ASTRONOMY 2023

AUSTRALIA

Ken Wallace
Glenn Dawes
Peter Northfield

YOUR GUIDE TO THE NIGHT SKY

CALENDAR 2023

JANUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	
8	9	10	11	12	13	14
	16	17	18	19	20	21
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	30	31				

FEBRUARY

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APRIL

Sun	Mon	Tue	Wed	Thu	Fri	Sat
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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31					1	2
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ASTRONOMY 2023

AUSTRALIA

Glenn Dawes Peter Northfield Ken Wallace

Quasar Publishing 2022

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Rear cover: Part of NGC 3324 and its associated nebula. Taken by the James Webb Space Telescope and the Hubble Space Telescope. JWST is optimised for the infra-red end of the spectrum, where it can detect stars normally hidden behind clouds of dust and nebulosity, largely out of view from Hubble.

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INTRODUCTION TO THE 2023 EDITION

Welcome to Astronomy 2023, yes, thirty three years in the making.

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

- The Milky Way, structure and centre.
- Our closest star, the Alpha Centauri system.
- Discovery of Neptune, earlier than you may think.
- Just what is this stuff — astrology.
- The sad and lonely life of the author of an astronomical bible.

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

Part I of Astronomy 2023 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

We also encourage you to check out our website as some data, previously included in these pages, has been moved online and downloadable. A lot of this information is either well catered for in modern day apps and planetarium programs or made redundant given the technology in today's telescopes.

To see beyond the horizon …

Someone posted a picture on Facebook under the title of, 'First Image from James Webb Space Telescope'. It was intended to be the view from the inside of a translucent lens cap, with the phrase printed back-to-front, 'Remove before Flight', resulting in dozens of smiley and laughter emojis. After writing the two-part monthly feature covering the hurdles the Hubble Space Telescope had to overcome to become the astronomical discovery machine of the last 30 years, it gave the authors some time to pause. In the brief time 'Webb' has been fully operational, it has already shown enormous potential to build considerably on our knowledge of the early Universe, the hidden inner Milky Way, exoplanets and much more. To achieve this feat in the infrared spectrum, it needed to hide behind a heat shield far from the Earth and the Sun's radiation (1.5 million km from home) and way too far for any repair or servicing mission!

Before its flawless deployment and commissioning, some couldn't resist referring to it as NASA's 30 year, 10-billion-dollar gamble! Even if it went silent tomorrow, it was worth the risk and the money wasn't wasted. It employed hundreds of technicians and scientists building on their skills, the same talents that will get it right the next time, or the time after that. It's part of the human condition. As long as we continue to thirst for knowledge, there is hope for us all.

Anyway, enough from the Quasar pulpit for another year!

To all our readers, stay well and keep stargazing!

Glenn Dawes Peter Northfield Ken Wallace

NOTE. As we stated above, some lesser used data, published in earlier years, can be downloaded from our website. Search 'Quasar Publishing' or go to: www.quasarastronomy.com.au

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 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

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?

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 (p. 87) and finder chart (p. 130) 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. Although it reaches opposition in December this year, it is not favourable.

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. 143–145).

With any of these naked-eye objects, binoculars are very handy and open up a whole new perspective on the night sky (next page).

DISTANCES ARE TRULY ASTRONOMICAL

Sometimes the word astronomical is used to describe something that is excessive or exorbitant and that sums up pretty well the scale of the Universe. As someone once said, space is well named 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.
- The average distance to Neptune from the Sun, about 4 light hours (remember this encloses all the currently accepted planets).
- The nearest star, the Alpha Centauri system, just over 4 light-years (ly).
- The brightest star, Sirius 8.6 ly
- Two nearby open star clusters, the Hyades (the face of Taurus the Bull) about 150 ly and the Pleiades is 430 ly.
- Two of the closest globular clusters, M4 in Scorpius is 6,800 ly and NGC 6397 in Pavo is 7,500 ly
- The centre of the Milky Way around 25,000 ly (our galaxy's main disc is around 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!

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 140.

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 close together it's called a conjunction. They can be quite attractive, especially those involving the brightest planets. Conjunctions between the thin crescent Moon and Venus or Jupiter are spectacular. An example this year is the meeting of the Moon and Venus on February 22 and between Venus and Jupiter on March 2 (see Sky Views, pages 32 and 37).

Although not covered in the book, it's also fun looking for Earth-orbiting satellites. Remember these don't generate any light themselves, they need to reflect sunlight to be visible. Look for low Earth orbiting satellites up to three hours after sunset or before sunrise where they can still *see* the Sun. Look out for those that slowly appear or disappear for no obvious reason, they have likely moved out of, or into, the Earth's

shadow. For evening events the shadow rises slowly from the eastern horizon and for mornings drops slowly in the west. Current examples include the International Space Station (ISS) and the Hubble Space Telescope (HST). The Heavens Above website (www.heavens-above.com) will allow you to generate predictions for visibility of these and other satellites for your location. There are also Apps for tablets and smart phones that do the same.

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 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

USES FOR BINOCULARS

There are a multitude of uses for binoculars 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.
- 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 130 and 131 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 121 to 127. 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. 149) or organisations such as Variable Stars South www.variablestarssouth.org or AAVSO www.aavso.org.

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

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 inside front cover will help. Unless you wish to view our natural satellite, or just the planets, New Moon is favoured by most observers, preferring long nights with their skies as dark as possible. Up to First Quarter the morning sky is Moon-free, as are evenings after Last Quarter. The Rise–Set 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 (starting page 110).

Observing the Moon (pp. 114–117). Viewing the terminator, the sunrise/sunset line on the Moon, makes our satellite come alive as the crater walls and mountains cast shadows across the surface. Lunar observers love the daily change with something different offered every night. This section helps identify the features on the terminator as the Moon waxes and wanes. Possibly the most unpopular time is Full Moon which presents an overly bright, flat 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 start using June. Mars and Venus are in the evening sky and, in the morning sky we have Mercury, Uranus, Jupiter, Neptune and Saturn. You will notice that Uranus and Jupiter cross the midnight line in November, so both planets are close to opposition and up most of the night. The Rise–Set chart for November confirms this. Venus is approaching the Sun line in August and will soon leave the evening sky.

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., Jul 1) 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 September 6. Mercury then enters the morning sky with a thin sliver phase and the process reverses until superior conjunction is reached again (October 20). 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 August 10 it's at a maximum eastern elongation. Note its high altitude while in conjunction with the Moon on August 18, about a week past maximum elongation (Sky View page 63).

Its fellow inner world **Venus** goes through the same process as Mercury but much slower, being further from the Sun. In 2023, following a superior conjunction in October 2022, it begins rising in the evening sky, reaching a greatest elongation east on June 4, when it then begins to drop back to Sol towards an inferior conjunction on August 13. 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. The year opens with its disc around 14 arcseconds (") in diameter (magnitude –1.2) following opposition in December 2022. The Red Planet continues to shrink, finally reaches a size of 3.7" and brightness of magnitude 1.4 at conjunction on November 18.

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 74) confirms that this happens for Jupiter in early November (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 118 to 119. An example is the evening of January 3 at 10:17 pm (EST) or 11:17 pm

including daylight saving. This transit is visible from anywhere in Australia (indicated by *).

Pages 120–127 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 evening of October 15, the diagram on page 126 shows this well. In this case there is a drawing on page 72. The *wiggly* diagrams also show instances where a moon's line crosses over or behind the Jupiter lines. An example explains this well. On October 2 (again pages 126 and 72) the evening sees a occultation of Ganymede (passing behind Jupiter) followed by a transit of Io.

Saturn, with its impressive ring system (still reasonably open this year, 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 examples for August 27 are also graphically presented on page 62.

Uranus and **Neptune** (p. 130 and 131 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 139. These can be plotted on the All Sky Maps. As an example we'll look at minor planet 6 Hebe on its opposition date. The January monthly text (p. 23) has the minor planet reaching opposition on the 26th at magnitude 8.7 in Cancer. Page 141 tells you Cancer is on All Sky Maps No 4 and 5. The ephemerides (page 139) when plotted on Map 5 gives the location on this date about 4° north-east of the star Beta (β) Cancri (near the faint star on the line joining β to δ).

Let's assume it's the evening of November 15 and you wish to find Comet 62P/Tsuchinshan 1 and don't mind waiting until late. Part I text (page 76) says the comet "… *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…* The Rise–Set chart and Moon section for November, shows that the Moon is a couple of days after New Moon, setting around the end of twilight on the 15th. With the comet rising around midnight, it should be above 20° in altitude by 2 am. The table on page 134 shows 62P to be about five weeks before perihelion (which is 25 December) and the ephemerides (page 136) confirms that it's expected to be brightening, perhaps magnitude 8.3. Carrying out the same exercise with its position (RA and Dec), like the minor planet (above) Map 5 is needed. Interpolating between November 11 and 18, the comet is within 1° of the Beehive Cluster (M44). This year we have also plotted the positions of the bright comets on the All Sky Maps.

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Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the formidable worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, the magazine is produced specifically for Southern Hemisphere astronomers. Cost (as at August 2022) is $59 for one year (6 issues), $110 for two years (12 issues).

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PLANISPHERE

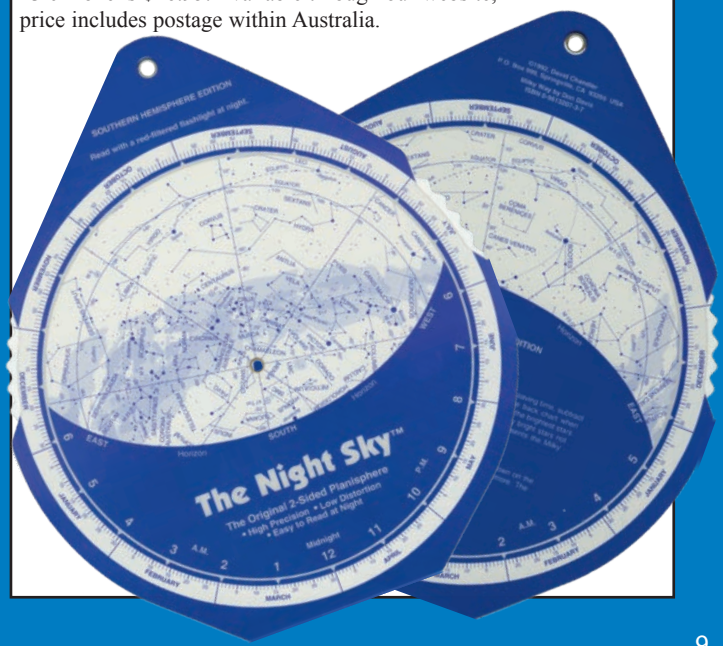
A planisphere makes a great companion to our book. It is a hand-held aid used to identify which stars and constellations are visible on any particular date and time.

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

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

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

They come in two sizes: the large 22 cm version is $29.95, the small 13 cm one is $16.95. Available through our website, price includes postage within Australia.



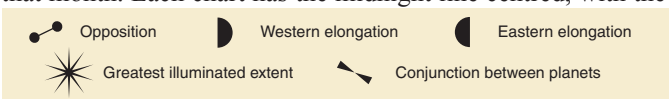
Meteors (Shooting Stars). Part I gives the best meteor showers for the year. Watching for meteors can be fun at any time. So, when taking a coffee break, sit back and relax. Who knows when an impressive fireball might light up the sky? If you don't go to sleep, you might be the only person to see it. 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 Pluto, but also includes Ceres, Eris and other dwarfs when at opposition.

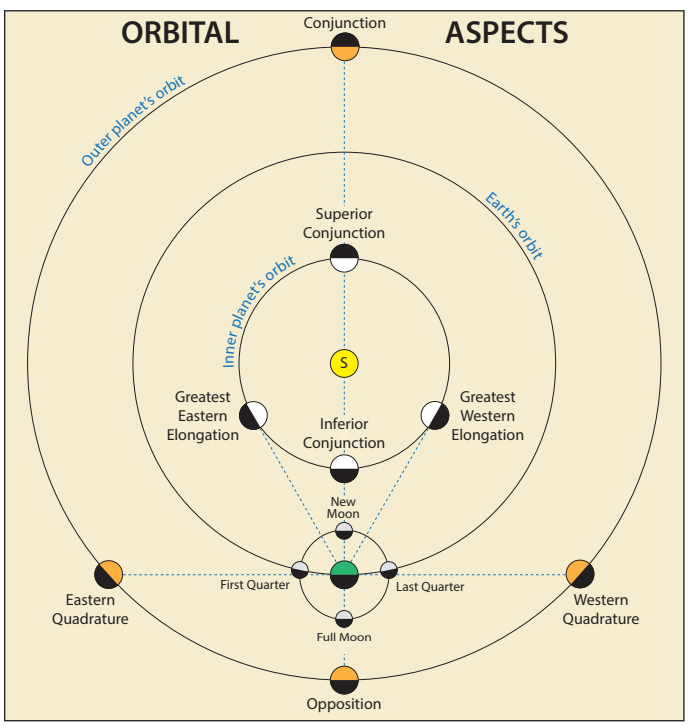
Minor Planets (or Asteroids) This covers the brightest asteroids that reach opposition each month (12.5 magnitude or brighter). An entry includes the date of opposition (when near brightest), its magnitude and the constellation the asteroid is in at this time. The 15 brightest dwarf and minor planets have ephemerides included in Part II (p. 139). 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 138 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. 140). 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 and stars visible during the month, concentrating on the evenings when most people are out gazing at the night sky. This year we undertake an epic journey along the path of the Sun, the ecliptic. We explore these constellations, including their brightest stars and deep sky objects.

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

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

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

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

Dwarf Planet. This is a recently created class of objects, with only five designated so far. This book concentrates on the brightest two, Pluto and Ceres. Incidentally both bodies are ex-planets, but you need to go back to the 19th century for Ceres' 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 Moon is gibbous when more than half is illuminated i.e., from after First Quarter to just before Last Quarter. On either side of New Moon, when less than half is lit, it is a crescent. Gibbous and crescent are also sometimes used to describe the appearance of Mercury or Venus. Mars can also be gibbous.

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

Twilight does not 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.

30 minutes) before sunrise or after sunset. Although this is twilight, it is sometimes necessary to catch a glimpse of the planets when close to the Sun. This is especially needed for Mercury as it never wanders more than 28° from 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.

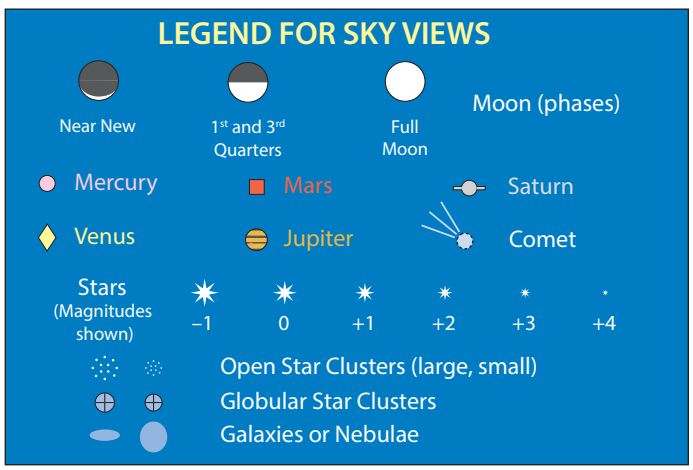
The Sky Views (see also the legend below) include:

- 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 a diagram for months close to their opposition (Saturn in August and September, Jupiter in October and November in 2023). Only the brightest moons are included. There are key differences between these planets worth keeping in mind.

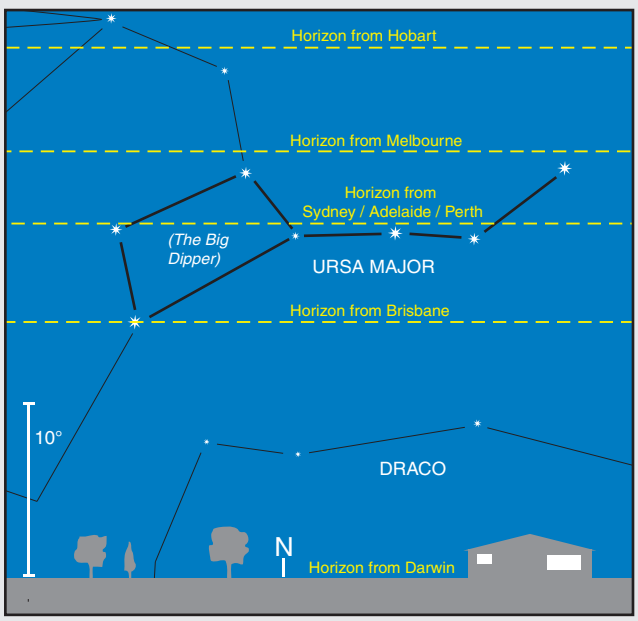
The plane of the orbits of Jupiter's moons is close to the Earth's orbital plane, so we see them shuttle back and forth in straight lines, passing in front of and behind the planet and even in and out of its shadow. Of the bright four Galilean moons, the most distant satellite, Callisto is the exception which spends many years (including 2023) 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.

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.



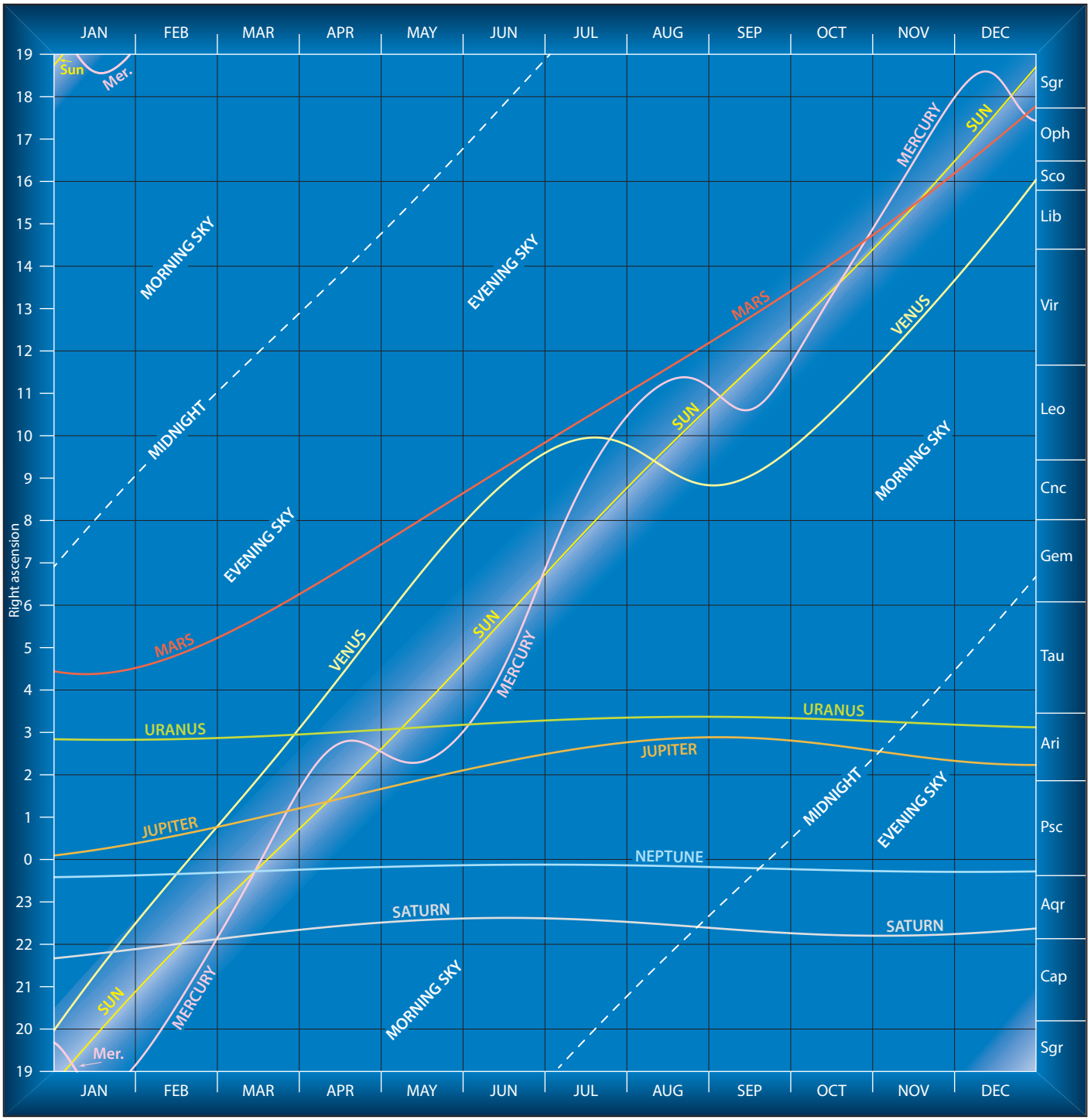
WHAT TIME IS IT? Unless a time zone or a location is specifically mentioned, times given in the Monthly Section will be approximate local standard time. No adjustments are made for Daylight Saving anywhere in this book. When it is in force you will need to add one hour to times given here. e.g., any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

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



EFFECT OF LATITUDE The Sky Views have been drawn for a latitude of 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

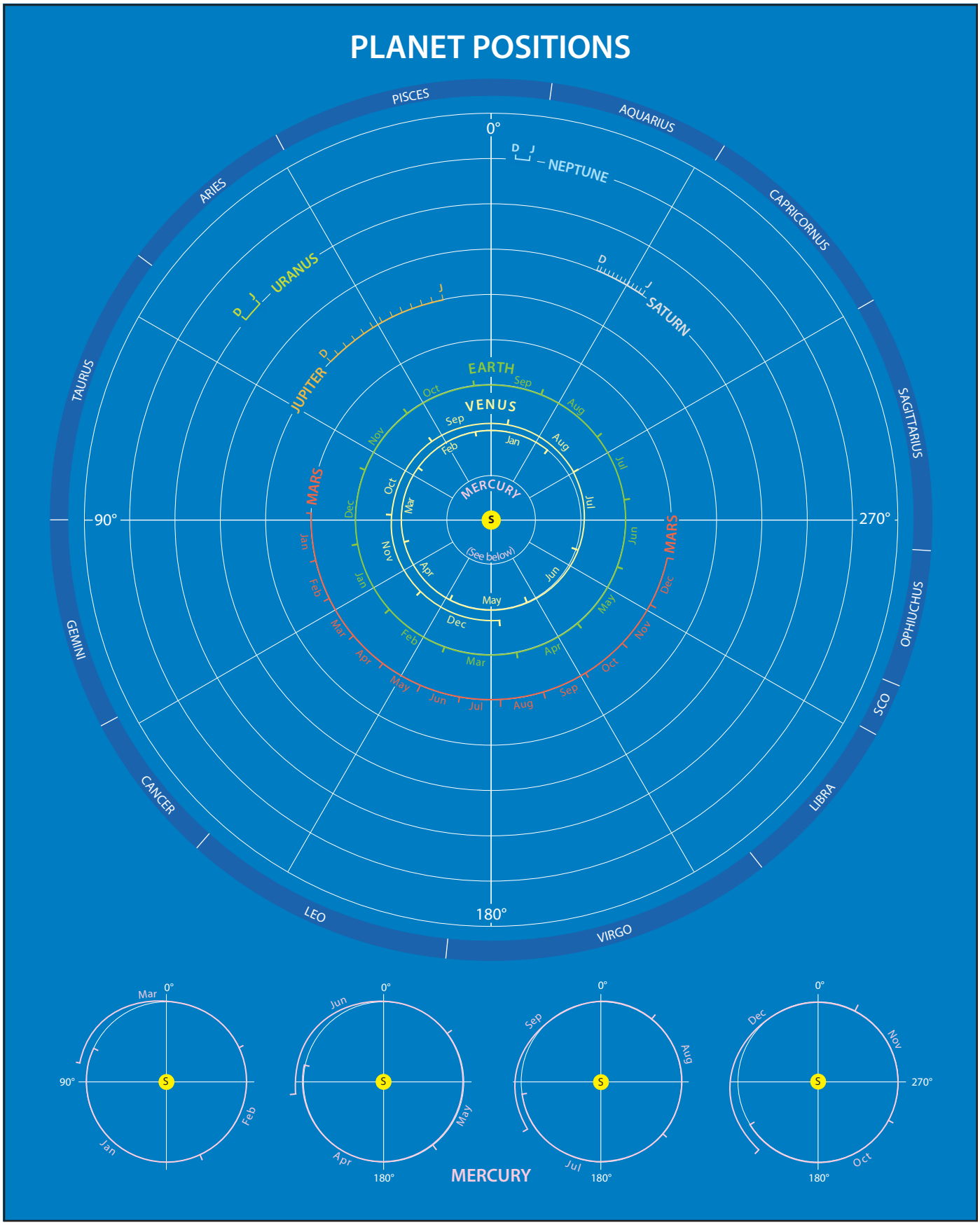


This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation 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 April evening 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 is when a maximum elongation occurs around September. For optimum morning returns, March is best.

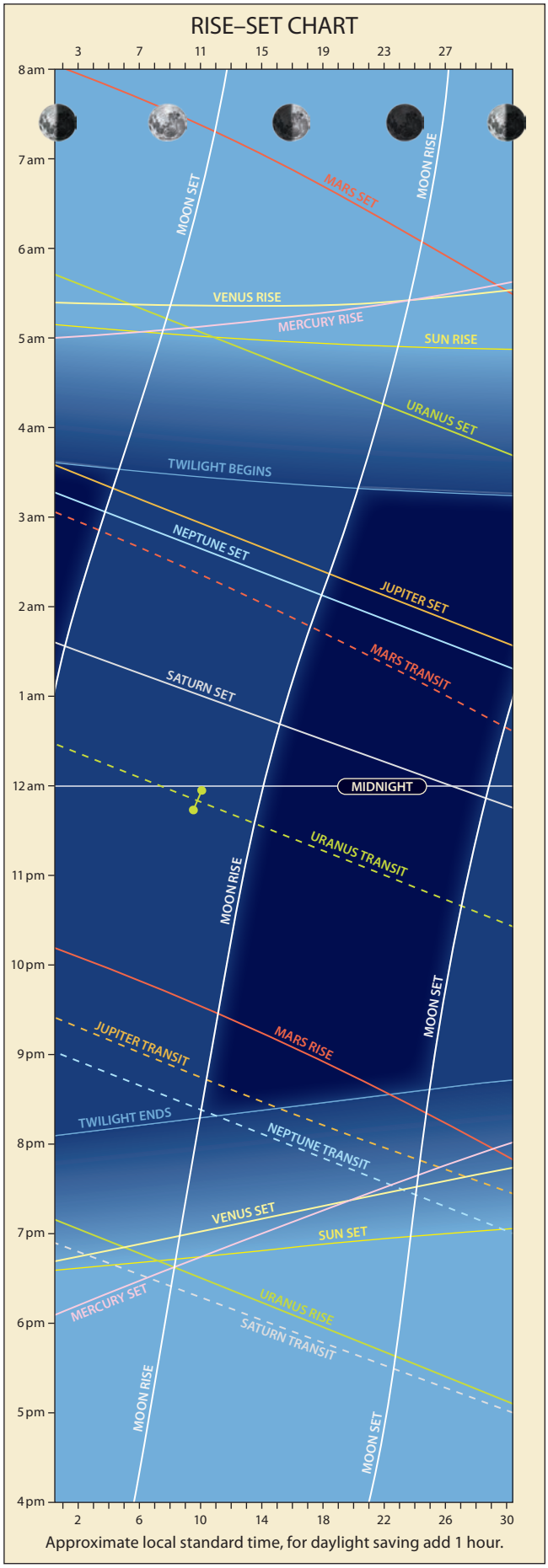
Early in the year, Venus is close to the Sun in the evening sky, eventually reaching maximum elongation (greatest altitude) around early June. It then dives quickly towards the Sun reaching conjunction in August, before spending the rest of the year in the morning sky.

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 Venus and Mars in the late June evening sky (see Sky View p. 52).



This diagram illustrates the relative positions of the planets during the course of their orbits in 2023. 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 2022

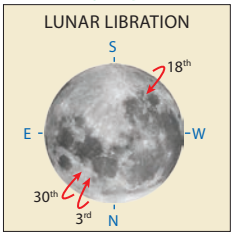


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mars at best and near opposition.
- Mars and Moon together.
- Total lunar eclipse.
- Uranus and Moon close.

THE MOON



1st 5 pm (3 pm WST) First Quarter.

3rd 4 am (2 am WST) Maximum Libration (7.5°), bright NE limb.

8th 9 pm (7 pm WST) Full Moon. Total lunar eclipse—visible from Australia.

14th 5 pm (3 pm WST) Moon at apogee (furthest from Earth at 404,921 km).

16th 11 pm (9 pm WST) Last Quarter.

18th 9 am (7 am WST) Maximum Libration (7.9°), bright SW limb.

24th 9 am (7 am WST) New Moon.

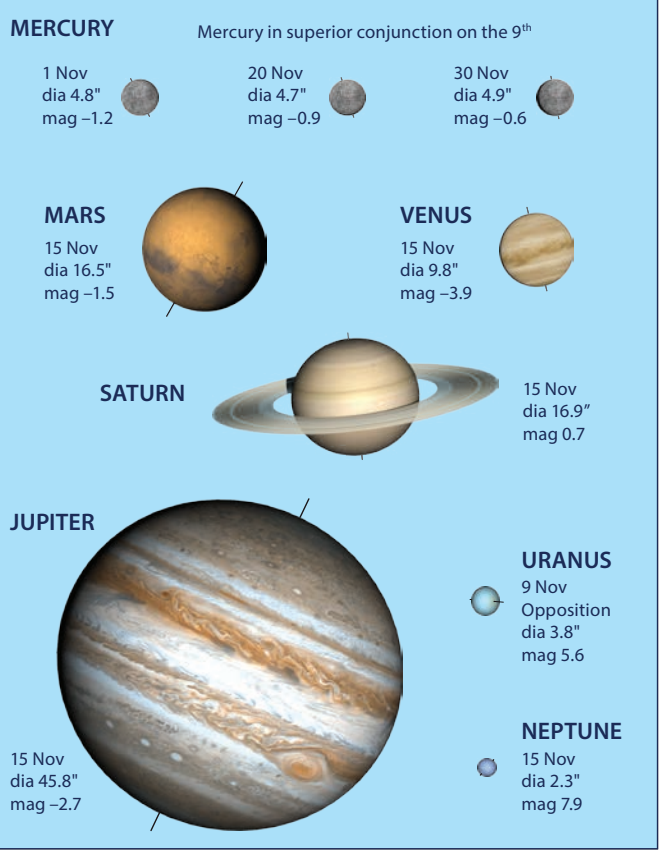
26th Noon (10 am WST) Moon at perigee (closest to Earth at 362,826 km).

30th 10 pm (8 pm WST) Maximum Libration (8.2°), bright NE limb.

THE PLANETS

Mercury moves from the morning sky and into the evening twilight after its superior conjunction on the 9th. As a matter of interest, although unobservable, Mercury will be occulted by the Sun at this conjunction. If you have an

APPEARANCE of the PLANETS



excellent low western horizon, you can get a glimpse of Mercury just a few degrees from Venus at the end of the month, deep in the evening twilight.

Venus remains within the Sun's glare until the end of the month, when it may be seen very low to the western evening horizon with Mercury a few degrees above. Binoculars and an unobstructed horizon will help here.

With **Mars** at opposition early next month, it's time to devote some observing time to the planet that has captured people's imagination for centuries. Rising in the eastern evening sky below the Hyades star cluster in Taurus, its bright orange beacon is unmistakable. This coming opposition is the first of five apparitions where the planet's diameter is less than 20 arcseconds. Although not the best of oppositions, the planet should deliver pleasant views (possible planet-wide sandstorms aside) in moderate to large size telescopes during periods of good seeing. By the end of November, this world reaches its greatest angular size in 2022 of 17.2 arcseconds and very close to –2 magnitude. On the 11th, the 18-day old waning gibbous Moon will be 3° from the planet as they rise a little after 9 pm (see Sky View).

Jupiter is visible in the northern evening sky at the end of twilight. Its brilliant globe is near the asterism known as the Circlet of Pisces, a grouping of six stars representing the head of the western fish. The giant planet resumes its west to east motion across the sky as its retrograde loop ends toward the end of the month. The waxing gibbous Moon appears near the planet on the 4th and 5th (see Sky View).

Saturn is visible in the early north-western evening sky in Capricornus. On the 11th, Saturn is at the point in its orbit known as eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 10). It is also the best time to view the maximum extent of the shadow of the planet's globe cast onto the back of the rings, giving Saturn a 3-D appearance. On the 29th, the 6-day old waxing crescent Moon will appear near Saturn (see Sky View).

Uranus comes to opposition on the 9th, rising in the early evening eastern sky and visible the entire night. On the 8th, the planet will be less than 1° away from the Full Moon's western limb, and as a bonus, our satellite will be in eclipse. Uranus' apparent diameter is a little less than 4 arcseconds at 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 will immediately note its disc and blue/green colour.

Neptune appears high in the early northern evening sky in Aquarius at the end of astronomical dusk, around 6° west (right) of Jupiter.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the morning of the 7th, d.p. 1 Ceres can be found passing through the famous Leo triplet of galaxies, particularly close to NGC 3628 (see Diary). On the night of the 17th, m.p. 115 Thyra has an extremely close encounter with Beta (β) Persei (Algol). At opposition (magnitude 9.7), Thyra will be closest at the end of twilight from the eastern states (only 9 arcseconds apart), but low in altitude. As the evening progresses the gap will widen reaching approximately 2 arcminutes by midnight (EST). If you want to be able to say you've seen a minor planet, watching these separate is the way to go, and can be viewed through a small telescope from

DIARY

Tue	1st		m.p. 29 Amphitrite 0.4° S of Djorgovski 2 (GC) in Sagittarius.
Tue	1st	5 pm	(3 pm WST) First Quarter Moon.
Tue	1st	Midn	(10 pm WST) Saturn 7° NE of Moon.
Wed	2nd		m.p. 4 Vesta 0.15° NW of NGC 7184 (G) in Aquarius.
Thu	3rd	am	m.p. 2 Pallas 1.3° NE of star Omicron^2 Canis Majoris.
Thu	3rd	4 am	(2 am WST) Maximum Libration (7.5°), bright NE limb.
Fri	4th	8 pm	(6 pm WST) Neptune 3° NW of Moon.
Sat	5th	2 am	(Midn WST, prev day) Jupiter 4° NE of Moon.
Mon	7th		d.p. 1 Ceres 0.1° SW of NGC 3628 (G) in Leo.
Mon	7th		d.p. 1 Ceres 0.5° NE of M65 (SG) in Leo.
Mon	7th		d.p. 1 Ceres 0.5° N of M66 (SG) in Leo.
Mon	7th		Comet C/2017 K2 (PANSTARRS) 1.2° SW of NGC 6169 (OC) in Norma.
Mon	7th	2 am	(Midn WST, prev day) m.p. 30 Urania 0.02° S of IC 2087 (BN) in Taurus.
Tue	8th	9 pm	(7 pm WST) Full Moon (390,660 km), total lunar eclipse.
Tue	8th	11 pm	(9 pm WST) Uranus 1.5° S of Moon.
Wed	9th		Mercury in superior conjunction.
Wed	9th		Uranus at opposition.
Thu	10th		Comet C/2017 K2 (PANSTARRS) 0.5° NW of NGC 6178 (OC) in Scorpius.
Thu	10th	10 pm	(8 pm WST) star Aldebaran 9° S of Moon.
Fri	11th	Midn	(10 pm WST) Mars 3° S of Moon.
Sun	13th		m.p. 9 Metis 0.3° NW of NGC 6907 (G) in Capricornus.
Sun	13th	am	m.p. 2 Pallas 0.4° W of NGC 2354 (OC) in Canis Major.
Sun	13th	am	Northern Taurids meteor shower, Oct 20 to Dec 10, Moon affected.
Mon	14th		Comet C/2017 K2 (PANSTARRS) 1.8° W of NGC 6204 (OC) in Ara.
Mon	14th	3 am	(1 am WST) star Pollux 3° E of Moon.
Mon	14th	5 pm	(3 pm WST) Moon at apogee (furthest from Earth at 404,921 km).
Tue	15th		Comet C/2017 K2 (PANSTARRS) 0.6° W of NGC 6200 (OC) in Ara.
Wed	16th	am	m.p. 2 Pallas 1.1° E of star Delta Canis Majoris.
Wed	16th	11 pm	(9 pm WST) Last Quarter Moon.
Thu	17th	3 am	(1 am WST) star Regulus 7° S of Moon.
Fri	17th		8:15 pm (6:15 pm WST) m.p. 115 Thyra 0.002° SW of star Algol (Beta Persei).
Thu	17th	pm	Comet C/2017 K2 (PANSTARRS) 0.6° NE of NGC 6193 (OC) in Ara.
Fri	18th	am	m.p. 2 Pallas 0.2° W of star Omega Canis Majoris.
Fri	18th	am	Leonids meteor shower, Nov 6–30, Moon affected.
Fri	18th	9 am	(7 am WST) Maximum Libration (7.9°), bright SW limb.
Sat	19th		m.p. 192 Nausikaa 0.8° NW of star Theta Capricorni.
Tue	22nd	am	alpha-Monocerotids meteor shower, Nov 15–25, Moon affected.
Thu	24th	9 am	(7 am WST) New Moon.
Fri	25th	pm	m.p. 532 Herculina 0.1° SE of star Pi^3 Orionis.
Sat	26th	Noon	(10 am WST) Moon at perigee (closest to Earth at 362,826 km).
Tue	29th	9 pm	(7 pm WST) Saturn 4° NW of Moon.
Tue	29th	pm	Comet C/2017 K2 (PANSTARRS) 0.9° E of NGC 6253 (OC) in Ara.
Wed	30th	10 pm	(8 pm WST) Maximum Libration (8.2°), bright NE limb.
Wed	30th	pm	Comet C/2017 K2 (PANSTARRS) 1.0° E of star Epsilon^1 Arae.

anywhere in Australia. Another opportunity to find a minor planet happens later in the month. Between the 24th and 27th, m.p. 532 Herculina is within 0.3° of Pi[3] (π^3) Orionis. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
7 Nov	71 Niobe	Andromeda	12.0
8 Nov	451 Patientia	Cetus	10.9
11 Nov	63 Ausonia	Aries	10.8
13 Nov	27 Euterpe	Aries	8.8
18 Nov	115 Thyra	Perseus	9.7
22 Nov	324 Bamberga	Perseus	9.2
29 Nov	30 Urania	Taurus	9.6

COMETS

Comet 81P/Wild 2 spends the month in Virgo, rising in the eastern sky before dawn. During the month it brightens from magnitude 11.0 to 10.6.

Comet C/2017 K2 (PANSTARRS) continues its passage south in our skies. Predicted to be glowing around 9th magnitude, the comet begins the month in Norma, setting around 10 pm. Mid-month sees PANSTARRS move into Ara, having an interesting tour of some of its open star clusters (see Diary). By the end of November, the comet has moved so far south it is also visible in the morning, rising an hour before astronomical dawn begins.

DOUBLE STARS

Beta (β) [1, 2, 3] Tucanae form a lovely binocular pair separated by 10 arcminutes. Through a telescope Beta[1] and Beta[2] (LCL 119AC) are a wide pair of bluish-white stars (magnitude 4.3 and 4.5) separated by 27 arcseconds. Beta[3] is a white star (magnitude 5.2). All three stars are also close pairs, and the system is actually a sextuple. Beta[1]'s companion's orbit is a little over three times Neptune's distance from the Sun. The Beta[2] pair is located over ten times further away and the pair is separated by less than the distance from the Sun to Uranus. The Beta[3] pair is much further away, and they are separated by a distance less than that between the Sun and Jupiter. (All Sky Map 1)

Gamma (γ) Arietis (Mesarthim, STF 180AB) is an excellent telescopic double and was one of the first double stars to be discovered (Robert Hooke in 1664). The matching pair (magnitude 4.5 and 4.6, spectral type A1pSi and B9V) of bluish-white stars is separated by 7.4 arcseconds. The pair is located at a distance of 164 light-years and the orbital period is over 5,000 years. (All Sky Map 3)

METEOR SHOWERS

The **Northern Taurids** are bright slow meteors active from October 20 to December 10, with their peak around November 12 and the morning of the 13th. The Northern Taurids are frequently bright, slow-moving, and noted for producing colourful fireballs (although not every year). They are associated with Comet 2P/Encke and visible from late evening to early morning. The waning gibbous Moon will impair viewing during the showers' peak this year.

The **Leonids** is one of the better-known showers. It is associated with the periodic comet 55P/Tempel-Tuttle and is best about every 33 years when the comet returns to perihelion (last in 2001). The Leonids are active from November 6 to 30, reaching a maximum peak of around 15 meteors per hour predicted for the morning of the 18th. Since Leo rises after midnight, there will only be a few hours available before the onset of dawn for observation. During the peak, the 23-day old waning crescent Moon will make it difficult for all but the brightest Leonids to be visible.

The **alpha-Monocerotids** is a minor shower with unusual short-lived outbursts. Active from 15th to 25th, the shower peaks on the late evening of the 21st until dawn on the 22nd. While the zenith hourly rate is variable, very high rates have been recorded occasionally over the years. The waning crescent Moon will interfere during the peak (rising around 3 am).

Continued from December 2022 page 21.

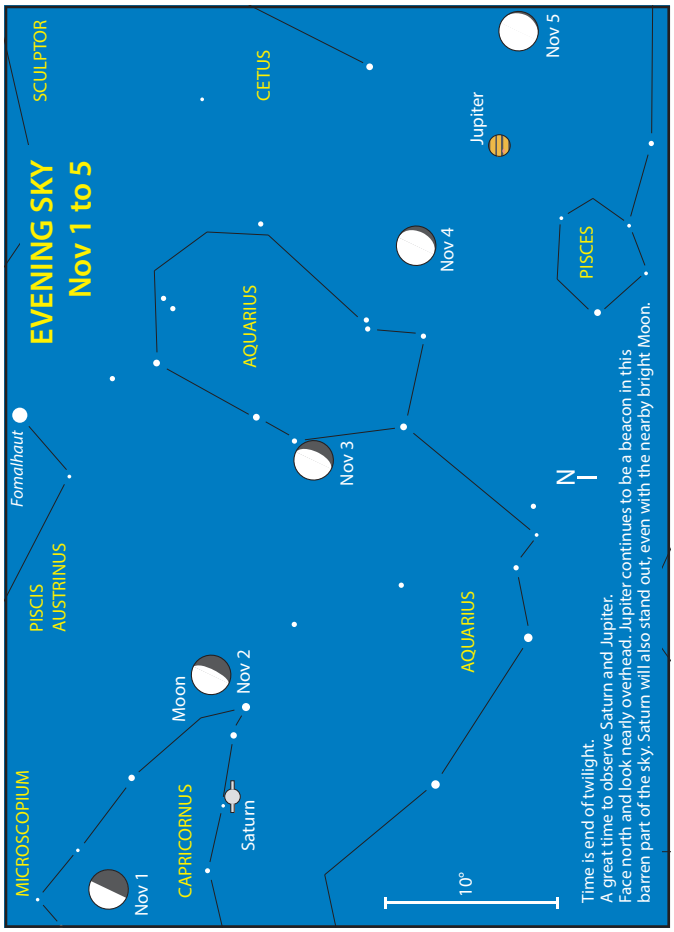
secondary eclipse. The 6.8 magnitude binocular companion, HD 36485, is a chemically peculiar B-type main-sequence star and is itself a spectroscopic binary with a faint A-type companion in a 30-day orbit. (All Sky Map 2)

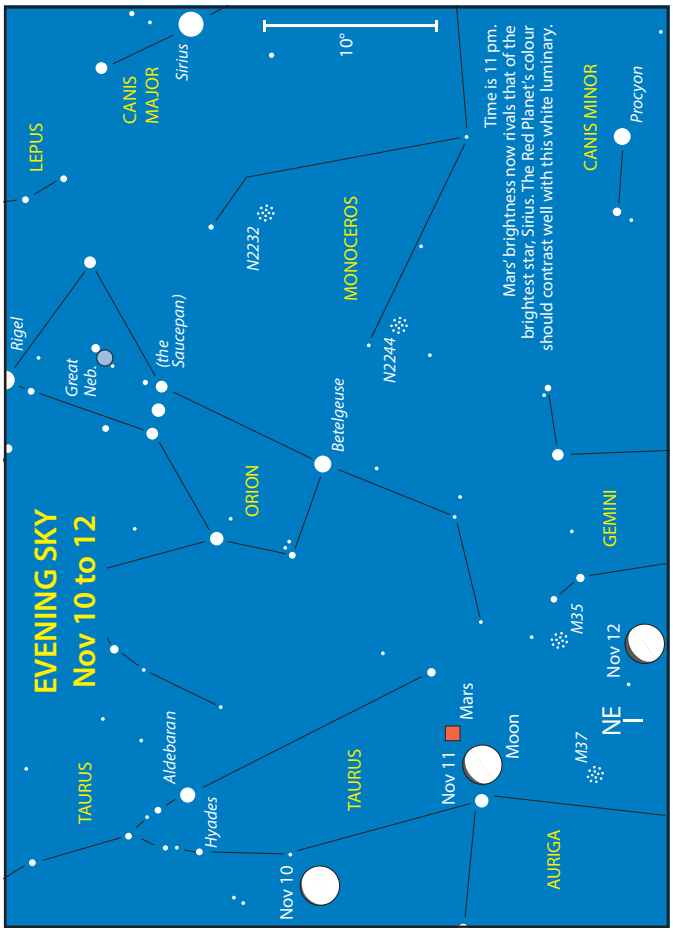
METEOR SHOWERS

The **Phoenicids** are a southern shower discovered in 1956 during its only known major outburst with rates of around 100 plus. Since then, there have been three minor bursts and some significant activity in 2014; therefore a shower to keep an eye on, just in case. They are active from November 28 to December 9, with maximum around the 2nd after dusk and before dawn on the 3rd. The Phoenicids' radiant culminates at dusk, so early evening viewing should provide the best activity. There will be lunar interference until 2 am.

The **Puppid-Velids** are a vast, complex system of southern showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. They are active from December 1–15 and could produce a zenith hourly rate of 10 around the evening of the 7th and morning of the 8th. The Full Moon around the peak this year will spoil any chance of observation.

The **Geminids** are one of the finest and reliable of the major annual showers. Visible from the 4th to 17th, 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 rising waning gibbous Moon around midnight will interfere with pre-dawn observations.





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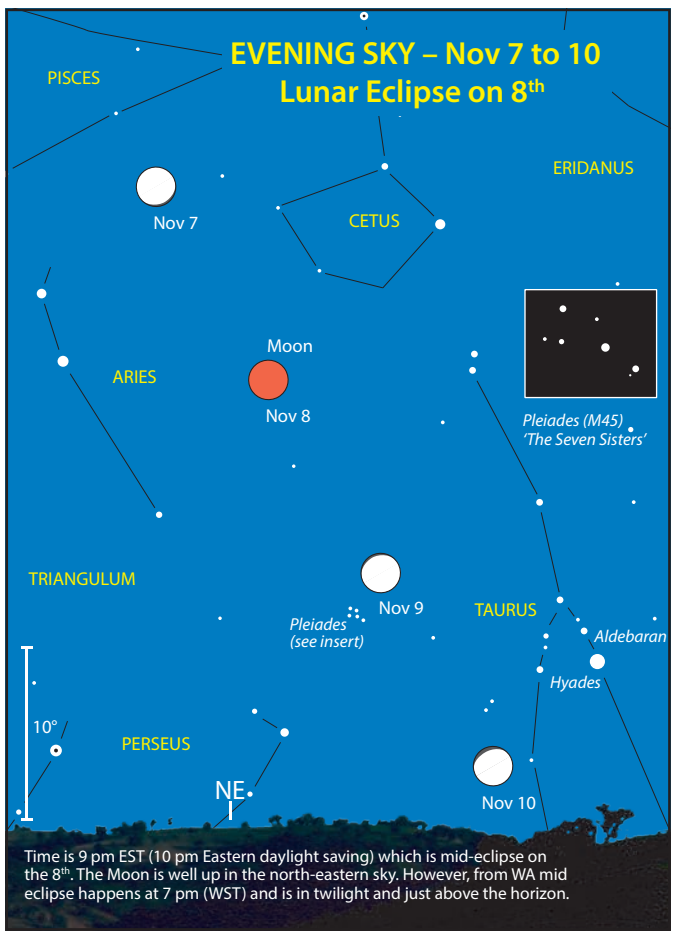
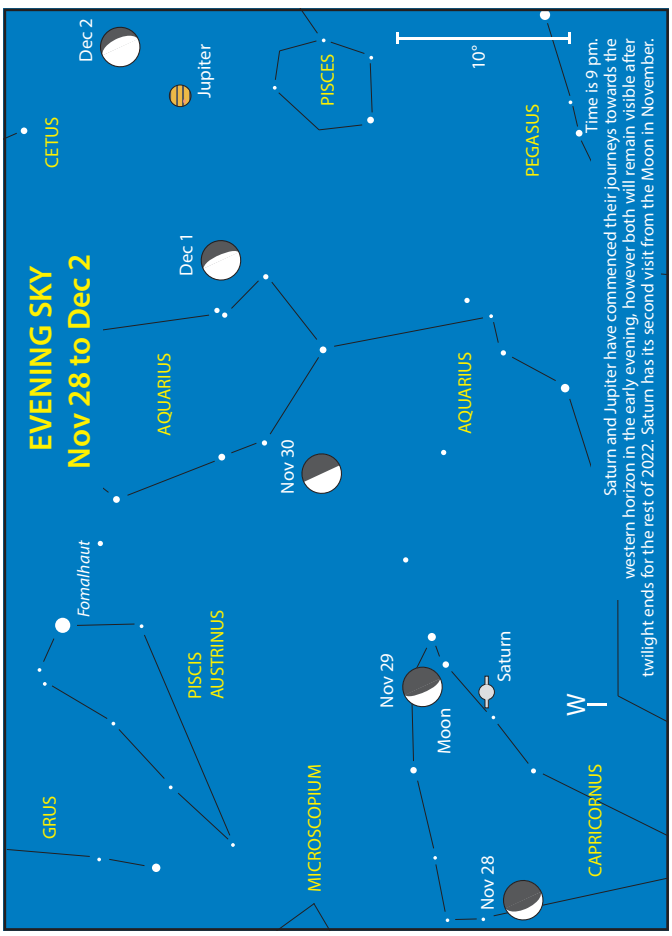
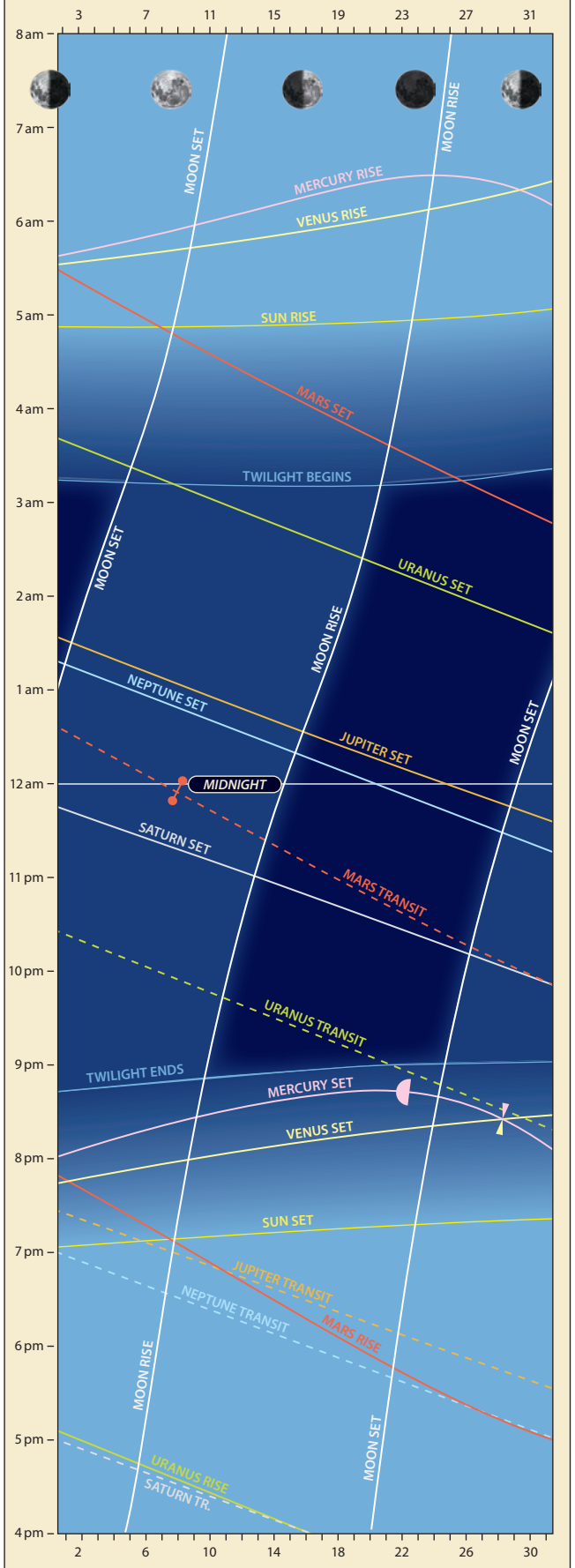




DECEMBER 2022

RISE–SET CHART

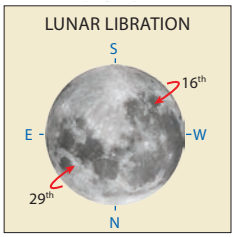


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mercury and Venus close.
- Mercury, Venus and the Moon together.
- Mars at opposition.
- Jupiter and Moon close.
- Comet C/2017 K2 (PANSTARRS) deep in the southern skies.

THE MOON



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

8th 2 pm (Noon WST) Full Moon.

12th 10 am (8 am WST) Moon at apogee (furthest from Earth at 405,869 km).

16th 7 pm (5 pm WST) Last Quarter.

16th 11 pm (9 pm WST) Maximum Libration (8.0°), bright SW limb.

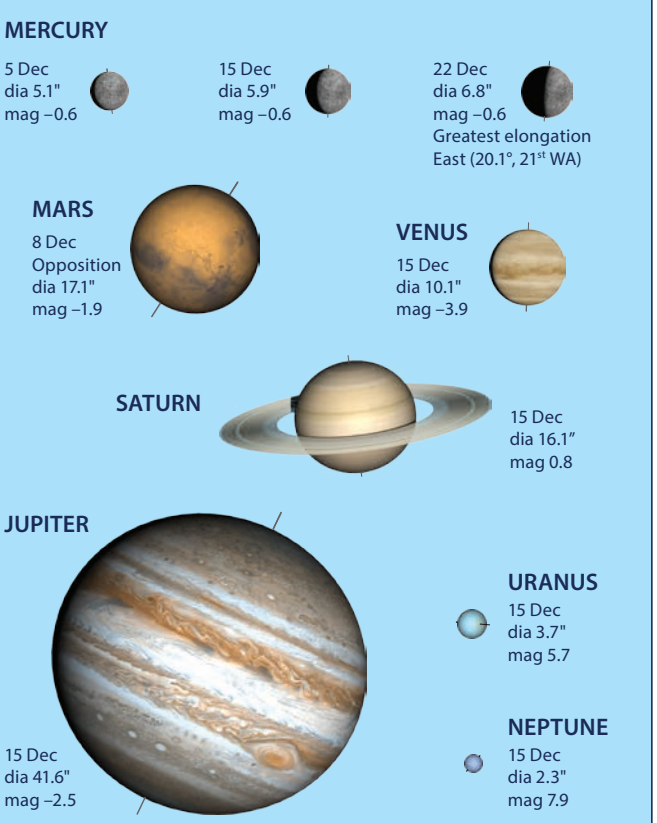
23rd 8 pm (6 pm WST) New Moon.

24th 6 pm (4 pm WST) Moon at perigee (closest to Earth at 358,270 km).

29th 4 am (2 am WST) Maximum Libration (8.5°), bright NE limb.

30th 11 am (9 am WST) First Quarter.

APPEARANCE of the PLANETS



THE PLANETS

Mercury is visible the entire month in the western twilight sky. Venus is never too far from Mercury during the month—closest at less than 2° on the 28th to 30th (see Sky View). On the 24th these planets have a impressive encounter with the Moon (see Venus below). In either conjunction, if you have trouble seeing the planet in the bright sky, try looking for brilliant Venus in binoculars, this elusive little one will be in the same field. Mercury reaches its greatest elongation of 20° east of the Sun on the 22nd.

Venus appears just a few degrees above the horizon in the western evening dusk, early in the month. The best viewing time is toward the end of December, after it gains a little altitude. Christmas Eve has a pleasant view in store when the very thin crescent Moon (1-day old) is 4° to the left of Venus low in the early twilight sky. Mercury is to the upper right of Venus a similar distance, with all three fitting in a 7° circle (see Sky View)—binoculars will help. Venus and Mercury have a close encounter on the 28th to 30th when they appear less than 2° apart (see Sky View).

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

Mars rises in the early eastern evening sky in Taurus. Coming to opposition on the 8th, its closest approach to our planet occurs on the 1st. The timing of opposition and closest approach can vary by up to two weeks due to the orbits of Mars and Earth being eccentric and inclined to each other. Its northerly declination of +25° puts it low in the sky from mid-latitude Australian skies, favouring Northern Hemisphere observers—but that's okay, as it's always high in the sky south of the equator during the best oppositions.

The Red Planet can be a delight for the casual or serious observer at any time. Being the only planet where amateurs can observe surface detail makes it more Earth-like than all the others. Due to this relatively unfavourable opposition, visual observers will need good optics, steady seeing, and patience to bring out the best of Mars. Those using modern CCD technology can produce good images for months on either side of opposition. On the 8th, Mars rises with the Full Moon around 4° below.

Jupiter stands out brilliantly in the north-western sky at the end of evening twilight this month. The gas giant has two visits by the Moon, on the 2nd by the 9-day old waxing gibbous Moon, and on the 29th by the 7-day old waxing crescent Moon—the last is the closest, only 1° from the lunar limb around 11 pm EST (9 pm WST). See Sky Views November and December.

Saturn, in Capricornus, is visible in the early western evening sky, setting around 11 pm mid-month. Although not really close, the 4-day old waxing crescent Moon to Saturn's south (left), makes a pleasant summer evening view on the 26th (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 pm mid-month.

Neptune, in Aquarius, comes to the end of five months in retrograde motion on the 4th and appears in the early north-western evening sky at the end of astronomical dusk.

DIARY			
Thu	1st		Mercury 0.2° S of star Theta Ophiuchi.
Thu	1st	1 am	(11 pm WST, prev day) First Quarter Moon.
Thu	1st	11 pm	(9 pm WST) Neptune 3° N of Moon.
Fri	2nd	9 pm	(7 pm WST) Jupiter 5° W of Moon.
Fri	2nd	pm	Phoenicids meteor shower, Nov 28 to Dec 9, Moon affected.
Sat	3rd	pm	m.p. 324 Bamberga 1.0° SE of star Algol (Beta Persei).
Sun	4th	pm	Mars 1.2° N of NGC 1746 (OC) in Taurus.
Tue	6th	1 am	(11 pm WST, prev day) Uranus 2° E of Moon.
Wed	7th		Comet C/2017 K2 (PANSTARRS) 0.4° W of star Beta Arae.
Thu	8th		Mercury 0.3° NW of NGC 6553 (GC) in Sagittarius.
Thu	8th	am	Puppid-Velids meteor shower, Dec 1–15, Moon affected.
Thu	8th	2 am	(Midn WST, prev day) star Aldebaran 9° SE of Moon.
Thu	8th	2 pm	(Noon WST) Full Moon (400,239 km).
Thu	8th		Mars at opposition.
Thu	8th	9 pm	(7 pm WST) Mars 4° SW of Moon.
Fri	9th		Comet C/2017 K2 (PANSTARRS) 0.3° E of star Gamma Arae.
Sun	11th		Mercury 1.0° SE of M28 (GC) in Sagittarius.
Sun	11th		Mercury 0.2° S of star Lambda Sagittarii.
Sun	11th	11 pm	(9 pm WST) star Pollux 4° W of Moon.
Mon	12th		Mercury 0.7° E of NGC 6638 (GC) in Sagittarius.
Mon	12th		d.p. 1 Ceres 0.1° N of NGC 4124 (G) in Virgo.
Mon	12th	10 am	(8 am WST) Moon at apogee (furthest from Earth at 405,869 km).
Mon	12th	pm	m.p. 324 Bamberga 0.3° E of star Rho Persei.
Wed	14th	pm	Geminids meteor shower, Dec 4–17, Moon affected.
Thu	15th	1 am	(11 pm WST, prev day) star Regulus 6° SW of Moon.
Fri	16th		d.p. 1 Ceres 0.6° S of NGC 4178 (G) in Virgo.
Fri	16th	7 pm	(5 pm WST) Last Quarter Moon.
Fri	16th	11 pm	(9 pm WST) Maximum Libration (8.0°), bright SW limb.
Mon	19th	3 am	(1 am WST) star Spica 4° SW of Moon.
Tue	20th	pm	Saturn 1.5° NW of star Gamma Capricorni.
Thu	22nd		Mercury at greatest elongation East (20.1°).
Thu	22nd		Solstice.
Thu	22nd		star Aldebaran 8° S of Mars.
Fri	23rd	8 pm	(6 pm WST) New Moon.
Sat	24th	6 pm	(4 pm WST) Moon at perigee (closest to Earth at 358,270 km).
Mon	26th	9 pm	(7 pm WST) Saturn 6° NE of Moon.
Wed	28th		d.p. 1 Ceres 0.1° NW of IC 3318 (G) in Virgo.
Wed	28th	9 pm	(7 pm WST) Neptune 7° NE of Moon.
Thu	29th	4 am	(2 am WST) Maximum Libration (8.5°), bright NE limb.
Thu	29th	9 pm	(7 pm WST) Jupiter 1.5° N of Moon.
Thu	29th	pm	Venus 1.5° S of Mercury.
Fri	30th		d.p. 1 Ceres 0.3° N of NGC 4417 (G) in Virgo.
Fri	30th	11 am	(9 am WST) First Quarter Moon.
Sat	31st	3 am	(1 am WST) d.p. 1 Ceres 0.05° E of NGC 4442 (G) in Virgo.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Commencing mid-month, d.p. 1 Ceres enters the Virgo cluster of galaxies. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
2 Dec	349 Dembowska	Taurus	9.6
3 Dec	532 Herculina	Taurus	10.0
20 Dec	121 Hermione	Taurus	11.9
20 Dec	129 Antigone	Orion	12.0

COMETS

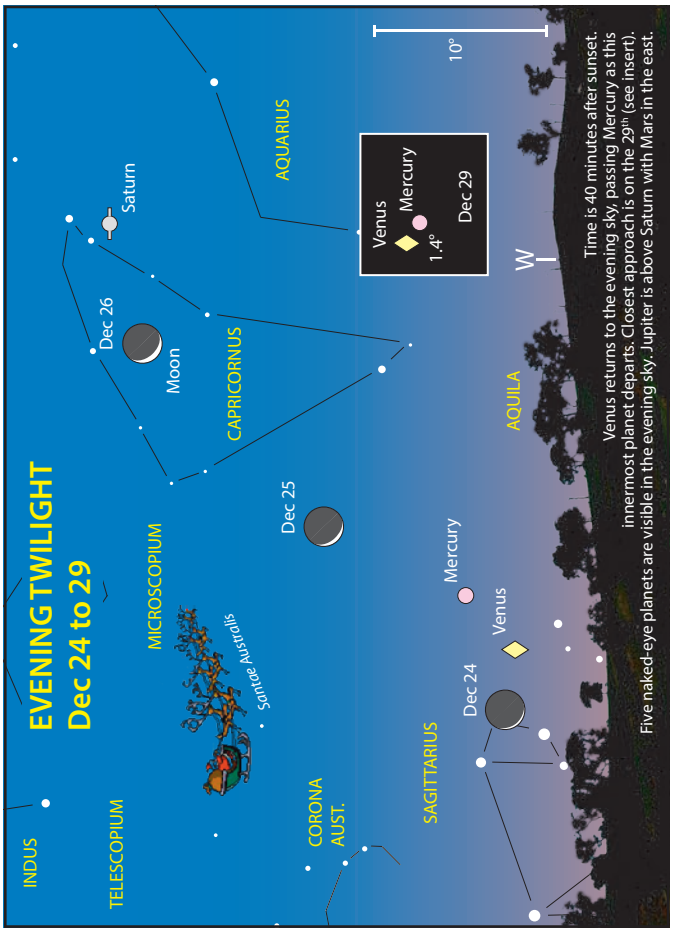
Comet 81P/Wild 2, at about 11th magnitude, commences the month in Virgo, rising before dawn. It crossed into Libra late last month and by now, it is rising at around 1 am.

Comet C/2017 K2 (PANSTARRS) reaches perihelion on 20 December, at 1.8 au from the Sun, well outside the orbit of Mars. Predicted to brighten from 9th to 8th magnitude by the end of the month, PANSTARRS is in Ara initially, before moving into Pavo mid-month. The comet is visible until late in the evening, and again before dawn. By the second week of December, it is above the horizon all night (circumpolar), although it will be just above the southern horizon in the middle of the night.

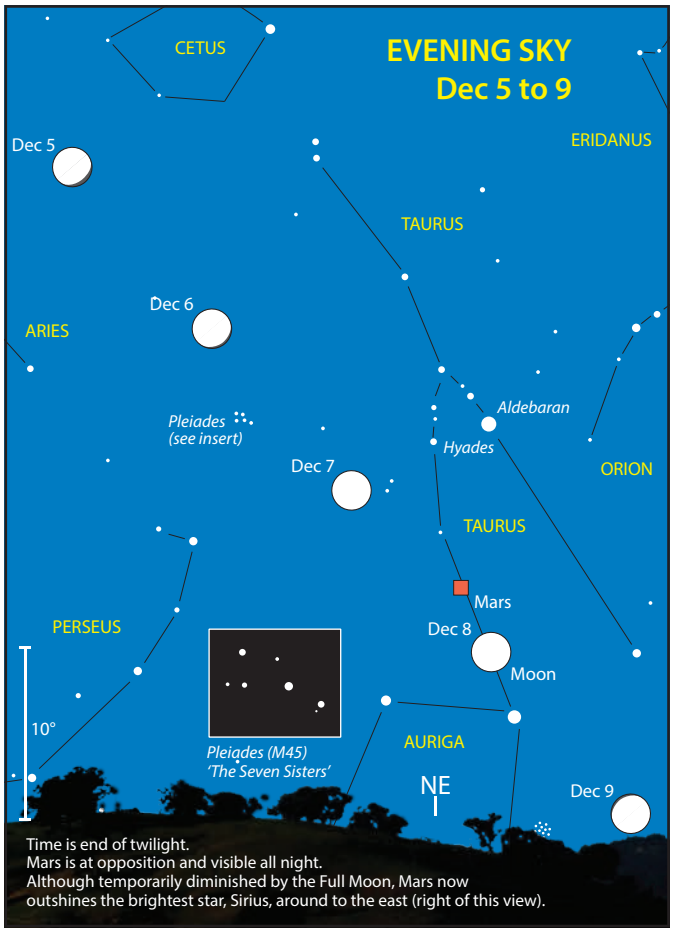
DOUBLE STARS

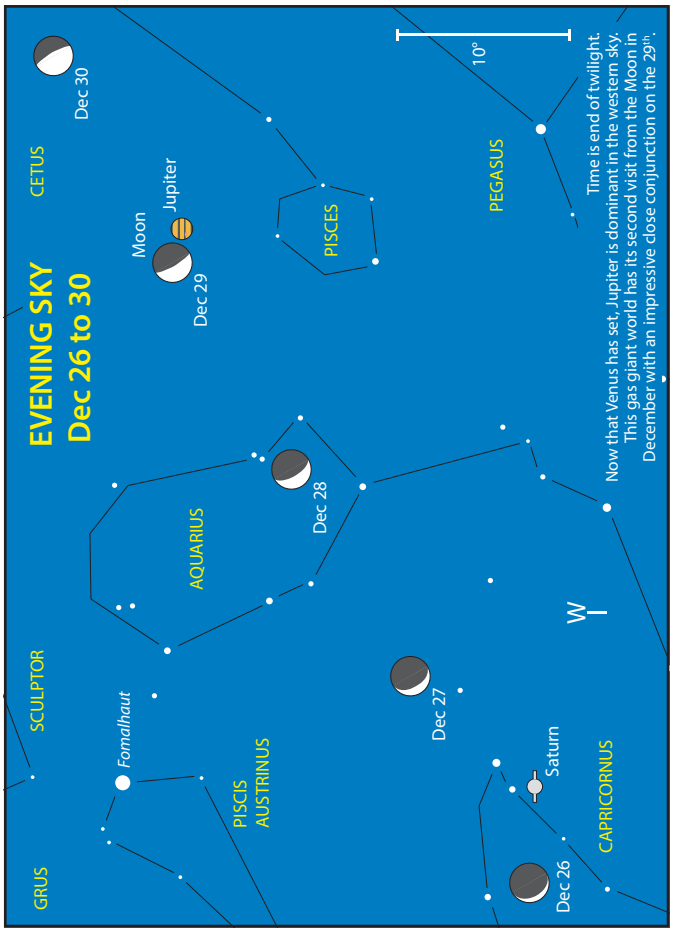
This month's binocular pair is an Orion belt star. Located 1,200 light-years from the Sun, **Delta (δ) Orionis** (Mintaka, STFA 14AC) is a lovely pair of magnitude 2.4 and 6.8 stars separated by 56 arcseconds. The stars look bluish and violet through binoculars. This is a very interesting complex multiple star system. The primary A component is itself a triple system. The class O9.5 bright giant star and class B main-sequence star orbit each other every 5.73 days and exhibit shallow eclipses when the star dims by about 0.2 magnitude. There is a B-class sub-giant located 0.3 arcseconds away (HEI 42Aa,Ab). At the primary eclipse, the apparent magnitude (of the whole system) drops from 2.23 to 2.35, while it only drops to 2.29 at the

Continued on page 17



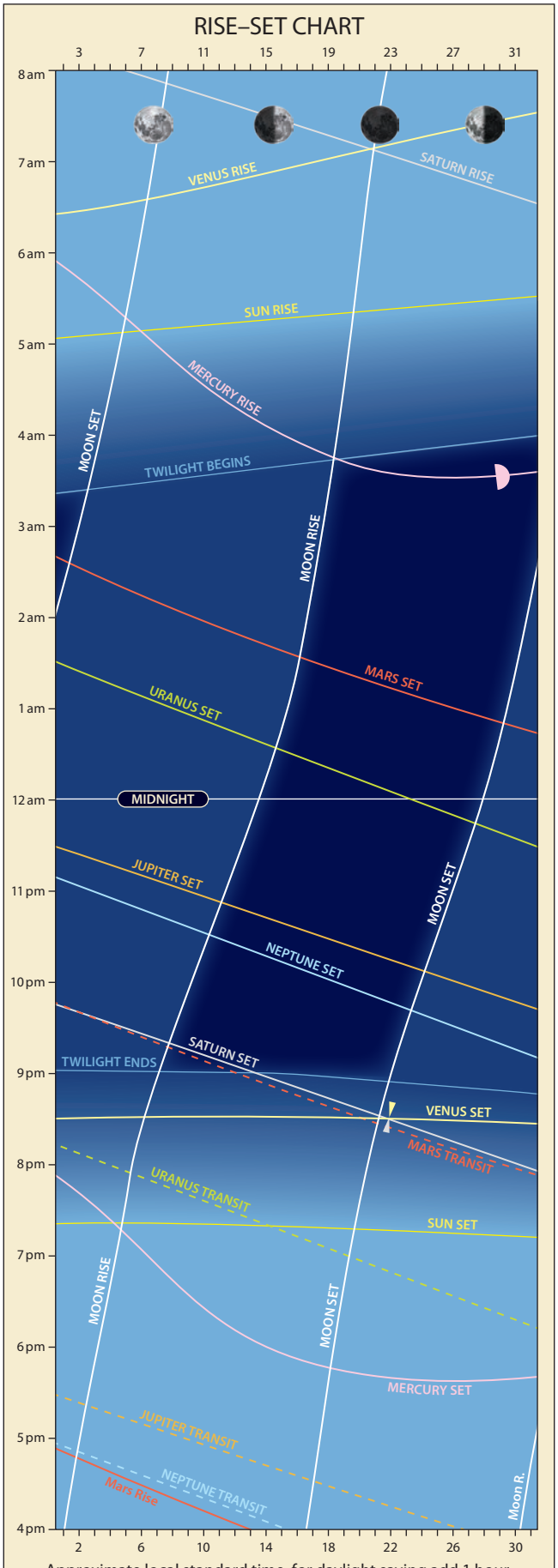
Approximate local standard time, for daylight saving add one hour.





JANUARY 2023

RISE–SET CHART

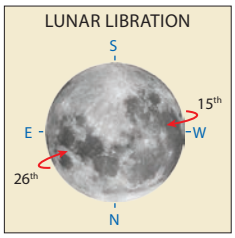


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mercury at best in the morning.
- Venus, Saturn, and Moon close.

THE MOON



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

8th 7 pm (5 pm WST) Moon at apogee (furthest from Earth at 406,458 km).

15th Noon (10 am WST) Last Quarter.

15th 10 pm (8 pm WST) Maximum Libration (7.8°), bright SW limb.

22nd 7 am (5 am WST) Moon at perigee (closest to Earth at 356,569 km).

22nd 7 am (5 am WST) New Moon.

26th 11 pm (9 pm WST) Maximum Libration (8.1°), bright NE 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 (Border Sea) east of Mare Crisium (Sea of Crises) appear as dark elongated regions along the limb.

29th 1 am (11 pm WST, previous day) First Quarter.

APPEARANCE of the PLANETS

MERCURY

Mercury in inferior conjunction on the 7th

1 Jan
dia 9.0"
mag 1.3

18 Jan
dia 8.7"
mag 0.5

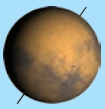
30 Jan
dia 6.8"
mag –0.2

Greatest elongation West (25°)

VENUS

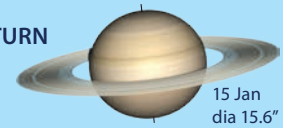
15 Jan
dia 10.7"
mag –3.9

MARS



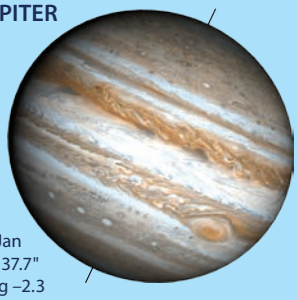
15 Jan
dia 12.8"
mag –0.8

SATURN



15 Jan
dia 15.6″
mag 0.8

JUPITER



15 Jan
dia 37.7"
mag –2.3

URANUS

15 Jan
dia 3.7"
mag 5.7

NEPTUNE

15 Jan
dia 2.9"
mag 7.9

THE PLANETS

Mercury departs the evening dusk as it moves into inferior conjunction (between Earth and the Sun) on the 7th. Its return to the morning sky in Sagittarius later this month heralds the beginning of the best period to see the planet in the morning sky. On the 30th, this world reaches its greatest elongation, 25° west of the Sun (see Sky View).

Venus is very bright in the western evening sky from the beginning of the year to early August when it becomes too close to the Sun for observation. As Venus gains altitude in the twilight, it passes planet Saturn heading toward its solar conjunction. On the 22nd and 23rd, the planetary duo will be less than 1° apart—as a bonus, on the 23rd, they're joined by the slender crescent of the 2-day old waxing Moon (see Sky View). You will need to observe these events about 45 minutes after sunset, before true astronomical twilight. Binoculars will help here, as the objects will be at a very low altitude.

The **Earth** is at perihelion on the 5th, the closest point in its orbit to the Sun (147,098,917 km or 0.983296 au distant).

Now past opposition, **Mars**, in Taurus, is evident in the mid-evening northern sky as a bright golden orange *star* shining at magnitude –1.2 early in the month. Last December, the planet's angular diameter was just over 17 arcseconds at its closest approach. By the end of this month, it decreases to 11 arcseconds, a tiny target for visual observers. On the 13th, Mars ends 2.5 months of retrograde motion and resumes its west to east track against the starfield. The Red Planet has two visits by the waxing gibbous Moon this month; on the 3rd, the 12-day old Moon appears within 5°, and again on the 31st when it will be around 3° (see Sky Views). Do not confuse Mars with the nearby 1st magnitude star, Aldebaran. This is the alpha star of Taurus and marks the bull's red eye; Mars itself is considerably brighter.

Jupiter begins the year in the early western evening sky in Pisces. At a little over –2 magnitude, it is the brightest object in a region devoid of bright stars. On the 26th, the 5-day old waxing crescent Moon appears 4° from the planet (see Sky View).

Saturn, in Capricornus, is low in the western evening sky early in the month. With its solar conjunction in mid February, it becomes more difficult to find in the brightening sky as the month progresses. If you have an excellent western horizon, you may like to attempt to observe the planet when Venus is close on the 22nd and 23rd, as detailed in the Venus section (see Sky View).

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 ends four months of retrograde motion on the 23rd and then resumes its west to east drift against the stellar background.

Neptune is visible at the beginning of the year, low in the western evening sky in Aquarius. However, it becomes too close to the Sun for observation by late February and reappears in early April in the eastern morning sky.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet 1 Ceres opens the year travelling through the Coma-Virgo cluster of galaxies. Being ably assisted by retrograde motion, Ceres remains amongst the galaxies up until the end of July. Keep an eye on the monthly diaries as there are many close approaches coming. Spending much of the time around 7th to 8th magnitude it will be hard to miss and undoubtedly will produce a few false supernovae alerts. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
3 Jan	12 Victoria	Gemini	11.1
4 Jan	64 Angelina	Gemini	10.3
5 Jan	43 Ariadne	Gemini	11.2
9 Jan	2 Pallas	Canis Major	7.8
22 Jan	25 Phocaea	Monoceros	12.5
25 Jan	89 Julia	Cancer	10.4
26 Jan	6 Hebe	Cancer	8.7

COMETS

Comet 81P/Wild 2 spends the month in Libra around 10th magnitude, rising in the eastern sky just after midnight. In mid-January, it is near maximum brightness and can be seen crossing the kite shaped asterism of Libra.

Following perihelion in mid-December, January opens with **Comet C/2017 K2 (PANSTARRS)** in the far south and also circumpolar at 8th magnitude for the month, beginning in Pavo then Indus from the 24th. It is low in the south at the beginning of January, getting higher by the end, in either dawn or evening twilight.

Comet C/2020 K1 (PANSTARRS) is in Sagittarius at 12th magnitude, rising in the south-eastern sky shortly before sunrise. By month's end it has brightened slightly and rising about an hour before dawn. The comet crosses the Teapot of Sagittarius this month. It has some nice conjunctions with bright stars and star clusters in January (see Diary).

Comet C/2022 E3 (ZTF) is only briefly visible each day as it rises in the north-eastern sky before sunrise. ZTF reaches perihelion mid-month, continuing to move northward and is briefly lost from mid-latitude Australian skies. The comet returns next month.

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 the time spent waiting.

The **Quadrantids** are a strong and consistent northern shower. They are difficult for southern observers, with the radiant 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 26 to January 12, with up to 40

Astrology — the First Astronomers

Yes, you read the heading correctly, but before returning this book to where you purchased it, please indulge us.

What do the constellations of Cancer, Pisces, Libra, and Aquarius have in common? You may reply, they all consist of faint, uninteresting groupings of stars and are invisible from suburbia. Well, we don't disagree with you and they, like most constellations, certainly don't resemble the objects they are supposed to represent either. However, they belong to a particular set of constellations, those that the Sun passes through on its annual movement across the sky. This path is called the ecliptic (marked on the All Sky Maps).

The astrological signs do not corresponded precisely with the astronomical constellations. For example, the signs break the ecliptic into 12 equal sections of sky, each of which is 30° in longitude along the ecliptic (which takes the Sun approximately a month to cover). When we look at today's official constellation boundaries, the Sun spends only a week in Scorpius, around six weeks in Virgo and three weeks in Ophiuchus which should have followed Scorpius but never was made a sign. But what about the borders of these 'signs', they extend 8° above and below the Sun's path (hence, 12 equal areas). This keeps the Moon approximately within a sign all the time. Incidentally, for the purpose of astrology the Moon, and even the Sun, are considered *planets*.

This article is not a criticism of astrology, but more spelling out the differences between astronomy and astrology. A bit like how science cannot be used to disprove God (whichever version) or in this case, astronomy disprove astrology. They are just different. Astrology and religions are belief systems which are effectively non-falsifiable. For those non-sceptics, this means there is no test known (or perhaps even possible?) that would disprove a concept. By religions, we include all the gods, including those that used to be worshiped by the ancient Mediterranean and Middle East cultures, responsible for the mythological figures immortalized in today's constellations.

Credit Vedicgrace Foundation © 2012–2016, vedicgrace.com

Several well-known astronomers in history have dabbled in astrology. Galileo certainly made a study, although in his time it was considered a legitimate part of astronomy and mathematics. Ptolemy might have been famous for his Almagest, but he also wrote the *Tetrabiblos* (four books) which was treated by the astrologers of the first millennium CE to be *the* astrological bible. Tycho Brahe was believed to do horoscopes for many famous people of his time. To be fair to all these scholars, this doesn't mean they all believed in astrology. In trying to understand the Solar System they certainly recorded the movement of the planets (wandering stars) amongst the stars, so why not use these to do astrological readings? Often this gave a much better income than the pure science.

It might surprise some that Ptolemy, through his Tetrabiblos (second Century CE), was very much responsible for the adoption of the current version of astrology followed in western societies. This in turn had continued the previous Hellenistic period views held in Mediterranean countries and Egypt dating to the first Century BCE, which was picked up from Babylonian astrology (second Century BCE). Note, as mentioned in the constellation sections, many of the mythologies arising from Greek and adopted by the Romans had their origins in Babylon. So, there is no surprise that ancient astronomy and astrology share common terminology, even dating from the same eras.

Today's western astrology can be broken down into two camps, the Sun Sign and horoscopic versions. Sun Sign astrology is based purely on which of the traditional zodiacal constellations (not the astronomical definitions of their boundaries), that the Sun was *in* on the day you were born.* This is the version popular in newspapers. It firstly allocates broad personality traits into the 12 signs (like Cancerians are home bodies) and then makes predictions for the future (normally, short-term) of each, based upon where the planets lie within the Zodiac now. Because the planets, including the Sun, move so slowly, the day-to-day variations (which may determine whether it is worthwhile getting out of bed in the morning) is heavily dictated by the Moon, which moves quickly in the sky.

The horoscopic or horoscope type, delves deeper into defining the individual's traits considering where celestial bodies were located at the exact time of your birth. This is your 'birth chart' which to some extent includes predicting your destiny.

Astrologers have clearly defined methods on how to create such charts, but the problem is the validity of their initial assumptions to start with. From a scientific basis, it has never been demonstrated how the arrangement of these distant bodies can influence individuals' characteristics. Normally a force needs to be first defined, which never has been—it's certainly not gravity.

This year's 'constellations' in the Monthly sections will follow those that have been immortalized in astrology. We

meteors per hour at their peak. For the eastern states, observers have a narrow window of opportunity between moonset (2:15 am) and the beginning of twilight (4 am). From Central and Western Australia, there will be Moon and twilight interference.

CONSTELLATIONS

As mentioned, in the article (left), the monthly constellations section this year will concentrate on the traditional members of the Zodiac. For convenience, we have selected the zodiacal constellation which is closest to due north around 9 pm local time during the month. A much more convenient time to observe, especially for young people. As a general comment, many of the constellations are faint and difficult to see under light polluted skies—it is well worth travelling into the country on a moonless night. It can be amazing what even humble binoculars will show.

January's constellation is Taurus the Bull (All Sky Map No. 3). The most noticeable marker is its alpha star, Aldebaran, located on the eastern edge of the brilliant Hyades star cluster. Only binoculars are needed to see this grouping at its best. The most brilliant members form the naked-eye 'V' shaped face of the bull. Approximately 6° in diameter, the cluster fills the field of low power binoculars with over 100 stars. Mostly hot blue in colour, four of the brightest members, Epsilon (ε), Delta^{1} (δ^{1}), Gamma (γ) and Theta^{1} (θ^{1}) Tauri are noticeably yellow. In particular, Theta^{1} contrasts well with its white companion star, Theta^{2}, an impressive 3.8 and 3.4 magnitudes respectively, six arcminutes apart. Another striking double is Sigma^{1} and ^{2}, with both white and nearly matching 5th magnitude stars, 8 arcminutes apart. Its 1st magnitude alpha star, Aldebaran (the bull's right eye), is distinctly yellow/orange in colour being a cooler K class giant star. Interestingly, Aldebaran is not a member of the Hyades, being a foreground object (65 light-years away) compared to the cluster at 147 light-years distant.

From the Southern Hemisphere, the face is well tilted, and the horns can easily be missed. The tip of the left horn is marked by Beta Tauri (Elnath). Beta is the brightest star closest to the galactic anti-centre, the point in the heavens directly opposite the centre of the Milky Way. From Elnath looking towards Sagittarius, our home star is reduced to a binocular object (7.8 magnitude) embedded in a star rich galactic field, looking quite ordinary. The other 'horn' star is Zeta (ζ) Tauri (also naked-eye), whose claim to fame is being the gateway to the Crab Nebula M1, the brightest supernova remnant in the sky and the most accessible to the amateur. This slightly oval shaped (4 × 5 arcminutes) hazy patch is easy to find, only one degree from Zeta. The larger the telescope, the more filaments and mottling that can be glimpsed, especially using averted vision.

can't practically cover the specific constellations where the Sun resides in each month of interest, but instead, chose that which is due north (culminating or crossing the meridian) around 9 pm in the current month.

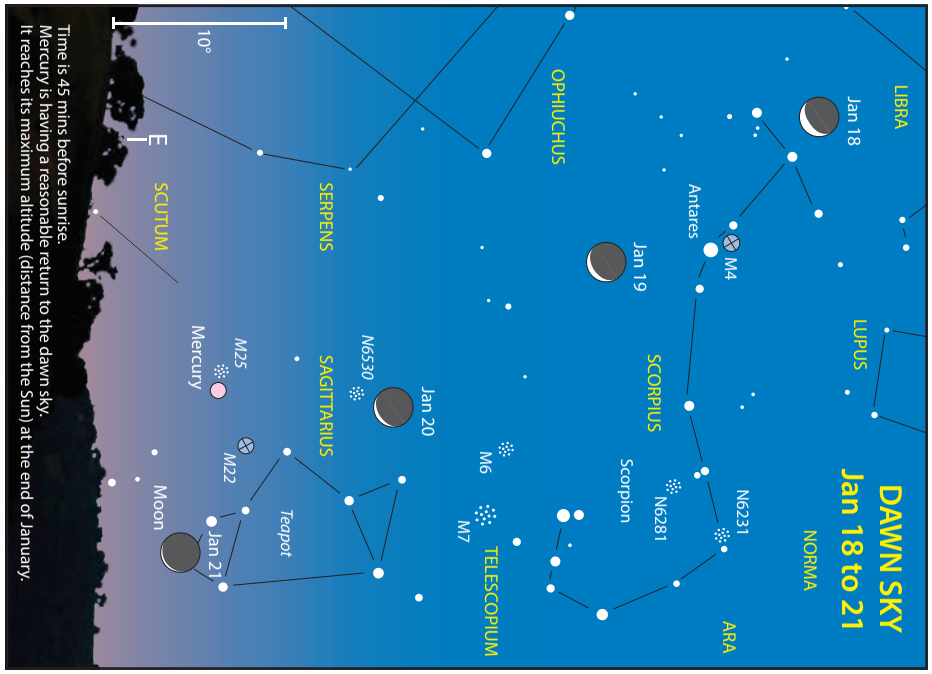
* Your astrological sign is based on where the Sun resided when this system was invented, some 3,000 years ago, not today! The wobbling of the Earth on its axis over a period of around 26,000 years (called precession) has seen a change in the signs, around every 2,100 years (26,000 divided by 12 signs). At the time astrology was created, the traditional start of the year was when the Sun crossed the vernal equinox (Northern Hemisphere). This was the 'First Point of Aries', which now resides in Pisces (the age of Pisces) and will then move into Aquarius. For those who can remember the sixties, this will be the "dawning of the age of Aquarius". Within astrology circles there appears to be no clear definition of when this will occur!

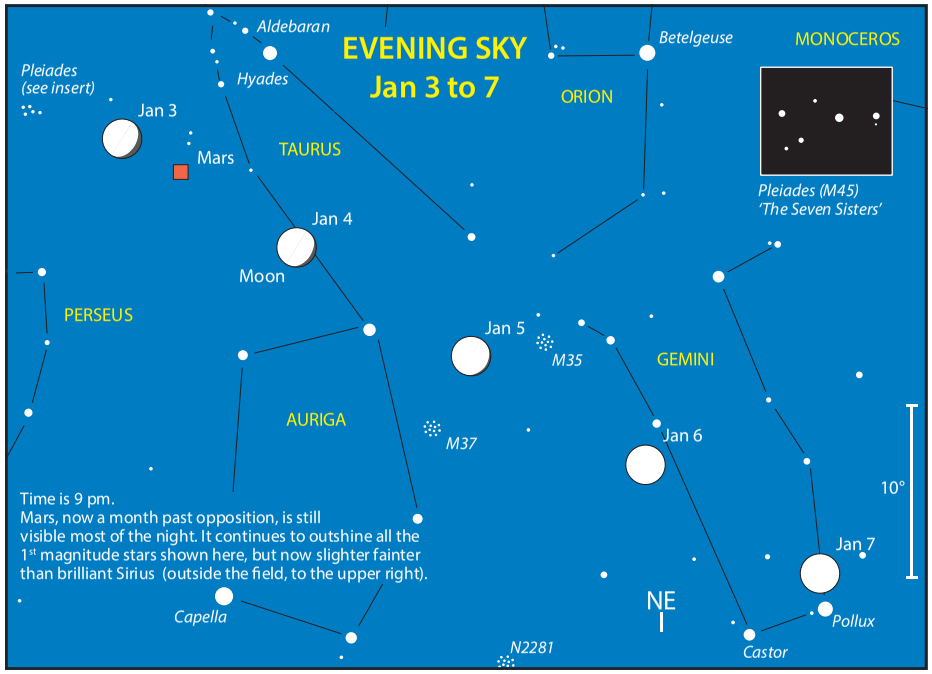
DIARY			
Sun	1st		Comet C/2020 K1 (PANSTARRS) 0.3° S of M28 (GC) in Sagittarius
Sun	1st		d.p. 1 Ceres 0.3° E of NGC 4442 (G) in Virgo
Sun	1st	Midn	(10 pm WST) Uranus 5° E of Moon
Sun	1st	pm	m.p. 2 Pallas 1.2° NE of star Kappa Canis Majoris
Mon	2nd		Saturn 1.3° N of star Gamma Capricorni
Mon	2nd	am	Comet C/2017 K2 (PANSTARRS) 0.3° E of NGC 6684 (G) in Pavo
Tue	3rd		Comet C/2020 K1 (PANSTARRS) 0.3° SW of star Lambda Sagittarii
Wed	4th	am	Quadrantids meteor shower, Jan 1–5, Moon affected until about 2 am.
Wed	4th	1 am	(11 pm WST, prev day) Mars 3° E of Moon
Thu	5th		Comet C/2020 K1 (PANSTARRS) 0.5° SW of NGC 6638 (GC) in Sagittarius
Thu	5th		Earth at perihelion, 0.983295578 au
Fri	6th		d.p. 1 Ceres 1.0° N of NGC 4519 (G) in Virgo
Sat	7th	9 am	(7 am WST) Full Moon (405,791 km).
Sat	7th		Mercury in inferior conjunction
Sun	8th	7 pm	(5 pm WST) Moon at apogee (furthest from Earth at 406,458 km).
Mon	9th		Pallas at opposition
Wed	11th		d.p. 1 Ceres 0.2° N of NGC 4578 (G) in Virgo
Sun	15th	am	d.p. 1 Ceres 0.3° S of NGC 4596 (G) in Virgo
Sun	15th	Noon	(10 am WST) Last Quarter Moon.
Sun	15th	10 pm	(8 pm WST) Maximum Libration (7.8°), bright SW limb.
Sun	15th	pm	m.p. 64 Angelina 1.2° S of star Epsilon Geminorum
Mon	16th	3 am	(1 am WST) Comet 81P/Wild 2 1.0° S of NGC 5878 (G) in Libra
Tue	17th		Comet C/2020 K1 (PANSTARRS) 1.0° SW of star Phi Sagittarii
Tue	17th	am	d.p. 1 Ceres 0.2° S of NGC 4608 (G) in Virgo
Wed	18th		Mercury 1.0° S of M25 (OC) in Sagittarius
Wed	18th	9 pm	(7 pm WST) m.p. 4 Vesta 5° S of Neptune
Wed	18th	pm	Comet C/2017 K2 (PANSTARRS) 1.0° SW of IC 5052 (G) in Pavo
Thu	19th		Saturn 1.4° N of star Delta Capricorni
Sun	22nd	7 am	(5 am WST) Moon at perigee (closest to Earth at 356,569 km).
Sun	22nd	7 am	(5 am WST) New Moon.
Sun	22nd	8 pm	(6 pm WST) Saturn 0.5° NE of Venus
Mon	23rd	8 pm	(6 pm WST) Saturn 3° N of Moon
Mon	23rd	8 pm	(6 pm WST) Venus 3° N of Moon
Wed	25th	8 pm	(6 pm WST) Neptune 2° NW of Moon
Thu	26th	8 pm	(6 pm WST) Jupiter 3° W of Moon
Thu	26th	11 pm	(9 pm WST) Maximum Libration (8.1°), bright NE limb.
Sat	28th		Comet C/2020 K1 (PANSTARRS) 0.8° N of M54 (GC) in Sagittarius
Sun	29th	1 am	(11 pm WST, prev day) First Quarter Moon.
Sun	29th	9 pm	(7 pm WST) Uranus 4° SW of Moon
Mon	30th		Mercury at greatest elongation West (25.0°)
Tue	31st	9 pm	(7 pm WST) Mars 3° SW of Moon

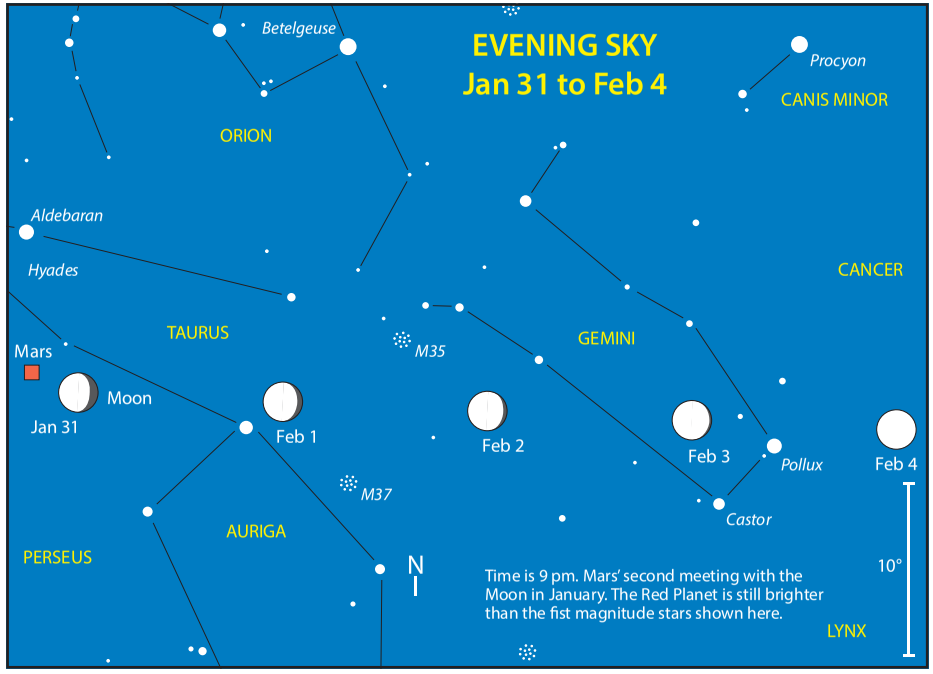
The Hyades are impressive, but Taurus is fortunate to have another brilliant naked-eye star cluster, the Pleiades, M45. It has six main stars ranging from magnitude 2.8 to 4.3, fitting within a 1° diameter circle. Through binoculars it's breath-taking, easily revealing a couple of dozen stars out to 1° from the centre, with the brightest members an obvious blue colour.

