 53	11.9			20 05.0	-19 48	12.0												
	19	15 46.1	-10 48	10.6			14 39.7	-29 33	10.8			23 34.7	-04 00	11.1			17 20.7	-13 35	11.7			21 28.1	-13 48	11.9			20 16.6	-19 11	12.0												
Mar	26	15 54.0	-11 04	10.5			14 41.3	-30 08	10.7			23 46.7	-02 47	11.1			17 29.9	-13 24	11.7			21 41.9	-12 41	12.0			20 28.0	-18 32	12.0												
	5	16 00.8	-11 17	10.4			14 41.7	-30 40	10.6			23 58.7	-01 32	11.0			17 38.6	-13 09	11.6			21 55.6	-11 30	12.0			20 39.2	-17 51	12.0												
	12	16 06.5	-11 25	10.3			14 40.9	-31 05	10.5			00 10.7	-00 17	11.0			17 46.7	-12 51	11.5			22 09.2	-10 16	12.1			20 50.1	-17 08	12.0												
Apr	19	16 10.8	-11 30	10.2			14 38.9	-31 25	10.4			00 22.8	+00 58	10.9			17 54.1	-12 29	11.4			22 22.7	-09 00	12.1			21 00.7	-16 24	12.0												
	26	16 13.7	-11 33	10.0			14 35.7	-31 37	10.3			00 35.0	+02 13	10.8			18 00.7	-12 04	11.3			22 36.1	-07 42	12.1			21 10.9	-15 38	12.0												
	2	16 15.0	-11 34	9.9			14 31.3	-31 41	10.2			00 47.2	+03 28	10.7			18 06.4	-11 37	11.2			22 49.4	-06 22	12.1			21 20.8	-14 52	12.0												
May	9	16 14.7	-11 33	9.8			14 26.0	-31 36	10.1			00 59.4	+04 41	10.8			18 11.2	-11 08	11.0			23 02.6	-05 01	12.1			21 30.4	-14 06	12.0												
	16	16 12.8	-11 32	9.6			14 19.9	-31 21	9.9			01 11.6	+05 53	10.9			18 14.9	-10 38	10.9			23 15.7	-03 39	12.1			21 39.5	-13 20	11.9												
	23	16 09.3	-11 32	9.5			14 13.4	-30 57	9.9			01 23.9	+07 03	11.0			18 17.5	-10 07	10.8			23 28.7	-02 17	12.1			21 48.2	-12 35	11.9												
	30	16 04.5	-11 33	9.3			14 06.7	-30 24	9.8			01 36.2	+08 12	11.0			18 18.7	-09 36	10.6			23 41.6	-00 54	12.1			21 56.4	-11 51	11.8												
	7	15 58.5	-11 36	9.1			14 00.3	-29 44	9.8			01 48.5	+09 19	11.1			18 18.7	-09 07	10.5			23 54.4	+00 29	12.1			22 04.1	-11 08	11.8												
Jun	14	15 51.8	-11 42	9.0			13 54.4	-28 58	9.9			02 00.8	+10 22	11.1			18 17.1	-08 40	10.3			00 07.1	+01 51	12.0			22 11.2	-10 27	11.7												
	21	15 44.9	-11 51	9.0			13 49.2	-28 09	10.0			02 13.1	+11 24	11.2			18 14.2	-08 17	10.1			00 19.7	+03 12	12.0			22 17.7	-09 50	11.6												
	28	15 38.1	-12 05	9.2			13 45.1	-27 20	10.1			02 25.4	+12 22	11.2			18 09.9	-07 58	9.9			00 32.2	+04 31	12.0			22 23.5	-09 15	11.5												
	4	15 32.0	-12 23	9.4			13 42.1	-26 32	10.2			02 37.6	+13 17	11.2			18 04.4	-07 46	9.8			00 44.6	+05 49	11.9			22 28.5	-08 44	11.4												
	11	15 26.8	-12 45	9.5			13 40.2	-25 48	10.3			02 49.8	+14 09	11.2			17 57.9	-07 40	9.6			00 56.8	+07 05	11.9			22 32.7	-08 18	11.3												
Jul	18	15 22.9	-13 12	9.7			13 39.5	-25 08	10.4			03 01.9	+14 57	11.2			17 50.8	-07 43	9.5			01 08.8	+08 18	11.8			22 36.0	-07 57	11.2												
	25	15 20.4	-13 44	9.9			13 40.0	-24 34	10.5			03 13.9	+15 41	11.2			17 43.4	-07 54	9.5			01 20.7	+09 28	11.8			22 38.2	-07 42	11.1												
	2	15 19.3	-14 19	10.1			13 41.5	-24 05	10.6			03 25.8	+16 22	11.2			17 36.3	-08 13	9.6			01 32.3	+10 34	11.7			22 39.4	-07 33	11.0												
	9	15 19.6	-14 57	10.3			13 44.1	-23 43	10.7			03 37.4	+16 58	11.2			17 29.7	-08 40	9.7			01 43.6	+11 37	11.6			22 39.5	-07 31	10.8												
	16	15 21.3	-15 38	10.4			13 47.7	-23 28	10.8			03 48.9	+17 30	11.2			17 24.2	-09 15	9.8			01 54.6	+12 36	11.6			22 38.2	-07 37	10.7												
Aug	23	15 24.3	-16 21	10.6			13 52.1	-23 18	10.9			04 00.1	+17 59	11.2			17 19.9	-09 54	9.9			02 05.1	+13 31	11.5			22 35.8	-07 50	10.5												
	30	15 28.4	-17 05	10.7			13 57.3	-23 13	10.9			04 11.0	+18 23	11.2			17 17.1	-10 39	10.0			02 15.2	+14 21	11.4			22 32.2	-08 11	10.4												
	6	15 33.7	-17 51	10.9			14 03.2	-23 14	11.0			04 21.5	+18 43	11.1			17 15.8	-11 26	10.1			02 24.6	+15 05	11.3			22 27.5	-08 37	10.2												
	13	15 40.0	-18 36	11.0			14 09.8	-23 19	11.0			04 31.5	+19 00	11.1			17 16.2	-12 16	10.2			02 33.3	+15 44	11.2			22 21.9	-09 10	10.0												
	20	15 47.1	-19 22	11.1			14 17.0	-23 28	11.1			04 41.0	+19 12	11.0			17 18.2	-13 06	10.3			02 41.2	+16 17	11.0			22 15.7	-09 46	9.8												
Sep	27	15 55.1	-20 06	11.2			14 24.8	-23 41	11.1			04 50.0	+19 21	11.0			17 21.6	-13 56	10.4			02 48.1	+16 45	10.9			22 09.2	-10 23	9.7												
	3	16 03.8	-20 50	11.3			14 33.1	-23 56	11.2			04 58.3	+19 27	10.9			17 26.5	-14 46	10.5			02 53.8	+17 05	10.7			22 02.8	-11 00	9.9												
	10	16 13.2	-21 32	11.4			14 41.8	-24 14	11.2			05 05.8	+19 30	10.8			17 32.8	-15 33	10.6			02 58.2	+17 19	10.6			21 56.8	-11 35	10.1												
Oct	17	16 23.1	-22 11	11.4			14 51.1	-24 33	11.2			05 12.4	+19 29	10.8			17																								

COMETS FOR 2005

WHAT IS A COMET? It is a member of the Solar System which is normally in a very eccentric orbit around the Sun. The orbits of periodic, or regularly reappearing comets are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive and mainly composed of water in the form of ice and dust. A common analogy is a 'dirty snowball' (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, Encke, takes just over 3 years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of a number of new comets that have not been recorded before. The majority of these have either open-ended orbits (they are believed to be making their only visit to the Solar System and are not expected to return) or have extremely long orbital periods measured in thousands of years.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a *coma* around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionized particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of dust grains that trail behind the comet along the direction of its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails. In fact some may only show the coma. Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' means the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 2P/Encke indicates Encke was the 2nd comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. Interestingly, the prefix of Halley's Comet is 1P/ because it was the first comet shown to be periodic. In fact Halley did not find the comet. It was named after him after he

successfully predicted its return. You will also see references to another naming system, best explained with an example. You will notice one of the Comet LINEARs is referred to as 'C/2003 K4'. 2003 refers to the year, K is the 10th half month period ('I' is not used) during the year and 4 shows it was the 4th discovery in this half of the month. Therefore LINEAR was the 4th comet discovered in the 2nd half of May 2003.

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 comets that are expected to be observable during 2005. The table (opposite) lists these objects as well as their orbital elements. This is the data required to calculate their locations in the sky. It lists all the known comets expected to be visible that reach perihelion (closest approach to the Sun) during 2005. There are also a few included that are bright during 2005 but have a perihelion date in 2004. The elements are followed by 'ephemerides' (a list of expected positions in the sky and magnitude estimates for different dates) for some of the brighter comets. 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 likely be considered unfavourable.

Many of the comets expected in 2005 are extremely faint and would require professional-size telescopes or long exposure astrophotographs to detect them, but who knows what could be discovered tomorrow? For example, the newly discovered C/2004 Q2 may be visible through binoculars early in the year.

NOTES ON SELECTED COMETS FOR 2005 – by Greg Bryant

Comet 9P/Tempel: Wilhelm Tempel, one of the prolific comet discoverers of the 19th century, discovered this comet on April 3 1867. Ninth magnitude at the time, the comet's brightness remained relatively unchanged until perihelion, which occurred on May 24. The comet was observed until August 27, and the extensive arc of observations enabled a good orbit to be calculated. It was found that the comet was of short-period, orbiting the Sun every 5.7 years.

The comet was observed at its returns in 1873 and 1879, but following an approach of 0.55 AU to Jupiter in 1881, the comet was lost. In 1963, Brian Marsden investigated the comet's history and found that additional encounters with Jupiter in 1941 (0.41 AU) and 1953 (0.77 AU) had further altered the comet's orbit, such that the comet's perihelion distance and orbital period was now smaller than in 1873. Comet Tempel was observed again in 1967 and 1972, and has been observed at every apparition since. In July 2005, Comet Tempel will be the focus of much attention. The Deep Impact spacecraft, scheduled for launch in December 2004, will release an impactor that will collide with the comet, creating a very large crater. The resulting eruption of dust and ice should also see the comet brighten, perhaps by several magnitudes to 5th magnitude.

Comet 21P/Giacobini-Zinner: Michel Giacobini initially discovered this comet on December 20, 1900 (the last comet discovery of the 19th century) when it was near Upsilon Aquarii. The comet was 10th magnitude around discovery. While the comet was recognized as being of short period, calculations of its orbital period were out by several months. The comet was missed in 1907, and expectations were that it would similarly go unseen in 1914.

However, on October 23, 1913, Ernst Zinner accidentally discovered a comet whilst observing variable stars near Beta Scuti. A week later, it was suggested that the comet may be a return of Giacobini's 1900 comet, but it wasn't until mid-November that the identity was confirmed, and thus the comet was renamed Giacobini-Zinner.

Twenty years ago, in September 1985, Giacobini-Zinner became very well known among astronomers, as it became the target of the first ever spacecraft flyby. The International Cometary Explorer (ICE), launched in 1978 to study the Sun-Earth environment before being renamed, passed within 8,000 km of Giacobini-Zinner. ICE also managed to make distant non-visual observations of Comet Halley in 1986.

Comet 37P/Forbes: This is comet Forbes' 10th return since its discovery in 1929, including the perihelion of that year which occurred some two months pre-discovery, but not all of the returns have been observed. Alexander Forbes of South Africa visually discovered this comet on August 1, 1929. It was followed for some three months, which enabled an accurate short-period orbit to be calculated. However, the 1935 return was very unfavourable, and the subsequent return in 1942 saw the comet unsighted until three months after perihelion. Comet Forbes has also been missed at its 1955 and 1967 returns, but it has been seen at every perihelion passage since.

Comet 49P/Arend-Rigaux: Astronomers Sylvain Arend and Fernand Rigaux discovered this comet on photographic plates taken as part of a survey of minor planets on February 5 and 6, 1951. The comet, 11th magnitude at the time, was described as diffuse with a central condensation, hence its classification as a comet. Since then, however, it has only shown a coma or tail on a few occasions under very favourable apparitions and is regarded to be on the verge of becoming totally inactive.

Comet 62P/Tsuchinshan: Discovered in January 1965, and named after the Purple Mountain Observatory in China at which it was first spotted, Tsuchinshan is making its 7th observed apparition. Prior to its discovery, Tsuchinshan made a close approach (0.14 AU) to Jupiter in December 1960, reducing its perihelion distance by nearly 0.6 AU and its period by more than a year. In 2004, Tsuchinshan reaches perihelion in December and should be between 12th and 13th magnitude in the morning skies of

October 2004 to February 2005.

Comet 78P/Gehrels: During the course of a minor planet survey, Tom Gehrels discovered this comet on photographic plates taken with Palomar's 1.2m Schmidt telescope in the United States in 1973 between September 29 and October 5. At its last return in 1997, Gehrels 2 was observed quite favourably. This year, Gehrels 2 will be a telescopic object visible in the second half of 2004 and in early 2005.

Comet 141P/Machholz: American amateur Donald Machholz discovered this comet on August 13, 1994. Tenth magnitude at the time, calculations over the following fortnight surprisingly revealed it to be of short period — only 5.2 years in length — and making this Machholz's second periodic comet. That same month, on August 28, Austrian amateur Michael Jager discovered another comet less than a degree from comet Machholz. He noted that the new discovery had the same motion as Machholz, and it was realised that the comet had split. At the comet's first predicted return in 1999, it peaked in brightness at about 10th magnitude, several magnitudes fainter than had been predicted.

Comet P/1983 V1 (Hartley-IRAS): On November 10, 1983, a new comet was detected on images taken with the orbiting Infrared Astronomy Satellite (IRAS). Upon being asked to confirm the object, astronomers at the UK Schmidt Telescope at Siding Spring reported that Malcolm Hartley had already discovered a comet on November 4 and it appeared that the two might be the same, which was subsequently confirmed.

Visual observations over the next few weeks, including an independent discovery by David Levy, revealed the comet to be 11th magnitude. By mid-December, it had become apparent that the comet was of intermediate period, in the order of 20 years. Comet Hartley-IRAS surprisingly brightened to 8th magnitude by late January 1984, and it was visually followed until June of that year.

This is Hartley-IRAS' first return to the inner Solar System since 1984, but unfortunately it is not a favourable return for Australia. Northern hemisphere observers are better placed, as the comet will be circumpolar for most northern comet watchers during mid 2005.

Comet C/2003 K4 (LINEAR): This comet was discovered on May 28, 2003, by the LINEAR program, and an initial preliminary orbit suggested that it would not enter the inner Solar System. Shortly afterwards, orbital calculators noted that additional measured positions suggested a vastly different orbit, reaching perihelion in late 2004, and this was confirmed a few days later by the Central Bureau. A first-time visitor to the inner Solar System, comet LINEAR may brighten to 7th magnitude or better in Spring 2004 before fading.

Comet C/2003 T4 (LINEAR): On October 13, 2003, the LINEAR program discovered a 20th magnitude asteroidal object that was subsequently revealed to be a comet. Initially thought to be remaining in the outer Solar System, orbital calculations dramatically changed a month later when it was revealed that the comet would instead reach perihelion at 0.8 AU from the Sun in April 2005. Our best views of the comet will come in autumn when it may reach 6th magnitude in the morning sky.

Comet C/2004 Q2 (Machholz): On the morning of August 27, 2004, American amateur Donald Machholz discovered C/2004 Q2 using a 150mm f/8 reflector. This was his 10th discovery. The comet was in a fairly empty region in Eridanus, and was at 11th magnitude, but could reach 4th magnitude by January 2005.

BIOGRAPHICAL NOTE – Greg Bryant, who often observes comets from north of Sydney, is a Contributing Editor for *Sky & Telescope* magazine and can be reached at gchbryant@fastmail.fm

COMETS FOR 2005 – ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q AU	e	Period years	ω °	Ω °	Incl. °	H1	K1
C/2003 K4 (LINEAR)	2004 10 13.7154	1.023621	1.000360	-	198.4401	18.6752	134.2527	4.5	7.5
78P/Gehrels	2004 10 27.0675	2.008183	0.462535	7.2	192.9623	210.5472	6.2527	1.5	30.0
62P/Tsuchinshan	2004 12 07.9463	1.489255	0.577811	6.6	22.8480	96.7684	10.5023	8.0	25.0
56P/Slaughter-Burnham	2005 01 15.0207	2.535226	0.503867	11.6	44.0969	346.2714	8.1555	8.5	15.0
C/2004 Q2 (Machholz)	2005 01 24.849	1.203790	1.000000	-	19.5710	93.5890	38.5950	5.5	10.0
10P/Tempel	2005 02 15.0384	1.426861	0.535387	5.4	195.5585	117.8488	12.0177	13.5	7.0
49P/Arend-Rigaux	2005 02 24.5575	1.368551	0.611593	6.6	330.7017	121.6483	18.3021	11.3	11.0
141P/Machholz	2005 03 02.5490	0.752967	0.750216	5.2	149.2591	246.1594	12.7959	12.0	30.0
32P/Comas Sola	2005 04 01.3238	1.833015	0.569242	8.8	45.8249	60.7946	12.9275	7.0	18.0
C/2003 T4 (LINEAR)	2005 04 03.6259	0.849656	1.000617	-	181.6760	93.9042	86.7620	6.5	7.5
P/1998 X1 (ODAS)	2005 05 02.5290	1.981029	0.447028	6.8	69.0300	358.7489	1.3495	13.0	10.0
119P/Parker-Hartley	2005 05 24.3217	3.044494	0.290722	8.9	181.4101	244.0938	5.1878	2.0	23.0
129P/Shoemaker-Levy	2005 06 04.6975	2.806946	0.249371	7.2	181.6735	303.6319	5.0120	11.0	8.0
P/1983 V1 (Hartley-IRAS)	2005 06 25.6089	1.275183	0.835147	21.5	47.0775	1.3976	95.6972	8.5	10.0
91P/Russell	2005 06 26.8334	2.601924	0.330790	7.7	354.7025	247.8970	14.0924	11.5	10.0
21P/Giacobini-Zinner	2005 07 02.7761	1.037915	0.705699	6.6	172.5443	195.4300	31.8109	9.0	18.0
9P/Tempel	2005 07 05.3153	1.506167	0.517491	5.5	178.8390	68.9373	10.5301	6.0	21.0
107P/Wilson-Harrington	2005 07 10.7268	0.992946	0.623714	4.3	91.2809	270.5736	2.7853	-	-
P/2000 G1 (LINEAR)	2005 07 13.9009	0.998476	0.673114	5.4	343.3476	190.9813	10.3951	-	-
138P/Shoemaker-Levy	2005 07 19.9161	1.707303	0.529468	6.9	95.6498	309.4433	10.0793	14.0	15.0
37P/Forbes	2005 08 01.7455	1.572394	0.541357	6.4	329.2577	315.1000	8.9584	10.5	12.0
P/1998 W1 (Spahr)	2005 09 03.3994	1.729687	0.509498	6.6	346.8446	101.9198	21.9545	13.5	10.0
105P/Singer-Brewster	2005 09 11.3484	2.041290	0.410908	6.5	46.6484	192.4717	9.1796	11.5	15.0
P/1998 W2 (Hergenrother)	2005 11 02.2064	1.425770	0.607484	6.9	13.8801	356.5030	21.8938	15.5	10.0
117P/Helin-Roman-Alu	2005 12 19.9071	3.036972	0.255594	8.2	222.6710	58.9404	8.7081	3.0	20.0
60P/Tsuchinshan	2005 12 24.0554	1.766389	0.507113	6.8	203.3490	288.1247	6.7184	11.5	15.0
101P/Chernykh	2005 12 24.9997	2.350552	0.593851	13.9	163.1713	130.2694	5.0800	7.5	15.0

