# ASTRONOMY 2024

## AUSTRALIA

Ken Wallace
Glenn Dawes
Peter Northfield

YOUR GUIDE TO THE NIGHT SKY

# ASTRONOMY 2024
## AUSTRALIA

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Glenn Dawes Peter Northfield Ken Wallace

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# Astronomy 2024
# Contents

# INTRODUCTION TO THE 2024 EDITION

Welcome to Astronomy 2024, yes, thirty four years in the making.

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

- The upcoming solar maximum.
- Choosing an eyepiece.
- Amateur discovery of a Trans Neptunian Object's ring.
- James Webb Space Telescope's first year of operation.
- Prospects for Comet Tsuchinshan-ATLAS.

We continue to include most of the monthly information for November and December of the previous year.

Part I of Astronomy 2024 is intended as a general quick reference to observing the Solar System. 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, includes sections on the constellations, bright stars, places of interest, amateur societies and a glossary to explain some of the unavoidable jargon. You can also visit our website where you will find links to all of the sites listed in Part III of this book and other supplementary information. www.quasarastronomy.com.au

## The End is Nigh? (or end of night?)

This publication has been a hobby, a business, a nightmare, and an absolute pleasure. It has filled our lives with many rewarding adventures in the name of astronomy. Under the umbrella of publishing, we have been able to demonstrate our love for the night sky. We hope our pages have left a positive impression on our readers and inspired both beginners and experienced stargazers to discover the night sky.

The world is changing, we are aging, and the printed word is diminishing. Our future is uncertain at this stage. Over the years, we have been approached by advertisers and we have been in the fortunate position of being able to avoid assistance. This year, however, you will notice this is different. The decision to accept the offers ensured we could produce for another year. We have carefully selected advertisers who promote and encourage astronomy.

Due to these commitments, we had to break our long-standing tradition of using one of Joe Cauchi's wonderful images on page 1. We cannot thank him enough for his past contributions and encourage those who love his photographs to check out his website www.joecauchi.com.au for more astronomical beauty.

We can only hope that the decrease in our sales is due to increased online activity and not a decreased interest in stargazing, dimming, as the stars dim from increased light pollution, forcing amateur astronomers to search further afield for dark skies. We all know technology allows anyone to take breath-taking images, even under bright skies, but we're talking about observing here. Will the simple pleasure of standing under dark skies and drinking in the glorious sight of the Milky Way also go the way of printed matter? Will our descendants need to experience a massive power outage before they rediscover their birthright? Are we heading towards an Isaac Asimov 'Nightfall' concept – we hope not! (This brief tale can be enjoyed as an audiobook or listened to on YouTube).

Currently, we haven't made a final decision on whether to continue with our 2025 edition. Although we would like to, we cannot guarantee anything at this point.

To all our readers, stay well and keep stargazing!

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

# 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, in addition to optical aids, 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 struggle to understand the difference between the Sun, stars, planets or even galaxies. 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, e.g., summer, we are talking about the appearance of the evening sky, 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-latitude Northern Hemisphere locations, with all of the earliest recorded observations coming from Europe, England, the Middle East or Asia. 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. This is also the time of the year when the long nights give us *down under* more time to spend soaking up this panorama. 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

### 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 several layers of 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? There are free compass apps available, so just point your phone. Also, taking note of where the Sun sets to get a rough direction for west might help. Remember, 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 the device around the sky. All this is offered using red light to supposedly preserve your dark adaption. This sounds good but they can't avoid being backlit, which under these low light levels are blinding. We suggest using these devices to help plan your night, then, under the stars use this book, maps or 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 good but does it leave you exposed to strong wind, such as on hilltops? If you are low or near water, is fog a concern?

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. 6 or 8). Looking with just the eyes two things become apparent. First, how wide this central *milky* area (called the hub) appears 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 star-rich Carina 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 offers a view of other galaxies that belong to our local group. For example, the unique Magellanic Clouds. These are smaller galaxies passing nearby, which appear like detached portions of the Milky Way. They are easy to spot under dark skies, as normal clouds look black whereas the Large and Small Magellanic Clouds (LMC and 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 (see All Sky Map No. 1).

Low in the spring northern evening sky lies another member of our local group, the Andromeda Galaxy (M31). It has the distinction of being the most distant object easily visible to the unaided eye. Knowing that 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.

Dark skies also offer the opportunity to try and see the planet Uranus with the unaided eye (not easy). All Sky Map 3 and finder chart (p. 131) will help find this elusive distant member of the Solar System. Try around the time of opposition (in November) when it is slightly brighter than normal. Also, occasionally the minor planet 4 Vesta, when at opposition, can brighten sufficiently to be visible with the naked eye, as it did in 2018.

You can always go on a voyage of discovery. There is a good chance that any fuzzy object (unless it is a comet) will be a bright deep sky object and marked on the All Sky Maps (see pp. 84–93) and listed in 'Deep Sky Objects' (pp. 142–4). With any of these naked-eye objects, binoculars are very handy and open up a whole new perspective on the night sky (next page).

Try looking for 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 a grain 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 10 and a list of showers on page 139.

### 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 because there is a lot of it! We have found that this is one aspect 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. 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 a little over 8 light minutes.
- Average distance to Neptune from the Sun, about 4 light hours (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 120,000 ly across)
- The Magellanic Clouds, Large (LMC) is 165,000 ly and Small (SMC) is 200,000 ly.
- The most distant object easily visible to the naked eye, the Andromeda Galaxy 2,500,000 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 more 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. This makes reading star charts and making notes under red light important (see sidebar, A Few Tips for Beginners, p. 5). 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 a 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 originally called *aster planetes* (from the Greek meaning wandering star) as they continued 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 daylight we always recommend that you hide the Sun behind a tree or building.

When two celestial bodies appear visually close together it's called a conjunction. They can be quite attractive, especially those involving the brightest planets. Those between the thin crescent Moon and Venus or Jupiter are spectacular. An example this year is the meeting of the Moon and Venus on September 5 and between the Moon and Jupiter on April 11 (see Sky Views, pages 66 and 41).

Although not covered in the book, it's also fun looking for Earth-orbiting satellites. Remember these don't generate any light themselves, they reflect sunlight to be visible. Search for low orbiting satellites up to three hours after sunset or before sunrise where *they* can still *see* the Sun. Look 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. Current examples include the International Space Station (ISS), the Tiangong space station and the Hubble Space Telescope (HST). The Heavens Above website (www.heavens-above.com) can 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.

# 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 terrestrial pursuits. Such an investment can be a relatively 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 also 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 (maximum). A pair of 7 × 50

**BINOCULARS** have a multitude of uses in amateur astronomy. 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.
- Looking for 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 the Sun reflects off different surfaces. You can follow them further into the Earth's shadow before they disappear.
- Searching out Uranus and Neptune, using the finder charts, see pages 131 and 132 plus All Sky Maps 3 and 8.
- Observing bright comets.
- Looking at bright, wide double stars.
- Observing the moons of Jupiter as they oscillate across and behind the planet from night to night. See the diagrams on pages 120 to 125. 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 Maps, 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.
- 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.

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 to tilt the binoculars up. One method that may help is to find an obvious nearby bright star, or better still, a bright star pattern (called an asterism) and star-hop across. If your object isn't too high in the sky, you can try finding something on the horizon directly under it, like a distinctive tree outline, and move the binoculars up. Another method, that might take a little getting used to, is to stare intently at the area of the sky with your unaided eyes and then 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 overhead, 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 companion 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

One purpose of this book is to help you plan your nights under the stars. Think of it as offering a number of pieces of a picture, the nature of which will vary greatly depending on 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 also has its own introductory pages.

**The Moon**. Knowing the phase of the Moon is a good place to start. The calendar (p. 1) gives an overview for the year. 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 chart 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.

**Observing the Moon** (pp. 112–115). Viewing on or near 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 and dull picture which is not only a poor time to observe the Moon but it lights up the sky for the whole night, drowning out any nebulous objects including the most attractive galaxy of all, the Milky Way!

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 wobbles and nods in its orbit.

**The Planets**. Mercury, Venus, Mars, Jupiter and Saturn are naked-eye objects. Uranus can be challenging and Neptune requires at least binoculars. To get a quick overview of what is on offer, start with the **Visibility of the Planets** (p. 13). As an example we'll chose July. Mercury and Venus are in the evening sky and, in the morning sky we have Mars, Uranus, Jupiter, Neptune and Saturn. You will notice that Neptune and Saturn cross the midnight line in September, so both planets are close to opposition and up most of the night. The Rise–Set chart for September confirms this. Mercury crosses the Sun line in June showing it moving from the morning into the evening.

The **Appearance of the Planets** diagram (first page on each monthly section) gives the relative size and phase (where relevant) for the planets.

It is fascinating to watch **Mercury** as it quickly zips around the Sun. When this innermost planet is at superior conjunction, behind the Sun and out of sight (e.g., Feb 28) Mercury is small with a full phase (a Full Moon shape). It then enters the evening sky growing in size with its phase waning as it approaches inferior conjunction (between us and the Sun) on April 12. Mercury then enters the morning sky with a thin sliver phase and the process reverses until superior conjunction is reached again (Jun 15). It is best to observe this 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 greatest height in the sky, for example, when Mercury is in the evening sky on July 22 it's at a greatest elongation east. Notice how quickly it gains altitude as it passes Regulus (Sky View page 56).

Its fellow inner world **Venus** goes through the same process as Mercury but much slower, being further from the Sun. In 2024, following a superior conjunction in early June, it begins rising in the evening sky, which continues until it reaches greatest elongation east in January 2025, when it then begins to drop back to Sol towards an inferior conjunction in late March 2025. All this time it grows in size with its phase decreasing. This can be followed in the monthly Appearance of the Planets diagrams.

**Mars** only achieves a reasonable size when near opposition, a time when features such as a polar ice cap and various surface marking are easier to see. 2024 opens with its disc around 3.9 arcseconds (") in diameter (magnitude 1.4) having just been in conjunction in November 2023. The Red Planet continues to grow, reaching opposition on January 16, 2025 with a diameter of 14.6" and magnitude –1.4.

**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 77) confirms that this happens for Jupiter in early December (which can also be gleaned from the Visibility of the Planets, page 13). Besides observing its atmospheric belts, the **Great Red Spot (GRS)** is worth looking for; see the table and explanation on pages 126 to 127. An example is the evening of January 12 at 10:26 pm (EST) or 11:26 pm including daylight saving. This transit is visible from anywhere in Australia (indicated by *).

Pages 119–125 cover the **Jovian Satellite Phenomena** as the four major moons shuttle 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 early morning of December 30, the diagram on page 125 shows this well. In this case there is also a drawing on page 82. The *wiggly* diagrams also show instances where a moon's line crosses over (a transit) or behind (an occultation) the Jupiter lines. An example explains this well. On the evening of January 26 there is an occultation of Io followed by an occultation of Europa (both moons passing behind Jupiter), leaving only two moons visible for just over a couple of hours.

**Saturn**, with its impressive ring system (obviously closing this year, being next edge-on in March 2025) is spectacular in any telescope. It 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. Pages 128 and 129 show a worked example of how to identify their configuration for your date and time. There are also Sky Views in August and September giving illustrations of some actual configurations. The worked example for September 22 is also graphically presented on page 66.

**Uranus** and **Neptune** (p. 131 and 132 respectively) can be challenging but are still considered visible in binoculars provided you know where to look. That is why the separate finder charts are needed for these distant planets. To identify four of Uranus' moons and Neptune's Triton, a similar calculation to Saturn is used, with worked examples on these pages.

**Minor Bodies of the Solar System**

The monthly sections give dates for opposition of the brighter **minor and dwarf planets**. Observing notes are also presented for prominent **comets**. Positions in the sky of the brightest comets and minor planets are presented on pages 135 to 138. These can be plotted on the All Sky Maps. As an example we'll look at minor planet 2 Pallas on its opposition date. The May monthly text (p. 43) has the minor planet reaching opposition on the 20th at magnitude 9.1 in Hercules. Page 140 tells you Hercules is on All Sky Maps No 7 and 9. The ephemerides (page 138) when plotted on Map 7 (interpolating between the positions given for 18th and 25th) gives the location on this date about 5° north of the star Beta (β) Herculis (approaching the border with Corona Borealis).

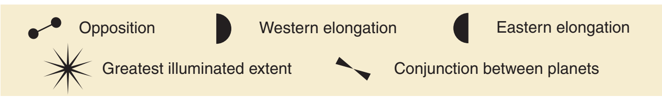
Let's assume it's the evening of February 13 and you wish to find Comet 144P/Kushida. Part I text (page 29) says the comet "… *spends the month in Taurus, rising in daylight, transiting in the northern sky shortly after sunset, then setting in the western sky around midnight*". The Rise–Set chart and Moon section for February, shows that the Moon is three days after New Moon, setting around 9:30 pm. With the comet setting around midnight, there should be a brief window late in the evening to see the comet under dark skies. The ephemerides (p. 137) shows it may be around magnitude 9.7. Carrying out the same exercise with its position (RA and Dec), like the minor planet (above) Map 3 is needed. Interpolating between February 10 and 17, the comet is around 3° east of the bright star Aldebaran. In this case, plotting the position is unnecessary, for we have already done this for all the known bright comets (when expected magnitude is brighter than 10) on the All Sky Maps.

**Meteors** (Shooting Stars). Part I gives the best meteor showers for the year. 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 might be the only person to see it. Awesome!

# THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

### Rise–Set Chart




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

These charts give approximate local standard time not taking into account daylight saving (if in force, add one hour).

### Highlights

This lists a few interesting events during the month.

### The Moon

This provides information on major events relating to the Moon. Included are the Moon's phases, apogee, perigee, libration, occultation of planets, minor planets or bright stars and lunar and solar eclipses.

### 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, 59% of the surface can be viewed due to 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 significant. Firstly, the Moon suffers from a longitudinal wobble; as the Moon approaches perigee its motion through space speeds up, faster than its rotation, and so it does not turn quickly 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.

### 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-like images but you may be surprised how much 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. Each image is shown north up with a date, the planet's angular diameter and magnitude.

### The Planets

Presented are general notes on each planet, including its location in the sky and the 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 mainly deals with Ceres, being far brighter than other dwarf planets.

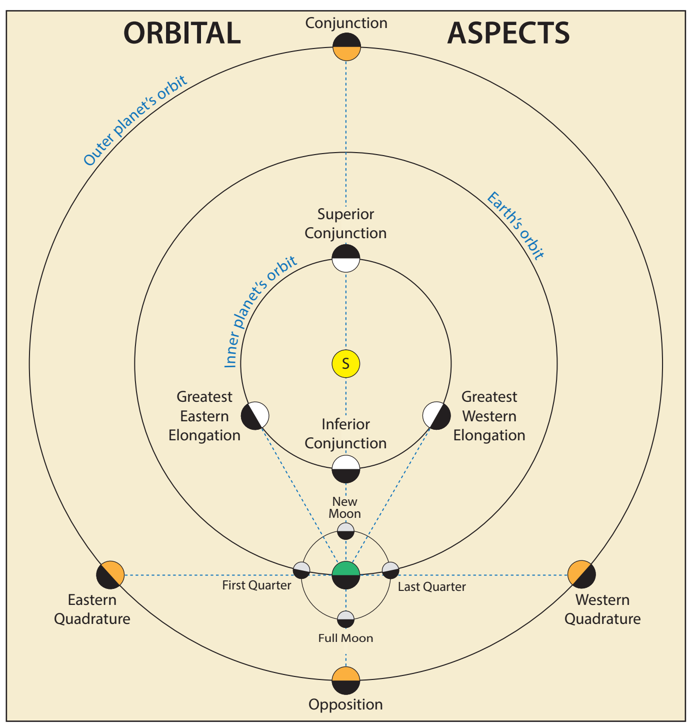
**Minor Planets (or Asteroids)** This covers the brightest asteroids that reach opposition each month (12.7 magnitude or brighter). An entry includes the date of opposition (when near brightest), its magnitude and the constellation the asteroid is in at this time. The 15 brightest dwarf and minor planets have ephemerides included in Part II (p. 138). A number also have selected conjunctions included in the Diary in Part I. The period considered for the conjunctions in the Diary was three months either side of opposition (if it's brighter than 11.0 magnitude throughout) and Ceres, Pallas, Juno and Vesta for the whole year except when near solar conjunction (within 18° of the Sun).

### Comets

This section deals with the brightest comets expected to be visible during the year. Although most of the known comets returning this year are faint you never know what will be discovered tomorrow. For further information, including ephemerides, see pages 133 to 137 in Part II.

### 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 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 in the Southern Hemisphere this year. A comment is made when the Moon could potentially interfere 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.

**Constellations**

This is a general discussion on the constellations, stars and deep sky objects visible during the month, concentrating on the evenings when most people are out gazing at the night sky.

**Feature Articles**

This section covers 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, meteor showers 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. Times are rounded to the nearest hour. We don't 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. Occasionally 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

## 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 19$^{th}$ century for Ceres' demotion to a minor planet, which is now considered a dwarf.

**Minor Planet** (asteroids) 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 –4.5 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 phase of a planet or the Moon is gibbous when more than fifty percent, but less that one hundred percent of it is illuminated. For example, aside from Full Moon, the Moon is gibbous between First and Last Quarter.

**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 fully end until the Sun is 18° below the horizon, when *astronomical* twilight ends. This happens about 90 minutes after sunset (or before sunrise) but it does vary with latitude. Only then is the sky considered truly dark (assuming the Moon is not up). See also civil and nautical twilight in the glossary.

**Culmination** When an object culminates it has reached its highest point in the sky, this 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 due south.

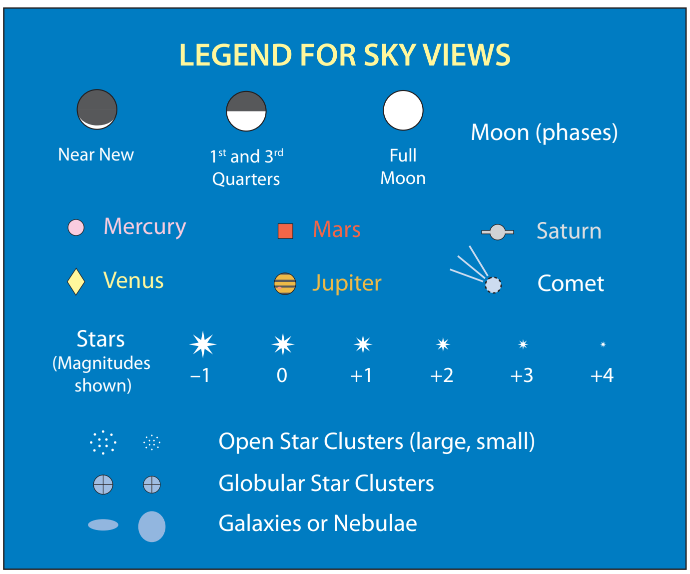
never wanders more than 28° from our star. Sky Views which show a twilight view after sunset are called Evening Twilight and morning twilights are Dawn Sky. Those before midnight are Evening Sky and after midnight, Morning Sky.

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 an object in 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 star pattern.

**Saturn and Jupiter Satellites**. Both planets have diagrams for months close to their opposition (Saturn in September and October, Jupiter in November and December in 2024). Only the brightest moons are included. There are key differences between these planets worth keeping in mind.

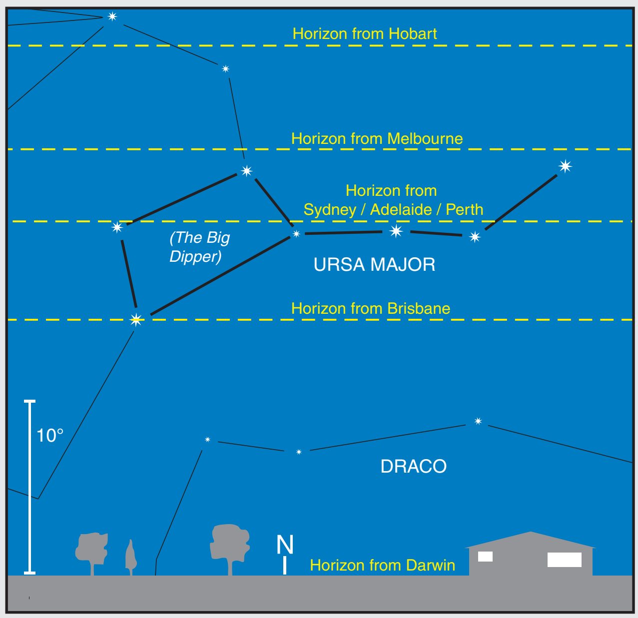
The plane of the orbits of Jupiter's moons is close to the Earth's orbital plane, so we see them shuttle back and forth in straight lines, passing in front of and behind the planet and even in and out of its shadow. Of the bright four Galilean moons, the most distant satellite, Callisto is the exception which spends many years (including 2024) passing over or 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 rings. The further out the satellite is, the larger the ellipse will be. 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.




**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.

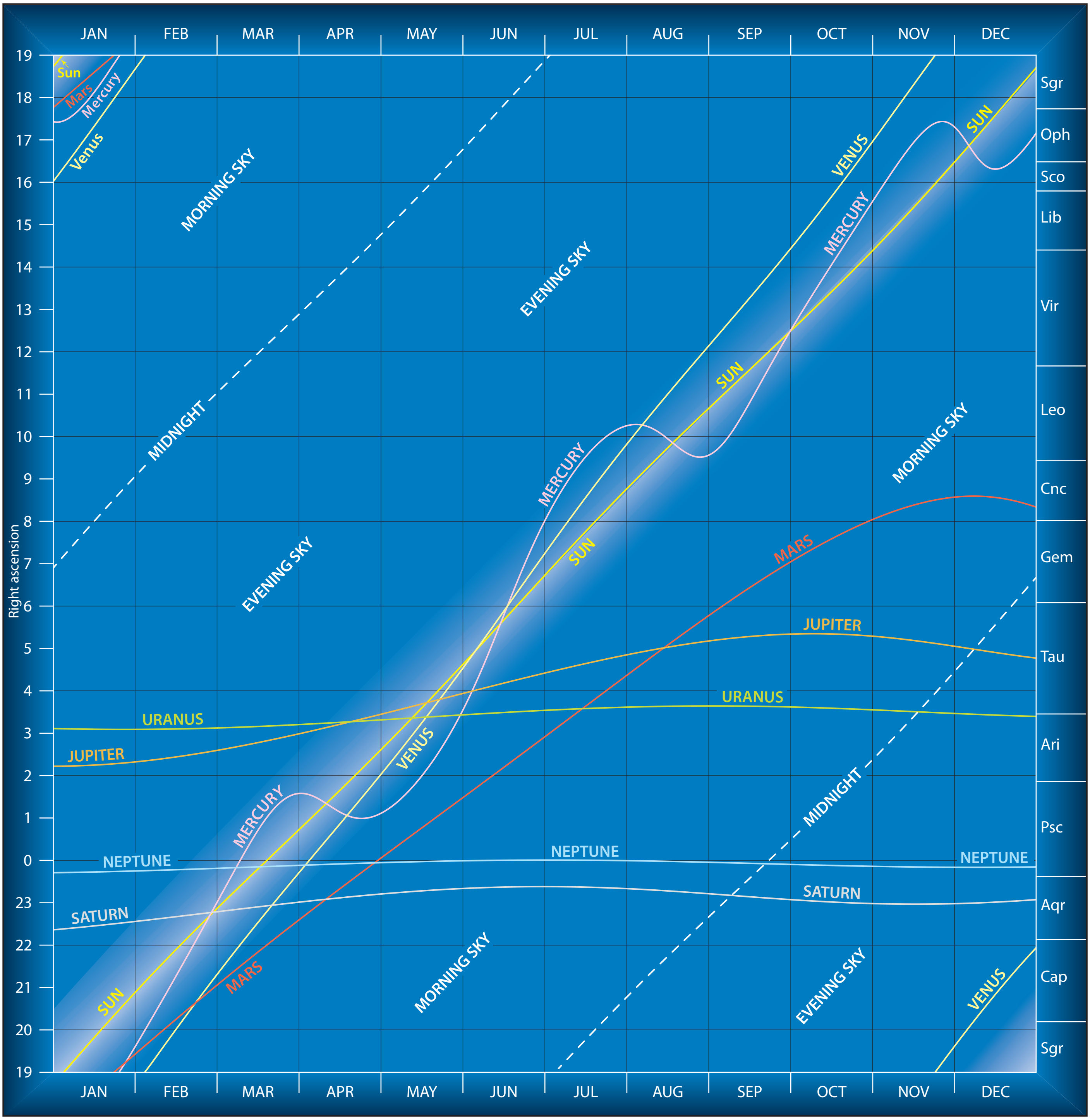
When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST); the mean solar time on the meridians of longitude 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from EST times given. Any specific times given for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

**Uranus and Neptune** 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 at least binoculars. 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.




**EFFECT OF LATITUDE** The Sky Views have been drawn for a latitude of about 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 will see that are 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



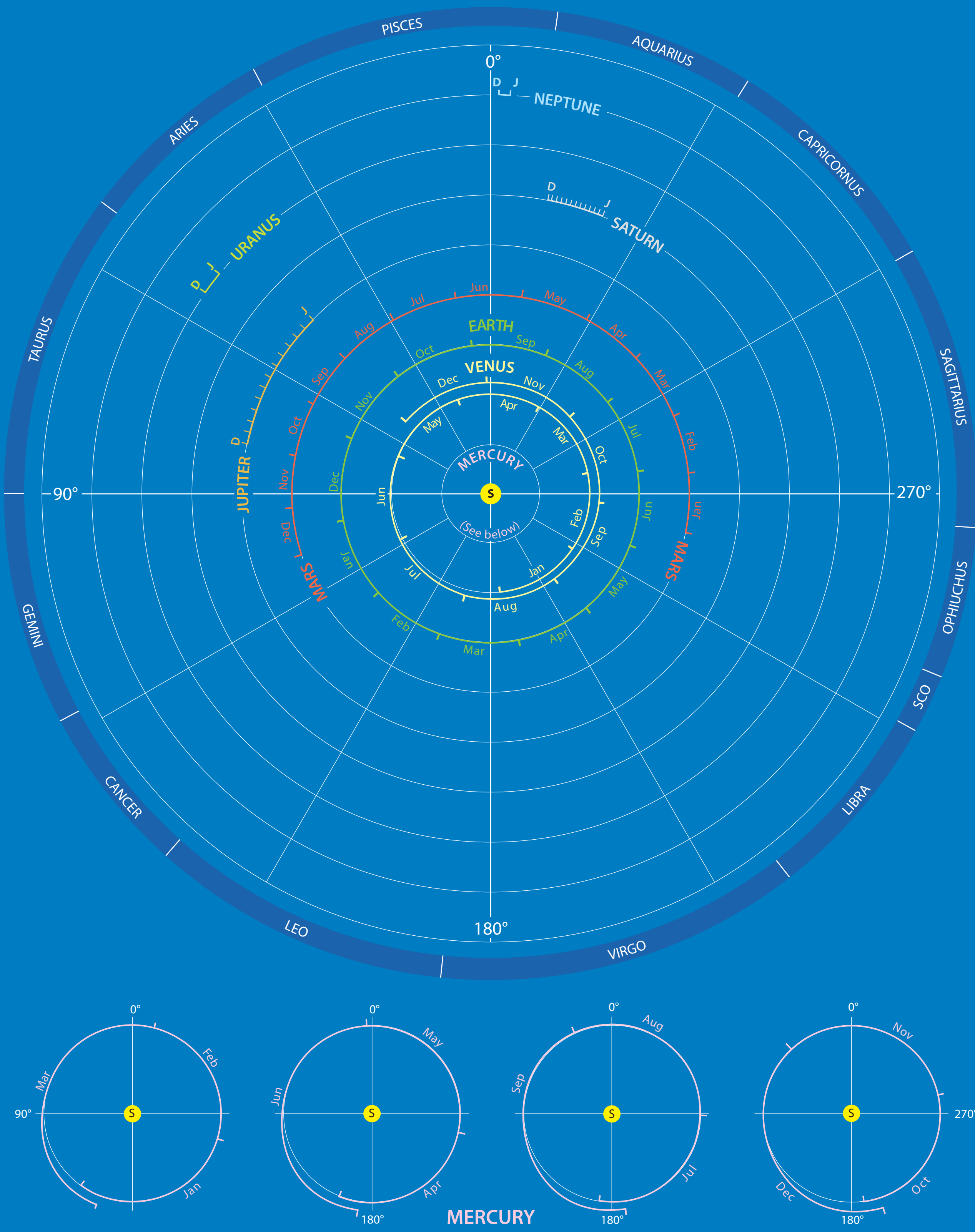

This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation 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. Mars, for example, is in Gemini (Gem) in September and October morning skies (also see All Sky Map 5).

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 ideal time to observe these inner planets is when their paths extend beyond twilight. For Mercury, the best period in the evening sky occurs in July. For optimum morning returns, May is best.

Early in the year, Venus is in the morning sky, eventually reaching conjunction around early June before spending the rest of the year in the evening, slowly gaining altitude.

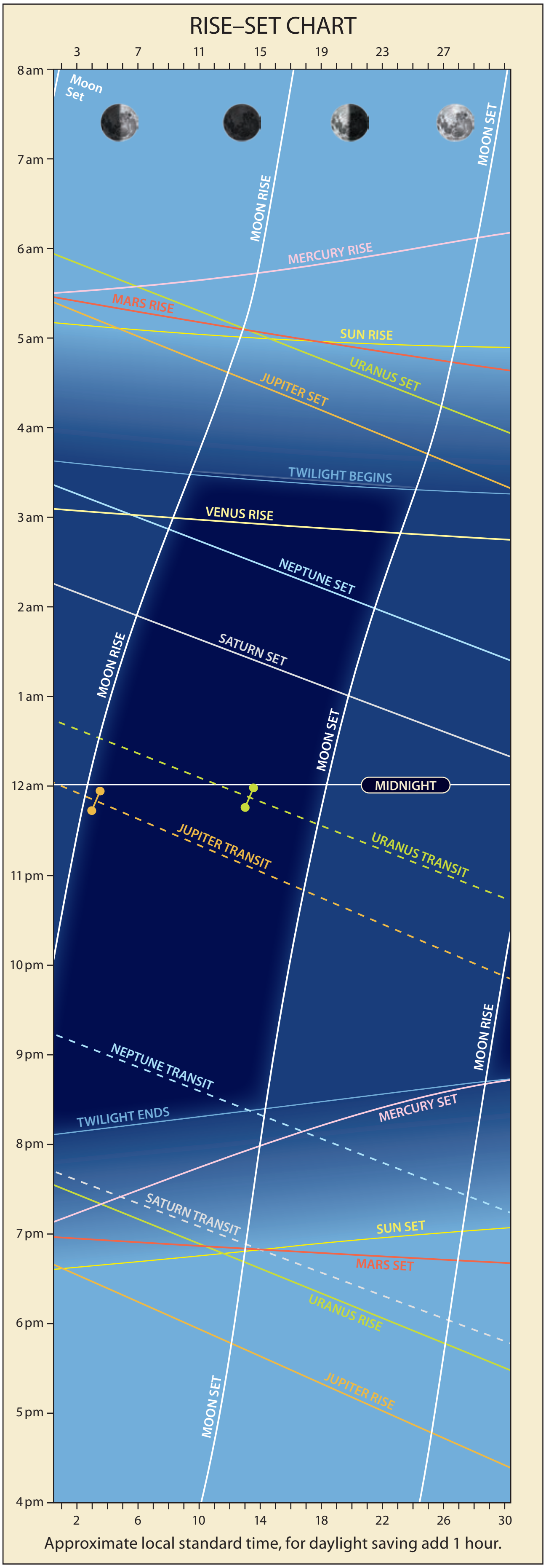
When an outer planet crosses a midnight line, it is at opposition and visible the entire night, and when crossing the Sun line, it is in conjunction. The diagram also shows conjunctions between the planets. When two planet lines cross or are close, they will be near each other in the sky. A fine example this year is Jupiter and Mars in the August morning sky (see Sky View p. 61).

# PLANET POSITIONS




This diagram illustrates the relative positions of the planets during the course of their orbits in 2024. The relationships between the major Solar System bodies are clearly shown. The diagram is drawn as viewed from above (north of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the Sun and planet distances are not drawn to scale. The thirteen named constellations are those situated on the ecliptic.

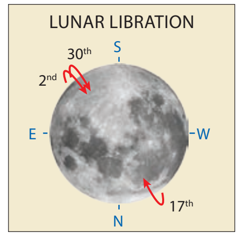
# NOVEMBER 2023




## HIGHLIGHTS

- Jupiter at opposition.
- Uranus at opposition.
- The Leonids meteor shower.

## THE MOON




2nd 9 pm (7 pm WST) Maximum Libration (8.6°), dark SE limb.

5th 7 pm (5 pm WST) Last Quarter.

7th 8 am (6 am WST) Moon at apogee (furthest from Earth at 404,569 km).

13th 7 pm (5 pm WST) New Moon.

17th 11 am (9 am WST) Maximum Libration (7.5°), dark NW limb.

20th 9 pm (7 pm WST) First Quarter.

22nd 7 am (5 am WST) Moon at perigee (closest to Earth at 369,818 km).

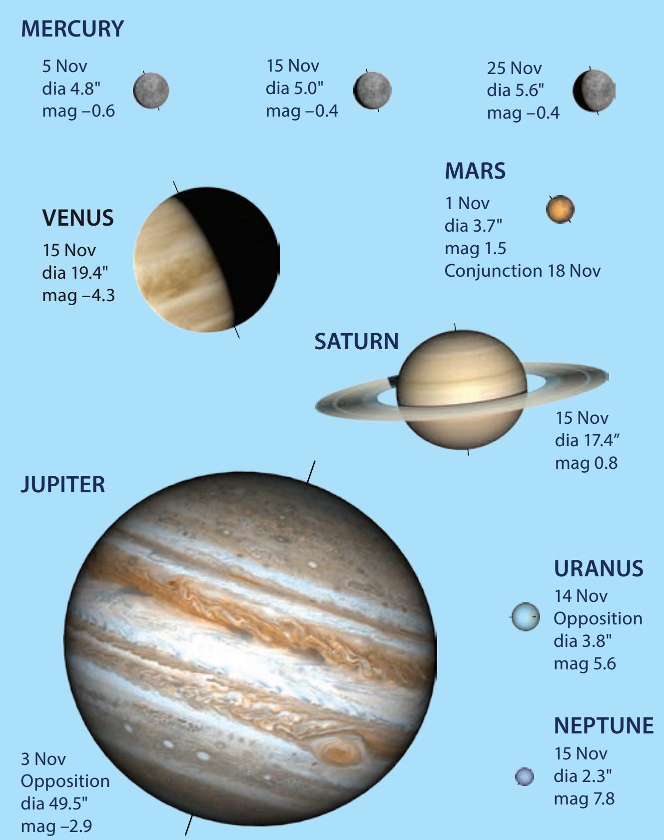
27th 7 pm (5 pm WST) Full Moon.

30th 2 pm (Noon WST) Maximum Libration (8.0°), dark SE limb.

## THE PLANETS

**Mercury** returns to the western evening dusk after its solar conjunction last month. It is visible from mid-month as it moves across several constellations and finally ends up near the galactic centre region of Sagittarius.

## APPEARANCE of the PLANETS



Visible in the early morning dawn sky, **Venus** moves from Leo to Virgo this month. On the 10th, the planet will be 4° from the 26-day old waning crescent Moon (see Sky View).

**Mars** is in conjunction with the Sun on the 18th and will not be visible until its reappearance in the morning sky during late January in Sagittarius.

**Jupiter** comes to opposition on the 3rd and is brilliant above the eastern horizon after dusk in Aries. As the planet orbits the Sun once every 11.9 years, oppositions occur every 399 days or 13 months. At –2.9 magnitude, Jove is the brightest object in the evening sky aside from the Moon. The equatorial diameter at this apparition is 49.5 arcseconds, very close to the largest that the gas giant ever gets from our viewpoint. The smallest of telescopes will show detail on the planet. Look for the polar flattening, changing cloud bands and the massive ancient storm known as the Great Red Spot (GRS). Keep in mind that things move fast on Jupiter with its 10-hour rotation period, and the GRS is best observed at the time of meridian passage or at most an hour on either side. In the late 19th century, the length of the GRS was about 48,000 km, and since then, it has been shrinking. The Voyager spacecraft measured the spot's length at 23,000 km in 1979, and since 2012 it has become more circular and has continued to decrease in size (16,000 km in 2014). On the 25th, the 13-day old waxing gibbous Moon will be close to Jupiter (see Sky View).

**Saturn** is visible in the early north-western evening sky in Aquarius. The planet ends 4.5 months in retrograde early this month, resuming its west to east motion against the stellar background. On the 23rd, Saturn is at a point in its orbit known as eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 10). Saturn will be at its highest altitude as the Sun sets in the west. It is also a favourable time to view the maximum shadow of the planet's globe cast onto the rear of the rings, giving Saturn a 3-D appearance. On the 20th, the ringed world will be near the First Quarter Moon (see Sky View).

**Uranus** comes to opposition on the 14th, rising in the early evening eastern sky and visible the entire night. This outer ice giant has a couple of odd features; firstly, it is the only planet named after a Greek God (all the others are Roman gods). Secondly, it has an axial tilt of 98°, meaning it practically spins on its side as it orbits the Sun; presently, and until 2030, the planet's south pole is pointed toward Earth. Uranus' apparent diameter is a little less than 4 arcseconds at this opposition, and at 5.6 magnitude, it is within naked-eye visibility (under dark skies, without the Moon). The planet shows no distinguishable atmospheric features through a telescope, but observers (even with small instruments) will immediately notice its disc and blue-green colour.

**Neptune** appears high in the early northern evening at the end of astronomical dusk. The planet crosses into Aquarius briefly at month's end before returning to Pisces early next month. The Moon is a little over a degree away on the 22nd.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag |
|---|---|---|---|
| 3 Nov | 21 Lutetia | Aries | 10.0 |
| 6 Nov | 18 Melpomene | Eridanus | 8.1 |
| 15 Nov | 409 Aspasia | Aries | 11.2 |
| 16 Nov | 387 Aquitania | Eridanus | 12.1 |
| 23 Nov | 24 Themis | Taurus | 11.3 |
| 25 Nov | 65 Cybele | Taurus | 12.3 |
| 27 Nov | 346 Hermentaria | Taurus | 10.7 |

Continued on page 20

### DIARY

| | | | |
|---|---|---|---|
| Thu | 2nd | | m.p 11 Parthenope 0.6° N of NGC 6642 (GC) in Sagittarius |
| Thu | 2nd | 9 pm | (7 pm WST) Maximum Libration (8.6°), dark SE limb. |
| Fri | 3rd | am | Comet C/2021 S3 (PANSTARRS) 1.0° S of NGC 3706 (G) in Centaurus |
| Fri | 3rd | | Jupiter at opposition |
| Sat | 4th | | m.p. 11 Parthenope 1.0° N of M22 (GC) in Sagittarius |
| Sun | 5th | | Saturn 1.4° NE of star Iota Aquarii |
| Sun | 5th | 7 pm | (5 pm WST) Last Quarter Moon. |
| Mon | 6th | | Venus 0.4° N of star Beta Virginis |
| Mon | 6th | pm | m.p. 88 Thisbe 0.3° NE of star Gamma Piscium |
| Tue | 7th | 8 am | (6 am WST) Moon at apogee (furthest from Earth at 404,569 km). |
| Thu | 9th | | Venus 1.0° SW of NGC 4073 (G) in Virgo |
| Fri | 10th | 4 am | (2 am WST) Venus 4° W of Moon |
| Mon | 13th | | Venus 0.3° NW of star Eta Virginis |
| Mon | 13th | | Northern Taurids meteor shower, Oct 20 to Dec 10, Moon affected after about 4 am. |
| Mon | 13th | am | m.p. 4 Vesta 1.0° S of star Nu Geminorum |
| Mon | 13th | 7 pm | (5 pm WST) New Moon. |
| Mon | 13th | pm | m.p. 135 Hertha 0.6° SE of NGC 514 (G) in Pisces |
| Tue | 14th | | Uranus at opposition |
| Wed | 15th | am | Comet 62P/Tsuchinshan 1 1.0° N of M44 Beehive Cluster (OC) in Cancer |
| Thu | 16th | am | Comet 62P/Tsuchinshan 1 1.0° S of star Gamma Cancri |
| Fri | 17th | 11 am | (9 am WST) Maximum Libration (7.5°), dark NW limb. |
| Sat | 18th | | Venus 1.0° SW of star Gamma Virginis |
| Sat | 18th | am | Leonids meteor shower, Nov 6–30. |
| Sat | 18th | | Mars in conjunction with Sun |
| Mon | 20th | | Venus 0.1° N of NGC 4691 (G) in Virgo |
| Mon | 20th | 9 pm | (7 pm WST) First Quarter Moon. |
| Mon | 20th | Midn | (10 pm WST) Saturn 2° N of Moon |
| Tue | 21st | am | Comet C/2021 S3 (PANSTARRS) 0.4° N of NGC 4373 (G) in Centaurus |
| Tue | 21st | | Ceres in conjunction with Sun |
| Wed | 22nd | am | Alpha-Monocerotids meteor shower, Nov 15–25, Moon affected until about 1 am. |
| Wed | 22nd | 7 am | (5 am WST) Moon at perigee (closest to Earth at 369,818 km). |
| Wed | 22nd | 8 pm | (6 pm WST) Neptune 1° W of Moon |
| Sat | 25th | 9 pm | (7 pm WST) Jupiter 3° S of Moon |
| Sun | 26th | 8 pm | (6 pm WST) Uranus 4° S of Moon |
| Mon | 27th | 7 pm | (5 pm WST) Full Moon (380,485 km). |
| Mon | 27th | pm | Lyrids meteor shower, Apr 16–25, Moon affected. |
| Wed | 29th | am | Comet C/2021 S3 (PANSTARRS) 0.3° SW of NGC 4767 (G) in Centaurus |
| Wed | 29th | 3 am | (1 am WST) star Spica 4° S of Venus |
| Thu | 30th | 2 pm | (Noon WST) Maximum Libration (8.0°), dark SE limb. |
| Thu | 30th | pm | m.p. 8 Flora 1.2° NW of star Delta Aquarii |

## Jupiter's Satellites for November 2023

1 arc min.

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

**Nov 1, 1 am EST ( 11 pm 31st WST)**

Ganymede · Io · Europa · Callisto →

Europa and its shadow have egressed from transit in the last hour. Io will be eclipsed later in the morning.

**Nov 5, 11 pm EST ( 9 pm WST)**

Callisto · Europa · Io · Ganymede

All Galilean satellites gathered on the western side of Jupiter.

**Nov 15, 1 am EST ( 11 pm 14th WST)**

Ganymede · Europa · Callisto · Io

An interesting arrangement of the moons showing we are not currently close enough to the plane of Callisto's orbit to see it transit. Europa and its shadow will complete a transit later in the morning.

**Nov 17, midnight EST ( 10 pm WST)**

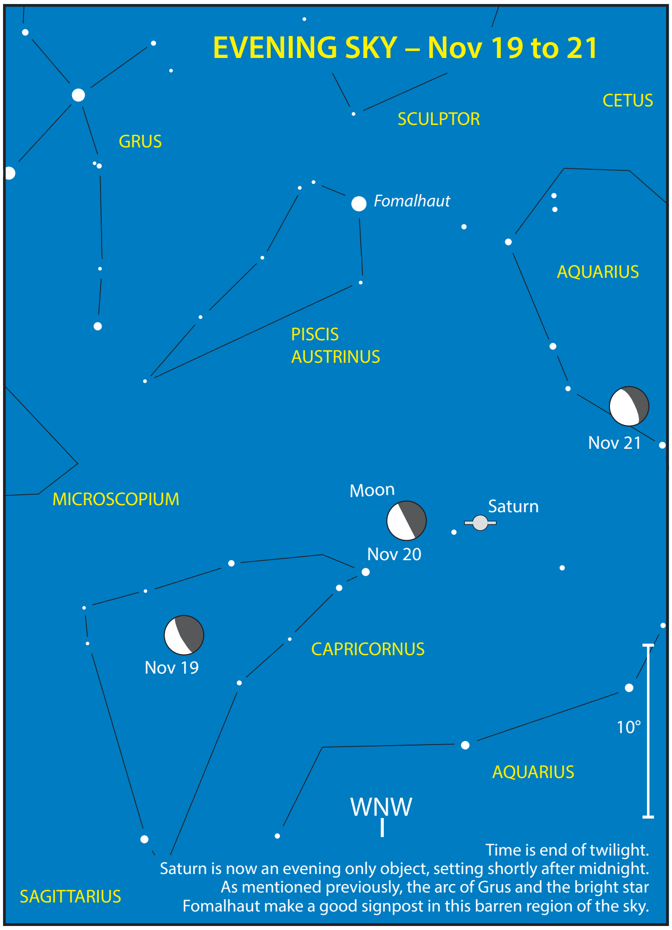
Europa · Ganymede · Io & Shadow · Callisto →

Io and its shadow are currently in mid-transit after ingressing in the previous hour.

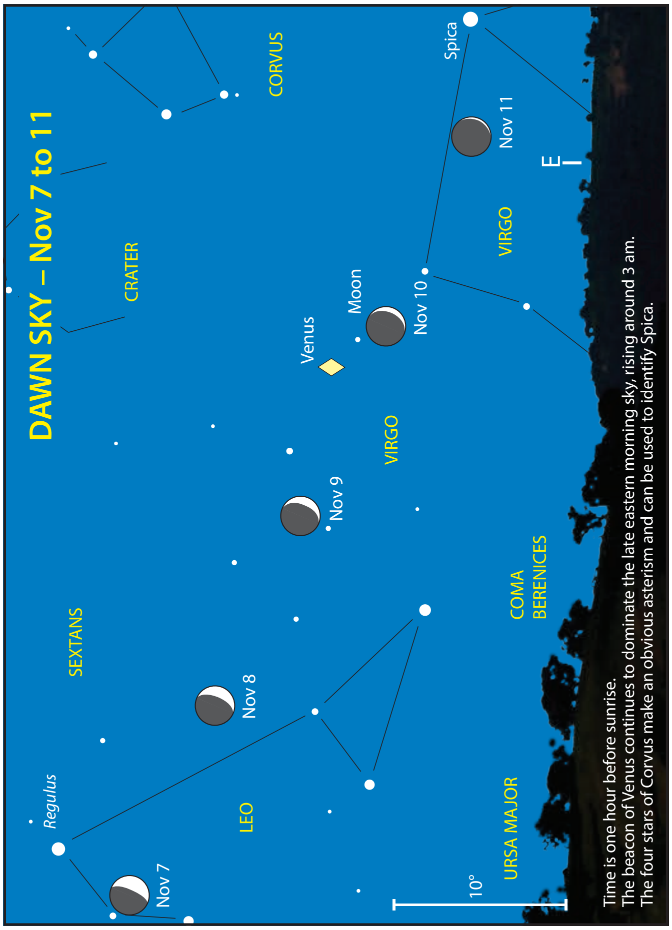
**Nov 25, 9 pm EST ( East Only)**

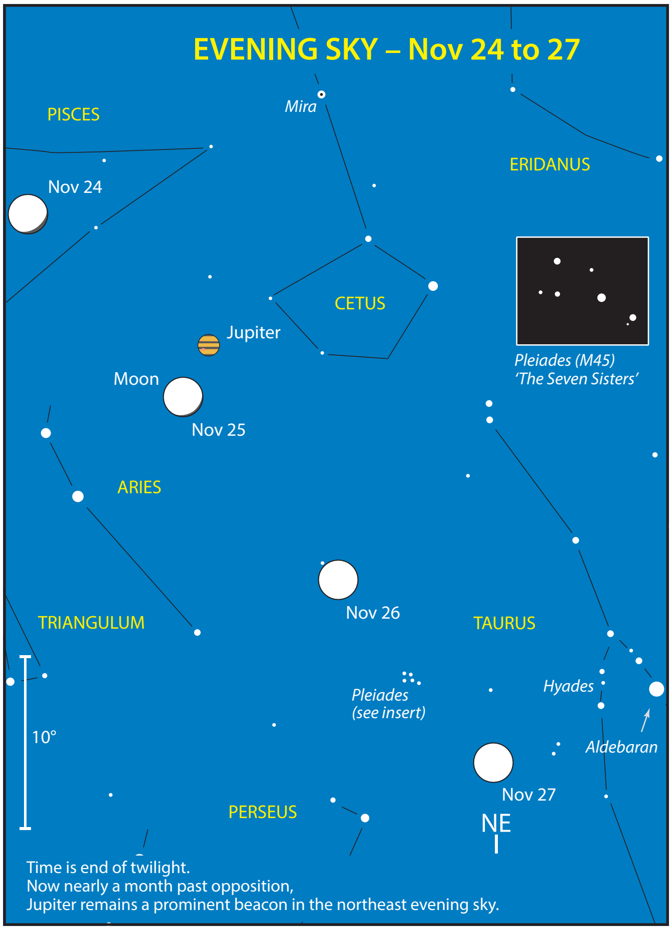
← Callisto · Io · Ganymede · Europa & Shadow

Europa has recently emerged from transit with its shadow to follow shortly. Io will be occulted by Jupiter in around an hour.



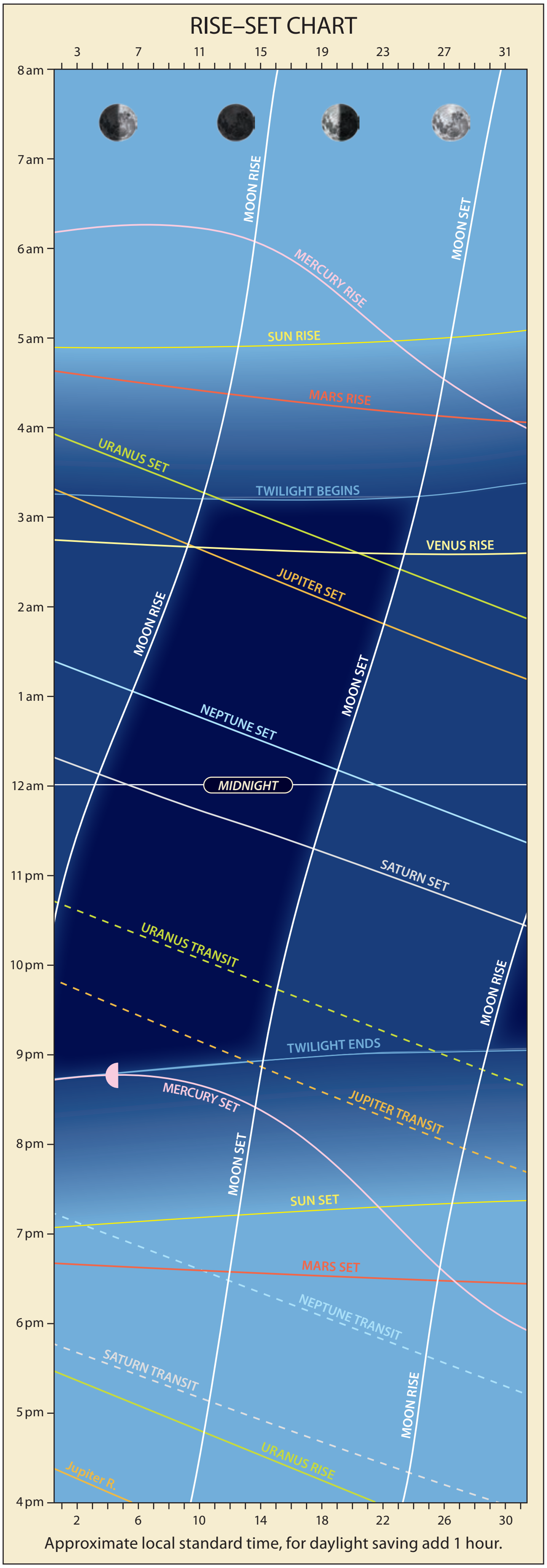

Approximate local standard time, for daylight saving add one hour.




NOVEMBER 2023

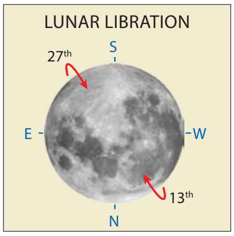
# DECEMBER 2023




## HIGHLIGHT

- The Geminids meteor shower.

## THE MOON




5th 5 am (3 am WST) Moon at apogee (furthest from Earth at 404,346 km).

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

13th 10 am (8 am WST) New Moon.

13th Midnight (10 pm WST) Maximum Libration (7.4°), too close to New Moon to observe.

17th 5 am (3 am WST) Moon at perigee (closest to Earth at 367,901 km).

20th 5 am (3 am WST) First Quarter.

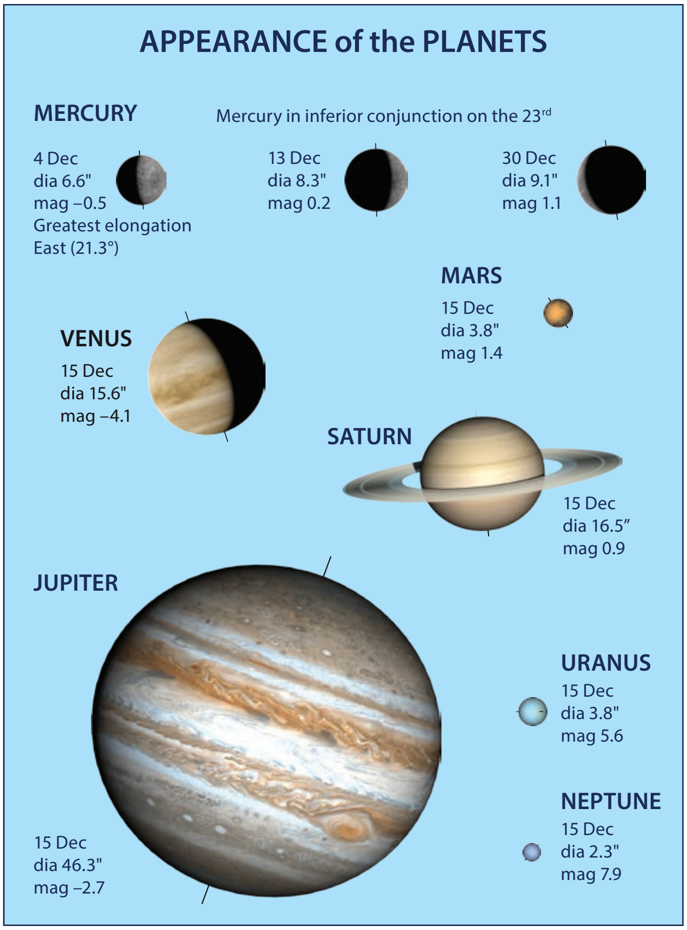
27th 11 am (9 am WST) Full Moon.

27th 8 pm (6 pm WST) Maximum Libration (7.8°), Full Moon.

## THE PLANETS

**Mercury** is visible in the western evening dusk sky. It reaches its greatest elongation of 21° east of the Sun on the 4th. The planet then loses altitude as it moves back toward the Sun and inferior conjunction (between Earth and the Sun) on the 23rd, returning to the morning dawn at month's end. On the 14th, the planet will be 5° below and north of the 2-day old slim waxing crescent Moon (see Sky View).

Visible in the early pre-dawn sky, **Venus** moves from Virgo to Libra this month. On the 10th the planet will be within 4° of the 26-day old waning crescent Moon (see Sky View). On the 17th



and 18th, Venus will be 2° from Alpha Librae, the second brightest star in Libra (despite its designation, the beta star of Libra is more brilliant than its alpha). Alpha[1] and Alpha[2] form a splendid wide double pair of 3rd and 5th magnitude suns at a wide 4 arcminutes, with a contrasting yellow and pale blue colour.

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** remains too close to the Sun for observation. However, it will reappear in the morning sky during late January in Sagittarius.

Now past opposition, **Jupiter**, in Aries, is visible in the early north-eastern evening sky. The prominent summer constellations of Taurus and Orion are now extending back toward the east. The King of Planets is always fascinating to observe; besides the to-and-fro dance of the four Galilean moons, there are changes in the planet's atmosphere worth looking for. The most obvious and easiest to identify features on Jove are the dark north (NEB) and south equatorial (SEB) belts. At first glance, an inexperienced observer may see the two belts as straight bands across the disc. However, with steady seeing, short-term protuberances, gaps, and bright and dark spots are all visible within the bands. With Jupiter's rapid 10-hour rotation, things move quickly, and a feature noted in a belt will move perceptibly in half an hour. On the 22nd, the 10-day old waxing gibbous Moon appears near the planet (see Sky View).

**Saturn** is visible in Aquarius in the western sky at the end of dusk. Aside from the 1st magnitude star, Fomalhaut (Alpha Piscis Austrini), in neighbouring Piscis Austrinus, the planet is the brightest object in a region devoid of bright stars. Although not real close, the waxing crescent Moon enhances the western view with Saturn on the 17th and 18th (see Sky View).

**Uranus**, now past opposition, is in the northern evening sky at the end of astronomical twilight in Aries, transiting the meridian around 9:30 pm mid-month. Most amateur astronomers would have seen Mercury, Venus, Mars, Jupiter, and Saturn with the unaided eye or through a telescope. But to complete a planetary tour of the Solar System, one must observe the remaining two outer ice giants. They are not difficult to locate under a dark sky, and you can cross them off your bucket list.

**Neptune**, in Aquarius, comes to the end of five months in retrograde on the 7th and appears high in the early north-western evening sky at the end of astronomical dusk. The planet had a brief sojourn into Aquarius late last month, but its west to east motion brings it back into Pisces mid-month.

| DIARY | | | |
|---|---|---|---|
| Fri | 1st | pm | m.p. 704 Interamnia 1.0° SE of M37 (OC) in Auriga |
| Sat | 2nd | am | Phoenicids meteor shower, Nov 28 to Dec 9, Moon affected. |
| Tue | 5th | | Mercury at greatest elongation East (21.3°) |
| Tue | 5th | 5 am | (3 am WST) Moon at apogee (furthest from Earth at 404,346 km). |
| Tue | 5th | 4 pm | (2 pm WST) Last Quarter Moon. |
| Thu | 7th | | Mercury 0.3° S of M28 (GC) in Sagittarius |
| Thu | 7th | am | Comet 62P/Tsuchinshan 1 0.7° NW of star Eta Leonis |
| Fri | 8th | | m.p. 15 Eunomia 0.1° NW of star Beta[1] Capricorni |
| Fri | 8th | | Mercury 0.3° N of star Lambda Sagittarii |
| Fri | 8th | am | Puppid-Velids meteor shower, Dec 1–15. |
| Sat | 9th | | m.p. 3 Juno 1.1° SW of NGC 3521 (G) in Leo |
| Sun | 10th | am | Comet C/2021 S3 (PANSTARRS) 0.6° S of star d Centauri |
| Sun | 10th | 3 am | (1 am WST) Venus 3° N of Moon |
| Mon | 11th | | Saturn 0.3° NE of star 42 Aquarii |
| Tue | 12th | pm | m.p. 5 Astraea 0.5° S of star Gamma Geminorum |
| Wed | 13th | | Mercury 0.2° W of M22 (GC) in Sagittarius |
| Wed | 13th | 10 am | (8 am WST) New Moon. |
| Wed | 13th | Midn | (10 pm WST) Maximum Libration (7.4°), too close to New Moon. |
| Thu | 14th | am | Geminids meteor shower, Dec 4–17. |
| Sun | 17th | 5 am | (3 am WST) Moon at perigee (closest to Earth at 367,901 km). |
| Sun | 17th | 10 pm | (8 pm WST) Saturn 8° NE of Moon |
| Tue | 19th | 11 pm | (9 pm WST) Neptune 1° NE of Moon |
| Wed | 20th | 5 am | (3 am WST) First Quarter Moon. |
| Fri | 22nd | am | Comet 62P/Tsuchinshan 1 1.0° N of NGC 3489 (G) in Leo |
| Fri | 22nd | | Vesta at opposition |
| Fri | 22nd | | Solstice |
| Fri | 22nd | 10 pm | (8 pm WST) Jupiter 3° SE of Moon |
| Sat | 23rd | | Mercury in inferior conjunction |
| Sat | 23rd | Midn | (10 pm WST) Uranus 3° S of Moon |
| Sat | 23rd | pm | m.p. 21 Lutetia 0.2° E of NGC 821 (G) in Aries |
| Sun | 24th | am | Comet C/2021 S3 (PANSTARRS) 1.0° S of star Psi Centauri |
| Tue | 26th | am | Comet 62P/Tsuchinshan 1 1.3° S of star Theta Leonis |
| Wed | 27th | 11 am | (9 am WST) Full Moon (391,769 km). |
| Wed | 27th | 8 pm | (6 pm WST) Maximum Libration (7.8°), Full Moon. |
| Wed | 27th | pm | m.p. 18 Melpomene 0.7° SE of NGC 1087 (G) in Cetus |
| Fri | 29th | 3 am | (1 am WST) Comet 62P/Tsuchinshan 1 0.3° NW of NGC 3628 (G) in Leo |
| Fri | 29th | 3 am | (1 am WST) Comet 62P/Tsuchinshan 1 0.7° N of M65 (SG) in Leo |
| Fri | 29th | 3 am | (1 am WST) Comet 62P/Tsuchinshan 1 0.8° N of M66 (SG) in Leo |
| Sun | 31st | pm | m.p. 37 Fides 0.8° E of star Beta Tauri |
| Sun | 31st | pm | m.p. 704 Interamnia 0.4° N of star Beta Tauri |

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the evening of the 31st, minor planets 37 Fides and 704 Interamnia have a close encounter with 2nd magnitude Beta Tauri (Elnath), see Diary. Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag |
|---|---|---|---|
| 11 Dec | 389 Industria | Taurus | 11.3 |
| 18 Dec | 704 Interamnia | Auriga | 10.3 |
| 19 Dec | 37 Fides | Auriga | 9.8 |
| 22 Dec | 4 Vesta | Orion | 6.6 |
| 23 Dec | 9 Metis | Gemini | 8.5 |
| 26 Dec | 48 Doris | Orion | 11.3 |
| 28 Dec | 5 Astraea | Orion | 9.4 |

## COMETS

**Comet 62P/Tsuchinshan 1** (All Sky Map 5), approaching perihelion on Christmas Day, spends December in Leo, rising in the eastern sky around midnight this month, around 7th magnitude. The comet spends the first week of December crossing the Sickle asterism in Leo. It then goes onto an astrophotographer's dream, being within 1° of the M65/M66 group of galaxies in Leo on the 29th, see Diary.

**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 6) spends the month in Centaurus, rising in the south-eastern sky around midnight, brightening from magnitude 10.5 to 9.6.

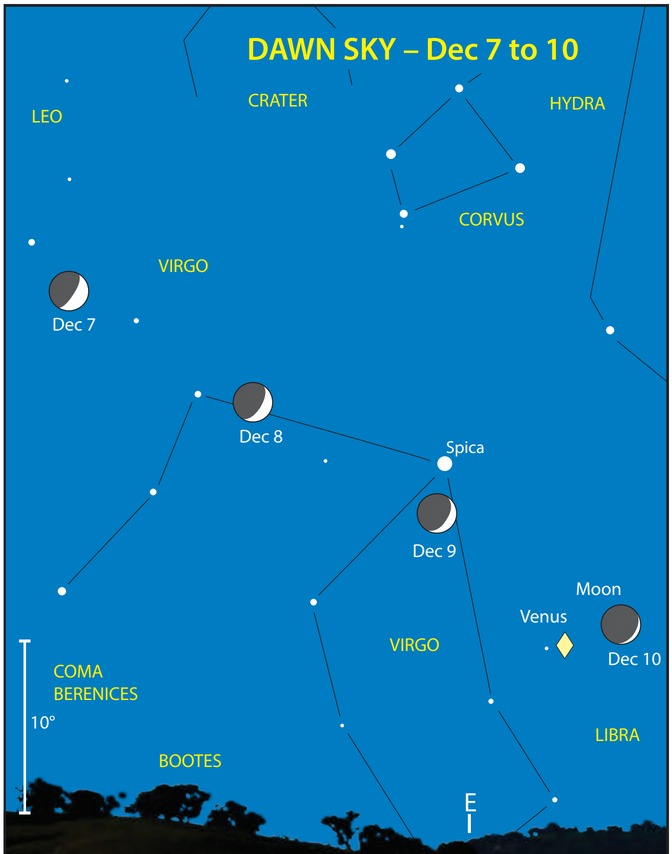
**Comet 144P/Kushida** (All Sky Map 3) continues in Aries, brightening from mag 10 to 9.2. It rises in daylight, transiting the northern evening sky and setting in the western sky before dawn.

**Comet 2P/Encke** begins in Ophiuchus at magnitude 11, setting in the south-western sky around 90 minutes after sunset. It moves into Sagittarius on the 6th and ends the month at magnitude 13, setting about an hour after sunset.

## METEOR SHOWERS

The **Phoenicids** is a southern shower discovered in 1956 during its only known major outburst when rates of around 100 plus were observed. Since then, there have been three minor bursts and some significant activity in 2014; therefore, they are a shower to keep an eye on, just in case. Their period of activity appears to be from November 28 to December 9, with maxima around the 2nd. The Phoenicids' radiant culminates at dusk, so early evening viewing should provide the best activity when the sky is Moon free.

The **Puppid-Velids** are a vastly complex system of showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. Active from December 1–15, a ZHR of 10 around the evening of the 7th through to dawn on the 8th is possible. With New Moon on the 13th, there will be minimal lunar interference during the peak.



Time is one hour before sunrise.
The close meeting between the thin crescent Moon and Spica (9th) and then Venus (10th) on consecutive mornings will be impressive.

The **Geminids** are among the finest and most reliable of the major annual showers. Visible from the 5th to 16th, with maximum predicted late evening on the 14th and morning of the 15th. The Geminids often produce bright, medium-speed meteors with zenith hourly rates of up to 120. Even though our northern counterparts will see the best of the Geminids, they can still provide a spectacular display for us south of the equator. The sky will be Moon free during the peak.

Continued from November 2023, page 16.

## COMETS

**Comet 103P/Hartley 2** spends November in Hydra, early in the month rising in the eastern sky around midnight, progressing to 90 minutes after twilight, its magnitude fading from 9th to 11th.

**Comet 62P/Tsuchinshan 1** (All Sky Map 5) is rising in the north-eastern sky around midnight. It starts the month in Gemini at magnitude 9.5, moves into Cancer on the 4th and Leo on the 25th. It ends the month having brightened to 8th magnitude. Here's an imaging opportunity, on the morning of the 15th, the comet will be 1° north of the Beehive Cluster (M44).

**Comet C/2020 V2 (ZTF)** is in Phoenix starting at magnitude 11, fading to 12. It is transiting high in the southern evening sky and by month's end has moved into Grus, setting in the south-western sky shortly before sunrise.

**Comet 144P/Kushida** spends the month in Aries beginning about magnitude 11.5, rising in the north-eastern sky shortly after sunset. By mid-month it is rising in daylight, transiting late in the northern evening sky and setting before sunrise. By month's end it has brightened to 10th magnitude.

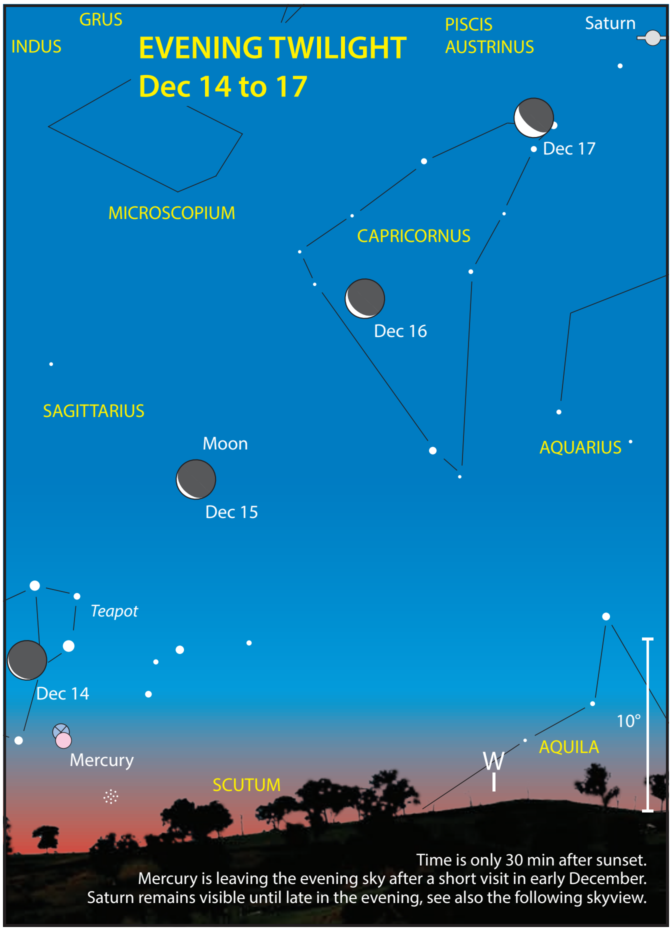
**Comet 2P/Encke** is only briefly visible early in the month, a little more by the end. It starts in Virgo at 8th magnitude, rising in the eastern sky about an hour before sunrise, setting in the western sky just after sunset. On the 2nd the comet moves into Libra and then Scorpius on the 13th and setting in the south-western sky about an hour after sunset. Encke moves into Ophiuchus on the 25th and ends the month at magnitude 11 setting around 90 minutes after sunset.

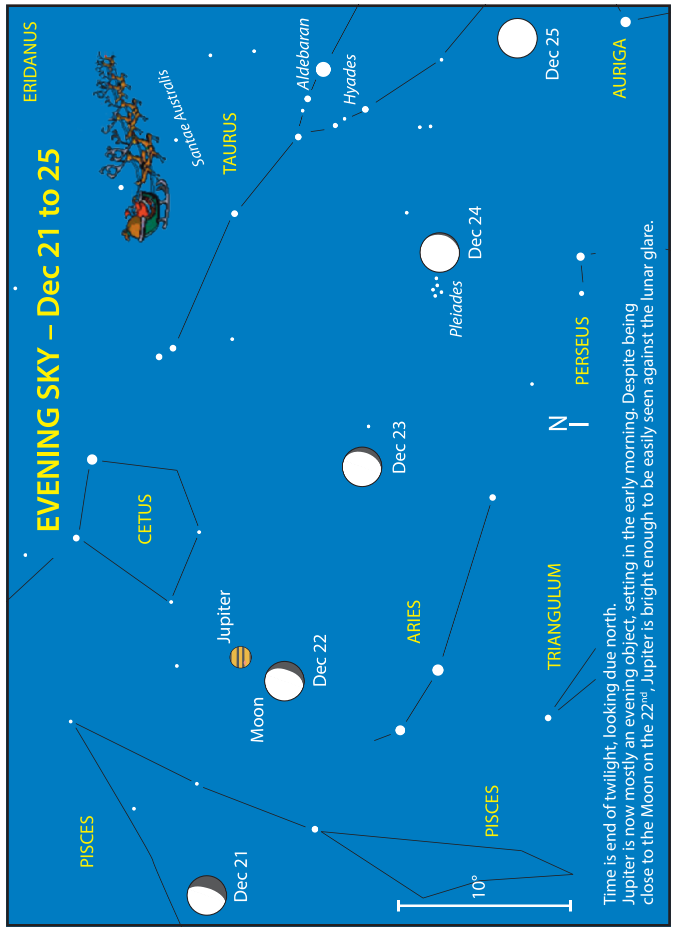
**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 6) spends the month in Centaurus, rising in the south-eastern sky around midnight, brightening from magnitude 11.3 to 10.5.

METEOR SHOWERS

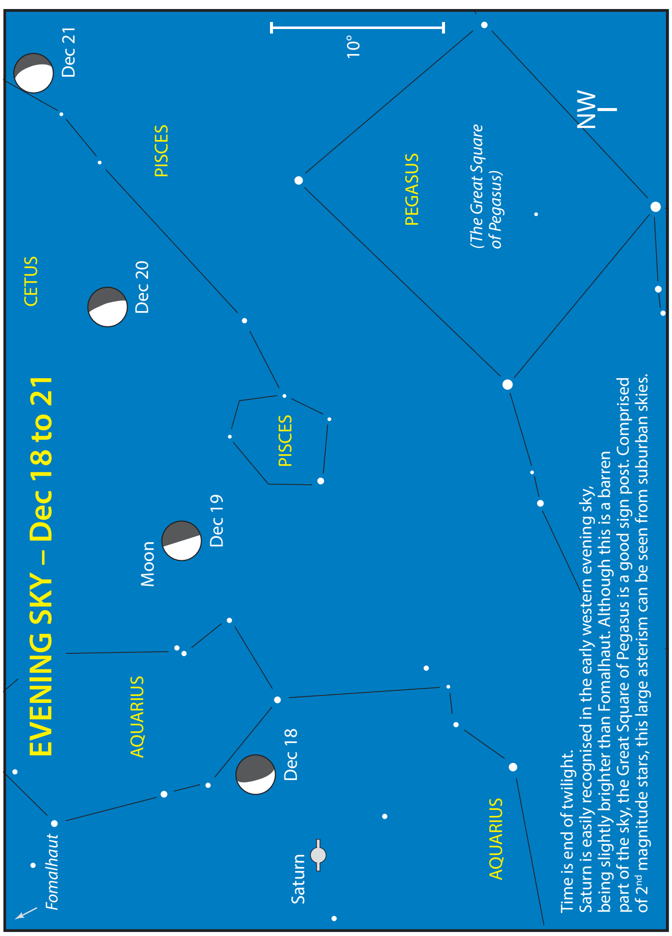
The **Northern Taurids** are bright slow meteors active from October 20 to December 10, with their peak late evening around November 12 and through to the morning dawn. Taurids are frequently bright, slow-moving, and noted for producing colourful fireballs (although not every year). They are associated with Comet 2P/Encke and are visible from late evening to early morning. There will be no lunar interference with the New Moon falling on the 13th.

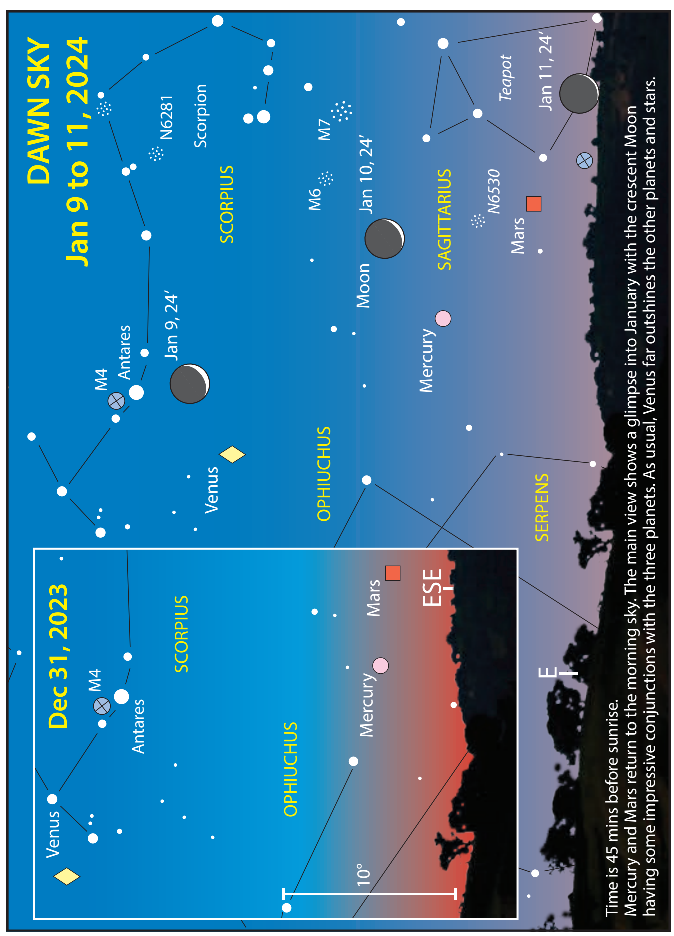
The **Leonids** is one of the better-known showers. It is associated with the periodic comet 55P/Tempel-Tuttle and is best every 33 years when it returns to perihelion (last in 2001). The Leonids are active from November 6 to 30, reaching a maximum peak of around 10 meteors per hour (possibly around 4–5 from mid-Australian latitudes) for the morning of the 18th and possibly the 19th. Since Leo rises after midnight, there will only be a few hours available before the onset of dawn for observation. The First Quarter Moon on the 20th will not interfere with observations after midnight.



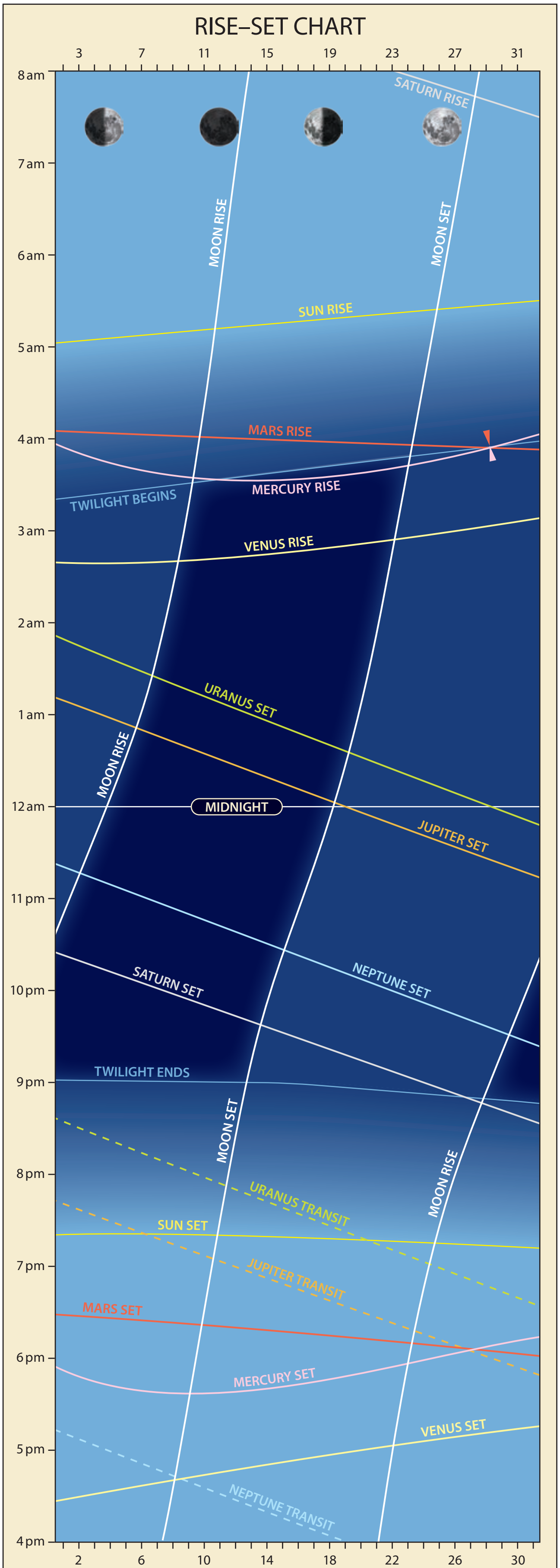




Approximate local standard time, for daylight saving add one hour.



# JANUARY 2024

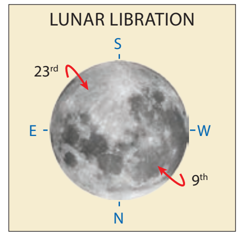



Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury and Mars close.
- Saturn and the crescent Moon close.

## THE MOON




2nd 1 am (11 pm WST, previous day) Moon at apogee (furthest from Earth at 404,909 km).

4th 2 pm (Noon WST) Last Quarter.

9th 6 pm (4 pm WST) Maximum Libration (8.3°), too close to New Moon.

11th 10 pm (8 pm WST) New Moon.

13th 9 pm (7 pm WST) Moon at perigee (closest to Earth at 362,267 km).

18th 2 pm (Noon WST) First Quarter.

20th 9 pm WST Perth observers will see the Pleiades soon occulted by the Moon, starting with Electra (17 Tauri) around 9:14 pm.

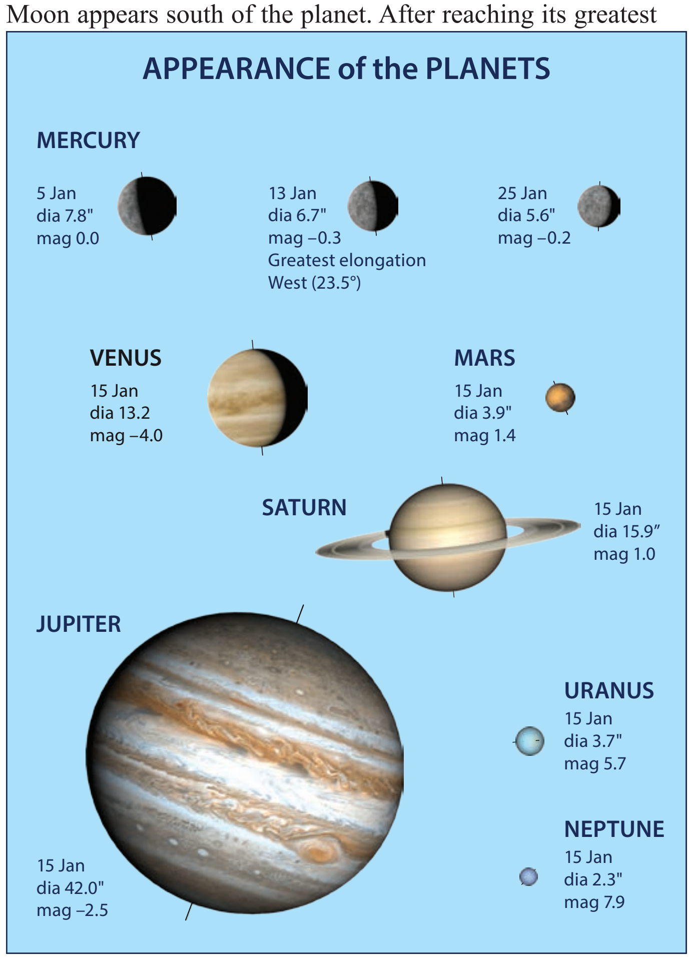
23rd 1 pm (11 am WST) Maximum Libration (8.1°), bright SE limb.

26th 4 am (2 am WST) Full Moon.

29th 6 pm (4 pm WST) Moon at apogee (furthest from Earth at 405,777 km).

## THE PLANETS

**Mercury** begins the year in the eastern dawn sky. On the 10th, the slender crescent of the 28-day-old waning crescent Moon appears south of the planet. After reaching its greatest



elongation 24° west of the Sun on the 13th, it descends back toward Sol and a Mars rendezvous. From the 27th to the 29th, the planetary duo will be less than 1° apart and closest at just 0.2° on the 28th, see Sky View. Mercury is the brighter at 0 magnitude, with Mars about a full magnitude fainter. It is always recommended that binoculars be used for these observations close to the horizon at dawn or dusk. Mercury tours several star clusters in Sagittarius this month, including M21 and M22 (see Diary). However, with this inner speedy messenger, the twilight and horizon are never far away, so observing Mercury conjunctions can be tricky.

**Venus** is a bright object in the morning sky from the beginning of the year until late April, when it becomes too close to the Sun for observation. It reappears in mid-July in the evening sky and remains there for the rest of the year. On the 9th, the waning crescent of the 27-day-old Moon makes an attractive sight 5° from the planet. Venus makes a similar voyage through Sagittarius around one week after Mercury (see Diary).

The **Earth** is at perihelion on the 3rd, the closest point in its orbit to the Sun (147,100,633 km or 0.983307 au distant).

**Mars** is lost in the bright eastern dawn sky early in January. After gaining a little altitude during the month, the Red Planet meets up with Mercury for a close conjunction on the 28th (see Mercury and Sky View). For most of the year, Mars will be a disappointing target for visual observers. With opposition in January 2025, things improve late this year, but being a poor aphelic opposition, the Martian disc will only reach 14 arcseconds in diameter.

**Jupiter**, in Aries, slowly returns to its west-to-east path against the starfield as it ends four months in retrograde (see retrograde motion p. 94). At astronomical twilight, the bright planet in the north-western sky easily outshines the stars of the Ram and neighbouring Pisces and Cetus. On the 18th, Jupiter will be 6° from the First Quarter Moon (see Sky View).

**Saturn**, in Aquarius, is visible low in the western evening sky at dusk. However, the planet will be in conjunction in late February, and as the month advances, it will become increasingly more challenging to see in the brightening sky. On the 14th, the 3-day-old waxing crescent Moon will be just 1.5° from the planet (see Sky View).

Saturn's magnificent ring system is tilted with respect to the plane of the Earth's orbit, and our view changes over time. In March 2025, the rings will be edge-on, although we will not see this event as the planet is in conjunction with the Sun. They then open to their maximum tilt of 27° in 2032 before closing and appearing edge-on again in 2038. Over the course of this year, we see the inclination of the rings at 9° in January—they then gradually close to 2° by June and expand again to 5° in December (it is interesting to see the changes in the rings in the Appearance of the Planets diagrams throughout the year). When the inclination of the rings is this narrow, it isn't easy to see detail in them. Therefore, observers must wait until around 2027 when they reopen enough to reveal their intricate features. We are currently looking down on the rings' northern face; after March 2025, this view will switch to the southern side.

**Uranus** is in the northern evening sky at the end of astronomical twilight in Aries, transiting the meridian around 7 pm mid-month. The planet has been sharing the constellation of the Ram with Jupiter since May last year. Uranus ends four months of retrograde motion on the 27th and then resumes its west-to-east drift against the stellar background.

**Neptune**, in Pisces, sets in the western evening sky around 10 pm mid-month.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Tenth magnitude Fides has a close encounter with bright star Beta Tauri on the evenings of the 3rd and 4th (see Diary). Iris spends the month touring deep sky objects in Sagittarius, being on the edge of M20, the Trifid Nebula, on the 8th. Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 9 Jan | 92 Undina | Gemini | 11.4 |
| 19 Jan | 354 Eleonora | Canis Minor | 9.6 |
| 21 Jan | 128 Nemesis | Cancer | 11.5 |
| 22 Jan | 71 Niobe | Cancer | 10.9 |

## COMETS

**Comet 62P/Tsuchinshan 1** (All Sky Map 5) begins the month in Leo about magnitude 7, rising in the eastern sky around 11:30 pm. By the 11th it has moved into Virgo, now rising about 11 pm and transiting in the northern sky shortly before sunrise. The comet ends the month having faded to magnitude 7.7. For the next three months, 62P/Tsuchinshan 1, with the aid of retrograde motion, will visit members of the Virgo/Coma Cluster of galaxies (see Diary).

**Comet 144P/Kushida** (All Sky Map 3) spends the month at about 9th magnitude, commencing in Aries, before moving into Taurus on the 12th. It is transiting in the northern early evening sky before setting in the western sky in the morning.

**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 6) spends the month rising in the south-eastern sky around midnight. It begins in Centaurus at magnitude 9.6 before moving to Lupus on 4th then into Scorpius on the 22nd, ending the month at magnitude 8.9. The close of January sees PANSTARRS pass through the head and claws region of Scorpius (see Diary for some interesting conjunctions).

## METEOR SHOWER

**Note:** In the meteor section, we refer to the zenith hourly rate (ZHR) of meteors per hour. It is a theoretical rate observed at a shower's peak, with the radiant at the zenith, under dark skies with a limiting naked-eye magnitude of 6.5, by an experienced observer, with no light pollution, cloud, or Moon. Since these conditions rarely coincide, you can expect a considerably lower rate than that given. But don't let us put you off; capturing just one or two bright meteors is generally enough reward for those waiting hours.

The **Quadrantids** are a strong and consistent northern shower. They are difficult for southern observers, with the radiant (in Boötes) below the early morning north-eastern horizon. If observing before dawn, you may glimpse an occasional long-pathed member on the morning of the 4th. The Quadrantids are active from December 28 to January 12, peaking on the 4th, with up to 40 meteors per hour at their peak. There will be lunar interference with the Last Quarter Moon transiting around 6 am.

| DIARY | | | |
|---|---|---|---|
| Mon | 1st | | m.p. 2 Pallas 1.0° S of M5 (GC) in Serpens |
| Mon | 1st | | m.p. 15 Eunomia 0.4° W of NGC 7009 (PN) in Aquarius |
| Tue | 2nd | | Mercury 1.0° SE of NGC 6342 (GC) in Ophiuchus |
| Tue | 2nd | | Venus 0.9° N of star Beta Scorpii |
| Tue | 2nd | 1 am | (11 pm WST, prev day) Moon at apogee (furthest from Earth at 404,909 km). |
| Wed | 3rd | | Venus 0.3° NW of star Nu Scorpii |
| Wed | 3rd | | m.p. 7 Iris 0.9° S of NGC 6469 (OC) in Sagittarius |
| Wed | 3rd | | m.p. 7 Iris 0.9° N of Mars |
| Wed | 3rd | | Earth at perihelion, 0.983306994 au |
| Thu | 4th | | m.p. 37 Fides 0.1° SW of star Beta Tauri |
| Thu | 4th | am | Quadrantids meteor shower, Dec 28 – Jan 12, moon affected. |
| Thu | 4th | 2 pm | (Noon WST) Last Quarter Moon. |
| Fri | 5th | am | Comet 62P/Tsuchinshan 1, 1.0° N of NGC 3810 (G) in Leo |
| Sun | 7th | 3 am | (1 am WST) star Antares 6° S of Venus |
| Mon | 8th | | m.p. 4 Vesta 0.2° NE of star Zeta Tauri |
| Mon | 8th | | m.p. 7 Iris 0.1° W of M20 Trifid Nebula (BN) in Sagittarius |
| Tue | 9th | | m.p. 7 Iris 0.6° S of M21 (OC) in Sagittarius |
| Tue | 9th | | Comet C/2021 S3 (PANSTARRS) 0.7° NW of star Phi$^1$ Lupi |
| Tue | 9th | 4 am | (2 am WST) Venus 5° N of Moon |
| Tue | 9th | 6 pm | (4 pm WST) Maximum Libration (8.3°), too close to New Moon. |
| Wed | 10th | 4 am | (2 am WST) Mercury 6° N of Moon |
| Thu | 11th | | m.p. 7 Iris 0.2° N of NGC 6546 (OC) in Sagittarius |
| Thu | 11th | 10 pm | (8 pm WST) New Moon. |
| Sat | 13th | | Mercury 0.5° NW of NGC 6469 (OC) in Sagittarius |
| Sat | 13th | | Mercury at greatest elongation West (23.5°) |
| Sat | 13th | 9 pm | (7 pm WST) Moon at perigee (closest to Earth at 362,267 km). |
| Sat | 13th | pm | m.p. 4 Vesta 0.5° S of M1 Crab Nebula (PN) in Taurus |
| Sun | 14th | 8 pm | (6 pm WST) Saturn 1.5° N of Moon |
| Tue | 16th | | Mercury 0.5° NE of M21 (OC) in Sagittarius |
| Tue | 16th | | Mercury 1.0° N of NGC 6546 (OC) in Sagittarius |
| Tue | 16th | | m.p. 7 Iris 0.8° S of NGC 6583 (OC) in Sagittarius |
| Wed | 17th | | Mercury 0.9° S of NGC 6568 (OC) in Sagittarius |
| Wed | 17th | 4 am | (2 am WST) d.p. 1 Ceres 0.2° NW of Venus |
| Thu | 18th | | Mercury 0.5° SE of NGC 6583 (OC) in Sagittarius |
| Thu | 18th | | Comet C/2021 S3 (PANSTARRS) 0.6° N of star Chi Lupi |
| Thu | 18th | 2 pm | (Noon WST) First Quarter Moon. |
| Thu | 18th | 11 pm | (9 pm WST) Jupiter 5° E of Moon |
| Fri | 19th | am | m.p. 23 Thalia 0.4° NW of M98 (SG) in Coma Berenices |
| Fri | 19th | 2 am | (Midnight WST, prev day) Comet 62P/Tsuchinshan 1, 0.1° N of NGC 4178 (G) in Virgo |
| Fri | 19th | 10 pm | (8 pm WST) Uranus 5° SE of Moon |
| Sat | 20th | | m.p. 532 Herculina 0.2° N of NGC 5248 (G) in Boötes |
| Sun | 21st | | Mercury 0.7° NE of NGC 6642 (GC) in Sagittarius |
| Mon | 22nd | | Mercury 1.0° NE of M22 (GC) in Sagittarius |
| Mon | 22nd | 9 pm | (7 pm WST) m.p. 4 Vesta 0.05° S of star o Tauri |
| Tue | 23rd | | Venus 0.4° E of NGC 6469 (OC) in Sagittarius |
| Tue | 23rd | 1 pm | (11 am WST) Maximum Libration (8.1°), bright SE limb. |
| Wed | 24th | | Venus 0.7° NW of M20 Trifid Nebula (BN) in Sagittarius |
| Thu | 25th | | Venus 0.4° E of M21 (OC) in Sagittarius |
| Thu | 25th | | m.p. 7 Iris 0.8° N of NGC 6642 (GC) in Sagittarius |
| Fri | 26th | | Venus 0.9° S of NGC 6568 (OC) in Sagittarius |
| Fri | 26th | | Saturn 0.4° SE of star Sigma Aquarii |
| Fri | 26th | am | m.p. 23 Thalia 0.4° NW of NGC 4237 (G) in Coma Berenices |
| Fri | 26th | 4 am | (2 am WST) Full Moon (400,995 km). |
| Sat | 27th | am | Comet 62P/Tsuchinshan 1, 0.8° S of NGC 4429 (G) in Virgo |
| Sat | 27th | am | Comet 62P/Tsuchinshan 1, 0.5° N of NGC 4442 (G) in Virgo |
| Sun | 28th | | m.p. 7 Iris 1.0° N of M22 (GC) in Sagittarius |
| Sun | 28th | 5 am | (3 am WST) Mars 0.5° SW of Mercury |
| Mon | 29th | | Comet C/2021 S3 (PANSTARRS) 2.0° SE of M4 (GC) in Scorpius |
| Mon | 29th | 6 pm | (4 pm WST) Moon at apogee (furthest from Earth at 405,777 km). |
| Tue | 30th | | Venus 1.0° N of NGC 6642 (GC) in Sagittarius |
| Tue | 30th | | Comet C/2021 S3 (PANSTARRS) 1.4° SE of star Antares |
| Tue | 30th | | Comet C/2021 S3 (PANSTARRS) 0.8° NW of star Tau Scorpii |
| Wed | 31st | | m.p. 9 Metis 1.5° E of star Beta Tauri |

## CONSTELLATIONS

Our ‘constellations’ section is designed to help people to find their way around the sky, concentrating on bright stars or their patterns (but we do stray from time to time). We’ll point out those clearly visible under light polluted skies, but won’t hesitate to go to any particularly interesting, but fainter offerings needing dark skies. Unless otherwise mentioned we have arbitrarily chosen a time of around 9 pm mid-month keeping in mind if you stay up long enough (especially in winter) most of the sky is visible. A planisphere (page 9) is useful to follow along with our descriptions. All Sky Map references are also given (see pp. 84 to 93). Along the way a few outstanding deep sky objects or double stars, ideal for the beginner using a small telescope or sometimes even binoculars are highlighted.

Don’t hesitate to use binoculars to not only enhance your experience, but also, for some large celestial objects, that may be ideal for the observation. These are handy to detect the faintest (invisible?) constellations from suburbia. Sometimes it’s worthwhile trading light gathering power or going to a lower magnification to get a wide field. This is why Opera Glasses are a possible option, with 3× magnification the best. This is a can of worms, with the quality varying greatly across the products. Perhaps borrowing a pair is a good move and getting advice from telescope shops, who may sell them and have some experience applying them to stargazing.

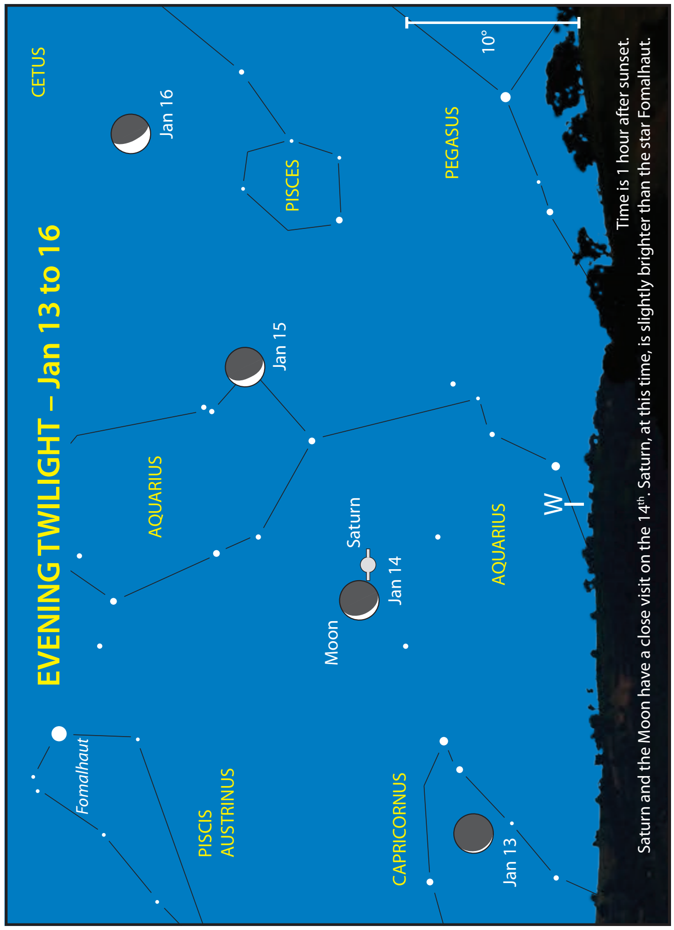
There are a handful of bright, distinctive constellations which are synonymous with the seasons. Summer’s is Orion. The key here is the distinctive three bright stars in a line close together, in the northern sky, being flanked by the first magnitude stars, blue coloured Rigel (above) and red Betelgeuse (below). The colour difference really stands out under dark skies or through binoculars. Rigel brings with it a real bonus being a brilliant double star with a great brightness contrast (components of magnitude zero and 6.8) and a comfortable 9 arcseconds apart.

Returning to the three stars, they are called the belt of Orion or for us southern dwellers, these three stars forming the base of the Saucepan asterism. While in this area check out Delta (δ) (left most belt star) and Zeta (ζ) (right) Orionis being impressive doubles. The Saucepan has a handle, made up of fainter stars going off to the upper right, with the impressive Great Nebula in Orion (M42) appearing as a fuzzy naked-eye star. A wide-angle eyepiece shows a bowl-shaped complex of nebula including the prominent multiple star Theta (θ) Orionis called the Trapezium, after the shape its four brightest stars make. This is worth a trip to dark skies with your telescope!

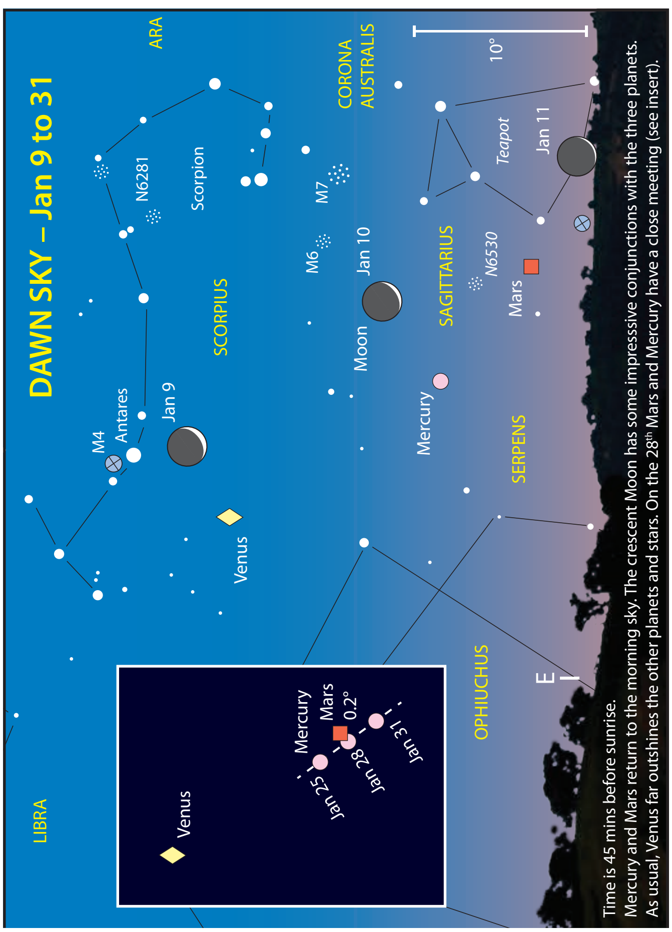
Note the design of the All-Sky Maps where Orion is in the north-east corner of Map 2. It conveniently forms a linking constellation to adjoining maps. with Betelgeuse making a great bridging object to the Autumn Maps 4 and 5. Betelgeuse and the belt stars show the way to the northern summer sky (Map 3)

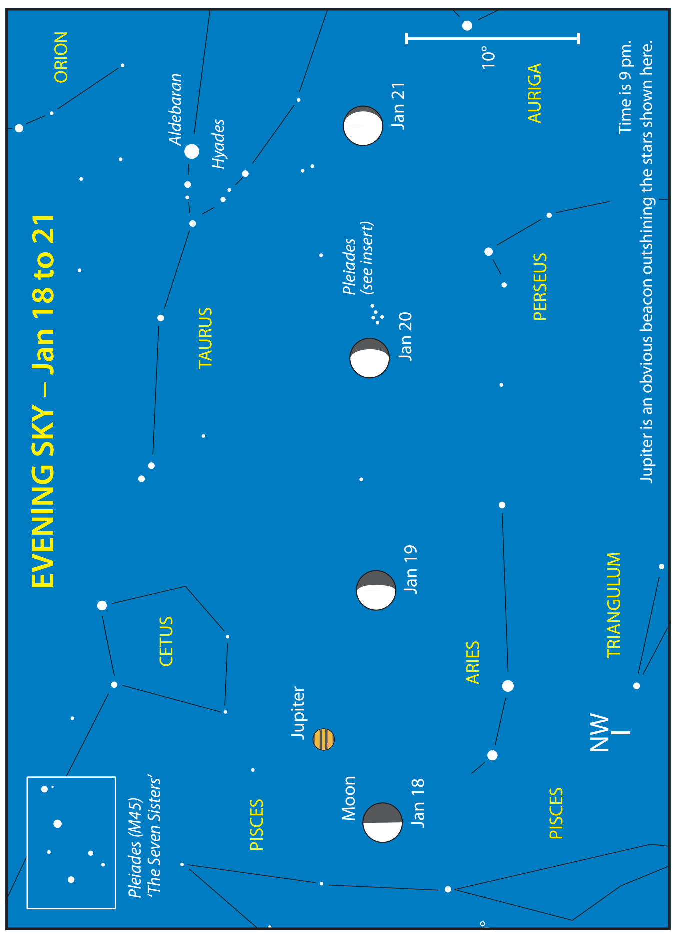
Below, north of, Orion is Taurus the Bull (Map 3). The most noticeable marker is its alpha star, Aldebaran, located on the eastern edge of the brilliant Hyades star cluster. The brightest members form the naked eye 'V' shaped face of the bull. Being around 6° in diameter, the cluster is ideal to observe in low power binoculars. Here's another famous open cluster in Taurus, brilliant for observing in binoculars as well, M45, the Pleiades. Located two binocular fields to the lower left of the Hyades, M45 has six main stars ranging from magn. 2.8 to 4.3, fitting within a 1° diameter circle. Binoculars easily reveal a couple of dozen stars out to 1° from the centre, with the brightest members an obvious blue colour.

Positioned lower in the north is the constellation of Auriga the Charioteer, most easily recognised by a distinctive group of five stars arranged in a pentagon shape. This group's brightest and most northerly member is Capella. Although at a declination of +46°, it still rises briefly above the northern horizon from Australia and marks the most northerly first magnitude star in the entire sky.

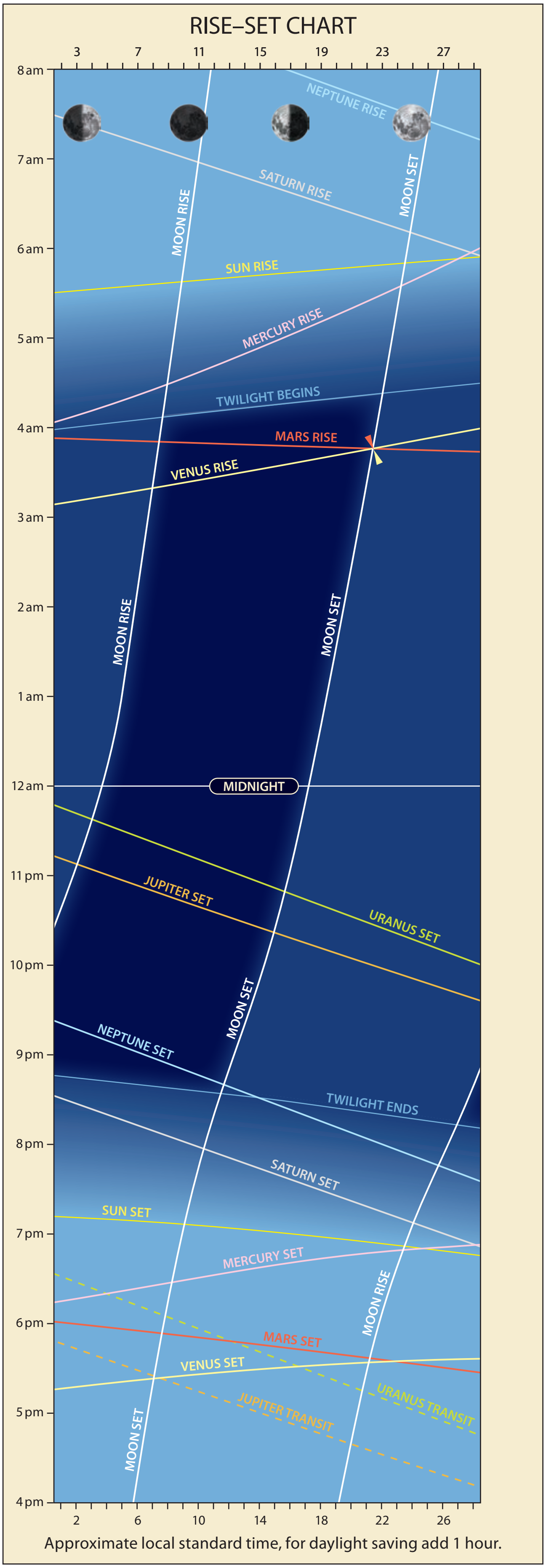



Approximate local standard time, for daylight saving add one hour.



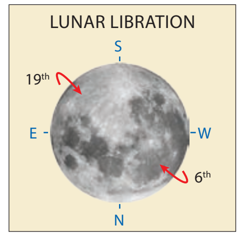
# FEBRUARY 2024




## HIGHLIGHTS

- Venus, Mars, and Mercury line up in the dawn sky.
- Venus and Mars close.
- The alpha-Centaurids meteor shower.

## THE MOON




3rd 9 am (7 am WST) Last Quarter.

6th 9 am (7 am WST) Maximum Libration (9.6°), bright NW limb.

10th 9 am (7 am WST) New Moon.

11th 5 am (3 am WST) Moon at perigee (closest to Earth at 358,088 km).

17th 1 am (11 pm WST, previous day) First Quarter.

19th 8 am (6 am WST) Maximum Libration (9.0°), bright SE limb.

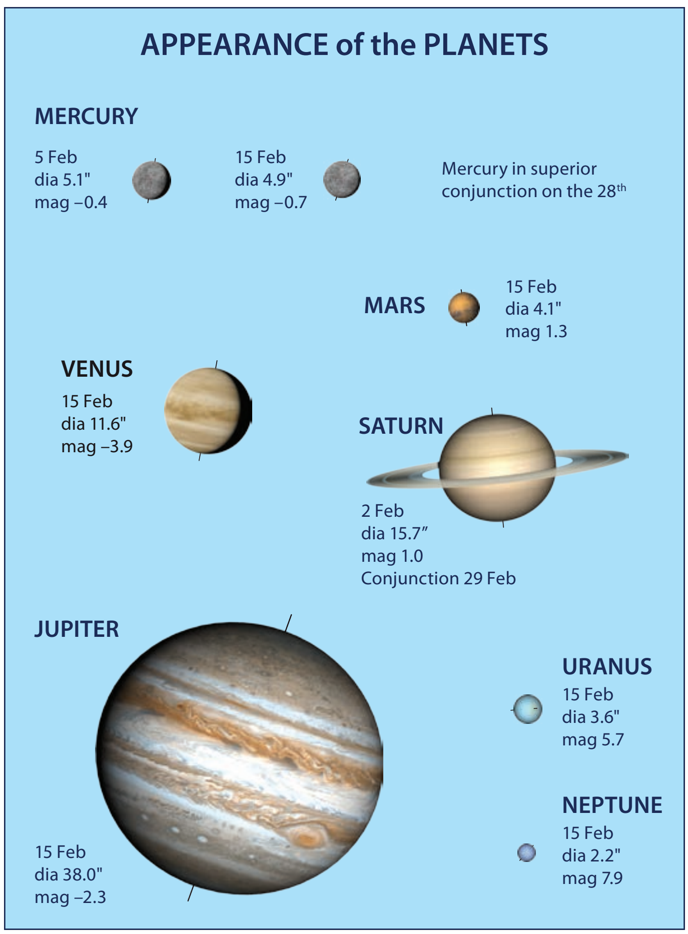
24th 11 pm (9 pm WST) Full Moon.

26th 1 am (11 pm WST, previous day) Moon at apogee (furthest from Earth at 406,312 km).

## THE PLANETS

**Mercury** is visible in the eastern dawn sky early in the month. However, it soon becomes lost in the Sun's glare as it nears superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 28th.

Brilliant **Venus** is easily visible in the eastern morning sky before dawn. On the 8th, the waning crescent of the 27-day-old Moon makes an attractive sight 5° from the planet (see Sky



View). The Morning Star will have a companion for a few weeks with Mars within 5° from 12 February until 5 March. The planetary duo will be closest at 1° or less from the 21st to the 24th.

**Mars** is visible low in the eastern sky before the start of dawn. The Red Planet and Venus unite as they travel through Sagittarius and Capricornus. The pair will be within 1° of each other from the 21st till the 24th (see Venus section and Sky View).

**Jupiter**, in Aries, is visible in the western evening sky setting around 10 pm mid-month. On the 15th, the giant planet will be 4° from the 6-day-old waxing crescent Moon (see Sky View).

**Saturn**, in Aquarius, remains hidden in the bright evening twilight sky as it moves into conjunction with the Sun on the 29th. The Ringed Planet then reappears in the morning sky in late March.

**Uranus**, in Aries, appears low in the early north-western evening sky after the end of astronomical twilight.

**Neptune** is located low in the early western dusk sky in Pisces early in the month. It becomes too close to the Sun for observation by late February and will reappear in early April in the morning sky.



# Solar Max Cycle 25, Part 1 – White Light

Observing the Sun can be a fulfilling and enjoyable hobby for amateur astronomers; it brings astronomy into the convenience of daylight hours. The Sun is the closest star to Earth, providing a substantial disc that can be studied in detail with even the smallest telescopes. For those who have yet to observe the Sun through a telescope, now is an excellent opportunity as Solar Cycle 25 approaches its maximum. This brief overview explores what can be observed in white light (the visible spectrum). In Part 2 (p. 44), we'll delve into safe techniques for observing the Sun, and in Part 3 (p. 54), we will look at narrow-band filter options for a different view.

**Under no circumstances should you look directly at the Sun with your naked eye, or any optical instrument not designed or modified for solar observing, as irreparable damage or blindness can result.**

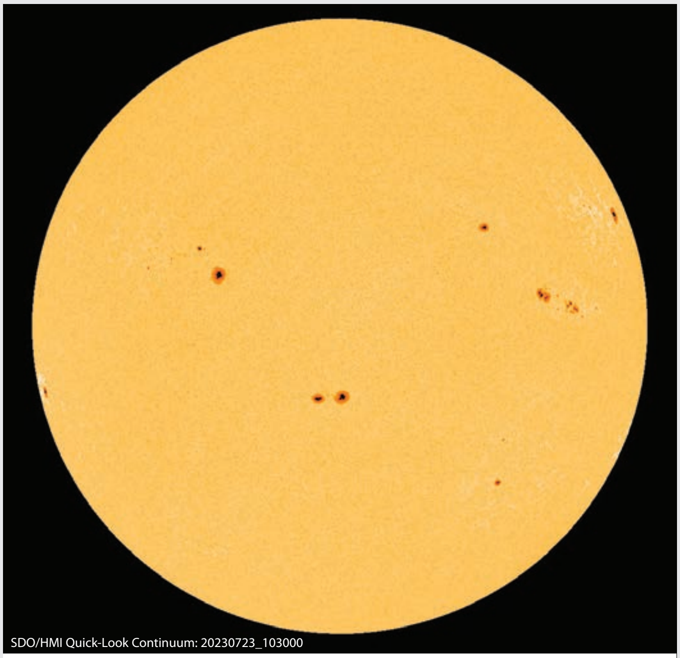
The dark blemishes known as sunspots are the most noticeable features on the Sun's visible surface, the photosphere. These are caused by chaotic twisted magnetic fields that are thousands of times stronger than our planet's magnetic field. Typically, they have a dark central region called the umbra, surrounded by a lighter area known as the penumbra. They appear darker than the photosphere because they are cooler, with the temperature of the umbra around 3700 K (Kelvin) compared to 5800 K for the photosphere.

Spots may occur singularly but are often found in pairs or complex groups attended by many minor spots or pores. The development is varied; a few follow classic evolutionary rules and emerge as spectacularly large groups, while others reach a certain level and regress. Whatever stage is attained, all sunspots are conceived as pores (small sunspots, lacking any penumbral structure) and ultimately end their life similarly. Sunspots vary significantly from the smallest, limited only by atmospheric seeing, to giants spanning a considerable portion of the disc. The largest, most complex groups tend to occur around solar maximum and display intricate detail, even in small telescopes.

The development and decay of sunspots are fascinating to watch as they move from east to west as the Sun rotates—a spot can last for several days, while large ones may live for several weeks or more. There are no set rules, but generally, the larger the area of a group, the longer it will survive. Since the Sun takes about a month to rotate on its axis, a spot observed on the east limb will be carried over to the western limb after about two weeks. If the spot survives, it will then reappear on the east limb after a fortnight.

The Sun's actual equatorial rotation is 24.47 days, but a spot very near the equator can be followed across the disc for about 13.5 days and reappear 13.5 days later—a total of 27 days. The inconsistency lies in the Earth's motion; as the Sun rotates about its axis, the Earth advances in its orbit, effectively lengthening the apparent solar day. The Sun is gaseous and does not rotate as a solid body; the equatorial regions rotate faster than the poles. Hence, high-latitude spots will take longer to move across the disc than those near the equator.

Sunspots follow an 11-year cycle, starting with few or no spots and gradually increasing until reaching a peak at solar maximum. Then, the number of spots decreases until solar minimum, and a new cycle begins. Additionally, the position of the spots changes as the cycle progresses. Early in each cycle, they appear at higher latitudes and then gradually migrate closer to the Sun's equator as the cycle approaches its maximum. Not only are sunspots an indicator of when maximum occurs, but the Sun's magnetic field completely




*The Sun, 23 July 2023. Credit NASA's Solar Dynamics Observatory. With small telescopes, one can observe a similar view of sunspots, faculae, and granulation.*

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

During February and early March, dwarf planet Ceres visits several deep sky objects in Sagittarius, including passing between the Trifid Nebula and M21 the bright open cluster (see Diary). Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 7 Feb | 451 Patientia | Leo | 11.1 |
| 10 Feb | 192 Nausikaa | Leo | 10.8 |
| 15 Feb | 216 Kleopatra | Hydra | 11.2 |
| 17 Feb | 63 Ausonia | Leo | 10.6 |
| 17 Feb | 372 Palma | Leo | 10.8 |
| 18 Feb | 31 Euphrosyne | Ursa Major | 11.0 |
| 19 Feb | 121 Hermione | Leo | 12.7 |
| 27 Feb | 349 Dembowska | Leo | 10.3 |

## COMETS

**Comet 62P/Tsuchinshan 1** (All Sky Map 7) spends the month in Virgo starting at magnitude 7.7, rising in the eastern sky around 10 pm, transiting in the northern sky around 4 am. By month's end, it is rising shortly after twilight and has faded to 9th magnitude. The comet continues its visit with members of the Virgo/Coma Cluster of galaxies (see Diary).

**Comet 144P/Kushida** (All Sky Map 3) spends the month in Taurus, rising in daylight, transiting in the northern sky shortly after sunset, then setting in the western sky around midnight. It continues to fade from 9.4 to 10.3. For the first half of February, the comet runs along the edge of the Hyades cluster in Taurus, including a close approach to Aldebaran on the evening of the 10th (see Diary).