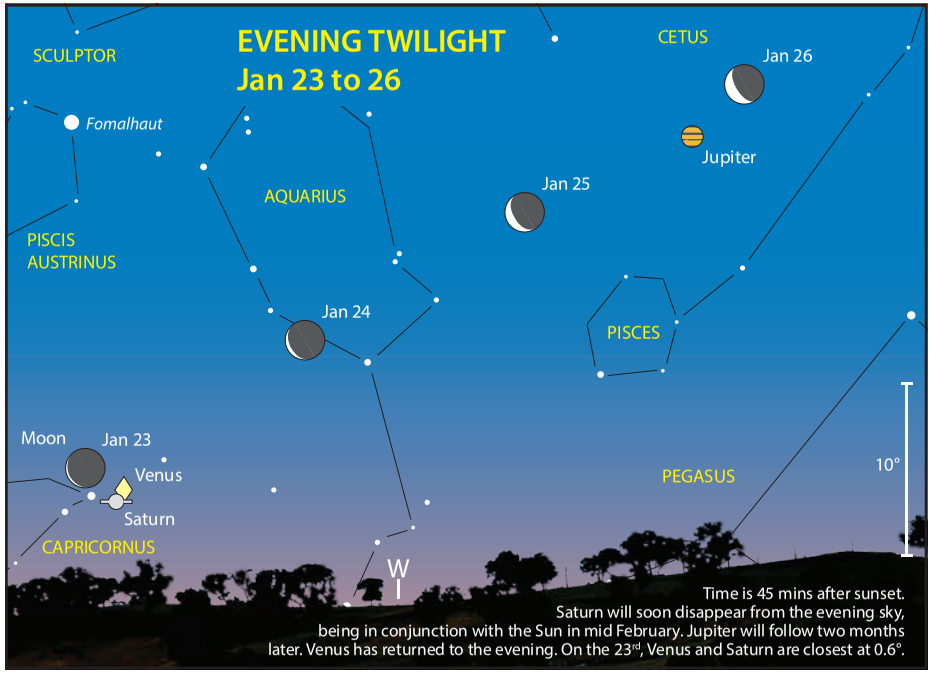
Right, a large portion of the Hyades cluster, credit Giuseppe Donatiello

Below, the Pleiades (M45) in Taurus





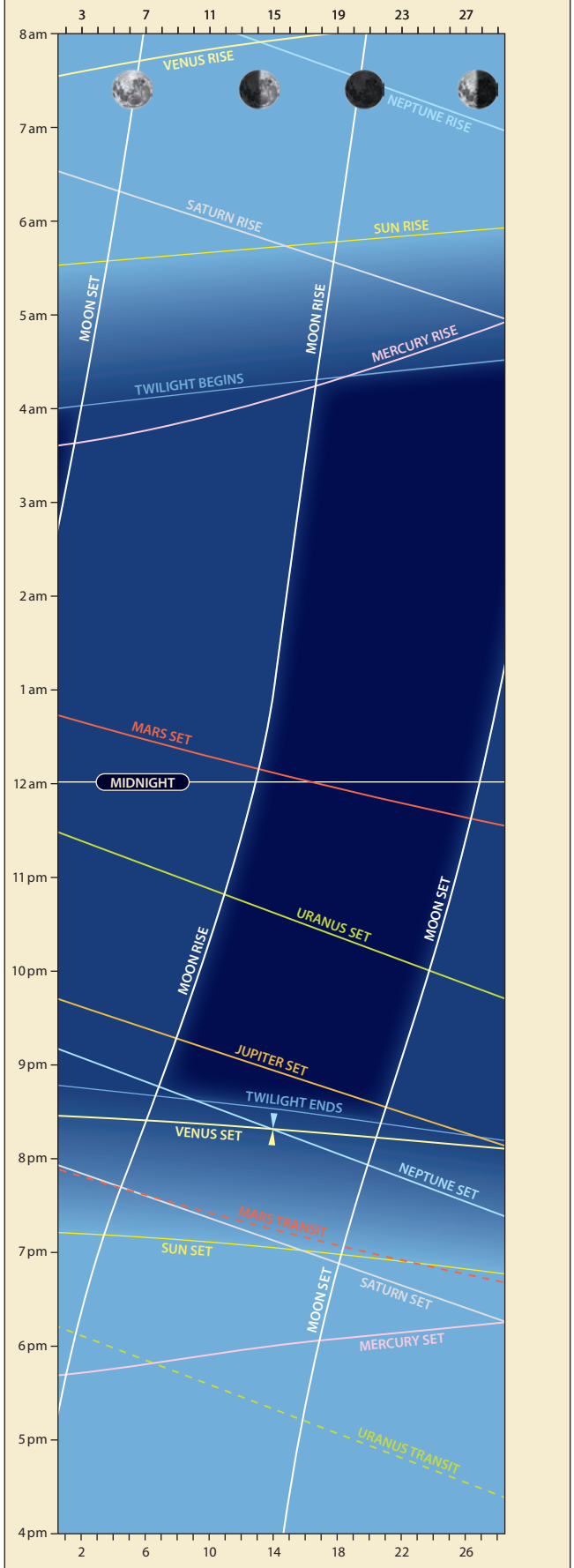




Approximate local standard time, for daylight saving add one hour.

FEBRUARY 2023

RISE–SET CHART

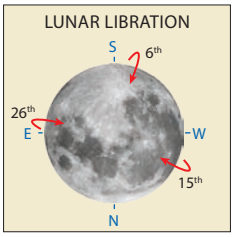


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mercury and Moon close.
- Venus and Jupiter close.
- Venus and Moon close.
- The alpha-Centaurids meteor shower.

THE MOON



4th 7 pm (5 pm WST) Moon at apogee (furthest from Earth at 406,476 km).

6th 4 am (2 am WST) Full Moon.

6th 9 pm (7 pm WST) Maximum Libration (6.6°), bright SW limb.

14th 2 am (Midnight WST, previous day) Last Quarter.

15th 9 am (7 am WST) Maximum Libration (7.8°), bright NW limb.

19th 7 pm (5 pm WST) Moon at perigee (closest to Earth at 358,267 km).

20th 5 pm (3 pm WST) New Moon.

26th 1 am (11 pm WST, previous day) Maximum Libration (7.3°), 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 (Border Sea) east of Mare Crisium (Sea of Crises) appear as dark elongated regions along the limb.

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

APPEARANCE of the PLANETS

MERCURY

5 Feb
dia 6.2"
mag –0.1

15 Feb
dia 5.5"
mag –0.2

25 Feb
dia 5.1"
mag –0.4

VENUS

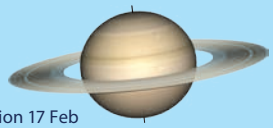
15 Feb
dia 11.6"
mag –3.9

MARS

15 Feb
dia 9.3"
mag 0.1

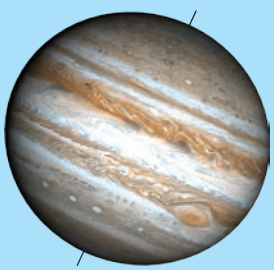
SATURN

1 Feb
dia 15.5"
mag 1.0
Conjunction 17 Feb



JUPITER

15 Feb
dia 35.0"
mag –2.1



URANUS

15 Feb
dia 3.6"
mag 5.8

NEPTUNE

15 Feb
dia 2.2"
mag 8.0

THE PLANETS

Mercury begins its descent back toward the Sun in the morning dawn this month, moving from Sagittarius into Capricornus. On the 19th, the 28-day old Moon will be less than 4° from the planet. At this time, the Moon is a very slender crescent (just 4% illuminated by the Sun), and binoculars may assist in the brightening dawn (see Sky View).

Venus is visible in the western evening twilight sky. It commences the month in Aquarius before moving into Pisces on the 16th. Neptune, the outermost planet, has a close rendezvous with Venus on the 15th, with the pair just 10 arcminutes apart. This conjunction will be almost impossible to observe, being deep in the twilight sky. On the 22nd, Venus will be just 1° from the limb of the waxing crescent of the 2-day old Moon. Lastly, Venus and Jupiter have been nearing each other during February and appear just 2° apart on the 28th, and even closer in early March (see Sky View).

Since its opposition late last year, **Mars** has gradually faded, although still the brightest object in Taurus in the early northern evening sky. Being a non-opposition year, the Red Planet offers little for the visual observer—its disc diameter decreasing in size from 10 arcseconds this month to around 4 at year's end. On the 28th, the 8-day old waxing gibbous Moon appears 3° from the planet (see Sky View).

Jupiter spends the first few days of the month in Pisces before moving into Cetus, then back into Pisces during the last week of February. Unfortunately, the planet's low altitude in the early western evening sky does not lend itself to telescopic scrutiny or imaging. However, Jupiter, Venus, and the crescent Moon make a pleasant twilight vista for the unaided eye on the 22nd and 23rd (see Sky View). Venus rises toward Jupiter throughout February for a close rendezvous at month's end (see Venus and Sky View).

Saturn will be in conjunction with the Sun on the 17th and remains hidden from view until its return to the morning skies in mid-March.

Uranus, in Aries, appears low in the early north-western evening sky after the end of astronomical twilight. The planet remains in the constellation of the Ram until it moves into Taurus (the Bull) in 2024.

Neptune, in Aquarius, opens the month very low to the western horizon after dusk. On the 15th, Venus will be a close 10 arcminutes from the outermost planet; this will be a most challenging observation. See Venus for details.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
12 Feb	654 Zelinda	Hydra	10.4
13 Feb	80 Sappho	Hydra	11.7
14 Feb	85 Io	Hydra	12.4
27 Feb	185 Eunike	Leo	11.7
27 Feb	42 Isis	Leo	11.8
28 Feb	40 Harmonia	Leo	10.0

COMETS

Comet 81P/Wild 2 spends the month at about magnitude 10, rising in the south-eastern sky around midnight. Beginning in Libra, it crosses into Scorpius on the 4th, then into Ophiuchus on the 13th. On the mornings of the 8th to 10th, the comet, still close to maximum brightness, can be found just north of IC

DIARY			
Wed	1st		Comet C/2020 K1 (PANSTARRS) 0.8° SW of star Zeta Sagittarii
Sat	4th	7 pm	(5 pm WST) Moon at apogee (furthest from Earth at 406,476 km).
Sun	5th	9 pm	(7 pm WST) star Aldebaran 8° S of Mars
Mon	6th	3 am	(1 am WST) d.p. 1 Ceres 0.05° NW of NGC 4694 (G) in Virgo
Mon	6th	4 am	(2 am WST) Full Moon (405,830 km, furthest for this year).
Mon	6th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 0.7° NE of star Epsilon Aurigae
Mon	6th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 2.7° SW of star Capella
Mon	6th	9 pm	(7 pm WST) Maximum Libration (6.6°), bright SW limb.
Wed	8th	am	alpha-Centaurids meteor shower, Jan 28 to Feb 21, Moon affected.
Wed	8th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 2.0° N of star Iota Aurigae
Fri	10th		m.p. 44 Nysa 0.3° N of star Theta Librae
Fri	10th	3 am	(1 am WST) Comet 81P/Wild 2 1.5° N of IC 4592 (BN) in Scorpius
Sat	11th		Mercury 0.9° NW of M75 (GC) in Sagittarius
Mon	13th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 0.7° NW of NGC 1647 (OC) in Taurus
Tue	14th	2 am	(Midnight WST, prev day) Last Quarter Moon.
Wed	15th	9 am	(7 am WST) Maximum Libration (7.8°), bright NW limb.
Wed	15th	7 pm	(5 pm WST) Neptune 0.2° NE of Venus
Wed	15th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 1.7° SE of star Aldebaran
Thu	16th	3 am	(1 am WST) Comet 81P/Wild 2 0.1° NE of star Chi Ophiuchi
Thu	16th	pm	m.p. 64 Angelina 1.5° NE of star Mu Geminorum
Fri	17th		Saturn in conjunction with Sun
Sun	19th	5 am	(3 am WST) Mercury 3° N of Moon
Sun	19th	7 pm	(5 pm WST) Moon at perigee (closest to Earth at 358,267 km).
Sun	19th	pm	m.p. 40 Harmonia 0.5° SW of NGC 3489 (G) in Leo
Mon	20th	5 pm	(3 pm WST) New Moon.
Wed	22nd	7 pm	(5 pm WST) Venus 1.5° N of Moon
Thu	23rd	am	Comet C/2020 K1 (PANSTARRS) 0.6° NE of star Iota Sagittarii
Thu	23rd	7 pm	(5 pm WST) Jupiter 5° SW of Moon
Sat	25th		Mars 1.5° N of NGC 1746 (OC) in Taurus
Sat	25th	8 pm	(6 pm WST) Uranus 3° SE of Moon
Sat	25th	pm	Comet C/2017 K2 (PANSTARRS) 2.0° NW of star Alpha Hydri
Sat	25th	pm	m.p. 40 Harmonia 1.0° NE of NGC 3412 (G) in Leo
Sun	26th		m.p. 32 Pomona 0.3° N of NGC 5791 (G) in Libra
Sun	26th		Mercury 0.8° NW of star Iota Capricorni
Sun	26th	1 am	(11 pm WST, prev day) Maximum Libration (7.3°), bright SE limb.
Sun	26th	pm	Comet C/2017 K2 (PANSTARRS) 3.0° SE of star Achernar
Mon	27th		Mercury 0.9° W of star Delta Capricorni
Mon	27th	3 am	(1 am WST) d.p. 1 Ceres 0.02° NW of NGC 4654 (G) in Virgo
Mon	27th	6 pm	(4 pm WST) First Quarter Moon.
Tue	28th	8 pm	(6 pm WST) Mars 3° SW of Moon
Tue	28th	11 pm	(9 pm WST) d.p. 1 Ceres 0.06° N of NGC 4639 (G) in Virgo

Robert Burnham, Jr

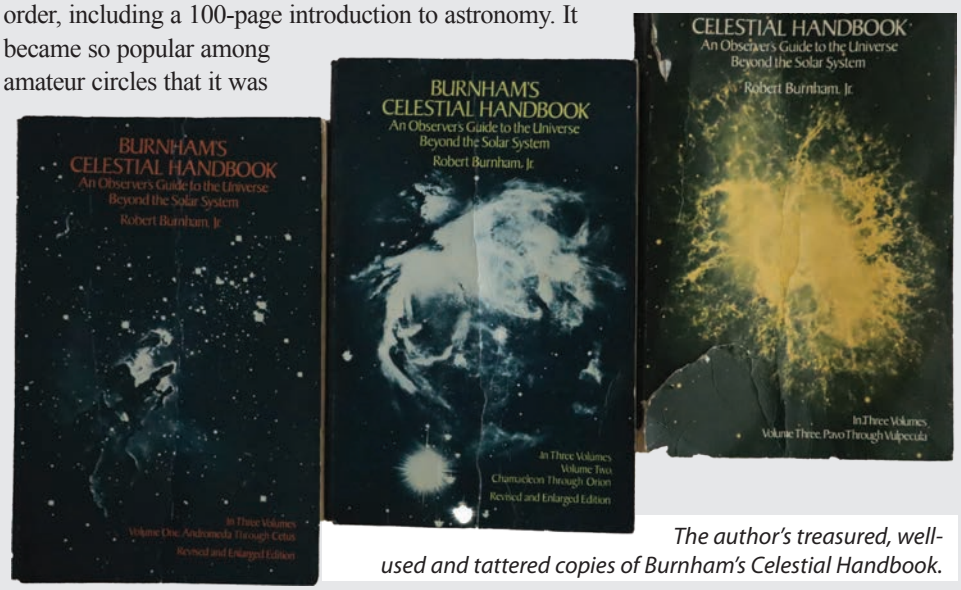
May there always be Starlight on the Path

If you grew up mid-last century with a passion for astronomy, you would remember the scarcity of good astronomy books, particularly those relating to the needs of amateurs. Of the few available, most had a hefty Northern Hemisphere bias.

Pre-internet, books and magazines were our only source of information on the heavens. So, imagine our delight with the publication of *Astronomical Objects for Southern Telescopes* by Professor E. J. Hartung in 1968. This work was revised and illustrated by David Malin and David Frew in 1995.

Before this, our primary source of where things were in the heavens was *Norton's Star Atlas*, which, although updated, was initially published in 1910. Then, during the 60s and early 70s, you could purchase a set of 16 celestial charts that covered the entire sky. Known as the *Skalnaté Pleso Atlas of the Heavens (Atlas Coeli Skalnaté Pleso 1950.0)* by Antonín Bečvář. You could also buy a 369-page catalogue that listed 12,000 objects plotted on the charts. The objects included stars brighter than magnitude 7.75 (over 32,000) and all non-stellar objects within reach of an 8-inch telescope. The authors recall many cloudy nights pouring over the atlas, searching for celestial gems to tackle when the skies cleared.

There were exceptions, but it was fundamentally all we had to work with in those days. Then, in the late 1970s, along came *Burnham's Celestial Handbook. An Observers Guide to the Universe Beyond the Solar System*, by Robert Burnham, Jr. This 2,138-page work in three volumes covered the entire sky in meticulous detail, constellation by constellation in alphabetical order, including a 100-page introduction to astronomy. It became so popular among amateur circles that it was just known as Burnhams (as synonymous as Hoover is to vacuum cleaners). It was a bible to us back then, with each constellation divided into sections, listing double and multiple stars, variables, star clusters, nebulae, and galaxies. Burnham's excellent descriptions and scientific insights would keep us occupied for hours on cloudy nights.



The author's treasured, well-used and tattered copies of Burnham's Celestial Handbook.

Armed with Burnhams, an atlas, and setting circles (no computer-controlled telescopes back then), we would go deep sky hunting. We never before had such a treasure at hand, and here begins one of the most tragic and sad stories in modern astronomy history.

Robert Burnham, Jr. was born in Chicago in 1931. He collected ancient artifacts, fossils, coins, rocks, and minerals and had an insatiable appetite for astronomy. He graduated from high school (the height of his formal education) in 1949 and enlisted in the air force two years later. Four years after his military career finished, Burnham took work as a shipping clerk. During his time in this mundane job, he dreamed of compiling an astronomy handbook. It would be a unique guide to the Universe and unlike anything published before.

In 1957, he discovered a comet whilst observing with his homemade telescope from his parents' front veranda. Burnham was not the only discoverer; two other observers independently noticed this visitor. The comet, designated C/1957 U1 (Latyshev-Wild-Burnham), was parabolic and destined never to return to the Solar System. Three months later, he would be the sole discoverer of comet C/1958 D1 (Burnham). His observations gained him some local notoriety as the self-taught amateur from Prescott, Arizona. On learning of this achievement by an amateur with no professional training and very modest equipment, he was offered paid work and onsite accommodation at Lowell Observatory in Flagstaff.

The observatory had begun a proper motion survey to identify stars close to our Sun. Burnham was employed to do this work, expected to take no more than three years. The task was tedious and time-consuming, using a blink comparator to compare older photographic plates with current ones.

The earlier comparison plates were taken by Clyde Tombaugh (also an amateur hired by the observatory) in his search for a trans-Neptunian planet and subsequent discovery of Pluto in 1930. During this process, Burnham and his co-worker, Norman Thomas, discovered four more comets, thousands of variable stars, and 1,500 asteroids. In addition, they identified over 9,000 high-motion stars and 2,000 suspect white dwarfs.

After Burnham's daily observatory duties were finished, he would devote all his spare time to his dream of creating the celestial handbook. By 1966, he had painstakingly self-published an eight-volume, loose-leaf version of his vision. Had he not worked at Lowell, he may not have been able to create such a masterpiece; he used the observatory's telescopes, plate collection, and extensive library. Unfortunately, the Lowell Observatory was unwilling to support or endorse his efforts, fearing in part that any errors would be detrimental to the observatory's reputation.

Seeking a wider circulation and potentially large royalty payments, Burnham sought the assistance of the New York publisher, Dover Publications. As a result, Dover published a three-volume paperback edition in 1978, which retained Burnham's original typescript pages (it had previously been turned down by Sky & Telescope magazine because they said it would be a mammoth undertaking to typeset and proofread all

4592 in Scorpius, a reflection nebula sometimes called the Blue Horsehead.

Comet C/2017 K2 (PANSTARRS) continues being circumpolar at 8th magnitude for the month, beginning in Indus then Tucana from the 5th and Hydrus from the 21st. It is low in the south-west, best during early evening. In the first half of the month, it skirts by the SMC, around 4° to the north-west of this extragalactic neighbour.

Comet C/2020 K1 (PANSTARRS) is continuing its tour of Sagittarius, starting at 12th magnitude and rising in the south-eastern sky about an hour before dawn. By month's end it has brightened slightly and is rising around 1 am.

After going through perihelion in January, **Comet C/2022 E3 (ZTF)** moves rapidly south, charging into the evening sky, at around 8th magnitude mid-month, setting around midnight. From the 4th to the 9th, it is in Auriga at a possible 6th magnitude, remaining low before setting in the northern sky. From the 10th it moves into Taurus gradually transiting higher before setting around midnight. At mid-month it skims past Aldebaran and the Hyades. By month's end it has faded to about magnitude 9.

METEOR SHOWER

The **alpha-Centaurids**, one of the main southern summer showers, are active from January 28 to February 21, with a maximum zenith hourly rate of six around the 8th. 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. However, the Full Moon on the 6th will spoil this year's peak.

CONSTELLATIONS

In February we move to the right (east) of last month's zodiacal constellation (as we will the whole year) to Gemini. Although, not as obscure as some signs of the Zodiac it relies heavily on its two first magnitude stars, Castor (Alpha Geminorum) and Pollux (Beta), to betray its position, especially from light polluted locations. These are the names of the classical twins from mythology with the stars marking the position of their heads. Their bodies and legs consist of parallel lines of mostly 4th magnitude stars running away from these luminaries to the left (west), towards the Milky Way. From the perspective of the Southern Hemisphere, the twins are lying on their side, with Castor always the one closer to the horizon. You can think of the twins as standing in the Milky Way with their legs and bodies extending away. Hence, the constellation contains both

the typed pages). Receiving rave reviews, it soon became a huge success.

Unfortunately, the proper motion study ended the following year, and his tenure at the observatory was terminated. The observatory directors offered him a caretaker/handyman job in lieu, but he turned this down. After 21 years at Lowell, Burnham found himself without employment, a home, and a regular income. He was an extremely reclusive and introverted person with few friends. A former observatory director described him as the "most shy person he ever met". After all his years at Lowell, his termination and the offer of a menial job, his self-esteem sank to levels few would understand. On leaving his onsite accommodation, he rented an apartment in Flagstaff, where he moved his extensive collection of ancient artifacts, fossils, coins, and other curiosities.

Despite the popularity of his Celestial Handbooks during the 1980s, the royalty cheques began to diminish, partly because book clubs began heavily discounting his work as an enticement to join. In addition, he had constant clashes with Dover over other language versions and special editions of his handbook. Not only was he bitter about his sacking from the observatory, but he was overcome with depression and became even more reclusive. To pay the rent, he began selling parts of his prized collection that he had spent years accumulating. He tried several money-making schemes, including treasure hunting with a metal detector. Too shy to seek unemployment benefits, his life continued its downward spiral.

In July 1985, he disappeared from a canyon near Flagstaff, where he was treasure hunting. Seven weeks later, he was found by police looking unkempt and confused, wandering along Newport Beach in California. His bare feet had second-degree burns from Sun exposure. Suffering from a mental breakdown, he had no recollection of those missing weeks. After recuperating in a mental hospital, he was taken to a shelter, then picked up by his sister, and returned to Phoenix.

In June 1986, without warning, he vanished, and his sister would never see him alive again. Then, in 1991, Bruce Thomas (the son of his co-worker at Lowell) moved to San Diego and whilst walking through a park, noticed a familiar face sitting on a bench selling paintings of cats. It was (the now bearded) Robert Burnham; Bruce made some small talk to an uncomfortable Burnham and purchased one of his paintings. Later that same year, when Bruce's father visited his son, they again went to the park and chatted with Burnham. They subsequently made several more visits looking for him, but he had again disappeared. During his time in San Diego, Burnham had lived in a run-down apartment building for older men with meagre incomes.

In 1995, Burnhams niece and husband tried to trace his whereabouts, only to find he had died almost two years before. At first, not realising his stature in the amateur astronomical community, his family did not report his death until some years later. Destitute and alone, he had entered Mercy Hospital in San Diego, suffering from a gangrenous foot, pneumonia, malnourishment, and heart failure, passing away on 20 March 1993, aged 61.

His ashes were interred in a remembrance wall for servicemen and women in San Diego. Due to a clerical error, his name on the plaque was incorrectly spelt as 'Burham' (since corrected). The main belt asteroid 3467 Bernheim is named in his honour. In 2009 a bronze plaque resembling an open page from his Celestial Handbook was installed on the Pluto Walk at Lowell Observatory.

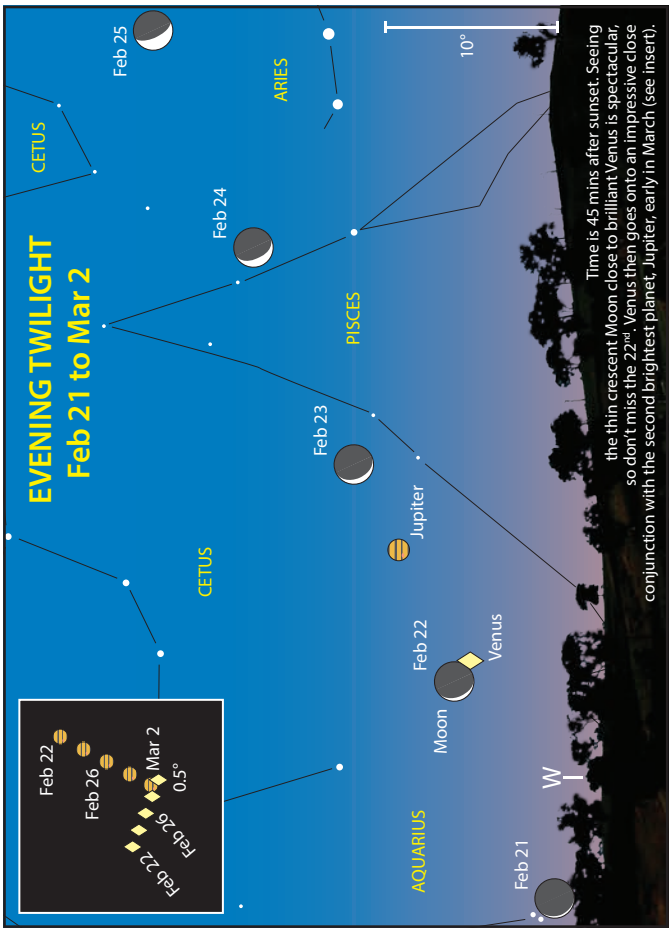
Until recently, no other work contained so much useful information in one place. Some of the science is technically outdated, and the coordinates are for Epoch 1950. But I still use my Burnhams, and, as I thumb my way through my tattered 45-year-old volumes, I am reminded of his sad life and how he died alone and unnoticed. From his classic and unique work that we all treasured to an impoverished artist selling paintings of cats in a park.

star clusters and galaxies, a bit like Centaurus, but having no prominent galaxies like this centaur. This explains why Gemini's feet are the home of several open star clusters, with M35 the best and brightest.

In mythology, Castor and Pollux were considered protectors of sailors (the source of St Elmo's fire) and were present on the Argo when Jason searched for the golden fleece, the origin of which was Aries the Ram (another zodiacal constellation). The twins were inseparable, hence their side-by-side immortality in the sky. An example of their devotion was when Castor died, Pollux, who was immortal, begged Jupiter for him to join Castor in Hades. This wasn't allowed but he spent alternate days between Hades and Elysium, the realm of the gods.

Besides M35, Gemini is also well known for the Eskimo Nebula, a stunningly blue (9.2 magnitude) planetary nebula with a distinctive 10.1 magnitude central star in a bright core. A mottled fainter region surrounds it out to the edge.

'The twins' also have some impressive bright double stars. By bright, we mean their primary components can be seen with the unaided eye (so easy to find). The brightest is Castor itself, which is a wide multiple star system. We'll concentrate on its two brightest binary members, meaning they orbit each other. Currently these 1.9 and 2.9 magnitude components are separated by a tight 5.5 arcseconds, but nowhere near as close as during their last periastron passage, being under 2 arcseconds apart in 1960, their maximum separation of 6.96 arcseconds is in 2077. There is also Zeta Geminorum, with its magnitude 4.0 and 7.7 components separated by 2 arcminutes and ideal for binoculars. The fainter star looks distinctively yellow compared to its white partner. Also, Delta Geminorum or Wasat, is a yellow (3.6 magnitude) star with an 8.2 magnitude companion a snug 6 arcseconds away.



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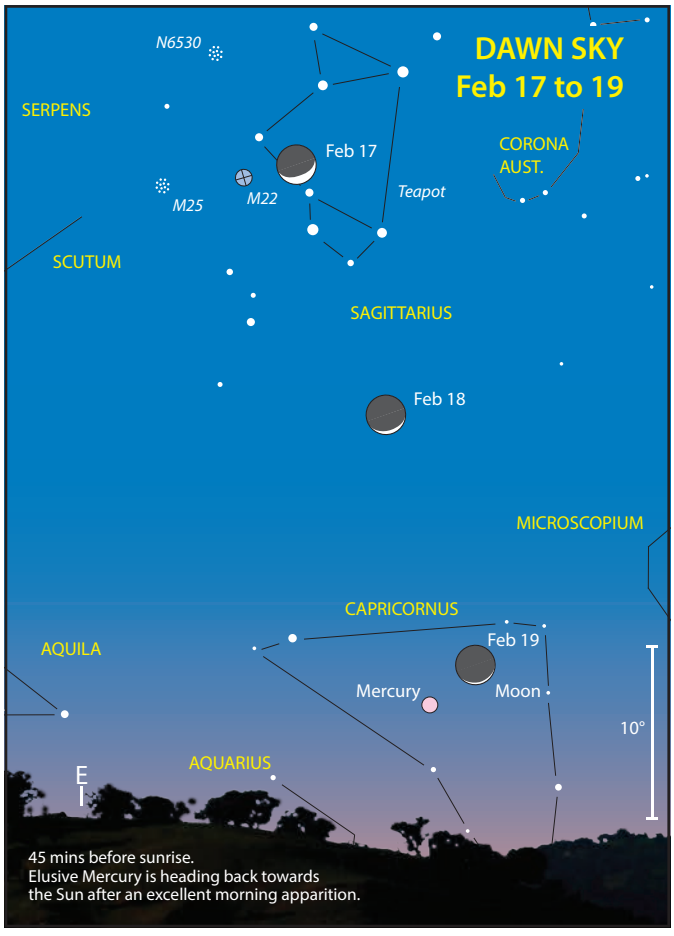
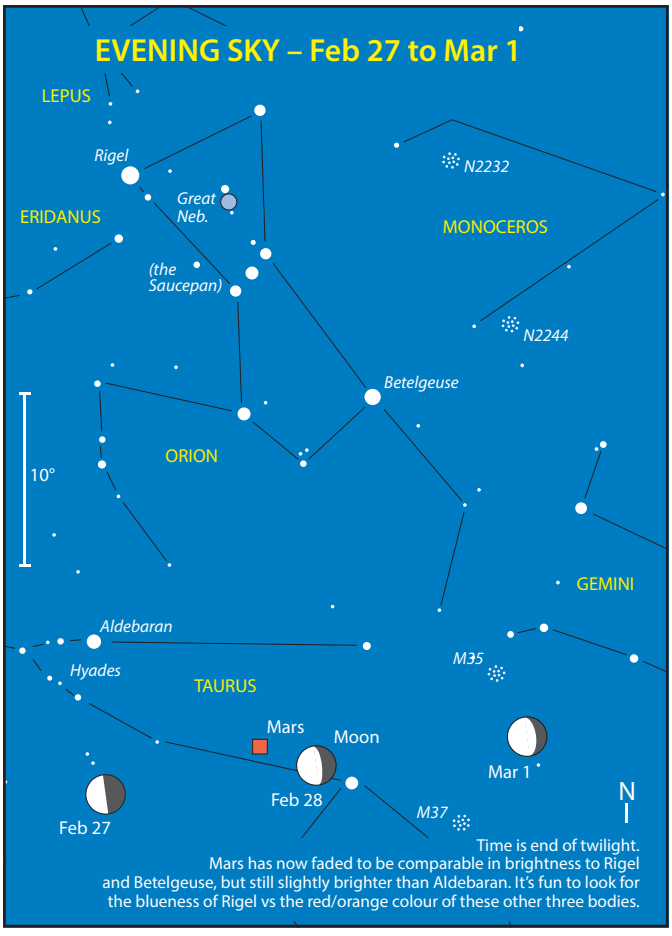
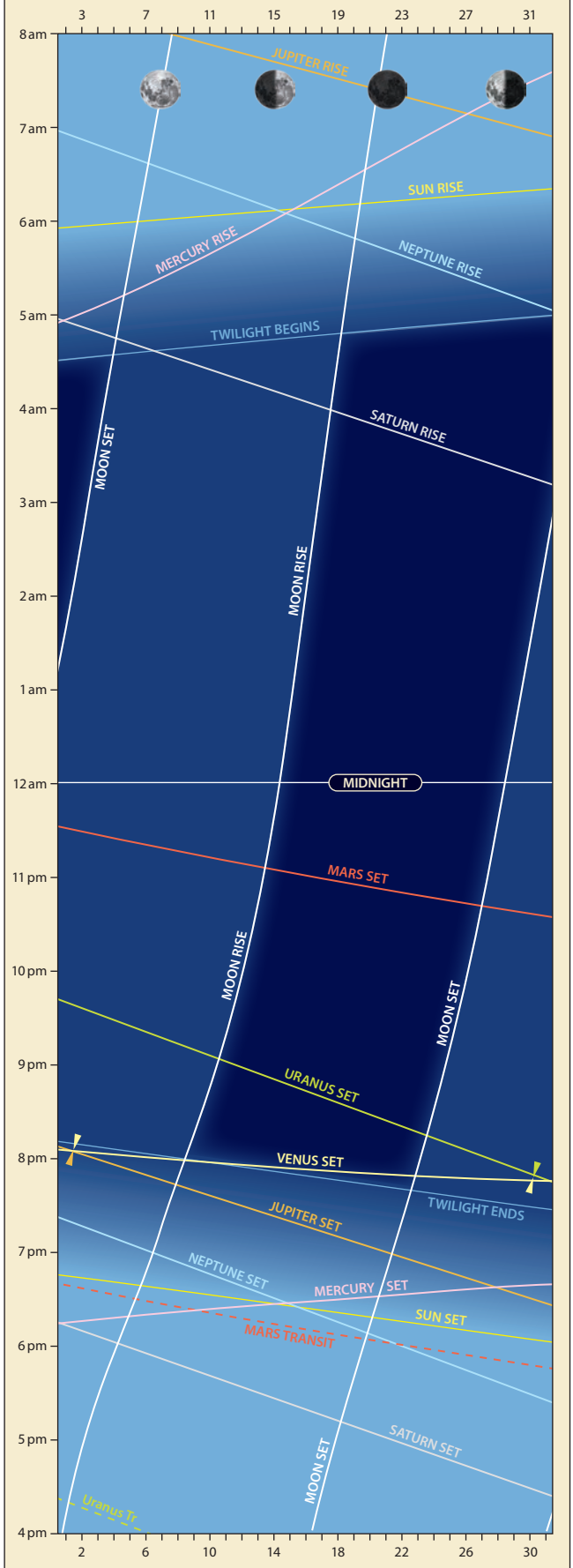




MARCH 2023

RISE–SET CHART

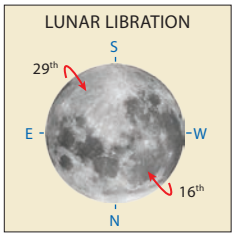


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mercury and Saturn close.
- Venus and Jupiter very close.
- Venus and Uranus close.
- Mars close to the open cluster M35.
- Best time to see the Emu (see Sky View).

THE MOON



4th 4 am (2 am WST) Moon at apogee (furthest from Earth at 405,889 km).

7th 11 pm (9 pm WST) Full Moon.

15th Noon (10 am WST) Last Quarter.

16th 8 am (6 am WST) Maximum Libration (7.6°), bright NW limb.

20th 1 am (11 pm WST, previous day) Moon at perigee (closest to Earth at 362,696 km).

22nd 3 am (1 am WST) New Moon.

29th 2 am (Midnight WST, previous day) Maximum Libration (7.1°), bright SE limb.

29th 1 pm (11 am WST) First Quarter.

31st 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 404,919 km).

APPEARANCE of the PLANETS

MERCURY Mercury in superior conjunction on the 17th

5 Mar
dia 5.0"
mag –0.8

30 Mar
dia 5.6"
mag –1.2

VENUS
15 Mar
dia 12.9"
mag –4.0

MARS
15 Mar
dia 7.3"
mag 0.7

SATURN
15 Mar
dia 15.5″
mag 0.9

JUPITER
15 Mar
dia 33.6"
mag –2.1

URANUS
15 Mar
dia 3.5"
mag 5.8

NEPTUNE
1 Mar
dia 2.2"
mag 8.0
Conjunction 16 Mar

Moonbase Alpha

From around a day after First Quarter until the Last Quarter, a remarkable and distinctive crater becomes visible in the Moon's northern hemisphere. Named after the ancient Greek philosopher Plato, it lies in the alpine region between Mare Imbrium (Sea of Rains) and Mare Frigoris (Sea of Cold). It is one of the most impressive areas on the Moon, with the Montes Alpes (The Alps) and the well-known Vallis Alps (Alpine Valley) lying to the east.

Early cartographers of the Moon considered the dark floored crater a body of water and named it appropriately. In the mid-17th century, Michael van Langren named it Lacus Panciroli (Lake Panciroli), and Johannes Hevelius called it Lacus Niger Major (Greater Black Lake). We owe the current name to Giovanni Riccioli from his 1651 lunar map. Fans of the 1970s British Sci-Fi television programme Space 1999 will recognise it as the location of Moonbase Alpha.

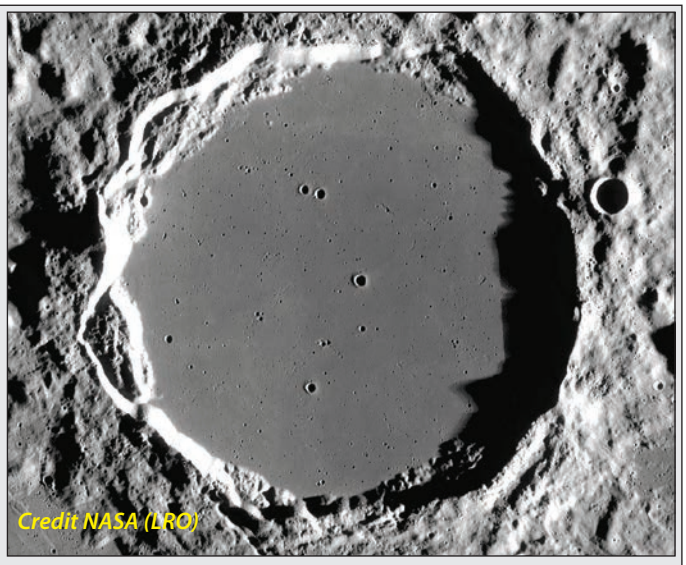
Along with the craters Endymion and Grimaldi, the 101 km diameter crater with its lava-filled floor and bright rim, is one of the darkest regions on the Moon. Interestingly, as the lunar phase goes from First Quarter to post Full Moon, Plato's floor appears to darken. However, this effect is an apparent illusion as photometric studies reveal the opposite, as the Moon waxes, the floor gets lighter (as does the rest of the Moon).

At a glance, the crater floor appears smooth and featureless, although there are many craterlets, most of which are too small to detect. However, there are four that are 2 to 2.5 km in diameter and amateurs have successfully imaged and sighted them. They are the favourite targets of lunar observers testing their instruments' optical quality and resolution. If the reader is up to the challenge, several factors will determine their visibility, including the illumination angle of the Sun, seeing conditions and optical quality. Craters of Plato's size generally have a central peak, although if one ever existed, it is now under several kilometres of lava.

The crater itself is circular, although due to foreshortening, it appears elliptical from Earth. Along the northern and western walls, many sections suffer from extensive damage. The enormous 15 km long triangular massif (known as Plato Zeta) on the west rim is interesting. It appears to have slumped down onto the floor, and there is a chasm behind where it broke away from the main wall. Looking around the rest of the rim, several other significant landslide areas exist.

Plato's rim contains many uneven high peaks, as is evidenced by their shadows on the floor at low Sun angles. Watching these shadows as they retract just after sunrise is fascinating, and visible changes can be seen during observation for a few minutes or so. A mystery surrounds the shadow cast by one particular peak onto the floor during First Quarter. Known as Plato's Hook, a shadow originating from this peak has been reported to be curved when you expect to see a triangular shape with straight sides.

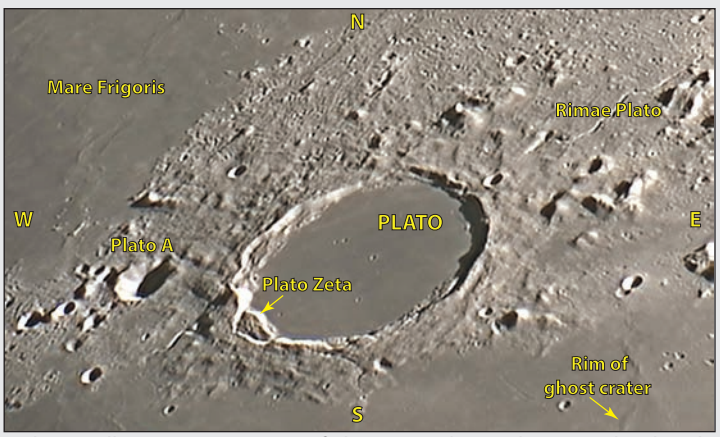
The Hook is just one of many curious effects caused by the interaction of light and shadow on the Moon. Known as Clair-Obscur effects (French for light and shadow), they are short-lived but repeat at each lunation. Since they are not a permanent feature like craters and mountain ranges, they do not have official names. However, several hundred are known, and amateurs have given them informal names like Plato's Hook.



The Plato region has the second largest number of reported transient lunar phenomena (TLP); first place goes to the Aristarchus Plateau (see Astronomy 2021, p. 66). TLPs are short-lived (from a few seconds to several hours) changes that manifest as flashes, changes in colour, or blurring of areas of the Moon. However, there is some scepticism about TLPs, primarily due to anecdotal and singular visual descriptions by amateur and professional astronomers. Some would argue that there must be something behind the numerous reports, possibly outgassing. A NASA report, 'Chronological Catalog of Reported Lunar Events', listed 579 cases of TLPs before the first Moon landing.

There is much to explore in Plato's neighbourhood. Directly south is a ghost crater on the shores of Mare Imbrium and, at 115 km, is a little larger than Plato. On the ghost crater's southern rim is the impressive Mons Pico. This mountain range measures 15 × 25 km around its base, stands 2.4 km above the surrounding plain, and is exceptional at lunar sunrise or sunset, casting its long shadow. Looking eastward from Plato is the Rimae Plato, a long serpentine rille.

Further east along the Montes Alpes is the Alpine Valley, a 180 km long gash cutting north-east and bisecting the mountain range. A narrow channel like rille winds its way along the valley floor, although this is another test of your instrument and seeing. West is a deep, 22 km crater named Plato A.



This excellent amateur image of Plato was taken with an 8-inch Schmidt Cassegrain Telescope. Note the craterlets on the floor.

THE PLANETS

Mercury encounters Saturn on the 3rd in the morning eastern dawn, with the planetary duo just 1° apart. A low eastern horizon and binoculars are recommended for viewing, with Mercury the brighter of the pair (see Sky View). The planet is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 17th, and it then returns to the western evening twilight sky late in the month.

An excellent conjunction between **Venus** and Jupiter begins the month in the western evening dusk sky (see Sky View). The two brightest planets will be just 1° apart, the gap narrowing to 0.5° on the 2nd. Another striking conjunction occurs on the 24th with the 3-day old waxing crescent Moon just 1° below Venus (see Sky View). Finally, on the 31st, a conjunction requiring a pair of binoculars (and a low unobstructed western horizon), with Venus 1.5° from the planet Uranus. This meet-up will be nowhere near as close as the Neptune encounter last month, but still neat to view.

The **Earth** is at its autumnal equinox on the 21st.

Mars continues its journey through Taurus in the early evening northern sky before entering Gemini at month's end. While in the constellation of the Twins, the Red Planet passes close to the beautiful open star cluster M35 (NGC 2168). Being close to the ecliptic, the Moon and planets often visit this cluster. M35 is visible to the unaided eye under good dark skies and is splendid in small instruments. On the 28th, the 7-day old waxing gibbous Moon appears 4° from the planet (see Sky View).

The month opens with **Jupiter** and Venus very close in the western evening dusk (see Venus and Sky View). These conjunctions of the two brightest planets are not uncommon, occurring roughly 13 months apart. This one, however, is quite close and will be most impressive whether viewed with the unaided eye, binocular, or small instrument. Later this month, Jupiter will be too close to the Sun for observation.

Saturn returns to the morning eastern sky mid-month after its solar conjunction. While journeying behind the Sun, the planet moved out of Capricornus and into Aquarius. The constellation of the water bearer remains its home for the rest of the year. On the 3rd, the ringed world has a close encounter with the innermost planet (see Mercury and Sky View). On the 20th, the slender fingernail crescent of the 27-day old Moon will be near Saturn (see Sky View).

On its way toward conjunction in early May, **Uranus** will be lost in the western evening twilight by the end of the month. On the 31st, the planet will be close to Venus. A challenging observation, being late dusk and also close to the horizon (see Venus).

Neptune is in conjunction with the Sun on the 16th and reappears in the morning sky in April.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **1 Ceres** continues its journey through the Coma-Virgo cluster of galaxies. In early March it comes close to Markarian's Chain of galaxies (see Diary). From the 27th to April 4, 10 Hygiea and 8 Flora will be within 0.5° of each other. These 11th magnitude minor planets will be closest on the 31st (see Diary). An imaging challenge? Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
21 Mar	1 Ceres	Coma Berenices	7.1
28 Mar	68 Leto	Virgo	11.6
29 Mar	194 Prokne	Virgo	12.0

COMETS

Comet 81P/Wild 2 is in Ophiuchus at magnitude 10.5, rising in the south-eastern sky around 11 pm. By the second half of the month, it is transiting high in the northern sky, shortly before sunrise. Early in March, the comet, still near maximum brightness enters the hub of the Milky Way and mid-month has a close meeting with three globular clusters in Ophiuchus (see Diary).

Comet C/2017 K2 (PANSTARRS) is still circumpolar at about 8th magnitude for the first five days of the month. The comet spends March moving back and forth between Eridanus and Horologium, finishing in the former. It is setting in the southern sky shortly after midnight and fades by month's end.

Comet C/2020 K1 (PANSTARRS) is in Sagittarius starting at 12th magnitude. It is still well placed to observe in the morning sky, rising in the south-eastern sky around 1 am. By month's end it has brightened slightly and rising around 10:30 pm.

While beginning the month in Taurus, **Comet C/2022 E3 (ZTF)** moves into Eridanus on the 3rd. Transiting before sunset this month, the comet remains in the western sky, setting before midnight. It fades from 9th to 11th magnitude during the month.

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 occurs around March 15, when rates can reach six per hour. Generally, the gamma-Normids are bright and 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 Last Quarter Moon has set.

CONSTELLATIONS

This month, a trip to possibly the most underwhelming zodiacal constellation, Cancer the Crab (All Sky Map No 5). Like all members of the Zodiac, Cancer is an ancient constellation dating back to early Greek and Babylonian times. One mythology mentions its origin relates to the second of the Twelve Labors of Hercules, his slaying of the Hydra (another faint constellation). While he was distracted by this serpent, Hera sent a giant crab to murder Hercules, which he noticed and crushed under his foot. To recognize the bravery of the crab, Hera placed it in the heavens. Unfortunately, because it failed to make its kill, the crab was given a somewhat less impressive constellation.

What do we mean by less impressive? Cancer's brightest star Beta (β) Cancri or Altarf, meaning the end (of one of the claws), is only magnitude 3.5. The remaining 'bright' stars drop quickly to 4th magnitude with even Alpha (α) Cancri or Acubens (the Arabic word for claw) a diminutive 4.2 magnitude. So, from under light polluted skies, Cancer

DIARY			
Wed	1st	7 pm	(5 pm WST) m.p. 4 Vesta 5° S of Venus
Thu	2nd	7 pm	(5 pm WST) Jupiter 0.5° S of Venus
Thu	2nd	pm	m.p. 40 Harmonia 0.8° N of NGC 3377 (G) in Leo
Sat	4th	4 am	(2 am WST) Moon at apogee (furthest from Earth at 405,889 km).
Sat	4th	7 pm	(5 pm WST) m.p. 4 Vesta 5° S of Jupiter
Sun	5th		m.p. 39 Laetitia 0.8° NW of NGC 6309 (PN) in Ophiuchus
Tue	7th	11 pm	(9 pm WST) Full Moon (400,436 km).
Thu	9th	pm	d.p. 1 Ceres 0.1° NE of NGC 4571 (G) in Coma Berenices
Fri	10th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 0.1° W of NGC 1637 (G) in Eridanus
Sat	11th		m.p. 3 Juno 0.7° N of star Alpha Piscium
Sat	11th	pm	d.p. 1 Ceres 0.1° E of M91 (SG) in Coma Berenices
Sun	12th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 1.0° W of star Mu Eridani
Tue	14th	pm	d.p. 1 Ceres 0.5° NE of M88 (SG) in Coma Berenices
Wed	15th	am	gamma-Normids meteor shower, Feb 25 to Mar 28, Moon affected.
Wed	15th	2 am	(Midnight WST, prev day) Comet 81P/Wild 2 0.6° S of M9 (GC) in Ophiuchus
Wed	15th	Noon	(10 am WST) Last Quarter Moon.
Wed	16th		Neptune in conjunction with Sun
Thu	16th	8 am	(6 am WST) Maximum Libration (7.6°), bright NW limb.
Fri	17th	2 am	(Midnight WST, prev day) Comet 81P/Wild 2 0.5° N of NGC 6342 (GC) in Ophiuchus
Fri	17th		Mercury in superior conjunction
Sun	19th	2 am	(Midnight WST, prev day) Comet 81P/Wild 2 1.2° S of NGC 6356 (GC) in Ophiuchus
Mon	20th	1 am	(11 pm WST, prev day) Moon at perigee (closest to Earth at 362,696 km).
Mon	20th	5 am	(3 am WST) Saturn 4° NW of Moon
Tue	21st		Equinox
Tue	21st		Ceres at opposition
Wed	22nd		m.p. 15 Eunomia 1.5° NE of star Zeta Sagittarii
Wed	22nd	3 am	(1 am WST) New Moon.
Wed	22nd	pm	d.p. 1 Ceres 0.1° NW of NGC 4421 (G) in Coma Berenices
Wed	22nd	pm	m.p. 2 Pallas 0.4° SE of NGC 2302 (OC) in Monoceros
Thu	23rd	pm	m.p. 2 Pallas 0.5° NW of NGC 2309 (OC) in Monoceros
Fri	24th	7 pm	(5 pm WST) Venus 6° N of Moon
Fri	24th	pm	d.p. 1 Ceres 0.1° N of NGC 4379 (G) in Coma Berenices
Sat	25th	7 pm	(5 pm WST) Uranus 5° SW of Moon
Sun	26th		m.p. 3 Juno 0.7° NW of star Nu Ceti
Mon	27th		m.p. 15 Eunomia 0.6° S of star Tau Sagittarii
Mon	27th	pm	d.p. 1 Ceres 0.1° NW of M100 (SG) in Coma Berenices
Tue	28th	pm	m.p. 2 Pallas 0.8° SE of NGC 2311 (OC) in Monoceros
Wed	29th	2 am	(Midnight WST, prev day) Maximum Libration (7.1°), bright SE limb.
Wed	29th	1 pm	(11 am WST) First Quarter Moon.
Wed	29th	pm	Comet C/2017 K2 (PANSTARRS) 0.5° S of star y Eridani
Thu	30th		Mars 1.0° N of M35 (OC) in Gemini
Fri	31st		m.p. 8 Flora 0.1° SW of m.p. 10 Hygiea
Fri	31st	7 pm	(5 pm WST) Uranus 1.5° S of Venus
Fri	31st	9 pm	(7 pm WST) Moon at apogee (furthest from Earth at 404,919 km).

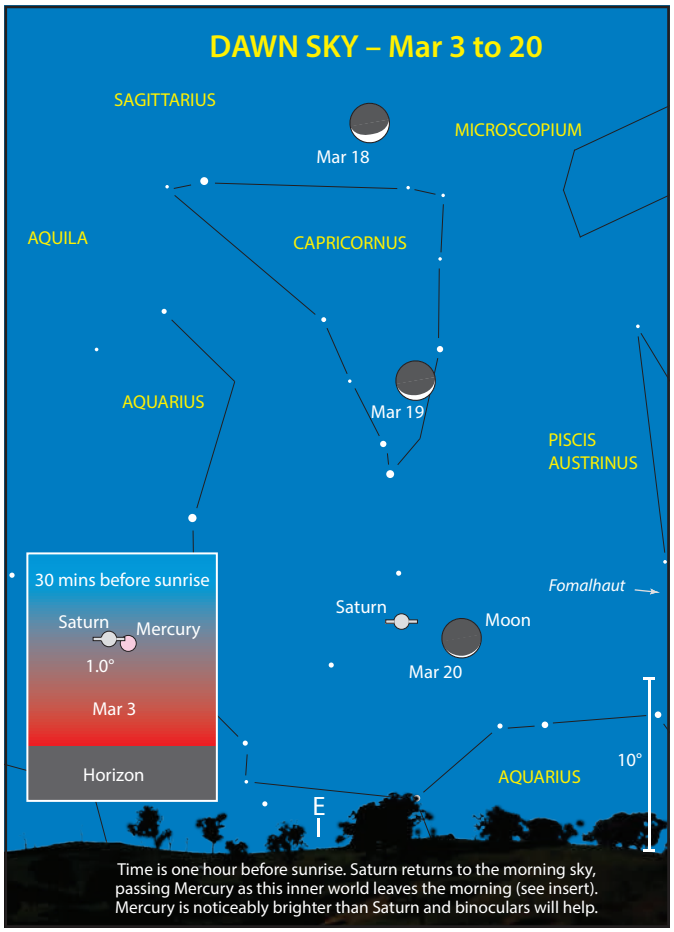
is the vacant part of sky between the stars Castor/Pollux and Regulus.

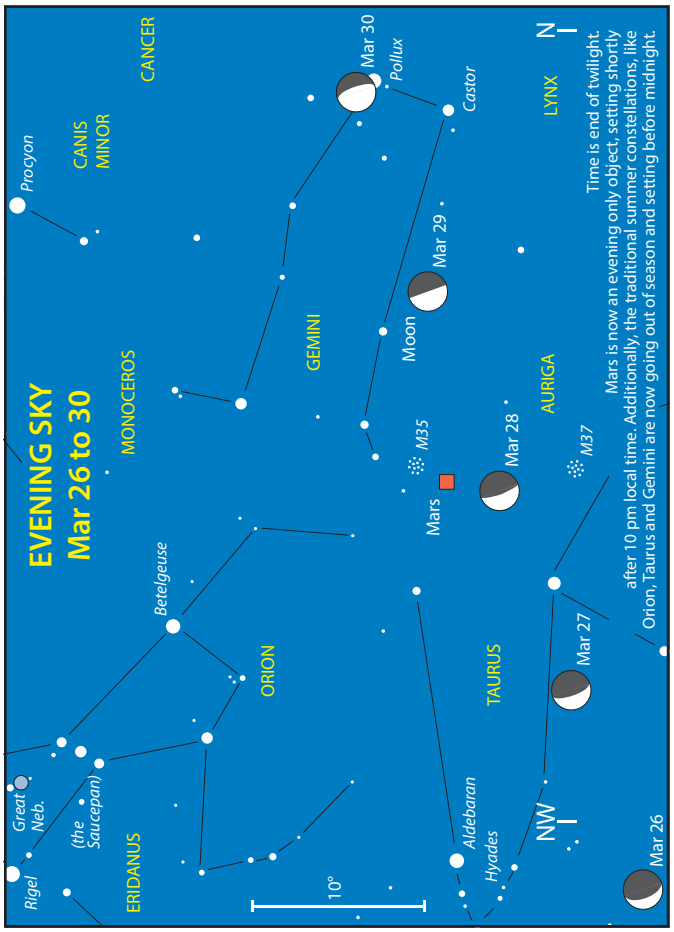
Cancer is probably best known for the impressive 3rd magnitude open star cluster, the Beehive or Messier 44 (M44). It's an obvious hazy patch to the unaided eye and a brilliant binocular object. Covering one degree of sky, its brightest members consist of approximately a dozen 6th to 8th magnitude stars, which includes three arranged in an obvious isosceles triangle shape 10 arcseconds south-east of centre. The equal 6th magnitude stars of 39 and 40 Cancri, 20 arcminutes north (below) make an attractive pair. A small telescope reveals over a hundred stars in the cluster. M44 was also known since antiquity as the Praesepe or Manger by the Greeks and Romans. Hence the reason the two flanking 4th magnitude companion stars, Delta and Gamma Cancri are also known as Asellus Australis and Asellus Borealis, which translate to the southern and northern donkeys respectively.

You wouldn't think the Beehive and the Hyades (the V shaped face of Taurus) have something in common. They not only appear quite different and well separated in the sky; M44 is 600 light-years distant with the Hyades the closest star cluster to us (only 147 light-years away). The clusters have similar proper motions, and their origins can be traced back to the same region in space. So, many millions of years ago they may have been born from the same stellar nursery (nebula).

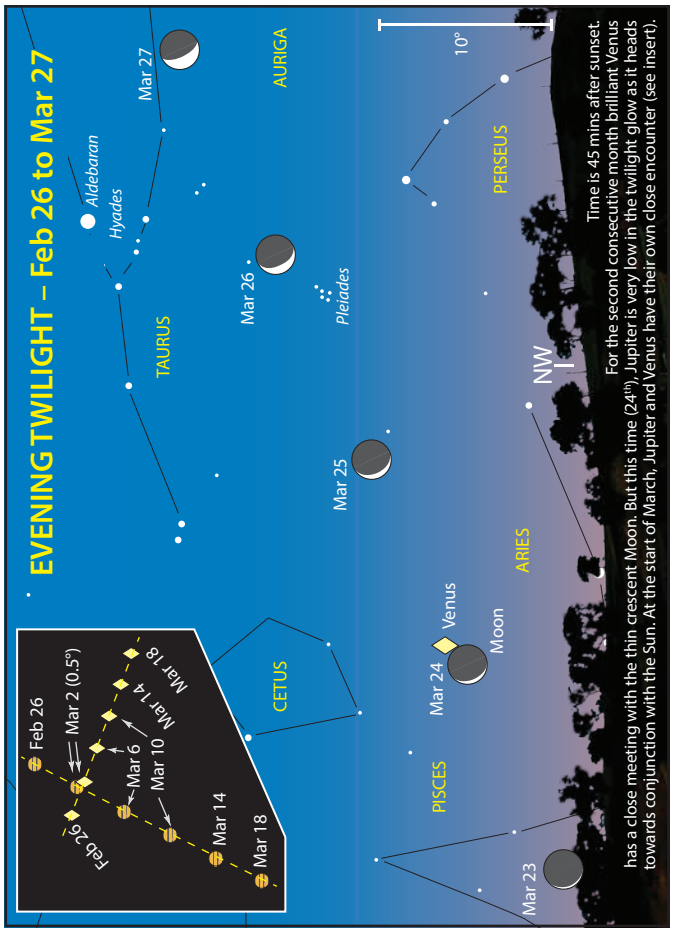
Cancer has another deep sky object of note, the star cluster M67. Located 8° south-east of the Beehive, this bright (6th magnitude) open cluster is approximately 25 arcminutes across with its brightest members arranged in loose groups interspersed with arcs of stars—very pretty. Its approximate 100 members cover a large range of brightness from 9th to 14th magnitude.

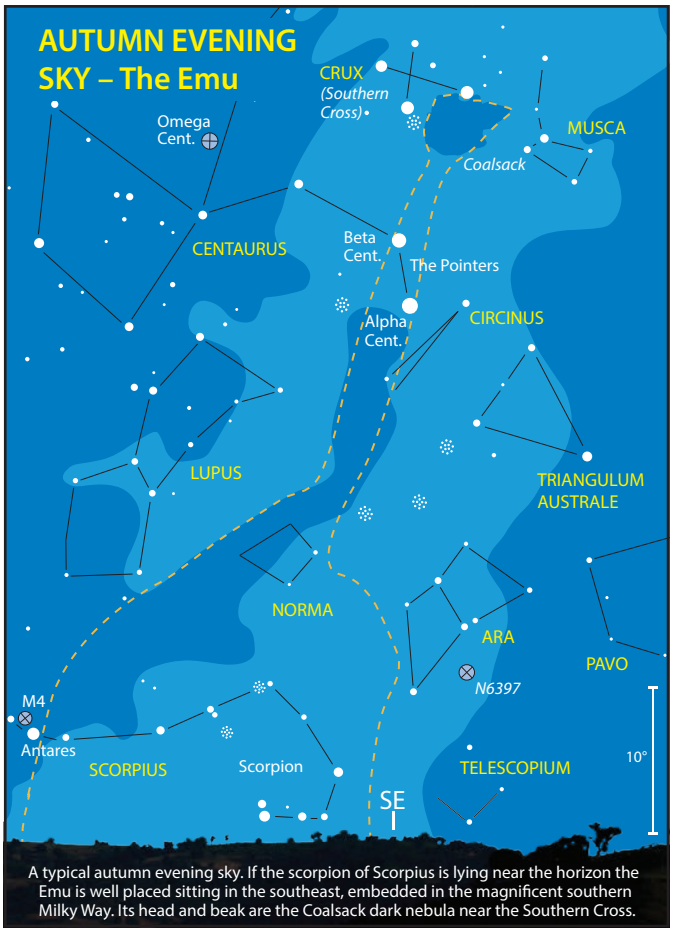
M44, Beehive Cluster in Cancer





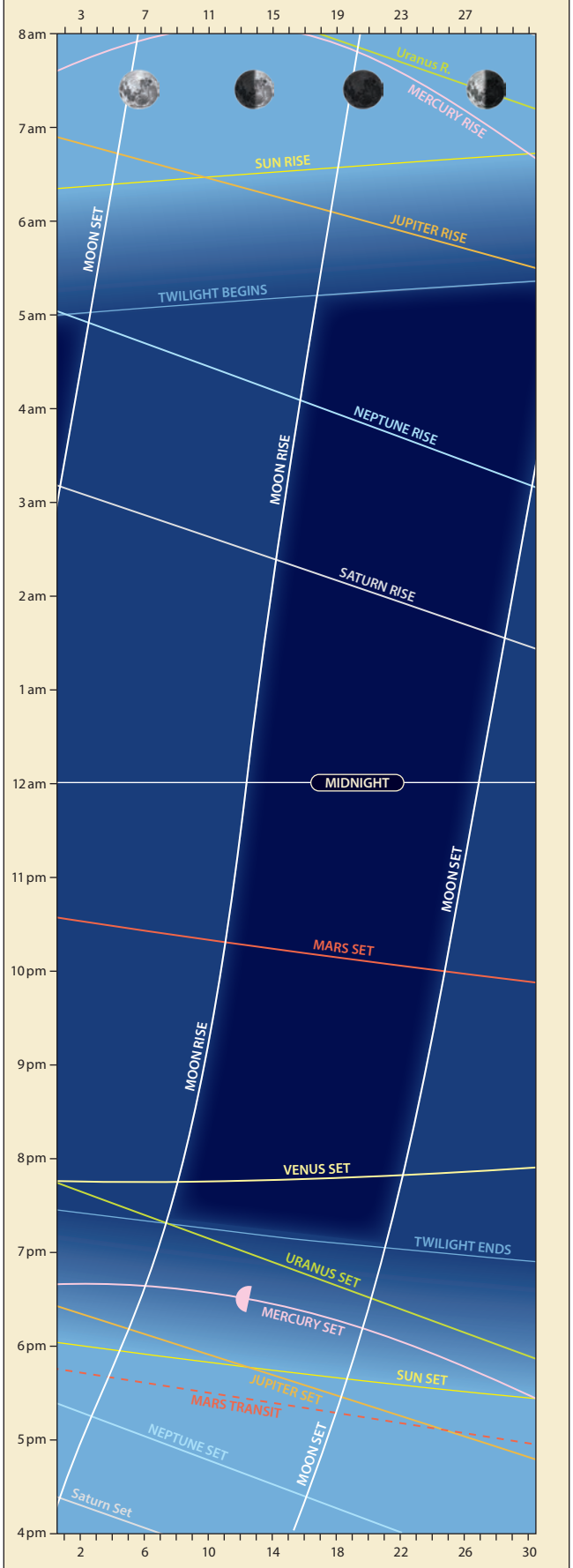
Approximate local standard time, for daylight saving add one hour.





APRIL 2023

RISE–SET CHART

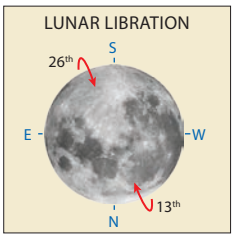


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Venus near the Pleiades.
- Mars very close to Epsilon Geminorum.
- Total solar eclipse, Exmouth WA.

THE MOON



6th 3 pm (1 pm WST) Full Moon.

13th 1 pm (11 am WST) Maximum Libration (7.1°), bright NW limb.

13th 7 pm (5 pm WST) Last Quarter.

16th Noon (10 am WST) Moon at perigee (closest to Earth at 367,968 km).

20th 2 pm (Noon WST) New Moon, hybrid solar eclipse, SE Asia, E. Indies, Australia, Philippines, N.Z. (Hybrid: Indonesia, Australia, Papua New Guinea). See Sky View and pages 101–104.

26th 2 pm (Noon WST) Maximum Libration (7.0°), bright SE limb. The south pole region is best seen at this libration.

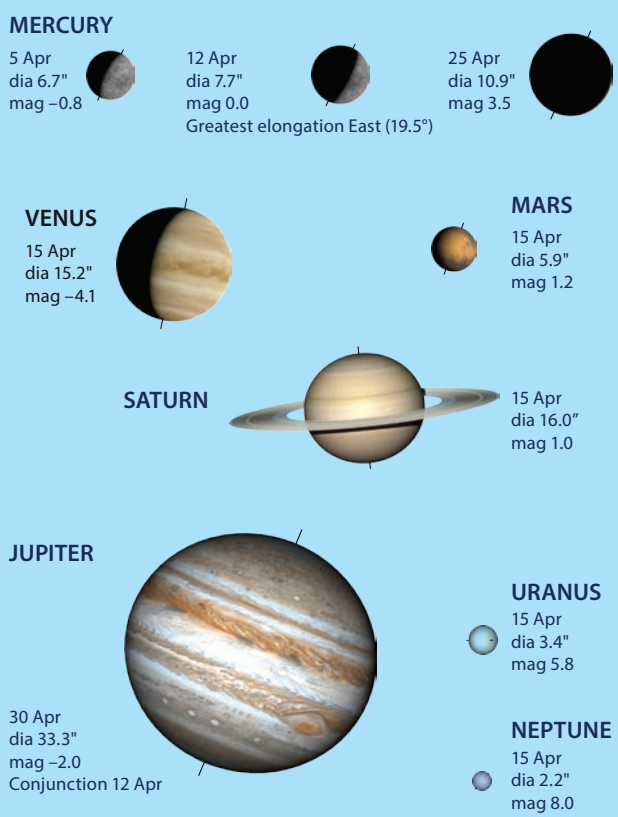
28th 7 am (5 am WST) First Quarter.

28th 5 pm (3 pm WST) Moon at apogee (furthest from Earth at 404,299 km).

THE PLANETS

This month, **Mercury** returns to the evening dusk for a relatively poor apparition, with the planet barely a few degrees above the horizon at the end of civil twilight. It reaches its greatest elongation of 19° east of the Sun on the 12th.

APPEARANCE of the PLANETS



Venus is brilliant in the early western evening sky. The planet spends the first week of the month in Aries before moving into Taurus, passing close to the open star cluster M45. Commonly called the Pleiades or Seven Sisters, they are visible to the unaided eye under dark skies as a prominent group of six or seven stars. Under ideal conditions (and eyesight), some observers have reported seeing 9 to 12 members. Good binoculars show more than 100 stars in the group, and large telescopes reveal more than 500 members spread over a 2° field. The cluster has a prominent place in ancient mythology and, in modern times, features as the corporate logo for a well-known car manufacturer. If you are wondering, the Japanese name for the Pleiades is Subaru. On the 23rd, the 3-day old waxing crescent Moon will be 3° below the planet (see Sky View).

Mars, in Gemini, is visible in the early north-western evening sky. The Red Planet is now just 1.2 magnitude mid-month, the same brightness as the constellation's brightest star Pollux (Beta Geminorum). Its disc has decreased in size to 6 arcseconds, offering little for the visual telescope observer. On the 14th, the planet will be just 0.2° from the 3rd magnitude star Epsilon Geminorum. The star has a 9th magnitude companion about 2 arcminutes away. Interestingly, Mars occulted Epsilon 47 years ago on 8 April 1976. On the 26th, the 6-day old waxing crescent Moon will be around 5° from the planet (see Sky View).

Jupiter is in conjunction with the Sun on the 12th and remains hidden in Sol's glare until its return to the morning skies late this month. However, if you are in Exmouth WA, you can view Jupiter just 6° from the Sun during the total eclipse on 20 April (see Sky View).

Saturn, in Aquarius, rises in the eastern sky in the early morning. The constellation of the Water Bearer will be the Ringed Planet's home until it moves into Pisces in April 2025. The constellation's stars are comparatively faint, with Saturn at 1st magnitude, outshining its 3rd magnitude alpha star (see Sky View).

This month, **Uranus** is lost in the western evening twilight as it moves toward its conjunction with the Sun in May.

Neptune returns to the morning eastern dawn sky after conjunction with the Sun last month. The outermost planet moved from Aquarius into Piscis during its time behind the Sun. From the 6th, for a month, the 5.5 magnitude star 20 Piscium is within 0.5° of Neptune. Its closest passage occurs on the 21st (see Diary) and this alignment will be fun to follow with binoculars.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
4 Apr	22 Kalliope	Virgo	11.0
9 Apr	17 Thetis	Virgo	10.5
10 Apr	270 Anahita	Virgo	11.7

COMETS

Comet 237P/LINEAR is in Sagittarius at around 12th magnitude, rising late evening in the south-eastern sky at the beginning of the month, moving to the eastern sky towards the end of April, having brightened to about 11th magnitude.

Comet 364P/(PANSTARRS) is moving rapidly this month. It starts in Hercules then goes into Lyra (4th), Vulpecula (6th), Sagitta (8th), Delphinus (9th), Pegasus then Equuleus (12th), Pegasus again (13th), Aquarius (18th), Pisces (21st) and finally Aquarius (23rd). At the start of the month, it is at 12th magnitude, rising in the north-eastern sky around 12:30 am, transiting low in the northern sky about an hour before sunrise. During the month it is brightening and rising earlier, and ends April rising in the eastern sky around 3 am.

Comet 81P/Wild 2 is about 11th magnitude during the month, beginning in Ophiuchus and crossing into Sagittarius on the 4th before returning to Ophiuchus next month. It rises in the evening in the south-eastern sky, transiting high in the northern sky an hour before sunrise at the start of the month, about 3 am at month's end.

Comet C/2017 K2 (PANSTARRS) is in Eridanus starting about magnitude 9, setting in the south-western sky around 11:30 pm. By month's end it is setting around 9:30 pm, now at 10th magnitude. For all of April, C/2017 K2 swims up the river Eridanus as the comet moves quickly northward, now setting late in the evening. On 13th there is an imaging opportunity when the comet is 0.5° from the impressive spiral galaxy NGC 1532.

Comet C/2020 K1 (PANSTARRS) starts in Sagittarius at 11th magnitude, rising in the south-eastern sky around 10:30 pm. It moves into Telescopium on the 3rd then Indus on the 19th, rising in the southern sky around 90 minutes after twilight. By the end of the month, it will be circumpolar from mid-latitude Australia, transiting around 6 am.

Comet C/2022 E3 (ZTF) begins in Eridanus at 11th magnitude, setting in the western sky around 10:30 pm, moving into Lepus on the 25th. By month's end it is around magnitude 13, setting about 9 pm.

METEOR SHOWERS

The **Lyrids** are a Northern Hemisphere shower that can be seen south of the equator. Best from April 16–25, with maximum rates during pre-dawn hours of the 22nd and 23rd when their radiant is highest. The peak may only last an hour or so; typically, the ZHR is around 18 (perhaps five or six from mid-Australian latitudes). The Lyrids have occasionally produced higher rates and, because of their erratic nature, are a shower to be watched. There will be no lunar interference, with the peak close to the New Moon.

The **pi-Puppids** are a young southern shower produced by Comet 26P/Grigg-Skjellerup. Best seen from April 15–28, with peak activity on the 24th. Before and after maximum, the rates are low and difficult to separate from sporadic meteors. The pi-Puppids are known for their slow speed, brightness, persistent trains, and many yellow meteors and occasional fireballs. They are best seen from dusk to midnight, and there should be minimal interference by the New Moon, which falls a few days before maxima.

CONSTELLATIONS

Our next constellation in this zodiacal voyage is Leo the Lion (All Sky Map No. 5). Leo's association with a lion goes back to ancient times as it does resemble a crouching cat, with Leo in Latin meaning lion. The lion association likely dates to before 1000 BCE and, in one mythology, thought to represent

the beast that devoured the people of the town of Nemea. The first of Hercules' Twelve Labors was to kill this animal, showing a mythological link between Leo and the adjoining constellation of Cancer (see constellations for March). From the Southern Hemisphere we see it upside down so, Leo's head and chest is the asterism of the Sickle, with its top star, Regulus, forming the handle (also marking the chest of the lion).

Seeing we are following the Zodiac, it's quite fitting that we take a closer look at Regulus, being the closest of the 100 brightest stars in the heavens to the ecliptic (only 0.5° away). Hence, it is no surprise that of all the 1st magnitude stars, Regulus holds the record for the most occultations by the Moon and planets. Although rare, Venus occulted Regulus last in 1959 and will again on October 1, 2044. From Australia it will be a morning daylight event on the 2nd (see Astronomy 2044 for more details, note it is possible you will need the Ouija Board edition).

The ancient Babylonians called it the 'lion's heart' and an early Latin name for Regulus was Cor Leonis, 'the heart of the Lion'. Copernicus named Regulus after the Latin word for 'prince' or 'little king' which is a nod to the long-held belief connecting lions to royalty across many cultures. Persian astrologers, as far back as 3000 BCE, called the star Venant, one of the four royal stars used to mark the northern seasons: Fomalhaut was spring (close to the equinox), Aldebaran for summer (solstice), Regulus was autumn (equinox) and Antares for winter (solstice).

Regulus is a multiple star system, but we will concentrate on the A component, that at magnitude +1.4 makes it the 21st brightest star in the sky. 'A' is a binary star made up of a blue/white super giant and a white dwarf, taking only 40 days to orbit their centre of gravity. The supergiant is about four times the mass of the Sun and spinning very fast, completing a rotation in only 16 hours! Its surface at the equator is moving at 320 km per second, 96% of the way to ripping itself apart! The disc is significantly flattened with an equatorial bulge 32% greater than the polar diameter. Located 78 light-years away, Regulus is intrinsically brighter than the Sun having an absolute magnitude of –0.5 vs Sol's +4.5.

The Celestial Police

Following Johannes Kepler's (1571–1630) success in calculating the motion of the planets, astronomers knew of their order from the Sun and their distances in proportion to the Earth's distance from the Sun. Many then tried to discover why the planets had the spacing they observed.

Johann Titus made the best-known attempt at solving this problem in 1766. Titus found a surprising relationship between the distances of the planets, discovering that a simple rule gave the distance between a planet and the Sun:

Start with the series 0, 3, 6, 12, 24, … in which each term after the first, is double the one before.

Add 4 to each number.

Divide the result by 10.

You now have the distance to the planet in astronomical units.

Titus' formula showed the proportionate distances of the known planets quite nicely, although there was a gap between Mars and Jupiter (see table). Titus included this rule in a translation of a book by Charles Bonnet called *Reflections on Nature,* in which Bonnet attempted to show God's handiwork in the order of nature.

Working at the Berlin Academy of Sciences, Johann Bode later publicised the rule when he included it in an astronomical almanac he edited in 1772. However, Bode gave no credit to either Bonnet or Titus, and the formula became known as Bode's Law. In 1834 Bode finally acknowledged that Titus was the source. Today it is now commonly referred to as the Titus-Bode Law.

Planet	Titus-Bode	Actual
Mercury	0.4	0.39
Venus	0.7	0.72
Earth	1.0	1.00
Mars	1.6	1.52
?	2.8	
Jupiter	5.2	5.20
Saturn	10.2	9.54
Uranus	19.6	19.20
Neptune	38.8	30.10

The Titus-Bode Law at the time was generally considered nothing more than a mathematical curiosity until 1781, when William Herschel discovered Uranus. The new planet fitted the pattern quite well and Bode saw this as further strengthening and confirming the rule. The detection of Uranus caused much excitement among astronomers. But what of the gap at 2.8 au? Was there another undiscovered planet out there? In 1787, the Hungarian astronomer, Baron Franz von Zach, convinced that there was a missing planet, set out to find it.

After a fruitless search, the Baron called a meeting of his astronomer friends in Lilienthal, Germany, on 21 September 1800. The gathering of seven astronomers devised a plan to find the missing planet. Since they expected to find it near the ecliptic, they divided it into 24 zones, each covering one hour of right ascension. Von Zach named the group the Lilienthal Detectives (commonly called the Celestial Police). In addition, letters were sent to an assortment of international observers inviting them to join the hunt. Each would be assigned a 15° × 15° section of the ecliptic to search—this would be one of the earliest examples of international scientific collaboration.

In the meantime, an Italian Catholic priest named Giuseppe Piazzi was working on measuring the exact positions of stars, a task he had begun in 1790. Then, on 1 January 1801, the first day of the nineteenth century, and eleven years into his project, he noticed an object in the constellation of Taurus. It had moved over a few nights and, therefore, was a member of the Solar System. Giuseppe was one of the astronomers invited to join in the search, but ironically the letter arrived at his observatory after he made his find.

When astronomers received Piazzi's letters of discovery, the object had moved too close to the Sun to be observed. In 1801, the mathematician Carl Gauss worked out a method to determine the orbit of an object from just three positional measurements. Late that year, he provided the Baron (from the Lilienthal Detectives) with his orbital calculations and positional predictions for Piazzi's object. The Baron recovered the planet

Regulus and Leo 1 Dwarf galaxy (marked above) in Leo

just half a degree from Gauss' estimates. Gauss also confirmed that its distance from the Sun was 2.77 au, very close to the 2.8 predicted. Bode immediately suspected that the object was the planet the Detectives were searching for.

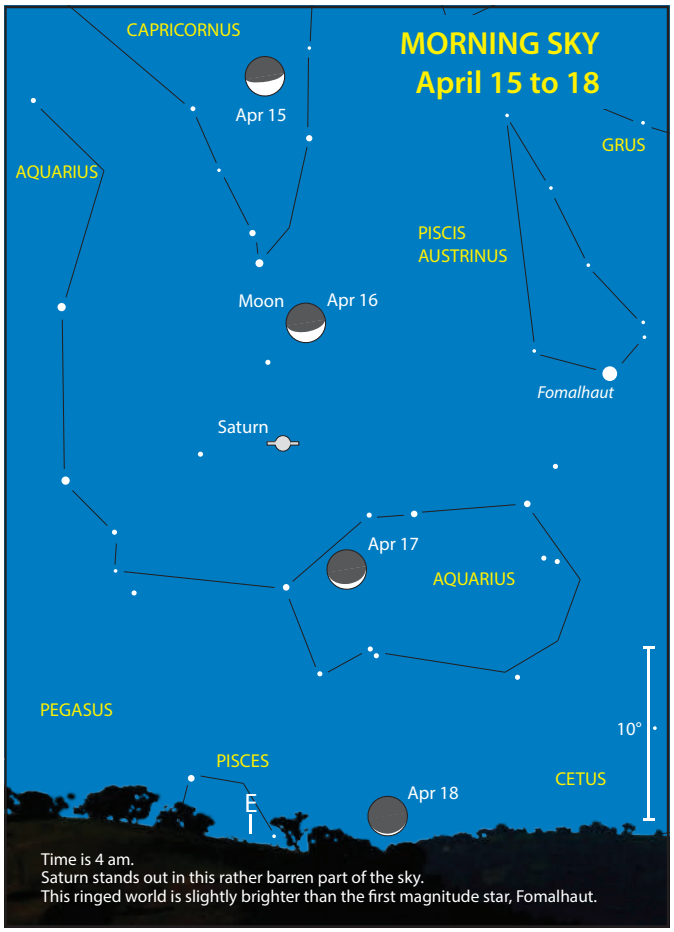
The new *planet* was named Ceres by Piazzi. On 28 March 1802, Wilhelm Olbers, one of the Lilienthal Detectives, discovered another object. After its orbit was calculated, Olbers named the object Pallas, thus creating a problem, the rule predicted one planet at 2.8 au, and now there were two. Olbers suggested that perhaps they were fragments of a larger planet that had broken up. Since both appeared small, Herschel proposed that these objects were a new class of Solar System member. He suggested the name 'asteroid' because they appeared as stars through the telescope. The name stuck, but the preferred term is minor planet, as recommended by Piazzi, as they have nothing to do with stars.

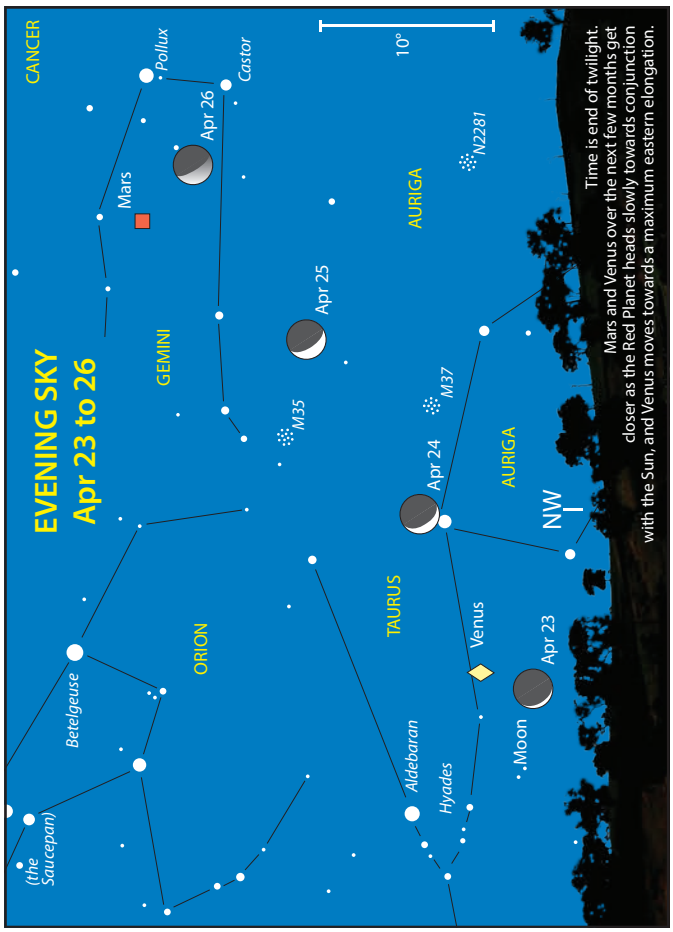
On 2 September 1804, Carl Harding, another of the Detectives, discovered Juno. Then on 29 March 1807, Olbers discovered Vesta, his second find and the fourth minor planet. From then on, despite their searching, the Detectives could not find another, and eventually, they stopped looking. Finally, the nail in the coffin for the Titus-Bode Law was the discovery of Neptune in 1846 since the error between the actual distance and the formula was quite large (see table).

It wasn't until 1845 that another minor planet was located by a German amateur astronomer named Karl Hencke. He called the fifth minor planet Astraea, and since that time, not a year has gone by without more minor planets being discovered, many by amateurs. The thousandth, Piazzia, was found in 1923, the two thousandth, Herschel, in 1973 and the three thousandth, Leonardo, in 1984. As of July 2022, there are 616,690 numbered minor planets (secured discoveries) out of 1,211,765 observed small Solar System bodies, the remainder being unnumbered minor planets and comets.* Five of these bodies are officially recognised as dwarf planets, including number 134340 Pluto.

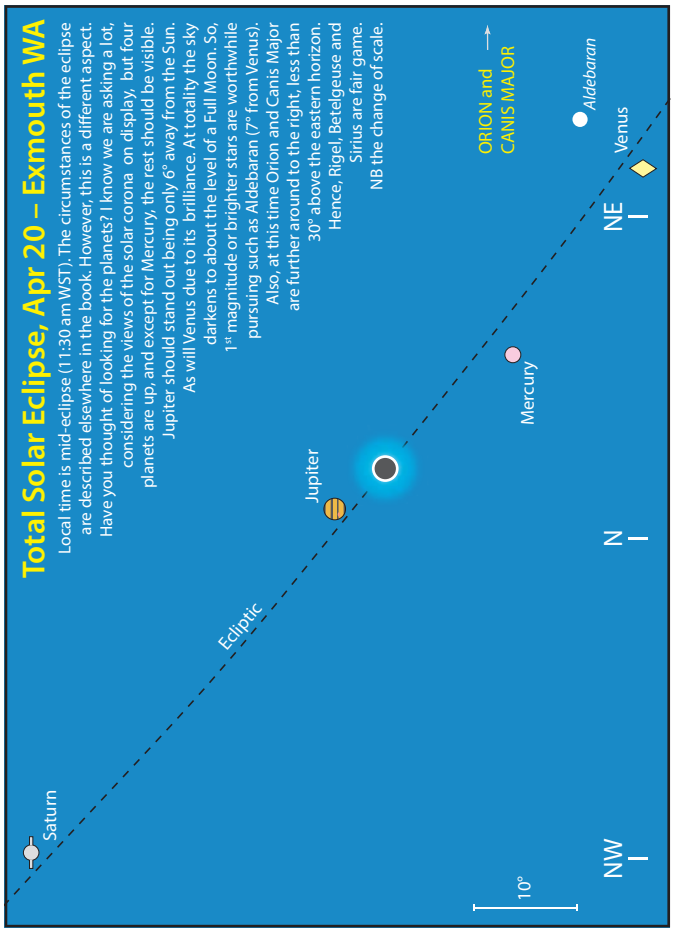
* Statistics from Wikipedia.