Perihelion Date	Date of closest approach to the Sun.	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.
q	The perihelion distance, in AU (Astronomical Units)	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).
e	The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to one 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.	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.
Period	The comet's period in years. The time taken for one orbit of the Sun.	K1	A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' for further details)
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).		
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 9P/Tempel

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2005 Mar 5	13 29.6	+10 41	1.022	1.912	143	12.0
2005 Mar 12	13 29.7	+11 20	0.951	1.874	149	11.6
2005 Mar 19	13 28.2	+11 58	0.890	1.837	154	11.3
2005 Mar 26	13 25.1	+12 33	0.837	1.801	158	11.0
2005 Apr 2	13 20.7	+12 58	0.794	1.767	160	10.7
2005 Apr 9	13 15.1	+13 10	0.760	1.734	159	10.4
2005 Apr 16	13 09.1	+13 03	0.736	1.702	156	10.2
2005 Apr 23	13 03.2	+12 33	0.720	1.672	151	10.0
2005 Apr 30	12 58.1	+11 40	0.713	1.644	145	9.8
2005 May 7	12 54.2	+10 23	0.712	1.618	140	9.7
2005 May 14	12 52.2	+08 45	0.718	1.594	134	9.5
2005 May 21	12 52.1	+06 47	0.730	1.573	128	9.4
2005 May 28	12 54.2	+04 34	0.746	1.554	123	9.4
2005 Jun 4	12 58.3	+02 08	0.766	1.539	119	9.4
2005 Jun 11	13 04.5	-00 27	0.790	1.526	115	9.3
2005 Jun 18	13 12.6	-03 09	0.818	1.516	111	9.4
2005 Jun 25	13 22.4	-05 54	0.849	1.510	108	9.4
2005 Jul 2	13 33.9	-08 41	0.882	1.507	105	9.5
2005 Jul 9	13 46.8	-11 26	0.920	1.507	102	9.6
2005 Jul 16	14 01.1	-14 07	0.960	1.510	100	9.7
2005 Jul 23	14 16.7	-16 43	1.004	1.517	97	9.8
2005 Jul 30	14 33.4	-19 11	1.052	1.526	95	10.0
2005 Aug 6	14 51.2	-21 29	1.103	1.539	93	10.1
2005 Aug 13	15 09.9	-23 36	1.159	1.555	91	10.3
2005 Aug 20	15 29.5	-25 30	1.218	1.574	89	10.6
2005 Aug 27	15 49.7	-27 11	1.281	1.595	87	10.8
2005 Sep 3	16 10.5	-28 37	1.348	1.619	86	11.0
2005 Sep 10	16 31.7	-29 49	1.420	1.645	84	11.3
2005 Sep 17	16 53.1	-30 45	1.495	1.673	82	11.6
2005 Sep 24	17 14.7	-31 27	1.574	1.704	79	11.8

Comet C/2003 K4 (LINEAR)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2004 Oct 30	12 23.9	-19 24	1.831	1.060	28	6.0
2004 Nov 6	12 16.4	-23 24	1.735	1.097	36	6.0
2004 Nov 13	12 07.0	-27 52	1.628	1.144	44	6.0
2004 Nov 20	11 54.5	-32 56	1.516	1.199	52	6.0
2004 Nov 27	11 37.1	-38 41	1.405	1.262	61	6.0
2004 Dec 4	11 11.3	-45 06	1.303	1.331	70	6.0
2004 Dec 11	10 31.2	-51 48	1.220	1.404	78	6.0
2004 Dec 18	09 28.4	-57 38	1.167	1.480	87	6.1
2004 Dec 25	08 00.4	-60 34	1.153	1.559	93	6.3
2005 Jan 1	06 28.3	-59 00	1.184	1.640	98	6.5
2005 Jan 8	05 18.9	-53 56	1.258	1.722	100	6.8
2005 Jan 15	04 34.9	-47 36	1.370	1.805	99	7.1
2005 Jan 22	04 08.0	-41 23	1.511	1.888	96	7.5
2005 Jan 29	03 51.5	-35 51	1.674	1.972	92	7.8
2005 Feb 5	03 41.5	-31 05	1.851	2.057	87	8.2
2005 Feb 12	03 35.6	-27 01	2.037	2.141	82	8.5
2005 Feb 19	03 32.4	-23 35	2.227	2.225	77	8.8
2005 Feb 26	03 31.3	-20 38	2.419	2.308	72	9.1
2005 Mar 5	03 31.5	-18 07	2.609	2.392	67	9.4
2005 Mar 12	03 32.7	-15 56	2.795	2.475	61	9.7
2005 Mar 19	03 34.7	-14 03	2.975	2.558	56	9.9
2005 Mar 26	03 37.4	-12 24	3.148	2.640	51	10.2
2005 Apr 2	03 40.4	-10 58	3.313	2.722	46	10.4
2005 Apr 9	03 43.8	-09 42	3.469	2.803	42	10.6
2005 Apr 16	03 47.4	-08 36	3.614	2.884	38	10.7
2005 Apr 23	03 51.2	-07 39	3.748	2.964	34	10.9
2005 Apr 30	03 55.1	-06 49	3.871	3.044	30	11.1
2005 May 7	03 59.0	-06 06	3.982	3.123	28	11.2
2005 May 14	04 02.9	-05 30	4.080	3.202	26	11.3
2005 May 21	04 06.8	-05 00	4.165	3.280	25	11.5
2005 May 28	04 10.5	-04 36	4.238	3.358	26	11.6
2005 Jun 4	04 14.2	-04 17	4.298	3.435	28	11.7
2005 Jun 11	04 17.6	-04 04	4.346	3.512	31	11.8
2005 Jun 18	04 20.8	-03 55	4.381	3.588	34	11.9
2005 Jun 25	04 23.7	-03 52	4.405	3.664	39	11.9
2005 Jul 2	04 26.3	-03 53	4.417	3.739	43	12.0



Comet Halley, March 23, 1986

Comet 78P/Gehrels

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2004 Oct 30	03 22.2	+15 26	1.034	2.008	164	10.7
2004 Nov 6	03 18.9	+14 34	1.024	2.010	172	10.6
2004 Nov 13	03 15.2	+13 43	1.025	2.013	176	10.7
2004 Nov 20	03 11.5	+12 55	1.038	2.018	170	10.7
2004 Nov 27	03 08.4	+12 14	1.062	2.024	162	10.8
2004 Dec 4	03 06.2	+11 41	1.097	2.032	155	10.9
2004 Dec 11	03 05.2	+11 19	1.142	2.042	147	11.1
2004 Dec 18	03 05.5	+11 07	1.197	2.053	140	11.3
2004 Dec 25	03 07.2	+11 06	1.260	2.066	134	11.5
2005 Jan 1	03 10.4	+11 14	1.330	2.080	127	11.7
2005 Jan 8	03 14.8	+11 30	1.407	2.095	122	11.9

Comet 21P/Giacobini-Zinner

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2005 May 14	23 35.4	+21 07	1.548	1.246	53	11.7
2005 May 21	00 05.7	+22 26	1.509	1.197	52	11.3
2005 May 28	00 37.2	+23 25	1.477	1.152	51	11.0
2005 Jun 4	01 09.7	+24 00	1.453	1.114	50	10.7
2005 Jun 11	01 42.8	+24 08	1.437	1.082	49	10.4
2005 Jun 18	02 16.2	+23 48	1.427	1.059	48	10.2
2005 Jun 25	02 49.3	+23 01	1.425	1.044	47	10.1
2005 Jul 2	03 21.8	+21 48	1.429	1.038	47	10.1
2005 Jul 9	03 53.2	+20 13	1.439	1.042	46	10.1
2005 Jul 16	04 23.3	+18 19	1.454	1.055	47	10.2
2005 Jul 23	04 51.8	+16 10	1.473	1.076	47	10.4
2005 Jul 30	05 18.7	+13 51	1.496	1.106	48	10.7
2005 Aug 6	05 43.8	+11 25	1.521	1.143	49	11.0
2005 Aug 13	06 07.2	+08 55	1.548	1.186	50	11.3
2005 Aug 20	06 28.9	+06 24	1.575	1.234	52	11.6
2005 Aug 27	06 49.0	+03 52	1.603	1.287	53	12.0

EXPLANATION OF COMET EPHEMERIDES

Date	is for 0 hr UT (10am EST, 9:30am CST and 8am WST) of date.
R.A., Dec	Right Ascension and Declination are for equinox 2000.0
Δ (delta)	Geocentric distance (distance from the Earth) in AU.
R	Heliocentric distance (distance from the Sun) in AU.
Elg	Elongation; angular distance of the comet from the Sun.
Mag	This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is invariably based on the behaviour of its brightness during previous return(s).

Comet C/2003 T4 (LINEAR)						
Date	R.A. h m	Dec ° ' "	Δ AU	R AU	Elg °	Mag
2004 Nov 13	15 29.7	+57 51	2.466	2.423	76	11.3
2004 Nov 20	15 56.5	+55 34	2.380	2.334	75	11.1
2004 Nov 27	16 22.1	+53 05	2.302	2.245	74	10.9
2004 Dec 4	16 46.4	+50 26	2.232	2.155	73	10.7
2004 Dec 11	17 09.4	+47 39	2.170	2.064	71	10.5
2004 Dec 18	17 31.2	+44 46	2.114	1.973	68	10.3
2004 Dec 25	17 51.8	+41 50	2.064	1.881	65	10.1
2005 Jan 1	18 11.3	+38 52	2.018	1.789	62	9.9
2005 Jan 8	18 29.8	+35 53	1.975	1.697	59	9.7
2005 Jan 15	18 47.4	+32 54	1.934	1.605	56	9.5
2005 Jan 22	19 04.1	+29 55	1.892	1.513	53	9.2
2005 Jan 29	19 20.2	+26 54	1.848	1.421	50	9.0
2005 Feb 5	19 35.7	+23 50	1.800	1.332	47	8.7
2005 Feb 12	19 50.9	+20 41	1.748	1.244	44	8.4
2005 Feb 19	20 05.9	+17 22	1.688	1.160	42	8.1
2005 Feb 26	20 21.0	+13 48	1.622	1.081	41	7.8
2005 Mar 5	20 36.8	+09 54	1.548	1.009	40	7.5
2005 Mar 12	20 53.7	+05 33	1.467	0.947	40	7.2
2005 Mar 19	21 12.6	+00 38	1.382	0.898	40	6.9
2005 Mar 26	21 34.5	-04 57	1.295	0.865	42	6.6
2005 Apr 2	22 01.1	-11 13	1.213	0.850	44	6.4
2005 Apr 9	22 33.8	-18 01	1.145	0.856	46	6.3
2005 Apr 16	23 14.2	-24 55	1.098	0.880	49	6.3
2005 Apr 23	00 02.8	-31 12	1.082	0.922	52	6.4
2005 Apr 30	00 57.9	-36 02	1.100	0.979	55	6.6
2005 May 7	01 55.0	-38 56	1.151	1.046	58	7.0
2005 May 14	02 48.9	-40 02	1.230	1.122	59	7.3
2005 May 21	03 35.9	-39 50	1.330	1.204	60	7.7
2005 May 28	04 15.2	-38 57	1.443	1.290	60	8.1
2005 Jun 4	04 47.5	-37 48	1.566	1.379	60	8.5
2005 Jun 11	05 14.2	-36 39	1.692	1.470	60	8.9
2005 Jun 18	05 36.6	-35 37	1.818	1.561	59	9.2
2005 Jun 25	05 55.5	-34 46	1.943	1.654	58	9.6
2005 Jul 2	06 11.8	-34 08	2.063	1.746	58	9.9
2005 Jul 9	06 25.9	-33 42	2.179	1.838	57	10.2
2005 Jul 16	06 38.3	-33 28	2.288	1.930	57	10.4
2005 Jul 23	06 49.2	-33 25	2.390	2.022	57	10.7
2005 Jul 30	06 58.8	-33 32	2.484	2.113	57	10.9
2005 Aug 6	07 07.2	-33 48	2.571	2.203	58	11.1
2005 Aug 13	07 14.6	-34 14	2.649	2.293	59	11.3
2005 Aug 20	07 20.9	-34 47	2.720	2.382	60	11.5
2005 Aug 27	07 26.2	-35 28	2.782	2.470	62	11.7
2005 Sep 3	07 30.5	-36 15	2.837	2.557	64	11.8
2005 Sep 10	07 33.7	-37 08	2.885	2.644	66	12.0
2005 Sep 17	07 35.8	-38 06	2.926	2.730	69	12.1
2005 Sep 24	07 36.7	-39 07	2.960	2.815	72	12.2

Comet 141P/Machholz						
Date	R.A. h m	Dec ° ' "	Δ AU	R AU	Elg °	Mag
2005 Feb 5	22 05.6	-05 14	1.767	0.868	17	11.4
2005 Feb 12	22 38.0	-02 38	1.701	0.816	18	10.5
2005 Feb 19	23 12.3	+00 08	1.639	0.778	19	9.8
2005 Feb 26	23 48.6	+03 00	1.586	0.757	22	9.4
2005 Mar 5	00 26.6	+05 49	1.542	0.754	24	9.3
2005 Mar 12	01 05.8	+08 29	1.510	0.770	27	9.5
2005 Mar 19	01 45.9	+10 51	1.492	0.803	30	10.0
2005 Mar 26	02 26.1	+12 51	1.490	0.851	33	10.8
2005 Apr 2	03 05.7	+14 23	1.506	0.910	36	11.7

C/2004 Q2 (Machholz)						
Date	R.A. h m	Dec ° ' "	Δ AU	R AU	Elg °	Mag
2004 Nov 6	05 12.6	-30 13	0.961	1.706	122	7.7
2004 Nov 13	05 10.7	-30 15	0.861	1.636	124	7.3
2004 Nov 20	05 06.4	-29 42	0.764	1.569	127	6.9
2004 Nov 27	04 59.6	-28 16	0.672	1.505	129	6.4
2004 Dec 4	04 50.1	-25 35	0.585	1.445	132	5.9
2004 Dec 11	04 38.1	-21 08	0.506	1.390	135	5.4
2004 Dec 18	04 23.8	-14 11	0.437	1.340	138	5.0
2004 Dec 25	04 07.9	-04 08	0.384	1.296	139	4.5
2005 Jan 1	03 51.2	+09 02	0.352	1.260	136	4.2
2005 Jan 8	03 34.6	+23 58	0.347	1.232	129	4.1
2005 Jan 15	03 19.2	+38 15	0.369	1.214	121	4.2
2005 Jan 22	03 05.9	+50 13	0.412	1.205	113	4.4
2005 Jan 29	02 55.6	+59 36	0.468	1.206	107	4.7
2005 Feb 5	02 49.8	+66 53	0.533	1.216	102	5.0
2005 Feb 12	02 50.7	+72 40	0.602	1.237	99	5.3
2005 Feb 19	03 02.8	+77 25	0.673	1.266	98	5.7
2005 Feb 26	03 37.2	+81 20	0.744	1.304	97	6.0
2005 Mar 5	05 02.3	+84 13	0.814	1.349	96	6.4
2005 Mar 12	07 42.3	+85 00	0.885	1.400	96	6.7
2005 Mar 19	09 51.1	+83 10	0.956	1.456	97	7.0
2005 Mar 26	10 52.0	+80 07	1.027	1.517	97	7.4
2005 Apr 2	11 22.5	+76 39	1.099	1.581	98	7.7
2005 Apr 9	11 40.6	+73 00	1.174	1.649	98	8.0
2005 Apr 16	11 53.2	+69 16	1.253	1.719	99	8.3
2005 Apr 23	12 03.1	+65 30	1.335	1.791	99	8.7
2005 Apr 30	12 11.5	+61 44	1.421	1.864	99	9.0
2005 May 7	12 19.3	+58 01	1.513	1.939	99	9.3
2005 May 14	12 26.6	+54 21	1.610	2.015	98	9.6
2005 May 21	12 33.8	+50 48	1.713	2.091	97	9.9
2005 May 28	12 40.9	+47 21	1.822	2.168	96	10.2
2005 Jun 4	12 48.0	+44 03	1.936	2.246	94	10.4
2005 Jun 11	12 55.1	+40 52	2.057	2.323	92	10.7
2005 Jun 18	13 02.3	+37 51	2.182	2.401	90	11.0
2005 Jun 25	13 09.6	+34 58	2.312	2.478	87	11.3
2005 Jul 2	13 17.0	+32 15	2.446	2.556	84	11.5
2005 Jul 9	13 24.4	+29 39	2.584	2.633	82	11.8
2005 Jul 16	13 31.9	+27 13	2.725	2.710	78	12.0

Comet P/1983 V1 (Hartley-IRAS)						
Date	R.A. h m	Dec ° ' "	Δ AU	R AU	Elg °	Mag
2005 May 7	01 07.1	+10 28	2.268	1.446	27	11.9
2005 May 14	01 12.9	+14 43	2.163	1.404	31	11.6
2005 May 21	01 19.0	+19 23	2.054	1.367	36	11.4
2005 May 28	01 25.6	+24 33	1.943	1.335	40	11.2
2005 Jun 4	01 33.0	+30 18	1.833	1.310	44	11.0
2005 Jun 11	01 41.6	+36 44	1.727	1.291	48	10.8
2005 Jun 18	01 52.0	+43 55	1.632	1.280	52	10.6
2005 Jun 25	02 05.8	+51 50	1.552	1.275	55	10.5
2005 Jul 2	02 26.0	+60 23	1.492	1.278	58	10.4
2005 Jul 9	03 01.0	+69 12	1.457	1.289	60	10.4
2005 Jul 16	04 19.2	+77 20	1.451	1.306	61	10.5
2005 Jul 23	07 38.1	+81 26	1.474	1.330	61	10.6
2005 Jul 30	10 46.1	+77 28	1.523	1.361	61	10.8
2005 Aug 6	11 58.8	+70 39	1.596	1.397	60	11.0
2005 Aug 13	12 32.5	+63 51	1.686	1.438	58	11.2
2005 Aug 20	12 52.6	+57 41	1.789	1.484	56	11.5
2005 Aug 27	13 06.7	+52 13	1.900	1.533	54	11.7
2005 Sep 3	13 17.7	+47 25	2.015	1.585	51	12.0

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. 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 K 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.

