ASTRONOMY 2022 AUSTRALIA

Ken Wallace
Glenn Dawes
Peter Northfield

YOUR GUIDE TO THE NIGHT SKY

CALENDAR 2022

JANUARY

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DECEMBER

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ASTRONOMY 2022

AUSTRALIA

Glenn Dawes   Peter Northfield   Ken Wallace

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We the authors are responsible for any remaining errors. Whether we rant, rave, scream or even just stick our heads in the sand and pretend we are perfect, it makes no difference. Once we lay this document at the feet of the printing gods, there's no going back!

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Illustrations

Front cover. A small section of the Veil Nebula. Mosaic of six Hubble Telescope images. Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA.

p. 1 Orion Nebula (M42) 40' × 40', Feb 2021 at Ilford NSW with an Orion Optics UK AG12 and SBig ST4000 XCM OSC CCD. Exposures; 12 × 600 sec, 16 × 300 sec, 15 × 120 sec, 15 × 60 sec, 30 × 30 sec (Joe Cauchi)

p. 10 NGC 6362 globular in Ara. STL11000M camera on 31.75 cm Ritchey Chretien @ ƒ9, exposure LRGB 135:75:75:75 with Astrodon filters (Steve Crouch)

p. 10 NGC 1398 in Fornax Orion Optics AG12 ƒ3.8, Starlightxpress SXVR-H694, exposure LRGB = 240 60 60 70 mins. Astronomik filters (Mike Sidonio)

p. 10 Omega Centauri Orion Optics AG12 ƒ3.8 Starlightxpress SXVR-H694, exposure LRGB = 60 15 15 15 min, Astronomik filters – 20C chip temp, no flats or dark frames (Mike Sidonio).

p. 11 NGC 6188 Emission Nebula in Ara and Norma, STL11000M camera on FSQ106ED @ ƒ5, exposure HaRGB 140:100:100:100 1 × 1 with Baader filters (Steve Crouch).

p. 11 NGC 6188 Fighting Dragons of Ara, Espirit 150 mm refractor, Losmandy G11T and QHY16200A camera. Exposure 15 hrs (30 × 30 mins) for each filter (Sulfur, H-Alpha and O III) (Ted Dobosz).

pp. 12–13 Variable finder chart and light curve, copyright AAVSO.

p. 27 Veil Nebula; composite of images from Digitised Sky Survey 2. Credit: NASA, ESA, the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration, and the Digitized Sky Survey 2, J. Hester (Arizona State University) and Davide De Martin (ESA/Hubble).

p. 32 Betelgeuse from ESO's VLT credit: ESO and P. Kervella

p. 33 Betelgeuse: ALMA (ESO/NAOJ/NRAO)/E. O'Gorman/P. Kervella.

p. 33 Comparison images of Betelgeuse with the SPHERE adaptive optics system on VLT, credit: ESO/M. Montargès et al.

p. 33 Antares using ESO's VLT Interferometer credit: ESO/K. Ohnaka

p. 36 Eta Carina region credit Dylan O'Donnell and DNA Digital.

p. 42 Hubble comparison, credit NASA/ESA/C. Kochanek (OSU)

p. 44 Uluru and sky image, Canon 5D Mark II, Samyang 14 mm ƒ/2.8 lens, 20 sec exposure, ƒ/2.8, ISO 5000 May 2014 (Greg Priestley).

p. 46 Gemini 6 and 7, credit NASA

p. 52 Harrison Schmitt beside the flag credit NASA.

p. 53 Apollo 15 CSM credit NASA.

p. 56 LRO lunar image, credit NASA/GSFC/ASU.

p. 57 Apollo 16 ascent module with Messier and Messier A, credit NASA

p. 57 Messier craters from Apollo 11, credit NASA.

p. 62 Starlink satellites trailing image (Greg Priestly).

p. 63 Satellite trails,CTIO/NOIRLab/NSF/AURA/DECam DELVE Survey

pp. 72–3 Images Wiki Commons.

p. 78 Crater images from LRO, credit NASA/GSFC/ASU.

p. 82 NGC 3576/3603 Orion Optics UK AG12 with SBig ST4000 XCM OSC CCD. Exp: 30 × 10 min May 2021 at Ilford NSW. (Joe Cauchi)

p. 84 Canon 5D Mark III , Samyang 24 mm ƒ/1.4 ED AS UMC lens, Kenko diffusion filter, 20 sec, ƒ/1.4, ISO 1600 (Greg Priestley).

p. 102 Solar active region 9933 in 2001, courtesy of SOHO/[MDI] consortium

p. 102 EUV Sun images (Solar Orbiter/EUI Team/ESA & NASA; CSL, IAS, MPS, PMOD/WRC, ROB, UCL/MSSL)

p. 103 Eclipse predictions by Fred Espenak, NASA/GSFC

pp. 110–11 Texture maps of Moon, credit NASA/Naval Research

p. 117 Mars map, credit planetary society. Something special included for those fans of 'The Martian'.

Rear cover: Eta Carina Nebula NGC 3372 Taken by Ted Dobosz with Canon 6D using a 127 mm refractor, 10 × 8 minute exposures tracked on Losmandy G11 mount.

Text, photographs and illustrations not otherwise credited are by the authors.

Astronomy 2022
Contents

Part I — Monthly Guide

Part II — The Solar System

Part III — Appendices

INTRODUCTION TO THE 2022 EDITION

Welcome to Astronomy 2022, yes, thirty two years in the making. We haven't gone—yet!

In this edition, we continue to feature the work of Australian astro-imagers. We appreciate the skills of Ted Dobrosz, Steve Crouch, Mike Sidonio, Joe Cauci and Greg Priestley and thank them for their contributions.

We also take the opportunity to encourage you to observe variable stars. Bright examples of the reliable Mira types are given including expected times of future maxima and minima.

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

- The mystery of vanishing stars.
- Upsized giant stars.
- Lunar concentrics.
- The treasure trove of the constellation of Carina.
- The Messier twins and much more.

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

Part I of Astronomy 2022 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.

Which have Eyes and See Not …

One great thing about reaching retirement age is that the three of us are fortunate to have memories of the Apollo Moon landings. This year we celebrate the 50th anniversary of the conclusion of these epic voyages. Although, much of the technology would be considered primitive today, the sixties was a time of enormous innovation in aerospace—if you needed something, well, go and invent it! Post 1972, humankind has retreated to low Earth orbit, mostly due to lack of funding and NOT because the Moon walks were faked as some would still like us to believe. There were so many aspects to Apollo that disproved the deception theory that it was laughable, and this resulted in NASA making a big mistake. They thought it was so ridiculous that they refused, for many years, to defend themselves. In this silence, doubt festered, and the conspiracy became a 'fact' in some people's minds—unfortunately human nature.

Within these pages we often mention how incredible the Universe is, like its age and size. Many of the processes mentioned such as the evolution of galaxies, stars and life only work on time scales totally unimaginable based on human experience. This view is rejected by a minority. Just because someone feels it *can't be* doesn't make it magically false. There are none so blind as those who will not see. A saying sometimes (ironically) attributed to the Bible, "Hear now this, O foolish people, and without understanding; which have eyes, and see not; which have ears, and hear not …" (NKJV Jeremiah 5:21). With this anti-science sentiment, it's substituted with totally unsupported ideas such as creationism, young and flat Earth beliefs, homoeopathy and the much more dangerous, anti-vaxers! Yes, in the absence of comprehension, good old superstition takes centre stage. The same mentality that resulted in the burning of witches.

The authors know we won't get heated emails; our readership is much more enlightened (although we have crossed swords with astrologers in the past). To those who share our fascination in the Universe and revel in scientific discoveries and even the mysteries that haven't been solved yet, this book is dedicated to you.

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 previous 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 even 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 during that season, the most convenient time to look. In reality most of the night sky is available any night (especially in winter), provided you are willing to stay up until dawn. Playing with a planisphere illustrates this quite well. An example is shown on page 9.

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?

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 1).

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

Dark skies also offer the opportunity to try and see the planet Uranus with the unaided eye (not easy). All Sky Map 3 (p. 87) and finder chart (p. 132) will help find this elusive distant member of the Solar System. Try around the time of opposition (in November 2022) 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 August this year it is not favourable and is a real challenge.

You can always go on a voyage of discovery. There is a good chance 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!

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 between all three in the morning sky on April 27 and 28 (see Sky View, p. 44).

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.

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 14 and page 140 for a list of showers.

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 hand-holding the binoculars makes it easier. If your seat doesn't recline, try leaning the tripod on two legs or use a monopod.

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 disappearing.
- Searching out Uranus and Neptune, using the finder charts, see pages 132 and 133 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 123 to 129. 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 (see page 12). 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.

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 104).

Observing the Moon (pp. 108–111). 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 tonight start with the **Visibility of the Planets** (p. 17). As an example we'll use early September. Neptune, Jupiter, Uranus, Mars and Venus are shown in the morning sky with Saturn and Mercury in the evening. You will notice that Saturn crossed the midnight line in August, with Neptune and Jupiter following suit later in September, so all three planets are close to opposition and up most of the night. The Rise–Set chart for September confirms this. Venus is approaching the Sun line and will soon leave the morning 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 17) 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 23. Mercury then enters the morning sky with a thin sliver phase and the process reverses until superior conjunction is reached again (November 9). 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 28 it's at a maximum eastern elongation. Note its high altitude while in conjunction with the Moon on August 29, one day past maximum elongation (Sky View page 65).

Its fellow inner world **Venus** goes through the same process as Mercury but much slower, being further from the Sun. In 2022 an inferior conjunction occurs on January 9. It then rises in the eastern morning sky reaching a greatest elongation west on March 20, when it then commences to drop back towards Sol to a superior conjunction on October 23. All this time it shrinks in size with its phase increasing to full. 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 4 arcseconds (") in diameter (magnitude 1.5) which then slowly grows. The Red Planet finally reaches a maximum size of 17.1" and brightness of magnitude –1.9 at opposition on December 8.

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 68) confirms that this happens for Jupiter in September 2022 (which can also be gleaned from the Visibility of the Planets, page 17). Besides observing its atmospheric belts, the **Great Red Spot (GRS)** is worth looking for; see the table and explanation on pages 120 to 121. An example is the evening of December 29 at 10:29 pm (EST) or 11:29 pm including daylight saving. This transit is visible from anywhere in Australia (indicated by *).

Pages 122–129 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 September 22, the diagram on page 127 shows this well. In this case there is a drawing on page 69. The *wiggly* diagrams also show instances where a moon's line crosses over or behind the Jupiter lines. An example explains this well. On September 28 (again pages 69 and 127) the evening sees a transit of Europa followed by Io being occulted (passing behind Jupiter).

Saturn, with its impressive ring system (still reasonably open this year) 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 130 and 131 show a worked example of how to identify their configuration for your date and time. There are also Sky Views in August and September giving illustrations of some actual configurations. The worked example for August 26 is also graphically presented on page 65.

Uranus and **Neptune** (p. 132 and 133 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 137 to 139. These can be plotted on the All Sky Maps. As an example we'll look at minor planet 20 Massalia on its opposition date. The February monthly text (p. 32) has the minor planet reaching opposition on the 5th at magnitude 8.5 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 very close to the star Pi (π) Cancri (about 0.5° west), moving roughly towards the Beehive Cluster (M44).

Let's assume it's the evening of February 3 and you wish to find Comet 104P/Kowal 2. Part I text (page 33) says the comet "*… begins February in Cetus and visible until late in the evening, passing across the head of Cetus from the 3rd to 8th…* The Rise–Set chart and Moon section for February, shows that the Moon is a couple of days after New Moon, setting around the end of twilight on the 3rd. With the comet setting around 11:30 pm there should be time to catch it mid-evening. The table on page 136 shows 104P to be three weeks past perihelion (which was 11 January) and the ephemerides (page 137) confirms that it's expected to be fading, perhaps magnitude 10.4. Carrying out the same exercise, with its position (RA and Dec), like the minor planet (above) Map 2 is needed. Interpolating between January 29 and Feb 5, the comet is indeed entering the head of Cetus between Gamma (γ) and Nu (ν) Ceti.

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!

ASTRO GALLERY

(above) **NGC 6362 globular in Ara** has a magnitude of 7.6 and is about 4' across. (Steve Crouch)

(right) **NGC 1398, The Dreamcatcher** in Fornax. Looking as if drawn with a Spirograph, this isolated barred spiral galaxy has a geometrical double ring structure resembling a Dreamcatcher. It is slightly larger than the Milky Way. (Mike Sidonio)

(left) Big, bright and bold, **Omega Centauri** is the largest Globular Cluster in The Milky Way. (Mike Sidonio)

Two images of NGC 6188 in Ara. Above is a wide angle image by Steve Crouch in Ha and RGB colour. Below is a close up image by Ted Dobosz, oriented at right angles compared to Steve's image and using narrow band filters (Sulfur, Hydrogen-Alpha and Oxygen III) producing quite a different result.

Variable Stars

To most of us, the stars seem pretty constant and unchanging. We are not only talking over a human lifetime but, except for the odd supernova or bright nova, over recorded history—certainly the naked-eye view. For those relatively new to astronomy it may come as a surprise there are tens of thousands of stars known to significantly vary in brightness. Many of these changes occur in a repeatable pattern. Amateurs have discovered many variables and although the majority need a telescope to be seen, some only need binoculars or even the unaided eye to witness the changes. We will concentrate here on some predictable ones that can be monitored with modest equipment, such as binoculars or a small telescope.

Types of Variables.

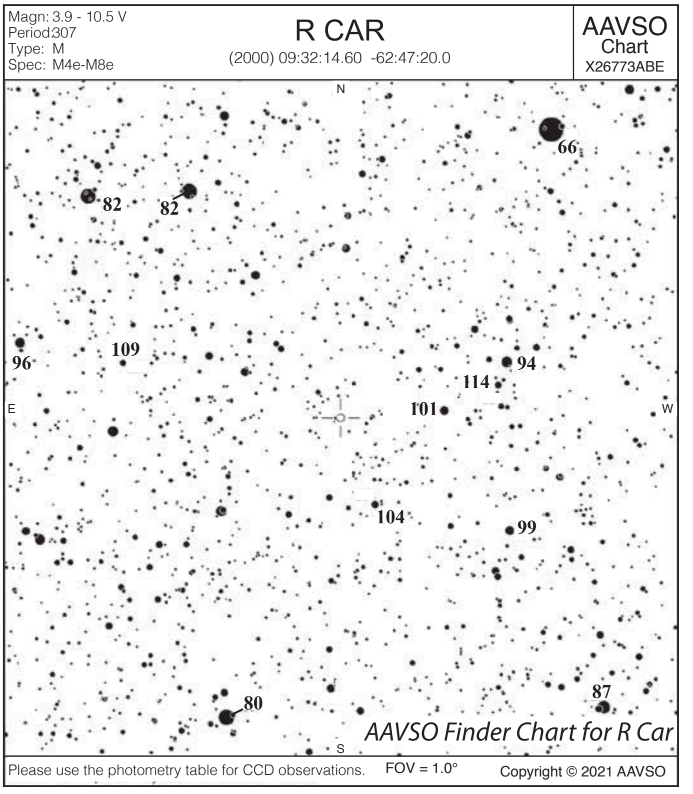
There are two fundamental types of variables. Those where the brightness changes are caused by an external factor (extrinsic), and the other due to internal factors (intrinsic) such as the pulsating variables. There are other types of intrinsics, such as eruptive or cataclysmic types, whose brightness changes are related to material being accreted or lost from the star. Examples include the R CorBor type, and recurrent novae which we don't have room to discuss here. With practice these can be the most exciting stars to monitor because of their unpredictable nature.

Pulsating Variables

The majority of variables fit into this camp, with long period ones (LPV) and Cepheids being the most common. If you plot the brightness (magnitude) against time for the pulsating types they look a little like sine waves, with the different types often distinguished by the shape of the curve.

Long Period Variables (LPVs, also called Mira variables) are evolved red giants; that is, stars of up to eight or so solar masses that have left the main sequence and are close to the end of their evolution (Betelgeuse is going through such a phase, page 32). Miras physically pulsate over 100 or more days giving rise to changes in brightness of two to seven or more magnitudes. Mira or Omicron Ceti, which is included in the attached table, varies by around six magnitudes. To get a feel for how extreme this is try comparing the brightest stars to the faintest stars visible to the naked eye under moonless country nights—a pretty dramatic change!

The short period Cepheids are most famous for their period/luminosity relationship, a discovery made by Henrietta Swift while studying these stars in the Large Magellanic Cloud. This established a key yardstick in determining extragalactic distances. By short period we mean that the star takes only days to pass through a full cycle.



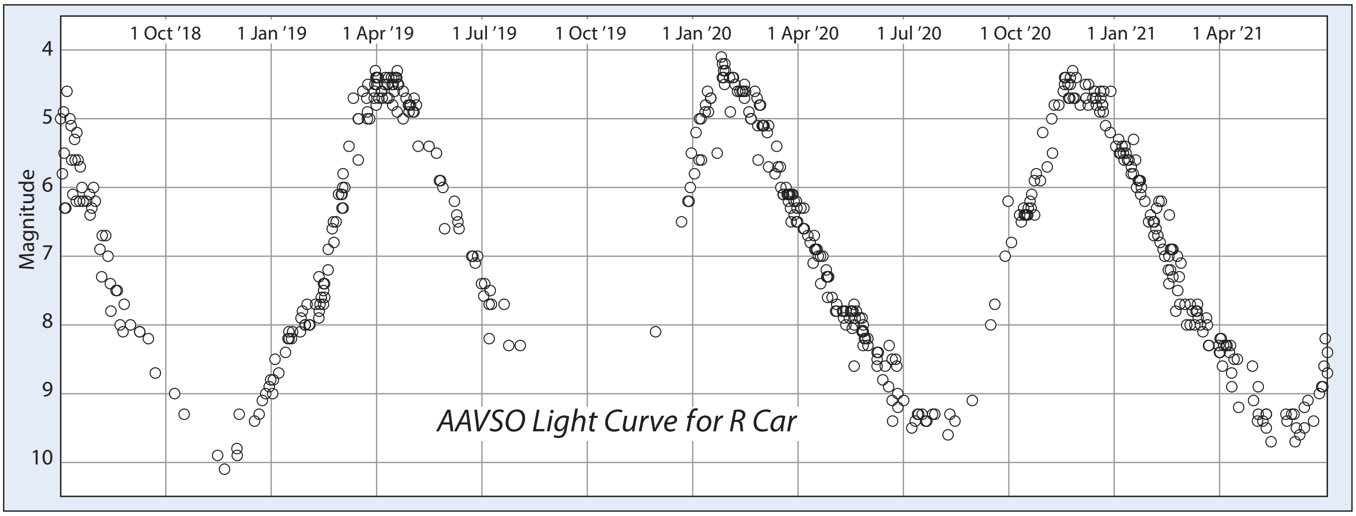
Eclipsing Binaries (EB)

These are the most common external type and, as the name implies, there are two stars orbiting each other, where from Earth's perspective, a dimming of the star is caused by a much fainter companion passing in front of (eclipsing) the brighter primary on each orbit. The brightest example known is Algol (Beta (β) Persei) in Perseus, which drops from magnitude 2.1 to 3.4 and back over around 10 hours every 2.87 days. We have included in the table BL Telescopium, which is one of the longest period EBs, whose eclipse lasts for a couple of months, every 778 days.

Name	Category	Brightness range (visible)		Period	Months/Times of Culmination (i)			
		Max	min	(days)	3 am	1 am	11 pm	9 pm
S Scl	LPV	5.5	13.6	367	Aug	Sep	Oct	Nov
Omicron Ceti (Mira)	LPV	3.4	9.3	332	Sep	Oct	Nov	Dec
R Hor	LPV	6.0	13.0	408	Sep	Oct	Nov	Dec
L2 Pup	LPV	6	~8	141	Nov	Dec	Jan	Feb
R Car	LPV	4.0	10.0	307	Dec	Jan	Feb	Mar
L Car (ii)	Delta Cepheid	3.3	4.2	35.5	Jan	Feb	Mar	Apr
R Leo	LPV	4.4	10.0	310	Jan	Feb	Mar	Apr
S Car	LPV	4.5	9.9	150	Jan	Feb	Mar	Apr
T Cen	LPV	5.5	9.0	88	Feb	Mar	Apr	May
RS Sco	LPV	6.0	13.0	319	Apr	May	Jun	Jul
RR Sco	LPV	5.9	11.8	281	Apr	May	Jun	Jul
BL Tel. (i)	Eclipsing binary	7.1	9.1	778	May	Jun	Jul	Aug

(i) BL Telescopii (see also main text) next mid-eclipse is due early Jan 22. It is not favourable, being low in the south-east at the start of dawn, however an observer will be able to see it brighten over the following month.

(ii) With L Car having a maximum and minimum almost monthly, no dates have been given



How Can You Contribute to Science?

Measuring the brightness of variables is still a key area in which amateurs can contribute to astronomy, having something professionals don't have, namely strength in number of observers and instruments (telescopes/binoculars). No special measuring equipment such as CCD, or digital cameras is needed (unless you want to go to this level). With practice, visual observers can make estimates to the closest tenth of a magnitude (0.1) by interpolating between reference stars in the same field. These are stars whose brightness has previously been accurately determined, often by professionals. There are a number of variable star associations such as the AAVSO and Variable Stars South (an Australia/New Zealand based organisation). Their websites typically alert observers to stars that need observations, either due to unusual behaviour or just lack of current measurements. This isn't unusual for stars in the deep south, which are inaccessible to the larger number of observers in the Northern Hemisphere. A bonus is that such work can be done under light polluted skies, especially for bright stars. If you don't need to travel long distances to dark skies, you are more likely to grab the odd hour from time to time from the comfort of your backyard.

The Table

The stars tabled here are mostly bright Miras with expected times for maximum/minimum shown. By bright, we mean much of their range should be within view of typical binoculars, even from light polluted skies. From dark skies many may be glimpsed with the unaided eye when at maximum. The 'Months/Times of Culmination' columns are when the star is highest in the sky and is offered only as a broad guideline to the ideal time to observe. The further south in the sky the longer a star is accessible. Also, during winter months you will be able to observe earlier in the evenings and later into the mornings, offering a much wider window of opportunity.

The predictions shown have been calculated from data on the American Association of Variable Star Observer (AAVSO) website. Variable star charts with reference magnitude stars marked can also be printed from this site, including plots of magnitude estimates gathered from their many observers (mostly amateurs) throughout the world. If you go to aavso.org at the bottom of the first window enter the star (as in the table, i.e., the letter(s) followed by the standard 3 letter constellation abbreviation) and request the star map or the magnitude plot. For beginners the 'Getting Started' dropdown is invaluable and we recommend downloading the 'Manual for Visual Observing of Variable Stars'. With a bit of practice, you too could become a valued contributor to this vital bank of observations.

Approximate Dates of Predicted Maximum and Minimum (iii)							All Sky Map (iv)
Max	Min	Max	Min	Max	Min	Max	
late Dec '21	late Jul '22	late Dec '22	late Jul '23	late Dec '23	late Jul '24	early Jan '25	2, 8
late Aug '21	late Mar '22	late Jul '22	late Feb '23	mid Jun '23	late Jan '24	mid May '24	2
	mid Oct '21	mid Apr '22	late Nov '22	late May '23	early Jan '24	early Jul '24	2
late Sep '21	early Jan '22	mid Feb '22	mid May '22	late Jun '22	late Sep '22	early Nov '22	4
late Sep '21	la te Mar '22	early Aug '22	late Jan '23	early Jun '23	late Nov '23	early Apr '24	1
							1
early Sep '21	late Feb '22	mid Jul '22	early Jan '23	mid May '23	early Nov '23	late Mar '24	5
early Oct '21	early Dec '21	early Mar '22	early May '22	late Jul '22	early Oct '22	late Dec '22	1
mid Nov '21	late Dec '21	early Feb '22	late Mar '22	early May '22	mid Jun '22	early Aug '22	6
	mid Sep '22	late Oct '22	mid Dec '22	late Jan '23			
	early Nov '21	early Apr '22	late Sep '22	mid Feb '23	early Aug '23	early Jan '24	6
late Jul '21	late Dec '21	early May '22	early Oct '22	mid Feb '23	mid Jul '23	mid Nov '23	6
	late Nov '19		mid Jan '22		early Mar '24		1

(iii) If maximum can be observed (i.e., not too close to the Sun), it is highlighted blue for morning observation, green for evening or orange if available sometime in the evening and morning.

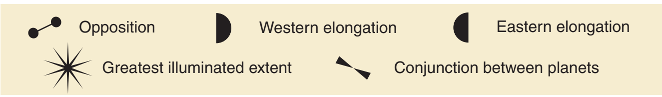
(iv) Positions for these stars have been marked on the All Sky Maps

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.

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 base our journey in the sky starting from some prominent asterism (star pattern)—a great way to learn the sky! Then we explore the associated constellations including their brightest stars and deep sky objects.

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 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 by an effect called libration. The diagrams show the wobble or nod of the Moon during the course of each month.

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

The Planets

Presented are general notes on each planet, including 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.

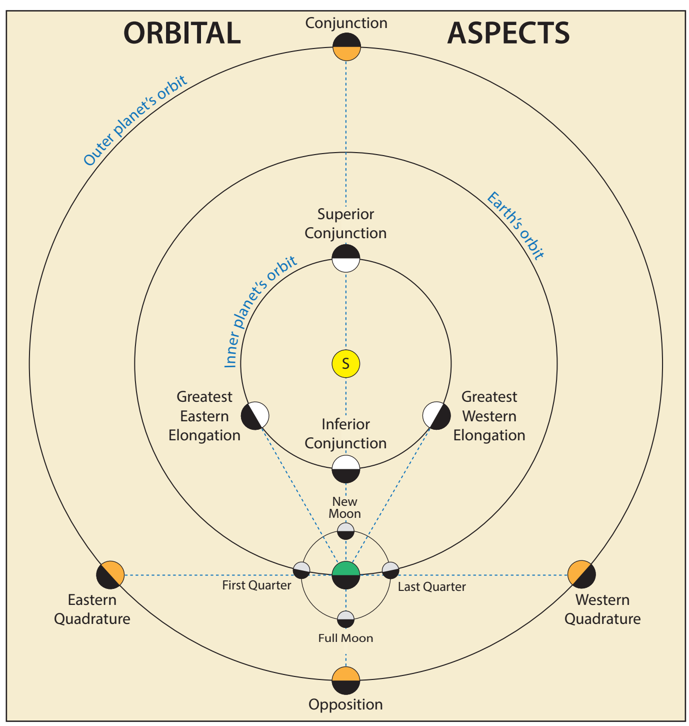
Minor Planets (or Asteroids) This covers the brightest asteroids that reach opposition each month (12.6 magnitude or brighter). An entry includes the date of opposition (when near brightest), its magnitude and the constellation the asteroid is in at this time. The 15 brightest dwarf and minor planets 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 135 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.

Double Stars

Each month two impressive double stars are presented. One that is ideally suited for binoculars and the other for small telescopes. They are also marked on the All Sky Maps.

Feature Articles

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

Diary

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

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

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

Abbreviations. These include:

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

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

Time. When times are given, both EST and WST are presented. 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. Sometimes the times correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although this is

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

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

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

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

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

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

Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'mag.'). The numbers work backwards. The faintest stars you're likely to see with the naked eye are about 6.0 magnitude (under country skies), while the brightest stars are around zero magnitude, with the most brilliant, Sirius, at –1.4 magnitude. Planets can be much brighter. Venus, for example, can be as bright as –4.5 magnitude, the Full Moon, –12 magnitude.

Waxing, waning, gibbous and crescent. The Moon is considered waxing between New and Full, after this time it is said to be waning. The 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.

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.

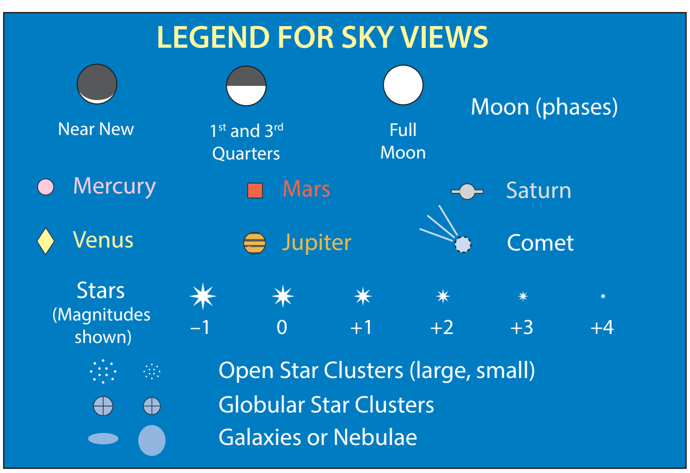
The Sky Views (see also the legend below) include:

- 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 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 is August/September and Jupiter is September/October in 2022). 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 passing over or under Jupiter's disc. In 2022, Callisto eclipses occur up until August, for the last four months of the year it doesn't (also see bottom of p. 122). 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.

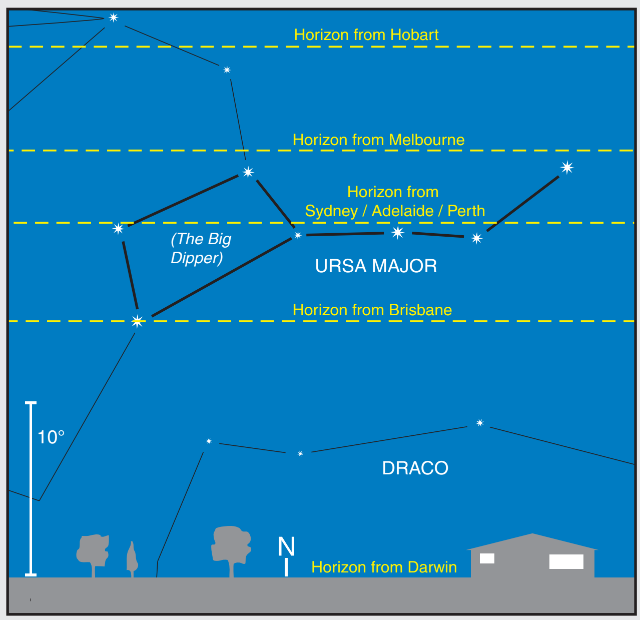
Uranus and Neptune have been excluded from the Sky Views, as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions.



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.

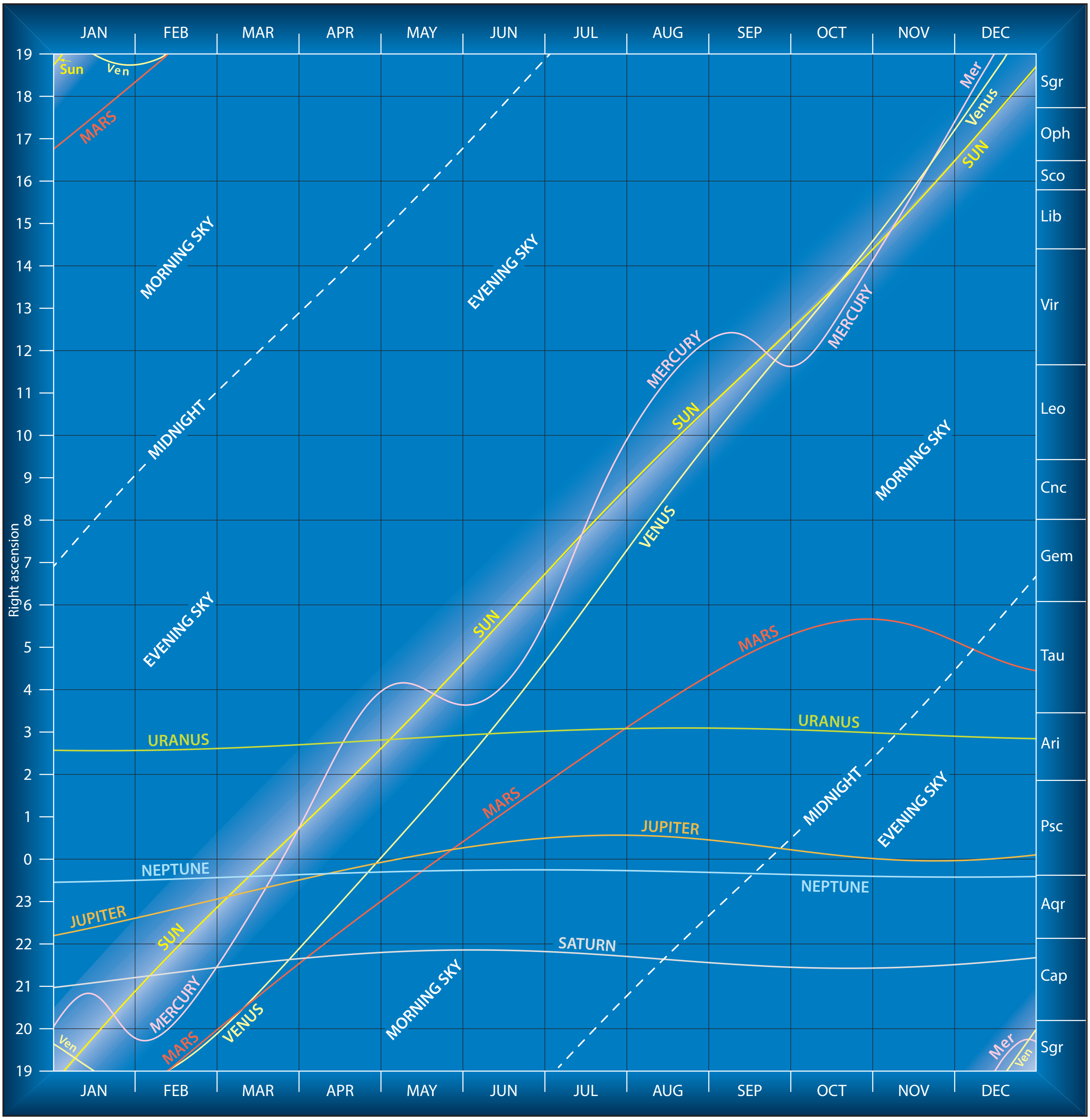
When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST); the mean solar time on the meridians of longitude 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from EST times given. Any specific times given for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

Neptune will need at least binoculars. Because of the many faint stars of similar brightness close by, separate finder charts (see Part II) are needed for these outer worlds. Their approximate positions are marked on the All Sky Maps to point you to the right area and then go to the finders.



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

VISIBILITY OF THE PLANETS

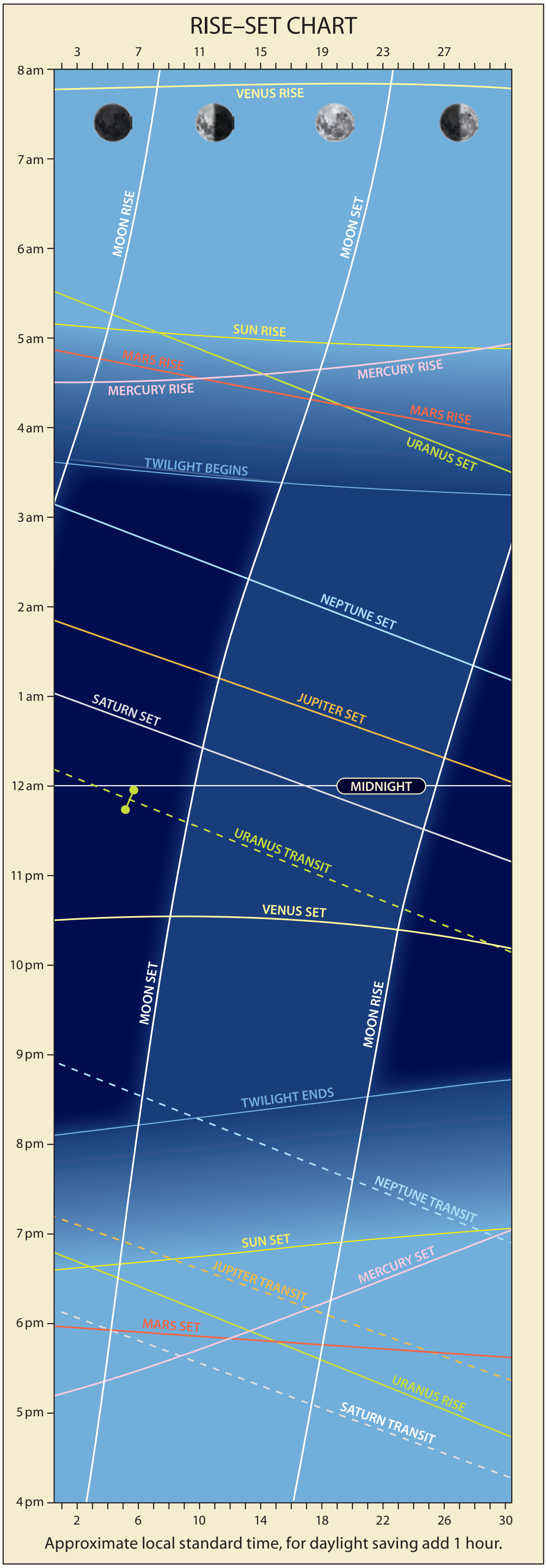


This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point, a horizontal line to the right vertical axis will show which constellation the planet is in. Mars for example will be in Aries (Ari) in the July Morning sky (also see All Sky Map 3)

Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best time to observe these inner planets is when their paths extend beyond twilight. For Mercury, the optimum period in the evening sky is during September and in the mornings of late February and March. Early in the year Venus is close to the Sun before spending most of the year in the morning sky until conjunction in October, reappearing in the evening sky from mid December.

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 when Mars is in conjunction with Jupiter in late May (see Sky View p. 49).

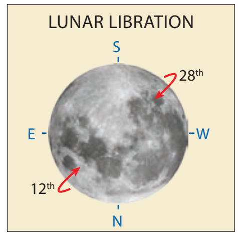
NOVEMBER 2021



HIGHLIGHTS

- Venus and Moon close.
- Venus passes through the Teapot.
- Uranus at opposition.

THE MOON



5th 7 am (5 am WST) New Moon.

6th 8 am (6 am WST) Moon at perigee (closest to Earth at 358,844 km).

11th 11 pm (9 pm WST) First Quarter.

12th 11 pm (9 pm WST) Maximum Libration (10.0°), bright NE limb.

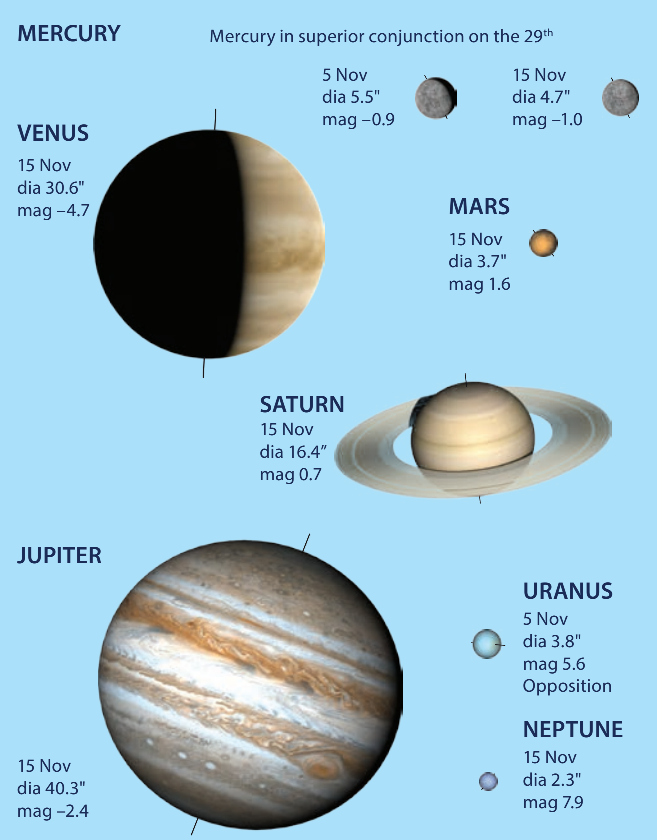
19th 7 pm (5 pm WST) Full Moon.

21st Noon (10 am WST) Moon at apogee (furthest from Earth at 406,279 km).

27th 10 pm (8 pm) Last Quarter.

28th 4 am (2 am WST) Maximum Libration (10.1°), bright SW limb. Libration features on limb washed out due to lunar phase, although many craters near the south pole will be seen to good advantage.

APPEARANCE of the PLANETS



THE PLANETS

Mercury is virtually unobservable this month. At best, the planet is just a few degrees above the eastern dawn horizon in early November (see Sky View), sinking back toward the Sun and superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 29th.

Venus spends the month in Sagittarius, beginning near the galactic centre, then cruising through the region of the Teapot asterism (see Sky View). On the 8th, the planet will be 2° from the 4-day old waxing crescent Moon, an impressive sight in the early western evening sky (see Sky View).

Having been lost in the Sun's glare since conjunction early October, **Mars** finally reappears a few degrees above the horizon at the end of the month, still well in the dawn glare.

Jupiter, in Capricornus, is high in the north-western evening sky at the end of twilight. On the 11th, the First Quarter Moon appears near Jupiter, not the closest of conjunctions but it's always pleasant to see a bright planet near the Moon (see Sky View). Toward the end of the month, Jupiter, Saturn and Venus all appear in a straight line, dominating the early western sky.

Saturn is visible in the early western evening sky in Capricornus. With the planet at quadrature the maximum extent of the shadow of the planet's globe is cast onto its magnificent rings. When viewing this world, it's interesting to reflect on Galileo's first observations of Saturn when he noted it was flanked by two star-like protrusions. Telescopes have certainly come a long way and changed our view and understanding of the Universe. On the 10th, the 6-day old waxing crescent Moon appears near the planet (see Sky View).

Uranus is at opposition on the 5th, rising in the early evening eastern sky in Aries and visible the entire night. With an apparent diameter a little less than four arcseconds you will need a telescope and high magnification to resolve the planet into a disc. Through the telescope, at 5.6 magnitude Uranus shows no distinguishable atmospheric features, but observers will immediately note its blue/green colour.

Neptune appears high in the early north-western evening sky in Aquarius at the end of astronomical dusk.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet 1 Ceres, near opposition, passes through the Hyades star cluster (the face of the bull of Taurus) this month.

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
15 Nov	185 Eunike	Eridanus	11.4
26 Nov	85 Io	Taurus	11.3

COMETS

Comet 4P/Faye is in Monoceros, where it remains for the rest of the year. Rising in the mid-evening, the comet is expected to fade from 10th to 11th magnitude by month's end.

Comet 19P/Borrelly is predicted to brighten from 11th to 9th magnitude this month. Residing in Grus, the comet is visible as evening twilight ends until just before dawn. On the evenings of the 22nd and 23rd, Borrelly has a close encounter with the Grus Quartet of Galaxies—great for observers or imagers!

Comet 67P/Churyumov-Gerasimenko, reaching perihelion in early November, is expected to hover around 9th magnitude in the morning skies. Beginning in Gemini, the comet moves into Cancer mid-month where it resides for the remainder of the year. Early November sees the comet near Pollux.

DIARY

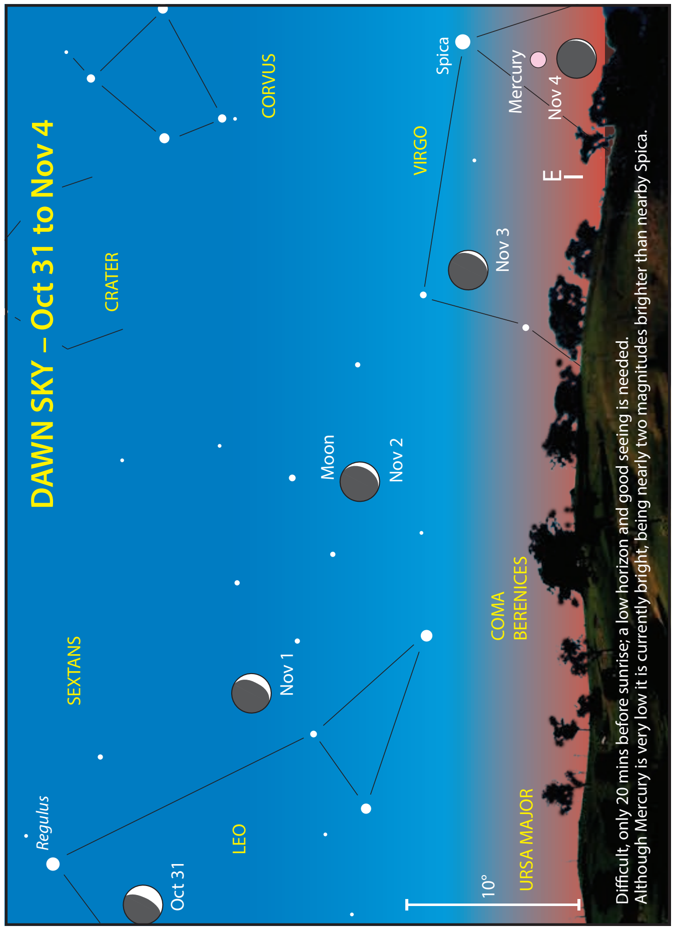
Mon	1st		m.p. 3 Juno 0.2° SW of star Omicron Serpentis.
Wed	3rd	pm	d.p. 1 Ceres 0.1° S of star Aldebaran.
Thu	4th		Uranus at opposition.
Fri	5th	7 am	(5 am WST) New Moon.
Fri	5th	pm	m.p. 349 Dembowska 0.4° SE of star Zeta Capricorni.
Sat	6th		Comet 67P/Churyumov-Gerasimenko 0.4° S of star Upsilon Geminorum.
Sat	6th	8 am	(6 am WST) Moon at perigee (358,844 km).
Sat	6th	8 pm	(6 pm WST) star Antares 7° SE of Moon.
Sun	7th		Venus 0.6° N of NGC 6540 (GC) in Sagittarius.
Mon	8th	pm	Venus 2° SW of Moon.
Tue	9th		Comet 67P/Churyumov-Gerasimenko 1.5° S of star Pollux.
Wed	10th	10 pm	(8 pm WST) Saturn 5° NE of Moon.
Thu	11th	3 am	(1 am WST) Comet 67P/Churyumov-Gerasimenko 0.1° S of star Phi Geminorum.
Thu	11th	10 pm	(8 pm WST) Jupiter 6° NE of Moon.
Thu	11th	11 pm	(9 pm WST) First Quarter Moon.
Fri	12th		Venus 1.7° S of star Lambda Sagittarii.
Fri	12th	11 pm	(9 pm WST) Maximum Libration (10.0°), bright NE limb.
Fri	12th	pm	d.p. 1 Ceres 0.5° N of star Theta^1 Tauri.
Sat	13th	am	Northern Taurids meteor shower, Oct 20 to Dec 10.
Sun	14th	1 am	(11 pm WST, prev day) Neptune 5° NE of Moon.
Wed	17th		Venus 0.3° NE of star Phi Sagittarii.
Wed	17th	pm	Comet 19P/ Borrelly 0.3° NE of star Iota Gruis.
Wed	17th	pm	d.p. 1 Ceres 0.9° S of star Delta^2 Tauri.
Thu	18th		Comet 8P/Tuttle 1.5° NE of Omega Centauri (GC) in Centaurus.
Thu	18th	am	Leonids meteor shower, Nov 6–30, near Full Moon affected.
Thu	18th	8 pm	(6 pm WST) Uranus 4° W of Moon.
Fri	19th		Venus 0.4° SW of star Sigma Sagittarii.
Fri	19th	7 pm	(5 pm WST) Full Moon (405,300 km).
Sat	20th	10 pm	(8 pm WST) star Aldebaran 7° S of Moon.
Sun	21st	am	m.p. 22 Kalliope 0.8° W of star Tau Geminorum.
Sun	21st	Noon	(10 am WST) Moon at apogee (406,279 km).
Mon	22nd		Mars 0.4° W of star Alpha Librae.
Mon	22nd	am	alpha-Monocerotids meteor shower, Nov 15–25, Moon affected.
Mon	22nd	9 pm	(7 pm WST) Comet 19P/ Borrelly 0.05° SE of NGC 7552 (G) in Grus.
Mon	22nd	pm	d.p. 1 Ceres 1.0° N of star Gamma Tauri.
Tue	23rd	9 pm	(7 pm WST) Comet 19P/ Borrelly 0.3° NW of NGC 7582 (G) in Grus.
Wed	24th	2 am	(Midn. WST, prev day) star Pollux 6° E of Moon.
Sat	27th	3 am	(1 am WST) star Regulus 7° SE of Moon.
Sat	27th		d.p. 1 Ceres at opposition.
Sat	27th	10 pm	(8 pm WST) Last Quarter Moon.
Sun	28th		m.p. 3 Juno 0.2° SW of M16 Eagle Nebula (BN) in Serpens.
Sun	28th	4 am	(2 am WST) Maximum Libration (10.1°), bright SW limb.
Sun	28th		m.p. 4 Vesta in conjunction with Sun.
Mon	29th		Mercury in superior conjunction.

METEOR SHOWERS

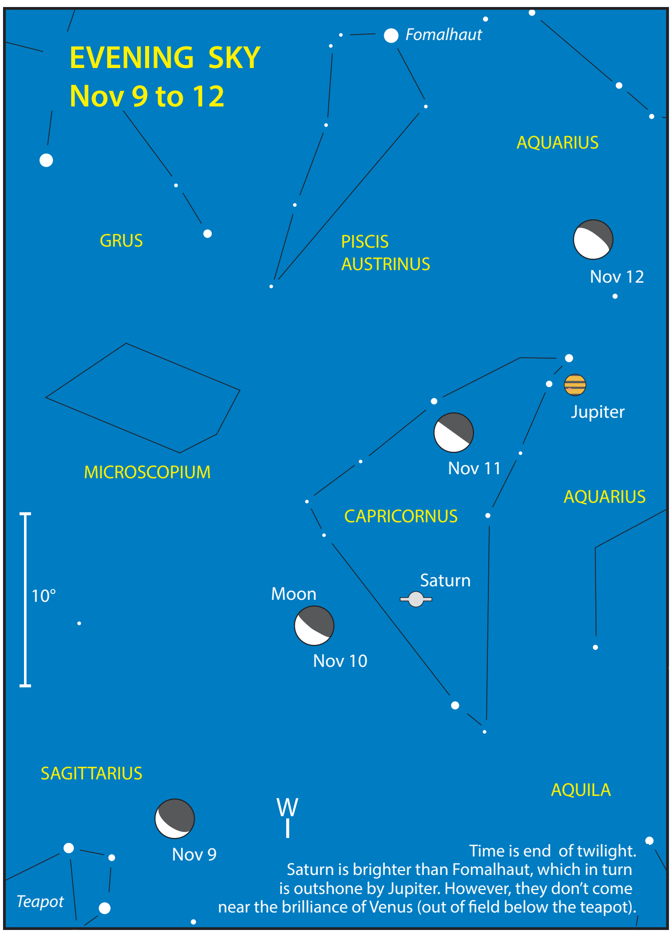
The **Northern Taurids** are active from 20 October to 10 December, with their peak around 12 November. Taurids are frequently bright, slow moving, and noted for producing colourful fireballs (although not in every year). They are associated with Comet 2P/Encke and can be seen from late evening to early morning. The waxing crescent Moon will impair viewing during peak until it sets a little after midnight.

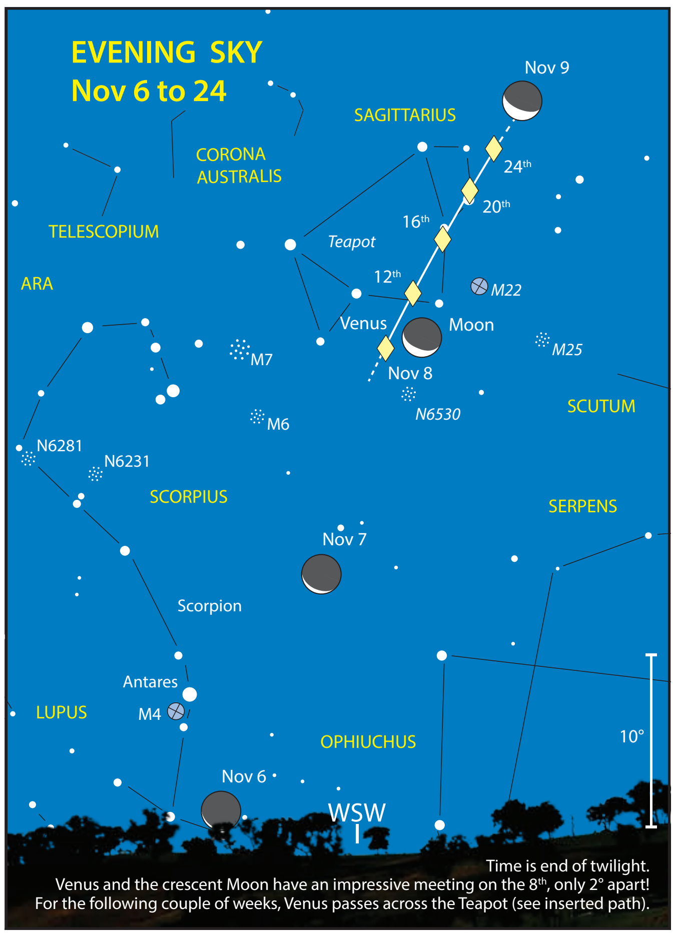
The **Leonids** is one of the better-known showers. It is associated with the periodic comet 55P/Tempel-Tuttle and is best about every 33 years when the comet returns to perihelion (last in 2001). The Leonids are active from the 6th to 30th, with a maximum peak of around 15 meteors per hour predicted 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 near Full Moon will make it difficult for all but the brightest Leonids to be visible.

The **alpha-Monocerotids** are a minor shower, with unusual short-lived outbursts. Active from 15th to 25th, they are expected to peak around the 21st and are best seen after midnight. While the zenith hourly rate is variable, very high rates have been recorded occasionally over the years. Like the Leonids, the Moon will be an issue during the peak this year.

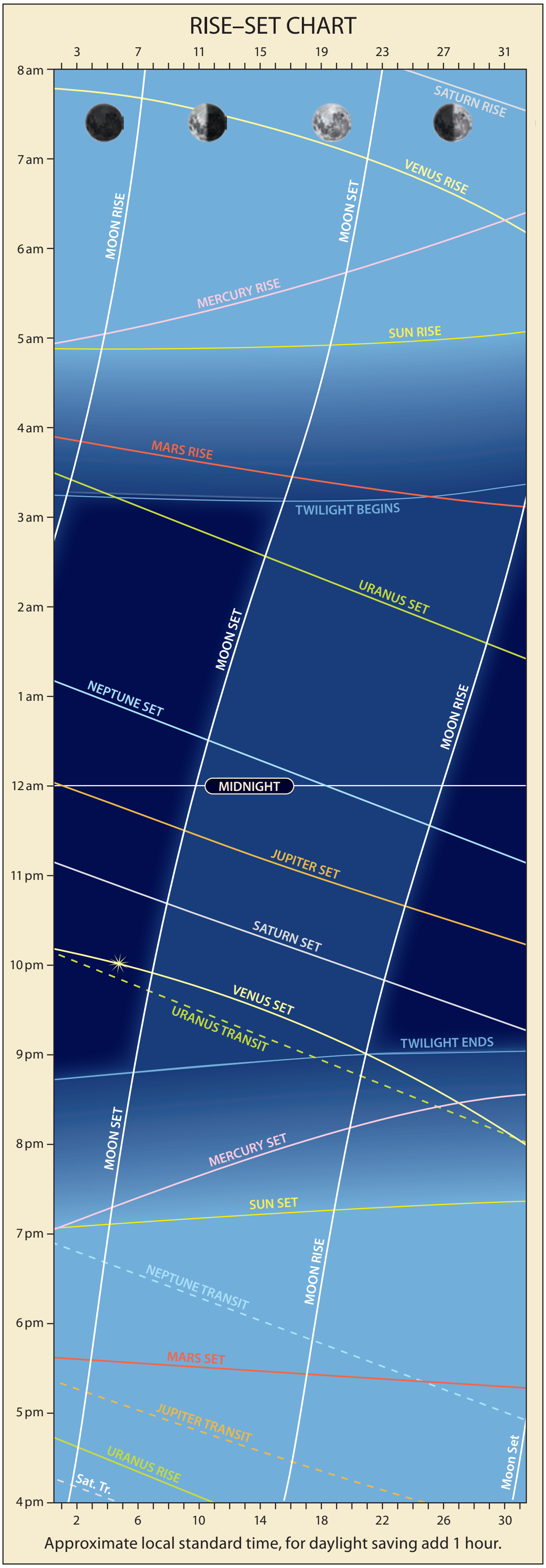


Approximate local standard time, for daylight saving add one hour.





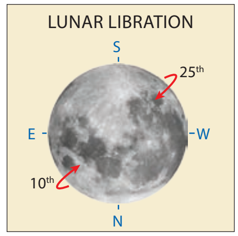
DECEMBER 2021



HIGHLIGHTS

- Four bright planets in the western evening sky.
- Venus at greatest brilliancy.
- Mars occulted by the Moon.
- Jupiter near the Moon.
- Mercury near Venus.

THE MOON



4th 6 pm (4 pm WST) New Moon.

4th 8 pm (6 pm WST) Moon at perigee (closest to Earth at 356,794 km).

10th 5 pm (3 pm WST) Maximum Libration (10.4°), bright NE limb. At this libration, features in the zone of librations will be washed out along the limb due to the absence of shadow relief.

11th Noon (10 am WST) First Quarter.

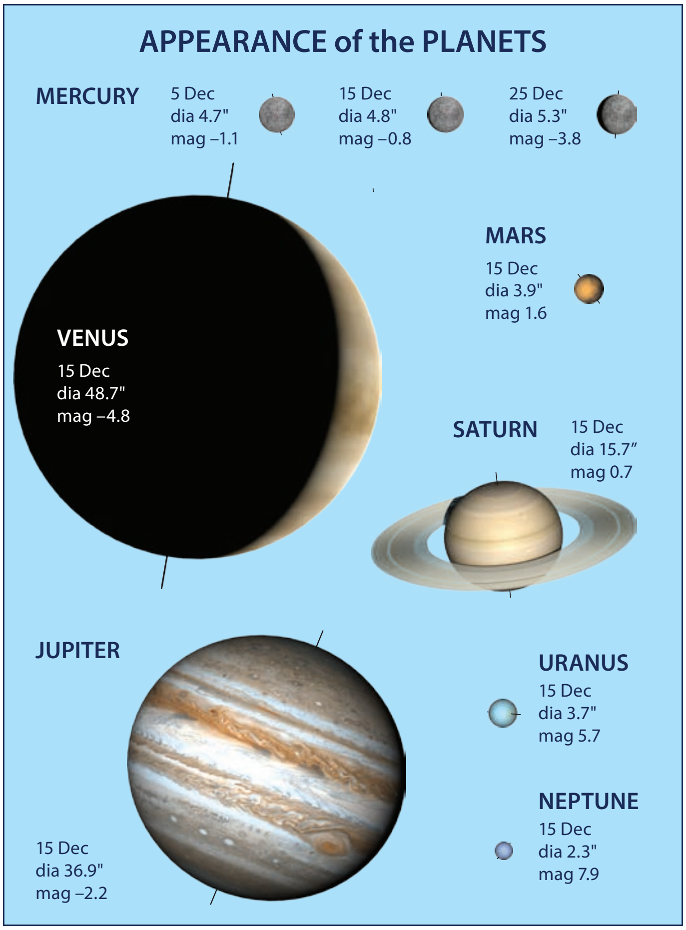
18th Noon (10 am WST) Moon at apogee (furthest from Earth at 406,320 km).

19th 3 pm (1 pm WST) Full Moon.

25th 8 pm (6 pm WST) Maximum Libration (9.6°), bright SW limb. Libration features on the limb are washed out due to lunar phase, although many craters near the south pole will be seen to good advantage.

27th Noon (10 am WST) Last Quarter.

APPEARANCE of the PLANETS



THE PLANETS

Mercury returns to the western evening twilight and is best seen late in the month sharing the sky with Venus, Saturn and Jupiter. On the 27th the duo of Mercury and Venus will be parallel to the horizon and best viewed about 30 minutes after sunset. They appear at their closest on the 29th at 4.2° apart (see Sky View).

After eight months as the Evening Star, **Venus** rapidly descends back toward the Sun. By month's end it will be lost in the Sun's glare as it nears inferior conjunction early in January. Venus reaches its greatest brilliancy on the 4th at –4.7 magnitude—known as *greatest illuminated extent*. It is defined as when the planet's illuminated portion or day side covers the greatest amount of sky. At this time, we see Venus one-quarter illuminated, just like a 3 or 4-day old Moon. On the 7th the 4-day old waxing crescent Moon appears about 5° above the planet. The Moon then goes on to visit Saturn on the 8th and Jupiter on the 9th (see Sky View).

DIARY			
Wed	1st	3 am	(1 am WST) star Spica 8° S of Moon.
Thu	2nd	pm	Phoenicids meteor shower, Nov 28 to Dec 9.
Fri	3rd	4 am	(2 am WST) Mars 4° SE of Moon.
Sat	4th		Comet 19P/ Borrelly 0.7° W of IC 5332 (G) in Sculptor.
Sat	4th	6 pm	(4 pm WST) New Moon.
Sat	4th	8 pm	(6 pm WST) Moon at perigee (356,794 km).
Sat	4th	9 pm	(7 pm WST) Comet 6P/d'Arrest 0.3° N of star Epsilon Piscis Austrini.
Tue	7th	pm	Venus 5° W of Moon.
Wed	8th	am	Puppid-Velids meteor shower, Dec 1–15.
Wed	8th	9 pm	(7 pm WST) Saturn 5° NW of Moon.
Thu	9th	9 pm	(7 pm WST) Jupiter 4° NW of Moon.
Fri	10th	5 pm	(3 pm WST) Maximum Libration (10.4°), bright NE limb.
Fri	10th	10 pm	(8 pm WST) Neptune 10° NE of Moon.
Fri	10th	pm	m.p. 44 Nysa 0.7° N of NGC 1817 (OC) in Taurus.
Sat	11th		m.p. 80 Sappho 1.0° NE of m.p. 43 Ariadne.
Sat	11th	Noon	(10 am WST) First Quarter Moon.
Sat	11th	pm	m.p. 44 Nysa 0.9° N of NGC 1807 (OC) in Taurus.
Tue	14th	am	Geminids meteor shower, Dec 4–20.
Wed	15th	9 pm	(7 pm WST) Uranus 2° W of Moon.
Fri	17th		Comet 104P/Kowal 2 0.8° NW of NGC 7606 (G) in Aquarius.
Fri	17th	Midn.	(10 pm WST) star Aldebaran 7° SE of Moon.
Sat	18th		Mars 1.0° SW of star Beta Scorpii.
Sat	18th	am	m.p. 22 Kalliope 0.5° SW of star Theta Geminorum.
Sat	18th	Noon	(10 am WST) Moon at apogee (406,320 km).
Sat	18th	10 pm	(8 pm WST) m.p. 25 Phocaea 0.07° E of star f Piscium.
Sun	19th		Mars 0.3° SW of star Omega^1 Scorpii.
Sun	19th	3 pm	(1 pm WST) Full Moon (405,935 km, furthest for 2021).
Tue	21st	10 pm	(8 pm WST) m.p. 25 Phocaea 0.1° N of NGC 474 (G) in Pisces.
Wed	22nd	1 am	(11 pm WST, prev day) star Pollux 3° NW of Moon.
Wed	22nd		Solstice.
Sat	25th	3 am	(1 am WST) star Regulus 7° SW of Moon.
Sat	25th	8 pm	(6 pm WST) Maximum Libration (9.6°), bright SW limb.
Mon	27th	4 am	(2 am WST) star Antares 5° S of Mars.
Mon	27th	Noon	(10 am WST) Last Quarter Moon.
Mon	27th	pm	Comet 4P/Faye 0.4° S of NGC 2254 (OC) in Monoceros.
Mon	27th	pm	m.p. 25 Phocaea 0.4° S of NGC 520 (G) in Pisces.
Wed	29th		Comet 6P/d'Arrest 5.3° W of Comet 19P/Borrelly.
Wed	29th	2 am	(Midn. WST, prev day) star Spica 7° SW of Moon.
Wed	29th	8 pm	(6 pm WST) Venus 4° N of Mercury.
Fri	31st		Uranus 0.4° S of star 29 Arietas.

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 is visible in the eastern dawn sky in Libra during the first half of the month. It then crosses the claw region of Scorpius and lastly into Ophiuchus. On the 3rd, the planet will be 4° to the south of the slender crescent of the waning 28-day old Moon—binoculars and a good eastern horizon will help you see it in the dawn sky (see Sky View).

In the western evening sky **Jupiter** stands out at the end of twilight, the only bright star nearby being 1st magnitude Fomalhaut in Piscis Austrinus. If you want to view the planet through a telescope, you should do so early in the month before it loses too much altitude. Jupiter's brightness has decreased a little over half a magnitude since its opposition last August. Its equatorial diameter has also diminished by 32% to 37 arcseconds (49 at opposition). On the 9th, the 6-day old waxing crescent Moon will be 4° from the planet (see Sky View).

Saturn is visible low in the western evening sky, setting around 10 pm mid-month. Although a little too low for meaningful telescopic observations of the planet, the waxing crescent Moon provides a pleasant visual display at the end of twilight. First, on the 7th the Moon will be seen near Venus, then on the following evening near Saturn and finally on the 9th near Jupiter. With each visit the Moon appears within 5° of the planet.

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 comes to the end of five months in retrograde on the 2nd and appears high in the early north-western evening sky at the end of astronomical dusk.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
9 Dec	42 Isis	Taurus	10.7
10 Dec	44 Nysa	Taurus	9.0
17 Dec	270 Anahita	Taurus	11.2
20 Dec	17 Thetis	Orion	11.5
24 Dec	32 Pomona	Orion	11.1
29 Dec	22 Kalliope	Auriga	10.1

COMETS

Comet 19P/Borrelly may brighten from 9th to 8th magnitude by month's end. Beginning December in Sculptor, the comet moves into Cetus late in the month. Visible as evening twilight ends, the comet will be setting around midnight by the end of the year.

Comet 67P/Churyumov-Gerasimenko is rising in the late evening and well placed to observe in December's morning skies. Predicted to fade from 9th to 10th magnitude, the comet moves slowly through Cancer throughout the month.

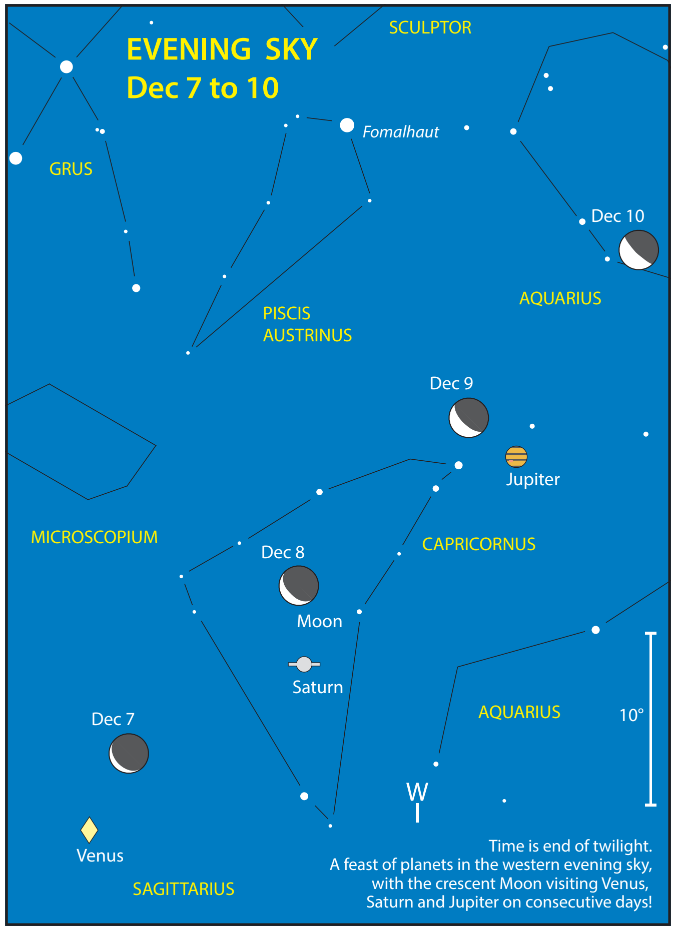
Comet 104P/Kowal 2 is predicted to brighten from 11th to 10th magnitude this month. Visible in the early evening hours, the comet is in Aquarius for all but the last two days of December, when it then moves into Pisces.

METEOR SHOWERS

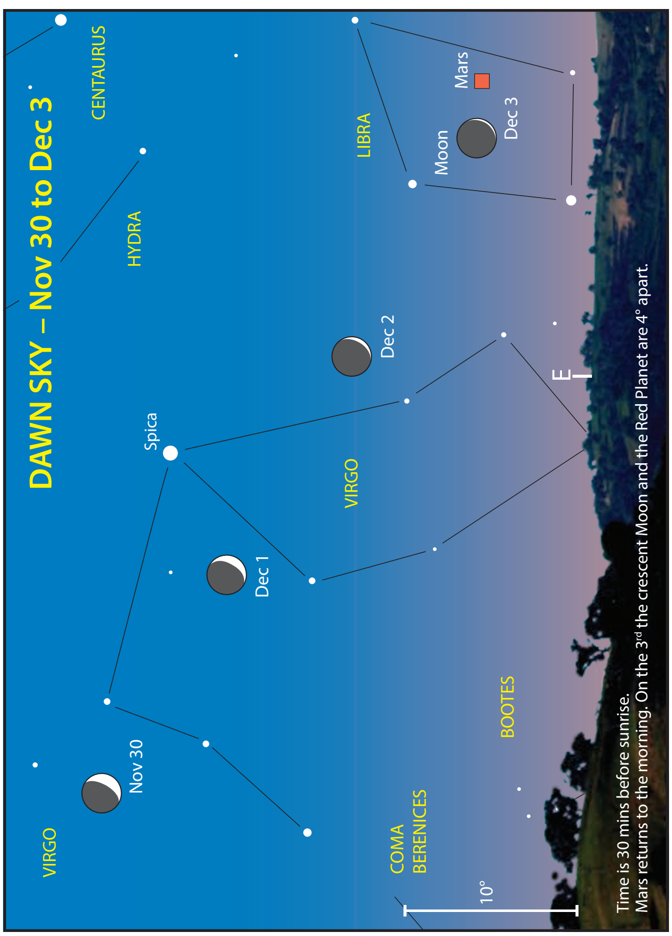
The **Phoenicids** are a southern shower discovered in 1956 during its only known major outburst when rates of 100 plus were observed. There have been three minor bursts since then and some significant activity in 2014. They are therefore a shower to keep an eye on, just in case. Their period of activity appears to be 28 November through to 9 December, with maxima around the 2nd. The Phoenicids' radiant culminates at dusk so early evening viewing should provide the best activity. This year offers perfect conditions for this shower with New Moon on the 4th.

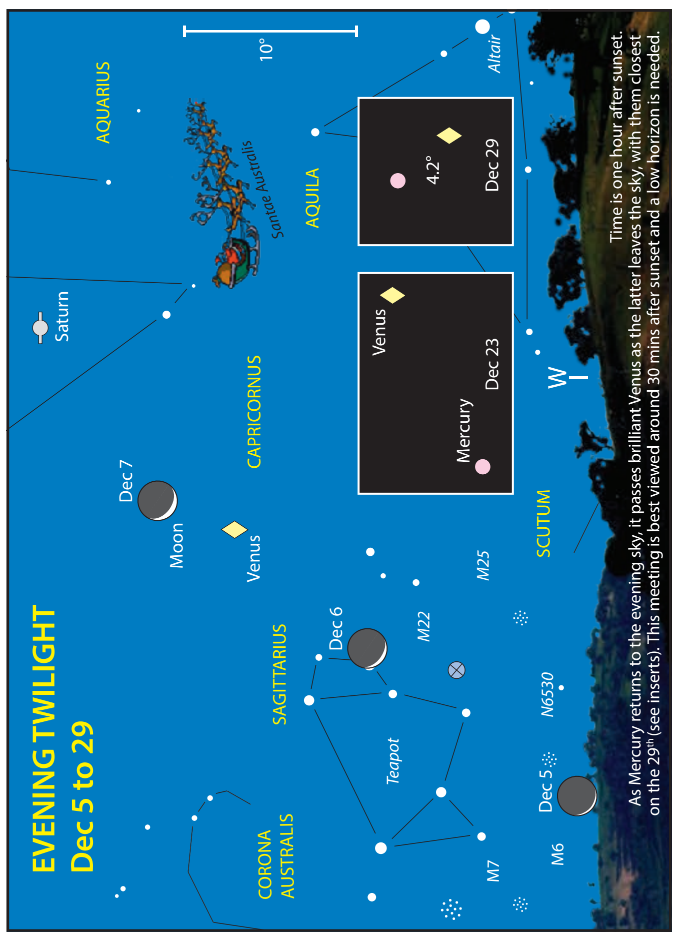
The **Puppid-Velids** are a vast complex system of showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. They are active from 1–15 December and could produce a peak zenith hourly rate of 10 around the evening of the 7th and morning of the 8th. The radiant culminates after midnight and, with First Quarter approaching, the morning skies will be Moon free during the peak this year.

The **Geminids** are one of the finest and reliable of the major annual showers. Visible from the 4th to 20th, with maximum predicted on the evening of the 13th and morning of the 14th. The Geminids often produce bright, medium-speed meteors with zenith hourly rates of up to 150. Even though our northern counterparts will see the best of the Geminids, they can still provide a spectacular display for us *down under*. The waxing gibbous Moon will be a hindrance until after 2 am but from then until dawn the sky will be Moon free.

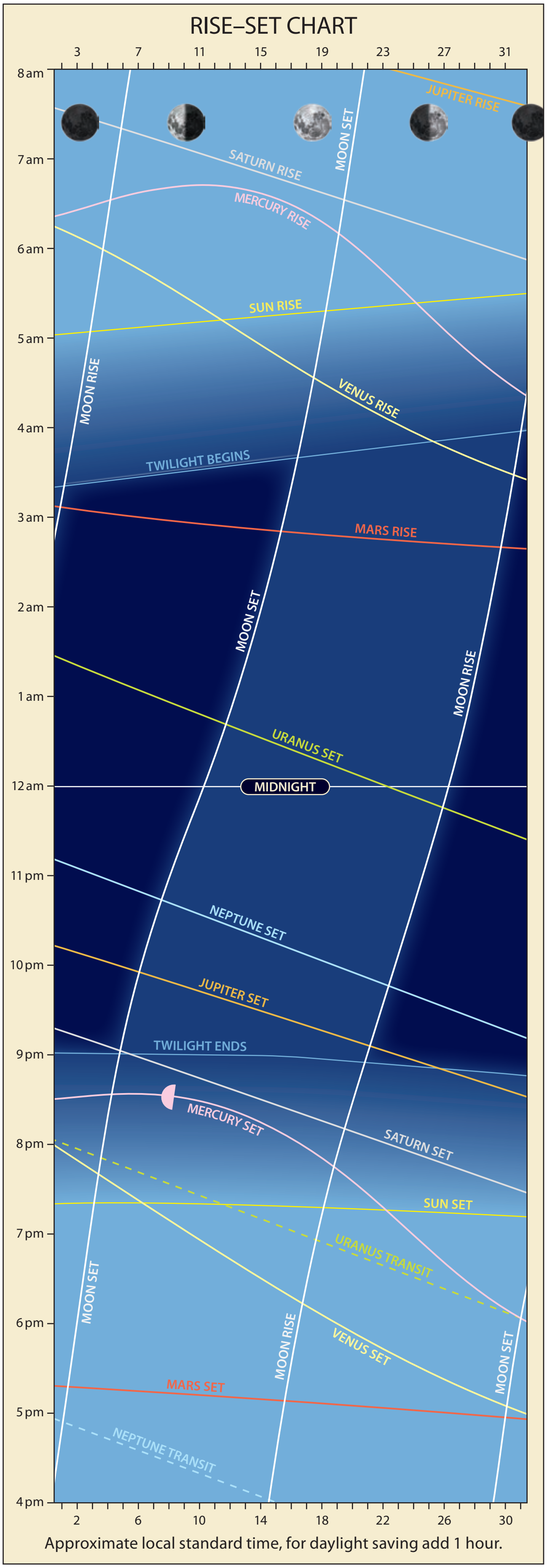


Approximate local standard time, for daylight saving add one hour.





JANUARY 2022



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

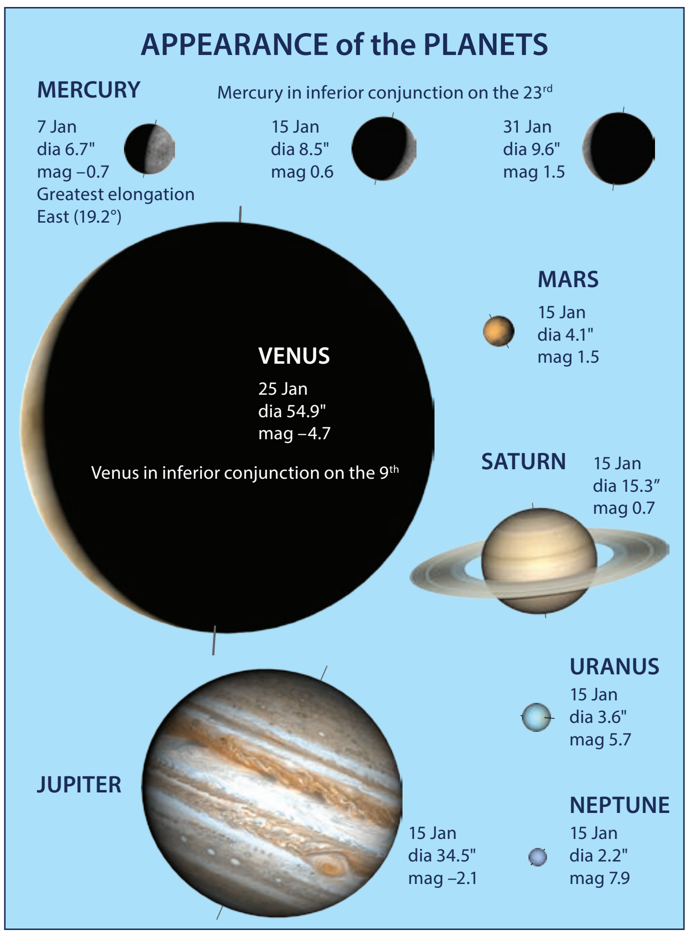
HIGHLIGHTS

- Mercury and Saturn close.
- Occultation of Mars by the Moon.
- Mars close to the Lagoon Nebula.
- Comets C/2021 A1 (Leonard) and 19P/Borrelly at their brightest.

CONSTELLATIONS

In our warm summer evening skies, from the Southern Hemisphere we have possibly the largest, certainly the brightest asterism sitting above the northern horizon, the Winter Hexagon (showing a northern bias—see All Sky Maps 2, 3, 4 and 5). If we start at the top, the six corners begin with the brightest star, Sirius (Alpha (α) Canis Majoris). Then heading anticlockwise, you come to Rigel in Orion, Aldebaran in Taurus, Capella in Auriga, Castor and Pollux in Gemini and Procyon in Canis Minor. The lowest and most northerly member is the star Capella, which is close to the horizon from mid-latitude Australia. The hexagon is the brightest asterism as all these stars are at least 1st magnitude with Sirius at –1.4 magnitude. Sometimes, depending on your source, you may hear it referred to as the Winter Octagon (or Circle) where two additional members are made by separating Castor and Pollux and adding Beta (β) Aurigae.

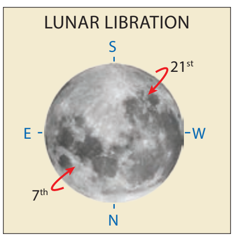
Another prominent asterism (within the hexagon), and possibly the most famous is Orion's Belt; three bright (2nd magnitude) stars equally spaced and arranged in a near straight line. They fit in a 3° circle making them an excellent binocular target (see All Sky Map 2). Being so obvious and visible from most of the Earth, certainly the populated parts, its mythology



varies greatly around the globe. They have been referred to as the Three Kings, sometimes inferred to be the Magi from the Bible. Although there is some confusion over the translation of the star names, Alnitak, Alnilam and Mintaka, their Arabic origins may be related to pearls. This is especially the case for the middle star, Alnilam, which is derived from 'an-nizam' meaning String of Pearls. If we expand the asterism to include Eta (η) Orionis and the less obvious short arm leading to the Orion Nebula (M42) we have the Saucepan with these *pearls* being the base. A grouping well orientated for the Southern Hemisphere observer.

Today the three *pearls* are widely accepted as the waist of Orion the Hunter, a traditional constellation derived from ancient Greek mythology. From our perspective *down under* the bright blue star above the belt is Beta (β) Orionis or Rigel (Arabic for foot) and the equally bright red star Alpha (α) Orionis, Betelgeuse, a similar distance below the belt, marks his armpit. Yes, we see him upside down. If you make a rectangle using these two stars as opposite corners, the star to the left of Betelgeuse, Gamma (γ) Orionis is the start of his left arm. This leads to the distinctive but faint arc of stars, all designated Pi (π), forming his shield. His right arm extends up (down for us) where he brandishes a club. How do we know this isn't his sword? Well, the handle of the saucepan is his sword hanging down (up) from the belt. We know this because the remaining rectangle star (right of Rigel) is Kappa (κ) Orionis or Saiph, derived from an Arabic phrase meaning, 'sword of the giant'.

THE MOON



Our regular readers may note that we usually list occultations of first magnitude stars by the Moon in this section. However, since the occultation of Aldebaran on 3 September 2018, there are no further occurrences with the brightest stars until 25 August 2023, when a new series with Antares begins. The next sequence involving Aldebaran starts on 18 August 2033.

- 2nd 9 am (7 am WST) Moon at perigee (closest to Earth at 358,033 km).
- 3rd 5 am (3 am WST) New Moon.
- 7th 2 pm (Noon WST) Maximum Libration (9.9°), bright NE limb.
- 10th 4 am (2 am WST) First Quarter.
- 14th 7 pm (5 pm WST) Moon at apogee (furthest from Earth at 405,805 km).
- 18th 10 am (8 am WST) Full Moon.
- 21st 9 pm (7 pm WST) Maximum Libration (8.6°), bright SW limb.
- 25th Midnight (10 pm WST) Last Quarter.
- 30th 5 pm (3 pm WST) Moon at perigee (closest to Earth at 362,252 km).

THE PLANETS

Mercury is visible in the early western evening sky at the beginning of the year, reaching its greatest elongation 19° east of the Sun on the 7th. The slender crescent of the 2-day old Moon will be a few degrees above Mercury on the 4th (see Sky View). On the 13th, the inner planet and Saturn meet up just 3.4° apart—Mercury is slightly brighter than Saturn currently (see Sky View).

Mercury is then lost from sight by mid-month as it moves toward its inferior conjunction (between Earth and the Sun) on the 23rd. It then reappears in late January in the eastern morning twilight (see Sky View).

Like Mercury, **Venus** will be in inferior conjunction this month (9th). This inner planet then reappears as the Morning Star in the eastern dawn sky toward month's end.

The **Earth** is at perihelion on the 4th, the closest point in its orbit to the Sun (147,105,121 km or 0.983337 au distant).

Mars is visible in the eastern dawn sky in Ophiuchus during the first two-thirds of the month. It then moves into Sagittarius, crossing the star clouds of the galactic centre. From southeast mainland Australia there will be an occultation of Mars by the Moon visible during the dawn of January 1. Canberra and Melbourne will see the disappearance at around 30 minutes before sunrise, where Sydney at this time will see a near miss (4 arcminutes from the limb). Adelaide will get the best view of any capital city seeing the disappearance and reappearance around 70 and 40 minutes respectively before sunrise. The lunar crescent will be quite thin and low in the east being only 2 days from New Moon. On the 30th, the planet again encounters a 27-day old Moon, this time a close approach at around 3° (see Sky View). Over January and February, Mars takes a tour of a number of deep sky objects in Ophiuchus and Sagittarius (see Diary). This includes being located between the Lagoon (Messier 8) and Trifid (Messier 20) Nebulae on January 26.

Jupiter is visible in the early western evening sky in Aquarius. If you know your ancient mythological figures, the planet is located near the mouth of the Water Jar asterism, formed by the stars Gamma (γ), Pi (π), Eta (η), and Zeta (ζ) Aquarii, that Aquarius is holding. Its low altitude this month does not lend itself to visual observation or imaging. On the 6th, the slender waxing crescent of the 4-day old Moon appears above the planet (see Sky View).

Saturn is low in the western evening sky during the first half of the month. On the 13th, the planet will be close to Mercury, visible just 30 minutes after sunset (see Sky View). After this approach, Saturn becomes too close to the Sun for observation, reappearing in the morning twilight in late February.

Uranus, in Aries, is visible in the early north-western evening sky. The planet spends the month within half a degree of the 6th magnitude star 29 Arietis. Since both are of similar brightness, the best way to distinguish them is to use moderate magnification, the one that shows a greenish disc is Uranus. The planet ends four months of retrograde motion on the 19th and then resumes drifting eastward against the stellar background.

Neptune is visible at the beginning of the year in the early western evening sky. Situated in Aquarius, the planet moves into Pisces in May and back to Aquarius in August.

Hubble Lifts the Veil
Cover Story

Approximately 10,000 years ago, well before recorded history, a guest star appeared in the east wing of the constellation of Cygnus the Swan. Located about 3° south-south-east from the naked-eye (2nd magnitude) star, Epsilon (ε) Cygni, it would have outshone Venus and likely been visible during the day. This signalled the death or supernova of a star around 20 times the mass of the Sun, located around 2,100 light-years away. Prior to this its progenitor could easily have been a reasonably bright naked-eye star, similar to one of the supergiants referred to on page 32.

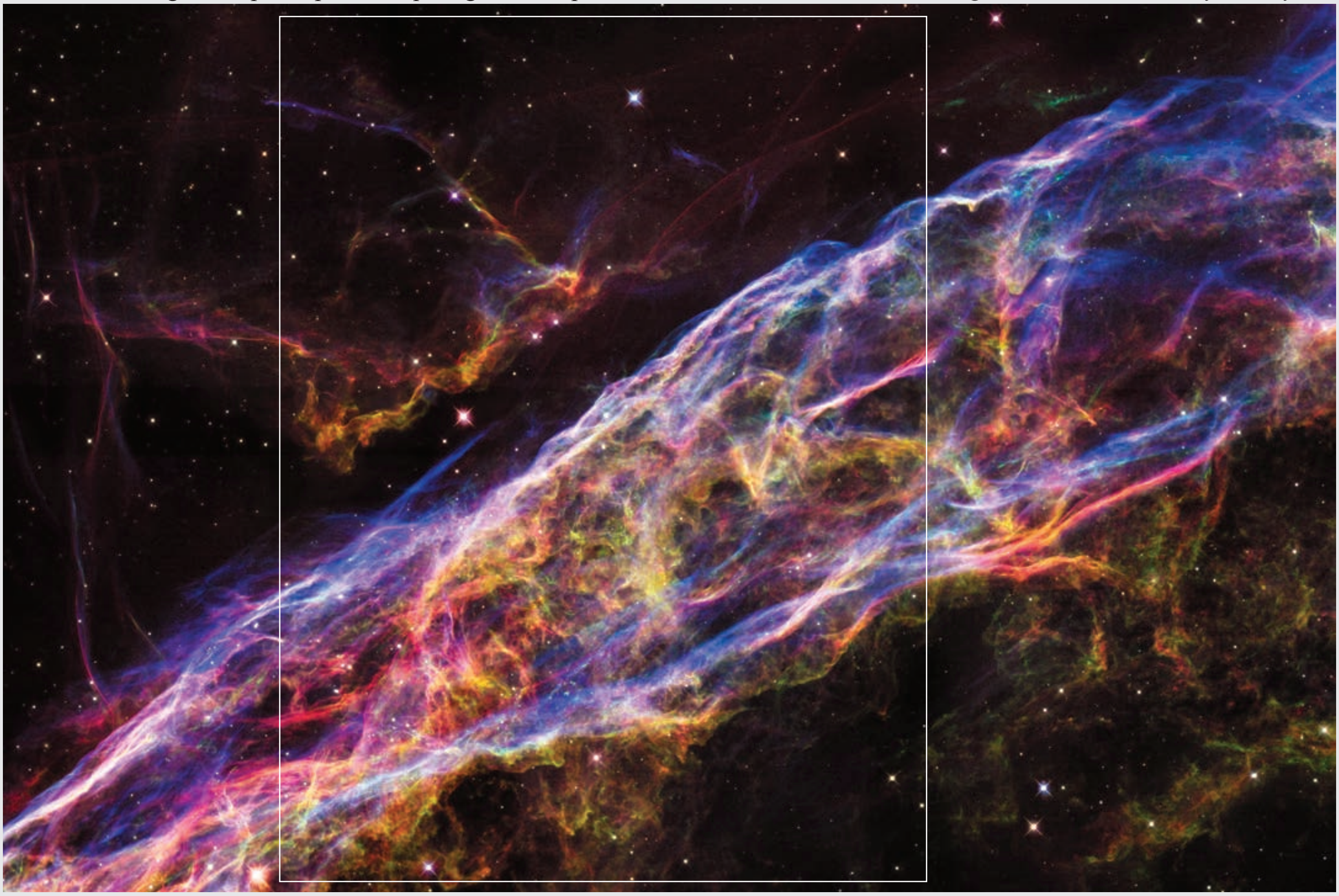
The resulting streams of light are caused by a rapidly expanding shock wave of material ploughing into a wall of dark, cooler gas previously expelled by the same star. This causes elements present to superheat and fluoresce at their particular wavelengths of light. This relatively thin-walled bubble is visible when thickest, that is, when looking down an edge from our perspective. The expansion is continuing, with the Hubble Telescope being able to detect its movement over only a 15-year period. The numerous interwoven thin filaments visible are responsible for its name. The entire Veil Nebula is often referred to as the Great Cygnus Loop.

The close up (cover) image is a composite of images taken by the Hubble Telescope's Wide Field Camera 3. It started out as a series of greyscale images taken through narrow band filters each designed to pick up the unique light from specific elements. It was then coloured. In this case, blue was used for visual and Oxygen III lines, red for Hydrogen-alpha, Nitrogen II and infrared light and green for Sulphur II.

The image is only a small portion of the Veil, around two light-years across. The entire remnant of the supernova has now expanded into a shell around 130 light-years across (or covering three degrees of sky as we see it). The position and size of the Hubble image is drawn in the wide field image. To give you a feel for the size of the entire Veil in the sky, the wide field size is shown on All Sky Map 9.

When it comes to observing the Veil, although you may hear its praises sung, a lot of these reviews come from the Northern Hemisphere. In northern mid-latitudes, Cygnus passes overhead. For Australian latitudes we average around 20° to 30° maximum elevation (Darwin gets 40°). At these altitudes any loss of atmospheric transparency (haze, dust etc) is magnified by how much atmosphere you are looking through. You need a dark sky to view the nebula and for those advanced amateurs an OIII filter can work wonders. As a general guide a 20 to 25 cm telescope minimum is recommended, with the Eastern Veil (NGC 6992/95) the easiest to see. If you hear of people viewing the Veil through binoculars, this is probably the area they are referring to. The Western Veil (NGC 6960) is also a good target, especially north of the bright double star 52 Cygni. As you can see, the location of the Hubble composite image is a bright spot. South of the star the nebula widens and gets fainter.

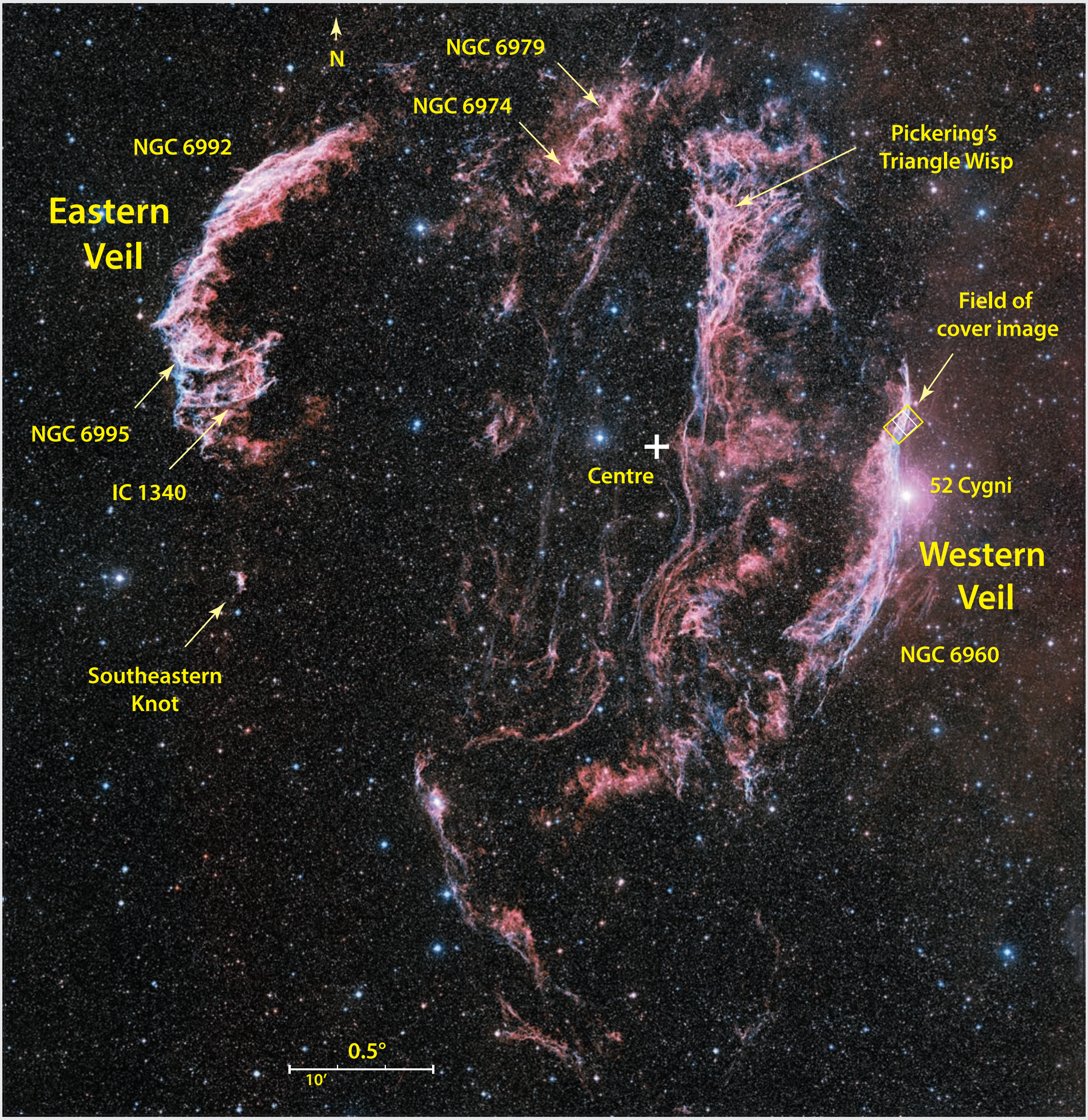
To get an idea of how challenging the Veil Nebula is to view, it's worthwhile having a look at its discovery history.



A close up of a small section of the Veil Nebula, around 2 light-years wide. The white box shows the portion used on the cover. Six Hubble Telescope images where mosaiced together to create this view. Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

It was first seen by William Herschel in 1784 using an 18-inch (450 mm) instrument. Although other observers such as Messier and Mechain were active earlier in the 18th Century, nothing was reported for the Veil. Incidentally these gentlemen published the Messier Catalogue (the first 103 deep sky objects) just three years before Herschel's discovery. Although, to give Messier some *latitude*, his observations were done with only a 4-inch (100 mm) telescope. Fainter regions of the Veil were still being discovered early in the 20th Century, such as Williamina Fleming's photographic finding of the faint portion known as Pickering's Triangle (named after her observatory's director) in 1904.

Like the ancient Greeks responsible for most of the mythology around the constellations we follow today, many other cultures were rich with their interpretations of the heavens. This included the Australian Aboriginals. For thousands of years these first Aussies had many legends associated with the night sky and knew the positions of the stars well. It is interesting to wonder what they would have thought of this strange, temporary bright addition to the night sky, and whether the supernova has a place in their dreamtime. If the supernova did happen around 10,000 years ago, precession would have made it around 8° closer to the northern horizon than we see Cygnus from Australia today.



Wide Field image of the Veil Nebula. Made as a composite of images from the Digitised Sky Survey 2. The field of view is 4.2° × 4.4°. The position and size of the Hubble close up image is shown as a yellow box.

