ASTRONOMY 2025 AUSTRALIA

Ken Wallace
Glenn Dawes
Peter Northfield

YOUR GUIDE TO THE NIGHT SKY

ASTRONOMY 2025
AUSTRALIA

JANUARY

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Glenn Dawes Peter Northfield Ken Wallace

Quasar Publishing 2024

Dear Reader,

For the past 35 years, we have been dedicated to producing this annual astronomy almanac, writing, editing, and publishing these books has been both challenging and immensely rewarding. It has allowed us to connect with a diverse audience and share our passion for astronomy. Each edition has been a labour of love, painstakingly crafted to provide our readers with valuable and educational content for their astronomical journey. The feedback and support from our loyal readers have been invaluable, motivating us to push boundaries and strive for excellence with each new edition.

When the three of us started these yearbooks in 1990, we had no idea we would still be doing them 35 years later! In fact, for ten years, we produced two editions. From 1993 to 2002, an Eastern Australian edition and one for Western Australia, the latter produced for and distributed by the Perth Observatory. Since 2003, we have published a single edition suitable for all of Australia.

The concept of our yearbook was born in conversations around campfires in the late 1980s, often while waiting for clouds to clear. The vision was an astronomy annual with the information we wished was at our fingertips when we first got into the hobby. At the time, this data was only available from small print-run astronomical societies or professional publications. Also, in the 1980s, the Northern Hemisphere magazines were often outdated when they reached our shores and were not particularly tailored for the Southern Hemisphere.

For that first edition 35 years ago, we took a gamble and published 500 copies. It was a moderate success although we only sold half of them. It took a few years, but it slowly dawned on us that even though Quasar may never be a full-time job, it had to be more than just fun; we had to get commercially savvy. To make this book successful, it had to be attractive, with astronomical images and many illustrations to explain the complex numbers. This was very confronting for three amateurs with little publishing or graphic design experience. Also, no artistic flare, which probably still shows!

From our humble beginnings, we were selling over 17,000 per year in the early 2000s with 2025 numbers expected to be about a third of this. The majority of our readers apparently beyond our known astronomical community.

The world has changed since we published our first edition. As people increasingly turn to digital sources for information, our sales have declined. Leading to high production costs for smaller print runs. This has led us to the bittersweet decision to retire from astronomical publishing after three and a half decades. We are not walking away from the hobby; instead, the time previously spent on this book will now be used to do some practical astronomy.

Over the years, we have been fortunate to have strong support from both the professional and amateur community. The feedback and encouragement have, in part, been the driving force behind our work. Finally, we would like to acknowledge the many people (listed below) who contributed articles and images and assisted with proofreading and advice.

"May there always be starlight on the path" Robert Burnham, Jr

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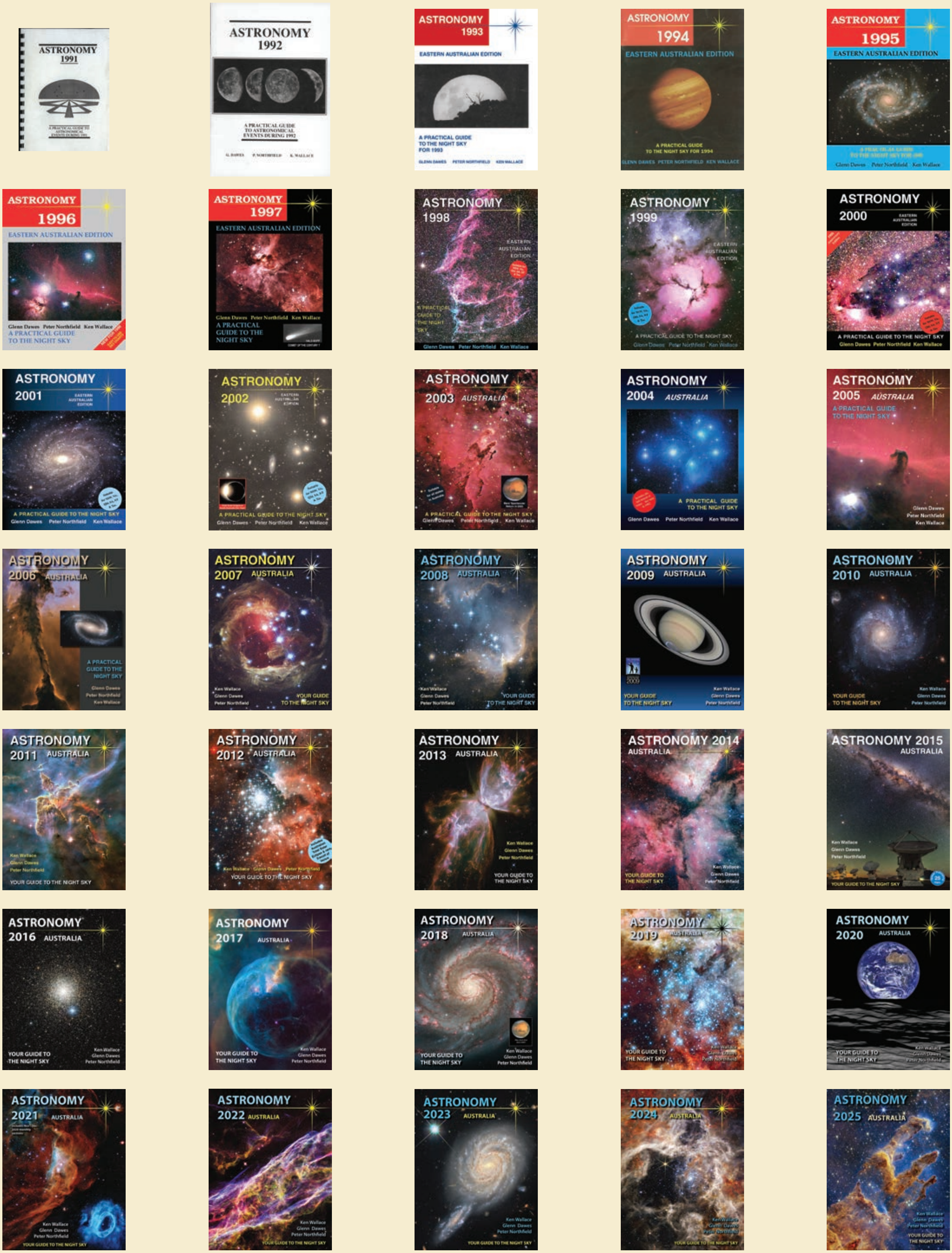
Sincerest apologies if we have missed anyone.

Our Journey



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Astronomy 2025

Part I — Monthly Guide

Part II — The Solar System

Part III — Appendices

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Surf's Up!

Just how long *is* a wavelength?

Most waves, of course, have no defined length, when we say wavelength, we are referring to the distance between the peeks (or troughs). Also, of course, we are not talking about the ocean, but the vast amount of radiation that bathes us constantly, the electromagnetic spectrum.

HISTORY

We have always been aware of visible light and radiant heat but for most of history, it was not known that these phenomena were connected or were representatives of a more extensive principle.

The ancient Greeks recognised that light travelled in straight lines and studied some of its properties, including reflection and refraction. Light was intensively studied from the beginning of the 17th century, leading to the invention of important instruments like the telescope and microscope.

Isaac Newton (1643–1727) was the first to use the term *spectrum* for the range of colours that white light could be split into with a prism. Starting in 1666, Newton showed that these colours were intrinsic to light and could be recombined into white light.

A debate arose over whether light had a wave nature or a particle nature with René Descartes (1596–1650), Robert Hooke (1635–1703) and Christiaan Huygens (1629–1695) favouring a wave description and Newton favouring a particle description. Huygens in particular had a well-developed theory from which he was able to derive the laws of reflection and refraction. Around 1801, Thomas Young (1773–1829) measured the wavelength of a light beam with his two-slit experiment thus conclusively demonstrating that light was a wave.

In 1800, William Herschel (1738–1832) discovered infrared radiation. He was studying the temperature of different colours by moving a thermometer through light split by a prism. He noticed that the highest temperature was beyond red. He theorised that this temperature change was due to *calorific rays*, a type of light ray that could not be seen.

The next year, Johann Ritter (1776–1810), working at the other end of the spectrum, noticed what he called "chemical rays" (invisible light rays that induced certain chemical reactions). These behaved similarly to visible violet light rays but were beyond them in the spectrum. They were later renamed ultraviolet radiation.

During the 1860s, James Clerk Maxwell (1831–1879) developed equations (Maxwell's Equations) for the electromagnetic field. Two of these predicted the possibility and behaviour of waves in the field. Analysing the speed of these theoretical waves, Maxwell realised that they must travel at a speed that was about the known speed of light. This startling coincidence in value led Maxwell to make the inference that light itself is a type of electromagnetic wave. Maxwell's equations predicted an infinite range of frequencies of electromagnetic waves, all travelling at the speed of light. This was the first indication of the existence of the entire electromagnetic spectrum.

Maxwell's predicted waves included waves at very low frequencies compared to infrared, which in theory might be created by oscillating charges in an ordinary electrical circuit of a certain type. Attempting to prove Maxwell's equations and detect such low frequency electromagnetic radiation, in 1886, the physicist Heinrich Hertz (1857–1894) built an apparatus to generate and detect what are now called radio waves. Hertz found the waves and was able to infer (by measuring their wavelength and multiplying it by their frequency) that they travelled at the speed of light. Hertz also demonstrated that the new radiation could be both reflected and refracted by various dielectric media, in the same manner as light. For example, Hertz was able to focus the waves using a lens made of tree resin. In a later experiment, Hertz similarly produced and measured the properties of microwaves. These new types of waves paved the way for inventions such as the wireless telegraph and the radio.

In 1895, Wilhelm Röntgen (1845–1923) noticed a new type of radiation emitted during an experiment with an evacuated tube subjected to a high voltage. He called this radiation *X-rays*.

The last portion of the electromagnetic spectrum was filled in with the discovery of gamma rays. In 1900, Paul Villard (1860–1934) was studying the radioactive emissions of radium when he identified a new type of radiation that he at first thought consisted of particles similar to known alpha and beta particles, but with the power of being far more penetrating than either. However, in 1910, British physicist William Henry Bragg (1862–1942) demonstrated that gamma rays are electromagnetic radiation, not particles, and in 1914, Ernest Rutherford (1871–1937) (who had named them gamma rays in 1903 when he realised that they were fundamentally different from charged alpha and beta particles) and Edward Andrade (1887–1971) measured their wavelengths, and found that gamma rays were similar to X-rays, but with shorter wavelengths.

WAVES OR PARTICLES

Is electromagnetic radiation a wave or particle. We know it is a wave as we can reflect and refract it. At the extremely short wavelengths of X-Rays, reflection only occurs at very shallow angles and the refraction is also very slight. Gamma rays, whose wavelength (less than 10^{-11} m) is smaller than an atomic radius (on the order of 10^{-10} m), results in them being absorbed by most surfaces so no reflection. Gamma rays however, can be refracted, albeit at an extremely small angle (about a millionth of a degree in one experiment).

This debate was rekindled in 1901 when Max Planck (1858–1947) discovered that light is absorbed only in discrete quanta, now known as photons, implying that light has a particle nature. However, at the subatomic level, it is carried by a stream of photons. The energy of a photon depends solely on its wavelength or frequency. Thus, electromagnetic radiation has both a wave and a particle nature, the wave-particle duality.

MEASURING

While this article is about wavelengths (λ), we also have two closely related factors: frequency (f) and energy (E).

Most of you probably know the formula:

Wavelength equals Velocity divided by Frequency.

For electromagnetic waves, λ is in metres, f in Hz (cycles per second) and c is the speed of light, about 3×10^8 metres per second (actual speed of light in a vacuum is now defined as exactly 299,792,458 m sec^{-1}). The energy of a single photon is given by Planck's equation. This relates the frequency of a photon to its energy through the Planck constant h.

$$h = 6.6261\times10^{-34} \text{ (J.s)}$$

The photon energy equation is:

$$E = hc/\lambda = h \times f$$

where:

- E – Energy of a photon (electron-volt, eV)
- h – Planck constant
- c – Speed of light (m sec^{-1})
- λ – Wavelength of a photon (m)
- f – Frequency of a photon (Hz)

This equation gives us the energy of a single, indivisible quanta of light, and we can think of light as a collection of particles. The energy of a single photon is a small number because the Planck constant is tiny. The energy of a single photon of green light with a wavelength of 520 nm has an energy of 2.38 eV.

While each of the three units (wavelength, frequency and energy) are interchangeable, there are common usages. Radio astronomy tends to use frequency, infrared and ultraviolet use wavelength and X-ray and gamma ray use energy.

SPECTROSCOPY

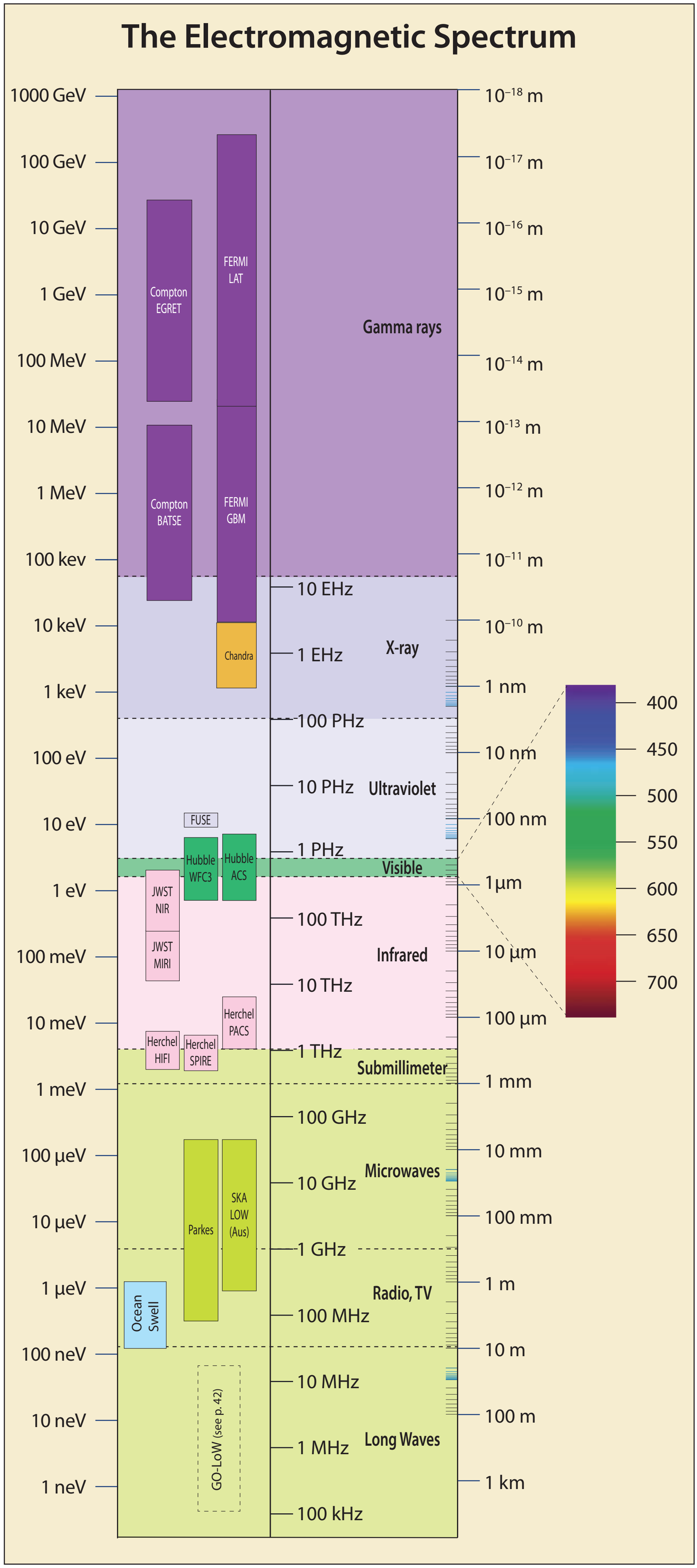
Many astronomical observations are actually made using a spectrometer. It involves splitting the electromagnetic radiation into its component wavelengths (a spectrum), much the same way as a prism splits light into a rainbow of colours. Spectroscopy is the study of the absorption and emission of light and other radiation by matter and has been crucial in the development of the most fundamental theories in physics.

RED SHIFT

Our Universe is expanding so objects we observe in the sky are receding from us, the further away, the faster they appear to be travelling. The Doppler effect causes the sound of an object receding from us to be at a lower pitch. Similarly, the frequency of light from a receding object is lowered, leading its spectrum to be shifted towards the red, thus the term Red Shift. By measuring how far the emission and absorption lines have moved, we can determine how far away the object is (see diagram p. 8).

RADIO

In 1932 Karl Jansky (1905–1950), an engineer for Bell Laboratories, was investigating a problem involving noisy static interfering with short-wave radio communications. He built a directional antenna designed to receive radio waves at a frequency of 20.5 MHz (wavelength about 14.6 metres). It had a diameter of approximately 30 m and stood 6 m tall. It was mounted on top of a turntable which could be



rotated in azimuth, allowing the direction of the signal to be determined, but only a rough altitude.

Having found a source, he noticed that the direction of the signal changed nearly 360° in 24 hours and, at the time was approximately the azimuth of the Sun, leading him to think that the source was somehow associated with the Sun.

After a few months of following the signal, however, the point of maximum static moved away from the position of the Sun. Jansky also found that the signal repeated on a cycle of 23 hours and 56 minutes. He discussed this with his friend, astrophysicist Albert Melvin Skellett (1901–1991), who pointed out that this was the length of a sidereal day. By comparing his observations with optical astronomical maps, Jansky concluded that the radiation was coming from the Milky Way and was strongest in the direction of the centre of the galaxy, in Sagittarius.

Jansky had discovered something at the heart of the Milky Way galaxy. His work led to one of the most important papers in the history of astronomy in the 20th century, called "Radio Waves from Outside the Solar System", published in 1933. His work laid the foundation for the science of radio astronomy.

In 1936, an amateur astronomer named Grote Reber (1911–2002) built a radio telescope in his backyard. His was the first telescope ever built specifically to receive radio waves from the sky. Over the next several years, he pointed his telescope all over the sky, and discovered many new sources of radio waves. One of the sources he found, Cygnus A, would prove to change the course of modern astronomy.

Fifteen years later, in 1951, astronomers Walter Baade (1893–1960) and Rudolph Minkowski (1895–1976) found the object that created Cygnus A's radio emissions. They used the 200-inch visible-light telescope on Mount Palomar in California to find an unusual-looking galaxy. But when they looked at the spectrum of the galaxy, they found an even greater surprise.

Cygnus A turned out to be a galaxy with a redshift of 0.057. This redshift measurement put it over 700 million light-years from Earth, the most distant object yet observed. For Reber to detect its radio source from that distance, Cygnus A had to be the most intense radio source ever seen.

As the years progressed, astronomers found more radio sources that corresponded to distant galaxies. Eventually, they started to find radio sources that appeared to correspond to stars! Stars are not a strong source of radio waves, so astronomers knew they were seeing something very unusual.

Since then, we have the discovery of synchrotron radiation, quasars, pulsars, molecules and molecular clouds, the cosmic microwave background, gravitational lenses, and more.

INFRARED

While infrared (IR) astronomy began in the 1830s, a few decades after the discovery by Herschel, it was not until the early 20th century that conclusive detections of astronomical objects other than the Sun and Moon were made in infrared light. After a number of discoveries were made in the 1950s and 1960s in radio astronomy, astronomers realised the information available outside the visible wavelength range, and modern infrared astronomy was born.