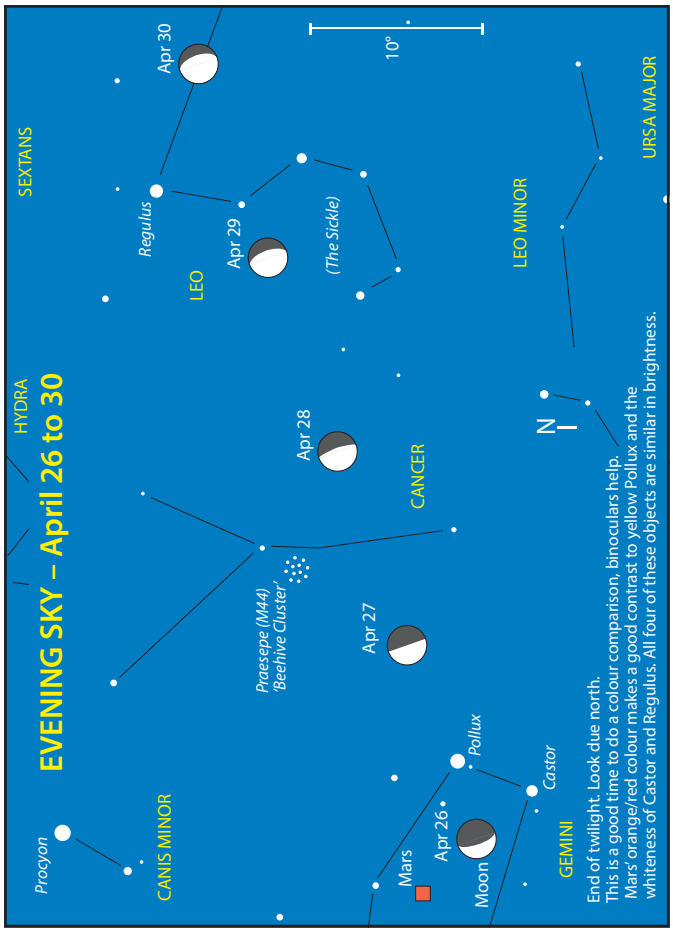
DIARY			
Sun	2nd		m.p. 20 Massalia 0.15° N of M20 Trifid Nebula (BN) in Sagittarius
Tue	4th	am	Comet 237P/LINEAR 0.7° NW of star Xi² Sagittarii
Tue	4th	am	Comet 237P/LINEAR 0.7° SE of NGC 6716 (OC) in Sagittarius
Tue	4th	am	m.p. 11 Parthenope 1.0° N of M9 (GC) in Ophiuchus
Wed	5th		m.p. 20 Massalia 0.4° S of M21 (OC) in Sagittarius
Wed	5th	am	m.p. 44 Nysa 0.3° W of star Phi Ophiuchi
Thu	6th	3 pm	(1 pm WST) Full Moon (391,135 km).
Thu	6th	pm	Comet C/2017 K2 (PANSTARRS) 0.5° SE of IC 2006 (G) in Eridanus
Sun	9th	9 pm	(7 pm WST) Comet C/2022 E3 (ZTF) 3° SW of IC 2118 (Witches Head Nebula) in Eridanus
Tue	11th		m.p. 20 Massalia 0.5° N of NGC 6546 (OC) in Sagittarius
Tue	11th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.3° NW of star Gamma² Delphini
Wed	12th		Venus 2.7° SE of M45 the Pleiades (OC) in Taurus
Wed	12th	3 am	(1 am WST) Comet C/2020 K1 (PANSTARRS) 0.06° NE of NGC 6893 (G) in Telescopium
Wed	12th		Jupiter in conjunction with Sun
Wed	12th		Mercury at greatest elongation East (19.5°)
Thu	13th		m.p. 8 Flora 0.8° N of star Theta Capricorni
Thu	13th	1 pm	(11 am WST) Maximum Libration (7.1°), bright NW limb.
Thu	13th	7 pm	(5 pm WST) Last Quarter Moon.
Thu	13th	pm	Comet C/2017 K2 (PANSTARRS) 0.5° W of NGC 1532 (G) in Eridanus
Fri	14th		Mars 0.2° SW of star Epsilon Geminorum
Fri	14th	am	m.p. 11 Parthenope 0.5° N of NGC 6356 (GC) in Ophiuchus
Sun	16th	5 am	(3 am WST) Saturn 7° NE of Moon
Sun	16th	Noon	(10 am WST) Moon at perigee (closest to Earth at 367,968 km).
Sun	16th	pm	Comet C/2017 K2 (PANSTARRS) 0.5° E of NGC 1537 (G) in Eridanus
Mon	17th	am	m.p. 32 Pomona 0.7° SW of 4
Tue	18th	5 am	(3 am WST) Neptune 2° NW of Moon
Wed	19th	3 am	(1 am WST) Comet 237P/LINEAR 0.2° NW of star Rho¹ Sagittarii
Thu	20th	4 am	(2 am WST) Comet 364P/PANSTARRS 1.3° NE of star Eta Aquarii
Thu	20th	2 pm	(Noon WST) New Moon, hybrid solar eclipse, SE Asia, E. Indies, Australia, Philippines, N.Z. [Hybrid: Indonesia, Australia, Papua New Guinea].
Thu	20th	7 pm	(5 pm WST) star Aldebaran 7° S of Venus
Fri	21st		Neptune 0.15° NW of star 20 Piscium
Sat	22nd		m.p. 8 Flora 1.2° N of star Iota Capricorni
Sat	22nd	am	Lyrids meteor shower, Apr 16–25.
Sun	23rd	2 am	(Midnight WST, prev day) Comet 81P/Wild 2 1.2° W of M23 (OC) in Sagittarius
Sun	23rd	6 pm	(4 pm WST) Venus 3° SE of Moon
Mon	24th		Vesta in conjunction with Sun
Mon	24th	pm	pi-Puppids meteor shower, Apr 15–28.
Tue	25th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.8° NW of NGC 7585 (G) in Aquarius
Tue	25th	pm	m.p. 32 Pomona 0.3° S of star Alpha² Librae
Wed	26th		Venus 1.3° N of NGC 1746 (OC) in Taurus
Wed	26th	2 pm	(Noon WST) Maximum Libration (7.0°), bright SE limb.
Wed	26th	7 pm	(5 pm WST) Mars 5° SW of Moon
Fri	28th	7 am	(5 am WST) First Quarter Moon.
Fri	28th	5 pm	(3 pm WST) Moon at apogee (furthest from Earth at 404,299 km).
Sat	29th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.5° W of NGC 7721 (G) in Aquarius





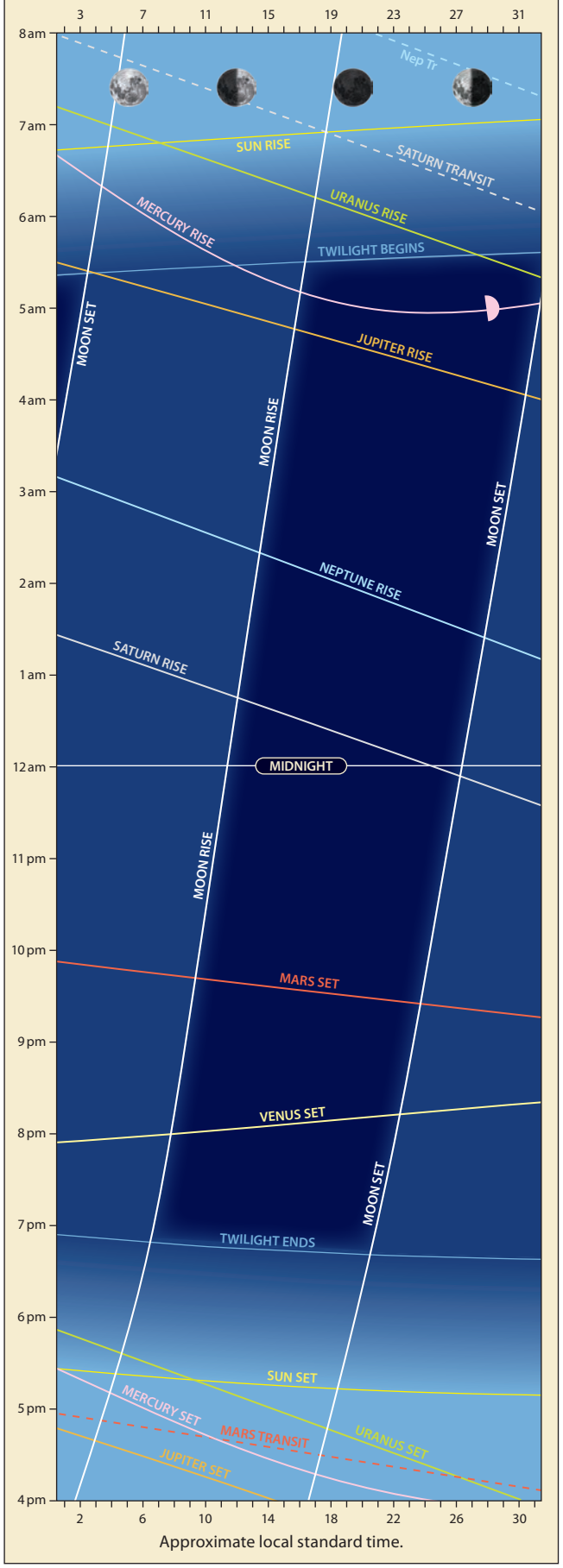
Approximate local standard time.





MAY 2023

RISE–SET CHART



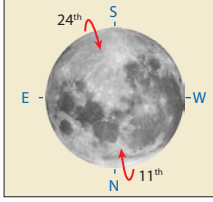
Approximate local standard time.

HIGHLIGHT

- Mercury, Jupiter, and Moon in the evening sky.
- Mercury at best in the morning sky.
- Mars close to M35, the Beehive Cluster.
- The eta-Aquariid meteor shower.

THE MOON

LUNAR LIBRATION



6th 4 am (2 am WST) Full Moon, penumbral lunar eclipse, Africa, Asia, Australia. See Eclipses page 102.

11th 10 am (8 am WST) Maximum Libration (6.8°), bright NW limb. The north pole region is seen to best advantage at this libration.

11th 3 pm (1 pm WST) Moon at perigee (closest to Earth at 369,343 km).

12th Midnight (10 pm WST) Last Quarter.

20th 2 am (Midnight WST, previous day) New Moon.

24th 6 am (4 am WST) Maximum Libration (6.9°), bright SE limb. The 114 km crater Demonax, in the south polar region, is ideally suited for observation as it emerges from the zone of librations.

26th Noon (10 am WST) Moon at apogee (furthest from Earth at 404,509 km).

28th 1 am (11 pm WST, previous day) First Quarter.

APPEARANCE of the PLANETS

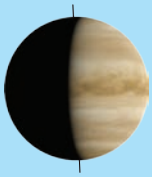
MERCURY Mercury in inferior conjunction on the 2nd

10 May
dia 11.7"
mag 3.5

20 May
dia 10.0"
mag 1.3

29 May
dia 8.3"
mag 0.5
Greatest elongation
West (24.9°)

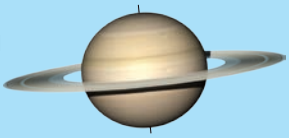
VENUS
15 May
dia 19.1"
mag –4.3



MARS

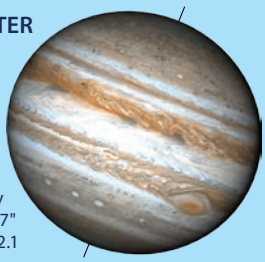
15 May
dia 5.0"
mag 1.5

SATURN



15 May
dia 16.7″
mag 1.0

JUPITER



15 May
dia 33.7"
mag –2.1

URANUS

30 May
dia 3.4"
mag 5.8
Conjunction 10 May

NEPTUNE

15 May
dia 2.2"
mag 7.9

THE PLANETS

After inferior conjunction on the 2nd, **Mercury** returns to the eastern dawn sky. This apparition (May to early June) marks the second period this year when the planet can be seen to good advantage, away from the Sun's glare. On the 18th, the slender waning crescent of the 28-day old Moon (just 3.5% illuminated) appears less than 4° from the planet, and as a bonus, brightly shining Jupiter is above the pair (see Sky View). Binoculars will assist here if searching for the trio in the twilight. Mercury reaches its greatest elongation 25° west of the Sun on the 29th.

Venus is spectacular in the early western evening sky. The planet spends the first week of the month in Taurus before moving into Gemini, passing close (1.8° north on the 9th) to the beautiful open star cluster M35 (NGC 2168). M35 is visible to the unaided eye under good dark skies and is splendid in small instruments. On the 23rd, the waxing crescent of the 4-day old Moon appears directly below Venus (see Sky View). On 30th, Venus is in the same eyepiece field with the double star Kappa Geminorum.

Mars spends the first half of the month in Gemini in the early north-western evening sky before moving into Cancer. Although not close, the 4-day old waxing crescent Moon makes for a pleasant sight with Mars and Venus on the 24th (see Sky View). Finally, on the 31st, the Red Planet will be located just 1° from the outer fringes of M44, the Beehive Cluster (closer in June). This event will be a real treat for astrophotographers over the coming days as it passes directly over this large (70-arcminute) open star cluster. Visual observers using binoculars or small telescopes will note the colour contrast between the planet and the brighter cluster members of about a dozen yellow-white suns brighter than 7th magnitude.

Jupiter rises in the early morning north-eastern dawn in Pisces before moving into Aries later this month. On the 18th, the King of Planets will be directly above the slender crescent of the 28-day old waning crescent Moon—included in the scene is Mercury, a few degrees south of the Moon (see Sky View).

Saturn is still an object for insomniacs, rising in the east around 1 am mid-month. On the 14th, the 23-day old waning crescent Moon will be near the planet (see Sky View). On the 28th, Saturn 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). 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 Saturn a 3-D appearance.

Uranus is in conjunction with the Sun on the 10th, after which it reappears in early June in the eastern dawn sky.

Neptune is in Pisces, not too distant from the asterism known as the Circlet. The planet is only visible in the morning eastern sky, rising after 2 am mid-month.

The Alpha Centauri System

High up in the evening sky this month is the famous asterism of the Southern Cross and Pointers. It is interesting to see Alpha and Beta Centauri being referred to as the 'Pointers'. For if you draw a line joining the stars and extend it towards the Cross it passes over the top, well… for the time being. Alpha has a high proper motion and is moving towards Beta and the direction of this line is swinging towards the south. By about 4000 CE the separation of these stars will be half the current 4.5° and the line will be pointing at the centre of the Cross. Alpha will make its closest approach to Beta around 6200 CE when it will be 23 arcminutes north—less than the diameter of the Moon away!

Alpha Centauri's claim to fame (besides being the destination for the space family Robinson in 'Lost in Space') is being the closest star to our Solar System; a little over 4 light-years away. The distance to alpha was first determined by Henderson from the Cape of Good Hope in 1839 using the technique of stellar parallax. This method can be best demonstrated by holding up a finger in front of your face. Look at the finger from one eye (closing the other) and then the other and see how its position against the background shifts between the views. The closer the finger, the larger the shift. In the case of stellar parallax, the position of the eyes is the Earth on opposite sides of the Sun and the background is the distant field of stars. Even in the case of alpha, this is a tiny shift, needing some very high precision measurements. A parallax of only 1 arcsecond corresponds to a distance of 3.26 light-years (which defines the unit of measurement of the parsec).

Alpha Centauri is also one of the finest and brightest visual binaries in the heavens with both components being clearly visible in the smallest of telescopes. Alpha Centauri is a true binary, being made up of two Sun-like stars of magnitudes –0.01 and 1.34 (A and B) in orbit about each other. The orbital motion of the pair has been followed since the first accurate measurements from the Cape of Good Hope in 1752, by Lacaille. The orbital period of the stars is 79.1 years, and the orbit forms quite an elongated or eccentric ellipse. The true distance between the stars varies from 11 to about 35 au or to compare it to the Solar System—a little beyond the distance from the Sun to Saturn out to halfway between Neptune and Pluto. From Earth the orbit is tilted from edge-on by about 11°, hence, to us their paths appear even more elongated (see diagram). As you can see, the separation angle has widened over the last 7 years to a comfortable 7 arcseconds and now obviously wider than the main stars of Alpha Crucis (about 4 arcseconds).

Looking at the two components, 'A' is the more Sun-like, being a yellow spectral class G2 star and 10% larger than Sol. Companion 'B', historically called Toliman, is 90% the mass of the Sun and a cooler and more orange, spectral class K1 star.

Alpha Centauri is in fact a triple star with a much more distant, faint companion called Proxima Centauri. It is located approximately 2° south-west of Alpha and is only magnitude 10.7, and a little closer to us than its much brighter brothers (4.23 vs. 4.37 light-years away). It is a little ironic that, with all the thousands of naked-eye stars in the heavens, a small telescope and a good finder chart is needed to see the closest star of them all (excluding the Sun). Proxima's closeness was confirmed by measurements of its proper motion by R.T. Innes in 1915. Being so close and faint it comes as no surprise

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
1 May	7 Iris	Libra	9.6
1 May	471 Papagena	Libra	11.8
4 May	32 Pomona	Libra	10.3
10 May	702 Alauda	Centaurus	12.2
11 May	16 Psyche	Libra	10.6
17 May	67 Asia	Libra	10.8
22 May	44 Nysa	Libra	10.2
23 May	423 Diotima	Libra	11.3
24 May	45 Eugenia	Scorpius	10.9
27 May	19 Fortuna	Scorpius	10.9

COMETS

Comet 237P/LINEAR starts in Sagittarius at 11th magnitude, moving to Aquila mid-month. It is rising in the eastern sky and transiting high in the northern sky in the early morning.

Comet 364P/(PANSTARRS) spends the month rising in the eastern sky around 2–3 am. Starting in Aquarius about magnitude 11, it moves into Cetus on the 3rd and ends the month having faded to around magnitude 13.

Comet 81P/Wild 2, at around 11th magnitude this month, begins in Sagittarius, rising in the south-eastern sky after twilight, transiting high in the northern sky around 3 am. These times get progressively earlier, ending the month rising in the south-eastern sky about an hour after sunset, transiting high in the northern sky around 1 am. It also crosses back into Ophiuchus on the 17th.

Comet C/2017 K2 (PANSTARRS) starts the month in Eridanus at 10th magnitude, setting in the south-western sky around 9:30 pm. It moves into Lepus on the 10th, rising in the south-eastern sky just before sunrise and setting in the south-western sky around 8:30 pm. By month's end the comet is rising in the eastern sky about an hour before sunrise, setting in the western sky about an hour after twilight.

Comet C/2020 K1 (PANSTARRS) is in Indus about magnitude 11, moving to Pavo on the 7th. It is circumpolar from mid-latitude Australia, transiting high in the southern dawn sky.

After perihelion on the 8th, **Comet C/2020 V2 (ZTF)**, moves into the dawn sky, spending the month in Aries at around 10th magnitude.

METEOR SHOWER

The **eta-Aquarids** are linked with Halley's Comet and rank as one of the most popular Southern Hemisphere showers. Visible from April 19 to May 28, with the peak expected during the morning of the 7th. 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. The Full Moon on the 6th will cause considerable interference this year.

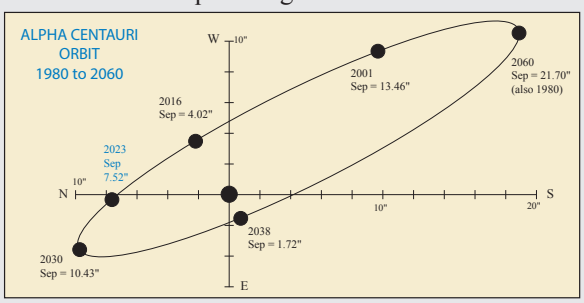
to learn that at one time Proxima was considered one of the least luminous stars ever found (many brown dwarfs found in recent years have lower luminosities). If Proxima replaced the Sun, it would only be as bright as 45 Full Moons and about 1/20 of its diameter. The star is believed to be gravitationally linked to Alpha Centauri but 400 times further away than the mean separation of the main pair and taking some 500,000 years to complete one orbit. Although Proxima is thought to be around 12,000 au (0.2 light-years) from alpha, its orbit is highly eccentric, ranging from 4,100 au (periastron) to 12,300 au (apoastron), so the star is currently close to its maximum distance in its orbit.

Alright, let's assume life exists on a planet orbiting one of the bright Alpha Centauri components. How would their night sky differ from ours? Being so close to our Sun (only 4.3 light-years away) there wouldn't be a great difference, the biggest change would be one of the Pointers is now missing. Also, the constellation of Cassiopeia would have a new alpha star, shining at 0.5 magnitude, adding a further arm to the famous 'W'—the Sun! (See All Sky Map No 3). Even from bright alpha, Proxima would not stand out in the sky, but at least reach naked-eye brightness of magnitude 4.4. It would be located in Taurus, about 6° from the Hyades star cluster.

Unfortunately, we may need to change our extra-terrestrial example (not to mention the possibility the Robinson family would be wasting their time heading for Alpha Centauri), for despite scrutiny by the astronomical world for many years, no evidence has been found for either of the main stars having any planets. However, Proxima has at least two confirmed planets and perhaps a third. One appears to be in its habitable zone (which means water can exist as a liquid on its surface).

Unfortunately, the existence of life has a major problem, for Proxima is a red dwarf (spectral class dM5e) and a flare star. This means it goes through random increases in brightness due to magnetic activity, resulting in substantial x-ray emissions. It can increase in brightness by up to a magnitude in only a few minutes. These temporary flashes occur at irregular intervals and the star returns to its normal brightness in less than 30 minutes. Harlow Sharpley, studying Harvard plates, detected 48 flares during the interval of 1925 to 1950. Back in the 60s a number of Australian amateurs took part in a program to monitor Proxima for flares.

From Proxima, the most impressive stellar sight would be its brothers. Alpha would reside near the head of Scorpius, about 8° from Beta Scorpii. The combined brightness (A and B) would be –6 magnitude, about 6 times brighter than Venus! It's difficult to comment on the apparent separation A and B would have, due to their eccentric orbit, and inclination from Proxima, but a separation of around 20 au with no foreshortening would be around 7 arcminutes—quite a sight.



CONSTELLATIONS

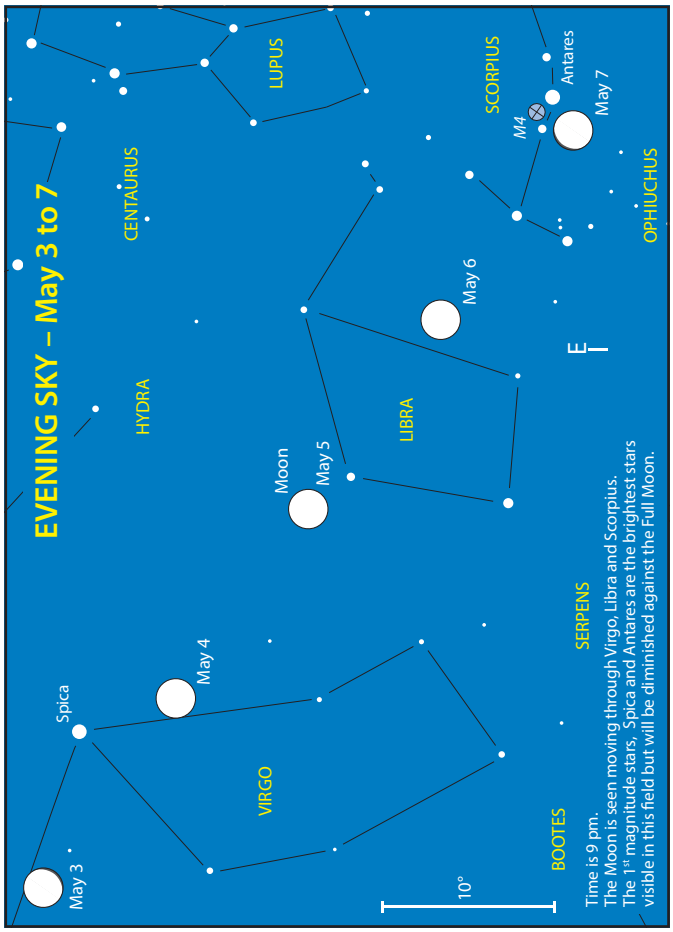
Next in our zodiacal journey is the constellation of Virgo the Virgin (All Sky Maps 6 and 7). This translates from Latin to 'virgin' or 'young maiden' and recorded by Ptolemy in the 2nd century CE. Good luck trying to find a human shaped figure in this collection of mostly 4th magnitude stars. Yet, it has been linked to a young woman across many cultures, including multiple references in Greek mythology. These associations possibly originated in Iraq. Remains were found in an archaeological dig in southern Iraq predating 3000 BCE, which depicted the constellation as a goddess holding ears of wheat. Early Greek culture depicted a goddess of justice, 'Dike', who, when becoming disheartened by human greed, flew into the heavens to escape. Therefore, some ancient star atlases show her with wings. So, Virgo resides appropriately next to Libra, the scales of justice. The closest myth to that assigned by Ptolemy, was the Greek goddess of the harvest with her holding wheat in her left hand at the position of Virgo's alpha star, Spica, which translates to 'ear of grain'. Approximately halfway between Regulus and Spica is the vernal or spring equinox (for the Southern Hemisphere). The position where the Sun crosses the celestial equator in September.

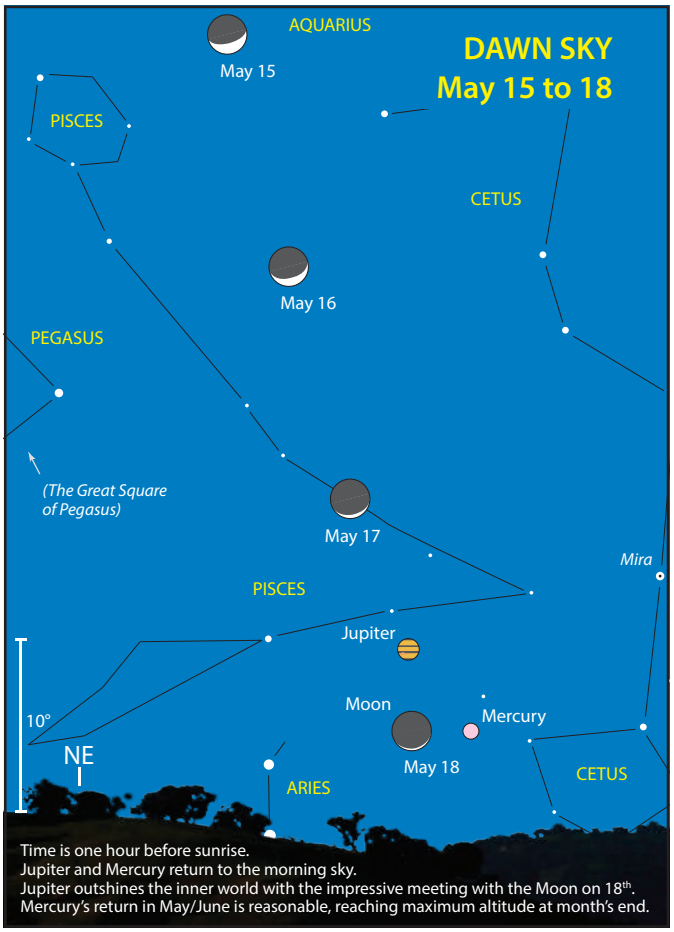
DIARY			
Mon	1st		Venus 3.0° S of star Beta Tauri
Tue	2nd		Mercury in inferior conjunction
Sat	6th		Saturn 0.2° SE of star Sigma Aquarii
Sat	6th	am	Comet 237P/LINEAR 0.3° W of NGC 6818 (PN) in Sagittarius
Sat	6th	am	Comet 237P/LINEAR 1.0° NW of NGC 6822 (G) in Sagittarius
Sat	6th	am	Comet C/2020 K1 (PANSTARRS) 1.0° W of star Beta Indi
Sat	6th	4 am	(2 am WST) Full Moon (380,202 km), penumbral lunar eclipse, Africa, Asia, Australia.
Sun	7th	am	eta-Aquarids meteor shower, Apr 19 to May 28, Moon affected.
Tue	9th		Jupiter 0.5° N of star Omicron Piscium
Wed	10th		m.p. 6 Hebe 1.2° N of M44 Beehive Cluster (OC) in Cancer
Wed	10th		Mars 1.5° S of star Kappa Geminorum
Wed	10th		Uranus in conjunction with Sun
Wed	10th	7 pm	(5 pm WST) star Pollux 5° N of Mars
Thu	11th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.4° SE of star Iota Ceti
Thu	11th	10 am	(8 am WST) Maximum Libration (6.8°), bright NW limb.
Thu	11th	3 pm	(1 pm WST) Moon at perigee (closest to Earth at 369,343 km).
Fri	12th	Midn	(10 pm WST) Last Quarter Moon.
Sun	14th	2 am	(Midnight WST, prev day) Saturn 3° NW of Moon
Mon	15th	5 am	(3 am WST) Neptune 4° NE of Moon
Tue	16th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.7° N of NGC 153 (G) in Cetus
Tue	16th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.7° S of NGC 157 (G) in Cetus
Wed	17th		Venus 0.8° NE of star Epsilon Geminorum
Thu	18th	am	m.p. 20 Massalia 0.15° SW of M21 (OC) in Sagittarius
Thu	18th	6 am	(4 am WST) Jupiter 5° SW of Moon
Thu	18th	7 am	(5 am WST) Mercury 4° SE of Moon
Sat	20th	am	m.p. 20 Massalia 0.4° N of M20 Trifid Nebula (BN) in Sagittarius
Sat	20th	2 am	(Midnight WST, prev day) New Moon.
Sun	21st		m.p. 8 Flora 0.9° NW of star Iota Aquarii
Tue	23rd	6 pm	(4 pm WST) Venus 6° SE of Moon
Wed	24th	6 am	(4 am WST) Maximum Libration (6.9°), bright SE limb.
Wed	24th	8 pm	(6 pm WST) Mars 6° SE of Moon
Wed	24th	pm	m.p. 11 Parthenope 0.7° S of star Eta Ophiuchi
Fri	26th	am	Comet C/2020 K1 (PANSTARRS) 1.0° E of IC 5052 (G) in Pavo
Fri	26th	4 am	(2 am WST) Comet 364P/PANSTARRS 0.6° SE of NGC 337 (G) in Cetus
Fri	26th	Noon	(10 am WST) Moon at apogee (furthest from Earth at 404,509 km).
Sat	27th		m.p. 29 Amphitrite 0.9° SE of Neptune
Sun	28th	1 am	(11 pm WST, prev day) First Quarter Moon.
Mon	29th		Mercury at greatest elongation West (24.9°)
Tue	30th		Venus 0.4° S of star Kappa Geminorum
Tue	30th	7 pm	(5 pm WST) star Pollux 4° N of Venus
Wed	31st		m.p. 2 Pallas 1.2° N of star Epsilon Hydrae

Spica happens to be the second closest bright star to the ecliptic (2° away), after Regulus (see April constellations). Hence this has earned special attention this month. It is interesting, in all the constellations of the Zodiac, this is one of only six 1st magnitude stars. The star is isolated but if you see a bright star high in the northern evening sky this month preceded by (to the star's left) a squashed square shaped asterism (the constellation of Corvus), you have found Spica. Of all the 1st magnitude stars, Spica is one of the hottest and bluest examples, fitting into the early B spectral class. It is also a close binary, with two very similar stars whipping around each other in only four days. They are so close, the slight variability detected in the star's brightness is thought to be due to the stars' gravity warping each other (presenting different aspects during their rotation). Spica's colour is often compared visually to Arcturus (Alpha Boötis), for the latter is a much cooler, yellow/orange star. Arcturus only looks brighter as it's much closer than Spica, 37 versus 260 light-years respectively. Also, when you take the ultraviolet radiation into account, Spica is 12,000 times brighter, and 11 times the mass of the Sun.

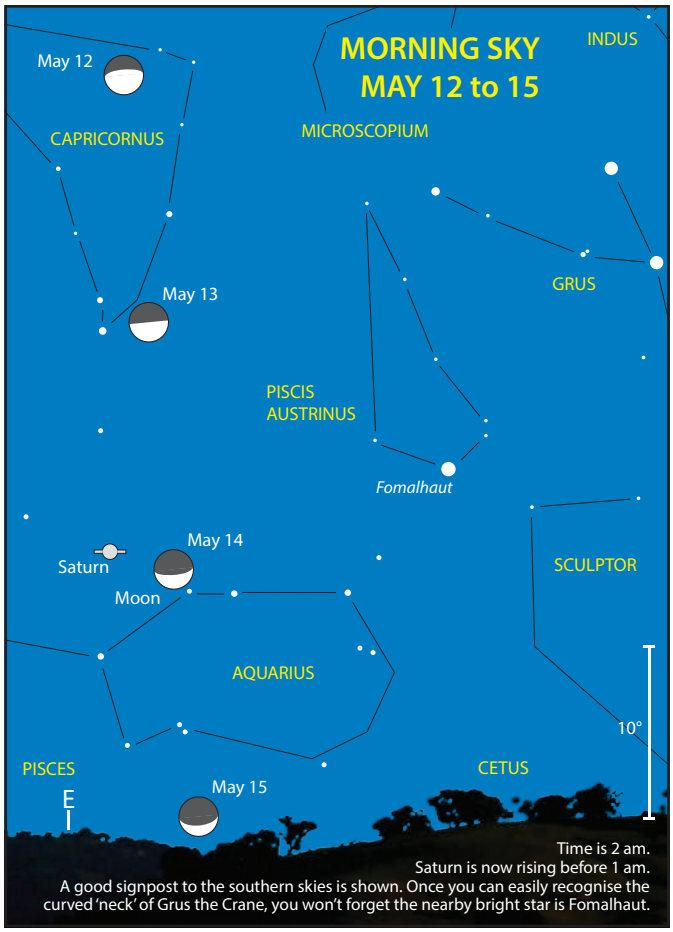
While talking naked-eye attractions, finding any easily recognised asterisms in Virgo isn't easy. If you start with Spica at the top and move anticlockwise to Porrima (Gamma Virginis—a brilliant double star), then Vindemiatrix (Epsilon Virginis) and finally Heze (Zeta Virginis), you've found the Diamond (All Sky Map No 6).

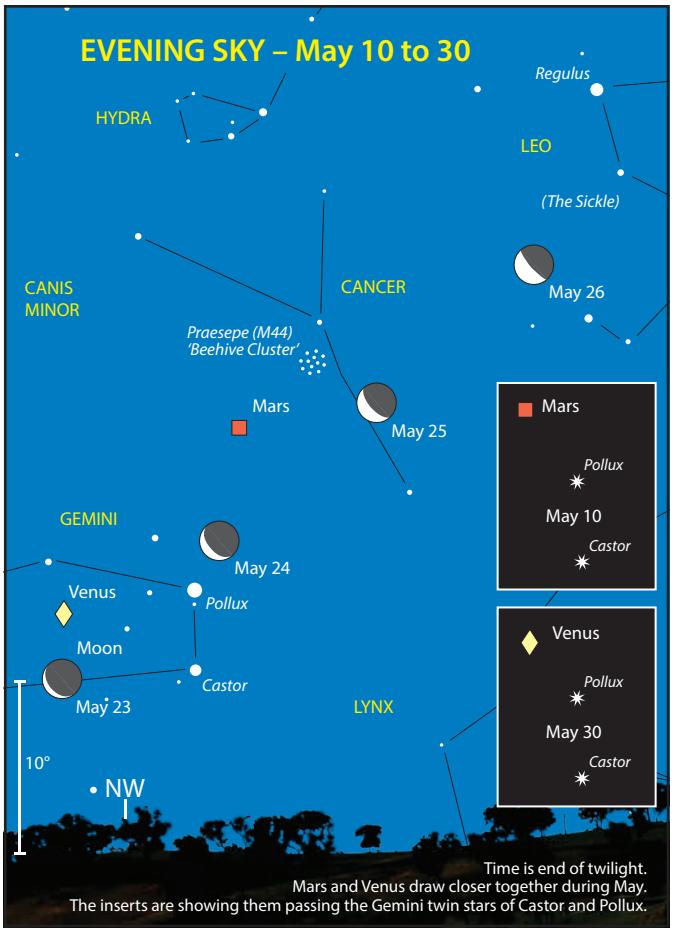
Now for the most famous aspect of Virgo, well at least for deep sky enthusiasts. You would think being so far from the plane of the Milky Way it would have some galaxies to observe, in fact it has far more than you'd expect, containing the heart of the Virgo/Coma Supercluster. The centre, or main concentration, straddles the border between Virgo and Coma Berenices and is found between the stars Vindemiatrix and Denebola (Beta Leonis)—All Sky Map No 7. In our maps we have given preference to calling deep sky objects by their Messier Catalogue (M) numbers as often these are the brightest examples. You may be surprised what treasure trove is waiting for you in this cluster, even using a humble pair of binoculars. Note, these fuzzy patches will be small, as binoculars lack the magnifying power of telescopes. There are around 3,000 galaxies in this cluster and outliers extend as far as Hydra and Centaurus (in the south-east) to Canes Venatici and Ursa Major (in the north-west).





Approximate local standard time.





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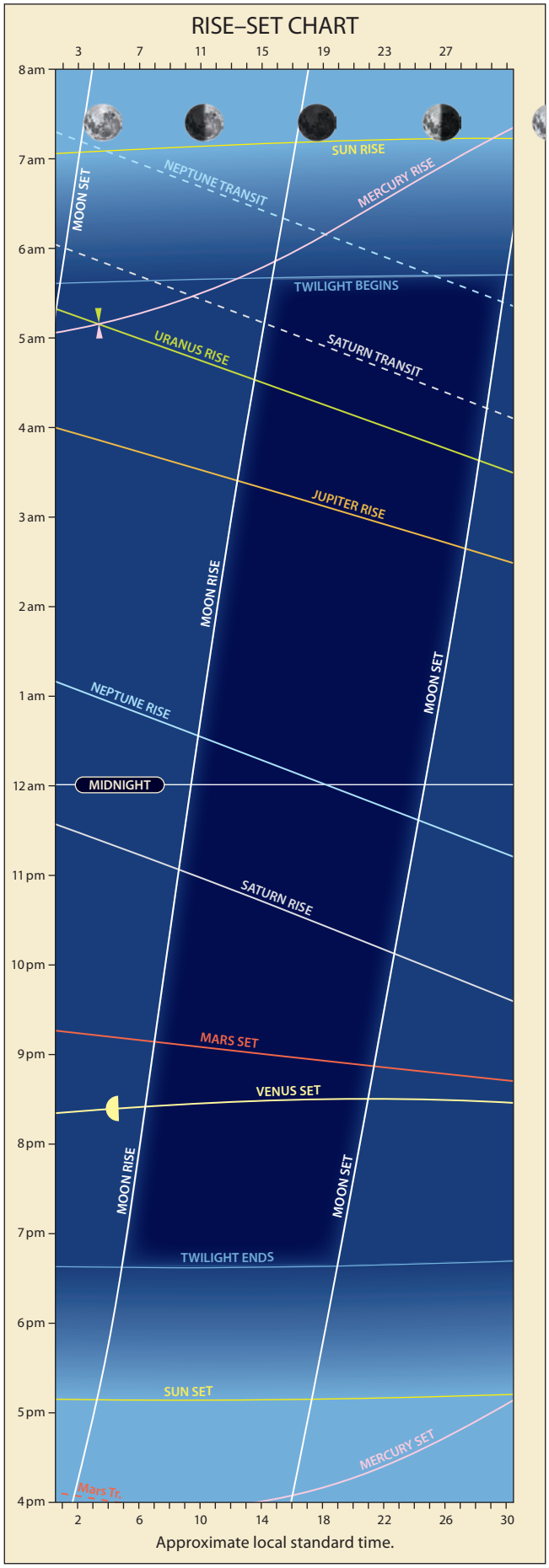
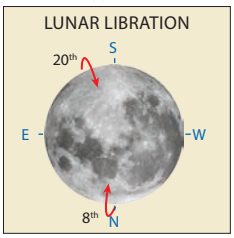


HIGHLIGHTS

- Moon, Venus, and Mars close.
- Mars crosses Messier 44.
- Venus close to Messier 44.

THE MOON



4th 2 pm (Noon WST) Full Moon.

7th 9 am (7 am WST) Moon at perigee (closest to Earth at 364,861 km).

8th 8 am (6 am WST) Maximum Libration (6.7°), dark NE limb.

11th 6 am (4 am WST) Last Quarter.

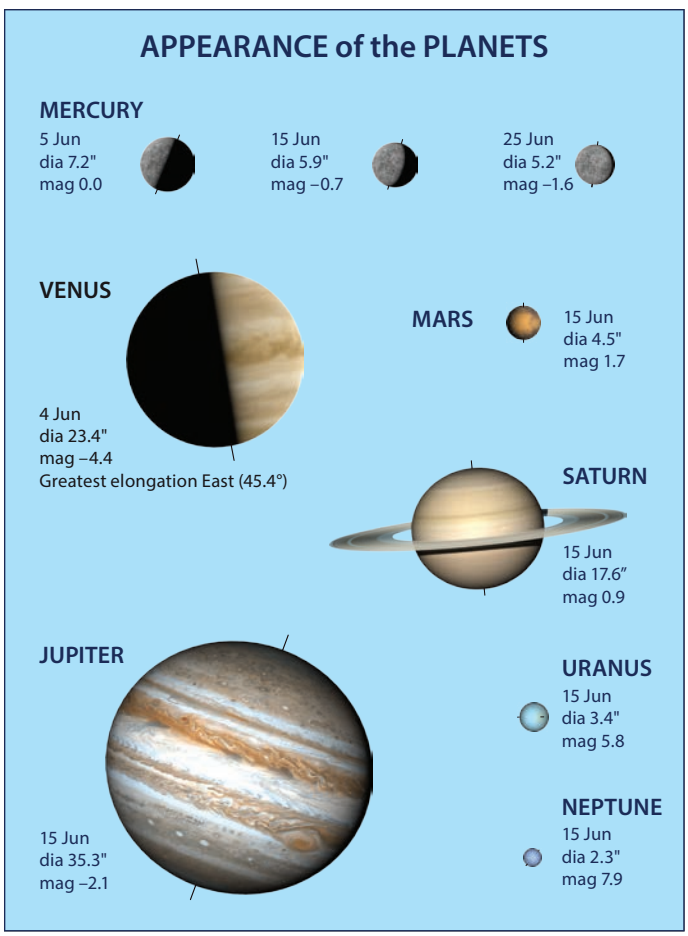
18th 3 pm (1 pm WST) New Moon.

20th 6 am (4 am WST) Maximum Libration (6.9°), bright SE limb. The 114 km crater Lyot is ideally suited for observation as it emerges from the zone of librations. Note: with the Moon just 39 hours old, observations could be made during the daytime.

23rd 5 am (3 am WST) Moon at apogee (furthest from Earth at 405,385 km).

26th 6 pm (4 pm WST) First Quarter.

APPEARANCE of the PLANETS



THE PLANETS

After its greatest elongation last month, **Mercury** begins its descent back toward the Sun. It becomes lost in the brightening eastern dawn sky late this month (see Sky View) and will return to grace the evening twilight in July.

Leaving Gemini, **Venus** crosses Cancer before ending up in Leo at month's end. On 2nd, Venus is found low in the early north-west evening sky forming a line with Castor and Pollux (Gemini twin stars). Venus is the top and brightest body, with the three being nearly equidistant. In its journey in the early western evening sky, Venus skims past the outer fringes of the Beehive Cluster on the 13th and 14th. The Beehive, also known as Messier 44 or Praesepe, is considered a naked-eye object, but it does require dark skies to be visible. A small telescope or binoculars will show about 75 stars in this large cluster. On the 4th, the planet reaches its greatest elongation 45° east of the Sun. Venus appears to chase Mars as it crosses Cancer—although the gap closes to about 4°, the pair separate next month. A neat conjunction occurs between the 4-day old waxing crescent Moon, Venus, and Mars on the 22nd, the trio fitting within a 5° circle (see Sky View).

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

On the 1st of the month, **Mars** can be found on the outskirts of Messier 44 in the early evening north-western sky in Cancer. On the 2nd and 3rd, the Red Planet will cross the cluster, making a nice colour contrast between the planet and the brighter cluster members of about a dozen yellow-white suns brighter than 7th magnitude. Even small telescopes will show more than 50 to 100 members in this cluster that was first resolved into stars by Galileo in 1610. Visible to the unaided eye under dark skies, the cluster was known in antiquity as Little Cloud or Little Mist. Galileo recorded 37 stars, although his drawing included many beyond its currently accepted environs. He noted around a dozen actual members through his small telescope. Not bad for a crude instrument that amateurs today would not even consider a worthy finderscope with its very narrow field and low magnification. On the 22nd, a pleasant evening view occurs when the Red Planet appears near Venus and the crescent Moon (see Sky View and Venus).

Jupiter, in Aries, is visible low in the north-eastern sky before dawn. On the 14th the planet will be 5° from the 25-day old waning crescent Moon (see Sky View).

Saturn rises around 10:30 pm mid-month in the eastern evening sky. The Ringed Planet's apparent path against the starfield reverses this month as this world begins its retrograde track ahead of the August opposition (see Retrograde Motion p. 94). On the 10th the 21-day old waning gibbous Moon will be near the planet (see Sky View).

Uranus returns to the late morning eastern sky in Aries this month after its solar conjunction in May. During the first week of June, three planets make the constellation of the Ram their home: Mercury, Jupiter, and Uranus.

Neptune is still a morning object, rising around midnight about the 15th.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
6 Jun	11 Parthenope	Ophiuchus	9.4
8 Jun	39 Laetitia	Ophiuchus	10.1
16 Jun	20 Massalia	Ophiuchus	10.0
21 Jun	52 Europa	Sagittarius	11.3
25 Jun	94 Aurora	Sagittarius	12.6
29 Jun	196 Philomela	Sagittarius	10.8

COMETS

Comet 237P/LINEAR spends the month in Aquila at magnitude 11, rising in the eastern sky early evening and transiting in the northern sky around early morning.

Comet 81P/Wild 2 spends June in Ophiuchus at magnitude 11, fading to 12 during the month. It begins rising in the south-eastern sky about an hour after sunset, transiting high in the northern sky around 1 am. By month's end, it has already risen by dark, transiting high in the northern sky around 11:30 pm, setting in the western sky shortly before sunrise. By month's end it is transiting high in the northern sky around 10:30 pm, setting in the western sky just before dawn.

Comet C/2017 K2 (PANSTARRS) begins in Lepus around 10th magnitude, rising in the eastern sky about an hour before sunrise, setting in the western sky about an hour after twilight. By month's end it is rising shortly before dawn, setting about an hour after sunset, having faded slightly.

Comet C/2020 K1 (PANSTARRS) is in Pavo at magnitude 11, moving to Octans on the 4th. It is circumpolar, transiting in the southern sky.

Comet C/2020 V2 (ZTF) is in Aries about magnitude 10, rising in the north-eastern sky just before dawn at the start of the month, progressing to rising around 3:30 am by month's end.

Comet C/2021 T4 (Lemmon) spends the first half of the month rising in the eastern sky after midnight, before moving to rise in the south-eastern sky before midnight and transiting high in the northern sky just before sunrise. On the 27th it moves into Sculptor, now rising around 10 pm. The comet brightens from magnitude 12 to 10 during the month.

CONSTELLATIONS

Continue your eastward trek to the constellation of Libra the Scales (All Sky Map No. 6). It's a faint constellation, marked by its four brightest stars (around 3rd magnitude) arranged in a kite shape, lying midway between the stars Spica and Antares. As mentioned in previous yearbooks, it's interesting that Libra is the only inanimate member of the Zodiac, which after all is defined as 'the circle of life'.

In classical times, Libra was called the scales because the autumnal equinox occurred within the constellation when day and night were equal, that is, in balance. Since then, the equinox has moved into Virgo due to precession. Feel free to throw into the astrological pot the ideas that one, the scales are needed to bring a balance in one's life or two, they are symbolic of the lady holding the scales to represent justice (perhaps Virgo, Constellations in May). No one can say you are wrong and it's great trivia for star parties.

Structure of the Milky Way

For as long as humankind has known that the Universe is made up of enormous islands of stars, called galaxies, we have wondered about the structure of our Milky Way. Going back to the early 20th century, lacking the technology of today and being restricted to the visual part of the spectrum, we turned to these extragalactic bodies to try and understand our own galaxy. The distinction between the formless spherical-like ellipticals (plus the irregulars) versus the developed arms of spiral galaxies was obvious. So was the fact that spirals had to be flattened entities, just by looking at the different inclinations or tilts that we saw in them. From our viewpoint, buried in the plane, the Milky Way had an uncanny resemblance to edge-on spirals. Today, the Needle Galaxy NGC 4565 (see image) is thought to be very close to our galaxy's overall structure and appearance as seen from an Earth-like position. From a face on perspective, Messier 83, the Southern Pinwheel Galaxy is believed to be close, with the Milky Way perhaps having a more pronounced bar (see the map).

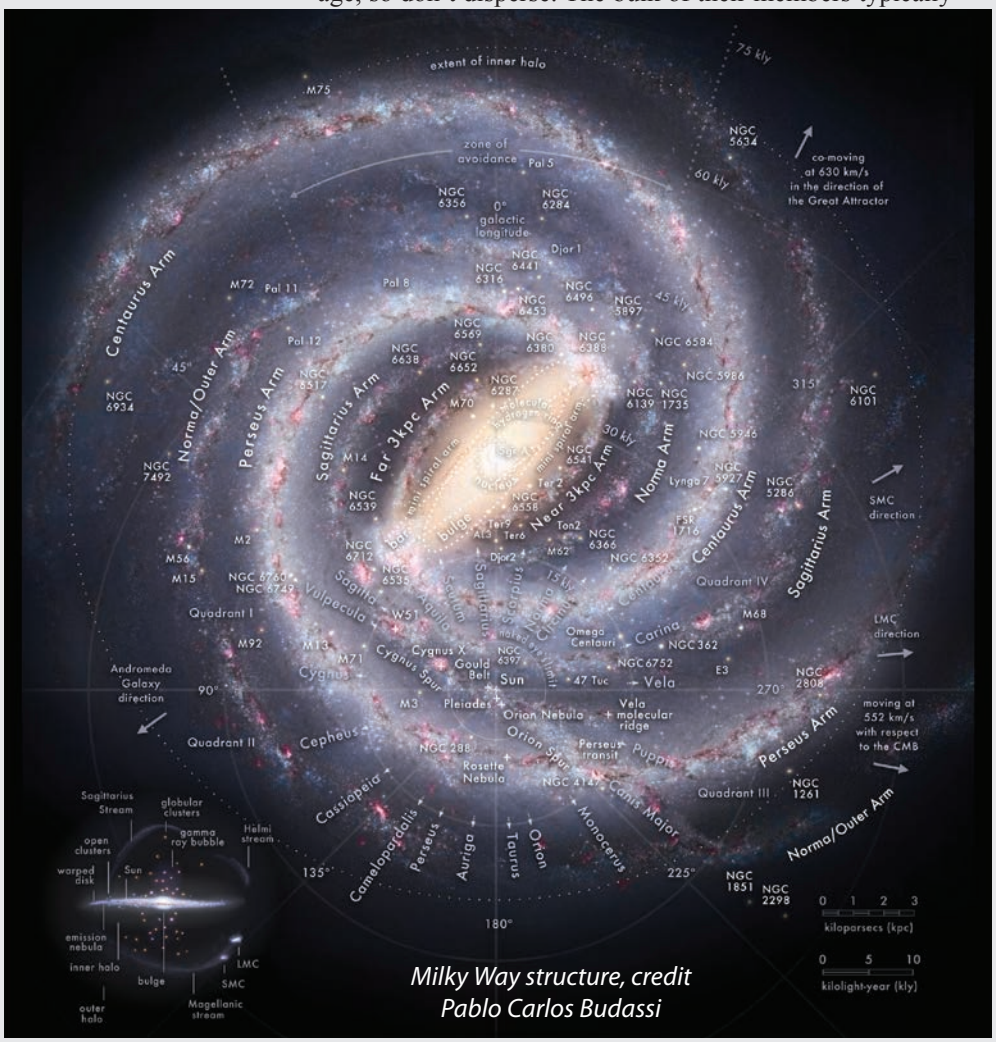
The bar feature is not well understood but thought to start out in about 10% of all spirals as they formed, today making up about two thirds. It's believed to be caused by a gravitational disruption, originating from the violent centre of the galaxy, gradually reshaping the orbits of the inner stars.

All the stars in galaxies are in orbit around their centre, with the Sun taking around 220 million years to complete one trip around ours. Except for their curved shape, the spirals don't reflect this orbital movement directly. Instead, they are pressure waves, a bit like ripples on a pond. The water doesn't move along with the wave, in this case just go up and down. The propagation of sound through the air is another analogy to the galactic situation. The stars slow down slightly causing them and their interstellar medium to compress resulting in star forming (H II) regions, the red clumps seen along the edge of spiral arms. These lead to newly formed hot, blue stars (population II stars), with the nursery becoming open star clusters which gradually disperse. So, it's only within the plane of the disc we see open clusters, many with their star forming regions still intact and active, like the Carina and Orion complexes. The remaining nebulae can either fluoresce (from the heat of nearby stars), reflect the light from these hot stars (blue reflection nebulae) or block the light showing as silhouetted dark clouds.

These newly formed hot blue (OB) stars are considered metal poor (population II stars). Unlike in chemistry, astronomers consider all elements heavier than hydrogen or helium to be 'metals' needing the nuclear fusion of stars and novae or supernovae to create them. These 'blue' stars are not only super-hot (20,000K or greater), but tend to be massive (20 plus times the Sun) so burn their hydrogen quickly and often within only a few million years will go supernovae dispersing their 'metals' into the surrounding region. Stars also release some elements via their stellar winds. We are fortunate our Sun formed in an area which had been previously seeded by remnants of ancient stars, for metal rich environments are needed for rocky planets to form and life as we know to occur.

NGC 4565, Needle galaxy

In contrast to open clusters, globular star clusters are more compact, containing significantly more stars and thought to be some of the oldest objects in galaxies. They consist of long-lived, metal poor (population II) stars. There is no evidence of nebulae, which was perhaps used up when the stars formed, or blown away by the combined stellar winds of such a condensed group. Also, unlike open clusters, stars of globulars remain gravitationally bound for at least their age, so don't disperse. The bulk of their members typically



Milky Way structure, credit Pablo Carlos Budassi

Libra was also called the obscure name of Chelae which is Latin for Claw. The Greeks and Arabs considered Libra to be an extension of Scorpius and this tradition is honoured in the name of the brightest stars. Alpha Librae or Zubenelgenubi's translation is Southern Claw and Beta Librae or Zubeneschamali means the Northern Claw. Reverting to the 'scales' these two brightest stars were considered to form the balance beam with Sigma (σ) and Gamma (γ) the weighing pans.

Libra was also considered the lighthouse of Alexandria, i.e., a bright (really?) light shining between the scorpion's claws or the altar from the top of the Tower of Babel. Today, the only altar that has survived as a constellation is Ara, belonging to the Centaurus/Lupus myth.

In terms of double stars, naked-eye Alpha (α) has components of magnitudes 2.7 and 5.2 separated by 4 arcminutes. Binoculars show the stars are distinctively white and yellow respectively. They are a visual binary, both being 77 light-years away and moving together in space, that is having the same proper motion. Binoculars show Iota (ι) Librae has 4.5 magnitude (Iota[1]) and 6.0 magnitude (Iota[2])

M 83, Southern Pinwheel Galaxy

fit within a volume of radius, 20 to 50 light-years. Although the cores are highly compacted with massive stars, whether they have succeeded in producing black holes remains controversial. The formation of globulars is poorly understood, including why they appear to be randomly distributed within a spherical shell surrounding the galaxy (see bottom left-hand corner of the Milky Way map). A possible contributing factor might be that most massive examples, such as Omega Centauri (which measures several million solar masses), are thought to be formed from the cores of dwarf galaxies consumed by the Milky Way. So, they could come from any direction. The Milky Way has currently 157 known globulars, but that number is likely to increase.

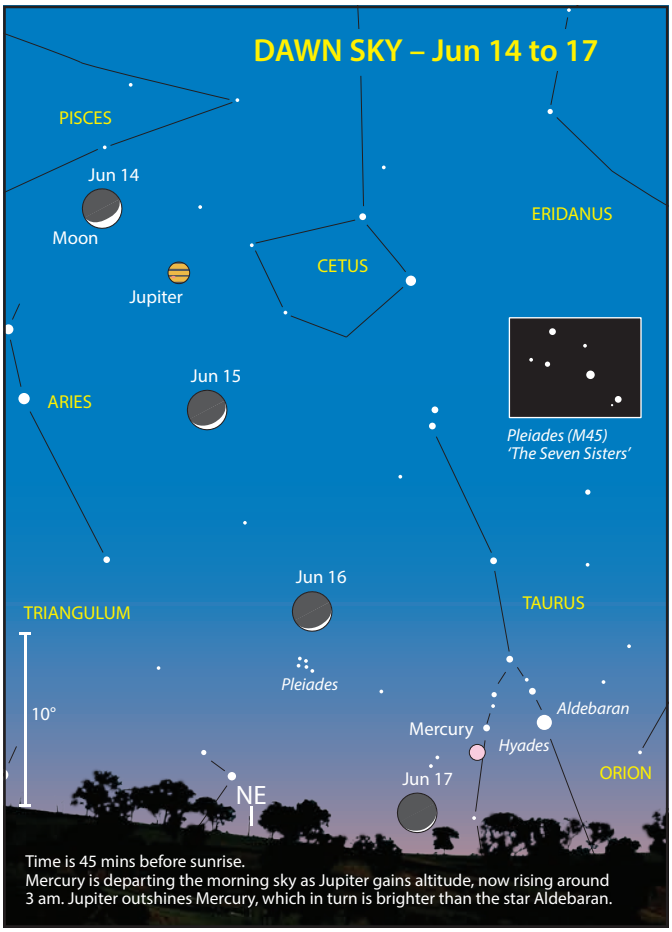
Everyone should take the opportunity at some time to lie back under dark (moonless) winter country skies taking in the Milky Way at the grandest scale. Notice the gradual widening of the Milky Way environment as you get closer to the Sagittarian Teapot and Scorpius. This central bulge is common to spirals and consists of older, cooler population II stars, which have a distinctive yellow hue compared to the hotter bluish stars that dominate the arms. This can be seen in the image of Messier 83 (above). What causes spiral galaxy bulges is not well understood but in some cases, it seems likely that early collisions, with other galactic bodies, resulted in these spherical shaped structures with the stars' orbits much more random compared to the disc stars.

A most obvious feature is the dark lanes running up the centre of our galaxy, massive clouds of mostly unilluminated hydrogen, waiting their turn to take part in star formation (as discussed above). The closer to the centre near the Teapot, the wider the obscuration becomes. This is the body of the Aboriginal constellation of the Emu (see Sky View p. 37), composed of a complex of intertwined dark lanes. Try following the lanes down to the Southern Cross, where the Coalsack forms its head. If it weren't for this interstellar extinction, the brilliancy of this central region would be breath taking, perhaps even being able to read a book by its glow! More information on the galactic hub, see article on page 60.

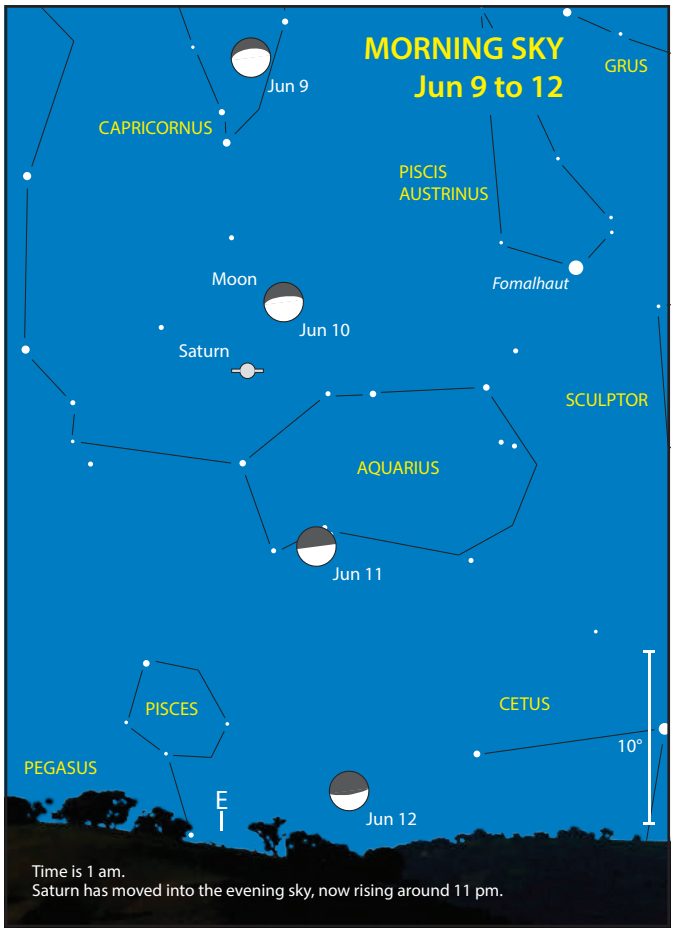
DIARY			
Thu	1st		Comet C/2021 T4 (Lemmon) 0.7° E of NGC 210 (G) in Cetus
Thu	1st	am	m.p. 20 Massalia 0.3° S of NGC 6469 (OC) in Sagittarius
Fri	2nd		Comet C/2020 V2 (ZTF) 0.9° SW of star Epsilon Arietis
Sat	3rd		Jupiter 0.8° NW of NGC 821 (G) in Aries
Sat	3rd		Mars 0.2° NE of M44 Beehive Cluster (OC) in Cancer
Sun	4th	2 pm	(Noon WST) Full Moon (369,885 km).
Sun	4th		Venus at greatest elongation East (45.4°)
Mon	5th	6 am	(4 am WST) Uranus 3° N of Mercury
Tue	6th		Mars 0.3° NW of NGC 2672 (G) in Cancer
Wed	7th	9 am	(7 am WST) Moon at perigee (closest to Earth at 364,861 km).
Wed	7th	9 pm	(7 pm WST) Comet 81P/Wild 2 0.5° S of NGC 6356 (GC) in Ophiuchus
Thu	8th	6 am	(4 am WST) m.p. 4 Vesta 2° S of Mercury
Thu	8th	8 am	(6 am WST) Maximum Libration (6.7°), dark NE limb.
Fri	9th		m.p. 4 Vesta 1.2° N of star f Tauri
Fri	9th		m.p. 88 Thisbe 0.2° SE of star Kappa Piscium
Sat	10th	5 am	(3 am WST) Saturn 3° N of Moon
Sat	10th	9 pm	(7 pm WST) Comet 81P/Wild 2 1.2° N of NGC 6342 (GC) in Ophiuchus
Sun	11th	6 am	(4 am WST) Last Quarter Moon.
Mon	12th	2 am	(Midnight WST, prev day) Neptune 5° W of Moon
Mon	12th	9 pm	(7 pm WST) Comet 81P/Wild 2 0.2° NW of M9 (GC) in Ophiuchus
Mon	12th	pm	d.p. 1 Ceres 0.1° N of NGC 4124 (G) in Virgo
Tue	13th		Comet C/2021 T4 (Lemmon) 1.4° NW of star Beta Ceti
Tue	13th		Mars 0.2° S of NGC 2749 (G) in Cancer
Wed	14th		Venus 0.9° NE of M44 Beehive Cluster (OC) in Cancer
Thu	15th	5 am	(3 am WST) Jupiter 8° SW of Moon
Fri	16th	5 am	(3 am WST) Uranus 7° SW of Moon
Sat	17th		Mercury 1.5° N of star Epsilon Tauri
Sun	18th	3 pm	(1 pm WST) New Moon.
Sun	18th	pm	m.p. 44 Nysa 0.7° N of star Gamma Librae
Mon	19th	am	m.p. 8 Flora 1.0° S of Saturn
Tue	20th	6 am	(4 am WST) Maximum Libration (6.9°), bright SE limb.
Tue	20th		Juno in conjunction with Sun
Thu	22nd		Solstice
Thu	22nd	6 pm	(4 pm WST) Venus 4° SW of Moon
Thu	22nd	7 pm	(5 pm WST) Mars 5° S of Moon
Thu	22nd	7 pm	(5 pm WST) Mars 4° E of Venus
Fri	23rd		Comet C/2020 V2 (ZTF) 2° SW of Uranus
Fri	23rd	5 am	(3 am WST) Moon at apogee (furthest from Earth at 405,385 km).
Mon	26th	6 pm	(4 pm WST) First Quarter Moon.
Tue	27th		d.p. 1 Ceres 0.9° NE of NGC 4224 (G) in Virgo
Wed	28th		m.p. 2 Pallas 1.0° S of star Omicron Leonis
Thu	29th	pm	m.p. 15 Eunomia 0.2° S of star Psi Sagittarii
Fri	30th		m.p. 29 Amphitrite 1.2° SE of NGC 128 (G) in Pisces

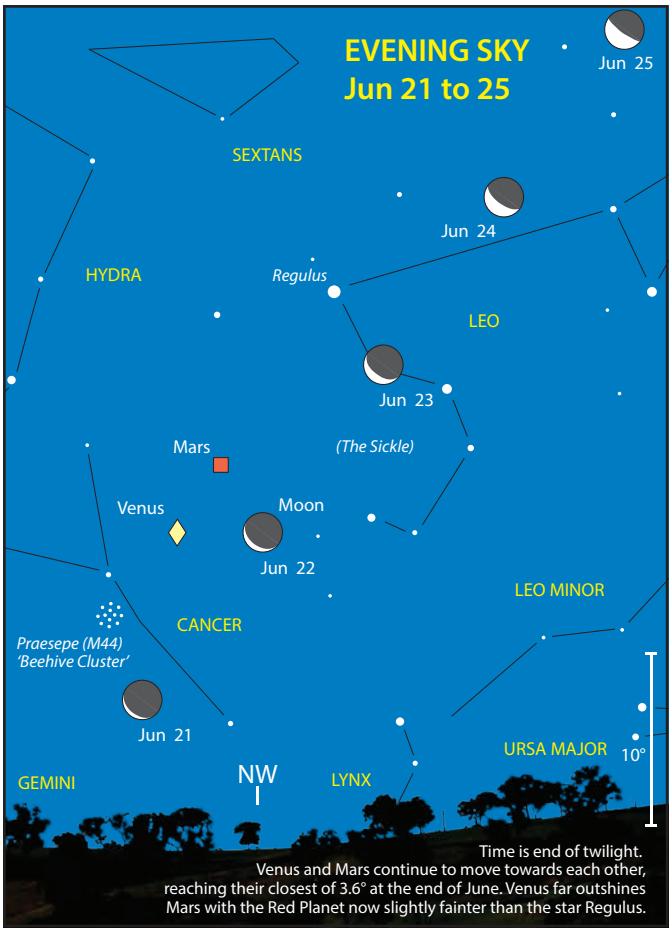
components, separated by 17 arcminutes. A telescope reveals Iota[1] has a closer companion 58 arcseconds away, itself a double with mag 10.1 and 10.5 components only 2 arcseconds apart. Located a short hop (1.7° south-east) from Iota is the globular cluster NGC 5897. This approximately 5-arcminute diameter hazy patch needs at least a 15 cm telescope to start resolving individual stars. Being one of the least condensed globulars, it shows an even illumination with little central brightening.

Globular cluster NGC 5897 in Libra

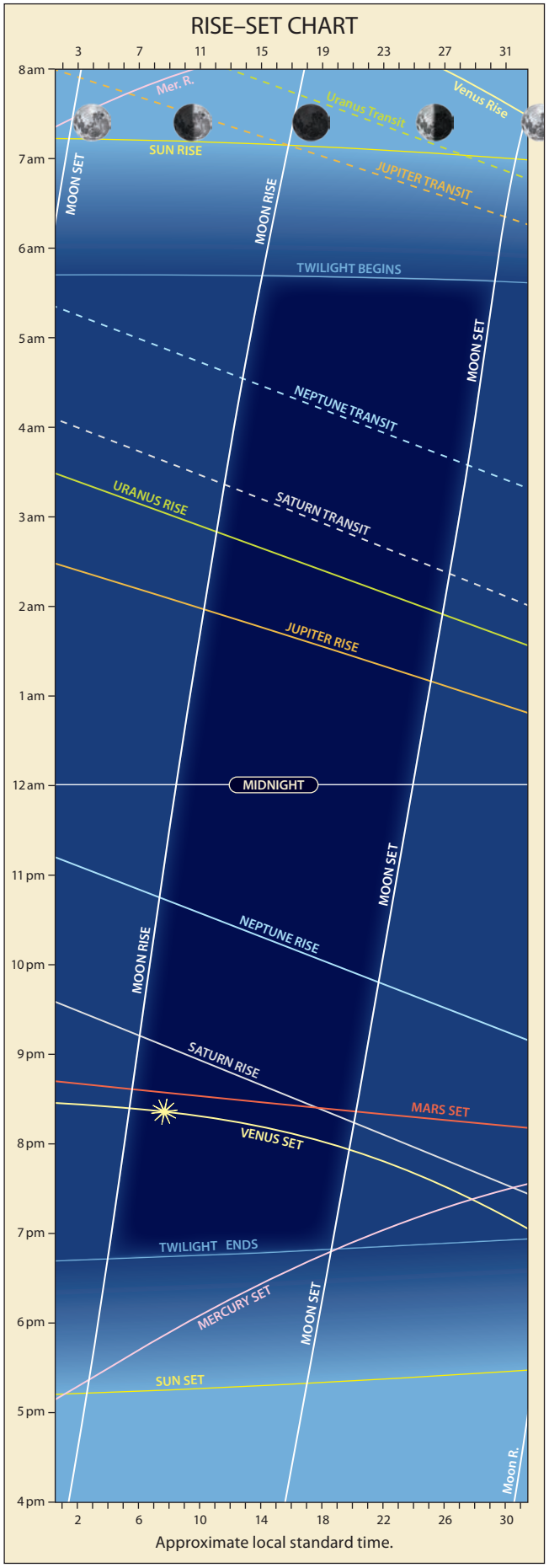


Approximate local standard time.





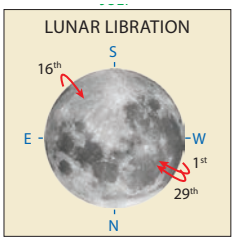
JULY 2023



HIGHLIGHTS

- Mercury and Venus close.
- Mercury and Regulus close.
- Mercury at best in the evening sky.
- Supermoon.*

THE MOON



1st 2 am (Midnight WST, previous day) Maximum Libration (7.4°), dark NW limb.

3rd 10 pm (8 pm WST) Full Moon, supermoon.*

5th 8 am (6 am WST) Moon at perigee (closest to Earth at 360,149 km).

10th Noon (10 am WST) Last Quarter.

16th 5 am (3 am WST) Maximum Libration (7.2°), too close to New Moon to observe.

18th 5 am (3 am WST) New Moon.

20th 5 pm (3 pm WST) Moon at apogee (furthest from Earth at 406,289 km).

26th 8 am (6 am WST) First Quarter.

29th 6 am (4 am WST) Maximum Libration (8.4°), dark NW 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 in its orbit around Earth.

APPEARANCE of the PLANETS

MERCURY Mercury in superior conjunction on the 1st

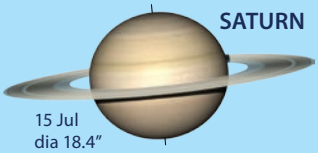
10 Jul dia 5.2" mag –1.2

20 Jul dia 5.7" mag –0.4

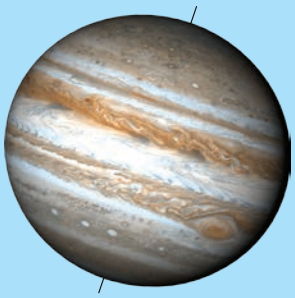
30 Jul dia 6.4" mag 0.0

VENUS
15 Jul
dia 41.8"
mag –4.7

MARS
15 Jul
dia 4.1"
mag 1.8



SATURN
15 Jul
dia 18.4"
mag 0.7



JUPITER
15 Jul
dia 37.9"
mag –2.3

URANUS
15 Jul
dia 3.5"
mag 5.8

NEPTUNE
15 Jul
dia 2.3"
mag 7.9

THE PLANETS

Mercury begins the month in superior conjunction (Mercury and Earth on opposite sides of the Sun). It then ascends away from Sol to begin its best period for observation in the evening sky (mid-July to late August). On the 19th, a 36-hour old slender waxing crescent Moon will be 4° from Mercury (see Sky View). Later this month, the tiny planet joins Venus and Mars in Leo, passing within 5° to the north of the Evening Star on the 27th and 28th. At the same time, Mercury moves directly toward Regulus, the alpha star of Leo—on the 28th, the planet will be 1° below, and on the 29th, just 0.5° above the star. Mercury is the brighter of the pair (see Sky View).

Venus is visible in the early western evening sky in Leo. The planet remains within 4° of Mars during the first week of July. Venus reaches its greatest brilliancy on the 8th at –4.7 magnitude. This is its greatest illuminated extent, or when the planet's bright portion or day side covers the greatest amount of sky. At this time, we see Venus one-quarter illuminated, just like a three or 4-day old Moon. On the 21st, there is a loose celestial grouping between Venus, 1st magnitude Regulus, Mars, and the 3-day old crescent Moon (see Sky View). Venus is within 5° of Regulus from the 8th to 26th with closest approach (3.5°) on the 18th.

The **Earth** is at aphelion on the 7th, the furthest point in its orbit from the Sun (152,093,258 km or 1.016681 au distant).

Mars begins July in the early north-western evening sky in Leo. It has Venus as a companion for the first week, just 4° away. From the 9th to the 12th, the Red Planet will be around 1° from the 1st magnitude star, Regulus (closest on the 11th at 0.7°). Regulus (Alpha Leonis) is the handle star of the Sickle asterism, also known as the Backwards Question Mark. At this time, Mars is 1.7 magnitude compared to 1.4 for Regulus. So even though almost evenly matched in magnitude, the planet's colour should be a dead give-away. On the 21st, the 3-day old waxing crescent Moon will be 3° from Mars (see Sky View).

Jupiter, in Aries, remains a morning object rising around 2 am mid-month. On the 12th, the planet will be about 3° from the 24-day old waning crescent Moon (see Sky View).

With opposition in late August, **Saturn** rises around 8:30 pm mid-month. The planet's magnificent rings commenced this year with a tilt of 13.6° (to Earth), and at opposition (next month), they will be noticeably narrower at 8.9° (in contrast to their last widest angle of 27° in 2017). The rings will continue to close until the Earth next passes through the ring plane in March 2025 to begin another 15-year cycle. On the 7th, the 19-day old waning gibbous Moon will be close to the planet (see Sky View).

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

Neptune, in Pisces, rises in the late evening eastern sky. On the 1st, the planet begins five months in retrogression, appearing to travel westward against the stellar background (see retrograde motion p. 94).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **1 Ceres** concludes its journey through the Coma-Virgo cluster of galaxies this month, with the Diary still listing a few close approaches. In the first half of July, 8th magnitude m.p. 4 Vesta crosses the Hyades cluster in Taurus. On the morning of the 25th and 26th, 11th magnitude 354 Eleonora is seen crossing the Christmas Tree Cluster (NGC 2264) in Monoceros. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
8 Jul	15 Eunomia	Sagittarius	8.8
16 Jul	79 Eurynome	Sagittarius	11.3
20 Jul	87 Sylvia	Sagittarius	11.5
21 Jul	54 Alexandra	Sagittarius	10.1
23 Jul	103 Hera	Sagittarius	10.6

COMETS

Comet 237P/LINEAR is in Aquila at about 11th magnitude and rising in the eastern sky shortly after twilight. It transits in the northern sky around 1 am. By month's end the comet has faded to magnitude slightly, now transiting in the northern sky around 11 pm and setting in the western sky shortly before dawn.

Comet C/ 2017 K2 (PANSTARRS) starts in Lepus at about 11th magnitude, rising in the eastern sky shortly before dawn, setting in the western sky about an hour after sunset. It moves into Monoceros on the 6th, setting in the western sky shortly after sunset. The comet ends the month rising in the eastern sky around 3:30 am.

Comet C/2020 K1 (PANSTARRS) is in Octans at magnitude 11, moving to Chamaeleon on the 21st. It is circumpolar from all of Australia.

Comet C/2020 V2 (ZTF) starts in Aries at magnitude 10, rising in the eastern sky around 3 am, progressing to rising around midnight and transiting in the northern sky just before sunrise, finishing the month in Cetus.

Comet C/2021 T4 (Lemmon) begins the month in Sculptor at 10th magnitude, rising in the south-eastern sky around 10 pm, transiting high in the northern sky just before dawn. On the 8th it moves into Grus, is now rising at 8 pm, then Indus on the 15th at 9th magnitude followed by Telescopium (19th), Ara (24th), Scorpius (30th) and finally Norma on the 31st. On the evening of the 10th, Lemmon is around 1.5° north-west of the Grus Quartet of galaxies. For mid-latitude Australia, Lemmon will be circumpolar from around 20–21 July. If you are further south, this period will be greater. Moving rapidly, as it approaches perihelion at month's end, the last week sees Lemmon pass close to some star clusters in Ara.

METEOR SHOWERS

The **Southern delta-Aquarids** are one of the strongest and most consistent of the southern showers. The range of activity of these medium-speed meteors extends from July 18 to August 23. Maximum this month is expected on the night of the 30th and 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. The near Full Moon will cause considerable interference during the peak this year.

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 30th, with a zenith hourly rate of around five. Their spectacular nature generally makes up for the low hourly rates over the period. Like the Southern delta-Aquarids, the near Full Moon will cause considerable interference during this year's peak.

The **Piscis Austrinids** is visible from 15 July to 10 August, reaching their peak zenith hourly rate of 5 this month around the 29th. The shower should be active from late evening until dawn. The Piscis Austrinids are generally blue, white, or yellow in colour, with some leaving trains. This year the near Full Moon will cause considerable interference.

CONSTELLATIONS

Continuing along the ecliptic we enter Scorpius the Scorpion, one of the most recognisable constellations and resembling its namesake. This identity is also reflected in some traditional star names. Beta (β) Scorpii or Graffias translates to Claws. Delta is Dschubba from an Arabic phrase meaning 'forehead of the scorpion'. Antares might be the Greek 'rival to Mars' (because it's red), but the Roman name was Cor Scorpionis, the Heart of the Scorpion. The brighter star at the end of the tail, Lambda is named Shaula or 'stinger'.

With such a distinctive shape it is not surprising that the Chinese related this asterism to a blue dragon. Antares was also considered its heart. The tail of the scorpion was the tail of the blue dragon. In many cultures this tail represented death.

Cover Story — Galaxies in Collision?

Our cover image shows a spectacular cosmic galaxy duo, taken by the NASA/ESA Hubble Space Telescope with its Wide Field Camera 3. Every smudge, spot, or squiggle shown in the background is another distant galaxy. The only exception is the star in the upper left, a 14th magnitude star in our Milky Way Galaxy.

The large spiral, designated NGC 105, was discovered by French astronomer Édouard Stephan in 1884. He also found Arp 319, a group of five galaxies—commonly known as Stephan's Quintet. As a by-the-way, using interferometry in 1873 Stephan was the first person to attempt to measure the angular diameter of a star. He chose Sirius for the experiment but failed to resolve the Dog Star. However, he set an upper limit of 0.158 arcseconds (the actual angular size is 0.0059).

First impressions of this image give the viewer the sense of galaxies in collision, with the smaller (PGC 212515) seemingly slicing through the outer spiral arms of the larger (NGC 105). However, the reality is far less dramatic and is simply a chance alignment between the pair. The estimated distance from our Solar System to NGC 105 is roughly 215 million light-years, and PGC 212515 is possibly at least another 100 million light-years beyond. There is, however, a pair of colliding galaxies at 4 o'clock (the small orange galaxy with opposing tails, reminiscent of the famous Antennae Galaxies NGC 4038 in Corvus).

The image is only a part of a vast collection of Hubble images that astronomers use to determine the immense distances to astronomical objects. The galaxy, NGC 105, was chosen as part of this task for two reasons: it contains Cepheid variable stars and has hosted at least three Type 1a supernovae. Both these objects are known as standard candles and are used as galactic distance markers. Comparing the two distance measuring techniques will enable astronomers to refine and calibrate one against the other.

Cepheids expand and contract in a predictable way, directly related to their luminosity. The longer the variability period, the more luminous the Cepheid. Astronomers compare a Cepheid's apparent brightness with its intrinsic brightness. The difference between the observed and actual reveals its distance. They help measure distances not only within the Milky Way, but to galaxies beyond.

Type 1a supernovae occur when a white dwarf in a binary system siphons material from its companion. Once the dwarf gains a certain mass, it becomes unstable, triggering a massive supernova. These explosions peak at a similar intrinsic brightness, allowing astronomers to determine their distance by their brightness. Type 1a supernovae enable us to measure distances to galaxies so far away that their Cepheids are invisible.

For amateurs wishing to view or image NGC 105, it is faint at magnitude 14 and small, with an apparent size of 0.7 by 0.5 arcminutes. It is in the constellation of Pisces at RA 00h 25m, Dec +12°53'.

Globular clusters M4 (left) and M80 (right).

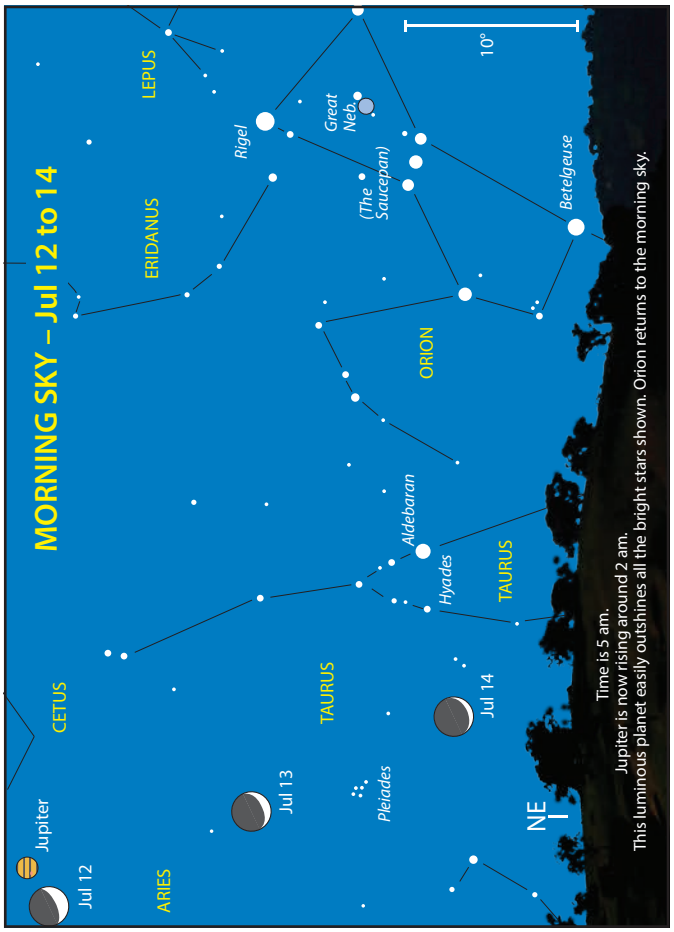
The yellow squares are 3 arcminutes .

DIARY			
Sat	1st	2 am	(Midnight WST, prev day) Maximum Libration (7.4°), dark NW limb.
Sat	1st		Mercury in superior conjunction
Sun	2nd		d.p. 1 Ceres 0.2° SW of NGC 4365 (G) in Virgo
Sun	2nd	pm	m.p. 20 Massalia 1.0° S of star Xi Ophiuchi
Mon	3rd	10 pm	(8 pm WST) Full Moon (361,935 km), supermoon.
Tue	4th	am	Comet C/2021 T4 (Lemmon) 0.8° N of NGC 7793 (G) in Sculptor
Wed	5th		Comet C/2020 K1 (PANSTARRS) 1.5° from South Celestial Pole
Wed	5th		d.p. 1 Ceres 0.9° NE of NGC 4339 (G) in Virgo
Wed	5th		m.p. 18 Melpomene 0.2° S of NGC 488 (G) in Pisces
Wed	5th	8 am	(6 am WST) Moon at perigee (closest to Earth at 360,149 km).
Fri	7th		Earth at aphelion, 1.016680584 au
Fri	7th	11 pm	(9 pm WST) Saturn 6° W of Moon
Fri	7th	pm	Comet C/2021 T4 (Lemmon) 0.8° SE of IC 5332 (G) in Sculptor
Sat	8th		m.p. 4 Vesta 1.2° N of star Gamma Tauri
Sat	8th	pm	m.p. 11 Parthenope 0.3° SE of star Phi Ophiuchi
Sun	9th	1 am	(11 pm WST, prev day) Neptune 1.5° NW of Moon
Mon	10th		m.p. 4 Vesta 0.5° S of star Delta[1] Tauri
Mon	10th	Noon	(10 am WST) Last Quarter Moon.
Mon	10th	6 pm	(4 pm WST) star Regulus 0.5° S of Mars
Mon	10th	pm	Comet C/2021 T4 (Lemmon) 1.5° NW of NGC 7582 (G) in Grus
Tue	11th		m.p. 4 Vesta 0.4° S of star Delta[2] Tauri
Tue	11th	am	m.p. 88 Thisbe 0.15° SE of NGC 7785 (G) in Pisces
Tue	11th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 0.5° E of IC 5267 (G) in Grus
Wed	12th	5 am	(3 am WST) Jupiter 3° S of Moon
Thu	13th		m.p. 135 Hertha 0.2° S of NGC 524 (G) in Pisces
Thu	13th		m.p. 4 Vesta 1.3° N of star Theta Tauri
Thu	13th	4 am	(2 am WST) Uranus 3° S of Moon
Thu	13th	8 pm	(6 pm WST) Comet C/2021 T4 (Lemmon) 1.4° W of star Beta Gruis
Sat	15th		m.p. 18 Melpomene 0.4° N of star Nu Piscium
Sat	15th		Mercury 0.8° NW of M44 Beehive Cluster (OC) in Cancer
Sun	16th	5 am	(3 am WST) Maximum Libration (7.2°), too close to New Moon.
Mon	17th		d.p. 1 Ceres 0.2° NE of NGC 4586 (G) in Virgo
Mon	17th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 0.4° SW of star Theta Indi
Tue	18th		m.p. 4 Vesta 1.0° N of star Aldebaran
Tue	18th		Venus 3.5° SW of star Regulus
Tue	18th	5 am	(3 am WST) New Moon.
Wed	19th		m.p. 18 Melpomene 0.2° N of NGC 676 (G) in Pisces
Wed	19th	am	m.p. 88 Thisbe 0.2° SE of star Omega Piscium
Wed	19th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 1.0° N of star Peacock
Thu	20th	5 pm	(3 pm WST) Moon at apogee (furthest from Earth at 406,289 km).
Fri	21st		Mars 0.9° N of star Rho Leonis
Fri	21st	6 pm	(4 pm WST) Mars 3° S of Moon
Sun	23rd		d.p. 1 Ceres 0.3° N of NGC 4665 (G) in Virgo
Sun	23rd		d.p. 1 Ceres 0.9° NE of NGC 4636 (G) in Virgo
Sun	23rd		m.p. 18 Melpomene 0.8° N of NGC 741 (G) in Pisces
Tue	25th		m.p. 2 Pallas 1.0° S of star Rho Leonis
Tue	25th		m.p. 4 Vesta 1.2° S of NGC 1647 (OC) in Taurus
Tue	25th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 2.0° NE of NGC 6397 (GC) in Ara
Wed	26th	8 am	(6 am WST) First Quarter Moon.
Wed	26th	6 pm	(4 pm WST) Venus 5° S of Mercury
Thu	27th		m.p. 3 Juno 0.2° NE of NGC 2355 (OC) in Gemini
Thu	27th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 1.5° W of IC 4651 (OC) in Ara
Sat	29th		Saturn 0.5° SE of star Sigma Aquarii
Sat	29th	6 am	(4 am WST) Maximum Libration (8.4°), dark NW limb.
Sat	29th	6 pm	(4 pm WST) star Regulus 0.5° NW of Mercury
Sat	29th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 1.0° N of NGC 6200 (OC) in Ara
Sun	30th		d.p. 1 Ceres 0.1° SE of NGC 4772 (G) in Virgo
Sun	30th		Southern delta-Aquarids meteor shower, Jul 12 to Aug 23, Moon affected.
Sun	30th		alpha-Capricornids meteor shower, Jul 3 to Aug 15, Moon affected.
Sun	30th	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 0.8° S of NGC 6169 (OC) in Norma
Sun	30th	pm	m.p. 11 Parthenope 0.7° NE of star Chi Ophiuchi
Sun	30th	pm	m.p. 8 Flora 0.5° E of star Tau[2] Aquarii
Mon	31st	pm	Comet C/2020 K1 (PANSTARRS) 0.9° E star Delta Chamaeleontis
Mon	31st	pm	m.p. 20 Massalia 0.7° N of NGC 6287 (GC) in Ophiuchus
Mon	31st	pm	m.p. 44 Nysa 0.7° SW of star Gamma Librae

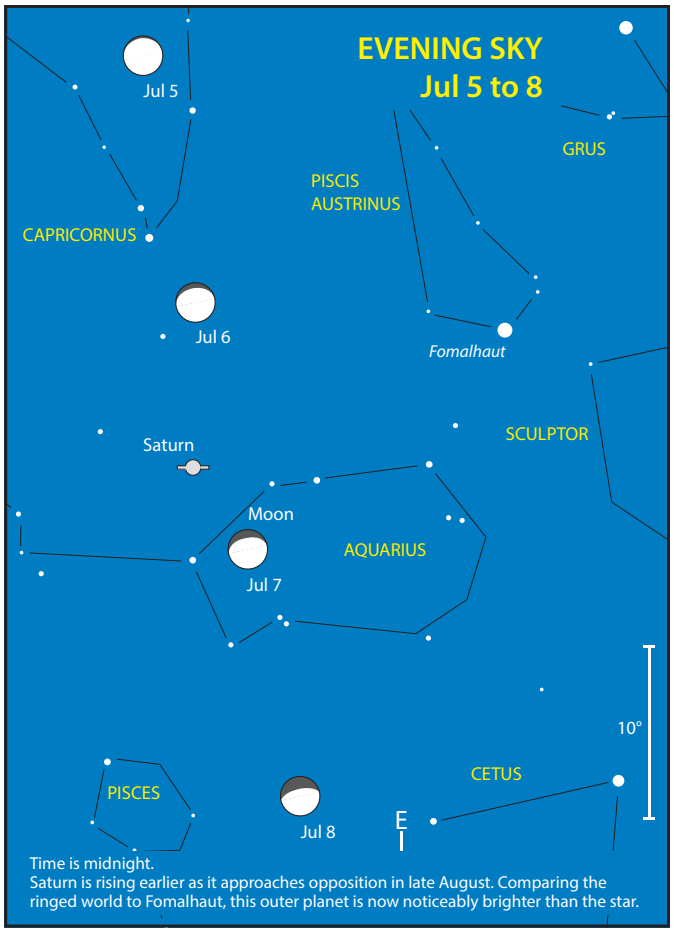
Dante referred to Scorpius as, “that cold animal with which its tail smite the nations”.

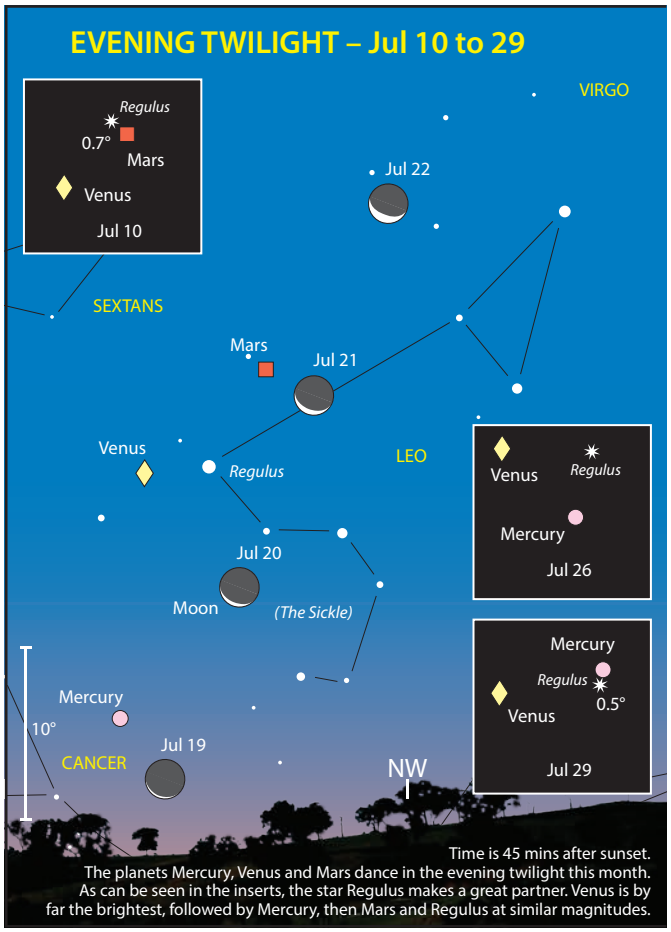
The Sun spends only a week within Scorpius, then the ecliptic passes into Ophiuchus where it commences its trek across the central hub of the Milky Way. Why this ‘Serpent Bearer’ wasn’t a sign of the Zodiac is a mystery. Admittedly, it’s a faint constellation, with its main six stars (2nd to 3rd magnitude) arranged in a box shape, often referred to as the coffin. It’s certainly more obvious than others such as Cancer or Aquarius. If you face north, as Scorpius crosses the meridian, Ophiuchus is directly underneath (to its north). The ecliptic passes in a west to east direction beneath (north of) Antares, coming within 5° of this red giant.

Being a Milky Way constellation, Scorpius has no shortage of doubles and star clusters. Keeping in the head region, Beta (β) Scorpii is obvious to the naked eye and easily resolved through a small telescope into a bright (magnitude 2.6) white primary with a magnitude 4.5 blue companion 13 arcseconds away. Then move 1.6° east to discover the double-double Nu (ν) Scorpii. Its main components are magnitudes 4.2 (A) and 6.6 (B) separated by 41 arcseconds. On close inspection ‘B’ has a magnitude 7.2 partner a snug 2.3 arcseconds away. ‘A’ also has a mate (magnitude 5.3). However with a separation of only 1.2 arcseconds it needs high power and good seeing to observe. Also nearby there is the superb globular star cluster M4, however M80 shouldn’t be overlooked. Located Halfway between Beta (β) Scorpii and Antares, M80 is a very compact globular (2 arcminutes across) and appears as a bright (magnitude 7.3) circular haze through small telescopes, needing 15–20 cm instruments to start resolving individual stars.



Approximate local standard time.





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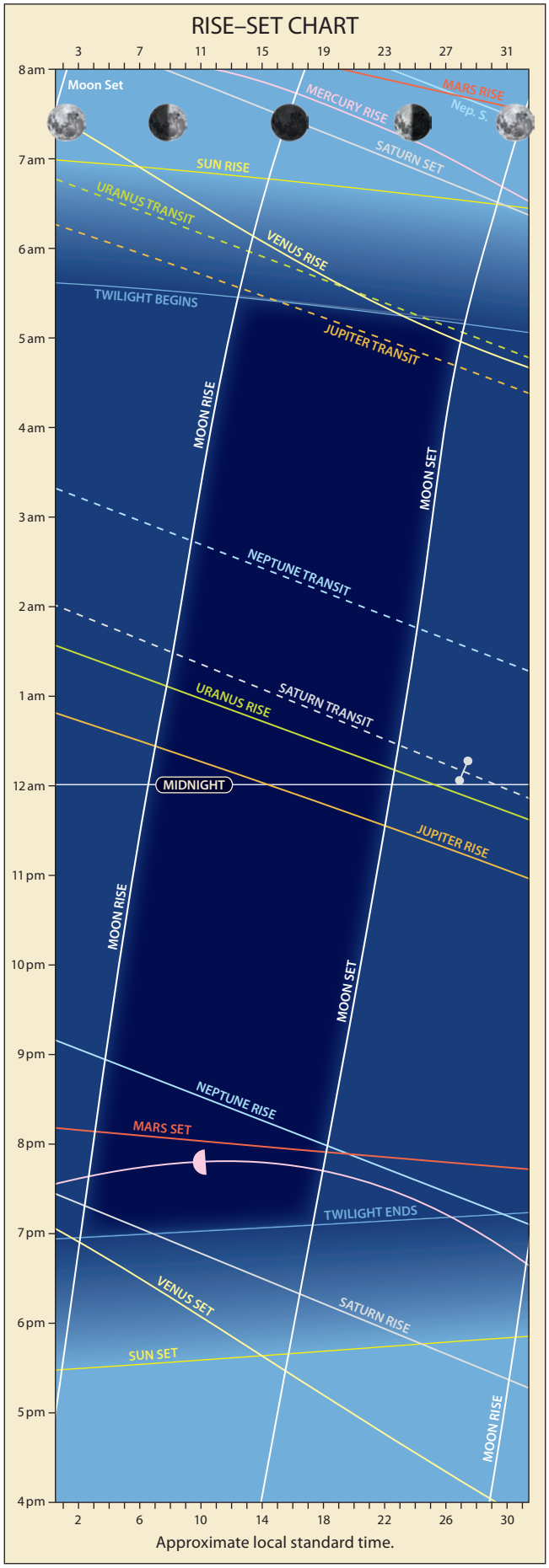
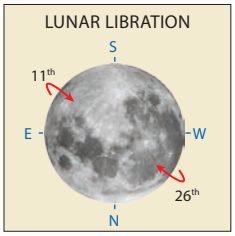


HIGHLIGHTS

- Mercury and Mars close.
- Jupiter and Sigma Arietis close.
- Supermoon, Blue Moon.*
- Saturn at opposition.