Credit: NASA, ESA, the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration, and the Digitized Sky Survey 2. Credit: J. Hester (Arizona State University) and Davide De Martin (ESA/Hubble)

DIARY			
Sat	1st		Mercury 0.6° SW of M75 (GC) in Sagittarius.
Sat	1st	am	m.p. 11 Parthenope 0.8° NW of star Regulus (Alpha Leonis).
Sat	1st	am	m.p. 15 Eunomia 1.0° NE of NGC 5068 (G) in Virgo.
Sat	1st	3 am	(1 am WST) star Antares 5° SW of Moon.
Sat	1st	4 am	(2 am WST) Mars 0.5° E of Moon.
Sun	2nd	9 am	(7 am WST) Moon at perigee (closest to Earth at 358,033 km).
Mon	3rd	5 am	(3 am WST) New Moon.
Tue	4th		Mars 0.5° S of NGC 6235 (GC) in Ophiuchus.
Tue	4th		Comet 19P/Borrelly 5.0° NW of star Beta Ceti.
Tue	4th	am	Quadrantids meteor shower, Jan 1–5.
Tue	4th		Earth at perihelion, 0.983336540 au.
Tue	4th	8 pm	(6 pm WST) Saturn 7° NE of Moon.
Tue	4th	8 pm	(6 pm WST) Mercury 4° W of Moon.
Thu	6th	8 pm	(6 pm WST) Jupiter 5° W of Moon.
Fri	7th	2 pm	(Noon WST) Maximum Libration (9.9°), bright NE limb.
Fri	7th	9 pm	(7 pm WST) Neptune 3° N of Moon.
Fri	7th		Mercury at greatest elongation East (19.2°).
Sat	8th		Mars 0.4° SE of NGC 6287 (GC) in Ophiuchus.
Sat	8th		Comet 19P/Borrelly 2.0° NW of NGC 210 (G) in Cetus.
Sun	9th		Venus in inferior conjunction.
Mon	10th	4 am	(2 am WST) First Quarter Moon.
Tue	11th		Comet 19P/Borrelly 2.0° NW of NGC 246 (PN) in Cetus.
Tue	11th	9 pm	(7 pm WST) Uranus 1° NE of Moon.
Wed	12th		Mars 0.4° N of NGC 6325 (GC) in Ophiuchus.
Wed	12th		Comet C/2021 A1(Leonard) 2.5° W of star Gamma Gruis.
Wed	12th		Juno in conjunction with Sun.
Fri	14th		Comet 104P/Kowal 2 8° NE of Comet 19P/Borrelly.
Fri	14th	7 pm	(5 pm WST) Moon at apogee (furthest from Earth at 405,805 km).
Sat	15th		d.p. 1 Ceres 1.0° NW of star Kappa[1] Tauri.
Sat	15th	pm	Comet 67P/Churyumov-Gerasimenko 0.4° N of star Iota Cancri.
Mon	17th		d.p. 1 Ceres 0.5° NW of star Upsilon Tauri.
Tue	18th	2 am	(Midn WST, prev day) star Pollux 2° N of Moon.
Tue	18th	10 am	(8 am WST) Full Moon (401,024 km, furthest for this year).
Wed	19th		Mars 0.4° NE of NGC 6401 (GC) in Ophiuchus.
Thu	20th	11 pm	(9 pm WST) star Regulus 5° S of Moon.
Fri	21st	9 pm	(7 pm WST) Maximum Libration (8.6°), bright SW limb.
Sun	23rd		Mercury in inferior conjunction.
Mon	24th	Midn	(10 pm WST) star Spica 6° S of Moon.
Tue	25th		Jupiter 0.2° N of star Sigma Aquarii.
Tue	25th	Midn	(10 pm WST) Last Quarter Moon.
Wed	26th		Mars 0.7° SE of M20 Trifid Nebula (BN) in Sagittarius.
Wed	26th		Mars 0.9° S of M8 Lagoon Nebula (BN) in Sagittarius.
Thu	27th		Comet 19P/Borrelly 0.5° E of NGC 428 (G) in Cetus.
Thu	27th	9 pm	(7 pm WST) Comet 104P/Kowal 2 0.05° SW of star Alpha Piscium.
Fri	28th		Mars 0.7° SE of NGC 6546 (OC) in Sagittarius.
Fri	28th	3 am	(1 am WST) star Antares 6° SE of Moon.
Sun	30th		Comet 19P/Borrelly 0.5° SE of NGC 474 (G) in Pisces.
Sun	30th	3 am	(1 am WST) Mars 3° N of Moon.
Sun	30th	5 pm	(3 pm WST) Moon at perigee (closest to Earth at 362,252 km).
Mon	31st		m.p. 29 Amphitrite 0.3° S of star Sigma Scorpii.
Mon	31st	5 am	(3 am WST) Mercury 8° N of Moon.
Mon	31st	9 pm	(7 pm WST) Comet 19P/Borrelly 0.05° N of NGC 520 (G) in Pisces.
Mon	31st	pm	Comet C/2009 L3 (ATLAS) 0.3° E of NGC 2266 (OC) in Gemini.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf planet **Pluto** is in conjunction with the Sun on the 16th and returns to the morning skies in February. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
14 Jan	7 Iris	Gemini	7.7
20 Jan	68 Leto	Cancer	11.4
24 Jan	194 Prokne	Canis Minor	12.5
26 Jan	45 Eugenia	Cancer	11.3

COMETS

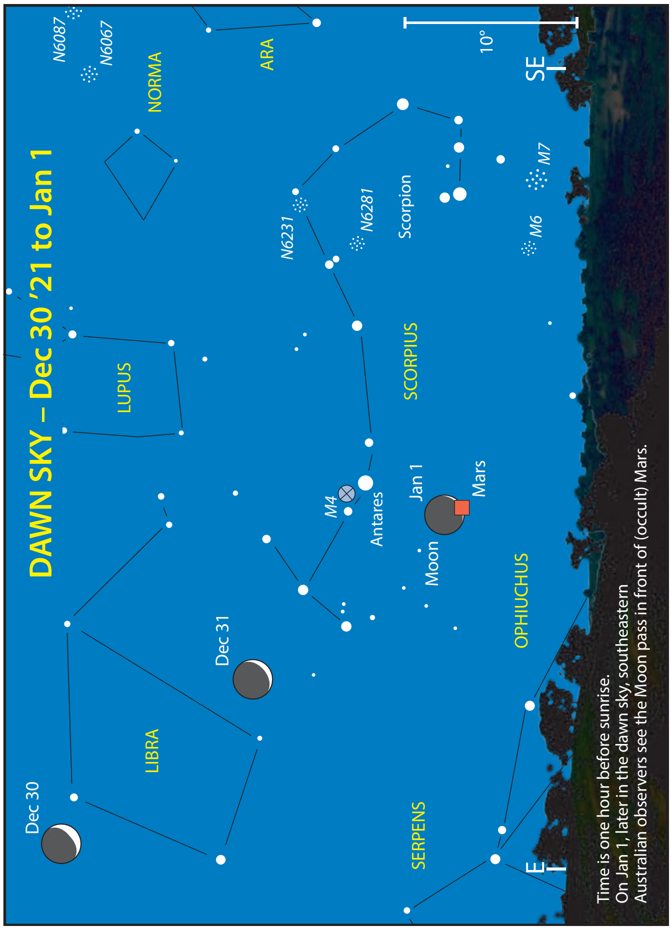
Comet 19P/Borrelly should remain around 8th magnitude this month. Visible until late in the evening, Borrelly opens the month around 5° from Beta (β) Ceti. It remains in Cetus for all but the last two days of January, when it crosses into Pisces. On the 31st it makes a very close approach to the Flying Ghost Galaxy (NGC 520), see diary. Next month sees the comet at perihelion.

Comet 67P/Churyumov-Gerasimenko is rising in the evening around the end of astronomical twilight at the beginning of January. Glowing at 10th magnitude, the comet is slowly moving through northern Cancer, around 10° north of the Beehive Cluster, and is best observed after midnight. It has a close approach to 4th magnitude Iota (ι) Cancri on 15th. Having reached perihelion in November 2021, 67P is moving away from both the Sun and Earth and should fade to 11th magnitude by month's end.

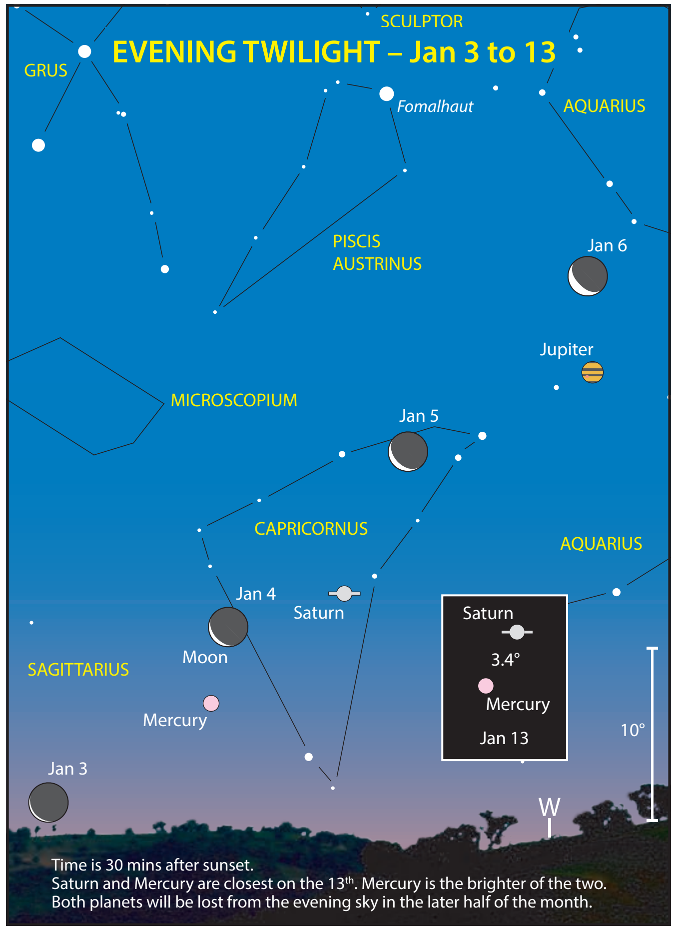
Comet 104P/Kowal 2 is in the evening sky throughout January, setting just before midnight. Reaching perihelion on 11 January at a distance of 1.07 au from the Sun, the comet is closest to Earth in late January (around 0.6 au) and should remain around 10th magnitude throughout the month. Kowal 2 moves from Pisces into Cetus at the end of the first week of January, moving along the border of the two constellations and finishing January near Alpha (α) Piscium (a very close approach on the evening of the 27th, see diary).

Comet C/2021 A1 (Leonard) could open the year at 6th magnitude in January's evening skies. At perihelion on 3 January, at just over 0.6 au from the Sun, the comet will be best seen in early January. It's in Piscis Austrinus throughout the month, near the borders of Grus and Microscopium, and only a few degrees from 3rd magnitude Gamma (γ) Gruis for much of the month. As January progresses, Leonard will sink closer to the glare of the Sun, becoming lost from view late in the month as it fades to 9th magnitude as a result of its increasing distance from both the Earth and the Sun.

Comet C/2009 L3 (ATLAS), reaching perihelion on the 10th, spends January near maximum brightness (10th magnitude) in Gemini. ATLAS is visible most of the night, transiting low in the northern sky in the late evening. It opens January a few degrees from Castor (Alpha (α) Geminorum). The comet is slowly drifting southward, so continues to gain altitude over the coming months.



Time is one hour before sunrise.
On Jan 1, later in the dawn sky, southeastern Australian observers see the Moon pass in front of (occult) Mars.



Time is 30 mins after sunset.
Saturn and Mercury are closest on the 13th. Mercury is the brighter of the two.
Both planets will be lost from the evening sky in the later half of the month.

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

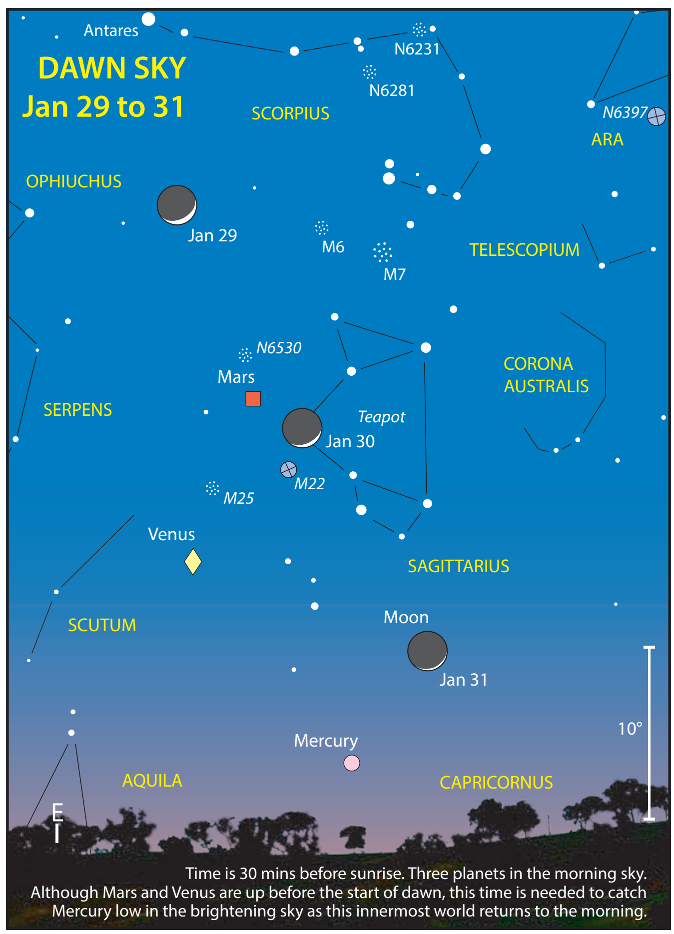
DOUBLE STARS

Located in Lepus, the Hare, at a distance of 29 light-years, **Gamma (γ) Leporis** (H VI 40) is a memorable, colourful binocular double. The wide yellow and orange pair (magnitude 3.6 and 6.3, spectral types F6V and K2V) is separated by 95 arcseconds and easily split in binoculars. A tip for viewing binocular double stars, try sitting in a chair, preferably one with a sloping back and tucking your elbows into your chest whilst holding the binoculars. Observing the star when it is away from the zenith also helps. The steadier you can hold the binoculars, the better the view. (All Sky Map 2)

Located 900 light-years away, **Rigel** (Beta (β) Orionis, STF 668) is an excellent double star for small telescopes. The brilliant blue-white supergiant primary (magnitude 0.3, spectral class B8Iae) has a fainter bluish companion (magnitude 6.8, spectral class B5V) located 9.7 arcseconds away. The companion is itself a spectroscopic binary. (All Sky Map 2)

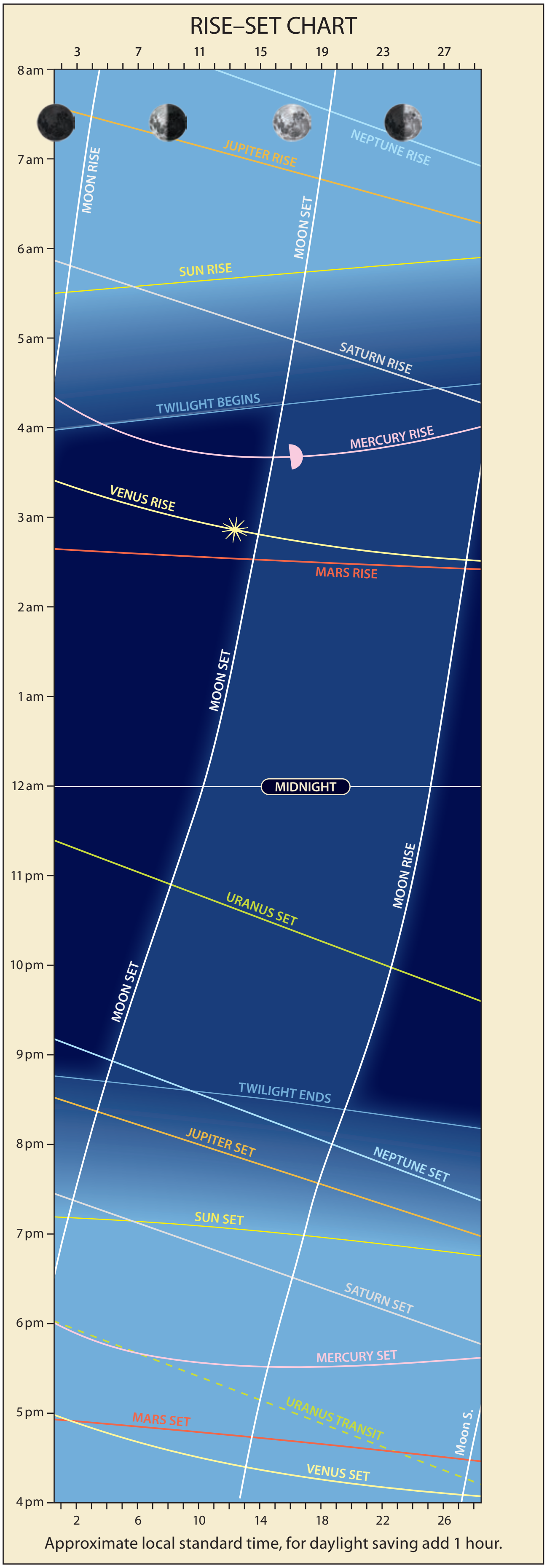
METEOR SHOWER

The **Quadrantids** is 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 January 1–5, with up to 40 meteors per hour at their peak. With New Moon on the 3rd, there will be no lunar interference.



Time is 30 mins before sunrise. Three planets in the morning sky.
Although Mars and Venus are up before the start of dawn, this time is needed to catch Mercury low in the brightening sky as this innermost world returns to the morning.

FEBRUARY 2022



HIGHLIGHTS

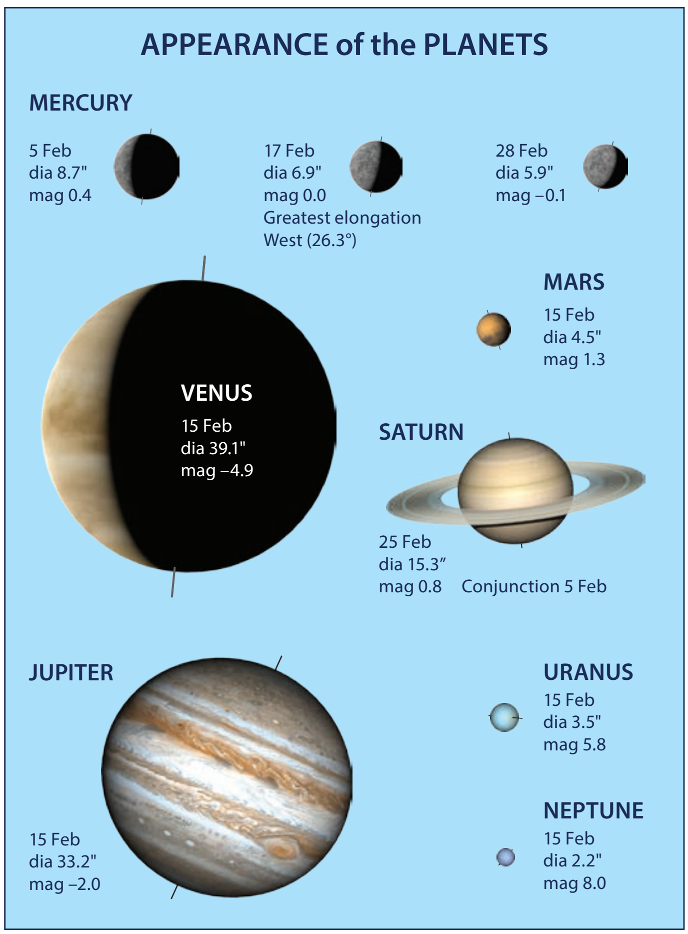
- Four naked-eye planets in the morning.
- Mercury and Saturn close.
- Venus and Mars travel together.
- Mars visits two globular clusters.
- Mercury at its best in the morning.

CONSTELLATIONS

This month we stay within the Winter Hexagon, moving onto the constellation of Gemini the Twins (All Sky Map 5). Like Orion, this is another of the traditional 48 constellations derived from Greek mythology. However, this is also on the ecliptic (the apparent path that the Sun follows) so is a sign of the Zodiac, hence visited by the planets at times. In fact, of the three discovered planets (that is those needing optical aids to see), two were found in Gemini. William Herschel discovered Uranus while it was near Eta (η) Geminorum in 1781. Clyde Tombaugh found Pluto (now a dwarf planet) photographically while it was near Delta (δ) Geminorum in 1930.

The mythical twins of Gemini were called Castor and Pollux. In this constellation these names are also used for Gemini's two brightest stars, which also mark the position of their heads. This couple is associated with the mythology of the ship Argo Navis—the ancient southern constellation now divided into Carina, Vela and Puppis. The twins accompanied Jason on his search for the Golden Fleece, whose origin is also heavenly immortalised as Aries the Ram (a somewhat unimpressive member of the Zodiac).

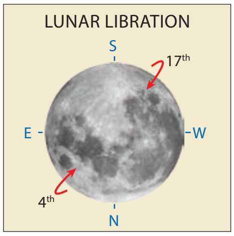
You might say that two bright stars doesn't make much of an asterism, but they stand out, so are useful for navigating the



night sky. In a way they are similar to the Pointers, now rising in the south-east, even with similar separations (about 4.5°). Other than these two 1st magnitude stars, the twins' bodies consist of stick figures, made by joining 2nd to 4th magnitude stars stretching away towards Orion. Hence, these *beings* are mostly on their side or upside down from the Southern Hemisphere. The twins are more easily recognised from the Northern Hemisphere where they were *created*, standing on the horizon just before setting.

Gemini contains a few objects ideal for small telescopes. Here's a taste. Castor is a brilliant blue/white double star, with 1.9 and 3.0 magnitude components currently separated by 6.6 arcseconds. This is not a line-of-sight double but a true binary, orbiting each other every 445 years. Don't miss the gathering of star clusters approximately 2° north-west of Eta (η) Geminorum. The highlight is M35, an open cluster around 0.5° across, containing around 100 stars with some of the brightest stars forming curved lines. In contrast to M35, within the same low power eyepiece field is another more compact cluster, NGC 2158, looking more like a fuzzy ball. Incidentally, Eta Gem is also known as Propus, taken from the Greek for 'forward foot', which is appropriate as it marks the position of the leading foot of the western twin, Castor.

THE MOON



- 1st 4 pm (2 pm WST) New Moon.
- 4th 7 am (5 am WST) Maximum Libration (8.8°), bright NE limb. The 200 km Mare Smythii emerges from the zone of librations.
- 8th Midnight (10 pm WST) First Quarter.
- 11th 1 pm (11 am WST) Moon at apogee (furthest from Earth at 404,897 km).
- 17th 3 am (1 am WST) Full Moon.
- 17th 3 pm (1 pm WST) Maximum Libration (8.1°), bright SW limb.
- 24th 9 am (7 am WST) Last Quarter.
- 27th 8 am (6 am WST) Moon at perigee (closest to Earth at 367,789 km).

THE PLANETS

Having returned to the eastern dawn sky in late January, **Mercury** ascends toward its greatest elongation 26° west of the Sun on the 17th. Mid February to early March marks the best period this year for observing the planet in the morning sky. As Mercury again sinks back toward the Sun, it finishes the month 4° above Saturn. Keep a watch for an even closer rendezvous early next month.

Venus rises in the early morning sky in Sagittarius, sharing the constellation of the Archer with Mars (see Sky View). At month's end, the planetary duo will be 5° apart. Venus reaches its greatest brilliancy on the 13th at –4.8 magnitude. This is known as its *greatest illuminated extent*. Or when the planet's illuminated portion or day side covers the greatest amount of sky. At this time, we see Venus one-quarter illuminated, just like a three or four day old Moon.

DIARY			
Tue	1st	am	m.p. 4 Vesta 5° S of Venus.
Tue	1st	4 pm	(2 pm WST) New Moon.
Tue	1st	pm	m.p. 7 Iris 0.7° S of star Lambda Geminorum.
Wed	2nd		Mars 1.0° N of M28 (GC) in Sagittarius.
Wed	2nd		m.p. 29 Amphitrite 0.4° N of M4 (GC) in Scorpius.
Thu	3rd		Comet 19P/Borrelly 0.7° SE of m.p. 40 Harmonia.
Thu	3rd		Comet 19P/Borrelly 0.4° SE of star Mu Piscium.
Fri	4th		Mars 0.3° SW of NGC 6642 (GC) in Sagittarius.
Fri	4th		m.p. 29 Amphitrite 0.3° SW of NGC 6144 (GC) in Scorpius.
Fri	4th	7 am	(5 am WST) Maximum Libration (8.8°), bright NE limb.
Sat	5th		Saturn in conjunction with Sun.
Sun	6th		Mars 0.3° NE of M22 (GC) in Sagittarius.
Sun	6th	3 am	(1 am WST) m.p. 29 Amphitrite 0.05° NW of star Antares (Alpha Scorpii).
Mon	7th	9 pm	(7 pm WST) Uranus 5° NE of Moon.
Tue	8th		Comet 104P/Kowal 2 2.7° N of star Alpha Ceti.
Tue	8th		Comet 19P/Borrelly 0.4° NW of star Omicron Piscium.
Tue	8th		alpha-Centaurids meteor shower, Jan 28 to Feb 21.
Tue	8th	Midn	(10 pm WST) First Quarter Moon.
Tue	8th	pm	Comet C/2009 L3 (ATLAS) 0.9° W of star Epsilon Geminorum.
Wed	9th		m.p. 4 Vesta 0.4° NW of star Omicron Sagittarii.
Thu	10th		Comet 22P/Kopff 0.4° N of star Xi^2 Sagittarii.
Thu	10th	9 pm	(7 pm WST) star Aldebaran 8° S of Moon.
Fri	11th	1 pm	(11 am WST) Moon at apogee (furthest from Earth at 404,897 km).
Sat	12th		Mars 0.8° SE of NGC 6717 (GC) in Sagittarius.
Sat	12th		m.p. 4 Vesta 0.2° S of star Pi Sagittarii.
Sat	12th		Comet 104P/Kowal 2 0.9° S of star Omicron Tauri.
Sat	12th		Comet 22P/Kopff 1.2° N of star Omicron Sagittarii.
Sun	13th		Venus greatest illuminated extent.
Sun	13th		Comet 104P/Kowal 2 1.3° S of star Xi Tauri.
Sun	13th	am	Mars 6° S of Venus.
Mon	14th		Comet 22P/Kopff 0.6° N of star Pi Sagittarii.
Mon	14th	1 am	(11 pm WST, prev day) star Pollux 5° E of Moon.
Thu	17th		m.p. 2 Pallas 0.1° SW of star Iota Ceti.
Thu	17th		Comet 22P/Kopff 0.8° N of m.p. 4 Vesta.
Thu	17th	3 am	(1 am WST) star Regulus 6° S of Moon.
Thu	17th	3 am	(1 am WST) Full Moon (391,888 km).
Thu	17th		Mercury at greatest elongation West (26.3°).
Thu	17th	3 pm	(1 pm WST) Maximum Libration (8.1°), bright SW limb.
Sat	19th		Comet 104P/Kowal 2 2.2° S of star Lambda Tauri.
Mon	21st	3 am	(1 am WST) star Spica 7° S of Moon.
Tue	22nd		Venus 1.0° N of star Rho^1 Sagittarii.
Wed	23rd		Saturn 0.5° N of star Iota Capricorni.
Thu	24th	9 am	(7 am WST) Last Quarter Moon.
Fri	25th	1 am	(11 pm WST, prev day) star Antares 7° SW of Moon.
Fri	25th		m.p. 4 Vesta 1.5° N of Mars.
Sat	26th		Comet 104P/Kowal 2 4.5° S of star Aldebaran.
Sun	27th		Mercury 0.7° S of star Theta Capricorni.
Sun	27th	8 am	(6 am WST) Moon at perigee (closest to Earth at 367,789 km).
Mon	28th	3 am	(1 am WST) Venus 10° NW of Moon.
Mon	28th	3 am	(1 am WST) Mars 6° W of Moon.

Mars is visible in the early morning eastern sky in Sagittarius, together with Venus (see Sky View). Although not really close, the inclusion of a waning crescent Moon on the 27th and 28th makes a pleasing sight with the two planets. The Red Planet continues its tour of Sagittarius' deep sky objects this month including visiting two Messier globulars—M28 on the 2nd and magnificent M22 on the 6th (see diary).

Jupiter may be glimpsed early in the month low in the early western evening twilight (see Sky View). It then becomes too close to the Sun for observation and reappears in the morning sky in mid-March.

Saturn returns to the morning eastern twilight at the end of the month after solar conjunction on the 5th. The planet is in Capricornus (the Sea-Goat) and remains in this constellation throughout the year. On the 28th, Saturn and Mercury appear 4° apart, and in early March, the pair get even closer.

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 moving into Taurus in 2024. Do not confuse the nearby star, 29 Arietis, with Uranus as both are very close in magnitude.

Neptune will be lost in the evening twilight as it nears conjunction with the Sun in mid-March.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

In the latter half of February, d.p. 1 Ceres can be found passing between the Pleiades and Hyades open star clusters. Early in the month, 11th magnitude m.p. 29 Amphitrite, spends a few days in the head of the scorpion, near a couple of globular clusters and has a close encounter with Antares on the 6th (see diary). Brightest minor planets at opposition this month include:

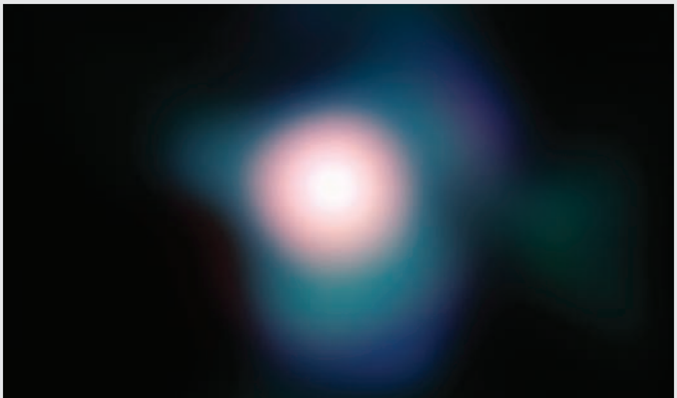
Date	Minor Planet	Constellation	Mag.
1 Feb	67 Asia	Cancer	12.4
5 Feb	20 Massalia	Cancer	8.5
11 Feb	11 Parthenope	Leo	10.0
18 Feb	702 Alauda	Hydra	12.1
22 Feb	19 Fortuna	Leo	10.6
25 Feb	423 Diotima	Leo	11.9
26 Feb	471 Papagena	Leo	11.1

Giants Amongst Giants!

Just looking at the brightest stars in the night sky it is impossible to tell which appear bright because they are close or because they have very high inherent luminosities (like comparing 100 watt light bulb vs a 20 W). In reality there are some real powerhouses out there, stars we should be happy we are not close to.

To understand such behemoths, we need to look at the early history of all stars. Stars condense out of nebulae (clouds of mostly hydrogen). If it's a large enough star forming region, this could happen in the company of another star (leading to a binary) or many others—the birth of a star cluster. By condense we mean the particles/atoms are pulled together by their mutual gravitational attraction. The pressure in the core gets to a point where hydrogen atoms fuse into helium generating enormous energy. As this contraction continues, the outward pressure of this radiation grows, pushing back out against the weight of the surrounding gas trying to crush it, until they reach a balance. This is when a star becomes a dwarf and, on the Hertzsprung-Russell diagram, it has entered the main sequence. At this time in its history the temperature and its colour (spectral class) directly reflect its mass. The higher the mass the hotter the star (see also overview of the basic spectral classification system on page 141). Stars continue to burn hydrogen until the core has been converted to helium. At that time, it contracts further until the inner temperature reaches a point when it dramatically pushes back and the entire star expands causing the luminosity to dramatically increase (larger radiating surface area) as it enters the giant phase.

The star's future is determined by its mass. As well as being guaranteed future supernovae status, high mass dwarfs (over 10 and perhaps as high as 100+ solar masses) have so much external pressure, they are forced to burn through their core's hydrogen quickly, some spending only tens of millions of years in this phase. These stars are hot and blue, having temperatures of 10,000K up to 50,000K. This 'dwarf' period dramatically increases as the mass drops. Our yellow Sun (one solar mass) is 5780K and has a life expectancy of about 10,000 million years. As an interesting side point, once we get below half a solar mass, the stars are known as red dwarfs and have such a low luminosity, sometimes they may be invisible to the human eye, radiating mostly in the infrared. At this point their lifetimes are expected to be comparable to the life span of the Milky Way itself! No wonder we have so many red dwarfs. Solar mass stars are estimated to be only around ten percent of the stellar population, so the Sun is certainly larger than your average star.



Betelgeuse from ESO's Very Large Telescope showing the stellar disc and an extended atmosphere with a previously unknown plume of surrounding gas. Credit: ESO and P. Kervella

We return to the high mass dwarf. Fortunately for us these supersize stars, destined to go supernova, are rare. Then why are they so amply represented amongst the brightest stars? Simply because they are so luminous and therefore can be seen at great distances (see the brightest star list p. 141). If we look just at 1st magnitude stars and brighter (apparent magnitude at least 1.5) there are four highly luminous supergiants (designated as '1a' in their spectral type). Deneb and Rigel are quite hot (A and B respectively) with Antares and Betelgeuse cool (class M). The expansion of a star causes its outer layers to cool, the larger the expansion the greater the cooling. This is how monstrously large, massive stars are seen across a wide range of temperatures. Also, don't be fooled into thinking there is not a central seething caldron buried within the low temperature facade of Betelgeuse. The star is only 8-million years old and is already on the verge of going supernova!

COMETS

Comet 19P/Borrelly is expected to shine at around 8^{th} magnitude through February. Setting mid-evening, the comet is best observed towards the end of astronomical twilight. Beginning the month in Pisces it reaches perihelion on the 2^{nd} at a distance of 1.3 au from the Sun before moving into Aries mid-month.

Comet 104P/Kowal 2 begins February in Cetus and is visible until late in the evening, passing across the head of Cetus from the 3^{rd} to 8^{th}. Expected to fade from 10^{th} to 11^{th} magnitude, the comet moves into Taurus mid-month, and ends February just south of Aldebaran.

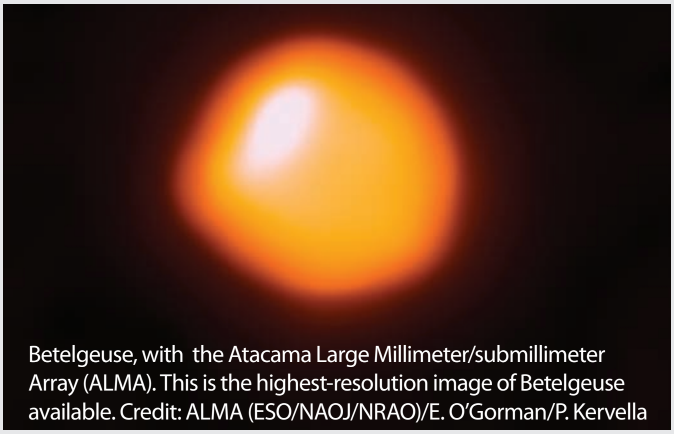
Comet C/2017 K2 (PANSTARRS) is predicted to brighten to 10^{th} magnitude in February as it heads towards perihelion in December. Emerging into the pre-dawn sky, PANSTARRS is slowly moving through Ophiuchus, near the borders of Hercules and Aquila.

Comet C/2021 A1 (Leonard) may become visible in the pre-dawn sky at the end of February in Microscopium, faintly glowing at 11^{th} magnitude.

Comet C/2009 L3 (ATLAS) Like January, February sees the comet remain in Gemini and possibly around maximum brightness of 10^{th} magnitude. Commencing the month within a couple of degrees of Epsilon (ε) Geminorum, ATLAS remains low in the northern evening sky, transiting in the mid-evening.

Comet 22P/Kopff spends February in Sagittarius commencing the month 10° above the eastern horizon at the start of dawn, remaining low in the late morning sky. Reaching perihelion in March the comet is near its maximum brightness of 11^{th} magnitude.

Looking at Deneb, in Cygnus. It might be an average 1^{st} magnitude star, but that's only because of its great distance of 1,600 light-years. In reality, it has the highest luminosity

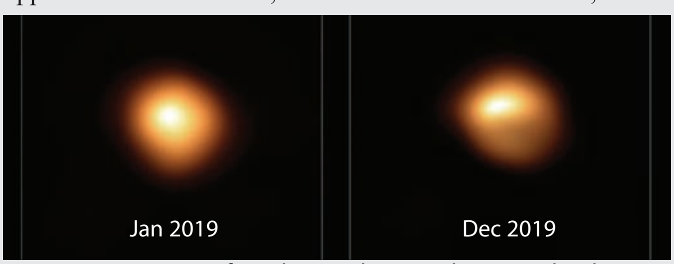


Betelgeuse, with the Atacama Large Millimeter/submillimeter Array (ALMA). This is the highest-resolution image of Betelgeuse available. Credit: ALMA (ESO/NAOJ/NRAO)/E. O'Gorman/P. Kervella

of any of the 1^{st} magnitude stars as indicated by its absolute magnitude of –7.2. This is the magnitude the stars would be if each were moved to the same distance (10 parsecs). The star would easily outshine Venus if brought this close. And we are only talking about Deneb's visible light, its UV contribution is enormous.

So, how big are these supergiant stars? From the discussion above, we would expect the two M class stars, Betelgeuse and Antares to be giants amongst giants. To be so luminous at such low temperatures (both around 3,600K) they have to be enormous.

Betelgeuse was suspected to be a large star and was the first to be measured using the Michelson Stellar Interferometer mounted on the Mt Wilson Observatory's 100-inch reflecting telescope in 1920. Betelgeuse was a good choice, turning out to be the star with the third largest apparent size from Earth, after the Sun and R Doradus,

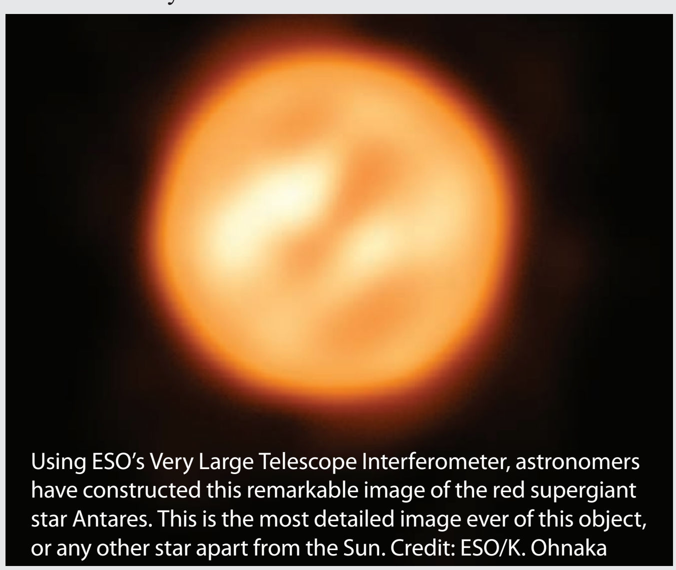


Comparison images of Betelgeuse showing changes in brightness and shape. Taken with the SPHERE adaptive optics system on the Very Large Telescope. Credit: ESO/M. Montargès et al.

measuring around 0.050 arcseconds. Given its distance this corresponds to an actual size of around 760 solar diameters. If it replaced the Sun the surface would be between the orbits of Mars and Jupiter, perhaps within the asteroid field (approximately 3.5 au). Being a pulsating semi-regular variable, ranging in magnitude from 0.0 to 1.6, its size varies between around 700 to 870 solar diameters. Being large enough to image, it has been seen to change shape and have intermittent hot spots such as those detected during its most recent, well published dimming in 2019/20. Antares is slightly smaller than Betelgeuse, around 700 solar diameters, with an apparent size of 0.041 arcseconds.

Higher temperature stars do not need such a high surface area, for example, Betelgeuse's Orion companion, Rigel (12,100K) has a higher luminosity than Betelgeuse but is only about 10% the diameter. Deneb at 8,500K is about 20% the size.

As a final word, the Earth is not immune from the Sun expanding. As mentioned above, it just takes a lot longer. Our star is currently middle aged and still going through the stable dwarf stage. In the next few billion years, it too will expand and bake the Earth, before its outer atmosphere swallows our planet. The star responsible for the birth of the human race won't go out with a bang, its mass being way too small to become a supernova. On a positive note, humankind has plenty of time to find alternative accommodation, assuming we don't destroy ourselves first!



Using ESO's Very Large Telescope Interferometer, astronomers have constructed this remarkable image of the red supergiant star Antares. This is the most detailed image ever of this object, or any other star apart from the Sun. Credit: ESO/K. Ohnaka

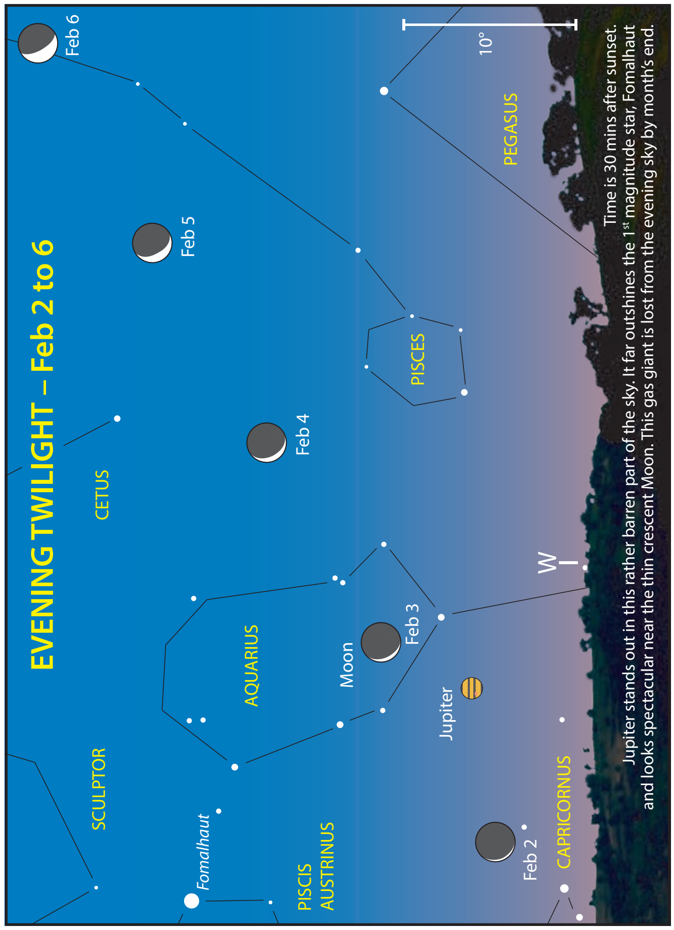
DOUBLE STARS

This month's binocular double is **Eta (η) Canis Majoris** (Aldura). This very wide, but very unequal pair (magnitude 2.5 and 6.8) is separated by 179 arcseconds. Located 1,988 light-years away, Aldura is a very luminous blue-white supergiant star, spectral type B5Ia. The pair is an optical double with the fainter star located five times closer to us than Aldura. (All Sky Map 4)

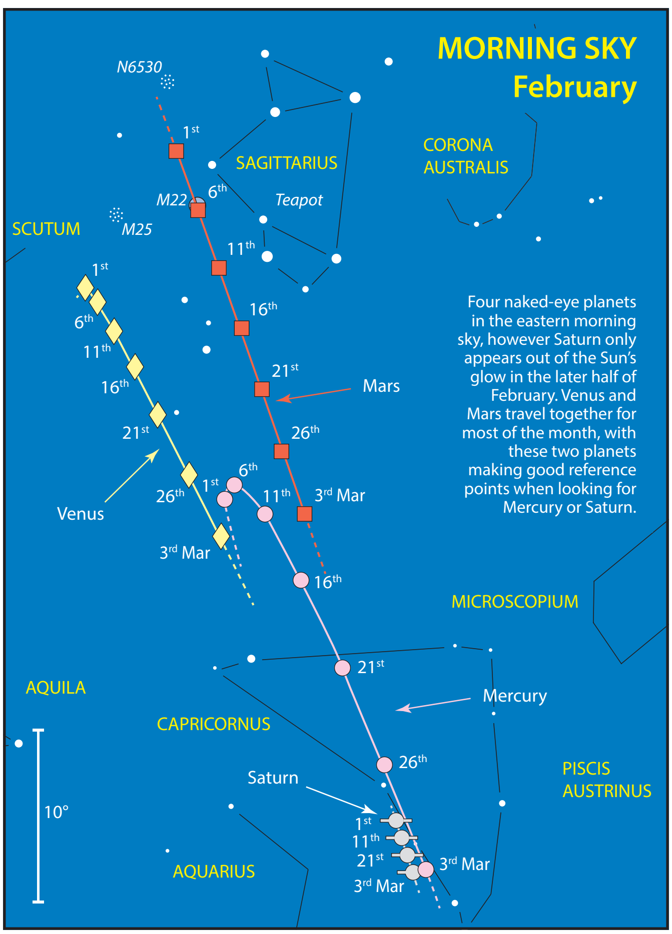
Located in Monoceros, the Unicorn, is the triple star **Beta (β) Monocerotis** (STF 919), also known as William Herschel's Wonder Star. This is a trio of bright stars, magnitude 4.6 (A), 5.0 (B) and 5.4 (C), separated by 7.1 arcseconds (AB components) and 3.0 arcseconds (BC components). The stars are all bluish white and form a narrow triangle. The C component has a close companion, thus making the system at least quadruple. It is located 700 light-years away. (All Sky Map 4)

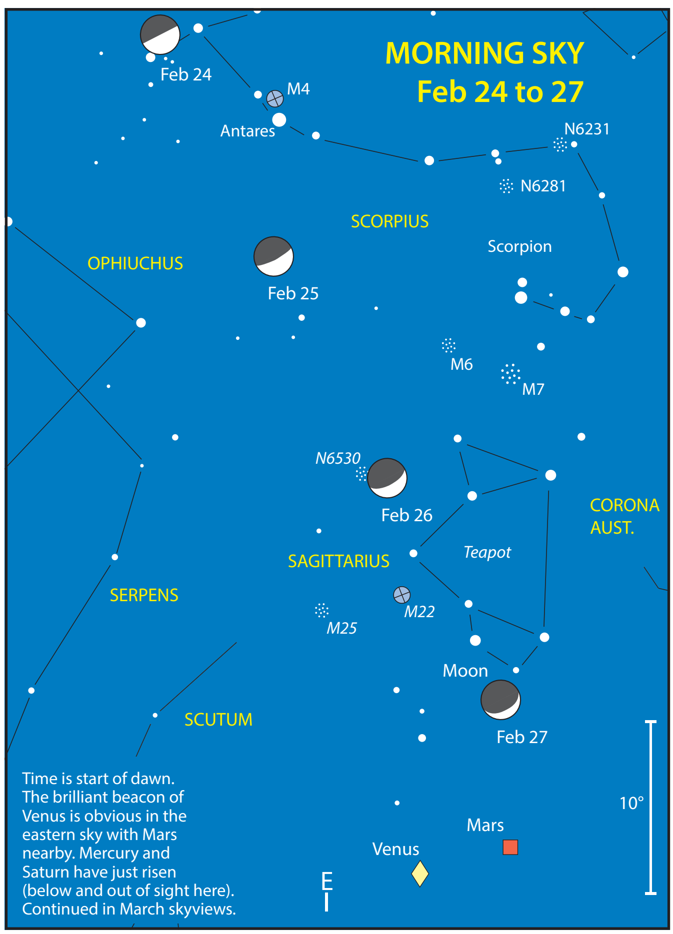
METEOR SHOWER

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 6 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.

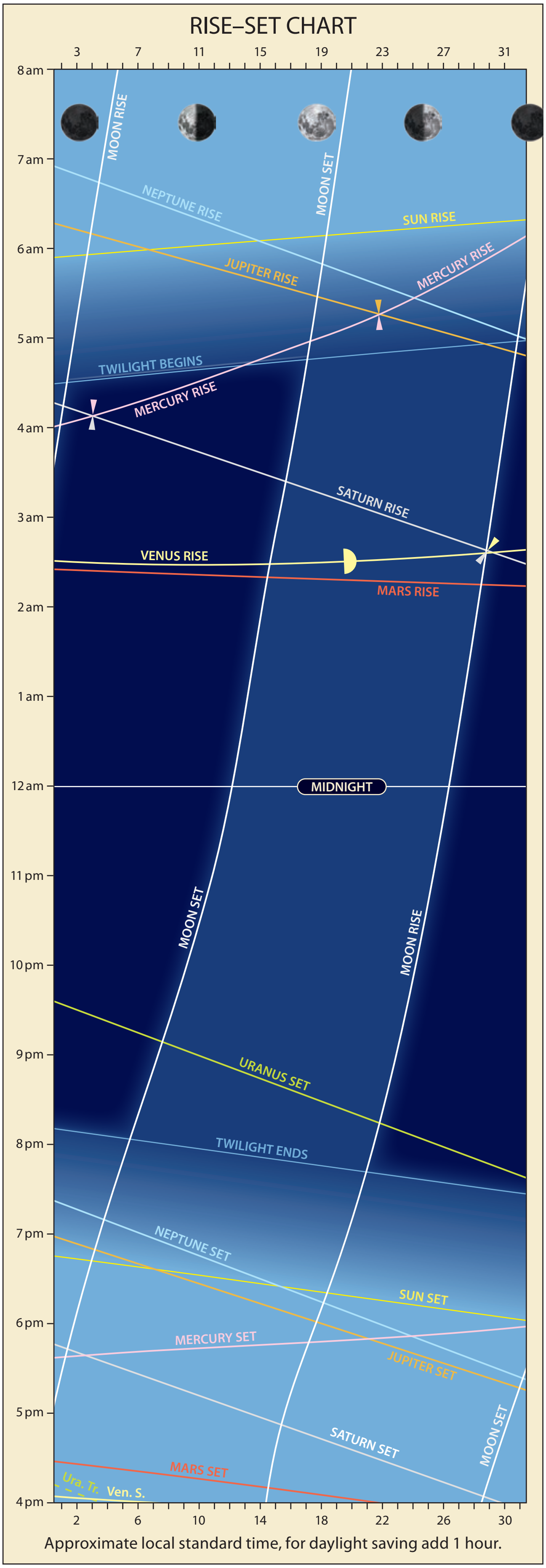


Approximate local standard time, for daylight saving add one hour.





MARCH 2022



HIGHLIGHTS

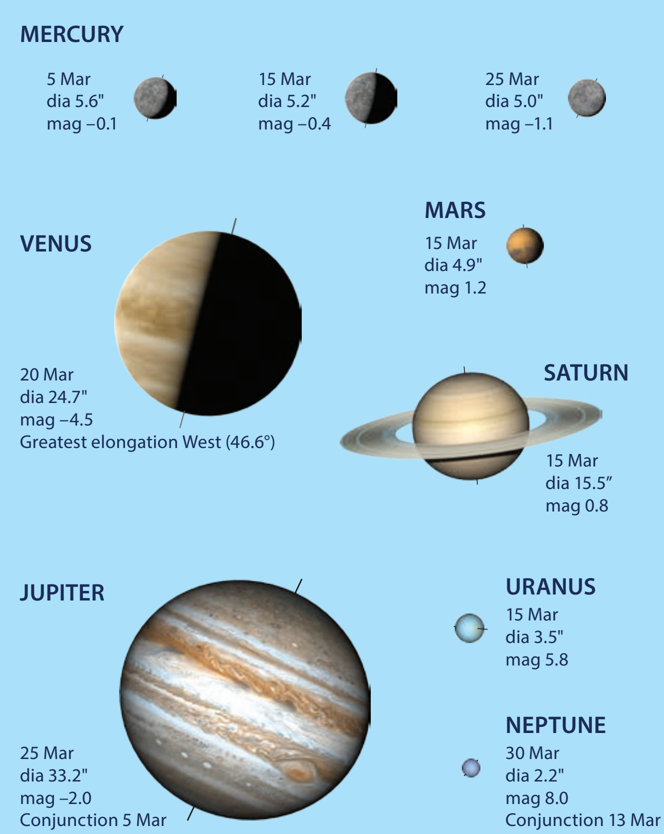
- ❍ All five naked-eye planets in the morning.
- ❍ Mercury, Saturn, and Moon together.
- ❍ Mercury and Jupiter close.
- ❍ Mercury and Saturn very close.
- ❍ Venus and Saturn close.
- ❍ Saturn, Venus, Mars, and the Moon gather in Capricornus.

CONSTELLATIONS

High up in the south is the False Cross asterism. It's false because the real Southern Cross is following behind about 26° to the south-east (try using the scale on the rear cover). The False Cross used to be central to the now obsolete constellation of Argo Navis (see also February Constellations). Now, this cross has a foot in each camp, borrowing two stars from the constellation of Vela the Sails, Kappa (κ) and Delta (δ), and two from Carina the Ship's Keel, Iota (ι) and Epsilon (ε). Think of the cross as part of the ship's mast. If you want to test how dark your sky is, try tracing the complete oval of Vela's sails, starting from the False Cross. Its western extreme is the 2nd magnitude star Gamma (γ) Velorum, an impressive multiple star system ideal for small telescopes.

Being embedded in the plane of the Milky Way this is the realm of the open clusters and gas clouds (nebulae). Near the bottom star of the False Cross, 3° west of Epsilon (ε) Carinae, is an example of a spectacular star cluster, NGC 2516.

APPEARANCE of the PLANETS



Carina's Treasure Trove!

The jewel in the crown of the southern Milky Way is no doubt the famous Eta (η) Carinae Nebula (NGC 3372). It is awash with star clusters as well as bright and dark nebulae. This massive star-forming region resides in the Carina-Sagittarius arm of the Milky Way, approximately 8,500 light-years away. It is one of the largest nebulae in our skies, four times the size of the Orion Nebula. It can be seen with the naked eye roughly halfway between the Southern Cross and False Cross. Even 7 × 50 binoculars show the prominent L shaped dark lane cutting across this 3° × 2° bright nebula. There is a further minor dark lane going towards the south-west.

This wide field view shown was selected because the majority of images of the Eta Carinae region are either too small, that is, cutting out the impressive outlying clusters, or over exposed to bring out the glorious nebula while drowning out the detail especially around Eta itself. The field's position has been marked on All Sky Map 1. Low power binoculars would cover this easily in two fields of view.

There are many catalogued open clusters not labelled here. One of the challenges in such a star-busy region is recognising the sometimes fairly defuse and spread-out clusters from the surrounding star field—the narrower the field the more difficult to recognise (so don't dismiss the humble pair of binoculars). We have restricted ourselves to the obvious visual gems.

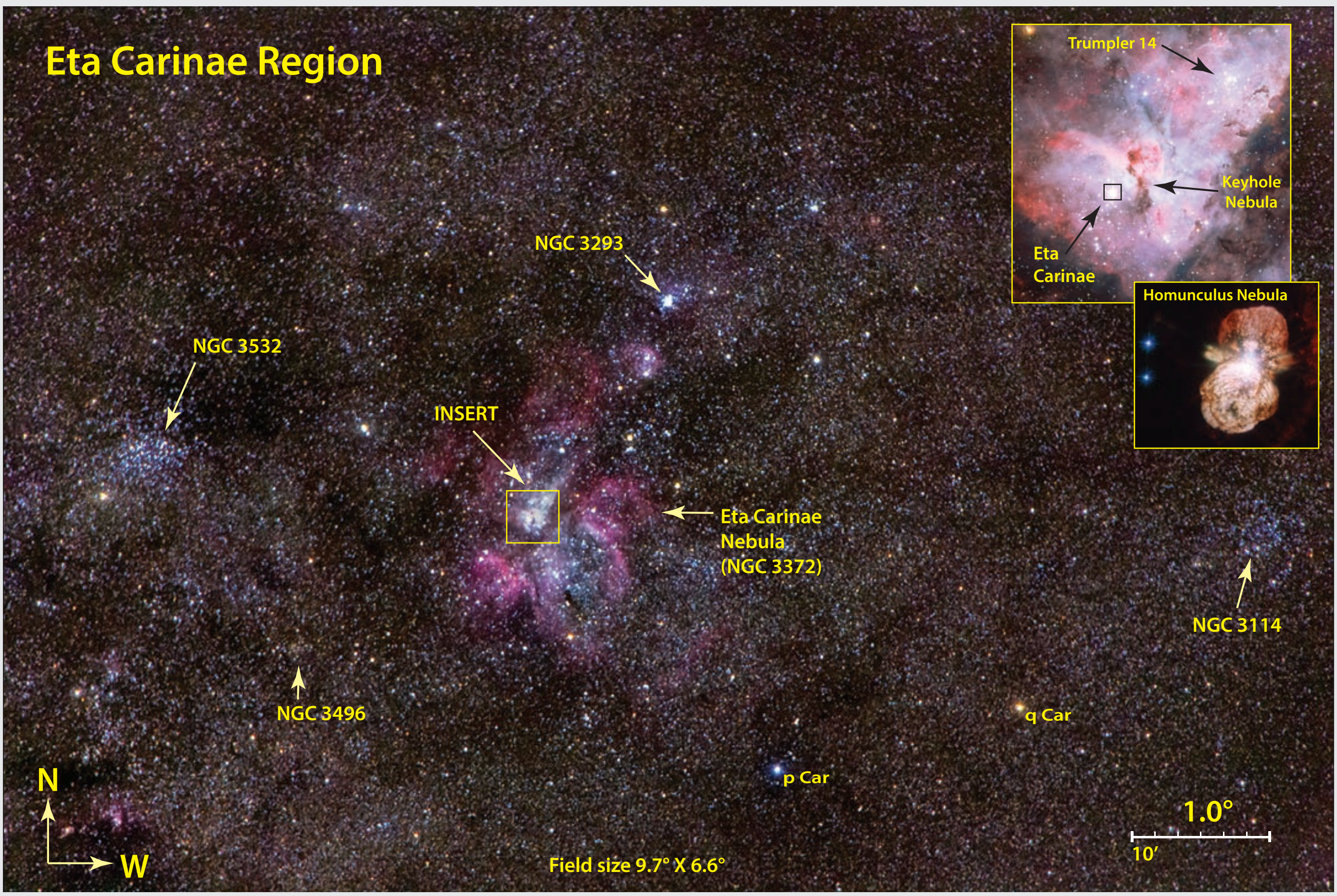
The Inserts

Eta Carinae is a most remarkable star. It is super massive, being around 120 times the mass of the Sun and 5 million times more luminous. Although known to be variable for centuries, astronomers were astonished by a massive eruption in the 19th century, attaining the brief status as the 2nd brightest star, reaching nearly –1 magnitude in 1842, dropping to a minimum of around 7th magnitude in the 1880s. Since the early 1960s it has been brightening again, currently at 4th magnitude and once again visible to the naked eye. Eta belongs to an open cluster of massive stars, called Trumpler 16, whose UV emission powers the glow of the Eta Carina nebulae.

Homunculus Nebula. Following its nova-like flare-up in the 19th Century, Eta was reported by the early 1900s to appear non-stellar. Then, two distinct lobes of material were detected. Knowing the distance and the rate of expansion it was confirmed they resulted from the 1842 eruption. Even under low power (50×), amateur telescopes reveal the star to be distinctly fuzzy. It takes good seeing and high magnification to see the lobes, as they are only around 5 to 7 arcseconds wide. Homunculus comes from the Latin meaning 'little man' and it does have a doll-like appearance.

Keyhole Nebula is a dark cloud of dust and cold gas residing within the Carina Nebula. Because of changing levels of ionising radiation being emitted from Trumpler 16 its appearance has changed over the years and no longer looks an obvious keyhole shape as when it was described in 1873.

Trumpler 14 is a 7th magnitude compact cluster siting in a brighter part of the nebula. Look for distinctive lines of stars on the south and western extremes. A close pair of 8th magnitude

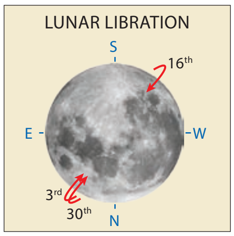


The naked eye sees it as a ghostly apparition about 0.5° in diameter. Although great through any binoculars it is best in a small telescope showing around 100 members, with a large variation in colour and brightness, arranged around a red 8th magnitude central star.

Lying to the west of this cross is the second brightest star in the night sky, Alpha (α) Carinae or Canopus. Having the two brightest stars high in our southern skies is a bonus, with Sirius to the north. There was a time briefly in 1843 where Canopus lost its second place with the nova-like eruption of another star, coincidentally in the same constellation, Eta (η) Carinae.

This is a good introduction to the true jewel in Carina's crown, the famous Eta Carinae Nebula (NGC 3372). It is awash with star clusters and nebulae. This massive star-forming region can be seen with the naked eye roughly halfway between the Southern Cross and False Cross, see feature article opposite.

THE MOON



- 3rd 4 am (2 am WST) New Moon.
- 3rd 10 am (8 am WST) Maximum Libration (7.8°), too close to New Moon.
- 10th 9 pm (7 pm WST) First Quarter.
- 11th 9 am (7 am WST) Moon at apogee (furthest from Earth at 404,268 km).
- 16th 5 pm (3 pm WST) Maximum Libration (8.3°), dark SW limb.
- 18th 5 pm (3 pm WST) Full Moon.
- 24th 10 am (8 am WST) Moon at perigee (closest to Earth at 369,760 km).
- 25th 4 pm (2 pm WST) Last Quarter.
- 30th 3 am (1 am WST) Maximum Libration (7.7°), dark NE limb.

THE PLANETS

Mercury begins the month 2.5° above Saturn in the eastern dawn sky; as a bonus, included in the view is the 27-day old slender waning crescent Moon, the trio fitting into a 5° circle (see Sky View). On the 3rd, Mercury passes just 0.7° to the right of Saturn (see Sky View). The inner planet is noticeably brighter than the distant ringed world. On the 21st and 22nd, Mercury and Jupiter meet up just 1.5° apart; the pair will be close to the horizon at the time of civil dawn, and binoculars will assist (see Sky View).

Venus starts the month in the eastern morning sky in Sagittarius before moving into Capricornus then Aquarius and closing March back in Capricornus. As a matter of interest on the 8th Venus, Mars, Saturn, and Mercury all gather within the boundaries of Capricornus for one day, becoming the brightest objects in the faint constellation. Venus and Mars remain companions at 4° apart for most of March. On the 29th, Venus will be 2° from Saturn, with Mars above and the waning 26-day old crescent Moon to the right (see Sky View). The planet's greatest elongation of 47° west of the Sun occurs on the 20th.

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

Mars is visible in the early morning eastern sky in Sagittarius for the first week of the month before moving into Capricornus. A pleasant view for unaided-eye observers occurs on the 29th, with the Red Planet 5° above Venus, Saturn and the waning 26-day old crescent Moon to the right of the planets (see Sky View).

Jupiter returns to the morning dawn after solar conjunction on the 5th. If you have a clear eastern horizon, you may be able to make out Jupiter and Mercury close together (1.5°) about half an hour before sunrise on the 21st—Jupiter is the brighter of the pair, and binoculars will help. Easier to see with the unaided eye is the slender waning crescent of the 28-day old Moon and Jupiter, 4° apart on the 31st (see Sky View).

Saturn, Mercury, and the Moon put on a show on the 1st in the early eastern dawn sky (see Mercury and Sky View). On the 3rd, the planetary duo of Saturn and Mercury will be just 0.7° apart, although low to the horizon at astronomical dawn (see Sky View insert). On the 29th, Saturn, Venus, Mars, and the Moon gather for a pleasing early morning display (see Venus and Sky View).

stars lie to the south-east. To the south-west lies a distinct boundary with the dark nebula. The intruding dark *fingers* have been called 'Dinosaurs in the Mist'. Trumpler 14 is one of the youngest star clusters known, only 500,000 years old.

The Surrounding Clusters.

NGC 3532, also known as the Firefly Party Cluster, is a brilliant 3rd magnitude open star cluster, 3° east-north-east of Eta. It is approximately 60 × 30 arcminutes in size. The cluster's odd shape also contributed to its other nickname of the Football Cluster. It is visible to the naked eye as an obvious hazy patch. NGC 3532 looks impressive through any rich field instrument (binoculars or 60 mm telescope) being peppered with around one hundred 8–9th magnitude, mostly white stars with a smattering of red/orange ones. The 4th magnitude yellow star 0.4° south-east makes a pretty sight in the same field with the cluster.

NGC 3496. This is a bit of a change of pace from other clusters in the region. Yes, it's true that a low power field of view (0.5°) shows many scattered bright stars, but it has a central condensed region made up of mostly 12th to 13th magnitude stars, with some smaller scopes showing this as a strong haze.

NGC 3114. This magnificent open cluster appears as an obvious cloudy patch to the unaided eye. A small telescope (60 mm), at a low power, reveals this large (0.5°) 4th magnitude cluster to consist of numerous faint stars with a handful of 6–7 magnitude members. They are arranged in attractive intertwined curving lines imbedded in a rich galactic star field.

NGC 3293—Magnificent! Even a 60 mm telescope reveals its 40 blue/white stars (8th to 10th magnitude) arranged in a rough 5-arcminute square shape. The cluster has an attractive 7th magnitude orange star on one edge. It is called the Gem Cluster, perhaps because it resembles a cut diamond seen from the side.

DIARY			
Tue	1st	5 am	(3 am WST) Saturn 5° NE of Moon.
Tue	1st	5 am	(3 am WST) Mercury 3° N of Moon.
Wed	2nd		Comet 104P/Kowal 2 0.7° S of star Omicron² Orionis.
Wed	2nd	am	m.p. 4 Vesta 3° S of Venus.
Thu	3rd	am	Saturn 0.5° NW of Mercury.
Thu	3rd	4 am	(2 am WST) New Moon.
Thu	3rd	10 am	(8 am WST) Maximum Libration (7.8°), too close to New Moon.
Fri	4th		Mars 1.0° N of d.p. Pluto.
Sat	5th		Mercury 0.8° NW of star Gamma Capricorni.
Sat	5th		m.p. 3 Juno 0.4° SE of star Epsilon Aquarii.
Sun	6th		Jupiter in conjunction with Sun.
Sun	6th		Mercury 0.9° NW of star Delta Capricorni.
Sun	6th		Mars 0.7° N of M75 (GC) in Sagittarius.
Mon	7th		Comet C/2009 L3 (ATLAS) 1.3° E of star Nu Geminorum.
Mon	7th	8 pm	(6 pm WST) Uranus 1.5° W of Moon.
Wed	9th	9 pm	(7 pm WST) star Aldebaran 8° SE of Moon.
Thu	10th	9 pm	(7 pm WST) First Quarter Moon.
Fri	11th	9 am	(7 am WST) Moon at apogee (furthest from Earth at 404,268 km).
Sun	13th	am	Mars 4° S of Venus.
Sun	13th	8 pm	(6 pm WST) star Pollux 2° NW of Moon.
Sun	13th		Neptune in conjunction with Sun.
Tue	15th	am	Gamma Normids meteor shower, Feb 25 to Mar 28.
Wed	16th	5 pm	(3 pm WST) Maximum Libration (8.3°), dark SW limb.
Wed	16th	8 pm	(6 pm WST) star Regulus 6° SW of Moon.
Thu	17th		Comet 19P/Borrelly 0.7° SE of NGC 1333 (BN) in Perseus.
Thu	17th	pm	m.p. 7 Iris 0.3° S of star Lambda Geminorum.
Fri	18th		Comet 104P/Kowal 2 0.2° N of star Nu Orionis.
Fri	18th	am	m.p. 29 Amphitrite 0.4° N of NGC 6304 (GC) in Ophiuchus.
Fri	18th	5 pm	(3 pm WST) Full Moon (380,831 km).
Sat	19th		Comet 104P/Kowal 2 0.9° N of star Xi Orionis.
Sun	20th		Comet 19P/Borrelly 0.4° NW of IC 348 (OC) in Perseus.
Sun	20th		Comet 19P/Borrelly 0.3° W of star Omicron Persei.
Sun	20th		Comet C/2017 K2 (PANSTARRS) 1.1° N of NGC 6709 (OC) in Aquila.
Sun	20th		Venus at greatest elongation West (46.6°).
Sun	20th	9 pm	(7 pm WST) star Spica 6° SW of Moon.
Mon	21st		Equinox.
Tue	22nd		Comet 19P/Borrelly 1.6° NW of star Zeta Persei.
Tue	22nd		Comet 22P/Kopff 1.4° N of star Theta Capricorni.
Wed	23rd		Comet 22P/Kopff 1.0° S of Venus.
Wed	23rd	11 pm	(9 pm WST) star Antares 4° SW of Moon.
Wed	23rd	pm	m.p. 8 Flora 0.2° S of star p Virginis.
Thu	24th	10 am	(8 am WST) Moon at perigee (closest to Earth at 369,760 km).
Fri	25th		Mars 0.6° S of star Theta Capricorni.
Fri	25th	4 pm	(2 pm WST) Last Quarter Moon.
Sat	26th		Comet 104P/Kowal 2 1.0° SE of star Gamma Geminorum.
Sun	27th		Comet 104P/Kowal 2 2.6° N of star Xi Geminorum.
Mon	28th		m.p. 14 Irene 0.5° S of star Xi 2 Sagittarii.
Mon	28th		Comet C/2009 L3 (ATLAS) 1.0° NE of star Gamma Geminorum.
Mon	28th	4 am	(2 am WST) Mars 6° NE of Moon.
Tue	29th	4 am	(2 am WST) Venus 7° NW of Moon.
Tue	29th	4 am	(2 am WST) Saturn 5° NW of Moon.
Wed	30th	am	Saturn 2° S of Venus.
Wed	30th	3 am	(1 am WST) Maximum Libration (7.7°), dark NE limb.
Thu	31st		Mars 0.4° NE of star Iota Capricorni.
Thu	31st	5 am	(3 am WST) Neptune 4° N of Moon.
Thu	31st	6 am	(4 am WST) Jupiter 4° NW of Moon.

Uranus will be lost in the western evening twilight by the end of the month as it moves closer to the Sun and conjunction in May.

Neptune is in conjunction with the Sun on the 13th and reappears in the morning sky in April.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 Mar	16 Psyche	Leo	10.4
9 Mar	54 Alexandra	Leo	12.0
16 Mar	39 Laetitia	Virgo	10.3
31 Mar	103 Hera	Virgo	11.5

COMETS

Comet C/2017 K2 (PANSTARRS) could brighten from 10th to 9th magnitude by the end of March. Rising around two hours before the beginning of astronomical dawn at the start of March, PANSTARRS is in Ophiuchus at this time and moves into Aquila in the second week of the month.

Comet 19P/Borrelly is expected to fade from 9th to 10th magnitude this month. Having reached perihelion last month, the comet is now moving away from both the Sun and Earth. As Borrelly moves north through Aries, Taurus and Perseus, it will become more difficult to observe as its altitude drops by the time astronomical twilight ends.

Comet C/2021 A1 (Leonard) continues its slow trek through Microscopium in the south-east morning sky. During March the comet fades from around 11th to 12th magnitude.

Comet C/2009 L3 (ATLAS). As it has been all year, the comet remains in Gemini, possibly fading to around 11th magnitude by month's end. ATLAS in now an evening only object, low in the northern evening sky during twilight and setting around midnight.

Comet 22P/Kopff, rising slowly in the pre-dawn eastern sky, spends most of the month in Capricornus. Reaching perihelion on the 10th, Kopff will unlikely reach 11th magnitude, being a distant 3.5 au. Commencing in late March the comet has a tour of some planets, ideal for wide field imagers. On 23rd there is Venus followed by Saturn in April and Mars plus Neptune in May (see diary).

DOUBLE STARS

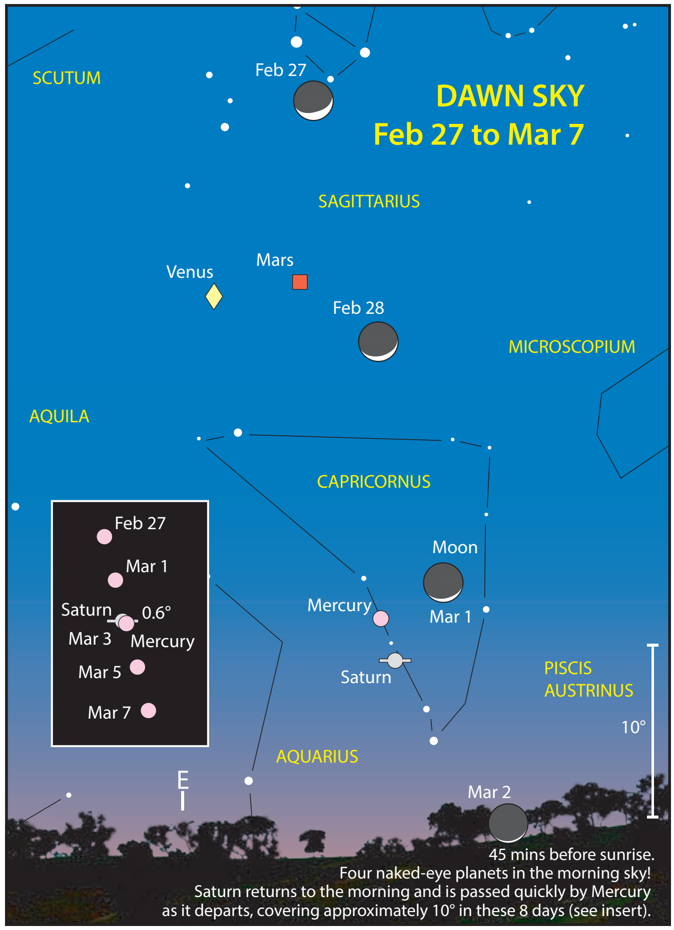
Gamma (γ) Velorum (Dunlop 65) is a multiple star system with the main pair (magnitude 1.8 and 4.1) separated by 41 arcseconds, divisible in steadily held binoculars. The primary is itself the brightest Wolf-Rayet star known. Through a telescope there are two more bluish companions, C and D (magnitude 7.3 and 9.3) almost at right angles to the main pair. The AC component is separated by 62 arcseconds and the AD component is separated by 94 arcseconds. The distance to Gamma Velorum is uncertain and may be of the order of 1,000 light-years. (All Sky Map 4)

Gamma (γ) Leonis (Algieba, STF 1424) is one of the finest visual double stars for telescopes with small apertures. The close pair of golden suns (magnitude 2.4 and 3.6) is separated by 4.7 arcseconds. The A component is spectral class

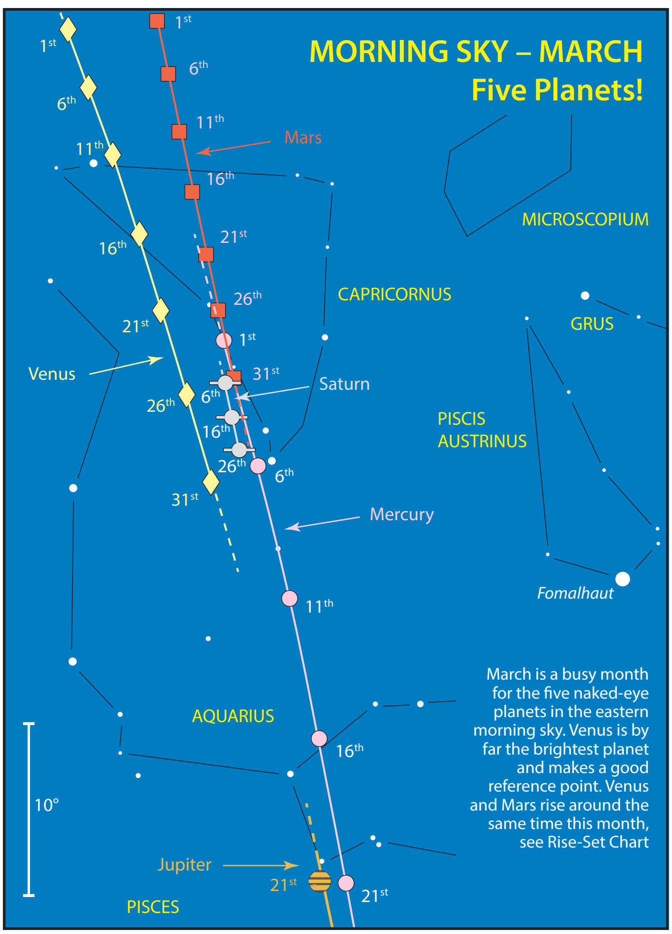
K0III. The separation is currently widening. The pair forms a true binary system with a period of 620 years and is located 170 light-years away. (All Sky Map 5)

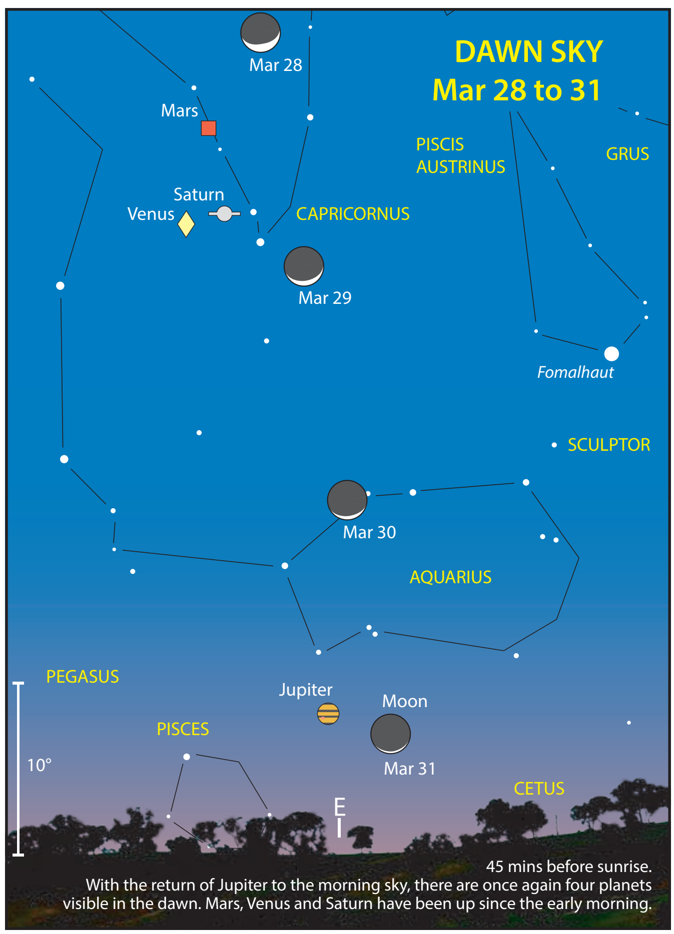
METEOR SHOWER

The **gamma Normids** are active between February 25 and March 28. For most of the period, the rate is low, and members are difficult to sort out from the sporadic background activity. The peak occurs around March 15, when rates can reach 6 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 waxing gibbous Moon has set.



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





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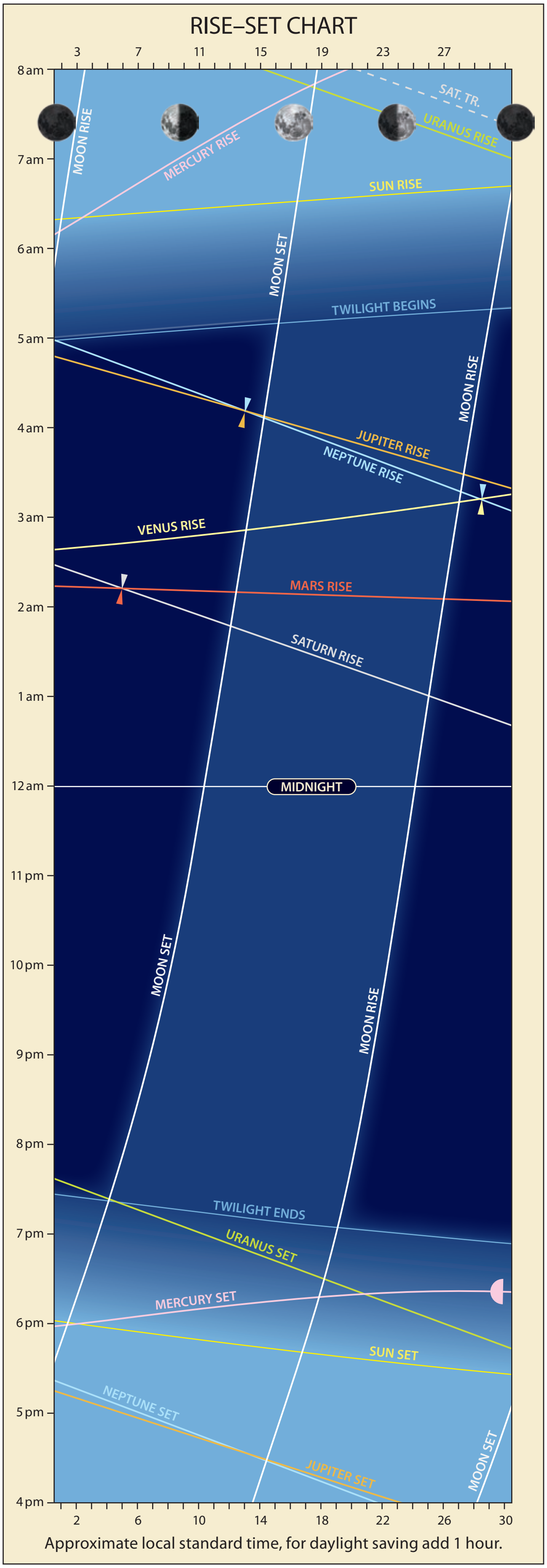


HIGHLIGHTS

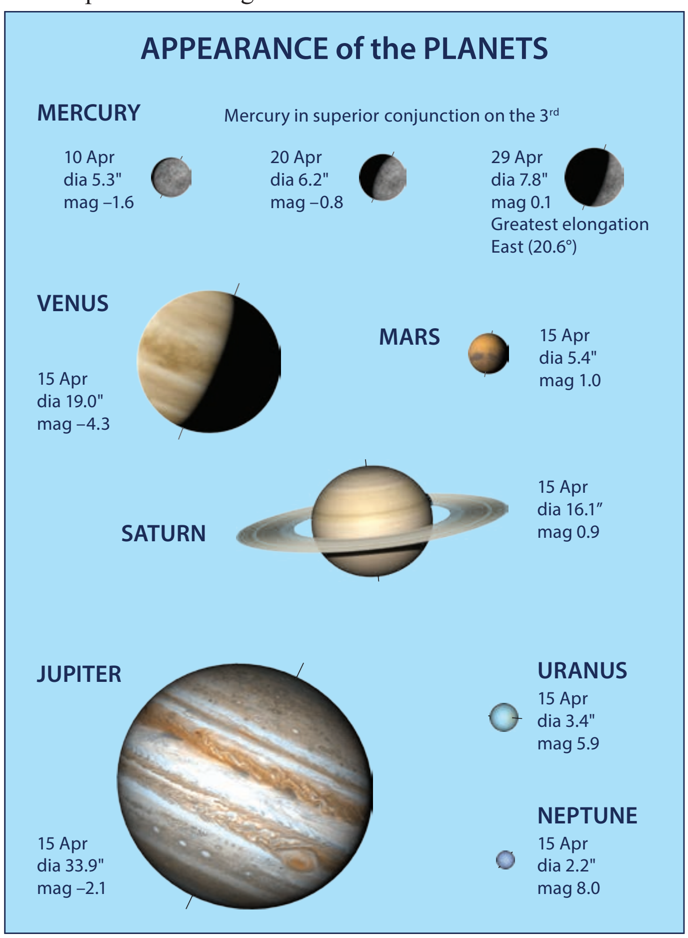
- Four bright planets in the morning.
- Venus is remarkably close to Neptune.
- Venus and Jupiter close.
- Mars and Saturn close.
- Jupiter and Neptune very close.

CONSTELLATIONS

This is a great time of the year to enjoy the splendour of the southern Milky Way now on display high in the south. We are going to literally turn our backs, look to the north and find the Sickle asterism, which lies in the constellation of Leo the Lion (see All Sky Map 5).

Leo's brightest star, Alpha (α) Leonis or Regulus is quite isolated, you need to take a large eastward leap along the ecliptic from the Gemini's twin stars to find it. The constellation is certainly a tribute to this king of the beast, with Regulus being Latin for 'prince' or 'little king'. The star was also one of the four royal stars of the ancient Persians. The others being Aldebaran, Antares and Fomalhaut.

To see the crouching lion shape, you have to first understand that from down under we see Leo upside down. What the north sees is Regulus as his heart and then a curved line of 2nd to 4th magnitude stars outlining the neck, mane and head which ends at Epsilon (ε) with the beast looking to the west (left). We call this the Sickle, hanging below Regulus. To complete the picture of the lion, his body stretches eastward (to the right) with the 2nd magnitude star, Beta (β) Leonis or Denebola, marking the tail. Denebola's origin is from an Arabic phrase meaning 'tail of the lion'.



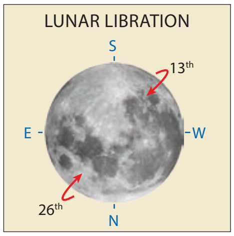
In the Double Stars sections (March and April) the double stars Zeta (ζ) and Gamma (γ) Leonis have already been mentioned. Here's another well suited for small telescopes. The colourful, bright double 54 Leonis is near the border of Leo with Leo Minor. It has a 4.5 magnitude yellow primary with a 6.3 magnitude blue companion, separated by 6.5 arcseconds.

However, we didn't drag you halfway across the sky just to look at double stars, no matter how impressive they are. Looking at Leo you are gazing outside the plane of our galaxy, for an unobstructed view of distant galaxies. Some of the brightest examples (outside our local group) reside in Leo and there is a bonanza of galaxies awaiting the brave deep sky enthusiast willing to dive into Leo's neighbouring constellations of Virgo and Coma Berenices.

We have no room here to go into details of the appearance of the individual galaxies that follow, but we can give an idea of what attracts amateurs to look at these distant fuzzies. There are three main features to look for, although in many cases, some are absent. Going from the centre outward, the nucleus, the core and, the normally faint halo (which sometimes hints at spiral arms). In all of these, look at their brightness, size, shape, dark lanes and mottling.

Starting from Regulus, 9° to the east is the impressive pair of spiral galaxies M95 and M96, both fitting in the same low power eyepiece. Only 1.0° north of (below) M96 lies M105. This bright elliptical galaxy is part of a close trio of galaxies, forming a triangle with another elliptical NGC 3384 and the fainter spiral NGC 3389 fitting easily in an eyepiece field—brilliant! A further 7° jump eastward finds an excellent triplet of edge-on spiral galaxies with M66, M65 and NGC 3628 fitting in a low power eyepiece field.

THE MOON



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

8th 5 am (3 am WST) Moon at apogee (furthest from Earth at 404,438 km).

9th 5 pm (3 pm WST) First Quarter.

13th 6 am (4 am WST) Maximum Libration (8.9°), dark SW limb.

17th 5 am (3 am WST) Full Moon.

20th 1 am (11 pm WST, previous day) Moon at perigee (closest to Earth at 365,143 km).

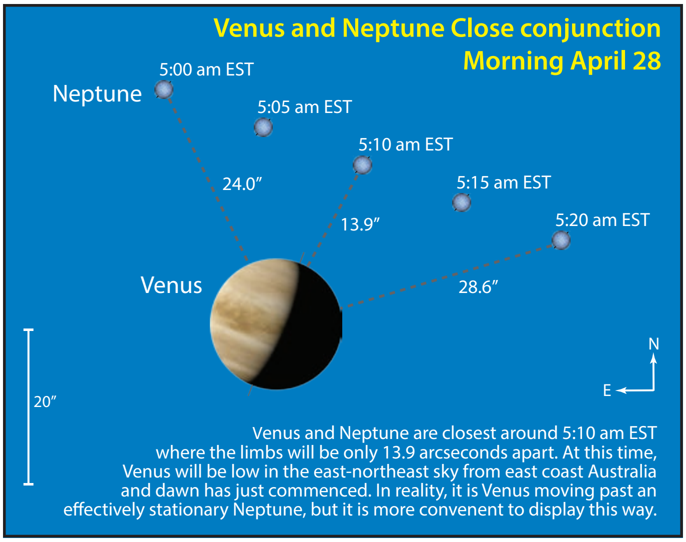
23rd 10 pm (8 pm WST) Last Quarter.

26th 3 am (1 am WST) Maximum Libration (8.4°), dark NE limb.

THE PLANETS

Mercury is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 3rd, and then returns to the western evening twilight sky. The planet slowly climbs toward its greatest elongation of 21° east of the Sun on the 2 9th—this is a relatively poor apparition with Mercury barely a few degrees above the horizon at the end of civil twilight.

Brilliant **Venus** begins the month in the pre-dawn eastern sky in Capricornus with Saturn and Mars just above. The planet then moves into Aquarius as it heads toward close conjunctions with both Neptune and Jupiter. On the morning of the 28th, it's Neptune. Closest approach is at 5:10 am (EST), where the separation will be less than 30 arcseconds. The eastern states sees them closest just on the start of twilight. Unfortunately, at this time from Perth it is still below the horizon. However, 30 minutes after Venus rise (at 3:55 am WST) the planets will still be a snug 2 arcminutes apart, easily fitting in an eyepiece field. In theory this event should be visible through binoculars, but when Venus' beacon gets closest, its glare could easily swamp 8th magnitude Neptune. On the 30th, Venus will be just 1° from Jupiter and even closer on 1st May (see Sky View). Seeing these two brightest planets this close together shouldn't be missed!



Venus and Neptune are closest around 5:10 am EST where the limbs will be only 13.9 arcseconds apart. At this time, Venus will be low in the east-northeast sky from east coast Australia and dawn has just commenced. In reality, it is Venus moving past an effectively stationary Neptune, but it is more convenient to display this way.

Mars begins the month in the morning eastern sky 3° above Saturn and 6° above Venus in Capricornus. On the 5th and 6th, the Red Planet appears within 0.5° of Saturn (see Sky View insert). Both planets are near the same magnitude, but Mars' distinctive orangish colour will help with identification (see Sky View). On the 26th, the 25-day old waning crescent Moon with be 4° from Mars (see Sky View).

Jupiter, in the pre-dawn eastern sky, has two close planetary encounters this month. Firstly, on the 13th, Neptune will be a close 0.1° from Jupiter—the pair just 10° above the horizon as astronomical twilight begins. The next meeting is with Venus when the duo will be 1° apart on the last day of April, and even closer on 1 May (see Sky View). A pleasant naked-eye vista occurs on the 27th and 28th when the slender waning crescent Moon appears near Jupiter and Venus, with Mars and Saturn above the brighter planets.

Saturn, in Capricornus, is visible in the eastern midmorning sky. On the 1st, Saturn will be between Mars and Venus (about 3° from the two brighter planets). On the 5th and 6th, a nice colour contrast is seen as Mars approaches within 0.5° of the Ringed Planet, both bodies evenly matched in magnitude at this time (see Sky View). On the 25th, the 24-day old waning crescent Moon will be near Saturn (see Sky View).

Uranus disappears into the evening twilight as it moves closer to its solar conjunction in May.

Neptune, in Aquarius, returns to the morning eastern dawn sky after its conjunction with the Sun last month. On the 13th, the planet will be just 0.1° from Jupiter (see Jupiter). A very close encounter with Venus occurs on the 28th (see Venus, above).

GOING DARK—The Mystery of the Vanishing Stars

When a star exhausts its nuclear fuel, it either undergoes slow changes over a long period and becomes a white dwarf or goes out with a bang in a supernova explosion. The amount of matter that a star begins with determines how it will spend its life. Stars like our Sun burn their fuel at a steady state for a long time, around 10,000 million years. Massive stars consume their fuel at a fast rate and die young, perhaps only tens of millions of years. The lowest mass stars will last longer than the current age of the Universe (around 13.8 billion years).

Stellar evolution is reasonably well understood by astronomers, although an international team of researchers recently discovered something that may well change existing ideas on astrophysics. Beatriz Villarroel, a researcher in astrophysics at Nordita and Stockholm Universities, is the principal investigator of the 'Vanishing & Appearing Sources during a Century of Observations' (the VASCO project). Her team specialises in identifying abnormalities in space by comparing images taken 70 years apart. So far, they have found nearly 100 stars present in the older databases that have now disappeared.

They initially compared images from the US Naval Observatory Catalogue (USNO) with the Sloan Digital Sky Survey (SDSS). They found that out of 10 million objects, some 290,000 irregularities existed. After careful inspection, most of these were able to be explained away. However, one candidate for a missing star remained, although the evidence was not robust enough to make it a convincing case for an example of a vanishing star.

Their following study compared the USNO data with the Pan-STARR catalogue. The USNO catalogue records objects down to magnitude 21 and Pan-STARRs down to 23 (compared with 22 for the SDSS). They found more than 150,000 anomalies in this search. They then inspected the data for artefacts of various sorts and objects like asteroids and known variable stars. Next, they further cut stars that may have moved or had been near the edge of the field. Finally, after the team eliminated all variables, they found close to 100 stars that only appear on the older images.

Stars are not supposed to vanish into the dark. The missing stars are primarily red, faint, and tend to have large proper motions. So what mechanism transforms a once visible star to completely disappear or at least go beyond the threshold of our best star surveys?

One possibility is that they may be failed supernova, i.e., a star collapsing directly into a black hole without the accompanying supernova explosion. Theoretically, red giants that are in the 18–25 solar mass range may well do this. A couple of possible candidates are known, including N6946-BH1, a star in NGC 6946, a galaxy on the Cepheus/Cygnus border. The star was 25 times the mass of our Sun and appeared to be going supernova in 2009. However, by 2015 it had vanished and is now thought to be a black hole. Astronomers now believe that as many as 30 percent of the most massive stars quietly collapse into black holes without the stellar fireworks.

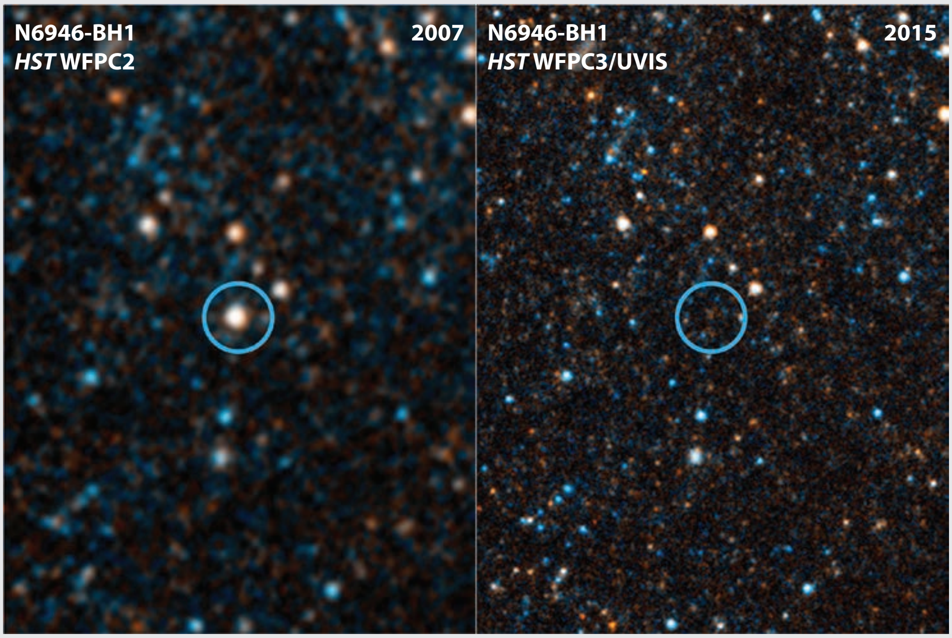
Could the culprit for the missing luminaries have been red dwarfs? These most common stars in our galaxy are known for their volatility with their powerful flares. Could the missing 100 have been red dwarfs producing super-strong flares before fading into obscurity and beyond our limits of detection?

Of course, the popular press is quick to suggest aliens. Could extraterrestrials be flashing their powerful red lasers for interstellar communications, or Dyson spheres—the hypothetical megastructures constructed around stars to harvest their energy. Although VASCO set out to detect unusual stuff in the Universe and potential aliens, they have since stated that *"... we are clear that none of these events have shown any direct signs of being ETI ... we believe that they are natural, if somewhat extreme, astrophysical sources."*

We know that many stars pulsate and change in brightness, but VASCO is looking for something different. *"We know that there are variables, but their timescales tend to be a few years at most. We want to find something that goes from a completely steady star to just vanishing entirely – this hasn't been documented, and it's the kind of discovery that could lead to new physics."*

VASCO has developed a citizen science project where interested persons can assist by searching images for vanishing and appearing stars – Google 'The VASCO Network.'

Reference: The Vanishing and Appearing Sources during a Century of Observations Project. I. USNO Objects Missing in Modern Sky Surveys and Follow-up Observations of a "Missing Star" *The Astronomical Journal, Volume 159, Number 1. 2020 January 1.*



DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
5 Apr	196 Philomela	Virgo	11.0
7 Apr	52 Europa	Virgo	10.7
12 Apr	135 Hertha	Virgo	11.4
12 Apr	8 Flora	Virgo	9.8
16 Apr	79 Eurynome	Virgo	11.6
16 Apr	15 Eunomia	Hydra	9.9
20 Apr	94 Aurora	Virgo	12.4
26 Apr	51 Nemausa	Virgo	10.3
29 Apr	88 Thisbe	Virgo	10.9
29 Apr	10 Hygiea	Virgo	9.3

COMETS

Comet 19P/Borrelly spends the month immersed in the evening twilight close to the north-western horizon, less than 10° from Capella (Alpha (α) Aurigae)

Comet C/2017 K2 (PANSTARRS) is expected to shine at around 9th magnitude throughout April. Residing in Aquila throughout the month, PANSTARRS will be rising late in the evening by the end of April.

Comet C/2009 L3 (ATLAS) opens April around 1° from Gamma (γ) Geminorum and spends another month in the constellation of the twins. Expected to remain around 11th magnitude this month, observations need to be early as ATLAS is setting mid-evening.

Comet 22P/Kopff commences the month in Capricornus, moving into Aquarius after the first week and finishes April around 1° from Lambda (λ) Aquarii. Kopff remains in the pre-dawn eastern sky at a possible 11th magnitude. On the 2nd the comet has an encounter with Saturn (see diary).

