ASTRONOMY 2018

AUSTRALIA

Mars, best view since 2003 !

Ken Wallace
Glenn Dawes
Peter Northfield

YOUR GUIDE TO THE NIGHT SKY

CALENDAR 2018

JANUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
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NOVEMBER

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DECEMBER

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ASTRONOMY 2018

AUSTRALIA

Glenn Dawes Peter Northfield Ken Wallace

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- Astronomical Almanac for the Year 2018 (US Naval Observatory and UK Hydrographic Office)
- Astronomical Tables of the Sun, Moon and Planets (Meeus)
- Atlas of the Moon (Rükl)
- Cambridge Guide to the Constellations (Bakich)
- Comet orbital elements (International Astronomical Union)
- Exploring the Moon (Massey)
- International Astronomical Union
- International Meteor Organisation Calendar
- Mathematical Astronomy Morsels series, volumes 1 to 5 (Meeus)
- NASA/JPL websites
- Stars (Jim Kaler)
- The Moon: A Biography (Whitehouse)

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

- Multiyear Interactive Computer Almanac 1800–2050 version 2.22 (MICA) (US Naval Observatory)
- TheSky (Software Bisque)
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- Voyager version 4.5 (Carina Software)
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We (the authors) are responsible for any remaining errors, yes, but as someone once said, “perfection isn't all it's cracked up to be!” We have certainly cracked over the years seeking this state of nirvana!

Illustrations

Front cover image and page 66: M51, Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA).

p. 1:	Joe Cauchi, M 16 (The Eagle Nebula) taken with his 16" ƒ/4.5 Newtonian, 15×15 minute plus 14×15 minute exposures July 2013 and July 2017 with an S Big ST4000 XCM OSC CCD at Wiruna, NSW.
p. 11:	Image of Celestron GoTo NexStar 6 supplied by Binocular and Telescope Shop.
p. 21:	Wow signal, Wikimedia Commons.
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p. 48, 49:	Star trials by David Malin
p. 52:	ISS transit diagram provided by ISS Transit Finder transit-finder.com.
p. 53:	IIS lunar transit by Dylan O'Donnell. Canon 70D 1/1600 ƒ10 ISO500 with Celestron 9.25” Edge HD
p. 58:	Crater Copernicus, image by Lunar Reconnaissance Orbiter, Wikimedia Commons.
p. 91:	Solar active region 9933 in 2001, courtesy of SOHO/[MDI] consortium.
p. 91:	Eclipse predictions by Fred Espenak, NASA/GSFC.
pp. 100–101:	Texture maps of Moon, credit NASA/Naval Research.

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

Rear cover: Greg Priestley images of the Total Solar Eclipse, August 2017 from Wyoming, USA. Taken with a Canon 7D Mark II with Canon EF 100–400 mm ƒ/4.5-5.6L IS II USM lens.

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Introduction to the 2018 Edition

Welcome to Astronomy 2018. This year has much to offer astronomically speaking, including two lunar eclipses and a partial solar eclipse visible from Australia. The first lunar one is visible in its entirety on the night of January 31 with totality reached in the late evening (a special for school kids?). The other lunar eclipse is in the morning of July 28 with the period up to mid-eclipse visible across the country before dawn interferes in the eastern states. The partial solar eclipse is more for the devotees, being only a fingernail bite and then only visible from the far south-east of the mainland and Tasmania.

Mars has a most favourable opposition, with the Red Planet's apparent size close to the record breaking one in 2003.

This yearbook contains its regular information, including our monthly features covering the usual diverse range of interests, which include:

- What happened to once in a Blue Moon? We have two this year!
- Binocular double stars from the city.
- Minor planet Vesta visible to the unaided eye.
- The legacy of Eugene Shoemaker.
- The Crater Copernicus, the Monarch of the Moon.
- What to really expect when observing galaxies.
- An update on spacecraft probing the depths of the Solar System.

Part I of Astronomy 2018 is intended as a general quick reference to finding and observing the planets. This section is ideal for those just starting to navigate the heavens. The All Sky Maps cover the entire Southern Hemisphere sky in nine easy to use charts. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, include sections on the constellations, bright stars and astronomical objects to observe as well as places of interest and amateur societies. You can also visit our website www.quasarastronomy.com.au where you will find links to all of the sites listed in Part III of this book.

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

It's unfortunate, but no surprise, that light pollution remains an increasing concern. The Siding Spring Observatory near Coonabarabran in NSW has grown over the years to be a truly international astronomical hub with telescopes from many countries taking advantage of its Southern Hemisphere pristine skies. Although it is 350 km from Sydney the level of sky glow has drastically increased over recent years.

One development that may have a detrimental effect on astronomy is the greater use of LED lighting. True, they are energy efficient and today deliver a more natural 'white' light. Without careful design and application, the LEDs could contribute more to sky glow than some traditional lights such as the yellow sodium ones! Remember, getting white light needs a contribution from the blue end of the spectrum, which is more scattered by the atmosphere. You only have to look at the colour of the sky during the day to prove this!

We have mentioned in previous yearbooks that a dark night sky should be as much a part of our natural heritage as wildlife, bushland and clean air and water. We mustn't let future generations learn about the heavens just from the Internet. Don't deprive them of the simple pleasure of being able to go outside and look up and see our small corner of the universe.

We appreciate we are preaching to the choir. Keep looking up and be willing to fight to keep the view!

Wishing you clear skies and see you next year.

Glenn Dawes   Peter Northfield   Ken Wallace

Probing The Solar System

MERCURY

BepiColombo is the first large-scale joint Europe-Japan mission. Due to launch in October 2018 (awaiting confirmation at time of publication), this mission consists of two orbiters and will conduct comprehensive studies of Mercury, including the magnetic field, the magnetosphere, the interior and the surface.

www.stp.isas.jaxa.jp/mercury/p_bepi.html

VENUS

Akatsuki, also known as the Venus Climate Orbiter (VCO), is a Japanese (JAXA) space probe to study the atmosphere of Venus. Launched in 2010, after a main engine failure during orbital insertion, the spacecraft ended up in a 203-day solar orbit. In 2015, when it was close to Venus again, they used the manoeuvring thrusters to alter its orbit from solar to a 13-day highly elliptical one around Venus (between 400 km and 440,000 km). Data from the three working cameras: Lightning and Airglow, (552–777 nm), ultraviolet imager (293–365 nm) and the long-wave infrared camera (10 µm) continues to arrive. In September they reported evidence of a fast atmospheric flow near the planet's equator.

global.jaxa.jp/projects/sat/planet_c/index.html

MARS

Opportunity is in Perseverance Valley on the west rim of Endeavour Crater. It is stationary at the moment collecting extensive Panoramic Camera (Pancam) stereo panoramas so that a 3D digital elevation model of the entire valley can be constructed. Total distance covered as of 22 August 2017 is 44.99 km, having travelled 1.89 km in the previous 12 months.

www.nasa.gov/mission_pages/mer/

Curiosity has now been exploring Mars for over five years and has now arrived at Vera Rubin Ridge, a key mission destination. It is driving parallel to and below the ridge as JPL work out a safe route to the top. A major appeal here is an iron oxide mineral, hematite, which can form under wet conditions and reveal information about ancient environments.

mars.jpl.nasa.gov/msl/

ExoMars Trace Gas Orbiter (TGO) arrived at Mars in October 2016 on a mission to gain a better understanding of methane and other atmospheric gases that are present in small concentrations. The orbiter is currently using aerobraking to bring it into a 400 km circular orbit ready to begin science operations in March 2018.

exploration.esa.int/mars/46475-trace-gas-orbiter/

Mars Odyssey, now in its 17th year of operation, continues to be the longest serving of the Martian missions. Seasonal dark streaks (called recurring slope lineae or RSL) on Mars don't hold much water. Results from the spacecraft's Thermal Emission Imaging System (THEMIS) show that they hold very little water with an upper limit of three percent, about as much as in the driest desert sands on Earth.

mars.jpl.nasa.gov/odyssey/

In March 2017, **Mars Reconnaissance Orbiter**, having exceeded 50,000 orbits, continues to compile the most global coverage ever accomplished by a camera at the Red Planet.

mars.jpl.nasa.gov/mro/

Mars Express continues to image the surface of Mars in 10 metre resolution (with some areas in 2 m) as it has been doing for over 13 years. www.esa.int/esaMI/Mars_Express/

MAVEN (Mars Atmosphere and Volatile EvolutioN) has measured the rate at which the Sun and the solar wind are stripping gas from the top of the atmosphere into space. This process has changed the climate from a warmer and wetter environment early in history to the cold, dry climate that we see today. www.nasa.gov/mission_pages/maven/

Still on track for launch in May 2018 and arrival at Mars in November, **InSight** (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) is a NASA mission that will place a lander on Mars to study its deep interior. insight.jpl.nasa.gov/home.cfm

JUPITER

Juno arrived at Jupiter on 4 July 2016 and in early September 2017 completed its seventh science flyby over Jupiter's cloud tops. www.nasa.gov/juno/

SATURN

After over 20 years in space, 14 of them orbiting Saturn, the **Cassini** probe entered Saturn's atmosphere 15 September 2017 at 9:55 pm EST. It was sending science data right up to the last minute. Although the spacecraft is gone, its enormous collection of data about Saturn—the giant planet itself, its magnetosphere, rings and moons—will continue to yield new discoveries for decades. saturn.jpl.nasa.gov

DWARF PLANETS

The **Dawn** space probe, despite the loss of three of its reaction wheels, is still observing Ceres in its extended mission. It is currently orbiting the dwarf planet between 17,000 and 25,000 km altitude. dawn.jpl.nasa.gov

MINOR PLANETS

After rewriting the textbook on Pluto, the **New Horizons** probe is still en route to Kuiper Belt Object 2014 MU69, scheduled for arrival January 2019. In July 2017 Earth based observations of an occultation showed MU69 could be possibly double-lobed or a binary object. pluto.jhuapl.edu

The **OSIRIS-REx** (Origins Spectral Interpretation Resource Identification Security—Regolith Explorer) spacecraft will travel to a near-Earth asteroid, Bennu, and bring a small sample back to Earth for study. It is still on track to reach its target in 2018 and return a sample to Earth in 2023.

www.nasa.gov/osiris-rex

After two successful flybys of Earth in 2014 and 2015, **Hayabusa 2** is on schedule to arrive at 162173 Ryugu in late 2018. The probe has a small rover, lander and an impactor to create a small crater to release fresh samples from the ground. It will observe the minor planet for about a year and return samples to Earth in late 2020.

global.jaxa.jp/projects/sat/hayabusa2/

NAKED EYE STARGAZING

A Fun Pastime for Beginners

Do you find the night sky fascinating? However, when looking up at the stars do they also seem incomprehensible, far removed from the real world that you know? Despite this do you still feel drawn to it, as people have been for thousands of years? Like the ancients, you are using the only equipment they had, the naked eye. In the whole of human history it has only been in the last 400 years that we've had anything better. Unlike those early people you have available a wealth of knowledge. For example, we don't need to rely on the appearance of certain stars to know when to plant crops any more. We no longer fear the appearance of eclipses or comets. Some ancient astrologers were expected to predict such bad omens under the threat of death! Much of our early interest in the heavens was certainly driven by superstition. Look at how many constellation names are based on Greek and Roman mythology. We do have a little fun in this book occasionally injecting these stories. Things are so much easier now. The ultimate ego driven mind-set that the Earth was the centre of the universe has long died (hang on, doesn't everything revolve around us?).

Putting all this aside, if you are a beginner and approach stargazing as a chance for a little fun and are willing to learn, but not in a hurry to buy a telescope or even binoculars, you have the right attitude. Many people even struggle to understand the difference between words such as Sun, star, planet, Solar System or even galaxy. As long as your sense of wonder remains, the knowledge will come when there is a need to know. We hope this book will help satiate some of this hunger as it arises.

As a general guide to using this book, when we refer to observing in a particular time of the year, like 'summer', we are talking about the appearance of the evening sky during that season, the most convenient time to look. In reality most of the night sky is available any night (especially in winter), provided you are willing to stay up until dawn. Playing with a planisphere illustrates this quite well. An example is shown on page 9.

The Attraction of Dark Skies

Observing with the naked eye from the Southern Hemisphere offers much more than northern astronomers had before the invention of the telescope. This is especially the case if you head into the country to escape the bright urban skies on a moonless night. The ancients were very much stuck in mid to high latitude Northern Hemisphere locations, with all of the earliest observations coming from Europe, England, the Middle East or China. These locations see the bright centre of the Milky Way low in the south in summer, whereas from Australia it passes directly overhead in our autumn and winter evening skies. Incidentally, a time of the year when the long nights give us *down under* more time to spend soaking up this vista. The structure of the Milky Way is more appreciated by the wide-angle views available to the unaided eye. With us immersed in the flattened, circular disc of our galaxy we see it edge on, hence the 'river' that flows across the sky. The Sun is around halfway out from the galactic centre, which lies roughly in the direction of the spout star of Sagittarius' Teapot (see All Sky Map No 8). Looking just with the eyes two things become apparent. First, how wide this central 'milky' area appears (called the hub) with our galaxy tapering and fading out as you follow it towards the opposite end of the sky, around Orion (which is setting early in autumn evenings). Second, the numerous dark lanes that crisscross the Milky Way in this hub. Both aspects are ideal for naked eye observers. There are other impressive regions in our galaxy quite attractive to the unaided eye such as the number of bright star clouds and clusters also around the centre. Another is the brilliant section from the Southern Cross around to the Carina star-rich nebulae region, which contrasts well with the adjacent dark Coalsack Nebula (All Sky Map No 1).

Leaving winter and our galaxy, the Southern Hemisphere summer evenings offer the unique Magellanic Clouds. These are satellite galaxies to our own and appear like detached portions of the Milky Way. They are easy to spot under dark skies, as normal clouds look black whereas the Large Magellanic Cloud (LMC) and its smaller companion the SMC appear white from the accumulated effect of countless stars (like the *milkiness* of our galaxy). Even the unaided eye can see the prominent bar in the LMC.

Low in the spring northern evening sky lies another member of our local group of galaxies, the Andromeda Galaxy (M31). It has the distinction of being the most distant object easily visible to the unaided eye. Knowing M31 has a similar structure to the Milky Way and that it appears as a squashed oval, shows we are seeing it nearly edge-on. Occasionally

A FEW TIPS FOR BEGINNERS

Red light torch. The easiest way to make a red light source (to preserve your night vision) is to cover the front of a torch with red cellophane, held in place with a rubber band. If you wish to free up your hands, the same can be done with a headlamp. However, they can become annoying when trying to look through an eyepiece.

Compass Bearings. One way to learn the night sky is to start with the more obvious constellations. These stand out well on planispheres, having the main compass bearings marked around the horizon, but how do you relate this to your actual horizon? If you don't have a compass, taking note of where the Sun sets to get a rough direction for west might help. Also, shadows point south at midday. Other useful resources are maps or street directories, which are conveniently drawn with north towards the top of the page.

Astronomical Apps. Planetarium Apps have become popular with smart phones and tablets—brilliant! Some are even interactive, identifying the stars, planets and constellations as you move (tilt and pan) the device around the sky. All this is offered using red light to supposedly preserve your dark adaption. This sounds good, however they can't avoid being backlit, which under these low light levels are blinding. We suggest using them to plan your night and under the stars use instead this book/maps/planisphere with a red light torch.

Location. Take a little time to plan where you will observe. There is much to consider. Possibly the most important is security, do you feel safe there? Being in mobile phone range is a nice bonus. Ensure there are no obvious sources of nearby lighting (e.g., roads, security lights). Having a low horizon is nice but does it leave you exposed to strong wind, such as on hilltops? If you are low or near water is fog a concern?

these and other naked eye deep sky objects will be mentioned in Constellations in the monthly sections.

Dark skies also offer the opportunity to try and see the planet Uranus with the unaided eye. The All Sky Map No 3 (p. 77) and finder chart (p. 132) will help find this elusive distant member of the Solar System. Also, occasionally the minor planet Vesta can brighten sufficiently to be visible with the naked eye, with this year one of its best oppositions, see page 40.

You can always go on a voyage of self-discovery. There is a good chance any fuzzy object (unless it is a comet) will be marked on the All Sky charts (see pp. 74–83).

With any of the naked eye challenges mentioned in this section, binoculars are very handy and open up a whole new perspective on the night sky (see next page).

DISTANCES ARE TRULY ASTRONOMICAL!

Sometimes the word 'astronomical' is used to describe something that is excessive or exorbitant and that sums up pretty well the scale of the universe. As someone once said, space is well named for there is a lot of it! We have found this is one of the aspects of astronomy that can turn people off—they simply can't relate to its size.

The light year is defined as the distance light travels in a year. Trying to convert this to a more human scale it is approximately 9,500,000,000,000 kilometres. It's not just your calculator that goes into overflow but your mind as well! Even the eight minutes needed for light to come to Earth from the Sun feels strange when compared to flicking a switch at home and seeing the room instantly illuminated.

The light year to an astronomer is just a convenient tool. The same can be said for the main source of our astronomical knowledge, light. Is its wavelength any more understandable? The blue part of the visible spectrum is around 450 nanometres or 0.000000450 metres! The best advice is to accept both extremes and move on.

Returning to the speed of light, let's use it to get an idea of the scale of the Universe, well … our small end.

The distance to:

- The Moon, a little over 1 light second.
- The Sun approximately 8 light minutes.
- The average distance to Neptune from the Sun, about 4 light hours (remember this encloses all the currently accepted planets).
- The nearest star, the Alpha Centauri system, just over 4 light years (ly).
- The brightest star, Sirius 8.6 ly
- Two nearby open star clusters, the Hyades (the face of Taurus the bull) about 150 ly and the Pleiades is 430 ly.
- Two of the closest globular clusters, M4 in Scorpius is 6,800 ly and NGC 6397 in Pavo is 7,500 ly
- The centre of the Milky Way around 25,000 ly (our galaxy's main disc is around 100,000 ly across)
- The Magellanic Clouds, Large (LMC) is 160,000 ly and Small (SMC) is 190,000 ly.
- The most distant object visible to the naked eye, the Andromeda Galaxy 2,300,000 ly!

Suburban Skies offer much as well!

If you find it hard to escape the city lights there is still a lot to enjoy. Seeing only a few hundred of the brightest stars can make it easier to learn the major constellations. The many stars visible from the country, certainly more than those shown on the All Sky Maps, can swamp distinctive star patterns making them difficult to find.

Whether your skies are dark or flooded by light pollution it is still important to try and maintain dark adaption for your eyes and this makes reading star charts and making notes under red light important (see side bar, A Few Tips for Beginners, opposite). As part of this, avoid any direct lighting, even if it means sacrificing some horizon by hiding behind your home or fence. If you have the annoying neighbour with the constant backyard light on, invite them over to view the sky. Trying to see past their floodlight might give them the message.

Light polluted skies don't prevent you from easily following the five naked eye planets, Mercury, Venus, Mars, Jupiter and Saturn. The retrograde loops of the outer planets can be fascinating to follow over a number of months. It makes you appreciate why they were called *aster planetes* (from the Greek meaning wandering star) as they continue to disturb the otherwise reliable fixed heavenly pattern.

Venus is so bright it can be seen in daylight! You need to know precisely where it is and this is where binoculars will help to find it. It's critical to have your eyes focused correctly, which can be difficult in a featureless blue sky. Having the Moon nearby helps address both issues. For your comfort and safety, if observing in the daylight we always recommend you hide the Sun behind a tree or building.

When two celestial bodies are close together it's called a conjunction. They can be quite attractive, especially those involving the brightest planets. Conjunctions between the thin crescent Moon and Venus or Jupiter are spectacular. For example have a look at the close meeting between the Moon and Venus in the early evening sky on June 16 (see Sky View, page 44).

Although not covered in the book, it's also fun looking for Earth orbiting satellites. Remember satellites don't generate any light themselves so they need to reflect sunlight to be visible. So look for low Earth orbiting satellites up to three hours after sunset or before sunrise where they can still 'see' the Sun. Look out for those that slowly appear or disappear for no obvious reason, they have likely moved out of, or into, the Earth's shadow. For evening events the shadow rises slowly from the eastern horizon and for mornings drops slowly in the west. Although the most famous current examples are the International Space Station (ISS) and the Hubble Space Telescope (HST), possibly the most impressive sights related to satellites are the Iridium flares. The Iridiums are a collection of approximately 70 communication satellites in orbit which, when the angle between you-satellite-Sun is just right, a brilliant reflection is seen off their antenna panels for a few seconds, resulting in a rapid brightening, sometimes rivalling or exceeding the brilliance of Venus! The Heavens Above website (www.heavens-above.com) will allow you to generate predictions for visibility of these and other satellites for your location. There are also Apps for tablets and smart phones that do the same.

Meteors or shooting stars. These streaks or fireballs occur when particles burn up in the Earth's atmosphere. Most range from about the size of grains of sand up to a few millimetres (pea size) and are called meteoroids when in space. Those that survive to hit the ground are called meteorites. Around a half dozen meteors per hour can be seen under dark skies, with a tendency for more after midnight. These are the sporadics. Meteors also occur in annual *showers*. This happens when a sudden increase in number are seen around the same time each year as the Earth passes through or near ancient debris trails left by passing comets. Part I discusses the favourable ones visible this year; also see the introduction on page 13.

A WORD ABOUT BINOCULARS

Probably the most cost-effective accessory for the beginner are binoculars. A reasonable quality pair can be purchased for the same price as a cheap, sub-standard telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a low cost way of gauging your child's level of interest. We suggest that they should be purchased from a reputable optics or telescope dealer. These people understand the quality required for stargazing. To observe detail on the Moon or to look for Jupiter's moons, avoid just holding them in your hands. Try bracing yourself on something like the arms of a chair, a fence or the roof of a car. Telescope dealers can assist with mounts to hold the binoculars steady. There are also brackets designed to attach binoculars to a camera tripod. This is probably the cheapest option, especially if you already have a tripod. Keeping the binoculars steady is important if the power of the binoculars is more than 10×. A power of 7× is a reasonable compromise. It can give a good field of view with adequate magnification to glimpse some of the moons of Jupiter. The size of the aperture normally comes down to what is comfortable for a person to hold in the hand and the budget; 7 × 50 binoculars (7 times magnification, 50 mm diameter objective lens) are fairly popular with amateurs.

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

Even with binoculars you still need to practice pointing the instrument. There is a tendency to look too low, so if you don't see what you are after, the first thing to try is tilt the binoculars up. One method that may help is to find an obvious nearby bright star, or better still, a bright star pattern (called an asterism) and star hop across. If your object isn't too high in

USES FOR BINOCULARS

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 maria (seas), larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views, All Sky Maps and finder charts in this publication. Binoculars can help in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Contrast the yellow of Alpha (α) Centauri with the blue of Beta (β) Centauri (see also feature on page 48).
- Stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky. You might find them with the naked eye, but binoculars will help; sometimes they vary in brightness as they tumble. You can follow them further into the Earth's shadow before disappearing.
- Lunar occultations of some of the brighter stars (see Part II). Small binoculars are well suited for magnitude four or brighter events, preferably on a dark limb.
- Searching out Uranus and Neptune, using the finder charts, see page 132 and All Sky Maps 3 and 8.
- Observing bright comets.
- Looking at bright, wide double stars (also see feature on page 37).
- Observing the moons of Jupiter as they oscillate across the planet from night to night, see the diagrams on pages 117 to 122. The magnification of the binoculars will dictate how close to Jupiter you can see these satellites.
- Some of the bright deep sky objects such as star clusters, Milky Way regions, and the Magellanic Clouds. The galaxies M33 in Triangulum and NGC 253 in Sculptor are worth going after as well. Most Messier objects, marked as 'M__' on the All Sky Charts, are visible in binoculars, the galaxies may need a small telescope.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart to see which star has moved. Taking the coordinates of a minor planet from Part II, and plotting that position on the All Sky Maps, will help you find the correct area. Also, this year Vesta is particularly bright (see page 40)
- Monitoring the change in magnitude of some of the brighter variable stars. There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society (p. 148) or organisations such as Variable Stars South www.variablestarssouth.org or AAVSO www.aavso.org.

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

the sky you can try finding something on the horizon directly under it, like a distinctive tree outline, and move the binoculars up. Another method, that might take a little getting used to, is to stare intently at the area of the sky with your unaided eyes and then move the binoculars into place without moving your eyes. Practice on bright stars first until you are comfortable. Talking of comfort, plan your observing, as it can be very difficult to look directly up, especially if the binoculars are mounted on a tripod. This is where sitting back in a reclining chair and hand-holding the binoculars makes it easier. If your seat doesn't recline, try leaning the tripod on two legs or use a monopod.

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

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

Using this Book

The purpose of this book is to help you plan your night under the stars. Think of it as offering a number of pieces of a picture, the nature of which will vary greatly whether you are using binoculars, a telescope or just your eyes. Such an exercise can be fun, so let's go! Each section of the book has its own introductory pages, below gives examples of how to tie them together.

The Moon. The phase of the Moon is a good place to start, the inside front cover will help. Unless you wish to view our natural satellite, or just the planets, New Moon is favoured by most observers, preferring long nights with their skies as dark as possible. Up to First Quarter the morning sky is Moon free as are evenings after Last Quarter. The Rise/Set diagram, which is on the first page of each monthly section, helps further define the 'Moon observing' and 'dark' windows. More specific times, on a day-by-day basis for each of the Australian capitals, are presented in Part II (starting page 94).

Observing the Moon (pp. 98–101). Viewing the terminator, the sunrise/sunset line on the Moon, makes our satellite come alive as the crater walls and mountains cast shadows across the surface. Lunar observers love the daily change with something different offered every night. This section helps identify the features on the terminator as the Moon waxes and wanes. Possibly the most unpopular time is Full Moon which presents an overly bright, flat picture which lights up the sky drowning out any nebulous objects, including the most attractive galaxy of all, the Milky Way!

Lunar occultations (when the Moon passes in front of stars) are very time and location dependent. Details for several cities are listed starting on p. 103 with formula for adjusting for other locations on p. 102. Events, either disappearances or reappearances, are best seen on dark limbs, which are also identified.

Optimum times for **librations** are presented in the monthly sections, allowing the observer to glimpse features, normally out of sight, that temporarily appear on the limb as our satellite from our perspective wobbles in its orbit.

The Planets. Mercury, Venus, Mars, Jupiter and Saturn are naked eye objects with Uranus and Neptune requiring at least binoculars. To get a quick overview of what is on offer tonight start with the **Visibility of the Planets** (p. 15). As an example we'll use the start of July. Saturn, Jupiter, Venus and Mercury are visible in the evening sky with Uranus, Neptune, Mars and Pluto in the morning. You will notice that Saturn is near the midnight line and likely to be close to opposition and up the whole night, which is correct as shown in the June and July monthly Rise/Set charts. In fact, Mars and Pluto are approaching the midnight line and the July section confirms they are at opposition later that month and also up the whole night.

The **Appearance of the Planets** diagram (first page on each monthly section) gives the relative sizes and phases (where relevant) for planets. Saturn's rings are still well open this year and should be spectacular in any small telescope. It is fascinating to watch **Mercury** in particular as it quickly zips around the Sun. At superior conjunction, behind the Sun and out of sight (e.g. February 17) this inner world is small with a full phase. It then enters the evening sky growing in size but its phase waning as it approaches inferior conjunction (between us and the Sun) for example April 2. Mercury then enters the morning sky and the process reverses until superior conjunction is reached again (June 6). It is best to observe this innermost world around times of maximum elongation (conjunctions are too close to the solar glare). This is the time of greatest angular distance from the Sun and highest in the sky, for example Mercury in the evening sky on July 12. See its altitude while in conjunction with the Moon on July 15 (Sky View page 50).

Its fellow inner world **Venus** goes through the same process as Mercury but much slower, being further from the Sun. In 2018 a superior conjunction occurs early on (January 9) and it then spends most of the year growing in size towards inferior conjunction on October 26.

Mars only achieves a reasonable size when at opposition. Not only is there an opposition in 2018, but it is most favourable, a great time to observe features on its surface, see page 110 for an observing guide. At this time, its two normally evasive moons are at their brightest and can be seen at their maximum distance from the bright Martian disc, page 113 explains how to identify and observe them. When away from opposition, Mars' reddish disc remains small and possibly featureless. Even then you may occasionally see a polar ice cap or other surface marking.

Jupiter, like any of the outer planets, is best observed when the planet transits the meridian (is due north). The ideal time is near opposition when the widest observing window is available with the planet transiting around midnight. The Rise/Set chart (page 34), confirms that this happens for Jupiter in early May. Besides observing its atmospheric belts, the **Great Red Spot (GRS)** is worthwhile looking for; see the table and explanation on pages 114–115. An example is the evening of May 28 around 10:14 pm (EST), a transit that is visible from anywhere in Australia.

Pages 116–122 cover the **Jovian Satellite Phenomena** as the four major moons shuffle back and forth, crossing in front of and passing behind the planet. They can look quite attractive when all four are gathered on the same side. Looking on the evening of June 7, the diagram on page 120 shows this well. In this case there is also a drawing (see Sky View page 43). The 'wiggly' diagrams also indicate when events are occurring when a moon's line crosses Jupiter. For example the night of June 10 has transits of Europa followed by Io see page 120.

Saturn, with its impressive ring system, is visible in any small telescope, and has six moons that are considered observable in amateur equipment, however, they are much fainter than the Jovian satellites. Even 'bright' Titan is a lot dimmer. Page 126–127 shows a worked example of how to identify their configuration for your date and time.

Uranus and **Neptune** can be challenging but are still considered visible in binoculars provided you know where to look. That is why the separate finder charts (p. 132) are needed for these distant planets. To identify four of Uranus' moons and Neptune's Triton a similar calculation to Saturn is used, see page 129.

Minor Bodies of the Solar System

The monthly sections give predicted dates for opposition of the brighter **minor and dwarf planets**. Observing notes are also presented for the prominent **comets**. Positions in the sky of the brightest minor planets and comets are presented on pages 138 and 136–137 respectively. These can be plotted on the All Sky Maps to get an approximate position. Let's take our impressive example this year, the opposition of Vesta. The June monthly text (p. 43) has the minor planet reaching opposition on the 19th at magnitude 5.3 in Sagittarius. Page 140 tells you Sagittarius is on All Sky Maps No 8 and 6. The ephemerides (page 138) when plotted on this map gives the location on this date very close to M23 (approximately 1° SW of the cluster). In this case we have cheated having already plotted it and having a separate finder chart on page 41.

Let's assume it's the evening of July 4 and you wish to find Comet C/2016 M1 (PANSTARRS). Part I text (page 48) says the comet is in Ara early in the month. Carrying out the same exercise with its position (p. 137) it is located on Map No 6. Interpolating between the June 30 and July 7 it is very close (within 1°) to the star Iota Arae. The ephemerides (page 137) also indicates it's quite high in the evening sky (transiting around 10:30 pm) and its southerly travel will, by the end of July, make it circumpolar.

Meteors (Shooting Stars). The annual Geminids shower is one of the finest visible from down under. They are expected to peak on December 14. This year at the time of maximum the morning hours will be Moon free (see the December monthly text page 72). Watching for meteors can be fun at any time. So, when taking a coffee break, sit back and relax. Who knows when an impressive fireball might light up the sky? If you don't go to sleep, you may be the only person to see it. Awesome!

BUYING YOUR FIRST TELESCOPE

There will come a time when you will want to take the plunge and buy a telescope. You can only go so far with binoculars and the chance of seeing more of the Universe up close, live and personal has to be experienced.

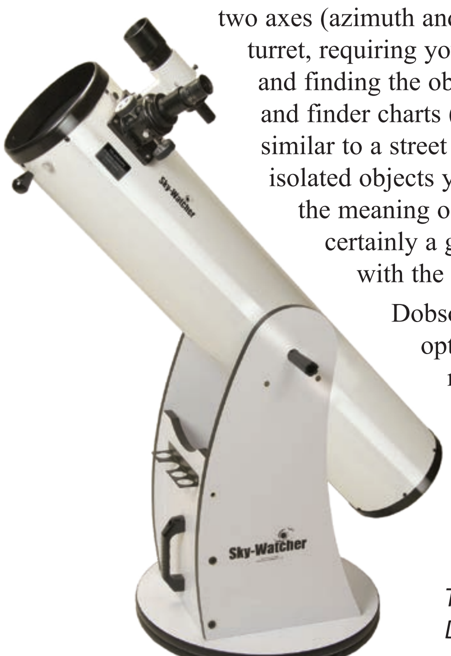
Don't buy anything without spending some time evaluating the various telescopes available to establish what suits you best. This is where your local astronomical society can be a goldmine of information (see Part III). These people are more than willing to show off their telescopes and discuss the various features available and their associated pros and cons. Learn from these experts. If you can look through their instruments under light polluted conditions as well as under dark, country skies, all the better. This gives you a realistic feel of what to expect. The telescope shops and public observatories also have many years of experience in this area, so draw on their advice as well. You might pick up a bargain through the amateur ranks, maybe check out the IceInSpace website.

Here is a brief overview of two broad categories of reflecting instruments we would consider ideal for those starting out. This is purely for visual observing. Equipment for taking images is more complicated and beyond the scope of this book, also the traditional refractor (lens type) scopes are not covered here.

We will briefly discuss the totally manual ones and the high tech 'GoTos'. For the manual type there are two basic variations mainly related to the mount, the equatorial and altazimuth types. We'll concentrate on the most common, the Dobsonian, which fits into the latter camp.

Dobsonians, named after the American amateur John Dobson, are the most economic telescopes. The term 'more bang for buck' comes to mind; in this case the bang is the light gathering power (the diameter of the main mirror). As this gets larger, you can see fainter objects and more detail (higher resolution). These are usually no frills telescopes, easiest to set up and use. They move around in two axes (azimuth and altitude), like a gun turret, requiring you to push the telescope and finding the object by using star maps and finder charts (see Part II of this book) similar to a street directory. For faint and isolated objects you will soon understand the meaning of the term star hopping—certainly a great way to get familiar with the heavens.

Dobsonians use Newtonian optics, which are easily recognised having long tubes with the eyepiece holder sticking out the side near the top. Along with learning the sky, another skill set you'll develop is aligning the optics. This is called collimation. The mirrors will slowly move over time, especially when transported. Unless you are experienced at collimation we wouldn't recommend the split tube designs, which need to be assembled. These are the ones with metal poles joining the primary mirror box to the secondary mirror top end. They need considerable adjustments every time they are put together but there are tools available to make this exercise easier. This is not a problem if you can leave it set up.



Typical commercial Dobsonian telescope.

GoTos require some initial fiddling to get going, but after this you just select the object from a list in its on-board computer and the telescope automatically takes you there—magic! They are driven by a control paddle or even remotely via Wi-Fi by planetarium programs on tablets or smart phones. GoTos require very little knowledge of the sky, although when setting up most need the operator to help the electronics get its bearing by pointing to two bright stars in its memory bank. The GoTos are quite portable with most utilising the shorter Schmidt Cassegrain optics, which easily swing into their fork mount with the tripod quickly collapsible. Another advantage for these power-driven scopes is they compensate for the rotation of the Earth, keeping the object in the field of view.

Coming back to 'bang for buck', as a very rough guide you can buy a 250 mm (10 inch) to 300 mm (12 inch) Dobsonian for about the same money as a 100 mm (4 inch) to 150 mm (6 inch) GoTo with all the bells and whistles. We've refrained from talking actual pricing here because these vary greatly between brands, especially the GoTos with numerous features available. Also, the image quality can be poor if the instrument comes with low quality eyepieces. Talk to the dealer about the eyepieces that come with the telescope and if you have a choice and can afford a few extra dollars don't skimp on quality.

There is an interesting philosophical discussion over these two types. Some argue that learning the sky is the traditional amateur way and using the manual scopes certainly helps build this knowledge and pride in developing the skill to drive them. However, the GoTos once correctly set up are hassle free and being able to find objects quickly, especially under light polluted skies where there are few naked eye stars to use as guides, is a major advantage. The argument that anything that prevents frustration, leading to the scope going back in the cupboard too early, is worthy of serious consideration. Also, many traditionalists point out with their hectic lives today less and less time is spent under dark skies and anything that speeds up the process is a bonus. Ultimately the choice is yours!

Celestron NexStar GoTo telescope.

The Monthly Sections

Each monthly chapter in Part I contains the following:

Rise–Set Chart

This enables you to quickly determine when (or if) a planet or the Moon is visible in the night sky for any day in that month. Each chart has the midnight line centred, with the evening sky below this line and the following morning sky above. The ideal time to observe an outer planet is at the time of transit (represented by dashed lines), which is when it is due north and has reached its maximum altitude. A number of events during the year have been shown with symbols.

Opposition · Western elongation · Eastern elongation
Greatest illuminated extent · Conjunction between planets

These charts give approximate local standard time and you will see from the specific rise and set times in Part II that there is variation from city to city. If more accurate times are required, see the tables for the object of interest in Part II. For regional locations if you need a more accurate time use the appendix on page 144.

Highlights

This lists a few interesting events during the month.

Constellations

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

Appearance of the Planets

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

The Moon

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

Lunar Libration Because of synchronised rotation, the Moon always keeps the same face pointed towards the Earth and we should only see 50% of its surface. In reality, though, 59% of the surface can be viewed by an effect called libration. The diagrams show the wobble or nod of the Moon during the course of each month.

Lunar Libration is a complicated mix of three different effects, with two being prominent. Firstly, the Moon suffers from a longitudinal wobble; as the Moon approaches perigee its motion through space speeds up, faster than its rotation, and

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

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

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

Dwarf Planet. This is a recently created class of objects, with only five designated so far. This book concentrates on the brightest two, Pluto and Ceres. Incidentally both bodies are ex-planets, but you need to go back to the 19th century for Ceres's demotion to a minor planet.

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

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

Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'mag.'). The numbers work backwards. The faintest stars you're likely to see with the naked eye are about 6.0 magnitude (under country skies), while the brightest stars are around zero magnitude, with the most brilliant, Sirius, at –1.4 magnitude. Planets can be much brighter. Venus, for example, can be as bright as –4.0 magnitude, the Full Moon, –12 magnitude.

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

Angles in the sky are measured in degrees. You'll see that the Sky Views have a line showing what an angle of 10° looks like on the scale of these drawings. On the back cover is a scale that can help you measure angles.

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

Culmination When an object culminates it has reached its highest point in the sky and is generally considered to be the best time to observe it. This is sometimes referred to as transiting or crossing the meridian. The meridian is an imaginary line, which starts at due north on the horizon and runs up to overhead (the zenith) and down to the south.

so it does not turn fast enough to maintain the same face to us, giving us a view around its eastern limb. Then as the Moon moves slower, approaching apogee, it turns a little too much to keep facing us, giving a view beyond the western limb. The second type of libration is a latitudinal nod and is caused by the slight tilt of the Moon's axis. We can see a little over the south pole during one half of each revolution with the north pole hidden; during the other half of its orbit we see over the northern limb while the south pole is hidden from view.

The Planets

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

Dwarf Planets and Small Solar System Bodies

Dwarf Planets. This section mainly deals with Pluto, but also includes Ceres when at opposition.

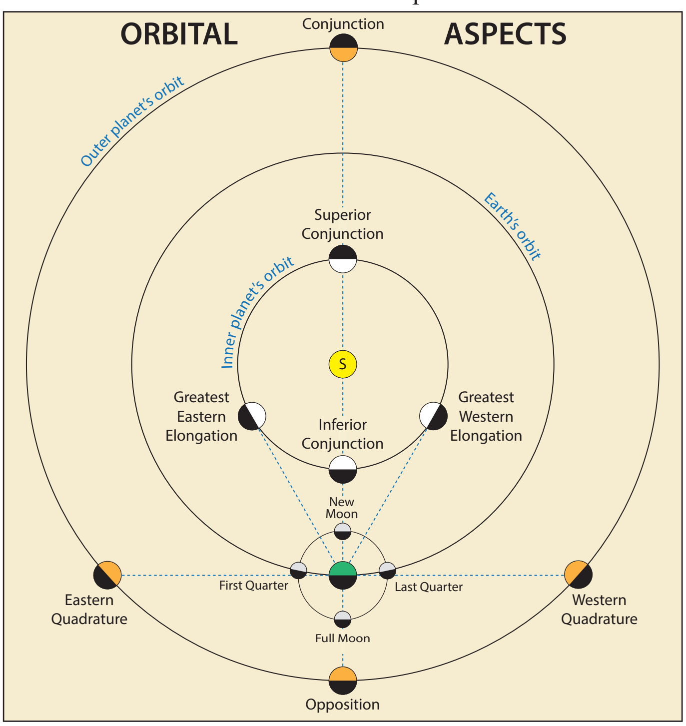
Minor Planets (or Asteroids) This section covers the brightest asteroids that reach opposition each month (12.5 magnitude or brighter). An entry includes the date of opposition (when it is brightest), its magnitude and the constellation the asteroid is in at this time. The 15 brightest dwarf and minor planets have ephemerides included in Part II (page 138).

Comets

This section deals with the brightest comets expected to be visible during the year. Note that most of the known comets are relatively faint and need a telescope. However, 2018 is looking reasonable for periodic comets with two that may reach binocular visibility. Comet 21P/Giacobini-Zinner appears over the morning northern horizon in September at possibly 7th magnitude. The other is 46P/Wirtanen in the evening sky late in the year that might reach 4th magnitude in December! See also Part II pp. 134–7.

Meteor Showers

On any clear night we may see up to five shooting stars per hour. These are known as random or sporadic meteors. There are also annual showers, which return at the same time each year. Each shower seems to radiate from a focal point in the sky and is named after the constellation or a bright star that the radiant lies near. For example, the radiant for the Leonids lies within the constellation of Leo. The monthly section lists the major showers that are suitable for observation this year—those largely unaffected by moonlight in the mornings during their peak period. Information for other known showers is given in Part II (p. 139). It is best to do your searching on moonless nights, away from light polluted cities. In general, more meteors are seen after midnight.



Double Stars

An impressive double star (or two) is presented each month that is ideal to see through small telescopes.

Feature Article

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

Diary

This is a list of general phenomena associated with the planets, Moon, minor planets and comets. 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. Minor differences can sometimes be found between the separations and times quoted and those found elsewhere in Part I. Some entries are geocentric (the theoretical view from the centre of the Earth), others may have times and separations given in the text or Sky Views as seen from Australia. For conjunctions involving the Moon, the distances given are measured from the centre of the Moon (which has a radius of about one quarter of a degree).

Abbreviations. These include:

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

There are also some astronomical catalogues including NGC (New General Catalogue), IC (Index Catalogue) and M (Messier Catalogue).

Time. When times are given, both EST and WST are presented. With the exception of lunar phases (which are given to the nearest minute) times are rounded to the nearest hour. It is unnecessary to include a separate entry for CST as there is only a 30 minute difference from EST. The remaining entries are less time sensitive and either have no time (that is the closest day) or a pm or am designation for an evening or morning event respectively. For *timed* events that occur in the very early hours (before 2 am) for EST, the WST conversion (subtracting two hours) takes them into the previous day and are shown as 'prev day'.

Sky Views

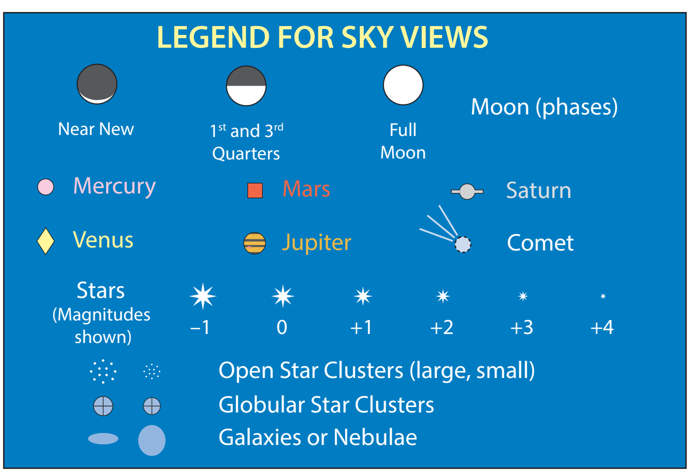
These diagrams are designed to help you find the naked eye planets. The date and time chosen give the most interesting patterns of the planets and Moon. Sometimes the times correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although this is twilight, it is sometimes necessary to catch a glimpse of the planets when close to the Sun. This is especially needed for Mercury as 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 (approximate phase) and planets visible to the naked eye.
- All stars down to 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies. A prefix of N means the object is in the New General Catalogue (NGC), an I is the Index Catalogue (IC) and M is an entry in the Messier Catalogue.
- Constellations are labelled (capital letters) and have black lines joining key stars to show the constellation's recognisable pattern.

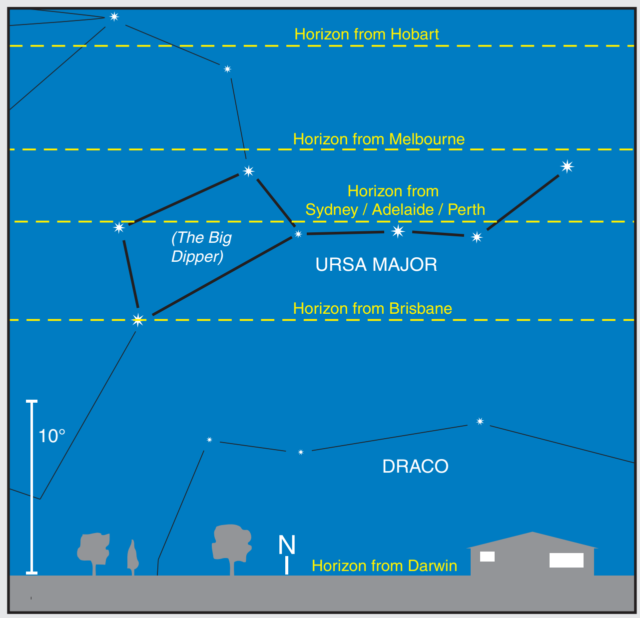
Saturn and Jupiter Satellites. Each planet has a diagram for months close to their opposition. Only the brightest moons are included. There are key differences worth keeping in mind between these planets. The plane of the orbits of Jupiter's moons is close to the Earth's orbital plane, so we see them shuffle back and forth in straight lines, passing in front of and behind the planet and even in and out of its shadow. Of the bright four Galilean moons, Callisto is the exception at the moment passing over/under Jupiter's disc. Saturn's moons orbit in the plane of the rings. As the rings spend most of the time inclined to our line of sight (hence our brilliant view), so the orbits of the satellites are ellipses appearing to pass below, then half an orbit later above the planet. The further out the satellite is, the larger the ellipse. Saturn's moons are considerably fainter than Jupiter's Galilean satellites with Titan the only standout. The inner ones are swamped by the glow of the nearby rings, making them hard to see.

Uranus, Neptune and Pluto have been excluded from the Sky Views, as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20 cm telescope to glimpse this faint dwarf planet. In any case, because of the many faint stars of similar brightness close by, separate finder charts (see Part II) are needed for these outer worlds. Their approximate positions are marked on the All Sky Maps to point you to the right area and then go to the finders.



WHAT TIME IS IT? Unless a time zone or a location is specifically mentioned, times given in the Monthly Section will be approximate local standard time. No adjustments are made for Daylight Saving anywhere in this book. When it is in force you will need to add one hour to times given here. e.g., any rise or set time from the charts will need to have one hour added to get daylight saving time.

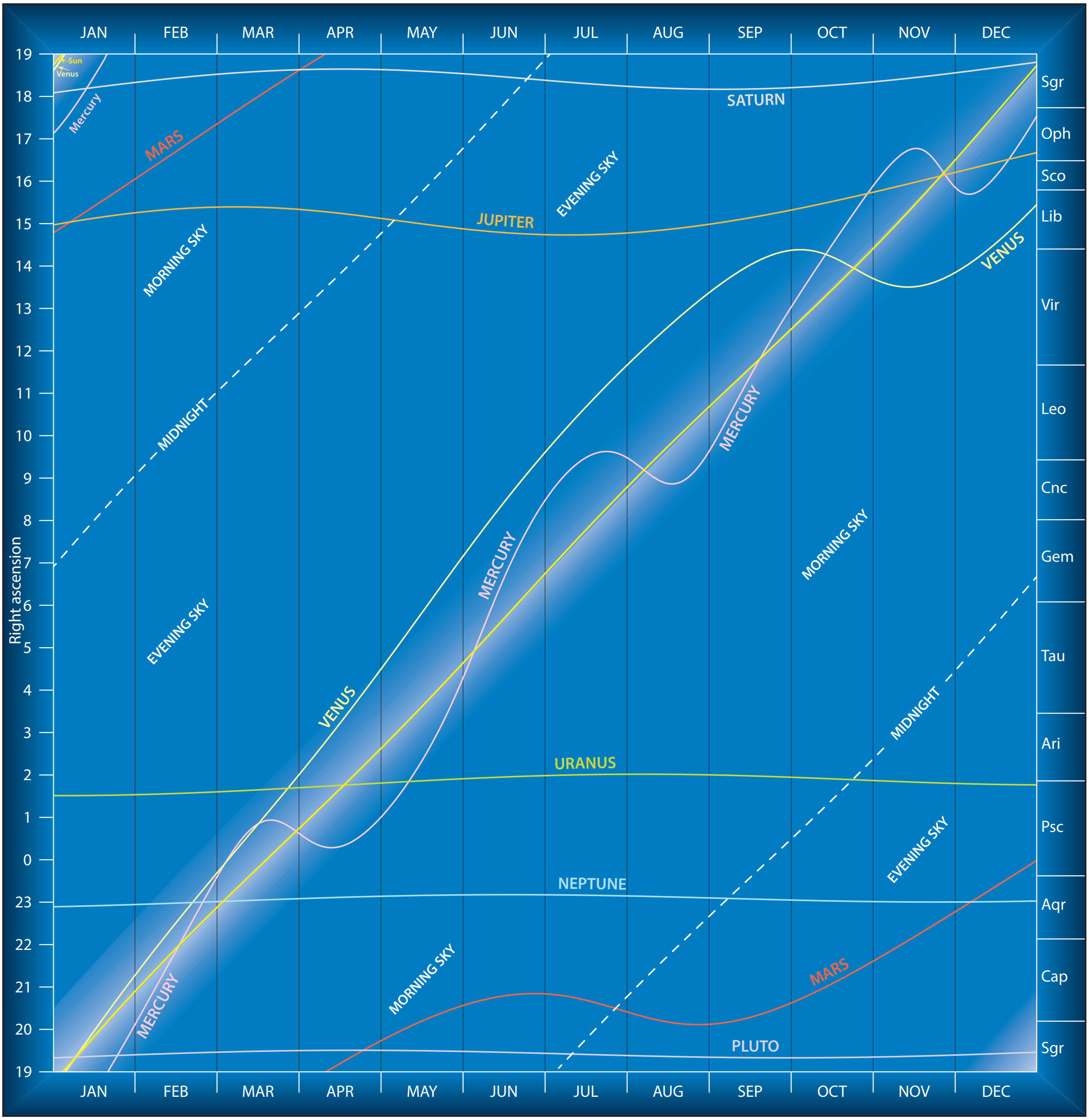
When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST); the mean solar time on the meridians of longitude 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from EST times given. Any specific times given for Darwin or Adelaide are CST. Queensland, NSW, ACT, Victoria and Tasmania use EST. SA and NT use CST and WA uses WST.



EFFECT OF LATITUDE

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

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. Jupiter for example will be in Libra in the June evening sky (also see All Sky Map No. 6).

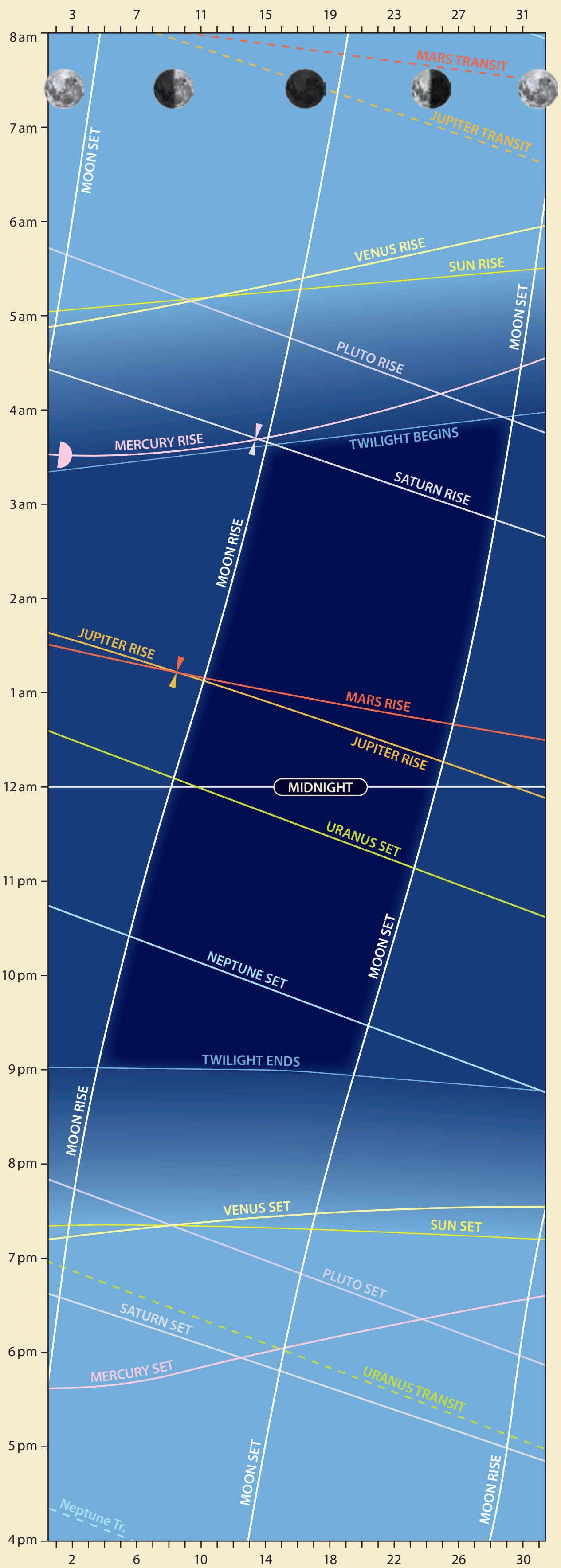
Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best time to observe these inner planets is when their paths extend beyond the twilight. For Mercury, the optimum period in the evening sky is from mid June to mid July and in the mornings from mid April to mid May. Venus is visible from late March until early October in the evening sky, returning to the morning in November.

When an outer planet crosses a midnight line, it is at opposition and visible the entire night, and when crossing the Sun line it is in conjunction.

The diagram also shows when conjunctions between the planets occur. When two planet lines cross or are close, they will be near each other in the sky. A fine example this year is when Mercury is in conjunction with Venus, then with Jupiter both in October, see also the sky view on page 64.

JANUARY

RISE–SET CHART



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

HIGHLIGHTS

- Total lunar eclipse (Blue Moon).
- Four planets in the morning sky!
- Mercury and Saturn close.
- Mars and Jupiter very close.

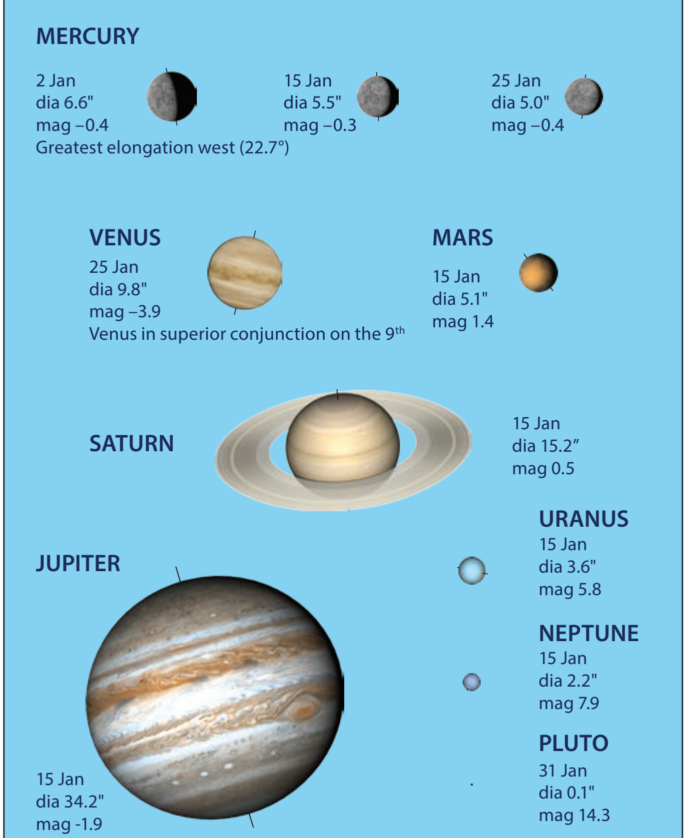
CONSTELLATIONS

Eridanus the River is one of the longest but faintest constellations in the sky (see All Sky Map No 2). From suburbia it is nearly invisible, but under dark skies you can get a strained neck following this meandering group of mostly 4[th] magnitude stars crossing overhead in the evening sky at this time of year. This waterway has been depicted quite elaborately in Johann Bayer's Uranometria (star atlas) complete with bulrushes. Its origin goes back to antiquity, being one of Ptolemy's original constellations. In biblical times it was associated with the Euphrates and Nile rivers, however its name originates from the Greek "Eridanos", a name for the River Po in Italy.

Its 2[nd] brightest (2.8 magnitude) star, Beta (β) Eridani, Cursa, marks Eridanus' headwaters. However, its name means 'footstool' relating to nearby Rigel (Beta (β) Orionis), which means 'foot'. So it offered a place for the tired hunter, Orion, to rest.

The constellation then flows south-west, directly away from the Milky Way, soon finding naked eye (3.0 magnitude) Gamma (γ), called Zaurak or 'boat'. This red giant is one of the visually brightest 'M' class stars in the heavens. What colour can you see? Binoculars will help.

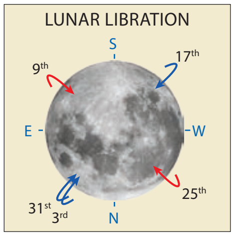
APPEARANCE of the PLANETS



The river continues into truly extragalactic territory, in fact flowing around Fornax, a constellation famous for its galaxies. Notable Eridanus highlights, suitable for the medium size telescope, include NGC1300, 1232, 1532 and 1291.

With its Northern Hemisphere roots Eridanus traditionally finished at magnitude 3.2 Theta (θ) Eridani or Acamar. From ancient Greece the current end of the river, the brilliant Alpha (α) Eridani or Achernar, was not visible. Both names were derived from Arabic phases referring to a river's end. At magnitude 0.45, Achernar is the 9th brightest star in the sky and certainly one of the most isolated being 39° from either Canopus or Fomalhaut. Returning to Acamar, it is an impressive double star for small telescopes, having two white components (mag. 3.2 and 4.1) separated by 8 arcseconds.

THE MOON



- 2nd 8 am (6 am WST) Moon at perigee (closest to Earth at 356,565 km).
- 2nd Noon (10 am WST) Full Moon.
- 3rd 5 am (3 am WST) Minimum Libration (3.4°), Full Moon.
- 5th 6 pm (4 pm WST) Occultation of Regulus by the Moon, visible from Alaska, Canada, Greenland, Iceland & Europe except S. This is the 15th in a series of 19 occultations of Regulus that began in December 2016 and ends in April this year.
- 9th 8 am (6 am WST) Last Quarter.
- 9th 5 pm (3 pm WST) Maximum Libration (9.6°), dark SE limb.
- 12th 2 pm (noon WST) Occultation of minor planet Vesta by the Moon, visible from S Africa, Madagascar, SW Australia including Tasmania (daytime event).
- 15th Noon (10 am WST) Moon at apogee (furthest from Earth at 406,464 km).
- 17th Noon (10 am WST) New Moon.
- 17th 4 pm (2 pm WST) Minimum Libration (2.7°), too close to New Moon.
- 25th 2 am (midnight previous day WST) Maximum Libration (9.7°), dark NW limb. Libration zone features are in shadow. However observers will note the effect with Mare Crisium close to the eastern limb.
- 25th 8 am (6 am WST) First Quarter.
- 27th 9 pm (7 pm WST) Occultation of Aldebaran by the Moon, visible from Asia (except SE) & NW North America. From Australia the pair appear within 2° of each other in the early evening. This is the 41st in a series of 49 occultations that began in January 2015 and ends in September this year.
- 30th 8 pm (6 pm WST) Moon at perigee (closest to Earth at 358,994 km).
- 31st 9 am (7 am WST) Minimum Libration (2°), bright NE limb.
- 31st 11 pm (9 pm WST) Full Moon. Total lunar eclipse, visible from Australia. See Part II (p. 91) for details. A second Full Moon in a calendar month has become known as a Blue Moon. It has no astronomical significance and is not particularly rare (see previous page).

Double Blue Moons

If the first Full Moon of the year occurs on or before 10 January (11th in a leap year), there will be thirteen Full Moons in that year, and at least one month will contain two. The interval between successive months with two Full Moons is around 2.5 to 3 years, so it is not uncommon. The months with 31 days are statistically more likely to have two Full Moons than those with only 30 days, and as the average lunar cycle is 29.5 days February always misses out, even in a leap year.

The second Full Moon to occur in a calendar month has become known as a Blue Moon. This modern definition was the result of a 1943 quiz question in Sky & Telescope (S&T) magazine, the reference source being the 1937 Maine Farmer's Almanac. The answer was a misinterpretation of the almanac's seasonal meaning, where a Blue Moon was defined as the third in a season containing four Full Moons. Actually it's a little more convoluted than that, see the May 1999 issue of S&T for an excellent article on the mistake. Also 'Once in a Blue Moon' in Astronomy 2004.

A careful look at the lunar phases on our calendar (inside front cover) reveals a rare situation indeed, two Blue Moons in the same year! This double Blue Moon scenario is rare and happens only a few times per century (last occurrence in Australian time zones was 2010). This year January and March have two Full Moons each and February none, this is the most common sequence but it is also possible in January/April or January/May and only when February has no Full Moon at all. Also possible is a December one year and March the following year, again with no Full Moon in February.

There is nothing strange going on here. The Metonic Cycle is the Moon's 19-year cycle where the phases of the Moon occur on the same dates of the year in exactly the same place in the sky. During this 19-year period there will be 236 Full Moons but only 228 calendar months. The eight left over Full Moons must squeeze into some of those months that already have one, and infrequently we end up with a double Blue Moon like this year.

It should be noted that for astronomical use the phases of the Moon have no length but occur at well-defined instants. Technically, the four phases are defined to occur when the excess of the apparent (celestial) longitude of the Moon over that of the Sun is 0 (New Moon), 90 (First Quarter), 180 (Full Moon), and 270 degrees (Last Quarter) respectively. For the casual observer the Moon may be said to be 'full' over a couple of days. It should also be noted that if daylight saving is taken into account the January 31 Full Moon would fall on February 1 and we would only have a single Blue Moon in March this year.

THE PLANETS

Mercury, in the eastern morning dawn sky, reaches its greatest western elongation (23°) from the Sun on the 2nd. Although not the best of elongations, observers may like to view Mercury and Saturn on the 13th and 14th when they will be a little less than 1° apart, Mercury being the brighter of the pair (see Sky View). On the 15th the waning crescent of the 27-day old Moon joins the planets to the north (see Sky View). Like most observations in the twilight, a pair of binoculars is a great help. By month's end Mercury will be too close to the Sun for observation.

Venus, in superior conjunction (Earth and Venus on opposite sides of the Sun) on the 9th, is too close to the Sun for observation until the end of February. It then becomes a brilliant object in the western evening sky until late October when it passes between the Earth and Sun to become a morning object in November.

The **Earth** is at perihelion on the 3rd, the closest point in its orbit to the Sun (147,097,193 km or 0.983284 au distant).

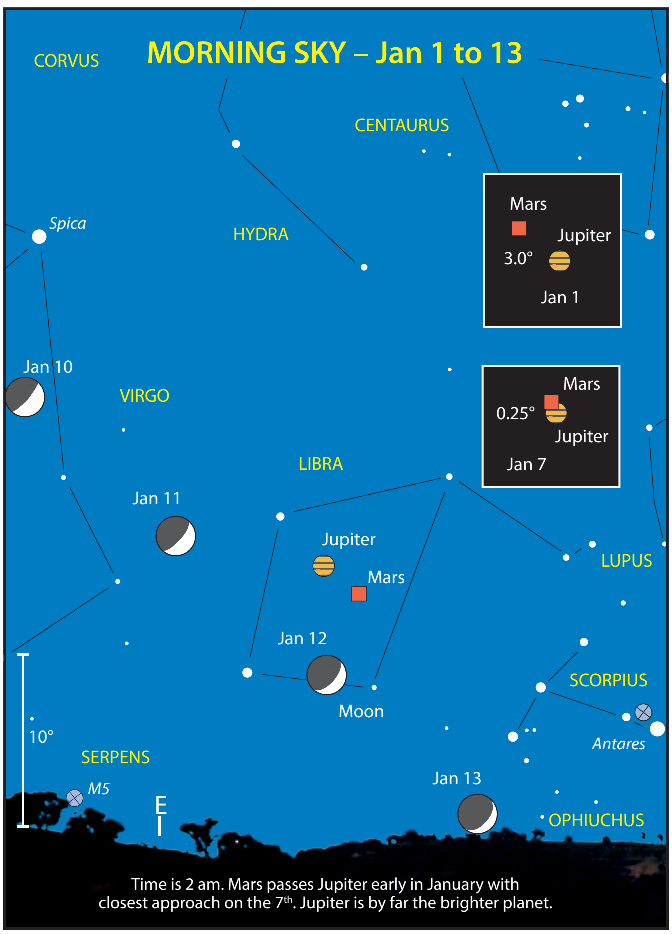
Mars observers are in for a real treat this year with a perihelic opposition occurring in late July, the most favourable since 2003. Much was made of the fact that Mars came nearer to Earth in 2003 than at any time in close to 60,000 years. Whilst true, the difference between Mars' diameter during favourable perihelic oppositions varies only by one or two arcseconds at most. For example, in 2003 the planet's maximum diameter was 25.11 arcseconds compared with this year's 24.31—less than one arcsecond or 97% the size of the previous 'best ever' opposition. The distance between our two planets also makes an interesting comparison. In 2003 the closest approach was 55.76 million km, compared with this year's 57.59, just 1.8 million km further. As a bonus to us 'down under' observers, the planet is at its greatest southerly declination during perihelic oppositions.

At the beginning of January, Mars will be 3° from Jupiter in Libra. The distance decreases until the 7th when the pair will be just 0.25° apart—perhaps the best conjunction of the year and all the better with binoculars or telescope (see Sky View). On the 12th, the 25-day old waning crescent Moon will be below Mars and Jupiter providing a neat pre-dawn display (see Sky View).

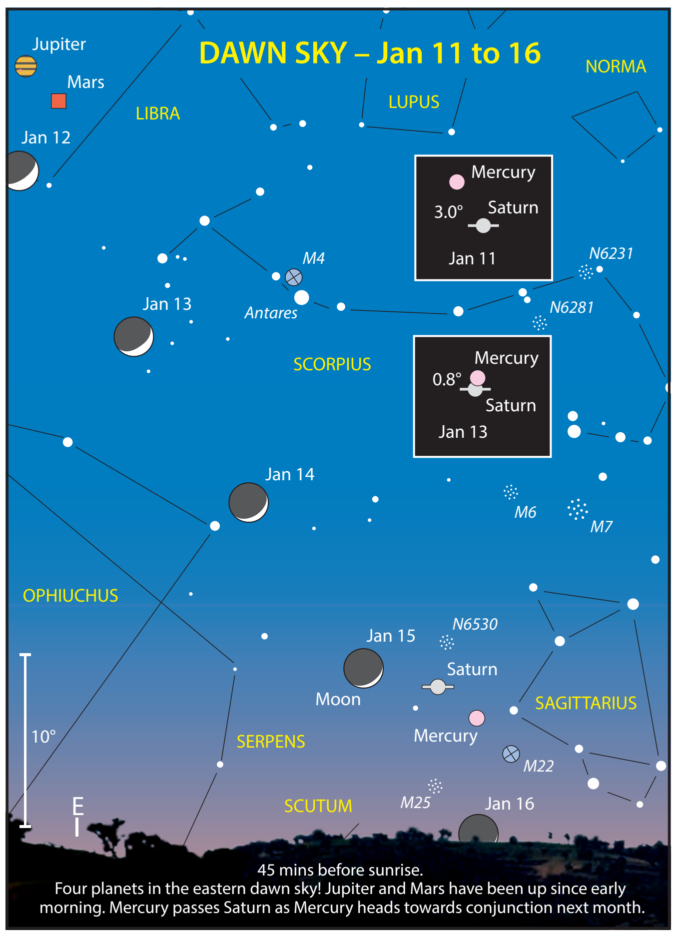
Jupiter begins the month in the pre-dawn eastern sky in Libra. The gas giant and the Red Planet have a close encounter when they appear less than 1° apart from the 5th to the 10th and closest at 0.25° on the 7th (see Sky View). The 25-day old waning crescent Moon appears below the planetary duo on the 12th—not real close but it's always pleasant to see the Moon near the brighter planets (see Sky View).

Saturn, moving from behind the Sun after its December conjunction, returns to the morning eastern sky in Sagittarius. Saturn and Mercury will be less than 1° apart on two consecutive mornings this month. For the early birds the pair will be in a twilight sky and close to the horizon—on the 13th Mercury will be directly above Saturn (see Sky View) and to the right on the following morning with the innermost planet the brighter of the two. On the 15th, the 27-day old slender

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



Time is 2 am. Mars passes Jupiter early in January with closest approach on the 7th. Jupiter is by far the brighter planet.



45 mins before sunrise.
Four planets in the eastern dawn sky! Jupiter and Mars have been up since early morning. Mercury passes Saturn as Mercury heads towards conjunction next month.

crescent of the waning crescent Moon will be just to the north (left) of Saturn with Mercury further to the south or lower right (see Sky View).

Uranus is located in the north-western evening sky in Pisces at the end of astronomical twilight. The planet appears stationary on the 3rd, ending five months of retrograde motion—it now begins travelling from west to east against the star field.

Neptune is in Aquarius, its home until 2022, setting at 9:30 pm around the middle of the month. At the beginning of January the planet is 0.5° from the 4th magnitude red giant star Hydor (Lambda (λ) Aquarii), the distance increases to 1° by month's end.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** is in conjunction with the Sun on the 9th and will return to the morning skies in February. **Ceres**, at magnitude 6.9, is at opposition on the 31st in Cancer.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
2 Jan	8 Flora	Gemini	8.2
11 Jan	32 Pomona	Gemini	10.9
12 Jan	67 Asia	Gemini	12.2
19 Jan	185 Eunike	near Mon/CMi border	11.6
26 Jan	11 Parthenope	Cancer	9.9

COMETS

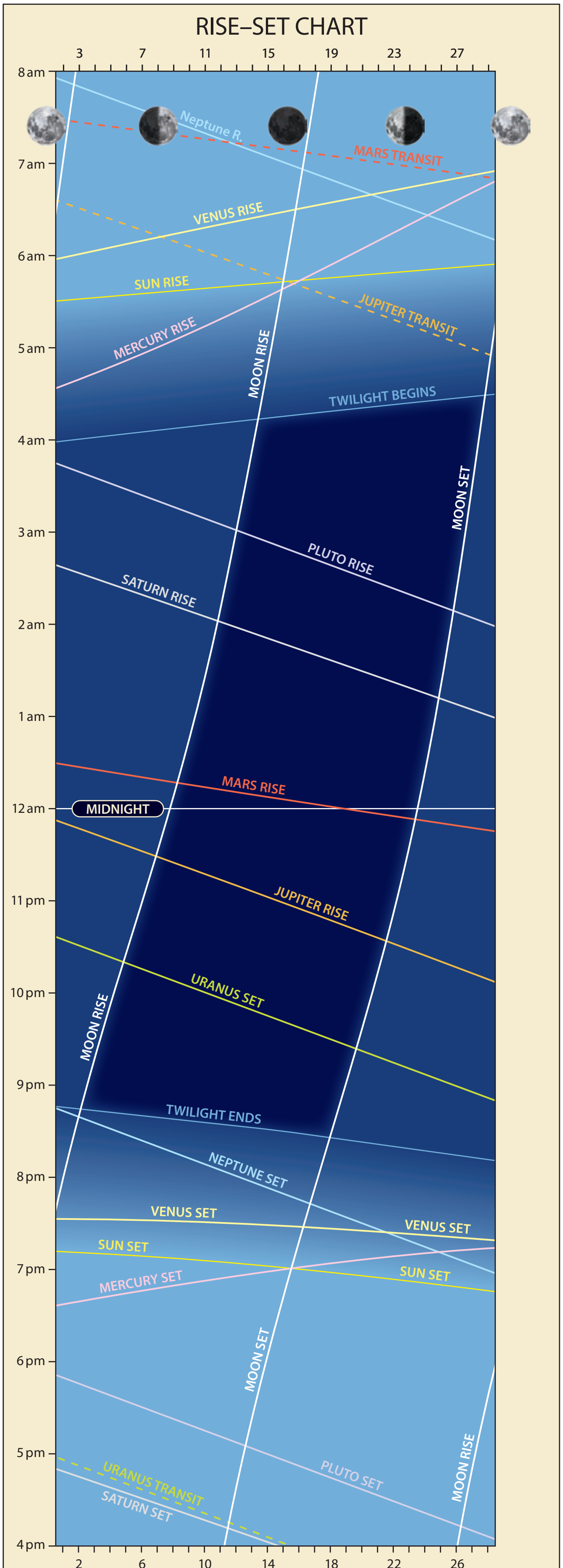
Comet C/2016 R2 (PANSTARRS) opens the year in Taurus, initially near Aldebaran. It skirts the western edge of the Hyades for the first week of January. Shining at 10th magnitude, the comet is visible until the early hours of the morning. By month's end, PANSTARRS is setting around midnight.

DOUBLE STARS

Located in the inconspicuous constellation of Caelum (representing an engraving tool, chisel or burin) right on the border with neighbouring Columba (the Dove), Gamma-1 (γ^1) Caeli (see All Sky Map 2) is a fine double star for a warm summer night. The stars, magnitudes 4.7 and 8.2, are separated by 3.2 arcseconds with a position angle of 305 degrees. The pair is orange (spectrum K3III) and white and well seen in a 150 mm Newtonian reflector. A 100 mm scope should also split the pair nicely. John Herschel missed the pair. There is slow retrograde motion and the separation is gradually increasing since the first measurement done by its discoverer, Captain W.S. Jacob in 1847. Located approximately 185 light years away, common proper motion indicates a long period binary. Gamma-1 forms an easy binocular double with magnitude 6.3 Gamma-2 (γ^2) Caeli located due south and which is itself a very close double star.

DIARY			
Mon	1st		Neptune 0.5° SE of star Lambda (λ) Aquarii
Tue	2nd	6 am	(4 am WST) Mercury at greatest elongation West (22.7°)
Tue	2nd	8 am	(6 am WST) Moon at perigee, 356,565 km
Tue	2nd	12:24 pm	(10:24 am WST) Full Moon (356,602 km, closest for this year)
Wed	3rd		Mars 0.6° N of star Alpha (α) Librae
Wed	3rd	7 am	(5 am WST) Uranus stationary
Wed	3rd	9 am	(7 am WST) star Pollux 9° N of Moon
Wed	3rd	4 pm	(2 pm WST) Earth at perihelion, 0.983284268 au
Fri	5th	4 am	(2 am WST) Mercury 0.2° W of m.p. 14 Irene
Fri	5th	6 pm	(4 pm WST) star Regulus 0.9° S of Moon
Fri	5th	10 pm	(8 pm WST) Comet C/2016 R2 (PANSTARRS) 0.2° SW of star Gamma (γ) Tauri
Sat	6th		m.p. 4 Vesta 1.0° N of star Gamma (γ) Librae
Sun	7th	2 pm	(Noon WST) Jupiter 0.2° N of Mars
Tue	9th	8:25 am	(6:25 am WST) Last Quarter Moon
Tue	9th	2 pm	(Noon WST) star Spica 7° S of Moon
Tue	9th	5 pm	(3 pm WST) Venus in superior conjunction
Tue	9th	8 pm	(6 pm WST) d.p. Pluto in conjunction with Sun
Wed	10th		Mercury 0.7° SW of NGC 6469 (OC) in Sagittarius
Thu	11th	4 pm	(2 pm WST) Jupiter 4° S of Moon
Thu	11th	8 pm	(6 pm WST) Mars 5° S of Moon
Fri	12th	4 am	(2 am WST) Mercury 0.1° NW of M20 Trifid Nebula (BN) in Sagittarius
Fri	12th	10 am	(8 am WST) star Antares 9° S of Moon
Fri	12th	2 pm	(Noon WST) m.p. 4 Vesta 0.4° N of Moon
Sat	13th	4 am	(2 am WST) Mercury 0.2° NE of NGC 6546 (OC) in Sagittarius
Sat	13th	5 pm	(3 pm WST) Saturn 0.6° N of Mercury
Sun	14th	am	Jupiter 0.15° SW of star Nu (ν) Librae
Mon	15th		Mercury at descending node
Mon	15th	Noon	(10 am WST) Moon at apogee, 406,464 km
Mon	15th	Noon	(10 am WST) Saturn 3° S of Moon
Mon	15th	5 pm	(3 pm WST) Mercury 3° S of Moon
Wed	17th	4 am	(2 am WST) Mercury 0.1° NE of NGC 6642 (GC) in Sagittarius
Wed	17th	12:17 pm	(10:17 am WST) New Moon
Wed	17th	pm	m.p. 11 Parthenope 0.2° SW of star Delta (δ) Cancri
Thu	18th		Mercury 0.7° NE of M22 (GC) in Sagittarius
Thu	18th	7 pm	(5 pm WST) m.p. 3 Juno 5° N of Moon
Sun	21st	6 am	(4 am WST) Neptune 1.6° N of Moon
Tue	23rd		Venus at aphelion
Tue	23rd		Saturn 0.4° S of NGC 6583 (OC) in Sagittarius
Wed	24th	11 am	(9 am WST) Uranus 5° N of Moon
Wed	24th	pm	m.p. 11 Parthenope 1.3° SW of M44 Beehive Cluster (OC) in Cancer
Thu	25th		Mercury at aphelion
Thu	25th	3 am	(1 am WST) d.p. Pluto 1.5° N of Mercury
Thu	25th	8:20 am	(6:20 am WST) First Quarter Moon
Sat	27th	9 pm	(7 pm WST) star Aldebaran 0.7° S of Moon
Mon	29th	pm	m.p. 8 Flora 1.2° NE of star Mu (μ) Geminorum
Tue	30th	8 pm	(6 pm WST) Moon at perigee, 358,994 km
Tue	30th	9 pm	(7 pm WST) star Pollux 9° N of Moon
Wed	31st		Mercury 0.6° SW of M75 (GC) in Sagittarius
Wed	31st	11 pm	(9 pm WST) d.p. 1 Ceres at opposition
Wed	31st	11:27 pm	(9:27 pm WST) Full Moon (360,198 km); eclipse

FEBRUARY



HIGHLIGHTS

- Venus returns to the evening twilight.
- Mars and Jupiter in the morning sky.
- The alpha-Centaurids meteor shower.

CONSTELLATIONS

We have all heard of the 12 signs of the zodiac. This is supposed to cover the motion of the Sun and encompass the movement of the planets and Moon. So how come Venus spent the last week of January 2014 in Scutum and Jupiter and Saturn visited Cetus in March 1999 and March 1997 respectively? In March 1798 Venus also made a short visit to Pegasus. Orion, Cetus, Pegasus and Scutum are not constellations normally associated with the movement of the planets through the zodiac. In reality the 12 signs don't even describe the Sun correctly with our star actually passing through 13 constellations each year, Ophiuchus being the missing 'sign'.

These signs have nothing to do with the official astronomical boundaries of the constellations but instead refer to arbitrary rectangular spaces, which are exactly 30 degrees wide in celestial longitude. For example, when the Sun is close to Aldebaran (Alpha (α) Tauri) around May 30 each year, it may be astronomically in Taurus but it is in the astrological star sign of Gemini, The Twins. It is not just the size of the astrological *constellation* that affects this. The precession of the equinoxes, due to the slow wobble of the Earth's axis over many thousands of years, also has an influence.

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 17th

1 Feb
dia 4.9"
mag –0.6

28 Feb
dia 5.3"
mag –1.4

VENUS

15 Feb
dia 9.9"
mag -3.9

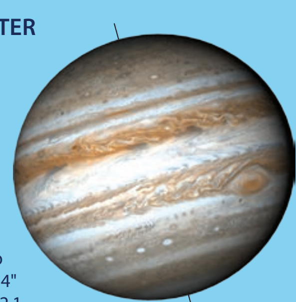
MARS

15 Feb
dia 6.1"
mag 1.0

SATURN

15 Feb
dia 15.6"
mag 0.6

JUPITER



15 Feb
dia 37.4"
mag –2.1

URANUS

15 Feb
dia 3.5"
mag 5.6

NEPTUNE

15 Feb
dia 2.2"
mag 8.0

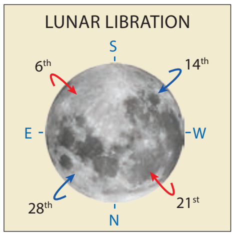
PLUTO

15 Feb
dia 0.1"
mag 14.3

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

In summary there are 21 constellations in which some of the planets from Mercury to Neptune can at times enter. The Moon adds Auriga to the list. Hence we have a total of 22 constellations. The additional 10 are: Auriga, Cetus, Corvus, Crater, Hydra, Ophiuchus, Orion, Pegasus, Scutum and Sextans.

THE MOON



Readers may note that there is no Full Moon this month, February is the only month that can have only three lunar phases. This is rather rare and will happen next in 2029 (no Full Moon) and in 2031 (no First Quarter) for Australian time zones (See also p. 17).

- 2nd 5 am (3 am WST) Occultation of Regulus by the Moon, visible from N Europe, Siberia and Japan.
- 6th 3 pm (1 pm WST) Maximum Libration (9.5°), libration zone features in shadow on dark SE limb.
- 8th 2 am (midnight previous day WST) Last Quarter.
- 9th 11 pm (9 pm WST) Occultation of minor planet Vesta by the Moon, visible from Chatham Island and most of Antarctica.
- 11th Midnight (10 pm WST) Moon at apogee (furthest from Earth at 405,700 km).
- 14th 5 am (3 am WST). Minimum Libration (2.3°), too close to New Moon.
- 16th 7 am (5 am WST) New Moon. Partial eclipse of the Sun, not visible from Australia. See Part II for details.
- 21st 2 pm (noon WST) Maximum Libration (8.9°), dark NW limb.
- 23rd 6 pm (4 pm WST) First Quarter.
- 24th 4 am (2 am WST) Occultation of Aldebaran by the Moon, visible from NE North America, Greenland, Iceland, Europe except S and parts of Asia.
- 28th 1 am (11 pm WST previous day) Moon at perigee (closest to Earth at 363,933 km).
- 28th 5 am (3 am WST). Minimum Libration (1°), bright NE limb.

WOW! Revisited — Comets, Aliens or?

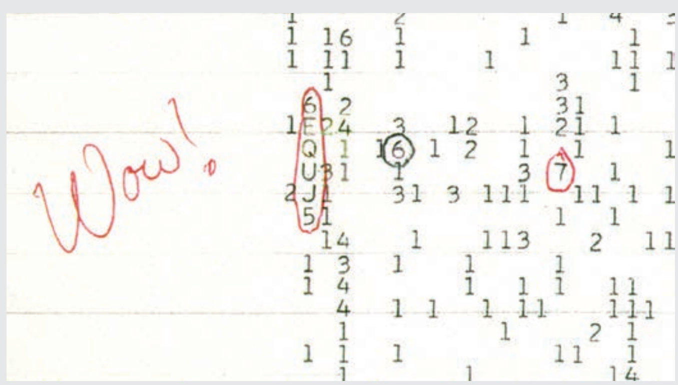
In Astronomy 2014 we presented a short feature on an event that became known as the 'Wow! signal'. This unexplained and unrepeated signal was received on 15 August 1977 by the Big Ear radio telescope in Ohio, USA. A few days later a SETI volunteer, Jerry Ehman, was routinely reviewing the telescope's computer printout when he was surprised to discover a string of numbers and letters '6EQUJ5' that indicated, on a linear scale, a signal 30 times louder than the normal background of deep space. In his excitement he circled the characters in red pen and wrote the now famous 'Wow!' next to them. The numbers and letters were a measure of the intensity of the signal; the numbers 0 to 9 were used, then the letters of the alphabet (A was 10, B was 11 and so on) as the power increased.

The signal lasted 72 seconds, the time it took for the Earth's rotation to carry it through the observing window of the fixed Big Ear. It was only picked up by one of the telescopes' two horns that follow each other across the sky indicating that it was not a long continuous signal but a short intermittent one. The precise location of the signal is unknown since the incoming data was not processed in a way that indicated which horn made the detection but its general whereabouts was approximately 2.5° south of Chi Sagittarii.

The telescope was aimed towards the Wow! source for a month after its detection with no sign of a repeat signal. The Big Ear periodically monitored the region for the next 20 years until it was dismantled in 1998 to make way for a golf course, all these searches and others by various radio telescopes also proved fruitless.

It had been proposed that aliens trying to signal us would use a frequency that had some meaning to beings that understood mathematics and chemistry. It was suggested that the hydrogen line (1420 MHz) would be considered a universal standard for galactic communication, it also has very few natural interferences. The Wow! was a very narrow band signal that came in on just one channel, just like a radio broadcast, and ironically at that magical hydrogen line as predicted.

All earthly possibilities on what caused the signal so far have been explored and discounted or deemed improbable, from satellites, military, aircraft or signals bounced off space junk. Newly discovered off world noisemakers like colliding black holes and gamma ray bursts also do not fit the profile. As Big Ear used a fifty-channel receiver any natural signals from objects like quasars or pulsars would have flooded across all frequencies.



THE PLANETS

Mercury is too close to the Sun during February for observation. The planet moves from the morning dawn, into superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 17th and thence into the evening twilight.

Venus makes a slow climb into the western evening sky after its superior conjunction (Earth and Venus on opposite sides of the Sun) last month. By month's end the planet will barely be above the horizon at the end of civil twilight.

Mars, visible only in the morning eastern sky (see Sky View), is located within 0.5° of the 3rd magnitude star Beta Scorpii (Graffias, Arabic meaning 'claws') at the start of February. Beta is an excellent double star with both components bluish white and well suited to small telescopes, the 2.6 and 4.5 magnitude suns are separated by 14 arcseconds. The Red Planet has commenced a three-month tour of the galactic hub, passing a number of deep sky objects. It spends the first third of the month in Scorpius before moving into Ophiuchus for the remainder. From late February, for a month, Mars visits a number of globular clusters in Ophiuchus (see diary).

The Martian disc reaches six arcseconds in diameter this month and will not fall below this size for 12 months. The use of modern CCD and web cameras can enable the amateur to take useful images of the planet right through this apparition, without having to wait for the period around opposition.

Jupiter rises in the late evening eastern sky in Libra. The planet will remain in the constellation of the Scales until its solar conjunction in November. It then reappears in the morning sky in Scorpius in December. Interestingly Libra is the only zodiacal constellation that does not symbolise a living creature. On the 7th, the planet rises with the Last Quarter Moon nearby (see Sky View).

Saturn, drifting through Sagittarius, its home constellation until 2020, can only be seen in the morning sky rising around 2 am in the eastern sky midmonth. On the 12th, the 26-day old waning crescent Moon appears near the planet (see Sky View).

Uranus, in Pisces, is low in the early western evening sky after the end of astronomical twilight this month.

Neptune begins the month low in the western dusk sky in Aquarius. Gradually the planet becomes lost in the twilight as it nears its conjunction with the Sun early next month.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in Sagittarius, returns to the pre-dawn eastern sky after its conjunction with the Sun last month. The constellation of the Archer will be home to this slow-moving dwarf until 2023 when it moves into Capricornus.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
1 Feb	19 Fortuna	Cancer	10.1
7 Feb	194 Prokne	Hydra	12.3
25 Feb	51 Nemausa	Sextans	9.8

In February and March, 18 Melpomene tours a number of galaxies in Virgo (see diary entries).

COMETS

Comet C/2016 R2 (PANSTARRS) resides in Taurus throughout February. Beginning the month near the Pleiades, the 10th magnitude comet sets late in the evening.

Ultimately the 'Wow! signal' became a cold case until in 2015, Professor Antonio Paris, an astronomer at St Petersburg College in Florida, proposed that the signal might have come from a passing comet. Paris found two suspects, comets 266P/Christensen and 335P/Gibbs, that he traced back to the neighbourhood of Chi Sagittarii when the 'Wow! signal' was detected. Since active comets near the Sun are surrounded by large clouds of hydrogen gas, could it be that the Big Ear telescope detected a comet and not ET?

The pair of short period Jupiter-family comets was not known in 1977 and therefore not investigated as a possible cause (266P/Christensen was discovered in 2006 and 335P/Gibbs in 2008). As it turns out 266P/Christensen returned to the region of the signal in January 2017. To test his hypothesis Paris used a 10-metre radio telescope equipped with a spectrometer and a custom feed horn designed to collect a signal centred at 1420 MHz.

His team observed the comet as it transited the area of the Wow! signal during January. They claimed to have matched the comet's frequency to the same 1420 MHz bandwidth as the Wow! signal and concluded that the signal was a natural phenomenon from a Solar System body, solving the case once and for all (see link for Paris' paper below).

Mystery solved? Not quite, the controversy continues with many astronomers strongly disputing Paris' findings. James Bauer from NASA's JPL remarked that "If comets were radio-bright at 21 centimetres, I would be puzzled as to why they aren't observed more often at those wavelengths." Professor Alan Fitzsimmons, a noted comet expert, also struggles with the findings commenting that 266P/Christensen has very little activity even when near perihelion and "When he (Paris) observed the comet it was over four astronomical units from the Sun, which means it would have been effectively inactive." None of the detractors are saying it's aliens; they are just not satisfied with Paris' conclusions.

Another hurdle to overcome is the fact that the 1977 signal was only detected by one of Big Ears horns. The telescope had two 'feed horns' to capture slightly different fields of view. Had it been a comet the signal would have been followed by a pause and then another signal as it passed through the second horn.

As much as we would like a definitive solution to the signal (and it would be cool if it was aliens), it seems the jury is still out.

A final word from Jerry Ehman: "It's an intriguing possibility that it's a signal from extraterrestrial intelligence, but it's also one that I've had to declare that I can't prove that it is, or prove that it isn't."

Paris' paper may be found at: planetary-science.org/wp-content/uploads/2017/06/Paris_WAS_103_02.pdf

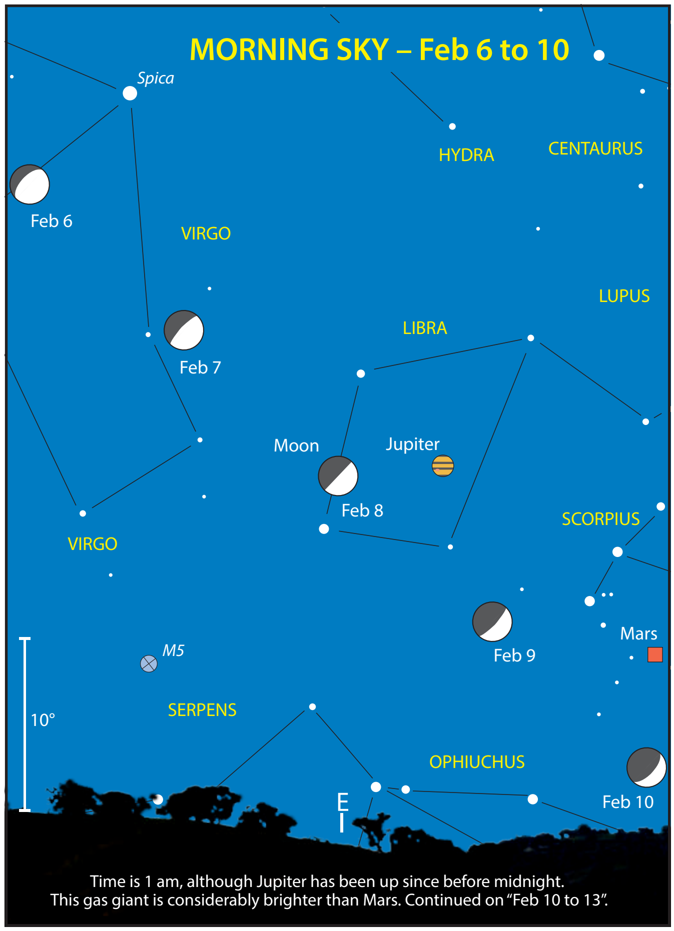
METEOR SHOWERS

The **alpha-Centaurids**, one of the main southern summer showers, are active from the 28 January to 21 February, with maximum on the 8th. Unfortunately the Last Quarter Moon falls right on the peak, however, since their activity is spread over such a wide period observers are sure to catch the odd meteor at any time. The shower is noted for its brightly coloured fireballs that frequently reach negative magnitudes, and are predominantly yellow or blue. The alpha-Centaurids are also well known for their long lasting trains that may vary from a few seconds to several minutes.

DOUBLE STARS

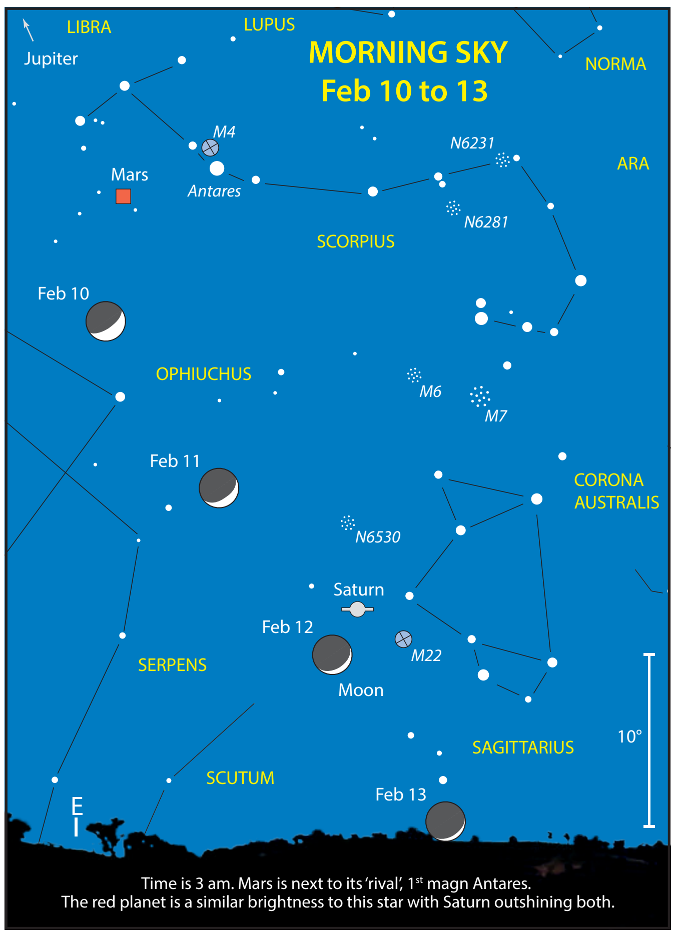
Located in Pictor (the Painter's Easel) is the fine double star Iota (ι) Pictoris (DUN 18, All Sky Map 1). The stars, magnitudes 5.6 and 6.2 are separated by 12.8 arcseconds with a position angle of 59 degrees. The stars are both white (spectrum F0IV and F4V). No real change has occurred since the measures of James Dunlop in 1826. Iota is located approximately 140 light years away and common proper motion suggests the stars are gravitationally connected. The primary may also be a spectroscopic binary. The system has a third, magnitude 9.1 C component located five arcminutes from the A component with a position angle of 48 degrees.

DIARY		
Thu	1st	Mars 0.4° SW of star Beta (β) Scorpii
Fri	2nd	Mars 0.4° N of star Omega (ω) Scorpii
Fri	2nd	5 am (3 am WST) star Regulus 1.0° S of Moon
Sun	4th	m.p. 4 Vesta 0.4° N of star Phi (φ) Ophiuchi
Mon	5th	Comet C/2016 R2 (PANSTARRS) 2.7° E of M45 the Pleiades (OC) in Taurus
Mon	5th	10 pm (8 pm WST) star Spica 7° S of Moon
Thu	8th	1:54 am (11:54 pm WST, prev day) Last Quarter Moon
Thu	8th	6 am (4 am WST) Jupiter 4° S of Moon
Fri	9th	3 pm (1 pm WST) Mars 4° S of Moon
Fri	9th	5 pm (3 pm WST) star Antares 10° S of Moon
Fri	9th	11 pm (9 pm WST) m.p. 4 Vesta 0.9° N of Moon
Sun	11th	1 am (11 pm WST, prev day) star Antares 5° S of Mars
Sun	11th	Midnight (10 pm WST) Moon at apogee, 405,700 km
Mon	12th	1 am (11 pm WST, prev day) Saturn 2° S of Moon
Mon	12th	3 am (1 am WST) Mars 0.1° N of star Omega (ω) Ophiuchi
Tue	13th	6 am (4 am WST) d.p. Pluto 1.8° S of Moon
Wed	14th	Mercury at greatest latitude south
Wed	14th	Venus at greatest latitude south
Wed	14th	9 pm (7 pm WST) m.p. 3 Juno in conjunction with Sun
Thu	15th	d.p. Pluto 0.2° N of star 50 Sagittarii
Fri	16th	7:05 am (5:05 am WST) New Moon
Sat	17th	1 pm (11 am WST) Neptune 1.7° N of Moon
Sat	17th	10 pm (8 pm WST) Mercury in superior conjunction
Mon	19th	am m.p. 18 Melpomene 0.7° NE of NGC 4536 (G) in Virgo
Tue	20th	Mars 0.2° NW of NGC 6235 (GC) in Ophiuchus
Tue	20th	6 pm (4 pm WST) Uranus 5° N of Moon
Wed	21st	am m.p. 18 Melpomene 0.4° NE of NGC 4527 (G) in Virgo
Fri	23rd	6:09 pm (4:09 pm WST) First Quarter Moon
Sat	24th	m.p. 2 Pallas 0.4° NW of NGC 1309 (G) in Eridanus
Sat	24th	4 am (2 am WST) star Aldebaran 0.7° S of Moon
Sun	25th	Mars 0.2° N of NGC 6287 (GC) in Ophiuchus
Tue	27th	7 am (5 am WST) star Pollux 9° N of Moon
Wed	28th	Comet C/2016 M1 (PANSTARRS) 0.4° NE of NGC 6760 (GC) in Aquila
Wed	28th	1 am (11 pm WST, prev day) Moon at perigee, 363,933 km



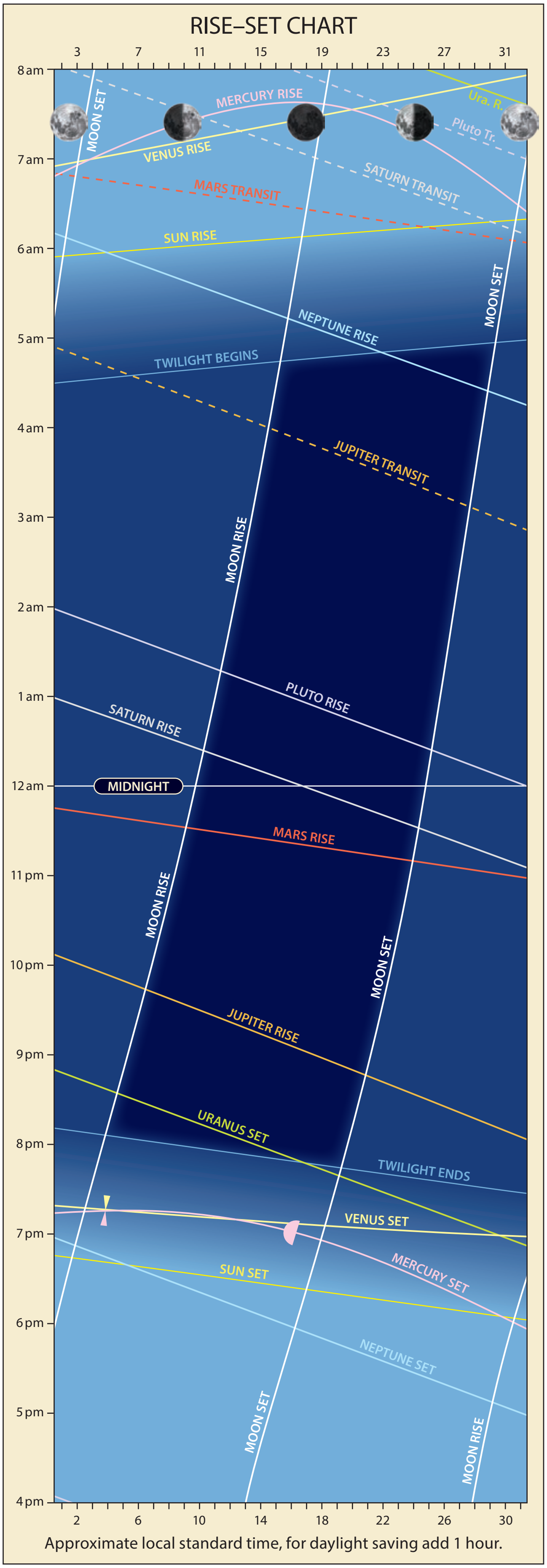
Time is 1 am, although Jupiter has been up since before midnight.
This gas giant is considerably brighter than Mars. Continued on "Feb 10 to 13".

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



Time is 3 am. Mars is next to its 'rival,' 1st magn Antares.
The red planet is a similar brightness to this star with Saturn outshining both.

MARCH



HIGHLIGHTS

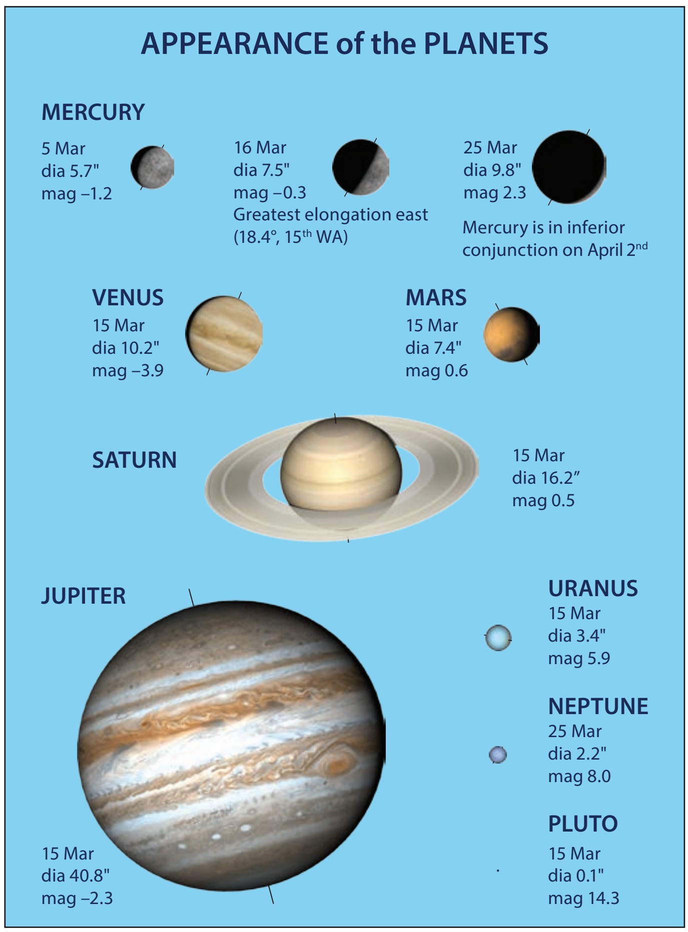
- Mercury and Venus close.
- Mars and Saturn closing.
- Mars passes between the Lagoon and Trifid.
- Saturn close to M22.

CONSTELLATIONS

You may be aware that towards the end of the year a number of constellations in the evening take on two themes. The northern sky has a definite watery bias with Aquarius, Pisces, Cetus, Pisces Austrinus, Capricornus and even a river in Eridanus. Likewise there are the birds of the south with Grus, Phoenix, Tucana and Pavo. Did you know autumn evenings have a canine connection?

The best-known example is one of Orion's hunting dogs, Canis Major or the Greater Dog. Besides being an obvious asterism, its claim to fame is the brightest star in the sky, Sirius, often referred to as the Dog Star. Nearby is Orion's other companion, the Lesser Dog or Canis Minor. Although more obscure it still owns a quite respectable star, the 8th brightest, Procyon (Alpha Canis Minoris). Both canines are following their master, as Orion gets low in the west.

Rising in the north-east is Böötes the Herdsman, easily recognised by his alpha star, Arcturus meaning 'Bear Watcher', also no slouch being the 4th brightest star. This is an apt name as Böötes is following the greater bear, Ursa Major, around the sky, which is unfortunately out of sight for most of Australia. Preceding the herdsman, and being connected to him by

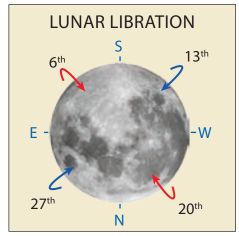


leashes are his two dogs, represented by Canes Venatici. This is quite faint with very little pattern to recognise, the dogs roughly marked by its two brightest stars, 2.9 magnitude Alpha (α) (Cor Caroli) and 4.2 magnitude Beta (β) (Chara). As an aside Cor Caroli is a magnificent double star suitable for any small telescope.

So far, four dogs have been identified. Yes, it's at this point we admit to now making a stretch. To go beyond is to evoke a legend, not an official constellation or even an obsolete one. We first found this curiosity when looking at the translation of star names in Virgo the Virgin. This constellation is best known for its bright star Spica, high in the evening sky. It marks her left hand and translates to 'ear of grain' revealing that the maiden is holding some wheat. However, how do the following Virgo stars relate to this lady; Delta (δ) or Auva means 'barking' and Beta (β) or Zavijava being 'corner'? An old Arabic story had Beta (β), Eta (η), Gamma (γ), Delta (δ) and Epsilon (ε) Virginis forming two sides of a kennel, a home to some dogs which are barking at nearby Leo the Lion. Where these canines are supposed to be remains a mystery.

THE MOON

- 1st 4 pm (2 pm WST) Occultation of Regulus by the Moon, visible from N North America, Greenland, Iceland and NW Europe.
- 2nd 11 am (9 am WST) Full Moon.
- 6th Noon (10 am WST) Maximum Libration (8.9°), libration zone features in shadow on dark SE limb.



- 9th 9 pm (7 pm WST) Last Quarter.
- 11th 7 pm (5 pm WST) Moon at apogee (furthest from Earth at 404,678 km).
- 13th 11 am (9 am WST) Minimum Libration (2.1°), bright SW limb.
- 17th 11 pm (9 pm WST) New Moon.
- 20th 1 pm (11 am WST) Maximum Libration (8.2°), dark NW limb.
- 23rd 9 am (7 am WST) Occultation of Aldebaran by the Moon, visible from N North America, Greenland, Iceland and W Europe.
- 25th 2 am (midnight previous day WST) First Quarter.
- 27th 3 am (1 am WST) Moon at perigee (closest to Earth at 369,106 km).
- 27th Noon (10 am WST) Minimum Libration (1.0°), bright NE limb.
- 28th Midnight (10 pm previous day WST) Occultation of Regulus by the Moon, visible from N Europe and N & E Siberia.
- 31st 11 pm (9 pm WST) Full Moon, Blue Moon (see p. 17).

Banging On The Moon

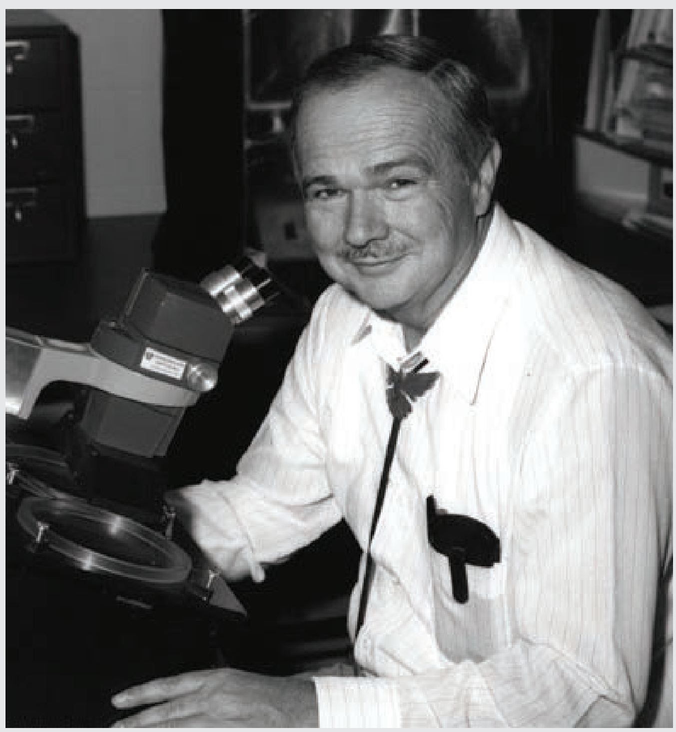
And, when he shall die
Take him and cut him out in little stars
And he will make the face of heaven so fine
That all the world will be in love with night
And pay no worship to the garish sun.