THE MOON



2nd 5 am (3 am WST) Full Moon, supermoon.*

2nd 4 pm (2 pm WST) Moon at perigee (closest to Earth at 357,311 km).

8th 8 pm (6 pm WST) Last Quarter.

11th 3 am (1 am WST) Maximum Libration (8.2°), dark SE limb.

16th 8 pm (6 pm WST) New Moon.

16th 10 pm (8 pm WST) Moon at apogee (furthest from Earth at 406,634 km).

24th 8 pm (6 pm WST) First Quarter.

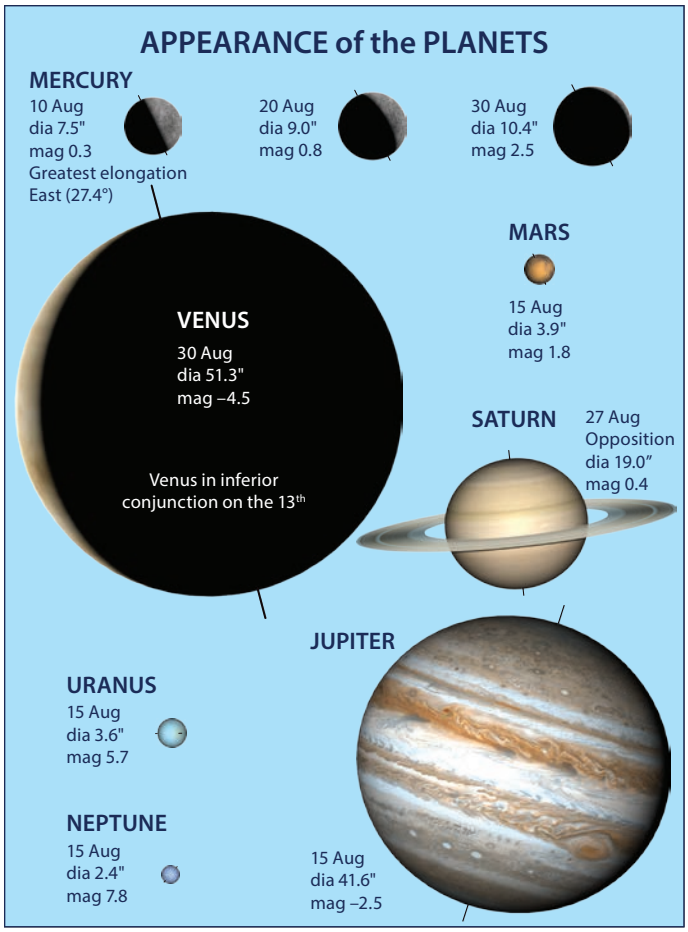
26th 10 am (8 am WST) Maximum Libration (9.0°), dark NW limb.

31st 2 am (Midnight WST, previous day) Moon at perigee (closest to Earth at 357,181 km).

31st Noon (10 am WST) Full Moon, supermoon and Blue Moon.*

***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 in its orbit around Earth. A Blue

APPEARANCE of the PLANETS



Moon refers to a second Full Moon in a calendar month. It is not all that rare and usually happens every two-and-a-half years. The term's usage goes back to an erroneous interpretation in a 1940s article in Sky & Telescope magazine. Since then, it has fallen into widespread use.

THE PLANETS

Mercury continues its journey through the constellation of Leo, the Lion, in the western evening sky this month. Between the 10th and 16th, the innermost planet will be within 5° of Mars. Mercury will be one magnitude brighter than Mars, but the Red Planet's colour will also be an easy identifier, best observed with binoculars about an hour after sunset. On the 10th, the planet reaches its greatest elongation of 27° east of the Sun.

We lose **Venus** this month after its 9-month reign as the Evening Star. It will be visible for a few days at the beginning of the month in the western evening dusk before it becomes lost in the Sun's glare. It will be in inferior conjunction (between Earth and the Sun) on the 13th. The planet then debuts as the Morning Star in the eastern dawn sky at month's end.

Mars spends the first half of the month low in the early north-western evening sky. The planet moves from Leo and into Virgo mid-month. Between the 10th and 16th, Mars and Mercury will be within 5° of each other. Do not confuse the brighter inner planet with Mars at this time—binoculars will help here, about an hour after sunset. Currently, the Red Planet is around 2nd magnitude with a disc diameter of just under 4 arcseconds—a far cry from when it's in opposition. On the 19th, the 3-day old waxing crescent Moon will be around 3° from the planet (see Sky View).

Jupiter, in Aries, rises in the north-eastern evening sky around 12 am mid-month (see Sky View). It's an uneventful month for the largest of the planets, although if you are up late, you can catch a glimpse of Sigma Arietis mixing it up with the Galilean moons. From the 19th to the 24th, Sigma will be visible along the plane of the major moons. At 5.5 magnitude, it will not be too dissimilar in brightness from them (you may need to refer to our 'Jupiter Moon Events' on page 124 to identify which is the stellar interloper). On November 20, 1952, there was an occultation of this star by Jupiter. However, the closest they get at this event is around one Jupiter diameter from each other on the 22nd.

Saturn, in Aquarius, is at opposition on the 27th, rising in the east around 6:30 pm mid-month. Galileo Galilei first viewed the planet's magnificent rings in 1610. However, his crude instrument could not resolve the rings, and he first guessed they were two large moons on either side of the

DIARY			
Tue	1st		m.p. 354 Eleonora 0.2° W of NGC 2141 (OC) in Orion
Tue	1st		m.p. 354 Eleonora 0.8° N of star Mu Orionis
Tue	1st	3 am	(1 am WST) Comet 103P/Hartley 2 0.3° NE of star Alpha Andromedae
Tue	1st	8 pm	(6 pm WST) Comet C/2021 T4 (Lemmon) 2.3° SW of NGC 6124 (OC) in Scorpius
Wed	2nd		d.p. 1 Ceres 0.2° SW of NGC 4845 (G) in Virgo
Wed	2nd		m.p. 18 Melpomene 0.7° N of NGC 864 (G) in Cetus
Wed	2nd	5 am	(3 am WST) Full Moon (357,528 km), supermoon.
Wed	2nd	4 pm	(2 pm WST) Moon at perigee (closest to Earth at 357,311 km).
Thu	3rd	9 pm	(7 pm WST) Saturn 2° NW of Moon
Thu	3rd	10 pm	(8 pm WST) Comet C/2021 T4 (Lemmon) 0.4° SW of star Eta Lupi
Fri	4th	8 pm	(6 pm WST) Comet C/2021 T4 (Lemmon) 1.3° E of NGC 5986 (GC) in Lupus
Sat	5th		Comet C/2020 V2 (ZTF) 1.8° E of star Alpha Ceti
Sat	5th	5 am	(3 am WST) Neptune 3° NE of Moon
Sun	6th		m.p. 9 Metis 0.4° N of star Epsilon Tauri
Mon	7th	pm	m.p. 39 Laetitia 1.0° NE of star Zeta Ophiuchi
Tue	8th	4 am	(2 am WST) Comet 2P/Encke 1.0° SE of NGC 1514 (PN) in Taurus
Tue	8th	8 pm	(6 pm WST) Last Quarter Moon.
Tue	8th	pm	m.p. 15 Eunomia 0.6° NE of M22 (GC) in Sagittarius
Wed	9th	2 am	(Midnight WST, prev day) Jupiter 6° SW of Moon
Wed	9th	5 am	(3 am WST) Uranus 4° SE of Moon
Thu	10th		Mars 0.8° S of star Sigma Leonis
Thu	10th		Mercury at greatest elongation East (27.4°)
Fri	11th	3 am	(1 am WST) Maximum Libration (8.2°), dark SE limb.
Fri	11th	7 pm	(5 pm WST) m.p. 2 Pallas 0.15° NW of star Chi Leonis
Sat	12th	am	Perseids meteor shower, Jul 17 to Aug 24, Moon affected after about 4 am.
Sat	12th	7 pm	(5 pm WST) m.p. 2 Pallas 4° N of Mercury
Sun	13th		Venus in inferior conjunction
Sun	13th	pm	m.p. 20 Massalia 0.7° N of NGC 6287 (GC) in Ophiuchus
Tue	15th		m.p. 9 Metis 1.2° N of NGC 1647 (OC) in Taurus
Wed	16th	8 pm	(6 pm WST) New Moon.
Wed	16th	10 pm	(8 pm WST) Moon at apogee (furthest from Earth at 406,634 km).
Wed	16th	pm	m.p. 15 Eunomia 0.7° NE of NGC 6642 (GC) in Sagittarius
Fri	18th	8 pm	(6 pm WST) Comet C/2021 T4 (Lemmon) 0.8° NE of star Sigma Librae
Sat	19th	4 am	(2 am WST) Comet 2P/Encke 0.7° SE of star Iota Aurigae
Sat	19th	6 pm	(4 pm WST) Mars 3° W of Moon
Sun	20th		m.p. 2 Pallas 0.8° N of star Sigma Leonis
Sun	20th	3 am	(1 am WST) Comet 103P/Hartley 2 5° SE of M31 Andromeda Galaxy (SG) in Andromeda
Tue	22nd		Jupiter 0.008° N of star Sigma Arietis
Wed	23rd		Mars 0.2° W of star Beta Virginis
Wed	23rd	4 am	(2 am WST) Comet 2P/Encke 1.0° SE of IC 405 The Flaming Star Nebula in Aurigae
Thu	24th	4 am	(2 am WST) Comet 2P/Encke 0.3° E of NGC 1893 (OC) in Auriga
Thu	24th	8 pm	(6 pm WST) First Quarter Moon.
Fri	25th		m.p. 354 Eleonora 0.2° W of NGC 2264 (OC) in Monoceros
Sat	26th	4 am	(2 am WST) Comet 2P/Encke 0.6° SW of M36 (OC) in Auriga
Sat	26th	4 am	(2 am WST) Comet 2P/Encke 1.0° SE of NGC 1931 (N) in Auriga
Sat	26th	10 am	(8 am WST) Maximum Libration (9.0°), dark NW limb.
Sun	27th	3 am	(1 am WST) Comet 103P/Hartley 2 1.4° SE of star Gamma Andromedae
Sun	27th		Saturn at opposition
Mon	28th	am	Comet C/2020 V2 (ZTF) 1.5° W of star Eta Eridani
Mon	28th	pm	m.p. 10 Hygiea 1.0° SE of M73 (OC) in Aquarius
Tue	29th	3 am	(1 am WST) Comet 103P/Hartley 2 0.7° SW of NGC 891 (G) in Andromeda
Tue	29th	4 am	(2 am WST) Comet 2P/Encke 1.3° N of M37 (OC) in Auriga
Thu	31st	2 am	(Midnight WST, prev day) Moon at perigee (closest to Earth at 357,181 km).
Thu	31st	5 am	(3 am WST) Saturn 2° N of Moon
Thu	31st	Noon	(10 am WST) Full Moon (357,341 km, closest for this year), supermoon.

The Galactic Centre

As mentioned on page 50, having the Milky Way hub directly overhead is spectacular under dark, country skies. Unfortunately, the dark lanes (nebulae) block any chance of seeing the centre of our galaxy. Otherwise, the view would be impressive, just with the unaided eye. We would likely have discovered much earlier the Milky Way's barred-spiral structure, with two dominant arms extending from the ends of a central bar, typical of barred-spirals elsewhere in the Universe. The visible spectrum isn't the only part of the spectrum blocked by interstellar dust, it's also opaque to low energy X-rays and ultraviolet.

It has only been in recent years we have been able to penetrate this veil with imaging in the gamma ray, high energy X-ray, submillimetre, infrared and radio regions of the spectrum. The atmosphere blocks out damaging high energy radiation such as gamma rays, X-rays and most of the ultraviolet (lucky for us).

Infrared is also blocked, being absorbed by atmospheric water—hence the need for observatories in orbit. Some of our most complete views of the Milky Way's structure have come from the Spitzer Space Telescope. This is a key area of investigation for the James Webb Space Telescope and we await its contributions with bated breath.

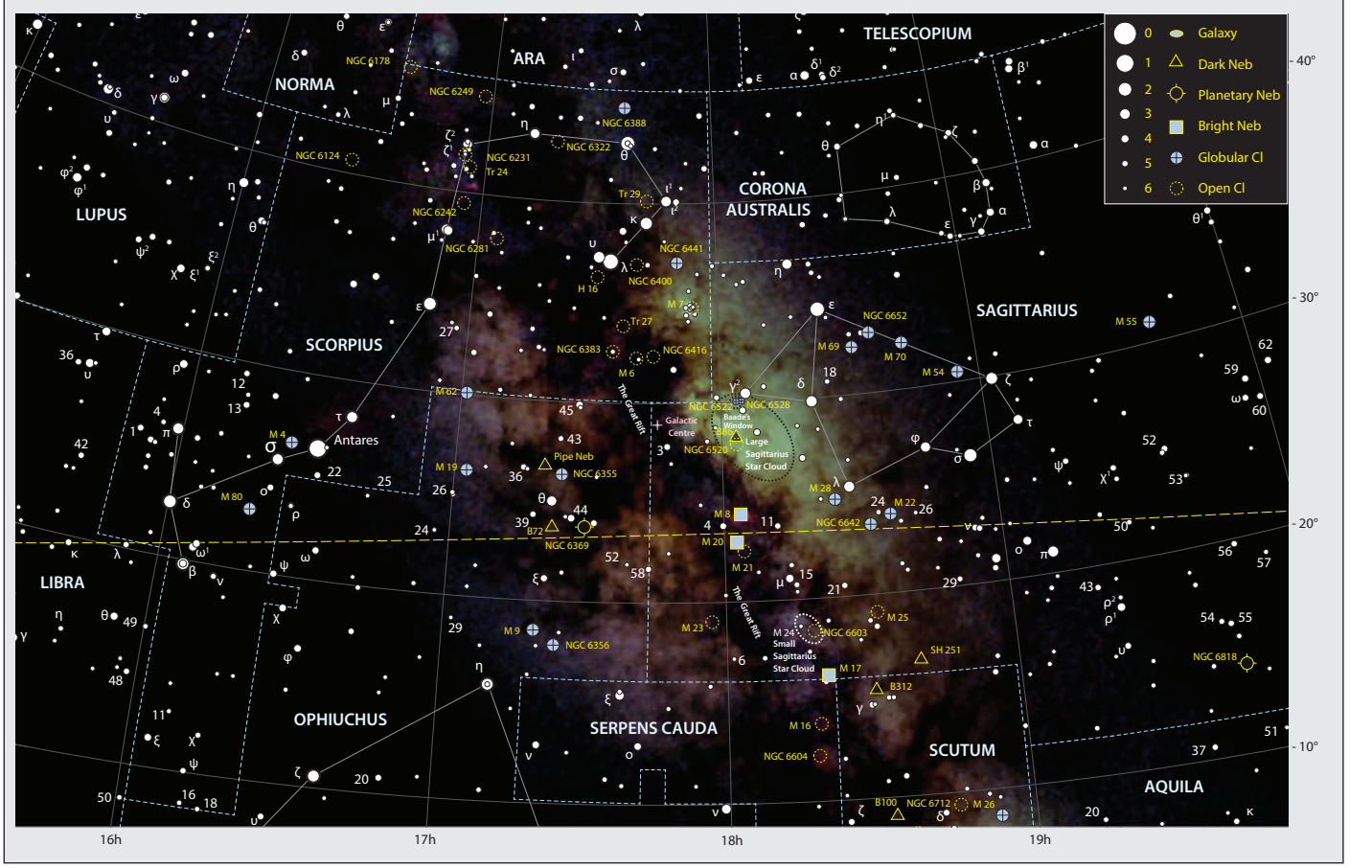
NASA's Chandra X-ray satellite telescope, launched in 1999, has contributed greatly to our knowledge of the Milky Way's central, four million solar mass, black hole around 26,000 light-years away. It is at the rotational centre of the galaxy, located in the direction of the Teapot's spout star. There are around 10 million stars within a radius of 3 light-years from the black hole. At this distance this very busy 'cluster' would have a diameter of only 48 arcseconds.

Australia has made significant contributions with the HI4PI survey conducted by the CSIRO Parkes Radio Telescope in conjunction with the Max-Planck Institute's Effelsberg Radio telescope in Germany. Over one billion individual objects were mapped showing the distribution of atomic hydrogen in interstellar space.

An Observers Guide

Facing north, follow the equatorial dark band (Great Rift) running up the centre of the Milky Way (the meat in the sandwich), until it's close to the Teapot. The glowing area between the *spout* star and rift is the Large Sagittarius Star Cloud. This shouldn't be confused with another brilliant binocular object, the Small Sagittarius Star Cloud (M24), appearing similar but smaller, an oval region about 2° × 1°, approximately 12° away. These two star clouds are worth a special mention. They are not star clusters, but clearings between the dark nebulae giving a view penetrating the Milky Way's hub allowing a view closer to the galactic centre.

The Large Sagittarius Star Cloud is not only the brightest area of the Milky Way but shows the inner most region of our galaxy accessible in visible light and the most distant part of the Milky Way that can be seen with the naked eye. It's roughly an oval 5° × 3° looking like a puff of steam leaving the spout of the Teapot. Binoculars show an intense glow covered in stars. An object of note is the bright open star cluster NGC 6520 superimposed on the cloud, with its adjacent dark nebular region, Barnard 86, a Bok globule.



planet. Christiaan Huygens realised their nature as a ring system in 1659 with his improved telescope optics.

Who can forget their first view of the planet through a telescope? No matter what sized instrument you have, there is nothing that quite compares with the Ringed Planet. In general, telescopes in the 60 to 100 mm range can see the rings and the small dark gap known as the Cassini Division. In addition, there is a light-coloured equatorial band on the globe and a noticeable darkening and flattening of the poles. Moving to 150 mm and larger should reveal the Encke Gap (a gap in the outermost ring) and the inner translucent Crepe Ring.

On the 3rd, the 17-day old waning gibbous Moon will be 2° from the planet (see Sky View).

Uranus, in Aries near the border of Taurus, remains an object for morning observers only this month. On the 29th the planet begins five months in retrogression, appearing to travel westward against the stars (see retrograde motion p. 94).

Neptune comes to opposition next month and is now rising 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
7 Aug	511 Davida	Capricornus	11.4
10 Aug	10 Hygiea	Aquarius	9.7
13 Aug	433 Eros	Aquarius	11.3
14 Aug	107 Camilla	Aquarius	12.4
16 Aug	13 Egeria	Grus	11.0
27 Aug	8 Flora	Aquarius	8.4

COMETS

Comet 103P/Hartley 2 begins August in Andromeda at 13th magnitude, rising in the north-eastern sky around 11 pm, transiting low in the northern sky around 3:30 am. By month's end it has moved into Perseus (31st) having brightened considerably to magnitude 10. It is now rising in the north-eastern sky around midnight and transiting very low in the northern sky about an hour before dawn. The comet passes within 5° of the Andromeda Galaxy (M31) mid-month.

Comet 237P/LINEAR is in Aquila at 11th magnitude, rising in daylight, transiting in the northern sky around 11 pm and setting in the western sky shortly before dawn. By month's end it has faded to about 12th magnitude, transiting around 9 pm and setting in the western sky around 3 am.

Comet 2P/Encke starts in Taurus at about 13th magnitude, rising in the north-eastern sky around 2:30 am. It moves into Perseus on the 11th then Auriga on the 14th and by month's end has brightened to 11th magnitude. In the last week of August, although low in the north, Encke has some nice encounters with deep sky objects in Auriga (see Diary).

Comet C/2017 K2 (PANSTARRS) spends the month in Monoceros at magnitude 11, rising in the eastern sky around 3:30 am at the start, progressing to 1:30 am by month's end.

Comet C/2020 K1 (PANSTARRS) is in Chamaeleon at 11th magnitude, moving to Musca on the 28th. It is circumpolar from Australia.

Comet C/2020 V2 (ZTF), at 10th magnitude, begins in Cetus, rising in the eastern sky around midnight, transiting in the northern sky shortly before sunrise. It moves into Eridanus on the 14th and by month's end is rising in the eastern sky around 10 pm, transiting in the northern sky shortly before dawn.

Barnard himself, accurately described it as "a drop of ink on the luminous sky".

Possibly the best clearing within the Large Star Cloud is Baade's Window, a bright region north-west of the Teapot's spout star, Gamma Sagittarii, approximately 1° in diameter, with the two globular clusters NGC 6522 and 6528 overlaid. Although this hole is about 4° from the galactic centre, it appears to penetrate to a comparable distance, getting us to within 1,800 light-years of the core. Any sized telescope shows a very star rich region. In 2006, the Hubble telescope took advantage of one of these highly packed star regions to search for exoplanets using the transit method, called the 'Sagittarius Window Eclipsing Extrasolar Planets' or SWEEPS. For 7 days, 180,000 stars were searched, finding 16 candidates.

The Small Star Cloud, M24 contains a number of deep sky objects including the open clusters of NGC 6603, Collinder 469 and Turner 2, 3 and 4. The inky black, dark nebulae of Barnard 92 and 93, side by side in the northern part of M24, are a stark contrast to the luminous nature of the remaining cloud.

The galactic bulge is home to many bright deep sky objects and despite the numerous dark clouds, star forming regions are abundant. A trip northward from the Large Star Cloud along the bank of the great rift, includes the Lagoon, Trifid, Omega and Eagle nebulae, several open star clusters and the Small Star Cloud, all within a distance of around 15°. The region also has more than its fair share of globular star clusters. Although they are typically found well away from the galactic equator, they dwell in great abundance in the galactic bulge. Currently 157 globulars are known in the Milky Way, but many more are likely to be discovered as we peal back the obscuring layers of dust.

The Galactic Bulge Map

This diagram, centred on the Milky Way's centre, shows the hub region (see also All Sky Maps No 6 and 8). Originally, we were hoping to include brief descriptions of the most impressive objects, but there are so many! Although several are listed in Part III, under 'Deep Sky Objects'. All the non-stellar objects shown are considered visible in binoculars. The fact that so many belong to the Messier catalogue is a tribute to their brilliance. To minimize cluttering we have defaulted to using their 'M' numbers only.

Although, binoculars give wide views and are probably the best instruments to look at nebulous regions or large open star clusters, their low power makes some objects difficult to detect. An example being some small globulars; without close examination they could easily be overlooked as individual stars.

Comet C/2021 T4 (Lemmon) begins the month in Scorpius at 9th magnitude, transiting high in the southern sky about an hour after twilight and setting in the south-western sky around 90 minutes before dawn. It moves into Lupus on the 2nd and Libra on the 11th where it stays for the rest of the month. During the month it sets progressively earlier, ending up around 11 pm at 11th magnitude.

METEOR SHOWER

The famous **Perseids** are not readily observable, as the radiant will be below the horizon for many southern observers. The Perseids are probably 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 maximum is are expected on the morning of the 13th before dawn. This shower has produced some exceptional rates in the past, but generally, a ZHR of 150 is 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." There will be no pre-dawn interference, with the waning crescent Moon setting around 2:30.

CONSTELLATIONS

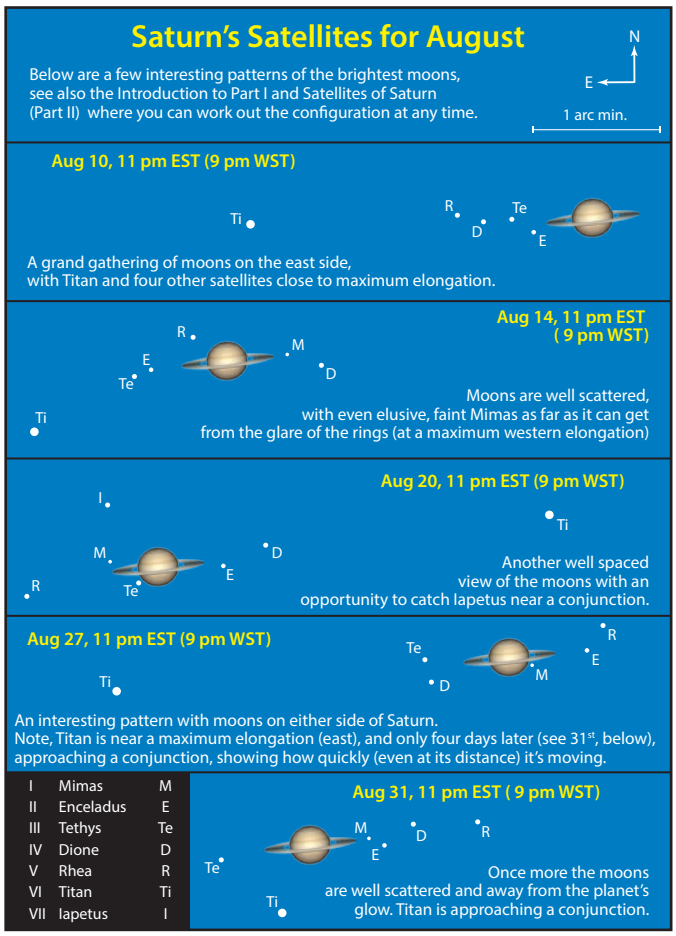
After passing through Ophiuchus, the ecliptic next enters Sagittarius (All Sky Map No. 6, 8), near the well know dark lane, the Pipe Nebula. It continues its eastward journey passing 2° over (north) of the famous Teapot. This is certainly one of the most prominent asterisms in the sky, consisting of eight stars ranging from the brightest member, Epsilon (ε) at magnitude 1.8 (Kaus Australis, the southern star of the bow), to the faintest, the adjacent (spout) star Gamma (γ) also known as Alnasl (Arabic for arrowhead) at magnitude 3.6. For those interested in observing colour in stars, the Teapot stars fall into two distinct camps. Tau (τ), Lambda (λ), Delta (δ) and Gamma[1] (γ^1) are all cool yellow/orange (K class) stars, with the remaining four, hot blue/white A and B class. Wide field binoculars are ideal to enhance the colour contrast.

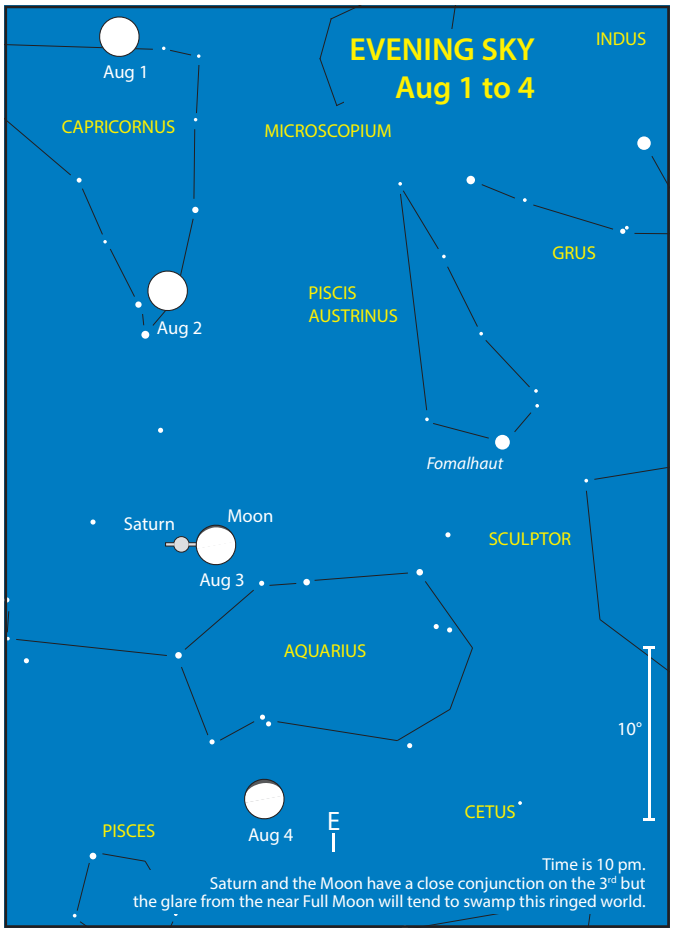
The name Sagittarius is Latin for 'the archer' and the constellation's current form was assigned by Ptolemy in the 2nd century CE. Like all of the constellations of the Zodiac, records related to Sagittarius go back at least to 1000 BCE. Then, the ancient Babylonians knew it as Pa Bil Sag believed to be some kind of god which was both a warrior and a bull, a combination of two different creatures. This is something in common with the current interpretation where Ptolemy's archer is a centaur, a creature half human-like (the chest, head, and arms) with a body and legs of a horse. There is another heavenly centaur, the constellation, Centaurus, still visible in the south-west. Unlike Centaurus, who is holding a spear, Sagittarius has a classical bow and arrow pointed at the heart of Scorpius (the star, Antares).

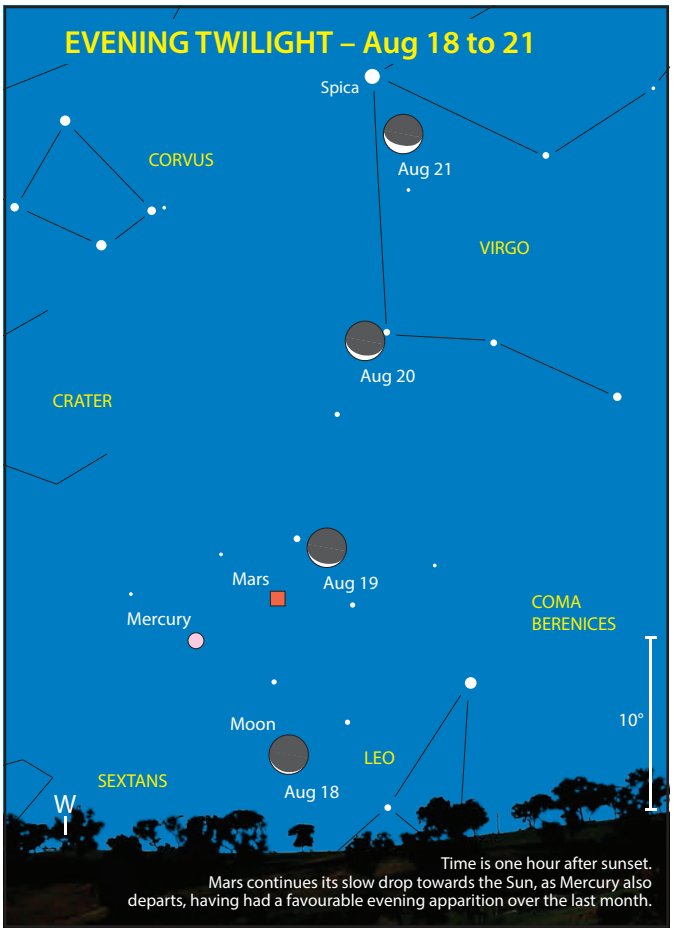
As we've mentioned every year, having the asterism of the Teapot next to Scorpius' sweeping tail passing overhead is hard to miss, even from the suburbs. These two constellations are also the most southerly members of the Zodiac, with the summer solstice occurring in Sagittarius. Observing them under dark country skies reveals they also mark the central hub of the Milky Way with its bright and interspersed dark lanes clearly visible to the unaided eye. Any regions close to the equator of our galaxy, especially the hub, are rich in star clusters and star forming regions (see p. 60). What isn't expected is a prominent external galaxy.

Generally, the profusion of nebulae and dust within the plane of the Milky Way forms a zone of avoidance, blocking our view of distant galaxies. Because Sagittarius is quite a large constellation extending well eastward of the hub, we can see NGC 6822 or Barnard's Galaxy. At magnitude 9.3 it's considered bright, but this is spread across around 12 arcminutes, so the surface brightness is faint. Low magnification is the key, try using binoculars. Lying only 1.6 million light-years away, it's a member of the local group of galaxies, also having a similar structure to the Small Magellanic Cloud.

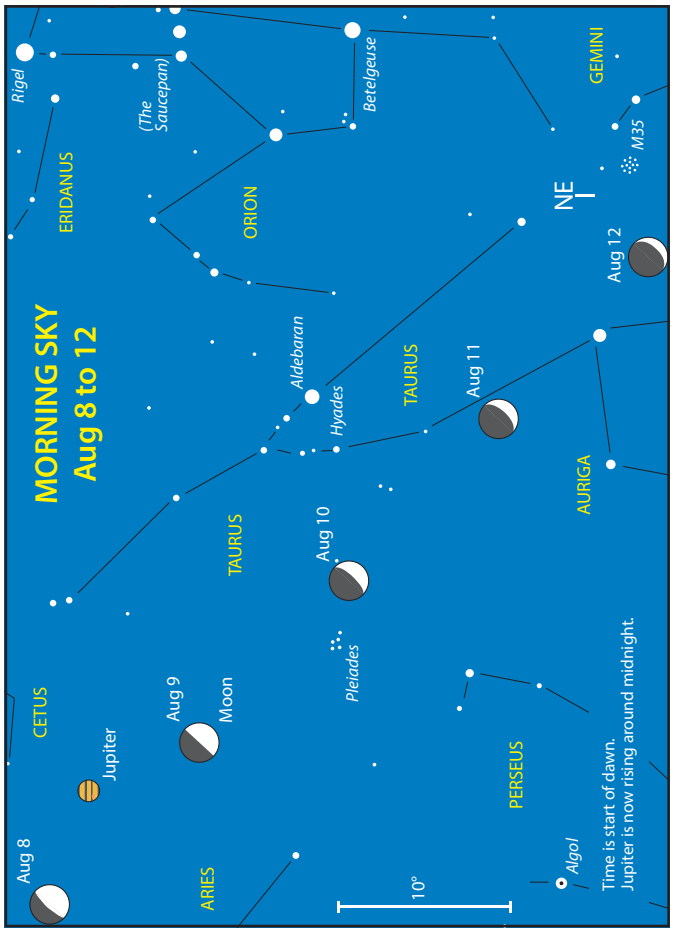
NGC 6822 , Barnard's Galaxy in Sagittarius

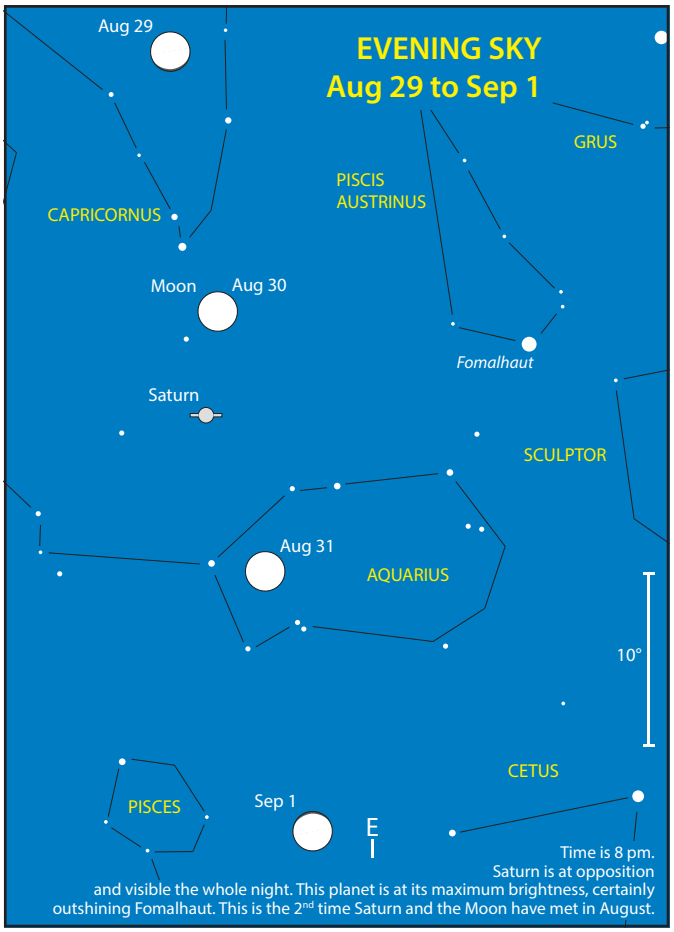






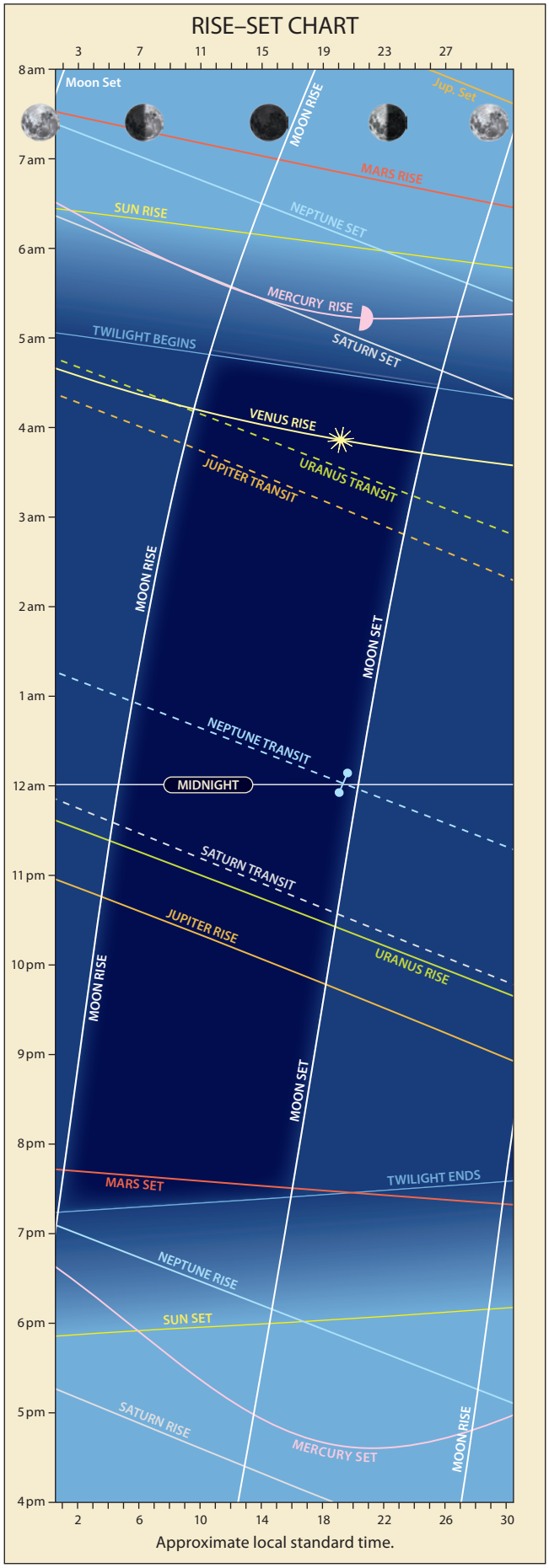
Approximate local standard time.





SEPTEMBER 2023

RISE–SET CHART

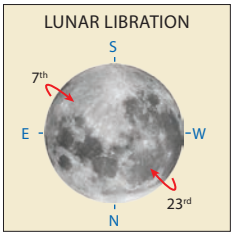


Approximate local standard time.

HIGHLIGHTS

- Saturn just past opposition.
- Supermoon.*
- Neptune at opposition.

THE MOON



7th 8 am (6 am WST) Last Quarter.

7th 9 pm (7 pm WST) Maximum Libration (8.9°), dark SE limb.

13th 2 am (Midnight WST, previous day) Moon at apogee (furthest from Earth at 406,291 km).

15th Noon (10 am WST) New Moon.

23rd 6 am (4 am WST) First Quarter.

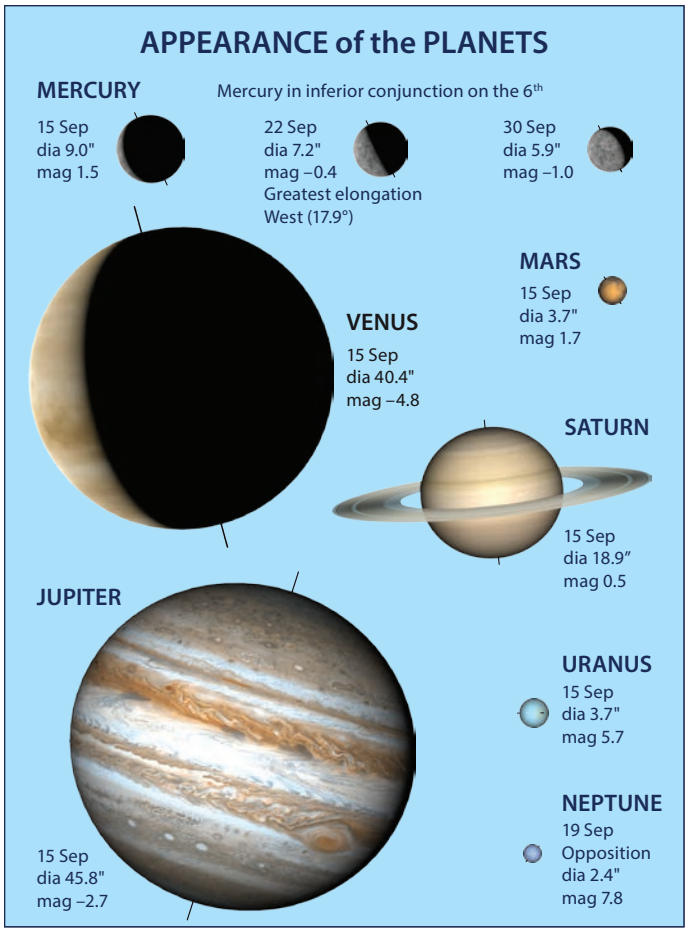
23rd Noon (10 am WST) Maximum Libration (8.9°), dark NW limb.

28th 11 am (9 am WST) Moon at perigee (closest to Earth at 359,911 km).

29th 8 pm (6 pm WST) Full Moon, supermoon.*

*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 in its orbit around Earth.

APPEARANCE of the PLANETS



THE PLANETS

Mercury moves quickly from the evening dusk sky and into inferior conjunction (between the Earth and the Sun) on the 6th. Then, it returns to the eastern morning dawn for a poor apparition, scarcely a few degrees above the horizon at the beginning of civil twilight. Mercury reaches its greatest elongation 18° west of the Sun on the 22nd.

Since its conjunction last month, **Venus** is now prominent in the early morning dawn sky (see Sky View). The planet moves through Cancer and finally into Leo at month's end. Venus reaches its greatest brilliancy on the 19th at –4.5 magnitude. This is its greatest illuminated extent (see July Venus section for definition).

The **Earth** is at its vernal (spring) equinox on the 23rd.

Mars begins September low in the early western evening sky. However, it is soon lost as it approaches the Sun and its upcoming conjunction in November. It will reappear early next year in the morning sky in Sagittarius.

Jupiter, in Aries, rises in the north-eastern evening sky around 10 pm mid-month. Early in the month, the planet begins its retrograde path against the starfield (see Retrograde Motion p. 94). If you were up late observing the close Jupiter encounter with Sigma Arietis in August, this motion reversal brings Sigma back. However, there should be no confusion between the 5.5 magnitude star and the Galilean moons this time. At its closest, Sigma will be 5 arcminutes from Jupiter (on the 17–18th) and away from the plane of the satellites. On the 4th, the 20-day old waning gibbous Moon will be 4° from the planet (see Sky View).

Saturn is visible in the eastern sky at the end of evening dusk in Aquarius. A quick look through a telescope reveals why the 6th planet from the Sun is called The Jewel of the Solar System—many amateurs will tell you that their first glimpse of this globe with its grand rings initiated their interest in astronomy. At this time, the main Saturnian moons are fun to track down and identify; the brightest, Titan, can be seen in binoculars. Titan ranks as the second-largest Moon in the Solar System after Jupiter's Ganymede and the only one with a substantial atmosphere. Four other Moons: Enceladus, Tethys, Dione, and Rhea, can be seen in small telescopes but can be tricky to locate as they are much fainter than Titan (see Sky View p. 67).

Later this month, try looking for the planet's shadow on the back of the rings (this cannot be seen right at opposition as the shadow is directly behind Saturn's globe). On the 27th, Saturn rises just 5° from the 12-day old waxing gibbous Moon (see Sky View).

Uranus rises in the eastern evening sky around 11 pm mid-month in Aries.

Neptune, the only planet not visible to the unaided eye from Earth, comes to opposition on the 19th, rising in the east during astronomical twilight. At 7.8 magnitude and 2.4 arcseconds in diameter, the planet requires at least a 100 mm telescope, 200 magnification and good seeing to resolve its small featureless bluish disc. A 5.5 magnitude star known as 20 Piscium will appear not too distant from Neptune during the month in a low-power field. This star will be a handy marker to locate the planet. The pair will be within 5 arcminutes of each other from the 10th to the 14th.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
9 Sep	69 Hesperia	Pisces	11.7
13 Sep	51 Nemausa	Pisces	10.7
20 Sep	97 Klotho	Aquarius	10.5
21 Sep	88 Thisbe	Pisces	10.3
22 Sep	60 Echo	Pisces	11.3
25 Sep	26 Proserpina	Pisces	11.1

COMETS

Comet 103P/Hartley 2 spends the first half of the month in Perseus, rising in the north-eastern sky after midnight then transiting low in the northern sky before dawn. By mid-month it has moved into Auriga and now transiting later in the morning and by month's end in daylight. The comet begins September at magnitude 10 and brightens to perhaps magnitude 8 by the end.

Comet 2P/Encke commences the month in Auriga at 11th magnitude, rising in the north-eastern sky around 3 am. It moves into Gemini on the 4th, Cancer on the 15th and Leo on the 24th. By month's end it has brightened to maybe 8th magnitude and rising about an hour before sunrise. In the closing days of September, Encke crosses the Sickle asterism of Leo.

Comet C/2017 K2 (PANSTARRS) spends the month in Monoceros at around 12th magnitude, rising in the eastern sky around midnight.

Comet C/2020 K1 (PANSTARRS) is circumpolar and low in the south in Musca at 12th magnitude.

Comet C/2020 V2 (ZTF) starts the month in Cetus at magnitude 10, rising in the eastern sky around 9:30 pm, transiting high in the northern sky about an hour before dawn. The comet moves into Fornax on the 18th, rising earlier as the month progresses. By the 27th, when it moves into Sculptor, it is transiting high in the northern sky around midnight.

Comet C/2021 T4 (Lemmon) spends the month in Libra, setting in the western sky around 11 pm early September and 9 pm by month's end. The comet fades from magnitude 11 to 12. Lemmon has a close meeting with Libra's alpha star on the evening of the 12th (see Diary).

CONSTELLATIONS

The ecliptic now departs the Milky Way environment and enters a region of constellations with a water theme for the next three months. September is Capricornus the 'Sea Goat', comprising the head, shoulders and front legs of a goat with the tail of a fish. In Greek mythology it was related to the goat-footed god Pan. When being chased by a monster, it leapt into the water to escape. Just before hitting the water, Pan transformed into this part-fish. Although, as with a lot of mythology, the water gets muddier (excuse the pun) for the Babylonians had already created this goat/fish constellation prior to the Pan legend.

Glass Rain

About 790,000 years ago, a sizeable asteroid entered the Earth's atmosphere and struck south-east Asia at an oblique angle. Instantly a large crater was formed as the ground was crushed, vaporised, and melted. Millions of tonnes of material were displaced, some attaining sufficient speed to propel it out of the atmosphere and into space. This material then re-entered the atmosphere over Australia. Slower ejecta that failed to reach escape velocity fell to Earth closer to the impact site over Asia. In 1900, Franz Suess, an Austrian geologist, coined the term tektite (from the Greek *tēktós* meaning molten or melted) to describe these glassy objects.

The Australasian tektite strewnfield is the largest and youngest of the world's major fields, covering more than 10 per cent of the Earth's surface. It is also the world's richest source of tektites, with thousands of specimens recovered. Other significant fields include North America (age 35 million years), Central European (15 Ma) and the Ivory Coast (1.1 Ma).

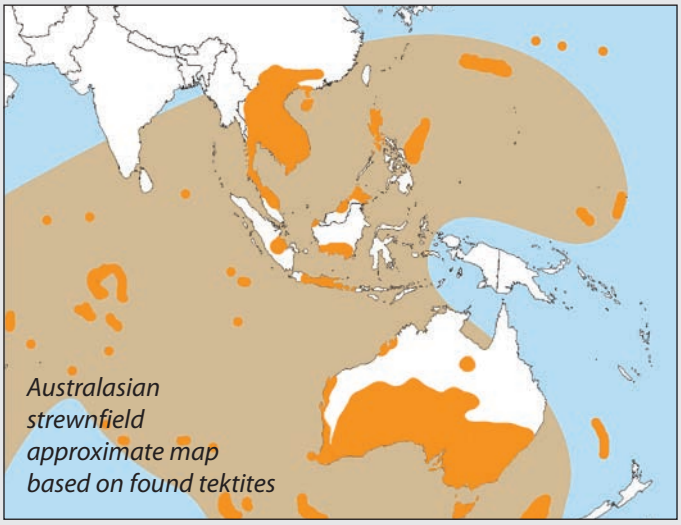
Several theories for the origin of tektites included ejection from the Moon via volcanism or meteor impacts—both discounted after the samples returned by the Apollo missions in the 60s and 70s showed no compositional similarities to tektites. In addition, they could not be meteorites arriving from deep space since cosmic rays had not irradiated them.

Today, scientists agree that tektites are of terrestrial origin and the result of an impactor striking our planet. However, despite years of searching, the central mystery of the Australasian strewnfield was the lack of a source crater. The other major strewn fields can all be traced back to large meteor craters. Recently, researchers mapping gravitational anomalies in the Bolaven Plateau in southern Laos have discovered a candidate elliptical crater about 13 × 17 km in size beneath a 300 m deep lava field[1]. A crater of this shape would indicate an impactor striking the surface at about 10° from the horizontal. In addition, the lava flows over the crater postdate the tektite formation event. The conclusive proof, however, will involve an expensive drilling operation in a remote location through 300 m basalt to find shock-metamorphosed rocks, minerals, and melt.

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

Australian tektites are distinctive from their Asian counterparts even though they originate from the same impact. Because of their higher velocity and smaller size, australites were ejected entirely from the atmosphere into space. Their re-entry caused a secondary melt of the glass, creating the distinctive australite forms we see today. With some rare exceptions, only the australites undergo this secondary melt.

The Asian tektites, or indochinites, are termed *splash form* tektites and are usually larger than australites; these

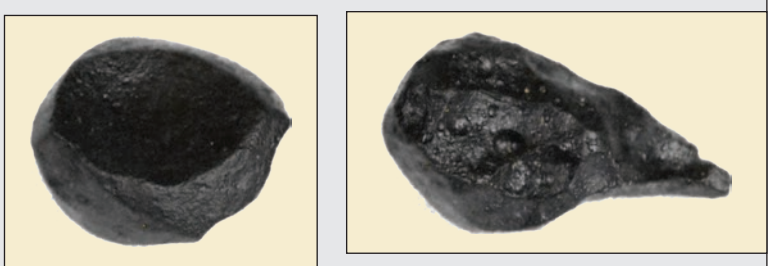


tektites are typically spheres, ellipsoids, teardrops, or dumbbells. The smaller Australites can take the form of the much sought-after *flanged button* type or other aerodynamic shapes such as ovals, boats, canoes, cores (a flange type stripped of its flange) and classic teardrops and dumbbells. The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

Next time you wander in the outback, try looking down for small dark, glassy fragments; you may find a piece of Earth that has spent a little time in space. Tektites can be found in all states of Australia and the Northern Territory, mostly south of about 25° latitude. Favourite hunting grounds include the edges of salt flats, where they are easier to spot on the surface. If you think of making a fortune, you will probably do better by buying a gold detector and prospecting for nuggets. Most tektite specimens sell for around $1 to $2 per gram. Although, the rarer button type could demand high prices depending on their shape and condition. These are in high demand and sought after by collectors.

Note: In all states of Australia, there is no restriction on collecting tektites in the field; however, it is illegal to collect meteorites. In the Northern Territory, it is against the law to fossick for tektites and meteorites as they have the same classification.

[1]K. Sieh et al., Australasian impact crater buried under the Bolaven volcanic field, Southern Laos. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 1346–1353 (2020).



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

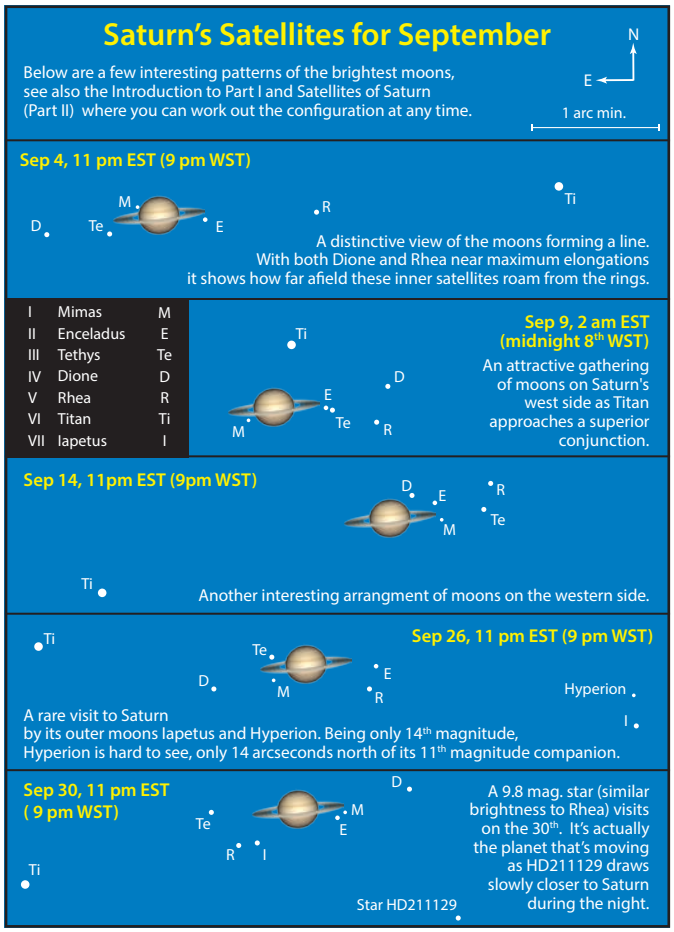
These abominations (creatures made from two different beings) were very common in Greek and Roman mythology such as the previously mentioned centaurs. Here's another water related example. Although it is known today as a whale, traditionally the constellation of Cetus was called the 'Sea Monster'. In Johann Bayer's Uranometria atlas (1603 CE) it is drawn as a dragon's upper body (head and arms) with a fish's tail. As with many of the traditional constellations, the depiction of Cetus varies greatly between different atlases. More muddy water?

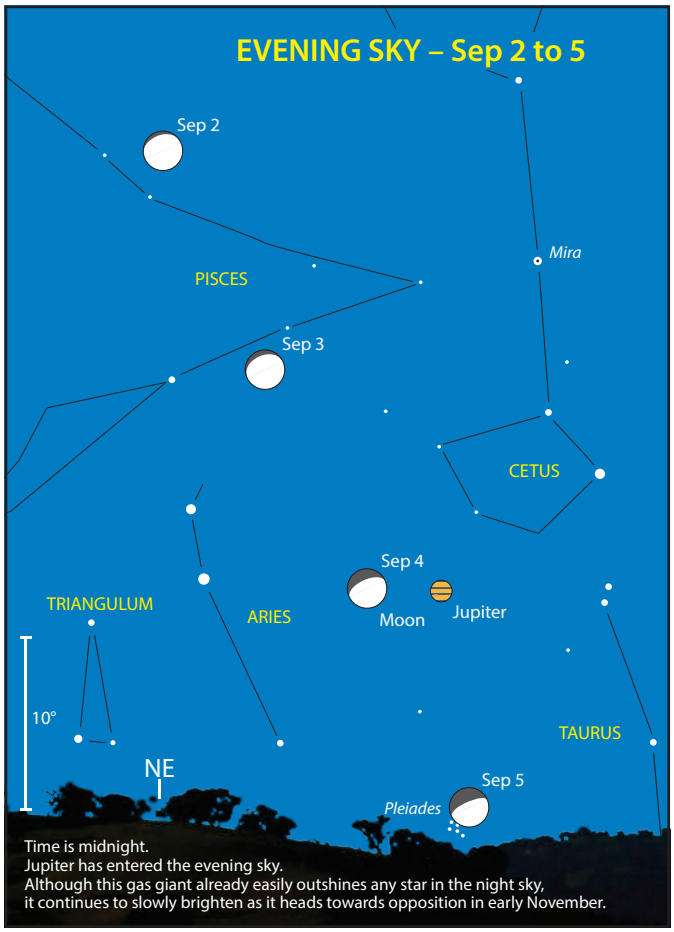
DIARY		
Fri	1st	3 am (1 am WST) Comet 103P/Hartley 2 0.3° S of M34 (OC) in Perseus
Fri	1st	8 pm (6 pm WST) Neptune 2° W of Moon
Sun	3rd	m.p. 7 Iris 0.15° SW of NGC 5728 (G) in Libra
Sun	3rd	am m.p. 18 Melpomene 1.5° N of star Alpha Ceti
Sun	3rd	pm m.p. 10 Hygiea 1.5° SE of M72 (GC) in Aquarius
Mon	4th	Mars 0.8° SW of star Eta Virginis
Tue	5th	5 am (3 am WST) Jupiter 4° S of Moon
Wed	6th	1 am (11 pm WST, prev day) Uranus 6° SW of Moon
Wed	6th	Mercury in inferior conjunction
Thu	7th	m.p. 704 Interamnia 0.2° S of M36 (OC) in Auriga
Thu	7th	4 am (2 am WST) Comet 2P/Encke 0.3° SE of star Theta Geminorum
Thu	7th	8 am (6 am WST) Last Quarter Moon.
Thu	7th	9 pm (7 pm WST) Maximum Libration (8.9°), dark SE limb.
Fri	8th	m.p. 3 Juno 1.5° SW of Venus
Sun	10th	Venus 0.8° SE of M67 (OC) in Cancer
Tue	12th	m.p. 9 Metis 0.2° SW of M1 Crab Nebula (PN) in Taurus
Tue	12th	5 am (3 am WST) Comet 2P/Encke 0.7° N of star Castor in Geminorum
Tue	12th	10 pm (8 pm WST) Comet C/2021 T4 (Lemmon) 0.1° E of star Alpha^2 Librae
Wed	13th	2 am (Midnight WST, prev day) Moon at apogee (furthest from Earth at 406,291 km).
Wed	13th	5 am (3 am WST) m.p. 3 Juno 2° S of Venus
Wed	13th	pm Neptune 0.07° NW of star 20 Piscium
Thu	14th	m.p. 9 Metis 0.8° N of star Zeta Tauri
Thu	14th	pm Comet C/2020 V2 (ZTF) 1.0° W of NGC 908 (G) in Cetus
Fri	15th	Noon (10 am WST) New Moon.
Mon	18th	Mars 1.0° NE of NGC 4697 (G) in Virgo
Mon	18th	am Jupiter 0.1° NW of star Sigma Arietis
Tue	19th	Neptune at opposition
Wed	20th	5 am (3 am WST) Comet 2P/Encke 0.8° W of star Iota Cancri
Thu	21st	3 am (1 am WST) Comet 103P/Hartley 2 0.6° S of NGC 1857 (OC) in Auriga
Thu	21st	3 am (1 am WST) m.p. 18 Melpomene 0.05° SW of star Kappa^1 Ceti
Fri	22nd	Mercury at greatest elongation West (17.9°)
Sat	23rd	6 am (4 am WST) First Quarter Moon.
Sat	23rd	Noon (10 am WST) Maximum Libration (8.9°), dark NW limb.
Sat	23rd	Equinox
Mon	25th	m.p. 5 Astraea 1.2° S of m.p. 4 Vesta
Tue	26th	Saturn 0.2° NW of star 42 Aquarii
Wed	27th	4 am (2 am WST) m.p. 354 Eleonora 0.05° SE of star Beta Canis Minoris
Wed	27th	5 am (3 am WST) Comet 2P/Encke 0.8° S of star Epsilon Leonis
Wed	27th	7 pm (5 pm WST) Saturn 5° W of Moon
Thu	28th	11 am (9 am WST) Moon at perigee (closest to Earth at 359,911 km).
Fri	29th	4 am (2 am WST) Neptune 0.5° N of Moon
Fri	29th	8 pm (6 pm WST) Full Moon (361,553 km), supermoon.
Sat	30th	m.p. 20 Massalia 1.2° N of NGC 6401 (GC) in Ophiuchus

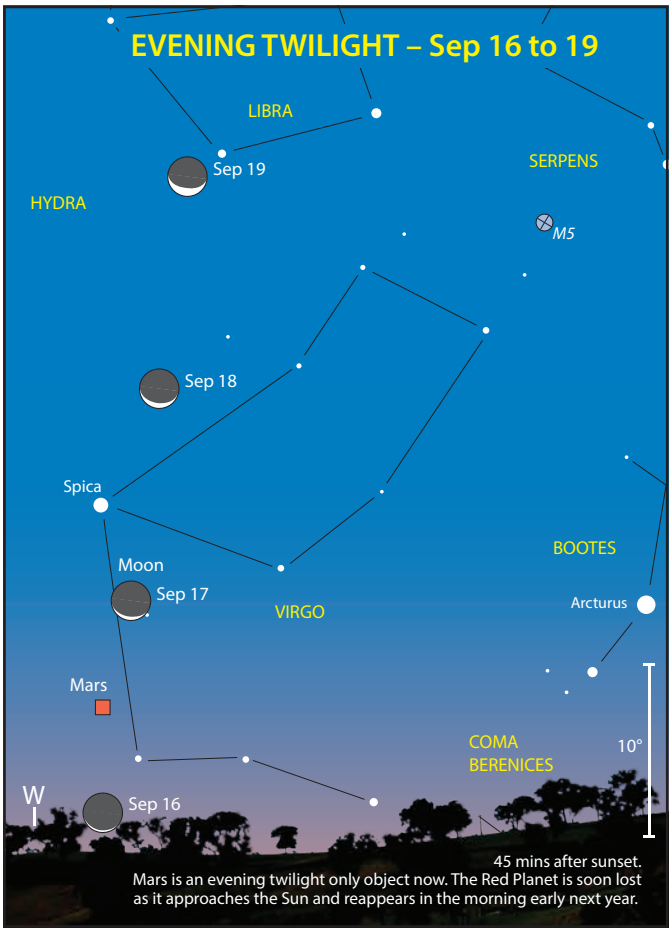
Like Scorpius and Sagittarius, Capricornus is one of the more southerly signs of the Zodiac, with the constellation passing nearly overhead from mid-latitude Australia during September evenings. Virtually invisible from the suburbs, dark skies show a mostly 4th magnitude asterism shaped like a right-angled isosceles triangle. Face north and look close to the zenith to see it lying on its long side which is bent in the centre towards the right angle (see All Sky Map No. 8).

This Sea Goat is strangely devoid of deep sky objects, even galaxies. This makes its globular cluster stand out, especially seeing it was bright enough for Messier to make it object number 30 in his famous catalogue. At magnitude 7.3, M30 is visible in binoculars. Telescopes show an overall diameter of 4 arcminutes, with a 2-arcminute bright, highly compact core, difficult to resolve in small instruments. The star density drops away quickly at the edges where individual stars are easier to see. Look for lines of stars and a striking 5th mag star, 41 Capricorni, 0.4° to the east of centre.

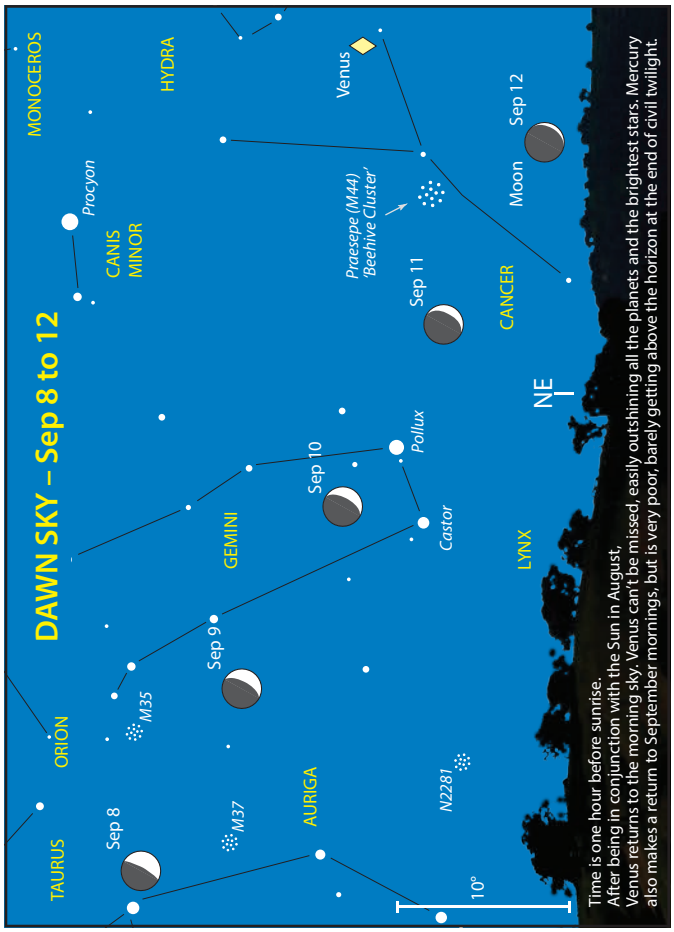
Capricornus does have some nice double stars. Don't miss Alpha and Beta Capricorni, two 3rd magnitude stars, separated by 2°, at the western end of the triangle. Alpha's (α) most obvious feature is two brilliant naked-eye yellow stars separated by 6 arcminutes. The eastern member, Alpha^2 (magnitude 3.5) is a multiple star with an 11.2 magnitude companion 7 arcseconds south, which is itself a pair of matching stars, a snug 1.3 arcseconds apart. Alpha^1 is magnitude 4.3 with a 9.6 mag component a comfortable 45 arcseconds south-west. Overall, the alpha complex is a brilliant sight in any telescope.

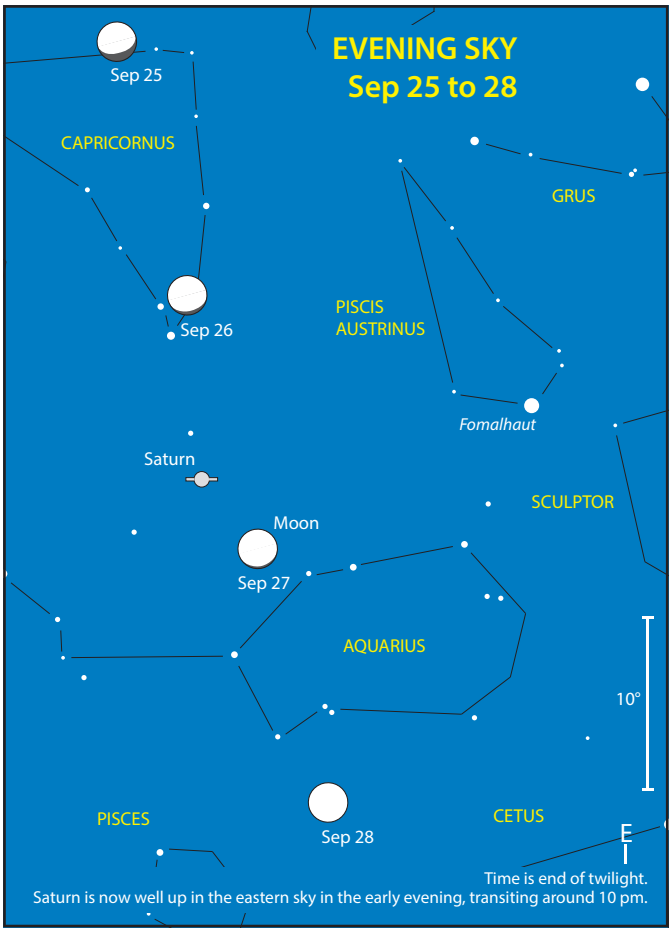






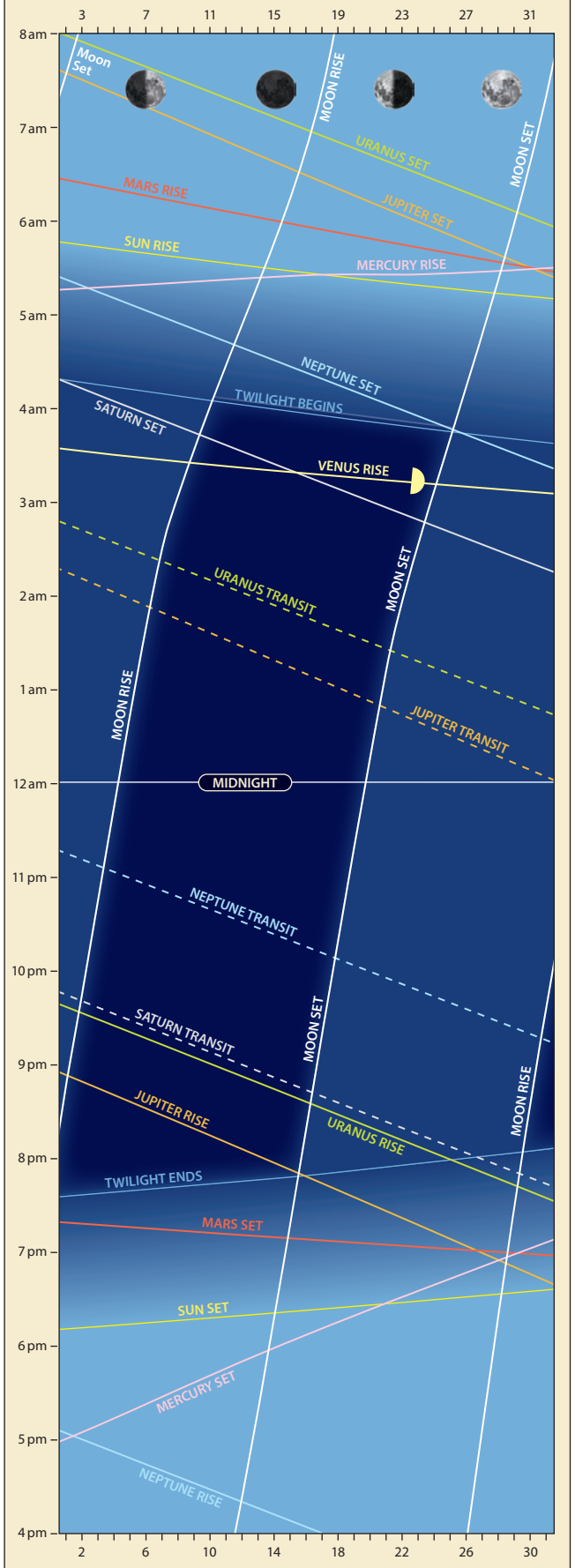
Approximate local standard time.





OCTOBER 2023

RISE–SET CHART

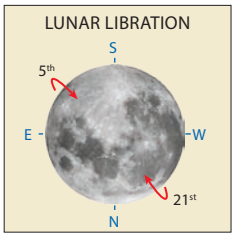


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Venus, Regulus, and crescent Moon in morning sky.
- Jupiter nearing opposition.
- Saturn near the Moon.
- Orionids meteor shower.

THE MOON



5th 10 pm (8 pm WST) Maximum Libration (9.0°), dark SE limb.

6th Midnight (10 pm WST) Last Quarter.

10th 2 pm (Noon WST) Moon at apogee (furthest from Earth at 405,425 km).

15th 4 am (2 am WST) New Moon, annular solar eclipse, N. America, C. America, S. America (Annular: W US, C. America, Colombia, Brazil). See Eclipses page 102.

21st 5 am (3 am WST) Maximum Libration (8.2°), dark NW limb.

22nd 1 pm (11 am WST) First Quarter.

26th 1 pm (11 am WST) Moon at perigee (closest to Earth at 364,872 km).

29th 6 am (4 am WST) Full Moon, partial lunar eclipse, E Americas, Europe, Africa, Asia, Australia. See Eclipses page 102.

APPEARANCE of the PLANETS

MERCURY

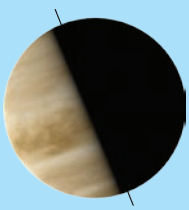
Mercury in superior conjunction on the 20th

1 Oct
dia 5.7"
mag –1.0

10 Oct
dia 5.1"
mag –1.2

30 Oct
dia 4.7"
mag –0.9

VENUS

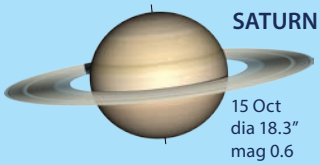


24 Oct
dia 24.0"
mag –4.5
Greatest elongation West (46.4°)

MARS

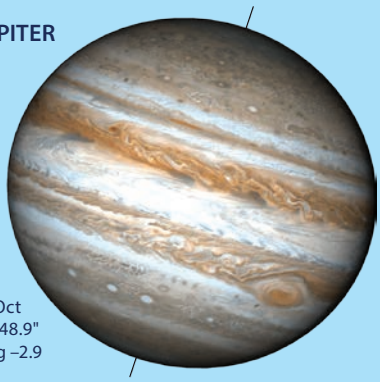
15 Oct
dia 3.7"
mag 1.6

SATURN



15 Oct
dia 18.3″
mag 0.6

JUPITER



15 Oct
dia 48.9"
mag –2.9

URANUS

15 Oct
dia 3.8"
mag 5.6

NEPTUNE

15 Oct
dia 2.4"
mag 7.8

30th Late on the evening of 30th and early morning 31st, the Pleiades are occulted by the Moon. The southern half of the cluster is involved and is best seen from the south-east of the country. Looking at the insert on the All Sky Map No 3, the brightest stars involved are labelled in the occultation section.

THE PLANETS

Mercury remains too close to the Sun this month for observation. It is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 20th.

Rising in the pre-dawn, **Venus** remains in the constellation of Leo for the month. The planet reaches its greatest elongation, 46° from the Sun, on the 24th. On the 11th, Venus will be 2° from Regulus, the Lion's first magnitude alpha star, and as a bonus, the 25-day waning crescent Moon appears south of the pair (see Sky View).

Mars is lost in the western evening twilight as it heads toward solar conjunction in November.

Jupiter, in Aries, dominates the eastern evening sky as it rises around 8 pm mid-month. On the 29th, the planet will be around 5° from the Full Moon (see Sky View). As the pair clear the horizon, they will provide an excellent wide-angle photo opportunity, especially with a foreground object in the frame. With the planet's opposition early in November, its magnitude increases to –2.9 and its angular diameter to 49.5 arcseconds by month's end. It's interesting to observe the daily dance of Jove's four major moons—Io, Europa, Ganymede, and Callisto. Like a miniature solar system, they undergo transits, shadow transits, occultations, and eclipses. Predictions for these events can be found beginning on page 120, also see Sky View page 72.

Saturn transits the meridian (is due north) at 9 pm mid-month, affording comfortable mid-evening spring views when the planet is highest. As darkness falls on the 24th, the 10-day old waxing gibbous Moon appears 2° from Saturn, the distance increasing slightly as the evening progresses (see Sky View). When the planet's rings are inclined, it can be challenging to identify and separate the fainter scattered, observable moons from the background stars, except perhaps for 8th magnitude Titan. Our section on Saturn's moons on page 128 will assist here.

With opposition in November, **Uranus** rises in the eastern evening sky around 8:30 pm mid-month. Presently this outer gas giant is in Aries near the border of Taurus; in 2024, the planet moves into the constellation of the Bull.

Now past opposition, **Neptune** transits the meridian (is due north) around 10 pm mid-month in Pisces, very close to the border of Aquarius.

DIARY

Sun	1st	5 am	(3 am WST) Comet 2P/Encke 1.0° SW of star Gamma[1] Leonis
Sun	1st	pm	m.p. 88 Thisbe 0.3° SE of star Theta Piscium
Mon	2nd		Pallas in conjunction with Sun
Mon	2nd	11 pm	(9 pm WST) Jupiter 9° SW of Moon
Tue	3rd		m.p. 9 Metis 0.6° S of star 1 Geminorum
Tue	3rd	2 am	(Midnight WST, prev day) Uranus 4° S of Moon
Thu	5th	am	Comet 62P/Tsuchinshan 1 0.8° S of star Eta Geminorum
Thu	5th	5 am	(3 am WST) Comet 2P/Encke 0.6° NE of NGC 3377 (G) in Leo
Thu	5th	10 pm	(8 pm WST) Maximum Libration (9.0°), dark SE limb.
Fri	6th	Midn	(10 pm WST) Last Quarter Moon.
Sat	7th	am	Comet 62P/Tsuchinshan 1 0.8° S of star Mu Geminorum
Sat	7th	3 am	(1 am WST) Comet 103P/Hartley 2 1.5° SW of NGC 2331 (OC) in Gemini
Sun	8th		m.p. 15 Eunomia 0.1° W NGC 6716 (OC) in Sagittarius
Sun	8th	pm	m.p. 8 Flora 1.0° E of NGC 7184 (G) in Aquarius
Mon	9th	am	Comet C/2021 S3 (PANSTARRS) 0.6° N of NGC 3223 (G) in Antlia
Tue	10th		m.p. 15 Eunomia 1.4° N of star Xi[2] Sagittarii
Tue	10th		Southern Taurids meteor shower, Sep 10 to Nov 20, Moon affected after about 3 am.
Tue	10th	2 pm	(Noon WST) Moon at apogee (furthest from Earth at 405,425 km).
Wed	11th	3 am	(1 am WST) Comet 103P/Hartley 2 0.7° NE of star Delta Geminorum
Wed	11th	4 am	(2 am WST) star Regulus 2° N of Venus
Wed	11th	4 am	(2 am WST) Venus 7° SW of Moon
Thu	12th		m.p. 11 Parthenope 0.3° SW of NGC 6469 (OC) in Sagittarius
Fri	13th		m.p. 9 Metis 0.5° N of star Eta Geminorum
Fri	13th	am	Comet C/2021 S3 (PANSTARRS) 0.6° N of NGC 3281 (G) in Antlia
Sat	14th	11 pm	(9 pm WST) Comet C/2020 V2 (ZTF) 0.3° SE of NGC 300 (G) in Sculptor
Sun	15th	4 am	(2 am WST) New Moon, annular solar eclipse, N. America, C. America, S. America [Annular: W US, C. America, Colombia].
Wed	18th		m.p. 11 Parthenope 0.3° N of M20 Trifid Nebula (BN) in Sagittarius
Thu	19th		m.p. 11 Parthenope 0.2° SW of M21 (OC) in Sagittarius
Thu	19th		m.p. 9 Metis 0.7° SE of Collinder 89 (OC) in Gemini
Fri	20th		m.p. 11 Parthenope 0.6° NW of NGC 6546 (OC) in Sagittarius
Fri	20th		Mercury in superior conjunction
Sat	21st	am	Orionids meteor shower, Oct 2 to Nov 7.
Sat	21st	5 am	(3 am WST) Maximum Libration (8.2°), dark NW limb.
Sun	22nd		m.p. 5 Astraea 0.4° N of star Gamma Geminorum
Sun	22nd		m.p. 9 Metis 0.8° N of star Mu Geminorum
Sun	22nd	1 pm	(11 am WST) First Quarter Moon.
Mon	23rd	pm	m.p. 135 Hertha 0.3° N of NGC 660 (G) in Pisces
Tue	24th	am	m.p. 4 Vesta 1.2° S of star Nu Geminorum
Tue	24th		Venus at greatest elongation West (46.4°)
Tue	24th	8 pm	(6 pm WST) Saturn 2° NW of Moon
Wed	25th	3 am	(1 am WST) Comet 62P/Tsuchinshan 1 0.2° SE of star Delta Geminorum
Thu	26th		m.p. 18 Melpomene 0.3° E of NGC 1253 (G) in Eridanus
Thu	26th	3 am	(1 am WST) Neptune 6° NE of Moon
Thu	26th	1 pm	(11 am WST) Moon at perigee (closest to Earth at 364,872 km).
Fri	27th	am	Comet C/2021 S3 (PANSTARRS) 1.0° N of NGC 3557 (G) in Centaurus
Fri	27th	3 am	(1 am WST) Comet 103P/Hartley 2 0.4° N of star Beta Cancri
Fri	27th	pm	Comet C/2020 V2 (ZTF) 1.4° NW of star Alpha Phoenicis
Fri	27th	pm	m.p. 88 Thisbe 0.9° SE of NGC 7541 (G) in Pisces
Sun	29th		m.p. 3 Juno 0.1° E of NGC 3166 (G) in Sextans
Sun	29th		m.p. 3 Juno 0.1° S of NGC 3169 (G) in Sextans
Sun	29th	6 am	(4 am WST) Full Moon (369,702 km), partial lunar eclipse, E Americas, Europe, Africa, Asia, Australia.
Sun	29th	8 pm	(6 pm WST) Jupiter 5° S of Moon
Mon	30th	3 am	(1 am WST) Uranus 6° E of Moon
Tue	31st		m.p. 15 Eunomia 0.5° S of star Rho[1] Sagittarii

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

During October and into early November, a fading (11th magnitude) 11 Parthenope passes close to several prominent nebulae and clusters in Sagittarius (see Diary). On the 29th 3 Juno makes a close approach to the bright galaxy pair of NGC 3166/69 in Sextans (see Diary). Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag
1 Oct	41 Daphne	Cetus	12.0
2 Oct	29 Amphitrite	Pisces	8.9
5 Oct	14 Irene	Cetus	10.8
5 Oct	28 Bellona	Cetus	11.3
23 Oct	135 Hertha	Pisces	10.3
27 Oct	287 Nephthys	Cetus	11.4

COMETS

During October, **Comet 103P/Hartley 2** is rising in the north-eastern sky just after midnight. It starts the month in Auriga at possibly 8th magnitude then proceeds into Gemini (2nd), Cancer (19th) and Hydra (31st) fading slightly during the month.

Comet 2P/Encke begins the month in Leo, rising in the eastern sky before sunrise, moving to Virgo on the 11th. Encke may get brighter than 8th magnitude during the month, but is difficult to observe, being only visible in the bright dawn sky.

Comet 62P/Tsuchinshan 1 spends October in Gemini, rising in the north-eastern sky around midnight. It starts the month around 12th magnitude before possibly brightening to 10th by month's end.

Comet C/2017 K2 (PANSTARRS) is in Monoceros at 12th magnitude, rising in the eastern sky around midnight. From mid-month it is transiting in the northern sky shortly before sunrise. By month's end the comet is rising about 10 pm.

Comet C/2020 V2 (ZTF) commences in Sculptor at 10th magnitude, transiting high in the northern sky around midnight. On the 4th it crosses the zenith, now transiting high in the southern sky late evening. By month's end, the comet has moved into Phoenix and faded to about 11th magnitude. Here's an imaging opportunity. On the evening of the 10th, ZTF has a meeting with the brilliant galaxy NGC 300 in Sculptor.

Comet C/2021 S3 (PANSTARRS), starting in Antlia at 12th magnitude, spends the month rising in the south-eastern sky after midnight. On the 25th it moves into Centaurus, ending the month at around 11th magnitude.

METEOR SHOWERS

The **Southern Taurids** are active from September 10 through to November 20. The shower comprises two radiants of nearly equal activity ten degrees apart. The Southern Taurids should peak late evening on October 10 through to

An Astronomical Legacy
30 years of the Hubble Space Telescope (Part 1)

This year marks a significant milestone of one of the most prolific contributors to astronomy and cosmology, the Hubble Space Telescope (HST). We'll start with an overview of the tremendous challenges that were overcome, allowing the HST to be still functioning today. Hubble was the visible light instrument of NASA's Great Observatories missions, with other orbital telescopes being the Compton Gamma Ray Observatory, the Chandra X-ray Observatory and the Spitzer (infrared) Space Telescope.

A Bit of History

In April 1990 the Hubble Telescope was deployed in low Earth orbit by the space shuttle, Discovery. This was the culmination of an effort that spanned many decades. The path to Hubble goes back well before the space race of the 60s, in fact, to 1946 when Lyman Spitzer proposed a space telescope. Although NASA has always been a supporter of the concept since its inception in 1958, it wasn't until 1969 that the American National Academy of Sciences backed the project. The early 1970s saw Congress approve the funding but even then, it needed to be a joint operation with the European Space Agency (ESA) to make it a reality. With the space shuttle becoming available, the effort intensified, originally shooting for a 1983 launch.

Its design hinged around the fundamental prerequisite (and its most powerful feature) that the telescope could be regularly serviced and have the capability to swap out entire instruments as technology advanced, all carried out by astronauts in bulky EVA suits and gloves. Due to a string of technical delays, the newly named Hubble Space Telescope (HST) didn't make its scheduled launch date, and following the 1986 Challenger disaster went into hiatus, along with the entire space shuttle programme. The shuttles were grounded for nearly three years, with the eventual launch of the HST in 1990.

Do I hear you say, it's been 33 years? Although the 30th anniversary was recognised in 2020, in honour of all of us who have drooled over the magnificent images, we are celebrating 30-years since its first servicing mission. For in December 1993 the Space Shuttle Endeavour (STS-61), finally delivered Hubble its *spectacles*. These corrective optics were needed because the main mirror had been incorrectly shaped, suffering from spherical aberration. This was only discovered after being placed to orbit when its first images were blurry. Finally with COSTAR (Corrective Optics Space Telescope Axial Replacement) in place, it could deliver sharp, diffraction limited views. After all, this was a major reason to put an optical telescope in orbit, to escape the boiling effect of the Earth's atmosphere. This does not mean the HST sat idle between 1990 and 1993. During this period, it still made productive observations, being restricted to spectroscopy and high-resolution work on bright objects. So, as an example, the deep field images would have to wait.

continued on page 81

dawn, with about five meteors per hour. The Northern Taurids peak next month on the 12th. 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. There will be some interference during the peak by the waning crescent Moon before it sets around 3 am.

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 22nd to 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. The shower was first recorded by Chinese observers in 288 CE and is associated with Halley's Comet. The First Quarter Moon will hamper observation until it sets around 1 am.

CONSTELLATIONS

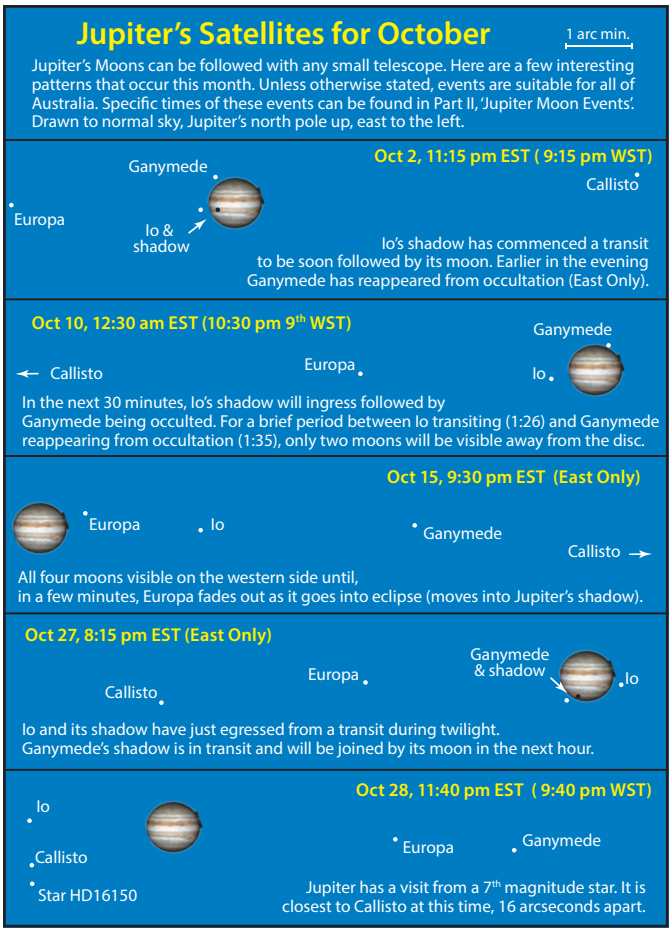
The next zodiacal constellation is Aquarius the Water Bearer, which continues the water theme. The origin of this heavenly, watery region, dates to the Babylonians who considered it a celestial sea. The Greeks adopted not only Aquarius but also Capricornus (Goat Fish), Pisces (the Fish), Piscis Austrinus (Southern Fish) and Eridanus (the River). Aquarius' brightest stars are mostly 4th magnitude, and not only does it look nothing like a human shape pouring water from a container but has no bright stars and only one distinctive asterism, the Water Jar. Marked on All Sky Map No. 8, it is a naked-eye group of four stars arranged in a 'Y' shape, approximately 3° across. The Jar consists of Pi (π), Gamma (γ) and Eta (η) with its centre 3.6 magnitude Zeta (ζ) Aquarii a brilliant double star. It's made up of two nearly matched yellow 4th magnitude components separated by 2 arcseconds—ideal for small telescopes with reasonably high magnification (100+) and good seeing.

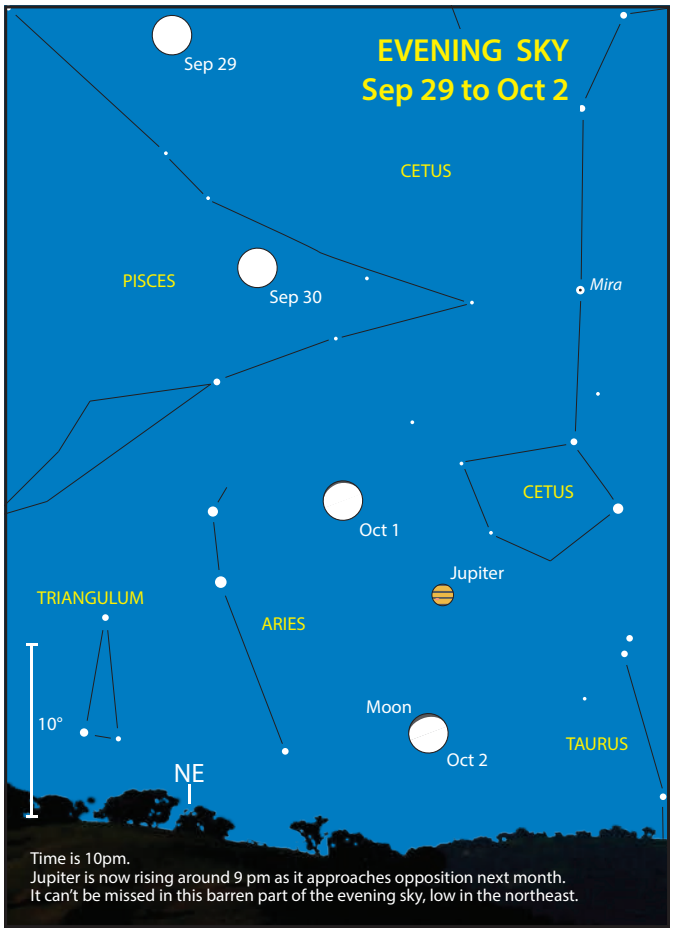
Being well away from the plane of the Milky Way, Aquarius has few open star clusters or nebulae and as expected, many galaxies, with NGC 7606 one of the best. This magnitude 10.8 spiral galaxy has an extended oval shaped core (1 × 3 arcminutes) with a noticeably brighter centre and star-like nucleus.

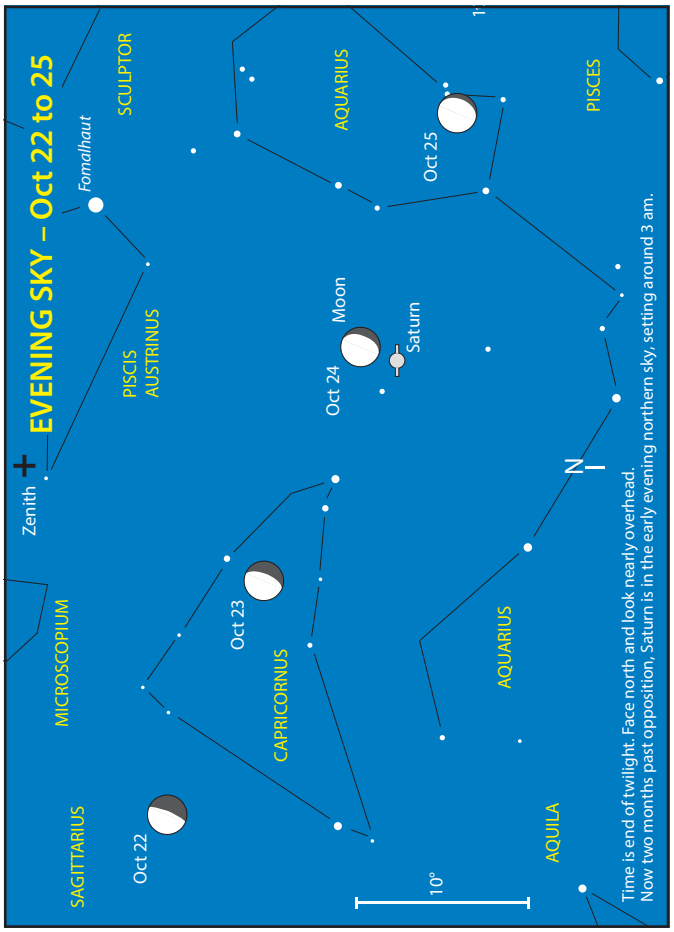
There are two brilliant globular clusters. Magnitude 9.3 M72 (NGC 6981) is 3 arcminutes in diameter and has a very low concentration shown by its quite broad core with a handful of brighter stars spread across the disc. It needs around a 20 cm telescope (minimum) to start resolving the cluster stars. In contrast, bright (magnitude 6.5) globular star cluster M2 (NGC 7089) has a very condensed (compact) nucleus. It has a larger halo (5 arcminutes across) which is much more concentrated, than M72. To resolve the stars, it too needs around a 20 cm instrument.