A big issue with infrared is absorption by water vapour in the atmosphere. While the amount varies depending on the wavelength and location on Earth, you need to observe from as high an elevation as possible, one of the highest is Mauna Kea Observatory in Hawaii at about 4,200 metres above sea level, where infrared observations were done in the 1970s. Other mountain locations are at La Palma and Tenerife in the Canary Islands at about 2,400 m and The Atacama region of Chile, also at 2,400 metres, the latter of which also has one of the driest locations on the planet. IR astronomy there was first done in the 1990s.

Of course, you can get higher if you put a telescope in an aeroplane. NASA's Kuiper Airborne Observatory (1974–1995) and its successor, SOFIA (2010–2022) could observe from in excess of 13,000 metres. While these are better conditions for observing, there are limits on the size of the mirror (0.9 m in KAO and 2.5 m in SOFIA) whereas on the ground, you can go much larger, compensating for lack of altitude. See Mirror Size Comparison (p. 48) for some examples of big mirrors.

The highest ground based telescope is the Japanese University of Tokyo Atacama Observatory, at 5,640 metres above sea level. Of course, we can remove the effect of the atmosphere completely by putting telescopes in space. The first infrared capable satellite was IRAS in 1983, followed by several more, the most recent of which is the James Webb Space Telescope.

ULTRAVIOLET

Ultraviolet astronomy is the observation of wavelengths between approximately 10 and 320 nanometres. These wavelengths on Earth, which are largely from our Sun, are almost completely absorbed by our atmosphere. Apart from some early rocket based observations, UV astronomy started with orbiting satellites in the 1960s.

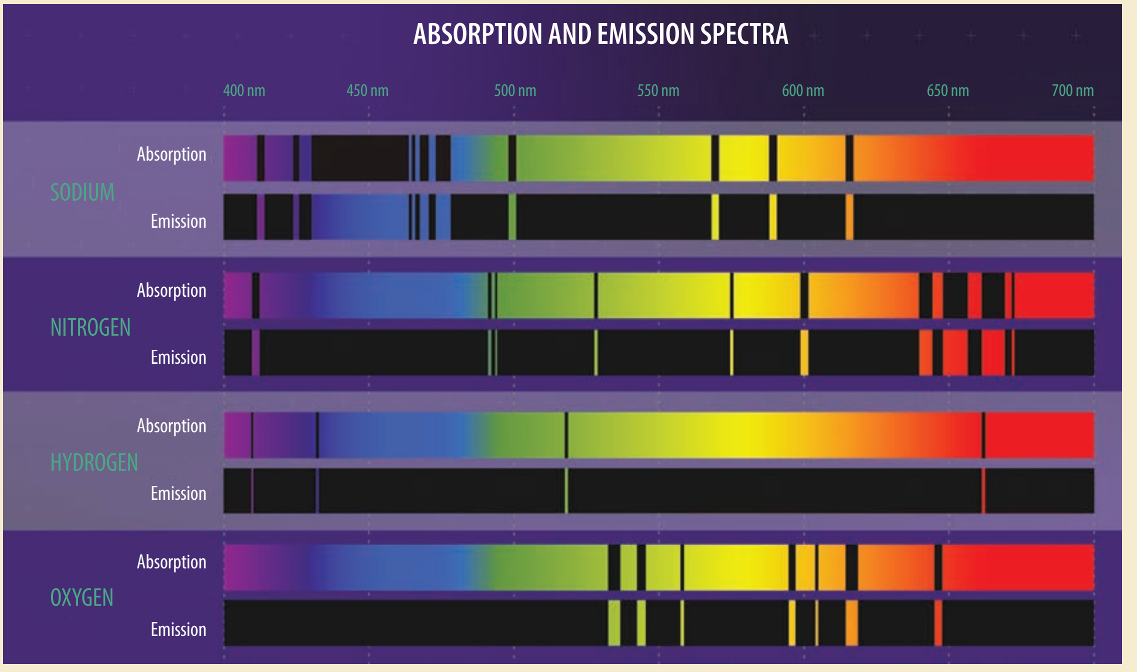
Ultraviolet spectroscopy is used to identify the chemical composition, densities, and temperatures of the interstellar medium, and the temperature and composition of hot young stars. UV observations can also provide essential information about the evolution of galaxies. They can be used to discern the presence of a hot white dwarf or main sequence companion in orbit around a cooler star.

Most stars are relatively cool objects, emitting much of their electromagnetic radiation in the visible or near-infrared part of the spectrum. UV is seen in hotter objects, typically in the early and late stages of their evolution.

Space-based solar observatories such as SDO and SOHO use ultraviolet telescopes (called AIA and EIT, respectively) to view activity on the Sun and its corona. The Hubble Space Telescope and FUSE have been the most recent major space telescopes to view the near and far UV spectrum of the sky.

X-RAYS and GAMMA RAYS

The higher energy end of the spectrum, with the exception of some brief observation with high altitude balloons or sounding rockets, is the purview of space based instruments. Most of these have a very narrow field of view so they are accompanied by a different type of sensor that can detect the energy over a wider field, the telescope can then slew to those coordinates for more detailed observations. As the phenomena are frequently brief in nature, this is done by the satellite itself. In addition, they will frequently notify ground support



Absorption Spectra: When light passes through a gas, atoms and molecules in the gas absorb certain colours, or wavelengths, of that light. The result is an absorption spectrum: a rainbow with dark absorption lines.

Emission Spectra: The same gas can glow, giving off very specific colours to form an emission spectrum with bright lines known as emission lines.

Every element has a unique set of absorption and emission lines. The pattern of lines is known as a spectral signature. The absorption and emission spectra of each element are inverses of each other. The wavelengths of a particular element's absorption lines are the same as the wavelengths of its emission lines. Astronomers can compare the spectrum of a celestial object or material with the spectra of known elements and molecules to figure out what the object or material is made of. Credit: NASA, ESA, Leah Hustak (STScI)

so same time observations can be done by other Earth based instruments in other parts of the spectrum.

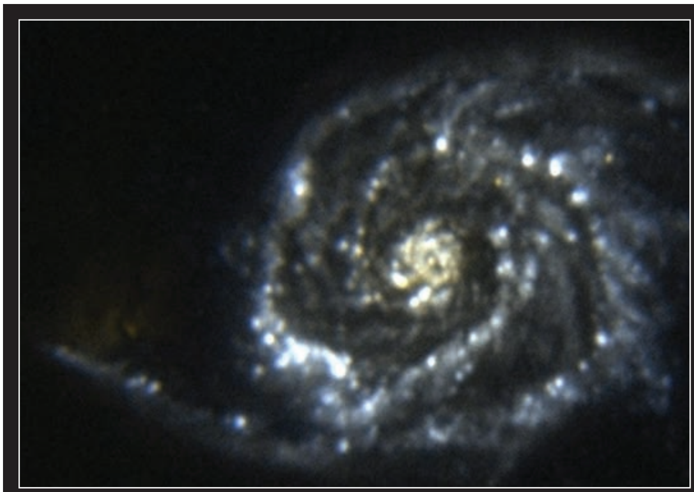
X-rays allow us to observe supernova remnants, hot gases in galaxy clusters, black holes, and neutron stars. Galaxy clusters are the largest structures in the Universe, and studying their evolution is essential to grasping the entire historical picture.

Studying gamma rays provides valuable insights into extreme astrophysical environments, as observed by the H.E.S.S. Observatory. Ongoing research aims to expand our understanding of gamma-ray sources, such as blazars, and their implications for cosmology. As GeV gamma rays are important in the study of extra-solar, and especially extragalactic astronomy, new observations may complicate some prior models and findings.

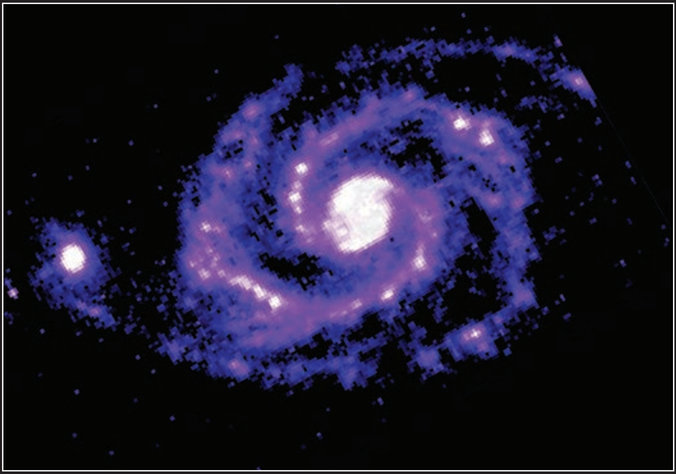
MULTIPLE SPECTRUM

Of course, many objects in the Universe emit at multiple wavelengths and it's often useful to combine different observations. Lower right is a composite image of M51, a majestic spiral galaxy. Chandra finds point-like X-ray sources (purple) that are black holes and neutron stars in binary star systems, along with a diffuse glow of hot gas. Data from Hubble (green) and Spitzer (red) both highlight long lanes of stars and gas laced with dust.

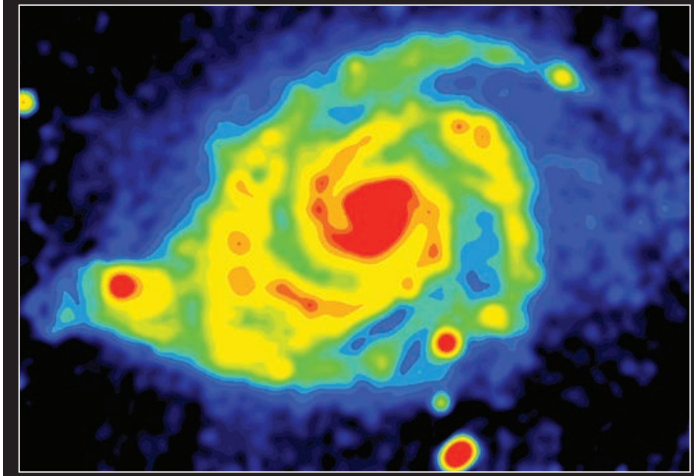
Left, M51 taken with the NOAO Mosaic CCD camera on the National Science Foundation's 0.9-meter telescope located at Kitt Peak National Observatory (Credit: NOAO/AURA/NSF/T.A.Rector & M.Ramirez).



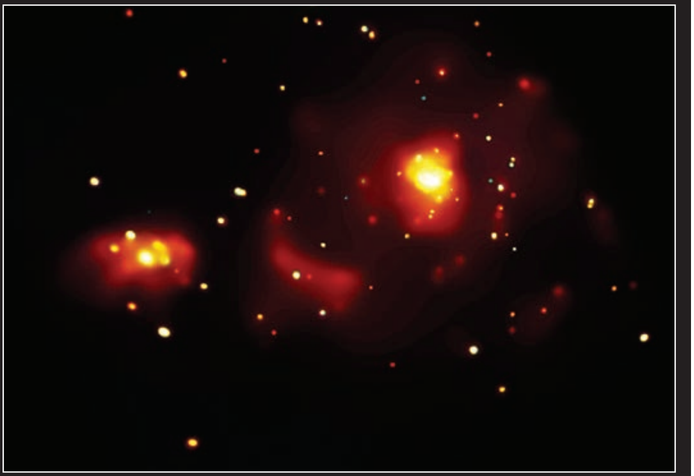
GALEX Ultraviolet Image of M51, credit: NASA/JPL-Caltech



Infrared image from ESA's Infrared Space Observatory (ISO) Credit: ESA/ISO, CAM, M.Sauvage et al



VLA image of M51 at radio wavelengths, credit: NRAO/AUI/NSF



Chandra X-Ray image of M51 Credit: NASA/CXC/UMd./A.Wilson et al

(Credit: X-ray: NASA/CXC/Wesleyan Univ./R.Kilgard et al; UV: NASA/JPL-Caltech; Optical: NASA/ESA/S. Beckwith & Hubble Heritage Team (STScI/AURA); IR: NASA/JPL-Caltech/Univ. of AZ/R. Kennicutt)

Telescope	Instrument	From	To
Compton Gamma Ray Observatory (Compton)	Burst and Transient Source Experiment (BATSE)	25 keV	10 MeV
	Energetic Gamma Ray Experiment Telescope (EGRET)	20 MeV	30 GeV
Fermi Gamma-ray Space Telescope (Fermi)	Large Area Telescope (LAT)	20 MeV	300 GeV
	Gamma-ray Burst Monitor (GBM)	10 keV	25 MeV
Chandra X-ray Observatory (Chandra)	Advanced Charged Couple Imaging Spectrometer (ACIS)	0.2 keV	10 keV
	High Resolution Camera (HRC)	0.1 keV	10 keV
	High Energy Transmission Grating (HETG)	0.4 keV	10 keV
	Low Energy Transmission Grating (LETG)	0.1 keV	3 keV
Neil Gehrels Swift Observatory (SWIFT)	Burst Alert Telescope (BAT)	15 keV	150 keV
	X-ray Telescope (XRT)	0.2 keV	10 keV
	Ultraviolet/Optical Telescope (UVOT)	170 nm	650 nm
Far Ultraviolet Spectroscopic Explorer (FUSE)	FUSE spectrograph (FUSE)	90.5 nm	119.5 nm
Euclid Telescope (Euclid)	Visible instrument (VIS)	550 nm	900 nm
	Near-Infrared Spectrometer and Photometer (NISP)	900 nm	2000 nm
Hubble Space Telescope (HST)	Wide Field Camera 3 (WFC3)	200 nm	1.7 µm
	Advanced Camera for Surveys (ACS)	170 nm	1.1 µm
GAIA	Photometric Instrument (BP/RP)	330 nm	1050 nm
	Radial-Velocity Spectrometer (RVS)	845 nm	872 nm
James Webb Space Telescope (WEBB)	Near-Infrared Camera (NIRCam)	0.6 µm	5.0 µm
	Near-Infrared Spectrograph (NIRSpec)	0.6 µm	5.0 µm
	Mid-Infrared Imager (MIRI)	4.9 µm	27.9 µm
Wide-Field Infrared Survey Explorer (WISE)		3 µm	25 µm
Spitzer Space Telescope (Spitzer)	Infrared Array Camera (IRAC)	3.6 µm	8.0 µm
	Infrared Spectrograph (IRS)	5.0 µm	40.0 µm
Stratospheric Observatory for Infrared Astronomy (SOFIA)	Multiband Imaging Photometer (MIPS)	24 µm	160 µm
	High-resolution Airborne Wideband Camera Plus (HAWC+)	50 µm	240 µm
Herschel Space Observatory (Herschel)	Photodetector Array Camera and Spectrometer (PACS)	51 µm	220 µm
	Heterodyne Instrument for the Far Infrared (HIFI)	157 µm	625 µm
	Spectral and Photometric Imaging Receiver (SPIRE)	194 µm	671 µm
Parkes Radio Telescope (Parkes)		75 MHz	43 GHz
Square Kilometre Array, Australia	SKA-LOW — Australia	50 MHz	350 MHz
Square Kilometre Array, South Africa	SKA-MID — South Africa	350 MHz	24 GHz
Great Observatory for Long Wavelengths (GO-LoW)	Possible future observatory (see p. 42)	100 kHz	15 MHz

Selected observatories and instruments and the area of the EM spectrum they cover. Note that most do not cover all of the range indicated but a series of bands within.

NAKED-EYE STARGAZING

A Fun Pastime for Beginners

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

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

As a general guide to using this book, when we refer to observing in a particular time of the year, e.g. summer, we are talking about the appearance of the evening sky, the most convenient time to look. In reality most of the night sky is available any night (especially in winter), provided you are willing to stay up until dawn. Playing with a planisphere illustrates this quite well. An example is shown on page 15.

The Attraction of Dark Skies

Observing with the naked eye from the Southern Hemisphere offers much more than northern astronomers had before the invention of the telescope. This is especially the case if you head into the country to escape the bright urban skies on a moonless night. The ancients were very much stuck in mid-latitude Northern Hemisphere locations, with all of the earliest recorded observations coming from Europe, England, the Middle East or Asia. These locations see the bright centre of the Milky Way low in the south in summer, whereas from Australia it passes directly overhead in our autumn and winter evening skies. This is also the time of the year when the long nights give us *down under* more time to spend soaking up this panorama. The structure of the Milky Way is more appreciated by the wide-angle views available to the unaided eye. With us immersed in the flattened, circular disc of our galaxy we see it edge-on, hence the *river* that flows across the sky. The

A FEW TIPS FOR BEGINNERS

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

Compass Bearings. One way to learn the night sky is to start with the more obvious constellations. These stand out well on planispheres, having the main compass bearings marked around the horizon, but how do you relate this to your actual horizon? There are free compass apps available, so just point your phone. Also, taking note of where the Sun sets to get a rough direction for west might help. Remember, shadows point south at midday. Other useful resources are maps or street directories, which are conveniently drawn with north towards the top of the page.

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

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

Sun is around halfway out from the galactic centre, which lies roughly in the direction of the spout star of Sagittarius' Teapot (see All Sky Map No. 6 or 8). Looking with just the eyes two things become apparent. First, how wide this central *milky* area (called the hub) appears with our galaxy tapering and fading out as you follow it towards the opposite end of the sky, around Orion (which is setting early in autumn evenings). Second, the numerous dark lanes that crisscross the Milky Way in this hub. Both aspects are ideal for naked-eye observers. There are other impressive regions in our galaxy quite attractive to the unaided eye such as the number of bright star clouds and clusters also around the centre. Another is the brilliant section from the Southern Cross around to the star-rich Carina nebulae region, which contrasts well with the adjacent dark Coalsack Nebula (All Sky Map No. 1).

Leaving winter and our galaxy, the Southern Hemisphere summer evenings offer a view of other galaxies that belong to our local group. For example, the unique Magellanic Clouds. These are smaller galaxies passing nearby, which appear like detached portions of the Milky Way. They are easy to spot under dark skies, as normal clouds look black whereas the Large and Small Magellanic Clouds (LMC and SMC) appear white from the accumulated effect of countless stars (like the *milkiness* of our galaxy). Even the unaided eye can see the prominent bar in the LMC (see All Sky Map No. 1).

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

Dark skies also offer the opportunity to try and see the planet Uranus with the unaided eye (not easy). All Sky Map 3 and finder chart (p. 129) will help find this elusive distant member of the Solar System. Try around the time of opposition (in November) when it is slightly brighter than normal. Also, this year, the minor planet 4 Vesta, when at opposition in May, can brighten sufficiently to be just visible with the naked eye (mag 5.8) in dark skies (see All Sky Map 6).

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

Try looking for meteors or shooting stars. These streaks or fireballs occur when particles burn up in the Earth's atmosphere. Most range from about the size of a grain of sand up to a few millimetres (pea size) and are called meteoroids when in space. Those that survive to hit the ground are called meteorites. Around a half dozen meteors per hour can be seen under dark skies, with a tendency for more after midnight. These are the sporadics. Meteors also occur in annual *showers*. This happens when a sudden increase in number are seen around the same time each year as the Earth passes through or near ancient debris trails left by passing comets. Part I discusses the favourable ones visible this year; also see the introduction on page 16 and a list of showers on page 135.

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. 11). 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

DISTANCES ARE TRULY ASTRONOMICAL

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

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

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

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

The distance to:

- The Moon, a little over 1 light second.
- The Sun a little over 8 light minutes.
- Average distance to Neptune from the Sun, about 4 light hours (this encloses all the currently accepted planets).
- The nearest star, the Alpha Centauri system, just over 4 light-years (ly).
- The brightest star, Sirius 8.6 ly
- Two nearby open star clusters, the Hyades (the face of Taurus the Bull) about 150 ly and the Pleiades is 430 ly.
- Two of the closest globular clusters, M4 in Scorpius is 6,800 ly and NGC 6397 in Pavo is 7,500 ly
- The centre of the Milky Way around 25,000 ly (our galaxy's main disc is around 120,000 ly across)
- The Magellanic Clouds, Large (LMC) is 165,000 ly and Small (SMC) is 200,000 ly.
- The most distant object easily visible to the naked eye, the Andromeda Galaxy 2,500,000 ly!

and Saturn. The retrograde loops of the outer planets can be fascinating to follow over a number of months. It makes you appreciate why they were originally called *aster planetes* (from the Greek meaning wandering star) as they continued to disturb the otherwise reliable fixed heavenly pattern.