William Shakespeare

Before Eugene Shoemaker (1928–1997) there was no science known as astrogeology. In fact, Gene was the very first astrogeologist. By himself he virtually created planetary science as a discipline distinct from astronomy. His peers knew him as the god of planetary geology. By age 20, Gene had earned his masters degree in geology from Caltech and subsequently joined the United States Geological Survey from 1948 until his retirement in 1993. He founded the U.S. Geological Surveys Center of Astrogeology in Flagstaff in 1961 and served as the centre's chief scientist. At the time the principle work at the centre was mapping the lunar landscape in preparation for the Apollo missions.

In 1952 Gene visited Meteor Crater (Barringer Crater) in Arizona and this led him to the view that both it and the craters on the Moon were the result of asteroidal impacts. Up until this time, despite early views by Albert Foote (in 1891) and Daniel Barringer (in 1903) suggesting its meteoric origin, the conventional wisdom by the majority of scientists was that it was caused by volcanic activity. Gene found structural similarities between Meteor Crater and nuclear weapons testing sites. He discovered that both contained the mineral coesite, which is only formed when quartz is shocked by immense pressures and temperatures. For the first time a terrestrial crater was shown to have been caused by an impact from an extra-terrestrial object. Gene said, "For a long while, nobody believed me, but eventually I convinced them".

Gene had longed to become the first geologist to walk on the Moon but was eliminated from the astronaut corps due to a



THE PLANETS

Mercury's return to the evening sky is a somewhat poor apparition this month. At best the planet will be just a few degrees above the horizon at the end of civil twilight. Keen observers may like to tackle the close approach to Venus on the 4th (see Sky View).

Venus remains close to the western horizon at the end of civil twilight this month. From the 3rd to 5th this brilliant planet will be around 1° from the fainter inner planet Mercury (see Sky View). This is a relatively difficult observation and binoculars may be required to tease the pair from the bright sky. You will need a good unobstructed western horizon and begin sweeping soon after sunset.

The **Earth** is at its autumnal equinox on the 21st. From any place on Earth the Sun rises due east and sets due west, day and night are equal.

Mars, rising in the late evening eastern sky, spends the first half of March in Ophiuchus before moving into Sagittarius (see Sky View). As it travels through the constellation of the Archer the Red Planet passes directly between the Lagoon and Trifid nebulae on the 20th. It then makes a beeline toward another favourite with astroimagers, the majestic globular

minor medical condition. It would be Harrison 'Jack' Schmitt that took out that honour on Apollo 17, the last manned mission to the Moon and it was Gene who trained Jack for the job. Shortly before his untimely death Gene said *"Not going to the Moon and banging on it with my own hammer has been the biggest disappointment in life."* He worked on several U.S. space missions including Apollo and trained the astronauts on how to look for significant rocks and recognise geological features.

His life's work was enthusiastically devoted to the geology of Solar System bodies, impact craters and searching for comets with his wife Carolyn. Separately, or as a team, they were credited with the discovery of 32 comets and 1,125 asteroids. The Shoemakers achieved worldwide fame as co-discoverers of Comet Shoemaker-Levy 9 (SL9) that slammed into Jupiter.

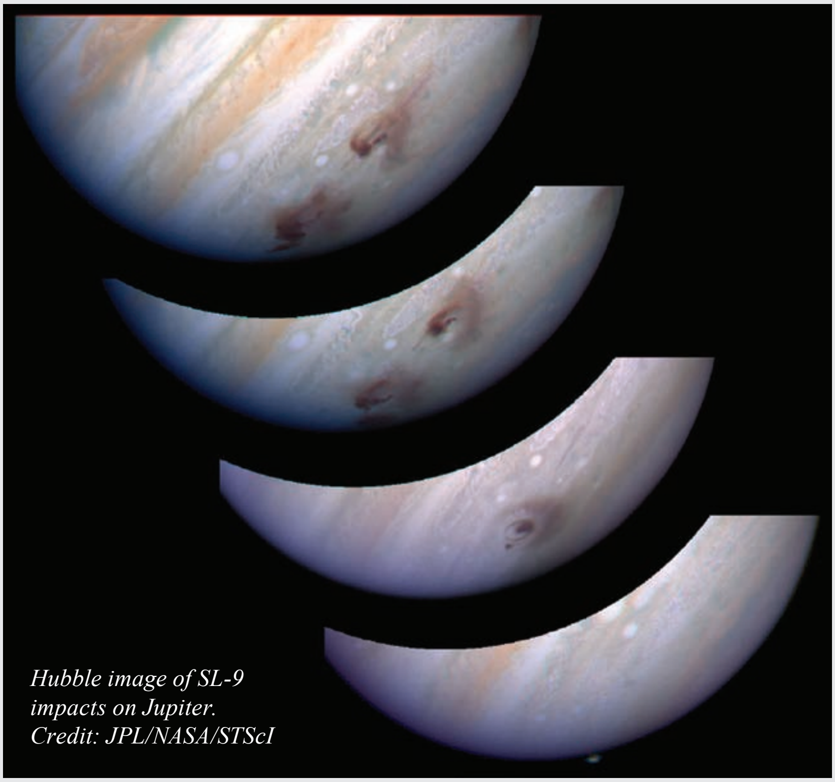
On 23 March 1993 Gene and Carolyn, together with friend and fellow comet hunter David Levy, were photographing the sky with the 0.46 metre Schmidt camera at Mount Palomar Observatory. On developing the film the following day, Carolyn noticed a small streak that turned out to be a comet that had multiple nuclei and was actually orbiting Jupiter and not the Sun. It was thought that it was captured by Jupiter's immense gravity as early as 1966 and then torn into fragments during a very close approach to the giant planet in July 1992. Orbital calculations showed that the divided comet would crash into Jupiter in July 1994.

For not the first time in his career Gene again was the odd one out, predicting that the SL9 impacts would produce tremendous fireworks, while most astronomers thought the fragments would barely cause a ripple in the deep Jovian atmosphere. Although the collisions occurred just out of sight from Earth, the world's professional and amateur astronomers were amazed as the resulting scars rotated into view. For close to a week at least 21 fragments made the plunge into Jupiter's gravity well leaving behind 'wounds' that were easily visible in amateur telescopes, conceivably the most spectacular planetary show in history.

Gene regularly travelled to Australia to examine and search for impact craters. Tragically, his life was cut short when he was killed in a car crash on 18 July 1997, aged 69, in the Tanami Desert in Northern Australia. His wife Carolyn survived the accident with injuries.

As a final and fitting tribute to the legendary geologist a small amount of his ashes were sent to the Moon aboard Lunar Prospector on 6 January 1998. The craft was designed to map the lunar surface composition, look for possible polar ice, and measure magnetic and gravity fields. Gene's ashes were placed in a capsule, then wrapped in a piece of brass foil laser inscribed with an image of Comet Hale-Bopp (the last comet the Shoemakers observed together), Gene's favourite image of Meteor Crater and the above passage from William Shakespeare's Romeo and Juliet. On 31 July 1999, the craft was deliberately aimed to crash into a crater near the lunar south pole, hoping the impact would release water vapour from suspected ice deposits. The anticipated plume, thought to have been detectable from Earth, was not observed. The crater is now called Shoemaker Crater.

Thirty years to the month after Apollo 11 landed on the Moon, Eugene E. Shoemaker became the first inhabitant of Earth to be sent to rest on another celestial body. Shortly before watching Lunar Prospector blast-off Carolyn said, *"This is so important to us, it brings a little closure, in a way, to our feelings. We will always know when we look at the Moon, that Gene is there."*



Hubble image of SL-9 impacts on Jupiter. Credit: JPL/NASA/STScI cluster M22. The planet ends the month around 1° from this cluster and 2° from Saturn (see April Sky View), the trio forming a right angle triangle, a nice binocular view against the star clouds near the galactic centre.

On the 25th Mars will be at its western quadrature, where the Sun-Earth-Mars angle is 90° (see Orbital Aspects diagram p. 13). At this time, Mars displays its minimum phase with 88% of the planet's surface illuminated by the Sun. Even a small telescope will show the disc to be distinctly gibbous in shape, just like the Moon three or fours days before or after Full Moon.

Jupiter rises in the eastern evening sky in Libra. On the 7th, the 20-day old waning gibbous Moon appears nearby (see Sky View). Moving lethargically through the constellation of the Scales, Jupiter appears stationary on the 9th, marking the beginning of four months in retrograde motion, when the planet moves from west to east against the stellar background.

Midmonth, Mars joins **Saturn** in Sagittarius, the ringed planet rising around midnight with the Red Planet above. Both planets are close to identical magnitude at this time although the golden orange hue of Mars will help identify which is which for the unaided eye observer. Saturn remains within 2° of the striking globular cluster M22 throughout March (see Sky View) and is joined by Mars on the last few days of the month (see April Sky View). At this time the pair of planets and M22 all fit into a 2° circle, making an excellent binocular field against the star-rich Milky Way. Also, for good measure the fine open star cluster M25 is not far from the trio. On the 30th Saturn will be at its western quadrature, the time in its orbit that we see the maximum shadow of the planet cast onto the back of the rings. This helps give the planet a real 3-D look through a telescope.

Uranus sets in the western evening sky around the end of astronomical dusk during the first half of the month, it then becomes too close to the Sun for observation as it nears conjunction in April.

Neptune is in conjunction with the Sun on the 4th, and lost from view until its reappearance in the morning sky at the end of the month in Aquarius.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in the constellation of the Archer, rises around midnight in the east. The closest *bright* star to this distant world is 5.6 magnitude 50 Sagittarii, which will be 45 arcminutes away midmonth.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
4 Mar	68 Leto	Leo	11.5
13 Mar	121 Hermione	Leo	12.8
18 Mar	45 Eugenia	Virgo	10.8
21 Mar	18 Melpomene	Virgo	10.2
22 Mar	135 Hertha	Virgo	11.8
31 Mar	79 Eurynome	Virgo	11.5

Over the next six months 29 Amphitrite has numerous encounters with star clusters as the minor planet slowly moves through the galactic hub in its retrograde loop.

DIARY			
Thu	1st		m.p. 20 Massalia 0.4° N of M1 Crab Nebula in Taurus
Thu	1st	am	m.p. 18 Melpomene 0.7° NE of NGC 4457 (G) in Virgo
Thu	1st	4 pm	(2 pm WST) star Regulus 1.0° S of Moon
Fri	2nd		Mars 0.9° N of NGC 6235 (GC) in Ophiuchus
Fri	2nd	10:51 am	(8:51 am WST) Full Moon (368,037 km)
Sun	4th		m.p. 2 Pallas 0.3° NW of NGC 1357 (G) in Eridanus
Sun	4th	Midnight	(10 pm WST) Neptune in conjunction with Sun
Mon	5th		Mercury at ascending node
Mon	5th		Saturn 1.0° N of NGC 6642 (GC) in Sagittarius
Mon	5th	8 am	(6 am WST) star Spica 7° S of Moon
Tue	6th		m.p. 4 Vesta 0.5° N of NGC 6356 (GC) in Ophiuchus
Wed	7th	5 pm	(3 pm WST) Jupiter 4° S of Moon
Thu	8th	pm	m.p. 18 Melpomene 1.0° NE of M61 (SG) in Virgo
Fri	9th	1 am	(11 pm WST, prev day) star Antares 9° S of Moon
Fri	9th	8 pm	(6 pm WST) Jupiter stationary
Fri	9th	9:20 pm	(7:20 pm WST) Last Quarter Moon
Sat	10th		Mercury at perihelion
Sat	10th		Mars 0.7° N of NGC 6401 (GC) in Ophiuchus
Sat	10th	6 am	(4 am WST) m.p. 4 Vesta 1.8° N of Moon
Sat	10th	11 am	(9 am WST) Mars 4° S of Moon
Sun	11th	Noon	(10 am WST) Saturn 2° S of Moon
Sun	11th	7 pm	(5 pm WST) Moon at apogee, 404,678 km
Mon	12th	3 pm	(1 pm WST) d.p. Pluto 1.7° S of Moon
Mon	12th	pm	m.p. 18 Melpomene 0.5° SW of NGC 4339 (G) in Virgo
Mon	12th	pm	m.p. 18 Melpomene 0.6° NE of NGC 4281 (G) in Virgo
Wed	14th	pm	m.p. 18 Melpomene 0.4° NE of NGC 4261 (G) in Virgo
Fri	16th		Mars at descending node
Fri	16th	1 am	(11 pm WST, prev day) Mercury at greatest elongation East (18.4°)
Fri	16th	11 am	(9 am WST) m.p. 3 Juno 5° N of Moon
Sat	17th	11:12 pm	(9:12 pm WST) New Moon
Sun	18th		m.p. 8 Flora 0.02° S of star Epsilon (ε) Geminorum
Sun	18th	11 am	(9 am WST) Venus 4° S of Mercury
Mon	19th	4 am	(2 am WST) Mercury 8° N of Moon
Mon	19th	5 am	(3 am WST) Venus 4° N of Moon
Tue	20th		Mercury at greatest latitude north
Tue	20th		Mars 0.6° SE of M20 Trifid Nebula (BN) in Sagittarius
Tue	20th		Mars 0.9° N of M8 Lagoon Nebula (BN) in Sagittarius
Tue	20th	2 am	(Midnight WST, prev day) Uranus 5° N of Moon
Wed	21st		Mars 0.3° SW of NGC 6546 (OC) in Sagittarius
Wed	21st		m.p. 7 Iris 1.0° N of star Epsilon (ε) Tauri
Wed	21st	2 am	(Midnight WST, prev day) Equinox
Wed	21st	7 am	(5 am WST) d.p. 1 Ceres stationary
Fri	23rd	3 am	(1 am WST) Mercury stationary
Fri	23rd	9 am	(7 am WST) star Aldebaran 0.9° S of Moon
Sun	25th	1:35 am	(11:35 pm WST, prev day) First Quarter Moon
Mon	26th	am	m.p. 29 Amphitrite 0.4° SE of NGC 6451 (OC) in Scorpius
Mon	26th	1 pm	(11 am WST) star Pollux 8° N of Moon
Tue	27th	3 am	(1 am WST) Moon at perigee, 369,106 km
Wed	28th	10 am	(8 am WST) Uranus 0.07° N of Venus
Wed	28th	Midnight	(10 pm WST) star Regulus 1.0° S of Moon
Thu	29th		m.p. 8 Flora 0.3° SW of star Kappa (κ) Geminorum
Fri	30th	7 pm	(5 pm WST) m.p. 3 Juno 3° N of Neptune
Sat	31st	am	Mars 0.2° W of NGC 6642 (GC) in Sagittarius
Sat	31st	10:37 pm	(8:37 pm WST) Full Moon (378,489 km)
Sat	31st	pm	m.p. 18 Melpomene 0.2° S of star Omicron (o) Virginis

COMETS

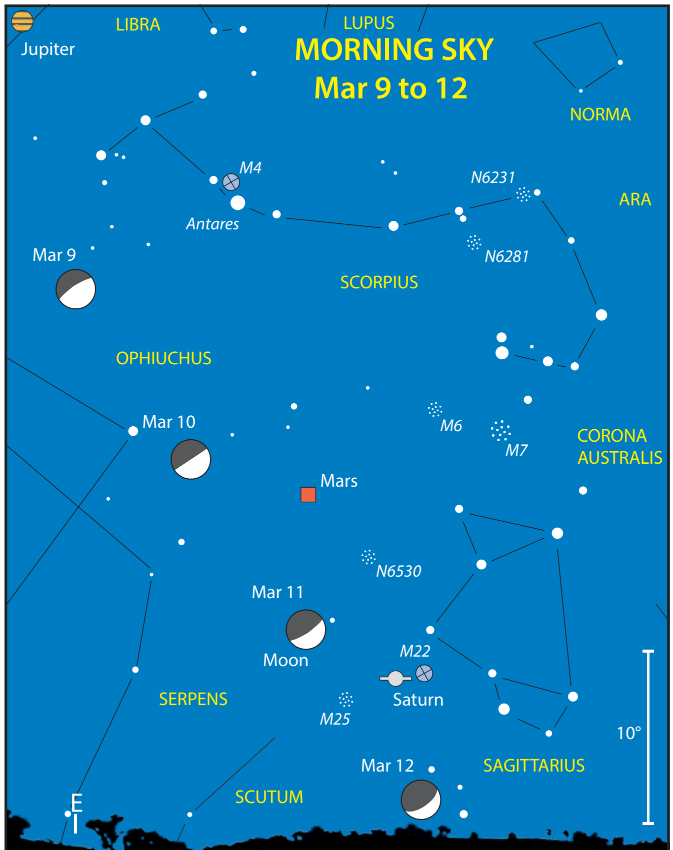
Comet C/2016 R2 (PANSTARRS) fades from 10th to 11th magnitude in March. Moving north from Taurus into Perseus early on, the comet will be low in the north-west in the early evening.

METEOR SHOWERS

The **gamma-Normids** are active between 25 February and 28 March, with maximum around the 14th. For most of the period, the rate is low, and members are difficult to sort out from the background sporadic activity. From 1988 to 2007 the shower has generated an average zenith hourly rate of six. Generally, the gamma-Normids are bright and chiefly yellow, white or orange with a few leaving trains. Since the constellation Norma rises late in the evening, the shower is best viewed after midnight when Moon free and the radiant reaches a reasonable altitude.

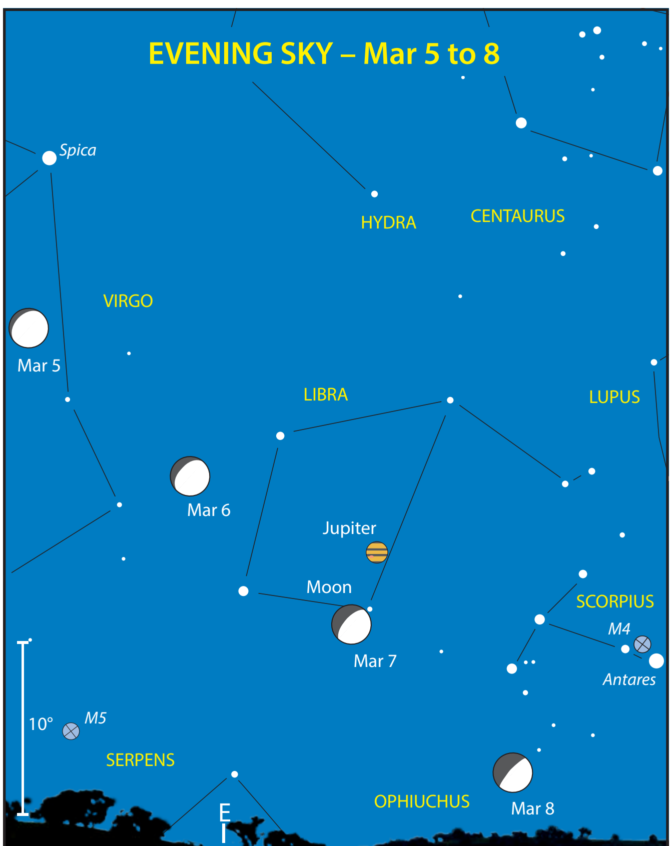
DOUBLE STARS

Regulus, Alpha (α) Leonis (see All Sky Map 5), is an often overlooked double star. This is an unequal, very wide pair through a small telescope. The stars, magnitudes 1.4 and 8.2 (spectra B7V and K2), are separated by three arcminutes with a position angle of 308 degrees. This equates to about 100 times the distance of Pluto from the Sun, with an orbital period of at least 125,000 years. The orange-red companion is also a close double star with the components separated by about 97 astronomical units. In addition, Regulus has an intriguing white dwarf companion that circles it every 40.11 days and is located about the same distance as Mercury is from the Sun. The whole system of four stars is located 79 light years from the Earth. Regulus is so close to the ecliptic that it is occasionally occulted by the Moon or comes into conjunction with a major planet.

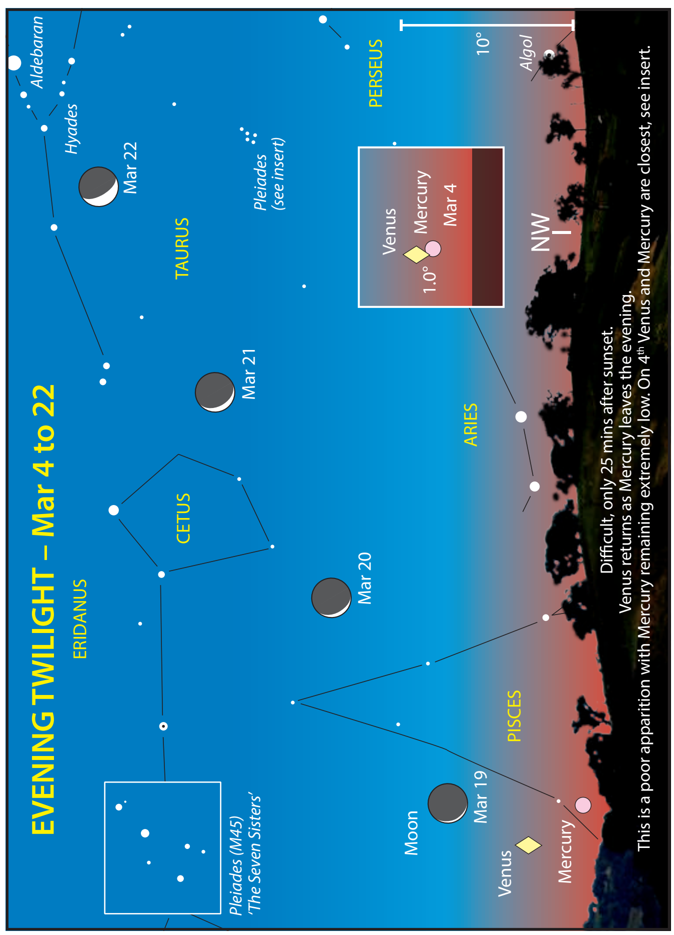


Time is 1 am. Three planets in the eastern morning sky!
The conjunction on 11th between the Moon, Mars and Saturn is brilliant.
Mars, like Jupiter, is now visible in the evening, rising around 11 pm.

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

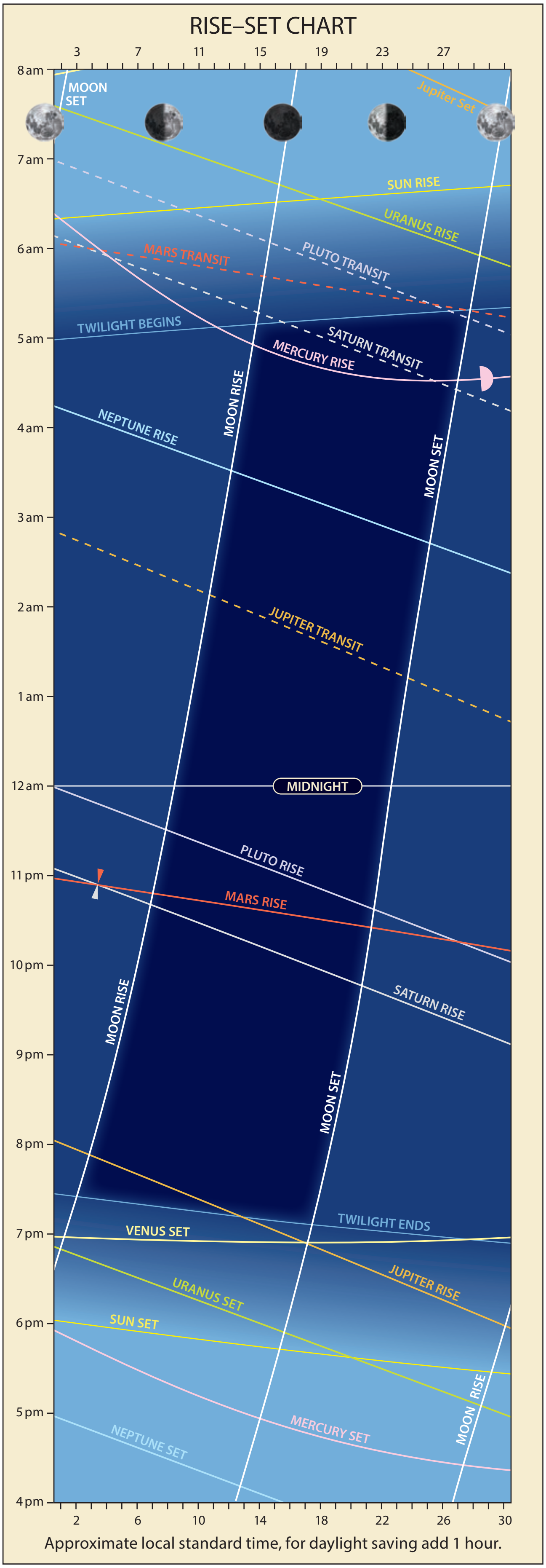


Time is 11 pm.
Jupiter outshines all stars in the heavens, even the brightest, Sirius, which is currently in the western sky. Continued on "Mar 9 to 12".



Difficult, only 25 mins after sunset.
Venus returns as Mercury leaves the evening.
This is a poor apparition with Mercury remaining extremely low. On 4th Venus and Mercury are closest, see insert.

APRIL



HIGHLIGHTS

- ❍ Mercury begins best period for morning observation.
- ❍ Mars and Saturn close.
- ❍ Mars and globular cluster M22 close.
- ❍ Mars, Saturn and Moon close.
- ❍ Brilliant Venus gaining altitude in evening sky.
- ❍ Jupiter meets with the Moon twice.

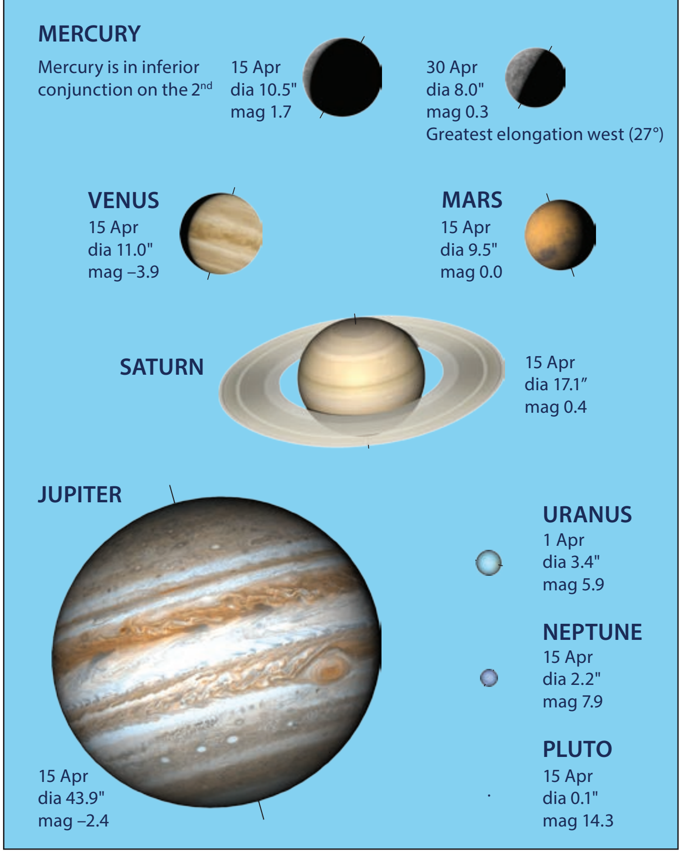
CONSTELLATIONS

The autumn and winter evening sky is certainly a happy hunting ground for ‘crosses’. In reality we have noticed a few such asterisms over the years, but we’ll restrict ourselves to the recognised naked eye ones. The early evening southern sky is a good place to start with three within a 35° circle (see All Sky Map 1). They are:

The Southern Cross (Crux) is the most compact and most brilliant member of this category, being only 6° long with its main four stars (bottom and then clockwise) Alpha (α), Beta (β), Gamma (γ) and Delta (δ) being the 12th, 20th, 25th and 127th brightest stars respectively in the sky. This would be a major contributing factor to Crux being heralded by some as the brightest constellation in the heavens; however, this really depends on how it’s defined.

The False Cross needs to combine stars from two constellations for the asterism. From the top (most northerly) going clockwise are Kappa (κ) and Delta (δ) Velorum and then Epsilon (ε) and Iota (ι) Carinae, their brightness being 2.5, 1.9, 1.9 and 2.2 magnitude respectively.

APPEARANCE of the PLANETS



The Diamond Cross, located between Crux and the false one, lies totally within Carina. The uppermost (northern) star is Theta (θ) and then clockwise is Upsilon (υ), Beta (β) then Omega (ω) Carinae. Their brightness being 2.7, 3.0, 1.7 and 3.3 respectively.

While in the area, Theta has its own attraction, being centred on the Southern Pleiades, IC 2602. This distinctive open cluster has six 5th magnitude stars and 3rd magnitude Theta within a 1° diameter circle. It is ideal for binoculars, with a further 30–50 fainter stars revealed.

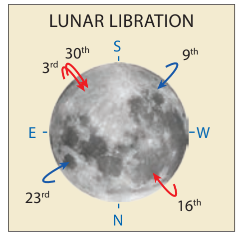
There is a more northern 'Diamond' cross lying in Virgo comprised of Spica (top, most southerly) then clockwise, Zeta (ζ), Epsilon (ε) and Gamma (γ) Virginis (see All Sky Map 6). Spica is 1st magnitude then there's a big drop to around 3rd magnitude to the other stars. This cross does not have the more pleasing symmetry of the Carina 'diamond'.

You will have to wait until the pre-dawn to see the largest member, the inverted crucifix of Cygnus low in the north (see All Sky Map 9).

THE MOON

3rd 2 am (midnight previous day WST) Maximum Libration (8.2°), dark SE limb. Libration features in shadow, however the densely chaotic cratered area east of the South Polar Region is seen to good advantage.

8th 4 pm (2 pm WST) Moon at apogee (furthest from Earth at 404,144 km).



8th 5 pm (3 pm WST) Last Quarter.

9th 2 pm (noon WST) Minimum Libration (2.1°), bright SW limb.

16th 8 am (6 am WST) Maximum Libration (8.2°), too close to New Moon.

16th Noon (10 am WST) New Moon.

19th 3 pm (1 pm WST) Occultation of Aldebaran by the Moon, visible from W & N Siberia and the Arctic.

21st 1 am (11 pm previous day WST) Moon at perigee (closest to Earth at 368,714 km).

23rd 8 am (6 am WST) First Quarter.

23rd 8 am (6 am WST) Minimum Libration (1.9°), bright NE limb.

25th 6 am (4 am WST) Occultation of Regulus by the Moon, visible from the Arctic regions and Siberia. This is the last in a series of 19 occultations of Regulus that began in December 2016. The next starts in July 2025.

30th 4 am (2 am WST) Maximum Libration (8.0°), bright SE limb. The 141 km crater Lyot situated in the zone of librations seen at best.

30th 11 am (9 am WST) Full Moon.

George's Star

"On Tuesday the 13th of March, between ten and eleven in the evening, while I was examining the small stars in the neighbourhood of H Geminorum, I perceived one that appeared visibly larger than the rest: being struck with its uncommon magnitude, I compared it to H Geminorum and the small star in the quartile between Auriga and Gemini, and finding it so much larger than either of them, suspected it to be a comet."

It was with these words that on 26 April 1781 William Herschel announced to the Royal Society in London the discovery of what would be a new planet. For thousands of years people had observed the five wandering planets. They were given names, worshipped by some and tracked methodically in their passage across the heavens. It never entered the collective imaginations of the people that there could be more than five, so it came as a bit of a surprise when another was found.

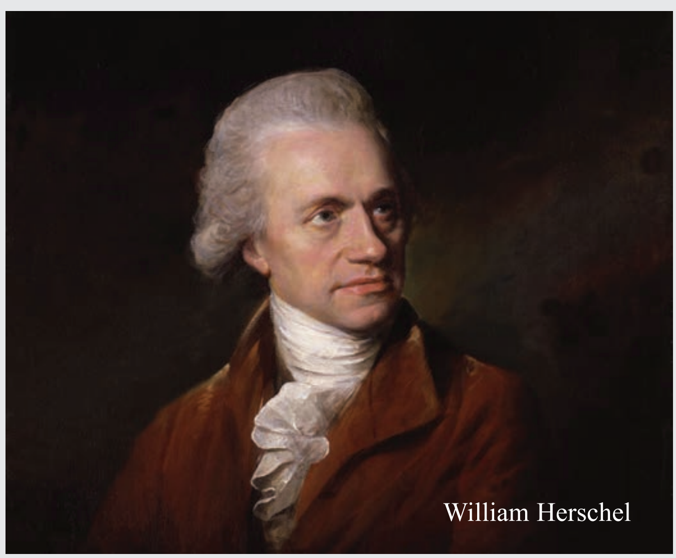
Interestingly, Hershel was not the first to observe the new planet. There is evidence to suggest that it was sighted by the Greek astronomer Hipparchus and recorded in the 2nd century Almagest. The first Astronomer Royal, John Flamsteed recorded the planet in his catalogue of Fixed Stars as 34 Tauri* in 1690 and again observed the star in 1712 and 1715. Then the third Astronomer Royal James Bradley saw the same faint star in the years 1748, 1750 and 1753. The French astronomer Pierre Le Monnier spotted the planet at least 12 times between 1750 and 1769. No one realised they were observing the same object, despite the fact that the star was wandering across the sky, a dead giveaway of its planetary nature.

The planet would become the Solar System's seventh, the first found since antiquity and the first discovered by telescope. One might expect that a new planet would be located by the combined efforts of the world's astronomers searching diligently night after night, so it is even more surprising still that this discovery was made by an English amateur astronomer using a homemade telescope. At the time Herschel was engaged in his second sky survey, looking at stars down to 8th magnitude. He later explained:

"it was that night its turn to be discovered"

It was Neville Maskelyne, the then Astronomer Royal, who first publicly suggested that the new object might be a planet. On writing to Hershel, he said:

"it is likely to be a regular planet moving in an orbit nearly circular round the Sun"



William Herschel

THE PLANETS

Mercury returns to the eastern dawn sky for the beginning of the best morning observing period this year. The planet is in inferior conjunction (between the Earth and Sun) on the 2nd and then climbs into the morning sky (see Sky View). On the 30th, the tiny world reaches its greatest elongation (27°) west of the Sun, before beginning its journey back toward Sol.

Venus spends the month in the western evening twilight. By month's end the dazzling planet really begins to stand out in Taurus as the sky darkens. On the 18th, the slender crescent of the 2-day old Moon will be seen above Venus. The pair are not overly close but it always makes a pleasant sight when the Moon is near one of the bright planets (see Sky View). This 'Goddess of Love' can be found within 4° of M45, the Pleiades star cluster, from the 23rd to 26th.

Mars rises in the late evening eastern sky in Sagittarius and remains in the constellation of the Archer throughout April. From the 1st to the 3rd the planet skims past the outer regions of the globular cluster M22. Considered one of the finest of its kind, M22 is only outranked in brightness by Omega Centauri and 47 Tucanae. With a visual magnitude of five, M22 is visible to the unaided eye under dark sky conditions. Also at the beginning of the month Mars will be within 1.2° of Saturn (see Sky View), the two planets and the globular making for a great view through binoculars or wide field telescope—all set near the Great Sagittarius Star Cloud. Continuing a busy start to the month Mars will be within 4° of the 22-day old waxing gibbous Moon on the 7th with Saturn above the pair forming an equilateral triangle (see Sky View). With the forthcoming opposition in late July the planet reaches negative magnitudes by month's end and the disc grows to over ten arcseconds.

Jupiter, moving slowly in retrograde in Libra, rises around the time astronomical dusk ends midmonth. Twice during April the Moon rises with the planet. On the 3rd the 18-day old waning gibbous Moon will be nearby to the north (lower left) and on the 30th the Full Moon will be in a similar position (see Sky Views). With opposition early next month, now is the time to focus attention on the gas giant during those pleasant autumn nights. Even the smallest of telescopes will show detail on the planet and also show the fascinating Galilean satellites as they shuttle back and forth, providing a renewed and different view every time they are observed. Since the moons move in a plane that is close to the plane of the Earth's orbit we can see some interesting events over a period of time. The moons can be occulted by the planet's disc and eclipsed by its shadow, we can see a transit as a moon passes in front of Jupiter and observe the shadow of a moon as it is projected onto the cloud tops (see Jupiter Moon Events in Part II for detailed predictions).

Saturn, rising in the late evening eastern sky, spends a second month within 2° of the globular cluster M22 in Sagittarius. On the 7th, the 22-day old waning gibbous Moon forms a triangle with Saturn and Mars (see Sky View), providing a spectacular binocular view. On the 17th, Saturn will be at aphelion, the point in its orbit furthest from the Sun. The planet appears stationary against the stellar background on the 18th before beginning close to five months of retrograde motion.

Uranus is in conjunction with the Sun on the 18th (the planet on the opposite side of the Sun from the Earth) and will not be observable until its reappearance in the morning eastern sky in mid-May.

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 3 am midmonth.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** rises in the late evening eastern sky in Sagittarius. It appears stationary on the 23rd before beginning five months of retrograde motion, as the Earth overtakes the slow-moving dwarf in its orbit. Mars sails past Pluto on the 26th at a distance of 1.5° (see diary).

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
1 Apr	22 Kalliope	Virgo	10.9
3 Apr	287 Nephthys	Virgo	11.2
11 Apr	21 Lutetia	Virgo	10.8
23 Apr	54 Alexandra	near Cen/Hya border	11.2
25 Apr	471 Papagena	Virgo	11.8

Six months after the discovery most astronomers acknowledged Herschel's *comet* as a large new planet. Its calculated orbit placed it almost twice as far from the Sun as Saturn—Herschel had doubled the size of the Solar System.

The Royal Society, England's foremost scientific establishment, gave Herschel its Copley Medal and honorary membership. Herschel's achievement in discovering the new planet by recognising its disc as being different from a star stunned the astronomical community. Many would not believe the claims he made about the quality of his telescopes, but when Maskelyne viewed through some of the instruments and declared them to be superior to those of the Royal Observatory, these critics were soon silenced.

The official name of the new planet would take more than 60 years to become common usage. King George III granted Herschel a royal pension to continue his work, and in honour of his patron Herschel suggested the name Georgium Sidus (George's Star). The name was instantly unpopular everywhere except England because of its political flavour, its length and because the object wasn't a star. Other names to be suggested included Neptune, Herschel and Astraea. Johann Bode (of Bode's Law fame) proposed Uranus. His reasoning was simple: as Jupiter was the father of Mars, Venus and Mercury, and Saturn was Jupiter's father, and Uranus was Saturn's father, it made sense to keep all the planets as part of one family, albeit mythological.

* Fans of Joss Whedon's science fiction classic Firefly, would know that in July 2020, a new star was discovered in Taurus. It was decided that the defunct designation 34 Tauri be reapplied to this star. The new 34 Tauri (2020) turns out to be a rather complicated cluster of main sequence stars, asteroid belts, gas giants, protostars and dozens of terrestrial planets and their moons, where Captain Reynolds and his renegade crew plied their trade.

COMETS

Comet C/2016 M1 (PANSTARRS) should brighten to 11th magnitude in April. Spending the month in Aquila, the comet rises around midnight and best observed in the morning sky.

METEOR SHOWERS

Both showers listed below benefit from a Moon free sky after midnight at expected maximum.

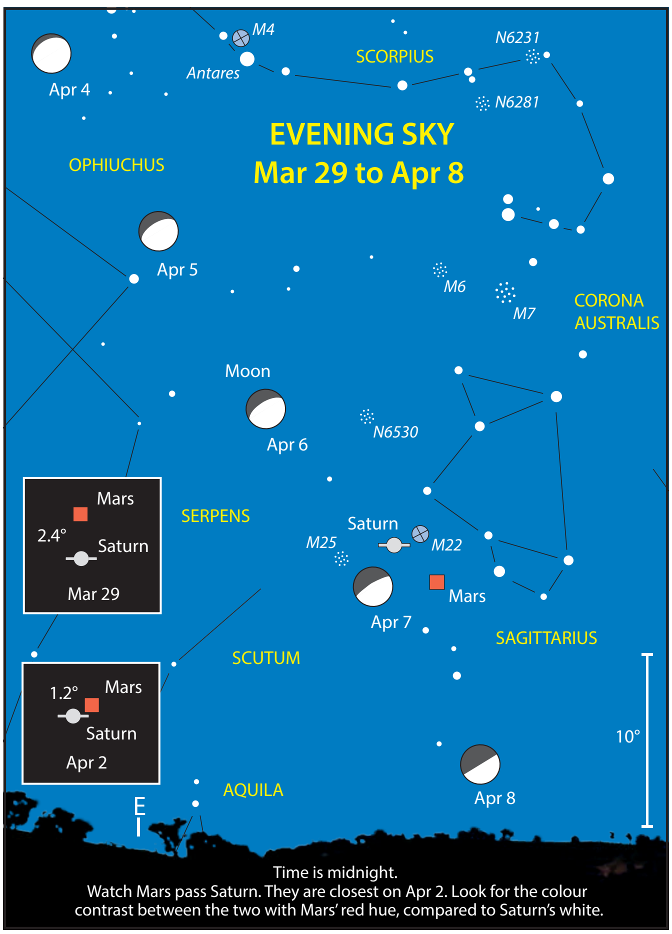
The **Lyrids** are a Northern Hemisphere shower, but they are visible south of the equator. They are best seen well past midnight in the Southern Hemisphere from the 14th to 30th, with maximum on the 22nd. High rates may only last an hour or so, and typically, the zenith hourly rate is around 18. The Lyrids have on occasion produced higher rates, and because of their erratic nature, they are a shower to be watched. In 1982, American observers noticed a short peak of 90 per hour.

The **pi-Puppids** are a young southern shower first observed in 1972 and produced by debris from Comet 26P/Grigg-Skjellerup. They are best seen from the 15th to 28th, with maximum activity on the 23rd. Leading up to and after maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil, occasionally three to four per hour or more (40 in 1977 and 1982, 13 in 1983). The pi-Puppids are noted for their very slow speed, bright, persistent trains with a large proportion of yellow meteors and occasional fireballs. They are best seen prior to local midnight, before the radiant becomes too low.

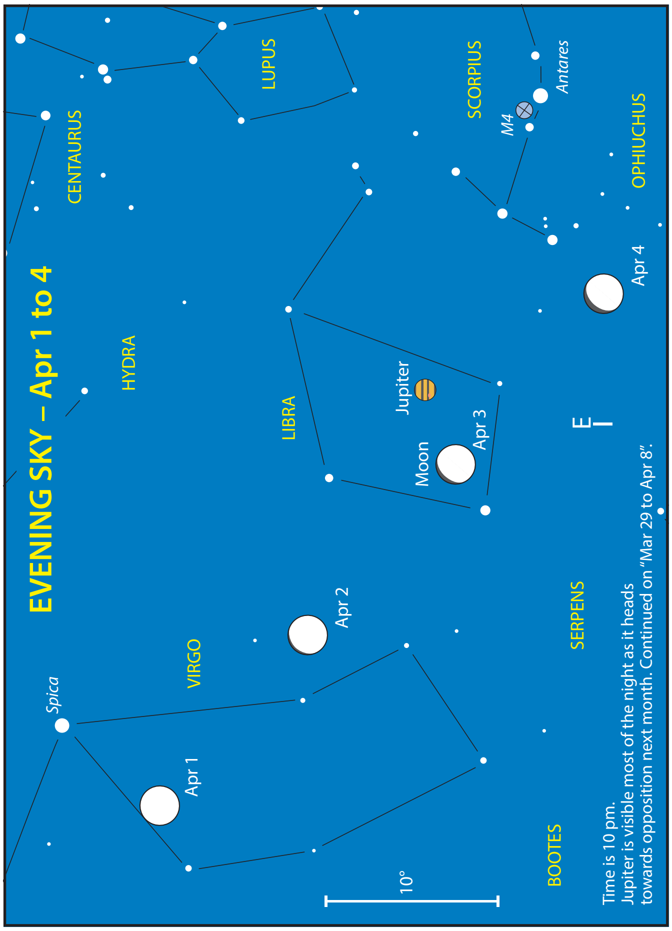
DOUBLE STARS

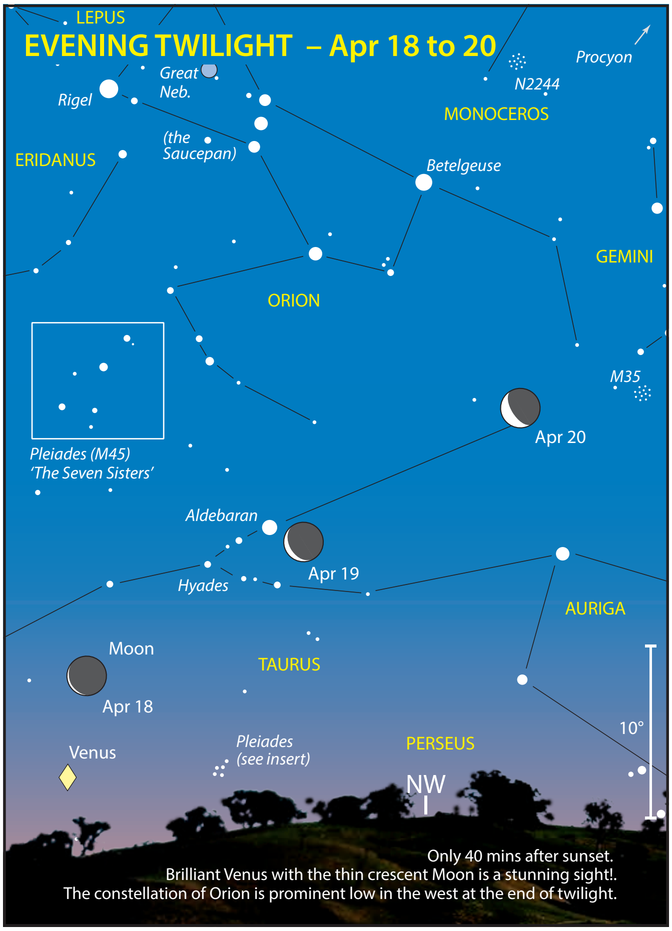
In the faint southern constellation of Sextans (the Sextant) near Beta (β) Sextantis is 35 Sextantis (see All Sky Map 4), a fine double for a small telescope. This pair of orange and yellowish stars, magnitudes 6.2 (spectrum K2) and 7.1 (spectrum K1), is separated by 6.8 arcseconds with a position angle of 240 degrees. No real change has occurred since the measures of F.G.W. Struve in 1832 and the stars form a long-period binary.4

DIARY			
Sun	1st	5 pm	(3 pm WST) star Spica 7° S of Moon
Mon	2nd	am	Mars 0.4° NW of M22 (GC) in Sagittarius
Mon	2nd	4 am	(2 am WST) Mercury in inferior conjunction
Mon	2nd	10 pm	(8 pm WST) Saturn 1.3° N of Mars
Tue	3rd	3 am	(1 am WST) m.p. 4 Vesta 0.1° SW of NGC 6507 (C) in Sagittarius
Tue	3rd	Midnight	(10 pm WST) Jupiter 4° S of Moon
Wed	4th	10 am	(8 am WST) star Antares 9° S of Moon
Sat	7th	6 am	(4 am WST) m.p. 4 Vesta 3° N of Moon
Sat	7th	11 pm	(9 pm WST) Saturn 1.9° S of Moon
Sun	8th	4 am	(2 am WST) Mars 3° S of Moon
Sun	8th	4 pm	(2 pm WST) Moon at apogee, 404,144 km
Sun	8th	5:18 pm	(3:18 pm WST) Last Quarter Moon
Sun	8th	Midnight	(10 pm WST) d.p. Pluto 1.5° S of Moon
Wed	11th	am	m.p. 29 Amphitrite 0.7° SW of NGC 6522 (GC) in Sagittarius
Wed	11th	pm	m.p. 15 Eunomia 0.3° S of NGC 5824 (GC) in Lupus
Thu	12th		Venus at ascending node
Fri	13th		Mercury at descending node
Fri	13th	am	m.p. 29 Amphitrite 0.8° SW of NGC 6528 (GC) in Sagittarius
Fri	13th	9 am	(7 am WST) Neptune 1.9° N of Moon
Fri	13th	8 pm	(6 pm WST) m.p. 3 Juno 5° N of Moon
Sat	14th	2 pm	(Noon WST) Mercury stationary
Sat	14th	7 pm	(5 pm WST) Mercury 4° N of Moon
Sun	15th	pm	m.p. 29 Amphitrite 0.6° SW of star Gamma^2 (γ^2) Sagittarii
Mon	16th	11:57 am	(9:57 am WST) New Moon
Tue	17th		Saturn at aphelion
Wed	18th	5 am	(3 am WST) Venus 5° N of Moon
Wed	18th	Noon	(10 am WST) Saturn stationary
Wed	18th	Midnight	(10 pm WST) Uranus in conjunction with Sun
Thu	19th	3 pm	(1 pm WST) star Aldebaran 1.1° S of Moon
Sat	21st	1 am	(11 pm WST, prev day) Moon at perigee, 368,714 km
Sun	22nd	7 pm	(5 pm WST) star Pollux 8° N of Moon
Sun	22nd	pm	m.p. 51 Nemausa 1.1° S of star Regulus
Mon	23rd		Mercury at aphelion
Mon	23rd	7:46 am	(5:46 am WST) First Quarter Moon
Mon	23rd	Noon	(10 am WST) d.p. Pluto stationary
Tue	24th		Venus 3.6° S of M45 the Pleiades (OC) in Taurus
Wed	25th	6 am	(4 am WST) star Regulus 1.2° S of Moon
Wed	25th	10 am	(8 am WST) d.p. Pluto 1.4° N of Mars
Thu	26th	pm	Mars 1.5° S of d.p. Pluto
Fri	27th	am	Comet C/2016 M1 (PANSTARRS) 0.7° W of Palomar 11 (GC) in Aquila
Sun	29th	2 am	(Midnight WST, prev day) star Spica 7° S of Moon
Mon	30th		m.p. 4 Vesta 0.8° N of M24 Sagittarius Star Cloud (OC) in Sagittarius
Mon	30th	4 am	(2 am WST) Mercury at greatest elongation West (27.0°)
Mon	30th	10:58 am	(8:58 am WST) Full Moon (389,460 km)

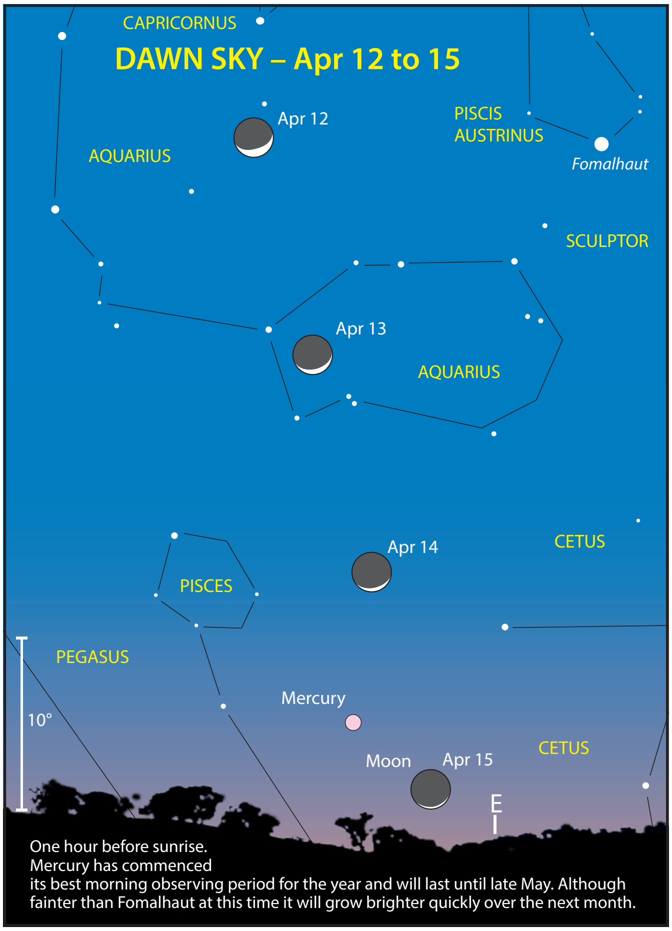


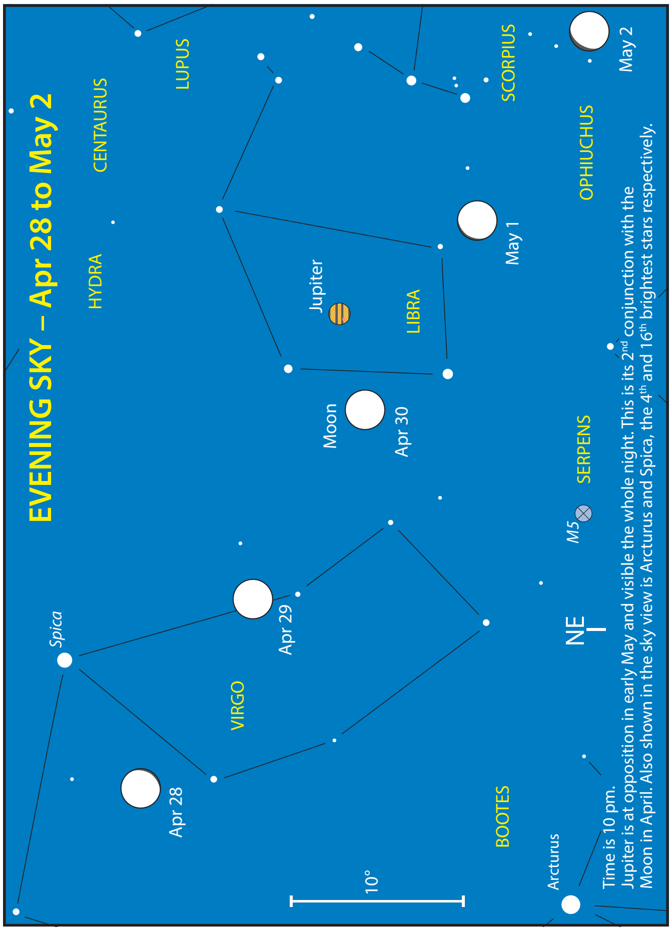
Time is midnight.
Watch Mars pass Saturn. They are closest on Apr 2. Look for the colour contrast between the two with Mars' red hue, compared to Saturn's white.



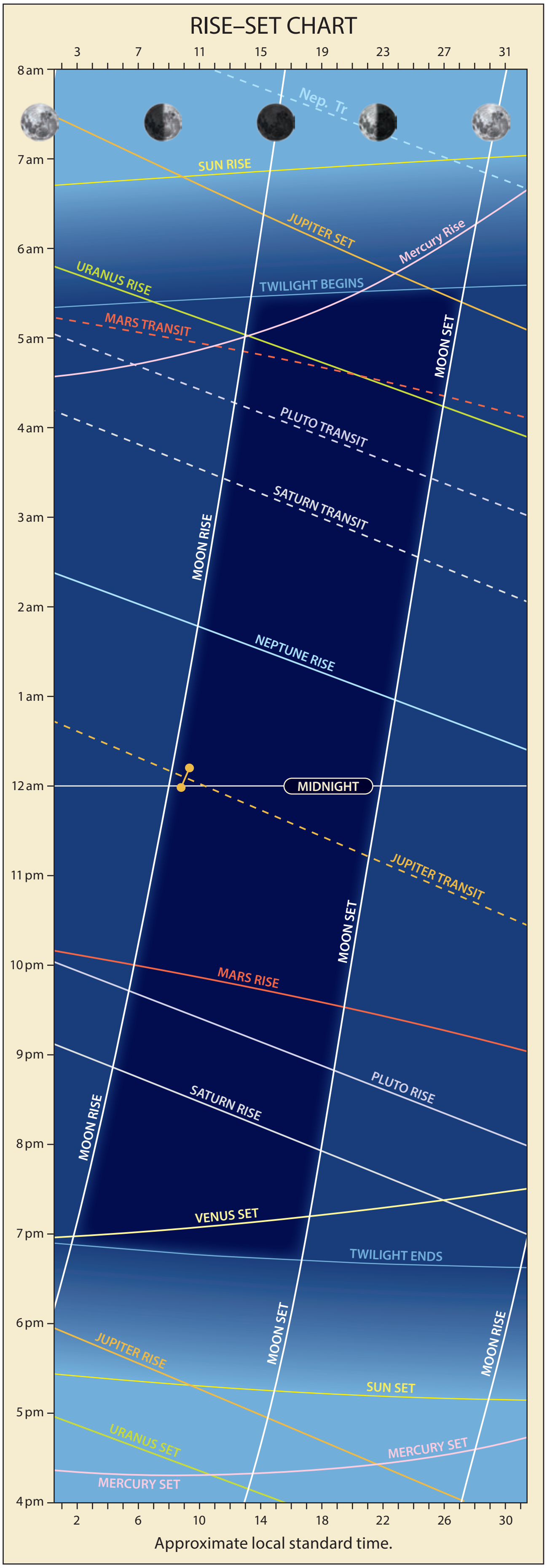


Approximate local standard time, for daylight saving add one hour.





MAY



HIGHLIGHT

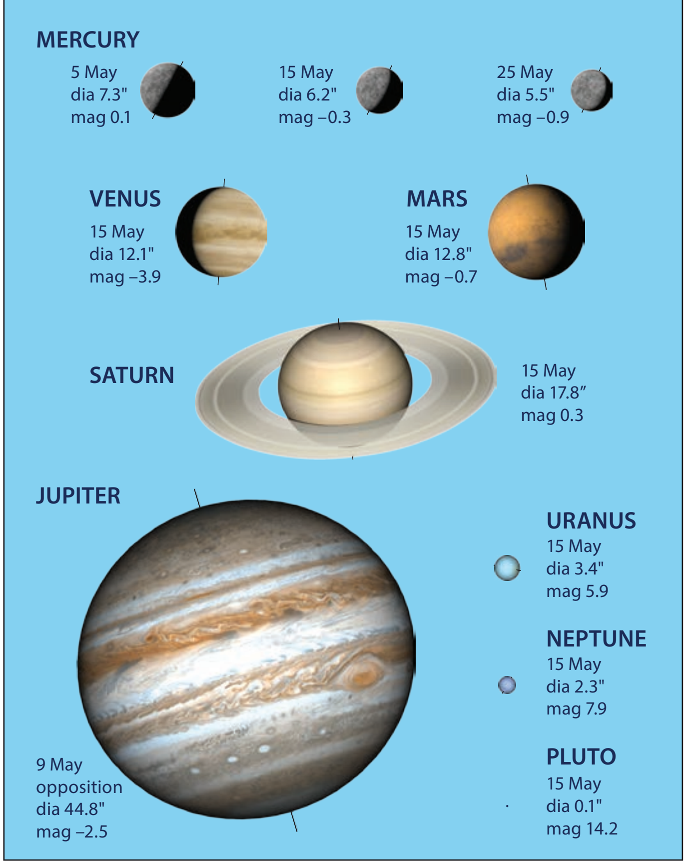
- Mercury, Uranus and Moon close.
- Mars close to globular cluster M75.
- Saturn close to globular cluster M22.
- Jupiter at opposition.

CONSTELLATIONS

In the introduction it was mentioned this section would be based on the appearance of the night sky in the evenings, a time when most people are likely to observe. We also stated in the introduction to the All Sky Maps that if you stay up all night only a small section of the entire sky, visible from your latitude, isn't available. We thought it was worthwhile trying to define this a bit better. Without a doubt long dark hours are recommended, so looking around the winter months is a good start. Keep in mind, the further north a constellation the quicker it is lost. On the other extreme, far southern objects may be circumpolar and never set.

The comments that follow will assume a mid-latitude Southern Hemisphere location and when a month is mentioned the comment relates to midmonth. For simplicity we'll define something to be observable if it is above the horizon at night outside of astronomical twilight. We recognise the difficulties and challenges of observing close to the horizon. We hope that, depending on the object, you may be able to push further into twilight to gain some altitude.

APPEARANCE of the PLANETS



Now the choice becomes quite subjective. For example, if you don't want to lose the true summer icon of Orion, you can forget June. In May, look low in the west after twilight and in July switches to low in the east before dawn. July mornings also see the recovery of Taurus. Here are a few tips:

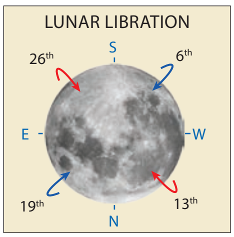
May. The prominent losses are Andromeda, Perseus, Taurus and Auriga and further north (see All Sky Maps 2 and 3).

June. Amongst the missing include Perseus, Taurus, Auriga, Orion and Gemini, plus northward (Maps 2, 3 and 5). A real challenge would be M31 (Andromeda Galaxy) low in the pre-dawn.

July. Lost are Auriga, Gemini, Canis Minor and Ursa Major (Maps 4 and 5). If you really enjoy the galaxy clusters in Leo, Virgo and Coma Berenices, by August they will be pretty low in the evening.

The regions of the sky covered by All Sky Maps 1, 6, 7, 8 and most of 9 are easily available some time in the night during these months.

THE MOON



6th 11 am (9 am WST) Moon at apogee (furthest from Earth at 404,457 km).

6th 6 pm (4 pm WST) Minimum Libration (2.0°), bright SW limb.

8th Noon (10 am WST) Last Quarter.

13th 11 am (9 am WST) Maximum Libration (8.9°), bright NW limb. The 53 km libration zone crater Bunsen now in view.

15th 10 pm (8 pm WST) New Moon.

16th 11 pm (9 pm WST) Occultation of Aldebaran by the Moon, visible from N Canada, NW Greenland and Arctic regions.

18th 7 am (5 am WST) Moon at perigee (closest to Earth at 363,776 km).

19th Midnight (10 pm WST) Minimum Libration (2.5°), bright NE limb.

22nd 2 pm (noon WST) First Quarter.

26th 11 pm (9 pm WST) Maximum Libration (8.4°), bright SE limb. The 141 km circular formation Lyot seen to best advantage.

29th Midnight (10 pm WST) Full Moon.

THE PLANETS

Mercury remains at its best for morning observation until midmonth. Early risers will be rewarded on the 14th with the planet situated between the 28-day old slender crescent of the waning Moon (see Sky View) and Uranus. Ideally observed with low power binoculars (e.g. 7 × 50), the Moon is 2° (around 3° from WA) to the south (right) of Mercury and the outer planet 2° to the north (left). As the trio will be best seen within half hour of the end of astronomical dawn, they will be close to the horizon.

Venus, in the early western evening sky, spends the first two thirds of May in Taurus before crossing into Gemini. Whilst in the constellation of the Twins the planet passes 0.7° north of the beautiful naked eye cluster M35 on the 21st (see Sky View and diary). On the 28th, Venus will be just 0.4° from the 3rd magnitude star Epsilon (ε) Geminorum (Mebsuta). Because Epsilon is near the ecliptic it can be occulted by the Moon and less frequently by a planet. The last recorded planetary events were in 1940 by Mercury and in 1976 by Mars.

Mars rises in the late evening eastern sky this month, its time spent equally in Sagittarius and then Capricornus. On the 14th and 15th as the Red Planet nears the border of Capricornus it has a close encounter with the 8.5 magnitude globular M75, passing less than 0.5° from the cluster. This is one of the more compact of the globulars and reasonably large instruments are required to resolve it into stars. On the 6th, the 21-day old waxing gibbous Moon will be seen rising a few degrees below Mars (see Sky View).

May 23rd marks the Martian equinox that heralds the beginning of its northern autumn and southern spring. As the disc enlarges (13 arcseconds at midmonth) observers will note the South Polar Cap (SPC) as it emerges from the darkness of winter. At this time the SPC will be at its maximum width and begins to shrink from now on. This will be particularly apparent after opposition in July. Also, the South Polar Hood (cloud zones that develop over the SPC during late summer and continue through winter) may be thinning and show the *Life Saver Effect*, a darkening in the centre of the SPC that gives it the appearance of that well known sweet.

Jupiter is at opposition on the 9th and is a brilliant object in the eastern evening sky after twilight ends. Aside from Venus (on the opposite skyline) and the Moon, the gas giant, at –2.5 magnitude, is the brightest object in the evening sky. The equatorial diameter of Jupiter at this opposition is slightly under 45 arcseconds, compared with 50 arcseconds when the planet is closest to us. Since it was at aphelion (the point in its orbit furthest from the Sun) last year, each subsequent apparition will be a little more favourable until 2023 when at perihelion (the point in its orbit closest to the Sun). Its size will not hinder observations, even with small telescopes.

Features like polar flattening on the rapidly spinning globe, distinctive ever-changing equatorial cloud bands, the Great Red Spot (GRS) and the daily dance of its major moons provide hours of interest for the observer. When looking for the GRS (a storm that has been raging at least since its discovery in 1664), keep in mind that things move really fast on Jupiter with its 10-hour rotation period. The best time to see the GRS is at the time of meridian passage or at most an hour on either side (see Part II for estimated GRS meridian passage date and times).

Between the 3rd and 4th a fifth magnitude orange star Nu (ν) Librae will be seen around 0.1° from the planet (see diary). Although at a similar brightness to the Galilean moons there should be no confusion with the star south of the satellite plane and the obvious colour difference. This red giant star, some 765 light years from our Solar System, has an absolute magnitude of –1.21 (if viewed from a distance of 10 parsecs or 32.6 light years).

On the 27th and 28th the near Full Moon will be seen in Jupiter's neighbourhood. At this time the planet will also be close to Zubenelgenubi, Libra's duo of alpha stars (see Sky View). They form a splendid pair of 3rd and 5th magnitude suns at a wide four arcminutes, with contrasting pale blue and yellow colours respectively.

Saturn, rising in the mid-evening eastern sky, spends May within 2° of the globular cluster M22 in Sagittarius. On the 4th, the 19-day old waning gibbous Moon is near the planet (see Sky View). With opposition late in June, it's time to turn your telescopes onto this jewel of the Solar System. Last year the planet's splendid ring system reached maximum openness. The rings will now gradually close until the Earth again passes through the ring plane in 2025 when they will appear edge on.

DIARY			
Tue	1st	3 am	(1 am WST) Jupiter 4° S of Moon
Tue	1st	pm	m.p. 13 Egeria 0.9° NW of star Pi (π) Scorpii
Wed	2nd	6 pm	(4 pm WST) star Antares 9° S of Moon
Wed	2nd	pm	m.p. 29 Amphitrite 1.0° W of NGC 6558 (GC) in Sagittarius
Thu	3rd	11 pm	(9 pm WST) Jupiter 0.1° NE of star Nu (ν) Librae
Fri	4th	am	Comet C/2016 M1 (PANSTARRS) 0.2° W of NGC 6814 (G) in Aquila
Fri	4th	3 am	(1 am WST) star Aldebaran 7° S of Venus
Fri	4th	10 pm	(8 pm WST) m.p. 4 Vesta 3° N of Moon
Sat	5th		m.p. 2 Pallas 0.2° E of star Eta (η) Orionis
Sat	5th	6 am	(4 am WST) Saturn 1.7° S of Moon
Sun	6th	7 am	(5 am WST) d.p. Pluto 1.3° S of Moon
Sun	6th	11 am	(9 am WST) Moon at apogee, 404,457 km
Sun	6th	5 pm	(3 pm WST) Mars 3° S of Moon
Mon	7th		Mercury 0.7° W of NGC 488 (G) in Pisces
Tue	8th	12:09 pm	(10:09 am WST) Last Quarter Moon
Tue	8th	8 pm	(6 pm WST) m.p. 4 Vesta stationary
Tue	8th	pm	m.p. 4 Vesta 0.8° S of M18 (OC) in Sagittarius
Wed	9th		Venus 0.4° NE of NGC 1746 (OC) in Taurus
Wed	9th	11 am	(9 am WST) Jupiter at opposition
Thu	10th	7 pm	(5 pm WST) Neptune 2° N of Moon
Fri	11th		m.p. 2 Pallas 0.6° SE of star Epsilon (ε) Orionis
Sat	12th		m.p. 2 Pallas 0.5° NW of star Zeta (ζ) Orionis
Sat	12th	am	Comet C/2016 M1 (PANSTARRS) 2.0° NW of NGC 6822 (G) in Sagittarius
Sat	12th	7 am	(5 am WST) m.p. 3 Juno 5° N of Moon
Sun	13th		Mercury at greatest latitude south
Sun	13th	7 am	(5 am WST) Uranus 2° N of Mercury
Mon	14th	1 am	(11 pm WST, prev day) Uranus 5° N of Moon
Mon	14th	3 am	(1 am WST) Mercury 2° N of Moon
Tue	15th		Venus at perihelion
Tue	15th	am	Mars 0.3° SE of M75 (GC) in Sagittarius
Tue	15th	9:48 pm	(7:48 pm WST) New Moon
Wed	16th		Mercury 0.8° S of NGC 821 (G) in Aries
Wed	16th	11 pm	(9 pm WST) star Aldebaran 1.2° S of Moon
Fri	18th	4 am	(2 am WST) Venus 5° N of Moon
Fri	18th	7 am	(5 am WST) Moon at perigee, 363,776 km
Sat	19th		d.p. Ceres 0.2° S of star Kappa (κ) Leonis
Sat	19th	pm	m.p. 4 Vesta 0.4° NW of M24 Sagittarius Star Cloud (OC) in Sagittarius
Sat	19th	pm	m.p. 9 Metis 0.8° SE of M8 Lagoon Nebula (BN) in Sagittarius
Sun	20th	1 am	(11 pm WST, prev day) star Pollux 8° N of Moon
Mon	21st		Venus 0.7° N of M35 (OC) in Gemini
Tue	22nd	11 am	(9 am WST) star Regulus 1.5° S of Moon
Tue	22nd	1:49 pm	(11:49 am WST) First Quarter Moon
Sat	26th	8 am	(6 am WST) star Spica 7° S of Moon
Sat	26th	pm	Comet C/2016 M1 (PANSTARRS) 1.2° NW of d.p. Pluto
Mon	28th		Venus 0.4° SE of star Epsilon (ε) Geminorum
Mon	28th	4 am	(2 am WST) Jupiter 4° S of Moon
Wed	30th	12:20 am	(10:20 pm WST, prev day) Full Moon (398,834 km)
Wed	30th	1 am	(11 pm WST, prev day) star Antares 9° S of Moon

Uranus returns to the eastern dawn sky after its solar conjunction last month. Moving from its long-term home in Pisces, the planet slips over the border into Aries where it will remain until December before its return to the constellation of the Fishes. Uranus, Mercury and the Moon line up on the 14th for an attractive binocular view (see Mercury).

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 1:30 am midmonth.

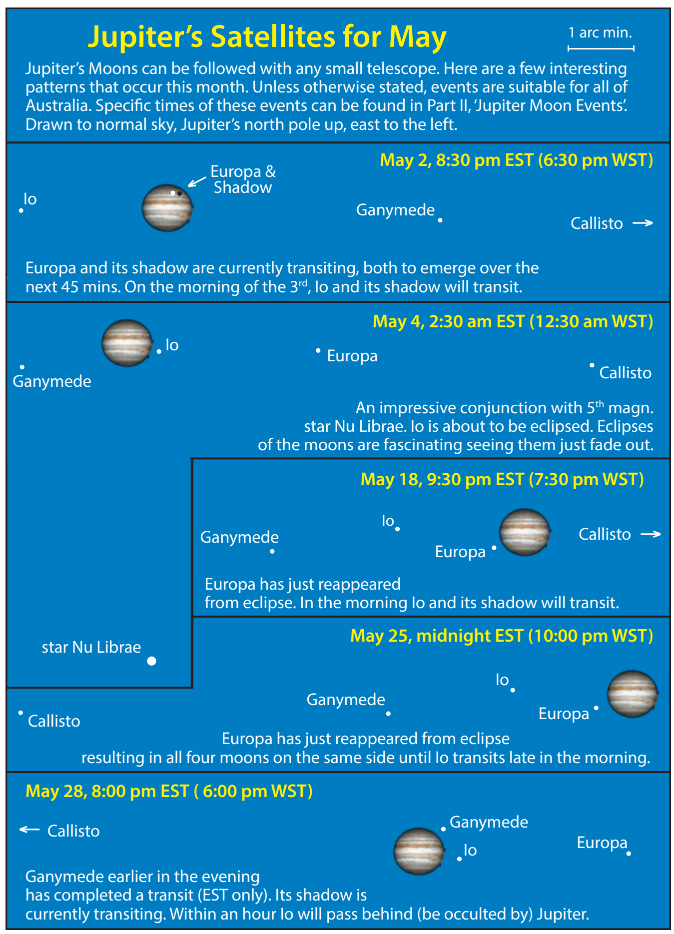
DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in Sagittarius, rises around 9 pm midmonth in the eastern evening sky.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 May	39 Laetitia	Libra	10.3
8 May	15 Eunomia	Centaurus	9.8
10 May	16 Psyche	Libra	10.4
14 May	103 Hera	Libra	11.3
17 May	60 Echo	Libra	11.6
19 May	13 Egeria	Libra	10.2

Not only is Vesta at its brilliant best over the next couple of months, it also spends most of the year in the hub of the Milky Way, visiting a number of star clusters in Sagittarius and Ophiuchus (see monthly diaries). Minor planet Pallas visits Orion in May, passing through his belt midmonth.



COMETS

Comet C/2016 M1 (PANSTARRS) may brighten from 11th to 10th magnitude this month. Rising in the evening (around 9 pm midmonth), the comet begins May in Aquila, moving into Sagittarius early on where it remains for the rest of the month. From the 9th to 18th C/2016 M1 is within 3° of Barnard's Galaxy (NGC 6822).

DOUBLE STARS

This month's double star is located in Coma Berenices (the hair of Berenice). 24 Comae Berenices (STF 1657, see All Sky Map 7) is a wide, unequal colourful double star. The stars, magnitudes 5.1 and 6.3, are separated by 20.4 arcseconds with a position angle of 272 degrees. They are yellowish-orange (spectrum K2III) and bluish respectively. Northern Hemisphere observers refer to this object as the spring Albireo (the well-known double star Beta Cygni). No real change has occurred since the measures of F.G.W. Struve in 1830. The pair appears to form a long-period binary. The secondary star is also a spectroscopic binary with a period of 7.34 days.

Seeing Binocular Double Stars from the Suburbs

No, this article doesn't relate to the alignment of the optics in your binoculars. However, if every star looks double we suggest having them checked! For many years we have stated there is much you can discover about the night sky with a humble pair of binoculars (see page 8). You don't even have to leave suburbia to get a taste, double stars are an example.

You may not get the spectacular views of the Milky Way or get down to the faint stars that country skies offer, but bright wide doubles can be as attractive through binoculars as fainter, closer ones through a telescope. The wide views make the stars easier to find and also offer the comfort of using both eyes. By easier to find we mean there is a better chance bright, easy to identify stars will be in the same field and of course the view is not inverted or mirror imaged. It is a must that the binoculars are held steady.

The doubles presented are well suited for evenings this time of year and have been marked on the All Sky Maps. They were observed over a few nights using two binoculars, a pair of 7 × 50 and 10 × 50. These are typical instruments people might buy for more terrestrial pursuits. In these examples the lower magnification of the 7 × 50 didn't cause any problems with seeing the components. In fact its wider field offered some very aesthetic views such as fitting the Southern Cross in completely! Although the optical quality was known to be reasonable on these instruments, the light pollution certainly restricted which stars were visible with the limiting magnitude being around 9.0. This didn't vary much even with the presence of a crescent Moon (as long as it was at least 30° away).

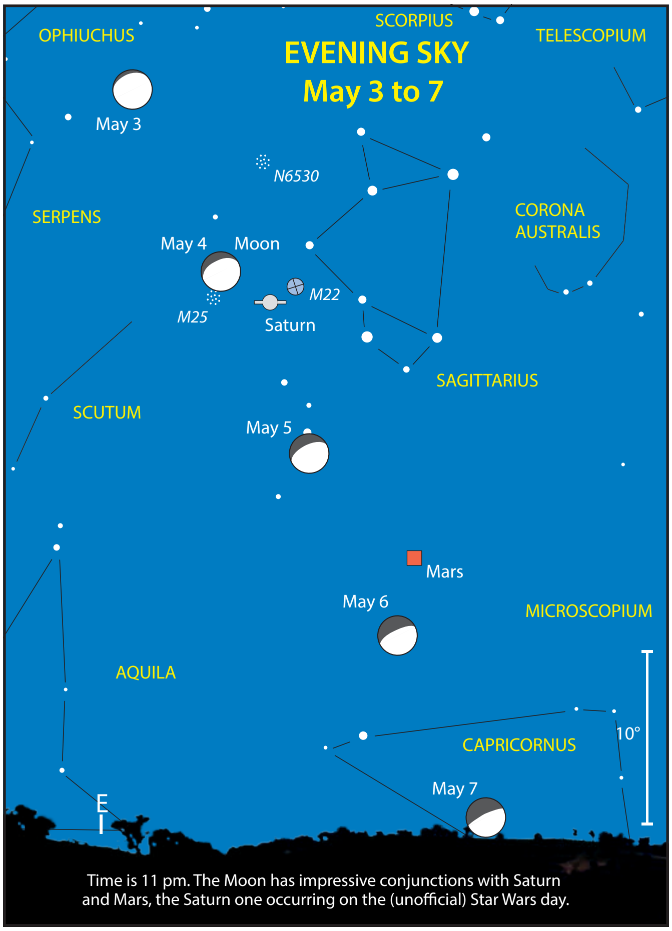
Being an article for binocular observing, to simplify the table we have avoided pointing out telescopic components. For example the primary star of Alpha Crucis is made up of two stars of magnitudes 1.2 and 1.6 separated by 4 arcseconds, making the star even through a small telescope a magnificent triple system.

We have also included the position angle of the stars. This is the direction the fainter star lies from the primary. It is measured as degrees east from north, so due east would be 90°, south 180° and west 270°. The north/south direction runs parallel to the right ascension (RA) lines (north has the declination increasing). Going east the RA increases.

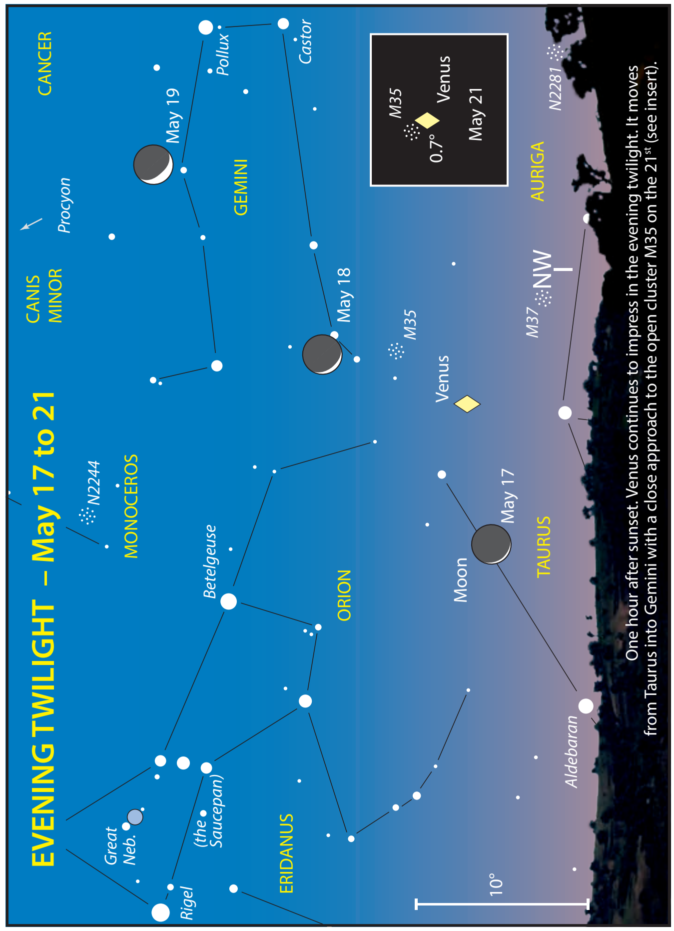
Name	Constellation	Primary	Secondary	Separation (")	Position angle	Comment	All Sky Map
J Centauri (HR5035)	Centaurus	4.5	6.2	60	346	Easy split, located between the Southern Cross and the Pointers.	1
Alpha (α) Crucis	Crux	1.5	4.8	91	202	Great contrast, the yellow companion is well separated from the blue/white primary in a good star field.	1
Mu (μ) Crucis	Crux	3.9	4.9	35	17	Nicely split at 10×, a good test for 7× magnification. The difference of 1 magnitude is obvious with the fainter star having a yellow tinge.	1
Gamma (γ) Crucis	Crux	1.8	6.5	125	27	Well split, fainter star easily seen. Good contrast with the primary a brilliant orange/red with a white companion.	1
Zeta (ζ) Lupi	Lupus	3.5	6.7	72	249	Brilliant, well split, a fainter and wider double nearby makes good field.	6
Rho (ρ) Ophiuchi	Ophiuchus	5.1	6.8, 7.3	156, 150	252, 359	The two fainter companions are clearly visible, making an approximate isosceles triangle. In same field as Antares (3° away).	6
Nu (ν) Scorpii	Scorpius	4.2	6.6	41	337	Companion is obvious, just split a good test for 7×.	6
Zeta^2 (ζ^2) Scorpii	Scorpius	3.6	4.8, 5.8	390, 433	270, 191	A very wide binocular triple, making a near right angle triangle, with Zeta^2 the yellow primary and Zeta^1 and HR6266 the blue/white secondaries respectively, in an attractive field with the bright open star cluster (NGC 6231) only 0.5° away.	6
Gamma (γ) Velorum *	Vela	1.8	4.1	41	220	Close, just split, both components are blue/white.	1

* The famous multiple star system well suited for small telescopes, information here refers only to the two brightest members

MAY

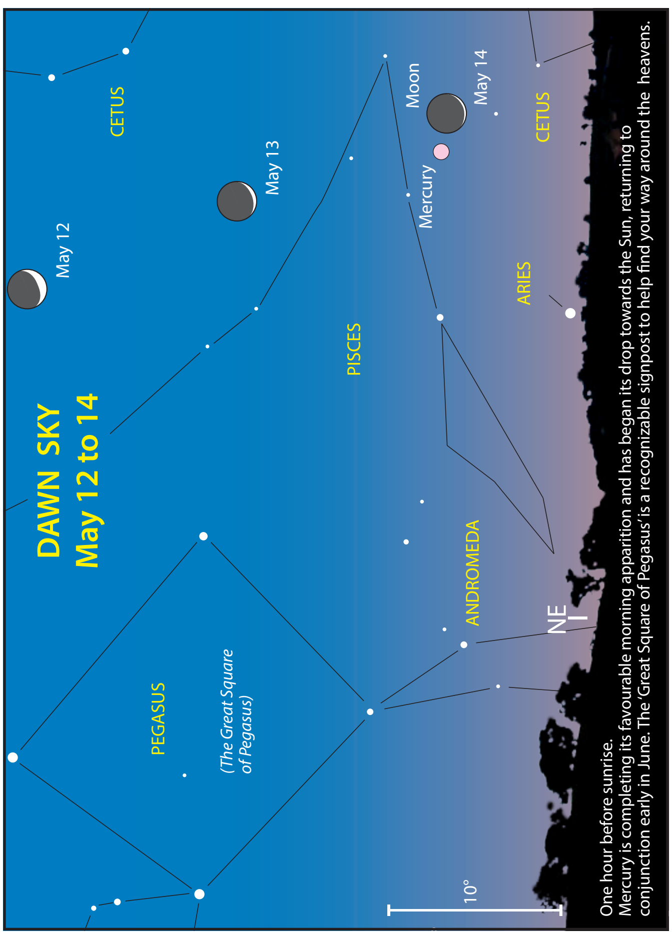


Time is 11 pm. The Moon has impressive conjunctions with Saturn and Mars, the Saturn one occurring on the (unofficial) Star Wars day.

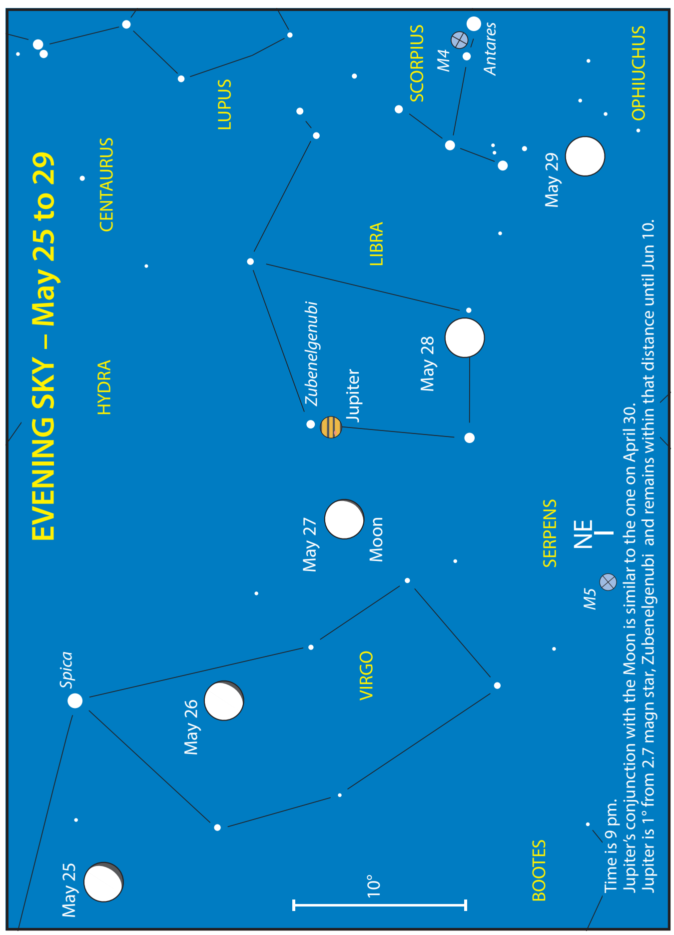


One hour after sunset. Venus continues to impress in the evening twilight. It moves from Taurus into Gemini with a close approach to the open cluster M35 on the 21st (see insert).

Approximate local standard time.

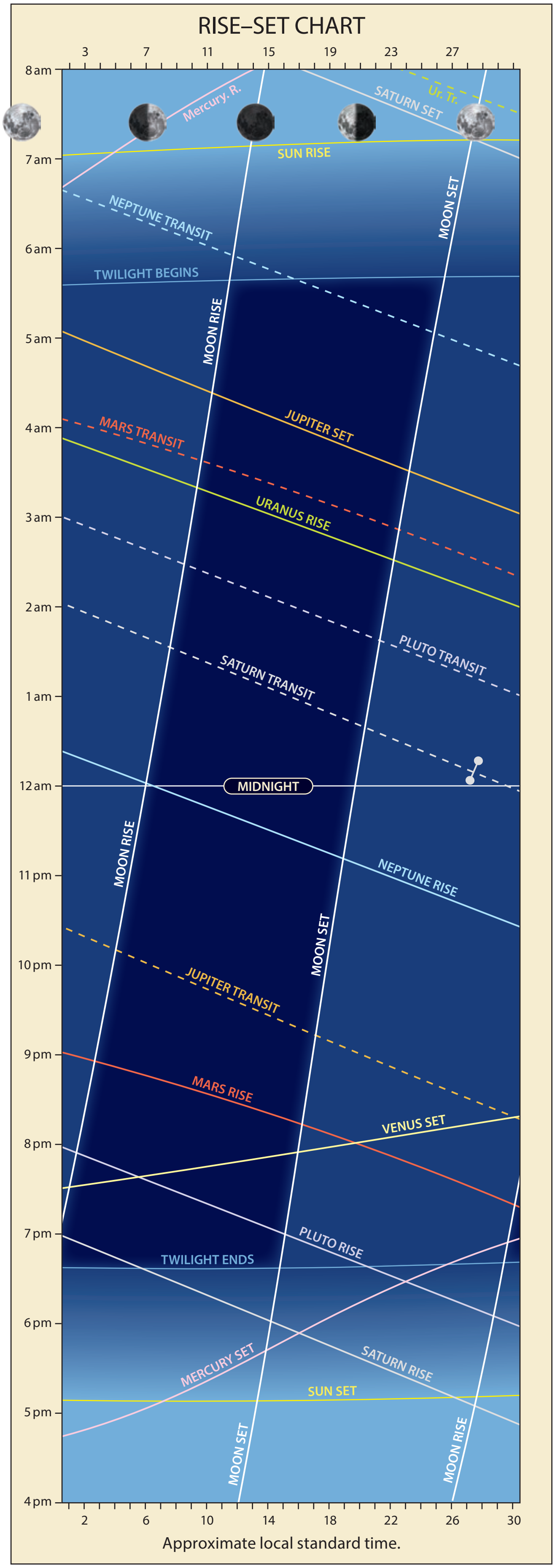


One hour before sunrise.
Mercury is completing its favourable morning apparition and has began its drop towards the Sun, returning to conjunction early in June. The 'Great Square of Pegasus' is a recognizable signpost to help find your way around the heavens.



Time is 9 pm.
Jupiter's conjunction with the Moon is similar to the one on April 30.
Jupiter is 1° from 2.7 magn star, Zubenelgenubi and remains within that distance until Jun 10.

JUNE



HIGHLIGHTS

- Venus passes the Beehive Cluster.
- Saturn at opposition.
- The Moon visits Mars twice.

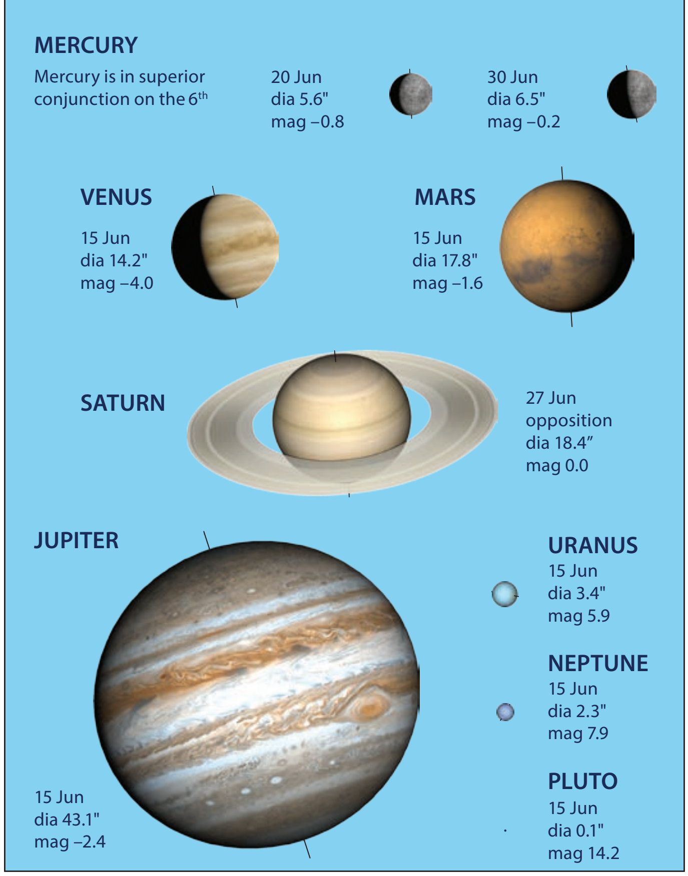
CONSTELLATIONS

Many of the constellations are based on mythical entities. A number are steeped in antiquity dating back to before Christ. In the 2nd century CE, Ptolemy, in his Almagest, recorded 47 of the current 88. It is little wonder these constellations have survived, for the Almagest has been one of the most influential scientific works of all time. There was a 48th, the ship Argo Navis, which has since been divided into three, Carina (the Keel), Puppis (the Stern) and Vela (the Sail).

The current figures depicted in the heavens are a strange mixture of humans (we'll include gods here), animals (land and sea), an insect, geological features, shapes and various inanimate objects. These include parts of a boat (see above) and scientific and musical instruments. What about the strange amalgams of normally unrelated creatures?

Two of the most famous examples are both centaurs. These creatures have the upper body of a man (head, shoulders, arms and chest) on an equine body from the neck down. We are referring to Centaurus and Sagittarius (the Teapot asterism) both riding the Milky Way high in the evening sky in winter. Although facing each other, Sagittarius with a raised bow and arrow and Centaurus pointing a spear, their attentions are elsewhere. Centaurus is carrying a recently speared Wolf (the constellation Lupus) and Sagittarius' arrow is pointing towards the Scorpion (Scorpius).

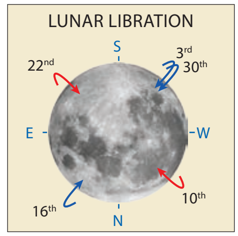
APPEARANCE of the PLANETS



Another example is Capricornus the 'Sea Goat' comprising the head/shoulders and front legs of a goat with the tail of a fish. A further water related hybrid is Cetus. Although it is known today as a whale, traditionally Cetus was called the 'Sea Monster'. In Johann Bayer's Uranometria atlas (1603 CE) it is drawn as a dragon's upper body, head and arms with a fish's tail. As with many of the traditional constellations, the depictions of Cetus vary greatly between different atlases. Finally an honorary mention for Pegasus, a flying horse complete with wings!

THE MOON

- 3rd 1 am (11 pm previous day WST) Minimum Libration (1.7°), bright SW limb.
- 3rd 3 am (1 am WST) Moon at apogee (furthest from Earth at 405,317 km).
- 7th 5 am (3 am WST) Last Quarter.
- 10th 2 am (midnight previous day WST) Maximum Libration (9.7°), bright NW limb. The 80 km Crater Galvani now in view.
- 14th 6 am (4 am WST) New Moon.
- 15th 10 am (8 am WST) Moon at perigee (closest to Earth at 359,503 km).
- 16th 7 am (5 am WST) Minimum Libration (2.1°), bright NE limb.
- 20th 9 pm (7 pm WST) First Quarter.
- 22nd Midnight (10 pm WST) Maximum Libration (9.4°), bright SE limb. The 141 km circular formation Lyot, situated in the zone of librations, now seen at best. Note the many smaller craters to the west and south-west of Lyot.
- 27th 7 pm (5 pm WST) Occultation of minor planet Vesta by the Moon, visible from Micronesia, S Mexico, Central America.
- 28th 3 pm (1 pm WST) Full Moon.
- 30th 1 pm (11 am WST) Moon at apogee (furthest from Earth at 406,061 km).
- 30th 1 pm (11 am WST) Minimum Libration (1.1°), bright SW limb.

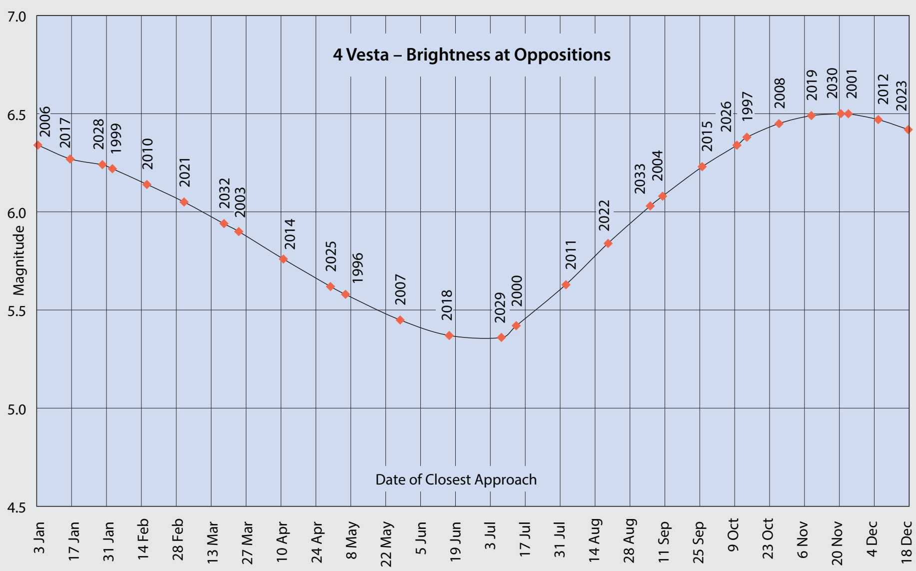


A Bright Minor Planet — Vesta 2018

The yearbook enjoys highlighting the bright naked eye planets for they are no doubt the easiest to find, not to mention most spectacular. These are Mercury, Venus, Mars, Jupiter and Saturn. In fact, if we define 6.0 magnitude as the faintest visible "star-like" object the dark-adapted observer can see under dark skies, Uranus also makes the cut. This year presents a reasonably rare opportunity to add an asteroid to the count, Vesta. An outer Solar System object is brightest when closest to the Earth, which occurs near its opposition date when our planet passes between the Sun and the body. Although Vesta resides in the main asteroid belt with hundreds of thousands of others, all at a similar distance, it has the distinction of being the second largest, 512 km in diameter (9% of the total mass of the belt) and brightest. However this doesn't explain the wide range of brightness from opposition to opposition. This variation is from 5.3 to 6.5 magnitude and you can see from the graph that this depends on the time of year it happens. This effect is certainly related to distance corresponding to close approaches ranging from 1.15 to 1.58 au respectively. It all comes down to Vesta's orbit.

Switching to Earth, the relevant paragraph in the monthly sections shows our perihelion (closest approach to the Sun) happens on January 3, with aphelion (furthest distance) on July 7. These are distinct points in space the Earth returns to each year close to these dates. Because all bodies have elliptical orbits with the Sun at one focal point, they have similar unique positions in their orbital paths. Vesta's perihelion happens to lie roughly in the same direction as the Earth's position around the end of June as seen from the Sun. If such an alignment happens (an opposition) the two bodies are as close as possible, which can only occur near this date. Vesta's aphelion lies in the direction of where the Earth is in late November. If an opposition happens at this time, the reverse occurs. Vesta is at its furthest from the Sun and hence more distant from us; a faint or aphelic opposition. With Earth and Vesta orbiting the Sun in one and 3.63 years respectively an opposition is seen approximately every 17 months, with those occurring at any specific time of the year around 10 to 11 years apart. That is why the last bright opposition was seen in 2007 and the next in 2029. On the graph you will see similar intervals at other times in the year. This is exactly the reason why Mars has some oppositions more favourable than others. This year it has a good perihelic opposition; see page 110 for further information.

This situation is by no means unique to Vesta amongst the minor planets, it's just more appealing to occasionally come into naked eye view. Pallas shows an even greater swing. Two



JUNE

THE PLANETS

Mercury is in superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 6th. It remains too close to the Sun for observation until midmonth when it appears in the western evening twilight in the constellation of the Twins (Gemini). From the 24th to 26th the planet passes 5° to the south of 1st magnitude star Pollux, Mercury is the brighter of the pair.

Venus begins June directly between the Twins of Gemini in the early western evening sky. It crosses into Cancer early in the month before slipping into Leo during the last few days. On the 16th, the 3-day old waxing crescent Moon appears to the south (lower left) of the planet. On the 20th, Venus passes by the outer boundaries of the open star cluster M44, the Beehive Cluster—a pleasing binocular view (see Sky View and diary).

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

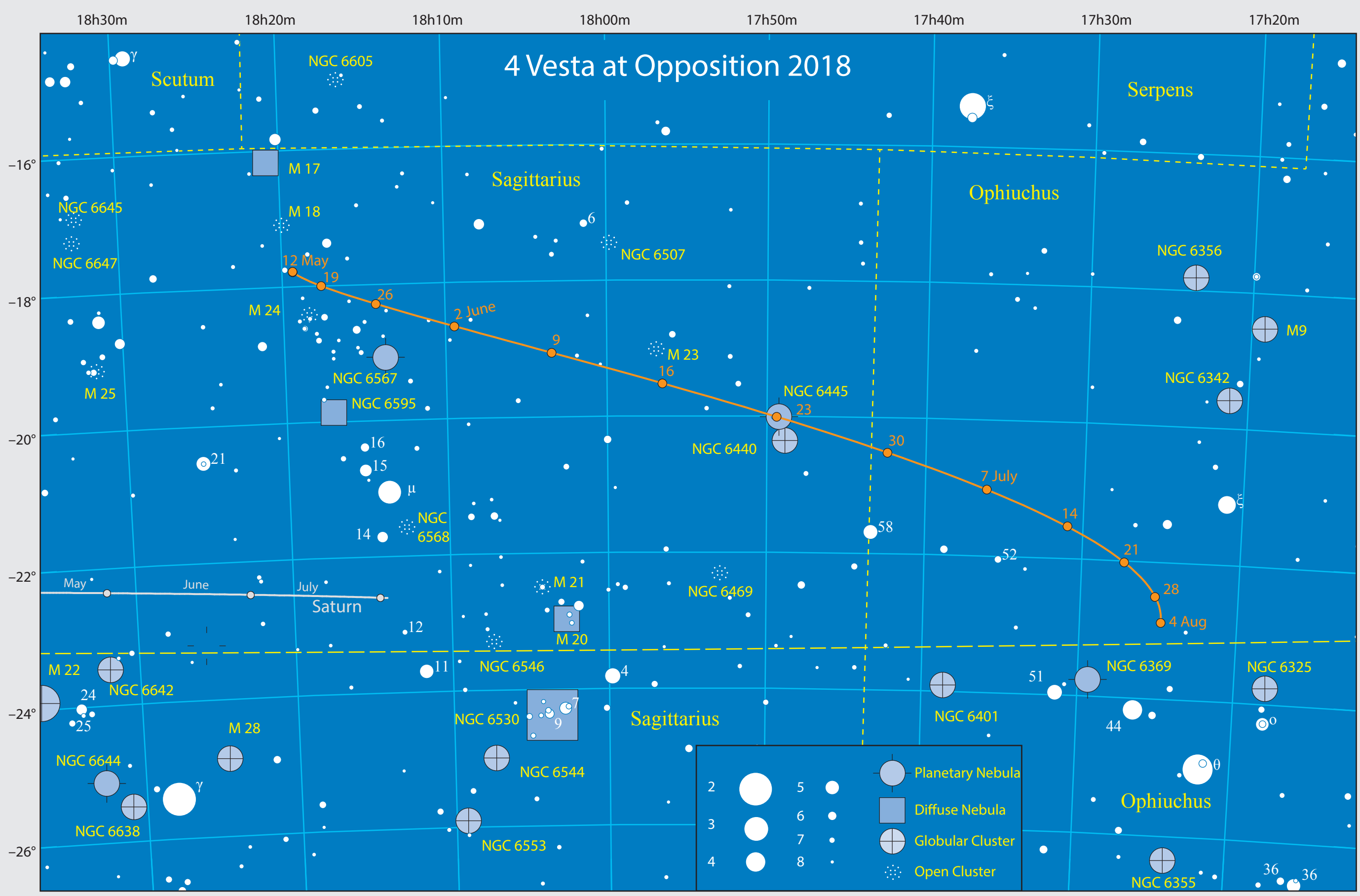
Mars rises around 8 pm midmonth in the eastern evening sky in Capricornus. In this faint constellation of the Sea Goat, the –1.6 magnitude planet dominates the 3rd and 4th magnitude stars that have earned the constellation the nickname *smile in the sky*. The *smile* is the asterism composed of the 12 brightest stars of the constellation. Another asterism within these same stars is a lady's high heeled shoe. Both are easy to detect visually using a little imagination (and dark skies).

The planet begins retrograde motion against the background stars at month's end when it appears to move backwards across the sky to the west. This apparent reversal, lasting two months, occurs just before, during and after opposition as the Earth passes the slower moving outer world (see retrograde motion p. 84 and All Sky Chart Map 8).

On the 3rd the 19-day old waning gibbous Moon rises just under the Red Planet (see Sky View). With opposition late in July the orb reaches –2 magnitude with a diameter of 20 arcseconds by month's end. Small telescope users should have no difficulty viewing the shrinking south polar cap and major surface markings.

recent oppositions in February 2014 and August 2016 had magnitudes (distance to the Earth in au) of 7.0 (1.23) and 9.2 (2.40) respectively.

To help you find Vesta in 2018 the period of naked eye visibility is marked on the All Sky Maps 6 and 8 and the finder chart (below) helps you lock it down. Note the opposition of any outer Solar System body occurs at the midpoint of its retrograde loop. For example, Mars is at opposition on July 27, so look where this date occurs in the loop on All Sky Map 8. This is why Vesta slows down at the end of the track shown here for it is close to its stationary points (see also page 84). It can take practice to see faint objects with the unaided eye, especially against numerous other stars, so it may help to find Vesta in binoculars first. If you are restricted to bright suburban skies then binoculars are a must. It can also be interesting to draw the star field a few days apart and pick the *star* that has moved. A great exercise for a student or any kid no matter how old (yes, we'll admit it, having done such stuff for fun over many years!)



Jupiter, now past opposition, begins the month 1° from Libra's duo of Alpha stars in the eastern evening sky (see May Sky View). The planet passed close by this pair in the morning skies in December last year and now retrograde motion has brought them back together. The waxing gibbous Moon, a few days after First Quarter, will be near the planet on the 23rd and 24th (see Sky View).

When observing the oblate (flattened) disc with a small telescope, the most obvious features are the dark belts and light zones. The most prominent of these are the broad north and south equatorial belts (NEB and SEB). The SEB has a tendency to fade every few decades and last disappeared in 2009 and returned late in 2010—the belt will often be hidden for one to three years. It doesn't really go anywhere, just gets obscured by a higher cloud layer of ammonia ice. Within the SEB lies the Great Red Spot, the largest known cyclone in the Solar System that has been raging for at least 300 years (predictions for this can be found in Part II, page 115).

Saturn is at opposition on the 27th and can be seen in the eastern evening sky after the end of astronomical twilight (see Sky Views). Although Saturn's rings are not unique in the Solar System (Jupiter, Uranus and Neptune also have them) none are as spectacular nor as beautiful as those that surround the second largest planet. If there is any doubt just look at the incredible images returned to Earth from the Cassini spacecraft. They are the only planetary rings observable from Earth with nothing more than a small telescope. Indeed Galileo discovered them in 1610 with his tiny instrument although he did not identify them as such. It would be another 45 years before Christiaan Huygens recognised their true nature.

Telescopes in the 50 to 100 mm range show the rings and the dark gap known as the Cassini Division. Moving to 150 mm and larger telescopes will reveal the Encke Gap in the outermost ring and the inner translucent Crepe Ring. On the planet itself, there is a light coloured band around the equator, and a noticeable darkening and flattening at the poles. For a few days around opposition time the planet's rings can brighten considerably. Known as the *opposition surge* or *Seeliger Effect* it occurs as the Sun illuminates the rings from directly behind us (see Astronomy 2016). Shadows projected from lumps and irregularities in the ring system will be hidden behind these particles, without shadows to darken the overall view, the rings surge dramatically in brightness.