**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 6) spends the month rising in the south-eastern sky shortly after



flips. After the north and south poles switch places, it takes another 11 years before they flip again. Please keep in mind that the 11-year cycle is just an average and can differ significantly in duration, ranging from as little as 9 to almost 14 years.

Solar activity has been recorded since 1755, and we are currently in the 25th 11-year cycle. The solar minimum between cycles 24 and 25 occurred in December 2019, with cycle 24 being the weakest in the past 100 years. Cycle 25 was predicted to peak around July 2025. Although with a recent significant rise in sunspots, solar storms, and other phenomena, some astronomers are changing their forecast to sometime this year—and it could be more powerful than first thought. If it's any indication, more sunspots have been observed than predicted since 2021. As of mid-July 2023, the highest monthly sunspot number in the past 20 years was recorded in June 2023.

The Sun appears darker at the edges than the rest of the disc. Limb darkening occurs as you look into the deepest and hottest layers that emit light when viewing near the centre of the disc. Towards the limb, you look along a path that travels through the upper cooler layers, dimming the light compared to the centre.

Associated with sunspots are extensive, irregularly shaped masses of bright material known as faculae. These luminous hydrogen clouds lie above the photosphere, resembling a white serpentine latticework. It is difficult to see them over the disc's central portions; they are best viewed towards the edge due to the contrast effect of limb darkening. They are mostly found near active regions or where one is about to form and can last long after the sunspots have decayed.

When the seeing is steady, the Sun will display a mottled texture over the entire disc—often described as having a rice pudding appearance. The granulation appears as small bright spots of irregular shape, often like polygons, bounded by darker material. Granulation is evidence that the solar surface is in constant motion; the bright portions represent the tops of rising columns or cells of hot gas, and the dark lanes are cooled gas descending. On average, the granules are about 700 to 1500 km across and typically short-lived with a life span of 8 to 15 minutes.

The ever-changing Sun in white light will provide countless hours of pleasure for the amateur with relatively modest equipment.

See Part 2, page 44 for safe solar observing techniques.

### The Solar Cycle and Neptune Connection.

The Sun's influence on the Earth's climate is well understood, and recently scientists also discovered a link between Neptune's weather and our star. In 1989, NASA's Voyager 2 spacecraft discovered bright white clouds, similar to Earth's cirrus clouds, located high in Neptune's atmosphere. At Neptune's distance of 4,498,396,000 km (30.1 au), the Sun appears starlike, with a diameter 1/30th of the full Moon, and the planet only receives about 0.1% of the intensity of sunlight compared to the Earth.

A team of planetary scientists have now discovered a connection between the solar cycle and Neptune's cloudy weather pattern by examining 2.5 cycles of cloud activity recorded over 29 years of Neptunian observations. During this time, the planet's reflectivity increased in 2002 and then dimmed in 2007. Neptune became bright again in 2015, then darkened in 2020 to the lowest observed level when most clouds disappeared. This discovery is based on observations of Neptune using NASA's Hubble Space Telescope, the Keck Observatory in Hawaii, and data from the Lick Observatory in California.

The changes in Neptune's brightness caused by the Sun appear to go up and down relatively in sync with the coming and going of clouds on the planet. However, there is a two-year time lag between the peak of the solar cycle and the abundance of clouds seen on Neptune.

As the solar cycle progresses, the Sun's turbulence builds to a maximum until the magnetic field beaks down and reverses polarity. Around this time of peak solar activity, sunspot numbers surge, the rate of violent flares increases, and intense ultraviolet (UV) radiation floods the Solar System. It has been proposed that when the UV radiation is strong enough, it triggers a photochemical reaction in Neptune's upper atmosphere, which takes a couple of years to form clouds.

Reference: HubbleSite.org

midnight. It begins in Scorpius at 9th magnitude before moving to Ophiuchus on the 4th then into Serpens on the 17th, ending the month having brightened slightly. Early February finds the comet passing through a nest of globular clusters in Ophiuchus (see Diary).

**Comet C/2022 L2 (ATLAS)** commences the month in Libra at about magnitude 13, rising in the south-eastern sky, late evening. On the 22nd it briefly enters Lupus before moving into Centaurus. The comet ends the month at magnitude 12, rising in the south-eastern sky just after twilight and transiting high in the northern sky shortly before dawn.

**Comet 13P/Olbers** spends February around 12th magnitude, opening the month in Eridanus, setting around 12:30 am. On the 15th, it moves into Cetus, setting around 11 pm and by month's end setting about 10 pm.

## METEOR SHOWER

The **alpha-Centaurids**, one of the main southern summer showers, are active from January 31 to February 20, with a maximum zenith hourly rate of six before dawn on the 9th. The shower is known for its bright yellow and blue coloured fireballs that frequently reach negative magnitude. The alpha-Centaurids are also well known for their long-lasting trains that may vary from seconds to several minutes. Since the radiant is above the horizon all night from most southern locations and their activity is spread over such a broad period, observers are sure to catch the odd meteor at any time. The shower may have an excellent display this year, with New Moon on the 10th.

## CONSTELLATIONS

Take a moment to lie back and take in the entire sky. The Milky Way gives a unique view as it bisects the heavens as it runs from the northern horizon, passing nearly overhead, before stretching into the south. Face north, and pick up our January bridging star going from Map 2 to Map 4, Alpha (α) Orionis or Betelgeuse. look for an obvious equilateral triangle it forms with Sirius (high in the sky) and then down to Procyon. This asterism is called the Winter Triangle which betrays its Northern Hemisphere origin. These three have much in common. Besides being the alpha stars to their respective constellations, they all relate back to Orion. Sirius belonging to Canis Major, the Greater Dog and Procyon is in Canis Minor, the Lesser Dog. These canines are Orion's hunting dogs spending eternity following their master across the sky.

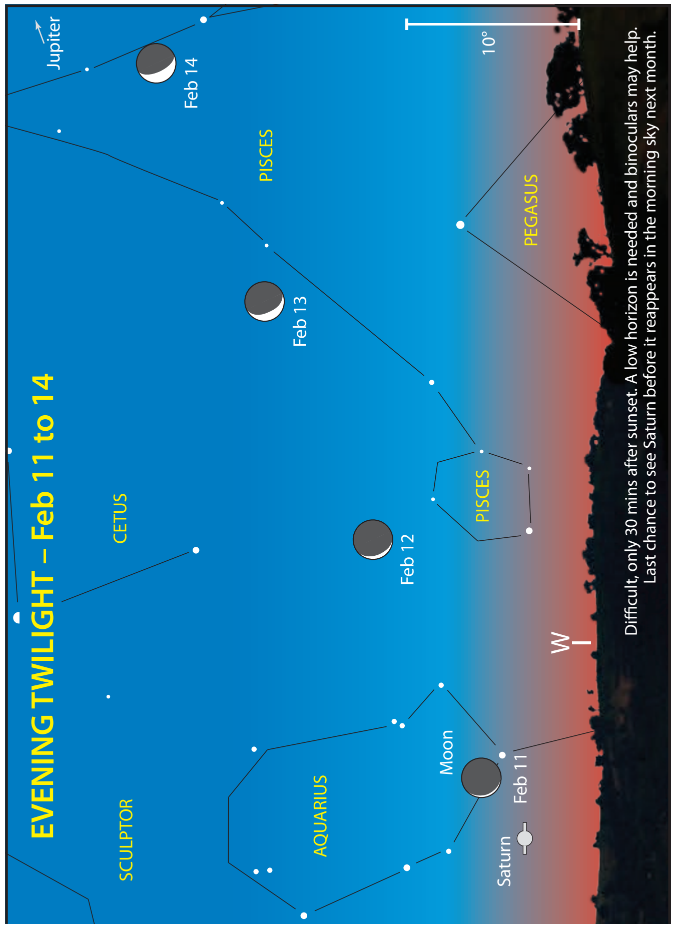
Canis Major might be best known for its brilliant Dog Star, Sirius, but its status as the brightest star is only because it is nearby (only 8.6 light-years away). However, the hindquarter

| DIARY | | | |
|---|---|---|---|
| Thu | 1st | | m.p. 6 Hebe 0.8° S of NGC 5713 (G) in Virgo |
| Thu | 1st | | m.p. 7 Iris 0.2° E of Venus |
| Sat | 3rd | 9 am | (7 am WST) Last Quarter Moon. |
| Sun | 4th | | d.p. 1 Ceres 0.2° SW of NGC 6469 (OC) in Sagittarius |
| Sun | 4th | | Comet 144P/Kushida 0.4° NW of star Gamma Tauri |
| Mon | 5th | | Mercury 0.2° NW of M75 (GC) in Sagittarius |
| Mon | 5th | am | Comet 62P/Tsuchinshan 1, 0.4° N of NGC 4578 (G) in Virgo |
| Tue | 6th | 9 am | (7 am WST) Maximum Libration (9.6°), bright NW limb. |
| Wed | 7th | pm | Comet 144P/Kushida 0.4° NW of star Theta 2 Tauri |
| Thu | 8th | | Comet C/2021 S3 (PANSTARRS) 0.6° W of NGC 6287 (GC) in Ophiuchus |
| Thu | 8th | | alpha-Centaurids meteor shower, Jan 31 to Feb 20. |
| Thu | 8th | 4 am | (2 am WST) Venus 5° N of Moon |
| Fri | 9th | | m.p. 7 Iris 0.8° S of star Xi² Sagittarii |
| Fri | 9th | am | Comet 62P/Tsuchinshan 1, 0.3° S of NGC 4596 (G) in Virgo |
| Fri | 9th | 5 am | (3 am WST) Mercury 3° N of Moon |
| Sat | 10th | | d.p. 1 Ceres 0.4° N of M20 Trifid Nebula (BN) in Sagittarius |
| Sat | 10th | 9 am | (7 am WST) New Moon. |
| Sat | 10th | 9 pm | (7 pm WST) Comet 144P/Kushida 0.2° SW of star Aldebaran |
| Sun | 11th | | d.p. 1 Ceres 0.2° SW of M21 (OC) in Sagittarius |
| Sun | 11th | 5 am | (3 am WST) Moon at perigee (closest to Earth at 358,088 km). |
| Mon | 12th | 8 pm | (6 pm WST) Neptune 1.5° SW of Moon |
| Tue | 13th | | Mars 0.7° N of M75 (GC) in Sagittarius |
| Tue | 13th | | m.p. 7 Iris 0.1° NE of star Omicron Sagittarii |
| Tue | 13th | | Comet C/2021 S3 (PANSTARRS) 0.7° NW of NGC 6342 (GC) in Ophiuchus |
| Wed | 14th | | d.p. 1 Ceres 0.6° N of N GC 6546 (OC) in Sagittarius |
| Wed | 14th | | Comet C/2021 S3 (PANSTARRS) 0.6° E of M9 (GC) in Ophiuchus |
| Wed | 14th | am | Comet 62P/Tsuchinshan 1, 0.2° S of NGC 4608 (G) in Virgo |
| Thu | 15th | | Comet C/2021 S3 (PANSTARRS) 0.3° E of NGC 6356 (GC) in Ophiuchus |
| Thu | 15th | 9 pm | (7 pm WST) Uranus 5° S of Moon |
| Fri | 16th | | m.p. 7 Iris 0.4° S of star Pi Sagittarii |
| Sat | 17th | | m.p. 5 Astraea 1.0° SE of star Chi¹ Orionis |
| Sat | 17th | 1 am | (11 pm WST, prev day) First Quarter Moon. |
| Mon | 19th | | d.p. 1 Ceres 0.7° S of NGC 6583 (OC) in Sagittarius |
| Mon | 19th | | Comet C/2021 S3 (PANSTARRS) 0.5° N of star Xi Serpentis |
| Mon | 19th | 8 am | (6 am WST) Maximum Libration (9.0°), bright SE limb. |
| Wed | 21st | | Neptune 0.1° NW of star 20 Piscium |
| Thu | 22nd | | Comet 144P/Kushida 0.6° N of NGC 1807 (OC) in Taurus |
| Thu | 22nd | | Comet 144P/Kushida 0.4° NW of NGC 1817 (OC) in Taurus |
| Fri | 23rd | 4 am | (2 am WST) Mars 0.5° S of Venus |
| Fri | 23rd | 11 pm | (9 pm WST) Comet 62P/Tsuchinshan 1, 0.1° SE of NGC 4596 (G) in Virgo |
| Sat | 24th | 11 pm | (9 pm WST) Full Moon (405,917 km). |
| Mon | 26th | | Comet C/2021 S3 (PANSTARRS) 0.5° N of star Nu Ophiuchi |
| Mon | 26th | am | m.p. 23 Thalia 0.2° NE of NGC 4147 (GC) in Coma Berenices |
| Mon | 26th | 1 am | (11 pm WST, prev day) Moon at apogee (furthest from Earth at 406,312 km). |
| Wed | 28th | | Venus 0.5° W of star Theta Capricorni |
| Wed | 28th | | m.p. 5 Astraea 0.3° NW of star Chi² Orionis |
| Wed | 28th | | Comet C/2021 S3 (PANSTARRS) 0.2° W of NGC 6539 (GC) in Serpens |
| Wed | 28th | | Mercury in superior conjunction |
| Wed | 28th | pm | Comet 62P/Tsuchinshan 1, 0.6° N of NGC 4578 (G) in Virgo |
| Thu | 29th | | Comet 13P/Olbers 0.6° SE of star Alpha Ceti |
| Thu | 29th | | Saturn in conjunction with Sun |

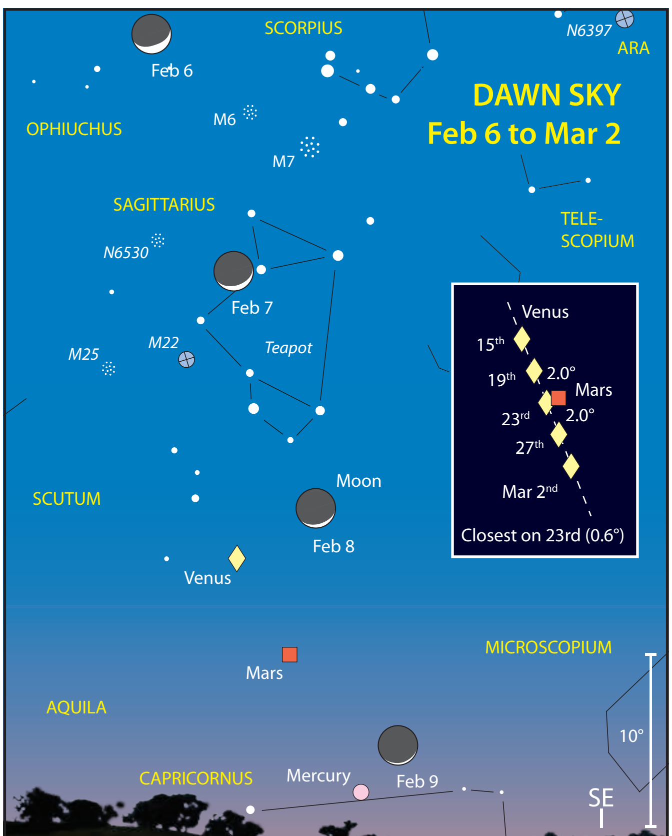
of this canine is made up of a truly remarkable group known as The Virgins. Arranged in a distorted Mercedes Benz logo shape: Epsilon (ε), Eta (η), Omicron² ($o^2$) with central star, Delta (δ) Canis Majoris (magnitudes 1.5, 2.4, 3.0 and 1.8 respectively) are four of the most luminous stars known. Omicron² faintness is only due to its shear distance of 3,400 light-years. The star's brilliance is over 60,000 times our Sun!

While in Canis Major, here are some objects, close to Sirius, ideally suited for small telescopes, starting with two impressive double stars. Pi (π) CMa has a 4.6 magnitude yellow primary with a 9.6 magnitude blue companion, separated by 11 arcseconds. Within the same eyepiece field, only 0.3° away is the multiple star, 17 CMa, comprised of a 5.8 magnitude primary with two companions both approximately 45 arcseconds away, one to the south and the other south-east, magnitudes 9.2 and 8.7 respectively. Move 2° west and discover the brilliant open star cluster M41. The cluster has around 100 well-scattered stars down to mag 12, within a 40 arcminute circle. Its highlight is around a dozen 8th to 9th magnitude blue/white stars with a brilliant 7th magnitude orange star near the centre!

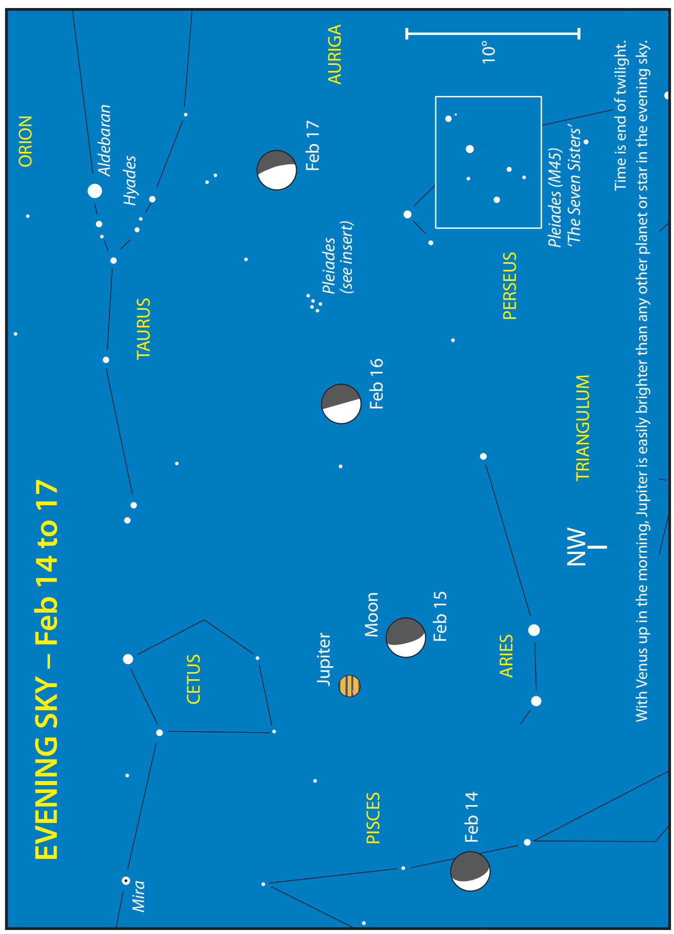
It is interesting that of the 20 closest stars to Earth, only four are considered bright (better than magnitude 1). Two are Procyon, which is 11.4 light-years distant and Sirius, located 8.6 light-years away. The morning sees another, low in the south-east sky, Alpha Centauri, the second closest star at only 4.3 light-years. The fourth is the brightest and closest star of all, but you'll have to wait until daylight to see the Sun!



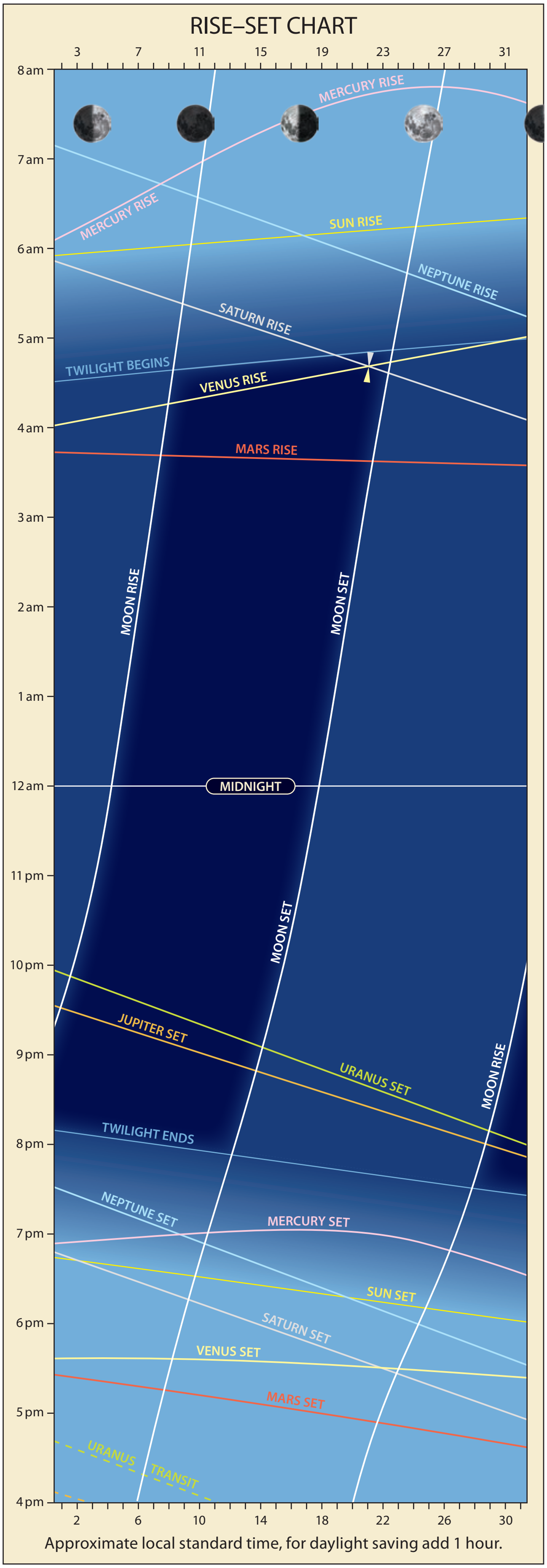

Approximate local standard time, for daylight saving add one hour.




Time is 45 mins before sunrise.
Venus, Mars and Mercury continue to look impressive in the dawn sky, although Mercury will be lost from the morning by month's end.
Note, the close conjunction on the 23rd between Venus and Mars (see insert)



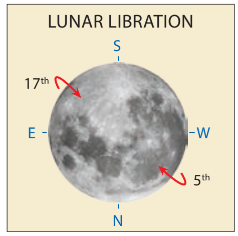
# MARCH 2024




## HIGHLIGHTS

- Venus and Moon close.
- Venus and Saturn close.

## THE MOON




4th 1 am (11 pm WST, previous day) Last Quarter.

5th 7 am (5 am WST) Maximum Libration (10.2°), bright NW limb. Although not in the libration zone, the 222 km very dark-floored circular formation Grimaldi can be seen to good advantage.

10th 5 pm (3 pm WST) Moon at perigee (closest to Earth at 356,895 km).

10th 7 pm (5 pm WST) New Moon.

17th 2 pm (Noon WST) First Quarter.

17th 9 pm (7 pm WST) Maximum Libration (9.7°), bright SE limb. The bright limb will wash out most eastern limb features like craters and mountains during this libration. However, Mare Smythii (Smyth's Sea) will be easily visible centred on the equator, and Mare Marginis (The Border Sea) east of Mare Crisium (Sea of Crises) will appear as dark elongated regions along the limb.

24th 2 am (Midnight WST, previous day) Moon at apogee (furthest from Earth at 406,294 km).

25th 5 pm (3 pm WST) Full Moon, penumbral lunar eclipse, Americas, Pacific Ocean and eastern Australia.

## APPEARANCE of the PLANETS

### MERCURY

10 Mar
dia 5.4"
mag –1.4

25 Mar
dia 7.5"
mag –0.2
Greatest elongation East (18.7°)

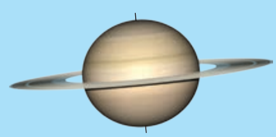
### VENUS

15 Mar
dia 10.7"
mag –3.8

### MARS

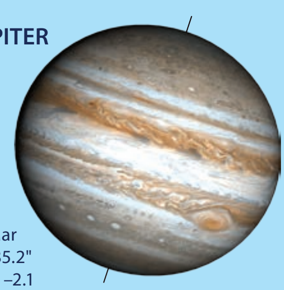
15 Mar
dia 4.3"
mag 1.2

### SATURN



15 Mar
dia 15.6″
mag 1.0

### JUPITER



15 Mar
dia 35.2"
mag –2.1

### URANUS

15 Mar
dia 3.5"
mag 5.8

### NEPTUNE

1 Mar
dia 2.2"
mag 8.0
Conjunction 17 Mar

## THE PLANETS

**Mercury** returns to the evening sky after last month's solar conjunction. Unfortunately, this apparition is poor, with the planet barely a few degrees above the horizon at the end of civil twilight. The speedy little world reaches its greatest elongation 19° east of the Sun on the 25th.

**Venus** is visible in the eastern morning sky a little before the beginning of civil dawn. The Red Planet, Mars, can be seen less than 5° above Venus for the first few days of the month. On the 9th, Venus will be just 3° from the slender crescent of the 28-day-old waning crescent Moon, creating a splendid sight (see Sky View). Finally, on the 22nd, Venus and Saturn will be just 0.6° apart (see Sky View). Binoculars are recommended for a difficult observation with the pair low to the eastern horizon about an hour before sunrise.

The **Earth** is at its autumnal equinox on the 20th.

**Mars** is visible in the eastern morning sky before the onset of twilight. The Red Planet will be within 5° of Venus for the first few days of the month before its brighter companion slips away toward the horizon. Mars spends the first two thirds of March in Capricornus before moving into Aquarius.

**Jupiter**, in Aries, is visible in the early western evening sky setting around 8:30 pm mid-month. On the 14th, the 5-day-old waxing crescent Moon appears 7° north of the planet (see Sky View); whilst not that close, a bright planet near the Moon always grabs one's attention. Since May 2023, the giant world has shared the constellation of the Ram with Uranus, and by month's end, the pair will be 4° apart. Although lost in the evening twilight, the pair move within 0.5° of each other next month.

**Saturn**, in Aquarius, returns to the eastern morning sky after its conjunction with the Sun late last month. On the 22nd, the Ringed Planet will be approximately half a degree from Venus—a challenging observation, see Venus for details and Sky View).

**Uranus**, in Aries, appears low in the early north-western evening sky after the end of astronomical twilight.

**Neptune** is in conjunction with the Sun on the 17th and reappears in the morning sky in early April.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 3 Mar | 129 Antigone | Leo | 10.6 |
| 3 Mar | 230 Athamantis | Sextans | 10.7 |
| 4 Mar | 3 Juno | Leo | 8.7 |
| 4 Mar | 324 Bamberga | Leo | 11.8 |
| 12 Mar | 23 Thalia | Leo | 9.7 |

## COMETS

**Comet 62P/Tsuchinshan 1** (All Sky Map 7) spends the month in Virgo. As March opens it is around magnitude 9, rising in the eastern sky shortly after twilight and transiting in the northern sky around 2 am. By month's end it has faded to around magnitude 12, rising just before sunset in the eastern sky and setting in the western sky just before sunrise. The comet continues to visit members of the Virgo/Coma Cluster of Galaxies (see Diary).

**Comet 144P/Kushida** (All Sky Map 3) opens the month in Taurus and moves briefly into Orion before spending the second half of the month in Gemini. It is transiting in the northern sky shortly after sunset, then sets in the western sky around midnight. It continues to fade from around magnitude 10 to 12.

**Comet C/2021 S3 (PANSTARRS)** (All Sky Maps 8 and 9) spends the month rising in the north-eastern sky around 1:30 am. It begins in Serpens at magnitude 8.6 before moving to Aquila on the 15th then into Vulpecula on the 30th, ending the month at magnitude 8.9.

**Comet C/2022 L2 (ATLAS)** is in Centaurus about magnitude 12, initially rising in the south-eastern sky just after twilight and overhead before dawn. From mid-month it is rising in daylight and transiting in the early morning.

For most of March, **Comet 12P/Pons-Brooks** (All Sky Map 3) is in daylight. During the last week it can be seen in

### DIARY

| | | | |
|---|---|---|---|
| Fri | 1st | | d.p. 1 Ceres 0.4° N of NGC 6642 (GC) in Sagittarius |
| Sun | 3rd | | Mars 0.5° SE of star Theta Capricorni |
| Mon | 4th | | d.p. 1 Ceres 0.8° N of M22 (GC) in Sagittarius |
| Mon | 4th | 1 am | (11 pm WST, prev day) Last Quarter Moon. |
| Mon | 4th | | m.p.3 Juno at opposition |
| Tue | 5th | | Comet C/2021 S3 (PANSTARRS) 0.5° N of star Eta Serpentis |
| Tue | 5th | 7 am | (5 am WST) Maximum Libration (10.2°), bright NW limb. |
| Fri | 8th | | Mars 0.3° N of star Iota Capricorni |
| Fri | 8th | 5 am | (3 am WST) Mars 7° NE of Moon |
| Sat | 9th | 5 am | (3 am WST) Venus 3° NW of Moon |
| Sun | 10th | 5 pm | (3 pm WST) Moon at perigee (closest to Earth at 356,895 km). |
| Sun | 10th | 7 pm | (5 pm WST) New Moon. |
| Sun | 10th | pm | m.p. 3 Juno 0.5° SW of NGC 3423 (G) in Sextans |
| Mon | 11th | pm | Comet 62P/Tsuchinshan 1, 0.6° N of NGC 4442 (G) in Virgo |
| Tue | 12th | pm | Comet 62P/Tsuchinshan 1, 0.7° S of NGC 4429 (G) in Virgo |
| Wed | 13th | | Comet C/2021 S3 (PANSTARRS) 1.0° SE of IC 4756 (OC) in Serpens |
| Fri | 15th | | Jupiter 0.3° SE of star Omicron Arietis |
| Fri | 15th | am | gamma-Normids meteor shower, Feb 25 to Mar 28. |
| Sun | 17th | | Comet 13P/Olbers 1.2° NW of star Omicron Tauri |
| Sun | 17th | 2 pm | (Noon WST) First Quarter Moon. |
| Sun | 17th | | Neptune in conjunction with Sun |
| Sun | 17th | 9 pm | (7 pm WST) Maximum Libration (9.7°), bright SE limb. |
| Tue | 19th | | Comet 13P/Olbers 1.2° NW of star Xi Tauri |
| Wed | 20th | | Comet C/2021 S3 (PANSTARRS) 0.5° S of NGC 6738 (OC) in Aquila |
| Wed | 20th | | Equinox |
| Thu | 21st | | Comet 144P/Kushida 1.0° N of star Gamma Geminorum |
| Thu | 21st | am | m.p. 6 Hebe 0.3° W of NGC 5775 (G) in Virgo |
| Fri | 22nd | | Jupiter 0.4° NW of star Sigma Arietis |
| Fri | 22nd | 5 am | (3 am WST) Saturn 0.5° SE of Venus |
| Sat | 23rd | | Comet C/2021 S3 (PANSTARRS) 0.6° E of star Zeta Aquilae |
| Sun | 24th | 2 am | (Midnight WST, prev day) Moon at apogee (furthest from Earth at 406,294 km). |
| Mon | 25th | | Mercury at greatest elongation East (18.7°) |
| Mon | 25th | 5 pm | (3 pm WST) Full Moon (405,394 km), penumbral lunar eclipse, Americas. |
| Sat | 30th | | Comet C/2021 S3 (PANSTARRS) 0.4° SW of Collinder 399 (Coat hanger) OC in Vulpecula |

# In the Dark

The International Dark-Sky Association (IDA) has a Dark Places program, that works with communities, parks, municipalities, and the public to certify and protect dark places for humans and wildlife alike.

There are five types of certifications with different criteria. The IDA has certified more than 200 Places in 22 countries on 6 continents, growing every year, Australia has four: two sanctuaries, one reserve and one park.

**International Dark Sky Sanctuaries**

A Dark Sky Sanctuary is public or private land that has an exceptional or distinguished quality of starry nights and a nocturnal environment that is protected for its scientific, natural, or educational value, its cultural heritage, and/or public enjoyment.

A sanctuary differs from a Dark Sky Park or Reserve in that it is typically situated in a very remote location with few (if any) nearby threats to the quality of its dark night skies and does not otherwise meet the requirements for designation as a park or reserve. The typical geographic isolation of Dark Sky Sanctuaries significantly limits opportunities for public outreach, so a Sanctuary designation is specifically designed to increase awareness of these fragile sites and promote their long-term conservation.

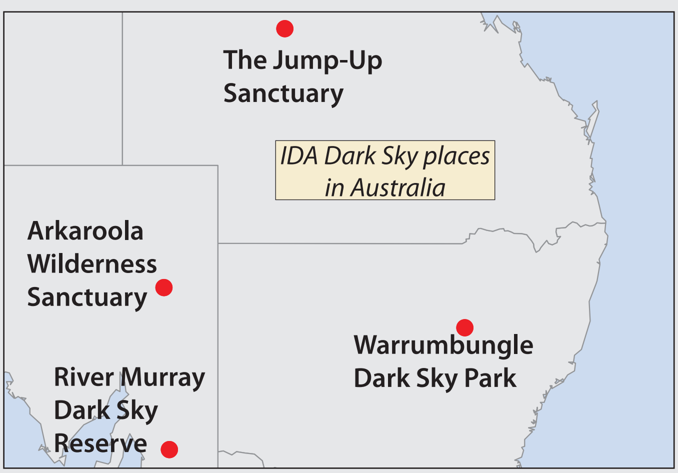
**International Dark Sky Reserves**

A Dark Sky Reserve is public or private land possessing an exceptional or distinguished quality of starry nights and nocturnal environment that is specifically protected for its scientific, natural, or educational value, its cultural heritage, and/or public enjoyment.

Reserves consist of a core area meeting minimum criteria for sky quality and natural darkness, and a peripheral area that supports dark sky preservation in the core. Reserves are formed through a partnership of multiple land managers who have recognised the value of the natural night-time environment through regulations and long-term planning.

**International Dark Sky Parks**

A certified Dark Sky Park is land possessing an exceptional or distinguished quality of starry nights and a nocturnal environment that is specifically protected for its scientific, natural, or educational value, its cultural heritage, and/or public enjoyment.




The land may be publicly or privately owned, provided that the landowner(s) consent to the right of permanent, ongoing public access to specific areas included in the Dark Sky Park designation.

**International Dark Sky Communities**

A Dark Sky Community is a town, city, municipality, or other legally organised community that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of a quality outdoor lighting ordinance, dark sky education, and citizen support of dark skies.

**Urban Night Sky Places**

An Urban Night Sky Place is a municipal park, open space, observing site, or other similar property near or surrounded by large urban environs, and whose planning and design actively promote an authentic night-time experience in the midst of significant artificial light.

## Australian Dark Sky Places

**Warrumbungle Dark Sky Park**

This is a 23,000-hectare park in NSW. In addition to its spectacular daytime vistas of the Warrumbungle Mountain Range, the Park has long been known for the quality of its dark night skies. In the 1950s, seeking relief from the light pollution of Canberra that negatively impacted its Mount Stromlo Observatory, the Australian government relocated major operations to a new observatory at Siding Spring. Lessons learnt at Mount Stromlo encouraged early conservation of dark skies in the area, including at Warrumbungle, to protect the national investment in Australia's professional astronomy infrastructure.

Warrumbungle's status as the first IDA Dark Sky Park in Australia is a natural extension of the work it has done for years to contain threats to the observatory site through outdoor lighting policy and regional planning. The National Park has increased opportunities for all visitors to take in remarkably dark night skies, whether or not they visit the observatory.

**The Jump-Up International Dark-Sky Sanctuary**

As the Dinosaur's Museum's position atop The Jump-Up is bereft of population and light pollution; it is the perfect spot to stargaze.

When viewing the Milky Way from The Jump-Up what you are actually seeing is the breadth of our spiral galaxy. Earth is located about two-thirds of the way out from the centre of the galaxy in one of the spiral arms known as the Orion Arm.

When on The Jump-Up, take time to find the parts of the Milky Way which are dark, areas where stars have been blocked out by dark nebulae. These nebulae are accumulations of gas and dust so thick that we can't see through them. The Star Gallery is the perfect place to enjoy some of the darkest skies in the world. The viewing area is free, open year-round and located at the base of The Jump-Up. Bring your telescope, binoculars, picnic and enjoy our spectacular southern skies!

**The River Murray International Dark Sky Reserve**

The River Murray International Dark Sky Reserve consists of over 3300 km$^2$ of rural land within the Mid Murray Council area in SA, situated between the eastern slopes of the Adelaide Hills and the River Murray, it is known for its dry climate and cloudless skies. Measurements have

Aries possibly as bright as 5th magnitude, low in the in the north-western sky where it sets shortly after sunset.

**Comet 13P/Olbers** begins the month in Cetus at magnitude 11.6, setting around 10 pm in the western sky. On the 19th it moves briefly into Aries then Taurus on the 20th at about magnitude 11, setting around 9 pm and ends March about 10.6 magnitude, setting about an hour after twilight.

## METEOR SHOWER

The **gamma-Normids** are active between February 25 and March 28. The rate is low for most of the period, and members are difficult to sort out from the sporadic background activity. The peak is expected around March 14, when rates can reach six per hour. Generally, the gamma-Normids are bright, chiefly yellow, white, or orange, with about 15% leaving trains. The best viewing is before dawn on the 15th when the radiant is highest, and the Moon has set.

## CONSTELLATIONS

Many of the distinctive summer constellations, such as Taurus and Orion are now sinking towards the western horizon. This includes Canis Major with the brightest star, Sirius. However, we in the antipodes, are also blessed with the second brightest star, Canopus, only 36° south of Sirius and currently high in the south (see Map 1 and 4). It's not only people from down-under who appreciate its southerly prominence, but many robotic space probes use it as a key navigation star while exploring the Solar System.

As discussed in previous yearbooks, one of the original constellations, the ship Argo, was dedicated to the mythology of Jason and his search for the Golden Fleece. Today Argo exists as three constellations, broken up into Carina (the keel), Puppis (the stern) and Vela (its sails) – Map 1.

The use of letters from the Greek alphabet, is called the Bayer naming system, where the brightest star in the constellation is normally designated alpha, the second brightest beta and so on (this doesn't work out for all constellations).

shown exceptional darkness right across the region, and Sky Quality Meter (SQM) readings of 21.9 are common. This is Australia's first Dark Sky Reserve, receiving accreditation from the IDA in October 2019.

The Reserve's core is in the Swan Reach Conservation Park, originally established in 1970 principally to protect the endangered southern hairy-nosed wombat, whilst its public education centre is at Meldanda, a 100-acre property just outside the hamlet of Cambrai, where camping is available for a small fee per head. A well-equipped hall is also available, and two large (300 m x 600 m) car-accessible flat astro paddocks, well away from any road, are available with very low horizons, along with a portable loo. A number of concrete telescope pads are provided throughout the Reserve.

The Reserve includes some 80 kilometres of the magnificent River Murray, small townships, Conservation Parks, farmland, and some of the darkest skies on the planet.

The park comes under the control of the South Australian Ministry for Environment and Water and is managed on its behalf by the Department of Environment and Water (DEW). State government legislation and associated regulations mean that development inside the park is restricted solely to structures associated with conservation management.

The River Murray International Dark Sky Reserve is an initiative of Mid Murray Landcare SA working closely with the Mid Murray Council and aims to raise awareness of the problems of light pollution and its impact on Australia's unique nocturnal wildlife.

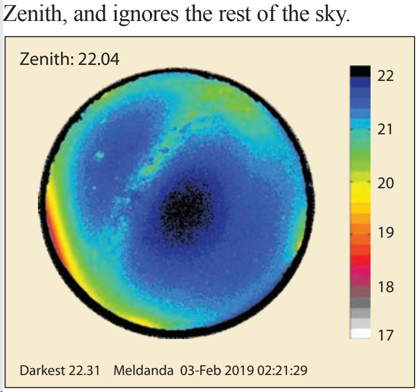
**Arkaroola Wilderness Sanctuary (SA)**

Located in the Flinders Ranges it spans over 63,000 hectares of conservation land. It holds great cultural significance for the Adnyamathanha people, who maintain a strong connection to the landscape and its stories.

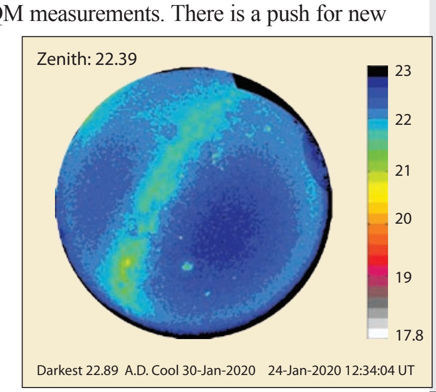
Arkaroola's arid environment, elevation, and remote location contribute to exceptional stargazing conditions. Since establishing the first observatory in 1986, the sanctuary has expanded to feature six Designated Observatories. These observatories cater to various purposes, including guided tours, an international organisation dedicated to spaceflight safety, and a freely accessible facility for visiting astronomers.

Founded in 1968 by Dr Reg Sprigg and Griselda Sprigg, Arkaroola was intended to promote tourism to support ongoing conservation, education, and research. The legacy continues through the Arkaroola Education and Research Foundation. With over 12,000 visitors from around the world annually, the sanctuary offers a range of accommodation and camping options and guided and self-guided experiences. Astronomy enthusiasts can choose activities such as traditional eye-to-telescope observing, a state-of-the-art digital Astro Experience, and learning.

The current method of measuring sky brightness (or lack there of) uses an SQM measurement, which only looks at a small keyhole around the Zenith, and ignores the rest of the sky.



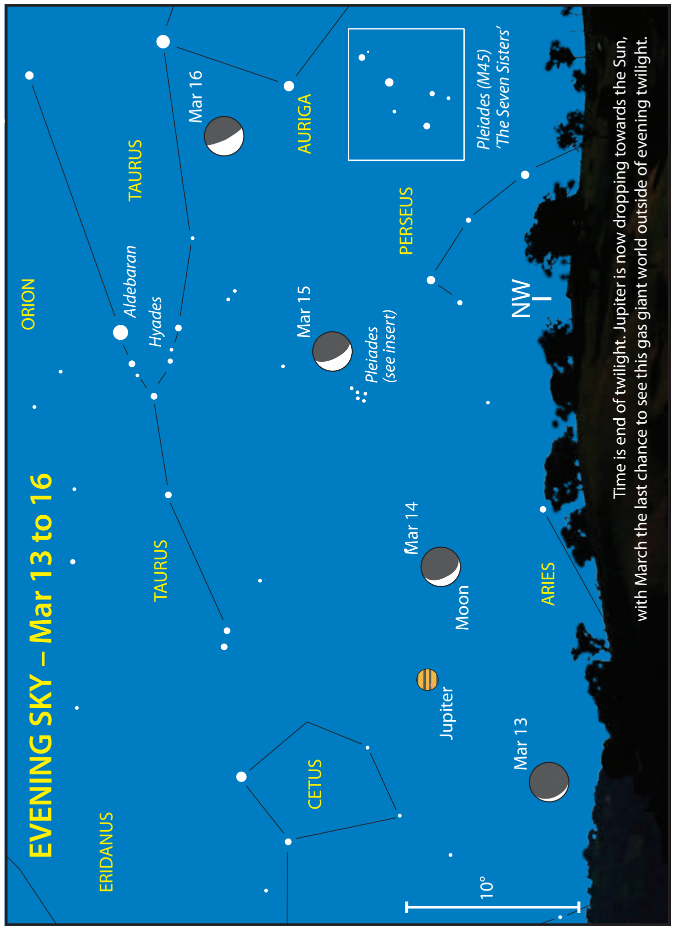

An alternate method uses a calibrated camera system, and software written by Prof Zoltan Kollath, a noted Hungarian Light Pollution Researcher. This plots the sky and each pixel is converted to Magnitude/arcsec². Prof Kollath's software is called Dicalum, so these are currently called Dicalum plots for short. The allsky images and the resulting Dicalum plots are a better description of a site's Night Sky Brightness than an SQM measurements. There is a push for new applicants for IDA Dark Sky status to be required to present a Dicalum-like plot, from which some metric would be derived that describes the whole sky. How that metric might be derived is open for discussion and table-thumping. Shown here are Dicalum plots for River Murray (left) and Arkaroola (right).



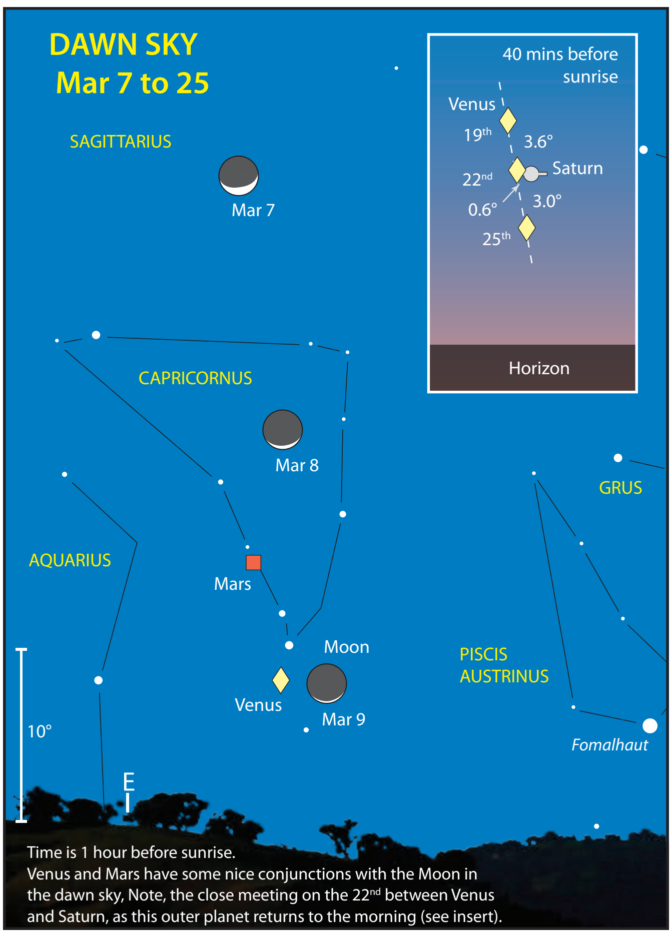
The three Argo constellations still reflect the original legacy treating them as a single constellation. Amongst these three modern constellations there is only one star called ‘Alpha’, ‘Beta’, ‘Gamma’ etc. The alpha star resides in Carina, Canopus or Alpha (α) Carinae, but originally called Alpha Argus. It marks the position of the rudder. Beta (β) also resides in Carina, the 1.6 magnitude star, Miaplacidus, located at the base of the Diamond Cross. The other cross residing in Argo Navis is the False Cross, making up the mast and joining the constellation of the keel to its sails.

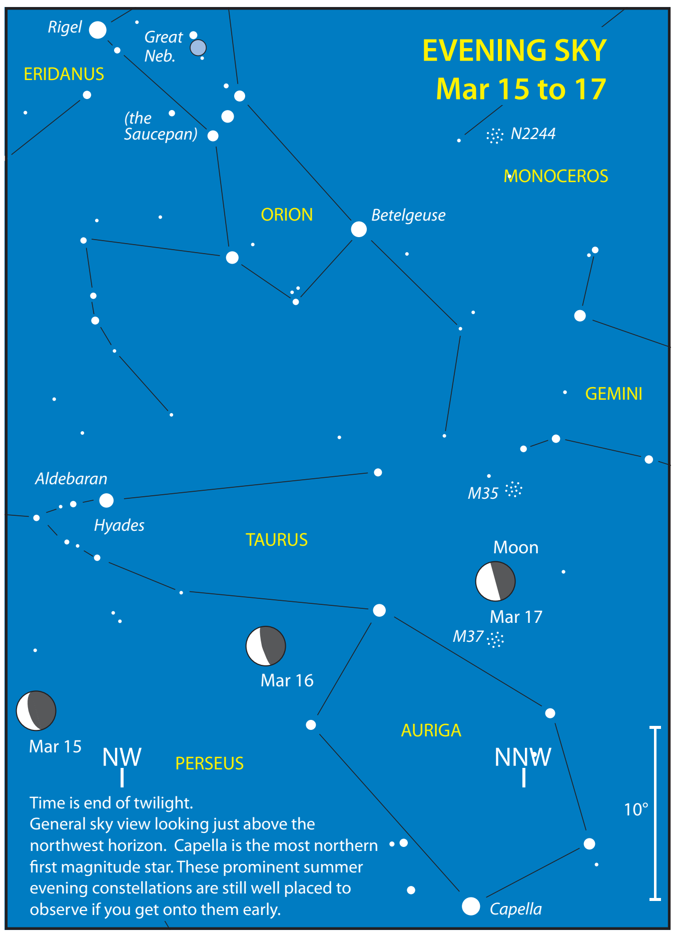
Although observers often charge off to look at the magnificent Eta Carinae complex of nebulae and clusters, perhaps Carina’s best and overlooked star cluster is the one at the base of the false cross, NGC 2516. The naked eye sees it as a ghostly apparition about 0.5° in diameter. Although great through any binoculars it is best in a 150 mm telescope showing around 100 stars, with a large variation in colour and magnitude, many arranged as doubles or in chains. Look for the nice clump of bright stars (some 6th magnitude), off centre to the south-east.

The brilliant 2nd magnitude multiple star Gamma (γ) Velorum (originally Gamma Argus) resides at the western end of Vela. Binoculars show two white stars of magnitude 1.8 and 4.2, separated by 41 arcseconds. Two additional, slightly yellow companions go off at a right angle to this pair towards the south-east. They are magnitude 7.4 and 9.2 separated by 60 and 90 arcseconds respectively from the main pair, giving the overall shape of a capital Y. Delta and Epsilon are two of the False Cross stars. We need to get to Zeta (ζ) to find the brightest star in Puppis. Second magnitude, Zeta (ζ) Puppis is the alpha star of the stern (sometimes called the poop deck).



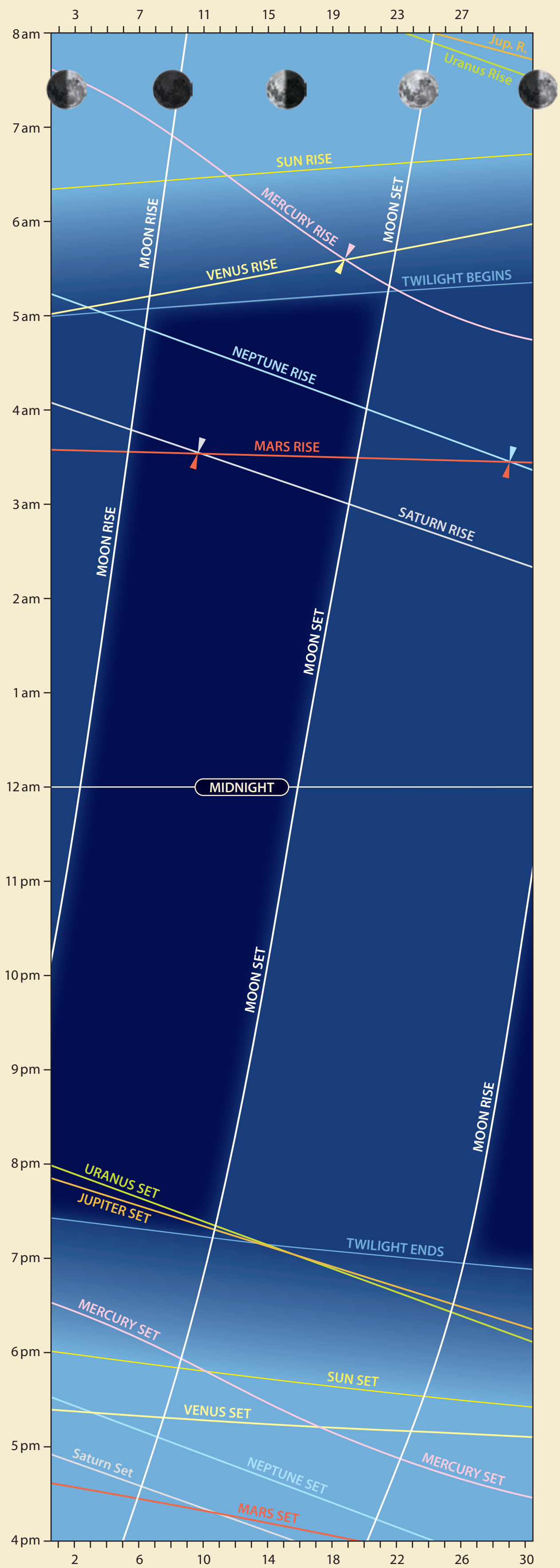

Approximate local standard time, for daylight saving add one hour.



# APRIL 2024

RISE–SET CHART

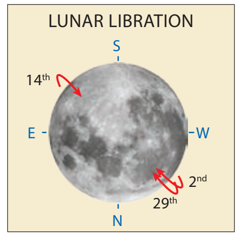


Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Mercury, Venus, Mars, Saturn and Neptune all rising in the morning sky.
- Mercury and Venus close.
- Mars and Saturn together.
- Mars and Neptune close.

## THE MOON




2nd 3 am (1 am WST) Maximum Libration (10.0°), bright NW limb.

2nd 1 pm (11 am WST) Last Quarter.

8th 4 am (2 am WST) Moon at perigee (closest to Earth at 358,850 km).

9th 4 am (2 am WST) New Moon, total solar eclipse north and central America (see eclipse page 102).

14th 5 pm (3 pm WST) Maximum Libration (9.7°), bright SE limb.

16th 5 am (3 am WST) First Quarter.

20th Noon (10 am WST) Moon at apogee (furthest from Earth at 405,623 km).

24th 10 am (8 am WST) Full Moon.

29th 1 pm (11 am WST) Maximum Libration (9.1°), bright NW limb.

## APPEARANCE of the PLANETS

**MERCURY** Mercury in inferior conjunction on the 12th

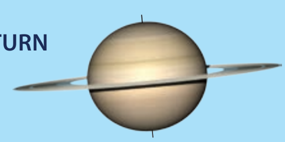
2 Apr
dia 9.5"
mag 1.8

25 Apr
dia 10.7"
mag 1.9

**VENUS**
15 Apr
dia 10.0"
mag –3.8

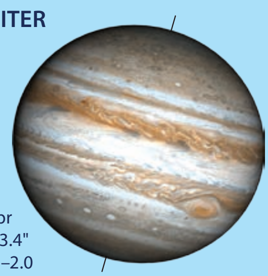
**MARS**
15 Apr
dia 4.6"
mag 1.2

**SATURN**



15 Apr
dia 15.9"
mag 1.1

**JUPITER**



15 Apr
dia 33.4"
mag –2.0

**URANUS**

15 Apr
dia 3.4"
mag 5.8

**NEPTUNE**

15 Apr
dia 2.2"
mag 8.0

# James Webb Space Telescope – Cover Image

At the time of writing, the James Webb Space Telescope (JWST) had just celebrated its first full year of scientific observations. its infrared view of the Universe has led to numerous discoveries over these 12 months.

**The cover image – Stellar Nurseries**

One of the earlier JWST images is shown on our cover, the magnificent Tarantula Nebula (30 Doradus). This is one of the largest star forming regions known and is located in the Large Magellanic Cloud, a nearby companion galaxy to the Milky Way, approximately 160,000 light-years away. These stellar nurseries consist of groups of newly born (and still forming) hot stars, surrounded by the nebulae (gas and dust) from which they were formed. This LMC nebula shows as filaments, which are the legs of this arachnid. Compared to the life cycle of stars they exist for brief periods (perhaps a few million years) with the extremely energetic stellar winds of these new luminaries eventually blowing away the gas which has not been consumed, before the stars disperse into their surroundings.

The below (left) image shows a wider view of our JWST cover with the right image the same field taken by the Hubble Space Telescope (HST), which observes mostly in the visible part of the spectrum. The most obvious feature is the brilliance of the nebulae almost swamping Hubble's detectors, whereas the JWST looks at the longer wavelength, infrared radiation that passes straight through the nebula. This has revealed much more detail in the nebulous knots and eddies and the best view to date of the inner cluster of massive stars and the hollow cavity it is in the process of forming (blowing away the gas). In general, JWST being effectively a 6-metre mirror gives a more detailed view (higher resolution) than the smaller 2-metre optics of Hubble.

'Webb' has done some astonishing imaging of star forming regions, with other famous examples being the Eagle Nebula (search on Pillars of Creation), the Orion Nebulae and Rho Ophiuchi (the closest stellar nursery to us). The following gives a brief overview of some other JWST highlights to date.

**The Early Universe**

This is a key area of study for JWST, for objects that could be seen in the visible spectrum one billion years after the big bang, have now had their light red shifted into the infrared. JWST has already detected objects as early as 300-400 million years after the big bang (the previous record was just under a billion light-years). In many cases the objects were so faint, JWST had to rely on gravitational lensing to detect them. The telescope has shown the mature nature of many of the earliest spiral galaxies, which were seen to be completely formed with hubs and spiral arms.

Some, as far back as 570 million light-years after the big bang, were developed enough to have quasars. These are extremely active galactic nuclei (AGN), being radiated by massive central black holes. Although quasars are so distant (so far in the past), it was still thought more time was needed for enough material to accrete on the black hole for the quasar to kick-in.

Although this work is in its early phase, JWST has looked at a previous area, corresponding to part of a famous Deep Field image and found ten times more galaxies than Hubble! Looking on the cosmic scale, it is now thought the arrangement of galaxies into filaments and voids might have been evident as early as 800 million years after the big bang.

Spectroscopy has also contributed significantly to this knowledge of the early universe, with organic molecules (specifically polycyclic aromatic hydrocarbons) being detected in gravitational lenses. This may indicate that life had the potential to develop early in the Universe.

**Contributions to Exo-Planet studies**

JWST has looked at known transiting exo-planets, planets that from our perspective pass in front of their star on each orbit (transit across the stellar disc). JWST's spectroscopy, having the ability to see past stellar spectroscopic lines, has detected in the atmosphere of some of these planets chemical fingerprints corresponding to water vapour, potassium, sodium, and carbon monoxide. For the first time carbon

*Tarantula nebula (30 Doradus) from JWST (left) and HST (right), both scaled the same.*

## THE PLANETS

**Mercury** leaves the evening twilight to return to the eastern morning sky this month. It is in inferior conjunction (between the Earth and Sun) on the 12th and gradually becomes visible as it gains altitude before sunrise. On the 19th, Mercury will be 2° north of Venus, a difficult observation in the brightening dawn and low to the horizon (see Sky View). The best option is to locate Venus and use binoculars to see the fainter companion.

Low in the eastern dawn sky, **Venus** is visible until late April. After that, it becomes too close to the Sun for observation as it moves toward superior conjunction in June. However, early risers could try for a view of Venus and Mercury when they are 2° apart on the 19th (see Mercury).

**Mars** is visible in the eastern morning sky in Aquarius. From the 4th till the 18th, the planet will be within 5° of Saturn, and only 0.4° on the 11th, an excellent sight in a low-power telescope field (see Sky View). The pair are currently very closely matched in magnitude. The orangish Mars will stand out readily from the dusky white of Saturn to the unaided eye. Moving from Aquarius at the end of April to Pisces, Mars has another close planetary encounter—this time with the outermost planet, Neptune. On the 29th and the 30th, they will be just 0.5° apart, providing an excellent contrasty telescope field of orangish and bluish worlds.

**Jupiter**, in Aries since last May, travels into Taurus at month's end, where it will remain for the rest of the year. As the planet moves toward solar conjunction next month, it becomes increasingly difficult to spot in the brightening western dusk sky.

Once Jupiter and Uranus drop into the evening twilight (mid-April), the evening sky will show no planets until mid-June when Saturn will be rising before midnight.

**Saturn**, in Aquarius, rises in the eastern sky around 3 am mid-month. The constellation of the Water Bearer will be the planet's home until it moves into Pisces in May 2025. The constellation can be challenging to identify with its brightest stars (Alpha and Beta Aquarii), just 3rd magnitude. Saturn, on the other hand, at 1st magnitude, stands out in this whole section of sky devoid of bright stars. The Ringed Planet has a close encounter with Mars on the 11th, rewarding early-morning observers with a neat view with any size telescope (see Mars). The gas giant will be in conjunction with the Sun next month, reappearing in the morning sky in June in the constellation of Taurus.

This month, **Uranus** becomes lost in the western dusk sky as it moves toward its conjunction with the Sun in May.

**Neptune**, in Pisces, reappears in the eastern dawn sky after its conjunction with the Sun last month. On the 29th and 30th, the blue coloured Neptune and the Red Planet meet up. At just 0.5° apart, the pair will make an excellent colour display in small telescopes.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the evening of 4th, magnitude 8 Vesta is on the northern edge of the open cluster M35 in Gemini. Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 2 Apr | 12 Victoria | Corvus | 10.4 |
| 8 Apr | 30 Urania | Virgo | 10.9 |
| 9 Apr | 532 Herculina | Boötes | 9.0 |
| 9 Apr | 115 Thyra | Hydra | 11.6 |
| 11 Apr | 89 Julia | Hydra | 11.2 |
| 21 Apr | 25 Phocaea | Virgo | 10.3 |
| 23 Apr | 6 Hebe | Boötes | 9.9 |

## COMETS

**Comet 62P/Tsuchinshan 1** is still in Virgo, beginning about magnitude 12, rising in daylight, transiting around 11:30 pm and setting in the western sky about an hour before sunrise. By mid-month it has faded to 13th magnitude and down to 14th at month's end.

**Comet 144P/Kushida** commences April in Gemini before moving to Cancer mid-month. It is rising in daylight, transiting in the northern sky shortly after sunset, then setting in the western sky around midnight. It continues to fade from around magnitude 12 to 13.

dioxide has also been 'seen'. JWST has started to look at the famous planetary system of the cool red star, Trappist 1. It has confirmed 1b and 1c have no atmospheres. With analysis of its five other planets to soon follow, some known to exist in the star's habitable zone, we could be in for some interesting discoveries. JWST has also studied the famous hot Jupiter planet, WASP 18b. This planet is ten times the mass of Jupiter and orbits its star in only 23 hours! JWST was able to study the distribution of heat on the planet and discovered it was tidally locked, having one side continually baking under the glare of its star.

**Solar System**

The telescope has also surveyed the outer planets of the Solar System, producing fascinating images, showing which areas are the most reflective in infrared. For example, Jupiter's Great Red Spot well and truly stands out as the 'brightest' part of the disc. Looking at the ring systems, Saturn's are brilliant being composed mainly of ice where Uranus and Neptune's are more subdued, being very dusty. Neptune shows storms and banding in its upper atmosphere.

JWST has also imaged many of the major moons. Saturn's Enceladus shows its water geysers with their plumes extending 10 thousand kilometres into space, spraying out around 300 litres per second of water into space. This is enough to fill an Olympic sized swimming pool in two hours! The telescope's infrared capability allowed JWST to peer through the thick hazy methane atmosphere of Titan, showing clouds and surface features clearly.

In conclusion, the future of Webb is looking very bright, with current estimates showing a life of at least 20 years. Like Hubble, after one year, all the images of JWST are released into the public domain. So, keep an eye on the websites for future breathtaking images and developments.

**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 9) spends the month rising in the north-eastern sky around 2 am. It begins in Vulpecula at magnitude 9 before moving to Cygnus on the 9th, ending the month at about magnitude 10.

**Comet C/2022 L2 (ATLAS)** begins in Centaurus at magnitude 12, rising in daylight, transiting high in the southern sky around midnight. On the 24th, ATLAS moves into Hydra, fading slightly and transiting around 9 pm. It moves into Antilia on the 29th, and sets in the south-western sky about an hour before dawn.

**Comet 12P/Pons-Brooks** (All Sky Map 3) spends the month rising and transiting in daylight but can be seen low in the north-western sky where it sets early in the evening. It starts in Aries at magnitude 5 before moving to Taurus on the 20th, ending the month at slightly brighter. In early April the comet joins 13P/Olbers in the north-west evening twilight sky.

**Comet 154P/Brewington** spends the month in Pisces, beginning at magnitude 12, rising in the eastern sky about an hour before sunrise. By month's end it has brightened to magnitude 11 and is rising shortly before dawn.

**Comet 13P/Olbers** (All Sky Map 3) is rising in daylight in Taurus. It begins April at magnitude 11, setting in the western sky about an hour after twilight and ends the month at possibly 9th magnitude and setting in the north-western sky just after twilight. In early April, the comet joins 12P/Pons-Brooks in the north-west evening twilight sky.

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** is in Virgo, beginning the month about magnitude 12, rising in the eastern sky shortly after twilight and transiting in the northern sky around 2 am. By month's end it is rising in daylight, transiting in the northern sky around 10:30 pm and setting in the western sky shortly before dawn.

## METEOR SHOWERS

The **Lyrids** are a Northern Hemisphere shower that can be seen south of the equator. Best from April 14–30, with maximum rates during pre-dawn hours of the 22nd and 23rd when their radiant is highest. The peak may only last an hour; typically the ZHR is around 18 (perhaps five or six from mid-Australian latitudes). The Lyrids have occasionally produced higher rates and are a shower to be watched because of their erratic nature. Unfortunately, there will be significant lunar interference this year, with the peak close to the Full Moon.

The **pi-Puppids** are a young southern shower produced by Comet 26P/Grigg-Skjellerup. It is best seen from April 15–28, and it is producing its peak rate of meteors on the 23rd. However, before and after the maximum, the rates are low and difficult to separate from sporadic meteors. The pi-Puppids are known for their slow speed, brightness, persistent trains, yellow meteors, and occasional fireballs. They are best seen from dusk to midnight, but this year's Full Moon will cause significant interference during maximum.

## CONSTELLATIONS

Don't ever take the southern Milky Way for granted. This month look high in the southern evening sky and soak in the grandeur that is the envy of Northern Hemisphere observers. The Southern Cross (Crux) is the jewel in the crown! Extend your closed hand and see how easily it covers this smallest,

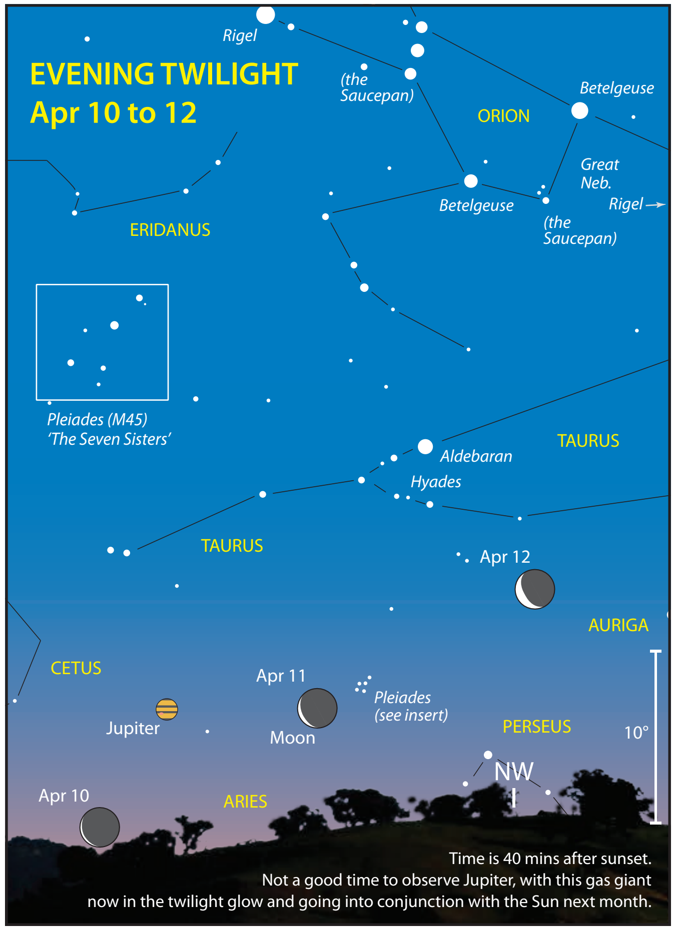
| DIARY | | | |
|---|---|---|---|
| Tue | 2nd | 3 am | (1 am WST) Maximum Libration (10.0°), bright NW limb. |
| Tue | 2nd | 1 pm | (11 am WST) Last Quarter Moon. |
| Wed | 3rd | | Comet 144P/Kushida 0.4° NW of star Lambda Geminorum |
| Wed | 3rd | 9 pm | (7 pm WST) Neptune 0.5° N of Venus |
| Sat | 6th | | m.p. 4 Vesta 0.6° N of NGC 2158 (OC) in Gemini |
| Sat | 6th | | m.p. 532 Herculina 0.2° N of star Eta Boötis |
| Sun | 7th | 5 am | (3 am WST) Saturn 6° NW of Moon |
| Mon | 8th | | Mars 0.9° SE of star Lambda Aquarii |
| Mon | 8th | | m.p. 4 Vesta 0.3° N of M35 (OC) in Gemini |
| Mon | 8th | | m.p. 3 Juno 0.2° E of star Rho Leonis |
| Mon | 8th | 4 am | (2 am WST) Moon at perigee (closest to Earth at 358,850 km). |
| Tue | 9th | | m.p. 9 Metis 1.0° N of NGC 2266 (OC) in Gemini |
| Tue | 9th | 4 am | (2 am WST) New Moon, total solar eclipse N. America, C. America (Totality: Mexico, c US, e Canada). |
| Tue | 9th | pm | m.p. 6 Hebe 1.0° NE of NGC 5701 (G) in Virgo |
| Thu | 11th | 5 am | (3 am WST) Saturn 0.5° SE of Mars |
| Fri | 12th | | Comet 13P/Olbers 16° E of Comet 12P/Pons-Brooks |
| Fri | 12th | 4 am | (2 am WST) Saturn 0.05° E of star h Aquarii |
| Fri | 12th | | Mercury in inferior conjunction |
| Sat | 13th | 11 pm | (9 pm WST) Comet 62P/Tsuchinshan 1, 0.03° SE of star Omicron Virginis |
| Sun | 14th | | m.p. 43 Ariadne 0.3° N of M19 (GC) in Ophiuchus |
| Sun | 14th | 5 pm | (3 pm WST) Maximum Libration (9.7°), bright SE limb. |
| Tue | 16th | 5 am | (3 am WST) First Quarter Moon. |
| Sat | 20th | | Comet C/2021 S3 (PANSTARRS) 0.5° NW of NGC 6871 (OC) in Cygnus |
| Sat | 20th | Noon | (10 am WST) Moon at apogee (furthest from Earth at 405,623 km). |
| Sat | 20th | 6 pm | (4 pm WST) Uranus 0.5° N of Jupiter |
| Sun | 21st | | Comet 12P/Pons-Brooks 0.4° E of star Xi Tauri |
| Sun | 21st | | Comet 12P/Pons-Brooks 1.2° NE of star Omicron Tauri |
| Mon | 22nd | am | Lyrids meteor shower, Apr 14–30, Moon affected. |
| Tue | 23rd | | m.p. 9 Metis 0.1° E of NGC 2331 (OC) in Gemini |
| Wed | 24th | | Comet C/2021 S3 (PANSTARRS) 0.5° NW of NGC 6888 (N) in Cygnus |
| Wed | 24th | 10 am | (8 am WST) Full Moon (399,781 km). |
| Wed | 24th | pm | pi-Puppids meteor shower, Apr 15–28, Moon affected. |
| Fri | 26th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.9° S of star Zeta Virginis |
| Sat | 27th | | m.p. 354 Eleonora 0.3° S of star Mu$^2$ Cancri |
| Sat | 27th | | m.p. 43 Ariadne 1.0° NW of NGC 6293 (GC) in Ophiuchus |
| Sat | 27th | | Comet C/2021 S3 (PANSTARRS) 1.0° W of Gamma Cygni Nebula (IC 1318) |
| Mon | 29th | 1 pm | (11 am WST) Maximum Libration (9.1°), bright NW limb. |
| Mon | 29th | 2 pm | (Noon WST) Neptune 0.04° N of Mars |

brightest, and most star dense constellation in the entire heavens. Opening your hand and stretching the fingers, it now spans the distance from Crux to the False Cross which encompasses the magnificent Carina nebulae and star cluster region. The smallest binoculars or naked eye reveals a profusion of star clusters and bright and dark nebulae in this area. We have insufficient room here to begin to describe and do justice to the telescopic view.

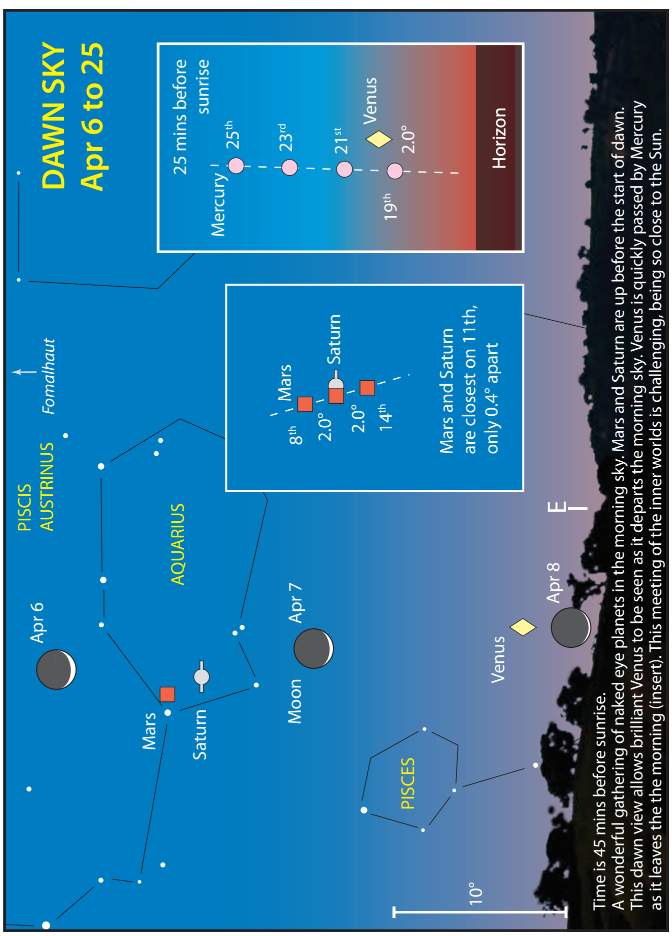
This is indeed a fantastic time of the year to observe! Early in the evening you can still catch the best of the summer skies low in the west, such as Canis Major and Orion about to set. This hunter is lying on his side with his distinctive three belt stars pointing straight up. While looking close to the horizon, turn around and face east to see the winter symbol of Scorpius commencing its return to the evening sky, soon to be followed by Sagittarius.

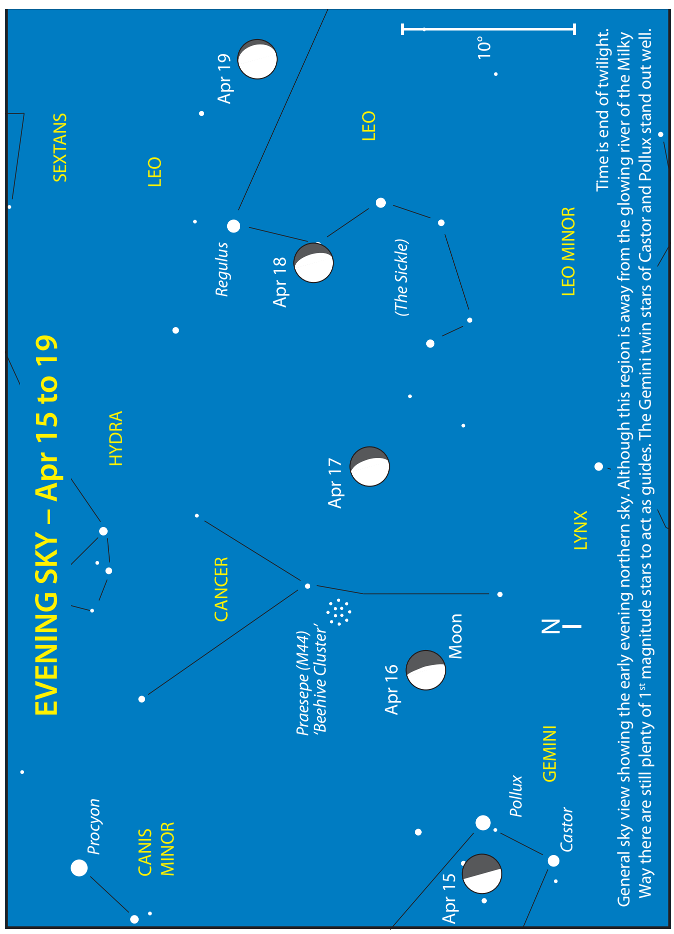
Although our galaxy offers brilliant sights, don't forget the pleasure of observing colour in the brightest stars. Look high in the south and find the two Pointers. Alpha Centauri is an obvious yellow in contrast to the distinctive blue of Beta Centauri. Now take in the Southern Cross (Crux). See how blue Alpha (the bottom star) and Beta (9 o'clock position) are compared to the orange of Gamma (the top star). Next glance at red Antares in Scorpius, its name doesn't translate to 'Rival to Mars' for nothing!

Here's something different. Did you know the evening sky this month contains one of the longest constellations? It runs parallel to the Milky Way along its northern edge but goes unnoticed. Hydra, the Water Serpent, is made up mainly of 4th magnitude stars and needs dark skies to see and the field of view of the unaided eye to appreciate. His head is a tight circle of five stars, roughly halfway between the naked eye stars, Regulus and Procyon (Maps 4 and 5). Hydra's body then slithers its way east passing other lesser-known constellations such as Sextans, Antlia and Crater. It then dives past Corvus to finish near 1st magnitude Spica. This snake's brightest star, Alpha (α) Hydrae may be only 2nd magnitude but stands out in a rather barren part of the sky, 23° to the upper right of Regulus. In fact, its Arabic name, 'Al Fard' means 'the solitary one'.

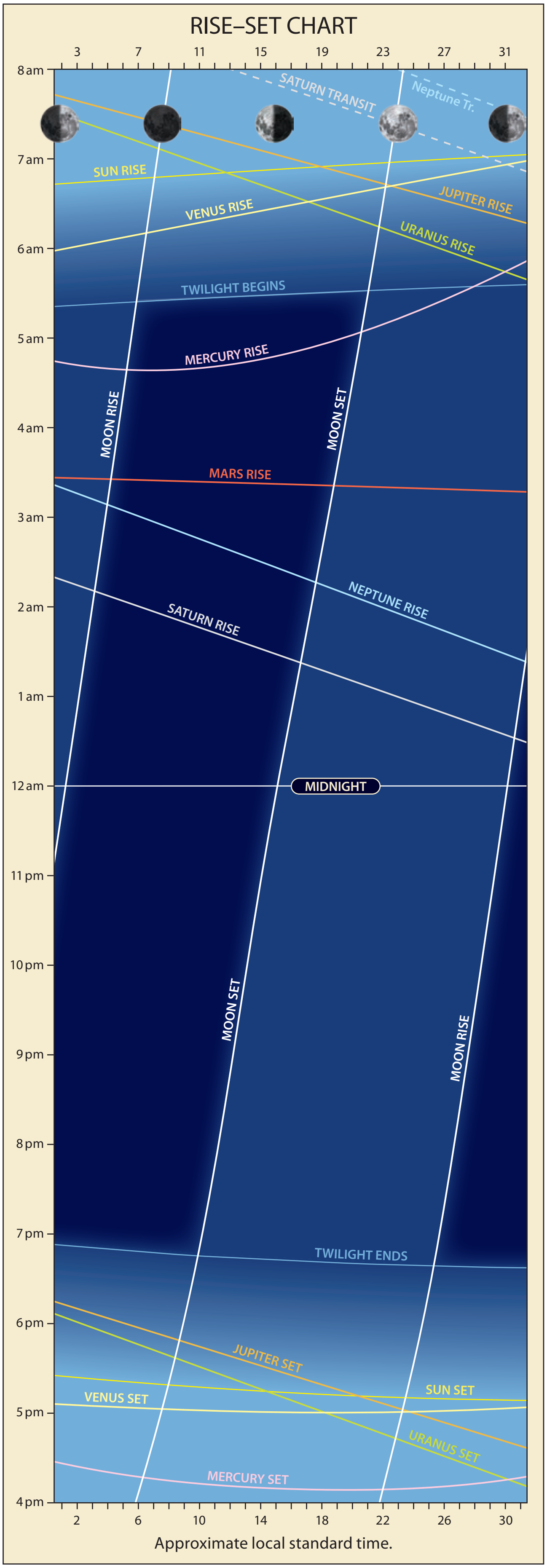



Approximate local standard time, for daylight saving add one hour.



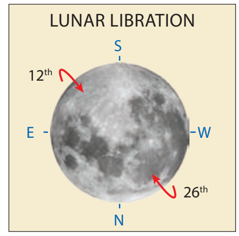
# MAY 2024




## HIGHLIGHT

- Saturn and Neptune are occulted by the Moon.
- Mercury at best in the morning sky.

## THE MOON




1st 9 pm (7 pm WST) Last Quarter.

4th 9 am (7 am WST) Occultation of Saturn (see next page).

5th 4 am (2 am WST) Occultation of Neptune (see next page).

6th 8 am (6 am WST) Moon at perigee (closest to Earth at 363,163 km).

8th 1 pm (11 am WST) New Moon.

12th Noon (10 am WST) Maximum Libration (9.1°), bright SE limb. The 114-km crater Demonax in the south polar region is ideally suited for observation as it rotates into view.

15th 10 pm (8 pm WST) First Quarter.

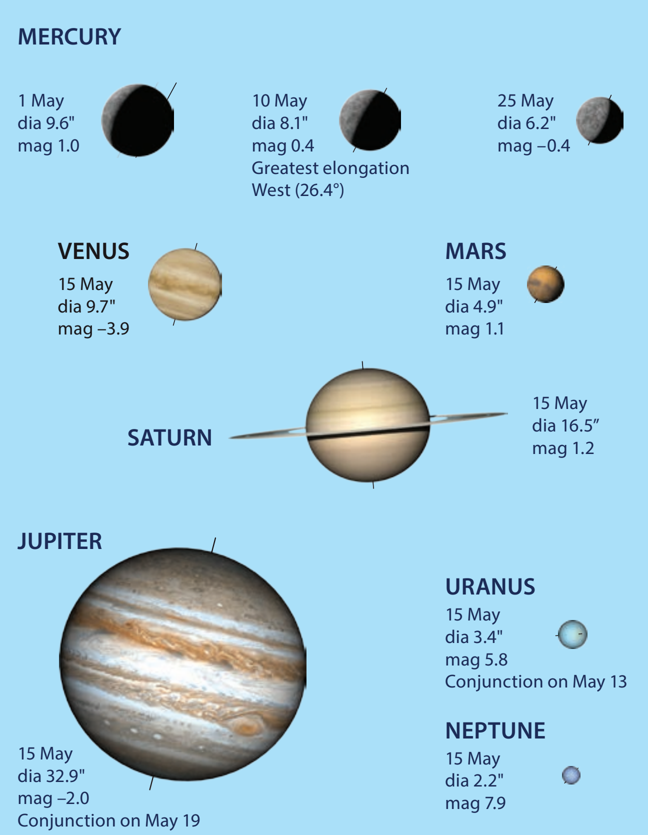
18th 5 am (3 am WST) Moon at apogee (furthest from Earth at 404,640 km).

23rd Midnight (10 pm WST) Full Moon.

26th Noon (10 am WST) Maximum Libration (8.3°), bright NW limb.

31st 3 am (1 am WST) Last Quarter.

## APPEARANCE of the PLANETS



## THE PLANETS

The ever-elusive **Mercury** has its best morning apparition for the year in late April and May. The planet reaches its greatest elongation 26° west of the Sun on the 10th. With the ecliptic (the plane of the planetary orbits) near vertical, this is an excellent opportunity to glimpse this small world without interference from the brightening dawn. On the 6th, Mercury has a nice conjunction with the thin crescent Moon (see Sky View).

**Venus** remains too close to the Sun for observation. However, after superior conjunction (Venus and Earth on opposite sides of the Sun) early next month, the planet will return to the western evening sky in mid-July as the Evening Star.

**Mars** rises around 3 am in the eastern morning sky in Pisces. The planet spends the entire month in the constellation of the Fishes, aside from a bit of corner-cutting into Cetus for a few days. On the 5th, the planet will be just 3° from the 26-day-old waning crescent Moon (see Sky View).

**Jupiter** will be lost in the glare of the Sun this month as it moves into solar conjunction on the 19th. It reappears in the eastern morning dawn sky in early June.

**Saturn** is still an object for night owls, rising around 1:30 am mid-month. The planet has a close encounter with the 25-day-old waning crescent Moon when it appears just 2° away on the 4th (see Sky View). There is a daylight occultation of Saturn by the Moon, visible from southeast Australia. Parts of Sydney and Hobart should see the event with Melbourne, Canberra and Brisbane seeing a close approach (around 8:50 am EST). With the Moon high in the northern sky at the time, it might be a good opportunity to see Saturn in daylight (through a telescope) (see Part II under Lunar Occultations for further details). For safety and comfort ensure the Sun (to the right or East at the time) is well hidden behind a building.

**Uranus** is in conjunction with the Sun on the 13th, after which it reappears in early June in the morning eastern dawn sky. It is interesting to note (although unobservable) that the Sun occults Uranus at this conjunction. This occurs when Uranus passes through the nodes of its orbit, resulting in a series of ten annual occultations. The last series, each year from 1980 to 1989, was on the descending node. This current series, beginning this month and ending in 2033, is on the ascending node. With an 84-year orbital period, the next set of ten starts in 2113.

**Neptune** is in Pisces, near the asterism known as the Circlet. The planet is only visible in the morning eastern sky, rising after 2 am mid-month. At the beginning of May, Neptune and Mars are just 1° apart and easily visible together in binoculars for a few days until Mars moves away. On the morning of May 5th, Neptune is occulted by the Moon. The event is visible from southeastern Australia and with the Moon having just risen, the reappearance of the planet from the dark limb is favoured (see Part II under Lunar Occultations for further details).

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 3 May | 85 Io | Libra | 11.3 |
| 5 May | 27 Euterpe | Libra | 10.3 |
| 14 May | 185 Eunike | Serpens | 12.4 |
| 15 May | 64 Angelina | Libra | 11.1 |
| 19 May | 80 Sappho | Libra | 11.1 |
| 20 May | 2 Pallas | Hercules | 9.1 |

**DIARY**

| | | | |
|---|---|---|---|
| Wed | 1st | | m.p. 4 Vesta 0.4° SW of star Epsilon Geminorum |
| Wed | 1st | am | m.p. 2 Pallas 0.8° SW of NGC 6210 (PN) in Hercules |
| Wed | 1st | 9 pm | (7 pm WST) Last Quarter Moon. |
| Thu | 2nd | pm | m.p. 23 Thalia 0.4° E of NGC 3686 (G) in Leo |
| Sat | 4th | 5 am | (3 am WST) Saturn 2° NE of Moon |
| Sun | 5th | 5 am | (3 am WST) Neptune 1° W of Moon |
| Sun | 5th | 5 am | (3 am WST) Mars 3° N of Moon |
| Mon | 6th | 8 am | (6 am WST) Moon at perigee (closest to Earth at 363,163 km). |
| Tue | 7th | | Mercury 0.5° W of NGC 488 (G) in Pisces |
| Tue | 7th | | m.p. 43 Ariadne 0.8° S of NGC 6284 (GC) in Ophiuchus |
| Tue | 7th | am | eta-Aquarids meteor shower, Apr 19 to May 28. |
| Wed | 8th | | m.p. 9 Metis 0.6° S of star Upsilon Geminorum |
| Wed | 8th | 1 pm | (11 am WST) New Moon. |
| Thu | 9th | pm | m.p. 27 Euterpe 0.1° SW of star Mu Librae |
| Fri | 10th | | Comet 12P/Pons-Brooks 1.0° SW of star Nu Eridani |
| Fri | 10th | | Mercury at greatest elongation West (26.4°) |
| Sat | 11th | | Comet 12P/Pons-Brooks 1.0° NE of NGC 1600 (G) in Eridanus |
| Sun | 12th | Noon | (10 am WST) Maximum Libration (9.1°), bright SE limb. |
| Mon | 13th | | Saturn 0.7° SE of star Phi Aquarii |
| Mon | 13th | | Uranus in conjunction with Sun |
| Tue | 14th | | Comet 154P/Brewington 0.3° SW of star Eta Piscium |
| Wed | 15th | 10 pm | (8 pm WST) First Quarter Moon. |
| Wed | 15th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.8° S of NGC 4643 (G) in Virgo |
| Thu | 16th | | Comet 154P/Brewington 0.2° NW of M74 (SG) in Pisces |
| Sat | 18th | 5 am | (3 am WST) Moon at apogee (furthest from Earth at 404,640 km). |
| Sat | 18th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.7° S of NGC 4536 (G) in Virgo |
| Sun | 19th | | Jupiter in conjunction with Sun |
| Mon | 20th | | m.p. 354 Eleonora 1.5° N of M44 Beehive Cluster (OC) in Cancer |
| Mon | 20th | | m.p. 3 Juno 1.0° S of M95 (SG) in Leo |
| Mon | 20th | | m.p. 2 Pallas at opposition |
| Wed | 22nd | | m.p. 354 Eleonora 0.4° S of star Gamma Cancri |
| Thu | 23rd | | Comet 154P/Brewington 0.8° SE of star Gamma Arietis |
| Thu | 23rd | Midn | (10 pm WST) Full Moon (390,646 km). |
| Fri | 24th | | Comet 154P/Brewington 0.1° NW of NGC 772 (G) in Aries |
| Sun | 26th | Noon | (10 am WST) Maximum Libration (8.3°), bright NW limb. |
| Mon | 27th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 1.0° N of NGC 4179 (G) in Virgo |
| Wed | 29th | | Comet 12P/Pons-Brooks 1.3° NE of star Alpha Leporis |
| Wed | 29th | | Comet 13P/Olbers 1.0° SE of star Theta Aurigae |
| Wed | 29th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.4° S of NGC 4123 (G) in Virgo |
| Fri | 31st | 3 am | (1 am WST) Last Quarter Moon. |
| Fri | 31st | 6 am | (4 am WST) Uranus 1.5° N of Mercury |
| Fri | 31st | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.7° N of NGC 4073 (G) in Virgo |

# Solar Max Cycle 25, Part 2 – Techniques

In Part 1 (p. 28), we outlined the characteristics of the Sun that can be observed in everyday white light, e.g., sunspots, faculae, and granulation. We suggest starting with this area if you want to explore the Sun. Below are some safe ways to view the Sun using your current equipment with minimal or no expense. You may become curious about seeing solar flares and eruptions as your interest grows. To observe these features, expensive narrow-band Hydrogen Alpha (H-alpha or Hα) filters or a specialised Hα telescope are necessary (see Part 3, p. 54).

**Under no circumstances should you look directly at the Sun with your naked eye, or any optical instrument not designed or modified for solar observing, as irreparable damage or blindness can result.**

When using a telescope, it's important to remember that some objects may appear faint and require a larger aperture to improve image quality. However, observing the surface of the Sun is an entirely different story. It's exceptionally bright, and we must reduce the amount of light to observe it safely. It's worth noting that even the brightest star in the night sky, Sirius (Alpha Canis Majoris), pales compared to the Sun's brightness—the Sun is a staggering 10,000 million times brighter!

No matter what method is selected to view the Sun, covering the finderscope or removing it is essential. Not doing this can lead to unwanted consequences. While incinerating the finder's crosshairs may be a minor issue, accidentally burning your clothing, body, or retina could be much more severe. Without a finderscope to centre the Sun in the main optical tube, move the telescope until its circular shadow cast onto the ground is smallest.

*A full aperture glass-coated nickel-chromium filter.*

The projection method is one of the easiest and most cost-effective ways to view the Sun. In its most basic form, the Sun's image is projected onto a stiff white paper handheld about 20 to 50 cm behind a telescope fitted with a low-power eyepiece. This indirect method ideally suits small refracting telescopes (around 80 to 100 mm aperture). You'll need a projection screen attached to the telescope to hold the paper for more than a quick look. Some telescope manufacturers will supply projection screens that can be fixed to the tube, but you can make your own. Some form of shielding is recommended to improve contrast by shading the screen.


*Projecting the Sun's image with a refracting telescope.*

The projection method is not recommended for Schmidt-Cassegrain type telescopes. Their folded optical design results in tremendous heat accumulating within the tube that will damage the telescope or its attachments. Newtonians can be used, but the aperture should be limited to around 80–100 mm. A circular hole cut in a piece of cardboard and taped securely to the front of the telescope, is sufficient to achieve this.

The second option is directly viewing the Sun with a pre-filter fitted to the front of the telescope. These filters protect from IR and UV light and filter 99.999% of visible light. There are three basic types of pre-filters available: glass coated with nickel-chromium (most expensive),

## COMETS

**Comet C/2021 S3 (PANSTARRS)** (All Sky Map 9) is in Cygnus at about 10th magnitude, rising in the north-eastern sky around 2 am and transiting very low in the northern sky about an hour before sunrise. By month's end it has moved too far north to be visible.

**Comet C/2022 L2(ATLAS)** spends most of the month in Antlia before moving into Hydra on the 26th. Beginning at magnitude 12.3, rising in daylight, transiting high in the northern sky around 8 pm and setting in the south-western sky about an hour before dawn. It ends the month having faded to 13th magnitude and sets in the south-western sky around midnight.

**Comet 12P/Pons-Brooks** (All Sky Map 2) begins the month in Taurus about magnitude 5 before moving into Eridanus on the 5th. It is rising in daylight and setting in the western sky shortly after twilight.

**Comet 154P/Brewington** (All Sky Map 3) begins the month in Pisces about magnitude 11, rising in the eastern sky shortly before dawn. It moves into Aries on the 20th and by month's end has brightened to magnitude 10 and rising in the north-eastern sky shortly before dawn.

**Comet 13P/Olbers** (All Sky Map 3) is rising in daylight and begins the month in Taurus at magnitude 9, setting in the north-western sky just after twilight. On the 8th it moves into Auriga, setting in the north-western sky about an hour after sunset and ends the month about magnitude 8, setting in the north-western sky shortly after sunset.

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** is in Virgo, rising in daylight. It begins the month about magnitude 11, setting in the western sky shortly before dawn. By month's end it is setting in the western sky around 1:30 am, slightly brighter. In the latter half of May, the comet explores some galaxies in Virgo (see Diary).

## METEOR SHOWER

The **eta-Aquarids** are linked with Halley's Comet and are among the most popular Southern Hemisphere showers. Visible from April 19 to May 28, with the peak expected during the morning of the 6th. The maximum rate of 40 or more will likely be seen before dawn since the radiant in Aquarius reaches its highest altitude a little after sunrise. Their high percentage of persistent trains characterises the eta-Aquarids. They are very swift and are a striking yellow colour. With New Moon on the 8th, the Moon will not cause any interference this year.

## CONSTELLATIONS

As discussed, this time of the year the evening sky can be breathtaking as the far southern regions of the Milky Way are prominently displayed, with our galaxy stretching from the eastern horizon, passing overhead, and heading down in the west.

Autumn evenings also present a dramatic contrast. Moving northward away from the 'milky' environs of our galaxy fewer stars are seen and suddenly few open star clusters are found. You have moved out of the plane of the Milky Way into the realm of galaxies. In reality, the galaxies are spread across the whole sky but the Milky Way obscures the view beyond. You don't have to go far to see these island universes, with famous constellations like Centaurus having a foot in each camp. The southern regions of this centaur, around the two pointer stars, is awash with open star clusters and nebulae. Moving to its northern region two of the brightest and best galaxies visible from down under reside, the large edge-on spiral, NGC 4945 and the lenticular (elliptical like) NGC 5128. This is renowned

aluminised polyester film (mylar), and polymer (Solarlite film). Glass and polymer give a pleasant natural yellowish-orange image (even though the Sun is white), whereas polyester makes the Sun look an odd bluish-white colour. Pre-filters can be used with any telescope, regardless of aperture size.

Which of these options is best? Colour aside, they all provide a good view of the Sun. Mylar is prone to pinholes and, when cell-mounted, will have creases and wrinkles (these will not affect the image quality, just a little less appealing to the eye). Glass is the most expensive and offers little over the film types. Polymer is economical, has the optical quality of glass, will not tear or puncture, and is lightweight. All these filter types can be used for solar photography.

Lastly, for the more experienced solar observer, it's hard to beat a Herschel Wedge. These provide the ultimate visual and photographic views of the Sun in white light. Unlike front-mounted solar filters mentioned above, a Herschel Wedge subdues the light just before it reaches the eyepiece or camera, giving a sharper, higher-contrast image. The wedge suppresses 95% of the incoming light; a pre-installed ND3 filter then dims the remaining 5%. For visual use, a polarising filter should be fitted to the bottom of the eyepiece, and the brightness then controlled to a comfortable level by rotating the eyepiece.

Despite their advantages, Herschel Wedges have some drawbacks: they are expensive (although cheaper than narrow-band filters). They can ONLY be used with refracting telescopes of apertures from around 100 to 150 mm. Before purchasing, always check on the manufacturer's recommendations.

See Part 3, page 54, for the Hydrogen Alpha view.

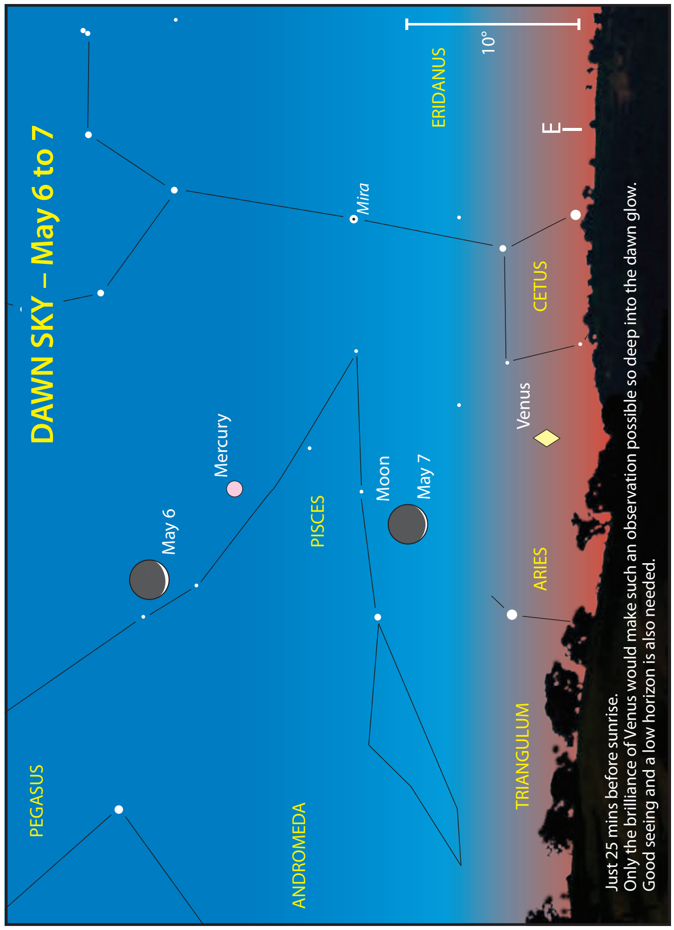

*Herschel Wedge.*

for its prominent equatorial dark band, making it known as the Hamburger Galaxy.

Heading further north, you'll cross constellations most famous for their galaxies, such as Hydra (Map 6), with its famous Milky Way like face-on spiral M83 and Corvus (Map 6) with its interacting Antennae Galaxies (NGC 4038/4039), visually looking like a 'pac man'.

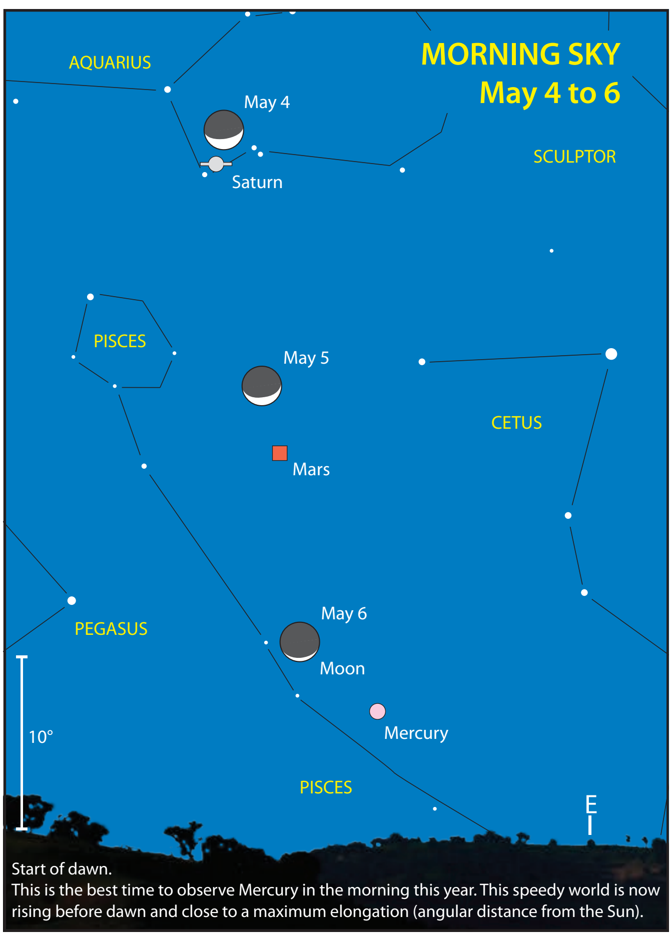
Low in the north-west is Leo the Lion (Map 5). From down under this regal beast sits low in the north, but upside down. Its head and shoulders are referred to as the sickle, with its top member Leo's brightest (alpha) star, Regulus. To the east (right) lies its hindquarters consisting of a conspicuous triangle of stars. This group's brightest star, and furthest eastward, is Denebola (Beta Leonis).

Leo is famous for some impressive galaxies, but nothing like the largest gathering of galaxies accessible to amateurs, the Virgo/Coma super cluster, approximately 65 million light-years away (Maps 5 and 7). Its centre lies halfway between Denebola and Vindemiatrix (Epsilon (ε) Virginis). This line also roughly follows the border between Virgo and Coma Berenices, hence its name. Here, amongst over a hundred faint fuzzes, you'll find a remarkable collection—Markarian's Chain—seven bright galaxies arranged in an arc 1.5° long visible in 150 mm telescopes. The western end is the impressive 9.1 magnitude elliptical NGC 4374 or M84. It has a 3 arcminute circular core, brighter but smaller than the next member 16 arcminutes east, another elliptical NGC 4406 (M86). A further 22 arcminutes finds the pair NGC 4435/38. The chain continues 50 arcminutes north-east with the fainter NGC 4461, 4473 and 4477.

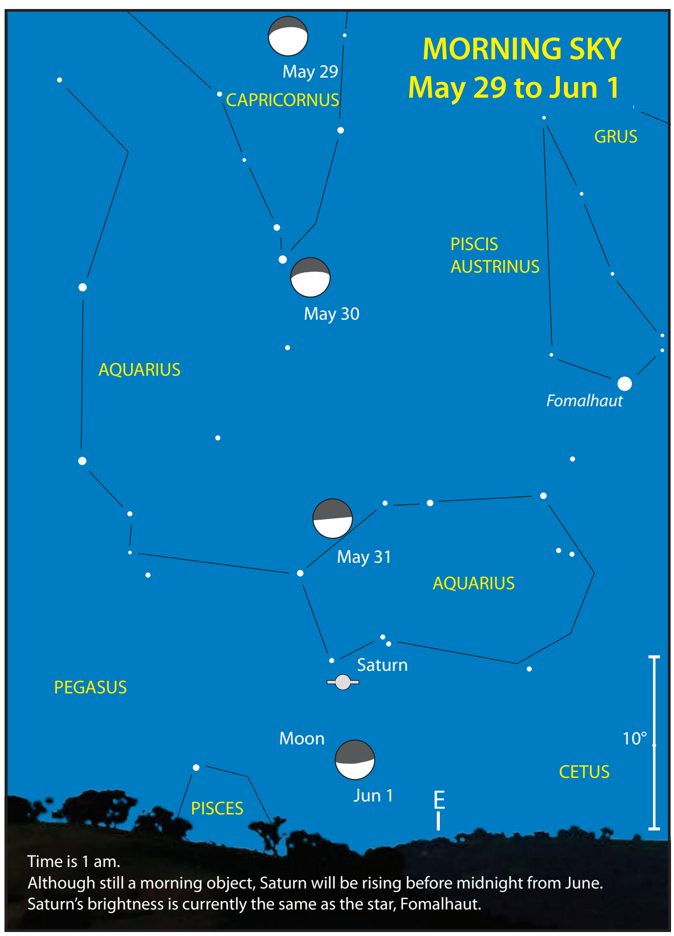


Just 25 mins before sunrise.
Only the brilliance of Venus would make such an observation possible so deep into the dawn glow.
Good seeing and a low horizon is also needed.

Approximate local standard time.



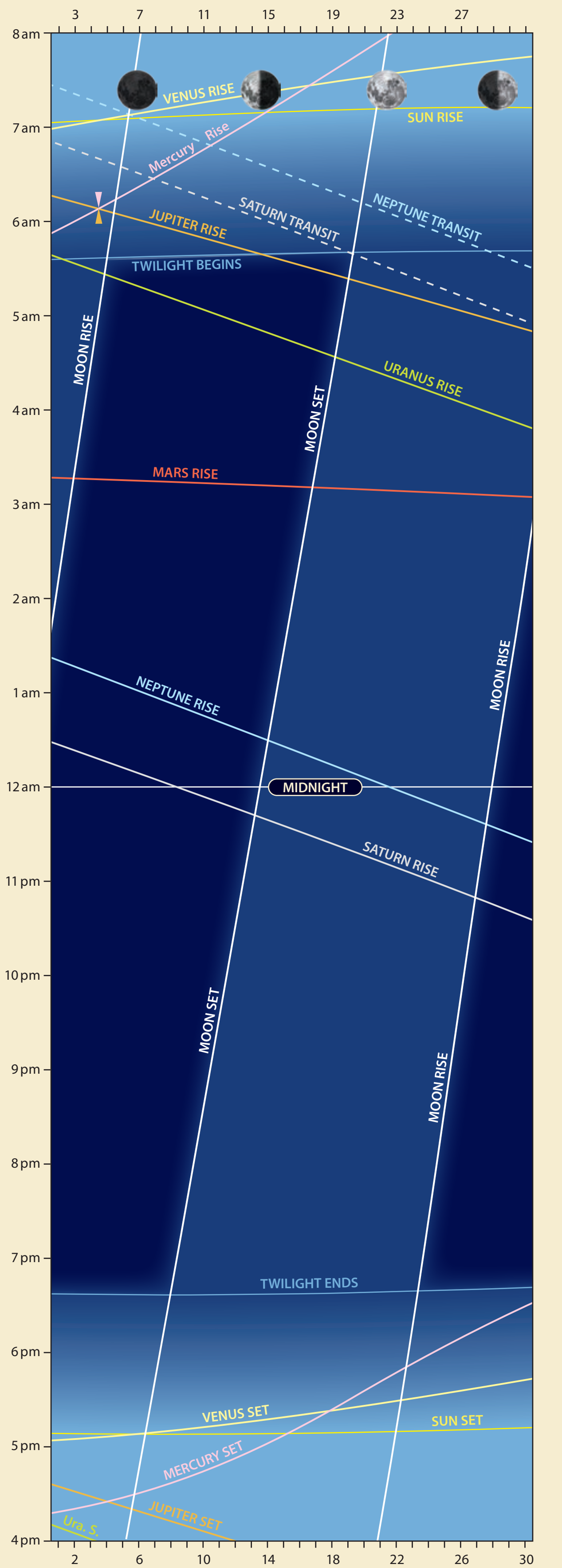
Start of dawn.
This is the best time to observe Mercury in the morning this year. This speedy world is now rising before dawn and close to a maximum elongation (angular distance from the Sun).



Time is 1 am.
Although still a morning object, Saturn will be rising before midnight from June.
Saturn's brightness is currently the same as the star, Fomalhaut.

# JUNE 2024

## RISE–SET CHART

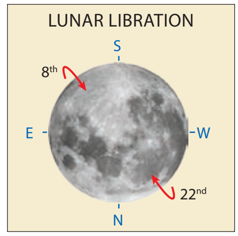



Approximate local standard time.

## HIGHLIGHTS

- Mercury and Jupiter close.
- Saturn reappears from behind the Sun.

## THE MOON




2nd 5 pm (3 pm WST) Moon at perigee (closest to Earth at 368,102 km).

6th 11 pm (9 pm WST) New Moon.

8th Midnight (10 pm WST) Maximum Libration (8.5°), bright SE limb. The 2-day-old Moon provides ideal conditions for observing features emerging from the zone of libration, including the 141-km crater Lyot.

14th 3 pm (1 pm WST) First Quarter.

14th Midnight (10 pm WST) Moon at apogee (furthest from Earth at 404,077 km).

22nd 9 am (7 am WST) Maximum Libration (8.2°), Full Moon.

22nd 11 am (9 am WST) Full Moon.

27th 10 pm (8 pm WST) Moon at perigee (closest to Earth at 369,286 km).

29th 8 am (6 am WST) Last Quarter.

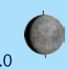
## APPEARANCE of the PLANETS

### MERCURY

5 Jun
dia 5.4"
mag –1.2

Mercury in superior conjunction on the 15th

25 Jun
dia 5.3"
mag –1.0



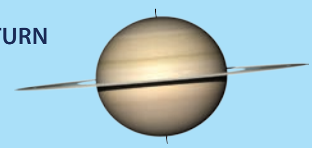
### VENUS

30 Jun
dia 9.7"
mag –3.9
superior conjunction on 5th (4th WA)

### MARS

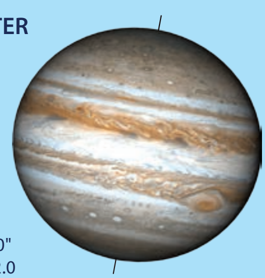
15 Jun
dia 5.2"
mag 1.0

### SATURN



15 Jun
dia 17.4"
mag 1.1

### JUPITER



15 Jun
dia 33.0"
mag –2.0

### URANUS

15 Jun
dia 3.4"
mag 5.8

### NEPTUNE

15 Jun
dia 2.3"
mag 7.9

JUNE

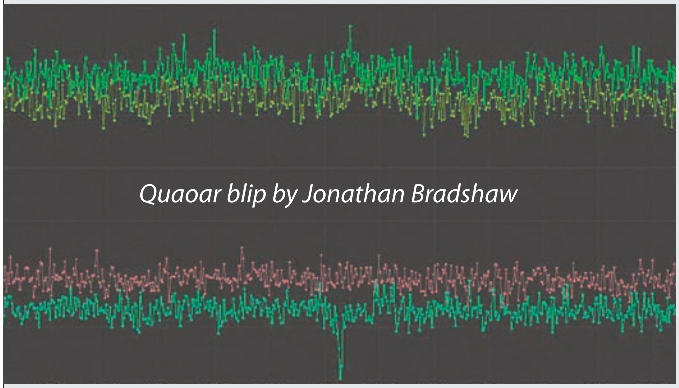
# Far Away Rings

**by John Broughton, Jonathan Bradshaw and Renato Langersek**

Dwarf Planet 50000 Quaoar is the third small Solar System body known and confirmed to have a ring system, after 10199 Chariklo and 136108 Haumea. A partly dense, mostly tenuous and uniquely distant ring was first recognised and reported by Australian observers soon after recording a stellar occultation in August 2021. This is the first planetary ring in history discovered by amateur astronomers.

Quaoar itself was discovered by American professional astronomers in early June 2002 when Chad Trujillo walked into Mike Brown's office and declared "We just found something bigger than Pluto!". Mike and Chad recently started a project on the 48 inch Mt Palomar telescope to find new planets in our Solar System.

In anticipation of having found a new planet in the Kuiper belt beyond the orbits of Neptune and Pluto, they gave it the temporary name "Object X", a nod to the fabled planet X.



*Quaoar blip by Jonathan Bradshaw*

To announce the discovery in a scientific paper, they needed more information starting with preliminary orbital elements derived from astrometric positions of the object in their images. Using photographic plates from the Palomar archives, they pinpointed the positions of Object X extending up to 20 years in the past and computed more accurate orbital elements. Mike and Chad ascertained that the orbit had a low eccentricity, was inclined 8° to the ecliptic and orbited the Sun every 288 years.

Next, Mike estimated the diameter by imaging it using the new camera astronauts recently installed in the Hubble Space Telescope and comparing that with simulated images of different-sized objects. It turned out to be only half the size of Pluto. The discrepancy was solved by measuring its spectrum with the Keck Telescope and finding Object X to be covered by methane and water ice instead of bare rock, giving it a significantly higher albedo.

The International Astronomical Union requires new Kuiper belt objects to be named after creation deities of mythology. Mt Palomar, where Object X was discovered, had a local tribe of Indians, the Tongva. In their mythology, the creation force was pronounced Kwa-war. Mike and Chad decided to use Quaoar as the official name for Object X after gaining permission from the Tongva people.

In the weeks following the announcement of its discovery, the scientific community was not so much concerned about Quaoar itself. The paramount question became whether Quaoar's discovery would prompt a reconsideration of Pluto's classification as a planet.

Nineteen years later, on the 27th of August 2021 a team of Australasian based amateur astronomers affiliated with the Trans-Tasman Occultation Alliance (TTOA)* prepared for a favourable main body occultation armed with predictions from the International Occultation Timing Association (IOTA) and the Luckystar groups of professional astronomers based in Paris, Meudon, Granada and Rio.

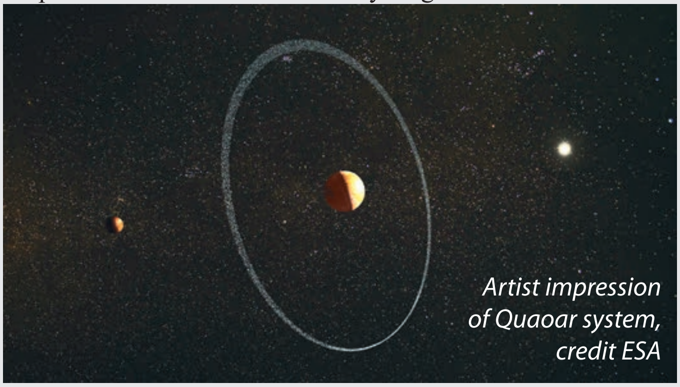
Jonathan Bradshaw, Renato Langersek and John Broughton were observing this event from South-east Queensland; to the north, Steve Kerr and to the south, Dave Gault, Peter Nosworthy, William Hanna and David Herald. Observers further south and in New Zealand unfortunately were clouded out.

The stellar occultation technique measures the shadow on Earth cast by an object passing in front of a distant star. By making simultaneous observations of a single event from different locations, observers can use the data to make accurate determinations of the size, shape and position of the occulting body which is critical data in understanding the true nature of the object and to refine its orbit.

Protocol normally suggests the recording a couple of minutes either side of the event to cover for prediction inaccuracies, but three SEQ observers were well outside of the predicted path and had decided to take a long-shot and record for a much longer period to see if they could discover anything unusual.

During the run up to the event, Jonathan was watching the video live and chatting to Renato over Facebook Messenger whilst they discussed settings and captured data early. Jonathan spotted a 'blip' several minutes early. "Did you see that?!" He jotted down the time in his observers log to review later. The main event came and went as expected—a miss—and they kept recording for another ten minutes or so to keep that data symmetrical. When the data was reduced it was clear that the 'blip' was a true extinction event and that Renato and John had captured the event too. With a little processing, it could be seen that the events perfectly lined up – it had to be a ring!