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

When two celestial bodies appear visually close together it's called a conjunction. They can be quite attractive, especially those involving the brightest planets. Those between the thin crescent Moon and Venus or Jupiter are spectacular. An example this year is the meeting of the Moon and Venus on January 5 and between the Moon, Venus and Jupiter on August 20 (see Sky Views, pages 25 and 60).

Although not covered in the book, it's also fun looking for Earth-orbiting satellites. Remember these don't generate any light themselves, they reflect sunlight to be visible. Search for low orbiting satellites up to three hours after sunset or before sunrise where they can still *see* the Sun. Look for those that slowly appear or disappear for no obvious reason, they have likely moved out of, or into, the Earth's shadow. For evening events the shadow rises slowly from the eastern horizon and for mornings drops slowly in the west. Current examples include the International Space Station (ISS), the Tiangong space station and the Hubble Space Telescope (HST). The Heavens Above website (www.heavens-above.com) can generate predictions for visibility of these and other satellites for your location. There are also Apps for tablets and smart phones that do the same.

A WORD ABOUT BINOCULARS

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

For the novice, finding your way around the sky is far easier with binoculars than with a telescope. Using a telescope is a bit like looking at the sky through a straw and the view is usually upside down and sometimes mirror-imaged! Even when using low power in a typical amateur telescope, the field of view is only about one degree (maximum). A pair of 7 × 50

BINOCULARS have a multitude of uses in amateur astronomy. These include:

- Helping to find stars and planets in a bright twilight sky.
- Looking at the maria (seas), larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views, All Sky Maps and finder charts in this publication
- Binoculars can help in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Contrast the yellow of Alpha (α) Centauri with the blue of Beta (β) Centauri.
- Looking for stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky. You might find them with the naked eye, but binoculars will help; sometimes they vary in brightness as the Sun reflects off different surfaces. You can follow them further into the Earth's shadow before they disappear.
- Searching out Uranus and Neptune, using the finder charts, see pages 129 and 130 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 118 to 123. 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-like object has moved. Taking the coordinates of a minor planet from Part II, and plotting that position on the All Sky Maps, will help you find the correct area.
- Monitoring the change in magnitude of some of the brighter variable stars. There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society (p. 140) or organisations such as Variable Stars South www.variablestarssouth.org or AAVSO www.aavso.org.

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

binoculars can give a field about seven degrees in diameter (roughly the size of the Southern Cross), or if you like, 40 to 50 times the area visible through a small telescope. It is not unusual for the general public to ask when looking through a telescope, "where in the sky is that?" Looking at the star field doesn't make the location obvious. Having a larger field will help with knowing where you are looking. The field size in degrees is normally marked on the binoculars. To get a feel for how that translates to the sky, look at the Sky View diagrams. Each has a 10° scale marked on it.

Even with binoculars, you still need to practice pointing the instrument. There is a tendency to look too low, so if you don't see what you are after, the first thing to try is to tilt the binoculars up. One method that may help is to find an obvious nearby bright star, or better still, a bright star pattern (called an asterism) and star-hop across. If your object isn't too high in the sky, you can try finding something on the horizon directly under it, like a distinctive tree outline, and move the binoculars up. Another method, that might take a little getting used to, is to stare intently at the area of the sky with your unaided eyes and then move the binoculars into place without moving your eyes. Practice on bright stars first until you are comfortable. Talking of comfort, plan your observing, as it can be very difficult to look directly overhead, especially if the binoculars are mounted on a tripod. This is where sitting back in a reclining chair and hand-holding the binoculars makes it easier. If your seat doesn't recline, try leaning the tripod on two legs or use a monopod.

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

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

USING THIS BOOK

One purpose of this book is to help you plan your nights under the stars. Think of it as offering a number of pieces of a picture, the nature of which will vary greatly depending on whether you are using binoculars, a telescope or just your eyes. Such an exercise can be fun, so let's go! Each section of the book also has its own introductory pages.

The Moon. Knowing the phase of the Moon is a good place to start. The calendar (p. 1) gives an overview for the year. Unless you wish to view our natural satellite, or just the planets, New Moon is favoured by most observers, preferring long nights with their skies as dark as possible. Up to First Quarter the morning sky is Moon-free, as are evenings after Last Quarter. The Rise–Set chart on the first page of each monthly section, helps further define the 'Moon observing' and 'dark' windows. More specific times, on a day-by-day basis for each of the Australian capitals, are presented in Part II.

Observing the Moon (pp. 110–113). Viewing on or near the terminator, the sunrise/sunset line on the Moon, makes our satellite come alive as the crater walls and mountains cast shadows across the surface. Lunar observers love the daily change with something different offered every night. This section helps identify the features on the terminator as the Moon waxes and wanes. Possibly the most unpopular time is Full Moon which presents an overly bright, flat and dull picture which is not only a poor time to observe the Moon, but it lights up the sky for the whole night, drowning out any nebulous objects including the most attractive galaxy of all, the Milky Way!

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

The Planets. Mercury, Venus, Mars, Jupiter and Saturn are naked-eye objects. Uranus can be challenging, and Neptune requires at least binoculars. To get a quick overview of what is on offer, start with the Visibility of the Planets (p. 19). For example, looking at April we have Mercury, Venus, Neptune and Saturn in the morning sky, while Mars, Uranus and Jupiter are in the evening sky. You will notice that Neptune and Saturn cross the midnight line in September, so both planets are close to opposition and up most of the night. The Rise–Set chart for September confirms this. Mercury crosses the Sun line in late May, showing it moving from the morning into the evening.

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

It is fascinating to watch **Mercury** as it quickly zips around the Sun. When this innermost planet is at superior conjunction, behind the Sun and out of sight (e.g. Feb 9) 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 March 25. Mercury then enters the morning sky with a thin sliver phase and the process reverses until superior conjunction is reached again (May 30). 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 in late October when near a greatest elongation east (Sky View page 69).

Its fellow inner world **Venus** goes through the same process as Mercury but much slower, being further from the Sun. In 2025, following an inferior conjunction in late March, it begins rising in the morning sky, which continues until it reaches greatest elongation west in June, when it then begins to drop back to Sol towards a superior conjunction in early January 2026. All this time it reduces in size with its phase increasing. 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 markings are easier to see. It reaches opposition on January 16 with its disc around 15 arcseconds (") in diameter (magnitude −1.4). The Red Planet will then shrink to about 4 arcseconds (magnitude 1.2) by year's end, as it heads towards conjunction on January 10, 2026. See also opposition of Mars in Part II.

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. Since oppositions occur roughly once every 13 months, 2025 will be without one (last Dec 8, 2024, next Jan 11, 2026) making January and December 2025 the best times. The Rise–Set charts (pages 20 and 76) confirm this, as does the Visibility of the Planets, page 19). Besides observing its atmospheric belts, the Great Red Spot (GRS) is worth looking for; see the table and explanation on pages 124–25. An example is the evening of January 13 at 10:03 pm (EST) or 11:03 pm including daylight saving. This transit is visible from anywhere in Australia (indicated by *).

Pages 117–23 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 in the late evening of January 8, the diagram on page 118 shows this well. In this case there is also a drawing on page 25. The wiggly diagrams also show instances where a moon's line crosses over (a transit) or behind (an occultation) the Jupiter lines. An example explains this well. On the evening of March 24 there is an occultation of Europa followed by an occultation of Io (both moons passing behind Jupiter), leaving only two moons visible for just over a couple of hours.

Saturn, with its impressive ring system (being edge-on 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 126 and 127 show a worked example of how to identify their configuration for your date and time. There are also Sky Views in September and October giving illustrations of some actual configurations. The worked example for September 22 is also graphically presented on page 64.

Uranus and **Neptune** (pp. 129 and 130 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 131–34. These can be plotted on the All Sky Maps. As an example, we'll look at minor planet 2 Pallas on its opposition date. The August monthly text (p. 58) has the minor planet reaching opposition on the 8^{th} at magnitude 9.5 in Delphinus. Page 136 tells you Delphinus is on All Sky Maps No 8 and 9. The ephemerides (p. 134) when plotted on Map 9 (interpolating between the positions given for the 2^{nd} and 9^{th}) gives the location on this date about 1° west of the star Beta (β) Delphinus.

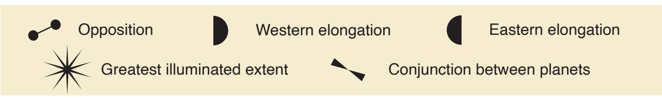
Let's assume it's the evening of December 24 and, while waiting for Santa, you wish to find Comet 24P/Schaumasse. Part I text (page 77) says the comet is rising around midnight, which is confirmed by the comet's ephemerides on page 133 (interpolating between Dec 20 and 27), which also confirms 24P/ is near maximum brightness, possibly around 8^{th} magnitude. A big bonus having to wait until the morning is that the Moon will have gone by then. The rise/set graph on page 76 confirms this and, being between New Moon and First Quarter, the Moon sets before midnight. Also, from the monthly text (p. 77) the comet must be approaching the Virgo/Coma Cluster of Galaxies, having crossed from Leo into Coma Berenices. The constellation listing on page 136 shows both constellations as being on All Sky Maps 5 and 7. Fortunately the positions for Dec 20 and 27 are already shown for the comet (otherwise its positions can still be plotted, like we did for 2 Pallas, above). The maps show Schaumasse to be approximately 1° north of the galaxy M98.

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

THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

Rise–Set Chart



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

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

Highlights

This lists a few interesting events during the month.

The Moon

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

Lunar Libration

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

Lunar Libration is a complicated mix of three different effects, with two being significant. Firstly, the Moon suffers from a longitudinal wobble; as the Moon approaches perigee its motion through space speeds up, faster than its rotation, and so it does not turn quickly enough to maintain the same face to us, giving us a view around its eastern limb. Then as the Moon moves slower, approaching apogee, it turns a little too much to keep facing us, giving a view beyond the western limb. The second type of libration is a latitudinal nod and is caused by the slight tilt of the Moon's axis. We can see a little over the south pole during one half of each revolution with the north pole hidden; during the other half of its orbit we see over the northern limb while the south pole is hidden from view.

Appearance of the Planets

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

The Planets

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

Dwarf Planets and Small Solar System Bodies

Dwarf Planets. This only deals with Ceres, which is far brighter than other dwarf planets.

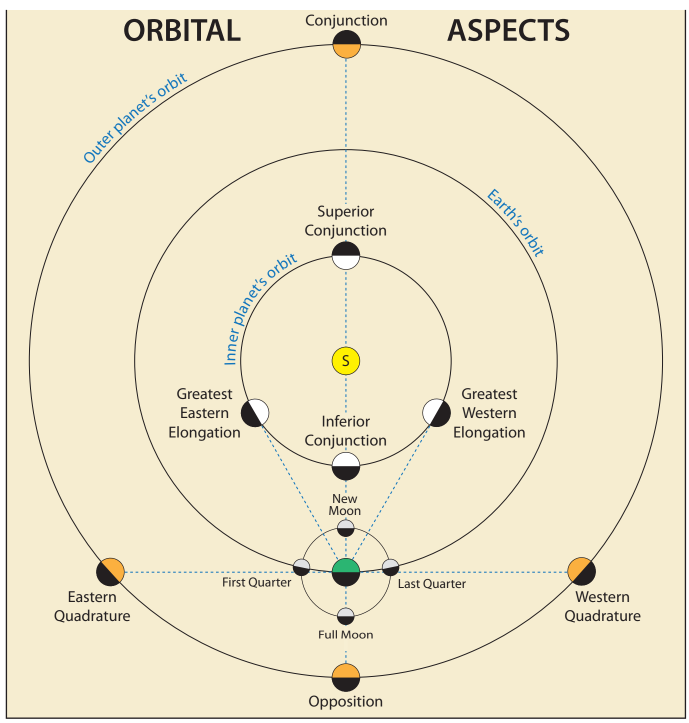
Minor Planets (or Asteroids) This covers the brightest asteroids that reach opposition each month (13th magnitude or brighter). An entry includes the date of opposition (when near brightest), its magnitude and the constellation the asteroid is in at this time. The 15 brightest dwarf and minor planets have ephemerides included in Part II (p. 134). 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 131 to 133 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. 135). It is best to do your searching on moonless nights, away from light polluted cities. In general, more meteors are seen after midnight.

Constellations

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

Feature Articles

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

Diary

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

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

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

Abbreviations. These include:

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

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

Time. When times are given, both EST and WST are presented. Times are rounded to the nearest hour. We don't include a separate entry for CST as there is only a 30 minute difference from EST. The remaining entries are less time sensitive and either have no time (that is the closest day) or a pm or am designation for an evening or morning event respectively. For timed events that occur in the very early hours (before 2 am) for EST, the WST conversion (subtracting two hours) takes them into the previous day and are shown as 'prev day'.

Sky Views

These diagrams are designed to help you find the naked-eye planets. The date and time chosen give the most interesting patterns of the planets and Moon. Occasionally the times

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 only deals with Ceres. Incidentally Ceres was considered to be a planet until it was demoted to a minor planet back in the 19th century, and now considered a dwarf planet.

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 −4.8 magnitude, the Full Moon, −12 magnitude.

Waxing, waning, gibbous and crescent. The Moon is considered waxing between New and Full, after this time it is said to be waning. The phase of a planet or the Moon is gibbous when more than fifty percent, but less that one hundred percent of it is illuminated. For example, aside from Full Moon, the Moon is gibbous between First and Last Quarter.

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

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

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

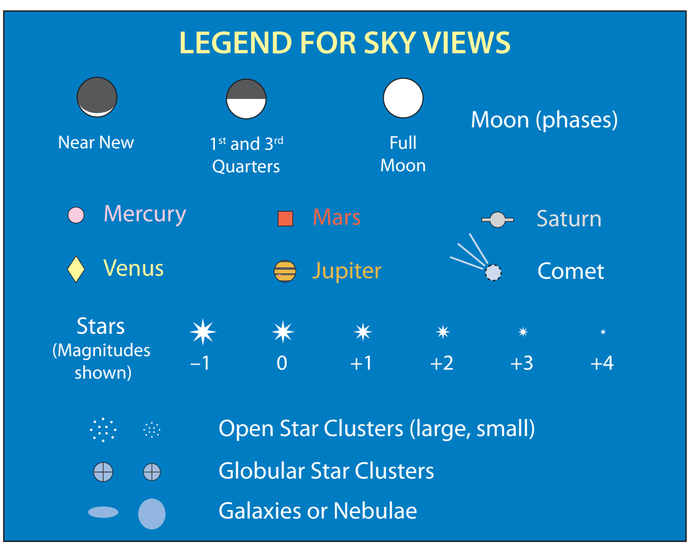
correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although this is twilight, it is sometimes necessary to catch a glimpse of the planets when close to the Sun. This is especially needed for Mercury as it never wanders more than 28° from our star. Sky Views which show a twilight view after sunset are called Evening Twilight and morning twilights are Dawn Sky. Those before midnight are Evening Sky and after midnight, Morning Sky.

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

- The Moon (approximate phase) and planets visible to the naked eye.
- All stars down to 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies. A prefix of N means the object is in the New General Catalogue (NGC), an I is an object in the Index Catalogue (IC) and M is an entry in the Messier Catalogue.
- Constellations are labelled (capital letters) and have black lines joining key stars to show the constellation's recognisable star pattern.

Saturn and Jupiter Satellites. Both planets have diagrams for months close to their opposition (Saturn in September and October, Jupiter in January and December in 2025). Only the brightest moons are included. There are key differences between these planets worth keeping in mind.

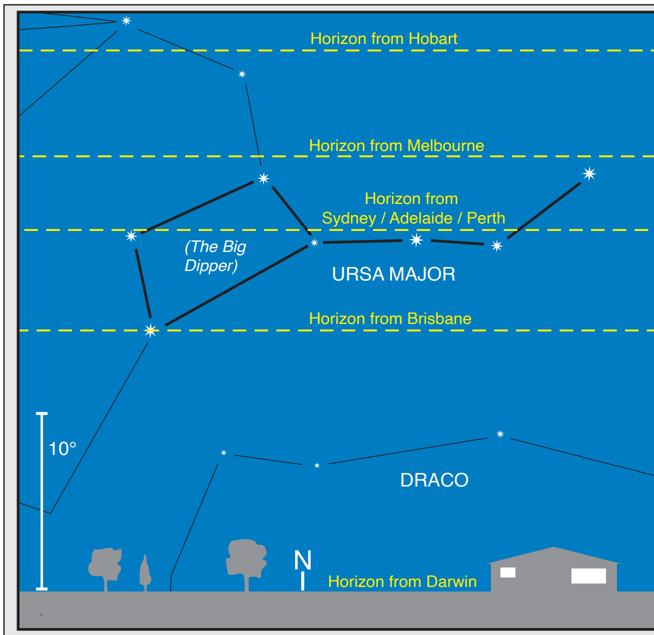
The plane of the orbits of Jupiter's moons is close to the Earth's orbital plane, so we see them shuttle back and forth in straightish lines, passing in front of and behind the planet and even in and out of its shadow. Of the bright four Galilean moons, the most distant satellite, Callisto is the exception which spends several years passing over or under Jupiter's disc, however this year, it will have events from May onwards. Saturn's moons orbit in the plane of the rings. As the rings spend most of the time inclined to our line of sight (hence our brilliant view), so the orbits of the satellites are ellipses appearing to pass below, then half an orbit later above the rings. The further out the satellite is, the larger the ellipse will be. Saturn's moons are considerably fainter than Jupiter's Galilean satellites with Titan the only standout. The inner ones are swamped by the glow of the nearby rings, making them hard to see.