DIARY

Fri	1st		Mercury at ascending node
Fri	1st	1 am	(11 pm WST, prev day) m.p. 4 Vesta 1.9° N of Moon
Fri	1st	11 am	(9 am WST) Saturn 1.6° S of Moon
Sat	2nd	2 pm	(Noon WST) d.p. Pluto 1.2° S of Moon
Sun	3rd		Saturn 1.0° N of NGC 6642 (GC) in Sagittarius
Sun	3rd	3 am	(1 am WST) Moon at apogee, 405,317 km
Sun	3rd	10 pm	(8 pm WST) Mars 3° S of Moon
Mon	4th		d.p. Ceres 0.02° S of star Epsilon (ε) Leonis
Mon	4th	pm	m.p. 29 Amphitrite 0.6° S of NGC 6416 (OC) in Scorpius
Tue	5th	10 pm	(8 pm WST) Comet C/2016 M1 (PANSTARRS) 0.1° N of star Tau (τ) Sagittarii
Tue	5th	pm	Jupiter 0.9° N of star Alpha (α) Librae
Wed	6th		Mercury at perihelion
Wed	6th		Venus at greatest latitude north
Wed	6th	Noon	(10 am WST) Mercury in superior conjunction
Thu	7th	4 am	(2 am WST) Neptune 2° N of Moon
Thu	7th	4:32 am	(2:32 am WST) Last Quarter Moon
Fri	8th		Venus 1.1° SW of star Kappa (κ) Geminorum
Fri	8th	pm	m.p. 29 Amphitrite 0.7° S of M6 Butterfly Cluster (OC) in Scorpius
Fri	8th	pm	Comet C/2016 M1 (PANSTARRS) 0.6° W of star Zeta (ζ) Sagittarii
Sat	9th		m.p. 2 Pallas 0.3° SE of NGC 2262 (OC) in Monoceros
Sat	9th	11 am	(9 am WST) star Pollux 5° N of Venus
Sat	9th	6 pm	(4 pm WST) m.p. 3 Juno 4° N of Moon
Sat	9th	pm	Comet C/2016 M1 (PANSTARRS) 0.5° E of M54 (GC) in Sagittarius
Sun	10th	1 pm	(11 am WST) Uranus 5° N of Moon
Tue	12th	pm	Comet C/2016 M1 (PANSTARRS) 1.2° SE of M70 (GC) in Sagittarius
Wed	13th	pm	m.p. 29 Amphitrite 0.4° S of NGC 6383 (OC) in Scorpius
Thu	14th	5:43 am	(3:43 am WST) New Moon
Thu	14th	10 am	(8 am WST) Moon at perigee, 359,503 km
Thu	14th	pm	m.p. 4 Vesta 0.5° SE of M23 (OC) in Sagittarius
Sat	16th		Mercury at greatest latitude north
Sat	16th	am	Comet 21P/Giacobini-Zinner 0.4° W of star Nu (ν) Cygni
Sat	16th	9 am	(7 am WST) star Pollux 8° N of Moon
Sat	16th	11 pm	(9 pm WST) Venus 2° N of Moon
Mon	18th	6 pm	(4 pm WST) star Regulus 1.7° S of Moon
Tue	19th		Neptune 0.9° W of star Phi (φ) Aquarii
Tue	19th		m.p. 2 Pallas 0.6° NW of NGC 2324 (OC) in Monoceros
Tue	19th	10 pm	(8 pm WST) Neptune stationary
Wed	20th		Venus 0.7° N of M44 Beehive Cluster (OC) in Cancer
Wed	20th		P/2013 CU_{129} (PANSTARRS) 0.5° E of star Epsilon (ε) Hydrae
Wed	20th		P/2013 CU_{129} (PANSTARRS) 0.4° N of star Rho (ρ) Hydrae
Wed	20th	6 am	(4 am WST) m.p. 4 Vesta at opposition
Wed	20th	8:51 pm	(6:51 pm WST) First Quarter Moon
Thu	21st	am	Comet 21P/Giacobini-Zinner 0.3° N of star Xi (ξ) Cygni
Thu	21st	am	Comet 21P/Giacobini-Zinner 1.0° E of NGC 7000 (N) in Cygnus
Thu	21st	8 pm	(6 pm WST) Solstice
Fri	22nd	1 pm	(11 am WST) star Spica 8° S of Moon
Sat	23rd	7 pm	(5 pm WST) P/2013 CU_{129} (PANSTARRS) 0.1° NW of star Eta (η) Hydrae
Sat	23rd	pm	m.p. 4 Vesta 0.3° N of NGC 6440 (GC) in Sagittarius
Sun	24th	am	Comet 21P/Giacobini-Zinner 0.3° N of NGC 7039 (OC) in Cygnus
Sun	24th	5 am	(3 am WST) Jupiter 4° S of Moon
Mon	25th		Comet C/2016 M1 (PANSTARRS) 1.0° NW of NGC 6541 (GC) in Corona Australis
Mon	25th	pm	m.p. 14 Irene 0.5° NW of star Psi (ψ) Capricorni
Tue	26th	2 am	(Midnight WST, prev day) star Pollux 5° N of Mercury
Tue	26th	7 am	(5 am WST) star Antares 9° S of Moon
Wed	27th		m.p. 3 Juno 1.0° S of star Omicron (ο) Piscium
Wed	27th	7 pm	(5 pm WST) m.p. 4 Vesta 0.3° S of Moon
Wed	27th	11 pm	(9 pm WST) Saturn at opposition
Wed	27th	pm	Comet C/2016 M1 (PANSTARRS) 0.7W of NGC 6496 (GC) in Scorpius
Thu	28th		d.p. Ceres 0.2° NE of star Gamma (γ) Leonis
Thu	28th	2 pm	(Noon WST) Saturn 1.8° S of Moon
Thu	28th	2:53 pm	(12:53 pm WST) Full Moon (404,791 km)
Thu	28th	Midnight	(10 pm WST) Mars stationary
Fri	29th		P/2013 CU_{129} (PANSTARRS) 0.8° N of star C Hydrae
Fri	29th	7 pm	(5 pm WST) d.p. Pluto 1.2° S of Moon
Fri	29th	pm	m.p. 15 Eunomia 1.2° E of star Pi (π) Hydrae
Sat	30th	am	Comet 21P/Giacobini-Zinner 1.4° NW of M39 (OC) in Cygnus
Sat	30th	1 pm	(11 am WST) Moon at apogee, 406,061 km

Uranus, in Aries, is only visible in the eastern morning sky, rising around 3 am midmonth.

Neptune rises around 11:30 pm in the evening eastern sky in Aquarius midmonth. The planet appears stationary on the 19th, approximately 0.9° from 4.2 magnitude Phi (φ) Aquarii, and thereafter will be in retrograde motion until late November.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in Sagittarius, rises around 7 pm midmonth in the eastern evening sky and comes to opposition next month. The Plutoid ends the month just five arcminutes from the *bright* 5.6 magnitude star 50 Sagittarii. **Ceres** has two close encounters with bright stars in Leo: on the 4th, Epsilon and then on 28th, Gamma (see diary).

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
11 Jun	192 Nausikaa	Scorpius	10.5
15 Jun	29 Amphitrite	Scorpius	9.5
16 Jun	9 Metis	Ophiuchus	9.7
19 Jun	4 Vesta	Sagittarius	5.3
26 Jun	423 Diotima	Sagittarius	11.3

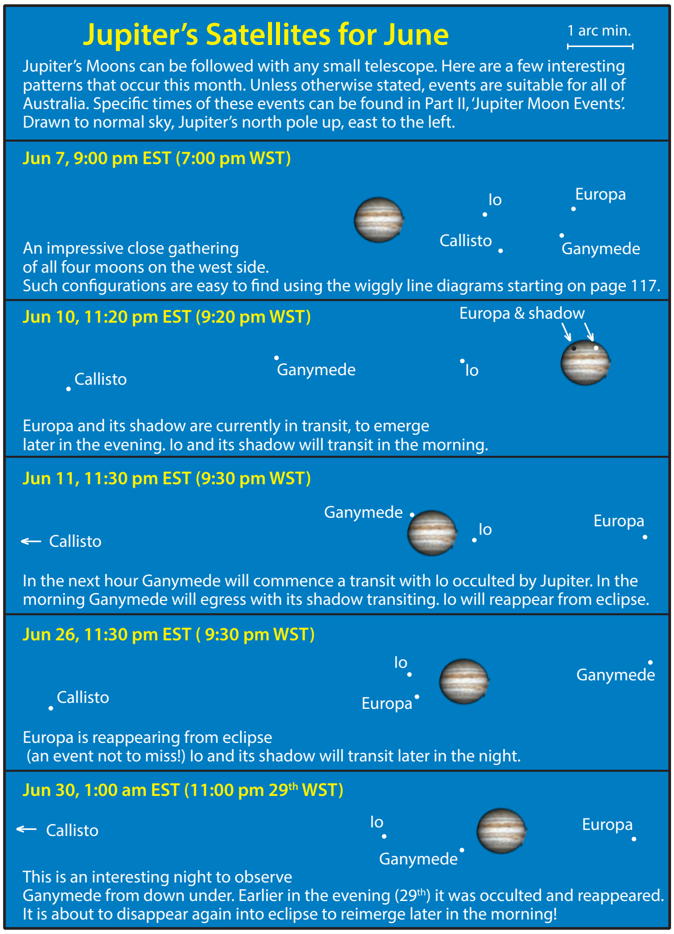
COMETS

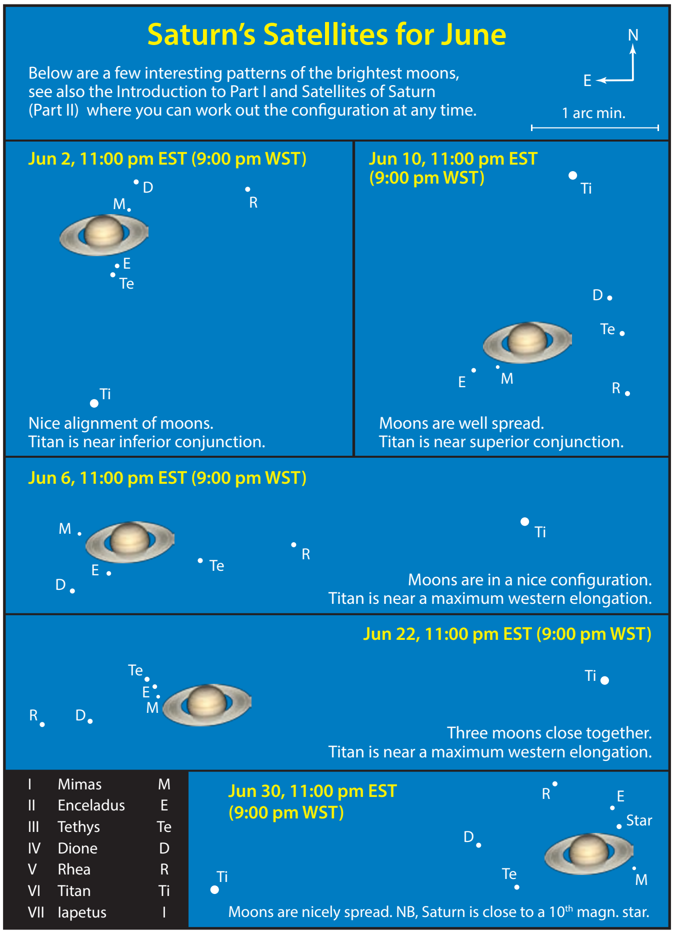
Comet C/2016 M1 (PANSTARRS) begins June in Sagittarius, shining at 10th magnitude. Visible throughout the night, on the 5th the comet will be very close to 3.3 magnitude star Tau (τ) Sagittarii (see diary). The following week it quickly swings around the teapot of Sagittarius. C/2016 M1 then moves into Corona Australis midmonth before finishing June in Scorpius and then Ara, by which time it may have brightened to 9th magnitude.

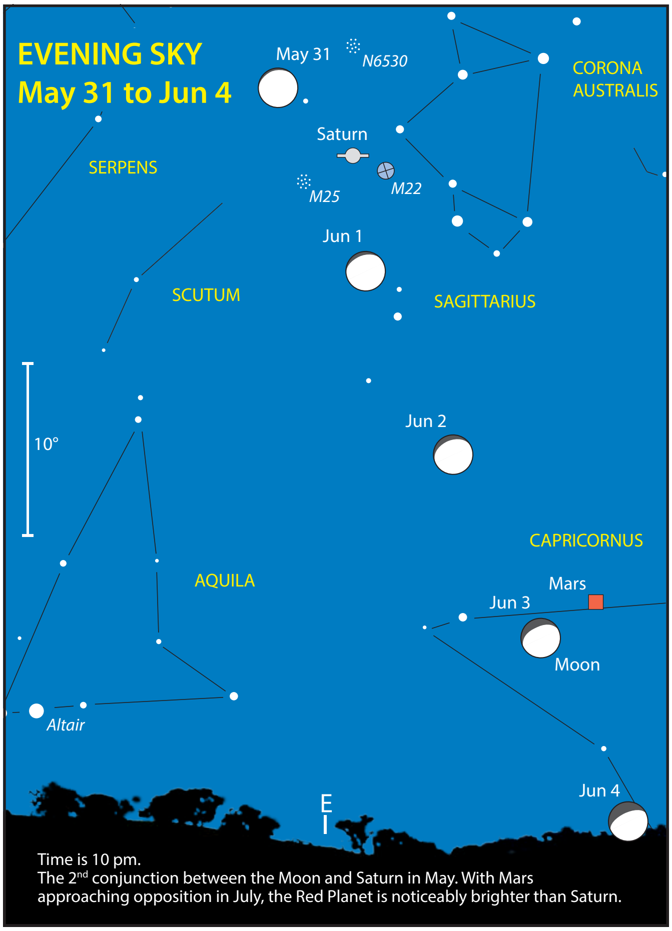
Comet 21P/Giacobini-Zinner brightens to be briefly visible low in the northern morning sky this month in Cygnus. It is soon lost from view as it moves over the northern horizon, returning in September. From June 19 to 22 the comet runs up the *west coast* of the North American Nebula (NGC 7000).

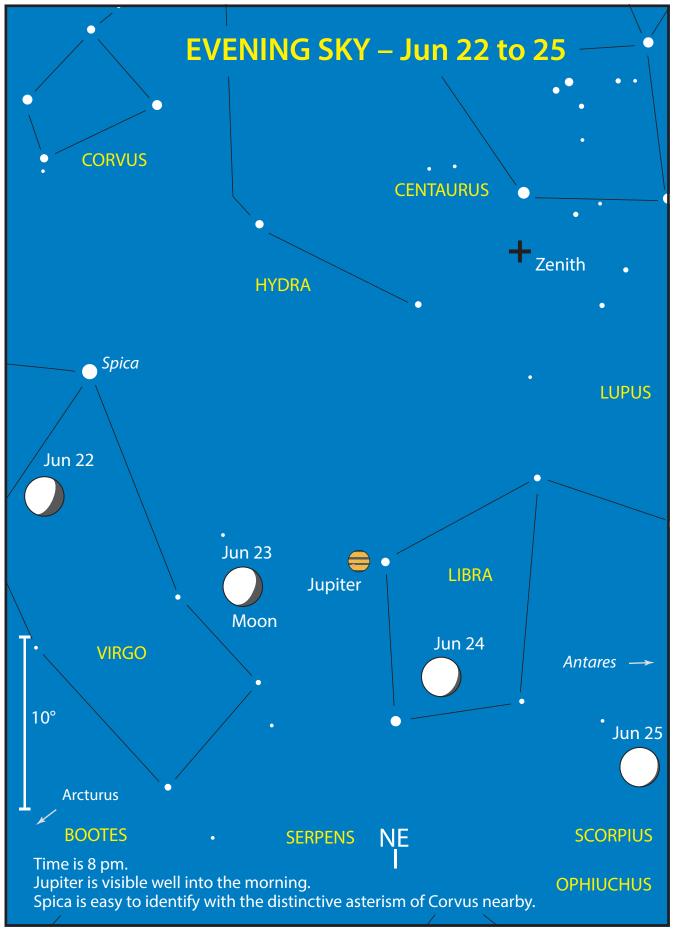
DOUBLE STARS

Located in the constellation of Böötes, Xi (ξ) Böötis (see All Sky Map 7) is a striking colourful pair. The stars, magnitudes 4.8 and 7.0, are separated by 5.5 arcseconds with a position angle of 302 degrees. The stars are yellow (spectrum G8V) and deep orange (spectrum K5V). The period is about 152 years and the stars were at their closest at 2.1 arcseconds in 1914. The pair is located only 22 light years away. Whilst in the area also have a look at Pi (π) Böötis. Appearing different to Xi, this pair of bright, pale yellowish-white stars (the primary is B9), magnitudes 4.9 and 5.8, is separated by 5.4 arcseconds with a position angle of 113 degrees. The position angle is slowly increasing with little change in separation and the system is a long-period binary. Both doubles are excellent objects for a small telescope.

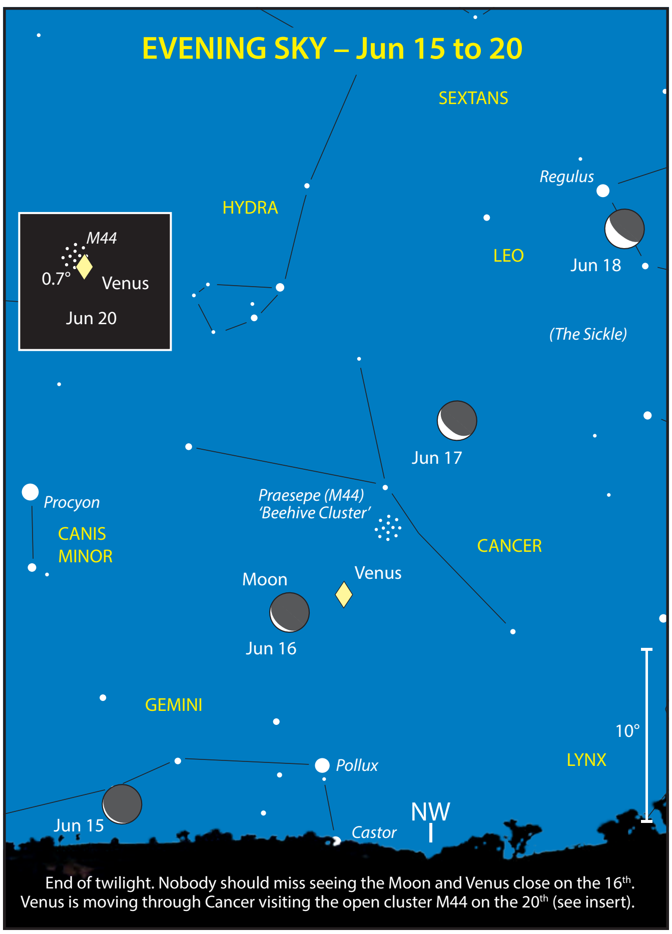


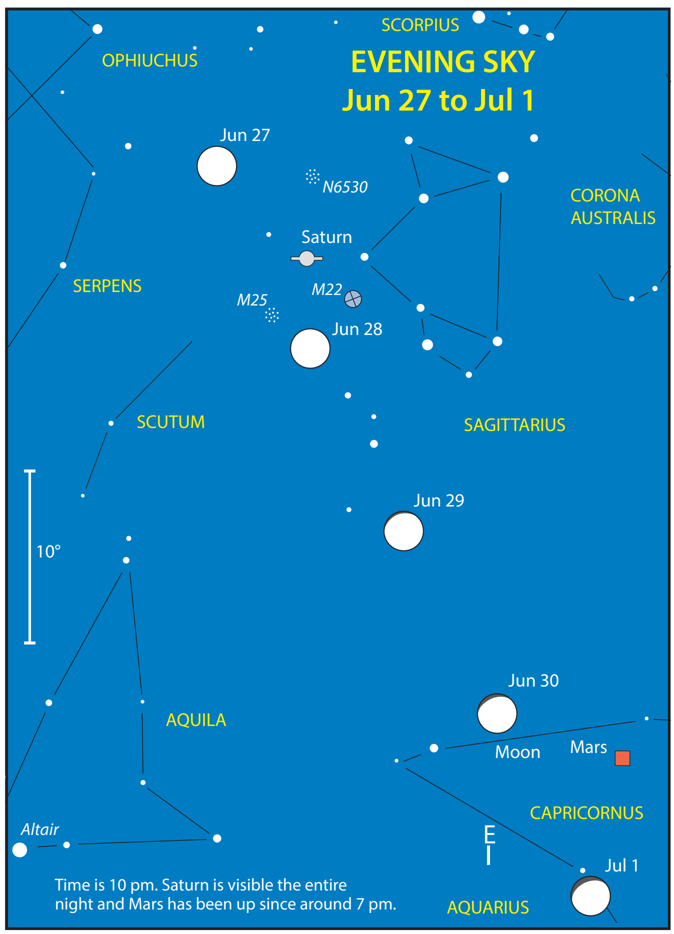






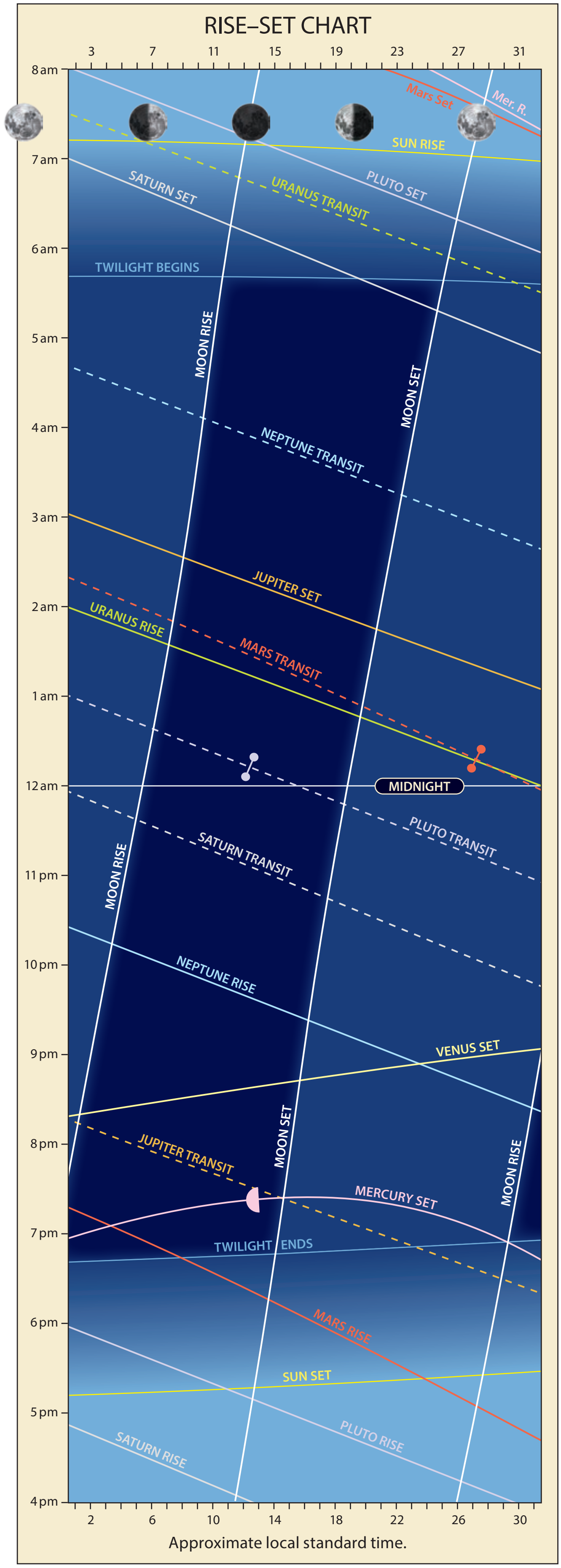
Approximate local standard time.





JUNE

JULY



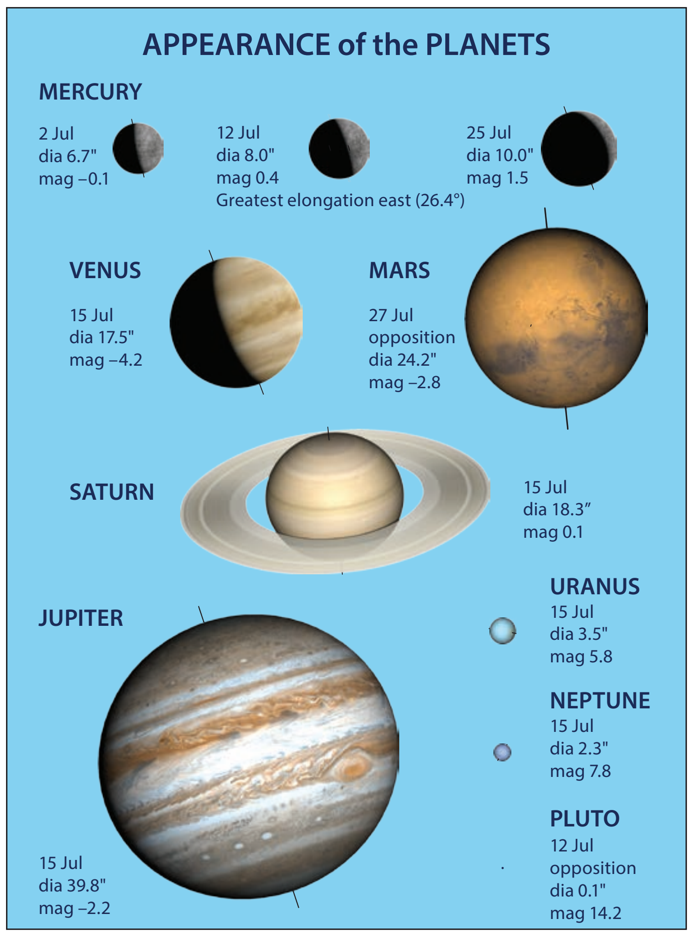
HIGHLIGHTS

- Mercury at best for evening observation.
- Venus and Moon close.
- Mars at opposition.
- Saturn, just past opposition, still excellent in small telescopes.
- Three planets brighter than magnitude –2 in the evening: Mars, Jupiter and Venus.

CONSTELLATIONS

Many of the brightest stars in the sky have proper names. There was a need however for an orderly method of identification to include fainter ones and in 1603 the German uranographer Johann Bayer introduced such a system. The Bayer system usually classifies the stars within a constellation according to their brightness, by labelling them with a Greek letter: alpha for the brightest star, beta for the next and so on to omega for the 24th brightest. The Greek letter is then attached to the genitive case of the Latin name for the constellation. Thus, the brightest star in the constellation of Andromeda would be Alpha (α) Andromedae. The sixth brightest star would be Zeta (ζ) (see p. 152 for all the Greek letters).

Of course many constellations have more than 24 naked-eye stars and therefore run out of Greek letters. The solution put forward by English astronomer John Flamsteed (1646-1719) was to number the stars, not by their brightness but from the eastern to the western edge of their respective constellations. In this system a star is given a numeral followed by the constellation's Latin genitive case. Astronomers adopted this new numbering scheme, but retained the Bayer Greek letters

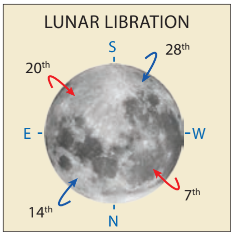


for stars that already had them. Therefore, the 50th star in Cygnus is identified as 50 Cygni, This one is also known by its Arabic name Deneb. Since Deneb is the brightest star in the constellation it also goes by its Bayer description of Alpha (α) Cygni.

The famous Gemini Twins, Castor and Pollux, are stars that have about a half magnitude difference in brightness, however the fainter of the pair, Castor, is designated by the Greek letter alpha. The northern constellation of Ursa Major is a strange case, where Bayer himself chose to label the stars of the Big Dipper by their position, and not by their relative brightness.

Readers may think that these little peculiarities are not all that common, but 34 of the 88 constellations have stars brighter than their alphas!

THE MOON



- 6th 6 pm (4 pm WST) Last Quarter.
- 7th 9 pm (7 pm WST) Maximum Libration (10.2°), bright NW limb. The libration zone crater Bunsen (53 km) now in view.
- 10th 8 pm (6 pm WST) Occultation of Aldebaran by the Moon, visible from Canada, Greenland and the Arctic.
- 13th 1 pm (11 am WST) New Moon. Partial solar eclipse visible from Tasmania and parts of southern South Australia and Victoria, see Part II for details.
- 13th 6 pm (2 pm WST) Moon at perigee (closest to Earth at 357,431 km).
- 14th 2 am (midnight previous day WST) Minimum Libration (1.1°), too close to New Moon.
- 20th 6 am (4 am WST) First Quarter.
- 20th 11 am (9 am WST) Maximum Libration (10.1°), bright SE limb. The 58 km crater Hamilton, situated inside the ruins of a large crater, seen at best.
- 27th 4 pm (2 pm WST) Moon at apogee (furthest from Earth at 406,223 km).
- 28th 2 am (midnight previous day WST). Minimum Libration (0.4°), Full Moon.
- 28th 6 am (4 am WST) Full Moon. Total lunar eclipse visible in part from Australia, see Part II for details.

THE PLANETS

Mercury, in the western evening sky, is at its best for observation throughout July (see Sky View). Travelling through Cancer for the first half of the month it then moves into Leo for the remainder, all the while setting after the end of astronomical twilight. On the 4th, the planet will be seen on the outer fringes of the Beehive Cluster. This open cluster, numbered 44 in Messier's famous catalogue is also known as Praesepe. It is one of nearest open clusters to our Solar System and can be seen as a fuzzy patch with the unaided eye. Binoculars or a small telescope are required to resolve its many members. On the 15th, the slender crescent of the 3-day old Moon will be seen above and to the north (right) of the planet. If looking in late July do not confuse the 1st magnitude star Regulus with Mercury. Around the 25th it is of a similar brightness to the star. On the 12th, Mercury reaches its greatest elongation (26°) east of the Sun and subsequently begins its journey back toward the Sun and inferior conjunction next month.

Venus spends the month crossing the constellation of Leo in the early western evening sky. On the 10th, the planet will be just 1° from the 1st magnitude star Alpha Leonis (Regulus), the Lion's heart or more commonly the handle star of the Sickle asterism (see Sky View). Interestingly, the star's proper name *Regulus* does not go back far into antiquity like most. The name in Latin means *prince* or *little king* and was given by Nicolaus Copernicus (1473–1543). The 4-day old waxing crescent Moon appears close to Venus on the 16th making a pleasant sight in the early evening winter sky (see Sky View).

The **Earth** is at aphelion on the 7th, the furthest point in its orbit from the Sun (152,095,557 km or 1.016696 au distant).

Mars, drifting slowly in retrograde motion through Capricornus, rises in the eastern sky during twilight midmonth and is visible all night (see Sky View). Coming to opposition on the 27th, the planet will be the centre of attention for planetary observers with its best apparition since August 2003. From the beginning of the month until the end of August the Martian disc will be at least 20 arcseconds in diameter (24 arcseconds during the last week of July/first week of August). Steady seeing and sensible magnification will allow small to moderate sized telescope users views of the shrinking south polar cap, light and dark features and maybe even dust storms.

Favourable oppositions also present the chance to observe Mars' two moons, Phobos and Deimos. Normally their faintness and close proximity to the brilliant Martian disc makes this exceedingly difficult. Ask any seasoned observer about trying to observe Sirius' close companion star, Mars is normally a bigger challenge! However, being so much closer at the moment, the moons are not only brighter but appear further from the planet (angular distance). Fainter Deimos is the easier to attempt. See page 113 for further explanation.

For those that just enjoy the visual pleasure of the night sky, the view of the rising planet will be impressive. Shining above –2 magnitude throughout July/August and –2.8 for a few days around opposition its orange orb will dominate the eastern sky.

These favourable perihelic oppositions occur only every 15 to 17 years due to Mars' elliptical orbit. When the planet is at perihelion (closest to the Sun) and the Earth passes between the Sun and Mars, we get a particularly good view. The next *best* opposition occurs in September 2035, although the October 2020 and July 2033 apparitions would still be considered favourable with the disc diameter over 20 arcseconds. Mars' closest approach to Earth is on the 31st at a distance of 57,589,196 km (0.38496 au). If the orbits of Mars and Earth were circular and coplanar (in the same geometric plane), opposition and closest approach would occur at the same instant. Since the real orbits are eccentric and inclined to each other the timing between the two events can vary by up to two weeks.

Jupiter, in Libra, is visible high in the northern sky as it transits the meridian (is due north) soon after astronomical dusk midmonth. For the first time since opposition the equatorial diameter drops below 40 arcseconds in the second half of the month, with a slight decrease in magnitude. The planet appears stationary on the 11th as it comes to the end of four months of retrograde motion; thereafter Jupiter moves from west to east among the stars instead of appearing to move backwards! On the 21st the 9-day old waxing gibbous Moon appears nearby (see Sky View).

Post opposition the gas giant's size begins to decrease as does its brightness slightly. However, the planet is always a delight to observe in telescopes of all sizes. Besides planetary details like the ever-changing equatorial cloud bands, the continuous motion of the four major moons provides a renewed and different view each time they are observed. Watch as these satellites (Io, Europa, Ganymede and Callisto) undergo transits and shadow transits of the planet, occultations and eclipses. Predictions for these events can be found in Part II.

Saturn is visible in the east as the sky darkens after sunset. On the 25th, the 13-day old waxing gibbous Moon appears close to the planet (see Sky View). With opposition late last month the planet is ideally positioned for observation throughout the night. At this time the main Saturnian moons are fun to track down and identify. The brightest and largest, Titan, can be seen in binoculars. Titan ranks as the second largest moon in the Solar System after Jupiter's Ganymede and the only one with a substantial atmosphere. Four other moons, Enceladus, Tethys, Dione and Rhea can be seen in small telescopes but can be tricky to locate as they are much fainter than Titan (see also Sky View for some interesting arrangement of the satellites in July).

Uranus in Aries is only visible in the morning sky, rising around 1 am midmonth.

Neptune, moving through Aquarius in retrograde motion, rises in the mid-evening eastern sky.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** is at opposition on the 12th at magnitude 14.2 in Sagittarius and above the horizon the entire night. It is presently 4,874 million km (32.5825 au) from Earth, with its light taking four hours and thirty-one minutes to reach us. Astroimagers have the best chance of tracking this distant world down. Try imaging its location over several days to sort out the wanderer from the many fixed stars of similar brightness (see also our finder chart on p. 133). Between the 3rd and 4th Pluto will be within one arcminute of the 5.6 magnitude star 50 Sagittarii.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
6 Jul	702 Alauda	Sagittarius	11.5
7 Jul	26 Proserpina	Sagittarius	10.4
14 Jul	97 Klotho	Aquila	12.0
20 Jul	88 Thisbe	Sagittarius	9.7
20 Jul	52 Europa	Sagittarius	11.0
24 Jul	14 Irene	Sagittarius	10.0

Metis visits some globular clusters in Ophiuchus over the next two months (see diary).

DIARY

Sun	1st		P/2013 CU_{129} (PANSTARRS) 0.9° NE of M48 (OC) in Hydra
Sun	1st	Noon	(10 am WST) Mars 5° S of Moon
Sun	1st	pm	m.p. 9 Metis 0.2° N of NGC 6355 (GC) in Ophiuchus
Tue	3rd	10 am	(8 am WST) Neptune 3° N of Moon
Wed	4th		Mercury 0.5° SW of M44 Beehive Cluster (OC) in Cancer
Wed	4th	6 am	(4 am WST) m.p. 3 Juno 3° S of Uranus
Wed	4th	10 pm	(8 pm WST) d.p. Pluto 0.01° NE of star 50 Sagittarii
Wed	4th	pm	Comet C/2016 M1 (PANSTARRS) 0.4° W of NGC 6352 (GC) in Ara
Thu	5th		Mercury 0.8° N of star Delta (δ) Cancri
Thu	5th		P/2013 CU_{129} (PANSTARRS) 0.6° NW of NGC 2506 (OC) in Monoceros
Fri	6th	5:51 pm	(3:51 pm WST) Last Quarter Moon
Sat	7th	3 am	(1 am WST) Earth at aphelion, 1.016696059 au
Sat	7th	Midnight	(10 pm WST) Uranus 5° N of Moon
Sun	8th		P/2013 CU_{129} (PANSTARRS) 0.6° NW of M46 (OC) in Puppis
Sun	8th		P/2013 CU_{129} (PANSTARRS) 0.9° E of M47 (OC) in Puppis
Sun	8th	3 am	(1 am WST) m.p. 3 Juno 1.9° N of Moon
Tue	10th		Mercury at descending node
Tue	10th	6 am	(4 am WST) star Regulus 1.1° S of Venus
Tue	10th	8 pm	(6 pm WST) star Aldebaran 1.1° S of Moon
Wed	11th		m.p. 3 Juno 0.5° NW of star Xi (ξ) Ceti
Wed	11th	2 pm	(Noon WST) Jupiter stationary
Thu	12th	3 pm	(1 pm WST) Mercury at greatest elongation East (26.4°)
Thu	12th	8 pm	(6 pm WST) d.p. Pluto at opposition
Fri	13th	12:48 pm	(10:48 am WST) New Moon; eclipse
Fri	13th	6 pm	(4 pm WST) Moon at perigee, 357,431 km
Sat	14th	pm	Comet C/2016 M1 (PANSTARRS) 0.4° SE of NGC 6152 (OC) in Norma
Sun	15th	8 am	(6 am WST) Mercury 2° S of Moon
Mon	16th		Venus 1.0° NE of star Rho (ρ) Leonis
Mon	16th	3 am	(1 am WST) star Regulus 1.8° S of Moon
Mon	16th	2 pm	(Noon WST) Venus 1.6° S of Moon
Mon	16th	pm	Mars 1.0° NW of star Psi (ψ) Capricorni
Wed	18th	pm	m.p. 9 Metis 0.3° N of NGC 6293 (GC) in Ophiuchus
Thu	19th		P/2013 CU_{129} (PANSTARRS) 0.8° NW of NGC 2217 (G) in Canis Major
Thu	19th	7 pm	(5 pm WST) star Spica 8° S of Moon
Fri	20th		Mercury at aphelion
Fri	20th	5:52 am	(3:52 am WST) First Quarter Moon
Fri	20th	6 am	(4 am WST) Comet C/2016 M1 (PANSTARRS) 0.1° NW of NGC 6067 (OC) in Norma
Fri	20th	10 am	(8 am WST) Jupiter 4° S of Moon
Mon	23rd	1 pm	(11 am WST) star Antares 9° S of Moon
Tue	24th	4 pm	(2 pm WST) m.p. 4 Vesta 3° S of Moon
Wed	25th	4 pm	(2 pm WST) Saturn 2° S of Moon
Wed	25th	5 pm	(3 pm WST) Mercury stationary
Wed	25th	pm	Saturn 0.4° S of NGC 6583 (OC) in Sagittarius
Thu	26th	Midnight	(10 pm WST) d.p. Pluto 1.3° S of Moon
Fri	27th		Venus 1.3° SW of star Sigma (σ) Leonis
Fri	27th	3 pm	(1 pm WST) Mars at opposition
Fri	27th	4 pm	(2 pm WST) Moon at apogee, 406,223 km
Sat	28th		Mercury 1.2° W of star Omicron (o) Leonis
Sat	28th	6:20 am	(4:20 am WST) Full Moon (406,099 km, furthest for this year); eclipse
Sat	28th	8 am	(6 am WST) Mars 7° S of Moon
Mon	30th	3 am	(1 am WST) m.p. 3 Juno 0.1° S of star Mu (μ) Ceti
Tue	31st	4 pm	(2 pm WST) Neptune 3° N of Moon
Tue	31st	6 pm	(4 pm WST) Mars closest approach

COMETS

Comet P/2013 CU_{129} (PANSTARRS) begins July low in the western evening sky in Hydra. Shining at 11th magnitude, the comet rapidly moves south of the Sun and into the dawn sky, reappearing in Canis Major and Columba midmonth before ending July in Caelum. On the 8th it is close to the open star clusters M46 and M47 in Puppis (see diary).

Comet C/2016 M1 (PANSTARRS) is expected to fade from 9th to 10th magnitude during July. Visible all night, the comet begins the month in Ara before moving into Norma midmonth and then finishing in Circinus. On the evening of 19th C/2016 M1 will be in front of the open cluster NGC 6067 in Norma.

DOUBLE STARS

Situated in Hercules (the Roman name of the Greek hero Heracles), Alpha (α) Herculis (Rasalgethi, see All Sky Map 7) has to be one of the finest colourful double stars. The pair, magnitudes 3.5 and 5.4, are separated by 4.8 arcseconds with a position angle of 104 degrees. The stars are yellowish-orange (spectrum M5Ib-II) and bluish-white. The motion is slowly retrograde and there has been little change in separation. The orbital period is estimated to be over 3,000 years. The bright red supergiant primary star is an irregular variable and has a very close companion separated by 0.2 arcseconds revealed by speckle interferometry in 1986. The secondary is also a spectroscopic binary, the pair separated by 0.4 au, with a period of just over 51 days.

Colourful Stars

It's always enjoyable showing someone his or her first view through a telescope. There are the spellbinding planets and clusters, but an under appreciated area is the colour in stars. The double star HR2764 (Map 4) in Canis Major is a favourite with its blue and orange stars having it sometimes called the southern 'Alberio' (another double famous for its colour in Cygnus). An often overlooked part of the enjoyment is how easy the colour is to recognise when you can see the contrast between two stars side by side. The critical aspect is having the individual stars bright enough to fire the cones in our eyes which are needed to see colour, which is impossible with faint nebulae, as mentioned in the viewing galaxies article (page 66). Often the faint white (grey) of stars is due to the limitation of our eyes and does not show the true colour. With a little practice colour can be seen in the brightest stars with the unaided eye. An extreme example is the contrast between red Betelgeuse and blue Rigel in Orion (All Sky Map 2). This colour variance hints at the incredible differences between these two dramatic giant stars (see opposite). Another good naked-eye example is the pointers in Centaurus, with the yellow of Alpha (α) vs. the blue of Beta (β) Centauri (see All Sky Map 1).

To rapidly expand the number of coloured stars visible only requires binoculars. These have the advantage of pulling in considerably more light than the eye (a help in light polluted areas) coupled with a low magnification allowing more bright comparison stars visible in the same wide field.

The following examples are based on observations made with a pair of 7 × 50 binoculars, field size 7°. A circle marks the areas on the relevant All Sky Map. The spectral classes are mentioned for each star, which is discussed in further detail on page 140. Keep in mind the colour is indicative of the star's temperature, so in the basic spectral types O B A F G K

Southern Cross and Pointers *The exposure was 30 minutes, where the lens was defocused from infinity to about two metres in six steps, with five minutes exposure on each. Note how the yellow of Alpha (α) Centauri and the red of Gamma (γ) Crucis contrast against the blue stars. David Malin.*

M at the 'O' end we have the hottest blue stars and moving to the right it goes white, yellow, orange and finally to the cool red 'M's. Each type is also broken down into 10 sub classes.

Field 1, Map 1 The main stars of Crux (the Southern Cross) has red Gamma (γ) (M3, mag. 1.6) at 3,200K in contrast to Alpha (α) (B0, mag. 1.3), Beta (β) (B0, mag. 1.3) and Delta (δ) (B2, mag. 2.8), which are hot blue/white stars (around 17,000K). Although not as obvious, the final and faintest (mag. 3.6) star in the asterism, Epsilon (ε) (K3) is more yellow.

Field 2, Map 1 This is a somewhat colourful stellar area straddling Carina and Vela and makes part of the 'False Cross'. N Velorum is yellow (K5, mag. 3.1) and g Carinae orange/red (M0, mag. 4.3). Their colours stand out well against the white of Iota (ι) Carinae (A8, mag. 2.2) and the blue/white of Kappa (κ) Velorum (B2, mag. 2.5).

Field 3, Map 4 This is part of the Virgins asterism in Canis Major. Epsilon (ε) is white (B2, mag. 1.5) with Delta (δ) showing a distinct yellow (F8, mag. 1.8) and between them Sigma (σ) looking more orange (K7, mag. 3.5).

Field 4, Map 6 The heart of Scorpius. Bright Antares or Alpha (α) Scorpii (M1, mag. 1.0) is a brilliant red and stands out well against the blue/white of its two flanking stars, Sigma (σ) (B1, mag. 2.9) and Tau (τ) (B0, mag. 2.8). The heart is a good description of this area for Antares might be the heart star but the other two share the Arabic name of Alniyat, which derives from a term meaning 'the arteries'.

An impressive colourful area is the Bull's face in Taurus (Map 3), the 'A' shaped Hyades open star cluster. Aldebaran (Alpha (α) Tauri) is a yellow/orange (K5, mag. 1.0) star making a bright 'eye' for the bovine. This is a brilliant binocular field with the remaining bright members consisting of around a dozen 3rd and 4th magnitude stars, which are mostly blue with a scattering of yellow stars.

Finally, for those who wish to really see 'red' there are the carbon stars whose colour is not related to temperature but instead due to massive quantities of carbon molecules in their atmosphere which are very good at absorbing the blue end of the spectrum. There are a few suited for binoculars. Here are three well positioned for down under observations, U Hydrae (Map 4), W Orionis (Map 2) and 19 Piscium which is part of the Circlet of Pisces (Map 8). By their nature, these types of stars vary in brightness, but for those who wish to go fishing they are marked on the maps.

Capturing the Colour

It is a simple process to image the colour of stars. A normal camera can achieve this with long exposures just sitting on a tripod, i.e., no tracking telescope mount required. The trick is to avoid overloading the detector chip. This is the same effect as burning or washing out the image in good old-fashioned film. The images here were taken by the famous astrophotographer David Malin using a manual Hasselblad camera with an 80 mm *f*/2.8 lens and 400 ASA film. Each is a single exposure with the camera defocused in steps. The result of expanding the star trails reduces the effective exposure. This caters for the wide range of star brightnesses with one of these steps being an optimum exposure for the colour of each.

Two Extreme Stars in Orion

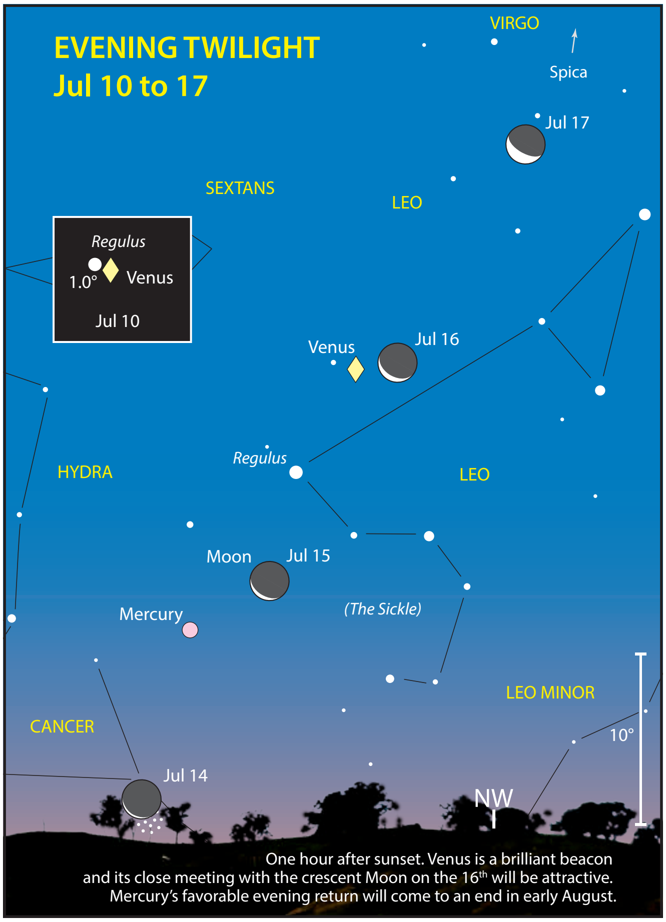
The constellation of the Hunter's two brightest stars are Rigel (Beta Orionis) and Betelgeuse (Alpha). They are of comparable brightness and both are extremely luminous supergiants but that's where the similarity ends. The unaided eye can easily see their different colours with Rigel being blue/white (B8) and Betelgeuse a distinct red (M2), a distinction classically explained by their temperatures, 11,000K and 3,000K respectively. From here on the statistics get mind blowing.

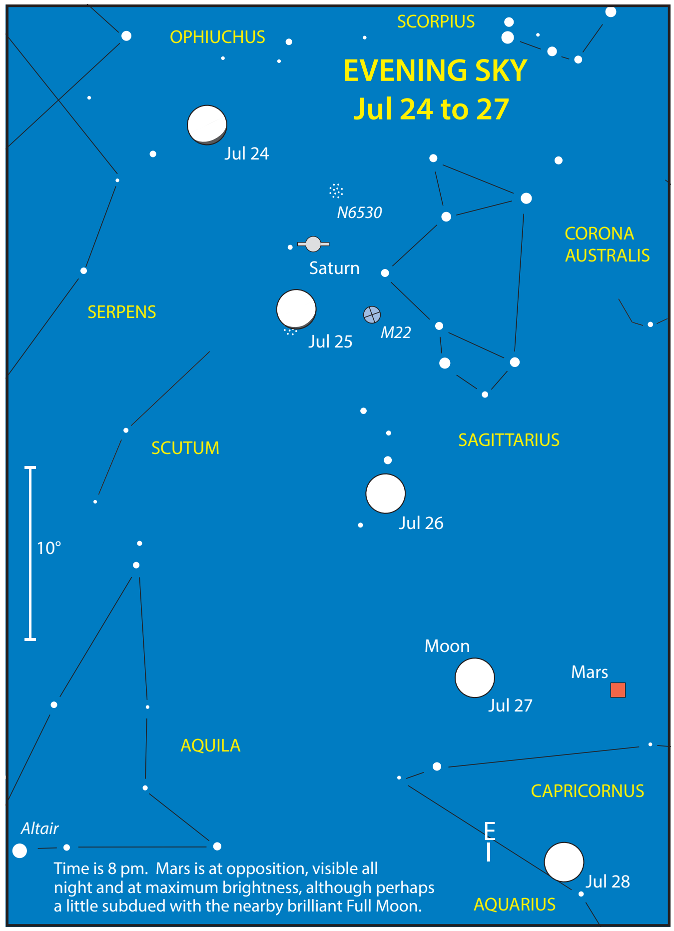
Comparing Rigel to the Sun everything is greater. The visual luminosity is 40,000 times (60,000 if you included the UV), the mass 17× and the radius 70×. If placed where the Sun is, Rigel's *surface* would extend 84% of the distance to Mercury! It is not surprising that even from the considerable distance of 800 light years, it's still the 7th brightest star in the heavens. In the top 30 brightest stars it is second in luminosity only to Deneb in Cygnus (see page 141). Rigel is so bright it is the source illuminating nearby IC2118, the Witch Head nebula.

Turning to Betelgeuse, we'll continue to compare to the Sun/Solar System. Its visual luminosity is 9,400× (however if the infrared is included it may be 100,000×), the mass 14× and the radius a massive 650×. Betelgeuse is so big it would swallow up Mercury, Venus, Earth and Mars extending to nearly the asteroid belt! It is one of the few stars besides the Sun to have had its disc imaged, being around 0.5 arcseconds in diameter. The star is a prime candidate for the next supernova, perhaps within a thousand years. Being approximately 450 light years distant it may already have happened, but the light just hasn't arrived yet!

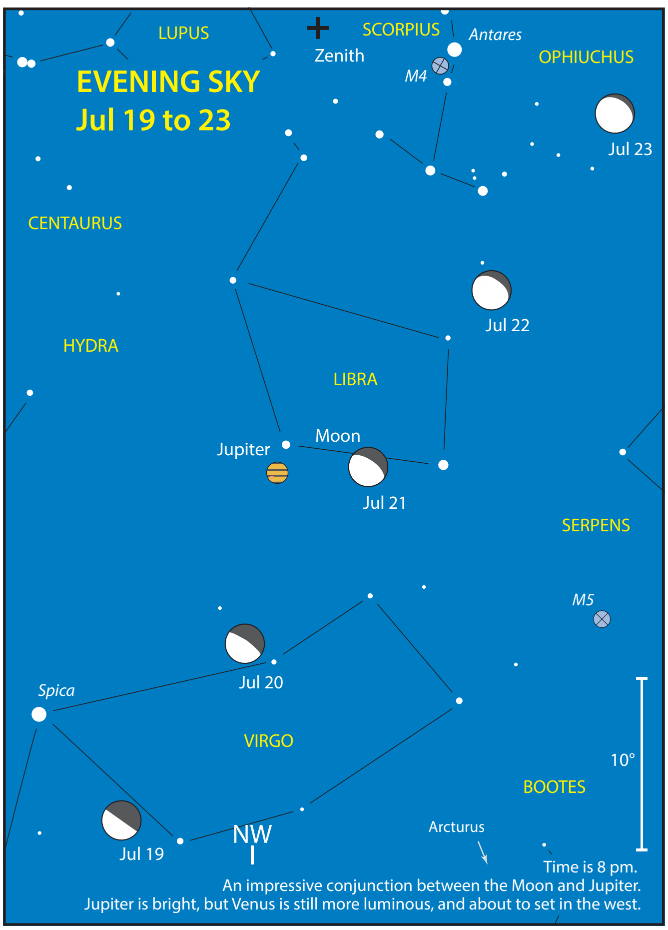
Constellation of Orion *The exposure was 30 minutes, where the lens was defocused from infinity to about one metre in ten steps, with three minutes exposure on each. Note how the red of M42 and orange of Betelgeuse contrast against the blue stars. David Malin.*

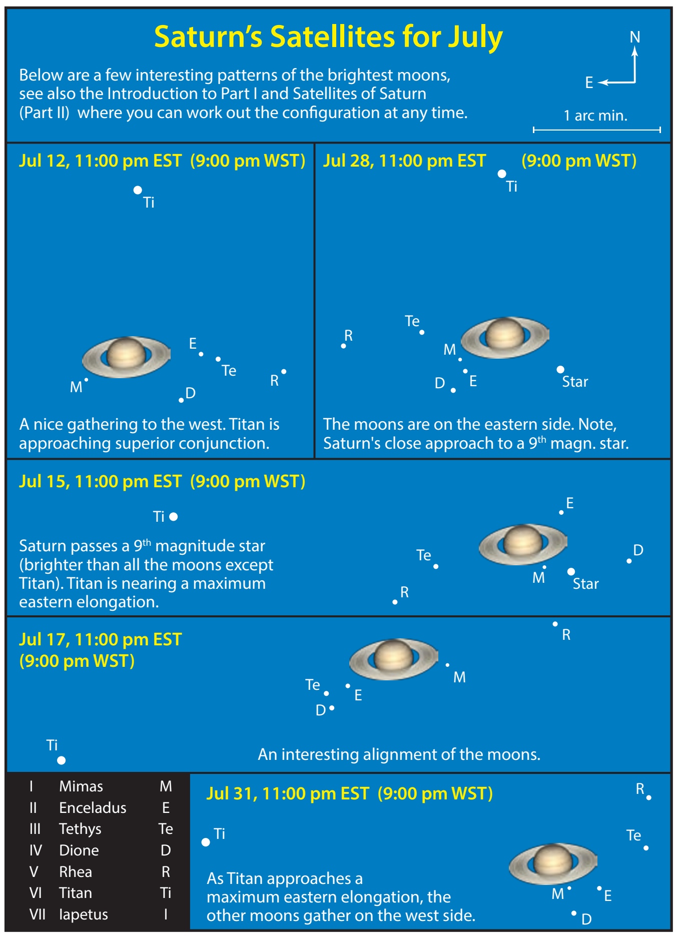
JULY



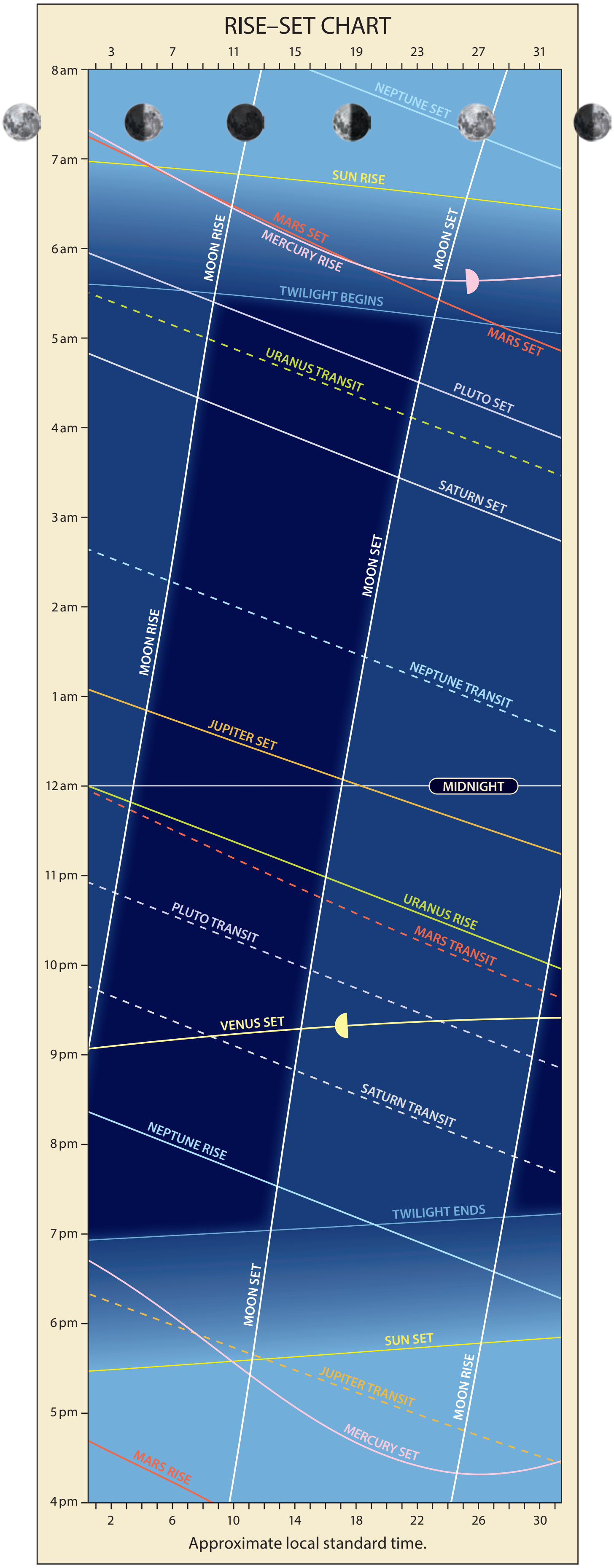


Approximate local standard time.





AUGUST



HIGHLIGHTS

- Venus and Spica close.
- Mars, just past opposition, still excellent in small telescopes.
- Jupiter and colourful double star Alpha Librae close.
- Three planets brighter than magnitude –2 continues in the evening: Mars, Jupiter and Venus.

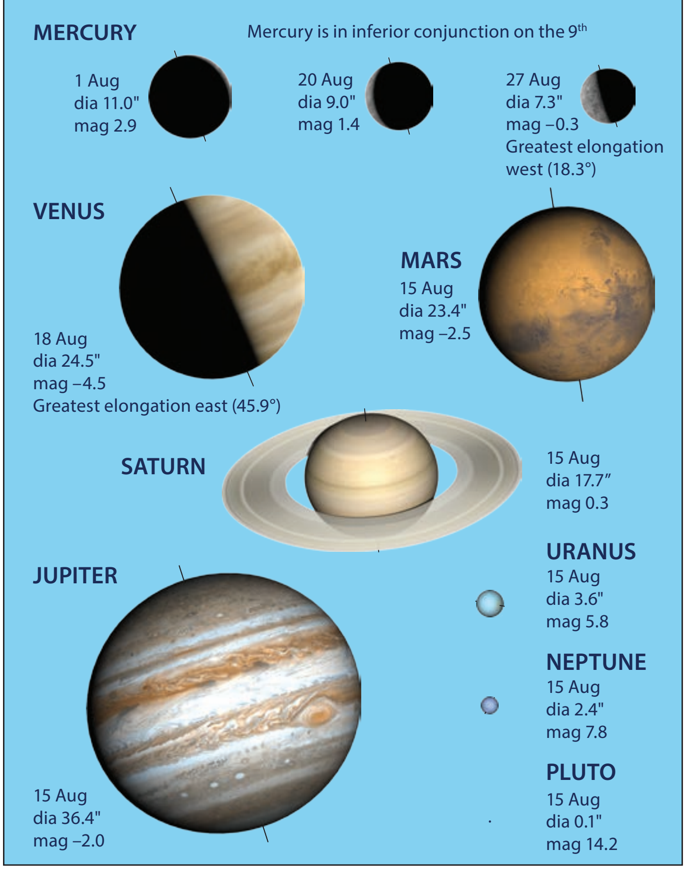
CONSTELLATIONS

The traditional names of the stars can sometimes not only relate to the constellations' legends but also give some anatomical information. Some are used more than once.

There are *five* naked eye stars in the evening sky with their Arabic names sharing the word Deneb meaning Tail. Rising in the early evening is the constellation of Cetus the Whale. Its brightest star is Beta (β) Ceti called Deneb Kaitos, which translates to Whale's Tail. Further west lies Capricornus with 2.8 magnitude Delta (δ) Capricorni or Deneb Algedi, or Tail of the Goat. The back of this *Sea Goat* more resembles the hind part of a fish. The adjoining constellation of Aquila contains Zeta (ζ) and Epsilon (ε) Aquilae, which share the name Deneb al Okab or the Eagle's Tail. Finally, the brightest and most famous example of Deneb belongs to the alpha star of Cygnus. You can guess which part of the swan this is!

There are two *Feet* or Rigels in the sky. The best-known example is Beta (β) Orionis. A more complete Arabic name was Rigel al-gabbar or Foot of the Great One, marking this hunter's left foot. The other Rigel refers to the more traditional name of Alpha (α) Centauri, Rigel Kentaurus, which translates to Foot of the Centaur. This was an obvious name considering

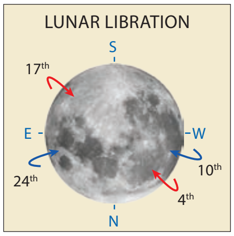
APPEARANCE of the PLANETS



Centaurus stands proudly on the southern horizon during Northern Hemisphere spring evenings.

Getting away from body parts, the sky also contains two Alnairs, which means Bright One. The first, Alpha (α) Gruis' Alnair derives from a traditional Arabic phrase meaning 'Bright one of the tail of the southern whale'. This is because the Arabians used to consider this star part of the southern fish, Piscis Austrinus. The second Alnair is 2.5 magnitude Zeta (ζ) Centauri, 5° east of the famous globular cluster Omega Centauri. Its full name was Alnair Albatn for 'The bright one of the stomach' (the Centaur's stomach).

THE MOON



4th 3 pm (1 pm WST) Maximum Libration (10°), bright NW limb. Pair of craters Nernst (116 km) and Röntgen (126 km) visible

5th 4 am (2 am WST) Last Quarter.

5th 9 am (7 am WST) Occultation of minor planet Juno by the Moon, visible from E Europe, W Russia and Scandinavia.

7th 5 am (3 am WST) Occultation of Aldebaran by the Moon, visible from Siberia and the Arctic regions.

10th 11 pm (9 pm WST) Minimum Libration (0.2°), too close to New Moon.

11th 4 am (2 am WST) Moon at perigee (closest to Earth at 358,078 km).

11th 8 pm (6 pm WST) New Moon. Partial solar eclipse, not visible from Australia see Part II for details.

17th 6 am (4 am WST) Maximum Libration (10.2°), bright SE limb. The libration zone feature known as Lyot seen at best. This 141 km flooded walled plain has a dark floor and many smaller craters to the west and south-west.

18th 6 pm (4 pm WST) First Quarter.

23rd 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 405,746 km).

24th 3 pm (11 pm WST) Minimum Libration (0.2°), bright NE limb.

26th 10 pm (8 pm WST) Full Moon.

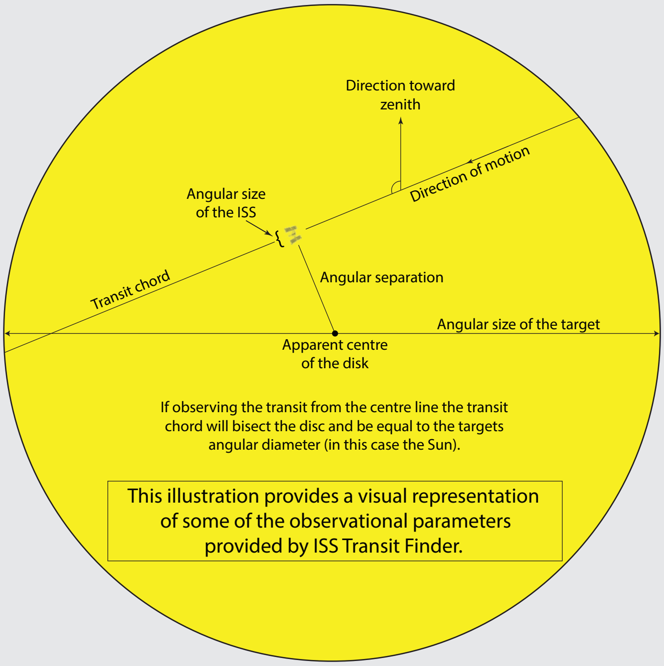
THE PLANETS

Mercury is quickly lost from sight in the evening twilight as it moves towards inferior conjunction (between the Earth and the Sun) on the 9th. Its return to the morning sky is an anticlimax

Imaging the ISS

After the Moon, Venus and occasionally Jupiter, the International Space Station (ISS) is the brightest object in the night sky at –2 magnitude. It is the single most expensive object ever built (estimated in 2015 at over US $150 billion) and is the largest manned object ever put into space (109 metres long), circling the Earth once every 90 minutes. Constructed by sixteen nations, it is a testament to human cooperation in space and the spirit of exploration.

If you want to watch and identify satellites as they pass across the sky, its hard to go past the Heavens Above website (www.heavens-above.com). They offer predictions for the ISS, daily observability of all the brighter satellites, Iridium Flares plus spacecraft of special interest, all for your location. Besides all the satellite material, Heavens Above offers some great astronomical stuff also tailored to your location (although we would really prefer you to buy our book). There are also other sources for satellite predictions on the web plus quite a few Apps for Android or IOS. It's just a matter of using what you feel comfortable with.



This illustration provides a visual representation of some of the observational parameters provided by ISS Transit Finder.

The simplest method to image the ISS or other satellites is to let them trail though the field of a camera. Once you have the predicted date, time and direction of travel, just set your camera on a tripod, point it in the right direction and open the shutter. A DSLR with wide-angle lens is probably best suited, although the latest generation of point and shoot cameras will also work well.

Perhaps the most spectacular images of the ISS come from amateurs who capture it transiting the Sun or Moon—you can even see the actual shape of the station, solar panels and all. This is an even greater challenge than just pointing a camera with open shutter at the sky; it does require more equipment, skill and patience. Unlike the passage of a satellite across the sky, a transit is rarely going to happen in your backyard any time soon. Be resigned to the fact that you will have to travel, so equipment portability and ease of setup are essential.

The rewards are great and worth the effort as can be seen by Dylan O'Donnell's accompanying image of an ISS lunar transit. If undertaking solar transits you must use the same safe methods as you would when observing sunspots i.e. optical glass or Mylar filters specifically designed for solar observing and fitted in front of the objective.

If you currently dabble in astrophotography you will probably have most of what you need. A DSLR camera (or webcam) with a long telephoto lens or telescope should get you going, as it barely reaches 5° in altitude at the time of civil dawn. The planet is at its greatest elongation (18°) west of the Sun on the 27th.

Venus is brilliant in the western evening sky. Spending the entire month in Virgo, it is joined by the young waxing crescent Moon on the 14th and 15th (see Sky View). On the 18th, the planet reaches its greatest elongation (46°) east of the Sun and through a telescope its phase appears just like a little First Quarter Moon. As the month progresses the distance between Venus and the 1st magnitude star Alpha (α) Virginis (Spica) diminishes, until at month's end they are just 1.6° apart and a little closer on September 1 and 2.

Mars, just days after opposition, dominates the early eastern evening sky as a vivid golden orange orb. On the 23rd, the 12-day old waxing gibbous Moon and the Red Planet appear side by side (see Sky View). At –2.8 magnitude as August opens, Mars gradually fades to –2 by early September; likewise its size also shrinks from 24 arcseconds to 20 over the same period. Nearing the end of two months in retrograde motion, the planet moves sluggishly through Capricornus before crossing the border briefly into Sagittarius during the last week of August. It then returns to Capricornus on September 2 as it resumes its normal west to east motion across the sky (see retrograde motion p. 84 and All Sky Chart Map 8).

During the current season on Mars, dust storm activity is common and can obscure many features. The casual observer may find these storms annoying but they do show the dynamic

you do not have to be polar aligned or even tracking all that well. You will however need to know the exact location and time of the event and this is where transit-finder.com comes in.

This easy to use ISS transit finder by Polish photographer Bartosz Wojczyáski, will predict solar and lunar events 30 days into the future and you can set the maximum distance you wish to travel (default is 80 kilometres).

Once you set your location and date range the ISS Transit Finder will list all passes of the station within your specified driving distance. The data listed will then help you decide the practicality of whether to make an effort or not. Factors like the time of day, altitude of object, distance to centre line and the angular size of the ISS etc. will all need to be considered. You can then select 'show on map' where the path is shown overlayed on Google Maps. If you cannot get to the centre line because of terrain etc., you can recalculate for another location nearby. The diagram (left) illustrates some of the observational parameters provided.

A few things to keep in mind when chasing transits:

1. Looking at the Sun without proper solar filters, even for an instant, can cause permanent eye damage.
2. The transit happens really fast, typically not much more than a second or so.
3. Seeing the tiny craft speeding against such a bright background through a camera viewfinder is next to impossible.
4. Because of (2 and 3) it is best not to attempt still images and instead capture the transit with video.
5. When using the ISS Transit Finder read the 'How to use this website' section, this help page contains information on how to interpret the prediction results and is invaluable.
6. Predictions further out than 10–14 days should be treated as a rough approximation. Always check a few hours before an event when the predicted time is known with a precision of a faction of a second and the centre line accurate down to 100 metres.

IIS lunar transit by Dylan O'Donnell. Canon 70D 1/1600 ƒ10 ISO500 with Celestron 9.25" Edge HD nature of the planet. Keep an eye on the south polar cap that is now in rapid retreat. Dark features like the wedge shaped Syrtis Major, Mares Cimmerium, Tyrrhenum and Sirenum are all easy to spot but can be altered dramatically by dust storms. The mysterious *Eye of Mars* or Solis Lacus (Lake of the Sun) can be outstanding at some oppositions and difficult at others due to the shifting sands.

Jupiter, in Libra, is high in the north-western evening sky after the end of astronomical twilight. During the month the planet remains within 2° of Alpha (α) Librae, the second brightest star in the constellation (despite its designation, the Beta star of Libra is brighter). A great low power field presents itself from the 15th to 19th when Alpha and Jupiter are a little over half a degree apart. The 6-day old waxing crescent Moon will be near Jupiter on the 17th (see Sky View).

Saturn can be seen midmonth transiting the meridian (is due north) around 9 pm, a great time to observe the ringed world while at maximum elevation above the horizon. Moving slowly across the dense star fields of Sagittarius in retrograde, Saturn finishes the month 2° from the well-known Trifid and Lagoon nebulae. On the 21st, the 10-day old waxing gibbous Moon will be close to the planet (see Sky View).

Uranus, rising in the late eastern evening sky, transits the meridian around 4:30 am midmonth. On the 8th, the planet appears stationary and subsequently begins to head westward against the backdrop of stars. This change of direction or retrograde motion is an illusion caused by Earth's movement around the Sun (see Retrograde Motion p. 84).

Neptune, at opposition early next month, is now rising a little after the end of astronomical twilight midmonth and visible the rest of the night.

DIARY			
Wed	1st		Venus at descending node
Thu	2nd	9 am	(7 am WST) m.p. 4 Vesta stationary
Sat	4th		Venus 0.9° SW of star Beta (β) Virginis
Sat	4th	7 am	(5 am WST) Uranus 5° N of Moon
Sun	5th		d.p. Ceres 0.2° E of M65 (SG) in Leo
Sun	5th		d.p. Ceres 0.15° NW of M66 (SG) in Leo
Sun	5th		d.p. Ceres 0.5° S of NGC 3628 (G) in Leo
Sun	5th	4:18 am	(2:18 am WST) Last Quarter Moon
Sun	5th	9 am	(7 am WST) m.p. 3 Juno 1.2° S of Moon
Tue	7th	5 am	(3 am WST) star Aldebaran 1.1° S of Moon
Tue	7th	11 pm	(9 pm WST) m.p. 2 Pallas in conjunction with Sun
Wed	8th	7 am	(5 am WST) Uranus stationary
Thu	9th		Mercury at greatest latitude south
Thu	9th	Noon	(10 am WST) Mercury in inferior conjunction
Thu	9th	11 pm	(9 pm WST) m.p. 230 Athamantis 0.1° NE of star Theta Pegasi
Thu	9th	pm	m.p. 9 Metis 0.5° E of M19 (GC) in Ophiuchus
Fri	10th	6 am	(4 am WST) star Pollux 8° N of Moon
Sat	11th	4 am	(2 am WST) Moon at perigee, 358,078 km
Sat	11th	7:58 pm	(5:58 pm WST) New Moon
Mon	13th	Midnight	(10 pm WST) d.p. 1 Ceres 4° N of Moon
Tue	14th	Midnight	(10 pm WST) Venus 6° S of Moon
Thu	16th	3 am	(1 am WST) star Spica 8° S of Moon
Fri	17th	9 pm	(7 pm WST) Jupiter 5° S of Moon
Fri	17th	pm	m.p. 29 Amphitrite 0.3° SE of M62 (GC) in Ophiuchus
Sat	18th		Jupiter 0.6° NE of star Alpha (α) Librae
Sat	18th	4 am	(2 am WST) Venus at greatest elongation East (45.9°)
Sat	18th	5:49 pm	(3:49 pm WST) First Quarter Moon
Sat	18th	10 pm	(8 pm WST) Mercury stationary
Sun	19th		Comet C/2016 M1 (PANSTARRS) 1.3° SE of NGC 5662 (OC) in Centaurus
Sun	19th	8 pm	(6 pm WST) star Antares 9° S of Moon
Sun	19th	pm	Comet C/2016 M1 (PANSTARRS) 0.1° NW of NGC 5715 (OC) in Circinus
Tue	21st		Mars at greatest latitude south
Tue	21st	1 am	(11 pm WST, prev day) m.p. 4 Vesta 4° S of Moon
Tue	21st	8 pm	(6 pm WST) Saturn 2° S of Moon
Wed	22nd		Venus 1.0° NE of NGC 4699 (G) in Virgo
Thu	23rd	5 am	(3 am WST) d.p. Pluto 1.4° S of Moon
Thu	23rd	9 pm	(7 pm WST) Moon at apogee, 405,746 km
Fri	24th		m.p. 3 Juno 0.6° N of star Omicron (o) Tauri
Fri	24th	3 am	(1 am WST) Mars 7° S of Moon
Sun	26th		m.p. 3 Juno 0.3° S of star Xi (ξ) Tauri
Sun	26th	9:56 pm	(7:56 pm WST) Full Moon (402,420 km)
Mon	27th		Venus 0.8° NE of NGC 4939 (G) in Virgo
Mon	27th	7 am	(5 am WST) Mercury at greatest elongation West (18.3°)
Mon	27th	8 pm	(6 pm WST) Neptune 2° N of Moon
Tue	28th		Mercury at ascending node
Tue	28th	8 pm	(6 pm WST) Mars stationary
Tue	28th	pm	m.p. 4 Vesta 0.8° SW of NGC 6401 (GC) in Ophiuchus
Wed	29th		m.p. 6 Hebe 0.9° S of star Lambda (λ) Orionis
Wed	29th		m.p. 6 Hebe 0.4° SW of star Phi² (φ^2) Orionis
Fri	31st	1 pm	(11 am WST) Uranus 5° N of Moon

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, now past opposition, transits the meridian (is due north) around 9 pm midmonth. Due to retrograde motion Pluto spends the next three months (commencing August 17) within 0.5° of the 5.6 magnitude star HR7327 in Sagittarius (see diary and finder chart). On the 5th, **Ceres** passes through the Leo triplet of galaxies (see diary). Catch this early for the dwarf planet sets only one hour after the end of twilight.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
8 Aug	94 Aurora	Capricornus	12.1
11 Aug	196 Philomela	near Cap/PsA border	10.9
15 Aug	409 Aspasia	Equuleus	11.1
26 Aug	230 Athamantis	Pegasus	10.1
30 Aug	37 Fides	Aquarius	10.5

COMETS

Comet C/2016 M1 (PANSTARRS), now circumpolar for much of Australia, is transiting in the early evening. It is in Circinus as August opens. Visible throughout the night, the 10th magnitude comet moves into Centaurus late in the month.

METEOR SHOWERS

Both showers below are difficult for southern observers but will benefit from Moon free morning skies this month around the time they are expected to peak.

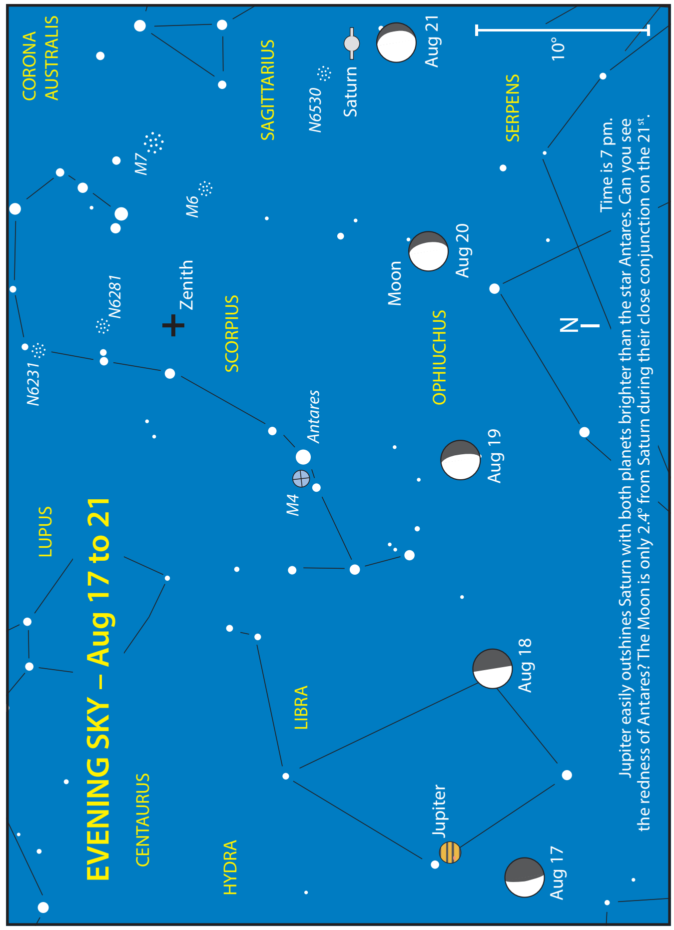
The famous **Perseids** unfortunately are not easily observable, for many Australian observers the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17 July through to 24 August, with maxima around 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. The 2005

Perseids produced a zenith hourly rate of about 90 meteors. This year their time of maxima is ideal being on New Moon.

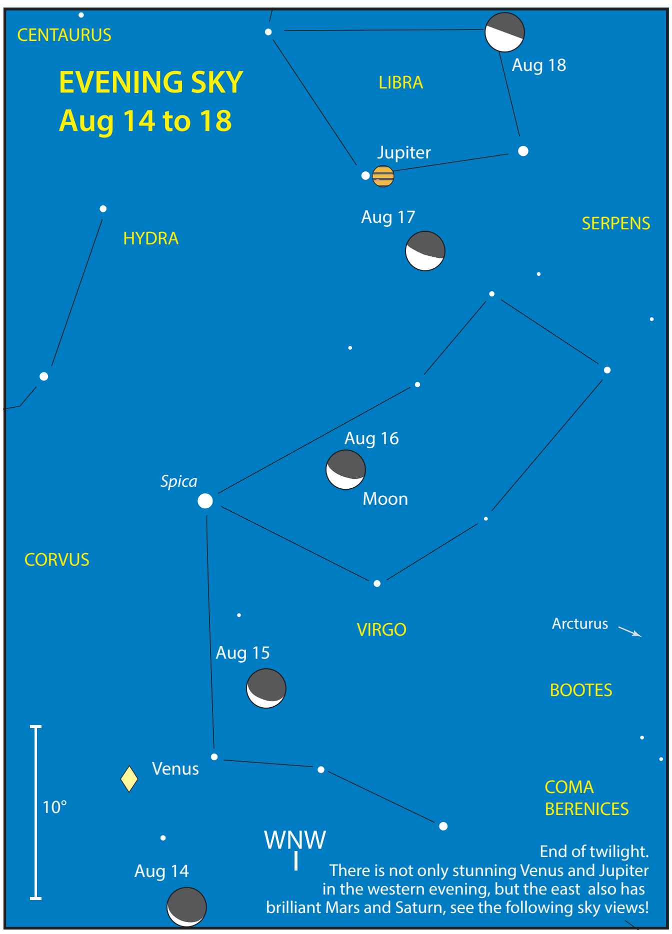
The **kappa-Cygnids** tend to be overshadowed by the more popular Perseids. Active from 3 to 25 August, with maximum around the 18th, the zenith hourly rate is three. The kappa-Cygnids meteors are infrequent and faint, although white/bluish fireballs are sometimes produced.

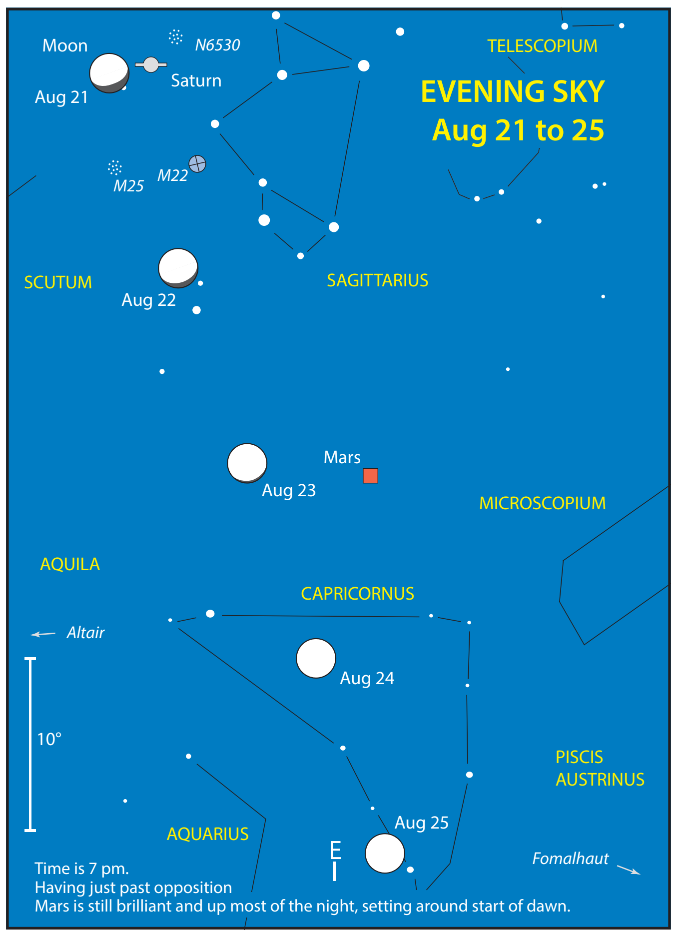
DOUBLE STARS

This month's double stars are located in the constellation Corona Australis (the Southern Crown). Kappa (κ) Coronae Australis (see All Sky Maps 6 and 8) is a bright wide pair well-suited for small telescopes. The stars, magnitudes 5.6 and 6.2, are separated by 21.5 arcseconds with a position angle of 358 degrees. This wide pair is set in a lovely starry field. No real change has occurred since the measures of John Herschel in 1836 and the pair is thought to be an optical (line of sight) double. If you are up for a challenge, have a look at nearby Gamma (γ) Coronae Australis. This pair of white stars (spectra F8V and F8V), magnitudes 4.5 and 6.4, is separated by only 1.6 arcseconds with a position angle of 343 degrees. A 15 cm telescope at high power may split them under reasonable seeing. The orbital period is 122 years and they have recently passed through their minimal separation. The system is located about 58 light years away.



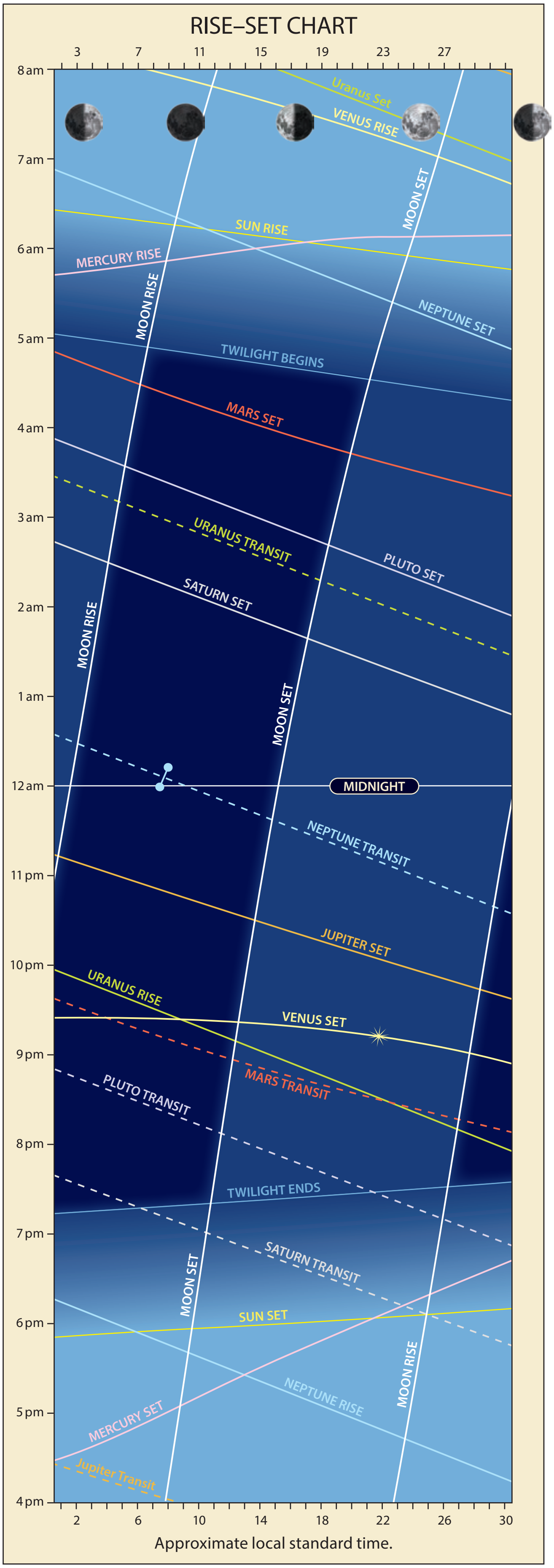
Approximate local standard time.





AUGUST

SEPTEMBER



HIGHLIGHTS

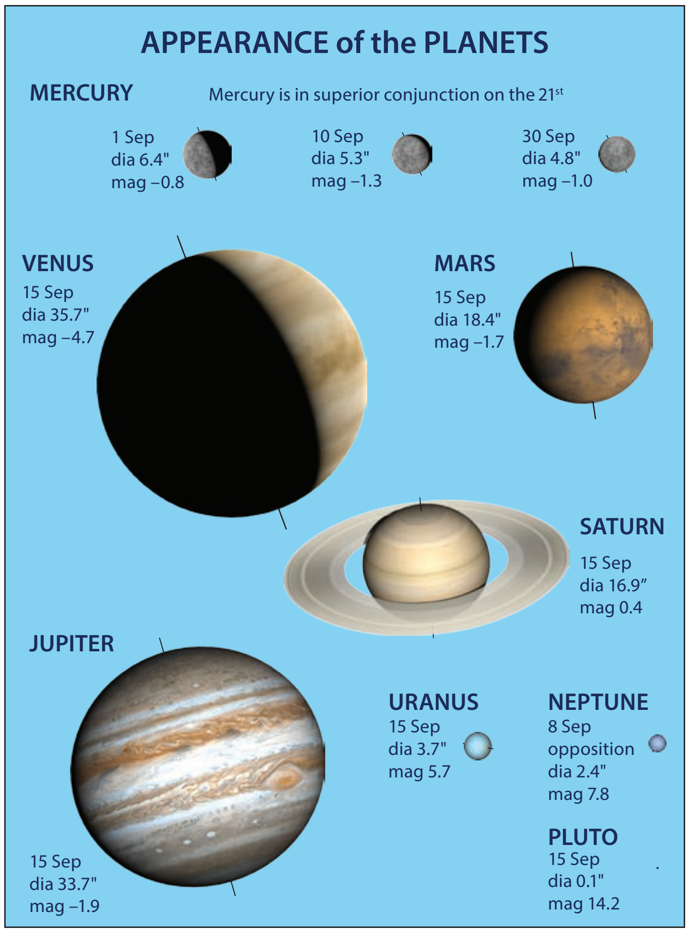
- Venus and Spica close.
- Venus at greatest brilliancy.
- Neptune at opposition.
- Comet 21P/Giacobini-Zinner at brightest in morning sky.

CONSTELLATIONS

When Europeans started to explore the Southern Hemisphere it must have been a real treat seeing the hub of our galaxy in Sagittarius and Scorpius passing overhead. Observing the spectacular southern Milky Way, its highlights being Centaurus, the Southern Cross and Carina, riding high for the first time must have been wonderful. This includes speculating over Magellan's intriguing ghostly clouds. However, given all this the southern polar region would have been a real disappointment, a desert by comparison, well … astronomically speaking (see All Sky Map 1).

The South Celestial Pole (SCP) lies in the obscure constellation of Octans and lacks an obvious marker such as 2nd magnitude Polaris sitting less that 1° from its northern counterpart. The SCP has a star with the grand name of Polaris Australis approximately 1° away. Also known as Sigma (σ) Octantis, it is only 5th magnitude and unfortunately needs dark skies to glimpse with the unaided eye and invisible from suburbia.

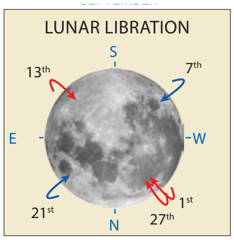
To estimate the position of the SCP, it is roughly halfway between Beta (β) Centauri and Achernar. That covers a lot of sky, approximately 30° either side of the pole and depending on your latitude and the time of the year and day, the stars alternate between getting very close to or going below the southern



horizon. September early evenings are a great time to make this observation since both stars are at a similar elevation to the pole; a line passing through them is close to horizontal, making an estimate of the pole easier from anywhere down under.

The Earth's axial poles are slowly moving relative to the stars, scribing a circle in the heavens. They complete one rotation every 26,000 years. This is also known as the Precession of the Equinoxes. Think of it like the wobbling of a top as it slows down. Currently the SCP is moving away from Sigma (σ) Octantis in an arc towards Carina. Around the year 5,800 CE it will make a close approach to 3rd magnitude Omega (ω) Carinae, only 0.7° away, quite a wait for a reasonable southern pole star!

THE MOON



1st 1 am (11 pm previous day WST) Maximum Libration (9.1°), bright NW limb. Many libration zone craters now visible, Galvani (80 km), Volta (113 km) and Xenophanes (121 km) to name a few.

3rd Noon (10 am WA) Occultation of Aldebaran by the Moon, visible from Greenland and northernmost Canada. This is not only the last in a series of 49 occultations of Aldebaran that began in January 2015, but also the last for any 1st magnitude star until a new series involving Antares commences in August 2023.

3rd 1 pm (11 am WST) Last Quarter.

7th 5 pm (3 pm WST) Minimum Libration (1.0°), bright SW limb.

8th 11 am (9 am WST) Moon at perigee (closest to Earth at 361,351 km).

10th 4 am (2 am WST) New Moon.

13th Midnight (10 pm WST) Maximum Libration (9.6°), bright SE limb. The 141 km circular formation Lyot, situated in the zone of librations now seen at best; note the many smaller craters to the west and south-west.

17th 9 am (7 am WST) First Quarter.

21st 1 am (11 pm previous day WST) Minimum Libration (0.6°), bright NE limb.

20th 11 am (9 am WST) Moon at apogee (furthest from Earth at 404,876 km).

27th Midnight (10 pm WST) Maximum Libration (8.3°), bright NW limb. For the second time this month libration zone craters Galvani (80 km), Volta (113 km) and Xenophanes (121 km) favoured.

25th 1 pm (11 am WST) Full Moon.

THE PLANETS

Mercury can be a difficult planet for an inexperienced observer to find. This month, even seasoned amateurs will struggle with the planet hugging the eastern horizon at civil dawn as it draws closer to the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 21st. The smallest of planets then joins the brightest planets, Venus and Jupiter, in the early western evening twilight at month's end.

Venus begins the month just 1.2° from the 1st magnitude star Alpha (α) Virginis (Spica) in the early western evening sky (see Sky View). Since Spica is located close to the ecliptic the Moon or planets can on occasion occult it. The last planetary event was by Venus in 1783, and the next, again by Venus occurs in 2197.

Venus reaches its greatest brilliancy on the 21st at –4.8 magnitude, known as *greatest illuminated extent*. It is defined as when the planet's illuminated portion or day side covers the greatest area. At this time we see Venus one-quarter illuminated, just like a 3 or 4 day old Moon.

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

Mars, in Capricornus, is visible high in the northern sky around 9 pm. For visual telescopic observers, this month is the last opportunity to study the planet whilst it still presents a reasonable sized disc, although toward month's end the planet's size is approaching that of an unfavourable aphelic opposition. The south polar cap will be rapidly diminishing and it is possible that the planet could be encircled by dust storms, obscuring prominent features. Mars is now slightly gibbous with 90% of the globe illuminated, unlike the full phase at opposition. On the 16th, the Red Planet will be in perihelion or the point in its orbit nearest the Sun (1.38144 au). This resulted in the favourable opposition in July when the Earth and Mars were 0.38496 au apart. On the 20th, the 11-day old waxing gibbous Moon will be seen near Mars in the evening sky (see Sky View).

Jupiter can be seen in the western evening sky before it sets around 10:30 pm midmonth (not to be confused with the brighter Venus nearer the horizon). September and October will be the last chance to view the giant planet before it loses too much altitude as it moves toward conjunction in November. On the 14th, the 5-day old waxing crescent Moon will be around 5° to the north (right) of the planet (see Sky View).

Saturn, in Sagittarius, appears high in the north-western evening sky towards the end of astronomical twilight. The planet appears stationary on the 6th as it comes to the end of five months in retrograde motion. It then resumes its west to east motion across Sagittarius heading back towards the globular cluster M22. On the 17th, the First Quarter Moon will be near the planet (see Sky View).

On the 26th, Saturn is at its eastern quadrature where the Sun-Earth-Saturn angle is 90°, this configuration of the three bodies is shown on the Orbital Aspects diagram p. 13. It is during quadrature that the maximum shadow of the planet is visible on the back of the rings.

Uranus, rising in the mid-evening eastern sky, spends an uneventful month in Aries near the border of Pisces.

Neptune is at opposition on the 8th and is visible in the eastern sky after the end of astronomical twilight in Aquarius. Interestingly, it was in this constellation of the Water Bearer that the German astronomer Galle discovered the planet 172 years ago on 23 September 1846. Whilst Uranus can be resolved into a disc in most small instruments, Neptune is more difficult. At 7.8 magnitude it is more than six times fainter than Uranus, and requires at least a 100 mm telescope and 200 power to resolve it into a small bluish disc. Also here's a challenge for amateurs with larger telescopes, 25 cm plus. Consider observing its bright satellite Triton. Although only magnitude 13.5, the moon can reach a reasonable distance of 17 arcseconds from Neptune, provided you plan a time when it is near a maximum elongation. Page 129 will help you make such a prediction or determine its position angle at any time.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** appears stationary on the 30th as it ends five months of retrograde motion. The icy dwarf is visible most of the night, crossing the meridian (is due north) around 8 pm midmonth.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
1 Sep	41 Daphne	Aquarius	11.1
2 Sep	115 Thyra	near Peg/Aqu border	9.9
3 Sep	28 Bellona	Aquarius	11.3
6 Sep	27 Euterpe	Aquarius	9.8
18 Sep	69 Hesperia	Pisces	11.3
18 Sep	5 Astraea	Aquarius	10.8
19 Sep	30 Urania	Pisces	9.6
22 Sep	511 Davida	Cetus	10.7
24 Sep	10 Hygiea	Pisces	10.1
24 Sep	389 Industria	Pegasus	11.8
28 Sep	387 Aquitania	Cetus	11.0

COMETS

Comet C/2016 M1 (PANSTARRS) is circumpolar, transiting in the afternoon, so it's best to observe in the early evening. The comet resides in Centaurus throughout the month and is expected to fade from 10th to 11th magnitude. On the 23rd, it passes between Alpha (α) and Beta (β) Centauri.

Comet 21P/Giacobini-Zinner reappears for all Australian observers this month in the morning sky. Beginning the month in Auriga, the 7th magnitude comet moves through Gemini and Orion before finishing in Monoceros.

Comet 46P/Wirtanen should brighten from 12th to 10th magnitude this month. Rising early in the evening, the comet spends most of September in Cetus before moving into Fornax.

DOUBLE STARS

Located in Aquarius (the Water Pourer), 94 Aquarii (see All Sky Map 8) is this month's target. The stars, magnitudes 5.3 and 7.0 (spectra G8.5 IV and K2 V), are separated by 12.3 arcseconds with a position angle of 353 degrees. The stars are yellow and orange. At a distance of 69 light years from the Earth, the pair share a similar common proper motion consistent with a binary system but of very long period. The primary star is also a spectroscopic binary with a period of 6.4 years that has been resolved by speckle interferometry.

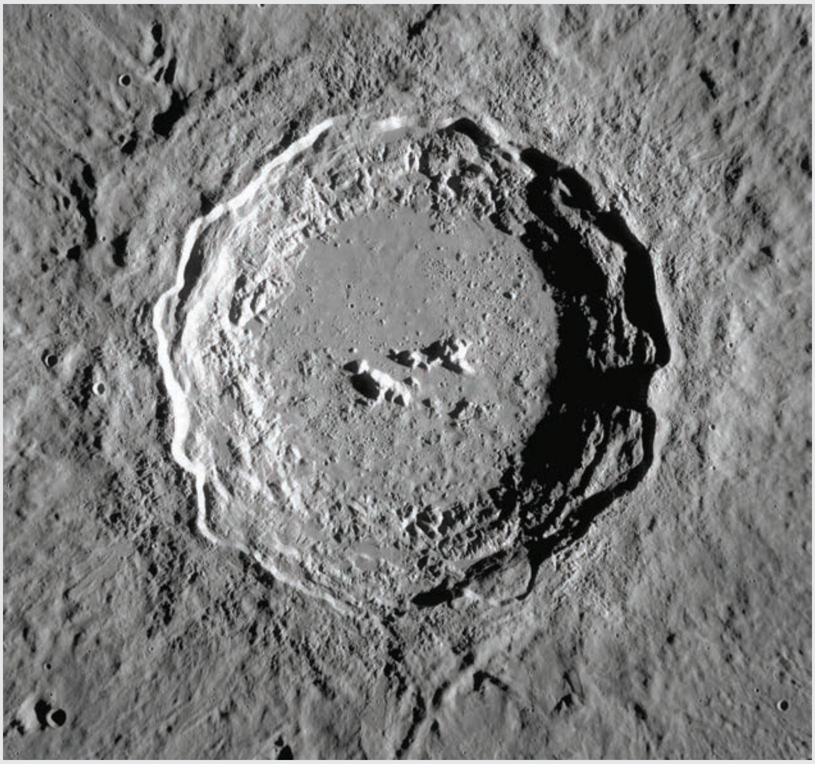
Monarch Of The Moon

Copernicus is undoubtedly one of the most noticeable and finest of the craters on the lunar near side. The noted British selenographer Thomas Elger (1836–1897) aptly crowned the impact structure "the Monarch of the Moon", a title that few would argue with. Its location between Mare Imbrium (Sea of Rains) and Mare Insularum (Sea of Isles) just north of the equator affords observers a bird's eye view of this magnificent crater without foreshortening.

The crater is named after the Polish mathematician and astronomer Nicolaus Copernicus (1473–1543) who proposed a heliocentric model of the universe where the Sun, not the Earth, was the centre.

Best viewed around two days after First Quarter or one day after Last Quarter, the crater itself is typical of all large craters on the Moon. Almost imperceptible at low Sun angles are the crater's system of rays that become prominent as the Moon nears its full phase. An image, taken in 1966 by the Lunar Orbiter 2 spacecraft as it was photographing the Moon's surface for potential landing sites for the upcoming Apollo missions, was subsequently named as "The Picture of the Century" by Life Magazine.

Copernicus is easily visible in binoculars and plainly stands out against the surrounding dark basaltic maria. Measuring 93 km in diameter the crater is 3.7 km deep, with its walls towering 900 metres above the surrounding terrain. If you were to stand at the centre of the crater, the walls would not be visible due to the Moon's curvature. The walls have collapsed into terraces, a feature



Crater Copernicus on the Moon. Mosaic of photos by Lunar Reconnaissance Orbiter, made with Wide Angle Camera. Size of the image is 150×150 km, north is up.

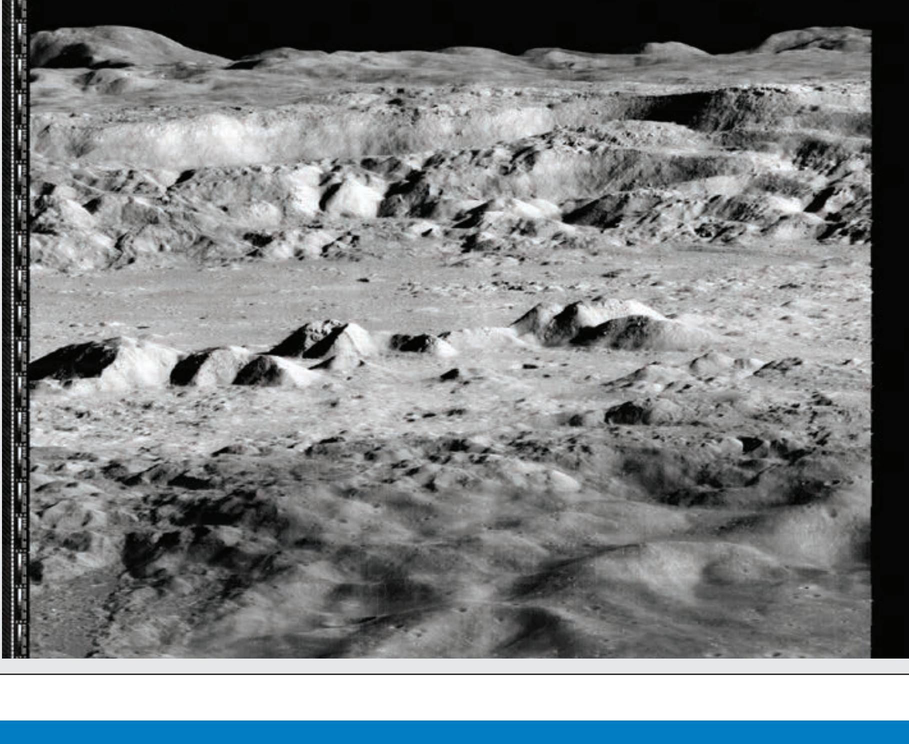
DIARY			
Sat	1st	10 am	(8 am WST) m.p. 3 Juno 5° S of Moon
Sun	2nd		Mercury at perihelion
Sun	2nd	7 pm	(5 pm WST) star Spica 1.4° N of Venus
Mon	3rd		Comet 21P/Giacobini-Zinner 1.0° W of star Capella
Mon	3rd	Noon	(10 am WST) star Aldebaran 1.2° S of Moon
Mon	3rd	12:37 pm	(10:37 am WST) Last Quarter Moon
Tue	4th		Comet 38P/Stephan-Oterma 0.7° N of star Pi³ (π³) Orionis
Wed	5th		Venus at aphelion
Thu	6th	3 pm	(1 pm WST) star Pollux 8° N of Moon
Thu	6th	8 pm	(6 pm WST) Saturn stationary
Thu	6th	pm	m.p. 29 Amphitrite 0.2° S of NGC 6304 (GC) in Ophiuchus
Sat	8th	4 am	(2 am WST) Neptune at opposition
Sat	8th	11 am	(9 am WST) Moon at perigee, 361,351 km
Sat	8th	Midnight	(10 pm WST) star Regulus 1.8° S of Moon
Sun	9th		m.p. 6 Hebe 1.0° N of star Betelgeuse
Mon	10th		d.p. Pluto 0.3° N of star HR7327
Mon	10th	4:01 am	(2:01 am WST) New Moon
Tue	11th		Comet 21P/Giacobini-Zinner 0.6° NW of M37 (OC) in Auriga
Tue	11th	7 am	(5 am WST) d.p. 1 Ceres 3° N of Moon
Wed	12th		Mercury at greatest latitude north
Wed	12th	1 pm	(11 am WST) star Spica 8° S of Moon
Thu	13th	2 am	(Midnight WST, prev day) Venus 10° S of Moon
Fri	14th	Noon	(10 am WST) Jupiter 4° S of Moon
Sun	16th		Mars at perihelion
Sun	16th	2 am	(Midnight WST, prev day) Comet 21P/Giacobini-Zinner 0.2° SE of M35 (OC) in Gemini
Sun	16th	3 am	(1 am WST) star Antares 9° S of Moon
Mon	17th		Comet 21P/Giacobini-Zinner 0.5° W of star Eta (η) Geminorum
Mon	17th	9:15 am	(7:15 am WST) First Quarter Moon
Mon	17th	9 pm	(7 pm WST) m.p. 4 Vesta 5° S of Moon
Tue	18th	3 am	(1 am WST) Saturn 2° S of Moon
Wed	19th	11 am	(9 am WST) d.p. Pluto 1.4° S of Moon
Thu	20th	11 am	(9 am WST) Moon at apogee, 404,876 km
Thu	20th	5 pm	(3 pm WST) Mars 5° S of Moon
Fri	21st	Noon	(10 am WST) Mercury in superior conjunction
Fri	21st	8 pm	(6 pm WST) Venus greatest illuminated extent
Sat	22nd		Comet 38P/Stephan-Oterma 0.6° NW of star Lambda (λ) Orionis
Sun	23rd		Comet C/2016 M1 (PANSTARRS) 1.8° W of star Alpha (α) Centauri
Sun	23rd	Noon	(10 am WST) Equinox
Mon	24th	2 am	(Midnight WST, prev day) Neptune 2° N of Moon
Tue	25th		Comet 21P/Giacobini-Zinner 1.3° SW of NGC 2264 (OC) in Monoceros
Tue	25th	12:52 pm	(10:52 am WST) Full Moon (394,466 km)
Tue	25th	pm	m.p. 4 Vesta 0.3° N of NGC 6553 (GC) in Sagittarius
Thu	27th		Venus at greatest latitude south
Thu	27th		m.p. 3 Juno 0.5° SW of star Nu (ν) Tauri
Thu	27th	1 pm	(11 am WST) m.p. 4 Vesta 3° S of Saturn
Thu	27th	5 pm	(3 pm WST) Uranus 5° N of Moon
Sun	30th	6 pm	(4 pm WST) star Aldebaran 1.4° S of Moon

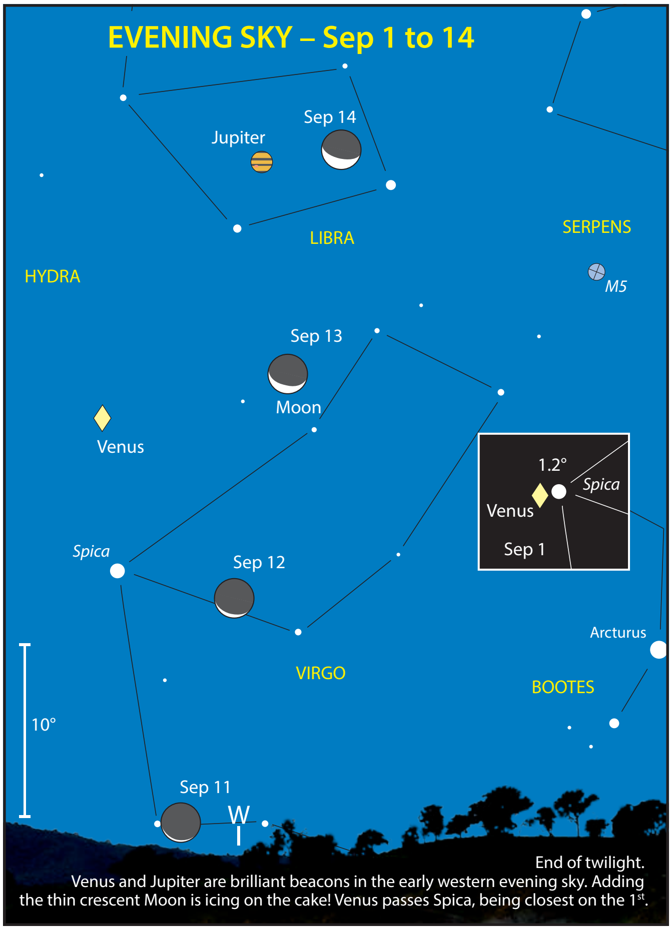
of all large lunar craters, and appear distinctly hexagonal in shape. The floor is relatively flat to the north, while there are many small hills sprinkled across the southern portion. Rising up to 1200 metres above the floor is the central mountain massif, three isolated peaks that stretch across a third of the crater's diameter.