The constellation of Aquarius is famous for two planetary nebulae. NGC 7293, better known as the Helix Nebula, is visible as a hazy patch through binoculars. Wide field telescopes (15 cm or larger) show a faint, white smoky ring with a dark centre. Although it's listed as magnitude 7.6, it has a very low surface brightness with this light spread across a diameter of 15 arcminutes (yes, half the size of the Moon!). The other is the Saturn Nebula (NGC 7009) which is very different to the Helix. At mag 7.8 and only 25 arcseconds across it has a high surface brightness showing pale blue in colour. High power (200×) reveals an oval shape. Images of NGC 7009 explain its name showing extensions from both sides resembling Saturn's rings. These faint projections are visible through large telescopes (25 cm plus) and an OIII filter works well on both planetaries.

Helix Nebula (NGC 7293) in Aquarius







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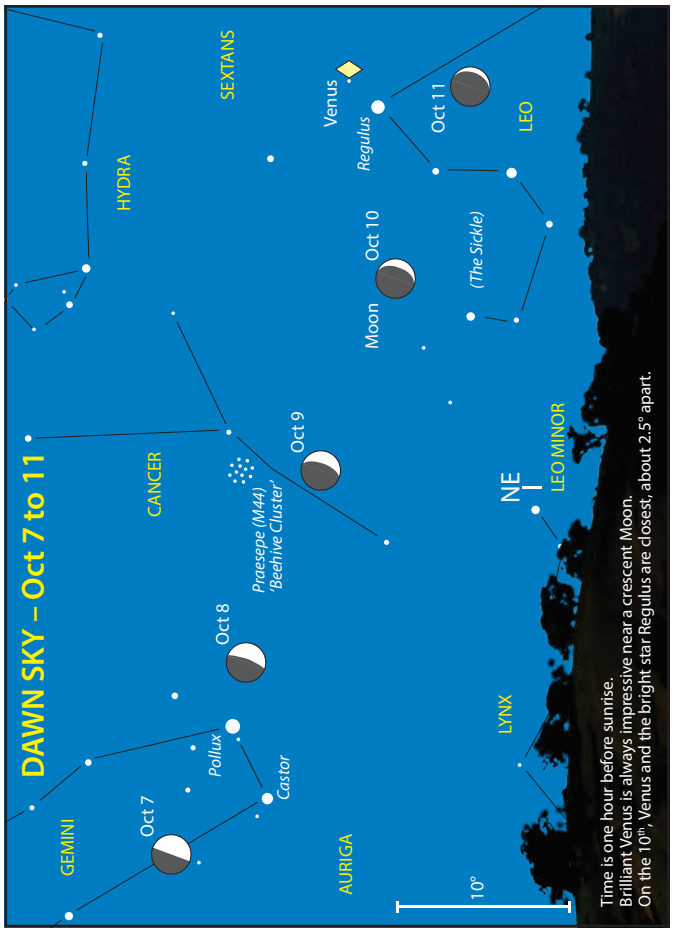
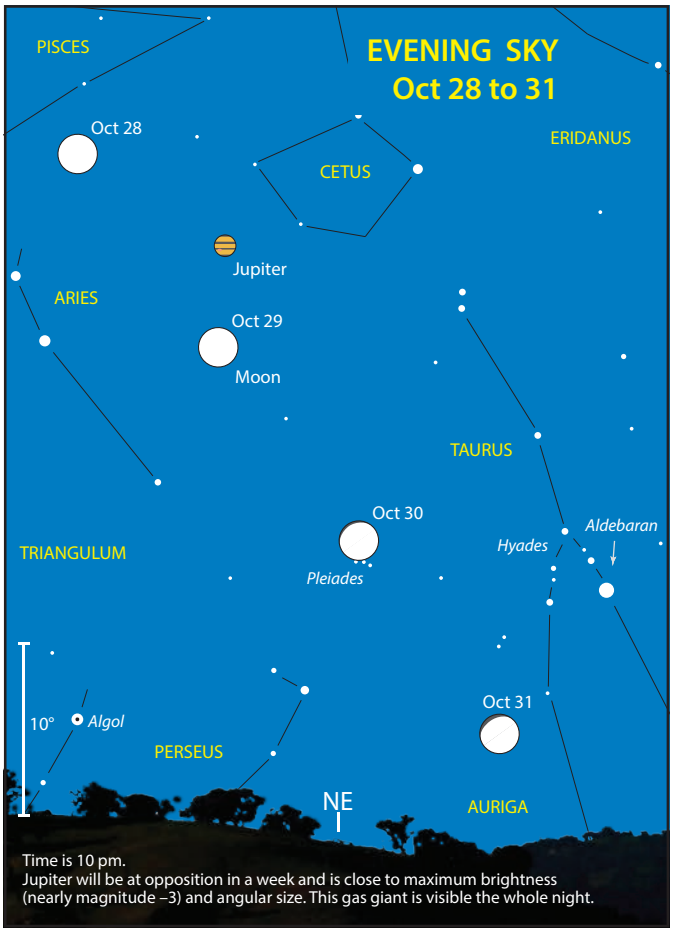
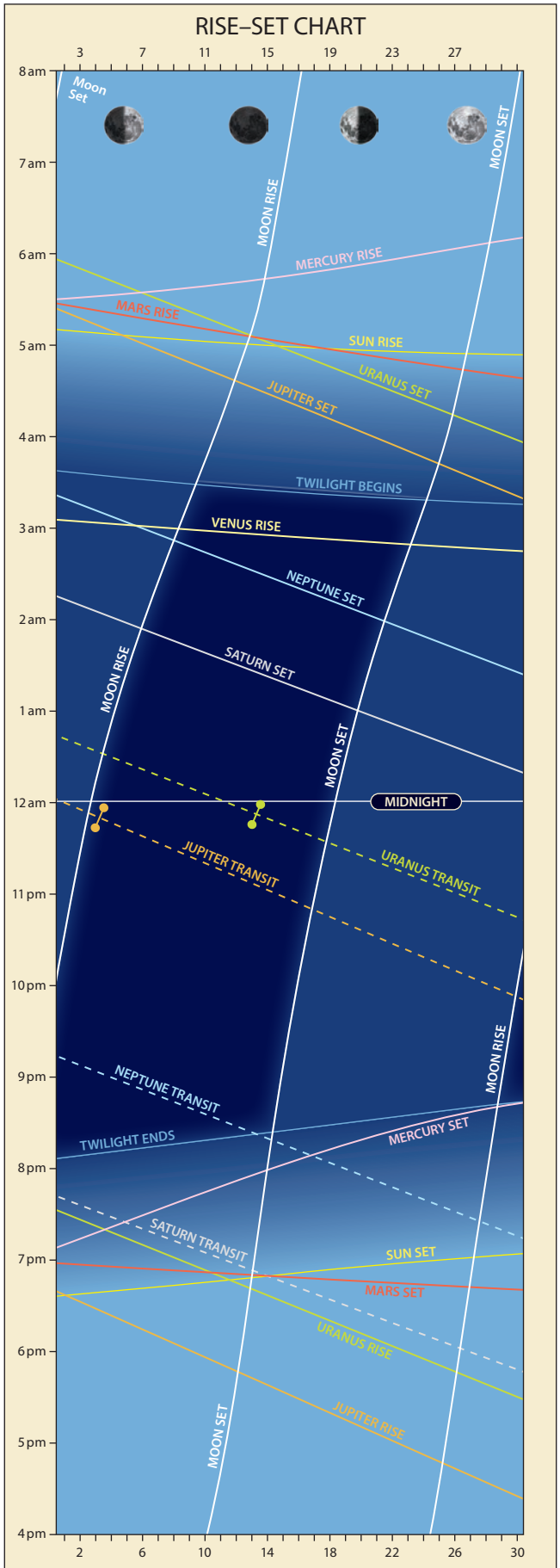




NOVEMBER 2023

RISE–SET CHART

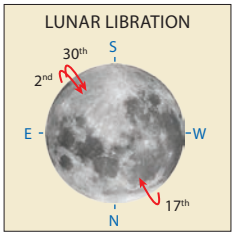


Approximate local standard time, for daylight saving add 1 hour.

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).

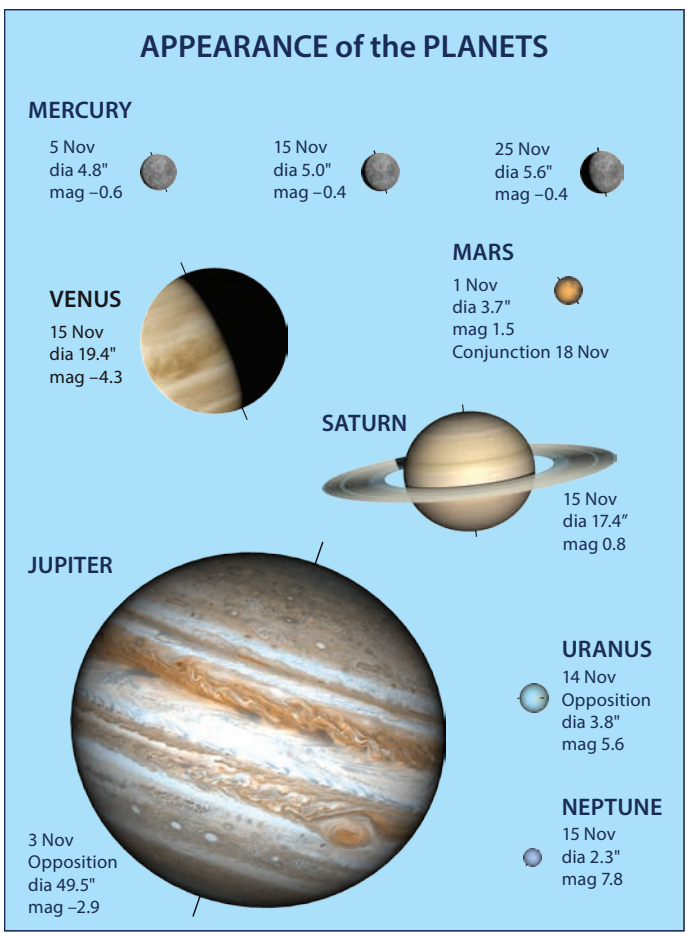
27th 7 pm (5 pm WST) Full Moon.

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 (see pp. 118–119 for GRS predictions). 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 gas 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

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	Comet C/2017 K2 (PANSTARRS) 0.6° S of star Beta Monocerotis
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
Tue	21st	11 pm	(9 pm WST) Comet C/2017 K2 (PANSTARRS) 0.05° E of NGC 2215 (OC) in Monoceros
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

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 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 62P/Tsuchinshan 1 is rising in the north-eastern sky around midnight. It starts the month in Gemini at magnitude 10, moves into Cancer on the 4th and Leo on the 25th. It ends the month having brightened to a possible 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/2017 K2 (PANSTARRS) spends the month in Monoceros at 12th magnitude, rising in the eastern sky around 9:30 pm, transiting in the northern sky about an hour before sunrise. By month's end it is rising shortly after sunset and transiting around 1:30 am.

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 C/2021 S3 (PANSTARRS) spends the month in Centaurus, rising in the south-eastern sky around midnight, brightening from magnitude 11 to 10.

METEOR SHOWERS

The **Northern Taurids** are bright slow meteors active from October 20 to December 10, with their peak late evening around November 13 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 15 meteors per hour (possibly around 5–6 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

Galileo's Discovery Of Neptune

Uranus was discovered in 1781 by an amateur astronomer, William Herschel, using his homemade telescope. Herschel thought he had found a comet and entitled his discovery report "An Account of a Comet". However, when astronomers calculated this new object's orbit, it turned out to be a new planet, the first detected since antiquity. This discovery took the astronomical world by storm as no one had even suspected that there could be another member of the Sun's family (see *"It was that Night its turn to be discovered"* – Astronomy 2021 p. 56).

Once Uranus had been observed for a reasonable time, astronomers noticed that it did not behave precisely as it should; its orbit was irregular. Calculations by some of the best mathematicians in the world showed that another undiscovered planet might have caused these discrepancies. Two mathematicians, John Adams in England, and Urbain Le Verrier in France, independently calculated expected positions for this new planet.

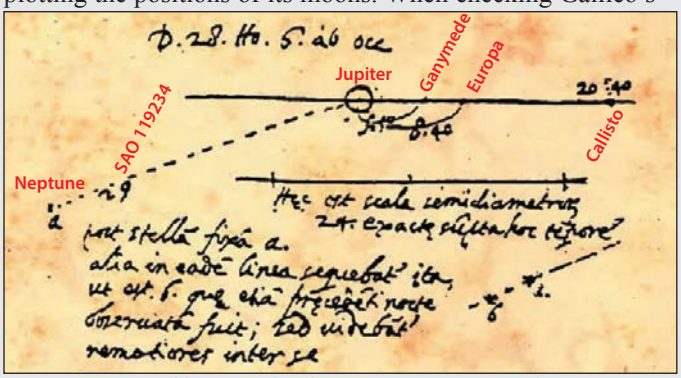
In 1846 Adams sent his predictions to George Airy, the Astronomer Royal, and Le Verrier sent his to Johann Galle at the Berlin Observatory. Airy shelved the report, and Galle started observing at once with the aid of a young student named Heinrich d'Arrest. The Berlin Observatory director, Johann Encke, was attending his birthday party that night. The party finished early when Galle and d'Arrest interrupted to announce that they had thought they had discovered the new planet. The trio then spent the night observing the suspicious object, but they could not be sure if it moved or showed a disc.

On the following evening, they looked again, and in a few moments, they confirmed that the object had moved and that it indeed showed a disc. When Encke notified the scientific community, he credited the discovery to himself and Galle, omitting d'Arrest. The new planet was named Neptune after the god of the sea in keeping with the mythological flavour of planetary names.

The claims and controversy surrounding Neptune's discovery could fill a good-sized book. At 8th magnitude, Neptune could only have been found after the invention of the telescope, and the 1846 discovery is cemented rightly into history. However, as with many great discoveries, somebody beat them to it, and it comes as a surprise just who that person was and when.

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

Jupiter fascinated Galileo, and he spent many hours plotting the positions of its moons. When checking Galileo's



From Galileo's notebook 28 January 1613. On this night, Jupiter's moon Io is behind the planet.

hours available before the onset of dawn for observation. The First Quarter Moon on the 20th will not interfere with observations after midnight.

CONSTELLATIONS

Continuing our trip down the zodiacal road, next up is Pisces the Fish. It has a lot in common with Aquarius. From a mythological perspective it also came across from the Babylonian's celestial sea (see October Constellations). Pisces also had special meaning to the Babylonians for their god of water and wisdom, Ea, considered fish as sacred.

Pisces' brightest stars are invisible from the suburbs being mostly 4th magnitude. Like Aquarius' Water Jar, it has only one easily recognisable asterism, a very non-fish-like Circlet. This group of six 4th to 5th magnitude stars, arranged in a hexagon shape, can be seen directly above the distinctive Great Square of Pegasus (see All Sky Maps 8 and 9).

The Circlet is one of two fish, called the Western Fish. The other lies between Pegasus and Aries, the Northern Fish. The fish have cords running from each, as shown on All Sky Maps 2 and 3. The Greek writer Aratos (3rd century BCE) had them joining at a star he called, "*the great and beautiful knot star*". Today this star is assumed to be 4th magnitude Alpha (α) Piscium, which isn't great, it's not even bright! It appears Aratos had the cords originally joining at Omicron Ceti, the variable star Mira, which when at maximum was known to reach 2nd magnitude at times. Perhaps, this makes the cord star 'great'. Even the name Mira comes from the Latin word meaning 'wonderful'. However, this relates more to the fact the star on an annual basis faded from visibility for some months. The words 'amazing' and 'miracle' also have the same Latin roots.

Being a faint and unremarkable constellation, isn't the only thing Pisces has in common with Aquarius. Both are well away from the Milky Way environs and hence sparse in open star clusters and nebulae. Both have a reasonable number of galaxies, although mostly faint.

Pisces' deep sky highlight is certainly the face-on spiral galaxy M74 (NGC 628). At magnitude 9.1 it is a magnificent object to image but to observe can be challenging and a 25 cm telescope (or larger) is recommended. Visually it reveals a bright compact core, almost star-like nucleus, surrounded by a large faint halo (approximately 8 arcminutes in diameter) with some faint stars superimposed. Averted vision reveals hints of the two prominent spiral arms, showing as bright and dark patches.

Another face-on spiral worth a visit is NGC 488 which has a bright, well condensed core. In contrast try NGC 7541, which is more edge-on, showing not only a bright oval shaped core, but its halo also has a good surface brightness. Look for its fainter companion galaxy, NGC 7537, in the same field (only 3 arcminutes away), which looks like a miniature version of NGC 7541, with its halo pointing towards its partner.

Pisces also has some double stars worth observing. Try the striking double Zeta (ζ) Piscium, which has magnitude 5.2 and 6.2 components separated by a comfortable 23 arcseconds, with a nice colour contrast—white and yellow respectively. Other similarly wide doubles, ideal for small telescopes include: 35 Piscium, 42 Piscium, 51 Piscium, Psi^1 (ψ^1), 77 Piscium and, for a challenge, the close pair of Alpha (α) Piscium.

Spiral galaxy M74 in Pisces

notebook that he kept exclusively for the Jovian satellites, Kowal and Drake found a star marked at the correct position for Neptune for 27 December 1612. They continued their search through Galileo's observations finding another dated 28 January 1613. In this observation, Galileo noted the position not only of Neptune but also of the 7th magnitude star SAO 119234 (see Galileo's drawing). Along with the sketch he made, Galileo wrote, "*past the fixed star* **a** (SAO 119234) *in a straight line, this is* **b** (Neptune) *which was observed last night, but it seemed further from the other*". Another possible sighting of Neptune by Galileo on 6 January 1613 was uncovered by Erland Standish and Anna Nobili in 1996. Galileo marked the location of a 'fixed star' corresponding to Neptune's location on that date.

It was fortunate that both Jupiter and Neptune remained relatively close during the period of Galileo's observations. Both planets were in retrograde at the time and moving very slowly against the stellar background. Interestingly an exceedingly rare occultation between Jupiter and Neptune occurred on 4 January 1613 but was not observed by Galileo. Imagine the excitement among astronomers worldwide if this were to happen today.

So not only did Galileo observe Neptune several times, but he also noted that it had moved. Thus, Galileo was the first person to see the eighth planet Neptune, 234 years before its official discovery and 170 years before the seventh planet Uranus. He also wrote that he would follow up on the observations over succeeding nights but never did (was it cloudy?).

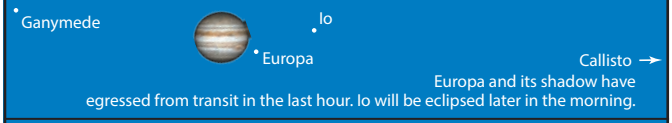
It is interesting to speculate on its effects had Galileo announced the discovery of a new planet and what problems this may have caused in seventeenth-century Europe. Galileo was already in dispute with the Church over the Universe's structure. The existence of another world, one hidden from view, may not have gone down well with the Catholic Church.

Jupiter's Satellites for November

1 arc min.

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

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

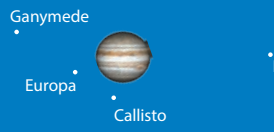


Europa and its shadow have egressed from transit in the last hour. Io will be eclipsed later in the morning.

Nov 5, 11 pm EST (9 pm WST)

All Galilean satellites gathered on the western side of Jupiter.

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

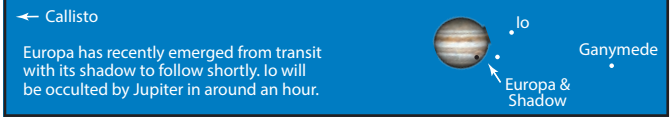


An interesting arrangement of the moons showing we are not currently close enough to the plane of Callisto's orbit to see it transit. Europa and its shadow will complete a transit later in the morning.

Nov 17, midnight EST (10 pm WST)

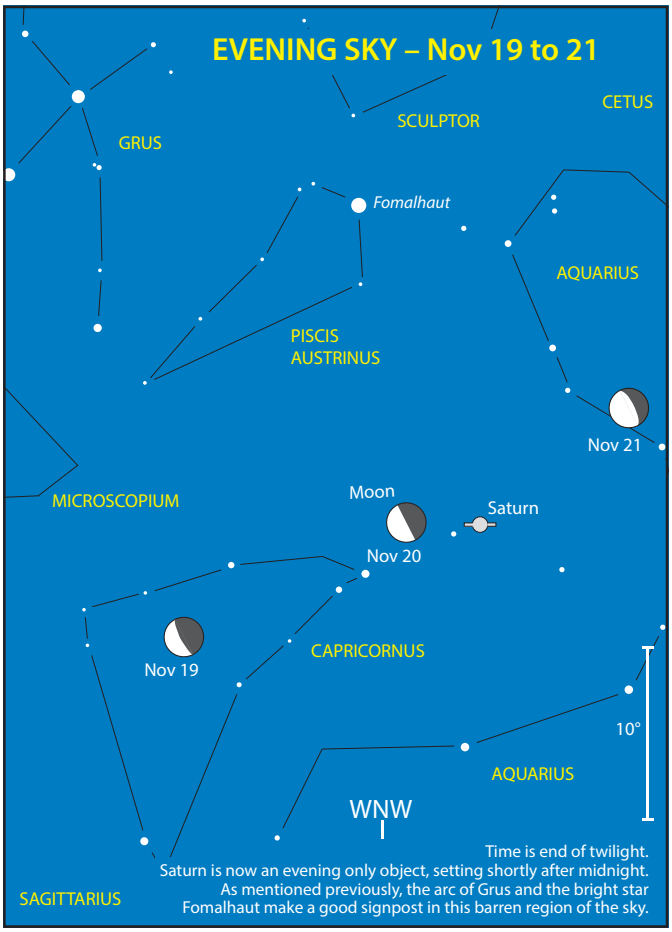
Io and its shadow are currently in mid-transit after ingressing in the previous hour.

Nov 25, 9 pm EST (East Only)



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

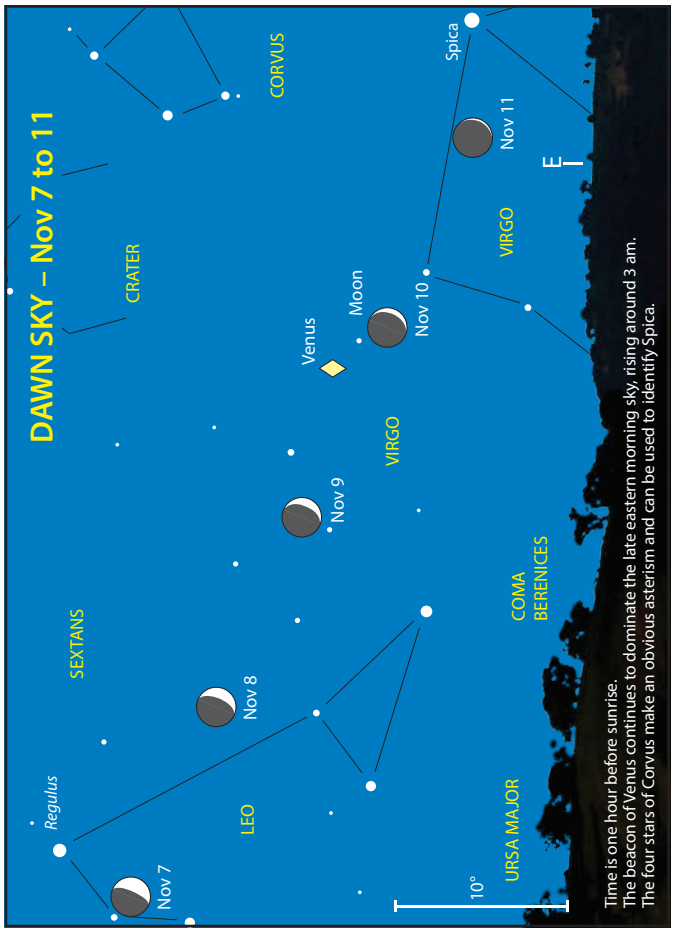
EVENING SKY – Nov 19 to 21



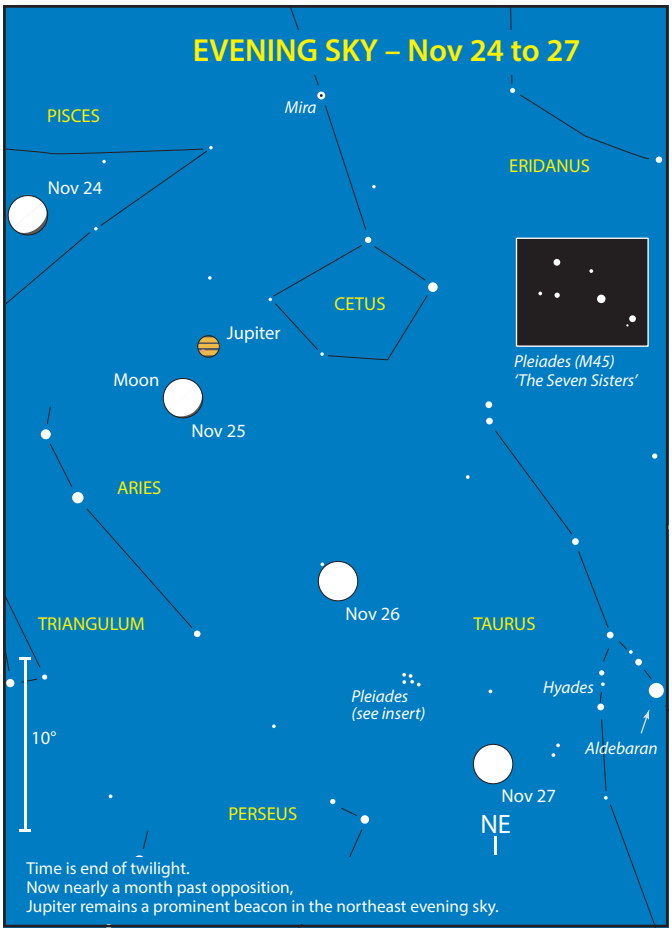
Time is end of twilight.
Saturn is now an evening only object, setting shortly after midnight.
As mentioned previously, the arc of Grus and the bright star Fomalhaut make a good signpost in this barren region of the sky.

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

DAWN SKY – Nov 7 to 11



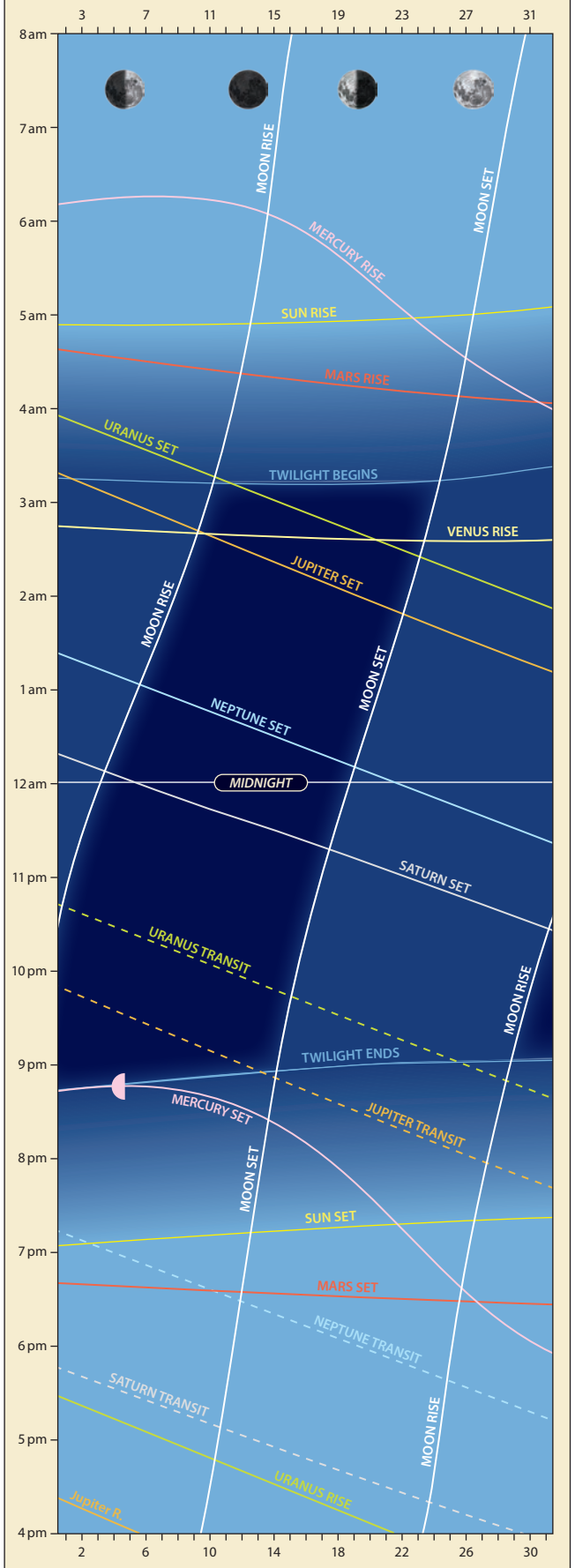
EVENING SKY – Nov 24 to 27



Time is end of twilight.
Now nearly a month past opposition,
Jupiter remains a prominent beacon in the northeast evening sky.

DECEMBER 2023

RISE–SET CHART

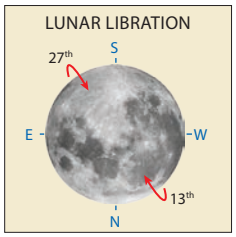


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- 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.

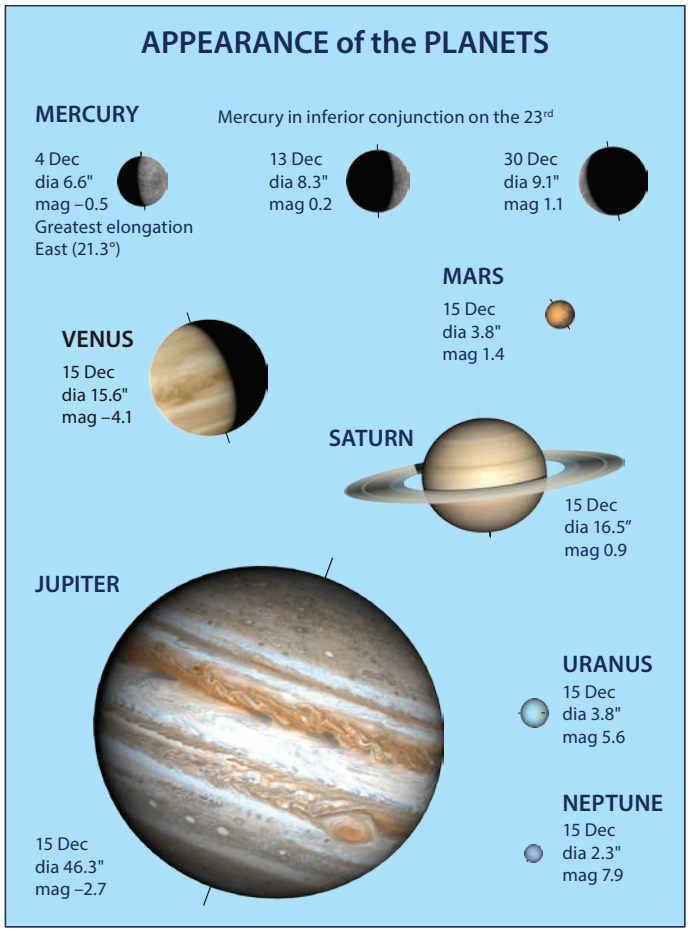
27th 11 am (9 am WST) Full Moon.

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

APPEARANCE of the PLANETS



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.

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.
Wed	13th	pm	Comet C/2020 V2 (ZTF) 0.1° NE of NGC 7582 (G) in Grus
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

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 gas 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.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the evening of 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 103P/Hartley 2 is in Hydra starting the month at about 11th magnitude before fading to 13th by the end. Beginning rising in the eastern sky around 90 minutes after twilight and transiting high in the northern sky shortly before sunrise. By month's end then it is rising just after sunset and transiting about an hour 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.

Comet 62P/Tsuchinshan 1, approaching perihelion on Christmas Day, spends December in Leo, rising in the eastern sky around midnight this month, possibly 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.

Comet C/2021 S3 (PANSTARRS) spends the month in Centaurus, rising in the south-eastern sky around midnight, at around 10th magnitude.

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.

The **Geminid**s are among the finest and most reliable of the major annual showers. Visible from the 4th to 17th, with maximum predicted late evening on the 14th and morning of the 15th. The Geminids often produce bright, medium-speed

30 years of the Hubble Space Telescope (Part 2)

(continued from page 71)

A total of five servicing missions were conducted by the Space Shuttle fleet from 1993 until 2009. Several cameras (wide and narrow field) and spectrographs were changed out, taking advantage of upgrades in digital imaging systems, plus batteries and solar cell arrays were replaced. The moving parts required to point and track the HST especially needed regular changing, such as gyroscopes, fine guidance controls and reaction wheel assemblies. Hubble was even dragged into the 21st Century with a new high speed computer and had the original reel to reel data recorder replaced with a digital one.

The last servicing mission nearly didn't happen. Originally scheduled for 2004 it was postponed and even cancelled at one stage as NASA was rocked by the loss of a second shuttle, when Columbia disintegrated during its re-entry in February 2003. It's interesting that Columbia's previous mission had been Hubble's fourth servicing. This could easily have put an end to all shuttle flights, but fortunately the programme continued until 2011. However, Hubble was still left on tenterhooks. One of the prerequisites made for manned flights to resume was the ability to retreat to the International Space Station in case the shuttle got into trouble. However, the orbit required to service Hubble would not allow a rendezvous with the IIS. In 2005, the then NASA administer, Michael D. Griffen, due to public protests and requests from Congress to try and save the telescope, agreed to a final service. It was fortunate that NASA knew before STS-125 (flown by Atlantis) this was going to be the last time astronauts would visit Hubble. It became a very intensive and comprehensive mission. The work done on this flight is responsible for Hubble still working today, and hopefully will continue until 2030.

An Abundance of Scientific Return

Here are a few highlights of Hubble's achievements. Looking at cosmology, HST has contributed significantly to answering many fundamental questions, like improving the accuracy of the Hubble constant. This is the rate of expansion of the Universe, as measured by the red shift of galaxies, allowing its age to be determined. Prior to this work the range was quite broad, from around 10 to 20 billion years. After Hubble, it's now considered to be 13.7 billion (+/– 10%). A fitting achievement seeing the telescope was named after Edwin Hubble who discovered in the 1920s that the Universe was expanding.

The Ultra Deep field images appealed not only to scientists but fired the imagination of everyone. Effectively the telescope was pointed to blank areas of sky and a single exposure of one to two weeks taken. These narrow field images have probed the early Universe showing thousands of galaxies with many in their early days of formation. Subsequently Hubble revealed embryonic galaxies as they appeared less that 500 million years after the big bang.

High resolution work by HST has led to the conclusion that the majority of large galaxies have central black holes, some supermassive, such as M87's. Other observations and discoveries included: two new moons of Pluto, a detailed study of the plumes of debris when Comet Shoemaker-Levy 9 collided with Jupiter, the confirmation of water erupting off the surface of Jupiter's moon, Europa, and helping map out the distribution of dark matter in the Universe. Its work on exoplanets comprised the detection of organic molecules and elements in their atmosphere, and the first image of an exoplanet, Formalhaut b. This will likely be a good prelude as the James Webb Space Telescope builds on this knowledge.

Finally, the Hubble Space Telescope's most endearing legacy are the thousands of images of deep sky objects, many of which have appeared in this publication over the years. The extraordinary detail often revealed previously unknown aspects of many deep sky objects. A famous example is the 'pillars of creation' image, a small part of the Eagle Nebula.

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.

CONSTELLATIONS

We complete our tour along the ecliptic with the constellation considered to be the first sign of the Zodiac, Aries the Ram. The early Egyptians visualised it as representing their god of fertility, Ammon Ra, drawn as having the head of a ram and the body of a man. The Greeks saw it as the magical flying ram which was the source of the legendary golden fleece, as of Jason and the Argonauts fame. Other interesting connections with heavenly bodies were Jason's ship the Argo, which was eventually broken up into the constellations of Vela the Sails, Carina the Keel and Puppis the Poop Deck. Other associations were the Gemini twins (Castor and Pollux) and Hercules which were part of Jason's crew.

So why was Aries considered the first sign of the Zodiac? Around 1800 BCE, the vernal equinox, where the Sun crosses the celestial equator going from south to north, was in Aries. This defined the start of Spring in the Northern Hemisphere, considered by many cultures as the start of the New Year. This defined the First Point of Aries, which ironically due to precession, has since moved into Pisces where it currently resides.

Lying halfway between the eastern (right) side of the Great Square of Pegasus and the open star cluster, the Pleiades in Taurus, Aries isn't much to look at. The most obvious feature is two stars (see All Sky Map No. 3). This region of the sky is so barren, these 2.0 and 2.6 magnitude stars, separated by only 4°, stand out well. The brighter star is Hamal (Alpha (α) Arietis) which is Arabic for 'lamb'. It is a cool K class star so is yellowy-orange in colour. The other is the much hotter Sheratan (Beta (β) Arietis) an A class, white star. The sight of both in the same binocular field really shows the colour contrast.

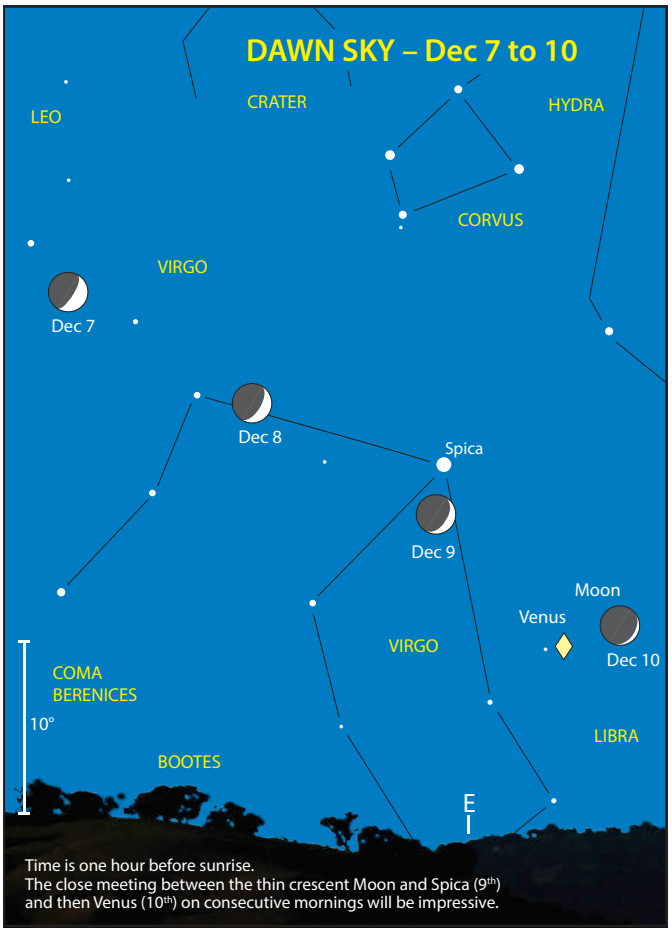
However, for the latter half of 2023, Aries will be easier to find, having brilliant Jupiter residing in its southern regions. In December it will be directly above the alpha and beta stars.

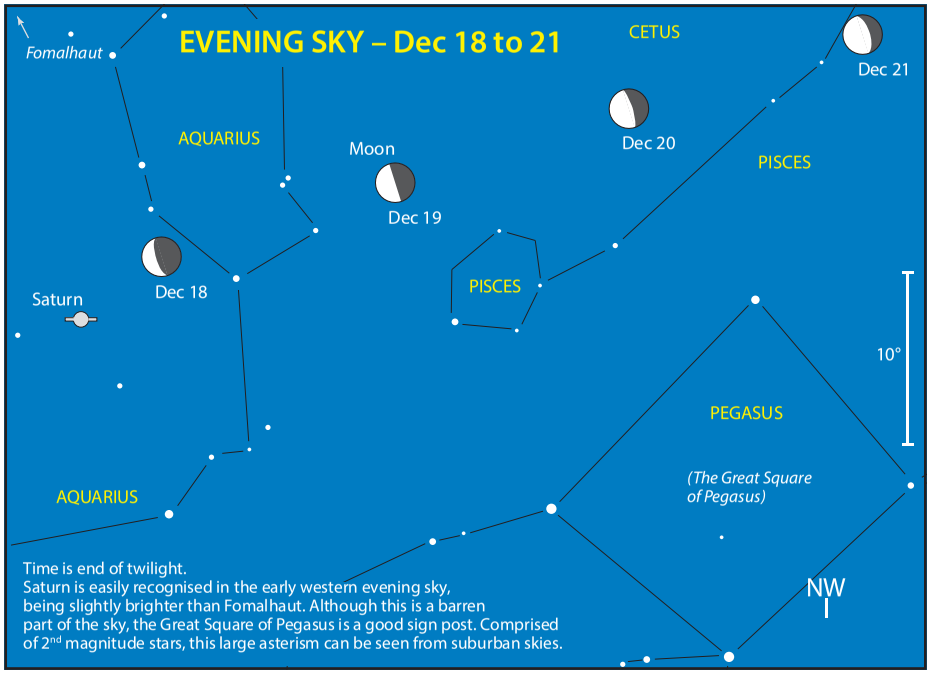
There is a third star, located only 1.5° south (above) Sheratan, called Gamma (γ) Arietis or Mesarthim. This 3.9 magnitude star is a brilliant double with a small telescope revealing two matched 4.5 magnitude white stars, separated by 7.4 arcseconds. These three stars make up the asterism of the horns (or head) of the ram. A fourth star, 41 Arietis (3.6 magnitude) completes the doglegged asterism of Aries, with all its remaining stars fainter than 4.0 magnitude. Here's something for the real trivia buffs, 41 Arietis used to be the brightest member of the constellation of Musca Borealis. The three fainter stars in a vertical line 1.5° west of 41 Arietis completed this Northern Fly. It became obsolete and its modern-day southern counterpart, Musca Australis, became just Musca.

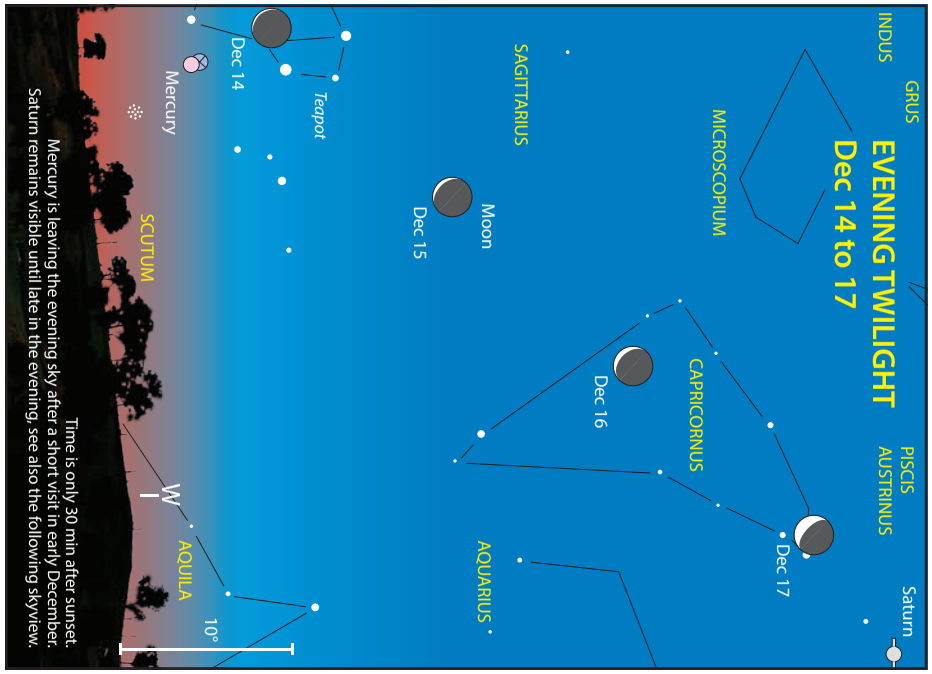
Besides gamma, there are some fine double stars suitable for small telescopes, many exhibiting good colour contrast. Try Lambda (λ), 33 and 30 Arietis.

Being well away from the Milky Way the only deep sky objects on offer are faint galaxies. NGC 772 shows a small bright core (1 arcminute) with a faint oval shaped halo (3 × 2 arcminutes). For those well-endowed amateurs (25 cm and larger telescopes) there are six faint galaxies (11th to 13th magnitude) within 0.5° of the impressive 6th magnitude double star, 1 Arietis—happy hunting!

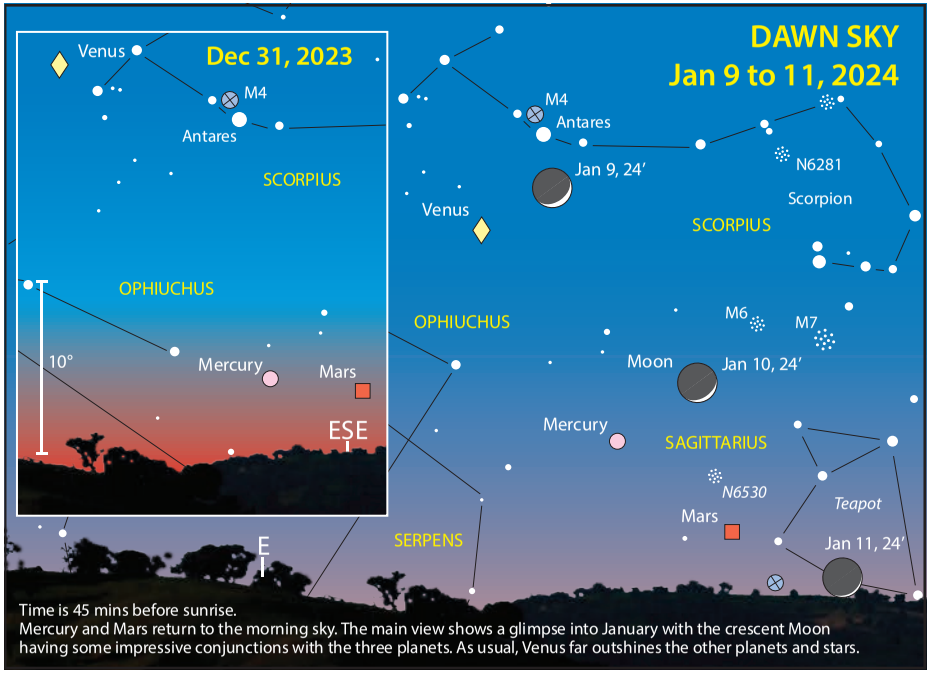
Galaxy NGC 772 in Aries

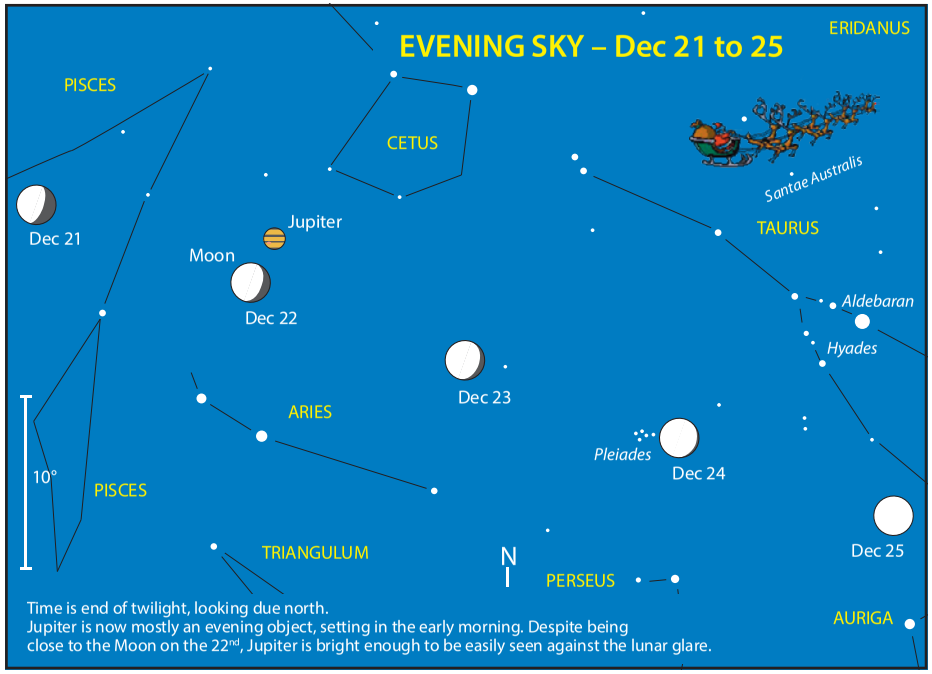






Approximate local standard time, for daylight saving add one hour.





ALL SKY MAPS 2023

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.

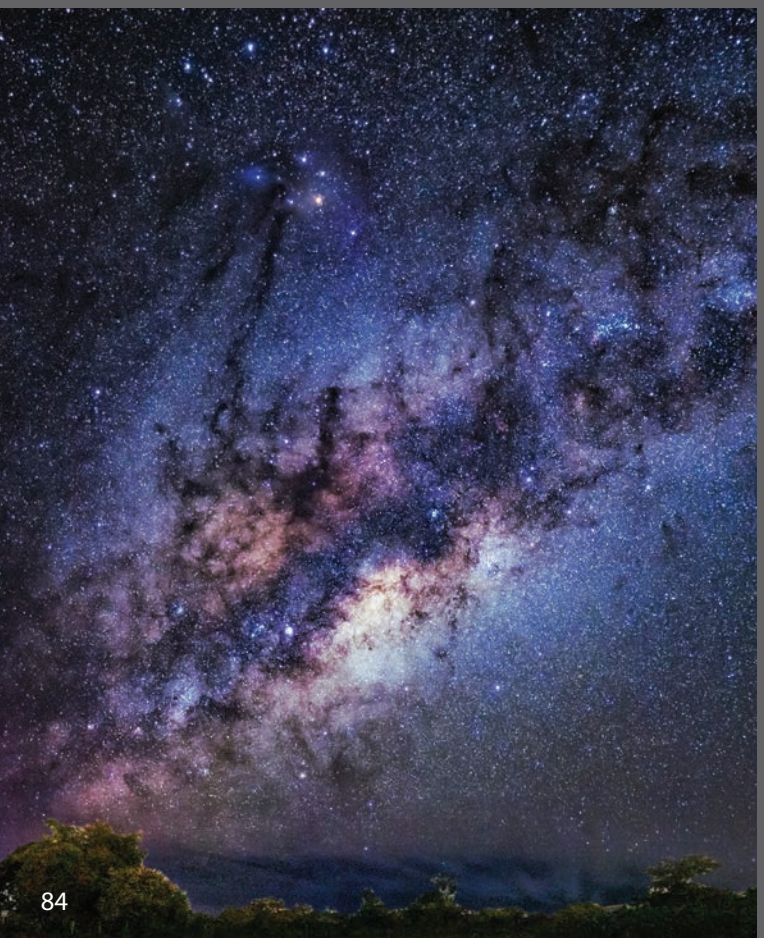
What do the dashed lines, labelled with city names, on the North maps mean? Australia is a large country, and your latitude dictates how far north in the sky you can see. These lines represent the declination furthest north you can see from each of the cities. If a star is very close, but still above 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.

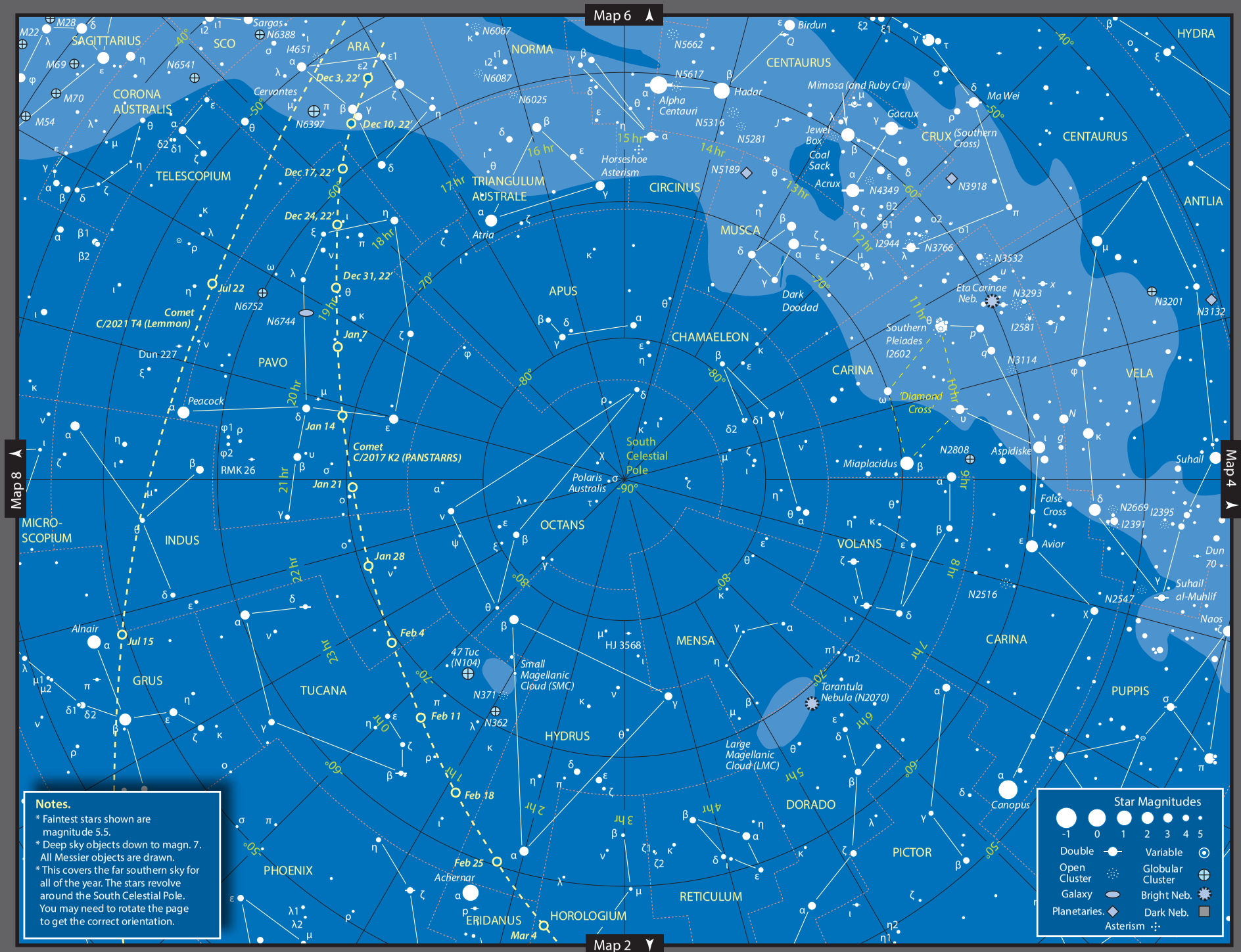
What else is shown on the maps?

- 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 include double stars and deep space objects mentioned in the monthly 'constellations' section (objects are circled). When a comet listed this year (p. 134), is predicted to achieve magnitude 10.0 or brighter it has been plotted for the brightest part of its orbit.

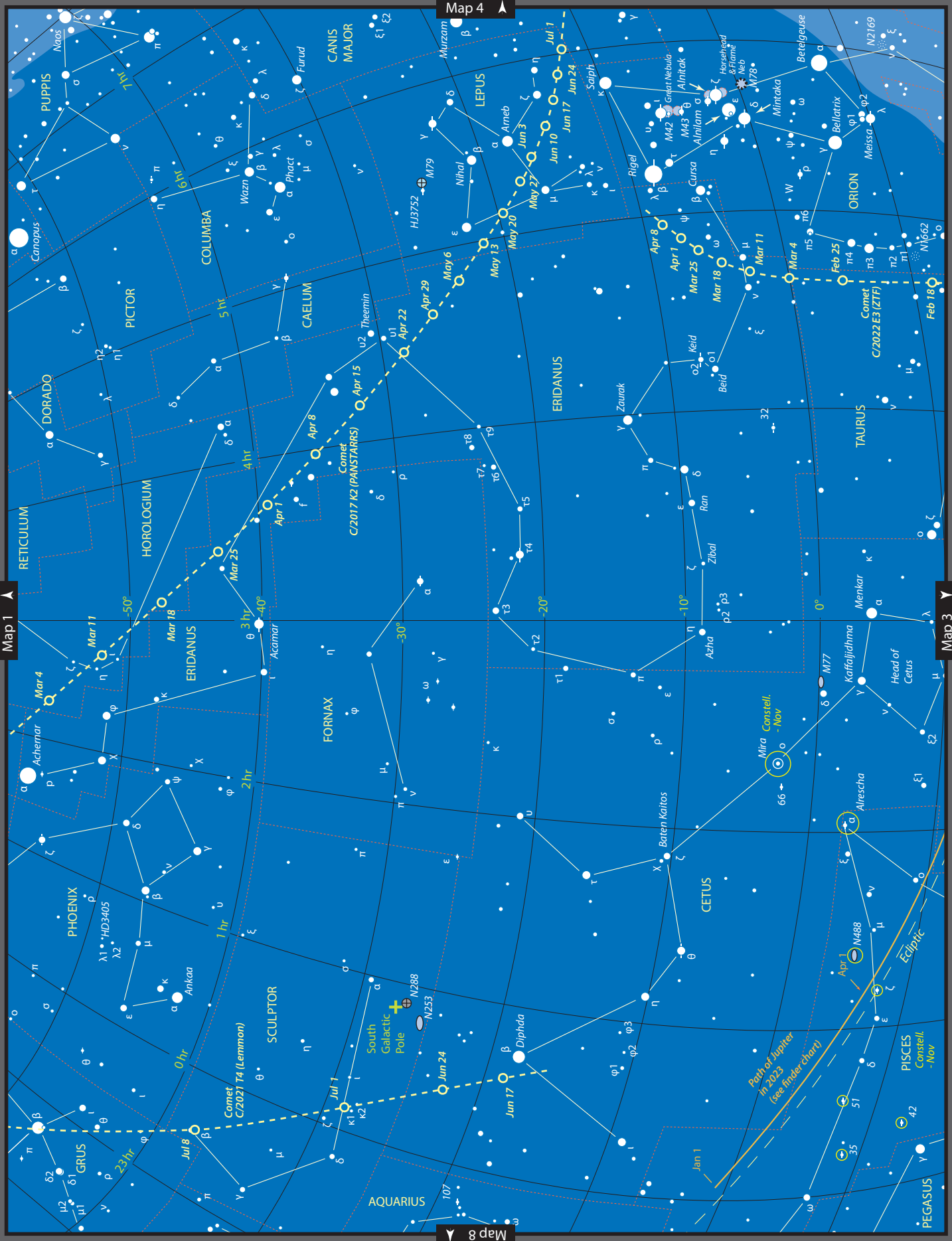


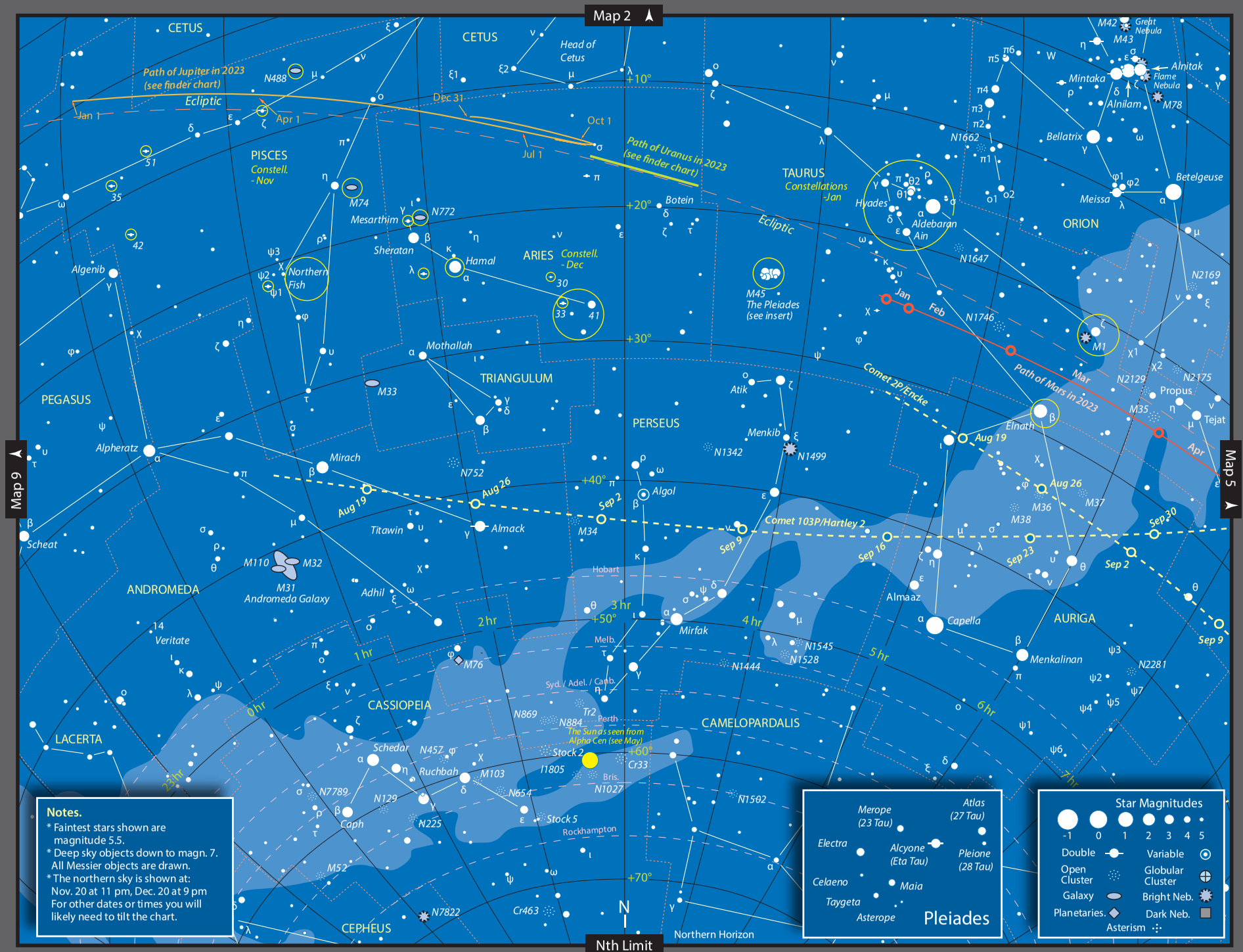
Green Trees Under Starry Sky with Milky Way, credit Gustavo Tavares, Brazil



Map 1 - Looking South

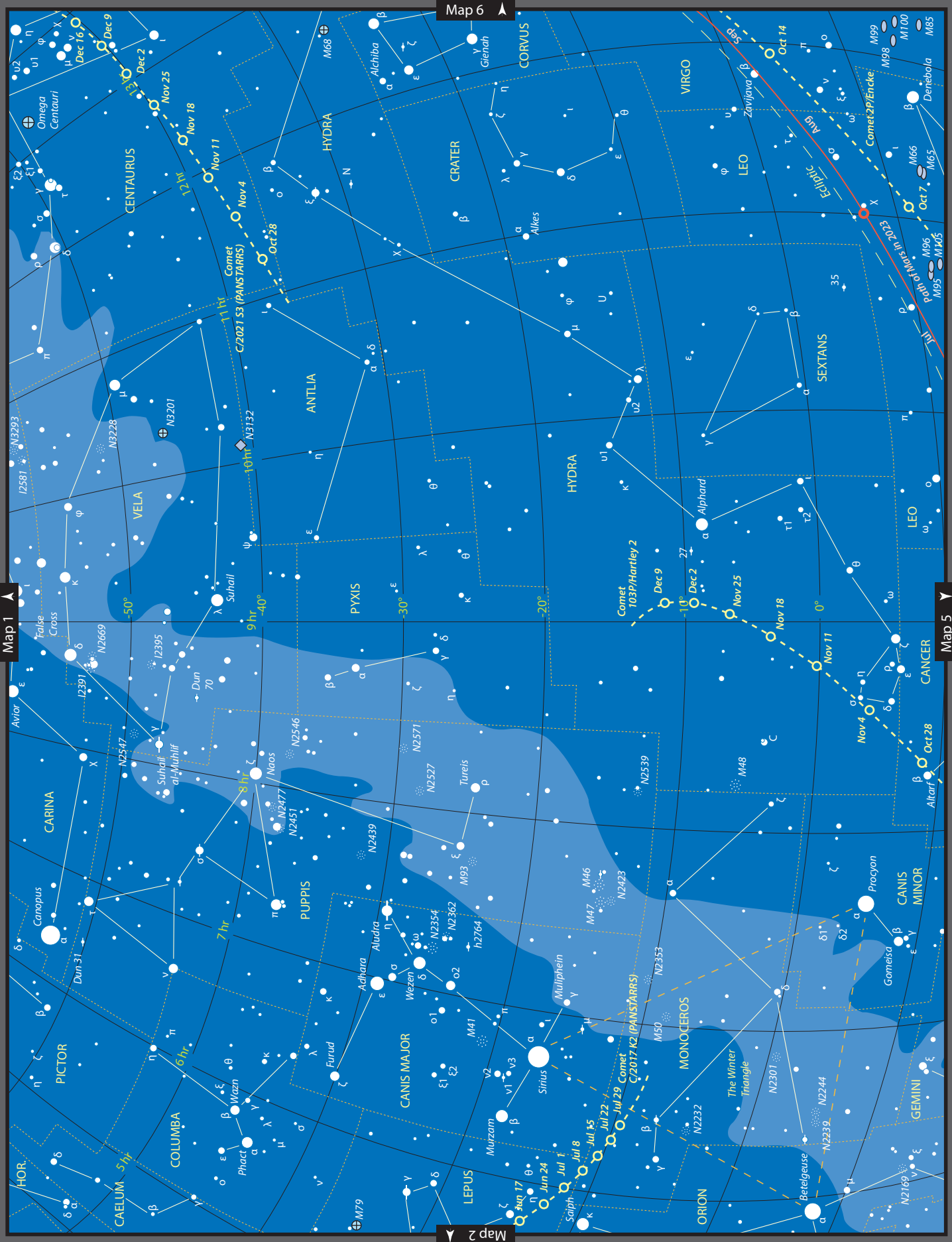
Map 2 - Summer (Centre)

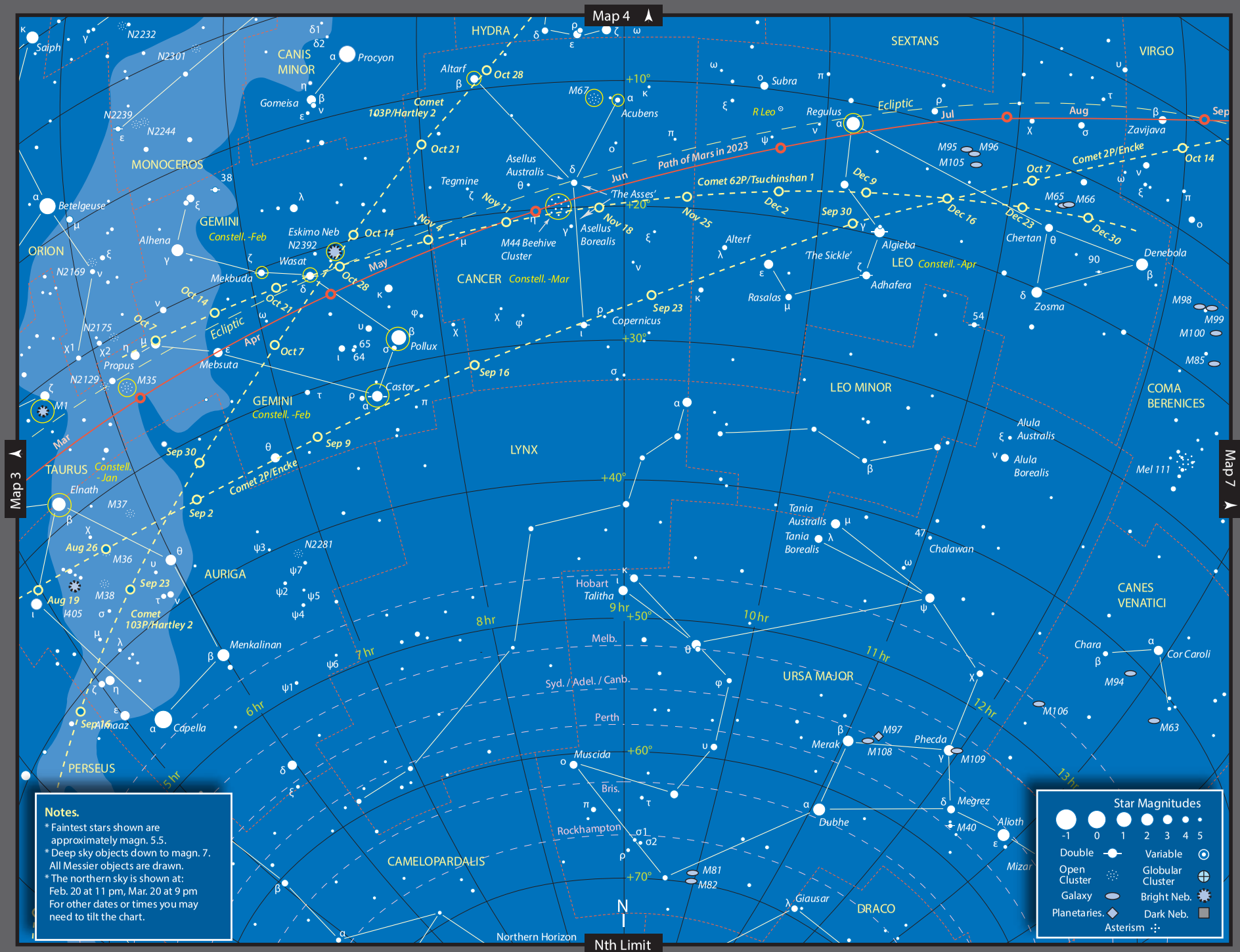




Map 3 - Summer (North)

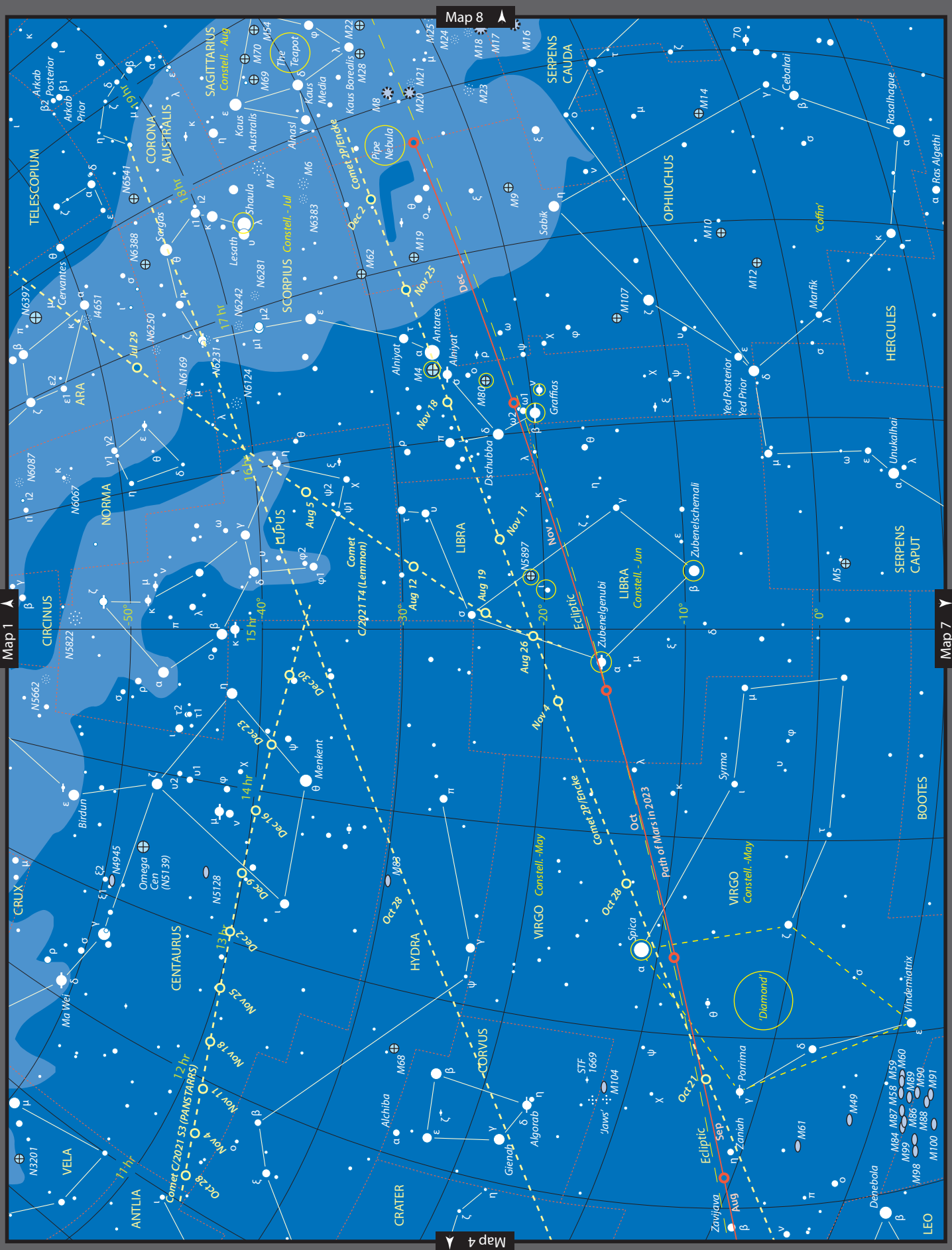
Map 4 - Autumn (Centre)

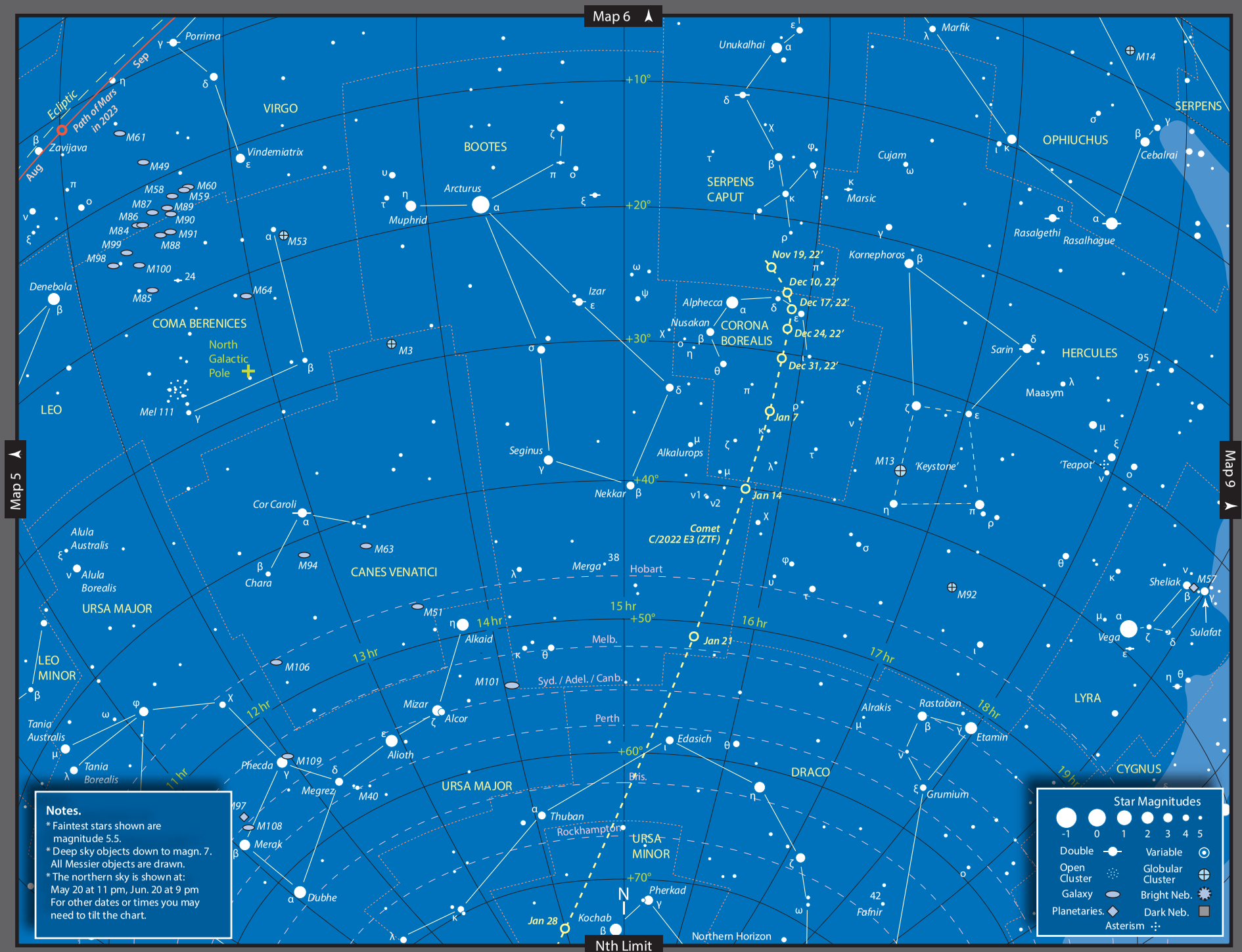




Map 5 - Autumn (North)

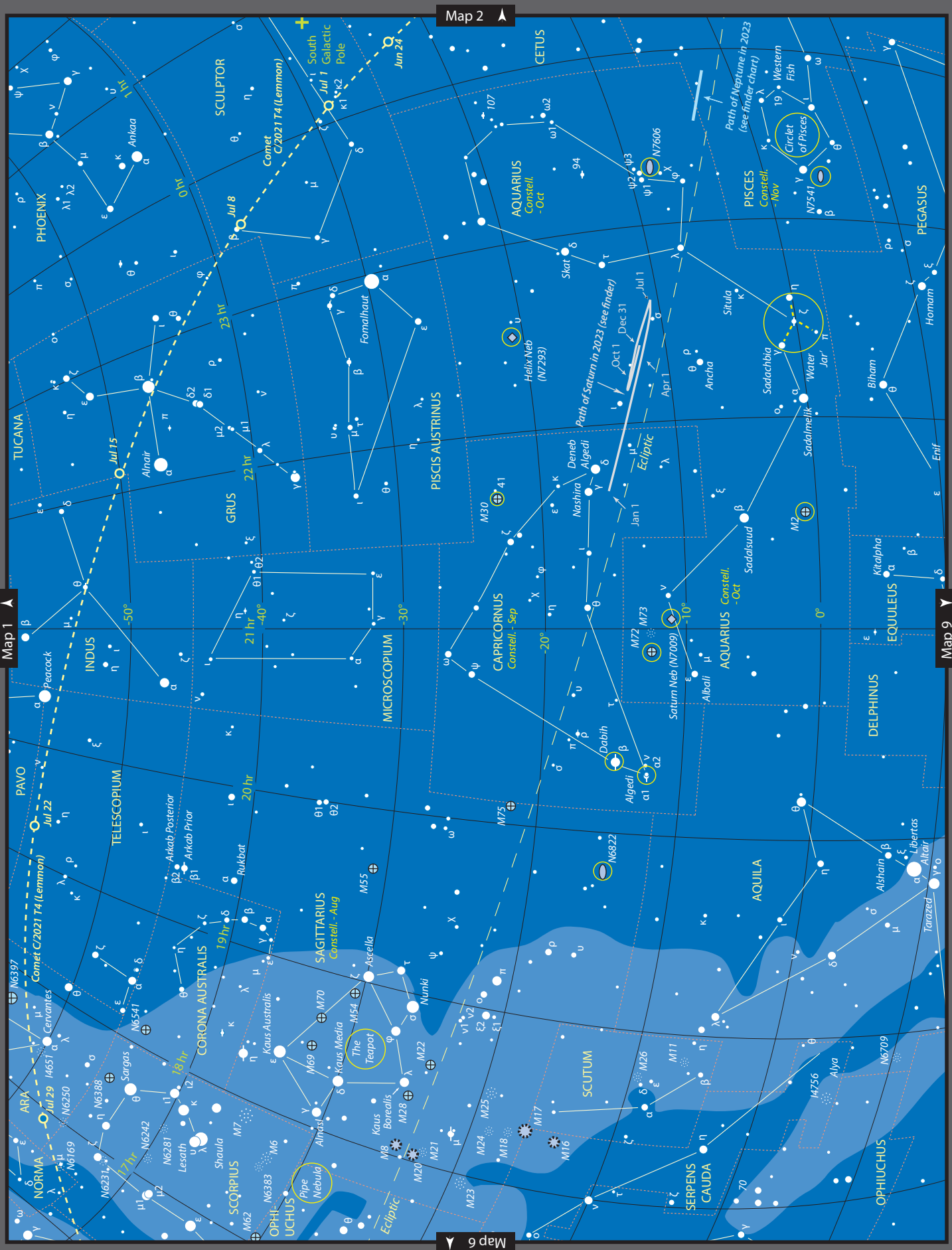
Map 6 - Winter (Centre)

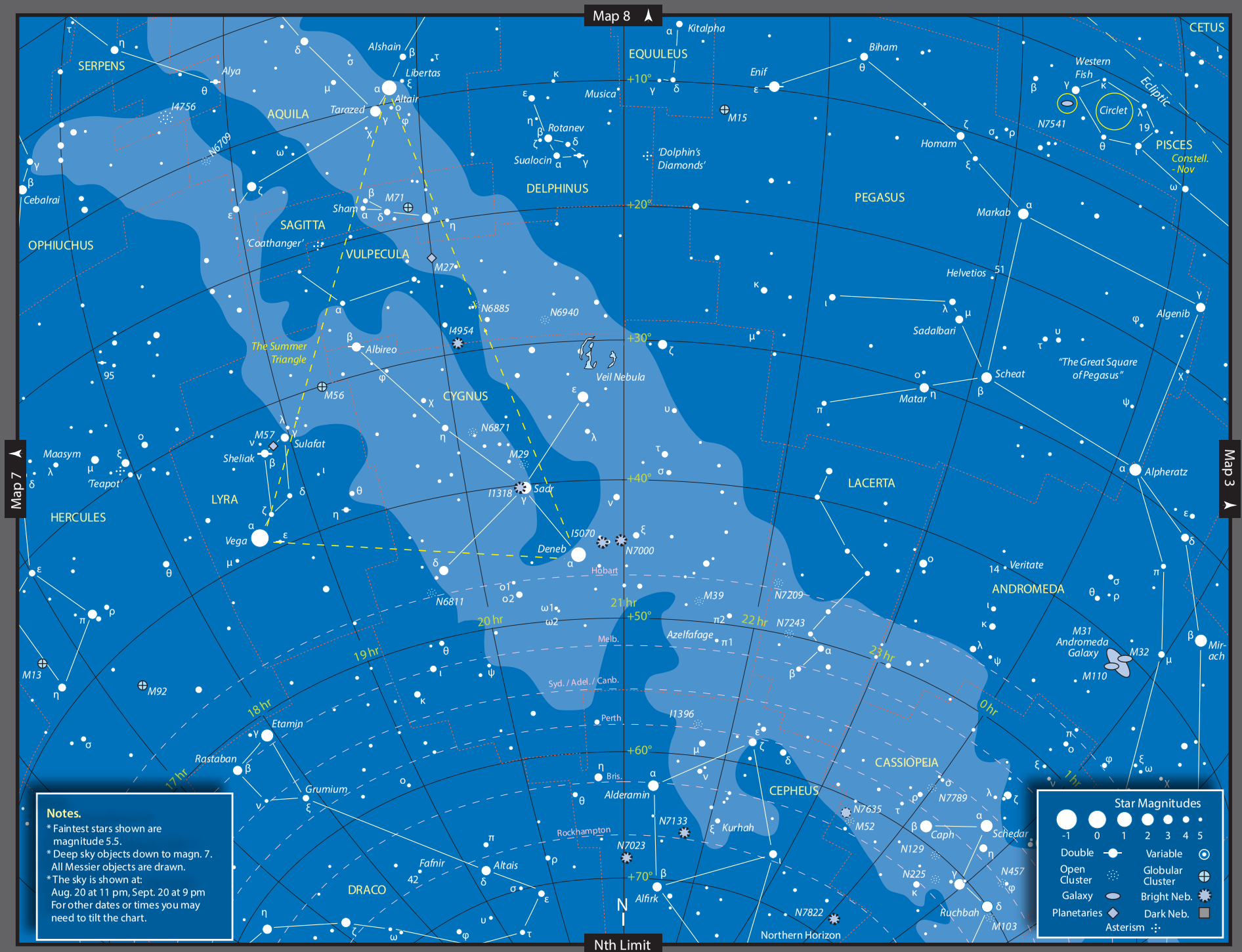




Map 7 - Winter (North)

Map 8 - Spring (Centre)





Map 9 - Spring (North)

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

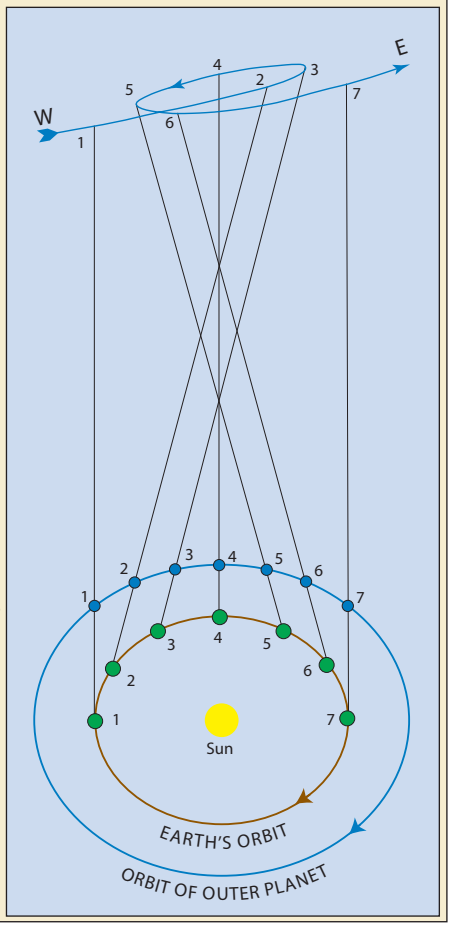
Rise and Set Times. Those given are when the upper limb of the object is coincident with the theoretical horizon. The times are adjusted for atmospheric refraction. The intervals used for Moon rise and set are daily with the Sun weekly and corresponding to Saturdays. Also see note on time zones under 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 2023. 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	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]
Jul 03	21:39	361,934	33.02	0.961	1.254/1.128	Jul 05	08:28	1.451
Aug 02	04:31	357,530	33.42	0.996	1.291/1.156	Aug 02	15:52	0.472
Aug 31	11:35	357,344 [6]	33.44	0.997	1.293/1.157	Aug 31	01:51	–0.406
Sep 29	19:57	361,552	33.05	0.964	1.257/1.130	Sep 28	11:05	–1.370

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.

MOON PHASE (UT)

Lunation	New Moon		First Quarter		Full Moon		Last Quarter	
1237					Jan 6	23:08	Jan 15	02:10
1238	Jan 21	20:53	Jan 28	15:19	Feb 5	18:29	Feb 13	16:01
1239	Feb 20	07:06	Feb 27	08:06	Mar 7	12:40	Mar 15	02:08
1240	Mar 21	17:23	Mar 29	02:32	Apr 6	04:34	Apr 13	09:11
1241	Apr 20	04:12	Apr 27	21:20	May 5	17:34	May 12	14:28
1242	May 19	15:53	May 27	15:22	Jun 4	03:42	Jun 10	19:31
1243	Jun 18	04:37	Jun 26	07:50	Jul 3	11:39	Jul 10	01:48
1244	Jul 17	18:32	Jul 25	22:07	Aug 1	18:32	Aug 8	10:28
1245	Aug 16	09:38	Aug 24	09:57	Aug 31	01:36	Sep 6	22:21
1246	Sep 15	01:40	Sep 22	19:32	Sep 29	09:57	Oct 6	13:48
1247	Oct 14	17:55	Oct 22	03:29	Oct 28	20:24	Nov 5	08:37
1248	Nov 13	09:27	Nov 20	10:50	Nov 27	09:16	Dec 5	05:49
1249	Dec 12	23:32	Dec 19	18:39	Dec 27	00:33		

PERIGEE AND APOGEE (UT)

Apogee			Perigee		
Date	Time	Distance (km)	Date	Time	Distance (km)
Jan 8	09:19	406,458	Jan 21	20:57	356,569
Feb 4	08:55	406,476	Feb 19	09:06	358,267
Mar 3	18:00	405,889	Mar 19	15:12	362,696
Mar 31	11:17	404,919	Apr 16	02:24	367,968
Apr 28	06:43	404,299	May 11	05:05	369,343
May 26	01:39	404,509	Jun 6	23:06	364,861
Jun 22	18:30	405,385	Jul 4	22:25	360,149
Jul 20	06:57	406,289	Aug 2	05:52	357,311
Aug 16	11:54	406,634	Aug 30	15:54	357,181
Sep 12	15:43	406,291	Sep 28	00:59	359,911
Oct 10	03:42	405,425	Oct 26	03:02	364,872
Nov 6	21:49	404,569	Nov 21	21:01	369,818
Dec 4	18:42	404,346	Dec 16	18:53	367,901

GEOCENTRIC PHENOMENA (UT)

Planet	Inferior Conjunction	Stationary	Greatest Elongation West	Superior Conjunction	Greatest Elongation East	Stationary
Mercury	7 Jan, 13 h 1 May, 23 h 6 Sep, 11 h 22 Dec, 19 h	18 Jan, 12 h 14 May, 7 h 15 Sep, 0 h	30 Jan, 6 h (25.0°) 29 May, 6 h (24.9°) 22 Sep, 13 h (17.9°)	17 Mar, 11 h 1 Jul, 5 h 20 Oct, 6 h	11 Apr, 22 h (19.5°) 10 Aug, 2 h (27.4°) 4 Dec, 14 h (21.3°)	21 Apr, 16 h 23 Aug, 5 h 13 Dec, 5 h
Venus	13 Aug, 11 h	3 Sep, 4 h	23 Oct, 23 h (46.4°)		4 Jun, 11 h (45.4°)	20 Jul, 23 h

Planet	Stationary	Conjunction	Stationary	Opposition	Stationary	Earth	
Mars	12 Jan, 20 h	18 Nov, 6 h				Perihelion	4 Jan, 16 h
Jupiter		11 Apr, 22 h	4 Sep, 21 h	3 Nov, 5 h	31 Dec, 15 h	Equinox	20 Mar, 21 h
Saturn		16 Feb, 17 h	18 Jun, 15 h	27 Aug, 8 h	4 Nov, 17 h	Solstice	21 Jun, 15 h
Uranus	23 Jan, 3 h	9 May, 20 h	29 Aug, 3 h	13 Nov, 17 h		Aphelion	6 Jul, 20 h
Neptune		15 Mar, 24 h	1 Jul, 13 h	19 Sep, 11 h	7 Dec, 0 h	Equinox	23 Sep, 7 h
Pluto		18 Jan, h	2 May, h	22 Jul, h	11 Oct, h	Solstice	22 Dec, 3 h

HELIOCENTRIC PHENOMENA (UT)

Planet	Perihelion	Aphelion	Descending Node	Greatest Latitude South	Ascending Node	Greatest Latitude North
Mercury	Jan 2 Mar 31 Jun 27 Sep 23 Dec 20	Feb 15 May 14 Aug 10 Nov 6	Feb 5 May 4 Jul 31 Oct 27	Mar 8 Jun 4 Aug 31 Nov 26	Mar 27 Jun 23 Sep 19 Dec 16	Jan 13 Apr 11 Jul 8 Oct 3 Dec 30
Venus	Apr 17 Nov 28	Aug 7	 Jul 4	Jan 17 Aug 30	Mar 14 Oct 25	May 9 Dec 19
Mars		May 30	Nov 6			Apr 22
Jupiter	Jan 20					
Saturn, Uranus, and Neptune have no events in 2023						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS and PLUTO

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun ($\times 10^3$ km)	-	-	57856	108132	149492	227780	777776	1425983	2867760	4492800	5745000
Mean Distance from Sun (Earth = 1)	-	-	0.387	0.723	1.000	1.524	5.203	9.540	19.180	30.700	39.670
Magnitude at Opposition	−26.8	−12.74 [11]	0.16 [12]	−4.07 [12]	−3.5 [13]	−2.01	−2.70	0.67	5.52	7.84	13.7
Equatorial Diameter (km)	1392530	3474.8	4879.4	12103.6	12756.3	6792.4	142984	120536	51118	49528	2370
Flattening [1]	0	0	0	0	0.00335281	0.005886	0.064874	0.097962	0.022927	0.017081	0
No of Moons	-	-	0	0	1	2	79	82	27	14	5
Mass ($\times 10^{24}$ kg)	1.9884×10^{30}	0.073458	0.3301	4.8673	5.9721986	0.64169	1898.1	568.31	86.809	102.41	0.013041
Mass (Earth = 1)	332946	0.012300	0.0553	0.8150	1.0000000	0.10745	317.8	95.16	14.536	17.148	0.002184
Volume (Earth = 1)	1300000	0.02	0.06	0.86	1	0.15	1323	752	64	54	0.007
Sidereal Period [2]	-	27.32 d	87.97 d	224.7 d	365.256 d	687 d	11.86 y	29.46 y	84.01 y	164.8 y	249.9 y
Synodic Period (Days) [3]	-	29.4	115.8	583.9	-	779.8	398.8	378.0	369.7	367.5	366.7
Axial Rotation (Days) [4]	25.38 [9]	27.32166	58.6462	−243.0185	0.99726963	1.02595676	0.41354 [14]	0.44401 [14]	−0.71833	0.67125	−6.3872
Albedo [5]	-	0.12	0.106	0.65	0.367	0.150	0.52	0.47	0.51	0.41	0.3
Eccentricity [6]	-	0.0549	0.20562	0.00681	0.01681	0.09333	0.04837	0.05582	0.0471	0.00855	0.2486
Inclination [7]	-	5° 08' 40"	7° 00' 00"	3° 23' 38"	0° 00' 00"	1° 51' 01"	1° 18' 28"	2° 29' 29"	0° 46' 22"	1° 46' 38"	17° 09' 00"
Obliquity [8]	7° 15' [10]	6° 41'	0° 01'	2° 38'	23° 26'	25° 11'	3° 07'	26° 45'	82° 14'	28° 20'	60° 25'

Notes (above and opposite):

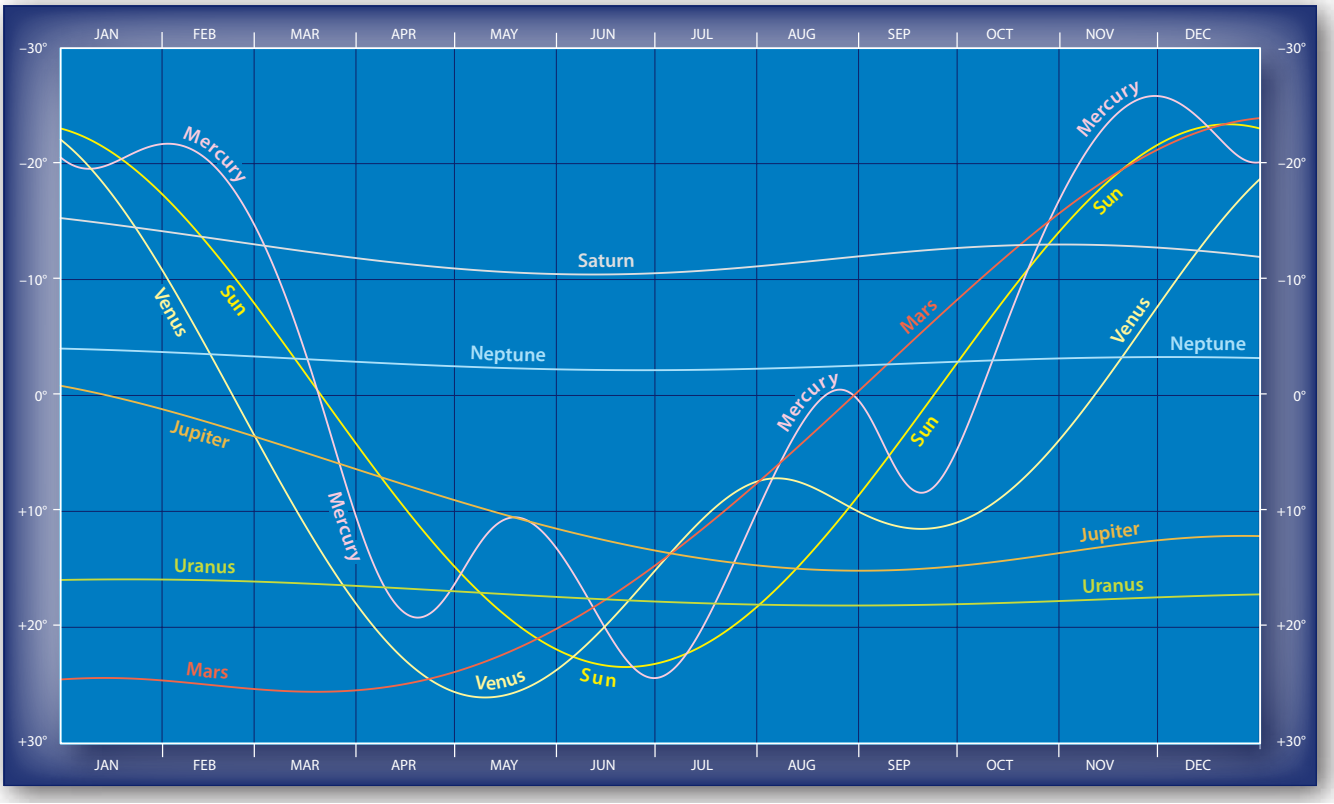
1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
5 The ratio of the sunlight reflected 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 those currently known (as of August 2022). Some are not yet named, instead they have a preliminary designation such as S/2009 S1.