DOUBLE STARS

Located in the Sickle of Leo, **Zeta (ζ) Leonis** (Adhafera, 36 Leonis) is an easy wide binocular optical double. The companion, 35 Leonis (magnitude 6.0) is separated from Zeta (magnitude 3.5) by 335 arcseconds. Zeta is a white giant star (spectral class F0III) about three times the mass of our Sun and 85 times its luminosity. (All Sky Map 5)

Located in Corvus is the fine pair, **Delta (δ) Corvi** (Algorab, SHJ 145). This pair shows a nice magnitude and colour contrast. The primary (magnitude 3.0) is yellow whilst the secondary (magnitude 8.5), located 24 arcseconds away, is violet or lilac by comparison. The pair is situated 125 light-years away and appears to form a very long period binary. (All Sky Map 6)

METEOR SHOWERS

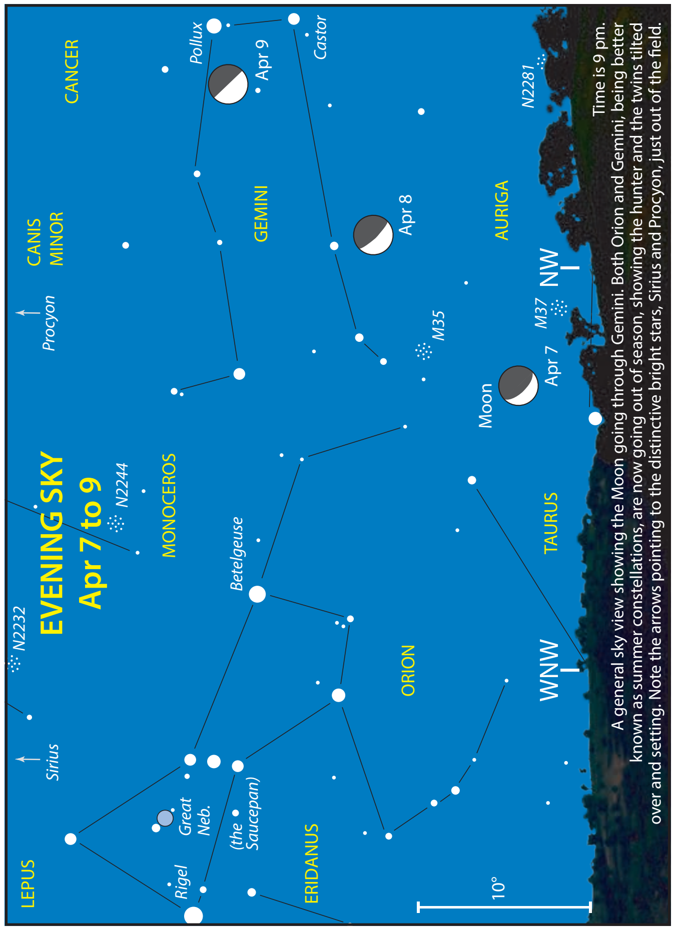
The **Lyrids** are a Northern Hemisphere shower that is possible to see south of the equator. Best from April 16–25, with maximum rates during the pre-dawn hours of around the 22nd and 23rd when their radiant is at its highest. The peak may only last an hour or so, and typically the zenith hourly rate is around 18. The Lyrids have, on occasion, produced higher rates and, because of their erratic nature, are a shower to be watched. At their peak, the waning gibbous Moon will be an issue.

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 a large proportion of yellow meteors and occasional fireballs. They are best seen from dusk to midnight when the sky will be Moon free. Last Quarter Moon will interfere with morning observations.

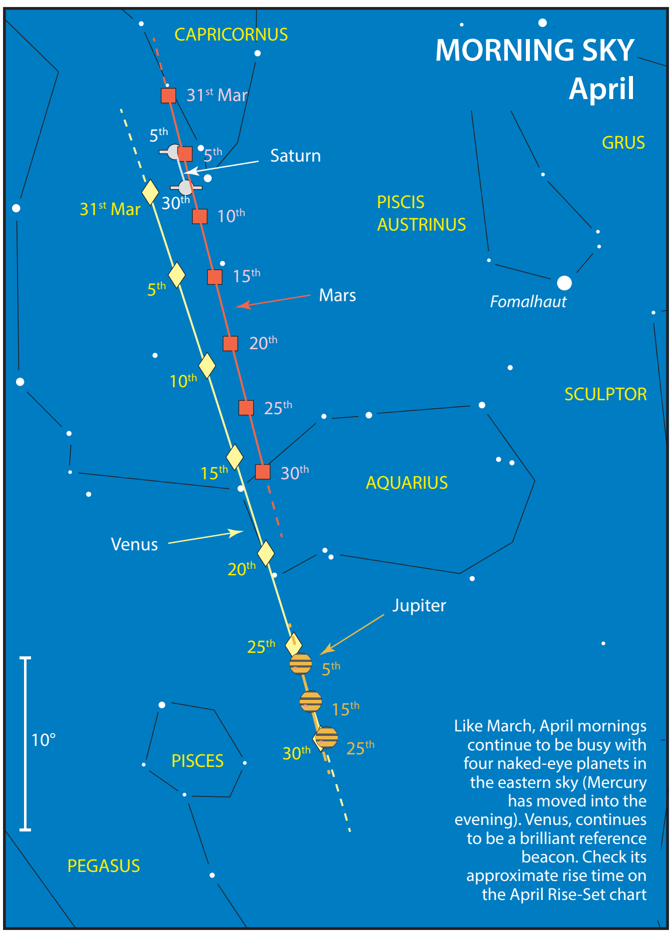
DIARY			
Fri	1st	4 pm	(2 pm WST) New Moon.
Fri	1st	pm	m.p. 15 Eunomia 0.5° NE of NGC 5101 (G) in Hydra.
Sat	2nd		Comet 22P/Kopff 1.5° N of Saturn.
Sat	2nd	3 am	(1 am WST) m.p. 14 Irene 0.1° NW of star Omicron Sagittarii.
Sun	3rd		Mercury in superior conjunction.
Mon	4th	pm	m.p. 15 Eunomia 0.5° N of NGC 5078 (G) in Hydra.
Tue	5th		m.p. 3 Juno 1.2° SE of star Beta Aquarii.
Tue	5th		Saturn 0.5° N of Mars.
Thu	7th	am	m.p. 14 Irene 0.7° S of star Pi Sagittarii.
Fri	8th	5 am	(3 am WST) Moon at apogee (furthest from Earth at 404,438 km).
Sat	9th	5 pm	(3 pm WST) First Quarter Moon.
Sat	9th	10 pm	(8 pm WST) star Pollux 3° NE of Moon.
Mon	11th	3 am	(1 am WST) m.p. 4 Vesta 0.02° W of star Theta Capricorni.
Mon	11th	pm	m.p. 8 Flora 1.0° NE of star Zeta Virginis.
Tue	12th		Pallas in conjunction with Sun.
Tue	12th	9 pm	(7 pm WST) star Regulus 6° S of Moon.
Wed	13th		m.p. 9 Metis 0.7° S of d.p. Pluto.
Wed	13th		Neptune 0.1° S of Jupiter.
Wed	13th	6 am	(4 am WST) Maximum Libration (8.9°), dark SW limb.
Thu	14th		Mars 0.7° NW of star Iota Aquarii.
Fri	15th		Comet C/2017 K2 (PANSTARRS) 1.5° W of NGC 6738 (OC) in Aquila.
Sat	16th	9 pm	(7 pm WST) star Spica 6° S of Moon.
Sun	17th	4 am	(2 am WST) Venus 0.2° E of star Lambda Aquarii.
Sun	17th	5 am	(3 am WST) Full Moon (370,265 km).
Wed	20th		m.p. 4 Vesta 0.4° NW of star Iota Capricorni.
Wed	20th	1 am	(11 pm WST, prev day) Moon at perigee (closest to Earth at 365,143 km).
Wed	20th	4 am	(2 am WST) star Antares 3° S of Moon.
Thu	21st		Saturn 0.06° N of star 45 Capricorni.
Fri	22nd		Venus 0.4° N of star Phi Aquarii.
Fri	22nd	am	Lyrids meteor shower, Apr 16–25, Moon affected.
Sat	23rd	10 pm	(8 pm WST) Last Quarter Moon.
Sun	24th	pm	pi-Puppids meteor shower, Apr 15–28.
Mon	25th	5 am	(3 am WST) Saturn 5° N of Moon.
Tue	26th	3 am	(1 am WST) Maximum Libration (8.4°), dark NE limb.
Tue	26th	5 am	(3 am WST) Mars 4° N of Moon.
Wed	27th	5 am	(3 am WST) Venus 5° N of Moon.
Wed	27th	5 am	(3 am WST) Neptune 6° NE of Moon.
Thu	28th	am	Neptune 0.01° N of Venus.
Thu	28th	5 am	(3 am WST) Jupiter 6° W of Moon.
Fri	29th		Comet 22P/Kopff 0.4° S of star Lambda Aquarii.
Fri	29th		Mercury at greatest elongation East (20.6°).
Sat	30th		Mercury 1.4° S of M45 the Pleiades (OC) in Taurus.
Sat	30th		m.p. 4 Vesta 1.2° NW of star Gamma Capricorni.
Sat	30th		m.p. 324 Bamberga 0.4° S of NGC 7585 (G) in Aquarius.
Sat	30th	pm	m.p. 13 Egeria 0.3° S of star Alpha[1] Librae.

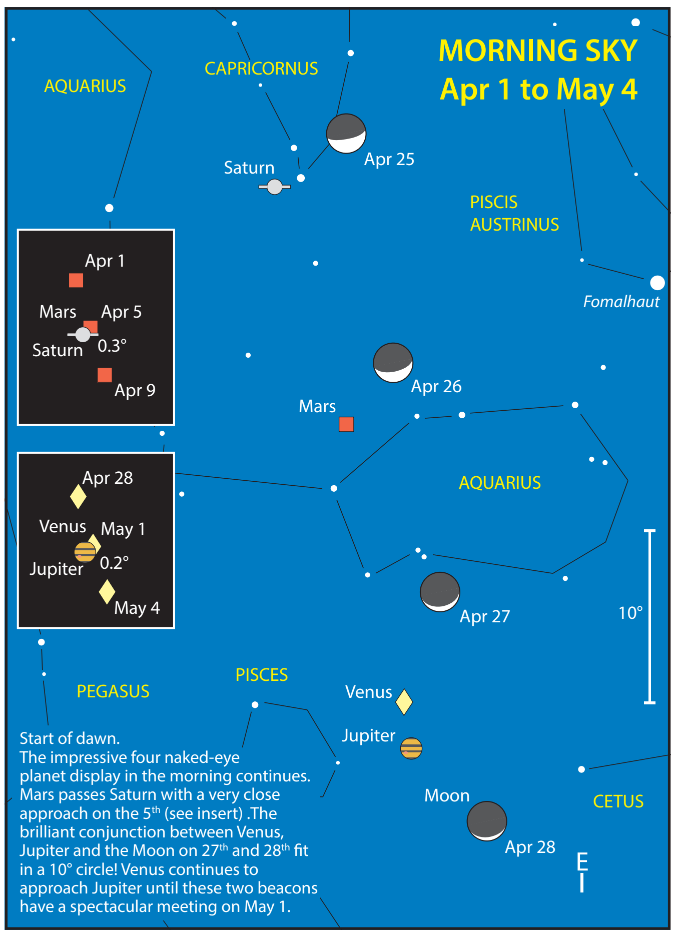
The Australian Aborigines have their own ‘constellations’ in the sky, with the ‘Emu’ representing the dark nebula across the plane of our Milky Way galaxy. The head of the Emu is the Coalsack Nebula adjacent to the Southern Cross (Crux), with the body and legs represented by the dark nebula through the core of the Milky Way around Scorpius. This image illustrates the Milky Way, and specifically the Emu rising above Uluru in the Northern Territory.

Credit Greg Priestley.

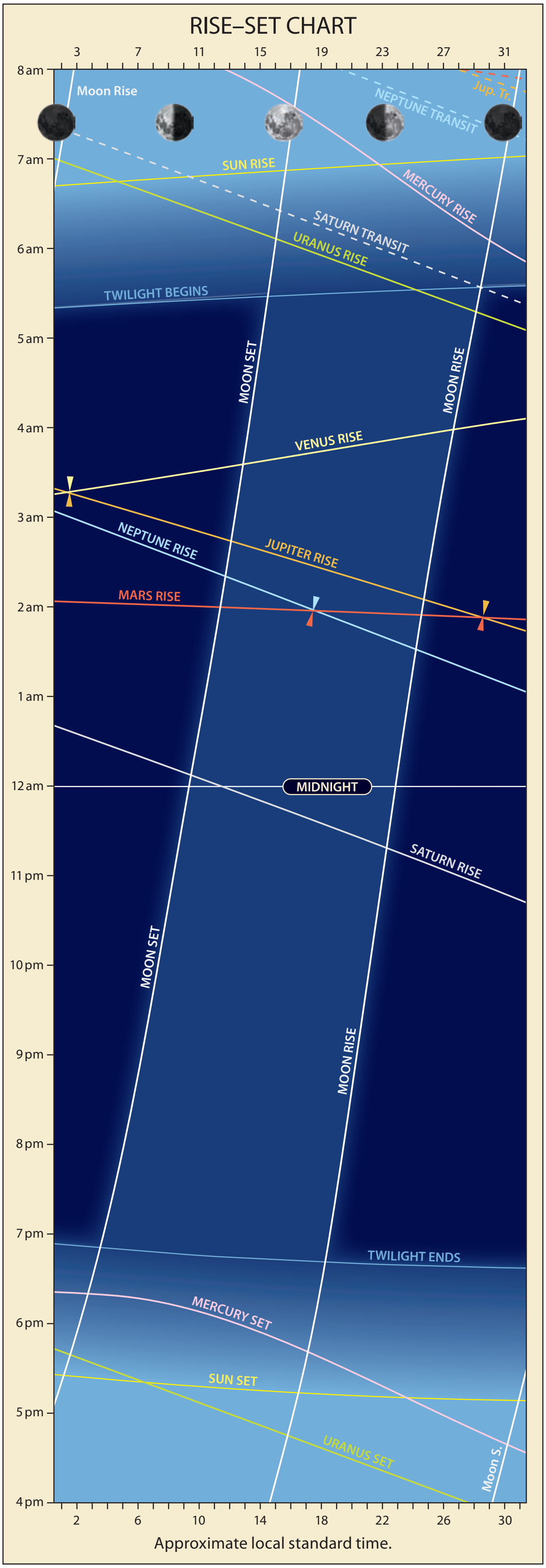


Approximate local standard time.





MAY 2022



HIGHLIGHT

- Venus and Jupiter very close.
- Venus and Moon an attractive pair.
- Mars and Neptune close.
- Mars and Jupiter close.
- Mars, Jupiter and Moon together.

CONSTELLATIONS

A Tale of two Quadrilaterals. The Southern Cross and Pointers is the most famous asterism in the southern sky. Being surrounded by the brilliance of the Milky Way, including the intruding dark nebulae (such as the Coal Sack) makes quite a sight. Directly underneath the cross is the constellation of Musca the Fly (All Sky Map 1). Its four brightest stars form a quadrilateral, ranging from 3.8 to 2.7 magnitude Alpha (α) Muscae or Myla (Greek for 'fly'). This is a more modern designation, as the constellation was originally Apis the Bee. It then went to Musca Australis as there used to be a Musca Borealis. When this northern *fly* became part of Aries, Musca Australis became just Musca. The constellation contains two easy to find globular clusters, both within 1° of the bottom (most southerly) two bright stars, NGC 4833 north of Delta (δ) and NGC 4372 south-west of Gamma (γ).

The other quadrilateral located directly above the Southern Cross is the constellation of Corvus the Crow. Crossing the zenith from northern Australia (All Sky Map 6), it's comprised of mainly 3rd magnitude stars. Corvus is only distinctive because of its isolation and if you include 1st magnitude Spica or Alpha (α) Virginis, 15° north-west, the asterism is much

APPEARANCE of the PLANETS

MERCURY Mercury in inferior conjunction on the 22nd

1 May
dia 8.3"
mag 0.4

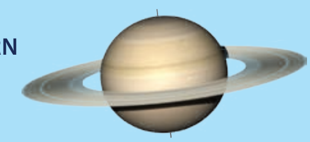
10 May
dia 10.4"
mag 2.3

31 May
dia 11.5"
mag 3.2

VENUS
15 May
dia 15.2"
mag −4.0

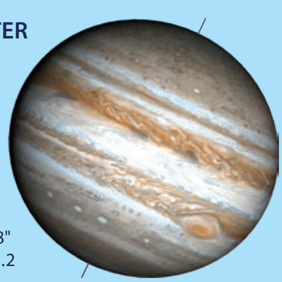
MARS
15 May
dia 6.0"
mag 0.8

SATURN



15 May
dia 16.9"
mag 0.8

JUPITER



15 May
dia 35.8"
mag −2.2

URANUS
25 May
dia 3.4"
mag 5.9
Conjunction 5 May

NEPTUNE
15 May
dia 2.2"
mag 7.9

For All Mankind – Part 1

This year marks the fiftieth anniversary of the end of manned flights to the Moon. Yes, folks, I know it's hard for some of us to believe but in this ancient primitive time of BC—before computers (well… as we know them today), humankind achieved this extraordinary feat! A time when scientists felt pride posing for photographs with pocket protectors on their lab coats and playing with slide rules (hmm… Google it). We use 'manned' here as back in the sixties and seventies, America's astronauts came mostly out of the test pilot arena—an exclusively testosterone fuelled pool of candidates.

It's amazing to think that as the sixties opened (only 10 years before Armstrong left his famous footprints) no human had even flown in space. This time saw an enormous leap in the development of space engineering, mostly driven by the space race, with America and the USSR vying for the 'high ground'.

Part 1 of this article will give a brief background, leading up to the manned Apollo flights. Both parts have a few interesting stories related to the astronauts with some bias towards those destined to be the first and last moonwalkers, that is Neil Armstrong and Eugene Cernan (Michael Jackson doesn't count).

The USA's effort really shifted into high gear after the Soviets beat them by putting cosmonaut Yuri Gagarin into orbit on April 12, 1961. Shortly after (May 25) the American President John F. Kennedy made an amazing declaration to Congress,

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth."

JFK's level of vision was particularly ambitious when one considers until then the USA had only 15 minutes of space flight under its belt with the suborbital flight by Alan Shepard in his Mercury capsule, Freedom 7. This flight went smoothly, however during a lengthy delay in the countdown there was a moment of discomfort for Shepard when he had to urinate in his space suit! The thinking was who needs a human waste collection system for only a 15-minute flight.

In the Mercury programme there were two potentially life-threatening incidents. In the second flight, Gus Grissom's Liberty Bell 7 capsule, after splash down unexpectedly blew its hatch off, causing the craft to flood and sink, forcing Gus to prematurely exit his craft, nearly drowning. The other involved the first orbital mission belonging to John Glen in Friendship 7 which developed a concern that the heat shield had become loose. Like all spacecraft, this was designed to prevent the capsule from burning up on re-entry. The retro-pack was left on to hopefully keep the shield in place. Fortunately, it turned out there was no problem with the shield.

These single astronaut flights culminated with Gordon Cooper's Faith 7 setting an endurance record by spending around 39 hours in orbit. While also going through extended delays in the countdown, 'Gordo' was so calm he fell asleep! Talk about the right stuff! The movie The Right Stuff portrays this well.

The six Mercury flights were very successful paving the way for the two-man Gemini missions. It was here that Cernan and Armstrong entered the flight roster. Gemini was designed to test aspects that would be critical for the Apollo programme. It was two of these facets that could easily have killed either Cernan or Armstrong. Being their first flights, they had pretty rough initiations!

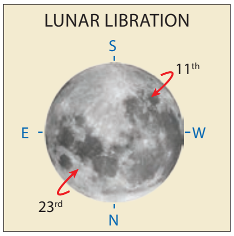
Photograph taken from Gemini 6 of Gemini 7 during the first rendezvous of two manned space vehicles. The spacecraft were about 300 km (185 miles) above the Pacific and about 12 m (40 feet) apart when this image was taken.

more noticeable. Although Corvus looks as much like a crow as Musca does a fly, it's interesting that the two quadrilateral stars Gamma (γ) and Delta (δ) Corvi, which point towards Alpha (α) Virginis, have been called Spica's Spanker, a type of ship's sail. A much better description for this asterism.

Being away from the Milky Way environment, Corvus is a bit star poor, but one of its brightest stars is a great naked-eye double, Delta (δ) or Algorab with Eta (η) 0.6° distant. A small telescope shows Delta itself is a double, composed of mags 3.0 and 8.5 stars, separated by a comfortable 24 arcseconds. Zeta (ζ), inside the asterism, forms a great binocular double with HR4691, six arcminutes away.

Corvus has the brightest example of two interacting galaxies visible in amateur telescopes. Starting at Algorab, move towards Gienah, pass it and continue out a similar distance again (3.5°) to find NGC 4038/4039, the Antennae Galaxies. These merged blobs appear to have a large chunk missing out of one side with the northern lobe being more prominent. Here's a test. Can you see bright knots running along its edge? These are star forming regions.

THE MOON



1st 6 am (4 am WST) New Moon. Partial solar eclipse (not visible from Australia—see p. 103).

5th 11 pm (9 pm WST) Moon at apogee (furthest from Earth at 405,285 km).

9th 10 am (8 am WST) First Quarter.

11th 1 am (11 pm WST, previous day) Maximum Libration (9.4°), dark SW limb.

16th 2 pm (Noon WST) Full Moon, supermoon (see p. 95). Total eclipse of the Moon (not visible from Australia—see p. 103).

18th 1 am (11 pm WST, previous day) Moon at perigee (closest to Earth at 360,298 km).

23rd 5 am (3 am WST) Last Quarter.

23rd 3 pm (1 pm WST) Maximum Libration (9.2°), dark NE limb.

30th 10 pm (8 pm WST) New Moon.

THE PLANETS

Mercury hugs the early western evening skyline for most of the month before moving into inferior conjunction with the Sun on the 22nd (between the Earth and the Sun). You may catch a glimpse of the planet early in May if you have an excellent horizon (see Sky View). This innermost world is only visible low in the twilight glow during this poor dusk apparition. The best opportunity for evening observation this year will be from mid-August to early September. At the end of the month, after inferior conjunction, Mercury returns to the morning dawn.

Venus and Jupiter provide a spectacular display on the 1st when the pair are separated by just 0.2° in the morning eastern sky, fitting in the same eyepiece field (see April Sky View). Conjunctions of the two brightest planets are reasonably common, occurring roughly 13 months apart. This one, however, is quite close and will be most impressive viewed with the unaided eye or any small instrument. On the 27th, the 26-day old waning crescent will be 3° above Venus (see Sky View).

Mars spends the first half of the month in Aquarius in the eastern morning sky before moving into Pisces. On the 18th and 19th the Red Planet passes within 0.7° of Neptune. While not visible to the unaided eye, a pair of binoculars will readily show the duo, and a telescope will show the colour contrast between them. After the Neptune encounter, Mars moves towards Jupiter, and from the 28th to the 31st, the two will be 1° or less apart (see Sky View). A neat conjunction occurs on the 25th when the 24-day old waning crescent Moon, Mars, and Jupiter group together within a 6° circle (see Sky View).

Jupiter opens and ends the month spectacularly. On the 1st, the planetary duo of Jupiter and Venus will be just 0.2° apart in the early morning eastern sky just south (to the right) of the Circlet of Pisces asterism (see April Sky View). At –2 (Jupiter) and –4 (Venus) magnitude, the luminaries will be

One aspect was spacewalking or EVA, the need for an astronaut to exit his craft and do work in zero gravity in a bulky spacesuit. While outside the Gemini 9A craft, Cernan became physically exhausted finding it hard to do anything or go anywhere. Then his visor fogged up so badly he couldn't see. After terminating the spacewalk early, he and his partner, Tom Stafford, had to fight to get his highly inflated, stiff spacesuit back into the cockpit. Stafford later stated that for a while he was very concerned they mightn't get the hatch closed!

Another critical aspect was docking, which proved to be near fatal for Armstrong and Scott in Gemini 8. This was the first successful docking in space, the target being an unmanned Agena vehicle. A thruster malfunctioned on the Gemini capsule putting the craft into an uncontrollable tumble. With only seconds remaining before blacking out Armstrong brought the craft under control. Having used the re-entry thrusters to do this, mission rules required an abort and they reentered on the next orbit.

The 10 manned Gemini flights had ticked all the boxes and handed the baton over to Apollo. The first crewed Apollo mission, to be flown by Grissom, White and Chaffee was undergoing final testing in January 1967, for a launch the following month, when a fire broke out in the cockpit, killing the astronauts. There was always a possibility of losing a crew in space but such a disaster, in what was considered a non-hazardous routine test, on the ground was devastating. There was only three years left to meet JFK's goal!

In hindsight, the Apollo command module fire was an accident waiting to happen with a poorly designed escape hatch and with highly combustible equipment and inadequately insulated electrical wiring operating under a pure oxygen atmosphere. The redesigned, much safer Apollo command module likely contributed greatly to the ultimate success of the programme.

continued on page 52.

visually stunning no matter whether you are using binoculars, a telescope or just the unaided eye. At month's end, 28th to 31st the King of Planets will be within 1° of the Red Planet, Mars (see Sky View).

Saturn rises in the east a little before midnight mid-month. Between the 5th and 9th, the 7.6 magnitude asteroid 4 Vesta sails past the planet at just under 1° away. The easiest way to identify the minor planet is on the morning of the 7th when it will be midway between Saturn and the 3rd magnitude star Delta (δ) Capricorni—a good pair of binoculars and dark skies is all that is required. On the 16th, the planet is at the point in its orbit known as its eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 14). It is also the best time to view the maximum shadow of the planet's globe cast onto the back of the rings, giving Saturn a 3-D appearance. The shadow will decrease in size as opposition approaches in August.

DIARY			
Sun	1st	am	Jupiter 0.3° N of Venus.
Sun	1st	am	Comet C/2021 E3 (ZTF) 0.5° NW of NGC 7079 (G) in Grus.
Sun	1st	6 am	(4 am WST) New Moon, Partial solar eclipse.
Mon	2nd	6 pm	(4 pm WST) Mercury 4° NE of Moon.
Thu	5th		m.p. 2 Pallas 0.4° N of star Omicron Ceti (Mira).
Thu	5th		Uranus in conjunction with Sun.
Thu	5th	11 pm	(9 pm WST) Moon at apogee (furthest from Earth at 405,285 km).
Fri	6th		m.p. 4 Vesta 0.9° N of star Delta Capricorni.
Fri	6th		m.p. 349 Dembowska 0.4° NW of star Omicron Piscium.
Sat	7th		m.p. 4 Vesta 0.7° S of Saturn.
Sat	7th	am	eta-Aquarids meteor shower, Apr 19 to May 28.
Sat	7th	7 pm	(5 pm WST) star Pollux 5° W of Moon.
Sun	8th	4 am	(2 am WST) Comet 22P/Kopff 0.1° W of star Phi Aquarii.
Sun	8th	pm	m.p. 13 Egeria 0.7° N of NGC 5728 (G) in Libra.
Mon	9th		Mars 0.6° SE of star Phi Aquarii.
Mon	9th		m.p. 324 Bamberga 1.3° NW of Neptune.
Mon	9th	10 am	(8 am WST) First Quarter Moon.
Mon	9th	10 pm	(8 pm WST) star Regulus 8° SE of Moon.
Wed	11th	1 am	(11 pm WST, prev day) Maximum Libration (9.4°), dark SW limb.
Thu	12th		Comet 22P/Kopff 0.5° NW of Mars.
Thu	12th	am	Comet C/2021 E3 (ZTF) 0.6° NW of star Delta Indi.
Fri	13th		m.p. 3 Juno 1.1° SE of star Gamma Aquarii.
Sat	14th	am	Comet C/2021 E3 (ZTF) 0.3° W of star Epsilon Indi.
Sat	14th	2 am	(Midn WST, prev day) star Spica 8° SE of Moon.
Mon	16th	2 pm	(Noon WST) Full Moon (362,127 km), supermoon and total lunar eclipse.
Tue	17th	am	Comet C/2021 E3 (ZTF) 0.8° W of star Alpha Tucanae.
Tue	17th	7 pm	(5 pm WST) star Antares 5° SW of Moon.
Wed	18th	1 am	(11 pm WST, prev day) Moon at perigee (closest to Earth at 360,298 km).
Wed	18th		Neptune 0.5° N of Mars.
Sat	21st		m.p. 4 Vesta 0.4° S of star Iota Aquarii.
Sat	21st		Comet 22P/Kopff 0.5° SE of Neptune.
Sat	21st	am	Comet C/2021 E3 (ZTF) 0.5° SE of star Delta Tucanae.
Sun	22nd		Mercury in inferior conjunction.
Sun	22nd	Midn	(10 pm WST) Saturn 6° W of Moon.
Mon	23rd	5 am	(3 am WST) Last Quarter Moon.
Mon	23rd	3 pm	(1 pm WST) Maximum Libration (9.2°), dark NE limb.
Wed	25th		m.p. 3 Juno 1.1° SE of star Eta Aquarii.
Wed	25th	3 am	(1 am WST) Neptune 4° W of Moon.
Wed	25th	5 am	(3 am WST) Mars 2° N of Moon.
Wed	25th	5 am	(3 am WST) Jupiter 4° NE of Moon.
Fri	27th		Venus 0.4° S of star Omicron Piscium.
Fri	27th	5 am	(3 am WST) Venus 3° NE of Moon.
Sun	29th		Jupiter 0.5° N of Mars.
Mon	30th	am	Comet C/2021 E3 (ZTF) 0.4° NW of star Theta Octantis.
Mon	30th	10 pm	(8 pm WST) New Moon.
Tue	31st		m.p. 7 Iris 0.7° N of M67 (OC) in Cancer.
Tue	31st	am	Comet C/2021 E3 (ZTF) 0.8° SW of star Beta Hydri.

Uranus is in conjunction with the Sun on the 5th and reappears in the morning eastern dawn in Aries late this month.

Neptune begins the month in Aquarius before slipping over the boundary into Pisces. The planet is only visible in the morning eastern sky, rising around 2 am mid-month. Both Neptune and Mars have a close encounter on the 18th and 19th (see Mars).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 May	21 Lutetia	Libra	10.6
5 May	13 Egeria	Libra	10.0
6 May	18 Melpomene	Libra	10.3
8 May	87 Sylvia	Libra	11.9
22 May	26 Proserpina	Scorpius	10.3

COMETS

Comet C/2017 K2 (PANSTARRS) is predicted to brighten from 9th to 8th magnitude by the end of May. Beginning the month in Aquila and rising late in the evening, PANSTARRS moves back into Ophiuchus in mid-May, where it will remain until August.

Comet 22P/Kopff spends most of May in Aquarius, moving into Pisces in the last week. Rising around 2 am it is well up and nicely placed to observe in the late morning. The comet is slowly fading, perhaps around 11.5 magnitude at month's end. On the 12th Kopff has an encounter with Mars and with Neptune on the 21st (see diary).

Comet C/2021 E3 (ZTF). Being a new comet, with few observations made (at the time of publication), there is always a high level of uncertainty as to how bright such comets will become. ZTF has been included here because it is so well placed for observing from the Southern Hemisphere during its perihelion passage. It might be around 11th magnitude throughout May and June. The comet commences May in Grus. Due to its fast southerly motion ZTF then passes through Indus, Tucana, back into Indus and Octans. It finishes the month in Hydrus, not far from the Large Magellanic Cloud (LMC) and close to Beta (β) Hydri. By mid-May the comet becomes circumpolar, transiting around 6 am mid-month, so having the best altitude in the pre-dawn.

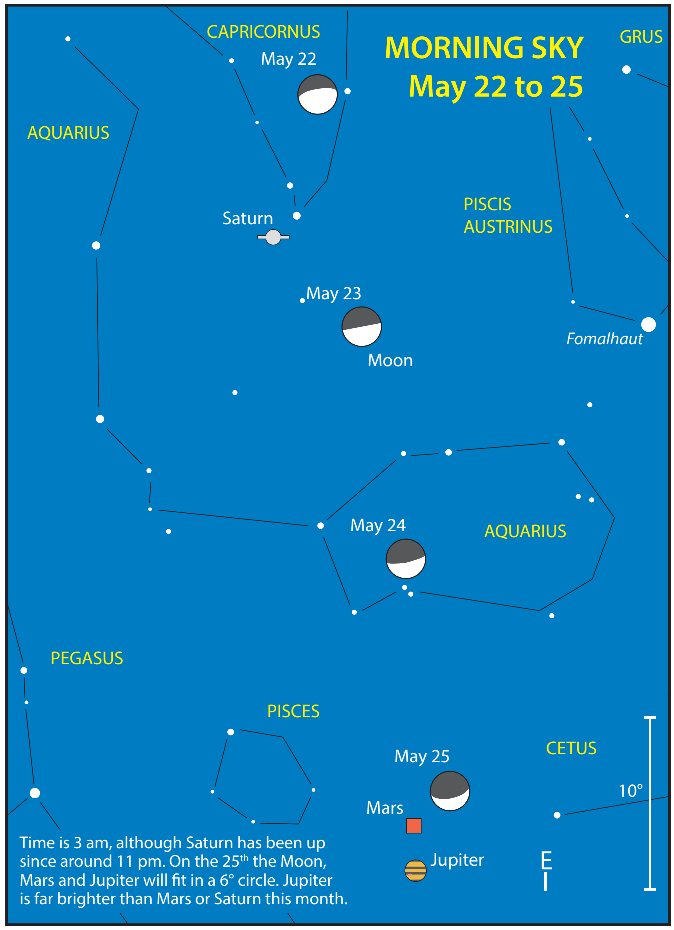
DOUBLE STARS

Located at the foot of the Southern Cross, the AB-C components of **Alpha (α) Crucis** (Acrux, DUN 252) form a beautiful close double visible through 10 × 50 mm binoculars. The pair of bluish-white (magnitude 1.3 and 4.8) stars is separated by 90 arcseconds. This spacing has not changed significantly since James Dunlop's measures in 1826 and the pair probably form a long period binary. The brighter of these stars is a brilliant close telescopic double (DUN 252AB) magnitude 1.3 and 1.6 separated by 3.5 arcseconds and a test of how well your telescope is performing. (All Sky Map 1)

Alpha (α) Circini (DUN 166) is a lovely colour contrasting telescopic pair located near Alpha (α) Centauri. The primary (magnitude 3.2, spectral type A7 Vp) is bright yellow whilst the fainter companion (magnitude 8.5, spectral type K5) appears to be reddish in comparison. The primary star belongs to a class of variables known as rapidly oscillating Ap stars. It oscillates with multiple, non-radial pulsation cycles and a dominant cycle of 6.8 minutes. The pair is separated by 15.7 arcseconds and forms a long period binary with an orbital period estimated to be at least 2,600 years. This is a lovely pair to show your friends. (All Sky Map 1)

METEOR SHOWER

The **eta-Aquarids** are linked with Halley's Comet and rank as one of the most popular of the Southern Hemisphere showers. Visible from April 19 to May 28, they peak on the night of the 6th and the morning of the 7th. Their maximum rates of 40 or more will likely be seen before dawn since the radiant in Aquarius reaches its highest altitude a little after sunrise. The eta-Aquarids are characterised by their high percentage of persistent trains. They are very swift and are a striking yellow colour. The waxing crescent Moon sets before midnight around the peak, leaving morning observations free of lunar interference.



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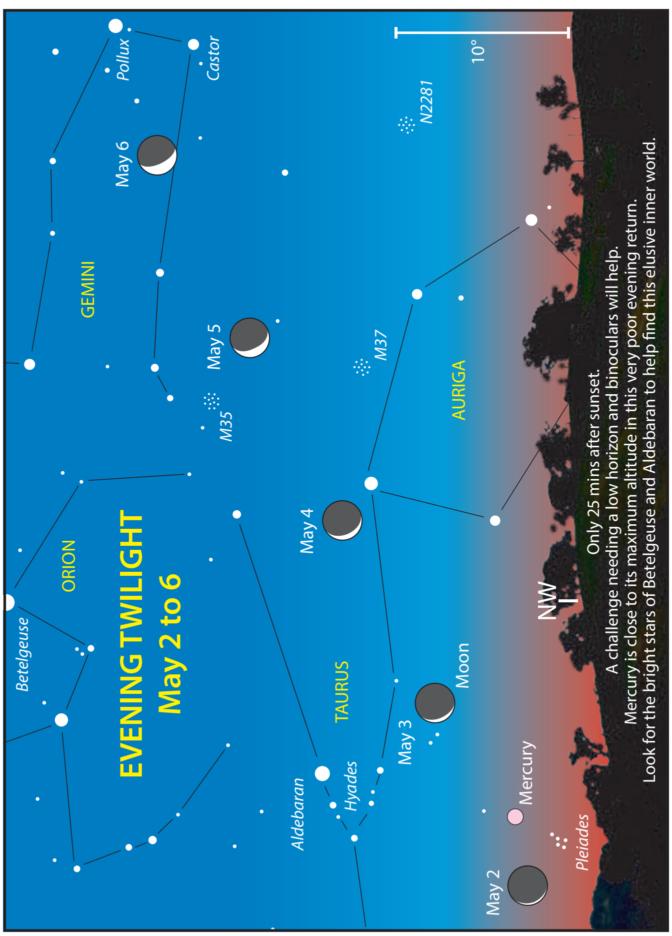
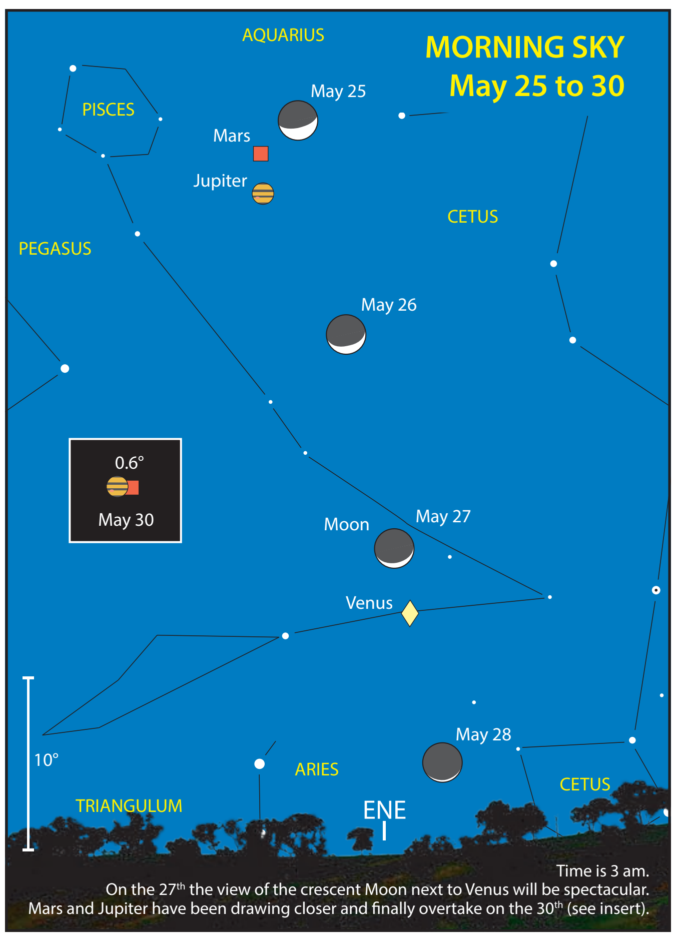
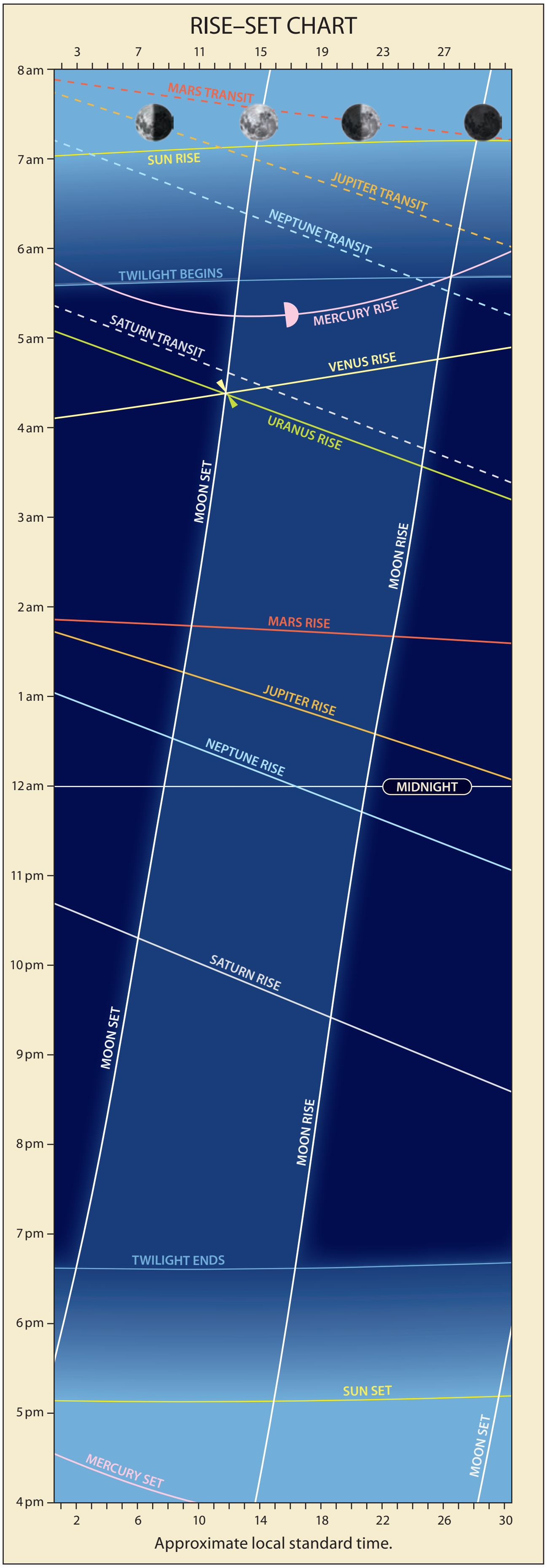




JUNE 2022



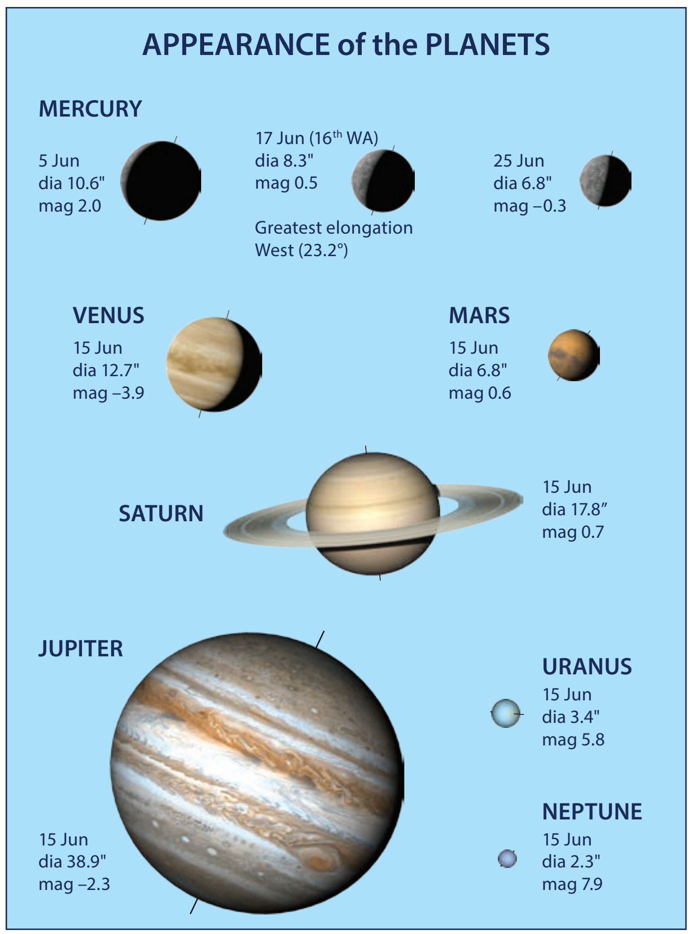
HIGHLIGHTS

- Venus and Uranus close.
- Mars and Jupiter close.
- Mars and Moon close.
- Moon and Uranus close (occultation from WA).

CONSTELLATIONS

The view of our magnificent galaxy flowing from the eastern horizon, passing overhead and extending to the west is truly inspiring. Having the winter solstice on the 21st means you have longer nights to enjoy it. This is a great time to see the star and nebulae rich southern regions of the Milky Way. Perched high in the eastern mid-evening sky is Scorpius and Sagittarius, which mark the galactic hub. Next month we'll discuss the scorpion, but under its stinger lies the famous Teapot asterism in Sagittarius.

The night sky has three asterisms called 'dippers'. The most famous is the Big Dipper which is the most obvious part of the constellation of Ursa Major the Big Bear (Map 7). All seven of these mostly 2nd magnitude stars, can be seen briefly scraping the horizon from northern Australia (see also diagram on page 16) around the end of twilight this time of year. The second dipper or Little Dipper is well known in the Northern Hemisphere for those looking for the north celestial pole. The end of the handle is the North Star, 2nd magnitude Polaris. The other lesser known is the Milk Dipper, which lies within the Teapot. It's easier to see this time of year in the early evening when Sagittarius is lying on its side. The four handle stars and the lid star (Lambda (λ) Sagittarii) make up the asterism, with the base being Sigma (σ) and Tau (τ) Sagittarii.

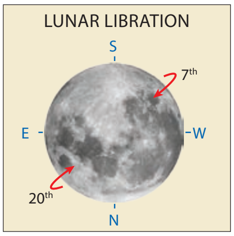


JUNE

Looking at Sagittarius, the ancients envisaged a centaur (half-man, half-horse), which is certainly not the first thing that comes to mind when viewing its star pattern. In fact, it's hard to look past the obvious bright Teapot asterism on the constellation's western edge (Map 8). However, the front (spout) half of this instrument wasn't designed to brew tea, instead it's somewhat more deadly with the ancient depiction showing him holding a bow and arrow. The traditional star names betray this weapon. The top or lid star, Lambda (λ) Sagittarii is also known as Kaus Borealis, which translates to 'northern (tip of the) bow'. Heading towards the spout you come to Delta (δ) Sagittarii or Kaus Media or 'middle bow' and then, further south is Epsilon (ε) Sagittarii or Kaus Australis, the 'southern (end of the) bow'. The spout star, Gamma^2 (γ^2) Sagittarii is called Alnasl, which is derived from 'arrowhead' and shows this projectile roughly pointing towards Antares, the 'heart' star of the scorpion (Scorpius).

Below the Teapot, lies a faint semicircle of stars, the constellation of Corona Australis, the Southern Crown. It may relate to the Sagittarius myth, being a wreath having fallen off his head and now lying at the feet of this centaur.

THE MOON



- 2nd 11 am (9 am WST) Moon at apogee (furthest from Earth at 406,192 km).
- 7th 10 pm (8 pm WST) Maximum Libration (9.5°), dark SW limb.
- 8th 1 am (11 pm WST, previous day) First Quarter.
- 14th 10 pm (8 pm WST) Full Moon, supermoon (see p. 95).
- 15th 9 am (7 am WST) Moon at perigee (closest to Earth at 357,432 km).
- 20th 11 am (9 am WST) Maximum Libration (9.6°), dark NE limb.
- 21st 1 pm (11 am WST) Last Quarter.
- 29th 1 pm (11 am WST) New Moon.
- 29th 4 pm (2 pm WST) Moon at apogee (furthest from Earth at 406,580 km).

THE PLANETS

Mercury spends an uneventful month traversing Taurus in the eastern morning sky (see Sky View). It reaches its greatest elongation of 23° west of the Sun on the 17th, making mid-month an excellent rare opportunity to glimpse this small world under reasonably dark skies before the dawn glow.

Venus and Uranus appear within 2° of each other from the 11th to 13th in the eastern morning sky in Taurus. Even under the darkest skies, the brilliance of Venus will overwhelm the fainter outer planet and binoculars, or a telescope will help. On the 26th, the 27-day old waning crescent Moon will be 5° from Venus, a pretty sight together with the rising Pleiades and the Hyades star clusters (see Sky View).

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

Mars rises around 2 am in the eastern morning sky in Pisces. The planet spends the entire month in Pisces, aside from a bit of corner-cutting into Cetus for a few days. After Mars' close approach to Jupiter on the 30th of last month, on the 1st they will still be an attractive view, now separated by 1.5°. On the 23rd, the Red Planet will be less than 1° from the 24-day old waning crescent Moon (see Sky View). Closest approach is around 3:30 am EST (1:30 WST, however the Moon won't rise for another 20 minutes from Perth)

Jupiter remains a morning object during the month and can be seen close to Mars on the 1st; they then go their separate ways. Conjunctions between these two outer planets are common, occurring a little over twenty-six months apart (next August 2024). On the 22nd, the 23-day old waning crescent Moon will be close to Jove (see Sky View).

DIARY			
Wed	1st		Venus 0.3° SW of NGC 821 (G) in Aries.
Thu	2nd	11 am	(9 am WST) Moon at apogee (furthest from Earth at 406,192 km).
Fri	3rd	6 pm	(4 pm WST) star Pollux 1.5° N of Moon.
Sat	4th		m.p. 2 Pallas 0.3° SW of star 94 Ceti.
Sun	5th		m.p. 7 Iris 0.4° NE of star Alpha Cancri.
Mon	6th	7 pm	(5 pm WST) star Regulus 5° SW of Moon.
Tue	7th		m.p. 20 Massalia 0.8° S of star Regulus (Alpha Leonis).
Tue	7th	10 pm	(8 pm WST) Maximum Libration (9.5°), dark SW limb.
Wed	8th	1 am	(11 pm WST, prev day) First Quarter Moon.
Thu	9th		m.p. 349 Dembowska 1.8° NW of Venus.
Fri	10th	7 pm	(5 pm WST) star Spica 5° S of Moon.
Sun	12th		m.p. 324 Bamberga 0.7° NW of star Delta Piscium.
Sun	12th	am	Uranus 1.5° N of Venus.
Mon	13th	Midn	(10 pm WST) star Antares 3° S of Moon.
Tue	14th	10 pm	(8 pm WST) Full Moon (357,656 km), supermoon.
Wed	15th	9 am	(7 am WST) Moon at perigee (closest to Earth at 357,432 km).
Fri	17th		Mercury at greatest elongation West (23.2°).
Fri	17th	pm	Comet C/2021 E3 (ZTF) 0.3° SE of star Zeta Volantis.
Sat	18th	10 pm	(8 pm WST) Saturn 4° N of Moon.
Mon	20th	11 am	(9 am WST) Maximum Libration (9.6°), dark NE limb.
Mon	20th	pm	Comet C/2017 K2 (PANSTARRS) 0.6° SE of IC 4665 (OC) in Ophiuchus.
Tue	21st	4 am	(2 am WST) Neptune 3° N of Moon.
Tue	21st	1 pm	(11 am WST) Last Quarter Moon.
Tue	21st		Solstice.
Tue	21st	pm	Comet C/2021 E3 (ZTF) 0.5° E of star Epsilon Volantis.
Wed	22nd		Mercury 0.6° SW of star Epsilon Tauri.
Wed	22nd		m.p. 349 Dembowska 0.3° N of Uranus.
Wed	22nd	2 am	(Midn WST, prev day) Jupiter 3° NW of Moon.
Wed	22nd	11 pm	(9 pm WST) Comet C/2017 K2 (PANSTARRS) 0.15° N of star Beta Ophiuchi.
Thu	23rd	am	star Aldebaran 3° S of Mercury.
Thu	23rd	4 am	(2 am WST) Mars 0.5° NW of Moon.
Thu	23rd	pm	Comet C/2017 K2 (PANSTARRS) 1.5° NW of NGC 6426 (GC) in Ophiuchus.
Fri	24th	pm	Comet C/2021 E3 (ZTF) 0.3° NE of star Beta Volantis.
Sat	25th		Mercury 1.0° NW of NGC 1642 (G) in Taurus.
Sat	25th	5 am	(3 am WST) Uranus 1° E of Moon.
Sun	26th	am	m.p. 9 Metis 0.7° SE of NGC 6907 (G) in Capricornus.
Sun	26th	6 am	(4 am WST) Venus 5° E of Moon.
Mon	27th	6 am	(4 am WST) Mercury 6° SE of Moon.
Wed	29th	1 pm	(11 am WST) New Moon.
Wed	29th	4 pm	(2 pm WST) Moon at apogee (furthest from Earth at 406,580 km).
Thu	30th		Venus 1.3° NW of star Epsilon Tauri.

For All Mankind – Part 2

The first crewed Apollo flight, Apollo 7, flew in October 1968. This flawless shakedown mission in Earth orbit cleared the way for what many thought an extremely audacious mission. Apollo 8 took the command/service module to orbit the Moon! Launched in December 1968 this mission saw astronauts Borman, Lovell and Anders become the first people to visit another astronomical body and are best remembered for the famous Earthrise photograph and for reading from the Bible during their Christmas Eve television broadcast.

Apollos 9 and 10 were essentially test missions for the Moon lander, Lunar Module (LM). Apollo 10 flew in May 1969 and its highlight was when Stafford and Cernan flew the LM to within 16 km of the lunar surface. Then a heart stopping moment when initiating the burn to return the ascent stage to the command module in orbit. At this point the craft violently gyrated including a few unplanned tumbles (and swear words) which Cernan finally brought under control with the attitude thrusters. Here's an interesting tidbit, the tanks on their ascent stage were never full. NASA needed to simulate as closely as possible the amount of fuel Apollo 11 would have remaining after take-off when it got to the same altitude as Apollo 10, that is, have both craft about the same weight. This made sense; however, there was a legendary concern around the nature of the astronauts. Allegedly, the agency did not totally trust Cernan and Stafford not to try and land. Therefore, NASA deliberately left them insufficient fuel to return to orbit from the surface!

The dress rehearsal was over, it was time for Apollo 11. This mission went off almost without a hitch, except when Armstrong and Aldrin were in the final stages of landing on the Moon. First there was a persistent '1202' alarm, which after an unnerving period was eventually safely ignored. Armstrong then unexpectedly took over manual control from the computer and finally landed with only seconds of fuel remaining! This from the man who had a crash in the LLRV (Lunar Landing Research Vehicle, nicknamed the Flying Bedstead) the previous year. Apollo 11 had simple mission goals of just landing a man on the Moon, collect a rock and safely return. So, the landing site was chosen to be a large flat part of the Sea of Tranquillity. However, they had well overshot the planned landing area and unknown even to Aldrin at the time, at a height of only 122 metres, Neil had found them rapidly descending into a boulder filled crater and had to manually fly past.

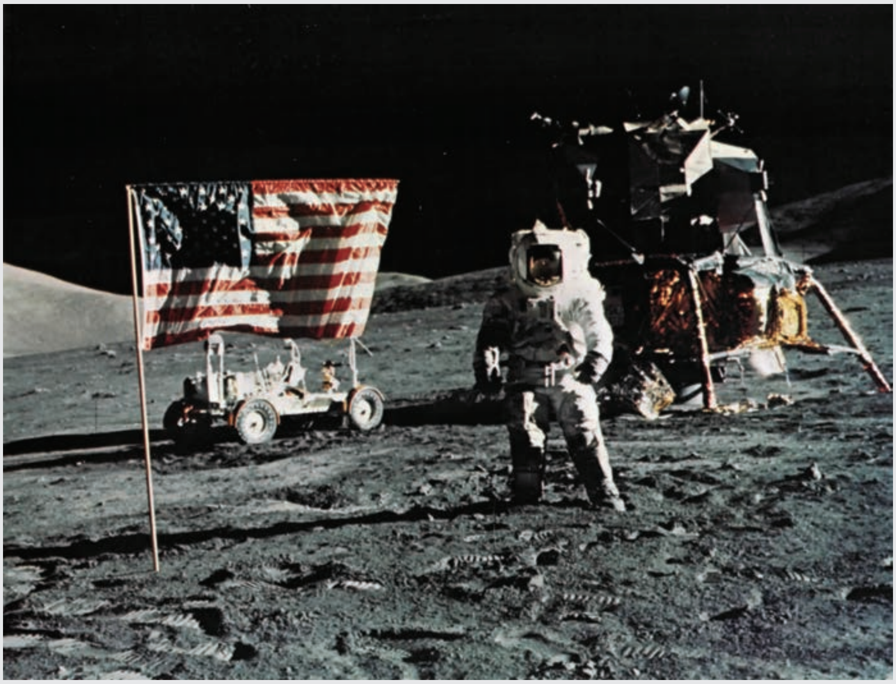
The success of Apollo 11 had brought to a close the political goals of the programme, that is, America had beaten the Russians! Now the science phase began. Of the remaining successful landings [i] each mission got increasingly ambitious heading for more and more geologically interesting sites. These would need precise landings, an aspect Apollo 12 (Nov 1969) excelled at. Part of its mission was to land close to the Surveyor 3 spacecraft, with the LM landing within 200 metres of the probe. This was close to a perfect mission, however, like nearly all Apollo flights it had its glitch(es) that could have threatened the outcome of the mission. Apollo 12's was possibly the most dramatic with the flight nearly scrubbed, only seconds after lift-off from Florida, due a lightning strike which caused a total blackout in the craft!

Apollo 14 saw the programme switch to a more rugged region, on the edge of Fra Mauro, collecting rocks that proved this basin was the result of an ancient meteor impact. Alan Shepard also showed his golfing talent hitting two golf balls. Apollo 15 headed into the foothills of the Apennine Mountains, with the landing site lying between two 4,000-metre-high mountains and next to the strange narrow valley, Hadley Rille. Astronaut David Scott also delivered the famous television broadcast of him simultaneously dropping a feather and hammer. Proving that when they hit the ground together, that all objects fall at the same speed in the absence of atmospheric resistance.

The last three Apollo flights, that is 15, 16 and 17 were the 'J' type missions which were designed for longer duration, leading to three EVAs and the Lunar Roving Vehicle allowing for much further traverses and the return of more rock samples.

Apollo 16 (Apr 1972), returned to the lunar highlands, to a rugged terrain near Descartes Crater. What was thought to be a volcanic region, instead showed it to be sculptured by meteorite impacts. Both 15 and 16 covered around 28 km and returned around 90 kg of lunar samples each.

With the cancellation of Apollos 18, 19 and 20, Apollo 17 was going to be the last hurrah. So, NASA set out to maximise the returns from this mission. This resulted in many records being set including: the longest time in lunar orbit



Harrison Schmitt beside the flag at Apollo 17 landing site, credit NASA.

Saturn rises in the late evening eastern sky in Capricornus. Early in the month, the planet begins retrograde motion against the background stars and will appear to travel from east to west across the sky for the next 4 months (see Retrograde Motion p. 94). On the 18th, the 19-day old waning gibbous Moon will be near the Ringed Planet (see Sky View).

Uranus returns to the morning eastern sky in Aries this month. This outer planet encounters Venus on the 11th to 13th when the pair are less than 2° apart. On the 25th, Uranus has a close meeting with the 26-day old waning crescent Moon. The planet will be less than 0.5° from the bright limb at the start of astronomical dawn from the eastern states. From South Australia, the angular distance between the bodies will be around 15 arcminutes. From Western Australia, Uranus will be occulted by the Moon. From Perth, ingress occurs on the bright limb with the Moon close to the horizon (4° altitude) at 4:07 am WST, and egress from the dark limb at 4:48 am WST at 12° altitude.

Neptune is still basically a morning object, rising around midnight mid-month. On the 29th, 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

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
2 Jun	287 Nephthys	Ophiuchus	11.1
7 Jun	29 Amphitrite	Scorpius	9.7
8 Jun	41 Daphne	Ophiuchus	10.1
13 Jun	511 Davida	Serpens	11.8
14 Jun	107 Camilla	Ophiuchus	12.5
15 Jun	60 Echo	Ophiuchus	12.2
19 Jun	97 Klotho	Ophiuchus	12.6
26 Jun	387 Aquitania	Serpens	10.1

(6 days 4 hours), the longest time spent on the Moon by men and their EVAs (totalling 22 hours), drove 35 km and netted some 110 kg of rock samples. Knowing this was the last Apollo the scientific community had pushed for a professional geologist to be part of the landing crew, hence the inclusion of Harrison Schmitt.

Eugene Cernan, Harrison Schmitt, Ron Evans and five mice(ii) were launched on December 7, 1972. Apollo 17 was the only night launch of the series. Three days later Cernan and Schmitt in their lunar module, Challenger set down in the Taurus-Littrow valley. This final mission turned out to be a goldmine (geologically speaking). The diversity of the rocks collected delivered the most complete picture of the Moon's history, going back some 4,600 million years.

We all know of Armstrong's inspirational first words, *"That's one small step…"*, however, Cernan's closing words as he was preparing to leave the surface of the Moon for the last time, although less famous, were equally poignant:

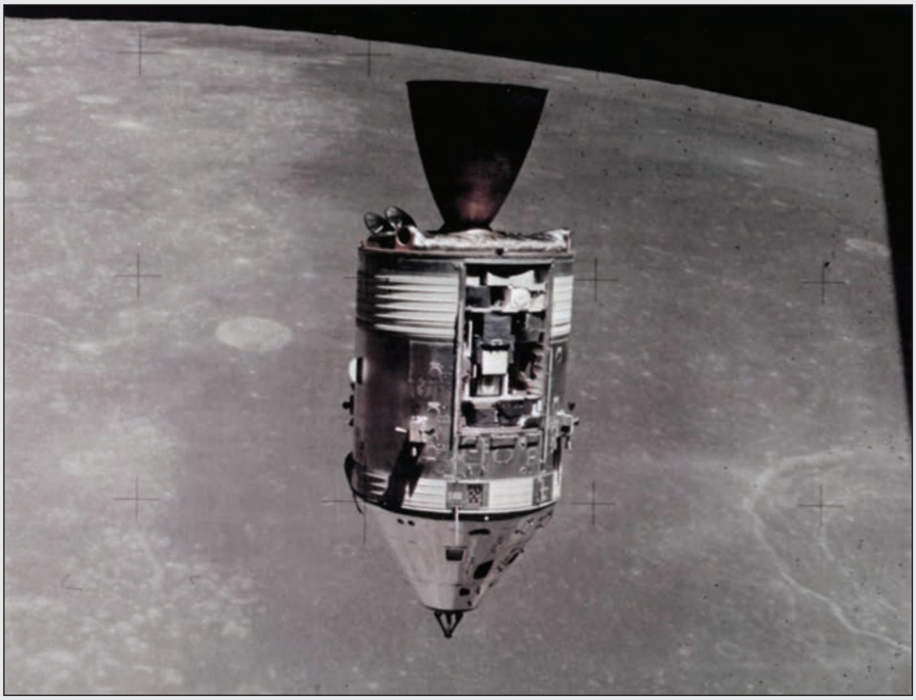
"As we leave the Moon and Taurus Littrow, we leave as we came and, God willing, we shall return with peace and hope for all Mankind".

The Next Step...

The Artemis programme's goal is to return humankind to the Moon around the mid-2020s. It is a NASA run project, collaborating with many international space agencies. Since the mid-2010s NASA has had a contract with Space X to develop a Lunar lander variant of their Starship programme, called Starship HLS (Human Landing System). With the Biden administration endorsing Artemis in February 2021, NASA has now signed a $2.9 billion contract with Space X to manufacture two HSLs, one intended for an uncrewed test flight and the second a crewed lunar landing. For those interested in Greek mythological connections, Artemis was the twin sister to Apollo and the Goddess of the Moon.

(i) There is no room here to go into the incredible drama of Apollo 13, considered by some to be NASA's greatest moment. For those not aware of these events, Tom Hank's movie portrayal is historically accurate.

(ii) We thought we couldn't get away without explaining the mice. They were implanted with radiation monitors to see if the accumulated exposure to cosmic rays would have any ill effects. Apart from one dying mysteriously (not related to radiation) the other four after extensive testing showed no changes at all. The crew were not happy with the arbitrary test numbers the mice were assigned, so they called them Fe, Fi, Fo, Fum and Phooey.



Apollo 15 CSM and SIM bay viewed from the LM during rendezvous, credit NASA.

COMETS

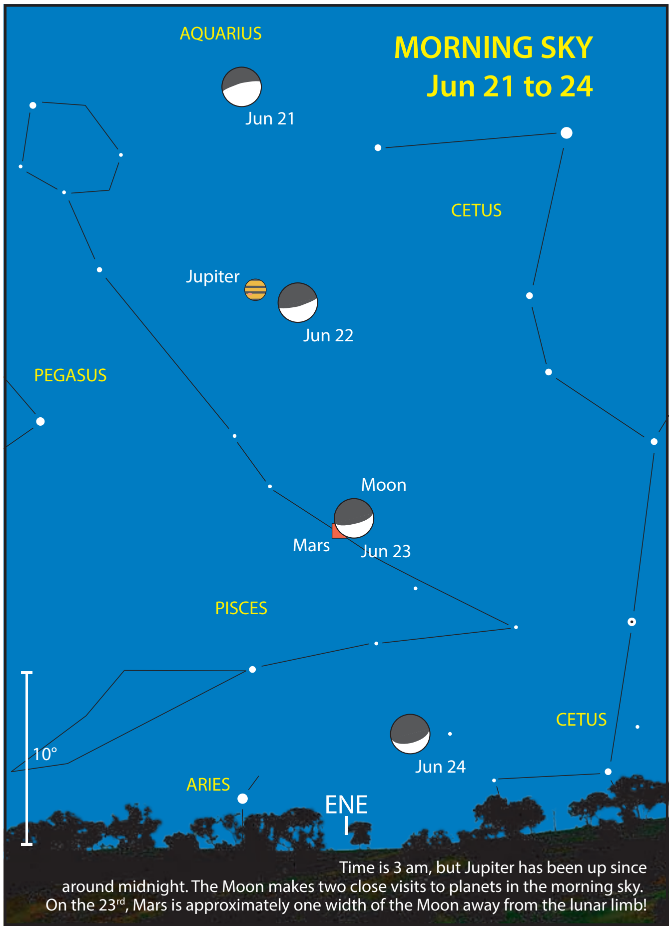
Comet C/2017 K2 (PANSTARRS) could brighten from 8th to 7th magnitude by month's end. Located in Ophiuchus throughout June, PANSTARRS is rising early in the evening. Late in the month the comet comes close to Beta (β) Ophiuchi (see diary). Around mid-June it is visible most of the night, transiting around midnight.

Comet C/2021 E3 (ZTF) starts June around 5° south of the SMC in Hydrus. The comet then passes into Mensa, south of the Large Magellanic Cloud (LMC). It reaches perihelion on the 12th at 1.8 au. Mid-month it moves into Volans as it heads north, finishing June in Carina, only a few degrees from the False Cross asterism.

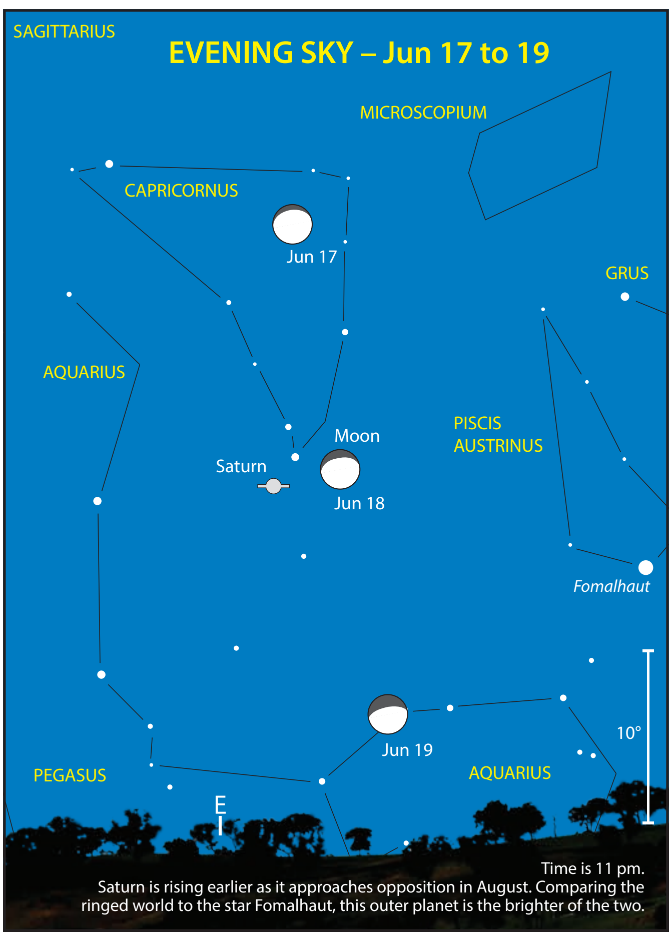
DOUBLE STARS

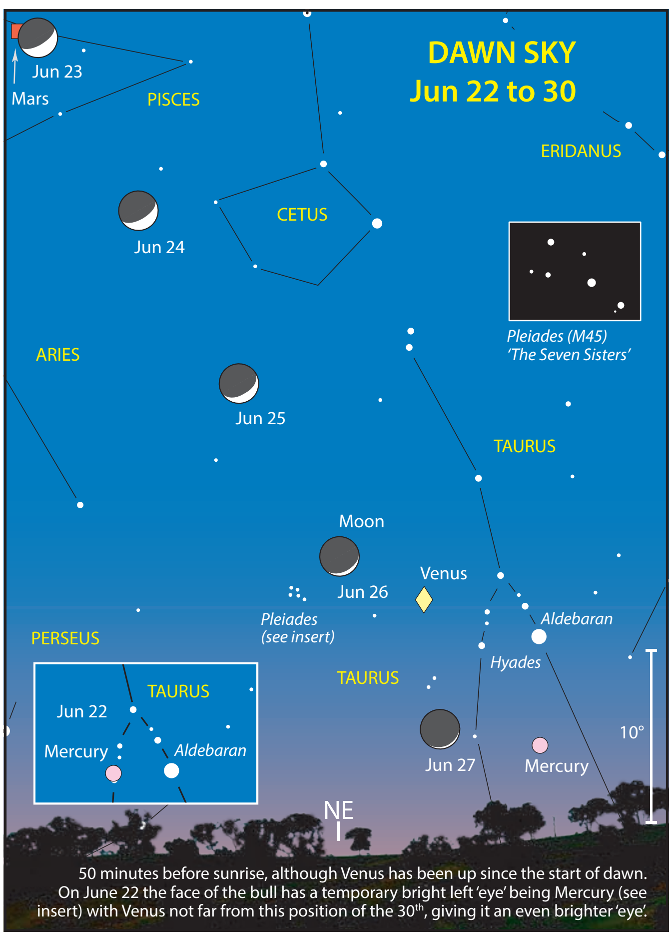
Alpha¹ and Alpha² (α) Librae (SHJ 186; Alpha² is known as Zubenelgenubi) is a bright easy binocular double. The primary (magnitude 2.7, spectral class A3IV) is separated from the secondary (magnitude 5.2, spectral type F4IV) by a very wide 231 arcseconds. Both stars also appear to be spectroscopic binaries. The pair shares a common proper motion suggesting a physically associated pair. The system may have a fifth component, the star KU Librae at a separation of 2.6°, thus forming a quintuple star system. (All Sky Map 6)

Located in the head of the Scorpion, **Beta (β) Scorpii** (Graffias, H 3 7AC) is a pair of blue-white gems and a showpiece of the winter sky. The pair, magnitude 2.6 and 4.5, is separated by 13.4 arcseconds and is easily split in a small telescope. Studies using spectroscopy and speckle interferometry have shown that the system is actually quintuple. (All Sky Map 6)

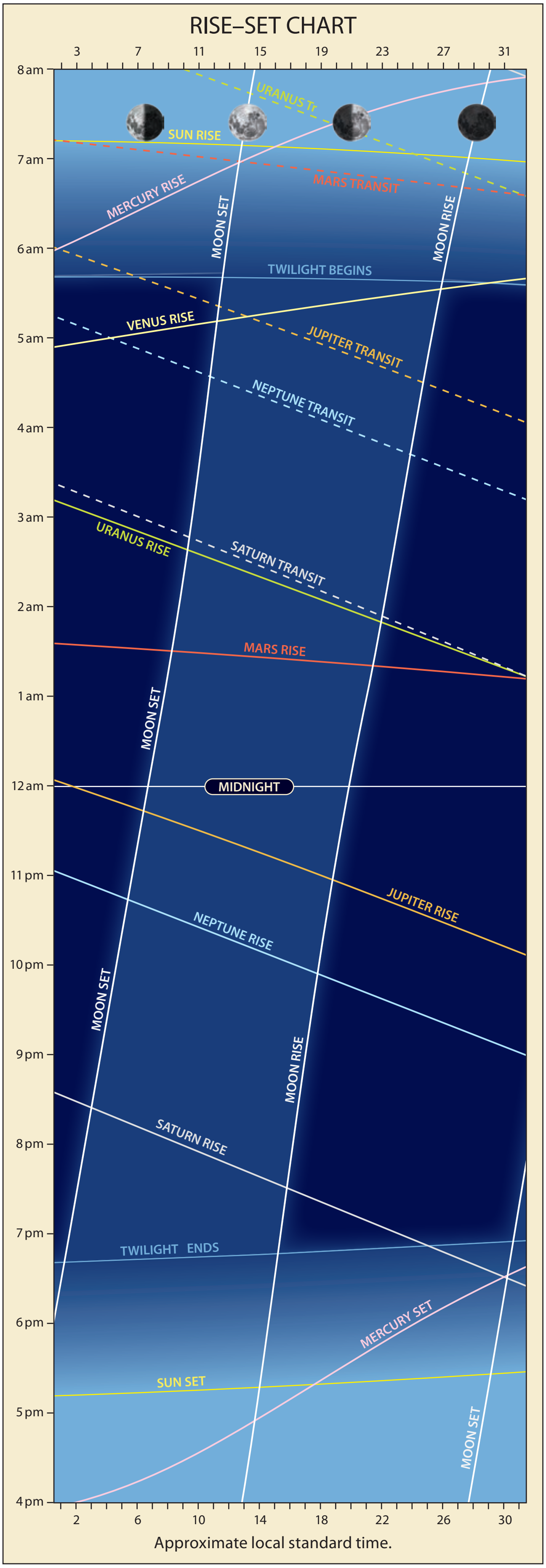


Approximate local standard time.





JULY 2022



HIGHLIGHTS

- Mars and Uranus close.
- Mars and Moon together.

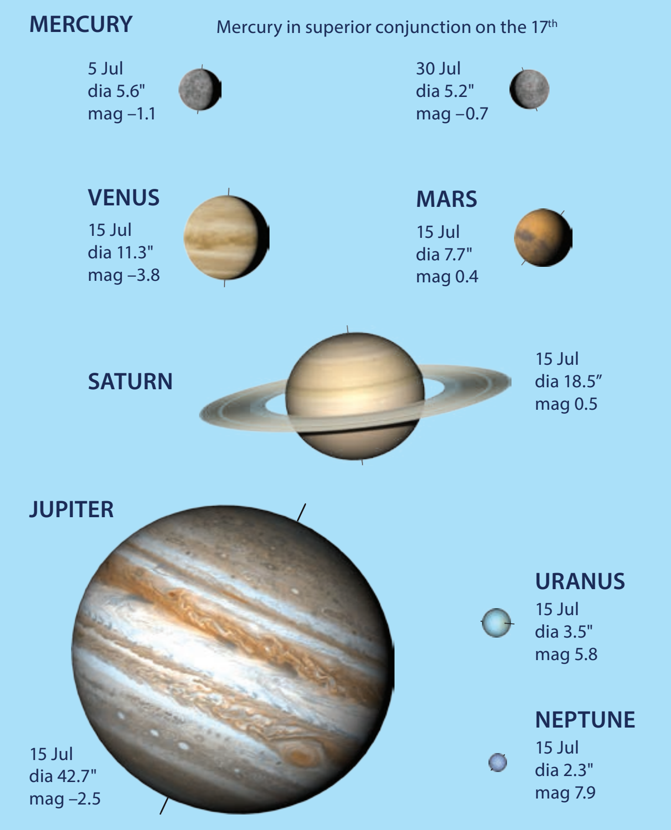
CONSTELLATIONS

Low in the northern sky is the constellation of Boötes the Herdsman, although it looks more like a traditional kite, turned upside down from our perspective. This asterism is made up of five 2nd and 3rd magnitude stars, topped off by the bright (zero magnitude) Alpha (α) Boötes or Arcturus. But there is a much fainter kite higher up in the sky, which is easy to miss—Libra.

Between the bright stars of Antares and Spica (Alpha (α) Virginis) you'll find Libra the Scales, one of a number of less than impressive constellations that make up the signs of the Zodiac. At one time these scales were considered to be an extension of Scorpius. Alpha (α) Librae or Zubenelgenubi's translation is Southern Claw and Beta (β) Librae or Zubeneschamali means the Northern Claw.

Next we move to Scorpius, which, unlike many constellations, resembles its namesake, which is also confirmed by some of the traditional star names. The brighter star at the end of the tail, Lambda (λ) is named Shaula or 'stinger'. Following your way up the tail, Antares might be the Greek 'rival to Mars' (because it's red), but the Roman name was Cor Scorpionis, the 'Heart of the Scorpion'. Its two flanking stars, Tau (τ) and Sigma (σ), are 'Alniyat' which means the heart's arteries. Beta (β) Scorpii or Graffias translates to 'Claws'. Delta (δ) is Dschubba from an Arabic phrase meaning 'forehead of the scorpion'. Going westward, next up is Libra, so anatomically it fits.

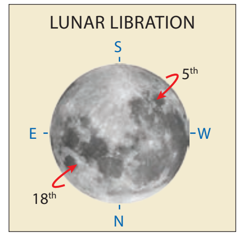
APPEARANCE of the PLANETS



Up until the first century BCE the Greek-defined constellation of Scorpius was much larger than we know today. It not only had its obvious tail and body (the modern version) but also claws. The Romans then carved off the claws creating Libra the Scales. This is just as well for, without this division, there might have been only eleven signs of the Zodiac—twelve was good, for the signs divided nicely into 30-degree wide segments of the sky (two hours in RA). Yet, although the Sun also spends time in Ophiuchus, for whatever reason it was ignored.

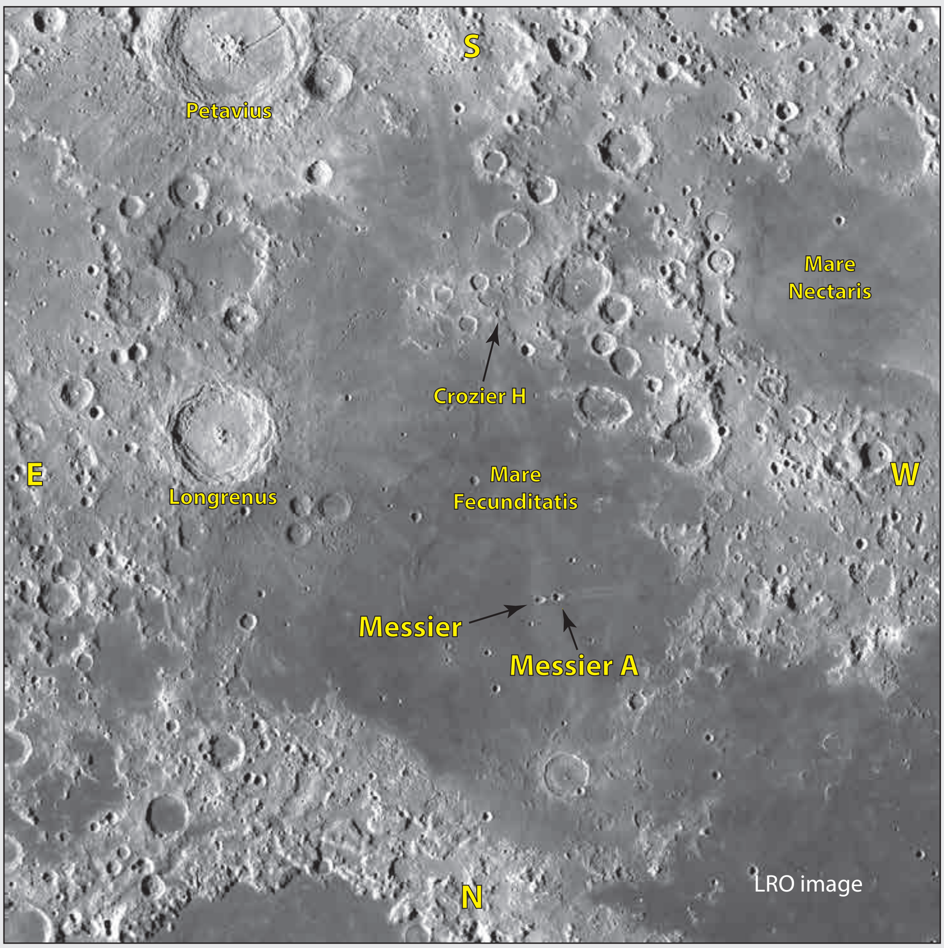
Given the above history, it's interesting Libra is the only inanimate member of the, which after all is defined as 'the circle of life'. The two most common excuses given are, one, scales are needed to bring a balance in one's life (whatever that means) and, two they are symbolic of the lady holding the scales to represent justice. Perhaps the real explanation goes back to when it was part of a 'living creature'.

THE MOON



- 5th 3 pm (1 pm WST) Maximum Libration (8.9°), dark SW limb.
- 7th Noon (10 am WST) First Quarter.
- 13th 7 pm (5 pm WST) Moon at perigee (closest to Earth at 357,264 km).
- 14th 5 am (3 am WST) Full Moon, supermoon, the closest Full Moon perigee syzygy of the year (see p. 95).
- 18th 11 am (9 am WST) Maximum Libration (9.2°), dark NE limb.
- 20th Midnight (10 pm WST) Last Quarter.
- 26th 8 pm (6 pm WST) Moon at apogee (furthest from Earth at 406,274 km).
- 29th 4 am (2 am WST) New Moon.

The Messier Twins



On the lunar plain known as Mare Fecunditatis (Sea of Fertility) lies a remarkable pair of craters. Known as Messier and Messier A, the twins are just 6 km apart. Both craters appear oval, with Messier measuring 15 by 8 km and Messier A to the west is 16 by 11 km.

Messier A had a couple of name changes early last century from W.H. Pickering to W. Pickering. Finally, in 1964 the International Astronomical Union (IAU) adopted Messier A as the official name for this crater. The IAU rules are against close pairs of craters honouring different people, which can lead to confusion. Once named, the smaller neighbouring craters are given an alphabetical designation. Although not necessarily related to each other, we end up with Messier, Messier A, B, D, etc.

Despite their size, they are visible in telescopes as small as 75 mm. The best time to observe them is when the Moon is around 4 to 8 days old. They are affected by foreshortening and libration near the limb but are visible at virtually any illumination. The craters vary significantly in appearance during each lunation depending on the Sun angle. A low angle highlights the crater's rims, while higher angles show the ejecta fields well. Around Full Moon, the rays emanating from both are prominent while the craters themselves appear as brilliant white patches.

Visually, under good seeing and high magnification, the craters themselves are fascinating. They appear relatively young (a billion years or less) and in pristine condition. Messier is oval and broader towards the east (sort of an acorn shape). Messier A is rounder (almost triangular), and its western limb appears engorged as if material from the impact was ejected over its rim.

Their ray systems are unique; those from Messier A resemble the tail of a comet, two almost parallel narrow rays heading westward across Mare Fecunditatis for about 140 km. In contrast, Messier's are a little harder to detect and are somewhat dependant on the Sun angle. They emanate north and south at right angles to those of Messier A.

THE PLANETS

Mercury is lost to the morning dawn this month as it moves back toward the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 17th. After its return to the evening twilight, this tiny world may be seen 4.5° south of the very slender crescent of a 1-day old waxing Moon on the 30th, and binoculars will help locate them at the beginning of civil twilight about 7° above the western horizon (see Sky View).

Venus begins the month 4° from the reddish 1st magnitude star Aldebaran (Alpha (α) Tauri) in the early morning eastern sky. Aldebaran appears as part of the 'V' shaped asterism known as the Hyades, a group of stars representing the bull's head. While not a genuine cluster member, the star marks the creature's 'red-eye'. On the 27th, in the dawn sky, the narrow crescent of the waning 28-day old Moon appears below the planet (see Sky View).

The **Earth** is at aphelion on the 4th, the furthest point in its orbit from the Sun (152,098,399 km or 1.016715 au distant).

Mars spends the first week of the month in Pisces before moving into Aries. It remains an object for morning observers, rising around 1 am in the eastern morning sky. With opposition occurring in early December, the Martian disc has grown from 4 arcseconds at the beginning of the year to 8 arcseconds in diameter. On the 22nd, the 23-day old waning crescent Moon appears around 3° from the planet (see Sky View). Since taking up residence in Aries, Mars has been gradually moving closer to Uranus. On the 31st the pair will be 2° apart (a small pair of binoculars will help show Uranus under light-affected skies). The Martian northern winter/southern summer commences on the 21st.

Jupiter is now rising in the late evening western sky in Cetus, just across the border of Pisces. With the giant planet's forthcoming opposition in September, its motion against the starfield slows as it nears the beginning of its retrograde path at the end of the month.

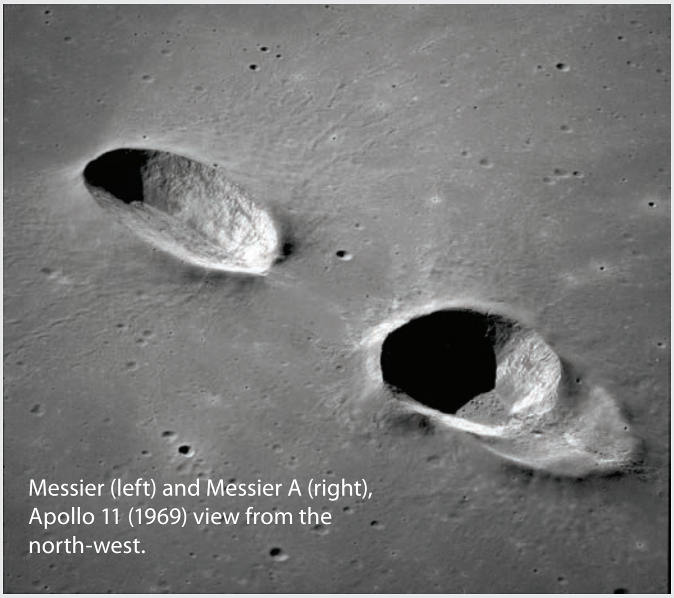
With opposition in August, **Saturn** rises in the early evening sky mid-month (see Sky View). The planet's magnificent rings commenced this year with a tilt of 17.5° (to Earth), and at opposition, they will be slightly narrower at 14° (in contrast to their last widest angle of 27° in 2017). The rings will continue to close until the Earth next passes through the ring plane in March 2025 to begin another 15-year cycle.

Uranus is only visible in the eastern morning sky, rising around 2:30 am mid-month. The planet is joined in Aries by Mars, and at month's end, the pair will be 2° apart, making a nice colour contrast.

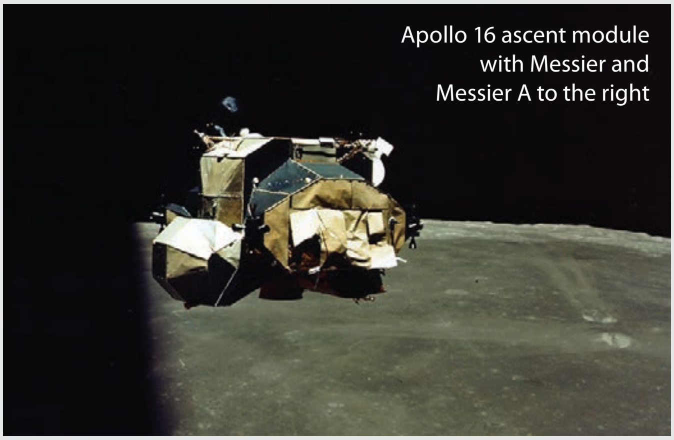
Neptune, in Pisces, rises in the late evening eastern sky around 10 pm mid-month.

The craters can vary significantly in appearance during each lunation, confusing early observers. Two of the pioneers of selenography (the study of the lunar surface), Wilhelm Beer and Johann Mädler, drew and described these craters as identical in over three hundred drawings (between 1829 and 1837). Later observers, however, saw them change in size and shape from night to night and sometimes shrouded in mist. Even as late as the 1960s, Valdemar Axel Firsoff thought Messier A was moving toward the east (just one of his unorthodox lunar ideas).

How the twins formed has produced some interesting theories. One such idea (now discounted) suggested that a meteor crashed into a ridge and tunnelled through to the other side, creating a pair of craters. In 1978, laboratory experiments were conducted by Don Gault of NASA's Ames



Messier (left) and Messier A (right), Apollo 11 (1969) view from the north-west.



Apollo 16 ascent module with Messier and Messier A to the right

Research Centre and John Wedekind of Caltech. They showed that with impact angles of 5° or less, they could duplicate the non-circular shapes and rays of the craters. It is believed that the impactor came in at a very shallow angle, blasted out Messier, with the ejecta splashing sideways across the Mare (at right angles to the direction of meteor travel). On breaking apart, a large, detached portion bounced, and travelled a further 6 km westward at a lesser speed, and gouged out Messier A, sending two streams of ejecta downrange.

Aside from the Messier twins, Mare Fecunditatis is relatively uninteresting for Earth-based observers. It is crossed by numerous wrinkle ridges and contains many ghost craters. On its eastern shore lies the large 133 km crater Langrenus with its double 1000 m high central mountains and terraced walls. It is an unusual formation best observed a day or two before the twins come into view. In 1970 the Mare hosted an Earthly visitor when the Soviet spacecraft Luna 16 touched down to become the first robotic probe to land and return a sample of lunar soil to Earth (the American Apollo crewed missions returned samples before and after Luna 16).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the 20th, dwarf planet 134340 Pluto is at opposition at magnitude 14.3 in Sagittarius. While close to opposition (maximum brightness), the retrograde loop of 14 Irene causes this minor planet to pass into the Teapot of Sagittarius in early July. It remains there until December. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
6 Jul	69 Hesperia	Scutum	12.2
6 Jul	14 Irene	Sagittarius	9.8
20 Jul	28 Bellona	Sagittarius	11.7
21 Jul	9 Metis	Sagittarius	9.7
23 Jul	192 Nausikaa	Sagittarius	9.6
25 Jul	346 Hermentaria	Capricornus	11.0
29 Jul	409 Aspasia	Aquila	10.9
30 Jul	37 Fides	Capricornus	11.1

COMETS

Comet C/2017 K2 (PANSTARRS) may reach 6th magnitude by the end of July. Beginning the month at 7th magnitude, PANSTARRS is slowly moving through Ophiuchus, visible throughout the evening and until a few hours before dawn. Mid-July sees the comet near the 6th magnitude globular cluster M10, and both objects could be of similar brightness (from 14th to 16th their separation will be less than 1°). Even though it's still five months until perihelion, this month sees the comet make its closest approach to Earth during this apparition—a distant 1.8 au.

DOUBLE STARS

One of the showpieces in Scorpius is the pair **Zeta^1 and Zeta^2 (ζ) Scorpii**. These naked-eye orange and blue stars (magnitude 4.7 and 3.6) separated by 391 arcseconds are located in the False Comet region of the Scorpion's tail. Through binoculars this pair, the adjacent star SAO 227392 (magnitude 5.6) and the star cluster NGC 6231 are a wondrous sight. Whilst in the region have a look at nearby Mu^1 and Mu^2 (μ) Scorpii, a lovely naked-eye pair, magnitude 3.1 and 3.6, separated by 347 arcseconds. (All Sky Map 6)

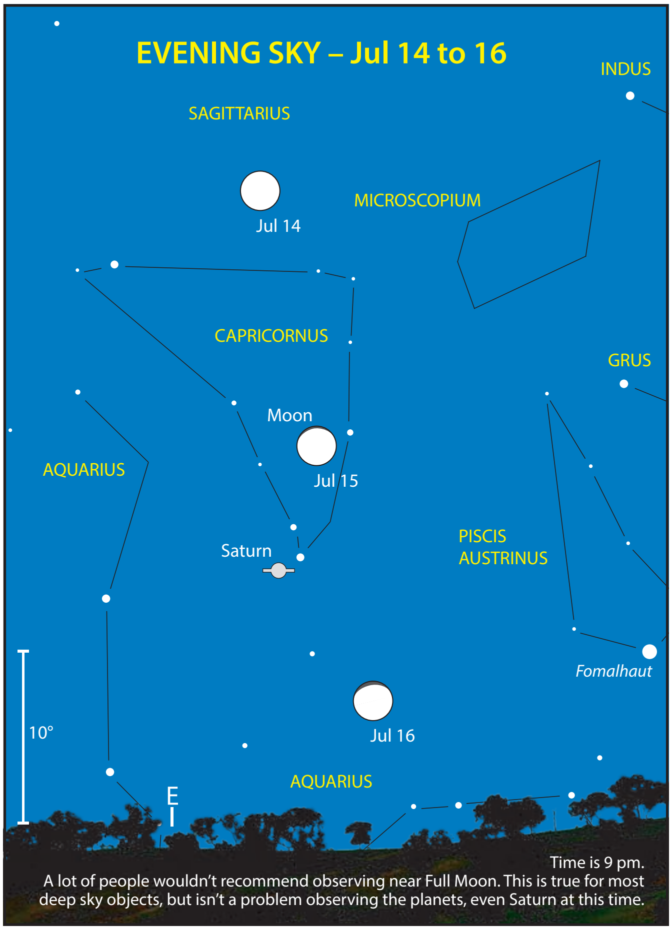
36 Ophiuchi is both a fine telescopic triple and a binocular pair. Located 18 light-years away, the AB pair (SHJ243AB) is a telescopic double with the components 5.1 and 5.1 separated by 5.1 arcseconds. The orbital period is 550 years. The AC (SHJ243AC) components, magnitude 5.1 and 6.5 are separated by 732 arcseconds and visible in 10 × 50 mm binoculars. All the stars are golden orange (spectral types K5Ve, K1V and K5Ve) and are physically connected. To the Kamilaroi and Euahlayi Aboriginal people in NSW, the A star is called Guniibuu, representing the robin red-breast bird. (All Sky Map 6)

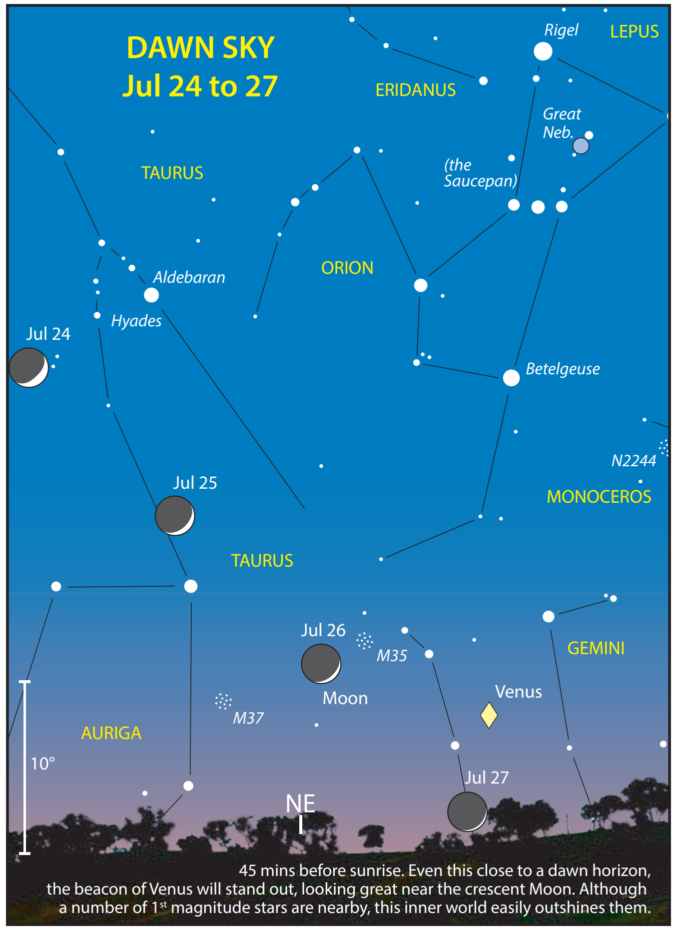
METEOR SHOWERS

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 12 through 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 leave trains. Except for the early evening, the sky will be Moon free during the peak.

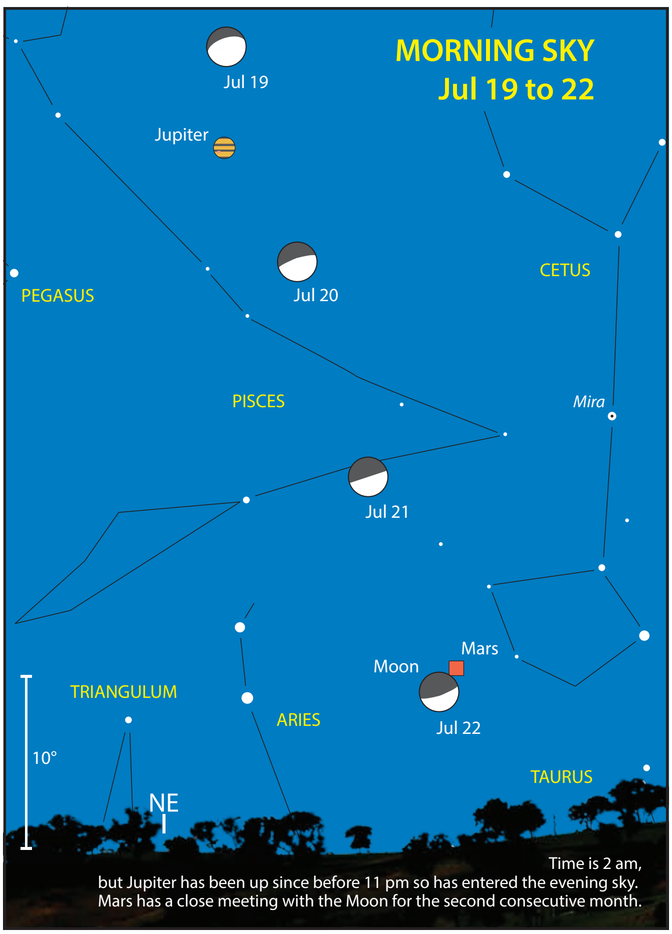
The **alpha-Capricornids** are known for their bright, slow meteors with long paths and frequent fireballs. The shower is visible from dusk till dawn, from July 3 through to August 15. Maximum activity occurs around the 30th, with a zenith hourly rate of around five. Their spectacular nature generally makes up for the low hourly rates over the period. Except for the early evening, the sky will be Moon free during the peak.