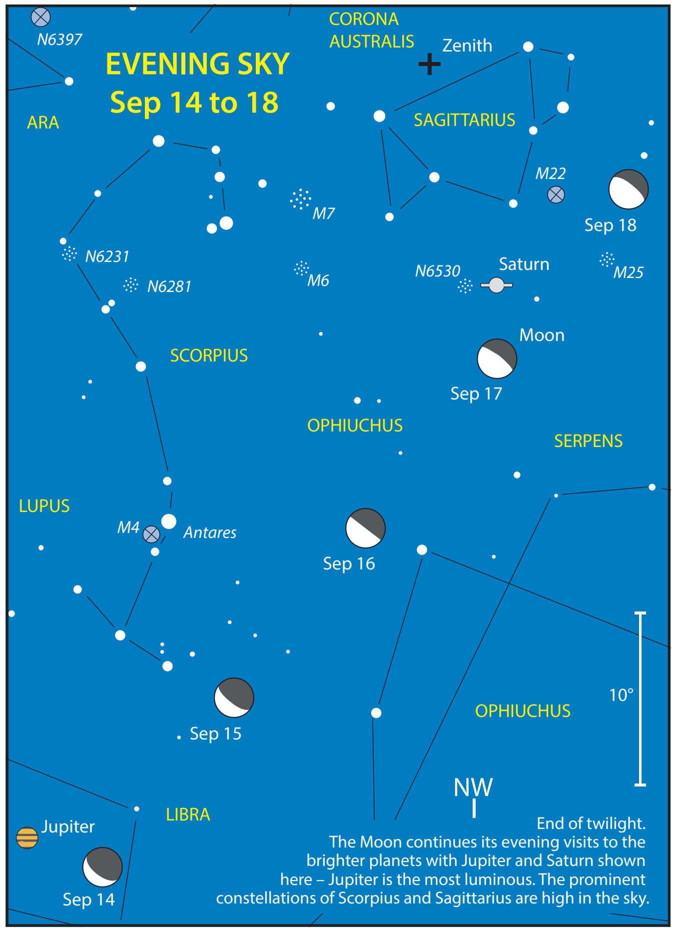
Around the time of Full Moon a few lunar craters display bright radial lines or ray systems emanating from them. These rays are the result of light coloured debris being blasted out by the crater-forming impacts. The most spectacular ray systems belong to the craters Tycho and Copernicus. Tycho's far reaching rays span up to 1500 km across the lunar surface and appear as neat straight lines. In contrast, the ejecta from Copernicus is more like a chaotic spider web radiating over a 500 km area and standing out against the dark maria.

The fact that the rays from such craters generally overlay the lunar terrain is an indicator of the relatively young age of these impacts. Ray craters like Copernicus formed during the Copernican Period that runs from approximately

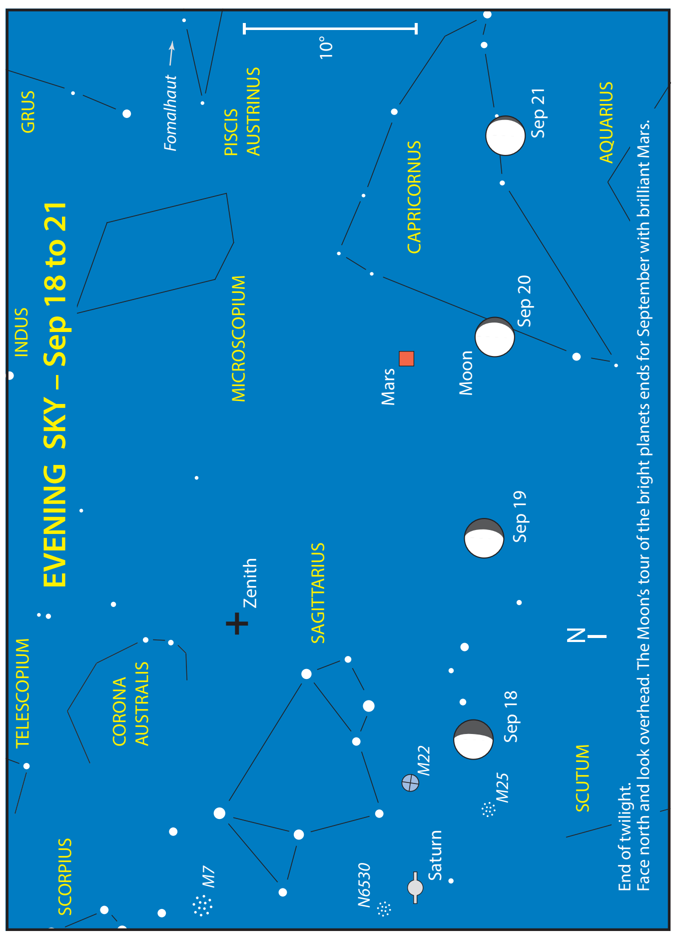
This newly reprocessed view of Copernicus, an iconic image from the initial exploration of the Moon, shows detail that could not have been seen using technology available at the time the photo was taken. This image features a dramatic view inside the majestic crater Copernicus taken on 24 November 1966 by the Lunar Orbiter 2 spacecraft. What made this photo so unique was the oblique angle it was taken at as well the close proximity of the spacecraft to its target. The image was taken at an altitude of 45 km at a distance of approximately 208 km from the centre of the crater. Credit: NASA / LOIRP







Approximate local standard time.

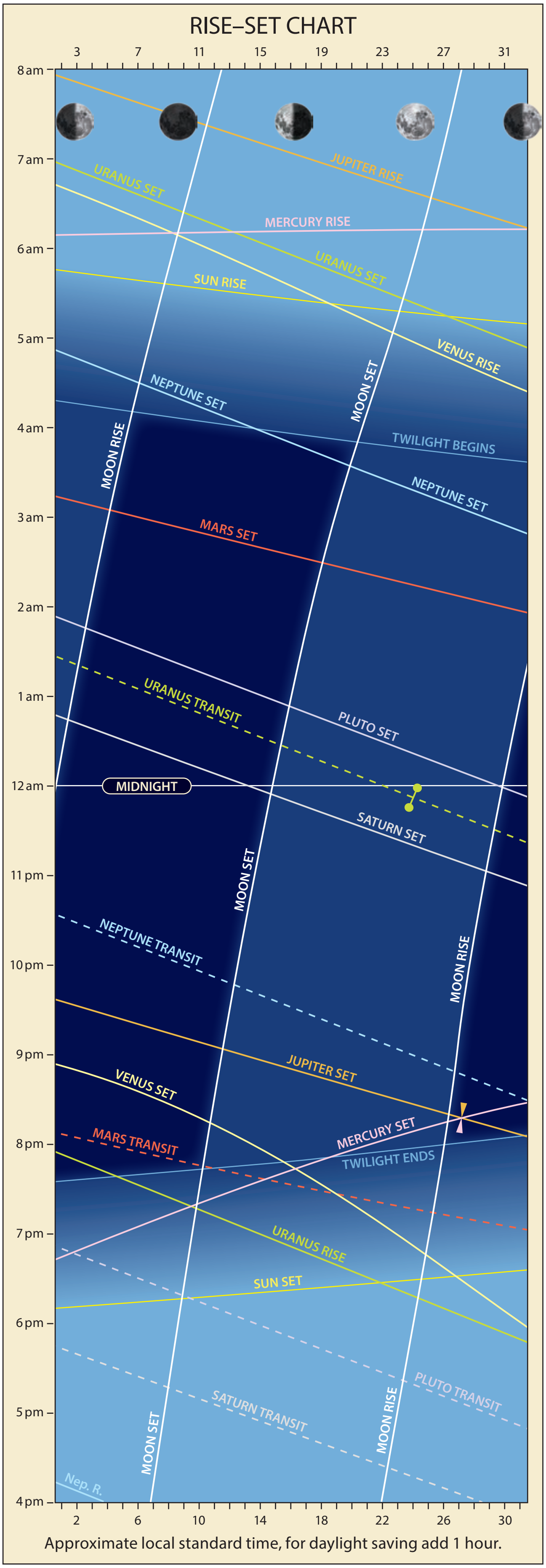


1.1 billion years ago to the present day; Copernicus itself is believed to be around 800 million years old. This age was derived from radiometrically dated material believed to be Copernicus ejecta returned to Earth by the Apollo 12 astronauts.

The area surrounding Copernicus is varied and interesting. To the north lies the Montes Carpatus (named after the Carpathian Mountains in Europe), a rugged mountain range on the edge of Mare Imbrium measuring 280 by 60 km with 2400 metre peaks. On the southern side is the double crater Fauth, the primary crater is 12 km across and 2 km deep with a 9.5 km crater cutting through its southern wall. On the east side of Copernicus lies the 69 km ghost crater Stadius, from which a craterlet chain of dozens of 4 to 7 km craters snake their way northwards. It is thought that this chain was caused by secondary impacts from large ejecta from the impactor that gouged out Copernicus. Further eastward is the prominent and deep 59 km diameter crater Eratosthenes that is best viewed when the Sun is low. Rays from Copernicus cut across Eratosthenes, although under a high Sun the crater itself all but disappears.

Instead of treating the Moon as an annoying bright light that spoils your view of galaxies and nebulae, try viewing it! You may even get hooked on the 'magnificent desolation' that is our nearest neighbour (to use the words of Buzz Aldrin describing the lunar landscape).

OCTOBER



HIGHLIGHTS

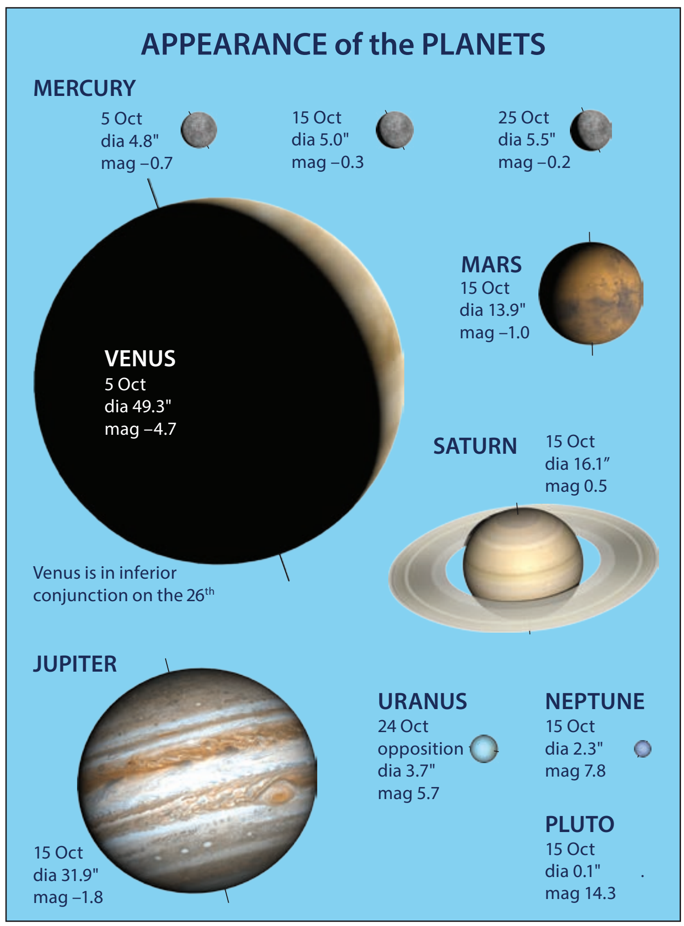
- Mercury and Venus close.
- Mercury and Jupiter close.
- Uranus at opposition.
- All planets visible in the evening sky.
- Comet 46P/Wirtanen brightens to 7th magnitude.
- Five comets visible this month.

CONSTELLATIONS

The heavens are somewhat aquatic this month, including two ‘fish’ constellations. Pisces is low in the northern evening sky, consisting of two fish. Its western member is recognised by its ‘Circlet’, consisting of a circle of six 4th and 5th magnitude stars 7° in diameter. Look directly above the Great Square of Pegasus (All Sky Maps 2, 3, 8 and 9). Although typically faint for Pisces, this asterism is easily found under dark skies.

The other constellation is Piscis Austrinus or Southern Fish, well above the Circlet and passing overhead during October evenings from mid-latitude Australia. The majority of its naked-eye stars are faint, similar to its northern counterpart, however a fish shape is easier to recognise and obvious away from light polluted skies, see All Sky Map 8.

Piscis Austrinus is best known for its one brilliant star, 1st magnitude Fomalhaut, the 18th brightest in the heavens. Being only 25 light years away, it has certainly helped with the imaging of a disc of dust that surrounds it. In fact, it may resemble how the Solar System looked four billion years ago. Within the disc a planet was found, ‘Fomalhaut b’ which,

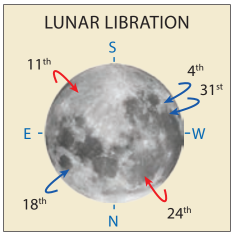


thanks to the Hubble Space Telescope, became the first exoplanet to be directly imaged.

Fomalhaut comes from an Arabic phrase Fum al Hut which translates to 'mouth of the fish'. There is also a northern version, Beta (β) Piscium called Fum al Samakah, which means 'fish's mouth'. This faint but naked eye star (only 4.5 mag.) relates to the western fish, located 3° west of the brightest and most western member of the circlet, Gamma (γ) Piscium.

However, Beta is much more distant than Fomalhaut and would easily outshine its southern partner if placed at the same distance (500 and 25 light years respectively). Fomalhaut's absolute magnitude is 1.7 and Beta Piscium is –1.4, a difference of 3.1. Given Fomalhaut is 1.2; Beta would jump to –1.9, rivalling the planet Jupiter!

THE MOON



- 2nd 8 pm (6 pm WST) Last Quarter.
- 4th 10 pm (8 pm WST) Minimum Libration (1.2°), bright SW limb.
- 6th 8 am (6 am WST) Moon at perigee (closest to Earth at 366,392 km).
- 9th 2 pm (noon WST) New Moon.
- 11th 2 pm (noon WST) Maximum Libration (8.8°), bright SE limb. Two days after New Moon and maximum libration is the optimum time to view libration zone craters on the SE limb. The observer will be rewarded with views of Mare Australe, the 141 km crater Lyot, and the 79 km crater Jeans plus many smaller craters in this region.
- 17th 4 am (2 am WST) First Quarter.
- 18th 5 am (3 am WST) Moon at apogee (furthest from Earth at 404,227 km).
- 18th 6 am (4 am WST) Minimum Libration (0.8°), bright NE limb.
- 24th 9 pm (7 pm WST) Maximum Libration (8.1°), near Full Moon, NW limb including Craters Volta (113 km) and Xenophanes (121 km).
- 25th 3 am (1 am WST) Full Moon.
- 31st 4 pm (2 pm WST) Minimum Libration (0.3°), bright SW limb.

THE PLANETS

Mercury joins Venus and Jupiter in the western evening twilight this month and has encounters with both these bright planets. On the 16th, Mercury appears around 6° to the north (right) of dazzling Venus (see Sky View). From the 27th until the end of the month the planet slips past Jupiter at an angular distance less than 4° to the south (left), see Sky View.

With Mercury joining Venus all seven planets can be viewed in the evening sky midmonth, however you will have to get onto these two inner worlds early seeing they set around the end of twilight. You can tell people the eighth is available any time, just look down!

Venus is visible in the western evening twilight for the first half of the month, before moving too close to the Sun for observation. The planet will be in inferior conjunction (between the Earth and the Sun) on the 26th, ending an eight month reign as the *Evening Star*. Venus then reappears in the dawn sky as the *Morning Star* next month. Just prior to its departure from the evening dusk, Venus will be seen around 6° south of Mercury on the 16th (see Sky View).

Mars is visible high in the northern sky in Capricornus as the sky darkens after dusk. October 16 marks the Martian solstice that heralds the beginning of its northern winter and southern summer. The planet's disc decreases from 16 arcseconds in diameter to 12 over the month, as does its brightness from –1.3 magnitude down to –0.6, although still brilliant against the fainter stars of the constellation. Telescopically the south polar cap appears as a shadow of its former self when compared to its appearance in the months leading up to opposition. On the 18th, the 9-day old waxing gibbous Moon will be within 3° of the planet (see Sky View).

Jupiter, with its impending solar conjunction in November, sets in the west around an hour after the end of astronomical twilight midmonth. On two consecutive days the slender crescent of the young Moon will join the planet in Libra—appearing below on the 11th and to the north (upper right) on the 12th (see Sky View). The innermost planet, Mercury, will be seen passing within 4° of this brightest gas giant from the 27th to month's end (see Sky View). Since Jupiter will be very close to the horizon when the sky becomes truly dark, it will be best to seek out the pair soon after sunset, binoculars will help here.

Saturn, in the western evening sky at the end of astronomical dusk, sets around midnight midmonth. On the 15th, the 6-day old waxing crescent Moon will be near the planet (see Sky View).

Uranus is at opposition on the 24th, rising in the early evening eastern sky in Aries and visible the entire night. Uranus' magnitude at opposition is 5.7 (only marginally brighter than its post conjunction magnitude), those with keen eyesight and dark moonless skies should have no difficulty seeing this outer world, provided you know where to look. Through the telescope the planet is devoid of detail, but under moderate magnification observers will note its blue/green colour and obvious disc that separates it from background stars. Also those with larger telescopes, maybe 25 cm and larger, could consider the challenge of observing its moons. Although the outer, brighter satellites Titania and Oberon are faint by amateur standards (magnitudes 13.5 and 13.7 respectively) they can reach respectable distances from the planet. At either their northern or southern elongations both moons exceed 40 arcseconds from Uranus. Page 129 will help you identify or predict the positions of all four bright satellites.

Neptune, now past opposition, transits the meridian (is due north) around 9:30 pm midmonth in Aquarius.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in Sagittarius, crosses the meridian (due north) around 6 pm midmonth.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
7 Oct	63 Ausonia	Pisces	10.5
13 Oct	43 Ariadne	Pisces	10.3
16 Oct	346 Hermentaria	Cetus	10.5
22 Oct	654 Zelinda	Andromeda	11.8
28 Oct	23 Thalia	Cetus	10.2

In early October, 6 Hebe visits a number of open star clusters in Monoceros (see diary).

COMETS

Comet C/2016 M1 (PANSTARRS) opens October near Alpha (α) Centauri. Shining at 11th magnitude, it moves from Centaurus midmonth into Circinus. Visible all night, the comet is best observed early in the evening.

Comet 21P/Giacobini-Zinner is in Monoceros as October opens, rising around midnight. Expected to fade from 8th to 9th magnitude, the comet moves into Canis Major early on and remains there for the remainder of October.

Comet 38P/Stephan-Oterma is predicted to brighten from 11th to 9th magnitude this month. Rising around midnight, the comet begins October in Orion, moving into Gemini midmonth.

Comet 46P/Wirtanen brightens rapidly this month, from 10th to 7th magnitude. Visible throughout the night, the comet resides in Fornax throughout October.

Comet 64P/Swift-Gehrels should brighten to 11th magnitude this month. Rising early in the evening and visible until the early hours, the comet remains in Andromeda during October.

METEOR SHOWERS

With New Moon on the 9th, the showers below will be Moon free for their peak activity.

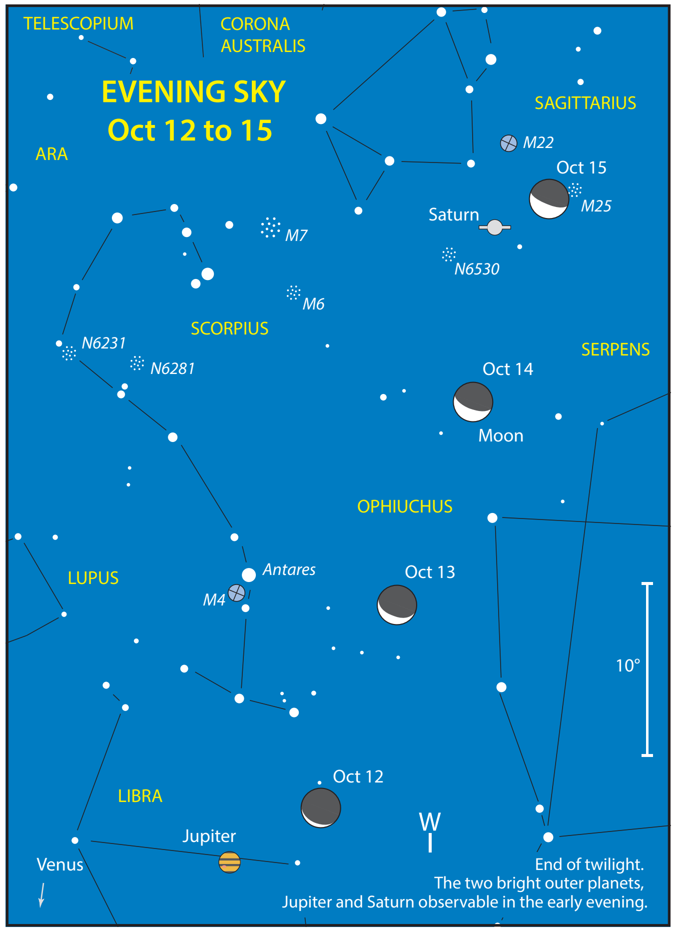
The **Draconids** are a Northern Hemisphere shower that produced spectacular, brief meteor storms in 1933 and 1946 with zenith hourly rates of 500+. It is active from the 6th to 10th, maximum on the 9th. Mostly the shower is strongest when the stream's parent comet, 21P/Giacobini-Zinner, returns to perihelion every 6.6 years. The comet is back this year (see above) with the previous apparition in 2012.

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

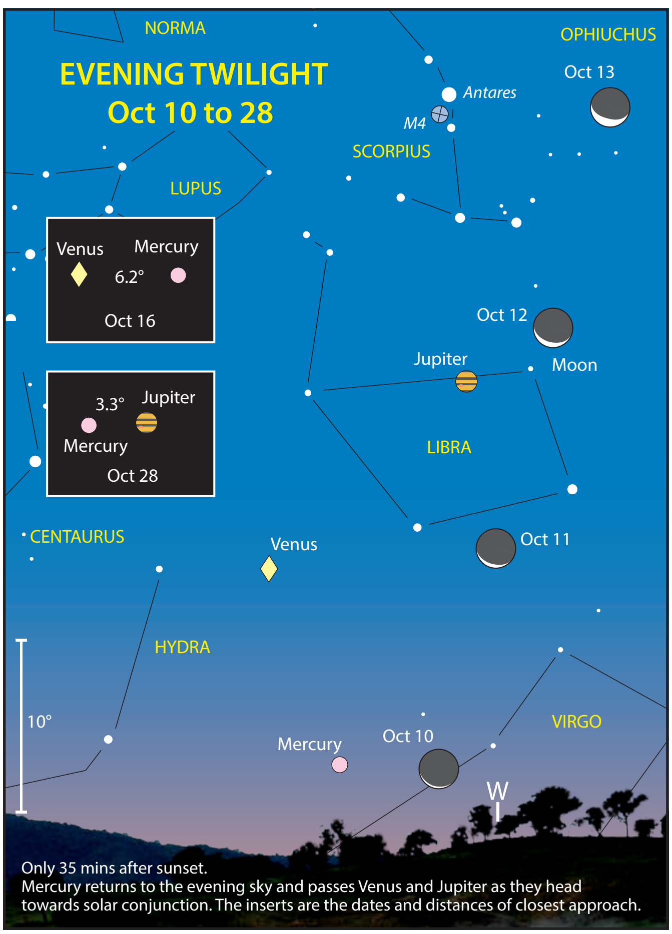
DIARY			
Mon	1st		Comet 21P/Giacobini-Zinner 0.4° W of NGC 2301 (OC) in Monoceros
Mon	1st	2 am	(Midnight WST, prev day) d.p. Pluto stationary
Tue	2nd	7:45 pm	(5:45 pm WST) Last Quarter Moon
Wed	3rd		m.p. 6 Hebe 0.2° W of NGC 2236 (OC) in Monoceros
Wed	3rd	10 pm	(8 pm WST) star Pollux 8° N of Moon
Fri	5th		m.p. 6 Hebe 0.7° N of Collinder 97 (OC) in Monoceros
Fri	5th	2 pm	(Noon WST) Venus stationary
Fri	5th	pm	m.p. 4 Vesta 0.8° S of M28 (GC) in Sagittarius
Sat	6th		Mercury at descending node
Sat	6th		m.p. 6 Hebe 1.5° N of Rosette Nebula (BN) in Monoceros
Sat	6th	8 am	(6 am WST) Moon at perigee, 366,392 km
Sat	6th	8 am	(6 am WST) star Regulus 1.9° S of Moon
Sun	7th	8 pm	(6 pm WST) d.p. 1 Ceres in conjunction with Sun
Sun	7th	pm	m.p. 4 Vesta 0.3° S of star Lambda (λ) Sagittarii
Mon	8th		m.p. 6 Hebe 1.0° N of NGC 2252 (OC) in Monoceros
Mon	8th		Comet 38P/Stephan-Oterma 0.5° N of NGC 2194 (OC) in Orion
Mon	8th	am	Comet 21P/Giacobini-Zinner 0.3° N of M50 (OC) in Monoceros
Tue	9th	1:47 pm	(11:47 am WST) New Moon
Tue	9th	pm	m.p. 4 Vesta 0.3° S of NGC 6638 (GC) in Sagittarius
Wed	10th	am	Comet 21P/Giacobini-Zinner 0.4° N of The Seagull Nebula (IC2177) in Monoceros
Thu	11th		m.p. 6 Hebe 0.2° NE of Collinder 106 (OC) in Monoceros
Fri	12th	am	m.p. 12 Victoria 0.3° NW of star Upsilon Tauri
Fri	12th	7 am	(5 am WST) Jupiter 4° S of Moon
Sat	13th	am	Comet 21P/Giacobini-Zinner 0.5° E of NGC 2345 (OC) in Canis Major
Sat	13th	Noon	(10 am WST) star Antares 9° S of Moon
Sat	13th	pm	m.p. 230 Athamantis 0.7° NE of M2 (GC) in Aquarius
Mon	15th	1 am	(11 pm WST, prev day) Venus 7° S of Mercury
Mon	15th	1 pm	(11 am WST) Saturn 1.8° S of Moon
Tue	16th		Mercury at aphelion
Tue	16th	am	Comet 21P/Giacobini-Zinner 1.0° SW of NGC 2360 (OC) in Canis Major
Tue	16th	1 am	(11 pm WST, prev day) m.p. 4 Vesta 5° S of Moon
Tue	16th	7 pm	(5 pm WST) d.p. Pluto 1.2° S of Moon
Tue	16th	11 pm	(9 pm WST) Mars 0.1° SW of star Eta (η) Capricorni
Wed	17th	4 am	(2 am WST) m.p. 3 Juno stationary
Wed	17th	4:02 am	(2:02 am WST) First Quarter Moon
Thu	18th		Saturn 0.6° S of NGC 6583 (OC) in Sagittarius
Thu	18th		Comet C/2016 M1 (PANSTARRS) 0.5° W of star Alpha (α) Circini
Thu	18th	5 am	(3 am WST) Moon at apogee, 404,227 km
Thu	18th	11 pm	(9 pm WST) Mars 2° S of Moon
Fri	19th		Comet 38P/Stephan-Oterma 1.1° SE of star Gamma (γ) Geminorum
Sat	20th		Mercury 2.0° S of star Alpha (α) Librae
Sun	21st	8 am	(6 am WST) Neptune 3° N of Moon
Mon	22nd	am	m.p. 40 Harmonia 1.2° S of star Zeta (ζ) Tauri
Tue	23rd		d.p. Pluto 0.25° N of star HR7327
Tue	23rd		m.p. 4 Vesta 0.6° N of star Sigma (σ) Sagittarii
Tue	23rd	3 am	(1 am WST) Comet 21P/Giacobini-Zinner 0.1° S of NGC 2367 (OC) in Canis Major
Wed	24th		Mercury 0.3° W of star Iota^1 (ι^1) Librae
Wed	24th	11 am	(9 am WST) Uranus at opposition
Wed	24th	11 pm	(9 pm WST) Uranus 5° N of Moon
Thu	25th	am	m.p. 354 Eleonora 0.6° E of NGC 2112 (OC) in Orion
Thu	25th	2:45 am	(12:45 am WST) Full Moon (383,848 km)
Fri	26th	Midnight	(10 pm WST) Venus in inferior conjunction
Sat	27th	am	Comet 21P/Giacobini-Zinner 0.8° E of NGC 2362 (OC) in Canis Major
Sat	27th	Midnight	(10 pm WST) star Aldebaran 1.6° S of Moon
Tue	30th	2 pm	(Noon WST) Jupiter 3° N of Mercury
Wed	31st	4 am	(2 am WST) star Pollux 7° N of Moon

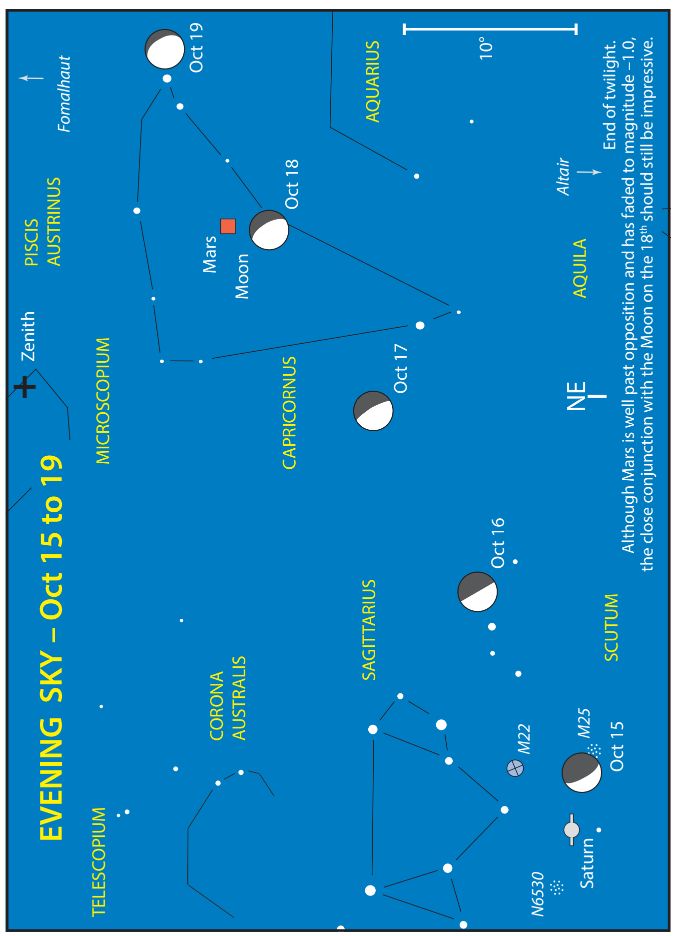
DOUBLE STARS

For this month's double we venture into the southern constellation of Phoenix, the mythical bird who rose from its own ashes. Theta (θ) Phoenicis (see All Sky Maps 2 and 8) is a lovely double to observe on a spring evening. The stars, magnitudes 6.5 and 7.3, are separated by 4.1 arcseconds with a position angle of 279 degrees. This slightly unequal pair of white stars (spectra A8V and F0V) has shown a slight increase in separation since John Herschel's measure in 1835 and probably comprises a true binary system. The system is located about 257 light years away.



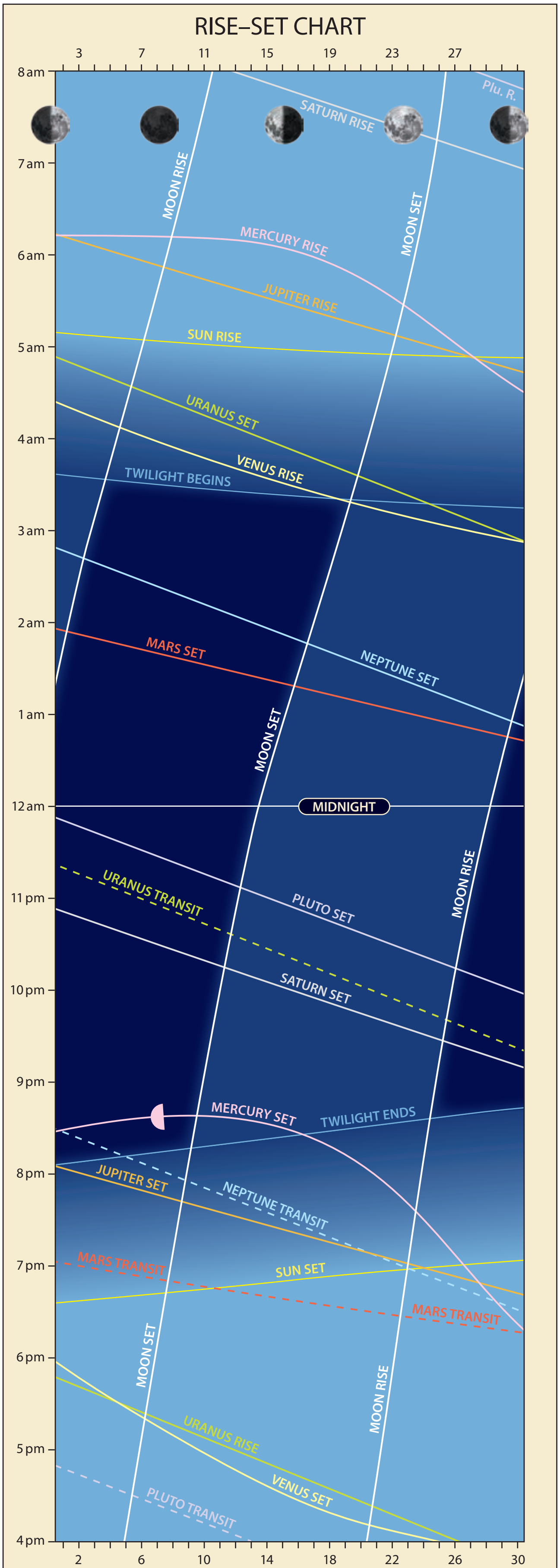
Approximate local standard time, for daylight saving add one hour.





OCTOBER

NOVEMBER



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

HIGHLIGHTS

- Venus returns to the morning sky.
- Moon and Mars close.
- Mars and Neptune close.
- Antares and Mercury close.
- Comet 46P/Wirtanen may brighten to 5th magnitude.

CONSTELLATIONS

The earliest written records of the heavens were made in the Northern Hemisphere, or to be more specific the Middle East, Europe and China. Many of our southern highlights, like Centaurus, the Southern Cross and Carina were either not visible or sitting on the southern horizon from these latitudes. Hence it is not surprising that south of these declinations the constellations are much more modern, lacking the interesting legends associated with the traditional ones, some dating back over 2,000 years.

Much of the early work in the far south was done by the French Astronomer Abbe Nicholas Louis de la Caille (1713–1762). He headed up an astronomical expedition to the Cape of Good Hope from 1750–54. At that time the southern skies were nearly 'untouched' and he was responsible for the naming of a number of far southern constellations. Instead of using animals or mythical creatures he chose to use scientific instruments, with the exception of Mensa, which he named after the mountain on which his observatory was located at Cape Town. The constellations were: Norma (the Level), Circinus (the Compasses for drawing circles), Telescopium (the Telescope), Microscopium (the Microscope), Sculptor

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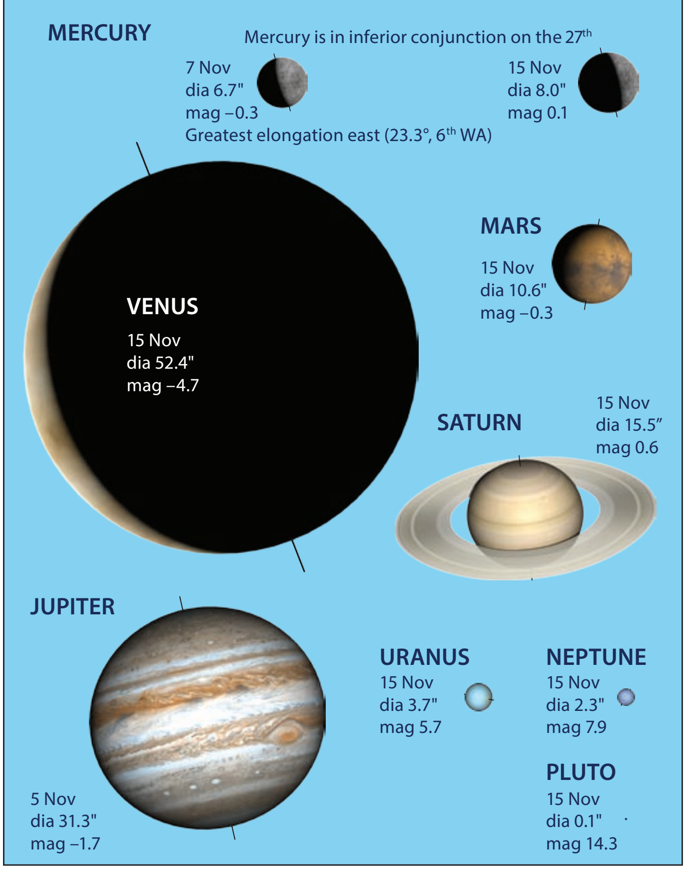
APPEARANCE of the PLANETS



Challenges of Observing Galaxies

This year's cover is the brilliant face-on spiral galaxy M51 also known as NGC 5194. It was framed to show off its magnificent complexity; hence it was necessary to crop the nearby galaxy that it is interacting with, NGC 5195. To be fair the complete image is reproduced above. It was obtained by the Hubble Space Telescope and released in 2005 to celebrate its 15th year of operation. It is wonderful to look at the structure, which would be very similar to our Milky Way if we could see it from well above the galactic plane. Ignoring its companion and its interactions, the only significant difference is that our galaxy is a barred spiral with the main arms originating from the ends of a central bar. It is interesting to ponder that every red (HII) region is a hot-bed of stellar growth; if you like, think of them as an extra-terrestrials' version of the Orion Nebula, Eta Carinae region or Lagoon Nebula. There are also the young hot, blue (Population I) stars near these nebulae and also in the spiral arms and the shadows of dark gas and dust waiting to be swept up and recycled through the red stellar nurseries. Also obvious is the yellow/white bright core made up of older (Population II) stars, all textbook stuff.

Having tried to introduce beginners to the subtle joys of extragalactic observing over many years, it leaves us wondering how many novices have purchased a telescope expecting to see a similar feast visually? Observing galaxies needs a big reality check! Yes, it's true the planets especially Jupiter and Saturn never fail to impress with their telescopic views similar to the electronic images. We still remember our first views of Saturn's rings and Jupiter's Great Red Spot and Galilean satellites. Well our Moon certainly doesn't need any elaborating, except maybe—wow! The show continues with star clusters, especially globular clusters, leaving observers totally mesmerised as they fall into their eyepiece yelling those immortal words, "My God, it's full of stars"—simply magic! However, with galaxies …

You'll see no colour. Although the eye is sensitive, the mind doesn't have the ability to store data and build up an image like an electronic camera. Remember images such as M51 (above) were taken over a number of hours through multiple coloured filters and then later combined. Also, the most sensitive region of the eye, the rods, see only in grey scale whereas the less responsive cones are needed for colour. This is why averted vision is employed to see faint detail since the rods perceive off centre from where our eyes are looking.

Seeing spiral arms can be very difficult. Being a more Northern Hemisphere object we had to wait for a trip to America to see M51. The arms were obvious but we were spoiled using a borrowed 14-inch Celestron at the time. In reality even this prominent galaxy probably needs a 250 mm to perceive even a brighter segment as part of an arm. However with modern day cost effective Dobsonian telescopes, apertures of 400 mm are well within reach.

OK, so much for the disclaimer, so what are the attractions of extragalactic observing? While it is true many appear just as faint featureless blobs it's worthwhile looking initially for three regions, they are from the centre out:

Nucleus Does it have a compact bright centre? If it looks star-like it may indirectly indicate the unobservable; a massive black hole attracting and feeding on millions (billions?) of nearby swarming stars.

Core If present, these tend to be more diffuse than a nucleus, having a distinct shape, and sometimes showing graduation in brightness towards the centre.

Halo This is the fainter outer region and may be all that is visible (that is the featureless blob mentioned above). In the case of spirals this can be the ghost-like hint of the existence of arms. Bright patches can be segments of arms or even HII regions. Sometimes in nearby galaxies like Andromeda (M31) star-like objects can be entire globular clusters. Often, the overall impact of these features reveals themselves as mottling. Spirals being flattened discs can be tilted to some extent or even edge-on to our line of sight, like we see the Milky Way. Visually they can be distinctly oval (famous examples are M31, NGC 253 and NGC 4945) to slashing lines like NGC 4216. Spirals commonly have equatorial dark dust bands, which become more visible the more inclined or edge-on the galaxy, also like the structure of the Milky Way. NGC 5128 (Centaurus A) might be classified as a spiral, but has the appearance of an elliptical with its most obvious feature being a broad equatorial dark band clearly visible in moderate telescopes. Another famous visible dark equatorial band belongs to the Sombrero Galaxy (M104). Barred spirals present a further bonus, taking the famous example of NGC 1365 in Fornax. The arms may only be visible as a halo, but the bar is quite obvious. The brightest case is the LMC where its impressive bar can be seen with the unaided eye!

So far in these characteristic features we have used spirals as illustrations. The elliptical galaxies by appearance and morphology are not that different to globular clusters except for their enormous size and distance. They look like unresolved globulars and like globulars their nucleus/core can vary from broad to quite narrow (compact) fuzzies. In general these galaxies are mostly spherical with some being distinctly oval.

To view multiple galaxies in the same field of view can be most attractive. The Virgo/Coma cluster offers numerous examples of this. To compare different galaxies side by side with their own unique characteristics can be an exciting experience.

In conclusion remember much of the enjoyment of astronomy lies in the imagination tempered by facts. Think of the incredible distances these photons have travelled to end their existence plunging into the receptors of your eyes. Many left their sources while the dinosaurs roamed the Earth!

Observing Tips for Galaxies.

The fundamental requirement is to maintain as much contrast between the often-ghostly galaxy and the background sky. So avoid light polluted suburban skies. Transparency is more important than seeing. It doesn't matter if the stars are twinkling providing the causes such as heat haze and wind don't kick up volumes of dust, which can lead to poor transparency. Although northern objects might in theory culminate above your horizon, looking through a thicker atmosphere can easily magnify these effects leading to significant sky glow often visible to the naked eye.

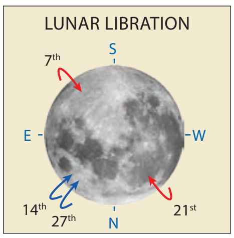
There is a skill to teasing detail out of faint objects. Practice using averted vision (see main text). Play with different eyepieces, for example increasing the magnification leads to a darker background, but also spreads the galactic glow across more of your field of view, offering more detail but perhaps becoming more difficult to see. This is why bright but large galaxies such as M33 can be easier to pick up in the low power fields of binoculars than that of a narrow, high magnification field of view of a telescope. The authors have had M33 filling the view and not recognising it at first!

(the Sculptor's Apparatus), Fornax (the Furnace), Caelum (the Sculptors Chisel), Horologium (the Clock), Octans (the Octant), Mensa (the Table Mountain), Reticulum (the Net), Pictor (the Easel) and Antlia (the Air Pump).

La Caille also catalogued 42 deep sky objects, 25 of these were original discoveries including the Eta Carinae Nebula (NGC 3372), globular cluster 47 Tucanae (NGC 104) and the Tarantula Nebula (NGC 2070) in the LMC. He also found the spiral galaxy M83, which would eventually be recognised as the first galaxy discovered beyond the Local Group. The fact that 47 Tuc is classed as a nebula without stars is indicative of the size of his telescope—a lowly 15 mm refractor, not even a finder scope by today's standards!

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

THE MOON



- 1st 3 am (1 am) Last Quarter.
- 1st 6 am (4 am WST) Moon at perigee (closest to Earth at 370,204 km).
- 7th 3 pm (1 pm WST) Maximum Libration (8.2°), too close to New Moon.
- 8th 2 am (midnight WST) New Moon.
- 13th 4 am (2 am WST) Occultation of dwarf planet Pluto by the Moon, visible from NE North America, S Greenland, Iceland, Azores and most of W Europe.
- 14th 10 am (8 am WST) Minimum Libration (0.8°), bright NE limb.
- 15th 2 am (midnight previous day WST) Moon at apogee (furthest from Earth at 404,339 km).
- 16th 1 am (11 pm previous day WST) First Quarter.
- 16th 2 pm (Noon WST) Occultation of Mars by the Moon, visible from Antarctica, SE Pacific and S South America. From Australia Mars will appear near the Moon in the early evening (see Sky View).
- 21st 2 am (midnight previous day WST) Maximum Libration (8.7°), dark NW limb.
- 23rd 4 pm (2 pm WST) Full Moon.
- 26th 10 pm (8 pm WST) Moon at perigee (closest to Earth at 366,620 km).
- 27th Noon (10 am WST) Minimum Libration (0.4°), dark NE limb.
- 30th 10 am (8 am) Last Quarter.

THE PLANETS

Mercury opens the month around 5° above the brighter Jupiter in the western evening twilight sky. The planet reaches its greatest eastern elongation from the Sun (23°) on the 7th and subsequently begins its descent back toward Sol to end its last appearance in the evening twilight this year. From the 8th to 11th Mercury will be 2° northward from Antares (Alpha (α) Scorpii), the brightest star in the constellation of the Scorpion. At this time the planet will be one magnitude brighter than the star (see Sky View). On the 27th, the speedy little messenger will be in inferior conjunction (between the Earth and the Sun) and then reappear in the morning dawn next month.

Venus, in the constellation of Virgo, returns to the dawn sky as the *Morning Star* this month. On the 15th, the planet will be 1.2° from the 1st magnitude star Spica (Alpha (α) Virginis)—a difficult observation just prior to sunrise (see Sky View). The planet maintains its status as the morning star until next June when it becomes too close to the Sun to observe, pending its superior conjunction mid-August 2019 and subsequent return to the evening sky.

Mars spends the first third of the month in Capricornus before moving into Aquarius. Visible in the mid-evening north-western sky, the planet has an encounter with the 8-day old waxing gibbous Moon on the 16th when the pair appear less than 3° from each other (see Sky View). Although amateurs using CCD devices can continue to image the planet, the visual observer may be disappointed as the Martian disc diameter drops from 12 to 9 arcseconds. The planet's brightness remains in low negative magnitudes during the month, its only rival being the fainter 1st magnitude star Fomalhaut in neighbouring Piscis Austrinus. Watch out early next month for a spectacular conjunction between the Red Planet and Neptune.

Jupiter is only visible low to the western horizon in the twilight early in the month (see Sky View). From mid-November it becomes too close to the Sun for observation and will be in conjunction with the Sun on the 26th. The planet reappears in the dawn sky in Scorpius in early December.

Saturn, low in the western evening sky at the end of twilight, has reached the stage where our atmosphere will hinder telescopic observation particularly toward month's end. On the 11th, the 4-day old waxing crescent Moon appears directly below the ringed planet (see Sky View).

Uranus, now past opposition, transits the meridian (is due north) around 10 pm midmonth in Aries.

Neptune is joined by Mars in Aquarius and by month's end the pair of planets will be 4° apart. Keep an eye (or at least binoculars) on this pair as they culminate in one of the best conjunctions this year in early December. High in the early north-western evening sky at the end of astronomical dusk, Neptune comes to the end of five months in retrograde motion on the 25th.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto**, in Sagittarius, in the western evening sky sets around 11 pm.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
17 Nov	107 Camilla	Taurus	12.0
17 Nov	3 Juno	Eridanus	7.4
18 Nov	87 Sylvia	Taurus	11.7
22 Nov	12 Victoria	Taurus	10.1

COMETS

Comet C/2016 M1 (PANSTARRS) begins November in Circinus. It briefly moves into Triangulum Australe early on, and then onto Apus for the rest of the month. The 11th magnitude comet is visible throughout the night, however being circumpolar and transiting in the middle of the day, it spends the night quite low (below the South Celestial Pole).

Comet 21P/Giacobini-Zinner is expected to fade from 9th to 11th magnitude this month. Rising mid-evening, the comet moves from Canis Major into Puppis during November.

Comet 38P/Stephan-Oterma should remain around 9th magnitude during November. Residing in Gemini for all but a few days, it closes November in Cancer. The comet is rising late in the evening.

Comet 46P/Wirtanen could brighten from 7th to 5th magnitude by month's end. Visible until just before dawn, the comet spends most of November in Fornax before moving into Cetus.

Comet 64P/Swift-Gehrels is visible until shortly after midnight. Shining at 11th magnitude, the comet begins November in Andromeda, moving to Triangulum by month's end.

METEOR SHOWERS

The **Northern Taurids** are bright, slow meteors active during October and November. The shower is composed of two radiants of nearly equal activity ten degrees apart. The Northern Taurids peak around 12 November and the Southern Taurids in October. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs (although not in every

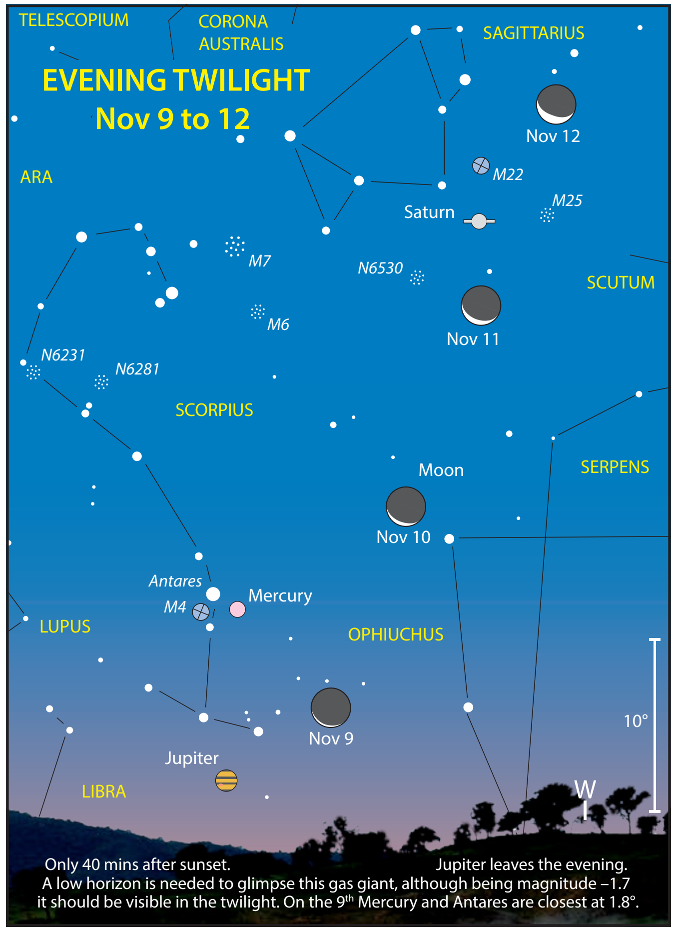
DIARY			
Thu	1st	2:40 am	(12:40 am WST) Last Quarter Moon
Thu	1st	6 am	(4 am WST) Moon at perigee, 370,204 km
Fri	2nd		Mercury 0.7° SW of star Delta (δ) Scorpii
Fri	2nd	3 pm	(1 pm WST) star Regulus 2° S of Moon
Fri	2nd	pm	Mars 0.3° NW of star Gamma (γ) Capricorni
Sat	3rd	3 am	(1 am WST) Comet 21P/Giacobini-Zinner 0.2° N of star Eta (η) Canis Majoris
Mon	5th		Mercury at greatest latitude south
Mon	5th	pm	Mars 0.5° NW of star Delta (δ) Capricorni
Tue	6th	8 am	(6 am WST) star Spica 8° S of Moon
Tue	6th	Noon	(10 am WST) Venus 10° S of Moon
Wed	7th		Mercury 1.2° SW of star Rho (ρ) Ophiuchi
Wed	7th	2 am	(Midnight WST, prev day) Mercury at greatest elongation East (23.3°)
Wed	7th	5 am	(3 am WST) m.p. 4 Vesta 3° S of d.p. Pluto
Thu	8th	2:02 am	(12:02 am WST) New Moon
Fri	9th	4 am	(2 am WST) Jupiter 4° S of Moon
Fri	9th	4 pm	(2 pm WST) star Antares 1.8° S of Mercury
Fri	9th	9 pm	(7 pm WST) star Antares 9° S of Moon
Fri	9th	10 pm	(8 pm WST) Mercury 7° S of Moon
Mon	12th	2 am	(Midnight WST, prev day) Saturn 1.5° S of Moon
Mon	12th	10 am	(8 am WST) m.p. 4 Vesta 4° S of Moon
Tue	13th	am	Comet 38P/Stephan-Oterma 0.7° NW of NGC 2420 (OC) in Gemini
Tue	13th	4 am	(2 am WST) d.p. Pluto 0.9° S of Moon
Wed	14th	1 pm	(11 am WST) Venus stationary
Thu	15th		Venus 1.2° E of star Spica
Thu	15th		d.p. Ceres 0.6° NE of NGC 5427 (G) in Virgo
Thu	15th	2 am	(Midnight WST, prev day) Moon at apogee, 404,339 km
Fri	16th	12:54 am	(10:54 pm WST, prev day) First Quarter Moon
Fri	16th	2 pm	(Noon WST) Mars 1.0° N of Moon
Fri	16th	pm	64P/Swift-Gehrels 0.7° NE of star Beta (β) Andromedae
Sat	17th	3 pm	(1 pm WST) Mercury stationary
Sat	17th	4 pm	(2 pm WST) Neptune 3° N of Moon
Sun	18th	am	Comet 38P/Stephan-Oterma 0.8° SE of star Kappa (κ) Geminorum
Sun	18th	8 am	(6 am WST) m.p. 3 Juno at opposition
Wed	21st	6 am	(4 am WST) Uranus 5° N of Moon
Wed	21st	pm	Comet 21P/Giacobini-Zinner 0.3° NW of star Pi (π) Puppis
Thu	22nd		Venus at ascending node
Fri	23rd	3:39 pm	(1:39 pm WST) Full Moon (372,721 km)
Sat	24th		Mercury at ascending node
Sat	24th	8 am	(6 am WST) star Aldebaran 1.7° S of Moon
Sun	25th	6 pm	(4 pm WST) Neptune stationary
Mon	26th	10 am	(8 am WST) star Pollux 7° N of Moon
Mon	26th	5 pm	(3 pm WST) Jupiter in conjunction with Sun
Mon	26th	10 pm	(8 pm WST) Moon at perigee, 366,620 km
Tue	27th	7 pm	(5 pm WST) Mercury in inferior conjunction
Wed	28th		Saturn 0.8° N of NGC 6642 (GC) in Sagittarius
Thu	29th		Mercury at perihelion
Thu	29th	8 pm	(6 pm WST) star Regulus 2° S of Moon
Thu	29th	pm	Comet 46P/Wirtanen 1.0° SE of NGC 908 (G) in Cetus
Fri	30th	10:19 am	(8:19 am WST) Last Quarter Moon

year). Their relative slowness and brightness makes them an ideal target for astrophotography. They are associated with Comet 2P/Encke, and can be seen from late evening to early morning. At maximum there will be no lunar interference in the morning this year with New Moon on the 8th.

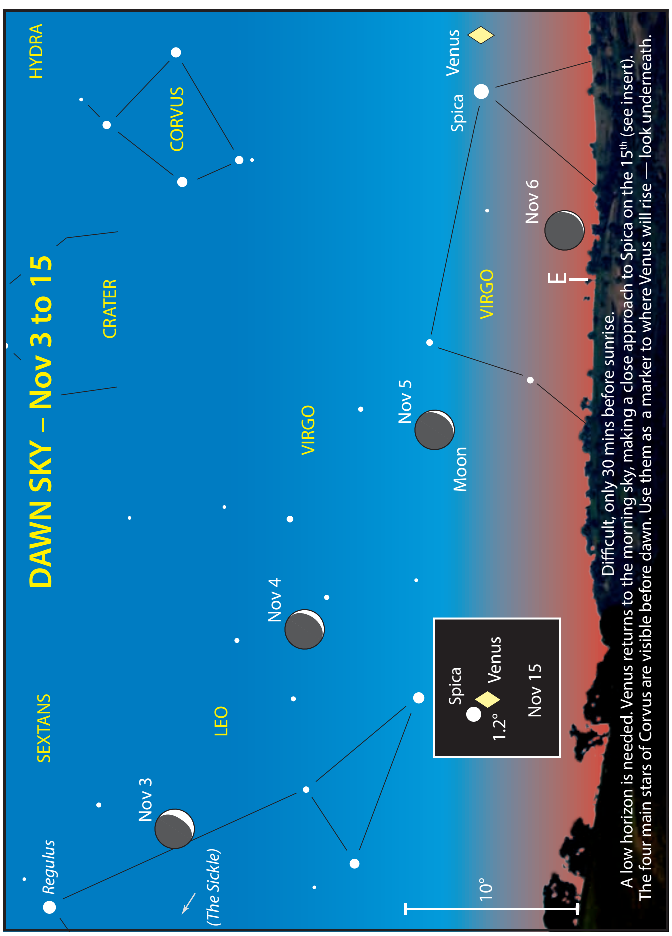
The **Leonids** is one of the better-known showers. It is associated with the periodic comet 55P/Tempel-Tuttle and is at its best about every 33 years when the comet returns to perihelion (last in 2001). The Leonids are active from the 6th to 30th, with maximum on the morning of the 18th. Current predictions for 2018 indicate a possible zenith hourly rate of 10–20 meteors. We would encourage observers to be on the lookout for updates nearer the time of the shower as this is not one to be missed if active. First Quarter being on the 16th will leave the pre-dawn sky Moon free.

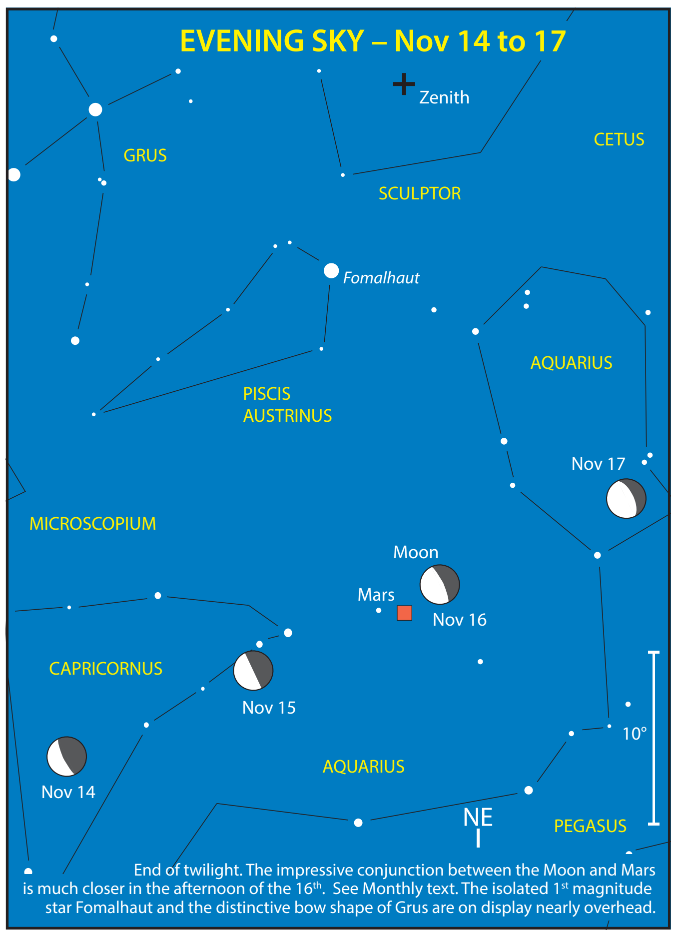
DOUBLE STARS

This month's double is located in the faint southern constellation of Fornax (the Furnace). When you think of Fornax you usually associate it with lovely galaxies. However, it contains a few double stars of which Omega (ω) Fornacis (see All Sky Map 2) is a fine example. Discovered by John Herschel, this pair of magnitude 5.0 and 7.7 stars (spectra B9.5IV and A7V) is separated by 11.0 arcseconds with a position angle of 246 degrees. The white and blue pair has shown little change since the measures of W.S. Jacob in 1858. Their similar proper motion is consistent with a long-period binary. The pair is located about 484 light years away. For those with large telescopes have a look for a similar appearing, but much fainter pair of stars located about two arcminutes west of Omega.

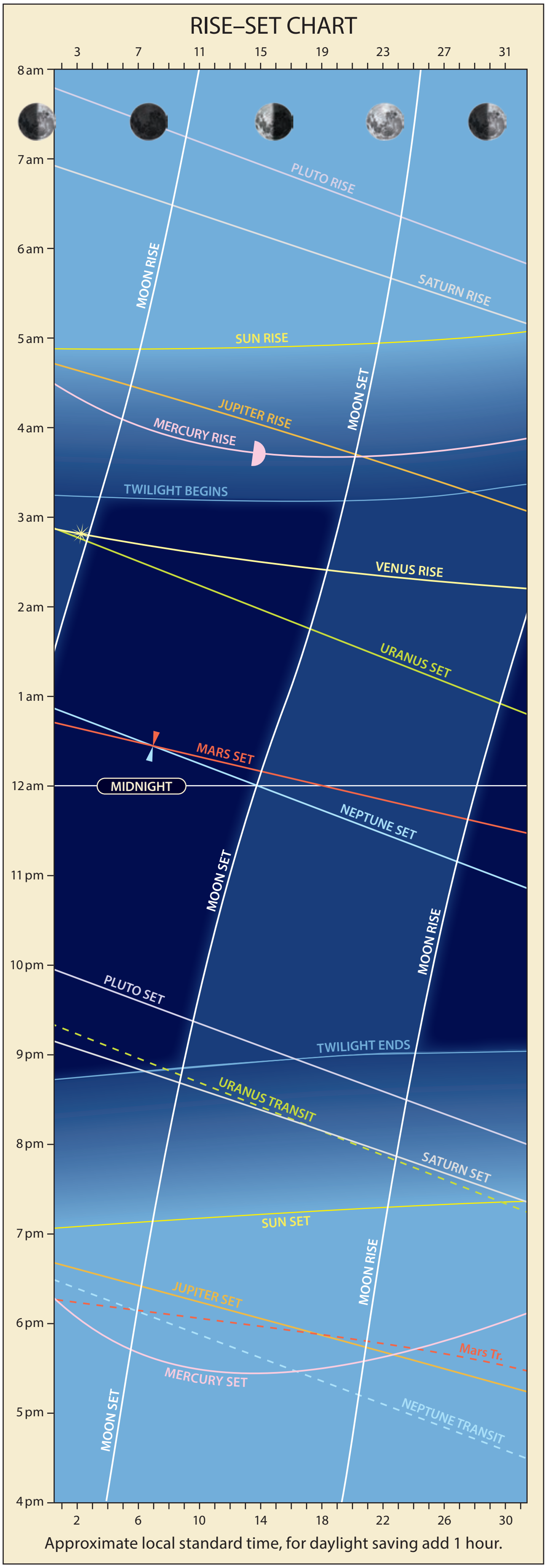


Approximate local standard time, for daylight saving add one hour.





DECEMBER



HIGHLIGHTS

- Mercury and Jupiter close.
- Venus at greatest brilliancy.
- Moon and Venus a brilliant meeting.
- Mars and Neptune very close.
- Comet 46P/Wirtanen may reach 4th magnitude as it makes its close approach to the Earth.

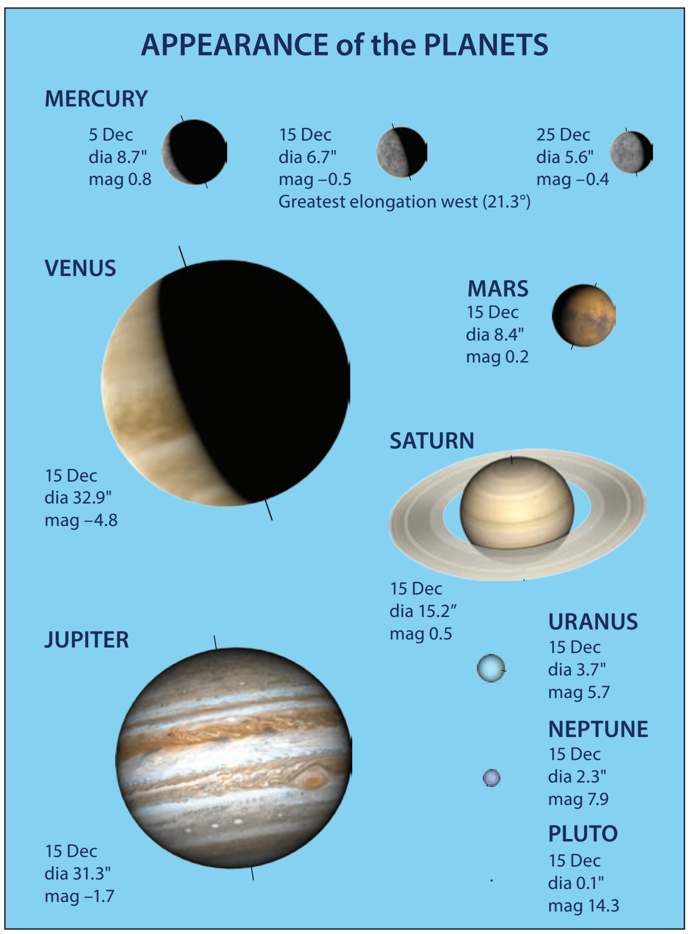
CONSTELLATIONS

A few years back the authors were attending a star party this time of year, under nice dark country skies. One of the visitors was heard to remark, “I’ve been watching those two clouds for a while and they don’t seem to be moving”. Someone was heard to quickly point out, “they are also white and out here real clouds are black”.

They are two satellite galaxies to the Milky Way called the Magellanic Clouds, the Small (SMC), located in Tucana and Large (LMC) in Dorado (see All Sky Map 1). So it is little wonder they appear as detached sections of our galaxy for they too are comprised of millions of stars, clusters and nebulae.

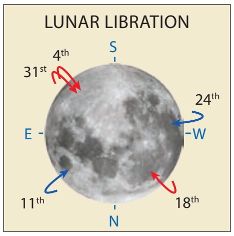
They are named after the Portuguese explorer Ferdinand Magellan after being recorded during his expedition to the East Indies in 1519 to 1522, becoming the first circumnavigation of the world. These irregular galaxies are located approximately 160,000 (LMC) and 190,000 light years away (SMC). In 1987 a naked-eye supernova was discovered in the large cloud.

An interesting aspect of the clouds is that being so far south they were out of sight for the early, mainly Northern



Hemisphere based telescopes. Astronomers have remarked if this hadn't been the case our knowledge of star formation would have been gained much earlier. You can see as much detail through a reasonable sized amateur telescope in the relatively nearby 'clouds' as professionals can see in the Andromeda Galaxy, just over two million light years away.

THE MOON



- 4th 10 am (8 am WST) Maximum Libration (8.5°), dark SE limb.
- 7th 5 pm (3 pm WST) New Moon.
- 9th 3 pm (1 pm WST) Occultation of Saturn by the Moon, visible from part of Siberia.
- 10th 2 pm (noon WST) Occultation of Pluto by the Moon, visible from NE China, Japan, SE Russia and N Micronesia.
- 11th 2 pm (noon WST) Minimum Libration (0.9°), bright NE limb.
- 12th 10 pm (8 pm WST) Moon at apogee (furthest from Earth at 405,177 km).
- 15th 10 pm (8 pm WST) First Quarter.
- 18th 5 pm (3 pm WST) Maximum Libration (9.6°), dark NW limb.
- 23rd 4 am (2 am WST) Full Moon.
- 24th 8 pm (6 pm WST) Moon at perigee (closest to Earth at 361,062 km).
- 24th 11 pm (9 pm WST) Minimum Libration (0.1°), bright SW limb.
- 29th 8 pm (6 pm WST) Last Quarter.
- 31st 11 am (9 am WST) Maximum Libration (9.4°), dark SE limb.

THE PLANETS

Mercury returns to the dawn sky this month, reaching its greatest elongation (21°) west of the Sun on the 15th. As the month progresses, Jupiter rises up to meet Mercury and on the 22nd the pair will be just 0.8° apart—the giant, a full two magnitudes brighter than the innermost planet (see Sky View).

Venus, in the morning dawn sky, spends the first half of December in Virgo before moving into Libra. The view of Venus through any small telescope at this time shows the planet shaped like the Moon before first quarter; commencing December resembling a 3-day old crescent and finishing more like 6-days old. Venus reaches its greatest illuminated extent (see September Venus section for definition) on the 2nd at –4.9 magnitude. A nice view is on the 4th, when the 26-day old waning crescent Moon will be 4° from the brilliant planet (see Sky View).

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

Mars, setting around midnight, spends the first two thirds of December in Aquarius before moving into Pisces. At month's end the planet will be just above the six stars known as the Circlet of Pisces. On the 15th, the First Quarter Moon will be near Mars providing a pleasing midmonth vista in the western evening sky (see Sky View).

With the planetary disc now shrinking to around eight arcseconds in diameter it offers little for the visual telescopic observer. However, Mars shares the constellation of the Water Bearer with Neptune and the angular distance between the pair decreases until the 7th when they will be just six arcminutes apart at the end of twilight from the eastern states and even closer at three arcminutes from Western Australia. The golden orange and bluish pair will be a real delight with optical aid in what the authors consider to be one of the best conjunctions of the year—at least for those using binoculars or telescopes. If using binoculars (properly braced) the two will be unmistakable but Neptune will lack colour. A telescope with an aperture of 100 mm or more, under about 200 power, will provide the most stunning view, bringing out the colours of the planets.

On the 3rd Mars will be at its eastern quadrature, where the Sun-Earth-Mars angle is 90° (see Orbital Aspects diagram p. 13). At this time, Mars displays its minimum phase with 86% of the planet's surface illuminated by the Sun. Even a small telescope will show the disc to be distinctly gibbous in shape, just like the Moon about three days before or after Full Moon. Galileo was first to note the odd shape of the planet in the 17th century, in those pioneering days of astronomical telescopic observations.

Jupiter returns to the morning eastern sky following its solar conjunction last month. After spending the greater part of the year in Libra, its return from behind the Sun sees it in Scorpius, before moving into Ophiuchus midmonth. In the pre-dawn twilight Jupiter is joined by Mercury in Ophiuchus, the pair approaching within 0.8° on the 22nd (see Sky View).

Saturn, low in the western evening twilight, can only be sighted early this month before it becomes too close to the Sun for observation. On the 9th, the slender crescent of the 2-day old waxing Moon will be just northwards of the planet—binoculars will help here in the evening dusk (see Sky View). Saturn will be in conjunction with the Sun on January 2, returning to the morning dawn later that month.

Uranus leaves Aries, returning to Pisces early in December, transiting the meridian around 8 pm midmonth. Next month marks the end of four months in retrograde when it begins drifting eastward against the stellar background. This brings Uranus back into Aries in February where it will remain until 2024 when in wanders into Taurus.

Neptune, in the north-western evening sky in Aquarius, has a close encounter with Mars. On the 7th the two planets will be extremely close (see Mars) and reminiscent of when the pair were almost as close on the evening of 1 January 2017.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** is close to the early western evening horizon at the beginning of December. The outer world will be in conjunction with the Sun in January and will return to the morning skies in February.

Brightest **Minor Planets** at opposition this month include:

Date	Minor Planet	Constellation	Mag.
4 Dec	128 Nemesis	Taurus	10.5
7 Dec	433 Eros	Camelopardalis	9.7
8 Dec	40 Harmonia	Taurus	9.4
10 Dec	80 Sappho	Orion	10.3
14 Dec	354 Eleonora	Orion	10.2
19 Dec	71 Niobe	Auriga	11.8
28 Dec	6 Hebe	Orion	8.4
30 Dec	25 Phocaea	Monoceros	12.3

Retrograde motion causes Hebe to revisit Monoceros in December, including crossing the southern edge of the Rosette Nebulae on the 20th (perhaps an imaging opportunity?).

COMETS

Comet 38P/Stephan-Oterma opens December in Cancer, rising late in the evening. Moving midmonth into Lynx, the comet is likely to fade from 9th to 10th magnitude.

Comet 46P/Wirtanen could brighten from 5th to 4th magnitude this month as it nears Earth. It begins December in Cetus and visible all night. The comet rapidly moves through a number of constellations as it heads north, Eridanus, Cetus, Taurus, Perseus and Auriga finishing the month in Lynx. On the evening of the 16th, while in Taurus, Wirtanen passes between the naked eye Hyades and Pleiades star clusters. At month's end, it will be briefly visible low in the northern sky, rising in the late evening and gone by early morning.

METEOR SHOWERS

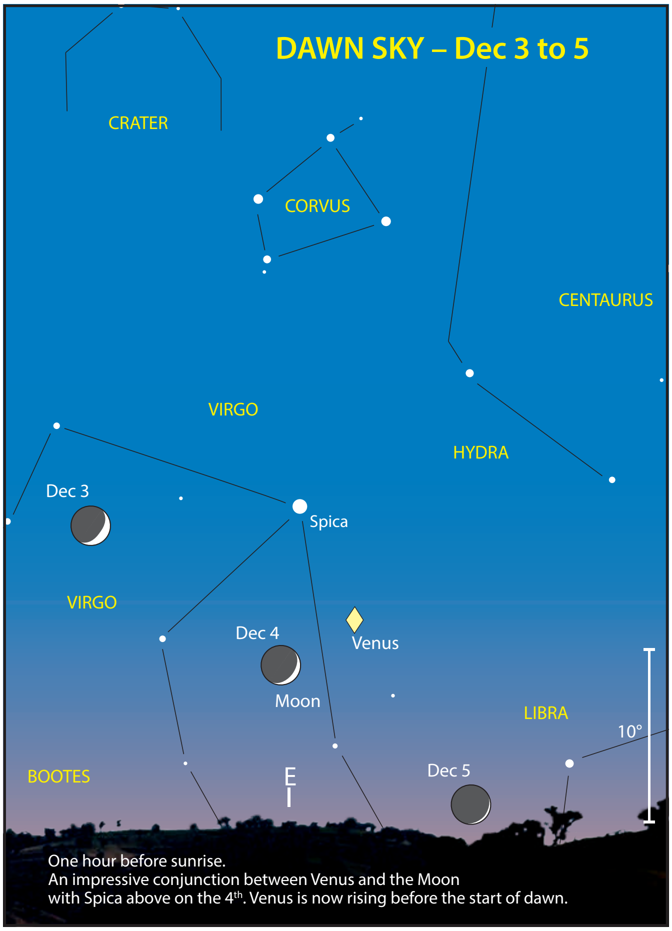
The **Puppid-Velids** complex contains a series of radiants located in the constellations of Carina, Puppis, Pyxis and Vela. Some of the showers are thought to be visible from late October to early January, but have been so poorly observed that the International Meteor Organization can only confirm high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

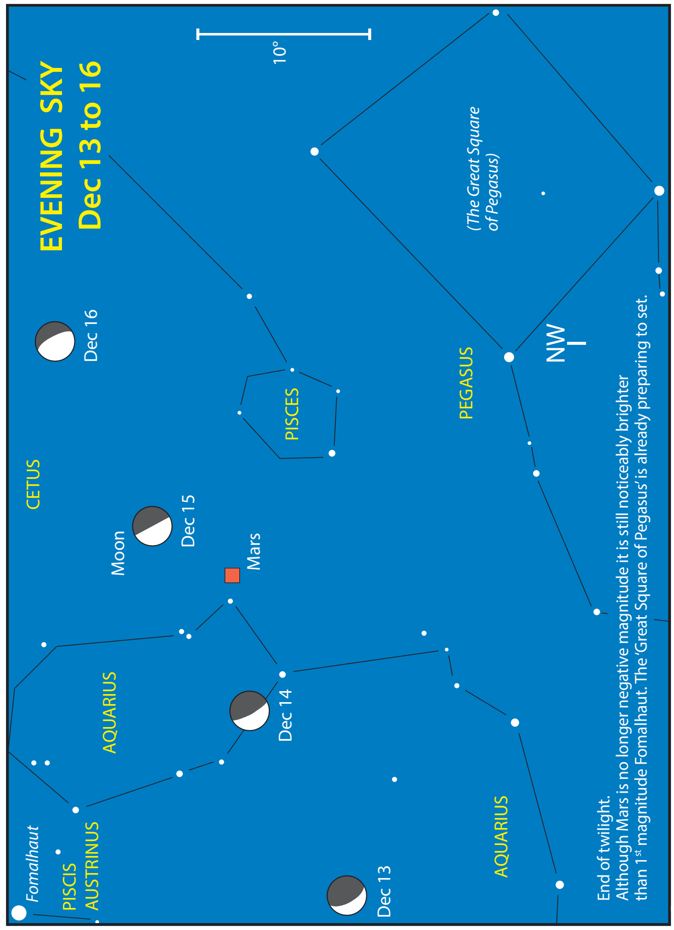
The **Geminids** are one of the finest and most reliable of the major annual showers. Visible from the 4th to 17th, with maximum predicted on the 14th, the Geminids often produce bright, medium-speed meteors. The zenith hourly rate is variable but around 120 are possible. Even though our northern counterparts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

DOUBLE STARS

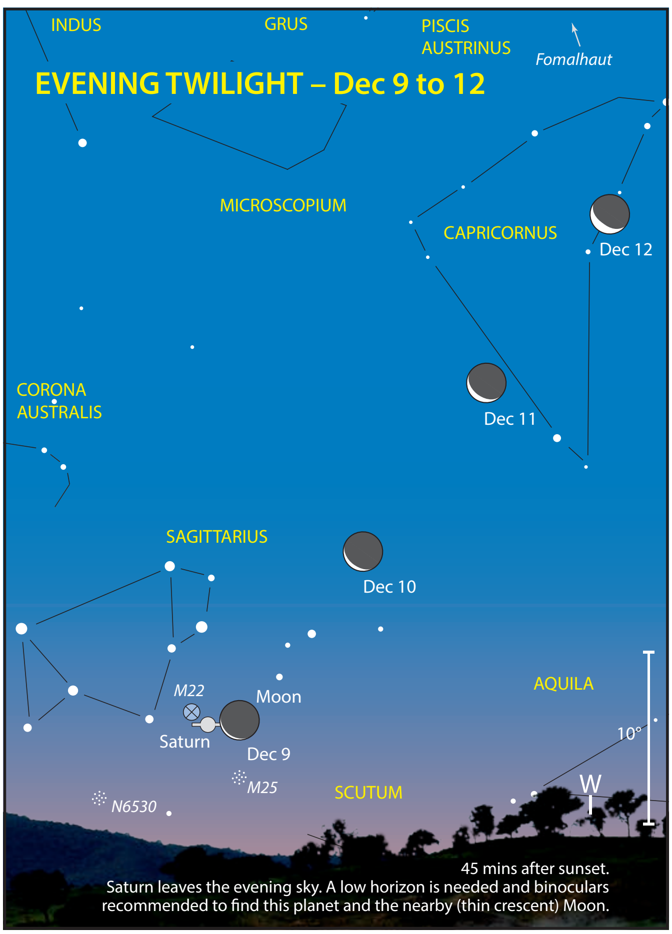
We end the year in the constellation of Eridanus (the River). f Eridani (see All Sky Map 2) is a fine pair located near the border with Fornax and forms a triangle with g and h Eridani. The stars, magnitudes 4.7 and 5.3, are separated by 8.4 arcseconds with a position angle of 216 degrees. The pale yellow-white pair (spectra B9V and A1V) dominates a field sprinkled with fainter stars. Since the measures of 1826 there has been a slight change in position angle from 202 degrees and some widening. Shared proper motion favours a long-period binary system.

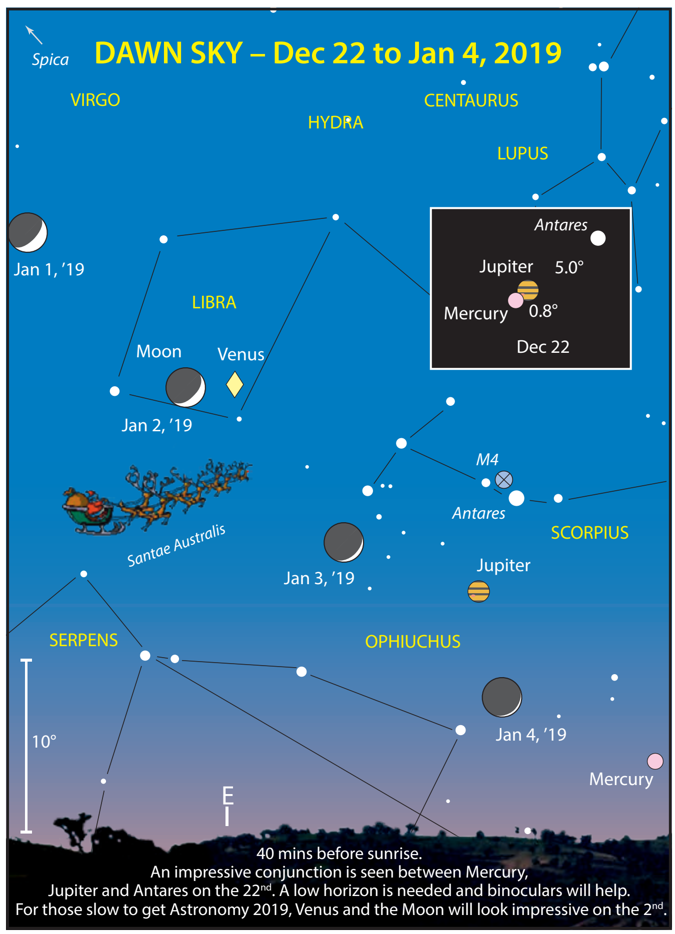
DIARY			
Sun	2nd	10 am	(8 am WST) Venus greatest illuminated extent
Sun	2nd	11 pm	(9 pm WST) m.p. 354 Eleonora 0.1° N of star Zeta (ζ) Orionis
Mon	3rd	2 pm	(Noon WST) star Spica 8° S of Moon
Tue	4th		Mars 0.7° S of star Lambda (λ) Aquarii
Tue	4th	5 am	(3 am WST) Venus 4° S of Moon
Wed	5th	1 am	(11 pm WST, prev day) d.p. 1 Ceres 1.6° N of Moon
Thu	6th	7 am	(5 am WST) Mercury 1.9° S of Moon
Fri	7th	6 am	(4 am WST) Mercury stationary
Fri	7th	5:20 pm	(3:20 pm WST) New Moon
Fri	7th	pm	Comet 46P/Wirtanen 1.3° N of star Eta (η) Eridani
Sat	8th		Saturn 1.2° N of M22 (GC) in Sagittarius
Sat	8th	1 am	(11 pm WST, prev day) Neptune 0.04° S of Mars
Sun	9th		Mercury at greatest latitude north
Sun	9th	3 pm	(1 pm WST) Saturn 1.1° S of Moon
Sun	9th	9 pm	(7 pm WST) 64P/Swift-Gehrels 0.2° SW of star Epsilon (ε) Trianguli
Mon	10th	2 pm	(Noon WST) d.p. Pluto 0.7° S of Moon
Tue	11th		Venus 0.6° S of star Kappa (κ) Virginis
Tue	11th		m.p. 2 Pallas 0.3° S of NGC 4731 (G) in Virgo
Tue	11th	8 pm	(6 pm WST) m.p. 4 Vesta 3° S of Moon
Wed	12th	10 pm	(8 pm WST) Moon at apogee, 405,177 km
Thu	13th		Mars 0.3° N of star Phi (φ) Aquarii
Thu	13th		m.p. 2 Pallas 0.02° SE of NGC 4775 (G) in Virgo
Thu	13th	9 pm	(7 pm WST) m.p. 23 Thalia 0.06° SW of NGC 676 (G) in Pisces
Thu	13th	pm	Comet 46P/Wirtanen 1.7° NE of star Xi (ξ) Tauri
Fri	14th	Midnight	(10 pm WST) Neptune 3° N of Moon
Sat	15th	9 am	(7 am WST) Mars 4° N of Moon
Sat	15th	9:49 pm	(7:49 pm WST) First Quarter Moon
Sat	15th	10 pm	(8 pm WST) Mercury at greatest elongation West (21.3°)
Sat	15th	pm	m.p. 6 Hebe 0.7° SW of Collinder 107 (OC) in Monoceros
Sun	16th	pm	m.p. 6 Hebe 0.7° SW of Collinder 104 (OC) in Monoceros
Sun	16th	pm	Comet 46P/Wirtanen 3.4° SE of M45 the Pleiades (OC) in Taurus
Mon	17th		Mercury 1.0° N of star Beta (β) Scorpii
Tue	18th		Mercury 0.4° N of star Nu (ν) Scorpii
Tue	18th	2 pm	(Noon WST) Uranus 5° N of Moon
Thu	20th	10 am	(8 am WST) Venus greatest illuminated extent
Thu	20th	Noon	(10 am WST) star Antares 5° S of Jupiter
Thu	20th	pm	m.p. 6 Hebe 0.5° S of Rosette Nebula (BN) in Monoceros
Thu	20th	pm	m.p. 354 Eleonora 1.0° N of star Eta (η) Orionis
Fri	21st	6 pm	(4 pm WST) star Aldebaran 1.7° S of Moon
Fri	21st	6 pm	(4 pm WST) star Antares 6° S of Mercury
Sat	22nd	1 am	(11 pm WST, prev day) Jupiter 0.9° S of Mercury
Sat	22nd	8 am	(6 am WST) Solstice
Sat	22nd	pm	Comet 46P/Wirtanen 1.0° N of star Zeta (ζ) Aurigae
Sat	22nd	pm	Comet 46P/Wirtanen 1.2° NW of star Eta (η) Aurigae
Sun	23rd	3:49 am	(1:49 am WST) Full Moon (363,368 km)
Sun	23rd	pm	Comet 46P/Wirtanen 1.4° S of star Capella
Mon	24th	6 pm	(4 pm WST) star Pollux 7° N of Moon
Mon	24th	8 pm	(6 pm WST) Moon at perigee, 361,061 km
Wed	26th		Venus at perihelion
Wed	26th		Mercury 0.6° N of NGC 6235 (GC) in Ophiuchus
Thu	27th	3 am	(1 am WST) star Regulus 3° S of Moon
Thu	27th	pm	m.p. 6 Hebe 0.2° NE of Collinder 92 (OC) in Monoceros
Fri	28th		Mercury 0.6° N of NGC 6287 (GC) in Ophiuchus
Fri	28th	1 am	(11 pm WST, prev day) m.p. 3 Juno stationary
Sat	29th	Noon	(10 am WST) d.p. 1 Ceres 3° N of Venus
Sat	29th	7:34 pm	(5:34 pm WST) Last Quarter Moon
Sun	30th	5 pm	(3 pm WST) m.p. 2 Pallas 3° S of Moon
Sun	30th	8 pm	(6 pm WST) star Spica 8° S of Moon





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





ALL SKY MAPS

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

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

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

How Do I Use Them? There are nine maps. Map 1 *Looking South* covers the far southern sky. Then there are four pairs of maps, one pair (a Centre and a North map) for each season.

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

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

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

What does the fine black grid represent? These are the right ascension (RA) and declination (Dec.) lines. The RA line, which starts on the due north point (N on the North charts) and runs vertically up the page, crossing through the point directly overhead and heading down to the southern horizon, is called the local central meridian. When objects cross this meridian they are said to be culminating and they have reached their highest point in the sky. Looking at the Spring (North) chart, the RA of the central meridian at 11 pm on 20 August is approximately 21 hours (as an aside this is also the definition of the local sidereal time, see page 144). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1 am) the star Alpha (α) Pegasi (Markab), with an RA close to 23 hours, will culminate.

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

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

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

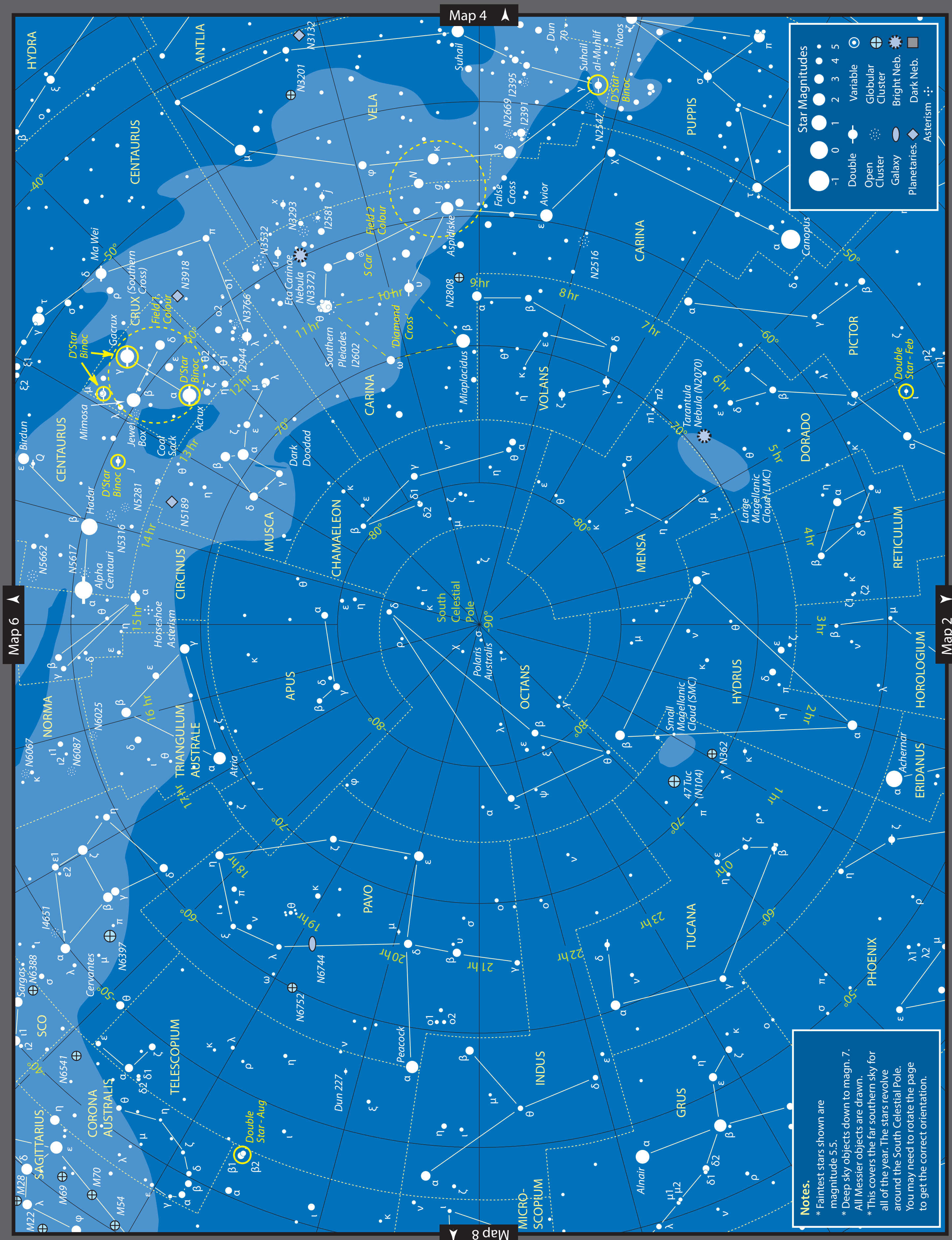
What else is shown on the maps?

- Deep sky objects down to magnitude 7 and all of the Messier objects (see the legend). These objects are identified by their common names (such as asterisms), Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope. There are occasionally other objects included when referred to elsewhere in the book.
- Star Names. The number of named stars has been extended this year to include 230 officially approved by the International Astronomical Union's Working Group on Star Names (WGSN) as of 2016. There were 10 not included either being too far north or too faint for the limiting magnitude of our maps (e.g., Barnard's Star and Proxima Centauri)
- Constellation lines. The yellow dotted lines are the boundaries and the solid lines joining some of the brighter stars help recognise the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A light blue shading shows the Milky Way and Magellanic Clouds.

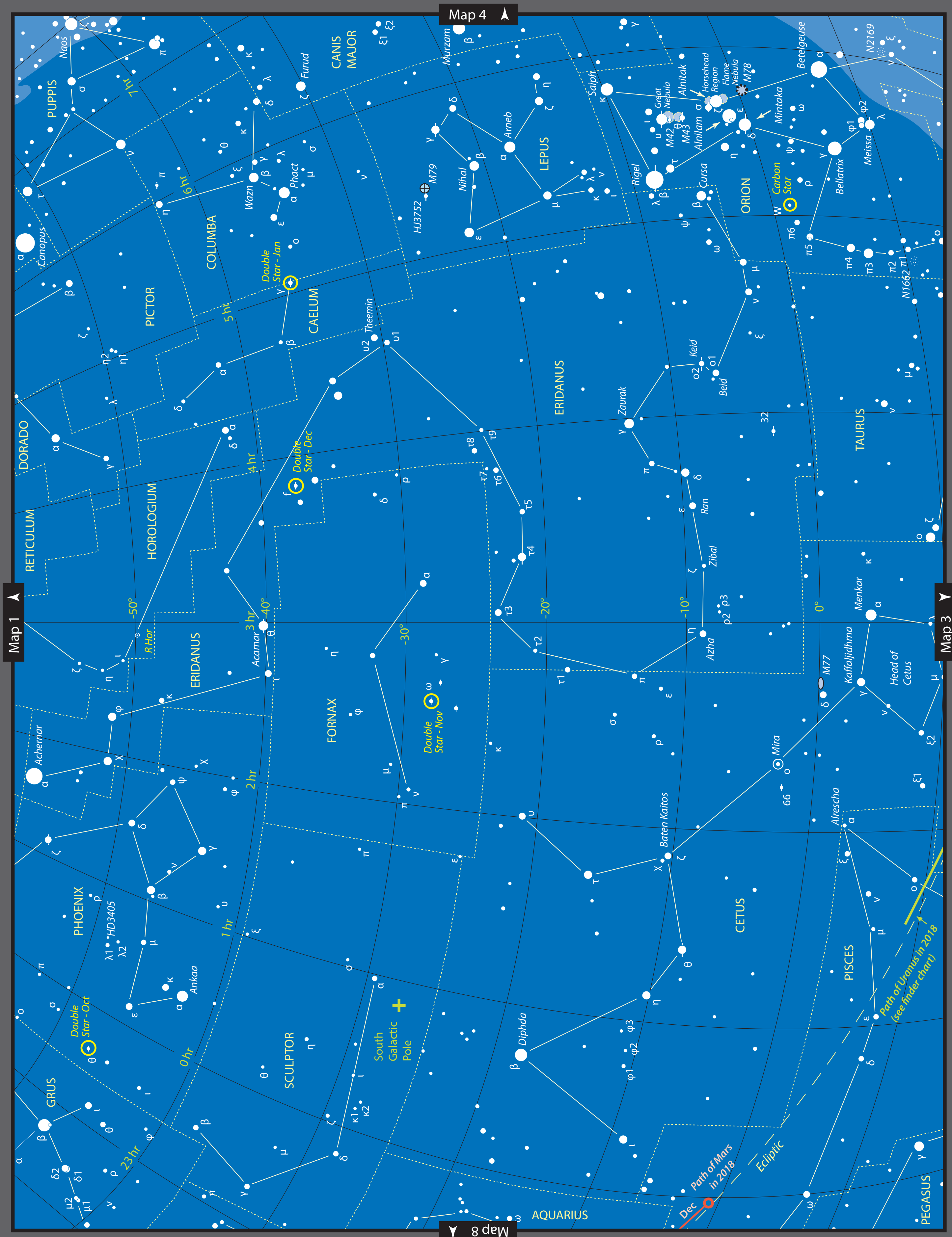
Special objects marked this year are:

- The monthly double stars, those mentioned in the Part I sections, are labelled with the specific month and circled.
- The stars mentioned in the binocular doubles feature are circled and marked as "D'Star Binoc"
- The coloured stars feature mentions four specific binocular fields. These are shown as 7° diameter dashed circles. Also, the three (red) carbon stars are labelled.
- Minor planet Vesta when visible to the naked eye near opposition.