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

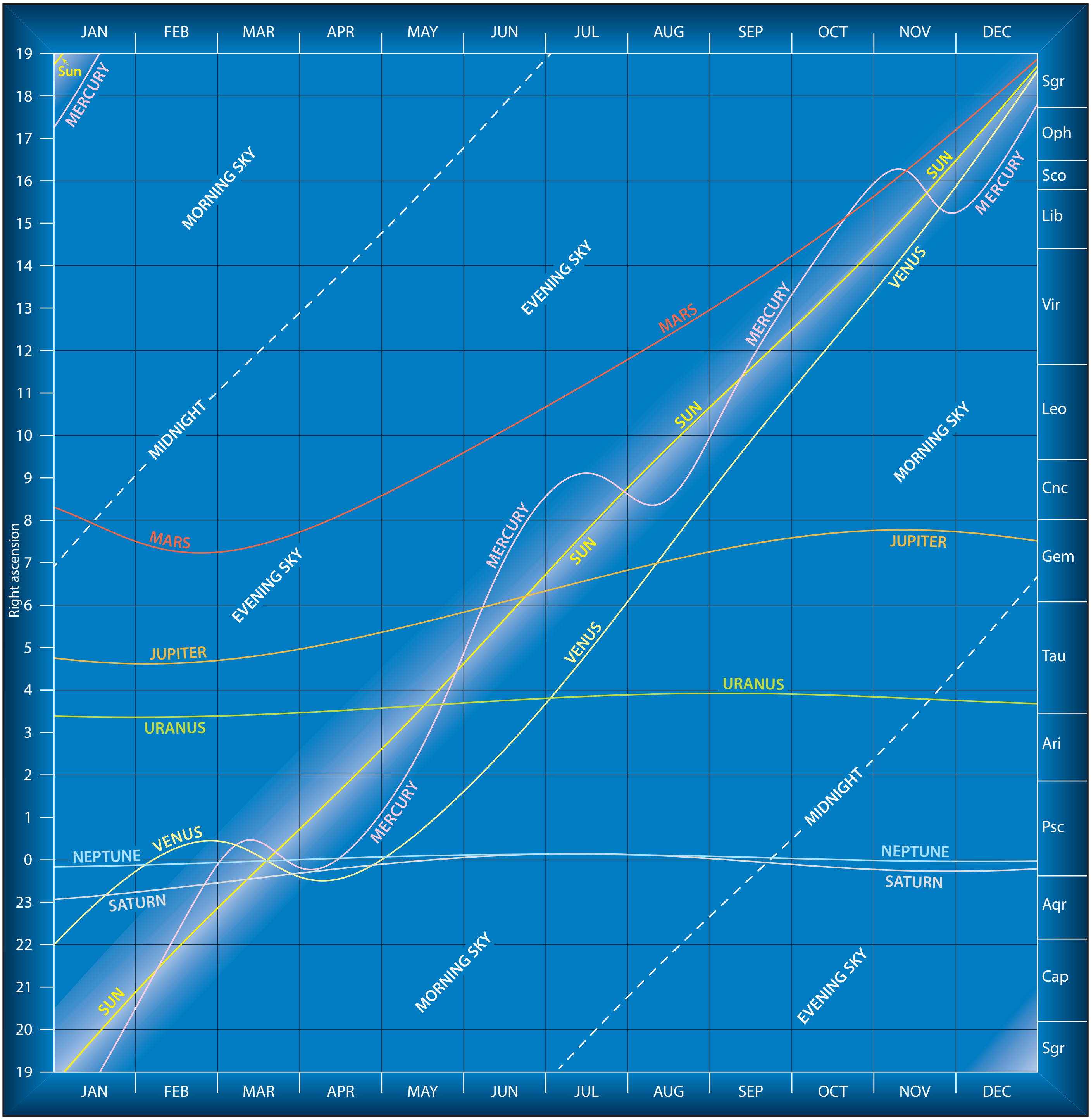
When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST); the mean solar time on the meridians of longitude 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from EST times given. Any specific times given for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

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



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

VISIBILITY OF THE PLANETS



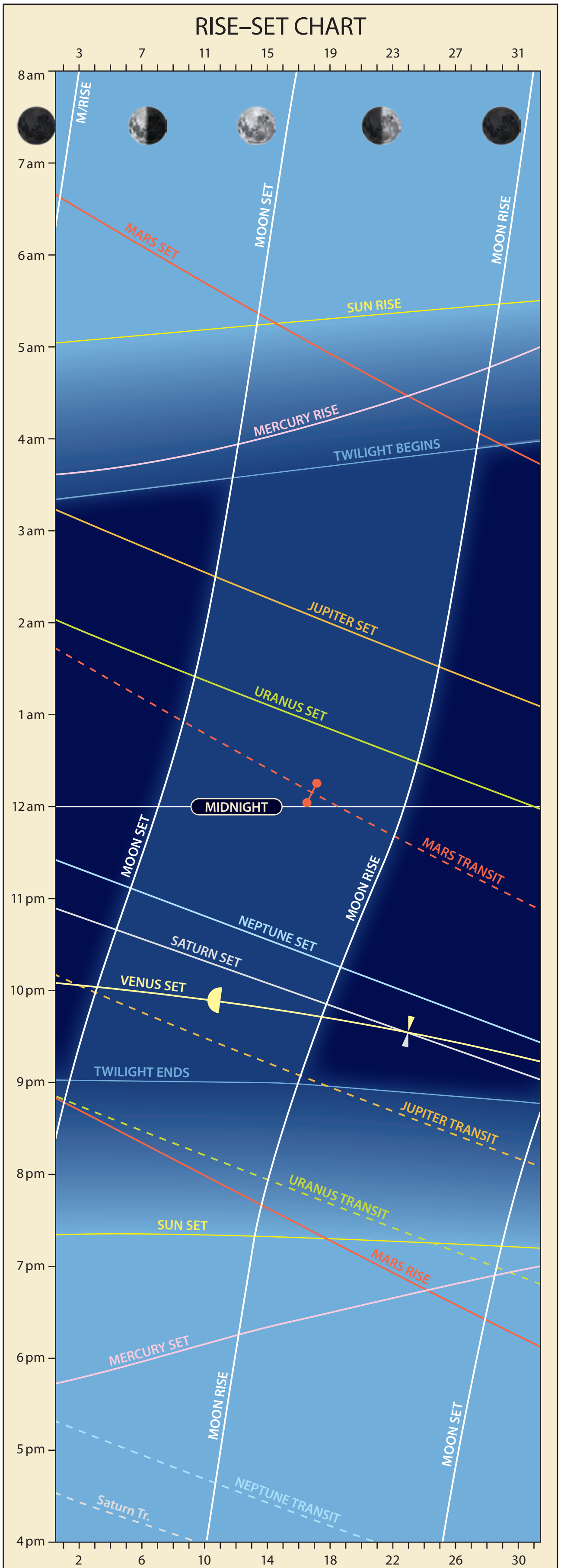
This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point, a horizontal line to the right vertical axis will show which constellation the planet is in. Mars, for example, is in Gemini (Gem) in February and March evening skies (also see All Sky Map 5).

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

Early in the year, Venus is in the evening sky, eventually reaching conjunction in March before spending the rest of the year in the morning.

When an outer planet crosses a midnight line, it is at opposition and visible the entire night, and when crossing the Sun line, it is in conjunction. The diagram also shows conjunctions between the planets. When two planet lines cross or are close, they will be near each other in the sky. A fine example this year is Jupiter and Venus in the August morning sky (see Sky View p. 60).

JANUARY

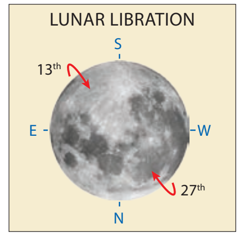


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Moon and Venus close.
- Venus and Saturn close.
- Mars at opposition.

THE MOON



7th 10 am (8 am WST) First Quarter.

8th 10 am (8 am WST) Moon at perigee (closest to Earth at 370,171 km).

13th 3 pm (1 pm WST) Maximum Libration (7.9°), bright SE limb. The bright limb will wash out detail on the eastern limb, however Mare Smythii (Smyth's Sea) and Mare Marginis (The Border Sea) will appear as dark elongated areas on the limb.

14th 8 am (6 am WST) Full Moon.

21st 3 pm (1 pm WST) Moon at apogee (furthest from Earth at 404,298 km).

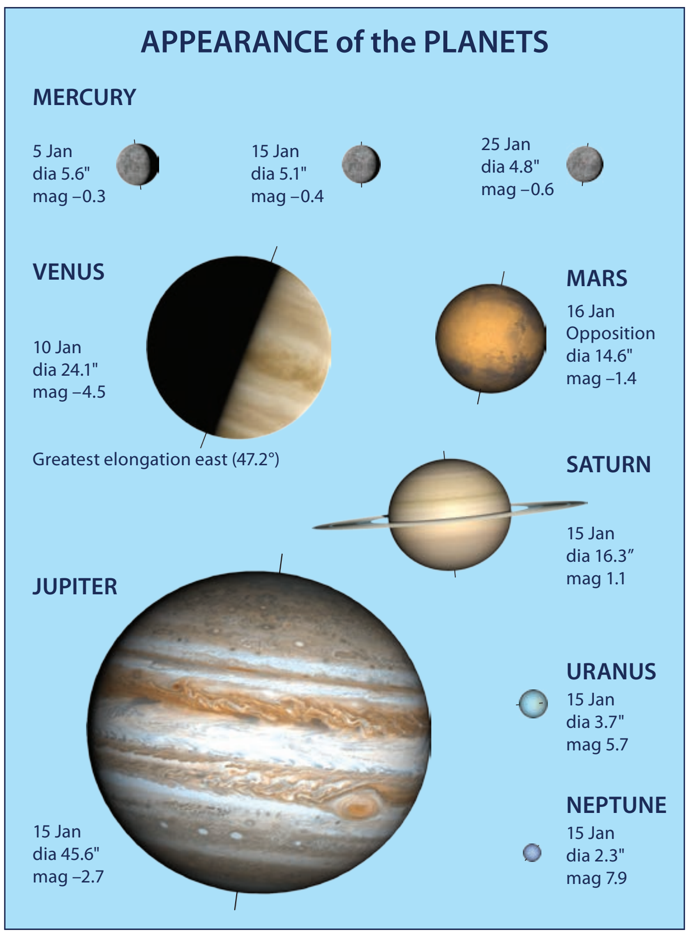
22nd 7 am (5 am WST) Last Quarter.

27th 4 am (2 am WST) Maximum Libration (8.7°), bright NW limb. An ideal time to view craters Volta (113 km) and Xenophanes (121 km).

29th 11 pm (9 pm WST) New Moon.

THE PLANETS

Mercury begins the year in the eastern dawn. It is visible until about mid-month when it starts to succumb to the



brightening sky. The planet is in superior conjunction early next month and then returns to the evening sky.

Venus is a brilliant object in the evening sky from the beginning of the year until March, when it becomes too close to the Sun for observation. It reappears in the morning sky in April and remains there until the end of the year. The planet begins January in Aquarius before moving into Pisces during the last week of the month. On the 3rd, the 4-day-old waxing crescent Moon appears near Venus (see Sky View). Between the 17th and 20th, the planet will be within 3° of Saturn (see February Sky View). On the 10th, Venus reaches its greatest elongation 47° east of the Sun.

On the 4th, the **Earth** is at perihelion, the closest point in its orbit to the Sun at 0.983 au.

Mars comes to opposition this month on the 16th and is visible as a bright orange orb rising in the mid-evening north-eastern sky. This opposition marks the third of five aphelic apparitions, during which the planet's angular diameter measures less than 20 arcseconds. Although not the best of oppositions, this world should deliver pleasant views in moderate to large-size telescopes during periods of good atmospheric seeing (see also Opposition of Mars 2025 p. 114). At opposition, Mars will be bright at −1.4 magnitude with a disc diameter of 14.6 arcseconds. In retrograde since last month, the Red Planet moves out of Cancer and into Gemini. On its travels, it will be seen close to the Full Moon on the 14th and within a couple of degrees of Beta (β) Geminorum (Pollux, the brightest star in the constellation of The Twins) toward the end of the month (see Sky View).

Jupiter is visible in the northern evening sky in Taurus, a few degrees from the Hyades star cluster (see Sky View). The planet came to opposition on the 8th of last month, and since these close approaches to Earth occur roughly once every 13 months, 2025 will be without a Jovian opposition. Even though the planet's angular size and brightness have decreased slightly, it is still a pleasure to observe with even the smallest telescopes.

When observing the planet, one of the first things you may note is that it's not a perfect sphere but slightly flattened at the poles and bulging at the equator. This oblate spheroid shape is caused by Jupiter's fast rotation of 9.9 hours, forcing material away from its axis of rotation. The planet is divided into dark belts and lighter zones, the most obvious of which are the north and south equatorial belts (NEB and SEB). At first glance, an inexperienced observer may see the two belts as straight, even bands across the disc. However, careful observation will reveal bumps, gaps, and bright and dark spots within the bands when the seeing is steady. The famous ancient storm known as the Great Red Spot (GRS) is fun to track down, but keep in mind that with its fast rotation period, things move quickly on Jupiter, and the GRS is best observed at the time of meridian passage or at most an hour on either side. Predictions for the Great Red Spot can be found in Part II.

Saturn, in Aquarius, can be seen low in the western evening sky, setting around 10 pm mid-month. On the 4th, the planet will be 4° from the 5-day-old waxing crescent Moon. Between the 17th and 20th, Venus visits Saturn with the pair within 3° of each other (see February Sky View). From Earth, every 13.5 to 15.7 years, we see Saturn on a perfectly horizontal plane, with the planet's magnificent ring system vanishing for at few days as we cross that plane. This year, when this happens, the planet will be in conjunction with the Sun and hidden from view. This disappearing act happens because the rings measure as thin as 90 metres in most places, like looking at a piece of paper edge-on from a distance. Currently, we are gazing upon the north side of the rings, and after March, when the Earth crosses the ring plane, we will see the southern side until the following passage in 2038. The rings will not be easy to see in small instruments, particularly late in the year, when they will be almost invisible or, at best, a dark line across the disc (compare the monthly Appearance of the Planets diagrams throughout the year).

Uranus, in Aries, is visible in the northern evening sky at the end of astronomical twilight. The planet ends four months of retrograde motion on the 31st and then resumes its west-to-east drift against the stellar background.

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

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

On the night of the 23rd, 10th magnitude Eurynome is traversing the open star cluster NGC 2395 in Gemini. The first quarter of 2025 finds Melpomene touring several bright galaxies in Virgo. During the same period, Eurynome encounters some bright deep-sky objects in Gemini. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 Jan	14 Irene	Gemini	9.6
14 Jan	65 Cybele	Gemini	12.1
14 Jan	79 Eurynome	Gemini	10.4
15 Jan	51 Nemausa	Canis Minor	10.5
16 Jan	387 Aquitania	Gemini	12.3

METEOR SHOWER

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

The **Quadrantids** are a strong and consistent northern shower. Due to their high north declination, these meteors are challenging from the Southern Hemisphere. If observing before dawn, you may glimpse an occasional long-pathed member on the morning of the 3rd. The Quadrantids are active from December 28 to January 12, with up to 25 meteors per hour at their peak. The morning sky will be free of moonlight during the peak.

CONSTELLATIONS

For the constellation section in our last yearbook, we decided to return to our roots, observing and even a bit of star hopping. Back when we started this hobby, amateur telescope mounts were somewhat rudimentary, with equatorial mounts relatively basic. It was easy to get caught up in the Dobsonian movement. It presented a low cost, stable, easy to use mount (and suitable for DIY). This allowed the novice to spend more money on better and larger mirrors. Dobsonians are altazimuth (a bit like a gun turret, push left-right, push up-down), so the amateur needed to know the constellations and the art of star hopping. It's for this reason in the following pages that, for many of the objects, we give directions to finding using nearby visible objects as starting points. Most of the deep sky objects will need dark skies, so even a 5th magnitude star is considered naked eye and a welcome guide. Many of the double stars mentioned are naked eye, so just point the telescope to see them as double. Fifth magnitude is slightly brighter than the faintest stars shown in the All Sky Maps, so we hope this publication is all you need to find most of these night-sky treats. Objects reviewed and their constellation names have been circled in the All Sky Maps.

In keeping with our original mantra to promote Southern Hemisphere observing and preventing this section from blowing out into hundreds of pages, we have kept to objects south of around −33° declination. Yes, a bit arbitrary, but maybe a nod to Charles Messier whose most southerly object was −34.8°, the brilliant open cluster, M7 in Scorpius (as an aside, did you know there is a small globular cluster NGC 6453 lying on M7's western edge?) This southerly bias allows us to spend more time on relatively obscure, lesser-known constellations which often hide some real gems. Considering we are presenting many of the best objects, a number of these have been covered in previous yearbooks, so this was a chance to pull them together. It was also the opportunity to throw in some unusual objects, some being more challenging. Preference is given to objects ideal for binoculars; the most underrated instrument, especially for the novice stargazer starting their exploration of the heavens.

The two Magellanic Clouds (All Sky Map 1), known as the Large (LMC) and Small (SMC) are icons in the southern skies and are rewarding visual hunting grounds to down-under deep sky observers. They appear to the naked eye as detached sections of the Milky Way in a barren part of the far southern sky. They are really satellite galaxies to our own. With the Magellanic Clouds being significantly more distant than Milky Way objects observable, star clusters are generally smaller and fainter. In general, every time you get to use a larger telescope, there's always more to discover. Don't dismiss using any sized telescopes on the clouds. Although there is no doubt you can see heaps through a large scope, start your exploration with binoculars. Wherever you see a bright knot in the clouds, it's a target. There is a brilliant website "Clouds of Magellan" (cloudsofmagellan.net.au) which is a great introduction to the clouds with an emphasis on observing. For anyone that would like an in-depth book on both clouds, Jeff Kanipe's Annals of the Deep Sky vol 9, is a must read! We cover the SMC in November constellations.

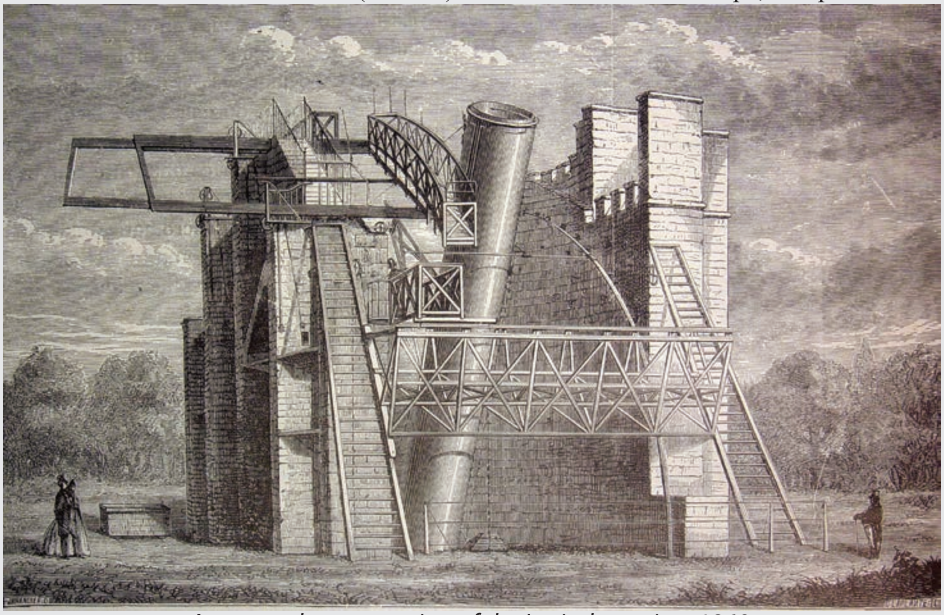
The LMC, which straddles the Dorado/Mensa border, is the largest satellite galaxy to the Milky Way and is 160,000 light-years away. It is a barred spiral galaxy with its most striking feature being a brilliant 5° long bar, easily visible

The Leviathan of Parsonstown

William Parsons (1800–1867), the 3rd Earl of Rosse, served as a Member of the UK Parliament from 1822 to 1834 but resigned to devote his time to astronomy. He built the largest reflecting telescope of the 19th century at Birr Castle in Parsonstown, central Ireland. Today, the town is known as Birr, after Birr Castle, the seat of the Earls of Rosse. The mammoth 72-inch (1.83 m) instrument would remain the world's largest until 1917 when the 100-inch (2.5 m) Hooker Telescope was installed at Mt Wilson Observatory in California.

Undoubtedly inspired by William Herschel's (1738–1822) great reflectors, the Earl designed and constructed several telescopes with the help of his wife, Mary. The two largest were a 36-inch (0.9 m) and the famous 72-inch (1.83 m), which became known as the Leviathan of Parsonstown. Other experts, including the well-known telescope maker Thomas Grubb, helped with advice on its construction. The Earl had to start from scratch since Herschel passed away without publishing any details of the methods used for his Great Forty-Foot (12.2 m) telescope, with its 48-inch (1.22 m) mirror. Built in 1789, it was the largest telescope of the 18th century.

Back in 1668, Isaac Newton built the first reflecting telescope, a 1.3-inch (33 mm) instrument (the first Newtonian reflector). Newton's telescope mirror was crafted from speculum, an alloy of copper and tin. For the following 179 years, all reflecting telescopes used speculum mirrors. The 48-inch (122 cm) Great Melbourne Telescope, completed



A copperplate engraving of the Leviathan, circa 1860.