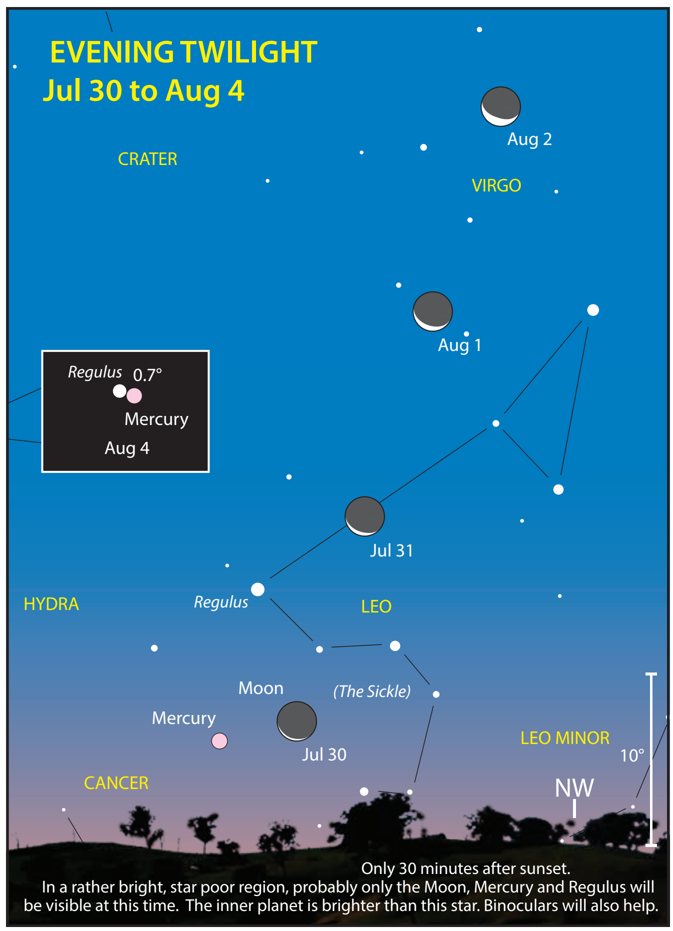
DIARY			
Sat	2nd	am	star Aldebaran 4° S of Venus.
Sun	3rd		Mars 0.3° SE of star Omicron Piscium.
Sun	3rd	7 pm	(5 pm WST) star Regulus 6° S of Moon.
Mon	4th		Earth at aphelion, 1.016715374 au.
Mon	4th	pm	m.p. 14 Irene 0.7° NW of star Tau Sagittarii.
Tue	5th		m.p. 324 Bamberga 0.4° SE of star Eta Piscium.
Tue	5th	3 pm	(1 pm WST) Maximum Libration (8.9°), dark SW limb.
Thu	7th		m.p. 324 Bamberga 0.2° S of M74 (SG) in Pisces.
Thu	7th	Noon	(10 am WST) First Quarter Moon.
Thu	7th	11 pm	(9 pm WST) star Spica 6° S of Moon.
Fri	8th	am	m.p. 216 Kleopatra 0.8° SE of NGC 7479 (G) in Pegasus.
Mon	11th	7 pm	(5 pm WST) star Antares 6° W of Moon.
Wed	13th	7 pm	(5 pm WST) Moon at perigee (closest to Earth at 357,264 km).
Thu	14th		Venus 0.6° SW of M1 Crab Nebula (PN) in Taurus.
Thu	14th		m.p. 27 Euterpe 0.2° N of Mars.
Thu	14th	5 am	(3 am WST) Full Moon (357,418 km, closest for this year), supermoon.
Fri	15th	pm	Comet C/2017 K2 (PANSTARRS) 0.4° NW of M10 (GC) in Ophiuchus.
Sat	16th	5 am	(3 am WST) Saturn 4° N of Moon.
Sun	17th		m.p. 324 Bamberga 1.0° SE of star Gamma Arietis.
Sun	17th		Mercury in superior conjunction.
Mon	18th		m.p. 324 Bamberga 0.2° W of NGC 772 (G) in Aries.
Mon	18th	11 am	(9 am WST) Maximum Libration (9.2°), dark NE limb.
Mon	18th	11 pm	(9 pm WST) Neptune 7° W of Moon.
Tue	19th	5 am	(3 am WST) Jupiter 5° NE of Moon.
Wed	20th		m.p. 2 Pallas 1.0° N of star Nu Eridani.
Wed	20th		Pluto at opposition.
Wed	20th	Midn	(10 pm WST) Last Quarter Moon.
Thu	21st		Venus 0.5° NW of star Eta Geminorum.
Fri	22nd	3 am	(1 am WST) Uranus 6° NE of Moon.
Fri	22nd	3 am	(1 am WST) Mars 2° SW of Moon.
Fri	22nd		Ceres in conjunction with Sun.
Sat	23rd		Venus 0.4° N of star Mu Geminorum.
Sat	23rd		m.p. 2 Pallas 0.3° NW of NGC 1637 (G) in Eridanus.
Sun	24th	5 am	(3 am WST) star Aldebaran 8° SE of Moon.
Tue	26th		m.p. 2 Pallas 0.4° N of star Mu Eridani.
Tue	26th	8 pm	(6 pm WST) Moon at apogee (furthest from Earth at 406,274 km).
Thu	28th	pm	Saturn 1.5° NW of star Delta Capricorni.
Fri	29th	4 am	(2 am WST) New Moon.
Fri	29th	9 pm	(7 pm WST) m.p. 15 Eunomia 0.1° W of NGC 5018 (G) in Virgo.
Fri	29th	pm	Comet C/2017 K2 (PANSTARRS) 1.7° NW of star Zeta Ophiuchi.
Sat	30th		Southern delta-Aquarids meteor shower, Jul 12 to Aug 23.
Sat	30th		alpha-Capricornids meteor shower, Jul 3 to Aug 15.
Sat	30th	6 pm	(4 pm WST) Mercury 5° SW of Moon.



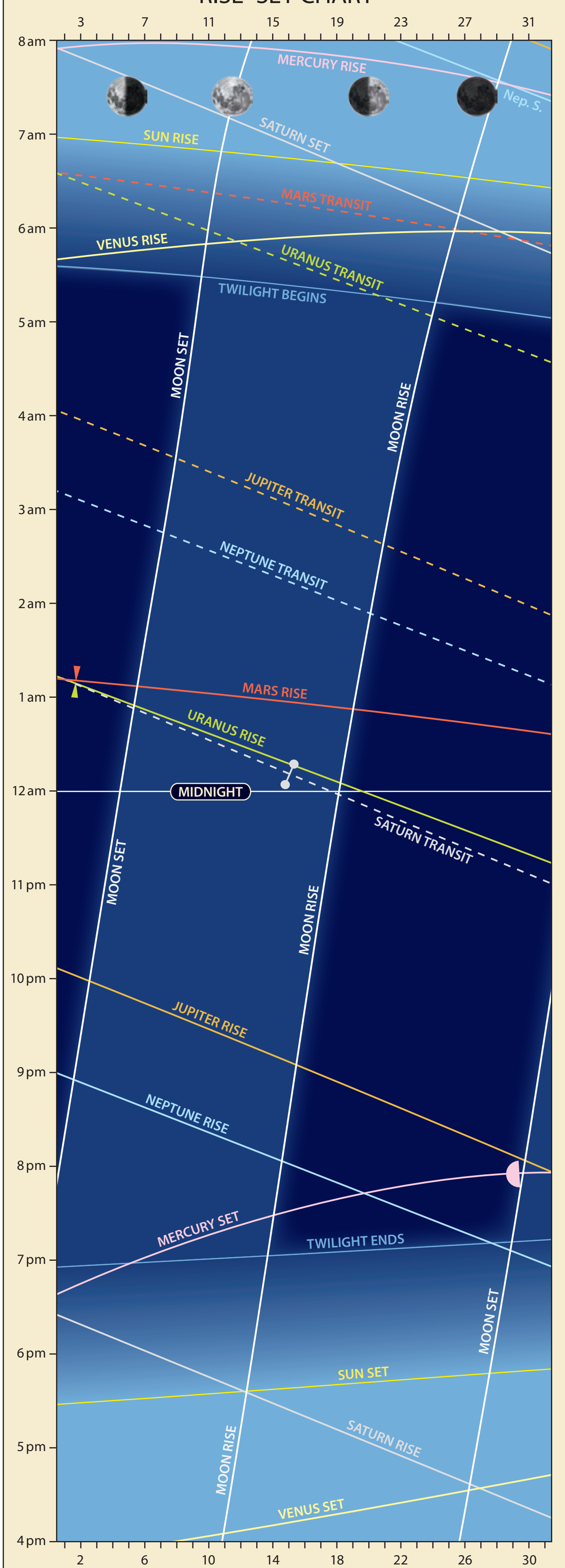


Approximate local standard time.





AUGUST 2022



HIGHLIGHTS

- Mercury at best for evening observing.
- Mars and Uranus close.
- Saturn at opposition.
- Jupiter and the Moon come together.
- Supermoon.

CONSTELLATIONS

August evenings are a great time to explore the Milky Way. Not only is the brilliant hub in Sagittarius and Scorpius visible overhead, but also its most obvious dark nebulae are on display. Low in the north you will find the Great Rift, which starts in Cygnus (Map 9). This obvious, naked-eye silhouette of unilluminated gas and dust runs up the centre of our galaxy, crossing the Summer Triangle (see September Constellations) and exits near Ophiuchus.

The central hub is festooned with intertwined dark lanes. An outstanding example is the Pipe Nebula in Ophiuchus. These dark roads diminish as you move towards Centaurus, but the stark blackness of the Coal Sack near Crux stands out (Map 1).

While looking towards the Southern Cross, so distant from Scorpius, it's hard to believe they have anything in common. Many of their luminaries belong to a grouping known as the Scorpius-Centaurus Association, the closest such assembly to our Sun. It encompasses the head region of Scorpius down through Lupus, Centaurus, Crux and parts of Carina and Musca. Hundreds of stars have been identified as belonging to this group. Some of the most prominent are Antares and

APPEARANCE of the PLANETS

MERCURY

5 Aug
dia 5.5"
mag −0.4

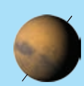
15 Aug
dia 6.1"
mag −0.1

28 Aug
dia 7.3"
mag 0.2
Greatest elongation East (27.3°, 27th WA)

VENUS

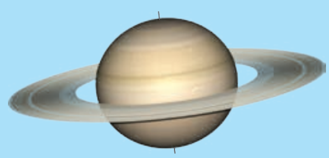
15 Aug
dia 10.4"
mag −3.8

MARS



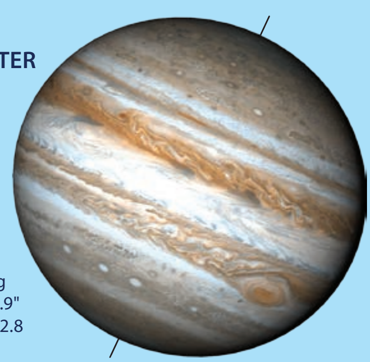
15 Aug
dia 8.9"
mag 0.1

SATURN



15 Aug
Opposition
dia 18.8″
mag 0.3

JUPITER



15 Aug
dia 46.9"
mag −2.8

URANUS

15 Aug
dia 3.6"
mag 5.7

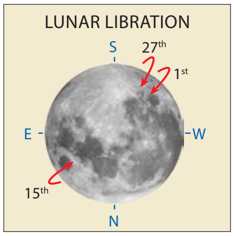
NEPTUNE

15 Aug
dia 2.4"
mag 7.8

the bright stars of the Southern Cross. These naked-eye stars, along with other bright members of these constellations are moving together in space (around 400 light-years away), having been recently born in nearby stellar nurseries less than 20 million years ago (think of it as an enormous, loose, open star cluster!)

The Sco-Cen association is just part of a much larger complex which still has active star forming regions such as those in Ophiuchus (Rho (ρ) Oph and the Pipe Nebula), Lupus, Corona Australis and Crux (the Coalsack). Several supernovae have exploded over the past 15 million years in Sco-Cen, leaving a complex of expanding gas super-bubbles nearby.

THE MOON



1st 11 am (9 am WST) Maximum Libration (7.9°), dark SW limb.

5th 9 pm (7 pm WST) First Quarter.

11th 3 am (1 am WST) Moon at perigee (closest to Earth at 359,828 km).

12th Noon (10 am WST) Full Moon, supermoon (see p. 95).

15th 7 am (5 am WST) Maximum Libration (8.3°), dark NE limb.

19th 3 pm (1 pm WST) Last Quarter.

23rd 8 am (6 am WST) Moon at apogee (furthest from Earth at 405,418 km).

27th 6 pm (4 pm WST) Maximum Libration (7.3°), too close to New Moon.

27th 6 pm (4 pm WST) New Moon.

THE PLANETS

Mercury enters its best period for evening observation from mid-month till early September when it can be seen in a dark sky free of twilight—reaching its greatest elongation of 27° east of the Sun on the 28th. The littlest planet spends three-quarters of the month in Leo before moving into Virgo (see Sky View). On the 4th, Mercury has a close encounter with the 1st magnitude star, Regulus, being separated by only 0.7° (see July Sky View)

Venus, low in the morning eastern dawn sky, is visible early this month (see Sky View). It then becomes too close to the Sun for observation as it moves toward superior conjunction in October.

Mars remains an object for morning observers, rising shortly after midnight in the eastern morning sky. It is at its western quadrature on the 27th, where the Sun-Earth-Mars angle is 90° (see Orbital Aspects diagram p. 14). At this time, Mars displays its minimum phase with 84% of the planet's surface illuminated by the Sun when viewed from Earth. Even a small telescope will show the disc to be distinctly gibbous in shape—just like the Moon three or four days before or after Full Moon. Between the 1st and 3rd, the Red Planet will be within 1.5° of Uranus (a small pair of binoculars will help show Uranus). On the 20th, the 23-day old waning gibbous Moon will be close to the planet (see Sky View). The latter half of August finds Mars passing between the Pleiades and Hyades open star clusters in Taurus.

Jupiter comes to opposition late next month and is now very prominent in the mid-evening eastern sky upon rising. It is interesting to identify and view the motion of the planet's four major moons from night to night—even the smallest of telescopes are suitable for this task. Discovered by Galileo in 1610, with his newly improved 20-power telescope, they provided strong evidence for the Copernican theory that not all celestial objects orbited the Earth. On the 15th, the 19-day old waning gibbous Moon and Jupiter make a splendid sight as they rise together (see Sky View) with the planet only 1° from the lunar limb from the eastern states and around 2° from WA.

Saturn, in Capricornus, is at opposition on the 15th and can be seen low in the eastern evening sky after the end of astronomical twilight. The sight of Saturn through a telescope, more than any other object, is the one that gets many people starting their journey into astronomy as a hobby. The orb with its grand rings is always a delight in any sized instrument. What can you expect to see of Saturn through a telescope? It depends significantly on the telescope size, the seeing, and the eyepiece used—even a 60 mm refractor will show the rings. Large telescopes will reveal the three main rings and the Cassini division, the shadow of the rings against the planet, and the planet's shadow on the back of the rings. Saturn's shadow on the back of the rings is not visible during opposition as the shadow is directly behind the planet; try a month or so before or after opposition. There is a light-coloured band around the equator on the planet itself and a noticeable darkening and flattening at the poles. Try using a colour filter on your eyepiece; yellow will enhance the contrast of Saturnian features.

On the 12th, Saturn and the Full Moon (supermoon) will be seen nearby as they rise, the separation increasing during the night (see Sky View).

Uranus and Mars spend the first few days of the month close together in the morning sky in Aries, making a nice colour contrast in a wide-field view. On the 25th, 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. The Solar System's most distant planet moves back into Aquarius this month after its three-month sojourn in Pisces.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the 23rd m.p. 2 Pallas briefly visits the Orion Nebula (M42), see the diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
19 Aug	704 Interamnia	Equuleus	10.4
23 Aug	4 Vesta	Aquarius	5.9

COMETS

Comet C/2017 K2 (PANSTARRS) should be around 6th magnitude throughout August. Visible in the evening sky, PANSTARRS begins the month in Ophiuchus. In the first week it moves into Scorpius where it remains for the rest of August (except for a one-night passage through Libra). By month's end it's setting around midnight. From the last

The End of Night?

Looking at the night sky on a clear moonless evening is one of nature's most awe-inspiring wonders. With the naked eye alone, you'll see thousands of stars, meteors, the zodiacal light, the Milky Way, and occasionally auroras and comets. Bring a pair of binoculars or a telescope into the equation, and the whole Universe opens up before your eyes. To see this breathtaking splendour, one must first escape the light pollution of urban areas.

Astronomy is not a total write-off in suburbia, but generally, the amateur is limited to the Solar System and perhaps a few brighter double stars and clusters. Forget stuff like galaxies, emission/reflection nebulae, and planetaries. Regrettably, light pollution (LP) is a side effect of our civilization. Unlike the professionals, most amateurs do not have the luxury of a permanent installation atop a mountain away from major cities.

Visually, light pollution or nebula filters will help enhance the view of emission and planetary nebulae and supernovae remnants, but they are not a replacement or substitute for dark skies. Nor will these filters screen out all types of light pollution, like broadband emissions from incandescent globes and the now standard and widely used LED lights. Nevertheless, astrophotographers can take advantage of narrowband filters for their work in cities, eliminating light pollution, including the old archenemy, the Moon (alas, at an increase in exposure time).

As urban dwellers, we have learned to cope and adapt to the light pollution hurdle. We were resigning ourselves to the use of filters, restricting ourselves to the brighter objects or joining the New Moon exodus to dark skies. Many astronomy clubs have 'deep sky' observing sites where their members can enjoy a night or two under pristine skies. But then, in January 2015, an out-of-left-field announcement by Elon Musk caught astronomers by surprise. Elon revealed that his company, SpaceX, intended to launch thousands of communication satellites into low Earth orbit.

Named Starlink, the mega-constellation network of satellites is designed to deliver affordable internet access to remote locations worldwide. The first two Starlink satellites were placed into orbit in February 2018, followed by a mass launch of 60 in May 2019. As of May 2021, more than 1,600 Starlink satellites are in orbit, and ultimately SpaceX plans deployment of up to 42,000 satellites. Other companies like OneWeb have plans for more than 6,000 satellites and Amazon's Kuiper project over 3,200. Also jumping on the bandwagon are AST SpaceMobile, Swarm, and China's Hongyan. Without any regulation, the number of satellites in Earth orbit could eventually number 100,000 within the coming decade.

In May 2019, in response to a Twitter request about the light polluting effects of the Starlink satellites, Elon Musk replied, *"There are already 4900 satellites in orbit, which people notice ~0% of the time. Starlink won't be seen by anyone unless looking very carefully & will have ~0% impact on advancements in astronomy. We need to move telescopes to orbit anyway. Atmospheric attenuation is terrible"*. These remarks would justifiably perturb professional and amateur astronomers. Besides, space telescopes are costly compared with their ground-based counterparts. Terrestrial telescopes are more cost-effective and can deliver remarkably sharp images with the addition of adaptive optics.

According to the European Space Agency, as of 9 July 2021, there have been about 12,000 satellites placed in orbit since 1957 (how many of our readers are old enough to remember that beeping ball called Sputnik?) Of these, 7510 are still in space, with about 4500 (including Starlinks) still functioning. Pre-Starlink, only about 200 of these were visible to the naked eye. For example, when Starlinks are in their parking orbits, they are visually bright at around 2nd or 3rd magnitude; they then dim to about 5th magnitude upon reaching their operational orbit of around 550 km. Some satellite mega-constellations planned will be in higher orbits of approximately 1200 km, e.g., OneWeb.

The unexpected brightness of the Starlinks took astronomers by surprise and resulted in urgent talks with SpaceX. In fairness to the company, their engineers have cooperated with astronomers to try and resolve the issue. To this end, SpaceX painted parts of the Starlinks matte black to help reduce their brightness. In addition, since June 2020,

Image by Greg Priestley taken near Ilford, NSW 17 May 2021 4:56 am. Sony A7III with Sigma 14 mm ƒ/1.8 lens, 20 sec at ƒ/1.8 ISO 800.

week of August through to mid-September the comet travels through the head region of Scorpius, having a number of close conjunctions with some of its bright stars (see diary).

DOUBLE STARS

This month our attention turns towards Capricornus. **Alpha[1] and Alpha[2] (α) Capricorni** form a bright naked-eye and fine binocular double. The saffron-orange stars (magnitude 4.3 and 3.7) are separated by 381 arcseconds. The pair is an optical double. Alpha[2] Capricorni (Algiedi) is the brighter of the two and is located 102 light-years away. The system contains three stars. The other two components of the Alpha[2] Capricorni system form a binary pair with an orbital period of 244 years. Both stars orbit the primary once every 1,500 years. In contrast, Alpha[1] Capricorni (Algiedi Prima) lies about 870 light-years away. Alpha[1] Capricorni has three dim visual companions; however, these are not believed to be physically connected with the star. (All Sky Map 8)

Alya, **Theta (θ) Serpentis** (STF2417) is a fine wide pair of stars. The white stars (spectral class A5V and A5Vn) are magnitude 4.6 and 4.9 and are separated by 22 arcseconds. Located 160 light-years away, the pair share a common proper motion and are physically connected with an orbital period of at least 14,000 years. There is also a wide optical C component, located 86 light-years from the Sun, magnitude 6.8 located 421 arcseconds from the A component. (All Sky Map 8)

Starlinks have been fitted with sunshades (VisorSats), and their orientation in space altered to help lessen reflected sunlight.

At a Satellite Conference in March 2020, Elon Musk said, *"I am confident that we will not cause any effect whatsoever in astronomical discoveries,"* Musk said. *"Zero. That's my prediction. We'll take corrective action if it's above zero."* Let's hope that future competitor companies are also cooperative and sympathetic to the need to preserve the night sky.

Satellites are easily visible just before dawn and right after dusk. However, once a satellite passes into the Earth's shadow, it becomes invisible. Generally, satellites in a low Earth orbit are brighter but visible for shorter periods of the night. Those in higher orbits are fainter but visible for longer. However, latitude makes a big difference – those living at higher latitudes will see satellites well into the night, particularly in the summer months.

Wide-field sky surveys will suffer from these mega-constellations. Especially surveys conducted during twilight hours when searching for near-Earth asteroids on potential collision paths with Earth. 30–40% of images made with the soon-to-be commissioned 8.4 metre Vera C. Rubin Observatory in Chile could be affected. This telescope will image the entire visible sky every few days to gain an insight into changes in the Universe over time. Radio telescopes like the Square Kilometre Array (SKA) will also be affected by satellites beaming down radio signals. The SKA reported that Starlink satellites would hamper one of the frequencies intended to search for organic and water molecules in space.

Most disturbingly, the worrying thing about satellite mega-constellations is their overall potential effect on night sky brightness (NSB). A recent study published in the Monthly Notices of the Royal Astronomical Society* raises concerns about the impact of a cloud of satellites and space debris on NSB. Even under pristine skies away from light pollution, the sky has natural skyglow caused by ionised particles in the upper atmosphere. The researchers found as of mid-2021, skyglow produced by sunlight reflected and scattered by a large set of orbiting bodies may have already increased NSB by as much as 10%. This percentage is the critical limit adopted in 1979 by the International Astronomical Union for the light pollution level not to be exceeded at the sites of astronomical observatories.

On his return to Earth after riding his Blue Origin rocket into space in July 2021, Jeff Bezos said of his experience, *"It's this tiny little fragile thing, and as we move about the planet, we're damaging it. So, that's very profound."* Let's hope that he also considers our wonderful legacy in the starry night when launching Amazon's Kuiper mega-constellation satellites. Caitlin Casey, a University of Texas Austin astronomer said, *"The fact that one person, or one company, can take control and completely transform humans' experience of the night sky, and not just humans, but every organism on Earth … that seems profoundly wrong,"*.

Remember when we used to get excited to see a bright artificial satellite or the International Space Station transit our skies. Now we look in trepidation and wonder what is to come. Is it too late to reclaim the night?

* "The proliferation of space objects is a rapidly increasing source of artificial night sky brightness" M Kocifaj, F Kundracik, J C Barentine, S Bará. Volume 504, Issue 1, June 2021, Pages L40-L44.

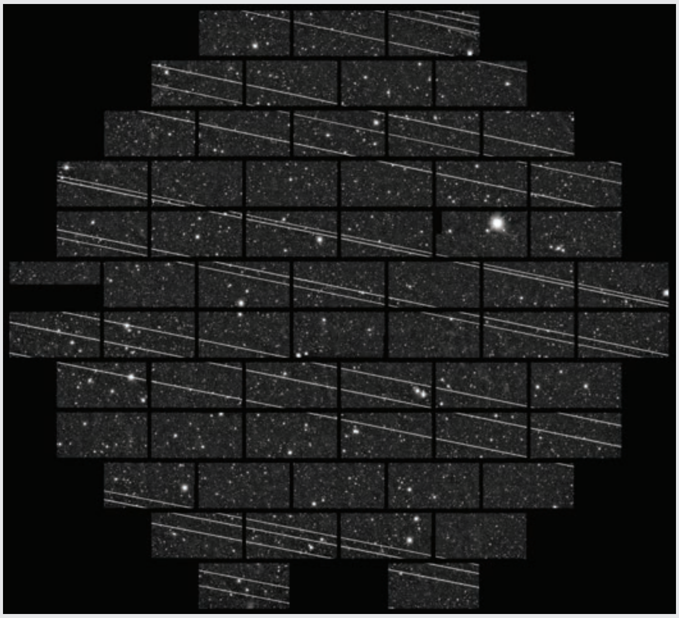
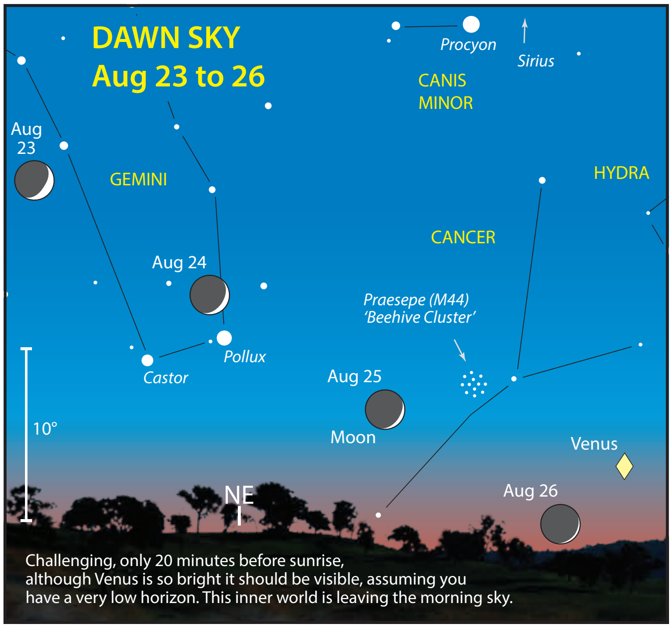


Image from DECam on the Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory (CTIO). This 333 seconds-exposure contains at least 19 streaks due to the second batch of Starlink satellites. The gaps in the satellite tracks are due to the gaps between the CCD chips in the 2.2-degree field. Credit Martínez-Vázquez and Johnson, CTIO/NOIRLab/NSF/AURA/DECam DELVE Survey

METEOR SHOWER

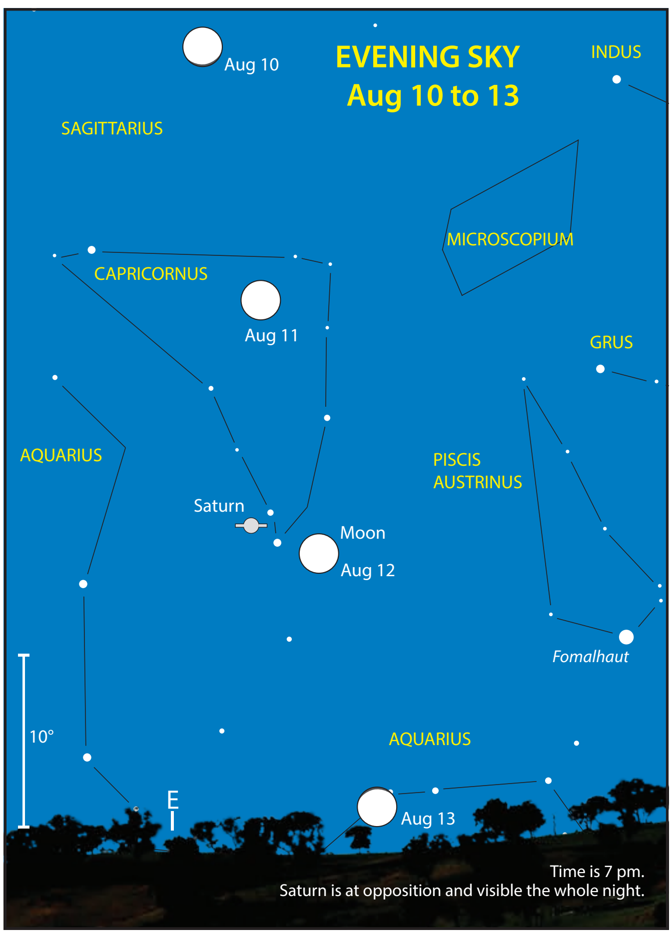
The famous **Perseids** are not readily observable for many southern observers, because the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over 1,000 years. Their duration is from July 17 through to August 24. Maximum is expected on the night of the 12th and the morning of the 13th. This shower has produced some exceptional rates in the past, with a zenith hourly rate of 150 possible. During the peak, the Full Moon will make it difficult for all but the brightest Perseids to be visible. This spectacular shower was immortalised by John Denver in his song, Rocky Mountain High, when he sings, “I’ve seen it rainin’ fire in the sky!”

DIARY			
Mon	1st	11 am	(9 am WST) Maximum Libration (7.9°), dark SW limb.
Tue	2nd		Uranus 1.5° N of Mars.
Wed	3rd		Venus 0.3° NE of star Delta Geminorum.
Wed	3rd		m.p. 6 Hebe 0.6° SW of NGC 2169 (OC) in Orion.
Thu	4th		m.p. 6 Hebe 0.8° S of star Xi Orionis.
Thu	4th	7 pm	(5 pm WST) star Spica 6° SW of Moon.
Thu	4th	pm	star Regulus 0.5° S of Mercury.
Fri	5th		m.p. 6 Hebe 0.6° N of NGC 2194 (OC) in Orion.
Fri	5th	9 pm	(7 pm WST) First Quarter Moon.
Sat	6th		Venus 0.4° NW of NGC 2420 (OC) in Gemini.
Sun	7th	7 pm	(5 pm WST) star Antares 3° S of Moon.
Mon	8th		Mercury 0.6° N of star Rho Leonis.
Mon	8th		m.p. 2 Pallas 1.0° N of star Beta Eridani.
Thu	11th	3 am	(1 am WST) Moon at perigee (closest to Earth at 359,828 km).
Fri	12th	am	Perseids meteor shower, Jul 17 to Aug 24, Moon affected.
Fri	12th	Noon	(10 am WST) Full Moon (361,412 km), supermoon.
Fri	12th	7 pm	(5 pm WST) Saturn 5° NW of Moon.
Sun	14th	10 pm	(8 pm WST) Neptune 3° NW of Moon.
Mon	15th		m.p. 115 Thyra 0.5° N of star 39 Arietis.
Mon	15th		m.p. 324 Bamberga 0.4° SE of star 41 Arietis.
Mon	15th		Saturn at opposition.
Mon	15th	7 am	(5 am WST) Maximum Libration (8.3°), dark NE limb.
Mon	15th	10 pm	(8 pm WST) Jupiter 2° W of Moon.
Wed	17th		Mercury 0.5° NW of NGC 3640 (G) in Leo.
Fri	19th	1 am	(11 pm WST, prev day) Uranus 1.5° SW of Moon.
Fri	19th	3 pm	(1 pm WST) Last Quarter Moon.
Fri	19th	pm	Saturn 1.4° NW of star Gamma Capricorni.
Sat	20th		m.p. 6 Hebe 0.1° S of star 30 Geminorum.
Sat	20th	2 am	(Midn WST, prev day) Mars 5° SW of Moon.
Sun	21st		m.p. 6 Hebe 0.2° E of star Xi Geminorum.
Mon	22nd		m.p. 349 Dembowska 1.0° NW of star Upsilon Tauri.
Tue	23rd		m.p. 2 Pallas 0.5° S of star Iota Orionis.
Tue	23rd		m.p. 2 Pallas 1.0° S of M42 Orion Nebula (BN) in Orion.
Tue	23rd		Vesta at opposition.
Tue	23rd	8 am	(6 am WST) Moon at apogee (furthest from Earth at 405,418 km).
Tue	23rd	pm	Comet C/2017 K2 (PANSTARRS) 0.7° W of star Beta Scorpii.
Thu	25th		d.p. 1 Ceres 5° N of Venus.
Thu	25th	pm	Comet C/2017 K2 (PANSTARRS) 1.3° W of star Omega^1 Scorpii.
Sat	27th	6 pm	(4 pm WST) Maximum Libration (7.3°), too close to New Moon.
Sat	27th	6 pm	(4 pm WST) New Moon.
Sun	28th		m.p. 532 Herculina 0.15° SW of star Pi 2 Orionis.
Sun	28th		Mercury at greatest elongation East (27.3°).
Sun	28th	3 am	(1 am WST) Mars 0.1° W of star Omega^1 Tauri.
Sun	28th	pm	m.p. 29 Amphitrite 0.7° S of star Tau Scorpii.
Mon	29th	7 pm	(5 pm WST) Mercury 8° S of Moon.
Wed	31st		Comet C/2017 K2 (PANSTARRS) 0.5° W of star Delta Scorpii.
Wed	31st	7 pm	(5 pm WST) star Spica 4° SW of Moon.

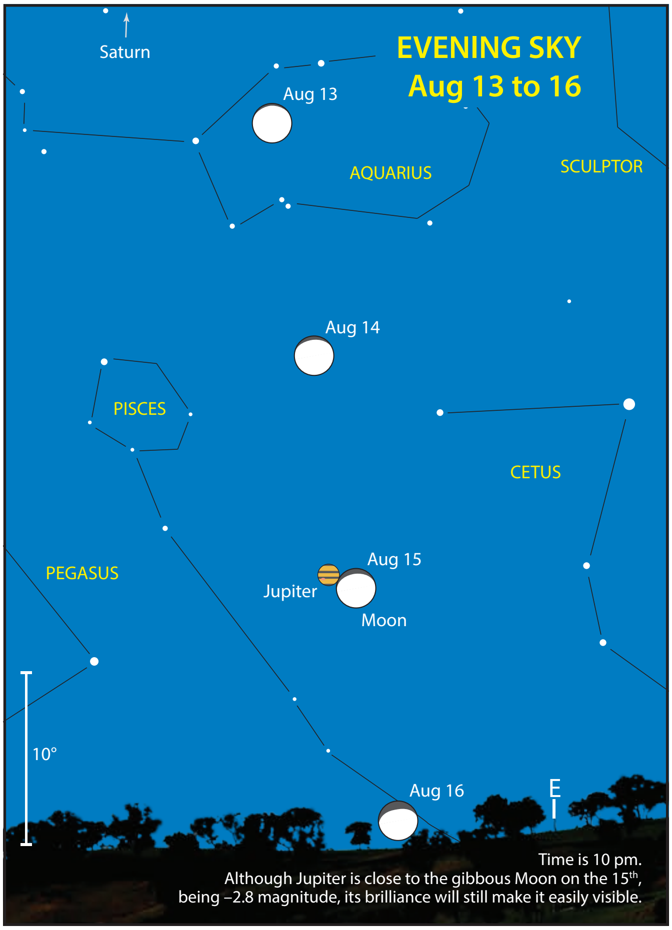


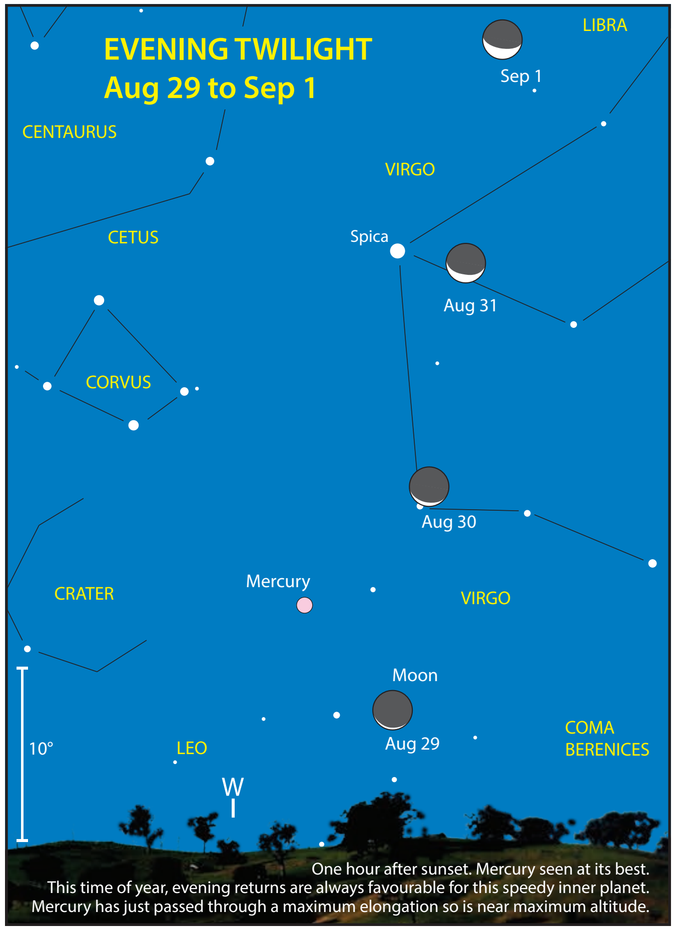
Challenging, only 20 minutes before sunrise, although Venus is so bright it should be visible, assuming you have a very low horizon. This inner world is leaving the morning sky.

Approximate local standard time.

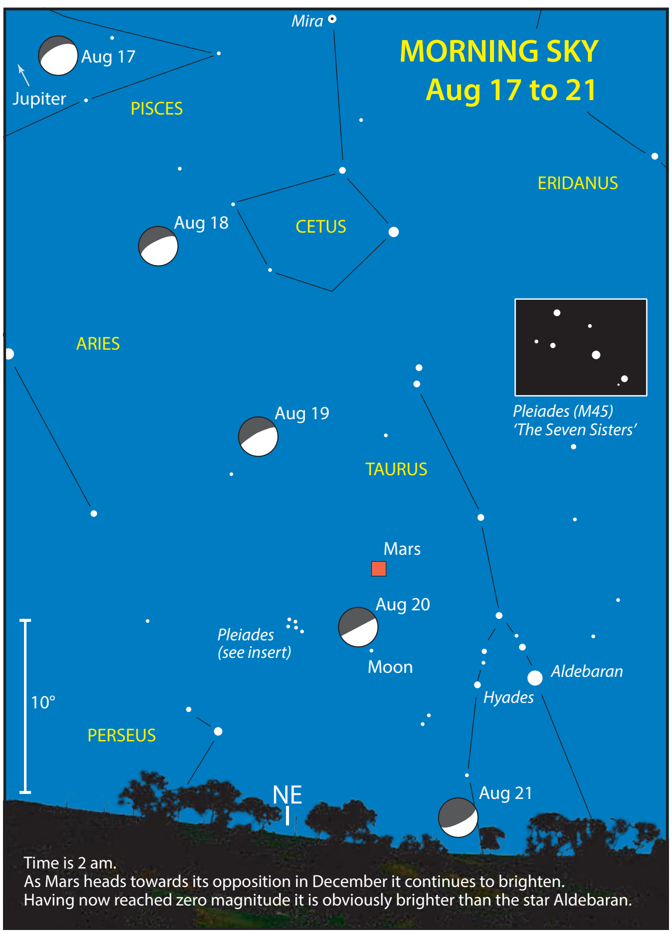


Time is 7 pm.
Saturn is at opposition and visible the whole night.



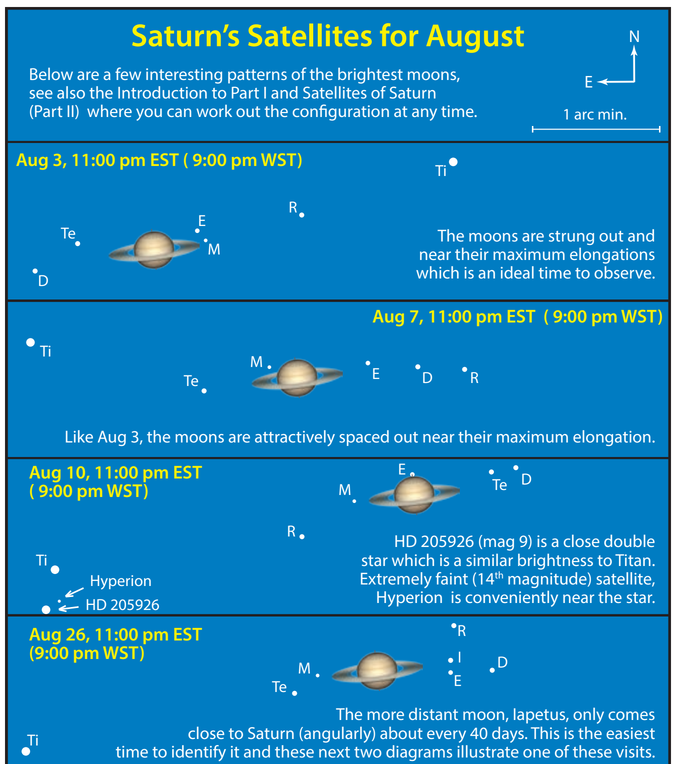


Approximate local standard time.

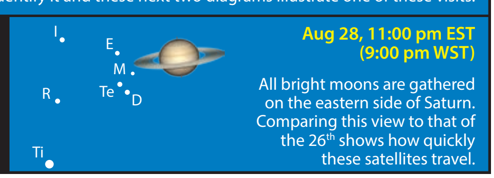


Saturn's Satellites for August

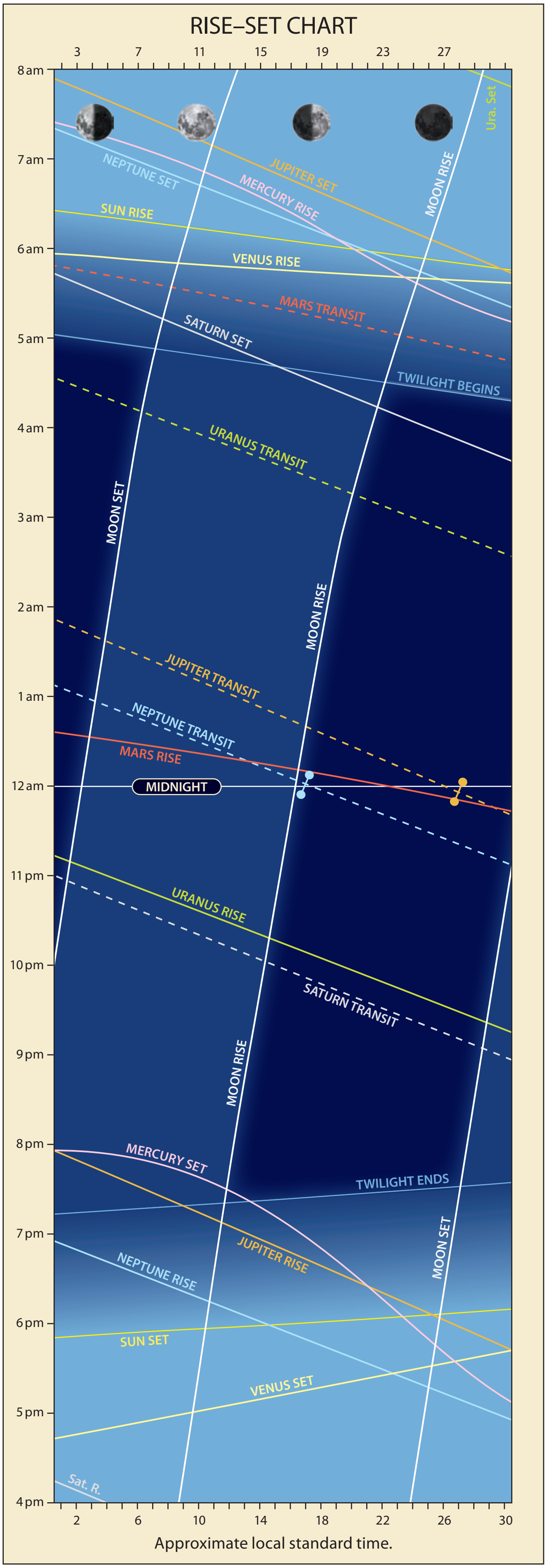
Below are a few interesting patterns of the brightest moons, see also the Introduction to Part I and Satellites of Saturn (Part II) where you can work out the configuration at any time.



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



SEPTEMBER 2022



HIGHLIGHTS

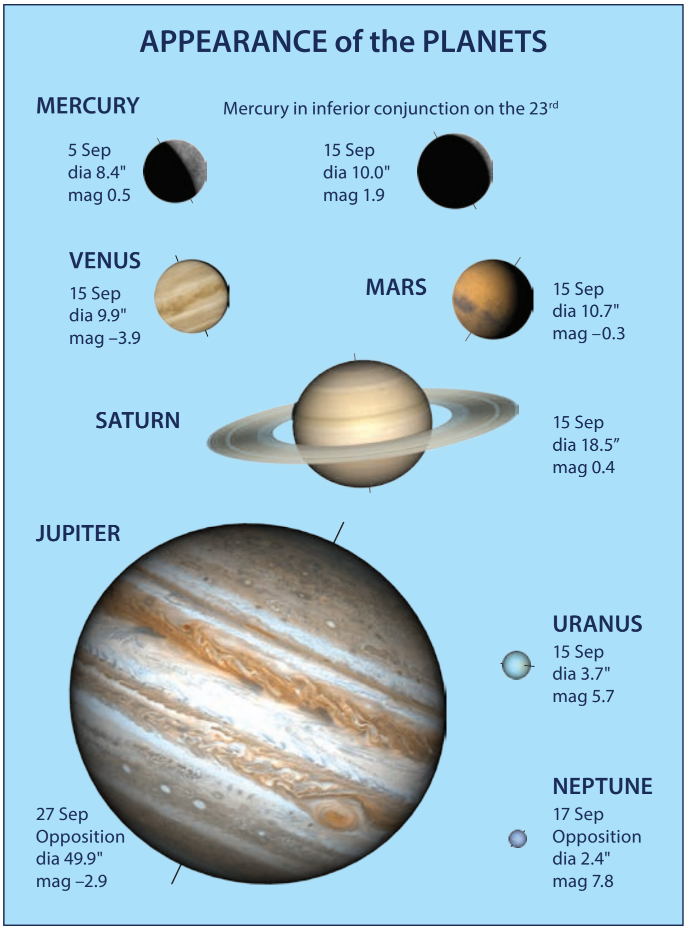
- Jupiter at opposition.
- Comet PANSTARS possible 6th magnitude in evening sky.
- Hyades gets a second *red eye* (Mars).

CONSTELLATIONS

In the northern evening sky lies an impressive asterism, the Summer Triangle. Although it is formed by three bright stars, it may not be noticeable at first because of its size, stretching a third of the way to the zenith (overhead). These three white stars are the alpha members of their respective constellations and all make the top twenty brightest list (see p. 141).

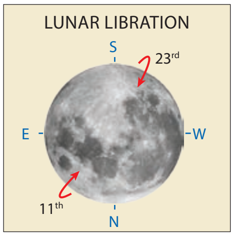
The top star is Altair in Aquila, its name has an Arabic origin from a phrase meaning 'the flying eagle'. If you look at the triangular shape of Aquila, it's not surprising that in many cultures throughout the ages, it's been associated with birds. Of the three Summer Triangle stars, Altair is the coolest (7550 K) and the least luminous, only achieving its brightness (0.9 magnitude) because it's one of the closest stars at only 16 light-years.

At the lower left corner is Vega in Lyra. Although Lyra was supposed to be Orpheus' Harp in Greek mythology, the origin of Vega is from an Arabic phrase meaning 'the swooping eagle'. This has nothing to do with nearby Aquila as ancient Egyptians used to consider Lyra to be a vulture. Like Altair it is a nearby bright star, 25 light-years away, with a higher



luminosity and mass (2.7 vs 1.7 solar masses respectively). However, turning to the third member (lower right) Deneb, it is a supergiant star. Don't be fooled by it being the faintest of the triangle stars (magnitude 1.3), it's only because it is about 1,600 light-years distant (see more on this truly remarkable star on page 32). In Arabic, Deneb means 'tail'. In this case referring to its position in Cygnus the Swan. Cygnus forms another recognizable asterism within the Summer Triangle, referred to as the Northern Cross. From our down under perspective it appears like an inverted crucifix. Deneb is at the base with its body and long neck, made up of mostly 4th magnitude stars stretching up to the head, marked by the brilliant 3rd magnitude double star, colourful Albireo or Beta (β) Cygni—most famous for its colour. It is easily split in a small telescope into its yellow primary (magnitude 3.1) and its fainter (magnitude 4.7) blue companion. The horizontal beam represents the swan's outstretched wings, crossing the body at bright (2.2 magnitude) Sadr or Gamma (γ) Cygni. This name comes from an Arabic phrase meaning, 'the hen's breast'.

THE MOON



- 4th 4 am (2 am WST) First Quarter.
- 8th 4 am (2 am WST) Moon at perigee (closest to Earth at 364,492 km).
- 10th 8 pm (6 pm WST) Full Moon.
- 11th 6 am (4 am WST) Maximum Libration (7.2°), near Full Moon.
- 18th 8 am (6 am WST) Last Quarter.
- 20th 1 am (11 pm WST, previous day) Moon at apogee (furthest from Earth at 404,556 km).
- 23rd 5 pm (3 pm WST) Maximum Libration (7.2°), bright SW limb. The 160 km crater Hausen is ideally suited for observation as it emerges from the zone of librations.
- 26th 8 am (6 am WST) New Moon.

THE PLANETS

Mercury, in Virgo, is low in the western evening sky, free from twilight for the first half of the month. It then rapidly moves back toward the Sun and inferior conjunction (between the Earth and the Sun) on the 23rd before returning to the morning dawn.

Venus remains too close to the Sun for observation. After superior conjunction next month, the planet will return to the western evening sky.

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

Spending the month in Taurus, **Mars** rises around midnight in the eastern evening sky. During the first week, the planet will be near the Hyades star cluster shining brighter than the nearby 1st magnitude star Aldebaran (Alpha (α) Tauri). On the 17th, the 21-day old waning gibbous Moon appears nearby (see Sky View).

Jupiter is at opposition on the 27th, rising in the early evening, visible the entire night and shining very brightly at –2.9 magnitude. This month, the planet's retrograde motion brings it back from Cetus into Pisces. Since conjunction earlier this year, Jupiter's equatorial diameter has grown steadily from 33 to almost 50 arcseconds (as good as it gets)—a fitting target for even the smallest of telescopes that will reveal plenty of detail.

The planet's visible atmosphere is composed of dark belts and lighter zones, the most obvious of which are the north and south equatorial belts (NEB and SEB)—see diagram page 120. Within the SEB lies the planet's most famous feature, the Great Red Spot (GRS), the longest enduring storm known in the Solar System. The GRS was observed by the German amateur astronomer Schwabe in 1831 and is perhaps the same storm that the Italian astronomer Cassini sighted in 1665. It has been continuously monitored since 1878, so at a minimum, the GRS has persisted for over 200 years. It has varied in colour from grey to pinkish and has changed in size over time. The best time to see the GRS is when it crosses the planet's meridian or at most an hour on either side (see Part II for estimated GRS meridian passage dates and times).

On the 11th, Jupiter rises just below the Full Moon, the distance between the pair decreasing overnight (see Sky View).

Saturn, now just past opposition, transits the meridian (is due north) around 10 pm mid-month—a great time to observe the jewel of the Solar System while at its maximum elevation above the horizon. The Saturnian moons are fun to track down and identify; the brightest and largest, Titan, can be seen in binoculars. Other moons can be a little harder to find as they are scattered all around the planet when the rings are open, unlike the neat, orderly shuttling of Jupiter's Galilean moons. On the 8th, the 13-day old waxing gibbous will be near Saturn (see Sky View).

Uranus rises in the eastern evening sky around 10 pm mid-month in Aries.

Neptune, in Aquarius, comes to opposition on the 17th, 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 power and good seeing to resolve its small bluish disc.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the morning of the 21st m.p. 115 Thyra is crossing the open star cluster NGC 1342 in Perseus. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 Sep	389 Industria	Aquarius	11.6
8 Sep	3 Juno	Aquarius	7.8
8 Sep	5 Astraea	Aquarius	11.0
12 Sep	216 Kleopatra	Pegasus	9.8
13 Sep	24 Themis	Aquarius	12.0
18 Sep	128 Nemesis	Aquarius	10.8
26 Sep	48 Doris	Pisces	11.2
30 Sep	372 Palma	Pegasus	11.5
30 Sep	65 Cybele	Cetus	11.8

COMETS

Comet C/2017 K2 (PANSTARRS) is likely to be 6th magnitude in September, visible in the evening sky. The comet continues its tour of the head of Scorpius, crossing into Lupus late in the month.

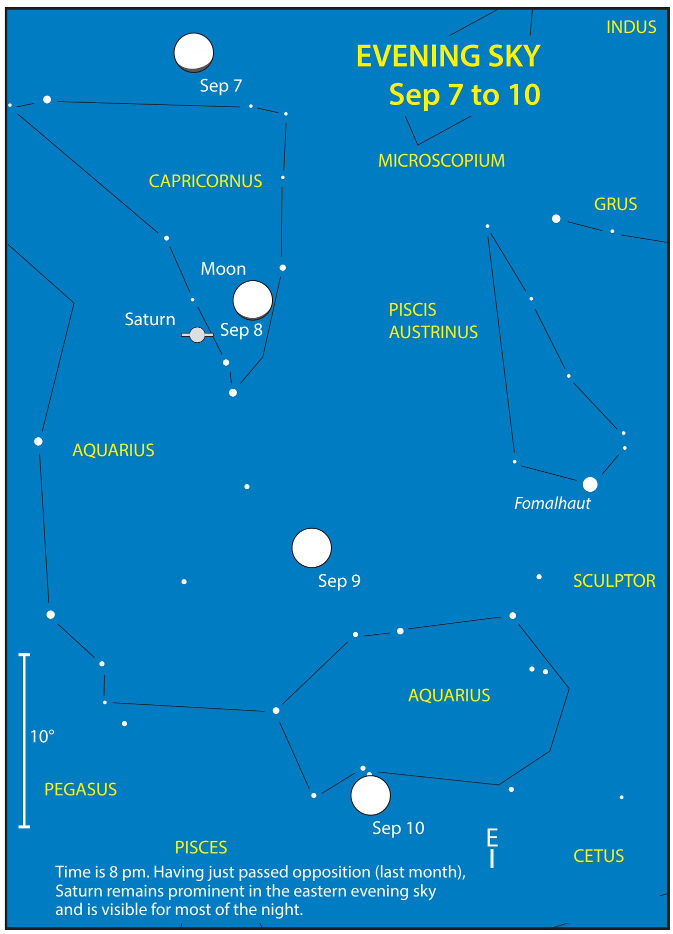
DIARY			
Sat	3rd	11 pm	(9 pm WST) star Antares 4° SE of Moon.
Sun	4th	4 am	(2 am WST) First Quarter Moon.
Tue	6th		m.p. 13 Egeria 0.3° N of star Sigma Librae.
Thu	8th		Juno at opposition.
Thu	8th	4 am	(2 am WST) Moon at perigee (closest to Earth at 364,492 km).
Thu	8th	9 pm	(7 pm WST) Saturn 4° N of Moon.
Fri	9th		star Aldebaran 4° S of Mars.
Sat	10th		Mercury 0.8° NE of star Beta Virginis.
Sat	10th		m.p. 349 Dembowska 0.7° SE of IC 2087 (BN) in Taurus.
Sat	10th		Comet C/2017 K2 (PANSTARRS) 0.8° W of star Pi Scorpii.
Sat	10th	8 pm	(6 pm WST) Full Moon (369,131 km).
Sun	11th	4 am	(2 am WST) Neptune 3° N of Moon.
Sun	11th	6 am	(4 am WST) Maximum Libration (7.2°), near Full Moon.
Mon	12th	1 am	(11 pm WST, prev day) Jupiter 1.5° N of Moon.
Wed	14th		m.p. 10 Hygiea 0.1° SE of star Iota^1 Librae.
Thu	15th	4 am	(2 am WST) Uranus 3° E of Moon.
Sat	17th	1 am	(11 pm WST, prev day) Mars 6° SE of Moon.
Sat	17th	3 am	(1 am WST) star Aldebaran 8° S of Moon.
Sat	17th		Neptune at opposition.
Sun	18th	8 am	(6 am WST) Last Quarter Moon.
Mon	19th		Comet C/2017 K2 (PANSTARRS) 0.4° W of star Rho Scorpii.
Tue	20th	1 am	(11 pm WST, prev day) Moon at apogee (furthest from Earth at 404,556 km).
Wed	21st	3 am	(1 am WST) m.p. 115 Thyra 0.1° W of NGC 1342 (OC) in Perseus.
Wed	21st	4 am	(2 am WST) star Pollux 6° W of Moon.
Thu	22nd	pm	m.p. 3 Juno 0.8° NW of star Lambda Aquarii.
Fri	23rd		Equinox.
Fri	23rd		Mercury in inferior conjunction.
Fri	23rd	5 pm	(3 pm WST) Maximum Libration (7.2°), bright SW limb.
Mon	26th	8 am	(6 am WST) New Moon.
Tue	27th		Jupiter at opposition.
Thu	29th	am	m.p. 30 Urania 0.6° S of IC 2087 (BN) in Taurus.
Fri	30th		m.p. 13 Egeria 0.8° NE of star Upsilon Librae.
Fri	30th	9 pm	(7 pm WST) star Antares 8° SE of Moon.

3-day old waxing crescent Moon with earthshine and Venus (4.5° from the Moon). Star directly above the Moon is 4th magnitude Nu (ν) Virginis. Nikon D3100 130 mm ƒ4.8 1/4 sec. Blue Mountains NSW 11 August 2021.

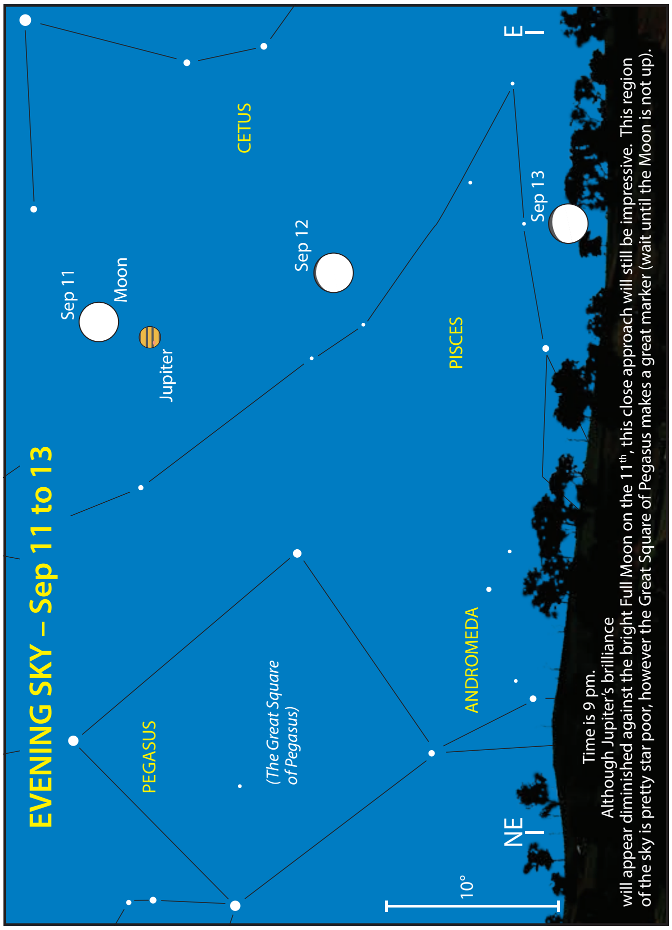
DOUBLE STARS

For the binocular observer, **Beta^1 (β^1) Capricorni (Dabih)** and **Beta^2 (β^2) Capricorni** (STFA 52AB) is a lovely sight. The primary is a bright yellow star (mag 3.2) with a wide white companion (mag 6.1) located 205 arcseconds away. The spectral types are F8V and A0. They orbit each other with a period of 700,000 years. Beta^1 Capricorni is actually a spectroscopic triple and Beta^2 Capricorni has a close companion. Thus, the system is composed of five connected stars. The system is located 328 light-years from the Sun. (All Sky Map 8)

This month's telescopic double is **Epsilon (ε) Pegasi** (Enif, S 798AC), the brightest star in the constellation of Pegasus. Located 690 light-years away, this is a wide unequal pair of yellowish and violet stars magnitude 2.5 and 8.7, separated by 144 arcseconds with a position angle of 318°. Enif is also known as John Herschel's 'Pendulum Star'. Centre the pair in the eyepiece field (60–100 × is the recommended magnification) and mentally trace a line between them. While keeping your eye at the eyepiece, gently tap the telescope back and forth so that the two stars move at right angles to the imaginary line. The faint companion star seems to lag behind its brighter companion producing the effect of a pendulum. The explanation is thought to be the Pulfrich effect, it appears the light from the fainter star takes longer to stimulate the retina than the brighter primary. (All Sky Map 9)



SEPTEMBER

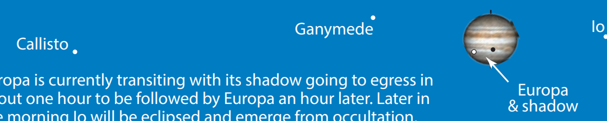


Jupiter's Satellites for September

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.

1 arc min.

Sep 3, midnight EST (10:00 pm WST)



Europa is currently transiting with its shadow going to egress in about one hour to be followed by Europa an hour later. Later in the morning Io will be eclipsed and emerge from occultation.

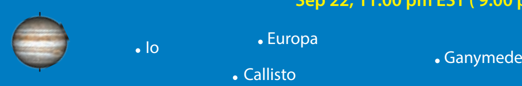
Sep 13, 10:00 pm EST (8:00 pm WST)

In the previous hour Io and its shadow have ingressed and will egress by midnight (EST). Note, Callisto is currently not producing events as it is passing over Jupiter's poles.

Sep 19, 10:00 pm EST (8:00 pm WST)

Europa is going into eclipse. It's fascinating to see a moon fade out. It will reappear from occultation in around two hours. The morning sees Io disappear into eclipse and reappear.

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

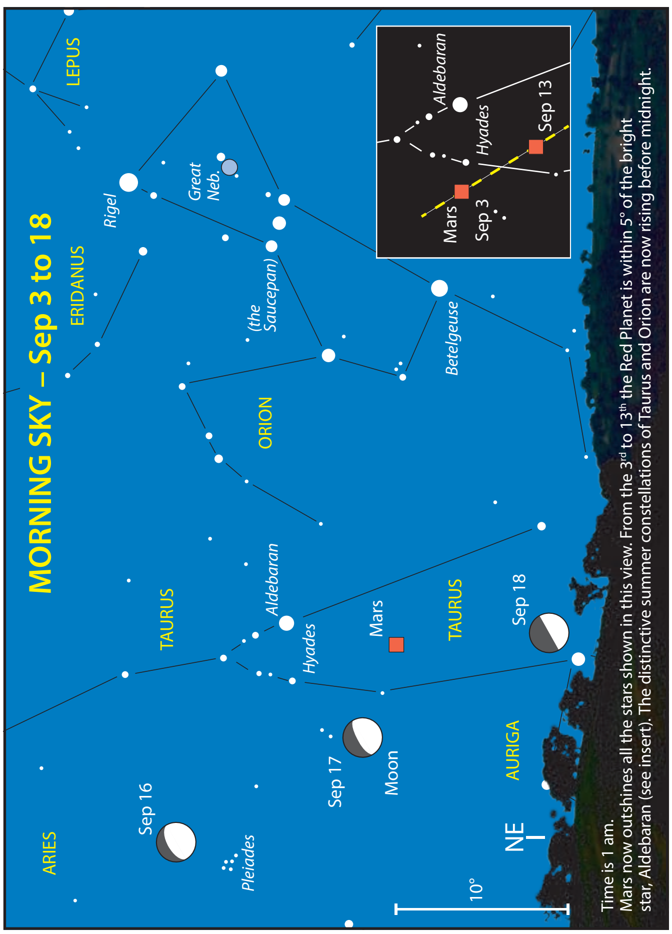


A nice arrangements of the satellites with all four gathered on the west side of Jupiter

Sep 28, 9:30 pm EST (7:30 pm WST)

In the next hour Europa and its shadow will egress from transiting and Io will be occulted.

Approximate local standard time.

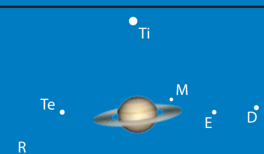


Saturn's Satellites for September

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

N E 1 arc min.

Sep 6, 11:00 pm EST (9:00 pm WST)

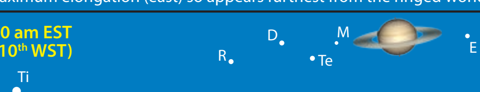


Moons are well spread. With Titan at one of its conjunctions (superior) it's the closest this brightest moon can appear to Saturn.

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

An interesting arrangement of the moons on the northern side of Saturn. Titan is close to a maximum elongation (east) so appears furthest from the ringed world.

Sep 11, 1:00 am EST (11:00 pm 10th WST)



Of all the bright moons of Saturn, Mimas is by far the hardest to observe being so faint and spending so much time close to Saturn and the rings. It is briefly at a maximum elongation here, giving you the best chance to observe it.

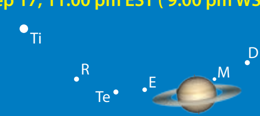
Sep 17, 11:00 pm EST (9:00 pm WST)

A gathering of the six brightest moons on the western side of Saturn. Four of them (including Titan) are near their maximum elongations so a good time to observe them.

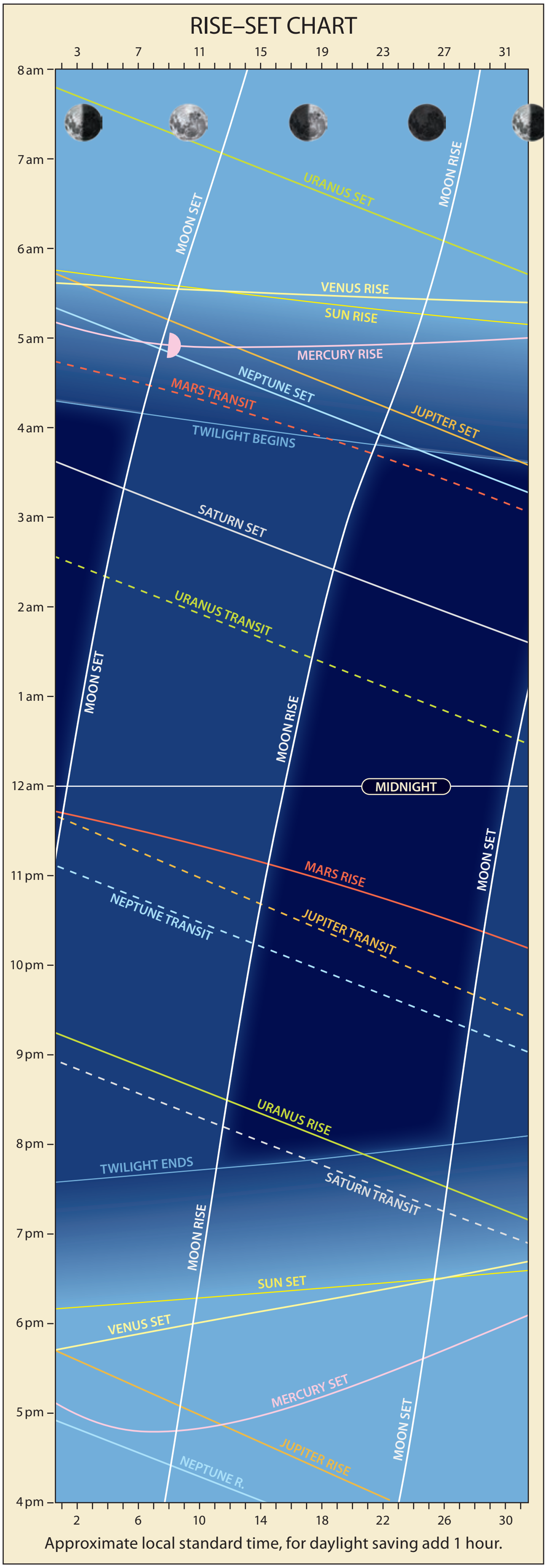
I	Mimas	M
II	Enceladus	E
III	Tethys	Te
IV	Dione	D
V	Rhea	R
VI	Titan	Ti
VII	Iapetus	I

Sep 17, 11:00 pm EST (9:00 pm WST)

Nothing significant here, the authors just liked the curved alignment of the moons!



OCTOBER 2022



HIGHLIGHTS

- Jupiter a beacon in the early eastern evening sky.
- Great views of Saturn high in the early northern evening sky.

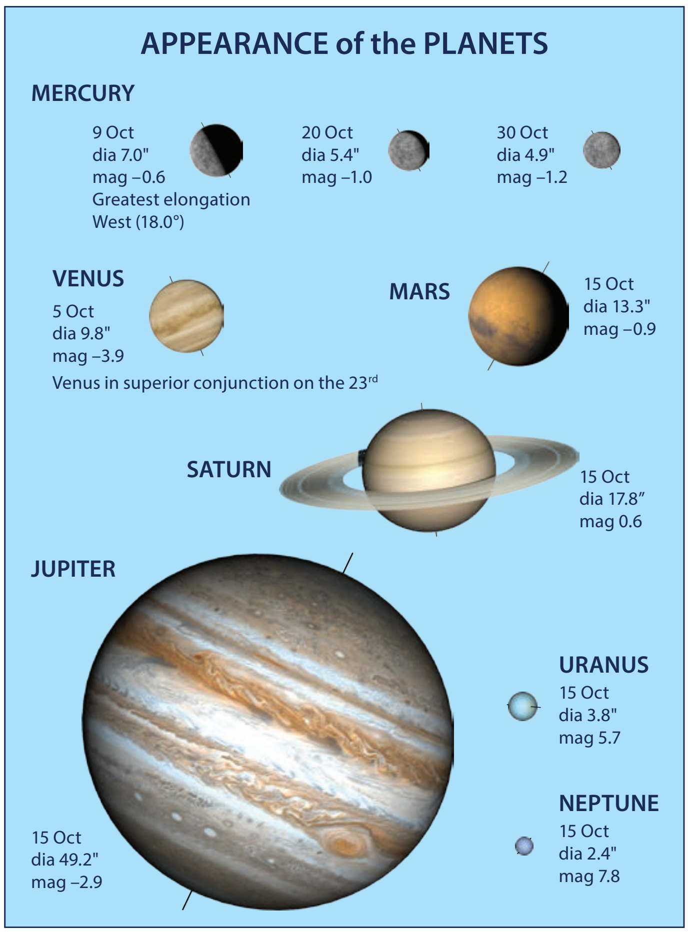
CONSTELLATIONS

With the Milky Way dropping into the western sky it takes with it many of the obvious asterisms so easy to navigate by. Scorpius is now taking a headlong dive towards the horizon, followed by the tilting Teapot of Sagittarius looking to pour its contents onto the Scorpion.

There is a convenient asterism crossing the meridian low in the north, which is our springboard into the less obvious constellations. We say springboard for there is quite a water theme happening. This marker is the Great Square of Pegasus (the Winged Horse). Located in the northern sky (Map 9), this group of four distinct stars (2nd to 3rd magnitude), are arranged in a square approximately 14° each side.

Directly above (south) of the horse is Pisces the Fish, which is best recognised by its Circlet, a group of six 4th to 5th magnitude stars arranged in a hexagon shape (Map 8). A view from the suburbs with a low power, wide-field pair of binoculars will show this well. Also conveniently placed at this time, a few degrees away to the upper right, is brilliant Jupiter.

Heading to the left (west) you'll enter Aquarius the Water Bearer, another faint constellation showing no discernible pattern, certainly not a human figure pouring water from a vessel. However, the Water Jar is well marked by a 'Y' shaped asterism (centred on Zeta (ζ) Aquarii) from which water is flowing into the mouth of the Southern Fish, Piscis Austrinus.

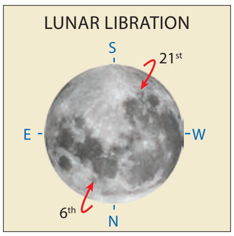


OCTOBER

Let's follow this stream up to its target which can't be missed, 1st magnitude Fomalhaut. This isolated star culminates for much of Australia near the zenith. The body of this fish, made up of 4th magnitude stars can be seen towards the west, narrowing to a point (it has no tail fin).

Continuing westward you'll run into Capricornus (Map 8), known since antiquity as the Sea Goat. Often depicted in ancient star maps with a goat's head, front legs and body with its hindquarters being a fish's tail, the heavens present an arrangement of 3rd and 4th magnitude stars in a triangular shape resembling a house roof or an inverted smile. Below (to the north) is a distinctive, compact group of five faint (4th magnitude) stars, Delphinus the Dolphin. Covering only 6° of sky this constellation makes for another great target for low power binoculars under suburban lights. Four of the stars are arranged in a small distinctive diamond shape.

THE MOON



- 3rd 10 am (8 am WST) First Quarter.
- 5th 3 am (1 am WST) Moon at perigee (closest to Earth at 369,325 km).
- 6th 11 pm (9 pm WST) Maximum Libration (7.0°), bright NE limb.
- 10th 7 am (5 am WST) Full Moon.
- 17th 8 pm (6 pm WST) Moon at apogee (furthest from Earth at 404,328 km).
- 18th 3 am (1 am WST) Last Quarter.
- 21st 7 am (5 am WST) Maximum Libration (7.5°), bright SW limb. The 160 km crater Hausen is ideally suited for observation as it emerges from the zone of librations.
- 25th 9 pm (7 pm WST) New Moon. Partial solar eclipse—not visible from Australia (see p. 103)
- 30th 1 am (11 pm WST, previous day) Moon at perigee (closest to Earth at 368,291 km).

THE PLANETS

Mercury returns to the morning dawn this month. This is a poor apparition with the planet barely a few degrees above the horizon at the end of civil twilight. Mercury reaches its greatest elongation 18° west of the Sun on the 9th.

Venus is in superior conjunction (Earth and Venus on opposite sides of the Sun) on the 23rd. The planet then remains too close to the Sun for observation until December.

Rising in the late evening eastern sky, **Mars** in Taurus, meanders near the Bull's horns (Beta (β) and Zeta (ζ) Tauri). On the 30th, the planet begins retrograde motion against the background stars (see diagram on p. 94). This apparent reversal of direction continues until January 2023. With the Red Planet's forthcoming opposition in early December, its brightness increases to –1.0, and its disc swells to 15 arcseconds in diameter by month's end as the Earth draws nearer to this world.

With opposition late last month, **Jupiter** is visible as the sky darkens after sunset in the east. At close to –3 magnitude, it stands out like a beacon in a region devoid of bright stars, a little south of (right of) the Circlet of Pisces. The most obvious and easiest to identify features on the planet for the small telescope user are the dark north equatorial (NEB) and south (SEB) belts. At first glance, an inexperienced observer will see the two belts as even straight bands across the disc. However, there is much to see as the planet rotates and short-term bumps, gaps, bright and dark spots are visible within the bands. With Jupiter's short 10-hour rotation period, things move quickly, and a feature noted in a belt will move perceptibly in less than half an hour. Don't neglect the Galilean moons as they shuttle back and forth, undergoing satellite transits, shadow transits, occultations, and eclipses—just like a miniature solar system (predictions for moon events are in Part II).

On the 8th, the early evening sees Jupiter below the 13-day old waxing gibbous Moon, the distance between the pair decreasing during the night (see Sky View).

Saturn, in Capricornus, is visible high in the northern sky towards the end of astronomical twilight (see Sky View). The planet ends 4.5 months of retrograde motion on the 23rd and then resumes its west to east motion against the background

DIARY			
Sat	1st		m.p. 29 Amphitrite 0.8° N of NGC 6304 (GC) in Ophiuchus.
Sun	2nd		m.p. 29 Amphitrite 0.5° S of NGC 6316 (GC) in Ophiuchus.
Mon	3rd	10 am	(8 am WST) First Quarter Moon.
Tue	4th	pm	m.p. 192 Nausikaa 0.6° SE of d.p. Pluto.
Wed	5th	3 am	(1 am WST) Moon at perigee (closest to Earth at 369,325 km).
Thu	6th	2 am	(Midn WST, prev day) Saturn 4° N of Moon.
Thu	6th	11 pm	(9 pm WST) Maximum Libration (7.0°), bright NE limb.
Sat	8th	8 pm	(6 pm WST) Neptune 5° W of Moon.
Sun	9th	4 am	(2 am WST) Jupiter 2° N of Moon.
Sun	9th		Mercury at greatest elongation West (18.0°).
Mon	10th	am	m.p. 2 Pallas 0.1° E of star Sirius (Alpha Canis Majoris).
Mon	10th	am	Southern Taurids meteor shower, Sep 10 to Nov 20, Moon affected.
Mon	10th	7 am	(5 am WST) Full Moon (379,483 km).
Tue	11th	am	m.p. 324 Bamberga 0.7° W of star Epsilon Persei.
Wed	12th	10 pm	(8 pm WST) Uranus 4° SW of Moon.
Thu	13th		Comet C/2017 K2 (PANSTARRS) 0.3° W of star Theta Lupi.
Fri	14th		m.p. 6 Hebe 0.7° N of star Beta Cancri.
Fri	14th	pm	m.p. 192 Nausikaa 0.4° S of M75 (GC) in Sagittarius.
Sat	15th		Mercury 0.6° NE of star Eta Virginis.
Sat	15th		Mars 1.2° NW of M1 Crab Nebula (PN) in Taurus.
Sun	16th	1 am	(11 pm WST, prev day) Mars 8° SW of Moon.
Mon	17th	8 pm	(6 pm WST) Moon at apogee (furthest from Earth at 404,328 km).
Tue	18th	3 am	(1 am WST) star Pollux 1.5° NW of Moon.
Tue	18th	3 am	(1 am WST) Last Quarter Moon.
Fri	21st		Orionids meteor shower, Oct 2 to Nov 7.
Fri	21st	4 am	(2 am WST) star Regulus 6° SW of Moon.
Fri	21st	7 am	(5 am WST) Maximum Libration (7.5°), bright SW limb.
Sat	22nd	pm	Saturn 0.6° E of star Iota Capricorni.
Sun	23rd		Venus in superior conjunction.
Tue	25th	9 pm	(7 pm WST) New Moon, partial solar eclipse.
Wed	26th		Comet C/2017 K2 (PANSTARRS) 1.8° W of NGC 6124 (OC) in Scorpius.
Fri	28th	8 pm	(6 pm WST) star Antares 4° SW of Moon.
Sun	30th	1 am	(11 pm WST, prev day) Moon at perigee (closest to Earth at 368,291 km).
Mon	31st		m.p. 29 Amphitrite 0.4° S of NGC 6540 (C) in Sagittarius.
Mon	31st	am	m.p. 324 Bamberga 0.3° S of star Nu Persei.

stars. From here on, the optical view of the planet in a telescope affords the observer a truly 3-D appearance; caused by the now visible planet's shadow on the back of the rings coupled with limb darkening.

Uranus comes to opposition early next month and rises in the eastern evening sky after the end of twilight.

Now past opposition, **Neptune** transits the meridian (is due north) around 10 pm mid-month in Aquarius.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the 10th, 2 Pallas has a close encounter with the brightest star, Sirius. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
2 Oct	23 Thalia	Cetus	11.1
7 Oct	354 Eleonora	Cetus	10.7
14 Oct	31 Euphrosyne	Cetus	10.7
18 Oct	230 Athamantis	Pisces	9.9
24 Oct	92 Undina	Cetus	11.0

COMETS

Comet C/2017 K2 (PANSTARRS) is expected to remain around 6th magnitude this month. Visible until late in the evening, the comet begins October in Lupus. Mid-month sees PANSTARRS cross back into Scorpius and then into Norma at the month's end.

DOUBLE STARS

Located in the southern constellation of Grus, the Crane, **Pi^1 and Pi^2 (π) Gruis** are a fine binocular pair. Pi^1 is a bright orange-red irregular variable (mag 5.8–6.4) whilst Pi^2 is brighter and yellow (mag 5.7). The pair is separated by about 4 arcminutes. Pi^1 is a very close unequal double (I 135) and Pi^2 is also an unequal double (I 382) both requiring a large aperture telescope to separate the component stars. Whilst in the constellation also have a look at the bright wide binocular triple made up of Mu^1, Mu^2 (μ) Gruis and the adjacent magnitude 6.2 star designated GSC 7999.1570. (All Sky Map 8)

Moonlight On The Nepean

Ruby Payne-Scott 1912 – 1981

The Australian government passed the Maternity Allowance Act in 1912, granting a baby bonus of five pounds to the mother of every child born in Australia (excluding indigenous mothers and other non-citizens). Other than that, it was not a particularly significant year in our history, except for the birth of Ruby Payne Scott on May 28 at Grafton NSW. Little did Ruby's parents know at the time; she would become the world's first female radio astronomer.

Ruby attended Penrith Public District School and then went on to Cleveland Street Girls High School, finishing her secondary education at Sydney Girls High School. At Sydney GHS, Ruby received honours in mathematics and botany in 1928. After winning two scholarships, she attended Sydney University, where she studied physics, chemistry, mathematics, and botany. Ruby graduated with a Bachelor of Science with first-class honours in 1933 at Sydney University (only the third woman to do so) and later achieved her Master of Science degree in physics in 1936. Finally, she gained a Diploma of Education in 1938.

As a graduate, Ruby gained employment at the Cancer Research Laboratory at the University of Sydney as a physicist. Here she worked on radiation, the newly developed method for treating cancer. She also completed her master's thesis while there. Her stay finished in 1938, at which time there appeared to be nothing available in the workforce for a woman physicist. She then took up a teaching position at Woodlands Church of England Girls Grammar School in Adelaide.

Although many would have benefitted from Ruby staying in the teaching profession, her first love was physics. In 1939 she was offered a position as librarian at Amalgamated Wireless (Australasia) Ltd, which she accepted willingly. Women were usually hired as typists and cleaners, not researchers, so this was a first for AWA. However, she quickly managed to involve herself in other things, eventually turning the focus of her position into electrical engineering research.

Ruby Payne-Scott, circa 1930s

In 1941, along with other engineers from AWA, she was recruited by the Council for Scientific and Industrial Research (CSIR) (now the Commonwealth Scientific and Industrial Research Organisation (CSIRO)). Their research involved developing and improving radar (**RA**dio **D**etection **A**nd **R**anging) as a defensive weapon during the second world war. Significant advances were made in radar technology during this time by the team. However, it is interesting to note after only three months with the CSIR, the head of the division, Edward 'Taffy' Bowen, wrote of Ruby as a probationary employee: *"Well, she's a bit loud and we don't think she's quite what we want, and she may be a bit unstable, but we'll let her continue and see how she works out."*

Karl Jansky accidentally discovered radio noise coming from an extraterrestrial source (the centre of the Milky Way) in 1932. Although not an astronomer, he became known as the father of radio astronomy. However, he did not pursue its further development. Grote Reber took up the task in 1937 when he constructed a 9.4 metre dish, and by 1942 had completed the first radio map of the sky.

After the war, Ruby, and others from the CSIR teamed up with their group leader, Joseph Pawsey, and they turned their attention to possible post-war applications of their research. Interested in the recently discovered extraterrestrial radio signals, they carried out the first Southern Hemisphere radio astronomy experiments in 1944—including early radio observations of the Sun. British radar operators had detected an intense, low-frequency solar radio burst in February 1942 that lasted several days which coincided with the appearance of an enormous sunspot. Still, it remained a secret during the war. So, with radio astronomy in its infancy, the CSIR team made many advances in this new science.

Ruby discovered Type III solar radio bursts (SRB) in 1946. She also contributed to the later discovery of Type 1 and II SRBs. An SRB is an intense radio emission generated by sunspots, solar flares, and coronal mass ejections. The SRBs are classified into five classic types, depending on their characteristics and frequency range. In 1948 Ruby, and Alec Little led the research on the design and construction of the *swept lobe* interferometer, an instrument that imaged the Sun 25 times per second at 97 MHz, creating a *movie* that allowed observers to follow the evolution of the SRBs.

Outspoken and controversial, Ruby was a woman in a man's world, a woman who confronted inequality and injustice wherever she perceived it. For example, men were allowed to smoke in the workplace, but women were not. So, in defiance, Ruby attended an interview smoking a cigarette to highlight the paradox of this rule. Another odd regulation was that men could wear shorts, but women had to wear skirts. Attending a meeting on the subject, Ruby said, *"Well, this is absurd. We're climbing up on ladders, up on aerials every day. I'm not going up on a ladder with a skirt on. The shorts are much better attire for us".* ASIO even investigated her as an alleged member of the Communist Party of Australia. However, there was no evidence to support this claim.

Back then, female public service employees were not allowed to hold permanent positions. Ruby had married William Hall in 1944, and in 1950, when the CSIRO discovered this fact, she was asked to resign and take up a temporary position. Her provident fund was returned to her, although she forfeited the contributions made by her employer.

She resigned from the CSIRO in 1951 to deliver her first child, a boy named Peter Gavin Hall, who would become a well-known mathematician. Peter passed away in 2016 from leukaemia—the School of Mathematics and Statistics Building at the University of Melbourne was renamed in his honour. Her second child, Fiona Margaret Hall, born in 1953, would become one of Australia's most prominent contemporary artists. Ruby returned to the workforce in 1963 as a mathematics and science teacher at Danebank Anglican School for Girls in Sydney. She retired in 1974 and passed away on May 25, 1981, just before her 69th birthday.

Ruby's career as a radio astronomer spanned just seven years. She became the first female radio astronomer and pioneered solar radio astronomy and radiophysics techniques to study our Universe—a remarkable lady.

If the reader is curious about the title Moonlight on the Nepean, it is a piece of prose written by Ruby when she was just 11 years old. Published in the Nepean Times in 1923, it's worth a read and gives an insight into Ruby's mind at such a young age (Google Trove and enter 'Moonlight on the Nepean' in the search bar).

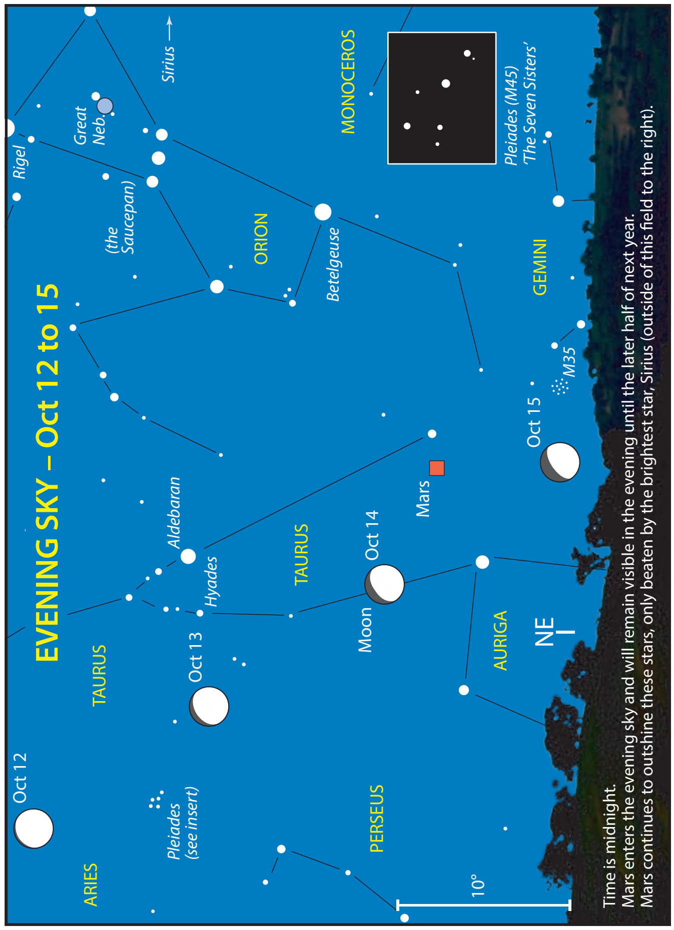
L to R. Ruby Payne-Scott, Alec Little and Chris Christiansen at the Potts Hill Reservoir Division of Radiophysics in the late 1940s.

Theta (θ) Eridani (Acamar, PZ 2) is truly one of the gems of the southern sky. Definitely one to show your family and friends. This brilliant white pair of stars (magnitude 3.2 and 4.1, spectral types A4III and A1V) is separated by 8.2 arcseconds. The system forms a long-period binary and is located at a distance of 120 light-years from the Sun. (All Sky Map 2)

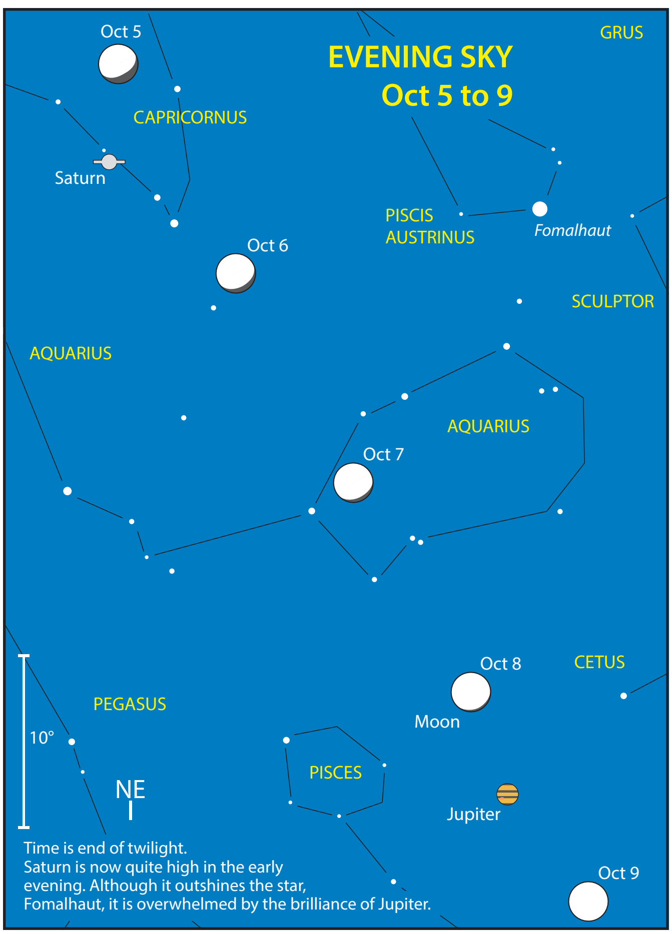
METEOR SHOWERS

The **Southern Taurids** are active from September 10 through to November 20. The shower is composed of two radiants of nearly equal activity ten degrees apart. The Southern Taurids peak around October 10, 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. At their peak, the Full Moon will hamper any observations.

The **Orionids** are best seen from late evening until dawn and are visible from October 2 through to November 7. Maximum activity is due around the evening of the 21st through to the morning of the 22nd. Over the past twenty years or so, the Orionids have produced rates of around 20 meteors per hour. With many sub-maxima, reasonable rates can occur on several consecutive nights around the peak. The Orionids are typically very swift and often bright, with some leaving trains. Chinese observers recorded this shower in 288 CE, and it is associated with Halley's Comet. With New Moon on the 25th, there will be minimal lunar interference.



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



Jupiter's Satellites for October

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.

Oct 5, 8:25 pm EST (6:45 pm WST)

← Callisto

In the remainder of the night, Europa and its shadow will complete a transit and Io will be occulted and reappear from eclipse.

Europa, Io, Ganymede & Shadow

Oct 12, 10:40 pm EST (8:40 pm WST)

Europa, Io, Ganymede & Shadow

A rare night with many events, if you start early and are willing to do an all nighter. Ganymede and Europa (plus shadows) will do a full transit with Io being occulted and reappearing from eclipse. All visible from anywhere in Australia. (Callisto is out of view to the right)

Oct 18, 10:00 pm EST (8:00 pm WST)

Callisto, Ganymede, Europa, Io

The moons are well spread with all four on the east side of Jupiter.

Oct 20, 3:00 am EST (1:00 am WST)

An interesting view with Ganymede's shadow transit close to the silhouette of Europa. Over a period of 6 hours complete transits of Ganymede and Europa (plus shadows) and an Io occultation can be seen. Western Australia is favoured for the egresses. (Callisto is out of view to the left).

Io, Europa, Ganymede & Shadow

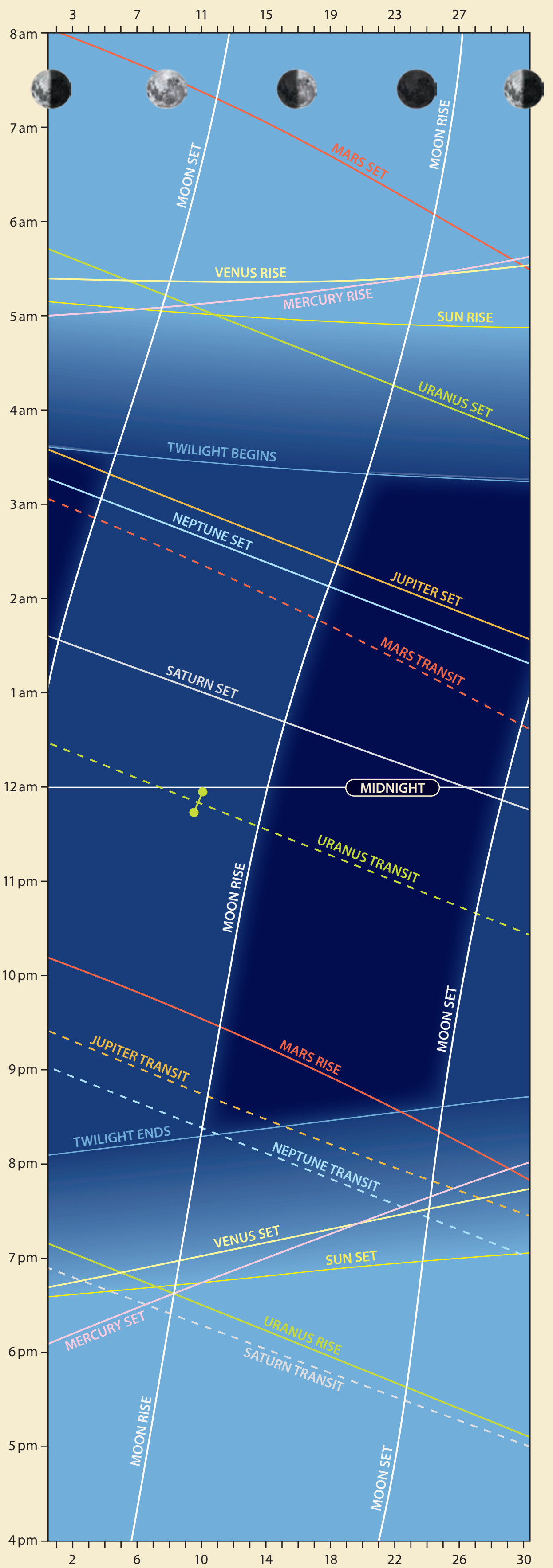
Oct 30, 8:10 pm Eastern States only

Ganymede, Io, Europa & Shadow

Twilight ends for the eastern states with only one moon visible away from the disk, Callisto, (not shown here) until Ganymede reappears from occultation. The illustration shows Ganymede about to disappear into eclipse with Europa having just completed a transit. Io will soon reappear from eclipse (shown here as dark).