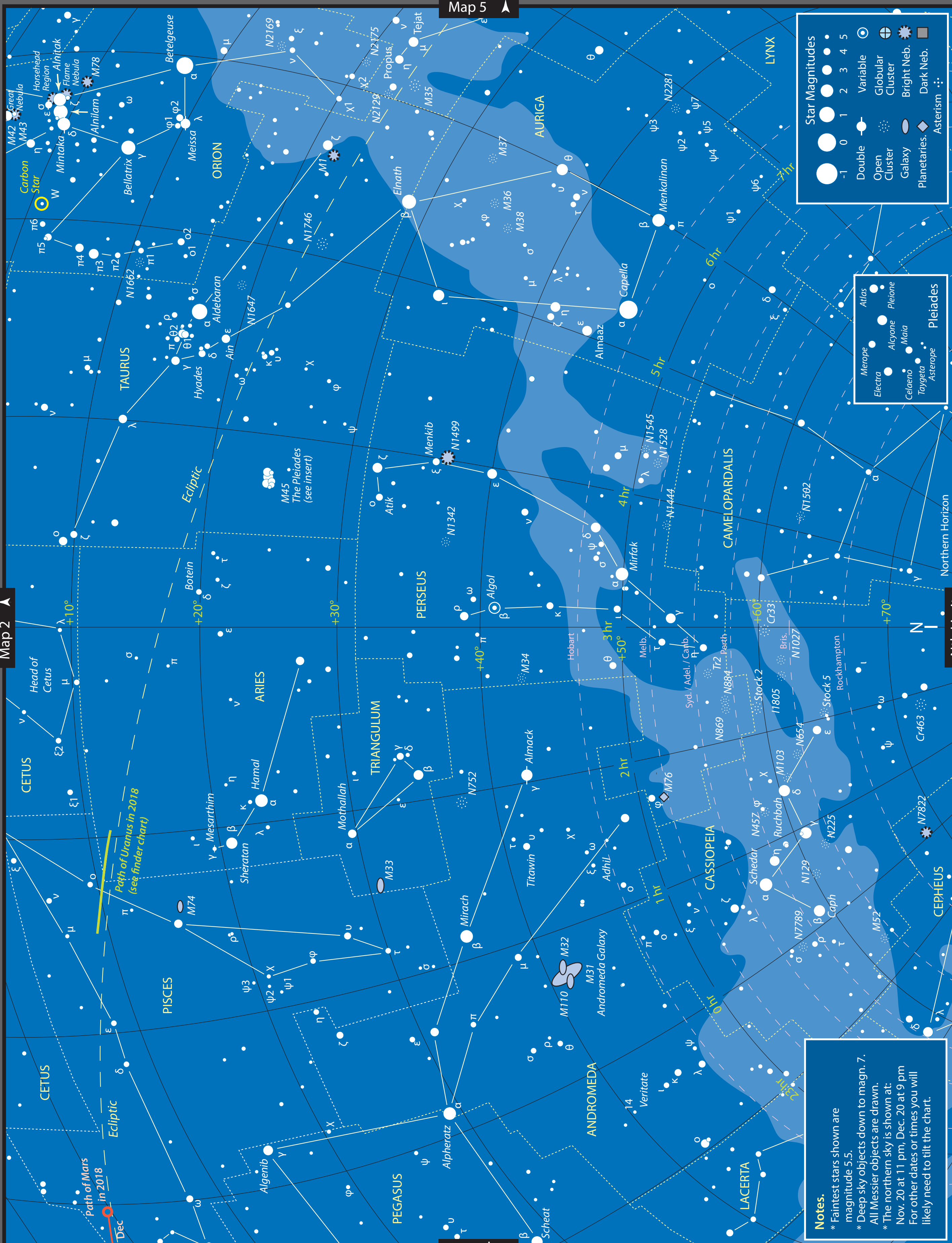
Map 1 - Looking South



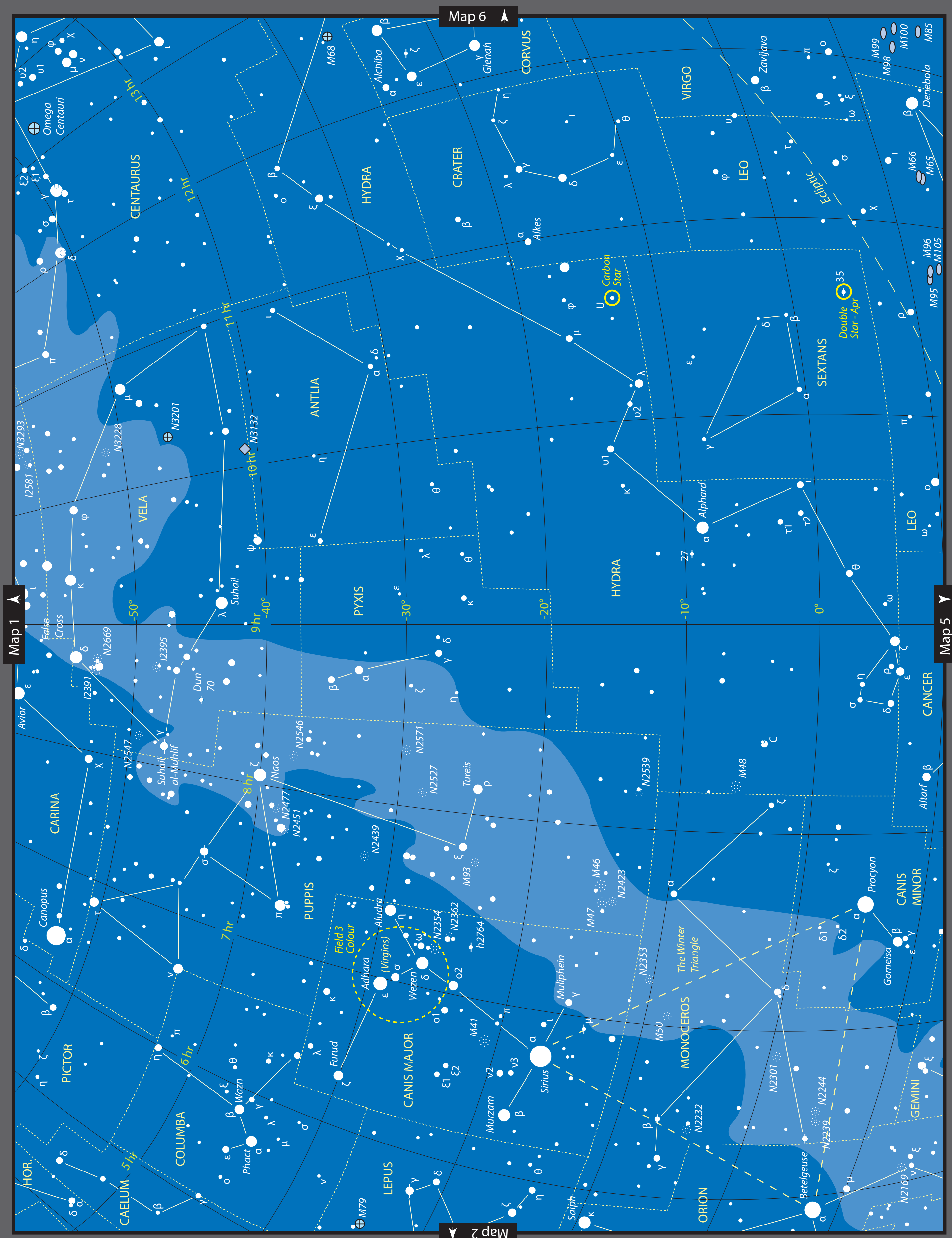
Map 2 - Summer (Centre)



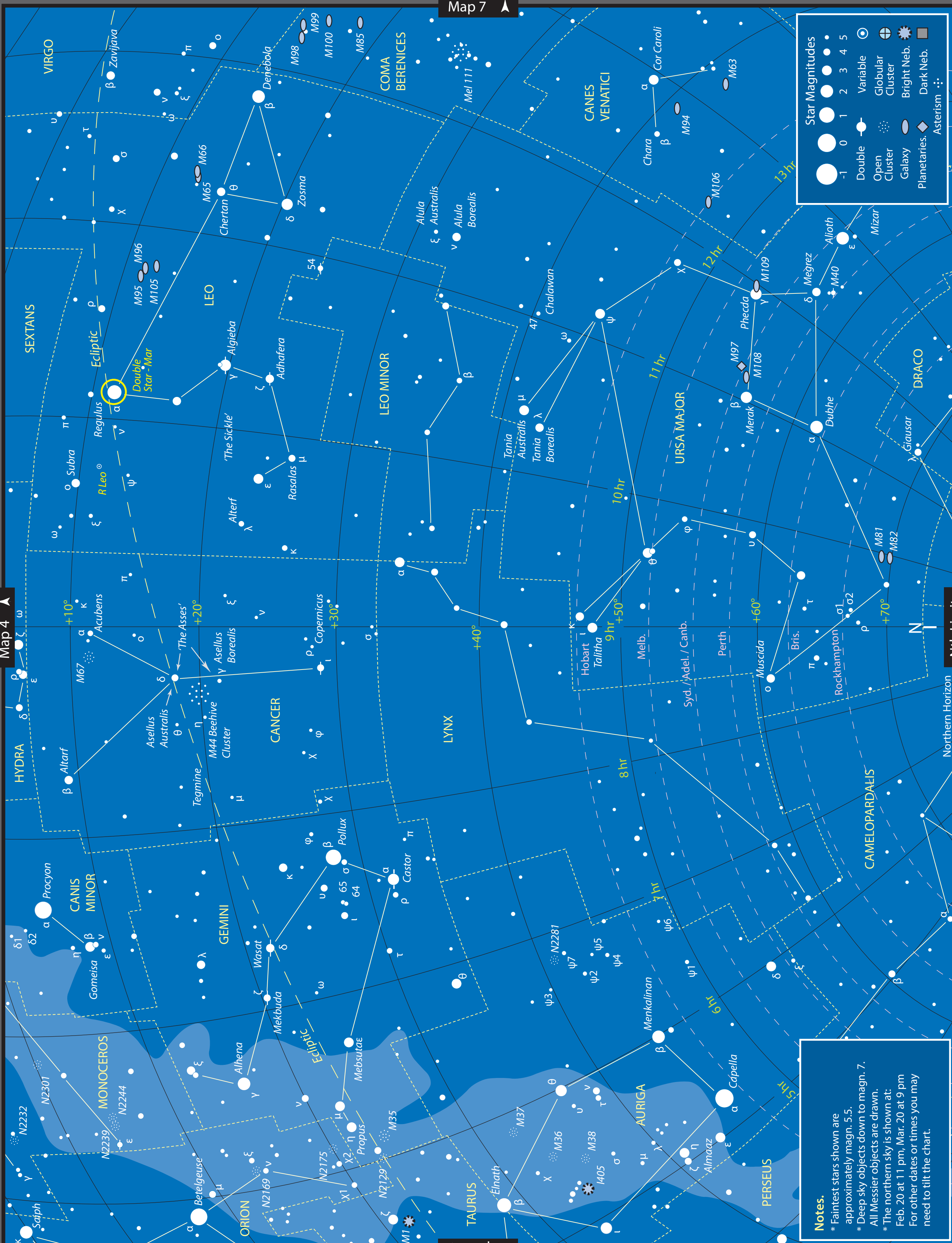
Map 3 - Summer (North)



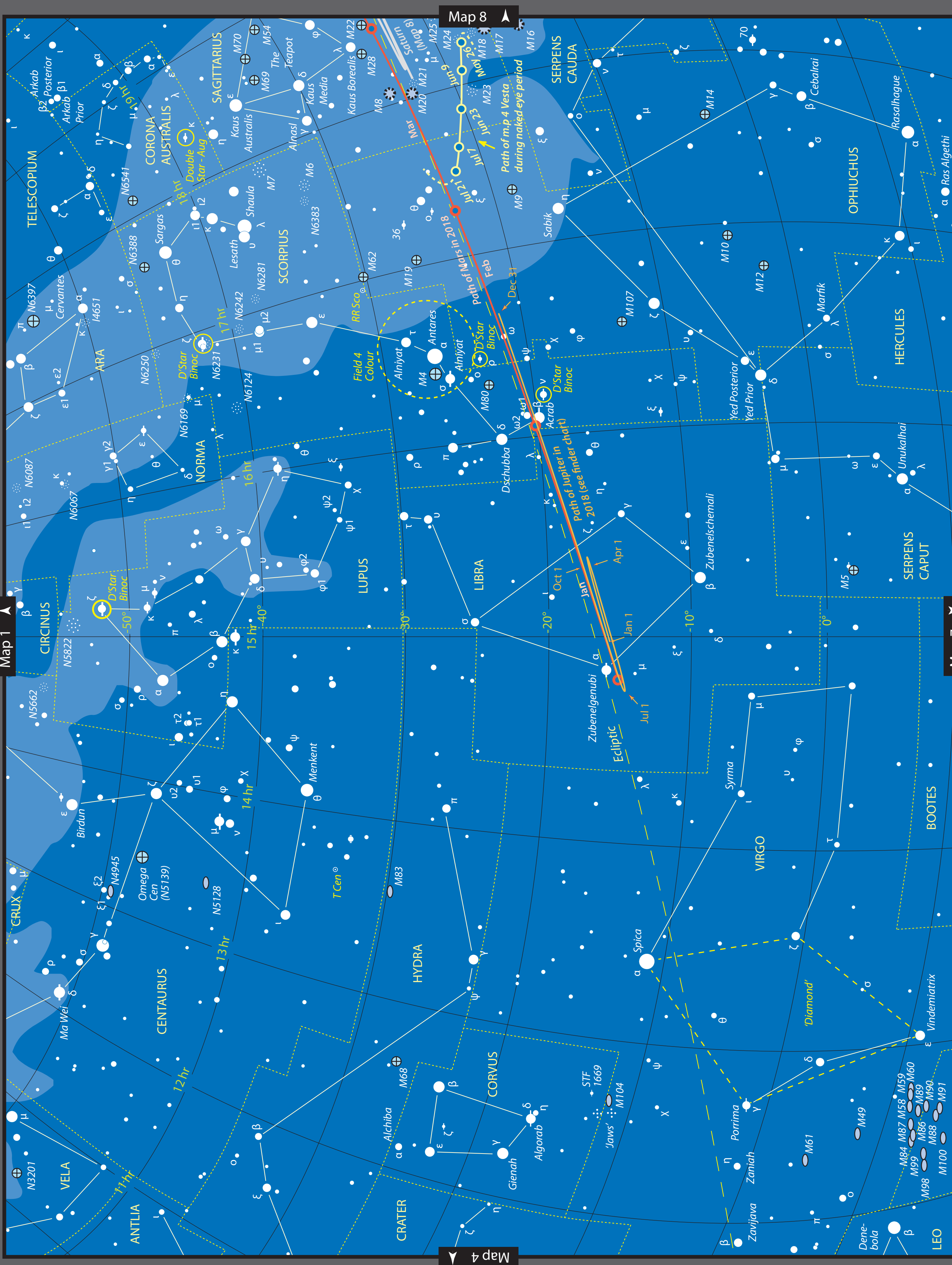
Map 4 - Autumn (Centre)



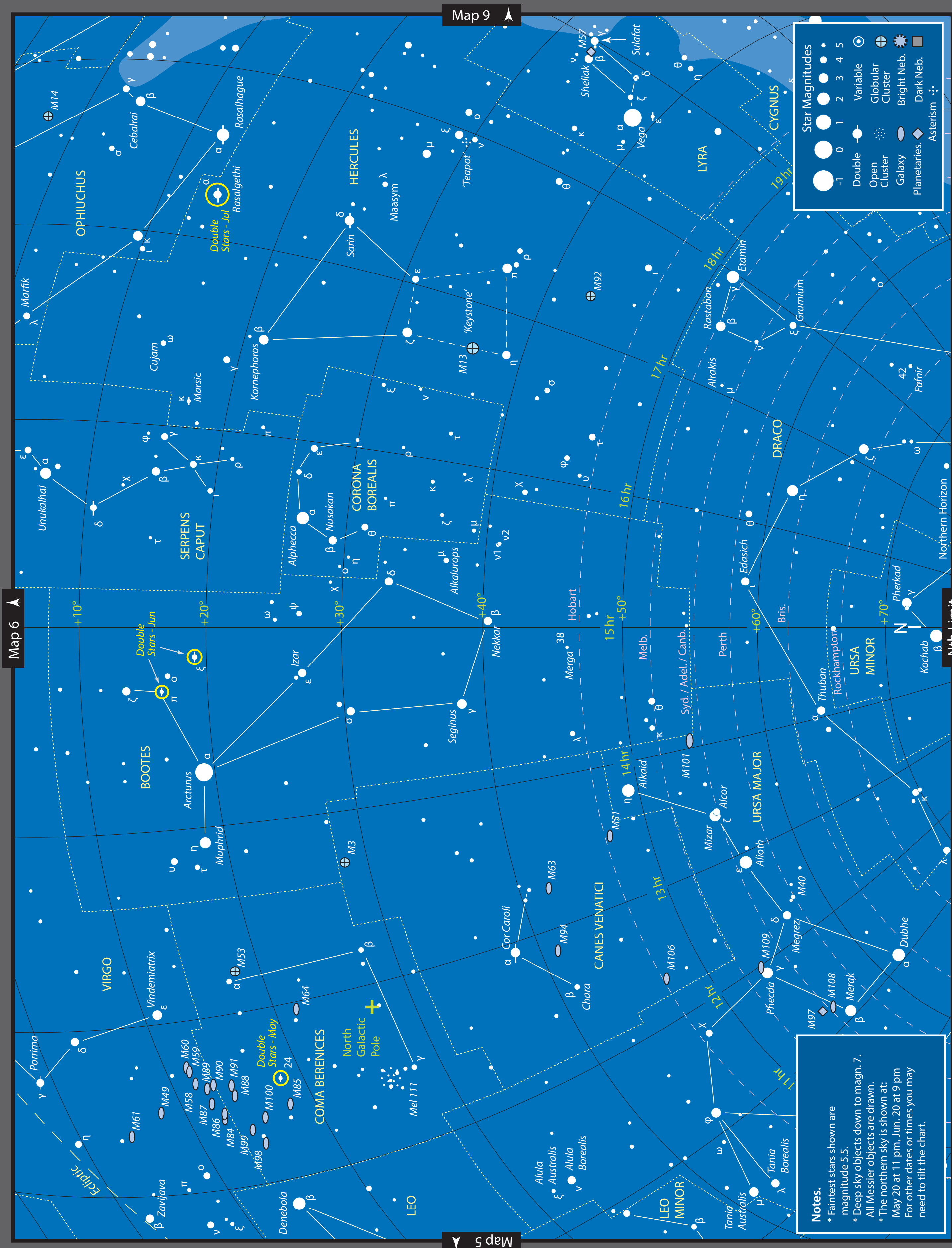
Map 5 - Autumn (North)



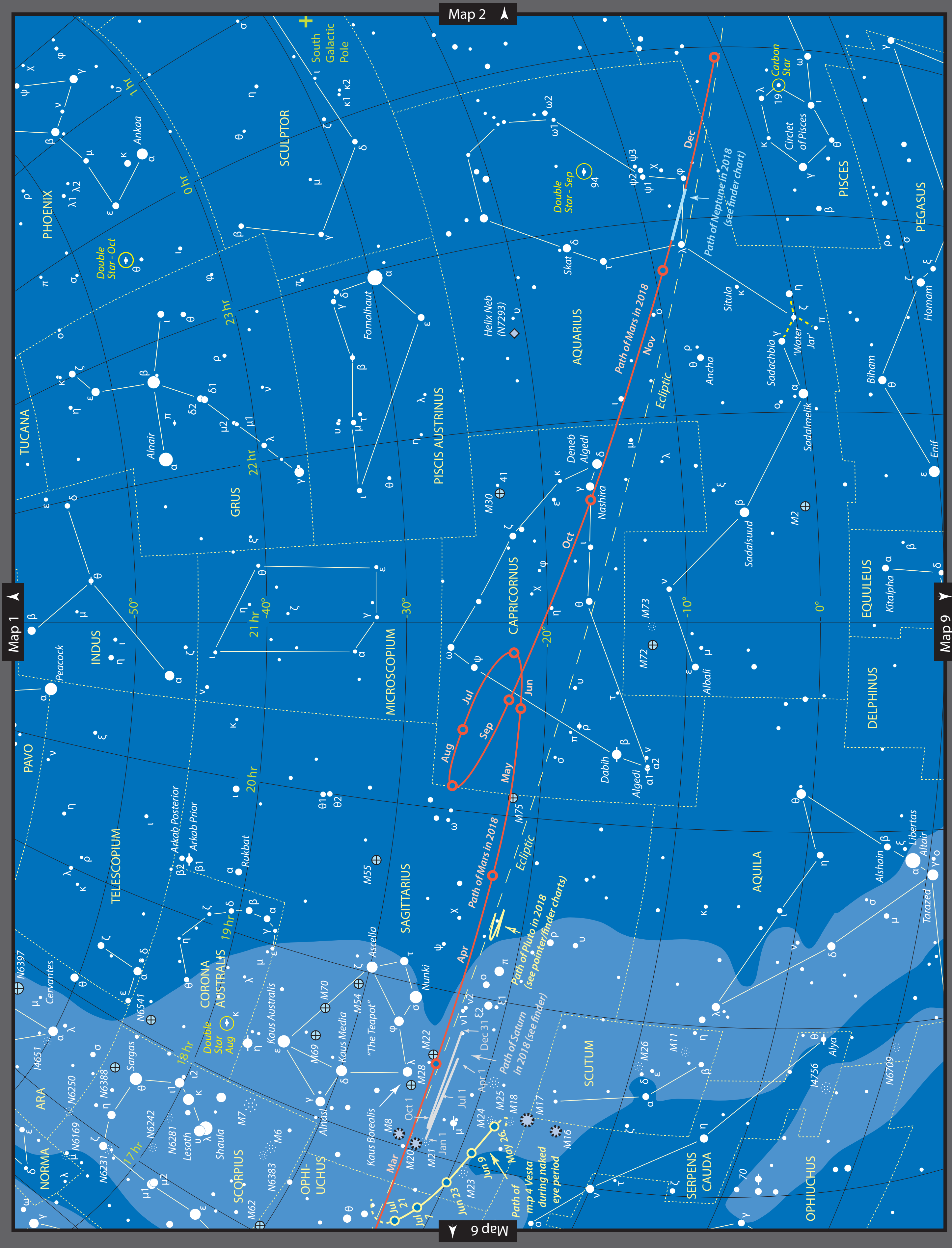
Map 6 - Winter (Centre)



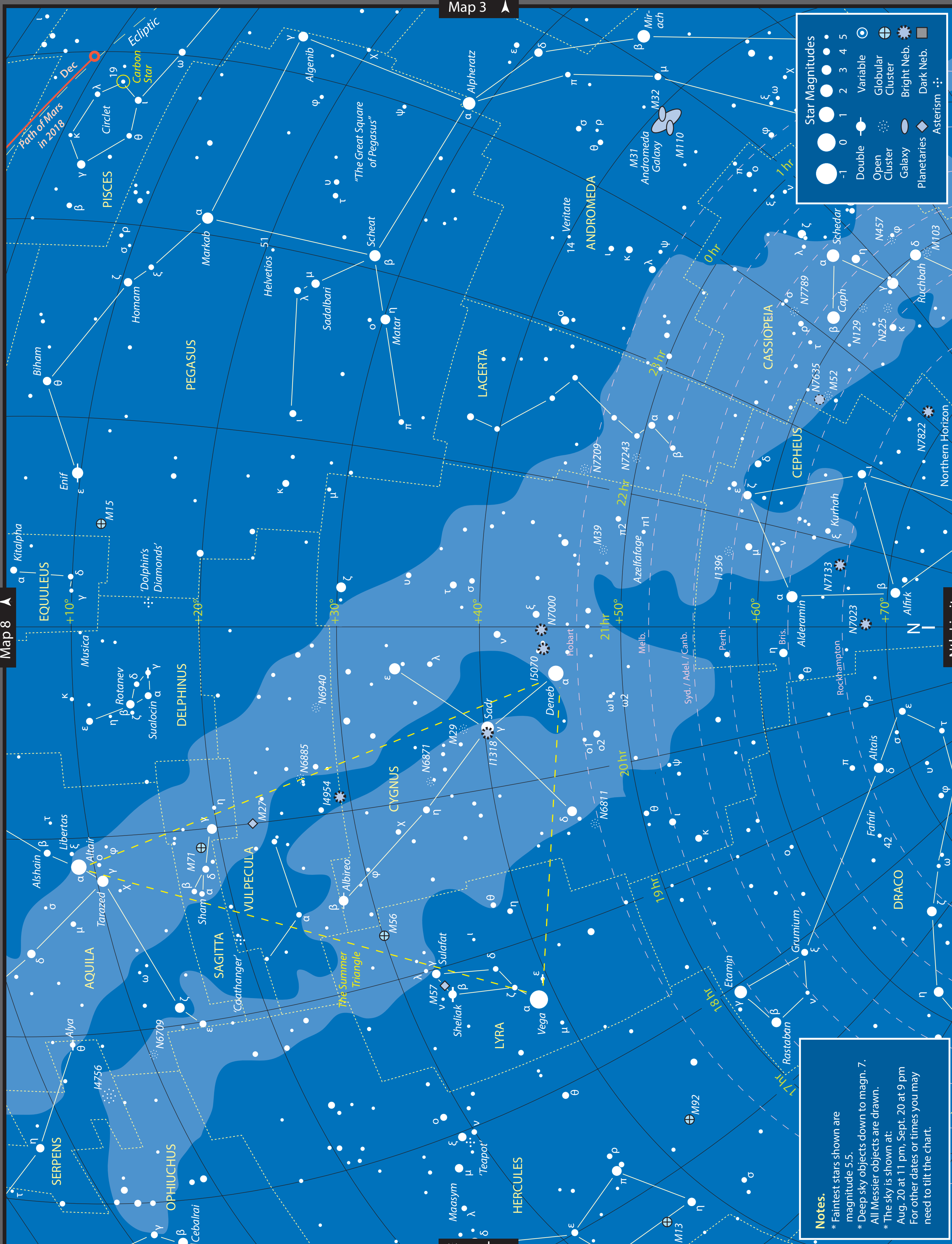
Map 7 - Winter (North)



Map 8 - Spring (Centre)



Map 9 - Spring (North)



PART II — THE SOLAR SYSTEM

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

Time. There are four time zones used in Part II: Eastern Standard Time (EST), Central Standard Time (CST), Western Standard Time (WST) and Universal Time (UT).These are used wherever we have 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 will need to add one hour to the times given.

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

The 24 hour clock is often used in astronomy for example, 16:00 is the same as 4:00 pm. This avoids the need to distinguish between 'am' and 'pm' and is frequently used in Part II of this book, for example for rising and setting 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 Coordinates or Positions. The astronomical positions are given in equatorial coordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one-hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations; those south have negative (–). The Right Ascension and Declination grid has been marked on the All Sky Maps (see previous pages). The RA has a line for each hour and the Declination has a line every 10°. The finders also have them marked.

The Earth's daily rotation on its polar axis causes the stars to appear to rotate around a point in the sky. From southern latitudes, including Australia, this point is called the South Celestial Pole and is at declination –90° (see All Sky Map 1 in the All Sky Maps). The North Celestial Pole, not visible from the Southern Hemisphere, is at +90°. The celestial equator and poles can be described as projections on the sky of their terrestrial counterparts.

Position Tables. Right Ascension and Declination are calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Positions for the planets, dwarf and minor planets and comets are given in weekly intervals and correspond to Saturdays. Positions for the Sun and Moon are not included.

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 Moonrise and sets are daily, the remainder are weekly and correspond to Saturdays. Also see note on time zones (above).

Use of Star Atlases. As the Earth orbits the Sun the polar axis, around which the stars rotate (the celestial poles) appears to never change no matter what time of the year you are observing. However, the positions of the 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 as it slows down, 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, that is east to the left, and north to the top (in the sky, east and west are opposite to terrestrial maps). Binoculars (and the eyes) or straight Newtonians show this appearance (the Newtonian image will be upside down). 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.

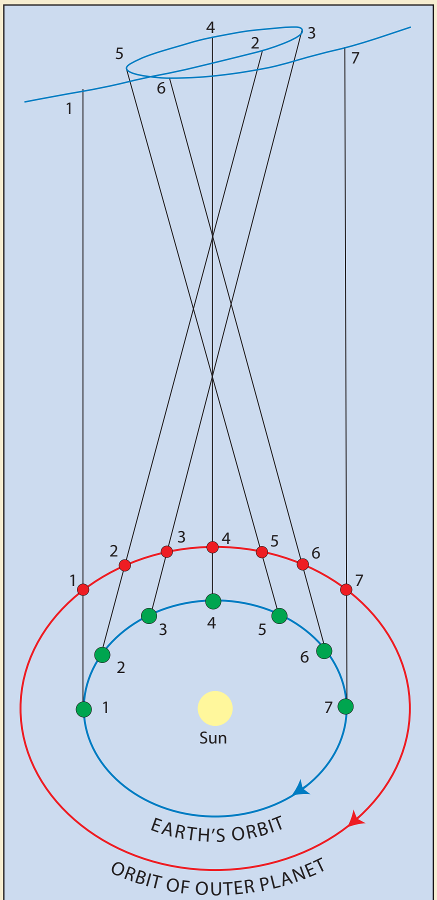
Finder Charts. No finder charts are presented for the Moon, Mercury, Venus or Mars. Their rapid motion during the year causes them to cover a very large section of the sky, which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams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

RETROGRADE MOTION

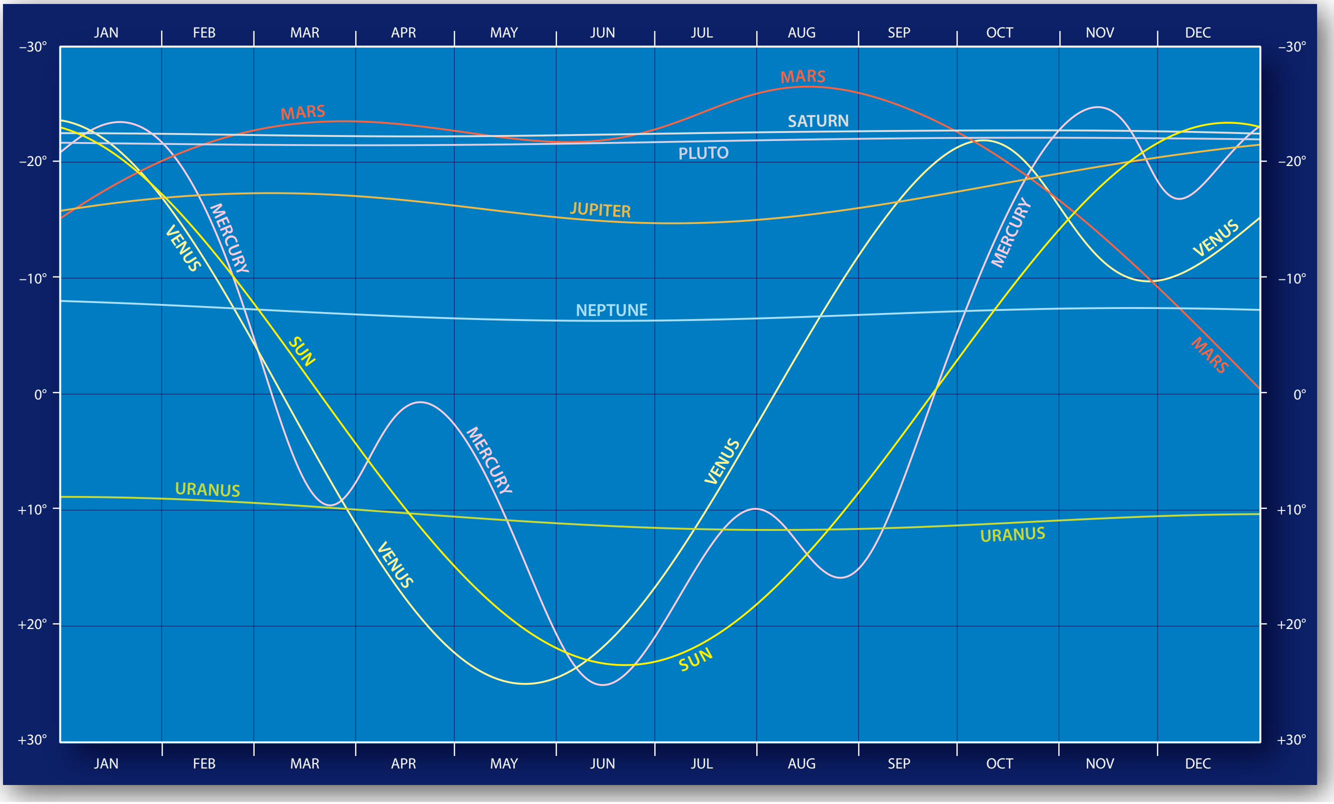
The finder charts for the outer planets have one thing in common, an apparent motion with a loop or 'S' shape. This only applies to the period during opposition. See the All Sky Maps or the Finder Charts for examples. The diagram below illustrates the combined effects of the orbital motions of Earth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

In the diagram, the top section represents the path of an outer planet against the celestial sphere viewed from the south (below the ecliptic). As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is a loop in its path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and during this time the planet appears to move among the stars 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 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, thus having some north/south motion, the path can never be a straight line. It will always be a loop or an S-bend.

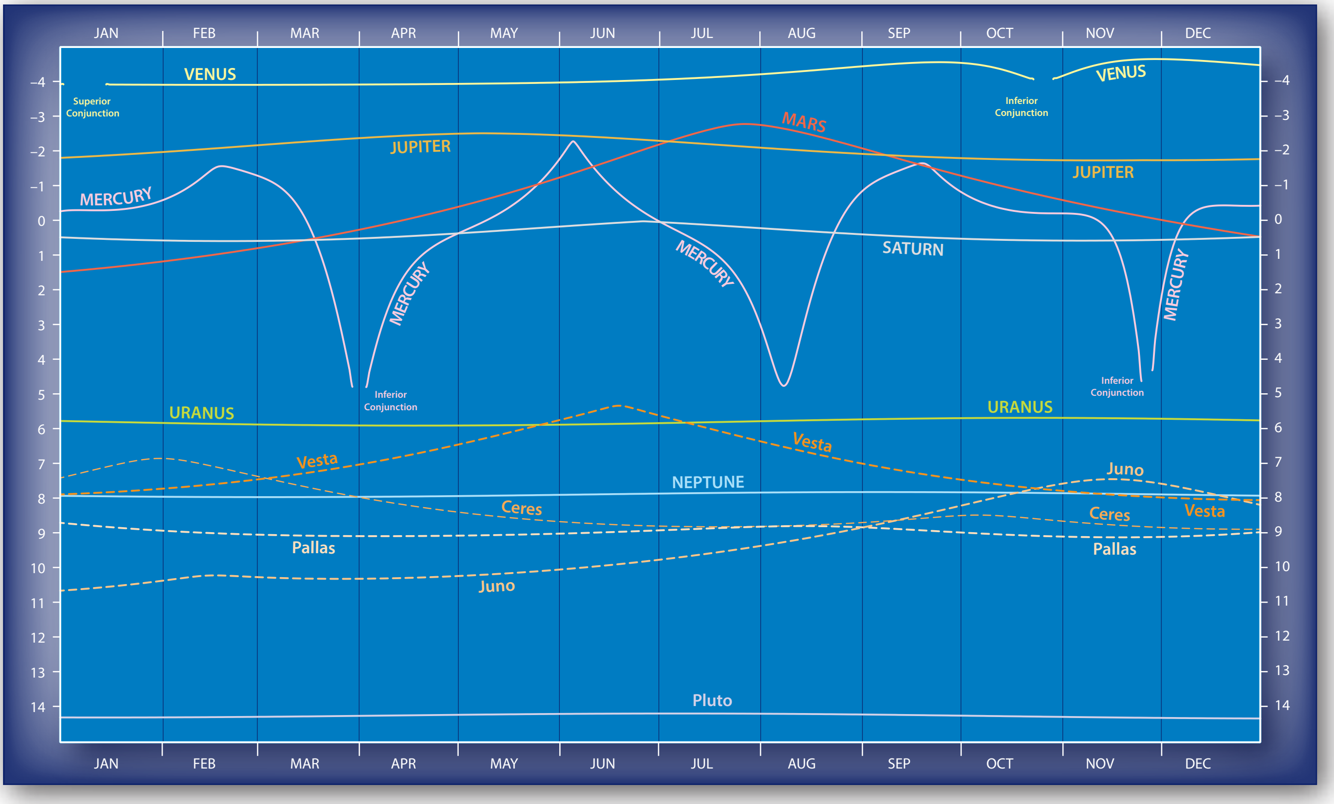


DECLINATIONS of the SUN, PLANETS and PLUTO



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

MAGNITUDES of the PLANETS, BRIGHT DWARF and MINOR PLANETS



GEOCENTRIC PHENOMENA (UT)

Planet	Greatest Elongation West	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary
Mercury	1 Jan, 20h (22.7°) 29 Apr, 18h (27.0°) 26 Aug, 21h (18.3°) 15 Dec, 12h (21.3°)	17 Feb, 12h 6 Jun, 02h 21 Sep, 02h	15 Mar, 15h (18.4°) 12 Jul, 05h (26.4°) 6 Nov, 16h (23.3°)	22 Mar, 17h 25 Jul, 7h 17 Nov, 5h	1 Apr, 18h 9 Aug, 02h 27 Nov, 09h	14 Apr, 4h 18 Aug, 12h 6 Dec, 20h
Venus		9 Jan, 07h	17 Aug, 18h (45.9°)	5 Oct, 4h	26 Oct, 14h	14 Nov, 3h

Planet	Conjunction	Stationary	Opposition	Stationary	Conjunction	Stationary	Opposition	EARTH	
Mars		28 Jun, 14h	27 Jul, 05h	28 Aug, 10h				Perihelion	3 Jan, 06h
Jupiter		9 Mar, 10h	9 May, 01h	11 Jul, 4h	26 Nov, 07h			Equinox	20 Mar, 16h
Saturn		18 Apr, 2h	27 Jun, 13h	6 Sep, 10h				Solstice	21 Jun, 10h
Uranus				2 Jan, 21h	18 Apr, 14h	7 Aug, 21h	24 Oct, 01h	Aphelion	6 Jul, 17h
Neptune	4 Mar, 14h	19 Jun, 12h	7 Sep, 18h	25 Nov, 8h				Equinox	23 Sep, 02h
Pluto	9 Jan, 10h	23 Apr, 2h	12 Jul, 10h	30 Sep, 16h				Solstice	21 Dec, 22h

HELIOCENTRIC PHENOMENA (UT)

Planet	Aphelion	Perihelion	Descending Node	Greatest Latitude South	Ascending Node	Greatest Latitude North
Mercury	Jan 25 Apr 23 Jul 20 Oct 16	Mar 10 Jun 6 Sep 2 Nov 29	Jan 15 Apr 13 Jul 10 Oct 6	Feb 14 May 13 Aug 9 Nov 5	Mar 5 Jun 1 Aug 28 Nov 24	Mar 20 Jun 16 Sep 12 Dec 9
Venus	Jan 23 Sep 5	May 15 Dec 26	Aug 1	Feb 14 Sep 27	Apr 12 Nov 22	Jun 6
Mars		Sep 16	Mar 16	Aug 21		
Saturn	Apr 17					
Jupiter, Uranus, and Neptune have no events in 2018						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS and PLUTO

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun ($\times 10^3$ km)	-	-	57856	108132	149492	227780	777776	1425983	2867760	4492800	5745000
Mean Distance from Sun (Earth = 1)	-	-	0.387	0.723	1.000	1.524	5.203	9.540	19.180	30.700	39.670
Magnitude at Opposition	–26.8	–12.74 [11]	0.16 [12]	–4.07 [12]	–3.5 [13]	–2.01	–2.70	0.67	5.52	7.84	13.7
Equatorial Diameter (km)	1392530	3474.8	4879.4	12103.6	12756.3	6792.4	142984	120536	51118	49528	2370
Flattening [1]	0	0	0	0	0.00335281	0.005886	0.064874	0.097962	0.022927	0.017081	0
No of Moons	-	-	0	0	1	2	69	62	27	14	5
Mass ($\times 10^{24}$ kg)	1.9884×10^{30}	0.073458	0.3301	4.8673	5.9721986	0.64169	1898.1	568.31	86.809	102.41	0.013041
Mass (Earth = 1)	332946	0.012300	0.0553	0.8150	1.0000000	0.10745	317.8	95.16	14.536	17.148	0.002184
Volume (Earth = 1)	1300000	0.02	0.06	0.86	1	0.15	1323	752	64	54	0.007
Sidereal Period [2]	-	27.32 d	87.97 d	224.7 d	365.256 d	687 d	11.86 y	29.46 y	84.01 y	164.8 y	249.9 y
Synodic Period (Days) [3]	-	29.4	115.8	583.9	-	779.8	398.8	378.0	369.7	367.5	366.7
Axial Rotation (Days) [4]	25.38 [9]	27.32166	58.6462	–243.0185	0.99726963	1.02595676	0.41354 [14]	0.44401 [14]	–0.71833	0.67125	–6.3872
Albedo [5]	-	0.12	0.106	0.65	0.367	0.150	0.52	0.47	0.51	0.41	0.3
Eccentricity [6]	-	0.0549	0.20562	0.00681	0.01681	0.09333	0.04837	0.05582	0.0471	0.00855	0.2486
Inclination [7]	-	5° 08' 40"	7° 00' 00"	3° 23' 38"	0° 00' 00"	1° 51' 01"	1° 18' 28"	2° 29' 29"	0° 46' 22"	1° 46' 38"	17° 09' 00"
Obliquity [8]	7° 15' [10]	6° 41'	0° 01'	2° 38'	23° 26'	25° 11'	3° 07'	26° 45'	82° 14'	28° 20'	60° 25'

Notes:

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

The satellite table (right) covers those currently known (as of August 2017). Some are not yet named, instead they have a preliminary designation such as S/2007 S3.

SOLAR SYSTEM DATA — SATELLITES

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (×10³ km)	RADIUS (km)	MAG AT OPP
Earth	Moon	27.321661		384.400	1,737.4	–12.74
Mars	Phobos	0.31891023	25"	9.380	13.4×11.2×9.2	11.9
	Deimos	1.2624407	1' 02"	23.460	7.5×6.1×5.2	13.0
Jupiter	Metis	0.295	42"	128.00	30 x 20 x 17	17.5
	Adrastea	0.298	42"	129.00	10 x 8 x 7	18.7
	Amalthea	0.49817908	59"	181.40	125 x 73 x 64	14.1
	Thebe	0.675	01' 13"	221.90	58 x 49 x 42	16.0
	Io	1.769137761	02' 18"	421.80	1829 x 1819 x 1816	5.0
	Europa	3.551181055	03' 40"	671.10	1563 x 1560 x 1560	5.3
	Ganymede	7.15455325	05' 51"	1,070.40	2631.2	4.6
	Callisto	16.689017	10' 18"	1,882.70	2410.3	5.7
	Themisto	130.02	40' 44"	7504	4	21.0R
	Leda	240.93	1° 00' 58"	11,164.00	5 [15]	19.0
	Himalia	250.56	1° 02' 34"	11,460.00	85	14.6
	Lysithea	259.20	1° 03' 58"	11,717.00	12 [15]	18.3
	Elara	259.64	1° 04' 03"	11,740.00	40	16.3
	Dia	287.0	1° 06' 15"	12,118.00	1.0 [15]	22.4
	Carpo	455.07	1° 33' 14"	17,056.04	1.5 [15]	23.0
	S/2003 J 12	489.67	1° 49' 12"	17830	0.5	23.9R
	Euporie	555.2 [16]	1° 46' 38"	19,509.12	1.0 [15]	23.1
	S/2003 J 3	583.87	1° 44' 24"	20221	1	23.4R
	Chaldene	591.7 [16]	1° 50' 57"	20,299.46	1.9 [15]	22.5
	Mneme	599.65 [16]	1° 52' 03"	20,500.28	1.0 [15]	23.3
	S/2003 J 18	598.13	2°	20508	1	23.4R
	Helike	601.40 [16]	1° 52' 16"	20,540.27	2.0 [15]	22.6
	Iocaste	606.3 [16]	1° 52' 50"	20,642.86	2.6 [15]	22.5
	S/2016 J 1	602.7		20650.845	0.5	24
	Thyone	610.0 [16]	1° 53' 31"	20,769.90	2.0 [15]	22.3
	Orthosie	613.6 [16]	1° 53' 58"	20,849.89	1.0 [15]	23.1
	Harpalyke	617.3 [16]	1° 54' 20"	20,917.72	2.2 [15]	22.2
	Euanthe	620.9 [16]	1° 54' 41"	20,983.14	1.5 [15]	22.8
	S/2010 J 2	618.84		21004	1	24.0R
	Hermippe	624.6 [16]	1° 55' 03"	21,047.99	2.0 [15]	22.1
	S/2003 J 16	622.88	1° 58' 48"	21097	1	23.3R
	Praxidike	624.6 [16]	1° 55' 19"	21,098.10	3.4 [15]	22.5
	Ananke	629.80 [16]	1° 55' 03"	21,254.00	10 [15]	18.8
	Thelxinoe	635.82 [16]	1° 56' 31"	21,316.68	1.0 [15]	23.5
	Taygete	650.1 [16]	1° 58' 27"	21,671.85	2.5 [15]	22.9
	Erinome	661.1 [16]	1° 59' 31"	21,867.75	1.6 [15]	22.8
	Aitne	679.3 [16]	2° 01' 44"	22,274.41	1.5 [15]	22.7
	Kale	679.4 [16]	2° 01' 53"	22,300.64	1.0 [15]	23.0
	Kallichore	681.94 [16]	2° 02' 04"	22,335.35	1.0 [15]	23.7
	Sponde	690.3 [16]	2° 03' 14"	22,548.24	1.0 [15]	23.0
	S/2003 J 15	689.78	2° 7' 48"	22627	1	23.5R
	Isonoe	704.9 [16]	2° 04' 38"	22,804.70	1.9 [15]	22.5
	Hegemone	715 [16]	2° 05' 44"	23,006.33	1.5 [15]	22.8
	S/2003 J 10	716.25	2° 19' 48"	23042	1	23.6R
	Herse	715.4 [16]	2° 06' 14"	23,097.00	1.0 [15]	23.4
	S/2011 J 2	718.37		23124	1	23.5R
	S/2003 J 9	733.32	2° 9' 36"	23385	0.5	23.7R
	Carme	734.17 [16]	2° 07' 14"	23,401.00	15 [15]	17.6
	Megaclite	734.1 [16]	2° 08' 06"	23,439.08	2.7 [15]	22.1
	S/2011 J 1	736.35		23446	1	23.7R
	S/2010 J 1	736.5		23449	1	23.2R
	Eukelade	735.27 [16]	2° 08' 21"	23,485.28	2.0 [15]	22.6
	S/2003 J 5	738.75	2° 19' 12"	23495	2	22.4R
	S/2003 J 19	740.41	2° 12' 0"	23533	1	23.7R
	Cyllene	737.80 [16]	2° 08' 41"	23,544.84	1.0 [15]	23.2
	S/2017 J 1	734.2		23547.105	1	23.8
	S/2003 J 23	732.46	2° 19' 12"	23567	1	23.6R

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (×10³ km)	RADIUS (km)	MAG AT OPP
Jupiter	Pasiphae	743.61 [16]	2° 09' 18"	23,629.00	18 [15]	17.0
	Aoede	747 [16]	2° 09' 46"	23,743.83	2.0 [15]	22.5
	Arche	748.7 [16]	2° 09' 53"	23,765.12	1.5 [15]	22.8
	Pasithee	748.76 [16]	2° 09' 58"	23,780.14	1.0 [15]	23.2
	Eurydome	752.4 [16]	2° 10' 14"	23,830.94	1.5 [15]	22.7
	S/2003 J 4	755.25	2° 14' 24"	23929	1	23.0R
	Sinope	758.89 [16]	2° 10' 20"	23,942.00	14 [15]	18.1
	Kalyke	767 [16]	2° 11' 54"	24,135.61	2.6 [15]	21.8
	Autonoe	778.0 [16]	2° 13' 25"	24,413.09	2.0 [15]	22.0
	Callirrhoe	736 [16]	2° 14' 25"	24,596.24	4.3 [15]	20.7
	Kore	807.20 [16]	2° 16' 29"	24,974.03	1.0 [15]	23.6
	S/2003 J 2	980.53	2° 42' 36"	28347	1	23.2R
Saturn	S/2009 S1	0.4715	19"	117	0.15	
	Pan	0.575	22"	133.58	14.2	19.4
	Daphnis	0.594	22"	136.50	3.9	23.4
	Atlas	0.602	22"	137.67	20.9×18.1×8.9	19.0
	Prometheus	0.613	22"	139.38	66.3×39.5×30.7	15.8
	Pandora	0.629	23"	141.72	51.6×39.8×32.0	16.4
	Epimetheus	0.694	24"	151.41	58.0×58.7×53.2	15.6
	Janus	0.695	24"	151.46	97.4×96.9×77.2	14.4
	Aegaeon	0.8081	27" 15	167.5	0.25	27R
	Mimas	0.942421813	30"	185.54	207×197×191	12.8
	Methone	1.01	31"	194.44	1.6	25.1
	Anthe	1.037	32"	197.70	1 15	26 15
	Pallene	1.14	34"	212.28	2.2	24.5
	Enceladus	1.370217855	38"	238.20	257×251×248	11.8
	Calypso	1.888	48"	294.71	15.0×11.5×7	18.7
	Telesto	1.888	48"	294.71	15.7×11.7×10.4	18.5
	Tethys	1.887802160	48"	294.99	540×531×528	10.3
	Polydeuces	2.74	1' 01"	377.20	1.3	24.8
	Helene	2.737	1' 01"	377.42	16.5	18.4
	Dione	2.736914742	1' 01"	377.65	562	10.4
	Rhea	4.517500436	1' 25"	527.37	764	9.7
	Titan	15.94542068	3' 17"	1,221.80	2,575	8.4
	Hyperion	21.2766088	3' 59"	1,481.10	164×130×107	14.4
	Iapetus	79.3301825	9' 35"	3,561.85	736	11.0
	Kiviuq	449.2	30' 27"	11,319.01	8 15	22.7
	Ijiraq	451.4	30' 33"	11,359.25	6 15	22.6
	Phoebe	548.2 16	34' 41"	12,893.24	110	16.7
	Paaliaq	686.9	40' 18"	14,985.05	13 15	21.0
	Skathi	728.2 16	41' 37"	15,471.94	4 15	23.6
	Albiorix	783.5	44' 22"	16,495.93	16 15	20.5
	S/2007 S2	799.8975	0° 46' 48"	16,560	3	24.4
	Bebhionn	834.8	45' 36"	16,950.00	3 15	24.1
	Skoll	878.3 16	47' 22"	17,610.00	3 15	24.5
	Erriapus	871.2	47' 54"	17,807.71	5 15	23.9
	Tarqeq	887.5	48' 12"	17,920.00	3.5 15	23.9
	Tarvos	926.2	48' 21"	17,977.24	7 15	22.3
	Greip	921.2 16	48' 42"	18,105.00	3 15	24.4
	Siarnaq	895.6	48' 57"	18,201.44	21 15	20.4
	Hyrrokkin	931.8 16	49' 00"	18,217.13	4 15	23.5
	Mundilfari	952.6 16	49' 32"	18,412.67	3 15	23.8
	S/2004 S13	905.82	0° 52' 48"	18,450	3	24.5
	S/2004 S17	913.125	0° 53' 24"	18,600	2	25.2
	Bergelmir	1,005.9 16	50' 26"	18,750.00	3 15	24.2
	S/2006 S1	971.565	0° 54' 0"	18,981.135	3	24.6
	Narvi	1,003.9 16	51' 29"	19,140.48	2.5 15	23.8
	Suttungr	1,016.7 16	51' 36"	19,185.70	4 15	23.9
	A egir	1,116.5 16	52' 03"	19,350.00	3 15	24.4
	S/2004 S12	1,048.2675	0° 57' 0"	19,650	2.5	24.8

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (×10³ km)	RADIUS (km)	MAG AT OPP
Saturn	Bestla	1,083.6 16	52' 51"	19,650.00	3.5 15	23.8
	S/2004 S7	1,103.055	0° 57' 0"	19,800	3	24.5
	Farbauti	1,086.1 16	53' 15"	19,800.00	2.5 15	24.7
	Hati	1,038.7 16	53' 40"	19,950.00	3 15	24.4
	Thrymr	1,094.3 16	53' 41"	19,957.54	4 15	23.9
	S/2007 S3	1,099.4025	0° 58' 48"	20,578	2.5	24.9
	S/2006 S3	1,143.2325	1° 0' 0"	21,132	3	24.6
	Fenrir	1,260.3 16	59' 43"	22,200.00	2 15	25.0
	Fornjot	1,490.9 16	59' 43"	22,200.00	3 15	24.6
	Surtur	1,297.7 16	59' 57"	22,290.00	3 15	24.8
	Kari	1,233.6 16	1° 00' 07"	22,350.00	3.5 15	23.9
	Jarnsaxa	964.7 16	1° 02' 22"	23,190.00	3 15	24.7
	Loge	1,312.0 16	1° 02' 22"	23,190.00	3 15	24.6
	Ymir	1,315.4 16	1° 02' 41"	23,305.87	10 15	22.4
Uranus	Cordelia	0.335	4"	49.75	25×18×18	23.1
	Ophelia	0.376	4"	53.76	27×19×19	22.8
	Bianca	0.435	4"	59.17	27	22.0
	Cressida	0.46356960	5"	61.77	41	21.1
	Desdemona	0.47364960	5"	62.66	35	21.5
	Juliet	0.49306549	5"	64.36	53	20.6
	Portia	0.51319592	5"	66.10	70	19.9
	Rosalind	0.55845953	5"	69.93	36	21.3
	Cupid	0.616	6"	74.80	8.9	25.9
	Belinda	0.62352747	6"	75.26	45	21.0
	Perdita	0.638	6"	76.42	13.3	24.0
	Puck	0.76183287	7"	86.00	81	19.2
	Mab	0.923	7"	97.73	12.4	25.4
	Miranda	1.41347925	10"	129.87	240×234×233	15.3
	Ariel	2.52037935	14"	190.95	581×578×578	13.2
	Umbriel	4.1441772	20"	266.00	585	14.0
	Titania	8.7058717	33"	436.30	789	13.0
	Oberon	13.4632389	44"	583.52	761	13.2
	Francisco	266.6 16	5' 24"	4,276.00	7 15	25.0
	Caliban	579.6 16	9' 03"	7,170.00	49	22.4
	Stephano	675.7 16	10' 19"	7,942.00	10 15	24.1
	Trinculo	759.7 16	10' 50"	8,571.02	7 15	25.4
	Sycorax	1,289.0 16	15' 24"	12,216.00	95	20.8
	Margaret	1,694.8	18' 07"	14,345.00	7.5 15	25.2
	Prospero	1,948.1 16	20' 19"	16,089.00	15 15	23.2
	Setebos	2,303.1 16	22' 43"	17,988.00	17.5 15	23.3
	Ferdinand	2,823.4 16	26' 24"	20,901.00	8 15	25.1
Neptune	Naiad	0.294	2"	48.227	33	23.9
	Thalassa	0.311	2"	50.075	41	23.3
	Despina	0.334655	2"	52.526	75	22.0
	Galatea	0.428745	3"	61.953	88	21.9
	Larissa	0.554654	3"	73.548	97	21.5
	S/2004 N1	0.950	5"	105.284	9	26.5
	Proteus	1.122315	6"	117.647	210	19.8
	Triton	5.8768541 16	17"	354.759	1,353	13.0
	Nereid	360.13	4' 22"	5,513.4	170	19.7
	Halimede	1,881.00	12' 26"	15,728.00	25 15	24.5
	Sao	2,914.63	17' 44"	22,422.00	13.5 15	25.4
	Laomedeia	3,166.65	18' 38"	23,571.00	16.5 15	25.4
	Psamathe	9,116.45	36' 55"	46,695.00	18 15	25.6
	Neso	9,737.36	38' 15"	48,387.00	21.5 15	24.6
Pluto	Charon	6.38723	1"	19.571	604	17.3
	Styx	20.16	2"	42.393	10	27.0
	Nix	24.8562	2"	48.671	13	23.4
	Kerberos	32.17	2"	57.729	14	26.1
	Hydra	38.2065	2"	64.698	30.5	22.9

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN

GEOCENTRIC POSITION

(0 hr UT, Epoch 2000.0)

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

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	06 38 40	+ 23 08 21	08 43 34	+ 18 08 41	10 39 39	+ 08 28 07	12 27 36	- 02 58 52	14 23 32	- 14 15 21	16 26 56	- 21 42 52
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14	07 32 00	+ 21 45 14	09 33 16	+ 14 31 10	11 26 31	+ 03 36 43	13 15 09	- 07 56 49	15 15 30	- 18 05 02	17 23 45	- 23 10 31
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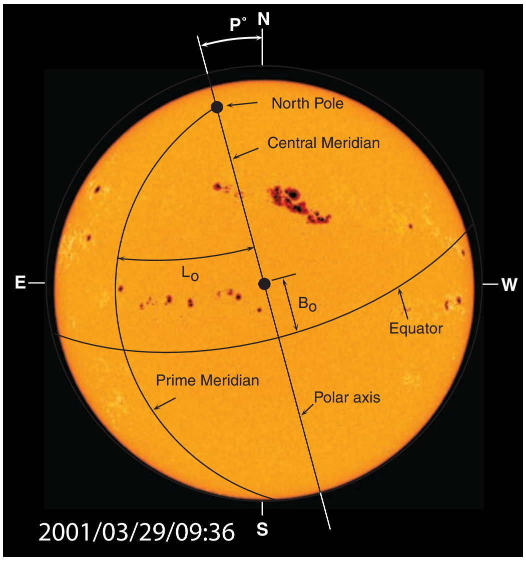


SYNODIC ROTATION NUMBERS (UT)		
Rotation	Month	d.dd
2200	Jan	27.27
2201	Feb	23.61
2202	Mar	22.94
2203	Apr	19.22
2204	May	16.45
2205	Jun	12.66
2206	Jul	9.86
2207	Aug	6.07
2208	Sep	2.31
2209	Sep	29.58
2210	Oct	26.87
2211	Nov	23.17
2212	Dec	20.49

ORIENTATION OF THE SUN

Date		P°	B_0°	L_0°
Jan	6	- 0.3	- 3.6	280.1
	13	- 3.7	- 4.3	187.9
	20	- 6.9	- 5.0	095.8
	27	- 10.0	- 5.6	003.6
Feb	3	- 12.9	- 6.2	271.4
	10	- 15.6	- 6.6	179.3
	17	- 18.0	- 6.9	087.1
	24	- 20.2	- 7.1	354.9
Mar	3	- 22.0	- 7.2	262.7
	10	- 23.5	- 7.2	170.5
	17	- 24.7	- 7.1	078.2
	24	- 25.6	- 6.9	346.0
	31	- 26.1	- 6.6	253.6
Apr	7	- 26.3	- 6.2	161.3
	14	- 26.1	- 5.7	068.9
	21	- 25.5	- 5.1	336.4
	28	- 24.6	- 4.5	244.0
May	5	- 23.4	- 3.8	151.4
	12	- 21.8	- 3.0	058.9
	19	- 19.8	- 2.2	326.3
	26	- 17.6	- 1.4	233.7
Jun	2	- 15.1	- 0.6	141.1
	9	- 12.3	+ 0.3	048.4
	16	- 9.4	+ 1.1	315.8
	23	- 6.3	+ 1.9	223.1
	30	- 3.2	+ 2.7	130.5

Date		P°	B_0°	L_0°
Jul	7	- 0.0	+ 3.5	037.8
	14	+ 3.1	+ 4.2	305.2
	21	+ 6.2	+ 4.9	212.6
	28	+ 9.1	+ 5.5	120.0
Aug	4	+ 11.9	+ 6.0	027.4
	11	+ 14.6	+ 6.4	294.8
	18	+ 16.9	+ 6.8	202.3
	25	+ 19.1	+ 7.0	109.8
Sep	1	+ 21.0	+ 7.2	017.3
	8	+ 22.7	+ 7.3	284.8
	15	+ 24.0	+ 7.2	192.4
	22	+ 25.1	+ 7.1	100.0
	29	+ 25.8	+ 6.8	007.6
Oct	6	+ 26.2	+ 6.5	275.2
	13	+ 26.2	+ 6.0	182.9
	20	+ 25.9	+ 5.5	090.6
	27	+ 25.2	+ 4.9	358.2
Nov	3	+ 24.2	+ 4.2	265.9
	10	+ 22.7	+ 3.5	173.6
	17	+ 20.9	+ 2.6	081.4
	24	+ 18.7	+ 1.8	349.1
Dec	1	+ 16.1	+ 0.9	256.8
	8	+ 13.3	+ 0.0	164.6
	15	+ 10.3	- 0.9	072.4
	22	+ 7.0	- 1.8	340.1
	29	+ 3.7	- 2.6	247.9

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

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

B_0° Heliocentric Latitude of centre of Sun

L_0° Heliocentric Longitude of centre of Sun

At the date of commencement of each synodic rotation period the value of L_0 is zero; that is, the prime meridian passes through the central point of the disc. The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is 27.28 days.

Example Heliocentric Longitude value for 7 March at 2 pm WST. 2 pm WST is 6 hours UT (0 hr UT is 8 am WST). To get the value for 7 March (0 hr UT) start with the value from the main table for 3 March (262.7°) plus 4 days which from the daily variation table is –52.7°. Then you add the value for 6 hours, which is –3.3°. The calculation becomes:

262.7° + (–52.7°) + (–3.3°) = 206.7° (If negative, add 360°, if > 360°, subtract 360°)

VARIATION OF L_0					
Daily		Hourly			
1	– 13.2	1	– 0.6	13	– 7.1
2	– 26.4	2	– 1.1	14	– 7.7
3	– 39.6	3	– 1.7	15	– 8.2
4	– 52.7	4	– 2.2	16	– 8.8
5	– 65.9	5	– 2.8	17	– 9.3
6	– 79.1	6	– 3.3	18	– 9.9
		7	– 3.8	19	– 10.4
		8	– 4.4	20	– 11.0
		9	– 4.9	21	– 11.5
		10	– 5.5	22	– 12.1
		11	– 6.0	23	– 12.6
		12	– 6.6	24	– 13.2

SOLAR AND LUNAR ECLIPSES

During 2018 there are five eclipses, three of the Sun and two of the Moon. All three solar eclipses are partial and both lunar eclipses are total. One of the solar eclipses is observable from the far south east of Australia and both lunar eclipses will be visible.

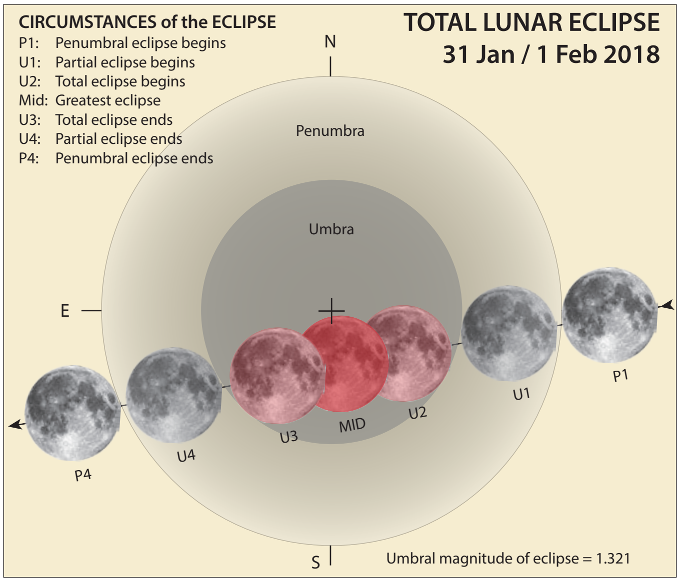
To cater for all observers we use four time zones in the eclipse section, UT, EST, CST and WST **and no account is made for daylight saving time (add one hour if applicable)**. Carefully check the data you are using when planning your observing.

The magnitudes quoted below for eclipses are not a measure of brightness. For solar eclipses it is the fraction of the Sun's diameter covered by the Moon. Annular or partial solar eclipses have a maximum magnitude of less than 1 and for total solar eclipses the value is 1 or greater. For lunar eclipses the umbral magnitude is the fraction on the Moon's diameter immersed in the umbra at maximum eclipse. For values greater than 1.0, it is a total eclipse. For negative values, it is a penumbral eclipse.

31 January/1 February **Total eclipse of the Moon**

The first eclipse of the year is a total lunar eclipse. It will be visible from Asia, Australia, New Zealand and western North America. From the eastern states of Australia the eclipse will be seen in its entirety and begins soon after the end of astronomical twilight. From the central regions of the continent the eclipse begins just before the end of astronomical twilight although this will have little overall effect. From Western Australia the eclipse starts with the Moon below the horizon with the partial phases occurring during a twilight sky, totality then begins around the end of astronomical twilight. The umbral magnitude of the eclipse is 1.32, with the Moon's track taking it just south of the centre of the umbra shadow. Depending on conditions the northern hemisphere of the Moon should noticeably darken to a dull reddish hue with the southern regions appearing a little brighter.

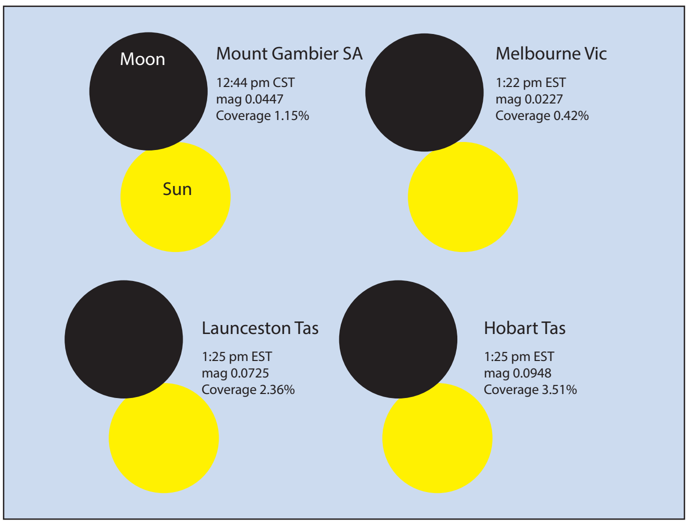
		UT	EST	CST	WST
Penumbral eclipse begins	P1	10:50	8:50 pm	8:20 pm	6:50 pm
Partial eclipse begins	U1	11:48	9:48 pm	9:18 pm	7:48 pm
Total eclipse begins	U2	12:51	10:51 pm	10:21 pm	8:51 pm
Greatest eclipse	Mid	13:30	11:30 pm	11:00 pm	9:30 pm
Total eclipse ends	U3	14:08	12:08 am	11:38 pm	10:08 pm
Partial eclipse ends	U4	15:12	1:12 am	12:42 am	11:12 pm
Penumbral eclipse ends	P4	16:10	2:10 am	1:40 am	12:10 am



15 February **Partial eclipse of the Sun**

The path of the first solar eclipse of 2018 begins over Antarctica, crosses the South Atlantic Ocean then makes landfall over Argentina and Chile. There will also be some visibility from parts of Uruguay, Paraguay and Brazil. Greatest eclipse occurs over Antarctica with a magnitude of 0.60.

13 July **Partial eclipse of the Sun**

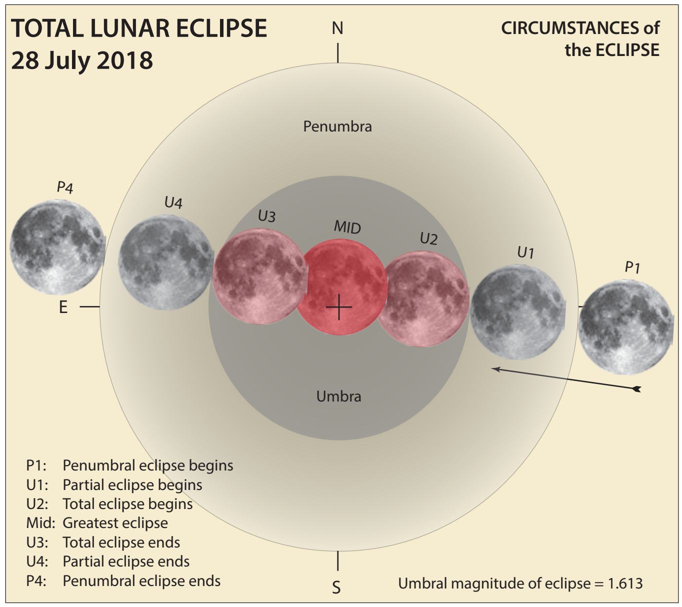


The second partial eclipse of the Sun for the year takes place almost entirely over open water. It will be 'visible' from parts of south-eastern Australia. The area of visibility from Australia is roughly south of a line drawn from Port Lincoln South Australia, through Bendigo and Lakes Entrance in Victoria. The incursion of the Moon in front of the Sun from anywhere

Location	Mag.	Coverage	Begins	Max	Ends	Duration
Port Lincoln SA	0.0059	0.06%	12:26:17	12:35:02	12:43:45	17m28s
Victor Harbour SA	0.0131	0.18%	12:27:19	12:40:16	12:53:12	25m53s
Mount Gambier SA	0.0447	1.15%	12:20:45	12:44:14	1:07:32	46m47s
Ballarat Vic	0.0244	0.46%	1:02:19	1:19:37	1:36:46	34m27s
Geelong Vic	0.0322	0.70%	1:00:37	1:20:25	1:40:02	39m25s
Melbourne Vic	0.0227	0.42%	1:04:51	1:21:28	1:37:57	33m06s
Traralgon Vic	0.0200	0.34%	1:08:32	1:24:04	1:39:26	30m54s
Launceston Tas	0.0725	2.36%	12:55:49	1:24:32	1:52:46	56m57s
Hobart Tas	0.0948	3.51%	12:52:07	1:24:31	1:56:19	1h4m12s
Note: South Australian times are CST, Victorian and Tasmanian times are EST						

in this area will be very minor, with the best view of maximum coverage of Sol from Tasmania. Greatest eclipse occurs over Antarctica with a magnitude of 0.34. The table below gives a few locations showing the magnitude, percent of coverage, times and duration. As can be seen, from mainland regions the Sun will be scarcely indented by the lunar limb.

28 July **Total eclipse of the Moon**



The second and last total lunar eclipse is also visible from Australia although it is certainly not as favourable as the January event. From the eastern states the eclipse begins in the early morning hours with astronomical twilight beginning just prior to mid-eclipse. From the central regions of Australia the eclipse can be viewed a little past mid-eclipse before the advent of astronomical twilight. Western Australia gets the best view with totality ending 30 minutes before the onset of dawn. As a bonus, for those that brave the cold winter morning for the eclipse, Mars is at opposition and close to the Moon at this time, a chance to kill two birds with the one stone so to speak. The umbral magnitude of this eclipse is 1.61, which should result in a dark total phase. This eclipse is known as a *central eclipse* with the Moon's disc passing through the axis of the Earth's umbral shadow. Because of the depth of such eclipses they have the longest duration of totality, in this case 104 minutes.

		UT(27th)	EST	CST	WST
Penumbral eclipse begins	P1	17:13	3:13 am	2:43 am	1:13 am
Umbral eclipse begins	UI	18:24	4:24 am	3:54 am	2:24 am
Total eclipse begins	U2	19:30	5:30 am	5:00 am	3:30 am
Greatest eclipse	Mid	20:22	6:22 am	5:52 am	4:22 am
Total eclipse ends	U3	21:14		6:44 am	5:14 am
Umbral eclipse ends	U4	22:19			6:19 am
Penumbral eclipse ends	P4	23:30			

11th August **Partial eclipse of the Sun**

This partial eclipse is very deep with a maximum magnitude of 0.74, it is visible across northernmost Canada, Greenland, Iceland, Scandinavia, most of Russia, most of Kazakhstan, Mongolia and most of China.

GEOCENTRIC POSITION of the MOON

(0 hr UT, Epoch 2000.0)

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

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

MOON PHASE (UT)

Lunation	New Moon		First Quarter		Full Moon		Last Quarter	
1175					Jan 2	02:24	Jan 8	22:25
1176	Jan 17	02:17	Jan 24	22:20	Jan 31	13:27	Feb 7	15:54
1177	Feb 15	21:05	Feb 23	08:09	Mar 2	00:51	Mar 9	11:20
1178	Mar 17	13:12	Mar 24	15:35	Mar 31	12:37	Apr 8	07:18
1179	Apr 16	01:57	Apr 22	21:46	Apr 30	00:58	May 8	02:09
1180	May 15	11:48	May 22	03:49	May 29	14:20	Jun 6	18:32
1181	Jun 13	19:43	Jun 20	10:51	Jun 28	04:53	Jul 6	07:51
1182	Jul 13	02:48	Jul 19	19:52	Jul 27	20:20	Aug 4	18:18
1183	Aug 11	09:58	Aug 18	07:49	Aug 26	11:56	Sep 3	02:37
1184	Sep 9	18:01	Sep 16	23:15	Sep 25	02:52	Oct 2	09:45
1185	Oct 9	03:47	Oct 16	18:02	Oct 24	16:45	Oct 31	16:40
1186	Nov 7	16:02	Nov 15	14:54	Nov 23	05:39	Nov 30	00:19
1187	Dec 7	07:20	Dec 15	11:49	Dec 22	17:49	Dec 29	09:34

PERIGEE AND APOGEE (UT)

Date	Time	Event	Distance (km)
Jan 1	21:49	Perigee	356,565
Jan 15	02:10	Apogee	406,464
Jan 30	09:57	Perigee	358,994
Feb 11	14:16	Apogee	405,700
Feb 27	14:39	Perigee	363,933
Mar 11	09:14	Apogee	404,678
Mar 26	17:17	Perigee	369,106
Apr 8	05:31	Apogee	404,144
Apr 20	14:41	Perigee	368,714
May 6	00:35	Apogee	404,457
May 17	21:05	Perigee	363,776
Jun 2	16:35	Apogee	405,317
Jun 14	23:53	Perigee	359,503
Jun 30	02:43	Apogee	406,061
Jul 13	08:25	Perigee	357,431
Jul 27	05:44	Apogee	406,223
Aug 10	18:07	Perigee	358,078
Aug 23	11:23	Apogee	405,746
Sep 8	01:20	Perigee	361,351
Sep 20	00:53	Apogee	404,876
Oct 5	22:27	Perigee	366,392
Oct 17	19:16	Apogee	404,227
Oct 31	20:23	Perigee	370,204
Nov 14	15:56	Apogee	404,339
Nov 26	12:12	Perigee	366,620
Dec 12	12:25	Apogee	405,177
Dec 24	09:49	Perigee	361,061

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

ADELAIDE (CST)

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

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

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

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

BRISBANE (EST)

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

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

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

MOON RISE AND SET

CANBERRA (EST)

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

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

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

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

DARWIN (CST)

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

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

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

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

HOBART (EST)

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

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

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

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

MELBOURNE (EST)

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

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

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

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

PERTH (WST)

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

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

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

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

SYDNEY (EST)

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

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

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

OBSERVING THE MOON

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

The Moon maps are drawn with south to the top giving a correct view as we see it from the Southern Hemisphere. After New Moon the phase grows (or waxes) from a thin phase on the eastern limb (left edge of page 100) toward the right. After Full Moon the bright limb starts to wane or shrink away from the eastern limb. Approximately 14 to 15 days after a feature has been on the terminator it is there again but this time illuminated from the opposite direction with shadows going the other way (it is sunrise before Full Moon and sunset after). This is why the table below goes only a few days beyond Full Moon, for the features would be repeated. If you are able to view well into the morning, beyond Third Quarter, you will be treated to a whole new perspective. For the first 1 to 2 days after being *New* the Moon is too close to the Sun and the horizon to give good views. It is better to wait until a couple of days beyond Full Moon (e.g. 17 days) to see these features return to the terminator under dark, night skies.

The Table

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

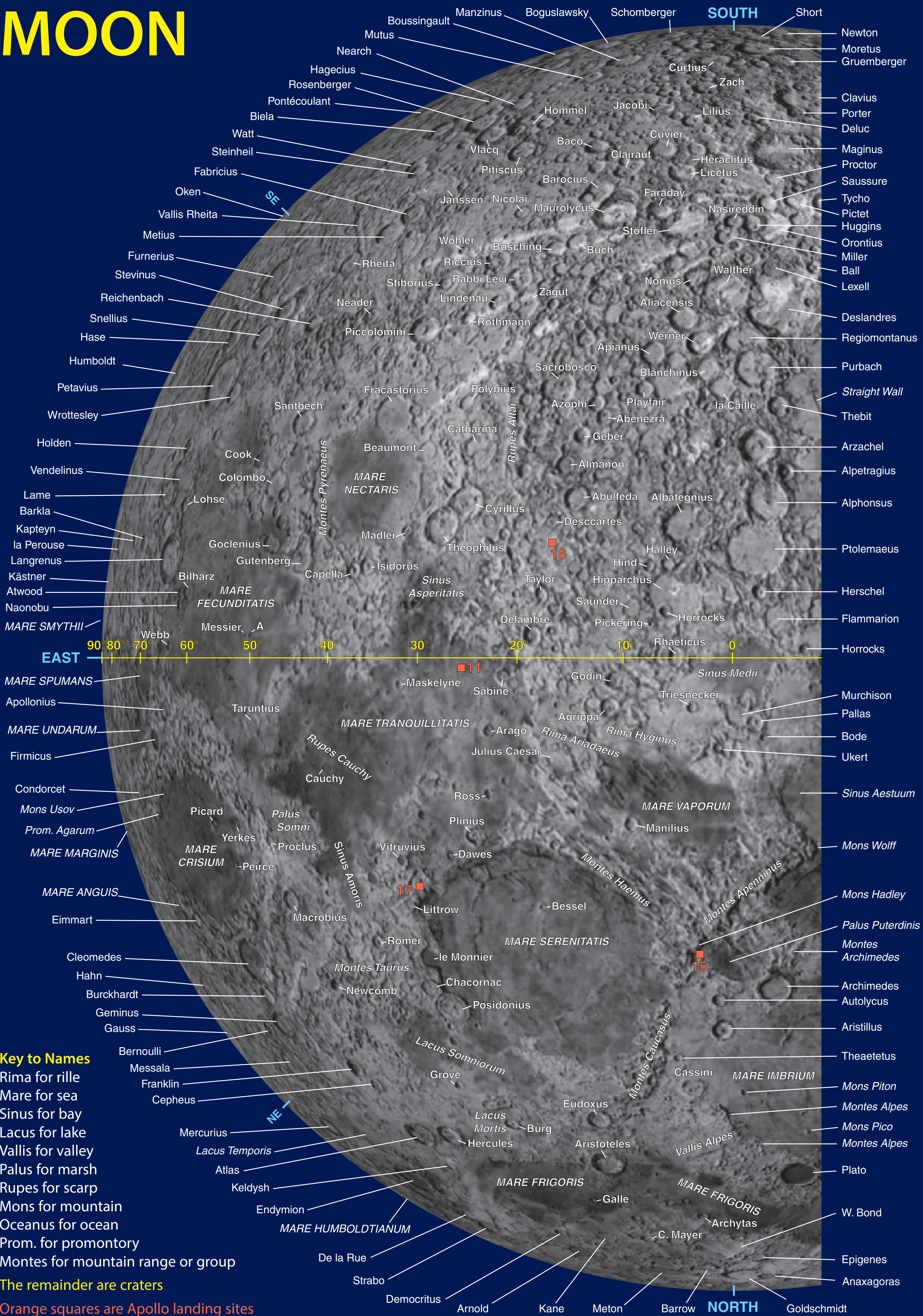
FEATURE	NOTES
Day 3 (48° E)	
Biela (76 km)	three central peaks
Furnerius, Petavius, Vendelinus and Langrenus	easily recognised row of four craters
Furnerius (130 km)	look for small crater on floor
Petavius (177 km)	central mountain and rille
Vendelinus (150 km) and Lame (84 km)	merged craters (Lame was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

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

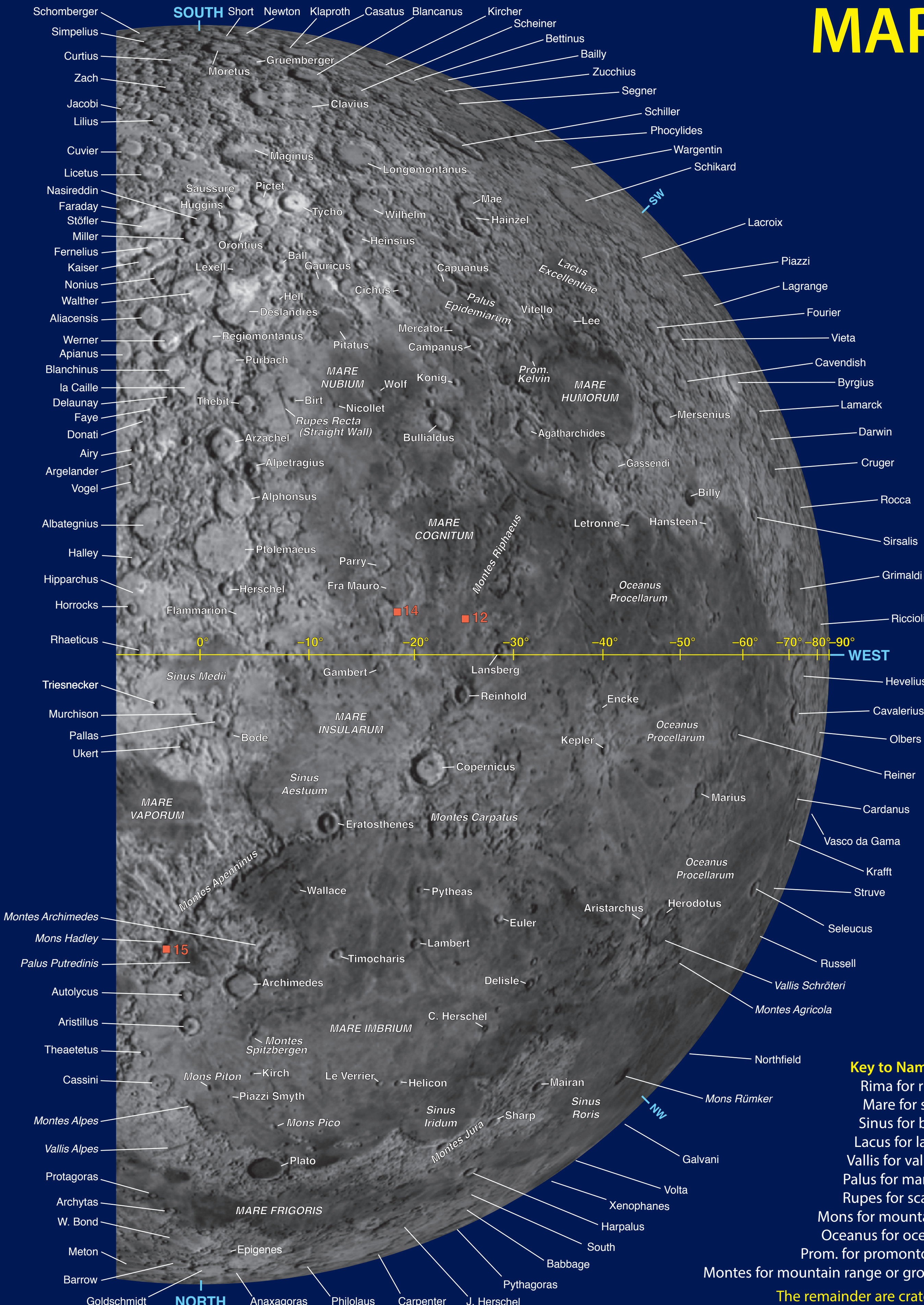
FEATURE	NOTES
Day 8 (4° W)	
Purbach (124 km)	damaged, containing slopes and ridges
Arzachel, Alphonsus and Ptolemaeus	possibly the most recognisable line of three craters on the Moon
Arzachel (97 km)	terraced walls with the floor having a central peak, small craters and a rille
Alphonsus (117 km)	central peak with two rilles running along the floor
Ptolemaeus (160 km)	a vast flat floor with degraded walls, note the small crater Ammonius (north-east of centre)
Herschel (41 km)	obvious crater close to Ptolemaeus (north side)
Ptolemaeus to Walther (132 km)	extending the Ptolemaeus group of three south to Walther, line of six large craters
Sinus Medii	Bay of the Centre (marking the Centre of the Moon)
Triesnecker (28 km)	prominent crater isolated in Sinus Medii
Mones Apennine	eastern end of this mountain range, on south-east edge of Mare Imbrium
Mare Imbrium	Sea of Rains, eastern part in view
Autolycus (39 km)	makes a distinctive pair with Aristillus to the north
Aristillus (56 km)	three central mountain peaks
Cassini (57 km)	crater in northern Mare Imbrium, with two smaller craters on floor
Vallis Alpes (Alpine Valley)	cuts through Montes Alpes
Montes Alpes	northern edge of Mare Imbrium
Day 9 (15° W)	
Moretus (117 km)	not far from the south pole, another distinctive crater with a central mountain that casts eye-catching shadows
Clavius (232 km)	a number of smaller craters are on the floor (location of Clavius Base, from where TMA-1 was discovered—for those Sci-Fi fans)
Rays extending to the east from Tycho	these develop as the Moon gets closer to full
Tycho (87 km)	prominent crater in the southern uplands, at low Sun angles its central peak casts a *witch's hat* shadow (location of TMA-1, see Clavius above)
Hell (35 km)	well defined crater in flat plain of Deslandres
Pitatus (88 km)	on southern edge of Mare Nubium, a flat lava filled crater with central peak
Mare Nubium	Sea of Clouds, eastern portion
Nicollet	small distinctive crater in the middle of Mare Nubium
Rupes Recta (Straight Wall)	running north-south (120 km) on eastern edge of Mare Nubium, small crater Birt is just west
Eratosthenes (58 km)	at the western end of the Apennines, has terraced walls and a central peak
Mones Apennine	the mountain range is now in full sunlight
Archimedes (80 km)	distinctive, flat floored crater in Mare Imbrium
Mons Piton and Mons Pico	two obvious isolated mountains in northern Mare Imbrium, both cast long shadows at low Sun angles
Plato (101 km)	at the northern end of Mare Imbrium, casts interesting shadows from its jagged crater walls and has challenging 1 km diameter craters on its floor
Day 10 (27° W)	
Longomontanus (149 km)	a walled plain with several craters around the edge of the floor plus some peaks
Mare Nubium	now in full sunlight
Bullialdus A, B and Konig (23 km)	a group of three craters, just south of Bullialdus, standing out well against the dark floor of Mare Nubium
Bullialdus (60 km)	prominent crater in Mare Nubium with terraced walls and multiple peaked central mountain
Lansberg (39 km)	isolated crater with central peak in Mare Insularum
Reinhold (45 km)	distinctive crater, near Lansberg in Mare Insularum

FEATURE	NOTES
Copernicus (91 km)	possibly the most recognisable crater on the Moon. It has terraced walls and a prominent central peak with surrounding ejector rays, standing out well against the dark floored mare. Located on the border of Mare Insularum and Mare Imbrium
Crater chain	a challenge, this string of craters (4–7 km) is between Copernicus and Eratosthenes, running roughly towards the south-east
Day 11 (40° W)	
Scheiner (115 km)	west of Clavius, this crater has four small craters on its floor. Makes a good pair with Blancanus.
Schiller (180 km)	this prominent elongated crater has an obvious ridge running along its floor visible at low Sun angles
Hainzel (73 km)	has an odd shape showing signs of multiple impacts in the past
Vitello (42 km)	on southern edge of Mare Humorum is a steep walled crater with central mountain
Gassendi (110 km)	contains a double mountain peak and several rilles and hills on the floor
Kepler (33 km)	in eastern part of Oceanus Procellarum is this well known *rayed* crater. These rays develop as the Moon gets closer to full.
Sinus Iridum	this obvious bay in north-west Mare Imbrium is probably a lava filled remnant of an old impact
Day 12 (55° W)	
Schickard (216 km)	has a dark floor with white stripe
Aristarchus (39 km)	the brightest feature on the near side of the Moon. This is even visible when lit only by earthshine (near New Moon). It sits on a smooth, dark plateau.
Herodotus (36 km)	next to Aristarchus. The prominent winding valley, Schröter's, extends from Herodotus towards the north.
Day 13 and 14 (about 70°–80° W)	
Bailly (295 km)	a large, foreshortened crater near the south pole limb, presents great views with favourable librations
Wargentin (84 km)	was once a crater but now filled with lava to the brim forming a plateau, that appears to stand above the surface with the right Sun angle
Mersenius (84 km)	west of Mare Humorum, has a lava flooded floor with small crater pits
Billy (46 km)	prominent crater with a dark floor
Grimaldi (228 km)	large, foreshortened, dark floored crater is an obvious signpost
Hevelius (109 km) and Cavalerius (60 km)	a distinctive pair near western limb. Hevelius is a walled plain with a small central peak and crisscross pattern of rilles
Cardanus (51 km) and Krafft (53 km)	impressive pair near limb against backdrop of dark plain of Oceanus Procellarum
Struve (175 km) and Russell (105 km)	both are extremely foreshortened limb features, appearing to merge
Mons Rumker	a well known lunar dome (mound-like), isolated in Sinus Roris
Pythagoras (129 km)	very close to the northern pole limb, is extremely foreshortened but displays good terraced walls and twin central peaks
Day 15 — Full Moon	
Bright Rays from craters	the most prominent example is Tycho (dominates the southern hemisphere). The rays of Copernicus, Aristarchus and Kepler form a triangle. Also worthwhile looking at are Stevinus, Proclus (fan shaped ejecta) and Anaxagoras
Bright craters	there are a number of these which include Dionysius, Byrgius, and Censorinus
Dark features	all the seas and walled plains of Grimaldi, Endymion and Plato
Day 16 to 17 (about 70°–80° E)	
Furnerius, Petavius, Vendelinus and Langrenus	seen at best (better view than day 3)
Mare Crisium	best phase to see the wrinkled ridges on floor

MOON


SOUTH
NORTH
EAST
SE
NE
Manzinus
Boguslawsky
Schomberger
Short
Boussingault
Mutus
Nearch
Hagecius
Rosenberger
Pontécoulant
Biela
Watt
Steinheil
Fabricius
Oken
Vallis Rheita
Metius
Furnerius
Stevinus
Reichenbach
Snellius
Hase
Humboldt
Petavius
Wrottesley
Holden
Vendelinus
Lame
Barkla
Kapteyn
la Perouse
Langrenus
Kästner
Atwood
Naonobu
MARE SMYTHII
Webb
Newton
Moretus
Gruemberger
Clavius
Porter
Deluc
Maginus
Proctor
Saussure
Tycho
Pictet
Huggins
Orontius
Miller
Ball
Lexell
Deslandres
Regiomontanus
Purbach
Straight Wall
Thebit
Arzachel
Alpetragius
Alphonsus
Ptolemaeus
Herschel
Flammarion
Horrocks
Curtius
Zach
Jacobi
Lilius
Hommel
Cuvier
Baco
Clairaut
Heraclitus
Licetus
Vlacq
Pitiscus
Barocius
Faraday
Janssen
Nicolai
Maurolycus
Nasireddin
Stöfler
Wohler
Busching
Buch
Rheita
Riccius
Walther
Stiborius
Rabbi Levi
Nonius
Zagut
Neader
Lindenau
Aliacensis
Rothmann
Piccolomini
Werner
Apianus
Sacrobosco
Blanchinus
Fracastorius
Polybius
Santbech
Azophi
Playfair
la Caille
Abenezra
Catharina
Rupes Altai
Geber
Cook
Beaumont
Montes Pyrenaeus
Almanon
Colombo
MARE NECTARIS
Lohse
Abulfeda
Albategnius
Cyrillus
Desccartes
Madler
Goclenius
Theophilus
16
Halley
Gutenberg
Hind
Isidorus
Capella
Bilharz
Sinus Asperitatis
Taylor
Hipparchus
MARE FECUNDITATIS
Saunder
Horrocks
Messier
A
Delambre
Pickering
Rhaeticus
90° 80° 70° 60° 50° 40° 30° 20° 10° 0°
11
Godin
Sinus Medii
MARE SPUMANS
Maskelyne
Sabine
Triesnecker
Murchison
Apollonius
Taruntius
Pallas
Agrippa
MARE UNDARUM
MARE TRANQUILLITATIS
Arago
Rima Ariadaeus
Rima Hyginus
Bode
Firmicus
Rupes Cauchy
Julius Caesar
Ukert
Cauchy
Condorcet
Ross
Sinus Aestuum
Mons Usov
Picard
Palus Somni
MARE VAPORUM
Prom. Agarum
Plinius
Manilius
Yerkes
MARE MARGINIS
MARE CRISIUM
Proclus
Sinus Amoris
Vitruvius
Dawes
Mons Wolff
Peirce
Montes Haemus
Montes Apenninus
MARE ANGUIS
17
Mons Hadley
Littrow
Bessel
Eimmart
Macrobius
Palus Puterdinis
Romer
MARE SERENITATIS
Montes Archimedes
Cleomedes
le Monnier
15
Montes Taurus
Hahn
Chacornac
Archimedes
Burckhardt
Newcomb
Autolycus
Posidonius
Geminus
Aristillus
Gauss
Montes Caucasus
Lacus Somniorum
Bernoulli
Theaetetus
Messala
Cassini
MARE IMBRIUM
Franklin
Grove
Mons Piton
Cepheus
Eudoxus
Montes Alpes
Lacus Mortis
Burg
Mons Pico
Mercurius
Hercules
Aristoteles
Vallis Alpes
Montes Alpes
Lacus Temporis
Atlas
Plato
MARE FRIGORIS
Keldysh
Galle
MARE FRIGORIS
Endymion
W. Bond
MARE HUMBOLDTIANUM
Archytas
C. Mayer
De la Rue
Epigenes
Strabo
Anaxagoras
Democritus
Arnold
Kane
Meton
Barrow
Goldschmidt
Key to Names
Rima for rille
Mare for sea
Sinus for bay
Lacus for lake
Vallis for valley
Palus for marsh
Rupes for scarp
Mons for mountain
Oceanus for ocean
Prom. for promontory
Montes for mountain range or group
The remainder are craters
Orange squares are Apollo landing sites

MAP



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LUNAR OCCULTATIONS

INTRODUCTION

An occultation happens 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 that the Moon occults are listed in the Zodiacal Catalogue (ZC). There are about 3500 stars in the ZC.

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

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

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

THE TIMING OF OCCULTATIONS.

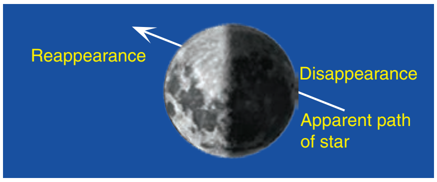
Besides being a spectacular event, the observation of occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

TIMING EQUIPMENT. Historically, amateurs timed these events by recording a radio time signal along with their voice calling out the events. There are several more modern techniques in use today. Some observers are now using a combination of video and a GPS signal to record an occultation. See links below for more information.

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

For further information on timing methods for occultations it would be worth contacting your local astronomical society (see Part III) or the International Occultation Timing Association.

www.lunar-occultations.com/iota/iotandx.htm
www.occultations.org.nz



LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 6.5 magnitude. The criteria for selection are complex involving the Sun and Moon altitude, star magnitude and whether it is a bright or dark limb event.

EXPLANATION

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

OBJECT
- n, nn, nnn, nnnn — ZC catalogue number
- ggg ccc — Greek letter and constellation abbreviation
- n ccc — Flamsteed number and constellation
- name of planet, satellite or deep sky object.

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

Mag magnitude of the star.

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

Alt altitude of the Moon during the occultation.

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

A coefficient of longitude (see below)

B coefficient of latitude (see below)

NB. For some stars, close to grazing, A and B values would be useless, and no values are shown.

CALCULATING EVENT TIME FOR OTHER LOCATIONS

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

Predicted Time at your location

= Time from Table + (A × n) + (B × p)

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

n is positive (+) if east, negative (–) if west

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

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

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

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the reappearance of Zeta Tauri on October 29 for their location in Albury NSW (146° 55' E, 36° 05' S), see page 144. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

= 149.13° – 146.92° = – 2.21° — 'n' (–)

The change in latitude from Canberra (decimal degrees)

= 35.25° – 36.08° = – 0.83° — 'p' (–)

From the Canberra table, the time of the event is 00:26 EST and the values of A and B are + 1.6 and – 1.2 respectively.

Therefore the equation becomes:

00:26 + (+1.6 × –2.21°) + (–1.2 × –0.83°)

= 00:26 + (–3.5) + (+1.0)

= 00:26 + (–2.5) = 00:23

The event will be visible from Albury approximately three minutes earlier than Canberra, i.e., about 12:23 am (EST) on October 29.

Lunar occultation predictions calculated using Occult version 4.3.2 by D. Herald.

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 03 00:26	56 Gem	RD	5.1	172	35	225	2.2	1.5	Jun 07 05:29	Chi Aqr	DB	4.9	89	59	35	1.5	2.1	Sep 17 21:51	2591	DD	6.2	95	44	118	1.7	-0.1
Jan 04 03:09	1276	RD	6.5	157	34	327	1.1	-1.3	Jun 10 04:02	Nu Psc	DB	4.5	54	12	54	0.3	0.1	Sep 19 01:27	Xi 1 Sgr	DD	5.0	108	11	164	4.0	-8.4
Jan 04 22:32	1395	RD	6.3	145	11	345	1.5	-4.2	Jun 10 05:06	Nu Psc	RD	4.5	53	25	254	1.0	-0.5	Sep 20 00:17	56 Sgr	DD	4.9	118	34	55	0.4	2.2
Jan 11 03:53	2100	RD	6.5	69	33	289	0.9	-1.7	Jun 26 19:46	2441	DD	6.6	160	44	96	1.3	-1.3	Sep 20 01:19	56 Sgr	RB	4.9	119	21	277	0.5	1.0
Jan 31 00:05	85 Gem	DD	5.4	166	35	113	1.9	-0.4	Jun 28 02:40	2591	DD	6.2	173	51	154	2.8	-4.2	Sep 20 19:45	Omi Cap	DD	5.9	128	68	13	1.9	6.7
Jan 31 02:50	1205	DD	6.3	167	19	68	1.6	1.7	Jun 29 01:31	29 Sgr	DB	5.2	175	72	12	9.9	9.9	Sep 20 20:26	Omi Cap	RB	5.9	128	73	322	3.6	-6.0
Feb 18 19:54	27 Psc	RB	4.9	29	8	177	-0.3	4.6	Jun 29 01:56	29 Sgr	RB	5.2	174	68	341	4.1	-9.9	Sep 21 02:12	Ups Cap	DD	5.2	130	20	93	0.4	1.1
Feb 23 22:31	Del 1 Tau	DD	3.8	92	12	50	1.1	2.2	Jun 30 04:49	56 Sgr	DB	4.9	163	44	73	1.1	1.7	Sep 22 18:54	Iot Aqr	RB	4.3	150	40	204	1.4	2.5
Feb 23 22:58	64 Tau	DD	4.8	92	7	80	0.7	1.3	Jun 30 06:02	56 Sgr	RD	4.9	163	29	258	0.6	1.5	Sep 26 00:02	14 Cet	RD	5.9	173	55	278	3.0	-0.7
Feb 24 22:00	798	DD	6.2	105	24	52	1.8	2.0	Jul 01 01:10	Omi Cap	RD	5.9	153	69	290	2.6	-1.7	Sep 29 00:39	454	DD	5.6	137	32	342	9.9	9.9
Feb 26 20:20	56 Gem	DD	5.1	131	33	141	2.2	-2.1	Jul 06 05:11	14 Cet	DB	5.9	96	54	3	0.2	4.0	Sep 29 00:52	454	RD	5.6	137	34	322	9.9	9.9
Feb 26 21:16	56 Gem	RB	5.1	132	35	227	2.4	1.6	Jul 06 06:02	14 Cet	RD	5.9	95	56	292	3.7	-1.4	Oct 15 22:43	2697	DD	6.5	76	18	122	0.7	0.2
Feb 26 23:23	61 Gem	DD	5.9	133	28	157	0.6	-1.9	Jul 25 18:26	21 Sgr	DD	4.9	154	35	170	-1.2	-6.2	Oct 17 23:47	Sig Cap	DD	5.3	99	24	82	0.4	1.4
Feb 28 00:36	1276	DD	6.5	147	27	31	4.8	7.0	Jul 25 18:52	21 Sgr	RB	4.9	154	40	211	3.1	3.6	Oct 18 21:56	The Cap	DD	4.1	109	54	64	1.5	1.9
Feb 28 20:07	1395	DD	6.3	159	23	59	1.3	0.0	Jul 28 21:27	21 Cap	RD	6.1	172	41	231	1.5	0.6	Oct 18 23:15	The Cap	RB	4.1	109	38	251	0.9	1.7
Mar 07 03:46	18 Lib	DB	5.9	120	65	111	2.1	-1.2	Jul 28 23:46	The Cap	DB	4.1	172	66	93	2.5	-0.7	Oct 27 22:42	697	RD	6.5	143	14	222	0.3	0.5
Mar 07 05:16	18 Lib	RD	5.9	120	63	300	2.0	-1.0	Jul 29 01:16	The Cap	RD	4.1	171	72	232	2.0	2.0	Oct 28 23:40	Zet Tau	RD	3.0	130	12	295	1.4	-2.0
Mar 09 00:08	Phi Oph	RD	4.3	99	14	240	0.6	-0.2	Aug 03 05:38	33 Cet	DB	6.0	113	50	134	6.4	-5.1	Nov 14 22:29	3041	DD	6.2	78	23	41	-0.1	2.4
Mar 10 01:58	2508	RD	6.3	87	28	301	0.3	-2.0	Aug 03 06:01	33 Cet	RD	6.0	113	48	163	-2.4	7.9	Nov 18 01:28	Chi Aqr	DD	4.9	112	8	8	-0.4	3.3
Mar 12 04:19	2798	RD	6.1	64	37	239	1.5	0.1	Aug 05 01:44	85 Ara	RD	6.3	90	13	284	1.0	-1.8	Nov 21 23:08	25 Cet	DD	6.5	158	45	24	1.2	2.3
Mar 15 04:51	44 Cap	DB	5.9	31	12	109	0.0	-1.8	Aug 20 18:46	2497	DD	6.5	113	70	154	1.3	-4.2	Nov 26 22:43	Del Gem	RD	3.5	135	4	266	0.6	-1.0
Mar 20 19:35	Xi 1 Cet	RB	4.4	35	8	253	0.5	1.5	Aug 21 20:51	16 Sgr	DD	6.0	125	75	96	2.6	-0.2	Nov 28 02:59	Eta Cnc	DB	5.3	120	31	88	2.0	-0.5
Mar 29 01:37	34 Leo	DD	6.5	142	20	79	1.3	1.5	Aug 21 22:26	16 Sgr	RB	6.0	126	61	266	2.1	1.0	Nov 28 04:20	Eta Cnc	RD	5.3	120	35	296	2.0	-0.7
Apr 10 01:50	Rho Cap	RD	4.9	74	13	317	-0.4	-3.0	Aug 24 21:59	3041	DD	6.2	159	69	104	2.6	-1.2	Dec 12 22:25	Iot Cap	DD	4.3	57	7	122	0.3	0.2
Apr 19 19:43	718	DD	6.0	43	7	90	0.6	1.1	Aug 26 02:19	45 Cap	DD	6.0	171	50	56	1.2	2.1	Dec 13 20:29	Iot Aqr	DD	4.3	67	37	44	0.6	2.4
Apr 26 00:27	53 Leo	DD	5.3	124	22	111	0.9	0.4	Aug 28 00:56	Chi Aqr	DD	4.9	167	63	341	9.9	9.9	Dec 13 21:35	Iot Aqr	RB	4.3	68	24	266	0.6	1.3
Apr 30 21:38	18 Lib	RD	5.9	172	42	296	1.1	-1.8	Aug 28 01:14	Chi Aqr	RD	4.9	167	63	318	8.1	-9.7	Dec 18 00:15	89 Psc	DD	5.1	114	17	35	0.6	2.4
May 11 04:11	3463	RD	6.4	59	23	309	0.9	-4.0	Aug 31 01:38	Nu Psc	DB	4.5	132	43	71	1.8	0.0	Dec 18 22:48	303	DD	6.4	125	37	109	2.3	0.2
May 31 01:34	2497	RD	6.5	167	73	244	2.7	1.8	Aug 31 03:01	Nu Psc	RD	4.5	131	49	226	1.7	1.4	Dec 19 00:01	308	DD	6.3	126	25	33	1.0	2.5
Jun 01 03:47	16 Sgr	RD	6.0	156	61	261	2.0	1.2	Sep 01 01:44	368	RD	6.2	119	34	208	0.7	1.4	Dec 25 02:11	Mu Cnc	DB	5.3	153	34	33	3.1	3.2
Jun 03 22:32	Ups Cap	RD	5.2	125	15	250	0.3	-0.6	Sep 03 05:47	Del 1 Tau	MB	3.8	93	38	161	9.9	9.9	Dec 25 02:41	Mu Cnc	RD	5.3	153	33	350	0.7	-3.7
Jun 04 04:02	3041	RD	6.2	123	73	181	0.4	9.8	Sep 04 05:36	793	RD	6.2	80	33	251	1.9	0.1	Dec 26 23:49	1479	RD	6.4	126	12	339	1.2	-3.1

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 03 00:23	56 Gem	DB	5.1	173	42	120	2.3	-1.0	Jun 01 21:09	Xi 1 Sgr	DB	5.0	147	23	156	-0.7	-3.9	Sep 01 02:41	368	RD	6.2	120	50	205	1.1	2.3
Jan 03 01:40	56 Gem	RD	5.1	172	39	255	2.4	0.9	Jun 01 21:46	Xi 1 Sgr	RD	5.0	147	31	220	2.0	1.8	Sep 16 18:34	29 Oph	DD	6.3	83	69	121	2.5	-1.2
Jan 03 04:15	61 Gem	RD	5.9	171	17	265	1.1	1.0	Jun 02 21:02	56 Sgr	RD	4.9	136	11	273	0.0	-1.0	Sep 16 19:58	29 Oph	RB	6.3	83	50	255	1.7	1.6
Jan 22 20:00	5 Psc	RB	6.2	59	25	279	1.1	0.7	Jun 03 23:00	Ups Cap	RD	5.2	125	25	287	0.5	-1.7	Sep 17 22:41	2591	DD	6.2	95	27	109	0.9	0.3
Jan 27 19:58	684	RB	6.2	122	45	313	3.6	-2.6	Jun 04 04:28	3041	DB	6.2	123	77	122	4.0	-2.4	Sep 20 01:03	56 Sgr	DD	4.9	118	17	53	-0.1	1.9
Jan 31 01:06	85 Gem	DD	5.4	166	35	81	2.1	0.9	Jun 04 05:26	3041	RD	6.2	123	66	196	0.6	4.8	Sep 22 18:39	Iot Aqr	DD	4.3	149	43	92	1.7	-1.1
Feb 02 21:00	53 Leo	RD	5.3	153	11	251	0.5	-0.3	Jun 10 04:44	Nu Psc	DB	4.5	54	29	41	0.7	1.0	Sep 22 20:02	Iot Aqr	RB	4.3	150	61	231	2.1	1.4
Feb 26 21:12	56 Gem	DD	5.1	131	42	117	2.3	-0.8	Jun 10 05:53	Nu Psc	RD	4.5	53	42	261	1.9	-0.3	Sep 26 00:01	14 Cet	DB	5.9	173	63	21	1.1	2.9
Feb 26 22:31	56 Gem	RB	5.1	132	36	260	2.2	0.9	Jun 26 22:58	29 Oph	DD	6.3	161	80	169	1.5	-7.3	Sep 26 01:15	14 Cet	RD	5.9	173	58	271	2.9	0.4
Feb 27 00:02	61 Gem	DD	5.9	132	24	112	1.1	0.1	Jun 28 03:26	2591	DD	6.2	173	35	134	1.8	-1.3	Sep 29 01:28	454	DB	5.6	137	47	354	-1.0	5.4
Mar 07 04:16	Xi Lib	DD	5.5	121	73	196	9.9	9.9	Jun 30 05:42	56 Sgr	DB	4.9	163	27	71	0.4	1.5	Sep 29 02:03	454	RD	5.6	137	49	308	5.1	-3.6
Mar 07 04:32	Xi Lib	RD	5.5	121	71	217	9.9	9.9	Jul 01 01:14	Omi Cap	DB	5.9	153	79	17	1.9	6.0	Oct 11 18:28	Xi Lib	DD	5.5	28	18	72	0.4	1.7
Mar 07 05:00	18 Lib	DB	5.9	120	67	61	3.6	3.0	Jul 01 02:08	Omi Cap	RD	5.9	153	80	313	4.3	-4.1	Oct 18 00:28	Sig Cap	DD	5.3	99	8	80	-0.1	1.1
Mar 08 23:38	Phi Oph	DB	4.3	99	12	120	-0.1	-1.6	Jul 02 23:37	Iot Aqr	DB	4.3	132	38	106	1.4	-1.8	Oct 18 19:41	21 Cap	DD	6.1	108	77	12	0.8	5.7
Mar 09 00:40	Phi Oph	RD	4.3	99	26	278	0.6	-1.2	Jul 03 00:50	Iot Aqr	RD	4.3	131	54	221	1.9	1.9	Oct 18 20:35	21 Cap	RB	6.1	108	66	304	4.0	-2.1
Mar 10 02:06	2508	RD	6.3	87	35	352	-1.0	-5.4	Jul 23 18:45	24 Oph	RB	4.9	131	65	255	3.0	0.3	Oct 18 22:56	The Cap	DD	4.1	109	36	66	0.8	1.7
Mar 12 03:45	2798	DB	6.1	65	36	91	1.1	-1.0	Jul 25 18:36	21 Sgr	DD	4.9	153	43	116	1.0	-1.9	Oct 19 00:05	The Cap	RB	4.1	109	21	251	0.3	1.5
Mar 15 05:18	44 Cap	DB	5.9	31	23	74	0.7	-0.4	Jul 25 19:59	21 Sgr	RB	4.9	154	61	266	2.4	-0.5	Oct 28 23:28	Zet Tau	DB	3.0	130	20	32	0.2	1.3
Mar 20 19:22	Xi 1 Cet	DD	4.4	35	6	51	0.5	1.9	Jul 28 03:29	Sig Cap	DD	5.3	178	39	121	2.0	-0.5	Oct 29 00:22	Zet Tau	RD	3.0	130	28	296	2.3	-1.9
Mar 25 21:36	Zet Gem	DD	4.0	100	26	144	0.7	-1.3	Jul 28 22:25	21 Cap	RD	6.1	172	61	261	2.4	-0.3	Oct 30 00:49	1021	RD	6.1	117	23	291	1.8	-1.6
Mar 25 22:29	Zet Gem	RB	4.0	101	17	237	1.7	2.2	Jul 29 00:56	The Cap	DB	4.1	172	78	80	2.8	0.7	Nov 12 18:33	Xi 2 Sgr	RB	3.5	54	46	292	2.0	-0.1
Mar 26 20:05	1205	RB	6.3	113	42	263	2.6	0.4	Jul 29 02:29	The Cap	RD	4.1	171	61	235	1.6	2.1	Nov 16 19:27	45 Aqr	RB	6.0	98	70	215	1.5	2.8
Apr 08 02:34	29 Sgr	DB	5.2	96	48	135	1.0	-3.1	Aug 07 03:08	684	RD	6.2	64	14	286	1.1	-1.5	Nov 26 22:13	Del Gem	DB	3.5	136	7	80	0.5	-0.6
Apr 08 03:44	29 Sgr	RD	5.2	96	64	238	2.9	1.3	Aug 21 22:03	16 Sgr	DD	6.0	125	62	74	2.2	1.5	Nov 26 23:19	Del Gem	RD	3.5	135	20	270	1.2	-0.8
Apr 10 01:38	Pi Cap	RD	5.1	75	15	259	0.4	-0.6	Aug 21 23:29	16 Sgr	RB	6.0	126	43	279	1.6	0.6	Nov 28 04:07	Eta Cnc	DB	5.3	120	42	61	3.1	1.3
Apr 26 01:18	53 Leo	DD	5.3	124	9	64	0.9	2.3	Aug 24 23:07	3041	DD	6.2	159	77	90	2.9	0.3	Dec 12 20:12	3105	RB	6.1	56	27	233	0.3	2.0
Apr 30 22:04	18 Lib	RB	5.9	172	56	338	0.7	-3.3	Aug 26 03:18	45 Cap	DD	6.0	171	33	59	0.6	1.9	Dec 13 21:21	Iot Aqr	DD	4.3	67	21	45	0.1	2.1
May 02 22:13	24 Oph	DB	4.9	150	40	159	-0.1	-3.5	Aug 28 01:58	Chi Aqr	DB	4.9	167	63	353	-0.9	6.2	Dec 13 22:18	Iot Aqr	RB	4.3	68	8	269	0.1	1.0
May 02 23:05	24 Oph	RD	4.9	150	51	243	2.6	0.6	Aug 28 02:36	Chi Aqr	RD	4.9	167	57	303	4.4	-2.1	Dec 16 20:31	49	DD	6.1	100	52	105	3.1	-0.1
May 13 05:05	33 Cet	RD	6.0	35	18	217	0.4	1.0	Aug 31 02:43	Nu Psc	DB	4.5	132	57	75	2.6	0.6	Dec 16 21:27	49	RB	6.1	101	41	190	0.4	3.7
Jun 01 03:24	16 Sgr	DB	6.0	156	63	79	2.2	1.3	Aug 31 04:10	Nu Psc	RD	4.5	131	52	220	1.7	2.2	Dec 17 19:40	33 Cet	DD	6.0	112	60	64	2.4	1.3
Jun 01 04:50	16 Sgr	RD	6.0	156	43	273	1.5	0.8	Sep 01 01:31	368	DB	6.2	120	42	93	2.3	-0.9	Dec 17 21:08	33 Cet	RB	6.0	112	50	228	1.7	2.1

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 01:20	56 Gem	RD	5.1	172	34	229	2.4	1.7
Jan 03 03:57	61 Gem	RD	5.9	171	18	234	1.8	2.3
Jan 04 03:47	1276	RD	6.5	157	28	345	0.2	-2.3
Jan 04 23:18	1395	RD	6.3	145	21	335	1.5	-3.1
Jan 31 00:55	85 Gem	DD	5.4	166	31	105	1.7	0.2
Feb 23 23:10	Del 1 Tau	DD	3.8	92	2	42	0.9	2.5
Feb 24 22:47	798	DD	6.2	105	15	44	1.5	2.5
Feb 26 21:12	56 Gem	DD	5.1	131	34	140	1.9	-1.6
Feb 26 22:12	56 Gem	RB	5.1	132	32	234	2.5	1.8
Feb 27 00:00	61 Gem	DD	5.9	132	21	141	0.7	-0.7
Feb 28 20:53	1395	DD	6.3	159	31	60	1.9	0.2
Mar 07 04:41	18 Lib	DB	5.9	120	65	98	2.4	-0.1
Mar 08 23:54	Phi Oph	DB	4.3	99	14	143	-0.3	-2.3
Mar 09 00:45	Phi Oph	RD	4.3	99	25	253	0.8	-0.7
Mar 10 02:33	2508	RD	6.3	87	37	314	0.5	-2.5
Mar 12 03:55	2798	DB	6.1	65	35	120	0.6	-2.3
Mar 15 05:24	44 Cap	DB	5.9	31	22	103	0.4	-1.7
Mar 20 19:07	Xi 1 Cet	DD	4.4	35	11	71	0.6	1.6
Mar 21 19:30	454	DD	5.6	47	13	27	1.0	2.9
Mar 25 21:52	Zet Gem	MB	4.0	100	21	189	9.9	9.9
Mar 29 02:19	34 Leo	DD	6.5	142	11	64	1.1	2.4
Apr 10 01:38	Pi Cap	RD	5.1	75	14	228	0.6	0.3
Apr 10 01:49	Rho Cap	DB	4.9	74	15	23	1.3	2.5
Apr 10 02:16	Rho Cap	RD	4.9	74	21	332	-0.6	-5.0
Apr 10 02:32	2990	RD	6.6	74	24	308	0.1	-2.7
Apr 22 18:43	79 Gem	DD	6.5	83	33	172	0.4	-4.4
Apr 26 01:04	53 Leo	DD	5.3	124	13	100	0.6	0.8
Apr 30 22:21	18 Lib	RD	5.9	172	52	310	1.3	-2.1
May 11 04:56	3463	RD	6.4	59	35	300	1.6	-3.3
May 13 04:50	33 Cet	RD	6.0	35	10	179	-0.2	4.3
May 20 20:02	1276	DD	6.5	66	18	181	-1.5	-4.8
May 31 02:29	2497	RD	6.5	167	63	245	2.2	2.1

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 01 04:35	16 Sgr	RD	6.0	156	50	252	1.4	1.8
Jun 02 21:07	56 Sgr	RD	4.9	136	11	246	0.2	-0.5
Jun 03 23:07	Ups Cap	RD	5.2	125	24	258	0.6	-0.8
Jun 07 06:16	Chi Aqr	DB	4.9	89	63	51	1.9	1.6
Jun 10 04:37	Nu Psc	DB	4.5	54	21	63	0.7	-0.2
Jun 10 05:48	Nu Psc	RD	4.5	53	34	241	1.2	0.1
Jun 26 20:34	2441	DD	6.6	160	56	82	2.1	-0.5
Jun 29 02:12	29 Sgr	DB	5.2	175	63	29	1.3	4.9
Jun 30 05:29	56 Sgr	DB	4.9	163	34	87	0.8	1.3
Jun 30 06:34	56 Sgr	RD	4.9	163	20	245	0.1	1.7
Jul 01 02:09	Omi Cap	RD	5.9	153	73	281	2.8	-0.6
Jul 06 05:48	14 Cet	DB	5.9	96	55	27	1.2	2.4
Jul 25 18:54	21 Sgr	DD	4.9	154	43	149	0.3	-3.7
Jul 25 19:48	21 Sgr	RB	4.9	154	54	232	2.5	1.2
Jul 28 22:15	21 Cap	RD	6.1	172	53	233	1.9	0.9
Jul 29 00:45	The Cap	DB	4.1	172	72	103	2.9	-0.7
Jul 29 02:03	The Cap	RD	4.1	171	65	217	1.4	3.0
Aug 02 00:52	128661	RD	6.6	126	40	218	1.1	1.2
Aug 05 02:04	398	RD	6.5	90	19	241	0.7	-0.1
Aug 05 02:26	85 Ara	RD	6.3	90	23	269	1.2	-1.1
Aug 07 04:56	697	RD	6.5	64	24	322	3.9	-5.6
Aug 20 19:35	2497	DD	6.5	113	74	144	2.0	-3.2
Aug 21 21:47	16 Sgr	DD	6.0	125	66	99	2.3	0.2
Aug 24 22:59	3041	DD	6.2	159	73	115	3.1	-1.5
Aug 26 03:00	45 Cap	DD	6.0	171	39	72	1.0	1.7
Aug 28 01:23	Chi Aqr	DB	4.9	167	62	17	0.9	3.4
Aug 28 02:28	Chi Aqr	RD	4.9	166	56	282	2.8	0.1
Aug 31 02:32	Nu Psc	DB	4.5	132	48	90	2.6	-0.3
Aug 31 03:46	Nu Psc	RD	4.5	131	48	207	1.2	2.4
Sep 01 02:18	368	RD	6.2	120	40	184	0.0	3.3
Sep 16 19:30	29 Oph	RB	6.3	83	58	220	1.9	4.9
Sep 17 22:37	2591	DD	6.2	95	32	132	1.4	-0.6

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 20 00:49	56 Sgr	DD	4.9	118	25	69	0.3	1.7
Sep 20 20:32	Omi Cap	DD	5.9	128	73	26	1.7	4.2
Sep 20 21:35	Omi Cap	RB	5.9	128	69	303	3.3	-1.8
Sep 21 02:44	Ups Cap	DD	5.2	130	11	105	0.2	0.8
Sep 22 18:49	Iot Aqr	DD	4.3	149	41	127	1.4	-3.7
Sep 22 19:39	Iot Aqr	RB	4.3	150	51	199	1.5	3.4
Sep 26 01:00	14 Cet	RD	5.9	173	54	257	2.3	0.8
Sep 29 02:03	454	RD	5.6	137	41	286	2.9	-1.0
Oct 01 00:59	736	RD	6.4	112	17	294	1.7	-2.0
Oct 11 19:19	Xi Lib	RB	5.5	28	11	290	0.2	0.5
Oct 18 00:20	Sig Cap	DD	5.3	99	15	94	0.2	1.0
Oct 18 20:28	21 Cap	RB	6.1	108	66	279	2.7	0.1
Oct 18 22:40	The Cap	DD	4.1	109	43	80	1.2	1.5
Oct 18 23:51	The Cap	RB	4.1	109	28	237	0.3	2.0
Oct 26 21:51	523	RD	6.4	156	19	297	1.8	-2.6
Oct 27 23:15	697	RD	6.5	143	21	202	0.1	1.5
Oct 28 23:22	Zet Tau	DB	3.0	130	11	52	0.4	0.0
Oct 29 00:26	Zet Tau	RD	3.0	130	21	278	1.6	-1.2
Oct 30 00:53	1021	RD	6.1	117	16	274	1.3	-1.1
Nov 14 22:57	3041	DD	6.2	78	15	54	-0.2	1.9
Nov 21 23:52	25 Cet	DD	6.5	158	41	40	1.5	1.9
Nov 26 01:56	Mu Gem	MD	2.9	148	32	356	9.9	9.9
Nov 26 23:21	Del Gem	RD	3.5	135	12	254	0.8	-0.6
Nov 28 03:52	Eta Cnc	DB	5.3	120	34	85	2.3	0.0
Dec 13 21:04	Iot Aqr	DD	4.3	67	28	58	0.4	2.0
Dec 13 22:08	Iot Aqr	RB	4.3	68	15	255	0.1	1.5
Dec 16 20:23	49	DD	6.1	100	50	127	4.7	-2.4
Dec 16 20:55	49	RB	6.1	101	46	169	-1.1	5.8
Dec 17 20:46	33 Cet	RB	6.0	112	48	217	1.4	2.2
Dec 18 00:49	89 Psc	DD	5.1	114	8	38	0.3	2.3
Dec 18 23:40	303	DD	6.4	125	26	122	1.7	-0.1
Dec 19 00:39	308	DD	6.3	126	16	37	0.8	2.4