PART III – APPENDICES

CONSTELLATIONS – Abbreviations and Culmination at 9pm

Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.
Andromeda	Andromedae	And	Nov 23	Crux	Crucis	Cru	May 12	Orion	Orionis	Ori	Jan 27
Antlia	Antliae	Ant	Apr 10	Cygnus	Cygni	Cyg	Sep 13	Pavo	Pavonis	Pav	Aug 29
Apus	Apodis	Aps	Jul 5	Delphinus	Delphini	Del	Sep 14	Pegasus	Pegasi	Peg	Oct 16
Aquarius	Aquarii	Aqr	Oct 9	Dorado	Doradus	Dor	Jan 31	Perseus	Persei	Per	Dec 22
Aquila	Aquilae	Aql	Aug 30	Draco	Draconis	Dra	Jul 8	Phoenix	Phoenicis	Phe	Nov 18
Ara	Arae	Ara	Jul 25	Equuleus	Equulei	Equ	Sep 22	Pictor	Pictoris	Pic	Jan 30
Aries	Arietis	Ari	Dec 14	Eridanus	Eridani	Eri	Dec 25	Pisces	Piscium	Psc	Nov 11
Auriga	Aurigae	Aur	Feb 4	Fornax	Fornacis	For	Dec 17	Piscis Austrinus	Piscis Austrini	PsA	Oct 9
Bootes	Bootis	Boo	Jun 16	Gemini	Geminorum	Gem	Feb 19	Puppis	Puppis	Pup	Feb 22
Caelum	Caeli	Cae	Jan 15	Grus	Gruis	Gru	Oct 12	Pyxis	Pyxidis	Pyx	Mar 21
Camelopardus	Camelopardi	Cam	Feb 6	Hercules	Herculis	Her	Jul 28	Reticulum	Reticuli	Ret	Jan 3
Cancer	Cancri	Cnc	Mar 16	Horologium	Horologii	Hor	Dec 25	Sagitta	Sagittae	Sge	Aug 30
Canes Venatici	Canum	CVn	May 22	Hydra	Hydrae	Hya	Apr 29	Sagittarius	Sagittarii	Sgr	Aug 21
	Venaticorum			Hydrus	Hydri	Hyi	Dec 10	Scorpius	Scorpii	Sco	Jul 18
Canis Major	Canis Majoris	CMa	Feb 16	Indus	Indi	Ind	Sep 26	Sculptor	Sculptoris	Scl	Nov 10
Canis Minor	Canis Minoris	CMi	Feb 28	Lacerta	Lacertae	Lac	Oct 12	Scutum	Scuti	Sct	Aug 15
Capricornus	Capricorni	Cap	Sep 22	Leo	Leonis	Leo	Apr 15	Serpens	Serpentis	Ser	Jul 21
Carina	Carinae	Car	Mar 17	Leo Minor	Leonis Minoris	LMi	Apr 9	Sextans	Sextantis	Sex	Apr 8
Cassiopeia	Cassiopeiae	Cas	Nov 23	Lepus	Leporis	Lep	Jan 28	Taurus	Tauri	Tau	Jan 14
Centaurus	Centauri	Cen	May 14	Libra	Librae	Lib	Jun 23	Telescopium	Telescopii	Tel	Aug 24
Cepheus	Cephei	Cep	Nov 13	Lupus	Lupi	Lup	Jun 23	Triangulum	Trianguli	Tri	Dec 7
Cetus	Ceti	Cet	Nov 29	Lynx	Lyncis	Lyn	Mar 5	Triangulum	Trianguli	TrA	Jul 7
Chamaeleon	Chamaeleontis	Cha	Apr 15	Lyra	Lyrae	Lyr	Aug 18	Australe	Australis		
Circinus	Circini	Cir	Jun 14	Mensa	Mensae	Men	Jan 28	Tucana	Tucanae	Tuc	Nov 1
Columba	Columbae	Col	Feb 1	Microscopium	Microscopii	Mic	Sep 18	Ursa Major	Ursae Majoris	UMa	Apr 25
Coma Berenices	Comae Berenices	Com	May 17	Monoceros	Monocerotis	Mon	Feb 19	Ursa Minor	Ursae Minoris	UMi	Jun 27
Corona Australis	Coronae Australis	CrA	Aug 14	Musca	Muscae	Mus	May 14	Vela	Velorum	Vel	Mar 30
Corona Borealis	Coronae Borealis	CrB	Jul 3	Norma	Normae	Nor	Jul 3	Virgo	Virginis	Vir	May 26
Corvus	Corvi	Crv	May 12	Octans	Octantis	Oct	Circum	Volans	Volantis	Vol	Mar 4
Crater	Crateris	Crt	Apr 26	Ophiuchus	Ophiuchi	Oph	Jul 26	Vulpecula	Vulpeculae	Vul	Sep 8

BRIGHTEST and NEAREST STARS

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.

ly is light year and **pc** is parsec (see glossary).

Note (d) is a visual double star

(sb) is a spectroscopic binary,

(eb) is an eclipsing binary and

(v) 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 **Oh Be A Fine Girl(Guy) Kiss Me**.

There are also now 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 photographed simply. Mount your normal 35mm camera on a tripod and take a time exposure (some minutes) using a fast film. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., 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 burn out on the negative. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation	Name	Constellation	R.A. (2000.0)	Dec (2000.0)	Magnitude		Spectral Type	Parallax	Distance		Note
					App	Abs			pc	ly	
1	α CMa	Sirius	06 45.1	-16 43	-1.44	1.5	A1 V	0.3800	2.63	8.58	d
2	α Car	Canopus	06 23.9	-52 42	-0.74	-5.6	F0 Ib	0.0104	96	310	
3	α Cen	Rigel Kent	14 39.6	-60 50	-0.28	4.1	G2V + K0V	0.7472	1.34	4.37	d
4	α Boo	Arcturus	14 15.7	+19 11	-0.05	-0.3	K2 III	0.0889	11.3	36.7	
5	α Lyr	Vega	18 36.9	+38 47	0.03	0.6	A0 V	0.1289	7.76	25.3	v
6	α Aur	Capella	05 16.7	+46 00	0.08	-0.5	G8III + G0III	0.0773	12.9	42.2	sb, v
7	β Ori	Rigel	05 14.5	-08 12	0.15	-6.8	B8 Ia	0.0042	240	780	d, v
8	α CMi	Procyon	07 39.3	+05 14	0.38	2.7	F5 IV-V	0.2861	3.50	11.4	d
9	α Eri	Achernar	01 37.7	-57 14	0.45	-2.8	B5 IV	0.0227	44.1	144	v
10	α Ori	Betelgeuse	05 55.2	+07 24	0.50	-5.2	M2 Iab	0.0076	131	430	v
11	β Cen	Hadar	14 03.8	-60 22	0.61	-5.4	B1 II + B	0.0062	161	525	d, v
12	α Cru	Acrux	12 26.6	-63 06	0.74	-4.2	B0.5IV + B0.5V	0.0102	98	320	d
13	α Aql	Altair	19 50.8	+08 52	0.76	2.2	A7 IV-V	0.1950	5.13	16.7	
14	α Tau	Aldebaran	04 35.9	+16 31	0.87	-0.6	K5 III	0.0501	20.0	65	v
15	α Sco	Antares	16 29.4	-26 26	0.96	-5.1	M1.5Iab + B4V	0.0067	150	490	d, v
16	α Vir	Spica	13 25.2	-11 10	0.98	-3.5	B1III-IV + B2V	0.0124	80	262	sb, v
17	β Gem	Pollux	07 45.3	+28 02	1.15	1.1	K0 III	0.0967	10.3	33.7	
18	α PsA	Fomalhaut	22 57.7	-29 37	1.16	1.7	A3 V	0.1301	7.69	25.1	
19	α Cyg	Deneb	20 41.4	+45 17	1.25	-7.2	A2 Ia	0.0020	500	1600	v
20	β Cru	Mimosa	12 47.7	-59 41	1.26	-3.9	B0.5 III	0.0093	108	353	v
21	α Leo	Regulus	10 08.4	+11 58	1.36	-0.5	B7 V	0.0421	23.8	78	d
22	ε CMa	Adhara	06 58.6	-28 58	1.50	-4.1	B2 II	0.0076	132	430	d
23	α Gem	Castor	07 34.6	+31 53	1.58	0.6	A1V + Am	0.0633	15.8	52	d, sb
24	λ Sco	Shaula	17 33.6	-37 06	1.62	-5.0	B1.5 III	0.0046	215	700	sb, v
25	γ Cru	Gacrux	12 31.2	-57 07	1.63	-0.5	M3 III	0.0371	27.0	88	v
26	γ Ori	Bellatrix	05 25.1	+06 21	1.64	-2.7	B2 III	0.0134	75	243	
27	β Tau	El Nath	05 26.3	+28 36	1.65	-1.4	B7 III	0.0249	40.2	131	
28	β Car	Miaplacidus	09 13.2	-69 43	1.67	-1.0	A0 III	0.0293	34.1	111	
29	ε Ori	Alnilam	05 36.2	-01 12	1.69	-6.4	B0 Ia	0.0024	410	1340	
30	γ Vel	Regor	08 09.5	-47 20	1.70	-5.4	O9Ib + WC8	0.0039	258	840	sb, v

THE NEAREST STARS

No	Star Name	Constellation	R.A. 2000.0 Dec		Magnitude		Spect Type	Parallax "	Proper Motion "/yr	Distance	
			hh mm.m	° ' "	Apparent	Absolute				pc	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

MESSIER OBJECTS (Epoch 2000.0)

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M1	NGC1952	05 34.5 + 22° 01'	6	Tau	SNR	8.4	5.3		Crab Nebula, remnant from supernova of A.D. 1054
M2	NGC7089	21 33.5 - 00° 49'	12.9	Aqr	GC	6.5	8		
M3	NGC5272	13 42.2 + 28° 23'	16.2	CVn	GC	6.4	7		Large bright globular, brightens suddenly towards the middle
M4	NGC6121	16 23.6 - 26° 32'	26.3	Sco	GC	5.9	6		Conspicuous globular near Antares
M5	NGC5904	15 18.6 + 02° 05'	17.4	Ser	GC	5.8	6		Bright, large very compressed in middle, slightly oval in shape
M6	NGC6405	17 40.1 - 32° 13'	15	Sco	OC	4.2	6.8		Butterfly Cluster, 80 stars
M7	NGC6475	17 53.9 - 34° 49'	80	Sco	OC	3.3	6.8		Ptolemy's Cluster, 80 stars brighter than 10th magnitude
M8	NGC6523	18 03.8 - 24° 23'	90	Sgr	BN	3.5	6.8		Lagoon Nebula, densest section known as the Hourglass, dark lane
M9	NGC6333	17 19.2 - 18° 31'	9.3	Oph	GC	7.9	6		
M10	NGC6254	16 57.1 - 04° 06'	15.1	Oph	GC	6.6	6		
M11	NGC6705	18 51.1 - 06° 16'	14	Sct	OC	5.8	8		Wild Duck Cluster, rich and compact open cluster
M12	NGC6218	16 47.2 - 01° 57'	14.5	Oph	GC	6.6	6		
M13	NGC6205	16 41.7 + 36° 28'	16.6	Her	GC	5.9	7.9		Great Hercules Cluster, showpiece of northern skies
M14	NGC6402	17 37.6 - 03° 15'	11.7	Oph	GC	7.6	6.7		
M15	NGC7078	21 30.0 + 12° 10'	12.3	Peg	GC	6.4	9		Bright, irregularly round, well resolved into faint stars
M16	NGC6611	18 18.8 - 13° 47'	35	Ser	BN	6	6.8		Associated with Eagle Nebula
M17	NGC6618	18 20.8 - 16° 11'	46	Sgr	BN	6	6.8		Omega or Swan Nebula
M18	NGC6613	18 19.9 - 17° 08'	9	Sgr	OC	6.9	6.8		
M19	NGC6273	17 02.6 - 26° 16'	13.5	Oph	GC	7.2	6		
M20	NGC6514	18 02.3 - 23° 02'	29	Sgr	BN	6.3	6.8		Trifid Nebula, emission and reflection nebulosity cut by dark lanes
M21	NGC6531	18 04.6 - 22° 30'	13	Sgr	OC	5.9	6.8		
M22	NGC6656	18 36.4 - 23° 54'	24	Sgr	GC	5.1	1.6,8		Fine globular, only Omega Centauri and 47 Tucanae are brighter
M23	NGC6494	17 56.8 - 19° 01'	27	Sgr	OC	5.5	6.8		150 stars, moderate brightness range, lies in good star field
M24	NGC6603	18 18.4 - 18° 25'	5	Sgr	OC	6.8			Sagittarius Star Cloud, Delle Caustiche
M25	IC4725	18 31.6 - 19° 15'	32	Sgr	OC	4.6	6.8		30 stars loosely scattered
M26	NGC6694	18 45.2 - 09° 24'	15	Sct	OC	8	8		
M27	NGC6853	19 59.6 + 22° 43'	15.2	Vul	PN	7.3	9		Dumbbell Nebula, bright dumbbell shaped, 14th mag. central star
M28	NGC6626	18 24.5 - 24° 52'	11.2	Sgr	GC	6.9	1.6,8		Large, round, increasingly compressed in the middle
M29	NGC6913	20 23.9 + 38° 32'	7	Cyg	OC	6.6	9		
M30	NGC7099	21 40.4 - 23° 11'	11	Cap	GC	7.5	8		
M31	NGC224	00 42.7 + 41° 16'	178	And	SG	3.5	3.9		Andromeda Galaxy
M32	NGC221	00 42.7 + 40° 52'	7.6	And	EG	8.2	3.9		
M33	NGC598	01 33.9 + 30° 39'	62	Tri	SG	5.7	3		Triangulum or Pinwheel Galaxy, member of Local Group

DEEP SKY

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M34	NGC1039	02 42.0 + 42° 47'	35	Per	OC	5.2	3		
M35	NGC2168	06 08.9 + 24° 20'	28	Gem	OC	5.1	3.5		200 stars, magnitude 9 to 16
M36	NGC1960	05 36.1 + 34° 08'	12	Aur	OC	6	3.5		60 stars, magnitude 9 to 14
M37	NGC2099	05 52.4 + 32° 33'	24	Aur	OC	5.6	3.5		150 stars, magnitude range 9 to 12.5
M38	NGC1912	05 28.7 + 35° 50'	21	Aur	OC	6.4	3.5		100 stars, mag 9.5 in splendid field
M39	NGC7092	21 32.2 + 48° 26'	32	Cyg	OC	4.6	9		
M40	WNC 4	12 22.4 + 58° 05'	0	UMa	DS	-	5.7		Double Star WNC4
M41	NGC2287	06 46.0 - 20° 44'	38	CMa	OC	4.5	4		80 stars, 7th magnitude and fainter, with 6.9 mag. red star near centre
M42	NGC1976	05 35.4 - 05° 27'	66	Ori	BN	3.7	2.3		Orion Nebula, emission and reflection nebula
M43	NGC1982	05 35.6 - 05° 16'	20	Ori	BN		1.3		de Mairan's nebula; part of Orion Nebula
M44	NGC2632	08 40.1 + 19° 59'	95	Cnc	OC	3.1			Praesepe or Beehive Cluster, very large cluster, 50 stars
M45	Pleiades	03 47.0 + 24° 07'	120	Tau	OC	1.2	3		Seven Sisters. naked-eye cluster
M46	NGC2437	07 41.8 - 14° 49'	27	Pup	OC	6.1	4		Rich open cluster, 100 stars, planetary nebula NGC2438 in same field
M47	NGC2422	07 36.6 - 14° 30'	30	Pup	OC	4.4	4		Large coarse cluster with 30 stars
M48	NGC2548	08 13.8 - 05° 48'	54	Hya	OC	5.8	4		Large cluster of 80 stars 8 to 13th mag.
M49	NGC4472	12 29.8 + 08° 00'	8.9	Vir	EG	8.4	7		
M50	NGC2323	07 03.2 - 08° 20'	16	Mon	OC	5.9	4		Rich cluster, 80 stars mags 8 to 12
M51	NGC5194	13 29.9 + 47° 12'	11	CVn	SG	8.4	5		Whirlpool Galaxy
M52	NGC7654	23 24.2 + 61° 35'	13	Cas	OC	6.9	3.9		
M53	NGC5024	13 12.9 + 18° 10'	12.6	Com	GC	7.7	7		Bright centre region, very compressed
M54	NGC6715	18 55.1 - 30° 29'	9.1	Sgr	GC	7.7	1.6,8		
M55	NGC6809	19 40.0 - 30° 58'	19	Sgr	GC	6.3	8		
M56	NGC6779	19 16.6 + 30° 11'	7.1	Lyr	GC	8.3	9		Irregularly round, compressed in the middle
M57	NGC6720	18 53.6 + 33° 02'	2.5	Lyr	PN	8.6	7.9		Ring Nebula, ring structure
M58	NGC4579	12 37.7 + 11° 49'	5.4	Vir	SG	9.8	7		Bright diffuse nucleus, dark lanes
M59	NGC4621	12 42.0 + 11° 39'	5.1	Vir	EG	9.8	7		
M60	NGC4649	12 43.7 + 11° 33'	7.2	Vir	EG	8.8	7		
M61	NGC4303	12 21.9 + 04° 28'	6	Vir	SG	9.7	7		
M62	NGC6266	17 01.2 - 30° 07'	14.1	Oph	GC	6.6	6.8		
M63	NGC5055	13 15.8 + 42° 02'	12.3	CVn	SG	8.6	5.7		Sunflower Galaxy
M64	NGC4826	12 56.7 + 21° 41'	9.3	Com	SG	8.5	7		Blackeye Galaxy
M65	NGC3623	11 18.9 + 13° 05'	10	Leo	SG	9.3	5		
M66	NGC3627	11 20.2 + 12° 59'	8.7	Leo	SG	9	5		
M67	NGC2682	08 50.4 + 11° 49'	30	Cnc	OC	6.9	5		200 stars mag. 10-15, large and rich
M68	NGC4590	12 39.5 - 26° 45'	12	Hya	GC	8.2	4.6		Rich and compressed
M69	NGC6637	18 31.4 - 32° 21'	7.1	Sgr	GC	7.7	1.6,8		
M70	NGC6681	18 43.2 - 32° 18'	7.8	Sgr	GC	8.1	1.6,8		
M71	NGC6838	19 53.8 + 18° 47'	7.2	Sge	GC	8.3	9		
M72	NGC6981	20 53.5 - 12° 32'	5.9	Aqr	GC	9.4	8		
M73	NGC6994	20 59.0 - 12° 38'	3	Aqr	OC	9	8		
M74	NGC628	01 36.7 + 15° 47'	10.2	Psc	SG	9.2	3		