The restored Leviathan

in 1867, marked the end of this era. Once Carl Steinheil (1801–1870) and Leon Foucault (1819–1868) developed a technique of depositing a thin layer of silver onto the front surface of glass in 1857, a new era of large glass-mirrored telescopes began. Glass was a more stable medium, and the metal coatings reflected 90% of light compared to about 60% for the speculum mirrors.

The Earl experimented for many years to find the best proportions of copper and tin for his mirrors. He constructed three huge crucibles, each with a furnace to heat the alloy before pouring it into a mould. Five blanks, each 5 inches thick (127 mm), were poured for the 72-inch mirror, but only two were successful, as the speculum was brittle and tended to form cracks or break altogether. The initial grinding and polishing process took about two months to complete with the help of a steam-powered machine that the Earl constructed in 1827. Since the alloy tarnished quickly in the open air, two mirrors were required so one could be used while the other was being re-polished, a task that was required every month. Removing and replacing a massive 3.5-tonne chunk of metal this frequently was no small task.

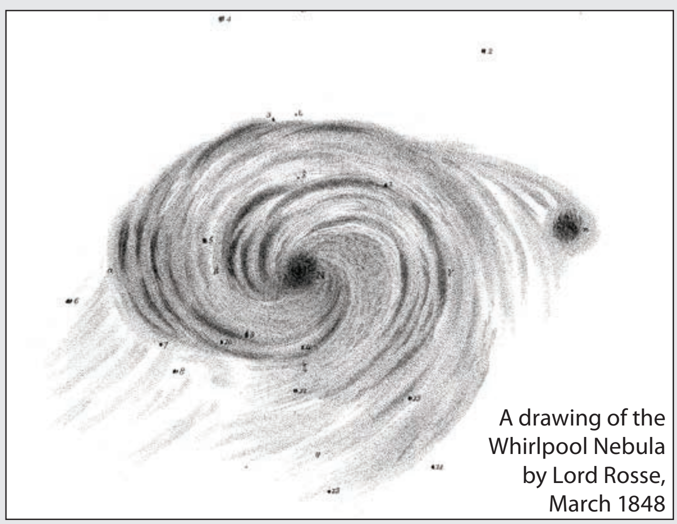
The 54-foot long (16.45 m) tube was fabricated using wooden staves and bound with metal hoops like a wine barrel. The 3.5-tonne $f/8.8$ mirror, with a focal length of 53 feet (16.15 m), was mounted in a cell that used a system of levers to correct for poor images if it sagged under its weight. Weighing in at 12 tonnes, the optical tube assembly required a massive support structure that consisted of two parallel north-south walls 7 m apart, each 12 m high and 22 m long, with the telescope slung between them. The Lord was concerned about the aesthetics of its design and had the wall facing Birr Castle mimic the castle's Gothic arches.

As an altazimuth-mounted telescope, an elaborate system of axles, cables, pulleys, and counterweights to adjust altitude was required. For azimuth movement, a rack-and-pinion system swung the telescope 15° between the walls, allowing an hour of observation time on an object and limited to targets as they neared and crossed the meridian. A team of five people was required to operate the instrument when in use, with the observer having to climb onto a moveable platform to reach the eyepiece.

The primary purpose of the telescope was to examine the objects in Charles Messier and John Herschel's catalogues and determine their nature. The catalogues included star clusters and fuzzy, or nebulous-type objects. There was much debate as to their composition. Were the fuzzies collections of stars far away or just nearby dust and gas? But with the Leviathan, Parsons could see that some of these nebulae had a spiral structure. The most famous example was Messier 51 (NGC 5194) in Canes Venatici, a face-on spiral. His drawing depicted its swirling structure, which led to it becoming known as the Whirlpool Galaxy.

The notorious Irish climate handicapped the telescopes, with only the occasional clear night. Observers often used the 36-inch telescope, which was less wieldy to manage than the 72-inch. But the engineering marvel that was the Leviathan attracted astronomers worldwide to study the heavens. Aside from the Earl's discovery of the spiral nature of the nebulae, the instrument gave the best views of the planets and the Moon ever observed. After the 3rd Earl died in 1867, his son, Laurence Parsons (1840–1908), the 4th Earl, continued astronomical observations, and the 72-inch remained in use until 1890. The Danish astronomer Louis Dreyer (1852–1926) used the 36 and 72-inch telescopes between 1874 and 1878 to observe nebulae that he would include in his New General Catalogue of Nebulae and Clusters of Stars (NGC) in 1888.

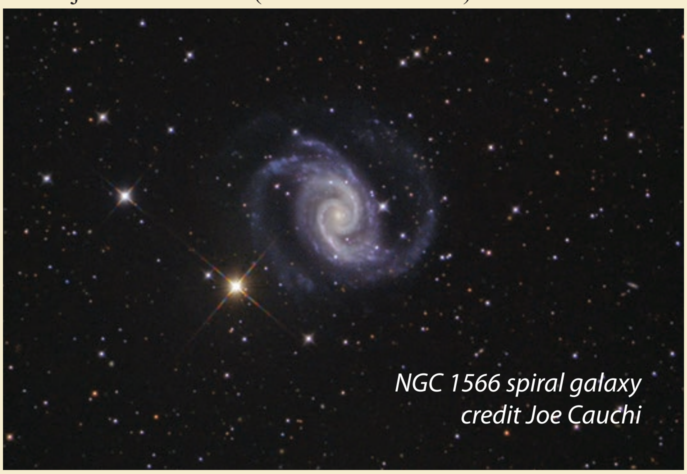
After the 4th Earl died in 1908, the 36-inch and 72-inch telescopes were never used again and fell into disrepair. In the 1990s, restoration work commenced, and today, you can visit Birr Castle in Ireland and see the Leviathan of Parsonstown as it looked over 100 years ago. Its only surviving mirror is on display at the Science Museum in London.


A drawing of the Whirlpool Nebula by Lord Rosse, March 1848

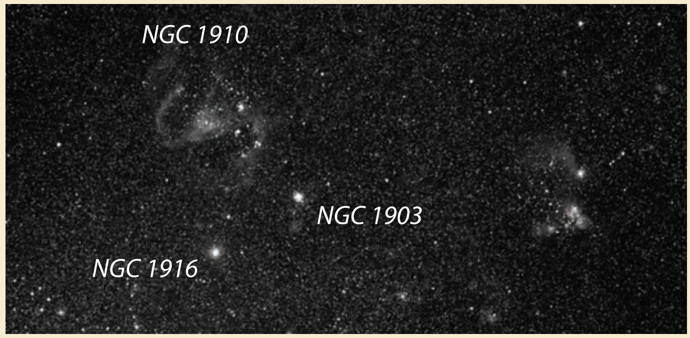
to the naked eye under dark skies. Also visible is a large bright knot above the eastern end of the bar, the magnificent Tarantula Nebula (30 Doradus or NGC 2070). Only a 150 mm telescope is needed to reveal this complex of nebulae and star clusters which extends for approximately 1°. A magnification of 100 × shows detail in the loops radiating from the central body, the legs of the arachnid. The astronomer John Herschel described the Tarantula as:

> "Stellar crucible and the most luminous star forming complex in the local group (of galaxies ed.). This is one of the most singular and extraordinary objects which the heavens present".

A telescopic stroll down the bar reveals numerous open star clusters and a few globular star clusters, with many one arcminute or less in diameter, due to their distance. In fact, over 1000 objects have been catalogued in the LMC, with 200 being in the New General Catalogue (NGC) alone! A great bar object for 150 mm (a knot not to miss!) is the nebula/star



NGC 1566 spiral galaxy
credit Joe Cauchi

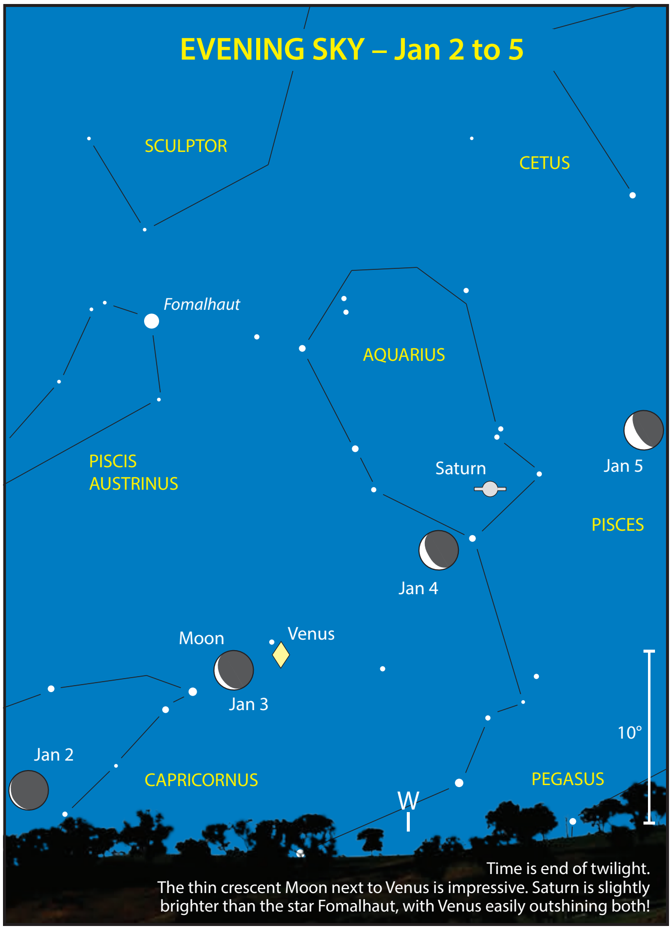


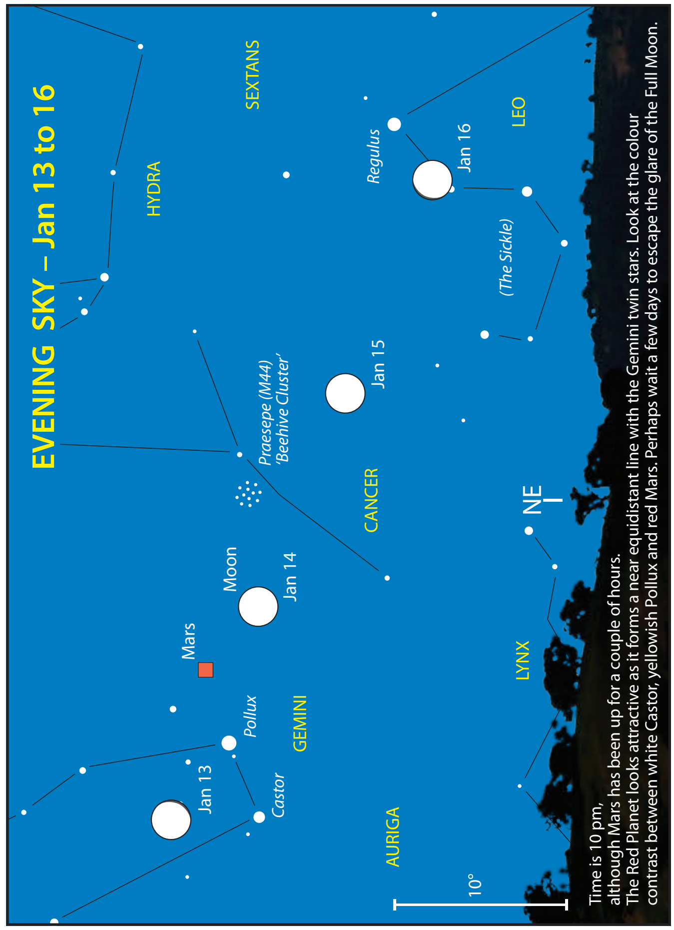
cluster NGC 1910 (resembling a barred spiral galaxy) which lies west of the centre. with the two small clusters NGC 1903 and 1916 only 10 arcminutes away. The LMC extends well above and below the bar. There are dozens more clusters, nebula and star fields which shape it into a rough 6° diameter circle; which is how it's often represented in star atlases.

The constellation of **Dorado** contains a cluster of galaxies, and we'll show you how to find its three brightest members. All are visible through 150 mm telescopes. As a stepping-stone, find the naked-eye (3rd magnitude) star Alpha (α) Doradus, which is 16° west and slightly south of Canopus (the 2nd brightest star in the sky). Alpha and Canopus form an equilateral triangle with the centre of the LMC. Going 2° due west of Alpha, you'll see the 9th magnitude spiral galaxy NGC 1566. It is an obvious disk, 2 arcminutes wide, with a very bright nucleus. Panning 1° south-west, you'll come to the 10th magnitude elliptical galaxy, NGC 1549 and 12 arcminutes below (south) is 9th magnitude spiral galaxy, NGC 1553. Both fit easily into the same eyepiece field. NGC 1549 is a near perfect disk, 1 arcminute in diameter, in contrast to the obvious oval shaped NGC 1553. Both galaxies have prominent, bright nuclei.

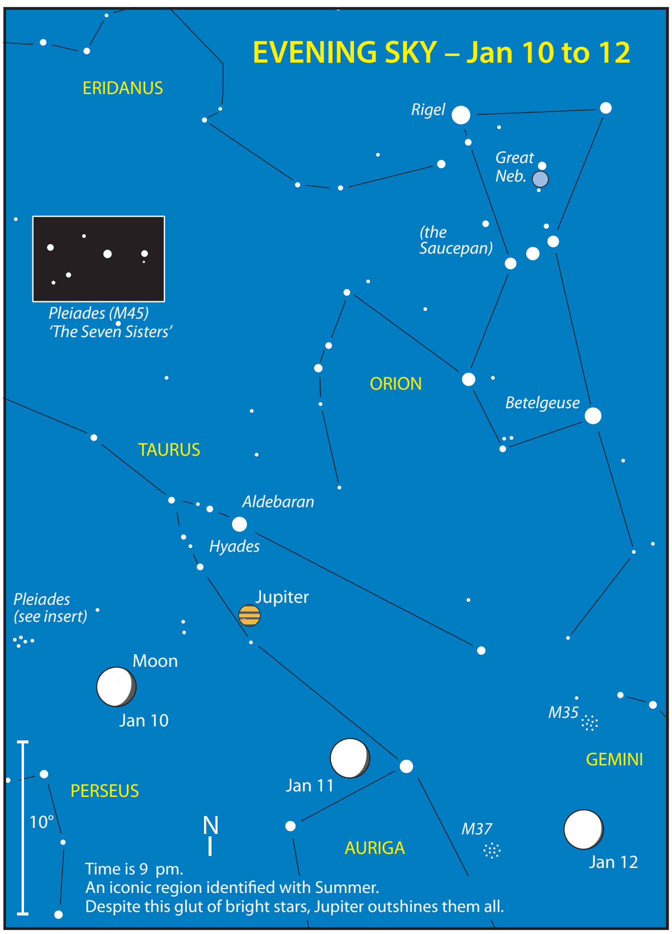
DIARY			
Thu	2nd		Venus 0.8° N of star Iota Aquarii
Fri	3rd		m.p. 18 Melpomene 0.7° N of star Gamma Virginis
Fri	3rd	am	Quadrantids meteor shower, Jan 1–5
Fri	3rd		Pallas in conjunction with Sun
Fri	3rd	9 pm	(7 pm WST) Venus 4° NE of Moon
Sat	4th		m.p. 3 Juno 0.4° SE of star Beta Librae
Sat	4th	9 pm	(7 pm WST) Saturn 4° E of Moon
Sat	4th		Earth at perihelion, 0.983327407 au
Sun	5th	9 pm	(7 pm WST) Neptune 3° E of Moon
Mon	6th		Mercury 1.0° NE of NGC 6401 (GC) in Ophiuchus
Tue	7th	10 am	(8 am WST) First Quarter Moon.
Wed	8th		Mercury 1.0° S of NGC 6469 (OC) in Sagittarius
Wed	8th	10 am	(8 am WST) Moon at perigee (closest to Earth at 370,171 km).
Thu	9th		Mercury 0.6° SW of M20 Trifid Nebula (BN) in Sagittarius
Thu	9th	am	m.p. 18 Melpomene 0.3° S of NGC 4666 (G) in Virgo
Thu	9th	11 pm	(9 pm WST) Uranus 5° SE of Moon
Fri	10th		Mercury 0.3° SW of NGC 6546 (OC) in Sagittarius
Fri	10th		Mercury 1.0° NE of M8 Lagoon Nebula (BN) in Sagittarius
Fri	10th		Venus at greatest elongation East (47.2°)
Fri	10th	Midn	(10 pm WST) Jupiter 8° SE of Moon
Fri	10th	pm	Jupiter 1.3° S of star Tau Tauri
Mon	13th	3 pm	(1 pm WST) Maximum Libration (7.9°), bright SE limb.
Tue	14th		Mercury 0.3° S of NGC 6642 (GC) in Sagittarius

Tue	14th		Venus 0.3° W of star Lambda Aquarii
Tue	14th	3 am	(1 am WST) star Pollux 4° E of Moon
Tue	14th	3 am	(1 am WST) m.p. 4 Vesta 0.1° N of star Iota Virginis
Tue	14th	8 am	(6 am WST) Full Moon (381,416 km).
Tue	14th	9 pm	(7 pm WST) Mars 5° W of Moon
Wed	15th		Mercury 0.5° E of M22 (GC) in Sagittarius
Thu	16th		Mars at opposition
Fri	17th	3 am	(1 am WST) star Regulus 3° S of Moon
Sun	19th	am	m.p. 18 Melpomene 0.7° NW of NGC 4753 (G) in Virgo
Mon	20th		Saturn 3° S of Venus
Tue	21st	3 pm	(1 pm WST) Moon at apogee (furthest from Earth at 404,298 km).
Tue	21st	Midn	(10 pm WST) star Spica 5° W of Moon
Tue	21st	pm	m.p. 28 Bellona 0.8° NE of star Alpha Cancri
Tue	21st	pm	m.p. 79 Eurynome 0.2° N of Medusa Nebula (PN) in Gemini
Wed	22nd		star Pollux 2° N of Mars
Wed	22nd	7 am	(5 am WST) Last Quarter Moon.
Wed	22nd	pm	Mars 1.3° N of star Kappa Geminorum
Thu	23rd	pm	m.p. 79 Eurynome 0.05° E of NGC 2395 (OC) in Gemini
Fri	24th		m.p. 4 Vesta 0.7° N of NGC 5634 (GC) in Virgo
Sat	25th	am	m.p. 29 Amphitrite 1.0° NE of star Eta Leonis
Sat	25th	3 am	(1 am WST) star Antares 3° E of Moon
Mon	27th	4 am	(2 am WST) Maximum Libration (8.7°), bright NW limb.
Mon	27th	pm	Mars 1.0° S of star Upsilon Geminorum
Wed	29th	11 pm	(9 pm WST) New Moon.





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



Jupiter's Satellites for January

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.

Jan 5, 8:30 pm EST

From the eastern states, Europa has just reappeared from being eclipsed (daylight event in WA). Later in the night, Io will be occulted and reappear from eclipse in the morning.

Jan 8, 11 pm EST (9 pm WST)

All four moons on the western side of Jupiter. Ganymede has just passed a maximum elongation with Callisto heading towards one. Europa and Io are passing each other.

Jan 14, 11:15 pm EST (9:15 pm WST)

Io has just reappeared from eclipse. The morning hours will see Callisto pass over Jupiter's north pole.