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Dec 31 21:33	104 Tau	DD	4.9	157	50	157	9.9	9.9
Dec 31 21:42	104 Tau	RB	4.9	157	51	168	9.9	9.9
Jan 02 22:55	56 Gem	DB	5.1	173	41	70	1.8	0.5
Jan 03 00:13	56 Gem	RD	5.1	172	53	289	2.7	-1.0
Jan 03 03:16	61 Gem	RD	5.9	171	48	282	2.1	-0.2
Jan 11 03:02	2100	RD	6.5	69	15	343	-0.3	-3.1
Jan 29 03:04	888	DD	6.0	139	11	102	0.4	0.0
Jan 30 23:51	85 Gem	DD	5.4	166	58	55	3.2	1.9
Feb 18 19:42	27 Psc	DD	4.9	29	18	60	0.5	1.4
Feb 21 20:27	368	DD	6.2	66	37	120	2.0	-1.3
Feb 26 00:58	16 Gem	DD	6.2	120	22	72	1.3	1.1
Feb 26 01:31	Nu Gem	DD	4.1	120	15	126	0.2	-0.8
Feb 26 19:40	56 Gem	DD	5.1	131	45	72	2.1	0.4
Feb 26 21:04	56 Gem	RB	5.1	132	56	289	2.8	-1.0
Feb 26 22:50	61 Gem	DD	5.9	132	54	95	2.7	0.0
Mar 07 02:19	Xi Lib	DB	5.5	121	54	179	-0.5	-5.2
Mar 07 03:05	Xi Lib	RD	5.5	120	65	242	4.6	2.2
Mar 09 05:32	24 Oph	DB	4.9	97	76	143	2.0	-3.3
Mar 12 03:51	2798	RD	6.1	64	21	305	0.1	-1.8
Mar 15 05:25	44 Cap	RD	5.9	31	9	312	-0.3	-2.5
Mar 15 05:49	45 Cap	RD	6.0	30	14	214	1.0	2.1
Mar 25 20:08	Zet Gem	DD	4.0	100	57	117	2.8	-1.2
Mar 25 21:34	Zet Gem	RB	4.0	101	47	258	2.6	0.8
Apr 02 02:45	1965	RD	6.5	165	75	291	2.7	-1.0
Apr 08 02:30	29 Sgr	RD	5.2	96	31	266	1.2	-0.3
Apr 09 05:01	56 Sgr	DB	4.9	84	54	87	2.5	-0.2
Apr 12 05:44	42 Aqr	DB	5.3	50	31	129	1.1	-3.1
Apr 19 20:18	718	DD	6.0	43	16	16	2.5	5.9
Apr 22 23:16	85 Gem	DD	5.4	85	15	69	1.1	1.3
Apr 30 19:49	Xi Lib	RD	5.5	172	11	223	1.4	3.1
May 02 22:00	24 Oph	RD	4.9	150	21	257	0.9	0.0
May 04 22:29	21 Sgr	RD	4.9	128	6	208	2.0	4.6

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
May 05 05:40	2697	RD	6.5	126	72	234	2.8	2.6
May 07 05:32	Sig Cap	DB	5.3	104	79	86	3.5	0.1
May 08 02:57	The Cap	DB	4.1	93	33	99	1.2	-0.9
May 08 04:21	The Cap	RD	4.1	93	53	244	2.5	1.0
May 12 05:29	49	DB	6.1	46	24	117	1.2	-2.1
May 13 05:25	35 Cet	RD	6.6	34	11	246	0.3	0.4
May 29 03:45	2245	DD	6.3	169	37	120	1.6	-0.9
May 31 00:54	2497	RD	6.5	168	78	324	2.2	-3.5
Jun 01 01:49	15 Sgr	DB	5.3	156	78	100	3.3	-0.7
Jun 01 03:38	15 Sgr	RD	5.3	156	71	267	3.2	0.4
Jun 02 04:54	Pi Sgr	MB	2.9	145	65	169	9.9	9.9
Jun 04 04:25	3041	RD	6.2	123	82	286	3.9	-1.2
Jun 18 19:44	34 Leo	DD	6.5	63	45	180	-0.7	-4.7
Jun 22 22:20	1965	DD	6.5	115	62	154	1.5	-2.9
Jun 26 20:57	29 Oph	DD	6.3	161	52	139	1.1	-2.6
Jun 28 22:31	2720	RD	6.4	175	52	235	3.1	1.9
Jul 02 01:20	Iot Cap	DB	4.3	142	58	112	2.8	-1.9
Jul 02 02:40	Iot Cap	RD	4.3	142	77	213	2.5	3.5
Jul 02 23:48	Iot Aqr	RD	4.3	131	26	277	0.9	-0.8
Jul 16 20:28	53 Leo	DD	5.3	46	20	138	0.3	-1.2
Jul 26 00:47	2697	DD	6.5	156	65	87	2.9	0.5
Jul 28 20:57	21 Cap	RD	6.1	172	26	312	0.4	-2.7
Jul 29 02:29	3086	RD	6.2	171	75	232	2.4	2.2
Jul 31 06:08	70 Aqr	RD	6.2	148	45	236	1.3	1.8
Aug 03 01:06	26 Cet	RD	6.1	114	29	257	1.1	0.1
Aug 03 04:29	29 Cet	RD	6.4	113	72	251	2.9	0.9
Aug 03 05:23	33 Cet	DB	6.0	113	75	40	2.0	2.4
Aug 17 23:48	Xi Lib	DD	5.5	81	6	89	0.1	0.4
Aug 18 22:08	2245	DD	6.3	92	41	154	1.9	-3.4
Aug 21 20:26	15 Sgr	DD	5.3	125	77	96	3.4	-0.5
Aug 21 22:17	15 Sgr	RB	5.3	126	71	272	3.2	0.1
Aug 22 23:30	Pi Sgr	DD	2.9	137	66	148	5.2	-6.9

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 23 00:06	Pi Sgr	RB	2.9	137	57	190	-0.3	8.1
Aug 25 02:09	19 Cap	DD	5.8	160	52	97	2.5	0.0
Sep 01 01:26	368	RD	6.2	119	38	308	3.8	-4.5
Sep 03 04:57	Del 1 Tau	DB	3.8	93	53	59	2.1	1.1
Sep 03 05:43	64 Tau	DB	4.8	93	58	106	3.6	-1.1
Sep 03 06:29	Del 1 Tau	RD	3.8	93	60	255	2.9	0.7
Sep 04 04:48	798	DB	6.2	80	41	92	2.2	-0.5
Sep 17 22:21	2591	DD	6.2	96	42	16	-0.6	7.6
Sep 19 01:25	Xi 1 Sgr	DD	5.0	108	11	64	-0.1	1.3
Sep 21 02:51	Ups Cap	DD	5.2	130	13	16	-0.8	3.3
Sep 21 20:42	Iot Cap	DD	4.3	139	69	93	3.2	-0.5
Sep 21 22:20	Iot Cap	RB	4.3	140	85	224	2.5	2.7
Sep 23 02:01	42 Aqr	DD	5.3	152	46	52	1.2	1.9
Sep 29 04:16	464	RD	6.1	136	62	218	2.1	2.5
Oct 15 23:06	2697	DD	6.5	76	14	39	-0.4	2.4
Oct 18 23:13	3086	DD	6.2	109	45	75	1.6	1.1
Oct 21 02:12	70 Aqr	DD	6.2	132	24	85	0.8	0.7
Oct 23 19:33	26 Cet	DD	6.1	165	26	93	1.2	-0.6
Oct 23 22:47	29 Cet	DD	6.4	166	69	99	3.9	-0.9
Oct 24 01:09	33 Cet	DD	6.0	166	65	102	3.8	-0.6
Oct 27 22:11	697	RD	6.5	143	12	333	9.9	9.9
Oct 30 05:47	36 Gem	DB	5.3	114	55	110	2.8	-0.8
Nov 11 21:27	Mu Sgr	DD	3.8	44	7	89	0.1	0.4
Nov 21 02:20	Nu Psc	DD	4.5	147	30	101	1.5	0.0
Nov 21 03:18	Nu Psc	RB	4.5	147	16	213	0.6	2.4
Nov 23 20:17	620	RD	6.1	175	16	309	1.8	-3.0
Nov 27 01:24	1125	RD	6.5	134	40	215	1.1	2.7
Dec 02 05:13	16 Vir	DB	5.0	66	40	135	1.3	-2.0
Dec 16 20:50	49	RB	6.1	101	68	273	3.6	0.1
Dec 18 22:58	303	DD	6.4	125	55	41	1.8	2.4
Dec 22 01:25	736	DD	6.4	165	49	112	2.6	-0.8
Dec 23 20:42	36 Gem	RD	5.3	169	11	243	0.2	0.5

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 23:34	1395	RD	6.3	145	17	316	1.2	-2.0
Jan 31 00:52	85 Gem	DD	5.4	166	25	123	1.3	-0.1
Feb 23 22:53	Del 1 Tau	DD	3.8	92	3	63	0.7	1.8
Feb 24 22:30	798	DD	6.2	105	13	65	1.3	1.7
Feb 26 21:26	56 Gem	DD	5.1	131	27	170	1.0	-4.1
Feb 26 21:48	56 Gem	RB	5.1	132	26	202	2.9	4.3
Feb 27 00:15	61 Gem	DD	5.9	133	15	183	-3.8	-9.8
Feb 28 01:01	1276	DD	6.5	147	17	52	2.0	2.5
Feb 28 20:52	1395	DD	6.3	159	23	77	1.5	-0.6
Mar 07 04:42	18 Lib	DB	5.9	120	58	124	1.7	-1.1
Mar 09 00:16	Phi Oph	DB	4.3	99	18	169	-0.8	-3.5
Mar 09 00:46	Phi Oph	RD	4.3	99	23	226	1.3	0.3
Mar 10 02:48	2508	RD	6.3	87	38	291	0.8	-1.9
Mar 12 04:17	2798	DB	6.1	65	37	152	0.0	-4.4
Mar 12 04:58	2798	RD	6.1	64	45	216	2.1	1.9
Mar 15 05:01	42 Cap	DB	5.2	31	16	28	0.7	1.1
Mar 21 19:10	454	DD	5.6	47	14	46	1.0	2.1
Mar 29 02:05	34 Leo	DD	6.5	142	11	95	0.7	1.1
Apr 08 01:13	2724	RD	6.3	97	27	343	-0.8	-4.8
Apr 10 01:44	Rho Cap	DB	4.9	75	14	58	0.4	-0.4
Apr 10 02:40	Rho Cap	RD	4.9	74	25	296	0.3	-2.3
Apr 10 02:48	2990	RD	6.6	74	26	280	0.5	-1.7
Apr 26 01:00	53 Leo	DD	5.3	124	12	127	0.4	0.2
Apr 30 22:07	17 Lib	RD	6.6	172	45	271	1.5	-1.1
Apr 30 22:32	18 Lib	RD	5.9	172	48	290	1.4	-1.5
May 11 05:08	3463	RD	6.4	59	33	268	1.2	-1.3
Jun 01 04:14	16 Sgr	RD	6.0	156	53	226	1.2	3.2
Jun 02 21:07	56 Sgr	RD	4.9	136	12	218	0.6	0.4
Jun 03 23:10	Ups Cap	RD	5.2	125	24	232	0.8	-0.1
Jun 07 06:04	Chi Aqr	DB	4.9	89	55	70	1.9	0.6
Jun 10 04:41	Nu Psc	DB	4.5	54	17	87	0.8	-1.3
Jun 10 05:43	Nu Psc	RD	4.5	53	27	219	0.7	0.6

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 26 20:39	2441	DD	6.6	160	53	106	1.4	-1.5
Jun 29 01:45	29 Sgr	DB	5.2	175	63	61	1.8	2.0
Jun 29 03:03	29 Sgr	RD	5.2	174	52	289	1.8	0.3
Jun 30 05:18	56 Sgr	DB	4.9	163	37	105	1.1	0.9
Jun 30 06:19	56 Sgr	RD	4.9	163	26	229	0.0	2.3
Jul 01 02:04	Omi Cap	RD	5.9	153	66	257	2.1	0.6
Jul 04 00:26	3355	RD	6.7	120	30	247	0.9	-0.5
Jul 06 05:32	14 Cet	DB	5.9	96	48	44	1.4	1.3
Jul 06 06:53	14 Cet	RD	5.9	95	46	254	1.9	1.0
Jul 17 21:28	Nu Vir	DD	4.0	60	5	54	0.6	3.5
Jul 20 21:37	2049	DD	6.5	97	37	38	2.4	8.4
Jul 28 21:56	21 Cap	RD	6.1	172	46	194	1.8	4.7
Jul 29 00:54	The Cap	DB	4.1	171	65	137	3.4	-4.4
Jul 29 01:32	The Cap	RD	4.1	171	63	186	0.3	6.0
Jul 29 19:15	45 Cap	RD	6.0	162	7	288	-0.2	-1.8
Aug 02 00:37	128661	RD	6.6	127	32	187	0.4	3.1
Aug 05 02:02	398	RD	6.5	90	14	218	0.3	0.4
Aug 05 02:30	85 Ara	RD	6.3	90	18	247	0.8	-0.5
Aug 07 05:13	697	RD	6.5	63	19	292	1.8	-1.8
Aug 21 21:46	16 Sgr	DD	6.0	125	62	127	2.1	-1.3
Aug 26 02:47	45 Cap	DD	6.0	171	41	86	1.3	1.4
Aug 28 01:01	Chi Aqr	DB	4.9	167	55	37	1.4	1.9
Aug 28 02:19	Chi Aqr	RD	4.9	166	51	264	2.0	0.8
Aug 31 02:33	Nu Psc	DB	4.5	132	41	111	2.8	-1.5
Aug 31 03:25	Nu Psc	RD	4.5	131	42	189	0.5	2.8
Sep 18 21:32	29 Sgr	DD	5.2	106	53	26	0.7	4.9
Sep 18 22:14	29 Sgr	RB	5.2	106	46	321	2.2	-1.7
Sep 20 00:36	56 Sgr	DD	4.9	118	29	84	0.6	1.5
Sep 20 01:40	56 Sgr	RB	4.9	119	18	250	0.0	1.7
Sep 20 20:08	2993	DD	6.7	128	65	57	2.0	1.3
Sep 20 20:09	Omi Cap	DD	5.9	128	65	56	2.0	1.3
Sep 20 21:35	Omi Cap	RB	5.9	128	64	276	2.2	0.2

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 21 02:38	Ups Cap	DD	5.2	130	15	123	0.5	0.5
Sep 26 00:49	14 Cet	RD	5.9	173	48	243	1.7	1.0
Sep 27 23:30	64 Cet	RD	5.6	150	29	285	1.9	-1.8
Sep 27 23:55	Xi 1 Cet	DB	4.4	150	31	1	-0.2	3.1
Sep 28 00:33	Xi 1 Cet	RD	4.4	150	35	301	3.1	-2.7
Sep 29 02:03	454	RD	5.6	137	33	269	2.0	-0.3
Oct 01 01:08	736	RD	6.4	112	12	273	1.1	-1.3
Oct 11 19:11	Xi Lib	RB	5.5	28	15	265	0.2	1.5
Oct 13 19:06	24 Oph	RB	4.9	52	37	318	1.3	-0.7
Oct 16 20:45	2829	DD	6.7	86	48	115	1.8	0.1
Oct 18 00:12	Sig Cap	DD	5.3	99	19	110	0.5	0.9
Oct 18 20:19	21 Cap	RB	6.1	108	62	258	2.0	1.0
Oct 18 22:28	The Cap	DD	4.1	109	45	96	1.5	1.1
Oct 18 23:33	The Cap	RB	4.1	109	33	223	0.3	2.5
Oct 22 00:03	3463	DD	6.4	143	42	356	-0.5	4.5
Oct 26 22:02	523	RD	6.4	156	15	272	1.1	-1.3
Oct 28 23:24	Zet Tau	DB	3.0	130	6	70	0.6	-0.7
Oct 29 00:31	Zet Tau	RD	3.0	130	15	262	1.2	-0.9
Oct 30 00:59	1021	RD	6.1	117	11	259	0.9	-0.9
Nov 14 22:43	3041	DD	6.2	78	20	67	0.1	1.8
Nov 18 01:36	Chi Aqr	DD	4.9	112	6	33	-0.2	2.2
Nov 21 23:37	25 Cet	DD	6.5	158	35	52	1.5	1.3
Nov 26 01:35	Mu Gem	DB	2.9	148	24	22	1.2	1.9
Nov 26 02:10	Mu Gem	RD	2.9	148	25	329	2.1	-2.1
Nov 26 23:24	Del Gem	RD	3.5	135	7	237	0.5	-0.4
Nov 28 03:50	Eta Cnc	DB	5.3	120	27	99	1.8	-0.4
Dec 13 20:48	Iot Aqr	DD	4.3	67	32	70	0.7	1.8
Dec 13 21:55	Iot Aqr	RB	4.3	68	19	243	0.2	1.9
Dec 18 00:33	89 Psc	DD	5.1	114	11	52	0.4	2.0
Dec 19 00:21	308	DD	6.3	126	17	51	0.8	2.0
Dec 25 03:34	Mu Cnc	RD	5.3	153	23	335	0.8	-1.1
Dec 27 00:48	1479	RD	6.4	126	17	316	1.2	-2.0

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 03:49	1276	RD	6.5	157	28	328	0.8	-1.1
Jan 04 23:20	1395	RD	6.3	145	17	329	1.3	-2.6
Jan 14 03:51	2460	RD	6.0	36	10	353	-1.2	-4.2
Jan 31 00:48	85 Gem	DD	5.4	166	30	114	1.6	-0.2
Jan 31 03:24	1205	DD	6.3	167	13	68	1.3	1.8
Feb 23 23:01	Del 1 Tau	DD	3.8	92	6	53	0.9	2.1
Feb 24 22:35	798	DD	6.2	105	17	55	1.5	1.9
Feb 26 21:09	56 Gem	DD	5.1	131	32	150	1.9	-2.2
Feb 26 21:57	56 Gem	RB	5.1	132	31	221	2.5	2.1
Feb 27 00:01	61 Gem	DD	5.9	133	21	157	0.3	-1.6
Feb 28 01:14	1276	DD	6.5	147	21	28	5.1	8.7
Feb 28 20:46	1395	DD	6.3	159	26	67	1.6	-0.3
Mar 07 04:33	18 Lib	DB	5.9	120	63	111	2.1	-0.9
Mar 09 00:02	Phi Oph	DB	4.3	99	13	156	-0.5	-2.7
Mar 09 00:43	Phi Oph	RD	4.3	99	21	240	0.8	-0.3
Mar 10 02:36	2508	RD	6.3	87	35	301	0.5	-2.1
Mar 12 04:00	2798	DB	6.1	65	33	134	0.3	-2.9
Mar 12 04:59	2798	RD	6.1	64	44	236	1.8	0.4
Mar 15 05:28	44 Cap	DB	5.9	31	19	116	0.2	-2.3
Mar 21 19:19	454	DD	5.6	47	16	36	1.1	2.5
Mar 29 02:10	34 Leo	DD	6.5	142	14	81	1.0	1.5
Apr 10 01:34	Pi Cap	RD	5.1	75	10	211	0.7	1.2
Apr 10 01:43	Rho Cap	DB	4.9	75	11	43	0.5	0.4
Apr 10 02:27	Rho Cap	RD	4.9	74	20	312	-0.1	-2.9
Apr 10 02:38	2990	RD	6.6	74	22	294	0.2	-2.1
Apr 26 01:00	53 Leo	DD	5.3	124	15	113	0.6	0.4
Apr 30 22:20	18 Lib	RD	5.9	172	48	298	1.3	-1.8
May 11 04:57	3463	RD	6.4	59	31	289	1.3	-2.3
May 31 02:14	2497	RD	6.5	167	67	233	2.4	2.9
Jun 01 04:24	16 Sgr	RD	6.0	156	54	246	1.5	2.0
Jun 02 21:07	56 Sgr	RD	4.9	136	9	233	0.3	-0.1
Jun 03 23:07	Ups Cap	RD	5.2	125	21	247	0.6	-0.5

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 07 06:05	Chi Aqr	DB	4.9	89	59	53	1.8	1.3
Jun 10 04:35	Nu Psc	DB	4.5	54	17	69	0.6	-0.5
Jun 10 05:43	Nu Psc	RD	4.5	53	29	238	1.0	0.1
Jun 29 01:54	29 Sgr	DB	5.2	175	67	39	1.8	3.7
Jun 29 02:57	29 Sgr	RD	5.2	174	56	311	2.4	-1.4
Jun 30 05:21	56 Sgr	DB	4.9	163	38	89	1.0	1.3
Jun 30 06:29	56 Sgr	RD	4.9	163	25	244	0.2	1.9
Jul 01 01:59	Omi Cap	RD	5.9	153	71	275	2.5	-0.4
Jul 06 05:37	14 Cet	DB	5.9	96	52	27	1.2	2.2
Jul 06 06:52	14 Cet	RD	5.9	95	51	269	2.5	0.5
Jul 17 21:44	Nu Vir	MD	4.0	60	4	23	9.9	9.9
Jul 25 19:08	21 Sgr	DD	4.9	154	42	173	-1.3	-7.7
Jul 25 19:31	21 Sgr	RB	4.9	154	47	207	3.7	5.1
Jul 28 22:04	21 Cap	RD	6.1	172	47	221	1.7	1.4
Jul 29 00:36	The Cap	DB	4.1	172	69	109	2.7	-1.3
Jul 29 01:50	The Cap	RD	4.1	171	67	214	1.4	3.1
Aug 05 02:01	398	RD	6.5	90	14	237	0.5	-0.1
Aug 05 02:24	85 Ara	RD	6.3	90	18	265	1.0	-1.0
Aug 07 04:55	697	RD	6.5	64	19	318	3.0	-4.5
Aug 20 19:38	2497	DD	6.5	113	72	162	1.4	-5.3
Aug 21 21:37	16 Sgr	DD	6.0	125	68	107	2.4	-0.4
Aug 24 22:52	3041	DD	6.2	159	70	122	3.0	-2.3
Aug 26 02:52	45 Cap	DD	6.0	171	44	72	1.2	1.7
Aug 28 01:11	Chi Aqr	DB	4.9	167	60	18	0.9	3.2
Aug 28 02:16	Chi Aqr	RD	4.9	166	57	282	2.8	-0.1
Aug 31 02:22	Nu Psc	DB	4.5	132	44	90	2.4	-0.5
Aug 31 03:35	Nu Psc	RD	4.5	131	47	208	1.2	2.1
Sep 01 02:10	368	RD	6.2	120	35	183	-0.2	3.2
Sep 17 22:33	2591	DD	6.2	96	36	138	1.7	-1.0
Sep 20 00:43	56 Sgr	DD	4.9	118	30	70	0.4	1.8
Sep 20 01:47	56 Sgr	RB	4.9	119	17	263	0.1	1.4
Sep 20 20:15	Omi Cap	DD	5.9	128	69	35	2.0	3.0

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 20 21:26	Omi Cap	RB	5.9	128	70	297	2.9	-1.4
Sep 21 02:41	Ups Cap	DD	5.2	130	15	107	0.3	0.8
Sep 22 18:57	Iot Aqr	DD	4.3	150	39	146	1.2	-7.8
Sep 22 19:21	Iot Aqr	RB	4.3	150	43	182	1.2	7.1
Sep 26 00:49	14 Cet	RD	5.9	173	53	258	2.3	0.6
Sep 27 22:53	64 Cet	DD	5.6	150	25	342	9.9	9.9
Sep 27 23:06	64 Cet	RD	5.6	150	27	321	9.9	9.9
Sep 29 01:54	454	RD	5.6	137	37	286	2.7	-1.2
Oct 01 00:58	736	RD	6.4	112	13	291	1.4	-2.0
Oct 11 19:16	Xi Lib	RB	5.5	28	15	283	0.3	0.8
Oct 15 23:18	2697	DD	6.5	76	13	144	0.9	-0.9
Oct 18 00:16	Sig Cap	DD	5.3	99	19	96	0.4	1.1
Oct 18 20:17	21 Cap	RB	6.1	108	68	276	2.6	0.1
Oct 18 22:31	The Cap	DD	4.1	109	47	80	1.4	1.5
Oct 18 23:44	The Cap	RB	4.1	109	33	237	0.5	2.1
Oct 26 21:51	523	RD	6.4	156	14	294	1.4	-2.3
Oct 27 23:11	697	RD	6.5	143	16	200	-0.1	1.5
Oct 28 23:21	Zet Tau	DB	3.0	130	7	54	0.3	-0.1
Oct 29 00:23	Zet Tau	RD	3.0	130	16	277	1.4	-1.2
Oct 30 00:52	1021	RD	6.1	117	12	273	1.1	-1.2
Nov 14 22:53	3041	DD	6.2	78	19	55	0.0	2.0
Nov 21 23:41	25 Cet	DD	6.5	158	40	40	1.5	1.7
Nov 26 01:48	Mu Gem	MD	2.9	148	29	355	9.9	9.9
Nov 26 23:20	Del Gem	RD	3.5	135	8	252	0.6	-0.7
Nov 28 03:44	Eta Cnc	DB	5.3	120	31	92	2.1	-0.4
Dec 13 20:56	Iot Aqr	DD	4.3	67	32	58	0.6	2.0
Dec 13 22:03	Iot Aqr	RB	4.3	68	19	254	0.3	1.6
Dec 18 00:42	89 Psc	DD	5.1	114	12	43	0.5	2.2
Dec 18 23:33	303	DD	6.4	125	29	127	2.1	-0.5
Dec 19 00:30	308	DD	6.3	126	19	42	0.9	2.2
Dec 25 03:24	Mu Cnc	RD	5.3	153	29	349	0.4	-2.9
Dec 27 00:35	1479	RD	6.4	126	17	327	1.2	-2.4

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 01 02:52	798	DD	6.2	160	14	46	1.4	2.3
Jan 02 22:18	56 Gem	RD	5.1	172	26	243	1.3	0.0
Jan 29 02:03	Chi 1 Ori	DD	4.4	140	8	90	0.7	1.0
Jan 30 21:46	85 Gem	DD	5.4	166	32	112	2.0	-1.2
Jan 31 00:40	1205	DD	6.3	167	36	89	2.2	0.4
Feb 18 19:33	29 Psc	DD	5.1	30	13	65	0.3	1.7
Feb 23 20:31	Del 1 Tau	DD	3.8	92	32	51	1.9	1.9
Feb 23 21:04	64 Tau	DD	4.8	92	28	84	1.7	1.0
Feb 23 21:40	Del 1 Tau	RB	3.8	92	22	289	1.3	0.4
Feb 23 22:19	64 Tau	RB	4.8	93	16	259	1.1	1.3
Feb 25 23:17	16 Gem	DD	6.2	120	23	159	0.1	-2.7
Mar 07 01:35	18 Lib	DB	5.9	120	47	138	0.9	-2.4
Mar 07 02:52	18 Lib	RD	5.9	120	61	277	2.3	-0.9
Mar 12 02:23	2798	RD	6.1	64	13	216	1.0	1.4
Mar 21 19:39	464	DD	6.1	48	16	142	0.6	-1.7
Mar 30 03:55	1625	DD	5.8	157	10	146	0.1	-0.9
Apr 20 18:53	881	DD	6.3	57	25	41	2.2	2.7
Apr 22 21:40	85 Gem	DD	5.4	85	18	163	-0.3	-2.3
Apr 25 22:29	53 Leo	DD	5.3	124	42	134	1.4	-1.0
Apr 25 23:43	53 Leo	RB	5.3	125	31	283	1.4	0.4
Apr 30 19:45	18 Lib	RD	5.9	172	19	277	0.4	-1.3
May 13 06:16	89 Psc	DB	5.1	33	24	13	0.2	2.4
May 28 03:38	Xi Lib	DD	5.5	158	22	114	0.7	0.2
Jun 01 01:21	16 Sgr	RD	6.0	156	76	273	2.6	-0.4
Jun 04 02:02	3041	RD	6.2	123	56	217	2.2	2.3
Jun 05 05:27	45 Cap	DB	6.0	111	72	47	2.0	2.2
Jun 18 20:05	37 Leo	DD	5.4	64	24	55	2.4	3.4
Jun 18 20:38	37 Leo	RB	5.4	64	19	356	-0.6	-3.1
Jun 28 00:04	2591	DD	6.2	173	78	128	2.5	-2.2
Jun 29 04:14	Xi 1 Sgr	DB	5.0	173	43	130	2.2	-1.1
Jun 29 05:02	Xi 1 Sgr	RD	5.0	173	33	210	-0.2	3.5
Jun 30 02:55	56 Sgr	DB	4.9	163	68	33	1.5	3.8

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 30 04:02	56 Sgr	RD	4.9	163	55	299	2.6	-0.7
Jun 30 22:50	Omi Cap	RD	5.9	153	43	297	1.2	-2.3
Jul 01 05:05	Ups Cap	DB	5.2	151	51	69	1.4	1.7
Jul 01 06:22	Ups Cap	RD	5.2	151	35	251	0.8	1.7
Jul 03 04:30	42 Aqr	DB	5.3	129	69	84	2.7	0.6
Jul 03 05:54	42 Aqr	RD	5.3	129	56	220	1.2	2.6
Jul 09 06:07	464	RD	6.1	57	35	261	1.7	-0.4
Jul 17 19:25	Nu Vir	MD	4.0	60	32	29	9.9	9.9
Jul 28 19:32	21 Cap	RD	6.1	172	17	223	0.8	0.7
Jul 28 21:30	The Cap	DB	4.1	172	41	82	1.4	-0.7
Jul 28 22:56	The Cap	RD	4.1	171	59	257	2.2	-0.2
Jul 31 03:30	70 Aqr	RD	6.2	148	65	207	1.2	3.1
Aug 03 02:55	33 Cet	DB	6.0	113	47	69	1.9	0.2
Aug 03 04:21	33 Cet	RD	6.0	113	55	226	1.8	1.6
Aug 17 22:20	Xi Lib	DD	5.5	81	21	161	0.9	-2.5
Aug 17 23:08	18 Lib	DD	5.9	81	11	63	0.0	2.2
Aug 20 00:26	24 Oph	DD	4.9	105	18	128	0.7	-0.3
Aug 21 19:59	16 Sgr	RB	6.0	126	76	277	2.6	-0.7
Aug 22 01:43	21 Sgr	DD	4.9	127	23	144	1.5	-1.6
Aug 22 02:15	21 Sgr	RB	4.9	128	16	203	-0.9	3.9
Aug 24 19:39	3041	DD	6.2	159	43	93	1.4	-1.2
Aug 26 00:35	45 Cap	DD	6.0	171	70	4	0.1	5.8
Aug 30 23:44	Nu Psc	DB	4.5	131	26	30	0.5	1.3
Aug 31 00:49	Nu Psc	RD	4.5	131	37	271	2.0	-1.0
Aug 31 23:57	368	RD	6.2	119	17	248	0.7	-0.3
Sep 03 02:59	Del 1 Tau	DB	3.8	93	25	93	1.6	-1.1
Sep 03 04:08	Del 1 Tau	RD	3.8	93	35	222	1.2	1.0
Sep 03 04:40	68 Tau	DB	4.3	93	37	66	1.9	0.3
Sep 04 03:24	793	RD	6.2	80	19	290	1.6	-1.7
Sep 04 03:41	798	RD	6.2	80	22	176	-2.6	7.3
Sep 06 05:11	63 Gem	DB	5.3	53	16	59	0.8	0.0
Sep 17 19:33	2591	DD	6.2	95	72	94	2.6	0.2

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 17 21:06	2591	RB	6.2	96	54	268	1.8	1.0
Sep 18 23:28	Xi 1 Sgr	DD	5.0	108	35	104	1.2	0.6
Sep 19 00:31	Xi 1 Sgr	RB	5.0	108	22	236	0.0	2.0
Sep 19 22:57	56 Sgr	DD	4.9	119	51	353	9.9	9.9
Sep 19 23:08	56 Sgr	RB	4.9	119	48	337	9.9	9.9
Sep 21 00:33	Ups Cap	DD	5.2	130	40	57	0.8	2.1
Sep 21 01:42	Ups Cap	RB	5.2	130	26	264	0.6	1.3
Sep 22 23:33	42 Aqr	DD	5.3	152	66	80	2.4	0.9
Sep 23 00:55	42 Aqr	RB	5.3	152	51	223	1.1	2.5
Sep 29 01:32	464	RD	6.1	136	40	179	-0.5	4.2
Sep 30 04:00	610	RD	6.1	123	41	290	3.0	-0.8
Oct 17 22:10	Sig Cap	DD	5.3	99	44	44	0.7	2.6
Oct 17 23:16	Sig Cap	RB	5.3	99	30	279	1.0	0.8
Oct 18 20:02	The Cap	DD	4.1	109	74	18	1.2	4.6
Oct 18 20:58	3086	DD	6.2	109	67	112	3.2	-0.8
Oct 18 21:03	The Cap	RB	4.1	109	65	298	3.4	-1.3
Oct 21 00:14	70 Aqr	DD	6.2	132	42	128	3.3	-1.5
Oct 24 04:06	89 Psc	DD	5.1	168	15	96	0.7	1.0
Nov 11 19:48	Mu Sgr	DD	3.8	44	28	139	1.5	-1.2
Nov 11 20:25	15 Sgr	DD	5.3	45	20	63	0.0	1.8
Nov 11 20:26	Mu Sgr	RB	3.8	45	20	210	-0.6	3.4
Nov 12 21:34	Pi Sgr	DD	2.9	56	16	118	0.6	0.2
Nov 12 22:20	Pi Sgr	RB	2.9	57	7	221	-0.6	2.2
Nov 14 23:36	19 Cap	DD	5.8	79	10	83	-0.1	1.2
Nov 28 02:00	Eta Cnc	RD	5.3	119	28	298	1.9	-1.5
Dec 12 20:45	Iot Cap	DD	4.3	57	28	86	0.7	1.2
Dec 12 21:46	Iot Cap	RB	4.3	58	15	231	-0.1	1.9
Dec 17 22:38	89 Psc	DD	5.1	114	37	7	0.5	3.8
Dec 17 23:22	89 Psc	RB	5.1	114	29	298	1.8	-0.1
Dec 18 22:19	308	DD	6.3	126	43	355	0.0	4.9
Dec 19 01:03	64 Cet	DD	5.6	127	15	63	0.8	1.7
Dec 25 00:21	Mu Cnc	RD	5.3	153	30	351	2.7	-6.7

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 00:27	56 Gem	DB	5.1	173	36	138	2.0	-1.6
Jan 03 01:27	56 Gem	RD	5.1	172	34	235	2.4	1.6
Jan 03 04:03	61 Gem	RD	5.9	171	16	242	1.5	1.9
Jan 04 23:17	1395	RD	6.3	145	23	340	1.6	-3.4
Jan 31 00:59	85 Gem	DD	5.4	166	31	99	1.7	0.3
Feb 02 21:00	53 Leo	RD	5.3	153	7	230	0.3	0.3
Feb 23 23:16	Del 1 Tau	DD	3.8	92	0	34	0.9	2.8
Feb 24 22:54	798	DD	6.2	105	13	37	1.6	2.9
Feb 26 21:14	56 Gem	DD	5.1	131	36	136	1.9	-1.3
Feb 26 22:19	56 Gem	RB	5.1	132	32	240	2.4	1.6
Feb 27 00:01	61 Gem	DD	5.9	132	21	134	0.7	-0.4
Feb 28 20:58	1395	DD	6.3	159	33	55	2.1	0.6
Mar 07 04:46	18 Lib	DB	5.9	120	65	91	2.6	0.3
Mar 08 23:50	Phi Oph	DB	4.3	99	15	138	-0.2	-2.2
Mar 09 00:46	Phi Oph	RD	4.3	99	26	259	0.8	-0.9
Mar 10 01:32	2508	DB	6.3	87	26	71	0.9	-0.5
Mar 10 02:30	2508	RD	6.3	87	39	321	0.4	-2.9
Mar 12 03:53	2798	DB	6.1	65	36	113	0.8	-2.0
Mar 15 05:23	44 Cap	DB	5.9	31	23	97	0.5	-1.4
Mar 20 19:10	Xi 1 Cet	DD	4.4	35	9	67	0.5	1.6
Mar 21 19:36	454	DD	5.6	47	11	21	1.0	3.3
Mar 25 21:56	Zet Gem	MB	4.0	100	20	190	9.9	9.9
Mar 26 19:56	1205	RB	6.3	113	36	245	2.6	1.0
Apr 10 01:39	Pi Cap	RD	5.1	75	16	235	0.6	0.0
Apr 26 01:07	53 Leo	DD	5.3	124	11	94	0.6	1.0
Apr 30 22:20	18 Lib	RD	5.9	172	54	316	1.2	-2.3
May 11 04:54	3463	RD	6.4	59	37	307	1.9	-4.2
May 13 04:54	33 Cet	RD	6.0	35	13	187	0.0	2.9
Jun 01 03:15	16 Sgr	DB	6.0	156	64	100	2.3	0.2
Jun 01 04:40	16 Sgr	RD	6.0	156	47	254	1.3	1.7
Jun 02 21:07	56 Sgr	RD	4.9	136	12	252	0.2	-0.6
Jun 03 23:08	Ups Cap	RD	5.2	125	26	264	0.7	-1.0

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 07 06:22	Chi Aqr	DB	4.9	89	64	51	1.9	1.7
Jun 10 04:39	Nu Psc	DB	4.5	54	24	61	0.8	0.0
Jun 10 05:51	Nu Psc	RD	4.5	53	36	242	1.3	0.1
Jun 29 02:21	29 Sgr	DB	5.2	175	60	23	0.9	5.6
Jun 29 03:05	29 Sgr	RD	5.2	174	51	322	2.9	-2.7
Jun 30 05:32	56 Sgr	DB	4.9	163	31	86	0.7	1.3
Jul 01 00:48	Omi Cap	DB	5.9	154	69	48	2.3	1.9
Jul 01 02:14	Omi Cap	RD	5.9	153	74	285	2.9	-0.7
Jul 02 23:56	Iot Aqr	DB	4.3	132	40	142	1.3	-6.4
Jul 03 00:27	Iot Aqr	RD	4.3	132	46	186	1.4	6.0
Jul 06 05:54	14 Cet	DB	5.9	96	56	27	1.2	2.5
Jul 23 18:07	24 Oph	DD	4.9	131	54	187	-2.4	-9.4
Jul 23 18:28	24 Oph	RB	4.9	131	58	215	5.7	6.5
Jul 25 18:51	21 Sgr	DD	4.9	154	44	140	0.6	-3.1
Jul 25 19:55	21 Sgr	RB	4.9	154	58	241	2.5	0.7
Jul 28 22:20	21 Cap	RD	6.1	172	56	238	2.0	0.7
Jul 29 00:50	The Cap	DB	4.1	172	73	100	2.9	-0.5
Jul 29 02:10	The Cap	RD	4.1	171	63	218	1.3	2.9
Aug 05 02:27	85 Ara	RD	6.3	90	25	271	1.4	-1.1
Aug 21 21:52	16 Sgr	DD	6.0	125	64	95	2.3	0.4
Aug 21 23:19	16 Sgr	RB	6.0	126	47	260	1.4	1.5
Aug 24 23:04	3041	DD	6.2	159	73	112	3.1	-1.2
Aug 25 00:14	3041	RB	6.2	159	63	209	1.0	3.5
Aug 26 03:05	45 Cap	DD	6.0	171	37	71	0.9	1.7
Aug 28 01:29	Chi Aqr	DB	4.9	167	62	16	0.8	3.5
Aug 28 02:34	Chi Aqr	RD	4.9	166	54	282	2.7	0.2
Aug 31 02:37	Nu Psc	DB	4.5	132	50	90	2.7	-0.2
Aug 31 03:52	Nu Psc	RD	4.5	131	49	207	1.3	2.5
Sep 01 01:36	368	DB	6.2	120	37	115	2.9	-2.6
Sep 01 02:23	368	RD	6.2	120	42	185	0.1	3.3
Sep 04 05:10	793	DB	6.2	81	33	90	2.2	-0.5
Sep 16 18:43	29 Oph	DD	6.3	83	66	150	2.2	-3.3

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 16 19:39	29 Oph	RB	6.3	83	55	227	1.7	3.8
Sep 17 22:39	2591	DD	6.2	95	30	130	1.3	-0.5
Sep 20 00:52	56 Sgr	DD	4.9	118	22	68	0.2	1.7
Sep 20 20:41	Omi Cap	DD	5.9	128	75	21	1.5	4.8
Sep 20 21:39	Omi Cap	RB	5.9	128	68	306	3.5	-2.1
Sep 21 02:45	Ups Cap	DD	5.2	130	8	104	0.1	0.7
Sep 22 18:48	Iot Aqr	DD	4.3	149	43	119	1.6	-3.0
Sep 22 19:46	Iot Aqr	RB	4.3	150	54	205	1.6	2.9
Sep 25 23:44	14 Cet	DB	5.9	173	56	37	1.5	1.9
Sep 26 01:06	14 Cet	RD	5.9	173	55	257	2.3	0.9
Sep 29 01:07	454	DB	5.6	137	39	18	0.6	2.1
Sep 29 02:08	454	RD	5.6	137	43	286	3.0	-0.9
Oct 11 19:20	Xi Lib	RB	5.5	28	9	293	0.2	0.3
Oct 18 00:22	Sig Cap	DD	5.3	99	12	94	0.1	1.0
Oct 18 19:13	21 Cap	DD	6.1	108	74	38	1.9	2.8
Oct 18 20:34	21 Cap	RB	6.1	108	65	280	2.7	0.1
Oct 18 22:44	The Cap	DD	4.1	109	40	79	1.1	1.5
Oct 18 23:54	The Cap	RB	4.1	109	26	238	0.3	1.9
Oct 28 23:23	Zet Tau	DB	3.0	130	14	51	0.5	0.2
Oct 29 00:28	Zet Tau	RD	3.0	130	23	279	1.7	-1.2
Oct 30 00:55	1021	RD	6.1	117	18	275	1.4	-1.1
Nov 14 22:59	3041	DD	6.2	78	12	53	-0.2	1.9
Nov 26 02:00	Mu Gem	MD	2.9	148	34	356	9.9	9.9
Nov 26 23:22	Del Gem	RD	3.5	135	15	255	0.9	-0.6
Nov 28 03:57	Eta Cnc	DB	5.3	120	36	80	2.4	0.3
Dec 13 21:07	Iot Aqr	DD	4.3	67	25	58	0.3	1.9
Dec 13 22:10	Iot Aqr	RB	4.3	68	12	256	0.1	1.4
Dec 16 20:30	49	DD	6.1	100	49	128	4.7	-2.5
Dec 16 20:59	49	RB	6.1	101	45	168	-1.2	5.9
Dec 17 20:52	33 Cet	RB	6.0	112	48	217	1.4	2.3
Dec 18 23:43	303	DD	6.4	125	25	119	1.5	0.0
Dec 19 00:44	308	DD	6.3	126	13	34	0.7	2.5

MERCURY

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

VENUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

OPPOSITION OF MARS

Of all the planets in the Solar System, Mars has long been the most fascinating. Others are bigger, better, closer and brighter, but Mars holds a place in people's imaginations. Only on Mars will you see thawing and growing polar caps, great planet-wide dust storms, cloud forming downwind from the largest volcanoes in the Solar System, and ever changing surface features.

This year Mars comes to opposition 27 July, four days later on the 31st the planet will be nearest Earth at 57.59 million km (Mkm) (0.385 au).

Not all oppositions of Mars are favourable; some give a better perspective than others. When the Earth passes Mars in its orbit every 26 months, we get a close view of the planet (Figure 1). When Mars is at or near perihelion at the same time, we get a particularly good view, for example the 2003 opposition. The reason for this is the elliptical orbit of Mars. On average, the planet is 228 Mkm from the Sun, but this distance varies by a considerable 42 Mkm. At an aphelic opposition (Mars furthest from the Sun) the planet averages 99 Mkm from Earth, and when at a perihelic opposition (Mars closest to the Sun), it will average around 57 Mkm from us.

Much was made of the fact that Mars came nearer to Earth in 2003 than at any time in close to 60,000 years. Whilst true, the difference between Mars' diameter during favourable perihelic oppositions varies only by one or two arcseconds at most. For example, in 2003 the planet's maximum diameter was 25.11 arcseconds compared with this year's 24.31, less than one arcsecond or 97% the size of the previous 'best ever' opposition. The distance between the two planets also makes an interesting comparison. In 2003 the closest approach was 55.76 million km, compared with this year's 57.59, just 1.8 million km further.

Oppositions in the early months of the year are always unfavourable as Mars is near aphelion. Perihelic oppositions occur around August, and fortunately for Southern Hemisphere observers, Mars is at its greatest southerly declination at that time (that is high in our sky). The favourable perihelic oppositions occur every 15 to 17 years and it will not be until 2035 that we will again see the planet at its largest angular size. However, the diameter of the planet at the next opposition in 2020 will still be a respectable 22.56 arcseconds. When Mars is in conjunction its disc is only 3.5 arcseconds (") in diameter, smaller than distant Uranus. At a poor opposition,

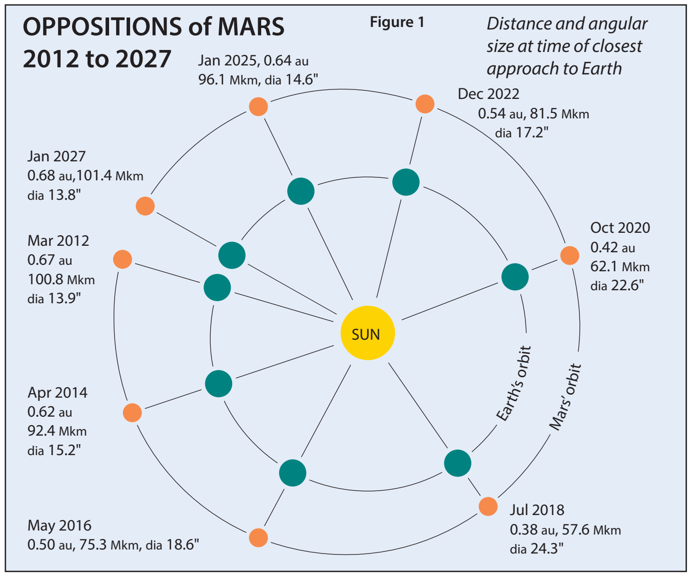


Figure 1

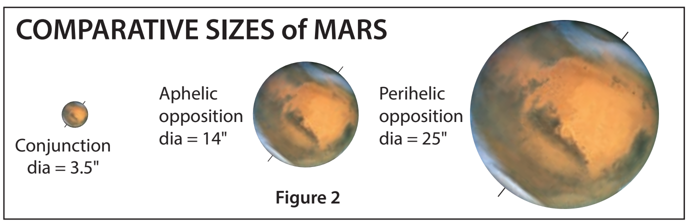


Figure 2

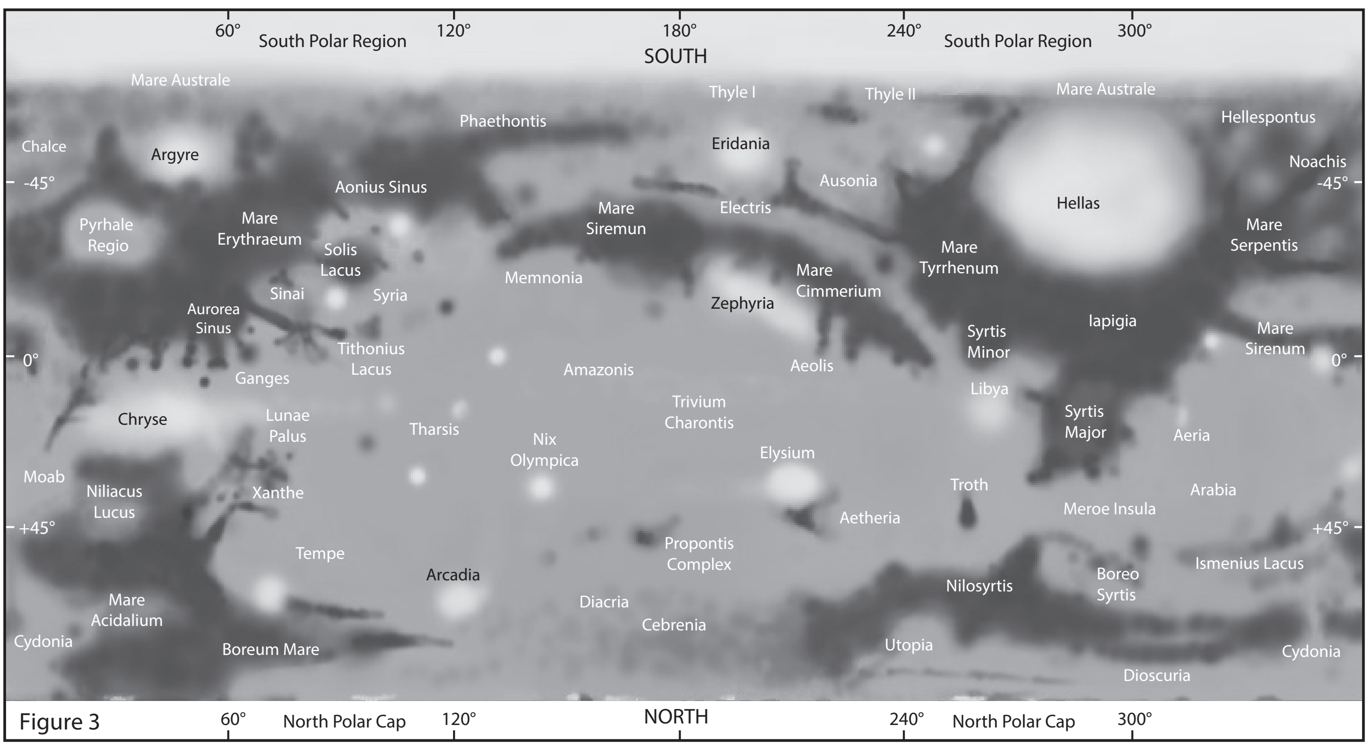


Figure 3

the diameter is 14", increasing to 25" at a perihelic opposition, see Figure 2 opposite.

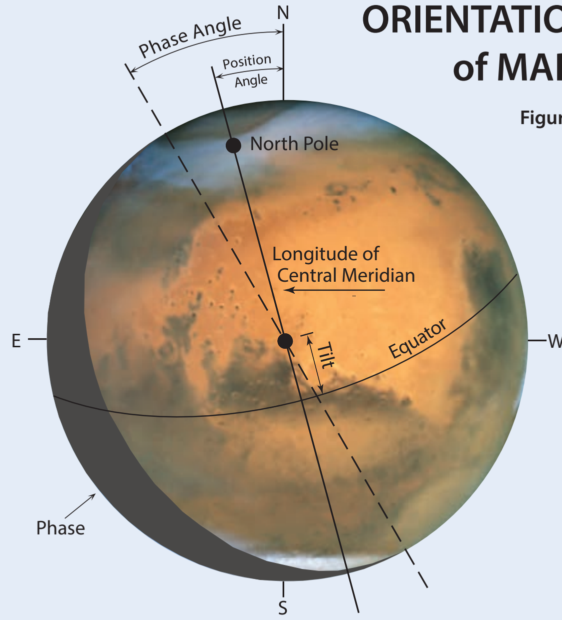
Mars observers have keenly awaited this year's apparition and July and August will be the prime time to train those telescopes, large and small, on the Red Planet. The detail you observe at opposition will depend on telescope size and those moments when the seeing magically settles down for a few seconds. With good optics and steady seeing try pushing the telescope to its maximum usable magnification — considered to be twice the aperture in millimetres (for an 80 mm telescope this will be 160×). With the arrival of modern day CCD technology, the study of Martian surface features is no longer solely restricted to the favourable oppositions; many amateurs are doing superb work in this field.

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 of tonnes of material over the landscape. Even with the constant movement of dust around the planet, several easily recognisable regions can be seen and identified from opposition to opposition. 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

ORIENTATION of MARS

Figure 4



NOTES on the Physical Ephemeris Table (next page).

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

Tilt: is the degrees that Mars' north pole is tilted towards (+) or away (–) as seen from Earth. It is also 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.

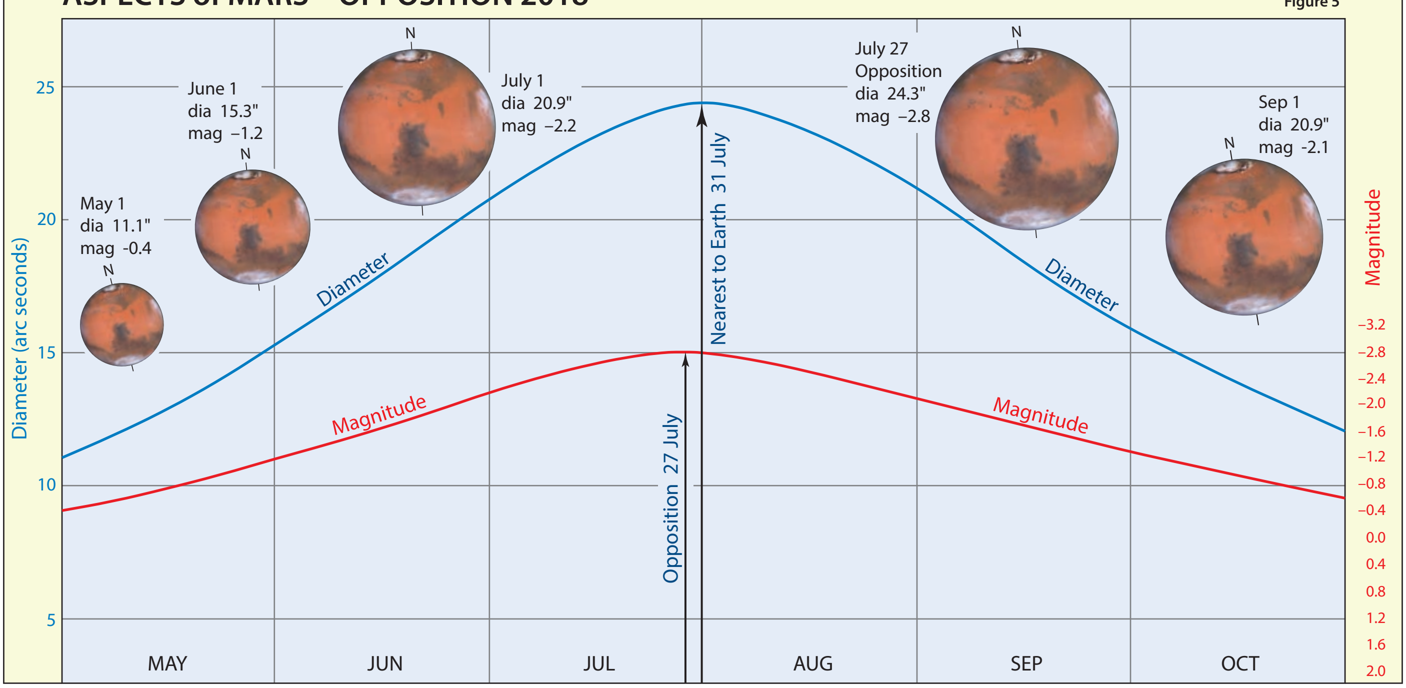
Phase Angle: The number of degrees (east of north) the phase is rotated.

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

Diagram does not represent any particular date.

ASPECTS of MARS – OPPOSITION 2018

Figure 5



(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 (see map, Figure 3 p. 110)

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

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

Calculating longitude of central meridian for a particular 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 1:20 am EST on June 9, converts to 15:20 UT on June 8. From the tables above our calculation is 153.3° + 219.3° + 4.9° = 377.5° Subtracting 360° to get a result less than 360° gives us a longitude of central meridian of 17.5°. The longitudes are shown on the map (Fig. 3). Around this time Moab will be crossing the central meridian.

Table 2.
Central Meridian
– Increase in
Longitude

min	deg°	min	deg°
10	2.4	40	9.7
20	4.9	50	12.2
30	7.3	60	14.6

hr	deg°	hr	deg°
1	014.6	13	190.1
2	029.2	14	204.7
3	043.9	15	219.3
4	058.5	16	233.9
5	073.1	17	248.6
6	087.7	18	263.2
7	102.3	19	277.8
8	117.0	20	292.4
9	131.6	21	307.0
10	146.2	22	321.7
11	160.8	23	336.3
12	175.5	24	350.9

Table 1 Physical Ephemeris (0 hr UT).
See previous page for description.

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Jun 1	218.8	–15.1	0.911	34.8	5.8
Jun 2	209.4	–15.1	0.912	34.5	5.6
Jun 3	200.0	–15.1	0.914	34.2	5.4
Jun 4	190.7	–15.2	0.915	33.9	5.3
Jun 5	181.3	–15.2	0.917	33.6	5.1
Jun 6	171.9	–15.2	0.918	33.2	4.9
Jun 7	162.6	–15.2	0.920	32.9	4.8
Jun 8	153.3	–15.2	0.922	32.5	4.6
Jun 9	143.9	–15.2	0.923	32.2	4.5
Jun 10	134.6	–15.2	0.925	31.8	4.3
Jun 11	125.3	–15.2	0.927	31.4	4.2
Jun 12	116.0	–15.2	0.929	31.0	4.1
Jun 13	106.7	–15.2	0.930	30.6	3.9
Jun 14	097.5	–15.2	0.932	30.2	3.8
Jun 15	088.2	–15.2	0.934	29.7	3.7
Jun 16	078.9	–15.2	0.936	29.3	3.6
Jun 17	069.7	–15.1	0.938	28.8	3.5
Jun 18	060.5	–15.1	0.940	28.4	3.4
Jun 19	051.2	–15.1	0.942	27.9	3.4
Jun 20	042.0	–15.0	0.944	27.4	3.3
Jun 21	032.8	–15.0	0.946	26.9	3.2
Jun 22	023.7	–14.9	0.948	26.4	3.2
Jun 23	014.5	–14.9	0.950	25.8	3.1
Jun 24	005.3	–14.8	0.952	25.3	3.1
Jun 25	356.2	–14.8	0.954	24.8	3.0
Jun 26	347.0	–14.7	0.956	24.2	3.0
Jun 27	337.9	–14.6	0.958	23.6	3.0
Jun 28	328.8	–14.5	0.960	23.0	3.0
Jun 29	319.7	–14.5	0.962	22.4	3.0
Jun 30	310.6	–14.4	0.964	21.8	3.0
Jul 1	301.5	–14.3	0.966	21.2	3.0
Jul 2	292.4	–14.2	0.968	20.5	3.0
Jul 3	283.4	–14.1	0.970	19.9	3.1
Jul 4	274.3	–14.0	0.972	19.2	3.1
Jul 5	265.3	–13.9	0.974	18.6	3.1
Jul 6	256.3	–13.8	0.976	17.9	3.2
Jul 7	247.3	–13.7	0.978	17.2	3.3
Jul 8	238.3	–13.6	0.979	16.5	3.3
Jul 9	229.3	–13.5	0.981	15.8	3.4
Jul 10	220.3	–13.4	0.983	15.1	3.5
Jul 11	211.4	–13.3	0.984	14.3	3.6
Jul 12	202.4	–13.1	0.986	13.6	3.7
Jul 13	193.5	–13.0	0.987	12.9	3.8
Jul 14	184.5	–12.9	0.989	12.1	3.9
Jul 15	175.6	–12.8	0.990	11.4	4.0
Jul 16	166.7	–12.6	0.991	10.6	4.2
Jul 17	157.8	–12.5	0.993	9.9	4.3
Jul 18	148.9	–12.4	0.994	9.2	4.4
Jul 19	140.0	–12.3	0.995	8.4	4.6
Jul 20	131.1	–12.1	0.995	7.8	4.7
Jul 21	122.2	–12.0	0.996	7.1	4.9
Jul 22	113.4	–11.9	0.997	6.5	5.0
Jul 23	104.5	–11.8	0.997	5.9	5.2
Jul 24	095.6	–11.6	0.998	5.4	5.4
Jul 25	086.8	–11.5	0.998	5.0	5.5
Jul 26	077.9	–11.4	0.998	4.8	5.7
Jul 27	069.0	–11.3	0.998	4.7	5.9
Jul 28	060.2	–11.1	0.998	4.8	6.0
Jul 29	051.3	–11.0	0.998	5.0	6.2
Jul 30	042.5	–10.9	0.998	5.3	6.4
Jul 31	033.6	–10.8	0.997	5.8	6.6

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Aug 1	024.8	–10.7	0.997	6.4	6.7
Aug 2	015.9	–10.6	0.996	7.0	6.9
Aug 3	007.0	–10.5	0.996	7.7	7.1
Aug 4	358.2	–10.4	0.995	8.4	7.2
Aug 5	349.3	–10.3	0.994	9.1	7.4
Aug 6	340.4	–10.2	0.993	9.9	7.6
Aug 7	331.5	–10.1	0.991	10.6	7.7
Aug 8	322.7	–10.1	0.990	11.4	7.9
Aug 9	313.8	–10.0	0.989	12.2	8.0
Aug 10	304.9	–9.9	0.987	12.9	8.2
Aug 11	296.0	–9.9	0.986	13.7	8.3
Aug 12	287.1	–9.8	0.984	14.5	8.4
Aug 13	278.1	–9.8	0.982	15.3	8.6
Aug 14	269.2	–9.7	0.981	16.0	8.7
Aug 15	260.3	–9.7	0.979	16.8	8.8
Aug 16	251.3	–9.6	0.977	17.5	8.9
Aug 17	242.3	–9.6	0.975	18.3	9.0
Aug 18	233.4	–9.6	0.973	19.0	9.1
Aug 19	224.4	–9.6	0.971	19.7	9.2
Aug 20	215.4	–9.6	0.969	20.4	9.2
Aug 21	206.4	–9.6	0.966	21.1	9.3
Aug 22	197.4	–9.6	0.964	21.8	9.4
Aug 23	188.3	–9.6	0.962	22.5	9.4
Aug 24	179.3	–9.6	0.960	23.2	9.5
Aug 25	170.2	–9.7	0.957	23.8	9.5
Aug 26	161.1	–9.7	0.955	24.5	9.5
Aug 27	152.1	–9.7	0.953	25.1	9.5
Aug 28	143.0	–9.8	0.951	25.7	9.6
Aug 29	133.9	–9.8	0.948	26.3	9.6
Aug 30	124.7	–9.9	0.946	26.9	9.5
Aug 31	115.6	–10.0	0.944	27.5	9.5
Sep 1	106.5	–10.0	0.941	28.0	9.5
Sep 2	097.3	–10.1	0.939	28.6	9.5
Sep 3	088.1	–10.2	0.937	29.1	9.4
Sep 4	079.0	–10.3	0.934	29.7	9.4
Sep 5	069.8	–10.4	0.932	30.2	9.3
Sep 6	060.6	–10.5	0.930	30.7	9.3
Sep 7	051.3	–10.6	0.928	31.2	9.2
Sep 8	042.1	–10.7	0.926	31.7	9.1
Sep 9	032.9	–10.8	0.923	32.1	9.0
Sep 10	023.6	–10.9	0.921	32.6	8.9
Sep 11	014.3	–11.1	0.919	33.0	8.8
Sep 12	005.1	–11.2	0.917	33.5	8.7
Sep 13	355.8	–11.3	0.915	33.9	8.6
Sep 14	346.5	–11.5	0.913	34.3	8.4
Sep 15	337.2	–11.6	0.911	34.7	8.3
Sep 16	327.8	–11.7	0.909	35.1	8.2
Sep 17	318.5	–11.9	0.907	35.5	8.0
Sep 18	309.2	–12.1	0.905	35.8	7.9
Sep 19	299.8	–12.2	0.904	36.2	7.7
Sep 20	290.4	–12.4	0.902	36.5	7.5
Sep 21	281.1	–12.5	0.900	36.9	7.3
Sep 22	271.7	–12.7	0.898	37.2	7.2
Sep 23	262.3	–12.9	0.897	37.5	7.0
Sep 24	252.9	–13.0	0.895	37.8	6.8
Sep 25	243.4	–13.2	0.893	38.1	6.6
Sep 26	234.0	–13.4	0.892	38.4	6.4
Sep 27	224.6	–13.6	0.890	38.7	6.2
Sep 28	215.1	–13.8	0.889	38.9	5.9
Sep 29	205.7	–13.9	0.888	39.2	5.7
Sep 30	196.2	–14.1	0.886	39.4	5.5

FINDING MARS' MOONS

Introduction. We rarely hear of people trying to observe Phobos or Deimos because the assumption is often made that it is too hard. If it wasn't for the brilliant beacon of the Red Planet all you would need is a 20 cm telescope to see them! In reality it is difficult, but not impossible, although your technique and timing is critical. Firstly the aim is to separate the planet and satellite as much as possible (and a night with good seeing is needed). In practice a time around a Martian opposition is needed and even then the moon should be near a maximum elongation, as graphically illustrated on the diagram. These are the '0 hr' positions (east of the planet) or on the western side around 15 hr for Deimos and 4 hr for Phobos. This page can be used to work out where the moons are in their orbits at any time from the beginning of June to the end of September 2018.

It might be worthwhile experimenting with an occulting bar to block the glare of Mars. This can be a thin strip of aluminium foil or a wire placed in the focal plane of a high power eyepiece. This focal point can sometimes be indicated by a field stop in the form of an annular disc at the telescope end of the eyepiece. Position it; perhaps using tape, across the eyepiece ensuring it crosses the centre. A dark (or dense) filter can sometimes be used to dramatically reduce the Martian glare but still see the disc. This way it is easier to judge the position of where the satellite should be using the location and size of Mars as a reference. An inexpensive plastic filter is preferred, being easier to cut and place across the field stop. When using the 'bar' orientate it to run north to south and know which side to look for the moon(s). If you are using a telescope without any tracking, such as a Dobsonian, remember objects on the western side are the first to leave the field. This is a good way to get your bearings. Also, don't fight with the scope to keep Mars just where you want it, especially under high power. It is best to leave your telescope in one position and let the Earth's rotation bring Mars and its satellites in and out of occultation; that way vibration is minimised.

The advantage to observing close to opposition is well illustrated in the diagram. Look at the dramatic increase in the angular size of the maximum elongations from June 1 to July 31. Deimos has moved from 43" to 68" (arcseconds) from the limb of Mars, Phobos from 13" to 21". Over the same period the brightness of the moons increases significantly as well, Deimos from 12.7 to 11.7 magnitude and Phobos from 11.6 to 10.5. Even though Phobos is the brighter of the pair, it is quite close to Mars and hence more challenging.

How to find Phobos and Deimos

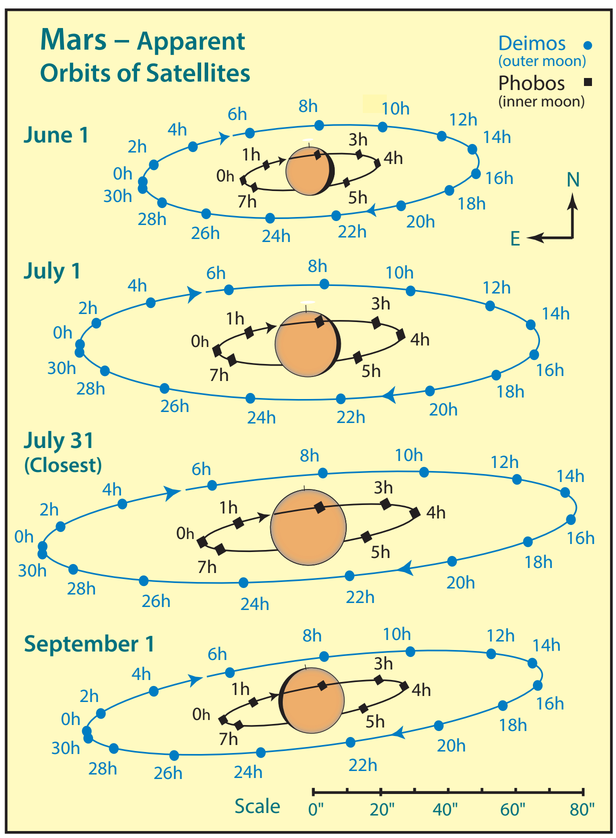
The table presents the times of the first greatest elongation to the east after 0 hr UT on the 1st, 10th and 20th of each month. These are times when the moon should be at the '0 hr' (zero hour) location on the Apparent Orbits diagram. Like the satellites of Saturn, Uranus and Neptune, the procedure is to work out how many orbits have elapsed since the most recent eastern elongation listed on the table. Then discard the completed number of orbits and convert the remaining fraction of days back to hours so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of **Deimos** for July 15 at 11 pm EST.

1. Convert to UT as a fractional day. July 15 at 11 pm (EST) = 15.542 UT (use table 3, page 127).
2. Subtract the date of the most recent greatest elongation east for July, i.e. 15.542 – 11.258 = 4.284
3. Express this as the number of orbits by dividing by the period 4.284 / 1.2624 = 3.393
4. Discarding the three completed orbits leaves 0.393
5. Multiply by the period, 0.393 × 1.2624 = 0.496 days.
6. Multiply 0.496 days × 24 = 11.9 hours.
7. Looking at the orbital path for Deimos for July 1 (see Apparent Orbits diagram), the satellite is very close to the 12 hour mark and about 3 hours from a western maximum elongation and this would be a good time to try and observe it.

Here's a challenge! The calculation for **Phobos** at the same date and time places it at 2.2 hrs, very close to the NW limb of Mars (in the process of completing a transit). In about 1.8 hours (just before 1 am) it will be at a maximum western elongation—go for it!

Time of Greatest Elongation East (UT)		
Moon	**Phobos**	**Deimos**
Magnitude [1]	10.5	11.7
Max. Elong. [1]	0' 34"	1' 24"
Period (days) [2]	0.31891	1.26244
	Elongation (d.ddd)	
June	1.1186	2.1125
	10.0500	10.9583
	20.2561	21.0625
July	1.1000	1.1625
	10.0288	11.2583
	20.2292	20.0917
August	1.0288	1.7042
	10.2750	10.5333
	20.1580	20.6250
September	1.2792	2.2500
	10.2080	11.0917
	20.0978	21.2000

Notes 1. Closest to Earth (Jul 31)
2. Mean Synodic Period



JUPITER — LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	222.7	075.6	177.3	035.0	096.1	314.5	012.2	224.3	073.7	123.8	331.2	021.3	1
2	020.5	233.5	335.2	193.0	254.2	112.5	170.0	022.1	231.4	281.5	128.9	179.0	2
3	178.3	031.4	133.2	351.1	052.2	270.5	327.9	179.8	029.1	079.2	286.5	336.7	3
4	336.1	189.3	291.1	149.1	210.2	068.4	125.7	337.6	186.7	236.8	084.2	134.4	4
5	133.9	347.2	089.1	307.1	008.3	226.4	283.6	135.3	344.4	034.5	241.9	292.1	5
6	291.7	145.1	247.1	105.1	166.3	024.4	081.5	293.1	142.1	192.1	039.5	089.7	6
7	089.6	303.0	045.0	263.2	324.3	182.3	239.3	090.8	299.8	349.8	197.2	247.4	7
8	247.4	100.8	203.0	061.2	122.4	340.3	037.1	248.5	097.5	147.5	354.8	045.1	8
9	045.2	258.7	001.0	219.2	280.4	138.2	195.0	046.3	255.2	305.1	152.5	202.8	9
10	203.0	056.6	159.0	017.3	078.4	296.2	352.8	204.0	052.8	102.8	310.2	000.5	10
11	000.8	214.5	316.9	175.3	236.5	094.1	150.6	001.8	210.5	260.4	107.8	158.2	11
12	158.6	012.5	114.9	333.3	034.5	252.0	308.5	159.5	008.2	058.1	265.5	315.9	12
13	316.5	170.4	272.9	131.4	192.5	050.0	106.3	317.2	165.9	215.7	063.2	113.6	13
14	114.3	328.3	070.9	289.4	350.5	207.9	264.1	114.9	323.5	013.4	220.8	271.3	14
15	272.1	126.2	228.9	087.5	148.6	005.8	061.9	272.7	121.2	171.0	018.5	069.0	15
16	070.0	284.1	026.9	245.5	306.6	163.8	219.7	070.4	278.9	328.7	176.2	226.7	16
17	227.8	082.0	184.9	043.5	104.6	321.7	017.5	228.1	076.5	126.4	333.8	024.4	17
18	025.6	239.9	342.8	201.6	262.6	119.6	175.4	025.8	234.2	284.0	131.5	182.1	18
19	183.5	037.9	140.8	359.6	060.6	277.5	333.2	183.5	031.9	081.7	289.2	339.8	19
20	341.3	195.8	298.8	157.7	218.6	075.4	131.0	341.3	189.6	239.3	086.9	137.5	20
21	139.2	353.7	096.8	315.7	016.6	233.3	288.7	139.0	347.2	037.0	244.5	295.3	21
22	297.0	151.7	254.9	113.8	174.6	031.2	086.5	296.7	144.9	194.6	042.2	093.0	22
23	094.9	309.6	052.9	271.8	332.6	189.1	244.3	094.4	302.5	352.3	199.9	250.7	23
24	252.7	107.5	210.9	069.8	130.6	347.0	042.1	252.1	100.2	149.9	357.5	048.4	24
25	050.6	265.5	008.9	227.9	288.6	144.9	199.9	049.8	257.9	307.6	155.2	206.1	25
26	208.4	063.4	166.9	025.9	086.6	302.8	357.7	207.5	055.5	105.3	312.9	003.8	26
27	006.3	221.4	324.9	184.0	244.6	100.7	155.5	005.2	213.2	262.9	110.6	161.6	27
28	164.2	019.3	122.9	342.0	042.6	258.6	313.2	162.9	010.9	060.6	268.3	319.3	28
29	322.0		280.9	140.0	200.6	056.4	111.0	320.6	168.5	218.2	065.9	117.0	29
30	119.9		079.0	298.1	358.6	214.3	268.8	118.3	326.2	015.9	223.6	274.7	30
31	277.8		237.0		156.6		066.5	276.0		173.6		072.5	31

SYSTEM II (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	075.7	052.1	300.1	281.3	113.5	095.4	284.1	259.7	232.6	053.9	024.7	205.9	1
2	225.9	202.4	090.4	071.7	263.9	245.7	074.3	049.9	022.7	203.9	174.8	356.0	2
3	016.1	352.6	240.7	222.1	054.3	036.0	224.6	200.0	172.7	353.9	324.8	146.0	3
4	166.3	142.9	031.1	012.5	204.7	186.4	014.8	350.1	322.8	144.0	114.8	296.1	4
5	316.4	293.1	181.4	162.8	355.1	336.7	165.0	140.2	112.8	294.0	264.9	086.2	5
6	106.6	083.4	331.7	313.2	145.5	127.0	315.2	290.3	262.9	084.0	054.9	236.2	6
7	256.8	233.6	122.1	103.7	295.9	277.4	105.5	080.5	052.9	234.1	204.9	026.3	7
8	047.0	023.9	272.4	254.1	086.3	067.7	255.7	230.6	203.0	024.1	354.9	176.3	8
9	197.2	174.2	062.7	044.5	236.7	218.0	045.9	020.7	353.0	174.1	145.0	326.4	9
10	347.3	324.4	213.1	194.9	027.1	008.3	196.1	170.8	143.1	324.1	295.0	116.5	10
11	137.5	114.7	003.4	345.3	177.5	158.6	346.3	320.9	293.1	114.2	085.1	266.5	11
12	287.7	265.0	153.8	135.7	327.9	308.9	136.5	111.0	083.2	264.2	235.1	056.6	12
13	077.9	055.3	304.1	286.1	118.3	099.3	286.7	261.1	233.2	054.2	025.1	206.7	13
14	228.1	205.5	094.5	076.5	268.7	249.6	076.9	051.2	023.3	204.2	175.2	356.7	14
15	018.3	355.8	244.9	226.9	059.1	039.9	227.1	201.3	173.3	354.3	325.2	146.8	15
16	168.5	146.1	035.2	017.3	209.5	190.1	017.2	351.4	323.4	144.3	115.2	296.9	16
17	318.7	296.4	185.6	167.7	359.9	340.4	167.4	141.5	113.4	294.3	265.3	087.0	17
18	108.9	086.7	335.9	318.1	150.3	130.7	317.6	291.6	263.4	084.3	055.3	237.0	18
19	259.1	237.0	126.3	108.5	300.6	281.0	107.8	081.6	053.5	234.4	205.4	027.1	19
20	049.4	027.3	276.7	259.0	091.0	071.3	257.9	231.7	203.5	024.4	355.4	177.2	20
21	199.6	177.6	067.0	049.4	241.4	221.6	048.1	021.8	353.5	174.4	145.4	327.3	21
22	349.8	327.9	217.4	199.8	031.8	011.8	198.3	171.9	143.6	324.5	295.5	117.4	22
23	140.0	118.2	007.8	350.2	182.1	162.1	348.4	322.0	293.6	114.5	085.5	267.4	23
24	290.2	268.5	158.2	140.6	332.5	312.4	138.6	112.1	083.7	264.5	235.6	057.5	24
25	080.5	058.8	308.6	291.0	122.9	102.6	288.7	262.1	233.7	054.5	025.6	207.6	25
26	230.7	209.1	098.9	081.4	273.2	252.9	078.9	052.2	023.7	204.6	175.7	357.7	26
27	020.9	359.4	249.3	231.8	063.6	043.1	229.0	202.3	173.8	354.6	325.7	147.8	27
28	171.2	149.8	039.7	022.3	214.0	193.4	019.2	352.3	323.8	144.6	115.8	297.9	28
29	321.4		190.1	172.7	004.3	343.6	169.3	142.4	113.8	294.6	265.8	088.0	29
30	111.6		340.5	323.1	154.7	133.9	319.5	292.5	263.8	084.7	055.9	238.1	30
31	261.9		130.9		305.0		109.6	082.5		234.7		028.2	31

Jupiter is a gas giant and we can only view the upper atmospheric features. Just a small telescope (even a 60 mm instrument) is required to view the equatorial belts and the Great Red Spot. When the seeing is good, numerous breaks can be glimpsed in the belts, as well as many minor spots.

There is no single rotation period for the features of Jupiter. The speed of any feature on the surface depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs record the time a feature crosses the central meridian of the planet. This central meridian is an imaginary line drawn from the north to south pole of Jupiter which passes through the centre of the disc.

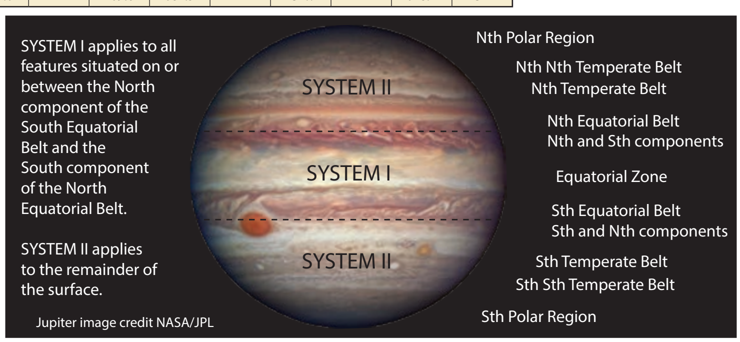
The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0 hr UT of date. You will need to add multiple hours and minutes from the small Increase in Longitude tables below. For example, the longitude of central meridian for Jupiter (System I) for 4 July at 2:20 am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on 3 July. From the table, the longitude on 3 July is 327.9°. 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 565.4°, less 360° giving a final answer of 205.4°.

GREAT RED SPOT TRANSIT TIME

The GRS can best be seen from about one hour before transiting the central meridian to one hour after. During this two-hour period it will move approximately 70% of the width of Jupiter at its latitude. It can be seen a further 30 minutes either side of this period, but it tends to appear foreshortened and merging with the limb. The longitude of the GRS (System II) does drift over the years and inconsistently. For example the following are some actual values for June: 2012 (180°), 2013 (197°), 2014 (214°), 2015 (228°), 2016 (248°) and 2017 (274°). The table of data for 2018 (opposite) has been based on 298°. For every degree of longitude greater than 298° it will transit 1.6 minutes later than shown (for every degree less than 298°, transit is 1.6 minutes earlier). If the recent trend continues the value could range from about 20 minutes earlier than shown here as the year opens to 20 minutes later by the end of 2018. This is an estimated midpoint of the GRS. The spot is about 15° in diameter, so it takes around 24 minutes to transit. The longitude of the GRS was obtained from the JUPOS website. jupos.privat.t-online.de/

Increase In Longitude
SYSTEM I
Rotation: 9 h 50 m 30.003 s

hr	deg°	hr	deg°	min	deg°
1	036.6	13	115.5	5	03.0
2	073.2	14	152.1	10	06.1
3	109.7	15	188.7	15	09.1
4	146.3	16	225.3	20	12.2
5	182.9	17	261.8	25	15.2
6	219.5	18	298.4	30	18.3
7	256.1	19	335.0	35	21.3
8	292.6	20	011.6	40	24.4
9	329.2	21	048.2	45	27.4
10	005.8	22	084.7	50	30.5
11	042.4	23	121.3	55	33.5
12	079.0	24	157.9	60	36.6



Jupiter image credit NASA/JPL

Increase In Longitude
SYSTEM II
Rotation: 9 h 55 m 40.062 s

hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

JUPITER — GREAT RED SPOT

Date	1st	2nd	3rd
Jan 1	(4:12)		
Jan 2	2:03		
Jan 4	3:42 *		
Jan 6	5:20 *		
Jan 7	1:12		
Jan 8	(4:59)		
Jan 9	2:51		
Jan 11	4:29 *		
Jan 13	(4:08)		
Jan 14	1:59		
Jan 15	(5:47)		
Jan 16	3:38 *		
Jan 18	5:17 *		
Jan 19	1:08		
Jan 20	(4:55)		
Jan 21	2:47 *		
Jan 23	4:25 *		
Jan 24	0:17		
Jan 25	(4:04)		
Jan 26	1:55		
Jan 27	(5:42)		
Jan 28	3:34 *		
Jan 30	5:12 *		
Jan 31	1:04		
Feb 1	(4:51)		
Feb 2	2:42 *		
Feb 4	4:20 *		
Feb 5	0:12		
Feb 6	(3:59)		(23:50)
Feb 7	1:50		
Feb 8	(5:37)		
Feb 9	3:29 *		23:20
Feb 11	5:07 *		
Feb 12	0:58		
Feb 13	(4:45)		
Feb 14	2:37 *		
Feb 16	4:15 *		
Feb 17	0:06		
Feb 18	5:53 *		(23:45)
Feb 19	1:45		
Feb 20	(5:32)		
Feb 21	3:23 *		23:14
Feb 23	5:01 *		(22:53)
Feb 24	0:53		
Feb 25	(4:40)		

Date	1st	2nd	3rd
Feb 26	2:31 *		22:22
Feb 27	(6:18)		
Feb 28	4:09 *		
Mar 1	0:00		
Mar 2	5:47 *		(23:39)
Mar 3	1:39		
Mar 4	(5:26)		
Mar 5	3:17 *		23:08
Mar 7	4:55 *		(22:46)
Mar 8	0:46		
Mar 9	(4:33)		
Mar 10	2:24 *		22:16
Mar 11	(6:11)		
Mar 12	4:02 *		23:54 *
Mar 14	5:41 *		(23:32)
Mar 15	1:32		21:23
Mar 16	(5:19)		
Mar 17	3:10 *		23:01
Mar 19	4:48 *		(22:39)
Mar 20	0:39		
Mar 21	6:26 *		
Mar 22	2:17 *		22:09
Mar 23	(6:04)		
Mar 24	3:55 *		23:47 *
Mar 26	5:33 *		(23:25)
Mar 27	1:24		21:16
Mar 28	(5:11)		
Mar 29	3:02 *		22:54 *
Mar 30	(6:49)		
Mar 31	4:40 *		(22:32)
Apr 1	0:31		20:23
Apr 2	6:18 *		
Apr 3	2:09 *		22:01
Apr 4	(5:56)		
Apr 5	3:47 *		23:39 *
Apr 6		19:30	
Apr 7	5:25 *		(23:17)
Apr 8	1:16		21:08
Apr 9	(5:03)		
Apr 10	2:54 *		22:46 *
Apr 11	(6:41)		
Apr 12	4:32 *		(22:24)
Apr 13	0:23		20:15
Apr 14	6:10 *		
Apr 15	2:01 *		21:53 *

Date	1st	2nd	3rd
Apr 16	(5:48)		
Apr 17	3:39 *		23:31 *
Apr 18		19:22	
Apr 19	5:17 *		(23:09)
Apr 20	1:08	(19:00)	21:00
Apr 21	(4:55)		
Apr 22	2:46 *		22:38 *
Apr 23	(6:33)	18:29	
Apr 24	4:24 *		(22:16)
Apr 25	0:15		20:07
Apr 26	6:02 *		(23:54)
Apr 27	1:53	(19:45)	21:45
Apr 28	(5:40)		
Apr 29	3:31 *		23:23 *
Apr 30		19:14	
May 1	5:09 *		(23:01)
May 2	1:00	(18:52)	20:52
May 3	6:47 *		
May 4	2:38 *		22:30 *
May 5	(6:25)	18:21	
May 6	4:16 *		(22:08)
May 7	0:07	(17:59)	19:59
May 8	5:54 *		(23:45)
May 9	1:45	(19:37)	21:37
May 10	(5:32)	17:28	
May 11	3:23 *		23:15 *
May 12		19:06	
May 13	5:01 *		(22:53)
May 14	0:52	(18:44)	20:44
May 15	(4:39)		
May 16	2:30 *		22:22 *
May 17	(6:17)	18:13	
May 18	4:08 *		(22:00)
May 19		19:51 *	
May 20	5:46 *		(23:38)
May 21	1:37	(19:29)	21:29
May 22	(5:24)	17:20	
May 23	3:15 *		23:07 *
May 24		18:58 *	
May 25	4:54 *		(22:45)
May 26	0:45	(18:36)	20:36
May 27	(4:32)	16:27	
May 28	2:23 *		22:14 *
May 29		18:05	
May 30	4:01 *		23:52 *

Date	1st	2nd	3rd
May 31		19:44 *	
Jun 1	(3:39)		(23:31)
Jun 2	1:30	(19:22)	21:22
Jun 3		17:13	
Jun 4	3:08 *		23:00 *
Jun 5		18:51 *	
Jun 6	(2:47)		(22:38)
Jun 7	0:38	(18:29)	20:29
Jun 8	(4:25)		
Jun 9	2:16 *		22:08 *
Jun 10		17:59	
Jun 11	3:54 *		23:46 *
Jun 12		19:37 *	
Jun 13	(3:33)		(23:24)
Jun 14	1:24	(19:15)	21:15
Jun 15		17:07	
Jun 16	3:02 *		22:54 *
Jun 17		18:45	
Jun 18	(2:41)		(22:32)
Jun 19	0:32	(18:23)	20:23
Jun 21	2:10 *		22:02 *
Jun 22		17:53	
Jun 23	(1:49)		23:40 *
Jun 24		19:31 *	
Jun 25	(3:27)		(23:19)
Jun 26	1:18	(19:10)	21:10
Jun 27		17:01	
Jun 28	2:57 *		22:48 *
Jun 29		18:40	
Jun 30	(2:35)		(22:27)
Jul 1	0:27	(18:18)	20:18
Jul 3	2:05 *		21:57 *
Jul 4		17:48	
Jul 5	(1:44)		23:35 *
Jul 6		19:27 *	
Jul 7			(23:14)
Jul 8	1:14	(19:05)	21:05
Jul 9		16:57	
Jul 10	(0:52)		22:44 *
Jul 11		18:35	
Jul 12			(22:22)
Jul 13	0:23	(18:14)	20:14
Jul 15	(0:01)		21:53 *
Jul 16		17:44	
Jul 17	(1:40)		23:31 *

Date	1st	2nd	3rd
Jul 18		19:23 *	
Jul 19			(23:10)
Jul 20	1:10	(19:02)	21:02
Jul 21		16:53	
Jul 22	(0:49)		22:40 *
Jul 23		18:32	
Jul 24			(22:19)
Jul 25	0:19	(18:11)	20:11
Jul 26			(23:58)
Jul 27		(19:49)	21:49
Jul 28		17:41	
Jul 29			23:28 *
Jul 30		19:20 *	
Jul 31			(23:07)
Aug 1		(18:59)	20:59
Aug 2		16:50	
Aug 3	(0:46)		22:37 *
Aug 4		18:29	
Aug 5			(22:16)
Aug 6	0:16	(18:08)	20:08
Aug 7			(23:55)
Aug 8		(19:47)	21:47
Aug 9		17:38	
Aug 10			23:26 *
Aug 11		19:17 *	
Aug 12			(23:05)
Aug 13		(18:56)	20:56
Aug 15			22:35 *
Aug 16		18:27	
Aug 17			(22:14)
Aug 18		(18:06)	20:06
Aug 19			(23:53)
Aug 20		(19:45)	21:45
Aug 21		17:37	
Aug 22			23:24 *
Aug 23		19:16	
Aug 24			(23:03)
Aug 25		(18:55)	20:55
Aug 27			22:34 *
Aug 28		18:25	
Aug 29			(22:13)
Aug 30		(18:04)	20:04
Sep 1		(19:43)	21:43
Sep 2		17:35	
Sep 3			(21:23)

Date	1st	2nd	3rd
Sep 4		19:14	
Sep 5			(23:02)
Sep 6		(18:53)	20:53
Sep 8			22:32 *
Sep 9		18:24	
Sep 10			(22:12)
Sep 11		(18:03)	20:03
Sep 13		(19:42)	21:42
Sep 14		17:34	
Sep 15			(21:22)
Sep 16		19:13	
Sep 18		(18:52)	20:52
Sep 20			(20:32)
Sep 21		18:23	
Sep 23		(18:02)	20:02
Sep 25		(19:42)	21:42
Sep 26		17:33	
Sep 27			(21:21)
Sep 28		19:13	
Sep 30		(18:52)	20:52
Oct 2			(20:31)
Oct 3		18:23	
Oct 5		(18:02)	20:02
Oct 7		(19:41)	
Oct 8		17:33	
Oct 10		19:12	
Oct 12		(18:51)	20:51
Oct 14			(20:30)
Oct 15		18:22	
Oct 17		(18:01)	20:01
Oct 19		(19:41)	
Oct 22		19:11	
Oct 24		(18:51)	
Oct 27		18:22	
Oct 29			20:01
Oct 31		(19:40)	
Dec 22	5:03		
Dec 24	(4:42)		
Dec 27	4:12		
Dec 29	(3:51)		
Dec 31	(5:30)		

1st, 2nd or 3rd GRS

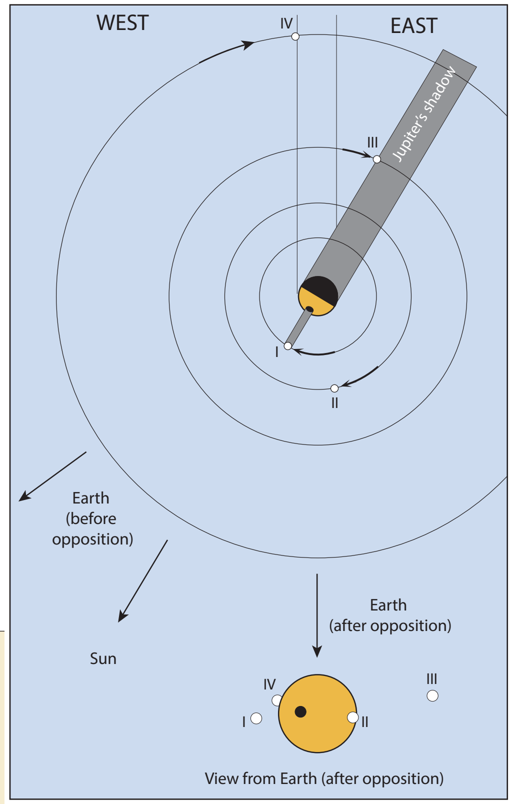
h:mm EST (Eastern only)
h:mm* EST (All States)
(h:mm) WST (WA only)

Predictions are shown for transit times for Sydney and Perth (giving a reasonable indication for eastern and western Australia). Times have been excluded when Jupiter is near conjunction (within 18° of the Sun) or below the horizon. If a transit is predicted when Jupiter is close to the horizon, the GRS may still be seen at least one hour before or after the time (allowing it to have some altitude). Predictions during daylight hours have also been omitted, except for those within 30 minutes after sunrise or before sunset. Even if there is a transit close to sunrise or sunset, the GRS can be seen well into the twilight period. For places that have extreme latitudes (such as Darwin or Hobart) you may need to check the GRS times against your local rise and set times for the Sun and Jupiter.

With a transit occurring every 9 hours 55 min 40 secs, two or three transits will occur every day, but a maximum of two are visible from any location. The three columns represent the 1st, 2nd and 3rd transits for each day. Note if the first transit for the day in EST is before 2 am, the event will be the last transit (3rd) for the previous day in WST (assuming Jupiter is visible). When the same transit is visible across the country, only the EST time is given followed by an asterisk (*). To get the WST time subtract two hours from the EST. For CST subtract 30 minutes from EST. For an event only visible from WA the time is given in brackets (WST). Daylight Saving is not allowed for, you will need to add one hour to the times in the table when in effect.

For example, on 23 June the first transit is only visible from WA at 1:49 am WST. The 3rd transit for the day is visible Australia wide at 23:40 EST or 11:40 pm EST (11:20 pm CST, 9:40 pm WST).

JUPITER'S MOONS



Jupiter, with its many moons, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are 69 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo, are bright enough to be visible in small telescopes or moderate-sized binoculars. The dance of these moons, as they pass back and forth across Jupiter, is illustrated in *Jupiter Moon Events* on the following pages. All the moons orbit in roughly the same plane, which is very close to the plane of the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From 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 2018 is 11 June.
3. A satellite can go into occultation, that is, 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 that the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

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.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7× or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation). This happens approximately every eight days; an example would be January 13.

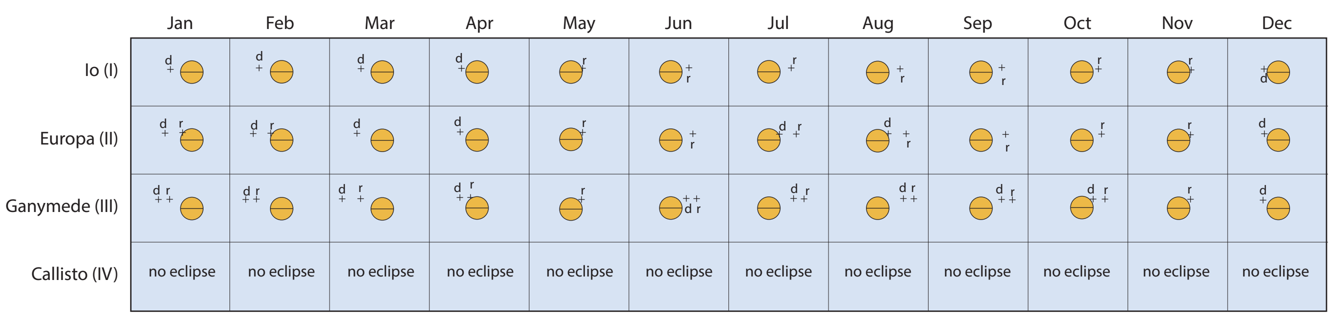
To see the moons with binoculars may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.

JUPITER'S MOON EVENTS Legend (following pages)

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

Note: In these tables, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia. Events near conjunction, with Jupiter closer than 18° to the Sun, have been omitted.

ECLIPSE POSITIONS

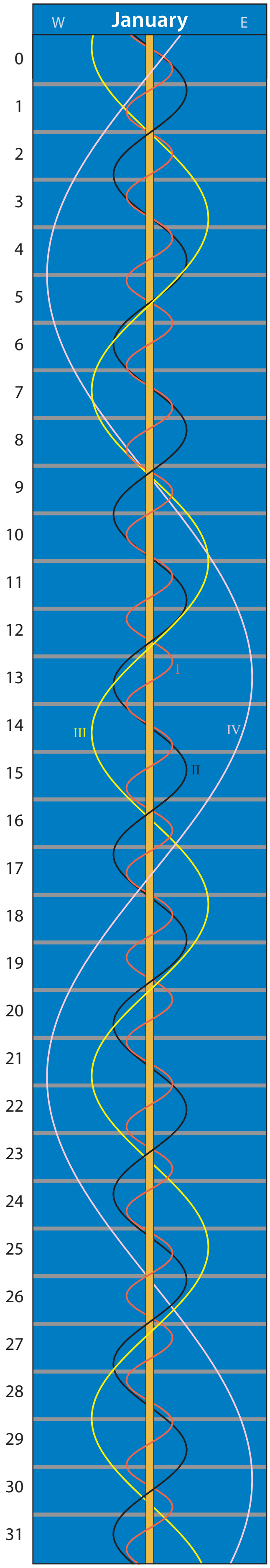


These diagrams show the positions of the eclipse events for each satellite for midmonth, relative to Jupiter. An eclipse happens when the moon passes into (disappearance or d) or out of (reappearance or r) Jupiter's shadow; west to the left, east to the right.

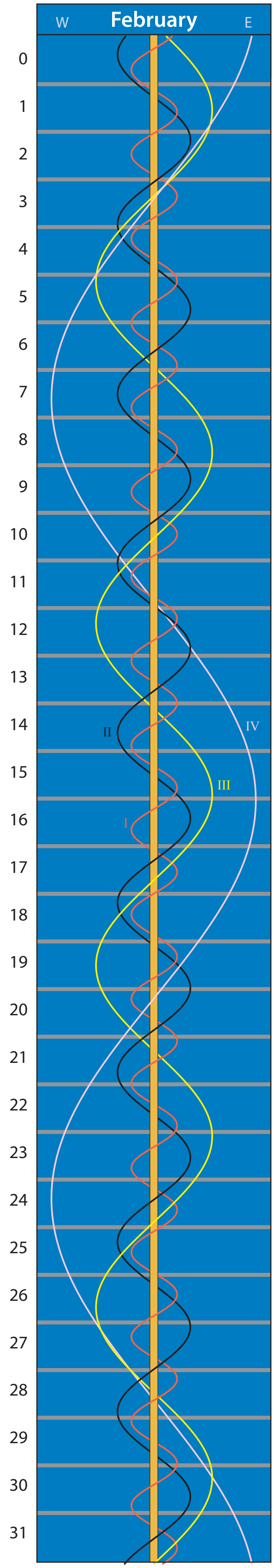
JUPITER MOON EVENTS

The diagrams here show the patterns the four major moons of Jupiter make as they shuffle back and forth. Each complete period represents one orbit of the satellite. Each horizontal grey date line represents midnight; the top edge of the line is midnight EST (14 hr UT), the bottom edge of the line is midnight WST (16 hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times. The same can be done with the occultation times, that is when the line disappears behind Jupiter. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.