NOVEMBER 2022

RISE–SET CHART



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

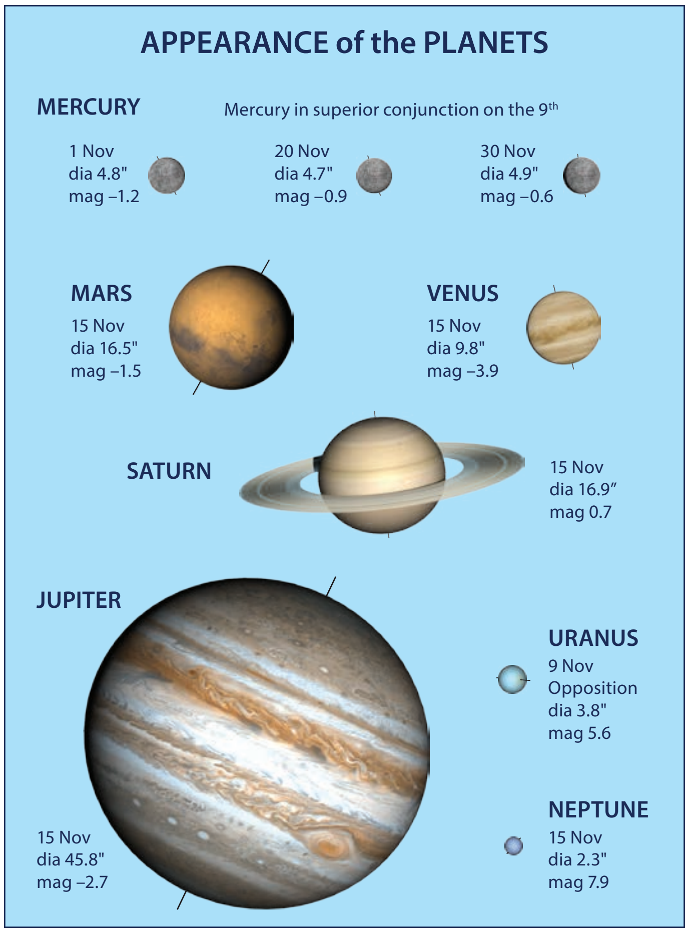
HIGHLIGHTS

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

CONSTELLATIONS

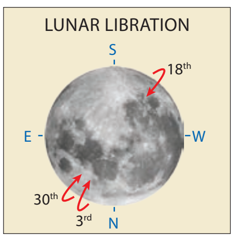
As we have pointed out in previous yearbooks, November evening skies from mid-latitude Southern Hemisphere locations present a unique view of the heavens. If you get out under dark skies with a low skyline, no matter which direction you look, the Milky Way can be seen on the horizon. You are in the plane of our flattened, disc-shaped galaxy, with an unobscured view of the half of the Universe that lies below (south) of the Milky Way (somewhat arbitrary directions, based on the assignment of the Earth's poles). You are looking through a relatively thin section of our galaxy devoid of rich star fields, dark and bright nebulae, blocking your view beyond. Most of the obvious stars, well away from the Milky Way, are only bright because they are nearby. Many of the constellations present are comprised of faint stars but some still have recognisable asterisms for those who let their eyes dark adapt and use our All Sky Maps with a red torch (this applies to October 'Constellations' as well).

The far south has some very obscure constellations which are not only considered faint but often have little or no recognisable patterns. The authors have found that trying to follow the patterns drawn in star maps and planispheres can be confusing, and sometimes best to settle on your own configuration. So, instead, we'll peg out some handy



references to help. Starting with the isolated 1st magnitude star Fomalhaut (see October 'Constellations'), nearby (south) is the relatively bright constellation of Grus the Crane, whose long-curved neck is also reminiscent of a bow (as in bow and arrow). Its 2nd magnitude brightest star, Alpha (α) Gruis or Alnair, is where the hand would hold the arrow. Drawing a straight line from Fomalhaut through Alnair and extending a similar distance finds a slightly fainter star than Alnair, Alpha (α) Pavonis or Peacock (Maps 1 and 8), which is also what this constellation is supposed to represent (as usual, good luck finding this bird). Besides Fomalhaut there is one other 1st magnitude star, in the south, well away from the Milky Way, Achernar, the alpha star to Eridanus the River (Maps 1 and 2). Fomalhaut, Achernar and Peacock form a large, near equilateral triangle. While talking about triangles, Hydrus is visible as an isosceles triangle made up of three 3rd magnitude stars, with its apex star a few degrees south of Achernar. Its western arm grazes the Small Magellanic Cloud (SMC). The constellation has been called the Southern Water Snake, Lesser Snake and even Male Water Snake with its larger, more northern companion, Hydra, being the Female Water Snake (best viewed in Autumn evening skies).

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 (see p. 103).
- 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 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

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.

greatest angular size 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 nearby 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. 14). 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 (see Eclipses p. 103 for details). 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 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 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 Pi³ (π) 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 C/2017 K2 (PANSTARRS) continues its passage south in our skies. Predicted to be glowing around 6th 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

Beta¹,² and Beta³ (β) Tucanae form a lovely binocular pair separated by 10 arcminutes. Through a telescope Beta¹ and Beta² (LCL 119AC) are a wide pair of bluish-white stars (magnitude 4.3 and 4.5) separated by 27 arcseconds. Beta³ is a white star (magnitude 5.2). All three stars are also close pairs, and the system is actually a sextuple. Beta¹'s companion's orbit is a little over three times Neptune's distance from the Sun. The Beta² pair is located over ten times further away and the pair is separated by less than the distance from the Sun to Uranus. The Beta³ 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)

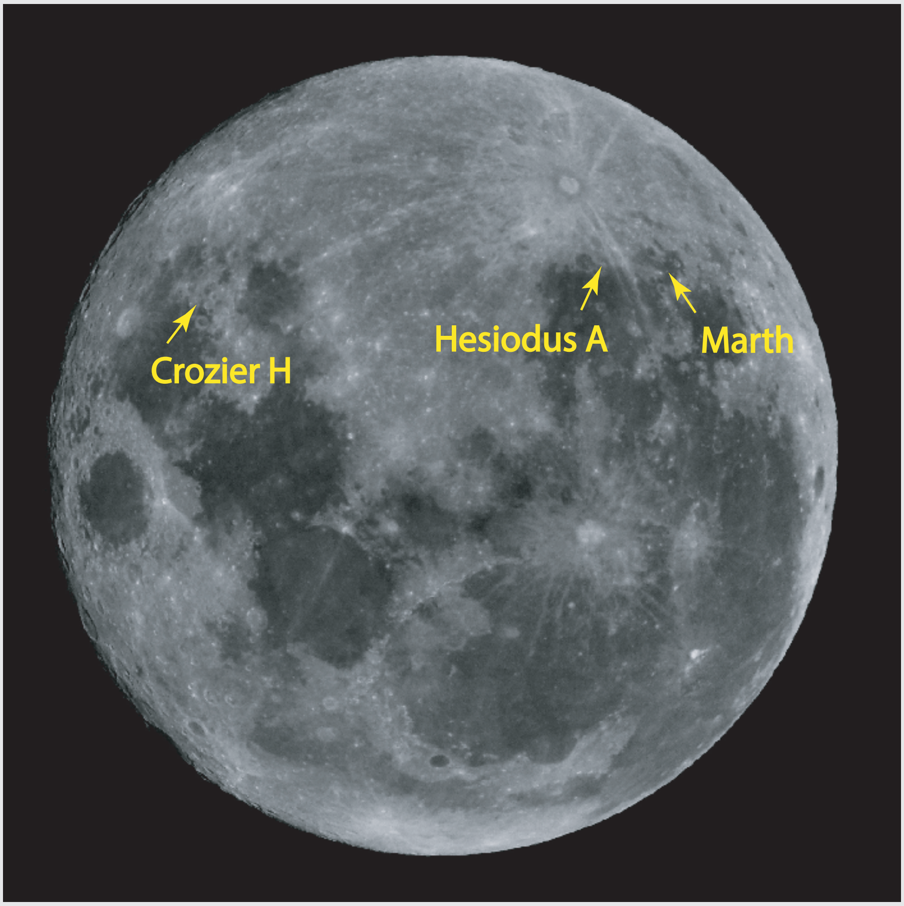
METEOR SHOWERS

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 is 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).

Lunar Concentrics



From sub-micron-sized pits to huge basins, the Moon's barren landscape is a wasteland of craters. On the nearside alone, there are thousands greater than 1 km in size. There are three basic categories of lunar impact craters: simple craters, complex craters, and impact basins. Simple craters are usually less than 10 to 15 km in diameter, are circular and bowl-shaped. Complex craters are larger than 15–25 km and often have terraced rims, flat floors and a central peak, or peaks. The crater Copernicus is typical of this class. Lastly, there are the massive (300 km plus) multi-ringed structures known as impact basins—e.g., the 1100 km Imbrium Basin (Mare Imbrium).

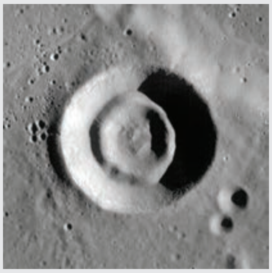
There are subdivisions in the basic categories plus some odd shapes like polygonal (Clavius), elliptical (Messier, p. 56), and concentric (Hesiodus A) craters. While impact crater formation on Solar System bodies is well understood, this last type still poses questions. The concentrics look like an impactor formed a crater followed by another lesser body that made a direct hit or bullseye inside the former. The result is these striking craters with nicely aligned dual concentric rings. Until recently, the double impact hypothesis was the accepted origin, and although feasible, it would be a very rare occurrence.

There are significant differences with concentric craters that sets them apart from regular ones of similar size. If they formed by chance collisions, there would be an expected random distribution across the lunar surface. However, this is not the case, with around 70 percent located on the highland/mare boundaries (particularly around Oceanus Procellarum), 20 percent on the floors of lava flooded craters, and 10 percent in the highlands. Their depth is shallower than similar-sized simple craters, and the majority seem to be of similar age and very old, ranging from 2.5 to more than 3.5 billion years old.

The current thoughts on the formation of many of the concentrics only involve one impactor, plus volcanism. After the initial strike, magma may have intruded into fractures on the floor inside the crater's inner wall creating the secondary ring. Alternatively, a dome may have formed from similar processes and then collapsed in the centre, again leaving an internal ring.

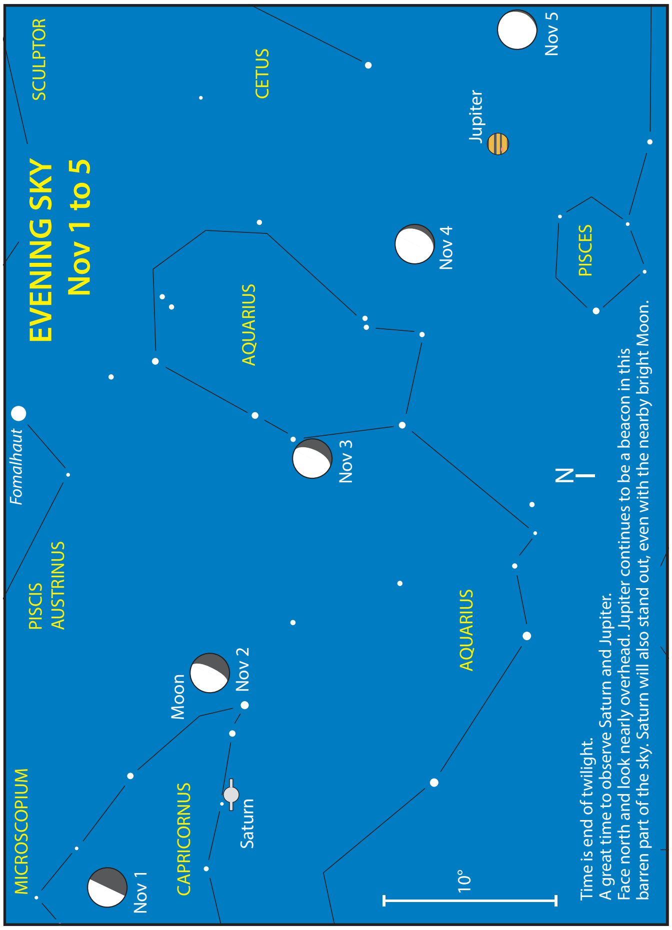
Whatever their origins, the concentrics are fun to track down. Many are within reach of small to medium-sized telescopes (100 to 250 mm) and provide an exciting challenge for amateur astronomy sleuths to seek them out. Optical quality, good steady seeing, and medium to high magnification are the key. There are 60 or more on the nearside, ranging in size from 3 to 20 km (average diameter 8 km). Below are three of the easier ones to observe. Should this sampling spark a desire for more, there are plenty of references on the web for others.

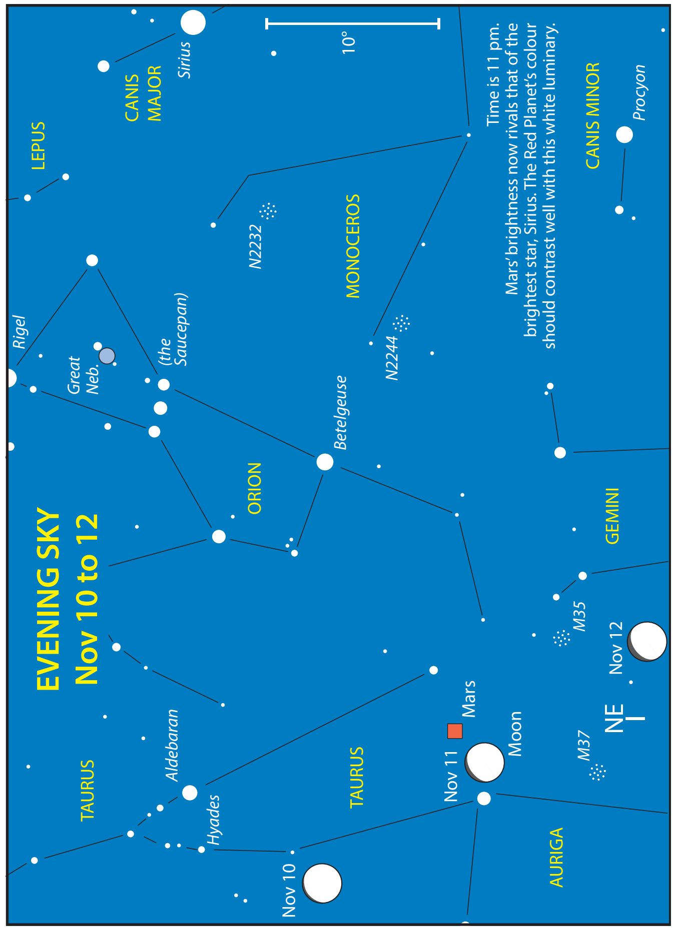
Crozier H is 11 km in diameter and located in the south of Mare Fecunditatis (Sea of Fertility) and identified on the LRO image p. 56, just west of the 22 km crater Crozier. Best viewed four days after New or three days after Full Moon.



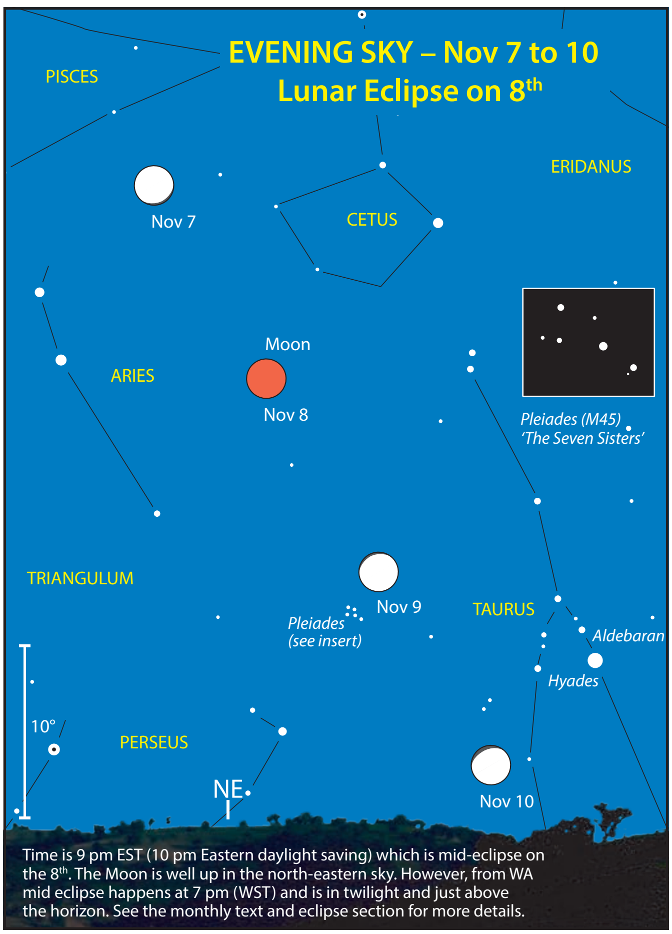
Hesiodus A is 15 km in diameter and sits upon the walls of the 43 km crater Hesiodus. It is on the southern shores of Mare Nubium (Sea of Clouds). Best viewed just after First or Last Quarter.

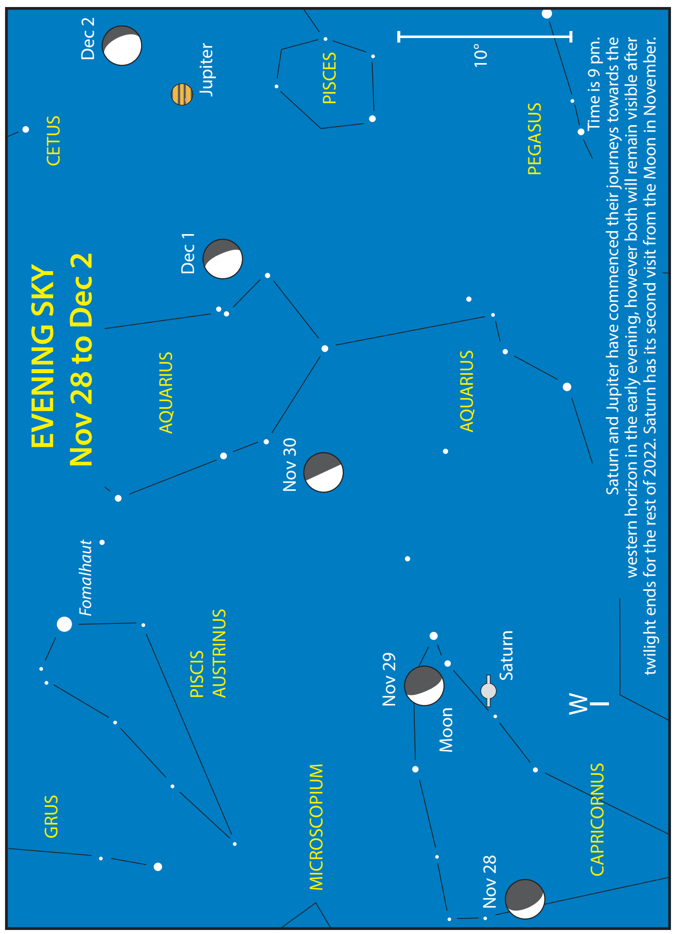
Marth is 7 km in diameter and lies to the west of Hesiodus A. Although the smallest of our examples, it is easily located on the dark floor of Palus Epidemiarum (Marsh of Epidemics).



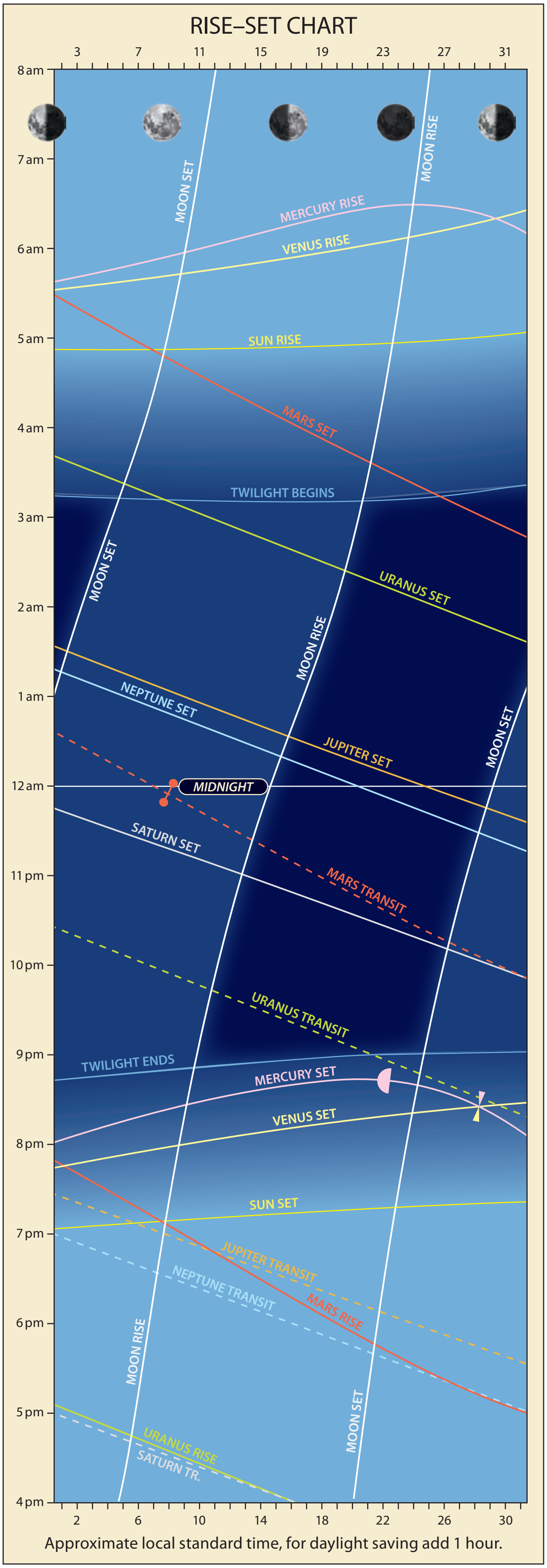


Approximate local standard time, for daylight saving add one hour.





DECEMBER 2022



HIGHLIGHTS

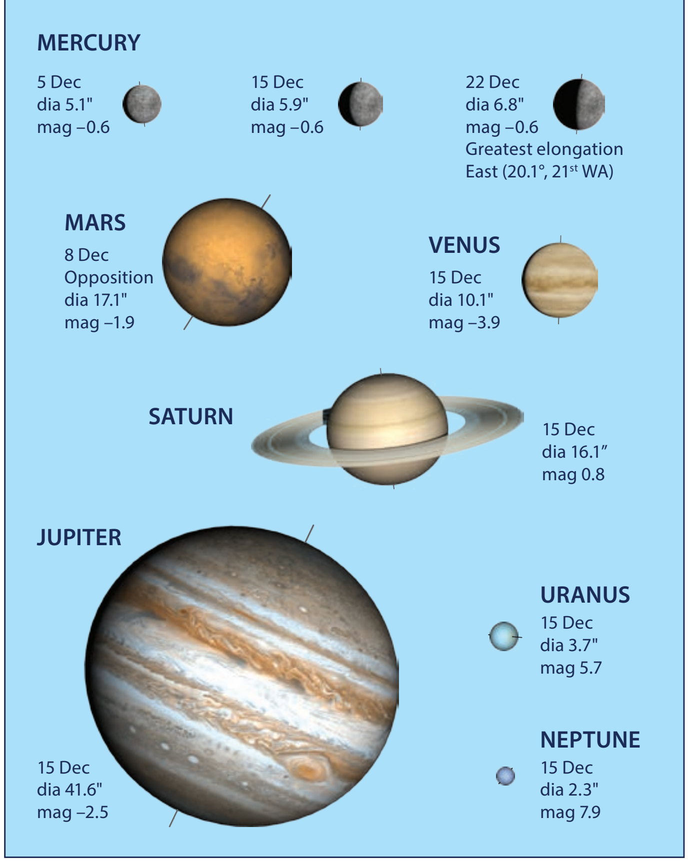
- Mercury and Venus close.
- Mercury, Venus and the Moon together.
- Mars at opposition.
- Jupiter and Moon close.
- Comet C/2017 K2 (PANSTARRS) at maximum brightness, deep in the southern skies.

CONSTELLATIONS

The majority of the early evening sky continues its barren appearance. The constellation of Grus and the star Fomalhaut continue to be oases in this desert, especially for those stuck under suburban lights. Now as the night gets older, our galaxy rises into view. Starting in the south-east the False Cross is more obvious. Heading northward you pass Puppis and then Canis Major, topped off by the brilliant star Sirius. Around this same time the Saucepan asterism is sitting low in the east, heralding the arrive of the three belt stars of Orion. We have now gone full circle, returning to our January 'Constellation' discussion.

Turning back to the south we can now add two prominent stars to Fomalhaut, Achernar to its south-east (left) and continuing this journey further south-east you'll encounter Canopus or Alpha (α) Carinae. The three stars lie in a straight line, equally spaced, spanning 80° of sky. These luminaries mark three distinct regions. With Canopus now rising it announces the return of the splendid southern Milky Way, with

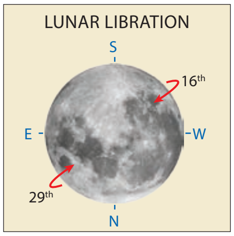
APPEARANCE of the PLANETS



its multitude of star clusters and nebulae. Achernar means it's a great time to get lost amongst the distant star clusters and nebulae of the two Magellanic Clouds. Fomalhaut's location, well out of the galactic plane, is a signpost for seeking distant galaxies.

Considering December doesn't have the spectacular evening skies normally associated with autumn or winter, there is certainly no shortage of bright stars around. In fact, the evening sky presents 7 of the 10 brightest stars in the night sky. High in the south is the 9th brightest, Achernar. Moving to the left in the south-east is the 2nd, Canopus. Keep going east to find the most brilliant, Sirius. The north-east contains a real gathering of these beauties. Orion has two members, the 7th is Rigel and 10th is Betelgeuse. Lower down is number 8, Procyon and close to the northern horizon is the 6th brightest, Capella.

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.

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 (see p. 117).

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.

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 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 6th to 5th magnitude by the end of December, PANSTARRS is in Ara initially, before moving into Pavo mid-month for the rest of December. The comet is visible until late in the evening, and again before dawn. By the second week of December, the comet 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 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)

Located close to the bright star Achernar (Alpha (α) Eridani), **p Eridani** (DUN 5) is a lovely pair for small telescopes. It was found to be a double star in December 1825 by James Dunlop, observing from Parramatta. Located at a distance of 26 light-years, the stars (magnitude 5.8 and 5.9) are both yellow-orange and are separated by 11.3 arcseconds. Both are main sequence dwarfs of spectral type K0V and K5V and are fainter and cooler than the Sun. The orbital period is 475 years. This pair has been well studied and the orbit is known with reasonable accuracy. Because of this, they are a suitable reference pair for those interested in measuring the separations and position angles of double stars. (All Sky Map 2)

NGC 3603 and NGC 3576 in Carina

NGC 3576 (above right) also called the Statue of Liberty Nebula, is a star forming region not far from the Eta Carinae complex and about the same distance away. NGC 3603 and 3576 are seen as two red spots in the wide field image (p. 36), just above the 'W' arm of the compass. NGC 3603 (above, lower left) is a massive star forming region, the largest visible cloud of glowing gas and dust (HII region) in the Milky Way. Its grandeur is somewhat diminished by distance, being over 20,000 light-years away. The cluster shown is quite young which includes 50 extremely hot O and B class stars totalling around 2,000 solar masses. Its ionising power far exceeds that of the trapezium in the Orion Nebula and has been compared to the central core of the Tarantula Nebula! (image credit Joe Cauchi)

DIARY

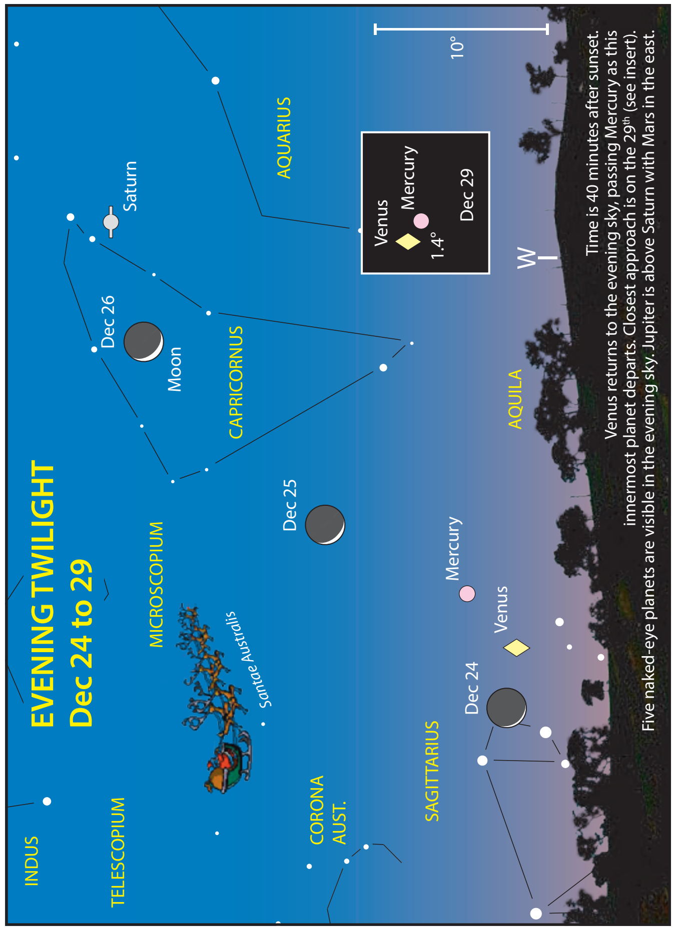
Thu	1st		Mercury 0.2° S of star Theta Ophiuchi.
Thu	1st	1 am	(11 pm WST, prev day) First Quarter Moon.
Thu	1st	11 pm	(9 pm WST) Neptune 3° N of Moon.
Fri	2nd	9 pm	(7 pm WST) Jupiter 5° W of Moon.
Fri	2nd	pm	Phoenicids meteor shower, Nov 28 to Dec 9, Moon affected.
Sat	3rd	pm	m.p. 324 Bamberga 1.0° SE 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.

METEOR SHOWERS

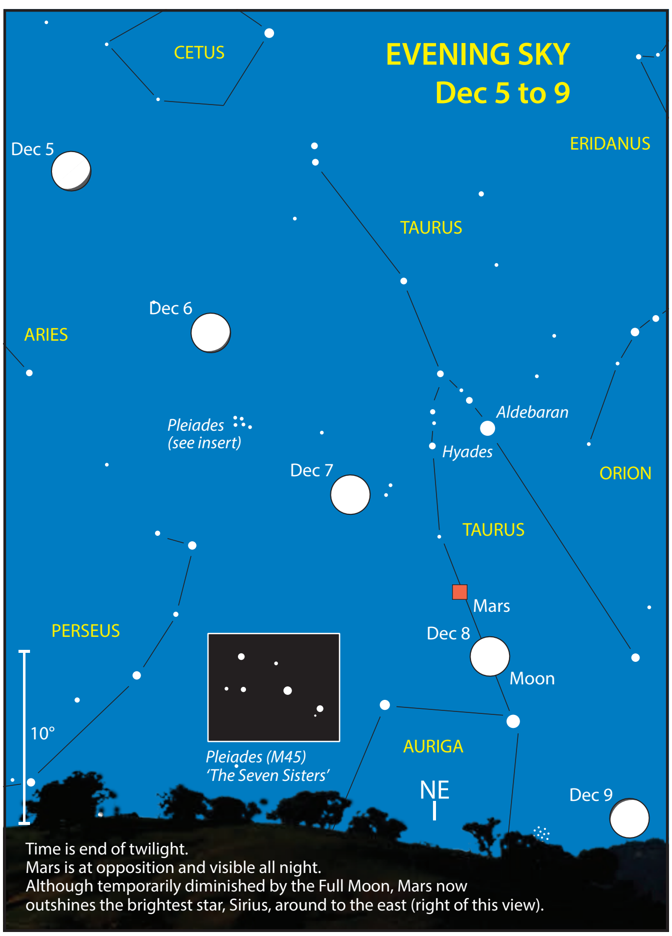
The **Phoenicids** is a southern shower discovered in 1956 during its only known major outburst with rates of around 100 plus. Since then, there have been three minor bursts and some significant activity in 2014; therefore a shower to keep an eye on, just in case. They are active from November 28 to December 9, with maxima 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 in the evening until 2 am.

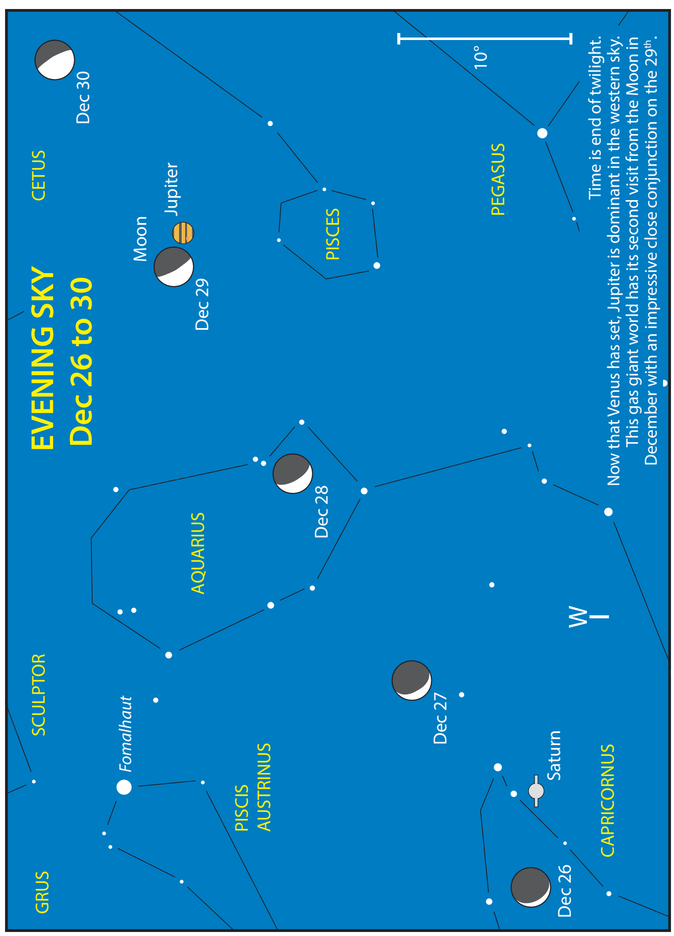
The **Puppid-Velids** are a vast, complex system of southern showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. They are active from December 1–15 and could produce a zenith hourly rate of 10 around the evening of the 7th and morning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

The **Geminids** is 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.



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





ALL SKY MAPS 2022

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 of the constellations.

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

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

To use the Looking South map, face south and rotate the chart to get the correct orientation. Use a distinctive star pattern like the Pointers and 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. With the exception of Mars, once you have found the general area you can go to the relevant finder chart. The path for Mars has the position marked for each month and thus replaces a separate finder chart. The Moon, Mercury and Venus are not shown. The Sky View diagrams (see Part I) show the location and optimum time to observe these objects.

What else is shown on the maps?

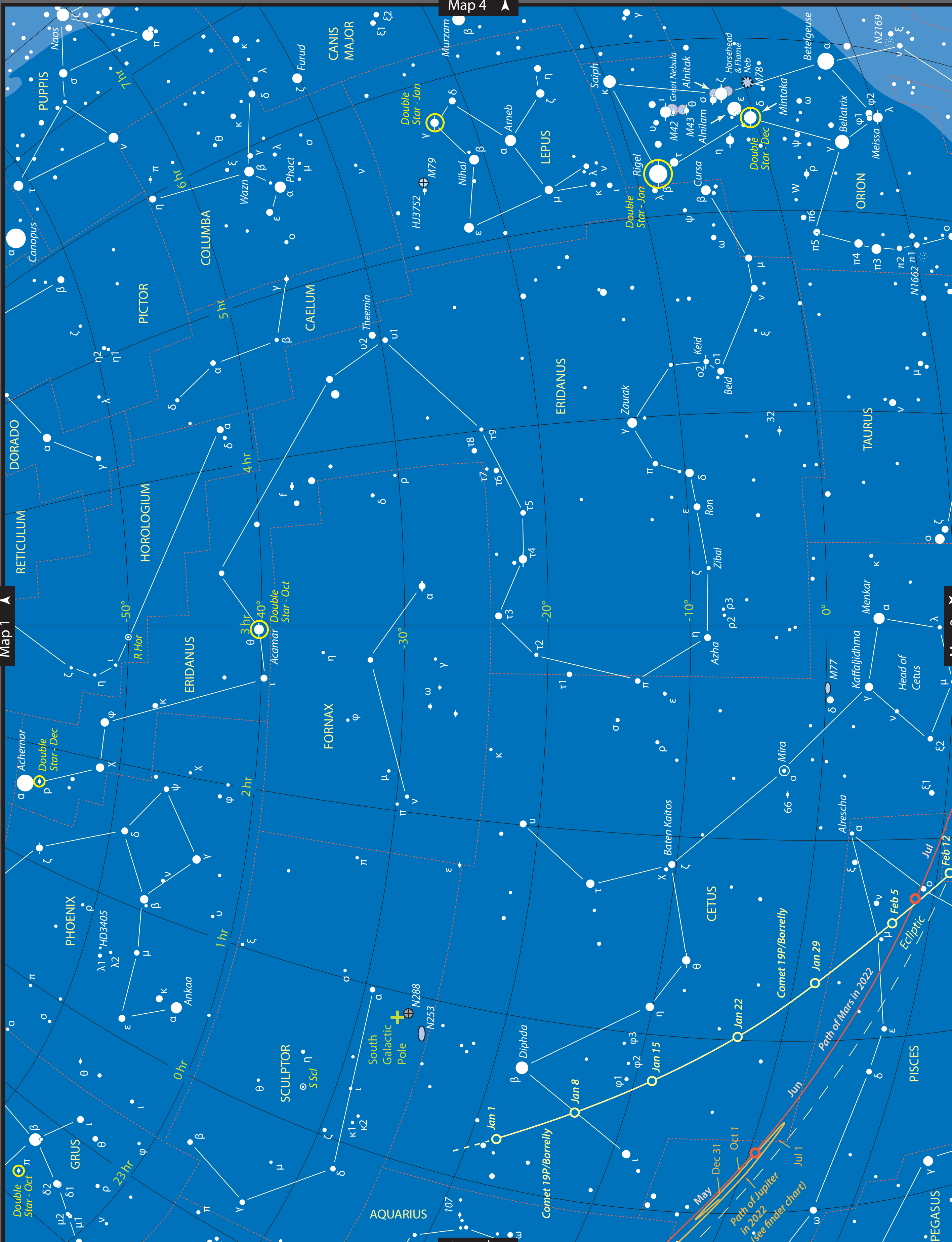
- Deep sky objects down to magnitude 7 and all of the Messier objects (see the legend). These objects are identified by their common names (such as asterisms), Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope.
- 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 the monthly double stars. Those mentioned in the Part I sections are labelled with the specific month and circled. Also, the variable stars from the feature (pp. 12, 13) are marked. The position and size of the Eta Carinae (p. 36) and Veil Nebulae (p. 27) wide field images are included. When a comet listed this year (p. 135) is predicted to achieve magnitude 10.0 or brighter it has been plotted. This includes Leonard (January and February only), Borrelly (January to April) and PANSTARRS for most of the year.

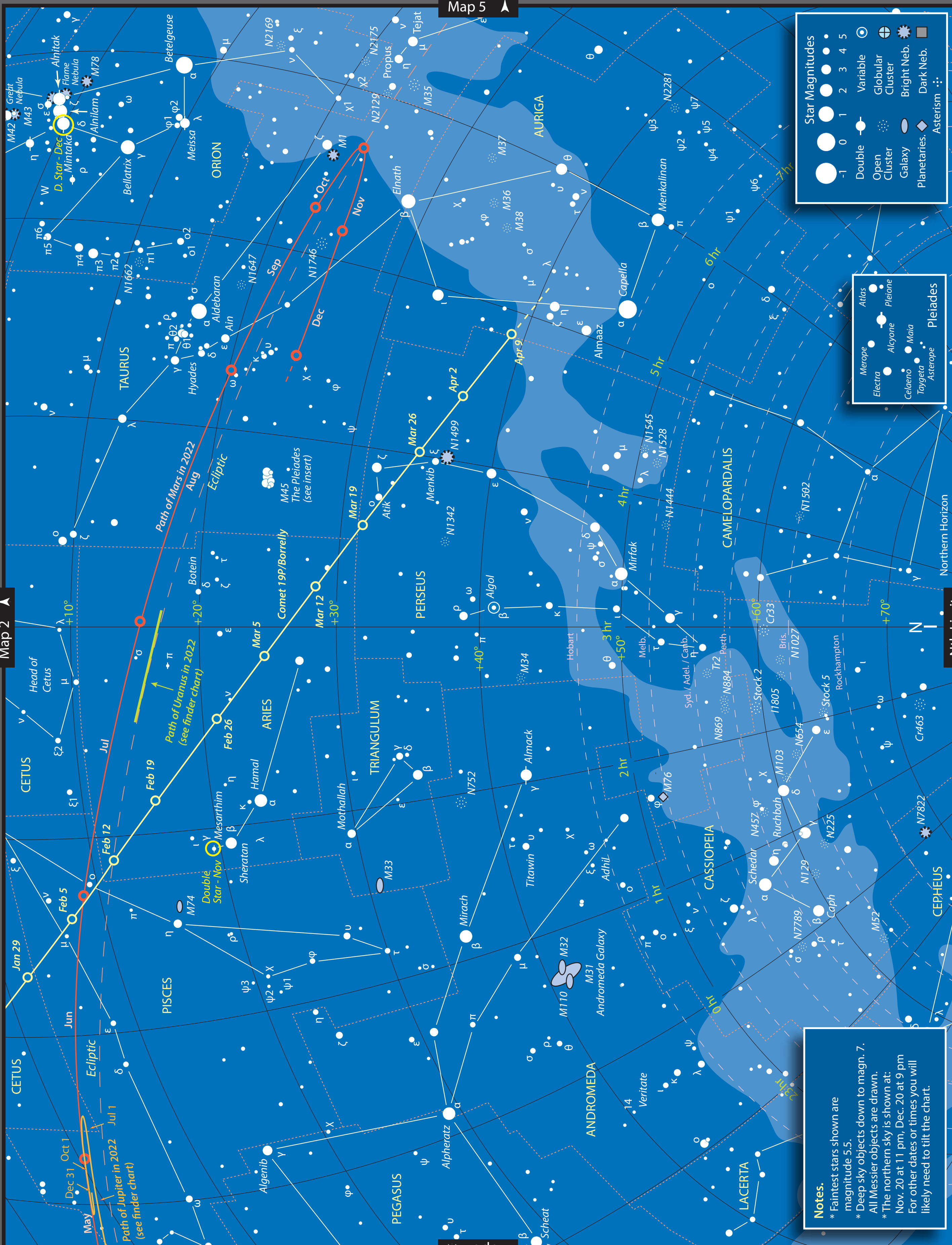
A diffusion filter helps to bring out the colour of the stars in the Milky Way by preventing over-saturation of individual pixels from the normally pin point stars. Saturn and Mars can be seen in between the gaps in the horse shoe orb sculpture. Ilford April 2018, credit Greg Priestley.

Map 1 - Looking South

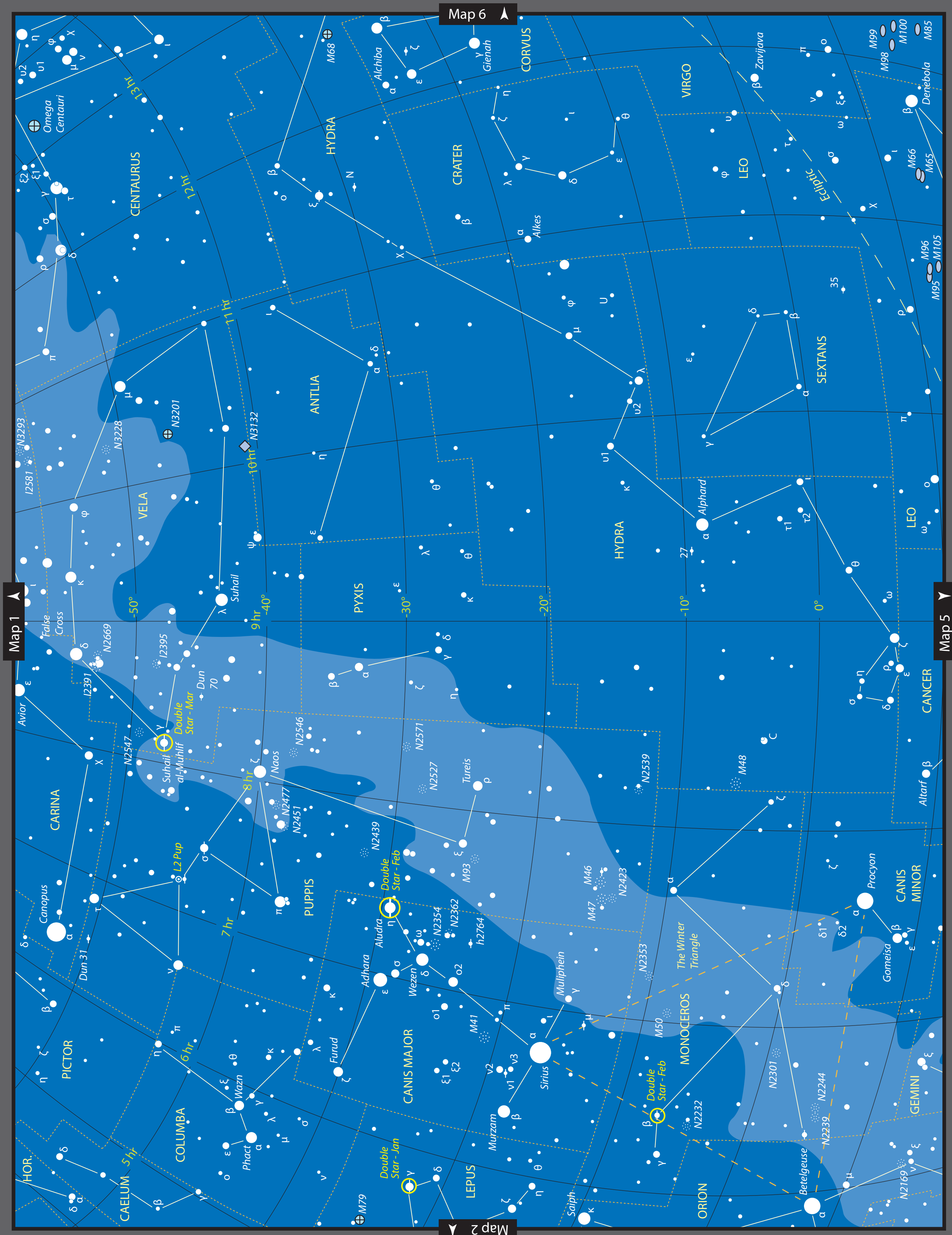
Map 2 - Summer (Centre)



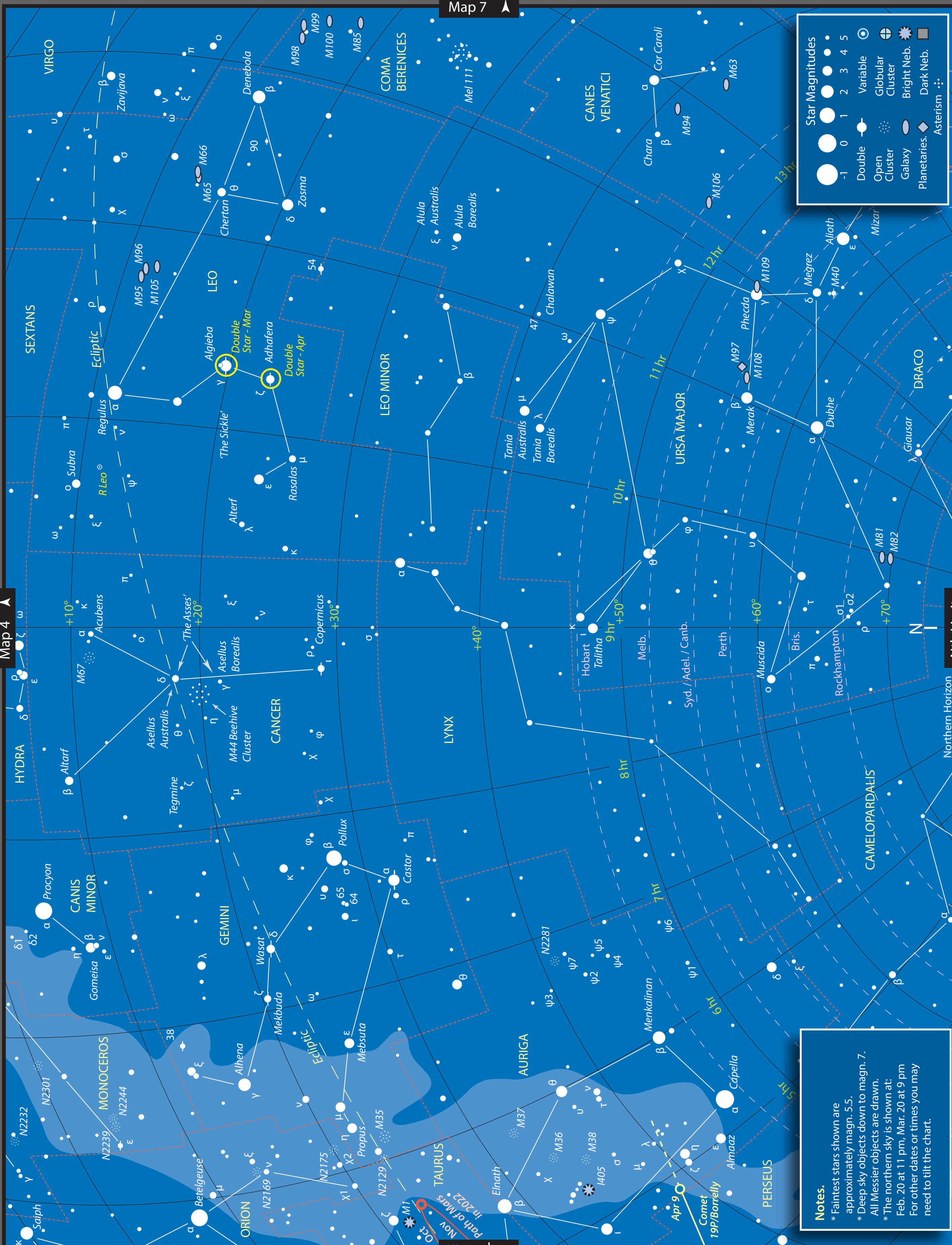
Map 3 - Summer (North)



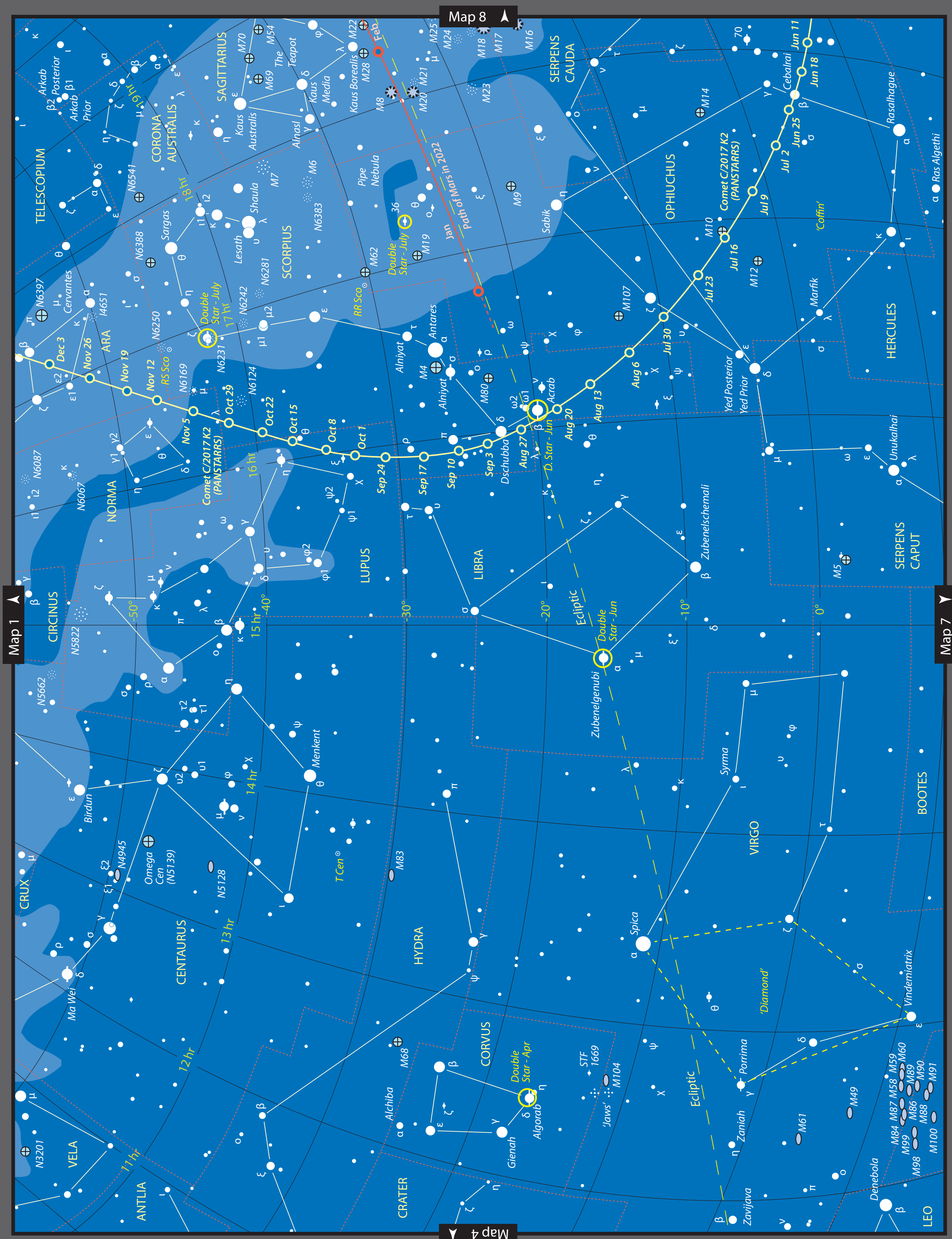
Map 4 - Autumn (Centre)



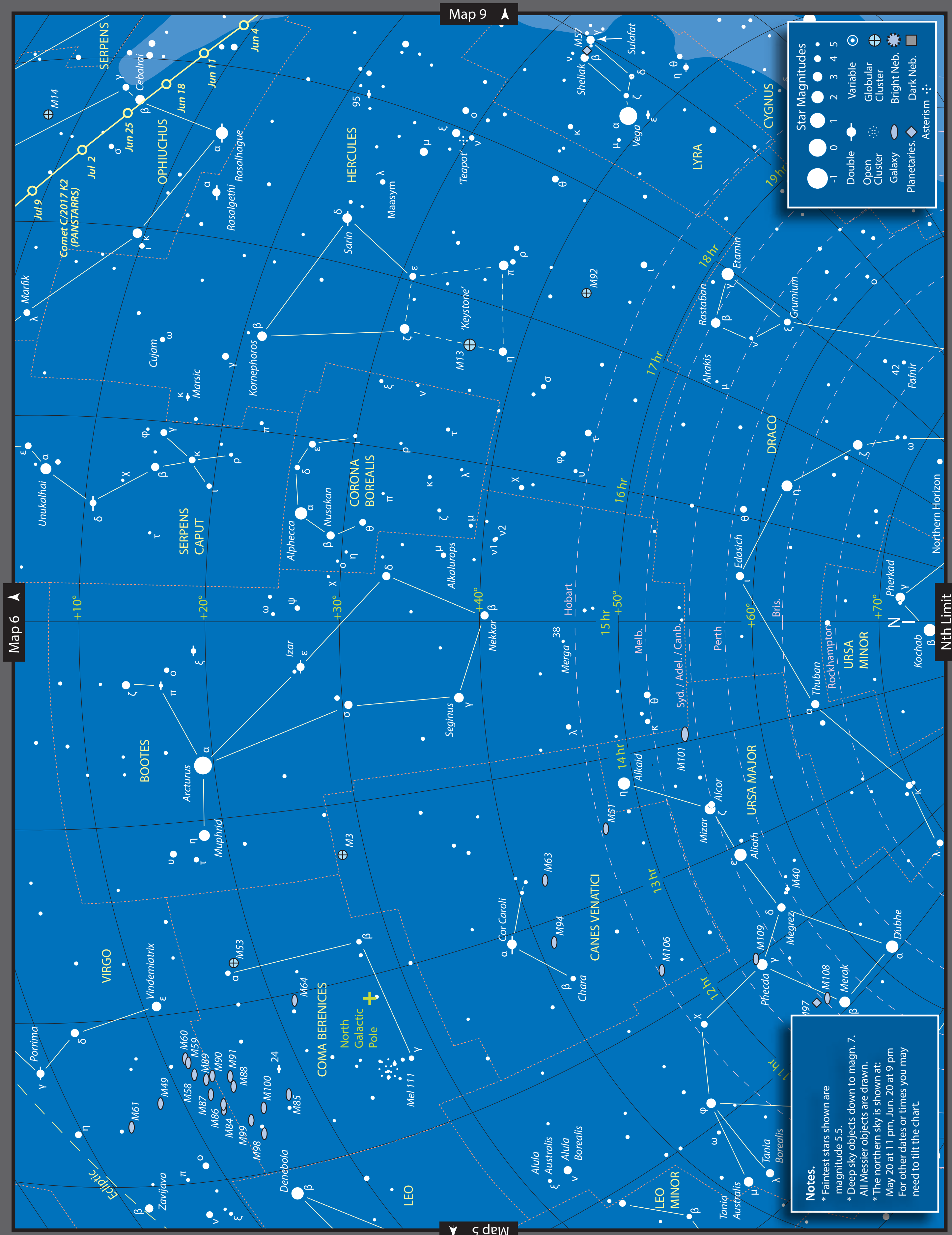
Map 5 - Autumn (North)



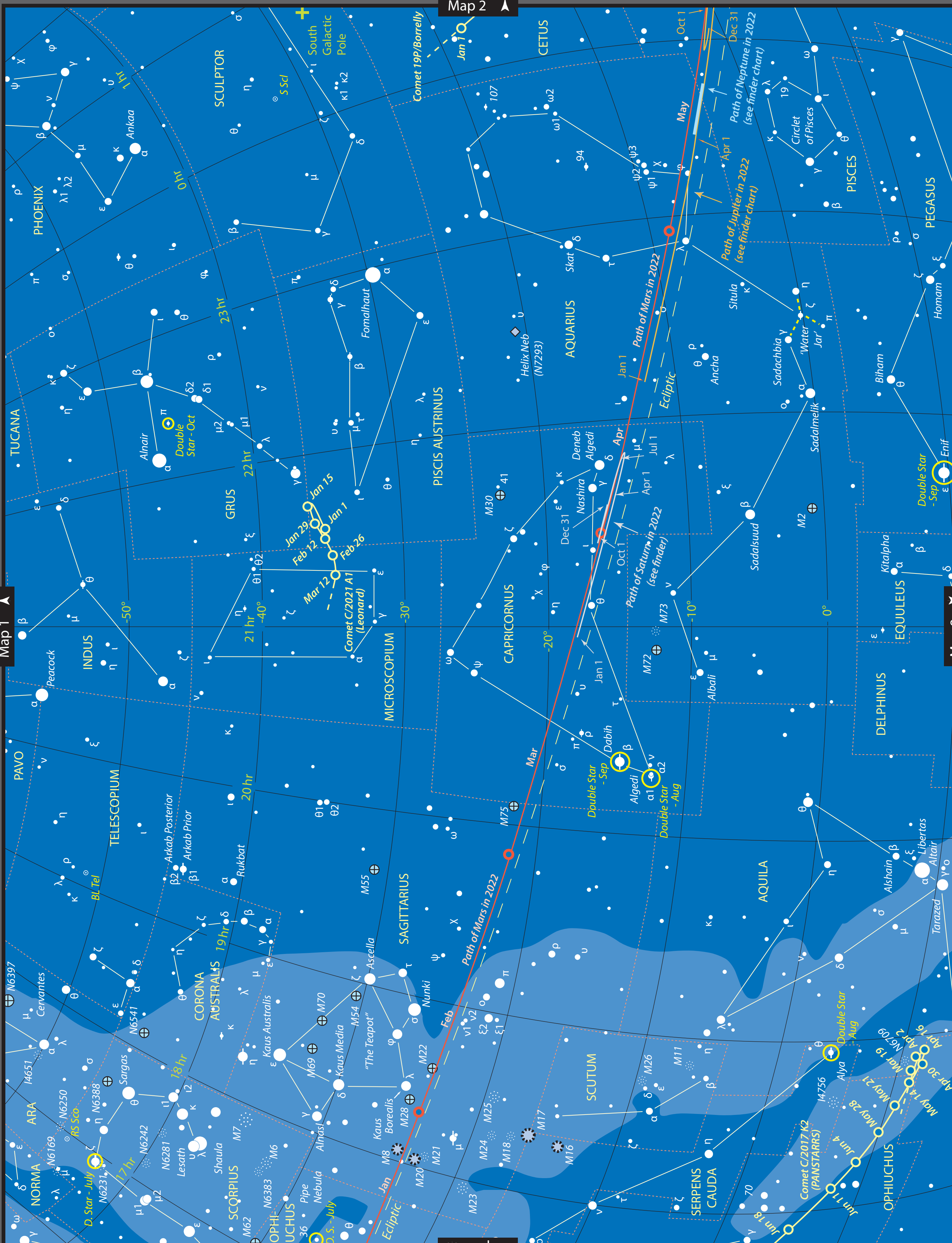
Map 6 - Winter (Centre)



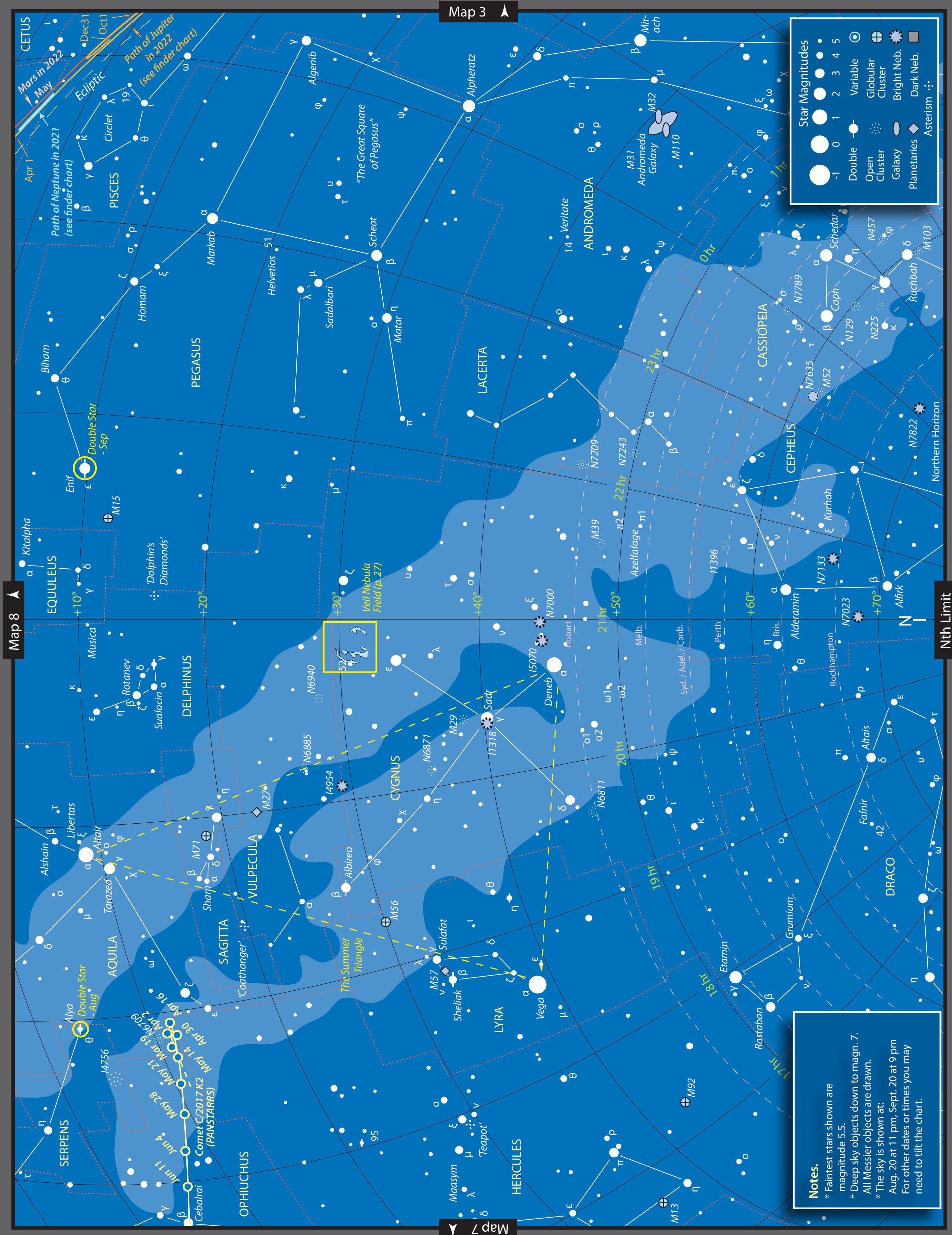
Map 7 - Winter (North)



Map 8 - Spring (Centre)



Map 9 - Spring (North)



PART II — THE SOLAR SYSTEM

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

Time. There are four time zones used in Part II: Eastern Standard Time (EST), Central Standard Time (CST), Western Standard Time (WST) and Universal Time (UT). Local times are used wherever we have location specific data, such as the rise and set times of the Sun and Moon. As in Part I, **no allowance has been made for Daylight Saving Time.** When in force you will need to add one hour to the times given.

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

The 24 hour clock is often used in astronomy for example, 16:00 is the same as 4:00 pm. This avoids the need to distinguish between ‘am’ and ‘pm’ and is frequently used in Part II of this book, for example for rising and setting times.

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

Locations: Rise and set times 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

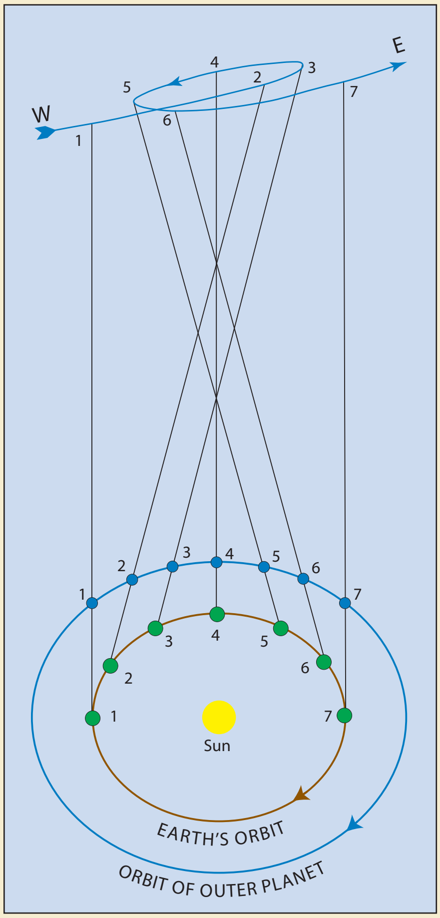
Use of Star Atlases. As the Earth orbits the Sun the polar axis, around which the stars rotate (the celestial poles) appears to never change no matter what time of the year you are observing. However, the positions of the poles do slowly move against the star field. This is called precession and is caused by the Earth’s axis slowly wobbling over thousands of years, like a spinning top slowing down. ‘Epoch 2000.0’ refers to an

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.



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. All the satellite diagrams and finder charts in this book are drawn to normal sky orientation, that is east to the left, and north to the top (in the sky, east and west are opposite to terrestrial maps). Binoculars (and the eyes) or straight Newtonians show this 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-Cassegrains 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 2022. 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]
May 16	04:14	362,127	33.00	0.959	1.252 / 1.127	May 17	15:27	1.467
Jun 14	11:52	357,656	33.41	0.995	1.290 / 1.155	Jun 14	23:23	0.480
Jul 13 [6]	18:38	357,418	33.43	0.997	1.292 / 1.157	Jul 13	09:06	–0.397
Aug 12	01:36	361,412	33.06	0.965	1.258 / 1.131	Aug 10	17:09	–1.352

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	
1225	Jan 2	18:33	Jan 9	18:11	Jan 17	23:48	Jan 25	13:41
1226	Feb 1	05:46	Feb 8	13:50	Feb 16	16:56	Feb 23	22:32
1227	Mar 2	17:35	Mar 10	10:45	Mar 18	07:18	Mar 25	05:37
1228	Apr 1	06:24	Apr 9	06:48	Apr 16	18:55	Apr 23	11:56
1229	Apr 30	20:28	May 9	00:21	May 16	04:14	May 22	18:43
1230	May 30	11:30	Jun 7	14:48	Jun 14	11:52	Jun 21	03:11
1231	Jun 29	02:52	Jul 7	02:14	Jul 13	18:38	Jul 20	14:19
1232	Jul 28	17:55	Aug 5	11:07	Aug 12	01:36	Aug 19	04:36
1233	Aug 27	08:17	Sep 3	18:08	Sep 10	09:59	Sep 17	21:52
1234	Sep 25	21:55	Oct 3	00:14	Oct 9	20:55	Oct 17	17:15
1235	Oct 25	10:49	Nov 1	06:37	Nov 8	11:02	Nov 16	13:27
1236	Nov 23	22:57	Nov 30	14:37	Dec 8	04:08	Dec 16	08:56
1237	Dec 23	10:17	Dec 30	01:21				

PERIGEE AND APOGEE (UT)

Perigee			Apogee		
Date	Time	Distance (km)	Date	Time	Distance (km)
Jan 1	22:55	358,033	Jan 14	09:26	405,805
Jan 30	07:11	362,252	Feb 11	02:37	404,897
Feb 26	22:25	367,789	Mar 10	23:04	404,268
Mar 23	23:37	369,760	Apr 7	19:11	404,438
Apr 19	15:13	365,143	May 5	12:46	405,285
May 17	15:27	360,298	Jun 2	01:13	406,192
Jun 14	23:23	357,432	Jun 29	06:08	406,580
Jul 13	09:06	357,264	Jul 26	10:22	406,274
Aug 10	17:09	359,828	Aug 22	21:52	405,418
Sep 7	18:19	364,492	Sep 19	14:43	404,556
Oct 4	16:34	369,325	Oct 17	10:20	404,328
Oct 29	14:36	368,291	Nov 14	06:40	404,921
Nov 26	01:31	362,826	Dec 12	00:28	405,869
Dec 24	08:27	358,270			

GEOCENTRIC PHENOMENA (UT)

Planet	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary	Greatest Elongation West	Superior Conjunction
Mercury	7 Jan, 11 h (19.2°) 29 Apr, 8 h (20.6°) 27 Aug, 16 h (27.3°) 21 Dec, 15 h (20.1°)	14 Jan, 1 h 10 May, 23 h 9 Sep, 20 h 29 Dec, 3 h	23 Jan, 10 h 21 May, 19 h 23 Sep, 7 h	3 Feb, 22 h 3 Jun, 0 h 1 Oct, 15 h	16 Feb, 21 h (26.3°) 16 Jun, 15 h (23.2°) 8 Oct, 21 h (18.0°)	2 Apr, 23 h 16 Jul, 20 h 8 Nov, 17 h
Venus			9 Jan, 1 h	29 Jan, 8 h	20 Mar, 9 h (46.6°)	22 Oct, 21 h

Planet	Stationary	Conjunction	Stationary	Opposition	Stationary	Earth	
Mars			30 Oct, 11 h	8 Dec, 6 h		Perihelion	4 Jan, 7 h
Jupiter		5 Mar, 14 h	29 Jul, 12 h	26 Sep, 20 h	24 Nov, 13 h	Equinox	20 Mar, 16 h
Saturn		4 Feb, 19 h	5 Jun, 14 h	14 Aug, 17 h	23 Oct, 9 h	Solstice	21 Jun, 9 h
Uranus	18 Jan, 20 h	5 May, 7 h	24 Aug, 15 h	9 Nov, 8 h		Aphelion	4 Jul, 7 h
Neptune		13 Mar, 12 h	28 Jun, 23 h	16 Sep, 22 h	4 Dec, 10 h	Equinox	23 Sep, 1 h
Pluto		16 Jan	30 Apr	20 Jul	8 Oct	Solstice	21 Dec, 22 h

HELIOCENTRIC PHENOMENA (UT)

Planet	Perihelion	Aphelion	Ascending Node	Greatest Latitude North	Descending Node	Greatest Latitude South
Mercury	Jan 15 Apr 13 Jul 10 Oct 6	Feb 28 May 27 Aug 23 Nov 19	Jan 11 Apr 9 Jul 6 Oct 2 Dec 29	Jan 26 Apr 24 Jul 21 Oct 17	Feb 18 May 17 Aug 13 Nov 9	Mar 21 Jun 17 Sep 13 Dec 10
Venus	Jan 23 Sep 4	May 15 Dec 26	Aug 2	Feb 13 Sep 26	Apr 10 Nov 21	Jun 6
Mars	Jun 21		Oct 20			May 26
Jupiter						Dec 12
Saturn, Uranus, and Neptune have no events in 2022						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS and PLUTO

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun (× 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 (× 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 The 20 new moons of Saturn announced in 2019, making Saturn King.
18 Maximum elongation at mean opposition

The satellite table (right) covers those currently known (as of August 2021). Some are not yet named, instead they have a preliminary designation such as S/2007 S3.

SOLAR SYSTEM DATA — SATELLITES

Earth

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
Moon	27.321661		384.400	1,737.4	–12.74

Mars

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
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

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
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

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
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[17]	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[17]	853.80		17402.8	2[15]	24.9
S/2004 S29[17]	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
S/2004 S20[17]	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
S/2004 S27[17]	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
S/2004 S22[17]	1080.4		20379.9	1.5[15]	25.3
S/2004 S30[17]	1084.1		20424	1.5[15]	25.4
S/2004 S25[17]	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
S/2004 S23[17]	1164.3		21427	2[15]	24.8
S/2004 S32[17]	1175.3		21564.2	2[15]	25.0
S/2004 S28[17]	1197.2		21791.3	2[15]	24.9
S/2004 S35[17]	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[17]	1277.5		22790.4	1[15]	25.5
S/2004 S38[17]	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[17]	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[17]	1354.2		23698.7	1.5[15]	25.3
S/2004 S33[17]	1361.5		23764.8	2[15]	25.0
S/2004 S21[17]	1365.1		23810.4	1.5[15]	25.4
S/2004 S34[17]	1412.5		24358.9	1.5[15]	25.3
S/2004 S26[17]	1624.2		26737.8	2[15]	25.0

Uranus

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
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

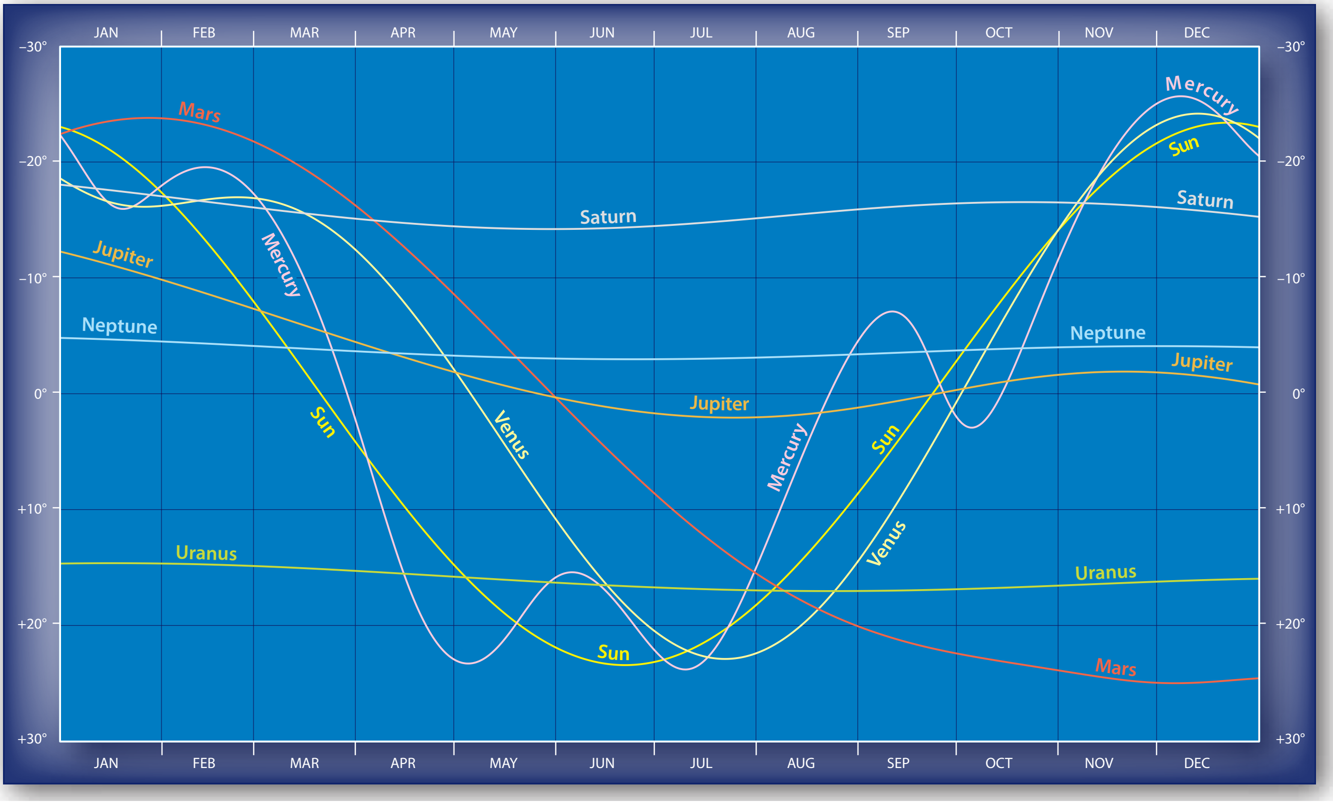
Neptune

SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
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

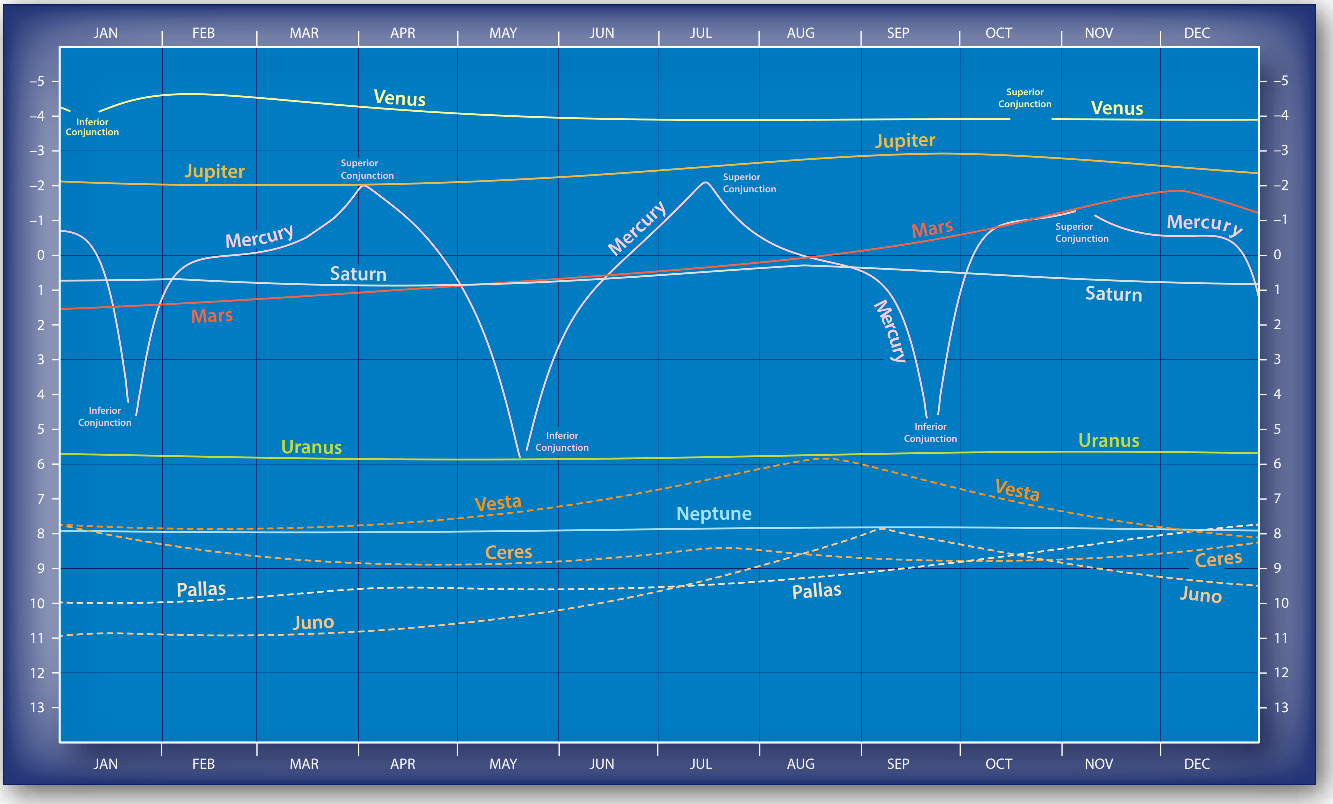
SATELLITE	ORBITAL PERIOD (days)	SEP[18]	SEMI MAJOR AXIS (x 10^3km)	RADIUS (km)	MAG AT OPP
Charon	6.38723	1"	19.571	604	17.3
Styx	20.16	2"	42.393	10	27.0
Nix	24.8562	2"	48.671	13	23.4
Kerberos	32.17	2"	57.729	14	26.1
Hydra	38.2065	2"	64.698	30.5	22.9

DECLINATIONS of the SUN and PLANETS

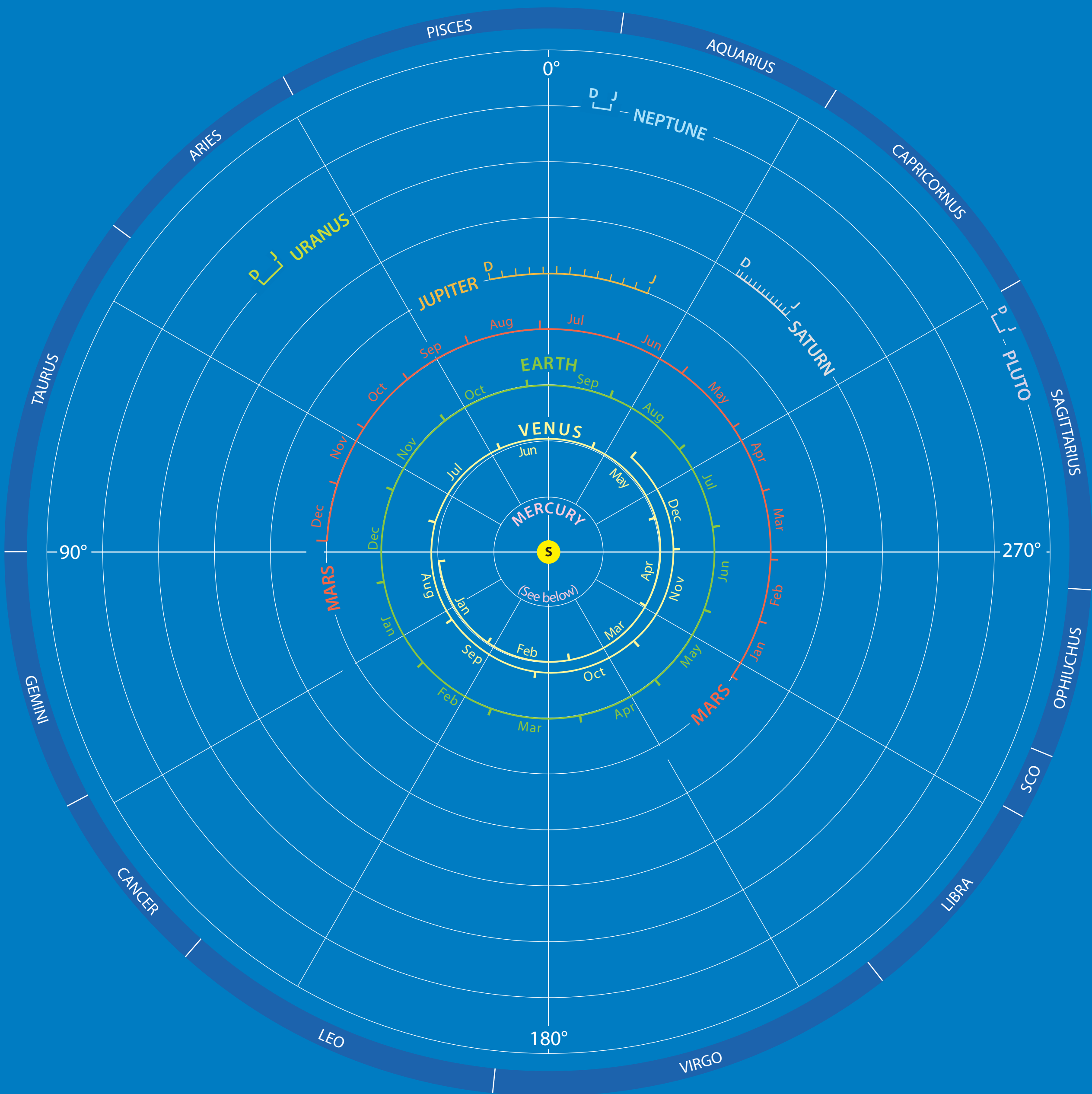


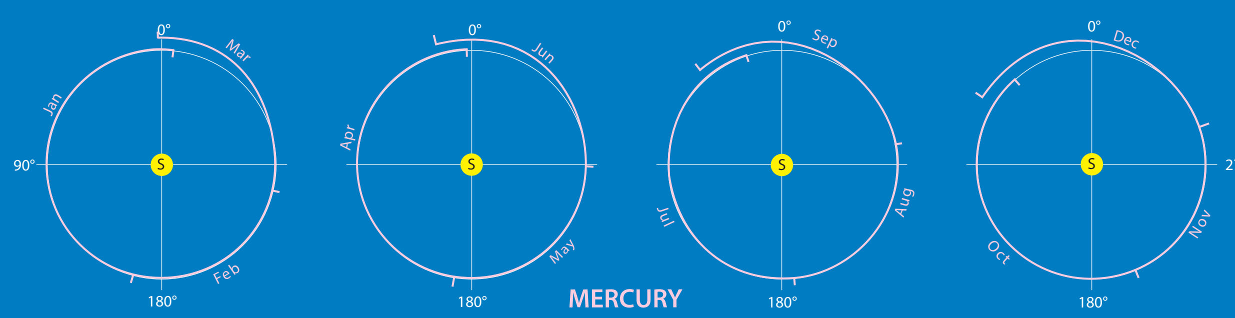
In general, the further south a planet is (lower declination), the higher in the northern sky it is, as seen from most of Australia. The higher in the sky, the less atmosphere you have to look through and the more stable the image, being less prone to turbulence. This can be particularly relevant when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

MAGNITUDES of the PLANETS, BRIGHT DWARF and MINOR PLANETS



PLANET POSITIONS





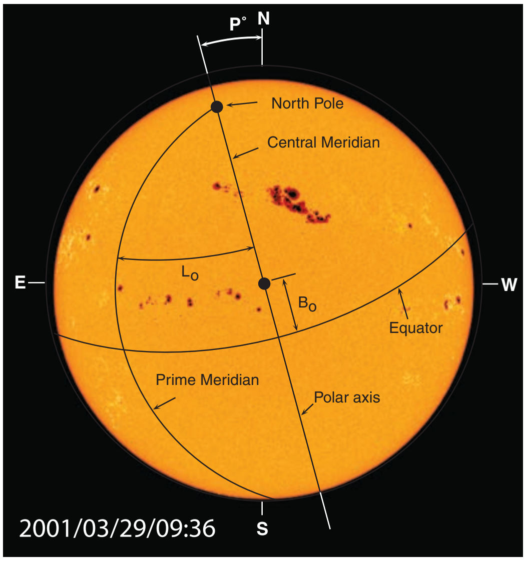
This diagram illustrates the relative positions of the planets during the course of their orbits in 2022. The relationships between the major Solar System bodies are clearly shown. The diagram is drawn as viewed from above (north of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the Sun and planet distances are not drawn to scale. The thirteen named constellations are those situated on the ecliptic.

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

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



ORIENTATION OF THE SUN

SYNODIC ROTATION NUMBERS (UT)		
Rotation	Month	d.dd
2253	Jan	11.83
2254	Feb	8.17
2255	Mar	7.50
2256	Apr	3.81
2257	May	1.07
2258	May	28.29
2259	Jun	24.49
2260	Jul	21.69
2261	Aug	17.92
2262	Sep	14.17
2263	Oct	11.45
2264	Nov	7.74
2265	Dec	5.05

Date (0 h UT)		P°	B_o°	L_o°
Jan	1	+ 2.1	– 3.0	142.5
	8	– 1.3	– 3.8	050.4
	15	– 4.6	– 4.5	318.2
	22	– 7.9	– 5.2	226.0
	29	– 10.9	– 5.8	133.8
Feb	5	– 13.7	– 6.3	041.7
	12	– 16.3	– 6.7	309.5
	19	– 18.7	– 7.0	217.3
	26	– 20.7	– 7.2	125.1
Mar	5	– 22.5	– 7.3	032.9
	12	– 23.9	– 7.2	300.7
	19	– 25.0	– 7.1	208.4
	26	– 25.8	– 6.8	116.1
Apr	2	– 26.2	– 6.5	023.8
	9	– 26.3	– 6.1	291.4
	16	– 26.0	– 5.6	199.0
	23	– 25.3	– 5.0	106.6
	30	– 24.3	– 4.3	014.1
May	7	– 23.0	– 3.6	281.6
	14	– 21.3	– 2.8	189.0
	21	– 19.2	– 2.0	096.4
	28	– 16.9	– 1.2	003.8
Jun	4	– 14.3	– 0.3	271.2
	11	– 11.5	+ 0.5	178.5
	18	– 8.5	+ 1.4	085.9
	25	– 5.4	+ 2.2	353.2

Date (0 h UT)		P°	B_o°	L_o°
Jul	2	– 2.3	+ 3.0	260.6
	9	+ 0.9	+ 3.7	167.9
	16	+ 4.0	+ 4.4	075.3
	23	+ 7.1	+ 5.0	342.7
	30	+ 10.0	+ 5.6	250.1
Aug	6	+ 12.7	+ 6.1	157.5
	13	+ 15.3	+ 6.5	064.9
	20	+ 17.6	+ 6.9	332.4
	27	+ 19.7	+ 7.1	239.9
Sep	3	+ 21.5	+ 7.2	147.4
	10	+ 23.1	+ 7.3	055.0
	17	+ 24.4	+ 7.2	322.6
	24	+ 25.3	+ 7.0	230.2
Oct	1	+ 25.9	+ 6.7	137.8
	8	+ 26.2	+ 6.4	045.4
	15	+ 26.2	+ 5.9	313.1
	22	+ 25.8	+ 5.3	220.8
	29	+ 25.0	+ 4.7	128.4
Nov	5	+ 23.8	+ 4.0	036.1
	12	+ 22.2	+ 3.2	303.8
	19	+ 20.3	+ 2.4	211.6
	26	+ 18.0	+ 1.6	119.3
Dec	3	+ 15.3	+ 0.7	027.0
	10	+ 12.5	– 0.2	294.8
	17	+ 9.3	– 1.1	202.6
	24	+ 6.1	– 2.0	110.3
	31	+ 2.7	– 2.9	018.1

Sun image shows active region 9393, hosting a large sunspot group. On 29 March 2001, the sunspot area within the group spanned an area of more than 13 times the entire surface of the Earth! It was the source of numerous flares and coronal mass ejections, including the largest flare recorded (at the time) in 25 years on 2 April 2001. Caused by intense magnetic fields emerging from the interior, a sunspot appears to be dark only when contrasted against the rest of the solar surface, because it is slightly cooler than the unmarked regions. Courtesy of SOHO/[MDI] consortium.

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

B_o° Heliocentric Latitude of centre of Sun

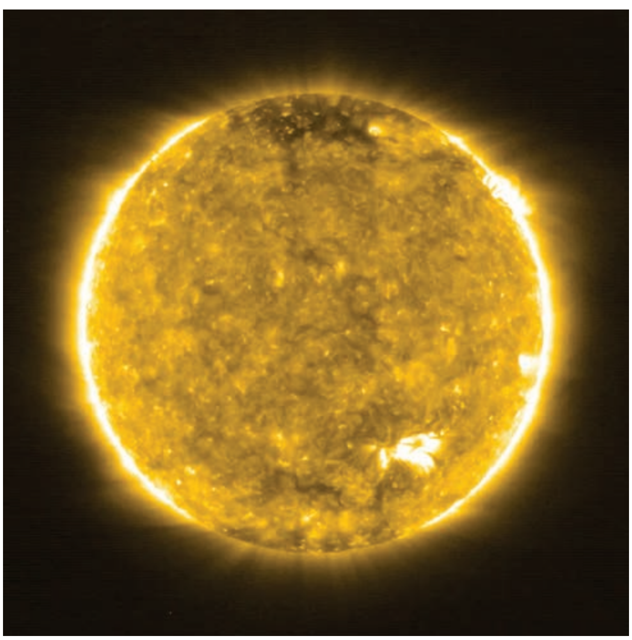
L_o° Heliocentric Longitude of centre of Sun

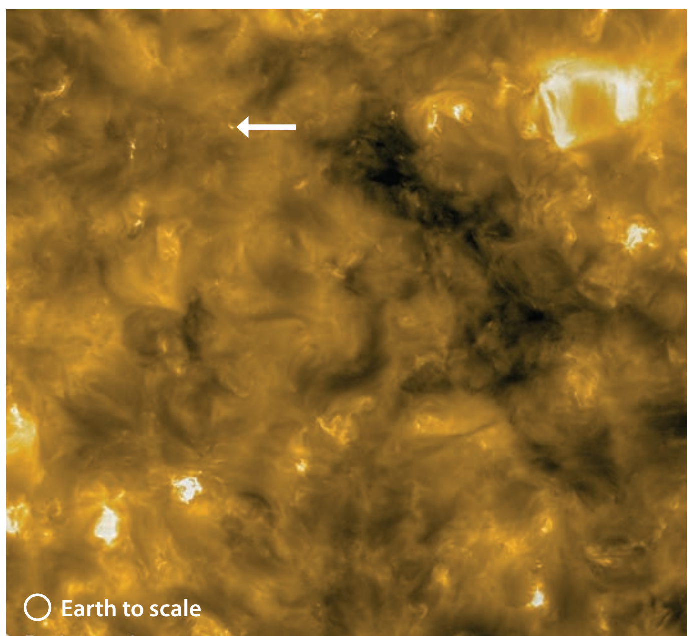
At the date of commencement of each synodic rotation period the value of L_o° is zero; that is, the prime meridian passes through the central point of the disc. The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is 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 12 March (300.7°) 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:

300.7° + (–26.4°) + (–3.3°) = 271.0° (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





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

SOLAR AND LUNAR ECLIPSES

In 2022 there are four eclipses, two of the Sun and two of the Moon. Of the solar eclipses, both are partial, and both lunar eclipses are total.

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 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)**. Carefully check the data you are using when planning your observing.

30 April (UT) — Partial Eclipse of the Sun

The first eclipse of the year is a partial eclipse of the Sun. It is visible from parts of Antarctica, the south-eastern Pacific Ocean, and southern South America. Greatest eclipse at magnitude 0.64 occurs over the ocean between the Antarctic Peninsula and Cape Horn in southern Chile. The eclipse begins at 18h 45m, greatest eclipse occurs at 20h 41m and ends at 22h 38m UT.

16 May (UT) — Total Eclipse of the Moon

The first lunar eclipse of the year is total and visible from South America, North America, Africa, western Europe, and the Middle East. The Moon's path through the umbral shadow takes it just south of the centre, ensuring a relatively dark eclipse. The umbral magnitude is 1.419. The first contact is at 01h 30m, mid-eclipse at 04h 11m, and last contact at 06h 52m UT.

25 October (UT) — Partial Eclipse of the Sun

This year's second partial solar eclipse is visible from Europe, the Middle East, northern Africa, and western Asia. Greatest eclipse at magnitude 0.86 occurs over central Russia. The eclipse begins at 08h 58m, greatest eclipse occurs at 11h 00m and ends at 13h 02m UT.

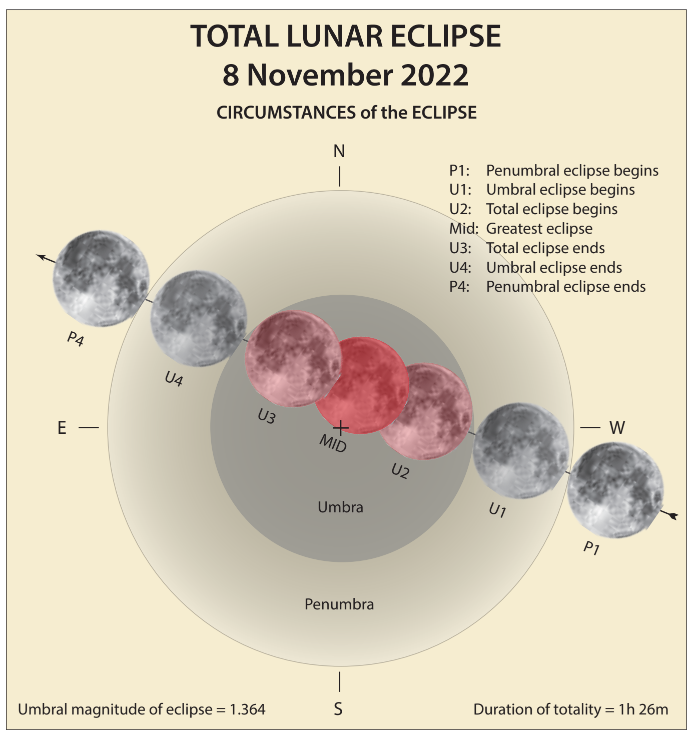
8 November (EST) — Total Eclipse of the Moon

The last eclipse is a total lunar eclipse and the first across Australia since May 2021. Unfortunately, it is not visible in its entirety across the country. The eastern states will get the best view, although the Moon will be partially in the penumbra at moonrise. There will be some twilight interference which increases the further south an observer is, although all in the east will see the totally eclipsed Moon. The view from Central Australia will be affected by twilight until the beginning of totality. Unluckily for Western Australians, the Moon will have started exiting the umbral shadow as twilight ends. The eclipse will be reasonably dark for those fortunate to view totality, with the Moon passing just north of the umbral centre.