And to quote John: "After downloading a SER viewer, I can confirm the occultation blip is for real! The only conclusion to come to is that Quaoar must have a narrow ring about 10 km wide and by implication is indirect evidence of shepherd moons. The fact that only single occultations have



*Artist impression of Quaoar system, credit ESA*

JUNE

| DIARY | | | |
|---|---|---|---|
| Sat | 1st | 5 am | (3 am WST) Neptune 4° N of Moon |
| Sun | 2nd | | m.p. 15 Eunomia 0.3° N of star Beta Arietis |
| Sun | 2nd | 5 pm | (3 pm WST) Moon at perigee (closest to Earth at 368,102 km). |
| Mon | 3rd | | Comet 12P/Pons-Brooks 1.2° NE of star Delta Leporis |
| Mon | 3rd | 5 am | (3 am WST) Mars 3° SE of Moon |
| Wed | 5th | | Venus in superior conjunction |
| Thu | 6th | | m.p. 4 Vesta 0.8° S of star Kappa Geminorum |
| Thu | 6th | 11 pm | (9 pm WST) New Moon. |
| Thu | 6th | pm | Comet C/2023 A3 (Tsuchinshan-ATLAS) 1.0° N of star Beta Virginis |
| Sat | 8th | Midn | (10 pm WST) Maximum Libration (8.5°), bright SE limb. |
| Sun | 9th | | m.p. 15 Eunomia 1.0° SE of star Alpha Arietis |
| Fri | 14th | 3 pm | (1 pm WST) First Quarter Moon. |
| Fri | 14th | Midn | (10 pm WST) Moon at apogee (furthest from Earth at 404,077 km). |
| Sat | 15th | | Mars 0.7° N of NGC 821 (G) in Aries |
| Sat | 15th | | Mercury in superior conjunction |
| Sat | 15th | 7 pm | (5 pm WST) Comet 12P/Pons-Brooks 0.1° W of NGC 2280 (G) in Canis Major |
| Sun | 16th | | Mars 1.3° S of NGC 1746 (OC) in Taurus |
| Tue | 18th | | Comet 12P/Pons-Brooks 0.5° SW of star Epsilon Canis Majoris |
| Wed | 19th | pm | m.p. 43 Ariadne 1.0° NE of star Rho Ophiuchi |
| Fri | 21st | | Solstice |
| Sat | 22nd | 9 am | (7 am WST) Maximum Libration (8.2°), Full Moon. |
| Sat | 22nd | 11 am | (9 am WST) Full Moon (380,042 km). |
| Sat | 22nd | pm | m.p. 2 Pallas 1.0° SE of star Epsilon Coronae Borealis |
| Sun | 23rd | | Jupiter 0.05° N of star Omega$^2$ Tauri |
| Wed | 26th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.3° S of NGC 3640 (G) in Leo |
| Thu | 27th | 10 pm | (8 pm WST) Moon at perigee (closest to Earth at 369,286 km). |
| Thu | 27th | Midn | (10 pm WST) Saturn 0.5° SW of Moon (Occultation) |
| Sat | 29th | 1 am | (11 pm WST, prev day) Neptune 5° SW of Moon |
| Sat | 29th | 8 am | (6 am WST) Last Quarter Moon. |
| Sat | 29th | 8 pm | (6 pm WST) star Pollux 5° N of Mercury |
| Sun | 30th | | Comet 154P/Brewington 1.0° S of star Zeta Persei |

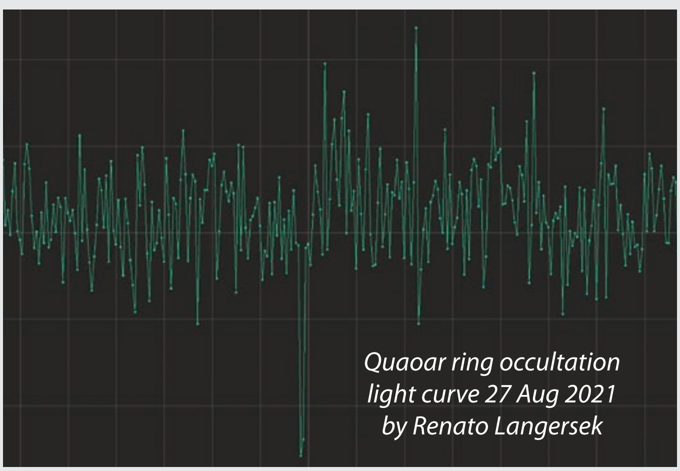
been observed from 3 out of 7 sites suggest it's a ring arc akin to those discovered in the 80s surrounding Neptune, but even those have non-opaque matter in the remainder of the orbit. With that in mind, and extrapolating the Queensland times southward, the NSW observers should look for a 1 or 2 second fade around 10:52:00 UT."

Scientists gained additional detections from subtle dimmings in a few earlier light curves that had gone unrecognised and after significant further research from the professional community, announced the discovery in February 2023 in the journal Nature.

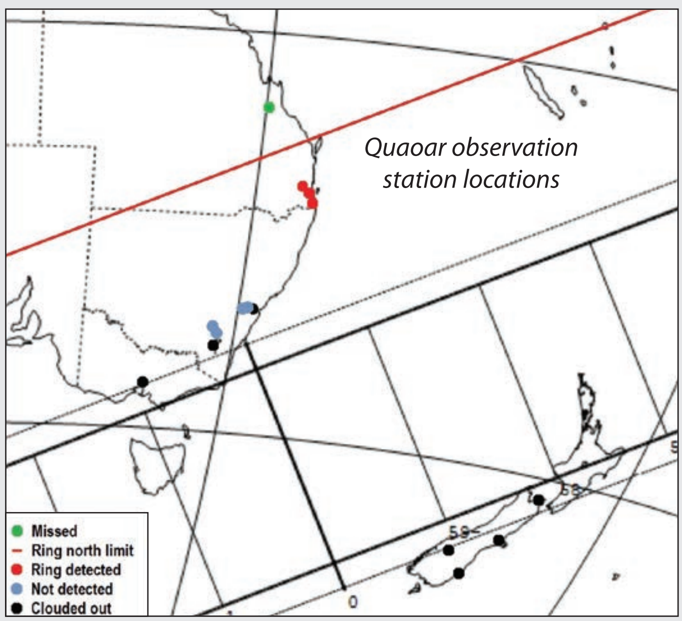
The ring is unique in that its radial distance from Quaoar far exceeds the supposed Roche Limit, a long-established theoretical limit beyond which ring particles are expected to accrete and form satellites. The only other known rings breaking that limit are extremely diffuse and maintained only by the continual volcanic activity of planetary moons Io and Enceladus. Twelve months after the discovery, a second ring interior to the first ring was detected in occultation light curves from large telescopes situated on Mauna Kea in Hawaii. The interior ring is narrow and tenuous but not known to possess a dense arc like the outer ring.

**TTOA, originally known as the occultation section of the Royal Astronomical Society of New Zealand, was formed in 1977 to promote all forms of occultation observing throughout Australasia. It provides a centralised focus for collecting observations and providing news and feedback to its members, largely confined to New Zealand and the eastern states of mainland Australia. Over time, observers progressed from visual observations of lunar occultations and grazes to that of small Solar System bodies recorded using low-light video cameras in conjunction with GPS timing devices. Hardware and software developed by the TTOA is used worldwide to predict, coordinate, time and analyse the results of occultations.*

*Important observations made by the group include the probing of Pluto's atmosphere on several occasions, NASA's Lucy mission binary asteroid target 617 Patroclus and Menoetius, the discovery of a relatively large and nearby moon of 4337 Arecibo, and the ground-breaking observations of Quaoar's ring. The latter discovery demonstrates the power of occultations when something just a few kilometres wide at the extraordinary distance of 6.3 billion kilometres can be detected from people's backyards.*



*Quaoar ring occultation light curve 27 Aug 2021 by Renato Langersek*




*Quaoar observation station locations*

JUNE

## THE PLANETS

In the eastern morning dawn sky, **Mercury** is heading towards superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 15th. After passing behind the Sun, the speedy little planet returns to the western sky to begin its best period for observation in the evening. Before becoming lost from sight in the solar glare, the planet will appear within 1° of Jupiter on the 4th and 5th (see Sky View). As always, binoculars will help locate the planets low to the horizon in the twilight sky: at this time, Mercury will be –1 magnitude and Jupiter –2.

On the 5th, **Venus** will be in superior conjunction (Venus and Earth on opposite sides of the Sun) and remain lost from view until its return to the western evening sky in mid-July as the Evening Star. As a matter of interest, Venus will be occulted by the Sun (hidden behind) at this conjunction for just over 45 hours beginning on the 4th. Unlike a regular transit of Venus, these occur in 8-year cycles and are not observable in telescopes for obvious reasons.* Venusian transits across the face of the Sun often happen in pairs eight years apart, separated by gaps of 121.5 and 105.5 years. Many amateurs today witnessed the last pair in 2004 and 2012.

**If you go to spaceweatherlive.com, you can find near real-time images taken by the LASCO C3 (Large Angle and Spectrometric Coronagraph) camera aboard the SOHO (Solar and Heliospheric Observatory spacecraft). You can then track Venus as it moves behind the Sun.*

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

**Mars**, in the eastern morning sky, rises around 3 am mid-month. On the 3rd, the planet will be 3° from the 26-day-old waning crescent Moon (see Sky View). Mars spends the first third of June in Pisces before moving into Aries for the rest of the month.

**Jupiter** returns to the morning eastern dawn this month, situated midway between the Pleiades and the Hyades star clusters in Taurus. The planet rises around 5:30 am mid-month, about 1.5 hours before the Sun.

**Saturn**, in Aquarius, rises around 11:30 pm mid-month in the eastern evening sky. On the 9th, the planet is at a point in its orbit known as western quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 10). At this time, Saturn will be at its highest altitude as the Sun rises in the east. It is also a favourable time to view the most shadow of the planet's globe cast onto the rings, giving the planet a 3-D appearance. On the morning of the 1st, Saturn appears 5° above the 23-day-old waning crescent Moon (see Sky View). The Moon returns one orbit later, this time occulting the ringed world. On the 27th, the eastern mainland will see Saturn reappear from behind the dark limb of the 21-day-old, waning gibbous Moon (see occultation section, Part II).

The planet's splendid ring system will be inclined to us at just 2° this month until mid-July. With the rings so narrow, little to no detail will be visible in small telescopes. Next year in March, there will be a ring plane crossing when the Earth is in the same plane as the rings, however we will not see them disappear as Saturn is behind the Sun at this time.

**Uranus** returns to the late morning eastern sky in Taurus this month after its solar conjunction last month. The planet rises around 5 am mid-month, about two hours before the Sun.

**Neptune** is still a morning object, rising around midnight mid-month.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

In June and July, 9th magnitude Isis is passing through the Teapot of Sagittarius visiting some globular star clusters (see Diary). Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 3 Jun | 43 Ariadne | Ophiuchus | 9.2 |
| 17 Jun | 22 Kalliope | Scorpius | 10.9 |
| 20 Jun | 68 Leto | Scorpius | 10.5 |
| 28 Jun | 42 Isis | Sagittarius | 9.3 |

## COMETS

**Comet 12P/Pons-Brooks** (All Sky Map 4) commences in Lepus at about magnitude 6, rising in the south-eastern sky shortly before sunrise and setting in the western sky around 8 pm. On the 8th it moves into Canis Major then into Puppis on the 25th. By month's end, it has faded to magnitude 9, rising in the south-eastern sky shortly before dawn and setting in the south-western sky around 9 pm.

**Comet 154P/Brewington** (All Sky Map 3) is about 10th magnitude for the month, rising in the north-eastern sky shortly before dawn. It begins in Aries then moves into Taurus on the 23rd.

**Comet 13P/Olbers** (All Sky Map 5) is rising in daylight and setting in the north-western sky shortly after sunset. It begins the month in Auriga at around magnitude 8, before moving into Lynx on the 19th.

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 4) is rising in daylight. It begins the month in Virgo about magnitude 11, setting in the western sky shortly before dawn. On the 14th it moves into Leo and sets in the western sky around midnight. The comet ends the month setting around 10:30 pm.

## CONSTELLATIONS

The evening sky this month could well be called the realm of the Centaurs. Both heavenly representatives of these mythological, part-human, part-horse creatures are well-placed to observe. They are, Centaurus, standing over the Southern Cross, and Sagittarius, which is prominent in the east.

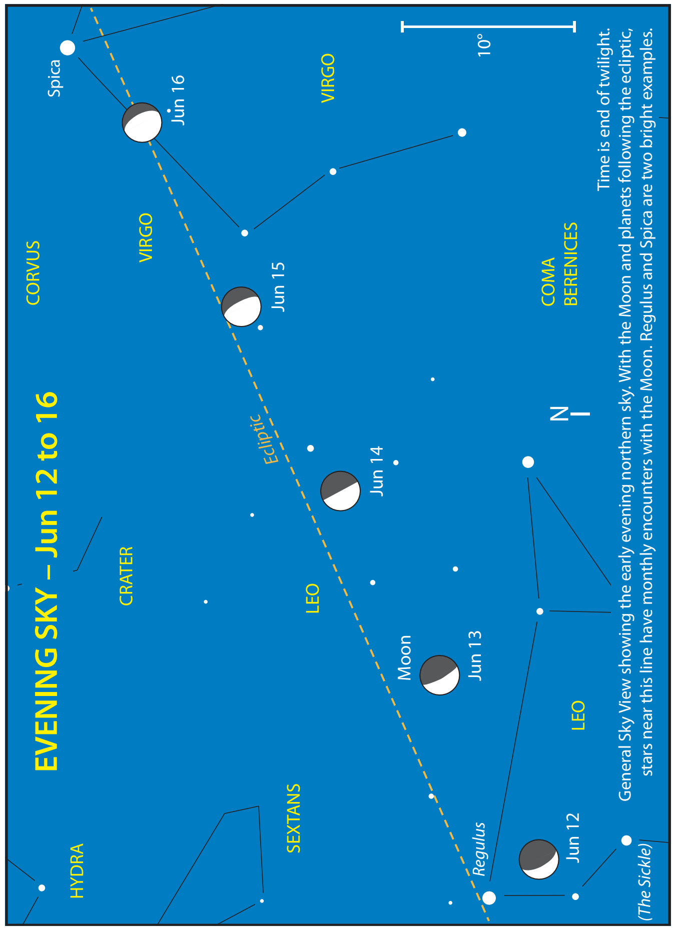
The traditional name of the first pointer, Alpha (α) Centauri was Rigel Kentaurus which translates to 'Foot of the Centaur' and ancient maps show him facing towards his fellow Centaur. Incidentally, for those novices, this star is not only the closest one to the Solar System, but the brightest double star in the heavens, easily observed in the smallest of telescopes.

The mythos of this centaur extends to neighbouring constellations. Lying between Centaurus and Scorpius is the constellation of Lupus the Wolf (Map 6). It is a bright constellation, although the pattern formed by its approximately two-dozen 2nd and 3rd magnitude stars doesn't look dog-like. In fact, it's hard to see an obvious division between Lupus and Centaurus and the two are closely related with the centaur carrying a spear impaling the wolf.

Here's another nearby constellation related to this mythology. Nestled between Scorpius and Triangulum Australe lies the ancient constellation of Ara (Map 1). It represents the altar on which the centaur was supposed to slay the wolf. Its pattern is easily recognised with seven stars ranging from magnitude 2.8 to 4.0 arranged in an open book shape. Ara's most distinctive feature is the pair of 3rd magnitude stars forming the southern end of the spine. Separated by only 1°, Beta (β) and Gamma (γ) Arae are distinctively yellow and white respectively. Binoculars help show this colour contrast.

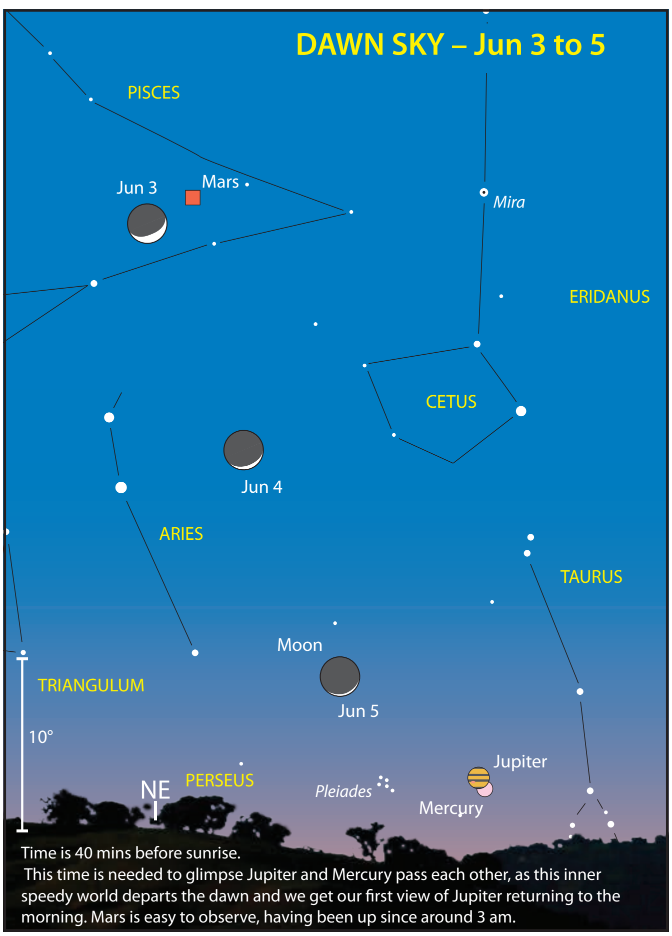
Sagittarius, better known for its Teapot asterism, is mythically related to an adjoining less obvious constellation, Corona Australis, the Southern Crown. Located below the base of the Teapot this consists of an 8° semi-circular arc of about a dozen 5th magnitude stars. It is thought to have been a wreath made from an olive branch that has dropped from the head of Sagittarius.

Sagittarius lies in the central bulge of our galaxy. This is a great time to see the star cluster and nebulae rich centre of the Milky Way. Another prominent constellation making up this 'hub' is Scorpius, which is one of the easiest constellations to recognise (the tip of his stinger is near the Teapot's spout star). There is a third, less conspicuous member of this group—Ophiuchus, the Serpent Bearer. Look to the left of the Teapot and you will find six 2nd and 3rd magnitude stars arranged in a box shape, often referred to as the coffin. It can be a little foreboding, needing to have reasonably dark skies to see any stars within this group with the unaided eye.

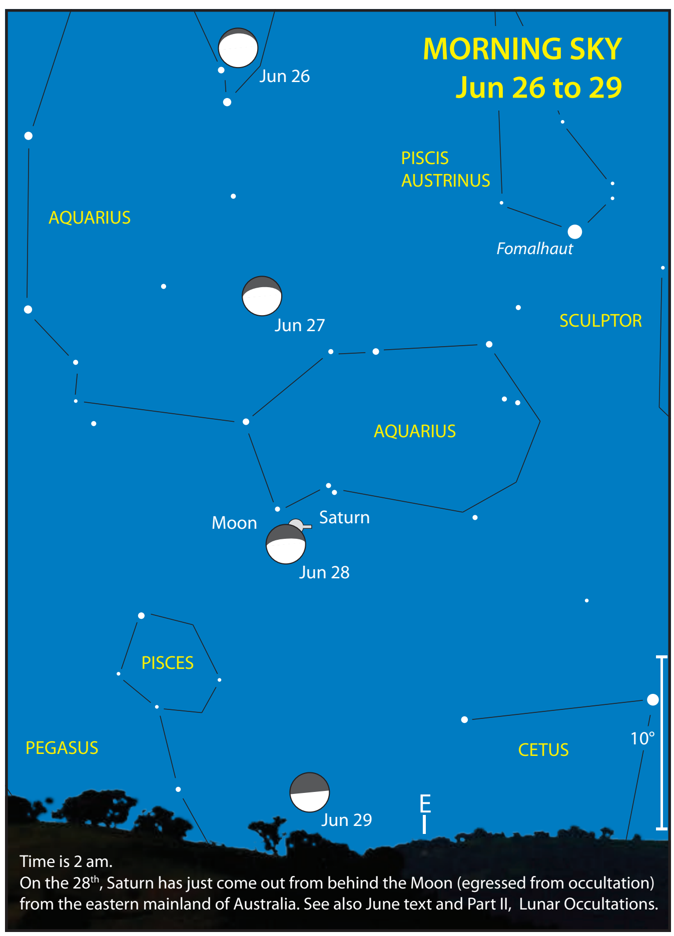


General Sky View showing the early evening northern sky. With the Moon and planets following the ecliptic, stars near this line have monthly encounters with the Moon. Regulus and Spica are two bright examples. Time is end of twilight.

Approximate local standard time.

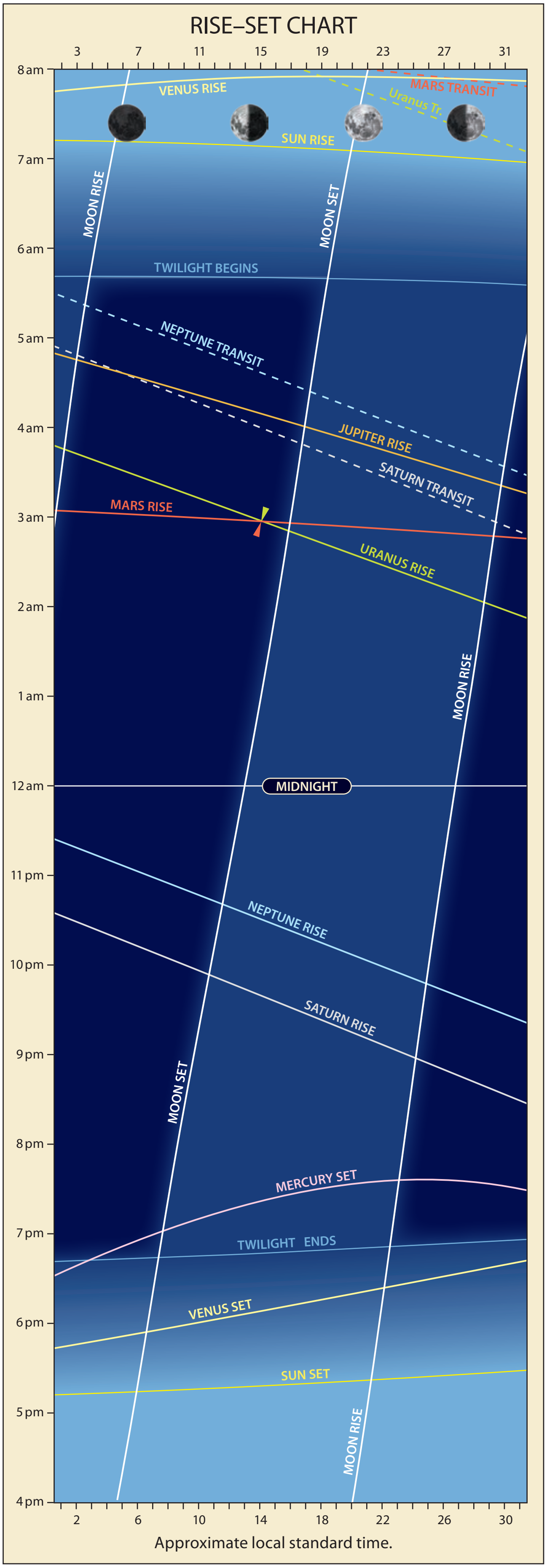


Time is 40 mins before sunrise.
This time is needed to glimpse Jupiter and Mercury pass each other, as this inner speedy world departs the dawn and we get our first view of Jupiter returning to the morning. Mars is easy to observe, having been up since around 3 am.



Time is 2 am.
On the 28th, Saturn has just come out from behind the Moon (egressed from occultation) from the eastern mainland of Australia. See also June text and Part II, Lunar Occultations.

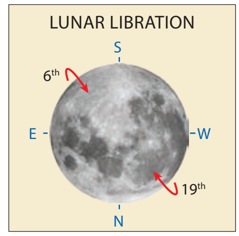
# JULY 2024




## HIGHLIGHTS

- Mercury at its best in the evening sky.
- Mars and Uranus are close.
- Jupiter gives the Bull a temporary left eye!
- Jupiter encounters the Moon twice.
- Mercury close to Regulus

## THE MOON




6th 3 am (1 am WST) Maximum Libration (8.2°), too close to New Moon.

6th 9 am (7 am WST) New Moon.

12th 6 pm (4 pm WST) Moon at apogee (furthest from Earth at 404,362 km).

14th 9 am (7 am WST) First Quarter.

19th 1 pm (11 am WST) Maximum Libration (8.7°), dark NW limb. The 106-km crater Pascal is ideally suited for observation as it emerges from the zone of libration.

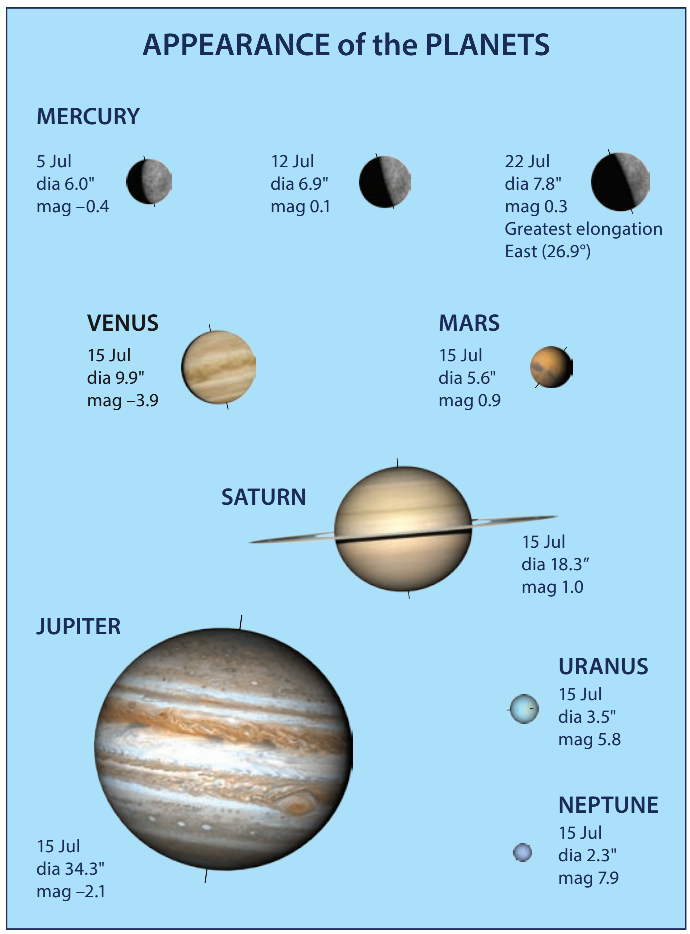
21st 8 pm (6 pm WST) Full Moon.

24th 4 pm (2 pm WST) Moon at perigee (closest to Earth at 364,917 km).

28th 1 pm (11 am WST) Last Quarter.

## THE PLANETS

**Mercury** begins its best period for evening observation this month. The planet reaches its greatest elongation 27° east of the Sun on the 22nd. With the ecliptic (the plane of the



planetary orbits) near vertical, this is an excellent opportunity to glimpse this small world without interference from the twilight glow. On the 8th, the 2-day-old waxing Moon's slender crescent appears around 6° from the planet (see Sky View). On the evening of the 7th, Mercury will be passing in front of M44, the Beehive star cluster in Cancer. During the last week of the month, Mercury will be near Regulus, the alpha star of Leo. The planet will be the brighter of the two and closest at 2° on the 25th.

**Venus** returns to the western evening dusk mid-month after hiding in the Sun's glare for the past ten weeks.

The **Earth** is at aphelion on the 5th, the furthest point in its orbit from the Sun (152,099,895 km or 1.016725 au distant).

**Mars**, in the eastern morning sky, rises around 3 am mid-month. On the 2nd, the planet will be 5° from the 25-day-old waning crescent Moon (see Sky View). After spending the first third of July in Aries, Mars moves into Taurus for a rendezvous with Uranus. Between the 15th and the 17th, the Red Planet will be within 1° of this greenish world. The pair are closest on the 16th at 0.5°, making a nice colour contrast in a low-power telescope or binocular field.

**Jupiter**, in Taurus, rises around 4 am mid-month. For all of July, the King of Planets remains within 6° of the magnificent 1st magnitude red giant star, Alpha Tauri (Aldebaran). It is fitting to mention Pioneer 10 here. This NASA spacecraft, launched in 1972, completed the first mission to Jupiter in 1973. It became the first of five artificial objects to reach escape velocity and leave the Solar System. Its current trajectory will take it in the general direction of Aldebaran (68 light-years away) and will make its closest approach to the star in about two million years.

Jupiter has two encounters with the Moon in July. The 3rd finds the planet 8° from the 26-day old, waning crescent Moon. At this time, Jupiter is close to giving Taurus the Bull's face a left eye. On the 31st, the planet will be 6° from the 25-day-old waning crescent Moon. Jupiter, Mars, Aldebaran, and the Moon form a neat irregular quadrilateral shape in the morning sky (see Sky Views).

**Saturn** rises around 9:30 pm mid-month in the eastern evening sky. The Ringed Planet's apparent path against the starfield reverses on the 1st as this world begins its retrograde track ahead of its September opposition (see Retrograde Motion p. 94). On the 24th, Saturn rises around 9 pm, 5° below the 18-day-old waning crescent Moon (see Sky View); overnight, their separation decreases, and before sunrise on the 25th, they will be just 1.5° apart.

For the first half of this month, the planet's splendid ring system will be inclined to us at just 2°. With the rings so narrow, there will be little to no detail visible in them, and they may even be challenging in small telescopes—or, at best, appear as a thin pencil-like line. They then begin to open slightly to 5° by December before the Earth crosses the ring plane in March of next year when they disappear for a short period. It is interesting to see the changes in the rings in the Appearance of the Planets diagrams throughout the year.

**Uranus**, in Taurus, is only visible in the eastern morning sky, rising around 3 am mid-month. The Red Planet, Mars, pays the ice giant a close visit between the 15th and 17th (see Mars).

**Neptune**, in Pisces, rises in the late evening eastern sky. On the 3rd, the planet begins five months in retrograde motion, appearing to travel westward against the stellar background (see Retrograde Motion p. 94).

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

At the end of July, 10th magnitude Isis makes a close approach to the spout star of the Teapot (Gamma$^2$ Sagittarii) and the twin globulars NGC 6528 and 6522 (see Diary). Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 1 Jul | 471 Papagena | Sagittarius | 10.9 |
| 6 Jul | 1 Ceres | Sagittarius | 7.5 |
| 18 Jul | 654 Zelinda | Sagittarius | 12.5 |
| 21 Jul | 40 Harmonia | Sagittarius | 9.5 |
| 28 Jul | 702 Alauda | Capricornus | 11.8 |

## COMETS

**Comet 12P/Pons-Brooks** (All Sky Map 4) begins the month in Puppis about magnitude 9, rising in the south-eastern sky shortly before dawn and setting in the south-western sky around 9 pm. On the 8th it moves into Vela and ends the month around magnitude 11, setting around 10:30 pm.

**Comet 154P/Brewington** (All Sky Map 3) moves into Perseus on the 1st at magnitude 10, rising in the north-eastern sky shortly before dawn. It then moves into Auriga on the 13th and ends the month having faded slightly.

**Comet 13P/Olbers** (All Sky Map 5) is rising in daylight and setting in the early north-western evening sky. It begins the month in Lynx at magnitude 8, then in Ursa Major on the 10th, Lynx again on the 11th, Leo Minor on the 14th and Ursa Major on the 28th. By month's end the comet has faded slightly.

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 4) is in Leo, beginning the month at magnitude 10 and setting in the western sky around 10:30 pm. By month's end it is setting around 8 pm and slightly brighter.

## METEOR SHOWERS

The **Southern delta-Aquarids** are among the strongest and most consistent southern showers. The range of activity of these medium-speed meteors extends from July 12 to August 23. Maximum this month is expected on the evening of the 30th and the morning of the 31st. At its peak, the delta-Aquarids can produce rates of up to 25 meteors per hour. They are generally faint (bright meteors are the exception), typically white with some blue members and occasionally leaving trains. There will be minimal lunar interference on the morning of 31st with the crescent Moon rising around 3 am.

The **alpha-Capricornids** are known for their bright, slow meteors, long paths, and frequent fireballs. From dusk till dawn, the shower is visible from July 3 to August 15. Maximum activity occurs around the 29th, with a zenith hourly rate of around five. Their spectacular nature generally makes up for the low hourly rates. The morning of July 29 sees the 3rd quarter Moon rising around 1 am.

## CONSTELLATIONS

In June we briefly discussed Sagittarius's wreath, Corona Australis (the Southern Crown). This is a good time to see its similar looking counterpart, Corona Borealis (the Northern Crown, Map 7), which is close to the northern horizon. It consists of seven stars ranging from 5.0 up to 2.2 magnitude Alpha (α) Coronae Borealis. This brightest star in the constellation is known by two names, Alphekka, which has Arabic roots meaning 'broken' relating to this semicircle of stars and 'Gemma' or jewel referring to its location in the crown. This hints it has a much more regal mythos compared to Sagittarius' humble vine branch!

Two mythical gentlemen, who from the Southern Hemisphere are standing on their heads, flank this Northern Crown. To the left (west) is Boötes the Herdsman whose star pattern looks more like an inverted kite, topped by the bright star, Alpha (α) Boötis or Arcturus. This luminary holds a place in modern history, taking centre stage to promote astronomy in an exercise called the Arcturus Project'. In 1933 the World Fair was held in Chicago. It celebrated, 'A Century of Progress', marking 100 years since the city was established and it was decided it should focus on scientific contributions. It had also been 40 years since Chicago previously held a World Fair in 1893. At the time the distance to Arcturus was believed to be 40 light-years (the modern figure is more like 37 light-years). So, the light arriving in 1933 would have left the star during the previous fair. It was decided to symbolically link the two fairs, by using light from Arcturus, collected at Yerkes Observatory, to generate an electric current (using the photoelectric effect) to illuminate the opening of the fair. It was a great success! (The story is covered in more detail in Astronomy 2019).

Moving to the east (right) of the Northern Crown, is the other gentleman, the constellation of Hercules, the Son of Zeus. Here lies a distinctive geometric shape the keystone. Named after the top stone of an arch, this asterism is made up of Zeta (ζ) (the brightest and top left star) then going clockwise, Epsilon (ε), Pi (π) and Eta (η) Herculis. For those people with some understanding of architecture, who think it looks strange, it is upside down from the Southern Hemisphere. If you add in Beta (β) and Delta (δ) Herculis (directly above or south of the keystone) it now forms the Butterfly asterism.

# Solar Max Cycle 25, Part 3 – Hydrogen Alpha

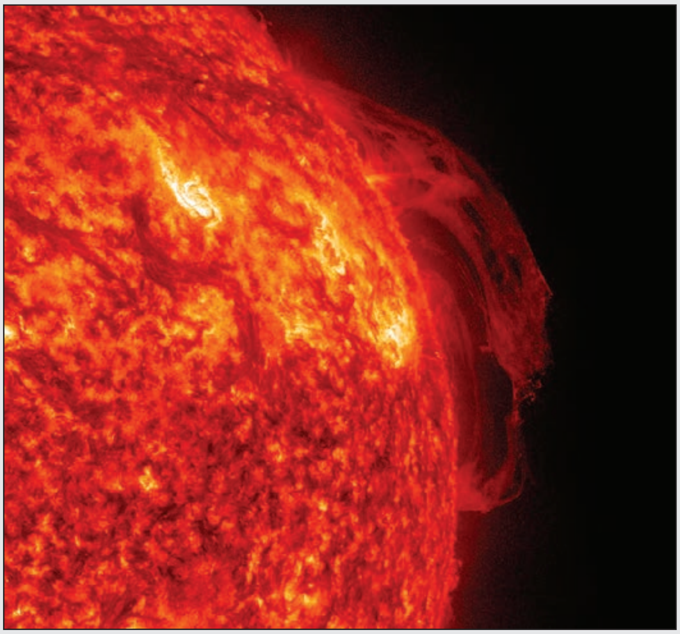
As discussed in Part 1, page 28, Solar Cycle 25 may reach its peak this year, despite previous forecasts. The period of solar maximum is potentially hazardous for Earth, with solar storms having the ability to interfere with communication systems, damage power infrastructure, harm humans in space, and even disrupt satellites. The positive aspect is that auroral activity increases for both hemispheres, and there is much more for the amateur to view and image on the Sun. In Parts 1 and 2, we covered solar white light features and techniques for observing them. This section will focus on a very narrow range of the solar spectrum.

**Under no circumstances should you look directly at the Sun with your naked eye, or any optical instrument not designed or modified for solar observing, as irreparable damage or blindness can result.**

Like Earth, the Sun has an atmosphere, but the parallels end there. The Sun's atmosphere is in two parts—the outer corona (visible during a total solar eclipse) and the inner chromosphere, a 2000–3000 km deep layer directly above the photosphere. In this layer, the temperature rises with altitude, from 6000° C to around 20,000° C. At these high temperatures, hydrogen emits light that gives off a reddish colour (Hydrogen Alpha, H-alpha or Hα). The chromosphere (from the Greek chroma meaning colour) is also visible for a few seconds during a total eclipse as a pinkish-red zone around the lunar limb.

Until recently, Hα observing was the realm of the professional observatory or the well-heeled amateur. Today several companies manufacture dedicated Hα telescopes and filters that are within reach of the amateur budget (although still expensive). Even the smallest of these instruments will deliver views of the chromosphere that certainly won't disappoint—but before rushing out and buying one, you must remember that they are for solar astronomy only (apart from the Sun, nothing else is bright enough to get through to the eyepiece or film plane). Consider Hα the next step in your solar observing, not the first. Have some fun with the white light view first; a full aperture filter for a small refractor is only a fraction of the cost of an Hα telescope.

The narrow-band Hα telescopes and filters allow only a specific wavelength of light (656.3 nm) to pass to the observer, effectively blocking the flood of light at other wavelengths. They look at a particular wavelength of the spectrum where excited hydrogen atoms are brightest—like manually tuning into your favourite radio station, you adjust to the strongest, clearest signal, blocking any static and unwanted stations.



*Solar Dynamics Observatory image of a huge prominence that arched 500,000 km across the Sun on 16–18 January 2012.*

| DIARY | | | |
|---|---|---|---|
| Mon | 1st | | m.p. 532 Herculina 0.4° SW of NGC 5248 (G) in Boötes |
| Tue | 2nd | 5 am | (3 am WST) Mars 5° S of Moon |
| Thu | 4th | | Jupiter 2.0° N of star Epsilon Tauri |
| Thu | 4th | | Comet 12P/Pons-Brooks 0.5° W of NGC 2546 (OC) in Puppis |
| Fri | 5th | | d.p. 1 Ceres at opposition |
| Fri | 5th | | Earth at aphelion, 1.016725489 au |
| Sat | 6th | | m.p. 4 Vesta 1.6° N of M44 Beehive Cluster (OC) in Cancer |
| Sat | 6th | | m.p. 6 Hebe 1.0° NE of NGC 5363 (G) in Virgo |
| Sat | 6th | 3 am | (1 am WST) Maximum Libration (8.2°), too close to New Moon. |
| Sat | 6th | 9 am | (7 am WST) New Moon. |
| Sun | 7th | | Mercury 0.3° NE of M44 Beehive Cluster (OC) in Cancer |
| Sun | 7th | 6 pm | (4 pm WST) m.p. 4 Vesta 1.5° N of Mercury |
| Mon | 8th | | m.p. 4 Vesta 0.5° S of star Gamma Cancri |
| Mon | 8th | pm | d.p. 1 Ceres 0.4° N of star Zeta Sagittarii |
| Fri | 12th | 6 pm | (4 pm WST) Moon at apogee (furthest from Earth at 404,362 km). |
| Sun | 14th | 5 am | (3 am WST) star Aldebaran 5° S of Jupiter |
| Sun | 14th | 9 am | (7 am WST) First Quarter Moon. |
| Mon | 15th | pm | d.p. 1 Ceres 0.5° N of M54 (GC) in Sagittarius |
| Tue | 16th | 4 am | (2 am WST) Uranus 0.5° NW of Mars |
| Thu | 18th | | Comet 154P/Brewington 1.3° N of star Iota Aurigae |
| Fri | 19th | 1 pm | (11 am WST) Maximum Libration (8.7°), dark NW limb. |
| Sat | 20th | | m.p. 532 Herculina 1.0° SW of NGC 5364 (G) in Virgo |
| Sun | 21st | 8 pm | (6 pm WST) Full Moon (369,929 km). |
| Mon | 22nd | | m.p. 3 Juno 0.8° SW of star Nu Virginis |
| Mon | 22nd | | Mercury at greatest elongation East (26.9°) |
| Wed | 24th | | Comet 154P/Brewington 1.0° N of IC 405 (Flaming Star Nebula) in Auriga |
| Wed | 24th | 4 pm | (2 pm WST) Moon at perigee (closest to Earth at 364,917 km). |
| Wed | 24th | 6 pm | (4 pm WST) m.p. 4 Vesta 1.5° N of Venus |
| Thu | 25th | 5 am | (3 am WST) Saturn 1.5° E of Moon |
| Thu | 25th | 11 pm | (9 pm WST) Neptune 0.5° S of Moon |
| Sat | 27th | | Comet 154P/Brewington 0.3° SW of M38 (OC) in Auriga |
| Sat | 27th | | Comet 13P/Olbers 0.3° N of NGC 3432 (G) in Leo Minor |
| Sat | 27th | 6 pm | (4 pm WST) star Regulus 3° N of Mercury |
| Sun | 28th | 1 pm | (11 am WST) Last Quarter Moon. |
| Mon | 29th | pm | m.p. 42 Isis 0.1° SE of NGC 6528 (GC) in Sagittarius |
| Tue | 30th | | m.p. 532 Herculina 0.6° NE of star Tau Virginis |
| Tue | 30th | | Southern delta-Aquarids meteor shower, Jul 12 to Aug 23. |
| Tue | 30th | | alpha-Capricornids meteor shower, Jul 3 to Aug 15. |
| Tue | 30th | 3 am | (1 am WST) Uranus 5° S of Moon |
| Tue | 30th | pm | m.p. 42 Isis 0.3° NW of star Gamma 2 Sagittarii |
| Wed | 31st | 4 am | (2 am WST) Mars 8° SW of Moon |
| Wed | 31st | 5 am | (3 am WST) Jupiter 6° S of Moon |
| Wed | 31st | pm | m.p. 42 Isis 0.2° SE of NGC 6522 (GC) in Sagittarius |

During solar maximum, we can expect to observe an increase in Hα activity in the chromosphere, some of which will be related to features visible on the photosphere in white light. Although when observing the chromosphere, most of the photospheric phenomena become invisible except sunspots. Indeed, the whole disc in this narrow band shows a wealth of detail hidden from the white-light observer.

Prominences are undoubtedly the most interesting of the Hα features to observe. These spectacular structures extend along magnetic field lines from the photosphere to the corona. Both prominences and the corona are made of plasma; however, prominences are much cooler. When silhouetted against the disc, prominences appear as dark, sinuous lanes called filaments. It is possible to see a prominence on the limb extend over the surface as a filament. They come in all shapes and sizes, from tiny little spikes to tree-like hedges to great looped arcs. They can be active and short-lived, moving and changing in appearance over a few minutes—in stark contrast to the quiescent type that develops slowly and has a lifetime of several months.

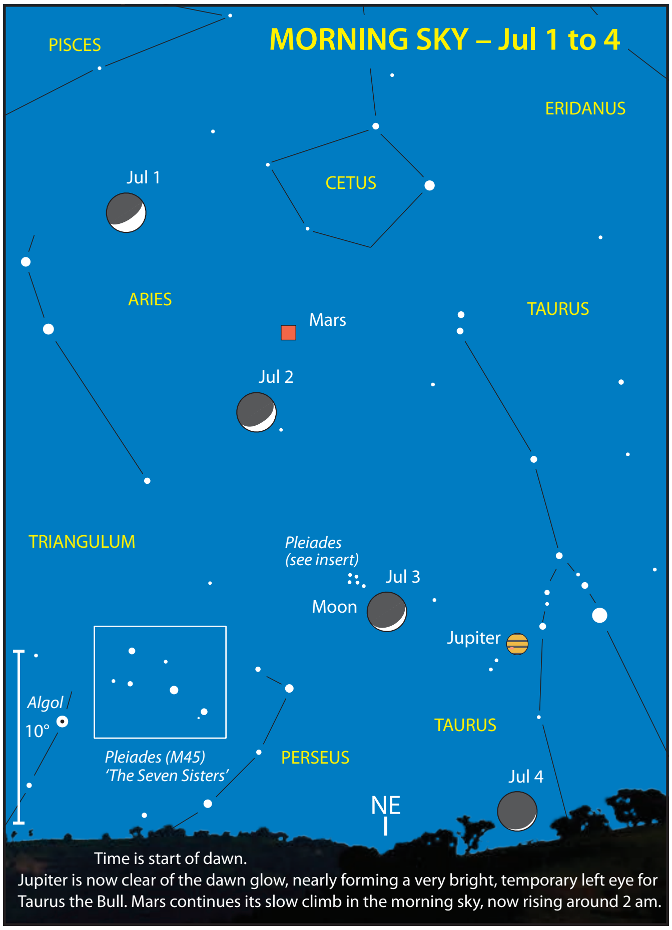
Sunspots are also visible in Hα, although the chromosphere above tends to mask them a little. The lack of the penumbral regions around the umbra is most noticeable, albeit much different detail, invisible in white light, becomes apparent. The plages (French for beach) are bright patchy areas near active sunspot groups. They are similar to the white-light faculae, although they occur on a larger scale and are more brilliant.

If you regularly observe the Sun, you may be lucky enough to see a solar flare, particularly during solar maximum. A solar flare occurs when magnetic energy that has built up is suddenly released. We are not talking about a little explosion here; the energy is equivalent to millions of 100-megaton hydrogen bombs exploding simultaneously. Flares are more likely to occur in sizeable complex sunspot groups and appear as one or more bright patches that rapidly increase brightness in a few minutes. A solar flare can last up to several hours—although rare in white light; they are very bright in Hα.

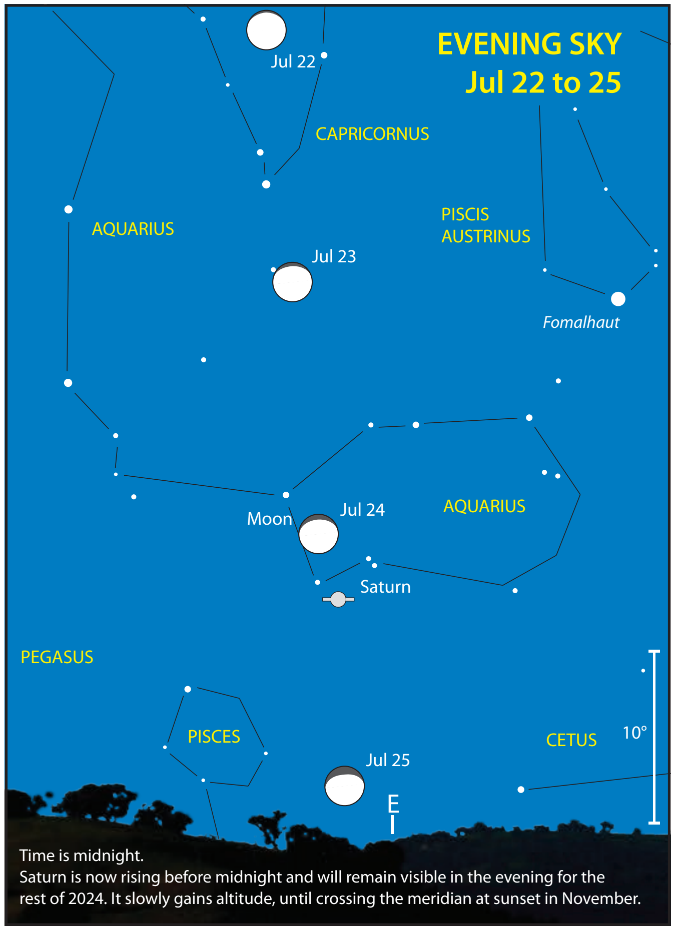
The much talked about coronal mass ejections (CME) were thought to be triggered by solar flares—although related; it is now understood that one does not cause the other, and they can both occur independently. A CME is a large eruption of the corona that releases super-hot charged plasma into space at high speeds. If the Earth takes a direct hit from a large CME, it can have devastating consequences like the one that knocked out power to all of Quebec in 1989 (see A Perfect Space Storm, Astronomy 2011).

With good-quality instrumentation becoming available and more affordable over recent years, solar astronomy has finally come of age for the amateur. The Hα Sun is amazing and dynamic, with spectacular short-term and day-to-day changes that make the Sun come 'alive'. For some, Old Sol is far more interesting than the static night sky.

*A 60 mm dedicated Hydrogen Alpha telescope*

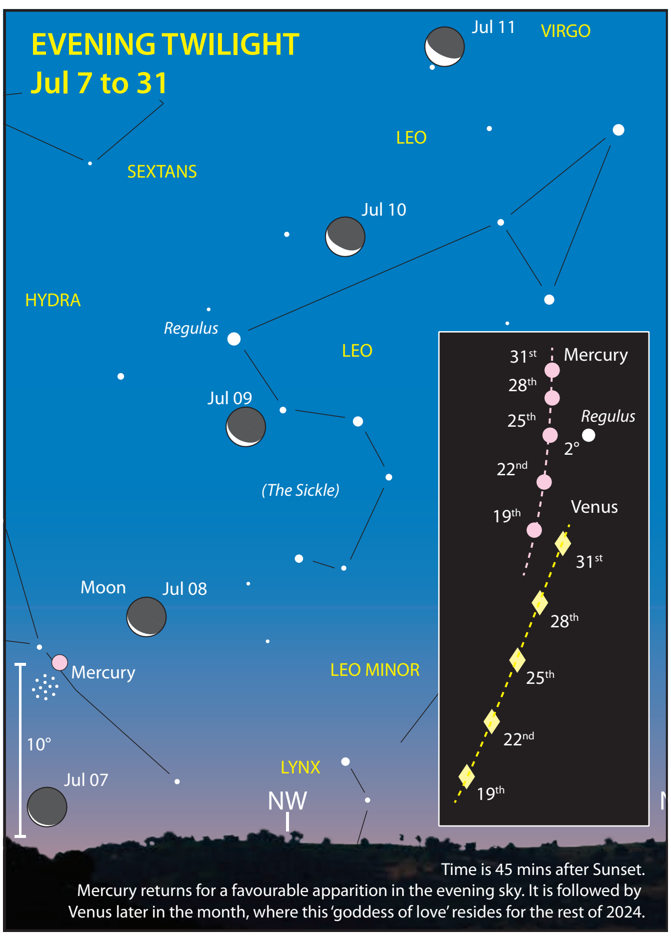



Time is start of dawn.
Jupiter is now clear of the dawn glow, nearly forming a very bright, temporary left eye for Taurus the Bull. Mars continues its slow climb in the morning sky, now rising around 2 am.

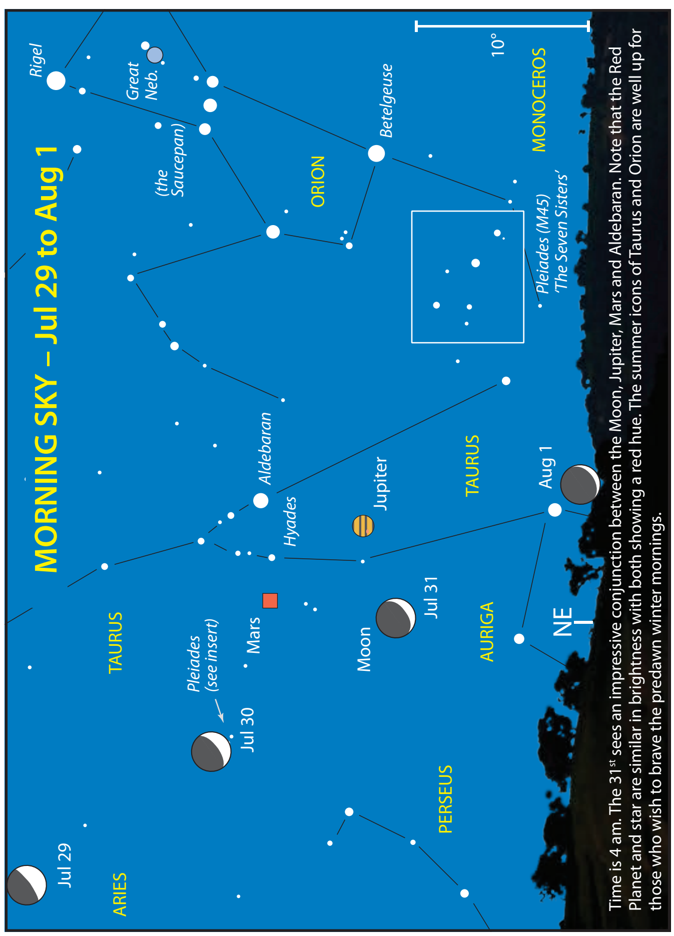



Time is midnight.
Saturn is now rising before midnight and will remain visible in the evening for the rest of 2024. It slowly gains altitude, until crossing the meridian at sunset in November.

Approximate local standard time.



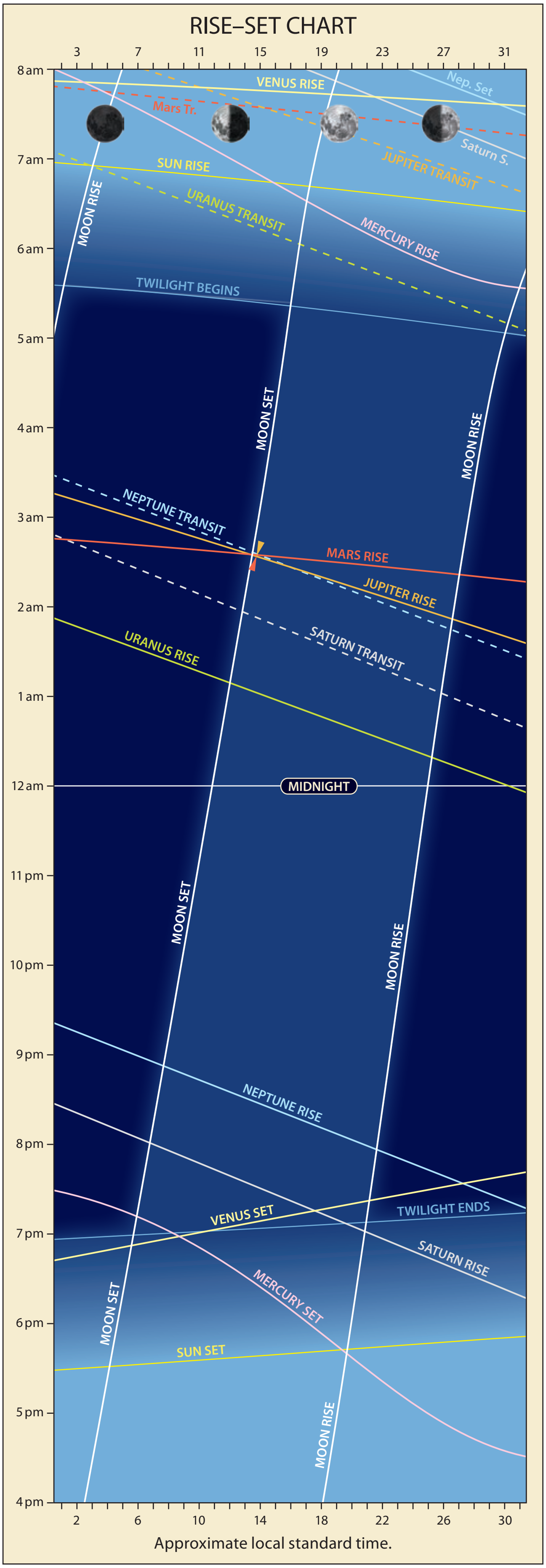

Time is 45 mins after Sunset.
Mercury returns for a favourable apparition in the evening sky. It is followed by Venus later in the month, where this 'goddess of love' resides for the rest of 2024.




Time is 4 am. The 31st sees an impressive conjunction between the Moon, Jupiter, Mars and Aldebaran. Note that the Red Planet and star are similar in brightness with both showing a red hue. The summer icons of Taurus and Orion are well up for those who wish to brave the predawn winter mornings.

JULY

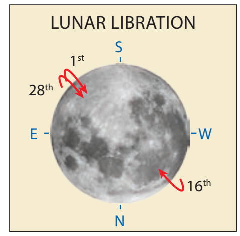
# AUGUST 2024




## HIGHLIGHTS

- Mars and Jupiter close.
- Mercury, Venus, Regulus and Moon together.
- Mars, Jupiter and the Moon make a neat triangle.

## THE MOON




1st Midnight (10 pm WST) Maximum Libration (8.6°), dark SE limb.

4th 9 pm (7 pm WST) New Moon.

9th Noon (10 am WST) Moon at apogee (furthest from Earth at 405,297 km).

13th 1 am (11 pm WST, previous day) First Quarter.

16th 3 am (1 am WST) Maximum Libration (9.6°), dark NW limb.

20th 4 am (2 am WST) Full Moon, supermoon.*

21st 3 pm (1 pm WST) Moon at perigee (closest to Earth at 360,196 km).

26th 7 pm (5 pm WST) Last Quarter.

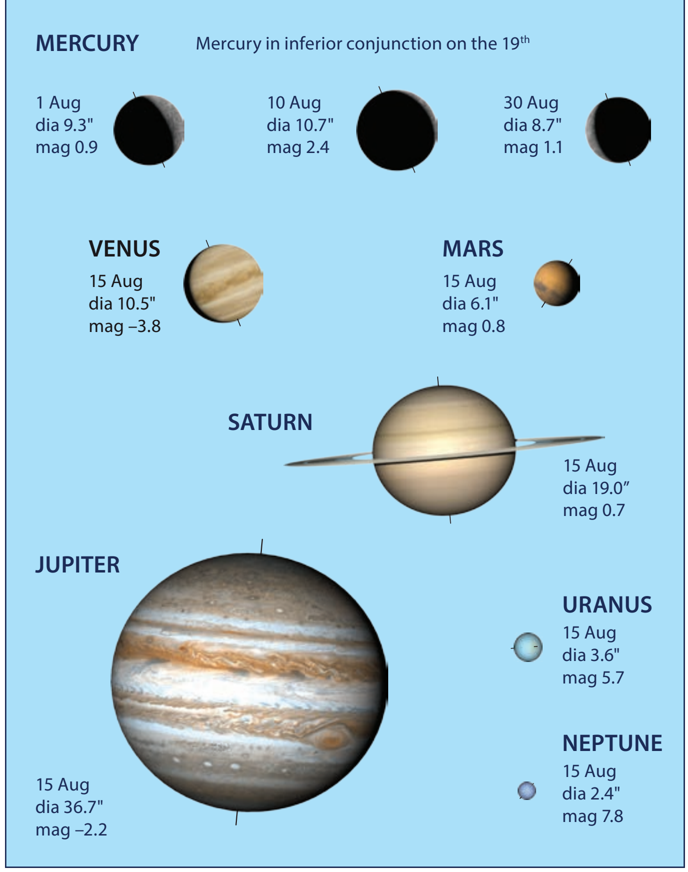
28th Midnight (10 pm WST) Maximum Libration (9.6°), dark SE limb.

*Note: The term supermoon is just a nickname for what astronomers call a Perigean Full Moon—a Moon that is full and near the closest point (perigee) in its orbit around Earth.

## THE PLANETS

A pleasant conjunction between **Mercury**, Venus and the 2-day-old slender crescent Moon is visible in the western

### APPEARANCE of the PLANETS



evening twilight on the 6th (see Sky View). Binoculars may be required to spot the fainter inner planet in the twilight. Do not confuse the 1st magnitude star Regulus, just below Venus, for the planet. Mercury then rapidly descends toward the Sun and will be in inferior conjunction (between the Earth and Sun) on the 19th. It then returns to the eastern morning sky for a poor appearance, scarcely a few degrees above the horizon at the beginning of civil twilight.

Brilliant **Venus** is visible in the western evening sky. The planet will reign as the Evening Star until March next year, when it swings west of the Sun and returns to the morning sky. Venus and the 2-day-old slender crescent Moon make an attractive sight just 4° apart on the 6th (see Sky View). Mercury and the 1st magnitude star Regulus are also included in this conjunction (see Mercury).

**Mars** spends the month in Taurus in the north-eastern morning sky, rising around 2:30 am. For those up before the morning dawn, a trio of bright orangish/red objects are visible in that direction: Mars, Aldebaran, and Betelgeuse. Early August sees the Red Planet about 5° from Aldebaran, the red eye of Taurus the Bull. At this time, Mars and Aldebaran are very closely matched in magnitude, although the star's position in the V-shaped grouping of stars known as the Hyades (the Bull's head) will give it away. Between the 15th and 17th, Mars will be within 1° of Jupiter and closest at 0.3° on the 15th. On the 28th, the 24-day-old waning crescent Moon will be near the planet; whilst not very close, a neat triangle is formed between the pair with Jupiter (see Sky View).

**Jupiter**, in Taurus, rises in the north-eastern evening sky around 2:30 am mid-month. This planet shares the constellation of the Bull with both Mars and Uranus. Whilst moving slowly between the Bull's horns, the faster-moving Mars catches up and overtakes the giant Jovian planet. The pair will be at their closest at 0.3° apart between the 15th and 17th.

With opposition early next month, **Saturn** can be seen rising in the east in the early evening winter sky. On the 21st, the planet will be 5° from the 17-day-old waning gibbous Moon (see Sky View). The planet's rings were first observed by Galileo Galilei soon after the invention of the telescope in 1609. While the other three Jovian planets have since been discovered to have rings, they're faint and no match for the magnificent system around Saturn. However, the tilt of the rings to the Earth this month will be a narrow 3°. This will allow a less obstructed view of the planet at the expense of ring detail. Features like the Cassini Division, Encke Gap, and the translucent Crepe Ring will be difficult to see until around 2027 when the rings reopen enough to reveal their intricate details.

In Taurus, near the border of Aries, **Uranus** remains an object for morning observers only this month, rising around 1 am.

**Neptune**, in Pisces, rises in the evening eastern sky around 8 pm mid-month.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Starting the end of August, the now faded Isis (11th mag) tours several globular star clusters in the body of Sagittarius' Teapot (see Diary). Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 6 Aug | 16 Psyche | Capricornus | 9.5 |
| 7 Aug | 7 Iris | Aquarius | 8.2 |
| 23 Aug | 423 Diotima | Piscis Austrinus | 11.7 |
| 26 Aug | 52 Europa | Aquarius | 11.1 |
| 28 Aug | 44 Nysa | Aquarius | 10.3 |

AUGUST

**DIARY**

| | | | |
|---|---|---|---|
| Thu | 1st | | m.p. 15 Eunomia 1.0° SE of star Zeta Persei |
| Thu | 1st | Midn | (10 pm WST) Maximum Libration (8.6°), dark SE limb. |
| Fri | 2nd | | Comet 13P/Olbers 1.0° NE of star Nu Ursae Majoris |
| Sun | 4th | am | m.p. 39 Laetitia 0.05° SE of NGC 474 (G) in Pisces |
| Sun | 4th | 6 pm | (4 pm WST) star Regulus 1.5° SE of Venus |
| Sun | 4th | 9 pm | (7 pm WST) New Moon. |
| Mon | 5th | | m.p. 15 Eunomia 1.0° NW of NGC 1514 (PN) in Taurus |
| Tue | 6th | | Comet 154P/Brewington 0.8° S of star Theta Aurigae |
| Tue | 6th | 5 am | (3 am WST) star Aldebaran 4° E of Mars |
| Tue | 6th | 6 pm | (4 pm WST) Venus 3° W of Moon |
| Tue | 6th | 6 pm | (4 pm WST) Mercury 7° SW of Moon |
| Tue | 6th | 6 pm | (4 pm WST) Venus 6° N of Mercury |
| Wed | 7th | am | m.p. 39 Laetitia 0.8° SW of NGC 520 (G) in Pisces |
| Fri | 9th | Noon | (10 am WST) Moon at apogee (furthest from Earth at 405,297 km). |
| Mon | 12th | am | Perseids meteor shower, Jul 17 to Aug 24, Moon affected in evening. |
| Tue | 13th | | m.p. 3 Juno 0.8° NE of NGC 4123 (G) in Virgo |
| Tue | 13th | 1 am | (11 pm WST, prev day) First Quarter Moon. |
| Wed | 14th | | Comet 13P/Olbers 1.0° W of NGC 4251 (G) in Coma Berenices |
| Thu | 15th | 5 am | (3 am WST) Jupiter 0.5° S of Mars |
| Fri | 16th | 3 am | (1 am WST) Maximum Libration (9.6°), dark NW limb. |
| Sat | 17th | | Comet 13P/Olbers 0.7° N of Mel 111 (OC) in Coma Berenices |
| Sat | 17th | pm | m.p. 7 Iris 0.4° N of star Epsilon Aquarii |
| Sun | 18th | | Jupiter 0.5° N of star Iota Tauri |
| Mon | 19th | | Comet 13P/Olbers 0.4° E of NGC 4494 (G) in Coma Berenices |
| Mon | 19th | | Comet 13P/Olbers 0.7° SW of NGC 4565 (G) in Coma Berenices |
| Mon | 19th | | Mercury in inferior conjunction |
| Tue | 20th | 4 am | (2 am WST) Full Moon (361,969 km), supermoon. |
| Tue | 20th | | m.p. 4 Vesta in conjunction with Sun |
| Wed | 21st | am | m.p. 39 Laetitia 0.7° NE of NGC 533 (G) in Cetus |
| Wed | 21st | 5 am | (3 am WST) Saturn 5° E of Moon |
| Wed | 21st | 3 pm | (1 pm WST) Moon at perigee (closest to Earth at 360,196 km). |
| Thu | 22nd | 5 am | (3 am WST) Neptune 3° E of Moon |
| Mon | 26th | | Comet 13P/Olbers 0.5° NE of M64 Blackeye Galaxy (SG) in Coma Berenices |
| Mon | 26th | 5 am | (3 am WST) Uranus 5° SE of Moon |
| Mon | 26th | 7 pm | (5 pm WST) Last Quarter Moon. |
| Mon | 26th | pm | m.p. 42 Isis 0.5° N of NGC 6558 (GC) in Sagittarius |
| Tue | 27th | | Mars 1.0° N of M1 Crab Nebula (PN) in Taurus |
| Wed | 28th | 3 am | (1 am WST) Jupiter 7° SW of Moon |
| Wed | 28th | 5 am | (3 am WST) Mars 6° SE of Moon |
| Wed | 28th | 5 am | (3 am WST) Jupiter 8° SW of Moon |
| Wed | 28th | Midn | (10 pm WST) Maximum Libration (9.6°), dark SE limb. |
| Fri | 30th | | m.p. 3 Juno 0.9° SW of NGC 4536 (G) in Virgo |
| Fri | 30th | pm | m.p. 42 Isis 0.5° N of NGC 6569 (GC) in Sagittarius |
| Sat | 31st | | m.p. 532 Herculina 0.8° NE of star Mu Virginis |
| Sat | 31st | | m.p. 194 Prokne 0.4° NW of star Lambda Aquarii |
| Sat | 31st | | m.p. 15 Eunomia 0.7° NW of star Iota Aurigae |
| Sat | 31st | | Comet 13P/Olbers 1.2° NE of M53 (GC) in Coma Berenices |

# The Magnificent Three

In Astronomy 2017, we featured a famous trio of lunar craters named Ptolemaeus, Alphonsus and Arzachel, dubbed the 'Big Three'. There is no doubt that these splendid craters and their location near the centre of the lunar disc account for their striking appearance, especially around the time of the First Quarter Moon. Equally impressive is another imposing group further east of the Big Three. All are around 100 km in diameter and located on the western shore of Mare Nectaris (Sea of Nectar). They are best viewed when the Moon is about five to six days old or four to five days after Full Moon.

The first of the Magnificent Three, **Theophilus**, is a beautiful and well-preserved crater that is the youngest of the three. It has been said that along with Tycho and Copernicus, Theophilus is one of the most spectacular craters visible from Earth. It has convoluted terraced walls and a flat floor with an imposing complex group of central mountains. Confirming its young age, the walls to the south-west spill over into neighbouring Cyrillus. On the inside of its north-western wall is an 8-km bowl-shaped crater named Theophilus B. This should be visible through telescopes around 100 mm in aperture. The bright central mountain range is impressive, extending 30 km along the floor with three prominent peaks, the highest standing around 2 km. From day to day, as the Sun moves over Theophilus, observers will note that the contour of the central mountain region changes due to light and shadow variations. It was suggested erroneously by the American astronomer Edward Pickering (1846–1919) that these changes were due to snow melt.

South-west of Theophilus lies the crater **Cyrillus**. In contrast with Theophilus' detailed terraced interior wall, that of Cyrillus appears more smoothed and worn. Its north-eastern side has been intruded upon by ejecta from the formation of Theophilus, an obvious sign that Cyrillus is the older of the pair. On the south-western side, a 17-km bowl-shaped crater, Cyrillus A, sits conspicuously atop its wall. On its rough floor, three prominent peaks rise, the largest of which is somewhat domed. Just south of the mountains is a narrow rille extending for about 10 km, visible under high magnification and good seeing.

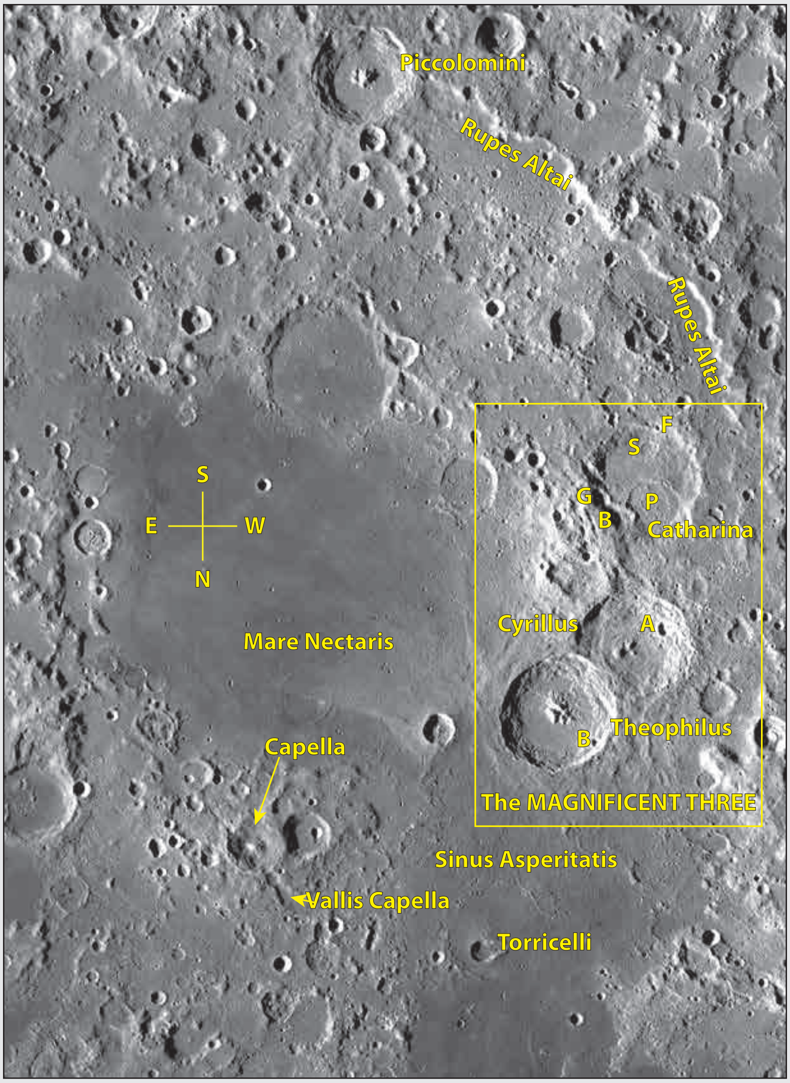
Following what appears to be a wide valley continuing southwards is the last and the oldest of the three. Known as **Catharina**, it has been severely battered by several impactors, the largest craters from this bombardment are Catharina B at 24 km in diameter, F at 7 km, G at 17 km, P at 46 km, and S at 16 km. Complex craters like these three large lunar craters have terraced walls, one or more uplifted central peaks, and a relatively level floor. Unlike the other two, the central peak is missing from Catharina, probably due to being decimated by the strike that created Catharina P. Catherina P and S are situated on the floor, whilst B, G, and F are atop the wall. F appears to be the youngest, with its well-defined rim.

There is much to explore around the Magnificent Three's general location, but we will list just a few to whet the appetite.

A region that links Mares Tranquillitatis and Nectaris is known as Sinus Asperitatis (Bay of Roughness). The bay itself is aptly named as it is covered by ejecta from the Theophilus impact. Within a ghost crater in the bay lies the pear-shaped 23-km crater Torricelli. Its western wall is open and interconnected with a smaller crater giving it its distinctive shape.

In a promontory on the northern shore of Mare Nectaris is the 49-km crater Capella which is noted for its unusual nature. Its central peak is enormous and broad compared to the crater's diameter. A 110-km valley (Vallis Capella), composed of an alignment of craters, runs through the crater.

Finally, curving away from Catharina to the prominent and beautiful 88-km crater Piccolomini is the 430 km long Rupes Altai (Altai Scarp or Range). This escarpment rises to around 1 km and forms the south-western rim of Mare Nectaris. It appears as a lengthy, bright arc when viewed approximately five days after the New Moon and illuminated by the Sun. Conversely, about four days after the Full Moon, it creates a dark shadow when the Sun is to the west.



## COMETS

**Comet 12P/Pons-Brooks** spends the month rising in the south-eastern sky shortly before dawn and setting in the south-western sky late evening. It begins in Vela at magnitude 11, moves into Centaurus on the 12th and ends the month having faded to magnitude 12.

**Comet 154P/Brewington** spends the month in Auriga, rising in the north-eastern sky shortly before dawn. During the month it fades from magnitude 11 to 12.

**Comet 13P/Olbers** (All Sky Map 7) is setting in the north-western sky just after twilight. It begins in Ursa Major at magnitude 8 and moves into Coma Berenices on the 13th. The comet ends the month having faded to magnitude 9. August finds the comet visiting the galaxy group in Coma Berenices, crossing the edge of the large open star cluster Mel 111 on the 17th and 18th (see Diary).

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 4) begins the month in Leo before moving into Sextans on the 11th. It starts about magnitude 10 and setting in the western sky around 8 pm. By month's end it is setting shortly after sunset having brightened to magnitude 8.

## METEOR SHOWER

The famous **Perseids** are not readily observable from down under, and the radiant will be below the horizon for many southern observers. The Perseids are the most dependable of the showers, with records of their activity going back over 1,000 years. Their duration is from July 17 to August 24. Their maxima are expected around the 12th and the morning of the 13th. This shower has produced exceptional rates, but a ZHR of 150 is generally possible. There would be considerably less activity from mid-Australian latitudes except for a few that may appear over the northern horizon. In his song, Rocky Mountain High, John Denver immortalised this spectacular shower when he sang, "I've seen it rainin' fire in the sky." The First Quarter Moon will interfere with evening observations this year, but the morning will be Moon free.

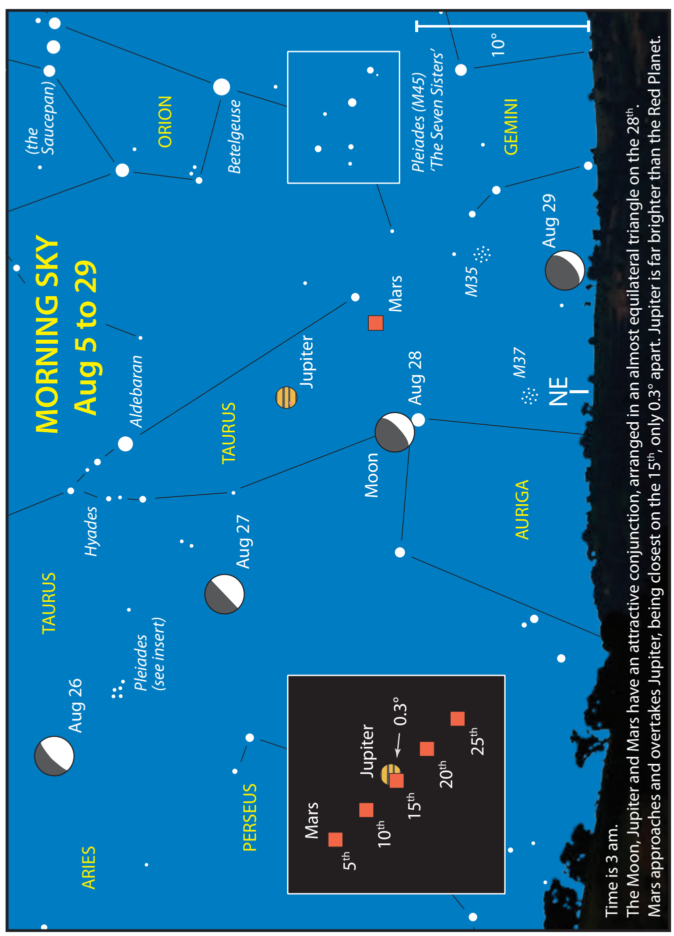
## CONSTELLATIONS

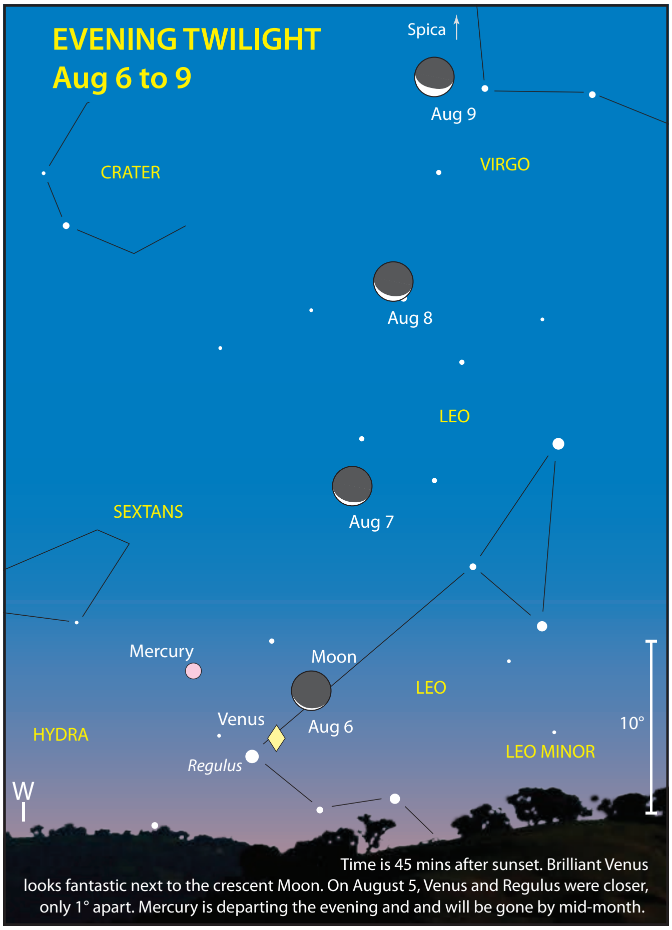
The dark lanes running from the Southern Cross (Crux) to Scorpius is known as the emu, with its head, complete with a beak and eye, being the famous Coalsack nebula in Crux. This is an Aboriginal constellation made up entirely of dark nebulae. It's best seen sitting on the south-eastern horizon with the neck extending towards the zenith during autumn evenings. This is just the southern part (west of the galactic centre) of what is a much larger collection of dark nebulae called the Great Rift. The northern portion is conveniently placed in the evening sky this month.

A good place to start is to identify the Northern Cross asterism standing on the northern horizon, resembling an inverted crucifix (Map 9). It is quite large standing over 20° high representing the constellation of Cygnus the Swan with the head to the top, its neck extending vertically, and wings spread wide open. The lowest (most northerly) star is 1.3 magnitude Alpha (α) Cygni or Deneb meaning 'tail'. It is from here the rift starts as a dark bulbous shape called the Northern Coalsack (upper left of the star). It narrows and heads up through Cygnus, passing the top star of the cross, the famous 3rd magnitude colourful double star, Beta Cygni, also known as Albireo. Its primary mag 3.1 star is a rich yellow in contrast to the obvious blue of its mag 5.1 companion, 36 arcseconds away. Returning to the bottom star, Deneb, move 4° eastward (left) to discover NGC 7000 the bright nebula known as the North American Nebula, but upside down for us down under. Look for the dark Gulf of Mexico region. This is a challenging observation because of its proximity to the northern horizon, needing good transparency and luck (try after a rain storm).

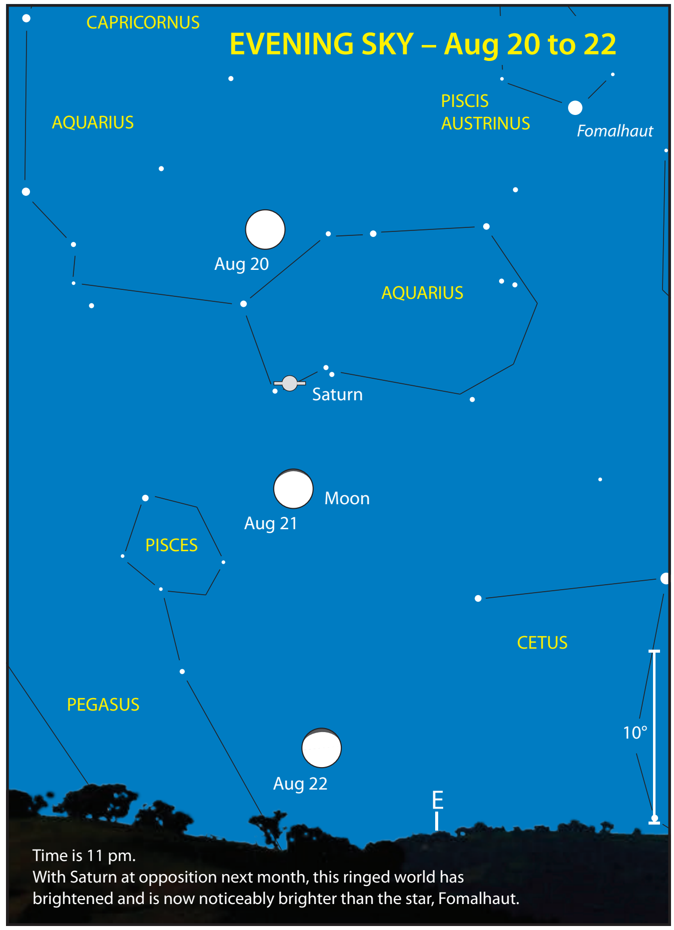
The dark rift widens as it passes through Vulpecula (the Fox), skirting the 'arrow' asterism of Sagitta. The distinctive binocular open star cluster known as the Coathanger is in the centre of this dark stream in Vulpecula (a brilliant binocular treat). Up to this point the rift is nicely framed by the asterism known as the Summer Triangle made up of three bright stars. The upper member is Altair in Aquila, then to the lower right, Deneb and lower left, Vega in Lyra.

The rift continues up, past Aquila the Eagle (Map 8) and runs along Serpens Cauda (the Serpent's Tail), becoming invisible as it appears to exit (temporarily) the Milky Way glow in Ophiuchus, the Serpent Bearer (Map 6). There is no doubt that its extinction effect on this area of our galaxy contributes to the dark eeriness of Ophiuchus; with its main asterism known as the Coffin. Overall, this northern rift is so big it's easy to overlook, being something like 70° long!



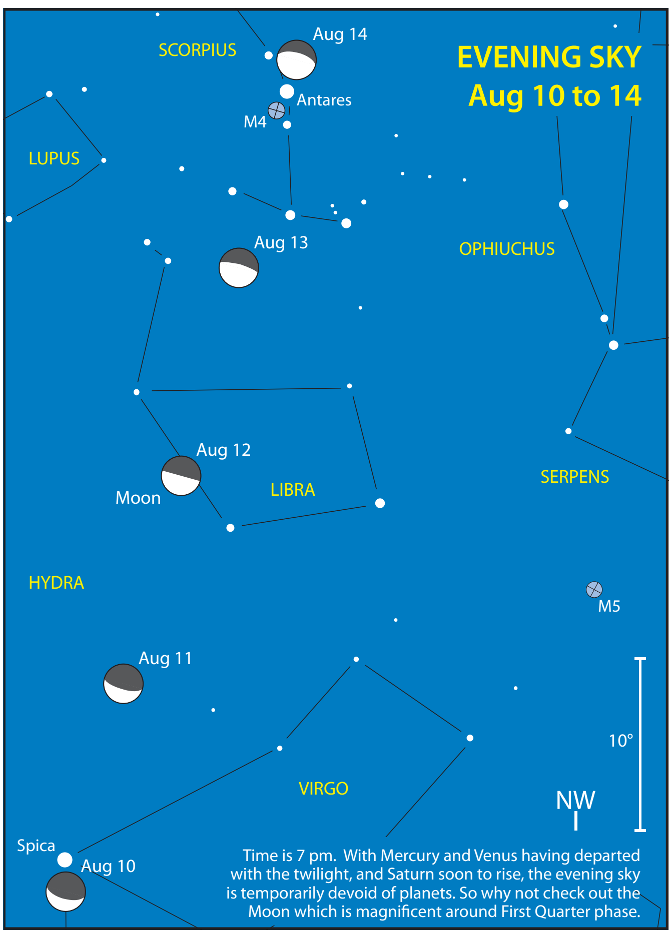



Time is 45 mins after sunset. Brilliant Venus looks fantastic next to the crescent Moon. On August 5, Venus and Regulus were closer, only 1° apart. Mercury is departing the evening and and will be gone by mid-month.

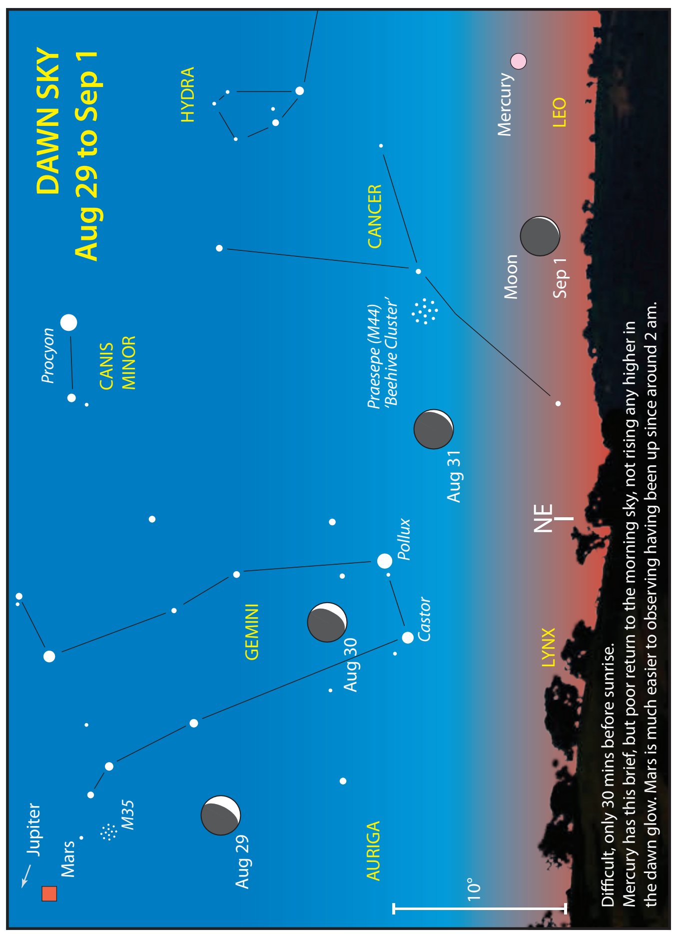



Time is 11 pm.
With Saturn at opposition next month, this ringed world has brightened and is now noticeably brighter than the star, Fomalhaut.

Approximate local standard time.

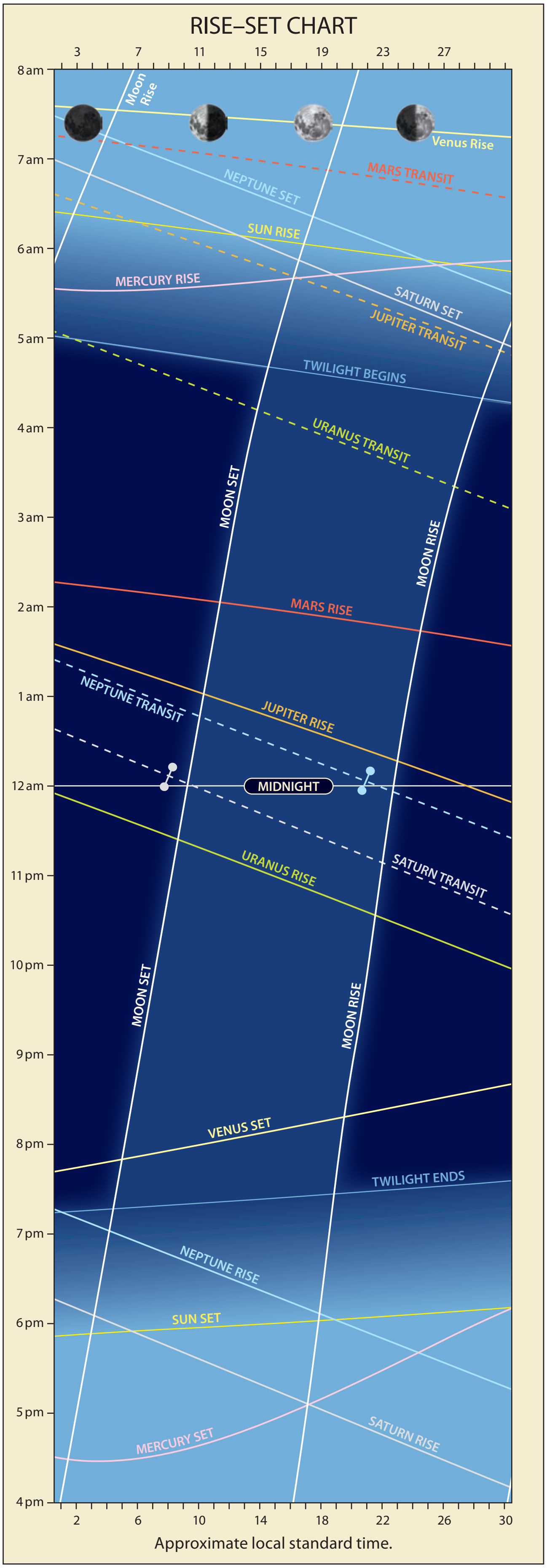



Time is 7 pm. With Mercury and Venus having departed with the twilight, and Saturn soon to rise, the evening sky is temporarily devoid of planets. So why not check out the Moon which is magnificent around First Quarter phase.




Difficult, only 30 mins before sunrise.
Mercury has this brief, but poor return to the morning sky, not rising any higher in the dawn glow. Mars is much easier to observing having been up since around 2 am.

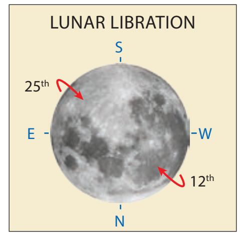
# SEPTEMBER 2024




## HIGHLIGHTS

- Venus and thin crescent Moon, spectacular meeting.
- Saturn at opposition.
- Saturn and Moon together.

## THE MOON




3rd Noon (10 am WST) New Moon.

6th 1 am (11 pm WST, previous day) Moon at apogee (furthest from Earth at 406,211 km).

10th Midnight (10 pm WST) Occultation of Antares. Best seen from WA with the First Quarter Moon setting (see Part II Lunar Occultations). Adelaide will see a brief disappearance with Hobart and Melbourne getting a close approach around 12:30 am (11th EST).

11th 4 pm (2 pm WST) First Quarter.

12th 10 pm (8 pm WST) Maximum Libration (10.1°), dark NW limb.

17th 6:30 pm (4:30 pm WST) Occultation of Saturn seen from northern Australia. Brisbane sees both events, with Darwin getting the reappearance shortly after moonrise.

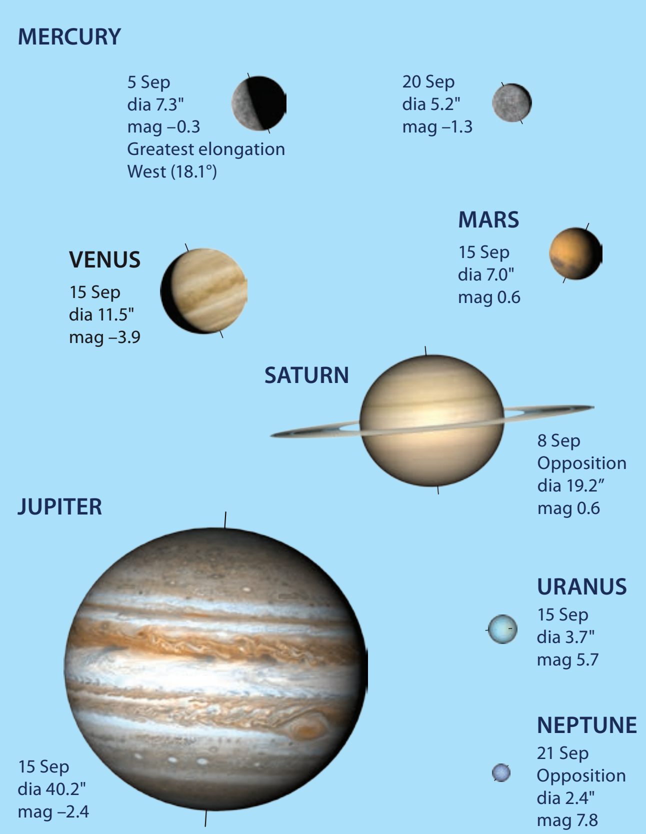
18th 1 pm (11 am WST) Full Moon, supermoon* and partial lunar eclipse, Americas, Europe, Africa.

18th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 357,286 km).

25th 5 am (3 am WST) Last Quarter.

25th 11 am (9 am WST) Maximum Libration (10.3°), dark SE limb.

## APPEARANCE of the PLANETS



*Note: The term supermoon is just a nickname for what astronomers call a Perigean Full Moon—a Moon that is full and near its closest point (perigee) in its orbit around Earth.

## THE PLANETS

**Mercury**, in the eastern morning sky, is not favourable to observe. It spends the entire month hugging the horizon barely a few degrees in altitude at civil dawn. The planet reaches its greatest elongation 18° west of the Sun on the 5th and will be in superior conjunction (Mercury and Earth on opposite sides of the Sun) on October 1.

**Venus** spends the month traversing Virgo in the western evening sky before entering Libra on the last day. On the 5th there will be a spectacular sight, with Venus just 1° from the limb of the earthshine-enhanced 2-day-old slender crescent Moon. On the 18th, the planet will be less than 3° from Virgo's brightest star, 1st magnitude Alpha Virginis (Spica).

The **Earth** is at its vernal (spring) equinox on the 22nd.

**Mars** moves from Taurus and into Gemini in the first week of September, rising around 2 am. On the 9th, the planet passes within 1.0° of M35, a large and splendid open cluster of more than 120 stars, visible in small telescopes. At the end of September, the Red Planet will be situated directly between the rising (upside-down) Gemini twins, Caster and Pollux, in the north-eastern morning sky.

**Jupiter**, in Taurus, rises in the eastern sky around 1 am mid-month.

**Saturn**, the crown jewel of the Solar System, is at opposition on the 8th and visible the entire night. The inclination of the planet's rings to the plane of the Earth's orbit is just 4° at this time, and minimal ring detail will be visible in small telescopes. In March 2025, the rings will be edge-on, although we will not see this event as the planet will be too close to the Sun after its late February conjunction. Even with the rings somewhat closed, the view will still be impressive, and as a bonus, we will gain a nearly unobstructed view of both hemispheres of the globe. If you have a set of colour filters, details of the planet's cloud bands can be enhanced. Typically, orange or blue filters help reveal details in the bands and the polar regions. Because filters absorb light, allowing only specific wavelengths through, they will darken the image in small instruments—so they are probably most advantageous in telescopes greater than 150 mm in aperture. Things to look for on the globe are the light-coloured equatorial band and the noticeable darkening and flattening at the poles.

Try tracking down and identifying some of the planet's satellites (about six are readily visible in amateur telescopes). Except for 8th magnitude Titan, the others are a little more difficult, and our diagrams on p. 66 and 70 plus 'Saturn's Moons' in Part II will assist. With its moons orbiting roughly in the plane of the rings, when the rings are close to edge-on, the moons (especially the inner ones), are seen shuffling back and forth across Saturn (like Jupiter and its satellites). The outer ones, like Titan, have large enough orbits, to still be seen passing above and below the planet when at their conjunctions.

On the 17th, the planet can be seen rising close to the nearly Full Moon (see Sky View). From the eastern states, the planet will appear 0.5° or less from the lunar limb, and the further north along the coast, the closer the pair will be. From the central and western states, the distance increases. Most of Queensland will see Saturn reappear from behind the Moon in the early evening. With the Moon so bright, you may find it more comfortable using a filter.

**Uranus**, in Taurus, rises in the late eastern evening sky. On the 2nd, the planet begins five months in retrogression, appearing to travel westward against the stars (see Retrograde Motion p. 94).

**Neptune**, the only planet not visible to the unaided eye from Earth, comes to opposition on the 21st, rising in the east during astronomical twilight. At 7.8 magnitude and 2.3 arcseconds in diameter, the planet requires at least a 100 mm telescope, 200× magnification, and good seeing to resolve its small featureless bluish disc.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the evening of the 30th, Psyche has a very close approach to 5th magnitude star, Upsilon Capricorni. Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 3 Sep | 194 Prokne | Aquarius | 9.4 |
| 4 Sep | 32 Pomona | Aquarius | 11.3 |
| 9 Sep | 94 Aurora | Aquarius | 11.8 |
| 18 Sep | 45 Eugenia | Aquarius | 11.4 |
| 23 Sep | 196 Philomela | Cetus | 11.0 |
| 25 Sep | 17 Thetis | Cetus | 10.9 |
| 30 Sep | 20 Massalia | Pisces | 9.3 |

## COMETS

**Comet 154P/Brewington** spends the month rising in the north-eastern sky shortly before dawn. It begins in Auriga about magnitude 12, moves into Lynx on the 5th and ends the month having faded to magnitude 13.

**Comet 13P/Olbers** (All Sky Map 7) is setting in the north-western sky just after twilight. It begins in Coma Berenices, moves to Boötes on the 7th then into Virgo on the 25th. The comet starts the month at magnitude 9 and ends having faded to 11.

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 4) begins the month in Sextans at about magnitude 7, rising in the eastern sky shortly before sunrise and setting in the western sky shortly after sunset. On the 29th it moves into Leo and by month's end. It may have brightened to magnitude 4 and will be rising in the eastern sky just before dawn.

## CONSTELLATIONS

In August Constellations the Summer Triangle was mentioned. As evening twilight closes, this asterism is at its maximum altitude, sitting on the northern horizon. Its lower left star is Vega. As well as being the 5th brightest (magnitude 0.0) star, Vega has the distinction of being the closest bright star to the solar apex (9° to the south, above). This is the position in the sky the Sun is currently heading towards as it continues its 230-million-year orbit of the Milky Way galaxy. Vega has not always been visible from the Southern Hemisphere. Thanks to precession, around 12,000 BCE it was the North Celestial Pole star, as it will be again in 14,500 CE (Polaris will need a new name?).

Vega is the alpha star to Lyra. Under dark skies (or through binoculars) a distinctive narrow parallelogram made of four 3rd and 4th magnitude stars sits above Vega, with all five stars fitting in a 7° circle. This is the harp of Lyra.

Here are a couple of objects in Lyra well worth observing. Epsilon (ε) Lyrae, the famous double-double star, although low in the north, is worth pursuing under favourable seeing. Located 1.7° north-east (right) of Vega, Epsilon is visible through binoculars as two white stars, magnitude 5.0 $\varepsilon^1$ and 5.2 $\varepsilon^2$, separated by 3.5 arcminutes. Small telescopes reveal $\varepsilon^1$ has magnitude 5.2 and 6.1 components, 2.4 arcseconds apart. As a bonus $\varepsilon^2$ is double as well with magnitude 5.2 and 5.4 stars separated by 2.3 arcseconds.

The other highlight is M57 or NGC 6720, the Ring Nebula, a spectacular 8.8 magnitude planetary nebula. Located conveniently between the stars Sheliak and Sulafat (the two top stars of the parallelogram), a 150 mm telescope shows an oval-shaped white smoke-like ring (1.1' × 1.4') with a dark centre. Under very dark skies, larger instruments show a haze across this central region.

Looking at Lyra's boundaries (Map 9), you might think it was one of the smallest constellations. In fact, Lyra is only the 37th smallest by area (0.7%). Nevertheless, from our Southern Hemisphere's perspective the six smallest constellations are visible in the early evening sky this month. Three are clustered low in the south-west (Map 1). Heading the list, taking up only 0.17% of the sky, is spectacular Crux (Southern Cross). The fourth smallest is Circinus and then adjacent Triangulum Australe (6th smallest). Look in the north above Sagittarius' Teapot to faint Scutum (5th). Then cast your vision lower (below Altair) to Sagitta (3rd), which is soon followed by obscure, 'Little Horse' Equuleus (2nd)—Map 3.

## Prospects for Comet Tsuchinshan-ATLAS by Greg Bryant

Skywatchers in Australia have not seen a notably bright comet in more than a decade. We had Comet C/2021 A1 (Leonard) at around 3rd magnitude in December 2021, and 46P/Wirtanen at 4th magnitude three years prior. To surpass that, we have to go back to 2011 when the Kreutz sungrazer comet C/2011 W3 (Lovejoy) reached magnitude –1 as spotted in difficult circumstances by a handful of ground-based observers in strong twilight, though most observers saw it some days later when it had faded by several magnitudes. However, a recent discovery, which has seen plenty of hype, may present a nice comet show in October 2024. Just how bright remains to be seen.

On 22 February 2023, images taken with the 0.5-metre ATLAS telescope in South Africa (one of four telescopes across Hawaii, Chile and South Africa that comprise the Asteroid Terrestrial-impact Last Alert System) revealed an 18th magnitude comet in the constellation Serpens. As further positions came in, it was linked to an apparent asteroid discovered a month earlier at the Purple Mountain Observatory (Tsuchinshan in Mandarin) in China, but subsequently lost. By the beginning of March, it was realised that the comet, now designated C/2023 A3 (Tsuchinshan-ATLAS), had been discovered at a distance of more than 7 au from the Sun and would reach perihelion nearly 19 months later on 27 September 2024, less than 0.4 au from the Sun. It's likely that this comet is a first-time visitor from the Oort Cloud, an important consideration in predicting its future brightness.

**Surviving Perihelion**

With a perihelion distance of 0.4 au, will it survive this passage so close to the Sun? Many comets have dissipated or crumbled as they succumbed to the intense heat of a close approach to the Sun. In 1991, the American amateur astronomer John Bortle addressed this topic in the International Comet Quarterly journal. Bortle, more popularly known these days for introducing the Bortle Class which helps observers to quantify their observing conditions, looked at comets over the period 1800–1989 that came within 0.5 au of the Sun and whether they survived or not. The vast majority of them were long-period in nature. He derived an empirical formula linking the comet's absolute magnitude (its intrinsic brightness) and perihelion distance which was a useful indicator as to whether a newly discovered comet would survive its closest approach to the Sun.

While many comet observers quote Bortle's formula in gauging the survival prospects of a new discovery, less well-known is a more recent study. In 2019, Zdenek Sekanina (Jet Propulsion Laboratory) revisited the survival problem of comets near the Sun. Using high-quality orbital elements for comets over the period 2001–2017, Sekanina was able to distinguish between dynamically new Oort Cloud comets and other long-period comets (which Bortle was unable to do due to the limited orbital data of past centuries), and found that around half of all Oort Cloud comets coming within 1 au of the Sun succumbed to the solar intensity and crumbled. Reducing the perihelion passage to less than 0.6 au saw the casualty rate rise to 70%. In contrast, nearly all of the non-Oort Cloud long-period comets survived close passages to the Sun.

Sekanina nevertheless found that there was a correlation between absolute magnitude and survivability, though the relationship is a little more complex and incorporates the relative dustiness of a comet, but it gives hope (though no guarantee) that Tsuchinshan-ATLAS—which is intrinsically brighter than the average Oort Cloud comet—will survive its September 2024 perihelion passage.

The accompanying ephemeris (p. 135) and monthly text in this book assume a conservative peak brightness of 3rd magnitude. Other optimistic observers have suggested that the comet may brighten at a quicker rate and reach 1st magnitude or better. However, new comets from the Oort Cloud, as Tsuchinshan-ATLAS appears to be, have been shown to typically brighten at a slower rate than other long-period comets as observed over the full length of their inward journey. They may initially brighten at a quick rate, as their icy surface is exposed to the solar intensity for the first time, but as the comet enters the inner Solar System, its underlying nature is revealed.

As noted in previous pages, Tsuchinshan-ATLAS should be observable until the second half of August, when it then becomes lost in the glare of evening twilight. A brief morning window then appears in the second half of September for us in the Southern Hemisphere, though observers trying to catch the comet, potentially at 4th magnitude, will be battling

| DIARY | | | |
|---|---|---|---|
| Sun | 1st | | Comet 13P/Olbers 1.0° N of NGC 5053 (GC) in Coma Berenices |
| Tue | 3rd | Noon | (10 am WST) New Moon. |
| Thu | 5th | | Mercury at greatest elongation West (18.1°) |
| Thu | 5th | 7 pm | (5 pm WST) Venus 1.5° E of Moon |
| Fri | 6th | | Mars 0.2° NW of NGC 2129 (OC) in Gemini |
| Fri | 6th | 1 am | (11 pm WST, prev day) Moon at apogee (furthest from Earth at 406,211 km). |
| Sun | 8th | | Saturn at opposition |
| Sun | 8th | 7 pm | (5 pm WST) m.p. 3 Juno 4° N of Venus |
| Sun | 8th | pm | m.p. 42 Isis 1.0° S of NGC 6624 (GC) in Sagittarius |
| Mon | 9th | | Mars 0.7° SE of NGC 2158 (OC) in Gemini |
| Mon | 9th | | Mars 0.8° S of M35 (OC) in Gemini |
| Mon | 9th | 5 pm | (3 pm WST) star Regulus 0.5° S of Mercury |
| Wed | 11th | | Mars 1.0° NW of star Eta Geminorum |
| Wed | 11th | | m.p. 532 Herculina 0.3° NE of NGC 5812 (G) in Libra |
| Wed | 11th | 4 pm | (2 pm WST) First Quarter Moon. |
| Thu | 12th | 10 pm | (8 pm WST) Maximum Libration (10.1°), dark NW limb. |
| Fri | 13th | | Mars 0.3° SE of Collinder 89 (OC) in Gemini |
| Sat | 14th | pm | m.p. 42 Isis 1.0° N of M69 (GC) in Sagittarius |
| Sun | 15th | | Mars 1.0° N of star Mu Geminorum |
| Tue | 17th | 7 pm | (5 pm WST) Saturn 0.5° S of Moon (Occultation) |
| Tue | 17th | 7 pm | (5 pm WST) star Spica 3° S of Venus |
| Wed | 18th | 1 pm | (11 am WST) Full Moon (357,485 km), supermoon and partial lunar eclipse, Americas, Europe, Africa. |
| Wed | 18th | 7 pm | (5 pm WST) Neptune 2° SW of Moon |
| Wed | 18th | 11 pm | (9 pm WST) Moon at perigee (closest to Earth at 357,286 km). |
| Fri | 20th | | Neptune at opposition |
| Sat | 21st | | m.p. 532 Herculina 0.2° N of star Beta Librae |
| Sat | 21st | | m.p. 15 Eunomia 0.4° S of NGC 1907 (OC) in Auriga |
| Sun | 22nd | | m.p. 15 Eunomia 0.8° S of M38 (OC) in Auriga |
| Sun | 22nd | | Equinox |
| Sun | 22nd | pm | m.p. 42 Isis 1.0° N of M70 (GC) in Sagittarius |
| Mon | 23rd | | Saturn 0.5° SE of star h Aquarii |
| Tue | 24th | | Jupiter 0.3° N of star n Tauri |
| Tue | 24th | 4 am | (2 am WST) Jupiter 7° SE of Moon |
| Wed | 25th | 5 am | (3 am WST) Last Quarter Moon. |
| Wed | 25th | 11 am | (9 am WST) Maximum Libration (10.3°), dark SE limb. |
| Thu | 26th | 3 am | (1 am WST) Mars 6° SW of Moon |
| Sat | 28th | | m.p. 15 Eunomia 1.0° N of M36 (OC) in Auriga |
| Sun | 29th | pm | m.p. 42 Isis 0.5° S of M54 (GC) in Sagittarius |
| Mon | 30th | | Comet 13P/Olbers 0.5° W of NGC 5701 (G) in Virgo |
| Mon | 30th | 11 pm | (9 pm WST) m.p. 16 Psyche 0.02° N of star Upsilon Capricorni |

the onset of morning twilight. This period coincides with Tsuchinshan-ATLAS's perihelion passage on 27 September when the comet will be less than 0.4 au from the Sun and about 0.9 au from Earth. That perihelion distance is inside Venus' orbit and just barely outside that of Mercury's. After this, the comet rapidly sinks back towards the solar glare.

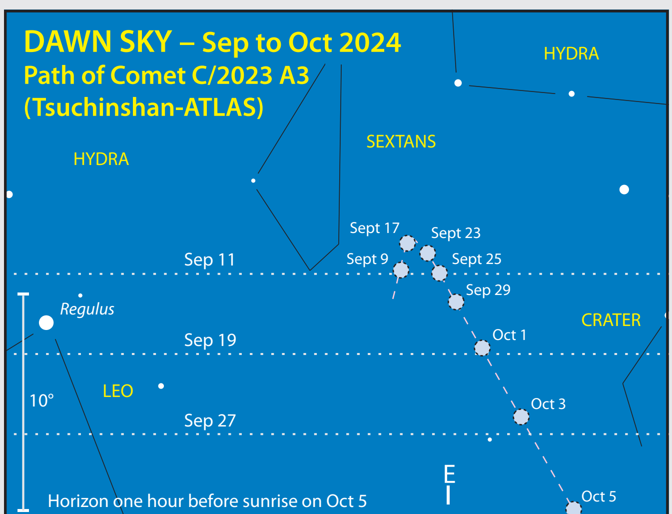
**A Fortuitous Alignment**

During the first two weeks of October, the comet is nearly in line between us and the Sun, presenting the opportunity of forward-scattering of the comet's light by its dust to temporarily enhance the brightness of Tsuchinshan-ATLAS. Just how dusty the comet will be remains to be seen, and this impacts the broad predictions here. They're based on the forward scattering that was observed with comet McNaught in 2007. Similar predictions were made for comet Leonard in 2021, but the comet didn't appear to be as dusty and so fell short. Nevertheless, there could potentially be an increase in brightness for Tsuchinshan-ATLAS from one to four magnitudes during this short two-week window, with the peak occurring around 9 October.

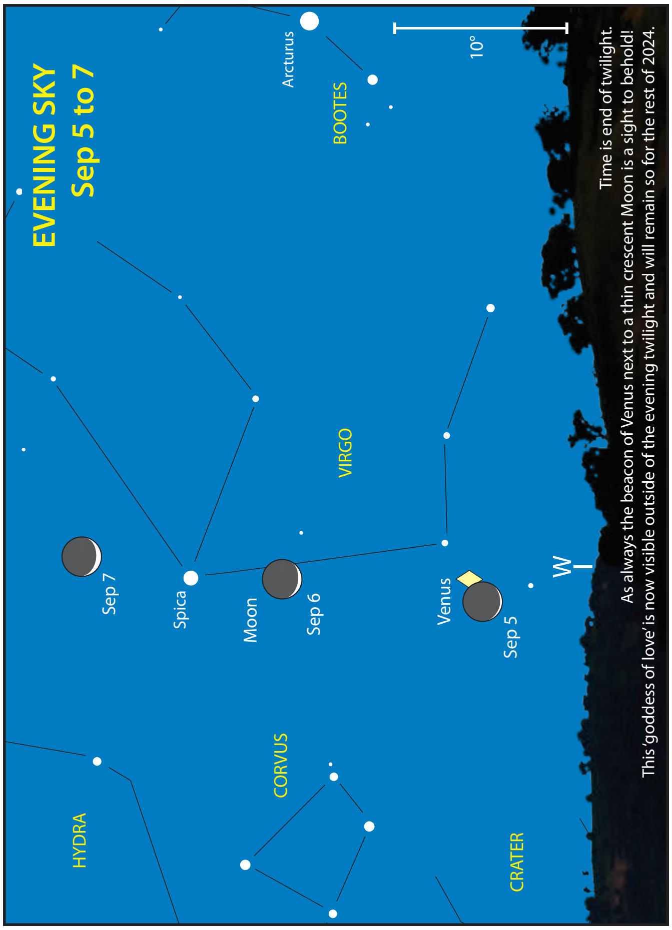
Following Tsuchinshan-ATLAS's conjunction with the Sun on 9 October, closest approach to Earth is three days later on 12 October (0.473 au) as it begins to slowly emerge into the evening twilight sky. Bright twilight will make observing the comet very difficult, but by 15 October, when the comet is predicted to be 4th magnitude (and any residual forward scattering may see it still at 3rd magnitude) the comet will be nearly 10° high at the beginning of nautical twilight (for mid-Australian latitudes) and setting around 7:15 pm Eastern Standard Time. The second half of October sees Tsuchinshan-ATLAS climbing higher. However, the comet will be fading, and moonlight will also interfere with observing until 18 October. By month's end, when the comet is perhaps bordering on unaided eye visibility, the comet will only be 15° above the horizon at the end of astronomical twilight and setting around 9 pm Eastern Standard Time.

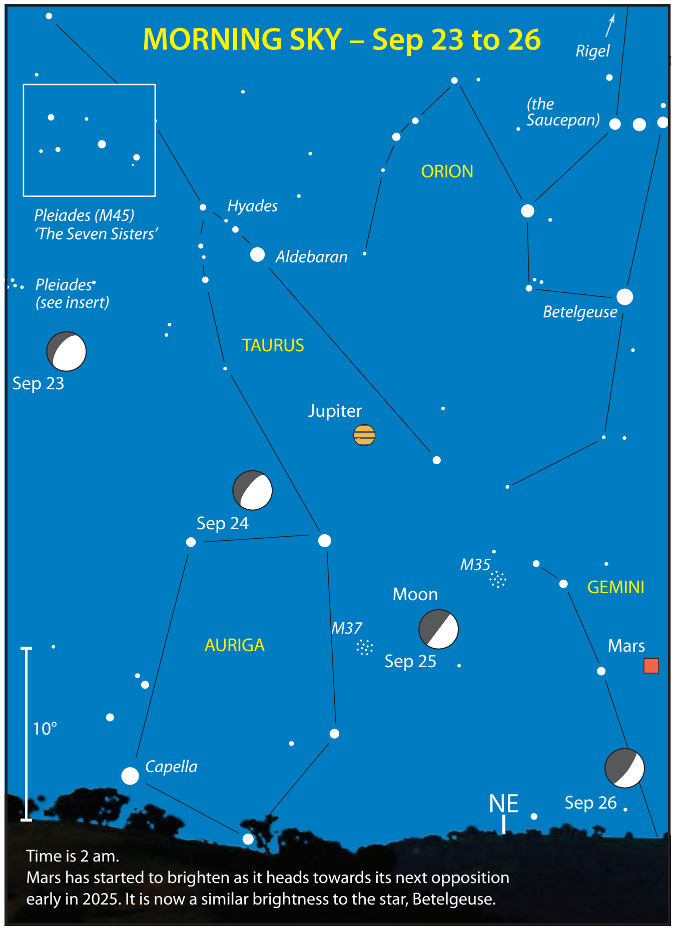
Working against the possible brightness enhancement from forward scattering in mid-October is the effect on an object's brightness low in the sky. The lower an object is, the more air mass its light has to pass through before it reaches our eyes, and that reduces the apparent brightness. A comet that is 10° above the horizon will typically appear more than one magnitude fainter than if it was at the zenith. By the time the comet has dropped to 5° above the horizon, the change in brightness compared to the zenith is nearly three magnitudes. The presence of a background twilight sky further lessens the appearance.

Comets predicted to be visible to the unaided eye in the evening sky are a rarity, and many of history's finest comets have been apparitions seen low on the horizon in twilight skies. No matter how comet Tsuchinshan-ATLAS's show pans out, it will be worthwhile following its progress to see how the story unfolds.

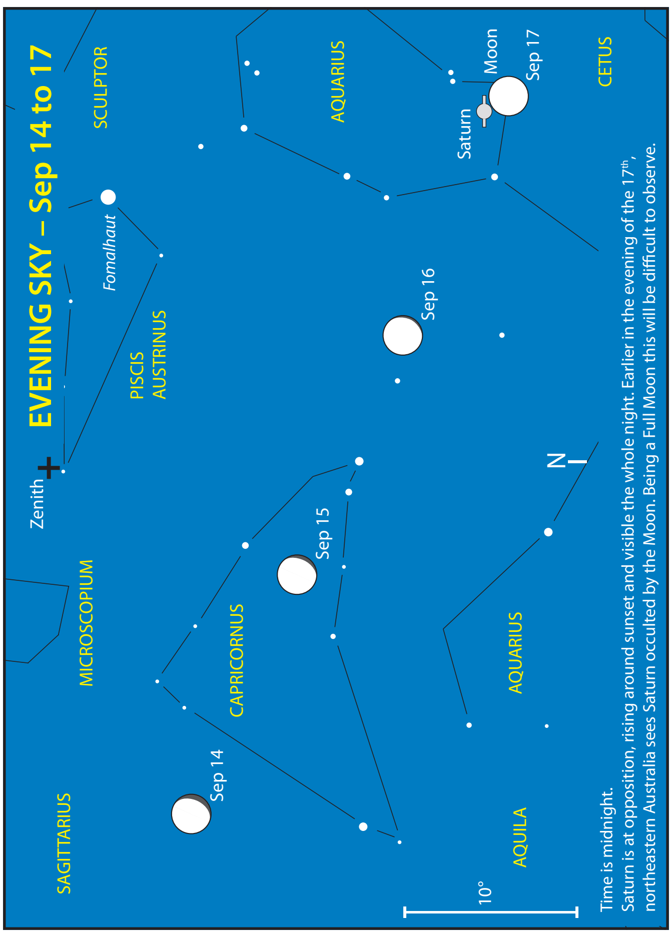



Path of Comet C/2023 A3 in the Sep/Oct dawn sky. Although a quite barren sky, Regulus would be a good starting point to find the comet. Binoculars may assist greatly. Note, the dashed Horizontal lines are the horizon on the relevant date for approximately one hour before sunrise.