Day	EST	WST	Sat	Event		Vis
January						
1	02:52	00:52	I	Sh	I	E
	03:52	01:52	I	Tr	I	E
	05:03	03:03	I	Sh	E	W
	06:02	04:02	I	Tr	E	W
2	01:33	23:33(p)	II	Sh	E	E
	02:06	00:06	III	Oc	D	E
	03:16	01:16	I	Oc	R	E
	03:30	01:30	II	Tr	E	E
	03:50	01:50	III	Oc	R	E
7	07:11	05:11	II	Ec	D	W
8	04:46	02:46	I	Sh	I	
	05:50	03:50	I	Tr	I	W
	06:56	04:56	I	Sh	E	W
9	01:50	23:50(p)	II	Sh	I	E
	01:58	23:58(p)	III	Ec	D	E
	02:01	00:01	I	Ec	D	E
	03:48	01:48	III	Ec	R	
	03:57	01:57	II	Tr	I	
	04:05	02:05	II	Sh	E	
	05:14	03:14	I	Oc	R	W
	06:11	04:11	II	Tr	E	W
	06:22	04:22	III	Oc	D	W
10	01:24	23:24(p)	I	Sh	E	E
	02:29	00:29	I	Tr	E	E
15	06:39	04:39	I	Sh	I	W
16	03:53	01:53	I	Ec	D	
	04:22	02:22	II	Sh	I	
	05:55	03:55	III	Ec	D	W
	06:37	04:37	II	Tr	I	W
	06:38	04:38	II	Sh	E	W
	07:10	05:10	I	Oc	R	W
17	01:08	23:08(p)	I	Sh	I	E
	02:17	00:17	I	Tr	I	E
	03:18	01:18	I	Sh	E	
	04:26	02:26	I	Tr	E	
18	01:21	23:21(p)	II	Ec	R	E
	01:26	23:26(p)	II	Oc	D	E
	01:39	23:39(p)	I	Oc	R	E
	03:40	01:40	II	Oc	R	
20	00:32	22:32(p)	III	Tr	I	E
	02:05	00:05	III	Tr	E	E



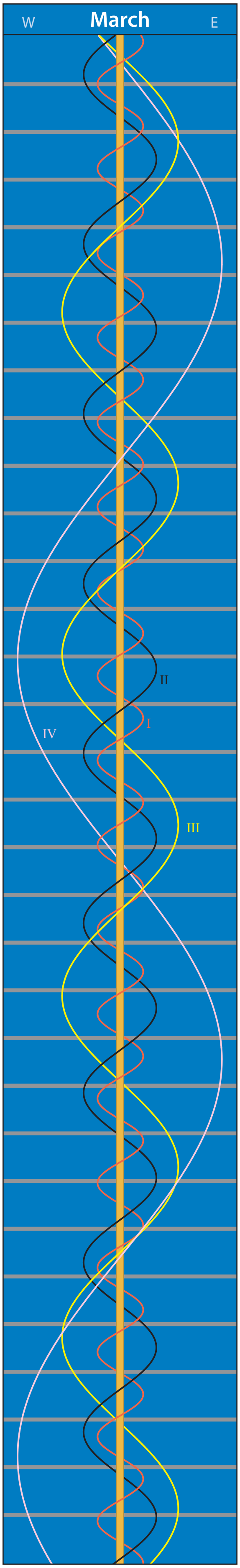
Day	EST	WST	Sat	Event		Vis
23	05:46	03:46	I	Ec	D	W
	06:55	04:55	II	Sh	I	W
24	03:01	01:01	I	Sh	I	
	04:13	02:13	I	Tr	I	
	05:11	03:11	I	Sh	E	
	06:23	04:23	I	Tr	E	W
25	00:14	22:14(p)	I	Ec	D	E
	01:40	23:40(p)	II	Ec	D	E
	03:34	01:34	I	Oc	R	
	03:57	01:57	II	Ec	R	
	04:07	02:07	II	Oc	D	
	06:21	04:21	II	Oc	R	W
26	00:52	22:52(p)	I	Tr	E	E
27	00:47	22:47(p)	II	Tr	E	E
	01:28	23:28(p)	III	Sh	E	E
	04:41	02:41	III	Tr	I	
	06:10	04:10	III	Tr	E	W
31	04:55	02:55	I	Sh	I	
	06:08	04:08	I	Tr	I	W
	07:05	05:05	I	Sh	E	W
February						
1	02:07	00:07	I	Ec	D	
	04:16	02:16	II	Ec	D	
	05:29	03:29	I	Oc	R	W
	06:32	04:32	II	Ec	R	W
	06:47	04:47	II	Oc	D	W
2	00:37	22:37(p)	I	Tr	I	E
	01:33	23:33(p)	I	Sh	E	E
	02:47	00:47	I	Tr	E	
	23:58	21:58	I	Oc	R	E
3	01:00	23:00(p)	II	Sh	E	E
	01:11	23:11(p)	II	Tr	I	E
	03:23	01:23	II	Tr	E	
	03:39	01:39	III	Sh	I	
	05:25	03:25	III	Sh	E	W
7	00:23	22:23(p)	III	Oc	R	E
	06:48	04:48	I	Sh	I	W
8	04:00	02:00	I	Ec	D	
	06:51	04:51	II	Ec	D	W
	07:23	05:23	I	Oc	R	W
9	01:16	23:16(p)	I	Sh	I	E
	02:32	00:32	I	Tr	I	
	03:27	01:27	I	Sh	E	
	04:41	02:41	I	Tr	E	
10	01:17	23:17(p)	II	Sh	I	E
	01:51	23:51(p)	I	Oc	R	
	03:32	01:32	II	Sh	E	
	03:46	01:46	II	Tr	I	
	05:57	03:57	II	Tr	E	W
	07:36	05:36	III	Sh	I	W
	23:09	21:09	I	Tr	E	E
12	00:55	22:55(p)	II	Oc	R	E
13	23:32	21:32	III	Ec	R	E
14	02:58	00:58	III	Oc	D	
	04:20	02:20	III	Oc	R	
15	05:53	03:53	I	Ec	D	W
16	03:10	01:10	I	Sh	I	
	04:25	02:25	I	Tr	I	
	05:20	03:20	I	Sh	E	
	06:34	04:34	I	Tr	E	W
17	00:21	22:21(p)	I	Ec	D	E
	03:44	01:44	I	Oc	R	
	03:50	01:50	II	Sh	I	
	06:05	04:05	II	Sh	E	W
	06:19	04:19	II	Tr	I	W
	22:53	20:53	I	Tr	I	E
	23:48	21:48	I	Sh	E	E
18	01:02	23:02(p)	I	Tr	E	E
	22:45	20:45	II	Ec	D	E
19	01:02	23:02(p)	II	Ec	R	
	01:19	23:19(p)	II	Oc	D	
	03:29	01:29	II	Oc	R	



JUPITER

JUPITER MOON EVENTS

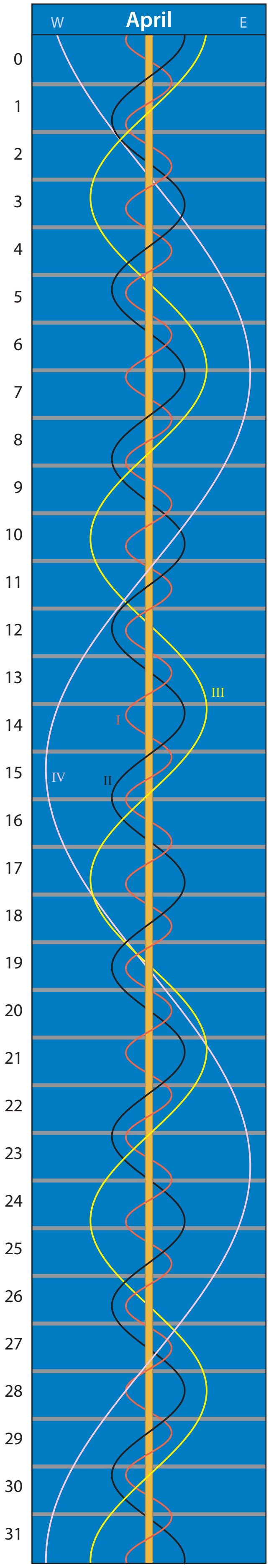
Day	EST	WST	Sat	Event	Vis
21	01:43	23:43(p)	III	Ec D	
	03:29	01:29	III	Ec R	
	06:54	04:54	III	Oc D	W
22	07:46	05:46	I	Ec D	W
23	05:03	03:03	I	Sh I	
	06:17	04:17	I	Tr I	W
	07:13	05:13	I	Sh E	W
24	02:14	00:14	I	Ec D	
	05:35	03:35	I	Oc R	
	06:23	04:23	II	Sh I	W
	23:32	21:32	I	Sh I	E
25	00:45	22:45(p)	I	Tr I	
	01:42	23:42(p)	I	Sh E	
	02:54	00:54	I	Tr E	
26	00:03	22:03(p)	I	Oc R	E
	01:21	23:21(p)	II	Ec D	
	03:37	01:37	II	Ec R	
	03:51	01:51	II	Oc D	
	06:01	04:01	II	Oc R	W
27	22:05	20:05	II	Tr I	E
28	00:14	22:14(p)	II	Tr E	E
	05:40	03:40	III	Ec D	
	07:25	05:25	III	Ec R	W
March					
2	06:57	04:57	I	Sh I	W
3	04:07	02:07	I	Ec D	
	07:26	05:26	I	Oc R	W
4	00:32	22:32(p)	III	Tr I	
	01:25	23:25(p)	I	Sh I	
	01:41	23:41(p)	III	Tr E	
	02:36	00:36	I	Tr I	
	03:35	01:35	I	Sh E	
	04:45	02:45	I	Tr E	
	22:35	20:35	I	Ec D	E
5	01:53	23:53(p)	I	Oc R	
	03:56	01:56	II	Ec D	
	06:12	04:12	II	Ec R	W
	06:21	04:21	II	Oc D	W
	22:03	20:03	I	Sh E	E
	23:13	21:13	I	Tr E	E
6	22:13	20:13	II	Sh I	E
7	00:28	22:28(p)	II	Sh E	
	00:33	22:33(p)	II	Tr I	
	02:41	00:41	II	Tr E	
8	21:44	19:44	II	Oc R	E
10	06:00	04:00	I	Ec D	W
	23:27	21:27	III	Sh I	E
11	01:11	23:11(p)	III	Sh E	
	03:18	01:18	I	Sh I	
	04:16	02:16	III	Tr I	
	04:26	02:26	I	Tr I	
	05:22	03:22	III	Tr E	
	05:28	03:28	I	Sh E	
	06:35	04:35	I	Tr E	W
12	00:28	22:28(p)	I	Ec D	
	03:43	01:43	I	Oc R	
	06:32	04:32	II	Ec D	W
	21:47	19:47	I	Sh I	E
	22:53	20:53	I	Tr I	E
	23:57	21:57	I	Sh E	
13	01:02	23:02(p)	I	Tr E	
	22:10	20:10	I	Oc R	E
14	00:46	22:46(p)	II	Sh I	
	02:58	00:58	II	Tr I	
	03:01	01:01	II	Sh E	
	05:07	03:07	II	Tr E	
16	00:11	22:11(p)	II	Oc R	
17	07:53	05:53	I	Ec D	W



Day	EST	WST	Sat	Event	Vis
18	03:25	01:25	III	Sh I	
	05:08	03:08	III	Sh E	
	05:12	03:12	I	Sh I	
	06:15	04:15	I	Tr I	W
	07:22	05:22	I	Sh E	W
	07:56	05:56	III	Tr I	W
19	02:21	00:21	I	Ec D	
	05:31	03:31	I	Oc R	
	23:40	21:40	I	Sh I	
20	00:42	22:42(p)	I	Tr I	
	01:50	23:50(p)	I	Sh E	
	02:50	00:50	I	Tr E	
	20:49	18:49	I	Ec D	E
	23:58	21:58	I	Oc R	
21	03:20	01:20	II	Sh I	
	05:22	03:22	II	Tr I	
	05:35	03:35	II	Sh E	
	07:30	05:30	II	Tr E	W
	21:17	19:17	I	Tr E	E
	21:51	19:51	III	Oc D	E
	22:55	20:55	III	Oc R	E
22	22:24	20:24	II	Ec D	E
23	02:35	00:35	II	Oc R	
24	20:41	18:41	II	Tr E	E
25	07:05	05:05	I	Sh I	W
	07:22	05:22	III	Sh I	W
	08:03	06:03	I	Tr I	W
26	04:14	02:14	I	Ec D	
	07:18	05:18	I	Oc R	W
27	01:34	23:34(p)	I	Sh I	
	02:29	00:29	I	Tr I	
	03:44	01:44	I	Sh E	
	04:38	02:38	I	Tr E	
	22:42	20:42	I	Ec D	
28	01:45	23:45(p)	I	Oc R	
	05:53	03:53	II	Sh I	
	07:44	05:44	II	Tr I	W
	08:08	06:08	II	Sh E	W
	20:56	18:56	I	Tr I	E
	21:30	19:30	III	Ec D	E
	22:12	20:12	I	Sh E	E
	23:04	21:04	I	Tr E	
	23:14	21:14	III	Ec R	
29	01:25	23:25(p)	III	Oc D	
	02:26	00:26	III	Oc R	
	20:11	18:11	I	Oc R	E
30	01:00	23:00(p)	II	Ec D	
	04:56	02:56	II	Oc R	
31	20:54	18:54	II	Tr I	E
	21:25	19:25	II	Sh E	E
	23:01	21:01	II	Tr E	
April					
2	06:07	04:07	I	Ec D	
3	03:27	01:27	I	Sh I	
	04:16	02:16	I	Tr I	
	05:37	03:37	I	Sh E	
	06:24	04:24	I	Tr E	W
4	00:36	22:36(p)	I	Ec D	
	03:31	01:31	I	Oc R	
	08:27	06:27	II	Sh I	W
	21:56	19:56	I	Sh I	E
	22:42	20:42	I	Tr I	
5	00:06	22:06(p)	I	Sh E	
	00:51	22:51(p)	I	Tr E	
	01:27	23:27(p)	III	Ec D	
	03:11	01:11	III	Ec R	
	04:53	02:53	III	Oc D	
	05:53	03:53	III	Oc R	
	21:57	19:57	I	Oc R	
6	03:35	01:35	II	Ec D	
	07:16	05:16	II	Oc R	W
7	21:44	19:44	II	Sh I	E
	23:13	21:13	II	Tr I	
	23:59	21:59	II	Sh E	

Day	EST	WST	Sat	Event	Vis
8	01:20	23:20(p)	II	Tr E	
	19:25	17:25	III	Tr E	E
9	08:01	06:01	I	Ec D	W
	20:26	18:26	II	Oc R	E
10	05:21	03:21	I	Sh I	
	06:02	04:02	I	Tr I	
	07:31	05:31	I	Sh E	W
	08:10	06:10	I	Tr E	W
11	02:29	00:29	I	Ec D	
	05:16	03:16	I	Oc R	
	23:49	21:49	I	Sh I	
12	00:28	22:28(p)	I	Tr I	
	01:59	23:59(p)	I	Sh E	
	02:36	00:36	I	Tr E	
	05:25	03:25	III	Ec D	
	07:09	05:09	III	Ec R	W
	08:17	06:17	III	Oc D	W
	20:57	18:57	I	Ec D	E
	23:43	21:43	I	Oc R	
13	06:10	04:10	II	Ec D	
	20:28	18:28	I	Sh E	E
	21:02	19:02	I	Tr E	E
15	00:19	22:19(p)	II	Sh I	
	01:30	23:30(p)	II	Tr I	
	02:34	00:34	II	Sh E	
	03:37	01:37	II	Tr E	
	19:15	17:15	III	Sh I	E
	20:58	18:58	III	Sh E	E
	21:50	19:50	III	Tr I	
	22:47	20:47	III	Tr E	
16	19:28	17:28	II	Ec D	E
	22:43	20:43	II	Oc R	
17	07:15	05:15	I	Sh I	W
	07:46	05:46	I	Tr I	W
18	04:23	02:23	I	Ec D	
	07:01	05:01	I	Oc R	W
19	01:43	23:43(p)	I	Sh I	
	02:13	00:13	I	Tr I	
	03:53	01:53	I	Sh E	
	04:21	02:21	I	Tr E	
	22:51	20:51	I	Ec D	
20	01:27	23:27(p)	I	Oc R	
	08:45	06:45	II	Ec D	W
	20:12	18:12	I	Sh I	E
	20:39	18:39	I	Tr I	E
	22:21	20:21	I	Sh E	
	22:47	20:47	I	Tr E	
21	19:53	17:53	I	Oc R	E
22	02:53	00:53	II	Sh I	
	03:46	01:46	II	Tr I	
	05:08	03:08	II	Sh E	
	05:53	03:53	II	Tr E	
	23:14	21:14	III	Sh I	
23	00:56	22:56(p)	III	Sh E	
	01:10	23:10(p)	III	Tr I	
	02:09	00:09	III	Tr E	
	22:03	20:03	II	Ec D	
24	00:59	22:59(p)	II	Oc R	
25	06:16	04:16	I	Ec D	
	08:45	06:45	I	Oc R	W
	18:25	16:25	II	Sh E	E
	19:01	17:01	II	Tr E	E
26	03:37	01:37	I	Sh I	
	03:57	01:57	I	Tr I	
	05:47	03:47	I	Sh E	
	06:05	04:05	I	Tr E	
27	00:45	22:45(p)	I	Ec D	
	03:11	01:11	I	Oc R	
	22:06	20:06	I	Sh I	
	22:23	20:23	I	Tr I	
28	00:15	22:15(p)	I	Sh E	
	00:31	22:31(p)	I	Tr E	
	19:13	17:13	I	Ec D	E
	21:37	19:37	I	Oc R	

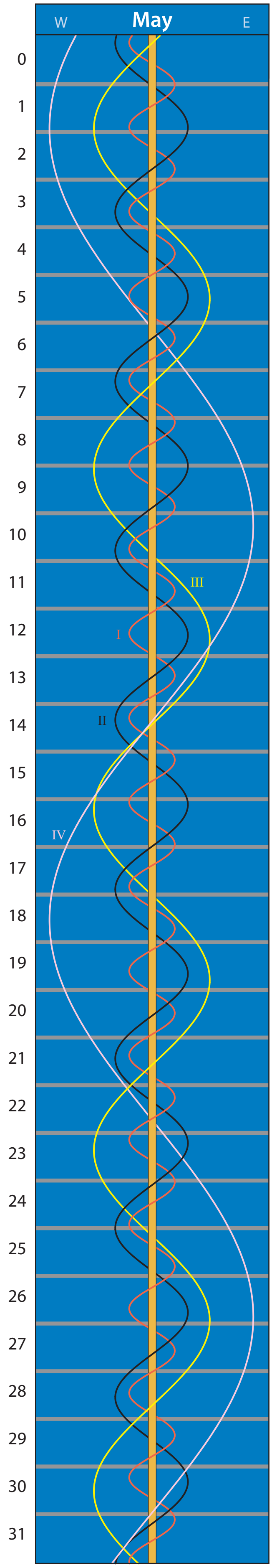
JUPITER MOON EVENTS



Day	EST	WST	Sat	Event	Vis
29	05:28	03:28	II	Sh I	
	06:01	04:01	II	Tr I	
	07:43	05:43	II	Sh E	W
	08:09	06:09	II	Tr E	W
	18:44	16:44	I	Sh E	E
	18:57	16:57	I	Tr E	E
30	03:12	01:12	III	Sh I	
	04:26	02:26	III	Tr I	
	04:54	02:54	III	Sh E	
	05:28	03:28	III	Tr E	

May

Day	EST	WST	Sat	Event	Vis
1	00:38	22:38(p)	II	Ec D	
	03:14	01:14	II	Oc R	
2	08:10	06:10	I	Ec D	W
	18:45	16:45	II	Sh I	E
	19:08	17:08	II	Tr I	E
	21:00	19:00	II	Sh E	
	21:16	19:16	II	Tr E	
3	05:31	03:31	I	Sh I	
	05:41	03:41	I	Tr I	
	07:41	05:41	I	Sh E	W
	07:49	05:49	I	Tr E	W
	19:16	17:16	III	Oc R	E
4	02:39	00:39	I	Ec D	
	04:55	02:55	I	Oc R	
	23:59	21:59	I	Sh I	
5	00:07	22:07(p)	I	Tr I	
	02:09	00:09	I	Sh E	
	02:15	00:15	I	Tr E	
	21:07	19:07	I	Ec D	
	23:21	21:21	I	Oc R	
6	08:03	06:03	II	Sh I	W
	08:15	06:15	II	Tr I	W
	18:28	16:28	I	Sh I	E
	18:32	16:32	I	Tr I	E
	20:38	18:38	I	Sh E	
	20:41	18:41	I	Tr E	
7	07:11	05:11	III	Sh I	W
	07:41	05:41	III	Tr I	W
	08:46	06:46	III	Tr E	W
	08:52	06:52	III	Sh E	W
	17:47	15:47	I	Oc R	E
8	03:13	01:13	II	Ec D	
	05:29	03:29	II	Oc R	
9	21:21	19:21	II	Sh I	
	21:22	19:22	II	Tr I	
	23:31	21:31	II	Tr E	
	23:36	21:36	II	Sh E	
10	07:24	05:24	I	Tr I	W
	07:25	05:25	I	Sh I	W
	21:17	19:17	III	Ec D	
	23:00	21:00	III	Ec R	
11	04:31	02:31	I	Oc D	
	06:43	04:43	I	Ec R	W
	18:46	16:46	II	Ec R	E
12	01:50	23:50(p)	I	Tr I	
	01:53	23:53(p)	I	Sh I	
	03:58	01:58	I	Tr E	
	04:03	02:03	I	Sh E	
	22:57	20:57	I	Oc D	
13	01:11	23:11(p)	I	Ec R	
	20:16	18:16	I	Tr I	
	20:22	18:22	I	Sh I	
	22:24	20:24	I	Tr E	
	22:32	20:32	I	Sh E	
14	17:23	15:23	I	Oc D	E
	19:40	17:40	I	Ec R	
15	05:34	03:34	II	Oc D	
	08:03	06:03	II	Ec R	W
16	23:37	21:37	II	Tr I	
	23:56	21:56	II	Sh I	
17	01:46	23:46(p)	II	Tr E	
	02:11	00:11	II	Sh E	
18	00:40	22:40(p)	III	Oc D	
	02:59	00:59	III	Ec R	
	06:15	04:15	I	Oc D	W
	18:41	16:41	II	Oc D	E
	21:21	19:21	II	Ec R	



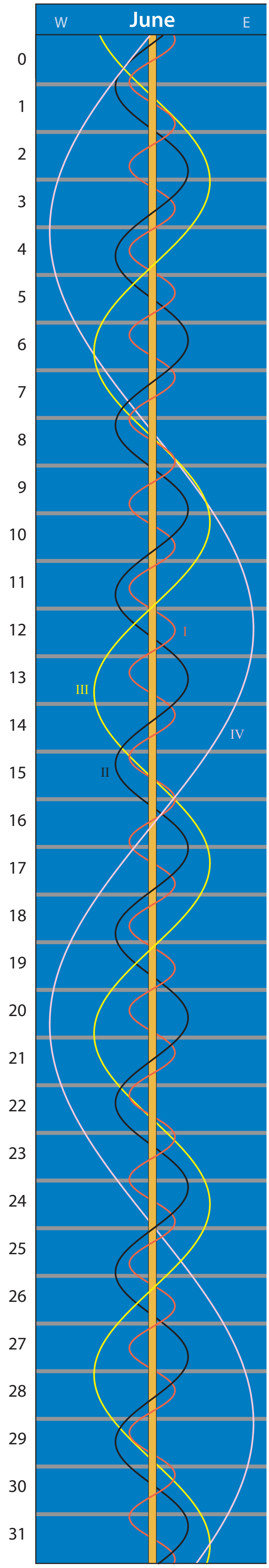
Day	EST	WST	Sat	Event	Vis
19	03:34	01:34	I	Tr I	
	03:48	01:48	I	Sh I	
	05:42	03:42	I	Tr E	
	05:57	03:57	I	Sh E	
20	00:41	22:41(p)	I	Oc D	
	03:05	01:05	I	Ec R	
	22:00	20:00	I	Tr I	
	22:16	20:16	I	Sh I	
21	00:08	22:08(p)	I	Tr E	
	00:26	22:26(p)	I	Sh E	
	19:07	17:07	I	Oc D	E
	21:34	19:34	I	Ec R	
22	07:49	05:49	II	Oc D	W
	18:35	16:35	I	Tr E	E
	18:54	16:54	I	Sh E	E
24	01:52	23:52(p)	II	Tr I	
	02:32	00:32	II	Sh I	
	04:02	02:02	II	Tr E	
	04:47	02:47	II	Sh E	
25	03:55	01:55	III	Oc D	
	05:15	03:15	III	Ec D	
	06:57	04:57	III	Ec R	W
	20:56	18:56	II	Oc D	
	23:56	21:56	II	Ec R	
26	05:18	03:18	I	Tr I	
	05:42	03:42	I	Sh I	W
	07:27	05:27	I	Tr E	W
	07:51	05:51	I	Sh E	W
27	02:25	00:25	I	Oc D	
	05:00	03:00	I	Ec R	
	17:11	15:11	II	Tr E	E
	18:05	16:05	II	Sh E	E
	23:45	21:45	I	Tr I	
28	00:10	22:10(p)	I	Sh I	
	01:53	23:53(p)	I	Tr E	
	02:20	00:20	I	Sh E	
	17:25	15:25	III	Tr I	E
	18:45	16:45	III	Tr E	E
	19:05	17:05	III	Sh I	E
	20:46	18:46	III	Sh E	
	20:51	18:51	I	Oc D	
	23:28	21:28	I	Ec R	
29	18:11	16:11	I	Tr I	E
	18:39	16:39	I	Sh I	E
	20:19	18:19	I	Tr E	
	20:48	18:48	I	Sh E	
30	17:57	15:57	I	Ec R	E
31	04:08	02:08	II	Tr I	
	05:08	03:08	II	Sh I	
	06:19	04:19	II	Tr E	W
	07:23	05:23	II	Sh E	W

June

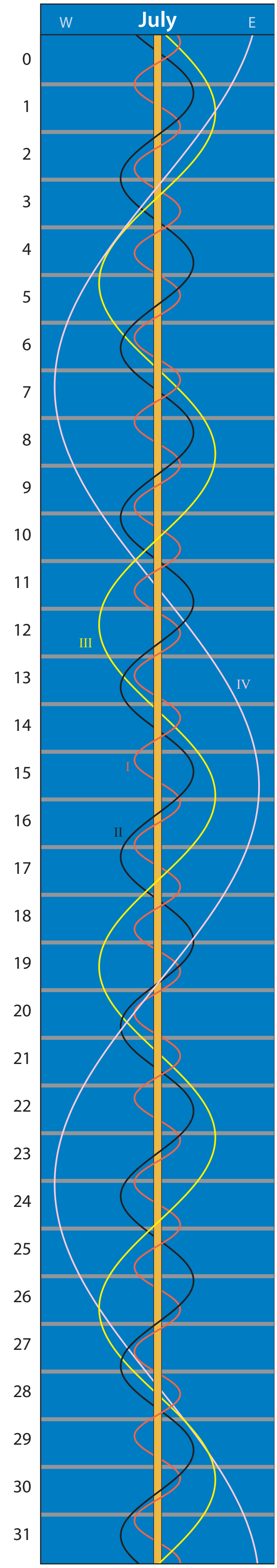
Day	EST	WST	Sat	Event	Vis
1	07:13	05:13	III	Oc D	W
	23:12	21:12	II	Oc D	
2	02:31	00:31	II	Ec R	
	07:03	05:03	I	Tr I	W
3	04:10	02:10	I	Oc D	
	06:54	04:54	I	Ec R	W
	17:17	15:17	II	Tr I	E
	18:27	16:27	II	Sh I	E
	19:29	17:29	II	Tr E	
	20:42	18:42	II	Sh E	
4	01:30	23:30(p)	I	Tr I	
	02:05	00:05	I	Sh I	
	03:38	01:38	I	Tr E	
	04:14	02:14	I	Sh E	
	20:44	18:44	III	Tr I	
	22:09	20:09	III	Tr E	
	22:37	20:37	I	Oc D	
	23:04	21:04	III	Sh I	
5	00:45	22:45(p)	III	Sh E	
	01:23	23:23(p)	I	Ec R	
	19:56	17:56	I	Tr I	
	20:33	18:33	I	Sh I	
	22:05	20:05	I	Tr E	
	22:43	20:43	I	Sh E	

JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
6	17:03	15:03	I	Oc D	E
	19:52	17:52	I	Ec R	
7	06:26	04:26	II	Tr I	W
	17:11	15:11	I	Sh E	E
9	01:29	23:29(p)	II	Oc D	
	05:06	03:06	II	Ec R	W
10	05:56	03:56	I	Oc D	W
	19:36	17:36	II	Tr I	
	21:03	19:03	II	Sh I	
	21:48	19:48	II	Tr E	
	23:18	21:18	II	Sh E	
11	03:15	01:15	I	Tr I	
	03:59	01:59	I	Sh I	
	05:24	03:24	I	Tr E	W
	06:08	04:08	I	Sh E	W
12	00:06	22:06(p)	III	Tr I	
	00:23	22:23(p)	I	Oc D	
	01:37	23:37(p)	III	Tr E	
	03:03	01:03	III	Sh I	
	03:18	01:18	I	Ec R	
	04:45	02:45	III	Sh E	W
	18:23	16:23	II	Ec R	E
	21:42	19:42	I	Tr I	
	22:28	20:28	I	Sh I	
	23:51	21:51	I	Tr E	
13	00:37	22:37(p)	I	Sh E	
	18:49	16:49	I	Oc D	E
	21:46	19:46	I	Ec R	
14	18:18	16:18	I	Tr E	E
	19:06	17:06	I	Sh E	E
15	17:10	15:10	III	Ec D	E
	18:53	16:53	III	Ec R	E
16	03:48	01:48	II	Oc D	
17	21:56	19:56	II	Tr I	
	23:40	21:40	II	Sh I	
18	00:10	22:10(p)	II	Tr E	
	01:55	23:55(p)	II	Sh E	
	05:02	03:02	I	Tr I	W
	05:54	03:54	I	Sh I	W
19	02:10	00:10	I	Oc D	
	03:32	01:32	III	Tr I	
	05:07	03:07	III	Tr E	W
	05:13	03:13	I	Ec R	W
	16:58	14:58	II	Oc D	E
	20:58	18:58	II	Ec R	
	23:29	21:29	I	Tr I	
20	00:22	22:22(p)	I	Sh I	
	01:38	23:38(p)	I	Tr E	
	02:32	00:32	I	Sh E	
	20:37	18:37	I	Oc D	
	23:41	21:41	I	Ec R	
21	17:56	15:56	I	Tr I	E
	18:51	16:51	I	Sh I	E
	20:05	18:05	I	Tr E	
	21:00	19:00	I	Sh E	
22	17:24	15:24	III	Oc D	E
	18:10	16:10	I	Ec R	E
	19:03	17:03	III	Oc R	E
	21:09	19:09	III	Ec D	
	22:52	20:52	III	Ec R	
25	00:19	22:19(p)	II	Tr I	
	02:17	00:17	II	Sh I	
	02:33	00:33	II	Tr E	
	04:32	02:32	II	Sh E	W
26	03:58	01:58	I	Oc D	W
	19:20	17:20	II	Oc D	
	23:33	21:33	II	Ec R	
27	01:17	23:17(p)	I	Tr I	
	02:17	00:17	I	Sh I	
	03:26	01:26	I	Tr E	W
	04:26	02:26	I	Sh E	W
	22:25	20:25	I	Oc D	
28	01:36	23:36(p)	I	Ec R	
	17:50	15:50	II	Sh E	E
	19:44	17:44	I	Tr I	
	20:45	18:45	I	Sh I	
	21:54	19:54	I	Tr E	
	22:55	20:55	I	Sh E	



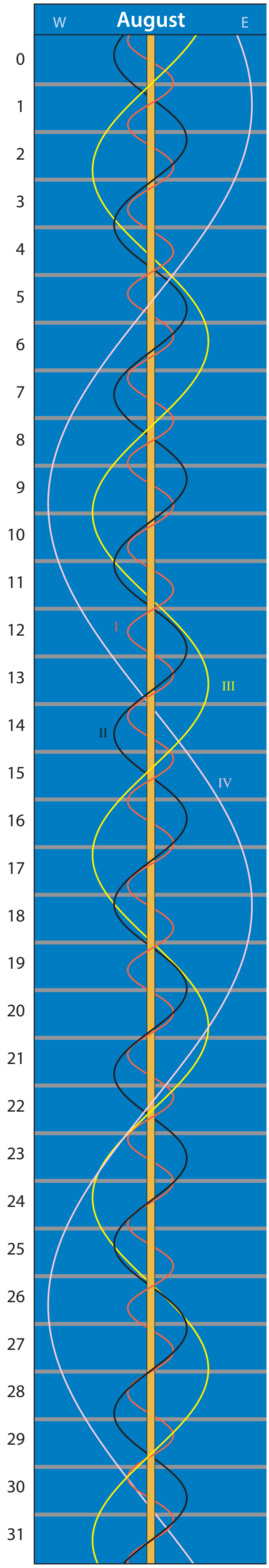
Day	EST	WST	Sat	Event	Vis
29	20:05	18:05	I	Ec R	
	20:56	18:56	III	Oc D	
	22:39	20:39	III	Oc R	
30	01:08	23:08(p)	III	Ec D	
	02:52	00:52	III	Ec R	
	17:23	15:23	I	Sh E	E
July					
2	02:44	00:44	II	Tr I	
	04:54	02:54	II	Sh I	W
	04:59	02:59	II	Tr E	W
3	21:43	19:43	II	Oc D	
4	02:08	00:08	II	Ec R	
	03:06	01:06	I	Tr I	W
	04:11	02:11	I	Sh I	W
5	00:15	22:15(p)	I	Oc D	
	03:32	01:32	I	Ec R	W
	18:12	16:12	II	Sh I	E
	18:12	16:12	II	Tr E	E
	20:27	18:27	II	Sh E	
	21:34	19:34	I	Tr I	
	22:40	20:40	I	Sh I	
	23:43	21:43	I	Tr E	
6	00:49	22:49(p)	I	Sh E	
	18:42	16:42	I	Oc D	E
	22:00	20:00	I	Ec R	
7	00:34	22:34(p)	III	Oc D	
	02:21	00:21	III	Oc R	
	17:09	15:09	I	Sh I	E
	18:11	16:11	I	Tr E	E
	19:18	17:18	I	Sh E	E
10	18:57	16:57	III	Sh I	E
	20:40	18:40	III	Sh E	
11	00:09	22:09(p)	II	Oc D	
	02:25	00:25	II	Oc R	W
	02:27	00:27	II	Ec D	W
12	02:06	00:06	I	Oc D	
	18:25	16:25	II	Tr I	E
	20:41	18:41	II	Tr E	
	20:49	18:49	II	Sh I	
	23:05	21:05	II	Sh E	
	23:24	21:24	I	Tr I	
13	00:35	22:35(p)	I	Sh I	
	01:34	23:34(p)	I	Tr E	
	02:44	00:44	I	Sh E	W
	20:34	18:34	I	Oc D	
	23:56	21:56	I	Ec R	
14	04:15	02:15	III	Oc D	W
	17:52	15:52	I	Tr I	E
	18:00	16:00	II	Ec R	E
	19:03	17:03	I	Sh I	E
	20:02	18:02	I	Tr E	
	21:13	19:13	I	Sh E	
15	18:24	16:24	I	Ec R	E
17	17:57	15:57	III	Tr I	E
	19:48	17:48	III	Tr E	
	22:57	20:57	III	Sh I	
18	00:39	22:39(p)	III	Sh E	
	02:37	00:37	II	Oc D	W
19	03:58	01:58	I	Oc D	W
	20:55	18:55	II	Tr I	
	23:13	21:13	II	Tr E	
	23:27	21:27	II	Sh I	
20	01:16	23:16(p)	I	Tr I	
	01:42	23:42(p)	II	Sh E	
	02:29	00:29	I	Sh I	W
	03:25	01:25	I	Tr E	W
	22:26	20:26	I	Oc D	
21	01:51	23:51(p)	I	Ec R	W
	18:09	16:09	II	Oc R	E
	18:19	16:19	II	Ec D	E
	19:44	17:44	I	Tr I	
	20:35	18:35	II	Ec R	
	20:58	18:58	I	Sh I	
	21:54	19:54	I	Tr E	
	23:07	21:07	I	Sh E	
22	20:20	18:20	I	Ec R	



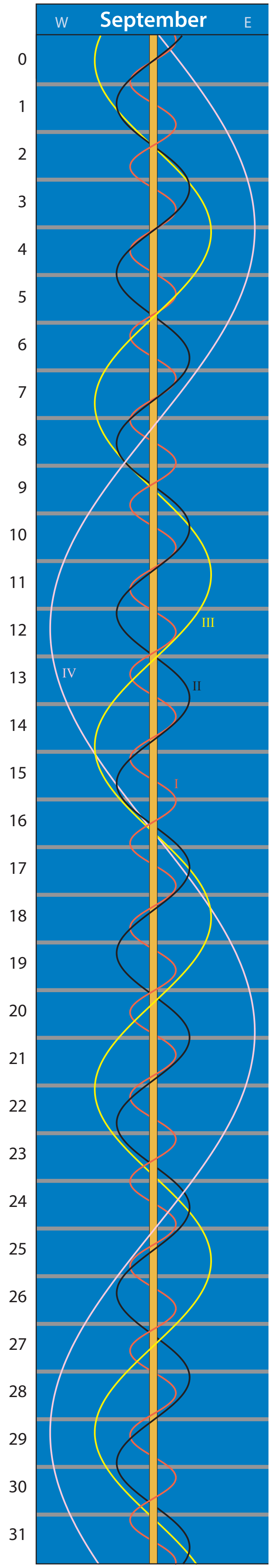
JUPITER

JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
23	17:36	15:36	I	Sh E	E
24	21:46	19:46	III	Tr I	
	23:39	21:39	III	Tr E	
25	02:55	00:55	III	Sh I	W
26	23:28	21:28	II	Tr I	
27	01:46	23:46(p)	II	Tr E	W
	02:04	00:04	II	Sh I	W
	03:08	01:08	I	Tr I	W
28	00:19	22:19(p)	I	Oc D	
	18:23	16:23	II	Oc D	E
	18:50	16:50	III	Ec R	E
	20:40	18:40	II	Oc R	
	20:54	18:54	II	Ec D	
	21:37	19:37	I	Tr I	
	22:53	20:53	I	Sh I	
	23:09	21:09	II	Ec R	
	23:47	21:47	I	Tr E	
29	01:02	23:02(p)	I	Sh E	
	18:47	16:47	I	Oc D	E
	22:15	20:15	I	Ec R	
30	17:21	15:21	I	Sh I	E
	17:39	15:39	II	Sh E	E
	18:15	16:15	I	Tr E	E
	19:31	17:31	I	Sh E	E
August					
1	01:39	23:39(p)	III	Tr I	W
3	02:04	00:04	II	Tr I	W
4	02:13	00:13	I	Oc D	W
	17:45	15:45	III	Oc R	E
	20:56	18:56	II	Oc D	
	21:05	19:05	III	Ec D	
	22:49	20:49	III	Ec R	
	23:14	21:14	II	Oc R	
	23:29	21:29	II	Ec D	
	23:31	21:31	I	Tr I	
5	00:47	22:47(p)	I	Sh I	W
	01:41	23:41(p)	I	Tr E	W
	01:44	23:44(p)	II	Ec R	W
	02:57	00:57	I	Sh E	W
	20:42	18:42	I	Oc D	
6	00:10	22:10(p)	I	Ec R	
	17:41	15:41	II	Tr E	E
	17:59	15:59	I	Tr I	E
	18:01	16:01	II	Sh I	E
	19:16	17:16	I	Sh I	E
	20:09	18:09	I	Tr E	
	20:17	18:17	II	Sh E	
	21:25	19:25	I	Sh E	
7	18:39	16:39	I	Ec R	E
11	19:46	17:46	III	Oc D	E
	21:46	19:46	III	Oc R	
	23:31	21:31	II	Oc D	
12	01:04	23:04(p)	III	Ec D	W
	01:25	23:25(p)	I	Tr I	W
	01:49	23:49(p)	II	Oc R	W
	02:03	00:03	II	Ec D	W
	22:38	20:38	I	Oc D	
13	02:06	00:06	I	Ec R	W
	18:01	16:01	II	Tr I	E
	19:54	17:54	I	Tr I	
	20:20	18:20	II	Tr E	
	20:39	18:39	II	Sh I	
	21:11	19:11	I	Sh I	
	22:04	20:04	I	Tr E	
	22:55	20:55	II	Sh E	
	23:20	21:20	I	Sh E	
14	20:35	18:35	I	Ec R	
15	17:36	15:36	II	Ec R	E
	17:49	15:49	I	Sh E	E
18	23:49	21:49	III	Oc D	
19	01:50	23:50(p)	III	Oc R	W
	02:07	00:07	II	Oc D	W

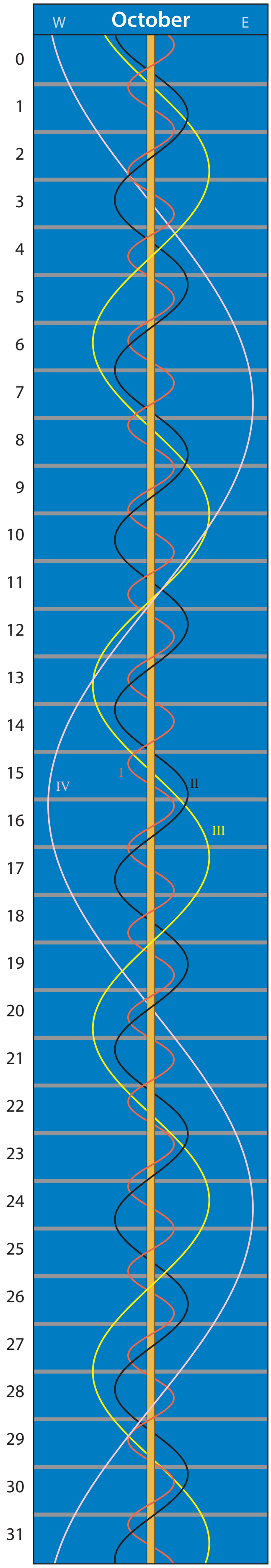


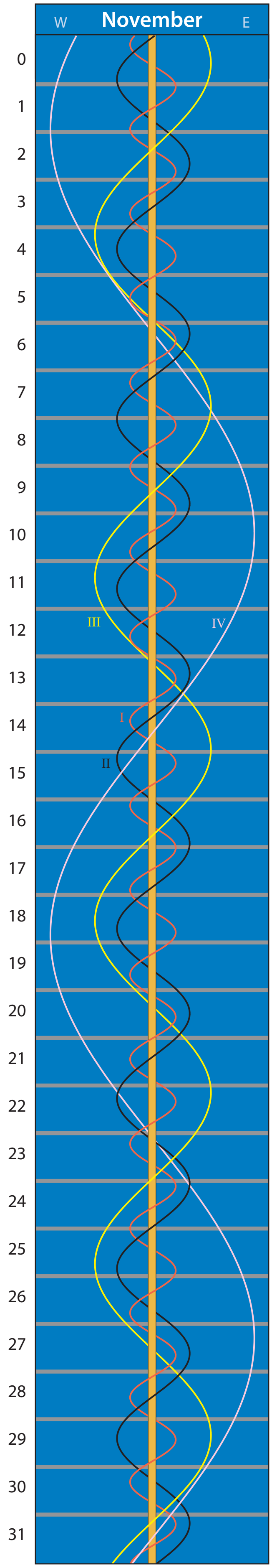
Day	EST	WST	Sat	Event	Vis
20	00:34	22:34(p)	I	Oc D	W
	20:41	18:41	II	Tr I	
	21:50	19:50	I	Tr I	
	23:01	21:01	II	Tr E	
	23:05	21:05	I	Sh I	
	23:16	21:16	II	Sh I	
21	00:00	22:00(p)	I	Tr E	W
	01:15	23:15(p)	I	Sh E	W
	01:33	23:33(p)	II	Sh E	W
	19:04	17:04	I	Oc D	E
	22:30	20:30	I	Ec R	
22	17:45	15:45	II	Oc R	E
	17:55	15:55	II	Ec D	E
	18:30	16:30	I	Tr E	E
	18:52	16:52	III	Sh I	E
	19:43	17:43	I	Sh E	E
	20:11	18:11	II	Ec R	
	20:36	18:36	III	Sh E	
27	23:23	21:23	II	Tr I	W
	23:47	21:47	I	Tr I	W
28	01:00	23:00(p)	I	Sh I	W
	01:43	23:43(p)	II	Tr E	W
	21:01	19:01	I	Oc D	
29	00:25	22:25(p)	I	Ec R	W
	17:49	15:49	III	Tr I	E
	18:05	16:05	II	Oc D	E
	18:16	16:16	I	Tr I	E
	19:29	17:29	I	Sh I	E
	19:51	17:51	III	Tr E	E
	20:25	18:25	II	Oc R	
	20:27	18:27	I	Tr E	
	20:30	18:30	II	Ec D	
	21:38	19:38	I	Sh E	
	22:46	20:46	II	Ec R	
	22:50	20:50	III	Sh I	
30	00:35	22:35(p)	III	Sh E	W
	18:54	16:54	I	Ec R	E
September					
4	22:59	20:59	I	Oc D	W
5	20:14	18:14	I	Tr I	
	20:46	18:46	II	Oc D	
	21:23	19:23	I	Sh I	
	22:00	20:00	III	Tr I	
	22:24	20:24	I	Tr E	
	23:33	21:33	I	Sh E	W
6	00:03	22:03(p)	III	Tr E	W
	20:49	18:49	I	Ec R	
7	17:48	15:48	II	Tr E	E
	17:50	15:50	II	Sh I	E
	18:01	16:01	I	Sh E	E
	20:06	18:06	II	Sh E	
9	18:49	16:49	III	Ec R	E
12	22:12	20:12	I	Tr I	
	23:18	21:18	I	Sh I	W
	23:28	21:28	II	Oc D	W
13	00:23	22:23(p)	I	Tr E	W
	19:28	17:28	I	Oc D	E
	22:45	20:45	I	Ec R	W
14	18:14	16:14	II	Tr I	E
	18:52	16:52	I	Tr E	E
	19:56	17:56	I	Sh E	E
	20:27	18:27	II	Sh I	
	20:34	18:34	II	Tr E	
	22:44	20:44	II	Sh E	W
16	18:41	16:41	III	Oc R	E
	21:01	19:01	III	Ec D	
	22:48	20:48	III	Ec R	W
20	00:11	22:11(p)	I	Tr I	W
	21:28	19:28	I	Oc D	
21	18:41	16:41	I	Tr I	E
	19:41	17:41	I	Sh I	E
	20:51	18:51	I	Tr E	
	21:00	19:00	II	Tr I	
	21:50	19:50	I	Sh E	
	23:05	21:05	II	Sh I	W
	23:21	21:21	II	Tr E	W

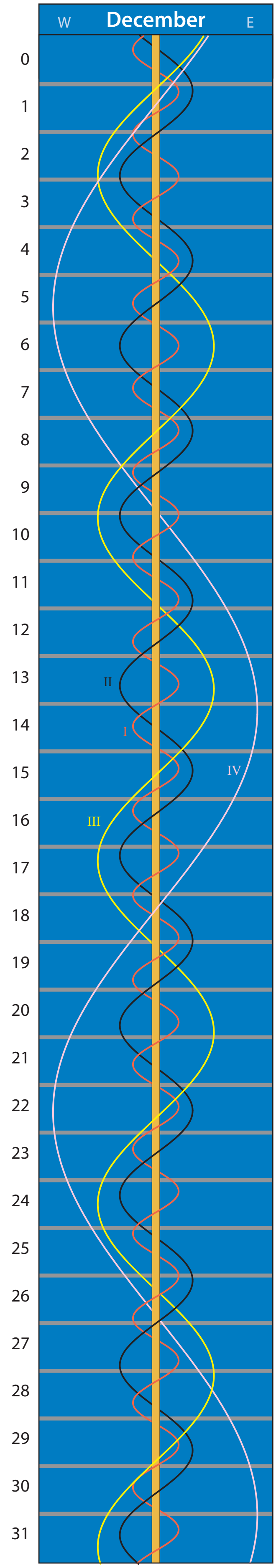


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
22	19:09	17:09	I	Ec R	E
23	19:47	17:47	II	Ec R	E
	20:54	18:54	III	Oc D	
	22:59	20:59	III	Oc R	W
27	23:28	21:28	I	Oc D	W
28	20:40	18:40	I	Tr I	
	21:35	19:35	I	Sh I	
	22:51	20:51	I	Tr E	W
	23:45	21:45	I	Sh E	W
	23:48	21:48	II	Tr I	W
29	21:04	19:04	I	Ec R	
30	18:14	16:14	I	Sh E	E
	18:18	16:18	II	Oc D	E
	22:22	20:22	II	Ec R	W
October					
4	18:45	16:45	III	Sh I	E
	20:32	18:32	III	Sh E	
5	22:40	20:40	I	Tr I	W
	23:30	21:30	I	Sh I	W
6	19:59	17:59	I	Oc D	E
	22:59	20:59	I	Ec R	W
7	19:21	17:21	I	Tr E	E
	20:08	18:08	I	Sh E	E
	21:03	19:03	II	Oc D	
9	18:22	16:22	II	Tr E	E
	19:55	17:55	II	Sh E	E
11	19:35	17:35	III	Tr I	E
	21:39	19:39	III	Tr E	W
	22:43	20:43	III	Sh I	W
13	22:00	20:00	I	Oc D	W
14	19:11	17:11	I	Tr I	E
	19:53	17:53	I	Sh I	E
	21:21	19:21	I	Tr E	W
	22:02	20:02	I	Sh E	W
15	19:22	17:22	I	Ec R	E
16	18:51	16:51	II	Tr I	E
	20:14	18:14	II	Sh I	E
	21:12	19:12	II	Tr E	W
	22:32	20:32	II	Sh E	W
21	21:11	19:11	I	Tr I	W
	21:47	19:47	I	Sh I	W
22	18:31	16:31	I	Oc D	E
	18:46	16:46	III	Ec R	E
	21:17	19:17	I	Ec R	W
23	18:26	16:26	I	Sh E	E
	21:41	19:41	II	Tr I	W
25	19:23	17:23	II	Ec R	E
29	18:55	16:55	III	Oc D	E
30	19:53	17:53	I	Tr E	E
November					
1	18:49	16:49	II	Oc D	E
	21:58	19:58	II	Ec R	W
December					
19	04:16	02:16	III	Oc R	E
21	04:07	02:07	I	Sh E	E
	04:33	02:33	I	Tr E	E
25	06:22	04:22	II	Oc R	W
26	04:41	02:41	III	Ec D	E
27	06:43	04:43	I	Ec D	W
28	03:51	01:51	I	Sh I	E
	04:22	02:22	I	Tr I	E
	06:01	04:01	I	Sh E	W
	06:33	04:33	I	Tr E	W
29	03:55	01:55	I	Oc R	E







JUPITER

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hrs UT Epoch 2000.0

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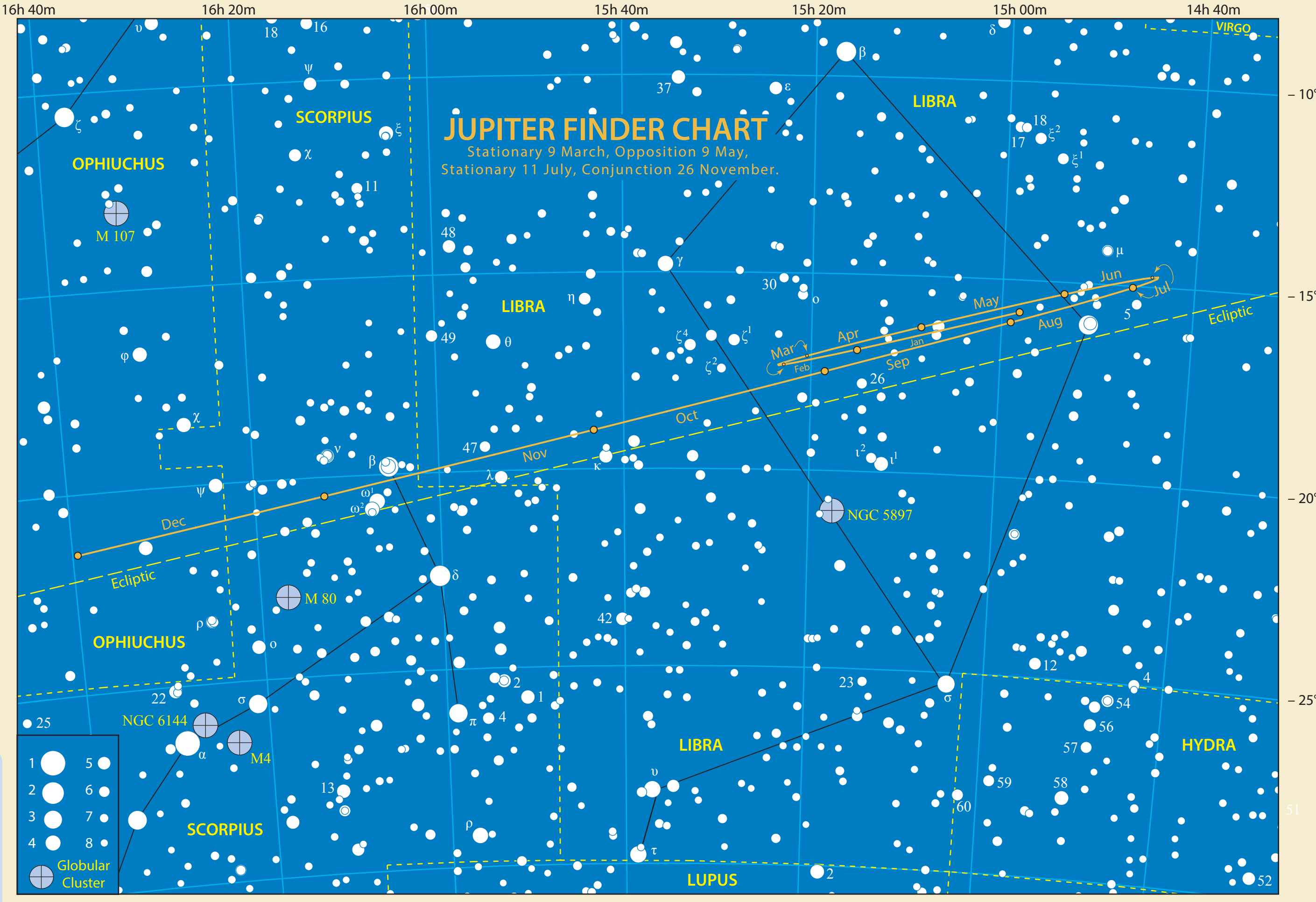
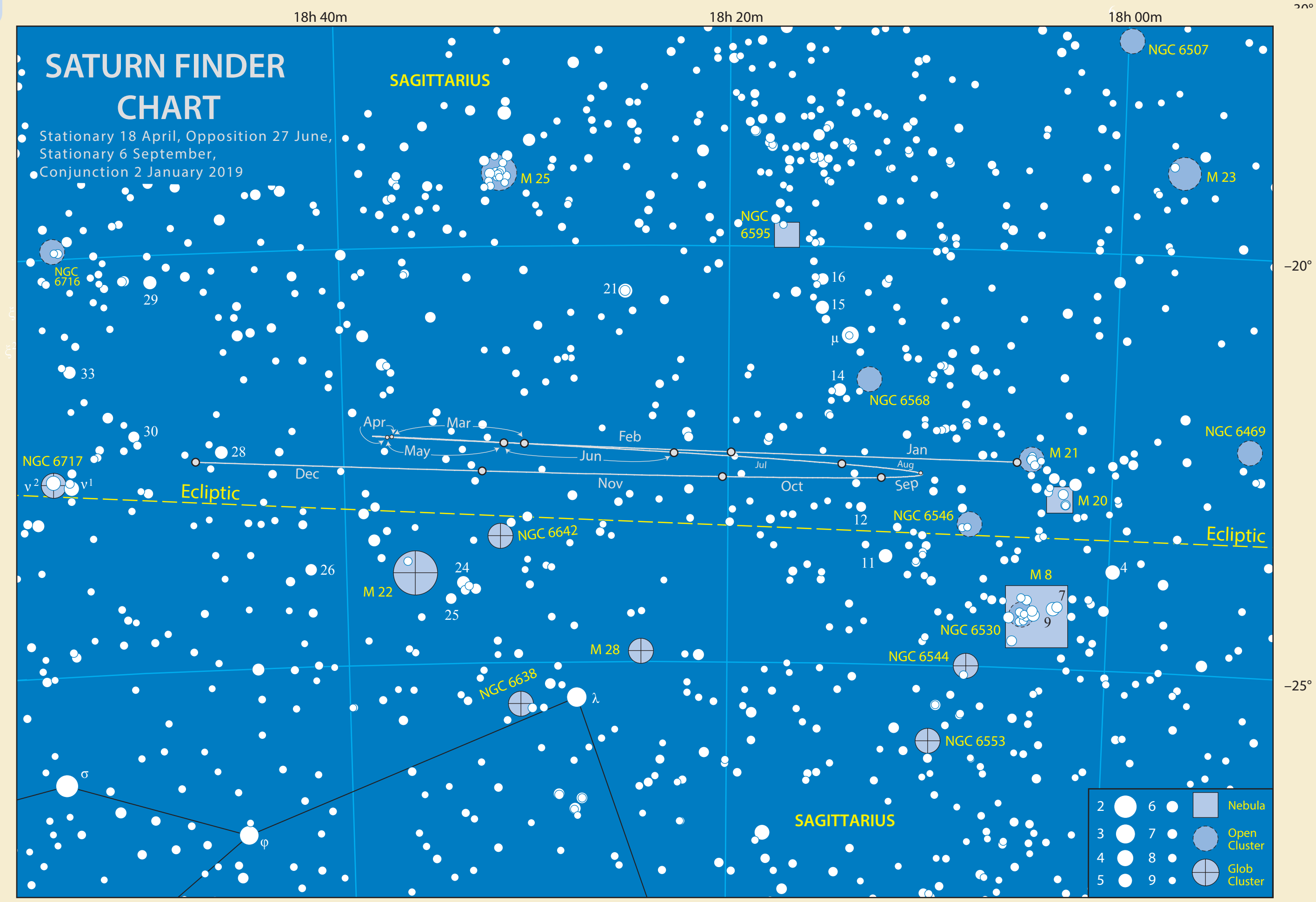
	27	06:37	20:32	06:24	19:50	06:25	20:21	07:47	20:25	06:14	20:47	06:35	20:43	06:44	20:27	06:19	20:09	15 39 41	– 18 48 33
Nov	3	06:15	20:12	06:02	19:29	06:02	20:00	07:25	20:04	05:51	20:27	06:13	20:23	06:22	20:06	05:56	19:49	15 45 52	– 19 09 29
	10	05:53	19:52	05:40	19:09	05:40	19:40	07:04	19:43	05:28	20:07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


JUPITER FINDER CHART
Stationary 9 March, Opposition 9 May,
Stationary 11 July, Conjunction 26 November.
16h 40m
16h 20m
16h 00m
15h 40m
15h 20m
15h 00m
14h 40m
– 10°
– 15°
– 20°
– 25°
VIRGO
LIBRA
SCORPIUS
OPHIUCHUS
HYDRA
LUPUS
M 107
M 80
M4
NGC 6144
NGC 5897
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Globular Cluster


SATURN FINDER CHART
Stationary 18 April, Opposition 27 June,
Stationary 6 September,
Conjunction 2 January 2019
18h 40m
18h 20m
18h 00m
–20°
–25°
SAGITTARIUS
M 25
M 23
M 21
M 20
M 8
M 22
M 28
NGC 6507
NGC 6595
NGC 6716
NGC 6568
NGC 6469
NGC 6717
NGC 6546
NGC 6642
NGC 6530
NGC 6544
NGC 6638
NGC 6553
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Nebula
Open Cluster
Glob Cluster

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

SATELLITES OF SATURN

These pages help you find the position of Saturn's major satellites. Note that dates and times here are given in days and fractions of days in UT. You will need to convert your local time to this format first. Table 3 will help.

The worked examples here are based on a diagram of the satellite's configuration for 28 July 11 pm EST (see page 50).

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 (below). The procedure is to work out how many orbits have elapsed since the first elongation of the month, then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram below. You wish to determine the position of **Dione** for the date above.

1. Convert to UT as a fractional day (table 3) to get 28.542 UT.
2. Subtract the date of the greatest elongation east for Dione for July, i.e., 28.542 – 3.454 = 25.088
3. Express this as the number of orbits by dividing by the period i.e., 25.088 / 2.737 = 9.166
4. Discard any complete orbits (9 in this case) leaving 0.166
5. Multiply by the period, 0.166 × 2.737 = 0.45 days or about 0 days 10.9 hr or 10.9 hour after elongation east.
6. Looking at the orbital path for Dione (see Apparent Orbits diagram, below), the satellite is south-east of the planet to the right of the 8 hr mark.

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

Moon	Mimas	Enceladus	Tethys	Dione	Rhea
Magnitude [1]	12.8	11.8	10.2	10.4	9.6
Max Elong. [1]	0' 30"	0' 38"	0' 48"	1' 01"	1' 25"
Period (days) [2]	0.942	1.370	1.888	2.737	4.518
Month	Elongation East (d.ddd)				
January	1.179	1.063	2.004	1.058	1.796
February	1.292	1.592	1.229	2.933	2.467
March	1.571	1.004	1.558	2.321	1.604
April	1.675	1.525	2.658	1.438	2.246
May	1.829	1.667	2.863	1.538	3.867
June	1.921	2.175	2.054	3.367	4.467
July	1.129	2.308	2.246	3.454	1.542
August	1.221	1.446	1.442	2.546	2.138
September	1.321	1.958	2.533	1.646	2.750
October	1.479	2.108	2.742	1.758	4.383
November	1.592	1.267	1.963	3.625	5.038
December	1.758	1.425	2.183	1.017	2.183

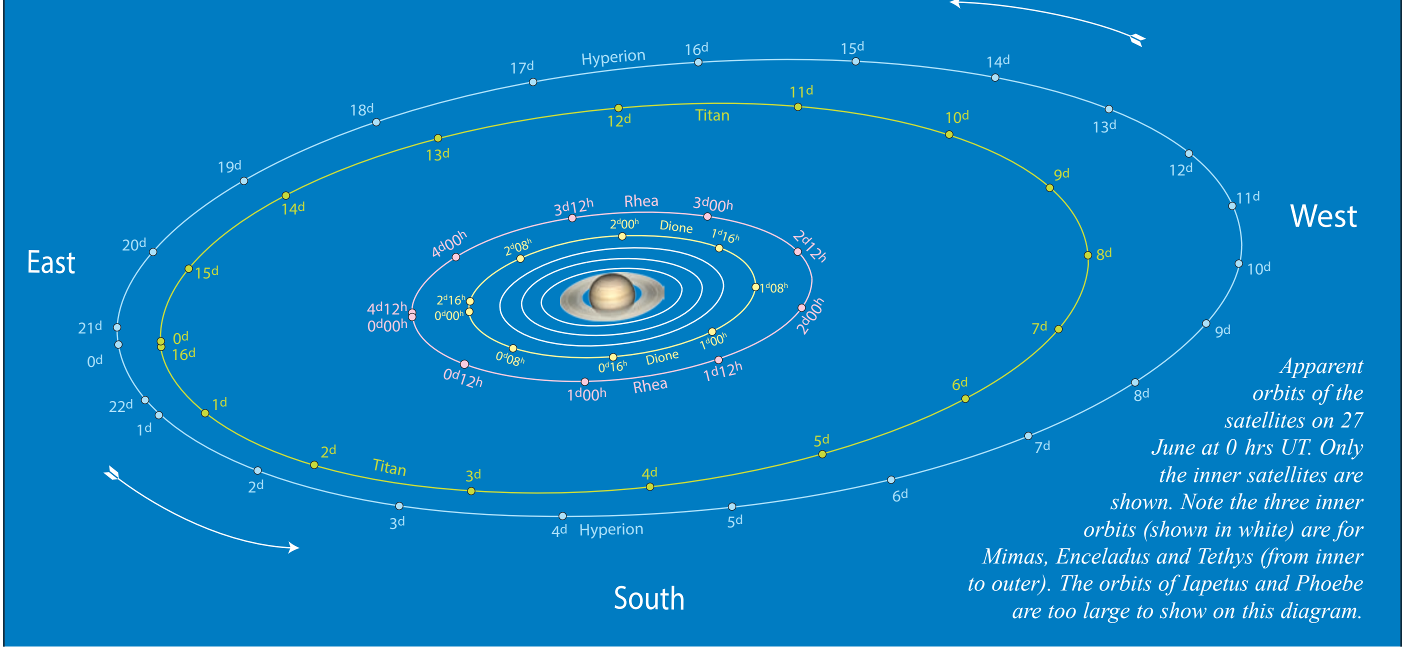
Notes 1. When at opposition 2. Mean Synodic Period

Mimas, Enceladus and Tethys

The procedure is similar to Rhea and Dione above with the times of the first greatest elongation east for each month also being listed in Table 1. However, these inner moons are so close to Saturn that while the orbits are represented on the diagram, it is difficult to put the day markers on and still have it readable. As above we calculate the fraction of the orbit and then estimate its position. Like the other major moons, these three still orbit in the same direction (anticlockwise), so three quarters of an orbit (0.75) would place it north of Saturn.

Estimate the position for **Tethys** using the same date, 28 July 28.542 UT; 13.93 orbits have elapsed since the first greatest elongation east for July on 2.246 UT. Discarding the 13 orbits leaves 0.93. This is close to a complete orbit so is east of Saturn approaching a maximum elongation.

APPARENT ORBITS OF SATURN'S SATELLITES



Apparent orbits of the satellites on 27 June at 0 hrs UT. Only the inner satellites are shown. Note the three inner orbits (shown in white) are for Mimas, Enceladus and Tethys (from inner to outer). The orbits of Iapetus and Phoebe are too large to show on this diagram.

SATURN

Titan and Hyperion

Because of their long orbital periods, compared to the moons shown opposite, it is possible to list all of their greatest eastern elongations for the year (see Table 2). Therefore, all you need to do is work out the number of days that have elapsed since the most recent elongation and read this position directly off the diagram.

Using our previous example 28 July 11 pm EST (28.542 UT), Titan is exactly 12 days past its most recent greatest elongation east (July 16.533 UT), which puts it due north of Saturn or at a superior conjunction. The diagrams opposite and on page 50 show this very well.

Table 3

Converting Time in Australia to Universal Time (UT) *

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

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

Table 2

Time of Greatest Elongation East (UT)

Moon	Titan	Hyperion
Magnitude [1]	8.4	14.4
Max. Elong. [1]	3' 17"	3' 59"
Period (days) [2]	15.945	21.277
	Elongation (d.ddd)	
January	6.088	19.529
	22.121	
February	7.146	9.992
	23.158	
March	11.158	3.450
	27.142	24.875
April	12.100	15.171
	28.042	
May	13.963	6.438
	29.867	27.671
June	14.758	17.783
	30.646	
July	16.533	8.904
		30.046
August	1.429	20.142
	17.342	
September	2.275	10.304
	18.225	
October	4.196	1.517
	20.188	22.717
November	5.196	13.008
	21.217	
December	7.246	4.313
	23.283	25.604

Notes 1. When at opposition
2. Mean Synodic Period

SATURN'S RINGS

Date	Major "	Minor "	U °	B °
Jan 2	34.20	15.28	142.45	26.54
Jan 10	34.29	15.27	143.47	26.44
Jan 18	34.44	15.28	144.48	26.34
Jan 26	34.64	15.31	145.44	26.23
Feb 3	34.89	15.36	146.35	26.13
Feb 11	35.19	15.43	147.20	26.02
Feb 19	35.53	15.53	147.99	25.91
Feb 27	35.91	15.64	148.69	25.81
Mar 7	36.33	15.77	149.31	25.72
Mar 15	36.78	15.92	149.83	25.64
Mar 23	37.25	16.08	150.25	25.58
Mar 31	37.75	16.27	150.56	25.53
Apr 8	38.26	16.47	150.76	25.49
Apr 16	38.77	16.68	150.85	25.48
Apr 24	39.28	16.90	150.82	25.48
May 2	39.76	17.12	150.68	25.50
May 10	40.22	17.34	150.43	25.54
May 18	40.63	17.55	150.08	25.60
May 26	40.99	17.75	149.64	25.67
Jun 3	41.28	17.93	149.13	25.75
Jun 11	41.50	18.09	148.55	25.84
Jun 19	41.64	18.21	147.93	25.93
Jun 27	41.69	18.29	147.29	26.03
Jul 5	41.65	18.34	146.64	26.12
Jul 13	41.53	18.35	146.01	26.22
Jul 21	41.33	18.31	145.42	26.30
Jul 29	41.05	18.24	144.89	26.38
Aug 6	40.70	18.13	144.44	26.45
Aug 14	40.30	17.99	144.07	26.51
Aug 22	39.85	17.82	143.80	26.56
Aug 30	39.37	17.63	143.64	26.59
Sep 7	38.88	17.42	143.59	26.62
Sep 15	38.37	17.20	143.66	26.63
Sep 23	37.86	16.97	143.84	26.63
Oct 1	37.36	16.74	144.13	26.62
Oct 9	36.88	16.51	144.54	26.59
Oct 17	36.43	16.28	145.05	26.55
Oct 25	36.01	16.06	145.65	26.50
Nov 2	35.62	15.85	146.34	26.43
Nov 10	35.27	15.65	147.11	26.34
Nov 18	34.97	15.46	147.95	26.25
Nov 26	34.71	15.29	148.85	26.13
Dec 4	34.50	15.13	149.80	26.01
Dec 12	34.34	14.98	150.78	25.87
Dec 20	34.23	14.85	151.79	25.72
Dec 28	34.17	14.74	152.81	25.55

The Appearance of the Planets diagrams in Part I show how open the rings are for 2018. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every seven years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were last edge-on during 2009. During 2018 they have just started to close up again from fully open.

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

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

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

Table 4: **Iapetus**

Magnitude [1]	11.0
Max Elong. [1]	9' 35"
Period (days) [2]	79.331

Elongation East		Inferior Conjunction		Elongation West		Superior Conjunction	
Feb	13.188	Mar	4.404	Jan	3.317	Jan	24.429
May	4.171	May	22.858	Mar	25.463	Apr	14.850
Jul	21.167	Aug	9.104	Jun	12.183	Jul	2.383
Oct	8.192	Oct	27.779	Aug	29.175	Sep	19.125
Dec	28.375	Dec	-	Nov	17.479	Dec	8.792

Notes 1. When at opposition
2. Mean Synodic Period

Iapetus

This moon's orbit is too large to place on the Apparent Orbits diagram. The shape of its orbit is similar to the others but more inclined and over twice the diameter of Hyperion's. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from stars of similar brightness. Table 4 shows this moon's greatest elongations east, inferior conjunctions (due south of Saturn), greatest elongations west and superior conjunctions (north of Saturn) for the year. Taking the same example date and time as above 28 July 11 pm EST (28.542 UT), the most recent event was an eastern elongation on July 21.167 UT. Iapetus is 7.38 days past this time, heading towards an inferior conjunction, so it's in the south-east quadrant.

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

SATELLITES OF URANUS AND NEPTUNE

This page helps you find the position of Uranus's major satellites and Neptune's moon Triton. Dates and times are in days and fractions of a day in UT. You need to convert your local time to UT first. Table 1 will help.

URANUS

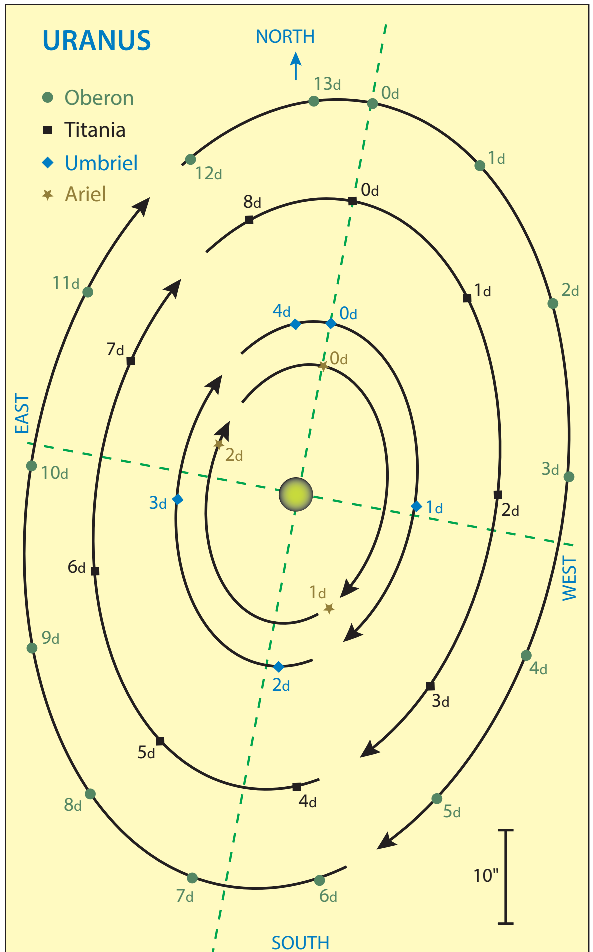
Table 2 presents the times of the first greatest elongation to the *north* for each month for **Ariel**, **Umbriel**, **Titania and Oberon**. This location is the day 0 (zero) point on the Apparent Orbits diagram. As with Saturn's satellites, the procedure is to work out how many orbits have elapsed since the first elongation of the month. Then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of **Umbriel** for 26 October at 1 am WST.

Table 1: **Converting Time in Australia to Universal Time (UT) ***

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

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

1. Convert to UT as a fractional day. 26 October at 1 am (WST) = 25.708 UT
2. Subtract the date of the greatest elongation north for October, i.e. 25.708 – 2.058 = 23.650 days
3. Divide by the period to get the number of orbits, i.e. 23.650 / 4.144 = 5.707
4. Discarding whole orbits leaves 0.707 (nearly three quarters of an orbit)
5. Multiply by the period, 0.707 × 4.144 = 2.930 days (2 days 22.3 hours)
6. Looking at the orbital path for Umbriel (see Apparent Orbits diagram), the satellite is just before the 3-day mark, placing it towards the east.

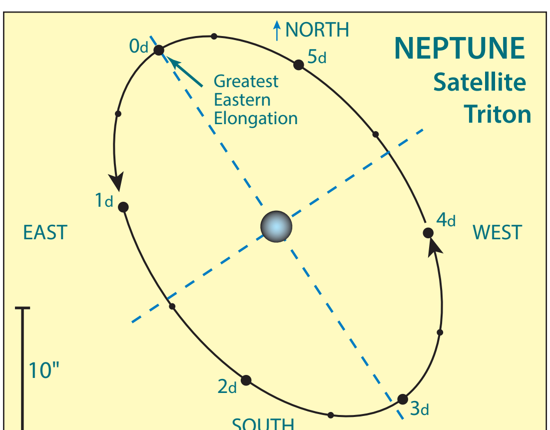


Apparent orbits of Uranus's satellites I–IV as at the date of opposition, 24 October.

NEPTUNE

The procedure for finding Neptune's major satellite **Triton** is identical to above, except the times of the first greatest elongation *east* for each month is listed in Table 2. The orientation of Triton's orbit places this day 0 (zero) point closer to north-east of Neptune (see diagram).

An example. Estimate the position for Triton for September 15 at 10 pm EST. 2.345 orbits have elapsed since its greatest elongation east on Sep 1.717 UT. Discarding the two orbits leaves 0.345. Multiplying by 5.877 (its period) gives 2.027 days. From the diagram the moon is south of Neptune a fraction past the 2 day marker.



Apparent orbit of Triton at date of opposition, 7 September.

Table 2: **Time of Greatest Elongation North or East** (UT)

Planet	Uranus				Neptune
Moon	**Ariel**	**Umbriel**	**Titania**	**Oberon**	**Triton**
Magnitude [1]	13.7	14.5	13.5	13.7	13.5
Max Elong. [1]	0' 14"	0' 20"	0' 33"	0' 44"	0' 17"
Period (days) [2]	2.520	4.144	8.706	13.463	5.877
Month	**Elongation North (d.ddd)**				**East** (d.ddd)
January	1.492	1.563	3.613	13.767	3.829
February	3.258	3.717	7.438	9.692	2.204
March	2.983	4.725	5.550	8.613	3.567
April	2.225	2.733	9.367	4.533	1.933
May	2.467	1.738	5.479	1.450	1.300
June	1.708	3.888	9.292	10.821	5.550
July	1.950	2.892	5.404	7.742	4.933
August	1.192	5.042	9.221	3.663	3.321
September	2.954	3.050	4.338	13.050	1.717
October	3.196	2.058	9.163	9.979	1.117
November	2.442	4.213	4.288	5.913	5.392
December	2.692	3.225	9.117	2.846	4.779

Notes 1. When at opposition 2. Sidereal Period

NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

PLUTO

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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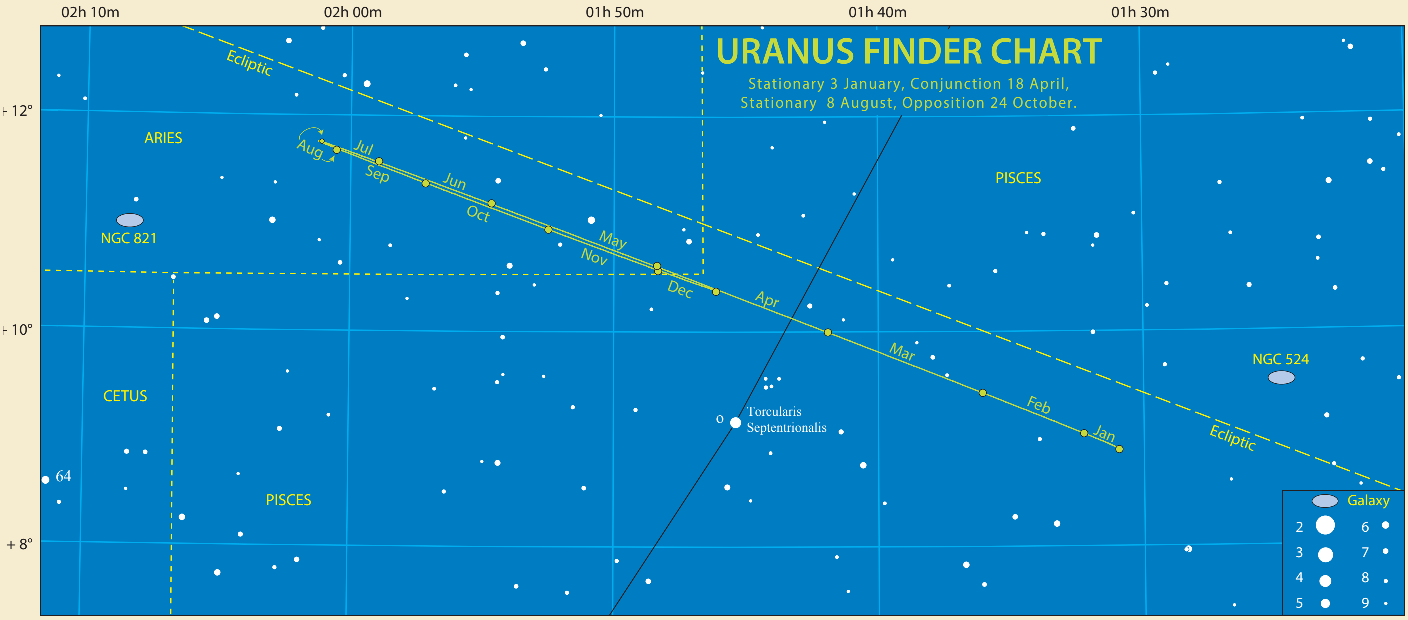
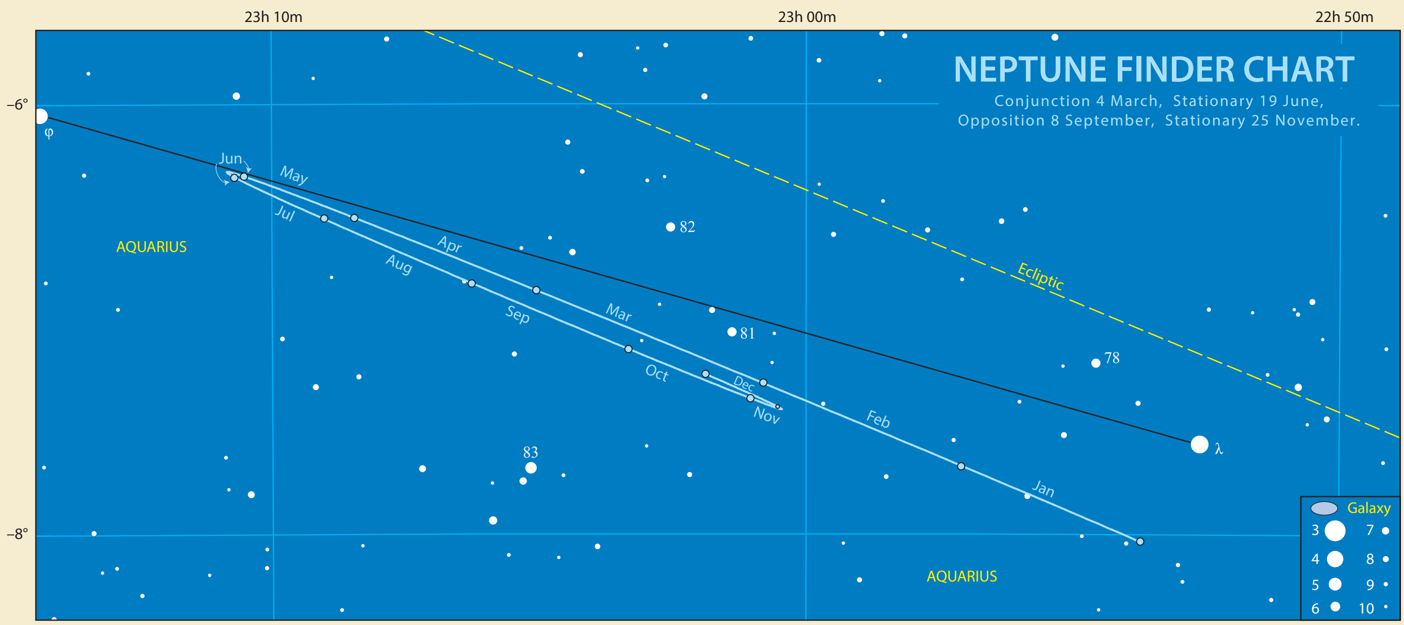
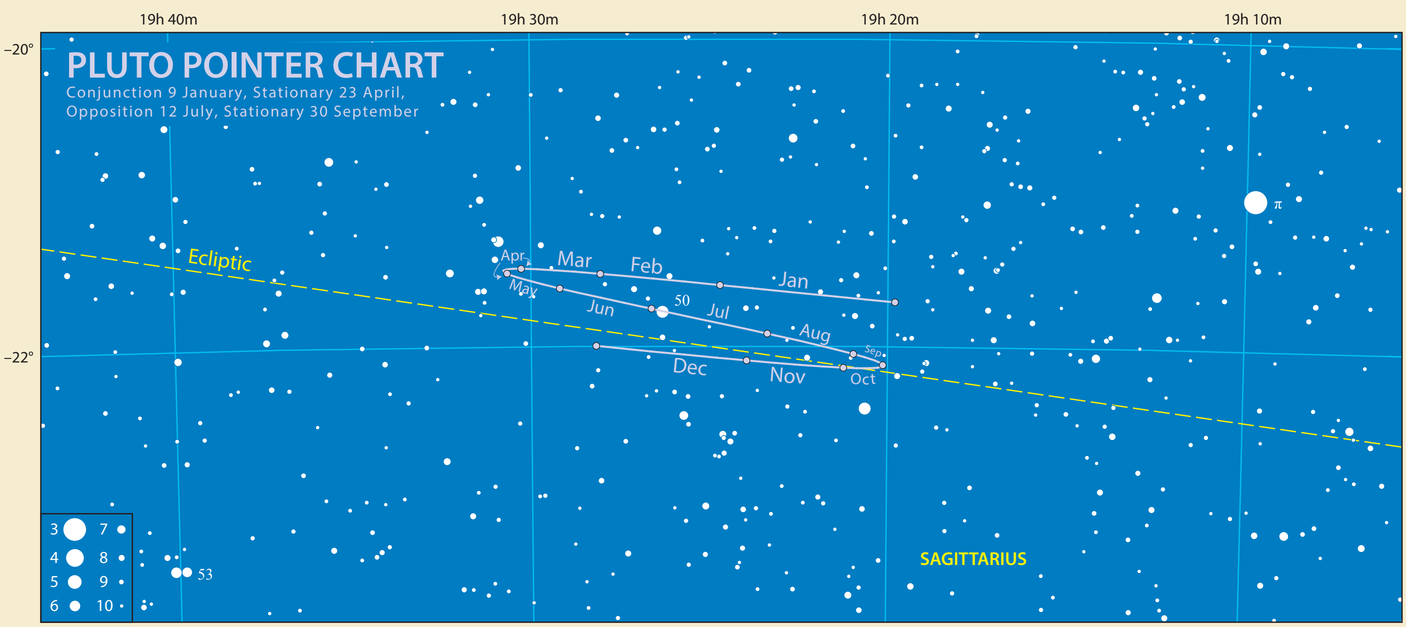
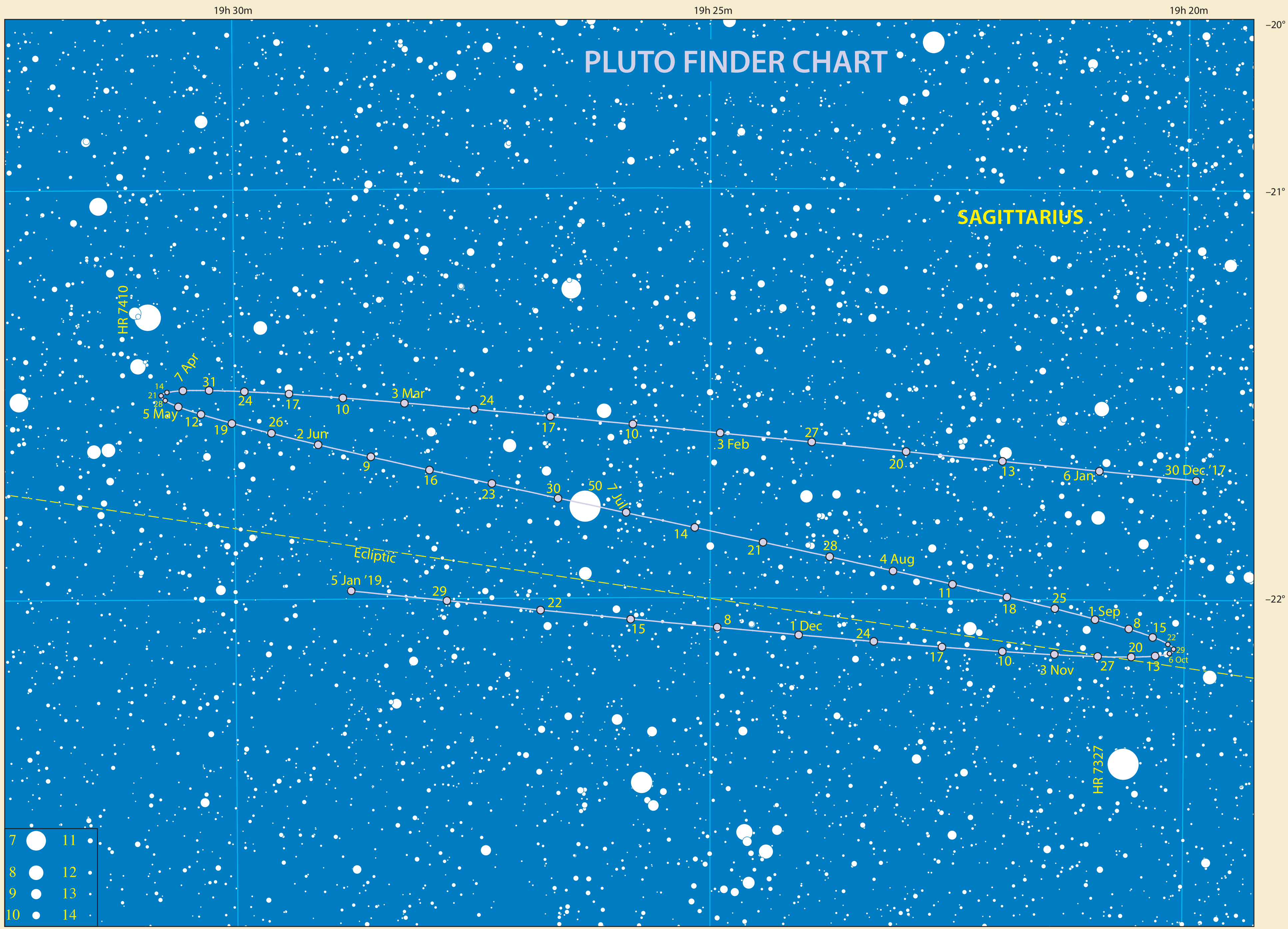
	29	06:07	20:21	05:56	19:37	05:54	20:10	07:24	20:07	05:40	20:40	06:03	20:34	06:15	20:15	05:49	19:59	19 27 38	– 22 00 38


URANUS FINDER CHART
Stationary 3 January, Conjunction 18 April,
Stationary 8 August, Opposition 24 October.
02h 10m
02h 00m
01h 50m
01h 40m
01h 30m
+12°
+10°
+8°
Ecliptic
ARIES
PISCES
CETUS
NGC 821
NGC 524
Torcularis Septentrionalis
o
64
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Galaxy
2 3 4 5 6 7 8 9


NEPTUNE FINDER CHART
Conjunction 4 March, Stationary 19 June,
Opposition 8 September, Stationary 25 November.
23h 10m
23h 00m
22h 50m
−6°
−8°
Ecliptic
AQUARIUS
φ
λ
82
81
78
83
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Galaxy
3 4 5 6 7 8 9 10


PLUTO POINTER CHART
Conjunction 9 January, Stationary 23 April,
Opposition 12 July, Stationary 30 September
19h 40m
19h 30m
19h 20m
19h 10m
−20°
−22°
Ecliptic
SAGITTARIUS
π
50
53
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
3 4 5 6 7 8 9 10


PLUTO FINDER CHART
SAGITTARIUS
19h 30m
19h 25m
19h 20m
−20°
−21°
−22°
HR 7410
HR 7327
Ecliptic
30 Dec '17
6 Jan
13
20
27
3 Feb
10
17
24
3 Mar
10
17
24
31
7 Apr
14
21
28
5 May
12
19
26
2 Jun
9
16
23
30
7 Jul
50
14
21
28
4 Aug
11
18
25
1 Sep
8
15
22
29
6 Oct
13
20
27
3 Nov
10
17
24
1 Dec
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5 Jan '19
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COMETS FOR 2018

WHAT IS A COMET? It is a member of the Solar System, which is normally in a highly elongated orbit around the Sun. The orbits of periodic, or regularly reappearing comets, are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive and containing significant quantities of water (in the form of ice) and dust. A common analogy is a dirty snowball (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, 2P/Encke, which returned in 2017, takes just over three years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of comets that have not been recorded before.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a coma around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionised particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of dust grains that trail behind the comet along 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 21P/Giacobini-Zinner indicates it was the 21st comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. You will also see references to another naming system, best explained with an example. One of the Pan-STARRS comets is referred to as 'C/2016 M1'. 2016 refers to the year of the discovery, M is the 12th half-month period ('I' is not used) during the year and the 1 shows it was the first discovery in this half month. Therefore C/2016 M1 (PANSTARRS) was the first comet discovered in the second half of June 2016.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbit, overall brightness, size of the coma and tail can vary dramatically from comet to comet and even from return to return. To watch one brighten, develop a tail and then fade away over a period of a few weeks can be a fascinating experience.

This section is devoted to the brightest comets that are expected to be observable during 2018, all of them passing through perihelion—closest approach to the Sun—during this year. The table opposite lists the comets along with their orbital elements that are expected to brighten to at least 13th magnitude sometime during 2018. This is the data required to calculate their locations in the sky. The elements are followed by ephemerides (a list of expected positions in the sky and magnitude estimates for different dates). These positions can be plotted on the All Sky Maps to get an idea of where they are in the sky. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could be too close to the Sun or on the opposite side of the Sun from Earth. This would be considered unfavourable.

There are many other comets not listed here that are expected in 2018, but they are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

NOTES ON SELECTED COMETS FOR 2018

Greg Bryant

21P/Giacobini-Zinner: First sighted by French astronomer Michel Giacobini on 20 December 1900, it was recognised as a new short-period comet. The 1907 return was unfavourable for recovery, and similar expectations were held for the next predicted return in 1914. German astronomer Ernst Zinner rediscovered it on 23 October 1913 when he came across the comet whilst observing variables. It was a week before it was realised that Comet Zinner was in fact Comet Giacobini, at perihelion some six months earlier than had been expected from the observations in 1900–01, and thus not where it was expected. The comet was renamed Giacobini-Zinner and presently has a period of 6.6 years.

Since then, the comet has been observed at all returns except for 1920 and 1953. The 1946 return was particularly favourable, with the comet coming to within 0.26 au of Earth and brightening to 6th magnitude. In 2018, Giacobini-Zinner is at perihelion on 10 September, 1.0 au from the Sun, and will pass within 0.4 au of Earth at this return, its closest approach since 1959.

In 1985, the comet was the first to be reached by a spacecraft, preceding Halley, when the International Cometary Explorer probe passed through its plasma tail.

38P/Stephan-Oterma: Jerome Coggia discovered an "uncatalogued nebula" on 22 January 1867 at Marseilles Observatory. The object was observed again the following night by Observatory director Edouard Stephan who noticed that the object had moved. The comet was subsequently announced as Comet Stephan. Several orbits were calculated based on the ten weeks of observing, with periods ranging between 33 and 40 years, but the comet was unsighted at its next predicted return and considered lost.

On 6 November 1942, Finnish astronomer Liisl Oterma discovered a comet. Fred Whipple then found a pre-discovery image of the comet and by mid-November, Whipple realised that the comet's orbit was similar to that of Comet Stephan, thus the comet was renamed Stephan-Oterma.

With a period of 37.7 years, Stephan-Oterma next returned to perihelion in 1980, when it brightened to 9th magnitude. The

2018 return will see it reach perihelion on 11 November, at a distance of 1.59 au from the Sun.

Comet Stephan-Oterma's next visit to the inner Solar System will be in 2056, just five years before the return of Halley.

46P/Wirtanen: Carl Wirtanen (Lick Observatory) discovered this comet on 15 January 1948. The following month saw the recognition that the comet had a short period, orbiting the Sun every 6.7 years. Since then, Comet Wirtanen has been sighted at each subsequent return except for that of 1980. Close approaches to Jupiter in 1972 (0.28 au) and 1984 (0.47 au) have reduced Wirtanen's perihelion distance since discovery from 1.6 au to 1.1 au, and its period down to 5.4 years.

2018 sees Wirtanen reach perihelion on 12 December. Four days later, Wirtanen's approach to within 0.078 au of Earth on 16 December will be the 15th closest approach of a comet to Earth in recorded history. It should reach naked-eye visibility but the coma will be spread out over a wide area, making the comet harder to see.

64P/Swift-Gehrels: American astronomer Lewis Swift discovered this comet on 17 November 1889. Several elliptical orbits were calculated, with periods ranging from 8.5 to 9 years, but the comet could not be sighted at subsequent returns and was considered lost.

On 8 February 1973, Tom Gehrels discovered a comet during the course of a minor planet search at Palomar Observatory. By the end of February, Brian Marsden had calculated an elliptical orbit that was very similar to the lost comet Swift. At present, Swift-Gehrels has a period of 9.3 years and reaches perihelion in 2018 on 3 November. It passes within 0.45 au of Earth during this return, its closest approach since discovery.

P/2013 CU_{129} (PANSTARRS): Discovered on 13 February 2013 during the course of the Pan-STARRS sky survey, which thus far has netted 157 comet discoveries, P/2013 CU_{129} (PANSTARRS) was originally classified as an asteroid. Subsequent observations in June of that year revealed cometary activity. With a period of 4.9 years, the intrinsically faint comet reaches perihelion in 2018 on 24 June, at a distance of 0.8 au from the Sun. The comet can pass close to Earth, coming within 0.25 au in July 2018 and 0.13 au in 2023.

C/2016 M1 (PANSTARRS): This comet was found on 22 June 2016 on images taken with the 1.8-metre Pan-STARRS telescope in Hawaii. Comet C/2016 M1 (PANSTARRS) reaches perihelion at 2.2 au from the Sun on 10 August, 2018.

C/2016 R2 (PANSTARRS): The third Pan-STARRS comet in this preview, it was first noticed on images taken 30 August 2016. Coming to perihelion in 2018 on 9 May at a distance of 2.6 au from the Sun, it has brightened rapidly since discovery.

BIOGRAPHICAL NOTE *Greg Bryant is Sky & Telescope magazine's Southern Hemisphere contributing editor and can be reached at gchbryant@fastmail.fm. He has been following comets since the mid-1980s and enjoys noting each year's new comet discoveries.*

BRIGHT COMETS FOR 2018 — ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
C/2016 R2 (PANSTARRS)	2018 05 09.5938	2.602346	0.996484		33.1935	80.5700	58.2196	4.0	10.0
P/2013 CU_{129} (PANSTARRS)	2018 06 24.3623	0.797942	0.722629	4.9	211.9303	46.2283	12.1554	15.0	10.0
C/2016 M1 (PANSTARRS)	2018 08 10.2120	2.210610	0.998904		209.8272	92.2041	90.9937	5.0	10.0
21P/Giacobini-Zinner	2018 09 10.3224	1.014062	0.710432	6.6	172.7756	195.4139	32.0083	9.0	15.0
38P/Stephan-Oterma	2018 11 10.9914	1.588033	0.859223	37.9	359.6001	78.0076	18.3535	3.5	30.0
64P/Swift-Gehrels	2018 11 03.8993	1.393516	0.687268	9.4	97.1397	300.0032	8.9476	10.0	17.5
46P/Wirtanen	2018 12 12.9892	1.055173	0.658487	5.4	356.3416	82.1696	11.7461	9.0	15.0

COMET ELEMENTS (above)

Perihelion Date The Date of closest approach to the Sun.

q The perihelion distance in au (astronomical units).

e The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to or greater than one indicates: an open orbit (a once only visitor to the Solar System), it has a very long period (thousands of years) or it is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period (time taken for one orbit of the Sun) in years.

ω Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).

Ω Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (Ecliptic) as the comet moves north.

i Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. A value greater than 90° means the comet's orbit direction is retrograde (moves in the opposite direction to the planets).

H1 The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it were 1 au from the Sun and the Earth.

K1 A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' opposite for further details).

Calculation of ephemerides from these elements is complex (but not difficult, with the power of home computers) but beyond the scope of this book.

Comet C/2016 R2 (PANSTARRS)

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
06 Jan	04 18.5	+15 37	2.089	2.910	15:52	21:11	02:33	139.8	10.2
13 Jan	04 11.7	+17 41	2.129	2.878	15:24	20:37	01:53	131.7	10.2
20 Jan	04 06.1	+19 44	2.182	2.848	14:57	20:04	01:14	123.7	10.2
27 Jan	04 02.0	+21 43	2.245	2.819	14:31	19:33	00:35	116.0	10.3
03 Feb	03 59.4	+23 38	2.315	2.792	14:08	19:02	23:55	108.7	10.3
10 Feb	03 58.3	+25 30	2.392	2.766	13:46	18:33	23:21	101.7	10.3
17 Feb	03 58.7	+27 19	2.472	2.742	13:25	18:06	22:47	95.1	10.3
24 Feb	04 00.5	+29 04	2.554	2.720	13:05	17:40	22:14	88.8	10.4
03 Mar	04 03.6	+30 46	2.636	2.699	12:47	17:16	21:44	82.9	10.4
10 Mar	04 07.9	+32 25	2.718	2.681	12:31	16:53	21:14	77.3	10.5
17 Mar	04 13.5	+34 02	2.798	2.664	12:15	16:31	20:45	72.0	10.5
24 Mar	04 20.3	+35 37	2.874	2.649	12:02	16:10	20:17	67.0	10.5
31 Mar	04 28.1	+37 09	2.948	2.636	11:50	15:50	19:51	62.3	10.6
07 Apr	04 37.0	+38 39	3.017	2.625	11:38	15:32	19:25	57.9	10.6
14 Apr	04 46.9	+40 06	3.081	2.617	11:28	15:14	19:00	53.8	10.6
21 Apr	04 57.9	+41 30	3.141	2.610	11:20	14:57	18:35	49.9	10.7
28 Apr	05 09.9	+42 52	3.195	2.605	11:12	14:42	18:11	46.4	10.7
05 May	05 22.8	+44 11	3.245	2.603	11:06	14:27	17:48	43.2	10.7

Comet 38P/Stephan-Oterma

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
01 Sep	04 43.3	+07 17	1.547	1.818	00:17	06:00	11:42	88.0	12.2
08 Sep	04 59.9	+08 18	1.459	1.778	00:09	05:49	11:28	90.4	11.8
15 Sep	05 16.8	+09 21	1.374	1.741	00:01	05:38	11:14	92.8	11.4
22 Sep	05 33.9	+10 26	1.294	1.708	23:50	05:28	11:01	95.2	11.0
29 Sep	05 51.1	+11 36	1.219	1.678	23:43	05:17	10:47	97.6	10.7
06 Oct	06 08.3	+12 51	1.149	1.652	23:36	05:07	10:33	100.2	10.3
13 Oct	06 25.4	+14 12	1.084	1.630	23:30	04:56	10:19	102.9	10.0
20 Oct	06 42.4	+15 41	1.024	1.612	23:23	04:46	10:04	105.9	9.8
27 Oct	06 59.0	+17 20	0.970	1.599	23:17	04:35	09:49	109.0	9.6
03 Nov	07 15.1	+19 10	0.921	1.591	23:11	04:23	09:32	112.5	9.4
10 Nov	07 30.4	+21 12	0.878	1.588	23:05	04:11	09:13	116.3	9.2
17 Nov	07 44.7	+23 27	0.841	1.590	22:59	03:58	08:52	120.4	9.2
24 Nov	07 57.8	+25 55	0.811	1.597	22:53	03:44	08:29	124.9	9.1
01 Dec	08 09.3	+28 35	0.788	1.608	22:46	03:28	08:04	129.6	9.2
08 Dec	08 19.0	+31 23	0.773	1.624	22:39	03:10	07:36	134.6	9.3
15 Dec	08 26.5	+34 14	0.766	1.645	22:31	02:50	07:04	139.7	9.4
22 Dec	08 31.9	+37 04	0.768	1.670	22:22	02:27	06:29	144.6	9.6
29 Dec	08 35.0	+39 43	0.779	1.699	22:11	02:03	05:51	149.0	9.9

Comet 64P/Swift-Gehrels

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
01 Sep	00 17.6	+20 27	0.663	1.587	20:27	01:35	06:38	142.4	12.6
08 Sep	00 21.1	+23 10	0.610	1.550	20:11	01:11	06:06	145.5	12.3
15 Sep	00 23.9	+25 51	0.566	1.516	19:56	00:46	05:32	148.1	11.9
22 Sep	00 26.1	+28 25	0.528	1.485	19:40	00:20	04:57	150.1	11.6
29 Sep	00 28.0	+30 48	0.498	1.459	19:23	23:51	04:22	151.3	11.4
06 Oct	00 30.0	+32 53	0.475	1.436	19:06	23:26	03:49	151.8	11.1
13 Oct	00 32.7	+34 34	0.459	1.418	18:48	23:01	03:17	151.6	11.0
20 Oct	00 36.6	+35 48	0.449	1.405	18:30	22:38	02:47	150.9	10.8
27 Oct	00 42.4	+36 35	0.445	1.397	18:12	22:16	02:22	149.8	10.8
03 Nov	00 50.3	+36 53	0.447	1.394	17:54	21:56	02:01	148.6	10.8
10 Nov	01 00.4	+36 45	0.456	1.396	17:36	21:38	01:44	147.2	10.8
17 Nov	01 12.7	+36 16	0.471	1.403	17:18	21:23	01:32	145.6	10.9
24 Nov	01 26.8	+35 30	0.492	1.414	17:01	21:10	01:22	143.8	11.1
01 Dec	01 42.3	+34 32	0.520	1.431	16:45	20:58	01:14	141.8	11.3
08 Dec	01 58.7	+33 28	0.555	1.453	16:29	20:47	01:07	139.5	11.6
15 Dec	02 15.7	+32 22	0.598	1.478	16:14	20:36	01:01	136.8	11.9
22 Dec	02 32.9	+31 17	0.648	1.508	15:59	20:26	00:55	133.9	12.2
29 Dec	02 50.0	+30 17	0.706	1.541	15:45	20:15	00:49	130.8	12.5

Comet 46P/Wirtanen

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
04 Aug	01 00.0	–14 13	1.173	1.908	21:22	04:07	10:47	121.3	13.6
11 Aug	01 08.7	–14 54	1.066	1.848	21:01	03:48	10:30	125.4	13.1
18 Aug	01 17.0	–15 47	0.964	1.788	20:39	03:29	10:14	129.6	12.7
25 Aug	01 24.7	–16 54	0.869	1.728	20:16	03:09	09:58	133.5	12.3
01 Sep	01 31.9	–18 15	0.781	1.668	19:52	02:49	09:42	137.1	11.8
08 Sep	01 38.4	–19 50	0.700	1.609	19:26	02:27	09:25	140.2	11.3
15 Sep	01 44.0	–21 37	0.625	1.550	18:58	02:05	09:09	142.6	10.8
22 Sep	01 48.7	–23 35	0.557	1.491	18:29	01:43	08:53	144.1	10.3
29 Sep	01 52.5	–25 40	0.496	1.434	17:58	01:19	08:36	144.3	9.8
06 Oct	01 55.1	–27 45	0.441	1.379	17:26	00:54	08:18	143.3	9.3
13 Oct	01 56.7	–29 43	0.391	1.325	16:52	00:28	08:00	141.2	8.8
20 Oct	01 57.7	–31 24	0.345	1.274	16:19	00:01	07:41	138.2	8.3
27 Oct	01 58.4	–32 36	0.303	1.227	15:47	23:32	07:19	134.8	7.7
03 Nov	01 59.4	–33 09	0.264	1.183	15:18	23:05	06:54	131.4	7.2
10 Nov	02 01.7	–32 44	0.226	1.145	14:55	22:40	06:27	128.4	6.6
17 Nov	02 06.6	–30 59	0.189	1.112	14:39	22:17	05:57	126.5	6.1
24 Nov	02 15.8	–27 10	0.154	1.086	14:35	21:59	05:25	126.5	5.5
01 Dec	02 31.9	–19 54	0.121	1.068	14:49	21:48	04:48	129.8	4.8
08 Dec	02 59.2	–06 21	0.093	1.057	15:28	21:47	04:09	139.0	4.2
15 Dec	03 44.7	+16 10	0.078	1.056	16:47	22:05	03:25	154.7	3.8
22 Dec	04 55.8	+40 37	0.084	1.062	19:05	22:49	02:35	158.3	4.0
29 Dec	06 24.7	+54 37	0.108	1.077	22:20	23:50	01:22	148.6	4.7

Hale-Bopp on 8 April 1997 from the VLA, New Mexico. Six minutes on Kodak Royal 1000, 135 mm ƒ/2.8 lens.

Comet 21P/Giacobini-Zinner

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
02 Jun	20 31.0	+33 48	1.146	1.673	23:27	03:47	08:02	101.4	12.6
09 Jun	20 42.9	+37 36	1.067	1.608	23:28	03:31	07:29	101.1	12.2
16 Jun	20 55.6	+41 32	0.993	1.544	23:34	03:16	06:53	100.4	11.8
23 Jun	21 09.7	+45 31	0.924	1.481	23:47	03:02	06:13	99.4	11.4
30 Jun	21 25.9	+49 33	0.859	1.418	00:13	02:51	05:28	97.9	10.9
07 Jul	21 45.4	+53 33	0.797	1.357	00:55	02:43	04:29	96.2	10.5
Too far North									
01 Sep	04 59.7	+48 30	0.407	1.023	03:29	06:16	09:04	80.4	7.2
08 Sep	05 38.2	+37 21	0.392	1.015	02:27	06:27	10:27	79.8	7.1
15 Sep	06 07.0	+25 15	0.394	1.016	01:40	06:28	11:17	80.3	7.1
22 Sep	06 29.1	+13 27	0.411	1.028	00:57	06:22	11:48	81.6	7.2
29 Sep	06 46.5	+02 52	0.442	1.049	00:18	06:12	12:06	83.6	7.5
06 Oct	07 00.1	–06 10	0.481	1.078	23:36	05:59	12:16	85.9	7.9
13 Oct	07 10.5	–13 41	0.527	1.116	22:58	05:41	12:20	88.4	8.3
20 Oct	07 18.0	–19 54	0.575	1.159	22:18	05:21	12:19	91.1	8.8
27 Oct	07 22.6	–25 03	0.624	1.208	21:39	04:58	12:13	93.8	9.2
03 Nov	07 24.5	–29 17	0.672	1.262	20:57	04:32	12:03	96.7	9.6
10 Nov	07 23.6	–32 45	0.719	1.318	20:15	04:04	11:49	99.7	10.1
17 Nov	07 20.0	–35 29	0.766	1.378	19:32	03:33	11:30	102.7	10.5
24 Nov	07 14.0	–37 32	0.812	1.439	18:48	02:59	11:06	105.8	10.9
01 Dec	07 05.9	–38 54	0.858	1.502	18:05	02:24	10:38	108.9	11.3
08 Dec	06 56.4	–39 36	0.905	1.566	17:25	01:47	10:05	111.8	11.7
15 Dec	06 46.1	–39 37	0.953	1.630	16:46	01:09	09:27	114.6	12.1
22 Dec	06 35.9	–39 01	1.005	1.695	16:12	00:31	08:46	117.0	12.4

COMET EPHEMERIDES

Date at 0 hr UT (10 am EST, 9:30 am CST and 8 am WST).

RA, Dec Right Ascension and Declination are for equinox 2000.0

Δ (delta) Geocentric distance (distance from the Earth) in au.

R Heliocentric distance (distance from the Sun) in au.

Rise, Transit, Set Times given are approximate and will vary between locations. Where no rise or set time is given, the comet is circumpolar.

Elg Elongation; angular distance of the comet from the Sun.

Mag This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is usually based on the behaviour of its brightness during previous return(s).

The estimate of total magnitude is normally calculated using:

$$\text{Mag} = \text{H1} + 5 \log(\Delta) + \text{K1} \log R$$

See the table of elements opposite 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 K1 value of approximately 7.5. Comets have also been known to suddenly flare up or fade away and some have even shown a different behaviour in their light curve (changed values for H1 and K1) after perihelion compared to before. There are also constants of H2 and K2 used by astronomers which refer to the absolute magnitude and the K constant for the nucleus of the comet. These are not used in this publication.

Comet P/2013 CU_{129} (PANSTARRS)

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
09 Jun	08 57.3	+15 17	0.464	0.836	10:23	15:43	21:03	54.5	12.6
16 Jun	08 54.0	+10 07	0.404	0.810	09:38	15:13	20:47	48.9	12.1
23 Jun	08 43.5	+03 49	0.346	0.798	08:42	14:34	20:26	42.9	11.7
30 Jun	08 22.7	–03 48	0.296	0.803	07:34	13:46	19:58	37.7	11.4
07 Jul	07 48.7	–12 31	0.259	0.824	06:08	12:45	19:21	36.9	11.2
14 Jul	07 01.3	–21 12	0.239	0.859	04:27	11:30	18:32	43.6	11.2
21 Jul	06 04.7	–28 11	0.236	0.906	02:39	10:05	17:32	56.2	11.4
28 Jul	05 06.6	–32 33	0.246	0.962	00:56	08:40	16:24	70.6	11.8

Comet C/2016 M1 (PANSTARRS)

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Elg °	Mag
03 Mar	19 15.1	+00 56	3.303	2.855	02:29	08:28	14:27	55.2	12.2
10 Mar	19 20.7	+00 10	3.171	2.808	02:05	08:06	14:07	59.9	12.0
17 Mar	19 25.8	–00 39	3.032	2.762	01:41	07:44	13:48	65.0	11.8
24 Mar	19 30.5	–01 33	2.887	2.717	01:16	07:21	13:27	70.2	11.6
31 Mar	19 34.5	–02 33	2.737	2.673	00:49	06:58	13:06	75.8	11.5
07 Apr	19 37.9	–03 42	2.583	2.630	00:22	06:34	12:45	81.6	11.3
14 Apr	19 40.4	–05 01	2.427	2.589	23:50	06:08	12:23	87.7	11.1
21 Apr	19 42.0	–06 35	2.270	2.549	23:19	05:43	12:02	94.2	10.8
28 Apr	19 42.3	–08 28	2.114	2.511	22:47	05:16	11:40	101.2	10.6
05 May	19 41.1	–10 43	1.961	2.475	22:12	04:47	11:18	108.6	10.4
12 May	19 38.2	–13 25	1.815	2.441	21:34	04:16	10:55	116.6	10.2
19 May	19 33.1	–16 41	1.678	2.408	20:52	03:44	10:32	125.3	9.9
26 May	19 25.2	–20 33	1.555	2.378	20:04	03:09	10:08	134.6	9.7
02 Jun	19 13.9	–25 04	1.450	2.350	19:11	02:30	09:45	144.4	9.5
09 Jun	18 58.6	–30 09	1.368	2.324	18:09	01:47	09:21	154.1	9.3
16 Jun	18 38.6	–35 33	1.313	2.300	16:58	01:00	08:57	161.8	9.2
23 Jun	18 13.5	–40 55	1.290	2.280	15:38	00:07	08:32	162.4	9.1
30 Jun	17 43.8	–45 46	1.298	2.261	14:07	23:07	08:08	155.2	9.1
07 Jul	17 10.9	–49 43	1.335	2.246	12:30	22:06	07:45	145.1	9.1
14 Jul	16 37.3	–52 37	1.398	2.233	10:50	21:06	07:24	134.6	9.2
21 Jul	16 05.8	–54 32	1.482	2.223	09:08	20:06	07:08	124.7	9.3
28 Jul	15 38.4	–55 44	1.580	2.216		19:11		115.6	9.4
04 Aug	15 15.9	–56 28	1.687	2.212		18:21		107.2	9.6
11 Aug	14 58.4	–56 57	1.801	2.211		17:36		99.7	9.7
18 Aug	14 45.3	–57 21	1.917	2.212		16:55		92.9	9.9
25 Aug	14 36.0	–57 46	2.032	2.217		16:18		86.7	10.0
01 Sep	14 29.8	–58 16	2.144	2.225		15:45		81.1	10.1
08 Sep	14 26.1	–58 53	2.253	2.236		15:14		76.1	10.3
15 Sep	14 24.5	–59 38	2.355	2.249		14:45		71.5	10.4
22 Sep	14 24.7	–60 31	2.451	2.265		14:17		67.5	10.5
29 Sep	14 26.4	–61 32	2.540	2.284		13:52		63.9	10.6
06 Oct	14 29.5	–62 42	2.621	2.305		13:27		60.8	10.7
13 Oct	14 33.7	–64 00	2.693	2.329		13:04		58.3	10.8
20 Oct	14 39.1	–65 27	2.757	2.356		12:42		56.3	10.9
27 Oct	14 45.6	–67 03	2.813	2.384		12:20		54.9	11.0
03 Nov	14 53.3	–68 47	2.861	2.415		12:01		54.0	11.1
10 Nov	15 02.4	–70 39	2.901	2.448		11:43		53.7	11.2
17 Nov	15 13.3	–72 39	2.934	2.483		11:26		53.8	11.3
24 Nov	15 26.4	–74 48	2.961	2.520		11:12		54.5	11.4
01 Dec	15 43.1	–77 03	2.982	2.558		11:01		55.6	11.5
08 Dec	16 05.6	–79 25	2.999	2.598		10:57		57.1	11.5
15 Dec	16 39.2	–81 50	3.012	2.640		11:03		58.8	11.6
22 Dec	17 37.7	–84 09	3.022	2.682		11:36		60.7	11.7
29 Dec	19 35.5	–85 54	3.032	2.727		13:06		62.8	11.8

BRIGHT DWARF AND MINOR PLANET POSITIONS (0 HR UT, EPOCH 2000.0)

As well as the planets, their moons and the comets, the Solar System contains numerous smaller bodies known as minor planets or asteroids. There are now hundreds of thousands of such bodies catalogued. Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe. Many can be found by imaging the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which *star* has moved. Be sure you have the right field of view. Only about sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

Included are ephemerides for the 14 brightest minor or dwarf planets reaching opposition in 2018, plus 2 Pallas (opposition 28 Oct 2017). Pallas reaches magnitude 8.7 with the rest with a maximum of 9.9 or brighter. As only the 15 bright ones are considered here, 1 Ceres is the only dwarf planet that makes the grade.