OTHER NON-STELLAR OBJECTS (Epoch 2000.0)

Cat	R.A.	Dec	Size	Con.	Type	Mag	Notes
SMC	00 52.7	-72° 30'	5"x4"	Tuc	IG	2.3	Small Magellanic Cloud. Visible to unaided eye from dark sky
NGC55	00 14.9	-39° 11'	30"x6.3'	Scl	SG	8.1	A bright galaxy in the Sculptor Group
NGC104	00 24.1	-72° 05'	30.9"	Tuc	GC	3.8	47 Tucanae, one of the finest globulars
NGC253	00 47.6	-25° 17'	30"x6.9"	Scl	SG	7.6	Silver Coin galaxy. Large, bright edge-on spiral
Hyades	04 27.0	+16° 00'	6"	Tau	OC	0.5	Naked-eye, V-shaped cluster. 28 stars, the brighter mag. 3 and 4
LMC	05 23.6	-69° 45'	9"x10"	Dor	IG	0.1	Large Magellanic Cloud. Visible to unaided eye from dark sky
NGC2070	05 38.6	-69° 05'	30"x20'	Dor	BN	5.4	30 Doradus, Tarantula Nebula, complex structure
NGC2169	06 08.4	+13° 57'	6'	Ori	OC	5.9	Rich loose cluster, 30 stars magnitude 7 and fainter
NGC2244	06 32.4	-04° 52'	23'	Mon	OC	4.8	100 stars, with nebulosity (Rosette Nebula)
NGC2264	06 41.1	+09° 53'	20'	Mon	OC	3.9	Christmas Tree cluster
NGC2301	06 51.8	+00° 28'	12'	Mon	OC	6.0	Rich cluster, 80 stars, large magnitude range
NGC2362	07 18.8	-24° 57'	8"	CMA	OC	4.1	60 stars, large brightness range (4th mag. down)
NGC2451	07 45.4	-37° 58'	45'	Pup	OC	2.8	Rich in stars with slight central concentration
NGC2477	07 52.3	-38° 33'	27'	Pup	OC	5.8	160 stars, mag. 10 to 12, central concentration
NGC2516	07 58.3	-60° 52'	29'	Car	OC	3.8	80 stars 6th mag. and fainter, central concentration
NGC2547	08 10.7	-49° 16'	74'	Vel	OC	4.7	Rich in stars with strong central concentration
IC2391	08 40.2	-53° 04'	50'	Vel	OC	2.5	Moderately rich in bright and faint stars
IC2395	08 41.1	-48° 12'	7'	Vel	OC	4.6	40 stars 6th magnitude and fainter
NGC2808	09 12.0	-64° 52'	13.8'	Car	GC	6.1	Large and rich, compressed centre, mag 13 – 15
NGC3114	10 02.7	-60° 07'	35'	Car	OC	4.2	Rich cluster, stars 9 to 14th magnitude
NGC3132	10 07.1	-40° 26'	30"	PN	PN	8.2	The Eight Burst Nebula, ring and disk
IC2602	10 43.2	-64° 24'	50'	Car	OC	1.9	Central concentration, brightest mag. 3
NGC3372	10 43.8	-59° 52'		Car	BN	2.5	Eta Carinae Nebula, bright, prominent dark lanes
NGC3532	11 06.4	-58° 40'	55'	Car	OC	3.0	Rich and large, 150 stars 7 to 12th magnitude
NGC3766	11 36.1	-61° 37'	12'	Cen	OC	5.3	Rich cluster, 100 stars magnitude range 7 to 12th
NGC4755	12 53.6	-60° 20'	10'	Cru	OC	4.2	Jewel Box, rich in stars, large brightness range
NGC4945	13 05.4	-49° 28'	23"x5.9"	Cen	SG	9.0	Big edge on spiral, small galaxy in same field
NGC5128	13 25.5	-43° 01'	31"x23'	Cen	G	6.7	Centaurus A, bright sphere crossed by dark lane
NGC5139	13 26.8	-47° 29'	36'	Cen	GC	3.5	Omega Centauri, perhaps the finest globular cluster
NGC5281	13 46.6	-62° 54'	5'	Cen	OC	5.9	40 stars, moderately rich in bright and faint stars
NGC5617	14 29.8	-60° 43'	10'	Cen	OC	6.3	80 stars, large brightness range, central conc.
NGC6025	16 03.7	-60° 30'	12'	TrA	OC	5.1	60 stars, large brightness range
NGC6067	16 13.2	-54° 13'	12'	Nor	OC	5.6	100 stars, large brightness range, central conc.
NGC6087	16 18.9	-57° 54'	12.5'	Nor	OC	5.4	40 stars, moderate brightness range
NGC6124	16 25.6	-40° 40'	29'	Sec	OC	5.8	100 stars, large brightness range
NGC6193	16 41.3	-48° 46'	14'	Ara	OC	5.2	Few stars, large brightness range
NGC6231	16 54.0	-41° 48'	14'	Sec	OC	2.6	A few stars with strong central concentration
NGC6397	17 40.7	-53° 40'	25.7'	Ara	GC	5.8	Loose structure, possibly the nearest globular
NGC7009	21 04.2	-11° 22'	25"	Aqr	PN	7.9	Saturn Nebula, ring structure in a larger faint halo
NGC7293	22 29.6	-20° 48'	12'	Aqr	PN	7.3	Helix Nebula, ring structure in large, fainter disk

DEEP SKY

Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M75	NGC6864	20 06.1 - 21° 55'	6	Sgr	GC	8.6	8	Little Dumbbell Nebula, Cork Nebula
M76	NGC650	01 42.3 + 51° 34'	4.8	Per	PN	10.2	3,9	Seyfert type with very bright nucleus
M77	NGC1068	02 42.7 - 00° 01'	6.9	Cet	SG	8.8	2	Brightest & largest in group of 4 nebulae
M78	NGC2068	05 46.7 + 00° 03'	8	Ori	BN	8.0	2,3	Rich and compressed, well resolved
M79	NGC1904	05 24.5 - 24° 33'	8.7	Lep	GC	7.8	2,4	Strong central concentration, bright & large
M80	NGC6093	16 17.0 - 22° 59'	8.9	Sco	GC	7.2	6	Strong central concentration, bright & large
M81	NGC3031	09 55.6 + 69° 04'	25.7	UMa	SG	6.9	5	Bode's Galaxy
M82	NGC3034	09 55.8 + 69° 41'	11.2	UMa	IG	8.4	5	Cigar Galaxy
M83	NGC5236	13 37.0 - 29° 52'	11.2	Hya	SG	7.6	6	Southern Pinwheel Galaxy
M84	NGC4374	12 25.1 + 12° 53'	5	Vir	EG	9.3	7	Bright centre, in same field as M86
M85	NGC4382	12 25.4 + 18° 11'	7.1	Com	EG	9.2	5,7	
M86	NGC4406	12 26.2 + 12° 57'	7.4	Vir	EG	9.2	7	
M87	NGC4486	12 30.8 + 12° 24'	7.2	Vir	EG	8.6	7	Virgo A., bright, smooth & featureless
M88	NGC4501	12 32.0 + 14° 25'	6.9	Com	SG	9.5	7	
M89	NGC4552	12 35.7 + 12° 33'	4.2	Vir	EG	9.8	7	
M90	NGC4569	12 36.8 + 13° 10'	9.5	Vir	SG	9.5	7	
M91	NGC4548	12 35.4 + 14° 30'	5.4	Com	SG	10.2	7	
M92	NGC6341	17 17.1 + 43° 08'	11.2	Her	GC	6.5	7,9	
M93	NGC2447	07 44.6 - 23° 52'	22	Pup	OC	6.2	4	80 stars magnitude 8 to 13
M94	NGC4736	12 50.9 + 41° 07'	11	CVn	SG	8.2	5,7	
M95	NGC3351	10 44.0 + 11° 42'	7.4	Leo	SG	9.7	4,5	
M96	NGC3368	10 46.8 + 11° 49'	7.1	Leo	SG	9.2	4,5	
M97	NGC3587	11 14.8 + 55° 01'	3.2	UMa	PN	9.7	5,7	Owl Nebula
M98	NGC4192	12 13.8 + 14° 54'	9.5	Com	SG	10.1	5,7	
M99	NGC4254	12 18.8 + 14° 25'	5.4	Com	SG	9.8	5,7	
M100	NGC4321	12 22.9 + 15° 49'	6.9	Com	SG	9.4	5,7	
M101	NGC5457	14 03.2 + 54° 21'	26.9	UMa	SG	7.7	7	Pinwheel Galaxy
M102								Same as M101
M103	NGC581	01 33.2 + 60° 42'	6	Cas	OC	7.4	3,9	
M104	NGC4594	12 40.0 - 11° 37'	8.9	Vir	SG	8.3	6	Sombrero Galaxy
M105	NGC3379	10 47.8 + 12° 35'	4.5	Leo	EG	9.3	4,5	
M106	NGC4258	12 19.0 + 47° 18'	18.2	CVn	SG	8.3	5,7	
M107	NGC6171	16 32.5 - 13° 03'	10	Oph	GC	8.1	6	
M108	NGC3556	11 11.5 + 55° 40'	8.3	UMa	SG	10.1	5,7	
M109	NGC3992	11 57.6 + 53° 23'	7.6	UMa	SG	9.8	5,7	
M110	NGC205	00 40.4 + 41° 41'	17.4	And	EG	8.1	3,9	

LEGEND

Other Ref/	Cat	Catalogue number (NGC New General Catalogue, IC Index Catalog, 'M'	Con.
R.A.	Messier number	Right Ascension (hh mm.m, Epoch 2000.0)	Type
Dec	Declination (° , Epoch 2000.0)		Mag
Size	In arc minutes		Map
			Notes
			Constellation
			Object type (see intro Part I p. 16)
			Magnitude of object
			All Sky Map number (pp. 68-77)
			Common name and/or description

RISE AND SET TIME CORRECTIONS FOR OTHER LOCATIONS

As mentioned previously in this book, the rise/set tables for the Sun, Moon and planets in Part II are calculated for Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney.

This page is designed to help people who live outside these cities make corrections to determine the rise/set times for their specific location. There are two corrections needed, they are:

1. An adjustment for the difference in longitude. **For every degree of longitude east or west of Sydney, subtract or add respectively 4 minutes to both the rise and set times.** Examples of corrections for various towns and cities are given in table 1.
2. An adjustment for the difference in latitude also requires the declination for the object of interest. Table 2 presents these corrections (southern latitudes are negative). NB. **for rise times you add these values, for set you subtract.** For your specific latitude it is normally sufficient to interpolate these figures.

It is important that rise and set times for Sydney are used, irrespective of which town in Australia the calculations are for, when using these tables.

In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example of rise/set time corrections:

Calculate the rise/set times for the Sun on January 15 for Albury (36° 05'S, 146° 55'E)

Rise Set

From page 85 the rise/set values for Sydney are: 4:59 19:09

Adjust for longitude (151.25–146.92) x 4 (table 1) + :17 + :17

(value is positive due to Albury being west of Sydney)

Adjust for latitude and declination of the Sun from – :05 + :05
table 2. Sun's declination is –21° 9' (p. 83)

Rise/Set times for Albury are: 5:11 19:31

If your local time is Central Standard Time, **subtract** 30 minutes, if your local time is Western Standard Time, **subtract** 2 hours

If daylight saving is in force, **add** 60 minutes.

**TABLE 2 – RISE/SET CORRECTIONS FOR LATITUDE/
DECLINATION (from Sydney)**

		Declination													
		30°	25°	20°	15°	10°	5°	0°	-5°	-10°	-15°	-20°	-25°	-30°	
South Latitude (negative)	-12°	-63	-50	-39	-28	-19	-9	0	9	19	28	39	50	63	
	-14°	-58	-46	-36	-26	-17	-8	0	8	17	26	36	46	58	
	-16°	-53	-42	-33	-24	-16	-8	0	8	16	24	33	42	53	
	-18°	-48	-38	-29	-22	-14	-7	0	7	14	22	29	38	48	
	-20°	-43	-34	-26	-19	-13	-6	0	6	13	19	26	34	43	
	-22°	-37	-30	-23	-17	-11	-5	0	5	11	17	23	30	37	
	-24°	-32	-25	-19	-14	-9	-5	0	5	9	14	19	25	32	
	-26°	-26	-20	-16	-11	-7	-4	0	4	7	11	16	20	26	
	-28°	-20	-16	-12	-9	-6	-3	0	3	6	9	12	16	20	
	-30°	-13	-11	-8	-6	-4	-2	0	2	4	6	8	11	13	
	-32°	-7	-5	-4	-3	-2	-1	0	1	2	3	4	5	7	
	-34°	0	0	0	0	0	0	0	0	0	0	0	0	0	
	-36°	8	6	5	3	2	1	0	-1	-2	-3	-5	-6	-8	
	-38°	16	12	9	7	4	2	0	-2	-4	-7	-9	-12	-16	
	-40°	25	19	15	10	7	3	0	-3	-7	-10	-15	-19	-25	
	-42°	34	26	20	14	9	5	0	-5	-9	-14	-20	-26	-34	
-44°	44	34	26	18	12	6	0	-6	-12	-18	-26	-34	-44		

Table 1 LONGITUDE ADJUSTMENTS FOR SOME TOWNS AND CITIES RELATIVE TO SYDNEY

Location	Latitude (° ' S)	Longitude (° ' E)	Change in Longitude (decimal °)	correction (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	32 0	141 27	9.8	39
Coffs Harbour	30 13	153 08	-1.9	-8
Dubbo	32 15	148 37	2.6	11
Goulburn	34 45	149 43	1.5	6
Katoomba	33 42	150 18	0.9	4
Newcastle	32 55	151 45	-0.5	-2
Parkes	33 05	148 10	3.1	12
Tamworth	31 03	151 02	0.2	1
Wagga Wagga	35 05	147 20	3.9	16
Wollongong	34 25	150 52	0.4	2
NORTHERN TERRITORY				
Alice Springs	23 42	133 56	17.3	69
Ayers Rock	25 11	130 58	20.3	8
QUEENSLAND				
Bundaberg	24 52	152 21	-1.1	-4
Cairns	16 55	145 49	5.4	22
Longreach	23 22	144 09	7.1	28
Mackay	21 08	149 10	2.1	8
Mount Isa	20 38	139 28	11.8	47
Rockhampton	23 21	150 28	0.8	3
Surfers Paradise	28 00	153 26	-2.2	-9
Toowoomba	27 33	151 58	-0.7	-3
Townsville	19 10	146 49	4.4	18
TASMANIA				
Launceston	41 20	147 08	4.1	16
Stanley	40 40	145 08	6.1	24
VICTORIA				
Ballarat	37 25	143 55	7.3	29
Benalla	36 30	146 01	5.2	21
Bendigo	36 46	144 17	7.1	28
Geelong	38 09	144 10	7.1	28
Morwell	38 12	146 21	4.9	20
Shepparton	36 13	145 25	5.8	23
Swan Hill	35 13	143 30	7.8	31
Wangaratta	36 17	146 13	5.0	20
Warrnambool	38 27	142 30	8.8	35
SOUTH AUSTRALIA				
Port Augusta	32 30	137 52	13.4	54
Port Lincoln	34 42	135 59	15.3	61
Mount Gambier	37 41	140 49	10.4	42
Whyalla	33 02	137 34	13.7	55
WEST AUSTRALIA				
Albany	35 01	117 53	33.37	133
Broome	17 58	122 14	29.02	116
Bunbury	33 20	115 38	35.62	142
Carnarvon	24 53	113 40	37.58	150
Denmark	34 58	117 21	33.90	136
Derby	17 19	123 38	27.62	110
Esperance	33 52	121 54	29.35	117
Eucla	31 41	128 53	22.37	89
Fitzroy Crossing	18 11	125 36	25.65	103
Geraldton	28 46	114 37	36.63	147
Kalgoorlie	30 45	121 28	29.78	119
Kellerberrin	31 38	117 43	33.53	134
Lake Grace	33 06	118 28	32.78	131
Marble Bar	21 10	119 45	31.50	126
Meekatharra	26 36	118 28	32.78	131
Mount Barker	34 38	117 40	33.58	134
Mount Magnet	28 04	117 51	33.40	134
Mount Newman	23 19	119 45	31.50	126
Mount Tom Price	22 41	117 47	33.47	134
Norseman	32 12	121 47	29.47	118
Northam	31 39	116 40	34.58	138
Onslow	21 38	115 07	36.13	145
Port Hedland	20 18	118 35	32.67	131
Rawlinna	31 01	125 20	25.92	104
Southern Cross	31 14	119 19	31.93	128
Wagin	33 19	117 20	33.92	136
Wiluna	26 35	120 14	31.02	124
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

JULIAN DATE – 2005

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 0hr UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you wish to know the Julian date at 23:00 EST on July 17th 2005. Subtract 10 hours to get UT.

$$23 - 10 = 13:00 \text{ hrs UT}$$

From the table the JD for July is 2453551.5

Add the day of month, 17 gives us 2453568.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 23:00hr 17 July 2005 EST is 2453569.042

JULIAN DATE at 0hr UT		Hours as decimal of a day.	
Month	Julian Date		
Jan 0	2453370.5	01 0.042	13 0.542
Feb 0	2453401.5	02 0.083	14 0.583
Mar 0	2453429.5	03 0.125	15 0.625
Apr 0	2453460.5	04 0.167	16 0.667
May 0	2453490.5	05 0.208	17 0.708
Jun 0	2453521.5	06 0.250	18 0.750
Jul 0	2453551.5	07 0.292	19 0.792
Aug 0	2453582.5	08 0.333	20 0.833
Sep 0	2453613.5	09 0.375	21 0.875
Oct 0	2453643.5	10 0.417	22 0.917
Nov 0	2453674.5	11 0.458	23 0.958
Dec 0	2453704.5	12 0.500	24 1.000

SIDEREAL TIME – 2005

Jan 0	6.6507	May 0	14.5358	Sep 0	22.6181
Feb 0	8.6877	Jun 0	16.5728	Oct 0	0.5894
Mar 0	10.5275	Jul 0	18.5441	Nov 0	2.6264
Apr 0	12.5645	Aug 0	20.5811	Dec 0	4.5977

Greenwich mean sidereal time (GMST) at 0hr UT

You can use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to UT. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day d of month at hour t UT

$$= \text{GMST at 0hr UT (from table above)} + 0.06571 d + 1.00274 t$$

To convert this to local mean sidereal time (LMST) we use

$$\text{LMST} = \text{GMST} + \text{east longitude (or - west longitude)}$$

where longitude is expressed in HOURS (not degrees!)