As a bonus, during this eclipse, Uranus, just one day after its opposition, will be less than 1° away from the Moon's western limb.

8 Nov		UT	EST	CST	WST
Penumbral eclipse begins	P1	08:00	6:00 pm	5:30 pm	4:00 pm
Umbral eclipse begins	U1	09:09	7:09 pm	6:39 pm	5:09 pm
Total eclipse begins	U2	10:16	8:16 pm	7:46 pm	6:16 pm
Greatest eclipse	Mid	10:59	8:59 pm	8:29 pm	6:59 pm
Total eclipse ends	U3	11:42	9:42 pm	9:12 pm	7:42 pm
Umbral eclipse ends	U4	12:49	10:49 pm	10:19 pm	8:49 pm
Penumbral eclipse ends	P4	13:58	11:58 pm	11:28 pm	9:58 pm


Total lunar eclipse on January 21, 2019 from Oria (Brindisi), Italy



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

ADELAIDE (CST)

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

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

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

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

BRISBANE (EST)

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

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

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

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

CANBERRA (EST)

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

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

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

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 of the month. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

DARWIN (CST)

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

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

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

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

HOBART (EST)

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

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

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

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

MELBOURNE (EST)

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

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

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

MOON RISE AND SET

PERTH (WST)

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

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

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

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

SYDNEY (EST)

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

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

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

OBSERVING THE MOON

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

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

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

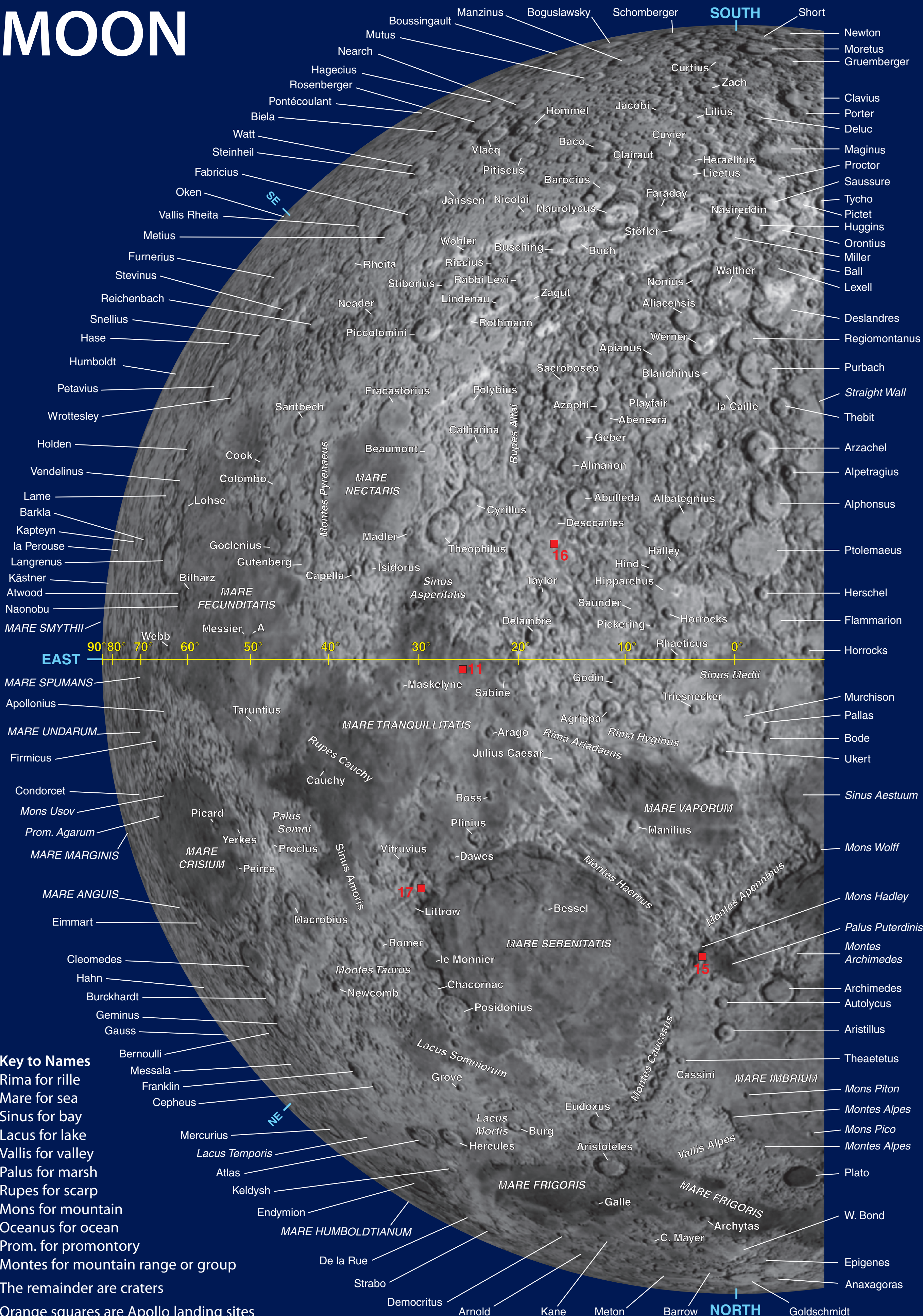
FEATURE	NOTES
Day 3 (48° E)	
Biela (76 km)	three central peaks
Furnerius, Petavius, Vendelinus and Langrenus	easily recognised row of four craters
Furnerius (130 km)	look for small crater on floor
Petavius (177 km)	central mountain and rille
Vendelinus (150 km) and Lame (84 km)	merged craters (Lame was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

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

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

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

MOON

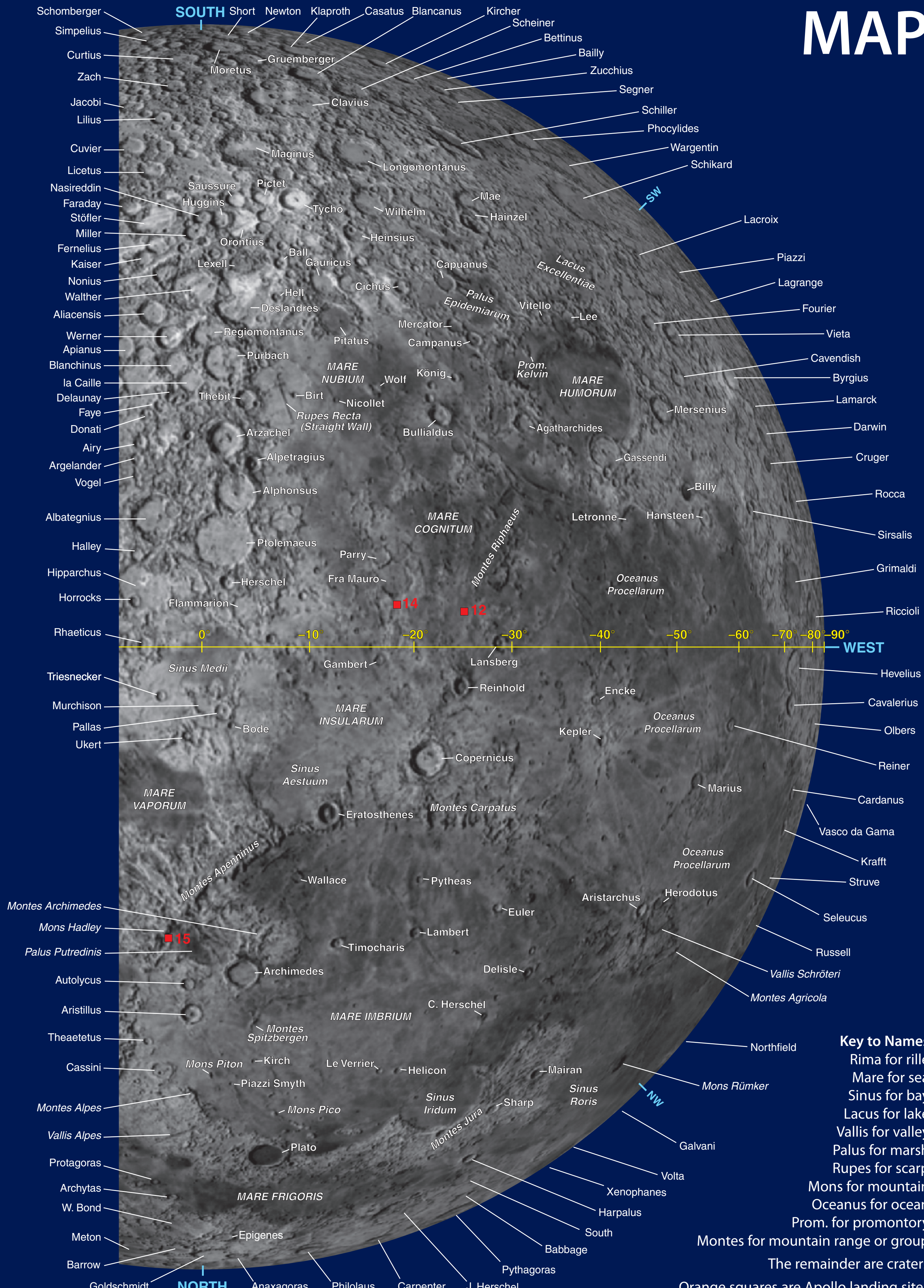


Key to Names
Rima for rille
Mare for sea
Sinus for bay
Lacus for lake
Vallis for valley
Palus for marsh
Rupes for scarp
Mons for mountain
Oceanus for ocean
Prom. for promontory
Montes for mountain range or group

The remainder are craters

Orange squares are Apollo landing sites

MAP



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The remainder are craters
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MOON

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 2022 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.

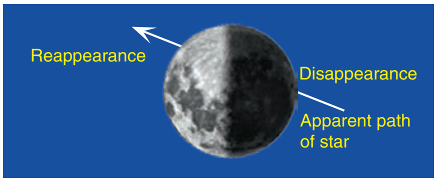
Besides being a spectacular event, the observation of occultations is an area in which the amateur can make a scientific contribution.

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
- 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 Iot Gem (Iota Geminorum) on November 14 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 00:18 EST and the values of A and B are + 4.1 and – 6.3 respectively.

Therefore the equation becomes:

00:18 + (+4.1 × –2.21°) + (–6.3 × –0.83°)
= 00:18 + (–9.1) + (+5.2)
= 00:18 + (–3.8) = 00:14

The event will be visible from Albury approximately four minutes earlier than Canberra, i.e., about 12:14 am (EST) on November 14.

Lunar occultation predictions calculated using Occult version 4.12.8.0 by D. Herald.

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 00:43	621	DD	6.1	132	12	73	1.3	1.6
Jan 14 21:25	98 Tau	DD	5.8	142	30	21	1.3	2.2
Jan 26 02:29	2 Lib	RD	6.2	88	33	257	1.3	−0.8
Jan 26 03:07	2064	RD	6.3	87	40	306	0.8	−1.9
Jan 28 02:05	2330	RD	6.4	62	12	280	−0.1	−1.2
Jan 29 02:41	39 Oph	RD	5.2	48	9	277	−0.2	−1.1
Feb 06 20:28	96 Psc	DD	6.5	66	22	26	0.8	2.6
Feb 15 22:49	Xi Cnc	DD	5.2	165	32	164	1.4	−2.7
Feb 15 23:23	79 Cnc	DD	6.0	166	33	149	1.6	−1.8
Feb 18 23:06	Ome Vir	RD	5.2	157	30	302	1.3	−1.8
Feb 19 04:12	Nu Vir	DB	4.0	155	40	172	0.2	−2.4
Feb 19 05:05	Nu Vir	RD	4.0	155	31	263	1.9	1.5
Feb 23 03:10	Nu Lib	DB	5.2	105	57	88	2.1	−0.7
Feb 23 04:13	Nu Lib	RD	5.2	105	67	339	0.7	−2.9
Feb 23 04:44	22 Lib	RD	6.4	105	71	301	1.8	−1.4
Feb 27 04:10	2804	DB	5.8	52	27	78	0.6	−0.7
Feb 27 05:11	2804	RD	5.8	51	40	291	0.7	−1.7
Mar 01 04:31	Phi Cap	RD	5.2	25	6	275	−0.2	−1.1
Mar 22 23:10	41 Lib	RD	5.5	124	26	252	0.9	−0.7
Mar 22 23:57	Kap Lib	DB	4.8	124	35	163	−0.3	−2.7
Mar 23 00:43	Kap Lib	RD	4.8	124	45	254	1.7	−0.5
Mar 26 02:54	2740	RD	6.3	83	38	219	2.0	1.4
Mar 26 03:25	Sig Sgr	DB	2.1	83	44	50	1.8	0.7
Mar 26 04:15	Sig Sgr	RD	2.1	82	54	322	0.7	−3.4
Apr 09 21:40	Ups Gem	DD	4.1	92	15	66	2.2	2.1
Apr 09 22:35	Ups Gem	RB	4.1	92	7	332	−0.2	−1.0
Apr 16 18:38	66 Vir	DD	5.8	174	10	133	0.1	−1.8
Apr 16 23:03	74 Vir	DD	4.7	176	58	100	2.2	−0.9
Apr 17 00:10	74 Vir	RB	4.7	176	62	339	0.9	−2.4
Apr 18 23:52	28 Lib	RD	6.2	155	59	256	2.4	−0.1
Apr 20 21:53	The Oph	DB	3.3	129	15	78	0.2	−0.8
Apr 20 22:25	2499	RD	6.4	129	22	335	−0.7	−2.5
Apr 20 22:40	The Oph	RD	3.3	129	25	317	−0.2	−2.0
Apr 21 23:11	2669	RD	6.4	115	19	230	0.9	0.2
Apr 25 01:57	Eps Cap	RD	4.5	74	14	263	0.2	−0.9
May 06 18:42	1093	DD	6.6	61	21	144	0.9	−0.9
May 07 21:29	Psi Cnc	DD	5.7	72	7	111	0.6	0.5
May 17 01:03	2282	RD	5.8	174	75	321	1.5	−2.0
May 22 01:37	33 Cap	DB	5.4	104	34	128	0.5	−3.3
May 22 02:19	33 Cap	RD	5.4	103	43	203	1.5	2.5
Jun 10 18:58	74 Vir	DD	4.7	124	54	103	2.0	−1.2
Jun 10 20:08	74 Vir	RB	4.7	124	61	335	0.9	−2.3
Jun 12 19:28	28 Lib	DD	6.2	151	49	160	0.1	−2.7
Jun 14 17:49	The Oph	RB	3.3	178	10	288	−0.3	−1.2
Jun 15 23:24	Phi Sgr	DB	3.2	164	63	153	0.7	−4.5
Jun 16 00:04	Phi Sgr	RD	3.2	163	70	215	2.6	3.2
Jun 16 03:52	2740	RD	6.3	162	59	269	1.6	0.8
Jun 18 05:25	Chi Cap	DB	5.3	133	63	18	0.4	3.2
Jun 18 06:17	Chi Cap	RD	5.3	133	53	286	2.1	0.3
Jul 05 22:49	Nu Vir	DD	4.0	71	0	73	0.3	2.1
Jul 10 21:15	2282	DD	5.8	134	76	38	5.5	8.9
Jul 10 21:34	2282	RD	5.8	134	74	10		
Jul 11 20:56	26 Oph	DD	5.7	147	73	165	0.5	−4.4
Jul 11 21:39	26 Oph	RB	5.7	148	79	230	3.0	2.7
Jul 12 02:43	2469	DD	6.5	150	31	117	0.9	0.2
Jul 16 01:35	Eps Cap	DB	4.5	152	72	97	2.4	−0.7
Jul 16 02:40	Eps Cap	RD	4.5	152	74	207	1.1	2.6
Jul 16 23:56	56 Aqr	RD	6.4	139	42	235	1.2	0.4
Aug 03 19:42	46 Vir	DD	6.2	64	36	132	1.0	−0.6
Aug 05 23:37	5 Lib	DD	6.3	91	15	114	0.4	0.4
Aug 06 18:51	2217	DD	5.5	102	75	131	1.7	−1.7
Aug 06 20:12	2217	RB	5.5	102	66	283	2.1	−0.1
Aug 09 20:10	Phi Sgr	DD	3.2	143	67	121	1.6	−2.0
Aug 09 21:20	Phi Sgr	RB	3.2	144	80	242	2.2	1.2
Aug 09 23:46	2740	DD	6.3	145	65	65	1.5	1.6
Aug 12 01:56	Chi Cap	DD	5.3	173	62	61	1.3	1.6
Aug 13 20:04	74 Aqr	RD	5.8	160	11	315	−0.3	−4.5
Aug 15 03:15	27 Psc	DB	4.9	143	58	32	1.1	2.0
Aug 15 04:28	27 Psc	RD	4.9	143	50	249	1.7	1.4
Aug 15 05:25	29 Psc	DB	5.1	143	41	50	1.1	1.9
Sep 01 19:28	2065	DD	6.5	60	39	43	1.9	7.4
Sep 04 00:28	Rho Oph	DD	5.0	87	6	130	0.2	−0.1
Sep 04 00:28	184381	DD	5.7	87	6	130	0.2	0.0
Sep 05 00:29	2514	DD	6.4	101	18	99	0.2	0.8
Sep 05 19:04	2650	RB	4.7	112	80	274	2.2	−0.4
Sep 05 23:19	2673	DD	6.3	113	44	44	0.4	2.6
Sep 08 21:51	Eps Cap	DD	4.5	154	71	98	2.4	−0.8
Sep 08 22:56	Eps Cap	RB	4.5	154	74	205	1.0	2.7
Sep 09 19:19	56 Aqr	DD	6.4	166	30	105	0.8	−1.9
Sep 15 05:00	Rho Ari	DB	5.6	125	34	28	1.5	2.1
Oct 01 21:23	31 Oph	DD	6.6	69	30	133	1.2	−0.4
Oct 08 22:03	27 Psc	DD	4.9	163	55	13	0.6	2.5
Oct 08 23:06	27 Psc	RB	4.9	163	59	267	2.6	0.2
Oct 09 00:13	29 Psc	DD	5.1	164	55	39	1.2	1.9
Oct 09 01:27	29 Psc	RB	5.1	164	45	242	1.4	1.6
Oct 18 04:16	Phi Gem	DB	5.0	89	21	103	2.1	−1.2
Oct 29 19:58	2558	DD	6.3	52	34	130	1.4	−0.4
Nov 02 00:50	Chi Cap	DD	5.3	94	10	78	−0.2	1.2
Nov 03 22:28	74 Aqr	DD	5.8	119	53	75	1.7	1.3
Nov 03 23:33	74 Aqr	RB	5.8	120	40	211	0.4	2.3
Nov 09 23:40	566	RD	6.1	166	30	230	1.5	0.6
Nov 14 01:49	1132	RD	6.4	121	19	275	1.9	−1.1
Nov 29 20:34	Kap Cap	DD	4.7	75	46	118	2.5	−0.3
Nov 29 21:07	Kap Cap	RB	4.7	75	39	179	−0.9	3.6
Dec 03 23:16	80 Psc	DD	5.5	127	35	71	1.6	1.5
Dec 07 21:43	62 Tau	DD	6.4	172	25	133	4.9	−4.4

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 10 20:45	258	DD	6.6	98	39	88	2.3	1.0
Jan 13 20:38	39 Tau	DD	5.9	131	40	24	1.6	2.5
Jan 14 20:31	740	DD	6.3	141	37	95	3.1	−0.5
Jan 14 22:47	98 Tau	DD	5.8	142	33	10	2.6	5.8
Jan 18 02:33	1169	DD	5.3	174	23	157	0.1	−1.8
Jan 19 00:09	Ups 2 Cnc	RD	6.4	172	38	236	3.8	1.7
Jan 26 03:08	2 Lib	RD	6.2	88	48	299	1.2	−1.7
Jan 26 03:29	2064	RD	6.3	88	53	349	0.1	−3.1
Jan 28 02:23	2330	RD	6.4	62	20	312	−0.1	−1.7
Jan 29 02:58	39 Oph	RD	5.2	48	16	312	−0.3	−1.7
Jan 29 04:29	The Oph	RD	3.3	47	35	207	7.7	9.8
Feb 12 23:54	994	DD	6.6	133	20	115	1.2	0.1
Feb 13 19:40	1105	DD	6.5	142	30	136	3.0	−2.6
Feb 14 19:13	Psi Cnc	DD	5.7	153	20	53	1.1	0.4
Feb 15 23:31	Xi Cnc	DD	5.2	165	41	126	2.1	−1.1
Feb 16 00:12	79 Cnc	DD	6.0	166	39	111	2.3	−0.4
Feb 16 03:07	1373	DD	6.5	167	17	172	−0.8	−2.5
Feb 18 23:40	Ome Vir	RD	5.2	157	45	334	1.2	−2.5
Feb 19 04:44	Nu Vir	DB	4.0	155	34	121	1.2	−0.4
Feb 23 23:55	Lam Lib	RD	5.0	94	15	256	0.4	−0.5
Mar 01 04:20	Phi Cap	DB	5.2	25	7	11	1.5	3.7
Mar 01 04:39	Phi Cap	RD	5.2	25	11	331	−1.3	−5.0
Mar 22 23:43	41 Lib	RD	5.5	124	38	293	0.7	−1.5
Mar 23 00:15	Kap Lib	DB	4.8	124	45	120	0.9	−1.7
Mar 23 01:27	Kap Lib	RD	4.8	124	61	302	1.3	−1.7
Mar 26 03:49	2740	RD	6.3	83	54	271	1.7	−0.8
Apr 16 19:00	66 Vir	DD	5.8	174	21	110	0.5	−1.4
Apr 16 23:17	72 Vir	DD	6.1	176	68	141	1.4	−2.0
Apr 19 00:44	28 Lib	RD	6.2	155	77	307	1.7	−1.7
Apr 21 01:52	2514	RD	6.4	127	70	241	3.0	1.3
Apr 21 03:56	2524	DB	6.0	127	83	167	1.8	−6.9
Apr 21 04:28	2524	RD	6.0	127	76	210	2.4	6.6
Apr 21 23:46	2669	RD	6.4	115	30	277	0.6	−1.0
Apr 21 23:55	2673	RD	6.3	115	32	254	1.0	−0.4
Apr 24 02:22	3018	RD	6.4	87	36	195	2.4	4.5
Apr 25 01:37	Eps Cap	DB	4.5	74	13	28	0.9	1.6
Apr 25 02:17	Eps Cap	RD	4.5	74	22	307	0.1	−2.8
May 18 00:57	2442	RD	5.9	160	87	223	3.8	4.4
May 18 01:17	26 Oph	RD	5.7	160	87	257	2.7	0.8
May 22 02:08	33 Cap	DB	5.4	104	47	89	1.6	−0.8
May 22 03:26	33 Cap	RD	5.4	103	64	233	2.0	1.1
Jun 10 19:12	72 Vir	DD	6.1	124	66	147	1.2	−2.3
Jun 12 19:55	28 Lib	DD	6.2	151	63	113	1.6	−1.4
Jun 14 18:03	The Oph	RD	3.3	178	16	325	−0.6	−2.0
Jun 15 23:59	Phi Sgr	DB	3.2	164	77	107	2.2	−1.1
Jun 16 01:19	Phi Sgr	RD	3.2	163	86	252	2.3	0.9
Jun 16 04:48	2740	RD	6.3	162	41	271	1.1	0.8
Jul 11 21:30	26 Oph	DD	5.7	147	88	115	2.2	−1.2
Jul 11 21:34	2442	DD	5.9	147	88	140	1.9	−2.4
Jul 11 22:53	26 Oph	RB	5.7	148	72	273	2.3	0.3
Jul 12 03:24	2469	DD	6.5	150	15	113	0.4	0.2
Jul 16 02:41	Eps Cap	DB	4.5	153	76	96	2.8	0.0
Jul 16 03:42	Eps Cap	RD	4.5	152	64	200	0.4	2.9
Jul 17 00:52	56 Aqr	RD	6.4	139	61	251	2.0	0.3
Aug 03 20:28	46 Vir	DD	6.2	64	22	94	0.9	0.9
Aug 06 19:48	2217	DD	5.5	102	69	87	2.6	0.7
Aug 06 21:04	2217	RB	5.5	102	52	318	1.7	−1.5
Aug 09 21:02	Phi Sgr	DD	3.2	143	85	87	2.4	0.0
Aug 09 22:28	Phi Sgr	RB	3.2	144	76	265	2.2	0.6
Aug 10 00:46	2740	DD	6.3	145	47	61	0.8	1.7
Aug 12 02:53	Chi Cap	DD	5.3	173	45	68	1.0	1.4
Aug 15 04:18	27 Psc	DB	4.9	143	52	45	1.3	2.0
Aug 15 05:30	27 Psc	RD	4.9	143	38	239	1.1	1.7
Aug 17 02:44	226	RD	6.5	119	52	263	2.8	−0.1
Aug 30 18:17	1825	RB	5.9	34	23	287	0.8	0.3
Sep 05 18:46	2650	DD	4.7	111	85	59	2.7	1.6
Sep 05 20:01	2650	RB	4.7	112	78	303	2.6	−1.6
Sep 06 00:08	2673	DD	6.3	113	27	45	−0.2	2.2
Sep 08 22:57	Eps Cap	DD	4.5	154	78	96	2.9	−0.1
Sep 08 23:57	Eps Cap	RB	4.5	154	65	198	0.4	3.1
Sep 09 19:58	56 Aqr	DD	6.4	166	45	77	1.5	−0.3
Sep 16 00:43	525	RD	6.5	115	24	212	0.3	1.1
Oct 06 00:19	3116	DD	6.6	124	33	357	−1.3	4.0
Oct 06 23:18	3265	DD	6.6	136	57	73	1.7	1.3
Oct 08 23:03	27 Psc	DD	4.9	163	65	25	1.0	2.4
Oct 09 00:16	27 Psc	RB	4.9	163	57	251	2.0	1.3
Oct 09 01:16	29 Psc	DD	5.1	164	46	51	1.2	1.9
Oct 10 21:00	226	RD	6.5	172	32	254	1.4	−0.2
Oct 12 21:49	467	RD	6.5	147	17	238	0.6	0.2
Oct 28 19:12	2398	DD	6.1	37	22	55	−0.1	2.1
Oct 29 20:41	2558	DD	6.3	52	17	130	0.9	−0.4
Nov 03 23:29	74 Aqr	DD	5.8	119	37	87	1.3	1.1
Nov 10 00:44	566	RD	6.1	166	40	221	2.0	1.7
Nov 10 22:22	703	RD	6.2	156	24	256	1.5	−0.4
Nov 11 23:44	840	RD	6.3	144	26	317	4.5	−4.3
Nov 13 02:07	49 Aur	DB	5.3	132	33	158	4.1	−5.7
Nov 13 02:43	49 Aur	RD	5.3	132	35	199	2.7	5.4
Nov 13 23:53	59 Gem	RD	5.8	122	12	305	1.9	−2.2
Nov 14 02:47	1132	RD	6.4	121	33	283	2.8	−0.8
Nov 29 19:17	Eps Cap	RB	4.5	74	56	219	0.8	2.2
Dec 04 00:15	80 Psc	DD	5.5	127	22	71	1.0	1.5
Dec 26 19:16	Phi Cap	RB	5.2	41	28	254	0.5	1.3
Dec 29 19:58	29 Psc	DD	5.1	82	45	95	2.3	0.7
Dec 29 20:51	29 Psc	RB	5.1	82	34	190	0.2	2.9
Dec 30 20:54	109	DD	6.4	95	39	115	3.0	−0.5
Dec 30 20:54	109	DD	6.4	95	39	115	3.0	−0.5

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 20:17	39 Tau	DD	5.9	131	33	35	1.5	1.4
Jan 14 20:26	740	DD	6.3	141	29	108	3.0	−1.1
Jan 14 22:13	98 Tau	DD	5.8	142	29	34	2.1	2.0
Jan 26 03:14	2 Lib	RD	6.2	88	44	275	1.5	−1.2
Jan 26 03:47	2064	RD	6.3	88	50	322	0.8	−2.2
Jan 28 02:35	2330	RD	6.4	62	21	291	0.1	−1.4
Jan 29 03:10	39 Oph	RD	5.2	48	17	289	−0.1	−1.4
Feb 15 23:35	Xi Cnc	DD	5.2	165	33	149	1.5	−1.6
Feb 16 00:10	79 Cnc	DD	6.0	166	32	134	1.6	−0.9
Feb 18 23:51	Ome Vir	RD	5.2	157	39	313	1.4	−1.8
Feb 19 04:47	Nu Vir	DB	4.0	155	32	152	0.6	−1.3
Feb 23 04:10	Nu Lib	DB	5.2	105	68	60	4.0	2.0
Feb 23 04:48	Nu Lib	RD	5.2	105	71	5	−0.5	−5.4
Feb 23 23:53	Lam Lib	RD	5.0	94	13	221	1.3	1.1
Feb 27 04:49	2804	DB	5.8	52	38	65	1.2	−0.2
Mar 01 05:00	Phi Cap	RD	5.2	25	14	286	−0.1	−1.6
Mar 22 23:49	41 Lib	RD	5.5	124	36	270	1.0	−1.1
Mar 23 00:28	Kap Lib	DB	4.8	124	44	144	0.3	−2.3
Mar 23 01:31	Kap Lib	RD	4.8	124	57	275	1.7	−1.0
Mar 26 03:44	2740	RD	6.3	83	51	238	1.9	0.4
Mar 26 04:19	Sig Sgr	DB	2.1	83	57	30	2.9	3.6
Mar 26 04:54	Sig Sgr	RD	2.1	82	64	337	0.7	−5.9
Apr 16 19:11	66 Vir	DD	5.8	174	19	127	0.3	−1.8
Apr 16 23:32	72 Vir	DD	6.1	176	61	171	0.4	−2.9
Apr 17 00:02	74 Vir	DD	4.7	176	61	74	3.5	1.1
Apr 17 00:46	74 Vir	RB	4.7	176	59	4	−0.1	−3.9
Apr 19 00:46	28 Lib	RD	6.2	155	69	278	2.1	−0.7
Apr 20 22:28	The Oph	DB	3.3	129	25	61	0.9	−0.3
Apr 20 23:08	The Oph	RD	3.3	129	33	335	−0.4	−2.8
Apr 21 23:48	2673	RD	6.3	115	29	214	2.1	1.8
Apr 21 23:49	2669	RD	6.4	115	30	248	0.9	−0.5
Apr 25 01:32	Eps Cap	DB	4.5	74	11	64	0.2	−0.3
Apr 25 02:30	Eps Cap	RD	4.5	74	23	271	0.4	−1.2
May 17 01:50	2282	RD	5.8	174	67	331	1.5	−2.4
May 22 02:17	33 Cap	DB	5.4	104	45	123	1.2	−3.1
May 22 03:05	33 Cap	RD	5.4	103	55	202	1.6	2.8
Jun 10 19:30	72 Vir	DD	6.1	124	59	177	0.1	−3.3
Jun 10 19:55	74 Vir	DD	4.7	124	61	79	3.2	0.4
Jun 10 20:45	74 Vir	RB	4.7	124	61	0	0.0	−3.6
Jun 12 20:04	28 Lib	DD	6.2	151	59	140	0.9	−2.2
Jun 14 17:28	The Oph	DD	3.3	177	9	92	−0.2	−1.0
Jun 14 18:17	The Oph	RB	3.3	178	18	300	−0.2	−1.5
Jun 16 00:08	Phi Sgr	DB	3.2	164	73	142	1.6	−3.4
Jun 16 00:57	Phi Sgr	RD	3.2	163	81	219	2.2	3.0
Jun 16 04:35	2740	RD	6.3	162	48	254	1.0	1.4
Jun 16 05:00	Sig Sgr	DB	2.1	162	43	32	0.0	3.0
Jun 16 05:43	Sig Sgr	RD	2.1	161	34	304	1.3	−0.1
Jun 18 06:00	Chi Cap	DB	5.3	133	54	41	0.7	2.2
Jun 26 06:07	534	RD	6.1	35	16	261	1.1	−0.8
Jul 11 21:38	26 Oph	DD	5.7	147	80	149	1.4	−3.0
Jul 11 22:36	26 Oph	RB	5.7	148	76	240	2.3	2.1
Jul 12 03:22	2469	DD	6.5	150	21	134	0.8	−0.3
Jul 16 02:35	Eps Cap	DB	4.5	152	73	120	3.5	−2.0
Jul 16 03:14	Eps Cap	RD	4.5	152	69	180	−0.3	4.5
Jul 17 00:40	56 Aqr	RD	6.4	139	53	228	1.4	0.9
Aug 03 20:22	46 Vir	DD	6.2	64	25	125	0.8	−0.1
Aug 06 19:41	2217	DD	5.5	102	69	119	1.9	−0.8
Aug 06 21:02	2217	RB	5.5	102	55	288	1.7	0.1
Aug 09 20:59	Phi Sgr	DD	3.2	143	78	117	2.0	−1.5
Aug 09 22:11	Phi Sgr	RB	3.2	144	79	239	1.9	1.7
Aug 10 00:30	2740	DD	6.3	145	54	79	1.3	1.2
Aug 10 02:03	Sig Sgr	DD	2.1	145	35	28	−0.4	3.0
Aug 10 02:41	Sig Sgr	RB	2.1	146	28	308	1.1	−0.2
Aug 12 02:39	Chi Cap	DD	5.3	173	51	80	1.3	1.2
Aug 13 20:34	74 Aqr	RD	5.8	160	20	323	0.1	−7.9
Aug 15 03:58	27 Psc	DB	4.9	143	52	53	1.4	1.7
Aug 15 05:12	27 Psc	RD	4.9	143	41	231	1.1	1.9
Aug 15 06:05	29 Psc	DB	5.1	143	31	64	0.9	1.7
Aug 24 05:51	Ups Gem	RD	4.1	39	9	265	1.1	−1.0
Sep 01 20:09	2065	DD	6.5	60	28	44	0.7	5.9
Sep 05 18:34	2650	DD	4.7	111	76	91	2.1	−0.4
Sep 05 19:57	2650	RB	4.7	112	79	274	2.2	0.0
Sep 05 23:53	2673	DD	6.3	113	35	62	0.3	1.8
Sep 05 23:56	2669	DD	6.4	113	34	27	−0.5	3.3
Sep 08 22:52	Eps Cap	DD	4.5	154	74	122	3.7	−2.4
Sep 08 23:28	Eps Cap	RB	4.5	154	70	177	−0.5	4.9
Sep 09 20:01	56 Aqr	DD	6.4	166	41	108	1.4	−2.1
Sep 12 21:47	77 Psc	RD	6.4	152	21	291	1.5	−2.7
Sep 16 00:33	525	RD	6.5	115	15	193	−0.4	1.7
Oct 05 22:33	Phi Cap	DD	5.2	123	58	358	−0.9	4.7
Oct 05 23:06	Phi Cap	RB	5.2	123	52	303	3.0	−0.9
Oct 08 22:42	27 Psc	DD	4.9	163	58	36	1.2	1.7
Oct 08 23:59	27 Psc	RB	4.9	163	55	243	1.8	1.3
Oct 09 00:57	29 Psc	DD	5.1	164	48	59	1.4	1.6
Oct 09 02:08	29 Psc	RB	5.1	164	35	226	0.8	2.0
Oct 29 20:47	2558	DD	6.3	52	22	163	3.2	−4.7
Nov 03 23:15	74 Aqr	DD	5.8	119	41	97	1.7	0.9
Nov 10 00:25	566	RD	6.1	166	33	211	1.3	1.5
Nov 10 22:20	703	RD	6.2	156	15	243	0.9	−0.3
Nov 11 23:53	840	RD	6.3	144	18	297	2.6	−2.0
Nov 14 00:02	59 Gem	RD	5.8	122	6	289	1.3	−1.7
Nov 14 00:18	Iot Gem	RD	3.8	122	8	341	4.1	−6.3
Nov 14 02:42	1132	RD	6.4	121	25	269	2.4	−0.6
Dec 03 23:59	80 Psc	DD	5.5	127	25	82	1.2	1.4
Dec 04 21:07	54 Ara	DD	5.9	138	44	350	−0.8	3.8
Dec 29 20:27	29 Psc	RB	5.1	82	39	178	−0.2	3.3

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 18 21:42	Ups 1 Cnc	RD	5.7	172	24	266	1.3	−0.3
Jan 26 01:59	2 Lib	RD	6.2	88	19	300	0.3	−1.3
Jan 29 03:47	The Oph	RD	3.3	47	7	224	1.3	1.9
Feb 10 22:24	95 Tau	DD	6.2	111	41	93	2.6	0.2
Feb 12 01:42	125 Tau	DD	5.2	123	12	144	−0.5	−2.0
Feb 15 21:44	Xi Cnc	DD	5.2	165	39	109	2.4	−1.2
Feb 15 22:28	79 Cnc	DD	6.0	166	47	104	2.8	−0.9
Feb 15 23:23	Xi Cnc	RB	5.2	166	53	291	3.0	−1.1
Feb 17 04:09	Eta Leo	DD	3.5	175	37	188	−1.5	−4.7
Feb 17 04:42	Eta Leo	RD	3.5	175	30	242	3.0	2.8
Feb 18 22:04	Ome Vir	RD	5.2	157	20	354	0.7	−3.9
Feb 19 03:22	Nu Vir	DB	4.0	155	68	124	2.3	−1.4
Feb 19 04:46	Nu Vir	RD	4.0	155	53	322	1.2	−1.8
Mar 07 20:54	Omi Ari	DD	5.8	57	20	112	0.9	−0.5
Mar 14 01:08	Ome Cnc	DD	5.9	124	24	104	1.1	−0.1
Mar 22 22:47	41 Lib	RD	5.5	124	9	297	−0.1	−1.1
Mar 22 23:14	Kap Lib	DB	4.8	124	14	119	0.0	−1.1
Mar 23 00:13	Kap Lib	RD	4.8	124	28	299	0.5	−1.2
Mar 26 02:42	2740	RD	6.3	83	22	285	0.4	−0.9
Apr 10 23:40	Ups 1 Cnc	DD	5.7	104	26	136	0.4	−1.2
Apr 16 21:48	72 Vir	DD	6.1	176	47	153	0.6	−2.4
Apr 18 23:18	28 Lib	RD	6.2	155	45	301	1.0	−1.4
Apr 20 01:24	Rho Oph	DD	5.0	141	60	192	−3.3	−8.3
Apr 20 01:24	184381	DD	5.7	141	60	192	−3.2	−8.2
Apr 20 01:47	Rho Oph	RD	5.0	141	65	224	6.9	5.9
Apr 20 01:47	184381	RD	5.7	141	65	225	6.8	5.8
Apr 21 03:21	2524	RD	6.0	126	69	265	2.9	0.1
Apr 25 04:30	3178	RD	6.2	73	34	229	1.5	1.3
May 07 21:51	Psi Cnc	DD	5.7	73	22	39	6.1	7.8
May 07 22:08	Psi Cnc	RD	5.7	73	18	12	−4.5	−8.5
May 17 23:39	2442	RD	5.9	160	53	246	2.9	1.0
May 17 23:49	26 Oph	RD	5.7	160	55	274	2.0	−0.5
May 19 04:38	2650	DB	4.7	144	67	70	2.4	1.2
May 19 05:59	2650	RD	4.7	143	50	280	2.1	−0.1
May 22 02:13	33 Cap	RD	5.4	103	32	289	1.0	−1.3
May 24 03:45	3413	RD	6.1	77	28	167	0.6	9.4
Jun 13 02:08	2217	DD	5.5	154	44	96	1.7	0.2
Jun 15 22:38	Phi Sgr	DB	3.2	164	41	80	1.6	0.0
Jun 15 23:50	Phi Sgr	RD	3.2	163	56	297	1.7	−1.5
Jun 21 03:25	3506	RD	6.1	94	41	202	0.9	2.5
Jun 22 03:01	14 Cet	RD	5.9	82	24	195	0.3	2.6
Jun 25 05:37	Uranus	DB	5.8	46	24	60	0.7	0.6
Jun 25 06:51	Uranus	RD	5.8	46	40	227	1.1	1.3
Jul 03 19:58	Eta Leo	DD	3.5	47	27	183	−1.1	−4.0
Jul 03 20:33	Eta Leo	RB	3.5	47	19	245	1.9	2.3
Jul 11 19:59	26 Oph	DD	5.7	147	52	102	1.7	−0.8
Jul 11 19:59	2442	DD	5.9	147	52	125	1.2	−1.6
Jul 11 21:17	26 Oph	RB	5.7	148	68	304	1.9	−1.7
Jul 13 01:45	2650	DD	4.7	163	58	82	2.1	0.6
Jul 13 03:01	2650	RB	4.7	164	42	263	1.4	0.6
Jul 16 01:02	37 Cap	RD	5.7	153	63	231	2.2	1.5
Jul 16 01:59	Eps Cap	DB	4.5	152	76	355	−0.1	7.0
Jul 16 02:35	Eps Cap	RD	4.5	152	82	306	5.4	−4.1
Jul 16 05:09	Kap Cap	DB	4.7	151	57	50	1.2	1.7
Jul 16 06:19	Kap Cap	RD	4.7	151	41	243	0.9	1.3
Jul 22 04:31	Omi Ari	DB	5.8	76	37	91	2.1	−0.5
Jul 22 05:33	Omi Ari	RD	5.8	75	49	191	0.1	3.0
Aug 03 19:44	44 Vir	DD	5.8	64	49	187	−0.2	−5.0
Aug 03 20:23	44 Vir	RB	5.8	65	39	246	2.6	2.6
Aug 06 19:10	2217	RB	5.5	102	82	355	0.3	−4.7
Aug 08 00:14	2398	DD	6.1	117	35	96	1.3	0.2
Aug 09 19:49	Phi Sgr	DD	3.2	143	51	45	3.1	2.4
Aug 09 20:40	Phi Sgr	RB	3.2	144	62	328	1.4	−3.9
Aug 12 05:39	Phi Cap	DD	5.2	174	19	55	0.1	1.3
Aug 29 19:10	7 Vir	RB	5.4	23	16	266	0.7	0.7
Sep 06 21:07	2848	DD	5.6	126	75	148	4.2	−7.0
Sep 06 21:38	2848	RB	5.6	126	75	187	0.7	8.0
Sep 08 19:59	37 Cap	DD	5.7	153	43	88	1.7	−0.3
Sep 08 22:13	Eps Cap	DD	4.5	154	73	357	0.3	6.4
Sep 08 22:53	Eps Cap	RB	4.5	154	81	303	5.1	−3.5
Sep 09 01:27	Kap Cap	DD	4.7	155	59	54	1.4	1.6
Sep 09 02:38	Kap Cap	RB	4.7	156	42	237	0.9	1.4
Sep 21 04:10	Psi Cnc	RD	5.7	58	10	261	0.5	−0.1
Sep 30 19:15	Del Sco	DD	2.3	55	45	114	1.9	−0.6
Sep 30 20:29	Del Sco	RB	2.3	56	28	269	1.0	0.5
Oct 08 03:22	Psi 1 Aqr	DD	4.2	152	25	97	1.1	0.2
Oct 08 04:07	Psi 1 Aqr	RB	4.2	152	14	196	−0.2	2.5
Oct 09 04:27	5 Psc	DD	6.2	165	20	92	0.8	0.4
Oct 12 03:00	29 Ara	RD	6.0	157	59	178	0.2	4.7
Oct 16 01:49	909	RD	6.0	111	27	242	1.0	0.6
Oct 18 04:04	Phi Gem	DB	5.0	89	33	33	0.8	3.4
Oct 18 04:52	Phi Gem	RD	5.0	89	41	334	3.6	−4.7
Oct 31 19:40	Ome Sgr	RB	4.7	78	64	195	0.3	4.2
Nov 03 23:08	74 Aqr	DD	5.8	119	56	4	−0.2	3.5
Nov 03 23:59	74 Aqr	RB	5.8	120	44	277	2.2	0.1
Nov 07 04:06	214	DD	6.2	159	14	71	0.7	1.1
Nov 11 22:59	844	RD	5.8	144	19	201	−0.7	2.4
Nov 13 00:14	49 Aur	DB	5.3	132	23	67	0.9	0.4
Nov 13 01:39	49 Aur	RD	5.3	132	38	269	2.5	−0.3
Nov 13 04:47	54 Aur	RD	6.0	131	48	320	2.6	−2.7
Nov 14 05:45	Ups Gem	DB	4.1	120	49	158	1.4	−3.7
Nov 29 20:47	Kap Cap	DD	4.7	75	49	39	0.7	2.0
Nov 29 21:52	Kap Cap	RB	4.7	75	33	253	0.9	1.0
Dec 03 23:53	80 Psc	DD	5.5	127	45	12	0.7	3.3
Dec 04 00:50	80 Psc	RB	5.5	127	32	278	1.7	0.1
Dec 29 20:24	29 Psc	RB	5.1	82	58	266	2.7	0.6

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 20:54	37 Tau	RB	4.4	131	25	302	3.2	−1.1
Jan 14 21:58	98 Tau	DD	5.8	142	22	46	1.8	1.0
Jan 26 03:19	2 Lib	RD	6.2	88	41	255	1.7	−0.8
Jan 28 02:46	2330	RD	6.4	62	22	275	0.2	−1.4
Jan 28 03:52	2337	RD	6.6	61	34	286	0.5	−1.6
Jan 29 03:13	2491	RD	6.6	48	19	318	−0.4	−1.9
Jan 29 03:20	39 Oph	RD	5.2	48	20	272	0.1	−1.2
Feb 06 20:46	96 Psc	DD	6.5	66	14	42	0.7	2.1
Feb 15 23:46	Xi Cnc	DD	5.2	165	25	169	0.6	−2.0
Feb 16 00:15	79 Cnc	DD	6.0	166	25	152	1.0	−1.1
Feb 17 21:27	52 Leo	RD	5.5	169	14	329	0.9	−2.3
Feb 19 00:01	Ome Vir	RD	5.2	157	33	300	1.4	−1.5
Feb 19 05:02	Nu Vir	DB	4.0	155	26	189	−0.7	−3.9
Feb 22 02:27	96 Vir	RD	6.5	119	50	295	1.4	−1.5
Feb 23 04:03	Nu Lib	DB	5.2	105	60	93	1.9	−0.6
Feb 27 04:53	2804	DB	5.8	52	38	90	0.7	−1.2
Mar 01 04:15	Phi Cap	DB	5.2	25	7	80	−0.1	−0.9
Mar 01 05:10	Phi Cap	RD	5.2	25	17	260	0.2	−1.0
Mar 21 03:49	1996	RD	6.7	149	51	235	3.5	4.7
Mar 22 23:14	41 Lib	DB	5.5	125	28	165	−0.4	−2.6
Mar 22 23:55	41 Lib	RD	5.5	124	35	249	1.3	−0.8
Mar 23 00:47	Kap Lib	DB	4.8	124	45	166	−0.2	−3.0
Mar 23 01:33	Kap Lib	RD	4.8	124	53	250	2.1	−0.2
Mar 26 04:08	Sig Sgr	DB	2.1	83	52	68	1.5	−0.2
Mar 26 05:16	Sig Sgr	RD	2.1	82	64	298	1.5	−1.9
Apr 16 18:41	65 Vir	DD	5.9	174	11	128	0.1	−1.8
Apr 16 19:24	66 Vir	DD	5.8	174	19	139	0.3	−2.0
Apr 16 23:56	74 Vir	DD	4.7	176	54	102	1.9	−0.5
Apr 17 01:04	74 Vir	RB	4.7	176	51	332	0.9	−1.7
Apr 19 00:43	28 Lib	RD	6.2	155	62	248	2.6	0.6
Apr 20 22:33	The Oph	DB	3.3	129	26	83	0.4	−1.1
Apr 20 23:11	2499	RD	6.4	129	33	328	−0.2	−2.5

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Apr 20 23:26	The Oph	RD	3.3	129	36	311	0.1	−2.1
Apr 21 23:47	2669	RD	6.4	115	29	217	1.5	0.8
Apr 25 01:37	Eps Cap	DB	4.5	74	13	89	0.0	−1.2
Apr 25 02:36	Eps Cap	RD	4.5	74	23	244	0.5	−0.5
Apr 25 04:37	Kap Cap	DB	4.7	73	44	36	1.2	1.1
Apr 25 05:40	Kap Cap	RD	4.7	72	55	282	1.8	−1.6
May 17 01:58	2282	RD	5.8	174	62	300	1.6	−0.6
Jun 10 19:53	74 Vir	DD	4.7	124	53	104	1.9	−0.8
Jun 10 21:03	74 Vir	RB	4.7	124	53	331	1.0	−1.8
Jun 12 20:21	28 Lib	DD	6.2	151	56	164	0.3	−2.9
Jun 14 17:37	The Oph	DD	3.3	177	12	108	−0.3	−1.3
Jun 14 18:28	The Oph	RB	3.3	178	21	283	0.0	−1.4
Jun 16 04:20	2740	RD	6.3	162	52	234	0.7	2.1
Jun 16 04:40	Sig Sgr	DB	2.1	162	48	55	0.6	2.1
Jun 16 05:38	Sig Sgr	RD	2.1	161	38	284	0.9	0.8
Jun 18 05:43	Chi Cap	DB	5.3	133	56	56	1.0	1.8
Jun 18 06:50	Chi Cap	RD	5.3	133	44	251	0.8	1.6
Jul 10 21:47	2282	DD	5.8	133	66	72	2.1	1.4
Jul 10 22:48	2282	RB	5.8	134	58	328	1.4	−1.9
Jul 17 00:27	56 Aqr	RD	6.4	139	46	199	0.9	2.1
Aug 03 20:25	46 Vir	DD	6.2	64	24	154	0.5	−1.1
Aug 06 19:48	2217	DD	5.5	102	64	147	1.3	−2.0
Aug 06 20:53	2217	RB	5.5	102	55	259	1.7	1.5
Aug 09 21:18	Phi Sgr	DD	3.2	143	73	158	1.6	−6.3
Aug 09 21:45	Phi Sgr	RB	3.2	144	74	199	1.6	6.2
Aug 10 00:20	2740	DD	6.3	145	56	100	1.5	0.6
Aug 10 01:43	Sig Sgr	DD	2.1	145	41	50	0.3	2.2
Aug 10 02:36	Sig Sgr	RB	2.1	146	31	288	0.7	0.8
Aug 12 02:28	Chi Cap	DD	5.3	173	52	95	1.5	0.8
Aug 13 20:56	74 Aqr	RB	5.8	159	22	276	0.5	−1.6
Aug 15 03:45	27 Psc	DB	4.9	143	48	63	1.5	1.3
Aug 15 04:56	27 Psc	RD	4.9	143	40	222	0.9	1.9

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 15 05:51	29 Psc	DB	5.1	143	32	73	1.1	1.6
Aug 17 02:29	226	RD	6.5	119	35	234	1.3	0.4
Aug 19 05:08	467	RD	6.5	94	28	212	1.1	1.1
Sep 01 19:45	2065	DD	6.5	59	33	86	1.0	1.6
Sep 05 00:58	2514	DD	6.4	101	15	134	0.5	0.1
Sep 05 18:37	2650	DD	4.7	111	71	119	1.6	−1.7
Sep 05 19:49	2650	RB	4.7	112	74	247	1.9	1.2
Sep 05 23:35	2669	DD	6.4	113	40	51	0.3	2.3
Sep 05 23:39	2673	DD	6.3	113	40	80	0.7	1.5
Sep 12 21:57	77 Psc	RD	6.4	152	19	260	0.8	−1.0
Oct 01 19:32	2442	DD	5.9	68	49	58	1.0	2.5
Oct 01 20:28	2442	RB	5.9	69	39	312	1.3	−0.3
Oct 05 22:06	Phi Cap	DD	5.2	123	60	22	0.5	2.9
Oct 05 23:01	Phi Cap	RB	5.2	123	52	281	1.7	0.7
Oct 05 23:36	3116	DD	6.6	123	46	30	0.2	2.5
Oct 06 22:53	3265	DD	6.6	137	57	101	2.2	0.3
Oct 08 22:29	27 Psc	DD	4.9	163	50	51	1.4	1.0
Oct 08 23:45	27 Psc	RB	4.9	163	50	231	1.3	1.4
Oct 09 00:43	29 Psc	DD	5.1	164	45	68	1.5	1.3
Oct 09 01:52	29 Psc	RB	5.1	164	36	218	0.7	2.0
Oct 10 20:52	226	RD	6.5	172	19	213	0.4	0.6
Oct 15 02:14	762	RD	6.6	123	18	203	0.6	1.0
Oct 16 02:43	77818	RD	6.7	112	15	279	1.9	−1.1
Nov 02 01:09	Chi Cap	DD	5.3	94	9	98	−0.1	1.1
Nov 03 23:06	74 Aqr	DD	5.8	119	42	112	2.1	0.5
Nov 10 00:12	566	RD	6.1	166	25	198	0.7	1.4
Nov 12 00:01	840	RD	6.3	144	12	282	1.8	−1.4
Nov 14 00:40	Iot Gem	RD	3.8	122	5	316	1.8	−2.5
Nov 14 02:42	1132	RD	6.4	121	17	258	1.9	−0.5
Dec 03 23:46	80 Psc	DD	5.5	127	24	92	1.3	1.3
Dec 04 20:46	54 Ara	DD	5.9	138	36	8	0.3	2.1
Dec 11 00:09	1081	RD	6.5	153	15	326	2.5	−2.4

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 14 22:01	98 Tau	DD	5.8	142	27	36	1.9	1.5
Jan 26 03:11	2 Lib	RD	6.2	88	40	262	1.5	−1.0
Jan 26 03:49	2064	RD	6.3	87	46	310	0.9	−2.0
Jan 28 02:39	2330	RD	6.4	62	19	281	0.1	−1.3
Jan 29 03:14	39 Oph	RD	5.2	48	16	278	0.0	−1.2
Feb 15 23:34	Xi Cnc	DD	5.2	165	30	161	1.1	−2.1
Feb 16 00:06	79 Cnc	DD	6.0	166	30	146	1.4	−1.3
Feb 18 23:50	Ome Vir	RD	5.2	157	34	304	1.4	−1.7
Feb 19 04:49	Nu Vir	DB	4.0	155	33	169	0.2	−2.1
Feb 23 03:56	Nu Lib	DB	5.2	105	62	82	2.4	−0.3
Feb 23 04:56	Nu Lib	RD	5.2	105	68	342	0.7	−3.1
Feb 27 04:46	2804	DB	5.8	52	34	78	0.8	−0.8
Mar 01 05:04	Phi Cap	RD	5.2	25	13	273	0.0	−1.2
Mar 22 23:48	41 Lib	RD	5.5	124	33	257	1.0	−0.9
Mar 23 00:34	Kap Lib	DB	4.8	124	41	158	0.0	−2.7
Mar 23 01:26	Kap Lib	RD	4.8	124	52	260	1.8	−0.7
Mar 26 03:33	2740	RD	6.3	83	45	219	2.2	1.6
Mar 26 04:05	Sig Sgr	DB	2.1	83	51	52	1.9	0.7
Mar 26 05:01	Sig Sgr	RD	2.1	82	62	317	1.2	−3.1
Apr 09 22:17	Ups Gem	DD	4.1	92	9	61	1.9	2.4
Apr 16 19:14	66 Vir	DD	5.8	174	16	134	0.2	−1.9
Apr 16 23:49	74 Vir	DD	4.7	176	58	93	2.4	−0.4
Apr 17 00:52	74 Vir	RB	4.7	176	58	343	0.7	−2.4
Apr 19 00:38	28 Lib	RD	6.2	155	64	261	2.3	−0.2
Apr 20 22:27	The Oph	DB	3.3	129	22	75	0.4	−0.8
Apr 20 22:59	2499	RD	6.4	129	28	339	−0.6	−2.8
Apr 20 23:15	The Oph	RD	3.3	129	31	320	−0.1	−2.2
Apr 21 23:46	2669	RD	6.4	115	26	232	1.0	0.0
Apr 25 01:33	Eps Cap	DB	4.5	74	9	76	0.0	−0.7
Apr 25 02:31	Eps Cap	RD	4.5	74	20	259	0.4	−0.9
Apr 25 04:44	Kap Cap	DB	4.7	73	45	10	1.4	3.9
Apr 25 05:23	Kap Cap	RD	4.7	73	52	309	2.0	−4.4

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
May 17 01:49	2282	RD	5.8	174	68	317	1.6	−1.6
May 22 02:24	33 Cap	DB	5.4	103	43	144	0.8	−6.4
May 22 02:49	33 Cap	RD	5.4	103	48	184	1.6	5.8
Jun 10 19:44	74 Vir	DD	4.7	124	56	97	2.2	−0.7
Jun 10 20:51	74 Vir	RB	4.7	124	59	341	0.8	−2.4
Jun 12 20:07	28 Lib	DD	6.2	151	55	154	0.4	−2.6
Jun 14 18:22	The Oph	RB	3.3	178	17	290	−0.1	−1.4
Jun 16 00:16	Phi Sgr	DB	3.2	164	71	167	0.6	−8.9
Jun 16 00:36	Phi Sgr	RD	3.2	163	74	197	2.8	8.1
Jun 16 04:27	2740	RD	6.3	162	53	252	1.1	1.5
Jun 16 04:51	Sig Sgr	DB	2.1	162	48	35	0.3	3.0
Jun 16 05:38	Sig Sgr	RD	2.1	161	39	303	1.4	−0.1
Jun 18 05:51	Chi Cap	DB	5.3	133	58	40	0.8	2.3
Jun 18 06:55	Chi Cap	RD	5.3	133	46	265	1.2	1.2
Jun 26 06:05	534	RD	6.1	35	11	260	0.9	−0.9
Jul 10 21:54	2282	DD	5.8	134	70	48	3.2	4.4
Jul 10 22:29	2282	RB	5.8	134	65	356	0.9	−5.5
Jul 11 21:44	26 Oph	DD	5.7	147	77	171	0.6	−5.6
Jul 11 22:18	26 Oph	RB	5.7	148	77	221	2.9	4.4
Jul 16 02:26	Eps Cap	DB	4.5	152	72	123	3.4	−2.6
Jul 16 03:03	Eps Cap	RD	4.5	152	70	179	−0.3	4.8
Jul 17 00:32	56 Aqr	RD	6.4	139	47	221	1.2	1.0
Aug 03 20:19	46 Vir	DD	6.2	64	28	137	0.8	−0.6
Aug 06 19:36	2217	DD	5.5	102	70	132	1.7	−1.5
Aug 06 20:54	2217	RB	5.5	102	58	277	1.8	0.5
Aug 09 20:57	Phi Sgr	DD	3.2	143	74	129	1.7	−2.4
Aug 09 21:58	Phi Sgr	RB	3.2	144	79	229	2.0	2.1
Aug 10 00:21	2740	DD	6.3	145	59	82	1.4	1.1
Aug 10 01:56	Sig Sgr	DD	2.1	145	40	29	−0.2	3.1
Aug 10 02:36	Sig Sgr	RB	2.1	146	32	307	1.3	−0.1
Aug 12 02:30	Chi Cap	DD	5.3	173	55	79	1.4	1.2
Aug 13 20:44	74 Aqr	RD	5.8	160	18	299	0.3	−2.9

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 15 03:48	27 Psc	DB	4.9	143	53	50	1.4	1.6
Aug 15 05:04	27 Psc	RD	4.9	143	44	233	1.2	1.8
Aug 15 05:57	29 Psc	DB	5.1	143	35	63	1.0	1.7
Aug 17 02:27	226	RD	6.5	119	38	251	1.7	−0.1
Aug 19 05:10	467	RD	6.5	94	33	225	1.5	0.9
Sep 05 00:59	2514	DD	6.4	101	15	116	0.3	0.5
Sep 05 19:48	2650	RB	4.7	112	79	265	2.1	0.3
Sep 05 23:45	2673	DD	6.3	113	40	64	0.5	1.9
Sep 05 23:49	2669	DD	6.4	113	39	29	−0.2	3.4
Sep 08 22:44	Eps Cap	DD	4.5	154	72	125	3.7	−3.1
Sep 08 23:17	Eps Cap	RB	4.5	154	71	176	−0.5	5.3
Sep 09 20:02	56 Aqr	DD	6.4	166	37	120	1.2	−3.3
Sep 12 21:48	77 Psc	RD	6.4	152	18	283	1.1	−2.1
Oct 01 19:48	2442	DD	5.9	68	48	28	0.2	6.1
Oct 01 20:17	2442	RB	5.9	69	43	341	2.4	−3.9
Oct 05 22:24	Phi Cap	DD	5.2	123	62	356	−1.0	5.1
Oct 05 22:55	Phi Cap	RB	5.2	123	56	305	3.4	−1.4
Oct 08 22:33	27 Psc	DD	4.9	163	55	34	1.2	1.6
Oct 08 23:48	27 Psc	RB	4.9	163	55	245	1.8	1.1
Oct 09 00:47	29 Psc	DD	5.1	164	49	56	1.4	1.6
Oct 09 02:00	29 Psc	RB	5.1	164	39	228	1.0	1.9
Oct 28 19:52	2398	RB	6.1	38	23	288	0.5	0.7
Nov 02 01:15	Chi Cap	DD	5.3	94	7	89	−0.2	1.1
Nov 03 23:06	74 Aqr	DD	5.8	119	45	95	1.8	1.0
Nov 10 00:16	566	RD	6.1	166	29	213	1.2	1.2
Nov 10 22:17	703	RD	6.2	156	11	243	0.7	−0.4
Nov 11 23:48	840	RD	6.3	144	14	298	2.3	−2.1
Nov 14 00:18	Iot Gem	RD	3.8	122	4	340	3.5	−5.7
Nov 14 02:35	1132	RD	6.4	121	20	266	2.1	−0.7
Dec 03 23:50	80 Psc	DD	5.5	127	28	83	1.4	1.4
Dec 04 21:01	54 Ara	DD	5.9	138	41	343	−1.7	4.5
Dec 29 20:19	29 Psc	RB	5.1	82	42	181	0.0	3.1

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 22:36	621	DD	6.1	132	31	71	2.4	1.2
Jan 26 01:19	2064	RD	6.3	87	18	283	0.3	−1.3
Feb 11 23:08	849	DD	6.5	123	21	38	2.7	3.0
Feb 15 20:29	Xi Cnc	DD	5.2	165	19	163	2.0	−3.8
Feb 15 21:05	79 Cnc	DD	6.0	166	24	159	1.9	−3.3
Feb 18 21:09	Ome Vir	RD	5.2	157	10	297	0.6	−1.7
Feb 21 02:06	66 Vir	DB	5.8	130	56	101	2.2	−1.1
Feb 21 02:18	65 Vir	RD	5.9	130	57	335	0.9	−2.5
Feb 21 03:16	66 Vir	RD	5.8	130	63	339	0.9	−2.6
Feb 21 23:37	96 Vir	RD	6.5	119	22	269	0.6	−1.1
Feb 23 01:09	Nu Lib	DB	5.2	105	33	121	0.5	−1.7
Feb 23 02:15	Nu Lib	RD	5.2	105	47	302	0.9	−1.8
Feb 23 02:29	22 Lib	RD	6.4	105	50	264	1.9	−0.7
Feb 27 03:28	2804	RD	5.8	51	18	269	0.2	−0.9
Mar 26 01:31	Sig Sgr	DB	2.1	83	19	78	0.4	−0.7
Mar 26 02:28	Sig Sgr	RD	2.1	82	31	297	0.3	−1.8
Apr 09 19:18	Ups Gem	DD	4.1	92	31	94	2.7	0.1
Apr 09 20:49	Ups Gem	RB	4.1	92	24	299	1.5	−0.1
Apr 16 20:56	74 Vir	DD	4.7	176	38	134	0.8	−2.0
Apr 16 22:07	74 Vir	RB	4.7	176	51	300	1.4	−1.6
Apr 20 21:12	The Oph	RD	3.3	128	6	293	−0.4	−1.2
Apr 22 04:55	Phi Sgr	DB	3.2	111	85	119	2.4	−1.6
Apr 22 06:07	Phi Sgr	RD	3.2	111	75	234	1.9	2.2
May 07 19:16	13 Cnc	DD	6.4	72	27	71	2.9	1.5
May 07 19:42	Psi Cnc	DD	5.7	73	24	143	0.8	−0.9
May 16 22:53	2282	RD	5.8	173	64	295	1.5	−1.5
May 18 04:35	2469	RD	6.5	157	53	285	1.6	0.2
May 19 02:44	2650	DB	4.7	143	85	146	2.1	−3.7
May 19 03:34	2650	RD	4.7	143	79	218	2.0	3.7
May 22 00:24	33 Cap	RD	5.4	103	19	193	1.6	3.3
May 24 04:27	Psi 3 Aqr	DB	5.0	76	42	84	1.6	−0.8
May 24 05:37	Psi 3 Aqr	RD	5.0	75	55	209	1.2	2.0

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jun 10 18:04	74 Vir	RB	4.7	125	47	298	1.3	−1.7
Jun 13 04:50	Kap Lib	DD	4.8	156	7	26	−1.8	6.1
Jun 16 01:34	2740	DD	6.3	162	85	298	2.3	−1.5
Jun 25 04:48	Uranus	RD	5.8	46	12	188	−0.5	2.2
Jul 04 21:04	1598	DD	6.5	59	11	136	0.2	−0.5
Jul 05 21:07	Nu Vir	DD	4.0	71	22	83	1.3	1.6
Jul 05 21:57	Nu Vir	RB	4.0	71	12	344	0.0	−1.8
Jul 10 18:38	2282	DD	5.8	134	56	88	1.9	−0.7
Jul 10 19:42	2282	RB	5.8	134	69	330	0.9	−2.7
Jul 12 00:47	2469	DD	6.5	150	55	85	1.6	1.0
Jul 13 00:00	2650	DD	4.7	164	79	157	2.7	−6.0
Jul 13 00:29	2650	RB	4.7	164	73	200	1.1	6.6
Jul 13 04:10	2669	DD	6.4	165	28	103	0.7	0.6
Jul 13 04:28	2673	DD	6.3	166	25	139	1.4	−1.0
Jul 15 23:20	Eps Cap	DB	4.5	152	48	71	1.5	−0.1
Jul 16 00:37	Eps Cap	RD	4.5	152	64	246	1.9	0.5
Jul 16 02:45	Kap Cap	DB	4.7	151	76	75	2.1	0.8
Jul 16 03:59	Kap Cap	RD	4.7	151	65	223	1.1	2.1
Jul 16 22:06	56 Aqr	RD	6.4	139	19	244	0.5	−0.2
Aug 03 18:54	46 Vir	RB	6.2	65	46	281	1.9	0.4
Aug 05 21:53	5 Lib	DD	6.3	91	36	95	1.2	0.9
Aug 06 00:23	8 Lib	DD	5.2	92	6	127	0.2	−0.1
Aug 06 00:31	Alp 2 Lib	DD	2.8	92	5	134	0.2	−0.4
Aug 09 18:12	Phi Sgr	DD	3.2	143	42	140	0.2	−2.8
Aug 09 19:03	Phi Sgr	RB	3.2	144	53	234	2.1	0.8
Aug 09 21:42	2740	DD	6.3	145	84	36	2.2	3.3
Aug 12 00:08	Chi Cap	DD	5.3	173	79	8	0.5	4.5
Aug 12 00:53	Chi Cap	RB	5.3	173	75	298	3.4	−1.7
Aug 12 03:37	Phi Cap	DD	5.2	174	43	78	1.0	1.3
Aug 15 03:45	29 Psc	DB	5.1	142	58	356	−0.3	3.6
Aug 15 04:32	29 Psc	RD	5.1	142	52	283	3.0	0.1
Aug 19 01:48	467	DD	6.5	94	14	344	−2.7	6.4

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 19 02:07	467	RD	6.5	94	17	311	4.2	−6.3
Aug 22 04:44	136 Tau	DB	4.6	60	13	16	−0.7	2.1
Aug 22 05:27	136 Tau	RD	4.6	60	19	311	3.2	−3.1
Aug 31 20:58	82 Vir	DD	5.0	49	9	114	0.2	0.3
Sep 03 22:53	Rho Oph	DD	5.0	87	24	92	0.5	1.0
Sep 03 22:53	184381	DD	5.7	87	24	92	0.5	1.0
Sep 04 22:55	2514	DD	6.4	101	37	60	0.5	2.1
Sep 05 01:05	2524	DD	6.0	102	11	149	1.1	−1.4
Sep 08 19:36	Eps Cap	DD	4.5	154	46	73	1.4	−0.2
Sep 08 20:53	Eps Cap	RB	4.5	154	62	244	1.9	0.5
Sep 08 23:04	Kap Cap	DD	4.7	155	77	78	2.2	0.6
Sep 09 00:17	Kap Cap	RB	4.7	156	66	218	1.0	2.3
Sep 12 02:10	10 Cet	RD	6.4	162	56	229	1.6	1.6
Sep 17 03:54	703	RD	6.2	102	30	257	2.2	−0.2
Sep 20 05:32	59 Gem	DB	5.8	68	22	52	1.6	0.4
Oct 03 00:00	2650	DD	4.7	85	12	116	0.3	0.3
Oct 06 20:17	3265	DD	6.6	137	66	12	0.9	3.4
Oct 18 03:27	Phi Gem	RD	5.0	89	18	287	1.9	−1.5
Nov 01 23:25	Chi Cap	DD	5.3	94	27	45	0.0	1.9
Nov 03 20:31	74 Aqr	DD	5.8	119	70	23	0.9	2.6
Nov 03 21:42	74 Aqr	RB	5.8	120	62	259	2.2	1.0
Nov 07 02:06	214	DD	6.2	159	27	119	2.0	−0.1
Nov 09 21:32	566	RD	6.1	166	18	283	1.8	−1.7
Nov 10 02:43	33 Tau	RD	6.1	165	30	297	2.6	−0.3
Nov 12 23:50	49 Aur	RD	5.3	132	11	239	0.7	−0.1
Nov 13 02:50	54 Aur	RD	6.0	131	29	267	2.6	−0.2
Nov 13 04:08	25 Gem	RD	6.5	131	29	254	2.8	0.7
Nov 29 19:38	Kap Cap	RB	4.7	75	58	235	1.2	1.8
Dec 03 21:15	80 Psc	DD	5.5	127	51	28	1.2	2.1
Dec 03 22:33	80 Psc	RB	5.5	127	43	252	2.0	1.4
Dec 06 01:07	Pi Ari	DD	5.3	152	25	35	1.5	2.4
Dec 11 03:02	53 Gem	RD	5.8	151	29	313	2.0	−1.0

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 20:22	39 Tau	DD	5.9	131	34	36	1.6	1.5
Jan 14 20:31	740	DD	6.3	141	31	108	3.1	−1.1
Jan 14 22:21	98 Tau	DD	5.8	142	29	32	2.2	2.3
Jan 26 03:15	2 Lib	RD	6.2	88	47	282	1.5	−1.3
Jan 26 03:45	2064	RD	6.3	88	52	329	0.7	−2.4
Jan 28 02:34	2330	RD	6.4	62	22	296	0.1	−1.5
Jan 29 03:08	39 Oph	RD	5.2	48	18	294	−0.1	−1.4
Feb 15 23:36	Xi Cnc	DD	5.2	165	34	143	1.6	−1.4
Feb 16 00:12	79 Cnc	DD	6.0	166	33	128	1.7	−0.8
Feb 18 23:52	Ome Vir	RD	5.2	157	41	318	1.4	−1.9
Feb 19 04:47	Nu Vir	DB	4.0	155	32	144	0.7	−1.0
Feb 22 02:16	96 Vir	RD	6.5	119	57	319	1.1	−2.1
Feb 23 23:56	Lam Lib	RD	5.0	94	15	233	0.8	0.1
Feb 27 04:52	2804	DB	5.8	52	40	56	1.5	0.3
Mar 01 04:58	Phi Cap	RD	5.2	25	15	294	−0.1	−1.8
Mar 22 23:50	41 Lib	RD	5.5	124	38	276	1.0	−1.2
Mar 23 00:26	Kap Lib	DB	4.8	124	45	137	0.5	−2.1
Mar 23 01:33	Kap Lib	RD	4.8	124	59	283	1.6	−1.2
Mar 26 03:48	2740	RD	6.3	83	53	246	1.8	0.1
Apr 16 18:26	65 Vir	DD	5.9	174	12	113	0.2	−1.5
Apr 16 19:09	66 Vir	DD	5.8	174	21	123	0.4	−1.7
Apr 16 23:29	72 Vir	DD	6.1	176	63	162	0.7	−2.5
Apr 17 00:14	74 Vir	DB	4.7	176	62	56	5.8	4.6
Apr 17 00:38	74 Vir	RB	4.7	176	60	21	−2.3	−7.4
Apr 19 00:49	28 Lib	RD	6.2	155	72	285	2.0	−0.9
Apr 20 22:31	The Oph	DB	3.3	129	27	51	1.4	0.4
Apr 20 23:03	The Oph	RD	3.3	129	33	346	−0.8	−3.4
Apr 21 23:51	2669	RD	6.4	115	31	256	0.8	−0.6
Apr 21 23:53	2673	RD	6.3	115	32	227	1.5	0.6
Apr 25 01:32	Eps Cap	DB	4.5	74	12	57	0.4	−0.1
Apr 25 02:29	Eps Cap	RD	4.5	74	24	278	0.4	−1.4
May 17 01:49	2282	RD	5.8	174	66	340	1.4	−3.2

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
May 18 00:59	26 Oph	RD	5.7	160	81	221	3.6	4.7
May 22 02:16	33 Cap	DB	5.4	104	47	116	1.4	−2.5
May 22 03:12	33 Cap	RD	5.4	103	58	208	1.6	2.4
Jun 10 19:26	72 Vir	DD	6.1	124	61	167	0.5	−2.8
Jun 10 20:04	74 Vir	DD	4.7	124	63	65	4.6	2.2
Jun 10 20:39	74 Vir	RB	4.7	124	62	14	−1.2	−5.4
Jun 12 20:03	28 Lib	DD	6.2	151	61	133	1.1	−2.0
Jun 14 17:26	The Oph	DD	3.3	177	9	87	−0.1	−0.9
Jun 14 18:15	The Oph	RB	3.3	178	19	306	−0.2	−1.6
Jun 16 00:07	Phi Sgr	DB	3.2	164	76	134	1.8	−2.7
Jun 16 01:05	Phi Sgr	RD	3.2	163	83	226	2.1	2.4
Jun 16 04:39	2740	RD	6.3	162	45	255	0.9	1.4
Jun 16 05:04	Sig Sgr	DB	2.1	162	41	31	−0.1	3.0
Jun 16 05:46	Sig Sgr	RD	2.1	161	32	305	1.3	−0.2
Jun 18 06:05	Chi Cap	DB	5.3	133	52	41	0.6	2.2
Jul 11 21:38	26 Oph	DD	5.7	147	81	141	1.7	−2.4
Jul 11 22:43	26 Oph	RB	5.7	148	74	247	2.2	1.6
Jul 12 03:23	2469	DD	6.5	150	19	133	0.8	−0.3
Jul 16 02:40	Eps Cap	DB	4.5	152	73	119	3.6	−1.8
Jul 16 03:19	Eps Cap	RD	4.5	152	67	180	−0.4	4.4
Jul 17 00:45	56 Aqr	RD	6.4	139	56	231	1.6	0.9
Jul 17 21:35	Psi 2 Aqr	RD	4.4	127	6	267	0.0	−1.0
Aug 03 20:23	46 Vir	DD	6.2	64	24	118	0.8	0.1
Aug 06 19:44	2217	DD	5.5	102	68	112	2.0	−0.5
Aug 06 21:05	2217	RB	5.5	102	53	293	1.7	−0.1
Aug 09 21:02	Phi Sgr	DD	3.2	143	81	111	2.1	−1.2
Aug 09 22:17	Phi Sgr	RB	3.2	144	78	243	1.9	1.5
Aug 10 00:34	2740	DD	6.3	145	51	78	1.2	1.3
Aug 10 02:07	Sig Sgr	DD	2.1	145	33	27	−0.5	3.0
Aug 10 02:43	Sig Sgr	RB	2.1	146	25	308	1.1	−0.2
Aug 12 02:43	Chi Cap	DD	5.3	173	49	80	1.2	1.2
Aug 15 04:04	27 Psc	DB	4.9	143	52	54	1.4	1.7

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 15 05:17	27 Psc	RD	4.9	143	39	230	1.0	1.9
Aug 19 05:25	467	RD	6.5	94	37	222	1.7	1.4
Aug 24 05:52	Ups Gem	RD	4.1	39	11	266	1.2	−1.0
Aug 30 18:09	1825	RB	5.9	34	25	259	1.2	1.9
Sep 05 18:37	2650	DD	4.7	111	79	85	2.2	0.0
Sep 05 20:02	2650	RB	4.7	112	78	279	2.2	−0.1
Sep 05 23:55	2673	DD	6.3	113	32	62	0.2	1.8
Sep 05 23:59	2669	DD	6.4	113	31	26	−0.6	3.3
Sep 08 22:57	Eps Cap	DD	4.5	154	74	120	3.8	−2.2
Sep 08 23:34	Eps Cap	RB	4.5	154	69	177	−0.6	4.8
Sep 09 20:02	56 Aqr	DD	6.4	166	43	102	1.5	−1.7
Sep 12 21:47	77 Psc	RD	6.4	152	23	295	1.8	−3.2
Oct 05 22:37	Phi Cap	DD	5.2	123	56	359	−0.9	4.5
Oct 05 23:11	Phi Cap	RB	5.2	123	49	301	2.8	−0.7
Oct 08 22:47	27 Psc	DD	4.9	163	60	37	1.3	1.8
Oct 09 00:04	27 Psc	RB	4.9	163	55	241	1.7	1.5
Oct 09 01:02	29 Psc	DD	5.1	164	46	60	1.4	1.7
Oct 09 02:13	29 Psc	RB	5.1	164	33	226	0.8	2.0
Oct 10 20:58	226	RD	6.5	172	27	236	0.9	0.2
Oct 29 20:47	2558	DD	6.3	52	20	160	2.7	−3.7
Nov 03 23:20	74 Aqr	DD	5.8	119	39	99	1.6	0.9
Nov 10 00:30	566	RD	6.1	166	34	210	1.4	1.6
Nov 10 22:21	703	RD	6.2	156	18	242	1.0	−0.2
Nov 11 23:56	840	RD	6.3	144	21	297	2.7	−1.9
Nov 13 23:59	Iot Gem	DB	3.8	122	8	11	−2.3	4.8
Nov 14 00:03	59 Gem	RD	5.8	122	8	289	1.4	−1.7
Nov 14 00:18	Iot Gem	RD	3.8	122	10	343	4.5	−6.9
Nov 14 02:47	1132	RD	6.4	121	27	271	2.5	−0.5
Dec 04 00:04	80 Psc	DD	5.5	127	23	82	1.1	1.4
Dec 04 21:10	54 Ara	DD	5.9	138	45	352	−0.5	3.6
Dec 29 19:50	29 Psc	DD	5.1	82	44	108	2.8	0.2
Dec 29 20:32	29 Psc	RB	5.1	82	37	176	−0.3	3.4

OPPOSITION OF MARS 2022

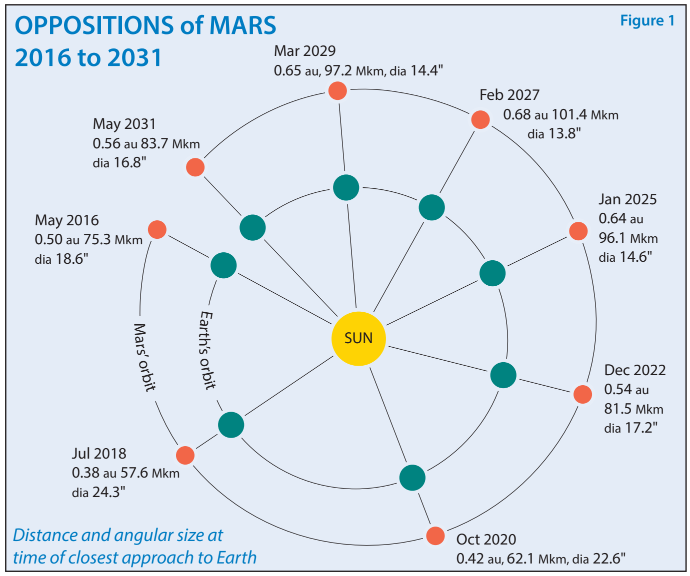
Of all the planets in the Solar System, Mars has long been the most fascinating. Others are bigger, prettier, closer, and brighter, but Mars holds a place in people's imaginations. Only on Mars will you see thawing and growing polar caps, great planet-wide dust storms, cloud forming downwind from the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

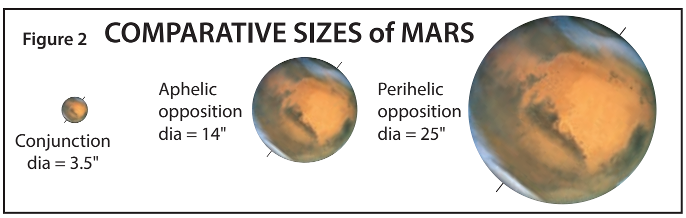
This year, Mars comes to opposition on December 8, seven days after its closest approach to Earth at 81.5 million km (Mkm) (0.5445 au). The timing of opposition and closest approach can vary by up to two weeks since the orbits of Mars and Earth are eccentric and inclined to each other. If they were circular and coplanar (in the same geometric plane), these events would coincide.

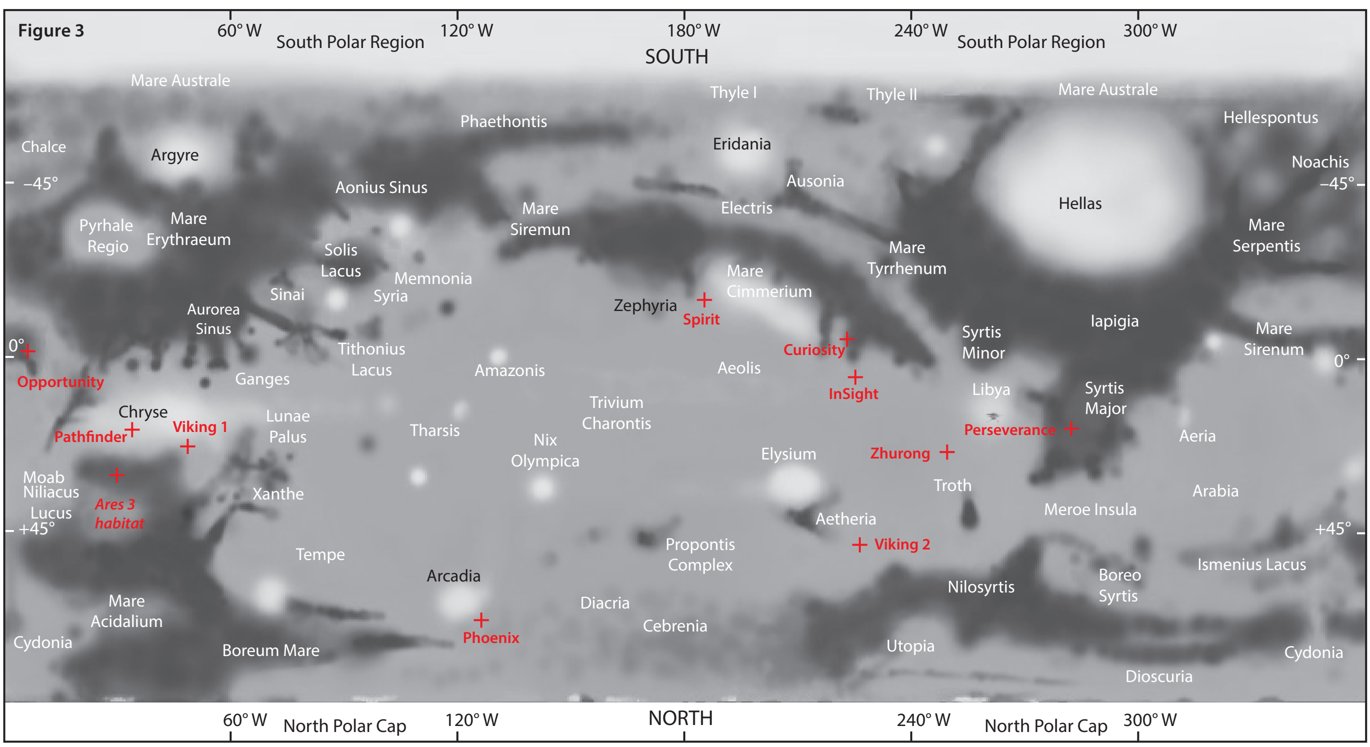
Not all oppositions of Mars are favourable; some give a better perspective than others. When the Earth passes Mars in its orbit every 26 months, we get a close view of the planet (Figure 1). When Mars is also at or near its perihelion, we get an excellent view, for example, the excellent 2003 opposition.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

Oppositions in the early months of the year are always unfavourable as Mars is near aphelion. Perihelic oppositions occur around August, and fortunately for Southern Hemisphere observers, the planet is at its greatest southerly declination at this time. The favourable perihelic oppositions occur every 15 to 17 years, and it will not be until 2035 that we will again see the planet at its largest angular size. When Mars is in conjunction, its disc is only 3.5 arcseconds (") in diameter, smaller than distant Uranus. At a poor opposition, the diameter is 14", increasing to 25" at a perihelic opposition see (Figure 2).

At this year's opposition, the size of the Martian disc is just 17" in angular size. This is the beginning of several oppositions that are relatively poor, with the disc being under 20". The nearest approach in 2020 was the last of the good perihelic oppositions until the next series of three in 2033, 35, and 37. This year, November and December will be the prime time to train telescopes, large and small, on the Red Planet. The detail you observe at opposition will depend on telescope size and those moments when the seeing magically settles







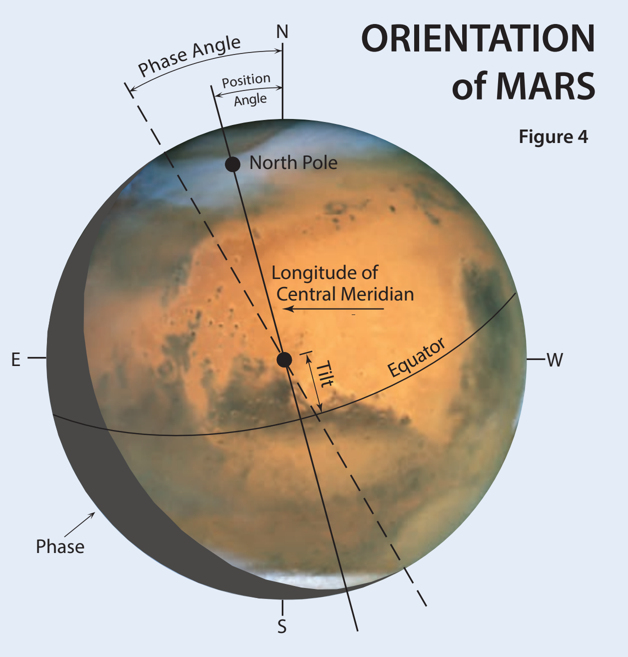
down for a few seconds. With good optics and steady skies (and no Martian dust storms), try pushing the telescope to its maximum usable magnification—considered twice the aperture in millimetres (for an 80 mm telescope, this will be 160×). With modern-day imaging technology, the study of Martian surface features is no longer solely restricted to favourable oppositions, and many amateurs are doing superb work in this field.

Since the Martian day is about 40 minutes longer than Earth's day, surface features cross the central meridian 40 minutes later each night. As this delay is about 9° of longitude per day, observations made at the same time each night will see all surface features cross the central meridian in under six weeks. The Martian dust storms, which can be global and last for months, may obscure some surface features or even create a total block-out; but the study of these storms is still crucial to our understanding of the workings of the planet's atmosphere.

The iron-rich soils of Mars, which give the Red Planet its colour, were shown by the Viking Landers to be much lighter in colour than the rocks underneath. Depending on the season, high-velocity winds can lift the soil and transport it around the planet. Sometimes the rocky surface is uncovered, showing a darker area. At other times, dark areas can be covered by lighter dust as storms deposit millions of tonnes of material over the landscape. Even with the constant movement of dust around the planet, several easily recognisable regions can be seen and identified from opposition to opposition. The most prominent dark area is Syrtis Major, a wedge-shaped region just north of the equator. Directly below Syrtis Major in the south is a light contrasting area known as Hellas, a depression that is very conspicuous when covered in a light dust. The mysterious Eye of Mars or Solis Lacus (Lake of the Sun) is located in the Southern Hemisphere, a small dark region ringed by lighter material. At some oppositions, the Eye is outstanding, and at others, it isn't easy because of the shifting sands of Mars (see map, Figure 3).

ORIENTATION of MARS

Figure 4



NOTES on the Physical Ephemeris Table (next page).

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

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

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

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

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

Diagram does not represent any particular date.

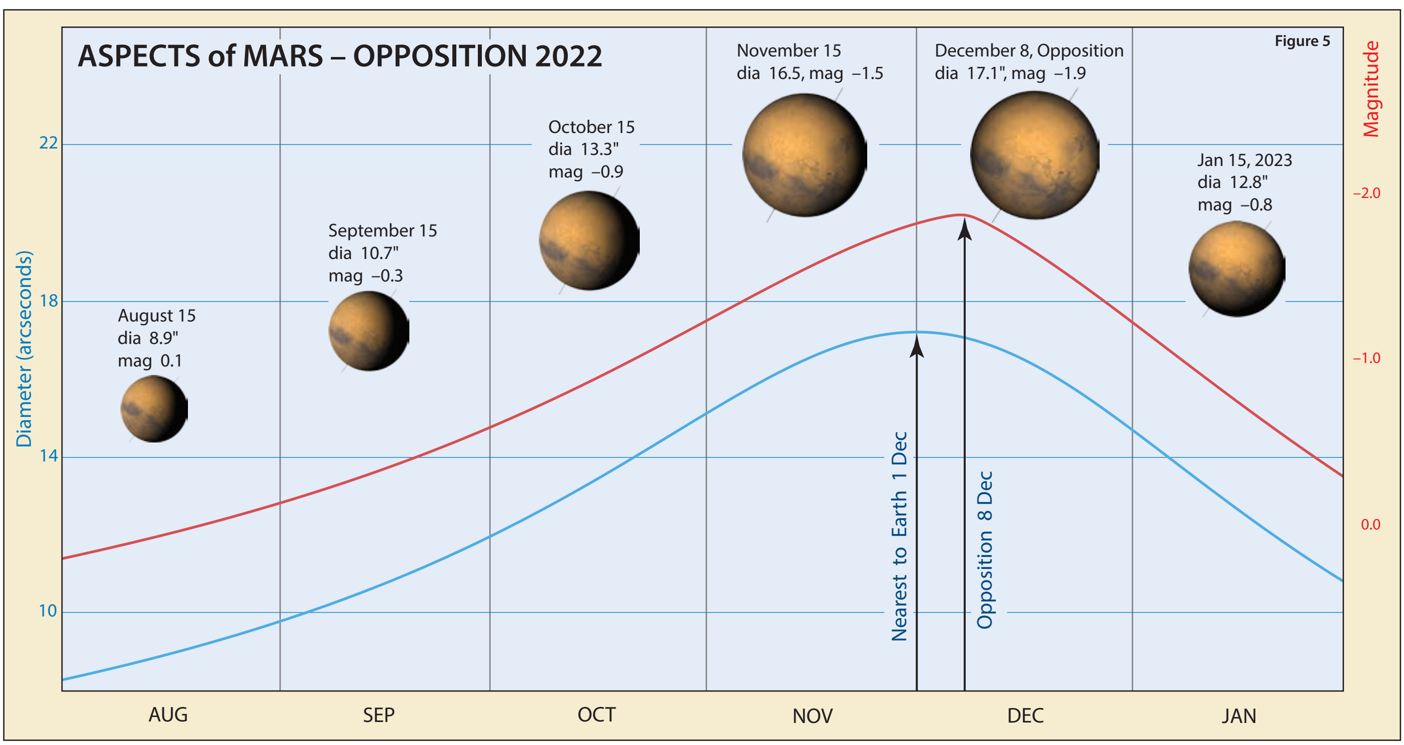


Table 1 Physical Ephemeris (0 hr UT).
See Figure 4 for description.

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Sep 30	073.0	–1.0	0.875	41.5	328.9
Oct 1	063.6	–0.8	0.876	41.2	329.1
Oct 2	054.2	–0.7	0.877	41.0	329.2
Oct 3	044.8	–0.6	0.879	40.7	329.3
Oct 4	035.4	–0.5	0.880	40.5	329.5
Oct 5	026.0	–0.3	0.882	40.2	329.6
Oct 6	016.6	–0.2	0.883	40.0	329.7
Oct 7	007.2	–0.1	0.885	39.7	329.8
Oct 8	357.9	–0.0	0.886	39.4	330.0
Oct 9	348.5	0.1	0.888	39.1	330.1
Oct 10	339.2	0.2	0.890	38.8	330.2
Oct 11	329.8	0.3	0.891	38.5	330.3
Oct 12	320.5	0.3	0.893	38.1	330.4
Oct 13	311.2	0.4	0.895	37.8	330.5
Oct 14	301.9	0.5	0.897	37.5	330.6
Oct 15	292.6	0.5	0.899	37.1	330.7
Oct 16	283.3	0.6	0.901	36.7	330.8
Oct 17	274.0	0.6	0.903	36.4	330.8
Oct 18	264.7	0.7	0.905	36.0	330.9
Oct 19	255.5	0.7	0.907	35.6	331.0
Oct 20	246.2	0.8	0.909	35.2	331.1
Oct 21	237.0	0.8	0.911	34.7	331.1
Oct 22	227.8	0.8	0.913	34.3	331.2
Oct 23	218.5	0.8	0.915	33.9	331.2
Oct 24	209.3	0.8	0.917	33.4	331.3
Oct 25	200.1	0.8	0.920	32.9	331.3
Oct 26	191.0	0.8	0.922	32.5	331.3
Oct 27	181.8	0.8	0.924	32.0	331.4
Oct 28	172.6	0.8	0.927	31.5	331.4
Oct 29	163.5	0.8	0.929	30.9	331.4
Oct 30	154.4	0.7	0.931	30.4	331.4
Oct 31	145.2	0.7	0.934	29.8	331.4
Nov 1	136.1	0.6	0.936	29.3	331.4
Nov 2	127.0	0.6	0.939	28.7	331.4
Nov 3	118.0	0.5	0.941	28.1	331.4
Nov 4	108.9	0.5	0.943	27.5	331.3
Nov 5	099.8	0.4	0.946	26.9	331.3
Nov 6	090.8	0.3	0.948	26.3	331.3
Nov 7	081.7	0.2	0.951	25.6	331.2
Nov 8	072.7	0.1	0.953	25.0	331.2
Nov 9	063.7	0.0	0.956	24.3	331.1
Nov 10	054.7	–0.1	0.958	23.6	331.0
Nov 11	045.7	–0.2	0.961	22.9	331.0
Nov 12	036.8	–0.4	0.963	22.2	330.9
Nov 13	027.8	–0.5	0.965	21.5	330.8
Nov 14	018.9	–0.6	0.968	20.7	330.7
Nov 15	009.9	–0.8	0.970	20.0	330.6
Nov 16	001.0	–0.9	0.972	19.2	330.5
Nov 17	352.1	–1.1	0.974	18.5	330.4
Nov 18	343.2	–1.2	0.976	17.7	330.3
Nov 19	334.3	–1.4	0.978	16.9	330.2
Nov 20	325.5	–1.6	0.980	16.1	330.0
Nov 21	316.6	–1.8	0.982	15.2	329.9
Nov 22	307.7	–1.9	0.984	14.4	329.8
Nov 23	298.9	–2.1	0.986	13.6	329.6
Nov 24	290.1	–2.3	0.988	12.7	329.5
Nov 25	281.2	–2.5	0.989	11.9	329.4
Nov 26	272.4	–2.7	0.991	11.0	329.2
Nov 27	263.6	–2.9	0.992	10.1	329.1
Nov 28	254.8	–3.1	0.993	9.3	328.9
Nov 29	246.0	–3.3	0.995	8.4	328.8
Nov 30	237.2	–3.5	0.996	7.5	328.6

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Dec 1	228.4	–3.8	0.997	6.6	328.5
Dec 2	219.6	–4.0	0.997	5.8	328.3
Dec 3	210.8	–4.2	0.998	4.9	328.1
Dec 4	202.0	–4.4	0.999	4.1	328.0
Dec 5	193.2	–4.6	0.999	3.2	327.8
Dec 6	184.5	–4.8	1.000	2.5	327.7
Dec 7	175.7	–5.0	1.000	1.8	327.5
Dec 8	166.9	–5.2	1.000	1.5	327.4
Dec 9	158.1	–5.5	1.000	1.6	327.2
Dec 10	149.3	–5.7	1.000	2.2	327.1
Dec 11	140.5	–5.9	0.999	2.9	326.9
Dec 12	131.7	–6.1	0.999	3.7	326.8
Dec 13	122.9	–6.3	0.998	4.5	326.6
Dec 14	114.1	–6.4	0.998	5.3	326.5
Dec 15	105.3	–6.6	0.997	6.2	326.4
Dec 16	096.5	–6.8	0.996	7.0	326.3
Dec 17	087.7	–7.0	0.995	7.8	326.1
Dec 18	078.9	–7.2	0.994	8.7	326.0
Dec 19	070.1	–7.3	0.993	9.5	325.9
Dec 20	061.2	–7.5	0.992	10.3	325.8
Dec 21	052.4	–7.7	0.991	11.1	325.7
Dec 22	043.5	–7.8	0.989	11.9	325.6
Dec 23	034.6	–7.9	0.988	12.7	325.5
Dec 24	025.8	–8.1	0.986	13.4	325.4
Dec 25	016.9	–8.2	0.985	14.2	325.3
Dec 26	008.0	–8.3	0.983	14.9	325.2
Dec 27	359.0	–8.5	0.981	15.6	325.1
Dec 28	350.1	–8.6	0.980	16.4	325.1
Dec 29	341.2	–8.7	0.978	17.1	325.0
Dec 30	332.2	–8.8	0.976	17.7	324.9
Dec 31	323.3	–8.8	0.974	18.4	324.9
Jan 1 ’23	314.3	–8.9	0.973	19.1	324.8
Jan 2 ’23	305.3	–9.0	0.971	19.7	324.8
Jan 3 ’23	296.3	–9.1	0.969	20.4	324.7
Jan 4 ’23	287.3	–9.1	0.967	21.0	324.7
Jan 5 ’23	278.3	–9.2	0.965	21.6	324.7
Jan 6 ’23	269.3	–9.2	0.963	22.2	324.6
Jan 7 ’23	260.2	–9.3	0.961	22.7	324.6
Jan 8 ’23	251.2	–9.3	0.959	23.3	324.6
Jan 9 ’23	242.1	–9.3	0.957	23.8	324.6
Jan 10 ’23	233.0	–9.3	0.955	24.4	324.6
Jan 11 ’23	223.9	–9.4	0.954	24.9	324.5
Jan 12 ’23	214.8	–9.4	0.952	25.4	324.5
Jan 13 ’23	205.7	–9.4	0.950	25.9	324.5
Jan 14 ’23	196.6	–9.4	0.948	26.3	324.5
Jan 15 ’23	187.4	–9.3	0.946	26.8	324.5
Jan 16 ’23	178.3	–9.3	0.944	27.3	324.6
Jan 17 ’23	169.1	–9.3	0.943	27.7	324.6
Jan 18 ’23	159.9	–9.3	0.941	28.1	324.6
Jan 19 ’23	150.7	–9.2	0.939	28.5	324.6
Jan 20 ’23	141.5	–9.2	0.938	28.9	324.6
Jan 21 ’23	132.3	–9.2	0.936	29.3	324.7
Jan 22 ’23	123.1	–9.1	0.934	29.7	324.7
Jan 23 ’23	113.9	–9.0	0.933	30.0	324.7
Jan 24 ’23	104.7	–9.0	0.931	30.4	324.8
Jan 25 ’23	095.4	–8.9	0.930	30.7	324.8
Jan 26 ’23	086.2	–8.8	0.928	31.1	324.9
Jan 27 ’23	076.9	–8.8	0.927	31.4	324.9
Jan 28 ’23	067.6	–8.7	0.925	31.7	325.0
Jan 29 ’23	058.3	–8.6	0.924	32.0	325.0
Jan 30 ’23	049.0	–8.5	0.923	32.3	325.1
Jan 31 ’23	039.7	–8.4	0.922	32.5	325.2

Mars can be fun to observe at any opposition through a telescope. The view, however, can be significantly improved by using filters. The greater contrast by using various coloured filters brings hard to detect areas into prominence. A red or orange filter will highlight dark features; green or red filters are best for seeing the projections and boundaries of the polar caps. Yellow and green filters can distinguish surface frost and fog from the lower-level cloud, and blue or violet filters will show the higher-level clouds. Using yellow, orange, and red filters will highlight dust storms.