SOLAR SYSTEM DATA — SATELLITES

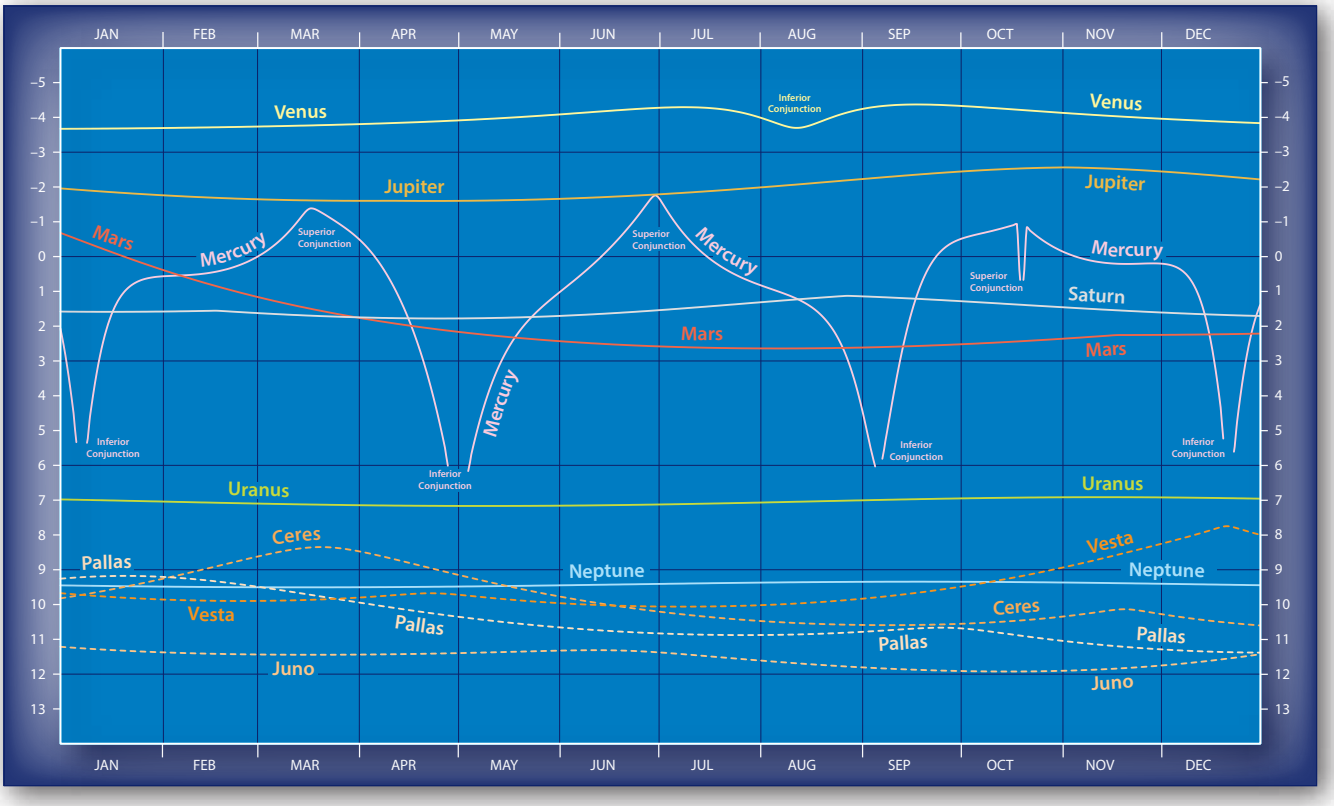
SATELLITE	ORBITAL PERIOD (days)	SEP[17]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
Earth					
Moon	27.321661		384.400	1,737.4	−12.74
Mars					
Phobos	0.31891023	25"	9.380	13.4×11.2×9.2	11.9
Deimos	1.2624407	1.0'	23.460	7.5×6.1×5.2	13.0
Jupiter					
Metis	0.295	42"	128	30×20×17	17.5
Adrastea	0.298	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
Pluto					
Charon	6.38723	1"	19.571	604	17.3
Styx	20.16	2"	42.393	10	27.0
Nix	24.8562	2"	48.671	13	23.4
Kerberos	32.17	2"	57.729	14	26.1
Hydra	38.2065	2"	64.698	30.5	22.9

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



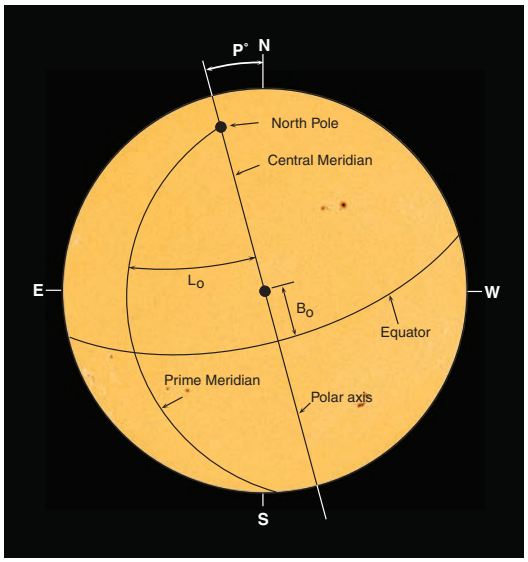
SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

ORIENTATION OF THE SUN



Sun image courtesy of SOHO/HMI 20220825_020000

SYNODIC ROTATION NUMBERS (UT)		
Rotation	Month	d.dd
2266	Jan	1.38
2267	Jan	28.72
2268	Feb	25.06
2269	Mar	24.38
2270	Apr	20.66
2271	May	17.90
2272	Jun	14.10
2273	Jul	11.30
2274	Aug	7.51
2275	Sep	3.75
2276	Oct	1.02
2277	Oct	28.31
2278	Nov	24.62
2279	Dec	21.94

Date (0 h UT)	P°	B_o°	L_o°
Jan 7	– 0.7	– 3.7	286.0
14	– 4.1	– 4.4	193.8
21	– 7.3	– 5.1	101.6
28	– 10.4	– 5.7	009.4
Feb 4	– 13.2	– 6.2	277.3
11	– 15.9	– 6.6	185.1
18	– 18.3	– 6.9	092.9
25	– 20.4	– 7.1	000.7
Mar 4	– 22.2	– 7.2	268.5
11	– 23.7	– 7.2	176.3
18	– 24.8	– 7.1	084.1
25	– 25.6	– 6.9	351.8
Apr 1	– 26.1	– 6.6	259.4
8	– 26.3	– 6.2	167.1
15	– 26.0	– 5.7	074.7
22	– 25.5	– 5.1	342.2
29	– 24.5	– 4.4	249.8
May 6	– 23.2	– 3.7	157.2
13	– 21.6	– 3.0	064.7
20	– 19.6	– 2.2	332.1
27	– 17.3	– 1.3	239.5
Jun 3	– 14.8	– 0.5	146.9
10	– 12.0	+ 0.4	054.2
17	– 9.1	+ 1.2	321.6
24	– 6.0	+ 2.0	228.9

Date (0 h UT)	P°	B_o°	L_o°
Jul 1	– 2.8	+ 2.8	136.3
8	+ 0.3	+ 3.6	043.6
15	+ 3.5	+ 4.3	311.0
22	+ 6.5	+ 4.9	218.3
29	+ 9.5	+ 5.5	125.7
Aug 5	+ 12.2	+ 6.0	033.2
12	+ 14.8	+ 6.5	300.6
19	+ 17.2	+ 6.8	208.1
26	+ 19.3	+ 7.1	115.6
Sep 2	+ 21.2	+ 7.2	023.1
9	+ 22.8	+ 7.3	290.6
16	+ 24.1	+ 7.2	198.2
23	+ 25.2	+ 7.1	105.8
30	+ 25.9	+ 6.8	013.4
Oct 7	+ 26.2	+ 6.4	281.1
14	+ 26.2	+ 6.0	188.7
21	+ 25.9	+ 5.5	096.4
28	+ 25.1	+ 4.8	004.1
Nov 4	+ 24.0	+ 4.1	271.8
11	+ 22.5	+ 3.4	179.5
18	+ 20.6	+ 2.6	087.2
25	+ 18.4	+ 1.7	354.9
Dec 2	+ 15.8	+ 0.8	262.7
9	+ 13.0	– 0.1	170.4
16	+ 9.9	– 1.0	078.2
23	+ 6.6	– 1.9	346.0
30	+ 3.3	– 2.7	253.8

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

B_o° Heliocentric Latitude of centre of Sun

L_o° Heliocentric Longitude of centre of Sun

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

Example: 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 11 March (176.3°) plus 2 days which from the daily variation table is –26.4°. Then you add the value for 6 hours, which is –3.3°. The calculation becomes:

176.3° + (–26.4°) + (–3.3°) = 146.6° (If negative, add 360°, if > 360°, subtract 360°)

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

SOLAR AND LUNAR ECLIPSES

In 2023 there are four eclipses, two of the Sun and two of the Moon. Of the solar eclipses, one is a hybrid annular-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, which is 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 for 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.

20 April (UT) Annular-Total Eclipse of the Sun

The first eclipse of the year is a hybrid annular-total eclipse. During this eclipse, the path begins as annular, changes to a total, and then returns to an annular. Hybrid eclipses are very rare, and out of a total of 224 in the 21st century, just seven fall into this category (3.1%). The eclipse is observable across Australia, but totality can only be experienced from the North West Cape, a peninsula about 1,250 km north of Perth. See *Under the Shadow of the Moon* for more details next page.

5 May (UT) Penumbral Eclipse of the Moon

The year's first lunar eclipse is penumbral and visible from Australia, Africa, and Asia. With a penumbral eclipse magnitude of 0.989, virtually the whole disc will pass through the Earth's penumbral shadow. Penumbral eclipses are rather subtle affairs with the Moon going through the diffuse outer shadow of the Earth. A casual observer would probably not notice any change in the Moon's appearance. However, keen

observers will see a definite darkening of the Moon's northern hemisphere due to its depth when it moves close to the inner umbral shadow.

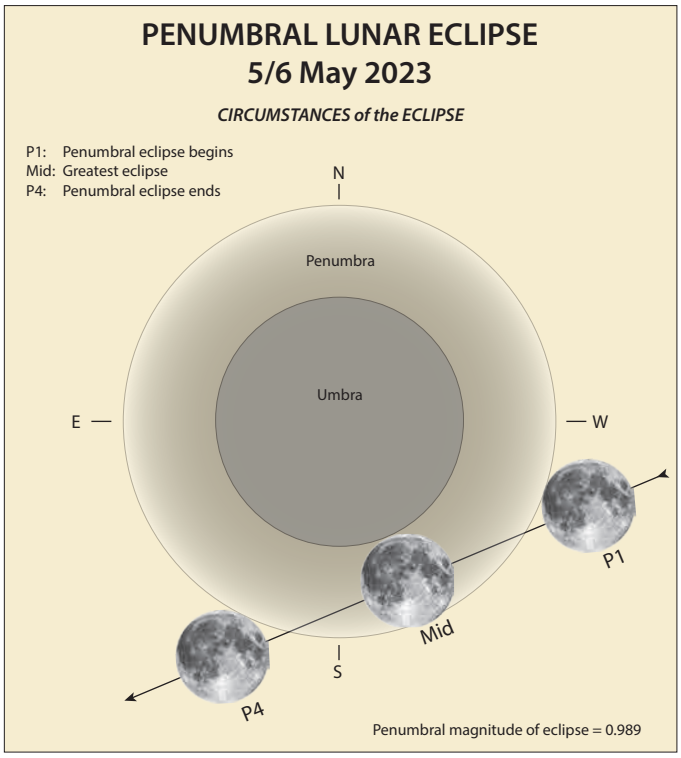
		UT 5th	EST 6th	CST 6th	WST 6th
Penumbral eclipse begins	P1	15:12	1:12 am	12:42 am	11:12 pm (5th)
Greatest eclipse	Mid	17:23	3:23 am	2:53 am	1:23 am
Penumbral eclipse ends	P4	19:34	5:34 am	5:04 am	3:34 am

14 October (UT) Annular Eclipse of the Sun

The path of this annular eclipse of the Sun sweeps across the west of the United States, Central America, Colombia, and Brazil. In addition, a partial eclipse will be visible over North, Central, and South America. The eclipse is just 4.6 days after the Moon reaches its apogee. When the Moon is at this point farthest from Earth, it appears slightly smaller than the Sun, thus allowing a narrow *ring of fire* to be visible.

28 October (UT) Partial Eclipse of the Moon

The last eclipse this year is a partial lunar eclipse. It is visible over Australia as the Moon sets in the western morning sky. Morning twilight will render this one tricky, if not impossible, to see from most eastern and central parts of the country. Western Australia will get the best view with mid-eclipse occurring just before the beginning of astronomical twilight with the Moon 12° above the horizon (at Perth). At magnitude 0.127, only a tiny portion of the northern lunar highlands will slide into the Earth's umbral shadow. Overall, not a spectacle to specially get up early for.



In the SHADOW of the MOON — The Ningaloo Eclipse 20 April 2023

A total solar eclipse is undoubtedly the most amazing spectacle in astronomy; some even consider it the most awe-inspiring event in all of nature. Total eclipses attract thousands of amateur and professional astronomers who travel around the globe to observe and photograph them, sometimes having to overcome significant obstacles and journey to remote corners of the world. The moment the Moon slips between the Earth and Sun is nothing short of spectacular. Those precious seconds of wonder under the Moon's shadow are worth all the difficulties of getting there.

The rarest type of solar eclipse will occur on Thursday, 20 April 2023, and be visible from Australia. Known as a hybrid or annular-total eclipse, only 7 out of 224 eclipses this century fall into this category (3.1%). During this hybrid solar eclipse, it transitions from an annular eclipse to a total eclipse and back again. The central eclipse path begins in the southern Indian Ocean near the Kerguelen Islands, passing over the North West Cape on the Western Australian Coast (Figure 1). It then continues its watery journey making landfall next in East Timor, then West Papua, before ending at sunset near the Marshall Islands in the central Pacific Ocean.

Fig. 1 Eclipse path as it just touches the WA coast, credit eclipsophile.com.

The eclipse begins with the Moon's umbral shadow falling just a little short of the Earth's surface. This near miss produces a narrow ring of fire around the Moon, known as an annular eclipse. After a watery touchdown, the eclipse path traverses the ocean for 700 km. It then turns from an annular into a total eclipse for the next 12,000 km. Finally, it reverts into an annular eclipse near the end of the track. For a hybrid eclipse to happen, the Sun and Moon must be almost identical in angular size, as they are at this event. Then the curvature of the Earth comes into play. At either end of the track, the Moon does not entirely cover the Sun, and a narrow annulus (Latin for 'little ring') of light appears around the Moon. During the total stage, the Moon is a little closer to the Earth's surface, therefore slightly larger, and covers the Sun entirely.

Like the past two Australian eclipses during this century, there are some vast distances to be covered to witness totality. In 2002, eclipse chasers travelled to Ceduna and outback South Australia for 30 seconds of totality. Then in 2012, it was Cairns in Queensland for two minutes of darkness. This time it's off to Western Australia to a point almost as far west as you can go without stepping into the Indian Ocean, for just one minute under the Moon's shadow.

The 40 km wide path of totality grazes Australia travelling just 65 km across the North West Cape (see Figure 2). The closest town is Exmouth, near the World Heritage-listed Ningaloo region. Eclipse chasers should be aware of the remoteness of the area.

The road travel distance from Perth is around 1,250 km (approximately 13 hours non-stop), and there are long stretches of road with limited fuel stations. In addition, not all regional towns have 24-hour fuel or food supplies. The road is single-lane bitumen, and traffic will likely be heavy on and around eclipse day.

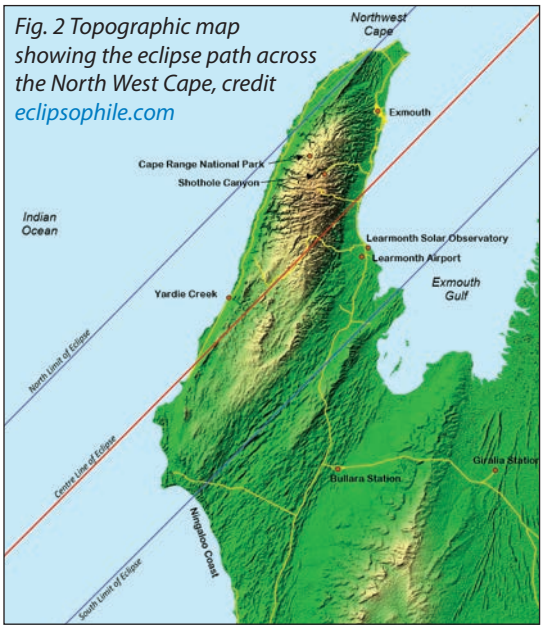


Fig. 2 Topographic map showing the eclipse path across the North West Cape, credit eclipsophile.com

According to the Western Australian government's official 2023 eclipse website[1], dedicated viewing areas in and around Exmouth and Learmonth Airport (36 km south of Exmouth) will be available for visitors. Unfortunately, on the peninsula, all accommodation has been booked out. The best the authors could do early in 2022 was a motel at Carnarvon, 350 km away. The North West Cape is a popular holiday spot for Western Australians travelling from the south of the state. Not only has the eclipse put a strain on resources in the region, but school holidays have compounded the situation.

The weather prospects for the eclipse are reasonably good, despite April being the cloudiest month of the year. Climate statistics from Learmonth Airport over the past 30 years show an average of 6.5 cloudy days and 14.6 clear days, with the rest somewhere in between. Clear days are defined as 25% or less cloud cover at 9 am and 3 pm. A cloudy day has an average of 75% cloud cover at the two times. When all lumped together, cloudiness is about 40% at 9 am and 3 pm at Exmouth[2]. The weather is generally sunny and warm, about 30° in the daytime and down to 20° at night. The problem is that if it is cloudy on the day, there is nowhere else to go to chase clear skies.

From the centre line (Lat. 22.0838°S long. 114.0968°E) midway between Exmouth and Learmonth Airport, the eclipse begins at 10:04 am and ends at 1:02 pm local time, a total duration of 2 hours and 58 minutes. Totality is short, just 60.5 seconds, beginning at 11:29:29.6 and ending at 11:30:30.1. However, anywhere between the two places will give around 55 seconds of totality. A good resource for this eclipse and the forthcoming 2028, 30, 37, and 38 eclipses over Australia can be found here[3].

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

Avoid using photographic neutral density filters (of any density), smoked glass and exposed photographic film; these can transmit UV and IR radiation. Perfectly safe for the partial phases are purpose-made hand-held aluminium coated Mylar filters, which can be purchased already supported in a cardboard frame or as 'spectacles'. These are also useful for checking the Sun at any time for large sunspots.

A straightforward and safe method to watch the partial progress of the eclipse is to project the Sun's image. To do this, make a small hole 1 to 5 millimetres in diameter in a piece of cardboard or thin sheet metal. The image of the Sun is then projected through this hole and viewed against a white screen. Then hold the screen about 20 cm behind a 1 mm hole and about 1 to 1.5 metres behind a 5 mm hole.

Direct observation of the Sun through an instrument using filters is quite safe, provided the filters are specifically designed for this purpose. These filters are fitted to the front of the telescope and are usually either aluminium-coated Mylar or nickel-chromium-coated glass. The economic Mylar filters show the Sun in an unusual blue light, whereas the more expensive glass filters provide a pleasant yellow image. On small refracting telescopes (< 100 mm), a Herschel wedge can be used to refract most of the light out of the optical path without the need for an additional filter in front of the objective.

If you intend to observe sunspots on the solar disc as a future long-term interest, the nickel-chromium coated glass filters are recommended. NEVER use filters over the eyepiece; they can crack with the magnified Sun's intense heat. Ensure any filter is fastened securely, and do not forget to cap the objective lens of the finderscope, a likely source of a nasty burn!

During totality, AND ONLY AT THIS TIME, it is perfectly safe to view the event with the unaided eye or optical equipment. However, IT IS NOT SAFE to view Baily's Beads or the diamond ring with optical aid. If you have doubts about how to view the Sun in perfect safety, do not take any chances; it is simply not worth the risk.

The Experience for eclipse novices: What can you expect to see at the Ningaloo eclipse? Firstly, the eclipse begins as the Moon makes a slight indentation on the limb of the Sun (point of first contact), the Sun at this stage will be 42° above the horizon. Then, for the next one hour and twenty-five minutes, the Sun's disc will be steadily obscured as the black face of the Moon passes over it. All around you, nervous watchers waiting for the moment of totality will make last-minute checks of cameras and telescopes.

Just before totality, with the Moon covering most of the Sun, the surrounding landscape starts to turn an eerie grey, with shadows disappearing. The temperature begins to drop, and a breeze develops. Only seconds before totality, the umbra of the Moon's shadow can be seen racing across the countryside. Then, the Sun's limb abruptly breaks into a series of tiny bright lights. These are known as Baily's Beads; they form as the Sun shines between mountain peaks and craters on the lunar limb. A phenomenon known as the diamond-ring effect appears as the last bright bead appears briefly ring-like together with the Sun's inner corona.

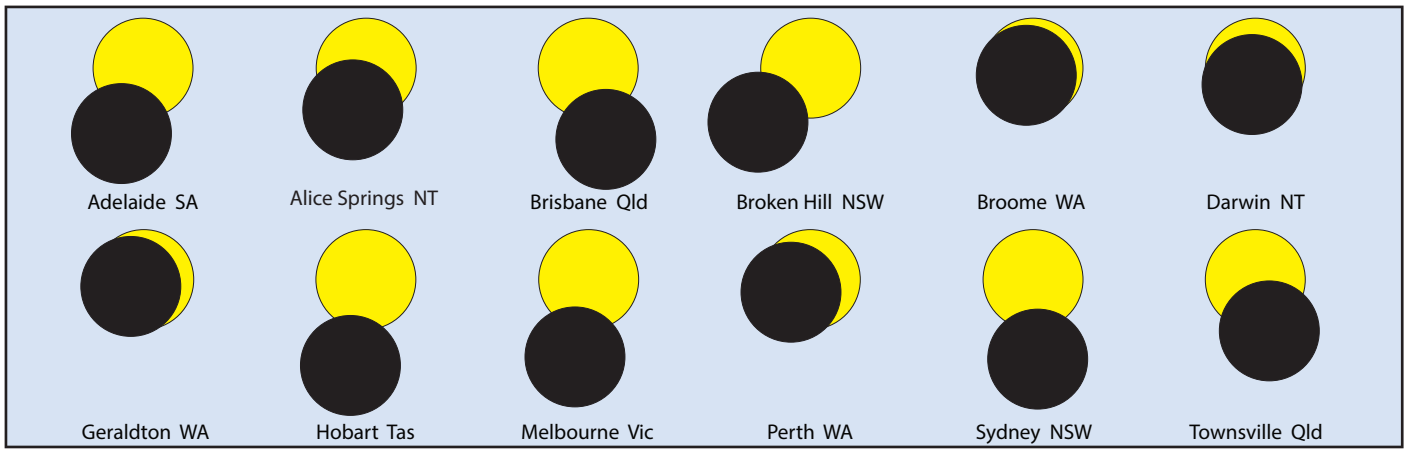


Fig.3 The partial phase at mid-eclipse from various locations around Australia, see table for local times.

After the beads and diamond ring vanish, the magical moment of totality begins (second contact). First, the Sun's inner atmosphere, the chromosphere (meaning colour sphere), appears for a few seconds as a reddish zone around the lunar limb. At this point, viewing the Sun without any filters is safe. Any prominences are now easily seen, projecting out from the limb in all their red and pink splendour. Then the Sun's faint tenuous outer atmosphere, the corona, appears, surrounding the Moon's black silhouette. The pearly white corona displays a petal structure, much like a flower. The Sun is now 54° above the horizon. If you dare take your eyes away from the precious moments of totality, you should see Jupiter 6° above and to the left of the Sun. Mercury, Venus, Saturn, and a few bright stars will also be up (see Sky View p. 42).

The display nears its end too soon, with the chromosphere reappearing. A bright bead of sunlight becomes visible through a deep valley as totality ends (third contact). Suddenly, the diamond ring reappears in a burst of glory, and unprotected eyes should be averted IMMEDIATELY. The Baily's Beads return as the photosphere streaks around the western limb. The uneventful, anticlimactic partial phase again takes over, and animals, birds and insects, confused by the false brief twilight, return. The eclipse ends with the Sun now 55° above the horizon.

Although not the same incredible display as those directly under the central path will witness, the rest of Australia will experience a partial eclipse. The partial phases are interesting and can be observed by projecting the Sun's image through a small hole in a card as described before; a straightforward and cheap tool to show friends and the neighbourhood kids what's happening (see Figure 3 and Table 1).

Photography: If you intend to photograph the eclipse, spend time in the weeks before the big day doing practice runs. Ensure your equipment points to the same altitude as it will be on the day, so you become thoroughly familiar with all the controls in this positioning. Most camera lenses and telescopes are suitable for eclipse photography, but like any astrophotography, a steady tripod or mount is essential. Since the outer corona can be visible to one or two solar diameters, the field of view in telescopes or telephoto lenses should cover several degrees.

Telephoto lenses and telescopes in the 200 to 2000 mm focal length range will give good results. Image stabilisation or vibration reduction is unnecessary while using a tripod and should be turned off. Allow a few seconds between exposures to let vibration dampen out and use a remote shutter or cable release. It is best to settle for a few good shots than numerous blurred exposures. With totality so brief, you will need to work calmly and systematically.

Image size is all-important and is determined by the focal length of the lens or telescope used. The longer the focal length, the larger the image, and the larger the image, the better for enlarging. To determine the image size, multiply the effective focal length (EFT) of your lens, in millimetres, by the diameter of the Sun or Moon in seconds of arc (1800"), and then divide the result by 202,265; the resultant answer is the image size in millimetres.

Applying this formula to a 50 mm lens, we get an image a little less than half a millimetre, not an acceptable size for detail or enlargement.

$$50 \times 1{,}800 / 202{,}265 = 0.44 \text{ mm}$$

Moving up to a 500 mm lens, things improve:

$$500 \times 1{,}800 / 202{,}265 = 4.45 \text{ mm}$$

A 15 times enlargement will give you an image of about 68 mm.

Working with popular 2000 mm Schmidt-Cassegrain telescopes we achieve 17.80 mm, an ample image size for enlargement.

$$2{,}000 \times 1{,}800 / 202{,}265 = 17.80 \text{ mm}$$

[1]ningalooeclipse.com [2]eclipsophile.com [3]thebackyarduniverse.com.au

Table 1. Partial eclipse times from various locations around Australia.

City	Eclipse Begins (Local Time)	Max Eclipse (Local Time)	Eclipse Ends (Local Time)	Obscuration %	Magnitude	Duration h:mm
Adelaide	12:24	13:30	14:35	21	0.32	2:11
Alice Springs	12:13	13:38	15:02	48	0.58	2:49
Brisbane	13:44	14:45	15:42	16	0.27	1:58
Broken Hill	12:33	13:41	14:47	21	0.33	2:14
Broome	10:22	11:53	13:27	89	0.91	3:05
Darwin	12:18	13:52	15:25	81	0.84	3:07
Geraldton	09:59	11:22	12:50	82	0.85	2:51
Hobart	13:25	14:06	14:47	5	0.13	1:22
Melbourne	13:15	14:09	15:01	11	0.21	1:46
Perth	10:00	11:21	12:47	71	0.77	2:47
Sydney	13:37	14:29	15:19	10	0.19	1:42
Townsville	13:27	14:47	16:00	36	0.47	2:33

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 2023 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.

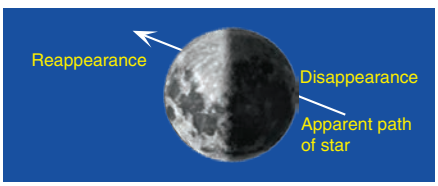
Besides being a spectacular event, the observation of occultations is an area in which the amateur can make a scientific contribution.

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 Adelaide and Darwin using CST and Perth using WST.

OBJECT n, nn, nnn, nnnn ZC catalogue number
ggg ccc Greek letter and constellation abbreviation
n ccc Flamsteed number and constellation
X nnnnn XD catalog 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 Eta Tau on October 31 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 02:04 EST and the values of A and B are + 2.7 and – 0.2 respectively.

Therefore the equation becomes:

02:04 + (+2.7 × –2.21°) + (–0.2 × –0.83°)
= 02:04 + (–6.0) + (+0.2)
= 02:04 + (–5.8) = 01:58

The event will be visible from Albury approximately six minutes earlier than Canberra, i.e., about 1:58 am (EST) on October 31.

Lunar occultation predictions calculated using Occult version 4.2202.3.10 by D. Herald.

LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 05 20:39	136 Tau	RB	4.6	164	18	198	–0.1	1.9
Jan 13 00:28	Nu Vir	DB	4.0	118	19	72	1.2	–0.8
Jan 13 01:16	Nu Vir	RD	4.0	117	28	351	0.5	–3.1
Jan 17 00:59	Alp 2 Lib	RD	2.8	71	4	289	–0.3	–1.3
Jan 30 22:55	33 Tau	DD	6.1	112	15	106	1.3	0.7
Feb 03 00:26	54 Aur	DD	6.0	145	19	82	2.1	1.2
Feb 04 02:25	Ups Gem	DD	4.1	156	11	133	0.4	–0.2
Feb 07 04:21	Eta Leo	DB	3.5	168	23	164	0.0	–1.6
Feb 07 05:16	Eta Leo	RD	3.5	168	14	265	1.2	1.6
Feb 10 23:53	44 Vir	RD	5.8	126	26	228	3.2	1.8
Feb 15 01:18	Rho Oph	RD	5.0	77	16	351	–1.1	–2.9
Feb 15 01:18	184381	RD	5.7	77	16	351	–1.1	–2.9
Feb 16 03:20	2524	RD	6.0	63	29	340	–0.7	–3.0
Mar 02 23:15	53 Gem	DD	5.8	125	19	85	2.0	1.1
Mar 09 19:55	Gam Vir	RD	2.8	158	2	262	0.0	–1.0
Mar 09 19:56	X 54027	RD	3.5	158	2	262	0.0	–1.0
Mar 09 21:01	1825	RD	5.9	157	15	296	0.4	–1.7
Mar 10 04:53	38 Vir	RD	6.1	155	40	286	1.5	0.4
Mar 11 21:42	Lam Vir	DB	4.5	134	12	127	–0.1	–1.7
Mar 11 22:41	Lam Vir	RD	4.5	133	24	295	0.4	–1.7
Mar 15 03:42	36 Oph N	DB	5.1	94	59	126	1.1	–2.1
Mar 15 03:42	36 Oph S	DB	5.2	94	59	126	1.1	–2.1
Mar 15 04:58	36 Oph N	RD	5.1	93	74	269	2.2	–0.4
Mar 15 04:58	36 Oph S	RD	5.2	93	74	269	2.2	–0.4
Mar 26 18:51	36 Tau	RB	5.5	59	19	212	1.9	2.5
Apr 13 04:10	Tau Sgr	DB	3.3	98	65	147	1.2	–4.6
Apr 13 04:53	Tau Sgr	RD	3.3	97	74	209	2.4	3.9
Apr 26 18:46	Iot Gem	DD	3.8	73	25	119	1.8	–0.2
Apr 26 20:11	Iot Gem	RB	3.8	74	16	278	1.5	0.8
May 03 20:24	44 Vir	DD	5.8	152	47	105	1.8	–1.4
May 04 04:18	The Vir	DD	4.4	155	8	61	0.1	3.1
May 04 20:42	1973	DD	6.2	165	47	75	2.5	–0.4
May 06 21:28	2212	RD	6.2	170	43	227	3.9	2.1
May 29 23:12	7 Vir	DD	5.4	111	29	78	1.9	2.2
May 29 23:59	7 Vir	RB	5.4	111	20	354	0.0	–2.5
Jun 03 00:13	25 Lib	DD	6.1	160	66	159	1.3	–2.9
Jun 03 17:59	Del Sco	DD	2.3	170	18	136	–0.3	–1.8
Jun 03 18:52	Del Sco	RB	2.3	170	29	274	0.5	–1.2
Jun 04 04:49	19 Sco	DD	4.6	174	26	99	0.5	0.8
Jun 05 00:29	36 Oph N	DB	5.1	173	82	85	2.3	0.2
Jun 05 00:30	36 Oph S	DB	5.2	173	82	85	2.3	0.2
Jun 05 01:50	36 Oph N	RD	5.1	172	73	296	2.1	–0.8
Jun 05 01:50	36 Oph S	RD	5.2	172	73	296	2.1	–0.8
Jun 07 01:37	2848	DB	5.6	145	73	129	2.0	–2.9
Jun 07 02:32	2848	RD	5.6	145	82	212	1.8	3.2
Jun 09 02:54	Eps Cap	DB	4.5	117	61	120	2.5	–3.2
Jun 09 03:38	Eps Cap	RD	4.5	117	68	186	0.8	4.2
Jun 13 04:32	73 Psc	RD	6.0	64	27	241	0.9	0.0
Jun 23 17:26	Eta Leo	DB	3.5	57	36	205	–4.8	–7.9
Jun 23 17:45	Eta Leo	RB	3.5	57	35	231	7.8	6.8
Jul 05 23:20	Chi Cap	DB	5.3	150	46	17	1.5	3.0
Jul 06 00:02	Chi Cap	RD	5.3	149	54	306	1.8	–3.5
Jul 06 03:05	Phi Cap	DB	5.2	148	75	55	1.6	1.5
Jul 06 04:20	Phi Cap	RD	5.2	148	64	245	1.4	1.5
Jul 13 04:12	63 Ara	RD	5.2	56	9	187	–0.7	2.1
Jul 23 20:22	10 Vir	DD	6.0	61	23	52	2.6	6.7
Jul 27 18:00	Iot Lib	DD	4.5	107	69	194	–2.2	–7.1
Jul 27 18:27	Iot Lib	RB	4.5	107	72	231	5.5	4.2
Jul 27 19:18	25 Lib	RB	6.1	108	75	304	1.9	–1.4
Jul 28 18:49	2314	RB	5.9	120	71	294	1.7	–1.4
Jul 29 20:44	36 Oph N	DD	5.1	134	81	42	3.2	3.9
Jul 29 20:44	36 Oph S	DD	5.2	134	81	42	3.1	3.8
Jul 29 21:27	36 Oph N	RB	5.1	134	81	341	1.7	–5.1
Jul 29 21:28	36 Oph S	RB	5.2	134	81	341	1.7	–5.1
Aug 26 18:23	3 Sgr	RB	4.5	115	71	251	2.3	0.4
Aug 26 22:39	2583	DD	5.8	116	55	160	4.2	–6.8
Aug 26 22:58	2583	RB	5.8	116	51	189	–1.6	8.7
Aug 29 20:28	Chi Cap	DD	5.3	157	55	27	1.5	2.2
Aug 29 21:25	Chi Cap	RB	5.3	157	66	289	2.3	–1.8
Aug 30 00:16	Phi Cap	DD	5.2	159	68	79	1.9	0.9
Aug 30 01:23	Phi Cap	RB	5.2	159	56	219	0.7	2.2
Sep 06 05:20	23 Tau	DB	4.1	103	31	360	0.1	3.4
Sep 06 05:56	23 Tau	RD	4.1	103	30	311	3.6	–1.7
Oct 03 00:08	Zet Ari	RD	4.9	137	22	238	1.0	0.0
Oct 24 23:50	50 Aqr	DD	5.8	122	40	28	0.3	2.3
Oct 25 22:27	Chi Aqr	DD	4.9	135	59	94	2.6	0.4
Oct 25 23:20	Chi Aqr	RB	4.9	136	51	186	0.1	2.9
Oct 30 23:43	23 Tau	DB	4.1	157	26	355	–1.3	3.4
Oct 31 00:15	23 Tau	RD	4.1	156	29	307	4.3	–2.9
Oct 31 00:32	Eta Tau	DB	2.9	156	30	350	–1.9	4.5
Oct 31 00:52	27 Tau	DB	3.6	156	30	56	1.7	0.6
Oct 31 00:57	Eta Tau	RD	2.9	156	31	315	5.2	–3.6
Oct 31 01:02	28 Tau	DB	5.1	156	31	40	1.4	1.0
Oct 31 02:16	27 Tau	RD	3.6	156	30	253	2.2	0.7
Oct 31 02:19	28 Tau	RD	5.1	156	30	270	2.4	0.4
Nov 03 02:01	28 Gem	RD	5.4	119	19	280	2.0	–1.1
Nov 19 20:31	Chi Cap	DD	5.3	77	49	99	1.7	0.7
Nov 19 21:22	Chi Cap	RB	5.3	77	38	201	–0.2	2.6
Nov 29 03:50	Bet Tau	DB	1.7	163	17	40	2.4	2.5
Nov 29 04:38	Bet Tau	RD	1.7	162	10	324	0.2	–0.7
Dec 03 04:08	Xi Cnc	DB	5.2	117	33	149	1.6	–1.8
Dec 11 03:46	Iot Lib	DB	4.5	27	6	181	–1.1	–3.0
Dec 11 04:08	Iot Lib	RD	4.5	27	10	230	0.7	0.2
Dec 20 20:53	44 Psc	RB	5.8	99	43	224	1.2	1.9
Dec 29 00:47	Phi Gem	DB	5.0	160	27	109	2.3	–0.9
Dec 29 02:20	Phi Gem	RD	5.0	160	28	286	2.2	–0.1

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 05 20:51	136 Tau	DD	4.6	163	29	141	4.5	–4.3
Jan 05 21:31	136 Tau	RD	4.6	163	32	192	0.4	4.1
Jan 17 01:07	8 Lib	RD	5.2	71	10	318	–0.3	–1.7
Jan 17 01:14	Alp 2 Lib	RD	2.8	71	11	314	–0.2	–1.7
Feb 02 22:54	49 Aur	DD	5.3	144	31	148	1.6	–2.0
Feb 03 19:21	59 Gem	DD	5.8	154	20	55	1.2	0.3
Feb 05 22:14	79 Cnc	DD	6.0	174	35	186	0.7	–7.0
Feb 05 22:43	79 Cnc	RD	6.0	174	38	221	5.3	4.4
Feb 07 04:52	Eta Leo	DB	3.5	169	17	114	0.7	0.1
Feb 11 00:49	44 Vir	RD	5.8	126	46	282	1.9	–1.3
Feb 11 22:13	82 Vir	RD	5.0	115	6	318	–0.2	–1.8
Mar 04 01:36	Psi Cnc	DD	5.7	136	8	125	0.2	–0.2
Mar 09 20:20	Gam Vir	RD	2.8	158	13	281	0.4	–1.3
Mar 09 20:21	X 54027	RD	3.5	158	13	282	0.5	–1.3
Mar 09 21:25	1825	RD	5.9	157	27	319	0.6	–2.2
Mar 11 22:04	Lam Vir	DB	4.5	134	22	100	0.5	–1.2
Mar 11 23:02	Lam Vir	RD	4.5	133	35	327	0.3	–2.3
Mar 15 04:30	36 Oph N	DB	5.1	94	75	81	2.7	0.1
Mar 15 04:30	36 Oph S	DB	5.2	94	75	81	2.7	0.1
Mar 26 18:48	36 Tau	DD	5.5	58	21	99	1.6	0.6
Apr 13 04:51	Tau Sgr	DB	3.3	98	81	105	2.5	–1.0
Apr 26 19:14	59 Gem	DD	5.8	73	26	136	1.1	–0.8
Apr 26 19:48	Iot Gem	DD	3.8	73	22	78	2.2	1.3
Apr 26 20:53	Iot Gem	RB	3.8	74	11	324	0.0	–0.9
Apr 28 20:57	Xi Cnc	DD	5.2	96	30	180	–0.9	–3.2
Apr 28 21:19	79 Cnc	DD	6.0	96	27	153	0.3	–1.4
Apr 28 21:40	Xi Cnc	RB	5.2	96	23	247	2.9	2.5
Jun 03 00:56	25 Lib	DD	6.1	159	53	119	1.8	–0.6
Jun 03 18:18	Del Sco	DD	2.3	170	26	101	0.4	–1.2
Jun 03 19:17	Del Sco	RB	2.3	170	39	314	0.3	–2.0
Jun 03 23:12	2314	DD	5.9	172	86	110	2.3	–0.9
Jun 04 05:28	19 Sco	DD	4.6	174	10	94	0.0	0.7
Jun 05 01:46	36 Oph N	DB	5.1	173	69	47	2.0	3.3
Jun 05 01:46	36 Oph S	DB	5.2	173	69	47	2.0	3.3
Jun 05 02:41	36 Oph N	RD	5.1	172	57	322	2.4	–2.2
Jun 05 02:42	36 Oph S	RD	5.2	172	57	321	2.4	–2.2
Jun 07 02:31	2848	DB	5.6	145	88	103	2.7	–0.6
Jun 07 03:45	2848	RD	5.6	145	71	226	1.4	2.3
Jun 09 03:51	Eps Cap	DB	4.5	117	80	106	3.3	–1.3
Jun 09 04:46	Eps Cap	RD	4.5	117	80	189	0.4	3.8
Jun 13 04:09	73 Psc	DB	6.0	64	31	41	0.7	0.9
Jun 13 05:21	73 Psc	RD	6.0	64	44	240	1.6	0.5
Jun 14 03:12	54 Ara	RD	5.9	52	8	215	0.0	0.9
Jun 23 17:40	Eta Leo	DD	3.5	57	39	137	1.3	–1.1
Jun 23 19:00	Eta Leo	RB	3.5	57	27	300	1.0	–0.2
Jul 02 23:18	3 Sgr	DD	4.5	166	85	153	2.3	–4.5
Jul 03 00:02	3 Sgr	RB	4.5	167	75	214	1.9	4.6
Jul 06 04:09	Phi Cap	DB	5.2	148	62	61	1.4	1.6
Jul 06 05:18	Phi Cap	RD	5.2	148	47	236	0.8	1.7
Jul 13 04:09	63 Ara	DB	5.2	56	18	113	2.2	–2.5
Jul 13 04:49	63 Ara	RD	5.2	56	25	181	–0.9	2.9
Jul 27 18:16	Iot Lib	DD	4.5	107	80	130	1.8	–1.9
Jul 27 19:00	25 Lib	DD	6.1	107	81	64	4.2	2.5
Jul 27 19:44	Iot Lib	RB	4.5	107	74	293	2.4	–0.8
Jul 27 19:50	25 Lib	RB	6.1	107	73	357	0.7	–5.3
Jul 28 18:06	2305	RB	5.9	120	70	297	1.8	–1.6
Jul 28 18:26	2314	DD	5.9	120	74	68	3.4	1.1
Jul 28 19:23	2314	RB	5.9	120	86	344	1.0	–4.3
Jul 31 21:57	2848	DD	5.6	161	80	109	2.5	–1.3
Aug 26 17:58	3 Sgr	DD	4.5	114	72	89	2.3	–0.4
Aug 26 19:25	3 Sgr	RB	4.5	115	89	288	2.5	–0.9
Aug 26 23:28	2583	DD	5.8	116	37	149	3.0	–3.1
Aug 29 21:44	Chi Cap	DD	5.3	157	78	0	0.4	5.7
Aug 29 22:22	Chi Cap	RB	5.3	157	84	304	4.2	–3.2
Aug 30 01:19	Phi Cap	DD	5.2	159	52	89	1.7	0.8
Aug 30 02:14	Phi Cap	RB	5.2	159	40	208	0.0	2.3
Sep 10 03:39	59 Gem	RD	5.8	58	7	228	0.1	0.5
Sep 10 04:29	Iot Gem	RD	3.8	57	15	266	1.3	–0.8
Sep 12 05:07	Xi Cnc	RD	5.2	35	8	235	0.4	0.3
Sep 26 18:15	Eps Cap	RB	4.5	137	50	193	1.4	3.5
Oct 02 23:43	Zet Ari	DB	4.9	137	28	63	1.2	0.1
Oct 03 00:58	Zet Ari	RD	4.9	137	38	228	1.4	0.9
Oct 05 01:20	771	RD	6.1	112	22	313	3.9	–3.7
Oct 25 00:38	50 Aqr	DD	5.8	122	25	36	0.1	2.0
Oct 25 23:40	Chi Aqr	DD	4.9	135	46	117	3.4	–0.8
Oct 26 00:08	Chi Aqr	RB	4.9	135	39	166	–1.2	4.2
Oct 31 00:30	23 Tau	DB	4.1	157	38	13	0.6	2.5
Oct 31 01:24	Eta Tau	DB	2.9	156	38	7	0.8	3.3
Oct 31 01:27	23 Tau	RD	4.1	156	38	292	3.4	–0.8
Oct 31 01:58	27 Tau	DB	3.6	156	37	61	2.3	1.1
Oct 31 02:07	28 Tau	DB	5.1	156	36	45	2.1	1.6
Oct 31 02:11	Eta Tau	RD	2.9	156	36	305	3.3	–1.3
Oct 31 03:24	27 Tau	RD	3.6	156	28	259	2.0	1.0
Oct 31 03:25	28 Tau	RD	5.1	156	28	276	2.0	0.6
Nov 03 01:29	28 Gem	DB	5.4	120	25	72	1.8	–0.2
Nov 03 03:00	28 Gem	RD	5.4	119	33	284	2.8	–0.7
Nov 16 18:49	2583	RB	5.8	36	28	241	0.1	1.7
Nov 19 21:28	Chi Cap	DD	5.3	77	30	112	1.4	0.2
Nov 19 22:05	Chi Cap	RB	5.3	77	22	190	–0.8	2.7
Nov 26 19:17	Zet Ari	DD	4.9	168	20	41	0.4	0.7
Nov 26 20:24	Zet Ari	RB	4.9	168	31	252	1.6	–0.1
Dec 11 03:49	Iot Lib	DB	4.5	27	10	143	–0.4	–1.8
Dec 20 20:43	44 Psc	DD	5.8	98	45	68	1.7	1.5
Dec 20 21:53	44 Psc	RB	5.8	99	31	217	0.8	2.1
Dec 29 01:54	Phi Gem	DB	5.0	160	35	81	3.1	0.6
Dec 29 03:10	Phi Gem	RD	5.0	160	29	326	0.9	–1.2

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 01:17	Nu Vir	DB	4.0	118	30	60	2.6	0.1
Jan 13 01:50	Nu Vir	RD	4.0	118	35	10	–0.3	–4.1
Jan 17 01:21	8 Lib	RD	5.2	71	11	300	–0.2	–1.6
Jan 17 01:27	Alp 2 Lib	RD	2.8	71	12	296	–0.1	–1.5
Feb 03 01:16	54 Aur	DD	6.0	145	11	66	1.9	2.0
Feb 07 04:53	Eta Leo	DB	3.5	169	15	145	0.2	–0.7
Feb 11 00:49	44 Vir	RD	5.8	126	39	256	2.3	–0.7
Feb 11 22:27	82 Vir	RD	5.0	115	6	302	–0.1	–1.7
Feb 12 02:04	1973	RD	6.2	114	49	287	1.6	–1.5
Feb 14 03:49	2214	RD	6.3	89	57	330	0.6	–2.7
Mar 03 00:05	53 Gem	DD	5.8	125	11	66	1.9	2.1
Mar 09 20:28	Gam Vir	RD	2.8	158	11	264	0.4	–1.2
Mar 09 20:29	X 54027	RD	3.5	158	11	265	0.4	–1.2
Mar 09 21:38	1825	RD	5.9	157	25	302	0.7	–1.9
Mar 11 22:13	Lam Vir	DB	4.5	134	21	118	0.2	–1.7
Mar 11 23:16	Lam Vir	RD	4.5	133	34	307	0.5	–1.9
Mar 15 04:28	36 Oph N	DB	5.1	94	70	112	1.7	–1.5
Mar 15 04:28	36 Oph S	DB	5.2	94	70	112	1.7	–1.5
Mar 15 04:56	2482	DB	6.3	94	75	89	2.2	–0.3
Mar 26 18:38	36 Tau	DD	5.5	59	19	118	1.6	0.2
Apr 11 22:40	2558	RD	6.3	113	16	305	–0.4	–1.7
Apr 13 04:59	Tau Sgr	DB	3.3	98	77	142	2.1	–4.2
Apr 13 05:45	Tau Sgr	RD	3.3	97	83	206	1.8	4.4
Apr 26 19:22	59 Gem	DD	5.8	73	20	169	–0.3	–2.4
Apr 26 19:35	Iot Gem	DD	3.8	73	19	105	1.6	0.5
Apr 26 20:52	Iot Gem	RB	3.8	74	9	294	0.7	0.5
May 03 21:19	44 Vir	DD	5.8	152	56	81	3.2	–0.1
May 06 22:25	2212	RD	6.2	170	57	260	2.2	–0.5
May 29 23:59	7 Vir	DD	5.4	111	18	59	1.6	4.3
Jun 03 00:59	25 Lib	DD	6.1	159	55	152	1.5	–2.1
Jun 03 18:28	Del Sco	DD	2.3	170	26	122	0.1	–1.7
Jun 03 19:28	Del Sco	RB	2.3	170	39	290	0.7	–1.5
Jun 03 23:17	2314	DD	5.9	172	78	141	1.5	–2.3
Jun 04 05:23	19 Sco	DD	4.6	174	16	112	0.3	0.5
Jun 05 01:23	36 Oph N	DB	5.1	173	76	81	2.2	0.8
Jun 05 01:23	36 Oph S	DB	5.2	173	76	81	2.1	0.8
Jun 05 02:41	36 Oph N	RD	5.1	172	61	291	1.9	–0.1
Jun 05 02:41	36 Oph S	RD	5.2	172	60	291	1.9	–0.1
Jun 05 03:03	2482	RD	6.3	172	56	307	1.9	–0.8
Jun 07 02:33	2848	DB	5.6	145	82	136	2.8	–3.6
Jun 07 03:15	2848	RD	5.6	145	78	198	0.9	4.8
Jun 13 05:12	73 Psc	RD	6.0	64	35	224	1.0	0.7
Jun 23 17:48	Eta Leo	DD	3.5	57	33	167	0.3	–1.9
Jun 23 18:50	Eta Leo	RB	3.5	57	25	268	2.0	1.3
Jul 06 00:05	Chi Cap	DB	5.3	150	57	20	1.5	2.9
Jul 06 00:56	Chi Cap	RD	5.3	149	67	296	2.5	–2.4
Jul 06 03:52	Phi Cap	DB	5.2	148	66	73	1.7	1.1
Jul 06 05:01	Phi Cap	RD	5.2	148	53	225	0.7	2.0
Jul 13 04:05	Tau Ari	DD	5.3	56	10	346	–2.6	5.7
Jul 13 04:24	Tau Ari	RD	5.3	56	13	313	3.9	–6.0
Jul 27 18:30	Iot Lib	DD	4.5	107	74	163	0.8	–3.3
Jul 27 18:45	25 Lib	DD	6.1	107	74	103	2.3	–0.7
Jul 27 19:34	Iot Lib	RB	4.5	107	73	259	2.8	1.0
Jul 27 20:07	25 Lib	RB	6.1	108	68	316	1.7	–1.7
Jul 28 18:07	2305	RB	5.9	120	65	267	2.1	–0.6
Jul 28 18:18	2314	DD	5.9	120	67	102	1.8	–1.1
Jul 28 19:38	2314	RB	5.9	120	78	308	1.8	–1.7
Jul 29 01:19	19 Sco	DD	4.6	122	22	39	–0.6	3.4
Jul 29 01:52	19 Sco	RB	4.6	123	15	331	1.0	–1.3
Jul 29 21:43	36 Oph N	DD	5.1	134	76	34	2.4	5.5
Jul 29 21:43	36 Oph S	DD	5.2	134	76	34	2.4	5.4
Jul 29 22:20	36 Oph N	RB	5.1	134	69	340	2.3	–5.1
Jul 29 22:21	36 Oph S	RB	5.2	134	69	340	2.3	–5.0
Aug 04 21:51	3463	RD	6.4	140	17	241	0.5	–0.2
Aug 26 19:18	3 Sgr	RB	4.5	115	82	258	2.3	0.4
Aug 29 21:13	Chi Cap	DD	5.3	157	66	35	1.5	1.9
Aug 29 22:21	Chi Cap	RB	5.3	157	75	275	2.4	–0.4
Aug 30 01:07	Phi Cap	DD	5.2	159	57	102	2.1	0.4
Aug 30 01:55	Phi Cap	RB	5.2	159	47	196	–0.1	2.8
Sep 10 04:31	Iot Gem	RD	3.8	58	8	253	0.9	–0.7
Sep 10 05:40	65 Gem	DB	5.0	57	17	79	1.6	–0.8
Sep 28 02:32	70 Aqr	DD	6.2	155	30	18	0.0	2.4
Oct 02 23:40	Zet Ari	DB	4.9	137	20	77	1.2	–0.6
Oct 03 00:48	Zet Ari	RD	4.9	137	28	218	0.9	0.8
Oct 05 01:28	771	RD	6.1	112	15	293	2.1	–1.9
Oct 25 00:22	50 Aqr	DD	5.8	122	31	44	0.3	1.9
Oct 27 22:55	136	DD	6.1	163	48	358	–0.1	2.9
Oct 31 00:13	23 Tau	DB	4.1	157	29	25	0.8	1.3
Oct 31 01:03	Eta Tau	DB	2.9	156	31	21	1.0	1.7
Oct 31 01:19	23 Tau	RD	4.1	156	31	280	2.7	–0.3
Oct 31 01:43	27 Tau	DB	3.6	156	31	71	2.1	0.6
Oct 31 01:50	28 Tau	DB	5.1	156	30	55	1.9	1.0
Oct 31 01:56	24 Tau	RD	6.3	156	30	296	2.9	–0.6
Oct 31 02:04	Eta Tau	RD	2.9	156	30	289	2.7	–0.2
Oct 31 03:07	27 Tau	RD	3.6	156	25	246	1.9	1.2
Oct 31 03:12	28 Tau	RD	5.1	156	25	262	2.0	0.9
Nov 03 02:54	28 Gem	RD	5.4	119	24	271	2.3	–0.5
Nov 19 21:22	Chi Cap	DD	5.3	77	36	130	2.7	–1.0
Nov 19 21:44	Chi Cap	RB	5.3	77	31	171	–1.8	4.2
Nov 19 22:09	27 Cap	DD	6.3	77	26	15	–0.5	2.6
Dec 11 04:08	Iot Lib	DB	4.5	27	13	165	–0.7	–2.4
Dec 17 21:02	3197	DD	6.4	59	24	57	0.2	1.7
Dec 20 20:25	44 Psc	DD	5.8	98	45	75	1.9	1.2
Dec 20 21:33	44 Psc	RB	5.8	99	34	209	0.7	2.2
Dec 24 22:33	587	DD	6.2	150	30	111	2.8	–0.3
Dec 29 01:42	Phi Gem	DB	5.0	160	28	102	2.4	–0.2

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 05 20:37	136 Tau	RB	4.6	164	30	280	2.2	–0.9
Jan 06 01:28	909	DD	6.0	165	43	167	0.2	–8.3
Jan 18 06:34	Del Sco	DB	2.3	55	54	125	1.2	–1.6
Jan 30 23:06	33 Tau	DD	6.1	112	34	54	2.3	1.9
Feb 02 20:51	49 Aur	DD	5.3	144	43	101	3.1	–0.8
Feb 02 22:37	49 Aur	RB	5.3	145	50	254	3.6	0.8
Feb 04 02:19	Ups Gem	DD	4.1	156	33	84	2.3	0.7
Feb 04 03:28	Ups Gem	RB	4.1	157	20	323	0.0	–1.5
Feb 05 04:48	Ups 1 Cnc	DD	5.7	168	15	117	0.4	–0.5
Feb 07 03:48	Eta Leo	DB	3.5	169	49	115	2.0	–0.8
Feb 07 05:07	Eta Leo	RD	3.5	168	33	324	0.5	–1.6
Feb 10 23:33	44 Vir	RD	5.8	126	17	287	0.5	–1.0
Feb 23 21:03	73 Psc	DD	6.0	43	8	104	0.3	–0.1
Mar 04 00:41	Psi Cnc	DD	5.7	136	38	126	1.4	–1.0
Mar 09 05:41	10 Vir	RD	6.0	166	32	314	0.9	–1.3
Mar 10 04:11	38 Vir	RD	6.1	155	64	346	0.8	–3.2
Mar 15 03:08	36 Oph N	DB	5.1	94	39	73	2.0	0.4
Mar 15 03:08	36 Oph S	DB	5.2	94	39	73	2.0	0.4
Mar 15 04:06	36 Oph N	RD	5.1	93	52	331	0.5	–3.0
Mar 15 04:06	36 Oph S	RD	5.2	93	52	331	0.5	–3.0
Apr 03 01:58	42 Leo	DD	6.2	139	31	164	–0.1	–2.4
Apr 13 03:27	Tau Sgr	DB	3.3	98	44	68	2.1	0.6
Apr 13 04:43	Tau Sgr	RD	3.3	97	60	297	2.2	–1.7
Apr 18 06:28	27 Psc	DB	4.9	29	21	19	0.4	2.3
Apr 25 21:49	49 Aur	DD	5.3	63	12	157	–0.9	–2.4
Apr 26 19:17	59 Gem	RB	5.8	73	46	265	3.3	0.5
Apr 26 19:51	Iot Gem	RB	3.8	74	41	322	1.3	–2.0
Apr 28 20:01	79 Cnc	DD	6.0	96	55	165	0.9	–3.4
Apr 28 21:17	79 Cnc	RB	6.0	96	48	267	3.4	0.5
May 03 19:55	44 Vir	DD	5.8	153	43	55	5.2	3.9
May 09 05:09	3 Sgr	DB	4.5	140	62	81	2.5	0.7
May 11 04:17	Ome Sgr	DB	4.7	114	68	68	2.7	0.9
May 11 05:50	Ome Sgr	RD	4.7	113	75	260	2.9	0.6
May 11 06:17	60 Sgr	DB	4.8	113	73	90	3.0	0.1
Jun 02 23:01	Iot Lib	DD	4.5	159	81	152	1.4	–2.8
Jun 02 23:24	25 Lib	DD	6.1	159	82	93	3.3	–0.1
Jun 03 00:21	Iot Lib	RB	4.5	160	73	274	3.1	0.0
Jun 03 21:39	2314	DD	5.9	172	52	106	1.7	–1.0
Jun 07 01:14	2848	DB	5.6	145	57	43	2.8	2.4
Jun 07 02:20	2848	RD	5.6	145	70	306	2.9	–2.5
Jun 09 01:57	37 Cap	RD	5.7	117	42	204	1.7	2.9
Jun 09 02:44	Eps Cap	DB	4.5	117	52	24	1.8	3.0
Jun 09 03:49	Eps Cap	RD	4.5	117	68	284	3.2	–1.2
Jun 09 06:21	Kap Cap	DB	4.7	116	75	62	2.1	1.4
Jun 13 05:02	80 Psc	DB	5.5	64	35	76	1.4	0.2
Jun 13 06:09	80 Psc	RD	5.5	63	50	203	0.7	2.3
Jun 15 06:11	Pi Ari	DB	5.3	38	25	63	0.7	0.5
Jul 02 21:31	3 Sgr	DD	4.5	166	53	117	1.5	–1.4
Jul 02 22:53	3 Sgr	RB	4.5	167	69	271	2.7	–0.2
Jul 03 02:58	2583	DD	5.8	168	46	133	2.8	–2.0
Jul 04 04:10	Tau Sgr	DB	3.3	174	45	130	3.2	–2.2
Jul 04 04:47	Tau Sgr	RB	3.3	174	37	193	–0.9	3.9
Jul 09 01:15	27 Psc	RD	4.9	107	23	198	0.5	2.4
Jul 09 02:20	29 Psc	DB	5.1	107	39	94	1.8	–0.7
Jul 09 03:16	29 Psc	RD	5.1	107	52	190	0.5	3.1
Jul 13 04:18	63 Ara	RD	5.2	56	15	281	1.2	–1.0
Jul 13 05:14	65 Ara	RD	6.1	56	27	241	0.8	0.6
Jul 31 20:36	2848	DD	5.6	161	44	65	2.0	0.7
Aug 02 20:35	Eps Cap	RD	4.5	168	16	226	0.8	1.1
Aug 02 22:23	Kap Cap	DB	4.7	167	40	62	1.5	0.7
Aug 02 23:39	Kap Cap	RD	4.7	167	59	250	2.2	0.6
Aug 10 04:24	36 Tau	DB	5.5	73	30	65	1.1	0.5
Aug 10 05:43	36 Tau	RD	5.5	73	44	232	1.5	1.2
Aug 26 22:18	2583	DD	5.8	116	60	53	1.9	2.2
Aug 26 23:30	2583	RB	5.8	117	45	293	2.2	–0.7
Aug 28 00:42	Tau Sgr	DD	3.3	131	43	91	1.6	0.3
Aug 28 01:46	Tau Sgr	RB	3.3	131	29	231	0.2	1.6
Aug 30 01:23	Phi Cap	RB	5.2	159	62	313	8.6	–7.0
Aug 31 05:37	50 Aqr	DD	5.8	175	17	18	–0.3	2.3
Sep 01 02:54	Chi Aqr	DB	4.9	170	68	42	1.4	1.9
Sep 01 04:07	Chi Aqr	RD	4.9	170	50	234	1.2	1.6
Sep 05 01:45	40 Ara	DB	5.8	117	37	48	0.9	1.1
Sep 05 03:02	40 Ara	RD	5.8	116	51	235	1.7	1.1
Sep 06 05:38	556	DB	5.4	103	54	104	4.1	–0.8
Sep 26 19:34	Kap Cap	DD	4.7	138	52	46	1.8	1.6
Sep 26 20:54	Kap Cap	RB	4.7	139	70	257	2.7	0.4
Oct 11 05:23	46 Leo	DB	5.4	43	16	129	1.0	–1.8
Oct 22 00:10	2848	DD	5.6	82	7	112	0.5	–0.3
Oct 25 22:48	Chi Aqr	DD	4.9	135	75	18	0.8	2.8
Oct 25 23:57	Chi Aqr	RB	4.9	136	59	254	2.1	1.0
Oct 29 22:52	40 Ara	RD	5.8	170	45	225	1.1	1.3
Oct 31 00:56	556	RD	5.4	156	51	212	1.3	2.1
Nov 17 20:32	Tau Sgr	DD	3.3	50	27	94	1.0	0.3
Nov 17 21:27	Tau Sgr	RB	3.3	51	15	228	–0.3	1.5
Nov 19 20:59	Chi Cap	DD	5.3	77	47	24	0.2	2.6
Nov 19 21:56	Chi Cap	RB	5.3	77	34	270	1.3	0.5
Nov 30 23:48	53 Gem	RD	5.8	140	23	267	1.4	–0.3
Dec 01 05:15	Iot Gem	DB	3.8	139	43	64	4.0	1.9
Dec 01 06:13	Iot Gem	RD	3.8	139	35	342	–0.1	–2.8
Dec 01 23:11	Psi Cnc	RD	5.7	129	6	199	–2.3	5.5
Dec 03 03:10	Xi Cnc	DB	5.2	117	44	108	2.8	–1.2
Dec 03 04:52	Xi Cnc	RD	5.2	116	55	308	2.6	–1.8
Dec 23 00:25	19 Ara	DD	5.7	126	32	78	1.6	0.9
Dec 29 00:22	Phi Gem	DB	5.0	160	42	56	2.7	1.6
Dec 29 01:32	Phi Gem	RD	5.0	160	50	331	2.5	–3.3
Jan 01 01:10	42 Leo	RD	6.2	127	33	310	1.7	–2.0

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 01:18	Nu Vir	DB	4.0	118	24	79	1.6	–1.2
Jan 13 02:13	Nu Vir	RD	4.0	117	32	349	0.6	–2.6
Jan 17 00:46	Alp 2 Lib	DB	2.8	71	5	129	–0.4	–1.6
Jan 17 01:33	8 Lib	RD	5.2	71	13	288	0.0	–1.5
Jan 17 01:39	Alp 2 Lib	RD	2.8	71	14	284	0.0	–1.5
Feb 03 01:01	54 Aur	DD	6.0	145	8	86	1.4	1.3
Feb 03 20:21	Iot Gem	DD	3.8	154	12	37	0.9	0.4
Feb 03 21:09	Iot Gem	RB	3.8	155	16	329	2.3	–2.2
Feb 07 05:04	Eta Leo	DD	3.5	168	11	179	–0.7	–2.4
Feb 11 00:34	44 Vir	DD	5.8	126	32	210	–6.2	–9.3
Feb 11 00:41	44 Vir	RD	5.8	126	33	222	8.2	5.5
Feb 11 22:39	82 Vir	RD	5.0	115	8	291	0.0	–1.6
Feb 12 02:11	1973	RD	6.2	114	45	269	1.8	–1.1
Feb 14 04:05	2214	RD	6.3	89	56	309	1.0	–2.0
Feb 15 01:29	Rho Oph	DB	5.0	77	21	58	0.7	–0.6
Feb 15 01:29	184381	DB	5.7	77	21	58	0.7	–0.6
Feb 15 02:02	184381	RD	5.7	77	27	345	–0.7	–2.8
Feb 15 02:03	Rho Oph	RD	5.0	77	27	345	–0.7	–2.8
Feb 16 03:26	2524	DB	6.0	63	32	60	1.0	–0.4
Feb 16 04:10	2524	RD	6.0	63	40	330	–0.1	–2.9
Mar 02 23:50	53 Gem	DD	5.8	125	8	89	1.3	1.3
Mar 09 20:36	Gam Vir	RD	2.8	158	10	249	0.5	–1.1
Mar 09 20:37	X 54027	RD	3.5	158	10	250	0.5	–1.1
Mar 09 21:50	1825	RD	5.9	157	23	291	0.8	–1.8
Mar 11 22:27	Lam Vir	DB	4.5	134	22	130	0.1	–1.9
Mar 11 23:29	Lam Vir	RD	4.5	133	33	294	0.7	–1.8
Mar 15 04:40	36 Oph N	DB	5.1	94	67	140	1.1	–2.6
Mar 15 04:40	36 Oph S	DB	5.2	94	67	140	1.1	–2.7
Mar 15 04:59	2482	DB	6.3	94	70	116	1.6	–1.5
Apr 11 22:53	2558	RD	6.3	113	20	287	–0.1	–1.5
Apr 26 19:29	Iot Gem	DD	3.8	73	14	122	1.2	0.3
May 03 21:20	44 Vir	DD	5.8	152	48	104	1.9	–1.0
May 04 18:03	82 Vir	DD	5.0	163	16	59	0.8	–0.7
May 04 21:38	1973	DD	6.2	165	51	74	2.7	–0.1
May 29 23:41	7 Vir	DD	5.4	111	20	99	0.9	1.1
Jun 03 18:42	Del Sco	DD	2.3	170	29	138	–0.1	–2.0
Jun 03 19:38	Del Sco	RB	2.3	170	39	272	0.9	–1.3
Jun 04 05:20	19 Sco	DD	4.6	174	21	134	0.6	0.0
Jun 05 01:18	36 Oph N	DB	5.1	173	72	109	1.8	–0.5
Jun 05 01:19	36 Oph S	DB	5.2	173	72	109	1.8	–0.5
Jun 05 02:34	36 Oph N	RD	5.1	172	61	265	1.5	1.0
Jun 05 02:34	36 Oph S	RD	5.2	172	61	265	1.5	1.0
Jun 05 03:01	2482	RD	6.3	172	57	280	1.5	0.5
Jun 13 05:03	73 Psc	RD	6.0	64	28	203	0.4	1.2
Jul 03 18:51	Phi Sgr	DD	3.2	176	24	32	1.4	1.0
Jul 03 19:16	Phi Sgr	RD	3.2	176	29	339	–1.0	–3.9
Jul 05 23:51	Chi Cap	DB	5.3	150	51	53	1.3	0.4
Jul 06 01:01	Chi Cap	RD	5.3	149	62	266	1.7	–0.5
Jul 06 03:42	Phi Cap	DB	5.2	148	64	91	1.9	0.5
Jul 06 04:43	Phi Cap	RD	5.2	148	55	210	0.5	2.4
Jul 13 04:41	Tau Ari	RD	5.3	56	10	279	1.3	–1.7
Jul 23 20:40	10 Vir	DD	6.0	61	17	88	0.8	1.7
Jul 27 18:50	25 Lib	DD	6.1	107	67	128	1.5	–1.6
Jul 27 20:11	25 Lib	RB	6.1	108	63	289	1.8	–0.3
Jul 28 18:01	2305	RB	5.9	120	60	234	3.0	1.3
Jul 28 18:27	2314	DD	5.9	120	63	126	1.2	–1.9
Jul 28 19:43	2314	RB	5.9	120	71	281	1.9	–0.6
Jul 29 01:00	19 Sco	DD	4.6	122	28	68	0.2	2.0
Jul 29 01:53	19 Sco	RB	4.6	123	19	305	0.5	0.3
Jul 29 21:20	36 Oph N	DD	5.1	134	74	74	2.0	0.9
Jul 29 21:20	36 Oph S	DD	5.2	134	74	74	2.0	0.9
Jul 29 21:56	2482	DD	6.3	134	70	51	1.9	2.7
Jul 29 22:33	36 Oph N	RB	5.1	134	65	302	1.8	–0.8
Jul 29 22:33	36 Oph S	RB	5.2	134	65	302	1.8	–0.7
Aug 04 05:26	70 Aqr	RD	6.2	151	37	299	2.2	0.2
Aug 26 18:17	3 Sgr	DD	4.5	115	67	153	0.8	–4.0
Aug 26 19:03	3 Sgr	RB	4.5	115	73	224	2.4	2.6
Aug 29 21:02	Chi Cap	DD	5.3	157	59	62	1.5	0.4
Aug 29 22:16	Chi Cap	RB	5.3	158	67	251	1.7	0.5
Aug 30 01:04	Phi Cap	DD	5.2	159	56	126	3.1	–1.3
Aug 30 01:31	Phi Cap	RB	5.2	159	51	174	–1.1	4.3
Sep 06 05:43	23 Tau	DB	4.1	103	23	31	1.4	1.3
Sep 10 04:35	Iot Gem	RD	3.8	58	2	239	0.5	–0.7
Sep 21 19:13	22 Sco	DD	4.8	72	55	47	1.2	3.8
Sep 21 20:00	22 Sco	RB	4.8	72	46	331	1.7	–2.0
Sep 28 02:15	70 Aqr	DD	6.2	155	33	28	0.2	2.1
Oct 03 00:41	Zet Ari	RD	4.9	137	20	202	0.3	0.9
Oct 25 00:07	50 Aqr	DD	5.8	122	34	53	0.5	1.8
Oct 27 22:37	136	DD	6.1	163	41	13	0.5	1.8
Oct 31 00:05	23 Tau	DB	4.1	157	21	38	0.9	0.5
Oct 31 00:52	Eta Tau	DB	2.9	156	23	33	1.1	0.8
Oct 31 01:15	23 Tau	RD	4.1	156	23	270	2.1	–0.1
Oct 31 01:36	27 Tau	DB	3.6	156	23	80	1.9	0.2
Oct 31 01:53	24 Tau	RD	6.3	156	23	284	2.3	0.0
Oct 31 01:59	Eta Tau	RD	2.9	156	23	278	2.2	0.1
Oct 31 02:55	27 Tau	RD	3.6	156	20	236	1.7	1.2
Oct 31 03:01	28 Tau	RD	5.1	156	20	253	1.7	1.0
Nov 03 02:54	28 Gem	RD	5.4	119	16	261	1.9	–0.5
Nov 19 21:51	27 Cap	DD	6.3	77	31	28	–0.1	2.3
Nov 29 04:20	Bet Tau	DB	1.7	163	6	48	1.8	2.1
Dec 14 20:24	Phi Sgr	DB	3.2	19	8	356	–4.4	7.5
Dec 14 20:29	Phi Sgr	RB	3.2	19	7	343	3.5	–5.0
Dec 20 21:14	44 Psc	RB	5.8	99	34	200	0.6	2.2
Dec 24 22:32	587	DD	6.2	150	22	125	2.7	–0.7
Dec 29 03:06	Phi Gem	RD	5.0	160	18	284	1.7	0.4
Jan 01 02:55	42 Leo	RD	6.2	127	31	268	2.4	–0.5

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 01:09	Nu Vir	DB	4.0	118	24	73	1.6	–0.9
Jan 13 01:58	Nu Vir	RD	4.0	117	32	355	0.4	–3.0
Jan 17 01:25	8 Lib	RD	5.2	71	9	293	–0.2	–1.5
Jan 17 01:31	Alp 2 Lib	RD	2.8	71	10	289	–0.1	–1.4
Feb 03 01:04	54 Aur	DD	6.0	145	13	79	1.7	1.4
Feb 03 20:26	Iot Gem	DB	3.8	154	16	14	–0.7	4.5
Feb 03 20:45	Iot Gem	RB	3.8	154	18	349	4.0	–6.5
Feb 07 04:55	Eta Leo	DB	3.5	168	16	162	–0.1	–1.3
Feb 11 00:40	44 Vir	RD	5.8	126	33	238	2.9	0.3
Feb 12 02:01	1973	RD	6.2	114	44	274	1.7	–1.3
Feb 14 03:53	2214	RD	6.3	89	54	316	0.8	–2.2
Feb 15 01:26	Rho Oph	DB	5.0	77	17	47	1.0	0.3
Feb 15 01:50	Rho Oph	RD	5.0	77	22	356	–1.3	–3.4
Feb 15 01:50	184381	RD	5.7	77	22	357	–1.3	–3.4
Feb 16 03:23	2524	DB	6.0	63	29	48	1.4	0.4
Feb 16 03:55	2524	RD	6.0	63	35	344	–0.8	–3.6
Mar 02 23:53	53 Gem	DD	5.8	125	13	81	1.7	1.4
Mar 09 20:29	Gam Vir	RD	2.8	158	8	257	0.3	–1.1
Mar 09 20:30	X 54027	RD	3.5	158	8	258	0.3	–1.1
Mar 09 21:40	1825	RD	5.9	157	21	295	0.6	–1.8
Mar 11 22:17	Lam Vir	DB	4.5	134	18	126	0.1	–1.8
Mar 11 23:19	Lam Vir	RD	4.5	133	31	298	0.5	–1.8
Mar 15 04:26	36 Oph N	DB	5.1	94	66	126	1.3	–2.1
Mar 15 04:26	36 Oph S	DB	5.2	94	66	126	1.3	–2.1
Mar 15 05:43	36 Oph N	RD	5.1	93	78	265	2.2	0.0
Mar 15 05:43	36 Oph S	RD	5.2	93	78	265	2.2	0.0
Apr 11 22:46	2558	RD	6.3	113	15	294	–0.3	–1.5
Apr 26 19:27	Iot Gem	DD	3.8	73	19	116	1.5	0.2
Apr 26 20:47	Iot Gem	RB	3.8	74	10	281	1.1	0.9
May 03 21:10	44 Vir	DD	5.8	152	51	98	2.2	–1.0
May 04 21:32	1973	DD	6.2	165	53	63	3.9	0.8
May 06 22:15	2212	RD	6.2	170	52	240	2.8	0.5
May 29 23:46	7 Vir	DD	5.4	111	22	81	1.3	1.9
Jun 03 01:01	25 Lib	DD	6.1	160	57	168	1.2	–3.6
Jun 03 18:33	Del Sco	DD	2.3	170	25	133	–0.1	–1.8
Jun 03 19:29	Del Sco	RB	2.3	170	36	278	0.7	–1.4
Jun 04 05:20	19 Sco	DD	4.6	174	21	115	0.5	0.4
Jun 05 01:13	36 Oph N	DB	5.1	173	78	92	2.1	0.1
Jun 05 01:13	36 Oph S	DB	5.2	173	78	92	2.1	0.1
Jun 05 02:33	36 Oph N	RD	5.1	172	65	284	1.8	0.1
Jun 05 02:34	36 Oph S	RD	5.2	172	65	284	1.8	0.1
Jun 07 02:35	2848	DB	5.6	145	79	154	3.2	–8.7
Jun 07 02:56	2848	RD	5.6	145	79	184	0.4	9.5
Jun 13 05:06	73 Psc	RD	6.0	64	30	222	0.8	0.6
Jun 23 17:56	Eta Leo	DD	3.5	57	32	189	–1.1	–3.5
Jun 23 18:35	Eta Leo	RB	3.5	57	28	245	3.5	3.0
Jul 05 23:53	Chi Cap	DB	5.3	150	51	32	1.4	1.6
Jul 06 00:52	Chi Cap	RD	5.3	149	62	287	2.0	–1.7
Jul 06 03:42	Phi Cap	DB	5.2	148	69	73	1.7	1.0
Jul 06 04:52	Phi Cap	RD	5.2	148	57	226	0.9	2.0
Jul 13 04:24	Tau Ari	RD	5.3	56	9	310	2.8	–4.9
Jul 23 20:50	10 Vir	DD	6.0	61	18	64	1.3	3.6
Jul 27 18:40	Iot Lib	DD	4.5	107	71	186	–0.7	–5.7
Jul 27 18:40	25 Lib	DD	6.1	107	70	117	1.8	–1.4
Jul 27 19:16	Iot Lib	RB	4.5	107	72	236	4.0	3.3
Jul 27 20:04	25 Lib	RB	6.1	108	69	303	1.9	–1.1
Jul 28 18:15	2314	DD	5.9	120	62	116	1.4	–1.6
Jul 28 19:35	2314	RB	5.9	120	74	294	1.8	–1.2
Jul 29 01:12	19 Sco	DD	4.6	122	27	45	–0.2	3.1
Jul 29 01:51	19 Sco	RB	4.6	123	20	326	1.0	–0.9
Jul 29 21:23	36 Oph S	DD	5.2	134	79	53	2.4	2.4
Jul 29 21:24	36 Oph N	DD	5.1	134	79	53	2.4	2.5
Jul 29 22:21	36 Oph N	RB	5.1	134	71	325	2.0	–2.6
Jul 29 22:21	36 Oph S	RB	5.2	134	71	324	2.0	–2.6
Aug 26 19:06	3 Sgr	RB	4.5	115	76	246	2.3	0.9
Aug 29 21:03	Chi Cap	DD	5.3	157	60	42	1.5	1.3
Aug 29 22:13	Chi Cap	RB	5.3	158	71	270	2.1	–0.4
Aug 30 00:57	Phi Cap	DD	5.2	159	61	101	2.1	0.3
Aug 30 01:48	Phi Cap	RB	5.2	159	51	198	0.0	2.8
Sep 06 05:48	23 Tau	DB	4.1	103	28	20	1.3	1.9
Sep 10 04:29	Iot Gem	RD	3.8	58	3	252	0.7	–0.8
Sep 10 05:36	65 Gem	DB	5.0	57	12	80	1.4	–0.9
Sep 28 02:25	70 Aqr	DD	6.2	155	34	16	0.0	2.4
Oct 03 00:43	Zet Ari	RD	4.9	137	24	219	0.7	0.5
Oct 25 00:16	50 Aqr	DD	5.8	122	35	43	0.4	2.0
Oct 25 23:21	Chi Aqr	DD	4.9	135	50	133	8.9	–6.0
Oct 25 23:31	Chi Aqr	RD	4.9	135	48	149	–6.5	9.3
Oct 27 22:49	136	DD	6.1	163	46	353	–0.4	3.1
Oct 31 00:07	23 Tau	DB	4.1	157	25	23	0.6	1.2
Oct 31 00:55	Eta Tau	DB	2.9	156	27	19	0.7	1.5
Oct 31 01:09	23 Tau	RD	4.1	156	28	282	2.6	–0.5
Oct 31 01:33	27 Tau	DB	3.6	156	28	70	2.0	0.4
Oct 31 01:40	28 Tau	DB	5.1	156	28	54	1.8	0.8
Oct 31 01:53	Eta Tau	RD	2.9	156	28	289	2.7	–0.4
Oct 31 02:56	27 Tau	RD	3.6	156	25	244	1.9	1.1
Oct 31 03:01	28 Tau	RD	5.1	156	25	260	2.0	0.8
Nov 03 02:47	28 Gem	RD	5.4	119	20	269	2.1	–0.7
Nov 19 21:13	Chi Cap	DD	5.3	77	41	126	2.5	–0.5
Nov 19 21:40	Chi Cap	RB	5.3	77	36	175	–1.3	3.8
Nov 29 04:28	Bet Tau	DB	1.7	163	10	38	2.2	2.7
Dec 18 22:59	70 Aqr	DD	6.2	73	11	102	0.3	1.0
Dec 20 21:24	44 Psc	RB	5.8	99	37	210	0.8	2.1
Dec 24 22:23	587	DD	6.2	150	28	111	2.8	–0.5
Dec 29 01:34	Phi Gem	DB	5.0	160	26	110	2.2	–0.5
Dec 29 03:03	Phi Gem	RD	5.0	160	23	290	1.8	0.1
Jan 01 02:47	42 Leo	RD	6.2	127	34	273	2.5	–0.8

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 12 23:25	Nu Vir	RD	4.0	117	7	345	0.4	–2.9
Jan 19 03:54	2442	DB	5.9	42	18	83	0.3	–0.8
Jan 19 04:05	26 Oph	DB	5.7	42	21	51	1.1	0.3
Jan 19 04:34	26 Oph	RD	5.7	42	27	348	–1.0	–3.2
Jan 19 04:44	2442	RD	5.9	42	29	316	–0.1	–2.0
Feb 02 22:02	54 Aur	DD	6.0	145	30	94	2.7	–0.2
Feb 04 00:47	Ups Gem	DD	4.1	156	26	176	–0.9	–3.9
Feb 04 01:22	Ups Gem	RB	4.1	157	22	224	4.4	4.3
Feb 11 05:04	The Vir	DB	4.4	123	60	147	1.3	–1.9
Feb 14 04:00	2228	DB	5.8	88	57	132	1.0	–2.1
Feb 14 05:18	2228	RD	5.8	87	72	291	2.0	–1.3
Feb 16 01:56	2524	RD	6.0	63	11	307	–0.5	–1.6
Mar 02 20:53	53 Gem	DD	5.8	125	30	105	2.7	–0.4
Mar 14 04:34	19 Sco	DB	4.6	105	78	103	2.2	–0.9
Mar 15 01:58	36 Oph N	DB	5.1	94	37	162	–0.7	–3.3
Mar 15 01:58	36 Oph S	DB	5.2	94	37	163	–0.7	–3.3
Mar 15 02:39	36 Oph N	RD	5.1	93	45	237	2.2	0.5
Mar 15 02:39	36 Oph S	RD	5.2	93	45	237	2.2	0.6
Mar 17 05:02	2848	DB	5.6	66	49	133	0.8	–2.9
Mar 30 22:18	Phi Gem	DD	5.0	106	21	95	1.7	0.8
Apr 18 05:34	27 Psc	RD	4.9	29	15	212	0.3	1.0
Apr 26 17:48	Iot Gem	RB	3.8	74	30	250	3.1	0.8
Apr 26 19:27	65 Gem	DD	5.0	74	24	42	4.8	4.2
Apr 26 19:59	65 Gem	RB	5.0	74	21	358	–1.5	–3.8
Apr 30 00:49	Eta Leo	DD	3.5	109	5	149	–0.2	–0.9
May 03 18:23	44 Vir	DD	5.8	152	25	132	0.6	–2.0
May 04 02:45	The Vir	DD	4.4	155	28	45	2.3	8.9
May 04 03:01	The Vir	RB	4.4	155	24	17	–0.3	–9.0
May 09 03:29	3 Sgr	DB	4.5	140	83	164	2.2	–7.4
May 09 03:57	3 Sgr	RD	4.5	140	77	203	1.8	7.5
May 14 05:01	74 Aqr	DB	5.8	73	47	83	1.7	–0.6
May 14 06:11	74 Aqr	RD	5.8	72	60	210	1.2	2.0
May 27 21:54	46 Leo	DD	5.4	89	23	152	0.3	–1.2
May 29 20:56	7 Vir	DD	5.4	111	51	115	2.1	–0.6
May 29 22:15	7 Vir	RB	5.4	111	41	329	0.9	–1.5
May 30 18:13	Gam Vir	DD	2.8	121	46	90	2.4	–1.0
May 30 18:14	X 54027	DD	3.5	121	46	89	2.4	–1.0
May 30 19:15	Gam Vir	RB	2.8	122	55	353	0.3	–3.1
May 30 19:15	X 54027	RB	3.5	122	55	354	0.3	–3.1
Jun 04 03:04	19 Sco	DD	4.6	174	47	67	1.2	2.0
Jun 04 04:05	19 Sco	RB	4.6	174	34	310	1.3	–0.5
Jun 04 22:13	36 Oph N	DB	5.1	173	57	104	1.4	–1.3
Jun 04 22:13	36 Oph S	DB	5.2	173	57	104	1.4	–1.3
Jun 04 23:30	36 Oph N	RD	5.1	172	73	291	1.8	–1.3
Jun 04 23:30	36 Oph S	RD	5.2	172	73	291	1.9	–1.3
Jun 06 23:29	2848	DB	5.6	145	46	134	0.6	–2.9
Jun 07 00:21	2848	RD	5.6	145	58	223	2.2	1.6
Jun 09 00:43	Eps Cap	DB	4.5	117	34	102	0.9	–1.6
Jun 09 01:44	Eps Cap	RD	4.5	117	47	219	1.5	1.3
Jun 09 04:02	Kap Cap	DB	4.7	116	73	96	2.6	–0.7
Jun 09 05:07	Kap Cap	RD	4.7	116	77	201	0.9	2.9
Jun 13 02:44	73 Psc	RD	6.0	64	6	275	0.4	–1.4
Jun 15 05:19	Pi Ari	RD	5.3	38	11	185	–0.7	2.3
Jul 05 22:01	Chi Cap	RD	5.3	149	29	312	0.2	–3.3
Jul 06 01:10	Phi Cap	DB	5.2	148	67	9	1.1	4.2
Jul 06 01:56	Phi Cap	RD	5.2	148	75	300	3.2	–2.6
Jul 08 05:53	Chi Aqr	DB	4.9	118	59	35	1.1	2.1
Jul 23 19:07	10 Vir	RB	6.0	62	39	347	0.4	–2.4
Jul 29 18:16	36 Oph N	DD	5.1	134	53	73	1.9	–0.2
Jul 29 18:16	36 Oph S	DD	5.2	134	53	73	1.9	–0.2
Jul 29 19:18	36 Oph N	RB	5.1	134	66	323	1.0	–2.9
Jul 29 19:18	36 Oph S	RB	5.2	134	66	323	1.0	–2.9
Aug 09 05:39	Zet Ari	DB	4.9	84	36	35	1.3	1.3
Aug 10 03:42	36 Tau	RD	5.5	73	15	206	0.0	1.1
Aug 26 20:03	2583	DD	5.8	116	86	121	2.3	–1.6
Aug 26 21:18	2583	RB	5.8	117	72	241	1.9	1.9
Aug 27 22:49	Tau Sgr	DD	3.3	131	67	141	3.8	–3.8
Aug 27 23:19	Tau Sgr	RB	3.3	131	60	188	–0.7	5.9
Aug 29 18:32	Chi Cap	DD	5.3	157	31	20	1.4	2.4
Aug 29 19:10	Chi Cap	RB	5.3	157	39	310	0.7	–3.5
Aug 29 22:12	Phi Cap	DD	5.2	159	74	34	1.5	2.2
Aug 29 23:22	Phi Cap	RB	5.2	159	78	269	2.4	0.2
Aug 31 03:25	50 Aqr	DD	5.8	175	41	41	0.5	2.0
Sep 01 00:28	Chi Aqr	DB	4.9	170	65	58	1.8	1.1
Sep 01 01:43	Chi Aqr	RD	4.9	170	63	221	1.3	1.8
Sep 05 00:59	40 Ara	RD	5.8	116	22	212	0.3	0.9
Sep 06 04:42	27 Tau	DB	3.6	102	34	12	0.6	2.4
Sep 06 05:37	27 Tau	RD	3.6	102	34	296	3.4	–0.8
Oct 25 20:16	Chi Aqr	DD	4.9	135	62	37	1.3	1.6
Oct 25 21:32	Chi Aqr	RB	4.9	136	66	242	1.9	1.2
Oct 29 20:50	40 Ara	RD	5.8	170	16	194	–0.3	1.6
Oct 30 22:42	556	RD	5.4	156	21	186	–0.7	2.3
Oct 30 23:10	27 Tau	DB	3.6	156	25	357	–1.3	3.3
Oct 30 23:44	27 Tau	RD	3.6	156	28	304	4.0	–2.9
Nov 17 19:15	Tau Sgr	RB	3.3	51	44	192	–0.9	4.3
Nov 19 19:45	Chi Cap	RB	5.3	77	59	250	1.5	1.4
Nov 24 00:52	104	DD	5.7	132	23	2	0.3	3.2
Nov 29 01:30	Bet Tau	DB	1.7	163	29	45	2.3	1.4
Nov 29 02:41	Bet Tau	RD	1.7	162	26	304	2.0	–0.4
Dec 01 03:06	Iot Gem	DB	3.8	139	30	134	2.2	–1.3
Dec 01 04:28	Iot Gem	RD	3.8	138	27	258	2.7	1.0
Dec 03 01:52	Xi Cnc	DB	5.2	117	23	163	1.8	–3.4
Dec 03 02:47	Xi Cnc	RD	5.2	116	30	239	2.8	0.5
Dec 07 03:55	10 Vir	RD	6.0	72	30	312	1.0	–2.1
Dec 22 22:14	19 Ara	DD	5.7	126	36	116	3.2	–0.5
Dec 28 23:54	Phi Gem	RD	5.0	160	26	278	2.3	–0.9

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 01:25	Nu Vir	DB	4.0	118	33	46	5.3	3.5
Jan 13 01:40	Nu Vir	RB	4.0	118	36	25	–3.0	–7.5
Jan 17 01:18	8 Lib	RD	5.2	71	12	304	–0.2	–1.6
Jan 17 01:25	Alp 2 Lib	RD	2.8	71	13	300	–0.1	–1.6
Feb 03 01:23	54 Aur	DD	6.0	145	9	57	2.0	2.4
Feb 03 22:09	1132	DD	6.4	155	29	76	2.7	0.2
Feb 07 04:53	Eta Leo	DB	3.5	169	15	138	0.3	–0.5
Feb 11 00:52	44 Vir	RD	5.8	126	42	264	2.2	–0.9
Feb 11 22:24	82 Vir	RD	5.0	115	7	305	–0.1	–1.7
Feb 12 02:05	1973	RD	6.2	114	51	294	1.6	–1.6
Feb 14 03:46	2214	RD	6.3	89	59	339	0.4	–3.0
Mar 03 00:13	53 Gem	DD	5.8	125	9	55	2.3	2.8
Mar 09 20:27	Gam Vir	RD	2.8	158	13	268	0.5	–1.2
Mar 09 20:28	X 54027	RD	3.5	158	13	268	0.5	–1.2
Mar 09 21:37	1825	RD	5.9	157	27	306	0.7	–2.0
Mar 11 22:12	Lam Vir	DB	4.5	134	22	114	0.3	–1.6
Mar 11 23:15	Lam Vir	RD	4.5	133	35	313	0.5	–2.0
Mar 15 04:30	36 Oph N	DB	5.1	94	73	105	2.0	–1.1
Mar 15 04:30	36 Oph S	DB	5.2	94	73	105	2.0	–1.1
Mar 26 18:42	36 Tau	DD	5.5	59	19	114	1.5	0.4
Apr 11 22:37	2558	RD	6.3	113	17	312	–0.4	–1.8
Apr 13 04:59	Tau Sgr	DB	3.3	98	79	134	2.3	–3.2
Apr 13 05:54	Tau Sgr	RD	3.3	97	83	212	1.8	3.6
Apr 26 19:20	59 Gem	DD	5.8	73	21	158	0.3	–1.5
Apr 26 19:38	Iot Gem	DD	3.8	73	19	98	1.7	0.7
Apr 26 20:54	Iot Gem	RB	3.8	74	8	301	0.5	0.2
Apr 28 21:32	79 Cnc	DD	6.0	96	21	182	–1.1	–3.1
May 03 21:28	44 Vir	DD	5.8	152	59	68	4.7	1.4
May 06 22:29	2212	RD	6.2	170	60	269	2.0	–0.8
Jun 03 01:00	25 Lib	DD	6.1	159	53	145	1.6	–1.7
Jun 03 18:26	Del Sco	DD	2.3	170	28	117	0.2	–1.6
Jun 03 19:28	Del Sco	RB	2.3	170	40	296	0.6	–1.7
Jun 03 23:18	2314	DD	5.9	172	80	134	1.7	–1.9
Jun 04 05:24	19 Sco	DD	4.6	174	14	111	0.3	0.5
Jun 05 01:29	36 Oph N	DB	5.1	173	74	76	2.1	1.1
Jun 05 01:29	36 Oph S	DB	5.2	173	74	76	2.1	1.1
Jun 05 02:45	36 Oph N	RD	5.1	172	58	295	1.9	–0.3
Jun 05 02:45	36 Oph S	RD	5.2	172	58	295	1.9	–0.3
Jun 05 03:06	2482	RD	6.3	172	54	311	2.0	–1.0
Jun 07 02:35	2848	DB	5.6	145	83	130	2.8	–2.7
Jun 07 03:23	2848	RD	5.6	145	76	202	0.9	4.1
Jun 13 04:05	73 Psc	DB	6.0	64	26	60	0.9	0.0
Jun 13 05:15	73 Psc	RD	6.0	64	38	224	1.0	0.8
Jun 23 17:47	Eta Leo	DD	3.5	57	33	158	0.6	–1.6
Jun 23 18:56	Eta Leo	RB	3.5	57	24	277	1.6	0.8
Jul 06 00:12	Chi Cap	DB	5.3	150	61	14	1.4	3.7
Jul 06 00:58	Chi Cap	RD	5.3	149	69	301	2.8	–2.9
Jul 06 03:57	Phi Cap	DB	5.2	148	64	74	1.7	1.2
Jul 06 05:05	Phi Cap	RD	5.2	148	51	224	0.7	2.0
Jul 13 04:07	Tau Ari	DD	5.3	56	13	343	–3.2	6.6
Jul 13 04:24	Tau Ari	RD	5.3	56	15	314	4.6	–6.8
Jul 27 18:28	Iot Lib	DD	4.5	107	75	153	1.1	–2.8
Jul 27 18:50	25 Lib	DD	6.1	107	76	95	2.6	–0.2
Jul 27 19:41	Iot Lib	RB	4.5	107	72	268	2.6	0.5
Jul 27 20:09	25 Lib	RB	6.1	108	68	324	1.7	–2.1
Jul 28 18:10	2305	RB	5.9	120	68	275	2.1	–0.8
Jul 28 18:21	2314	DD	5.9	120	70	95	2.1	–0.7
Jul 28 19:39	2314	RB	5.9	120	80	315	1.7	–2.1
Jul 28 22:05	2328	DD	6.4	121	59	161	2.0	–3.9
Jul 29 01:23	19 Sco	DD	4.6	122	19	36	–0.8	3.6
Jul 29 01:53	19 Sco	RB	4.6	123	13	333	1.1	–1.5
Jul 31 22:09	2848	DD	5.6	162	79	142	2.5	–4.6
Aug 04 21:52	3463	RD	6.4	140	19	246	0.5	–0.3
Aug 26 19:23	3 Sgr	RB	4.5	115	84	264	2.3	0.2
Aug 29 21:19	Chi Cap	DD	5.3	157	69	31	1.5	2.2
Aug 29 22:26	Chi Cap	RB	5.3	157	77	276	2.5	–0.4
Aug 30 01:11	Phi Cap	DD	5.2	159	54	103	2.1	0.3
Aug 30 01:58	Phi Cap	RB	5.2	159	45	194	–0.2	2.8
Sep 10 04:32	Iot Gem	RD	3.8	58	10	253	1.0	–0.7
Sep 25 19:56	3018	DD	6.4	124	79	137	4.2	–5.8
Sep 28 02:35	70 Aqr	DD	6.2	155	28	19	0.0	2.3
Oct 02 23:42	Zet Ari	DB	4.9	137	22	77	1.4	–0.5
Oct 03 00:51	Zet Ari	RD	4.9	137	31	217	0.9	0.9
Oct 05 01:30	771	RD	6.1	112	17	292	2.3	–1.8
Oct 25 00:26	50 Aqr	DD	5.8	122	29	45	0.3	1.9
Oct 27 22:59	136	DD	6.1	163	49	0	0.1	2.8
Oct 31 00:17	23 Tau	DB	4.1	157	31	26	0.9	1.4
Oct 31 01:07	Eta Tau	DB	2.9	156	32	22	1.1	1.8
Oct 31 01:24	23 Tau	RD	4.1	156	32	280	2.7	–0.2
Oct 31 01:48	27 Tau	DB	3.6	156	31	71	2.2	0.7
Oct 31 01:55	28 Tau	DB	5.1	156	31	55	2.0	1.1
Oct 31 02:02	24 Tau	RD	6.3	156	31	296	2.9	–0.5
Oct 31 02:09	Eta Tau	RD	2.9	156	30	289	2.7	–0.2
Oct 31 03:13	27 Tau	RD	3.6	156	25	247	1.9	1.3
Oct 31 03:17	28 Tau	RD	5.1	156	25	264	1.9	0.9
Nov 03 02:59	28 Gem	RD	5.4	119	26	273	2.4	–0.5
Nov 19 21:26	Chi Cap	DD	5.3	77	33	133	2.8	–1.4
Nov 19 21:45	Chi Cap	RB	5.3	77	29	169	–2.0	4.5
Nov 19 22:11	27 Cap	DD	6.3	77	24	16	–0.6	2.5
Dec 11 04:03	Iot Lib	DB	4.5	27	13	159	–0.6	–2.2
Dec 20 20:31	44 Psc	DD	5.8	98	44	76	1.9	1.3
Dec 20 21:37	44 Psc	RB	5.8	99	33	208	0.7	2.3
Dec 24 22:39	587	DD	6.2	150	30	111	2.7	–0.2
Dec 29 01:47	Phi Gem	DB	5.0	160	29	97	2.5	0.0
Dec 29 03:14	Phi Gem	RD	5.0	160	24	307	1.3	–0.3
Jan 01 02:59	42 Leo	RD	6.2	127	41	290	2.4	–1.0

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

ADELAIDE (CST)

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

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

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

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.