Approximate local standard time.




## Saturn's Satellites for September

Below are a few interesting patterns of the brightest moons, see also the Introduction to Part I and Satellites of Saturn (Part II) where you can work out the configuration at any time.

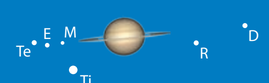
N E 1 arc min.

**Sep 2, 11:00 pm EST ( 9:00 pm WST)**

Five of the moons are well-spaced, being close to maximum eastern elongations. This is the best time to go after inner Mimas, when it is away from the glare of the rings.


**Sep 18, 1:00 am EST ( 11:00 pm 17th WST)**

An attractive gathering of four moons on the eastern side. Titan is approaching an inferior conjunction.

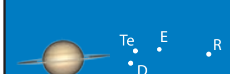



**Sep 18, 10:00 pm EST ( 8:00 pm WST)**

This diagram is dated only 21 hours after the previous one (above) to show how quickly the inner moons move. For example, Mimas has completed a full orbit with Enceladus, Tethys and Dione now on the opposite side of Saturn.


**Sep 22, 11:00 pm EST ( 9:00 pm WST)**

The distant moon, Iapetus, is making a rare appearance close to Saturn as it approaches conjunction. Its brightness should be slightly fainter than Tethys.



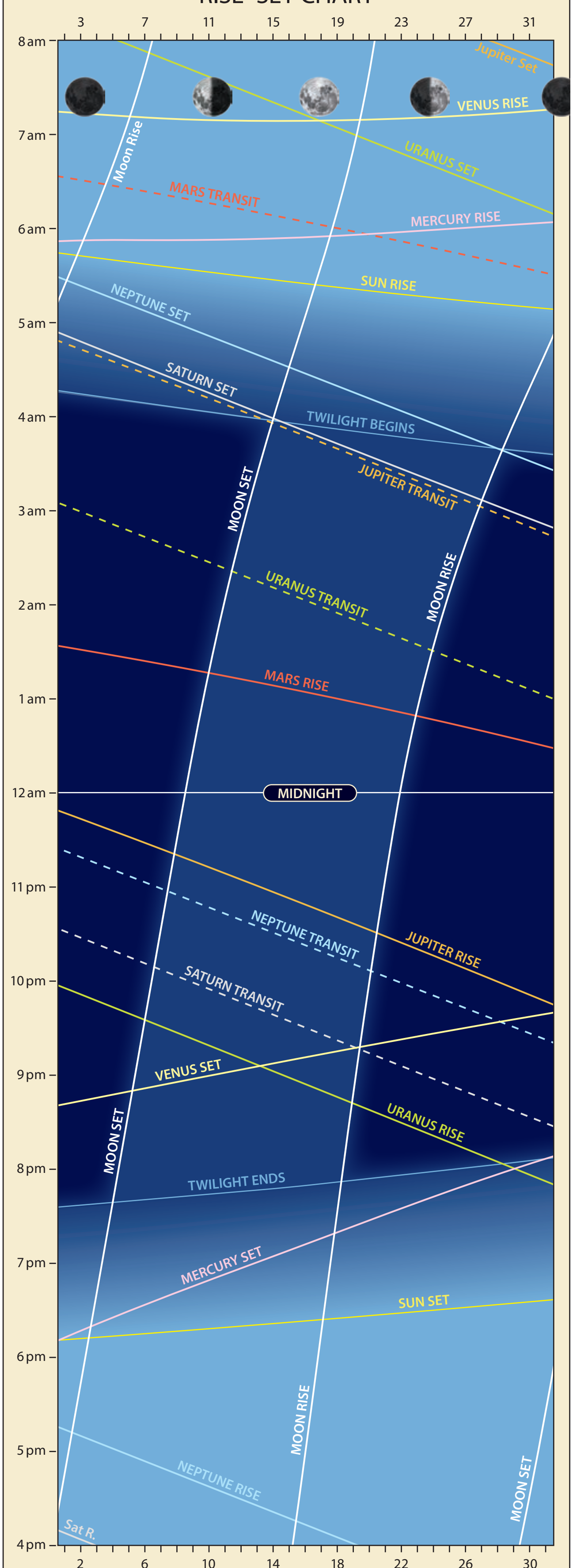

Titan is just past a maximum western elongation and close to its greatest angular distance from Saturn.

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

**Sep 26, 11:00 pm EST ( 9:00 pm WST)**


Interesting configuration with four moons clustered on the western side.

# OCTOBER 2024

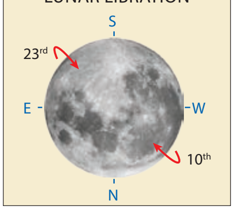


Approximate local standard time, for daylight saving add 1 hour.

## HIGHLIGHTS

- Saturn and Moon close.
- Mars, the Moon, Castor and Pollux together.
- Venus visits the bright star, Antares.
- Comet 2023 A3 (Tsuchinshan-ATLAS) in evening sky

## THE MOON




3rd 5 am (3 am WST) New Moon, annual solar eclipse, Pacific, southern parts of South America, parts of Mexico.

3rd 6 am (4 am WST) Moon at apogee (furthest from Earth at 406,516 km).

10th 5 pm (3 pm WST) Maximum Libration (10.0°), dark NW limb.

11th 5 am (3 am WST) First Quarter.

17th 11 am (9 am WST) Moon at perigee (closest to Earth at 357,175 km).

17th 9 pm (7 pm WST) Full Moon, supermoon.*

23rd 7 am (5 am WST) Maximum Libration (10.4°), dark SE limb.

24th 6 pm (4 pm WST) Last Quarter.

30th 9 am (7 am WST) Moon at apogee (furthest from Earth at 406,161 km).

*Note: The term supermoon is just a nickname for what astronomers call a Perigean Full Moon—a Moon that is full and near its closest point (perigee) in its orbit around Earth.

## APPEARANCE of the PLANETS

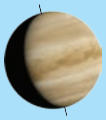
**MERCURY** Mercury in superior conjunction on the 1st

10 Oct
dia 4.7"
mag –1.0

20 Oct
dia 4.9"
mag –0.5

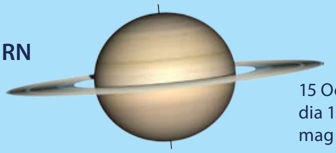
30 Oct
dia 5.2"
mag –0.3

**VENUS**
15 Oct
dia 13.0"
mag –3.9



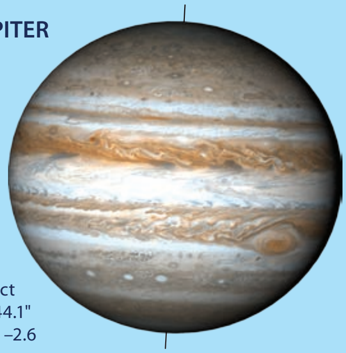
**MARS**
15 Oct
dia 8.2"
mag 0.3

**SATURN**



15 Oct
dia 18.8"
mag 0.7

**JUPITER**



15 Oct
dia 44.1"
mag –2.6

**URANUS**
15 Oct
dia 3.8"
mag 5.6

**NEPTUNE**
15 Oct
dia 2.4"
mag 7.8

OCTOBER

## THE PLANETS

**Mercury** returns to the western evening twilight after its superior conjunction at the end of last month. It does a slow climb away from the Sun and becomes visible in the second half of the month.

Brilliant **Venus** begins the month in the early western evening sky. On the 5th and 6th, the slender waxing crescent Moon shares the constellation of Libra with the planet; whilst not overly close, it's always a pleasant sight when the pair are near each other (see Sky View). On the 26th and 27th, Venus will be within 3° of Antares. This alpha star of Scorpius is a slow, irregular variable ranging from 0.6 to 1.6 magnitude. There is a 5.5 magnitude companion star, only 2.5 arcseconds away, that is often described as green in colour. This is probably a contrast effect due to the glare of Antares, and the secondary star can be difficult to see in smaller telescopes.

**Mars,** in Gemini, rises around 1 am in the eastern morning sky. The Red Planet is at its western quadrature on the 14th, where the Sun-Earth-Mars angle is 90° (see Orbital Aspects diagram p. 10). At this time, Mars displays its minimum phase with 88% of the planet's surface illuminated by the Sun when viewed from Earth. Even a small telescope will show the disc to be distinctly gibbous in shape—just like the Moon three or four days before or after Full Moon. However, with opposition in January next year, the planet is gradually brightening. These close approaches occur about every 26 months. Unfortunately, the coming three (2025, 27 and 29) are all aphelic oppositions (Mars furthest from the Sun), with its disc size reaching 14.6 arcseconds at best. On the 24th, the Red Planet will be 5° from the 22-day-old waning gibbous Moon with the Gemini Twins, Castor and Pollux close by (see Sky View).

**Jupiter**, in Taurus, rises in the north-eastern evening sky around 11 pm mid-month. On the 9th, the planet begins its retrograde path and will appear to be moving east-to-west against the starfield for the next four months (see Retrograde Motion p. 94). On the 21st and 22nd the waning gibbous Moon is not far of the Jovian planet (see Sky View).

**Saturn**, just past opposition, can be seen to good advantage as it transits the meridian around 9:30 pm mid-month. From now until the end of the year, the planet's ring system will be tilted about 5° to the plane of the Earth's orbit. This month try looking for the shadow of the planet cutting across the back of the rings (this cannot be seen near opposition as the shadow is directly behind the planet). This shadow and limb darkening give a natural 3-D effect in the eyepiece. On the 14th, as astronomical twilight begins, the 11-day-old waxing gibbous Moon will be around 5° from the planet (see Sky View). As the night progresses, the gap between the pair decreases to about 1.5° by sunrise on the 15th.

**Uranus**, in Taurus, rises in the eastern evening sky around 9 pm mid-month. This outer ice giant will be at opposition next month.

**Neptune,** now past last month's opposition, transits the meridian (is due north) around 10:30 pm mid-month in Pisces.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 8 Oct | 39 Laetitia | Cetus | 9.3 |
| 13 Oct | 87 Sylvia | Cetus | 11.6 |
| 13 Oct | 107 Camilla | Cetus | 12.1 |
| 18 Oct | 19 Fortuna | Pisces | 9.2 |
| 22 Oct | 10 Hygiea | Pisces | 10.4 |

## COMETS

**Comet 13P/Olbers** is setting in the north-western early evening sky. It begins in Virgo, moves into Serpens on the 16th then into Libra on the 27th. The comet starts the month at magnitude 11 and ends having faded to 12. Early October

| DIARY | | | |
|---|---|---|---|
| Tue | 1st | | Mercury in superior conjunction |
| Thu | 3rd | 5 am | (3 am WST) New Moon, annual solar eclipse, Pacific, s S. America [Annular: s Chile, s Argentina]. |
| Thu | 3rd | 6 am | (4 am WST) Moon at apogee (furthest from Earth at 406,516 km). |
| Sat | 5th | | Venus 0.9° SW of star Alpha Librae |
| Sat | 5th | 8 pm | (6 pm WST) Venus 5° E of Moon |
| Sun | 6th | | Comet 13P/Olbers 0.8° SW of NGC 5775 (G) in Virgo |
| Mon | 7th | pm | d.p. 1 Ceres 0.2° N of M54 (GC) in Sagittarius |
| Wed | 9th | | Mars 0.9° N of star Delta Geminorum |
| Thu | 10th | | Comet 13P/Olbers 0.3° SW of NGC 5813 (G) in Virgo |
| Thu | 10th | am | Southern Taurids meteor shower, Sep 10 to Nov 20, Moon affected before 2 am. |
| Thu | 10th | 5 pm | (3 pm WST) Maximum Libration (10.0°), dark NW limb. |
| Fri | 11th | | Comet 13P/Olbers 0.4° W of NGC 5846 (G) in Virgo |
| Fri | 11th | 5 am | (3 am WST) First Quarter Moon. |
| Tue | 15th | 3 am | (1 am WST) Saturn 1.5° E of Moon |
| Tue | 15th | pm | d.p. 1 Ceres 0.2° S of star Zeta Sagittarii |
| Wed | 16th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 2.0° SE of M5 (GC) in Serpens |
| Wed | 16th | 3 am | (1 am WST) Neptune 1.5° SE of Moon |
| Thu | 17th | | m.p. 3 Juno in conjunction with Sun |
| Thu | 17th | 11 am | (9 am WST) Moon at perigee (closest to Earth at 357,175 km). |
| Thu | 17th | 9 pm | (7 pm WST) Full Moon (357,367 km), supermoon. |
| Sat | 19th | 11 pm | (9 pm WST) Uranus 5° S of Moon |
| Sun | 20th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.5° N of star Lambda Ophiuchi |
| Mon | 21st | Midn | (10 pm WST) Jupiter 8° SW of Moon |
| Mon | 21st | pm | Orionids meteor shower, Oct 2 to Nov 7, Moon affected. |
| Tue | 22nd | 3 am | (1 am WST) star Pollux 6° N of Mars |
| Tue | 22nd | pm | m.p. 19 Fortuna 0.4° S of NGC 524 (G) in Pisces |
| Wed | 23rd | | Venus 0.3° N of M80 (GC) in Scorpius |
| Wed | 23rd | 7 am | (5 am WST) Maximum Libration (10.4°), dark SE limb. |
| Thu | 24th | 3 am | (1 am WST) Mars 5° S of Moon |
| Thu | 24th | 6 pm | (4 pm WST) Last Quarter Moon. |
| Fri | 25th | | Jupiter 0.3° N of star n Tauri |
| Fri | 25th | 8 pm | (6 pm WST) star Antares 3° S of Venus |
| Mon | 28th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 1.0° SW of star Beta Ophiuchi |
| Tue | 29th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.7° NE of NGC 6426 (GC) in Ophiuchus |
| Wed | 30th | 9 am | (7 am WST) Moon at apogee (furthest from Earth at 406,161 km). |
| Thu | 31st | | m.p. 14 Irene 0.4° N of star Delta Geminorum |

sees 13P/Olbers continuing its extragalactic journey, this time visiting some galaxies in Virgo (see Diary).

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Maps 4 and 6) begins the month in Leo at about magnitude 3, rising in the eastern sky just before dawn. It moves into Virgo on the 5th, into Serpens on the 16th and into Ophiuchus on the 20th. By the 10th it is setting in the western sky, shortly after sunset. At month's end it has faded to magnitude 7 and sets about an hour after twilight. Low in the evening twilight sky on the 16th, the comet is only 2° from the globular cluster M5 in Serpens—a good imaging opportunity? See diagram below.

## METEOR SHOWERS

The **Southern Taurids** are active from September 20 through to November 20. The shower comprises two radiants of nearly equal activity ten degrees apart. They should peak on November 5, with about five meteors per hour. The Taurids are frequently bright, slow-moving, and noted for occasionally producing colourful fireballs. They are associated with Comet 2P/Encke and are visible from late evening to early morning. During the shower's peak, the First Quarter Moon will cause some interference, but after Moon set around 1 am, observers can enjoy a few Moon free hours before dawn.

The **Orionids** are best seen from late evening until dawn and are visible from October 2 to November 7. Maximum activity is expected from the late evening of the 21st to the morning dawn. Over the past twenty years, the Orionids have produced around 20 meteors per hour. With many sub-maxima, reasonable rates can occur several nights around the peak. The Orionids are typically very swift and often bright, with some leaving trains. Chinese observers recorded this shower in 288 CE, associated with Halley's Comet. The Last Quarter Moon on the 24th will cause significant problems during the morning hours this year.

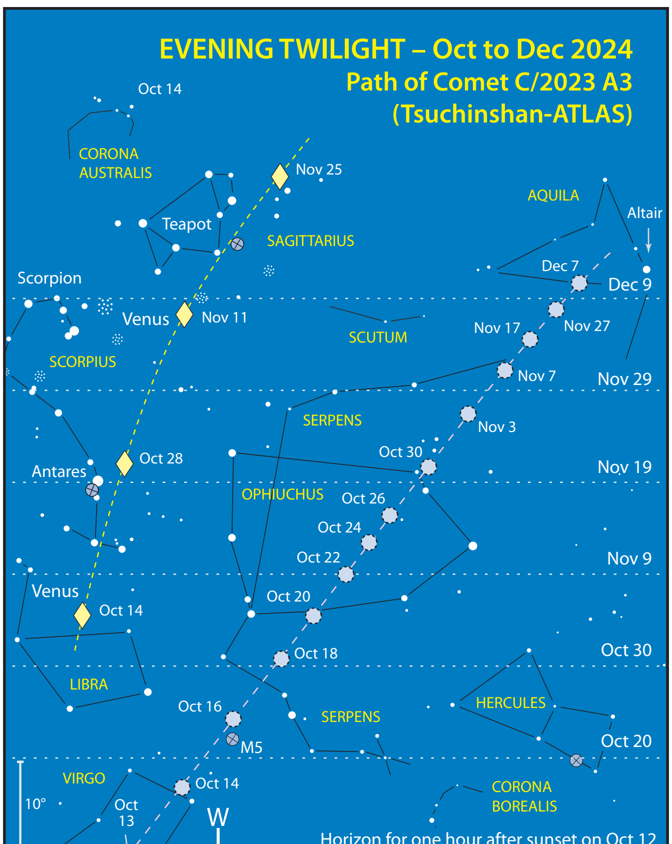
## CONSTELLATIONS

If you live under only light polluted skies, once the bright Milky Way constellations of Cygnus and Aquila have set, the sky low in the north can suddenly appear barren and certainly devoid of bright stars. For example, we are supposed to experience an equestrian treat with two constellations related to horses, but you wouldn't know it. You won't see the winged horse Pegasus gallop along the horizon, but its body is outlined by one of the few distinctive asterisms in the region, the four stars making the Great Square of Pegasus (Map 9). For us down under this equine is drawn standing upright. The Square's top left (south-west) star is Alpha Pegasi or Markab in Arabic meaning shoulder or saddle of the horse. Moving 20° west (left) is Epsilon or Enif meaning the nose. Further westward lies Equuleus or the Little Horse—an obscure, small constellation representing just the head, with its most 'distinguishing' feature being a lowly 4th magnitude alpha star called Kitalpha, a contraction of 'part of a horse'. If you have made it this far a little further west finds Delphinus, an impressive tight group of mostly 4th magnitude stars with four arranged in a diamond shape (3° long) with one above, totalling 6° in length—an ideal binocular object.

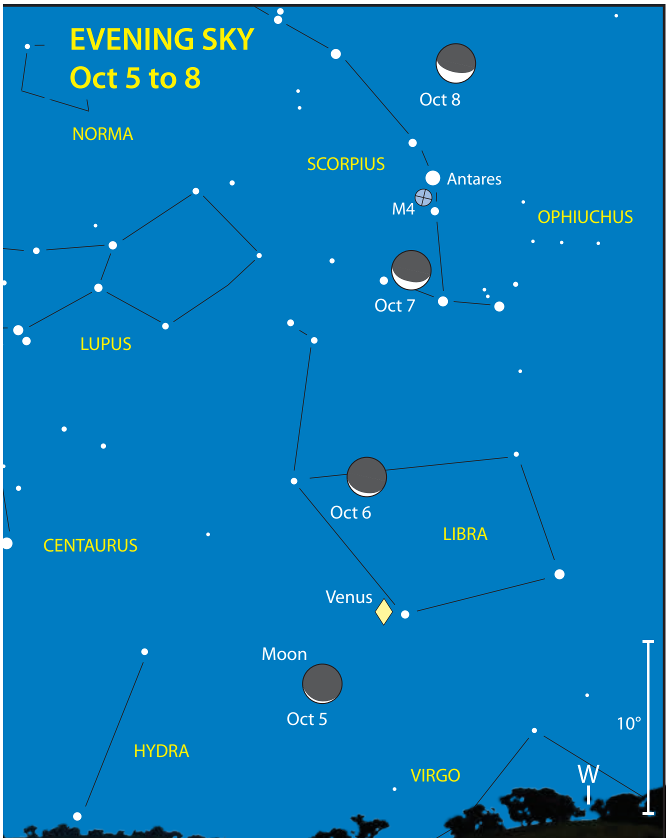
Returning to the Great Square, the number of stars you can see within the asterism can be used to estimate how dark your skies are. Ideally, it's best to try this when Pegasus is crossing the meridian (its maximum altitude) and even then, there will be some extinction due to its low altitude, so good seeing is preferred. Seeing the 'Square' easily gets to 3rd magnitude. Next up, netting the three brightest stars, upsilon (υ) plus tau (τ) (forming a wide double) and psi (ψ) gets you to 4.6 magnitude. Nabbing phi (φ) then gets you to 5.0 magnitude and if you can see all the stars marked in the Square (Map 9), you have reached magnitude 5.5.

Here are two, faint nearby constellations recognisable by their obvious, but equally faint, asterisms. Try finding them first with binoculars. Directly above the Great Square is the Circlet of Pisces. This group of six 4th to 5th magnitude stars, is arranged in a very non-fish like hexagonal shape, with magnitude 3.7 Gamma (γ) Piscium (left most star) the brightest member (Map 9).

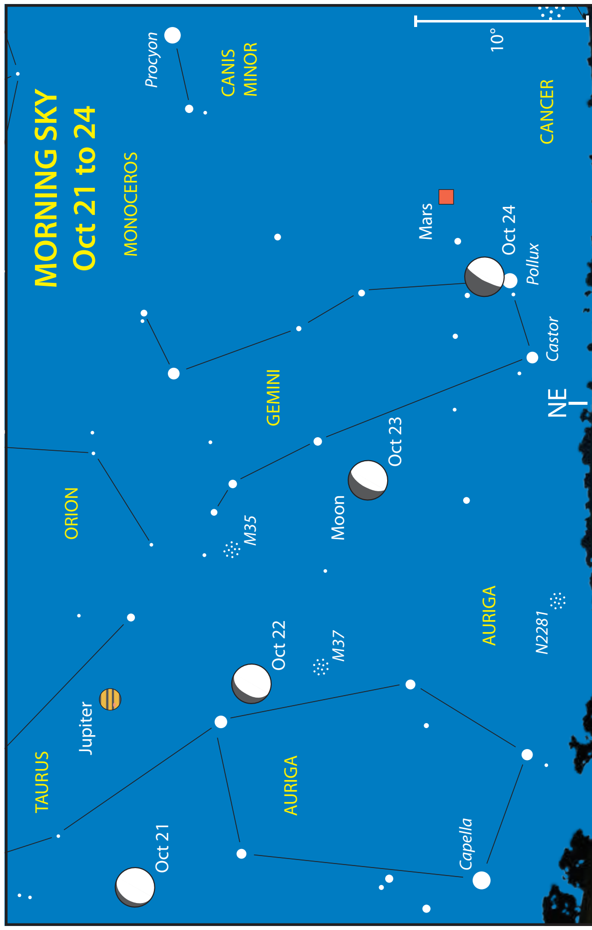
Low in the north-east is the large constellation of Cetus the Whale (Maps 2 and 3). Its most obvious feature, the Head of Cetus, is a group of six stars arranged in a pentagon shape. Its brightest member is Alpha Ceti (rightmost) at magnitude 2.5, then Gamma (centre top) at magnitude 3.4 with the rest ranging from 4.2 down to 4.8.



Path of Comet C/2023 A3 when near maximum brightness in the evening sky. Note, the dashed horizontal lines are the positions of the horizon on the relevant date for approx. one hour after sunset. Venus is also shown. The Moon has not been included to avoid crowding the diagram. See other sky views for its locations.

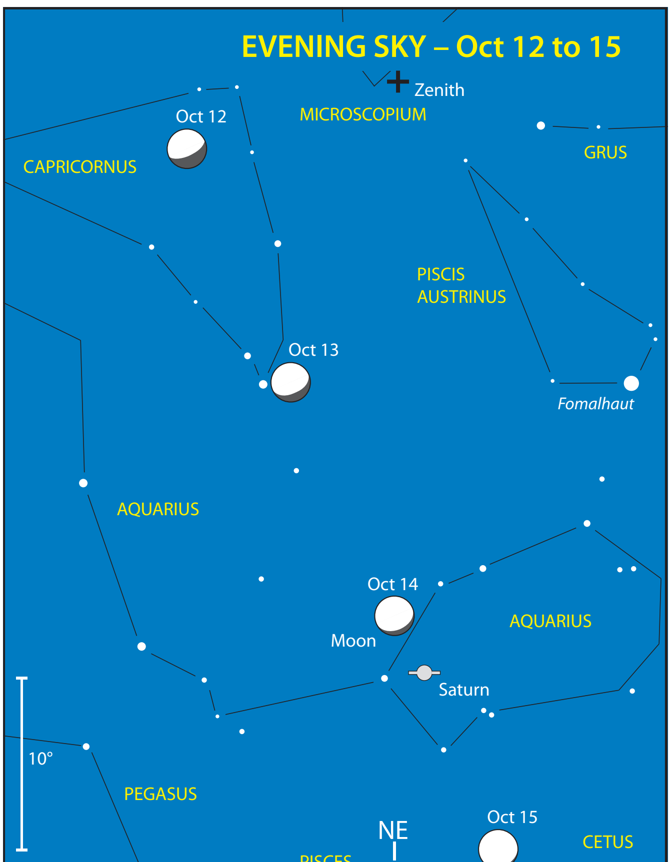



Time is end of twilight.
Venus always outshines the stars, including Antares. Scorpius, traditionally a winter constellation, is going out of season, dropping towards the western horizon.




Time is 1 am.
Jupiter has now entered the evening sky, as it heads towards its opposition in December. This gas giant is now rising around 11 pm mid-month. Mars continues its slow increase in brightness, now slighter brighter than the star, Procyon.

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




Time is end of twilight.
Having passed through opposition last month, Saturn still rides high in the evening sky.

## Saturn's Satellites for October

Below are a few interesting patterns of the brightest moons, see also the Introduction to Part I and Satellites of Saturn (Part II) where you can work out the configuration at any time.

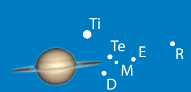
N
E
1 arc min.

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

**Oct 3, 11:00 pm EST ( 9:00 pm WST)**


A compact arrangement of the six brightest inner moons. Titan is also approaching an inferior conjunction.

**Oct 12, 1:00 am EST ( 11:00 pm 11th WST)**




The moons are clustered on the western side of Saturn. Titan is approaching a superior conjunction.

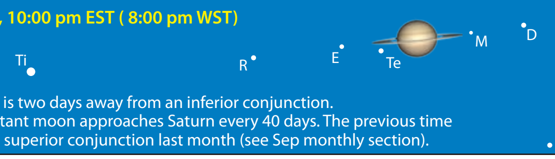
**Oct 20, midnight EST ( 10:00 pm WST)**


Mimas, at 13th magnitude, is easily the faintest of the moons covered here. Spending most of the time close to the bright rings makes it particularly difficult to see. Here it's near a maximum elongation and at the greatest distance from this glare.

**Oct 24, midnight EST ( 10:00 pm WST)**

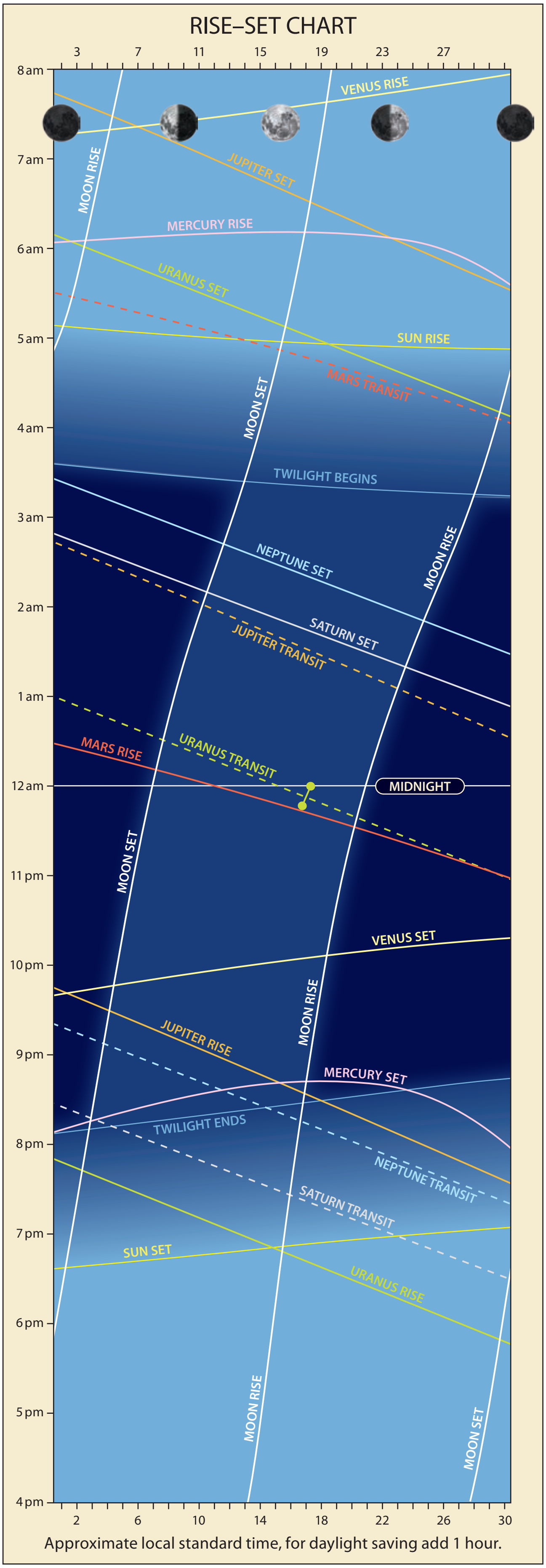

A rare sight with Dione, Enceladus, Tethys, Rhea and Titan close to their maximum elongations. Interestingly, Mimas, is currently transiting (passing in front of) Saturn.

**Oct 31, 10:00 pm EST ( 8:00 pm WST)**




Iapetus is two days away from an inferior conjunction. This distant moon approaches Saturn every 40 days. The previous time being a superior conjunction last month (see Sep monthly section).

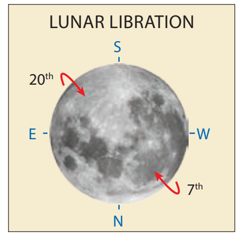
# NOVEMBER 2024




## HIGHLIGHTS

- Mercury and the Moon close.
- Mercury visits Antares

## THE MOON




1st  11 pm (9 pm WST) New Moon.

7th  4 am (2 am WST) Maximum Libration (9.2°), dark NW limb.

9th  4 pm (2 pm WST) First Quarter.

14th  9 pm (7 pm WST) Moon at perigee (closest to Earth at 360,109 km).

16th  7 am (5 am WST) Full Moon, supermoon.*

20th  3 am (1 am WST) Maximum Libration (9.7°), dark SE limb.

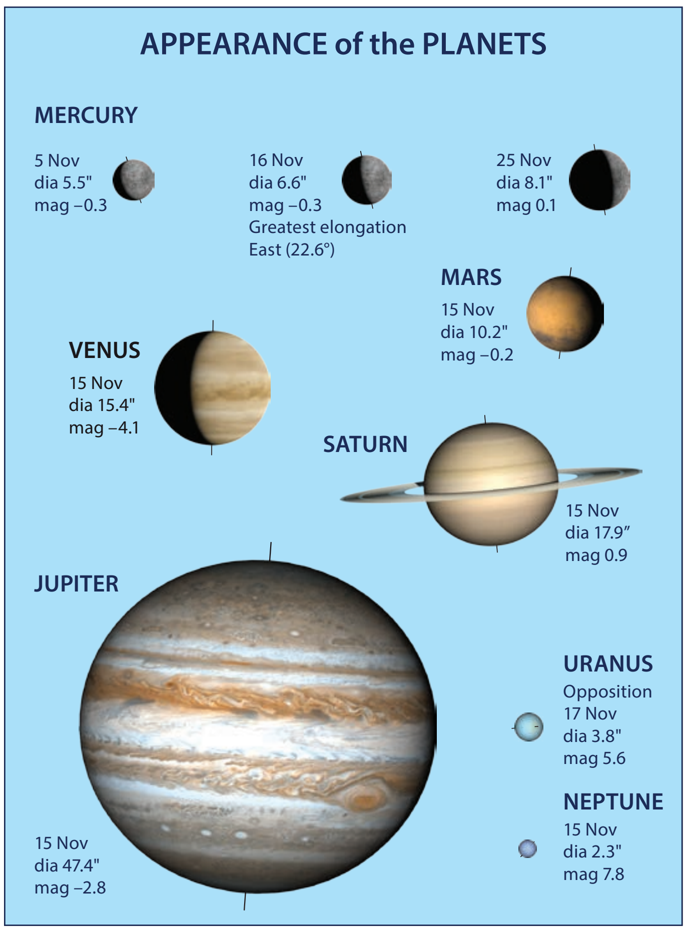
23rd  11 am (9 am WST) Last Quarter.

26th  10 pm (8 pm WST) Moon at apogee (furthest from Earth at 405,314 km).

*Note: The term supermoon is just a nickname for what astronomers call a Perigean Full Moon—a Moon that is full near its closest point (perigee) in its orbit around Earth.

## THE PLANETS

**Mercury** can be seen in the early western evening sky without interference from civil twilight until late this month. The planet reaches its greatest elongation 23° east of the Sun on the 16th. On the 3rd, Mercury will be just 2° from the slim crescent of the 2-day-old waxing crescent Moon (see Sky View). On the 10th, the planet will be 2° from Antares, the



# Choosing an Eyepiece – Part 1

by Don Whiteman

You have just bought or received a telescope, something you always really wanted. The first night you unpacked it, set it up and took it out to your backyard. Finder aligned, caps off, eyepieces in, point at the Moon. Welcome to the world of astronomy, that first view is something you will remember all of your life, look at the detail in the craters, crazy. I bet it would look better with more power.

This is a scenario I see everyday of my working life. People come in and want an eyepiece with more power. I always ask lots of questions, so I can make a well-judged suggestion. There are many things to take into consideration when buying an eyepiece that most people don't think of, not even seasoned astronomers. Most of those concern the person using the eyepiece, such as, your age, do you wear glasses. The human eye pupil when fully dark adapted is around 7 mm in diameter until about age 50+ when it starts to shrink. It can be measured by using a pupil gauge or your optometrist can measure it for you. If you wear glasses, you eye will be further away from the eyepiece, and this is important if you want to see the entire field of view on offer. Then I look at the equipment being used.

**Eyepieces: what does it all mean?**

With so many to choose from, how do you know what you're getting? This is where a little knowledge helps. Eyepieces have many differences based on design, focal length, apparent field of view, eye relief, eye lens size, field stop and filter threads. All these terms can become confusing, so let's have a look at what they all mean.

The first one I see is Magnification (more power), we all want it, but is it good for us? The magnification is determined by the focal length (F) of the telescope divided by the focal length of the eyepiece (Fe).

So, a telescope with 1000 mm focal length with a 20 mm eyepiece will give a 50× magnification.

In theory, the maximum magnification of a telescope system has been defined as about twice the aperture (in mm). In practical terms, the most *usable* magnification comes from multiplying the aperture (mm) x 1.4. For example, a 150 mm aperture telescope has a theoretical maximum magnification of 300× (150 × 2) but the practical limit is about 210× (150 × 1.4)

The next thing to look at is the apparent field of view (AF) that is how many degrees of sky you see if the eyepiece is held up to eye without the telescope. This will determine the area of sky you see through the eyepiece when put into a telescope which is called the real field (RF). It is calculated by dividing the apparent field (AF) by the magnification (M) that will be in degrees. If you multiply that by 60 it will be the size in arcminutes (').

Next comes exit pupil, (XP) which is the size of the light cone coming from the eyepiece to your eye, it's calculated by dividing the focal length of the eyepiece (Fe) by focal ratio (*f*/) of telescope. Just as light comes into the telescope, it also exits via the eyepiece into your eye. It is important that the XP is never larger than your pupil as this will cause shadows to appear in your image. This is why it helps to know your own pupil size.

Lastly, but by no means least, is eye relief. This is the distance that your eye is held from the eyepiece to see the entire field of view and is determined by design and substrate (glass type) used in the eyepiece. If you wear glasses the distance from your eye to the front of the glasses is generally between 17 and 20 mm and without glasses somewhere between 3 mm and upwards is acceptable, any less is a little uncomfortable. Normally, longer focal length eyepieces have longer eye relief because of design. Shorter focal lengths have less eye relief.

The mathematics behind all this can be seen here.

| | | | |
|---|---|---|---|
| F | | Focal Length | Focal length of telescope |
| D | | Aperture | Diameter of telescope |
| *f*/ | F / D | Focal Ratio | Focal length of telescope divided by aperture |
| Fe | | Focal Length | Focal length of eyepiece |
| M | F / Fe | Magnification | |
| AF | | Apparent Field | Of an eyepiece (area seen through eyepiece without telescope) is determined by the design of the eyepiece. |
| RF | AF / M | Real Field | Area of sky seen through eyepiece when used in telescope. |
| XP | Fe / *f*/ | Exit Pupil | Focal length of eyepiece divided by focal ratio of telescope |

**Sample cases**

These are the questions I normally ask someone trying to choose an eyepiece.

"What do you want to look at"?

"Which telescope do you have"?

"How old are you and do you wear glasses"?

This will give a firm idea as to what will work for you.

**Example 1**

For a start let's say our budding astronomer answers thus.

- planets
- 150 mm *f*/10 Schmidt Cassegrain telescope.
- 30 years old and wears glasses.

From these three answers we can determine what will work. Planets are small in astronomical terms, they are measured in arcseconds. Jupiter is 48.2 arcseconds at opposition in December this year.

The Schmidt Cassegrain has a focal length of 1500 mm and a focal ratio of *f*/10 and at 30 years your pupil dilation is around 7 mm and wearing glasses means you need an eyepiece with an eye relief around 20 mm so you can comfortably see the entire field of view.

So, for our budding astronomer, I would suggest, based on aperture of scope in mm multiplied by 1.4 we conclude that around 210 magnification could be maximum used on most nights.

I would suggest a 7 mm eyepiece with 55° AF. It has 20 mm of eye relief and produces 216 magnifications with a 15-arcminute real field of view (RF) with an exit pupil (XP)

| Eyepiece Type | Focal Length | Apparent Field | Eye Relief | Field Stop | Barrel Size | Weight | RF @ FL 2000 | RF @ FL 1500 | RF @ FL 1000 |
|---|---|---|---|---|---|---|---|---|---|
| DeLite | 18.2 mm | 62° | 20 mm | 19.1 mm | 1.25" | 215 g | 33.9' | 45.1' | 67.7' |
| DeLite | 15 mm | 62° | 20 mm | 16.0 mm | 1.25" | 213 g | 27.9' | 37.2' | 55.8' |
| DeLite | 13 mm | 62° | 20 mm | 13.8 mm | 1.25" | 221 g | 24.2' | 32.2' | 48.4' |
| DeLite | 11 mm | 62° | 20 mm | 11.7 mm | 1.25" | 213 g | 20.5' | 27.3' | 40.9' |
| DeLite | 9 mm | 62° | 20 mm | 9.6 mm | 1.25" | 213 g | 16.7' | 22.3' | 33.5' |
| DeLite | 7 mm | 62° | 20 mm | 7.5 mm | 1.25" | 207 g | 13.0' | 17.4' | 26.0' |
| DeLite | 5 mm | 62° | 20 mm | 5.3 mm | 1.25" | 213 g | 9.3' | 12.4' | 18.6' |
| DeLite | 4 mm | 62° | 20 mm | 4.3 mm | 1.25" | 216 g | 7.4' | 9.9' | 14.9' |
| DeLite | 3 mm | 62° | 20 mm | 3.2 mm | 1.25" | 221 g | 5.6' | 7.4' | 11.2' |
| Delos | 17.3 mm | 72° | 20 mm | 21.2 mm | 1.25" | 408 g | 37.4' | 49.8' | 74.7' |
| Delos | 14 mm | 72° | 20 mm | 17.3 mm | 1.25" | 408 g | 30.2' | 40.3' | 60.5' |
| Delos | 12 mm | 72° | 20 mm | 15.0 mm | 1.25" | 408 g | 25.9' | 34.6' | 51.8' |
| Delos | 10 mm | 72° | 20 mm | 12.7 mm | 1.25" | 408 g | 21.6' | 28.8' | 43.2' |
| Delos | 8 mm | 72° | 20 mm | 9.9 mm | 1.25" | 454 g | 17.3' | 23.0' | 34.6' |
| Delos | 6 mm | 72° | 20 mm | 7.6 mm | 1.25" | 453 g | 13.0' | 17.3' | 25.9' |
| Delos | 4.5 mm | 72° | 20 mm | 5.6 mm | 1.25" | 499 g | 9.7' | 13.0' | 19.4' |
| Delos | 3.5 mm | 72° | 20 mm | 4.4 mm | 1.25" | 499 g | 7.6' | 10.1' | 15.1' |
| Ethos | 21 mm | 100° | 15 mm | 36.2 mm | 2" | 1020 g | 63.0' | 84.0' | 126.0' |
| Ethos | 17 mm | 100° | 15 mm | 29.6 mm | 2" | 703 g | 51.0' | 68.0' | 102.0' |
| Ethos | 13 mm | 100° | 15 mm | 22.3 mm | 2" / 1.25" | 590 g | 39.0' | 52.0' | 78.0' |
| Ethos | 10 mm | 100° | 15 mm | 17.7 mm | 2" / 1.25" | 499 g | 30.0' | 40.0' | 60.0' |
| Ethos | 8 mm | 100° | 15 mm | 13.9 mm | 2" / 1.25" | 431 g | 24.0' | 32.0' | 48.0' |
| Ethos | 6 mm | 100° | 15 mm | 10.4 mm | 2" / 1.25" | 439 g | 18.0' | 24.0' | 36.0' |
| Ethos SX | 4.7 mm | 110° | 15 mm | 8.9 mm | 2" / 1.25" | 590 g | 15.5' | 20.7' | 31.0' |
| Ethos SX | 3.7 mm | 110° | 15 mm | 7.0 mm | 2" / 1.25" | 499 g | 12.2' | 16.3' | 24.4' |
| Nagler 5 | 31 mm | 82° | 19 mm | 42.0 mm | 2" | 998 g | 76.3' | 101.7' | 152.5' |
| Nagler 4 | 22 mm | 82° | 19 mm | 31.1 mm | 2" | 680 g | 54.1' | 72.2' | 108.2' |
| Nagler 5 | 16 mm | 82° | 10 mm | 22.1 mm | 1.25" | 201 g | 39.4' | 52.5' | 78.7' |
| Nagler 6 | 13 mm | 82° | 12 mm | 17.6 mm | 1.25" | 181 g | 32.0' | 42.6' | 64.0' |
| Nagler 6 | 9 mm | 82° | 12 mm | 12.4 mm | 1.25" | 190 g | 22.1' | 29.5' | 44.3' |
| Nagler 6 | 7 mm | 82° | 12 mm | 9.7 mm | 1.25" | 227 g | 17.2' | 23.0' | 34.4' |
| Nagler 6 | 5 mm | 82° | 12 mm | 7.0 mm | 1.25" | 224 g | 12.3' | 16.4' | 24.6' |
| Nagler 6 | 3.5 mm | 82° | 12 mm | 4.8 mm | 1.25" | 241 g | 8.6' | 11.5' | 17.2' |
| Panoptic | 41 mm | 68° | 27 mm | 46.0 mm | 2" | 953 g | 83.6' | 111.5' | 167.3' |
| Panoptic | 35 mm | 68° | 24 mm | 38.7 mm | 2" | 725 g | 71.4' | 95.2' | 142.8' |
| Panoptic | 27 mm | 68° | 19 mm | 30.5 mm | 2" | 450 g | 55.1' | 73.4' | 110.2' |
| Panoptic | 24 mm | 38° | 16 mm | 27.0 mm | 1.25" | 225 g | 27.4' | 36.5' | 54.7' |
| Panoptic | 19 mm | 68° | 13 mm | 21.3 mm | 1.25" | 180 g | 38.8' | 51.7' | 77.5' |
| Plössl | 55 mm | 50° | 38 mm | 46.0 mm | 2" | 500 g | 82.5' | 110.0' | 165.0' |
| Plössl | 40 mm | 43° | 28 mm | 27.0 mm | 1.25" | 180 g | 51.6' | 68.8' | 103.2' |
| Plössl | 32 mm | 50° | 22 mm | 27.0 mm | 1.25" | 180 g | 48.0' | 64.0' | 96.0' |
| Plössl | 25 mm | 50° | 17 mm | 21.2 mm | 1.25" | 135 g | 37.5' | 50.0' | 75.0' |
| Plössl | 20 mm | 50° | 14 mm | 17.1 mm | 1.25" | 45 g | 30.0' | 40.0' | 60.0' |
| Plössl | 15 mm | 50° | 10 mm | 12.6 mm | 1.25" | 74 g | 22.5' | 30.0' | 45.0' |
| Plössl | 11 mm | 50° | 8 mm | 9.1 mm | 1.25" | 45 g | 16.5' | 22.0' | 33.0' |
| Plössl | 8 mm | 50° | 6 mm | 6.5 mm | 1.25" | 45 g | 12.0' | 16.0' | 24.0' |

Some eyepieces have barrel size as 2" / 1.25". These can be used in either 2 inch or 1.25 inch focusers, however, the focal position is further out when used in a 1.25" adapter.

There are two ways to determine Real Field of view
If you know the field stop diameter the first method is accurate.
The second method is easiest and give a very similar result.

1. Real Field (°) = 57.3° x eyepiece field stop / telescope focal length
2. Real Field (') = Apparent Field / Magnification × 60

of 7 mm. With a 15-arcminute RF, Jupiter would fit 18 times across the field of the eyepiece. This would produce great images of the gas giant with good detail of the equatorial belts and temperate zones. However, if we were looking at the Moon, only part of it would fit using this eyepiece because the size of the Moon is about twice the size of the RF.

alpha star of Scorpius: at this time, Mercury is the brighter of the two.

The Evening Star, **Venus,** is unmistakable in the early western evening sky, above Mercury. On the 5th, the planet will be 5° below the 4-day-old waxing crescent Moon in Ophiuchus (see Sky View). Venus then moves into Sagittarius, mid-month briefly calling on the Teapot and passing close to the 'lid' star. The planet then begins a journey across the great star clouds near the galactic centre (see the diary for details of some of the brighter stars and deep sky objects it visits).

**Mars** moves into Cancer this month, the faintest of the Zodiacal constellations. Mid-month, the planet rises in the eastern sky just before midnight. On the 21st, it will be 5° from the 20-day-old waning gibbous Moon (see Sky View). At month's end, Mars will be less than 2° from the Beehive (M44), an open cluster visible to the unaided eye (under good dark skies). At 1.2° across, the Beehive is best viewed with binoculars or a small telescope to reveal more than 75 stars. With opposition next year on January 16, the planet's magnitude increases to –0.5, and the disc grows to 11.5 arcseconds.

**Jupiter**, moving slowly in retrograde in Taurus, rises around astronomical dusk mid-month. With opposition early next month, now is the time to focus attention on the gas giant during these pleasant spring evenings. Even the smallest telescopes will show detail on the planet and the fascinating Galilean satellites as they shuttle back and forth, providing a renewed and different view every time they are observed. In addition, since the moons move in a plane close to the plane of the Earth's orbit, we can see some exciting events over a short period. For example, the moons can be occulted by the planet's disc and eclipsed by its shadow; we can see a transit as a moon is silhouetted on Jupiter and observe the shadow of a moon as it is projected onto the cloud tops. See some specific examples of the arrangement of the moons on specific dates (pp. 75 and 82) and the Jupiter Moon Events in Part II for detailed predictions.

**Saturn**, in Aquarius, transits the meridian (is due north) around 7 pm mid-month. On the 11th, the 10-day-old waxing gibbous Moon appears 5° from the planet (see Sky View). On the 16th, Saturn ends 4.5 months in retrograde motion, resuming its west-to-east motion in the sky.

**Uranus** comes to opposition on the 17th, rising in the early evening eastern sky and visible the entire night. This outer ice giant has an axial tilt of 98°, meaning it practically spins on its side as it orbits the Sun; presently and until 2030, the planet's south pole is pointed toward Earth. Uranus' apparent diameter is a little less than 4 arcseconds at this opposition, and at 5.6 magnitude, it is within naked-eye visibility (under dark skies without the Moon). The planet shows no distinguishable atmospheric features through a telescope, but observers (even with small instruments) will immediately notice its disc and blue-green colour.

**Neptune**, in Pisces, appears high in the early northern evening as it transits the meridian around 8 pm mid-month.

## DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 1 Nov | 511 Davida | Eridanus | 10.4 |
| 4 Nov | 270 Anahita | Aries | 10.6 |
| 14 Nov | 11 Parthenope | Taurus | 9.6 |
| 23 Nov | 67 Asia | Taurus | 11.5 |
| 23 Nov | 103 Hera | Taurus | 11.3 |
| 25 Nov | 41 Daphne | Taurus | 12.6 |
| 30 Nov | 54 Alexandra | Perseus | 12.1 |

| DIARY | | | |
|---|---|---|---|
| Fri | 1st | | Venus 0.2° NW of NGC 6284 (GC) in Ophiuchus |
| Fri | 1st | 11 pm | (9 pm WST) New Moon. |
| Sun | 3rd | 7 pm | (5 pm WST) Mercury 2° N of Moon |
| Mon | 4th | | Comet 333P/LINEAR 1.0° E of NGC 3423 (G) in Sextans |
| Tue | 5th | | Mercury 0.7° SE of star Delta Scorpii |
| Tue | 5th | 7 pm | (5 pm WST) Venus 5° NW of Moon |
| Thu | 7th | | Mercury 1.0° SW of M80 (GC) in Scorpius |
| Thu | 7th | 4 am | (2 am WST) Maximum Libration (9.2°), dark NW limb. |
| Fri | 8th | | m.p. 16 Psyche 0.2° N of star Theta Capricorni |
| Fri | 8th | | m.p. 7 Iris 1.0° N of NGC 7009 (PN) in Aquarius |
| Sat | 9th | 4 pm | (2 pm WST) First Quarter Moon. |
| Sun | 10th | | Neptune 0.8° NW of star 24 Piscium |
| Sun | 10th | 7 pm | (5 pm WST) star Antares 2° S of Mercury |
| Mon | 11th | am | m.p. 13 Egeria 0.7° SW of star Iota Aurigae |
| Mon | 11th | 8 pm | (6 pm WST) Saturn 5° SW of Moon |
| Tue | 12th | 8 pm | (6 pm WST) Neptune 5° SW of Moon |
| Wed | 13th | | Venus 0.5° NW of NGC 6553 (GC) in Sagittarius |
| Wed | 13th | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 1.4° S of IC 4756 (OC) in Serpens |
| Wed | 13th | | Northern Taurids meteor shower, Oct 20 to Dec 10, Moon affected. |
| Thu | 14th | | Comet 333P/LINEAR 0.7° W of NGC 3593 (G) in Leo |
| Thu | 14th | 9 pm | (7 pm WST) Moon at perigee (closest to Earth at 360,109 km). |
| Fri | 15th | | Comet 333P/LINEAR 1.4° NW of M65 (SG) in Leo |
| Sat | 16th | | Venus 0.8° S of M28 (GC) in Sagittarius |
| Sat | 16th | | Comet 333P/LINEAR 0.7° SE of star Theta Leonis |
| Sat | 16th | 7 am | (5 am WST) Full Moon (361,873 km), supermoon. |
| Sat | 16th | | Mercury at greatest elongation East (22.6°) |
| Sun | 17th | | Mercury 0.9° NE of M19 (GC) in Ophiuchus |
| Sun | 17th | | Mercury 0.7° S of NGC 6284 (GC) in Ophiuchus |
| Sun | 17th | | Venus 0.2° S of star Lambda Sagittarii |
| Sun | 17th | | Venus 0.7° W of NGC 6638 (GC) in Sagittarius |
| Sun | 17th | | Uranus at opposition |
| Sun | 17th | 10 pm | (8 pm WST) Jupiter 6° S of Moon |
| Mon | 18th | am | Leonids meteor shower, Nov 6–30, Moon affected. |
| Wed | 20th | 3 am | (1 am WST) Maximum Libration (9.7°), dark SE limb. |
| Thu | 21st | 3 am | (1 am WST) Mars 6° S of Moon |
| Fri | 22nd | | Mercury 0.4° S of star Theta Ophiuchi |
| Fri | 22nd | | Venus 1.0° N of star Sigma Sagittarii |
| Sat | 23rd | 11 am | (9 am WST) Last Quarter Moon. |
| Tue | 26th | 10 pm | (8 pm WST) Moon at apogee (furthest from Earth at 405,314 km). |
| Sat | 30th | | Comet 333P/LINEAR 1.0° SW of NGC 4244 (G) in Canes Venatici |

## COMETS

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 8) is setting in the western sky in the early evening. It begins in Ophiuchus at about magnitude 7, moving into Serpens on the 11th at about magnitude 8 and into Aquila on the 25th. By month's end it has faded to magnitude 10.

**Comet 333P/LINEAR** begins in Leo at about magnitude 13, rising in the eastern sky about an hour before dawn. On the 26th it moves into Ursa Major then into Canes Venatici on the 29th. By month's end it is about magnitude 10 and rises in the north-eastern sky shortly before sunrise.

## METEOR SHOWERS

The **Northern Taurids** are active from October 20 to December 10, with their peak late evening around November 12 and through to the morning dawn. Taurids are frequently bright, slow-moving, and noted for producing colourful fireballs (although not every year). The zenith hourly rate is 5, although, from Australia's latitudes, it will be considerably lower. They are associated with Comet 2P/Encke and are visible from late evening to early morning. The Full Moon on the 16th will be a significant disrupter to this year's Northern Taurids.

The **Leonids** are one of the better-known showers. They are associated with the periodic comet 55P/Tempel-Tuttle and are at their best every 33 years when they return to perihelion (last in 2001). The Leonids are active from November 6 to 30, reaching a maximum peak of around 10 meteors per hour (possibly about 4–5 from mid-Australian latitudes) for the morning of the 18th and perhaps the 19th. Since Leo rises after midnight, there will only be a few hours available before the onset of dawn for observation. With the Moon just past its full phase, considerable interference will occur this year.

## CONSTELLATIONS

In May we described how the southern Milky Way was high in the evening with the northern sky giving a great view above (north of) the plane of our galaxy. It is not surprising that six months later the reverse has happened. The Milky Way is now low, revealing the Universe below (south) of our galaxy. In fact, if you choose the right time and place (latitude) the galactic equator coincides with the horizon, so given an absence of trees or hills you can find the Milky Way hugging the horizon forming an almost uninterrupted ring around you! An example would be mid-November around 9 pm EST from Brisbane. This also places the South Galactic Pole near the zenith (directly overhead), which is in the constellation of Sculptor (Map 2).

As you look higher in the sky (higher galactic latitude) fewer stars are seen. In fact, the bright stars of Fomalhaut (Map 8) and Achernar (Map 2) almost look out of place. This is just because they are nearby galactically speaking, being only 25 and 143 light-years away respectively. Also, there is nearly an absence of open star clusters or nebulae, for these are born and mostly exist in the spiral arms of the galaxy so imbedded low in the 'milky' glow.

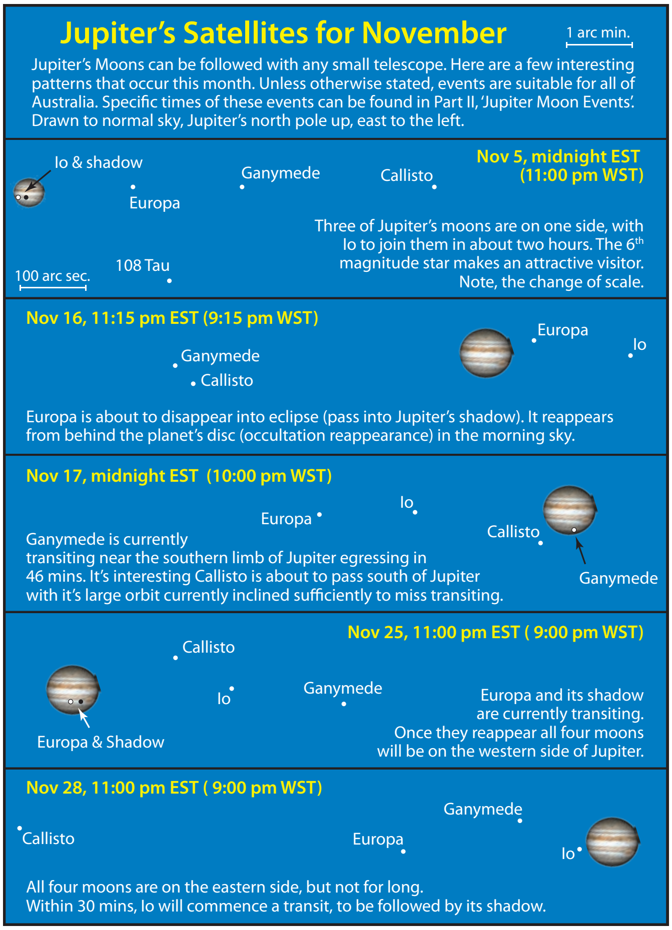
As mentioned previously, you have entered the realm of the galaxies. In general, galaxies form in clusters and groups, with the massive Virgo-Coma cluster a spectacular example (May constellations). The Milky Way is no exception, belonging to the local group of galaxies. It has over 50 members, approximately 10 million light-years in diameter, with its centre lying between the spirals, Andromeda (M31) and the Milky Way—the largest and most massive members. Most of the remaining local group members are nearby, low mass, low luminosity dwarf galaxies and difficult to see (big and faint). However, we are fortunate to have all the brightest members on the south side of the Milky Way and on display. Besides our home galaxy the next three brightest members are clearly visible to the naked eye under dark skies. The Small and Large Magellanic Clouds (Map 1) are high in the south and south-east respectively and low in the north is the Andromeda Galaxy—M31 (Map 3). Using binoculars, you can add M33 in Triangulum (near M31).

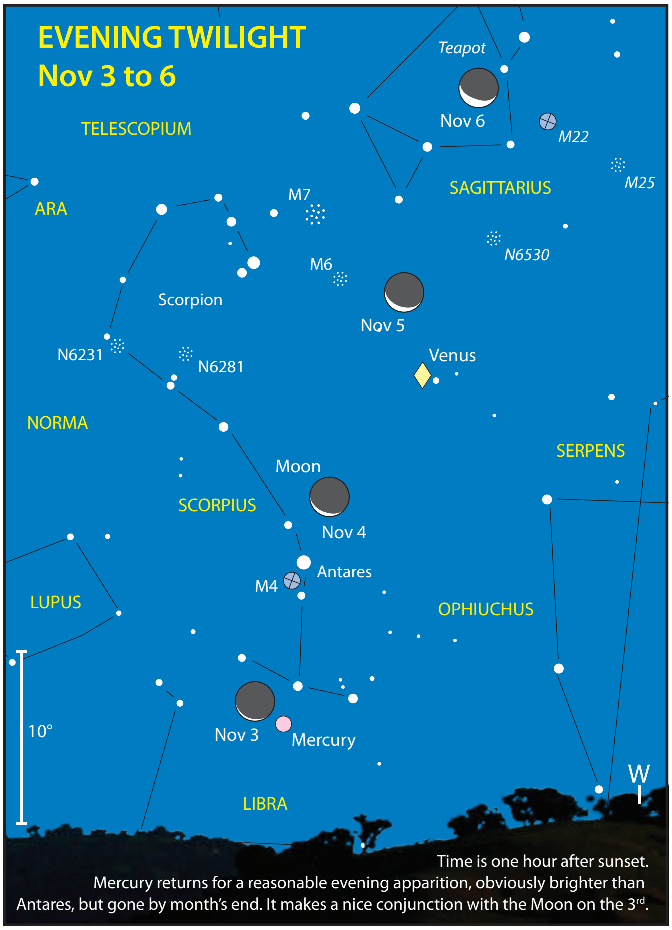
There are other galaxy groups, with around 20 being found even closer than the Virgo/Coma cluster. Many galaxies belonging to these assemblies present breath-taking sights and are well known to amateurs.

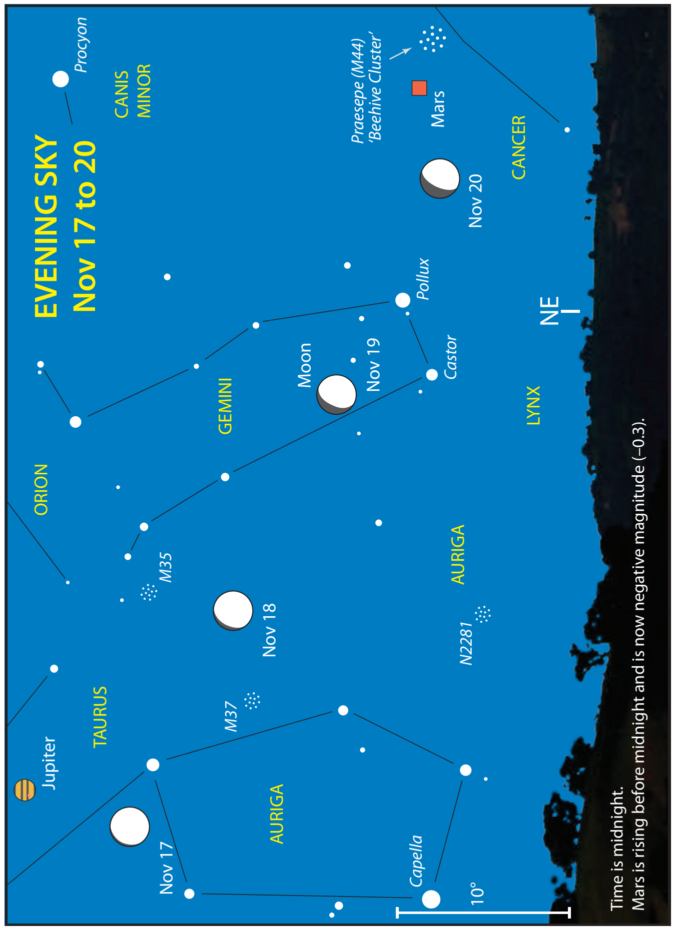
One of the closest and visible at this time of the year, is the Sculptor group also known as the South Polar Group. The brightest member is the near edge-on spiral, NGC 253, the Silver Coin Galaxy (Map 2), which is a great view in any telescope and visible in binoculars. Lying only 10.7 million light-years away and located 2° from the South Celestial Pole, any residents of NGC 253 looking in our direction would see the Milky Way as a magnificent face-on barred spiral galaxy, spanning a half degree of sky (the size of the Moon)!

### Jupiter's Satellites for November

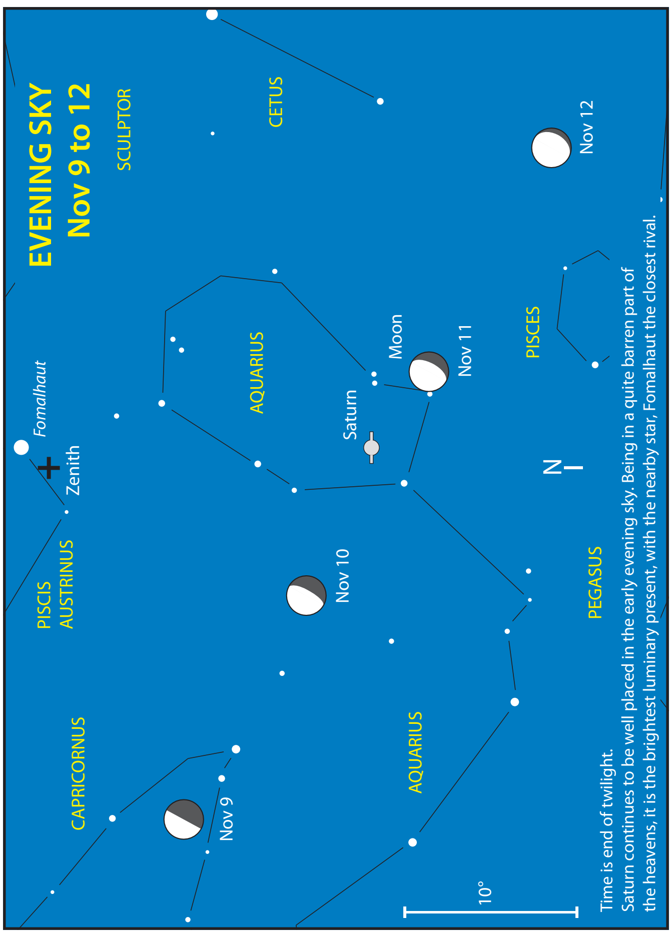
Jupiter's Moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole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

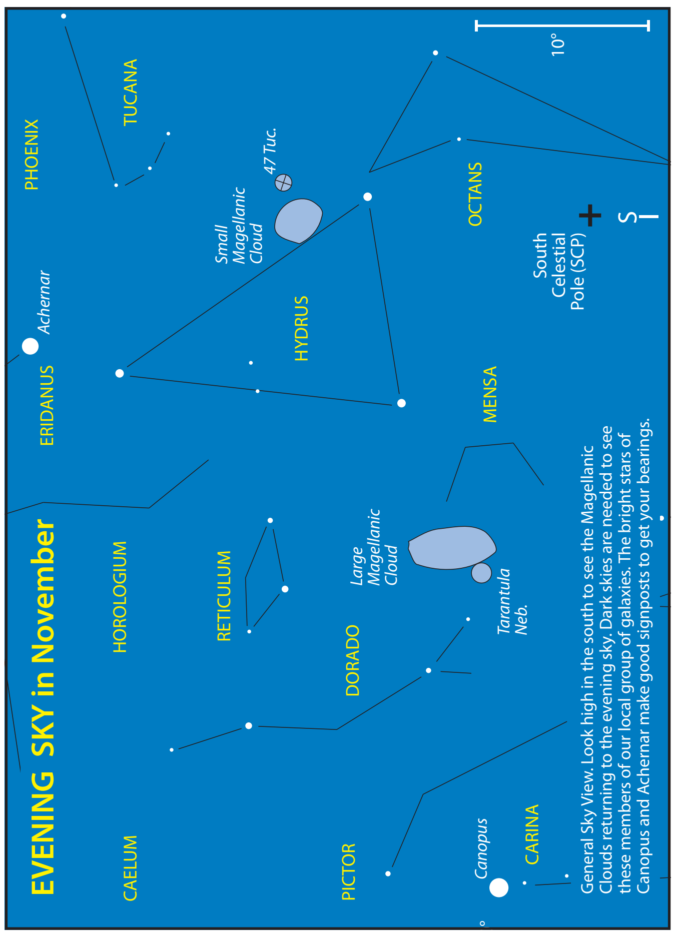




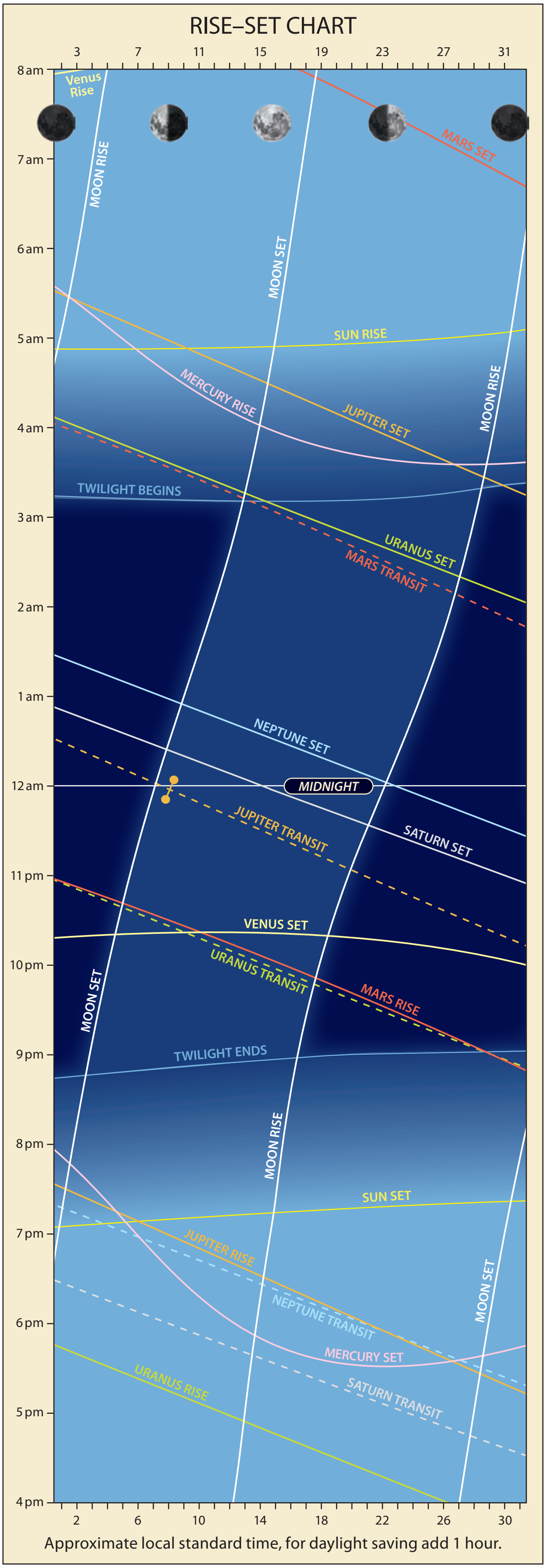




Approximate local standard time, for daylight saving add one hour.



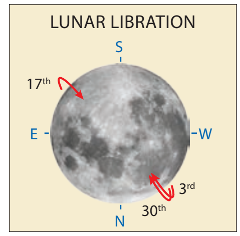
# DECEMBER 2024




## HIGHLIGHTS

- Venus and the thin crescent Moon close.
- Saturn and the Moon have a close visit.
- Jupiter at opposition.
- Mars is close to opposition.

## THE MOON




1st 4 pm (2 pm WST) New Moon.

3rd Midnight (10 pm WST) Maximum Libration (8.3°), dark NW limb.

8th 5:30 pm CST Daytime occultation of Saturn visible from Northern Australia (see Part II Lunar Occultation section under Darwin).

9th 1 am (11 pm WST, previous day) First Quarter.

12th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 365,361 km).

15th 7 pm (5 pm WST) Full Moon.

17th 4 pm (2 pm WST) Maximum Libration (8.6°), dark SE limb.

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

24th 5 pm (3 pm WST) Moon at apogee (furthest from Earth at 404,485 km).

30th 9 pm (7 pm WST) Maximum Libration (8.1°), too close to New Moon.

31st 8 am (6 am WST) New Moon.

## APPEARANCE of the PLANETS

**MERCURY** Mercury in inferior conjunction on the 6th

15 Dec
dia 8.5"
mag 0.5

25 Dec
dia 6.6"
mag −0.4
Greatest elongation West (22.0°)

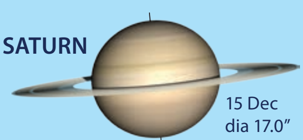
**MARS**

15 Dec
dia 13.0"
mag −0.8

**VENUS**

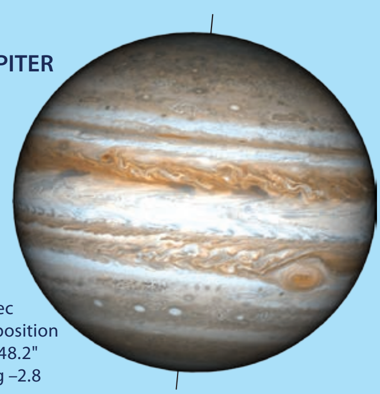
15 Dec
dia 19.1"
mag −4.3

**SATURN**



15 Dec
dia 17.0"
mag 1.0

**JUPITER**



8 Dec
Opposition
dia 48.2"
mag −2.8

**URANUS**

15 Dec
dia 3.8"
mag 5.6

**NEPTUNE**

15 Dec
dia 2.3"
mag 7.9

## THE PLANETS

**Mercury** returns to the eastern morning dawn sky after passing between the Earth and Sun (inferior conjunction) on the 6th. On the 25th, the planet reaches its greatest elongation 22° west of the Sun. In the eastern dawn sky on the 29th, this innermost world is 6° below the thin crescent Moon (see Sky View)

In the early western evening sky, **Venus** spends the first week of the month in Sagittarius and then moves into Capricornus for the remainder. On the 5th, the 4-day-old waxing crescent Moon appears around 5° above the planet (see Sky View).

The **Earth** is at Solstice on the 21st when the days are the longest. On this day, the Sun is at its most southerly position with a declination of –23.5°.

**Mars**, in Cancer, rises in the eastern evening sky around 10 pm mid-month. On the 8th, the planet begins retrograde motion against the background stars (see diagram on p. 94). This apparent reversal of direction continues until late February 2025. This also indicates that opposition is approaching as the Earth catches up and passes the slower-moving planet. On the 18th, the planet can be seen rising above the 18-day-old waning gibbous Moon in the late eastern evening sky (see Sky View).

With Mars at opposition on the 16th of January 2025, it's time to devote some observing or imaging time to the planet. By month's end, the bright orange orb reaches –1.2 magnitude, with its disc just over 14 arcseconds in diameter. This opposition is the second of five aphelic apparitions where the planet's diameter is less than 20 arcseconds. The opposition in 2027 is even worse; amateurs will have to wait until 2033 and 2035 for the next good perihelic ones. Although not the best of oppositions, this world should deliver pleasant views (planet-wide sandstorms aside) in moderate to large-size telescopes during periods of good seeing. Of course, you must use a magnification as high as the atmosphere and your instrument will allow (see also Opposition of Mars 2025 p. 116).

**Jupiter**, shining at –2.8 magnitude, is conspicuous in the early eastern evening sky as twilight begins (outshone only by Venus and the Moon in the night sky). It can only mean one thing when an outer planet rises in the east as the Sun sets in the west, its opposition time. The equatorial diameter at this opposition on the 8th is 48 arcseconds, compared to 50 when the planet is also at perihelion (next in 2032). Although many would agree that Saturn is the jewel of the Solar System's gas giants, the dynamic and fast-changing nature of the planet and its Moons make Jupiter an observer's favourite. This Jovian world is 7° from the Full Moon on 14th (see Sky View).

In a telescope, the most noticeable features on Jupiter's oblate disc are two dark-coloured bands known as the North and South Equatorial Belts (NEB and SEB). Between these two main belts is a light-coloured band known as the Equatorial Zone. Further scrutiny will reveal several more belts, zones, and shadings towards the poles. Depending on your telescope size and steady seeing, short-term protuberances, gaps, and bright and dark spots are all visible within the bands. Keep in mind Jupiter's rapid 10-hour rotation period, things move quickly, and a feature noted in a belt will move perceptibly in half an hour. The famous Great Red Spot (GRS) is located at the outer edge of the SEB (predictions for when to see the Great Red Spot can be found in Part II). The GRS is the largest known cyclone in the Solar System and has been raging for at least 300 years.

On the 5th, **Saturn** is at a point in its orbit known as eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 10). As a result, Saturn will be at its highest altitude as the Sun sets in the west. It is also a favourable time to view the maximum shadow of the planet's globe cast onto the rear of the rings, giving Saturn a 3-D appearance.

**Uranus**, now past opposition, is in the northern evening sky at the end of astronomical twilight in Taurus. Interestingly, Uranus is the only planet named after a Greek God (all the others are named after Roman Gods). At month's end, the planet slips over the border and into Aries until late February 2025 before returning to Taurus again.

| DIARY | | | |
|---|---|---|---|
| Sun | 1st | | Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.2° NE of NGC 6755 (OC) in Aquila |
| Sun | 1st | 4 pm | (2 pm WST) New Moon. |
| Mon | 2nd | | Jupiter 0.5° N of star Iota Tauri |
| Mon | 2nd | pm | Phoenicids meteor shower, Nov 28 to Dec 9. |
| Tue | 3rd | Midn | (10 pm WST) Maximum Libration (8.3°), dark NW limb. |
| Tue | 3rd | pm | m.p. 15 Eunomia 0.7° N of M36 (OC) in Auriga |
| Thu | 5th | | Mars 2.0° NW of M44 Beehive Cluster (OC) in Cancer |
| Thu | 5th | 8 pm | (6 pm WST) Venus 5° W of Moon |
| Fri | 6th | | Venus 0.9° S of M75 (GC) in Sagittarius |
| Fri | 6th | | Mercury in inferior conjunction |
| Sun | 8th | | Neptune 0.6° NE of star 20 Piscium |
| Sun | 8th | | Puppid-Velids meteor shower, Dec 1–15. |
| Sun | 8th | | Jupiter at opposition |
| Sun | 8th | 9 pm | (7 pm WST) Saturn 1.5° S of Moon |
| Sun | 8th | 9 pm | (7 pm WST) d.p. 1 Ceres 5° S of Venus |
| Mon | 9th | 1 am | (11 pm WST, prev day) First Quarter Moon. |
| Mon | 9th | 9 pm | (7 pm WST) Neptune 2° S of Moon |
| Thu | 12th | 11 pm | (9 pm WST) Moon at perigee (closest to Earth at 365,361 km). |
| Fri | 13th | 9 pm | (7 pm WST) Uranus 6° S of Moon |
| Sat | 14th | | Geminids meteor shower, Dec 4–17, Moon affected. |
| Sun | 15th | 2 am | (Midnight WST, prev day) Jupiter 7° SE of Moon |
| Sun | 15th | 7 pm | (5 pm WST) Full Moon (370,402 km). |
| Mon | 16th | pm | m.p. 15 Eunomia 0.3° NW of NGC 1893 (OC) in Auriga |
| Tue | 17th | 4 pm | (2 pm WST) Maximum Libration (8.6°), dark SE limb. |
| Wed | 18th | 11 pm | (9 pm WST) Mars 3° W of Moon |
| Sat | 21st | 10 am | (8 am WST) star Antares 7° S of Mercury |
| Sat | 21st | | Solstice |
| Mon | 23rd | 8 am | (6 am WST) Last Quarter Moon. |
| Tue | 24th | 5 pm | (3 pm WST) Moon at apogee (furthest from Earth at 404,485 km). |
| Wed | 25th | | Mercury at greatest elongation West (22.0°) |
| Wed | 25th | pm | m.p. 14 Irene 0.8° S of NGC 2331 (OC) in Gemini |
| Thu | 26th | | Venus 0.9° NW of star Gamma Capricorni |
| Fri | 27th | | d.p. 1 Ceres 0.1° W of star Psi Capricorni |
| Sat | 28th | | Venus 0.9° NW of star Delta Capricorni |
| Sun | 29th | 4 am | (2 am WST) Mercury 7° NE of Moon |
| Sun | 29th | pm | m.p. 13 Egeria 0.1° NE of star Xi Persei |
| Mon | 30th | 9 pm | (7 pm WST) Maximum Libration (8.1°), too close to New Moon. |
| Tue | 31st | 8 am | (6 am WST) New Moon. |

**Neptune**, in Pisces, comes to the end of five months in retrograde on the 8th and appears high in the early northwestern evening sky at the end of astronomical dusk.

DWARF PLANETS and
SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

| Date | Minor Planet | Constellation | Mag. |
|---|---|---|---|
| 3 Dec | 13 Egeria | Perseus | 10.0 |
| 12 Dec | 69 Hesperia | Orion | 10.6 |
| 14 Dec | 15 Eunomia | Auriga | 8.1 |
| 22 Dec | 26 Proserpina | Taurus | 11.3 |
| 29 Dec | 88 Thisbe | Gemini | 11.4 |

## COMET

**Comet C/2023 A3 (Tsuchinshan-ATLAS)** (All Sky Map 8) spends the month in Aquila. It starts at about magnitude 10, setting in the western sky around 90 minutes after sunset. By about the 24th, it has faded to magnitude 11 and is now a daylight object.

## METEOR SHOWERS

The **Phoenicids** is a southern shower discovered in 1956 during its only known major outburst when rates of around 100 plus were observed. Since then, there have been three minor bursts and some significant activity in 2014; therefore, they are a shower to keep an eye on, just in case. Their period of activity appears to be from November 28 to December 9, with maxima around the 2nd. The Phoenicids' radiant culminates at dusk, so early evening viewing should provide the best activity with New Moon on the 1st.

The **Puppid-Velids** is a vastly complex system of showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. Active from December 1–15, a ZHR of 10 around the evening of the 7th through to dawn on the 8th is possible. The radiant is highest from mid-Australian latitudes around 4 am and coming up to First Quarter Moon, there will be minimal lunar interference during the peak.

The **Geminid**s are among the finest and most reliable of the major annual showers. Visible from the 4th to the 20th, with their maximum predicted late evening on the 14th and morning of the 15th. The Geminids often produce bright, medium-speed meteors with zenith hourly rates of up to 150. Even though our northern counterparts will see the best of the Geminids, they can still provide a spectacular display for us south of the equator (with a ZHR of less than 50 from mid-Australian latitudes). Unfortunately, the near Full Moon will cause significant interference to the Geminids this year.

## CONSTELLATIONS

The objects that have been associated with the random star patterns we call constellations, are a strange assembly. Those with knowledge of Greek mythology may be fascinated by the rich tapestry on display in the heavens. For example, this month we see Perseus who rode Pegasus (the flying horse) to rescue the maiden Andromeda from the beast Cetus, all represented in the northern sky. Which contrasts with constellations in the south having ordinary names, examples are (once translated) fly, southern triangle, peacock, clock and the furnace. The explanation is simple, the boring constellations never rose above the southern horizon from Mediterranean latitudes when and where the constellations were invented thousands of years ago.

It's interesting that if precession didn't play a part, some of the traditional constellations may not have existed. For example, at that time the centaur, Centaurus walked (galloped?) along the south as did Jason's ship the Argo sail the same horizon. Today, the lower half of this mythical beast can no longer be seen from these latitudes. Likewise, only Argo's sail is visible. In fact, bright luminaries like Alpha and Beta Centauri and Canopus had to wait over a thousand years for the early explorers of the Southern Hemisphere to next record them.

Although, who assigned the specific legends to certain asterisms has been lost to antiquity, it wasn't until the first century CE, when Ptolemy pulled this ancient work together in his Almagest, defining the 48 traditional constellations. All these are still in use today, except for the ship Argo Navis, being carved into three constellations (see March constellations).


*Johannes Hevelius's chart of Centaurus and surrounding constellations, from his* Firmamentum Sobiescianum sive Uranographia.

# Choosing an Eyepiece – Part 2

by Don Whiteman

**Example 2**

Let's change our astronomers' answers to the three questions.

- Clusters and nebulae
- 200 mm Dobsonian telescope, *f*/5
- 30 years old, doesn't wear glasses

Clusters and nebula are much, much bigger than planets (measured in arcminutes), however they lie at a great distance from Earth. Because of their size we need to use an eyepiece that can produce a larger field of view (FOV).

Here we can look at some of the eyepieces with larger Apparent Field (AF) also, because our aperture is larger, we have finer resolution and can use higher magnification of up to 280× (200 mm × 1.4). Of course, for a larger object, we would be using lower magnification, so we get a larger FOV. Let's suppose that we wish to look at Messier 42 or NGC 1976 or the Great Orion Nebula (all the same object). The size in our star chart tells us it is 45 arcminutes. That means you need to use an eyepiece that will produce a 60 arcminute RF. Our telescope has a focal length (F) of 1000 mm and the focal ratio is *f*/5.

If I used a Plössl (with 50°AF) I could use a 20 mm focal length that would give you a magnification of 50 divided by AF of 50 and multiply by 60 to give you a RF of 60 arcminutes and an exit pupil of 4 mm.

You could choose to use an eyepiece with a wider AF such as a 14 mm TeleVue Delos (72° AF) which would give you 71 × (1000 / 14) with an almost 50% gain in magnification. Now divide the AF by magnification (72 AF / 71.4 × 60) to yield a field of view 61 arcminutes and have an XP of 2.8 mm. I am achieving higher power whilst getting the same RF and getting brighter image because of the smaller Exit Pupil.

In this second example we see the importance of Field of View over pure Magnification.

**So that brings us to Eyepiece types**

Next thing we look at is the different eyepiece designs. From the earliest designs, the eyepiece has gone through many changes, as technology has improved coatings and new substrates (glass) are discovered. There are multiple designs and many of those are no longer available. I will cover the main types used by amateur astronomers today. Unless a brand is the design of the eyepiece I will stick to generic terms.

The very first eyepieces were by Lippershay/ Galileo (early 1600s) and were a very simple Plano Convex design (similar to what is in reading glasses) Then in 1671 came the Huygens which had two glass elements that improved colour correction. They only had small apparent field of view and worked well in long refractors. All the major discoveries for the next 150 years were made with this type of lens set up and the Ramsden eyepiece which appeared around the end of this time.

1609 First sketch of the Moon using a telescope by English astronomer Thomas Harriot

1610 Galileo discovers the four main moons of Jupiter

1671 Christian Huygens discovers the first of Saturn's moons

1675 Giovanni Cassini discovered the division in the rings of Saturn that bears his name

1781 William Herschel discovers Uranus and between 1781 and 1821 published a catalogue of more than 800 binary stars and over 2400 deep sky objects.

1846 German Astronomer Johann Galle confirmed an observation of Neptune.

1877 Asaph Hall discovers Phobos and Demos

Many of us remember our first telescopes that came with eyepiece marked H or R, which stands for Huygens and Ramsdens, and turn our noses up at such simple design eyepieces but they have well paid their dues.

One of the early designs that was standard in telescopes from the 1960s onwards was the Kellner, invented by Carl Kellner in 1849. He started a company called Optisches Institut when he was in his early 20s and died before his 30th birthday of tuberculosis. The company is still around today however it is now called Leitz, and they still make optics. The Kellner eyepiece was a 3-element eyepiece with a doublet and a singlet, it had better colour correction, moderate eye relief, an apparent field of around 39°–40°. There are modified designs to this eyepiece that increased the AF out to 50°. It was a very popular eyepiece through the 60s through to the late 80s when it was surpassed by the Orthoscopics and Plössl.

The Orthoscopic eyepiece was invented by Ernst Abbe (1840–1905) and was an improvement on the Kellner. It had a triplet as the field lens and a single Plano Convex Eye lens. It offered very good colour correction, reasonable eye relief, they produced a sharp flat field and were excellent eyepieces for planetary viewing. They only had a smallish apparent field of 39–42°.

The Plössl named after the inventor Simon Plössl (1794–1868) differs from the earlier Kellner design by having a doublet as the eye lens making four elements which corrected astigmatism, good colour correction and had longer eye relief. They have a 50° apparent field and work well with telescopes down to *f*/4 and have been widely used since the late 80s as the standard eyepiece. Today most telescope will come with Plössl eyepieces. They are moderately priced starting at under $50.

There are a myriad of eyepieces that became popular from the mid 80s onwards. Designs such as Erfle, which had 5-6 elements and offered a wider field of view with longer eye relief but had a short working distance, the König with 60° AF, the Bertele had 70° AF and the RKE from Edmunds Scientific with 45° AF. Then in the 1977 an optician name Albert Nagler came along and changed modern amateur astronomy. The name of his company is Tele Vue and today they have become the standard by which most other eyepieces are compared.

Nagler had worked on a design that was used for the Apollo Lunar Lander back in the 60s. He designed an eyepiece that offered what he called a 'Spacewalk experience'. The design was called Nagler after the inventor and offered an 82° Apparent Field of View.

The original Type 1 Nagler had edge to edge sharpness, great colour correction and was perfect for the new wave of large Dobsonian telescopes that were beginning to make an impact. It was available in 4.8, 7, 9, 11 and 13 mm. Some improvements were made, and Type 2 became a great eyepiece with better eye relief. It was available in 12, 16 and the 20 mm, which weighed over 1 kg. It is probably one of the best eyepieces I have ever used and still use it regularly. The Type 4 Nagler offers longer eye relief in sizes 12 mm and 17 mm, they have since been discontinued. The Type 6 is the latest model and is available in shorter focal lengths, still with that 82° Apparent field 'Spacewalk', they are available in 3.5, 5, 7, 9 and 13 mm.

Other designs from Tele Vue include the Wide Field (discontinued) which has a 65° Apparent Field. This was similar to the Erfle design. The Panoptic, with 68° Apparent Field, offered greater contrast, originally in 15, 19, 22, 27, 35 and 41 mm, these eyepieces were and are a joy to use. The Radian offered 60° AF and had 20 mm of eye relief which made them a favourite with eyeglass wearers as they were in short focal lengths and ideal for planetary viewing. They were replaced by the DeLite which have a 62° AF, designed by Nagler protégé Paul Dellechiaie who worked for Tele Vue up until his death. Paul, and Al and David Nagler gave us the Ethos design eyepiece, which went back to Nagler original designs for the Apollo missions and gave 100° and 110° AF, this enables wide fields of view in telescopes with long focal lengths. The Delos is another of the later designs by Paul, Al, and David. It has a 72° AF, with 20 mm of eye relief and a very large eye lens that makes it the most comfortable eyepiece to look into. It is available in 3.5, 4.5, 6, 8, 10, 12, 14 and 17.3 mm. These are some of the best eyepieces I have used for smaller deep sky objects like small galaxies and small globular clusters.

And finally, when looking at planets, which by definition are tiny in size (astronomically speaking) and therefore don't require large fields of view. The Tele Vue DeLite has 62° AF with 20 mm of eye relief and a decent eye lens to make it comfortable to look into. They come in shorter focal lengths so are also great in short, fast refractors. Available in 3, 4, 5, 7, 9, 11, 13, 15, and 18.2 mm focal lengths, they represent great value.

**Here is the last bit of maths**

A 500 mm $f$/5 scope (or 250 mm $f$/10 SCT) has a focal length of ~2500 mm, divide by 21 mm Ethos equal 119 × and would yield 50.4 arcminute RF, big enough to fit M42, the Great Orion Nebula, with absolutely stunning views.

150 mm SCT $f$/10, looking at planets, F= 1500 mm, using a 7 mm DeLite 62° AF, would give 214× and yield 17.4 arcminute RF so Jupiter would fit in the field only 21 times and would give great views even with 7 mm of Exit Pupil.

There are still lots of other designs that have been built over the years with many still available and many more brands and types of eyepieces. They use exotic names for glass such as Lanthanum, which has become a standard for long eye relief eyepieces. At the end of the day the best eyepiece is the one you use the most as it gives the best use of what you pay for.

The most important thing about buying an eyepiece is do your homework, ask someone to explain the difference of designs to you. Consider your age, eye health, telescope and what you want to use the eyepiece for, the maths will always be what you get in the end. At BinTel we ask a lot of questions about you, your telescope and what you want to look at so we can ensure that you are happy with your eyepieces. Look after them and they will give you an amazing astronomical journey for life. Clear Skies.



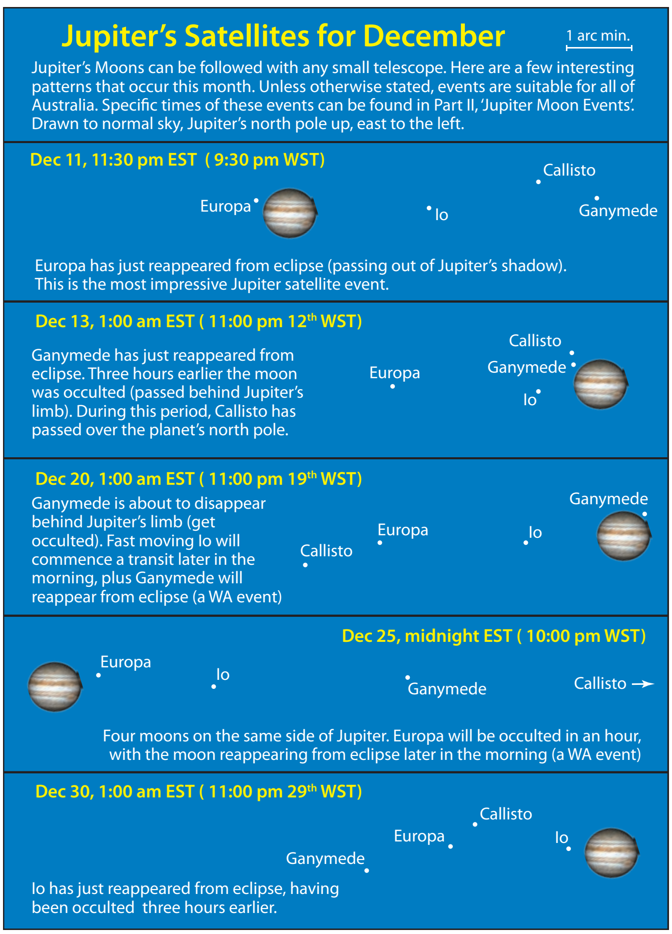
*Comparison of Teleview's lightest and heaviest eyepiece, roughly full size.*

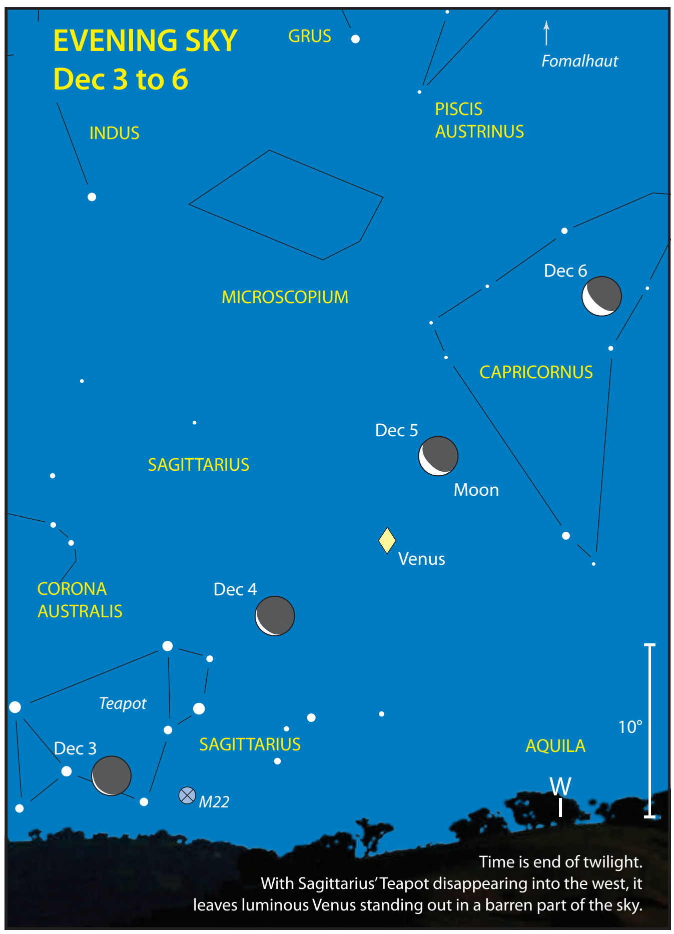
*Right is an 8 mm Plössl @ 45 g and far right, is a 21 mm Ethos @ 1,020 g.*

Much of the early work in the far south was done by the French Astronomer Abbe Nicholas Louis de la Caille from the Cape of Good Hope, 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, except for 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 (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)

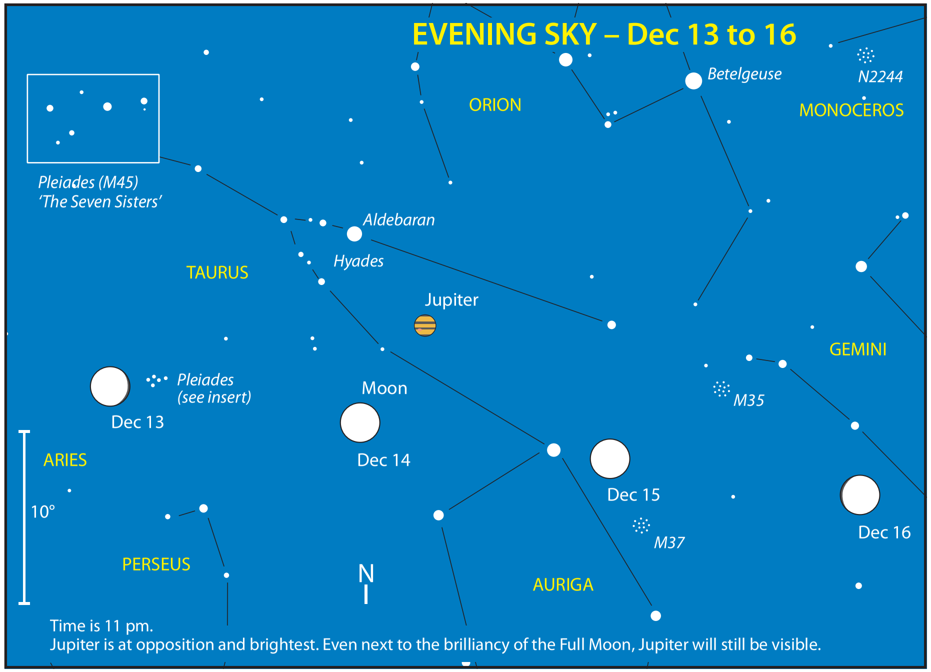
*Bayer’s celestial chart of the constellation Argo Navis*

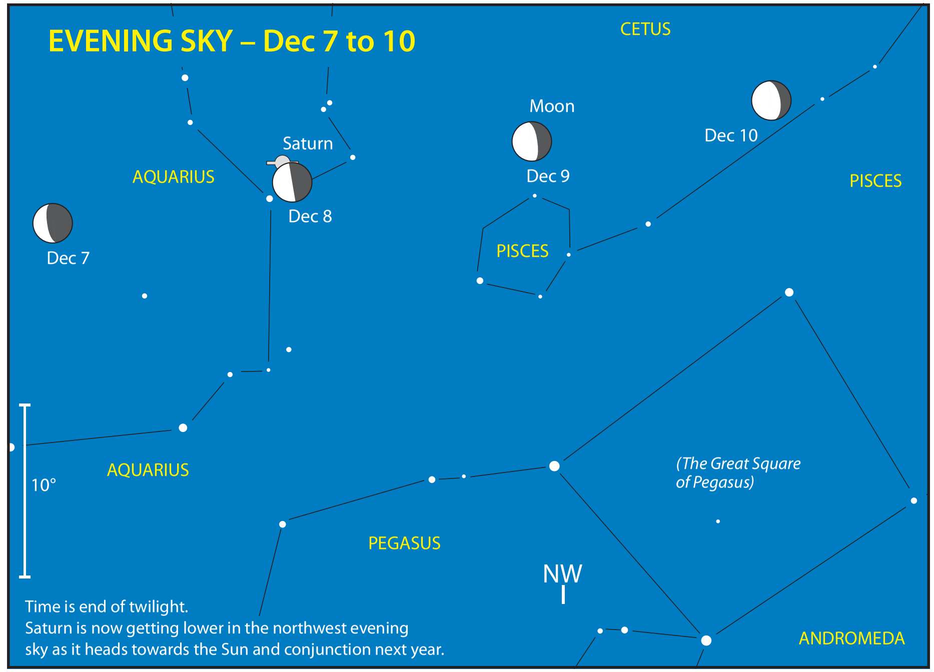
Twelve other ‘modern’ constellations in the far south, popularised by Johann Bayer in his 1603 star atlas Uranometria, are visible in December evening skies. Five are birds: Apus, Grus, Pavo, Phoenix and Tucana. Two of them are reptiles, Chamaeleon and Hydrus. Two are fish, Dorado and Volans, with the final miscellaneous three consisting of Indus the Indian, Musca the Fly and Triangulum Australe the Southern Triangle. Seeing all 12 this time of year is only possible because Volans, Chamaeleon, Musca and Triangulum Australe happen to be circumpolar from mid-latitude Australia.



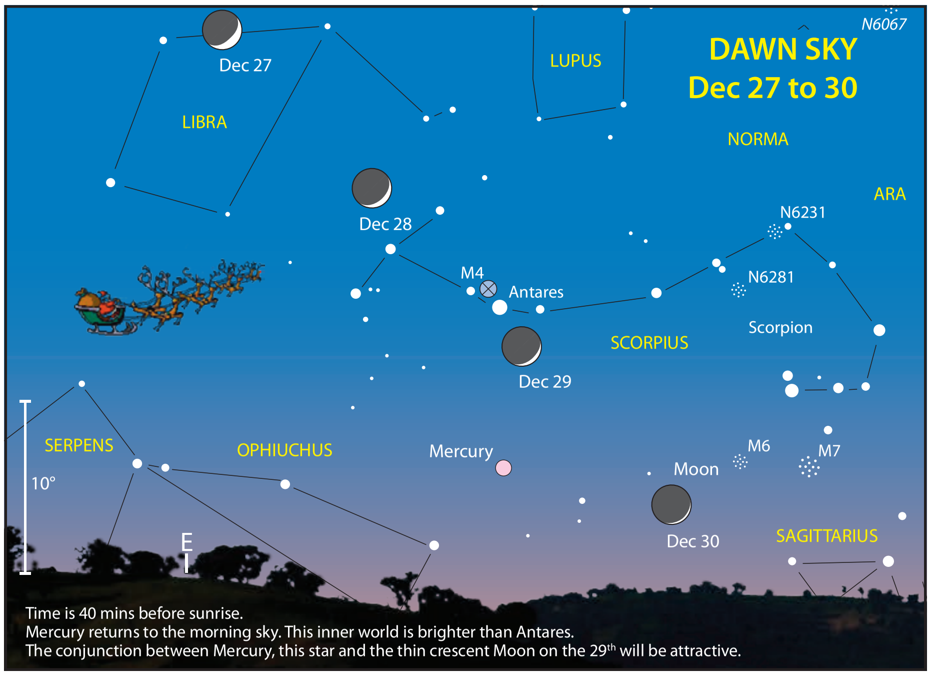



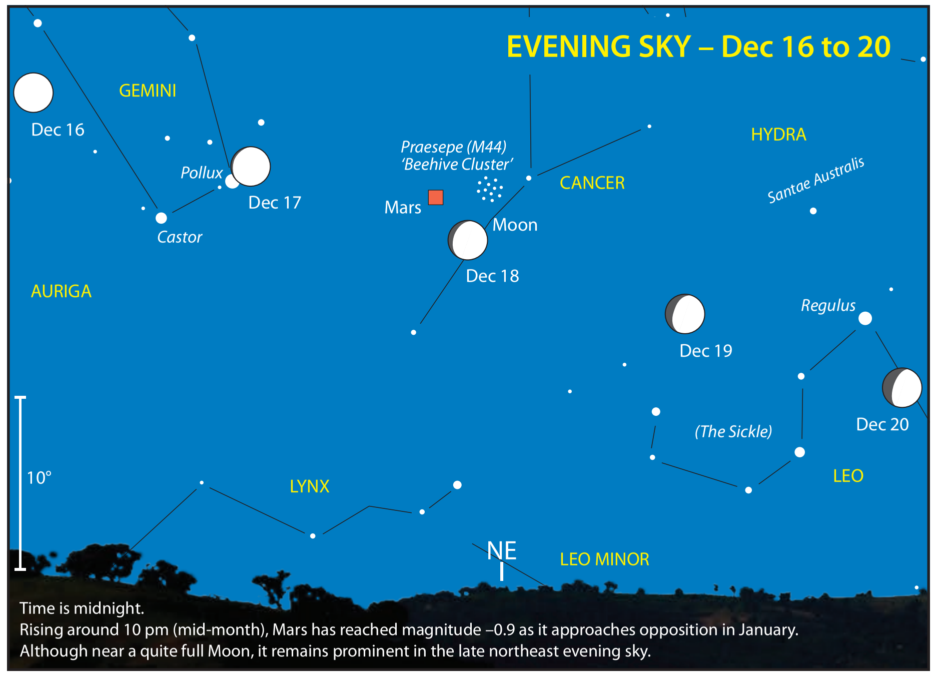

DECEMBER




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



# ALL SKY MAPS 2024

Introduction These maps have been created to show you the entire night sky at any time of the year from anywhere in Australia, 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 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 the 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. Rotating 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. 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. Let's take an example for Hobart (latitude around 43° S). Looking at the Autumn (Centre) map on 20 March at 9 pm the star Suhail, with a declination close to –43°, will pass overhead.

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 northern 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, and Neptune. Except for 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.

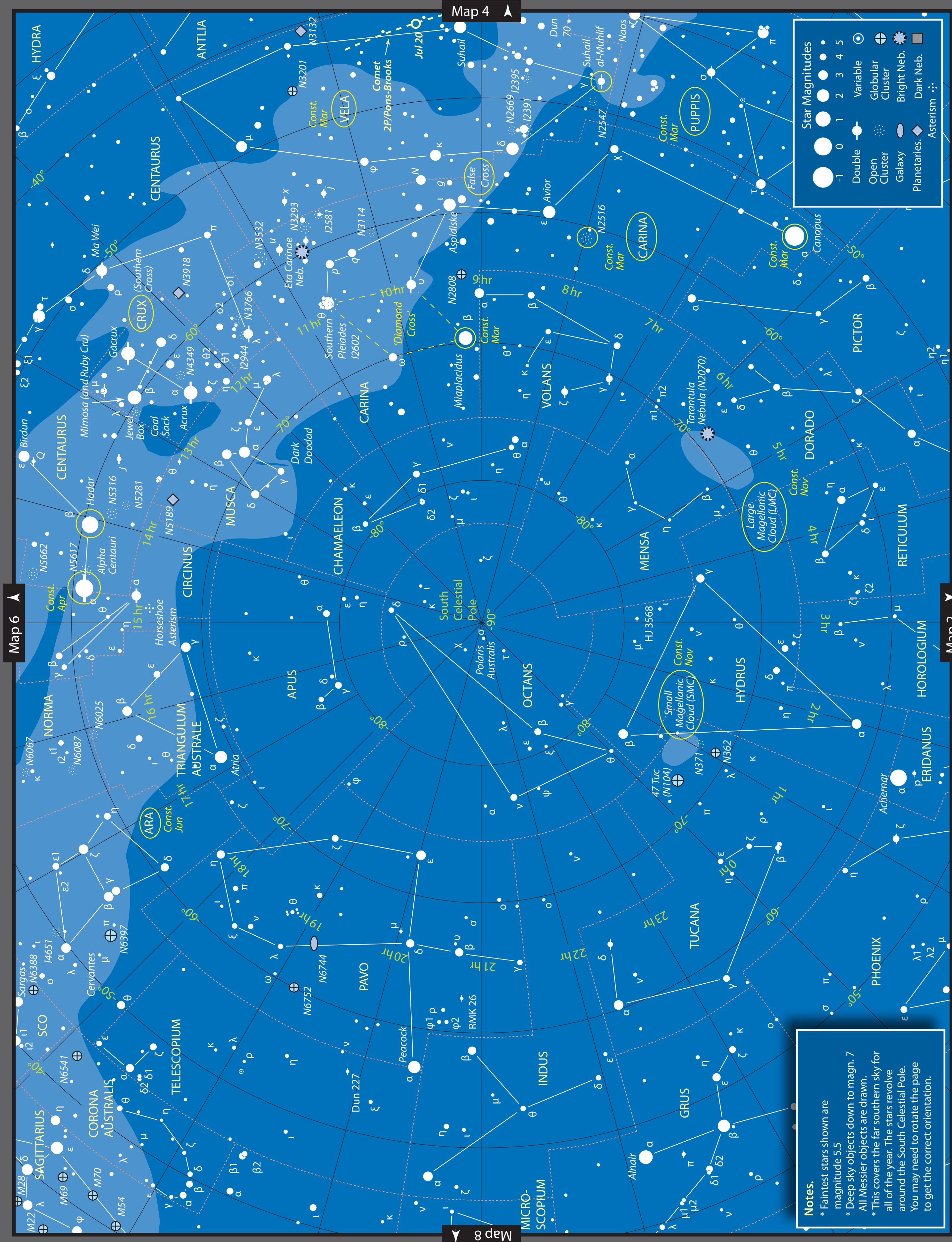
What else is shown on the maps?

- Deep sky objects down to magnitude 7 and all 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.
- Constellation lines. The orange dotted lines are the boundaries and the solid lines joining some of the brighter stars help us to recognise the constellation's pattern.
- A light blue shading shows the Milky Way and Magellanic Clouds.

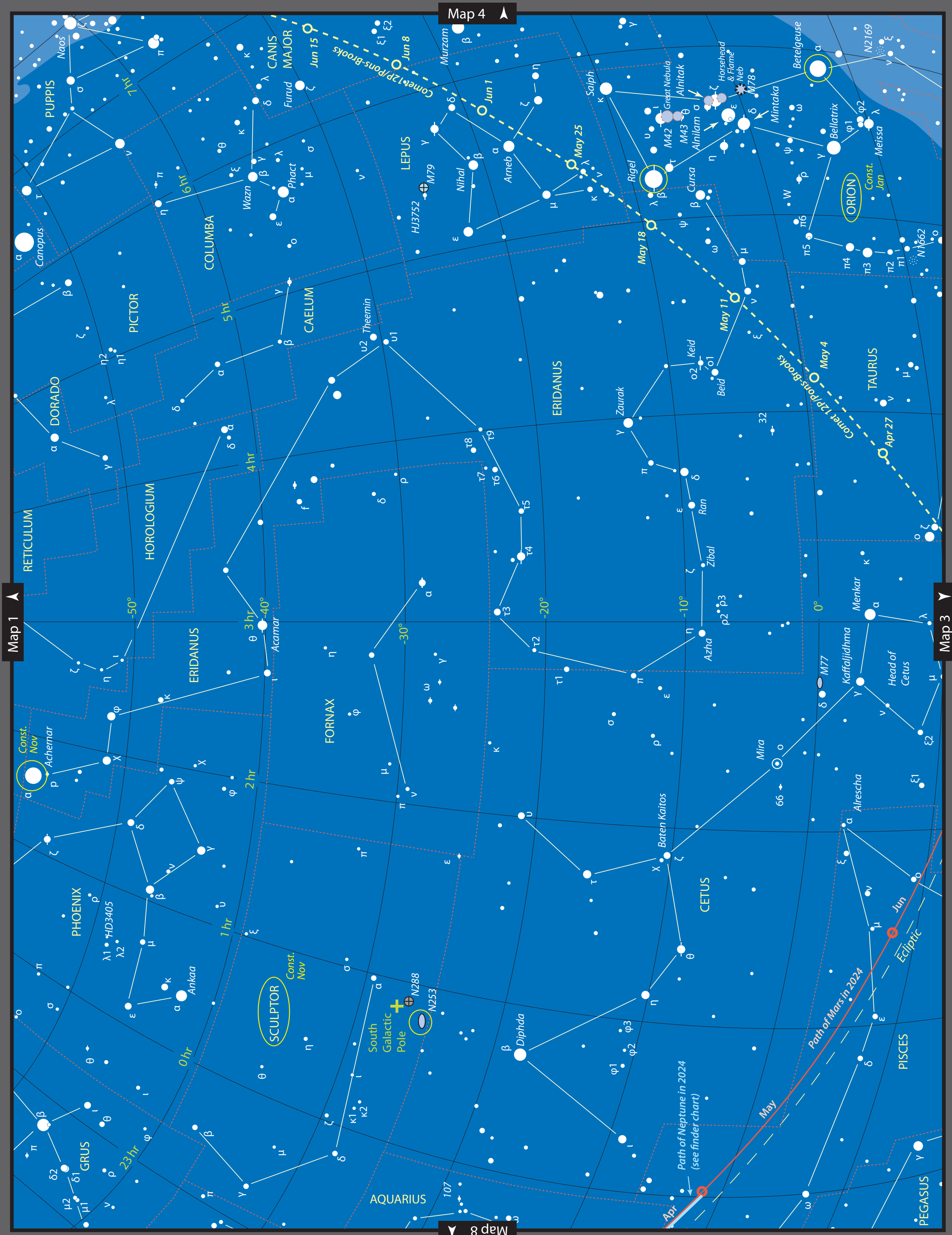
Special objects marked this year including constellations, deep sky objects and bright and double stars mentioned in the monthly 'constellations' section (objects are circled). When a comet listed this year (p. 133), is predicted to achieve around magnitude 10.0 or brighter it has been plotted for this part of its orbit.