A total of 28 reach magnitude 10.2 or greater, and have selected conjunctions included in the diary in Part I. The period considered for the conjunctions was three months either side of opposition (providing it's brighter than 11.0 magnitude throughout) and Ceres, Pallas and Vesta for the whole year except solar conjunction (within 18° of the Sun).

1 Ceres

Date		RA (hh mm)	Dec (° ′)	Mag
Jan	6	09 31.2	+26 45	7.3
	13	09 27.4	+27 43	7.1
	20	09 22.3	+28 41	7.0
	27	09 16.3	+29 36	6.9
Feb	3	09 09.8	+30 26	6.9
	10	09 03.1	+31 07	7.0
	17	08 56.7	+31 37	7.1
	24	08 51.1	+31 57	7.2
Mar	3	08 46.7	+32 05	7.4
	10	08 43.6	+32 04	7.5
	17	08 42.0	+31 53	7.7
	24	08 41.9	+31 35	7.8
	31	08 43.3	+31 09	7.9
Apr	7	08 46.0	+30 38	8.0
	14	08 50.0	+30 02	8.2
	21	08 55.2	+29 22	8.3
	28	09 01.3	+28 38	8.3
May	5	09 08.3	+27 50	8.4
	12	09 16.0	+26 59	8.5
	19	09 24.4	+26 04	8.6
	26	09 33.3	+25 07	8.6
Jun	2	09 42.6	+24 06	8.7
	9	09 52.3	+23 03	8.7
	16	10 02.3	+21 58	8.7
	23	10 12.6	+20 50	8.8

2 Pallas

Date		RA (hh mm)	Dec (° ′)	Mag
Jan	6	02 35.4	-25 07	8.7
	13	02 38.5	-23 55	8.8
	20	02 42.8	-22 37	8.8
	27	02 48.3	-21 14	8.9
Feb	3	02 54.9	-19 48	8.9
	10	03 02.4	-18 19	9.0
	17	03 10.8	-16 50	9.0
	24	03 20.0	-15 20	9.0
Mar	3	03 29.9	-13 50	9.0
	10	03 40.5	-12 22	9.0
	17	03 51.8	-10 55	9.1
	24	04 03.6	-09 31	9.1
	31	04 16.0	-08 10	9.1
Apr	7	04 28.8	-06 53	9.1
	14	04 42.1	-05 39	9.1
	21	04 55.7	-04 30	9.1
	28	05 09.8	-03 26	9.1
May	5	05 24.1	-02 28	9.1
	12	05 38.8	-01 34	9.0
	19	05 53.6	-00 47	9.0
	26	06 08.7	-00 06	9.0
Jun	2	06 24.0	+00 29	9.0
	9	06 39.3	+00 58	9.0
	16	06 54.8	+01 21	9.0
	23	07 10.3	+01 38	8.9

3 Juno

Date		RA (hh mm)	Dec (° ′)	Mag
Jul	14	02 17.6	+09 28	9.6
	21	02 29.9	+09 48	9.5
	28	02 42.0	+10 01	9.4
Aug	4	02 53.7	+10 06	9.3
	11	03 05.0	+10 03	9.2
	18	03 15.9	+09 51	9.1
	25	03 26.0	+09 30	9.0
Sep	1	03 35.4	+09 00	8.9
	8	03 43.9	+08 20	8.7
	15	03 51.4	+07 31	8.6
	22	03 57.6	+06 32	8.4
	29	04 02.5	+05 25	8.3
Oct	6	04 05.8	+04 11	8.1
	13	04 07.5	+02 51	8.0
	20	04 07.6	+01 27	7.8
	27	04 06.1	+00 05	7.7
Nov	3	04 03.1	-01 14	7.6
	10	03 58.9	-02 23	7.5
	17	03 53.9	-03 20	7.4
	24	03 48.6	-04 01	7.5
Dec	1	03 43.5	-04 22	7.6
	8	03 39.1	-04 25	7.7
	15	03 35.7	-04 10	7.8
	22	03 33.8	-03 38	8.0
	29	03 33.3	-02 52	8.1

4 Vesta

Date		RA (hh mm)	Dec (° ′)	Mag
Mar	24	17 48.5	-17 30	7.2
	31	17 56.7	-17 30	7.0
Apr	7	18 03.9	-17 30	6.9
	14	18 09.9	-17 30	6.8
	21	18 14.5	-17 30	6.7
	28	18 17.7	-17 33	6.5
May	5	18 19.3	-17 38	6.4
	12	18 19.3	-17 47	6.2
	19	18 17.5	-18 00	6.1
	26	18 14.2	-18 18	5.9
Jun	2	18 09.4	-18 39	5.7
	9	18 03.3	-19 04	5.6
	16	17 56.5	-19 31	5.4
	23	17 49.3	-20 01	5.4
	30	17 42.3	-20 31	5.6
Jul	7	17 36.1	-21 02	5.7
	14	17 30.9	-21 32	5.9
	21	17 27.2	-22 01	6.1
	28	17 25.2	-22 30	6.2
Aug	4	17 24.8	-22 58	6.4
	11	17 26.2	-23 25	6.5
	18	17 29.1	-23 51	6.7
	25	17 33.6	-24 15	6.8
Sep	1	17 39.5	-24 37	7.0
	8	17 46.6	-24 57	7.1

6 Hebe

Date		RA (hh mm)	Dec (° ′)	Mag
Jul	14	04 01.7	+08 49	10.1
	21	04 16.9	+09 08	10.1
	28	04 31.8	+09 21	10.0
Aug	4	04 46.4	+09 28	10.0
	11	05 00.6	+09 28	10.0
	18	05 14.3	+09 23	10.0
	25	05 27.6	+09 12	9.9
Sep	1	05 40.2	+08 55	9.9
	8	05 52.2	+08 34	9.8
	15	06 03.4	+08 09	9.8
	22	06 13.8	+07 39	9.7
	29	06 23.3	+07 08	9.7
Oct	6	06 31.7	+06 34	9.6
	13	06 38.9	+05 59	9.5
	20	06 44.9	+05 24	9.4
	27	06 49.4	+04 51	9.3
Nov	3	06 52.5	+04 22	9.2
	10	06 53.9	+03 56	9.1
	17	06 53.6	+03 38	9.0
	24	06 51.6	+03 28	8.9
Dec	1	06 48.0	+03 28	8.7
	8	06 42.8	+03 40	8.6
	15	06 36.5	+04 05	8.5
	22	06 29.5	+04 42	8.5
	29	06 22.1	+05 30	8.5

8 Flora

Date		RA (hh mm)	Dec (° ′)	Mag
Jan	6	06 48.0	+21 26	8.3
	13	06 40.3	+22 05	8.6
	20	06 33.6	+22 40	8.8
	27	06 28.4	+23 12	9.0
Feb	3	06 25.0	+23 39	9.2
	10	06 23.5	+24 03	9.4
	17	06 24.0	+24 23	9.6
	24	06 26.3	+24 39	9.8
Mar	3	06 30.2	+24 51	10.0
	10	06 35.6	+25 00	10.2
	17	06 42.4	+25 06	10.3
	24	06 50.2	+25 07	10.4
	31	06 59.1	+25 05	10.6
Apr	7	07 08.7	+24 58	10.7
	14	07 19.0	+24 47	10.8
	21	07 29.9	+24 31	10.9
	28	07 41.2	+24 11	11.0
May	5	07 53.0	+23 47	11.1
	12	08 04.9	+23 18	11.1
	19	08 17.2	+22 45	11.2
	26	08 29.6	+22 08	11.3
Jun	2	08 42.0	+21 26	11.3
	9	08 54.6	+20 41	11.4
	16	09 07.2	+19 52	11.4
	23	09 19.8	+18 59	11.4

9 Metis

Date		RA (hh mm)	Dec (° ′)	Mag
Mar	24	17 57.3	-23 18	11.4
	31	18 02.7	-23 27	11.3
Apr	7	18 07.1	-23 37	11.2
	14	18 10.3	-23 47	11.1
	21	18 12.3	-23 59	10.9
	28	18 12.9	-24 12	10.8
May	5	18 12.0	-24 26	10.7
	12	18 09.8	-24 41	10.5
	19	18 06.1	-24 57	10.4
	26	18 01.0	-25 13	10.2
Jun	2	17 54.8	-25 28	10.0
	9	17 47.8	-25 42	9.9
	16	17 40.2	-25 53	9.7
	23	17 32.6	-26 02	9.8
	30	17 25.3	-26 08	10.0
Jul	7	17 18.7	-26 12	10.2
	14	17 13.1	-26 14	10.3
	21	17 08.9	-26 15	10.5
	28	17 06.0	-26 17	10.6
Aug	4	17 04.7	-26 18	10.7
	11	17 04.8	-26 21	10.9
	18	17 06.3	-26 24	11.0
	25	17 09.1	-26 28	11.1
Sep	1	17 13.2	-26 33	11.2
	8	17 18.4	-26 39	11.3

15 Eunomia

Date		RA (hh mm)	Dec (° ′)	Mag
Feb	17	15 08.2	-30 36	10.9
	24	15 11.5	-31 13	10.8
Mar	3	15 13.8	-31 46	10.7
	10	15 15.0	-32 17	10.6
	17	15 14.9	-32 42	10.5
	24	15 13.6	-33 03	10.4
	31	15 11.0	-33 17	10.3
Apr	7	15 07.2	-33 24	10.2
	14	15 02.3	-33 23	10.1
	21	14 56.5	-33 12	10.0
	28	14 50.0	-32 53	9.9
May	5	14 43.2	-32 25	9.8
	12	14 36.5	-31 48	9.8
	19	14 30.1	-31 06	9.8
	26	14 24.3	-30 19	9.9
Jun	2	14 19.5	-29 30	10.0
	9	14 15.8	-28 41	10.1
	16	14 13.3	-27 55	10.2
	23	14 11.9	-27 12	10.3
	30	14 11.8	-26 34	10.4
Jul	7	14 12.9	-26 02	10.5
	14	14 15.0	-25 36	10.6
	21	14 18.2	-25 16	10.7
	28	14 22.3	-25 01	10.8
Aug	4	14 27.2	-24 52	10.9

27 Euterpe

Date		RA (hh mm)	Dec (° ′)	Mag
Jun	16	23 12.4	-06 36	11.8
	23	23 17.4	-06 11	11.7
	30	23 21.4	-05 52	11.6
Jul	7	23 24.5	-05 39	11.5
	14	23 26.5	-05 33	11.3
	21	23 27.3	-05 36	11.1
	28	23 26.8	-05 46	11.0
Aug	4	23 25.1	-06 05	10.8
	11	23 22.0	-06 32	10.6
	18	23 17.8	-07 05	10.4
	25	23 12.4	-07 45	10.2
Sep	1	23 06.3	-08 28	10.0
	8	22 59.7	-09 11	9.8
	15	22 53.0	-09 53	10.0
	22	22 46.8	-10 31	10.2
	29	22 41.3	-11 02	10.3
Oct	6	22 36.8	-11 24	10.5
	13	22 33.8	-11 38	10.6
	20	22 32.1	-11 42	10.8
	27	22 32.0	-11 38	10.9
Nov	3	22 33.3	-11 24	11.0
	10	22 36.1	-11 02	11.1
	17	22 40.1	-10 33	11.2
	24	22 45.3	-09 56	11.3
Dec	1	22 51.5	-09 13	11.4

29 Amphitrite

Date		RA (hh mm)	Dec (° ′)	Mag
Mar	24	17 49.9	-29 47	11.0
	31	17 55.5	-30 07	10.9
Apr	7	17 59.9	-30 27	10.8
	14	18 03.1	-30 47	10.7
	21	18 05.1	-31 08	10.5
	28	18 05.6	-31 29	10.4
May	5	18 04.6	-31 50	10.3
	12	18 02.1	-32 10	10.1
	19	17 58.2	-32 28	10.0
	26	17 53.0	-32 43	9.9
Jun	2	17 46.6	-32 54	9.7
	9	17 39.4	-32 59	9.6
	16	17 31.8	-32 58	9.5
	23	17 24.3	-32 51	9.6
	30	17 17.2	-32 39	9.7
Jul	7	17 11.0	-32 21	9.8
	14	17 05.9	-32 01	10.0
	21	17 02.1	-31 39	10.1
	28	16 59.9	-31 17	10.2
Aug	4	16 59.1	-30 56	10.4
	11	16 59.8	-30 37	10.5
	18	17 01.9	-30 19	10.6
	25	17 05.3	-30 03	10.7
Sep	1	17 09.9	-29 49	10.8
	8	17 15.6	-29 37	10.9

30 Urania

Date		RA (hh mm)	Dec (° ′)	Mag
Jun	30	23 45.7	-00 28	11.7
Jul	7	23 51.6	+00 19	11.6
	14	23 56.5	+01 01	11.5
	21	00 00.4	+01 37	11.3
	28	00 03.0	+02 06	11.2
Aug	4	00 04.3	+02 26	11.0
	11	00 04.2	+02 38	10.8
	18	00 02.6	+02 41	10.6
	25	23 59.6	+02 35	10.4
Sep	1	23 55.3	+02 19	10.2
	8	23 49.9	+01 55	10.0
	15	23 43.8	+01 25	9.7
	22	23 37.3	+00 51	9.7
	29	23 31.2	+00 16	9.9
Oct	6	23 25.6	-00 17	10.1
	13	23 21.2	-00 45	10.3
	20	23 18.2	-01 07	10.5
	27	23 16.7	-01 20	10.6
Nov	3	23 16.8	-01 23	10.8
	10	23 18.5	-01 18	11.0
	17	23 21.7	-01 03	11.1
	24	23 26.3	-00 40	11.2
Dec	1	23 32.1	-00 09	11.4
	8	23 39.0	+00 30	11.5
	15	23 47.0	+01 15	11.6

40 Harmonia

Date		RA (hh mm)	Dec (° ′)	Mag
Jul	14	03 30.7	+15 41	11.8
	21	03 43.3	+16 23	11.8
	28	03 55.6	+17 01	11.8
Aug	4	04 07.7	+17 34	11.7
	11	04 19.3	+18 03	11.7
	18	04 30.5	+18 28	11.6
	25	04 41.2	+18 48	11.5
Sep	1	04 51.2	+19 05	11.5
	8	05 00.5	+19 19	11.4
	15	05 09.0	+19 29	11.3
	22	05 16.5	+19 37	11.2
	29	05 22.8	+19 43	11.1
Oct	6	05 27.9	+19 48	11.0
	13	05 31.6	+19 52	10.8
	20	05 33.7	+19 55	10.7
	27	05 34.1	+19 58	10.5
Nov	3	05 32.7	+20 02	10.4
	10	05 29.5	+20 06	10.2
	17	05 24.6	+20 11	10.0
	24	05 18.3	+20 15	9.8
Dec	1	05 10.9	+20 20	9.6
	8	05 02.8	+20 25	9.4
	15	04 54.7	+20 30	9.6
	22	04 47.2	+20 35	9.8
	29	04 40.7	+20 41	10.0

51 Nemausa

Date		RA (hh mm)	Dec (° ′)	Mag
Jan	6	10 47.5	-01 07	11.2
	13	10 48.6	-01 09	11.1
	20	10 48.2	-00 59	10.9
	27	10 46.5	-00 35	10.7
Feb	3	10 43.3	+00 02	10.5
	10	10 39.0	+00 53	10.3
	17	10 33.7	+01 55	10.1
	24	10 27.9	+03 05	9.9
Mar	3	10 22.1	+04 21	9.9
	10	10 16.6	+05 38	10.1
	17	10 11.8	+06 51	10.3
	24	10 08.3	+07 59	10.5
	31	10 06.0	+08 57	10.7
Apr	7	10 05.3	+09 45	10.9
	14	10 06.1	+10 22	11.0
	21	10 08.3	+10 48	11.2
	28	10 11.9	+11 04	11.3
May	5	10 16.7	+11 09	11.5
	12	10 22.6	+11 04	11.6
	19	10 29.4	+10 51	11.7
	26	10 37.2	+10 30	11.8
Jun	2	10 45.6	+10 02	11.9
	9	10 54.7	+09 27	12.0
	16	11 04.3	+08 47	12.1
	23	11 14.4	+08 01	12.1

88 Thisbe

Date		RA (hh mm)	Dec (° ′)	Mag
Apr	28	19 59.4	-20 58	11.6
May	5	20 05.8	-20 27	11.5
	12	20 11.2	-19 56	11.4
	19	20 15.3	-19 28	11.2
	26	20 18.2	-19 01	11.1
Jun	2	20 19.8	-18 38	10.9
	9	20 19.9	-18 18	10.8
	16	20 18.6	-18 01	10.6
	23	20 15.8	-17 48	10.4
	30	20 11.8	-17 39	10.2
Jul	7	20 06.7	-17 33	10.0
	14	20 00.8	-17 29	9.8
	21	19 54.5	-17 27	9.7
	28	19 48.2	-17 26	9.9
Aug	4	19 42.5	-17 25	10.1
	11	19 37.6	-17 24	10.2
	18	19 33.8	-17 23	10.4
	25	19 31.5	-17 21	10.6
Sep	1	19 30.6	-17 18	10.7
	8	19 31.3	-17 14	10.9
	15	19 33.4	-17 08	11.0
	22	19 36.9	-16 59	11.2
	29	19 41.7	-16 48	11.3
Oct	6	19 47.6	-16 34	11.4
	13	19 54.6	-16 17	11.5

115 Thyra

Date		RA (hh mm)	Dec (° ′)	Mag
Jun	9	22 43.8	-06 40	12.0
	16	22 49.3	-05 31	11.8
	23	22 53.9	-04 24	11.7
	30	22 57.4	-03 18	11.5
Jul	7	22 59.8	-02 16	11.4
	14	23 00.8	-01 17	11.2
	21	23 00.5	-00 23	11.0
	28	22 58.6	+00 25	10.8
Aug	4	22 55.3	+01 08	10.6
	11	22 50.5	+01 43	10.4
	18	22 44.4	+02 10	10.2
	25	22 37.4	+02 29	10.0
Sep	1	22 29.7	+02 40	9.9
	8	22 22.0	+02 43	9.9
	15	22 14.7	+02 40	10.0
	22	22 08.4	+02 33	10.2
	29	22 03.5	+02 24	10.3
Oct	6	22 00.2	+02 16	10.5
	13	21 58.6	+02 11	10.6
	20	21 58.8	+02 09	10.8
	27	22 00.8	+02 13	10.9
Nov	3	22 04.5	+02 22	11.0
	10	22 09.6	+02 39	11.1
	17	22 16.1	+03 01	11.2
	24	22 23.8	+03 31	11.3

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a *dirty snowball*, a conglomerate of ice, gas, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classic dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical-shaped donut. The effects of solar radiation and the slight gravity tug from the planets will, over time, break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand, up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Quadrantids (QUA)	FM	Dec 28 – Jan 12	Jan 03	230°	+49°	41	120
alpha-Centaurids (ACE)	LQ	Jan 31 – Feb 20	Feb 08	210°	–59°	56	6
gamma-Normids (GNO)	NM	Feb 25 – Mar 28	Mar 14	239°	–50°	56	6
Lyrids (LYR)	FQ	Apr 14 – Apr 30	Apr 22	271°	+34°	49	18
pi-Puppids (PPU)*	FQ	Apr 15 – Apr 28	Apr 23	110°	–45°	18	var
eta-Aquarids (ETA)	LQ	Apr 19 – May 28	May 06	338°	–01°	66	50
eta-Lyrids (ELY)	LQ	May 03 – May 14	May 09	287°	+44°	43	3
June Bootids (JBO)*	FM	Jun 22 – Jul 02	Jun 27	224°	+48°	18	var
Pisces Austrinids (PAU)	FM	Jul 15 – Aug 10	Jul 28	341°	–30°	35	5
Southern delta-Aquarids (SDA)	FM	Jul 12 – Aug 23	Jul 30	340°	–16°	41	25
alpha-Capricornids (CAP)	FM	Jul 03 – Aug 15	Jul 30	307°	–10°	23	5
Perseids (PER)	NM	Jul 17 – Aug 24	Aug 12	048°	+58°	59	150
kappa-Cygnids (KCG)	FQ	Aug 03 – Aug 25	Aug 18	286°	+59°	25	3
Aurigids (AUR)	LQ	Aug 28 – Sep 05	Sep 01	091°	+39°	66	6
September Perseids (SPE)	NM	Sep 05 – Sep 21	Sep 09	048°	+40°	64	5
Draconids (DRA)*	NM	Oct 06 – Oct 10	Oct 09	262°	+54°	20	var
Southern Taurids (STA)	NM	Sep 10 – Nov 20	Oct 10	032°	+09°	27	5
delta-Aurigids (DAU)	NM	Oct 10 – Oct 18	Oct 11	084°	+44°	64	2
epsilon-Geminids (EGE)	FQ	Oct 14 – Oct 27	Oct 18	102°	+27°	70	3
Orionids (ORI)	FM	Oct 02 – Nov 07	Oct 21	095°	+16°	66	15
Leo Minorids (LMI)	FM	Oct 19 – Oct 27	Oct 24	162°	+37°	62	2
Northern Taurids (NTA)	NM	Oct 20 – Dec 10	Nov 12	058°	+22°	29	5
Leonids (LEO)	FQ	Nov 06 – Nov 30	Nov 17	152°	+22°	71	15
alpha-Monocerotids (AMO)	FM	Nov 15 – Nov 25	Nov 21	117°	+01°	65	Var
Phoenicids (PHO)	LQ	Nov 28 – Dec 09	Dec 02	018°	–53°	18	Var
Puppid-Velids (PUP)	NM	Dec 01 – Dec 15	Dec 07	123°	–45°	40	10
Monocerotids (MON)	NM	Dec 05 – Dec 20	Dec 09	100°	+08°	42	2
sigma-Hydrids (HYD)	NM	Dec 03 – Dec 15	Dec 12	127°	+02°	58	3
Geminids (GEM)	FQ	Dec 04 – Dec 17	Dec 14	112°	+33°	35	120
Coma Berenicids (COM)	FQ	Dec 12 – Dec 23	Dec 16	175°	+18°	65	3
Dec. Leonis Minorids (DLM)	FM	Dec 05 – Feb 04	Dec 20	161°	+30°	64	5
Ursids (URS)	FM	Dec 17 – Dec 26	Dec 22	217°	+75°	33	10

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

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

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

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

Table Notes (above)

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

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

Activity Duration The approximate dates when the shower is active.

Max Act The date when maximum activity can be expected.

Radiant The position of the shower radiant in right ascension and declination (RA is expressed in degrees). These coordinates refer to the radiant position on the date of maximum activity.

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

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

CONSTELLATIONS — Abbreviations and Culmination at 9 pm

Name	Genitive	Abr.	Map	Cul.
Andromeda	Andromedae	And	3, 9	Nov 23
Antlia	Antliae	Ant	4, 6	Apr 10
Apus	Apodis	Aps	1	Jul 5
Aquarius	Aquarii	Aqr	8	Oct 9
Aquila	Aquilae	Aql	8, 9	Aug 30
Ara	Arae	Ara	1, 6	Jul 25
Aries	Arietis	Ari	3	Dec 14
Auriga	Aurigae	Aur	3, 5	Feb 4
Böötes	Böötis	Boo	7	Jun 16
Caelum	Caeli	Cae	2, 4	Jan 15
Camelopardalis	Camelopardalis	Cam	3, 5	Feb 6
Cancer	Cancri	Cnc	5, 4	Mar 16
Canes Venatici	Canum Venaticorum	CVn	5, 7	May 22
Canis Major	Canis Majoris	CMa	4, 2	Feb 16
Canis Minor	Canis Minoris	CMi	5, 4	Feb 28
Capricornus	Capricorni	Cap	8	Sep 22
Carina	Carinae	Car	1, 4	Mar 17
Cassiopeia	Cassiopeiae	Cas	3, 9	Nov 23
Centaurus	Centauri	Cen	1, 6	May 14
Cepheus	Cephei	Cep	9, 3	Nov 13
Cetus	Ceti	Cet	2, 3	Nov 29
Chamaeleon	Chamaeleontis	Cha	1	Apr 15
Circinus	Circini	Cir	1, 6	Jun 14
Columba	Columbae	Col	4, 2	Feb 1
Coma Berenices	Comae Berenices	Com	7, 5	May 17
Corona Australis	Coronae Australis	CrA	8, 6	Aug 14
Corona Borealis	Coronae Borealis	CrB	7	Jul 3
Corvus	Corvi	Crv	6, 4	May 12

Name	Genitive	Abr.	Map	Cul.
Crater	Crateris	Crt	4, 6	Apr 26
Crux	Crucis	Cru	1	May 12
Cygnus	Cygni	Cyg	9	Sep 13
Delphinus	Delphini	Del	9, 8	Sep 14
Dorado	Doradus	Dor	2, 1	Jan 31
Draco	Draconis	Dra	7, 9	Jul 8
Equuleus	Equulei	Equ	9, 8	Sep 22
Eridanus	Eridani	Eri	2, 1	Dec 25
Fornax	Fornacis	For	2	Dec 17
Gemini	Geminorum	Gem	5, 4	Feb 19
Grus	Gruis	Gru	8, 1	Oct 12
Hercules	Herculis	Her	7, 9	Jul 28
Horologium	Horologii	Hor	2, 1	Dec 25
Hydra	Hydrae	Hya	4, 6	Apr 29
Hydrus	Hydri	Hyi	1	Dec 10
Indus	Indi	Ind	1, 8	Sep 26
Lacerta	Lacertae	Lac	9	Oct 12
Leo	Leonis	Leo	5, 7	Apr 15
Leo Minor	Leonis Minoris	LMi	5, 7	Apr 9
Lepus	Leporis	Lep	2, 4	Jan 28
Libra	Librae	Lib	6	Jun 23
Lupus	Lupi	Lup	6	Jun 23
Lynx	Lyncis	Lyn	5, 3	Mar 5
Lyra	Lyrae	Lyr	9, 7	Aug 18
Mensa	Mensae	Men	1	Jan 28
Microscopium	Microscopii	Mic	8	Sep 18
Monoceros	Monocerotis	Mon	4, 5	Feb 19
Musca	Muscae	Mus	1	May 14
Norma	Normae	Nor	6, 1	Jul 3
Octans	Octantis	Oct	1	Circum
Ophiuchus	Ophiuchi	Oph	6, 7	Jul 26

Name	Genitive	Abr.	Map	Cul.
Orion	Orionis	Ori	2, 3	Jan 27
Pavo	Pavonis	Pav	1, 8	Aug 29
Pegasus	Pegasi	Peg	9, 3	Oct 16
Perseus	Persei	Per	3	Dec 22
Phoenix	Phoenicis	Phe	2, 8	Nov 18
Pictor	Pictoris	Pic	1, 2	Jan 30
Pisces	Piscium	Psc	3, 9	Nov 11
Piscis Austrinus	Piscis Austrini	PsA	8	Oct 9
Puppis	Puppis	Pup	4, 2	Feb 22
Pyxis	Pyxidis	Pyx	4	Mar 21
Reticulum	Reticuli	Ret	1	Jan 3
Sagitta	Sagittae	Sge	9	Aug 30
Sagittarius	Sagittarii	Sgr	8, 6	Aug 21
Scorpius	Scorpii	Sco	6, 8	Jul 18
Sculptor	Sculptoris	Scl	2, 8	Nov 10
Scutum	Scuti	Sct	8	Aug 15
Serpens	Serpentis	Ser	6, 7	Jul 21
Sextans	Sextantis	Sex	4	Apr 8
Taurus	Tauri	Tau	3, 5	Jan 14
Telescopium	Telescopii	Tel	8, 1	Aug 24
Triangulum	Trianguli	Tri	3	Dec 7
Triangulum Australe	Trianguli Australis	TrA	1	Jul 7
Tucana	Tucanae	Tuc	1	Nov 1
Ursa Major	Ursae Majoris	UMa	5, 7	Apr 25
Ursa Minor	Ursae Minoris	UMi	7	Jun 27
Vela	Velorum	Vel	4, 1	Mar 30
Virgo	Virginis	Vir	6, 7	May 26
Volans	Volantis	Vol	1	Mar 4
Vulpecula	Vulpeculae	Vul	9	Sep 8

BRIGHTEST and NEAREST STARS (opposite)

The column descriptions are:

Designation The name of the star in the system created by Bayer, who numbered the stars in the constellations using Greek letters (p. 152). They were usually ordered by their brightness, Alpha being the brightest in most cases.

Name Common name for each star.
Constellation The star's constellation.
RA and Dec. The position of the star, epoch 2000.0.
Magnitude App. The apparent magnitude as seen in the sky.
Magnitude Abs. The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light years) from Earth.
Spectral Type The spectral classification of the star (see below).
Parallax see glossary.
Proper Motion see glossary.
Distance, ly is light year and **pc** is parsec, see glossary.
Note (d) is a visual double star.
(sb) is a spectroscopic binary.
(eb) is an eclipsing binary.
(v) indicates the star is variable.

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O**, **B**, **A**, **F**, **G**, **K** and **M**, remembered by the mnemonic **O**h **B**e **A** **F**ine **G**irl(Guy) **K**iss **M**e.

There are also the *colder* star classes **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel).
- **F** and **G** are yellow (e.g., Capella, and the Sun).
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only 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 (that is no colour).

The colours of stars can be imaged simply. Mount a camera on a tripod and take a time exposure of several minutes. The resulting star trails often show the colours very well. An equatorially tracked time exposure (for example piggy-backed on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images can saturate the detector. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation		Name	Constellation	RA (2000.0)	Dec (2000.0)	Magnitude App	Magnitude Abs	Spectral Type	Parallax	Distance pc	Distance ly	Note
1	α CMa	Sirius	Canis Major	06 45.1	–16 43	–1.44	1.5	A1 V	0.3800	2.63	8.58	d
2	α Car	Canopus	Carina	06 23.9	–52 42	–0.74	–5.6	F0 Ib	0.0104	96	310	
3	α Cen	Rigil Kent	Centaurus	14 39.6	–60 50	–0.28	4.1	G2V + K0V	0.7472	1.34	4.37	d
4	α Boo	Arcturus	Böötes	14 15.7	+19 11	–0.05	–0.3	K2 III	0.0889	11.3	36.7	
5	α Lyr	Vega	Lyra	18 36.9	+38 47	0.03	0.6	A0 V	0.1289	7.76	25.3	v
6	α Aur	Capella	Auriga	05 16.7	+46 00	0.08	–0.5	G8III + G0III	0.0773	12.9	42.2	sb, v
7	β Ori	Rigel	Orion	05 14.5	–08 12	0.15	–6.8	B8 Ia	0.0042	240	780	d, v
8	α CMi	Procyon	Canis Minor	07 39.3	+05 14	0.38	2.7	F5 IV–V	0.2861	3.50	11.4	d
9	α Eri	Achernar	Eridanus	01 37.7	–57 14	0.45	–2.8	B5 IV	0.0227	44.1	144	v
10	α Ori	Betelgeuse	Orion	05 55.2	+07 24	0.50	–5.2	M2 Iab	0.0076	131	430	v
11	β Cen	Hadar	Centaurus	14 03.8	–60 22	0.61	–5.4	B1 II + B	0.0062	161	525	d, v
12	α Cru	Acrux	Crux	12 26.6	–63 06	0.74	–4.2	B0.5IV + B0.5V	0.0102	98	320	d
13	α Aql	Altair	Aquila	19 50.8	+08 52	0.76	2.2	A7 IV–V	0.1950	5.13	16.7	
14	α Tau	Aldebaran	Taurus	04 35.9	+16 31	0.87	–0.6	K5 III	0.0501	20.0	65	v
15	α Sco	Antares	Scorpius	16 29.4	–26 26	0.96	–5.1	M1.5Iab + B4V	0.0067	150	490	d, v
16	α Vir	Spica	Virgo	13 25.2	–11 10	0.98	–3.5	B1III–IV + B2V	0.0124	80	262	sb, v
17	β Gem	Pollux	Gemini	07 45.3	+28 02	1.15	1.1	K0 III	0.0967	10.3	33.7	
18	α PsA	Fomalhaut	Piscis Austrinus	22 57.7	–29 37	1.16	1.7	A3 V	0.1301	7.69	25.1	
19	α Cyg	Deneb	Cygnus	20 41.4	+45 17	1.25	–7.2	A2 Ia	0.0020	500	1600	v
20	β Cru	Mimosa	Crux	12 47.7	–59 41	1.26	–3.9	B0.5 III	0.0093	108	353	v
21	α Leo	Regulus	Leo	10 08.4	+11 58	1.36	–0.5	B7 V	0.0421	23.8	78	d
22	ε CMa	Adhara	Canis Major	06 58.6	–28 58	1.50	–4.1	B2 II	0.0076	132	430	d
23	α Gem	Castor	Gemini	07 34.6	+31 53	1.58	0.6	A1V + Am	0.0633	15.8	52	d, sb
24	λ Sco	Shaula	Scorpius	17 33.6	–37 06	1.62	–5.0	B1.5 III	0.0046	215	700	sb, v
25	γ Cru	Gacrux	Crux	12 31.2	–57 07	1.63	–0.5	M3 III	0.0371	27.0	88	v
26	γ Ori	Bellatrix	Orion	05 25.1	+06 21	1.64	–2.7	B2 III	0.0134	75	243	
27	β Tau	Elnath	Taurus	05 26.3	+28 36	1.65	–1.4	B7 III	0.0249	40.2	131	
28	β Car	Miaplacidus	Carina	09 13.2	–69 43	1.67	–1.0	A0 III	0.0293	34.1	111	
29	ε Ori	Alnilam	Orion	05 36.2	–01 12	1.69	–6.4	B0 Ia	0.0024	410	1340	
30	γ Vel	Regor	Vela	08 09.5	–47 20	1.70	–5.4	O9Ib + WC8	0.0039	258	840	sb, v

THE NEAREST STARS

Note, this list does not include some recently discovered brown dwarf stars.

No	Star Name		Constellation	RA 2000.0 hh mm.m	Dec ° '	Magnitude Apparent	Magnitude Absolute	Spect Type	Parallax "	Proper Motion "/yr	Distance pc	Distance ly
--	Sun					–26.72	4.85	G2 V				
1	Proxima Centauri		Centaurus	14 29.7	–62 40	11.09	15.53	M5.5 V	0.7720	3.85	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	–60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		B				1.34	5.71	K0 V				
2	Barnard's Star		Ophiuchus	17 57.8	+04 41	9.53	13.22	M4.0 V	0.5470	10.36	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	–16 43	–1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		B				8.44	11.34	DA2				
6	L 726-8 (UV Ceti)	A	Cetus	01 39.0	–17 57	12.54	15.40	M5.5 V	0.3737	3.37	2.68	8.73
		B				12.99	15.85	M6.0 V				
7	Ross 154		Sagittarius	18 49.8	–23 50	10.43	13.07	M3.5 V	0.3369	0.67	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	–09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	–35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	–15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		B				13.27	15.58	M				
		C				14.03	16.34	M				
13	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.66	F5 IV–V	0.2861	1.26	3.50	11.40
		B				10.70	12.98	DA				
14	61 Cygni	A	Cygnus	21 06.9	+38 45	5.21	7.49	K5.0 V	0.2860	5.28	3.50	11.40
		B				6.03	8.31	K7.0 V				
15	Σ 2398	A	Draco	18 42.8	+59 38	8.90	11.16	M3.0 V	0.2830	2.24	3.53	11.53
		B				9.69	11.95	M3.5 V				
16	Groombridge 34	A	Andromeda	00 18.4	+44 01	8.08	10.32	M1.5 V	0.2806	2.92	3.56	11.63
		B				11.06	13.30	M3.5 V				
17	Epsilon Indi		Indus	22 03.4	–56 47	4.69	6.89	K5 Ve	0.2758	4.70	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	–15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	–44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	–17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten's Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

DEEP SKY OBJECTS

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 55	G	Scl	7.9	31.2	00 14.9	–39 11	10		A bright galaxy in the Sculptor Group
NGC 104	GC	Tuc	4.0	30	00 24.1	–72 05	10	1	47 Tucanae
NGC 205	G	And	8.1	19.5	00 40.4	+41 41	10	3,9	M110
NGC 221	G	And	8.1	8.5	00 42.7	+40 52	10	3,9	M32
NGC 224	G	And	3.4	189	00 42.7	+41 16	10	3,9	M31, Andromeda Galaxy
NGC 253	G	Scl	7.2	26.4	00 47.6	–25 18	10		Silver Coin galaxy. Large, bright edge-on spiral
SMC	G	Tuc	2.3	319	00 52.6	–72 48	10	1	Small Magellanic Cloud
NGC 288	GC	Scl	8.1	13.8	00 52.8	–26 35	10		Near galaxy NGC 253
NGC 346	BN	Tuc	10.3	5.2	00 59.1	–72 11	10		Nebula in the SMC
NGC 362	GC	Tuc	6.8	12.9	01 03.2	–70 51	11	1	
NGC 598	G	Tri	5.7	68.7	01 33.9	+30 39	11	3	M33, Triangulum Galaxy
NGC 628	G	Psc	9.4	10	01 36.7	+15 47	11	3	M74
NGC 891	G	And	9.9	13.1	02 22.6	+42 21	11		
NGC 1039	OC	Per	5.2	35	02 42.1	+42 47	11	3	M34
NGC 1068	G	Cet	8.9	7.3	02 42.7	–00 01	11	2	M77, Cetus A
NGC 1097	G	For	9.5	9.4	02 46.3	–30 17	11		
NGC 1261	GC	Hor	8.4	6.9	03 12.3	–55 13	12		
NGC 1269	G	Eri	8.5	9.7	03 17.3	–41 06	12		
NGC 1313	G	Ret	8.7	9.2	03 18.3	–66 30	12		
NGC 1316	G	For	8.5	11.2	03 22.7	–37 13	12		
NGC 1360	PN	For	9.4	360	03 33.2	–25 52	12		
NGC 1365	G	For	9.6	11	03 33.6	–36 08	12		
NGC 1399	G	For	9.6	6.6	03 38.5	–35 27	12		In Fornax galaxy group
Pleiades	OC	Tau	1.2	100	03 47.0	+24 07	12	3	M45, Contains Merope Nebula
NGC 1532	G	Eri	9.9	11.6	04 12.1	–32 52	12		
NGC 1535	PN	Eri	9.4	20	04 14.3	–12 44	12		
NGC 1553	G	Dor	9.4	5	04 16.2	–55 47	12		Near galaxy NGC 1549
NGC 1566	G	Dor	9.7	8.2	04 20.0	–54 56	12		
NGC 1808	G	Col	9.9	6.3	05 07.7	–37 31	1		Near galaxy NGC 1792
NGC 1851	GC	Col	7.1	11	05 14.1	–40 03	1		
LMC	G	Dor	0.4	550	05 23.6	–69 45	1	1	Large Magellanic Cloud
NGC 1904	GC	Lep	7.7	7.8	05 24.2	–24 31	1	2	M79, Rich and compressed, well resolved
NGC 1912	OC	Aur	6.4	21	05 28.7	+35 51	1	3,5	M38, 100 stars, magnitude 9.5 in splendid field
NGC 1952	BN	Tau	8.4	8	05 34.5	+22 01	1	5,3	M1, Crab Nebula
NGC 1976	BN	Ori	4.0	90	05 35.3	–05 23	1	2	M42, Orion Nebula
NGC 1982	BN	Ori	7.0	20	05 35.5	–05 16	1	2	M43, de Mairan's Nebula; part of Orion Nebula
NGC 1960	OC	Aur	6.0	12	05 36.3	+34 08	1	3,5	M36, 60 stars, magnitude 9 to 14
NGC 2070	BN	Dor	8.3	20	05 38.6	–69 06	1	1	Tarantula Nebula
NGC 2068	BN	Ori	8.0	8	05 46.8	+00 05	1	2,3	M78, Brightest and largest in group of four nebulae
NGC 2099	OC	Aur	5.6	24	05 52.3	+32 33	1	3,5	M37, 150 stars, magnitude 9 to 12.5
NGC 2168	OC	Gem	5.1	28	06 08.9	+24 21	1	3,5	M35, 200 stars, magnitude 9 to 16
NGC 2174	BN	Ori		40	06 09.4	+20 40	1		Near open cluster M35
NGC 2237	BN	Mon	5.5	80	06 30.9	+05 03	1		Rosette Nebula
NGC 2287	OC	CMa	4.5	38	06 46.0	–20 45	1	4	M41, 80 stars, magnitude 7 and fainter, with magnitude 6.9 red star near centre
NGC 2323	OC	Mon	5.9	16	07 02.5	–08 23	2	4	M50, Rich cluster, 80 stars magnitude 8 to 12
NGC 2362	OC	CMa	4.1	8	07 18.7	–24 57	2	4	Tau Canis Majoris
NGC 2392	PN	Gem	8.6	47	07 29.2	+20 55	2		Eskimo Nebula
NGC 2422	OC	Pup	4.4	30	07 36.6	–14 29	2	4	M47, Large coarse cluster with 30 stars
NGC 2438	PN	Pup	11.0	65	07 41.8	–14 44	2		In M46
NGC 2437	OC	Pup	6.1	27	07 41.8	–14 49	2	4	M46, Rich open cluster, 100 stars, planetary nebula NGC 2438 in same field
NGC 2440	PN	Pup	9.3	54	07 41.9	–18 13	2		
NGC 2447	OC	Pup	6.2	22	07 44.5	–23 51	2	4	M93, 80 stars magnitude 8 to 13
NGC 2477	OC	Pup	5.8	27	07 52.2	–38 32	2	4	160 stars, magnitude 10 to 12, central concentration
NGC 2467	BN	Pup	7.1	15	07 52.5	–26 26	2		Near open cluster M93
NGC 2516	OC	Car	3.8	21	07 58.1	–60 45	2	1	80 stars 6th mag. and fainter, central concentration
NGC 2547	OC	Vel	4.7	20	08 10.2	–49 12	2	4	Rich in stars with strong central concentration
NGC 2548	OC	Hya	5.8	54	08 13.7	–05 45	2	4	M48, Large cluster of 80 stars magnitude 8 to 13
NGC 2632	OC	Cnc	3.1	95	08 40.0	+19 40	2	5	M44, Beehive Cluster
NGC 2682	OC	Cnc	6.9	30	08 51.4	+11 49	2	5	M67, 200 stars magnitude 10 to 15, large and rich
NGC 2808	GC	Car	6.3	13.8	09 12.0	–64 52	3	1	Large and rich, compressed centre, mag. 13 to 15
NGC 2903	G	Leo	9.0	12	09 32.2	+21 30	3		
NGC 2997	G	Ant	9.4	9.2	09 45.6	–31 11	3		
NGC 3114	OC	Car	4.2	35	10 02.5	–60 08	3		Rich cluster, stars magnitude 9 to 14
NGC 3115	G	Sex	8.9	7.3	10 05.2	–07 43	3		
NGC 3132	PN	Vel	8.2	84	10 07.0	–40 26	3	4	Eight-burst Nebula
NGC 3201	GC	Vel	6.8	18.2	10 17.6	–46 25	3	4	
NGC 3242	PN	Hya	8.6	40	10 24.8	–18 39	3		Ghost of Jupiter
NGC 3293	OC	Car	4.7	40	10 35.8	–58 13	3	1	
NGC 3351	G	Leo	9.7	7.3	10 44.0	+11 42	3	5	M95
NGC 3372	BN	Car	3.0	120	10 45.1	–59 52	3	1	Eta Carinae
NGC 3368	G	Leo	9.3	7.8	10 46.8	+11 49	3	5	M96
NGC 3379	G	Leo	9.3	5.3	10 47.8	+12 35	3	5	M105, in group of three galaxies
NGC 3532	OC	Car	3.0	50	11 05.2	–58 44	4	1	Rich and large, 150 stars magnitude 7 to 12
NGC 3521	G	Leo	9.0	11.2	11 05.8	–00 02	4		
NGC 3623	G	Leo	9.3	9	11 18.9	+13 05	4	5	M65
NGC 3627	G	Leo	8.9	9.1	11 20.2	+13 00	4	5	M66
NGC 3628	G	Leo	9.5	13.1	11 20.3	+13 35	4		Near galaxies M65/66
NGC 3766	OC	Cen	5.3	12	11 36.2	–61 37	4	1	Rich cluster, 100 stars magnitude 7 to 12
IC 2948	BN	Cen	7.0	75	11 39.4	–63 28	4		Running Chicken Nebula
NGC 3918	PN	Cen	8.4	12	11 50.3	–57 11	4		
NGC 4192	G	Com	10.1	9.4	12 13.8	+14 54	4	7	M98
NGC 4216	G	Vir	10.0	7.8	12 15.9	+13 09	4		Edge-on galaxy
NGC 4254	G	Com	9.9	5.3	12 18.8	+14 25	4	7	M99
NGC 4258	G	CVn	8.4	17.4	12 19.0	+47 18	4	5,7	M106
NGC 4303	G	Vir	9.6	6.5	12 21.9	+04 28	4	6,7	M61
NGC 4321	G	Com	9.4	7.5	12 22.9	+15 49	4	7	M100
NGC 4361	PN	Crv	10.9	80	12 24.5	–18 47	4		
NGC 4374	G	Vir	9.1	6.7	12 25.1	+12 53	4	7	M84, Bright centre, in same field as M86
NGC 4382	G	Com	9.1	7.4	12 25.4	+18 11	4	7	M85
NGC 4406	G	Vir	8.9	9.8	12 26.2	+12 57	4	7	M86
NGC 4472	G	Vir	8.4	9.8	12 29.8	+08 00	4	7	M49
NGC 4486	G	Vir	8.6	8.7	12 30.8	+12 23	4	7	M87, Virgo A
NGC 4501	G	Com	9.6	6.8	12 32.0	+14 25	4	7	M88
NGC 4548	G	Com	10.1	5.2	12 35.4	+14 30	4	7	M91
NGC 4552	G	Vir	9.8	5.3	12 35.7	+12 33	4	7	M89
NGC 4565	G	Com	9.6	14.9	12 36.3	+25 59	4		

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 4569	G	Vir	9.5	9.9	12 36.8	+13 10	4	7	M90
NGC 4579	G	Vir	9.7	6	12 37.7	+11 49	4	7	M58, Bright diffuse nucleus, dark lanes
NGC 4590	GC	Hya	7.3	9.8	12 39.5	–26 45	4	6	M68, Rich and compressed
NGC 4594	G	Vir	8.0	8.6	12 40.0	–11 37	4	6	M104, Sombrero Galaxy
NGC 4621	G	Vir	9.6	5.3	12 42.0	+11 39	4	7	M59
NGC 4631	G	CVn	9.2	15.2	12 42.1	+32 32	4		Whale Galaxy
NGC 4649	G	Vir	8.8	7.6	12 43.7	+11 33	4	7	M60
NGC 4736	G	CVn	8.2	12.3	12 50.9	+41 07	4	5,7	M94
NGC 4755	OC	Cru	4.2	10	12 53.6	–60 21	4	1	Jewel Box
NGC 4826	G	Com	8.5	10.3	12 56.7	+21 41	4	7	M64, Black Eye Galaxy
NGC 4833	GC	Mus	8.4	13.5	12 59.6	–70 52	4		Near globular cluster NGC 4372
NGC 4945	G	Cen	8.6	19.8	13 05.4	–49 28	5	6	Big edge on spiral, small galaxy in same field
NGC 5024	GC	Com	7.7	14.4	13 12.9	+18 10	5	7	M53, Bright centre region, very compressed
NGC 5055	G	CVn	8.6	12.6	13 15.8	+42 02	5	5,7	M63, Sunflower Galaxy
NGC 5128	G	Cen	6.8	27.6	13 25.5	–43 01	5		Centaurus A (radio source)
NGC 5139	GC	Cen	3.9	36.3	13 26.8	–47 29	5	6	Omega Centauri
NGC 5194	G	CVn	8.4	10.8	13 29.9	+47 12	5	7	M51, Whirlpool Galaxy
NGC 5189	PN	Mus	10.3	140	13 33.5	–65 58	5	1	Dunlop's best planetary nebula
NGC 5236	G	Hya	7.5	13.1	13 37.0	–29 52	5	6	M83, Southern Pinwheel Galaxy
NGC 5272	GC	CVn	6.3	18.6	13 42.2	+28 23	5	7	M3, Large bright globular, brightens suddenly towards the middle
NGC 5286	GC	Cen	7.4	9.1	13 46.4	–51 22	5		
IC 4406	PN	Lup	11.0	46	14 22.4	–44 09	5		Retina Nebula
NGC 5904	GC	Ser	5.7	19.9	15 18.6	+02 05	6	6	M5, Bright, large very compressed in middle, slightly oval in shape
NGC 5986	GC	Lup	7.6	9.8	15 46.1	–37 47	6		
NGC 6067	OC	Nor	5.6	13	16 13.2	–54 13	6	6	100 stars, large brightness range, central conc.
NGC 6093	GC	Sco	7.3	5.1	16 17.0	–22 59	6	6	M80, Strong central concentration, bright & large
NGC 6121	GC	Sco	5.4	26.3	16 23.6	–26 32	6	6	M4, Near Antares
NGC 6124	OC	Sco	5.8	29.0	16 25.3	–40 39	6	6	Near planetary nebula NGC 6153
NGC 6171	GC	Oph	7.8	3.3	16 32.5	–13 03	6	6	M107
NGC 6193	OC	Ara	5.2	15	16 41.3	–48 46	6		In nebula NGC 6188
NGC 6205	GC	Her	5.8	23.2	16 41.7	+36 28	6	7	M13, Great Hercules Cluster
NGC 6218	GC	Oph	6.1	14.5	16 47.2	–01 57	6	6	M12
NGC 6231	OC	Sco	2.6	15	16 54.2	–41 49	6	6	A few stars with strong central concentration
IC 4628	BN	Sco		90	16 57.0	–40 27	6		Prawn Nebula
NGC 6254	GC	Oph	6.6	12.2	16 57.1	–04 06	6	6	M10
NGC 6266	GC	Oph	6.4	14.1	17 01.2	–30 07	7	6	M62
NGC 6273	GC	Oph	6.8	5.3	17 02.6	–26 16	7	6	M19
NGC 6302	PN	Sco	9.7	72	17 13.7	–37 06	7		Bug Nebula
NGC 6341	GC	Her	6.5	11.2	17 17.1	+43 08	7	7,9	M92
NGC 6333	GC	Oph	7.9	5.5	17 19.2	–18 31	7	6	M9
NGC 6402	GC	Oph	7.6	6.7	17 37.6	–03 15	7	6,7	M14
NGC 6405	OC	Sco	4.2	20	17 40.3	–32 15	7	6,8	M6, Butterfly Cluster
NGC 6397	GC	Ara	5.3	25.7	17 40.7	–53 40	7	1,6	Loose structure, possibly the nearest globular
NGC 6441	GC	Sco	7.4	7.8	17 50.2	–37 03	7		
NGC 6475	OC	Sco	3.3	80	17 53.9	–34 48	7	6,8	M7, Ptolemy's Cluster
NGC 6494	OC	Sgr	5.5	27	17 57.1	–18 59	7	6,8	M23, 150 stars, moderate brightness range, lies in good star field
NGC 6514	BN	Sgr	6.3	28	18 02.7	–22 58	7	6,8	M20, Trifid Nebula
NGC 6520	OC	Sgr	7.6	6	18 03.4	–27 53	7		Near Barnard 86
NGC 6523	BN	Sgr	5.0	45	18 03.7	–24 23	7	6,8	M8, Lagoon Nebula

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 6531	OC	Sgr	5.9	13	18 04.2	–22 29	7	6,8	M21
NGC 6541	GC	Cra	6.3	13.1	18 08.0	–43 42	7	8	
NGC 6572	PN	Oph	8.0	15	18 12.1	+06 51	7		
NGC 6611	BN	Ser	6.0	7	18 18.8	–13 47	7	8	M16, Eagle Nebula
NGC 6613	OC	Sgr	6.9	9	18 19.9	–17 08	7	8	M18
NGC 6618	BN	Sgr	6.0	11	18 20.8	–16 11	7	8	M17, Swan Nebula
NGC 6626	GC	Sgr	6.9	15	18 24.5	–24 52	7	6,8	M28, Large, round, increasingly compressed in the middle
		Sgr	3	95	18 19	–18 10	7	6,8	M24, Small Sagittarius Star Cloud
NGC 6633	OC	Oph	4.6	27	18 27.3	+06 31	7		Near open cluster IC 4756
NGC 6637	GC	Sgr	7.7	7.1	18 31.4	–32 21	7	1,6,8	M69
IC 4725	OC	Sgr	4.6	29	18 31.8	–19 07	7	8	M25, 30 stars loosely scattered
NGC 6656	GC	Sgr	5.2	24	18 36.4	–23 54	7	8	M22, Fine globular, only Omega Centauri and 47 Tucanae are brighter
NGC 6681	GC	Sgr	7.8	7.8	18 43.2	–32 18	7	1,6,8	M70
NGC 6694	OC	Sct	8.0	15	18 45.2	–09 24	7	8	M26
NGC 6705	OC	Sct	5.8	14	18 51.1	–06 16	7	8	M11, Wild Duck Cluster
NGC 6720	PN	Lyr	9.4	86	18 53.6	+33 02	7	7,9	M57, Ring Nebula
NGC 6715	GC	Sgr	7.7	9.1	18 55.1	–30 29	7	8	M54
NGC 6723	GC	Sgr	6.8	11	18 59.6	–36 38	7		
NGC 6726	BN	CrA		2	19 01.7	–36 53	8		
NGC 6744	G	Pav	8.3	20.2	19 09.8	–63 51	8	1	
NGC 6752	GC	Pav	5.4	20.4	19 10.9	–59 59	8	1	Starfish Cluster
NGC 6779	GC	Lyr	8.3	5	19 16.6	+30 11	8	9	M56, Irregularly round, compressed in the middle
NGC 6809	GC	Sgr	6.3	19	19 40.0	–30 58	8	8	M55
NGC 6818	PN	Sgr	10.0	22	19 44.0	–14 09	8		Near galaxy NGC 6822
NGC 6838	GC	Sge	8.3	6.1	19 53.8	+18 47	8	9	M71
NGC 6853	PN	Vul	7.3	480	19 59.6	+22 43	8	9	M27, Dumbbell Nebula
NGC 6864	GC	Sgr	8.6	6	20 06.1	–21 55	8	8	M75
NGC 6913	OC	Cyg	6.6	7	20 23.9	+38 32	8	9	M29
NGC 6981	GC	Aqr	9.2	5.9	20 53.5	–12 32	8	8	M72
NGC 6992	BN	Cyg	7.0	60	20 56.4	+31 43	8		Part of Veil Nebula
NGC 7000	BN	Cyg	4.0	120	21 01.8	+44 12	9	9	North American Nebula
NGC 7009	PN	Aqr	8.3	28	21 04.2	–11 22	9		Saturn Nebula
NGC 7078	GC	Peg	6.4	12.3	21 30.0	+12 10	9	9	M15, Bright, irregularly round, well resolved into faint stars
NGC 7092	OC	Cyg	4.6	32	21 32.2	+48 26	9	9	M39, Northern limit
NGC 7089	GC	Aqr	6.5	11.7	21 33.5	–00 49	9	8	M2
NGC 7099	GC	Cap	6.9	8.9	21 40.4	–23 11	9	8	M30
NGC 7293	PN	Aqr	6.3	960	22 29.6	–20 50	9	8	Helix Nebula
NGC 7662	PN	And	8.6	17	23 25.9	+42 32	10		Snowball Nebula
NGC 7793	G	Scl	9.1	9.6	23 57.8	–32 36	10		

LEGEND

Catalog Catalogue number (NGC New General Catalogue, IC Index Catalogue)

Type Object type:
- G Galaxy
- GC Globular Cluster
- OC Open Cluster
- BN Bright Nebula
- PN Planetary Nebula

Con Constellation
Mag Magnitude of object
Size In arcminutes (PN in arcseconds)
RA Right Ascension (hh mm.m, Epoch 2000.0)
Dec Declination (° ', Epoch 2000.0)
Mth 10 pm Month the object is highest at 10 pm.
Map All Sky Map number
Notes Common name and/or description

RISE & SET TIME ADJUSTMENTS FOR OTHER LOCATIONS

The rise and set tables for the Sun, Moon and planets in Part II are given for our capital cities. Here we help people who live outside these cities to make adjustments to determine the rise and set times for their specific location. There are two adjustments needed.

1. Adjust for the difference in longitude. **For every degree of longitude east or west of Sydney, subtract or add respectively 4 minutes to both the rise and set times**. Adjustments for various towns and cities are given in Table 1.
2. Adjust for the difference in latitude, that also requires the declination for the object of interest. Table 2 presents these adjustments (southern latitudes are negative). Note, **for rise times you add these values, for set you subtract**. For your specific latitude it is normally sufficient to interpolate these figures.

It is important that rise and set times for Sydney are used, irrespective of which town in Australia the calculations are for, when using these tables. If your local time is CST, **subtract** 30 minutes, if WST, **subtract** 2 hours. If daylight saving, **add** 60 minutes. In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example Calculate the rise and set times for Jupiter on 7 April for Albury (36° 05'S, 146° 55'E)	**Rise**	**Set**
Rise and set values for Sydney (p. 123):	19:22	09:04
Adjust for longitude (Table 1) positive as Albury is west of Sydney.	+ :17	+ :17
Adjust for latitude and declination of Jupiter from Table 2. Jupiter's declination is –16° 58' (p. 123)	– :03	+ :03
Rise and set times for Albury are:	19:36	9:24

Table 1 **Longitude adjustments for some places relative to Sydney**

Location	Lat. (° ' S)	Longitude (° ' E)	Long. dif (dec. °)	correct. (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	31 57	141 27	9.8	39
Coffs Harbour	30 13	153 08	–1.9	–8
Dubbo	32 15	148 37	2.6	11
Goulburn	34 45	149 43	1.5	6
Katoomba	33 42	150 18	0.9	4
Newcastle	32 55	151 45	–0.5	–2
Parkes	33 05	148 10	3.1	12
Tamworth	31 03	151 02	0.2	1
Wagga Wagga	35 05	147 20	3.9	16
Wollongong	34 25	150 52	0.4	2
NORTHERN TERRITORY				
Alice Springs	23 42	133 56	17.3	69
Uluru	25 11	130 58	20.3	81
QUEENSLAND				
Bundaberg	24 52	152 21	–1.1	–4
Cairns	16 55	145 49	5.4	22
Longreach	23 22	144 09	7.1	28
Mackay	21 08	149 10	2.1	8
Mount Isa	20 38	139 28	11.8	47
Rockhampton	23 21	150 28	0.8	3
Surfers Paradise	28 00	153 26	–2.2	–9
Toowoomba	27 33	151 58	–0.7	–3
Townsville	19 10	146 49	4.4	18
SOUTH AUSTRALIA				
Port Augusta	32 30	137 52	13.4	54
Port Lincoln	34 42	135 59	15.3	61
Mount Gambier	37 41	140 49	10.4	42
Whyalla	33 02	137 34	13.7	55
TASMANIA				
Launceston	41 20	147 08	4.1	16
Stanley	40 40	145 08	6.1	24
VICTORIA				
Ballarat	37 25	143 55	7.3	29
Benalla	36 30	146 01	5.2	21
Bendigo	36 46	144 17	7.1	28
Geelong	38 09	144 10	7.1	28
Morwell	38 12	146 21	4.9	20
Shepparton	36 13	145 25	5.8	23
Swan Hill	35 13	143 30	7.8	31
Wangaratta	36 17	146 13	5.0	20
Warrnambool	38 27	142 30	8.8	35
WESTERN AUSTRALIA				
Albany	35 01	117 53	33.37	133
Broome	17 58	122 14	29.02	116
Bunbury	33 20	115 38	35.62	142
Carnarvon	24 53	113 40	37.58	150
Derby	17 19	123 38	27.62	110
Esperance	33 52	121 54	29.35	117
Eucla	31 41	128 53	22.37	89
Fitzroy Crossing	18 11	125 36	25.65	103
Geraldton	28 46	114 37	36.63	147
Kalgoorlie	30 45	121 28	29.78	119
Marble Bar	21 10	119 45	31.50	126
Meekatharra	26 36	118 28	32.78	131
Mount Barker	34 38	117 40	33.58	134
Mount Magnet	28 04	117 51	33.40	134
Mount Newman	23 19	119 45	31.50	126
Mount Tom Price	22 41	117 47	33.47	134
Norseman	32 12	121 47	29.47	118
Northam	31 39	116 40	34.58	138
Port Hedland	20 18	118 35	32.67	131
Rawlinna	31 01	125 20	25.92	104
Southern Cross	31 14	119 19	31.93	128
Wagin	33 19	117 20	33.92	136
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

Table 2 **Rise and set corrections for latitude and declination (from Sydney)**

Declination	South Latitude (negative) –12°	–14°	–16°	–18°	–20°	–22°	–24°	–26°	–28°	–30°	–32°	–34°	–36°	–38°	–40°	–42°	–44°
30°	–63	–58	–53	–48	–43	–37	–32	–26	–20	–13	–7	0	8	16	25	34	44
25°	–50	–46	–42	–38	–34	–30	–25	–20	–16	–11	–5	0	6	12	19	26	34
20°	–39	–36	–33	–29	–26	–23	–19	–16	–12	–8	–4	0	5	9	15	20	26
15°	–28	–26	–24	–22	–19	–17	–14	–11	–9	–6	–3	0	3	7	10	14	18
10°	–19	–17	–16	–14	–13	–11	–9	–7	–6	–4	–2	0	2	4	7	9	12
5°	–9	–8	–8	–7	–6	–5	–5	–4	–3	–2	–1	0	1	2	3	5	6
0°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
–5°	9	8	8	7	6	5	5	4	3	2	1	0	–1	–2	–3	–5	–6
–10°	19	17	16	14	13	11	9	7	6	4	2	0	–2	–4	–7	–9	–12
–15°	28	26	24	22	19	17	14	11	9	6	3	0	–3	–7	–10	–14	–18
–20°	39	36	33	29	26	23	19	16	12	8	4	0	–5	–9	–15	–20	–26
–25°	50	46	42	38	34	30	25	20	16	11	5	0	–6	–12	–19	–26	–34
–30°	63	58	53	48	43	37	32	26	20	13	7	0	–8	–16	–25	–34	–44

JULIAN DATE

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 10 hrs from EST, 9.5 hrs from CST or 8 hrs from WST, correcting the date if necessary. Next find the Julian date given in the table (below left) for the month you are interested in. Now add the day of the month. This will give you JD for 0 hr UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you need the Julian date at 23:00 EST on 17 July 2018. Subtract 10 hours to get UT.

23 – 10 = 13:00 hrs UT

From the table the JD for July 0 is 2458299.5

Add the day of month, 17 gives us 2458316.5

Now add the hours as a fraction of a day from the 2nd table. 13 hr is 0.542. Thus JD at 23:00 17 July 2018 EST is 2458317.042

Julian Date (0 hr UT)

Month		Julian Date
Jan	0	2458118.5
Feb	0	2458149.5
Mar	0	2458177.5
Apr	0	2458208.5
May	0	2458238.5
Jun	0	2458269.5
Jul	0	2458299.5
Aug	0	2458330.5
Sep	0	2458361.5
Oct	0	2458391.5
Nov	0	2458422.5
Dec	0	2458452.5

Hours as decimal of a day.

1	0.042	13	0.542
2	0.083	14	0.583
3	0.125	15	0.625
4	0.167	16	0.667
5	0.208	17	0.708
6	0.250	18	0.750
7	0.292	19	0.792
8	0.333	20	0.833
9	0.375	21	0.875
10	0.417	22	0.917
11	0.458	23	0.958
12	0.500	24	1.000

SIDEREAL TIME

Jan	0	6.6409	Jul	0	18.5344
Feb	0	8.6779	Aug	0	20.5714
Mar	0	10.5178	Sep	0	22.6084
Apr	0	12.5548	Oct	0	0.5797
May	0	14.5261	Nov	0	2.6167
Jun	0	16.5631	Dec	0	4.5880

Greenwich mean sidereal time (GMST) at 0 hr UT

Use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to UT. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day d of month at hour t UT

= GMST at 0 hr UT (from table above) + 0.06571 d + 1.00274 t

To convert to local mean sidereal time (LMST)

LMST = GMST + east longitude (or – west)

where longitude is expressed in HOURS (not degrees!) To convert to hours, just divide by 15.

Example: Find LMST at 23 hours Sydney time (EST) on 17 July 2018.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5344 hours.

GMST = 18.5344 + (0.06571 × 17) + (1.00274 × 13) = 32.6871

Sydney's longitude (151.25°) is 10.0833 hrs so

LMST = 32.6871 + 10.0833 = 42.7704

Subtract from this multiples of 24 until it is in the range of 0 to 24

42.7704 – 24 = 18.7704 hrs or 18 h 46 m 13 s

PLACES OF ASTRONOMICAL INTEREST

Following is a list of places of astronomical interest. These facilities cater to the public with tours and/or displays. Information is subject to change. Web links are also on the Quasar site: www.quasarastronomy.com.au

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY RESEARCH FACILITY

They operate their 'Open Nights' public observatory tours on a regular basis. They cater for school groups and the general public. The facility is also dedicated to meteorite research and the meteorite collection is open by request. Information on tour dates and times can be found on the web site. They also have a Facebook page.
<info@bathurstobservatory.com.au>. www.bathurstobservatory.com.au

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The complex is located 35 km southwest of Canberra (Tourist Drive 5) and is a major link in NASA's Deep Space Network. Tidbinbilla sends and receives radio signals from distant spacecraft in our Solar System. The centrepiece is the 70-metre antenna, the largest in Australia. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft and an actual Moon rock. The Cafe and gift shop sells meals and souvenirs. Contact Korinne McDonnell (02) 6201 7809, (02) 6201 7838, <pr@cdscc.nasa.gov>.
www.cdscc.nasa.gov/ or twitter.com/CanberraDSN

CRAGO 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 40 cm telescope. The observatory enjoys the darkest sky in the Sydney region and is open on Saturday nights nearest to Last Quarter Moon. Visitors most welcome. Contact Paul Hatchman 0413 047 782, <VP_Crago@asnsw.com>. www.asnsw.com/crago/index.html

CSIRO PARKES RADIO TELESCOPE

The Parkes Observatory is 20 km north of Parkes (just off the Newell Highway). This landmark radio telescope is over 50 years old, but still considered one of the best single dish radio telescopes in the world. As well as a great view of the telescope, the visitor's centre has displays and a 3D Theatre. There is also the Dish Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available.
Contact (02) 6861 1777, <VCStaff-PA@csiro.au>. www.csiro.au/parkes

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra, Bookings are essential.
Contact Mark Monk (02) 6345 1900, <darbysob@gmail.com>.

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the Western Plains Zoo. Sky presentations are projected in their theatrette, followed by viewing through their telescopes including their large 17". Bring your SLR camera to take astrophotos through this scope or over the internet with their CCD camera. Contact 0488 425 940.
www.tenbyobservatory.com/dubbo_observatory

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The building houses 41 cm and 35 cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also run regular open nights for the general public. Contact secretary (voicemail) 0408 832 408,
<info@sasi.net.au>. www.sasi.net.au

MUDGEE OBSERVATORY

Mudgee Observatory caters for school groups, organised tours and the general public. The observatory is situated 15 mins west of Mudgee. The theatre and flat screen planetarium runs features on the night sky and the Sun. A variety of telescopes and binoculars are available for visitors as well as conducted tours of the night sky. Bookings are essential. Contact (02) 6373 3431, 0428 560 039, <john@mudgeeobservatory.com.au>.
www.mudgeeobservatory.com.au

MACQUARIE UNIVERSITY ASTRONOMICAL OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on various nights (unless raining) for several months during the year, check website for dates and status. Astronomy students will guide you with a range of telescopes.
www.mq.edu.au

MACQUARIE UNIVERSITY PLANETARIUM

Their Digitarium Epsilon planetarium projector system and portable GoDome (see also entry under Mobile Planetariums, page 148) also run public sessions during the month, in the early evening, see website for details. Bookings are essential. www.mq.edu.au

MILROY OBSERVATORY

Milroy Observatory at Coonabarabran has the largest publicly available telescope as well as a number of others for their evening stargazing sessions. They cater for the public, amateurs and professionals. Please call to make a booking. Contact 0428 288 244, <info@milroyobservatory.com.au> or message on Facebook. www.milroyobservatory.com.au
www.facebook.com/milroyCoonabarabran

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association Inc, is situated in Rotary Park (opposite Town Beach) Port Macquarie.
www.pmobs.org.au

SIDING SPRING OBSERVATORY

Siding Spring Observatory (SSO) is Australia's premier optical astronomy research facility and is home to telescopes from many organisations within Australia and around the world. These include Australia's two largest optical telescopes, the Australian Astronomical Observatory's 3.9 metre AAT and the Australian National University's 2.3 metre Advanced Technology Telescope. Examples of international organisations include the Las Cumbres Observatory Global Telescope Network, iTelescope.Net (the public global online network), the robotic telescopes of HAT-South, Project Solaris (searching for exoplanets), PROMPT (SKYNET) looking for Gamma Ray Bursts and the Korean Microlensing Telescope.

Siding Spring nestles into the Warrumbungle mountains at the entrance to the Warrumbungle National Park, 30 minutes west of Coonabarabran. The Visitor Centre includes a café serving light meals, souvenir shop and an astronomy exhibit. From the Visitor Centre there is access to the viewing gallery of the 3.9 m AAT and special tours can be organised on request for groups, information can be found on their website.
www.sidingspring.com.au

StarFest, a celebration of astronomy, is held on the long weekend in October. More information on the web. www.starfest.org.au.

THE AUSTRALIA TELESCOPE COMPACT ARRAY – NARRABRI

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22 m dishes, five spaced along a 3 km track with a sixth 3 km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations.
www.narrabri.atnf.csiro.au

WARRUMBUNGLE OBSERVATORY

The observatory is located at Coonabarabran and is open to the public for night viewing through a number of telescopes. Visitors are encouraged to bring DSLR cameras for astrophotography. The observatory can be hired by amateurs to take advantage of the 51 cm telescope and CCD for imaging and photometry. Piers are available for Meade and Celestron telescopes. The site also hosts remote controlled telescopes for Northern Hemisphere observers and is part of the Sierra Stars Observatory Network. Contact Peter Starr 0488 425 112,
<starr_peter@hotmail.com>. www.tenbyobservatory.com

WESTERN SYDNEY UNIVERSITY PENRITH OBSERVATORY

The Western Sydney University Penrith Observatory is open to the public and runs public evenings, school and group programs. A visit can include listening to lectures on various aspects of astronomy, a 3D astronomy movie and viewing through a variety of telescopes.
www.westernsydney.edu.au/observatorypenrith/penrith_observatory

SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a Space Theatre, digital planetarium, displays and telescope tours during the day and night (including stargazing weather permitting). Day tours also include solar viewing. Sydney Observatory is part of the Museum of Applied Arts and Sciences. Contact (02) 9217 0111, <info@maas.museum>.

www.maas.museum/Sydney-observatory

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes the full dome planetarium, an observatory, laser light shows, exhibits and a gift and resource shop. The Planetarium has the latest immersive full-dome technology. The observatory houses a telescope used to observe the Sun and stars. The Science Shop has a range of educational materials and telescopes. Contact (02) 4286 5000 (option 2), Fax (02) 4283 6665, <science_centre@uow.edu.au>.

www.sciencecentre.com.au

QUEENSLAND

ALLOWAY OBSERVATORY

The observatory, situated approximately 6 km south of Bundaberg, is operated by the Bundaberg Astronomical Society. The 6 metre dome houses a 480 mm Newtonian telescope and a 12 inch Meade telescope with CCD imaging. The observatory opens to the public on Friday nights. Midweek opening can also be arranged for large groups.
Contact Lonnie Smilas 0418 868 695, <lonnie37@me.com>.

alloway-observatory-bundaberg.webs.com

COSMOS CENTRE AND OBSERVATORY CHARLEVILLE

The public observatory is located on the airport precinct off the Cunnamulla Rd. They offer: general night-time observing sessions, a longer personalised observing session and introduction to the night sky sessions. During the day the centre is open and conducts several activities including Sun viewing through a solar telescope, interactive displays and the Outback Theatre presentations and guides give presentations on meteorites from the collection several times per day. Special programmes can be arranged for groups and schools. Bookings are essential.
Contact (07) 4654 7771, <enquires@cosmoscentre.com>.

www.cosmoscentre.com

KINGAROY OBSERVATORY

Kingaroy Observatory (formerly known as the Maidenwell Observatory) is now located in Geoff Raph Drive at the Kingaroy airport, a five minute drive from the town's CBD. Their night shows consist of a planetarium presentation in the Star Theatre before showing their visitors the wonders of the Southern night skies through their Meade 14 inch telescopes. Astronomer James also uses a registered green laser pointer as part of his night shows which begin at 7 pm in the Autumn/Winter period and 7:30 pm during Spring/Summer. All sessions run for two hours. Minimum number for a night show is four adults. Night show dates and prices on their website. Bookings are essential. Contact (07) 4164 6194 or 0427 961 391, <mao123@bigpond.com>. www.kingaroyobservatory.com

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs are presented in their Cosmic Skydome. All shows include a current night sky tour recreated in the dome. The Planetarium is one of the most advanced and versatile planetariums in the Southern Hemisphere equipped with both a digital fulldome system and an optical star projector. The display areas contain astronomical and space items and short videos are presented. The shop has educational products and souvenirs. Telescope sessions must be pre-booked. School shows also available during weekdays and are available to the public on a space-available basis. Monday opening only in Qld school holidays. Contact (07) 3403 2578, <bop@brisbane.qld.gov.au>.

www.brisbane.qld.gov.au/planetarium/
www.facebook.com/BrisbanePlanetarium

SOUTH AUSTRALIA

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

Located in the heart of the northern Flinders Ranges, Arkaroola have a total of eleven Advanced Ecotourism accredited products including Ridgetop, Astronomy and Waterholes tours. There are also many guided and unguided bushwalks. They have observatories offering two Celestron and three Meade computer assisted telescopes. There are also spare piers and wedges suitable for BYO telescopes. Contact (08) 8648 4848, Fax (08) 8648 4846, <res@arkaroola.com.au>. www.arkaroola.com.au

STOCKPORT OBSERVATORY

Owned and operated by the Astronomical Society of South Australia (ASSA), the observatory is located in the small town of Stockport, approximately 80 km north of Adelaide. Public star parties are held at Stockport in February, May, August and November. See web site for details. Contact ASSA Info Line (08) 8338 1231, <observatories@assa.org.au>. www.assa.org.au/facilities/stockport/

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury Heights, Adelaide. There are two main telescopes, 14" and research quality 12.5" plus two Coronado solar scopes. Private bookings are accepted. (08) 8263 6244.
Contact Andrew Cool, <andrew@cool.id.au>.

www.theheights.sa.edu.au/observatory.html
www.adelaideobservatory.org

UNIVERSITY OF SOUTH AUSTRALIA, ADELAIDE PLANETARIUM

The Adelaide Planetarium is open seven days a week by appointment for group and private bookings. Adult education courses are held throughout the year along with school holiday programs. General public sessions are held on the first and third Saturday of the month at 1 pm that combines a full dome movie with a condensed Night Sky session and a 2.45 pm one hour Night Sky Presentation session. Bookings essential.
Contact (08) 8302 3138, <adelaide.planetarium@unisa.edu.au>.

www.unisa.edu.au/planetarium/

TASMANIA

LAUNCESTON PLANETARIUM

The Launceston Planetarium is at the Queen Victoria Museum's Inveresk site. See their web site for details of shows. Contact (03) 6323 3777.

www.qvmag.tas.gov.au

VICTORIA

ASTROTOURS SWINBURNE

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during school holidays. AstroTour sessions can also be booked for school groups (Years 3-12) throughout the year. Contact Associate Professor Alan Duffy (school group enquiries) or Elizabeth Thackray (bookings) (03) 9214 5569, <astrotour@swin.edu.au>. astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The observatory has several historic telescopes including the Jelbart (a 125 mm refractor), the Oddie (a 220 mm Newtonian), the Baker Great Equatorial Telescope (a 650 mm Newtonian) and a 300 mm Newtonian. The Adcock-Federation telescope (406 mm) has disabled-access. Observatory open Tuesday to Saturday. Bookings essential. See website for open times and calendar of events Contact open hours (03) 5332 7526 or after hours for bookings 0429 199 312, <bas@cbl.com.au>.

observatory.ballarat.net

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 150 and produces shows for all ages. The planetarium is open seven days a week from 10 am, see website for details.

museumvictoria.com.au/planetarium/

MOUNT BURNETT OBSERVATORY

Visitors are most welcome, individuals and families wanting to look through their telescopes can join in one of their Public Viewing Nights. These run approximately once a month subject to the weather. They are very popular and must be pre-booked. Phone Mount Burnett Observatory hotline 0490 130 153 or email <info@mtburnettobservatory.org> for further details.

mtburnettobservatory.org/index.php/visit
www.facebook.com/MtBurnettObservatory

BENDIGO PLANETARIUM @ DISCOVERY

Part of the Discovery Science and Technology Centre, see web site for details. Contact (03) 5444 4400, <planetarium@discovery.asn.au>.

www.discovery.asn.au

WESTERN AUSTRALIA

ASTRO TOURS OF THE KIMBERLEY

Broome's Astronomy Experience is a two hour live performance educational and entertaining experience using big telescopes under dark skies. It operates in Broome from April to October a number of times a week according to the schedule and booking facility found on the website. Bookings essential. Greg Quicke, aka #spacegandalf, is a BBC and ABC TV presenter for Stargazing Live with Professor Brian Cox and other astronomy related programs.
Contact Greg Quicke 0417 949 958, <greg@astrotours.net>.

www.astrotours.net

GDC OBSERVATORY

The Gravity Discovery Centre Observatory is part of the Gravity Precinct and shares its bushland with the AIGO research centre and the Zadko Telescope and the USAFA Falcon Telescope Network. The observatory boasts professional staff and five telescopes including the largest for public viewing in WA. Events include their Monster Telescope, Indigenous Astronomy and specialised astronomy sessions. Located under dark skies, it is an hours drive north of Perth. Contact (08) 9575 7577 (Office).

www.gravitycentre.com.au/observatory

THE SPACE PLACE OBSERVATORY

The observatory moved from Gingin late 2015. See their web site for information. Contact (08) 9574 2295, <stars@thespaceplace.com.au>.

www.thespaceplace.com.au

PERTH OBSERVATORY

The Perth Observatory is situated in the Perth Hills about 35 km east of Perth (30 mins from Perth) and is run by the Perth Observatory Volunteer Group. The Observatory, WA's oldest, has a long tradition of research and public outreach. The Observatory offers a wide range of night and daytime tours as well as a star adoption program and has offsite capabilities. To book a tour go to their website. Contact (08) 9293 8255, Fax (08) 9293 8138, <info@perthobservatory.com.au>.

www.perthobservatory.com.au

EVENTS

AUSTRALIA

NATIONAL SCIENCE WEEK

Held in August each year, it celebrates Australian science and aims to increase public awareness of the role that science, engineering, mathematics, innovation and technology play in our daily lives and to encourage younger people to become involved. Astronomy is a key component, and amateur societies are ideally placed for such outreach. Support is available for event holders. See the web site for more information. www.scienceweek.net.au

NEW SOUTH WALES

CWAS ASTROFEST

The CWAS AstroFest is sponsored by the Central West Astronomical Society and held annually in July. 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 also share their knowledge and experiences. Contact John Sarkissian (Local Organising Committee), <astrofest@cwas.org.au>.

www.cwas.org.au/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 300 people. Advance registrations required. See the society web site for more details. <secretary@asnsw.com>. www.asnsw.com/node/712

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, telescopes operated by local amateurs and commercial stands. They are held once a year, normally in March – May (a Saturday night around First Quarter Moon). The venue is Macquarie University in North Ryde, Sydney, commencing around 6:30 pm. See website for details. www.mq.edu.au

STARGRAZING FESTIVAL NE NSW

The StarGrazing Festival is a developing annual astronomy festival at Ben Lomond Village, (between Armidale and Glenn Innes) NSW. One of the time and places those interested in astronomy can get together in the Northern Tablelands. After a successful trial in 2017, the next event is planned for 14–18 April 2018. The format has a public night on the 14th with the next four nights for amateurs and friends. If you are an amateur astronomer and want some observing away from city lights, you can do so at the village oval, north side of the village. See web site for more detail.

ne-nsw-stargrazing-festival.tumblr.com

QUEENSLAND

BAS MOON & PLANET TELESCOPE VIEWING NIGHTS

The Brisbane Astronomical Society (BAS) holds regular free public viewing nights at Mt Coot-tha Lookout on certain Saturdays nearest First Quarter Moon from 7–9 pm, check website for dates. <info@bas.asn.au>.

www.bas.asn.au/index.php/events/4-public-viewing-nights

QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The Queensland Astrofest is held annually at the Lions Club Camp Duckadang, situated at Linville 160 km north-west of Brisbane. There is bunk house accommodation and room for camping and caravans. Power is also available. Queensland Astrofest boasts a nine day format, Friday 3 to Sunday 12 August 2018. Each Saturday has vendor sales and talks. Workshops are run covering various topics. The renowned Astro-Feast is held on the last Saturday night. More details are on the Web site. Registration opens April/May, early bookings are recommended. Contact registrar, <registrar@qldastrofest.org.au>.

www.qldastrofest.org.au

URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at Barrett Street Reserve, Bracken Ridge (entry off Jude St) on the 1st and 3rd Sunday each month (weather permitting). All welcome. Contact Julie Straayer (07) 3325 2479, <urbanobs@seqas.org>. www.seqas.org

VICTORIA

NACAA

The National Australian Convention of Amateur Astronomers is a regular national forum at which amateur astronomers can exchange experiences, stay abreast of the latest trends, foster co-operative activities between individuals, societies and the professional sphere. They are held over Easter every two years. The 28th NACAA will be held at Ballarat, 30 March–2 April 2018, hosted by the Ballaarat Astronomical Society.

www.nacaa.org.au

VASTROC (VIC)

Victorian Amateur Astronomical Societies' Conventions (VASTROC) are held every second year (alternating years with NACAA). Activities include speakers, workshops, displays, observing and the convention dinner. The Mornington Peninsula Astronomical Society will host the 2019 one. More details on MPAS web site or the VASTROC web site when available. vastroc.net or www.mpas.asn.au/vastroc.html

VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party is an annual weekend of astronomy, held at the Little Desert Nature Lodge about 16 km south of Nhill in western Victoria. Jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, it offers a weekend of social, astronomical and observing activities. VicSouth 2018 is scheduled for October 20 to October 23, the following one for 2–6 November 2018. See website for more details. www.vicsouth.info

ORGANISATIONS

AUSTRALIA

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia is the society of professional astronomers in Australia. It has a Society website and a second Australian Astronomy site providing links, both professional and amateur, and including links to educational material.
Contact A/Prof. John O'Byrne, <john.obyrne@sydney.edu.au>.

asa.astronomy.org.au ASA site
www.astronomy.org.au Australian Astronomy site

VARIABLE STARS SOUTH

VSS is an international association of astronomers, amateur and professional, researching the under-explored realm of southern variable stars. VSS covers most techniques of variable star research: visual observing, imaging with DSLRs and CCD cameras and spectrography. Its research is project-oriented, often involving professional/amateur collaboration. Its 'home' is its website, visit it for further information and contacts. <director@variablestarssouth.org>. www.variablestarssouth.org

NEW SOUTH WALES

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY INC.

Since 1998 SOLIS has been working at protecting the view of the night sky by promoting better outdoor lighting.
Contact Ken Petersen 0412 358 194, <solissydney1@bigpond.com>.

www.solis.asn.au

COURSES

ACT

MY SKY ASTRONOMY – Projects for high school students

My Sky Astronomy is a new educational program designed for student-centred research projects in astronomy. Students operate MSATT, a teaching telescope suite at ANU's historic Mount Stromlo Observatory. No experience with astronomy or telescopes is necessary and any Year 9 to 12 student from the ACT region is welcome to apply. Single night sessions are also available. Students wishing to visit MSATT or take on projects in 2018* should contact Geoff for a copy of the Student Guide. There is no cost for any MSATT activities. Contact Geoff McNamara phone/text 0449 966 200 <geoffrey.mcnamara@ed.act.edu.au>

* The 2018 observing season begins with the end of DST on 1/4/18.)

msatt.teamapp.com/

NEW SOUTH WALES

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is a nine week course conducted by Sutherland Astronomical Society Inc (SASI). Each lecture is followed by observations with the society's equipment (weather permitting). Refer to website for course dates. Contact the Education Officer 0408 207 927, <info@sasi.net.au>.

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. See website for more information. www.physics.usyd.edu.au/about/cep.shtml

SOUTH AUSTRALIA

ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

A variety of astronomy themed courses are conducted at the Adelaide Planetarium during the year. See their web site for details.

www.unisa.edu.au/Business-community/galleries-museums-and-centres/Planetarium/Events-and-courses1/

TASMANIA

NIGHT SKY EXPLORER COURSE (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania, usually twice a year in March/April and October/November; six hours total (two by three hour sessions). Contact Richard Grudzien 0400 585 037 <regulus1951@gmail.com>.

www.astas.org.au

VICTORIA

ASTRONOMY PUBLIC LECTURES

The Centre for Astrophysics & Supercomputing have free public lectures on astronomy at the Hawthorn campus of Swinburne University of Technology. See web site for details.

astronomy.swin.edu.au/outreach/?topic=freelectures

MOBILE PLANETARIUMS

NEW SOUTH WALES

MACQUARIE UNIVERSITY PLANETARIUM

Their planetarium projector system and portable GoDome is available, by arrangement, for groups of up to 50 people per session. The planetarium simulates the night sky. You can take a tour of the local Solar System, peer into the depths of the galaxy, or watch amazing new planetarium movies. Presentations can be tailored to the interests and age of your groups.

www.mq.edu.au

SKYWORKS PLANETARIUM

Skyworks Planetarium is a multi award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. Since starting in 2000, Skyworks has become the most active planetarium in greater Sydney. Programs are curriculum based to suit years K-12. Contact Geoff & Diana Zenner 0419 112 899, Fax (02) 9753 1898 <info@skyworks.net.au>. www.skyworks.net.au

QUEENSLAND

STARLAB EDUCATION

Starlab Education provides astronomy and Earth science presentations throughout Queensland. Fully trained presenters visit your school or venue with a 'Cosmodome Science Theatre & Planetarium' or a 'Starlab Planetarium' to provide educational programs tailored to suit your level of interest and understanding. Contact Paul Tickner 0417 394 354, <info@starlab.net.au>. www.starlab.net.au

RESOURCES

AUSTRALIA

AUSTRALIAN SKY & TELESCOPE MAGAZINE

Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, it is produced specifically for the Southern Hemisphere astronomer. Delivering the latest news and developments in astronomy 8 times a year, Australian Sky & Telescope caters for everyone with an interest in space and astronomy, from the absolute beginner to the seasoned observer. Contact (02) 9439 1955, Fax (02) 9439 1977, <info@skyandtelescope.com.au>. www.skyandtelescope.com.au

ICEINSPACE

IceInSpace is a community website dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers discover, discuss and enjoy the night sky. IceInSpace is free to join and use, all you need is a valid email address. By registering you will be able to post topics, upload content and images and access other features. IceInSpace is the largest and most active astronomy community in the Southern Hemisphere, with over 13,500 members. Contact Mike Salway, <mike@iceinspace.com.au>. www.iceinspace.com.au

WESTERN AUSTRALIA

ASTRONOMY EDUCATION SERVICES

Astronomy Education Services (AES) activities include day presentations with safe viewing of the Sun and stargazing nights with telescopes. AES specialises in schools, Scout/youth/special interest groups and rural communities. See their web site and Facebook page for more details. Contact Richard Tonello 0417 961 357, <richard@astro-ed-services.com>.

www.astro-ed-services.com

ASTRONOMICAL SOCIETIES

NEW SOUTH WALES & ACT

ASTRONOMICAL SOCIETY OF ALBURY WODONGA meets regularly on the first Wednesday of each month (except January) at La Trobe University, Wodonga at 7 pm.
Contact David Thurley (02) 6040 3704 <enquiries@asaw.org.au>.
PO Box 1500, Lavington NSW 2641 www.asaw.org.au

ASTRONOMICAL SOCIETY OF NSW meets twice per lunar month where professional and amateur astronomers are invited to talk. See their website for details. Contact <secretary@asnsw.com>.
PO Box 870, Epping NSW 1710 www.asnsw.com

ASTRONOMICAL SOCIETY OF THE HUNTER meets at The Billabong Restaurant, East Maitland Bowling Club on the 1st Friday each even month at 6:30 PM. Contact Col Maybury (02) 4937 4664 or 0427 889 653 <cma45714@bigpond.net.au>.
21 Brooks St, Kurri Kurri NSW 2327

CANBERRA ASTRONOMICAL SOCIETY meetings are held on the 3rd Thursday of each month except June and December starting at 8 pm. An Introductory meeting begins one hour before the main meeting. The venue is usually the Duffield Lecture Theatre, Mt. Stromlo Observatory, Weston, ACT. Contact Fay Neil (02) 6231 0851 <casadmin@gmail.com>.
PO Box 1338, Woden ACT 2606 casastronomy.org.au

CENTRAL WEST ASTRONOMICAL SOCIETY INC (PARKES) meetings are held on the first Friday of the month except January, at the Parkes Observatory Visitors Centre, commencing 7:30 pm, visitors welcome. Contact Secretary <secretary@cwas.org.au>.
PO Box 819, Parkes NSW 2870 www.cwas.org.au

CLARENCE VALLEY ASTRONOMICAL SOCIETY Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>.
97 Skinner St, South Grafton NSW 2460

COFFS HARBOUR ASTRONOMICAL SOCIETY INC meets on the first Monday of each month (except January) at 7 pm at the Boambee East Community Centre, cnr. Bruce King Drive and Pacific Highway, Boambee East.
Contact Win Howard (02) 6653 2742 <winhoward@iprimus.com.au>.

ASTRONOMICAL SOCIETY OF COONABARABRAN MEETS on the third Wednesday each month at 7:30 pm at Room EG01, Coonabarabran TAFE campus, Robertson Street, Coonabarabran. Contact Donna Burton secretary 0428 288 244 <secretary@coona-astro.org.au\>.
www.coona-astro.org.au

ILLAWARRA ASTRONOMICAL SOCIETY meets at 7:30 pm, every second Tuesday of the month at the Wollongong Science Centre.
Contact <wanglese@bigpond.net.au>.
PO Box 3092, Balgownie NSW 2519

MACARTHUR ASTRONOMICAL SOCIETY meet in Campbelltown, NSW, on the 3rd Monday of the month, with guest speakers and workshops. They also schedule three dark-sky observing nights per month. Contact <contact@macastro.org.au>.
PO Box 17, Minto NSW 2566 www.macastro.org.au

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC meets at St Ignatius College at Lane Cove third Tuesday of every month, runs a course each year for New Astronomer's Group on the fourth Tuesday of the month, and conducts regular observing nights at Terrey Hills.
Contact <nsas@nsas.org.au>.
PO Box 56, Lane Cove NSW 1595 www.nsas.org.au

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC members meetings are held once a month, contact them for dates.
PO Box 1453, Port Macquarie NSW 2444 www.pmobs.org.au

SHOALHAVEN ASTRONOMERS meet at the University Of Wollongong, Shoalhaven Campus, Library and Resources Centre, Seminar Room LG.25 on the third Friday of the month at 7 for 7:30 pm.
Contact Frank Gross (president) 0402 836 523
PO Box 1053, Nowra NSW 2541 www.shoalhavenastronomers.asn.au

SUTHERLAND ASTRONOMICAL SOCIETY meets every Thursday at 7:30 pm at the Green Point Observatory near Sutherland, with the main meeting and guest speaker on the 1st Thursdays.
Contact Secretary 0408 832 408 (voicemail) <info@sasi.net.au>.
PO Box 31, Sutherland NSW 1499 www.sasi.net.au

SYDNEY CITY SKYWATCHERS meet at Sydney Observatory on the first Monday of the month (except January and December) at 6:30 pm.
Contact Secretary, Elizabeth (02) 9398 9705
Sydney Observatory, 1003 Upper Fort St, Millers Point NSW 2000
www.sydneycityskywatchers.org

SYDNEY NORTHWEST ASTRONOMY GROUP (SNAG) has viewing and imaging only (no meetings) on Friday nights under clear skies at Kenthurst.
Contact Ken Petersen 0412 358 194 <ken.petersen6@telstra.com>.

THE NEWCASTLE ASTRONOMICAL SOCIETY meetings are held on the first Friday each month (except January), at the University of Newcastle, Lecture Theatre GP 2.1 (room 1, 2nd floor) of Linguistics Building at 7:30 pm.
Contact Alan Meehan (02) 4950 0725 <info@nas.org.au>.
c/- Dept. Physics, University of Newcastle Callaghan NSW 2308
www.nas.org.au

UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY meetings are held once per month at the Kirby Observatory on Tuesday evenings close to New Moon at 7 for 7:30 pm. Contact Anne Parnell (02) 6772 1958 <parnellansw@gmail.com>.
Ms Anne Parnell, 81 Perrott St Armidale NSW 2350 www.unentas.org.au

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC meets at 7:30 pm on the 3rd Wednesday of the month at Penrith Observatory, Western Sydney University, Werrington Campus. Hear interesting guest speakers and attend astronomy workshops.
Contact <enquiry@wsaag.org>.
PO Box 400, Kingswood NSW 2747 wsaag.org

TAMWORTH REGIONAL ASTRONOMY CLUB INC meetings are held on the 1st Monday of every month starting at 6:30 pm followed by a Viewing Night at 7:00 pm. The venue is the Conference Room at the Botanic Gardens, Tamworth. A BBQ & Technical/Dark-sky night is held three Saturdays after the Monday meeting at the club's Dark Sky Site. Please phone secretary for confirmation and details.
Contact Secretary 0458 772 747 <tracthestars@gmail.com>.
PO Box 1023, Tamworth NSW 2340 tracthestars.weebly.com/

WOLLONGONG AMATEUR ASTRONOMY CLUB has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra. Visitors are most welcome to attend. Contact Jeff Pountney on 0423 972 181 or Joe Perulero on 0429 526 661. waacers.createmybb3.com

NORTHERN TERRITORY

GOVE AMATEUR ASTRONOMERS meets as advised for viewing nights on a Saturday close to the New Moon at a local dark sky site. Their nights are announced on their Facebook page.
www.facebook.com/GoveAstronomers

QUEENSLAND

ASTRONOMICAL ASSOCIATION OF QUEENSLAND meetings will be on nominated Saturdays each month from February to December. The normal venue is Lecture Theatre 222, the Parnell Building (School of Maths and Physics), located on the south side of the Great Court, The University of Queensland, St Lucia Campus. Meetings generally commence at 4 pm. Dates of meetings and further details are published on their website. Contact the General Secretary via the 'email us' link on the Contact page of their web site.
PO Box 6101, St Lucia Qld 4067 www.aaq.org.au

BRISBANE ASTRONOMICAL SOCIETY hold meetings each month except January, see their web site for meeting night details.
Contact Peter Allison 0488 140 755 <President@bas.asn.au>.
PO Box 15892, City East Qld 4002 www.bas.asn.au

BUNDABERG ASTRONOMICAL SOCIETY meetings are held at Alloway Observatory every Friday at 7:30 pm. The second Friday of the month are general meetings and are not held in January.
PO Box 4221, South Bundaberg Qld 4670
alloway-observatory-bundaberg.webs.com

FNQ ASTRONOMERS GROUP meet periodically in the Cairns region (Far North Qld) in conjunction with astronomical events as advised on the Facebook page. Contact Ian Maclean 0417 601490
www.facebook.com/FNQAstronomers

ASTRONOMY MOUNT ISA meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17 km outside of Mount Isa). Meetings are held monthly, usually the Saturday preceding New Moon. Contact Len Fulham (07) 0437 833 331 (AH), (07) 4743 2955 (W) <lfulham@tpg.com.au>.
PO Box 1556, Mount Isa Qld 4825

REDLANDS ASTRONOMICAL SOCIETY meets on the second Tuesday of the month at Ormiston College, Ormiston (27 km SE of Brisbane), see web site for details. Contact President: Rhondda Nickols 0403 185 586 <redlandsastronomicalsociety@gmail.com>.
PO Box 2048, Wellington Point Qld 4160 www.ras.org.au

SCENIC RIM ASTRONOMY ASSOCIATION meets twice a month on Saturdays near the New Moon at their dark site at Laravale (under one hour south of Brisbane), often having a guest speaker or workshop before twilight ends. Contact Mark Lohmann (Secretary) 0423 888 374 <secretary@sraa.org.au>.
77 Christmas Creek Road, Laravale Qld 4285 sraa.org.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY meets third Tuesday of the month at Bracken Ridge Library from January to November. Meetings commence at 7:30 pm.
Contact Julie Straayer (07) 3325 2479 <juliestraayer@hotmail.com>.
PO Box 60, Everton Park Qld 4053 www.seqas.org

SOUTHERN ASTRONOMICAL SOCIETY has monthly meetings at Ormeau Progress Hall, McCreadie Rd Ormeau Qld.
Contact Joe Zerafa 0421 866 376
PO Box 867, Beenleigh Qld 4207 www.sas.org.au

TOWNSVILLE ASTRONOMY GROUP INC holds a weekly public viewing at the Strand in Townsville. In addition there is a monthly viewing at a dark site further inland, usually on the Saturday closest to New Moon. Details and updates can be found on their website and in their Facebook group. Contact Bob Bartlett 0407 747 297
www.astronomytsv.org.au

WIDE BAY ASTRONOMICAL SOCIETY meet at 7 pm Wednesday nights at the University of Sunshine Coast, Pialba, two weeks after their monthly dark sky viewing nights in Takura (see website for details). Contact Joe Mather 0477 194 277 <president@wbastro.org>.
President, Wide Bay Astronomical Society
Unit 88 34-56 Elizabeth Street, Urangan Qld 4655 www.wbastro.org

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA meetings are held on the 1st Wednesday each month (except January) at the University of Adelaide, North Terrace Campus. Contact <secretary@assa.org.au>.
GPO Box 199, Adelaide SA 5001 www.assa.org.au

TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA has regular meetings and observing activities throughout Tasmania. Contact Hobart – Steve Harvey 0419 341 469, Launceston – Michael Booth 0408 240 576, Devonport – Peter Sayers (03) 6424 2588
or secretary, Brian Garland <info@astas.org.au>.
GPO Box 1654, Hobart Tas 7001 www.astas.org.au"

VICTORIA

ASTRONOMICAL SOCIETY OF VICTORIA has monthly meetings, held at 8 pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. ASV has 18 specialist sections that also hold regular meetings. Contact Linda Mockridge (Public Relations Officer) (03) 9888 7130
GPO Box 1059, Melbourne Vic 3001 www.asv.org.au

ASTRONOMY BENALLA meets on the third Wednesday of each month at 7:30 pm at Benalla Hockey Club Room, Churchill Park, Waller St Benalla. Contact Jeff Knight (President) (03) 5762 5429 or 0407 532 674
128 Cowan St, Benalla Vic 3672 www.astronomybenalla.org.au

ASTRONOMICAL SOCIETY OF GEELONG meets every Friday at 7:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong.
PO Box 1799, Geelong Vic 3220 www.asog.org.au

BALLAARAT ASTRONOMICAL SOCIETY holds members meetings, 2nd Friday of the month, beginning in February.
Contact 0429 199 312 <bas@cbl.com.au>.
PO Box 284, Ballarat Vic 3353 observatory.ballarat.net

BENDIGO DISTRICT ASTRONOMICAL SECTION OF THE ASTRONOMICAL SOCIETY OF VICTORIA arranges Astronomy and Science Presentations at the Discovery Centre, Bendigo, 7:30 pm, on the first Wednesday of each month. Contact <president@bdas.net>.
PO Box 164, Bendigo Vic 3552 www.bdas.net

BRIGHT ASTRONOMY CLUB INC is small group who meet at the Porepunkah airfield once a month or on special astronomical events and outreach works. Contact president Zachary 0438 863 739, secretary Rob <rob.kau@gmail.com> or treasurer Sean 0411 797 714 <brightastronomyclub@gmail.com>. brightastronomy.webs.com/

LATROBE VALLEY ASTRONOMICAL SOCIETY meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers; call for details.
Contact John Sunderland (03) 5122 3014 <info@LVastro.org>.
PO Box 459, Moe Vic 3825 www.LVastro.org

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND meetings are held at Bairnsdale and Perry Bridge. Dark sky site near Bairnsdale airport. Contact Mike Finn (03) 5153 2802,
0422 904 238 <mikef1@iprimus.com.au>.
53 Riley St, Bairnsdale Vic 3875

MORNINGTON PENINSULA ASTRONOMICAL SOCIETY meetings are held on the 3rd Wednesday of each month (except December) at 8 pm at The Briars Astronomy Centre, The Briars Historic Park, 450 Nepean Highway, Mount Martha.
Contact Peter Skilton 0419 253 252 <welcome@mpas.asn.au>.
PO Box 596, Frankston Vic 3199 www.mpas.asn.au

MOUNT BURNETT ASTRONOMICAL SOCIETY is open for members every Friday night from 7:30 pm. Contact Mount Burnett Observatory hotline 0490 130 153 <info@mtburnettobservatory.org>.
420 Paternoster Road, Mt Burnett, VIC 3781 mtburnettobservatory.org

SNAKE VALLEY ASTRONOMICAL ASSOCIATION meet and observe at the SVAA Clubroom at 825 Linton-Carngham Rd Snake Valley on the closest Friday to the New Moon each month.
c/o Snake Valley Post Office, Snake Valley Vic 3351
ballaratman.wix.com/svaa

WEST AUSTRALIA

ASTRONOMICAL SOCIETY OF THE SOUTH WEST has observing nights at their observatory south of Bunbury on the two Fridays before the New Moon. There is an active junior group which meets twice monthly.
Contact Phil Smith (08) 9721 1586
PO Box 1100, Bunbury WA 6231 www.facebook.com/ASSW.Inc

ASTRONOMICAL SOCIETY OF WESTERN AUSTRALIA meets at 8 pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como. Visitors most welcome. Contact <aswa@aswa.info>.
PO Box 421, Subiaco WA 6904 aswa.info

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. A perfectly reflecting body has an albedo of 1.0 or 100%. The average lunar albedo is 0.12 or 12%.

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

Almanac A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an ***Ephemeris***.

Altazimuth coordinates The angular height (***altitude***) of an object above or below the horizon and its angular direction (***azimuth***) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a body most distant from the Sun. It is the opposite to ***perihelion***.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to ***perigee.***

Arcminute An angular measure (each degree is divided into 60 arcminutes).

Arcsecond An angular measure. Each degree contains 3600 arcseconds, and each ***arcminute*** contains 60 arcseconds.

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See ***Minor Planet***.

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 au.

Azimuth Horizontal coordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the ***celestial sphere***.

Celestial poles Points on the ***celestial sphere*** directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth to which celestial bodies seem to be attached.

Circumpolar Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** it must have to be considered circumpolar.

Colour index The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a ***comet***, usually the brightest part. Also a defect in an optical system.

Comet Small icy body that orbits the Sun and produces a coma and often tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least ***angular separation*** as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

Conjunction — Inferior When an ***inferior planet*** (Mercury or Venus) passes between the Sun and the Earth.

Conjunction — Superior When the Earth and an ***inferior planet*** (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the Universe.

CST Central Standard Time.

Culmination The instant when a celestial body crosses the ***meridian***; an object culminates when it reaches its highest point above the observer's horizon.

Declination (Dec) One part of the equatorial coordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (–) of the ***celestial equator*** and is analogous to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how long or thin an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

Eclipse When one object passes in front of or into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the ***umbra***, and penumbral if the Moon passes only through the ***penumbra*** of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. It is total when the Moon has a larger ***angular diameter*** than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

Ecliptic The plane of the Earth's orbit projected onto the ***celestial sphere***. It can also be defined as the Sun's path against the stars.

Ellipse An oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

Elongation The ***angular separation*** of two bodies. The greatest elongations of Mercury and Venus occur when the planets are at their largest angular distance from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all coordinate data and is compatible with modern star atlases.

Equation of Time The difference between apparent and mean solar time.

Equinox The two times of the year when the Sun crosses the ***celestial equator***; vernal or spring equinox occurs about September 21, and autumnal equinox about March 22.

EST Eastern Standard Time.

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our ***galaxy***.

Galaxy A large disc or ball of billions of stars and ***nebulae***. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between First and Last Quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our ***galaxy*** and are seen in other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local ***meridian***.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually in reference to the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is, Mercury or Venus.

Julian date The number of days since noon on 1 January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the ***constellation*** of Dorado. From mid-southern latitudes the LMC is ***circumpolar***.

Librations The gentle rocking motion of the Moon as it orbits the Earth that allows observation of the side that normally faces away from our planet. In total, through this irregular motion fifty-nine percent of the Moon can be seen.

Light year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.5. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude –1 (except for the Sun which is –26.7). The faintest visible to the unaided eye are magnitude 6 (under dark skies).

Magnitude — absolute The magnitude a star would have if it were viewed from a distance of 10 ***parsecs*** (32.6 ***light years***).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The ***right ascension*** on the meridian equals local ***sidereal*** time.

Meteor (**also shooting or falling star**) A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of ***meteors*** that appear to originate from a small region of the sky (the radiant).

Meteor swarm (or ***stream***) ***Meteoroids*** grouped in a localised region in orbit around the Sun (the source of ***meteor showers***).

Meteorite A ***meteor*** that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet (***Asteroid***) Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Nadir The point on the ***celestial sphere*** directly opposite the ***zenith.***

Nebula A cloud of interstellar gas and dust. See also ***emission, reflection*** and ***planetary nebula.***

Node One of two points at which an orbit passes through a reference plane (usually the ***ecliptic***).

Oblateness The ratio of the difference of equatorial and polar radii to equatorial radius.

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 as viewed from Earth.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 ***light years***. A parsec is defined as the distance to a celestial body whose ***parallax*** is one arcsecond.

Penumbra Area of partial illumination in the shadow of a planet surrounding the ***Umbra***. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth. It is opposite to ***apogee.***

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to ***aphelion***.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. The outer layers of a red giant during the latter stages of its evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

Quadrature When two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

Reflection nebula A gas cloud illuminated by a nearby star.

Retrograde motion 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.

2. Apparent retrograde motion is the westward motion of a planet with respect to the stars. This occurs near ***opposition*** for the outer planets and near ***inferior conjunction*** for the inner planets.

Right ascension (RA) Part of the equatorial coordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is analogous to lines of longitude on the Earth but is measured in hours (24 hrs = 360°).

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23 hrs 56 m 4 s.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is ***circumpolar***.

Solstice The time when the Sun is farthest from the ***celestial equator***. In the Southern Hemisphere around 21 June marks the shortest day of the year, and around 21 December marks the longest day.

Spectral type A star's spectral classification determined by its ***spectrum***.

Spectrum The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The time that it takes for an object to reappear at the same point in the sky, relative to the Sun, as observed from Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the ***meridian***.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight — astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight — civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight — nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time (UT) A time system measured from the Meridian of Greenwich in England.

WST Western Standard Time.

Zenith The point directly overhead (90° in altitude).

Zenith Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the ***zenith*** with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the ***ecliptic*** (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

GREEK ALPHABET

α	Alpha	ε	Epsilon	ι	Iota	ν	Nu	ρ	Rho	φ	Phi
β	Beta	ζ	Zeta	κ	Kappa	ξ	Xi	σ	Sigma	χ	Chi
γ	Gamma	η	Eta	λ	Lambda	ο	Omicron	τ	Tau	ψ	Psi
δ	Delta	θ	Theta	μ	Mu	π	Pi	υ	Upsilon	ω	Omega

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Step outside and look up at the night sky. We are fortunate to live in Australia, where the stars of the Southern Hemisphere are spectacular. Does it leave you with a sense of wonder, wanting to know more about the heavens above? Then this book is for you.

Whatever your level of interest this publication has much to offer. Even if you are a beginner just starting your astronomical voyage, using nothing but your eyes, let this be your guide to:

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When will the Moon rise or set?

Which constellation is that?

What is that bright star?

ESTIMATING ANGLES IN THE SKY When 0.5m (20 inches) from the eye, each division on this scale corresponds to 1° of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°

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Drawings to easily identify the planets and stars

> *From its humble beginnings in 1990 to the splendid edition you hold today, this Yearbook has always been the outstanding Australian guide to the night sky. It's the perfect reference for newcomers and seasoned observers alike.*
>
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> *Australian Astronomical Observatory*

Quasar Publishing has been producing yearbooks since 1991. Astronomy 2018, the 28th edition, continues with the high standard established over the years. The authors have many years experience in observational astronomy, astronomical publications, public education and the amateur astronomical community. In 2009 the Astronomical Society of NSW awarded the authors McNiven Medals for excellence in astronomy.

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