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

Calculating longitude of central meridian for a particular date and time.

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

For example an observation at 1:20 am EST on December 2, converts to 15:20 UT on December 1. From the tables here our calculation is 228.4° + 219.3° + 4.9° = 452.6° Subtracting 360° to get a result less than 360° gives us a longitude of central meridian of 92.6°. The longitudes are shown on the map (Fig. 3). Around this time Solis Lacus will be crossing the central meridian.

Table 2: Central Meridian – Increase in Longitude

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

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

JUPITER — 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	053.1	259.8	353.8	201.6	253.2	104.3	159.8	015.8	234.2	295.4	152.8	208.7	1
2	210.7	057.5	151.5	359.3	050.9	262.1	317.7	173.8	032.3	093.4	310.7	006.5	2
3	008.4	215.1	309.1	157.0	208.7	059.9	115.6	331.8	190.3	251.5	108.7	164.3	3
4	166.0	012.7	106.8	314.7	006.4	217.7	273.5	129.8	348.3	049.5	266.6	322.1	4
5	323.6	170.4	264.5	112.4	164.2	015.6	071.4	287.8	146.4	207.5	064.5	119.8	5
6	121.3	328.0	062.1	270.1	321.9	173.4	229.3	085.7	304.4	005.5	222.4	277.6	6
7	278.9	125.7	219.8	067.8	119.7	331.2	027.2	243.7	102.5	163.5	020.3	075.4	7
8	076.6	283.3	017.4	225.5	277.4	129.0	185.1	041.7	260.5	321.5	178.2	233.2	8
9	234.2	080.9	175.1	023.2	075.2	286.9	343.1	199.7	058.6	119.5	336.1	031.0	9
10	031.8	238.6	332.8	180.9	233.0	084.7	141.0	357.7	216.6	277.5	134.0	188.7	10
11	189.5	036.2	130.4	338.6	030.7	242.5	298.9	155.7	014.6	075.6	291.9	346.5	11
12	347.1	193.8	288.1	136.4	188.5	040.4	096.8	313.7	172.7	233.6	089.7	144.2	12
13	144.8	351.5	085.7	294.1	346.3	198.2	254.7	111.7	330.7	031.5	247.6	302.0	13
14	302.4	149.1	243.4	091.8	144.0	356.1	052.7	269.7	128.8	189.5	045.5	099.8	14
15	100.0	306.8	041.1	249.5	301.8	153.9	210.6	067.8	286.8	347.5	203.4	257.5	15
16	257.7	104.4	198.8	047.2	099.6	311.8	008.5	225.8	084.9	145.5	001.2	055.3	16
17	055.3	262.1	356.4	204.9	257.3	109.6	166.5	023.8	242.9	303.5	159.1	213.0	17
18	212.9	059.7	154.1	002.6	055.1	267.5	324.4	181.8	040.9	101.5	316.9	010.7	18
19	010.6	217.3	311.8	160.4	212.9	065.3	122.3	339.8	199.0	259.5	114.8	168.5	19
20	168.2	015.0	109.4	318.1	010.7	223.2	280.3	137.8	357.0	057.4	272.6	326.2	20
21	325.8	172.6	267.1	115.8	168.5	021.1	078.2	295.9	155.1	215.4	070.5	123.9	21
22	123.5	330.3	064.8	273.5	326.3	178.9	236.2	093.9	313.1	013.4	228.3	281.7	22
23	281.1	127.9	222.5	071.3	124.1	336.8	034.1	251.9	111.2	171.3	026.1	079.4	23
24	078.7	285.6	020.2	229.0	281.9	134.7	192.1	049.9	269.2	329.3	184.0	237.1	24
25	236.4	083.2	177.8	026.7	079.6	292.5	350.0	208.0	067.2	127.2	341.8	034.8	25
26	034.0	240.9	335.5	184.5	237.4	090.4	148.0	006.0	225.3	285.2	139.6	192.6	26
27	191.7	038.5	133.2	342.2	035.2	248.3	306.0	164.0	023.3	083.1	297.4	350.3	27
28	349.3	196.2	290.9	139.9	193.0	046.2	103.9	322.1	181.3	241.1	095.3	148.0	28
29	146.9		088.6	297.7	350.9	204.1	261.9	120.1	339.4	039.0	253.1	305.7	29
30	304.6		246.3	095.4	148.7	001.9	059.9	278.1	137.4	197.0	050.9	103.4	30
31	102.2		043.9		306.5		217.8	076.2		354.9		261.1	31

SYSTEM II (° at 0 hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	278.7	248.9	129.3	100.5	283.1	257.7	084.3	063.8	045.6	237.9	218.8	045.8	1
2	068.7	038.9	279.3	250.6	073.3	047.9	234.6	214.1	196.0	028.3	009.1	195.9	2
3	218.7	188.9	069.3	040.7	223.4	198.1	024.9	004.5	346.5	178.7	159.4	346.1	3
4	008.7	338.9	219.3	190.7	013.5	348.3	175.1	154.8	136.9	329.1	309.7	136.3	4
5	158.7	128.9	009.4	340.8	163.6	138.5	325.4	305.2	287.3	119.5	100.0	286.4	5
6	308.7	278.9	159.4	130.9	313.7	288.7	115.7	095.6	077.7	269.9	250.2	076.6	6
7	098.7	068.9	309.4	280.9	103.9	078.9	266.0	245.9	228.1	060.3	040.5	226.7	7
8	248.7	218.9	099.4	071.0	254.0	229.1	056.2	036.3	018.5	210.6	190.8	016.9	8
9	038.7	008.9	249.5	221.1	044.1	019.3	206.5	186.6	168.9	001.0	341.0	167.0	9
10	188.8	159.0	039.5	011.2	194.3	169.5	356.8	337.0	319.3	151.4	131.3	317.2	10
11	338.8	309.0	189.5	161.2	344.4	319.7	147.1	127.4	109.8	301.8	281.6	107.3	11
12	128.8	099.0	339.6	311.3	134.5	109.9	297.4	277.8	260.2	092.1	071.8	257.4	12
13	278.8	249.0	129.6	101.4	284.7	260.1	087.7	068.1	050.6	242.5	222.1	047.6	13
14	068.8	039.0	279.6	251.5	074.8	050.3	238.0	218.5	201.0	032.9	012.3	197.7	14
15	218.8	189.0	069.7	041.6	224.9	200.5	028.3	008.9	351.4	183.2	162.5	347.8	15
16	008.8	339.0	219.7	191.6	015.1	350.7	178.6	159.3	141.8	333.6	312.8	137.9	16
17	158.8	129.0	009.8	341.7	165.2	141.0	328.9	309.7	292.2	123.9	103.0	288.0	17
18	308.8	279.0	159.8	131.8	315.4	291.2	119.2	100.0	082.7	274.3	253.2	078.1	18
19	098.8	069.1	309.8	281.9	105.5	081.4	269.5	250.4	233.1	064.6	043.4	228.3	19
20	248.8	219.1	099.9	072.0	255.7	231.6	059.8	040.8	023.5	215.0	193.7	018.4	20
21	038.8	009.1	249.9	222.1	045.8	021.9	210.1	191.2	173.9	005.3	343.9	168.5	21
22	188.8	159.1	040.0	012.2	196.0	172.1	000.4	341.6	324.3	155.7	134.1	318.6	22
23	338.8	309.1	190.0	162.3	346.2	322.3	150.8	132.0	114.7	306.0	284.3	108.7	23
24	128.8	099.1	340.1	312.4	136.3	112.6	301.1	282.4	265.1	096.3	074.5	258.8	24
25	278.8	249.2	130.1	102.5	286.5	262.8	091.4	072.8	055.5	246.6	224.7	048.8	25
26	068.9	039.2	280.2	252.6	076.7	053.1	241.7	223.2	205.9	037.0	014.9	198.9	26
27	218.9	189.2	070.2	042.7	226.8	203.3	032.1	013.6	356.3	187.3	165.1	349.0	27
28	008.9	339.2	220.3	192.8	017.0	353.6	182.4	164.0	146.7	337.6	315.3	139.1	28
29	158.9		010.4	342.9	167.2	143.8	332.8	314.4	297.1	127.9	105.4	289.2	29
30	308.9		160.4	133.0	317.4	294.1	123.1	104.8	087.5	278.2	255.6	079.3	30
31	098.9		310.5		107.5		273.4	255.2		068.5		229.3	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.

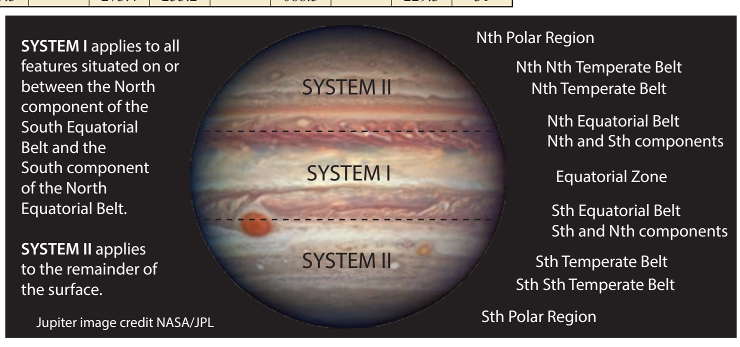
The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0 hr UT of date. You will need to add multiple hours and minutes from the small Increase in Longitude tables below. For example, the longitude of central meridian for Jupiter (System I) for 5 July 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 273.5°. 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 511.0°, less 360° giving a final answer of 151.0°.

GREAT RED SPOT TRANSIT TIME

The GRS can best be seen from about one hour before transiting the central meridian to one hour after. During this two-hour period it will move approximately 70% of the width of Jupiter at its latitude. It can be seen a further 30 minutes either side of this period, but it tends to appear foreshortened and merging with the limb. The longitude of the GRS (System II) does drift over the years and inconsistently. For example the following are some actual values for June: 2014 (214°), 2015 (228°), 2016 (248°), 2017 (274°), 2018 (290°), 2019 (312°), 2020 (339°) and 2021 (359°). The table of data for 2022 (opposite) has been based on 22°. For every degree of longitude greater than 22° it will transit 1.6 minutes later than shown (for every degree less than 22°, 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 2022. 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			(20:46)
Jan 4			20:17
Jan 6			(19:56)
Jan 8			(21:36)
Jan 9		19:28	
Jan 11		(19:07)	21:07
Jan 13			(20:46)
Jan 16			20:17
Jan 18			(19:56)
Jan 21		19:27	
Jan 23		(19:07)	
Jan 25			(20:46)
Jan 26		18:38	
Jan 28			20:17
Jan 30			(19:56)
Feb 2		19:27	
Feb 4		(19:07)	
Feb 7		18:38	
Feb 11			(19:56)
Mar 30	6:10		
Apr 1	(5:50)		
Apr 4	5:20		
Apr 6	(4:59)		
Apr 8	(6:38)		
Apr 9	4:30		
Apr 11	6:09		
Apr 13	(5:48)		
Apr 16	5:19		
Apr 18	(4:58)		
Apr 20	(6:37)		
Apr 21	4:28		
Apr 23	6:07 *		
Apr 25	(5:46)		
Apr 26	3:38		
Apr 28	5:17		
Apr 30	6:56 *		
May 2	(6:35)		
May 3	4:26		
May 5	6:05 *		
May 7	(5:44)		
May 8	3:36		
May 9	(7:23)		

Date	1st	2nd	3rd
May 10	5:14 *		
May 12	6:53 *		
May 13	2:45		
May 14	(6:32)		
May 15	4:24		
May 17	6:02 *		
May 19	(5:41)		
May 20	3:33		
May 21	(7:20)		
May 22	5:12 *		
May 24	6:50 *		
May 25	2:42		
May 26	(6:29)		
May 27	4:21 *		
May 29	5:59 *		
May 30	1:51		
May 31	(5:38)		
Jun 1	3:29		
Jun 2	(7:17)		
Jun 3	5:08 *		
Jun 5	6:47 *		
Jun 6	2:38		
Jun 7	(6:25)		
Jun 8	4:17 *		
Jun 10	5:55 *		
Jun 11	1:47		
Jun 12	(5:34)		
Jun 13	3:26 *		
Jun 14	(7:13)		
Jun 15	5:04 *		
Jun 16	0:56		
Jun 17	6:43 *		
Jun 18	2:34		
Jun 19	(6:21)		
Jun 20	4:13 *		
Jun 22	5:51 *		
Jun 23	1:42		
Jun 24	(5:30)		
Jun 25	3:21 *		
Jun 26	(7:08)		
Jun 27	4:59 *		
Jun 28	0:51		

Date	1st	2nd	3rd
Jun 29	6:38 *		
Jun 30	2:29 *		
Jul 1	(6:16)		
Jul 2	4:08 *		23:59
Jul 4	5:46 *		
Jul 5	1:37		
Jul 6	7:24 *		
Jul 7	3:16 *		
Jul 8	(7:03)		
Jul 9	4:54 *		
Jul 10	0:45		
Jul 11	6:32 *		
Jul 12	2:24 *		
Jul 13	(6:11)		
Jul 14	4:02 *		23:54
Jul 16	5:40 *		(23:32)
Jul 17	1:32		
Jul 18	7:19 *		
Jul 19	3:10 *		23:01
Jul 20	(6:57)		
Jul 21	4:48 *		
Jul 22	0:39		
Jul 23	6:26 *		
Jul 24	2:18 *		
Jul 25	(6:05)		
Jul 26	3:56 *		23:47
Jul 28	5:34 *		(23:25)
Jul 29	1:25		
Jul 30	7:12 *		
Jul 31	3:03 *		22:55
Aug 1	(6:50)		
Aug 2	4:42 *		(22:33)
Aug 3	0:33		
Aug 4	6:20 *		
Aug 5	2:11 *		22:02
Aug 6	(5:58)		
Aug 7	3:49 *		23:40
Aug 9	5:27 *		(23:18)
Aug 10	1:18		
Aug 11	7:05 *		
Aug 12	2:56 *		22:48
Aug 13	(6:43)		

Date	1st	2nd	3rd
Aug 14	4:34 *		(22:26)
Aug 15	0:25		
Aug 16	6:12 *		
Aug 17	2:03 *		21:55
Aug 18	(5:50)		
Aug 19	3:41 *		23:33 *
Aug 21	5:19 *		(23:11)
Aug 22	1:11		21:02
Aug 23	(4:57)		
Aug 24	2:49 *		22:40 *
Aug 25	(6:35)		
Aug 26	4:27 *		(22:18)
Aug 27	0:18		20:09
Aug 28	6:04 *		(23:56)
Aug 29	1:56		21:47
Aug 30	(5:42)		
Aug 31	3:34 *		23:25 *
Sep 2	5:11 *		(23:03)
Sep 3	1:03		20:54
Sep 4	(4:49)		
Sep 5	2:40 *		22:32 *
Sep 6	(6:27)		
Sep 7	4:18 *		(22:10)
Sep 8	0:10		20:01
Sep 9	5:56 *		(23:48)
Sep 10	1:47	(19:39)	21:39
Sep 11	(5:34)		
Sep 12	3:25 *		23:17 *
Sep 13		19:08	
Sep 14	5:03 *		(22:55)
Sep 15	0:54		20:46
Sep 16	(4:41)		
Sep 17	2:32 *		22:24 *
Sep 18	(6:19)		
Sep 19	4:10 *		(22:02)
Sep 20	0:01		19:53
Sep 21	5:48 *		(23:40)
Sep 22	1:39	(19:31)	21:31
Sep 23	(5:26)		
Sep 24	3:17 *		23:09 *
Sep 25		19:00	
Sep 26	4:55 *		(22:47)

Date	1st	2nd	3rd
Sep 27	0:46	(18:38)	20:38
Sep 28	(4:33)		
Sep 29	2:24 *		22:16 *
Sep 30		18:07	
Oct 1	4:02 *		23:54 *
Oct 2		19:45	
Oct 3	(3:40)		(23:32)
Oct 4	1:31	(19:23)	21:23
Oct 5	(5:18)		
Oct 6	3:09 *		23:01 *
Oct 7		18:52	
Oct 8	4:47 *		(22:39)
Oct 9	0:38	(18:30)	20:30
Oct 10	(4:25)		
Oct 11	2:17 *		22:08 *
Oct 12		17:59	
Oct 13	3:55 *		23:46 *
Oct 14		19:37	
Oct 15	(3:33)		(23:24)
Oct 16	1:24	(19:15)	21:15
Oct 18	3:02 *		22:53 *
Oct 19		18:45	
Oct 20	(2:40)		(22:32)
Oct 21	0:31	(18:23)	20:23
Oct 22	(4:18)		
Oct 23	2:10 *		22:01 *
Oct 24		17:52	
Oct 25	3:48 *		23:39 *
Oct 26		19:30	
Oct 27	(3:26)		(23:17)
Oct 28	1:17	(19:09)	21:09
Oct 30	2:56 *		22:47 *
Oct 31		18:38	
Nov 1	(2:34)		(22:25)
Nov 2	0:25	(18:17)	20:17
Nov 4	2:03 *		21:55 *
Nov 6	(1:42)		23:33 *
Nov 7		19:25	
Nov 8			(23:12)
Nov 9	1:12	(19:03)	21:03
Nov 11	(0:50)		22:41 *
Nov 12		18:33	

Date	1st	2nd	3rd
Nov 13	(2:28)		(22:20)
Nov 14	0:20		20:11
Nov 15			(23:58)
Nov 16	1:58	(19:50)	21:50
Nov 18	(1:37)		23:28 *
Nov 19		19:20	
Nov 20			(23:07)
Nov 21	1:07	(18:58)	20:58
Nov 23	(0:45)		22:37 *
Nov 24		18:28	
Nov 25			(22:16)
Nov 26	0:16		20:07
Nov 27			(23:54)
Nov 28		(19:46)	21:46
Nov 30	(1:33)		23:24 *
Dec 1		19:16	
Dec 2			(23:03)
Dec 3	1:03	(18:55)	20:55
Dec 5	(0:42)		22:33 *
Dec 6		18:25	
Dec 7			(22:12)
Dec 8	0:12		20:04
Dec 9			(23:51)
Dec 10		(19:43)	21:43
Dec 12			23:21 *
Dec 13		19:13	
Dec 14			(23:00)
Dec 15		(18:52)	20:52
Dec 17	(0:39)		22:31 *
Dec 19			(22:10)
Dec 20			20:01
Dec 21			(23:49)
Dec 22		(19:40)	21:40
Dec 24			23:19 *
Dec 25		19:11	
Dec 26			(22:58)
Dec 27			20:50
Dec 29			22:29 *
Dec 31			(22:08)

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 secs, two or three transits will occur every day, but a maximum of two are visible from any location. The three columns represent the 1st, 2nd and 3rd transits for each day. Note if the first transit for the day in EST is before 2 am, the event will be the last transit (3rd) for the previous day in WST (assuming Jupiter is visible). When the same transit is visible across the country, only the EST time is given followed by an asterisk (*). To get the WST time subtract two hours from the EST. For CST subtract 30 minutes from EST. For an event only visible from WA the time is given in brackets (WST). Daylight Saving is not allowed for, you will need to add one hour to the times in the table when in effect.

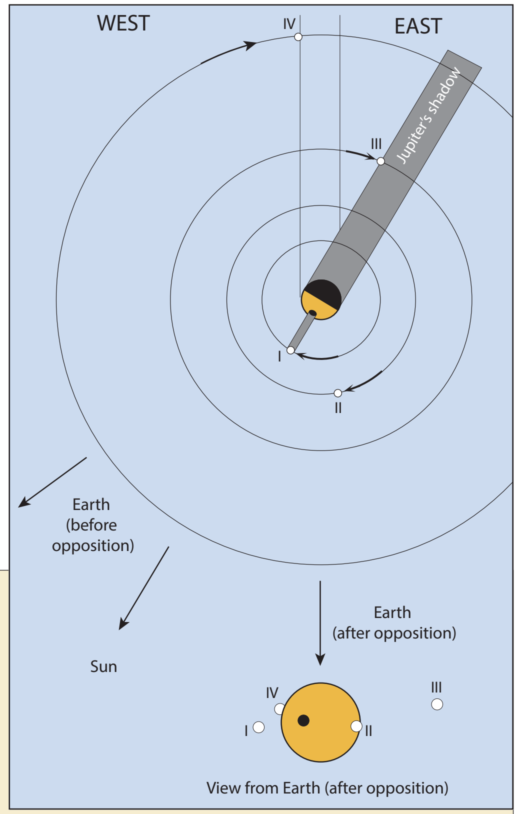
For example, on 17 December the first transit is only visible from WA at 12:39 am WST. The 3rd transit for the day is visible Australia wide at 22:31 EST or 10:31 pm EST (10:01 pm CST, 8:31 pm WST).

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 2022 is 27 September.
3. A satellite can go into occultation, that is, pass behind the disc of Jupiter.
4. A satellite can be eclipsed as it passes into Jupiter's shadow. The closer Jupiter is to opposition (or conjunction), the more likely that the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.



This diagram illustrates all of the Jupiter satellite events. It is only an example and does not represent any particular date 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.

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 17 January.

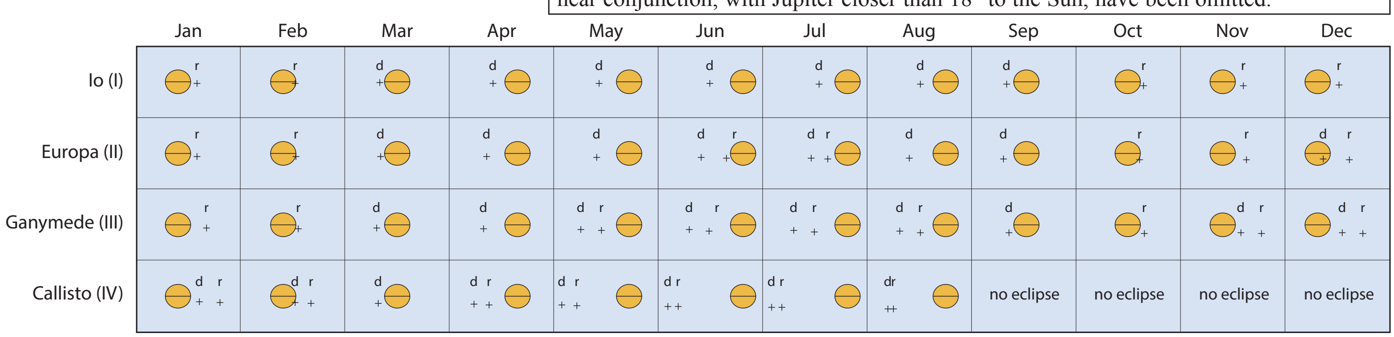
To see the moons with binoculars may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.

JUPITER'S MOON EVENTS Legend (following pages)

Column 1	Date (only appears for the first event each day).
Column 2	Time in EST.
Column 3	Time in WST, a (p) after the time means it is on the previous day.
Column 4	I = Io, II = Europa, III = Ganymede, IV = Callisto
Column 5	Oc = Occultation, Sh = Shadow Transit, Tr = Satellite Transit, Ec = Eclipse
Column 6	I = Ingress, E = Egress, D = Disappearance, R = Reappearance
Column 7	Visibility where E indicates the event is more suitable for the eastern states, W is for events more suitable for observation from Western Australia. A blank here means the event is suitable for most of Australia.

Note: In these tables, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia. Events near conjunction, with Jupiter closer than 18° to the Sun, have been omitted.

ECLIPSE POSITIONS



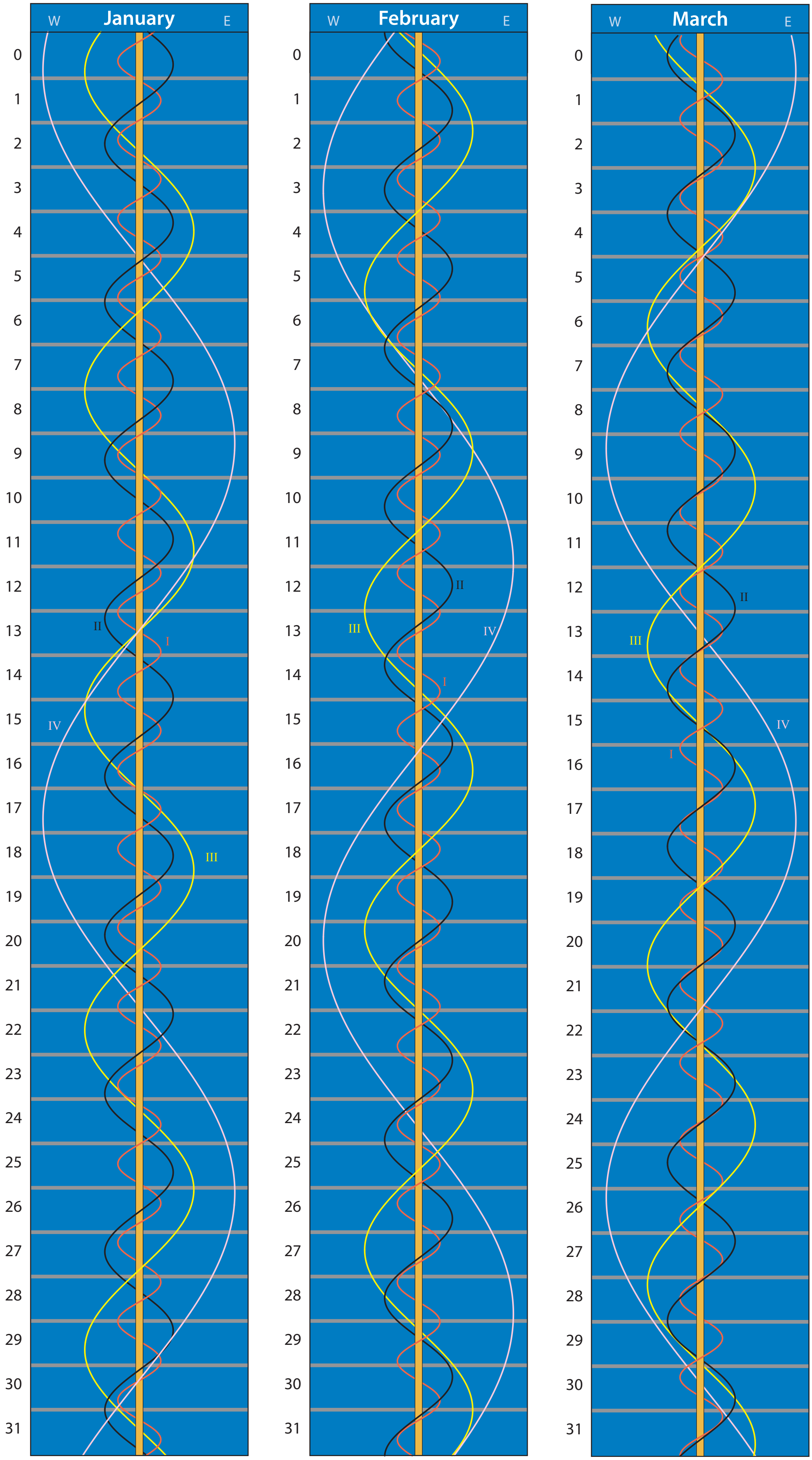
These diagrams show the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse happens when the moon passes into (disappearance or d) or out of (reappearance or r) Jupiter's shadow; west to the left, east to the right.

JUPITER MOON EVENTS

The diagrams here show the patterns 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.

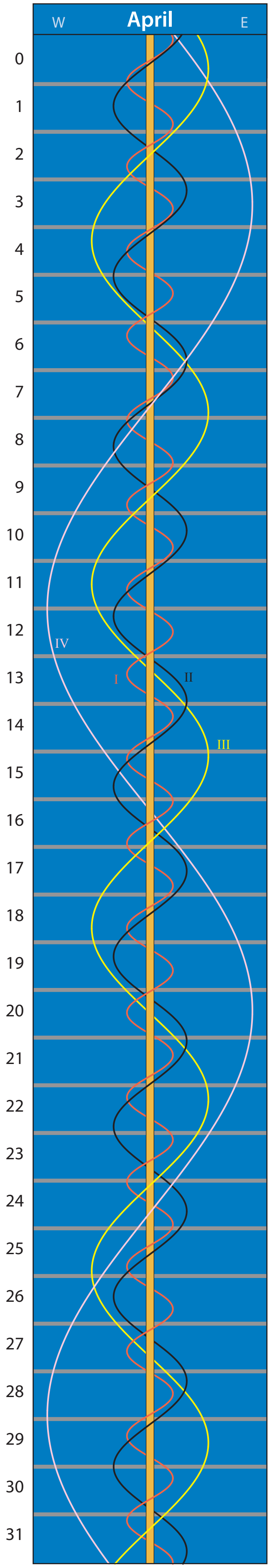
Satellite: **I** is **Io**
II is **Europa**
III is **Ganymede**
IV is **Callisto.**

Day	EST	WST	Sat	Event	Vis
January					
1	23:25	21:25	I	Tr I	W
2	20:34	18:34	I	Oc D	E
	22:43	20:43	III	Ec R	W
	23:52	21:52	I	Ec R	W
3	20:13	18:13	I	Tr E	E
	21:12	19:12	I	Sh E	E
4	23:09	21:09	IV	Oc D	W
6	22:37	20:37	II	Oc D	W
8	19:41	17:41	II	Tr E	E
	21:32	19:32	II	Sh E	E
9	19:31	17:31	III	Oc D	E
	22:35	20:35	I	Oc D	W
	23:07	21:07	III	Oc R	W
	23:16	21:16	III	Ec D	W
10	19:57	17:57	I	Tr I	E
	20:51	18:51	I	Sh I	E
	22:14	20:14	I	Tr E	W
	23:07	21:07	I	Sh E	W
11	20:16	18:16	I	Ec R	E
13	20:42	18:42	IV	Sh E	E
15	19:40	17:40	II	Tr I	E
	22:31	20:31	II	Tr E	W
17	21:58	19:58	I	Tr I	W
	22:46	20:46	I	Sh I	W

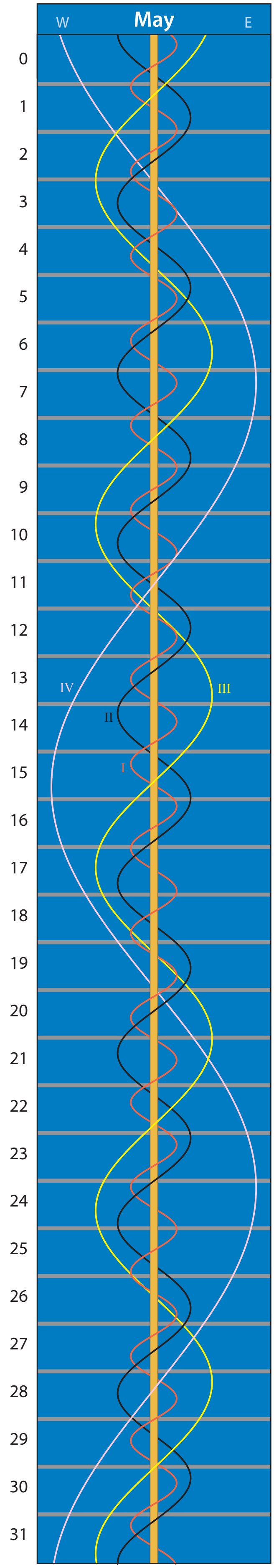


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event		Vis
18	22:12	20:12	I	Ec	R	W
19	19:31	17:31	I	Sh	E	E
20	20:52	18:52	III	Sh	E	E
21	19:41	17:41	IV	Oc	D	E
22	22:32	20:32	II	Tr	I	W
24	21:48	19:48	II	Ec	R	W
26	19:10	17:10	I	Sh	I	E
27	22:21	20:21	III	Tr	E	W
February						
9	21:23	19:23	II	Sh	E	W
March						
30	07:11	05:11	IV	Ec	R	W
	07:54	05:54	IV	Oc	D	W
April						
2	07:18	05:18	I	Tr	I	W
	07:40	05:40	II	Ec	D	W
4	05:08	03:08	II	Sh	E	E
	06:11	04:11	II	Tr	E	E
6	05:07	03:07	III	Oc	R	E
10	05:59	03:59	I	Ec	D	E
11	05:02	03:02	II	Sh	I	E
	05:27	03:27	I	Sh	E	E
	06:05	04:05	I	Tr	E	E
	07:45	05:45	II	Sh	E	W
16	04:53	02:53	IV	Oc	D	E
	07:51	05:51	IV	Oc	R	W
17	07:54	05:54	I	Ec	D	W
18	05:06	03:06	I	Sh	I	E
	05:50	03:50	I	Tr	I	E
	07:21	05:21	I	Sh	E	W
	07:40	05:40	II	Sh	I	W
	08:05	06:05	I	Tr	E	W
19	05:24	03:24	I	Oc	R	E
20	06:19	04:19	II	Oc	R	
	07:39	05:39	III	Ec	D	W
24	04:19	02:19	III	Tr	E	E
	06:50	04:50	IV	Sh	I	W
25	07:00	05:00	I	Sh	I	W
	07:51	05:51	I	Tr	I	W
26	04:17	02:17	I	Ec	D	E
	07:25	05:25	I	Oc	R	W

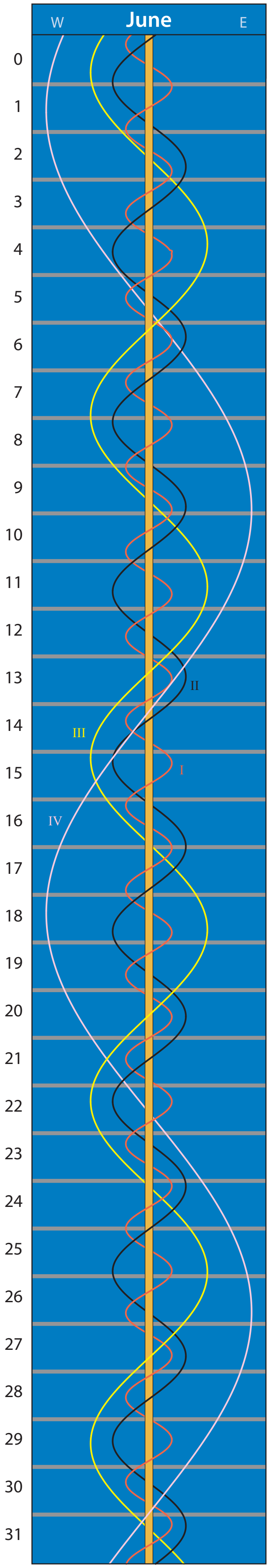


Day	EST	WST	Sat	Event		Vis
27	03:44	01:44	I	Sh	E	E
	04:36	02:36	I	Tr	E	E
	04:42	02:42	II	Ec	D	E
29	04:08	02:08	II	Tr	E	E
May						
1	04:59	02:59	III	Sh	E	E
	05:32	03:32	III	Tr	I	E
	08:43	06:43	III	Tr	E	W
2	08:54	06:54	I	Sh	I	W
3	04:03	02:03	IV	Oc	R	E
	06:12	04:12	I	Ec	D	
4	03:23	01:23	I	Sh	I	E
	04:21	02:21	I	Tr	I	E
	05:38	03:38	I	Sh	E	
	06:35	04:35	I	Tr	E	
	07:17	05:17	II	Ec	D	W
5	03:55	01:55	I	Oc	R	E
6	04:17	02:17	II	Tr	I	E
	04:56	02:56	II	Sh	E	E
	06:57	04:57	II	Tr	E	W
8	05:44	03:44	III	Sh	I	
	08:59	06:59	III	Sh	E	W
10	08:06	06:06	I	Ec	D	W
11	03:48	01:48	IV	Sh	E	E
	05:16	03:16	I	Sh	I	
	06:20	04:20	I	Tr	I	
	07:31	05:31	I	Sh	E	W
	08:34	06:34	I	Tr	E	W
12	03:13	01:13	III	Oc	R	E
	05:55	03:55	I	Oc	R	
13	03:04	01:04	I	Tr	E	E
	04:52	02:52	II	Sh	I	E
	07:06	05:06	II	Tr	I	W
	07:33	05:33	II	Sh	E	W
15	03:59	01:59	II	Oc	R	E
18	07:10	05:10	I	Sh	I	W
	08:19	06:19	I	Tr	I	W
19	02:57	00:57	III	Ec	R	E
	04:28	02:28	III	Oc	D	E
	04:29	02:29	I	Ec	D	E
	07:31	05:31	III	Oc	R	W
	07:54	05:54	I	Oc	R	W
20	02:49	00:49	I	Tr	I	E
	03:54	01:54	I	Sh	E	E
	05:03	03:03	I	Tr	E	
	07:29	05:29	II	Sh	I	W
21	02:24	00:24	I	Oc	R	E
22	06:43	04:43	II	Oc	R	



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

Day	EST	WST	Sat	Event	Vis
25	09:04	07:04	I	Sh I	W
26	03:44	01:44	III	Ec D	E
	06:23	04:23	I	Ec D	
	06:57	04:57	III	Ec R	W
	08:47	06:47	III	Oc D	W
27	03:33	01:33	I	Sh I	E
	04:47	02:47	I	Tr I	
	05:47	03:47	I	Sh E	
	07:01	05:01	I	Tr E	W
28	04:22	02:22	I	Oc R	
29	04:20	02:20	II	Ec D	
30	01:59	23:59(p)	III	Tr E	E
31	02:00	00:00	II	Tr I	E
	02:04	00:04	II	Sh E	E
	04:36	02:36	II	Tr E	
June					
2	07:46	05:46	III	Ec D	W
	08:18	06:18	I	Ec D	W
3	05:26	03:26	I	Sh I	
	06:44	04:44	I	Tr I	
	07:41	05:41	I	Sh E	W
	08:58	06:58	I	Tr E	W
4	02:46	00:46	I	Ec D	E
	06:19	04:19	I	Oc R	
5	02:10	00:10	I	Sh E	E
	03:27	01:27	I	Tr E	E
	05:08	03:08	IV	Ec D	
	06:55	04:55	II	Ec D	
	07:30	05:30	IV	Ec R	W
6	03:15	01:15	III	Tr I	E
	06:11	04:11	III	Tr E	
7	02:01	00:01	II	Sh I	E
	04:41	02:41	II	Sh E	
	04:44	02:44	II	Tr I	
	07:18	05:18	II	Tr E	W
9	01:28	23:28(p)	II	Oc R	E
10	07:20	05:20	I	Sh I	W
	08:41	06:41	I	Tr I	W
11	04:40	02:40	I	Ec D	
	08:16	06:16	I	Oc R	W
12	01:49	23:49(p)	I	Sh I	E
	03:10	01:10	I	Tr I	E
	04:03	02:03	I	Sh E	
	05:23	03:23	I	Tr E	
13	01:49	23:49(p)	III	Sh I	E
	02:45	00:45	I	Oc R	E
	04:58	02:58	III	Sh E	
	07:27	05:27	III	Tr I	W



Day	EST	WST	Sat	Event	Vis
14	04:38	02:38	II	Sh I	
	07:17	05:17	II	Sh E	W
	07:25	05:25	II	Tr I	W
16	01:26	23:26(p)	II	Ec R	E
	01:34	23:34(p)	II	Oc D	E
	04:07	02:07	II	Oc R	
17	09:14	07:14	I	Sh I	W
18	06:34	04:34	I	Ec D	
19	03:42	01:42	I	Sh I	
	05:06	03:06	I	Tr I	
	05:57	03:57	I	Sh E	
	07:19	05:19	I	Tr E	W
20	01:03	23:03(p)	I	Ec D	E
	04:40	02:40	I	Oc R	
	05:49	03:49	III	Sh I	
	08:58	06:58	III	Sh E	W
21	01:48	23:48(p)	I	Tr E	E
	07:14	05:14	II	Sh I	W
22	01:32	23:32(p)	IV	Ec R	E
23	01:23	23:23(p)	II	Ec D	E
	04:01	02:01	II	Ec R	
	04:13	02:13	II	Oc D	
	06:45	04:45	II	Oc R	
24	01:35	23:35(p)	III	Oc D	E
	04:24	02:24	III	Oc R	
25	01:55	23:55(p)	II	Tr E	E
	08:28	06:28	I	Ec D	W
26	05:36	03:36	I	Sh I	
	07:01	05:01	I	Tr I	
	07:51	05:51	I	Sh E	W
	09:14	07:14	I	Tr E	W
27	02:57	00:57	I	Ec D	
	06:35	04:35	I	Oc R	
28	01:29	23:29(p)	I	Tr I	E
	02:19	00:19	I	Sh E	E
	03:42	01:42	I	Tr E	
29	01:03	23:03(p)	I	Oc R	E
30	03:59	01:59	II	Ec D	
	06:37	04:37	II	Ec R	
	06:50	04:50	II	Oc D	
	08:18	06:18	IV	Sh I	W
	09:21	07:21	II	Oc R	W
July					
1	02:57	00:57	III	Ec R	
	05:38	03:38	III	Oc D	
	08:23	06:23	III	Oc R	W
2	01:46	23:46(p)	II	Sh E	E
	02:00	00:00	II	Tr I	E
	04:31	02:31	II	Tr E	

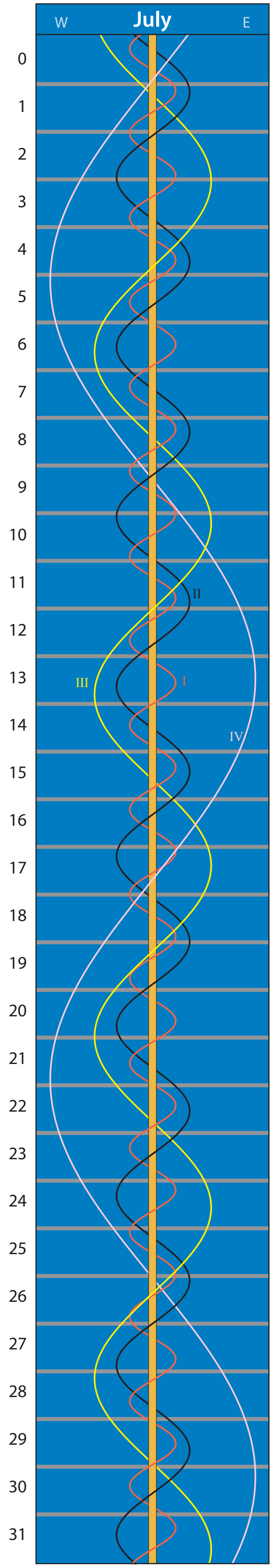
Day	EST	WST	Sat	Event	Vis
3	07:30	05:30	I	Sh I	W
	08:55	06:55	I	Tr I	W
4	04:51	02:51	I	Ec D	
	08:28	06:28	I	Oc R	W
5	01:59	23:59(p)	I	Sh I	E
	03:23	01:23	I	Tr I	
	04:13	02:13	I	Sh E	
	05:36	03:36	I	Tr E	
6	02:57	00:57	I	Oc R	
7	00:04	22:04(p)	I	Tr E	E
	06:35	04:35	II	Ec D	
	09:12	07:12	II	Ec R	W
	09:25	07:25	II	Oc D	W
8	03:50	01:50	III	Ec D	
	06:56	04:56	III	Ec R	
9	01:45	23:45(p)	II	Sh I	E
	04:22	02:22	II	Sh E	
	04:35	02:35	II	Tr I	
	07:04	05:04	II	Tr E	
10	09:24	07:24	I	Sh I	W
11	01:12	23:12(p)	II	Oc R	E
	06:45	04:45	I	Ec D	
	23:39	21:39	III	Tr I	E
12	02:19	00:19	III	Tr E	
	03:53	01:53	I	Sh I	
	05:16	03:16	I	Tr I	
	06:07	04:07	I	Sh E	
	07:28	05:28	I	Tr E	W
13	01:13	23:13(p)	I	Ec D	E
	04:49	02:49	I	Oc R	
	23:44	21:44	I	Tr I	E
14	00:36	22:36(p)	I	Sh E	E
	01:56	23:56(p)	I	Tr E	
	09:10	07:10	II	Ec D	W
	23:17	21:17	I	Oc R	E
15	07:50	05:50	III	Ec D	W
16	04:21	02:21	II	Sh I	
	06:57	04:57	II	Sh E	
	07:06	05:06	II	Tr I	W
17	02:44	00:44	IV	Sh I	
	04:03	02:03	IV	Sh E	
18	01:06	23:06(p)	II	Ec R	E
	01:14	23:14(p)	II	Oc D	E
	03:43	01:43	II	Oc R	
	08:39	06:39	I	Ec D	W

JUPITER MOON EVENTS

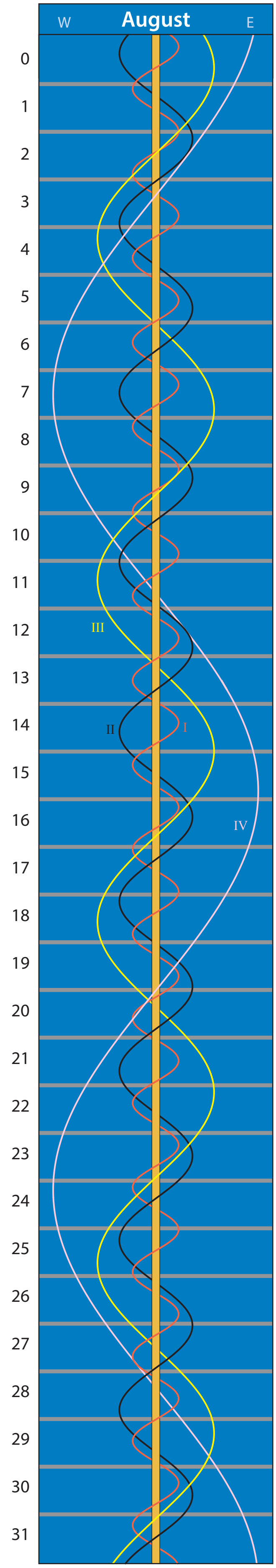
Day	EST	WST	Sat	Event	Vis
19	00:58	22:58(p)	III	Sh E	E
	03:31	01:31	III	Tr I	
	05:47	03:47	I	Sh I	
	06:09	04:09	III	Tr E	
	07:07	05:07	I	Tr I	W
	08:01	06:01	I	Sh E	W
	09:20	07:20	I	Tr E	W
	22:49	20:49	II	Tr E	E
20	03:07	01:07	I	Ec D	
	06:40	04:40	I	Oc R	
21	00:15	22:15(p)	I	Sh I	E
	01:35	23:35(p)	I	Tr I	
	02:30	00:30	I	Sh E	
	03:48	01:48	I	Tr E	
22	01:08	23:08(p)	I	Oc R	
23	06:56	04:56	II	Sh I	
25	01:05	23:05(p)	II	Ec D	
	03:41	01:41	II	Ec R	
	03:44	01:44	II	Oc D	
	06:12	04:12	II	Oc R	
26	01:55	23:55(p)	III	Sh I	
	04:58	02:58	III	Sh E	
	07:19	05:19	III	Tr I	W
	07:41	05:41	I	Sh I	W
	08:58	06:58	I	Tr I	W
	22:50	20:50	II	Tr I	E
	22:50	20:50	II	Sh E	E
27	01:17	23:17(p)	II	Tr E	
	05:01	03:01	I	Ec D	
	08:30	06:30	I	Oc R	W
28	02:09	00:09	I	Sh I	
	03:25	01:25	I	Tr I	
	04:24	02:24	I	Sh E	
	05:38	03:38	I	Tr E	
	23:30	21:30	I	Ec D	E
29	02:57	00:57	I	Oc R	
	22:52	20:52	I	Sh E	E
	23:39	21:39	III	Oc R	E
30	00:05	22:05(p)	I	Tr E	E

August

Day	EST	WST	Sat	Event	Vis
1	03:41	01:41	II	Ec D	
	08:39	06:39	II	Oc R	W
2	05:56	03:56	III	Sh I	
	08:57	06:57	III	Sh E	W
	21:57	19:57	IV	Sh E	E
	22:50	20:50	II	Sh I	E
3	01:16	23:16(p)	II	Tr I	
	01:25	23:25(p)	II	Sh E	
	03:42	01:42	II	Tr E	
	06:55	04:55	I	Ec D	W



Day	EST	WST	Sat	Event	Vis
4	04:03	02:03	I	Sh I	
	05:15	03:15	I	Tr I	
	06:18	04:18	I	Sh E	
	07:27	05:27	I	Tr E	W
	21:52	19:52	II	Oc R	E
5	01:24	23:24(p)	I	Ec D	
	04:46	02:46	I	Oc R	
	22:32	20:32	I	Sh I	E
	22:56	20:56	III	Ec R	E
	23:42	21:42	I	Tr I	E
6	00:45	22:45(p)	III	Oc D	
	00:46	22:46(p)	I	Sh E	
	01:54	23:54(p)	I	Tr E	
	03:18	01:18	III	Oc R	
	23:13	21:13	I	Oc R	E
8	06:17	04:17	II	Ec D	
10	01:25	23:25(p)	II	Sh I	
	03:39	01:39	II	Tr I	
	04:00	02:00	II	Sh E	
	06:05	04:05	II	Tr E	
	08:49	06:49	I	Ec D	W
11	05:58	03:58	I	Sh I	
	06:37	04:37	IV	Ec D	
	07:03	05:03	I	Tr I	W
	07:27	05:27	IV	Ec R	W
	08:12	06:12	I	Sh E	W
12	00:16	22:16(p)	II	Oc R	
	03:18	01:18	I	Ec D	
	06:34	04:34	I	Oc R	
	23:55	21:55	III	Ec D	
13	00:26	22:26(p)	I	Sh I	
	01:30	23:30(p)	I	Tr I	
	02:41	00:41	I	Sh E	
	02:55	00:55	III	Ec R	
	03:42	01:42	I	Tr E	
	04:20	02:20	III	Oc D	
	06:51	04:51	III	Oc R	W
	21:46	19:46	I	Ec D	E
14	01:00	23:00(p)	I	Oc R	
	21:09	19:09	I	Sh E	E
	22:09	20:09	I	Tr E	E
15	08:54	06:54	II	Ec D	W
17	04:01	02:01	II	Sh I	
	06:00	04:00	II	Tr I	
	06:35	04:35	II	Sh E	
	08:25	06:25	II	Tr E	W
18	07:52	05:52	I	Sh I	W
	08:50	06:50	I	Tr I	W
	22:13	20:13	II	Ec D	E
19	02:38	00:38	II	Oc R	
	05:12	03:12	I	Ec D	
	08:20	06:20	I	Oc R	W

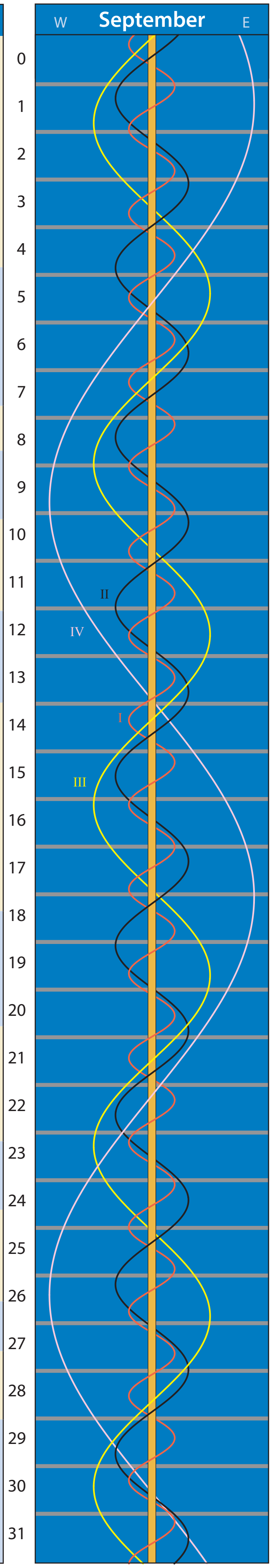


I – Io   II – Europa   III – Ganymede   IV – Callisto

Day	EST	WST	Sat	Event	Vis
20	02:21	00:21	I	Sh I	
	03:17	01:17	I	Tr I	
	03:56	01:56	III	Ec D	
	04:35	02:35	I	Sh E	
	05:29	03:29	I	Tr E	
	06:55	04:55	III	Ec R	W
	07:50	05:50	III	Oc D	W
	21:35	19:35	II	Tr E	E
	23:40	21:40	I	Ec D	
21	02:47	00:47	I	Oc R	
	20:49	18:49	I	Sh I	E
	21:43	19:43	I	Tr I	E
	23:03	21:03	I	Sh E	
	23:55	21:55	I	Tr E	
22	21:13	19:13	I	Oc R	E
23	20:58	18:58	III	Sh E	E
	21:39	19:39	III	Tr I	E
24	00:07	22:07(p)	III	Tr E	
	06:36	04:36	II	Sh I	W
	08:19	06:19	II	Tr I	W
26	00:50	22:50(p)	II	Ec D	
	04:58	02:58	II	Oc R	
	07:06	05:06	I	Ec D	W
27	04:15	02:15	I	Sh I	
	05:02	03:02	I	Tr I	
	06:29	04:29	I	Sh E	W
	07:15	05:15	I	Tr E	W
	07:57	05:57	III	Ec D	W
	21:28	19:28	II	Tr I	E
	22:27	20:27	II	Sh E	E
	23:52	21:52	II	Tr E	
28	01:35	23:35(p)	I	Ec D	
	04:32	02:32	I	Oc R	
	22:44	20:44	I	Sh I	
	23:29	21:29	I	Tr I	
29	00:58	22:58(p)	I	Sh E	
	01:41	23:41(p)	I	Tr E	
	20:03	18:03	I	Ec D	E
	22:58	20:58	I	Oc R	
30	20:07	18:07	I	Tr E	E
	22:03	20:03	III	Sh I	E
31	00:59	22:59(p)	III	Sh E	
	01:03	23:03(p)	III	Tr I	
	03:31	01:31	III	Tr E	

September

Day	EST	WST	Sat	Event	Vis
2	03:28	01:28	II	Ec D	
	07:16	05:16	II	Oc R	W
3	06:10	04:10	I	Sh I	
	06:47	04:47	I	Tr I	W
	08:24	06:24	I	Sh E	W
	22:29	20:29	II	Sh I	
	23:44	21:44	II	Tr I	



Day	EST	WST	Sat	Event	Vis
4	01:02	23:02(p)	II	Sh E	
	02:08	00:08	II	Tr E	
	03:29	01:29	I	Ec D	
	06:16	04:16	I	Oc R	
5	00:38	22:38(p)	I	Sh I	
	01:14	23:14(p)	I	Tr I	
	02:53	00:53	I	Sh E	
	03:26	01:26	I	Tr E	
	20:24	18:24	II	Oc R	E
	21:57	19:57	I	Ec D	
6	00:42	22:42(p)	I	Oc R	
	19:40	17:40	I	Tr I	E
	21:21	19:21	I	Sh E	E
	21:52	19:52	I	Tr E	
7	02:04	00:04	III	Sh I	
	04:23	02:23	III	Tr I	
	04:59	02:59	III	Sh E	
	06:52	04:52	III	Tr E	W
9	06:05	04:05	II	Ec D	
10	08:04	06:04	I	Sh I	W
	20:26	18:26	III	Oc R	E
11	01:04	23:04(p)	II	Sh I	
	01:58	23:58(p)	II	Tr I	
	03:37	01:37	II	Sh E	
	04:23	02:23	II	Tr E	
	05:23	03:23	I	Ec D	
	08:00	06:00	I	Oc R	W
12	02:33	00:33	I	Sh I	
	02:58	00:58	I	Tr I	
	04:47	02:47	I	Sh E	
	05:10	03:10	I	Tr E	
	19:24	17:24	II	Ec D	E
	22:40	20:40	II	Oc R	
	23:52	21:52	I	Ec D	
13	02:26	00:26	I	Oc R	
	21:02	19:02	I	Sh I	E
	21:24	19:24	I	Tr I	
	23:16	21:16	I	Sh E	
	23:36	21:36	I	Tr E	
14	06:06	04:06	III	Sh I	W
	07:40	05:40	III	Tr I	W
	20:52	18:52	I	Oc R	E
17	20:01	18:01	III	Ec D	E
	23:43	21:43	III	Oc R	
18	03:40	01:40	II	Sh I	
	04:11	02:11	II	Tr I	
	06:12	04:12	II	Sh E	W
	06:36	04:36	II	Tr E	W
	07:17	05:17	I	Ec D	W
19	04:28	02:28	I	Sh I	
	04:42	02:42	I	Tr I	
	06:42	04:42	I	Sh E	W
	06:54	04:54	I	Tr E	W
	22:02	20:02	II	Ec D	

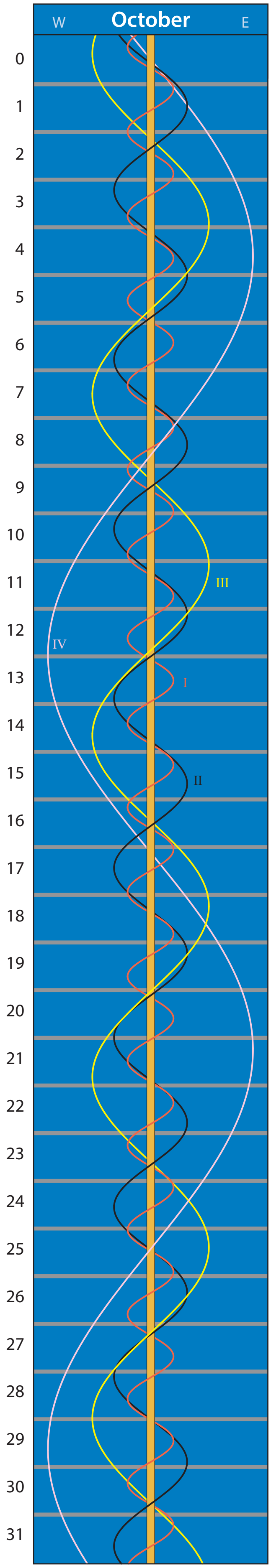
Day	EST	WST	Sat	Event	Vis
20	00:56	22:56(p)	II	Oc R	
	01:46	23:46(p)	I	Ec D	
	04:10	02:10	I	Oc R	
	22:57	20:57	I	Sh I	
	23:08	21:08	I	Tr I	
21	01:11	23:11(p)	I	Sh E	
	01:20	23:20(p)	I	Tr E	
	19:29	17:29	II	Sh E	E
	19:43	17:43	II	Tr E	E
	20:15	18:15	I	Ec D	E
	22:35	20:35	I	Oc R	
22	19:40	17:40	I	Sh E	E
	19:46	17:46	I	Tr E	E
25	00:03	22:03(p)	III	Ec D	
	03:00	01:00	III	Oc R	
	06:15	04:15	II	Sh I	W
	06:24	04:24	II	Tr I	W
26	06:23	04:23	I	Sh I	W
	06:25	04:25	I	Tr I	W
27	00:40	22:40(p)	II	Ec D	
	03:14	01:14	II	Ec R	
	03:41	01:41	I	Ec D	
	05:54	03:54	I	Ec R	W
28	00:51	22:51(p)	I	Tr I	
	00:52	22:52(p)	I	Sh I	
	03:04	01:04	I	Tr E	
	03:06	01:06	I	Sh E	
	19:30	17:30	II	Tr I	E
	19:33	17:33	II	Sh I	E
	21:56	19:56	II	Tr E	
	22:04	20:04	II	Sh E	
	22:07	20:07	I	Oc D	
29	00:22	22:22(p)	I	Ec R	
	19:17	17:17	I	Tr I	E
	19:21	17:21	I	Sh I	E
	21:30	19:30	I	Tr E	
	21:35	19:35	I	Sh E	
30	18:51	16:51	I	Ec R	E

October

Day	EST	WST	Sat	Event	Vis
2	03:41	01:41	III	Oc D	
	06:57	04:57	III	Ec R	W
4	02:58	00:58	II	Oc D	
	05:25	03:25	I	Oc D	
	05:52	03:52	II	Ec R	W
	07:48	05:48	I	Ec R	W

JUPITER MOON EVENTS

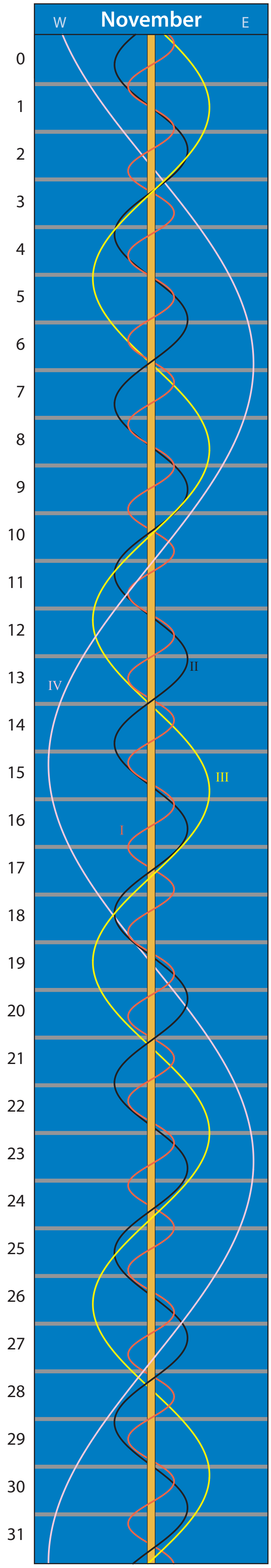
Day	EST	WST	Sat	Event	Vis
5	02:35	00:35	I	Tr I	
	02:47	00:47	I	Sh I	
	04:48	02:48	I	Tr E	
	05:01	03:01	I	Sh E	
	18:12	16:12	III	Sh I	E
	19:59	17:59	III	Tr E	E
	21:02	19:02	III	Sh E	
	21:43	19:43	II	Tr I	
	22:08	20:08	II	Sh I	
	23:51	21:51	I	Oc D	
6	00:09	22:09(p)	II	Tr E	
	00:39	22:39(p)	II	Sh E	
	02:17	00:17	I	Ec R	
	21:01	19:01	I	Tr I	
	21:16	19:16	I	Sh I	
	23:14	21:14	I	Tr E	
	23:30	21:30	I	Sh E	
7	18:16	16:16	I	Oc D	E
	19:11	17:11	II	Ec R	E
	20:46	18:46	I	Ec R	
9	06:56	04:56	III	Oc D	W
11	05:13	03:13	II	Oc D	W
	07:08	05:08	I	Oc D	W
12	04:19	02:19	I	Tr I	
	04:43	02:43	I	Sh I	
	06:32	04:32	I	Tr E	W
	06:57	04:57	I	Sh E	W
	20:40	18:40	III	Tr I	
	22:15	20:15	III	Sh I	
	23:18	21:18	III	Tr E	
	23:56	21:56	II	Tr I	
13	00:44	22:44(p)	II	Sh I	
	01:03	23:03(p)	III	Sh E	
	01:34	23:34(p)	I	Oc D	
	02:23	00:23	II	Tr E	
	03:14	01:14	II	Sh E	
	04:12	02:12	I	Ec R	
	22:46	20:46	I	Tr I	
	23:12	21:12	I	Sh I	
14	00:58	22:58(p)	I	Tr E	
	01:25	23:25(p)	I	Sh E	
	18:22	16:22	II	Oc D	E
	20:00	18:00	I	Oc D	E
	21:49	19:49	II	Ec R	
	22:40	20:40	I	Ec R	
15	19:25	17:25	I	Tr E	E
	19:54	17:54	I	Sh E	E
19	06:04	04:04	I	Tr I	W
	06:38	04:38	I	Sh I	W
	23:59	21:59	III	Tr I	



Day	EST	WST	Sat	Event	Vis
20	02:11	00:11	II	Tr I	
	02:18	00:18	III	Sh I	
	02:39	00:39	III	Tr E	
	03:19	01:19	I	Oc D	
	03:19	01:19	II	Sh I	
	04:39	02:39	II	Tr E	W
	05:06	03:06	III	Sh E	W
	05:50	03:50	II	Sh E	W
	06:06	04:06	I	Ec R	W
21	00:31	22:31(p)	I	Tr I	
	01:07	23:07(p)	I	Sh I	
	02:44	00:44	I	Tr E	
	03:21	01:21	I	Sh E	
	20:39	18:39	II	Oc D	
	21:45	19:45	I	Oc D	
22	00:28	22:28(p)	II	Ec R	
	00:35	22:35(p)	I	Ec R	
	18:57	16:57	I	Tr I	E
	19:36	17:36	I	Sh I	E
	21:10	19:10	I	Tr E	
	21:50	19:50	I	Sh E	
23	18:58	16:58	III	Ec R	E
	19:04	17:04	I	Ec R	E
	19:07	17:07	II	Sh E	E
27	03:20	01:20	III	Tr I	
	04:27	02:27	II	Tr I	W
	05:04	03:04	I	Oc D	W
	05:55	03:55	II	Sh I	W
	06:04	04:04	III	Tr E	W
28	02:17	00:17	I	Tr I	
	03:03	01:03	I	Sh I	
	04:30	02:30	I	Tr E	W
	05:16	03:16	I	Sh E	W
	22:58	20:58	II	Oc D	
	23:31	21:31	I	Oc D	
29	02:30	00:30	I	Ec R	
	03:06	01:06	II	Ec R	
	20:43	18:43	I	Tr I	E
	21:32	19:32	I	Sh I	
	22:57	20:57	I	Tr E	
	23:45	21:45	I	Sh E	
30	19:13	17:13	II	Sh I	E
	19:40	17:40	III	Oc R	E
	20:05	18:05	II	Tr E	E
	20:13	18:13	III	Ec D	E
	20:59	18:59	I	Ec R	
	21:43	19:43	II	Sh E	
	22:59	20:59	III	Ec R	

Day	EST	WST	Sat	Event	Vis
November					
4	04:04	02:04	I	Tr I	W
	04:59	02:59	I	Sh I	W
5	01:17	23:17(p)	I	Oc D	
	01:19	23:19(p)	II	Oc D	
	04:25	02:25	I	Ec R	W
	22:31	20:31	I	Tr I	
	23:28	21:28	I	Sh I	
6	00:44	22:44(p)	I	Tr E	
	01:41	23:41(p)	I	Sh E	
	19:44	17:44	I	Oc D	E
	19:55	17:55	II	Tr I	E
	20:22	18:22	III	Oc D	E
	21:49	19:49	II	Sh I	
	22:25	20:25	II	Tr E	
	22:54	20:54	I	Ec R	
	23:10	21:10	III	Oc R	
7	00:15	22:15(p)	III	Ec D	
	00:18	22:18(p)	II	Sh E	
	03:00	01:00	III	Ec R	
	19:11	17:11	I	Tr E	E
	20:10	18:10	I	Sh E	E
8	19:03	17:03	II	Ec R	E
12	03:05	01:05	I	Oc D	W
	03:43	01:43	II	Oc D	W
13	00:19	22:19(p)	I	Tr I	
	01:24	23:24(p)	I	Sh I	
	02:33	00:33	I	Tr E	
	03:37	01:37	I	Sh E	W
	21:32	19:32	I	Oc D	
	22:17	20:17	II	Tr I	
	23:56	21:56	III	Oc D	
14	00:25	22:25(p)	II	Sh I	
	00:48	22:48(p)	II	Tr E	
	00:49	22:49(p)	I	Ec R	
	02:46	00:46	III	Oc R	W
	02:54	00:54	II	Sh E	W
	04:19	02:19	III	Ec D	W
	18:47	16:47	I	Tr I	E
	19:52	17:52	I	Sh I	E
	21:00	19:00	I	Tr E	
	22:06	20:06	I	Sh E	
15	19:18	17:18	I	Ec R	E
	21:42	19:42	II	Ec R	
17	21:11	19:11	III	Sh E	
20	02:09	00:09	I	Tr I	
	03:20	01:20	I	Sh I	W
	04:23	02:23	I	Tr E	W
	23:22	21:22	I	Oc D	

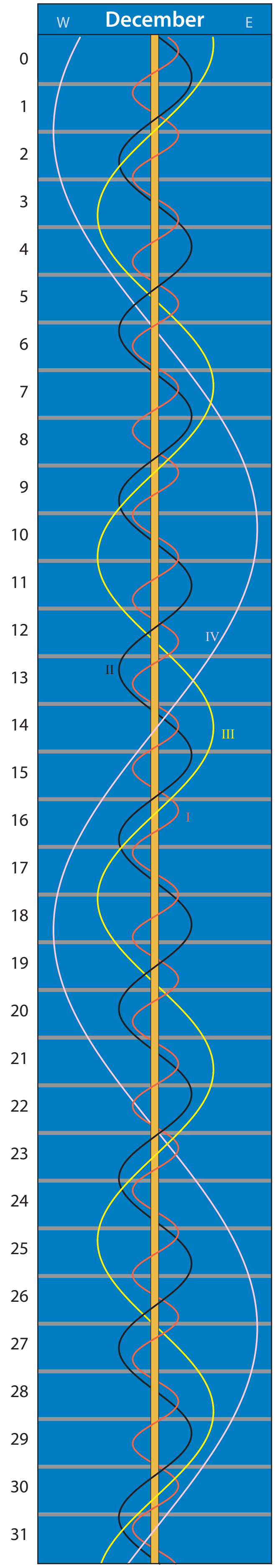
I – Io   II – Europa   III – Ganymede   IV – Callisto



Day	EST	WST	Sat	Event	Vis
21	00:41	22:41(p)	II	Tr I	
	02:44	00:44	I	Ec R	W
	03:01	01:01	II	Sh I	W
	03:12	01:12	II	Tr E	W
	03:33	01:33	III	Oc D	W
	20:37	18:37	I	Tr I	E
	21:48	19:48	I	Sh I	
	22:51	20:51	I	Tr E	
22	00:02	22:02(p)	I	Sh E	
	19:22	17:22	II	Oc D	E
	21:13	19:13	I	Ec R	
23	00:21	22:21(p)	II	Ec R	
24	20:23	18:23	III	Tr E	E
	22:32	20:32	III	Sh I	
25	01:13	23:13(p)	III	Sh E	
27	04:00	02:00	I	Tr I	W
28	01:13	23:13(p)	I	Oc D	
	03:07	01:07	II	Tr I	W
	22:28	20:28	I	Tr I	
	23:45	21:45	I	Sh I	
29	00:42	22:42(p)	I	Tr E	
	01:58	23:58(p)	I	Sh E	W
	19:41	17:41	I	Oc D	E
	21:52	19:52	II	Oc D	
	23:08	21:08	I	Ec R	
30	00:27	22:27(p)	II	Oc R	
	00:29	22:29(p)	II	Ec D	
	02:59	00:59	II	Ec R	W
	19:11	17:11	I	Tr E	E
	20:27	18:27	I	Sh E	E

December

Day	EST	WST	Sat	Event	Vis
1	21:17	19:17	III	Tr I	
	21:23	19:23	II	Sh E	
2	00:10	22:10(p)	III	Tr E	
	02:36	00:36	III	Sh I	W
5	03:05	01:05	I	Oc D	W
	19:05	17:05	III	Ec R	E
6	00:21	22:21(p)	I	Tr I	
	01:41	23:41(p)	I	Sh I	W
	02:35	00:35	I	Tr E	W
	21:33	19:33	I	Oc D	
7	00:25	22:25(p)	II	Oc D	
	01:04	23:04(p)	I	Ec R	
	03:00	01:00	II	Oc R	W
	03:08	01:08	II	Ec D	W
	20:10	18:10	I	Sh I	E
	21:04	19:04	I	Tr E	E
	22:23	20:23	I	Sh E	



Day	EST	WST	Sat	Event	Vis
8	19:33	17:33	I	Ec R	E
	21:25	19:25	II	Tr E	
	21:31	19:31	II	Sh I	
	23:59	21:59	II	Sh E	
9	01:08	23:08(p)	III	Tr I	W
12	20:28	18:28	III	Ec D	E
	23:06	21:06	III	Ec R	
13	02:15	00:15	I	Tr I	W
	23:26	21:26	I	Oc D	
14	02:59	00:59	I	Ec R	W
	03:00	01:00	II	Oc D	W
	20:44	18:44	I	Tr I	E
	22:06	20:06	I	Sh I	
	22:58	20:58	I	Tr E	
15	00:19	22:19(p)	I	Sh E	
	21:25	19:25	II	Tr I	E
	21:28	19:28	I	Ec R	
	23:58	21:58	II	Tr E	
16	00:08	22:08(p)	II	Sh I	
	02:35	00:35	II	Sh E	W
17	21:36	19:36	II	Ec R	
19	21:51	19:51	III	Oc R	
20	00:32	22:32(p)	III	Ec D	W
21	01:21	23:21(p)	I	Oc D	W
	22:39	20:39	I	Tr I	
22	00:02	22:02(p)	I	Sh I	
	00:54	22:54(p)	I	Tr E	W
	02:15	00:15	I	Sh E	W
	19:50	17:50	I	Oc D	E
	23:24	21:24	I	Ec R	
23	00:01	22:01(p)	II	Tr I	
	19:23	17:23	I	Tr E	E
	20:43	18:43	I	Sh E	E
24	21:33	19:33	II	Oc R	
	21:46	19:46	II	Ec D	
25	00:14	22:14(p)	II	Ec R	W
26	22:57	20:57	III	Oc D	
27	01:54	23:54(p)	III	Oc R	W
29	00:36	22:36(p)	I	Tr I	W
	01:58	23:58(p)	I	Sh I	W
	21:46	19:46	I	Oc D	
30	01:19	23:19(p)	I	Ec R	W
	20:27	18:27	I	Sh I	E
	21:19	19:19	I	Tr E	E
	21:22	19:22	III	Sh E	E
	22:39	20:39	I	Sh E	
31	19:48	17:48	I	Ec R	E
	21:38	19:38	II	Oc D	

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 26 August 11 pm EST (see page 65).

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 26.542 UT.
2. Subtract the date of the greatest elongation east for Rhea for August, i.e., 26.542 – 5.445 = 21.097
3. Express this as the number of orbits by dividing by the period i.e., 21.097 / 4.518 = 4.669
4. Discard any complete orbits (4 in this case) leaving 0.669
5. Multiply by the period, 0.669 × 4.518 = 3.023 days or about 3 days and 1 hour after elongation east.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is north-west of Saturn.

Table 1: **Saturn Satellites — Time of Greatest Elongation East** (dd.ddd UT)					
Moon	**Mimas**	**Enceladus**	**Tethys**	**Dione**	**Rhea**
Magnitude [1]	12.8	11.8	10.2	10.4	9.6
Max Elong. [1]	0' 30"	0' 38"	0' 48"	1' 01"	1' 25"
Period (days) [2]	0.942	1.370	1.888	2.737	4.518
Month	**Elongation East (d.ddd)**				
January	1.061	2.247	2.385	1.897	5.009
February	1.173	1.406	1.608	1.030	1.153
March	1.455	2.192	1.942	3.161	4.820
April	1.562	1.346	1.161	2.288	5.479
May	1.722	1.497	1.375	2.407	2.604
June	1.820	2.012	2.469	1.517	3.235
July	1.030	2.152	2.669	1.617	4.847
August	1.122	1.290	1.864	3.444	5.445
September	1.215	1.796	1.058	2.535	1.527
October	1.370	1.937	1.256	2.631	3.131
November	1.473	1.083	2.350	1.738	3.753
December	1.638	1.235	2.564	1.855	5.395

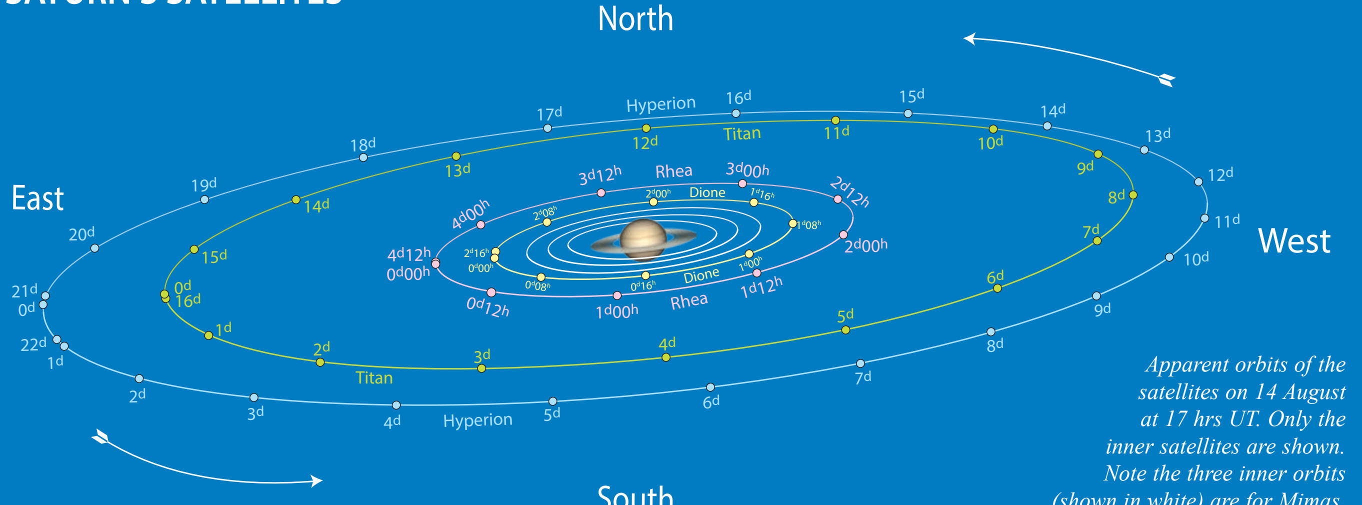
Notes 1. When at opposition 2. Mean Synodic Period

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 26.542 UT; 13.071 orbits have elapsed since the first greatest elongation east for August on 1.864 UT. Discarding the completed orbits leaves 0.071 of an orbit. This is east-south-east of Saturn just after its elongation east.

APPARENT ORBITS OF SATURN'S SATELLITES



Apparent orbits of the satellites on 14 August at 17 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 26 Aug 11 pm EST (26.542 UT), Titan is about 1.0 days past its most recent greatest elongation east (August 25.500 UT), which puts it east-south-east of Saturn. The diagrams opposite and on page 65 show this very well.

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	13.947	7.441
	29.974	28.831
February	15.001	19.153
March	3.026	12.464
	19.045	
April	4.054	2.782
	20.052	24.033
May	6.036	15.254
	22.004	
June	6.954	5.458
	22.888	26.607
July	8.805	17.740
	24.710	
August	9.606	7.867
	25.500	28.993
September	10.399	19.173
	26.308	
October	12.233	10.403
	28.175	31.688
November	13.136	22.061
	29.115	
December	15.110	13.495
	31.118	

Notes 1. When at opposition
2. Mean Synodic Period

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 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	18.899	Feb	7.890	Mar	1.115	Mar	21.668
Apr	10.341	Apr	29.947	May	20.990	Jun	9.853
Jun	29.068	Jul	18.201	Aug	7.514	Aug	27.326
Sep	15.018	Oct	4.455	Oct	24.694	Nov	14.266
Dec	3.321	Dec	23.382				

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, 26 Aug 11 pm EST (26.542 UT), the most recent event was a western elongation on August 7.514 (UT). Iapetus is 19.0 days past this time, heading towards a superior conjunction, so it is to the north-east of the planet.

SATURN'S RINGS 2022

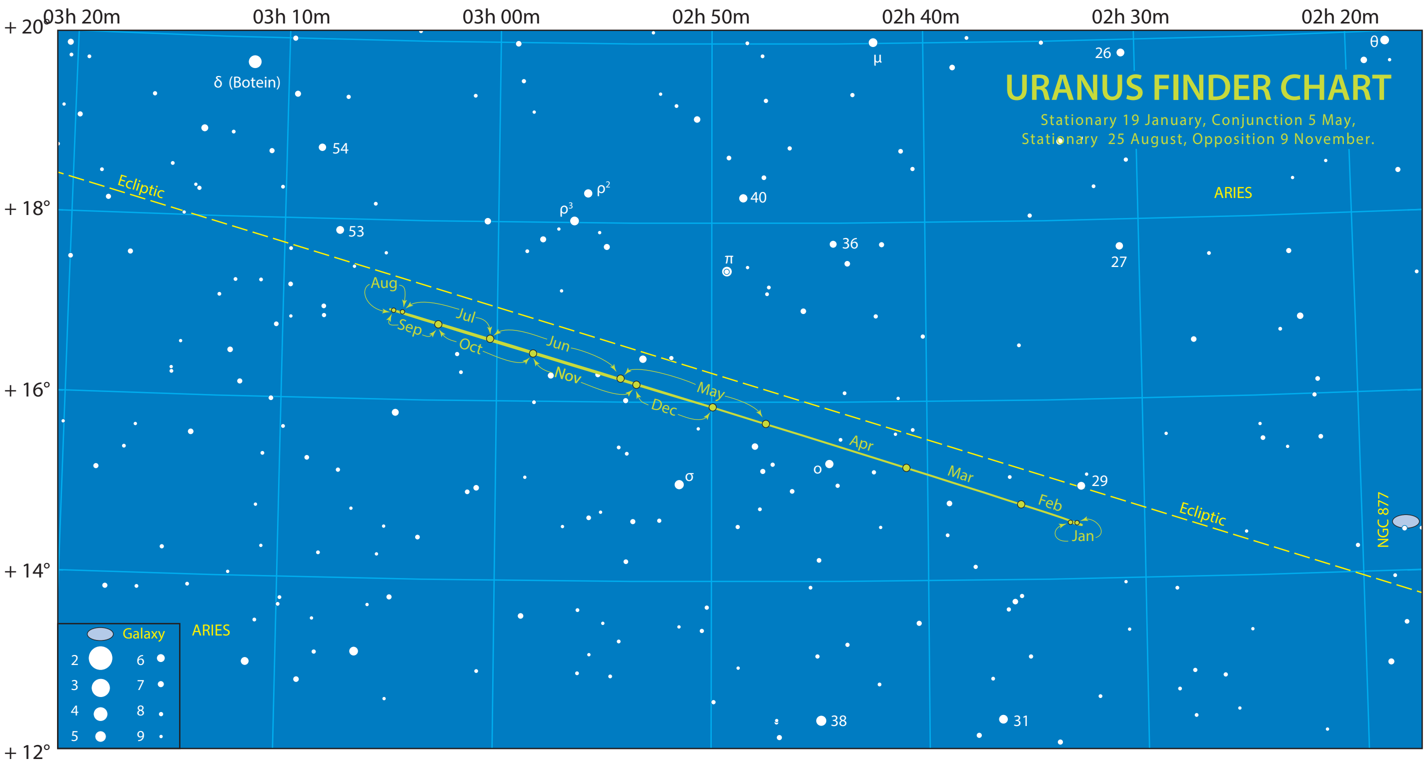
Date	Major "	Minor "	B °
Jan 1	35.1	10.6	17.6
Jan 9	34.9	10.3	17.2
Jan 17	34.8	10.1	16.9
Jan 25	34.7	9.8	16.5
Feb 2	34.6	9.6	16.1
Feb 10	34.6	9.4	15.7
Feb 18	34.7	9.2	15.3
Feb 26	34.8	9.0	15.0
Mar 6	35.0	8.8	14.6
Mar 14	35.2	8.7	14.2
Mar 22	35.4	8.5	13.9
Mar 30	35.8	8.4	13.6
Apr 7	36.1	8.3	13.3
Apr 15	36.5	8.2	13.0
Apr 23	36.9	8.2	12.8
May 1	37.4	8.2	12.6
May 9	37.9	8.2	12.5
May 17	38.4	8.2	12.4
May 25	38.9	8.3	12.3
Jun 2	39.5	8.4	12.3
Jun 10	40.0	8.5	12.3
Jun 18	40.5	8.7	12.4
Jun 26	41.0	8.9	12.5
Jul 4	41.4	9.1	12.7
Jul 12	41.8	9.3	12.9
Jul 20	42.1	9.5	13.1
Jul 28	42.4	9.8	13.3
Aug 5	42.5	10.0	13.6
Aug 13	42.6	10.2	13.8
Aug 21	42.6	10.4	14.1
Aug 29	42.4	10.5	14.4
Sep 6	42.2	10.6	14.6
Sep 14	42.0	10.7	14.8
Sep 22	41.6	10.8	15.0
Sep 30	41.2	10.8	15.1
Oct 8	40.7	10.7	15.2
Oct 16	40.2	10.6	15.3
Oct 24	39.7	10.5	15.3
Nov 1	39.2	10.3	15.3
Nov 9	38.7	10.1	15.2
Nov 17	38.1	9.9	15.1
Nov 25	37.6	9.7	14.9
Dec 3	37.2	9.4	14.7
Dec 11	36.7	9.2	14.4
Dec 19	36.3	8.9	14.2
Dec 27	36.0	8.6	13.8

The Appearance of the Planets diagrams in Part I show how open the rings are for 2022. 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 2022 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' 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)

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	2.275	3.408	5.090	6.622
February	1.523	1.419	8.913	2.550
March	1.248	2.429	7.026	1.473
April	3.011	4.578	2.136	10.840
May	3.252	3.581	6.947	7.743
June	2.491	1.583	2.049	3.650
July	2.729	4.727	6.853	14.018
August	1.968	2.729	1.959	9.934
September	1.209	4.880	5.780	5.850
October	1.453	3.889	1.903	2.777
November	3.220	1.902	5.734	12.189
December	3.469	5.062	1.859	9.131
Notes 1. When at opposition	2. Sidereal Period			

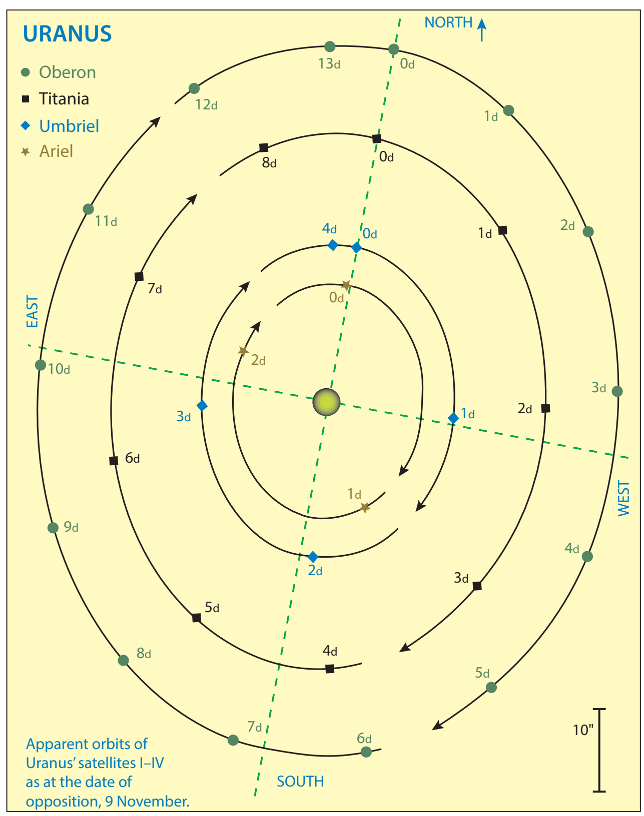
2 Subtract the date of the greatest elongation north for October, i.e. 25.708 – 3.889 = 21.819 days.

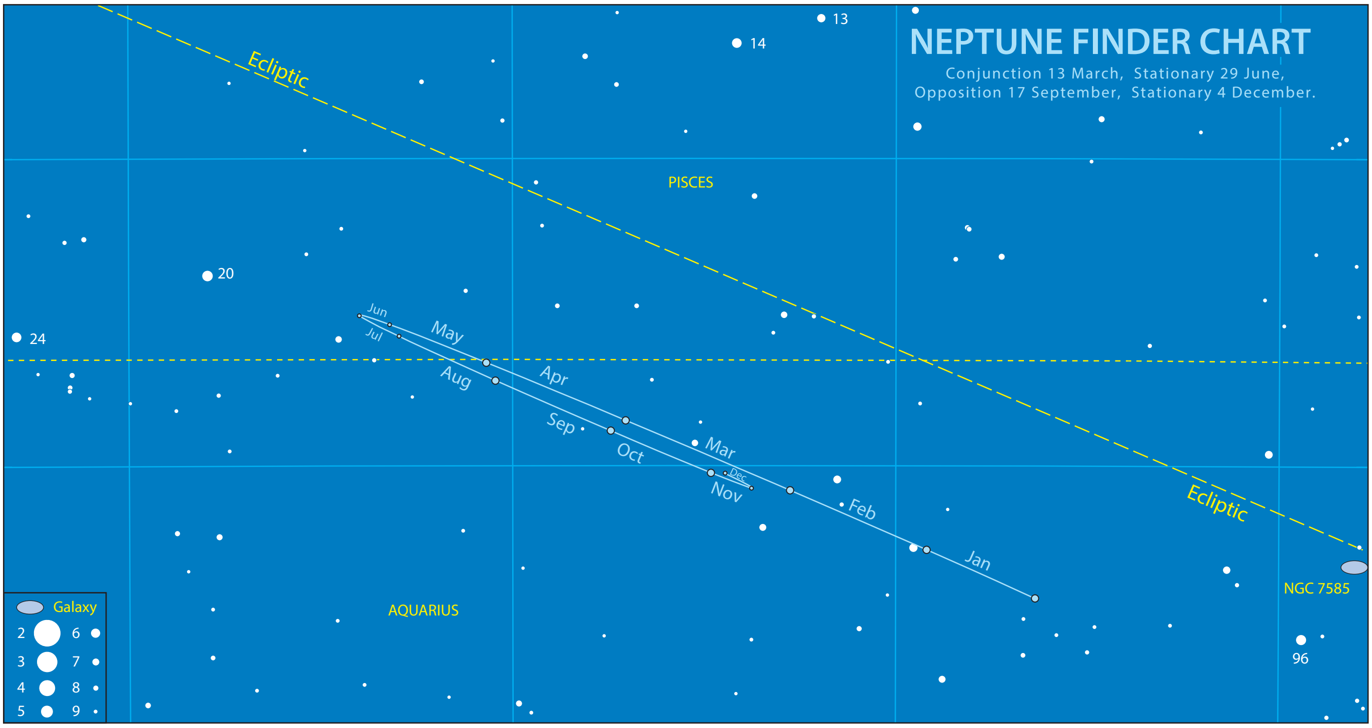
3 Divide by the period to get the number of orbits, i.e. 21.819 / 4.144 = 5.265 orbits.

4 Discarding whole orbits leaves 0.265 (about 27% of an orbit).

5 Multiply by the period, 0.265 × 4.144 = 1.098 days (26.4 hours).

6 Looking at its orbital path (see Apparent Orbits diagram), the satellite is a little after the one day mark, towards the west.





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.

These 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. 1.972 orbits have elapsed since its greatest elongation east on Sep 3.911 UT. Discarding the whole orbits leaves 0.972. Multiplying by 5.877 (its period) gives 5.712 days. From the diagram the moon is just east of north of Neptune, approaching an eastern elongation.