*Western Australia, the Milky Way showing the dark squarish Coalsack Nebula.*
*Credit Dylan O'Donnell*

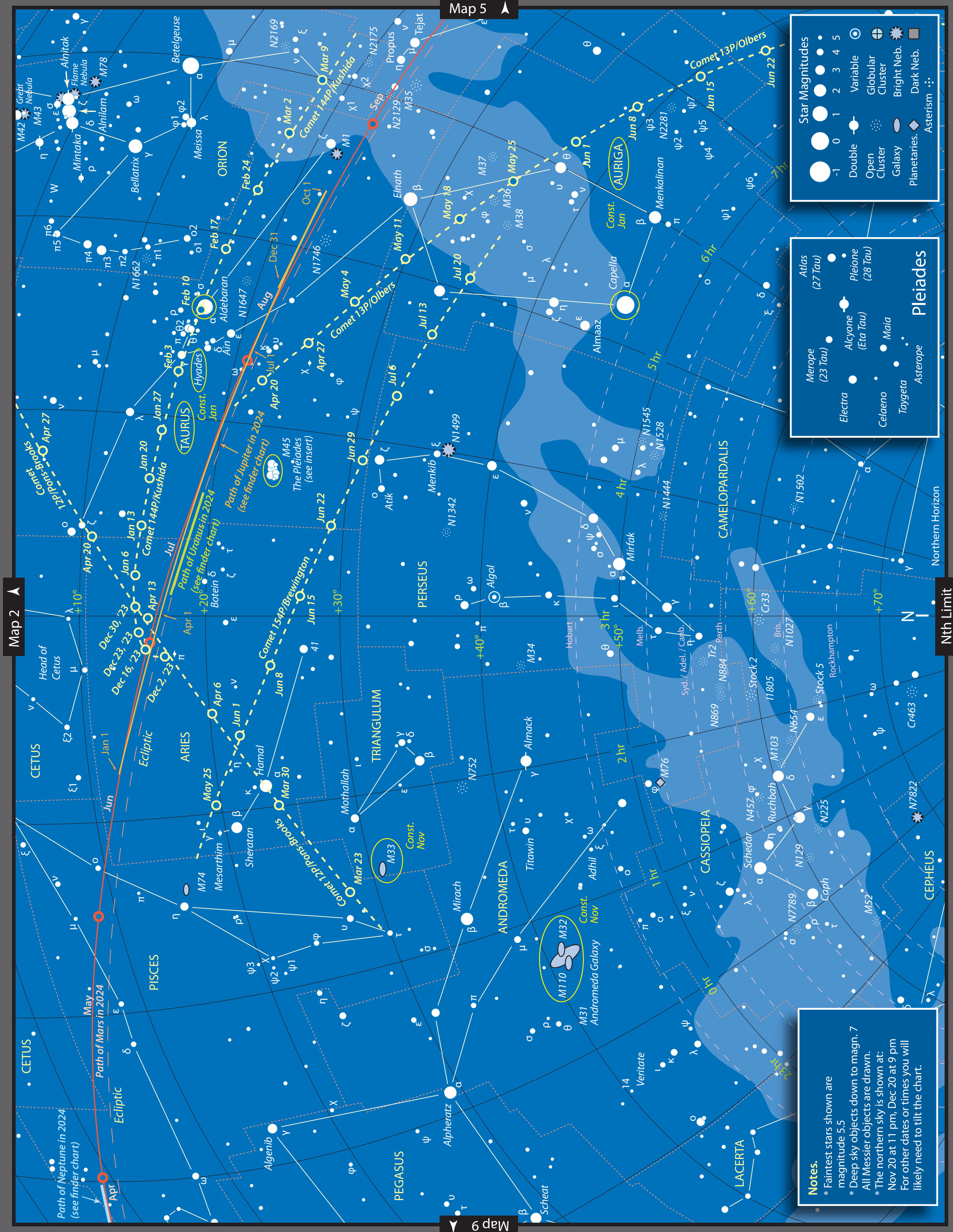
# Map 1 - Looking South



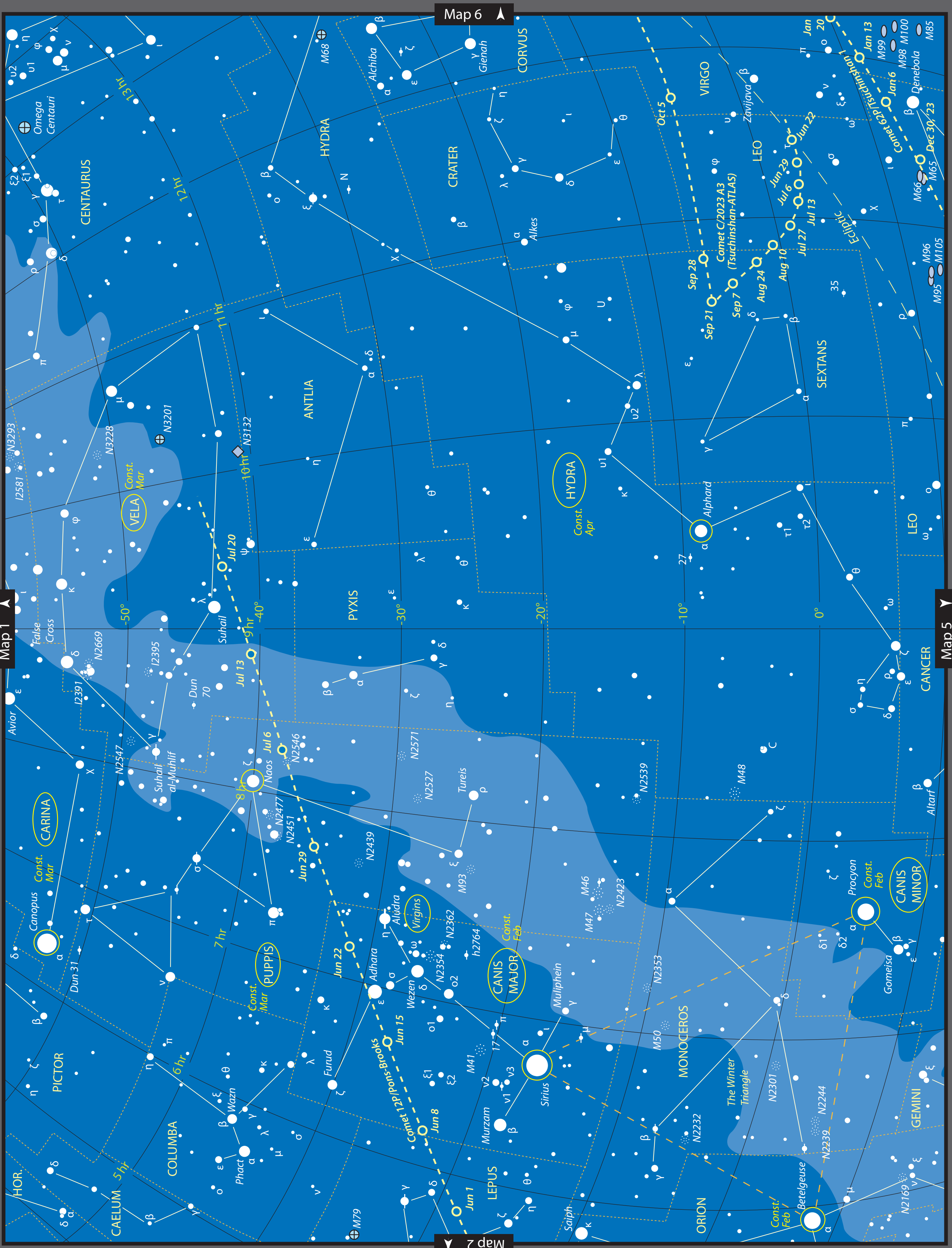
# Map 2 - Summer (Centre)



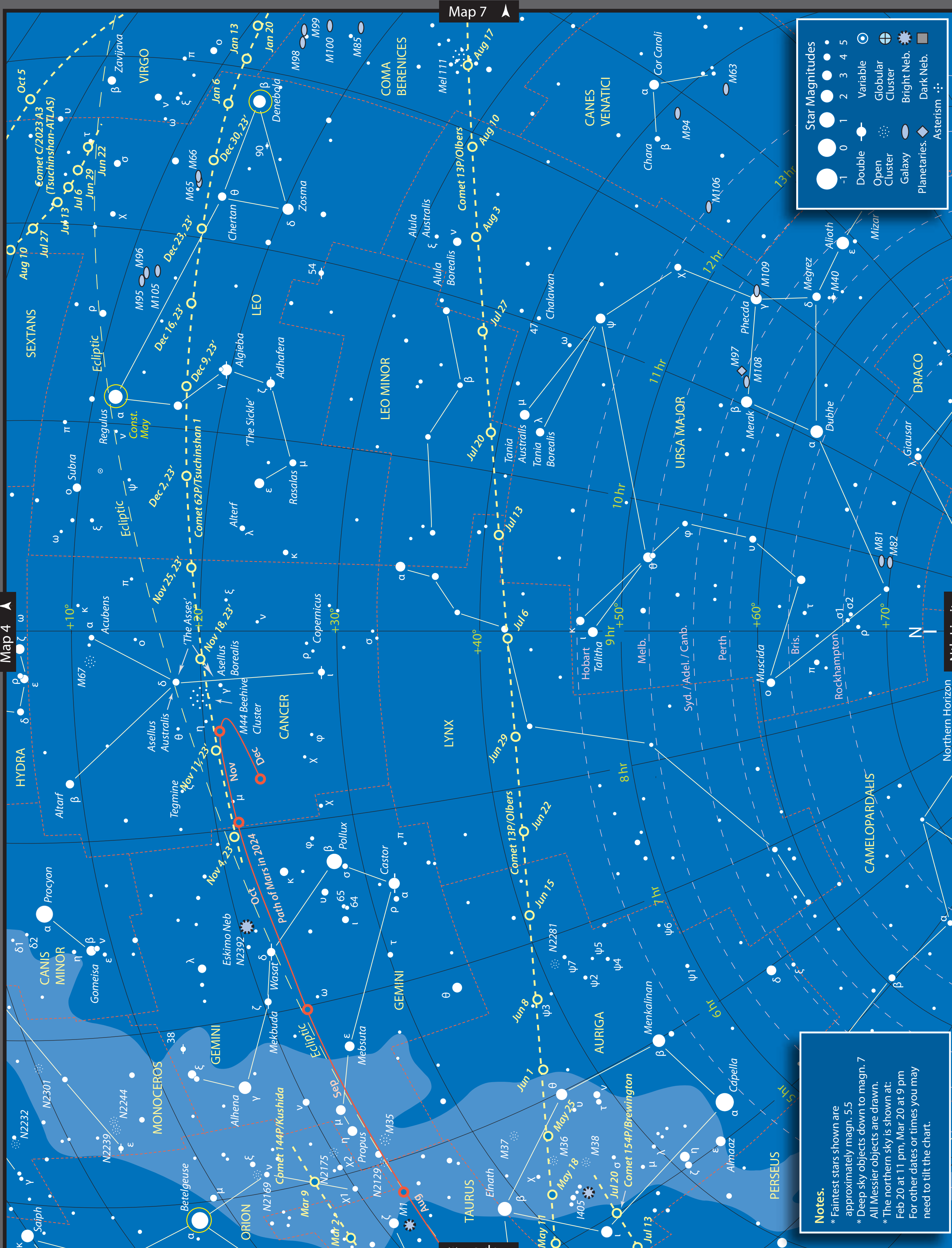
# Map 3 - Summer (North)



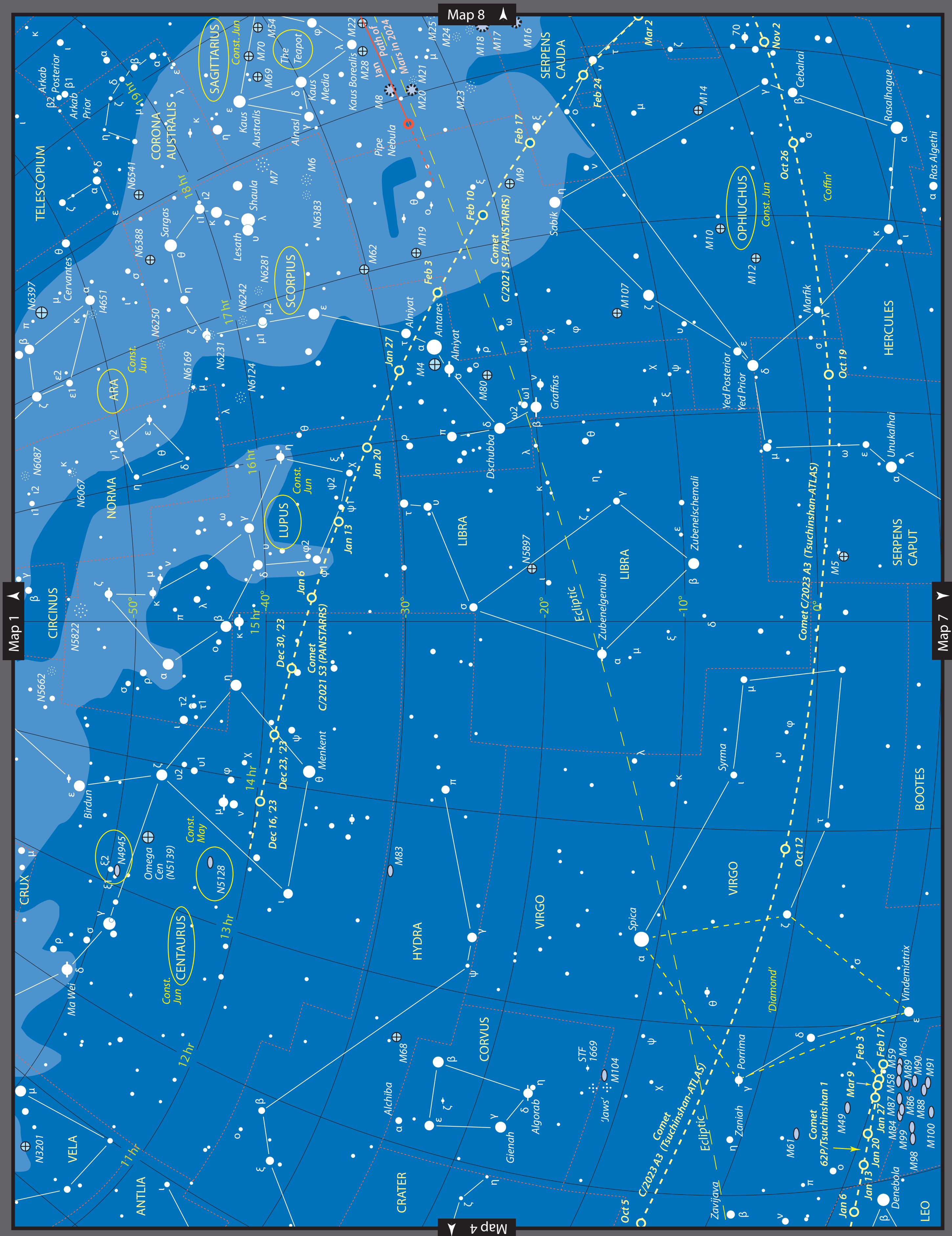
# Map 4 - Autumn (Centre)



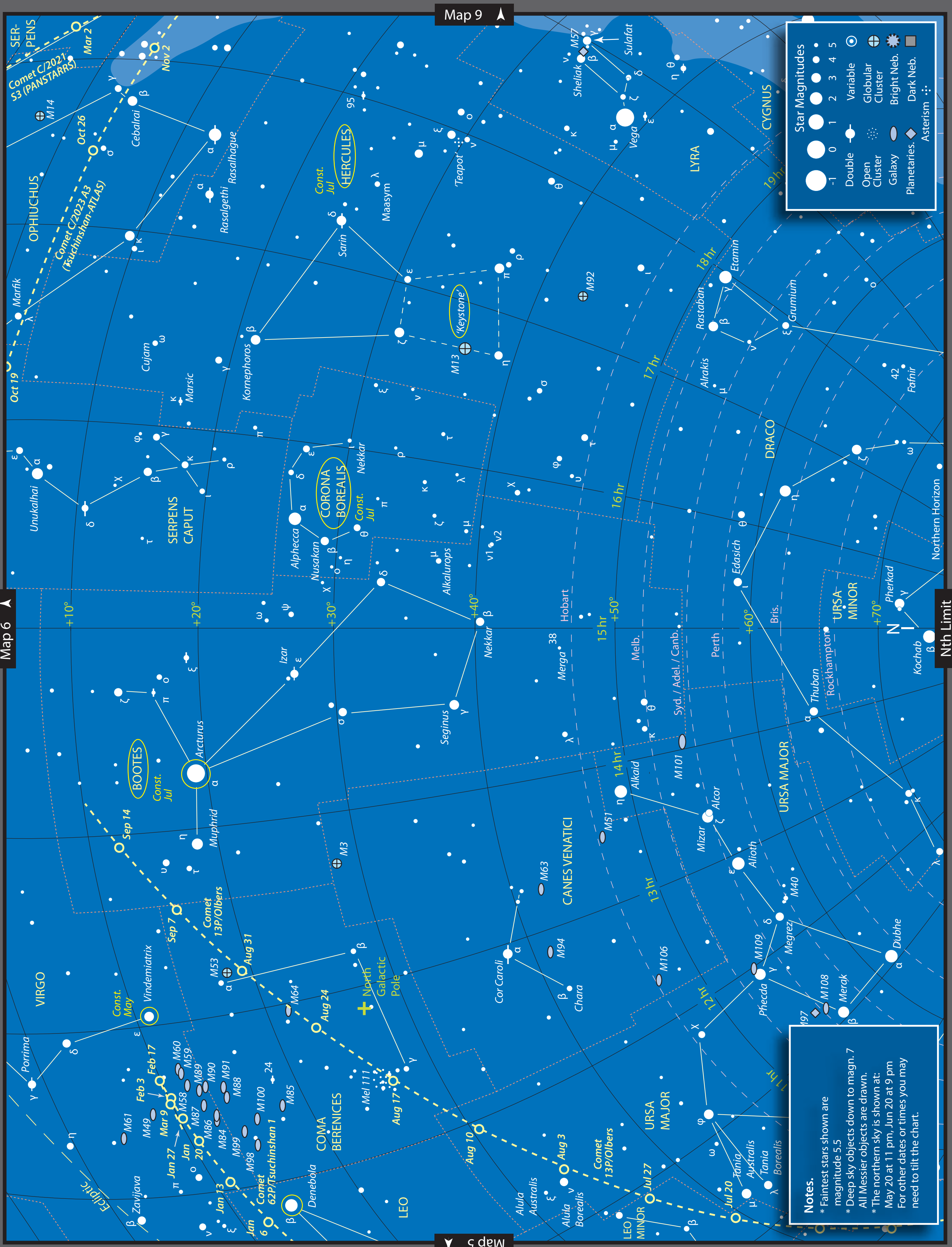
# Map 5 - Autumn (North)



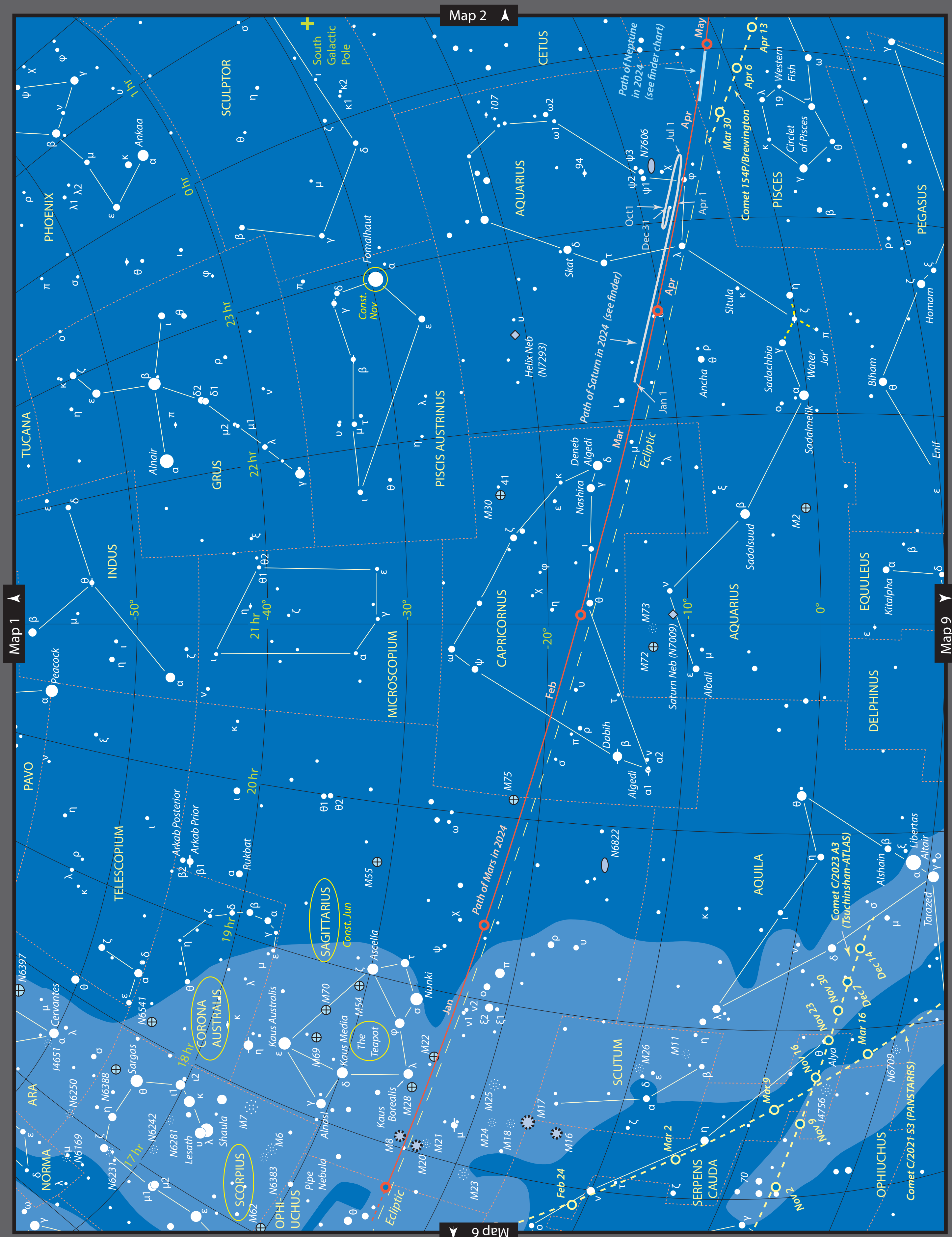
# Map 6 - Winter (Centre)



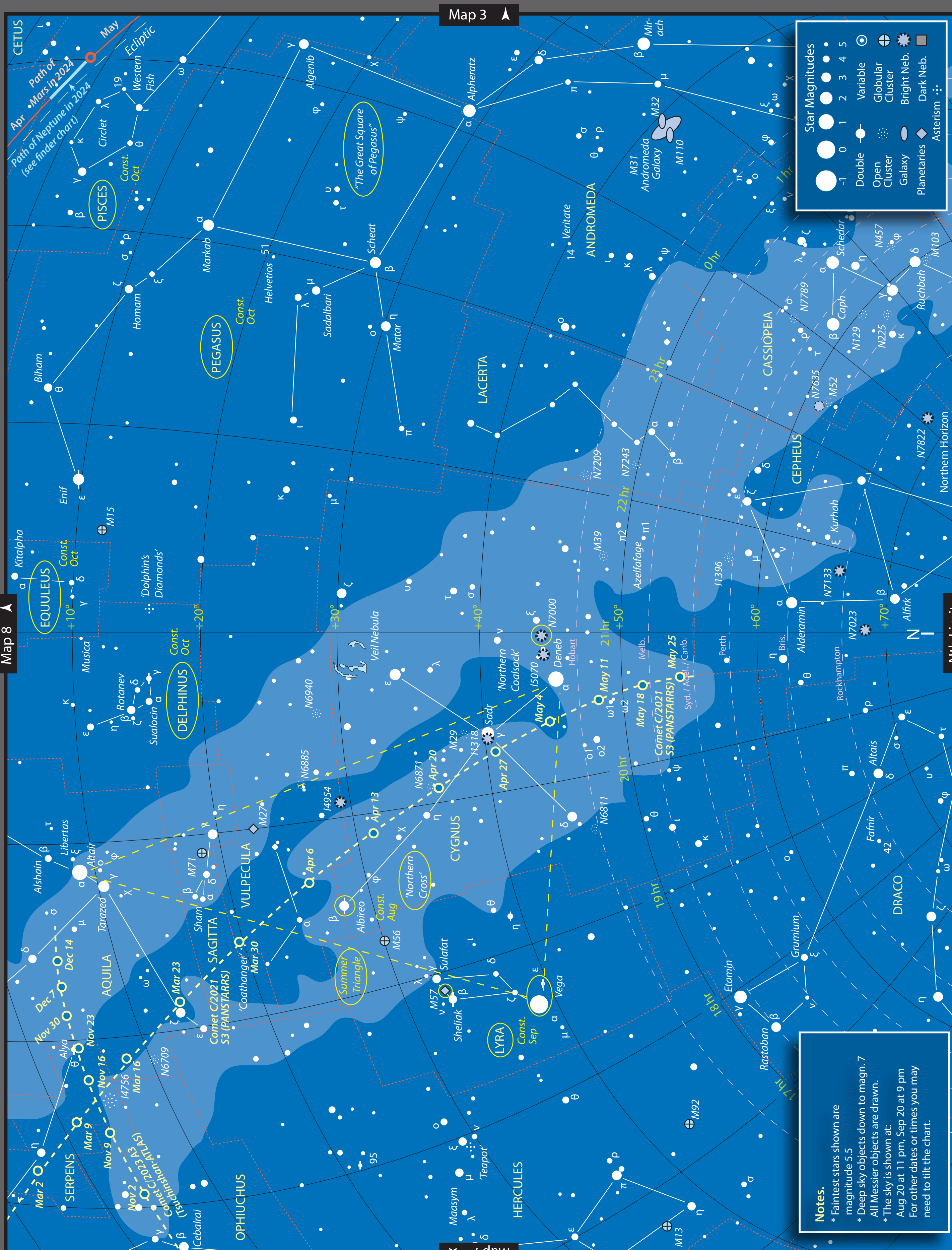
# Map 7 - Winter (North)



# Map 8 - Spring (Centre)



# Map 9 - Spring (North)



# PART II — THE SOLAR SYSTEM

This introduction is only brief, as 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). Local times are used wherever we have location specific data, such as the rise and set times of the Sun and Moon. 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, 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 for the Sun and Moon 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°, 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). 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 dwarf and minor planets and comets are given in weekly intervals and correspond to Saturdays. Positions for the Sun and Moon and planets are not included here, but are on our website. www.quasarastronomy.com.au

**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 Moon rise and set are daily with the Sun weekly and corresponding to Saturdays. Also see note on time zones under Time (above). Rise and set times for the planets are on our website. www.quasarastronomy.com.au

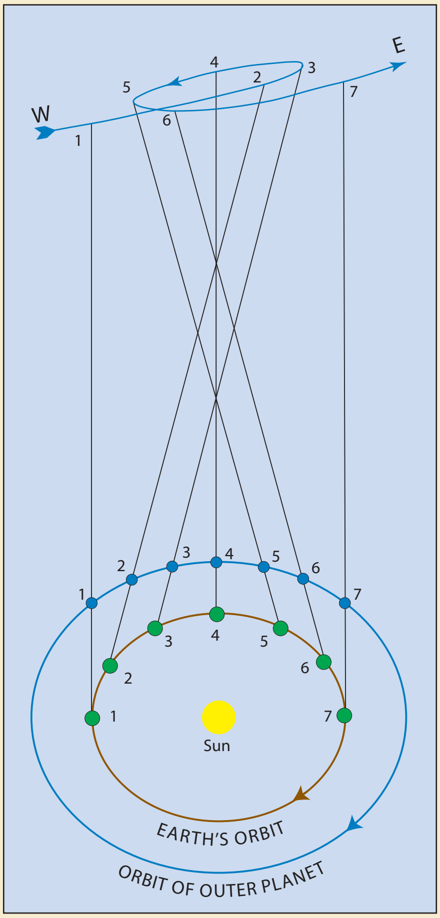
**Use of Star Atlases.** As the Earth orbits the Sun the polar axis, around which the stars appear to rotate (the celestial poles) appears to never change no matter what time of the year you are observing. However, the positions of the poles do slowly move against the star field. This is called precession and is caused by the Earth's axis slowly wobbling over thousands of years, like a spinning top slowing down. 'Epoch

## 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 around 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 with south up. 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.



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 and finder charts are Epoch 2000.0.

**Field of View in a Telescope**. The All Sky Maps and the finder charts are drawn with South up and east to the right to match the view from the Southern Hemisphere (in the sky, east and west are opposite to terrestrial maps). The satellite diagrams are drawn to traditional sky orientation, that is east to the left, and north to the top. For Binoculars (and the eyes) or straight Newtonians show this orientation (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-Cassegrain or traditional refractors causes this reversal.

**Finder Charts**. No finder charts are presented for Mercury or Venus. 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 no additional finder is needed. There are separate finder charts for Jupiter, Saturn, Uranus and Neptune and 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.

**Supermoons** The table below shows the so called supermoons for 2024. They occur when the time of the Moon's perigee (the point in its orbit when closest to the Earth) happens close to the time of Full Moon. This can be observed by comparing the dates (below) to those of perigee and Full Moon for the month of interest (see Moon section in Part I). As you can see, the Moon is not exactly super large and the effect is possibly enhanced by having the impressive fully illuminated globe close to the horizon with surrounding trees and buildings. This is known as the Moon Illusion.

**Downloads**. On our website we have a separate downloadable PDF for each of the eight locations on the opposite page. Each file includes daily geocentric positions of the Sun and Moon and weekly positions for the planets. It also has location specific planet rise and set times.

www.quasarastronomy.com.au

## FULL MOON at PERIGEE (Supermoon, UT)

| Date of FM [7] | Time of FM [1] | Geocentric Distance (km) | Geocentric Diameter (arcminutes) | Relative Distance [2] | Relative Brightness [3] | Date of Perigee [4] | Time of Perigee [1] | Nearest Perigee [5] |
|---|---|---|---|---|---|---|---|---|
| Aug 19 | 18:26 | 361,970 | 33.01 | 0.961 | 1.254/1.128 | Aug 21 | 05:05 | 1.444 |
| Sep 18 [p] | 02:34 | 357,486 | 33.43 | 0.996 | 1.291/1.156 | Sep 18 | 13:26 | 0.453 |
| Oct 17 | 11:26 | 357,364 [6] | 33.44 | 0.996 | 1.292/1.157 | Oct 17 | 00:46 | –0.445 |
| Nov 15 | 21:29 | 361,867 | 33.02 | 0.961 | 1.254/1.128 | Nov 14 | 11:18 | –1.424 |

1: Time given is UT, add 10 hours for EST, 9.5 hours for CST and 8 hours for WST.

2: The relative distance is equal to 1 when the Full Moon occurs at perigee and 0 when FM occurs at apogee. Any FM occuring at a relative distance of 0.9 or greater is by definition a supermoon.

3: The relative brightness is composed of two values that express that of the Full Moon relative to its brightness at the current apogee (left) and at its mean distance (right). A supermoon is typically 1.3 times (or 30%) brighter than a Full Moon at apogee, and 1.15 times (or 15%) brighter than a Full Moon at the Moon's mean distance.

4: The date of the nearest perigee.

5: Nearest perigee gives the time difference (in days) between nearest perigee and Full Moon. Note that the Full Moon occurs within two days of perigee for most supermoons.

6: The closest Full Moon perigee syzygy of the year.

7: Lunar eclipse (t total, p partial, n penumbral).

## MOON PHASE (UT)

| Lunation | New Moon | | First Quarter | | Full Moon | | Last Quarter | |
|---|---|---|---|---|---|---|---|---|
| 1249 | | | | | | | Jan 4 | 03:30 |
| 1250 | Jan 11 | 11:57 | Jan 18 | 03:53 | Jan 25 | 17:54 | Feb 2 | 23:18 |
| 1251 | Feb 9 | 22:59 | Feb 16 | 15:01 | Feb 24 | 12:30 | Mar 3 | 15:23 |
| 1252 | Mar 10 | 09:00 | Mar 17 | 04:11 | Mar 25 | 07:00 | Apr 2 | 03:15 |
| 1253 | Apr 8 | 18:21 | Apr 15 | 19:13 | Apr 23 | 23:49 | May 1 | 11:27 |
| 1254 | May 8 | 03:22 | May 15 | 11:48 | May 23 | 13:53 | May 30 | 17:13 |
| 1255 | Jun 6 | 12:38 | Jun 14 | 05:18 | Jun 22 | 01:08 | Jun 28 | 21:53 |
| 1256 | Jul 5 | 22:57 | Jul 13 | 22:49 | Jul 21 | 10:17 | Jul 28 | 02:52 |
| 1257 | Aug 4 | 11:13 | Aug 12 | 15:19 | Aug 19 | 18:26 | Aug 26 | 09:26 |
| 1258 | Sep 3 | 01:56 | Sep 11 | 06:06 | Sep 18 | 02:34 | Sep 24 | 18:50 |
| 1259 | Oct 2 | 18:49 | Oct 10 | 18:55 | Oct 17 | 11:26 | Oct 24 | 08:03 |
| 1260 | Nov 1 | 12:47 | Nov 9 | 05:55 | Nov 15 | 21:28 | Nov 23 | 01:28 |
| 1261 | Dec 1 | 06:21 | Dec 8 | 15:27 | Dec 15 | 09:02 | Dec 22 | 22:18 |
| 1262 | Dec 30 | 22:27 | | | | | | |

## PERIGEE AND APOGEE (UT)

| Apogee | | | Perigee | | |
|---|---|---|---|---|---|
| Date | Time | Distance (km) | Date | Time | Distance (km) |
| Jan 1 | 15:28 | 404,909 | Jan 13 | 10:36 | 362,267 |
| Jan 29 | 08:14 | 405,777 | Feb 10 | 18:53 | 358,088 |
| Feb 25 | 14:59 | 406,312 | Mar 10 | 07:04 | 356,895 |
| Mar 23 | 15:45 | 406,294 | Apr 7 | 17:51 | 358,850 |
| Apr 20 | 02:10 | 405,623 | May 5 | 22:04 | 363,163 |
| May 17 | 18:59 | 404,640 | Jun 2 | 07:16 | 368,102 |
| Jun 14 | 13:35 | 404,077 | Jun 27 | 11:30 | 369,286 |
| Jul 12 | 08:11 | 404,362 | Jul 24 | 05:41 | 364,917 |
| Aug 9 | 01:31 | 405,297 | Aug 21 | 05:02 | 360,196 |
| Sep 5 | 14:54 | 406,211 | Sep 18 | 13:22 | 357,286 |
| Oct 2 | 19:39 | 406,516 | Oct 17 | 00:51 | 357,175 |
| Oct 29 | 22:50 | 406,161 | Nov 14 | 11:16 | 360,109 |
| Nov 26 | 11:56 | 405,314 | Dec 12 | 13:20 | 365,361 |
| Dec 24 | 07:25 | 404,485 | | | |

## GEOCENTRIC PHENOMENA (UT)

| Planet | Stationary | Greatest Elongation West | Superior Conjunction | Greatest Elongation East | Stationary | Inferior Conjunction |
|---|---|---|---|---|---|---|
| Mercury | 2 Jan, 4 h<br>24 Apr, 8 h<br>28 Aug, 3 h<br>15 Dec, 21 h | 12 Jan, 15 h (23.5°)<br>9 May, 21 h (26.4°)<br>5 Sep, 3 h (18.1°)<br>25 Dec, 3 h (22.0°) | 28 Feb, 9 h<br>14 Jun, 17 h<br>30 Sep, 21 h | 24 Mar, 23 h (18.7°)<br>22 Jul, 7 h (26.9°)<br>16 Nov, 8 h (22.6°) | 1 Apr, 20 h<br>4 Aug, 8 h<br>26 Nov, 4 h | 11 Apr, 23 h<br>19 Aug, 2 h<br>6 Dec, 2 h |
| Venus | | | 4 Jun, 16 h | | | |

| Planet | Stationary | Conjunction | Stationary | Opposition | Stationary |
|---|---|---|---|---|---|
| Mars | | | | | 7 Dec, 21 h |
| Jupiter | | 18 May, 19 h | 9 Oct, 7 h | 7 Dec, 21 h | |
| Saturn | | 28 Feb, 21 h | 30 Jun, 21 h | 8 Sep, 5 h | 16 Nov, 6 h |
| Uranus | 27 Jan, 11 h | 13 May, 9 h | 1 Sep, 16 h | 17 Nov, 3 h | |
| Neptune | | 17 Mar, 11 h | 3 Jul, 3 h | 20 Sep, 24 h | 8 Dec, 11 h |

| Earth | |
|---|---|
| Perihelion | 3 Jan, 1 h |
| Equinox | 20 Mar, 3 h |
| Solstice | 20 Jun, 21 h |
| Aphelion | 5 Jul, 5 h |
| Equinox | 22 Sep, 13 h |
| Solstice | 21 Dec, 9 h |

## HELIOCENTRIC PHENOMENA (UT)

| Planet | Aphelion | Perihelion | Descending Node | Greatest Latitude South | Ascending Node | Greatest Latitude North |
|---|---|---|---|---|---|---|
| Mercury | Feb 2 | Mar 17 | Jan 23 | Feb 22 | Mar 13 | Mar 27 |
| Mercury | Apr 30 | Jun 13 | Apr 20 | May 20 | Jun 8 | Jun 23 |
| Mercury | Jul 27 | Sep 9 | Jul 17 | Aug 16 | Sep 4 | Sep 19 |
| Mercury | Oct 23 | Dec 6 | Oct 13 | Nov 12 | Dec 1 | Dec 16 |
| Venus | May 19 | Jul 10 | Feb 13 | Apr 10 | Jun 6 | Jul 31 |
| Venus | Oct 30 | | Sep 25 | Nov 21 | | |
| Mars | | May 8 | | Apr 11 | Sep 6 | |
| Jupiter, Saturn, Uranus, and Neptune have no events in 2024 | | | | | | |

## SOLAR SYSTEM DATA – SUN, MOON, PLANETS

| | Sun | Moon | Mercury | Venus | Earth | Mars | Jupiter | Saturn | Uranus | Neptune |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean Distance from Sun (× $10^3$ km) | - | - | 57856 | 108132 | 149492 | 227780 | 777776 | 1425983 | 2867760 | 4492800 |
| Mean Distance from Sun (Earth = 1) | - | - | 0.387 | 0.723 | 1.000 | 1.524 | 5.203 | 9.540 | 19.180 | 30.700 |
| 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 |
| Equatorial Diameter (km) | 1392530 | 3474.8 | 4879.4 | 12103.6 | 12756.3 | 6792.4 | 142984 | 120536 | 51118 | 49528 |
| Flattening [1] | 0 | 0 | 0 | 0 | 0.00335281 | 0.005886 | 0.064874 | 0.097962 | 0.022927 | 0.017081 |
| No of Moons | - | - | 0 | 0 | 1 | 2 | 95 | 146 | 27 | 14 |
| Mass (× $10^{24}$ kg) | $1.9884 \times 10^{30}$ | 0.073458 | 0.3301 | 4.8673 | 5.9721986 | 0.64169 | 1898.1 | 568.31 | 86.809 | 102.41 |
| Mass (Earth = 1) | 332946 | 0.012300 | 0.0553 | 0.8150 | 1.0000000 | 0.10745 | 317.8 | 95.16 | 14.536 | 17.148 |
| Volume (Earth = 1) | 1300000 | 0.02 | 0.06 | 0.86 | 1 | 0.15 | 1323 | 752 | 64 | 54 |
| 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 |
| Synodic Period (Days) [3] | - | 29.4 | 115.8 | 583.9 | - | 779.8 | 398.8 | 378.0 | 369.7 | 367.5 |
| 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 |
| Albedo [5] | - | 0.12 | 0.106 | 0.65 | 0.367 | 0.150 | 0.52 | 0.47 | 0.51 | 0.41 |
| Eccentricity [6] | - | 0.0549 | 0.20562 | 0.00681 | 0.01681 | 0.09333 | 0.04837 | 0.05582 | 0.0471 | 0.00855 |
| 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" |
| Obliquity [8] | 7° 15' [10] | 6° 41' | 0° 01' | 2° 38' | 23° 26' | 25° 11' | 3° 07' | 26° 45' | 82° 14' | 28° 20' |

Notes (above and opposite):

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
17 Maximum elongation at mean opposition

The satellite table (right) covers most of those currently known. Not included are the 80 new satellites confirmed for Jupiter and Saturn in 2023, most extremely faint and small.

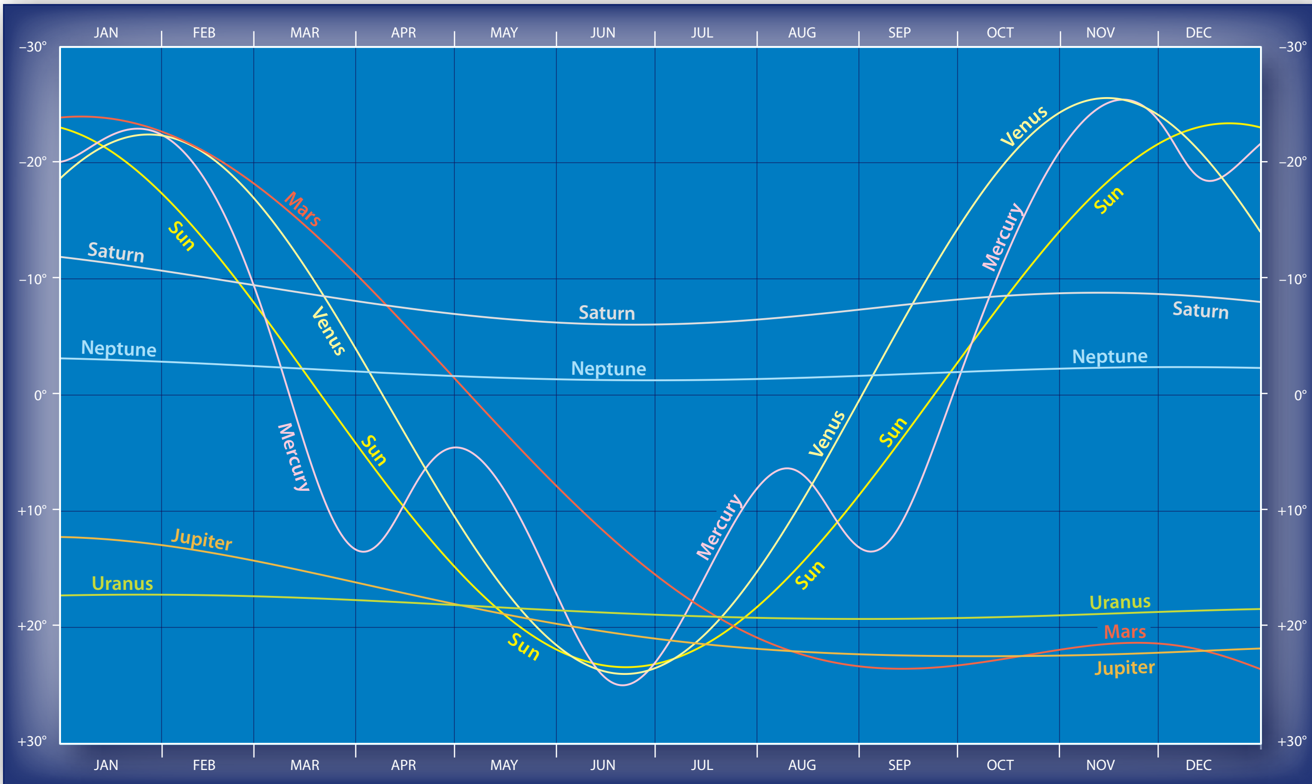
Satellites that have not been named yet, have a preliminary designation such as S/2009 S1. For more detail on the newer ones, see Scott Sheppard's page sites.google.com/carnegiescience.edu/sheppard/home

# SOLAR SYSTEM DATA — SATELLITES



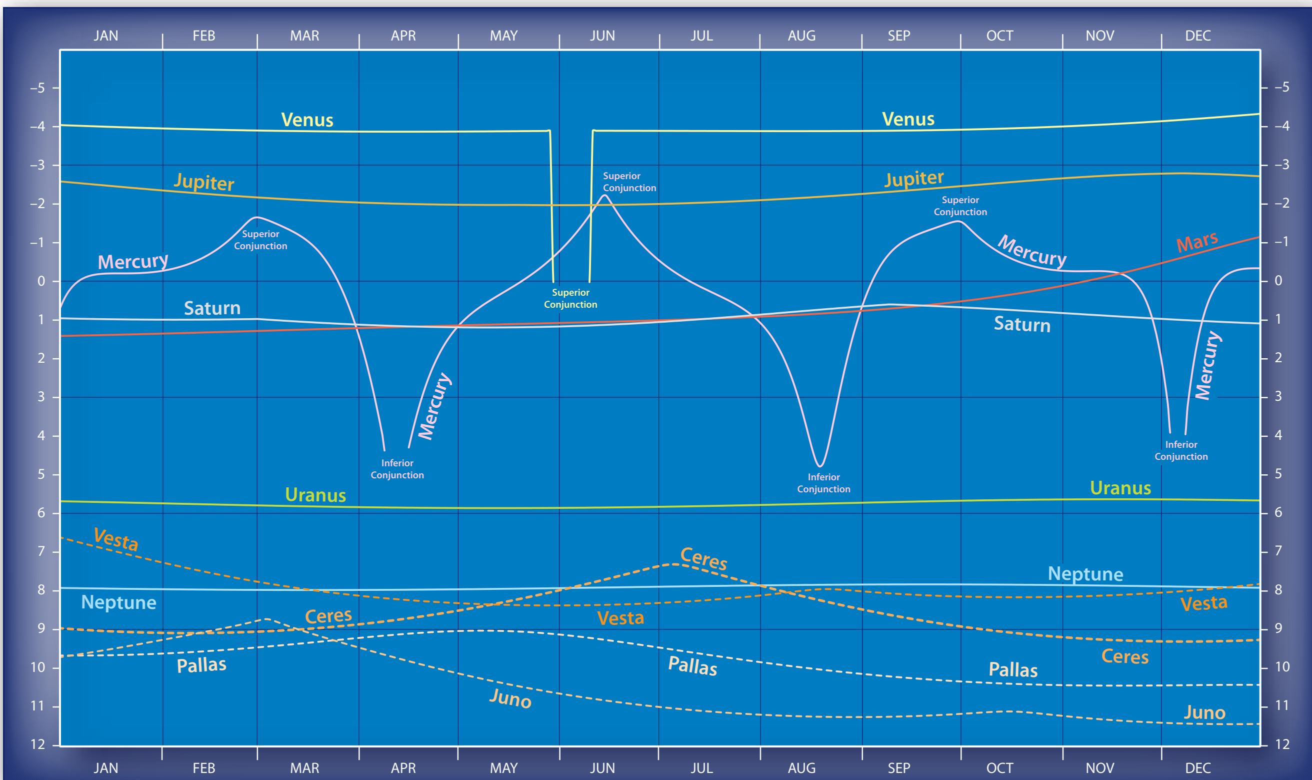
| SATELLITE | ORBITAL PERIOD (days) | SEP[17] | SEMI MAJOR AXIS (x $10^3$km) | RADIUS (km) | MAG AT OPP |
|---|---|---|---|---|---|
| **Earth** | | | | | |
| Moon | 27.321661 | | 384.400 | 1,737.4 | –12.74 |
| **Mars** | | | | | |
| Phobos | 0.31891023 | 25" | 9.380 | 13.4× 11.2× 9.2 | 11.9 |
| Deimos | 1.2624407 | 1.0' | 23.460 | 7.5×6.1×5.2 | 13.0 |
| **Jupiter** | | | | | |
| Metis | 0.295 | 42" | 128 | 30×20×17 | 17.5 |
| Adrastea | 0.298 | 42" | 129 | 10×8×7 | 18.7 |
| Amalthea | 0.49817908 | 59" | 181.4 | 125× 73× 64 | 14.1 |
| Thebe | 0.675 | 1.2' | 221.9 | 58×49×42 | 16 |
| Io | 1.769137761 | 2.3' | 421.8 | 1829 × 1819 × 1816 | 5 |
| Europa | 3.551181055 | 3.7' | 671.1 | 1563 × 1560 × 1560 | 5.3 |
| Ganymede | 7.15455325 | 5.9' | 1070.4 | 2631.2 | 4.6 |
| Callisto | 16.689017 | 10.3' | 1882.7 | 2410.3 | 5.7 |
| Themisto | 130.02 | 40.7' | 7504 | 4 | 21.0[R] |
| Leda | 240.93 | 1.02° | 11164 | 5[15] | 19 |
| Himalia | 250.56 | 1.04° | 11460 | 85 | 14.6 |
| Ersa | 252 | | 11483 | 3[15] | 22.9 |
| Pandia | 252.1 | | 11525 | 3[15] | 23 |
| Lysithea | 259.2 | 1.07° | 11717 | 12[15] | 18.3 |
| Elara | 259.64 | 1.07° | 11740 | 40 | 16.3 |
| Dia | 287 | 1.10° | 12118 | 1.0[15] | 22.4 |
| Carpo | 456.28 | 1.55° | 17056.04 | 1.5[15] | 23 |
| S/2003 J12 | 489.67 | 1.82° | 17830 | 0.5 | 23.9[R] |
| Valetudo | 533.3 | | 18980 | 1[15] | 24 |
| Euporie | 550.69[16] | 1.78° | 19336 | 1.0[15] | 23.1 |
| Eupheme | 583.87 | 1.74° | 20221 | 1.0[15] | 23.4[R] |
| S/2003 J18 | 598.13 | 2° | 20508 | 1.0[15] | 23.4[R] |
| S/2017 J7 | 602.6 | | 20627 | 2[15] | 23.6 |
| S/2016 J1 | 602.7 | | 20651 | 0.5 | 24 |
| S/2017 J3 | 606.3 | | 20694 | 2[15] | 23.4 |
| S/2010 J2 | 618.84 | | 21004 | 1.0[15] | 24.0[R] |
| Mneme | 620.05[16] | 1.87° | 21033 | 1.0[15] | 23.3 |
| Euanthe | 620.45[16] | 1.91° | 21039 | 1.5[15] | 22.8 |
| Helike | 626.33[16] | 1.87° | 21065 | 2.0[15] | 22.6 |
| S/2003 J16 | 622.88 | 1.98° | 21097 | 1.0[15] | 23.3[R] |
| Harpalyke | 623.32[16] | 1.91° | 21106 | 2.2[15] | 22.2 |
| Praxidike | 625.39[16] | 1.92° | 21148 | 3.4[15] | 22.5 |
| Orthosie | 622.58[16] | 1.90° | 21158 | 1.0[15] | 23.1 |
| Thelxinoe | 628.03[16] | 1.94° | 21160 | 1.0[15] | 23.5 |
| Thyone | 627.19[16] | 1.89° | 21197 | 2.0[15] | 22.3 |
| Ananke | 629.80[16] | 1.92° | 21254 | 10[15] | 18.8 |
| Iocaste | 631.6[16] | 1.88° | 21272 | 2.6[15] | 22.5 |
| Hermippe | 633.91[16] | 1.92° | 21297 | 2.0[15] | 22.1 |
| S/2017 J9 | 639.2 | | 21487 | 3[15] | 22.8 |
| S/2017 J6 | 683 | | 22455 | 2[15] | 23.5 |
| hilophrosyne | 689.78 | 2.13° | 22627 | 1.0[15] | 23.5[R] |
| S/2003 J10 | 716.25 | 2.33° | 23042 | 1.0[15] | 23.6[R] |
| Pasithee | 719.47[16] | 2.17° | 23091 | 1 .0[15] | 23.2 |
| Herse | 715.4[16] | 2.10° | 23097 | 1.0[15] | 23.4 |
| S/2011 J2 | 718.37 | | 23124 | 1[15] | 23.5[R] |
| Eurydome | 717.31[16] | 2.17° | 23146 | 1.5[15] | 22.7 |
| Chaldene | 723.73[16] | 1.85° | 23181 | 1.9[15] | 22.5 |
| Isonoe | 726.26[16] | 2.08° | 23231 | 1.9[15] | 22.5 |
| S/2017 J5 | 719.5 | | 23232 | 2[15] | 23.5 |
| S/2017 J8 | 719.6 | | 23233 | 1[15] | 24 |
| Kallichore | 728.23[16] | 2.03° | 23276 | 1.0[15] | 23.7 |
| Erinome | 728.49[16] | 1.99° | 23286 | 1.6[15] | 22.8 |
| S/2017 J2 | 723.1 | | 23303 | 2[15] | 23.5 |
| Kale | 729.61[16] | 2.03° | 23306 | 1.0[15] | 23 |
| Aitne | 730.12[16] | 2.03° | 23317 | 1.5[15] | 22.7 |
| Eukelade | 730.33[16] | 2.14° | 23323 | 2.0[15] | 22.6 |
| Arche | 731.9[16] | 2.16° | 23352 | 1.5[15] | 22.8 |
| Taygete | 732.42[16] | 1.97° | 23363 | 2.5[15] | 22.9 |
| S/2003 J9 | 733.32 | 2.16° | 23385 | 0.5[15] | 23.7[R] |
| Carme | 734.17[16] | 2.12° | 23401 | 15[15] | 17.6 |
| S/2011 J1 | 736.35 | | 23446 | 1[15] | 23.7[R] |
| S/2010 J1 | 736.5 | | 23449 | 1[15] | 23.2[R] |
| Eirene | 738.75 | 2.32° | 23495 | 2[15] | 22.4[R] |
| S/2003 J19 | 740.41 | 2.2° | 23533 | 1[15] | 23.7[R] |
| S/2017 J1 | 734.2 | | 23547 | 1[15] | 23.8 |
| Kalyke | 742.04[16] | 2.20° | 23565 | 2.6[15] | 21.8 |
| S/2003 J23 | 732.46 | 2.32° | 23567 | 1[15] | 23.6[R] |
| Hegemone | 739.82[16] | 2.10° | 23575 | 1.5[15] | 22.8 |
| Pasiphae | 743.61[16] | 2.16° | 23629 | 18[15] | 17 |
| Sponde | 748.32[16] | 2.05° | 23790 | 1.0[15] | 23 |
| Cyllene | 737.80[16] | 2.14° | 23800 | 1.0[15] | 23.2 |
| Megaclite | 752.88[16] | 2.14° | 23814 | 2.7[15] | 22.1 |
| S/2003 J4 | 755.25 | 2.24° | 23929 | 1[15] | 23.0[R] |
| Sinope | 758.89[16] | 2.17° | 23942 | 14[15] | 18.1 |
| Aoede | 761.41[16] | 2.16° | 23974 | 2.0[15] | 22.5 |
| Autonoe | 761.01[16] | 2.22° | 24037 | 2.0[15] | 22 |
| Callirrhoe | 758.82[16] | 2.24° | 24099 | 4.3[15] | 20.7 |
| Kore | 776.84[16] | 2.27° | 24482 | 1.0[15] | 23.6 |
| S/2003 J2 | 980.53 | 2.71° | 28347 | 1[15] | 23.2[R] |
| **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 | 27[R] |
| 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 | 1.0' | 377.20 | 1.3 | 24.8 |
| Helene | 2.737 | 1.0' | 377.42 | 16.5 | 18.4 |
| Dione | 2.736914742 | 1.0' | 377.65 | 562 | 10.4 |
| Rhea | 4.517500436 | 1.4' | 527.37 | 764 | 9.7 |
| Titan | 15.94542068 | 3.3' | 1,221.80 | 2,575 | 8.4 |
| Hyperion | 21.2766088 | 4.0' | 1,481.10 | 164× 130× 107 | 14.4 |
| Iapetus | 79.3301825 | 9.6' | 3,561.85 | 736 | 11.0 |
| Kiviuq | 449.2 | 30.5' | 11,319.01 | 8[15] | 22.7 |
| Ijiraq | 451.4 | 30.6' | 11,359.25 | 6[15] | 22.6 |
| Phoebe | 548.2[16] | 34.7' | 12,893.24 | 110 | 16.7 |
| Paaliaq | 686.9 | 40.3' | 14,985.05 | 13[15] | 21.0 |
| Skathi | 728.2[16] | 41.6' | 15,471.94 | 4[15] | 23.6 |
| S/2004 S37 | 752.88 | | 16003.3 | 2[15] | 25.1 |
| Albiorix | 783.5 | 44.4' | 16,495.93 | 16[15] | 20.5 |
| S/2007 S2 | 799.8975 | 0.78° | 16,560 | 3 | 24.4 |
| Bebhionn | 834.8 | 45.6' | 16,950.00 | 3[15] | 24.1 |
| S/2004 S31 | 853.80 | | 17402.8 | 2[15] | 24.9 |
| S/2004 S29 | 858.77 | | 17470.7 | 2[15] | 24.9 |
| Skoll | 878.3[16] | 47.4' | 17,610.00 | 3[15] | 24.5 |
| Erriapus | 871.2 | 47.9' | 17,807.71 | 5[15] | 23.9 |
| Tarqeq | 887.5 | 48.2' | 17,920.00 | 3.5[15] | 23.9 |
| Tarvos | 926.2 | 48.4' | 17,977.24 | 7[15] | 22.3 |
| Greip | 921.2[16] | 48.7' | 18,105.00 | 3[15] | 24.4 |
| Siarnaq | 895.6 | 49.0' | 18,201.44 | 21[15] | 20.4 |
| Hyrrokkin | 931.8[16] | 49.0' | 18,217.13 | 4[15] | 23.5 |
| Mundilfari | 952.6[16] | 49.5' | 18,412.67 | 3[15] | 23.8 |
| S/2004 S13 | 905.82 | 0.88° | 18,450 | 3 | 24.5 |
| S/2004 S17 | 913.125 | 0.89° | 18,600 | 2 | 25.2 |
| Bergelmir | 1,005.9[16] | 50.4' | 18,750.00 | 3[15] | 24.2 |
| S/2006 S1 | 971.565 | 54' | 18,981.135 | 3 | 24.6 |
| Narvi | 1,003.9[16] | 51.5' | 19,140.48 | 2.5[15] | 23.8 |
| Suttungr | 1,016.7[16] | 51.6' | 19,185.70 | 4[15] | 23.9 |
| Gridr | 990.23 | | 19211 | 2[15] | 25.0 |
| Aegir | 1,116.5[16] | 52.1' | 19,350.00 | 3[15] | 24.4 |
| S/2004 S12 | 1,048.2675 | 57' | 19,650 | 2.5 | 24.8 |
| Bestla | 1,083.6[16] | 52.9' | 19,650.00 | 3.5[15] | 23.8 |
| Eggther | 1033.0 | | 19776.7 | 2[15] | 24.5 |
| S/2004 S7 | 1,103.055 | 57' | 19,800 | 3 | 24.5 |
| Farbauti | 1,086.1[16] | 53.3' | 19,800.00 | 2.5[15] | 24.7 |
| Hati | 1,038.7[16] | 53.7' | 19,950.00 | 3[15] | 24.4 |
| Thrymr | 1,094.3[16] | 53.7' | 19,957.54 | 4[15] | 23.9 |
| Angrboda | 1080.4 | | 20379.9 | 1.5[15] | 25.3 |
| Beli | 1084.1 | | 20424 | 1.5[15] | 25.4 |
| Gerd | 1095.0 | | 20544.5 | 1.5[15] | 25.2 |
| S/2007 S3 | 1,099.4025 | 58.8' | 20,578 | 2.5 | 24.9 |
| S/2006 S3 | 1,143.2325 | 1° | 21,132 | 3 | 24.6 |
| Skrymir | 1164.3 | | 21427 | 2[15] | 24.8 |
| Gunnlod | 1175.3 | | 21564.2 | 2[15] | 25.0 |
| S/2004 S28 | 1197.2 | | 21791.3 | 2[15] | 24.9 |
| Alvaldi | 1208.1 | | 21953.2 | 2[15] | 24.6 |
| Fenrir | 1,260.3[16] | 59.7' | 22,200.00 | 2[15] | 25.0 |
| Fornjot | 1,490.9[16] | 59.7' | 22,200.00 | 3[15] | 24.6 |
| Surtur | 1,297.7[16] | 60.0' | 22,290.00 | 3[15] | 24.8 |
| Kari | 1,233.6[16] | 1.00° | 22,350.00 | 3.5[15] | 23.9 |
| S/2004 S39 | 1277.5 | | 22790.4 | 1[15] | 25.5 |
| Geirrod | 1295.8 | | 23006.2 | 2[15] | 25.1 |
| Jarnsaxa | 964.7[16] | 1.04° | 23,190.00 | 3[15] | 24.7 |
| Loge | 1,312.0[16] | 1.04° | 23,190.00 | 3[15] | 24.6 |
| S/2004 S24 | 1317.6 | | 23231.3 | 1.5[15] | 25.2 |
| Ymir | 1,315.4[16] | 1.04° | 23,305.87 | 10[15] | 22.4 |
| S/2004 S36 | 1354.2 | | 23698.7 | 1.5[15] | 25.3 |
| Thiazzi | 1361.5 | | 23764.8 | 2[15] | 25.0 |
| S/2004 S21 | 1365.1 | | 23810.4 | 1.5[15] | 25.4 |
| S/2004 S34 | 1412.5 | | 24358.9 | 1.5[15] | 25.3 |
| S/2004 S26 | 1624.2 | | 26737.8 | 2[15] | 25.0 |
| **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] | 5.4' | 4,276.00 | 7[15] | 25.0 |
| Caliban | 579.6[16] | 9.1' | 7,170.00 | 49 | 22.4 |
| Stephano | 675.7[16] | 10.3' | 7,942.00 | 10[15] | 24.1 |
| Trinculo | 759.7[16] | 10.8' | 8,571.02 | 7[15] | 25.4 |
| Sycorax | 1,289.0[16] | 15.4' | 12,216.00 | 95 | 20.8 |
| Margaret | 1,694.8 | 18.1' | 14,345.00 | 7.5[15] | 25.2 |
| Prospero | 1,948.1[16] | 20.3' | 16,089.00 | 15[15] | 23.2 |
| Setebos | 2,303.1[16] | 22.7' | 17,988.00 | 17.5[15] | 23.3 |
| Ferdinand | 2,823.4[16] | 26.4' | 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 |
| Hippocamp | 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 | 4.4' | 5,513.4 | 170 | 19.7 |
| Halimede | 1,881.00 | 12.4' | 15,728.00 | 25[15] | 24.5 |
| Sao | 2,914.63 | 17.7' | 22,422.00 | 13.5[15] | 25.4 |
| Laomedeia | 3,166.65 | 18.6' | 23,571.00 | 16.5[15] | 25.4 |
| Psamathe | 9,116.45 | 36.9' | 46,695.00 | 18[15] | 25.6 |
| Neso | 9,737.36 | 38.3' | 48,387.00 | 21.5[15] | 24.6 |

## DECLINATIONS of the SUN and PLANETS




In general, the further south a planet is (lower 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, being 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



# SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN

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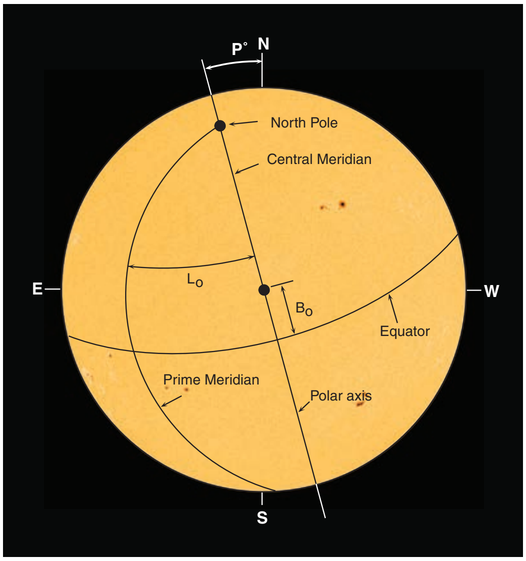
| 28 | 02:17 | 04:33 | 19:52 | 22:08 | 03:03 | 04:58 | 19:45 | 21:39 | 03:31 | 05:11 | 19:25 | 21:05 | 03:00 | 04:45 | 19:08 | 20:52 | 28 |

# ORIENTATION OF THE SUN




*Sun image courtesy of SOHO/HMI 20220825_020000*

**SYNODIC ROTATION NUMBERS (UT)**

| Rotation | Month | d.dd |
|---|---|---|
| 2280 | Jan | 18.27 |
| 2281 | Feb | 14.61 |
| 2282 | Mar | 12.94 |
| 2283 | Apr | 9.24 |
| 2284 | May | 6.49 |
| 2285 | Jun | 2.71 |
| 2286 | Jun | 29.91 |
| 2287 | Jul | 27.11 |
| 2288 | Aug | 23.34 |
| 2289 | Sep | 19.60 |
| 2290 | Oct | 16.88 |
| 2291 | Nov | 13.18 |
| 2292 | Dec | 10.50 |

| Date (0 h UT) | P° | $B_0$° | $L_0$° | Date (0 h UT) | P° | $B_0$° | $L_0$° |
|---|---|---|---|---|---|---|---|
| Jan 6 | - 0.1 | - 3.5 | 161.6 | Jul 6 | - 0.2 | + 3.4 | 279.3 |
| 13 | - 3.5 | - 4.3 | 069.4 | 13 | + 2.9 | + 4.2 | 186.7 |
| 20 | - 6.7 | - 5.0 | 337.2 | 20 | + 6.0 | + 4.8 | 094.0 |
| 27 | - 9.8 | - 5.6 | 245.0 | 27 | + 9.0 | + 5.4 | 001.4 |
| Feb 3 | - 12.8 | - 6.1 | 152.9 | Aug 3 | + 11.8 | + 5.9 | 268.8 |
| 10 | - 15.4 | - 6.6 | 060.7 | 10 | + 14.4 | + 6.4 | 176.3 |
| 17 | - 17.9 | - 6.9 | 328.5 | 17 | + 16.8 | + 6.8 | 083.7 |
| 24 | - 20.0 | - 7.1 | 236.4 | 24 | + 19.0 | + 7.0 | 351.2 |
| Mar 2 | - 21.9 | - 7.2 | 144.1 | 31 | + 20.9 | + 7.2 | 258.7 |
| 9 | - 23.4 | - 7.2 | 051.9 | Sep 7 | + 22.6 | + 7.3 | 166.3 |
| 16 | - 24.6 | - 7.2 | 319.7 | 14 | + 23.9 | + 7.2 | 073.9 |
| 23 | - 25.5 | - 6.9 | 227.4 | 21 | + 25.0 | + 7.1 | 341.5 |
| 30 | - 26.1 | - 6.6 | 135.1 | 28 | + 25.8 | + 6.8 | 249.1 |
| Apr 6 | - 26.3 | - 6.2 | 042.7 | Oct 5 | + 26.2 | + 6.5 | 156.7 |
| 13 | - 26.1 | - 5.8 | 310.3 | 12 | + 26.2 | + 6.1 | 064.3 |
| 20 | - 25.6 | - 5.2 | 217.9 | 19 | + 26.0 | + 5.6 | 332.0 |
| 27 | - 24.7 | - 4.5 | 125.4 | 26 | + 25.3 | + 4.9 | 239.7 |
| May 4 | - 23.5 | - 3.8 | 032.9 | Nov 2 | + 24.2 | + 4.3 | 147.4 |
| 11 | - 21.9 | - 3.1 | 300.4 | 9 | + 22.8 | + 3.5 | 055.1 |
| 18 | - 20.0 | - 2.3 | 207.8 | 16 | + 21.0 | + 2.7 | 322.8 |
| 25 | - 17.8 | - 1.5 | 115.2 | 23 | + 18.8 | + 1.9 | 230.5 |
| Jun 1 | - 15.3 | - 0.6 | 022.5 | 30 | + 16.3 | + 1.0 | 138.3 |
| 8 | - 12.5 | + 0.2 | 289.9 | Dec 7 | + 13.5 | + 0.1 | 046.0 |
| 15 | - 9.6 | + 1.1 | 197.3 | 14 | + 10.5 | - 0.8 | 313.8 |
| 22 | - 6.5 | + 1.9 | 104.6 | 21 | + 7.2 | - 1.7 | 221.6 |
| 29 | - 3.4 | + 2.7 | 011.9 | 28 | + 3.9 | - 2.6 | 129.4 |

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

$B_0$° Heliocentric Latitude of centre of Sun

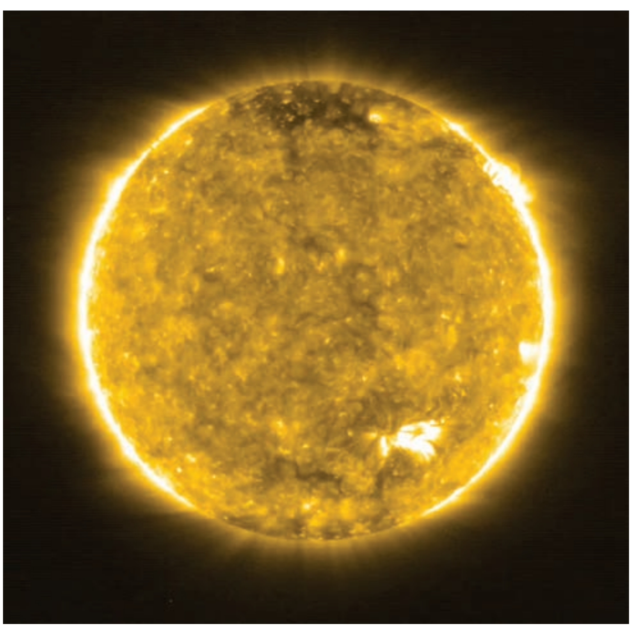
$L_0$° Heliocentric Longitude of centre of Sun

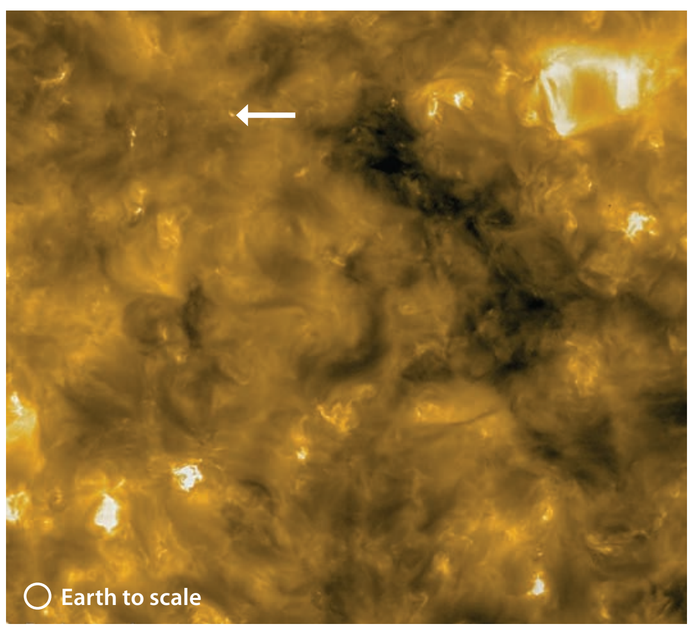
At the date of commencement of each synodic rotation period the value of $L_0$° is zero; that is, the prime meridian passes through the central point of the disc. The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period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

**Example: Heliocentric Longitude** value for 14 March at 2 pm WST. 2 pm WST is 6 hours UT (0 hr UT is 8 am WST). To get the value for 14 March (0 hr UT) start with the value from the main table for 9 March (51.9°) plus 5 days which from the daily variation table is –65.9°. Then you add the value for 6 hours, which is –3.3°. The calculation becomes: 51.9° + (–65.9°) + (–3.3°) = –17.3° (If negative, add 360°, if > 360°, subtract 360° so final result 342.7°)

**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 |






*Extreme Ultraviolet Imager on ESA's Solar Orbiter spacecraft images, 30 May 2020. On the close-up image to the right, the arrow points to one of the ubiquitous features of the solar surface, mini flares. Credit Solar Orbiter/EUI Team/ESA and NASA; CSL, IAS, MPS, PMOD/WRC, ROB, UCL/MSSL*

# SOLAR AND LUNAR ECLIPSES

In 2024 there are four eclipses: two of the Sun and two of the Moon. Of the solar eclipses, one is total and the other annular. Of the lunar eclipses, one is penumbral and the other partial.

The magnitudes quoted in this section are not a measure of brightness. For solar eclipses it is the fraction of the Sun's diameter occulted by the Moon. It is strictly a ratio of diameters and should not be confused with eclipse obscuration, a measure of the Sun's surface area occulted by the Moon. For lunar eclipses, it is the fraction of the Moon's diameter occulted by the Earth's penumbral or umbral shadow. By convention, the magnitude of all eclipses is given at the instant of the greatest eclipse.

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

**25 March Penumbral Eclipse of the Moon**

The year's first lunar eclipse is penumbral and will be visible from far eastern Asia, Australia (except Western Australia), the Americas, and western Europe and Africa. At maximum eclipse, 96% of the Moon's disc will be within the Earth's penumbral shadow. Technically the eclipse is visible from the eastern and central regions of Australia. Unfortunately, the subtle shading of a deep penumbral eclipse will be imperceptible to see because it will take place during mid-afternoon and twilight hours. Penumbral magnitude is 0.982.

| | | UT | EST | CST | WST |
|---|---|---|---|---|---|
| Penumbral eclipse begins | P1 | 04:53 | 02:53 pm | 02:23 pm | 12:53 pm |
| Greatest eclipse | Mid | 07:13 | 05:13 pm | 04:43 pm | 03:13 pm |
| Penumbral eclipse ends | P4 | 09:32 | 07:32 pm | 07:02 pm | 05:32 pm |

**8 April (UT) 9th April (EST) Total Eclipse of the Sun**

The year's first solar eclipse is total and will cross North America, passing over Mexico, the United States, and Canada. The eclipse begins over the South Pacific Ocean. Landfall occurs near the resort town of Mazatlán on Mexico's Pacific coast. The path continues, entering the United States in Texas and travelling through Oklahoma, Arkansas, Missouri, Illinois, Kentucky, Indiana, Ohio, Pennsylvania, New York, Vermont, New Hampshire, and Maine. It then enters Canada in Southern Ontario and continues through Quebec, New Brunswick, Prince Edward Island, and Cape Breton. The path exits continental North America on the Atlantic coast of Newfoundland, Canada.

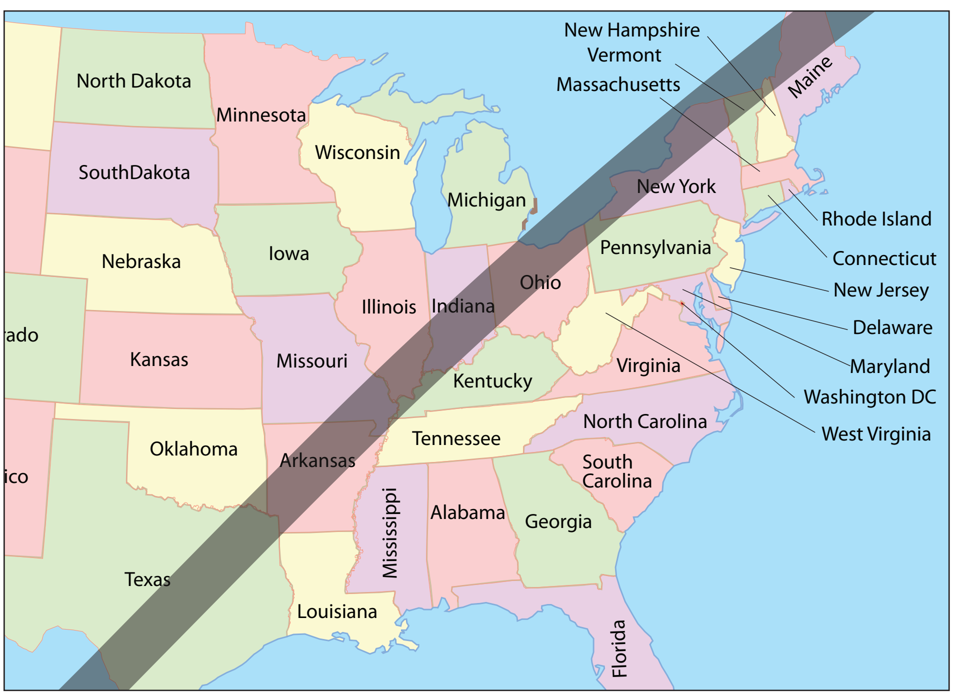
The greatest eclipse of 4m28s occurs over the sparsely populated Mexican state of Durango, with a path width of 197 km. The eclipse magnitude is 1.056, and the obscuration is 1.116. A partial eclipse is visible over North and Central America.

**18 September (UT) Partial Eclipse of the Moon**

The second lunar eclipse of the year will only be visible from the Americas, Africa, Europe, and the Middle East and not from Australia. During this partial eclipse, the Earth's umbral shadow will cover only 8.5% of the Moon. To an experienced observer, a small bite will be visible in the Moon's northern hemisphere with a subtle shading across the disc that fades towards the southern regions. The umbral magnitude of the eclipse is 0.091.

**2 October (UT) 3 October (EST) Annular Eclipse of the Sun**

This *Ring of Fire* eclipse follows a long watery track beginning in the middle of the Pacific Ocean. Making its first landfall on the small island of Rapa Nui (Easter Island), the path continues across the Pacific and crosses over Chile and Argentina at the southern tip of South America. The eclipse ends in the South Atlantic Ocean after passing north of the Falkland Islands. A partial eclipse from southern South America, Hawaii, the Falkland Islands, and the South Georgia/Sandwich Islands will be visible. This annular eclipse is relatively lengthy because the Moon is at apogee, its farthest point from Earth, just one hour before. The duration at greatest eclipse is 7m25s, with a magnitude of 0.9326.




Path of totality across the USA

# 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 2024 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.

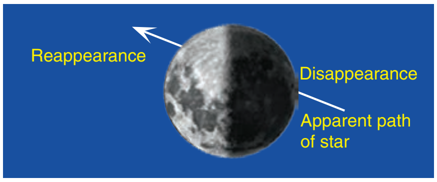
Besides being a spectacular event, the observation of occultations is an area in which the amateur can make a scientific contribution.

**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. Most 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 for Adelaide and Darwin which use CST and Perth which uses WST.

**OBJECT** n, nn, nnn, nnnn ZC Catalogue number
- ggg ccc Greek letter and constellation abbreviation
- n ccc Flamsteed number and constellation
- X nnnnn XD Catalogue number
- name of planet, satellite or deep sky object.

**PD** event, consisting of two letters.
The first letter is the type of Event: D = Disappearance and R = Reappearance. The second letter represents: D = Dark limb, B = a bright limb event. 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 (including those close to a graze) A and B would be useless, so 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:

The predicted time at your location is given by

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

where $A$ and $B$ are taken from the tables for your nearest city and $n$ and $p$ are given by

$n$ = your longitude – reference longitude

$p$ = reference latitude – your latitude

you need to preserve the signs of $n$ and $p$, that is, whether they are positive or negative and it is best to use your closest city.

## WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the reappearance of Sig Sco on April 27 for their location in Albury NSW (146° 55' E, 36° 05' S). Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

= 146.92° – 149.13° = – 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 04:24 EST and the values of A and B are + 1.9 and + 0.1 respectively.

Therefore the equation becomes:

04:24 + (+1.9 × –2.21°) + (+0.1 × –0.83°)
= 04:24 + (–4.2) + (–0.1)
= 04:24 + (–4.3) = 04:20

The event will be visible from Albury approximately four minutes earlier than Canberra, i.e., about 4:20 am (EST) on April 27.

Lunar occultation predictions calculated using Occult version 4.2023 by D. Herald.

LUNAR OCCULTATION TABLE

# ADELAIDE (34° 54' S, 138° 36' E)

| CST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 20 23:21 | 17 Tau | DD | 3.7 | 119 | 15 | 52 | 1.6 | 1.9 |
| Jan 21 00:03 | 23 Tau | DD | 4.1 | 120 | 9 | 105 | 0.9 | 0.8 |
| Jan 21 00:39 | Eta Tau | DD | 2.9 | 120 | 3 | 81 | 0.8 | 1.4 |
| Jan 24 00:17 | 53 Aur | DD | 5.8 | 155 | 23 | 65 | 2.6 | 1.4 |
| Jan 24 21:03 | 65 Gem | DD | 5.0 | 165 | 18 | 45 | 1.2 | 0.5 |
| Jan 31 04:17 | Eta Vir | DB | 3.9 | 125 | 56 | 162 | 0.8 | -2.5 |
| Jan 31 05:33 | Eta Vir | RD | 3.9 | 125 | 50 | 285 | 2.2 | 0.0 |
| Feb 14 20:09 | Pi Psc | DD | 5.5 | 62 | 18 | 44 | 0.9 | 2.0 |
| Feb 19 00:16 | Bet Tau | DD | 1.7 | 113 | 1 | 81 | 0.9 | 1.4 |
| Feb 29 03:54 | 76 Vir | DB | 5.2 | 134 | 64 | 77 | 3.8 | 1.5 |
| Feb 29 04:47 | 76 Vir | RD | 5.2 | 134 | 58 | 2 | 0.1 | -4.4 |
| Mar 05 01:30 | 3 Sgr | RD | 4.5 | 77 | 19 | 281 | 0.0 | -1.3 |
| Mar 05 04:49 | 2583 | DB | 5.8 | 75 | 57 | 50 | 2.6 | 1.3 |
| Mar 19 20:21 | Phi Gem | DD | 5.0 | 116 | 29 | 152 | 1.6 | -1.7 |
| Mar 19 21:31 | Phi Gem | RB | 5.0 | 116 | 26 | 251 | 3.0 | 1.3 |
| Mar 22 21:00 | 42 Leo | DD | 6.2 | 149 | 35 | 97 | 2.5 | -1.0 |
| Mar 24 04:20 | 1625 | DD | 5.8 | 163 | 8 | 74 | 0.8 | 2.4 |
| Apr 03 00:39 | 2848 | RD | 5.6 | 83 | 11 | 208 | 1.1 | 1.3 |
| Apr 14 20:01 | 53 Aur | DD | 5.8 | 74 | 16 | 128 | 0.9 | -0.1 |
| Apr 21 23:11 | 13 Vir | DD | 5.9 | 153 | 55 | 194 | -1.0 | -4.5 |
| Apr 21 23:16 | Eta Vir | DD | 3.9 | 153 | 55 | 114 | 2.2 | -0.7 |
| Apr 22 00:36 | Eta Vir | RB | 3.9 | 153 | 46 | 332 | 1.0 | -1.7 |
| Apr 27 02:01 | Sig Sco | DB | 2.9 | 149 | 80 | 109 | 2.2 | -1.0 |
| Apr 27 03:32 | Sig Sco | RD | 2.9 | 148 | 72 | 288 | 2.2 | -0.4 |
| Apr 29 05:32 | 2660 | RD | 6.2 | 123 | 71 | 254 | 2.0 | 1.3 |
| May 02 01:33 | Phi Cap | DB | 5.2 | 87 | 20 | 106 | 0.1 | -1.7 |
| May 02 02:27 | Phi Cap | RD | 5.2 | 86 | 31 | 224 | 1.0 | 0.6 |
| May 13 20:28 | Psi Cnc | DD | 5.7 | 66 | 12 | 163 | -0.4 | -1.4 |
| May 25 19:48 | 3 Sgr | RD | 4.5 | 156 | 15 | 261 | 0.1 | -0.9 |
| May 26 00:07 | 2583 | RD | 5.8 | 155 | 65 | 306 | 1.4 | -2.3 |
| May 27 04:10 | Tau Sgr | DB | 3.3 | 141 | 74 | 117 | 2.7 | -1.1 |
| May 27 05:10 | Tau Sgr | RD | 3.3 | 140 | 62 | 211 | 0.7 | 3.3 |
| May 31 01:46 | 70 Aqr | RD | 6.2 | 90 | 21 | 247 | 0.6 | -0.3 |
| Jun 01 05:40 | 20 Psc | DB | 5.5 | 75 | 50 | 80 | 2.0 | -0.3 |
| Jun 08 17:48 | 28 Gem | RB | 5.4 | 23 | 6 | 350 | -1.3 | -2.4 |
| Jun 19 22:01 | 2227 | DD | 5.8 | 149 | 79 | 163 | 1.0 | -3.8 |
| Jun 19 22:44 | 2235 | DD | 6.3 | 149 | 76 | 125 | 2.0 | -1.4 |
| Jun 22 05:18 | 3 Sgr | DD | 4.5 | 174 | 24 | 82 | 0.2 | 1.3 |
| Jun 27 23:07 | Saturn | RD | 1.1 | 107 | 2 | 198 | 0.2 | 1.5 |
| Jun 29 01:51 | 35 | RD | 6.2 | 92 | 20 | 286 | 1.1 | -2.2 |
| Jul 10 20:29 | 53 Leo | DD | 5.3 | 51 | 10 | 92 | 0.7 | 1.2 |
| Jul 15 00:29 | 86 Vir | DD | 5.5 | 97 | 7 | 75 | -0.1 | 1.9 |
| Jul 18 00:18 | 2332 | DD | 6.1 | 131 | 44 | 121 | 1.5 | -0.2 |
| Jul 18 03:19 | Sig Sco | DD | 2.9 | 132 | 10 | 123 | 0.2 | 0.2 |
| Jul 18 23:57 | 2470 | DD | 6.1 | 143 | 60 | 131 | 2.3 | -1.3 |
| Jul 19 20:26 | 2617 | DD | 4.6 | 154 | 62 | 139 | 1.0 | -3.2 |
| Jul 19 21:27 | 2617 | RB | 4.6 | 155 | 74 | 232 | 2.5 | 1.7 |
| Jul 22 19:27 | 27 Cap | RD | 6.3 | 165 | 12 | 230 | 0.4 | 0.1 |
| Jul 23 22:27 | 39 Aqr | RD | 6.1 | 150 | 33 | 278 | 1.0 | -1.6 |
| Jul 24 02:41 | 45 Aqr | RD | 6.0 | 149 | 68 | 253 | 2.1 | 0.8 |
| Jul 25 06:45 | 96 Aqr | DB | 5.6 | 133 | 35 | 343 | -1.2 | 4.2 |
| Jul 30 05:10 | 16 Tau | DB | 5.5 | 68 | 22 | 125 | 3.6 | -3.2 |
| Jul 30 05:17 | 19 Tau | DB | 4.3 | 68 | 23 | 90 | 1.9 | -0.9 |
| Jul 30 05:43 | 16 Tau | RD | 5.5 | 67 | 26 | 177 | -1.1 | 3.1 |
| Jul 30 05:43 | 21 Tau | DB | 5.8 | 67 | 25 | 90 | 2.1 | -0.7 |
| Jul 30 05:51 | 18 Tau | DB | 5.7 | 67 | 26 | 11 | 0.0 | 1.9 |
| Jul 30 06:26 | 19 Tau | RD | 4.3 | 67 | 29 | 214 | 1.1 | 1.0 |
| Jul 30 06:41 | 18 Tau | RD | 5.7 | 67 | 29 | 294 | 3.2 | -1.3 |
| Aug 14 00:31 | 2269 | DD | 5.4 | 100 | 16 | 169 | 2.2 | -4.1 |
| Aug 30 05:47 | Iot Gem | RD | 3.8 | 48 | 11 | 252 | 1.1 | -0.6 |
| Sep 10 23:58 | Antares | DD | 1.1 | 82 | 9 | 162 | 1.7 | -2.7 |
| Sep 11 00:17 | Antares | RB | 1.1 | 82 | 5 | 200 | -2.1 | 4.5 |
| Sep 11 22:38 | 43 Oph | DD | 5.3 | 93 | 35 | 122 | 1.3 | 0.0 |
| Sep 11 23:30 | 43 Oph | RB | 5.3 | 93 | 24 | 227 | -0.3 | 2.4 |
| Sep 12 19:29 | 2645 | DD | 6.2 | 104 | 82 | 113 | 2.5 | -1.1 |
| Sep 12 20:46 | 2645 | RB | 6.2 | 104 | 68 | 233 | 1.5 | 2.4 |
| Sep 12 22:10 | 2660 | DD | 6.2 | 105 | 52 | 98 | 1.6 | 0.7 |
| Sep 16 21:34 | 45 Aqr | DD | 6.0 | 158 | 62 | 36 | 1.3 | 1.6 |
| Sep 19 21:20 | Eps Psc | DB | 4.3 | 159 | 18 | 97 | 1.1 | -1.5 |
| Sep 19 22:05 | Eps Psc | RD | 4.3 | 159 | 26 | 190 | 0.0 | 1.9 |
| Sep 21 23:33 | Eps Ari | DB | 4.7 | 130 | 13 | 27 | 0.0 | 0.9 |
| Sep 22 00:29 | Eps Ari | RD | 4.7 | 130 | 22 | 269 | 1.6 | -0.9 |
| Sep 22 00:29 | X 54005 | RD | 5.6 | 130 | 22 | 269 | 1.6 | -0.9 |
| Sep 25 02:53 | 921 | RD | 6.0 | 90 | 11 | 287 | 1.6 | -1.5 |
| Oct 17 04:25 | 60 Psc | DD | 6.0 | 170 | 7 | 75 | 0.4 | 1.4 |
| Oct 20 01:21 | 7 Tau | RD | 6.0 | 149 | 30 | 301 | 3.5 | -1.6 |
| Oct 22 00:20 | 850 | RD | 6.0 | 122 | 8 | 270 | 1.1 | -1.0 |
| Oct 23 01:54 | 28 Gem | RD | 5.4 | 109 | 13 | 248 | 1.1 | -0.5 |
| Nov 03 19:48 | 2269 | DD | 5.4 | 21 | 8 | 153 | 0.9 | -1.3 |
| Nov 05 21:25 | 3 Sgr | DD | 4.5 | 44 | 11 | 32 | -1.0 | 2.5 |
| Nov 10 00:38 | Gam Cap | DD | 3.7 | 94 | 10 | 12 | -0.6 | 2.3 |
| Nov 11 21:38 | 96 Aqr | DD | 5.6 | 119 | 54 | 8 | 0.3 | 2.8 |
| Nov 11 22:32 | 96 Aqr | RB | 5.6 | 120 | 46 | 271 | 2.0 | 0.9 |
| Nov 15 21:09 | Eps Ari | DD | 4.7 | 174 | 24 | 49 | 0.8 | 0.3 |
| Nov 15 22:19 | Eps Ari | RB | 4.7 | 174 | 31 | 246 | 1.6 | 0.1 |
| Nov 17 03:31 | 44 Tau | RD | 5.4 | 167 | 17 | 252 | 1.6 | 1.3 |
| Nov 18 23:27 | Kap Aur | DB | 4.3 | 143 | 11 | 33 | 0.2 | 0.7 |
| Nov 19 00:15 | Kap Aur | RD | 4.3 | 142 | 17 | 313 | 2.5 | -2.2 |
| Nov 20 03:45 | Iot Gem | DB | 3.8 | 129 | 28 | 109 | 2.2 | -0.4 |
| Nov 20 04:14 | 59 Gem | RD | 5.8 | 128 | 27 | 223 | 3.8 | 2.5 |
| Nov 24 03:25 | 53 Leo | DB | 5.3 | 82 | 23 | 154 | 1.0 | -2.6 |
| Dec 07 23:02 | 42 Aqr | DD | 5.3 | 76 | 12 | 100 | 0.3 | 1.0 |
| Dec 09 22:04 | 3520 | DD | 5.8 | 101 | 34 | 7 | 0.2 | 2.8 |
| Dec 10 22:43 | 60 Psc | DD | 6.0 | 115 | 31 | 114 | 2.2 | 0.2 |
| Dec 10 23:32 | 62 Psc | DD | 5.9 | 115 | 22 | 32 | 0.8 | 2.2 |
| Dec 13 22:04 | 7 Tau | DD | 6.0 | 155 | 31 | 27 | 1.1 | 1.4 |

# BRISBANE (27° 30' S, 153° 01' E)

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 21 00:37 | 17 Tau | DD | 3.7 | 120 | 1 | 7 | 3.0 | 6.5 |
| Jan 24 19:10 | Iot Gem | DD | 3.8 | 164 | 12 | 79 | 1.0 | -0.6 |
| Jan 24 20:30 | Iot Gem | RB | 3.8 | 165 | 24 | 282 | 2.1 | -1.1 |
| Jan 24 21:11 | 1132 | DD | 6.4 | 165 | 29 | 135 | 2.7 | -2.2 |
| Jan 24 22:15 | 65 Gem | DB | 5.0 | 165 | 33 | 23 | 3.9 | 7.6 |
| Jan 24 22:34 | 65 Gem | RB | 5.0 | 165 | 34 | 1 | 0.6 | -8.8 |
| Jan 25 02:51 | Ups Gem | DD | 4.1 | 166 | 14 | 186 | -2.8 | -5.3 |
| Jan 31 04:49 | 13 Vir | DB | 5.9 | 125 | 57 | 189 | -0.6 | -4.4 |
| Jan 31 04:58 | Eta Vir | DB | 3.9 | 125 | 56 | 111 | 2.4 | -0.5 |
| Feb 05 02:57 | 2328 | RD | 6.4 | 69 | 35 | 347 | -0.8 | -3.2 |
| Feb 20 23:09 | 53 Gem | DD | 5.8 | 135 | 27 | 154 | 0.6 | -1.7 |
| Feb 21 22:46 | 13 Cnc | DD | 6.4 | 146 | 36 | 109 | 2.4 | -0.3 |
| Feb 21 23:55 | Psi Cnc | DD | 5.7 | 147 | 30 | 192 | -3.2 | -6.3 |
| Mar 03 01:54 | 2270 | DB | 5.4 | 101 | 48 | 153 | 0.1 | -2.8 |
| Mar 03 03:00 | 2270 | RD | 5.4 | 101 | 63 | 267 | 2.5 | -0.6 |
| Mar 05 01:00 | 3 Sgr | DB | 4.5 | 77 | 15 | 64 | 0.5 | -0.2 |
| Mar 05 01:45 | 3 Sgr | RD | 4.5 | 77 | 25 | 324 | -0.5 | -2.4 |
| Mar 19 21:09 | Phi Gem | DD | 5.0 | 116 | 33 | 115 | 2.1 | -0.3 |
| Mar 19 22:36 | Phi Gem | RB | 5.0 | 116 | 23 | 298 | 1.2 | -0.1 |
| Mar 30 01:12 | 2227 | DB | 5.8 | 131 | 66 | 184 | -1.2 | -5.5 |
| Mar 30 01:52 | 2227 | RD | 5.8 | 131 | 75 | 240 | 4.8 | 2.4 |
| Mar 30 03:12 | 2235 | RD | 6.3 | 131 | 85 | 288 | 2.6 | -0.9 |
| Apr 03 01:18 | 2848 | RD | 5.6 | 83 | 21 | 261 | 0.5 | -0.6 |
| Apr 14 20:50 | 53 Aur | DD | 5.8 | 74 | 10 | 86 | 1.2 | 1.1 |
| Apr 15 18:26 | 65 Gem | RB | 5.0 | 85 | 34 | 285 | 2.5 | -0.2 |
| Apr 21 23:33 | 13 Vir | DD | 5.9 | 153 | 57 | 134 | 1.7 | -1.4 |
| Apr 26 20:07 | 2311 | RD | 6.3 | 151 | 17 | 282 | 0.1 | -1.2 |
| Apr 27 03:12 | Sig Sco | DB | 2.9 | 149 | 72 | 68 | 2.7 | 2.0 |
| Apr 27 04:27 | Sig Sco | RD | 2.9 | 148 | 55 | 316 | 2.3 | -1.7 |
| Apr 28 00:23 | 2470 | RD | 6.1 | 138 | 60 | 242 | 3.0 | 0.9 |
| Apr 29 03:15 | 2644 | RD | 6.4 | 124 | 85 | 339 | 2.3 | -7.9 |
| Apr 29 03:41 | 2645 | RD | 6.2 | 124 | 89 | 243 | 2.7 | 1.5 |
| Apr 29 21:46 | Tau Sgr | RD | 3.3 | 114 | 5 | 210 | 1.0 | 1.6 |
| May 02 02:04 | Phi Cap | DB | 5.2 | 87 | 31 | 68 | 1.0 | -0.1 |
| May 02 03:17 | Phi Cap | RD | 5.2 | 86 | 47 | 256 | 1.6 | -0.3 |
| May 04 09:27 | Saturn | MD | 1.2 | 57 | 63 | 317 | | |
| May 05 03:41 | Neptune | RD | 7.9 | 46 | 11 | 312 | 0.7 | -5.5 |
| May 13 20:57 | Psi Cnc | DD | 5.7 | 66 | 7 | 112 | 0.4 | 0.3 |
| May 25 20:10 | 3 Sgr | RD | 4.5 | 156 | 22 | 301 | -0.1 | -1.6 |
| May 27 05:13 | Tau Sgr | DB | 3.3 | 141 | 55 | 114 | 2.5 | -0.4 |
| May 27 06:07 | Tau Sgr | RD | 3.3 | 140 | 44 | 208 | -0.1 | 3.0 |
| May 31 02:24 | 70 Aqr | RD | 6.2 | 90 | 36 | 272 | 1.4 | -1.1 |
| Jun 19 22:42 | 2227 | DD | 5.8 | 149 | 74 | 116 | 2.4 | -0.9 |
| Jun 19 23:45 | 2235 | DD | 6.3 | 149 | 61 | 89 | 2.3 | 0.8 |
| Jun 22 04:12 | 2545 | DD | 6.4 | 174 | 29 | 67 | 0.3 | 1.6 |
| Jun 22 05:55 | 3 Sgr | DD | 4.5 | 174 | 8 | 84 | -0.2 | 0.9 |
| Jun 26 22:49 | 3303 | RD | 6.4 | 120 | 17 | 189 | 0.8 | 3.0 |
| Jun 27 22:50 | Saturn | DB | 1.1 | 107 | 3 | 74 | 0.1 | -0.4 |
| Jun 27 23:47 | Saturn | RD | 1.1 | 107 | 16 | 231 | 0.5 | 0.4 |
| Jun 29 02:24 | 35 | RD | 6.2 | 92 | 35 | 306 | 3.9 | -6.2 |
| Jul 18 01:06 | 2332 | DD | 6.1 | 131 | 27 | 111 | 0.9 | 0.2 |
| Jul 19 00:51 | 2470 | DD | 6.1 | 143 | 42 | 119 | 1.7 | -0.3 |
| Jul 19 21:09 | 2617 | DD | 4.6 | 154 | 77 | 97 | 2.4 | -0.7 |
| Jul 19 22:40 | 2617 | RB | 4.6 | 155 | 83 | 264 | 2.5 | 0.5 |
| Jul 20 02:32 | 2644 | DD | 6.4 | 156 | 34 | 119 | 1.5 | -0.2 |
| Jul 20 18:57 | Tau Sgr | DD | 3.3 | 166 | 36 | 128 | 0.3 | -2.3 |
| Jul 20 19:55 | Tau Sgr | RB | 3.3 | 166 | 49 | 235 | 2.0 | 0.8 |
| Jul 22 20:00 | 27 Cap | RD | 6.3 | 165 | 23 | 269 | 0.5 | -0.9 |
| Jul 23 22:57 | 39 Aqr | RD | 6.1 | 151 | 47 | 316 | 3.1 | -8.5 |
| Jul 24 03:47 | 45 Aqr | RD | 6.0 | 149 | 61 | 241 | 1.6 | 1.5 |
| Aug 11 19:09 | 2017 | RB | 6.4 | 76 | 52 | 322 | 1.6 | -1.8 |
| Aug 30 05:15 | Iot Gem | DB | 3.8 | 48 | 16 | 111 | 1.7 | -1.5 |
| Aug 30 05:18 | 59 Gem | RB | 5.8 | 48 | 17 | 190 | -3.5 | 9.6 |
| Sep 11 23:23 | 43 Oph | DD | 5.3 | 93 | 18 | 123 | 0.8 | -0.1 |
| Sep 12 20:33 | 2645 | DD | 6.2 | 104 | 65 | 98 | 2.4 | 0.2 |
| Sep 12 23:04 | 2660 | DD | 6.2 | 105 | 33 | 101 | 1.0 | 0.6 |
| Sep 16 18:44 | 39 Aqr | DD | 6.1 | 156 | 38 | 359 | 0.8 | 4.7 |
| Sep 16 22:37 | 45 Aqr | DD | 6.0 | 158 | 76 | 41 | 1.4 | 1.9 |
| Sep 17 18:26 | Saturn | DD | 0.6 | 170 | 20 | 126 | 0.8 | -3.9 |
| Sep 17 18:53 | Saturn | RB | 0.6 | 170 | 26 | 177 | 0.4 | 4.3 |
| Sep 18 02:31 | 96 Aqr | DD | 5.6 | 174 | 39 | 9 | 0.1 | 2.7 |
| Sep 19 22:01 | Eps Psc | DB | 4.3 | 159 | 35 | 93 | 1.8 | -1.0 |
| Sep 19 22:51 | Eps Psc | RD | 4.3 | 159 | 43 | 187 | 0.1 | 2.4 |
| Sep 22 00:13 | Eps Ari | DB | 4.7 | 130 | 29 | 34 | 0.5 | 1.0 |
| Sep 22 01:22 | Eps Ari | RD | 4.7 | 130 | 37 | 257 | 2.1 | 0.0 |
| Sep 22 01:22 | X 54005 | RD | 5.6 | 130 | 37 | 257 | 2.1 | 0.0 |
| Sep 25 03:43 | 921 | RD | 6.0 | 90 | 27 | 284 | 2.4 | -1.1 |
| Oct 13 19:54 | 3197 | DD | 6.4 | 123 | 79 | 93 | 3.0 | -0.3 |
| Oct 20 02:30 | 7 Tau | RD | 6.0 | 149 | 36 | 293 | 2.9 | -0.5 |
| Oct 22 01:05 | 850 | RD | 6.0 | 122 | 24 | 265 | 1.8 | -0.5 |
| Oct 22 02:07 | 855 | RD | 6.4 | 122 | 30 | 307 | 3.1 | -1.9 |
| Oct 23 02:45 | 28 Gem | RD | 5.4 | 109 | 29 | 250 | 2.1 | 0.0 |
| Nov 11 22:33 | 96 Aqr | DD | 5.6 | 119 | 44 | 24 | 0.5 | 2.4 |
| Nov 11 23:33 | 96 Aqr | RB | 5.6 | 120 | 31 | 260 | 1.1 | 1.2 |
| Nov 15 22:00 | Eps Ari | DD | 4.7 | 174 | 38 | 59 | 1.7 | 0.5 |
| Nov 15 22:00 | X 54005 | DD | 5.6 | 174 | 38 | 59 | 1.7 | 0.5 |
| Nov 15 23:19 | Eps Ari | RB | 4.7 | 174 | 41 | 236 | 1.9 | 1.0 |
| Nov 19 00:13 | Kap Aur | DB | 4.3 | 143 | 26 | 36 | 1.1 | 1.3 |
| Nov 19 01:09 | Kap Aur | RD | 4.3 | 142 | 31 | 315 | 2.9 | -2.0 |
| Nov 20 00:00 | 53 Gem | RD | 5.8 | 130 | 19 | 231 | 0.9 | 0.5 |
| Nov 24 03:57 | 53 Leo | DB | 5.3 | 82 | 38 | 128 | 1.7 | -2.0 |
| Dec 09 22:58 | 3520 | DD | 5.8 | 101 | 20 | 9 | 0.2 | 2.8 |
| Dec 10 23:38 | 60 Psc | DD | 6.0 | 115 | 18 | 110 | 1.0 | 0.3 |
| Dec 11 00:28 | 62 Psc | DD | 5.9 | 115 | 8 | 21 | 0.4 | 2.5 |
| Dec 13 23:08 | 7 Tau | DD | 6.0 | 155 | 35 | 30 | 1.8 | 2.1 |
| Dec 16 22:14 | 28 Gem | RD | 5.4 | 164 | 22 | 321 | 2.7 | -2.8 |

## LUNAR OCCULTATION TABLE

# CANBERRA (35° 15' S, 149° 08' E)

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 15 21:01 | 3432 | DD | 6.2 | 54 | 13 | 27 | 0.0 | 2.1 |
| Jan 21 00:06 | 17 Tau | DD | 3.7 | 119 | 6 | 45 | 1.3 | 2.2 |
| Jan 24 01:15 | 53 Aur | DD | 5.8 | 155 | 16 | 46 | 3.0 | 2.9 |
| Jan 24 20:31 | Iot Gem | RB | 3.8 | 165 | 16 | 269 | 1.6 | -1.0 |
| Jan 24 21:50 | 65 Gem | DD | 5.0 | 165 | 23 | 53 | 2.1 | 0.4 |
| Jan 26 04:00 | Ups 1 Cnc | DD | 5.7 | 175 | 11 | 184 | -1.7 | -3.6 |
| Jan 31 04:59 | Eta Vir | DB | 3.9 | 125 | 52 | 140 | 1.4 | -1.5 |
| Feb 14 20:47 | Pi Psc | DD | 5.5 | 62 | 9 | 46 | 0.7 | 2.0 |
| Mar 05 01:04 | 3 Sgr | DB | 4.5 | 77 | 16 | 91 | 0.0 | -1.1 |
| Mar 05 02:01 | 3 Sgr | RD | 4.5 | 77 | 27 | 295 | 0.1 | -1.7 |
| Mar 19 21:07 | Phi Gem | DD | 5.0 | 116 | 27 | 137 | 1.5 | -0.8 |
| Mar 19 22:26 | Phi Gem | RB | 5.0 | 116 | 20 | 271 | 1.9 | 0.9 |
| Mar 22 22:02 | 42 Leo | DD | 6.2 | 149 | 40 | 75 | 3.8 | 0.6 |
| Mar 30 03:01 | 2235 | RD | 6.3 | 131 | 78 | 253 | 3.2 | 1.0 |
| Apr 03 01:17 | 2848 | RD | 5.6 | 83 | 21 | 230 | 0.8 | 0.1 |
| Apr 14 20:41 | 53 Aur | DD | 5.8 | 74 | 9 | 112 | 0.8 | 0.5 |
| Apr 15 18:15 | 65 Gem | RB | 5.0 | 85 | 27 | 265 | 2.6 | 0.3 |
| Apr 21 23:42 | 13 Vir | DD | 5.9 | 153 | 51 | 165 | 0.7 | -2.4 |
| Apr 22 00:11 | Eta Vir | DD | 3.9 | 153 | 48 | 91 | 2.6 | 0.8 |
| Apr 22 01:14 | Eta Vir | RB | 3.9 | 153 | 38 | 349 | 0.4 | -2.4 |
| Apr 26 20:15 | 2311 | RD | 6.3 | 151 | 18 | 260 | 0.3 | -0.9 |
| Apr 27 02:55 | Sig Sco | DB | 2.9 | 149 | 76 | 100 | 2.3 | -0.2 |
| Apr 27 04:24 | Sig Sco | RD | 2.9 | 148 | 59 | 287 | 1.9 | 0.1 |
| Apr 29 03:05 | 2645 | RD | 6.2 | 124 | 78 | 197 | 3.4 | 9.7 |
| May 02 02:07 | Phi Cap | DB | 5.2 | 87 | 29 | 99 | 0.6 | -1.5 |
| May 02 03:09 | Phi Cap | RD | 5.2 | 86 | 42 | 227 | 1.3 | 0.7 |
| May 04 09:01 | Saturn | DD | 1.2 | 57 | 61 | 327 | | |
| May 04 09:12 | Saturn | RD | 1.2 | 57 | 60 | 310 | | |
| May 05 03:56 | Neptune | RD | 7.9 | 45 | 10 | 268 | 0.3 | -1.1 |
| May 13 20:57 | Psi Cnc | DD | 5.7 | 66 | 6 | 142 | 0.0 | -0.4 |
| May 25 20:20 | 3 Sgr | RD | 4.5 | 156 | 24 | 276 | 0.2 | -1.2 |
| May 26 00:55 | 2583 | RD | 5.8 | 155 | 77 | 315 | 1.8 | -2.9 |
| May 27 05:14 | Tau Sgr | DB | 3.3 | 141 | 59 | 144 | 4.5 | -4.5 |
| May 27 05:37 | Tau Sgr | RD | 3.3 | 141 | 54 | 180 | -1.9 | 7.0 |
| May 31 02:24 | 70 Aqr | RD | 6.2 | 90 | 31 | 244 | 1.0 | -0.1 |
| Jun 19 22:47 | 2227 | DD | 5.8 | 149 | 73 | 149 | 1.7 | -2.7 |
| Jun 19 23:36 | 2235 | DD | 6.3 | 149 | 64 | 119 | 2.0 | -0.7 |
| Jun 22 05:49 | 3 Sgr | DD | 4.5 | 174 | 16 | 98 | 0.1 | 0.9 |
| Jun 27 22:58 | Saturn | DB | 1.1 | 107 | 2 | 108 | -0.1 | -1.9 |
| Jun 27 23:39 | Saturn | RD | 1.1 | 107 | 11 | 199 | 0.3 | 1.5 |
| Jun 28 04:13 | 3461 | RD | 6.3 | 105 | 57 | 298 | 4.7 | -3.5 |
| Jun 29 02:35 | 35 | RD | 6.2 | 92 | 31 | 269 | 1.4 | -1.1 |
| Jul 02 04:37 | 47 Ara | RD | 5.8 | 52 | 13 | 289 | 1.7 | -2.2 |
| Jul 18 01:03 | 2332 | DD | 6.1 | 131 | 33 | 134 | 1.3 | -0.6 |
| Jul 18 03:51 | Sig Sco | DD | 2.9 | 132 | 2 | 142 | 0.3 | -0.5 |
| Jul 19 00:52 | 2470 | DD | 6.1 | 143 | 47 | 149 | 2.5 | -2.6 |
| Jul 19 21:12 | 2617 | DD | 4.6 | 154 | 74 | 129 | 1.8 | -2.5 |
| Jul 19 22:22 | 2617 | RB | 4.6 | 155 | 83 | 235 | 2.3 | 1.9 |
| Jul 20 02:31 | 2644 | DD | 6.4 | 156 | 39 | 144 | 2.7 | -2.1 |
| Jul 22 20:02 | 27 Cap | RD | 6.3 | 165 | 21 | 239 | 0.6 | -0.1 |
| Jul 23 23:11 | 39 Aqr | RD | 6.1 | 150 | 45 | 273 | 1.5 | -1.2 |
| Jul 24 03:28 | 45 Aqr | RD | 6.0 | 149 | 63 | 232 | 1.4 | 1.7 |
| Jul 25 04:05 | Phi Aqr | DB | 4.2 | 135 | 58 | 346 | -1.1 | 4.2 |
| Jul 25 04:38 | Phi Aqr | RD | 4.2 | 135 | 54 | 292 | 3.6 | -0.6 |
| Jul 30 06:14 | 19 Tau | DB | 4.3 | 68 | 28 | 115 | 3.2 | -1.6 |
| Jul 30 06:27 | 18 Tau | DB | 5.7 | 67 | 29 | 35 | 1.2 | 1.0 |
| Aug 14 00:57 | 2270 | DD | 5.4 | 100 | 8 | 18 | -2.9 | 7.2 |
| Aug 30 05:22 | Iot Gem | DB | 3.8 | 48 | 9 | 125 | 1.7 | -2.1 |
| Sep 11 23:23 | 43 Oph | DD | 5.3 | 93 | 24 | 147 | 1.7 | -1.4 |
| Sep 11 23:51 | 43 Oph | RB | 5.3 | 93 | 18 | 202 | -1.4 | 3.7 |
| Sep 12 20:27 | 2645 | DD | 6.2 | 104 | 69 | 123 | 2.6 | -1.3 |
| Sep 12 21:27 | 2645 | RB | 6.2 | 104 | 57 | 217 | 0.6 | 3.3 |
| Sep 12 22:56 | 2660 | DD | 6.2 | 105 | 40 | 118 | 1.5 | 0.1 |
| Sep 16 22:19 | 45 Aqr | DD | 6.0 | 158 | 68 | 55 | 1.6 | 1.2 |
| Sep 17 23:11 | Phi Aqr | DD | 4.2 | 172 | 60 | 339 | -2.0 | 5.8 |
| Sep 17 23:36 | Phi Aqr | RB | 4.2 | 172 | 61 | 299 | 5.0 | -2.9 |
| Sep 18 02:10 | 96 Aqr | DD | 5.6 | 174 | 43 | 18 | 0.4 | 2.4 |
| Sep 19 22:10 | Eps Psc | DB | 4.3 | 159 | 29 | 127 | 4.0 | -6.1 |
| Sep 19 22:28 | Eps Psc | RD | 4.3 | 159 | 32 | 157 | -2.5 | 6.7 |
| Sep 22 00:06 | Eps Ari | DB | 4.7 | 130 | 20 | 47 | 0.6 | 0.3 |
| Sep 22 01:15 | Eps Ari | RD | 4.7 | 130 | 28 | 247 | 1.5 | 0.0 |
| Sep 22 01:15 | X 54005 | RD | 5.6 | 130 | 28 | 247 | 1.5 | 0.0 |
| Sep 25 03:42 | 921 | RD | 6.0 | 90 | 18 | 272 | 1.8 | -0.9 |
| Oct 20 02:21 | 7 Tau | RD | 6.0 | 149 | 30 | 281 | 2.4 | 0.0 |
| Oct 22 01:03 | 850 | RD | 6.0 | 122 | 16 | 253 | 1.3 | -0.5 |
| Oct 23 02:37 | 28 Gem | RD | 5.4 | 109 | 19 | 236 | 1.5 | 0.1 |
| Nov 05 21:45 | 3 Sgr | DD | 4.5 | 44 | 6 | 52 | -0.8 | 1.7 |
| Nov 10 01:02 | Gam Cap | DD | 3.7 | 94 | 3 | 23 | -0.6 | 2.0 |
| Nov 11 19:39 | Phi Aqr | RB | 4.2 | 118 | 61 | 281 | 3.3 | -0.8 |
| Nov 11 22:13 | 96 Aqr | DD | 5.6 | 119 | 47 | 31 | 0.8 | 2.2 |
| Nov 11 23:18 | 96 Aqr | RB | 5.6 | 120 | 35 | 252 | 1.1 | 1.5 |
| Nov 15 21:52 | Eps Ari | DD | 4.7 | 173 | 29 | 69 | 1.6 | 0.0 |
| Nov 15 21:52 | X 54005 | DD | 5.6 | 173 | 29 | 69 | 1.6 | 0.0 |
| Nov 15 23:05 | Eps Ari | RB | 4.7 | 174 | 33 | 227 | 1.5 | 0.9 |
| Nov 17 04:14 | 44 Tau | RD | 5.4 | 167 | 9 | 259 | 1.1 | 1.3 |
| Nov 19 00:04 | Kap Aur | DB | 4.3 | 143 | 17 | 51 | 1.1 | 0.1 |
| Nov 19 01:11 | Kap Aur | RD | 4.3 | 142 | 23 | 300 | 2.3 | -1.2 |
| Nov 19 23:53 | 53 Gem | RD | 5.8 | 130 | 10 | 212 | 0.0 | 1.1 |
| Nov 20 04:37 | Iot Gem | DB | 3.8 | 129 | 25 | 98 | 2.1 | 0.2 |
| Nov 24 04:08 | 53 Leo | DB | 5.3 | 82 | 32 | 145 | 1.3 | -2.3 |
| Dec 08 20:51 | 81 Aqr | DD | 6.2 | 87 | 41 | 355 | -0.5 | 3.4 |
| Dec 09 22:37 | 3520 | DD | 5.8 | 101 | 25 | 22 | 0.4 | 2.4 |
| Dec 10 23:35 | 60 Psc | DD | 6.0 | 115 | 19 | 138 | 2.3 | -2.6 |
| Dec 11 00:09 | 62 Psc | DD | 5.9 | 115 | 13 | 37 | 0.6 | 2.1 |
| Dec 13 22:49 | 7 Tau | DD | 6.0 | 155 | 30 | 42 | 1.7 | 1.3 |
| Dec 16 22:21 | 28 Gem | RD | 5.4 | 164 | 15 | 304 | 2.0 | -1.8 |