To convert longitude from degrees to hours, just divide by 15.

Example:

Find LMST at 23 hours Sydney time (EST) on 17th July 2005.

$$23:00 \text{ EST} = 13:00 \text{ UT}$$

GMST for July 0 is 18.5441 hours.

$$\text{GMST} = 18.5441 + (0.06571 \times 17) + (1.00274 \times 13) = 32.6968$$

Sydney's longitude is 151.25°, which is 10.0833 hrs so

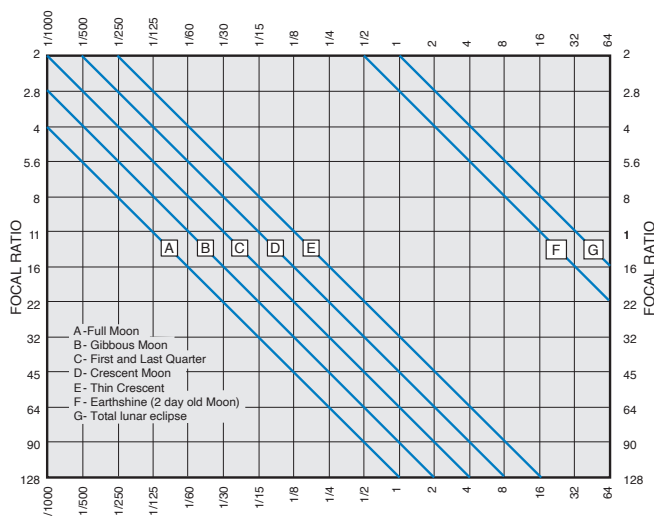
$$\text{LMST} = 32.6968 + 10.0833 = 42.7802$$

Subtract from this multiples of 24 until it is in the range of 0 to 24

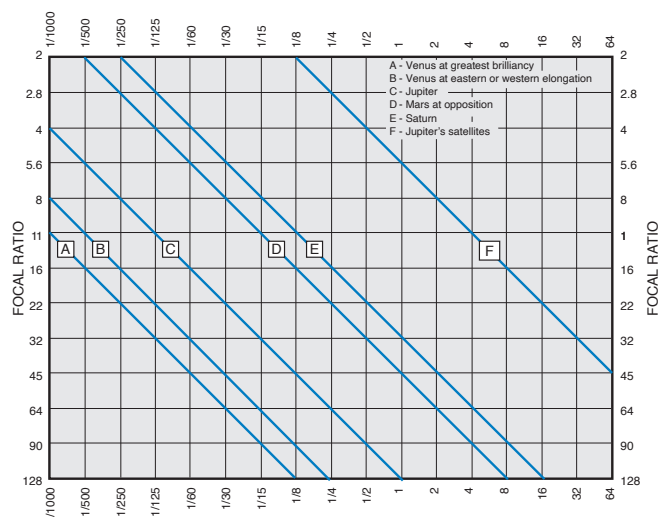
$$42.7961 - 24 = 18.7802 \text{ hrs or } 18\text{h } 46\text{m } 49\text{s}$$

PHOTOGRAPHIC EXPOSURE GUIDES

MOON



PLANETS



These charts provide recommended photographic exposures for the Moon (left) and selected planets (right) using 100 ISO film. The charts should only be treated as a guide, as many factors will influence the exposure time.

Follow a horizontal line nearest to your systems focal ratio to the oblique line that represents the Moon aspect or planet required, then follow the intersecting vertical line down to find the correct exposure.

For the best result, always take one photo at the recommended speed and follow up with one at half and one at twice the exposure (bracketing). This will help smooth out variables and should provide at least one image at the required density.

Film Speed	Multiply By	Film Speed	Divide By	For ISO values other than 100, apply the above factors to the exposure time.
32 ISO	4	200 ISO	2	
64 ISO	2	400 ISO	4	

Places of Astronomical Interest

Following is a list of places of astronomical interest. These facilities cater to the public in regards to tours and or displays. Prices are subject to change. Links to all of the web sites listed here can be found on the Quasar Publishing site: www.quasarastronomy.com.au

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY

This observatory is located 10km from Bathurst. Their dome houses a 14-inch telescope to view the dark rural skies. They also have a radio telescope for listening to signals from the Milky Way. Accommodation for individuals or groups is available at the adjacent Rossmore Park. The local Centaurus Astronomical Society has regular meetings at the observatory.

Address Rossmore Park, 624 Limekilns Road, Bathurst NSW 2795
 Times Open every clear night of the year (except Christmas Eve, Christmas Day and Boxing Day); tour times vary seasonally.
 Contact Ray and Cindy Pickard on (02) 6337 3988
 Email info@bathurstobservatory.com.au
 Web bathurstobservatory.com.au/

LINDEN OBSERVATORY

WSAAG (Western Sydney Amateur Astronomy Group) holds two observing nights a month, where anyone can drop in and look through their telescopes. Observing nights are usually held on Saturdays closest to the New Moon. Dates can be obtained by visiting the WSAAG website.

Address 105 Glosop Road, Linden NSW 2778
 Cost Donation to Linden Trust at \$5 per person.
 Contact Western Sydney Amateur Astronomy Group from more info.
 Email wsaag@tpg.com.au
 Web www4.tpgi.com.au/users/wsaag/

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association is situated in Rotary Park (opposite Town Beach) Port Macquarie. It is open to the public on Sunday and Wednesday evenings (also Friday during NSW school holidays) at 7:30pm (8:15pm during daylight saving). A multimedia presentation is given and celestial objects can be viewed through their 14 inch telescope. Special nights can be arranged for groups.

Address PO Box 1453, Port Macquarie NSW 2444
 Cost \$5 adults, \$4 children, \$15 family (2+2)
 Contact Matthew Wallace (02) 6584 9164 or Jim Daniel (02) 6583 1933
 Email info@pmobs.org.au
 Web www.pmobs.org.au

THE CANBERRA SPACE DOME AND OBSERVATORY

The Canberra Space Dome (Planetarium) is a virtual reality star theatre. Experience night sky simulations, interplanetary space flight, and explore the night sky. They also have research-grade telescopes under domes.

Address Hawdon Place, Dickson (off Antil Street)
 Times Tue to Sat evenings (phone for times) bookings essential.
 Cost Per facility: \$10 adult, \$8 conc, \$6 child, \$28 family (2 + 2, extra child \$2 each)
 Contact (02) 6248 5333 fax (02) 6249 7238
 Email planetarium@ctuc.asn.au
 Web www.ctuc.asn.au/planetarium/

KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE

Located on the border of the Central Coast and Lower Hunter, the centre is no more than two hours from most Sydney and Newcastle suburbs. Koolang's telescopes operate seven days and nights a week. Bookings are essential. Koolang staff have also developed curriculum and theme based presentations to cover all school levels K-12.

Address George Downes Drive, 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 vary, and booking is essential.
 Cost Public night shows: adults \$14, concession \$13, child \$9; group discounts available. Special prices and hours for schools.
 Contact (02) 4998 8216, fax (02) 4998 8580
 Email staff@koolang.com.au
 Web www.koolang.com.au

GROVE CREEK OBSERVATORY

This observatory is located 60km south of Bathurst. The facility caters for amateur astronomers who are looking to use large aperture telescopes under very dark skies. The facility boasts a C14, a 12.5 inch Newtonian, Meade 12 inch and 10 inch LX-200s with astrophotography and CCD cameras: ST-6, ST-8 & ST-9. The observatory has on-site accommodation, sleeping up to ten people.

Cost \$150 per person/per night fully inclusive.
 Contact (02) 6368 8611 or 0418 866 179, 2pm – 9pm
 Email info@gco.org.au
 Web www.gco.org.au/

PARKES CSIRO RADIO TELESCOPE



The observatory is located on the western plains of NSW, 20km north of Parkes (just off the Newell Highway). This landmark radio telescope is over 40 years old, but still considered to be one of the best single dish radio telescopes in the world. It also functions as part of the CSIRO Australia Telescope. As well as a great view of the telescope, the visitors centre has displays, audiovisual and 3D presentations. There is also the Dish Cafe and a public picnic area with free gas barbecues. Souvenirs and educational material are available.

Address Visitors Centre, Telescope Rd (PO Box 276), Parkes NSW 2870
 Times 8:30am to 4:15pm daily except Christmas and Boxing Day
 Cost Admission to the visitor's centre is free. A modest charge is made for the audio visual and 3D presentations.
 Contact (02) 6861 1777
 Email parkes-vdc@csiro.au
 Web www.csiro.au/parkesdish

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two buildings house 41cm and 35cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also run regular open nights for the general public. In 2005, open nights are scheduled for the weekend 13th & 14th May.

Address Cnr Green Point & Caravan Head Roads, Oyster Bay Sutherland
 Times from 8pm
 Cost Gold coin donation appreciated.
 Contact Secretary (02) 9589 1014 (voicemail phone/fax)
 Email sasi@sasi.net.au
 Web www.sasi.net.au

MACQUARIE UNIVERSITY OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on Friday nights unless raining (except Good Friday, Christmas Eve and New Year's Eve in 2005). Astronomy students will guide you with a range of telescopes. On cloudy nights, the program includes slide shows and Solar System demonstrations.

Times 8:30–10pm summer (Nov–Mar), 7:30–9pm winter (Apr–Oct)
 Cost \$5 per person (discounts for groups of 16 or more).
 Contact Lesa Moore 0427 433 388
 Email StarryLady@hotmail.com
 Web www.physics.mq.edu.au/astronomy/publicObs.html

SKYWATCH OBSERVATORY AND ASTRO GOLF

Skywatch Observatory is in Coonabarabran, (home of Siding Spring Observatory) and is open to the public day and night. During the day the exhibition features hands-on activities, a theatre, computers and displays. At night there is guided telescope viewing. There is also Astro Mini-Golf, an 18 hole mini golf course, planetarium and a restaurant/cafe featuring Thai and European cuisine (open 10:30 am till late).

Address Timor Rd, 2km west of the Clock Tower
Times 10:30 am until late — tour times vary during the year, with changing daylight hours, so it is a good idea to call ahead. Bookings not required, but appreciated, particularly during school and public holidays. Groups welcome but please book to obtain group rates. Open every day except Christmas day.
Cost Adult \$14; child/student \$9; senior/pensioner \$11; family \$38
Contact Merril Sana (02) 6842 3303 fax (02) 6842 2978
Email astro@skywatchobservatory.com
Web www.skywatchobservatory.com

THE AUSTRALIA TELESCOPE — NARRABRI ARRAY

The Compact Array is located at the CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22m dishes five of which are spaced along a 3km track with the sixth a further 3 km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations.

Address Locked Bag 194, Narrabri NSW 2390
Times 8am to 4pm daily (unstaffed, except by request for group bookings of 15+, three weeks notice required).
Cost No charge to visit the centre.
Contact Outreach staff (02) 6790 4070
Email atnf-narrabri-outreach@csiro.au
Web www.narrabri.atnf.csiro.au

MT. STROMLO OBSERVATORY



The oldest fully operational research observatory in Australia, Mt Stromlo Observatory (along with its sister observatory at Siding Spring) is part of the Research School of Astronomy and Astrophysics at the Australian National University. Once housing telescopes dating back to 1868, Mt Stromlo Observatory was devastated by the fire storms of 18 January 2003. Through the dedication of the staff, government and public, Mt Stromlo Observatory is rebuilding. The site is now open for visitors, please see their website or contact them for updates on visitor programs.

Address 15 minutes from Canberra City, Mt Stromlo Observatory, off Cotter Road, Weston Creek, ACT (On Tourist Drive 5)
Times Tue to Sun from 10am to 5pm. Night programs run on Saturdays. Contact Mt Stromlo Observatory Visitors' Centre for details.
Cost Day visits are free. Night programs are by gold coin donation.
Contact Visitors' Centre (02) 6125 0232 fax (02) 6125 0233
Email msovc@mso.anu.edu.au
Web www.mso.anu.edu.au/msovc/

SYDNEY OBSERVATORY

This is Australia's oldest observatory — being used to view the southern sky for almost 150 years. Situated near the Rocks on Observatory Hill, and overlooking Sydney Harbour, the observatory is an important site in the nation's early scientific history. There are interactive displays about our solar system and aboriginal astronomy. Day and night tours include our fabulous 3-D Space Theatre (there are a variety of programs such as 'Elysium 7: a Voyage to Mars' and 'After Stars: Blackholes' as well as the latest images of Mars from NASA). Night telescope tours include

stargazing through the observatory's telescopes with an astronomer (a Starlab planetarium is offered during wet weather). Day tours include a dome tour and solar viewing (weather permitting). Sydney Observatory is part of the Powerhouse Museum.

Address Watson Road, Observatory Hill, The Rocks Sydney
Times 10am–5pm, except Christmas Day. Night sessions are held every night of the week. Bookings required for evening tours.
Cost Daytime entry to the gardens and museum is free. Daytime telescope tour & 3D Space Theatre: \$6 adult, \$4 child, \$16 family (duration 45 minutes) Night time telescope tour and 3D Space Theatre: \$15 adults, \$12 students/concession, \$10 children, \$40 family (duration 1 hour 45 minutes).
Contact (02) 9217 0485
Email observatory@phm.gov.au
Web www.sydneyobservatory.com.au

RYDER HOMESTEAD OBSERVATORY

As well as providing accommodation in self contained log cabins, Ryder Homestead offers guests guided star gazing tours. Located 30 minutes north of Bathurst the Homestead enjoys very dark country skies.

Address 130 Thompson Street, Wattle Flat NSW 2795
Cost Homestead guests, free, other adult \$8, child \$5, family \$25
Contact Rodney Watters on (02) 6337 7171
Email rwyder@ryderhome.com.au
Web www.ryderhome.com.au

NEPEAN OBSERVATORY

The University of Western Sydney Observatory is located at Werrington North on the Penrith Campus. School, holiday, public and group programs are available day or night. A variety of curriculum related, hands-on activities are available for school groups from K to Year 12 including sun spot viewing and stargazing through our computerised telescopes.

Times Monday, Tuesday and Thursday
Cost \$12 adult; \$7 child/concession; \$25 family (2 + 2)
Contact Roslyn McCourt (02) 4736 0135
Email r.mccourt@uws.edu.au
Web sites.uws.edu.au/schools/aou/uwsn/observatory/tour.htm

SIDING SPRING OBSERVATORY

Siding Spring is home to ten telescopes, including the Anglo-Australian Telescope with a 3.9 metre mirror — the largest in Australia. The newest is the Faulkes South, a school educational tool (see article p. 45). Siding Spring nestles into the Warrumbungle's at the entrance to the national park, 30 minutes west of Coonabarabran. The exploratory at Siding Spring offers scale models, videos and interactive computers and much more. Guided tours are available most school holidays. Bus tours are available on booking. An open day is generally held in October.

Times 9:30am to 4pm daily except Christmas Day.
Cost Exploratory: adult \$5.50, child/pensioners \$3.50, family \$13.50
Tours: adult \$11, child/pensioner \$9, family \$27
(02) 6842 6211, fax (02) 6842 6226
Contact juls@mso.anu.edu.com.au
Email www.sidingspringexploratory.com.au/
Web

CANBERRA DEEP SPACE COMPLEX (TIDBINBILLA)

The complex is located 35km 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 visitor centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is an actual Moon rock. There is also the Moon Rock Cafe and Giftshop, where meals and souvenirs are available.

Address Tourist Drive 5, Discovery Dr, Tidbinbilla
Times 9am to 5pm, 7 days per week (6pm daylight saving time).
Cost Entry to the Canberra Space Centre is free.
Contact (02) 6201 7880 (recorded info)
Email cdscc-prc@cdscc.nasa.gov
Web www.cdscc.nasa.gov/

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive interactive exhibits, demonstration theatre, and a gift and resource shop. The Blue

Scope Steel Star Theatre has a state of the art Zeiss ZIP3 star projector. The observatory houses a high quality computer controlled telescope which is used to observe the Sun and stars.

Address Science Centre, Innovation Campus, Squires Way, Wollongong
Times 10am to 4pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Cost Child \$6, concession \$8, adult \$9.50. Discount on Planetarium Show tickets when purchased with general entry.
Contact (02) 4286 5000 fax (02) 4283 6665
Email gkm@uow.edu.au
Web www.uow.edu.au/science_centre/

KINGS TABLELAND OBSERVATORY

The observatory is located in the Blue Mountains at Wentworth Falls. It offers dark skies while still close to Sydney. It is open to any interested people or groups. There is a flat screen planetarium and two modern telescopes, housed in a dome. Classes for the Nepean Community College are also conducted including workshops on the night sky, use of star charts, astrophotography and telescopes. It is also open on Saturday and Sunday from 10am to 4pm for solar observing.

Times Flexible to meet demand
Contact Roger North, Sybil Barber (02) 4757 2954
Email north.barber@bigpond.com

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. The observatory offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments, a 6 inch refractor and a flat screen planetarium.

Times Winter: 7-10pm, Summer: 8:30-11pm, or by appointment.
 Coaches and schools welcome.
Contact Mark Monk (02) 6345 1900 fax (02) 6345 1920
Email darbysob@tpg.com.au

GILGANDRA OBSERVATORY

The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It provides a 31cm Newtonian reflector for public use. Tours of the night sky are held each night except Sunday. During NSW school holidays, Sunday nights and daytime by appointment. Booking is advised.

Address Willie Street, Gilgandra NSW 2827
Times 7pm to 10pm (daylight saving 8:30pm to 10pm)
Cost Adults \$9, pensioners \$7, children \$6, family \$25.
Contact (02) 6847 2646 fax (02) 6847 2845
Email mail@gilobs.com.au
Web www.gilobs.com.au/

MAGELLAN OBSERVATORY

This facility is at Lake Bathurst, 30km south of Goulburn. This well equipped observatory has accommodation and a variety of telescopes, which includes a computerised 46cm telescope (NGT18) in a dome. It also has some CCD equipment and a Hydrogen Alpha filter for viewing the Sun. An astrophotography rig is available for hire. For those travelling by train, your hosts will even pick you up from Goulburn station.