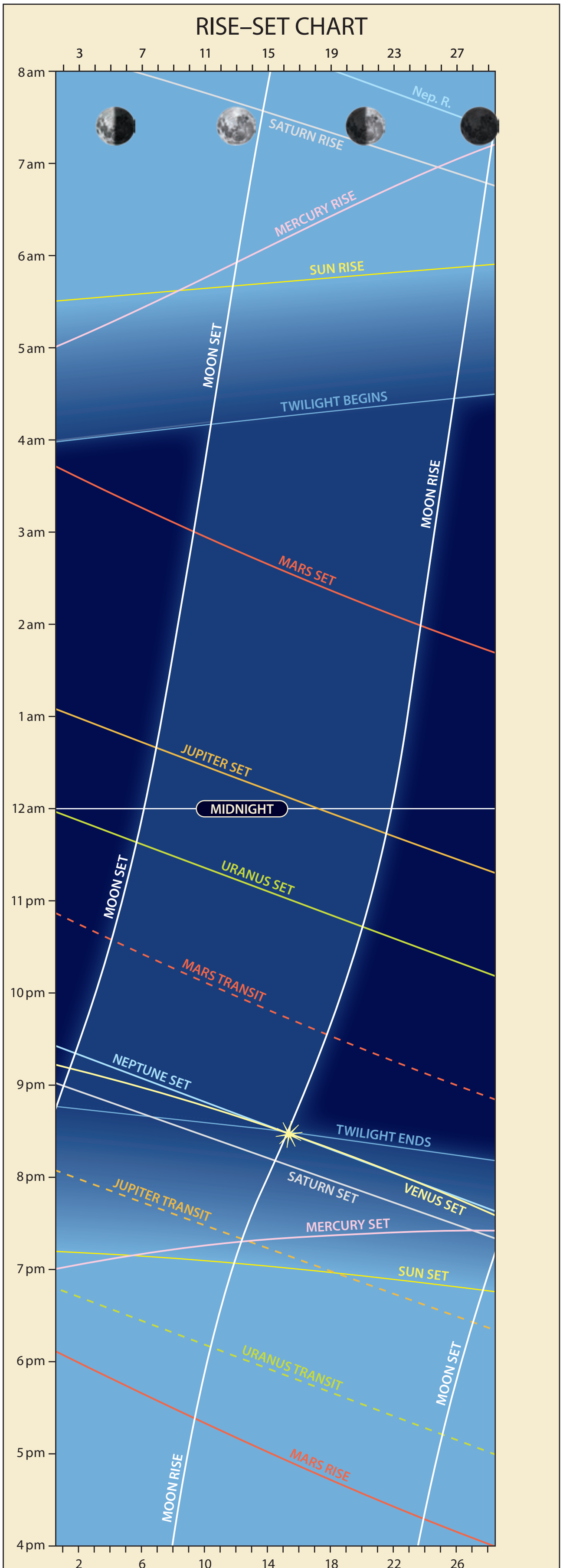
Jan 29, 10:15 pm EST (9:15 pm WST)

Io and its shadow are currently transiting Jupiter and will egress over the next two hours

Jan 31, 9:25 pm EST (7:25 pm WST)

A slightly unusual arrangement. Callisto has just passed over Jupiter's northern pole and Ganymede will be occulted (pass behind Jupiter) in 30 mins, to reappear around midnight. WA will see it eclipsed in the morning.

FEBRUARY

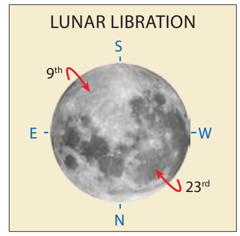


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- ❍ Venus at its greatest brightness.
- ❍ Saturn and the crescent Moon close.

THE MOON



2nd 1 pm (11 am WST) Moon at perigee (closest to Earth at 367,457 km).

5th 6 pm (4 pm WST) First Quarter.

9th 10 am (8 am WST) Maximum Libration (8.2°), bright SE limb. The bright limb will wash out detail on the eastern limb. However, Mare Smythii (Smyth's Sea) will be visible as a dark, elongated area on the limb.

12th Midnight (10 pm WST) Full Moon.

18th 11 am (9 am WST) Moon at apogee (furthest from Earth at 404,882 km).

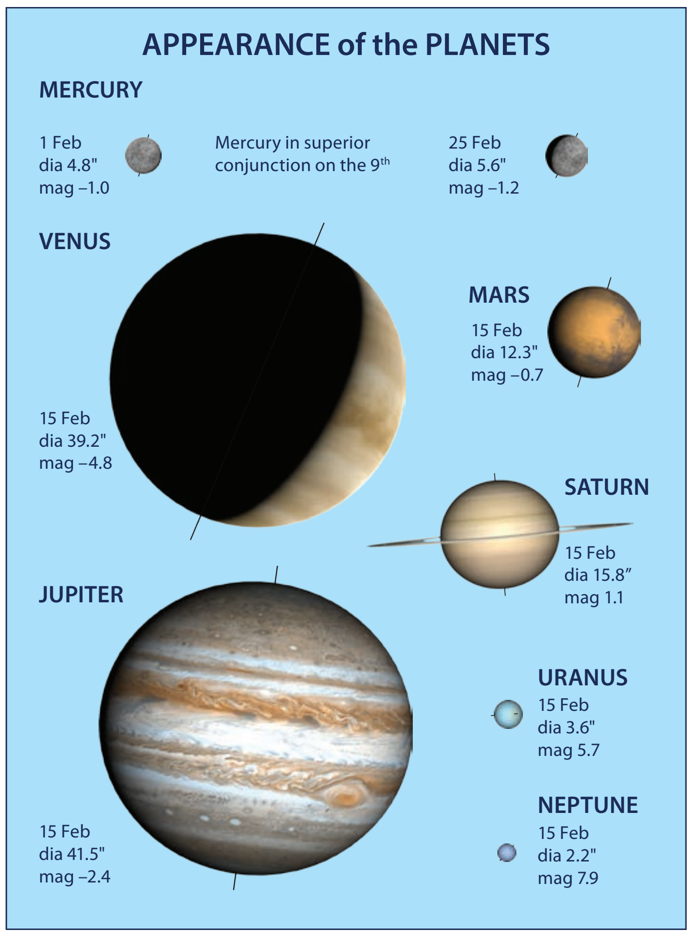
21st 4 am (2 am WST) Last Quarter.

23rd 8 pm (6 pm WST) Maximum Libration (9.4°), bright NW limb.

28th 11 am (9 am WST) New Moon.

THE PLANETS

Mercury returns to the evening dusk after superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 9th. This apparition is unfavourable, with the planet only a few degrees above the horizon after sunset.



Venus, in the early western evening sky, is at its greatest illuminated extent—or greatest brilliance—on the 15th at −4.8 magnitude. Why is the planet currently so bright while just a crescent? It's a combination of its phase and distance. During its crescent phase, it is much closer to Earth in its orbit than at other times and consequently appears much larger in apparent size. In the evening sky, this occurs about a month after its greatest elongation (January 10th) from the Sun when it displays a first quarter phase, and conversely, in the mornings, around a month before an elongation.

Since its opposition last month, **Mars** has begun to fade, and its diameter has decreased. In the mid-evening north-eastern sky in Gemini (see Sky View), the planet ends its retrograde period on the 24th and moves back toward Cancer. By mid-month, Mars drops a full magnitude from its opposition brightness of −1.4, and its diameter is now around 12 arcseconds. Although not the best of oppositions, patient visual observers can still tease detail from the planet under good seeing conditions and high magnification. For photographers, modern CCD camera technology can enable amateurs to produce useful images of Mars even when it is as tiny as 4 arcseconds.

Jupiter, in Taurus, is visible in the early north-western sky (see Sky View). The planet slowly returns to its west-to-east path against the starfield, ending four months in retrograde on the 4th (see retrograde motion p. 92). Post opposition (December 2024), the gas giant's angular size begins to decrease, and so does its brightness. However, the planet is always a delight to observe in telescopes of all sizes. Besides planetary details like the Great Red Spot and cloud bands, the continuous motion of the four major moons provides a renewed and different view each time observed. Watch as these satellites (Io, Europa, Ganymede, and Callisto) undergo transits and shadow transits of the planet, occultations and eclipses. Predictions for these events can be found in Part II.

Saturn is only visible for a very brief period in the early western evening sky this month. It soon succumbs to the twilight as it moves toward the Sun and conjunction next month. On the 1st, the 3-day-old waxing crescent Moon appears 4° to the north of the planet (see Sky View).

Uranus, in Aries and close to the border of Taurus, appears low in the early north-western evening sky after the end of astronomical twilight.

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

DIARY			
Sat	1st	8 pm	(6 pm WST) Saturn 4° SW of Moon
Sat	1st	8 pm	(6 pm WST) Venus 8° NE of Moon
Sun	2nd	1 pm	(11 am WST) Moon at perigee (closest to Earth at 367,457 km).
Sun	2nd	pm	m.p. 79 Eurynome 0.5° NE of NGC 2355 (OC) in Gemini
Mon	3rd		Neptune 4° S of Venus
Wed	5th	6 pm	(4 pm WST) First Quarter Moon.
Wed	5th	10 pm	(8 pm WST) Uranus 7° SE of Moon
Fri	7th	8 pm	(6 pm WST) Jupiter 8° SW of Moon
Sat	8th		m.p. 13 Egeria 0.1° SE of star Xi Persei
Sat	8th		alpha-Centaurids meteor shower, Jan 28 to Feb 21, Moon affected
Sun	9th	10 am	(8 am WST) Maximum Libration (8.2°), bright SE limb.
Sun	9th		Mercury in superior conjunction
Mon	10th	1 am	(11 pm WST, prev day) Mars 4° SE of Moon
Mon	10th	8 pm	(6 pm WST) star Pollux 3° NW of Moon
Wed	12th	Midn	(10 pm WST) Full Moon (392,627 km).
Thu	13th	4 am	(2 am WST) star Regulus 5° SE of Moon
Sat	15th		Ceres in conjunction with Sun
Mon	17th	10 pm	(8 pm WST) star Spica 0.5° SW of Moon
Tue	18th	11 am	(9 am WST) Moon at apogee (furthest from Earth at 404,882 km).
Thu	20th	pm	m.p. 18 Melpomene 0.6° SW of NGC 4772 (G) in Virgo
Thu	20th	pm	m.p. 8 Flora 0.6° SW of star Omicron Virginis
Fri	21st	4 am	(2 am WST) Last Quarter Moon.
Fri	21st	Midn	(10 pm WST) star Antares 3° W of Moon
Sun	23rd	8 pm	(6 pm WST) Maximum Libration (9.4°), bright NW limb.
Wed	26th		m.p. 2 Pallas 1.0° SE of star Beta Aquilae
Fri	28th	11 am	(9 am WST) New Moon.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
1 Feb	28 Bellona	Cancer	10.0
4 Feb	135 Hertha	Cancer	12.1
13 Feb	29 Amphitrite	Leo	9.2
16 Feb	21 Lutetia	Leo	11.3
22 Feb	409 Aspasia	Sextans	11.1
26 Feb	24 Themis	Leo	10.8
28 Feb	704 Interamnia	Sextans	11.6

COMET

Comet C/2023 A3 (Tsuchinshan-ATLAS) begins the month in Aquila, mostly in daylight. Mid-month sees it move into Delphinus at about magnitude 12, now rising in the eastern sky shortly before sunrise. By month's end, the comet is rising around 90 minutes before sunrise.

METEOR SHOWER

The **alpha-Centaurids**, one of the main southern summer showers, are active from January 28 to February 21, with a maximum zenith hourly rate of six before dawn on 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. This year, there will be considerable lunar interference, with the peak close to the Full Moon.

CONSTELLATIONS

Near the South Celestial Pole is the constellation of **Chamaeleon** (The Chameleon) All Sky Map 1. The naked-eye star Delta (δ) Chamaeleontis is an impressive binocular double star, having a 4.4 magnitude bluish-white primary (δ^2) with an orange 5.5 magnitude companion (δ^1), 4 arcminutes north. Move 1.5° west, and slightly south from Delta, to find the Planetary Nebula NGC 3195. Its

The Spectacular Montes Apenninus Region

Located on the south-eastern shores of Mare Imbrium, the Montes Apenninus is the longest mountain range on the Moon. It was named after the Apennine Mountains in Italy by Johannes Hevelius. This rugged, arc-shaped range is best observed near the First or Last Quarter Moon. It stretches 600 km from the Promontorium Fresnel to the 60 km crater Eratosthenes.

The range was formed by material ejected from the Imbrium impact basin. Rising steeply above the Mare, it then tapers away to the south-east. The Montes Apenninus is notable for its impressive rugged terrain and peaks with many over 5 km high, including Mons Huygens, the highest mountain on the Moon. The area is particularly striking around First Quarter as the mountainous summits cast their long, sharp shadows across the Mare.

Due to its diverse geological features, the Montes Apenninus was chosen as the site for the Apollo 15 landing in 1971, the first lunar mission that was focused primarily on geology. Scientists were particularly interested in sampling the rocks in the area to determine the depth of the Imbrium Basin excavation, the age of both the basin formation and the mare lava. The astronauts landed in the northern Apenninus between the massifs Mons Hadley (4.5 km) and Mons Hadley Delta (3.6 km) and close to the Rima Hadley, a sinuous rille. Apollo 15 was the first mission to include a Lunar Roving Vehicle (LRV), popularly named the 'Moon Buggy', allowing astronauts to traverse 28 km over their three-day stay on the Moon. The Apollo crew collected 370 rock and soil samples, including a drill core with material from 2.4 m below the surface. In total, 77 kg were returned to Earth.

Figure 3: Hadley Rille, taken by Apollo 15 astronaut James Irwin, with David Scott next to the Lunar Roving Vehicle.

Given its age (around 3.85 billion years), the Apenninus region has remarkably few impact craters. The largest is the 22 km Conon, which is unmistakable with its sharp rim. Nearby to Conon are the smaller craters Aratus (11 km) and Galen (10 km). Near the range is the largest crater on Mare Imbrium, the 83 km Archimedes, a very distinctive crater with a flooded floor. Impact craters the size of Archimedes usually have a central peak, and it is thought that lava upwelling within the crater was sufficient to bury it. To the south of Archimedes and seeming to extend from its rim, lies the Montes Archimedes, a mountain range about 140 km in diameter.

Two smaller craters near Archimedes are also worth observing. The closest, Autolycus (39 km), has a small crater on its irregular rim. The Soviet spacecraft Luna 2 became the first man-made object to impact another celestial body when it crash-landed near Autolycus in 1959 (the USSR scored a hat-trick on crashing into near-Earth bodies; they were the first to impact the Moon, Venus and Mars). Aristillus (55 km), just north of Autolycus, is interesting with its ray system and prominent ejecta blanket surrounding the crater. This crater has three central peaks rising 900 m above its floor. Just north of Aristillus' walls is an unnamed ghost crater faintly showing through the lava flows.

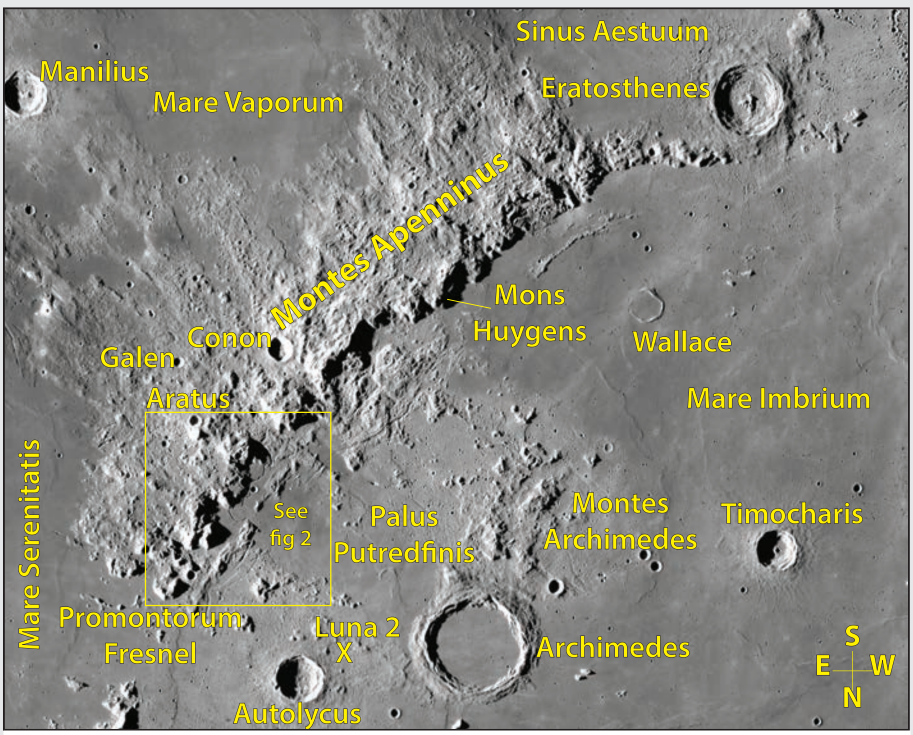


Figure 1: Mosaic of photos by the Lunar Reconnaissance Orbiter. The image covers 750×600 km.

Between Archimedes and Eratosthenes is the flooded 26 km crater Wallace, whose squarish broken walls protrude through the Mare. Eratosthenes is a deep impact crater on the southernmost tip of the Montes Apenninus; it is very prominent at low Sun angles due to shadows cast by its rim. The crater has several prominent central peaks and steep terraced walls; its ramparts are covered in ejecta material. Interestingly, early last century, the astronomer W.H. Pickering thought he could see apparent dull red

Through a 200 mm telescope this 10th magnitude spiral shows a distinctive central bar approximately 1 × 3 arcminutes. Larger instruments reveal this bar pointing to a nebulous patch a couple of arcminutes to the north-east. Although appearing to be detached this is part of a bright narrow sweeping arm of NGC 2442, called NGC 2443. Epsilon is also an impressive double having a bluish 4.4 magnitude primary with a yellowish 7.9 magnitude partner, a snug 7 arcseconds away.

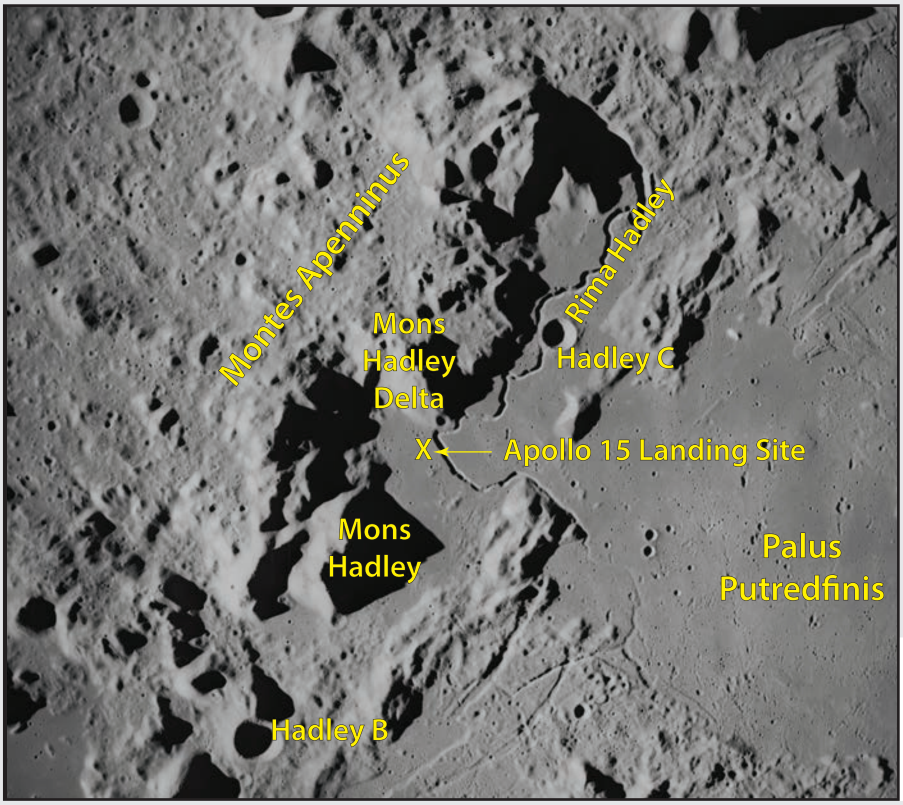
The neighbouring constellation of **Pictor** (The Painter), just west of Canopus, is home to some impressive double stars, such as Eta (η) Pictoris. Binoculars show a colourful wide pair, with 5.4 magnitude white Eta[1], making a great contrast to

NGC 2442, Meathook galaxy, credit Joe Cauchi

claim to fame is being the most southerly planetary easily visible in amateur telescopes. A 200 mm instrument shows this 30-arcsecond, 11th magnitude object to be round, with a bright uniform glow. Larger telescopes show a hint of surface mottling.