BRISBANE (EST)

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

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

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

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

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

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

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

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.

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

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

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

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

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

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

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

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.

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

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

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

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

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

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

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

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.

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

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

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

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.

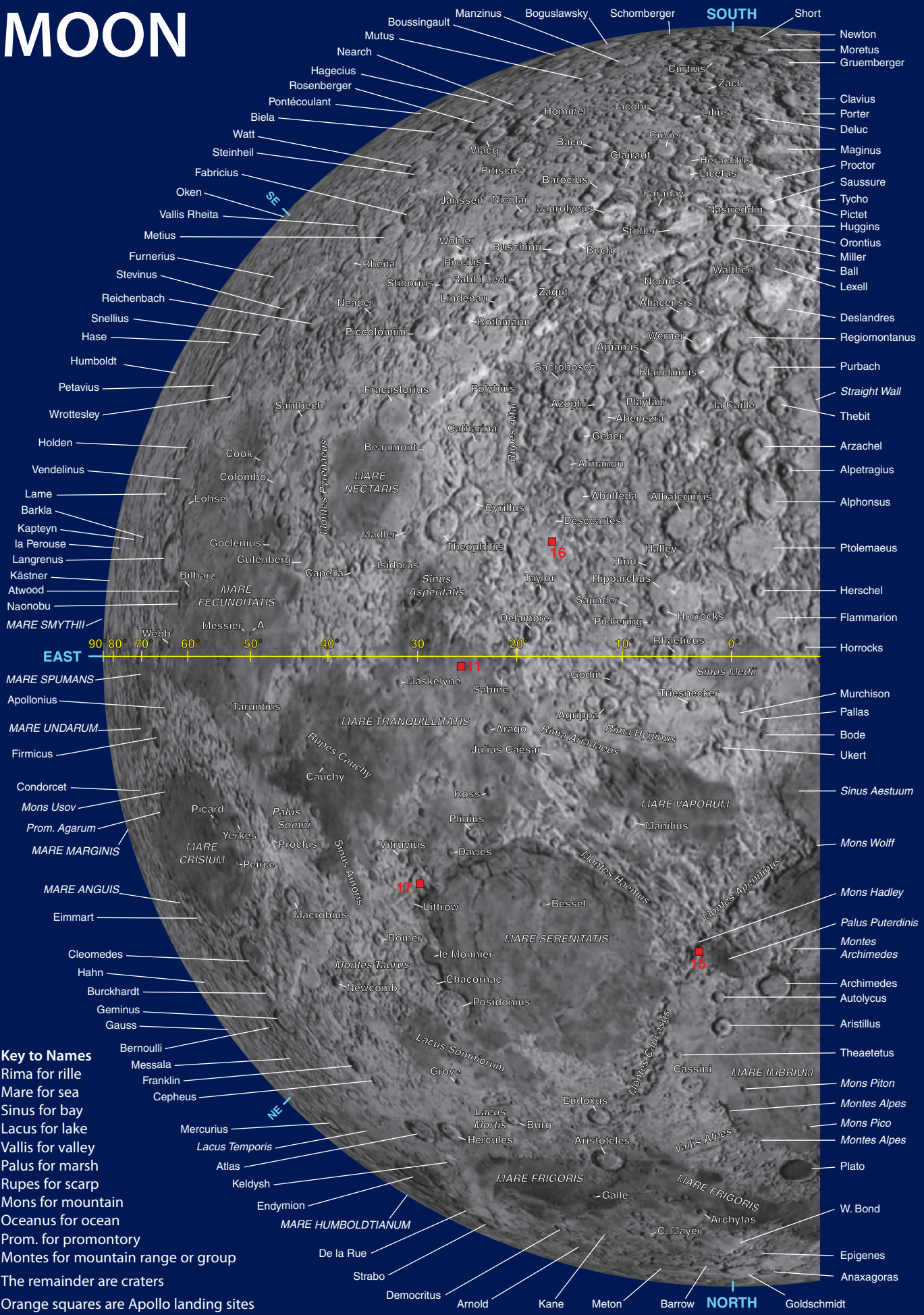
FEATURE	NOTES
Day 3 (48° E)	
Biela (76 km)	three central peaks
Furnerius, Petavius, Vendelinus and Langrenus	easily recognised row of four craters
Furnerius (130 km)	look for small crater on floor
Petavius (177 km)	central mountain and rille
Vendelinus (150 km) and Lame (84 km)	merged craters (Lame was 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



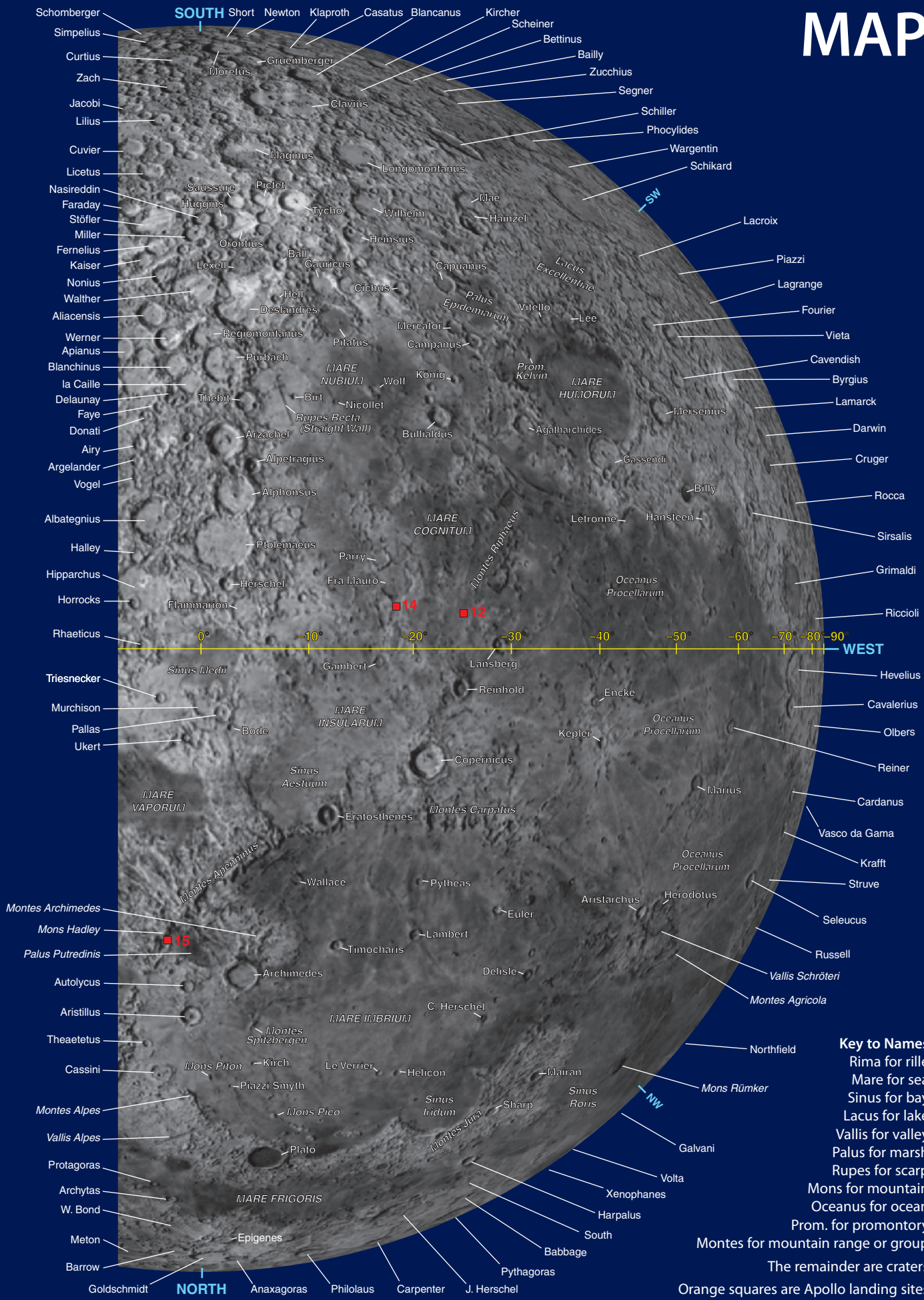
Key to Names

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



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

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	058.8	266.5	000.4	207.2	257.0	105.8	158.7	011.4	226.8	286.7	146.0	206.1	1
2	216.5	064.2	158.0	004.8	054.7	263.6	316.5	169.3	024.7	084.7	304.0	004.0	2
3	014.2	221.8	315.7	162.5	212.4	061.3	114.2	327.2	182.7	242.8	102.1	162.0	3
4	171.9	019.5	113.3	320.1	010.1	219.0	272.0	125.0	340.7	040.8	260.1	319.9	4
5	329.6	177.1	270.9	117.8	167.8	016.8	069.8	282.9	138.6	198.8	058.1	117.8	5
6	127.3	334.8	068.6	275.4	325.4	174.5	227.7	080.8	296.6	356.9	216.2	275.8	6
7	285.0	132.4	226.2	073.1	123.1	332.3	025.5	238.7	094.6	154.9	014.2	073.7	7
8	082.6	290.1	023.8	230.7	280.8	130.0	183.3	036.6	252.6	313.0	172.2	231.6	8
9	240.3	087.7	181.5	028.4	078.5	287.7	341.1	194.5	050.5	111.0	330.2	029.6	9
10	038.0	245.3	339.1	186.0	236.2	085.5	138.9	352.4	208.5	269.0	128.3	187.5	10
11	195.7	043.0	136.7	343.7	033.9	243.2	296.7	150.3	006.5	067.1	286.3	345.4	11
12	353.4	200.6	294.4	141.3	191.6	041.0	094.5	308.2	164.5	225.1	084.3	143.3	12
13	151.0	358.2	092.0	299.0	349.3	198.7	252.3	106.1	322.5	023.2	242.3	301.2	13
14	308.7	155.9	249.6	096.6	147.0	356.5	050.2	264.0	120.5	181.2	040.3	099.1	14
15	106.4	313.5	047.3	254.3	304.7	154.3	208.0	061.9	278.5	339.3	198.3	257.0	15
16	264.0	111.2	204.9	052.0	102.4	312.0	005.8	219.8	076.5	137.3	356.3	054.9	16
17	061.7	268.8	002.5	209.6	260.1	109.8	163.6	017.7	234.5	295.3	154.3	212.8	17
18	219.4	066.4	160.2	007.3	057.8	267.5	321.5	175.6	032.5	093.4	312.3	010.7	18
19	017.0	224.1	317.8	165.0	215.5	065.3	119.3	333.5	190.5	251.4	110.3	168.5	19
20	174.7	021.7	115.5	322.6	013.2	223.1	277.2	131.5	348.5	049.5	268.3	326.4	20
21	332.4	179.3	273.1	120.3	170.9	020.8	075.0	289.4	146.5	207.5	066.3	124.3	21
22	130.0	337.0	070.7	278.0	328.6	178.6	232.8	087.3	304.5	005.6	224.3	282.2	22
23	287.7	134.6	228.4	075.6	126.3	336.4	030.7	245.3	102.5	163.6	022.3	080.0	23
24	085.3	292.2	026.0	233.3	284.1	134.2	188.5	043.2	260.5	321.7	180.3	237.9	24
25	243.0	089.9	183.7	031.0	081.8	291.9	346.4	201.1	058.6	119.7	338.3	035.7	25
26	040.7	247.5	341.3	188.6	239.5	089.7	144.2	359.1	216.6	277.8	136.2	193.6	26
27	198.3	045.1	138.9	346.3	037.2	247.5	302.1	157.0	014.6	075.8	294.2	351.4	27
28	356.0	202.8	296.6	144.0	194.9	045.3	099.9	315.0	172.6	233.8	092.2	149.3	28
29	153.6		094.2	301.7	352.7	203.1	257.8	112.9	330.6	031.9	250.1	307.1	29
30	311.3		251.9	099.3	150.4	000.9	055.7	270.9	128.7	189.9	048.1	104.9	30
31	108.9		049.5		308.1		213.5	068.8		348.0		262.8	31

SYSTEM II (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	019.4	350.6	230.9	201.1	022.1	354.3	178.2	154.4	133.3	324.3	307.0	138.2	1
2	169.5	140.7	020.9	351.1	172.1	144.4	328.4	304.7	283.6	114.7	097.4	288.5	2
3	319.5	290.7	170.9	141.1	322.2	294.6	118.6	094.9	073.9	265.1	247.8	078.8	3
4	109.6	080.7	320.9	291.2	112.2	084.7	268.7	245.2	224.3	055.5	038.2	229.1	4
5	259.7	230.7	110.9	081.2	262.3	234.8	058.9	035.4	014.6	205.9	188.6	019.5	5
6	049.7	020.7	260.9	231.2	052.3	024.9	209.1	185.7	164.9	356.3	339.0	169.8	6
7	199.8	170.7	050.9	021.2	202.4	175.0	359.3	335.9	315.3	146.7	129.4	320.1	7
8	349.8	320.7	200.9	171.2	352.4	325.1	149.4	126.2	105.6	297.1	279.8	110.4	8
9	139.9	110.7	350.9	321.3	142.5	115.2	299.6	276.5	256.0	087.5	070.2	260.7	9
10	289.9	260.8	140.9	111.3	292.6	265.3	089.8	066.7	046.3	237.9	220.6	050.9	10
11	080.0	050.8	290.9	261.3	082.6	055.4	240.0	217.0	196.7	028.3	011.0	201.2	11
12	230.0	200.8	080.9	051.3	232.7	205.6	030.2	007.3	347.0	178.8	161.4	351.5	12
13	020.1	350.8	230.9	201.4	022.8	355.7	180.4	157.5	137.4	329.2	311.8	141.8	13
14	170.1	140.8	020.9	351.4	172.8	145.8	330.6	307.8	287.8	119.6	102.2	292.1	14
15	320.2	290.8	170.9	141.4	322.9	295.9	120.7	098.1	078.1	270.0	252.6	082.3	15
16	110.2	080.8	320.9	291.5	113.0	086.1	270.9	248.4	228.5	060.4	042.9	232.6	16
17	260.2	230.8	110.9	081.5	263.0	236.2	061.1	038.7	018.9	210.8	193.3	022.8	17
18	050.3	020.8	260.9	231.5	053.1	026.3	211.3	188.9	169.2	001.2	343.7	173.1	18
19	200.3	170.8	050.9	021.6	203.2	176.5	001.5	339.2	319.6	151.7	134.0	323.4	19
20	350.4	320.8	201.0	171.6	353.3	326.6	151.8	129.5	110.0	302.1	284.4	113.6	20
21	140.4	110.8	351.0	321.6	143.4	116.7	302.0	279.8	260.4	092.5	074.8	263.8	21
22	290.4	260.8	141.0	111.7	293.4	266.9	092.2	070.1	050.8	242.9	225.1	054.1	22
23	080.4	050.8	291.0	261.7	083.5	057.0	242.4	220.4	201.1	033.3	015.5	204.3	23
24	230.5	200.8	081.0	051.7	233.6	207.2	032.6	010.7	351.5	183.7	165.8	354.5	24
25	020.5	350.8	231.0	201.8	023.7	357.3	182.8	161.0	141.9	334.2	316.2	144.8	25
26	170.5	140.8	021.0	351.8	173.8	147.5	333.1	311.3	292.3	124.6	106.5	295.0	26
27	320.5	290.8	171.0	141.9	323.9	297.6	123.3	101.7	082.7	275.0	256.9	085.2	27
28	110.6	080.9	321.0	291.9	114.0	087.8	273.5	252.0	233.1	065.4	047.2	235.4	28
29	260.6		111.1	082.0	264.1	237.9	063.7	042.3	023.5	215.8	197.5	025.6	29
30	050.6		261.1	232.0	054.1	028.1	214.0	192.6	173.9	006.2	347.9	175.8	30
31	200.6		051.1		204.2		004.2	342.9		156.6		326.0	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.

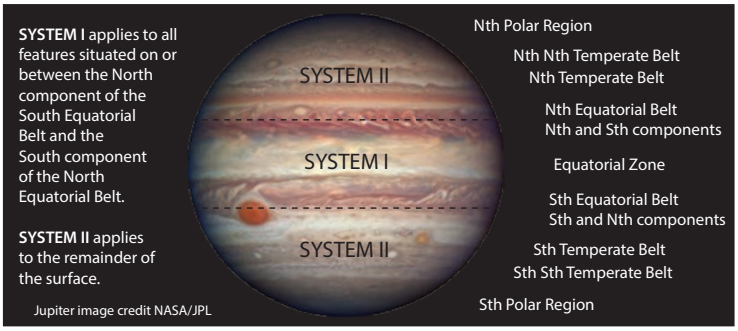
The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0 hr UT of date. You will need to add multiple hours and minutes from the small Increase in Longitude tables below. For example, the longitude of central meridian for Jupiter (System I) for 5 July 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 272.0°. 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 509.5°, less 360° giving a final answer of 149.5°.

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: 2015 (228°), 2016 (248°), 2017 (274°), 2018 (290°), 2019 (312°), 2020 (339°), 2021 (359°) and 2022 (22°). The table of data for 2023 (opposite) has been based on 45°. For every degree of longitude greater than 45° it will transit 1.6 minutes later than shown (for every degree less than 45°, 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 2023. 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



Increase In Longitude
SYSTEM II
Rotation: 9 h 55 m 40.062 s

hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

JUPITER — GREAT RED SPOT

Date	1st	2nd	3rd
Jan 1			20:38
Jan 3			22:17 *
Jan 5			(21:56)
Jan 6		19:47	
Jan 8		(19:26)	21:26
Jan 10			(21:06)
Jan 11		18:57	
Jan 12			(22:45)
Jan 13			20:36
Jan 15			22:16 *
Jan 17			(21:55)
Jan 18		19:46	
Jan 20		(19:26)	21:26
Jan 22			(21:05)
Jan 23		18:57	
Jan 25			20:36
Jan 27			(20:15)
Jan 29			(21:54)
Jan 30		19:46	
Feb 1		(19:25)	21:25
Feb 3			(21:04)
Feb 4		18:56	
Feb 6			20:35
Feb 8			(20:15)
Feb 11		19:46	
Feb 13		(19:25)	
Feb 15			(21:04)
Feb 16		18:56	
Feb 18		(18:35)	
Feb 20			(20:15)
Feb 23		19:46	
Feb 25		(19:25)	
Feb 28		18:56	
Mar 2		(18:35)	
Mar 5		18:06	
Mar 9		(19:25)	
Mar 12		18:56	
Mar 14		(18:35)	

Date	1st	2nd	3rd
Mar 17		18:06	
May 7	5:39		
May 11	(6:57)		
May 14	6:28		
May 16	(6:07)		
May 19	5:38		
May 21	(5:17)		
May 23	(6:56)		
May 24	4:47		
May 26	6:26		
May 28	(6:05)		
May 31	5:36		
Jun 2	7:15 *		
Jun 4	(6:54)		
Jun 5	4:45		
Jun 7	6:24 *		
Jun 9	(6:03)		
Jun 10	3:55		
Jun 11	(7:42)		
Jun 12	5:34		
Jun 14	7:13 *		
Jun 16	(6:52)		
Jun 17	4:43		
Jun 19	6:22 *		
Jun 21	(6:01)		
Jun 22	3:52		
Jun 23	(7:40)		
Jun 24	5:31 *		
Jun 26	7:10 *		
Jun 27	3:01		
Jun 28	(6:49)		
Jun 29	4:40		
Jul 1	6:19 *		
Jul 3	(5:58)		
Jul 4	3:49		
Jul 5	(7:36)		
Jul 6	5:28 *		
Jul 8	7:07 *		

Date	1st	2nd	3rd
Jul 9	2:58		
Jul 10	(6:45)		
Jul 11	4:37 *		
Jul 13	6:15 *		
Jul 14	2:07		
Jul 15	(5:54)		
Jul 16	3:46		
Jul 17	(7:33)		
Jul 18	5:24 *		
Jul 20	7:03 *		
Jul 21	2:54		
Jul 22	(6:41)		
Jul 23	4:33 *		
Jul 25	6:11 *		
Jul 26	2:03		
Jul 27	(5:50)		
Jul 28	3:41 *		
Jul 29	(7:28)		
Jul 30	5:20 *		
Jul 31	1:11		
Aug 1	6:58 *		
Aug 2	2:50		
Aug 3	(6:37)		
Aug 4	4:28 *		
Aug 6	6:07 *		
Aug 7	1:58		
Aug 8	(5:45)		
Aug 9	3:36 *		
Aug 10	(7:24)		
Aug 11	5:15 *		
Aug 12	1:06		
Aug 13	6:53 *		
Aug 14	2:45 *		
Aug 15	(6:32)		
Aug 16	4:23 *		
Aug 17	0:14		
Aug 18	6:01 *		
Aug 19	1:53		

Date	1st	2nd	3rd
Aug 20	(5:40)		
Aug 21	3:31 *		
Aug 23	5:09 *		
Aug 24	1:00		
Aug 25	6:47 *		
Aug 26	2:39 *		
Aug 27	(6:26)		
Aug 28	4:17 *		
Aug 29	0:08		
Aug 30	5:55 *		(23:47)
Aug 31	1:46		
Sep 1	(5:33)		
Sep 2	3:25 *		23:16
Sep 4	5:03 *		(22:54)
Sep 5	0:54		
Sep 6	(4:41)		
Sep 7	2:32 *		22:24
Sep 8	(6:19)		
Sep 9	4:10 *		
Sep 10	0:02		
Sep 11	5:48 *		(23:40)
Sep 12	1:40		
Sep 13	(5:27)		
Sep 14	3:18 *		23:09
Sep 16	4:56 *		(22:47)
Sep 17	0:47		
Sep 18	(4:34)		
Sep 19	2:25 *		22:16
Sep 20	(6:12)		
Sep 21	4:03 *		23:55 *
Sep 23	5:41 *		(23:33)
Sep 24	1:32		21:24
Sep 25	(5:19)		
Sep 26	3:10 *		23:02
Sep 28	4:48 *		(22:40)
Sep 29	0:39		
Sep 30	(4:26)		
Oct 1	2:17 *		22:09

Date	1st	2nd	3rd
Oct 2	(6:04)		
Oct 3	3:55 *		23:47 *
Oct 5	5:33 *		(23:25)
Oct 6	1:24		21:16
Oct 7	(5:11)		
Oct 8	3:02 *		22:54 *
Oct 10	4:40 *		(22:32)
Oct 11	0:31		20:23
Oct 12	(4:18)		
Oct 13	2:09 *		22:01
Oct 14	(5:56)		
Oct 15	3:47 *		23:39 *
Oct 17	5:25 *		(23:17)
Oct 18	1:16		21:08
Oct 19	(5:03)		
Oct 20	2:54 *		22:46 *
Oct 22	4:32 *		(22:23)
Oct 23	0:23		20:15
Oct 24	(4:10)		
Oct 25	2:01 *		21:52 *
Oct 26	(5:48)		
Oct 27	3:39 *		23:30 *
Oct 28		19:21	
Oct 29	5:17 *		(23:08)
Oct 30	1:08	(18:59)	20:59
Oct 31	(4:55)		
Nov 1	2:46 *		22:37 *
Nov 2		18:28	
Nov 3	4:24 *		(22:15)
Nov 4	0:15		20:06
Nov 5	(4:02)		(23:53)
Nov 6	1:53	(19:44)	21:44
Nov 8	3:31 *		23:22 *
Nov 9		19:13	
Nov 10	(3:09)		(23:00)
Nov 11	1:00	(18:51)	20:51
Nov 12	(4:47)		
Nov 13	2:38 *		22:29 *

Date	1st	2nd	3rd
Nov 14		18:21	
Nov 15	(2:16)		(22:07)
Nov 16	0:07		19:59
Nov 17	(3:54)		(23:46)
Nov 18	1:45	(19:37)	21:37
Nov 20	3:23 *		23:15 *
Nov 21		19:06	
Nov 22	(3:01)		(22:53)
Nov 23	0:53	(18:44)	20:44
Nov 25	2:31 *		22:22 *
Nov 27	(2:09)		(22:00)
Nov 28	0:00		19:52
Nov 29			(23:39)
Nov 30	1:38	(19:30)	21:30
Dec 2	(1:17)		23:08 *
Dec 3		18:59	
Dec 4	(2:55)		(22:46)
Dec 5	0:46		20:37
Dec 7	2:24 *		22:16 *
Dec 9	(2:03)		23:54 *
Dec 10		19:45	
Dec 11			(23:32)
Dec 12	1:32	(19:24)	21:24
Dec 14	(1:11)		23:02 *
Dec 15		18:53	
Dec 16			(22:41)
Dec 17	0:40		20:32
Dec 19	(0:19)		22:10 *
Dec 21	(1:57)		23:49 *
Dec 22		19:40	
Dec 23			(23:27)
Dec 24	1:27	(19:19)	21:19
Dec 26	(1:06)		22:57 *
Dec 27		18:49	
Dec 28			(22:36)
Dec 29	0:36		20:27
Dec 31	(0:14)		22:06 *

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 31 December the first transit is only visible from WA at 12:14 am WST. The 3rd transit for the day is visible Australia wide at 22:06 EST or 10:06 pm EST (9:36 pm CST, 8:06 pm WST).

JUPITER'S MOONS

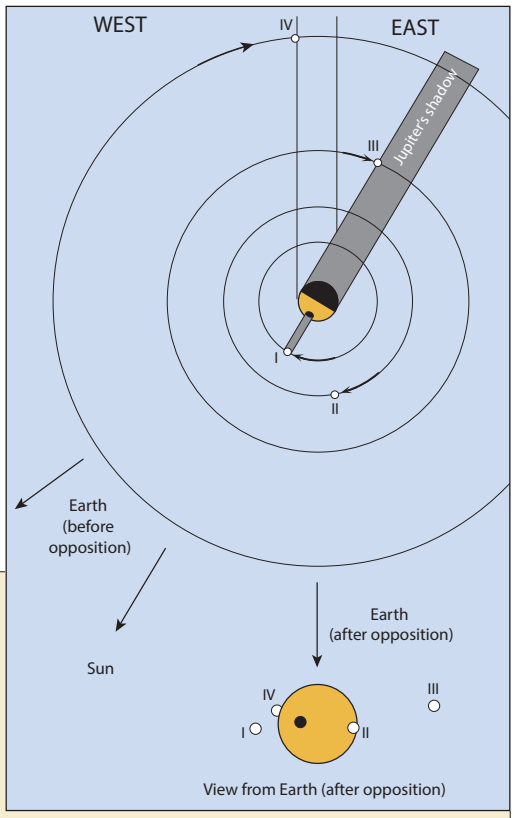
Jupiter, with its many moons, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are 79 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo, are 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 2023 is 3 November.
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 4 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

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

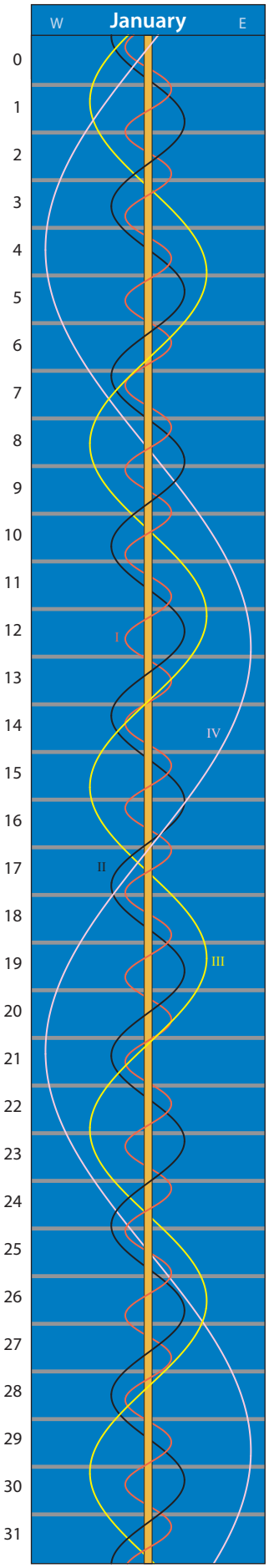
These diagrams show the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse happens when the moon passes into (disappearance or d) or out of (reappearance or r) Jupiter's shadow; west to the left, east to the right.

JUPITER MOON EVENTS

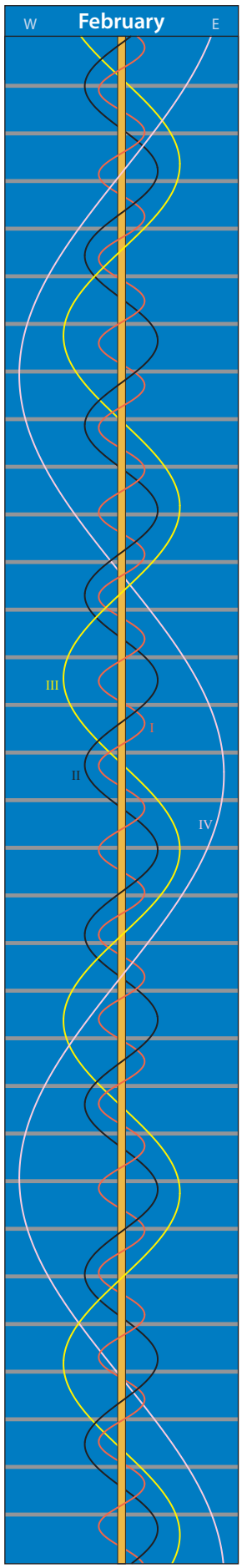
The diagrams here show the patterns the four major moons of Jupiter make as they shuttle back and forth. Each complete period represents one orbit of the satellite. Each horizontal grey date line represents midnight; the top edge of the line is midnight EST (14 hr UT), the bottom edge of the line is 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					
1	00:13	22:13(p)	II	Oc	R	W
	00:24	22:24(p)	II	Ec	D	W
2	21:06	19:06	II	Sh	E	E
5	23:43	21:43	I	Oc	D	W
6	20:15	18:15	III	Tr	E	E
	21:03	19:03	I	Tr	I	E
	22:23	20:23	I	Sh	I	
	22:51	20:51	III	Sh	I	
	23:17	21:17	I	Tr	E	W
7	00:35	22:35(p)	I	Sh	E	W
	01:23	23:23(p)	III	Sh	E	W
	21:44	19:44	I	Ec	R	
8	00:20	22:20(p)	II	Oc	D	W
9	21:12	19:12	II	Tr	E	E
	21:16	19:16	II	Sh	I	E
	23:43	21:43	II	Sh	E	W
13	21:33	19:33	III	Tr	I	E
	23:01	21:01	I	Tr	I	W
14	00:19	22:19(p)	I	Sh	I	W
	00:29	22:29(p)	III	Tr	E	W
	20:11	18:11	I	Oc	D	E
	23:39	21:39	I	Ec	R	W
15	19:45	17:45	I	Tr	E	E
	21:00	19:00	I	Sh	E	E
16	21:21	19:21	II	Tr	I	E
	23:53	21:53	II	Sh	I	W
	23:54	21:54	II	Tr	E	W
17	19:15	17:15	III	Ec	R	E
18	21:27	19:27	II	Ec	R	E
21	22:10	20:10	I	Oc	D	
22	19:31	17:31	I	Tr	I	E
	20:44	18:44	I	Sh	I	E
	21:45	19:45	I	Tr	E	
	22:56	20:56	I	Sh	E	W
23	20:04	18:04	I	Ec	R	E
24	00:05	22:05(p)	II	Tr	I	W
	20:46	18:46	III	Ec	D	E
	23:16	21:16	III	Ec	R	W
25	19:13	17:13	II	Oc	D	E
26	00:05	22:05(p)	II	Ec	R	W
29	00:10	22:10(p)	I	Oc	D	W
	21:31	19:31	I	Tr	I	
	22:39	20:39	I	Sh	I	W
	23:45	21:45	I	Tr	E	W
30	21:59	19:59	I	Ec	R	W
31	19:20	17:20	I	Sh	E	E
	20:09	18:09	III	Oc	D	E
	23:03	21:03	III	Oc	R	W
February					
1	22:00	20:00	II	Oc	D	W
3	20:52	18:52	II	Sh	E	E
5	23:32	21:32	I	Tr	I	W
6	20:40	18:40	I	Oc	D	E
7	19:04	17:04	I	Sh	I	E
	20:16	18:16	I	Tr	E	E
	21:16	19:16	I	Sh	E	E
10	19:02	17:02	II	Tr	I	E
	21:04	19:04	II	Sh	I	E
	21:35	19:35	II	Tr	E	W
11	19:07	17:07	III	Sh	I	E
	21:32	19:32	III	Sh	E	W



JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
13	22:41	20:41	I	Oc D	W
14	20:03	18:03	I	Tr I	E
	22:17	20:17	I	Tr E	W
	23:11	21:11	I	Sh E	W
15	20:19	18:19	I	Ec R	E
17	21:51	19:51	II	Tr I	W
18	19:24	17:24	III	Tr I	E
	22:14	20:14	III	Tr E	W
19	21:15	19:15	II	Ec R	W
21	22:05	20:05	I	Tr I	W
22	19:13	17:13	I	Oc D	E
	22:15	20:15	I	Ec R	W
23	18:48	16:48	I	Tr E	E
	19:35	17:35	I	Sh E	E
26	19:53	17:53	II	Oc D	E

March

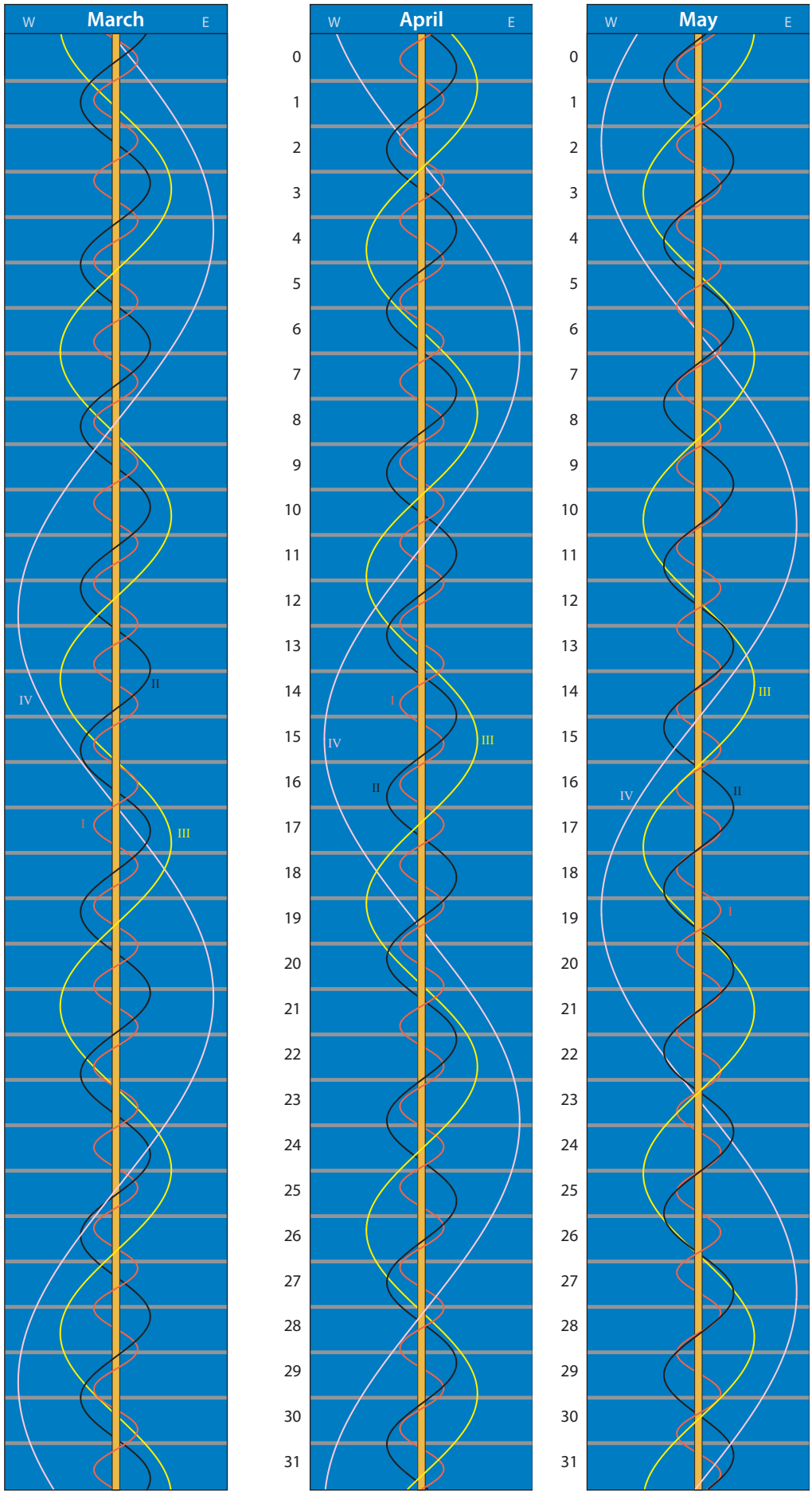
Day	EST	WST	Sat	Event	Vis
1	19:23	17:23	III	Ec R	E
	21:15	19:15	I	Oc D	W
2	18:37	16:37	I	Tr I	E
	19:19	17:19	I	Sh I	E
	21:31	19:31	I	Sh E	W
3	18:39	16:39	I	Ec R	E
7	19:29	17:29	II	Tr E	E
9	21:14	19:14	I	Sh I	W
14	20:53	18:53	II	Sh I	W
16	18:22	16:22	II	Ec R	E

April

No events shown as Jupiter is near solar conjunction

May

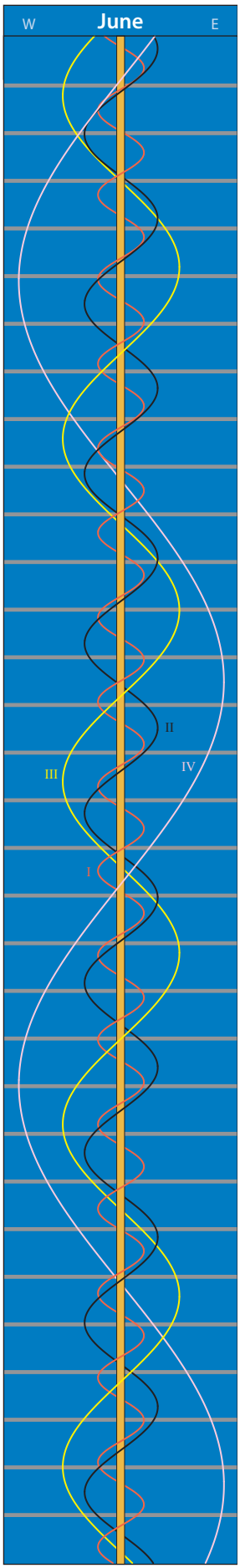
Day	EST	WST	Sat	Event	Vis
7	05:30	03:30	II	Tr I	E
	07:56	05:56	II	Tr E	W
14	07:16	05:16	II	Sh I	W
	08:23	06:23	II	Tr I	W
	08:55	06:55	I	Sh I	W



Day	EST	WST	Sat	Event	Vis
15	06:07	04:07	I	Ec D	E
	08:53	06:53	I	Oc R	W
16	05:32	03:32	II	Oc R	E
	05:34	03:34	I	Sh E	E
	06:09	04:09	I	Tr E	E
22	08:02	06:02	I	Ec D	W
23	04:36	02:36	II	Ec D	E
	05:18	03:18	I	Sh I	E
	05:42	03:42	III	Sh E	E
	05:59	03:59	I	Tr I	E
	06:24	04:24	III	Tr I	E
	07:28	05:28	I	Sh E	W
	08:09	06:09	I	Tr E	W
	08:20	06:20	II	Oc R	W
	08:32	06:32	III	Tr E	W
24	05:25	03:25	I	Oc R	E
30	07:11	05:11	II	Ec D	W
	07:12	05:12	I	Sh I	W
	07:37	05:37	III	Sh I	W
	07:59	05:59	I	Tr I	W
31	04:25	02:25	I	Ec D	E
	07:26	05:26	I	Oc R	W

June

Day	EST	WST	Sat	Event	Vis
1	04:13	02:13	II	Sh E	E
	04:40	02:40	I	Tr E	E
	05:55	03:55	II	Tr E	E
6	09:06	07:06	I	Sh I	W
7	06:20	04:20	I	Ec D	
8	04:29	02:29	II	Sh I	E
	04:29	02:29	I	Tr I	E
	05:44	03:44	I	Sh E	E
	06:23	04:23	II	Tr I	
	06:40	04:40	I	Tr E	
	06:50	04:50	II	Sh E	
	08:45	06:45	II	Tr E	W
9	03:57	01:57	I	Oc R	E
10	05:24	03:24	III	Oc D	E
	07:23	05:23	III	Oc R	W
14	08:15	06:15	I	Ec D	W



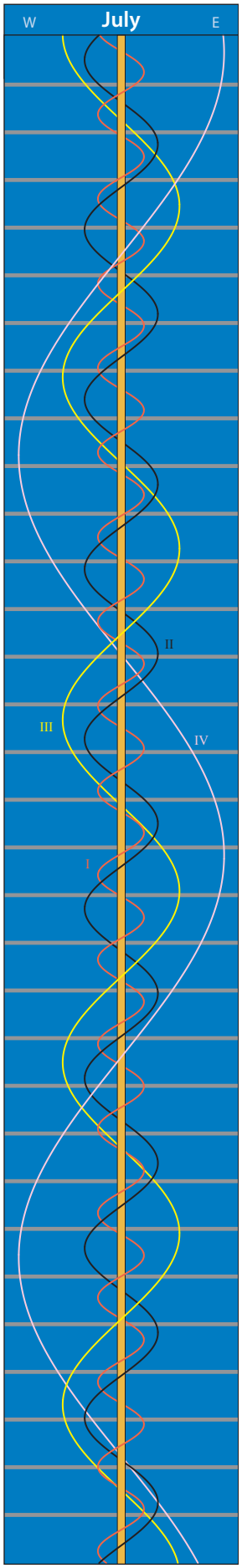
Day	EST	WST	Sat	Event	Vis
15	05:28	03:28	I	Sh I	E
	06:29	04:29	I	Tr I	
	07:06	05:06	II	Sh I	W
	07:38	05:38	I	Sh E	W
	08:39	06:39	I	Tr E	W
	09:12	07:12	II	Tr I	W
16	05:57	03:57	I	Oc R	
17	05:30	03:30	III	Ec D	E
	06:02	04:02	II	Oc R	
	07:33	05:33	III	Ec R	W
22	07:22	05:22	I	Sh I	W
	08:28	06:28	I	Tr I	W
23	04:38	02:38	I	Ec D	E
	07:56	05:56	I	Oc R	W
24	02:58	00:58	I	Tr I	E
	04:00	02:00	I	Sh E	E
	04:12	02:12	II	Ec D	E
	05:07	03:07	I	Tr E	E
	08:46	06:46	II	Oc R	W
26	03:45	01:45	II	Tr E	E
28	04:34	02:34	III	Tr I	E
	06:21	04:21	III	Tr E	
29	09:16	07:16	I	Sh I	W
30	06:32	04:32	I	Ec D	

July

Day	EST	WST	Sat	Event	Vis
1	03:44	01:44	I	Sh I	E
	04:56	02:56	I	Tr I	
	05:54	03:54	I	Sh E	
	06:46	04:46	II	Ec D	
	07:05	05:05	I	Tr E	
	09:07	07:07	II	Ec R	W
	09:10	07:10	II	Oc D	W
2	04:25	02:25	I	Oc R	E
3	04:02	02:02	II	Sh E	E
	04:11	02:11	II	Tr I	E
	06:31	04:31	II	Tr E	
5	03:43	01:43	III	Sh I	E
	05:42	03:42	III	Sh E	
	08:53	06:53	III	Tr I	W
7	08:27	06:27	I	Ec D	W

Day	EST	WST	Sat	Event	Vis
8	05:38	03:38	I	Sh I	
	06:54	04:54	I	Tr I	
	07:48	05:48	I	Sh E	W
	09:03	07:03	I	Tr E	W
	09:21	07:21	II	Ec D	W
9	02:55	00:55	I	Ec D	E
	06:23	04:23	I	Oc R	
10	02:16	00:16	I	Sh E	E
	03:32	01:32	I	Tr E	E
	04:18	02:18	II	Sh I	E
	06:39	04:39	II	Sh E	
	06:56	04:56	II	Tr I	
	09:15	07:15	II	Tr E	W
12	03:32	01:32	II	Oc R	E
	07:44	05:44	III	Sh I	W
15	07:31	05:31	I	Sh I	W
	08:50	06:50	I	Tr I	W
16	03:07	01:07	III	Oc D	E
	04:43	02:43	III	Oc R	
	04:49	02:49	I	Ec D	
	08:20	06:20	I	Oc R	W
17	02:00	00:00	I	Sh I	E
	03:20	01:20	I	Tr I	E
	04:10	02:10	I	Sh E	
	05:29	03:29	I	Tr E	
	06:55	04:55	II	Sh I	
	09:16	07:16	II	Sh E	W
18	02:49	00:49	I	Oc R	E
19	03:33	01:33	II	Ec R	E
	03:54	01:54	II	Oc D	E
	06:12	04:12	II	Oc R	
23	01:37	23:37(p)	III	Ec D	E
	03:33	01:33	III	Ec R	E
	06:44	04:44	I	Ec D	
	07:20	05:20	III	Oc D	W
	08:51	06:51	III	Oc R	W
24	03:54	01:54	I	Sh I	
	05:16	03:16	I	Tr I	
	06:04	04:04	I	Sh E	
	07:25	05:25	I	Tr E	W
25	04:45	02:45	I	Oc R	
26	01:53	23:53(p)	I	Tr E	E
	03:48	01:48	II	Ec D	
	06:08	04:08	II	Ec R	
	06:33	04:33	II	Oc D	
	08:50	06:50	II	Oc R	W

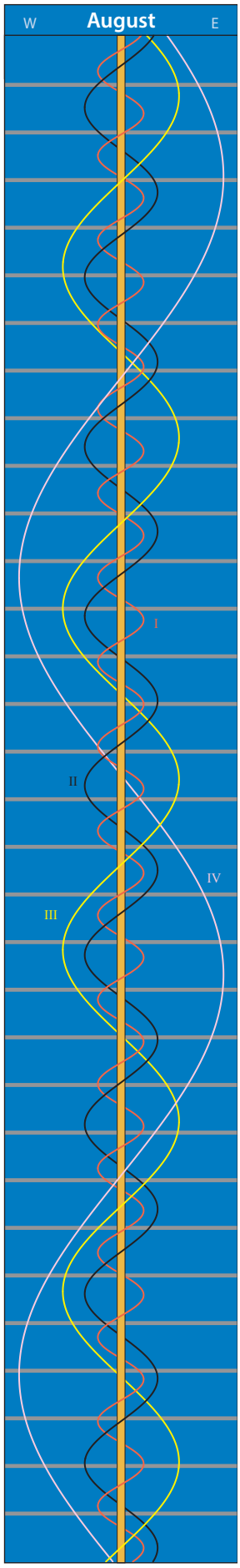
JUPITER MOON EVENTS



Day	EST	WST	Sat	Event	Vis
28	01:11	23:11(p)	II	Sh E	E
	01:40	23:40(p)	II	Tr I	E
	03:57	01:57	II	Tr E	
30	05:37	03:37	III	Ec D	
	07:33	05:33	III	Ec R	W
	08:38	06:38	I	Ec D	W
31	05:47	03:47	I	Sh I	
	07:11	05:11	I	Tr I	W
	07:57	05:57	I	Sh E	W

August

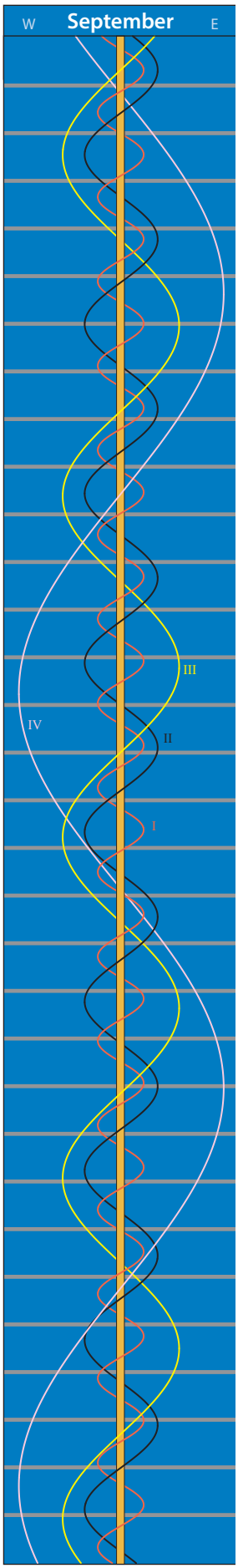
Day	EST	WST	Sat	Event	Vis
1	03:06	01:06	I	Ec D	E
	06:40	04:40	I	Oc R	
2	01:39	23:39(p)	I	Tr I	E
	02:26	00:26	I	Sh E	E
	03:48	01:48	I	Tr E	
	06:23	04:23	II	Ec D	
	08:43	06:43	II	Ec R	W
	09:11	07:11	II	Oc D	W
3	01:09	23:09(p)	I	Oc R	E
	01:41	23:41(p)	III	Tr I	E
	03:02	01:02	III	Tr E	E
4	01:27	23:27(p)	II	Sh I	E
	03:48	01:48	II	Sh E	
	04:19	02:19	II	Tr I	
	06:35	04:35	II	Tr E	
6	00:45	22:45(p)	II	Oc R	E
7	07:41	05:41	I	Sh I	W
	09:05	07:05	I	Tr I	W
8	05:01	03:01	I	Ec D	
	08:34	06:34	I	Oc R	W
9	02:09	00:09	I	Sh I	E
	03:33	01:33	I	Tr I	
	04:19	02:19	I	Sh E	
	05:42	03:42	I	Tr E	
	08:58	06:58	II	Ec D	W
10	01:40	23:40(p)	III	Sh E	E
	03:03	01:03	I	Oc R	
	05:44	03:44	III	Tr I	
	07:00	05:00	III	Tr E	W
11	04:04	02:04	II	Sh I	
	06:24	04:24	II	Sh E	
	06:55	04:55	II	Tr I	W
13	00:35	22:35(p)	II	Ec R	E
	01:04	23:04(p)	II	Oc D	E
	03:19	01:19	II	Oc R	



Day	EST	WST	Sat	Event	Vis
15	06:55	04:55	I	Ec D	W
16	04:03	02:03	I	Sh I	
	05:26	03:26	I	Tr I	
	06:13	04:13	I	Sh E	
	07:35	05:35	I	Tr E	W
17	01:23	23:23(p)	I	Ec D	E
	03:49	01:49	III	Sh I	
	04:56	02:56	I	Oc R	
	05:40	03:40	III	Sh E	
	23:54	21:54	I	Tr I	E
18	00:42	22:42(p)	I	Sh E	E
	02:03	00:03	I	Tr E	E
	06:41	04:41	II	Sh I	W
20	00:50	22:50(p)	II	Ec D	E
	03:10	01:10	II	Ec R	
	03:36	01:36	II	Oc D	
	05:51	03:51	II	Oc R	
21	00:40	22:40(p)	III	Oc R	E
22	01:00	23:00(p)	II	Tr E	E
	08:49	06:49	I	Ec D	W
23	05:57	03:57	I	Sh I	
	07:18	05:18	I	Tr I	W
	08:07	06:07	I	Sh E	W
24	03:17	01:17	I	Ec D	
	06:47	04:47	I	Oc R	W
	07:49	05:49	III	Sh I	W
25	00:25	22:25(p)	I	Sh I	E
	01:46	23:46(p)	I	Tr I	E
	02:35	00:35	I	Sh E	
	03:55	01:55	I	Tr E	
26	01:15	23:15(p)	I	Oc R	E
27	03:26	01:26	II	Ec D	
	05:46	03:46	II	Ec R	
	06:07	04:07	II	Oc D	
	08:21	06:21	II	Oc R	W
	23:32	21:32	III	Ec R	E
28	03:23	01:23	III	Oc D	
	04:27	02:27	III	Oc R	
29	00:55	22:55(p)	II	Sh E	E
	01:16	23:16(p)	II	Tr I	E
	03:30	01:30	II	Tr E	
30	07:51	05:51	I	Sh I	W
31	05:11	03:11	I	Ec D	
	08:38	06:38	I	Oc R	W

September

Day	EST	WST	Sat	Event	Vis
1	02:19	00:19	I	Sh	I
	03:37	01:37	I	Tr	I
	04:29	02:29	I	Sh	E
	05:45	03:45	I	Tr	E
	23:40	21:40	I	Ec D	E
2	03:06	01:06	I	Oc R	
	22:58	20:58	I	Sh E	E
3	00:12	22:12(p)	I	Tr E	E
	06:01	04:01	II	Ec D	
	08:21	06:21	II	Ec R	W
	08:36	06:36	II	Oc D	W
4	01:42	23:42(p)	III	Ec D	
	03:32	01:32	III	Ec R	
	07:10	05:10	III	Oc D	W
	08:09	06:09	III	Oc R	W
5	01:12	23:12(p)	II	Sh	I
	03:31	01:31	II	Sh E	
	03:44	01:44	II	Tr	I
	05:57	03:57	II	Tr E	
7	00:02	22:02(p)	II	Oc R	E
	07:05	05:05	I	Ec D	W
8	04:13	02:13	I	Sh	I
	05:26	03:26	I	Tr	I
	06:23	04:23	I	Sh E	W
	07:34	05:34	I	Tr E	W
9	01:34	23:34(p)	I	Ec D	
	04:55	02:55	I	Oc R	
	22:42	20:42	I	Sh I	E
	23:54	21:54	I	Tr I	E
10	00:52	22:52(p)	I	Sh E	
	02:02	00:02	I	Tr E	
	23:22	21:22	I	Oc R	E
11	05:43	03:43	III	Ec D	
	07:33	05:33	III	Ec R	W
12	03:48	01:48	II	Sh	I
	06:07	04:07	II	Sh E	W
	06:10	04:10	II	Tr I	W
	08:22	06:22	II	Tr E	W
14	02:27	00:27	II	Oc R	
15	00:51	22:51(p)	III	Tr	I
	01:39	23:39(p)	III	Tr E	
	06:07	04:07	I	Sh I	W
	07:15	05:15	I	Tr I	W
	08:17	06:17	I	Sh E	W



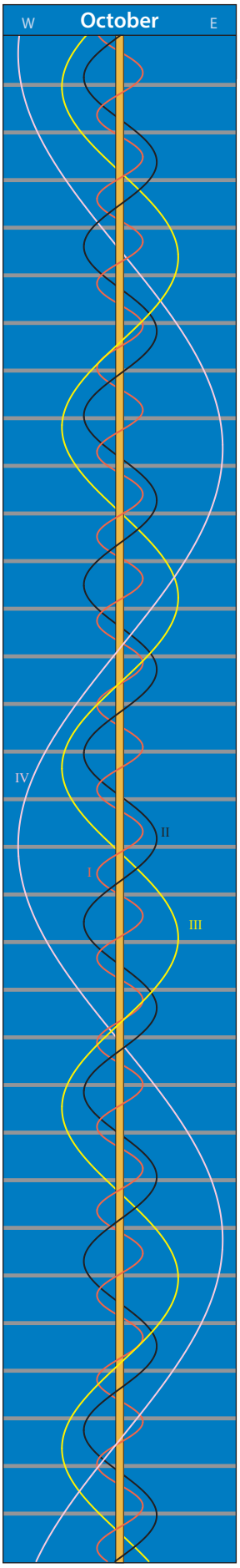
Day	EST	WST	Sat	Event	Vis
16	03:28	01:28	I	Ec D	
	06:43	04:43	I	Oc R	W
17	00:36	22:36(p)	I	Sh	I
	01:42	23:42(p)	I	Tr	I
	02:46	00:46	I	Sh E	
	03:50	01:50	I	Tr E	
	21:57	19:57	I	Ec D	E
18	01:10	23:10(p)	I	Oc R	
	22:17	20:17	I	Tr E	E
19	06:24	04:24	II	Sh I	W
21	00:31	22:31(p)	II	Ec D	
	04:50	02:50	II	Oc R	
	23:53	21:53	III	Sh I	
22	01:39	23:39(p)	III	Sh E	
	04:27	02:27	III	Tr I	
	05:10	03:10	III	Tr E	
	08:01	06:01	I	Sh I	W
	21:43	19:43	II	Tr I	E
	22:01	20:01	II	Sh E	E
	23:55	21:55	II	Tr E	
23	05:22	03:22	I	Ec D	
24	02:30	00:30	I	Sh	I
	03:29	01:29	I	Tr	I
	04:40	02:40	I	Sh E	
	05:37	03:37	I	Tr E	
	23:51	21:51	I	Ec D	
25	02:56	00:56	I	Oc R	
	21:55	19:55	I	Tr I	E
	23:09	21:09	I	Sh E	E
26	00:03	22:03(p)	I	Tr E	
	21:23	19:23	I	Oc R	E
28	03:07	01:07	II	Ec D	
	07:10	05:10	II	Oc R	W
29	03:54	01:54	III	Sh I	
	05:39	03:39	III	Sh E	
	07:56	05:56	III	Tr I	W
	22:17	20:17	II	Sh I	E
30	00:03	22:03(p)	II	Tr	I
	00:37	22:37(p)	II	Sh E	
	02:15	00:15	II	Tr E	
	07:16	05:16	I	Ec D	W

October

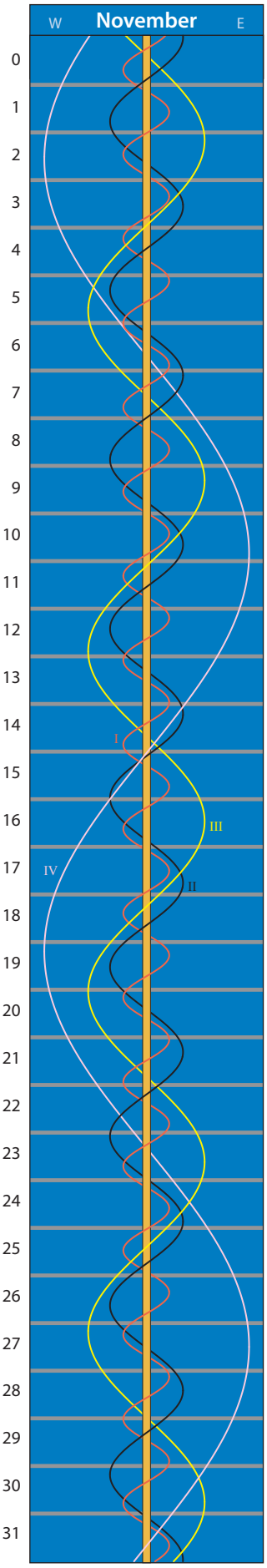
Day	EST	WST	Sat	Event	Vis
1	04:24	02:24	I	Sh	I
	05:15	03:15	I	Tr	I
	06:34	04:34	I	Sh E	W
	07:23	05:23	I	Tr E	W
2	01:45	23:45(p)	I	Ec D	
	04:42	02:42	I	Oc R	
	21:27	19:27	III	Oc D	E
	22:13	20:13	III	Oc R	E
	22:53	20:53	I	Sh I	E
	23:41	21:41	I	Tr I	
3	01:03	23:03(p)	I	Sh E	
	01:49	23:49(p)	I	Tr E	
	23:08	21:08	I	Oc R	
5	05:44	03:44	II	Ec D	W
7	00:53	22:53(p)	II	Sh	I
	02:20	00:20	II	Tr	I
	03:12	01:12	II	Sh E	
	04:32	02:32	II	Tr E	
8	06:19	04:19	I	Sh I	W
	07:00	05:00	I	Tr I	W
	22:38	20:38	II	Oc R	
9	03:39	01:39	I	Ec D	
	06:27	04:27	I	Oc R	W
	21:46	19:46	III	Ec D	E
	23:32	21:32	III	Ec R	
10	00:47	22:47(p)	I	Sh	I
	00:49	22:49(p)	III	Oc D	
	01:26	23:26(p)	I	Tr	I
	01:35	23:35(p)	III	Oc R	
	02:57	00:57	I	Sh E	
	03:34	01:34	I	Tr E	
	22:08	20:08	I	Ec D	E
11	00:53	22:53(p)	I	Oc R	
	21:26	19:26	I	Sh E	E
	22:00	20:00	I	Tr E	E
14	03:29	01:29	II	Sh	I
	04:36	02:36	II	Tr	I
	05:48	03:48	II	Sh E	W
	06:47	04:47	II	Tr E	W
15	21:39	19:39	II	Ec D	E
16	00:54	22:54(p)	II	Oc R	
	05:34	03:34	I	Ec D	W

JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
17	01:48	23:48(p)	III	Ec	D
	02:42	00:42	I	Sh	I
	03:10	01:10	I	Tr	I
	03:33	01:33	III	Ec	R
	04:07	02:07	III	Oc	D
	04:52	02:52	I	Sh	E
	04:55	02:55	III	Oc	R
	05:18	03:18	I	Tr	E
	19:55	17:55	II	Tr	E E
18	00:02	22:02(p)	I	Ec	D
	02:37	00:37	I	Oc	R
	21:10	19:10	I	Sh	I E
	21:36	19:36	I	Tr	I E
	23:21	21:21	I	Sh	E
	23:44	21:44	I	Tr	E
19	21:03	19:03	I	Oc	R E
21	06:05	04:05	II	Sh	I W
	06:50	04:50	II	Tr	I W
23	00:16	22:16(p)	II	Ec	D
	03:10	01:10	II	Oc	R
	07:28	05:28	I	Ec	D W
24	04:37	02:37	I	Sh	I
	04:54	02:54	I	Tr	I
	05:49	03:49	III	Ec	D W
	06:47	04:47	I	Sh	E W
	07:02	05:02	I	Tr	E W
	19:22	17:22	II	Sh	I E
	19:57	17:57	II	Tr	I E
	21:42	19:42	II	Sh	E
	22:09	20:09	II	Tr	E
25	01:57	23:57(p)	I	Ec	D
	04:20	02:20	I	Oc	R
	23:05	21:05	I	Sh	I
	23:20	21:20	I	Tr	I
26	01:15	23:15(p)	I	Sh	E
	01:28	23:28(p)	I	Tr	E
	20:25	18:25	I	Ec	D E
	22:46	20:46	I	Oc	R
27	19:44	17:44	I	Sh	E E
	19:54	17:54	I	Tr	E E
	19:59	17:59	III	Sh	I E
	21:08	19:08	III	Tr	I E
	21:41	19:41	III	Sh	E
	21:59	19:59	III	Tr	E
30	02:53	00:53	II	Ec	D
	05:24	03:24	II	Oc	R W
31	06:31	04:31	I	Sh	I W
	06:38	04:38	I	Tr	I W
	21:58	19:58	II	Sh	I
	22:10	20:10	II	Tr	I



Day	EST	WST	Sat	Event	Vis
November					
1	00:17	22:17(p)	II	Sh	E
	00:22	22:22(p)	II	Tr	E
	03:51	01:51	I	Ec	D
	06:04	04:04	I	Oc	R W
2	01:00	23:00(p)	I	Sh	I
	01:03	23:03(p)	I	Tr	I
	03:10	01:10	I	Sh	E
	03:12	01:12	I	Tr	E
	18:32	16:32	II	Ec	R E
	22:20	20:20	I	Ec	D
3	00:30	22:30(p)	I	Oc	R
	19:29	17:29	I	Sh	I E
	19:29	17:29	I	Tr	I E
	21:38	19:38	I	Tr	E
	21:39	19:39	I	Sh	E
4	00:01	22:01(p)	III	Sh	I
	00:20	22:20(p)	III	Tr	I
	01:17	23:17(p)	III	Tr	E
	01:42	23:42(p)	III	Sh	E
	18:58	16:58	I	Ec	R E
6	05:26	03:26	II	Oc	D W
8	00:23	22:23(p)	II	Tr	I
	00:34	22:34(p)	II	Sh	I
	02:35	00:35	II	Tr	E
	02:53	00:53	II	Sh	E
	05:39	03:39	I	Oc	D W
9	02:47	00:47	I	Tr	I
	02:55	00:55	I	Sh	I
	04:56	02:56	I	Tr	E W
	05:05	03:05	I	Sh	E W
	21:10	19:10	II	Ec	R
10	00:05	22:05(p)	I	Oc	D
	02:24	00:24	I	Ec	R
	21:13	19:13	I	Tr	I
	21:24	19:24	I	Sh	I
	23:22	21:22	I	Tr	E
	23:34	21:34	I	Sh	E
11	03:33	01:33	III	Tr	I
	04:03	02:03	III	Sh	I
	04:36	02:36	III	Tr	E
	05:44	03:44	III	Sh	E W
	20:53	18:53	I	Ec	R E
14	19:36	17:36	III	Ec	R E
15	02:36	00:36	II	Tr	I
	03:09	01:09	II	Sh	I
	04:49	02:49	II	Tr	E W
	05:28	03:28	II	Sh	E W

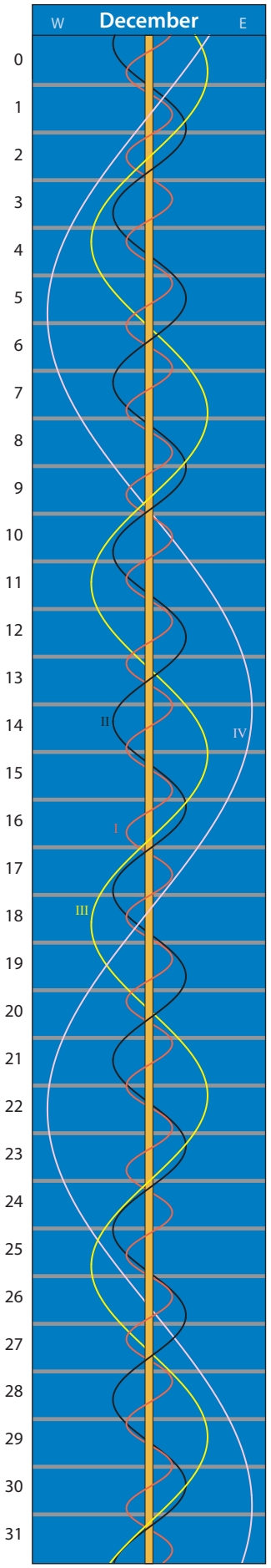


I – Io II – Europa III – Ganymede IV – Callisto

Day	EST	WST	Sat	Event	Vis
16	04:31	02:31	I	Tr I	W
	04:50	02:50	I	Sh I	W
	20:48	18:48	II	Oc D	E
	23:48	21:48	II	Ec R	
17	01:48	23:48(p)	I	Oc D	
	04:19	02:19	I	Ec R	W
	22:57	20:57	I	Tr I	
	23:19	21:19	I	Sh I	
18	01:06	23:06(p)	I	Tr E	
	01:29	23:29(p)	I	Sh E	
	18:46	16:46	II	Sh E	E
	20:15	18:15	I	Oc D	E
	22:47	20:47	I	Ec R	
19	19:32	17:32	I	Tr E	E
	19:58	17:58	I	Sh E	E
21	20:11	18:11	III	Oc D	E
	21:29	19:29	III	Oc R	
	21:54	19:54	III	Ec D	
	23:36	21:36	III	Ec R	
22	04:50	02:50	II	Tr I	W
	05:45	03:45	II	Sh I	W
23	23:04	21:04	II	Oc D	
24	02:26	00:26	II	Ec R	
	03:33	01:33	I	Oc D	
25	00:42	22:42(p)	I	Tr I	
	01:15	23:15(p)	I	Sh I	
	02:51	00:51	I	Tr E	
	03:25	01:25	I	Sh E	
	19:03	17:03	II	Sh I	E
	20:12	18:12	II	Tr E	E
	21:22	19:22	II	Sh E	
	21:59	19:59	I	Oc D	
26	00:42	22:42(p)	I	Ec R	
	19:08	17:08	I	Tr I	E
	19:44	17:44	I	Sh I	E
	21:17	19:17	I	Tr E	
	21:54	19:54	I	Sh E	
27	19:11	17:11	I	Ec R	E
28	23:28	21:28	III	Oc D	
29	00:52	22:52(p)	III	Oc R	
	01:56	23:56(p)	III	Ec D	
	03:37	01:37	III	Ec R	W

December

Day	EST	WST	Sat	Event	Vis
1	01:21	23:21(p)	II	Oc D	
	05:05	03:05	II	Ec R	W
	05:18	03:18	I	Oc D	W
2	02:27	00:27	I	Tr I	
	03:10	01:10	I	Sh I	
	04:37	02:37	I	Tr E	W
	05:20	03:20	I	Sh E	W
	20:13	18:13	II	Tr I	E
	21:38	19:38	II	Sh I	
	22:29	20:29	II	Tr E	
	23:44	21:44	I	Oc D	
	23:57	21:57	II	Sh E	
3	02:37	00:37	I	Ec R	
	20:54	18:54	I	Tr I	E
	21:39	19:39	I	Sh I	
	23:03	21:03	I	Tr E	
	23:49	21:49	I	Sh E	
4	21:06	19:06	I	Ec R	E
6	02:49	00:49	III	Oc D	
	04:20	02:20	III	Oc R	W
8	03:41	01:41	II	Oc D	W
9	04:14	02:14	I	Tr I	W
	20:11	18:11	III	Sh I	E
	21:50	19:50	III	Sh E	
	22:31	20:31	II	Tr I	
10	00:14	22:14(p)	II	Sh I	
	00:48	22:48(p)	II	Tr E	
	01:31	23:31(p)	I	Oc D	
	02:33	00:33	II	Sh E	
	04:32	02:32	I	Ec R	W
	22:41	20:41	I	Tr I	
	23:35	21:35	I	Sh I	
11	00:50	22:50(p)	I	Tr E	
	01:45	23:45(p)	I	Sh E	
	19:57	17:57	I	Oc D	E
	21:03	19:03	II	Ec R	E
	23:01	21:01	I	Ec R	
12	19:17	17:17	I	Tr E	E
	20:14	18:14	I	Sh E	E
16	20:10	18:10	III	Tr I	E
	21:46	19:46	III	Tr E	
17	00:13	22:13(p)	III	Sh I	
	00:52	22:52(p)	II	Tr I	
	01:51	23:51(p)	III	Sh E	
	02:50	00:50	II	Sh I	W
	03:09	01:09	II	Tr E	W
	03:18	01:18	I	Oc D	W



Day	EST	WST	Sat	Event	Vis
18	00:29	22:29(p)	I	Tr I	
	01:31	23:31(p)	I	Sh I	
	02:39	00:39	I	Tr E	W
	03:41	01:41	I	Sh E	W
	19:15	17:15	II	Oc D	E
	21:45	19:45	I	Oc D	
	23:42	21:42	II	Ec R	
19	00:56	22:56(p)	I	Ec R	
	20:00	18:00	I	Sh I	E
	21:06	19:06	I	Tr E	E
	22:10	20:10	I	Sh E	
20	19:25	17:25	I	Ec R	E
23	23:43	21:43	III	Tr I	
24	01:24	23:24(p)	III	Tr E	
	03:14	01:14	II	Tr I	W
25	02:18	00:18	I	Tr I	W
	03:26	01:26	I	Sh I	W
	21:41	19:41	II	Oc D	
	23:34	21:34	I	Oc D	
26	02:21	00:21	II	Ec R	W
	02:51	00:51	I	Ec R	W
	20:46	18:46	I	Tr I	E
	21:55	19:55	I	Sh I	
	22:56	20:56	I	Tr E	
27	00:06	22:06(p)	I	Sh E	
	19:44	17:44	III	Ec R	E
	21:03	19:03	II	Sh E	E
	21:20	19:20	I	Ec R	E
31	03:22	01:22	III	Tr I	W

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 27 August 11 pm EST (see page 62).

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 27.542 UT.
2. Subtract the date of the greatest elongation east for Rhea for August, i.e., 27.542 – 1.997 = 25.545
3. Express this as the number of orbits by dividing by the period i.e., 25.545 / 4.518 = 5.654
4. Discard any complete orbits (5 in this case) leaving 0.654
5. Multiply by the period, 0.654 × 4.518 = 2.955 days or about 2 days and 23 hours after elongation east.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is west-northwest of Saturn, just after an elongation west.

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	1.748	1.761	1.784	3.721	1.530
February	1.859	2.290	1.006	2.852	2.195
March	1.198	1.706	1.340	2.244	1.338
April	1.306	2.232	2.448	1.373	2.001
May	1.468	1.013	2.663	1.495	3.653
June	1.568	1.530	1.872	3.346	4.290
July	1.722	1.673	2.075	3.450	1.393
August	1.815	2.181	1.271	2.545	1.997
September	1.908	1.318	2.353	1.635	2.593
October	1.119	1.456	2.549	1.729	4.193
November	1.219	1.971	1.752	3.567	4.809
December	1.382	2.120	1.962	3.681	1.923

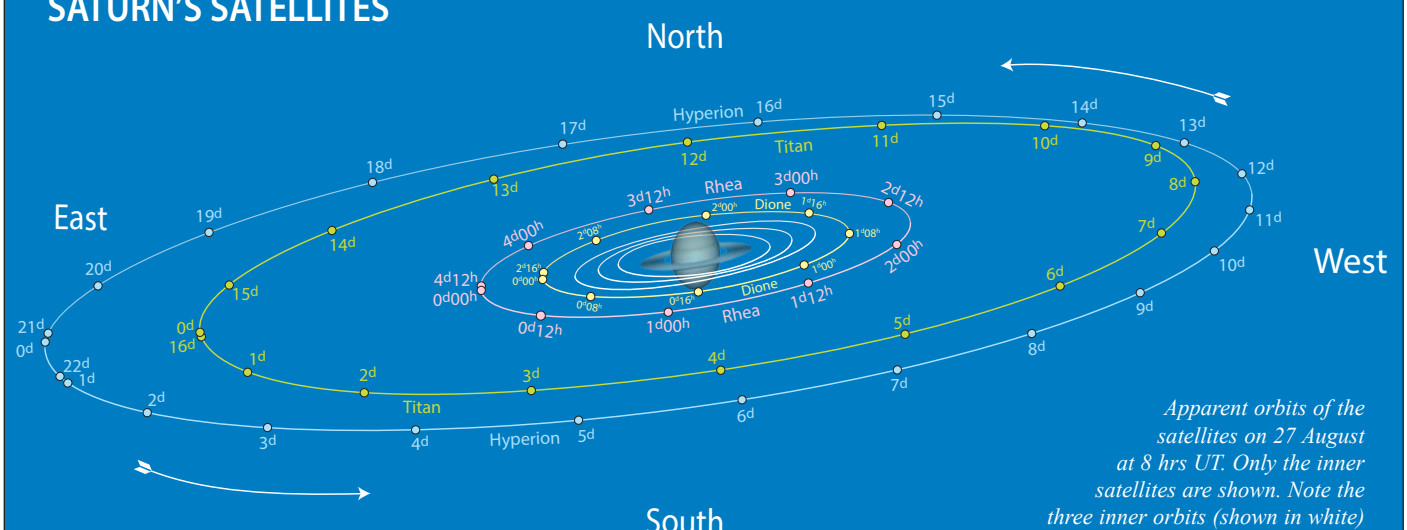
Notes 1. When at opposition 2. Mean Synodic Period

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, August 27.542 UT; 13.915 orbits have elapsed since the first greatest elongation east for August on 1.271 UT. Discarding the completed orbits leaves 0.915 of an orbit. This is east of Saturn, just before its elongation east.

APPARENT ORBITS OF SATURN'S SATELLITES



Saturn and the orbits have been elongated (two to one ratio) in the direction of the minor axes.

Apparent orbits of the satellites on 27 August at 8 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 27 Aug 11 pm EST (27.542 UT), Titan is about 15.7 days past its most recent greatest elongation east (August 11.870 UT), which puts it east of Saturn. The diagrams opposite and on page 62 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	16.135	3.966
		25.485
February	1.158	16.036
	17.183	
March	5.208	9.575
	21.229	31.103
April	6.244	21.630
	22.249	
May	8.242	13.089
	24.220	
June	9.182	3.496
	25.127	24.874
July	11.055	16.149
	26.968	
August	11.870	6.369
	27.766	27.582
September	12.662	17.730
	28.564	
October	14.478	8.881
	30.410	30.089
November	15.359	20.290
December	1.326	11.521
	17.311	

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	13.897	Feb	3.910
Feb	22.825	Mar	14.865	Apr	4.915	Apr	25.912
May	14.808	Jun	3.869	Jun	24.884	Jul	13.809
Aug	1.802	Aug	21.856	Sep	10.307	Sep	30.149
Oct	18.894	Nov	7.684	Nov	28.038	Dec	18.608

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, 27 Aug 11 pm EST (27.542 UT), the most recent event was an inferior conjunction on August 21.856 (UT). Iapetus is 5.7 days past this time, heading towards elongation west, so it is to the south of the planet..

SATURN'S RINGS 2023

Date	Major "	Minor "	B °
Jan 4	35.7	8.3	13.5
Jan 12	35.4	8.0	13.1
Jan 20	35.2	7.8	12.7
Jan 28	35.0	7.5	12.3
Feb 5	34.9	7.2	11.9
Feb 13	34.9	7.0	11.5
Feb 21	34.9	6.7	11.1
Mar 1	35.0	6.5	10.7
Mar 9	35.1	6.2	10.3
Mar 17	35.2	6.0	9.9
Mar 25	35.4	5.8	9.5
Apr 2	35.7	5.6	9.1
Apr 10	36.0	5.5	8.7
Apr 18	36.4	5.3	8.4
Apr 26	36.8	5.2	8.1
May 4	37.2	5.1	7.9
May 12	37.7	5.0	7.7
May 20	38.2	5.0	7.5
May 28	38.7	5.0	7.4
Jun 5	39.2	5.0	7.3
Jun 13	39.8	5.1	7.3
Jun 21	40.3	5.1	7.3
Jun 29	40.8	5.3	7.4
Jul 7	41.3	5.4	7.5
Jul 15	41.8	5.6	7.7
Jul 23	42.2	5.8	7.9
Jul 31	42.5	6.0	8.1
Aug 8	42.8	6.2	8.4
Aug 16	42.9	6.4	8.6
Aug 24	43.0	6.7	8.9
Sep 1	43.0	6.9	9.2
Sep 9	42.9	7.1	9.5
Sep 17	42.7	7.2	9.7
Sep 25	42.5	7.4	10.0
Oct 3	42.1	7.4	10.2
Oct 11	41.7	7.5	10.3
Oct 19	41.2	7.5	10.4
Oct 27	40.7	7.4	10.5
Nov 4	40.2	7.3	10.5
Nov 12	39.7	7.2	10.5
Nov 20	39.1	7.1	10.4
Nov 28	38.6	6.9	10.3
Dec 6	38.1	6.7	10.1
Dec 14	37.6	6.4	9.8
Dec 22	37.1	6.2	9.6
Dec 30	36.7	5.9	9.3

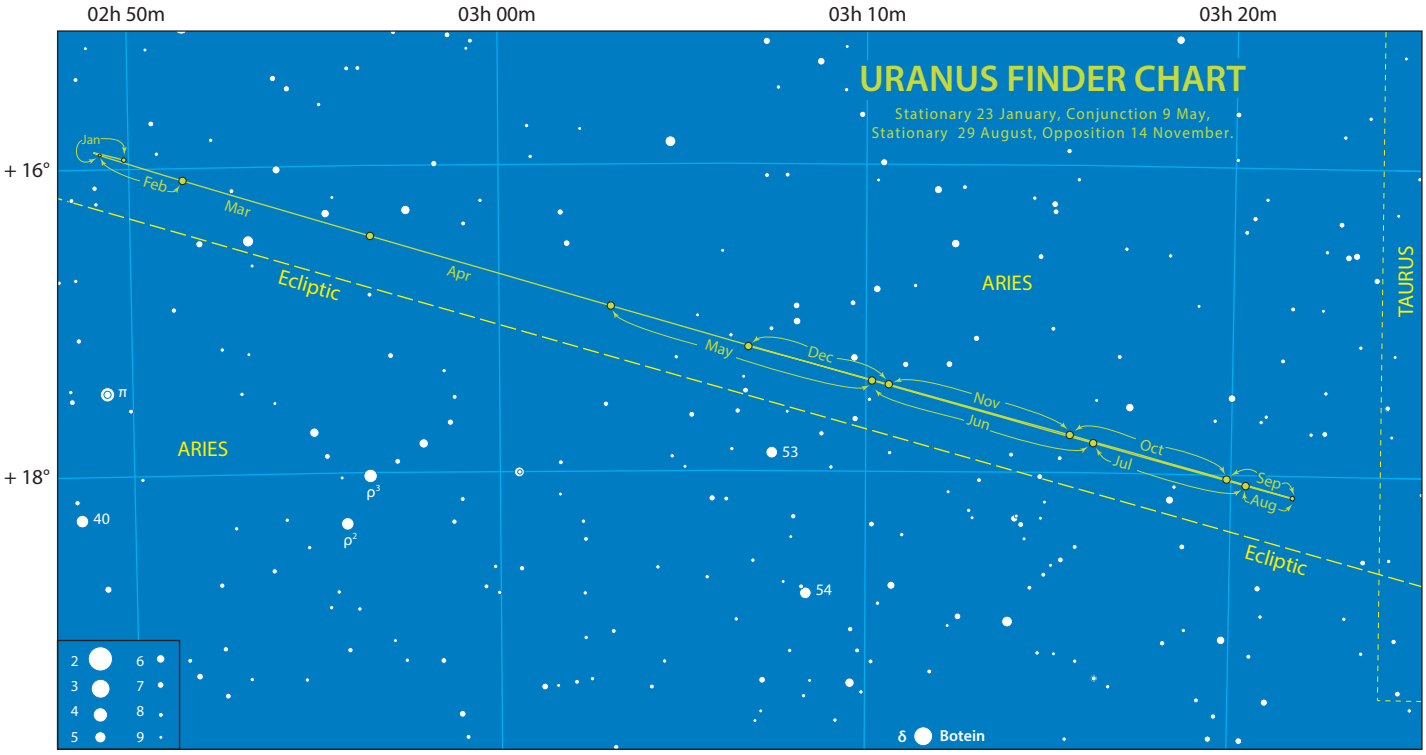
The Appearance of the Planets diagrams in Part I show how open the rings are for 2023. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every seven 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 2023 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.

URANUS



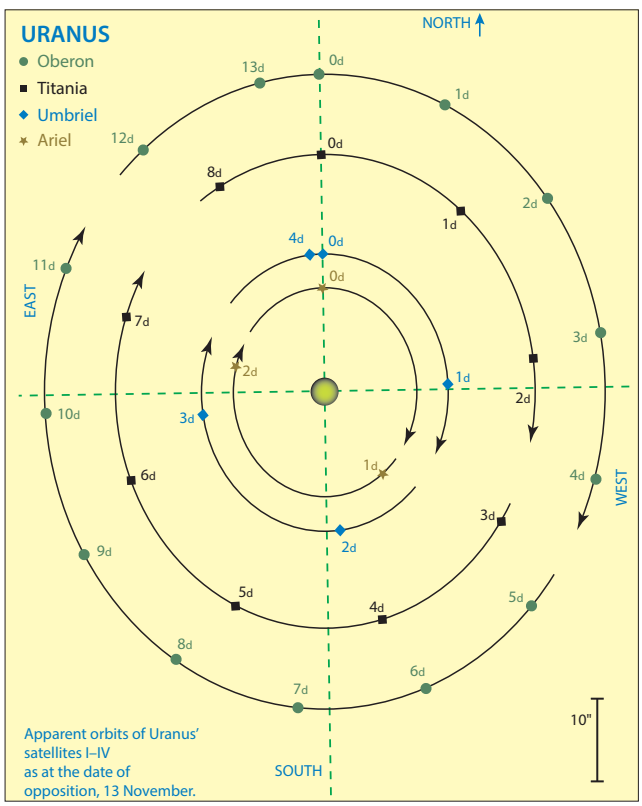
URANUS' MOONS Table 2a presents the times of the first greatest elongation to the *north* for each month for **Ariel**, **Umbriel**, **Titania and Oberon**. This location is the day 0 (zero) point on the Apparent Orbits diagram. As with Saturn's satellites, the procedure is to work out how many orbits 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 26 October at 1 am WST.