Address Lot 48 Covan Creek Rd, Lake Bathurst NSW 2580
Contact (02) 4849 4489
Email magellan@goulburn.net.au
Web home.goulburn.net.au/~magellan/

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. Stage one of the observatory is running, which includes viewing the night sky through three 300 mm Schmidt Cassegrain telescopes and large binoculars. Slides of the Universe, displays, videos and a well-stocked gift shop are available. An eighteen hole mini-golf course with an astronomical theme is due to open in January 2005.

Address 13L Camp Rd (PO Box 308) Dubbo NSW 2830
Times Open daily (except Christmas) from 10am until late. Bookings essential for night sessions.
Cost Adults \$13.50, family of four \$38.50, concession, school groups, tour groups and interested amateur astronomers.
Contact Peter Neilson (manager) (02) 6885 3022 fax (02) 6885 3012
Email DubboObs@hwy.com.au

Web www.hwy.com.au/~dubbobs/

CHESLEIGH HOMESTEAD

The homestead offers accommodation for couples to large groups. Chesleigh offers observing to its patrons through its 12-inch reflector telescope taking full advantage of its clean, dark sky site.

Address Chesleigh Homestead, 319 Hill End Road, Sofala NSW 2795
Cost Included with accommodation costs.
Contact Mike & Jan Cody (02) 6337 7077 fax (02) 6337 7092
Email cody@ix.net.au
Web www.sofala.net.au/astronomy.html

THE UNIVERSITY OF NSW OBSERVATORY

The observatory is open to the general public several times a year on Friday nights, usually accompanied by an astronomy talk and a visit to the Starlab, our portable planetarium. Activities are geared to a wide age range. Starlab is also available for school visits arranged through the Outreach Centre.

Address UNSW Kensington
Cost Details available on website.
Contact Outreach (02) 9385 7311
Email outreach@science.unsw.edu.au
Web www.science.unsw.edu.au/school/student/events.asp

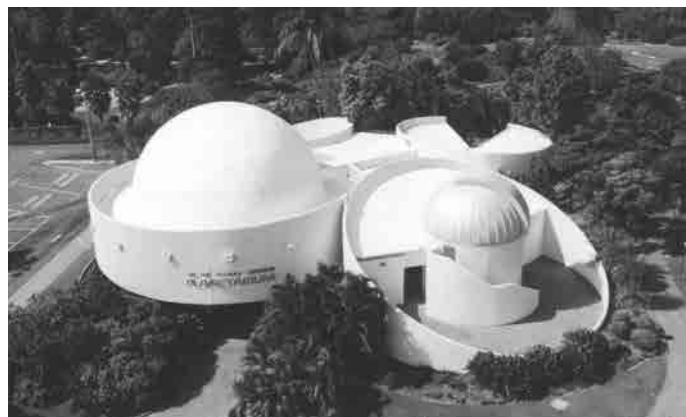
BOWEN MOUNTAIN OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (north west of Sydney). It houses a 40cm Dobsonian telescope. The observatory is open on Friday and Saturday nights (not every week). Visitors are most welcome.

Contact Adrian Saw (02) 4572 1568
Email secretary@asnsw.com

QUEENSLAND

THE SIR THOMAS BRISBANE PLANETARIUM



This world class planetarium is located in the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs are presented in the Cosmic Skydome which has an artificial sky projected onto the interior of a 12.5m dome. The Planetarium underwent a major upgrade during 2004 and shows are now in a digital format, which offers full dome immersion. The display areas contain interesting astronomical and space items, short videos run in a mini theatre, and the shop has astronomical and educational products. The Planetarium observatory has a variety of telescopes and sessions must be pre-booked. School shows are also available during weekdays.

Address Brisbane Botanic Gardens Mt Coot-tha Rd, Toowong Qld 4066
Times Tuesday-Friday: school shows and one afternoon public show. Saturday/Sunday: multiple public shows and children's shows. School shows are on a booking basis only. Additional weekday shows run during Queensland school holidays
Cost Admission and show charges apply.
Contact (07) 3403 2578
Email bop@brisbane.qld.gov.au
Web www.brisbane.qld.gov.au/planetarium/

ALLOWAY OBSERVATORY

The observatory, situated approximately 6 km south of Bundaberg, is operated by the Bundaberg Astronomical Society. The 6 metre dome houses a 480mm Newtonian telescope and a 14 inch computerised Meade with CCD imaging using ST8E and Starlight Express. The observatory opens to the public on Friday nights, midweek opening can be arranged for groups.

Address PO box 4221 South Bundaberg Qld 4670
Times Every Friday night, other nights by appointment.
Cost \$12 family; \$6 adults; \$3 child, discounts for groups.
Contact Mac Jonsen (07) 4153 6469 or (07) 4159 7232 (ans. service)
Email macsen2@yahoo.com or iluka@widebay.net.au
Web www.angelfire.com/al/AstronDirectory/

HEAVENS ABOVE

Heavens Above is a skywatching facility situated between Rockhampton and Yeppoon in Central Queensland. They have a theatre that seats forty — with a DVD introduction followed by a view of the night sky through large telescopes with commentary and explanations.

Address 350 Greenlake Road, Rockyview Qld 4702
Times Apr–Sep 6:30pm, Oct–Mar 7:30pm.
Cost All costs etc are noted on the website with map.
Contact (07) 4936 1344
Email info@heavensaboverocky.com.au
Web www.heavensaboverocky.com.au

SOUTH BURNETT — MAIDENWELL OBSERVATORY

The observatory is located at Maidenwell, two hours drive northwest from Brisbane. They offer daytime viewing of bright stars and planets and conduct tours of the night sky through three Meade LX200 GPS 14" telescopes which can be raised or lowered for viewing pleasure. Daytime activities include classroom presentations on astronomy, and video images of the Sun in hydrogen-alpha light. The observatory has full wheelchair access. There is also a retail outlet for astronomical equipment and they conduct astronomy and astro-imaging courses. Group enquires welcome.

Address 4150 Kingaroy-Cooyar Rd, Maidenwell Qld
Times Spring/Summer: 2pm – sunset, then 8pm – 11pm;
Autumn/Winter: 12 noon – sunset, then 7pm – 10pm
Cost Adult \$11, school age person \$5.50, senior citizen \$8.80; each night session lasts 60 – 90mins.
Contact Night session bookings (07) 4164 6205 fax (07) 4164 6166 mobile 0427 961 391
Email cosmos@big.net.au
Web www.sbstars.com/

COSMOS CENTRE CHARLEVILLE

The public observatory is located on Cunnamulla Rd, near the airport. The Centre includes an observatory and day interpretative centre.

Address PO Box 681, Charleville Qld 4470
Times 10am – 6pm, observing session from 7:30pm, booking essential
Cost \$19 single, \$50 family, \$19 student (under 18)
Contact Jane Morgan (07) 4654 3057
Email cosmoscentre@bigpond.com
Web www.murweh.qld.gov.au/cosmos/cosmos.html

THE GREAT BARRIER REEF OBSERVATORY



Situated on Hamilton Island, the observatory is open to the public regularly during the dry months from April to November. Special openings on request. The observatory enjoys dark skies, operates five telescopes, and

is staffed by members of the island's astronomical group. Viewing is complimentary.

Address PO Box 40, Hamilton Island Qld 4803
Contact Ray Johnston (07) 4946 8686
Email star@whitsunday.net.au

SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is only a 45-minute drive from Surfers Paradise. The observatory is open to the general public, astronomical groups, schools, and researchers by appointment. This facility has a C14 with Titan Robotic Mount, C11, 4.5-inch refractor, CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing. The new observatory is now open - contact them for details.

Address 2319 Springbrook Road, Springbrook Qld 4213
Times By appointment
Cost Adults \$10, children \$5
Contact Andre Clayden (07) 5533 5200 fax (07) 5533 5457
Email springbrook@iprimus.com.au
Web www.maguire.com/astromy/

SUNDOWN OBSERVATORY

The observatory is moving and, hopefully from January 2005, will be at its new home, approximately 230 kilometres southwest of Brisbane, on a dark sky site 8 km SE of Stanthorpe. The main instrument is a 46-cm Cassegrain telescope. The observatory has space for visitor telescopes. Bookings are essential — please try to give at least 24 hours notice.

Address 57 Nielsens Road Sugarloaf via Stanthorpe (PO Box 454 Stanthorpe) Qld 4380
Times Open to public bookings, Thurs-Sun nights from 8pm (subject to weather). Other nights usually not available.
Cost Adults \$8 each; groups of 10 or more \$7 each, school children (primary and high) \$5 each; supervising teachers free.
Contact (07) 4681 3334
Email sundownobservatory@bigpond.com
Web users.bigpond.com/sundownobservatory/

SOUTH AUSTRALIA

THE HEIGHTS OBSERVATORY

The observatory is located at the Heights School, Modbury, Adelaide. It was formed primarily for students of the school with an interest in astronomy, but anyone interested is encouraged to join. There are two main telescopes and a classroom. During the day solar observations are made.

Email rperkins@theheights.sa.edu.au
Web www.theheights.sa.edu.au/

UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM

The planetarium has sessions for primary/secondary schools as well as the general public. Sessions are by appointment only. An open to the public session is available on the first Saturday of the month at 3pm.

Address Uni of South Australia, Building P, Mowson Lakes Campus
Cost \$4.40 adults, \$3.30 students and concession
Contact (08) 8302 3138
Email Christine.Moore@unisa.edu.au
Web www.unisa.edu.au/planetarium/

ARKARoola WILDERNESS SANCTUARY AND RESORT

The Arkaroola Resort and Wildlife Sanctuary is a 610 square kilometre property in South Australia's remote outback which offers a unique range of nature and science based tours and activities. A large computer driven astronomical observatory offers an expert nightly tour through the universe. They have two observatories and three starchairs for viewing. Arkaroola now has advanced eco-tourism accreditation for its observatory tours.

Address Northern Flinders Ranges, PMB 106, Port Augusta SA 5710
Times Tours run every night on demand.
Cost \$30 including 30 minute briefing and 1 hour in the observatory.
Contact (08) 8648 4848 fax (08) 8648 4846
Email res@arkaroola.com.au
Web www.arkaroola.com.au

WOOMERA OBSERVATORY

The observatory houses a 10 inch LX200 Meade, an ST7, numerous eye pieces and 35mm accessories. The telescope is controlled by computer

with either Sky IV or Cartes du Ciel. A bottle of port is generally in the observatory during winter months. BYO flash disk or floppy if CCD photography.

Address PO Box 161, Woomera SA 5720
 Times Viewing can be virtually any night.
 Cost \$10 per person or \$20 per family for 2–3 hour viewing
 Contact Rob Dillon c/o the Woomera Post office

TASMANIA

LAUNCESTON PLANETARIUM

The planetarium is in the Queen Victoria Museum, Wellington St.

Address Queen Victoria Museum, Wellington St, Launceston Tas 7250
 Times Tuesday to Friday 3pm, Saturday 2pm and 3pm. During government school holidays, shows run Monday to Saturday 2pm and 3pm. Group bookings by arrangement.
 Cost \$3 children (under 15), \$5 adults and \$12 family (children under 5 years old are not admitted). 50% discounts available to museum admission ticket holders.
 Contact (03) 6323 3777
 Email martin@qvmag.tas.gov.au
 Web www.qvmag.tas.gov.au/planetarium.html

VICTORIA

MELBOURNE OBSERVATORY

The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. There is a self guided tour available 7 days per week. There are also Tuesday evening tours 'The Night Sky Experience' allowing visitors to look through the original telescopes. Bookings are essential for both programs (03) 9252-2429. The Royal Botanic Gardens Melbourne has a visitor centre, function rooms, Observatory Cafe and a Gardens' Shop.

Address Birdwood Avenue, South Yarra Vic 3141
 Times Day tour, 10am–4pm Mon–Sun. Night tour 7:30–9pm Tuesdays.
 Cost Day tour: \$2 per person.
 Night tour: \$15.50 adult, \$11 concession, \$37.50 family (2+2)
 Contact Visitor Centre, Observatory Gate (03) 9252 2429
 Email rbg@rbg.vic.gov.au
 Web www.rbg.vic.gov.au/visinfo/whatson/index.html

BALLARAT MUNICIPAL OBSERVATORY

The observatory contains three historic telescopes: The Jelbart – a 125mm refractor, the Oddie – a 220 mm Newtonian and the Baker Great Equatorial Telescope – a 650mm Newtonian, which was commissioned in 1886.

There are a number of other telescopes including a computer-enhanced, disabled-access 406mm Cassegrain. The observatory is open Friday and Saturday nights. Other nights and daytime tours can also be arranged by appointment.

Times Fri–Sat from 7pm, add 1 hr for Summer Time.
 Cost \$6.60 adult, \$5.50 concession, \$3.30 student/child
 Contact (03) 5332 7526
 Email bas@cbl.com.au
 Web observatory.ballarat.net/

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages. The planetarium is open seven days a week from 10am and runs special evening sessions from January to April.

Address 2 Booker St, Spotswood Vic
 Contact (03) 9392 4800
 Email mvplanet@museum.vic.gov.au
 Web www.museum.vic.gov.au/planetarium/index.html

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 the school holidays.

Address The Virtual Reality theatre is located in room AS406 on the 4th floor of the Applied Science building. Enter from Burwood Rd.
 Contact Sarah Maddison, phone (03) 9214 5971, fax (03) 9214 8797
 Email astrotour@swin.edu.au
 Web astronomy.swin.edu.au/astrotour/

WEST AUSTRALIA

PINGELLY HEIGHTS OBSERVATORY (ASTRO VENTURES)

An educational facility specialising in the presentation of astronomical information and the viewing of the night sky. They provide a wide range of talks and observing experiences through their telescopes. The observatory is one and a half hours drive from the Perth metropolitan area. The property is Sunarise, Lot 11 Pingelly Heights (off Aldersyde Road), Pingelly. Astro Ventures caters especially for: primary and secondary schools, youth groups, scout and guide units, recreational and sporting groups, community organisations, private parties and others on request.

Address PO Box 512, Pingelly WA 6308
 Times Night Programme starts Summer: 7:30pm Friday and Saturday, (other nights by appointment). We are closed during the winter months from May 1 to September 30 each year.
 Cost Adults \$25, child/pens/conc \$15, family (2+2) \$60
 Contact For further information and reservations ring Susie or Trevor on (08) 9887 0088, 0407 380 922 or write to Astro Ventures.
 Email astroventures@westnet.com.au
 Web members.westnet.com.au/astroventures/

PERTH OBSERVATORY



Situated in the Darling Ranges, 40km inland from the West Coast, Perth Observatory conducts astronomical research and educational activities. As part of the Observatory's public education program, several telescopes from 10 inch to 16 inch are available for use by visitors. Astronomers also take telescopes to conduct Field Nights at various locations. A portable display is available for use at public libraries and schools. There is a museum displaying instruments from the old observatory (founded in 1896), paintings and astrophotographs.

Times Normal office hours: 8:30am - 4:30pm.
 Star Viewing Nights: September to May - times vary with sunset. Bookings essential. No viewings May - September. Tour lasts 1.5 hours approx. Daytime Guided Tours: 10am and 12:30pm, by appointment only - bookings essential.
 Astronomy Field Nights: Telescopes taken to remote locations.
 Cost All services attract charges, contact the observatory for details.
 Contact (08) 9293 8255 fax (08) 9293 8138 info Line (08) 9293 8109
 Email perthobs@calm.wa.gov.au
 Web www.wa.gov.au/perthobs/

SOUTHERN CROSS COSMOS CENTRE

The Southern Cross Cosmos Centre is an observatory situated in the Shire of Gingin, an hour north of Perth. They have a 25 inch Brodie-Hall telescope, together with five other telescopes ranging from 11 to 16 inch as well as six specially adapted binoculars. The SCCC specializes in primary and secondary school programs and also caters to community groups.

Times Available any night of the week but bookings are essential. Evenings start at 7:30pm thru to 10pm and a light supper is served. Day time bookings are also available with viewing of the sun through a special solar filter.

Cost \$25 adults, \$20 seniors, \$10 children, \$65 family of four. Please phone for daytime prices.

Contact Donna or Barbara on (08) 9575 7740

Email cosmic@mail.com

Web www.sccc.asn.au

ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following lists astronomy courses, events, magazines and radio programs for this year. This list is by no means intended to be exhaustive. Across the country there are no doubt many other evening courses held at various universities and colleges. Enquiries from the general public are most welcome. A number of the amateur astronomical societies also provide an invaluable service to public education by their lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change.

GENERAL

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia has a website to provide links for Australian astronomy, both professional and amateur, including links to educational material.

Web www.astronomy.org.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, Turrumurra NSW 2074

Contact Reg. R. Wilson (Director, Asia / Pacific Region Representative)
phone/fax (02) 9488 7078

Email regrw@tpg.com.au

Web www.darksky.org/

LABNOTES - TIPS FOR TEACHERS - Astronomy And Space

Articles are listed and tips have been written for these articles. These tips will help you run learning activities, set homework, and guide student research. For educational purposes, you may print off pages, photocopy them and hand them to your students.

Web www.abc.net.au/labnotes/read/default.htm#astronomy

NACAA 2006

The National Australian Convention of Amateur Astronomers is a biennial event held over Easter. The 2006 gathering will be held in Frankston, Victoria. Hosted by the Mornington Peninsula Astronomical Society.

Contact Peter Lowe

Email aggro@pen.hotkey.net.au

Web www.nacaa.org.au/

QUESTACON STARLAB

Starlab is an inflatable planetarium which can accommodate up to 30 students. Starlab presentations are available in Sydney, Melbourne, Brisbane, Wollongong in collaboration with other science centres.

Address National Science and Technology Centre, Canberra ACT 2600

Contact Bookings Coordinator (02) 6270 2800 fax 1 800 641 171

Email gsmith@questacon.edu.au

Web www.questacon.edu.au/html/starlab_planatarium.html

SPACE ASSOCIATION OF AUSTRALIA

Activities include monthly free public meetings, public displays, radio programme and a newsletter to promote understanding of astronautics.