We now move to adjoining **Volans** (The Flying Fish) All Sky Map 1, which is sandwiched between the Milky Way and the LMC. The naked-eye star Gamma (γ) Volantis is a double with magnitude 3.8 and 5.6 components separated by 14 arcseconds. The brighter star is distinctly yellow with the other white. Halfway between Gamma and another naked-eye star (4th magnitude) Epsilon (ε) Volantis (also a nice double, see below) is the impressive Meat Hook galaxy, NGC 2442.

NGC 1851, globular cluster, credit Joe Cauchi



and green colour changes in Eratosthenes. He attributed these changes to great insect swarms or vegetation growing and dying.

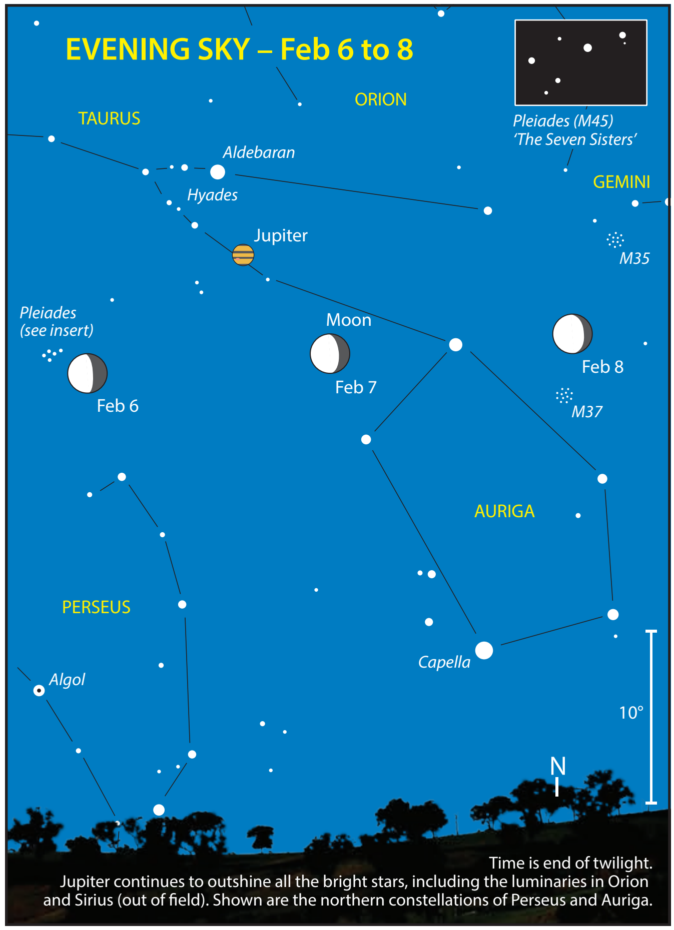
The Rima Hadley can be a challenge to observe. However, pinpointing it is arguably the most straightforward of the Apollo landing sites. The rille is 135 km long, and at the Apollo landing site, it is 1.5 km wide and 300 m deep. It is believed to have formed as a volcanic feature, probably originating as a lava tube whose roof later collapsed. When the seeing is good, and the rille is near the terminator, most small telescopes (100 mm and up) under medium to high magnification should have no trouble. It appears as a fine line with a solitary 6 km crater, Hadley C, at its midpoint.

Figure 2: View of Hadley–Apennine from Apollo 15 CSM, Endeavour, *taken with the Apollo Lunar Mapping Camera, based on the raw uncompressed scan, compressed and cropped*

5.0-magnitude orange Eta^2, 0.5° away. Here's a real challenge requiring dark skies and large aperture (200 mm plus). In the same field with Eta^2 (0.1° east) is the faint (12th magnitude) galaxy NGC 1803 showing an oval halo ($1.0' \times 0.5'$) with a stellar nucleus. Just 0.6° west of Eta^2 lies the double star WDS 04595-4927, with 7.3 and 9.0 magnitude yellow companions, separated by 10 arcseconds. Here's a true showpiece, Theta (θ) Pictoris. With matched (6.8 magnitude) stars, a comfortable 38 arcseconds apart, standing out in the field-of-view like brilliant white headlights.

Continue your trek northward and pass into the constellation of **Columba** the Dove (All Sky Map 2). The globular star cluster NGC 1851 may be isolated, but this 7th magnitude, 8-arcminute diameter object has a bright condensed core, only two arcminutes across and visible through binoculars. At this low power it looks star-like with a faint halo. Binoculars show this globular and naked-eye star Gamma Caeli (a brilliant triple star, see below) in the same field-of-view (5° apart). Halfway between them is a brilliant pair of 10th magnitude spiral galaxies NGC 1808 and NGC 1792, separated by 0.7°. Fitting into a low power field, they look like twins, having similar size and oval shapes (3×1 arcminutes), with bright nuclei and both tilted north-west to south-east.

Looking at naked-eye Gamma (γ) Caeli, binoculars show γ^1 (magnitude 4.5) to have a companion γ^2 (magnitude 6.3) 14 arcminutes south. A small telescope (60 mm) shows that γ^1 is double with a magnitude 8.2 star 3 arcseconds north-west.



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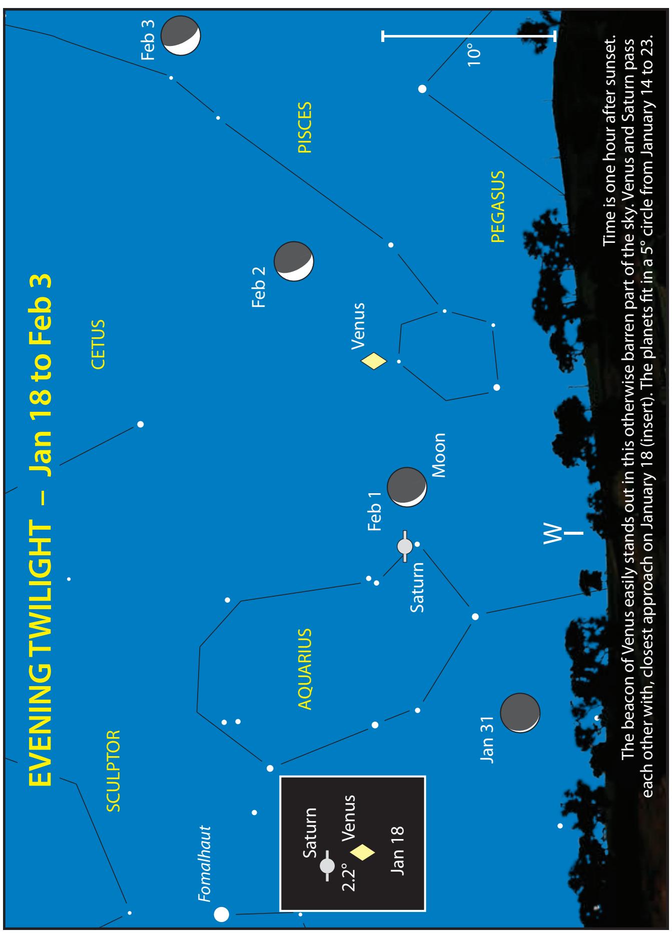
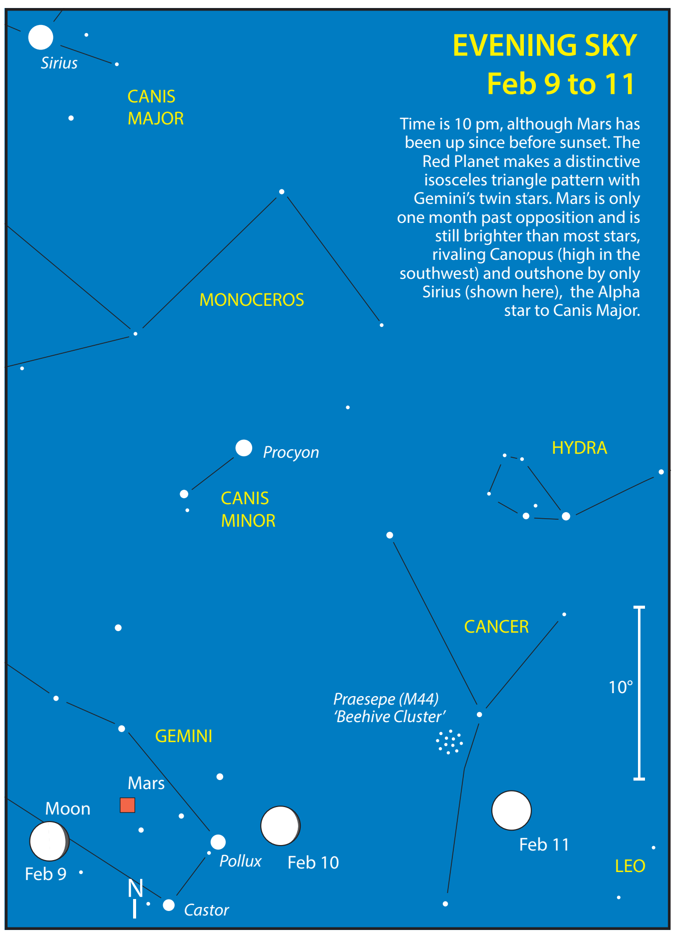
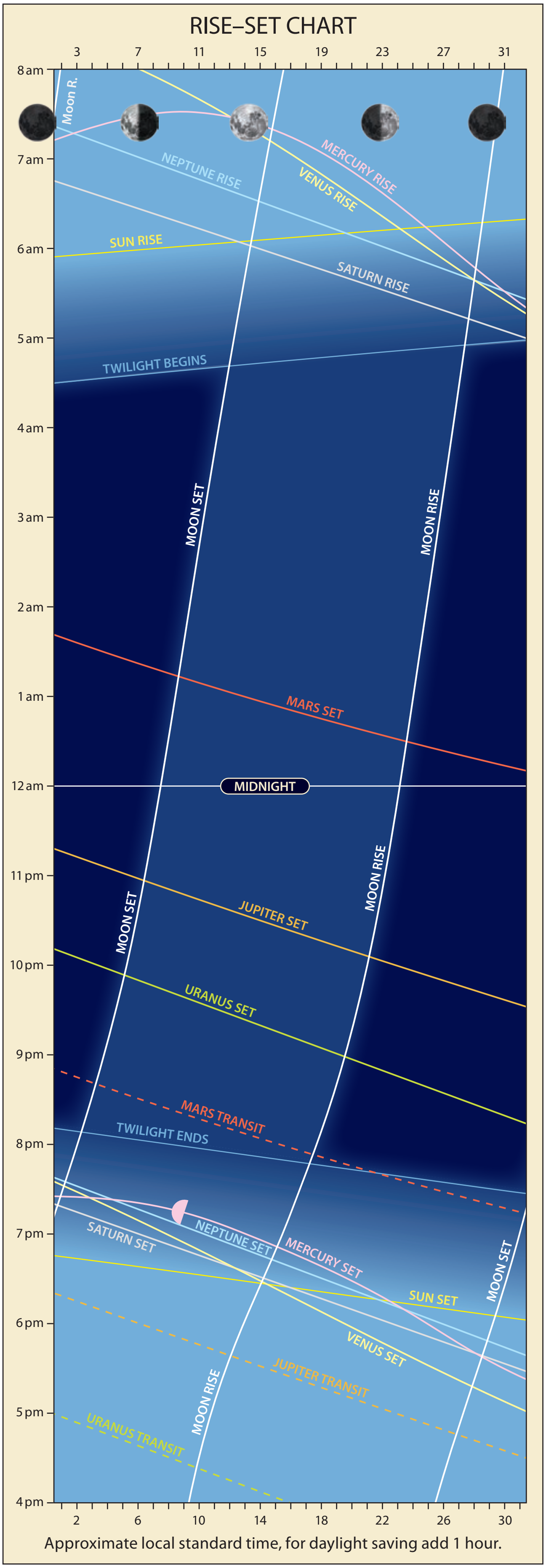




MARCH

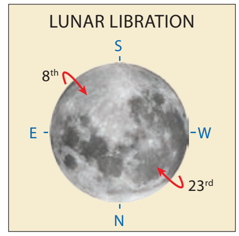


Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHT

- Mercury, Venus, Saturn and Neptune return to the morning sky.
- Partial lunar eclipse for eastern states.
- Saturn rings edge-on.

THE MOON



2nd 7 am (5 am WST) Moon at perigee (closest to Earth at 361,964 km).

7th 3 am (1 am WST) First Quarter.

8th 1 pm (11 am WST) Maximum Libration (9.0°), bright SE limb.

14th 5 pm (3 pm WST) Full Moon, total lunar eclipse, Pacific, Americas, w Europe, w Africa.

18th 3 am (1 am WST) Moon at apogee (furthest from Earth at 405,754 km).

22nd 9 pm (7 pm WST) Last Quarter.

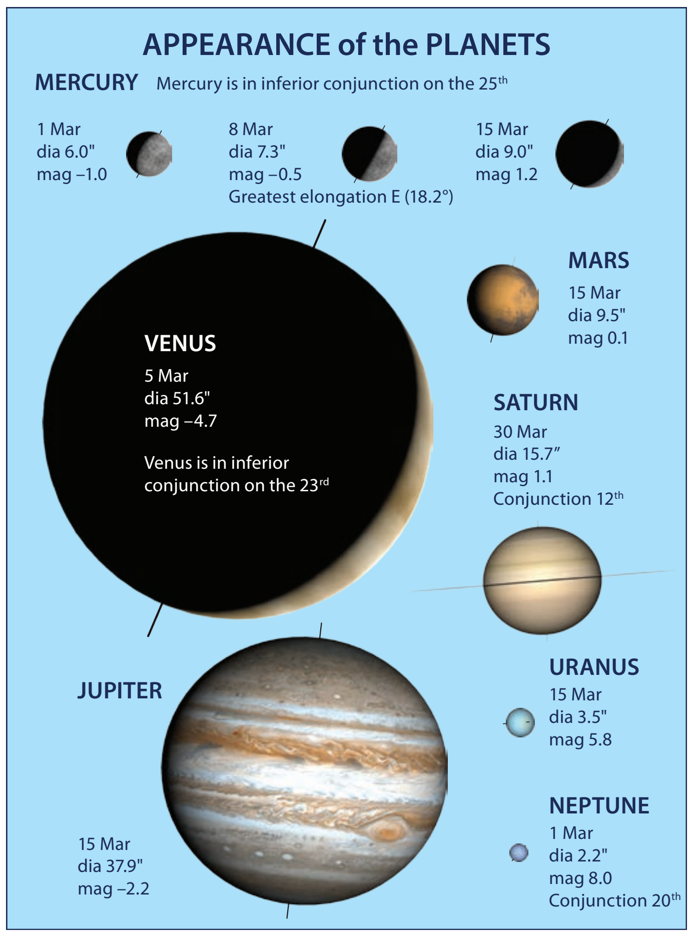
23rd 5 pm (3 pm WST) Maximum Libration (9.9°), bright NW limb.

29th 9 pm (7 pm WST) New Moon, partial solar eclipse, NW Africa, Europe, N Russia.

30th 3 pm (1 pm WST) Moon at perigee (closest to Earth at 358,128 km).

THE PLANETS

Mercury remains nearly impossible to observe in the evening twilight sky as it continues to hug the horizon. On the 1st, the planet will be 4° from the slender crescent of



DIARY			
Sat	1st		Jupiter 1.1° S of star Tau Tauri
Sat	1st	7 pm	(5 pm WST) Mercury 2° SW of Moon
Sun	2nd	7 am	(5 am WST) Moon at perigee (closest to Earth at 361,964 km).
Tue	4th	am	m.p. 9 Metis 0.5° S of star Gamma Librae
Tue	4th	pm	m.p. 18 Melpomene 0.9° NE of NGC 4636 (G) in Virgo
Wed	5th	8 pm	(6 pm WST) Uranus 7° SW of Moon
Thu	6th	8 pm	(6 pm WST) Jupiter 6° S of Moon
Fri	7th	3 am	(1 am WST) First Quarter Moon.
Sat	8th	1 pm	(11 am WST) Maximum Libration (9.0°), bright SE limb.
Sat	8th		Mercury at greatest elongation East (18.2°)
Sun	9th		Venus 6° N of Mercury
Sun	9th	8 pm	(6 pm WST) Mars 5° W of Moon
Sun	9th	9 pm	(7 pm WST) star Pollux 1° NE of Moon
Wed	12th	8 pm	(6 pm WST) star Regulus 3° SW of Moon
Wed	12th		Saturn in conjunction with Sun
Fri	14th		gamma-Normids meteor shower, Feb 25 to Mar 28, Moon affected.
Fri	14th	5 pm	(3 pm WST) Full Moon (401,500 km), total lunar eclipse, Pacific, Americas, w Europe, w Africa.
Sun	16th	pm	m.p. 79 Eurynome 0.3° S of star Lambda Geminorum
Sun	16th	pm	m.p. 8 Flora 0.2° NE of NGC 3810 (G) in Leo
Mon	17th	5 am	(3 am WST) star Spica 1° E of Moon
Tue	18th	3 am	(1 am WST) Moon at apogee (furthest from Earth at 405,754 km).
Thu	20th		d.p. 1 Ceres 0.5° N of star Delta Aquarii
Thu	20th		Neptune in conjunction with Sun
Thu	20th		Equinox
Fri	21st	1 am	(11 pm WST, prev day) star Antares 0.2° NE of Moon
Sat	22nd	9 pm	(7 pm WST) Last Quarter Moon.
Sun	23rd	am	m.p. 354 Eleonora 0.5° SE of star Lambda Ophiuchi
Sun	23rd		Venus in inferior conjunction
Sun	23rd	5 pm	(3 pm WST) Maximum Libration (9.9°), bright NW limb.
Tue	25th		Mercury in inferior conjunction
Thu	27th		m.p. 2 Pallas 1.5° NW of NGC 6934 (GC) in Delphinus
Fri	28th		d.p. 1 Ceres 1.4° NW of NGC 7492 (GC) in Aquarius
Fri	28th	pm	m.p. 18 Melpomene 1.5° SW of M49 (EG) in Virgo
Sat	29th	9 pm	(7 pm WST) New Moon, partial solar eclipse, nw Africa, Europe, n Russia.
Sun	30th	3 pm	(1 pm WST) Moon at perigee (closest to Earth at 358,128 km).
Sun	30th	11 pm	(9 pm WST) m.p. 18 Melpomene 0.2° W of NGC 4365 (G) in Virgo

the 2-day-old Moon (a difficult observation, see Sky View). It reaches its greatest elongation 18° east of the Sun on the 8th before moving between Earth and the Sun (inferior conjunction) on the 25th. Next month marks the optimal time of the year for morning observation of this elusive little world.

Venus, in the early western evening sky (see Sky View), soon becomes lost in the Sun's glare as it moves toward its inferior conjunction (between Earth and the Sun) on the 23rd. The planet then makes its debut as the Morning Star in the eastern dawn sky in late April.

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

Mars is visible in the northern sky between the Twins of Gemini in the early evening. Since its January opposition, the planet has continued to fade and shrink. It drops to zero magnitude by mid-month, and its angular size is under 10 arcseconds. On the 9th, the 10-day-old waxing crescent Moon appears 5° from Mars (see Sky View).