# DARWIN (12° 23' S, 130° 44' E)

| CST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 10 05:47 | 3 Sgr | RD | 4.5 | 22 | 11 | 273 | 0.2 | -0.5 |
| Jan 14 19:54 | 50 Aqr | RB | 5.8 | 40 | 28 | 210 | 0.1 | 2.0 |
| Jan 21 00:18 | 23 Tau | DD | 4.1 | 120 | 25 | 54 | 1.8 | 1.8 |
| Jan 21 01:15 | Eta Tau | DD | 2.9 | 120 | 13 | 20 | 2.3 | 4.3 |
| Jan 21 01:24 | 23 Tau | RB | 4.1 | 120 | 11 | 288 | 0.4 | -0.2 |
| Jan 21 01:45 | Eta Tau | RB | 2.9 | 120 | 7 | 326 | -0.9 | -2.7 |
| Jan 21 01:50 | 27 Tau | DD | 3.6 | 120 | 6 | 52 | 1.0 | 1.7 |
| Jan 26 02:43 | Ups 1 Cnc | DD | 5.7 | 175 | 46 | 148 | 1.0 | -2.1 |
| Jan 31 03:13 | Eta Vir | DB | 3.9 | 125 | 68 | 131 | 2.1 | -2.1 |
| Jan 31 04:46 | Eta Vir | RD | 3.9 | 125 | 78 | 327 | 1.7 | -2.5 |
| Feb 05 05:25 | Sig Sco | DB | 2.9 | 68 | 49 | 136 | 0.8 | -2.0 |
| Feb 07 05:20 | 2660 | RD | 6.2 | 42 | 22 | 237 | 1.4 | 0.9 |
| Feb 08 05:41 | 2848 | DB | 5.6 | 29 | 13 | 80 | 0.4 | -0.1 |
| Feb 20 21:26 | 53 Gem | DD | 5.8 | 135 | 49 | 141 | 3.0 | -2.8 |
| Feb 20 22:52 | 53 Gem | RB | 5.8 | 136 | 48 | 248 | 4.0 | 1.4 |
| Mar 03 01:41 | 2270 | RD | 5.4 | 101 | 28 | 258 | 1.4 | 0.0 |
| Mar 05 05:24 | 2586 | DB | 6.0 | 75 | 51 | 123 | 1.4 | -1.8 |
| Mar 19 19:25 | Phi Gem | DD | 5.0 | 116 | 46 | 104 | 3.1 | -0.9 |
| Mar 19 21:12 | Phi Gem | RB | 5.0 | 116 | 51 | 293 | 3.0 | -1.0 |
| Apr 14 19:50 | 53 Aur | DD | 5.8 | 74 | 40 | 84 | 2.8 | 0.6 |
| Apr 14 21:08 | 53 Aur | RB | 5.8 | 74 | 28 | 309 | 0.8 | -1.0 |
| Apr 21 21:54 | 13 Vir | DD | 5.9 | 153 | 69 | 153 | 1.3 | -2.8 |
| Apr 27 23:11 | 2470 | RD | 6.1 | 138 | 26 | 243 | 1.7 | 0.7 |
| Apr 28 04:54 | 43 Oph | DB | 5.3 | 136 | 68 | 68 | 2.9 | 1.5 |
| Apr 28 06:22 | 43 Oph | RD | 5.3 | 135 | 50 | 292 | 2.5 | -0.7 |
| May 02 02:09 | Phi Cap | RD | 5.2 | 86 | 15 | 303 | -0.1 | -2.0 |
| May 12 21:07 | 53 Gem | DD | 5.8 | 55 | 14 | 63 | 1.7 | 1.7 |
| May 13 20:04 | Psi Cnc | DD | 5.7 | 66 | 37 | 113 | 1.6 | -0.5 |
| May 13 21:20 | Psi Cnc | RB | 5.7 | 67 | 23 | 307 | 0.5 | -0.8 |
| May 26 00:50 | 2586 | RD | 6.0 | 154 | 61 | 235 | 3.6 | 2.0 |
| May 26 05:41 | 2617 | DB | 4.6 | 153 | 45 | 68 | 1.4 | 1.3 |
| May 27 04:22 | Tau Sgr | DB | 3.3 | 141 | 71 | 19 | 1.2 | 4.9 |
| May 27 05:17 | Tau Sgr | RD | 3.3 | 140 | 62 | 306 | 4.1 | -2.4 |
| May 29 05:33 | Chi Cap | DB | 5.3 | 115 | 81 | 64 | 2.6 | 1.3 |
| Jun 01 06:11 | 20 Psc | DB | 5.5 | 74 | 62 | 343 | -1.3 | 5.6 |
| Jun 19 20:58 | 2227 | DD | 5.8 | 149 | 65 | 107 | 2.4 | -1.1 |
| Jul 18 03:44 | Sig Sco | DD | 2.9 | 132 | 1 | 33 | -1.3 | 2.8 |
| Jul 19 00:02 | 2470 | DD | 6.1 | 143 | 60 | 33 | 1.7 | 4.9 |
| Jul 19 19:46 | 2617 | DD | 4.6 | 154 | 41 | 74 | 1.9 | 0.3 |
| Jul 19 20:58 | 2617 | RB | 4.6 | 155 | 56 | 308 | 1.6 | -2.2 |
| Jul 20 01:37 | 2645 | DD | 6.2 | 156 | 53 | 108 | 2.6 | -0.5 |
| Jul 20 04:01 | 2660 | DD | 6.2 | 157 | 23 | 117 | 1.3 | -0.6 |
| Jul 20 18:59 | Tau Sgr | RB | 3.3 | 166 | 18 | 254 | 0.7 | 0.1 |
| Jul 22 21:38 | Phi Cap | RD | 5.2 | 164 | 27 | 201 | 1.6 | 2.9 |
| Jul 27 05:39 | Eps Psc | DB | 4.3 | 107 | 70 | 69 | 2.7 | 1.0 |
| Jul 30 04:38 | 17 Tau | DB | 3.7 | 68 | 28 | 69 | 1.1 | 0.3 |
| Jul 30 04:51 | 16 Tau | DB | 5.5 | 68 | 31 | 34 | 0.3 | 1.5 |
| Jul 30 05:21 | 20 Tau | DB | 3.9 | 67 | 36 | 47 | 0.9 | 1.1 |
| Jul 30 05:26 | 19 Tau | DB | 4.3 | 67 | 37 | 6 | -0.7 | 3.2 |
| Jul 30 05:50 | 21 Tau | DB | 5.8 | 67 | 41 | 10 | -0.3 | 3.0 |
| Jul 30 05:51 | 17 Tau | RD | 3.7 | 67 | 42 | 227 | 1.2 | 1.2 |
| Jul 30 06:00 | 16 Tau | RD | 5.5 | 67 | 43 | 262 | 2.3 | 0.0 |
| Jul 30 06:14 | 19 Tau | RD | 4.3 | 67 | 45 | 290 | 3.8 | -1.6 |
| Jul 30 06:41 | 20 Tau | RD | 3.9 | 67 | 48 | 249 | 2.3 | 0.6 |
| Aug 11 22:20 | 2029 | DD | 4.9 | 77 | 22 | 171 | 1.5 | -4.3 |
| Aug 11 22:54 | 2029 | RB | 4.9 | 77 | 14 | 228 | -0.2 | 3.5 |
| Aug 14 00:24 | 2269 | DD | 5.4 | 100 | 16 | 66 | 0.1 | 1.4 |
| Aug 28 03:18 | Bet Tau | DB | 1.7 | 72 | 13 | 73 | 0.5 | 0.1 |
| Aug 28 04:28 | Bet Tau | RD | 1.7 | 72 | 26 | 249 | 1.1 | 0.3 |
| Aug 30 04:34 | Iot Gem | DB | 3.8 | 48 | 6 | 22 | -1.6 | 3.5 |
| Aug 30 04:44 | 59 Gem | RD | 5.8 | 48 | 8 | 287 | 0.9 | -1.0 |
| Aug 30 05:02 | Iot Gem | RD | 3.8 | 48 | 12 | 333 | 2.9 | -4.5 |
| Sep 06 19:41 | 1886 | RB | 5.6 | 35 | 19 | 262 | 0.8 | 1.0 |
| Sep 10 23:58 | Antares | DD | 1.1 | 82 | 5 | 67 | -0.4 | 1.1 |
| Sep 11 23:01 | 43 Oph | DD | 5.3 | 93 | 29 | 31 | -0.5 | 3.3 |
| Sep 11 23:44 | 43 Oph | RB | 5.3 | 93 | 20 | 313 | 1.7 | -1.6 |
| Sep 14 02:01 | 2848 | DD | 5.6 | 119 | 15 | 141 | 2.9 | -3.6 |
| Sep 17 18:33 | Saturn | RB | 0.6 | 170 | 7 | 245 | 0.3 | 0.4 |
| Sep 18 01:31 | 3432 | DD | 6.2 | 173 | 71 | 104 | 4.3 | -0.8 |
| Sep 19 21:30 | Eps Psc | DB | 4.3 | 159 | 21 | 1 | -0.4 | 3.0 |
| Sep 19 22:07 | Eps Psc | RD | 4.3 | 159 | 30 | 286 | 1.8 | -1.5 |
| Sep 21 23:24 | 47 Ara | RD | 5.8 | 130 | 18 | 261 | 0.8 | -0.1 |
| Sep 23 06:02 | 44 Tau | DB | 5.4 | 114 | 48 | 51 | 2.6 | 1.7 |
| Oct 06 20:27 | 2183 | DD | 5.5 | 39 | 13 | 137 | 1.0 | -1.4 |
| Oct 09 19:45 | 2586 | DD | 6.0 | 73 | 55 | 61 | 1.8 | 1.8 |
| Oct 09 21:05 | 2586 | RB | 6.0 | 74 | 38 | 276 | 1.6 | 0.2 |
| Oct 11 00:38 | Tau Sgr | DD | 3.3 | 87 | 5 | 124 | 0.7 | -0.9 |
| Oct 11 19:39 | Ome Sgr | RB | 4.7 | 98 | 76 | 193 | 0.9 | 4.9 |
| Oct 23 01:07 | 28 Gem | RD | 5.4 | 109 | 15 | 337 | 4.5 | -6.7 |
| Nov 13 19:21 | Eps Psc | DD | 4.3 | 146 | 41 | 50 | 1.0 | 1.1 |
| Nov 13 20:33 | Eps Psc | RB | 4.3 | 147 | 57 | 226 | 1.4 | 1.4 |
| Nov 15 20:03 | 47 Ara | DD | 5.8 | 174 | 22 | 55 | 0.4 | 0.7 |
| Nov 17 03:25 | 44 Tau | RD | 5.4 | 168 | 40 | 304 | 2.1 | -1.3 |
| Nov 17 23:05 | 771 | RD | 6.1 | 156 | 30 | 189 | -1.1 | 3.6 |
| Nov 20 02:31 | 59 Gem | DB | 5.8 | 129 | 43 | 107 | 2.7 | -1.0 |
| Nov 20 03:23 | Iot Gem | DB | 3.8 | 129 | 48 | 61 | 3.3 | 1.4 |
| Nov 20 04:09 | 59 Gem | RD | 5.8 | 128 | 50 | 277 | 3.1 | -0.3 |
| Nov 20 04:33 | Iot Gem | RD | 3.8 | 128 | 50 | 330 | 1.9 | -2.8 |
| Nov 24 03:46 | 53 Leo | RD | 5.3 | 82 | 31 | 312 | 1.4 | -2.0 |
| Dec 07 23:28 | 42 Aqr | DD | 5.3 | 76 | 10 | 44 | -0.1 | 1.6 |
| Dec 08 17:17 | Saturn | DD | 1.0 | 86 | 70 | 107 | 4.6 | -1.9 |
| Dec 08 18:00 | Saturn | RB | 1.0 | 86 | 80 | 166 | -1.1 | 5.3 |
| Dec 10 22:52 | 60 Psc | DD | 6.0 | 115 | 47 | 49 | 1.5 | 1.8 |
| Dec 13 02:29 | Mu Ari | DD | 5.7 | 143 | 17 | 47 | 1.2 | 1.8 |
| Dec 14 03:51 | 19 Tau | DD | 4.3 | 157 | 11 | 131 | -0.1 | -1.3 |
| Dec 14 03:51 | 18 Tau | DD | 5.7 | 157 | 10 | 45 | 1.3 | 1.9 |

# LUNAR OCCULTATION TABLE

## HOBART (42° 48' S, 147° 13' E)

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 20 23:48 | 17 Tau | DD | 3.7 | 119 | 5 | 60 | 1.1 | 1.8 |
| Jan 21 22:15 | 701 | DD | 6.6 | 131 | 18 | 106 | 1.9 | 0.4 |
| Jan 24 00:56 | 53 Aur | DD | 5.8 | 155 | 12 | 70 | 1.9 | 1.4 |
| Jan 24 20:36 | Iot Gem | RB | 3.8 | 164 | 10 | 258 | 1.3 | -0.9 |
| Jan 24 21:47 | 65 Gem | DD | 5.0 | 165 | 16 | 66 | 1.7 | -0.4 |
| Jan 31 05:11 | Eta Vir | DB | 3.9 | 125 | 45 | 166 | 0.6 | -2.2 |
| Feb 05 03:33 | 2328 | RD | 6.4 | 69 | 39 | 299 | 0.4 | -1.9 |
| Feb 14 20:31 | Pi Psc | DD | 5.5 | 62 | 10 | 57 | 0.7 | 1.8 |
| Feb 19 20:13 | Kap Aur | DD | 4.3 | 123 | 18 | 28 | 1.9 | 1.5 |
| Feb 19 20:53 | Kap Aur | RB | 4.3 | 123 | 18 | 334 | 1.8 | -1.5 |
| Feb 21 22:46 | 13 Cnc | DD | 6.4 | 146 | 21 | 146 | 1.3 | -0.9 |
| Feb 29 04:41 | 76 Vir | DB | 5.2 | 134 | 52 | 89 | 2.3 | 0.9 |
| Mar 05 01:14 | 3 Sgr | DB | 4.5 | 77 | 19 | 108 | -0.2 | -1.5 |
| Mar 05 02:12 | 3 Sgr | RD | 4.5 | 77 | 30 | 276 | 0.3 | -1.4 |
| Mar 19 21:12 | Phi Gem | DD | 5.0 | 116 | 20 | 155 | 0.9 | -1.0 |
| Mar 19 22:12 | Phi Gem | RB | 5.0 | 116 | 16 | 249 | 2.4 | 1.6 |
| Mar 22 21:57 | 42 Leo | DD | 6.2 | 149 | 32 | 95 | 2.3 | -0.5 |
| Apr 22 00:06 | Eta Vir | DD | 3.9 | 153 | 43 | 119 | 1.6 | -0.3 |
| Apr 22 01:24 | Eta Vir | RB | 3.9 | 153 | 33 | 319 | 0.9 | -0.6 |
| Apr 26 20:20 | 2311 | RD | 6.3 | 151 | 20 | 241 | 0.6 | -0.7 |
| Apr 26 21:31 | 2317 | RD | 6.6 | 151 | 32 | 268 | 0.6 | -1.3 |
| Apr 27 02:58 | Sig Sco | DB | 2.9 | 149 | 71 | 129 | 1.8 | -1.4 |
| Apr 27 04:15 | Sig Sco | RD | 2.9 | 148 | 60 | 260 | 1.7 | 1.4 |
| Apr 29 03:33 | 2644 | RD | 6.4 | 124 | 75 | 267 | 2.0 | -0.1 |
| May 02 00:26 | 27 Cap | RD | 6.3 | 88 | 11 | 307 | -0.5 | -2.6 |
| May 02 02:26 | Phi Cap | DB | 5.2 | 87 | 32 | 137 | 0.2 | -4.7 |
| May 02 02:55 | Phi Cap | RD | 5.2 | 86 | 37 | 188 | 1.4 | 3.6 |
| May 02 04:43 | 3116 | RD | 6.6 | 86 | 55 | 210 | 1.3 | 1.8 |
| May 04 08:28 | Saturn | DB | 1.2 | 57 | 54 | 1 | 0.0 | 3.0 |
| May 04 09:16 | Saturn | RD | 1.2 | 57 | 53 | 280 | 2.6 | -0.1 |
| May 05 04:01 | Neptune | RD | 7.9 | 45 | 9 | 240 | 0.2 | -0.4 |
| May 25 19:37 | 3 Sgr | DB | 4.5 | 157 | 17 | 127 | -0.4 | -1.8 |
| May 25 20:28 | 3 Sgr | RD | 4.5 | 156 | 26 | 256 | 0.4 | -1.0 |
| May 26 01:05 | 2583 | RD | 5.8 | 155 | 72 | 285 | 1.8 | -1.0 |
| May 29 23:48 | 3197 | RD | 6.4 | 104 | 14 | 264 | 0.1 | -1.1 |
| May 31 02:21 | 70 Aqr | RD | 6.2 | 90 | 28 | 217 | 0.7 | 0.6 |
| Jun 19 23:43 | 2235 | DD | 6.3 | 149 | 61 | 149 | 1.6 | -2.2 |
| Jun 22 05:42 | 3 Sgr | DD | 4.5 | 174 | 21 | 113 | 0.4 | 0.7 |
| Jun 23 05:15 | 2723 | RD | 6.6 | 170 | 36 | 275 | 0.7 | 1.1 |
| Jun 28 04:17 | 3461 | RD | 6.3 | 105 | 50 | 269 | 2.1 | -0.5 |
| Jun 28 05:46 | 3465 | RD | 6.5 | 104 | 51 | 277 | 2.5 | 0.0 |
| Jun 29 02:38 | 35 | RD | 6.2 | 92 | 26 | 244 | 0.9 | -0.3 |
| Jul 01 03:40 | 297 | RD | 6.5 | 65 | 11 | 286 | 1.2 | -2.2 |
| Jul 02 04:46 | 47 Ara | RD | 5.8 | 52 | 8 | 265 | 0.9 | -1.1 |
| Jul 17 18:21 | 2299 | DD | 6.2 | 129 | 57 | 158 | 0.3 | -3.2 |
| Jul 22 19:58 | 27 Cap | RD | 6.3 | 165 | 21 | 207 | 0.8 | 1.0 |
| Jul 23 23:13 | 39 Aqr | RD | 6.1 | 150 | 41 | 245 | 1.1 | -0.2 |
| Jul 24 03:13 | 45 Aqr | RD | 6.0 | 149 | 59 | 218 | 1.0 | 1.9 |
| Jul 24 22:37 | 83 Aqr | RD | 5.5 | 137 | 22 | 272 | 0.6 | -1.5 |
| Jul 25 03:40 | Phi Aqr | DB | 4.2 | 135 | 53 | 7 | 0.2 | 2.6 |
| Jul 25 04:32 | Phi Aqr | RD | 4.2 | 135 | 49 | 275 | 2.2 | 0.5 |
| Jul 30 06:20 | 18 Tau | DB | 5.7 | 68 | 21 | 46 | 1.2 | 0.4 |
| Jul 30 06:24 | 19 Tau | DB | 4.3 | 67 | 21 | 139 | 5.1 | -4.1 |
| Jul 30 06:45 | 19 Tau | RD | 4.3 | 67 | 22 | 170 | -1.8 | 4.0 |
| Jul 30 06:47 | 21 Tau | DB | 5.8 | 67 | 22 | 132 | 3.7 | -2.3 |
| Aug 11 18:59 | 2017 | RB | 6.4 | 76 | 52 | 261 | 2.1 | 1.7 |
| Aug 14 00:33 | 2270 | DD | 5.4 | 100 | 17 | 56 | -0.4 | 2.4 |
| Aug 16 00:34 | 3 Sgr | DD | 4.5 | 124 | 38 | 13 | -1.4 | 5.6 |
| Aug 16 00:56 | 3 Sgr | RB | 4.5 | 124 | 34 | 332 | 2.4 | -2.3 |
| Aug 30 06:29 | Iot Gem | RD | 3.8 | 48 | 11 | 228 | 1.1 | -0.2 |
| Sep 12 20:15 | 2644 | DD | 6.4 | 104 | 69 | 66 | 1.7 | 1.6 |
| Sep 12 22:57 | 2660 | DD | 6.2 | 105 | 42 | 148 | 2.9 | -2.4 |
| Sep 16 22:11 | 45 Aqr | DD | 6.0 | 158 | 59 | 73 | 1.7 | 0.4 |
| Sep 17 22:45 | Phi Aqr | DD | 4.2 | 172 | 51 | 9 | 0.4 | 2.4 |
| Sep 17 23:37 | Phi Aqr | RB | 4.2 | 172 | 53 | 273 | 2.3 | -0.2 |
| Sep 18 01:53 | 96 Aqr | DD | 5.6 | 173 | 43 | 28 | 0.6 | 2.0 |
| Sep 20 04:43 | 173 | RD | 6.5 | 156 | 21 | 322 | 4.0 | -3.6 |
| Sep 22 00:05 | Eps Ari | DB | 4.7 | 130 | 13 | 64 | 0.8 | -0.4 |
| Sep 22 01:13 | Eps Ari | RD | 4.7 | 130 | 21 | 234 | 1.0 | 0.0 |
| Sep 22 01:13 | X 54005 | RD | 5.6 | 130 | 21 | 234 | 1.0 | 0.0 |
| Sep 25 03:45 | 921 | RD | 6.0 | 90 | 11 | 261 | 1.4 | -0.8 |
| Oct 20 02:16 | 7 Tau | RD | 6.0 | 149 | 23 | 271 | 2.0 | 0.2 |
| Oct 22 01:04 | 850 | RD | 6.0 | 122 | 9 | 241 | 0.9 | -0.5 |
| Oct 22 02:12 | 855 | RD | 6.4 | 122 | 14 | 282 | 1.8 | -0.9 |
| Oct 22 02:44 | 864 | RD | 6.6 | 122 | 16 | 188 | -0.1 | 2.9 |
| Oct 23 02:35 | 28 Gem | RD | 5.4 | 109 | 12 | 223 | 1.0 | 0.1 |
| Nov 03 20:02 | 2270 | DD | 5.4 | 21 | 8 | 40 | -1.1 | 2.9 |
| Nov 05 21:34 | 3 Sgr | DD | 4.5 | 44 | 13 | 66 | -0.4 | 1.6 |
| Nov 06 21:56 | 2723 | DD | 6.6 | 56 | 18 | 71 | -0.2 | 1.5 |
| Nov 10 00:48 | Gam Cap | DD | 3.7 | 94 | 9 | 34 | -0.4 | 1.8 |
| Nov 11 00:30 | 3310 | DD | 6.4 | 107 | 17 | 23 | -0.1 | 2.1 |
| Nov 11 21:56 | 96 Aqr | DD | 5.6 | 119 | 45 | 40 | 0.9 | 1.8 |
| Nov 11 23:03 | 96 Aqr | RB | 5.6 | 120 | 36 | 244 | 1.0 | 1.7 |
| Nov 15 21:51 | Eps Ari | DD | 4.7 | 173 | 22 | 82 | 1.6 | -0.5 |
| Nov 15 21:51 | X 54005 | DD | 5.6 | 173 | 22 | 82 | 1.6 | -0.5 |
| Nov 15 22:57 | Eps Ari | RB | 4.7 | 174 | 25 | 217 | 1.0 | 0.7 |
| Nov 17 04:01 | 44 Tau | RD | 5.4 | 167 | 7 | 245 | 1.2 | 1.5 |
| Nov 19 01:15 | Kap Aur | RD | 4.3 | 142 | 16 | 289 | 1.9 | -0.9 |
| Nov 20 04:33 | Iot Gem | DB | 3.8 | 129 | 19 | 112 | 1.7 | 0.0 |
| Dec 07 23:28 | 42 Aqr | DD | 5.3 | 76 | 7 | 126 | 0.3 | 0.5 |
| Dec 09 22:19 | 3520 | DD | 5.8 | 101 | 27 | 31 | 0.5 | 2.1 |
| Dec 10 23:52 | 62 Psc | DD | 5.9 | 115 | 14 | 47 | 0.6 | 1.9 |
| Dec 11 00:41 | Del Psc | DD | 4.4 | 115 | 6 | 342 | 0.4 | 5.2 |
| Dec 13 22:38 | 7 Tau | DD | 6.0 | 155 | 23 | 51 | 1.5 | 0.7 |
| Dec 16 00:07 | 864 | RD | 6.6 | 173 | 18 | 248 | 1.8 | 0.2 |
| Dec 16 22:30 | 28 Gem | RD | 5.4 | 164 | 9 | 291 | 1.5 | -1.4 |

## MELBOURNE (37° 50' S, 145° 00' E)

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 15 20:55 | 3432 | DD | 6.2 | 54 | 17 | 28 | 0.1 | 2.1 |
| Jan 20 23:55 | 17 Tau | DD | 3.7 | 119 | 8 | 54 | 1.3 | 1.9 |
| Jan 24 00:59 | 53 Aur | DD | 5.8 | 155 | 17 | 62 | 2.4 | 1.7 |
| Jan 24 20:28 | Iot Gem | RB | 3.8 | 165 | 11 | 268 | 1.4 | -1.1 |
| Jan 24 21:42 | 65 Gem | DD | 5.0 | 165 | 19 | 57 | 1.7 | 0.0 |
| Jan 31 04:59 | Eta Vir | DB | 3.9 | 125 | 51 | 156 | 1.0 | -2.0 |
| Feb 14 20:39 | Pi Psc | DD | 5.5 | 62 | 12 | 50 | 0.8 | 1.9 |
| Feb 21 22:38 | 13 Cnc | DD | 6.4 | 146 | 27 | 141 | 1.6 | -1.1 |
| Feb 29 04:42 | 76 Vir | DB | 5.2 | 134 | 57 | 72 | 3.4 | 2.3 |
| Feb 29 05:31 | 76 Vir | RD | 5.2 | 134 | 50 | 2 | 0.3 | -4.2 |
| Mar 05 01:08 | 3 Sgr | DB | 4.5 | 77 | 15 | 101 | -0.2 | -1.3 |
| Mar 05 02:04 | 3 Sgr | RD | 4.5 | 77 | 25 | 283 | 0.1 | -1.4 |
| Mar 05 05:31 | 2583 | DB | 5.8 | 75 | 64 | 53 | 2.5 | 1.3 |
| Mar 19 21:04 | Phi Gem | DD | 5.0 | 116 | 25 | 149 | 1.3 | -1.2 |
| Mar 19 22:14 | Phi Gem | RB | 5.0 | 116 | 21 | 257 | 2.4 | 1.3 |
| Mar 22 21:49 | 42 Leo | DD | 6.2 | 149 | 36 | 91 | 2.7 | -0.5 |
| Mar 30 02:40 | 2235 | RD | 6.3 | 131 | 72 | 227 | 5.3 | 4.9 |
| Apr 03 01:12 | 2848 | RD | 5.6 | 83 | 17 | 210 | 1.2 | 1.1 |
| Apr 14 20:36 | 53 Aur | DD | 5.8 | 74 | 10 | 125 | 0.7 | 0.2 |
| Apr 21 23:49 | 13 Vir | DD | 5.9 | 153 | 50 | 184 | -0.2 | -3.6 |
| Apr 22 00:01 | Eta Vir | DD | 3.9 | 153 | 49 | 109 | 2.1 | -0.2 |
| Apr 22 01:16 | Eta Vir | RB | 3.9 | 153 | 39 | 333 | 0.8 | -1.5 |
| Apr 26 20:16 | 2311 | RD | 6.3 | 151 | 16 | 249 | 0.3 | -0.8 |
| Apr 27 02:48 | Sig Sco | DB | 2.9 | 149 | 77 | 112 | 2.1 | -0.9 |
| Apr 27 04:15 | Sig Sco | RD | 2.9 | 148 | 63 | 278 | 2.0 | 0.4 |
| May 02 02:10 | Phi Cap | DB | 5.2 | 87 | 27 | 112 | 0.3 | -2.2 |
| May 02 03:02 | Phi Cap | RD | 5.2 | 86 | 37 | 215 | 1.2 | 1.1 |
| May 04 08:56 | Saturn | MD | 1.2 | 57 | 59 | 319 | | |
| May 05 03:57 | Neptune | RD | 7.9 | 45 | 7 | 259 | 0.2 | -0.8 |
| May 13 20:27 | 13 Cnc | DD | 6.4 | 66 | 11 | 90 | 1.3 | 1.2 |
| May 13 20:59 | Psi Cnc | DD | 5.7 | 66 | 6 | 159 | -0.4 | -1.0 |
| May 24 05:24 | 2311 | RD | 6.3 | 176 | 26 | 345 | 2.1 | -3.5 |
| May 25 20:22 | 3 Sgr | RD | 4.5 | 156 | 22 | 264 | 0.3 | -1.0 |
| May 26 00:54 | 2583 | RD | 5.8 | 155 | 73 | 301 | 1.8 | -2.0 |
| May 27 05:07 | Tau Sgr | DB | 3.3 | 141 | 63 | 151 | 5.6 | -7.7 |
| May 31 02:21 | 70 Aqr | RD | 6.2 | 90 | 27 | 236 | 0.8 | 0.0 |
| Jun 01 06:28 | 20 Psc | DB | 5.5 | 75 | 52 | 107 | 3.3 | -1.8 |
| Jun 19 22:49 | 2227 | DD | 5.8 | 149 | 73 | 166 | 1.1 | -4.2 |
| Jun 19 23:30 | 2235 | DD | 6.3 | 149 | 67 | 130 | 1.9 | -1.3 |
| Jun 22 03:52 | 2545 | DD | 6.4 | 174 | 42 | 85 | 0.9 | 1.3 |
| Jun 22 05:46 | 3 Sgr | DD | 4.5 | 174 | 21 | 98 | 0.2 | 1.0 |
| Jun 27 23:33 | Saturn | RD | 1.1 | 107 | 6 | 183 | 0.3 | 2.7 |
| Jun 28 04:04 | 3461 | RD | 6.3 | 105 | 52 | 298 | 4.1 | -3.6 |
| Jun 29 02:33 | 35 | RD | 6.2 | 92 | 26 | 265 | 1.1 | -1.0 |
| Jul 02 04:36 | 47 Ara | RD | 5.8 | 52 | 9 | 288 | 1.3 | -2.1 |
| Jul 18 00:59 | 2332 | DD | 6.1 | 131 | 37 | 139 | 1.5 | -0.9 |
| Jul 18 03:51 | Sig Sco | DD | 2.9 | 132 | 6 | 144 | 0.4 | -0.5 |
| Jul 19 00:49 | 2470 | DD | 6.1 | 143 | 51 | 158 | 3.1 | -4.6 |
| Jul 19 21:14 | 2617 | DD | 4.6 | 154 | 70 | 145 | 1.3 | -3.8 |
| Jul 19 22:06 | 2617 | RB | 4.6 | 155 | 79 | 221 | 2.4 | 2.9 |
| Jul 22 19:59 | 27 Cap | RD | 6.3 | 165 | 18 | 226 | 0.6 | 0.2 |
| Jul 23 23:08 | 39 Aqr | RD | 6.1 | 150 | 40 | 264 | 1.3 | -0.9 |
| Jul 24 03:18 | 45 Aqr | RD | 6.0 | 149 | 63 | 234 | 1.4 | 1.5 |
| Jul 24 22:25 | 83 Aqr | RD | 5.5 | 137 | 18 | 297 | 0.6 | -3.0 |
| Jul 25 03:59 | Phi Aqr | DB | 4.2 | 135 | 57 | 340 | -1.9 | 5.2 |
| Jul 25 04:24 | Phi Aqr | RD | 4.2 | 135 | 55 | 299 | 4.6 | -1.8 |
| Jul 30 06:05 | 19 Tau | DB | 4.3 | 68 | 24 | 113 | 2.8 | -1.6 |
| Jul 30 06:21 | 18 Tau | DB | 5.7 | 67 | 25 | 33 | 0.9 | 0.9 |
| Jul 30 06:32 | 21 Tau | DB | 5.8 | 67 | 26 | 111 | 2.8 | -1.3 |
| Aug 14 00:51 | 2270 | DD | 5.4 | 100 | 13 | 27 | -1.6 | 5.0 |
| Aug 30 06:26 | Iot Gem | RD | 3.8 | 48 | 14 | 240 | 1.2 | -0.3 |
| Sep 11 23:19 | 43 Oph | DD | 5.3 | 93 | 28 | 149 | 1.9 | -1.6 |
| Sep 11 23:47 | 43 Oph | RB | 5.3 | 93 | 23 | 201 | -1.4 | 4.0 |
| Sep 12 20:20 | 2645 | DD | 6.2 | 104 | 73 | 131 | 2.7 | -2.1 |
| Sep 12 20:22 | 2644 | DD | 6.4 | 104 | 72 | 44 | 1.6 | 2.9 |
| Sep 12 21:15 | 2645 | RB | 6.2 | 104 | 63 | 212 | 0.8 | 3.8 |
| Sep 12 22:49 | 2660 | DD | 6.2 | 105 | 45 | 119 | 1.7 | 0.0 |
| Sep 16 22:10 | 45 Aqr | DD | 6.0 | 158 | 63 | 55 | 1.6 | 1.0 |
| Sep 17 23:04 | Phi Aqr | DD | 4.2 | 172 | 57 | 336 | -2.7 | 7.1 |
| Sep 17 23:24 | Phi Aqr | RB | 4.2 | 172 | 58 | 304 | 5.6 | -4.6 |
| Sep 18 02:03 | 96 Aqr | DD | 5.6 | 174 | 46 | 15 | 0.4 | 2.4 |
| Sep 22 00:03 | Eps Ari | DB | 4.7 | 130 | 15 | 47 | 0.5 | 0.1 |
| Sep 22 01:10 | Eps Ari | RD | 4.7 | 130 | 24 | 249 | 1.3 | -0.2 |
| Sep 22 01:10 | X 54005 | RD | 5.6 | 130 | 24 | 249 | 1.3 | -0.2 |
| Sep 25 03:37 | 921 | RD | 6.0 | 90 | 14 | 272 | 1.6 | -1.0 |
| Oct 20 02:11 | 7 Tau | RD | 6.0 | 149 | 28 | 281 | 2.4 | -0.2 |
| Oct 22 00:59 | 850 | RD | 6.0 | 122 | 11 | 254 | 1.1 | -0.6 |
| Oct 23 02:32 | 28 Gem | RD | 5.4 | 109 | 15 | 235 | 1.2 | -0.1 |
| Nov 05 21:44 | 3 Sgr | DD | 4.5 | 44 | 10 | 52 | -0.7 | 1.8 |
| Nov 10 00:59 | Gam Cap | DD | 3.7 | 94 | 7 | 25 | -0.5 | 2.0 |
| Nov 11 22:04 | 96 Aqr | DD | 5.6 | 119 | 49 | 28 | 0.8 | 2.2 |
| Nov 11 23:09 | 96 Aqr | RB | 5.6 | 120 | 39 | 254 | 1.3 | 1.5 |
| Nov 15 21:46 | Eps Ari | DD | 4.7 | 173 | 25 | 68 | 1.3 | -0.1 |
| Nov 15 21:46 | X 54005 | DD | 5.6 | 173 | 25 | 68 | 1.3 | -0.1 |
| Nov 15 22:58 | Eps Ari | RB | 4.7 | 174 | 30 | 229 | 1.3 | 0.6 |
| Nov 17 04:06 | 44 Tau | RD | 5.4 | 167 | 11 | 251 | 1.3 | 1.4 |
| Nov 19 00:00 | Kap Aur | DB | 4.3 | 143 | 13 | 51 | 0.9 | -0.1 |
| Nov 19 01:05 | Kap Aur | RD | 4.3 | 142 | 19 | 298 | 2.2 | -1.3 |
| Nov 20 04:29 | Iot Gem | DB | 3.8 | 129 | 24 | 107 | 2.0 | -0.1 |
| Nov 24 04:09 | 53 Leo | DB | 5.3 | 82 | 28 | 153 | 1.0 | -2.4 |
| Dec 07 23:31 | 42 Aqr | DD | 5.3 | 76 | 8 | 112 | 0.2 | 0.8 |
| Dec 08 20:45 | 81 Aqr | DD | 6.2 | 87 | 44 | 350 | -0.8 | 3.6 |
| Dec 09 22:29 | 3520 | DD | 5.8 | 101 | 29 | 21 | 0.5 | 2.3 |
| Dec 11 00:01 | 62 Psc | DD | 5.9 | 115 | 16 | 40 | 0.7 | 2.0 |
| Dec 13 22:39 | 7 Tau | DD | 6.0 | 155 | 28 | 42 | 1.5 | 1.0 |
| Dec 16 22:18 | 28 Gem | RD | 5.4 | 164 | 11 | 303 | 1.7 | -1.8 |

LUNAR OCCULTATION TABLE

# PERTH (31° 57' S, 115° 51' E)

| WST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 20 21:13 | 17 Tau | DD | 3.7 | 119 | 32 | 44 | 2.0 | 1.6 |
| Jan 20 22:01 | 23 Tau | DD | 4.1 | 120 | 28 | 106 | 2.3 | 0.3 |
| Jan 20 22:31 | 17 Tau | RB | 3.7 | 120 | 24 | 278 | 1.9 | 0.7 |
| Jan 20 22:45 | Eta Tau | DD | 2.9 | 120 | 23 | 89 | 1.8 | 0.9 |
| Jan 20 23:11 | 23 Tau | RB | 4.1 | 120 | 19 | 222 | 1.8 | 2.2 |
| Jan 20 23:46 | 28 Tau | DD | 5.1 | 120 | 14 | 103 | 1.1 | 0.7 |
| Jan 20 23:51 | 27 Tau | DD | 3.6 | 120 | 13 | 124 | 0.8 | 0.0 |
| Jan 21 00:01 | Eta Tau | RB | 2.9 | 120 | 11 | 246 | 1.3 | 1.7 |
| Jan 23 21:50 | 53 Aur | DD | 5.8 | 155 | 28 | 71 | 2.4 | 0.1 |
| Jan 27 22:49 | Eta Leo | DB | 3.5 | 159 | 23 | 44 | 2.3 | 2.0 |
| Jan 27 23:14 | Eta Leo | RB | 3.5 | 158 | 27 | 10 | 0.4 | -5.6 |
| Feb 18 22:22 | Bet Tau | DD | 1.7 | 113 | 20 | 104 | 1.7 | 0.5 |
| Feb 18 23:39 | Bet Tau | RB | 1.7 | 114 | 9 | 263 | 1.2 | 1.2 |
| Feb 21 01:08 | 59 Gem | DD | 5.8 | 137 | 13 | 126 | 0.6 | -0.1 |
| Feb 21 01:44 | Iot Gem | DD | 3.8 | 137 | 7 | 66 | 1.7 | 2.2 |
| Feb 29 01:23 | 76 Vir | DB | 5.2 | 134 | 56 | 125 | 1.5 | -1.9 |
| Feb 29 02:48 | 76 Vir | RD | 5.2 | 134 | 67 | 320 | 1.5 | -2.2 |
| Mar 05 02:43 | 2583 | DB | 5.8 | 75 | 30 | 83 | 0.7 | -0.8 |
| Mar 05 03:45 | 2583 | RD | 5.8 | 75 | 43 | 303 | 0.6 | -2.0 |
| Mar 08 04:55 | Chi Cap | DB | 5.3 | 35 | 18 | 86 | 0.3 | -0.9 |
| Mar 24 02:26 | 1625 | DD | 5.8 | 163 | 31 | 97 | 1.7 | 0.8 |
| Apr 14 18:53 | 53 Aur | RB | 5.8 | 74 | 26 | 224 | 3.5 | 2.6 |
| Apr 14 21:25 | 28 Gem | DD | 5.4 | 75 | 7 | 78 | 1.3 | 1.4 |
| Apr 18 18:31 | Eta Leo | RB | 3.5 | 119 | 33 | 358 | 0.8 | -3.6 |
| Apr 21 21:04 | Eta Vir | DD | 3.9 | 153 | 52 | 157 | 0.9 | -2.6 |
| Apr 21 22:25 | Eta Vir | RB | 3.9 | 153 | 59 | 292 | 2.4 | -1.1 |
| Apr 26 23:49 | Sig Sco | DB | 2.9 | 149 | 57 | 136 | 0.8 | -2.4 |
| Apr 27 01:06 | Sig Sco | RD | 2.9 | 148 | 73 | 274 | 2.4 | -0.7 |
| Apr 28 03:01 | 43 Oph | DB | 5.3 | 136 | 85 | 151 | 1.8 | -4.1 |
| Apr 28 03:57 | 43 Oph | RD | 5.3 | 135 | 80 | 226 | 2.6 | 3.5 |
| Apr 30 06:06 | 2848 | DB | 5.6 | 110 | 78 | 79 | 2.2 | 0.8 |
| May 02 00:41 | Phi Cap | RD | 5.2 | 86 | 8 | 210 | 0.6 | 1.1 |

| WST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| May 06 05:54 | 136 | DB | 6.1 | 30 | 16 | 96 | 0.9 | -1.4 |
| May 12 19:24 | 53 Gem | DD | 5.8 | 55 | 15 | 158 | -0.2 | -1.4 |
| May 20 21:42 | 76 Vir | DD | 5.2 | 145 | 68 | 60 | 6.9 | 4.1 |
| May 20 22:09 | 76 Vir | RD | 5.2 | 146 | 68 | 24 | -3.2 | -8.2 |
| May 25 22:07 | 2583 | RD | 5.8 | 155 | 40 | 282 | 0.8 | -1.4 |
| May 26 03:30 | 2617 | DB | 4.6 | 153 | 72 | 117 | 2.6 | -1.0 |
| May 26 04:40 | 2617 | RD | 4.6 | 152 | 58 | 228 | 1.0 | 2.6 |
| May 27 01:42 | Tau Sgr | DB | 3.3 | 141 | 71 | 93 | 2.2 | -0.7 |
| May 27 03:09 | Tau Sgr | RD | 3.3 | 140 | 86 | 251 | 2.3 | 1.0 |
| May 29 03:24 | Chi Cap | DB | 5.3 | 114 | 66 | 116 | 2.8 | -2.6 |
| May 29 04:16 | Chi Cap | RD | 5.3 | 114 | 76 | 191 | 0.9 | 4.1 |
| Jun 01 03:42 | 20 Psc | DB | 5.5 | 75 | 30 | 39 | 0.7 | 0.9 |
| Jun 01 04:49 | 20 Psc | RD | 5.5 | 74 | 43 | 248 | 1.5 | 0.0 |
| Jun 22 03:49 | 3 Sgr | DD | 4.5 | 174 | 41 | 35 | 0.0 | 3.3 |
| Jun 22 04:35 | 3 Sgr | RD | 4.5 | 174 | 32 | 309 | 1.5 | -0.5 |
| Jul 10 18:37 | 53 Leo | DD | 5.3 | 51 | 32 | 116 | 1.3 | -0.1 |
| Jul 10 19:49 | 53 Leo | RB | 5.3 | 52 | 19 | 321 | 0.4 | -0.7 |
| Jul 14 23:05 | 86 Vir | DD | 5.5 | 97 | 25 | 42 | 0.6 | 7.7 |
| Jul 14 23:27 | 86 Vir | RB | 5.5 | 97 | 20 | 7 | 1.1 | -7.0 |
| Jul 17 22:03 | 2332 | DD | 6.1 | 131 | 73 | 103 | 2.4 | -0.2 |
| Jul 18 01:43 | Sig Sco | DD | 2.9 | 132 | 28 | 83 | 0.5 | 1.3 |
| Jul 18 02:45 | Sig Sco | RB | 2.9 | 133 | 15 | 282 | 0.2 | 0.7 |
| Jul 18 21:31 | 2470 | DD | 6.1 | 143 | 85 | 117 | 2.3 | -1.4 |
| Jul 23 20:41 | 39 Aqr | RD | 6.1 | 150 | 11 | 283 | 0.0 | -1.5 |
| Jul 27 03:25 | Eps Psc | DB | 4.3 | 107 | 44 | 85 | 2.3 | -0.4 |
| Jul 27 04:25 | Eps Psc | RD | 4.3 | 106 | 49 | 191 | 0.4 | 2.3 |
| Jul 30 03:26 | 19 Tau | DB | 4.3 | 68 | 9 | 40 | 0.0 | 0.5 |
| Jul 30 03:34 | 20 Tau | DB | 3.9 | 67 | 10 | 74 | 0.7 | -0.5 |
| Jul 30 03:52 | 17 Tau | RD | 3.7 | 67 | 13 | 200 | -0.3 | 1.3 |
| Jul 30 04:09 | 16 Tau | RD | 5.5 | 67 | 16 | 239 | 0.7 | 0.0 |
| Jul 30 04:28 | 19 Tau | RD | 4.3 | 67 | 19 | 263 | 1.4 | -0.7 |
| Jul 30 04:40 | 20 Tau | RD | 3.9 | 67 | 20 | 229 | 0.7 | 0.3 |

| WST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jul 30 04:53 | 21 Tau | RD | 5.8 | 67 | 22 | 263 | 1.6 | -0.7 |
| Aug 13 22:28 | 2269 | DD | 5.4 | 100 | 40 | 118 | 1.4 | -0.1 |
| Aug 13 23:36 | 2269 | RB | 5.4 | 101 | 26 | 257 | 0.4 | 1.5 |
| Aug 16 02:11 | 2583 | DD | 5.8 | 126 | 19 | 71 | -0.1 | 1.4 |
| Aug 28 02:45 | Bet Tau | RD | 1.7 | 72 | 1 | 219 | -0.3 | 0.5 |
| Aug 30 05:49 | 65 Gem | RD | 5.0 | 47 | 13 | 323 | 2.2 | -2.9 |
| Sep 10 22:07 | Antares | DD | 1.1 | 82 | 30 | 107 | 0.9 | 0.5 |
| Sep 10 23:10 | Antares | RB | 1.1 | 82 | 17 | 256 | -0.1 | 1.4 |
| Sep 10 23:11 | 2373 | DD | 6.1 | 82 | 17 | 131 | 0.8 | -0.3 |
| Sep 11 20:36 | 43 Oph | DD | 5.3 | 93 | 60 | 82 | 1.8 | 1.2 |
| Sep 11 21:56 | 43 Oph | RB | 5.3 | 93 | 43 | 271 | 1.2 | 1.0 |
| Sep 19 20:32 | Eps Psc | RD | 4.3 | 159 | 10 | 231 | 0.2 | 0.2 |
| Sep 23 03:39 | 44 Tau | DB | 5.4 | 114 | 31 | 80 | 2.2 | 0.0 |
| Sep 23 05:04 | 44 Tau | RD | 5.4 | 114 | 31 | 239 | 2.1 | 1.0 |
| Sep 25 04:27 | Kap Aur | DB | 4.3 | 89 | 23 | 87 | 2.1 | -0.6 |
| Oct 09 22:45 | 2617 | DD | 4.6 | 75 | 20 | 129 | 1.0 | -0.2 |
| Oct 09 23:22 | 2617 | RB | 4.6 | 75 | 12 | 208 | -1.1 | 2.5 |
| Oct 17 02:42 | 60 Psc | DD | 6.0 | 170 | 29 | 60 | 1.1 | 1.6 |
| Oct 19 04:24 | Mu Ari | RD | 5.7 | 161 | 20 | 232 | 1.4 | 1.7 |
| Oct 20 05:02 | 18 Tau | RD | 5.7 | 146 | 20 | 203 | 1.9 | 2.9 |
| Oct 24 04:16 | Phi Gem | DB | 5.0 | 96 | 26 | 104 | 2.3 | -1.0 |
| Nov 17 01:19 | 44 Tau | RD | 5.4 | 167 | 31 | 259 | 2.2 | 0.5 |
| Nov 20 01:22 | Iot Gem | DB | 3.8 | 129 | 21 | 106 | 1.9 | -1.2 |
| Nov 20 01:46 | 59 Gem | RD | 5.8 | 128 | 24 | 216 | 1.5 | 1.6 |
| Nov 20 02:48 | Iot Gem | RD | 3.8 | 128 | 29 | 271 | 2.4 | -0.4 |
| Nov 24 02:26 | 53 Leo | RD | 5.3 | 82 | 13 | 261 | 0.9 | -1.0 |
| Dec 07 21:24 | 42 Aqr | DD | 5.3 | 76 | 33 | 68 | 0.7 | 1.6 |
| Dec 07 22:24 | 42 Aqr | RB | 5.3 | 76 | 20 | 225 | 0.1 | 1.9 |
| Dec 10 20:25 | 60 Psc | DD | 6.0 | 115 | 50 | 62 | 1.9 | 1.1 |
| Dec 10 21:55 | 62 Psc | DD | 5.9 | 115 | 40 | 354 | -0.1 | 3.4 |
| Dec 13 00:16 | Mu Ari | DD | 5.7 | 143 | 25 | 97 | 1.7 | 0.7 |
| Dec 14 01:45 | 18 Tau | DD | 5.7 | 157 | 17 | 113 | 1.2 | 0.3 |

# SYDNEY (33° 54' S, 151° 15' E)

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 15 21:03 | 3432 | DD | 6.2 | 54 | 11 | 25 | 0.0 | 2.1 |
| Jan 21 00:12 | 17 Tau | DD | 3.7 | 119 | 4 | 39 | 1.3 | 2.5 |
| Jan 24 01:28 | 53 Aur | DD | 5.8 | 155 | 14 | 32 | 4.6 | 5.6 |
| Jan 24 19:14 | Iot Gem | DD | 3.8 | 164 | 7 | 92 | 1.1 | -1.2 |
| Jan 24 20:34 | Iot Gem | RB | 3.8 | 165 | 18 | 270 | 1.8 | -0.9 |
| Jan 24 21:56 | 65 Gem | DD | 5.0 | 165 | 26 | 50 | 2.3 | 0.8 |
| Jan 26 03:55 | Ups 1 Cnc | DD | 5.7 | 175 | 11 | 170 | -0.7 | -1.9 |
| Jan 31 05:01 | Eta Vir | DB | 3.9 | 125 | 52 | 133 | 1.6 | -1.2 |
| Feb 05 03:15 | 2328 | RD | 6.4 | 69 | 38 | 325 | 0.0 | -2.4 |
| Feb 14 20:51 | Pi Psc | DD | 5.5 | 62 | 7 | 43 | 0.6 | 2.0 |
| Feb 21 22:46 | 13 Cnc | DD | 6.4 | 146 | 30 | 125 | 1.9 | -0.6 |
| Mar 03 02:17 | 2270 | DB | 5.4 | 101 | 52 | 180 | -1.2 | -4.6 |
| Mar 03 02:54 | 2270 | RD | 5.4 | 101 | 59 | 238 | 3.6 | 1.3 |
| Mar 05 01:03 | 3 Sgr | DB | 4.5 | 77 | 17 | 84 | 0.1 | -0.9 |
| Mar 05 01:58 | 3 Sgr | RD | 4.5 | 77 | 28 | 302 | 0.0 | -1.8 |
| Mar 19 21:09 | Phi Gem | DD | 5.0 | 116 | 27 | 131 | 1.6 | -0.6 |
| Mar 19 22:31 | Phi Gem | RB | 5.0 | 116 | 20 | 278 | 1.7 | 0.7 |
| Mar 22 22:14 | 42 Leo | DD | 6.2 | 149 | 41 | 62 | 5.7 | 2.4 |
| Mar 30 03:08 | 2235 | RD | 6.3 | 131 | 79 | 263 | 2.9 | 0.5 |
| Apr 03 01:19 | 2848 | RD | 5.6 | 83 | 22 | 238 | 0.7 | -0.1 |
| Apr 06 03:47 | 3303 | RD | 6.4 | 42 | 11 | 266 | 0.2 | -0.9 |
| Apr 14 20:44 | 53 Aur | DD | 5.8 | 74 | 8 | 106 | 0.8 | 0.6 |
| Apr 15 18:21 | 65 Gem | RB | 5.0 | 85 | 28 | 270 | 2.6 | 0.2 |
| Apr 21 23:41 | 13 Vir | DD | 5.9 | 153 | 51 | 156 | 0.9 | -2.0 |
| Apr 22 00:19 | Eta Vir | DD | 3.9 | 153 | 46 | 80 | 3.0 | 1.8 |
| Apr 22 01:11 | Eta Vir | RB | 3.9 | 153 | 37 | 360 | 0.0 | -3.4 |
| Apr 26 20:14 | 2311 | RD | 6.3 | 151 | 19 | 266 | 0.3 | -1.0 |
| Apr 27 03:01 | Sig Sco | DB | 2.9 | 149 | 74 | 94 | 2.4 | 0.2 |
| Apr 27 04:28 | Sig Sco | RD | 2.9 | 148 | 56 | 291 | 1.9 | -0.1 |
| Apr 29 03:20 | 2645 | RD | 6.2 | 124 | 83 | 211 | 2.7 | 4.6 |
| Apr 29 03:35 | 2644 | RD | 6.4 | 124 | 84 | 301 | 2.4 | -1.9 |
| May 02 02:07 | Phi Cap | DB | 5.2 | 87 | 31 | 92 | 0.7 | -1.2 |

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| May 02 03:13 | Phi Cap | RD | 5.2 | 86 | 44 | 233 | 1.4 | 0.5 |
| May 04 09:03 | Saturn | DD | 1.2 | 57 | 61 | 334 | -3.5 | 7.0 |
| May 04 09:22 | Saturn | RD | 1.2 | 57 | 59 | 303 | 6.3 | -3.3 |
| May 05 03:55 | Neptune | RD | 7.9 | 45 | 12 | 273 | 0.4 | -1.3 |
| May 25 20:19 | 3 Sgr | RD | 4.5 | 156 | 24 | 282 | 0.2 | -1.3 |
| May 26 00:54 | 2583 | RD | 5.8 | 155 | 79 | 324 | 1.8 | -3.7 |
| May 27 05:17 | Tau Sgr | DB | 3.3 | 141 | 57 | 142 | 4.2 | -3.8 |
| May 27 05:43 | Tau Sgr | RD | 3.3 | 141 | 51 | 182 | -1.8 | 6.4 |
| May 31 02:26 | 70 Aqr | RD | 6.2 | 90 | 34 | 248 | 1.1 | -0.2 |
| Jun 19 22:47 | 2227 | DD | 5.8 | 149 | 72 | 141 | 1.9 | -2.1 |
| Jun 19 23:39 | 2235 | DD | 6.3 | 149 | 62 | 113 | 2.0 | -0.3 |
| Jun 27 22:56 | Saturn | DB | 1.1 | 107 | 4 | 100 | 0.0 | -1.5 |
| Jun 27 23:41 | Saturn | RD | 1.1 | 107 | 13 | 206 | 0.4 | 1.2 |
| Jun 28 04:18 | 3461 | RD | 6.3 | 105 | 59 | 296 | 4.8 | -3.2 |
| Jun 29 02:37 | 35 | RD | 6.2 | 92 | 33 | 272 | 1.6 | -1.2 |
| Jul 02 04:38 | 47 Ara | RD | 5.8 | 52 | 15 | 290 | 1.8 | -2.2 |
| Jul 18 01:05 | 2332 | DD | 6.1 | 131 | 30 | 131 | 1.2 | -0.4 |
| Jul 19 00:54 | 2470 | DD | 6.1 | 143 | 44 | 145 | 2.4 | -2.1 |
| Jul 19 21:13 | 2617 | DD | 4.6 | 154 | 76 | 122 | 2.0 | -2.0 |
| Jul 19 22:29 | 2617 | RB | 4.6 | 155 | 84 | 240 | 2.3 | 1.7 |
| Jul 22 20:03 | 27 Cap | RD | 6.3 | 165 | 23 | 245 | 0.6 | -0.3 |
| Jul 23 23:12 | 39 Aqr | RD | 6.1 | 150 | 47 | 277 | 1.7 | -1.4 |
| Jul 24 03:34 | 45 Aqr | RD | 6.0 | 149 | 62 | 231 | 1.3 | 1.8 |
| Jul 25 04:08 | Phi Aqr | DB | 4.2 | 135 | 58 | 349 | -0.8 | 3.9 |
| Jul 25 04:45 | Phi Aqr | RD | 4.2 | 135 | 53 | 289 | 3.3 | -0.2 |
| Jul 30 06:19 | 19 Tau | DB | 4.3 | 68 | 30 | 117 | 3.4 | -1.6 |
| Aug 11 19:12 | 2017 | RB | 6.4 | 76 | 51 | 298 | 1.8 | -0.3 |
| Aug 30 05:23 | Iot Gem | DB | 3.8 | 48 | 12 | 125 | 1.8 | -2.0 |
| Sep 11 23:24 | 43 Oph | DD | 5.3 | 93 | 21 | 146 | 1.6 | -1.3 |
| Sep 12 20:31 | 2645 | DD | 6.2 | 104 | 67 | 120 | 2.6 | -1.0 |
| Sep 12 21:32 | 2645 | RB | 6.2 | 104 | 54 | 218 | 0.6 | 3.1 |
| Sep 12 23:00 | 2660 | DD | 6.2 | 105 | 37 | 118 | 1.4 | 0.1 |

| EST | Object | PD | Mag | Elg° | Alt° | PA° | A | B |
|---|---|---|---|---|---|---|---|---|
| Sep 16 22:24 | 45 Aqr | DD | 6.0 | 158 | 69 | 55 | 1.7 | 1.3 |
| Sep 17 23:14 | Phi Aqr | DD | 4.2 | 172 | 62 | 341 | -1.7 | 5.2 |
| Sep 17 23:43 | Phi Aqr | RB | 4.2 | 172 | 62 | 296 | 4.6 | -2.1 |
| Sep 18 02:14 | 96 Aqr | DD | 5.6 | 174 | 42 | 19 | 0.4 | 2.4 |
| Sep 19 22:11 | Eps Psc | DB | 4.3 | 159 | 32 | 124 | 3.8 | -5.1 |
| Sep 19 22:31 | Eps Psc | RD | 4.3 | 159 | 35 | 159 | -2.2 | 5.9 |
| Sep 22 00:08 | Eps Ari | DB | 4.7 | 130 | 22 | 48 | 0.7 | 0.3 |
| Sep 22 01:18 | Eps Ari | RD | 4.7 | 130 | 31 | 246 | 1.6 | 0.1 |
| Sep 22 01:18 | X 54005 | RD | 5.6 | 130 | 31 | 246 | 1.6 | 0.1 |
| Sep 25 03:45 | 921 | RD | 6.0 | 90 | 20 | 272 | 2.0 | -0.8 |
| Oct 20 02:26 | 7 Tau | RD | 6.0 | 149 | 31 | 281 | 2.4 | 0.1 |
| Oct 22 01:05 | 850 | RD | 6.0 | 122 | 18 | 253 | 1.4 | -0.4 |
| Oct 23 02:41 | 28 Gem | RD | 5.4 | 109 | 22 | 237 | 1.6 | 0.1 |
| Nov 10 01:03 | Gam Cap | DD | 3.7 | 94 | 0 | 22 | -0.6 | 2.0 |
| Nov 11 19:45 | Phi Aqr | RB | 4.2 | 118 | 62 | 280 | 3.3 | -0.6 |
| Nov 11 22:18 | 96 Aqr | DD | 5.6 | 119 | 45 | 33 | 0.8 | 2.2 |
| Nov 11 23:22 | 96 Aqr | RB | 5.6 | 120 | 33 | 251 | 1.0 | 1.5 |
| Nov 15 21:55 | Eps Ari | DD | 4.7 | 173 | 32 | 70 | 1.7 | 0.0 |
| Nov 15 21:55 | X 54005 | DD | 5.6 | 173 | 32 | 70 | 1.7 | 0.0 |
| Nov 15 23:10 | Eps Ari | RB | 4.7 | 174 | 35 | 226 | 1.5 | 1.0 |
| Nov 19 00:07 | Kap Aur | DB | 4.3 | 143 | 19 | 51 | 1.2 | 0.2 |
| Nov 19 01:14 | Kap Aur | RD | 4.3 | 142 | 25 | 301 | 2.4 | -1.2 |
| Nov 19 23:55 | 53 Gem | RD | 5.8 | 130 | 12 | 213 | 0.2 | 1.1 |
| Nov 20 04:42 | Iot Gem | DB | 3.8 | 129 | 26 | 92 | 2.2 | 0.5 |
| Nov 24 04:07 | 53 Leo | DB | 5.3 | 82 | 34 | 140 | 1.4 | -2.2 |
| Dec 08 20:55 | 81 Aqr | DD | 6.2 | 87 | 39 | 357 | -0.4 | 3.3 |
| Dec 09 22:41 | 3520 | DD | 5.8 | 101 | 23 | 22 | 0.4 | 2.4 |
| Dec 10 23:37 | 60 Psc | DD | 6.0 | 115 | 18 | 133 | 1.6 | -1.3 |
| Dec 11 00:13 | 62 Psc | DD | 5.9 | 115 | 11 | 35 | 0.5 | 2.1 |
| Dec 13 22:54 | 7 Tau | DD | 6.0 | 155 | 30 | 42 | 1.7 | 1.4 |
| Dec 16 22:23 | 28 Gem | RD | 5.4 | 164 | 17 | 304 | 2.1 | -1.8 |
| Dec 26 02:20 | 2017 | RD | 6.4 | 60 | 16 | 232 | 1.3 | 0.4 |

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

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

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

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

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

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

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

## CANBERRA (EST)

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

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

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

**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)

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

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

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

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

MOON

## HOBART (EST)

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

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

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

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

## MELBOURNE (EST)

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

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

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

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

## PERTH (WST)

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

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

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

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

## SYDNEY (EST)

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

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

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

# OBSERVING THE MOON

The Moon 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 south of the equator, 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 the left hand map) 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, because the features would be repeated. If you are able to view until 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 3-D effect with the low Sun angle sometimes resulting in complex, interesting shadows from peaks, crater walls, ridges and mountains. Seeing a *star* suspended in an otherwise dark crater as the sunlight touches the peak of its central mountain is impressive! For each day the features are listed starting in the south (top of the page) and moving north (down) along the terminator. The list covers prominent objects or those that present an observing challenge, such as ridges on the crater floor. The majority are craters unless otherwise named such as Mare for seas (see key list on the maps). The number following a crater's name is its diameter in kilometres. Note, there are numerous features that give great views over a number of lunar days (such as seas), but may not be listed on subsequent days.

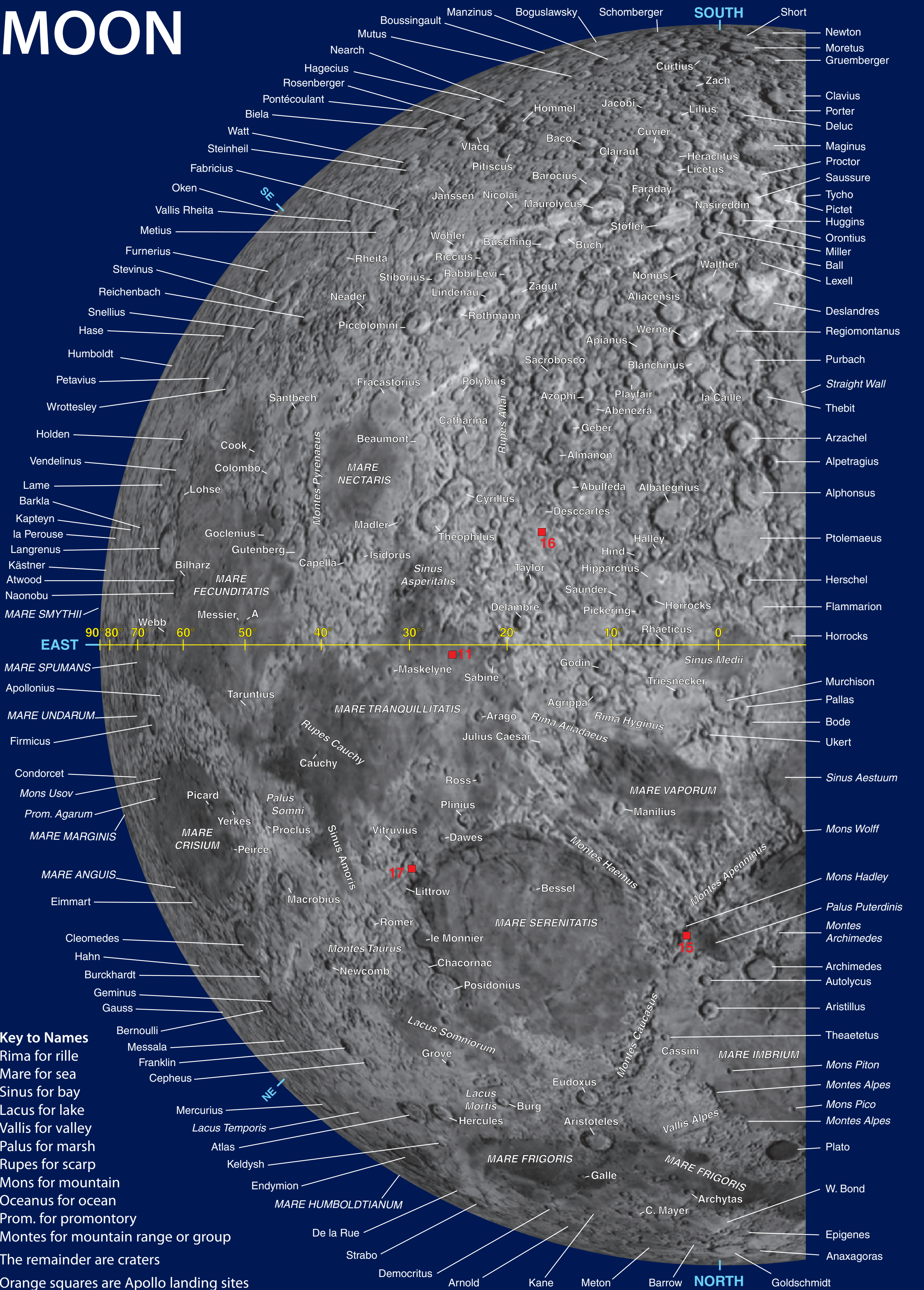
| FEATURE | NOTES |
|---|---|
| **Day 3 (48° E)** | |
| Biela (76 km) | three central peaks |
| Furnerius, Petavius, Vendelinus and Langrenus | easily recognised row of four craters |
| Furnerius (130 km) | look for small crater on floor |
| Petavius (177 km) | central mountain and rille |
| Vendelinus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

| FEATURE | NOTES |
|---|---|
| Posidonius (101 km) | impressive, circular walled plain |
| Lacus Somniorum | Lake of Dreams |
| Atlas (87 km) and Hercules (67 km) | prominent pair of craters near Mare Frigoris |
| Mare Frigoris | Sea of Cold |
| **Day 6 (20° E)** | |
| Manzinus (97 km) | deep crater with small craters on floor |
| Mutus (76 km) | paired with Manzinus with three small craters nearby |
| Hommel (120 km) | south of Pitiscus, with two obvious internal craters |
| Pitiscus (82 km) | prominent crater with central peak |
| Maurolycus (116km) | old, heavily cratered floor |
| Catharina (101 km), Cyrillus (93 km) and Theophilus (104 km) | Theophilus and Cyrillus are overlapping craters, these three make a very distinctive group |
| Delambre (46 km) | near equator |
| Arago (26 km), Ross (27 km) and Plinius (43 km) | three distinctive, isolated craters on western Mare Tranquillitatis |
| Bessel (16 km) | small isolated crater on Mare Serenitatis |
| Mare Serenitatis | Sea of Serenity |
| Eudoxus (67 km) and Aristoteles (88 km) | an impressive pair of craters near Mare Frigoris |
| **Day 7 (4° E) — First Quarter** | |
| Curtius (95 km) | contains three small mountain peaks |
| Lilius (62 km) | prominent central peak (casts a long spire shadow at low Sun angles) |
| Cuvier (78 km), Heraclitus (97 km) and Licetus (76 km) | three craters in an 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 König (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



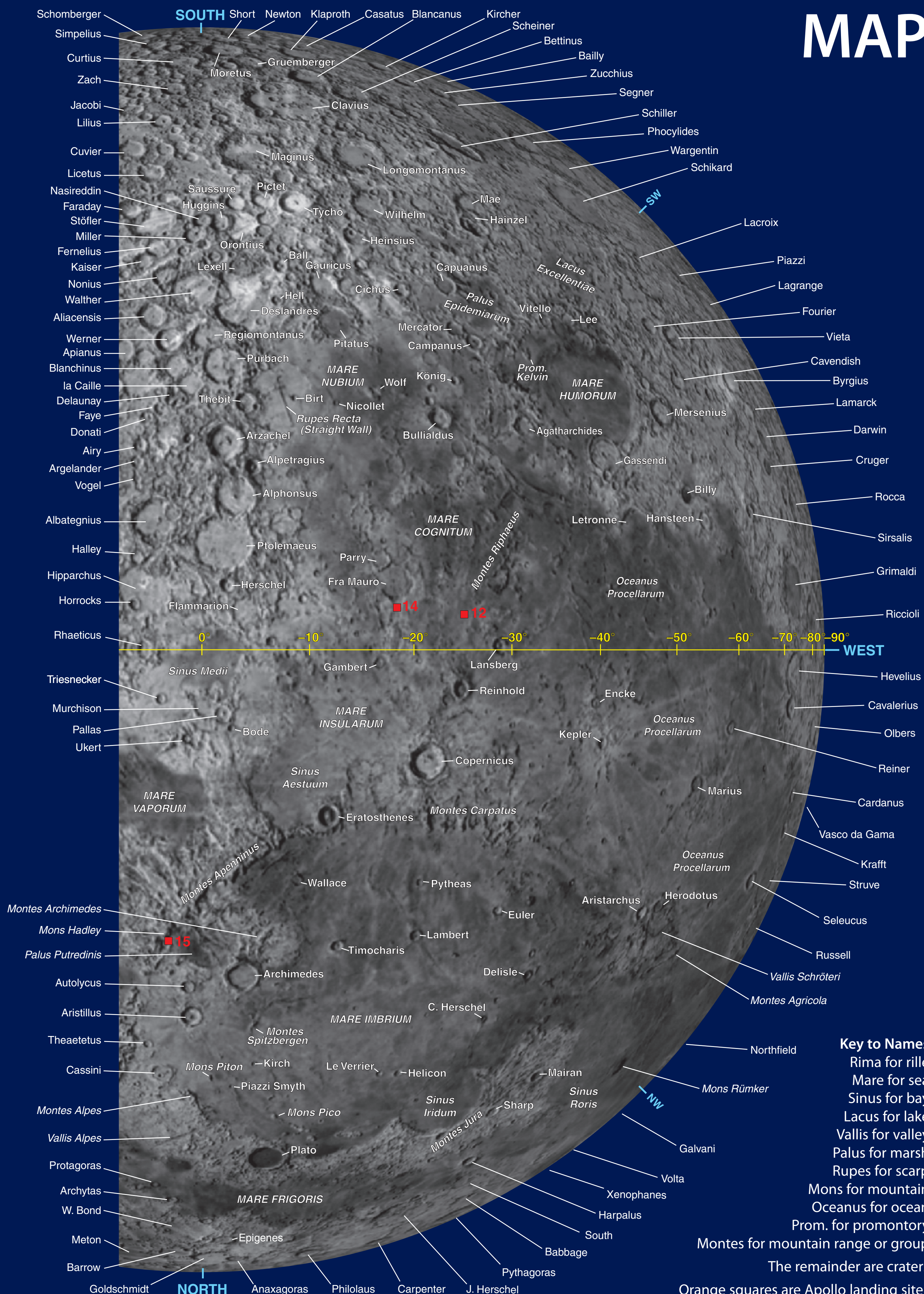

**Key to Names**

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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# OPPOSITION OF MARS 2025

Mars has long been the most fascinating of all the planets in the Solar System. Others are bigger, prettier, 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, clouds forming downwind from the largest volcanoes in the Solar System, and ever-changing surface features.

Mars next comes to opposition on January 16, 2025, four days after its closest approach to Earth at 96.1 million km (Mkm) (0.6423 au). The timing of opposition and closest approach can vary by up to two weeks since the orbits of Mars and Earth are eccentric and inclined to each other. These events would coincide if the orbits were circular and coplanar (in the same geometric plane).

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 it (Figure 1). When Mars is also at or near its perihelion, we get an excellent view, for example, the outstanding 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. At a perihelic opposition (Mars closest to the Sun), it will average around 57 Mkm from us.

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, the planet is at its greatest southerly declination. 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. When Mars is in conjunction, its disc is only 3.5 arcseconds (") in diameter, smaller than distant Uranus. At a poor opposition, the diameter is 14", increasing to 25" at a perihelic opposition see (Figure 2).

At next year's opposition, the size of the Martian disc is just 15" in angular size. This is one of several relatively poor oppositions, with the disc being under 20". The nearest approach in 2020 was the last of the good perihelic oppositions until the next series of three in 2033, 35, and 37. December to February 2025 will be the prime time to train large and small telescopes 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 skies (and no Martian

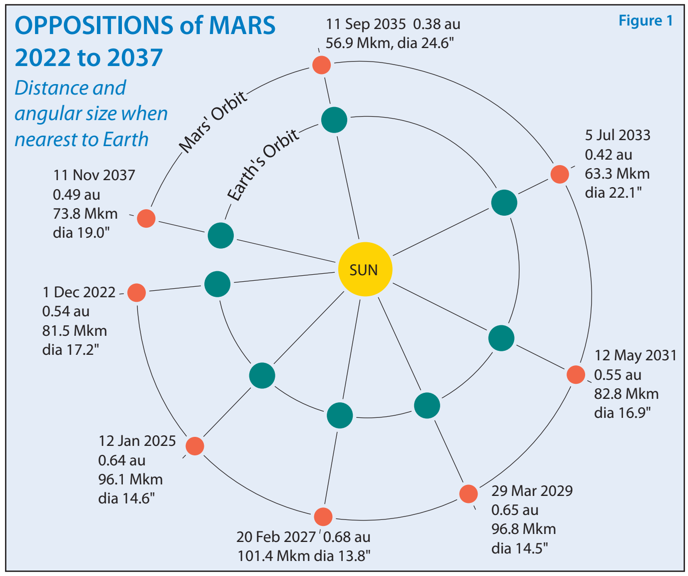



Figure 1 OPPOSITIONS of MARS 2022 to 2037

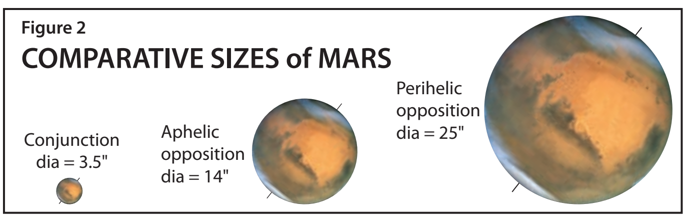



Figure 2 COMPARATIVE SIZES of MARS

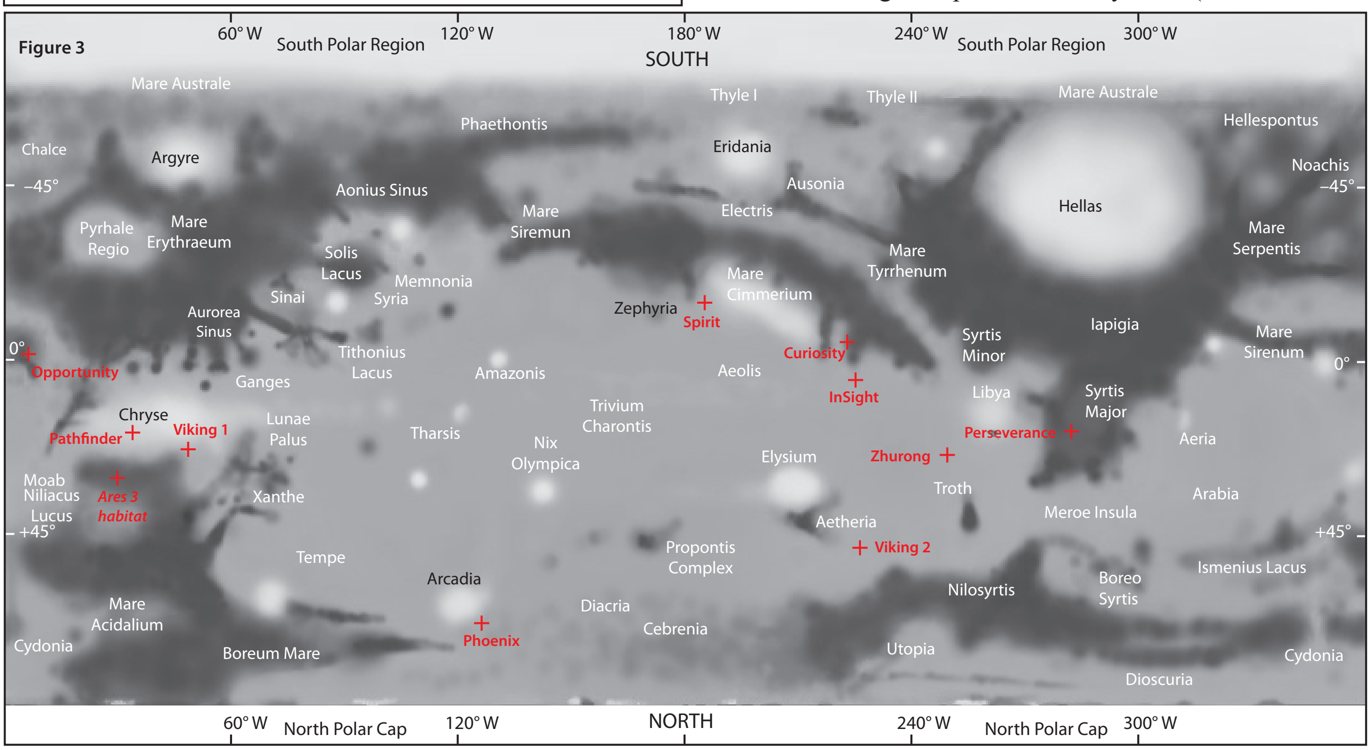



Figure 3

dust storms), try pushing the telescope to its maximum usable magnification—considered twice the aperture in millimetres (for an 80 mm telescope, this will be 160×). With modern-day imaging technology, the study of Martian surface features is no longer solely restricted to favourable oppositions, and many amateurs are doing superb work in this field.

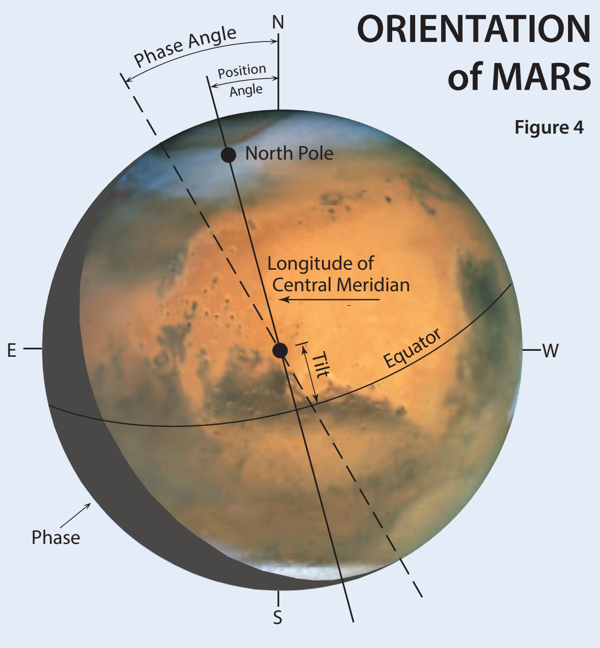
Since the Martian day is about 40 minutes longer than Earth's day, surface features cross the central meridian 40 minutes later each night. As this delay is about 9° of longitude per day, observations made at the same time each night will see all surface features cross the central meridian in under six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

The Viking Landers showed the iron-rich soils of Mars, which give the Red Planet its colour, to be much lighter than the rocks underneath. Depending on the season, high-velocity winds can lift and transport the soil around the planet. Sometimes the rocky surface is uncovered, showing a darker area. 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 is Syrtis Major, a wedge-shaped expanse just north of the equator. Directly below Syrtis Major in the south is a light contrasting area known as Hellas, a depression that is very conspicuous when covered in light dust. The mysterious Eye of Mars or Solis Lacus (Lake of the Sun) is in the Southern Hemisphere, a small dark region ringed by lighter material. At some oppositions, the Eye is outstanding, and at others, it isn't easily visible because of the shifting sands of Mars (see map, Figure 3).

Mars can be fun to observe at any opposition through a telescope. The view, however, can be significantly improved by using filters that can bring hard-to-detect areas into prominence.

## 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.

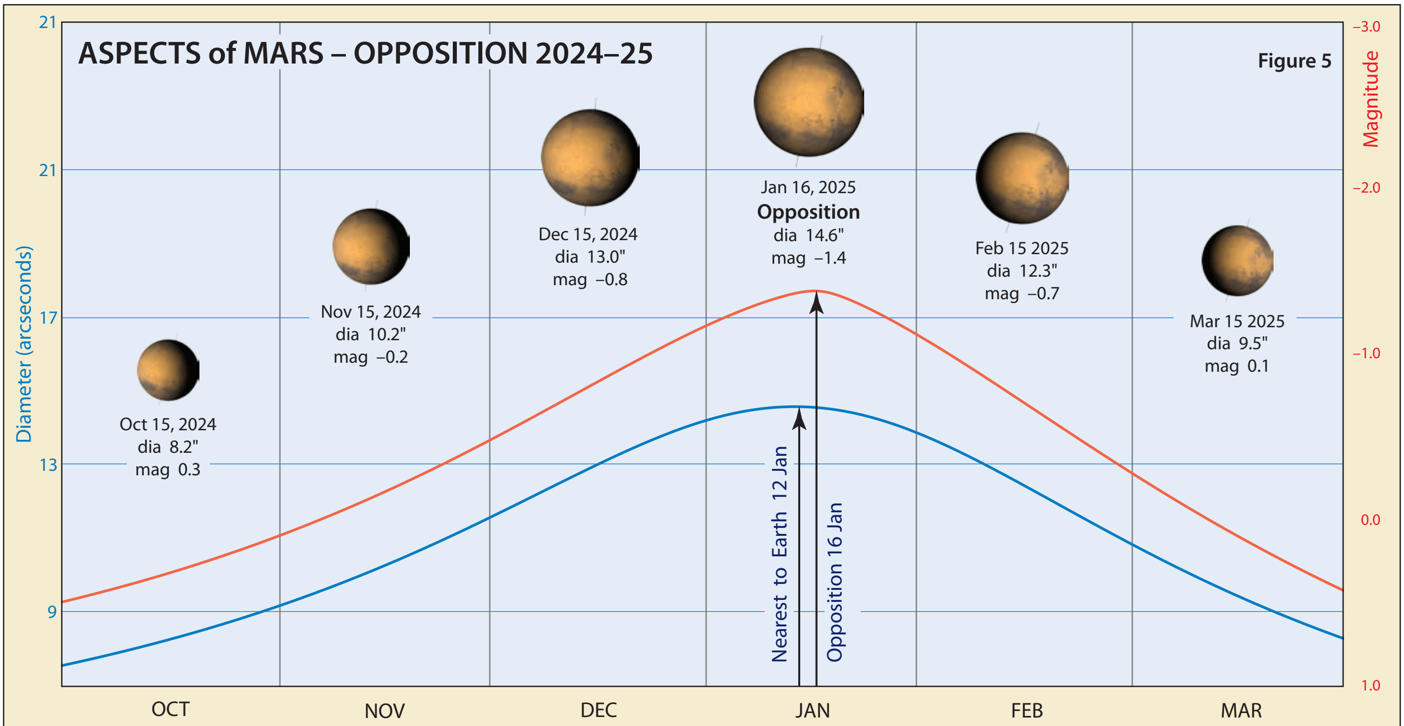
**Phase Angle**: The number of degrees (east of north) the phase is rotated.

**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 2024–25

Figure 5




MARS

## Table 1 Physical Ephemeris (0 hr UT).

See Figure 4 for description.

| Date | Cent Mer° | Tilt° | Phase | Phase Angle | P.A.° |
|---|---|---|---|---|---|
| Oct 28 | 324.4 | 13.6 | 0.884 | 39.8 | 348.9 |
| Oct 29 | 314.9 | 13.7 | 0.885 | 39.7 | 349.1 |
| Oct 30 | 305.5 | 13.9 | 0.885 | 39.6 | 349.4 |
| Oct 31 | 296.0 | 14.0 | 0.886 | 39.4 | 349.6 |
| Nov 1 | 286.5 | 14.1 | 0.887 | 39.3 | 349.8 |
| Nov 2 | 277.1 | 14.2 | 0.888 | 39.1 | 350.1 |
| Nov 3 | 267.6 | 14.3 | 0.889 | 39.0 | 350.3 |
| Nov 4 | 258.2 | 14.4 | 0.890 | 38.8 | 350.5 |
| Nov 5 | 248.8 | 14.5 | 0.890 | 38.7 | 350.7 |
| Nov 6 | 239.4 | 14.6 | 0.891 | 38.5 | 350.9 |
| Nov 7 | 229.9 | 14.7 | 0.892 | 38.3 | 351.2 |
| Nov 8 | 220.5 | 14.7 | 0.893 | 38.1 | 351.4 |
| Nov 9 | 211.1 | 14.8 | 0.894 | 37.9 | 351.6 |
| Nov 10 | 201.7 | 14.9 | 0.895 | 37.7 | 351.8 |
| Nov 11 | 192.3 | 15.0 | 0.897 | 37.5 | 351.9 |
| Nov 12 | 183.0 | 15.0 | 0.898 | 37.3 | 352.1 |
| Nov 13 | 173.6 | 15.1 | 0.899 | 37.1 | 352.3 |
| Nov 14 | 164.2 | 15.2 | 0.900 | 36.8 | 352.5 |
| Nov 15 | 154.9 | 15.2 | 0.901 | 36.6 | 352.6 |
| Nov 16 | 145.5 | 15.3 | 0.903 | 36.3 | 352.8 |
| Nov 17 | 136.2 | 15.3 | 0.904 | 36.1 | 353.0 |
| Nov 18 | 126.9 | 15.4 | 0.905 | 35.8 | 353.1 |
| Nov 19 | 117.5 | 15.4 | 0.907 | 35.5 | 353.3 |
| Nov 20 | 108.2 | 15.4 | 0.908 | 35.3 | 353.4 |
| Nov 21 | 098.9 | 15.5 | 0.910 | 35.0 | 353.5 |
| Nov 22 | 089.6 | 15.5 | 0.911 | 34.7 | 353.7 |
| Nov 23 | 080.4 | 15.5 | 0.913 | 34.3 | 353.8 |
| Nov 24 | 071.1 | 15.5 | 0.914 | 34.0 | 353.9 |
| Nov 25 | 061.8 | 15.6 | 0.916 | 33.7 | 354.0 |
| Nov 26 | 052.6 | 15.6 | 0.918 | 33.3 | 354.1 |
| Nov 27 | 043.3 | 15.6 | 0.919 | 33.0 | 354.2 |
| Nov 28 | 034.1 | 15.6 | 0.921 | 32.6 | 354.3 |
| Nov 29 | 024.9 | 15.6 | 0.923 | 32.2 | 354.4 |
| Nov 30 | 015.7 | 15.6 | 0.925 | 31.9 | 354.4 |
| Dec 1 | 006.5 | 15.5 | 0.927 | 31.5 | 354.5 |
| Dec 2 | 357.3 | 15.5 | 0.928 | 31.0 | 354.5 |
| Dec 3 | 348.2 | 15.5 | 0.930 | 30.6 | 354.6 |
| Dec 4 | 339.0 | 15.5 | 0.932 | 30.2 | 354.6 |
| Dec 5 | 329.9 | 15.5 | 0.934 | 29.7 | 354.6 |
| Dec 6 | 320.7 | 15.4 | 0.936 | 29.3 | 354.7 |
| Dec 7 | 311.6 | 15.4 | 0.938 | 28.8 | 354.7 |
| Dec 8 | 302.5 | 15.3 | 0.940 | 28.3 | 354.7 |
| Dec 9 | 293.4 | 15.3 | 0.942 | 27.8 | 354.7 |
| Dec 10 | 284.3 | 15.2 | 0.944 | 27.3 | 354.7 |
| Dec 11 | 275.3 | 15.2 | 0.946 | 26.8 | 354.6 |
| Dec 12 | 266.2 | 15.1 | 0.948 | 26.2 | 354.6 |
| Dec 13 | 257.2 | 15.0 | 0.951 | 25.7 | 354.6 |
| Dec 14 | 248.1 | 14.9 | 0.953 | 25.1 | 354.5 |
| Dec 15 | 239.1 | 14.9 | 0.955 | 24.6 | 354.5 |
| Dec 16 | 230.1 | 14.8 | 0.957 | 24.0 | 354.4 |
| Dec 17 | 221.1 | 14.7 | 0.959 | 23.4 | 354.3 |
| Dec 18 | 212.2 | 14.6 | 0.961 | 22.7 | 354.3 |
| Dec 19 | 203.2 | 14.5 | 0.963 | 22.1 | 354.2 |
| Dec 20 | 194.3 | 14.4 | 0.965 | 21.5 | 354.1 |
| Dec 21 | 185.3 | 14.3 | 0.967 | 20.8 | 354.0 |
| Dec 22 | 176.4 | 14.2 | 0.969 | 20.2 | 353.8 |
| Dec 23 | 167.5 | 14.1 | 0.971 | 19.5 | 353.7 |
| Dec 24 | 158.6 | 13.9 | 0.973 | 18.8 | 353.6 |
| Dec 25 | 149.7 | 13.8 | 0.975 | 18.1 | 353.4 |
| Dec 26 | 140.8 | 13.7 | 0.977 | 17.4 | 353.3 |
| Dec 27 | 132.0 | 13.6 | 0.979 | 16.7 | 353.1 |
| Dec 28 | 123.1 | 13.4 | 0.981 | 15.9 | 352.9 |

| Date | Cent Mer° | Tilt° | Phase | Phase Angle | P.A.° |
|---|---|---|---|---|---|
| Dec 29 | 114.3 | 13.3 | 0.983 | 15.2 | 352.8 |
| Dec 30 | 105.5 | 13.1 | 0.984 | 14.4 | 352.6 |
| Dec 31 | 096.6 | 13.0 | 0.986 | 13.7 | 352.4 |
| Jan 1 '25 | 087.8 | 12.8 | 0.987 | 12.9 | 352.2 |
| Jan 2 '25 | 079.0 | 12.7 | 0.989 | 12.1 | 352.0 |
| Jan 3 '25 | 070.3 | 12.5 | 0.990 | 11.3 | 351.8 |
| Jan 4 '25 | 061.5 | 12.4 | 0.992 | 10.5 | 351.6 |
| Jan 5 '25 | 052.7 | 12.2 | 0.993 | 9.7 | 351.3 |
| Jan 6 '25 | 043.9 | 12.0 | 0.994 | 8.9 | 351.1 |
| Jan 7 '25 | 035.2 | 11.9 | 0.995 | 8.2 | 350.9 |
| Jan 8 '25 | 026.4 | 11.7 | 0.996 | 7.4 | 350.6 |
| Jan 9 '25 | 017.7 | 11.5 | 0.997 | 6.6 | 350.4 |
| Jan 10 '25 | 008.9 | 11.4 | 0.997 | 5.8 | 350.2 |
| Jan 11 '25 | 000.2 | 11.2 | 0.998 | 5.1 | 349.9 |
| Jan 12 '25 | 351.4 | 11.0 | 0.999 | 4.4 | 349.7 |
| Jan 13 '25 | 342.7 | 10.9 | 0.999 | 3.7 | 349.4 |
| Jan 14 '25 | 333.9 | 10.7 | 0.999 | 3.1 | 349.2 |
| Jan 15 '25 | 325.2 | 10.5 | 0.999 | 2.8 | 348.9 |
| Jan 16 '25 | 316.5 | 10.4 | 0.999 | 2.6 | 348.7 |
| Jan 17 '25 | 307.7 | 10.2 | 0.999 | 2.7 | 348.4 |
| Jan 18 '25 | 299.0 | 10.0 | 0.999 | 3.1 | 348.2 |
| Jan 19 '25 | 290.2 | 9.9 | 0.999 | 3.6 | 348.0 |
| Jan 20 '25 | 281.5 | 9.7 | 0.999 | 4.2 | 347.7 |
| Jan 21 '25 | 272.7 | 9.6 | 0.998 | 4.9 | 347.5 |
| Jan 22 '25 | 264.0 | 9.4 | 0.998 | 5.6 | 347.2 |
| Jan 23 '25 | 255.2 | 9.3 | 0.997 | 6.4 | 347.0 |
| Jan 24 '25 | 246.4 | 9.1 | 0.996 | 7.1 | 346.8 |
| Jan 25 '25 | 237.7 | 9.0 | 0.995 | 7.9 | 346.5 |
| Jan 26 '25 | 228.9 | 8.8 | 0.994 | 8.7 | 346.3 |
| Jan 27 '25 | 220.1 | 8.7 | 0.993 | 9.4 | 346.1 |
| Jan 28 '25 | 211.3 | 8.6 | 0.992 | 10.2 | 345.9 |
| Jan 29 '25 | 202.5 | 8.4 | 0.991 | 11.0 | 345.7 |
| Jan 30 '25 | 193.7 | 8.3 | 0.990 | 11.7 | 345.5 |
| Jan 31 '25 | 184.9 | 8.2 | 0.988 | 12.5 | 345.3 |
| Feb 1 '25 | 176.0 | 8.1 | 0.987 | 13.2 | 345.1 |
| Feb 2 '25 | 167.2 | 8.0 | 0.985 | 13.9 | 344.9 |
| Feb 3 '25 | 158.3 | 7.9 | 0.984 | 14.6 | 344.8 |
| Feb 4 '25 | 149.5 | 7.8 | 0.982 | 15.3 | 344.6 |
| Feb 5 '25 | 140.6 | 7.7 | 0.981 | 16.0 | 344.4 |
| Feb 6 '25 | 131.7 | 7.6 | 0.979 | 16.7 | 344.3 |
| Feb 7 '25 | 122.8 | 7.6 | 0.977 | 17.4 | 344.1 |
| Feb 8 '25 | 113.9 | 7.5 | 0.975 | 18.0 | 344.0 |
| Feb 9 '25 | 105.0 | 7.4 | 0.974 | 18.7 | 343.9 |
| Feb 10 '25 | 096.0 | 7.4 | 0.972 | 19.3 | 343.8 |
| Feb 11 '25 | 087.1 | 7.3 | 0.970 | 19.9 | 343.7 |
| Feb 12 '25 | 078.1 | 7.3 | 0.968 | 20.5 | 343.6 |
| Feb 13 '25 | 069.2 | 7.2 | 0.966 | 21.1 | 343.5 |
| Feb 14 '25 | 060.2 | 7.2 | 0.965 | 21.7 | 343.4 |
| Feb 15 '25 | 051.2 | 7.2 | 0.963 | 22.2 | 343.3 |
| Feb 16 '25 | 042.2 | 7.1 | 0.961 | 22.8 | 343.2 |
| Feb 17 '25 | 033.2 | 7.1 | 0.959 | 23.3 | 343.2 |
| Feb 18 '25 | 024.1 | 7.1 | 0.957 | 23.9 | 343.1 |
| Feb 19 '25 | 015.1 | 7.1 | 0.955 | 24.4 | 343.1 |
| Feb 20 '25 | 006.0 | 7.1 | 0.954 | 24.9 | 343.0 |
| Feb 21 '25 | 356.9 | 7.1 | 0.952 | 25.4 | 343.0 |
| Feb 22 '25 | 347.9 | 7.1 | 0.950 | 25.8 | 343.0 |
| Feb 23 '25 | 338.8 | 7.2 | 0.948 | 26.3 | 343.0 |
| Feb 24 '25 | 329.7 | 7.2 | 0.947 | 26.7 | 343.0 |
| Feb 25 '25 | 320.6 | 7.2 | 0.945 | 27.2 | 343.0 |
| Feb 26 '25 | 311.4 | 7.3 | 0.943 | 27.6 | 343.0 |
| Feb 27 '25 | 302.3 | 7.3 | 0.941 | 28.0 | 343.0 |
| Feb 28 '25 | 293.1 | 7.3 | 0.940 | 28.4 | 343.0 |

A red or orange filter will highlight dark features; green or red filters are best for seeing the projections and boundaries of the polar caps. Yellow and green filters can distinguish surface frost and fog from lower-level clouds, while blue or violet filters show higher-altitude clouds. Using yellow, orange, and red filters will highlight dust storms.

There are many 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 the planet. Despite centuries of Earth-based telescope scrutiny and years of surveillance by orbiting spacecraft and landers, Mars still has many secrets. Some of these mysteries will be solved only by the dedication and enthusiasm of astronomers (primarily amateurs).

**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 January 27, converts to 15:20 UT on January 26. From the tables here our calculation is 228.9° + 219.3° + 4.9° = 453.1° Subtracting 360° to get a result less than 360° gives us a longitude of central meridian of 93.1°. The longitudes are shown on the map (Fig. 3). Around this time Solis Lacus 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 |

# JUPITER'S MOONS

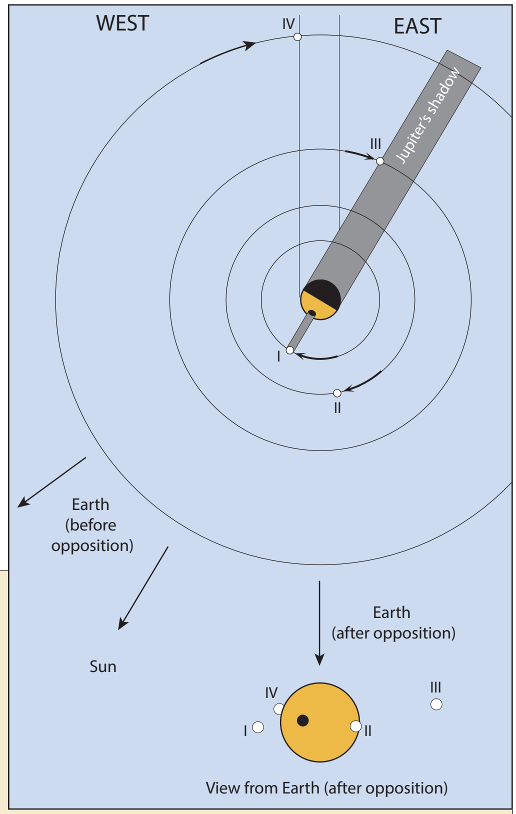
Jupiter, with its many moons, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are 95 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo, are 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 2024 is 8 December.
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.

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 7 January.

To see the moons with binoculars may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.




This diagram illustrates all of the Jupiter satellite events. It is only an example and does not represent any particular date or possible configuration.

Viewed from the Earth (after opposition):

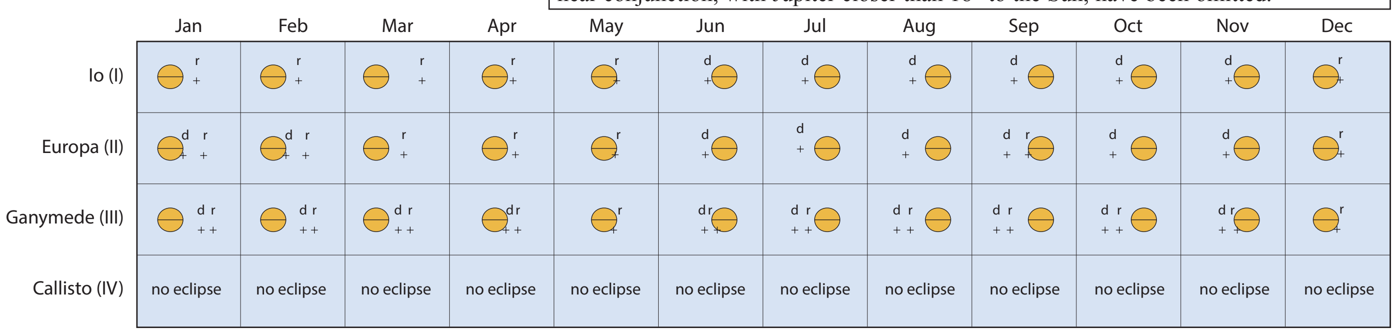
| | |
|---|---|
| Satellite I | (Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit. |
| Satellite II | (Europa) has just commenced a satellite transit (ingress). |
| Satellite III | (Ganymede) is about to be eclipsed (disappear). |
| Satellite IV | (Callisto) may be about to move out of sight as it is occulted by Jupiter's disc. |

**JUPITER'S MOON EVENTS Legend (following pages)**

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

Note: In these tables, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia. Events near conjunction, with Jupiter closer than 18° to the Sun, have been omitted.

## ECLIPSE POSITIONS



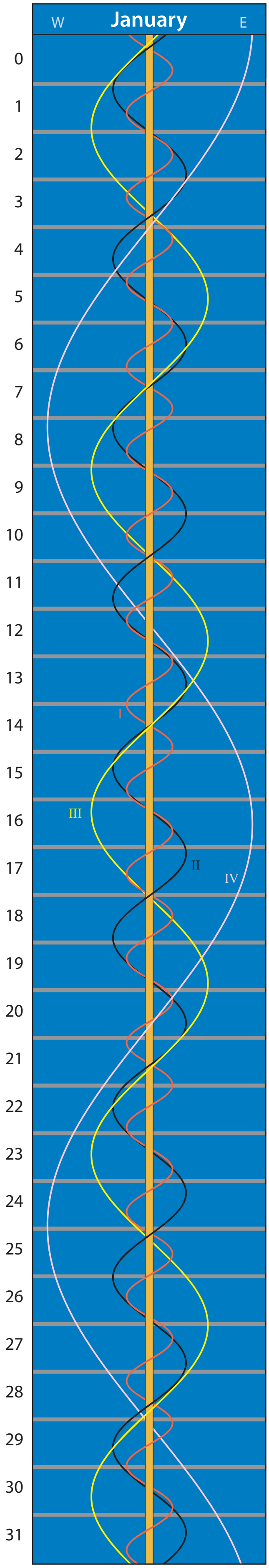

These diagrams show the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse happens when the moon passes into (disappearance or d) or out of (reappearance or r) Jupiter's shadow; west to the left, east to the right.

# JUPITER MOON EVENTS

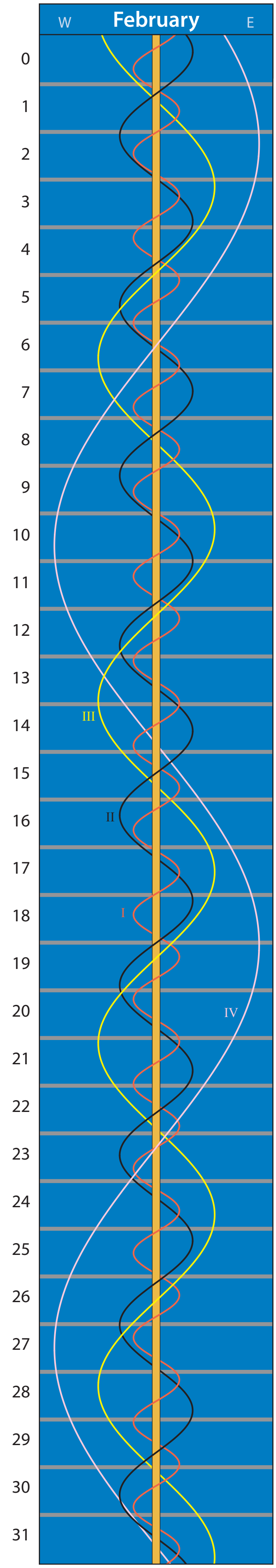
The diagrams here show the patterns that the four major moons of Jupiter make as they shuttle back and forth. Each complete period represents one orbit of the satellite. Each horizontal grey date line represents midnight; the top edge of the line is midnight EST (14 hr UT), the bottom edge of the line 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**
- **IV** is **Callisto.**

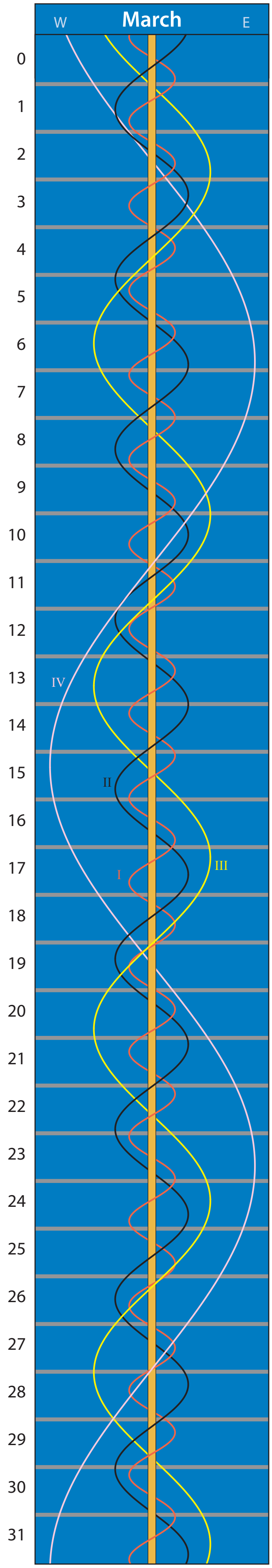



| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| **January** | | | | | |
| 2 | 00:09 | 22:09(p) | II | Oc D | |
| | 01:24 | 23:24(p) | I | Oc D | W |
| | 02:30 | 00:30 | II | Oc R | W |
| | 02:39 | 00:39 | II | Ec D | W |
| | 22:37 | 20:37 | I | Tr I | |
| | 23:51 | 21:51 | I | Sh I | |
| 3 | 00:48 | 22:48(p) | I | Tr E | |
| | 02:02 | 00:02 | I | Sh E | W |
| | 19:52 | 17:52 | I | Oc D | E |
| | 21:12 | 19:12 | II | Tr E | E |
| | 21:19 | 19:19 | II | Sh I | E |
| | 22:06 | 20:06 | III | Ec D | |
| | 23:15 | 21:15 | I | Ec R | |
| | 23:39 | 21:39 | II | Sh E | |
| | 23:45 | 21:45 | III | Ec R | |
| 4 | 19:16 | 17:16 | I | Tr E | E |
| | 20:31 | 18:31 | I | Sh E | E |
| 9 | 02:40 | 00:40 | II | Oc D | W |
| 10 | 00:29 | 22:29(p) | I | Tr I | |
| | 01:47 | 23:47(p) | I | Sh I | W |
| | 02:40 | 00:40 | I | Tr E | W |
| | 20:47 | 18:47 | III | Oc D | E |
| | 21:22 | 19:22 | II | Tr I | E |
| | 21:44 | 19:44 | I | Oc D | |
| | 22:41 | 20:41 | III | Oc R | |
| | 23:42 | 21:42 | II | Tr E | |
| | 23:55 | 21:55 | II | Sh I | |
| 11 | 01:11 | 23:11(p) | I | Ec R | W |
| | 02:07 | 00:07 | III | Ec D | W |
| | 02:14 | 00:14 | II | Sh E | W |
| | 20:16 | 18:16 | I | Sh I | E |
| | 21:08 | 19:08 | I | Tr E | E |
| | 22:27 | 20:27 | I | Sh E | |
| 12 | 19:40 | 17:40 | I | Ec R | E |
| | 20:58 | 18:58 | II | Ec R | E |
| 17 | 02:23 | 00:23 | I | Tr I | W |
| | 23:37 | 21:37 | I | Oc D | |
| | 23:53 | 21:53 | II | Tr I | |
| 18 | 00:39 | 22:39(p) | III | Oc D | W |
| | 02:14 | 00:14 | II | Tr E | W |
| | 20:52 | 18:52 | I | Tr I | E |
| | 22:12 | 20:12 | I | Sh I | |
| | 23:03 | 21:03 | I | Tr E | |
| 19 | 00:23 | 22:23(p) | I | Sh E | W |
| | 20:54 | 18:54 | II | Oc R | E |
| | 21:16 | 19:16 | II | Ec D | E |
| | 21:35 | 19:35 | I | Ec R | |
| | 23:37 | 21:37 | II | Ec R | |
| 21 | 20:26 | 18:26 | III | Sh I | E |
| | 22:02 | 20:02 | III | Sh E | |
| 25 | 01:32 | 23:32(p) | I | Oc D | W |
| | 22:47 | 20:47 | I | Tr I | |
| 26 | 00:08 | 22:08(p) | I | Sh I | W |
| | 00:58 | 22:58(p) | I | Tr E | W |
| | 20:00 | 18:00 | I | Oc D | E |
| | 21:08 | 19:08 | II | Oc D | E |
| | 23:30 | 21:30 | I | Ec R | W |
| | 23:32 | 21:32 | II | Oc R | W |
| | 23:55 | 21:55 | II | Ec D | W |
| 27 | 19:27 | 17:27 | I | Tr E | E |
| | 20:48 | 18:48 | I | Sh E | E |
| 28 | 20:45 | 18:45 | II | Sh E | E |
| | 20:48 | 18:48 | III | Tr E | E |
| 29 | 00:28 | 22:28(p) | III | Sh I | W |
| **February** | | | | | |
| 2 | 00:43 | 22:43(p) | I | Tr I | W |
| | 21:56 | 19:56 | I | Oc D | |
| | 23:48 | 21:48 | II | Oc D | W |
| 3 | 19:12 | 17:12 | I | Tr I | E |
| | 20:34 | 18:34 | I | Sh I | E |
| | 21:23 | 19:23 | I | Tr E | E |
| | 22:44 | 20:44 | I | Sh E | |
| 4 | 19:55 | 17:55 | I | Ec R | E |
| | 20:44 | 18:44 | II | Tr E | E |
| | 21:01 | 19:01 | II | Sh I | E |
| | 22:53 | 20:53 | III | Tr I | W |
| | 23:21 | 21:21 | II | Sh E | W |
| 5 | 00:53 | 22:53(p) | III | Tr E | W |
| 8 | 19:55 | 17:55 | III | Ec R | E |
| 9 | 23:53 | 21:53 | I | Oc D | W |
| 10 | 21:10 | 19:10 | I | Tr I | E |
| | 22:30 | 20:30 | I | Sh I | |
| | 23:21 | 21:21 | I | Tr E | W |

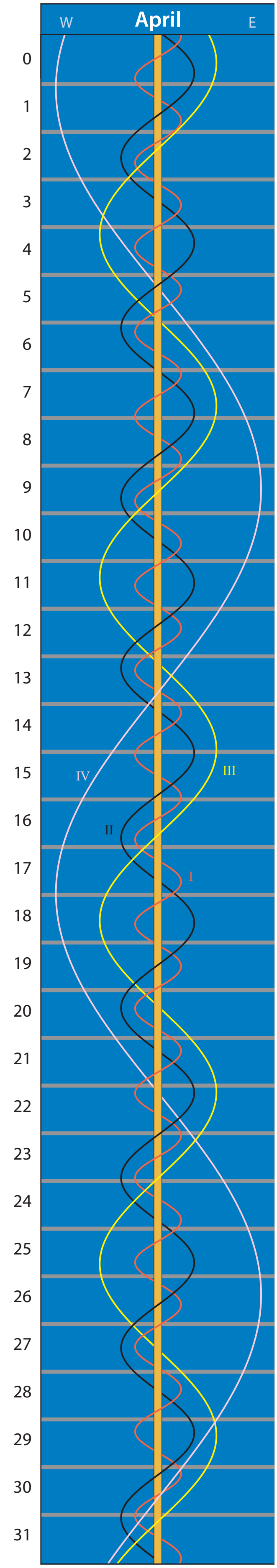


# JUPITER MOON EVENTS

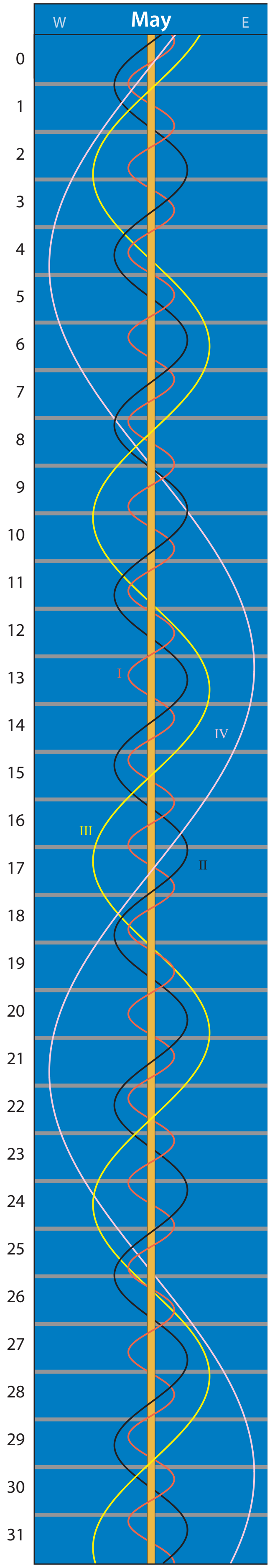
| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 11 | 00:40 | 22:40(p) | I | Sh E | W |
| | 21:00 | 19:00 | II | Tr I | E |
| | 21:50 | 19:50 | I | Ec R | |
| | 23:23 | 21:23 | II | Tr E | W |
| | 23:36 | 21:36 | II | Sh I | W |
| 12 | 19:09 | 17:09 | I | Sh E | E |
| 13 | 20:53 | 18:53 | II | Ec R | E |
| 15 | 18:56 | 16:56 | III | Oc R | E |
| | 22:18 | 20:18 | III | Ec D | W |
| | 23:56 | 21:56 | III | Ec R | W |
| 17 | 23:08 | 21:08 | I | Tr I | W |
| 18 | 00:25 | 22:25(p) | I | Sh I | W |
| | 20:20 | 18:20 | I | Oc D | E |
| | 23:41 | 21:41 | II | Tr I | W |
| | 23:45 | 21:45 | I | Ec R | W |
| 19 | 18:54 | 16:54 | I | Sh I | E |
| | 19:49 | 17:49 | I | Tr E | E |
| | 21:05 | 19:05 | I | Sh E | E |
| 20 | 21:00 | 19:00 | II | Oc R | E |
| | 21:10 | 19:10 | II | Ec D | |
| | 23:32 | 21:32 | II | Ec R | W |
| 22 | 21:06 | 19:06 | III | Oc D | |
| | 23:10 | 21:10 | III | Oc R | W |
| 25 | 22:18 | 20:18 | I | Oc D | W |
| 26 | 19:37 | 17:37 | I | Tr I | E |
| | 20:50 | 18:50 | I | Sh I | E |
| | 21:48 | 19:48 | I | Tr E | W |
| | 23:00 | 21:00 | I | Sh E | W |
| 27 | 20:10 | 18:10 | I | Ec R | E |
| | 21:21 | 19:21 | II | Oc D | |
| | 23:46 | 21:46 | II | Oc R | W |
| | 23:49 | 21:49 | II | Ec D | W |
| 29 | 20:28 | 18:28 | II | Sh E | E |
| **March** | | | | | |
| 4 | 20:39 | 18:39 | III | Sh I | E |
| | 21:37 | 19:37 | I | Tr I | W |
| | 22:16 | 20:16 | III | Sh E | W |
| | 22:46 | 20:46 | I | Sh I | W |
| 5 | 18:47 | 16:47 | I | Oc D | E |
| | 22:05 | 20:05 | I | Ec R | W |
| 6 | 19:25 | 17:25 | I | Sh E | E |
| 7 | 18:29 | 16:29 | II | Tr I | E |
| | 20:43 | 18:43 | II | Sh I | E |
| | 20:54 | 18:54 | II | Tr E | |
| | 23:04 | 21:04 | II | Sh E | W |
| 11 | 20:10 | 18:10 | III | Tr I | E |
| | 22:12 | 20:12 | III | Tr E | W |
| 12 | 20:47 | 18:47 | I | Oc D | W |
| 13 | 19:11 | 17:11 | I | Sh I | E |
| | 20:19 | 18:19 | I | Tr E | E |
| | 21:21 | 19:21 | I | Sh E | W |
| 14 | 18:29 | 16:29 | I | Ec R | E |
| | 21:15 | 19:15 | II | Tr I | W |
| 16 | 20:46 | 18:46 | II | Ec R | W |

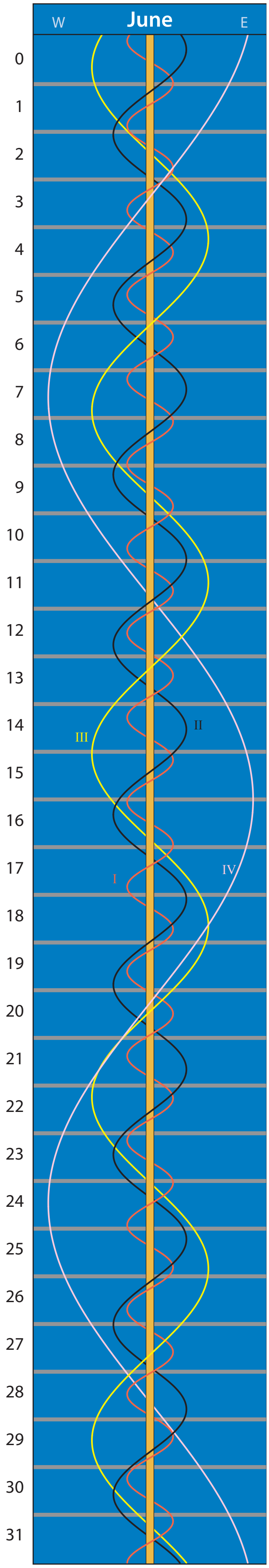



| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 20 | 20:09 | 18:09 | I | Tr I | E |
| | 21:06 | 19:06 | I | Sh I | W |
| | 22:20 | 20:20 | I | Tr E | W |
| 22 | 18:26 | 16:26 | III | Ec D | E |
| | 20:05 | 18:05 | III | Ec R | E |
| 23 | 19:09 | 17:09 | II | Oc D | E |
| 27 | 22:10 | 20:10 | I | Tr I | W |
| 28 | 19:19 | 17:19 | I | Oc D | E |
| 29 | 18:52 | 16:52 | I | Tr E | E |
| | 18:56 | 16:56 | III | Oc D | E |
| | 19:41 | 17:41 | I | Sh E | E |
| | 20:58 | 18:58 | III | Oc R | W |
| 30 | 21:58 | 19:58 | II | Oc D | W |
| **April** | | | | | |
| 1 | 18:40 | 16:40 | II | Tr E | E |
| 4 | 21:21 | 19:21 | I | Oc D | W |
| 5 | 18:42 | 16:42 | I | Tr I | E |
| | 20:53 | 18:53 | I | Tr E | W |
| | 21:36 | 19:36 | I | Sh E | W |
| 6 | 18:44 | 16:44 | I | Ec R | E |
| 8 | 19:04 | 17:04 | II | Tr I | E |
| | 20:27 | 18:27 | II | Sh I | W |
| | 21:29 | 19:29 | II | Tr E | W |
| 9 | 18:25 | 16:25 | III | Sh E | E |
| 10 | 17:57 | 15:57 | II | Ec R | E |
| 12 | 20:44 | 18:44 | I | Tr I | W |
| | 21:21 | 19:21 | I | Sh I | W |
| 13 | 17:53 | 15:53 | I | Oc D | E |
| | 20:39 | 18:39 | I | Ec R | W |
| 14 | 18:00 | 16:00 | I | Sh E | E |
| 16 | 18:24 | 16:24 | III | Tr I | E |
| | 20:24 | 18:24 | III | Tr E | W |
| | 20:48 | 18:48 | III | Sh I | W |
| 17 | 20:34 | 18:34 | II | Ec R | W |
| 20 | 19:55 | 17:55 | I | Oc D | W |
| 21 | 17:45 | 15:45 | I | Sh I | E |
| | 19:55 | 17:55 | I | Sh E | W |
| 24 | 19:56 | 17:56 | II | Oc D | W |
| **May** | | | | | |
| 3 | 17:35 | 15:35 | II | Sh I | E |
| | 19:58 | 17:58 | II | Sh E | W |
| 4 | 17:24 | 15:24 | III | Oc D | E |
| 10 | 19:52 | 17:52 | II | Tr I | W |
| 25 | 08:57 | 06:57 | I | Tr I | W |
| 26 | 06:36 | 04:36 | III | Ec D | E |
| | 08:56 | 06:56 | III | Oc R | W |
| **June** | | | | | |
| 1 | 06:27 | 04:27 | II | Sh E | E |
| | 06:56 | 04:56 | II | Tr E | E |
| 8 | 06:39 | 04:39 | II | Sh I | E |
| | 09:04 | 07:04 | II | Sh E | W |