Address PO Box 351, Mulgrave North Vic 3170

Contact Andrew Rennie

Web www.space.asn.au

NATIONAL SCIENCE WEEK

The aim of this week is a nationwide annual celebration of Australian science, and those who pursue it. It has the objective to increase public awareness of the role that science, engineering, innovation, technology and entrepreneurship play in our daily lives. Astronomy is a key component of

this, and amateur societies are ideally placed for outreach to the public, and themselves gain from the national media coverage. The week is launched with the awarding of the Eureka science prizes. In 2005, this will run from 13th to 21st August. The broad theme is currently set at being "Energy - Future Challenges", though any science-related event at the time is strongly encouraged.

Web www.scienceweek.info.au
www.sciencefestival.com.au/
www.abc.net.au/science/sweek/

THE PLANETARY SOCIETY - Australian Volunteer Co-ordinators

An Australian based space exploration lobby group linked to The Planetary Society. It contains information of relevance to the Australian scene.

Web www4.tpg.com.au/users/tps-seti/index.html

TUTORIALFIND - ASTRONOMY TUTORIALS

Web page that is a search engine for tutorials - in this case astronomical tutorials.

Web www.find.com.au/tutorials/education/astronomy/

U3A ONLINE - INTRODUCTION TO ASTRONOMY

University of the third age (U3A) offer an astronomy course online. For extra details contact Byron.

Contact Byron Soulsby

Email info@u3aonline.org.au

Web www2.gu.edu.au

AUSTRALIA TELESCOPE OUTREACH AND EDUCATION

This site aims to provide the media and the general public with information about the Australia Telescope National Facility. They also provide educational resources on many aspects of astronomy.

Web outreach.atnf.csiro.au/

PUBLICATIONS

ASTROCARDS

The Astronomical Society of NSW runs an information service called Astrocards. This service alerts subscribers to new observable discoveries such as comets, novae, supernovae, bright near-Earth asteroids, or unusual planetary phenomena. The service is available via email or letter and is open to all amateurs.

Address 7 Richards Close, Berowra NSW 2081

Fees \$10 for 10 - subscriptions payable to the ASNSW

Contact Greg Bryant

Email gchbryant@hotmail.com

Web gchbryant.tripod.com/

AUSTRALIAN SKY & TELESCOPE MAGAZINE

This is the local edition of this world-class American magazine about the science and hobby of astronomy. It's first issue is due out in December 2004. In eleven issues per year it will cover the latest news and developments in astronomy and cater for everyone with an interest in space and astronomy, from the beginner to the seasoned observer.

Contact (02) 9439 1955 fax (02) 9439 1977

Email info@austskyandtel.com.au

Web www.austskyandtel.com.au

COMET TALES

This quarterly publication covers news on newly discovered and currently observable comets, ephemerides for all comets visible from Australia, and in-depth histories of returning comets. The writer, Greg Bryant, also covers comets for Sky & Telescope magazine.

Address 7 Richards Close, Berowra NSW 2081

Fees \$14 for one year (payable to Greg Bryant, credit card accepted)

Contact Greg Bryant

Email gchbryant@hotmail.com

Web gchbryant.tripod.com/

PERIHELION COMET QUARTERLY

This bulletin, for comet observers, is published by David Seargent. It is a 16-page newsletter that carries articles of interest to the comet enthusiast, plus new discoveries and ephemerides of comets appropriate to southern hemisphere observers. There are also special bulletins which give discovery details for bright comets visible from Australia.

Address PO Box 204, The Entrance NSW 2261

Fees \$12 (for 4 issues per year), \$15 also includes special mail notices for new discoveries (cheques payable to Karagi Publication).
Contact David Sargent
Email sargent@ozemail.com.au

SKY & SPACE MAGAZINE

This is the southern hemisphere's first astronomy and space exploration magazine. SKY & SPACE has been wholly published and produced in Australia since 1988. The full-colour magazine is bi-monthly and available through newsagencies or by subscription.

Address SKY & SPACE Magazine, 23 Bronte Road (PO Box 1690)
Bondi Junction NSW 1355

Fees \$7.40 in newsagencies or \$41 for an annual subscription.

Contact (02) 9369 3344 fax (02) 9369 3366

Email info@SkyandSpace.com.au

Web www.SkyandSpace.com.au/public/home.html

NEW SOUTH WALES

ASTROFEST - COONABARABRAN

Activities on this weekend include: observing, lectures, tour of Siding Spring and Skywatch Observatories, and Science in the Pub (subject to availability). This event is hosted by the Warrumbungle Mountain Motel. Dates for 2005 were uncertain at time of publication.

Contact Mark Boyd (02) 6842 1832

Email warrumbunglelodge@bigpond.com.au

ASTROFEST - PARKES

The CWAS AstroFest is sponsored by the Central West Astronomical Society and was held for the first time on July 16-18, 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 will be held annually in July.

Address CWAS AstroFest, PO Box 819 Parkes NSW 2870

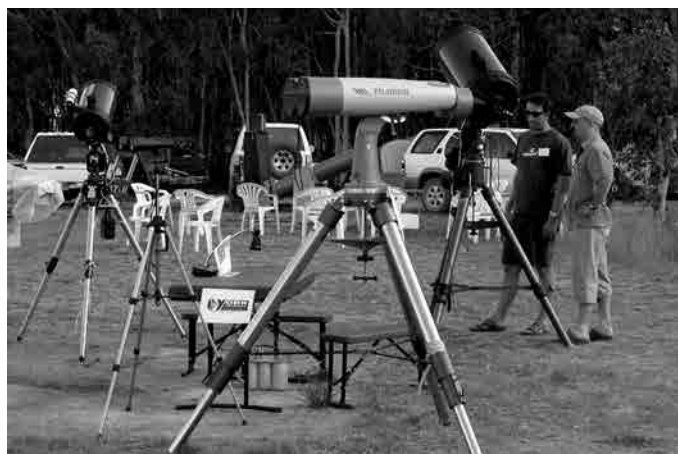
Fees To be determined (the 2004 AstroFest was \$40 per person).

Contact John Sarkissian (President, CWAS)

Email John.Sarkissian@csiro.au

Web www.parkes.atnf.csiro.au/events/astrofest

SOUTH PACIFIC STAR PARTY



An annual national gathering of amateurs for observing under country skies. This is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 400 people. The 2005 SPSP will be held from 11-13 March. Contact the ASNSW for details.

Email secretary@asnsw.com

Web www.asnsw.com/

SKYWORKS PLANETARIUM

Skyworks is a multi award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. It is authorised by the NSW Department of Education. Programs are curriculum based to suit years K-12.

Contact Geoff & Diana Zenner (02) 9610 2899, 0427 112 899, fax (02) 9753 1898

Email info@skyworks.net.au

Web www.skyworks.net.au

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY

SOLIS is an active group with the aim of bringing the ever increasing sky glow to a standstill.

Address PO Box 3002, North Turramurra NSW 2074

Contact Ken Petersen (02) 9634 1736

Email solissydney@telstra.com

Web solis.org.au

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. There are two such nights held each year normally in March-April and September-October (a Saturday night around First Quarter Moon). The venue is Macquarie University (off Epping Rd, North Ryde, Sydney), commencing around 6:30pm.

Address Dept of Physics, Macquarie Uni NSW 2109

Fees Adults \$8, children \$4, family \$20

Contact Dr Alan Vaughan

Email alanv@ics.mq.edu.au

Web www.astronomy.mq.edu.au

MACQUARIE UNI. FOUNDATION FOR ASTRONOMY

The FFA acts as a support group for astronomy activities at Macquarie University. Membership subscription is \$20 per year (students \$10). Through its activities it supports community education in astronomy.

Address Dept of Physics, Macquarie Uni NSW 2109

Fees \$20 (\$10 students)

Contact Dr Alan Vaughan

Email alanv@ics.mq.edu.au

Web www.astronomy.mq.edu.au

MACQUARIE UNIVERSITY PLANETARIUM

Macquarie University now operates a mobile planetarium. The planetarium simulates the appearance of the stars in the night sky. It can be set up on campus or can be taken to schools. The planetarium seats up to 20 adults.

Address Dept of Physics, Macquarie Uni NSW 2109

Contact Dr Alan Vaughan (02) 9850 8904

Email alanv@ics.mq.edu.au

Web www.astronomy.mq.edu.au

MACQUARIE UNIVERSITY ASTRONOMY COURSE

Leisure learning style courses titled "Star Gazing" are offered by the student union (SAM). Short courses at various times of year cover topics such as the Solar System, the southern sky, telescopes and stellar evolution, all at a level requiring no physics or astronomy background. Each short course includes an observatory night, weather permitting.

Address Dept of Physics, Macquarie Uni NSW 2109

Contact SAM office (02) 9850 7606 Lesa Moore (Tutor) 0427 433 388

Email courses@sam.mq.edu.au

Web www.sam.org.au

MACQUARIE UNIVERSITY ASTRONOMY COURSE

A university-level unit titled PHYS270 Astronomy aims to give a broad descriptive underpinning of basic astronomical subjects and concepts with essential but minimal mathematical content. The unit is open to non-award students through the Centre for Open Education.

Address Dept of Physics, Macquarie Uni NSW 2109

Contact Dr Alan Vaughan (02) 9850 8904

Email alanv@ics.mq.edu.au

Web www.coe.mq.edu.au/nonawd.html

NEPEAN COMMUNITY COLLEGE COURSES

Astronomy course run at Kings Tableland Observatory in Wentworth Falls (Blue Mountains). The course is basic and practical, learn how to use star charts and maps to find your way around the night sky. Find out how to use and set up a telescope. There are modern telescopes in a 4.5 m dome.

Contact Nepean Community College (02) 4721 5368 or (02) 4782 3532

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an 8 week course conducted by Sutherland Astronomical Society (SAS). Each lecture is followed by observations with the society's equipment (weather permitting). Dates for 2005 course to be determined.

Address Green Point Observatory (Sutherland, Sydney)
Fees \$120 per student, subject to change
Contact Education Officer (02) 9589 1014 (voicemail phone/fax)
Email education@sasi.net.au
Web www.sasi.net.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. Contact the university's Centre for Continuing Education on (02) 9351 2907 to enrol.

Address Centre for Continuing Education, University of Sydney
Fees Approximately \$240 for 10 weeks
Contact John O'Byrne
Email j.obyrne@physics.usyd.edu.au
Web www.physics.usyd.edu.au/~obyrne/cep/cep.html

INTRODUCTION TO AMATEUR ASTRONOMY

This course aims to convey an understanding of the objects that can be seen in the night sky, an appreciation of their nature and the equipment amateur astronomers use to observe them. Includes practical instruction outdoors when weather permits. Tutor is Andrew Wood BSc, PhD. This is a six week beginners course advertised regularly by the following institutions.

Macarthur Community College
(02) 9826 6455 info@macarthurcc.com.au www.macarthurcc.com.au/
WEA Illawarra
(02) 4226 1622 acewea@ozemail.com.au www.weaillawarra.com.au/
Kiaama Community College
(02) 4232 1051 debbie.littlehales@kcc.nsw.edu.au kcc.nsw.edu.au/

WEA - SYDNEY OBSERVATORY COURSE

Sydney Observatory and the WEA are likely to run some beginner astronomy courses, based at the observatory, during 2005.

Contact (02) 9264 2781 for cost and timetable details or see the web site.
Web www.weasydney.com.au

QUEENSLAND

ASTROFEST — DUCKADANG

The Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours northwest of Brisbane. It has a dark sky with accommodation and a C14 telescope (Stewart Observatory). Activities include: presentations from professional astronomers, awards, swap and sell, slide shows and light sports. The 2005 Astrofest is scheduled for 1st to 7th of August.

Address Lions Camp Duckadang, via Linville, Qld
Fees Prices will be posted on their webpage
Contact (07) 3274 5073 Anne-Louise Surma-Hawes (Registrar)
Email earthlight@optushome.com.au
Web www.qldastrofest.org.au

FUNDING FOR ASTRONOMICAL RESEARCH

The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateur astronomers and students. A grant is being made available in 2005. Further information concerning eligibility of applicants and obligations of successful applicants are available from the contact details.

Address PO Box 6101, St. Lucia Qld 4067
Contact The General Secretary, Astronomical Association of Queensland
Email info@aaq.org.au
Web www.aaq.org.au

BRISBANE FIELD NIGHTS

The Brisbane Astronomical Society (BAS) holds a free public field night on the Saturday nearest to the First Quarter Moon (weather permitting) at Mt Coot-tha Lookout, from 7pm to 9pm.

Address BAS Inc, PO Box 892, Brisbane Albert Street Qld 4002
Contact BAS Infoline (07) 3321 8511 (recorded club information service)

Email basmail@bas.asn.au
Web www.bas.asn.au/

SOUTH AUSTRALIA

ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

There are regularly run astronomy courses at the Adelaide planetarium. Three times a year a ten-week 'Night Sky' course is held Tuesday evenings from 7:30 pm until 10pm. They keep a ten inch Dobsonian on the roof of the building and have a viewing session for an hour or so if the weather is suitable after 10pm. Also about four times a year they run a one-day 'Way to the Stars' course on a Sunday from 1pm until 6:30. The planetarium is perfect for constellation and star identification and they have been running the courses successfully for around twenty years.

Fees Ten-week course \$130, one-day Sunday course \$29.
Contact (08) 8353 5762

STARLORE AND SOLAR SYSTEM ASTRONOMY

This is a one night course conducted at the Adelaide Planetarium around 2-3 times a year. The course emphasises how other cultures see the night sky including indigenous Australians.

Address University of South Australia, Mawson Lakes Campus
Fees \$20
Contact Paul Curnow 0402 079 578
Email paulc@ching.apana.org.au
Web ching.apana.org.au/~paulc/index.html

TASMANIA

INTRODUCTION TO ASTRONOMY (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Canopus Hill Optical Observatory site, usually twice a year in April/May and September/October.

Address Canopus Hill Observatory
Fees \$40 per participant
Contact 0419 305 722
Email joroco@trump.net.au
Web ast.n3.net

VICTORIA

AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. The net, conducted by Russell Ward, commences each Friday evening at 10pm EST on 3.543 MHz (LSB). New stations and shortwave listeners are most welcome.

Email mockrdge@alphalink.com.au
Web www.asv.org.au/

VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party is held annually, sometime between mid-October and mid-November, near Nhill in western Victoria. VicSouth is jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, and offers a weekend of social and astronomical activity as well as observing. VicSouth 2005 will be held November 4 to 7 inclusive. For more information see the VicSouth website.

Address PO Box 434, Christies Beach SA 5165
Contact 0410 422 498
Email vicsouth@trilobytes.com.au
Web astronomy.trilobytes.com.au/vicsouth

ASTRONOMY 'ALIVE'

This course is designed for beginners to intermediate level. Sessions include detail of history, solar systems, stars, the big bang, galaxies, major observatories, deep space, equipment & accessories. Course includes weekly viewing sessions with a range of telescopes and binoculars supplied.

Contact (03) 9576 5235 or 0412 318 125
Email ngc4755@i.net.au
Web www.telescope.i.net.au

VASTROC

Victorian Amateur Astronomical Society's Conventions (VASTROC's) are held every second year (alternating years with NACAA Conventions).

Activities include speakers, workshops, poster displays, observing and the convention dinner. For information regarding the 2005 event contact a Melbourne based society.

ASTRONOMY SHOW ON RADIO KLFM

The Bendigo District Astronomical Society has a fortnightly segment on Radio KLFM. This goes to air at 5:30pm on two Saturdays each month. KLFM can be found on 96.5 FM Bendigo and 106.3 FM Castlemaine (Victoria, Australia). The segment can also be accessed online.

Contact Bendigo District Astronomical Society
Web www.klfm.com.au/audiovault.html

THE SPACE SHOW

This show is broadcast on radio station 88.3 Southern FM (88.3 MHz), 7-8pm every Wednesday. Presented by Andrew Rennie.

Contact (03) 9553 5444
Email webmaster@southernfm.org.au
Web www.southernfm.org.au/

WEST AUSTRALIA

ASTRO GUIDES

Astro Guides run regular courses for beginners in Perth, telescopic viewing nights for schools, groups and parties, packages for schools (including a 114mm telescope and instructions) and directions to build a home for your telescope. All services available outside the metro area by arrangement.

Fees Course \$99
Contact Keith Galbraith (08) 9307 1353
Email info@astroguides.com.au
Web www.astroguides.com.au

ASTRO TOURS OF THE KIMBERLEY

Since 1995 Astro Tours has offered Astronomy Experiences catering for anyone who has ever looked up in the sky and wondered. Astro Tours operate in Broome from April to December and on Rottnest Island and southwest WA January through March. Two hour shows are run for the general public, schools, community and private groups using a selection of telescopes and binoculars under dark skies.

Address PO Box 2537 Broome WA 6725
Contact Greg Quicke 0417 949 958 fax (08) 6210 1468
Email info@astrotours.net
Web www.astrotours.net/

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. This year we have omitted fees from the society listings, please contact them for details. Most societies now have web sites. We have not printed them here, but links to these can be found on the Quasar web site: www.quasarastronomy.com.au

We are keen to keep the information in this section and on our web site 'evergreen'. It would be appreciated if you could keep us informed of any changes (see p. 2 for contact details). The deadline for Astronomy 2006 will be August 1, 2005.

NEW SOUTH WALES & ACT

ASTRONOMICAL SOCIETY OF COONABARABRAN

Meets on the third Wednesday of each month at 7:30pm at the Imperial Hotel, John Street, Coonabarabran.

Address c/- AAO Private Bag, Coonabarabran NSW 2357
Contact Paul Cass (02) 6842 2994
Email cpc@aaocbn.aaogov.au

CANBERRA ASTRONOMICAL SOCIETY

Meetings are held on the 3rd Thursday of every month (except June & Dec) starting at 8pm. (A beginners group starts one hour before the main meeting.) The venue is the Duffield lecture theatre, Mt. Stromlo Observatory, Weston, ACT. Contact John (below) for details.

Address PO Box 1338, Woden ACT 2606
Contact John Howard (02) 6248 0552

Email cas@enzerink.net

ASTRONOMICAL SOCIETY OF THE HUNTER

Meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday of each month at 7:30pm.

Address PO Box 69, Kurri Kurri NSW 2327
Contact Col Maybury (02) 4937 4664 (ph/fax)
Email colmay@koee.com.au

ASTRONOMICAL SOCIETY OF NSW

The society holds meetings twice per month at the CSIRO, Division of Radio Physics, Pembroke Rd (cnr Vimera Rd), Marsfield.

Address GPO Box 1123, Sydney NSW 2001
Contact Adrian Saw (Treasurer) (02) 4572 1568
Email secretary@asnsw.com

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC.



Club meetings are held on the last Thursday of the month (except December) at 7:30pm at the observatory.