1. Convert to UT as a fractional day. 26 October at 1 am (WST) = 25.708 UT (refer table 1 opposite)
2. Subtract the date of the greatest elongation north for October, i.e. 25.708 – 3.547 = 22.161 days.
3. Divide by the period to get the number of orbits, i.e. 22.161 / 4.144 = 5.348 orbits.
4. Discarding whole orbits leaves 0.348 (about 35% of an orbit).
5. Multiply by the period, 0.348 × 4.144 = 1.441 days (34.6 hours).
6. Looking at its orbital path (see Apparent Orbits diagram), the satellite is a little under half way between the one and two day marks, towards the south-west.

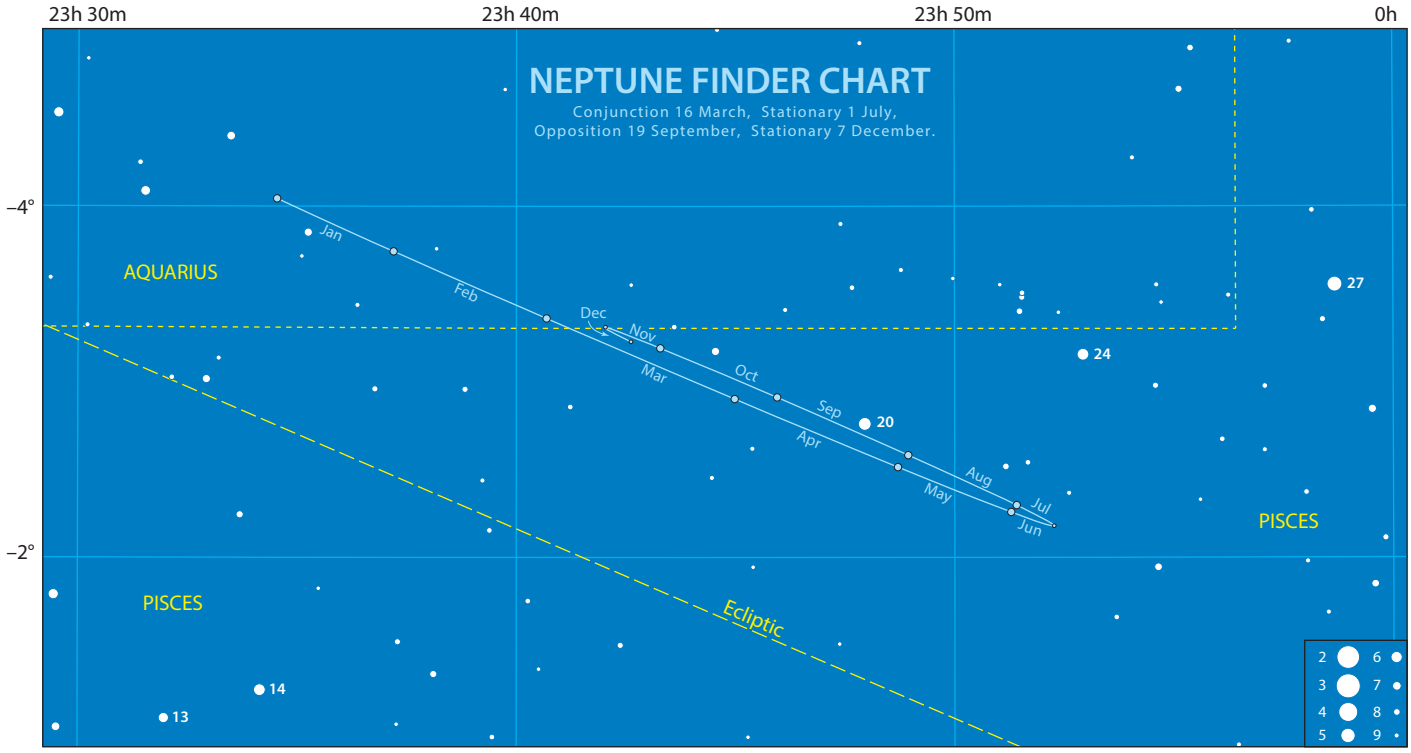
Table 2a: **Time of Greatest Elongation North** (UT)

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	2.718	3.075	5.691	5.066
February	1.965	1.088	9.520	14.450
March	1.690	2.097	7.633	13.367
April	3.453	4.246	2.740	9.278
May	1.173	3.248	7.541	6.186
June	2.931	1.249	2.641	2.087
July	3.168	4.389	7.448	12.429
August	2.406	2.390	2.553	8.337
September	1.646	4.539	6.366	4.263
October	1.890	3.547	2.483	1.200
November	1.138	1.563	6.322	10.603
December	1.387	4.724	2.454	7.542

Notes 1. When at opposition 2. Sidereal Period



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 21st = 20.625 days UT

An example. Estimate the position for Triton for September 15 at 10 pm EST. 2.086 orbits have elapsed since its greatest elongation east on Sep 3.242 UT. Discarding the whole orbits leaves 0.086. Multiplying by 5.877 (its period) gives 0.504 days. From the diagram the moon is north-east of Neptune, just after an eastern elongation.

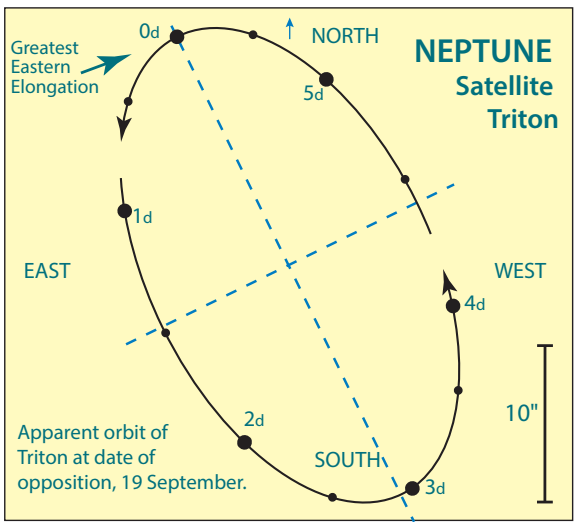
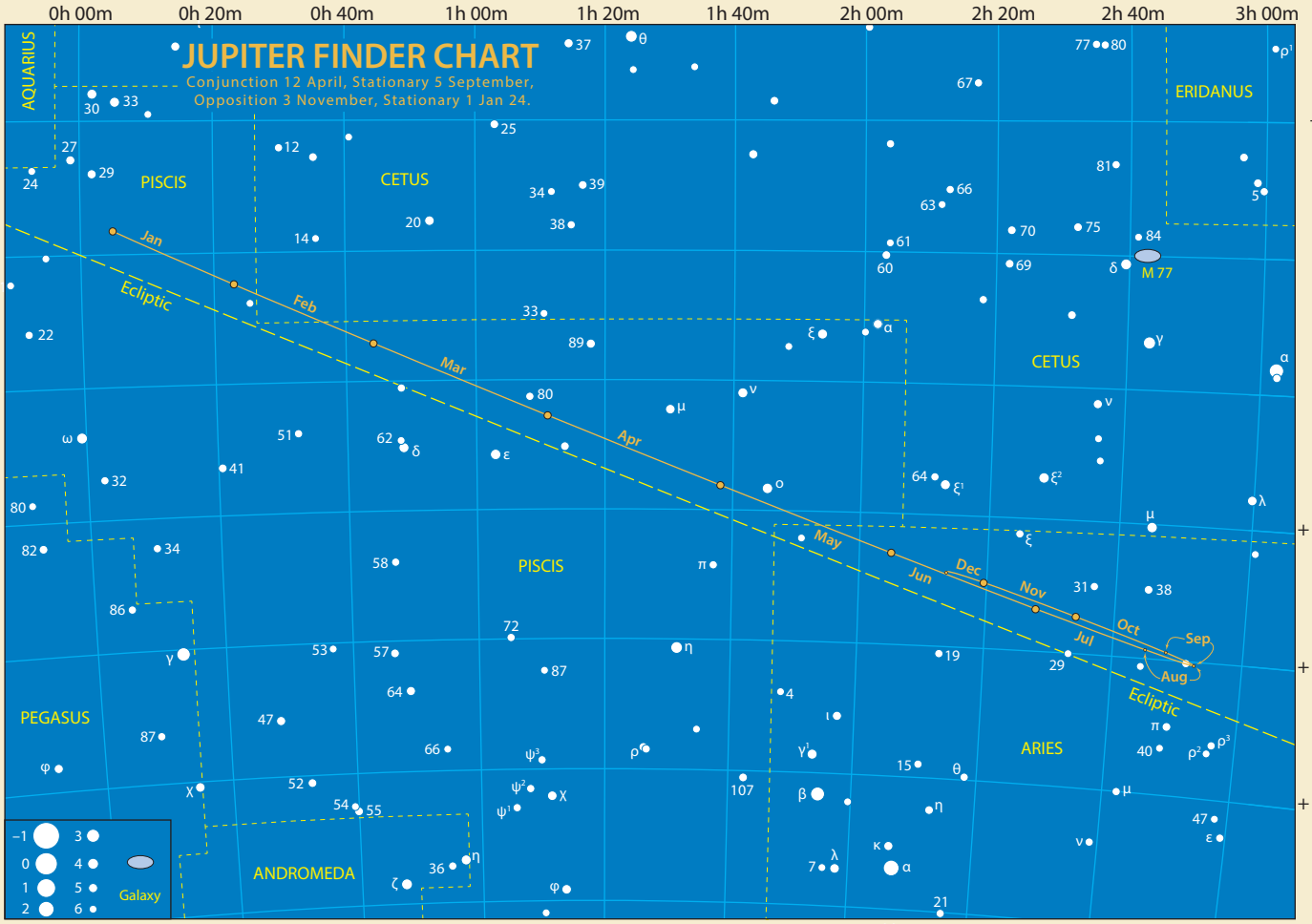
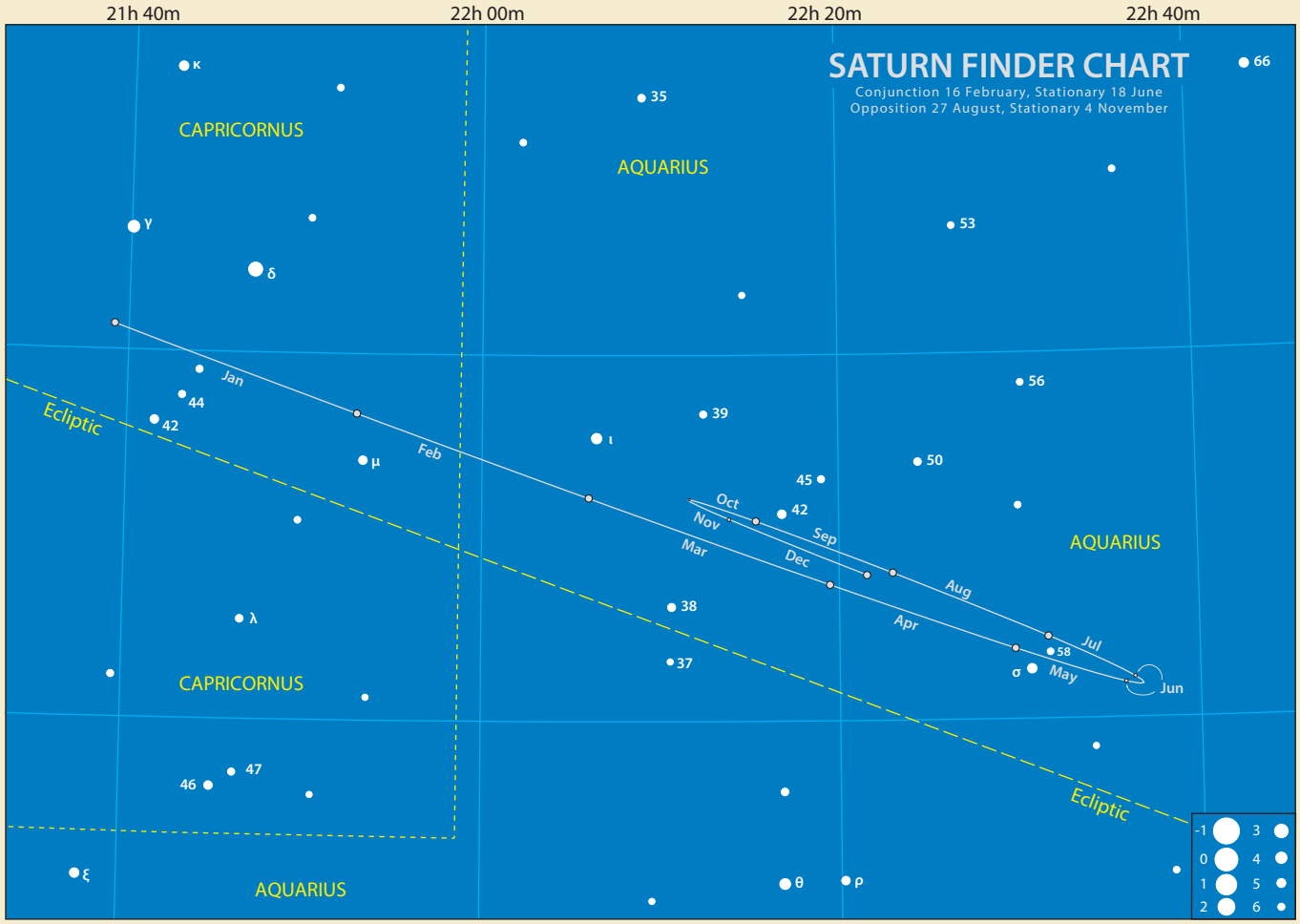


Table 2b: **Time of Greatest Elongation East** (UT)

Planet	**Neptune**
Moon	**Triton**
Magnitude [1]	13.5
Max Elong. [1]	0' 17"
Period (days) [2]	5.877
Month	**East** (d.ddd)
January	5.354
February	3.729
March	5.099
April	3.467
May	2.836
June	1.209
July	6.464
August	4.850
September	3.242
October	2.638
November	1.034
December	6.303

Notes 1. At opposition
2. Sidereal Period


JUPITER FINDER CHART
Conjunction 12 April, Stationary 5 September,
Opposition 3 November, Stationary 1 Jan 24.
0h 00m
0h 20m
0h 40m
1h 00m
1h 20m
1h 40m
2h 00m
2h 20m
2h 40m
3h 00m
− 5°
0°
+ 5°
+ 10°
+ 15°
+ 20°
AQUARIUS
PISCIS
CETUS
ERIDANUS
PEGASUS
ANDROMEDA
ARIES
M 77
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Galaxy


SATURN FINDER CHART
Conjunction 16 February, Stationary 18 June
Opposition 27 August, Stationary 4 November
21h 40m
22h 00m
22h 20m
22h 40m
−15°
−10°
CAPRICORNUS
AQUARIUS
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

COMETS FOR 2023

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 Lemon comet, mentioned (next page), is referred to as 'C/2021 T4'. 2021 refers to the year of the discovery, T is the 19th half-month period ('I' is not used) during the year and the 4 shows it was the fourth discovery in this half month. Therefore C/2021 T4 (Lemmon) was the fourth comet discovered in the first half of October 2021.

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 2023. 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 2023, 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 2023

by Greg Bryant

2P/Encke: Returning to perihelion every 3.3 years, one of the most famous comets is Encke. It was first sighted in 1786 by French comet hunter Pierre Mechain, who then jointly observed it with Charles Messier. The comet wasn't seen again until November 1795, this time by English astronomer Caroline Herschel. Another ten years would pass until European astronomers Jeans Pons, Johann Huth and Alexis Bouvard sighted the comet. Pons observed the comet again in 1818 and German astronomer Encke linked the comet with the sightings of previous years. Encke's prediction of the comet coming to perihelion again in 1822 was validated when Carl Rumker observed the comet from Parramatta, New South Wales.

62P/Tsuchinshan 1: This comet was found on an image taken on 1 January 1965 at Purple Mountain Observatory in Nanjing, China. Since the 1800s, several close approaches to Jupiter have successively reduced the comet's perihelion distance from 2.5 au to the current 1.3 au. Reaching perihelion on Christmas Day 2023, when it may brighten to 7th magnitude, Tsuchinshan 1 passes within 0.5 au of Earth a month later.

81P/Wild 2: Paul Wild discovered this comet on 6 January 1978 on images taken with a 0.4 m telescope in Switzerland. Four years prior to discovery, a close approach with Jupiter had moved the comet's perihelion distance from 5 au to the current 1.6 au. The Stardust spacecraft flew past the comet in 2004. Wild 2 reaches perihelion in December 2022 and may achieve 11th magnitude.

103P/Hartley 2: Malcom Hartley discovered this comet on an image taken on 15 March 1986 with the 1.2 m Schmidt telescope at Siding Spring. The comet was soon determined to be periodic, with close approaches to Jupiter in 1947 and 1971 moving the comet's perihelion distance from 2 au to 1 au. 2010 saw Hartley 2 become faintly visible to the unaided eye as it passed within 0.13 au of Earth, and it was the target of a flyby from the EPOXI spacecraft (formerly part of the Deep Impact mission). This year sees Hartley 2 reach perihelion in October and the comet may achieve 8th magnitude.

237P/LINEAR: Between 1998 and 2012, the Lincoln Near-Earth Asteroid Research (LINEAR) program operated a series of 1 m telescopes in New Mexico to search for minor planets and comets. Some 224 comets bear the name LINEAR, a record for ground-based discoveries that stood until being surpassed by the Pan-STARRS survey (below).

In 2010, a comet found on images taken with the WISE spacecraft was linked to an apparent asteroid discovered by LINEAR on 6 June 2002. Up until 1918, the comet perihelion's distance was 3.4 au, but a close approach to Jupiter that year and again in 2013 brought the comet closer to its current 2 au perihelion environment. At its last return in 2016, LINEAR was predicted to only reach 12th magnitude, but several observations saw it around 10th magnitude. This year's return, with the comet at perihelion in May 2023, is slightly more favourable. It remains to be seen as to whether the comet will be brighter than its forecast peak of 11th magnitude.

364P/PANSTARRS: Based in Hawaii, the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) survey saw first light in 2010 and currently consists of two telescopes scanning the sky north of declination –47°. At the time of writing (early July 2022), 272 comets have been discovered during the Pan-STARRS survey. Amongst ground-based surveys, it's ranked first.

On 13 February 2013, the survey found an asteroid that was subsequently revealed to be cometary in nature, orbiting every 4.9 years with a perihelion distance of 0.8 au. In 2023, 364P/PANSTARRS will come to within 0.13 au of Earth, its closest approach to us since 1954, and may reach 11th magnitude.

C/2017 K2 (PANSTARRS): Discovered more than five years ago on images taken on 21 May 2017, at which point the comet was only 21st magnitude and more than 16 au from the Sun, K2 PANSTARRS has been watched with interest by professional and amateur astronomers alike as it heads towards perihelion in December 2022. Never before had astronomers seen a comet showing the level of activity that it was at such a distance from the Sun. More recently, though, the rate of brightening for the comet has been slow and erratic, and it may be that it only peaks at around 8th magnitude in late 2022 and early 2023.

C/2020 K1 (PANSTARRS): In the space of a fortnight, from 17 to 30 May 2020, nine new comets were discovered. Six of them bear solely or jointly the name PANSTARRS. The first, C/2020 K1, was found on 17 May with pre-discovery images quickly found dating back a month to mid-April. At the time of discovery, K1 was nearly 10 au from both Earth and the Sun. The comet reaches perihelion in May 2023 at a distance of 3 au from the Sun and may reach 11th magnitude

BRIGHT COMETS FOR 2023 — ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
81P/Wild 2	2022 12 15.7303	1.597995	0.537045	6.4	41.6783	136.0969	3.2368	6.5	12.5
C/2017 K2 (PANSTARRS)	2022 12 19.6828	1.796923	1.000799		236.1973	88.2352	87.5619	4.5	7.5
C/2022 E3 (ZTF)	2023 01 12.7890	1.112258	1.000267		145.8150	302.5539	109.1685	8.5	7.5
C/2020 V2 (ZTF)	2023 05 08.5370	2.228012	1.000994		162.4192	212.3702	131.6110	4.5	10.0
C/2020 K1 (PANSTARRS)	2023 05 09.0664	3.073394	0.999952		213.9795	94.3555	89.6643	4.0	10.0
364P/PANSTARRS	2023 05 13.6548	0.799327	0.722363	4.9	211.9934	46.2027	12.1435	16.0	25.0
237P/LINEAR	2023 05 14.6053	1.986794	0.434333	6.6	25.2375	245.3759	14.0147	0.0	35.0
C/2021 T4 (Lemmon)	2023 07 31.5800	1.481957	0.999769		329.7854	257.7958	160.7553	9.0	7.5
103P/Hartley 2	2023 10 12.5163	1.064091	0.693831	6.5	181.3015	219.7498	13.6107	9.0	32.5
2P/Encke	2023 10 22.5243	0.339596	0.846935	3.3	187.2874	334.0197	11.3367	10.0	7.0
62P/Tsuchinshan 1	2023 12 25.0678	1.264968	0.624479	6.2	47.3074	68.6588	4.7373	5.0	32.5
C/2021 S3 (PANSTARRS)	2024 02 14.8163	1.318465	0.999715		6.9110	215.6474	58.5458	7.0	7.5

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.

deep in the southern sky. Comet PANSTARRS, like C/2017 K2 above, has an interesting orbit in being perpendicular to the plane of the Solar System.

C/2020 V2 (ZTF): The Zwicky Transient Facility (ZTF) is a wide-field robotic survey using the 1.2 m Samuel Oschin Schmidt Telescope at Palomar Observatory in California to scan the northern sky every two days. In operation since 2017, the survey discovered its first new comet in 2020. One month later, its second comet discovery, C/2020 V2, was found on images taken on 2 November 2020. Pre-discovery observations of the comet were found on images taken in April–June 2020 during the Mt Lemmon Survey (see below). Comet ZTF will reach perihelion on 8 May 2023 at a distance of 2.2 au from the Sun and is predicted to be 10th magnitude for much of the year.

C/2021 S3 (PANSTARRS): The fourth and final PANSTARRS comet in this year's coverage, C/2021 S3 was found on images taken on 24 September 2021. Nearly 20th magnitude at the time, and around 9 au from both Earth and the Sun at the time of discovery, PANSTARRS doesn't reach perihelion until February 2024. By the end of 2023, it may have brightened to 10th magnitude.

C/2021 T4 (Lemmon): Since 1998 the Lunar and Planetary Laboratory has conducted a survey for comets and minor planets from Mt Lemmon in Arizona. Comet C/2021 T4 was found as a 20th magnitude object on images taken with the 1.5 m reflector on 7 October 2021. Its cometary nature was revealed four days later. Perihelion is on 31 July 2023 at 1.5 au from the Sun, around which time the comet may reach 9th magnitude.

C/2022 E3 (ZTF): Another discovery from the ZTF survey, comet C/2022 E3 was found on images taken on 2 March 2022. Reaching perihelion on 12 January 2023 at a distance of 1.1 au from the Sun, comet ZTF will pass within 0.3 au of Earth a few weeks later in early February and may reach 7th magnitude in the evening sky around closest approach before fading rapidly as it moves away from both the Earth and the Sun.

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/2020 K1 (PANSTARRS)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
14 Jan	18 39.2	−27 22	4.212	3.272	03:35	11:03	18:29	12.3	Sgr
21 Jan	18 47.1	−28 32	4.152	3.250	03:11	10:44	18:14	12.2	Sgr
28 Jan	18 55.1	−29 43	4.081	3.228	02:47	10:24	17:59	12.1	Sgr
04 Feb	19 03.2	−30 57	4.002	3.208	02:22	10:05	17:44	12.1	Sgr
11 Feb	19 11.4	−32 15	3.915	3.189	01:58	09:43	17:30	12.0	Sgr
18 Feb	19 19.6	−33 37	3.820	3.172	01:32	09:23	17:17	11.9	Sgr
25 Feb	19 27.9	−35 05	3.718	3.156	01:06	09:04	17:04	11.8	Sgr
04 Mar	19 36.2	−36 39	3.611	3.141	00:40	08:45	16:52	11.8	Sgr
11 Mar	19 44.4	−38 20	3.500	3.127	00:12	08:25	16:42	11.7	Sgr
18 Mar	19 52.7	−40 11	3.387	3.115	23:42	08:06	16:33	11.6	Sgr
25 Mar	20 00.8	−42 12	3.272	3.105	23:10	07:47	16:26	11.5	Sgr
01 Apr	20 08.9	−44 24	3.158	3.096	22:36	07:27	16:21	11.4	Sgr
08 Apr	20 16.9	−46 48	3.047	3.088	21:57	07:08	16:21	11.3	Tel
15 Apr	20 24.7	−49 27	2.940	3.082	21:11	06:48	16:27	11.2	Tel
22 Apr	20 32.4	−52 20	2.839	3.078	20:12	06:28	16:46	11.1	Ind
29 Apr	20 39.9	−55 27	2.747	3.075		06:08		11.1	Ind
06 May	20 47.0	−58 48	2.666	3.074		05:48		11.0	Ind
13 May	20 53.7	−62 22	2.596	3.074		05:27		10.9	Pav
20 May	20 59.9	−66 07	2.541	3.075		05:06		10.9	Pav
27 May	21 05.1	−69 58	2.502	3.078		04:43		10.9	Pav
03 Jun	21 09.0	−73 53	2.479	3.083		04:20		10.9	Pav
10 Jun	21 10.2	−77 45	2.472	3.089		03:53		10.9	Oct
17 Jun	21 05.7	−81 30	2.481	3.097		03:21		10.9	Oct
24 Jun	20 44.5	−85 02	2.506	3.106		02:32		10.9	Oct
01 Jul	18 53.7	−87 59	2.546	3.117		00:06		11.0	Oct
08 Jul	12 51.2	−87 45	2.597	3.129		17:38		11.0	Oct
15 Jul	11 28.4	−85 18	2.659	3.142		15:52		11.1	Oct
22 Jul	11 11.1	−82 57	2.730	3.157		15:08		11.2	Cha
29 Jul	11 07.4	−80 54	2.807	3.174		14:37		11.3	Cha
05 Aug	11 08.6	−79 11	2.888	3.191		14:11		11.3	Cha
12 Aug	11 11.9	−77 46	2.972	3.210		13:47		11.4	Cha
19 Aug	11 16.4	−76 39	3.058	3.231		13:24		11.5	Cha
26 Aug	11 21.6	−75 50	3.143	3.252		13:02		11.6	Cha
02 Sep	11 27.1	−75 17	3.227	3.275		12:40		11.7	Mus
09 Sep	11 32.7	−75 00	3.308	3.299		12:18		11.8	Mus
16 Sep	11 38.3	−74 56	3.386	3.324		11:56		11.9	Mus
23 Sep	11 43.9	−75 06	3.460	3.350		11:34		11.9	Mus
30 Sep	11 49.1	−75 28	3.529	3.377		11:12		12.0	Mus

circumpolar

circumpolar

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. 141 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.

237P/LINEAR

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
11 Mar	18 09.7	−23 46	2.022	2.053	23:39	06:52	14:06	12.5	Sgr
18 Mar	18 24.1	−22 58	1.938	2.040	23:28	06:38	13:50	12.3	Sgr
25 Mar	18 37.9	−22 03	1.855	2.028	23:18	06:24	13:33	12.1	Sgr
01 Apr	18 51.0	−20 59	1.774	2.017	23:07	06:10	13:15	11.9	Sgr
08 Apr	19 03.3	−19 48	1.695	2.008	22:55	05:54	12:56	11.7	Sgr
15 Apr	19 14.7	−18 29	1.618	2.001	22:43	05:38	12:36	11.6	Sgr
22 Apr	19 25.1	−17 05	1.544	1.995	22:30	05:21	12:14	11.4	Sgr
29 Apr	19 34.4	−15 35	1.473	1.991	22:16	05:02	11:52	11.3	Sgr
06 May	19 42.5	−14 00	1.406	1.988	22:01	04:43	11:27	11.2	Sgr
13 May	19 49.2	−12 22	1.343	1.987	21:45	04:22	11:02	11.1	Sgr
20 May	19 54.5	−10 41	1.285	1.987	21:28	03:59	10:35	11.0	Aql
27 May	19 58.3	−09 00	1.231	1.989	21:08	03:35	10:06	10.9	Aql
03 Jun	20 00.5	−07 19	1.184	1.993	20:48	03:10	09:32	10.8	Aql
10 Jun	20 01.2	−05 42	1.144	1.998	20:25	02:43	09:01	10.8	Aql
17 Jun	20 00.3	−04 11	1.111	2.005	20:01	02:14	08:28	10.8	Aql
24 Jun	19 57.9	−02 48	1.086	2.013	19:34	01:44	07:54	10.8	Aql
01 Jul	19 54.4	−01 36	1.070	2.023	19:06	01:13	07:20	10.9	Aql
08 Jul	19 50.1	−00 37	1.064	2.034	18:37	00:41	06:46	10.9	Aql
15 Jul	19 45.2	+00 08	1.068	2.047	18:07	00:09	06:11	11.0	Aql
22 Jul	19 40.4	+00 37	1.082	2.060	17:36	23:37	05:38	11.2	Aql
29 Jul	19 35.9	+00 51	1.106	2.076	17:04	23:05	05:05	11.3	Aql
05 Aug	19 32.2	+00 52	1.141	2.092	16:33	22:34	04:34	11.5	Aql
12 Aug	19 29.7	+00 42	1.184	2.110	16:03	22:04	04:05	11.7	Aql
19 Aug	19 28.3	+00 23	1.237	2.129	15:33	21:35	03:37	11.9	Aql
26 Aug	19 28.4	−00 02	1.297	2.149	15:04	21:08	03:11	12.2	Aql

364P/(PANSTARRS)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
01 Apr	17 19.7	+31 03	0.143	1.044	00:18	04:52	09:27	12.3	Her
08 Apr	19 50.2	+22 19	0.124	0.980	01:49	06:58	11:45	11.3	Vul
15 Apr	21 51.0	+07 26	0.153	0.922	02:35	08:24	14:02	11.0	Peg
22 Apr	22 58.1	−01 59	0.212	0.873	02:47	08:59	15:06	11.0	Psc
29 Apr	23 37.8	−06 34	0.285	0.834	02:46	09:08	15:30	11.3	Aqr
06 May	00 05.3	−08 34	0.365	0.809	02:40	09:07	15:35	11.5	Cet
13 May	00 27.3	−09 07	0.449	0.799	02:33	09:01	15:30	11.8	Cet
20 May	00 46.3	−08 47	0.532	0.806	02:25	08:52	15:21	12.3	Cet

62P/Tsuchinshan 1

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
07 Oct	06 22.1	+21 49	1.075	1.567	00:15	05:17	10:20	11.5	Gem
14 Oct	06 44.5	+21 57	0.993	1.522	00:10	05:12	10:14	10.9	Gem
21 Oct	07 08.0	+21 57	0.917	1.480	00:06	05:08	10:10	10.3	Gem
28 Oct	07 32.6	+21 48	0.848	1.440	00:03	05:05	10:08	9.8	Gem
04 Nov	07 58.2	+21 28	0.786	1.404	23:59	05:03	10:07	9.3	Gem
11 Nov	08 24.7	+20 57	0.731	1.370	23:57	05:02	10:07	8.8	Cnc
18 Nov	08 51.9	+20 14	0.683	1.341	23:54	05:02	10:09	8.3	Cnc
25 Nov	09 19.5	+19 21	0.641	1.316	23:51	05:02	10:12	7.9	Cnc
02 Dec	09 46.9	+18 18	0.607	1.295	23:48	05:02	10:15	7.6	Leo
09 Dec	10 13.8	+17 07	0.579	1.280	23:44	05:01	10:18	7.3	Leo
16 Dec	10 39.7	+15 53	0.556	1.270	23:38	04:59	10:20	7.1	Leo
23 Dec	11 03.9	+14 38	0.538	1.265	23:31	04:55	10:20	7.0	Leo
30 Dec	11 26.1	+13 27	0.525	1.266	23:22	04:50	10:18	6.9	Leo
06 Jan '24	11 46.0	+12 23	0.515	1.273	23:11	04:42	10:13	7.0	Leo
13 Jan '24	12 03.1	+11 29	0.507	1.285	22:58	04:31	10:05	7.1	Vir
20 Jan '24	12 17.2	+10 47	0.503	1.303	22:42	04:17	09:52	7.2	Vir
27 Jan '24	12 28.2	+10 17	0.500	1.325	22:24	04:00	09:36	7.5	Vir
03 Feb '24	12 35.8	+10 00	0.501	1.352	22:03	03:40	09:16	7.8	Vir
10 Feb '24	12 40.2	+09 55	0.504	1.383	21:40	03:16	08:53	8.1	Vir
17 Feb '24	12 41.4	+09 58	0.511	1.418	21:13	02:50	08:26	8.5	Vir
24 Feb '24	12 39.8	+10 06	0.523	1.456	20:44	02:20	07:56	8.9	Vir
02 Mar '24	12 35.9	+10 15	0.541	1.497	20:13	01:49	07:24	9.4	Vir
09 Mar '24	12 30.5	+10 22	0.567	1.540	19:40	01:16	06:51	9.9	Vir
16 Mar '24	12 24.2	+10 21	0.601	1.585	19:07	00:42	06:17	10.4	Vir
23 Mar '24	12 18.1	+10 11	0.644	1.632	18:33	00:08	05:44	11.0	Vir
30 Mar '24	12 12.6	+09 52	0.696	1.681	17:59	23:35	05:12	11.5	Vir

C/2022 E3 (ZTF)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
07 Jan	15 51.4	+34 14	0.872	1.116	04:24	08:39	12:59	8.6	CrB
14 Jan	15 46.7	+40 09	0.672	1.112	04:22	08:06	11:58	8.0	Boo
21 Jan	15 32.7	+51 13	0.479	1.120	05:20	07:21	09:17	7.3	Boo
28 Jan	13 59.2	+73 53	0.325	1.139	too far north			6.5	UMi
04 Feb	05 29.2	+57 50	0.294	1.169	19:11	20:24	21:52	6.3	Cam
11 Feb	04 48.2	+26 12	0.419	1.209	14:31	19:20	00:12	7.2	Tau
18 Feb	04 39.8	+11 29	0.609	1.256	13:12	18:44	00:18	8.2	Tau
25 Feb	04 38.1	+04 05	0.817	1.311	12:23	18:15	00:08	8.9	Tau
04 Mar	04 38.9	−00 13	1.028	1.372	11:45	17:49	23:53	9.6	Eri
11 Mar	04 41.2	−03 00	1.236	1.437	11:12	17:23	23:35	10.1	Eri
18 Mar	04 44.3	−04 58	1.439	1.507	10:42	16:59	23:16	10.6	Eri
25 Mar	04 48.1	−06 27	1.635	1.579	10:15	16:35	22:56	11.1	Eri
01 Apr	04 52.4	−07 39	1.822	1.654	09:44	16:12	22:36	11.4	Eri
08 Apr	04 57.1	−08 40	1.999	1.730	09:19	15:49	22:16	11.8	Eri
15 Apr	05 02.1	−09 35	2.167	1.808	08:54	15:27	21:56	12.1	Eri
22 Apr	05 07.4	−10 27	2.324	1.887	08:29	15:04	21:36	12.4	Eri

C/2021 T4 (Lemmon)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
03 Jun	00 43.1	−14 20	1.769	1.693	01:09	07:51	14:38	12.0	Cet
10 Jun	00 40.6	−16 09	1.554	1.648	00:33	07:21	14:13	11.6	Cet
17 Jun	00 35.5	−18 46	1.335	1.609	23:52	06:48	13:49	11.2	Cet
24 Jun	00 26.1	−22 38	1.115	1.573	23:02	06:11	13:24	10.7	Cet
01 Jul	00 08.4	−28 33	0.903	1.543	21:54	05:24	13:00	10.2	Scl
08 Jul	23 32.4	−37 38	0.714	1.519	20:08	04:18	12:36	9.6	Scl
15 Jul	22 09.2	−49 51	0.579	1.500	16:44	02:21	12:16	9.1	Gru
22 Jul	19 18.0	−56 00	0.543	1.488	00:00	23:01	00:00	9.0	Tel
29 Jul	16 52.4	−47 19	0.626	1.482	11:08	20:17	05:15	9.3	Ara
05 Aug	15 48.8	−36 42	0.787	1.483	10:46	18:49	02:48	9.8	Lup
12 Aug	15 20.2	−29 14	0.986	1.491	10:23	17:54	01:24	10.3	Lib
19 Aug	15 05.6	−24 18	1.199	1.505	09:55	17:13	00:25	10.7	Lib
26 Aug	14 57.8	−20 55	1.414	1.525	09:31	16:38	23:40	11.1	Lib
02 Sep	14 53.6	−18 32	1.626	1.551	09:07	16:06	23:01	11.5	Lib
09 Sep	14 51.6	−16 46	1.830	1.582	08:43	15:36	22:26	11.8	Lib
16 Sep	14 51.1	−15 25	2.023	1.619	08:19	15:08	21:54	12.1	Lib
23 Sep	14 51.5	−14 22	2.203	1.660	07:55	14:41	21:24	12.4	Lib

2P/Encke

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
05 Aug	04 03.8	+29 35	1.599	1.533	02:33	07:07	11:43	12.3	Tau
12 Aug	04 29.6	+31 07	1.458	1.439	02:37	07:06	11:35	11.9	Per
19 Aug	05 00.0	+32 32	1.323	1.341	02:46	07:10	11:33	11.5	Aur
26 Aug	05 36.3	+33 38	1.198	1.239	03:00	07:19	11:37	11.0	Aur
02 Sep	06 20.0	+34 06	1.087	1.131	03:18	07:36	11:51	10.6	Aur
09 Sep	07 11.5	+33 26	0.995	1.019	03:39	08:01	12:18	10.0	Gem
16 Sep	08 09.8	+31 01	0.930	0.902	04:00	08:33	12:59	9.5	Cnc
23 Sep	09 11.0	+26 26	0.901	0.779	04:16	09:06	13:50	9.0	Cnc
30 Sep	10 10.5	+19 51	0.916	0.652	04:26	09:38	14:44	8.5	Leo
07 Oct	11 05.8	+11 56	0.978	0.524	04:29	10:01	15:35	8.0	Leo
14 Oct	11 57.8	+03 26	1.085	0.409	04:30	10:26	16:23	7.5	Vir
11 Nov	15 27.4	−23 16	1.557	0.596	04:54	12:05	19:19	9.4	Lib
18 Nov	16 11.7	−25 54	1.664	0.724	05:01	12:22	19:44	10.1	Sco
25 Nov	16 51.3	−27 24	1.777	0.849	05:08	12:34	20:01	10.8	Sco
02 Dec	17 26.5	−28 07	1.893	0.969	05:13	12:41	20:11	11.3	Oph
09 Dec	17 57.8	−28 17	2.012	1.083	05:16	12:45	20:15	11.8	Sgr
16 Dec	18 25.7	−28 03	2.130	1.192	05:17	12:45	20:14	12.2	Sgr
23 Dec	18 50.7	−27 34	2.245	1.297	05:16	12:43	20:09	12.5	Sgr

C/2020 V2 (ZTF)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
06 May	02 37.7	+25 25	3.217	2.228	06:47	11:40	16:30	10.5	Ari
13 May	02 42.8	+24 15	3.216	2.229	06:21	11:18	16:11	10.5	Ari
20 May	02 47.6	+23 05	3.202	2.232	05:54	10:55	15:52	10.5	Ari
27 May	02 52.2	+21 55	3.173	2.238	05:27	10:32	15:33	10.5	Ari
03 Jun	02 56.5	+20 42	3.131	2.247	05:00	10:09	15:14	10.5	Ari
10 Jun	03 00.5	+19 25	3.075	2.259	04:33	09:42	14:54	10.5	Ari
17 Jun	03 04.0	+18 04	3.007	2.274	04:04	09:18	14:34	10.5	Ari
24 Jun	03 07.1	+16 36	2.927	2.291	03:35	08:53	14:14	10.4	Ari
01 Jul	03 09.5	+14 59	2.837	2.311	03:06	08:28	13:53	10.4	Ari
08 Jul	03 11.4	+13 12	2.738	2.334	02:35	08:02	13:33	10.4	Ari
15 Jul	03 12.4	+11 12	2.632	2.359	02:02	07:36	13:12	10.3	Ari
22 Jul	03 12.5	+08 57	2.520	2.386	01:29	07:08	12:51	10.3	Cet
29 Jul	03 11.5	+06 24	2.407	2.415	00:53	06:39	12:29	10.2	Cet
05 Aug	03 09.2	+03 29	2.293	2.447	00:15	06:09	12:07	10.2	Cet
12 Aug	03 05.4	+00 10	2.184	2.481	23:35	05:38	11:45	10.1	Cet
19 Aug	02 59.8	−03 34	2.083	2.516	22:51	05:04	11:22	10.1	Eri
26 Aug	02 52.1	−07 44	1.995	2.553	22:05	04:29	10:58	10.1	Eri
02 Sep	02 42.2	−12 18	1.924	2.592	21:14	03:51	10:33	10.1	Cet
09 Sep	02 29.7	−17 08	1.877	2.633	20:20	03:11	10:07	10.1	Cet
16 Sep	02 14.8	−22 03	1.856	2.674	19:22	02:29	09:36	10.1	Cet
23 Sep	01 57.4	−26 48	1.864	2.718	18:21	01:44	09:07	10.2	For
30 Sep	01 38.1	−31 07	1.904	2.762	17:18	00:57	08:37	10.3	Scl
07 Oct	01 17.7	−34 48	1.972	2.808	16:14	00:09	08:05	10.5	Scl
14 Oct	00 57.1	−37 45	2.068	2.855	15:12	23:21	07:31	10.6	Scl
21 Oct	00 37.3	−39 56	2.186	2.902	14:14	22:34	06:55	10.8	Phe
28 Oct	00 19.2	−41 27	2.322	2.951	13:19	21:49	06:19	11.0	Phe
04 Nov	00 03.4	−42 24	2.473	3.000	12:30	21:06	05:41	11.2	Phe
11 Nov	23 50.1	−42 54	2.633	3.051	11:46	20:25	05:04	11.4	Phe
18 Nov	23 39.4	−43 05	2.800	3.102	11:07	19:47	04:27	11.7	Phe
25 Nov	23 31.1	−43 02	2.971	3.153	10:32	19:11	03:51	11.9	Phe
02 Dec	23 25.0	−42 51	3.141	3.206	09:55	18:38	03:16	12.0	Gru
09 Dec	23 20.8	−42 33	3.311	3.258	09:26	18:06	02:43	12.2	Gru

C/2021 S3 (PANSTARRS)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
07 Oct	10 17.3	−33 23	2.860	2.266	01:20	09:11	17:03	11.9	Ant
14 Oct	10 35.4	−34 30	2.780	2.193	01:06	09:02	16:59	11.8	Ant
21 Oct	10 54.2	−35 35	2.701	2.121	00:52	08:53	16:55	11.6	Ant
28 Oct	11 13.8	−36 38	2.621	2.050	00:39	08:45	16:52	11.4	Cen
04 Nov	11 34.2	−37 36	2.542	1.979	00:27	08:38	16:50	11.3	Cen
11 Nov	11 55.4	−38 28	2.463	1.910	00:16	08:32	16:48	11.1	Cen
18 Nov	12 17.4	−39 10	2.384	1.842	00:07	08:27	16:47	10.9	Cen
25 Nov	12 40.2	−39 42	2.304	1.776	23:59	08:22	16:45	10.7	Cen
02 Dec	13 03.7	−40 00	2.224	1.712	23:54	08:18	16:43	10.5	Cen
09 Dec	13 27.9	−40 03	2.144	1.651	23:50	08:15	16:39	10.3	Cen
16 Dec	13 52.7	−39 46	2.063	1.594	23:49	08:12	16:35	10.1	Cen
23 Dec	14 17.8	−39 09	1.982	1.540	23:51	08:10	16:29	9.9	Cen
30 Dec	14 43.2	−38 06	1.901	1.490	23:54	08:07	16:21	9.7	Cen
06 Jan '24	15 08.6	−36 37	1.820	1.445	00:01	08:05	16:11	9.5	Lup
13 Jan '24	15 33.8	−34 38	1.740	1.406	00:07	08:03	15:59	9.3	Lup
20 Jan '24	15 58.7	−32 07	1.662	1.374	00:16	08:00	15:45	9.1	Lup
27 Jan '24	16 23.1	−29 01	1.587	1.348	00:25	07:57	15:29	9.0	Sco
03 Feb '24	16 46.8	−25 19	1.517	1.330	00:35	07:53	15:12	8.8	Sco
10 Feb '24	17 09.8	−21 01	1.453	1.320	00:45	07:48	14:52	8.7	Oph
17 Feb '24	17 32.0	−16 07	1.398	1.319	00:55	07:42	14:32	8.6	Oph
24 Feb '24	17 53.3	−10 40	1.353	1.326	01:04	07:36	14:09	8.6	Ser
02 Mar '24	18 13.6	−04 47	1.321	1.340	01:13	07:28	13:46	8.6	Ser
09 Mar '24	18 32.9	+01 25	1.302	1.363	01:22	07:20	13:21	8.6	Ser
16 Mar '24	18 51.2	+07 45	1.297	1.393	01:29	07:10	12:54	8.6	Aql
23 Mar '24	19 08.3	+14 03	1.306	1.430	01:36	07:00	12:26	8.7	Aql

C/2017 K2 (PANSTARRS)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
05 Nov '22	16 25.9	−44 05	2.589	1.886	04:32	13:26	22:16	8.6	Nor
12 Nov '22	16 35.0	−46 27	2.595	1.861	03:55	13:08	22:17	8.6	Ara
19 Nov '22	16 45.6	−48 53	2.592	1.839	03:15	12:51	22:23	8.6	Ara
26 Nov '22	16 57.9	−51 24	2.580	1.822	02:29	12:35	22:39	8.5	Ara
03 Dec '22	17 12.2	−53 58	2.559	1.810	01:25	12:22	23:17	8.5	Ara
10 Dec '22	17 29.0	−56 38	2.531	1.801		12:12		8.4	Ara
17 Dec '22	17 49.1	−59 20	2.497	1.797		12:04		8.4	Pav
24 Dec '22	18 13.5	−62 03	2.458	1.798		12:01		8.4	Pav
31 Dec '22	18 43.7	−64 42	2.416	1.803		12:04		8.3	Pav
07 Jan	19 21.6	−67 09	2.373	1.812	circumpolar	12:14	circumpolar	8.3	Pav
14 Jan	20 09.1	−69 12	2.332	1.826		12:35		8.3	Pav
21 Jan	21 07.0	−70 30	2.295	1.844		13:05		8.3	Pav
28 Jan	22 12.3	−70 45	2.263	1.866		13:43		8.3	Ind
04 Feb	23 18.2	−69 44	2.240	1.892		14:21		8.3	Ind
11 Feb	00 17.4	−67 29	2.228	1.921		14:52		8.4	Tuc
18 Feb	01 06.7	−64 16	2.229	1.954		15:13		8.4	Tuc
25 Feb	01 46.5	−60 25	2.243	1.991		15:25		8.5	Hyi
04 Mar	02 18.7	−56 12	2.271	2.030		15:29		8.6	Hor
11 Mar	02 45.1	−51 51	2.314	2.071	05:28	15:28	01:28	8.7	Hor
18 Mar	03 07.5	−47 30	2.371	2.116	06:10	15:22	00:35	8.8	Hor
25 Mar	03 26.7	−43 19	2.440	2.162	06:33	15:14	23:55	8.9	Eri
01 Apr	03 43.7	−39 20	2.519	2.211	06:46	15:03	23:21	9.1	Eri
08 Apr	03 59.0	−35 37	2.608	2.261	06:52	14:51	22:50	9.2	Eri
15 Apr	04 12.8	−32 12	2.704	2.313	06:53	14:37	22:21	9.4	Eri
22 Apr	04 25.6	−29 05	2.804	2.367	06:50	14:23	21:54	9.5	Eri
29 Apr	04 37.6	−26 16	2.908	2.422	06:45	14:07	21:28	9.7	Eri
06 May	04 48.8	−23 44	3.012	2.478	06:37	13:51	21:03	9.9	Eri
13 May	04 59.3	−21 28	3.116	2.536	06:27	13:34	20:38	10.0	Lep
20 May	05 09.3	−19 27	3.218	2.594	06:16	13:16	20:14	10.1	Lep
27 May	05 18.8	−17 40	3.317	2.653	06:03	12:58	19:51	10.3	Lep
03 Jun	05 27.9	−16 05	3.411	2.713	05:49	12:40	19:27	10.4	Lep
10 Jun	05 36.5	−14 43	3.499	2.773	05:34	12:21	19:04	10.5	Lep
17 Jun	05 44.7	−13 31	3.580	2.834	05:18	12:01	18:42	10.7	Lep
24 Jun	05 52.5	−12 28	3.654	2.895	05:01	11:41	18:19	10.8	Lep
01 Jul	05 59.9	−11 35	3.719	2.957	04:44	11:21	17:56	10.9	Lep
08 Jul	06 06.9	−10 49	3.777	3.019	04:25	11:01	17:34	11.0	Mon
15 Jul	06 13.5	−10 11	3.824	3.082	04:06	10:40	17:11	11.1	Mon
22 Jul	06 19.6	−09 39	3.863	3.145	03:46	10:18	16:48	11.2	Mon
29 Jul	06 25.3	−09 13	3.892	3.208	03:25	09:53	16:25	11.2	Mon
05 Aug	06 30.5	−08 53	3.912	3.271	03:04	09:31	16:02	11.3	Mon
12 Aug	06 35.2	−08 38	3.922	3.334	02:41	09:08	15:38	11.4	Mon
19 Aug	06 39.4	−08 27	3.923	3.398	02:18	08:45	15:14	11.5	Mon
26 Aug	06 42.9	−08 19	3.915	3.461	01:55	08:21	14:50	11.5	Mon
02 Sep	06 45.9	−08 15	3.899	3.525	01:30	07:56	14:25	11.6	Mon
09 Sep	06 48.1	−08 13	3.875	3.588	01:05	07:30	14:00	11.6	Mon
16 Sep	06 49.7	−08 13	3.845	3.652	00:39	07:04	13:34	11.6	Mon
23 Sep	06 50.4	−08 14	3.810	3.715	00:12	06:38	13:07	11.7	Mon
30 Sep	06 50.4	−08 16	3.770	3.779	23:44	06:10	12:39	11.7	Mon
07 Oct	06 49.4	−08 17	3.727	3.842	23:16	05:41	12:11	11.7	Mon
14 Oct	06 47.6	−08 17	3.684	3.905	22:46	05:12	11:42	11.8	Mon
21 Oct	06 44.8	−08 16	3.641	3.969	22:16	04:41	11:11	11.8	Mon
28 Oct	06 41.0	−08 11	3.601	4.032	21:45	04:10	10:40	11.8	Mon
04 Nov	06 36.4	−08 02	3.566	4.095	21:13	03:38	10:07	11.9	Mon
11 Nov	06 30.8	−07 48	3.539	4.158	20:41	03:05	09:29	11.9	Mon
18 Nov	06 24.5	−07 28	3.521	4.221	20:08	02:31	08:54	11.9	Mon
25 Nov	06 17.5	−07 02	3.515	4.284	19:35	01:56	08:18	12.0	Mon
02 Dec	06 10.0	−06 29	3.522	4.346	19:01	01:21	07:41	12.0	Mon
09 Dec	06 02.3	−05 50	3.545	4.409	18:28	00:46	07:04	12.1	Mon
16 Dec	05 54.4	−05 04	3.584	4.471	17:54	00:11	06:27	12.2	Ori
23 Dec	05 46.7	−04 12	3.641	4.534	17:22	23:36	05:49	12.2	Ori
30 Dec	05 39.3	−03 15	3.715	4.596	16:49	23:01	05:12	12.3	Ori

81P/Wild 2

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
05 Nov '22	11 54.9	+01 21	2.212	1.648	02:53	08:54	14:56	10.9	Vir
12 Nov '22	12 14.0	−00 32	2.160	1.633	02:39	08:45	14:52	10.8	Vir
19 Nov '22	12 33.2	−02 24	2.110	1.620	02:26	08:37	14:49	10.7	Vir
26 Nov '22	12 52.5	−04 15	2.062	1.610	02:13	08:29	14:45	10.7	Vir
03 Dec '22	13 11.8	−06 04	2.017	1.603	01:59	08:20	14:42	10.6	Vir
10 Dec '22	13 31.3	−07 48	1.973	1.599	01:47	08:12	14:39	10.5	Vir
17 Dec '22	13 50.7	−09 27	1.931	1.598	01:34	08:04	14:35	10.5	Vir
24 Dec '22	14 10.0	−11 00	1.891	1.600	01:21	07:56	14:31	10.4	Vir
31 Dec '22	14 29.3	−12 26	1.853	1.605	01:09	07:47	14:27	10.4	Lib
07 Jan	14 48.3	−13 44	1.815	1.613	00:57	07:39	14:22	10.4	Lib
14 Jan	15 07.0	−14 53	1.778	1.624	00:44	07:30	14:17	10.4	Lib
21 Jan	15 25.3	−15 54	1.742	1.638	00:32	07:21	14:10	10.4	Lib
28 Jan	15 43.2	−16 45	1.706	1.655	00:20	07:11	14:03	10.4	Lib
04 Feb	16 00.4	−17 28	1.670	1.674	00:07	07:00	13:55	10.4	Lib
11 Feb	16 16.8	−18 02	1.634	1.695	23:54	06:49	13:45	10.4	Sco
18 Feb	16 32.4	−18 27	1.598	1.719	23:41	06:37	13:35	10.5	Oph
25 Feb	16 46.9	−18 46	1.560	1.745	23:27	06:24	13:23	10.5	Oph
04 Mar	17 00.3	−18 57	1.523	1.773	23:12	06:10	13:09	10.5	Oph
11 Mar	17 12.5	−19 03	1.485	1.802	22:57	05:54	12:54	10.6	Oph
18 Mar	17 23.2	−19 04	1.447	1.833	22:40	05:37	12:37	10.6	Oph
25 Mar	17 32.4	−19 01	1.410	1.866	22:21	05:18	12:18	10.6	Oph
01 Apr	17 40.0	−18 56	1.373	1.900	22:02	04:58	11:58	10.7	Oph
08 Apr	17 45.8	−18 48	1.337	1.935	21:40	04:36	11:36	10.7	Sgr
15 Apr	17 49.8	−18 41	1.304	1.971	21:17	04:13	11:12	10.8	Sgr
22 Apr	17 51.8	−18 33	1.275	2.008	20:51	03:47	10:46	10.8	Sgr
29 Apr	17 51.9	−18 26	1.249	2.046	20:24	03:19	10:18	10.9	Sgr
06 May	17 50.0	−18 20	1.230	2.085	19:55	02:50	09:44	10.9	Sgr
13 May	17 46.5	−18 17	1.219	2.124	19:24	02:18	09:13	11.0	Sgr
20 May	17 41.4	−18 14	1.216	2.164	18:52	01:46	08:40	11.1	Oph
27 May	17 35.3	−18 14	1.223	2.204	18:18	01:12	08:06	11.2	Oph
03 Jun	17 28.4	−18 15	1.242	2.245	17:44	00:38	07:32	11.4	Oph
10 Jun	17 21.4	−18 18	1.273	2.285	17:09	00:03	06:58	11.5	Oph
17 Jun	17 14.6	−18 22	1.315	2.326	16:34	23:29	06:24	11.7	Oph
24 Jun	17 08.5	−18 28	1.371	2.367	16:00	22:55	05:50	11.9	Oph
01 Jul	17 03.5	−18 36	1.437	2.409	15:28	22:23	05:18	12.1	Oph

103P/Hartley 2

Date	RA	Dec	Δ	R	Rise	Transit	Set	Mag	Con
	h m	° '	au	au	hh:mm	hh:mm	hh:mm		
12 Aug	00 50.3	+34 46	0.605	1.347	23:14	03:27	07:39	12.1	And
19 Aug	01 22.8	+38 03	0.544	1.295	23:35	03:32	07:29	11.3	And
26 Aug	02 02.6	+40 52	0.491	1.245	00:02	03:46	07:28	10.6	And
02 Sep	02 50.8	+42 42	0.448	1.200	00:34	04:07	07:40	9.8	Per
09 Sep	03 46.0	+42 58	0.416	1.159	01:03	04:36	08:09	9.2	Per
16 Sep	04 43.7	+41 10	0.394	1.125	01:21	05:06	08:51	8.6	Per
23 Sep	05 38.1	+37 20	0.384	1.098	01:26	05:32	09:38	8.2	Aur
30 Sep	06 25.1	+32 00	0.384	1.078	01:21	05:50	10:15	8.0	Aur
07 Oct	07 03.7	+25 56	0.394	1.067	01:09	06:00	10:48	7.9	Gem
14 Oct	07 34.7	+19 47	0.410	1.064	00:52	06:03	11:12	7.9	Gem
21 Oct	07 59.5	+13 59	0.431	1.071	00:32	05:59	11:26	8.1	Cnc
28 Oct	08 19.3	+08 42	0.455	1.086	00:09	05:51	11:33	8.5	Cnc
04 Nov	08 35.0	+04 01	0.480	1.109	23:44	05:38	11:33	8.9	Hya
11 Nov	08 47.2	−00 07	0.505	1.139	23:18	05:23	11:29	9.4	Hya
18 Nov	08 56.1	−03 42	0.528	1.176	22:49	05:04	11:20	9.9	Hya
25 Nov	09 02.0	−06 47	0.549	1.218	22:19	04:42	11:07	10.5	Hya
02 Dec	09 05.0	−09 22	0.570	1.266	21:47	04:17	10:49	11.1	Hya
09 Dec	09 05.2	−11 28	0.589	1.317	21:14	03:49	10:28	11.7	Hya
16 Dec	09 02.6	−13 03	0.608	1.371	20:39	03:19	10:02	12.4	Hya

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 14 bright minor or dwarf planets at opposition in 2023, plus Juno (3 Mar 2024). These include the most well-known four (Ceres, Pallas, Juno and Vesta) with the rest reaching magnitude 9.8 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
Jan 7	12 34.6	+ 09 45	8.4
14	12 39.6	+ 09 51	8.3
21	12 43.6	+ 10 04	8.2
28	12 46.4	+ 10 25	8.0
Feb 4	12 48.0	+ 10 54	7.9
11	12 48.2	+ 11 29	7.8
18	12 47.1	+ 12 11	7.6
25	12 44.7	+ 12 56	7.5
Mar 4	12 41.0	+ 13 43	7.3
11	12 36.3	+ 14 28	7.2
18	12 30.7	+ 15 09	7.2
25	12 24.8	+ 15 43	7.2
Apr 1	12 18.7	+ 16 07	7.2
8	12 13.0	+ 16 20	7.4
15	12 07.9	+ 16 22	7.5
22	12 03.7	+ 16 11	7.6
29	12 00.6	+ 15 50	7.8
May 6	11 58.7	+ 15 19	7.9
13	11 58.0	+ 14 39	8.1
20	11 58.5	+ 13 51	8.2
27	12 00.2	+ 12 57	8.3
Jun 3	12 02.9	+ 11 58	8.4
10	12 06.6	+ 10 54	8.5
17	12 11.1	+ 09 47	8.6
24	12 16.4	+ 08 37	8.7

2 Pallas

Date	RA hh mm	Dec ° ′	Mag
Jan 7	06 50.4	− 31 30	7.8
14	06 44.5	− 30 29	7.8
21	06 39.3	− 28 60	7.8
28	06 35.1	− 27 06	7.8
Feb 4	06 32.3	− 24 53	7.8
11	06 31.1	− 22 23	7.8
18	06 31.4	− 19 44	7.9
25	06 33.4	− 16 58	8.0
Mar 4	06 37.0	− 14 12	8.1
11	06 42.1	− 11 29	8.2
18	06 48.4	− 08 51	8.2
25	06 56.0	− 06 22	8.3
Apr 1	07 04.6	− 04 03	8.4
8	07 14.2	− 01 56	8.5
15	07 24.5	− 00 01	8.6
22	07 35.6	+ 01 42	8.7
29	07 47.2	+ 03 13	8.8
May 6	07 59.3	+ 04 32	8.9
13	08 11.8	+ 05 39	8.9
20	08 24.7	+ 06 35	9.0
27	08 37.7	+ 07 20	9.0
Jun 3	08 51.0	+ 07 56	9.1
10	09 04.4	+ 08 23	9.1
17	09 17.9	+ 08 41	9.2
24	09 31.4	+ 08 51	9.2

3 Juno

Date	RA hh mm	Dec ° ′	Mag
Jul 15	06 50.8	+ 14 30	9.7
22	07 06.6	+ 14 11	9.7
29	07 22.2	+ 13 46	9.8
Aug 5	07 37.5	+ 13 16	9.8
12	07 52.5	+ 12 42	9.9
19	08 07.1	+ 12 03	9.9
26	08 21.5	+ 11 20	10.0
Sep 2	08 35.5	+ 10 34	10.0
9	08 49.1	+ 09 45	10.0
16	09 02.4	+ 08 54	10.0
23	09 15.3	+ 08 01	10.1
30	09 27.7	+ 07 07	10.1
Oct 7	09 39.7	+ 06 12	10.1
14	09 51.3	+ 05 17	10.1
21	10 02.4	+ 04 22	10.1
28	10 12.9	+ 03 29	10.1
Nov 4	10 23.0	+ 02 37	10.1
11	10 32.4	+ 01 48	10.0
18	10 41.2	+ 01 02	10.0
25	10 49.3	+ 00 19	10.0
Dec 2	10 56.7	− 00 18	9.9
9	11 03.2	− 00 51	9.9
16	11 08.8	− 01 17	9.8
23	11 13.4	− 01 35	9.7
30	11 16.9	− 01 45	9.7

4 Vesta

Date	RA hh mm	Dec ° ′	Mag
Jul 15	04 31.0	+ 17 23	8.6
22	04 42.4	+ 17 47	8.6
29	04 53.5	+ 18 07	8.6
Aug 5	05 04.4	+ 18 24	8.6
12	05 15.0	+ 18 38	8.6
19	05 25.2	+ 18 48	8.5
26	05 34.9	+ 18 56	8.5
Sep 2	05 44.2	+ 19 01	8.4
9	05 52.8	+ 19 03	8.4
16	06 00.9	+ 19 04	8.3
23	06 08.1	+ 19 04	8.2
30	06 14.6	+ 19 03	8.2
Oct 7	06 20.1	+ 19 01	8.1
14	06 24.5	+ 19 00	8.0
21	06 27.8	+ 18 60	7.8
28	06 29.7	+ 19 01	7.7
Nov 4	06 30.3	+ 19 05	7.6
11	06 29.3	+ 19 11	7.5
18	06 26.8	+ 19 19	7.3
25	06 22.8	+ 19 31	7.2
Dec 2	06 17.5	+ 19 45	7.0
9	06 10.9	+ 20 00	6.9
16	06 03.5	+ 20 18	6.7
23	05 55.6	+ 20 36	6.6
30	05 47.8	+ 20 54	6.7

5 Astraea

Date	RA hh mm	Dec ° ′	Mag
Jul 15	04 17.3	+ 16 56	12.3
22	04 29.4	+ 17 19	12.3
29	04 41.3	+ 17 38	12.3
Aug 5	04 53.2	+ 17 53	12.2
12	05 04.9	+ 18 04	12.2
19	05 16.3	+ 18 10	12.1
26	05 27.5	+ 18 13	12.0
Sep 2	05 38.3	+ 18 12	12.0
9	05 48.7	+ 18 08	11.9
16	05 58.6	+ 18 00	11.8
23	06 07.9	+ 17 50	11.7
30	06 16.5	+ 17 37	11.6
Oct 7	06 24.4	+ 17 22	11.5
14	06 31.3	+ 17 06	11.3
21	06 37.2	+ 16 49	11.2
28	06 42.0	+ 16 33	11.1
Nov 4	06 45.5	+ 16 18	10.9
11	06 47.5	+ 16 05	10.7
18	06 48.0	+ 15 54	10.5
25	06 46.9	+ 15 48	10.3
Dec 2	06 44.2	+ 15 46	10.1
9	06 40.0	+ 15 49	9.9
16	06 34.4	+ 15 57	9.7
23	06 27.9	+ 16 10	9.5
30	06 20.9	+ 16 27	9.4

6 Hebe

Date	RA hh mm	Dec ° ′	Mag
Jan 7	08 45.4	+ 10 27	9.1
14	08 39.3	+ 11 27	8.9
21	08 32.5	+ 12 33	8.8
28	08 25.5	+ 13 43	8.7
Feb 4	08 18.7	+ 14 53	8.9
11	08 12.6	+ 15 60	9.1
18	08 07.4	+ 17 03	9.3
25	08 03.6	+ 17 59	9.5
Mar 4	08 01.1	+ 18 49	9.7
11	08 00.0	+ 19 31	9.8
18	08 00.5	+ 20 06	10.0
25	08 02.2	+ 20 33	10.1
Apr 1	08 05.3	+ 20 54	10.3
8	08 09.5	+ 21 08	10.4
15	08 14.7	+ 21 17	10.5
22	08 20.7	+ 21 19	10.6
29	08 27.6	+ 21 17	10.7
May 6	08 35.1	+ 21 09	10.8
13	08 43.2	+ 20 56	10.9
20	08 51.8	+ 20 39	11.0
27	09 00.7	+ 20 18	11.1
Jun 3	09 10.0	+ 19 53	11.1
10	09 19.6	+ 19 24	11.2
17	09 29.4	+ 18 52	11.2
24	09 39.4	+ 18 16	11.2

7 Iris

Date	RA hh mm	Dec ° ′	Mag
Feb 4	14 43.4	− 20 51	11.1
11	14 47.8	− 21 18	11.0
18	14 51.3	− 21 40	10.9
25	14 53.7	− 21 57	10.8
Mar 4	14 55.0	− 22 09	10.7
11	14 55.0	− 22 16	10.6
18	14 53.7	− 22 16	10.5
25	14 51.2	− 22 10	10.4
Apr 1	14 47.4	− 21 57	10.2
8	14 42.6	− 21 38	10.1
15	14 36.8	− 21 11	9.9
22	14 30.4	− 20 38	9.8
29	14 23.7	− 19 60	9.6
May 6	14 17.0	− 19 18	9.7
13	14 10.7	− 18 35	9.8
20	14 05.0	− 17 52	10.0
27	14 00.2	− 17 11	10.2
Jun 3	13 56.5	− 16 35	10.3
10	13 53.9	− 16 04	10.4
17	13 52.5	− 15 39	10.6
24	13 52.3	− 15 21	10.7
Jul 1	13 53.2	− 15 10	10.8
8	13 55.1	− 15 05	10.9
15	13 58.1	− 15 06	11.0
22	14 01.9	− 15 12	11.1

8 Flora

Date	RA hh mm	Dec ° ′	Mag
Jun 3	22 21.2	− 12 11	10.5
10	22 28.8	− 11 51	10.4
17	22 35.6	− 11 37	10.2
24	22 41.5	− 11 30	10.0
Jul 1	22 46.3	− 11 33	9.9
8	22 49.8	− 11 45	9.7
15	22 52.1	− 12 07	9.5
22	22 52.8	− 12 41	9.3
29	22 52.1	− 13 25	9.1
Aug 5	22 49.7	− 14 18	8.9
12	22 46.0	− 15 20	8.7
19	22 40.9	− 16 25	8.5
26	22 34.9	− 17 31	8.4
Sep 2	22 28.5	− 18 32	8.4
9	22 22.2	− 19 25	8.6
16	22 16.5	− 20 07	8.7
23	22 12.0	− 20 34	8.9
30	22 09.0	− 20 48	9.0
Oct 7	22 07.7	− 20 48	9.2
14	22 08.2	− 20 34	9.3
21	22 10.4	− 20 09	9.4
28	22 14.3	− 19 33	9.6
Nov 4	22 19.7	− 18 48	9.7
11	22 26.5	− 17 53	9.8
18	22 34.4	− 16 52	9.9

9 Metis

Date	RA hh mm	Dec ° ′	Mag
Jul 15	03 46.7	+ 17 20	11.1
22	04 00.4	+ 18 07	11.1
29	04 13.8	+ 18 50	11.1
Aug 5	04 27.2	+ 19 30	11.0
12	04 40.3	+ 20 05	11.0
19	04 53.2	+ 20 35	10.9
26	05 05.7	+ 21 03	10.8
Sep 2	05 17.9	+ 21 26	10.8
9	05 29.5	+ 21 47	10.7
16	05 40.5	+ 22 05	10.6
23	05 50.8	+ 22 21	10.5
30	06 00.3	+ 22 36	10.4
Oct 7	06 08.8	+ 22 50	10.3
14	06 16.1	+ 23 05	10.2
21	06 22.2	+ 23 21	10.0
28	06 26.8	+ 23 39	9.9
Nov 4	06 29.9	+ 23 59	9.7
11	06 31.1	+ 24 23	9.6
18	06 30.4	+ 24 50	9.4
25	06 27.9	+ 25 20	9.2
Dec 2	06 23.4	+ 25 51	9.0
9	06 17.4	+ 26 23	8.8
16	06 10.1	+ 26 52	8.6
23	06 02.2	+ 27 19	8.4
30	05 54.3	+ 27 41	8.6

10 Hygiea

Date	RA hh mm	Dec ° ′	Mag
May 20	21 32.7	− 13 09	11.0
27	21 36.4	− 12 42	11.0
Jun 3	21 39.1	− 12 18	10.9
10	21 40.8	− 11 59	10.8
17	21 41.5	− 11 45	10.7
24	21 41.1	− 11 35	10.6
Jul 1	21 39.7	− 11 31	10.5
8	21 37.2	− 11 33	10.3
15	21 33.7	− 11 39	10.2
22	21 29.4	− 11 50	10.1
29	21 24.4	− 12 04	9.9
Aug 5	21 19.1	− 12 22	9.8
12	21 13.5	− 12 40	9.7
19	21 08.1	− 12 60	9.9
26	21 03.1	− 13 18	10.1
Sep 2	20 58.7	− 13 35	10.2
9	20 55.1	− 13 49	10.4
16	20 52.5	− 13 60	10.5
23	20 51.0	− 14 07	10.7
30	20 50.6	− 14 11	10.8
Oct 7	20 51.2	− 14 11	10.9
14	20 52.9	− 14 07	11.0
21	20 55.5	− 13 59	11.1
28	20 59.1	− 13 47	11.2
Nov 4	21 03.4	− 13 32	11.3

11 Parthenope

Date	RA hh mm	Dec ° ′	Mag
Mar 11	16 59.4	− 17 38	11.3
18	17 06.5	− 17 38	11.2
25	17 12.5	− 17 35	11.1
Apr 1	17 17.5	− 17 29	11.0
8	17 21.3	− 17 22	10.8
15	17 23.7	− 17 14	10.7
22	17 24.7	− 17 05	10.5
29	17 24.3	− 16 55	10.3
May 6	17 22.3	− 16 46	10.2
13	17 18.8	− 16 38	10.0
20	17 14.1	− 16 30	9.8
27	17 08.2	− 16 25	9.6
Jun 3	17 01.6	− 16 21	9.4
10	16 54.6	− 16 20	9.4
17	16 47.8	− 16 22	9.5
24	16 41.6	− 16 28	9.7
Jul 1	16 36.3	− 16 37	9.9
8	16 32.3	− 16 50	10.0
15	16 29.6	− 17 07	10.2
22	16 28.6	− 17 27	10.3
29	16 29.1	− 17 51	10.4
Aug 5	16 31.1	− 18 17	10.6
12	16 34.5	− 18 45	10.7
19	16 39.3	− 19 15	10.8
26	16 45.4	− 19 45	10.9

15 Eunomia

Date	RA hh mm	Dec ° ′	Mag
Apr 15	19 25.1	− 27 33	10.6
22	19 30.2	− 27 19	10.5
29	19 34.2	− 27 04	10.4
May 6	19 37.1	− 26 51	10.3
13	19 38.8	− 26 39	10.2
20	19 39.2	− 26 28	10.0
27	19 38.2	− 26 18	9.9
Jun 3	19 35.9	− 26 09	9.7
10	19 32.2	− 25 60	9.6
17	19 27.2	− 25 50	9.4
24	19 21.1	− 25 38	9.2
Jul 1	19 14.2	− 25 25	9.0
8	19 06.8	− 25 09	8.8
15	18 59.3	− 24 50	9.0
22	18 52.1	− 24 28	9.1
29	18 45.6	− 24 04	9.2
Aug 5	18 40.2	− 23 39	9.4
12	18 36.1	− 23 13	9.5
19	18 33.3	− 22 47	9.6
26	18 32.1	− 22 22	9.7
Sep 2	18 32.3	− 21 57	9.8
9	18 33.9	− 21 33	9.9
16	18 36.9	− 21 09	10.0
23	18 41.1	− 20 46	10.1
30	18 46.4	− 20 23	10.2

18 Melpomene

Date	RA hh mm	Dec ° ′	Mag
Jul 15	01 42.0	+ 05 55	10.1
22	01 55.4	+ 06 21	10.0
29	02 08.4	+ 06 38	9.9
Aug 5	02 20.8	+ 06 47	9.8
12	02 32.6	+ 06 46	9.6
19	02 43.6	+ 06 34	9.5
26	02 53.6	+ 06 12	9.4
Sep 2	03 02.5	+ 05 39	9.2
9	03 10.1	+ 04 55	9.1
16	03 16.1	+ 04 01	9.0
23	03 20.5	+ 02 57	8.8
30	03 22.9	+ 01 47	8.6
Oct 7	03 23.5	+ 00 32	8.5
14	03 22.2	− 00 45	8.4
21	03 19.1	− 01 58	8.2
28	03 14.5	− 03 03	8.1
Nov 4	03 09.1	− 03 55	8.1
11	03 03.2	− 04 30	8.2
18	02 57.5	− 04 47	8.3
25	02 52.6	− 04 43	8.4
Dec 2	02 48.8	− 04 20	8.6
9	02 46.5	− 03 41	8.8
16	02 45.9	− 02 48	9.0
23	02 46.9	− 01 44	9.2
30	02 49.4	− 00 32	9.4

29 Amphitrite

Date	RA hh mm	Dec ° ′	Mag
Jul 8	00 39.3	+ 02 54	10.8
15	00 44.6	+ 03 39	10.7
22	00 49.1	+ 04 19	10.6
29	00 52.5	+ 04 54	10.4
Aug 5	00 54.9	+ 05 24	10.3
12	00 56.1	+ 05 47	10.2
19	00 55.9	+ 06 05	10.0
26	00 54.5	+ 06 15	9.9
Sep 2	00 51.7	+ 06 18	9.7
9	00 47.7	+ 06 15	9.5
16	00 42.5	+ 06 05	9.3
23	00 36.5	+ 05 49	9.2
30	00 29.9	+ 05 30	8.9
Oct 7	00 23.3	+ 05 08	9.0
14	00 16.9	+ 04 47	9.2
21	00 11.3	+ 04 27	9.4
28	00 06.6	+ 04 12	9.5
Nov 4	00 03.2	+ 04 02	9.7
11	00 01.2	+ 03 59	9.8
18	00 00.6	+ 04 03	10.0
25	00 01.4	+ 04 14	10.1
Dec 2	00 03.6	+ 04 33	10.3
9	00 07.0	+ 04 59	10.4
16	00 11.5	+ 05 31	10.5
23	00 17.1	+ 06 09	10.6

37 Fides

Date	RA hh mm	Dec ° ′	Mag
Jul 15	03 36.4	+ 20 35	12.2
22	03 49.6	+ 21 25	12.2
29	04 02.8	+ 22 11	12.1
Aug 5	04 15.8	+ 22 53	12.1
12	04 28.6	+ 23 31	12.0
19	04 41.1	+ 24 05	11.9
26	04 53.2	+ 24 35	11.9
Sep 2	05 04.9	+ 25 02	11.8
9	05 16.0	+ 25 26	11.7
16	05 26.5	+ 25 47	11.6
23	05 36.2	+ 26 06	11.5
30	05 44.9	+ 26 23	11.4
Oct 7	05 52.6	+ 26 39	11.3
14	05 59.1	+ 26 54	11.2
21	06 04.1	+ 27 09	11.0
28	06 07.7	+ 27 25	10.9
Nov 4	06 09.5	+ 27 40	10.8
11	06 09.5	+ 27 56	10.6
18	06 07.7	+ 28 12	10.4
25	06 04.0	+ 28 27	10.3
Dec 2	05 58.8	+ 28 39	10.1
9	05 52.3	+ 28 47	9.9
16	05 45.1	+ 28 50	9.8
23	05 37.6	+ 28 49	9.8
30	05 30.7	+ 28 42	10.0

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.

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

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

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

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

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Quadrantids (QUA)	FQ	Dec 26 – Jan 12	Jan 04	230˚	+49˚	41	110
alpha-Centaurids (ACE)	FM	Jan 28 – Feb 21	Feb 08	210˚	–59˚	58	6
gamma-Normids (GNO)	LQ	Feb 25 – Mar 28	Mar 14	239˚	–50˚	56	6
Lyrids (LYR)	NM	Apr 16 – Apr 25	Apr 22	271˚	+34˚	49	18
pi-Puppids (PPU)*	NM	Apr 15 – Apr 28	Apr 23	110˚	–45˚	18	var
eta-Aquarids (ETA)	FM	Apr 19 – May 28	May 07	338˚	–01˚	66	50
eta-Lyrids (ELY)	FM	May 03 – May 14	May 08	287˚	+44˚	43	3
June Bootids (JBO)*	FQ	Jun 22 – Jul 02	Jun 27	224˚	+48˚	18	var
Pisces Austrinids (PAU)	FM	Jul 15 – Aug 10	Jul 29	341˚	–30˚	35	5
Southern delta-Aquarids (SDA)	FM	Jul 18 – Aug 23	Jul 30	340˚	–16˚	41	25
alpha-Capricornids (CAP)	FM	Jul 03 – Aug 15	Jul 30	307˚	–10˚	23	5
Perseids (PER)	NM	Jul 17 – Aug 24	Aug 13	048˚	+58˚	59	100
kappa-Cygnids (KCG)	NM	Aug 03 – Aug 25	Aug 17	286˚	+59˚	25	3
Aurigids (AUR)	FM	Aug 28 – Sep 05	Sep 01	091˚	+39˚	66	6
September Perseids (SPE)	LQ	Sep 05 – Sep 21	Sep 09	048˚	+40˚	64	5
Draconids (DRA)*	LQ	Oct 06 – Oct 10	Oct 08	262˚	+54˚	20	10
Southern Taurids (STA)	LQ	Sep 10 – Nov 20	Oct 10	032˚	+09˚	27	5
delta-Aurigids (DAU)	NM	Oct 10 – Oct 18	Oct 11	084˚	+44˚	64	2
epsilon-Geminids (EGE)	FQ	Oct 14 – Oct 27	Oct 18	102˚	+27˚	70	3
Orionids (ORI)	FQ	Oct 02 – Nov 07	Oct 22	095˚	+16˚	66	20
Leo Minorids (LMI)	FQ	Oct 19 – Oct 27	Oct 24	162˚	+37˚	62	2
Northern Taurids (NTA)	NM	Oct 20 – Dec 10	Nov 13	058˚	+22˚	29	5
Leonids (LEO)	FQ	Nov 06 – Nov 30	Nov 18	152˚	+22˚	71	10
alpha-Monocerotids (AMO)	FQ	Nov 15 – Nov 25	Nov 21	117˚	+01˚	65	Var
Phoenicids (PHO)	LQ	Nov 28 – Dec 09	Dec 02	018˚	–53˚	18	Var
Puppid-Velids (PUP)	LQ	Dec 01 – Dec 15	Dec 07	123˚	–45˚	40	10
Monocerotids (MON)	NM	Dec 05 – Dec 20	Dec 09	100˚	+08˚	42	3
sigma-Hydrids (HYD)	NM	Dec 03 – Dec 20	Dec 09	127˚	+02˚	58	7
Geminids (GEM)	NM	Dec 04 – Dec 17	Dec 14	112˚	+33˚	35	150
Coma Berenicids (COM)	FQ	Dec 12 – Dec 23	Dec 16	175˚	+18˚	65	3
Dec. Leonis Minorids (DLM)	FQ	Dec 05 – Feb 04	Dec 19	161˚	+30˚	64	5
Ursids (URS)	FQ	Dec 17 – Dec 26	Dec 22	217˚	+75˚	33	10

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. 152). They were usually ordered by their brightness, Alpha being the brightest in most cases.

Name Common name for each star.

Constellation The star's constellation.

RA and Dec. The position of the star, epoch 2000.0.

Magnitude App. The apparent magnitude as seen in the sky.

Magnitude Abs. The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light-years) from Earth.

Spectral Type The spectral classification of the star (see below).

Parallax see glossary.

Proper Motion see glossary.

Distance, ly is light-year and **pc** is parsec, see glossary.

Note (d) is a visual double star.
(sb) is a spectroscopic binary.
(eb) is an eclipsing binary.
(v) indicates the star is variable.

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O**, **B**, **A**, **F**, **G**, **K** and **M**, remembered by the mnemonic **O**h **B**e **A** **F**ine **G**irl(**G**uy) **K**iss **M**e.

There are also the *colder* star classes **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel).
- **F** and **G** are yellow (e.g., Capella, and the Sun).
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (that is no colour).

The colours of stars can be imaged simply. Mount a camera on a tripod and take a time exposure of several minutes. The resulting star trails often show the colours very well. An equatorially tracked time exposure (for example piggy-backed on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images can saturate the detector. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

	Designation	Name	Constellation	RA (2000.0)	Dec (2000.0)	Magnitude App	Magnitude Abs	Spectral Type	Parallax	Distance pc	Distance ly	Note (p. 141)
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	Magnitude Absolute	Spect Type	Parallax "	Proper Motion "/yr	Distance pc	Distance ly
--	Sun					−26.72	4.85	G2 V				
1	Proxima Centauri		Centaurus	14 29.7	−62 40	11.09	15.53	M5.5 V	0.7720	3.85	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	−60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		B				1.34	5.71	K0 V				
2	Barnard's Star		Ophiuchus	17 57.8	+04 41	9.53	13.22	M4.0 V	0.5470	10.36	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	−16 43	−1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		B				8.44	11.34	DA2				
6	L 726-8 (UV Ceti)	A	Cetus	01 39.0	−17 57	12.54	15.40	M5.5 V	0.3737	3.37	2.68	8.73
		B				12.99	15.85	M6.0 V				
7	Ross 154		Sagittarius	18 49.8	−23 50	10.43	13.07	M3.5 V	0.3369	0.67	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	−09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	−35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	−15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		B				13.27	15.58	M				
		C				14.03	16.34	M				
13	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.66	F5 IV–V	0.2861	1.26	3.50	11.40
		B				10.70	12.98	DA				
14	61 Cygni	A	Cygnus	21 06.9	+38 45	5.21	7.49	K5.0 V	0.2860	5.28	3.50	11.40
		B				6.03	8.31	K7.0 V				
15	Σ 2398	A	Draco	18 42.8	+59 38	8.90	11.16	M3.0 V	0.2830	2.24	3.53	11.53
		B				9.69	11.95	M3.5 V				
16	Groombridge 34	A	Andromeda	00 18.4	+44 01	8.08	10.32	M1.5 V	0.2806	2.92	3.56	11.63
		B				11.06	13.30	M3.5 V				
17	Epsilon Indi		Indus	22 03.4	−56 47	4.69	6.89	K5 Ve	0.2758	4.70	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	−15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	−44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	−17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten's Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

DEEP SKY OBJECTS

Catalogue #	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 145 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 10 pm	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 10 pm	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

ASTRONOMY AND SCIENCE CENTRE (TAMWORTH)

The Tamworth Regional Astronomy Club Inc runs the Astronomy and Science Centre, open to the general public on Saturdays from 10 am to 2 pm to view the range of scientific displays, equipment and large telescopes. It is adjacent to the Botanical Gardens, Piper St, Tamworth. Please phone 0458 772 747 for confirmation and details. www.tamworthastronomy.com.au

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 south-west of Canberra, is a major link in NASA's Deep Space Network and is managed on their behalf by CSIRO. The facility provides two-way radio communication with distant robotic 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 Cafe. 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 Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available. Contact (02) 6861 1777
email <VCStaff-PA@csiro.au> 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, email <peter@dubboobservatory.com>
www.dubboobservatory.com

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 any Thursday night, with guest speakers on the 1st Thursday of the month. 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 0428 288 244, email <donna@donnatheastronomer.com.au>
www.donnatheastronomer.com.au
www.facebook.com/milroyCoonabarabran

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 is open to the public Friday and Sunday nights and also on Wednesday nights during school holidays. For further information visit their website. Bookings are under the Open Nights tab through trybooking. Email <pmobs.info@gmail.com> 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 cafe 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. www.maas.museum/Sydney-observatory

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

WESTERN SYDNEY UNIVERSITY PENRITH OBSERVATORY

The Western Sydney University Penrith Observatory runs public astronomy nights, public hands-on workshops, private school and group programs. A visit can include listening to lectures on various aspects of astronomy, a 3D astronomy movie and viewing through a variety of telescopes. Contact, see website
www.westernsydney.edu.au/observatory

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 Cafe has you covered with an extensive menu and daily lunch specials. If you love the night sky and learning about astronomy, this is the place for you.
Phone: (07) 4654 7771 | Group/educational packages available
on request: (07) 4656 8360 Contact (07) 4656 8377. www.cosmoscentre.com
www.experiencecharleville.com.au

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. Holiday accommodation is available on

the mountain for up to 10, or for a single or couple on site. 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 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. Telescope sessions must be pre-booked. School shows are also available during weekdays. Open Tuesday to Sunday (open on Monday during Qld school holidays). Contact (07) 3403 2578 email <bop@brisbane.qld.gov.au> www.brisbane.qld.gov.au/planetarium/ www.facebook.com/BrisbanePlanetarium

SOUTH AUSTRALIA

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 and 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 3000 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 × 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 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. 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

VICTORIA

ASTROTOURS SWINBURNE

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during school holidays. AstroTour sessions can also be booked for school groups (Years 3–12) throughout the year. Contact Dr Rebecca Allen, 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

BENDIGO PLANETARIUM @ DISCOVERY

This small planetarium inside The Discovery Science and Technology Centre, is interactive and engaging. A visit to this planetarium will take you for a trip through our Solar System and give you a chance to see tonight's sky today. Contact (03) 5444 4400, 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. All sessions must be pre-booked. Email or phone for further details. In addition to weekly online members nights they have regular Young Observers, AstroArts, Deep Sky, Radio Astronomy and Astrophotography events. 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

Perth Observatory is situated in the stunning Perth Hills, an easy 40 minutes drive (35 km) east of Perth. It is Western Australia's oldest astronomical institution, possessing a long tradition of research and public outreach. Now solely operated by the Perth Observatory Volunteer Group, the Observatory provides a wide range of night and daytime (including school) tours and activities. It also offers a star adoption program and conducts offsite events throughout the state. Visit their website for tour bookings and further information or contact by phone or email. 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/

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, commencing around 5:00 pm. See website and search for 'Astronomy Open Night' for details. Email <astronomyopennight@mq.edu.au> event.mq.edu.au/astronomy-open-night-2022

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 a 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

BAS MOON AND PLANET TELESCOPE VIEWING NIGHTS

The Brisbane Astronomical Society (BAS) holds regular free public viewing nights at Mt Coot-tha Lookout in Brisbane and at Maleny Golf Club on the Sunshine Coast. Members' observing nights also held at Tingalpa and Calvert. Monthly meetings are held at the Coorparoo School of Arts Memorial Hall. Check website event calendars for dates and times. Email <info@bas.asn.au> www.bas.asn.au www.facebook.com/BrisbaneAstronomicalSociety Also on YouTube.

QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The Queensland Astrofest is held annually at the Lions Club Camp Duckadang, situated at Linville 160 km north-west of Brisbane. There is bunk house accommodation and room for camping and caravans. Power is also available. Queensland Astrofest boasts a nine day format, and will be held from Friday 11 August to morning Sunday 20 August 2023. Each Saturday has vendor sales and talks. 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. Details of the next event will be on the VASTROC website when available. Contact, see website vastroc.net vastroc.ballaratobservatory.org.au

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. Email <info@astronomywa.com.au> www.astronomywa.net.au www.facebook.com/AstronomyWA/

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 <info@ausdarksky.org> www.australasiandarkskyalliance.org

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. Contact Mike Chapman email <mike.chapman@solis.asn.au> www.solis.asn.au

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 2023 should contact Geoff McNamara for a copy of the MSATT Student Guide. There is no cost for any MSATT activities. Contact Geoff McNamara phone or 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

SYDNEY UNIVERSITY ASTRONOMY COURSES

The University of Sydney Centre for Continuing Education runs regular astronomy courses on the main Sydney University campus, with occasional bus tours to NSW observatories. Some courses are also available online. See website for more information. Contact , see website. cce.sydney.edu.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'

TASMANIA

NIGHT SKY EXPLORER COURSE (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania, details on their website. Contact Richard, email <regulus1951@gmail.com> www.astas.org.au

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 and 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 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' or a 'Starlab 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

AUSTRALIAN SKY & TELESCOPE MAGAZINE

Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, it is produced specifically for the Southern Hemisphere astronomer. Delivering the latest news and developments in astronomy six times a year, Australian Sky & Telescope caters for everyone with an interest in space and astronomy, from the absolute beginner to the seasoned observer.
Contact (02) 9439 1955, email <info@skyandtelescope.com.au>
www.skyandtelescope.com.au

ICEINSPACE

IceInSpace is a community website dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers discover, discuss and enjoy the night sky. IceInSpace is free to join and use, all you need is a valid email address. By registering you will be able to post topics, upload content and images and access other features. IceInSpace is the largest and most active astronomy community in the Southern Hemisphere. www.iceinspace.com.au

WESTERN AUSTRALIA

ASTRONOMY EDUCATION SERVICES

Astronomy Education Services (AES) specialises in school excursions, Scout/youth/special interest groups and visiting rural communities. Activities include day presentations with safe viewing of the Sun and stargazing nights with telescopes. See their website and Facebook page for more details. Contact Richard Tonello 0417 961 357 or Gravity Discovery Centre Observatory 08 9575 7577, email <richard@astro-ed-services.com> www.astro-ed-services.com

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 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

The **ASTRONOMICAL SOCIETY OF THE HUNTER** meets on the 1st Friday of the month at 6:30 pm at Club Macquarie, Argenton. Contact Col Maybury 0427 889 653 <colmaybury@bigpond.com>.

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 **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 Matt Greenwood 0406 020 952 <tullytav@gmail.com>
. 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

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 at WSU (Western Sydney University) Campbelltown, NSW, on the 3rd Monday of the month, with guest speakers and workshops. They also schedule three dark-sky observing nights per month. Contact <contact@macastro.org.au>.
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

The **PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC** holds regular monthly meetings. Check their Facebook page for further information. Contact <pmobs.info@gmail.com>. www.facebook.com/portobservatory

SHOALHAVEN ASTRONOMERS meet at the University Of Wollongong, Shoalhaven Campus, Library and Resources Centre, Seminar Room LG.25 on the third Friday of the month at 7 for 7:30 pm. Contact Mark Town (president) 0474 859 788 <astronomers@shoalhaven.net.au>.
www.shoalhavenastronomers.asn.au

The **SUTHERLAND ASTRONOMICAL SOCIETY** meets every Thursday 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 **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 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 **UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY** meets on the first Wednesday of the month 7:30 pm. 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 at Penrith Observatory, Western Sydney University, Werrington Campus. Hear interesting guest speakers and attend astronomy workshops. Contact <enquiry@wsaag.org>. wsaag.org Also on Facebook.

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. 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 **WOLLONGONG AMATEUR ASTRONOMY CLUB** has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra. Visitors are most welcome to attend. 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. www.facebook.com/FNQAstronomers

THE ASTRONOMY GROUP OF MOUNT ISA meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17 km outside of Mount Isa). Meetings are held monthly, usually the Saturday preceding New Moon. Contact Grant Szabadics 0437 748 163 <gszabadics@bigpond.com>. Find them on Facebook.

The **REDLANDS ASTRONOMICAL SOCIETY** meets via Zoom, see website for details. Contact President Rhondda Nickols 0403 185 586 <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 Brendan Junge 0414 750 083 <calebkam.sas@gmail.com (Secretary)>. www.sas.org.au Also on Facebook.

TOWNSVILLE ASTRONOMY GROUP INC meet monthly at the Aitkenvale Library for Club Meetings, fortnighly 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, Twitter 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 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 3rd 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 **ASTRONOMICAL SOCIETY OF GEELONG** has regular meetings, see website or facebook for details. www.asog.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 **BENDIGO DISTRICT ASTRONOMICAL SECTION OF THE ASV** arranges public Astronomy and Science Presentations in Bendigo. Contact <bendigo@asv.org.au>. bdas.net

The **LATROBE VALLEY ASTRONOMICAL SOCIETY** meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers; call for details. Contact Chris Morley 0417 583 239 <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 0419 253 252 <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***.

Librations 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

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- ► Which constellation is that?
- ► What is that bright star?

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- Meteor showers
- Rise and set charts
- Identify the planets
- Public observatories
- Easy to use star maps
- Astronomical societies

Part of NGC 3324 and its associated nebula. Taken by the James Webb Space Telescope (left) and the Hubble Space Telescope (right)

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°

From its humble beginnings in 1990 to the splendid edition you hold today, this yearbook has always been the outstanding Australian guide to the night sky. It's the perfect reference for newcomers and seasoned observers alike.

Prof. Fred Watson AM, Astronomer-at-Large

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