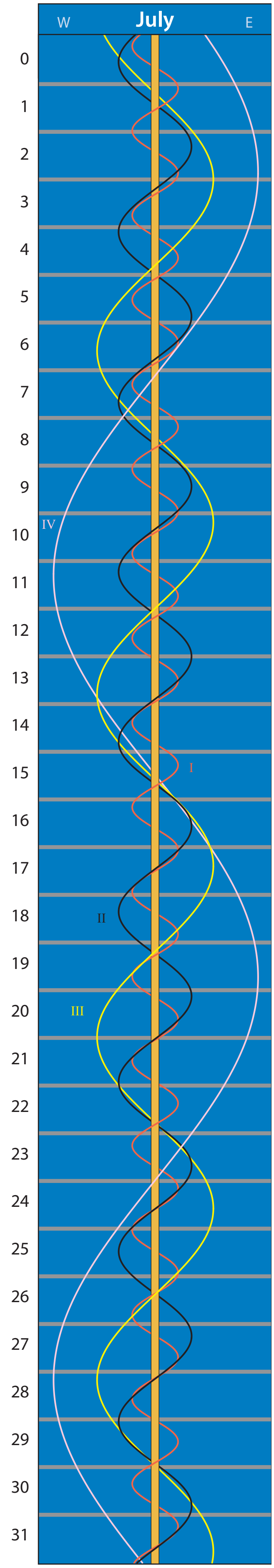


**I – Io II – Europa III – Ganymede IV – Callisto**



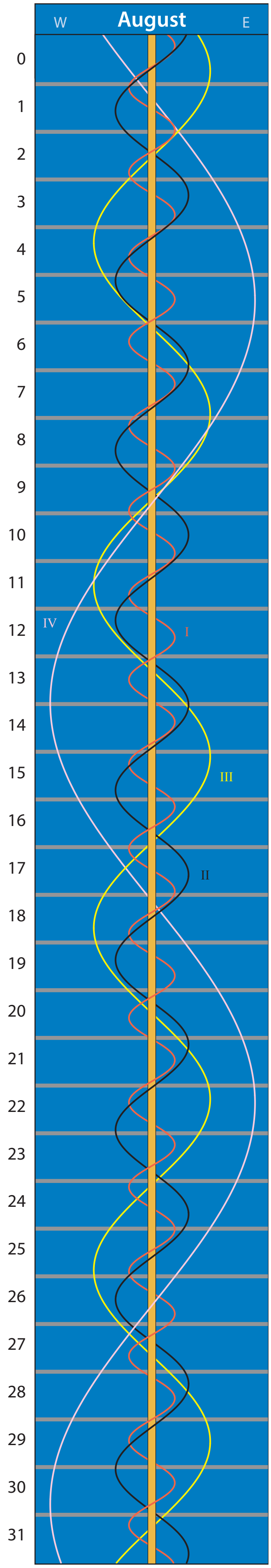




| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 10 | 09:18 | 07:18 | I | Sh E | W |
| 11 | 06:52 | 04:52 | I | Oc R | E |
| 13 | 06:31 | 04:31 | III | Tr I | E |
| | 06:37 | 04:37 | III | Sh E | E |
| | 08:27 | 06:27 | III | Tr E | W |
| 15 | 09:16 | 07:16 | II | Sh I | W |
| 17 | 09:02 | 07:02 | I | Sh I | W |
| 18 | 06:12 | 04:12 | I | Ec D | E |
| | 08:54 | 06:54 | I | Oc R | W |
| 19 | 05:41 | 03:41 | I | Sh E | E |
| | 06:12 | 04:12 | I | Tr E | E |
| 20 | 08:53 | 06:53 | III | Sh I | W |
| 24 | 06:49 | 04:49 | II | Ec D | E |
| 25 | 08:06 | 06:06 | I | Ec D | W |
| 26 | 05:25 | 03:25 | I | Sh I | E |
| | 06:02 | 04:02 | I | Tr I | E |
| | 07:35 | 05:35 | I | Sh E | W |
| | 08:13 | 06:13 | I | Tr E | W |
| 27 | 05:25 | 03:25 | I | Oc R | E |
| **July** | | | | | |
| 1 | 05:26 | 03:26 | III | Oc D | E |
| | 07:23 | 05:23 | III | Oc R | W |
| | 09:24 | 07:24 | II | Ec D | W |
| 3 | 05:19 | 03:19 | II | Tr I | E |
| | 06:16 | 04:16 | II | Sh E | E |
| | 07:19 | 05:19 | I | Sh I | W |
| | 07:48 | 05:48 | II | Tr E | W |
| | 08:03 | 06:03 | I | Tr I | W |
| 4 | 07:26 | 05:26 | I | Oc R | W |
| 5 | 04:43 | 02:43 | I | Tr E | E |
| 8 | 06:38 | 04:38 | III | Ec D | E |
| | 08:25 | 06:25 | III | Ec R | W |
| 10 | 06:26 | 04:26 | II | Sh I | E |
| | 08:08 | 06:08 | II | Tr I | W |
| | 08:53 | 06:53 | II | Sh E | W |
| | 09:13 | 07:13 | I | Sh I | W |
| 11 | 06:24 | 04:24 | I | Ec D | E |
| 12 | 04:33 | 02:33 | I | Tr I | E |
| | 05:25 | 03:25 | II | Oc R | E |
| | 05:51 | 03:51 | I | Sh E | E |
| | 06:43 | 04:43 | I | Tr E | |
| 17 | 09:03 | 07:03 | II | Sh I | W |
| 18 | 08:18 | 06:18 | I | Ec D | W |
| 19 | 04:42 | 02:42 | III | Tr I | E |
| | 05:35 | 03:35 | I | Sh I | E |
| | 06:32 | 04:32 | I | Tr I | |
| | 06:39 | 04:39 | III | Tr E | |
| | 07:45 | 05:45 | I | Sh E | W |
| | 08:11 | 06:11 | II | Oc R | W |
| | 08:43 | 06:43 | I | Tr E | W |
| 20 | 05:57 | 03:57 | I | Oc R | E |

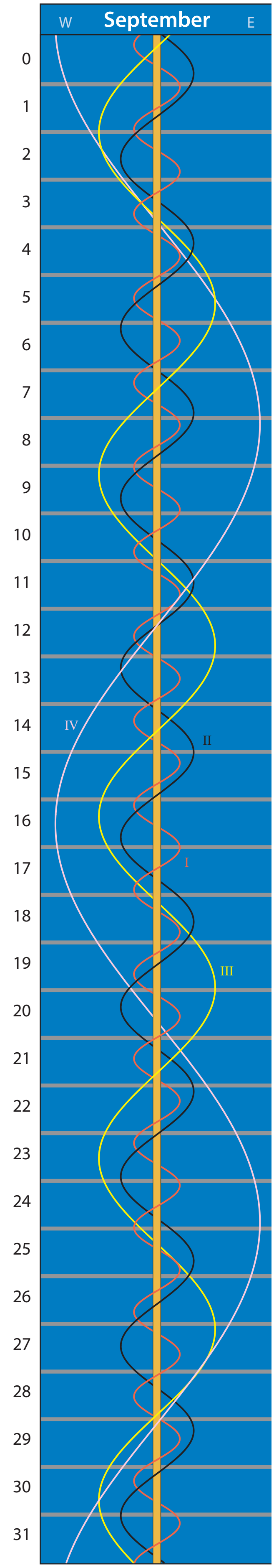


# JUPITER MOON EVENTS

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 26 | 04:52 | 02:52 | III | Sh I | E |
| | 06:23 | 04:23 | II | Ec D | |
| | 06:40 | 04:40 | III | Sh E | |
| | 07:28 | 05:28 | I | Sh I | W |
| | 08:31 | 06:31 | I | Tr I | W |
| | 09:03 | 07:03 | III | Tr I | W |
| 27 | 04:41 | 02:41 | I | Ec D | E |
| | 07:57 | 05:57 | I | Oc R | W |
| 28 | 04:07 | 02:07 | I | Sh E | E |
| | 05:11 | 03:11 | I | Tr E | E |
| | 05:40 | 03:40 | II | Tr E | E |
| **August** | | | | | |
| 2 | 08:51 | 06:51 | III | Sh I | W |
| | 08:57 | 06:57 | II | Ec D | W |
| 3 | 06:35 | 04:35 | I | Ec D | |
| 4 | 03:36 | 01:36 | II | Sh I | E |
| | 03:50 | 01:50 | I | Sh I | E |
| | 04:59 | 02:59 | I | Tr I | E |
| | 05:55 | 03:55 | II | Tr I | |
| | 06:00 | 04:00 | I | Sh E | |
| | 06:04 | 04:04 | II | Sh E | |
| | 07:09 | 05:09 | I | Tr E | W |
| | 08:26 | 06:26 | II | Tr E | W |
| 5 | 04:26 | 02:26 | I | Oc R | E |
| 6 | 03:18 | 01:18 | III | Oc D | E |
| | 05:16 | 03:16 | III | Oc R | E |
| 10 | 08:30 | 06:30 | I | Ec D | W |
| 11 | 05:44 | 03:44 | I | Sh I | |
| | 06:13 | 04:13 | II | Sh I | |
| | 06:56 | 04:56 | I | Tr I | W |
| | 07:54 | 05:54 | I | Sh E | W |
| | 08:40 | 06:40 | II | Tr I | W |
| | 08:41 | 06:41 | II | Sh E | W |
| 12 | 02:58 | 00:58 | I | Ec D | E |
| | 06:24 | 04:24 | I | Oc R | |
| 13 | 03:36 | 01:36 | I | Tr E | E |
| | 04:29 | 02:29 | III | Ec R | E |
| | 05:42 | 03:42 | II | Oc R | |
| | 07:34 | 05:34 | III | Oc D | W |
| 18 | 07:37 | 05:37 | I | Sh I | W |
| | 08:49 | 06:49 | II | Sh I | W |
| | 08:53 | 06:53 | I | Tr I | W |
| 19 | 04:52 | 02:52 | I | Ec D | |
| | 08:21 | 06:21 | I | Oc R | W |
| 20 | 03:22 | 01:22 | II | Ec D | E |
| | 03:22 | 01:22 | I | Tr I | E |
| | 04:16 | 02:16 | I | Sh E | E |
| | 05:33 | 03:33 | I | Tr E | |
| | 05:49 | 03:49 | II | Ec R | |
| | 05:52 | 03:52 | II | Oc D | |
| | 06:36 | 04:36 | III | Ec D | W |
| | 08:23 | 06:23 | II | Oc R | W |
| | 08:30 | 06:30 | III | Ec R | W |
| 21 | 02:50 | 00:50 | I | Oc R | E |
| 22 | 03:17 | 01:17 | II | Tr E | E |
| 24 | 04:00 | 02:00 | III | Tr E | E |




| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 26 | 06:47 | 04:47 | I | Ec D | W |
| 27 | 03:59 | 01:59 | I | Sh I | E |
| | 05:18 | 03:18 | I | Tr I | |
| | 05:56 | 03:56 | II | Ec D | |
| | 06:10 | 04:10 | I | Sh E | |
| | 07:28 | 05:28 | I | Tr E | W |
| | 08:23 | 06:23 | II | Ec R | W |
| | 08:31 | 06:31 | II | Oc D | W |
| 28 | 04:47 | 02:47 | I | Oc R | |
| 29 | 01:57 | 23:57(p) | I | Tr E | E |
| | 03:14 | 01:14 | II | Sh E | E |
| | 03:27 | 01:27 | II | Tr I | E |
| | 05:59 | 03:59 | II | Tr E | |
| 31 | 02:41 | 00:41 | III | Sh E | E |
| | 06:09 | 04:09 | III | Tr I | |
| | 08:08 | 06:08 | III | Tr E | W |
| **September** | | | | | |
| 3 | 05:53 | 03:53 | I | Sh I | |
| | 07:13 | 05:13 | I | Tr I | W |
| | 08:03 | 06:03 | I | Sh E | W |
| | 08:30 | 06:30 | II | Ec D | W |
| 4 | 03:09 | 01:09 | I | Ec D | E |
| | 06:42 | 04:42 | I | Oc R | W |
| 5 | 01:41 | 23:41(p) | I | Tr I | E |
| | 02:31 | 00:31 | I | Sh E | E |
| | 03:22 | 01:22 | II | Sh I | E |
| | 03:52 | 01:52 | I | Tr E | |
| | 05:51 | 03:51 | II | Sh E | |
| | 06:06 | 04:06 | II | Tr I | |
| 7 | 02:57 | 00:57 | II | Oc R | E |
| | 04:47 | 02:47 | III | Sh I | |
| | 06:42 | 04:42 | III | Sh E | W |
| 10 | 07:46 | 05:46 | I | Sh I | W |
| 11 | 02:02 | 00:02 | III | Oc R | E |
| | 05:03 | 03:03 | I | Ec D | |
| 12 | 02:14 | 00:14 | I | Sh I | E |
| | 03:35 | 01:35 | I | Tr I | |
| | 04:25 | 02:25 | I | Sh E | |
| | 05:46 | 03:46 | I | Tr E | |
| | 05:59 | 03:59 | II | Sh I | |
| 13 | 03:05 | 01:05 | I | Oc R | E |
| 14 | 02:49 | 00:49 | II | Ec R | E |
| | 03:01 | 01:01 | II | Oc D | E |
| | 05:31 | 03:31 | II | Oc R | |
| 18 | 04:02 | 02:02 | III | Oc D | |
| | 06:01 | 04:01 | III | Oc R | W |
| | 06:57 | 04:57 | I | Ec D | W |
| 19 | 04:08 | 02:08 | I | Sh I | |
| | 05:28 | 03:28 | I | Tr I | |
| | 06:18 | 04:18 | I | Sh E | W |
| | 07:39 | 05:39 | I | Tr E | W |
| 20 | 01:26 | 23:26(p) | I | Ec D | E |
| | 04:58 | 02:58 | I | Oc R | |

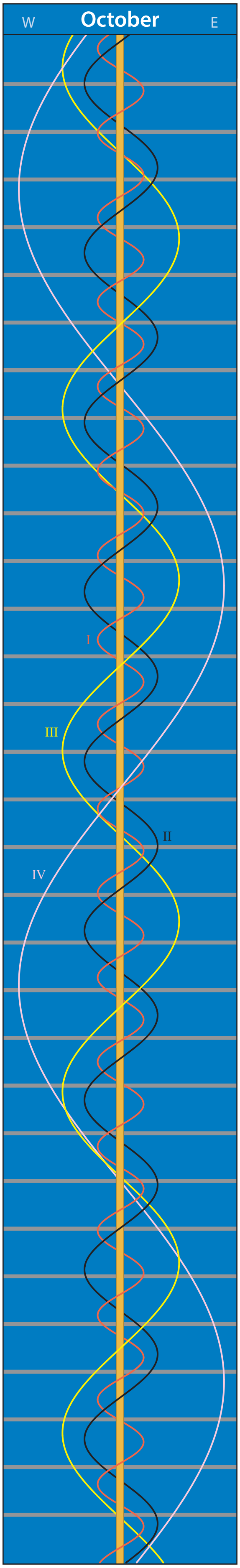


## I – Io II – Europa III – Ganymede IV – Callisto

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 21 | 00:47 | 22:47(p) | I | Sh E | E |
| | 02:07 | 00:07 | I | Tr E | E |
| | 02:54 | 00:54 | II | Ec D | |
| | 05:23 | 03:23 | II | Ec R | |
| | 05:33 | 03:33 | II | Oc D | |
| | 08:04 | 06:04 | II | Oc R | W |
| 23 | 00:23 | 22:23(p) | II | Sh E | E |
| | 00:35 | 22:35(p) | II | Tr I | E |
| | 03:07 | 01:07 | II | Tr E | |
| 25 | 02:33 | 00:33 | III | Ec D | |
| | 04:31 | 02:31 | III | Ec R | |
| | 07:55 | 05:55 | III | Oc D | W |
| 26 | 06:01 | 04:01 | I | Sh I | W |
| | 07:20 | 05:20 | I | Tr I | W |
| 27 | 03:20 | 01:20 | I | Ec D | |
| | 06:51 | 04:51 | I | Oc R | W |
| 28 | 00:30 | 22:30(p) | I | Sh I | E |
| | 01:48 | 23:48(p) | I | Tr I | E |
| | 02:40 | 00:40 | I | Sh E | |
| | 03:59 | 01:59 | I | Tr E | |
| | 05:28 | 03:28 | II | Ec D | |
| | 07:58 | 05:58 | II | Ec R | W |
| | 23:58 | 21:58 | III | Tr E | E |
| 29 | 01:18 | 23:18(p) | I | Oc R | E |
| 30 | 00:30 | 22:30(p) | II | Sh I | E |
| | 03:00 | 01:00 | II | Sh E | |
| | 03:07 | 01:07 | II | Tr I | |
| | 05:39 | 03:39 | II | Tr E | |

## October

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 1 | 23:49 | 21:49 | II | Oc R | E |
| 2 | 06:33 | 04:33 | III | Ec D | W |
| 3 | 07:55 | 05:55 | I | Sh I | W |
| 4 | 05:14 | 03:14 | I | Ec D | |
| 5 | 02:23 | 00:23 | I | Sh I | |
| | 03:38 | 01:38 | I | Tr I | |
| | 04:34 | 02:34 | I | Sh E | |
| | 05:49 | 03:49 | I | Tr E | W |
| | 23:42 | 21:42 | I | Ec D | E |
| 6 | 01:46 | 23:46(p) | III | Tr I | E |
| | 03:09 | 01:09 | I | Oc R | |
| | 03:44 | 01:44 | III | Tr E | |
| 7 | 00:17 | 22:17(p) | I | Tr E | E |
| | 03:06 | 01:06 | II | Sh I | |
| | 05:36 | 03:36 | II | Tr I | W |
| | 05:37 | 03:37 | II | Sh E | W |
| 9 | 02:17 | 00:17 | II | Oc R | |
| 11 | 07:08 | 05:08 | I | Ec D | W |
| 12 | 04:17 | 02:17 | I | Sh I | |
| | 05:28 | 03:28 | I | Tr I | W |
| | 06:28 | 04:28 | I | Sh E | W |
| | 07:39 | 05:39 | I | Tr E | W |



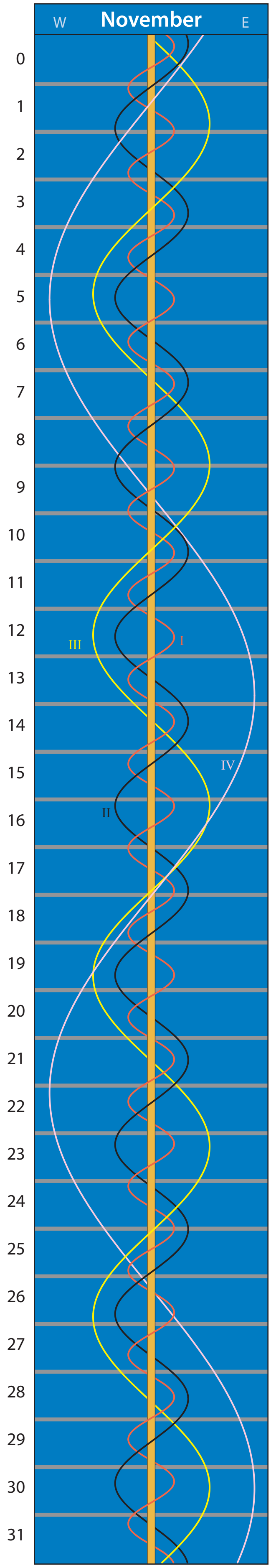

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 13 | 00:41 | 22:41(p) | III | Sh I | E |
| | 01:36 | 23:36(p) | I | Ec D | |
| | 02:42 | 00:42 | III | Sh E | |
| | 04:59 | 02:59 | I | Oc R | |
| | 05:28 | 03:28 | III | Tr I | W |
| | 07:26 | 05:26 | III | Tr E | W |
| | 23:55 | 21:55 | I | Tr I | E |
| 14 | 00:56 | 22:56(p) | I | Sh E | E |
| | 02:06 | 00:06 | I | Tr E | |
| | 05:42 | 03:42 | II | Sh I | W |
| | 23:26 | 21:26 | I | Oc R | E |
| 15 | 23:54 | 21:54 | II | Ec D | E |
| 16 | 04:42 | 02:42 | II | Oc R | |
| 17 | 23:48 | 21:48 | II | Tr E | E |
| 19 | 06:10 | 04:10 | I | Sh I | W |
| | 07:16 | 05:16 | I | Tr I | W |
| 20 | 03:30 | 01:30 | I | Ec D | |
| | 04:40 | 02:40 | III | Sh I | |
| | 06:42 | 04:42 | III | Sh E | W |
| | 06:47 | 04:47 | I | Oc R | W |
| 21 | 00:39 | 22:39(p) | I | Sh I | E |
| | 01:43 | 23:43(p) | I | Tr I | |
| | 02:50 | 00:50 | I | Sh E | |
| | 03:54 | 01:54 | I | Tr E | |
| 22 | 01:14 | 23:14(p) | I | Oc R | |
| | 22:21 | 20:21 | I | Tr E | E |
| 23 | 02:29 | 00:29 | II | Ec D | |
| | 07:05 | 05:05 | II | Oc R | W |
| | 22:43 | 20:43 | III | Oc D | E |
| 24 | 00:41 | 22:41(p) | III | Oc R | |
| | 23:39 | 21:39 | II | Tr I | E |
| 25 | 00:08 | 22:08(p) | II | Sh E | E |
| | 02:11 | 00:11 | II | Tr E | |
| 27 | 05:24 | 03:24 | I | Ec D | W |
| 28 | 02:33 | 00:33 | I | Sh I | |
| | 03:30 | 01:30 | I | Tr I | |
| | 04:44 | 02:44 | I | Sh E | |
| | 05:41 | 03:41 | I | Tr E | W |
| | 23:53 | 21:53 | I | Ec D | E |
| 29 | 03:01 | 01:01 | I | Oc R | |
| | 21:57 | 19:57 | I | Tr I | E |
| | 23:12 | 21:12 | I | Sh E | E |
| 30 | 00:07 | 22:07(p) | I | Tr E | E |
| | 05:04 | 03:04 | II | Ec D | W |
| | 22:29 | 20:29 | III | Ec D | E |
| 31 | 00:34 | 22:34(p) | III | Ec R | |
| | 02:13 | 00:13 | III | Oc D | |
| | 04:11 | 02:11 | III | Oc R | |

## November

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 1 | 00:13 | 22:13(p) | II | Sh I | |
| | 02:00 | 00:00 | II | Tr I | |
| | 02:45 | 00:45 | II | Sh E | |
| | 04:31 | 02:31 | II | Tr E | |
| 2 | 22:35 | 20:35 | II | Oc R | E |
| 3 | 07:18 | 05:18 | I | Ec D | W |

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 4 | 04:26 | 02:26 | I | Sh I | |
| | 05:16 | 03:16 | I | Tr I | W |
| | 06:38 | 04:38 | I | Sh E | W |
| 5 | 01:47 | 23:47(p) | I | Ec D | |
| | 04:47 | 02:47 | I | Oc R | |
| | 22:55 | 20:55 | I | Sh I | E |
| | 23:42 | 21:42 | I | Tr I | |
| 6 | 01:06 | 23:06(p) | I | Sh E | |
| | 01:53 | 23:53(p) | I | Tr E | |
| | 23:13 | 21:13 | I | Oc R | E |
| 7 | 02:28 | 00:28 | III | Ec D | |
| | 04:35 | 02:35 | III | Ec R | |
| | 05:38 | 03:38 | III | Oc D | W |
| 8 | 02:49 | 00:49 | II | Sh I | |
| | 04:19 | 02:19 | II | Tr I | |
| | 05:21 | 03:21 | II | Sh E | W |
| | 06:50 | 04:50 | II | Tr E | W |
| 10 | 00:53 | 22:53(p) | II | Oc R | |
| | 21:26 | 19:26 | III | Tr E | E |
| 11 | 06:20 | 04:20 | I | Sh I | W |
| | 07:01 | 05:01 | I | Tr I | W |
| 12 | 03:41 | 01:41 | I | Ec D | |
| | 06:32 | 04:32 | I | Oc R | W |
| 13 | 00:49 | 22:49(p) | I | Sh I | |
| | 01:27 | 23:27(p) | I | Tr I | |
| | 03:00 | 01:00 | I | Sh E | |
| | 03:38 | 01:38 | I | Tr E | |
| | 22:10 | 20:10 | I | Ec D | E |
| 14 | 00:58 | 22:58(p) | I | Oc R | |
| | 06:28 | 04:28 | III | Ec D | W |
| | 21:29 | 19:29 | I | Sh E | E |
| | 22:04 | 20:04 | I | Tr E | E |
| 15 | 05:25 | 03:25 | II | Sh I | W |
| | 06:36 | 04:36 | II | Tr I | W |
| 16 | 23:32 | 21:32 | II | Ec D | |
| 17 | 03:09 | 01:09 | II | Oc R | |
| | 20:37 | 18:37 | III | Sh I | E |
| | 22:44 | 20:44 | III | Sh E | E |
| | 22:49 | 20:49 | III | Tr I | |
| 18 | 00:46 | 22:46(p) | III | Tr E | |
| | 21:15 | 19:15 | II | Sh E | E |
| | 22:14 | 20:14 | II | Tr E | E |
| 19 | 05:35 | 03:35 | I | Ec D | W |
| 20 | 02:43 | 00:43 | I | Sh I | |
| | 03:11 | 01:11 | I | Tr I | |
| | 04:55 | 02:55 | I | Sh E | W |
| | 05:22 | 03:22 | I | Tr E | W |
| 21 | 00:04 | 22:04(p) | I | Ec D | |
| | 02:42 | 00:42 | I | Oc R | |
| | 21:12 | 19:12 | I | Sh I | E |
| | 21:37 | 19:37 | I | Tr I | E |
| | 23:23 | 21:23 | I | Sh E | |
| | 23:48 | 21:48 | I | Tr E | |
| 22 | 21:08 | 19:08 | I | Oc R | E |
| 24 | 02:08 | 00:08 | II | Ec D | |
| | 05:24 | 03:24 | II | Oc R | W |

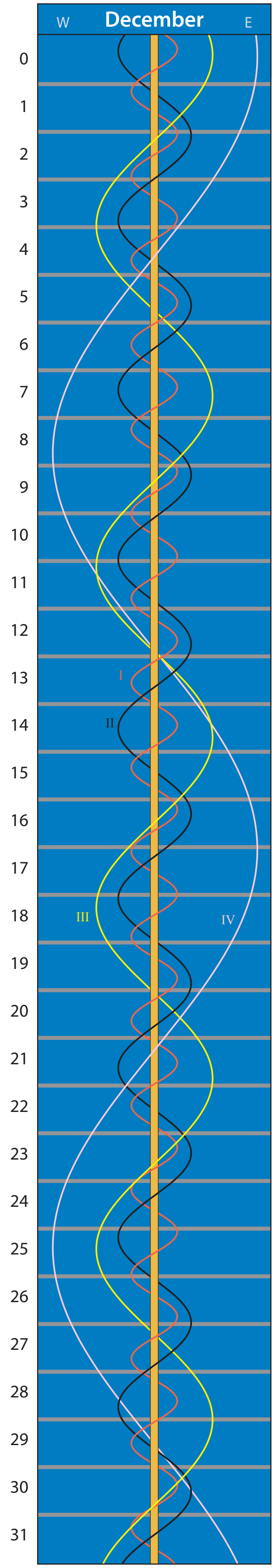
# JUPITER MOON EVENTS




| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 25 | 00:36 | 22:36(p) | III | Sh I | |
| | 02:05 | 00:05 | III | Tr I | |
| | 02:45 | 00:45 | III | Sh E | |
| | 04:03 | 02:03 | III | Tr E | |
| | 21:18 | 19:18 | II | Sh I | E |
| | 21:58 | 19:58 | II | Tr I | E |
| | 23:51 | 21:51 | II | Sh E | |
| 26 | 00:29 | 22:29(p) | II | Tr E | |
| 27 | 04:37 | 02:37 | I | Sh I | |
| | 04:55 | 02:55 | I | Tr I | W |
| | 06:49 | 04:49 | I | Sh E | W |
| 28 | 01:58 | 23:58(p) | I | Ec D | |
| | 04:26 | 02:26 | I | Oc R | |
| | 23:06 | 21:06 | I | Sh I | |
| | 23:21 | 21:21 | I | Tr I | |
| 29 | 01:18 | 23:18(p) | I | Sh E | |
| | 01:32 | 23:32(p) | I | Tr E | |
| | 20:27 | 18:27 | I | Ec D | E |
| | 22:51 | 20:51 | I | Oc R | |
| 30 | 19:46 | 17:46 | I | Sh E | E |
| | 19:58 | 17:58 | I | Tr E | E |

## December

| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 1 | 04:44 | 02:44 | II | Ec D | W |
| 2 | 04:36 | 02:36 | III | Sh I | |
| | 05:21 | 03:21 | III | Tr I | W |
| | 06:46 | 04:46 | III | Sh E | W |
| | 23:54 | 21:54 | II | Sh I | |
| 3 | 00:12 | 22:12(p) | II | Tr I | |
| | 02:27 | 00:27 | II | Sh E | |
| | 02:43 | 00:43 | II | Tr E | |
| 4 | 06:32 | 04:32 | I | Sh I | W |
| | 06:39 | 04:39 | I | Tr I | W |
| | 20:46 | 18:46 | II | Oc R | E |
| 5 | 03:53 | 01:53 | I | Ec D | |
| | 06:09 | 04:09 | I | Oc R | W |
| | 20:49 | 18:49 | III | Oc R | E |
| 6 | 01:01 | 23:01(p) | I | Sh I | |
| | 01:04 | 23:04(p) | I | Tr I | |
| | 03:12 | 01:12 | I | Sh E | |
| | 03:15 | 01:15 | I | Tr E | |
| | 22:21 | 20:21 | I | Ec D | |
| 7 | 00:35 | 22:35(p) | I | Oc R | |
| | 19:29 | 17:29 | I | Sh I | E |
| | 19:30 | 17:30 | I | Tr I | E |
| | 21:41 | 19:41 | I | Sh E | |
| | 21:41 | 19:41 | I | Tr E | |
| 8 | 19:02 | 17:02 | I | Ec R | E |
| 10 | 02:26 | 00:26 | II | Tr I | |
| | 02:30 | 00:30 | II | Sh I | |
| | 04:56 | 02:56 | II | Tr E | W |
| | 05:03 | 03:03 | II | Sh E | W |
| 11 | 20:28 | 18:28 | II | Oc D | E |
| | 23:13 | 21:13 | II | Ec R | |
| 12 | 05:41 | 03:41 | I | Oc D | W |
| | 22:03 | 20:03 | III | Oc D | |




| Day | EST | WST | Sat | Event | Vis |
|---|---|---|---|---|---|
| 13 | 00:40 | 22:40(p) | III | Ec R | |
| | 02:48 | 00:48 | I | Tr I | |
| | 02:55 | 00:55 | I | Sh I | |
| | 04:59 | 02:59 | I | Tr E | W |
| | 05:07 | 03:07 | I | Sh E | W |
| 14 | 00:07 | 22:07(p) | I | Oc D | |
| | 02:28 | 00:28 | I | Ec R | |
| | 21:14 | 19:14 | I | Tr I | E |
| | 21:24 | 19:24 | I | Sh I | E |
| | 23:25 | 21:25 | I | Tr E | |
| | 23:36 | 21:36 | I | Sh E | |
| 15 | 20:56 | 18:56 | I | Ec R | E |
| 17 | 04:39 | 02:39 | II | Tr I | W |
| | 05:06 | 03:06 | II | Sh I | W |
| 18 | 22:43 | 20:43 | II | Oc D | |
| 19 | 01:50 | 23:50(p) | II | Ec R | |
| 20 | 01:17 | 23:17(p) | III | Oc D | |
| | 04:32 | 02:32 | I | Tr I | W |
| | 04:40 | 02:40 | III | Ec R | W |
| | 04:50 | 02:50 | I | Sh I | W |
| | 20:17 | 18:17 | II | Tr E | E |
| | 20:58 | 18:58 | II | Sh E | E |
| 21 | 01:51 | 23:51(p) | I | Oc D | |
| | 04:22 | 02:22 | I | Ec R | W |
| | 22:58 | 20:58 | I | Tr I | |
| | 23:19 | 21:19 | I | Sh I | |
| 22 | 01:09 | 23:09(p) | I | Tr E | |
| | 01:31 | 23:31(p) | I | Sh E | |
| | 20:17 | 18:17 | I | Oc D | E |
| | 22:51 | 20:51 | I | Ec R | |
| 23 | 19:35 | 17:35 | I | Tr E | E |
| | 20:00 | 18:00 | I | Sh E | E |
| 26 | 00:58 | 22:58(p) | II | Oc D | |
| | 04:28 | 02:28 | II | Ec R | W |
| 27 | 04:34 | 02:34 | III | Oc D | W |
| | 20:01 | 18:01 | II | Tr I | E |
| | 21:00 | 19:00 | II | Sh I | E |
| | 22:32 | 20:32 | II | Tr E | |
| | 23:34 | 21:34 | II | Sh E | |
| 28 | 03:35 | 01:35 | I | Oc D | W |
| 29 | 00:42 | 22:42(p) | I | Tr I | |
| | 01:14 | 23:14(p) | I | Sh I | |
| | 02:54 | 00:54 | I | Tr E | |
| | 03:26 | 01:26 | I | Sh E | W |
| | 22:01 | 20:01 | I | Oc D | |
| 30 | 00:46 | 22:46(p) | I | Ec R | |
| | 19:43 | 17:43 | I | Sh I | E |
| | 20:28 | 18:28 | III | Tr E | E |
| | 20:37 | 18:37 | III | Sh I | E |
| | 21:20 | 19:20 | I | Tr E | E |
| | 21:55 | 19:55 | I | Sh E | |
| | 22:52 | 20:52 | III | Sh E | |
| 31 | 19:15 | 17:15 | I | Ec R | E |

# 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 | 060.6 | 271.3 | 164.1 | 011.1 | 060.3 | 267.8 | 318.7 | 169.0 | 021.5 | 078.6 | 296.2 | 357.4 | 1 |
| 2 | 218.4 | 069.0 | 321.8 | 168.8 | 217.9 | 065.4 | 116.4 | 326.8 | 179.3 | 236.5 | 094.2 | 155.5 | 2 |
| 3 | 016.2 | 226.8 | 119.5 | 326.4 | 015.6 | 223.1 | 274.2 | 124.6 | 337.2 | 034.5 | 252.2 | 313.5 | 3 |
| 4 | 174.0 | 024.5 | 277.1 | 124.0 | 173.2 | 020.8 | 071.9 | 282.4 | 135.1 | 192.4 | 050.3 | 111.5 | 4 |
| 5 | 331.9 | 182.2 | 074.8 | 281.7 | 330.9 | 178.5 | 229.6 | 080.2 | 292.9 | 350.4 | 208.3 | 269.6 | 5 |
| 6 | 129.7 | 339.9 | 232.4 | 079.3 | 128.5 | 336.2 | 027.3 | 238.0 | 090.8 | 148.3 | 006.3 | 067.6 | 6 |
| 7 | 287.5 | 137.6 | 030.1 | 236.9 | 286.2 | 133.8 | 185.1 | 035.8 | 248.7 | 306.3 | 164.4 | 225.7 | 7 |
| 8 | 085.3 | 295.3 | 187.7 | 034.6 | 083.8 | 291.5 | 342.8 | 193.6 | 046.6 | 104.3 | 322.4 | 023.7 | 8 |
| 9 | 243.1 | 093.0 | 345.4 | 192.2 | 241.5 | 089.2 | 140.5 | 351.4 | 204.4 | 262.2 | 120.4 | 181.7 | 9 |
| 10 | 040.8 | 250.7 | 143.0 | 349.8 | 039.1 | 246.9 | 298.3 | 149.2 | 002.3 | 060.2 | 278.5 | 339.8 | 10 |
| 11 | 198.6 | 048.4 | 300.7 | 147.5 | 196.8 | 044.6 | 096.0 | 307.0 | 160.2 | 218.2 | 076.5 | 137.8 | 11 |
| 12 | 356.4 | 206.0 | 098.3 | 305.1 | 354.5 | 202.3 | 253.8 | 104.8 | 318.1 | 016.1 | 234.6 | 295.8 | 12 |
| 13 | 154.2 | 003.7 | 256.0 | 102.8 | 152.1 | 360.0 | 051.5 | 262.6 | 116.0 | 174.1 | 032.6 | 093.8 | 13 |
| 14 | 312.0 | 161.4 | 053.6 | 260.4 | 309.8 | 157.7 | 209.3 | 060.4 | 273.9 | 332.1 | 190.6 | 251.9 | 14 |
| 15 | 109.7 | 319.1 | 211.2 | 058.0 | 107.4 | 315.4 | 007.0 | 218.2 | 071.8 | 130.1 | 348.7 | 049.9 | 15 |
| 16 | 267.5 | 116.8 | 008.9 | 215.7 | 265.1 | 113.1 | 164.7 | 016.0 | 229.7 | 288.1 | 146.7 | 207.9 | 16 |
| 17 | 065.3 | 274.5 | 166.5 | 013.3 | 062.7 | 270.8 | 322.5 | 173.9 | 027.6 | 086.1 | 304.8 | 005.9 | 17 |
| 18 | 223.0 | 072.1 | 324.2 | 170.9 | 220.4 | 068.5 | 120.3 | 331.7 | 185.5 | 244.1 | 102.8 | 163.9 | 18 |
| 19 | 020.8 | 229.8 | 121.8 | 328.6 | 018.1 | 226.2 | 278.0 | 129.5 | 343.4 | 042.1 | 260.9 | 321.9 | 19 |
| 20 | 178.5 | 027.5 | 279.5 | 126.2 | 175.7 | 023.9 | 075.8 | 287.3 | 141.3 | 200.1 | 058.9 | 120.0 | 20 |
| 21 | 336.3 | 185.2 | 077.1 | 283.9 | 333.4 | 181.6 | 233.5 | 085.2 | 299.2 | 358.1 | 217.0 | 278.0 | 21 |
| 22 | 134.0 | 342.8 | 234.7 | 081.5 | 131.0 | 339.3 | 031.3 | 243.0 | 097.2 | 156.1 | 015.0 | 076.0 | 22 |
| 23 | 291.8 | 140.5 | 032.4 | 239.2 | 288.7 | 137.0 | 189.0 | 040.8 | 255.1 | 314.1 | 173.1 | 234.0 | 23 |
| 24 | 089.5 | 298.2 | 190.0 | 036.8 | 086.4 | 294.7 | 346.8 | 198.7 | 053.0 | 112.1 | 331.1 | 032.0 | 24 |
| 25 | 247.3 | 095.8 | 347.7 | 194.4 | 244.0 | 092.4 | 144.6 | 356.5 | 210.9 | 270.1 | 129.1 | 190.0 | 25 |
| 26 | 045.0 | 253.5 | 145.3 | 352.1 | 041.7 | 250.1 | 302.4 | 154.4 | 008.9 | 068.1 | 287.2 | 347.9 | 26 |
| 27 | 202.7 | 051.2 | 302.9 | 149.7 | 199.4 | 047.8 | 100.1 | 312.2 | 166.8 | 226.1 | 085.2 | 145.9 | 27 |
| 28 | 000.4 | 208.8 | 100.6 | 307.4 | 357.1 | 205.5 | 257.9 | 110.1 | 324.7 | 024.1 | 243.3 | 303.9 | 28 |
| 29 | 158.2 | 006.5 | 258.2 | 105.0 | 154.7 | 003.3 | 055.7 | 267.9 | 122.7 | 182.1 | 041.3 | 101.9 | 29 |
| 30 | 315.9 | | 055.8 | 262.7 | 312.4 | 161.0 | 213.5 | 065.8 | 280.6 | 340.2 | 199.4 | 259.9 | 30 |
| 31 | 113.6 | | 213.5 | | 110.1 | | 011.2 | 223.6 | | 138.2 | | 057.8 | 31 |

**SYSTEM II (° at 0 hr UT)**

| Date | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 116.2 | 090.4 | 122.0 | 092.5 | 272.8 | 243.7 | 065.7 | 039.5 | 015.4 | 203.6 | 184.7 | 017.0 | 1 |
| 2 | 266.4 | 240.5 | 272.0 | 242.5 | 062.8 | 033.7 | 215.8 | 189.7 | 165.6 | 353.9 | 335.1 | 167.4 | 2 |
| 3 | 056.6 | 030.6 | 062.1 | 032.5 | 212.8 | 183.8 | 005.9 | 339.8 | 315.9 | 144.2 | 125.5 | 317.8 | 3 |
| 4 | 206.8 | 180.7 | 212.1 | 182.5 | 002.8 | 333.8 | 156.0 | 130.0 | 106.1 | 294.5 | 275.9 | 108.2 | 4 |
| 5 | 357.0 | 330.8 | 002.1 | 332.5 | 152.8 | 123.9 | 306.1 | 280.1 | 256.4 | 084.9 | 066.3 | 258.6 | 5 |
| 6 | 147.1 | 120.8 | 152.1 | 122.5 | 302.9 | 273.9 | 096.2 | 070.3 | 046.6 | 235.2 | 216.7 | 049.0 | 6 |
| 7 | 297.3 | 270.9 | 302.2 | 272.5 | 092.9 | 064.0 | 246.3 | 220.5 | 196.8 | 025.5 | 007.1 | 199.4 | 7 |
| 8 | 087.5 | 061.0 | 092.2 | 062.5 | 242.9 | 214.0 | 036.4 | 010.6 | 347.1 | 175.9 | 157.5 | 349.8 | 8 |
| 9 | 237.6 | 211.1 | 242.2 | 212.5 | 032.9 | 004.1 | 186.5 | 160.8 | 137.3 | 326.2 | 307.9 | 140.2 | 9 |
| 10 | 027.8 | 001.1 | 032.2 | 002.5 | 182.9 | 154.2 | 336.6 | 311.0 | 287.6 | 116.5 | 098.3 | 290.6 | 10 |
| 11 | 178.0 | 151.2 | 182.2 | 152.5 | 333.0 | 304.2 | 126.7 | 101.1 | 077.8 | 266.9 | 248.7 | 081.0 | 11 |
| 12 | 328.1 | 301.2 | 332.3 | 302.5 | 123.0 | 094.3 | 276.9 | 251.3 | 228.1 | 057.2 | 039.1 | 231.4 | 12 |
| 13 | 118.3 | 091.3 | 122.3 | 092.6 | 273.0 | 244.3 | 067.0 | 041.5 | 018.4 | 207.6 | 189.5 | 021.8 | 13 |
| 14 | 268.4 | 241.4 | 272.3 | 242.6 | 063.0 | 034.4 | 217.1 | 191.7 | 168.6 | 357.9 | 339.9 | 172.2 | 14 |
| 15 | 058.5 | 031.4 | 062.3 | 032.6 | 213.1 | 184.5 | 007.2 | 341.9 | 318.9 | 148.3 | 130.3 | 322.6 | 15 |
| 16 | 208.7 | 181.5 | 212.3 | 182.6 | 003.1 | 334.5 | 157.3 | 132.1 | 109.2 | 298.6 | 280.7 | 113.0 | 16 |
| 17 | 358.8 | 331.5 | 002.3 | 332.6 | 153.1 | 124.6 | 307.4 | 282.3 | 259.4 | 089.0 | 071.2 | 263.4 | 17 |
| 18 | 149.0 | 121.6 | 152.3 | 122.6 | 303.2 | 274.7 | 097.6 | 072.4 | 049.7 | 239.4 | 221.6 | 053.8 | 18 |
| 19 | 299.1 | 271.6 | 302.4 | 272.6 | 093.2 | 064.8 | 247.7 | 222.6 | 200.0 | 029.7 | 012.0 | 204.2 | 19 |
| 20 | 089.2 | 061.7 | 092.4 | 062.6 | 243.2 | 214.8 | 037.8 | 012.8 | 350.3 | 180.1 | 162.4 | 354.5 | 20 |
| 21 | 239.3 | 211.7 | 242.4 | 212.6 | 033.2 | 004.9 | 187.9 | 163.0 | 140.6 | 330.5 | 312.8 | 144.9 | 21 |
| 22 | 029.4 | 001.7 | 032.4 | 002.6 | 183.3 | 155.0 | 338.1 | 313.2 | 290.9 | 120.8 | 103.2 | 295.3 | 22 |
| 23 | 179.6 | 151.8 | 182.4 | 152.7 | 333.3 | 305.1 | 128.2 | 103.4 | 081.1 | 271.2 | 253.7 | 085.7 | 23 |
| 24 | 329.7 | 301.8 | 332.4 | 302.7 | 123.4 | 095.1 | 278.3 | 253.7 | 231.4 | 061.6 | 044.1 | 236.0 | 24 |
| 25 | 119.8 | 091.9 | 122.4 | 092.7 | 273.4 | 245.2 | 068.5 | 043.9 | 021.7 | 212.0 | 194.5 | 026.4 | 25 |
| 26 | 269.9 | 241.9 | 272.4 | 242.7 | 063.4 | 035.3 | 218.6 | 194.1 | 172.0 | 002.3 | 344.9 | 176.8 | 26 |
| 27 | 060.0 | 031.9 | 062.4 | 032.7 | 213.5 | 185.4 | 008.8 | 344.3 | 322.3 | 152.7 | 135.3 | 327.1 | 27 |
| 28 | 210.1 | 182.0 | 212.4 | 182.7 | 003.5 | 335.5 | 158.9 | 134.5 | 112.6 | 303.1 | 285.7 | 117.5 | 28 |
| 29 | 000.2 | 332.0 | 002.4 | 332.7 | 153.6 | 125.6 | 309.0 | 284.7 | 263.0 | 093.5 | 076.2 | 267.8 | 29 |
| 30 | 150.3 | | 152.5 | 122.7 | 303.6 | 275.6 | 099.2 | 075.0 | 053.3 | 243.9 | 226.6 | 058.2 | 30 |
| 31 | 300.4 | | 302.5 | | 093.6 | | 249.3 | 225.2 | | 034.3 | | 208.5 | 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.

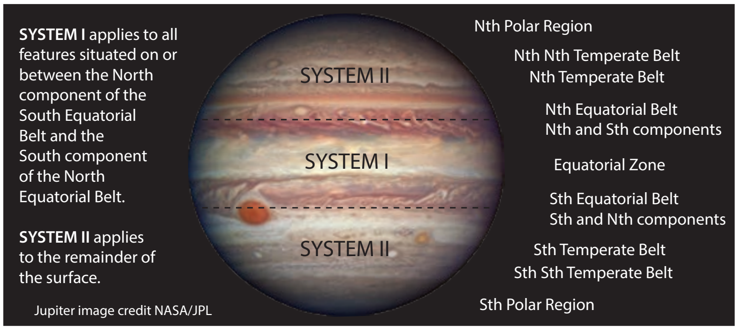
The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0 hr UT of date. You will need to add multiple hours and minutes from the small Increase in Longitude tables below. For example, the longitude of central meridian for Jupiter (System I) for 5 July at 2:20 am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on 4 July. From the table, the longitude on 4 July is 71.9°. 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 309.4°. (if greater than 360°, subtract 360°).

## 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 inconsistently over the years. For example the following are some actual values for June: 2016 (248°), 2017 (274°), 2018 (290°), 2019 (312°), 2020 (339°), 2021 (359°), 2022 (22°) and 2023 (45°). The table of data for 2024 (opposite) has been based on 59°. For every degree of longitude greater than 59° it will transit 1.6 minutes later than shown (for every degree less than 59°, 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 2024. 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 2 | | | (22:08) |
| Jan 3 | 0:08 | | 19:59 |
| Jan 4 | | | (23:46) |
| Jan 5 | | (19:38) | 21:38 |
| Jan 7 | | | 23:17 * |
| Jan 8 | | 19:08 | |
| Jan 9 | | | (22:55) |
| Jan 10 | | | 20:47 |
| Jan 12 | (0:34) | | 22:26 * |
| Jan 14 | | | (22:04) |
| Jan 15 | | | 19:56 |
| Jan 16 | | | (23:43) |
| Jan 17 | | (19:35) | 21:35 |
| Jan 19 | | | 23:14 * |
| Jan 20 | | 19:05 | |
| Jan 21 | | | (22:53) |
| Jan 22 | | | 20:44 |
| Jan 24 | | | 22:23 * |
| Jan 26 | | | (22:02) |
| Jan 27 | | | 19:54 |
| Jan 29 | | (19:33) | 21:33 |
| Jan 31 | | | (21:12) |
| Feb 1 | | 19:03 | |
| Feb 2 | | | (22:51) |
| Feb 3 | | | 20:42 |
| Feb 5 | | | 22:21 * |
| Feb 7 | | | (22:00) |
| Feb 8 | | | 19:52 |
| Feb 10 | | (19:31) | 21:31 |
| Feb 12 | | | (21:10) |
| Feb 13 | | 19:02 | |
| Feb 15 | | (18:41) | 20:41 |
| Feb 17 | | | (20:20) |
| Feb 19 | | | (21:59) |
| Feb 20 | | 19:51 | |
| Feb 22 | | (19:30) | 21:30 |
| Feb 24 | | | (21:09) |
| Feb 25 | | 19:01 | |
| Feb 27 | | (18:40) | 20:40 |
| Feb 29 | | | (20:19) |
| Mar 1 | | 18:11 | |
| Mar 3 | | 19:50 | |

| Date | 1st | 2nd | 3rd |
|---|---|---|---|
| Mar 5 | | (19:29) | |
| Mar 7 | | | (21:09) |
| Mar 8 | | 19:00 | |
| Mar 10 | | (18:40) | 20:40 |
| Mar 12 | | | (20:19) |
| Mar 13 | | 18:11 | |
| Mar 15 | | 19:50 | |
| Mar 17 | | (19:29) | |
| Mar 20 | | 19:00 | |
| Mar 22 | | (18:39) | |
| Mar 24 | | | (20:19) |
| Mar 25 | | 18:10 | |
| Mar 27 | | (17:50) | |
| Mar 29 | | (19:29) | |
| Apr 1 | | 19:00 | |
| Apr 3 | | (18:39) | |
| Apr 6 | | 18:10 | |
| Apr 8 | | (17:49) | |
| Apr 11 | | 17:20 | |
| Apr 15 | | (18:39) | |
| Apr 18 | | 18:10 | |
| Apr 20 | | (17:49) | |
| Apr 23 | | 17:20 | |
| Jun 15 | 6:32 | | |
| Jun 17 | (6:11) | | |
| Jun 20 | 5:42 | | |
| Jun 22 | 7:21 | | |
| Jun 24 | (7:00) | | |
| Jun 27 | 6:30 | | |
| Jun 29 | (6:09) | | |
| Jul 2 | 5:40 | | |
| Jul 4 | 7:19 * | | |
| Jul 6 | (6:58) | | |
| Jul 7 | 4:50 | | |
| Jul 9 | 6:28 | | |
| Jul 11 | (6:07) | | |
| Jul 14 | 5:38 | | |
| Jul 16 | 7:17 * | | |
| Jul 18 | (6:56) | | |
| Jul 19 | 4:47 | | |
| Jul 21 | 6:26 * | | |
| Jul 23 | (6:05) | | |

| Date | 1st | 2nd | 3rd |
|---|---|---|---|
| Jul 24 | 3:57 | | |
| Jul 26 | 5:35 | | |
| Jul 28 | 7:14 * | | |
| Jul 30 | (6:53) | | |
| Jul 31 | 4:45 | | |
| Aug 2 | 6:23 * | | |
| Aug 4 | (6:02) | | |
| Aug 5 | 3:54 | | |
| Aug 7 | 5:32 * | | |
| Aug 9 | (5:11) | | |
| Aug 10 | 3:03 | | |
| Aug 11 | (6:50) | | |
| Aug 12 | 4:41 | | |
| Aug 14 | 6:20 * | | |
| Aug 16 | (5:59) | | |
| Aug 17 | 3:50 | | |
| Aug 19 | 5:29 * | | |
| Aug 21 | (5:07) | | |
| Aug 22 | 2:59 | | |
| Aug 23 | (6:46) | | |
| Aug 24 | 4:37 * | | |
| Aug 26 | 6:16 * | | |
| Aug 27 | 2:07 | | |
| Aug 28 | (5:55) | | |
| Aug 29 | 3:46 | | |
| Aug 31 | 5:25 * | | |
| Sep 2 | (5:03) | | |
| Sep 3 | 2:54 | | |
| Sep 4 | (6:42) | | |
| Sep 5 | 4:33 * | | |
| Sep 7 | 6:11 * | | |
| Sep 8 | 2:03 | | |
| Sep 9 | (5:50) | | |
| Sep 10 | 3:41 * | | |
| Sep 12 | 5:20 * | | |
| Sep 13 | 1:11 | | |
| Sep 14 | (4:58) | | |
| Sep 15 | 2:49 | | |
| Sep 16 | (6:36) | | |
| Sep 17 | 4:28 * | | |
| Sep 19 | 6:06 * | | |
| Sep 20 | 1:57 | | |

| Date | 1st | 2nd | 3rd |
|---|---|---|---|
| Sep 21 | (5:45) | | |
| Sep 22 | 3:36 * | | |
| Sep 24 | 5:14 * | | |
| Sep 25 | 1:05 | | |
| Sep 26 | (4:52) | | |
| Sep 27 | 2:44 * | | |
| Sep 29 | 4:22 * | | |
| Sep 30 | 0:13 | | |
| Oct 1 | 6:00 * | | (23:52) |
| Oct 2 | 1:52 | | |
| Oct 3 | (5:38) | | |
| Oct 4 | 3:30 * | | |
| Oct 6 | 5:08 * | | |
| Oct 7 | 0:59 | | |
| Oct 8 | (4:46) | | |
| Oct 9 | 2:37 * | | |
| Oct 11 | 4:16 * | | |
| Oct 12 | 0:07 | | |
| Oct 13 | (3:54) | | (23:45) |
| Oct 14 | 1:45 | | |
| Oct 15 | (5:32) | | |
| Oct 16 | 3:23 * | | 23:14 |
| Oct 18 | 5:01 * | | (22:53) |
| Oct 19 | 0:52 | | |
| Oct 20 | (4:39) | | |
| Oct 21 | 2:30 * | | 22:22 |
| Oct 23 | 4:08 * | | |
| Oct 24 | 0:00 | | |
| Oct 25 | (3:46) | | (23:38) |
| Oct 26 | 1:38 | | |
| Oct 27 | (5:24) | | |
| Oct 28 | 3:16 * | | 23:07 |
| Oct 30 | 4:54 * | | (22:45) |
| Oct 31 | 0:45 | | |
| Nov 1 | (4:32) | | |
| Nov 2 | 2:23 * | | 22:14 |
| Nov 4 | 4:01 * | | 23:52 * |
| Nov 6 | (3:39) | | (23:30) |
| Nov 7 | 1:30 | | 21:21 |
| Nov 8 | (5:17) | | |
| Nov 9 | 3:08 * | | 22:59 |
| Nov 11 | 4:46 * | | (22:37) |

| Date | 1st | 2nd | 3rd |
|---|---|---|---|
| Nov 12 | 0:37 | | |
| Nov 13 | (4:24) | | |
| Nov 14 | 2:15 * | | 22:06 |
| Nov 16 | 3:53 * | | 23:44 * |
| Nov 18 | (3:30) | | (23:22) |
| Nov 19 | 1:22 | | 21:13 |
| Nov 20 | (5:08) | | |
| Nov 21 | 2:59 * | | 22:51 * |
| Nov 23 | 4:37 * | | (22:29) |
| Nov 24 | 0:28 | | 20:20 |
| Nov 25 | (4:15) | | |
| Nov 26 | 2:06 * | | 21:58 * |
| Nov 28 | 3:44 * | | 23:36 * |
| Nov 29 | | 19:27 | |
| Nov 30 | (3:22) | | (23:14) |
| Dec 1 | 1:13 | | 21:05 |
| Dec 2 | (5:00) | | |
| Dec 3 | 2:51 * | | 22:43 * |
| Dec 5 | 4:29 * | | (22:21) |
| Dec 6 | 0:20 | | 20:12 |
| Dec 7 | (4:07) | | (23:59) |
| Dec 8 | 1:58 | (19:50) | 21:50 |
| Dec 10 | 3:36 * | | 23:28 * |
| Dec 11 | | 19:19 | |
| Dec 12 | (3:14) | | (23:06) |
| Dec 13 | 1:05 | (18:57) | 20:57 |
| Dec 15 | 2:43 * | | 22:35 * |
| Dec 17 | (2:21) | | (22:13) |
| Dec 18 | 0:12 | | 20:04 |
| Dec 19 | (3:59) | | (23:51) |
| Dec 20 | 1:50 | (19:42) | 21:42 |
| Dec 22 | 3:28 * | | 23:20 * |
| Dec 23 | | 19:11 | |
| Dec 24 | (3:07) | | (22:58) |
| Dec 25 | 0:58 | | 20:49 |
| Dec 27 | 2:36 * | | 22:27 * |
| Dec 29 | (2:14) | | (22:05) |
| Dec 30 | 0:05 | | 19:57 |
| Dec 31 | | | (23:44) |

**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.

With a transit occurring every 9 hours 55 min 40 seconds, 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 12 January the first transit is only visible from WA at 12:34 am WST. The 3rd transit for the day is visible Australia wide at 22:26 EST or 10:26 pm EST (9:56 pm CST, 8:26 pm WST).

# SATURN'S MOONS



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 a day 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 22 September 11 pm EST (see page 66).**

**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 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 Rhea for the date above.

1. Convert to UT as a fractional day (table 3) to get 22.542 UT.
2. Subtract the date of the greatest elongation east for Rhea for September, i.e., 22.542 – 2.659 = 19.883
3. Express this as the number of orbits by dividing by the period i.e., 19.883 / 4.518 = 4.401
4. Discard any complete orbits (4 in this case) leaving 0.401
5. Multiply by the period, 0.401 × 4.518 = 1.812 days or about 1 day and 19 hours after elongation east.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is west of Saturn.

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

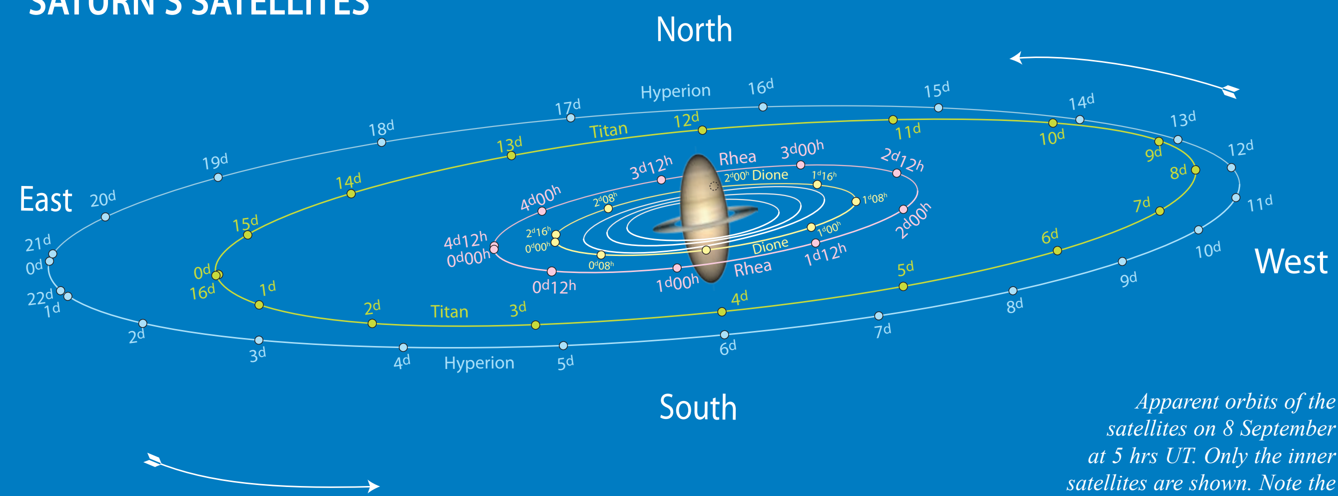
| Moon | Mimas | Enceladus | Tethys | Dione | Rhea |
|---|---|---|---|---|---|
| Magnitude [1] | 12.8 | 11.8 | 10.2 | 10.4 | 9.6 |
| Max Elong. [1] | 0' 30" | 0' 38" | 0' 48" | 1' 01" | 1' 25" |
| Period (days) [2] | 0.942 | 1.370 | 1.888 | 2.737 | 4.518 |
| Month | Elongation East (d.ddd) | | | | |
| January | 1.492 | 1.275 | 1.180 | 2.805 | 2.574 |
| February | 1.603 | 1.803 | 2.290 | 1.934 | 3.236 |
| March | 1.827 | 1.590 | 1.623 | 3.065 | 1.378 |
| April | 1.935 | 2.117 | 2.733 | 2.195 | 2.042 |
| May | 1.155 | 2.270 | 1.061 | 2.320 | 3.699 |
| June | 1.257 | 1.420 | 2.161 | 1.437 | 4.341 |
| July | 1.413 | 1.564 | 2.366 | 1.545 | 1.450 |
| August | 1.507 | 2.074 | 1.565 | 3.380 | 2.061 |
| September | 1.600 | 1.211 | 2.647 | 2.471 | 2.659 |
| October | 1.752 | 1.349 | 2.842 | 2.563 | 4.256 |
| November | 1.850 | 1.861 | 2.042 | 1.661 | 4.865 |
| December | 1.068 | 2.009 | 2.250 | 1.770 | 1.974 |
| Notes 1. When at opposition 2. Mean Synodic Period | | | | | |

**Mimas, Enceladus and Tethys**

The procedure is similar to Rhea and Dione 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, September 22.542 UT; 10.537 orbits have elapsed since the first greatest elongation east for September on 2.647 UT. Discarding the completed orbits leaves 0.537 of an orbit. This is west of Saturn just after its elongation west.

## APPARENT ORBITS OF SATURN'S SATELLITES




*Saturn and the orbits have been elongated (three to one ratio) in the direction of the minor axes.*

*Apparent orbits of the satellites on 8 September at 5 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.*

### 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 22 Sep 11 pm EST (22.542 UT), Titan is about 8.6 days past its most recent greatest elongation east (September 13.926 UT), which puts it west of Saturn. The diagrams opposite and on page 66 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 | 2.310 | 1.815 |
| | 18.320 | 23.114 |
| February | 3.339 | 13.42 |
| | 19.362 | |
| March | 6.387 | 5.762 |
| | 22.411 | 27.105 |
| April | 7.429 | 17.433 |
| | 23.441 | |
| May | 9.442 | 8.763 |
| | 25.431 | 30.09 |
| June | 10.404 | 20.382 |
| | 26.362 | |
| July | 12.301 | 11.655 |
| | 28.224 | |
| August | 13.133 | 1.919 |
| | 29.032 | 23.155 |
| September | 13.926 | 13.396 |
| | 29.824 | |
| October | 15.730 | 4.67 |
| | 31.649 | 25.972 |
| November | 16.587 | 16.338 |
| December | 2.542 | 7.76 |
| | 18.516 | 29.218 |

Notes 1. When at opposition
2. Mean Synodic Period

Table 4: **Iapetus**

Magnitude [1] 11.0
Max Elong. [1] 9' 35"
Period (days) [2] 79.331

| **Elongation East** | | **Inferior Conjunction** | | **Elongation West** | | **Superior Conjunction** | |
|---|---|---|---|---|---|---|---|
| Jan | 6.898 | Jan | 27.195 | Feb | 17.191 | Mar | 8.692 |
| Mar | 28.493 | Apr | 17.641 | May | 8.746 | May | 28.597 |
| Jun | 17.287 | Jul | 6.891 | Jul | 27.392 | Aug | 15.776 |
| Sep | 3.75 | Sep | 23.226 | Oct | 13.208 | Nov | 2.118 |
| Nov | 21.024 | Dec | 11.179 | Dec | 31.648 | | |

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, 22 Sep 11 pm EST (22.542 UT), the most recent event was an elongation east on September 3.750 (UT). Iapetus is 18.8 days past this time, about one day before an inferior conjunction, so it is to the south of the planet.

## SATURN'S RINGS 2024

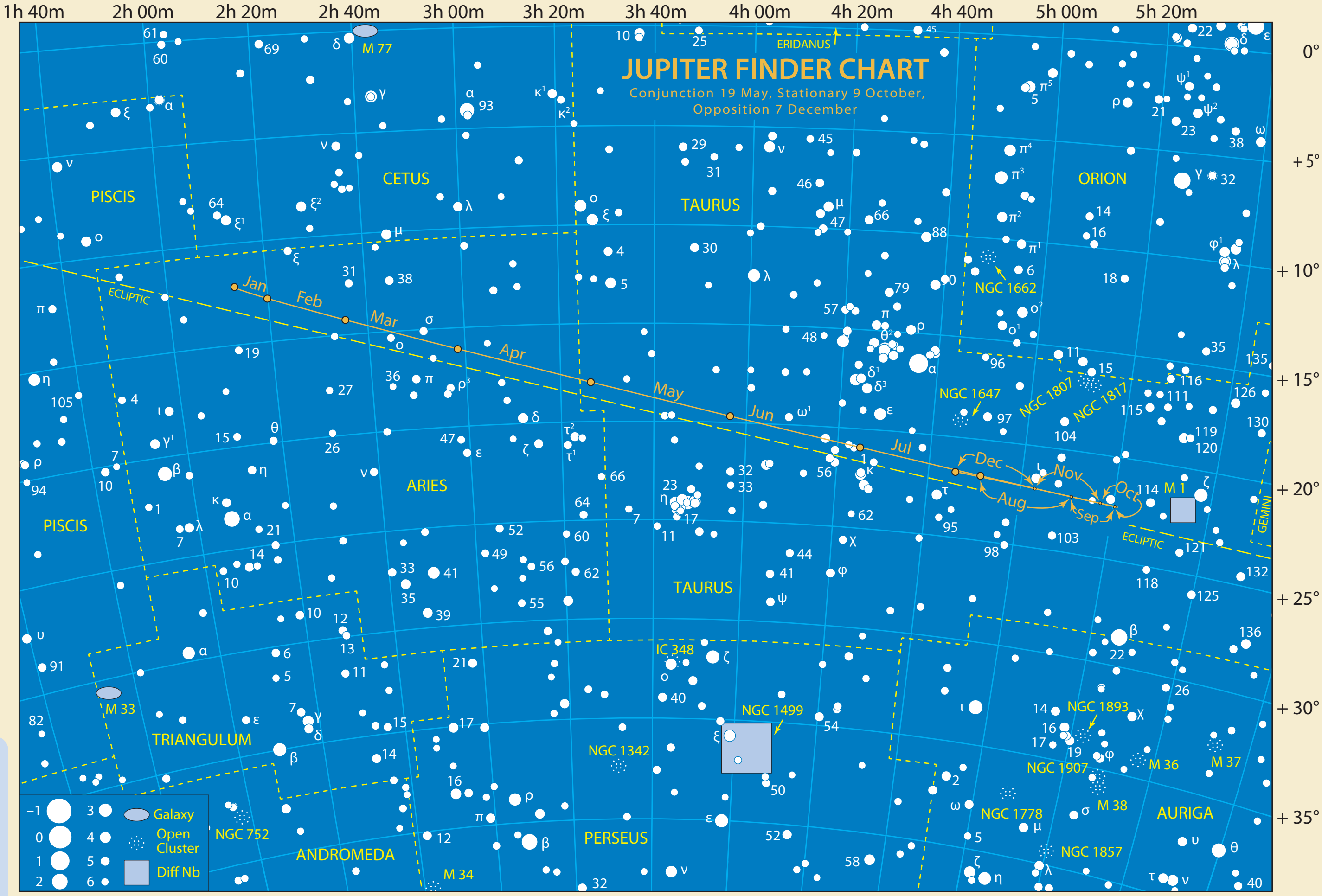
| Date | Major " | Minor " | B ° |
|---|---|---|---|
| Jan 3 | 36.5 | 5.8 | 9.1 |
| Jan 11 | 36.2 | 5.5 | 8.7 |
| Jan 19 | 35.9 | 5.2 | 8.4 |
| Jan 27 | 35.7 | 4.9 | 8.0 |
| Feb 4 | 35.5 | 4.7 | 7.5 |
| Feb 12 | 35.3 | 4.4 | 7.1 |
| Feb 20 | 35.2 | 4.1 | 6.7 |
| Feb 28 | 35.2 | 3.8 | 6.2 |
| Mar 7 | 35.2 | 3.5 | 5.8 |
| Mar 15 | 35.3 | 3.3 | 5.3 |
| Mar 23 | 35.4 | 3.0 | 4.9 |
| Mar 31 | 35.6 | 2.8 | 4.5 |
| Apr 8 | 35.9 | 2.5 | 4.1 |
| Apr 16 | 36.1 | 2.3 | 3.7 |
| Apr 24 | 36.5 | 2.1 | 3.3 |
| May 2 | 36.8 | 1.9 | 3.0 |
| May 10 | 37.3 | 1.8 | 2.7 |
| May 18 | 37.7 | 1.6 | 2.5 |
| May 26 | 38.2 | 1.5 | 2.3 |
| Jun 3 | 38.7 | 1.4 | 2.1 |
| Jun 11 | 39.2 | 1.4 | 2.0 |
| Jun 19 | 39.8 | 1.4 | 2.0 |
| Jun 27 | 40.3 | 1.4 | 1.9 |
| Jul 5 | 40.9 | 1.4 | 2.0 |
| Jul 13 | 41.4 | 1.5 | 2.1 |
| Jul 21 | 41.9 | 1.6 | 2.2 |
| Jul 29 | 42.4 | 1.8 | 2.4 |
| Aug 6 | 42.8 | 1.9 | 2.6 |
| Aug 14 | 43.1 | 2.1 | 2.8 |
| Aug 22 | 43.3 | 2.4 | 3.1 |
| Aug 30 | 43.5 | 2.6 | 3.4 |
| Sep 7 | 43.6 | 2.8 | 3.7 |
| Sep 15 | 43.5 | 3.0 | 4.0 |
| Sep 23 | 43.4 | 3.2 | 4.3 |
| Oct 1 | 43.2 | 3.4 | 4.5 |
| Oct 9 | 42.9 | 3.6 | 4.7 |
| Oct 17 | 42.5 | 3.7 | 4.9 |
| Oct 25 | 42.1 | 3.7 | 5.1 |
| Nov 2 | 41.6 | 3.8 | 5.2 |
| Nov 10 | 41.0 | 3.7 | 5.2 |
| Nov 18 | 40.5 | 3.7 | 5.2 |
| Nov 26 | 39.9 | 3.6 | 5.2 |
| Dec 4 | 39.4 | 3.5 | 5.0 |
| Dec 12 | 38.9 | 3.3 | 4.9 |
| Dec 20 | 38.3 | 3.1 | 4.7 |
| Dec 28 | 37.9 | 2.9 | 4.4 |

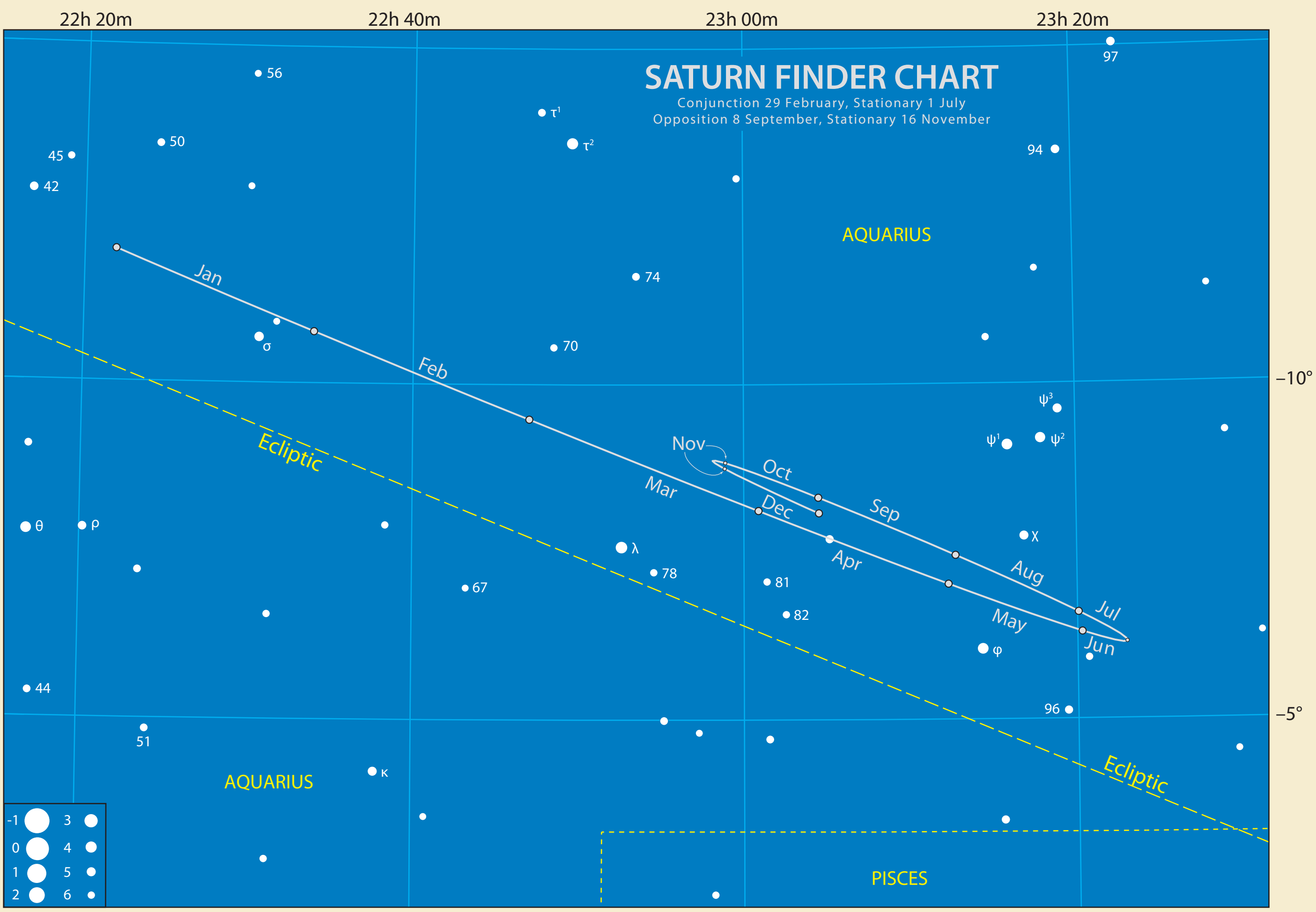
The Appearance of the Planets diagrams in Part I show how open the rings are for 2024. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every seven 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 2024 they are closing up again, the next edge-on is in 2025.

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.

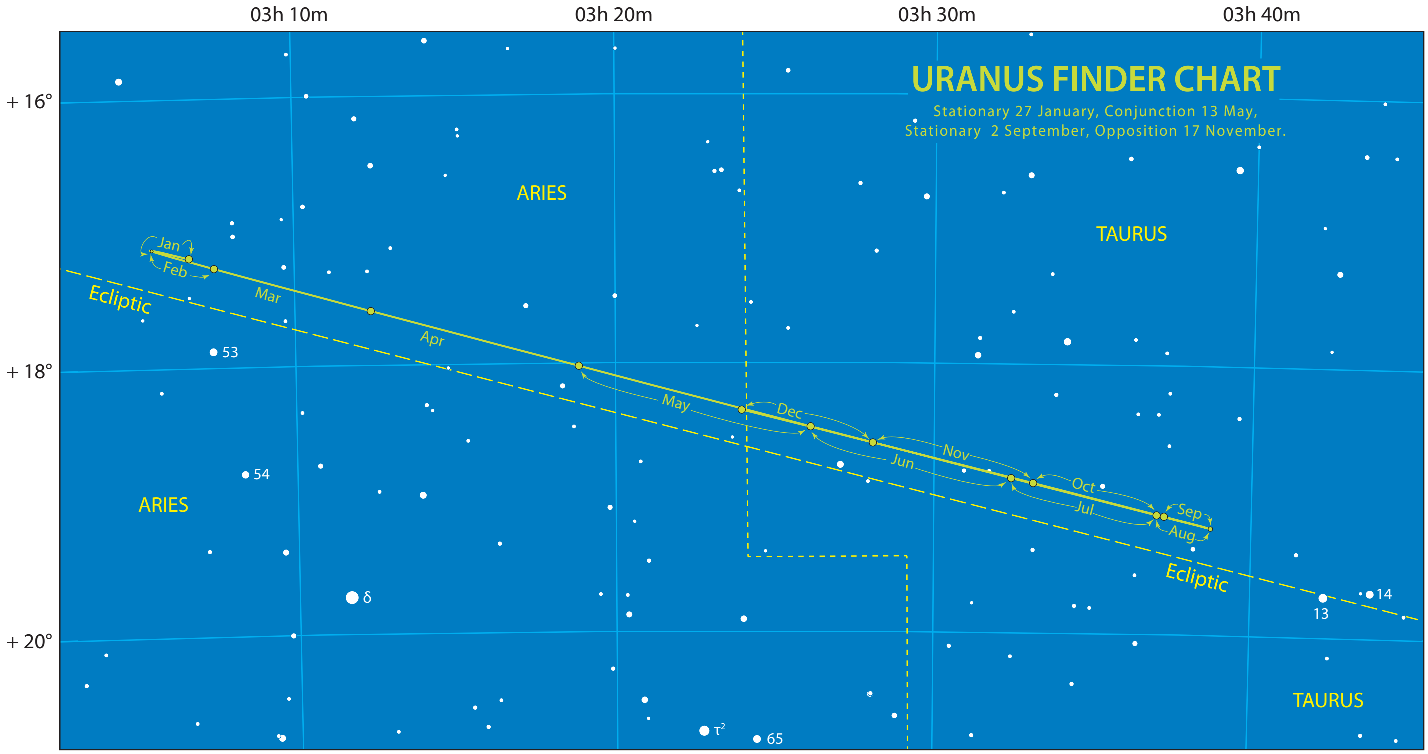
| | |
|---|---|
| Inner edge of outer ring | 0.8932 |
| Outer edge of inner ring | 0.8596 |
| Inner edge of inner ring | 0.6726 |
| Inner edge of dusky ring | 0.5477 |

B is the tilt of the rings.


JUPITER FINDER CHART
Conjunction 19 May, Stationary 9 October,
Opposition 7 December
1h 40m
2h 00m
2h 20m
2h 40m
3h 00m
3h 20m
3h 40m
4h 00m
4h 20m
4h 40m
5h 00m
5h 20m
0°
+5°
+10°
+15°
+20°
+25°
+30°
+35°
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
ECLIPTIC
PISCIS
CETUS
TAURUS
ORION
ARIES
TRIANGULUM
ANDROMEDA
PERSEUS
AURIGA
ERIDANUS
GEMINI
M 77
M 33
M 34
M 1
M 36
M 37
M 38
NGC 1662
NGC 1647
NGC 1807
NGC 1817
NGC 1893
NGC 1907
NGC 1778
NGC 1857
NGC 1499
NGC 1342
NGC 752
IC 348
Galaxy
Open Cluster
Diff Nb


SATURN FINDER CHART
Conjunction 29 February, Stationary 1 July
Opposition 8 September, Stationary 16 November
22h 20m
22h 40m
23h 00m
23h 20m
–10°
–5°
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ecliptic
AQUARIUS
PISCES

# URANUS




**URANUS' MOONS** Table 2a 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 17 November at 1 am (WST)

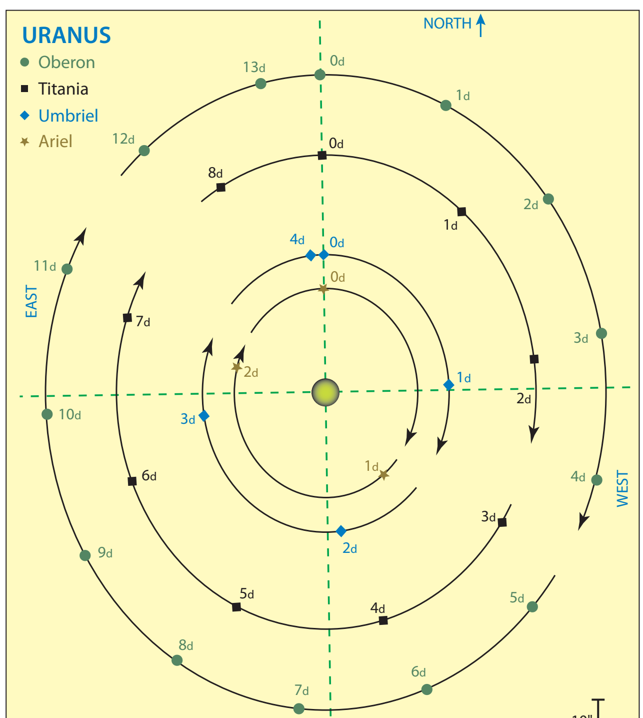
1. Convert to UT as a fractional day. 17 November at 1 am (WST) = 16.708 UT (refer table 1 next page).

Table 2a: **Time of Greatest Elongation North** (UT)

| **Planet** | **Uranus** | | | |
|---|---|---|---|---|
| **Moon** | **Ariel** | **Umbriel** | **Titania** | **Oberon** |
| Magnitude [1] | 13.7 | 14.5 | 13.5 | 13.7 |
| Max Elong. [1] | 0' 14" | 0' 20" | 0' 33" | 0' 44" |
| Period (days) [2] | 2.520 | 4.144 | 8.706 | 13.463 |
| **Month** | **Elongation North (d.ddd)** | | | |
| January | 3.157 | 2.739 | 6.289 | 3.481 |
| February | 2.405 | 4.897 | 1.407 | 12.880 |
| March | 1.130 | 4.904 | 7.224 | 10.796 |
| April | 2.892 | 2.908 | 2.333 | 6.697 |
| May | 3.131 | 1.910 | 7.134 | 3.589 |
| June | 2.368 | 4.047 | 2.229 | 12.931 |
| July | 2.602 | 3.043 | 7.016 | 9.834 |
| August | 1.838 | 1.043 | 2.115 | 5.735 |
| September | 1.078 | 3.186 | 5.933 | 1.640 |
| October | 1.321 | 2.197 | 2.058 | 12.030 |
| November | 3.091 | 4.360 | 5.893 | 7.987 |
| December | 3.342 | 3.376 | 2.023 | 4.943 |

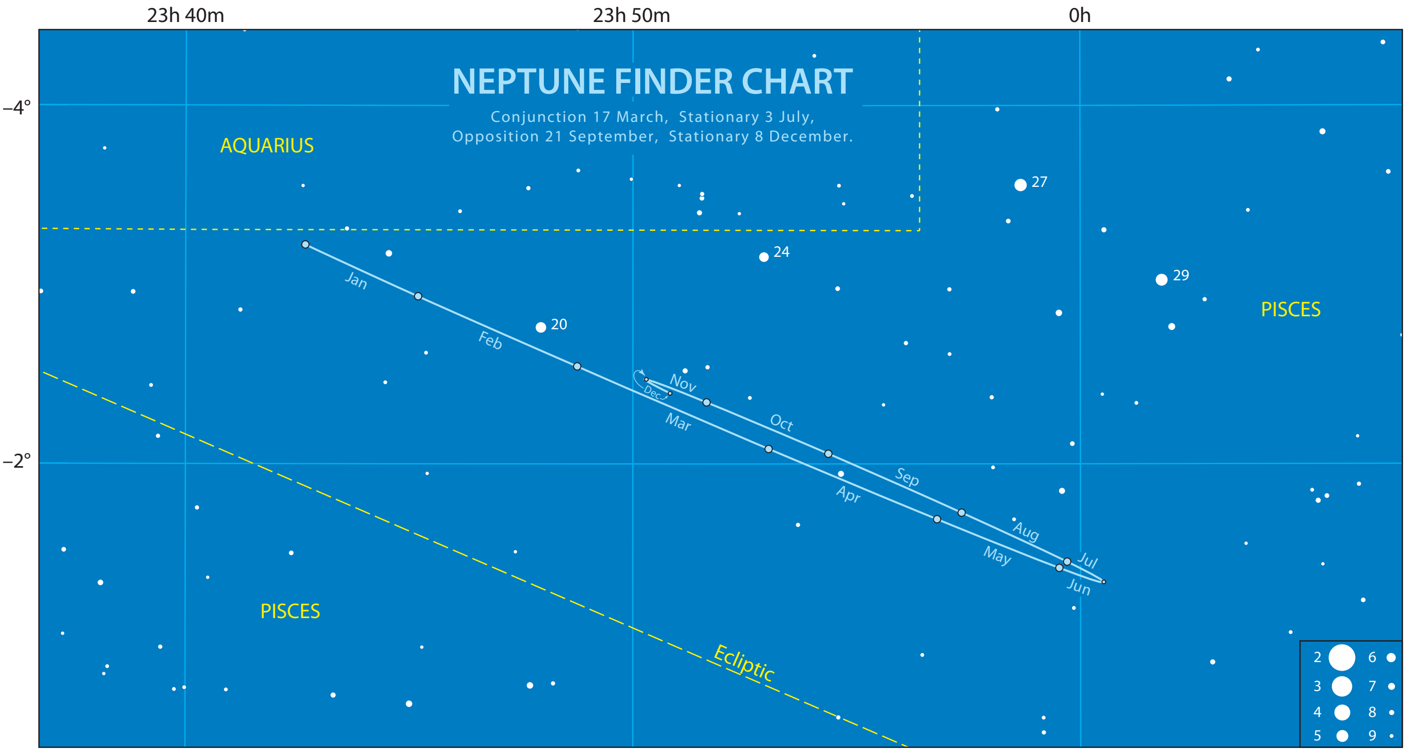
Notes 1. When at opposition 2. Sidereal Period

2. Subtract the date of the greatest elongation north for November, i.e. 16.708 – 4.360 = 12.348 days.
3. Divide by the period to get the number of orbits, i.e. 12.348 / 4.144 = 2.980 orbits.
4. Discarding whole orbits leaves 0.980 (almost a whole orbit).
5. Multiply by the period, 0.980 × 4.144 = 4.06 days.
6. Looking at its orbital path (see Apparent Orbits diagram), the satellite is just after the 4 day mark, close to a northern elongation.




Apparent orbits of Uranus' satellites I–IV as at the date of opposition, 17 November.

# NEPTUNE




Uranus and Neptune are unusual in that they are the only planets that needed optical aids to discover them. The remaining planets, being naked-eye, do not have a recognised known discoverer.

The information on these pages help you find the position of Uranus' 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.

## NEPTUNE'S MOON

The procedure for finding Neptune's major satellite **Triton** is identical to that for Uranus, except the times of the first greatest elongation *east* for each month are listed in Table 2b. The orientation of Triton's orbit places this day 0 (zero) point closer to north-east of Neptune (see diagram).

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 21$^{st}$ = 20.625 days UT

An example. Estimate the position for Triton for September 15 at 10 pm EST. 2.369 orbits have elapsed since its greatest elongation east on Sep 1.575 UT. Discarding the whole orbits leaves 0.369. Multiplying by 5.877 (its period) gives 2.17 days. From the diagram the moon is due south of Neptune, less than one day from a western elongation.

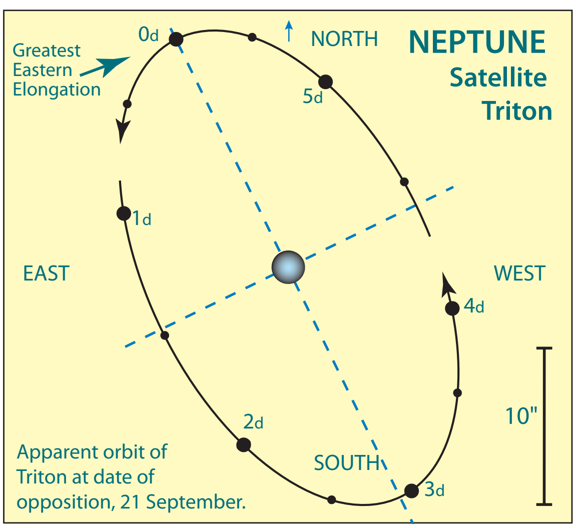



Table 2b: **Time of Greatest Elongation East** (UT)

| **Planet** | **Neptune** |
|---|---|
| **Moon** | **Triton** |
| Magnitude [1] | 13.5 |
| Max Elong. [1] | 0' 17" |
| Period (days) [2] | 5.877 |
| **Month** | **East** (d.ddd) |
| January | 4.686 |
| February | 3.062 |
| March | 3.433 |
| April | 1.802 |
| May | 1.171 |
| June | 5.418 |
| July | 4.797 |
| August | 3.183 |
| September | 1.575 |
| October | 6.849 |
| November | 5.244 |
| December | 4.635 |

Notes 1. At opposition
2. Sidereal Period

# COMETS FOR 2024

**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 rocks/dust. The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. One of the shortest period comets, 2P/Encke, takes just over three years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds or even thousands 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 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, some may only show a coma.

Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets—you will see examples on the following pages. The prefix 'P/' means the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 2P/Encke indicates it was the 2nd 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. The ATLAS comet, mentioned (next page), is referred to as 'C/2022 L2'. 2022 refers to the year of the discovery, L is the 11th half-month period ('I' is not used) during the year and the 2 shows it was the second discovery in this half month. Therefore C/2022 L2 (ATLAS) was the second comet discovered in the first half of June 2022.

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 2024. The table on page 134 lists comets that are expected to brighten to at least 13th magnitude sometime during the year, along with their orbital elements. 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 expected in 2024, but are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

# SELECTED NOTES ON COMETS FOR 2024 by Greg Bryant

**12P/Pons-Brooks**: French comet hunter Jean-Louis Pons discovered this comet on 21 July 1812, with it estimated to be between 6th and 7th magnitude in brightness. As Pons-Brooks headed towards perihelion in September, it brightened to 4th magnitude. Several astronomers realised the comet was of short period, with Johann Encke (of comet Encke fame) deriving a period of nearly 71 years. This orbit was used for searching for the comet at its next forecast return in 1883. Those searches were unsuccessful but the American astronomer William Brooks came across the comet in September of that year. By January 1884, it had brightened to 3rd magnitude.

In June 1953, eleven months out from its next perihelion passage, Pons-Brooks was recovered. The return of 1954 saw the comet brighten to 6th magnitude. During the last two returns of 1884 and 1954, observers noted several brightness outbursts of more than one magnitude. Observers will be watching for a repeat in 2024 when Pons-Brooks is predicted to brighten to between 4th and 5th magnitude.

As an interesting prelude to the return in 2024, German amateur astronomer Maik Mayer led a team that linked Pons-Brooks with sightings of comets seen in 1385 and 1457. The paper, published in 2021, also suggests a likely connection with a comet seen in 245 CE, which would give it the third longest observing history after comets 1P/Halley and 109P/Swift-Tuttle.

**13P/Olbers**: German astronomer Heinrich Olbers, best known for his discovery of the minor planets Pallas and Vesta in 1802 and 1807 respectively, found this comet on 6 March 1815. By late April, around the time of perihelion, Olbers had brightened to 5th magnitude. By mid 1815 it became apparent that Olbers was periodic, in the order of 70 years. Predictions were for its next return in 1887 were inaccurate, but it was accidentally rediscovered some two months before perihelion. The next return in 1956 saw the comet recovered five months before perihelion, and Olbers brightened to 7th magnitude during that apparition.

Olbers' return in 2024 sees it reach perihelion on 30 June at 1.2 au from the Sun. Based on its previous performance, the comet is likely to peak at between 7th and 8th magnitude, though Northern Hemisphere observers are favoured. During this return, Olbers remains quite distant from Earth, never coming closer than 1.9 au.

**62P/Tsuchinshan 1**: The discovery of this comet took place on 1 January 1965 at Purple Mountain Observatory (Tsuchinshan) in Nanjing, China. There was a delay of several weeks before the comet was announced. However, by the end of April, it was determined to be periodic, orbiting the Sun currently every 6.2 years. Reaching perihelion on Christmas Day 2023, Tsuchinshan 1 could potentially brighten to a magnitude of 7 around that time. About a month later, in late January, it will pass within 0.5 au of Earth, its closest known approach thus far.

**144P/Kushida**: Japanese amateur astronomer Yoshio Kushida discovered this comet on 8 January 1994 on images taken with a patrol camera. Within a few days, calculations had shown the 11th magnitude comet to be periodic, orbiting the Sun every 7 years with a perihelion distance of 1.4 au. The 2024 return of Kushida sees it reaching perihelion on 25 January. The comet, which has a steep brightening curve, may reach 9th magnitude during this time.

**154P/Brewington**: American amateur astronomer Howard Brewington discovered this comet on 28 August 1992. It was Brewington's fourth comet discovery in the space of less than three years, and his first that was not shared with anyone else. Initially observed at an estimated brightness of 11th magnitude, the comet faded after mid-September. During that same month, astronomers gathered additional astrometry data and determined that the comet followed a short-period orbit, completing each revolution around the Sun every 10.7 years with perihelion 1.6 au from the Sun. That year, Brewington had reached perihelion in early June, so the discovery of the comet had come some 11 weeks later.

In 2003, Brewington reached perihelion once again, peaking at around 11th magnitude. Its last return, in late 2013, saw it edge closer to 10th magnitude. 2024's apparition sees Brewington reaching perihelion in mid-June just over 1.5 au from the Sun.

**333P/LINEAR**: The Lincoln Near-Earth Asteroid Research (LINEAR) program was a survey conducted between 1998 and 2012 using a series of 1 m telescopes in New Mexico to search for minor planets and comets. During its time, it discovered 224 comets, which was a record for ground-based discoveries surpassed in recent years by the Pan-STARRS survey.

This comet was discovered by the LINEAR program on images taken on 4 November 2007. It did not appear cometary at the time and was given the minor planet designation 2007 VA85, orbiting the Sun every 8.6 years. Because of its comet-like eccentric orbit (e > 0.7), there was particular interest

## BRIGHT COMETS FOR 2024 — ORBITAL ELEMENTS (Equinox 2000.0)

| Comet Name | Perihelion Date yyyy mm dd.dddd | q au | e | Period years | ω ° | Ω ° | i ° | H1 | K1 |
|---|---|---|---|---|---|---|---|---|---|
| 62P/Tsuchinshan 1 | 2023 12 25.0678 | 1.264968 | 0.624479 | 6.2 | 47.3074 | 68.6588 | 4.7373 | 5.0 | 32.5 |
| 144P/Kushida | 2024 01 25.6116 | 1.398929 | 0.634891 | 7.5 | 216.3268 | 242.9193 | 3.9317 | 6.5 | 25.0 |
| C/2021 S3 (PANSTARRS) | 2024 02 14.8163 | 1.318465 | 0.999715 | | 6.9110 | 215.6474 | 58.5458 | 7.0 | 7.5 |
| C/2022 L2 (ATLAS) | 2024 03 12.3466 | 2.692156 | 1.001286 | | 199.9479 | 39.2430 | 129.3134 | 7.5 | 7.5 |
| 12P/Pons-Brooks | 2024 04 21.1617 | 0.781173 | 0.954524 | 71.2 | 198.9824 | 255.8445 | 74.1865 | 5.0 | 15.0 |
| 154P/Brewington | 2024 06 13.6038 | 1.552969 | 0.676349 | 10.5 | 47.9529 | 343.0160 | 17.6343 | 2.5 | 30.0 |
| 13P/Olbers | 2024 06 30.7715 | 1.175500 | 0.930308 | 69.3 | 64.4154 | 85.8473 | 44.6669 | 5.0 | 15.0 |
| C/2023 A3 (Tsuchinshan-ATLAS) | 2024 09 27.6382 | 0.391188 | 1.000196 | | 308.4889 | 21.5573 | 139.1185 | 7.0 | 7.5 |
| 333P/LINEAR | 2024 11 29.2993 | 1.112942 | 0.736321 | 8.7 | 26.0172 | 115.7057 | 132.0220 | 10.5 | 20.0 |

## COMET ORBITAL 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 in Comet Ephemerides next page for further details).

Calculation of ephemerides from these elements is complex (but not difficult with the power of home technology) but beyond the scope of this book.

in observing it at its next return in 2016. Images in January of that year did reveal faint cometary activity three months before perihelion and the object was renamed LINEAR, peaking between 11th and 12th magnitude. 2024 sees it reaching perihelion on 29 November at a distance of 1.1 au from the Sun, and it may peak at 10th magnitude.

**C/2021 S3 (PANSTARRS)**: This visitor was found on images taken by the survey telescope on 24 September 2021. 20th magnitude at the time, observations over the next fortnight from several telescopes revealed the comet would reach perihelion more than two years away in February 2024 at a distance of 1.3 au from the Sun. Most visual observers are likely to start sighting this comet in spring of 2023 when it is forecast to have brightened to 12th magnitude. PANSTARRS may peak between 8th and 9th magnitude early in 2024.

**C/2022 L2 (ATLAS)**: The Asteroid Terrestrial-impact Last Alert System (ATLAS) is a series of 0.5 m telescopes operated by the University of Hawaii to scan the sky for near-Earth asteroids and comets. The program began in 2015 with one telescope in Hawaii. A second telescope was added in 2017 and then two more saw first light in Chile and South Africa in 2022. At the time of writing (June 2023), 83 comets have been discovered by the ATLAS program. Comet C/2022 L2 (ATLAS) was found on images taken on 10 June 2022. The comet reaches perihelion on 12 March 2024 at a distance of 2.7 au from the Sun and may reach 12th magnitude.

**C/2023 A3 (Tsuchinshan-ATLAS)**: For notes and other info, see *Prospects for Comet Tsuchinshan-ATLAS* on page 64.

*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.*

## C/2023 A3 Tsuchinshan-ATLAS

| Date | RA h m | Dec ° ' | Δ au | R au | Rise hh:mm | Transit hh:mm | Set hh:mm | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| 23 Mar | 14 46.2 | -05 54 | 2.442 | 3.274 | 20:18 | 02:41 | 08:58 | 12.8 | Vir |
| 30 Mar | 14 35.9 | -05 12 | 2.282 | 3.185 | 19:42 | 02:03 | 08:19 | 12.6 | Vir |
| 06 Apr | 14 23.4 | -04 24 | 2.139 | 3.095 | 19:04 | 01:23 | 07:36 | 12.3 | Vir |
| 13 Apr | 14 08.7 | -03 29 | 2.016 | 3.004 | 18:24 | 00:41 | 06:52 | 12.1 | Vir |
| 20 Apr | 13 52.0 | -02 29 | 1.915 | 2.911 | 17:43 | 23:51 | 06:05 | 11.9 | Vir |
| 27 Apr | 13 33.7 | -01 26 | 1.838 | 2.818 | 17:00 | 23:05 | 05:17 | 11.7 | Vir |
| 04 May | 13 14.5 | -00 24 | 1.787 | 2.723 | 16:16 | 22:18 | 04:27 | 11.5 | Vir |
| 11 May | 12 55.0 | +00 34 | 1.759 | 2.627 | 15:32 | 21:31 | 03:38 | 11.4 | Vir |
| 18 May | 12 36.2 | +01 25 | 1.754 | 2.529 | 14:48 | 20:45 | 02:49 | 11.2 | Vir |
| 25 May | 12 18.5 | +02 06 | 1.767 | 2.430 | 14:04 | 20:00 | 02:03 | 11.1 | Vir |
| 01 Jun | 12 02.6 | +02 36 | 1.794 | 2.329 | 13:22 | 19:17 | 01:18 | 11.0 | Vir |
| 08 Jun | 11 48.6 | +02 54 | 1.831 | 2.226 | 12:42 | 18:36 | 00:35 | 10.9 | Vir |
| 15 Jun | 11 36.6 | +03 02 | 1.874 | 2.121 | 12:03 | 17:56 | 23:50 | 10.8 | Leo |
| 22 Jun | 11 26.6 | +03 01 | 1.918 | 2.015 | 11:25 | 17:19 | 23:13 | 10.7 | Leo |
| 29 Jun | 11 18.2 | +02 51 | 1.959 | 1.906 | 10:49 | 16:43 | 22:37 | 10.6 | Leo |
| 06 Jul | 11 11.4 | +02 33 | 1.995 | 1.795 | 10:14 | 16:09 | 22:04 | 10.4 | Leo |
| 13 Jul | 11 05.9 | +02 09 | 2.023 | 1.681 | 09:40 | 15:36 | 21:32 | 10.2 | Leo |
| 20 Jul | 11 01.4 | +01 38 | 2.039 | 1.564 | 09:06 | 15:04 | 21:02 | 10.0 | Leo |
| 27 Jul | 10 57.7 | +01 02 | 2.041 | 1.445 | 08:34 | 14:33 | 20:32 | 9.7 | Leo |
| 03 Aug | 10 54.7 | +00 22 | 2.028 | 1.322 | 08:01 | 14:02 | 20:03 | 9.4 | Leo |
| 10 Aug | 10 51.9 | -00 24 | 1.996 | 1.196 | 07:29 | 13:32 | 19:35 | 9.1 | Leo |
| 17 Aug | 10 49.3 | -01 15 | 1.943 | 1.067 | 06:57 | 13:02 | 19:07 | 8.7 | Sex |
| 24 Aug | 10 46.6 | -02 09 | 1.865 | 0.934 | 06:24 | 12:32 | 18:40 | 8.1 | Sex |
| 31 Aug | 10 43.5 | -03 08 | 1.759 | 0.799 | 05:51 | 12:01 | 18:12 | 7.5 | Sex |
| 07 Sep | 10 40.0 | -04 09 | 1.617 | 0.663 | 05:17 | 11:30 | 17:43 | 6.7 | Sex |
| 14 Sep | 10 36.3 | -05 08 | 1.431 | 0.534 | 04:43 | 10:59 | 17:15 | 5.7 | Sex |
| 21 Sep | 10 35.2 | -05 54 | 1.188 | 0.431 | 04:12 | 10:30 | 16:48 | 4.6 | Sex |
| 28 Sep | 10 47.9 | -05 59 | 0.893 | 0.391 | 03:56 | 10:15 | 16:35 | 3.7 | Sex |
| 05 Oct | 11 43.7 | -04 46 | 0.611 | 0.439 | 04:25 | 10:44 | 17:02 | 3.0 | Vir |
| 12 Oct | 13 54.5 | -01 19 | 0.473 | 0.547 | 06:17 | 12:29 | 18:40 | 3.0 | Vir |
| 19 Oct | 16 11.3 | +02 07 | 0.563 | 0.677 | 08:18 | 14:18 | 20:17 | 4.5 | Ser |
| 26 Oct | 17 25.5 | +03 24 | 0.774 | 0.812 | 09:09 | 15:03 | 20:58 | 5.8 | Oph |
| 02 Nov | 18 04.0 | +03 48 | 1.015 | 0.948 | 09:21 | 15:14 | 21:06 | 6.9 | Oph |
| 09 Nov | 18 27.3 | +03 57 | 1.258 | 1.080 | 09:17 | 15:09 | 21:01 | 7.8 | Oph |
| 16 Nov | 18 43.5 | +04 05 | 1.493 | 1.209 | 09:06 | 14:57 | 20:49 | 8.5 | Ser |
| 23 Nov | 18 55.9 | +04 14 | 1.718 | 1.335 | 08:52 | 14:42 | 20:33 | 9.1 | Ser |
| 30 Nov | 19 06.3 | +04 27 | 1.931 | 1.457 | 08:35 | 14:25 | 20:15 | 9.7 | Aql |
| 07 Dec | 19 15.3 | +04 45 | 2.131 | 1.576 | 08:17 | 14:06 | 19:56 | 10.1 | Aql |
| 14 Dec | 19 23.4 | +05 06 | 2.319 | 1.692 | 07:59 | 13:47 | 19:35 | 10.5 | Aql |

## 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 (from the Earth) in au.

**R** Heliocentric distance (from the Sun) in au.

**Rise, Transit, Set** Times given are for mid-latitude Australia and will vary between locations. Where no rise or set time is given, the comet is circumpolar or below the northern horizon.

**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).

**Con** Constellation abbreviation (see p. 140 for full name).

The estimate of total magnitude is normally calculated using:

$$\text{Mag} = H1 + 5 \log(\Delta) + K1 \log R$$

See the table of elements (previous page) 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.