Address PO Box 1453, Port Macquarie NSW 2444
Contact Matthew Wallace (02) 6584 9164
Email info@pmobs.org.au

SYDNEY CITY SKYWATCHERS

Sydney City Skywatchers meet at Sydney Observatory on the first Monday of the month commencing at 6:30 p.m.

Address Sydney Observatory, Watson Rd, The Rocks NSW 2000
Contact Elizabeth Cocking (02) 9398 9705

CENTAURUS ASTRONOMICAL SOCIETY

The society is located in Bathurst and holds regular meetings at the Bathurst Observatory.

Contact Ray Pickard (Bathurst Observatory) (02) 6337 3988
Email info@bathurstobservatory.com.au

CENTRAL WEST ASTRONOMICAL SOCIETY INC

Meetings are held on the 1st Friday each month (except Jan) at the Parkes Observatory Discovery Centre, commencing 7:30pm.

Address PO Box 819, Parkes NSW 2870
Contact John Sarkissian (Pres.) Alex Abbey (Secretary)
Email John.Sarkissian@csiro.au abbey@hn.ozemail.com.au

GRAFTON ASTRONOMICAL SOCIETY

The society meets on the first Wednesday of each month at 7pm at the Grafton Aero Club, Vere Street, South Grafton NSW 2460.

Contact Mick Austin (02) 6643 1349 or Stephen Fletcher (02) 6643 3288
Email jmashenden@yahoo.com

HAWKESBURY ASTRONOMICAL ASSOCIATION

Meetings are held once a month on the 2nd Wednesday, commencing 7:45pm, in the Tebbutt Rooms at the Windsor Library, Dight St Windsor.

Address PO Box 670 Windsor NSW 2756
Contact Adrian Saw (02) 4572 1568
Email haw@panthers.net.au

ILLAWARRA ASTRONOMICAL SOCIETY

Meetings are held at the Wollongong Science Centre and Planetarium on the second Tuesday of each month (except January) at 8pm.

Address PO Box 1814, Wollongong NSW 2500
Contact Dave Wheeler (02) 4226 3584
Email IllawarraAstro@optusnet.com.au

MACARTHUR ASTRONOMICAL SOCIETY

The MAS holds meetings, with guest speakers and workshops, every 3rd Monday of the month at 7:30pm at the University of Western Sydney - Macarthur, Building 22, Room 5.

Address c/- Secretary, PO Box 17, Minto NSW 2566
Contact Ian Cook 0415 915 771
Email skyview@zipworld.com.au

THE NEWCASTLE ASTRONOMICAL SOCIETY

Meetings are held on the last Friday of each month (except December), at the University of Newcastle, Lecture Theatre GP, first floor of Linguistics Building at 7:30pm.

Address c/- Dept. Physics, University of Newcastle Callaghan NSW 2308
Contact Ghul Hussain 0408 806 179 or Alan Meehan (02) 4950 0725
Email ghulhussain1@bigpond.com starnut01@yahoo.com.au

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC

Meetings are held at the Sports Pavilion, St Ignatius College, Lane Cove on the 3rd Tuesday of each month at 7:30pm.

Address PO Box 3002, North Turramurra NSW 2074
Contact Ron Washington (02) 9949 3544
Email info@nsas.ozau.net

SHOALHAVEN ASTRONOMERS

Meet at the Nowra Hill School on the third Friday of each month at 7:30pm.

Address PO Box 1053, Nowra NSW 2541
Contact Jack Apfelbaum (president) (02) 4423 2255
Email info@shoalhavenastronomers.asn.au

SUTHERLAND ASTRONOMICAL SOCIETY

Meets every Thursday at 8pm at Green Point Observatory near Sutherland, with the main meeting and guest speaker on 1st and 4th Thursdays.

Address PO Box 31, Sutherland NSW 1499
Contact Secretary (02) 9589 1014 (voicemail phone/fax)
Email sasi@sasi.net.au

UNIVERSITY OF NEW ENGLAND & NTH TABLELANDS AS

Meetings are held once per month at the Kirby Observatory on Thursday evenings close to New Moon, at 6:30pm EST (Dec and Jan 8pm DST).

Address Ms Anne Parnell, 81 Perrott St Armidale NSW 2350
Contact Anne Parnell (02) 6772 1859
Email msharpe@metz.une.edu.au

WOLLONGONG AMATEUR ASTRONOMY CLUB

Meetings are held on the first Thursday of the month, commencing at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra.

Address WAAC, PO Box 456 Thirroul NSW 2515
Contact Jeff Pountney (pres.) (02) 4268 2934
Laurie Marshall (sec.) (02) 4297 1052
Email waacjf@tpg.com.au

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC

The society meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus.

Address PO Box 400, Kingswood NSW 2747
Email wsaag@tpg.com.au

NORTHERN TERRITORY

ALICE SPRINGS ASTRONOMICAL SOCIETY

The society holds meetings at 7:30pm on the 2nd Monday of each month at the Motor Registry Office, METAL Centre, Nth Stuart Hwy.

Address Box 739, Alice Springs NT 0871
Contact Dan Barnett (President) (08) 8953 8039 or
Mike Heald (Sec) (08) 8952 9027
Email barnett.downunder@bigpond.com

DARWIN ASTRONOMY GROUP

Monthly viewing nights are held during the dry season as well as other activities.

Contact Phillip Smith (08) 8945 9450 or Gavin Mills (08) 8932 2727
Email info@darwinastronomy.com

GOVE AMATEUR ASTRONOMERS

Meets monthly for viewing nights on a Friday close to the New Moon at our Dark Sky Site on the Dhupma Rd. 1.3 km from the end of the bitumen, just past the northern end of the Airport runway, as announced in the local paper the Arafura Times and as shown in our web calendar of events.

Address PO Box 178 Nhulunbuy NT 0881
Contact Ian Maclean 0417 601 490
Email goveastronomers@yahoo.com.au

QUEENSLAND

BUNDABERG ASTRONOMICAL SOCIETY

Meetings are held at Alloway Observatory on every Friday at 7:30pm. The first Friday of the month are general meetings and are not held in January.

Address PO box 4221 South Bundaberg Qld 4670
Contact Mac Jonsen (07) 4153 6469

BUNDABERG SKYWATCHERS

Meets every Friday night at 7pm, two field nights and one training night each month.

Address 534 Moorlands Road, Bundaberg Qld 4670
Contact Karlene Galway (07) 4159 9674
Email karlene@interworx.com.au

CAIRNS ASTRONOMY GROUP

Holds monthly meetings from June to November, on the first Saturday of the month, at Bob's place, starting at 7:30pm.

Address 18 Yurongi St, Caravonica Qld 4878
Contact Bob Dollery (07) 4058 1180
Email jamesbak@bigpond.com

REDLANDS ASTRONOMICAL SOCIETY

Meets at Ormiston College, Ormiston (27km SE of Brisbane) on the 2nd Tuesday of the month.

Address PO Box 2048, Wellington Point Qld 4160
Contact Ross Spence (07) 3822 5545
Email snissen@powerup.com.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY

The society meets on the third Tuesday of the month at Chermiside Library from February to November, commencing at 7:30pm.

Address PO Box 60, Everton Park Qld 4053
Contact David Larkin (07) 3844 7904 or Julie Straayer (07) 3325 2479
Email dclarkin@optusnet.com.au

SOUTHERN ASTRONOMICAL SOCIETY

Monthly meetings are held at Pimpama State School, Hotham Creek Rd, Pimpama, on Saturdays (dates vary with Moon phase), at 7pm.

Address PO Box 867, Beenleigh Qld 4207
Contact Kevin Dixon (07) 5537 3852

TROPICAL STARGAZERS

This society has two branches. The Hamilton Island group meets regularly during April to December and operates the Great Barrier Reef Observatory. The Mackay section holds regular meetings and viewing nights.

Address PO Box 40, Hamilton Island Qld 4803
Contact Ray Johnston (Hamilton Is.) (07) 4946 8686 or
Michael Benedetti (Mackay) 0407 969 889
Email star@whitsunday.net.au

ASTRONOMICAL ASSOCIATION OF QUEENSLAND

Meetings are held in the late afternoon of the Saturday nearest the Full Moon each month at 4pm in the lecture theatre of the Sir Thomas Brisbane Planetarium, Mt. Coot-tha Botanic Gardens. Check web site for dates.

Address PO Box 6101, St. Lucia Qld 4067
Contact Peter Hall (07) 3378 1173
Email info@aaq.org.au

MT. ISA ASTRONOMY GROUP

The society meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17km outside of Mount Isa). Meetings are held monthly, usually near the New Moon.

Address PO Box 1556, Mount Isa Qld 4825
Contact Len Fulham (07) 4743 5385 (AH), fax (07) 4743 3381

Email lfulham@tpgi.com.au

BRISBANE ASTRONOMICAL SOCIETY

Meets on a Friday of each month at 7:30pm at the Kelvin Grove State High School Library (depends upon lunar phases) - see their web site for dates.

Address PO Box 892, Brisbane Albert Street Qld 4002

Contact BAS Infoline (07) 3321 8511 (recorded club information service)

Email basmail@bas.asn.au

TOWNSVILLE ASTRONOMY GROUP

Observe on the Saturday closest to New Moon at Alligator Creek (20km south of Townsville) or at Kelso Dam.

Address 96 Stagpole St, West End, Townsville Qld 4810

Contact Murray Gibson (07) 4772 1339

Email mgib@tpg.com.au

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA

Meetings are held on the 1st Wednesday of each month (except January) at the University of Adelaide, North Terrace Campus.

Address GPO Box 199, Adelaide SA 5001

Contact (08) 8338 1231

Email info@assa.org.au

WOOMERA ASTRONOMY GROUP

Address PO box 161 Woomera SA 5720

Contact Rob Dillon c/o the Woomera Post office or Heritage Centre

TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA (AST)



General Meetings are held at either the Canopus Observatory Site at Cambridge or the Hutchins School conference centre, Sandy Bay on the last Tuesday of each month except December.

Address Secretary, Mr. Laurie Priest, PO Box 1654, Hobart Tas 7001

Contact AST Hotline: 0419 305 722 Hobart (03) 6244 3476,

Launceston - Karenne Barnes (03) 6344 7100,

Devonport - Peter Sayers (03) 6424 2588

Email shevillm@southcom.com.au

VICTORIA

ASTRONOMICAL SOCIETY OF ALBURY WODONGA

The society meets regularly on the first Wednesday of each month (except January) at Victory Lutheran College, Drages Road, Wodonga at 8pm.

Address 1 Poplar St, Wodonga Vic 3690

Contact David Thurley (02) 6040 3704

Email astronomy@asaw.org.au

MORNINGTON PENINSULA ASTRONOMICAL SOCIETY

Meetings are on the 3rd Wednesday each month (except December) at 8pm, at the senior school theatre, Peninsula School, Wooralla Drive, Mt Eliza.

Address PO Box 596, Frankston Vic 3199

Contact Peter Skilton 0419 253 252

Email skywatch@iprimus.com.au

ASTRONOMICAL SOCIETY OF VICTORIA

Visitors are welcome at the society's general meetings, held at 8pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. Specialist sections also hold regular meetings.

Address GPO Box 1059J, Melbourne Vic 3001

Contact Linda Mockridge (Public Relations Officer) (03) 9888 7130

Email mockrdge@alphalink.com.au

BALLARAT ASTRONOMICAL SOCIETY

The BAS holds a general meeting on the second Friday of each month.

Address PO Box 284, Ballarat Vic 3353

Contact (03) 5332 7526 (society information)

Email bas@cbl.com.au

ASTRONOMICAL SOCIETY OF GEELONG

Meets every Friday at 8:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong.

Address PO Box 1799, Geelong Vic 3220

Contact Frank Baker (President) 0407 345 070

Email robmarineowl@bigpond.com

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND

Meetings are held at members homes. Dark sky observation sites are at Bairnsdale and Perry Bridge.

Address 53 Riley St, Bairnsdale Vic 3875

Contact Mike Finn (03) 5153 2802

LATROBE VALLEY ASTRONOMICAL SOCIETY

Meets every second Tuesday of the month (except December and January) at the Wirilda Park and Conference Centre, Tyers, call for details.

Address PO Box 1298, Traralgon BC Vic 3844

Contact Gavan Dinsdale (03) 5174 6453

Email gdinsdal@hotmail.com

THE BENDIGO DISTRICT ASTRONOMICAL SOCIETY

Meetings are held in the Eaglehawk Secondary College Library on the fourth Wednesday of the month except December and January.

Address PO Box 164 Bendigo Central Vic 3550

Contact Barry McPhee (Sec) (03) 5447 9918

Email contactclub@bdas.net

ASTRONOMICAL SOCIETY OF MELBOURNE

Conduct regular meetings at their club rooms and viewing nights at their 'Shallow Sky Site' in Melbourne. They also have viewing nights at their dark sky site to the southeast of Melbourne. Contact the society for details.

Address PO Box 92, Bentleigh Vic 3204

Contact Chris Ellis 0412 318 125 (recorded info line (03) 9517 9250)

Email ngc4755@i.net.au

OASIS STARGAZERS CLUB MILDURA INC

Oasis conduct regular viewing nights, which are open to the public, and once a month have a public activity night.

Address PO Box 378CP, Mildura Vic 3500

Contact Mark Vorwerk (sec) (03) 5024 5316 or Kerry Needs (Publicity Officer) 0414 535 122

Email oasisastronomy@yahoo.com.au

WEST AUSTRALIA

ASTRONOMICAL GROUP OF WA (AGWA)

The group meets at 7pm on the first Tuesday of every month (see address below), visitors are welcome.

Address 159A Scarborough Beach Rd, Mount Hawthorn WA 6016

Contact Keith Williams (08) 9201 0895

Email btow@iinet.net.au

ASTRONOMICAL SOCIETY OF THE SOUTH WEST

Observing nights are held at their observatory south of Bunbury on the two Fridays before the New Moon.

Address PO Box 1100, Bunbury WA 6231

Contact Phil Smith (08) 9721 1586

Email mail@assw.org.au

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. (A complete reflection gives an albedo of 1.0 or 100%).

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

Almanac A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an *Ephemeris*.

Altazimuth co-ordinates The angular height (*altitude*) of an object above or below the horizon and its angular direction (*azimuth*) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees or radians.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a comet, planet or minor planet most distant from the Sun. It is the opposite to *perihelion*.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to *perigee*.

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See *Minor Planet*.

Astrology A complete waste of time. See *rubbish*.

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 AU.

Azimuth Horizontal co-ordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the *celestial sphere*.

Celestial poles Points on the *celestial sphere* directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth and to which celestial bodies seem to be attached.

Circumpolar Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum *declination* it must have to be considered circumpolar.

Colour index The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a *comet*, usually the brightest part.

Comet Small icy body that orbits the Sun and produces tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least *angular separation* as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

Conjunction — Inferior When the Earth, an *inferior planet* (Mercury or Venus) and the Sun are in a line in that order.

Conjunction — Superior When the Earth and an *inferior planet* (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological gods, people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the whole Universe.

CST Central Standard Time.

Culmination The instant when a celestial body crosses the *meridian*; an object culminates when it reaches its highest point above the observers horizon.

Declination (Dec) One part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (-) of the *celestial equator* and is similar to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how 'long or thin' an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

Eclipse When one object passes into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow cone of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the *umbra*, and penumbral if the Moon passes only through the *penumbra* of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. 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 most angular distance from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all co-ordinate data and is compatible with modern star atlases.

Equation of Time The difference between apparent and mean solar time.

Equinox The two times of the year when the Sun crosses the *celestial equator*; vernal or spring equinox occurs about September 21st, and autumnal or fall equinox about March 22nd.

EST Eastern Standard Time.

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our *galaxy*.

Galaxy A large disk or ball of billions of stars and *nebulae*. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto, (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between first and last quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our *galaxy* and 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 the reference is the *ecliptic*.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is Mercury and Venus.

Julian date The number of days since noon on 1st January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite *galaxy* to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the *constellation* of Dorado. From mid-southern latitudes the LMC is *circumpolar*.

Light year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.512. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude -1 (except for the Sun which is -26.7). The faintest visible to the unaided eye are magnitude 6 (under dark skies).

Magnitude — absolute The apparent magnitude a star would have if it were placed at a distance of 10 *parsecs* (32.6 *light years*).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The *right ascension* on the meridian equals local *sidereal* time.

Meteor (also Shooting or Falling Star) A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of *meteors* that appear to originate from a small region of the sky (the *radiant*).

Meteor swarm (or *stream*) *Meteoroids* grouped in a localised region of an orbit around the Sun (the source of *meteor showers*).

Meteorite A *meteor* that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Minute of arc An angular measure (each degree is divided in 60 minutes of arc).

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.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 *light years*. A parsec is defined as the distance to a celestial body whose *parallax* is one arc second.

Penumbra Area of partial illumination in the shadow of a planet surrounding the *Umbra*. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth.

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to *aphelion*.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. Thought to be the outer layers of a red giant during its latter stages of evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

Quadrature A configuration that two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

Reflection nebula A gas cloud illuminated by a nearby star.

Retrograde motion 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.

2. Apparent retrograde motion is the westward motion of a planet with respect to the stars which occurs near opposition (outer planets) or near inferior conjunction (inner planets).

Right ascension (R.A.) Part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is similar to lines of longitude on the Earth but is measured in hours (24hrs = 360°).

Rubbish See *astrology*.

Second of arc An angular measure. Each degree contains 3600 seconds of arc, and each *minute of arc* contains 60 seconds.

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23hrs 56m 4s of normal solar time.

Small Magellanic Cloud (SMC) Satellite *galaxy* to our own Milky Way system, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is *circumpolar*.

Solstice The time when the Sun is farthest from the *celestial equator*. In the southern hemisphere around June 21st marks the shortest day of the year, and around December 21st marks the longest day.

Spectral type A star's spectral classification determined by its *spectrum*.

Spectrum The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The period of a planet's orbit with respect to the Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the *meridian*.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight — astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight — civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight — nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time (UT) A time system measured from the Meridian of Greenwich in England.

WST Western Standard Time.

Zenith The point directly overhead (90° in altitude).

Zenith Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the *zenith* with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the *ecliptic* (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

GREEK ALPHABET

A, α	Alpha	E, ε	Epsilon	I, ι	Iota	N, ν	Nu	P, ρ	Rho	Φ, φ	Phi
B, β	Beta	Z, ζ	Zeta	K, κ	Kappa	Ξ, ξ	Xi	Σ, σ	Sigma	X, χ	Chi
Γ, γ	Gamma	H, η	Eta	Λ, λ	Lambda	O, ο	Omicron	T, τ	Tau	Ψ, ψ	Psi
Δ, δ	Delta	Θ, θ, ϑ	Theta	M, 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:

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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°