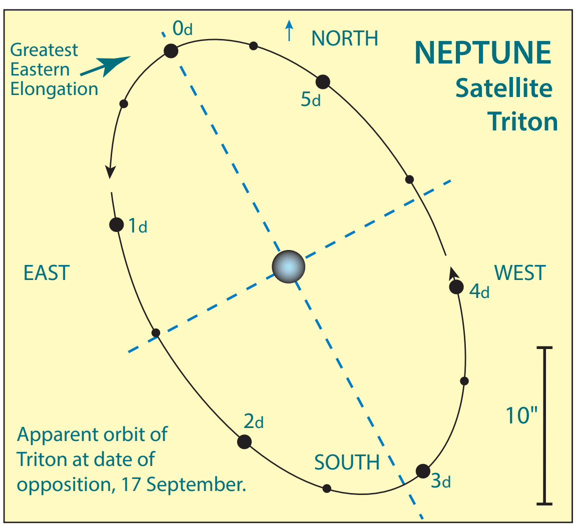
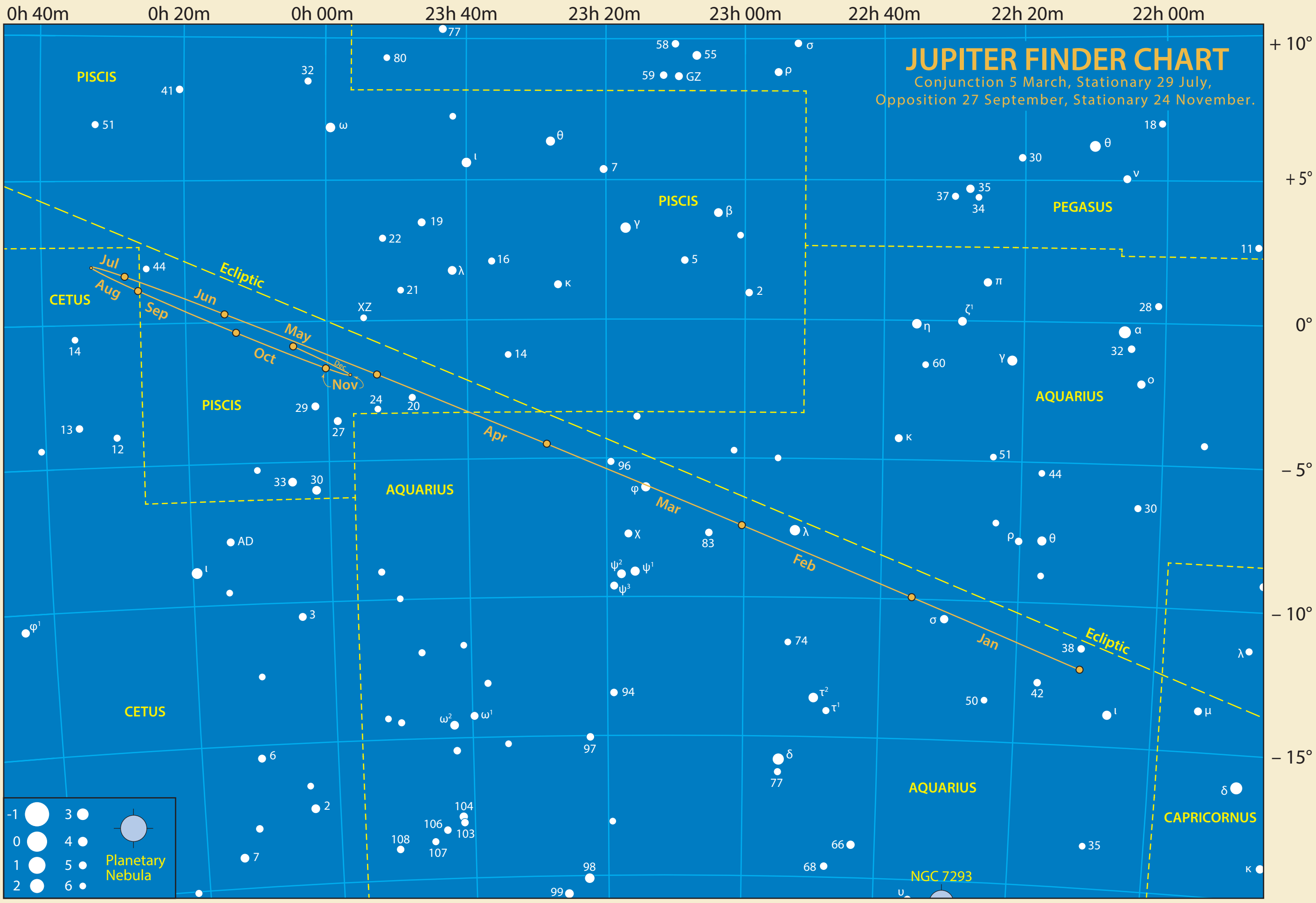


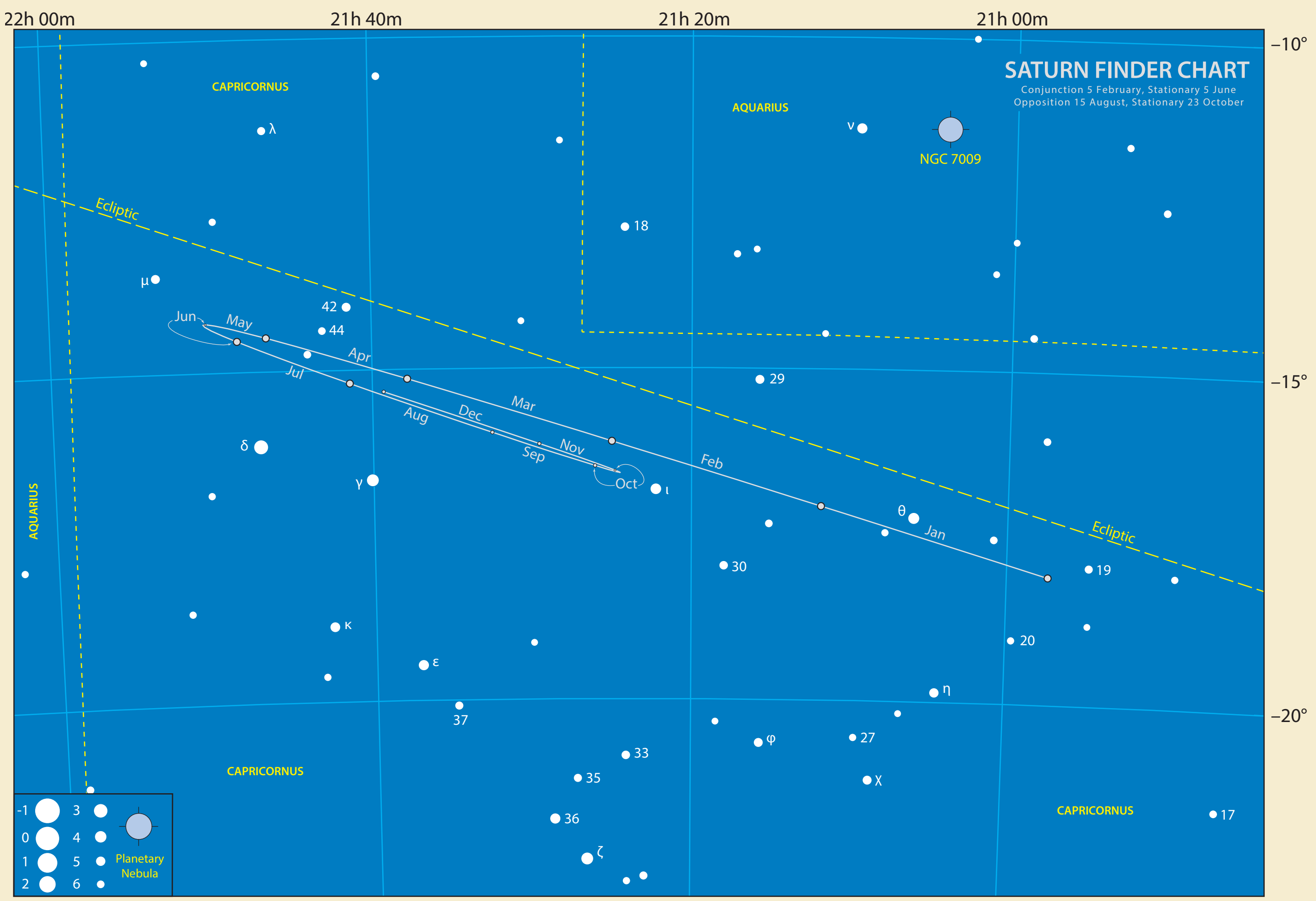
Table 2b: **Time of Greatest Elongation East** (UT)

Planet	**Neptune**
Moon	**Triton**
Magnitude [1]	13.5
Max Elong. [1]	0' 17"
Period (days) [2]	5.877
Month	**East** (d.ddd)
January	6.023
February	4.397
March	5.766
April	4.134
May	3.502
June	1.875
July	1.254
August	5.518
September	3.911
October	3.308
November	1.704
December	1.095

Notes 1. At opposition
2. Sidereal Period



JUPITER FINDER CHART
Conjunction 5 March, Stationary 29 July,
Opposition 27 September, Stationary 24 November.
0h 40m
0h 20m
0h 00m
23h 40m
23h 20m
23h 00m
22h 40m
22h 20m
22h 00m
+ 10°
+ 5°
0°
– 5°
– 10°
– 15°
PISCIS
CETUS
AQUARIUS
PEGASUS
CAPRICORNUS
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
NGC 7293
Planetary Nebula



SATURN FINDER CHART
Conjunction 5 February, Stationary 5 June
Opposition 15 August, Stationary 23 October
22h 00m
21h 40m
21h 20m
21h 00m
–10°
–15°
–20°
CAPRICORNUS
AQUARIUS
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
NGC 7009
Planetary Nebula

COMETS FOR 2022

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 19P/Borrelly indicates it was the 19th comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. You will also see references to another naming system, best explained with an example. The ATLAS comet, mentioned (next page), is referred to as ‘C/2019 L3’. 2019 refers to the year of the discovery, L is the 11th half-month period (‘I’ is not used) during the year and the 3 shows it was the third discovery in this half month. Therefore C/2019 L3 (ATLAS) was the third comet discovered in the first half of June 2019.

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 2022. The table opposite lists the 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 2022, but are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

NOTES ON SELECTED COMETS

Greg Bryant

19P/Borrelly: Discovered by French astronomer Alphonse Borrelly on 28 December 1904, comet Borrelly’s periodic orbit (7 years) was confirmed over the course of several months and was recovered at its next return in 1911. Since then, it has only been missed at the returns of 1939 and 1946. In 2001, the Deep Space 1 spacecraft flew past Borrelly, the first up-close imaging of a comet since Halley in 1986.

Borrelly reaches perihelion on 1 February 2022. At its next return, in 2028, it will pass within 0.42 au of Earth, its closest approach since discovery.

67P/Churyumov-Gerasimenko: In 1969 Soviet astronomers Klim Churyumov and Svetlana Gerasimenko were conducting a survey of known comets. What they thought was an image of 32P/Comas Sola on 11 September 1969 turned out, upon measurement of its position, to be a new comet. With a period of around 6.5 years, Churyumov-Gerasimenko has been seen at every return since its discovery. The current apparition sees it at perihelion on 2 November 2021. It will next return in 2028.

The European spacecraft Rosetta orbited the comet for two years from 2014–16, and deployed the lander Philae on the surface. The end of the mission saw the Rosetta spacecraft itself land on the comet.

104P/Kowal 2 was discovered by Charles Kowal at Palomar Observatory in the United States in January 1979. Within several weeks, it was determined to be periodic in nature, orbiting the Sun every six years, though its returns in 1985 and 2010 were missed. Close approaches to Jupiter have been shifting the comet’s orbit closer to the Sun, and will do so again in 2031. This return sees it reach perihelion on 11 January 2022.

C/2017 K2 (PANSTARRS): Discovered on images taken on 21 May 2017, when only 21st magnitude and more than 16 au from the Sun, the comet may reach 5th magnitude around the time of perihelion in December 2022, favouring southern observers.

The Pan-STARRS (Panoramic Survey Telescope and Rapid Response System) survey’s initial telescope saw first light in 2010, and its first comet was found later that year. Although the program is called Pan-STARRS, comets are named PANSTARRS. Pan-STARRS surveys the whole sky north of declination –47^{o}, searching for moving objects, such as near-Earth asteroids, or objects that vary in brightness. The initial plan was for there to be four 1.8-metre telescopes for the survey, but funding shortages has limited development to two.

At the time of writing (mid-June 2021), 244 comets have been discovered during the course of the Pan-STARRS survey, ranking it first on the all-time list for ground-based surveys (the most successful comet discovery program is the space-based SOHO satellite). In 2017, the interstellar asteroid Oumuamua was discovered with one of the Pan-STARRS telescopes.

C/2021 A1 (Leonard) was discovered as a 19th magnitude object on 3 January 2021 by Greg Leonard on images taken with the 1.5 m reflector at Mt Lemmon Observatory in the United States. More than 5 au from the Sun at the time of discovery, it reaches perihelion on 3 January 2022 when it will be just under 0.62 au from the Sun. Before that, it passed 0.23 au from Earth on 12 December 2021 (and less than 0.03 au from Venus on 18 December). Leonard is a long-period comet, but it's not a first-time visitor. Calculations suggest it was last in the inner Solar System around 70,000 years ago.

While observers in the Northern Hemisphere are likely to be able to begin visually following the comet from October 2021 onwards, when it has brightened to 13th magnitude, observers from mid-latitudes of Australia will have to wait until mid-December to see it emerge from the evening twilight glare. Perhaps 4th magnitude in brightness, it will be in Sagittarius at this time, and moving several degrees per day due to its proximity to Earth. The evening of 18 December will see the comet within a few degrees of Venus.

Over the following days, Leonard moves into Microscopium on 21 December, at which point it could be 5th magnitude, and then Piscis Austrinus on 30 December, by which time the comet may have faded to 6th magnitude. Viewing opportunities for January are in the monthly text.

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.

ADDITIONAL COMETS

22P/Kopff: German astronomer August Kopff discovered this comet on photographs taken in August 1906. The 12th magnitude comet was revealed to be periodic within a few weeks, although the subsequent return of 1912–13 was too unfavourable for recovery. 1919 saw the comet recovered by Max Wolf quite close to the predicted position. Since 1919, Kopff has been seen at every apparition. In 2022, comet Kopff returns to perihelion on 18 March, expected to be 11th magnitude or brighter in the morning sky February to May.

C/2019 L3 (ATLAS) was discovered in June 2019 with a 0.5 m reflector at Haleakala, Hawaii, in the course of the ATLAS (Asteroid Terrestrial-Impact Last Alert System) search program. It is in the evening sky in March/April when at magnitude 10–11.

C/2021 E3 (ZTF) was discovered in CCD images taken using the 1.2 m Schmidt telescope at Palomar as part of the ZTF survey (Zwicky Transient Facility). Although new, and probably a bit uncertain regarding brightness at this time, it will be well south (circumpolar) in the middle of the year at around 11th magnitude.

BRIGHT COMETS FOR 2022 — ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
67P/Churyumov-Gerasimenko	2021 11 02.0615	1.210620	0.649703	6.4	22.1333	36.3336	3.8715	9.5	14.0
C/2021 A1 (Leonard)	2022 01 03.2717	0.614930	1.000094		225.0882	255.8727	132.6860	8.5	10.0
104P/Kowal 2	2022 01 11.1792	1.072804	0.665414	5.9	227.1643	207.3650	5.7249	10.5	20.0
19P/Borrelly	2022 02 01.8283	1.306302	0.637643	6.8	351.9146	74.2475	29.3050	4.5	25.0
C/2017 K2 (PANSTARRS)	2022 12 19.8380	1.798267	1.000480		236.1787	88.2537	87.5477	1.0	10.0
22P/Kopff	2022 03 18.0659	1.552378	0.548756	6.4	163.02113	120.8315	4.74211	5.3	21.0
C/2019 L3 (ATLAS)	2022 01 09.6198	3.554484	1.001606		171.61096	290.7904	48.3612	0.5	14.0
C/2021 E3 (ZTF)	2022 06 11.9436	1.777477	1.000696		228.85397	104.4697	112.5537	8.0	10.0

COMET ORBITAL ELEMENTS (above)

Perihelion Date The date of closest approach to the Sun.

q The perihelion distance in au (astronomical units).

e The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to or greater than one indicates: an open orbit (a once only visitor to the Solar System), it has a very long period (thousands of years) or it is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period (time taken for one orbit of the Sun) in years.

ω Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).

Ω Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (ecliptic) as the comet moves north.

i Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. A value greater than 90° means the comet's orbit direction is retrograde (moves in the opposite direction to the planets).

H1 The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it were 1 au from the Sun and the Earth.

K1 A constant used in calculating the comet's total magnitude (see explanation in Comet Ephemerides next page for further details).

Calculation of ephemerides from these elements is complex (but not difficult with the power of home technology) but beyond the scope of this book.

C/2021 A1 (Leonard)

Date	RA (h m)	Dec (° ')	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Mag	Con
06 Nov '21	11 58.2	+34 29	1.401	1.314	04:39	08:53	13:06	10.4	UMa
13 Nov '21	12 10.3	+33 54	1.163	1.205	04:21	08:37	12:53	9.6	CVn
20 Nov '21	12 27.1	+33 09	0.917	1.097	04:07	08:26	12:46	8.7	CVn
27 Nov '21	12 54.7	+31 43	0.665	0.990	04:01	08:26	12:51	7.6	CVn
04 Dec '21	13 52.2	+27 22	0.419	0.887	04:15	08:56	13:38	6.1	Boo
11 Dec '21	16 19.0	+07 02	0.242	0.791	05:12	10:55	16:38	4.4	Her
18 Dec '21	19 39.4	–25 24	0.325	0.709	06:31	13:48	21:04	4.6	Sgr
25 Dec '21	21 05.2	–33 24	0.567	0.647	06:59	14:46	22:33	5.4	Mic
01 Jan	21 33.7	–35 27	0.833	0.617	06:50	14:47	22:43	6.0	PsA
08 Jan	21 41.9	–36 12	1.087	0.624	06:27	14:27	22:27	6.6	PsA
15 Jan	21 42.0	–36 25	1.313	0.666	05:59	14:00	22:01	7.3	PsA
22 Jan	21 39.2	–36 21	1.505	0.736	05:29	13:30	21:31	8.1	PsA
29 Jan	21 35.7	–36 06	1.660	0.824	04:59	12:59	20:58	8.8	PsA
05 Feb	21 32.4	–35 47	1.783	0.923	04:30	12:28	20:26	9.4	PsA
12 Feb	21 29.5	–35 29	1.877	1.027	04:01	11:58	19:54	10.0	PsA
19 Feb	21 26.8	–35 12	1.944	1.135	03:32	11:27	19:23	10.5	Mic
26 Feb	21 24.1	–35 00	1.987	1.243	03:03	10:57	18:51	10.9	Mic
05 Mar	21 21.2	–34 53	2.009	1.352	02:33	10:27	18:20	11.3	Mic
12 Mar	21 17.8	–34 52	2.013	1.460	02:02	09:56	17:50	11.7	Mic
19 Mar	21 13.7	–34 58	2.000	1.566	01:30	09:24	17:18	12.0	Mic
26 Mar	21 08.5	–35 11	1.973	1.672	00:56	08:51	16:46	12.2	Mic

104P/Kowal 2

Date	RA (h m)	Dec (° ')	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Mag	Con
20 Nov '21	22 10.5	–10 13	0.751	1.275	11:39	18:09	00:41	12.0	Aqr
27 Nov '21	22 23.9	–10 02	0.743	1.230	11:26	17:55	00:27	11.7	Aqr
04 Dec '21	22 39.6	–09 35	0.733	1.188	11:15	17:43	00:14	11.3	Aqr
11 Dec '21	22 57.8	–08 53	0.720	1.152	11:08	17:34	00:02	11.0	Aqr
18 Dec '21	23 18.3	–07 55	0.705	1.121	11:03	17:26	23:49	10.7	Aqr
25 Dec '21	23 41.1	–06 40	0.688	1.098	11:02	17:22	23:41	10.5	Aqr
01 Jan	00 06.3	–05 10	0.671	1.082	11:03	17:19	23:34	10.3	Psc
08 Jan	00 33.8	–03 23	0.655	1.074	11:08	17:19	23:29	10.2	Cet
15 Jan	01 03.6	–01 21	0.641	1.074	11:16	17:21	23:26	10.2	Cet
22 Jan	01 35.7	+00 53	0.632	1.083	11:26	17:26	23:25	10.2	Cet
29 Jan	02 09.6	+03 16	0.629	1.099	11:39	17:32	23:25	10.3	Cet
05 Feb	02 45.0	+05 41	0.635	1.124	11:53	17:40	23:26	10.5	Cet
12 Feb	03 21.3	+08 01	0.650	1.155	12:08	17:49	23:28	10.8	Cet
19 Feb	03 57.6	+10 07	0.676	1.192	12:22	17:57	23:31	11.2	Tau
26 Feb	04 33.2	+11 55	0.712	1.234	12:35	18:05	23:34	11.6	Tau
05 Mar	05 07.4	+13 21	0.760	1.280	12:46	18:11	23:37	12.0	Ori
12 Mar	05 39.7	+14 24	0.819	1.330	12:54	18:16	23:39	12.5	Ori
19 Mar	06 09.8	+15 05	0.888	1.382	12:58	18:19	23:39	13.1	Ori
26 Mar	06 37.8	+15 27	0.965	1.437	13:00	18:19	23:38	13.6	Gem

67P/Churyumov-Gerasimenko

Date	RA (h m)	Dec (° ')	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Mag	Con
06 Nov '21	07 36.6	+26 32	0.419	1.212	23:44	04:32	09:16	8.8	Gem
13 Nov '21	08 00.9	+26 44	0.418	1.218	23:42	04:29	09:12	8.8	Cnc
20 Nov '21	08 21.4	+26 50	0.420	1.231	23:35	04:22	09:05	8.9	Cnc
27 Nov '21	08 37.8	+26 57	0.423	1.250	23:24	04:10	08:53	9.0	Cnc
04 Dec '21	08 50.0	+27 07	0.429	1.275	23:09	03:56	08:37	9.1	Cnc
11 Dec '21	08 58.0	+27 22	0.437	1.304	22:50	03:36	08:17	9.3	Cnc
18 Dec '21	09 01.9	+27 44	0.447	1.339	22:28	03:12	07:52	9.5	Cnc
25 Dec '21	09 02.1	+28 09	0.461	1.377	22:02	02:45	07:24	9.8	Cnc
01 Jan	08 59.1	+28 34	0.481	1.418	21:34	02:14	06:51	10.0	Cnc
08 Jan	08 53.7	+28 55	0.506	1.463	21:02	01:42	06:17	10.3	Cnc
15 Jan	08 47.0	+29 08	0.539	1.509	20:28	01:07	05:42	10.7	Cnc
22 Jan	08 39.9	+29 10	0.581	1.558	19:54	00:32	05:07	11.0	Cnc
29 Jan	08 33.3	+29 01	0.632	1.609	19:19	23:56	04:34	11.4	Cnc
05 Feb	08 28.1	+28 41	0.692	1.661	18:45	23:23	04:02	11.8	Cnc

19P/Borrelly

Date	RA (h m)	Dec (° ')	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Mag	Con
06 Nov '21	23 05.0	–50 07	1.190	1.656	10:19	19:59	05:41	10.4	Gru
13 Nov '21	23 08.3	–47 09	1.185	1.610	10:24	19:35	04:47	10.0	Gru
20 Nov '21	23 13.9	–43 52	1.181	1.566	10:28	19:13	03:59	9.7	Gru
27 Nov '21	23 21.3	–40 15	1.178	1.524	10:30	18:52	03:17	9.4	Gru
04 Dec '21	23 30.3	–36 21	1.176	1.485	10:32	18:34	02:37	9.1	Scl
11 Dec '21	23 40.7	–32 10	1.175	1.448	10:34	18:16	02:01	8.9	Scl
18 Dec '21	23 52.2	–27 43	1.176	1.415	10:35	18:01	01:28	8.6	Scl
25 Dec '21	00 04.6	–23 04	1.179	1.386	10:36	17:45	00:56	8.4	Cet
01 Jan	00 17.9	–18 12	1.185	1.361	10:38	17:31	00:26	8.2	Cet
08 Jan	00 32.0	–13 12	1.196	1.340	10:39	17:17	23:55	8.1	Cet
15 Jan	00 46.8	–08 07	1.210	1.324	10:40	17:04	23:28	8.0	Cet
22 Jan	01 02.3	–03 00	1.229	1.313	10:42	16:52	23:01	7.9	Cet
29 Jan	01 18.6	+02 05	1.253	1.307	10:45	16:41	22:36	7.9	Cet
05 Feb	01 35.6	+07 04	1.283	1.307	10:48	16:30	22:12	7.9	Psc
12 Feb	01 53.5	+11 54	1.318	1.312	10:51	16:20	21:50	8.0	Ari
19 Feb	02 12.3	+16 29	1.358	1.322	10:56	16:12	21:28	8.2	Ari
26 Feb	02 32.1	+20 49	1.403	1.338	11:01	16:04	21:07	8.4	Ari
05 Mar	02 52.9	+24 50	1.453	1.358	11:08	15:58	20:47	8.6	Ari
12 Mar	03 14.8	+28 29	1.508	1.383	11:15	15:52	20:28	8.9	Ari
19 Mar	03 37.8	+31 46	1.567	1.412	11:23	15:48	20:11	9.2	Per
26 Mar	04 01.9	+34 38	1.630	1.445	11:32	15:44	19:56	9.6	Per
02 Apr	04 27.0	+37 05	1.697	1.481	11:41	15:42	19:42	9.9	Per
09 Apr	04 53.0	+39 06	1.767	1.520	11:49	15:40	19:31	10.3	Aur
16 Apr	05 19.5	+40 41	1.841	1.562	11:56	15:39	19:21	10.7	Aur
23 Apr	05 46.4	+41 51	1.917	1.606	12:02	15:38	19:14	11.1	Aur
30 Apr	06 13.3	+42 37	1.996	1.652	12:06	15:38	19:09	11.4	Aur

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.

C/2017 K2 (PANSTARRS)

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
06 Nov '21	17 16.1	+19 52	5.443	4.891	09:04	14:09	19:16	11.6	Her
13 Nov '21	17 20.5	+18 47	5.430	4.829	08:37	13:47	18:56	11.5	Her
20 Nov '21	17 25.2	+17 46	5.411	4.768	08:11	13:24	18:36	11.4	Her
27 Nov '21	17 30.2	+16 50	5.385	4.706	07:46	13:01	18:16	11.4	Her
04 Dec '21	17 35.4	+15 58	5.350	4.644	07:21	12:39	17:57	11.3	Her
11 Dec '21	17 40.8	+15 11	5.308	4.582	06:57	12:17	17:37	11.2	Her
18 Dec '21	17 46.3	+14 29	5.256	4.520	06:32	11:55	17:17	11.2	Her
25 Dec '21	17 51.9	+13 51	5.196	4.458	06:09	11:33	16:57	11.1	Oph
01 Jan	17 57.6	+13 17	5.127	4.395	05:46	11:11	16:36	11.0	Oph
08 Jan	18 03.3	+12 48	5.049	4.333	05:22	10:49	16:16	10.9	Oph
15 Jan	18 08.9	+12 24	4.961	4.270	04:59	10:27	15:55	10.8	Oph
22 Jan	18 14.5	+12 04	4.865	4.207	04:36	10:05	15:34	10.7	Oph
29 Jan	18 19.9	+11 48	4.760	4.145	04:13	09:43	15:13	10.6	Oph
05 Feb	18 25.2	+11 35	4.646	4.082	03:51	09:21	14:51	10.4	Oph
12 Feb	18 30.2	+11 27	4.524	4.018	03:28	08:58	14:29	10.3	Oph
19 Feb	18 35.0	+11 21	4.394	3.955	03:05	08:36	14:06	10.2	Oph
26 Feb	18 39.5	+11 19	4.258	3.892	02:41	08:12	13:44	10.0	Oph
05 Mar	18 43.5	+11 19	4.115	3.829	02:18	07:49	13:20	9.9	Oph
12 Mar	18 47.1	+11 22	3.966	3.765	01:54	07:25	12:56	9.7	Aql
19 Mar	18 50.2	+11 26	3.812	3.702	01:30	07:01	12:31	9.6	Aql
26 Mar	18 52.6	+11 32	3.654	3.638	01:05	06:35	12:06	9.4	Aql
02 Apr	18 54.3	+11 38	3.493	3.575	00:39	06:10	11:40	9.2	Aql
09 Apr	18 55.1	+11 43	3.331	3.511	00:13	05:43	11:13	9.1	Aql
16 Apr	18 55.0	+11 47	3.168	3.448	23:42	05:16	10:45	8.9	Aql
23 Apr	18 53.9	+11 48	3.005	3.384	23:13	04:47	10:16	8.7	Aql
30 Apr	18 51.6	+11 44	2.845	3.321	22:43	04:17	09:47	8.5	Aql
07 May	18 47.9	+11 34	2.689	3.258	22:11	03:46	09:16	8.3	Aql
14 May	18 42.7	+11 16	2.539	3.194	21:38	03:13	08:44	8.1	Oph
21 May	18 36.0	+10 46	2.397	3.132	21:02	02:39	08:11	7.9	Oph
28 May	18 27.6	+10 02	2.265	3.069	20:24	02:03	07:38	7.6	Oph
04 Jun	18 17.5	+09 01	2.145	3.006	19:44	01:26	07:03	7.4	Oph
11 Jun	18 05.8	+07 41	2.041	2.944	19:01	00:46	06:27	7.2	Oph
18 Jun	17 52.8	+06 00	1.954	2.883	18:16	00:06	05:51	7.1	Oph
25 Jun	17 38.7	+03 57	1.887	2.821	17:29	23:21	05:15	6.9	Oph
02 Jul	17 24.1	+01 34	1.840	2.760	16:40	22:39	04:39	6.7	Oph
09 Jul	17 09.4	−01 06	1.815	2.700	15:51	21:57	04:05	6.6	Oph
16 Jul	16 55.3	−03 58	1.810	2.641	15:02	21:15	03:31	6.5	Oph
23 Jul	16 42.2	−06 55	1.824	2.582	14:13	20:34	02:58	6.4	Oph
30 Jul	16 30.4	−09 53	1.856	2.524	13:26	19:56	02:27	6.4	Oph
06 Aug	16 20.3	−12 49	1.901	2.467	12:40	19:18	01:58	6.3	Sco
13 Aug	16 11.9	−15 39	1.958	2.411	11:56	18:42	01:31	6.3	Sco
20 Aug	16 05.3	−18 23	2.022	2.356	11:13	18:07	01:05	6.3	Sco
27 Aug	16 00.3	−20 59	2.090	2.303	10:32	17:36	00:40	6.2	Sco
03 Sep	15 57.1	−23 30	2.161	2.251	09:54	17:05	00:18	6.2	Sco
10 Sep	15 55.3	−25 54	2.231	2.201	09:16	16:35	23:53	6.2	Sco
17 Sep	15 55.0	−28 15	2.299	2.153	08:39	16:07	23:34	6.1	Sco
24 Sep	15 55.9	−30 32	2.363	2.107	08:04	15:41	23:16	6.1	Lup
01 Oct	15 58.1	−32 47	2.421	2.063	07:30	15:15	23:00	6.1	Lup
08 Oct	16 01.5	−35 00	2.472	2.022	06:56	14:51	22:46	6.0	Lup
15 Oct	16 05.9	−37 14	2.515	1.984	06:22	14:28	22:33	6.0	Lup
22 Oct	16 11.5	−39 28	2.550	1.948	05:48	14:06	22:23	5.9	Sco
29 Oct	16 18.2	−41 45	2.575	1.916	05:14	13:45	22:16	5.9	Sco
05 Nov	16 26.1	−44 03	2.591	1.887	04:39	13:26	22:11	5.8	Nor
12 Nov	16 35.2	−46 25	2.597	1.862	04:03	13:07	22:11	5.8	Ara
19 Nov	16 45.8	−48 51	2.594	1.841	03:24	12:50	22:16	5.7	Ara
26 Nov	16 58.1	−51 21	2.582	1.824	02:39	12:35	22:30	5.7	Ara
03 Dec	17 12.3	−53 55	2.561	1.811	01:41	12:21	23:02	5.6	Ara
10 Dec	17 29.1	−56 34	2.533	1.803		12:11		5.6	Ara
17 Dec	17 49.2	−59 16	2.499	1.799		12:03		5.5	Pav
24 Dec	18 13.5	−61 59	2.460	1.799		12:01		5.5	Pav
31 Dec	18 43.7	−64 38	2.419	1.804		12:03		5.5	Pav

C/2019 L3 (ATLAS)

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
06 Nov '21	07 47.2	+40 03	3.128	3.603	00:56	04:43	08:29	10.8	Lyn
13 Nov '21	07 46.8	+39 24	3.026	3.593	00:25	04:15	08:05	10.7	Lyn
20 Nov '21	07 45.2	+38 43	2.931	3.584	23:49	03:46	07:39	10.6	Lyn
27 Nov '21	07 42.3	+37 58	2.844	3.577	23:14	03:16	07:13	10.5	Lyn
04 Dec '21	07 38.2	+37 09	2.766	3.570	22:38	02:44	06:45	10.4	Lyn
11 Dec '21	07 32.9	+36 15	2.700	3.565	22:02	02:11	06:16	10.4	Lyn
18 Dec '21	07 26.8	+35 15	2.647	3.560	21:24	01:38	05:47	10.3	Gem
25 Dec '21	07 19.9	+34 09	2.609	3.557	20:44	01:03	05:18	10.3	Gem
01 Jan	07 12.7	+32 56	2.587	3.555	20:04	00:28	04:48	10.3	Gem
08 Jan	07 05.4	+31 38	2.581	3.555	19:25	23:51	04:18	10.3	Gem
15 Jan	06 58.4	+30 15	2.592	3.555	18:44	23:16	03:49	10.3	Gem
22 Jan	06 52.0	+28 50	2.620	3.556	18:05	22:42	03:21	10.3	Gem
29 Jan	06 46.3	+27 23	2.664	3.559	17:27	22:08	02:53	10.3	Gem
05 Feb	06 41.7	+25 57	2.722	3.563	16:49	21:37	02:25	10.4	Gem
12 Feb	06 38.2	+24 33	2.794	3.568	16:14	21:05	01:59	10.5	Gem
19 Feb	06 35.8	+23 12	2.877	3.574	15:40	20:35	01:34	10.5	Gem
26 Feb	06 34.6	+21 55	2.969	3.581	15:06	20:06	01:10	10.6	Gem
05 Mar	06 34.4	+20 43	3.070	3.589	14:35	19:39	00:45	10.7	Gem
12 Mar	06 35.3	+19 34	3.177	3.598	14:05	19:12	00:22	10.8	Gem
19 Mar	06 37.1	+18 29	3.289	3.609	13:36	18:46	23:56	10.9	Gem
26 Mar	06 39.7	+17 28	3.403	3.620	13:08	18:21	23:34	11.0	Gem
02 Apr	06 43.1	+16 30	3.519	3.633	12:40	17:57	23:13	11.1	Gem
09 Apr	06 47.2	+15 35	3.636	3.647	12:14	17:34	22:52	11.2	Gem
16 Apr	06 51.9	+14 41	3.752	3.661	11:49	17:11	22:32	11.3	Gem
23 Apr	06 57.1	+13 48	3.866	3.677	11:24	16:48	22:12	11.4	Gem
30 Apr	07 02.7	+12 56	3.978	3.694	11:00	16:26	21:53	11.4	Gem
07 May	07 08.8	+12 05	4.086	3.711	10:36	16:05	21:34	11.5	CMi
14 May	07 15.1	+11 14	4.190	3.730	10:12	15:44	21:15	11.6	CMi
21 May	07 21.7	+10 22	4.290	3.750	09:49	15:23	20:56	11.7	CMi

22P/Kopff

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
05 Feb	18 41.6	−20 51	2.294	1.608	02:36	09:38	16:38	11.4	Sgr
12 Feb	19 04.5	−20 31	2.250	1.591	02:32	09:33	16:33	11.3	Sgr
19 Feb	19 27.4	−20 00	2.208	1.577	02:29	09:28	16:26	11.2	Sgr
26 Feb	19 50.2	−19 18	2.169	1.566	02:27	09:24	16:19	11.1	Sgr
05 Mar	20 12.7	−18 26	2.132	1.558	02:25	09:18	16:11	11.0	Cap
12 Mar	20 34.9	−17 24	2.099	1.554	02:22	09:13	16:03	10.9	Cap
19 Mar	20 56.7	−16 14	2.068	1.552	02:20	09:07	15:54	10.9	Cap
26 Mar	21 17.9	−14 57	2.039	1.554	02:17	09:01	15:44	10.9	Cap
02 Apr	21 38.6	−13 34	2.012	1.560	02:15	08:54	15:33	10.9	Cap
09 Apr	21 58.7	−12 08	1.986	1.568	02:11	08:46	15:21	10.9	Cap
16 Apr	22 18.1	−10 39	1.962	1.580	02:07	08:38	15:09	10.9	Aqr
23 Apr	22 36.8	−09 09	1.939	1.595	02:03	08:30	14:55	11.0	Aqr
30 Apr	22 54.8	−07 39	1.916	1.613	01:57	08:20	14:41	11.1	Aqr
07 May	23 12.1	−06 11	1.894	1.633	01:51	08:10	14:27	11.2	Aqr
14 May	23 28.7	−04 45	1.870	1.656	01:44	07:59	14:12	11.3	Aqr
21 May	23 44.6	−03 23	1.846	1.681	01:36	07:47	13:57	11.4	Aqr

C/2021 E3 (ZTF)

Date	RA h m	Dec ° ′	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
07 May	21 43.7	−49 25	1.451	1.837	21:07	06:41	16:12	11.4	Gru
14 May	22 02.4	−57 03	1.342	1.816		06:33		11.2	Ind
21 May	22 31.6	−65 41	1.263	1.800		06:34		11.1	Tuc
28 May	23 30.4	−74 39	1.221	1.788		07:06		11.0	Oct
04 Jun	02 15.4	−81 17	1.219	1.780		09:20		10.9	Hyi
11 Jun	06 16.6	−79 06	1.256	1.778		12:52		11.0	Men
18 Jun	07 51.1	−72 08	1.327	1.779		14:01		11.1	Vol
25 Jun	08 30.1	−65 18	1.425	1.785		14:12		11.3	Vol
02 Jul	08 52.1	−59 28	1.540	1.796		14:07		11.5	Car

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 objects are extremely faint and difficult to observe. Many can be found by imaging the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which *star* has moved. Be sure you have the right field of view. Only about sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

Included are ephemerides for 12 bright minor or dwarf planets at opposition in 2022, plus Ceres (27 Nov 2021), Nysa (11 Dec 2021) and Pallas (6 Jan 2023). 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, 1 Ceres is the only dwarf planet that makes the grade.

1 Ceres

Date	RA (hh mm)	Dec (° ′)	Mag
Jan 1	03 46.3	+17 44	7.9
8	03 43.8	+18 04	8.1
15	03 42.7	+18 27	8.2
22	03 43.0	+18 54	8.3
29	03 44.7	+19 23	8.4
Feb 5	03 47.6	+19 54	8.5
12	03 51.7	+20 27	8.6
19	03 57.0	+21 01	8.7
26	04 03.2	+21 37	8.8
Mar 5	04 10.3	+22 12	8.9
12	04 18.3	+22 47	8.9
19	04 27.0	+23 21	9.0
26	04 36.4	+23 54	9.0
Apr 2	04 46.4	+24 25	9.0
9	04 56.9	+24 54	9.1
16	05 08.0	+25 20	9.1
23	05 19.5	+25 44	9.1
30	05 31.4	+26 04	9.1
May 7	05 43.7	+26 21	9.1
14	05 56.3	+26 34	9.1
21	06 09.1	+26 43	9.0
28	06 22.2	+26 49	9.0
Jun 4	06 35.4	+26 50	9.0
11	06 48.9	+26 46	8.9
18	07 02.4	+26 39	8.9

2 Pallas

Date	RA (hh mm)	Dec (° ′)	Mag
Jul 16	04 28.3	−02 09	9.5
23	04 41.0	−02 40	9.5
30	04 53.6	−03 19	9.5
Aug 6	05 06.1	−04 04	9.4
13	05 18.4	−04 57	9.4
20	05 30.5	−05 58	9.3
27	05 42.4	−07 06	9.2
Sep 3	05 53.8	−08 21	9.2
10	06 04.9	−09 43	9.1
17	06 15.5	−11 12	9.0
24	06 25.6	−12 48	9.0
Oct 1	06 35.0	−14 29	8.9
8	06 43.6	−16 14	8.8
15	06 51.5	−18 03	8.7
22	06 58.3	−19 55	8.6
29	07 04.2	−21 47	8.5
Nov 5	07 08.8	−23 38	8.5
12	07 12.2	−25 26	8.4
19	07 14.1	−27 08	8.3
26	07 14.6	−28 40	8.2
Dec 3	07 13.5	−30 00	8.1
10	07 11.0	−31 04	8.0
17	07 07.1	−31 48	7.9
24	07 02.1	−32 09	7.9
31	06 56.4	−32 03	7.8

3 Juno

Date	RA (hh mm)	Dec (° ′)	Mag
Jun 18	23 01.4	+01 08	9.9
25	23 06.6	+01 32	9.7
Jul 2	23 11.0	+01 50	9.6
9	23 14.5	+01 59	9.4
16	23 17.0	+02 00	9.3
23	23 18.5	+01 51	9.1
30	23 18.8	+01 30	8.9
Aug 6	23 17.9	+00 58	8.8
13	23 15.9	+00 12	8.6
20	23 12.8	−00 45	8.4
27	23 08.7	−01 53	8.2
Sep 3	23 03.9	−03 10	8.0
10	22 58.8	−04 33	7.8
17	22 53.6	−05 58	8.0
24	22 48.9	−07 21	8.1
Oct 1	22 45.0	−08 37	8.2
8	22 42.2	−09 45	8.4
15	22 40.6	−10 41	8.5
22	22 40.5	−11 26	8.6
29	22 41.9	−11 57	8.7
Nov 5	22 44.8	−12 16	8.8
12	22 49.0	−12 23	8.9
19	22 54.5	−12 18	9.0
26	23 01.2	−12 03	9.1
Dec 3	23 08.9	−11 39	9.2

4 Vesta

Date	RA (hh mm)	Dec (° ′)	Mag
May 28	22 15.1	−13 55	7.4
Jun 4	22 22.5	−13 42	7.3
11	22 28.8	−13 36	7.2
18	22 34.1	−13 37	7.1
25	22 38.2	−13 48	7.0
Jul 2	22 40.9	−14 07	6.8
9	22 42.3	−14 36	6.7
16	22 42.3	−15 15	6.6
23	22 40.7	−16 02	6.4
30	22 37.7	−16 56	6.3
Aug 6	22 33.4	−17 54	6.2
13	22 28.0	−18 54	6.0
20	22 21.9	−19 52	5.9
27	22 15.5	−20 45	6.0
Sep 3	22 09.2	−21 29	6.1
10	22 03.5	−22 03	6.3
17	21 58.8	−22 26	6.5
24	21 55.3	−22 37	6.6
Oct 1	21 53.3	−22 37	6.8
8	21 52.7	−22 27	6.9
15	21 53.6	−22 08	7.1
22	21 55.8	−21 41	7.2
29	21 59.4	−21 07	7.4
Nov 5	22 04.0	−20 27	7.5
12	22 09.7	−19 41	7.6

6 Hebe

Date	RA (hh mm)	Dec (° ′)	Mag
Jan 22	22 57.0	−14 25	10.0
29	23 12.5	−13 06	10.0
Feb 5	23 28.1	−11 44	10.0
12	23 43.6	−10 20	10.0
19	23 59.3	−08 53	10.0
26	00 14.9	−07 25	10.0
Mar 5	00 30.6	−05 56	9.9
12	00 46.3	−04 26	9.9
19	01 02.0	−02 57	9.9
26	01 17.7	−01 29	9.9
Apr 2	01 33.6	−00 03	9.8
9	01 49.4	+01 22	9.8
16	02 05.3	+02 43	9.8
23	02 21.2	+04 02	9.8
30	02 37.2	+05 17	9.8
May 7	02 53.2	+06 27	9.8
14	03 09.2	+07 33	9.9
21	03 25.3	+08 34	9.9
28	03 41.3	+09 30	10.0
Jun 4	03 57.3	+10 20	10.0
11	04 13.3	+11 05	10.0
18	04 29.2	+11 43	10.1
25	04 45.0	+12 15	10.1
Jul 2	05 00.7	+12 42	10.2
9	05 16.3	+13 02	10.2

7 Iris

Date	RA (hh mm)	Dec (° ′)	Mag
Jan 1	07 50.9	+15 49	7.9
8	07 43.2	+15 43	7.8
15	07 35.3	+15 42	7.7
22	07 27.8	+15 43	7.9
29	07 21.3	+15 46	8.2
Feb 5	07 16.1	+15 51	8.4
12	07 12.5	+15 56	8.7
19	07 10.6	+16 02	8.9
26	07 10.5	+16 06	9.1
Mar 5	07 12.0	+16 10	9.3
12	07 15.0	+16 11	9.5
19	07 19.4	+16 11	9.6
26	07 25.0	+16 08	9.8
Apr 2	07 31.5	+16 02	9.9
9	07 39.0	+15 52	10.1
16	07 47.2	+15 39	10.2
23	07 56.1	+15 22	10.3
30	08 05.4	+15 02	10.4
May 7	08 15.2	+14 37	10.5
14	08 25.4	+14 09	10.6
21	08 35.8	+13 37	10.7
28	08 46.4	+13 01	10.7
Jun 4	08 57.2	+12 22	10.8
11	09 08.1	+11 40	10.8
18	09 19.1	+10 54	10.9

10 Hygiea

Date	RA (hh mm)	Dec (° ′)	Mag
Feb 5	14 27.0	−18 58	10.9
12	14 31.9	−19 30	10.8
19	14 35.8	−19 58	10.7
26	14 38.7	−20 21	10.6
Mar 5	14 40.5	−20 39	10.4
12	14 41.1	−20 51	10.3
19	14 40.5	−20 57	10.2
26	14 38.7	−20 57	10.0
Apr 2	14 35.8	−20 51	9.9
9	14 31.9	−20 37	9.7
16	14 27.1	−20 17	9.6
23	14 21.8	−19 52	9.4
30	14 16.3	−19 22	9.3
May 7	14 10.9	−18 50	9.4
14	14 06.0	−18 16	9.6
21	14 01.7	−17 43	9.7
28	13 58.3	−17 13	9.9
Jun 4	13 56.0	−16 48	10.0
11	13 54.9	−16 27	10.1
18	13 54.9	−16 12	10.3
25	13 56.0	−16 04	10.4
Jul 2	13 58.3	−16 02	10.5
9	14 01.6	−16 05	10.6
16	14 05.8	−16 14	10.7
23	14 11.0	−16 28	10.8

20 Massalia

Date	RA (hh mm)	Dec (° ′)	Mag
Jan 1	09 37.9	+12 54	9.5
8	09 35.6	+13 03	9.3
15	09 31.7	+13 20	9.1
22	09 26.5	+13 45	8.9
29	09 20.2	+14 14	8.7
Feb 5	09 13.4	+14 46	8.5
12	09 06.6	+15 18	8.8
19	09 00.3	+15 47	9.0
26	08 55.1	+16 12	9.2
Mar 5	08 51.3	+16 32	9.4
12	08 49.1	+16 45	9.6
19	08 48.6	+16 51	9.7
26	08 49.7	+16 51	9.9
Apr 2	08 52.4	+16 44	10.1
9	08 56.5	+16 31	10.2
16	09 01.8	+16 12	10.4
23	09 08.2	+15 48	10.5
30	09 15.5	+15 19	10.7
May 7	09 23.7	+14 44	10.8
14	09 32.5	+14 04	10.9
21	09 41.9	+13 20	11.0
28	09 51.7	+12 32	11.1
Jun 4	10 01.9	+11 40	11.1
11	10 12.4	+10 44	11.2
18	10 23.2	+09 45	11.3

27 Euterpe

Date	RA (hh mm)	Dec (° ′)	Mag
Jul 16	02 18.5	+12 10	11.7
23	02 29.0	+12 59	11.6
30	02 39.2	+13 44	11.5
Aug 6	02 48.9	+14 25	11.4
13	02 58.1	+15 02	11.3
20	03 06.6	+15 34	11.2
27	03 14.4	+16 01	11.1
Sep 3	03 21.3	+16 24	10.9
10	03 27.1	+16 42	10.8
17	03 31.8	+16 54	10.6
24	03 35.0	+17 02	10.4
Oct 1	03 36.6	+17 04	10.2
8	03 36.6	+17 01	10.0
15	03 34.9	+16 53	9.8
22	03 31.4	+16 40	9.6
29	03 26.5	+16 23	9.4
Nov 5	03 20.2	+16 02	9.1
12	03 13.3	+15 40	8.8
19	03 06.2	+15 18	9.0
26	02 59.5	+14 58	9.2
Dec 3	02 53.8	+14 43	9.4
10	02 49.6	+14 35	9.6
17	02 47.0	+14 34	9.8
24	02 46.2	+14 41	10.0
31	02 47.3	+14 56	10.1

29 Amphitrite

Date	RA (hh mm)	Dec (° ′)	Mag
Mar 19	17 15.1	−29 11	11.1
26	17 19.9	−29 35	11.0
Apr 2	17 23.6	−29 59	10.9
9	17 26.0	−30 22	10.8
16	17 27.0	−30 45	10.7
23	17 26.6	−31 07	10.5
30	17 24.8	−31 27	10.4
May 7	17 21.4	−31 45	10.3
14	17 16.7	−31 59	10.1
21	17 10.7	−32 08	10.0
28	17 03.9	−32 12	9.8
Jun 4	16 56.5	−32 09	9.7
11	16 48.9	−32 01	9.7
18	16 41.7	−31 47	9.8
25	16 35.1	−31 28	10.0
Jul 2	16 29.6	−31 07	10.1
9	16 25.4	−30 44	10.3
16	16 22.5	−30 22	10.4
23	16 21.1	−30 01	10.5
30	16 21.1	−29 43	10.6
Aug 6	16 22.6	−29 27	10.8
13	16 25.4	−29 14	10.9
20	16 29.3	−29 04	11.0
27	16 34.5	−28 56	11.0
Sep 3	16 40.6	−28 51	11.1

30 Urania

Date	RA (hh mm)	Dec (° ′)	Mag
Jul 16	02 51.7	+18 22	12.1
23	03 04.4	+19 21	12.1
30	03 16.9	+20 16	12.0
Aug 6	03 29.1	+21 06	11.9
13	03 40.8	+21 51	11.9
20	03 52.0	+22 32	11.8
27	04 02.6	+23 09	11.7
Sep 3	04 12.3	+23 42	11.6
10	04 21.2	+24 10	11.5
17	04 29.1	+24 35	11.4
24	04 35.7	+24 55	11.2
Oct 1	04 40.9	+25 13	11.1
8	04 44.5	+25 27	11.0
15	04 46.3	+25 37	10.8
22	04 46.3	+25 44	10.6
29	04 44.4	+25 46	10.5
Nov 5	04 40.5	+25 43	10.3
12	04 35.1	+25 35	10.1
19	04 28.4	+25 21	9.9
26	04 20.9	+25 01	9.7
Dec 3	04 13.3	+24 37	9.7
10	04 06.1	+24 11	10.0
17	04 00.1	+23 44	10.2
24	03 55.4	+23 19	10.4
31	03 52.5	+22 58	10.6

44 Nysa

Date	RA (hh mm)	Dec (° ′)	Mag
Jan 1	04 51.3	+17 43	9.4
8	04 47.0	+17 56	9.5
15	04 44.4	+18 13	9.6
22	04 43.6	+18 34	9.8
29	04 44.6	+18 58	9.9
Feb 5	04 47.4	+19 24	10.1
12	04 51.9	+19 51	10.2
19	04 57.9	+20 19	10.3
26	05 05.3	+20 47	10.4
Mar 5	05 13.9	+21 14	10.5
12	05 23.6	+21 38	10.6
19	05 34.3	+22 00	10.7
26	05 45.8	+22 18	10.8
Apr 2	05 58.1	+22 33	10.9
9	06 11.0	+22 43	11.0
16	06 24.4	+22 47	11.0
23	06 38.3	+22 47	11.1
30	06 52.6	+22 40	11.1
May 7	07 07.1	+22 28	11.2
14	07 21.8	+22 10	11.2
21	07 36.8	+21 47	11.3
28	07 51.8	+21 17	11.3
Jun 4	08 06.8	+20 41	11.3
11	08 21.9	+20 00	11.3
18	08 36.9	+19 14	11.4

192 Nausikaa

Date	RA (hh mm)	Dec (° ′)	Mag
May 7	20 21.9	−27 30	11.9
14	20 28.3	−27 25	11.7
21	20 33.6	−27 22	11.5
28	20 37.6	−27 24	11.4
Jun 4	20 40.3	−27 29	11.2
11	20 41.4	−27 39	11.0
18	20 40.8	−27 52	10.7
25	20 38.6	−28 08	10.5
Jul 2	20 34.7	−28 26	10.3
9	20 29.1	−28 43	10.0
16	20 22.2	−28 57	9.8
23	20 14.5	−29 05	9.6
30	20 06.4	−29 05	9.7
Aug 6	19 58.5	−28 57	9.8
13	19 51.6	−28 40	10.0
20	19 46.0	−28 15	10.2
27	19 42.1	−27 43	10.3
Sep 3	19 40.2	−27 06	10.5
10	19 40.3	−26 24	10.6
17	19 42.4	−25 39	10.7
24	19 46.3	−24 52	10.9
Oct 1	19 51.8	−24 01	11.0
8	19 58.9	−23 08	11.1
15	20 07.3	−22 12	11.2
22	20 16.9	−21 12	11.3

324 Bamberga

Date	RA (hh mm)	Dec (° ′)	Mag
Jul 16	01 55.3	+18 27	10.9
23	02 09.0	+20 32	10.8
30	02 22.6	+22 35	10.8
Aug 6	02 35.8	+24 34	10.7
13	02 48.6	+26 31	10.6
20	03 00.8	+28 25	10.5
27	03 12.3	+30 14	10.4
Sep 3	03 22.9	+32 00	10.3
10	03 32.4	+33 42	10.2
17	03 40.4	+35 19	10.1
24	03 46.9	+36 50	10.0
Oct 1	03 51.3	+38 15	9.8
8	03 53.6	+39 32	9.7
15	03 53.6	+40 38	9.6
22	03 51.2	+41 31	9.4
29	03 46.6	+42 08	9.3
Nov 5	03 40.3	+42 25	9.2
12	03 32.8	+42 22	9.2
19	03 25.0	+41 57	9.2
26	03 17.8	+41 15	9.2
Dec 3	03 11.9	+40 19	9.4
10	03 07.8	+39 14	9.5
17	03 05.7	+38 07	9.7
24	03 05.6	+37 00	10.0
31	03 07.6	+35 58	10.2

349 Dembowska

Date	RA (hh mm)	Dec (° ′)	Mag
Jul 16	03 35.2	+20 00	11.2
23	03 45.2	+20 47	11.2
30	03 55.0	+21 31	11.1
Aug 6	04 04.3	+22 13	11.1
13	04 13.1	+22 52	11.0
20	04 21.5	+23 30	11.0
27	04 29.2	+24 05	10.9
Sep 3	04 36.2	+24 39	10.9
10	04 42.4	+25 11	10.8
17	04 47.7	+25 42	10.7
24	04 51.9	+26 13	10.6
Oct 1	04 54.9	+26 42	10.5
8	04 56.7	+27 11	10.4
15	04 57.0	+27 39	10.3
22	04 55.9	+28 05	10.2
29	04 53.4	+28 29	10.1
Nov 5	04 49.4	+28 50	9.9
12	04 44.1	+29 08	9.8
19	04 37.9	+29 21	9.7
26	04 30.9	+29 29	9.6
Dec 3	04 23.7	+29 31	9.6
10	04 16.6	+29 28	9.7
17	04 10.1	+29 21	9.8
24	04 04.6	+29 12	9.9
31	04 00.3	+29 01	10.1

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a *dirty snowball*, a conglomerate of ice, gas, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classic dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical-shaped donut. The effects of solar radiation and the slight gravity tug from the planets will, over time, break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand, up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Quadrantids (QUA)	NM	Dec 28 – Jan 12	Jan 03	230˚	+49˚	41	110
alpha-Centaurids (ACE)	FQ	Jan 31 – Feb 20	Feb 08	210˚	–59˚	58	6
gamma-Normids (GNO)	FM	Feb 25 – Mar 28	Mar 14	239˚	–50˚	56	6
Lyrids (LYR)	LQ	Apr 14 – Apr 30	Apr 22	271˚	+34˚	49	18
pi-Puppids (PPU)*	LQ	Apr 15 – Apr 28	Apr 23	110˚	–45˚	18	var
eta-Aquarids (ETA)	FQ	Apr 19 – May 28	May 06	338˚	–01˚	66	50
eta-Lyrids (ELY)	FQ	May 03 – May 14	May 08	287˚	+44˚	43	3
June Bootids (JBO)*	NM	Jun 22 – Jul 02	Jun 27	224˚	+48˚	18	var
Pisces Austrinids (PAU)	NM	Jul 15 – Aug 10	Jul 29	341˚	–30˚	35	5
Southern delta-Aquarids (SDA)	NM	Jul 12 – Aug 23	Jul 30	340˚	–16˚	41	25
alpha-Capricornids (CAP)	NM	Jul 03 – Aug 15	Jul 30	307˚	–10˚	23	5
Perseids (PER)	FM	Jul 17 – Aug 24	Aug 12	048˚	+58˚	59	100
kappa-Cygnids (KCG)	LQ	Aug 03 – Aug 25	Aug 17	286˚	+59˚	25	3
Aurigids (AUR)	FQ	Aug 28 – Sep 05	Sep 01	091˚	+39˚	66	6
September Perseids (SPE)	FM	Sep 05 – Sep 21	Sep 09	048˚	+40˚	64	5
Draconids (DRA)*	FM	Oct 06 – Oct 10	Oct 08	262˚	+54˚	20	10
Southern Taurids (STA)	FM	Sep 10 – Nov 20	Oct 10	032˚	+09˚	27	5
delta-Aurigids (DAU)	FM	Oct 10 – Oct 18	Oct 11	084˚	+44˚	64	2
epsilon-Geminids (EGE)	LQ	Oct 14 – Oct 27	Oct 18	102˚	+27˚	70	3
Orionids (ORI)	LQ	Oct 02 – Nov 07	Oct 21	095˚	+16˚	66	20
Leo Minorids (LMI)	NM	Oct 19 – Oct 27	Oct 24	162˚	+37˚	62	2
Northern Taurids (NTA)	FM	Oct 20 – Dec 10	Nov 12	058˚	+22˚	29	5
Leonids (LEO)	LQ	Nov 06 – Nov 30	Nov 18	152˚	+22˚	71	10
alpha-Monocerotids (AMO)	NM	Nov 15 – Nov 25	Nov 21	117˚	+01˚	65	Var
Phoenicids (PHO)	FQ	Nov 28 – Dec 09	Dec 02	018˚	–53˚	18	Var
Puppid-Velids (PUP)	FM	Dec 01 – Dec 15	Dec 07	123˚	–45˚	40	10
Monocerotids (MON)	FM	Dec 05 – Dec 20	Dec 09	100˚	+08˚	42	3
sigma-Hydrids (HYD)	FM	Dec 03 – Dec 20	Dec 09	127˚	+02˚	58	7
Geminids (GEM)	LQ	Dec 04 – Dec 20	Dec 13	112˚	+33˚	35	150
Coma Berenicids (COM)	LQ	Dec 12 – Dec 23	Dec 16	175˚	+18˚	65	3
Dec. Leonis Minorids (DLM)	LQ	Dec 05 – Feb 04	Dec 19	161˚	+30˚	64	5
Ursids (URS)	NM	Dec 17 – Dec 26	Dec 22	217˚	+75˚	33	10

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

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

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

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

Table Notes (above)

Shower Name The shower is named after the constellation (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

Name	Genitive	Abr.	Map	Cul.
Crater	Crateris	Crt	4, 6	Apr 26
Crux	Crucis	Cru	1	May 12
Cygnus	Cygni	Cyg	9	Sep 13
Delphinus	Delphini	Del	9, 8	Sep 14
Dorado	Doradus	Dor	2, 1	Jan 31
Draco	Draconis	Dra	7, 9	Jul 8
Equuleus	Equulei	Equ	9, 8	Sep 22
Eridanus	Eridani	Eri	2, 1	Dec 25
Fornax	Fornacis	For	2	Dec 17
Gemini	Geminorum	Gem	5, 4	Feb 19
Grus	Gruis	Gru	8, 1	Oct 12
Hercules	Herculis	Her	7, 9	Jul 28
Horologium	Horologii	Hor	2, 1	Dec 25
Hydra	Hydrae	Hya	4, 6	Apr 29
Hydrus	Hydri	Hyi	1	Dec 10
Indus	Indi	Ind	1, 8	Sep 26
Lacerta	Lacertae	Lac	9	Oct 12
Leo	Leonis	Leo	5, 7	Apr 15
Leo Minor	Leonis Minoris	LMi	5, 7	Apr 9
Lepus	Leporis	Lep	2, 4	Jan 28
Libra	Librae	Lib	6	Jun 23
Lupus	Lupi	Lup	6	Jun 23
Lynx	Lyncis	Lyn	5, 3	Mar 5
Lyra	Lyrae	Lyr	9, 7	Aug 18
Mensa	Mensae	Men	1	Jan 28
Microscopium	Microscopii	Mic	8	Sep 18
Monoceros	Monocerotis	Mon	4, 5	Feb 19
Musca	Muscae	Mus	1	May 14
Norma	Normae	Nor	6, 1	Jul 3
Octans	Octantis	Oct	1	Circum
Ophiuchus	Ophiuchi	Oph	6, 7	Jul 26

Name	Genitive	Abr.	Map	Cul.
Orion	Orionis	Ori	2, 3	Jan 27
Pavo	Pavonis	Pav	1, 8	Aug 29
Pegasus	Pegasi	Peg	9, 3	Oct 16
Perseus	Persei	Per	3	Dec 22
Phoenix	Phoenicis	Phe	2, 8	Nov 18
Pictor	Pictoris	Pic	1, 2	Jan 30
Pisces	Piscium	Psc	3, 9	Nov 11
Piscis Austrinus	Piscis Austrini	PsA	8	Oct 9
Puppis	Puppis	Pup	4, 2	Feb 22
Pyxis	Pyxidis	Pyx	4	Mar 21
Reticulum	Reticuli	Ret	1	Jan 3
Sagitta	Sagittae	Sge	9	Aug 30
Sagittarius	Sagittarii	Sgr	8, 6	Aug 21
Scorpius	Scorpii	Sco	6, 8	Jul 18
Sculptor	Sculptoris	Scl	2, 8	Nov 10
Scutum	Scuti	Sct	8	Aug 15
Serpens	Serpentis	Ser	6, 7	Jul 21
Sextans	Sextantis	Sex	4	Apr 8
Taurus	Tauri	Tau	3, 5	Jan 14
Telescopium	Telescopii	Tel	8, 1	Aug 24
Triangulum	Trianguli	Tri	3	Dec 7
Triangulum Australe	Trianguli Australis	TrA	1	Jul 7
Tucana	Tucanae	Tuc	1	Nov 1
Ursa Major	Ursae Majoris	UMa	5, 7	Apr 25
Ursa Minor	Ursae Minoris	UMi	7	Jun 27
Vela	Velorum	Vel	4, 1	Mar 30
Virgo	Virginis	Vir	6, 7	May 26
Volans	Volantis	Vol	1	Mar 4
Vulpecula	Vulpeculae	Vul	9	Sep 8

BRIGHTEST and NEAREST STARS (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(Guy) **K**iss **M**e.

There are also the *colder* star classes **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel).
- **F** and **G** are yellow (e.g., Capella, and the Sun).
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (that is no colour).

The colours of stars can be imaged simply. Mount a camera on a tripod and take a time exposure of several minutes. The resulting star trails often show the colours very well. An equatorially tracked time exposure (for example piggy-backed on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images can saturate the detector. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation		Name	Constellation	RA (2000.0)	Dec (2000.0)	Magnitude		Spectral Type	Parallax	Distance		Note
						App	Abs			pc	ly	
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	Dec	Magnitude		Spect Type	Parallax "	Proper Motion "/yr	Distance	
				hh mm.m	° '	Apparent	Absolute				pc	ly
--	Sun					–26.72	4.85	G2 V				
1	Proxima Centauri		Centaurus	14 29.7	–62 40	11.09	15.53	M5.5 V	0.7720	3.85	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	–60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		B				1.34	5.71	K0 V				
2	Barnard's Star		Ophiuchus	17 57.8	+04 41	9.53	13.22	M4.0 V	0.5470	10.36	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	–16 43	–1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		B				8.44	11.34	DA2				
6	L 726-8 (UV Ceti)	A	Cetus	01 39.0	–17 57	12.54	15.40	M5.5 V	0.3737	3.37	2.68	8.73
		B				12.99	15.85	M6.0 V				
7	Ross 154		Sagittarius	18 49.8	–23 50	10.43	13.07	M3.5 V	0.3369	0.67	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	–09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	–35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	–15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		B				13.27	15.58	M				
		C				14.03	16.34	M				
13	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.66	F5 IV–V	0.2861	1.26	3.50	11.40
		B				10.70	12.98	DA				
14	61 Cygni	A	Cygnus	21 06.9	+38 45	5.21	7.49	K5.0 V	0.2860	5.28	3.50	11.40
		B				6.03	8.31	K7.0 V				
15	Σ 2398	A	Draco	18 42.8	+59 38	8.90	11.16	M3.0 V	0.2830	2.24	3.53	11.53
		B				9.69	11.95	M3.5 V				
16	Groombridge 34	A	Andromeda	00 18.4	+44 01	8.08	10.32	M1.5 V	0.2806	2.92	3.56	11.63
		B				11.06	13.30	M3.5 V				
17	Epsilon Indi		Indus	22 03.4	–56 47	4.69	6.89	K5 Ve	0.2758	4.70	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	–15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	–44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	–17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten's Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

DEEP SKY OBJECTS

Catalogue #	Ben nett	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

See page 145 for legend.

Catalogue #	Ben nett	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 mag. and fainter, central concentration
NGC 2547		OC	Vel	4.7	20'	08 10.2	−49 12	2	4	Rich in stars with strong central concentration
NGC 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

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, mag. 13 to 15
NGC 2903		G	Leo	9.0	13'×6'	09 32.2	+21 30	3		
NGC 2972	41a	OC	Vel	9.9	4'	09 40.3	−50 20	3		
NGC 2997	41b	G	Ant	9.4	9'×7'	09 45.6	−31 11	3		
NGC 3114		OC	Car	4.2	35'	10 02.5	−60 08	3		Rich cluster, stars magnitude 9 to 14
NGC 3115	42	G	Sex	8.9	7'×3'	10 05.2	−07 43	3		
NGC 3132	43	PN	Vel	8.2	84"×53"	10 07.0	−40 26	3	4	Eight-burst Nebula
NGC 3201	44	GC	Vel	6.8	18'	10 17.6	−46 25	3	4	
NGC 3242	45	PN	Hya	8.6	45"×36"	10 24.8	−18 39	3		Ghost of Jupiter
NGC 3293		OC	Car	4.7	6'	10 35.8	−58 13	3	1	
NGC 3351		G	Leo	9.7	7'×5'	10 44.0	+11 42	3	5	M95
NGC 3372		BN	Car	3.0	120'×120'	10 45.1	−59 52	3	1	Eta Carinae
NGC 3368		G	Leo	9.3	8'×5'	10 46.8	+11 49	3	5	M96
NGC 3379		G	Leo	9.3	5'×5'	10 47.8	+12 35	3	5	M105, in group of three galaxies
NGC 3532		OC	Car	3.0	55'×50'	11 05.2	−58 44	4	1	Rich and large, 150 stars magnitude 7 to 12
NGC 3521		G	Leo	9.0	11'×5'	11 05.8	−00 02	4		
NGC 3621	46	G	Hya	9.2	12'×7'	11 18.3	−32 49	4		
NGC 3623		G	Leo	9.3	10'×3'	11 18.9	+13 05	4	5	M65
	47	OC	Car	8.5	5'	11 19.7	−63 30	4		Melotte 105
NGC 3627		G	Leo	8.9	9'×4'	11 20.2	+13 00	4	5	M66
NGC 3628		G	Leo	9.5	15'×3'	11 20.3	+13 35	4		Near galaxies M65/66
NGC 3766		OC	Cen	5.3	12'	11 36.2	−61 37	4	1	Rich cluster, 100 stars magnitude 7 to 12
IC 2948		BN	Cen	7.0	1.2°×0.8°	11 39.4	−63 28	4		Running Chicken Nebula
NGC 3918		PN	Cen	8.4	13"	11 50.3	−57 11	4		
NGC 3960	48	OC	Cen	8.3	6'	11 50.9	−55 41	4		
NGC 3923	49	G	Hya	10	6'×4'	11 51.0	−28 48	4		
NGC 4192		G	Com	10.1	10'×3'	12 13.8	+14 54	4	7	M98
NGC 4216		G	Vir	10.0	8'×2'	12 15.9	+13 09	4		Edge-on galaxy
NGC 4254		G	Com	9.9	5'×5'	12 18.8	+14 25	4	7	M99
NGC 4258		G	CVn	8.4	19'×7'	12 19.0	+47 18	4	5,7	M106
NGC 4303		G	Vir	9.6	7'×6'	12 21.9	+04 28	4	6,7	M61
NGC 4321		G	Com	9.4	7'×6'	12 22.9	+15 49	4	7	M100
NGC 4361		PN	Crv	10.9	2'×2'	12 24.5	−18 47	4		
NGC 4374		G	Vir	9.1	7'×6'	12 25.1	+12 53	4	7	M84, Bright centre, in same field as M86
NGC 4382		G	Com	9.1	7'×6'	12 25.4	+18 11	4	7	M85
NGC 4372	50	GC	Mus	7.2	19'	12 25.8	−72 40	4		Caldwell 108
NGC 4406		G	Vir	8.9	9'×6'	12 26.2	+12 57	4	7	M86
NGC 4472		G	Vir	8.4	10'×8'	12 29.8	+08 00	4	7	M49
NGC 4486		G	Vir	8.6	8'×7'	12 30.8	+12 23	4	7	M87, Virgo A
NGC 4501		G	Com	9.6	7'×4'	12 32.0	+14 25	4	7	M88
NGC 4548		G	Com	10.1	5'×4'	12 35.4	+14 30	4	7	M91
NGC 4552		G	Vir	9.8	5'×5'	12 35.7	+12 33	4	7	M89
NGC 4565		G	Com	9.6	16'×2'	12 36.3	+25 59	4		
NGC 4569		G	Vir	9.5	10'×4'	12 36.8	+13 10	4	7	M90
NGC 4579		G	Vir	9.7	6'×5'	12 37.7	+11 49	4	7	M58, Bright diffuse nucleus, dark lanes
NGC 4590	51	GC	Hya	7.3	12'	12 39.5	−26 45	4	6	M68, Rich and compressed
NGC 4594	52	G	Vir	8.0	9'×4'	12 40.0	−11 37	4	6	M104, Sombrero Galaxy
NGC 4621		G	Vir	9.6	5'×4'	12 42.0	+11 39	4	7	M59
NGC 4631		G	CVn	9.2	16'×3'	12 42.1	+32 32	4		Whale Galaxy
NGC 4649		G	Vir	8.8	7'×6'	12 43.7	+11 33	4	7	M60

Catalogue #	Bennett	Type	Con	Mag	Size	RA	Dec	Mth 10pm	Map	Notes
NGC 4697	53	G	Vir	9.2	7'×5'	12 48.6	−05 48	4		Caldwell 52
NGC 4699	54	G	Vir	10.2	4'×3'	12 49.0	−08 40	4		
NGC 4736		G	CVn	8.2	11'×9'	12 50.9	+41 07	4	5,7	M94
NGC 4753	55	G	Vir	10.5	6'×3'	12 52.4	−01 12	4		
NGC 4755		OC	Cru	4.2	10'	12 53.6	−60 21	4	1	Jewel Box
NGC 4826		G	Com	8.5	10'×5'	12 56.7	+21 41	4	7	M64, Black Eye Galaxy
NGC 4833	56	GC	Mus	8.4	14'	12 59.6	−70 52	4		Near globular cluster NGC 4372
NGC 4945	57	G	Cen	8.6	20'×4'	13 05.4	−49 28	5	6	Big edge-on spiral, small galaxy in same field
NGC 4976	58	G	Cen	10.2	6'×3'	13 08.6	−49 30	5		
NGC 5024		GC	Com	7.7	13'	13 12.9	+18 10	5	7	M53, Bright centre region, very compressed
NGC 5055		G	CVn	8.6	13'×7'	13 15.8	+42 02	5	5,7	M63, Sunflower Galaxy
NGC 5061	59	G	Hya	10.5	4'×3'	13 18.1	−26 50	5		
NGC 5068	59a	G	Vir	9.8	7'×6'	13 18.9	−21 02	5		
NGC 5128	60	G	Cen	6.8	26'×20'	13 25.5	−43 01	5		Centaurus A (radio source)
NGC 5139	61	GC	Cen	3.9	36'	13 26.8	−47 29	5	6	Omega Centauri
NGC 5194		G	CVn	8.4	11'×8'	13 29.9	+47 12	5	7	M51, Whirlpool Galaxy
NGC 5189	62	PN	Mus	10.3	140"	13 33.5	−65 58	5	1	Dunlop's best planetary nebula
NGC 5236	63	G	Hya	7.5	15'×13'	13 37.0	−29 52	5	6	M83, Southern Pinwheel Galaxy
NGC 5253	63a	G	Cen	10.7	5'×2'	13 39.9	−31 39	5		
NGC 5272		GC	CVn	6.3	18'	13 42.2	+28 23	5	7	M3, Large bright globular, brightens suddenly towards the middle
NGC 5286	64	GC	Cen	7.4	9'	13 46.4	−51 22	5		
IC 4406		PN	Lup	11.0	2'×2'	14 22.4	−44 09	5		Retina Nebula
NGC 5634	66	GC	Vir	9.5	5'	14 29.6	−05 59	5		
NGC 5617	65	OC	Cen	6.3	10'	14 29.8	−60 43	5		
NGC 5824	67	GC	Lup	9.1	6'	15 04.0	−33 04	6		
NGC 5897	68	GC	Lib	8.4	13'	15 17.4	−21 01	6		
NGC 5904		GC	Ser	5.7	23'	15 18.6	+02 05	6	6	M5, Bright, large very compressed in middle, slightly oval in shape
NGC 5927	69	GC	Lup	8	6'	15 28.0	−50 40	6		
NGC 5986	70	GC	Lup	7.6	10'	15 46.1	−37 47	6		
NGC 5999	71	OC	Nor	9	3'	15 52.2	−56 28	6		
NGC 6005	72	OC	Nor	10.7	3'	15 55.8	−57 26	6		
	72a	OC	Nor	11.2	5'	16 01.5	−53 32	6		Tr 23 (Trumpler)
NGC 6067		OC	Nor	5.6	12'	16 13.2	−54 13	6	6	100 stars, large brightness range, central conc.
NGC 6093	73	GC	Sco	7.3	9'	16 17.0	−22 59	6	6	M80, Strong central concentration, bright and large
NGC 6121	75	GC	Sco	5.4	26'	16 23.6	−26 32	6	6	M4, Near Antares
NGC 6124		OC	Sco	5.8	40'	16 25.3	−40 39	6	6	Near planetary nebula NGC 6153
NGC 6101	74	GC	Aps	9.2	11'	16 25.8	−72 12	6		Caldwell 107
NGC 6144	77	GC	Sco	9	9'	16 27.3	−26 02	6		
NGC 6134	76	OC	Nor	7.2	6'	16 27.7	−49 09	6		
NGC 6139	78	GC	Sco	9.1	6'	16 27.7	−38 51	6		
NGC 6171	79	GC	Oph	7.8	10'	16 32.5	−13 03	6	6	M107
NGC 6167	79a	OC	Nor	6.7	7'	16 34.4	−49 36	6		
NGC 6192	79b	OC	Sco	8.5	7'	16 40.3	−43 22	6		
NGC 6193		OC	Ara	5.2	14'	16 41.3	−48 46	6		In nebula NGC 6188
NGC 6205		GC	Her	5.8	17'	16 41.7	+36 28	6	7	M13, Great Hercules Cluster

Catalogue #	Bennett	Type	Con	Mag	Size	RA	Dec	Mth 10pm	Map	Notes
NGC 6218	80	GC	Oph	6.1	15'	16 47.2	–01 57	6	6	M12
NGC 6216	81	OC	Sco	10.1	4'	16 49.4	–44 44	6		
NGC 6235	82	GC	Oph	8.9	5'	16 53.4	–22 11	6		
NGC 6231		OC	Sco	2.6	14'	16 54.2	–41 49	6	6	A few stars with strong central concentration
IC 4628		BN	Sco		1.5° × 1.5°	16 57.0	–40 27	6		Prawn Nebula
NGC 6254	83	GC	Oph	6.6	15'	16 57.1	–04 06	6	6	M10
NGC 6253	84	OC	Ara	10.2	5'	16 59.1	–52 43	6		
NGC 6266	85	GC	Oph	6.4	14'	17 01.2	–30 07	7	6	M62
NGC 6273	86	GC	Oph	6.8	14'	17 02.6	–26 16	7	6	M19
NGC 6284	87	GC	Oph	8.9	6'	17 04.5	–24 46	7		
NGC 6287	88	GC	Oph	9.3	5'	17 05.2	–22 42	7		
NGC 6293	89	GC	Oph	8.3	8'	17 10.2	–26 35	7		
NGC 6302		PN	Sco	9.7	83" × 24"	17 13.7	–37 06	7		Bug Nebula
NGC 6304	90	GC	Oph	8.3	7'	17 14.5	–29 28	7		
NGC 6316	91	GC	Oph	8.1	5'	17 16.6	–28 08	7		
NGC 6341		GC	Her	6.5	14'	17 17.1	+43 08	7	7,9	M92
NGC 6318	91a	OC	Sco	11.8	5'	17 17.8	–39 27	7		
NGC 6333	92	GC	Oph	7.9	9'	17 19.2	–18 31	7	6	M9
NGC 6356	93	GC	Oph	8.2	7'	17 23.6	–17 49	7		
NGC 6352	94	GC	Ara	7.8	7'	17 25.5	–48 25	7		Caldwell 81
NGC 6362	95	GC	Ara	8.1	11'	17 31.9	–67 03	7		
NGC 6388	96	GC	Sco	6.8	9'	17 36.3	–44 44	7		
NGC 6402	97	GC	Oph	7.6	12'	17 37.6	–03 15	7	6,7	M14
NGC 6405		OC	Sco	4.2	33'	17 40.3	–32 15	7	6,8	M6, Butterfly Cluster
NGC 6397	98	GC	Ara	5.3	26'	17 40.7	–53 40	7	1,6	Loose structure, possibly the nearest globular
NGC 6440	98a	GC	Sgr	9.3	5'	17 48.9	–20 22	7		
NGC 6445	98b	PN	Sgr	11.2	3' × 1'	17 49.2	–20 01	7		Crescent Nebula
NGC 6441	99	GC	Sco	7.4	8'	17 50.2	–37 03	7		
NGC 6475		OC	Sco	3.3	80'	17 53.9	–34 48	7	6,8	M7, Ptolemy's Cluster
NGC 6494		OC	Sgr	5.5	30'	17 57.1	–18 59	7	6,8	M23, 150 stars, moderate brightness range, lies in good star field
NGC 6496	100	GC	CrA	8.6	7'	17 59.0	–44 16	7		
NGC 6514		BN	Sgr	6.3	20' × 20'	18 02.7	–22 58	7	6,8	M20, Trifid Nebula
NGC 6520		OC	Sgr	7.6	6'	18 03.4	–27 53	7		Near Barnard 86
NGC 6522	101	GC	Sgr	9.9	6'	18 03.6	–30 02	7		Near NGC 6528
NGC 6523		BN	Sgr	5.0	45' × 30'	18 03.7	–24 23	7	6,8	M8, Lagoon Nebula
NGC 6531		OC	Sgr	5.9	15'	18 04.2	–22 29	7	6,8	M21
NGC 6528	102	GC	Sgr	9.6	4'	18 04.8	–30 03	7		Near NGC 6522
NGC 6544	103	GC	Sgr	7.5	9'	18 07.3	–25 00	7		
NGC 6541	104	GC	Cra	6.3	13'	18 08.0	–43 42	7	8	
NGC 6553	105	GC	Sgr	8.3	9'	18 09.3	–25 54	7		
NGC 6572		PN	Oph	8.0	16" × 13"	18 12.1	+06 51	7		
NGC 6569	106	GC	Sgr	8.4	6'	18 13.6	–31 50	7		
NGC 6603	107a	OC	Sgr	11.1	5'	18 18.4	–18 25	7		In M24, Sagittarius Star Cloud
NGC 6584	107	GC	Tel	7.9	8'	18 18.6	–52 13	7		
NGC 6611		BN	Ser	6.0	120' × 25'	18 18.8	–13 47	7	8	M16, Eagle Nebula
		OC	Sgr	3.0	95'	18 19.6	–18 10	7	6,8	M24, Small Sagittarius Star Cloud
NGC 6613		OC	Sgr	6.9	9'	18 19.9	–17 08	7	8	M18
NGC 6618	108	BN	Sgr	6.0	20' × 15'	18 20.8	–16 11	7	8	M17, Swan Nebula
NGC 6624	109	GC	Sgr	7.6	9'	18 23.7	–30 22	7		

Catalogue #	Bennett	Type	Con	Mag	Size	RA	Dec	Mth 10pm	Map	Notes
NGC 6626	110	GC	Sgr	6.9	11'	18 24.5	–24 52	7	6,8	M28, Large, round, increasingly compressed in the middle
NGC 6633		OC	Oph	4.6	20'	18 27.3	+06 31	7		Near open cluster IC 4756
NGC 6638	111	GC	Sgr	9.2	7'	18 30.9	–25 30	7		
NGC 6637	112	GC	Sgr	7.7	7'	18 31.4	–32 21	7	1,6,8	M69
IC 4725		OC	Sgr	4.6	29'	18 31.8	–19 07	7	8	M25, 30 stars loosely scattered
NGC 6642	112a	GC	Sgr	8.9	5'	18 31.9	–23 29	7		
NGC 6652	113	GC	Sgr	8.5	4'	18 35.8	–32 59	7		
NGC 6656	114	GC	Sgr	5.2	24'	18 36.4	–23 54	7	8	M22, Fine globular, only Omega Centauri and 47 Tucanae are brighter
NGC 6681	115	GC	Sgr	7.8	8'	18 43.2	–32 18	7	1,6,8	M70
NGC 6694		OC	Sct	8.0	14'	18 45.2	–09 24	7	8	M26
NGC 6705	116	OC	Sct	5.8	13'	18 51.1	–06 16	7	8	M11, Wild Duck Cluster
NGC 6712	117	GC	Sct	8.1	7'	18 53.1	–08 42	7		
NGC 6720		PN	Lyr	9.4	86" × 62"	18 53.6	+33 02	7	7,9	M57, Ring Nebula
NGC 6715	118	GC	Sgr	7.7	9'	18 55.1	–30 29	7	8	M54
NGC 6723	119	GC	Sgr	6.8	11'	18 59.6	–36 38	7		
NGC 6726		BN	CrA		2' × 2'	19 01.7	–36 53	8		
NGC 6744	120	G	Pav	8.3	20' × 13'	19 09.8	–63 51	8	1	
NGC 6752	121	GC	Pav	5.4	20'	19 10.9	–59 59	8	1	Starfish Cluster
NGC 6779		GC	Lyr	8.3	7'	19 16.6	+30 11	8	9	M56, Irregularly round, compressed in the middle
NGC 6809	122	GC	Sgr	6.3	19'	19 40.0	–30 58	8	8	M55
NGC 6818	123	PN	Sgr	10.0	22" × 15"	19 44.0	–14 09	8		Near galaxy NGC 6822
NGC 6838		GC	Sge	8.3	7'	19 53.8	+18 47	8	9	M71
NGC 6853		PN	Vul	7.3	8' × 6'	19 59.6	+22 43	8	9	M27, Dumbbell Nebula
NGC 6864	124	GC	Sgr	8.6	6'	20 06.1	–21 55	8	8	M75
NGC 6913		OC	Cyg	6.6	10'	20 23.9	+38 32	8	9	M29
NGC 6981	125	GC	Aqr	9.2	6'	20 53.5	–12 32	8	8	M72
NGC 6992		BN	Cyg	7.0	60' × 8'	20 56.4	+31 43	8		Part of Veil Nebula
NGC 7000		BN	Cyg	4.0	100' × 60'	21 01.8	+44 12	9	9	North American Nebula
NGC 7009	126	PN	Aqr	8.3	44" × 23"	21 04.2	–11 22	9		Saturn Nebula
NGC 7078		GC	Peg	6.4	12'	21 30.0	+12 10	9	9	M15, Bright, irregularly round, well resolved into faint stars
NGC 7092		OC	Cyg	4.6	31'	21 32.2	+48 26	9	9	M39, Northern limit
NGC 7089	127	GC	Aqr	6.5	13'	21 33.5	–00 49	9	8	M2
NGC 7099	128	GC	Cap	6.9	11'	21 40.4	–23 11	9	8	M30
NGC 7293	129	PN	Aqr	6.3	15' × 12'	22 29.6	–20 50	9	8	Helix Nebula
NGC 7410	129a	G	Gru	10.6	6' × 2'	22 55.0	–39 40	9		
	129b	G	Gru	9.97	5' × 3'	22 57.0	–36 28	9		IC 1459
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

Note: The entries listed on these and following pages may be affected by pandemic restrictions. See their websites or contact for details.

PLACES OF ASTRONOMICAL INTEREST

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY RESEARCH FACILITY

They operate their Open Nights public observatory tours on a regular basis, catering for school groups and the general public. The facility is also dedicated to meteorite research and the meteorite collection is open by request. Information on tour dates and times can be found on the website. Regular updates are also on their Facebook page. <info@bathurstobservatory.com.au>
www.bathurstobservatory.com.au www.facebook.com/BathurstObservatory

CANBERRA DEEP SPACE COMMUNICATION COMPLEX

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 <pr@cdscc.nasa.gov> www.cdscc.nasa.gov/ facebook.com/CanberraDSN

CRAGO OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (north-west of Sydney). It houses a 55 cm telescope. The observatory enjoys the darkest sky in the Sydney region and is open on Saturday nights nearest to Last Quarter Moon. Visitors most welcome. Status updates for weather will be posted on the Facebook page around 4 pm on observing nights. Contact Paul Hatchman 0413 047 782 <VP_Crago@asnsw.com>
www.asnsw.com/crago/ www.facebook.com/CragoObs/

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 3-D Theatre. There is also the Dish Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available. Contact (02) 6861 1777
<VCStaff-PA@csiro.au> www.csiro.au/parkes

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the Western Plains Zoo. Sky presentations are projected in their theatrette, followed by viewing through their telescopes including a large 17". Bring your SLR camera to take astrophotos through this scope or over the internet with their CCD camera. Contact 0488 425 940 <peter@dubboobservatory.com> www.dubboobservatory.com

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
<info@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 various nights (unless raining) for several months during the year, see website for dates and status. Astronomy students will guide you with a range of telescopes. goto.mq/observatory

MACQUARIE UNIVERSITY PLANETARIUM

The Digitarium Epsilon planetarium projector system and portable GoDome (see also entry under Mobile Planetariums, page 149) also run public sessions during some school holidays, see website for details. Bookings are essential.
goto.mq/planetarium

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 <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. Theatre and flat screen planetarium runs features on the night sky and the Sun. A variety of telescopes and binoculars are available for visitors as well as conducted tours of the night sky. Bookings are essential. Contact (02) 6373 3431, 0428 560 039 <john@mudgeeobservatory.com.au> www.mudgeeobservatory.com.au

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. <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) <science-space@uow.edu.au> www.sciencespace.com.au

SIDING SPRING OBSERVATORY

Siding Spring Observatory (SSO) is Australia's premier optical astronomy research facility and is home to telescopes from many organisations within Australia and around the world. These include Australia's two largest optical telescopes, the Australian National University's 3.9 metre Anglo Australian Telescope and the 2.3 metre Advanced Technology Telescope. Siding Spring nestles into the Warrumbungle mountains at the entrance to the Warrumbungle National Park, 30 minutes west of Coonabarabran. The Visitor Centre includes a café serving light meals, souvenir shop and an astronomy exhibit. From the Visitor Centre there is access to the viewing gallery of the 3.9 m AAT and special tours can be organised on request for groups, information can be found on their website. StarFest is a celebration of astronomy at SSO every October long weekend, more information on the web. www.sidingspring.com.au
www.starfest.org.au

SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a variety of tours and displays. See website for details. Sydney Observatory is part of the Museum of Applied Arts and Sciences. <info@maas.museum> www.maas.museum/Sydney-observatory

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. Contact phone 0458 772 747 for confirmation and details. www.tamworthastronomy.com.au also on Facebook

THE AUSTRALIA TELESCOPE COMPACT ARRAY – NARRABRI

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22 m dishes, five spaced along a 3 km track with a sixth 3 km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations. www.narrabri.atnf.csiro.au

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 3-D astronomy movie and viewing through a variety of telescopes.
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 Mark Sugars 0409 697 734 alloway-observatory-bundaberg.webs.com

CHARLEVILLE COSMOS CENTRE AND OBSERVATORY

The centre, located off the Mitchell Highway within the airport precinct, 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 and Personal Observatory session using an enormous 30" 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, allowing you to observe sunspots and solar flares using a 10" Hydrogen-Alpha telescope. 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
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 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 <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 <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 our venue or yours. Bookings are essential, see website for details. <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 <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 SA, ADELAIDE PLANETARIUM

The 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 <adelaide.planetarium@unisa.edu.au> www.unisa.edu.au/planetarium/ www.facebook.com/AdelaidePlanetarium

TASMANIA

LAUNCESTON PLANETARIUM

The 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 3-D 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 <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 <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 <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 their 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. Contact Mount Burnett Observatory hotline 0490 665 004 <info@mbo.org.au> www.instagram.com/mtburnettobservatory/ www.facebook.com/MtBurnettObservatory mbo.org.au Also on 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 <greg@astrotours.net> www.astrotours.net

GDC OBSERVATORY

The Gravity Discovery Centre Observatory is part of the Gravity Precinct and shares its bushland with the AIGO research centre and the Zadko Telescope and the USAFA Falcon Telescope Network. The observatory boasts professional staff and five telescopes including the largest for public viewing in WA. Events include their Monster Telescope, Indigenous Astronomy and specialised astronomy sessions. Located under dark skies, it is an hours drive north of Perth. Contact (08) 9575 7577 (Office) www.gravitycentre.com.au/observatory

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 <info@perthobservatory.com.au>
www.perthobservatory.com.au twitter.com/perthobs, facebook.com/PerthObservatory instagram.com/perthobservatory

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) <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 at Macquarie University in North Ryde, Sydney, around 6:30 pm. The 2022 night is currently planned for 23 June. See website and search for 'Astronomy Open Night' for details.. www.mq.edu.au

NACAA

The National Australian Convention of Amateur Astronomers is a regular national forum at which amateur astronomers can exchange experiences, stay abreast of the latest trends, foster co-operative activities between individuals, societies and the professional sphere. Held over Easter every two years, the 30th NACAA will be held in Melbourne in 2022, hosted by the Astronomical Society of Victoria. 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 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. Member's observing nights also held at Tingalpa and Calvert. Check website event calendars for dates and times. Email <info@bas.asn.au> www.bas.asn.au

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 is normally held late August. Each Saturday has vendor sales and talks. Workshops are run covering various topics. The renowned Astro-Feast is held on the last Saturday night. More details are on the website. Registration usually opens April/May, early bookings are recommended. Contact registrar <registrar@qldastrofest.org.au> www.qldastrofest.org.au

URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at 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 <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 2nd year (alternating with NACAA). Activities include speakers, workshops, displays, observing and the convention dinner. Details on the website when available. vastroc.net vastroc.ballaratobservatory.org.au

VICSOUTH DESERT SPRING STAR PARTY

Jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, 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

ORGANISATIONS

AUSTRALIA

AUSTRALASIAN DARK SKY ALLIANCE

ADSA is promoting the preservation of the night environment, through education, public, policy and people. Contact Marnie Ogg, Director <info@australasiandarkskyalliance.org> www.australasiandarkskyalliance.org

INTERNATIONAL DARK-SKY ASSOCIATION

IDA's goal is to preserve and protect the night-time environment and our heritage of dark skies through quality outdoor lighting. Contact Dr Kellie Pendoley, VP of the IDA, and Australasian. <kellie.pendoley@penv.com.au> www.darksky.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) <asa.secretary@sydney.edu.au> asa.astronomy.org.au ASA site
www.astronomy.org.au Australian Astronomy site

VARIABLE STARS SOUTH

VSS is an international association of astronomers, amateur and professional, researching the under-explored realm of southern variable stars. VSS covers most techniques of variable star research: visual observing, imaging with DSLRs and CCD cameras and spectrography. Its research is project-oriented, often involving professional/amateur collaboration. Its 'home' is its website, visit it for further information and contacts. Email <markgblackford@outlook.com>
www.variablestarssouth.org VSS Site

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 <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 2022 should contact Geoff McNamara for a copy of the MSATT Student Guide. There is no cost for any MSATT activities. Contact Geoff McNamara phone/text 0449 966 200 <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 <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 tours to NSW observatories. See website for more information. 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.
Contact (08) 8302 3138 <adelaide.planetarium@unisa.edu.au>
adelaide-planetarium/explore/courses
www.unisa.edu.au/connect/galleries-museums-and-centres//

TASMANIA

NIGHT SKY EXPLORER COURSE (HOBART)

Beginner courses are conducted by members of the Astronomical Society of Tasmania, see their website. Richard, <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. astronomy.swin.edu.au/outreach/?topic=freelectures

MOBILE PLANETARIUMS

NEW SOUTH WALES

MACQUARIE UNIVERSITY MOBILE PLANETARIUM

The planetarium projector system and portable GoDome is available, by arrangement, for groups of up to 40 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 website for details. goto.mq/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 <info@skyworks.net.au> www.skyworks.net.au

QUEENSLAND

NIGHT SKY SECRETS PLANETARIUM

Night Sky Secrets operate a Cosmodome Planetarium in North and Far North Queensland. They conduct both 3-D 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 <info@starlab.net.au> www.starlab.net.au

RESOURCES

AUSTRALIA

AUSTRALIAN SKY & TELESCOPE MAGAZINE

AS & T 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, Fax (02) 9439 1977 <info@skyandtelescope.com.au> www.skyandtelescope.com.au

ICEINSPACE

IceInSpace is a community website dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers discover, discuss and enjoy the night sky. It is free to join and use, all you need is a valid email. By registering you will be able to post topics, upload content and images and access other features. It is the largest and most active astronomy community in the Southern Hemisphere. www.iceinspace.com.au

WESTERN AUSTRALIA

STARGAZERS CLUB WA

Stargazing and astronomy for beginners. Stargazers Club WA runs telescope classes, stargazing nights, astrophotography for beginners and hosts special trips to dark skies in country WA. See their website for costs and details. Contact 0487 187 603 <begin@stargazersclubwa.com.au> www.stargazersclubwa.com.au

ASTRONOMY EDUCATION SERVICES

Astronomy Education Services (AES) specialises in school incursions, 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 or Facebook page for more details. Contact Richard Tonello 0417 961 357 or Gravity Discovery Centre Observatory 9575 7577, email <richard@astro-ed-services.com> www.astro-ed-services.com

SOCIETIES

NEW SOUTH WALES & ACT

The **Astronomical Society of Albury Wodonga** meets as advertised on their facebook page. Contact David Thurley 0418 690 142 www.facebook.com/AstronomicalSocietyAlburyWodonga

The Astronomical Society of NSW holds one or 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 each even month at 6:30 PM.
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 <casadmin@gmail.com>. casastronomy.org.au
www.facebook.com/groups/casastronomy/

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

The Clarence Valley Astronomical Society Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>. Find them on Facebook

The **Coffs Harbour Astronomical Society Inc** meets on the first Monday of each month (except January) at 7 pm at the Boambee East Community Centre, cnr. Bruce King Drive and Pacific Highway, Boambee East. Contact Win Howard (02) 6653 2742 <winhoward@iprimus.com.au>
.www.facebook.com/Coffsastro/

The **Illawarra Astronomical Society** meets at 7:30 pm, every 2nd Tuesday of the month at the Wollongong Science Centre. Contact <IAS.secretary@outlook.com>. iasenquiry.wixsite.com/website Also 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
www.facebook.com/groups/macastro/

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 Website and 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 3rd 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. Contact Maree Emett (Sec) <info@sasi.net.au>
. www.sasi.net.au Also Facebook

The 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 www.facebook.com/SydneyCitySkywatchers/

The **Sydney North-west 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 0408 789 908 <starnut01@yahoo.com.au>. www.facebook.com/newcastleastrosociety/

The **University of New England and Northern Tablelands Astronomical Society** has regular meetings, see website for details. Contact <unentas@gmail.com>. www.unentas.org.au

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
www.facebook.com/WSAAG1

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'.
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. Contact Jeff Pountney on 0423 972 181 or Joe Perulero on 0466 146 005. <astronomy@internode.on.net>. 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
www.facebook.com/A.A.Q.astroclub

The **Brisbane Astronomical Society** hold meetings each month except January and December, see their website for meeting night details. Contact Peter Allison 0488 140 755 <President@bas.asn.au>. www.bas.asn.au
www.facebook.com/BrisbaneAstronomicalSociety

The **Bundaberg Astronomical Society** has regular meetings, see website for details. alloway-observatory-bundaberg.webs.com

The **FNQ Astronomers Group** meet periodically in the Cairns region (Far North Qld) in conjunction with astronomical events as advised on the Facebook page. Contact Ian Maclean 0417 601 490 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 on the first Tuesday of the month at Ormiston College, Ormiston (27 km SE of Brisbane), see website for details. Contact President Rhondda Nickols 0403 185 586 <redlandsastronomicalsociety@gmail.com>. www.ras.org.au
www.facebook.com/RASREDLANDS

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 www.facebook.com/ScenicRimAstronomyAssociation/

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

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 www.sas.org.au Also on Facebook

The **Townsville Astronomy Group Inc** holds a monthly public viewing at the Strand in Townsville. In addition there is viewing at a dark site at Oak Valley, usually on two Saturdays around New Moon. Details and updates can be found on their website and their Facebook group.
www.astronomytsv.org.au also Facebook

SOUTH AUSTRALIA

The **Astronomical Society of South Australia** meetings are held on the 1st Wednesday each month (except January) at the University of Adelaide, North Terrace Campus. Contact <info@assa.org.au>. www.assa.org.au
www.facebook.com/astronomysa

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 <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. Contact Linda Richmond (Public Relations Officer) 0409 403 051 <publicrel@asv.org.au>. www.asv.org.au
Follow them on: Facebook, Instagram and Twitter

The Astronomy Benalla meets on the third Wednesday of each month (unless otherwise specified on website!) at 7:30 pm at Benalla Hockey Club Room, Churchill Park, Waller St Benalla. Contact Jeff Knight (President) 0407 532 674 <president@astronomybenalla.org.au>. www.astronomybenalla.org.au
Also on Facebook: Astronomy Benalla

The **Astronomical Society of Geelong** has regular meetings, see website 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.ballaratobservatory.org.au

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 www.facebook.com/lvastro/

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.auwww.facebook.com/mpas0/
also on Twitter, Instagram, YouTube.

The **Mount Burnett Astronomical Society** has regular meetings, see website for details. Contact Mount Burnett Observatory hotline 0490 665 004 <info@mbo.org.au>.mbo.org.au www.facebook.com/MtBurnettObservatory

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
www.facebook.com/ASSW.Inc

The **Astronomical Society of Western Australia** has regular meetings, see website for details. Contact <aswa.info@aswa-inc.org.au>. aswa-inc.org.au
www.facebook.com/ASWA.Inc

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 more than fifty percent illuminated. For example, the Moon is gibbous between First and Last Quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our ***galaxy*** and are seen in other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local ***meridian***.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually in reference to the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is, Mercury or Venus.

Julian date The number of days since noon on 1 January 4713 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

α	Alpha	ε	Epsilon	ι	Iota	ν	Nu	ρ	Rho	φ	Phi
β	Beta	ζ	Zeta	κ	Kappa	ξ	Xi	σ	Sigma	χ	Chi
γ	Gamma	η	Eta	λ	Lambda	ο	Omicron	τ	Tau	ψ	Psi
δ	Delta	θ	Theta	μ	Mu	π	Pi	υ	Upsilon	ω	Omega

Includes Nov / Dec 2021 monthly sections

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0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°

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