## 13P/Olbers

| Date | RA h m | Dec ° ' | Δ au | R au | Rise hh:mm | Transit hh:mm | Set hh:mm | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| 13 Jan | 02 55.4 | -12 05 | 2.190 | 2.603 | 12:48 | 19:22 | 02:01 | 12.9 | Eri |
| 20 Jan | 02 52.8 | -09 57 | 2.204 | 2.529 | 12:24 | 18:52 | 01:25 | 12.8 | Eri |
| 27 Jan | 02 51.6 | -07 43 | 2.222 | 2.455 | 12:01 | 18:24 | 00:50 | 12.6 | Eri |
| 03 Feb | 02 51.9 | -05 24 | 2.242 | 2.381 | 11:40 | 17:56 | 00:17 | 12.4 | Eri |
| 10 Feb | 02 53.4 | -03 01 | 2.262 | 2.307 | 11:21 | 17:31 | 23:40 | 12.2 | Eri |
| 17 Feb | 02 56.3 | -00 36 | 2.281 | 2.232 | 11:03 | 17:06 | 23:09 | 12.0 | Cet |
| 24 Feb | 03 00.4 | +01 52 | 2.298 | 2.158 | 10:46 | 16:43 | 22:39 | 11.8 | Cet |
| 02 Mar | 03 05.6 | +04 20 | 2.312 | 2.084 | 10:30 | 16:20 | 22:10 | 11.6 | Cet |
| 09 Mar | 03 12.0 | +06 50 | 2.323 | 2.010 | 10:16 | 15:59 | 21:42 | 11.4 | Cet |
| 16 Mar | 03 19.5 | +09 22 | 2.330 | 1.937 | 10:03 | 15:39 | 21:15 | 11.1 | Cet |
| 23 Mar | 03 28.1 | +11 54 | 2.332 | 1.864 | 09:51 | 15:20 | 20:49 | 10.9 | Tau |
| 30 Mar | 03 37.8 | +14 28 | 2.329 | 1.792 | 09:40 | 15:02 | 20:24 | 10.6 | Tau |
| 06 Apr | 03 48.7 | +17 02 | 2.322 | 1.722 | 09:31 | 14:46 | 20:00 | 10.4 | Tau |
| 13 Apr | 04 00.8 | +19 37 | 2.309 | 1.653 | 09:24 | 14:30 | 19:37 | 10.1 | Tau |
| 20 Apr | 04 14.2 | +22 13 | 2.291 | 1.585 | 09:18 | 14:16 | 19:15 | 9.8 | Tau |
| 27 Apr | 04 29.1 | +24 49 | 2.268 | 1.521 | 09:14 | 14:04 | 18:53 | 9.5 | Tau |
| 04 May | 04 45.5 | +27 24 | 2.240 | 1.459 | 09:11 | 13:53 | 18:33 | 9.2 | Tau |
| 11 May | 05 03.8 | +29 57 | 2.209 | 1.402 | 09:12 | 13:43 | 18:15 | 8.9 | Aur |
| 18 May | 05 24.1 | +32 26 | 2.174 | 1.349 | 09:14 | 13:36 | 17:58 | 8.6 | Aur |
| 25 May | 05 46.7 | +34 49 | 2.136 | 1.301 | 09:19 | 13:31 | 17:43 | 8.4 | Aur |
| 01 Jun | 06 11.9 | +37 02 | 2.097 | 1.260 | 09:27 | 13:29 | 17:31 | 8.1 | Aur |
| 08 Jun | 06 39.9 | +38 59 | 2.057 | 1.226 | 09:37 | 13:29 | 17:21 | 7.9 | Aur |
| 15 Jun | 07 10.8 | +40 35 | 2.018 | 1.200 | 09:49 | 13:33 | 17:17 | 7.7 | Aur |
| 22 Jun | 07 44.6 | +41 43 | 1.981 | 1.183 | 10:01 | 13:39 | 17:17 | 7.6 | Lyn |
| 29 Jun | 08 20.8 | +42 14 | 1.949 | 1.176 | 10:13 | 13:48 | 17:22 | 7.5 | Lyn |
| 06 Jul | 08 58.6 | +42 04 | 1.924 | 1.178 | 10:22 | 13:58 | 17:34 | 7.5 | Lyn |
| 13 Jul | 09 37.0 | +41 07 | 1.907 | 1.190 | 10:27 | 14:09 | 17:51 | 7.5 | Lyn |
| 20 Jul | 10 14.8 | +39 25 | 1.900 | 1.212 | 10:28 | 14:19 | 18:10 | 7.6 | LMi |
| 27 Jul | 10 50.9 | +37 01 | 1.905 | 1.241 | 10:24 | 14:27 | 18:31 | 7.8 | LMi |
| 03 Aug | 11 24.6 | +34 02 | 1.923 | 1.279 | 10:17 | 14:33 | 18:50 | 8.0 | UMa |
| 10 Aug | 11 55.7 | +30 39 | 1.955 | 1.324 | 10:06 | 14:37 | 19:07 | 8.3 | UMa |
| 17 Aug | 12 24.1 | +27 01 | 2.000 | 1.374 | 09:54 | 14:37 | 19:21 | 8.6 | Com |
| 24 Aug | 12 50.0 | +23 17 | 2.058 | 1.430 | 09:39 | 14:35 | 19:32 | 8.9 | Com |
| 31 Aug | 13 13.6 | +19 33 | 2.127 | 1.489 | 09:24 | 14:31 | 19:40 | 9.2 | Com |
| 07 Sep | 13 35.4 | +15 57 | 2.207 | 1.552 | 09:07 | 14:25 | 19:45 | 9.6 | Com |
| 14 Sep | 13 55.5 | +12 31 | 2.295 | 1.618 | 08:49 | 14:18 | 19:47 | 9.9 | Boo |
| 21 Sep | 14 14.1 | +09 17 | 2.391 | 1.686 | 08:32 | 14:09 | 19:47 | 10.3 | Boo |
| 28 Sep | 14 31.7 | +06 18 | 2.491 | 1.756 | 08:13 | 13:59 | 19:45 | 10.7 | Vir |
| 05 Oct | 14 48.2 | +03 32 | 2.595 | 1.827 | 07:55 | 13:48 | 19:41 | 11.0 | Vir |
| 12 Oct | 15 03.9 | +01 00 | 2.700 | 1.900 | 07:36 | 13:36 | 19:36 | 11.3 | Vir |
| 19 Oct | 15 18.8 | -01 18 | 2.806 | 1.973 | 07:17 | 13:23 | 19:30 | 11.7 | Ser |
| 26 Oct | 15 33.2 | -03 23 | 2.911 | 2.046 | 06:59 | 13:10 | 19:22 | 12.0 | Ser |
| 02 Nov | 15 46.9 | -05 17 | 3.014 | 2.120 | 06:40 | 12:56 | 19:13 | 12.3 | Lib |
| 09 Nov | 16 00.2 | -07 00 | 3.113 | 2.194 | 06:21 | 12:42 | 19:04 | 12.6 | Lib |
| 16 Nov | 16 13.0 | -08 33 | 3.207 | 2.269 | 06:02 | 12:27 | 18:53 | 12.9 | Sco |

## 333P/LINEAR

| Date | RA h m | Dec ° ' | Δ au | R au | Rise hh:mm | Transit hh:mm | Set hh:mm | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| 02 Nov | 10 53.6 | +04 56 | 1.373 | 1.176 | 02:14 | 08:03 | 13:52 | 12.6 | Leo |
| 09 Nov | 11 03.7 | +09 11 | 1.177 | 1.148 | 02:08 | 07:46 | 13:23 | 12.1 | Leo |
| 16 Nov | 11 17.1 | +15 14 | 0.980 | 1.128 | 02:10 | 07:32 | 12:52 | 11.5 | Leo |
| 23 Nov | 11 37.6 | +24 17 | 0.792 | 1.116 | 02:30 | 07:24 | 12:17 | 11.0 | Leo |
| 30 Nov | 12 14.6 | +38 07 | 0.636 | 1.113 | 03:32 | 07:33 | 11:31 | 10.4 | CVn |

## 12P/Pons-Brooks

| Date | RA h m | Dec ° ' | Δ au | R au | Rise hh:mm | Transit hh:mm | Set hh:mm | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| 06 Jan | 19 51.1 | +37 48 | 2.202 | 1.935 | 08:49 | 12:47 | 16:45 | 11.0 | Cyg |
| 13 Jan | 20 12.8 | +37 56 | 2.122 | 1.844 | 08:44 | 12:41 | 16:38 | 10.6 | Cyg |
| 20 Jan | 20 36.6 | +38 05 | 2.044 | 1.752 | 08:41 | 12:37 | 16:34 | 10.2 | Cyg |
| 27 Jan | 21 02.5 | +38 13 | 1.969 | 1.660 | 08:40 | 12:36 | 16:31 | 9.8 | Cyg |
| 03 Feb | 21 30.8 | +38 16 | 1.899 | 1.567 | 08:41 | 12:36 | 16:32 | 9.3 | Cyg |
| 10 Feb | 22 01.3 | +38 07 | 1.834 | 1.474 | 08:43 | 12:39 | 16:36 | 8.8 | Lac |
| 17 Feb | 22 33.9 | +37 41 | 1.776 | 1.381 | 08:46 | 12:44 | 16:43 | 8.4 | Lac |
| 24 Feb | 23 08.2 | +36 51 | 1.726 | 1.289 | 08:49 | 12:51 | 16:54 | 7.8 | And |
| 02 Mar | 23 43.5 | +35 31 | 1.685 | 1.199 | 08:50 | 12:59 | 17:08 | 7.3 | And |
| 09 Mar | 00 19.2 | +33 36 | 1.654 | 1.111 | 08:50 | 13:07 | 17:25 | 6.8 | And |
| 16 Mar | 00 54.4 | +31 04 | 1.633 | 1.028 | 08:47 | 13:15 | 17:43 | 6.2 | Psc |
| 23 Mar | 01 28.3 | +27 56 | 1.620 | 0.952 | 08:42 | 13:21 | 18:01 | 5.7 | Psc |
| 30 Mar | 02 00.4 | +24 14 | 1.613 | 0.885 | 08:33 | 13:26 | 18:19 | 5.2 | Ari |
| 06 Apr | 02 30.4 | +20 03 | 1.611 | 0.832 | 08:22 | 13:28 | 18:35 | 4.8 | Ari |
| 13 Apr | 02 58.2 | +15 29 | 1.610 | 0.796 | 08:09 | 13:28 | 18:49 | 4.6 | Ari |
| 20 Apr | 03 24.1 | +10 40 | 1.607 | 0.781 | 07:53 | 13:26 | 19:00 | 4.4 | Tau |
| 27 Apr | 03 48.4 | +05 42 | 1.600 | 0.789 | 07:36 | 13:23 | 19:11 | 4.5 | Tau |
| 04 May | 04 11.7 | +00 43 | 1.590 | 0.818 | 07:18 | 13:19 | 19:20 | 4.7 | Tau |
| 11 May | 04 34.7 | -04 15 | 1.577 | 0.866 | 07:00 | 13:14 | 19:29 | 5.1 | Eri |
| 18 May | 04 57.9 | -09 08 | 1.564 | 0.928 | 06:43 | 13:10 | 19:38 | 5.5 | Eri |
| 25 May | 05 22.0 | -13 56 | 1.552 | 1.002 | 06:25 | 13:06 | 19:48 | 6.0 | Lep |
| 01 Jun | 05 47.3 | -18 37 | 1.547 | 1.083 | 06:09 | 13:04 | 20:00 | 6.5 | Lep |
| 08 Jun | 06 14.2 | -23 09 | 1.550 | 1.169 | 05:54 | 13:03 | 20:14 | 7.0 | CMa |
| 15 Jun | 06 42.9 | -27 28 | 1.564 | 1.259 | 05:39 | 13:04 | 20:30 | 7.5 | CMa |
| 22 Jun | 07 13.3 | -31 27 | 1.592 | 1.350 | 05:26 | 13:07 | 20:49 | 8.0 | CMa |
| 29 Jun | 07 45.2 | -35 02 | 1.634 | 1.443 | 05:15 | 13:11 | 21:09 | 8.5 | Pup |
| 06 Jul | 08 18.2 | -38 08 | 1.692 | 1.536 | 05:05 | 13:17 | 21:30 | 8.9 | Pup |
| 13 Jul | 08 51.8 | -40 43 | 1.764 | 1.629 | 04:56 | 13:23 | 21:50 | 9.4 | Vel |
| 20 Jul | 09 25.3 | -42 46 | 1.851 | 1.721 | 04:49 | 13:29 | 22:09 | 9.9 | Vel |
| 27 Jul | 09 58.0 | -44 20 | 1.951 | 1.813 | 04:44 | 13:34 | 22:25 | 10.3 | Vel |
| 03 Aug | 10 29.4 | -45 29 | 2.063 | 1.905 | 04:39 | 13:38 | 22:37 | 10.8 | Vel |
| 10 Aug | 10 59.1 | -46 17 | 2.184 | 1.995 | 04:34 | 13:40 | 22:46 | 11.2 | Vel |
| 17 Aug | 11 27.0 | -46 50 | 2.313 | 2.085 | 04:30 | 13:40 | 22:50 | 11.6 | Cen |
| 24 Aug | 11 53.0 | -47 10 | 2.447 | 2.174 | 04:26 | 13:38 | 22:52 | 12.0 | Cen |
| 31 Aug | 12 17.1 | -47 22 | 2.586 | 2.262 | 04:20 | 13:35 | 22:50 | 12.4 | Cen |

## C/2022 L2 (ATLAS)

| Date | RA h m | Dec ° ' | Δ au | R au | Rise hh:mm | Transit hh:mm | Set hh:mm | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| 03 Feb | 15 24.5 | -24 55 | 2.745 | 2.722 | 23:11 | 06:31 | 13:46 | 13.0 | Lib |
| 10 Feb | 15 18.8 | -26 44 | 2.594 | 2.712 | 22:31 | 05:58 | 13:19 | 12.8 | Lib |
| 17 Feb | 15 10.7 | -28 40 | 2.444 | 2.704 | 21:48 | 05:23 | 12:51 | 12.7 | Lib |
| 24 Feb | 14 59.6 | -30 42 | 2.299 | 2.698 | 21:02 | 04:44 | 12:20 | 12.5 | Cen |
| 02 Mar | 14 44.9 | -32 47 | 2.165 | 2.694 | 20:11 | 04:02 | 11:47 | 12.4 | Cen |
| 09 Mar | 14 26.0 | -34 50 | 2.045 | 2.692 | 19:15 | 03:16 | 11:10 | 12.3 | Cen |
| 16 Mar | 14 02.4 | -36 41 | 1.944 | 2.692 | 18:15 | 02:25 | 10:28 | 12.2 | Cen |
| 23 Mar | 13 34.3 | -38 07 | 1.869 | 2.694 | 17:12 | 01:30 | 09:39 | 12.1 | Cen |
| 30 Mar | 13 02.5 | -38 55 | 1.824 | 2.699 | 16:09 | 00:31 | 08:45 | 12.0 | Cen |
| 06 Apr | 12 29.1 | -38 54 | 1.811 | 2.705 | 15:08 | 23:22 | 07:44 | 12.0 | Cen |
| 13 Apr | 11 56.5 | -38 05 | 1.832 | 2.713 | 14:13 | 22:22 | 06:40 | 12.1 | Cen |
| 20 Apr | 11 26.9 | -36 37 | 1.884 | 2.722 | 13:24 | 21:25 | 05:35 | 12.1 | Cen |
| 27 Apr | 11 01.6 | -34 45 | 1.965 | 2.734 | 12:40 | 20:33 | 04:34 | 12.2 | Hya |
| 04 May | 10 41.0 | -32 43 | 2.069 | 2.748 | 12:01 | 19:45 | 03:37 | 12.4 | Ant |
| 11 May | 10 24.7 | -30 44 | 2.190 | 2.764 | 11:26 | 19:02 | 02:44 | 12.5 | Ant |
| 18 May | 10 12.1 | -28 54 | 2.325 | 2.781 | 10:53 | 18:22 | 01:57 | 12.7 | Ant |
| 25 May | 10 02.6 | -27 18 | 2.468 | 2.800 | 10:22 | 17:45 | 01:14 | 12.8 | Ant |

## 144P/Kushida

| Date | RA | Dec | Δ | R | Rise | Transit | Set | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ' | au | au | hh:mm | hh:mm | hh:mm | | |
| 04 Nov '23 | 02 59.0 | +20 13 | 0.693 | 1.681 | 18:57 | 00:06 | 05:10 | 11.3 | Ari |
| 11 Nov '23 | 02 55.9 | +19 29 | 0.650 | 1.640 | 18:24 | 23:31 | 04:42 | 10.9 | Ari |
| 18 Nov '23 | 02 52.6 | +18 36 | 0.618 | 1.602 | 17:50 | 23:00 | 04:13 | 10.6 | Ari |
| 25 Nov '23 | 02 49.8 | +17 39 | 0.594 | 1.566 | 17:17 | 22:30 | 03:46 | 10.2 | Ari |
| 02 Dec '23 | 02 48.1 | +16 43 | 0.580 | 1.532 | 16:45 | 22:00 | 03:20 | 9.9 | Ari |
| 09 Dec '23 | 02 48.1 | +15 51 | 0.572 | 1.502 | 16:15 | 21:33 | 02:54 | 9.7 | Ari |
| 16 Dec '23 | 02 50.4 | +15 10 | 0.572 | 1.475 | 15:48 | 21:08 | 02:31 | 9.5 | Ari |
| 23 Dec '23 | 02 55.2 | +14 41 | 0.578 | 1.452 | 15:24 | 20:45 | 02:10 | 9.4 | Ari |
| 30 Dec '23 | 03 02.7 | +14 26 | 0.589 | 1.432 | 15:03 | 20:26 | 01:50 | 9.3 | Ari |
| 06 Jan | 03 12.7 | +14 24 | 0.603 | 1.417 | 14:46 | 20:08 | 01:33 | 9.2 | Ari |
| 13 Jan | 03 25.1 | +14 34 | 0.623 | 1.407 | 14:31 | 19:53 | 01:17 | 9.2 | Tau |
| 20 Jan | 03 39.8 | +14 53 | 0.645 | 1.400 | 14:19 | 19:40 | 01:03 | 9.2 | Tau |
| 27 Jan | 03 56.4 | +15 20 | 0.672 | 1.399 | 14:10 | 19:29 | 00:51 | 9.3 | Tau |
| 03 Feb | 04 14.6 | +15 49 | 0.703 | 1.402 | 14:02 | 19:20 | 00:40 | 9.4 | Tau |
| 10 Feb | 04 34.1 | +16 20 | 0.738 | 1.410 | 13:55 | 19:12 | 00:30 | 9.6 | Tau |
| 17 Feb | 04 54.7 | +16 48 | 0.778 | 1.423 | 13:49 | 19:05 | 00:22 | 9.8 | Tau |
| 24 Feb | 05 16.0 | +17 11 | 0.823 | 1.439 | 13:44 | 18:59 | 00:14 | 10.0 | Tau |
| 02 Mar | 05 37.6 | +17 27 | 0.873 | 1.460 | 13:39 | 18:53 | 00:08 | 10.3 | Tau |
| 09 Mar | 05 59.4 | +17 36 | 0.928 | 1.485 | 13:34 | 18:47 | 00:02 | 10.6 | Ori |
| 16 Mar | 06 21.2 | +17 36 | 0.989 | 1.513 | 13:28 | 18:41 | 23:55 | 11.0 | Gem |
| 23 Mar | 06 42.6 | +17 27 | 1.055 | 1.545 | 13:21 | 18:35 | 23:49 | 11.3 | Gem |
| 30 Mar | 07 03.7 | +17 09 | 1.127 | 1.579 | 13:14 | 18:29 | 23:44 | 11.7 | Gem |
| 06 Apr | 07 24.1 | +16 43 | 1.205 | 1.617 | 13:05 | 18:21 | 23:38 | 12.1 | Gem |
| 13 Apr | 07 44.0 | +16 09 | 1.287 | 1.656 | 12:56 | 18:14 | 23:32 | 12.5 | Gem |
| 20 Apr | 08 03.2 | +15 28 | 1.375 | 1.697 | 12:45 | 18:05 | 23:25 | 12.9 | Cnc |
| 27 Apr | 08 21.7 | +14 42 | 1.467 | 1.740 | 12:34 | 17:56 | 23:18 | 13.3 | Cnc |

## 62P/Tsuchinshan 1

| Date | RA | Dec | Δ | R | Rise | Transit | Set | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ' | au | au | hh:mm | hh:mm | hh:mm | | |
| 04 Nov '23 | 07 58.2 | +21 28 | 0.786 | 1.404 | 00:01 | 05:03 | 10:05 | 9.3 | Gem |
| 11 Nov '23 | 08 24.7 | +20 57 | 0.731 | 1.370 | 23:58 | 05:02 | 10:06 | 8.8 | Cnc |
| 18 Nov '23 | 08 51.9 | +20 14 | 0.683 | 1.341 | 23:55 | 05:02 | 10:07 | 8.3 | Cnc |
| 25 Nov '23 | 09 19.5 | +19 21 | 0.641 | 1.316 | 23:53 | 05:01 | 10:10 | 7.9 | Cnc |
| 02 Dec '23 | 09 46.9 | +18 18 | 0.607 | 1.295 | 23:49 | 05:01 | 10:13 | 7.6 | Leo |
| 09 Dec '23 | 10 13.8 | +17 07 | 0.579 | 1.280 | 23:45 | 05:01 | 10:16 | 7.3 | Leo |
| 16 Dec '23 | 10 39.7 | +15 53 | 0.556 | 1.270 | 23:39 | 04:59 | 10:18 | 7.1 | Leo |
| 23 Dec '23 | 11 03.9 | +14 38 | 0.538 | 1.265 | 23:32 | 04:56 | 10:18 | 7.0 | Leo |
| 30 Dec '23 | 11 26.2 | +13 27 | 0.525 | 1.266 | 23:23 | 04:50 | 10:16 | 6.9 | Leo |
| 06 Jan | 11 46.0 | +12 23 | 0.515 | 1.273 | 23:12 | 04:43 | 10:12 | 7.0 | Leo |
| 13 Jan | 12 03.1 | +11 29 | 0.507 | 1.285 | 22:59 | 04:32 | 10:04 | 7.1 | Vir |
| 20 Jan | 12 17.2 | +10 47 | 0.503 | 1.303 | 22:43 | 04:19 | 09:52 | 7.2 | Vir |
| 27 Jan | 12 28.2 | +10 17 | 0.500 | 1.325 | 22:25 | 04:02 | 09:37 | 7.5 | Vir |
| 03 Feb | 12 35.9 | +10 00 | 0.501 | 1.352 | 22:04 | 03:43 | 09:18 | 7.8 | Vir |
| 10 Feb | 12 40.2 | +09 55 | 0.504 | 1.383 | 21:41 | 03:19 | 08:55 | 8.1 | Vir |
| 17 Feb | 12 41.4 | +09 58 | 0.511 | 1.418 | 21:14 | 02:53 | 08:28 | 8.5 | Vir |
| 24 Feb | 12 39.8 | +10 06 | 0.523 | 1.456 | 20:45 | 02:24 | 07:59 | 8.9 | Vir |
| 02 Mar | 12 35.9 | +10 15 | 0.541 | 1.497 | 20:14 | 01:53 | 07:27 | 9.4 | Vir |
| 09 Mar | 12 30.5 | +10 21 | 0.567 | 1.540 | 19:42 | 01:20 | 06:54 | 9.9 | Vir |
| 16 Mar | 12 24.2 | +10 21 | 0.601 | 1.585 | 19:08 | 00:46 | 06:20 | 10.4 | Vir |
| 23 Mar | 12 18.1 | +10 11 | 0.644 | 1.632 | 18:34 | 00:13 | 05:47 | 11.0 | Vir |
| 30 Mar | 12 12.6 | +09 52 | 0.696 | 1.681 | 18:00 | 23:35 | 05:15 | 11.5 | Vir |
| 06 Apr | 12 08.3 | +09 23 | 0.757 | 1.730 | 17:27 | 23:03 | 04:44 | 12.1 | Vir |
| 13 Apr | 12 05.4 | +08 45 | 0.828 | 1.781 | 16:55 | 22:33 | 04:16 | 12.7 | Vir |
| 20 Apr | 12 04.1 | +08 01 | 0.907 | 1.832 | 16:24 | 22:04 | 03:49 | 13.3 | Vir |

## C/2021 S3 (PANSTARRS)

| Date | RA | Dec | Δ | R | Rise | Transit | Set | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ' | au | au | hh:mm | hh:mm | hh:mm | | |
| 04 Nov '23 | 11 34.2 | -37 36 | 2.542 | 1.979 | 00:30 | 08:39 | 16:48 | 11.3 | Cen |
| 11 Nov '23 | 11 55.4 | -38 28 | 2.463 | 1.910 | 00:19 | 08:32 | 16:46 | 11.1 | Cen |
| 18 Nov '23 | 12 17.4 | -39 10 | 2.384 | 1.842 | 00:10 | 08:27 | 16:45 | 10.9 | Cen |
| 25 Nov '23 | 12 40.2 | -39 42 | 2.304 | 1.776 | 00:02 | 08:22 | 16:43 | 10.7 | Cen |
| 02 Dec '23 | 13 03.7 | -40 01 | 2.224 | 1.712 | 23:55 | 08:18 | 16:40 | 10.5 | Cen |
| 09 Dec '23 | 13 27.9 | -40 03 | 2.144 | 1.651 | 23:52 | 08:15 | 16:37 | 10.3 | Cen |
| 16 Dec '23 | 13 52.7 | -39 47 | 2.063 | 1.594 | 23:51 | 08:12 | 16:33 | 10.1 | Cen |
| 23 Dec '23 | 14 17.8 | -39 09 | 1.982 | 1.540 | 23:52 | 08:10 | 16:27 | 9.9 | Cen |
| 30 Dec '23 | 14 43.2 | -38 06 | 1.901 | 1.490 | 23:56 | 08:07 | 16:19 | 9.7 | Cen |
| 06 Jan | 15 08.6 | -36 37 | 1.820 | 1.445 | 00:01 | 08:05 | 16:09 | 9.5 | Lup |
| 13 Jan | 15 33.8 | -34 38 | 1.740 | 1.406 | 00:08 | 08:03 | 15:57 | 9.3 | Lup |
| 20 Jan | 15 58.7 | -32 07 | 1.662 | 1.374 | 00:16 | 08:00 | 15:43 | 9.1 | Lup |
| 27 Jan | 16 23.1 | -29 01 | 1.587 | 1.348 | 00:25 | 07:57 | 15:27 | 9.0 | Sco |
| 03 Feb | 16 46.8 | -25 19 | 1.517 | 1.330 | 00:35 | 07:53 | 15:10 | 8.8 | Sco |
| 10 Feb | 17 09.8 | -21 01 | 1.453 | 1.320 | 00:45 | 07:48 | 14:51 | 8.7 | Oph |
| 17 Feb | 17 32.0 | -16 07 | 1.398 | 1.319 | 00:55 | 07:43 | 14:30 | 8.6 | Oph |
| 24 Feb | 17 53.3 | -10 40 | 1.353 | 1.326 | 01:04 | 07:37 | 14:08 | 8.6 | Ser |
| 02 Mar | 18 13.6 | -04 47 | 1.321 | 1.340 | 01:13 | 07:29 | 13:44 | 8.6 | Ser |
| 09 Mar | 18 32.9 | +01 25 | 1.302 | 1.363 | 01:22 | 07:21 | 13:19 | 8.6 | Ser |
| 16 Mar | 18 51.2 | +07 45 | 1.297 | 1.393 | 01:29 | 07:12 | 12:53 | 8.6 | Aql |
| 23 Mar | 19 08.3 | +14 03 | 1.306 | 1.430 | 01:37 | 07:01 | 12:24 | 8.7 | Aql |
| 30 Mar | 19 24.3 | +20 09 | 1.328 | 1.472 | 01:43 | 06:49 | 11:55 | 8.9 | Vul |
| 06 Apr | 19 39.0 | +25 55 | 1.361 | 1.520 | 01:49 | 06:37 | 11:23 | 9.0 | Vul |
| 13 Apr | 19 52.4 | +31 18 | 1.404 | 1.573 | 01:55 | 06:22 | 10:49 | 9.2 | Cyg |
| 20 Apr | 20 04.2 | +36 13 | 1.453 | 1.629 | 02:00 | 06:07 | 10:12 | 9.4 | Cyg |
| 27 Apr | 20 14.5 | +40 40 | 1.509 | 1.689 | 02:06 | 05:49 | 09:32 | 9.6 | Cyg |
| 04 May | 20 23.1 | +44 41 | 1.568 | 1.752 | 02:12 | 05:30 | 08:48 | 9.8 | Cyg |
| 11 May | 20 29.9 | +48 16 | 1.628 | 1.817 | 02:19 | 05:10 | 07:59 | 10.0 | Cyg |
| 18 May | 20 34.6 | +51 26 | 1.690 | 1.884 | 02:28 | 04:47 | 07:04 | 10.2 | Cyg |
| 25 May | 20 37.2 | +54 12 | 1.752 | 1.953 | 02:45 | 04:22 | 05:58 | 10.4 | Cyg |

## 154P/Brewington

| Date | RA | Dec | Δ | R | Rise | Transit | Set | Mag | Con |
|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ' | au | au | hh:mm | hh:mm | hh:mm | | |
| 06 Apr | 23 53.6 | +00 35 | 2.659 | 1.732 | 04:50 | 10:51 | 16:51 | 11.8 | Psc |
| 13 Apr | 00 10.5 | +03 14 | 2.611 | 1.700 | 04:47 | 10:40 | 16:33 | 11.5 | Psc |
| 20 Apr | 00 27.9 | +05 55 | 2.564 | 1.670 | 04:44 | 10:30 | 16:16 | 11.2 | Psc |
| 27 Apr | 00 45.7 | +08 39 | 2.519 | 1.643 | 04:42 | 10:20 | 15:59 | 11.0 | Psc |
| 04 May | 01 04.0 | +11 24 | 2.477 | 1.619 | 04:40 | 10:11 | 15:42 | 10.7 | Psc |
| 11 May | 01 22.8 | +14 08 | 2.438 | 1.599 | 04:39 | 10:02 | 15:25 | 10.5 | Psc |
| 18 May | 01 42.3 | +16 51 | 2.402 | 1.582 | 04:39 | 09:54 | 15:09 | 10.4 | Psc |
| 25 May | 02 02.3 | +19 29 | 2.370 | 1.569 | 04:39 | 09:47 | 14:54 | 10.2 | Ari |
| 01 Jun | 02 23.1 | +22 02 | 2.341 | 1.560 | 04:40 | 09:40 | 14:39 | 10.1 | Ari |
| 08 Jun | 02 44.5 | +24 28 | 2.317 | 1.554 | 04:42 | 09:34 | 14:25 | 10.1 | Ari |
| 15 Jun | 03 06.5 | +26 44 | 2.295 | 1.553 | 04:44 | 09:28 | 14:12 | 10.0 | Ari |
| 22 Jun | 03 29.2 | +28 48 | 2.278 | 1.556 | 04:47 | 09:23 | 13:59 | 10.0 | Ari |
| 29 Jun | 03 52.4 | +30 40 | 2.263 | 1.563 | 04:50 | 09:19 | 13:48 | 10.1 | Tau |
| 06 Jul | 04 16.0 | +32 18 | 2.251 | 1.574 | 04:52 | 09:15 | 13:38 | 10.2 | Per |
| 13 Jul | 04 39.9 | +33 40 | 2.242 | 1.588 | 04:54 | 09:11 | 13:28 | 10.3 | Aur |
| 20 Jul | 05 03.8 | +34 47 | 2.234 | 1.607 | 04:55 | 09:08 | 13:20 | 10.4 | Aur |
| 27 Jul | 05 27.6 | +35 38 | 2.228 | 1.628 | 04:56 | 09:04 | 13:12 | 10.6 | Aur |
| 03 Aug | 05 51.1 | +36 15 | 2.222 | 1.653 | 04:54 | 09:00 | 13:05 | 10.8 | Aur |
| 10 Aug | 06 14.0 | +36 37 | 2.216 | 1.682 | 04:51 | 08:55 | 12:59 | 11.0 | Aur |
| 17 Aug | 06 36.2 | +36 46 | 2.210 | 1.712 | 04:47 | 08:50 | 12:53 | 11.2 | Aur |
| 24 Aug | 06 57.6 | +36 44 | 2.203 | 1.746 | 04:40 | 08:44 | 12:47 | 11.5 | Aur |
| 31 Aug | 07 17.9 | +36 33 | 2.195 | 1.782 | 04:32 | 08:36 | 12:41 | 11.7 | Aur |
| 07 Sep | 07 37.1 | +36 13 | 2.184 | 1.820 | 04:22 | 08:28 | 12:34 | 12.0 | Lyn |
| 14 Sep | 07 55.2 | +35 48 | 2.171 | 1.860 | 04:11 | 08:18 | 12:26 | 12.3 | Lyn |
| 21 Sep | 08 12.0 | +35 19 | 2.156 | 1.901 | 03:58 | 08:08 | 12:18 | 12.5 | Lyn |
| 28 Sep | 08 27.5 | +34 48 | 2.137 | 1.944 | 03:43 | 07:56 | 12:08 | 12.8 | Lyn |

# 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—dwarf and minor planets (asteroids). There are now over a million such bodies catalogued. Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these 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 15 bright minor or dwarf planets at opposition in 2024. These include the most well-known four (Ceres, Pallas, Juno and Vesta) with the rest reaching magnitude 9.7 or brighter. As only 15 bright ones are considered here, Ceres is the only d.p. bright enough to qualify.

### 1 Ceres

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Apr 13 | 19 20.0 | -23 42 | 8.7 |
| 20 | 19 25.0 | -23 54 | 8.6 |
| 27 | 19 29.0 | -24 09 | 8.5 |
| May 4 | 19 31.9 | -24 27 | 8.4 |
| 11 | 19 33.5 | -24 49 | 8.3 |
| 18 | 19 34.0 | -25 15 | 8.2 |
| 25 | 19 33.1 | -25 45 | 8.1 |
| Jun 1 | 19 31.0 | -26 19 | 8.0 |
| 8 | 19 27.6 | -26 55 | 7.8 |
| 15 | 19 23.0 | -27 32 | 7.7 |
| 22 | 19 17.4 | -28 10 | 7.5 |
| 29 | 19 11.1 | -28 45 | 7.4 |
| Jul 6 | 19 04.4 | -29 18 | 7.3 |
| 13 | 18 57.6 | -29 47 | 7.4 |
| 20 | 18 51.1 | -30 10 | 7.6 |
| 27 | 18 45.3 | -30 29 | 7.7 |
| Aug 3 | 18 40.4 | -30 42 | 7.9 |
| 10 | 18 36.7 | -30 51 | 8.0 |
| 17 | 18 34.2 | -30 55 | 8.2 |
| 24 | 18 33.1 | -30 57 | 8.3 |
| 31 | 18 33.3 | -30 56 | 8.4 |
| Sep 7 | 18 34.9 | -30 53 | 8.6 |
| 14 | 18 37.6 | -30 47 | 8.7 |
| 21 | 18 41.5 | -30 40 | 8.8 |
| 28 | 18 46.4 | -30 31 | 8.9 |

### 2 Pallas

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Feb 24 | 16 29.9 | +07 58 | 9.5 |
| Mar 2 | 16 35.9 | +09 25 | 9.4 |
| 9 | 16 41.0 | +10 58 | 9.4 |
| 16 | 16 44.9 | +12 36 | 9.3 |
| 23 | 16 47.8 | +14 18 | 9.2 |
| 30 | 16 49.4 | +16 03 | 9.2 |
| Apr 6 | 16 49.8 | +17 48 | 9.1 |
| 13 | 16 49.0 | +19 31 | 9.1 |
| 20 | 16 46.9 | +21 08 | 9.0 |
| 27 | 16 43.7 | +22 38 | 9.0 |
| May 4 | 16 39.5 | +23 57 | 9.0 |
| 11 | 16 34.4 | +25 04 | 9.0 |
| 18 | 16 28.7 | +25 54 | 9.0 |
| 25 | 16 22.7 | +26 29 | 9.0 |
| Jun 1 | 16 16.7 | +26 46 | 9.1 |
| 8 | 16 11.0 | +26 46 | 9.2 |
| 15 | 16 05.9 | +26 30 | 9.2 |
| 22 | 16 01.5 | +25 60 | 9.3 |
| 29 | 15 58.0 | +25 17 | 9.4 |
| Jul 6 | 15 55.5 | +24 24 | 9.5 |
| 13 | 15 54.1 | +23 23 | 9.6 |
| 20 | 15 53.7 | +22 15 | 9.7 |
| 27 | 15 54.4 | +21 02 | 9.7 |
| Aug 3 | 15 56.0 | +19 47 | 9.8 |
| 10 | 15 58.6 | +18 29 | 9.9 |

### 3 Juno

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jan 6 | 11 19.3 | -01 47 | 9.5 |
| 13 | 11 20.3 | -01 38 | 9.4 |
| 20 | 11 20.1 | -01 18 | 9.3 |
| 27 | 11 18.7 | -00 47 | 9.2 |
| Feb 3 | 11 15.9 | -00 06 | 9.0 |
| 10 | 11 12.1 | +00 46 | 8.9 |
| 17 | 11 07.3 | +01 47 | 8.8 |
| 24 | 11 01.9 | +02 53 | 8.7 |
| Mar 2 | 10 56.2 | +04 04 | 8.6 |
| 9 | 10 50.6 | +05 14 | 8.7 |
| 16 | 10 45.2 | +06 22 | 8.9 |
| 23 | 10 40.6 | +07 25 | 9.1 |
| 30 | 10 36.9 | +08 20 | 9.2 |
| Apr 6 | 10 34.3 | +09 06 | 9.4 |
| 13 | 10 32.8 | +09 43 | 9.6 |
| 20 | 10 32.4 | +10 11 | 9.7 |
| 27 | 10 33.2 | +10 30 | 9.9 |
| May 4 | 10 35.0 | +10 41 | 10.0 |
| 11 | 10 37.8 | +10 43 | 10.1 |
| 18 | 10 41.5 | +10 39 | 10.3 |
| 25 | 10 45.9 | +10 28 | 10.4 |
| Jun 1 | 10 51.1 | +10 11 | 10.5 |
| 8 | 10 56.8 | +09 49 | 10.6 |
| 15 | 11 03.1 | +09 22 | 10.6 |
| 22 | 11 09.9 | +08 51 | 10.7 |

### 4 Vesta

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jan 6 | 05 40.5 | +21 12 | 6.7 |
| 13 | 05 34.2 | +21 30 | 6.9 |
| 20 | 05 29.0 | +21 47 | 7.0 |
| 27 | 05 25.4 | +22 05 | 7.2 |
| Feb 3 | 05 23.3 | +22 23 | 7.3 |
| 10 | 05 22.8 | +22 40 | 7.4 |
| 17 | 05 23.8 | +22 58 | 7.5 |
| 24 | 05 26.3 | +23 16 | 7.7 |
| Mar 2 | 05 30.2 | +23 33 | 7.8 |
| 9 | 05 35.3 | +23 50 | 7.9 |
| 16 | 05 41.5 | +24 05 | 8.0 |
| 23 | 05 48.7 | +24 19 | 8.0 |
| 30 | 05 56.7 | +24 30 | 8.1 |
| Apr 6 | 06 05.6 | +24 40 | 8.2 |
| 13 | 06 15.2 | +24 46 | 8.2 |
| 20 | 06 25.3 | +24 50 | 8.3 |
| 27 | 06 36.1 | +24 50 | 8.3 |
| May 4 | 06 47.2 | +24 47 | 8.3 |
| 11 | 06 58.8 | +24 40 | 8.3 |
| 18 | 07 10.7 | +24 29 | 8.4 |
| 25 | 07 22.8 | +24 14 | 8.4 |
| Jun 1 | 07 35.3 | +23 55 | 8.4 |
| 8 | 07 47.9 | +23 32 | 8.4 |
| 15 | 08 00.6 | +23 04 | 8.4 |
| 22 | 08 13.5 | +22 33 | 8.3 |

### 7 Iris

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| May 18 | 21 12.8 | -12 19 | 10.3 |
| 25 | 21 17.8 | -11 35 | 10.2 |
| Jun 1 | 21 21.8 | -10 54 | 10.0 |
| 8 | 21 24.7 | -10 16 | 9.9 |
| 15 | 21 26.4 | -09 42 | 9.7 |
| 22 | 21 26.8 | -09 13 | 9.5 |
| 29 | 21 25.9 | -08 49 | 9.3 |
| Jul 6 | 21 23.5 | -08 32 | 9.1 |
| 13 | 21 19.8 | -08 21 | 8.9 |
| 20 | 21 14.9 | -08 18 | 8.7 |
| 27 | 21 08.8 | -08 21 | 8.5 |
| Aug 3 | 21 02.1 | -08 31 | 8.3 |
| 10 | 20 54.9 | -08 47 | 8.3 |
| 17 | 20 47.9 | -09 06 | 8.4 |
| 24 | 20 41.4 | -09 28 | 8.5 |
| 31 | 20 36.0 | -09 51 | 8.6 |
| Sep 7 | 20 31.8 | -10 12 | 8.8 |
| 14 | 20 29.3 | -10 31 | 8.9 |
| 21 | 20 28.4 | -10 47 | 9.0 |
| 28 | 20 29.2 | -10 59 | 9.2 |
| Oct 5 | 20 31.7 | -11 05 | 9.3 |
| 12 | 20 35.7 | -11 06 | 9.4 |
| 19 | 20 41.2 | -11 01 | 9.5 |
| 26 | 20 48.0 | -10 50 | 9.6 |
| Nov 2 | 20 56.0 | -10 33 | 9.6 |

### 15 Eunomia

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jul 13 | 03 19.8 | +28 32 | 10.1 |
| 20 | 03 34.3 | +29 32 | 10.1 |
| 27 | 03 48.6 | +30 27 | 10.0 |
| Aug 3 | 04 02.7 | +31 17 | 10.0 |
| 10 | 04 16.6 | +32 02 | 9.9 |
| 17 | 04 30.1 | +32 42 | 9.9 |
| 24 | 04 43.1 | +33 18 | 9.8 |
| 31 | 04 55.5 | +33 49 | 9.8 |
| Sep 7 | 05 07.3 | +34 16 | 9.7 |
| 14 | 05 18.1 | +34 39 | 9.6 |
| 21 | 05 28.0 | +34 59 | 9.5 |
| 28 | 05 36.8 | +35 15 | 9.4 |
| Oct 5 | 05 44.2 | +35 29 | 9.3 |
| 12 | 05 50.1 | +35 40 | 9.2 |
| 19 | 05 54.4 | +35 49 | 9.1 |
| 26 | 05 56.8 | +35 55 | 9.0 |
| Nov 2 | 05 57.3 | +35 58 | 8.9 |
| 9 | 05 55.7 | +35 55 | 8.7 |
| 16 | 05 52.1 | +35 47 | 8.6 |
| 23 | 05 46.8 | +35 32 | 8.4 |
| 30 | 05 40.0 | +35 07 | 8.3 |
| Dec 7 | 05 32.2 | +34 33 | 8.2 |
| 14 | 05 24.1 | +33 49 | 8.1 |
| 21 | 05 16.3 | +32 58 | 8.2 |
| 28 | 05 09.3 | +32 01 | 8.4 |

### 16 Psyche

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| May 11 | 21 10.8 | -14 13 | 11.4 |
| 18 | 21 15.9 | -13 50 | 11.3 |
| 25 | 21 20.2 | -13 30 | 11.2 |
| Jun 1 | 21 23.5 | -13 15 | 11.1 |
| 8 | 21 25.9 | -13 05 | 11.0 |
| 15 | 21 27.2 | -12 60 | 10.8 |
| 22 | 21 27.3 | -13 01 | 10.7 |
| 29 | 21 26.4 | -13 08 | 10.5 |
| Jul 6 | 21 24.3 | -13 21 | 10.4 |
| 13 | 21 21.1 | -13 41 | 10.2 |
| 20 | 21 16.9 | -14 05 | 10.1 |
| 27 | 21 12.0 | -14 34 | 9.9 |
| Aug 3 | 21 06.5 | -15 05 | 9.7 |
| 10 | 21 00.8 | -15 38 | 9.7 |
| 17 | 20 55.3 | -16 10 | 9.8 |
| 24 | 20 50.2 | -16 40 | 10.0 |
| 31 | 20 45.8 | -17 07 | 10.1 |
| Sep 7 | 20 42.4 | -17 29 | 10.3 |
| 14 | 20 40.2 | -17 47 | 10.4 |
| 21 | 20 39.2 | -17 59 | 10.5 |
| 28 | 20 39.6 | -18 06 | 10.6 |
| Oct 5 | 20 41.2 | -18 08 | 10.8 |
| 12 | 20 44.1 | -18 04 | 10.9 |
| 19 | 20 48.1 | -17 55 | 11.0 |
| 26 | 20 53.2 | -17 41 | 11.0 |

### 19 Fortuna

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jul 13 | 01 08.8 | +08 34 | 11.8 |
| 20 | 01 17.4 | +09 26 | 11.7 |
| 27 | 01 25.3 | +10 12 | 11.6 |
| Aug 3 | 01 32.4 | +10 52 | 11.5 |
| 10 | 01 38.5 | +11 26 | 11.3 |
| 17 | 01 43.6 | +11 53 | 11.2 |
| 24 | 01 47.4 | +12 12 | 11.0 |
| 31 | 01 49.9 | +12 23 | 10.8 |
| Sep 7 | 01 50.8 | +12 24 | 10.7 |
| 14 | 01 50.2 | +12 17 | 10.5 |
| 21 | 01 48.1 | +11 60 | 10.3 |
| 28 | 01 44.5 | +11 33 | 10.1 |
| Oct 5 | 01 39.7 | +10 59 | 9.8 |
| 12 | 01 34.1 | +10 19 | 9.6 |
| 19 | 01 28.1 | +09 35 | 9.4 |
| 26 | 01 22.2 | +08 52 | 9.7 |
| Nov 2 | 01 17.0 | +08 12 | 9.9 |
| 9 | 01 12.8 | +07 39 | 10.1 |
| 16 | 01 10.1 | +07 14 | 10.3 |
| 23 | 01 08.8 | +06 59 | 10.5 |
| 30 | 01 09.1 | +06 55 | 10.7 |
| Dec 7 | 01 11.0 | +07 01 | 10.9 |
| 14 | 01 14.4 | +07 17 | 11.1 |
| 21 | 01 19.2 | +07 41 | 11.2 |
| 28 | 01 25.1 | +08 13 | 11.4 |

### 20 Massalia

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jul 6 | 00 31.9 | +04 01 | 11.3 |
| 13 | 00 37.3 | +04 35 | 11.2 |
| 20 | 00 41.8 | +05 04 | 11.1 |
| 27 | 00 45.3 | +05 27 | 11.0 |
| Aug 3 | 00 47.9 | +05 43 | 10.8 |
| 10 | 00 49.3 | +05 52 | 10.7 |
| 17 | 00 49.4 | +05 52 | 10.5 |
| 24 | 00 48.3 | +05 45 | 10.4 |
| 31 | 00 45.9 | +05 29 | 10.2 |
| Sep 7 | 00 42.2 | +05 04 | 10.0 |
| 14 | 00 37.4 | +04 32 | 9.8 |
| 21 | 00 31.7 | +03 54 | 9.6 |
| 28 | 00 25.4 | +03 12 | 9.4 |
| Oct 5 | 00 19.0 | +02 28 | 9.5 |
| 12 | 00 12.8 | +01 45 | 9.7 |
| 19 | 00 07.2 | +01 06 | 9.8 |
| 26 | 00 02.7 | +00 34 | 9.9 |
| Nov 2 | 23 59.4 | +00 09 | 10.1 |
| 9 | 23 57.5 | -00 06 | 10.2 |
| 16 | 23 57.0 | -00 12 | 10.4 |
| 23 | 23 57.9 | -00 08 | 10.5 |
| 30 | 00 00.3 | +00 05 | 10.6 |
| Dec 7 | 00 03.9 | +00 26 | 10.7 |
| 14 | 00 08.7 | +00 55 | 10.8 |
| 21 | 00 14.6 | +01 32 | 10.9 |

### 39 Laetitia

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jul 13 | 01 02.7 | +03 25 | 11.0 |
| 20 | 01 09.2 | +03 33 | 10.9 |
| 27 | 01 15.0 | +03 33 | 10.8 |
| Aug 3 | 01 19.8 | +03 24 | 10.7 |
| 10 | 01 23.6 | +03 07 | 10.6 |
| 17 | 01 26.3 | +02 40 | 10.4 |
| 24 | 01 27.8 | +02 05 | 10.3 |
| 31 | 01 28.1 | +01 21 | 10.2 |
| Sep 7 | 01 27.1 | +00 28 | 10.0 |
| 14 | 01 24.8 | -00 31 | 9.8 |
| 21 | 01 21.5 | -01 34 | 9.7 |
| 28 | 01 17.2 | -02 39 | 9.5 |
| Oct 5 | 01 12.3 | -03 44 | 9.4 |
| 12 | 01 07.2 | -04 43 | 9.5 |
| 19 | 01 02.1 | -05 35 | 9.6 |
| 26 | 00 57.5 | -06 16 | 9.8 |
| Nov 2 | 00 53.6 | -06 47 | 9.9 |
| 9 | 00 50.8 | -07 05 | 10.1 |
| 16 | 00 49.0 | -07 10 | 10.3 |
| 23 | 00 48.5 | -07 04 | 10.4 |
| 30 | 00 49.3 | -06 48 | 10.5 |
| Dec 7 | 00 51.2 | -06 22 | 10.7 |
| 14 | 00 54.2 | -05 48 | 10.8 |
| 21 | 00 58.4 | -05 07 | 10.9 |
| 28 | 01 03.4 | -04 20 | 11.0 |

### 40 Harmonia

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Apr 27 | 20 07.7 | -20 09 | 11.7 |
| May 4 | 20 15.0 | -19 58 | 11.5 |
| 11 | 20 21.1 | -19 50 | 11.4 |
| 18 | 20 26.2 | -19 47 | 11.3 |
| 25 | 20 29.9 | -19 49 | 11.1 |
| Jun 1 | 20 32.3 | -19 57 | 11.0 |
| 8 | 20 33.1 | -20 11 | 10.8 |
| 15 | 20 32.4 | -20 33 | 10.6 |
| 22 | 20 30.2 | -21 00 | 10.5 |
| 29 | 20 26.3 | -21 34 | 10.3 |
| Jul 6 | 20 21.1 | -22 11 | 10.1 |
| 13 | 20 14.8 | -22 51 | 9.9 |
| 20 | 20 07.7 | -23 30 | 9.6 |
| 27 | 20 00.5 | -24 06 | 9.8 |
| Aug 3 | 19 53.5 | -24 38 | 10.0 |
| 10 | 19 47.3 | -25 04 | 10.2 |
| 17 | 19 42.3 | -25 23 | 10.3 |
| 24 | 19 38.8 | -25 36 | 10.5 |
| 31 | 19 37.0 | -25 43 | 10.7 |
| Sep 7 | 19 37.0 | -25 44 | 10.8 |
| 14 | 19 38.6 | -25 40 | 11.0 |
| 21 | 19 41.9 | -25 31 | 11.1 |
| 28 | 19 46.6 | -25 17 | 11.3 |
| Oct 5 | 19 52.7 | -24 59 | 11.4 |
| 12 | 19 59.9 | -24 36 | 11.5 |

### 42 Isis

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Apr 6 | 18 21.9 | -20 26 | 11.7 |
| 13 | 18 29.8 | -20 38 | 11.6 |
| 20 | 18 36.8 | -20 51 | 11.4 |
| 27 | 18 42.8 | -21 07 | 11.3 |
| May 4 | 18 47.4 | -21 27 | 11.1 |
| 11 | 18 50.7 | -21 52 | 10.9 |
| 18 | 18 52.4 | -22 22 | 10.7 |
| 25 | 18 52.5 | -22 59 | 10.5 |
| Jun 1 | 18 50.9 | -23 42 | 10.2 |
| 8 | 18 47.7 | -24 30 | 10.0 |
| 15 | 18 42.8 | -25 22 | 9.8 |
| 22 | 18 36.8 | -26 15 | 9.5 |
| 29 | 18 29.9 | -27 09 | 9.3 |
| Jul 6 | 18 22.8 | -27 59 | 9.5 |
| 13 | 18 16.1 | -28 44 | 9.7 |
| 20 | 18 10.4 | -29 24 | 9.9 |
| 27 | 18 06.2 | -29 57 | 10.0 |
| Aug 3 | 18 03.8 | -30 23 | 10.2 |
| 10 | 18 03.4 | -30 45 | 10.3 |
| 17 | 18 05.1 | -31 01 | 10.5 |
| 24 | 18 08.8 | -31 13 | 10.6 |
| 31 | 18 14.4 | -31 20 | 10.8 |
| Sep 7 | 18 21.8 | -31 23 | 10.9 |
| 14 | 18 30.7 | -31 21 | 11.0 |
| 21 | 18 41.0 | -31 14 | 11.1 |

### 43 Ariadne

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Mar 9 | 16 24.7 | -24 52 | 11.8 |
| 16 | 16 34.5 | -25 13 | 11.6 |
| 23 | 16 43.3 | -25 30 | 11.5 |
| 30 | 16 50.9 | -25 42 | 11.3 |
| Apr 6 | 16 57.2 | -25 51 | 11.1 |
| 13 | 17 01.9 | -25 54 | 10.9 |
| 20 | 17 04.9 | -25 54 | 10.7 |
| 27 | 17 06.1 | -25 49 | 10.5 |
| May 4 | 17 05.4 | -25 39 | 10.3 |
| 11 | 17 02.7 | -25 23 | 10.0 |
| 18 | 16 58.4 | -25 02 | 9.8 |
| 25 | 16 52.6 | -24 36 | 9.5 |
| Jun 1 | 16 46.0 | -24 04 | 9.2 |
| 8 | 16 39.1 | -23 29 | 9.3 |
| 15 | 16 32.6 | -22 52 | 9.6 |
| 22 | 16 27.2 | -22 17 | 9.8 |
| 29 | 16 23.3 | -21 44 | 10.0 |
| Jul 6 | 16 21.1 | -21 17 | 10.2 |
| 13 | 16 20.9 | -20 56 | 10.4 |
| 20 | 16 22.6 | -20 42 | 10.5 |
| 27 | 16 26.2 | -20 34 | 10.7 |
| Aug 3 | 16 31.5 | -20 31 | 10.9 |
| 10 | 16 38.4 | -20 33 | 11.0 |
| 17 | 16 46.8 | -20 37 | 11.2 |
| 24 | 16 56.4 | -20 44 | 11.3 |

### 194 Prokne

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jun 8 | 22 23.4 | +03 11 | 11.7 |
| 15 | 22 31.8 | +03 36 | 11.6 |
| 22 | 22 39.3 | +03 51 | 11.4 |
| 29 | 22 45.9 | +03 54 | 11.3 |
| Jul 6 | 22 51.4 | +03 45 | 11.2 |
| 13 | 22 55.8 | +03 20 | 11.0 |
| 20 | 22 58.8 | +02 38 | 10.8 |
| 27 | 23 00.6 | +01 38 | 10.7 |
| Aug 3 | 23 01.0 | +00 19 | 10.5 |
| 10 | 23 00.0 | -01 18 | 10.3 |
| 17 | 22 57.9 | -03 11 | 10.1 |
| 24 | 22 54.8 | -05 17 | 9.9 |
| 31 | 22 51.2 | -07 30 | 9.6 |
| Sep 7 | 22 47.3 | -09 43 | 9.7 |
| 14 | 22 43.8 | -11 49 | 10.0 |
| 21 | 22 40.8 | -13 42 | 10.2 |
| 28 | 22 38.9 | -15 20 | 10.5 |
| Oct 5 | 22 38.2 | -16 39 | 10.7 |
| 12 | 22 38.9 | -17 39 | 10.9 |
| 19 | 22 41.0 | -18 21 | 11.1 |
| 26 | 22 44.4 | -18 45 | 11.3 |
| Nov 2 | 22 49.0 | -18 54 | 11.4 |
| 9 | 22 54.8 | -18 49 | 11.6 |
| 16 | 23 01.7 | -18 32 | 11.8 |
| 23 | 23 09.3 | -18 04 | 11.9 |

### 532 Herculina

| Date | RA hh mm | Dec ° ' | Mag |
|---|---|---|---|
| Jan 13 | 13 29.5 | +08 53 | 10.2 |
| 20 | 13 38.2 | +09 07 | 10.1 |
| 27 | 13 46.1 | +09 30 | 10.0 |
| Feb 3 | 13 53.0 | +10 03 | 9.9 |
| 10 | 13 58.7 | +10 44 | 9.8 |
| 17 | 14 03.3 | +11 34 | 9.7 |
| 24 | 14 06.5 | +12 32 | 9.5 |
| Mar 2 | 14 08.2 | +13 35 | 9.4 |
| 9 | 14 08.4 | +14 41 | 9.3 |
| 16 | 14 07.0 | +15 48 | 9.2 |
| 23 | 14 04.3 | +16 52 | 9.1 |
| 30 | 14 00.2 | +17 48 | 9.0 |
| Apr 6 | 13 55.2 | +18 34 | 9.0 |
| 13 | 13 49.6 | +19 05 | 9.0 |
| 20 | 13 43.7 | +19 19 | 9.1 |
| 27 | 13 38.1 | +19 16 | 9.1 |
| May 4 | 13 33.2 | +18 56 | 9.3 |
| 11 | 13 29.1 | +18 19 | 9.4 |
| 18 | 13 26.2 | +17 28 | 9.5 |
| 25 | 13 24.5 | +16 24 | 9.6 |
| Jun 1 | 13 24.1 | +15 11 | 9.8 |
| 8 | 13 24.9 | +13 49 | 9.9 |
| 15 | 13 27.0 | +12 22 | 10.0 |
| 22 | 13 30.2 | +10 51 | 10.1 |
| 29 | 13 34.4 | +09 16 | 10.2 |

# 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 RA | RADIANT Dec | VEL km/s | ZHR |
|---|---|---|---|---|---|---|---|
| Quadrantids (QUA) | LQ | Dec 28 – Jan 12 | Jan 04 | 230˚ | +49˚ | 41 | 80 |
| alpha-Centaurids (ACE) | NM | Jan 31 – Feb 20 | Feb 09 | 210˚ | –59˚ | 58 | 6 |
| gamma-Normids (GNO) | FQ | Feb 25 – Mar 28 | Mar 14 | 239˚ | –50˚ | 56 | 6 |
| Lyrids (LYR) | FM | Apr 14 – Apr 30 | Apr 22 | 271˚ | +34˚ | 49 | 18 |
| pi-Puppids (PPU)* | FM | Apr 15 – Apr 28 | Apr 23 | 110˚ | –45˚ | 18 | var |
| eta-Aquarids (ETA) | NM | Apr 19 – May 28 | May 06 | 338˚ | –01˚ | 66 | 50 |
| eta-Lyrids (ELY) | NM | May 03 – May 14 | May 10 | 287˚ | +44˚ | 43 | 3 |
| June Bootids (JBO)* | LQ | Jun 22 – Jul 02 | Jun 27 | 224˚ | +48˚ | 18 | var |
| Pisces Austrinids (PAU) | LQ | Jul 15 – Aug 10 | Jul 29 | 341˚ | –30˚ | 35 | 5 |
| Southern delta-Aquarids (SDA) | LQ | Jul 12 – Aug 23 | Jul 31 | 340˚ | –16˚ | 41 | 25 |
| alpha-Capricornids (CAP) | LQ | Jul 03 – Aug 15 | Jul 29 | 307˚ | –10˚ | 23 | 5 |
| Perseids (PER) | FQ | Jul 17 – Aug 24 | Aug 12 | 048˚ | +58˚ | 59 | 100 |
| kappa-Cygnids (KCG) | FM | Aug 03 – Aug 28 | Aug 17 | 286˚ | +59˚ | 25 | 3 |
| Aurigids (AUR) | NM | Aug 28 – Sep 05 | Aug 31 | 091˚ | +39˚ | 66 | 6 |
| September Perseids (SPE) | FQ | Sep 05 – Sep 21 | Sep 09 | 048˚ | +40˚ | 64 | 8 |
| Draconids (DRA)* | FQ | Oct 06 – Oct 10 | Oct 08 | 262˚ | +54˚ | 20 | 5 |
| Southern Taurids (STA) | NM | Sep 20 – Nov 20 | Nov 05 | 032˚ | +09˚ | 27 | 7 |
| delta-Aurigids (DAU) | FQ | Oct 10 – Oct 18 | Oct 11 | 084˚ | +44˚ | 64 | 2 |
| epsilon-Geminids (EGE) | FM | Oct 14 – Oct 27 | Oct 18 | 102˚ | +27˚ | 70 | 3 |
| Orionids (ORI) | FM | Oct 02 – Nov 07 | Oct 21 | 095˚ | +16˚ | 66 | 20 |
| Leo Minorids (LMI) | LQ | Oct 19 – Oct 27 | Oct 24 | 162˚ | +37˚ | 62 | 2 |
| Northern Taurids (NTA) | FQ | Oct 20 – Dec 10 | Nov 12 | 058˚ | +22˚ | 29 | 5 |
| Leonids (LEO) | FM | Nov 06 – Nov 30 | Nov 18 | 152˚ | +22˚ | 71 | 10 |
| alpha-Monocerotids (AMO) | LQ | Nov 15 – Nov 25 | Nov 21 | 117˚ | +01˚ | 65 | Var |
| Phoenicids (PHO) | NM | Nov 28 – Dec 09 | Dec 02 | 018˚ | –53˚ | 18 | Var |
| Puppid-Velids (PUP) | FQ | Dec 01 – Dec 15 | Dec 07 | 123˚ | –45˚ | 40 | 10 |
| Monocerotids (MON) | FQ | Dec 05 – Dec 20 | Dec 09 | 100˚ | +08˚ | 42 | 3 |
| sigma-Hydrids (HYD) | FQ | Dec 03 – Dec 20 | Dec 09 | 127˚ | +02˚ | 58 | 7 |
| Geminids (GEM) | FM | Dec 04 – Dec 20 | Dec 14 | 112˚ | +33˚ | 35 | 150 |
| Coma Berenicids (COM) | FM | Dec 05 – Dec 16 | Dec 16 | 175˚ | +18˚ | 65 | 3 |
| Dec. Leonis Minorids (DLM) | FM | Dec 05 – Feb 04 | Dec 19 | 161˚ | +30˚ | 64 | 5 |
| Ursids (URS) | LQ | 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 connected with 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 (sometimes obsolete) 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 geocentric 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** Zenithal 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 |
| Boötes | Boötis | 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 |
| 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 |
| 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 (next page)

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. 151). 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 | Abs | Spectral Type | Parallax | Distance pc | ly | Note (p. 140) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | Boötes | 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 | Absolute | Spect Type | Parallax " | Proper Motion "/yr | Distance pc | ly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -- | Sun | | | | | –26.72 | 4.85 | G2 V | | | | |
| 1 | Proxima Centauri | | Centaurus | 14 29.7 | –62 40 | 11.09 | 15.53 | M5.5 V | 0.7720 | 3.85 | 1.30 | 4.23 |
| | Alpha Centauri | A | Centaurus | 14 39.6 | –60 50 | –0.01 | 4.38 | G2 V | 0.7472 | 3.71 | 1.34 | 4.37 |
| | | B | | | | 1.34 | 5.71 | K0 V | | | | |
| 2 | Barnard's Star | | Ophiuchus | 17 57.8 | +04 41 | 9.53 | 13.22 | M4.0 V | 0.5470 | 10.36 | 1.83 | 5.96 |
| 3 | Wolf 359 | | Leo | 10 56.5 | +07 00 | 13.44 | 16.55 | M6.0 V | 0.4191 | 4.70 | 2.39 | 7.78 |
| 4 | Lalande 21185 | | Ursa Major | 11 03.3 | +35 58 | 7.47 | 10.44 | M2.0 V | 0.3934 | 4.80 | 2.54 | 8.29 |
| 5 | Sirius | A | Canis Major | 06 45.1 | –16 43 | –1.44 | 1.46 | A1 V | 0.3800 | 1.34 | 2.63 | 8.58 |
| | | B | | | | 8.44 | 11.34 | DA2 | | | | |
| 6 | L 726-8 (UV Ceti) | A | Cetus | 01 39.0 | –17 57 | 12.54 | 15.40 | M5.5 V | 0.3737 | 3.37 | 2.68 | 8.73 |
| | | B | | | | 12.99 | 15.85 | M6.0 V | | | | |
| 7 | Ross 154 | | Sagittarius | 18 49.8 | –23 50 | 10.43 | 13.07 | M3.5 V | 0.3369 | 0.67 | 2.97 | 9.68 |
| 8 | Ross 248 | | Andromeda | 23 41.9 | +44 10 | 12.29 | 14.79 | M5.5 V | 0.3160 | 1.62 | 3.16 | 10.32 |
| 9 | Epsilon Eridani | | Eridanus | 03 32.9 | –09 27 | 3.73 | 6.19 | K2 V | 0.3100 | 0.98 | 3.23 | 10.52 |
| 10 | Lacaille 9352 | | Piscis Austrinus | 23 05.9 | –35 51 | 7.34 | 9.75 | M1.5 V | 0.3036 | 6.90 | 3.29 | 10.74 |
| 11 | Ross 128 | | Virgo | 11 47.7 | +00 48 | 11.13 | 13.51 | M4.0 V | 0.2987 | 1.36 | 3.35 | 10.92 |
| 12 | L 789-6 (EZ Aquarii) | A | Aquarius | 22 38.6 | –15 18 | 13.33 | 15.64 | M5.0 V | 0.2895 | 3.25 | 3.45 | 11.27 |
| | | B | | | | 13.27 | 15.58 | M | | | | |
| | | C | | | | 14.03 | 16.34 | M | | | | |
| 13 | Procyon | A | Canis Minor | 07 39.3 | +05 14 | 0.38 | 2.66 | F5 IV–V | 0.2861 | 1.26 | 3.50 | 11.40 |
| | | B | | | | 10.70 | 12.98 | DA | | | | |
| 14 | 61 Cygni | A | Cygnus | 21 06.9 | +38 45 | 5.21 | 7.49 | K5.0 V | 0.2860 | 5.28 | 3.50 | 11.40 |
| | | B | | | | 6.03 | 8.31 | K7.0 V | | | | |
| 15 | Σ 2398 | A | Draco | 18 42.8 | +59 38 | 8.90 | 11.16 | M3.0 V | 0.2830 | 2.24 | 3.53 | 11.53 |
| | | B | | | | 9.69 | 11.95 | M3.5 V | | | | |
| 16 | Groombridge 34 | A | Andromeda | 00 18.4 | +44 01 | 8.08 | 10.32 | M1.5 V | 0.2806 | 2.92 | 3.56 | 11.63 |
| | | B | | | | 11.06 | 13.30 | M3.5 V | | | | |
| 17 | Epsilon Indi | | Indus | 22 03.4 | –56 47 | 4.69 | 6.89 | K5 Ve | 0.2758 | 4.70 | 3.63 | 11.83 |
| 18 | DX Cancri | | Cancer | 08 29.8 | +26 47 | 14.78 | 16.98 | M6.5 V | 0.2758 | 1.29 | 3.63 | 11.83 |
| 19 | Tau Ceti | | Cetus | 01 44.1 | –15 56 | 3.49 | 5.68 | G8 Vp | 0.2744 | 1.92 | 3.64 | 11.89 |
| 20 | GJ 1061 | | Horologium | 03 36.0 | –44 31 | 13.03 | 15.21 | M5.5 V | 0.2720 | 0.81 | 3.68 | 11.99 |
| 21 | YZ Ceti | | Cetus | 01 12.5 | –17 00 | 12.02 | 14.17 | M4.5 V | 0.2688 | 1.37 | 3.72 | 12.13 |
| 22 | Luyten's Star | | Canis Minor | 07 27.4 | +05 14 | 9.86 | 11.97 | M3.5 V | 0.2638 | 3.74 | 3.79 | 12.37 |

# DEEP SKY OBJECTS

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 55 | 1 | G | Scl | 7.9 | 32' × 6' | 00 14.9 | –39 11 | 10 | | A bright galaxy in the Sculptor Group |
| NGC 104 | 2 | GC | Tuc | 4.0 | 43' | 00 24.1 | –72 05 | 10 | 1 | 47 Tucanae |
| NGC 205 | | G | And | 8.1 | 22' × 11' | 00 40.4 | +41 41 | 10 | 3,9 | M110 |
| NGC 221 | | G | And | 8.1 | 9' × 7' | 00 42.7 | +40 52 | 10 | 3,9 | M32 |
| NGC 224 | | G | And | 3.4 | 3.2° × 1.0° | 00 42.7 | +41 16 | 10 | 3,9 | M31, Andromeda Galaxy |
| NGC 247 | 3 | G | Cet | 9.2 | 21' × 7' | 00 47.1 | –20 46 | 10 | | |
| NGC 253 | 4 | G | Scl | 7.2 | 28' × 7' | 00 47.6 | –25 18 | 10 | | Silver Coin galaxy. Large, bright edge-on spiral |
| SMC | | G | Tuc | 2.3 | 6.6° × 3.7° | 00 52.6 | –72 48 | 10 | 1 | Small Magellanic Cloud |
| NGC 288 | 5 | GC | Scl | 8.1 | 14' | 00 52.8 | –26 35 | 10 | | Near galaxy NGC 253 |
| NGC 300 | 6 | G | Scl | 8.3 | 22' × 16' | 00 54.9 | –37 41 | 10 | | |
| NGC 346 | | BN | Tuc | 10.3 | 14' × 11' | 00 59.1 | –72 11 | 10 | | Nebula in the SMC |
| NGC 362 | 7 | GC | Tuc | 6.8 | 13' | 01 03.2 | –70 51 | 11 | 1 | |
| NGC 598 | | G | Tri | 5.7 | 71' × 42' | 01 33.9 | +30 39 | 11 | 3 | M33, Triangulum Galaxy |
| NGC 613 | 8 | G | Scl | 10.1 | 6' × 4' | 01 34.3 | –29 25 | 11 | | |
| NGC 628 | | G | Psc | 9.4 | 11' × 10' | 01 36.7 | +15 47 | 11 | 3 | M74 |
| NGC 891 | | G | And | 9.9 | 14' × 3' | 02 22.6 | +42 21 | 11 | | |
| NGC 1039 | | OC | Per | 5.2 | 35' | 02 42.1 | +42 47 | 11 | 3 | M34 |
| NGC 1068 | 9 | G | Cet | 8.9 | 7' × 6' | 02 42.7 | –00 01 | 11 | 2 | M77, Cetus A |
| NGC 1097 | 10 | G | For | 9.5 | 9' × 6' | 02 46.3 | –30 17 | 11 | | |
| NGC 1232 | 10a | G | Eri | 10.1 | 7' × 7' | 03 09.8 | –20 35 | 12 | | |
| NGC 1261 | 11 | GC | Hor | 8.4 | 7' | 03 12.3 | –55 13 | 12 | | |
| NGC 1269 | | G | Eri | 8.5 | 11' × 10' | 03 17.3 | –41 06 | 12 | | |
| NGC 1291 | 12 | G | Eri | 8.6 | 10' × 8' | 03 17.3 | –41 08 | 12 | | |
| NGC 1313 | 13 | G | Ret | 8.7 | 9' × 7' | 03 18.3 | –66 30 | 12 | | |
| NGC 1316 | 14 | G | For | 8.5 | 12' × 9' | 03 22.7 | –37 13 | 12 | | |
| NGC 1350 | 14a | G | For | 10.7 | 5' × 3' | 03 31.1 | –33 38 | 12 | | |
| NGC 1360 | 15 | PN | For | 9.4 | 11' × 8' | 03 33.2 | –25 52 | 12 | | |
| NGC 1365 | 16 | G | For | 9.6 | 11' × 6' | 03 33.6 | –36 08 | 12 | | |
| NGC 1380 | 17 | G | For | 10.2 | 5' × 2' | 03 36.5 | –34 59 | 12 | | |
| NGC 1387 | 18 | G | For | 10.9 | 3' × 3' | 03 37.0 | –35 31 | 12 | | |
| NGC 1399 | 19 | G | For | 9.6 | 7' × 7' | 03 38.5 | –35 27 | 12 | | In Fornax galaxy group |
| NGC 1398 | 19a | G | For | 9.8 | 7' × 5' | 03 38.9 | –26 20 | 12 | | |
| NGC 1404 | 20 | G | Eri | 10.2 | 3' × 3' | 03 38.9 | –35 35 | 12 | | |
| NGC 1433 | 21 | G | Hor | 10.1 | 7' × 6' | 03 42.0 | –47 13 | 12 | | |
| Pleiades | | OC | Tau | 1.2 | 2° | 03 47.0 | +24 07 | 12 | 3 | M45, Contains Merope Nebula |
| NGC 1512 | 21a | G | Hor | 10.6 | 9' × 6' | 04 03.9 | –43 21 | 12 | | |
| NGC 1532 | | G | Eri | 9.9 | 11' × 3' | 04 12.1 | –32 52 | 12 | | |
| NGC 1535 | 22 | PN | Eri | 9.4 | 48" × 42" | 04 14.3 | –12 44 | 12 | | |
| NGC 1549 | 23 | G | Dor | 9.7 | 5' × 4' | 04 15.7 | –55 36 | 12 | | |
| NGC 1553 | 24 | G | Dor | 9.4 | 5' × 3' | 04 16.2 | –55 47 | 12 | | Near galaxy NGC 1549 |
| NGC 1566 | 25 | G | Dor | 9.7 | 7' × 5' | 04 20.0 | –54 56 | 12 | | |
| NGC 1617 | 25a | G | Dor | 10.7 | 4' × 2' | 04 31.7 | –54 36 | 12 | | |
| NGC 1672 | 26 | G | Dor | 10.2 | 7' × 6' | 04 45.7 | –59 15 | 12 | | |
| NGC 1763 | 27 | BN | Dor | | 25' × 20' | 04 56.8 | –66 24 | 12 | | |
| NGC 1783 | 28 | GC | Dor | 10.9 | 3' | 04 58.9 | –66 00 | 12 | | Part of LMC |
| NGC 1818 | 30 | OC | Dor | 9.7 | 3' | 05 04.2 | –66 24 | 1 | | |
| NGC 1792 | 29 | G | Col | 10.2 | 5' × 3' | 05 05.2 | –37 59 | 1 | | |
| NGC 1808 | 31 | G | Col | 9.9 | 7' × 4' | 05 07.7 | –37 31 | 1 | | Near galaxy NGC 1792 |

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 1866 | 33 | OC | Dor | 9.7 | 5' | 05 13.5 | –65 28 | 1 | | |
| NGC 1851 | 32 | GC | Col | 7.1 | 11' | 05 14.1 | –40 03 | 1 | | |
| LMC | | G | Dor | 0.4 | 10.8° × 9.2° | 05 23.6 | –69 45 | 1 | 1 | Large Magellanic Cloud |
| NGC 1904 | 34 | GC | Lep | 7.7 | 9' | 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 | 6' × 4' | 05 34.5 | +22 01 | 1 | 5,3 | M1, Crab Nebula |
| NGC 1976 | | BN | Ori | 4.0 | 90' × 60' | 05 35.3 | –05 23 | 1 | 2 | M42, Orion Nebula |
| NGC 1982 | | BN | Ori | 7.0 | 20' × 15' | 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 | 35 | BN | Dor | 8.3 | 40' × 25' | 05 38.6 | –69 06 | 1 | 1 | Tarantula Nebula |
| NGC 2068 | | BN | Ori | 8.0 | 8' × 6' | 05 46.8 | +00 05 | 1 | 2,3 | M78, Brightest and largest in group of four nebulae |
| NGC 2099 | | OC | Aur | 5.6 | 23' | 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' × 30' | 06 09.4 | +20 40 | 1 | | Near open cluster M35 |
| NGC 2214 | 36 | OC | Dor | 10.9 | 4' | 06 12.8 | –68 16 | 1 | | Edge of LMC |
| NGC 2243 | 36a | OC | CMa | 9.4 | 5' | 06 29.8 | –31 17 | 1 | | |
| NGC 2237 | | BN | Mon | 5.5 | 90' × 90' | 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 2298 | 37 | GC | Pup | 9.3 | 7' | 06 49.0 | –36 00 | 1 | | |
| 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" × 43" | 07 29.2 | +20 55 | 2 | | Eskimo Nebula |
| NGC 2422 | | OC | Pup | 4.4 | 29' | 07 36.6 | –14 29 | 2 | 4 | M47, Large coarse cluster with 30 stars |
| NGC 2438 | | PN | Pup | 11.0 | 73" × 68" | 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 | 74" × 42" | 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 | 37a | BN | Pup | 7.1 | 15' | 07 52.5 | –26 26 | 2 | | Near open cluster M93 |
| NGC 2489 | 38 | OC | Pup | 7.9 | 8' | 07 56.2 | –30 04 | 2 | | |
| NGC 2516 | | OC | Car | 3.8 | 29' | 07 58.1 | –60 45 | 2 | 1 | 80 stars 6th magnitude 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 2506 | 39 | OC | Mon | 7.6 | 8' | 08 12.0 | –10 47 | 2 | | Caldwell 54 |
| 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 2627 | 40 | OC | Pyx | 8.4 | 11' | 08 37.3 | –29 57 | 2 | | |
| NGC 2632 | | OC | Cnc | 3.1 | 95' | 08 40.0 | +19 40 | 2 | 5 | M44, Beehive Cluster |
| NGC 2671 | 40a | OC | Vel | 11.6 | 4' | 08 46.2 | –41 53 | 2 | | |
| NGC 2682 | | OC | Cnc | 6.9 | 29' | 08 51.4 | +11 49 | 2 | 5 | M67, 200 stars magnitude 10 to 15, large and rich |

See page 144 for legend.

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 2808 | 41 | GC | Car | 6.3 | 14' | 09 12.0 | –64 52 | 3 | 1 | Large and rich, compressed centre, magnitude 13 to 15 |
| NGC 2903 | | G | Leo | 9.0 | 13' × 6' | 09 32.2 | +21 30 | 3 | | |
| NGC 2972 | 41a | OC | Vel | 9.9 | 4' | 09 40.3 | –50 20 | 3 | | |
| NGC 2997 | 41b | G | Ant | 9.4 | 9' × 7' | 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 | 42 | G | Sex | 8.9 | 7' × 3' | 10 05.2 | –07 43 | 3 | | |
| NGC 3132 | 43 | PN | Vel | 8.2 | 84" × 53" | 10 07.0 | –40 26 | 3 | 4 | Eight-burst Nebula |
| NGC 3201 | 44 | GC | Vel | 6.8 | 18' | 10 17.6 | –46 25 | 3 | 4 | |
| NGC 3242 | 45 | PN | Hya | 8.6 | 45" × 36" | 10 24.8 | –18 39 | 3 | | Ghost of Jupiter |
| NGC 3293 | | OC | Car | 4.7 | 6' | 10 35.8 | –58 13 | 3 | 1 | |
| NGC 3351 | | G | Leo | 9.7 | 7' × 5' | 10 44.0 | +11 42 | 3 | 5 | M95 |
| NGC 3372 | | BN | Car | 3.0 | 120' × 120' | 10 45.1 | –59 52 | 3 | 1 | Eta Carinae |
| NGC 3368 | | G | Leo | 9.3 | 8' × 5' | 10 46.8 | +11 49 | 3 | 5 | M96 |
| NGC 3379 | | G | Leo | 9.3 | 5' × 5' | 10 47.8 | +12 35 | 3 | 5 | M105, in group of three galaxies |
| NGC 3532 | | OC | Car | 3.0 | 55' × 50' | 11 05.2 | –58 44 | 4 | 1 | Rich and large, 150 stars magnitude 7 to 12 |
| NGC 3521 | | G | Leo | 9.0 | 11' × 5' | 11 05.8 | –00 02 | 4 | | |
| NGC 3621 | 46 | G | Hya | 9.2 | 12' × 7' | 11 18.3 | –32 49 | 4 | | |
| NGC 3623 | | G | Leo | 9.3 | 10' × 3' | 11 18.9 | +13 05 | 4 | 5 | M65 |
| | 47 | OC | Car | 8.5 | 5' | 11 19.7 | –63 30 | 4 | | Melotte 105 |
| NGC 3627 | | G | Leo | 8.9 | 9' × 4' | 11 20.2 | +13 00 | 4 | 5 | M66 |
| NGC 3628 | | G | Leo | 9.5 | 15' × 3' | 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 | 1.2° × 0.8° | 11 39.4 | –63 28 | 4 | | Running Chicken Nebula |
| NGC 3918 | | PN | Cen | 8.4 | 13" | 11 50.3 | –57 11 | 4 | | |
| NGC 3960 | 48 | OC | Cen | 8.3 | 6' | 11 50.9 | –55 41 | 4 | | |
| NGC 3923 | 49 | G | Hya | 10 | 6' × 4' | 11 51.0 | –28 48 | 4 | | |
| NGC 4192 | | G | Com | 10.1 | 10' × 3' | 12 13.8 | +14 54 | 4 | 7 | M98 |
| NGC 4216 | | G | Vir | 10.0 | 8' × 2' | 12 15.9 | +13 09 | 4 | | Edge-on galaxy |
| NGC 4254 | | G | Com | 9.9 | 5' × 5' | 12 18.8 | +14 25 | 4 | 7 | M99 |
| NGC 4258 | | G | CVn | 8.4 | 19' × 7' | 12 19.0 | +47 18 | 4 | 5,7 | M106 |
| NGC 4303 | | G | Vir | 9.6 | 7' × 6' | 12 21.9 | +04 28 | 4 | 6,7 | M61 |
| NGC 4321 | | G | Com | 9.4 | 7' × 6' | 12 22.9 | +15 49 | 4 | 7 | M100 |
| NGC 4361 | | PN | Crv | 10.9 | 2' × 2' | 12 24.5 | –18 47 | 4 | | |
| NGC 4374 | | G | Vir | 9.1 | 7' × 6' | 12 25.1 | +12 53 | 4 | 7 | M84, Bright centre, in same field as M86 |
| NGC 4382 | | G | Com | 9.1 | 7' × 6' | 12 25.4 | +18 11 | 4 | 7 | M85 |
| NGC 4372 | 50 | GC | Mus | 7.2 | 19' | 12 25.8 | –72 40 | 4 | | Caldwell 108 |
| NGC 4406 | | G | Vir | 8.9 | 9' × 6' | 12 26.2 | +12 57 | 4 | 7 | M86 |
| NGC 4472 | | G | Vir | 8.4 | 10' × 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 | 7' × 4' | 12 32.0 | +14 25 | 4 | 7 | M88 |
| NGC 4548 | | G | Com | 10.1 | 5' × 4' | 12 35.4 | +14 30 | 4 | 7 | M91 |
| NGC 4552 | | G | Vir | 9.8 | 5' × 5' | 12 35.7 | +12 33 | 4 | 7 | M89 |
| NGC 4565 | | G | Com | 9.6 | 16' × 2' | 12 36.3 | +25 59 | 4 | | |
| NGC 4569 | | G | Vir | 9.5 | 10' × 4' | 12 36.8 | +13 10 | 4 | 7 | M90 |
| NGC 4579 | | G | Vir | 9.7 | 6' × 5' | 12 37.7 | +11 49 | 4 | 7 | M58, Bright diffuse nucleus, dark lanes |
| NGC 4590 | 51 | GC | Hya | 7.3 | 12' | 12 39.5 | –26 45 | 4 | 6 | M68, Rich and compressed |
| NGC 4594 | 52 | G | Vir | 8.0 | 9' × 4' | 12 40.0 | –11 37 | 4 | 6 | M104, Sombrero Galaxy |
| NGC 4621 | | G | Vir | 9.6 | 5' × 4' | 12 42.0 | +11 39 | 4 | 7 | M59 |
| NGC 4631 | | G | CVn | 9.2 | 16' × 3' | 12 42.1 | +32 32 | 4 | | Whale Galaxy |
| NGC 4649 | | G | Vir | 8.8 | 7' × 6' | 12 43.7 | +11 33 | 4 | 7 | M60 |

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 4697 | 53 | G | Vir | 9.2 | 7' × 5' | 12 48.6 | –05 48 | 4 | | Caldwell 52 |
| NGC 4699 | 54 | G | Vir | 10.2 | 4' × 3' | 12 49.0 | –08 40 | 4 | | |
| NGC 4736 | | G | CVn | 8.2 | 11' × 9' | 12 50.9 | +41 07 | 4 | 5,7 | M94 |
| NGC 4753 | 55 | G | Vir | 10.5 | 6' × 3' | 12 52.4 | –01 12 | 4 | | |
| NGC 4755 | | OC | Cru | 4.2 | 10' | 12 53.6 | –60 21 | 4 | 1 | Jewel Box |
| NGC 4826 | | G | Com | 8.5 | 10' × 5' | 12 56.7 | +21 41 | 4 | 7 | M64, Black Eye Galaxy |
| NGC 4833 | 56 | GC | Mus | 8.4 | 14' | 12 59.6 | –70 52 | 4 | | Near globular cluster NGC 4372 |
| NGC 4945 | 57 | G | Cen | 8.6 | 20' × 4' | 13 05.4 | –49 28 | 5 | 6 | Big edge-on spiral, small galaxy in same field |
| NGC 4976 | 58 | G | Cen | 10.2 | 6' × 3' | 13 08.6 | –49 30 | 5 | | |
| NGC 5024 | | GC | Com | 7.7 | 13' | 13 12.9 | +18 10 | 5 | 7 | M53, Bright centre region, very compressed |
| NGC 5055 | | G | CVn | 8.6 | 13' × 7' | 13 15.8 | +42 02 | 5 | 5,7 | M63, Sunflower Galaxy |
| NGC 5061 | 59 | G | Hya | 10.5 | 4' × 3' | 13 18.1 | –26 50 | 5 | | |
| NGC 5068 | 59a | G | Vir | 9.8 | 7' × 6' | 13 18.9 | –21 02 | 5 | | |
| NGC 5128 | 60 | G | Cen | 6.8 | 26' × 20' | 13 25.5 | –43 01 | 5 | | Centaurus A (radio source) |
| NGC 5139 | 61 | GC | Cen | 3.9 | 36' | 13 26.8 | –47 29 | 5 | 6 | Omega Centauri |
| NGC 5194 | | G | CVn | 8.4 | 11' × 8' | 13 29.9 | +47 12 | 5 | 7 | M51, Whirlpool Galaxy |
| NGC 5189 | 62 | PN | Mus | 10.3 | 140" | 13 33.5 | –65 58 | 5 | 1 | Dunlop's best planetary nebula |
| NGC 5236 | 63 | G | Hya | 7.5 | 15' × 13' | 13 37.0 | –29 52 | 5 | 6 | M83, Southern Pinwheel Galaxy |
| NGC 5253 | 63a | G | Cen | 10.7 | 5' × 2' | 13 39.9 | –31 39 | 5 | | |
| NGC 5272 | | GC | CVn | 6.3 | 18' | 13 42.2 | +28 23 | 5 | 7 | M3, Large bright globular, brightens suddenly towards the middle |
| NGC 5286 | 64 | GC | Cen | 7.4 | 9' | 13 46.4 | –51 22 | 5 | | |
| IC 4406 | | PN | Lup | 11.0 | 2' × 2' | 14 22.4 | –44 09 | 5 | | Retina Nebula |
| NGC 5634 | 66 | GC | Vir | 9.5 | 5' | 14 29.6 | –05 59 | 5 | | |
| NGC 5617 | 65 | OC | Cen | 6.3 | 10' | 14 29.8 | –60 43 | 5 | | |
| NGC 5824 | 67 | GC | Lup | 9.1 | 6' | 15 04.0 | –33 04 | 6 | | |
| NGC 5897 | 68 | GC | Lib | 8.4 | 13' | 15 17.4 | –21 01 | 6 | | |
| NGC 5904 | | GC | Ser | 5.7 | 23' | 15 18.6 | +02 05 | 6 | 6 | M5, Bright, large very compressed in middle, slightly oval in shape |
| NGC 5927 | 69 | GC | Lup | 8 | 6' | 15 28.0 | –50 40 | 6 | | |
| NGC 5986 | 70 | GC | Lup | 7.6 | 10' | 15 46.1 | –37 47 | 6 | | |
| NGC 5999 | 71 | OC | Nor | 9 | 3' | 15 52.2 | –56 28 | 6 | | |
| NGC 6005 | 72 | OC | Nor | 10.7 | 3' | 15 55.8 | –57 26 | 6 | | |
| | 72a | OC | Nor | 11.2 | 5' | 16 01.5 | –53 32 | 6 | | Tr 23 (Trumpler) |
| NGC 6067 | | OC | Nor | 5.6 | 12' | 16 13.2 | –54 13 | 6 | 6 | 100 stars, large brightness range, central conc. |
| NGC 6093 | 73 | GC | Sco | 7.3 | 9' | 16 17.0 | –22 59 | 6 | 6 | M80, Strong central concentration, bright and large |
| NGC 6121 | 75 | GC | Sco | 5.4 | 26' | 16 23.6 | –26 32 | 6 | 6 | M4, Near Antares |
| NGC 6124 | | OC | Sco | 5.8 | 40' | 16 25.3 | –40 39 | 6 | 6 | Near planetary nebula NGC 6153 |
| NGC 6101 | 74 | GC | Aps | 9.2 | 11' | 16 25.8 | –72 12 | 6 | | Caldwell 107 |
| NGC 6144 | 77 | GC | Sco | 9 | 9' | 16 27.3 | –26 02 | 6 | | |
| NGC 6134 | 76 | OC | Nor | 7.2 | 6' | 16 27.7 | –49 09 | 6 | | |
| NGC 6139 | 78 | GC | Sco | 9.1 | 6' | 16 27.7 | –38 51 | 6 | | |
| NGC 6171 | 79 | GC | Oph | 7.8 | 10' | 16 32.5 | –13 03 | 6 | 6 | M107 |
| NGC 6167 | 79a | OC | Nor | 6.7 | 7' | 16 34.4 | –49 36 | 6 | | |
| NGC 6192 | 79b | OC | Sco | 8.5 | 7' | 16 40.3 | –43 22 | 6 | | |
| NGC 6193 | | OC | Ara | 5.2 | 14' | 16 41.3 | –48 46 | 6 | | In nebula NGC 6188 |
| NGC 6205 | | GC | Her | 5.8 | 17' | 16 41.7 | +36 28 | 6 | 7 | M13, Great Hercules Cluster |

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 6218 | 80 | GC | Oph | 6.1 | 15' | 16 47.2 | –01 57 | 6 | 6 | M12 |
| NGC 6216 | 81 | OC | Sco | 10.1 | 4' | 16 49.4 | –44 44 | 6 | | |
| NGC 6235 | 82 | GC | Oph | 8.9 | 5' | 16 53.4 | –22 11 | 6 | | |
| NGC 6231 | | OC | Sco | 2.6 | 14' | 16 54.2 | –41 49 | 6 | 6 | A few stars with strong central concentration |
| IC 4628 | | BN | Sco | | 1.5° × 1.5° | 16 57.0 | –40 27 | 6 | | Prawn Nebula |
| NGC 6254 | 83 | GC | Oph | 6.6 | 15' | 16 57.1 | –04 06 | 6 | 6 | M10 |
| NGC 6253 | 84 | OC | Ara | 10.2 | 5' | 16 59.1 | –52 43 | 6 | | |
| NGC 6266 | 85 | GC | Oph | 6.4 | 14' | 17 01.2 | –30 07 | 7 | 6 | M62 |
| NGC 6273 | 86 | GC | Oph | 6.8 | 14' | 17 02.6 | –26 16 | 7 | 6 | M19 |
| NGC 6284 | 87 | GC | Oph | 8.9 | 6' | 17 04.5 | –24 46 | 7 | | |
| NGC 6287 | 88 | GC | Oph | 9.3 | 5' | 17 05.2 | –22 42 | 7 | | |
| NGC 6293 | 89 | GC | Oph | 8.3 | 8' | 17 10.2 | –26 35 | 7 | | |
| NGC 6302 | | PN | Sco | 9.7 | 83" × 24" | 17 13.7 | –37 06 | 7 | | Bug Nebula |
| NGC 6304 | 90 | GC | Oph | 8.3 | 7' | 17 14.5 | –29 28 | 7 | | |
| NGC 6316 | 91 | GC | Oph | 8.1 | 5' | 17 16.6 | –28 08 | 7 | | |
| NGC 6341 | | GC | Her | 6.5 | 14' | 17 17.1 | +43 08 | 7 | 7,9 | M92 |
| NGC 6318 | 91a | OC | Sco | 11.8 | 5' | 17 17.8 | –39 27 | 7 | | |
| NGC 6333 | 92 | GC | Oph | 7.9 | 9' | 17 19.2 | –18 31 | 7 | 6 | M9 |
| NGC 6356 | 93 | GC | Oph | 8.2 | 7' | 17 23.6 | –17 49 | 7 | | |
| NGC 6352 | 94 | GC | Ara | 7.8 | 7' | 17 25.5 | –48 25 | 7 | | Caldwell 81 |
| NGC 6362 | 95 | GC | Ara | 8.1 | 11' | 17 31.9 | –67 03 | 7 | | |
| NGC 6388 | 96 | GC | Sco | 6.8 | 9' | 17 36.3 | –44 44 | 7 | | |
| NGC 6402 | 97 | GC | Oph | 7.6 | 12' | 17 37.6 | –03 15 | 7 | 6,7 | M14 |
| NGC 6405 | | OC | Sco | 4.2 | 33' | 17 40.3 | –32 15 | 7 | 6,8 | M6, Butterfly Cluster |
| NGC 6397 | 98 | GC | Ara | 5.3 | 26' | 17 40.7 | –53 40 | 7 | 1,6 | Loose structure, possibly the nearest globular |
| NGC 6440 | 98a | GC | Sgr | 9.3 | 5' | 17 48.9 | –20 22 | 7 | | |
| NGC 6445 | 98b | PN | Sgr | 11.2 | 3' × 1' | 17 49.2 | –20 01 | 7 | | Crescent Nebula |
| NGC 6441 | 99 | GC | Sco | 7.4 | 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 | 30' | 17 57.1 | –18 59 | 7 | 6,8 | M23, 150 stars, moderate brightness range, lies in good star field |
| NGC 6496 | 100 | GC | CrA | 8.6 | 7' | 17 59.0 | –44 16 | 7 | | |
| NGC 6514 | | BN | Sgr | 6.3 | 20' × 20' | 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 6522 | 101 | GC | Sgr | 9.9 | 6' | 18 03.6 | –30 02 | 7 | | Near NGC 6528 |
| NGC 6523 | | BN | Sgr | 5.0 | 45' × 30' | 18 03.7 | –24 23 | 7 | 6,8 | M8, Lagoon Nebula |
| NGC 6531 | | OC | Sgr | 5.9 | 15' | 18 04.2 | –22 29 | 7 | 6,8 | M21 |
| NGC 6528 | 102 | GC | Sgr | 9.6 | 4' | 18 04.8 | –30 03 | 7 | | Near NGC 6522 |
| NGC 6544 | 103 | GC | Sgr | 7.5 | 9' | 18 07.3 | –25 00 | 7 | | |
| NGC 6541 | 104 | GC | Cra | 6.3 | 13' | 18 08.0 | –43 42 | 7 | 8 | |
| NGC 6553 | 105 | GC | Sgr | 8.3 | 9' | 18 09.3 | –25 54 | 7 | | |
| NGC 6572 | | PN | Oph | 8.0 | 16" × 13" | 18 12.1 | +06 51 | 7 | | |
| NGC 6569 | 106 | GC | Sgr | 8.4 | 6' | 18 13.6 | –31 50 | 7 | | |
| NGC 6603 | 107a | OC | Sgr | 11.1 | 5' | 18 18.4 | –18 25 | 7 | | In M24, Sagittarius Star Cloud |
| NGC 6584 | 107 | GC | Tel | 7.9 | 8' | 18 18.6 | –52 13 | 7 | | |
| NGC 6611 | | BN | Ser | 6.0 | 120' × 25' | 18 18.8 | –13 47 | 7 | 8 | M16, Eagle Nebula |
| IC 4715 | | OC | Sgr | 3.0 | 95' | 18 19.6 | –18 10 | 7 | 6,8 | M24, Small Sagittarius Star Cloud |
| NGC 6613 | | OC | Sgr | 6.9 | 9' | 18 19.9 | –17 08 | 7 | 8 | M18 |
| NGC 6618 | 108 | BN | Sgr | 6.0 | 20' × 15' | 18 20.8 | –16 11 | 7 | 8 | M17, Swan Nebula |
| NGC 6624 | 109 | GC | Sgr | 7.6 | 9' | 18 23.7 | –30 22 | 7 | | |

| Catalogue # | Bennett | Type | Con | Mag | Size | RA | Dec | Mth 10pm | Map | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| NGC 6626 | 110 | GC | Sgr | 6.9 | 11' | 18 24.5 | –24 52 | 7 | 6,8 | M28, Large, round, increasingly compressed in the middle |
| NGC 6633 | | OC | Oph | 4.6 | 20' | 18 27.3 | +06 31 | 7 | | Near open cluster IC 4756 |
| NGC 6638 | 111 | GC | Sgr | 9.2 | 7' | 18 30.9 | –25 30 | 7 | | |
| NGC 6637 | 112 | GC | Sgr | 7.7 | 7' | 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 6642 | 112a | GC | Sgr | 8.9 | 5' | 18 31.9 | –23 29 | 7 | | |
| NGC 6652 | 113 | GC | Sgr | 8.5 | 4' | 18 35.8 | –32 59 | 7 | | |
| NGC 6656 | 114 | 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 | 115 | GC | Sgr | 7.8 | 8' | 18 43.2 | –32 18 | 7 | 1,6,8 | M70 |
| NGC 6694 | | OC | Sct | 8.0 | 14' | 18 45.2 | –09 24 | 7 | 8 | M26 |
| NGC 6705 | 116 | OC | Sct | 5.8 | 13' | 18 51.1 | –06 16 | 7 | 8 | M11, Wild Duck Cluster |
| NGC 6712 | 117 | GC | Sct | 8.1 | 7' | 18 53.1 | –08 42 | 7 | | |
| NGC 6720 | | PN | Lyr | 9.4 | 86" × 62" | 18 53.6 | +33 02 | 7 | 7,9 | M57, Ring Nebula |
| NGC 6715 | 118 | GC | Sgr | 7.7 | 9' | 18 55.1 | –30 29 | 7 | 8 | M54 |
| NGC 6723 | 119 | GC | Sgr | 6.8 | 11' | 18 59.6 | –36 38 | 7 | | |
| NGC 6726 | | BN | CrA | | 2' × 2' | 19 01.7 | –36 53 | 8 | | |
| NGC 6744 | 120 | G | Pav | 8.3 | 20' × 13' | 19 09.8 | –63 51 | 8 | 1 | |
| NGC 6752 | 121 | GC | Pav | 5.4 | 20' | 19 10.9 | –59 59 | 8 | 1 | Starfish Cluster |
| NGC 6779 | | GC | Lyr | 8.3 | 7' | 19 16.6 | +30 11 | 8 | 9 | M56, Irregularly round, compressed in the middle |
| NGC 6809 | 122 | GC | Sgr | 6.3 | 19' | 19 40.0 | –30 58 | 8 | 8 | M55 |
| NGC 6818 | 123 | PN | Sgr | 10.0 | 22" × 15" | 19 44.0 | –14 09 | 8 | | Near galaxy NGC 6822 |
| NGC 6838 | | GC | Sge | 8.3 | 7' | 19 53.8 | +18 47 | 8 | 9 | M71 |
| NGC 6853 | | PN | Vul | 7.3 | 8' × 6' | 19 59.6 | +22 43 | 8 | 9 | M27, Dumbbell Nebula |
| NGC 6864 | 124 | GC | Sgr | 8.6 | 6' | 20 06.1 | –21 55 | 8 | 8 | M75 |
| NGC 6913 | | OC | Cyg | 6.6 | 10' | 20 23.9 | +38 32 | 8 | 9 | M29 |
| NGC 6981 | 125 | GC | Aqr | 9.2 | 6' | 20 53.5 | –12 32 | 8 | 8 | M72 |
| NGC 6992 | | BN | Cyg | 7.0 | 60' × 8' | 20 56.4 | +31 43 | 8 | | Part of Veil Nebula |
| NGC 7000 | | BN | Cyg | 4.0 | 100' × 60' | 21 01.8 | +44 12 | 9 | 9 | North American Nebula |
| NGC 7009 | 126 | PN | Aqr | 8.3 | 44" × 23" | 21 04.2 | –11 22 | 9 | | Saturn Nebula |
| NGC 7078 | | GC | Peg | 6.4 | 12' | 21 30.0 | +12 10 | 9 | 9 | M15, Bright, irregularly round, well resolved into faint stars |
| NGC 7092 | | OC | Cyg | 4.6 | 31' | 21 32.2 | +48 26 | 9 | 9 | M39, Northern limit |
| NGC 7089 | 127 | GC | Aqr | 6.5 | 13' | 21 33.5 | –00 49 | 9 | 8 | M2 |
| NGC 7099 | 128 | GC | Cap | 6.9 | 11' | 21 40.4 | –23 11 | 9 | 8 | M30 |
| NGC 7293 | 129 | PN | Aqr | 6.3 | 15' × 12' | 22 29.6 | –20 50 | 9 | 8 | Helix Nebula |
| NGC 7410 | 129a | G | Gru | 10.6 | 6' × 2' | 22 55.0 | –39 40 | 9 | | |
| IC 1459 | 129b | G | Gru | 9.97 | 5' × 3' | 22 57.0 | –36 28 | 9 | | |
| NGC 7662 | | PN | And | 8.6 | 32" × 28" | 23 25.9 | +42 32 | 10 | | Snowball Nebula |
| NGC 7793 | 130 | G | Scl | 9.1 | 9' × 6' | 23 57.8 | –32 36 | 10 | | |

## LEGEND

**Catalogue** Catalogue number (NGC New General Catalogue, IC Index Catalogue)
**Bennett** Bennett Catalogue number
**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 (most 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

# PLACES OF ASTRONOMICAL INTEREST

## NEW SOUTH WALES & ACT

### BATHURST OBSERVATORY RESEARCH FACILITY

They operate their 'Open Nights' public observatory tours on a regular basis, catering 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 website. Regular updates are also on their facebook page. Email <info@bathurstobservatory.com.au>
www.bathurstobservatory.com.au www.facebook.com/BathurstObservatory

### CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The Complex, located 35 km southwest of Canberra, is a major link in NASA's Deep Space Network and is managed on their behalf by the CSIRO. The facility provides two-way radio communication with distant spacecraft exploring the Solar System and beyond. The centrepiece is the 70-metre antenna dish, the largest in Australia. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from spacecraft and includes a real Moon rock. Enjoy a meal at the Deep Space Café. The gift shop is open for space themed items and souvenirs. Contact Korinne McDonnell (02) 6201 7809, (02) 6201 7838, email <pr@cdscc.nasa.gov>
www.cdscc.nasa.gov/facebook.com/CanberraDSN
Also on Instagram, Twitter and YouTube.

### CSIRO PARKES RADIO TELESCOPE

The Parkes Observatory is located 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 visitors centre has displays and a 3D Theatre. There is also the Dish Café and a picnic area with free gas barbecues. Souvenirs and educational material are available. Contact (02) 6861 1777
www.csiro.au/parkes

### 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 a large 17". Bring your SLR camera to take astrophotos through this scope or over the internet with their CCD camera.
Contact 0488 425 940 <peter@dubboobservatory.com>.
www.dubboobservatory.com www.facebook.com/DubboObservatory/

### GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society Inc (SASI) in Sydney. The building houses 41 cm and 35 cm telescopes. Visitors are welcome first three Thursdays of the month at 7:30 pm. Please contact the secretary by email before your visit. The society also runs regular open nights for the general public. Contact Secretary, Maree Emett, email <honsecretary@sasi.net.au> www.sasi.net.au

### MACQUARIE UNIVERSITY ASTRONOMICAL OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on Friday and Saturday nights (weather permitting) for several months during the year, see website for dates and status. Astronomy students will guide you with a range of telescopes. They also offer private events for school, scout or other interested groups on other nights of the week. Email <starinfo@mq.edu.au>
www.mq.edu.au search 'Astronomical Observatory'

### MILROY OBSERVATORY

Milroy Observatory at Coonabarabran operates nightly stargazing sessions with Donna the Astronomer on most clear nights. They cater for the general public, groups of amateur astronomers or school groups. Please call to make a booking. Contact Donna 0428 288 244, email <donna@donnatheastronomer.com.au>
www.donnatheastronomer.com.au www.facebook.com/milroyCoonabarabran
Also on Instagram, TikTok (as donnatheastronomer) and YouTube.

### MUDGEE OBSERVATORY

Mudgee Observatory caters for school groups, organised tours and the general public. The observatory is situated 15 minutes west of Mudgee. The theatre and flat screen planetarium run 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, email <john@mudgeeobservatory.com.au> www.mudgeeobservatory.com.au

### PORT MACQUARIE ASTRONOMICAL OBSERVATORY

The Port Macquarie Astronomical Association operates on Friday night. They operate an extra night on Sunday night during the school holidays. Visit their website for more information. Booking is essential via Trybooking.
Email <administration@pmasc.org.au>
portastronomy.com.au www.facebook.com/portobservatory

### SCIENCE SPACE

Operated by the University of Wollongong, this public science centre includes the full dome planetarium, an observatory, 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), email <science-space@uow.edu.au>
www.sciencespace.com.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 National University's 3.9 metre Anglo Australian Telescope and the 2.3 metre Advanced Technology 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. StarFest is a celebration of astronomy at SSO every October long weekend, more information on the web.
www.sidingspring.com.au www.starfest.org.au

### SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a variety of tours and displays. See website for details. Sydney Observatory is part of the Museum of Applied Arts and Sciences. powerhouse.com.au/visit/sydney-observatory

### TAMWORTH REGIONAL ASTRONOMY AND SCIENCE CENTRE

The Tamworth Regional Astronomy Club Inc runs the Tamworth Regional Astronomy and Science Centre, open to the general public on Thursday evenings from 5 pm and Saturdays from 10 am to 1 pm to view the range of scientific displays, minerals & mega-fauna, planetarium, 34 inch Hewitt Camera and other large telescopes. It is adjacent to the Botanical Gardens, Piper St, Tamworth. Contact Please phone 0458 772 747 for confirmation and details., email <tracthestars@gmail.com> www.tamworthastronomy.com.au

### THE AUSTRALIA TELESCOPE COMPACT ARRAY – NARRABRI

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22 m dishes, five 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. Contact, see website. www.narrabri.atnf.csiro.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 the 1st Friday of the month weather permitting and other nights can also be arranged for large groups. Contact Mac Jonson (07) 4153 6469, email <macsen2@yahoo.com>
alloway-observatory-bundaberg.webs.com

### CHARLEVILLE COSMOS CENTRE AND OBSERVATORY

The Charleville Cosmos Centre is located off the Mitchell Highway within the airport precinct. The centre offers a range of activities for all ages to enjoy, including evening sessions in The Big Sky Observatory, stories of astrology from cultures across the globe in the Universal Dreaming tour and even a Small & Personal Observatory session using an enormous 30 inch telescope! There's plenty to see during the day too, starting with Astronomy by Day, the free walk-through exhibition with interactive displays, the Astrodome Planetarium, and the Sun Viewing, which allows you to observe sunspots and solar flares using a 10 inch Hydrogen-Alpha telescope. No need to pack a lunch, the Milky Way Café has you covered with an extensive menu and daily lunch specials.
Phone: (07) 4656 8377. Group/educational packages available on request.
www.cosmoscentre.com www.experiencecharleville.com.au
Also on Facebook and Instagram.

### SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is high in the McPherson Range, and the observatory is located 700 m above sea level away from light pollution. The drive from Surfers Paradise is only 45 minutes. They are open to the general public, astronomical groups, schools, and researchers by appointment. This facility houses a number of telescopes for night time viewing. See website or contact them on Facebook for details. www.springbrookobservatory.com.au

### THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located at the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs are presented in their Cosmic Skydome. All astronomy shows include a current night sky tour recreated in the dome. The Planetarium upgraded its digital projection system in 2019 and can now recreate the observable universe at 7K resolution with many more astronomical features available. The display areas contain astronomical and space items including a large display concerning Aboriginal and Torres Strait Islander astronomy. The shop has educational products and souvenirs. School shows are also available during weekdays. Open Tuesday to Sunday (open on Monday during Qld school holidays). Contact (07) 3403 8888, email <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 northern Flinders Ranges, Arkaroola has a range of accommodation and Advanced Ecotourism accredited products including three astronomy tours and the Ridgetop Tour. There are also many unguided bushwalks and driving tracks. See also feature on page 34. Arkaroola has:

- Two 3-metre dome observatories with equatorial fork mount Celestron C14 *f*/11 telescopes for eyepiece viewing.
- One 3 metre robotic dome observatory for real time astro-imaging. This observatory contains one Celestron C14 *f*/11 telescope with ZWO ASI186MC camera, a C14 *f*/2 FastStar telescope with ZWO ASI6200MC camera and a Coronado 60 mm Hydrogen Alpha telescope with ZWO ASI1600MC camera, all on a Software Bisque ME mount.
- One roll-off roof observatory with a Skywatcher 150 mm *f*/7 ED refractor on a Losmandi G11 mount, a Skywatcher 16" *f*/4.5 GoTo Dobsonian and spare piers and wedges suitable for BYO telescopes.

Contact (08) 8648 4848, email <res@arkaroola.com.au>
www.arkaroola.com.au www.facebook.com/arkaroola Also on Instagram.

### 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 in February, May, August and November. See website for details. Contact ASSA Info Line 0401 702 772, email <observatories@assa.org.au> www.assa.org.au/facilities/stockport/

### THE BACKYARD UNIVERSE

Multicultural guided tours of South Australia's night sky with laser pointer and large telescope. Enjoy an evening of traditional stargazing and modern astronomy in a small group tour with an experienced local guide. Experience a night sky that's practically as dark as the Outback but much closer to Adelaide. Also available for schools, events & private group tours at your venue. Bookings are essential, see website for details. Email <tbu@thebackyarduniverse.com.au> www.thebackyarduniverse.com.au

### THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury Heights, Adelaide. There are two main telescopes, a 14" and a research quality 12.5" plus two Coronado solar scopes. Private bookings are accepted. Ph (08) 8263 6244. Contact Andrew Cool, email <andrew@cool.id.au>
www.theheights.sa.edu.au/observatory.html www.adelaideobservatory.org

### THE RIVER MURRAY INTERNATIONAL DARK SKY RESERVE

The River Murray International Dark Sky Reserve consists of over 3300 km$^2$ of rural land within the Mid Murray Council area in South Australia, situated between the eastern slopes of the Adelaide Hills and the River Murray. It is Australia's first Dark Sky Reserve. The Reserve's core is in the Swan Reach Conservation Park, whilst its public Education centre is at Meldanda, a 100 acre property just outside the hamlet of Cambrai, where camping is available for a small fee per head. A well equipped hall is also available, and two large (300 m x 600 m) car-accessible flat astro paddocks, well away from any road, are available with very low horizons, along with a portable loo. A number of concrete telescope pads are provided throughout the Reserve. Contact Mid Murray Landcare SA (08) 8564 6044. See also feature on page 34.
www.rivermurraydarkskyreserve.org
www.facebook.com/RiverMurrayDarkSkyReserve/

### 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. Public Viewing sessions are held on the 1st and 3rd Saturday of the month. See website for session times and other information. Bookings essential. Contact (08) 8302 3138, email <adelaide.planetarium@unisa.edu.au> www.unisa.edu.au/planetarium/
www.facebook.com/AdelaidePlanetarium

## TASMANIA

### LAUNCESTON PLANETARIUM

The Launceston Planetarium is at the Queen Victoria Museum's Inveresk site. See their website for details of shows. Contact (03) 6323 3777
www.qvmag.tas.gov.au/Planetarium

## 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.
Email <astrotour@swin.edu.au> astronomy.swin.edu.au/astrotour/

### BALLARAT MUNICIPAL OBSERVATORY

The observatory has several historic telescopes including the Jelbart (125 mm refractor), the Oddie (220 mm Newtonian), the Baker Great Equatorial Telescope (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, email <info@ballaratobservatory.org.au> \
ballaratobservatory.org.au www.facebook.com/ObservatoryBAS/

### BENDIGO PLANETARIUM @ DISCOVERY

This small planetarium inside The Discovery Science and Technology Centre, is interactive and engaging. A visit will take you for a trip through our Solar System and give you a chance to see tonight's sky today.
Email <bookings@discovery.asn.au> www.discovery.asn.au

### MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. It regularly screens full-dome films for adults and families, as well as presenter-led tours through the night sky. See website for details.
museumsvictoria.com.au/scienceworks/visiting/melbourne-planetarium/

### MOUNT BURNETT OBSERVATORY

Community Observatory and Science Organisation. New members are most welcome. Individuals and families wanting to look through the telescopes can join in one of their Public Events. School, scout and community events are also catered for. All sessions must be pre-booked. Email or phone for further details. Members' events include onsite and online events, dedicated sessions for young observers and a radio astronomy group. Email <info@mbo.org.au>
mbo.org.au www.facebook.com/MtBurnettObservatory
Also on Instagram and Twitter.

## 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, email <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 OzGrav research facilities, the Zadko Telescope Facility and the USAFA Falcon Telescope Network. The observatory boasts professional staff and five telescopes including one of the largest for public observing in WA. Along with regular night tours, other special events include, Local Aboriginal Astronomy nights, Tame Your Telescope and Astrophotography classes. Added to this is the annual Gingin Dark Sky Star Party, held under protected Dark Skies an hours drive north of Perth.
Contact (08) 9575 7577 (Office). www.gravitycentre.com.au/observatory

### PERTH OBSERVATORY

Located in the breathtaking Perth Hills, a mere 40-minute drive east of Perth, lies the illustrious Perth Observatory. As Western Australia's oldest astronomical institution, it boasts a rich legacy of cutting-edge research and dedicated public outreach. Proudly managed by the Perth Observatory Volunteer Group, they provide a wide array of captivating night and daytime tours, catering even to school groups. Beyond the confines of its tranquil location, the Observatory hosts riveting stargazing events across WA, and they offer an enchanting star adoption program. For those eager to embark on a celestial journey, visit their website to book and for further information. Contact (08) 9293 8255, email <info@perthobservatory.com.au>
www.perthobservatory.com.au facebook.com/PerthObservatory
Also on Instagram, Twitter and YouTube.

# 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 website 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), email <astrofest@cwas.org.au>
www.cwas.org.au/astrofest/ www.facebook.com/CWASAstroFest

### MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, commercial stands and telescopes operated by MQ academic/research staff and local amateurs. They are held once a year on a Saturday night around a First Quarter Moon. The venue is Macquarie University in North Ryde, Sydney, see website and search for 'Astronomy Open Night' for details.
Email <astronomyopennight@mq.edu.au> event.mq.edu.au

### 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 31st NACAA will be held in Parkes, NSW in 2024, hosted by the Central West Astronomical Society. This is being planned as hybrid event, both at Parkes and streamed online. See website for more details. www.nacaa.org.au

### SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. It 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 website for more details. Email <secretary@asnsw.com>
www.asnsw.com/spsp

## QUEENSLAND

### QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The 2024 Queensland Astrofest will be the 30th camp held annually at the Lions Club Camp Duckadang, situated at Linville 160 km northwest of Brisbane. There is bunk house accommodation and limited sites for camping and caravans. Power is also available. Queensland Astrofest boasts a nine day format, and will be held from Friday 2 August to morning Sunday 11 August 2024. Each Saturday has a guest speaker. Workshops throughout the event are run covering various topics. The renowned Astro-Feast is held on the last Saturday Lunch. More details are on the website. Registration usually opens April/May, early bookings are recommended. Contact registrar, email <registrar@qldastrofest.org.au>
www.qldastrofest.org.au www.facebook.com/QLDAstrofest

### URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at the Barrett Street Reserve, Bracken Ridge (entry off Jude St) on the Saturday night around First Quarter Moon of each month (weather permitting). Special events are also organised. All welcome. Contact Julie Straayer 0411 047 439, email <seqldastro@gmail.com> www.seqas.org

## SOUTH AUSTRALIA

### VICSOUTH DESERT SPRING STAR PARTY

See entry for VicSouth under Victoria.

## VICTORIA

### 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 19th VASTROC will be hosted by the Mornington Peninsula Astronomical Society on Saturday 25th November 2023 Contact , see website. vastroc.net

### VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party is an annual weekend of astronomy, held at the Little Desert Nature Lodge about 16 km south of Nhill in western Victoria, roughly equidistant between Melbourne and Adelaide. It offers a weekend of social, astronomical and observing activities. See website for more details. www.vicsouth.info

## WESTERN AUSTRALIA

### ASTROFEST WA

WA's biggest astronomy festival is held in Perth annually. 2019 was the 10th anniversary. It's free and great family fun with multiple telescopes to look through, special guest presenters, hands on activities for kids, astrophotography exhibition, space shows, space domes and information stalls. Discover more about astronomy and stargazing in WA and how you can get involved, start studying or begin a career. More details on the next one on their website when available. Hosted by Astronomy WA. www.astronomywa.net.au
www.facebook.com/AstronomyWA/ Also on Twitter.

# ORGANISATIONS

## AUSTRALIA

### AUSTRALASIAN DARK SKY ALLIANCE

ADSA promotes the preservation of the night environment, through the education of industry, community and policy makers. Contact Marnie Ogg, Director, email <secretary@ausdarksky.org> www.darksky.orgIDA
www.australasiandarkskyalliance.org ADSA Also on Twitter and YouTube.

### 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 the ASA Secretary (A/Prof. John O'Byrne), email <asa.secretary@sydney.edu.au> asa.astronomy.org.au ASA site
www.astronomy.org.au Australian Astronomy site
Also on Facebook and Twitter.

### 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.
Email <markgblackford@outlook.com> 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. Find them on facebook.

# COURSES

## NEW SOUTH WALES & ACT

### MSATT – ASTRONOMY PROJECTS FOR HIGH SCHOOL STUDENTS

MSATT is an educational facility designed for student-centred research projects in astronomy. The facility consists of two primary instruments (300 mm Schmidt-Cassegrain and 400 mm Newtonian) with auxiliary instruments and cameras for visual work, imaging, spectroscopy, photometry and astrometry. Students operate MSATT, a teaching telescope suite at ANU's historic Mount Stromlo Observatory, to complete extended investigations based on their own observations. In most cases, an astronomer is appointed as the student's mentor for the duration of the project. Students produce a referenced and refereed report which can often contribute to their formal school assessment. No experience with astronomy or telescopes is necessary and any year 9 to 12 student from the ACT region is welcome to apply. Students wishing to visit MSATT or take on projects in 2024 should contact Geoff McNamara for a copy of the MSATT Student Guide. There is no cost for any MSATT activities. Contact Geoff McNamara phone/text 0449 966 200, email <geoffrey.mcnamara@ed.act.edu.au>
msatt.teamapp.com/ www.facebook.com/MSATTAustralia/

### PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an eight 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, email <info@sasi.net.au> www.sasi.net.au

## SOUTH AUSTRALIA

### ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

A variety of astronomy themed courses are conducted at the Adelaide Planetarium during the year. See their website for details.

www.unisa.edu.au search 'Astronomical Courses'

## VICTORIA

### ASTRONOMY PUBLIC LECTURES

The Centre for Astrophysics and Supercomputing have free public lectures on astronomy at the Hawthorn campus of Swinburne University of Technology. See website for details. Contact, see website.

astronomy.swin.edu.au/outreach/?topic=freelectures

# MOBILE PLANETARIUMS

## NEW SOUTH WALES

### MACQUARIE UNIVERSITY MOBILE PLANETARIUM

Their planetarium projector system and portable GoDome is available, by arrangement, for groups of up to 40 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. See the website for details. Email <starinfo@mq.edu.au>

www.mq.edu.au search 'Planetarium'

### SKYWORKS PLANETARIUM

Skyworks Planetarium is a multi-award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools, libraries, vacation care centres and university open nights. Since starting in 2000, they have visited over 750 schools in greater Sydney. Programs are curriculum based to suit years K–12. Contact Geoff and Diana Zenner 0419 112 899, email <info@skyworks.net.au>

www.skyworks.net.au facebook.com/skyworksplanetarium

## QUEENSLAND

### NIGHT SKY SECRETS PLANETARIUM

Night Sky Secrets operate a Cosmodome Planetarium in North & Far North Queensland. They conduct both 3D Surround movies and classic planetarium presentations in schools, museums and events across Northern Queensland. Contact 1 300 843 759, email <sales@nightskysecrets.com.au>

www.nightskysecrets.com.au/planetarium/

### 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 and Planetarium' to provide educational programs tailored to suit your level of interest and understanding. Contact Paul Tickner 0417 394 354, email <info@starlab.net.au> www.starlab.net.au

# RESOURCES

## AUSTRALIA

### 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 18,000 members.

www.iceinspace.com.au

## WESTERN AUSTRALIA

### STARGAZERS CLUB WA

Stargazing and astronomy for beginners. Stargazers Club WA runs telescope classes, stargazing nights, astrophotography for beginners and hosts special trips to dark skies in country WA. See their website for costs and details. Contact 0487 187 603, email <begin@stargazersclubwa.com.au>

www.stargazersclubwa.com.au www.facebook.com/StargazersClub

Also on Instagram.

# SOCIETIES

## NEW SOUTH WALES & ACT

The **ASTRONOMICAL SOCIETY OF ALBURY WODONGA** meets as advertised on their facebook page. Contact David Thurley 0418 690 142 <ASAWSecretary@gmail.com>.

www.facebook.com/AstronomicalSocietyAlburyWodonga Also on Twitter.

The **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 <Donna@born2fly.com.au>.

www.facebook.com/AstronomicalSocietyofCoonabarabran/

The **ASTRONOMICAL SOCIETY OF NSW** holds two meetings per month at Epping, runs two observing sites in NSW and publishes a monthly journal. The society welcomes members from all over Australia, as well as overseas. See their website for further details. Contact <secretary@asnsw.com>.

www.asnsw.com Also on Facebook.

The **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, ACT. Contact Peter Williamson 0417 635 205 <pwil6227@bigpond.net.au>.

casastronomy.org.au Also on Facebook.

The **CENTRAL WEST ASTRONOMICAL SOCIETY INC (PARKES)** meetings are held monthly. See the website for details. Visitors welcome. Contact Secretary <secretary@cwas.org.au>.

www.cwas.org.au Also on Facebook.

The **CLARENCE VALLEY ASTRONOMICAL SOCIETY** Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>.

Find them on Facebook.

The **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>.

www.facebook.com/Coffsastro/

The **ILLAWARRA ASTRONOMICAL SOCIETY** meets at 7:30 pm, every second Tuesday of the month at the Wollongong Science Centre. Contact <IAS.secretary@outlook.com>.

iasenquiry.wixsite.com/website Also on Facebook.

The **MACARTHUR ASTRONOMICAL SOCIETY** meets monthly at Western Sydney University, Campbelltown, NSW, with guest speakers. Visitors welcome. See website for details. Contact <contact@macastro.org.au>.

www.macastro.org.au Also on Facebook and Twitter.

The **NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC** meets at St Ignatius College at Lane Cove third Tuesday of every month. Contact <nsas@nsas.org.au>. www.nsas.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 pm ( 7:30 pm during Daylight Saving Time). Contact Andrew Wood (secretary) <astronomers@shoalhaven.net.au>.

www.shoalhavenastronomers.asn.au

The **SUTHERLAND ASTRONOMICAL SOCIETY** meets first three Thursdays of the month at 7:30 pm at the Green Point Observatory near Sutherland (cnr Green Point and Caravan Head Roads Oyster Bay), with the main meeting and guest speaker on the 1st Thursdays. Please email their secretary before attending. Contact Maree Emett (Sec) <honsecretary@sasi.net.au>.

www.sasi.net.au Also on Facebook.

**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 0419 254 961 <sydneycityskywatchers@gmail.com>.

www.sydneycityskywatchers.org Also on Facebook and Twitter.

**THE NEWCASTLE ASTRONOMICAL SOCIETY** meetings are held on the first Friday each month (except January), at the University of Newcastle, General Purpose building 1, level 1, at 7:30 pm. Contact Alan Meehan 0487 337 576 <starnut01@yahoo.com.au>.

www.facebook.com/newcastleastrosociety/

The **SYDNEY NORTHWEST ASTRONOMY GROUP (SNAG)** meets for viewing and imaging on Friday nights under clear skies at their Kenthurst site. Contact Geoff Bishop 0413 613 764 <snag.astronomy@gmail.com>.

The **TAMWORTH REGIONAL ASTRONOMY CLUB INC** holds meetings on the 1st Saturday of every month. The evening commences at 7 pm with an astronomy presentation (approximately 30 minute talk) and then telescope viewing. Members Technical evenings and viewings are also held every Thursday, commencing from 5 pm. The Club also meets every Saturday morning 10 am to 1 pm for Solar & Radio Telescope operation. All sessions are open to the public to attend. They also operate the Astronomy and Science Centre, see entry under 'Places'. Contact Garry 0458 772 747 <tracthestars@gmail.com>.
www.tamworthastronomy.com.au Also on Facebook.

The **UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY** meets on the first Wednesday of the month 6:30 for 7 pm start. Contact <unentas@gmail.com>.
www.unentas.org.au Also on Facebook.

The **WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC** meets at 7:30 pm on the 3rd Wednesday of the month. Hear interesting guest speakers and attend astronomy workshops. Contact <enquiry@wsaag.org>.
wsaag.org Also on Facebook.

The **WOLLONGONG AMATEUR ASTRONOMY CLUB** has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Wests Illawarra Club, Unanderra. Visitors are most welcome to attend.
Contact Joe Perulero 0479 188 381 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

The **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 'Contact Us' form on their website. <info@aaq.org.au>.
www.aaq.org.au Also on Facebook.

The **BRISBANE ASTRONOMICAL SOCIETY** hold meetings each month except January and December, see their website for meeting night details and live-stream options.
Contact Peter Allison 0488 140 755 <President@bas.asn.au>.
www.bas.asn.au Also on Facebook and YouTube.

The **BUNDABERG ASTRONOMICAL SOCIETY** has regular meetings, see website for details. Contact Mark Sugars 0409 697 734
alloway-observatory-bundaberg.webs.com

The **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 <ian@nightskysecrets.com.au>.
www.facebook.com/FNQAstronomers

The **REDLANDS ASTRONOMICAL SOCIETY** meets via Zoom, see website for details. Contact President Janice 0411 627 610 <redlandsastronomicalsociety@gmail.com>.
www.ras.org.au Also on Facebook.

The **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 Joel Bladen (President) 0431 436 500 <secretary@sraa.org.au>.
sraa.org.au Also on Facebook.

The **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 0411 047 439 <seqldastro@gmail.com>.
www.seqas.org Also on Facebook.

The **SOUTHERN ASTRONOMICAL SOCIETY** has monthly meetings at 26–42 Charlies Crossing Road North, Upper Coomera Qld 4209, see website for details. Contact Caleb Kam (President) <calebkam.sas@gmail.com>.
www.sas.org.au Also on Facebook and Instagram.

**TOWNSVILLE ASTRONOMY GROUP INC** meet monthly at the Aitkenvale Library for Club Meetings, fortnightly at the Strand, and weekly at their Oak Valley site for dark sky observing.
www.astronomytsv.org.au Also on Facebook.

## SOUTH AUSTRALIA

The **ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA** General Meetings are held at 8 pm on the 1st Wednesday each month (except January) in The Braggs Lecture Theatre, University of Adelaide, North Terrace Campus. Astronomy Education sessions at 7 pm precede the main meeting. The public are welcome to attend these meetings.
Contact 0401 702 772 <info@assa.org.au>.
www.assa.org.au Also on Facebook, Instagram and YouTube.

## TASMANIA

The **ASTRONOMICAL SOCIETY OF TASMANIA** has regular meetings and observing activities throughout Tasmania.
Contact Hobart – Steve Harvey 0419 341 469, Mark Rough – 0418564304, Devonport – Peter Sayers (03) 6424 2588 or email <info@astas.org.au>.
www.astas.org.au Also on Facebook.

## VICTORIA

The **ASTRONOMICAL SOCIETY OF GEELONG** has meetings every Friday from 7:30 pm. Section meetings on Thursday nights.
Contact Secretary 0423 743 908 <asog.org.au@gmail.com>.
www.asog.org.au Also on Facebook and Instagram.

The **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. The ASV has 19 specialist sections that also hold regular meetings in the Ellery Suite at Melbourne Observatory. Contact Linda Richmond (Public Relations Officer) M: 0409 403 051 <publicrel@asv.org.au>.
www.asv.org.au Also on Facebook, Instagram, Twitter and YouTube.

**ASTRONOMY BENALLA** meets on the 2nd Wednesday at 7:30 pm in Benalla, address varies, please consult their web page. Contact Peter Nankivell (President) 0428 308 234 <president@astronomybenalla.org.au>.
www.astronomybenalla.org.au Also on Facebook.

The **BALLAARAT ASTRONOMICAL SOCIETY** holds members meetings, 2nd Friday of the month, beginning in February. Contact 0429 199 312 <bas@ballaratobservatory.org.au>. ballaratobservatory.org.au/bas

The **LATROBE VALLEY ASTRONOMICAL SOCIETY** meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers or via Zoom; call for details or check website. Contact Paul Odgers 0466 836 627 <info@LVAstro.org>.
www.LVAstro.org Also on Facebook.

The **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 <welcome@mpas.asn.au>.
www.mpas.asn.au Also on Facebook, Instagram, Twitter and YouTube.

The **MOUNT BURNETT ASTRONOMICAL SOCIETY** has regular meetings, see website for details. mbo.org.au Also on Facebook, Instagram and Twitter.

The **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. ballaratman.wixsite.com/svastro

The **TALLANGATTA AND DISTRICT ASTRONOMY CLUB INC (TADAC)** get together once a month at the Tallangatta Showgrounds and various other locations for night sky observing. Contact Zachary West (president) 0438 863 739 <tallangattaastronomyclub@gmail.com>.
www.tadac.info Also on Facebook.

## WESTERN AUSTRALIA

The **ASTRONOMICAL SOCIETY OF THE SOUTH WEST** has regular meetings, see website for details.
Contact <enquiries@assw.org.au>. www.assw.org.au Also on Facebook.

The **ASTRONOMICAL SOCIETY OF WESTERN AUSTRALIA** has regular meetings, see website for details.
Contact <aswa.info@aswa-inc.org.au>. aswa-inc.org.au Also on Facebook.

# 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 magnitude 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*** A type of 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.

***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 with more than fifty percent, but less that one hundred percent illuminated. For example, aside from Full Moon, 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 BCE. 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***.

***Libration*** The gentle rocking motion of the Moon as it orbits the Earth that allows observation of part 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 dust 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).

***Zenithal 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 also lies across the ecliptic).

## GREEK ALPHABET (lower case)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

## Includes Nov / Dec 2023 monthly sections

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ESTIMATING ANGLES IN THE SKY When 0.5 metres 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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