Jupiter is visible in the early north-western evening sky in Taurus between the horns of The Bull (see Sky View). Making the planet an early target on your observing list is a good idea before it loses too much altitude.

Saturn will be in conjunction with the Sun on the 12th and remains hidden from view until its return to the morning skies late this month (see Sky View). On the 23rd, the Earth crosses Saturn's ring plane, and if we could view the planet, it would appear ringless for at least a day or so. From this time on, our view of the rings changes from the north to the southern side. This aspect will continue until the next passage of the Earth through the ring plane in 2038.

Uranus appears low in the early north-western evening sky after the end of astronomical twilight. The outer planet moves out of Aries and into Taurus early in the month. The constellation of The Bull will then be home to Uranus until it moves into Gemini in May 2033.

Neptune is in conjunction with the Sun on the 20th and reappears in the morning sky in early April.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 Mar	346 Hermentaria	Leo	11.6
4 Mar	287 Nephthys	Leo	11.1
10 Mar	92 Undina	Leo	11.9
13 Mar	8 Flora	Leo	9.5
15 Mar	97 Klotho	Virgo	11.3
21 Mar	48 Doris	Virgo	11.4
25 Mar	18 Melpomene	Virgo	10.3
29 Mar	60 Echo	Virgo	10.9

COMET

Comet C/2023 A3 (Tsuchinshan-ATLAS) spends March in Delphinus, at about magnitude 12. It begins the month rising in the eastern sky just before dawn and by month's end, is rising around 2:30 am, having faded to magnitude 12.5.

METEOR SHOWER

The **gamma-Normids** are active between February 25 and March 28. The rate is low for most of the period, and members are difficult to distinguish from the sporadic background activity. The peak is expected around March 14, when rates can reach six per hour. Generally, the gamma-Normids are bright, chiefly yellow, white, or orange, with about 15% leaving trains. The Full Moon on the 14th severely affects the shower this year.

CONSTELLATIONS

This month we enter the plane of the Milky Way. It's impossible to cover the richness and variety of the deep sky objects present in Puppis (All Sky Map 4) and Carina (All Sky Map 1), all we can do is present a taste. The constellation of Puppis the Poop Deck alone has around two dozen deep sky objects considered bright enough to be visible in binoculars. Carina has a similar number.

Starting in **Puppis**, although north of the area we are covering this year, we would be remiss to not mention the famous twin star clusters in northern Puppis, M47 and M46 (1° apart) with M46's bonus planetary nebula NGC 2438 (resembling a smoke ring).

From naked-eye (2nd magnitude) star Naos, or Zeta (ζ) Puppis, move 2.6° north-west to the open star cluster NGC 2477. Through binoculars it looks like a ghostly, unresolved globular, about 20 arcminutes in diameter. A 150 mm telescope reveals a compact array of over 100 stars, 10th magnitude and fainter. Continuing this trip a further 1.5° north-west discovers the open cluster NGC 2451. The centrepiece to this 1° diameter, celestial gathering is the naked-eye (4th magnitude) orange star c Puppis (HR 3017). Binoculars show around a dozen stars in the magnitude range of 6 to 9. A small instrument (60 mm) will show around 100 stars down to 11th magnitude, many arranged in curving lines. This scattered object is quite a contrast to compact NGC 2477 and these two clusters and Zeta make a brilliant binocular field. While in the area check out another bright luminary, Sigma (σ) Puppis. As well as being clearly visible to the unaided eye it is a brilliant double star for small telescopes, with an obvious yellow/orange primary (3.2 magnitude) in contrast to its white (8.8 magnitude) companion 22 arcseconds away.

Next up, we cross the border into **Carina**, the Ship's Keel (All Sky Map 1), a constellation considered by many as the southern Milky Way's Mecca. The attractive open cluster, NGC 2516, is located west of the False Cross asterism, with the cluster and Epsilon (ε) Carinae easily fitting into a binocular field. However, only the naked eye is needed to see it as a ghostly apparition about 0.5° in diameter. The cluster is best seen through medium sized (150 mm) instruments with around 100 members revealed showing a large variation in colour and brightness, arranged around an outstanding (8th magnitude) central red star.

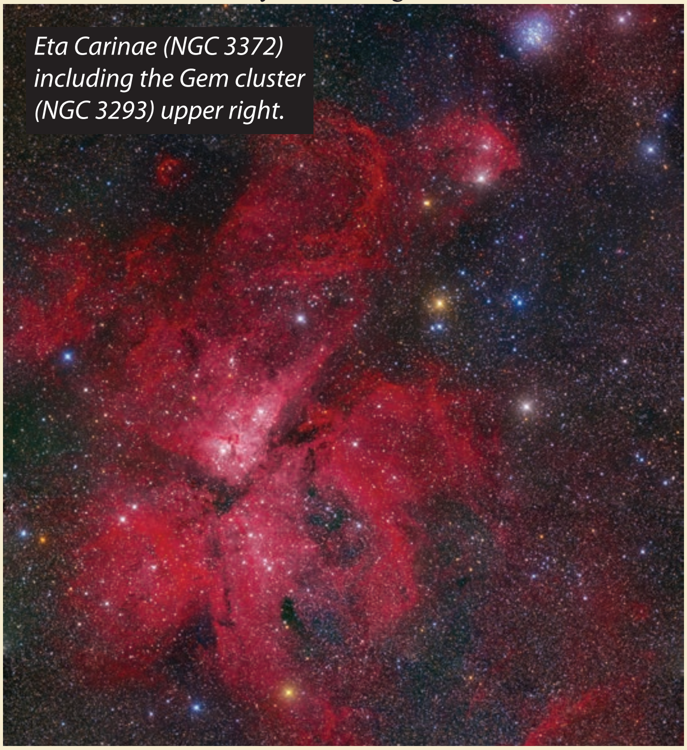
Naked-eye Upsilon (υ) Carinae is one of the finest and brightest double stars in Carina. It consists of a 3rd magnitude yellow primary with a 6th magnitude white companion only 5 arcseconds away to the south-east. A 60 mm telescope at 80 × is all that's needed to split this pair. Only 5 arcminutes to the south-east is WDS 09478-6507. This is a pair of matched, white, 9th magnitude stars, 12 arcseconds apart. This double-double looks great in the same telescopic field. The globular cluster NGC 2808 can be found in the same binocular field as Upsilon, appearing as a small 6th magnitude blob 3.5° west of the star. Any small telescope shows it as a round and very bright object in a star rich field. A 150–200 mm instrument is needed to glimpse some individual members of this city of stars. NGC 2808 is classified as class 1, hence considered one of the most compact globulars in the entire sky. Returning to Upsilon, about a binocular field (5°) north is an obvious naked-eye cloudy patch, the magnificent open cluster NGC 3114. The smallest telescope, 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 field.

Next up, the Southern Pleiades, IC 2602. This distinctive open cluster, is centred on the naked-eye (3rd magnitude) Theta (θ) Carinae, showing six 5th magnitude stars within a 1° diameter circle. It is ideal for small binoculars, which also reveal further fainter stars, in a rich field.

The highlight of Carina, if not the entire southern Milky Way, is the famous Eta Carinae Nebula (NGC 3372) and its surroundings. It is awash with star clusters and nebulae and this brief introduction just scratches the surface. This massive star-forming region is located roughly halfway between the Southern Cross and False Cross. Clearly visible to the unaided eye under dark skies as a prominent hazy patch around 3° across, this area has something for everyone, no matter what instrument is used. Binoculars show bright regions (nebula combined with star clusters) with dark lanes dividing it into three sections. The most prominent of these lanes forms a back-to-front capital L shape. For small telescopes, the inside corner contains the reddish coloured star, Eta (η) Carinae. This fuzzy 5th magnitude star, under high magnification and good seeing, reveals two lobes of gas, called the Homunculus Nebula. This formed in the mid 18th Century when the star went through a nova phase (blowing off these gaseous lobes) for a time outshining Canopus. Next to Eta is the small dark nebula, known as the Keyhole.

Just outside of the main nebula (2° north-west of Eta) lies a truly breath-taking open star cluster, the Gem Cluster (NGC 3293). Even a small telescope reveals its main 40 blue/white stars (8th to 10th magnitude) arranged in a rough 5-arcminute square shape. The cluster also showcases scattered orange, red and yellow stars, its gemstones.

Returning to Eta, pan 3° east to another highlight, the Football Cluster (NGC 3532). Its name comes from its shape, but its claim to fame, is the cluster's sheer size, covering nearly a full degree of sky and containing around 150 stars evenly distributed. There is a lot to see here. Look for coloured stars and many stars arranged in curved lines.


Eta Carinae (NGC 3372) including the Gem cluster (NGC 3293) upper right.

MARCH

Smart Telescopes

The Future of Astrophotography?

Over the past 75 years, amateur astronomy has seen many changes and developments. In the 1950s and 60s, most people who took up the hobby began with small refractors. If you wanted something larger, you could build a six or even a 12-inch (300 mm) Newtonian in kit form. If you were keen enough, you could even grind and polish the mirror.

The 1960s and 1970s marked a turning point with the advent of mass-produced, commercially built instruments. Companies like Criterion, Edmund Scientific, Meade, Unitron, and Questar competed in the marketplace. However, Celestron's 8-inch $f/10$ Schmidt-Cassegrain in 1970 was a game changer. This telescope was praised for its many reflector and refractor-like capabilities. They could be bought off the shelf, and above all, they were portable. For the first time, with light pollution increasing, amateurs could venture into dark skies with these compact instruments.

The late 1980s ushered in the era of computerised or 'goto' telescopes, which could automatically slew to celestial objects. These were a significant improvement from the manual methods of the past, which relied on setting circles or star hopping to locate an object. A comprehensive knowledge of the night sky was crucial for observing in the days before the automated telescopes.

The Dobsonian revolution occurred amid all the advances in telescope and eyepiece design. John Dobson (1915–2014) invented and popularised a basic and cheap altazimuth-mounted telescope. A 'Dob', as these telescopes were affectionately called, may have seemed regressive to some at the time, with a thin mirror, cardboard tube, and plywood mount. But they finally opened up large aperture telescopes at a fraction of the cost of commercial products. Forget tracking or photography with a Dob; grab and push the telescope to the object you want to observe. Today, dedicated visual observers still use these instruments to reveal the Universe's wonders directly to the eye.

In those early years, astrophotography consisted mainly of SLR cameras placed behind the objective or mirror in various configurations. Amateurs dabbled with conventional film, spectroscopic film, hypersensitised film, and homemade cold cameras. The advent of CCD cameras in the 1990s marked a significant leap forward. They were affordable and, combined with software, delivered real power to the hands of the amateur, marking the next stage in the evolution of astrophotography.

Even with all the modern technology, those wanting to get into imaging today soon discover the cost and complexity of building an astrophotography rig. To get started, you will need a telescope, an equatorial mount, a CMOS camera, a guide camera, an electric focuser, a filter wheel, and a computer. If your setup is portable so you can get out of light-polluted skies, you need to polar align on site, and if all is going well, you can begin your light, flat, bias, and dark frames, not to mention the post-processing when you get home and the time it takes to get that perfect image. If you're a beginner, and all this sounds too much, the most recent innovation to hit the amateur astronomy community may be the answer, the smart telescope.

What is a smart telescope? It's everything above in one bundle. All you have to do is take it out of its box, put it outside, switch it on, connect it to your phone or tablet, choose an object, and start photographing. At the end of the exposure, the software processes the frames taken, and the resulting image is then automatically uploaded to your phone or tablet. Simply put, a smart telescope simplifies the imaging process and can make astronomy more accessible and enjoyable for beginners and experienced amateurs alike.

At the time of writing (June 2024), there are four leading manufacturers of smart telescopes: Dwarf Lab, Unistellar, Vaonis, and ZWO. These companies have established themselves in the marketplace, with Celestron, a latecomer to the field, having just released its product. In total, there are around 20 different models across the various brands.

Globular cluster Omega Centauri (NGC 5139)
Exposure 5 min, Seestar S50

ZWO Seestar S50 smart telescope.

While most are expensive, two retail for less than $1,000 in Australia, the Dwarf Lab and the ZWO Seestar. A fantastic price for instruments that integrate a telescope, GOTO and auto-align mount, dew heater, autofocus, light pollution filter, solar filter, and a tripod. The Dwarf Lab and Seestar are designed solely for astrophotography and cannot be used for visual astronomy.

At their price point, both the Dwarf Lab and Seestar S50 are proving popular. Their images are surprising, especially considering their small aperture. As you would expect, they have limitations and can't compare with their large aperture cousins. That said, they both punch above their weight, often over performing expectations. The big selling point of these instruments is their simplicity and convenience. Plonk it down, turn it on, and they do the rest. Both lunar and solar photography are straightforward, although you can forget planetary. These telescopes were designed with a wider field for deep sky imaging, making them of limited value for the planets.

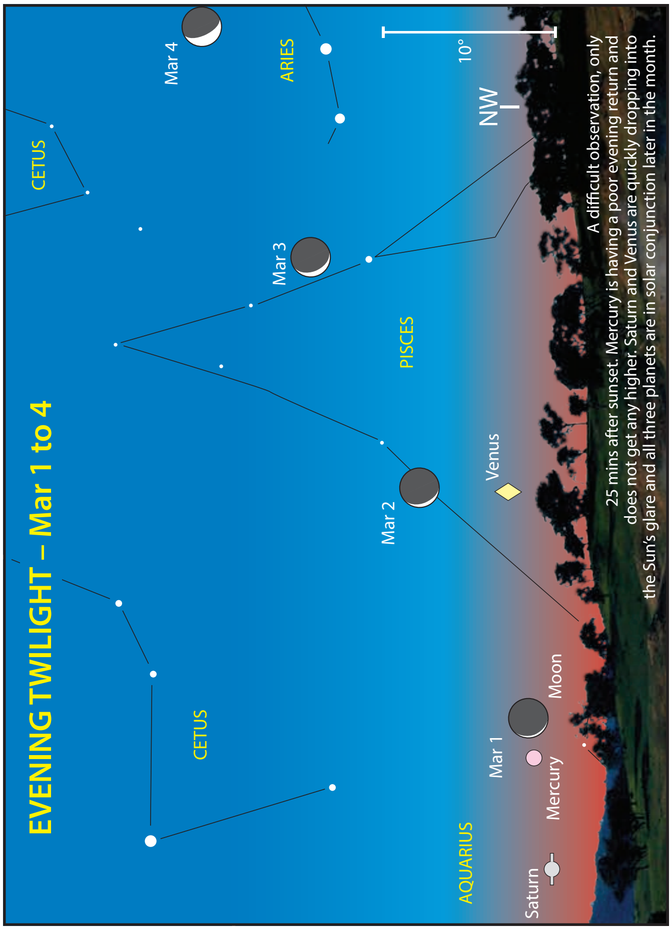
Dwarf Lab smart telescope.

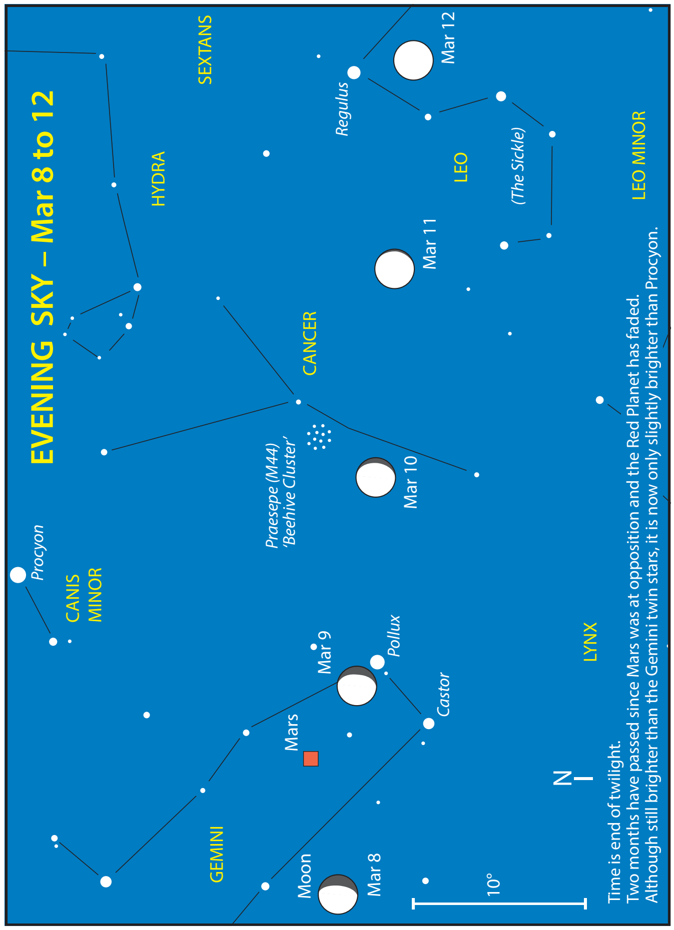
With a smart telescope, there is no need for calibration frames, post-processing, stacking, or any of that; the telescope takes care of all the technical stuff. However, you can significantly improve your images by post-processing using software. The user must decide whether they are happy with the result they achieved with their telescope or want to go down the rabbit hole of hours and hours of post-processing time. The sample images accompanying this article are straight from a Seestar S50 without further processing.

While some in the astrophotography community may view smart telescopes as too simplistic, they are gaining popularity among beginners and experienced amateurs alike. As lightweight, compact instruments, they are great for camping and travel. Conversely, their built-in light pollution filters make them equally at home under suburban skies.

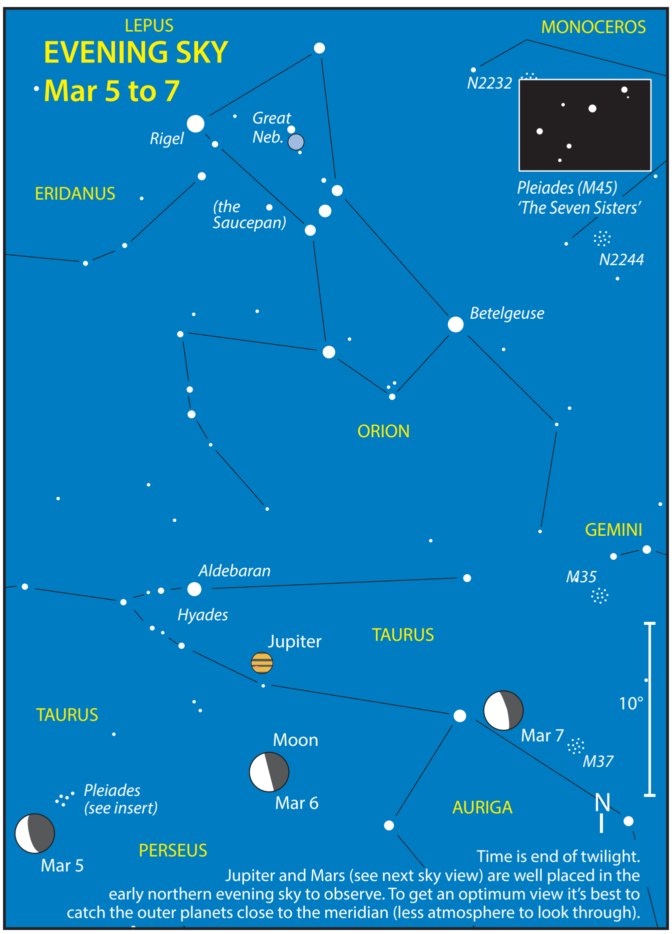
While high-end setups still offer unparalleled image quality, smart telescopes are now giving us a glimpse into the future of astrophotography. It will be interesting to see what develops in the next few years. These telescopes are gaining interest from a new generation of people who may have otherwise walked away from the hobby because they lack the time, technical ability, or budget. And that is a good thing.

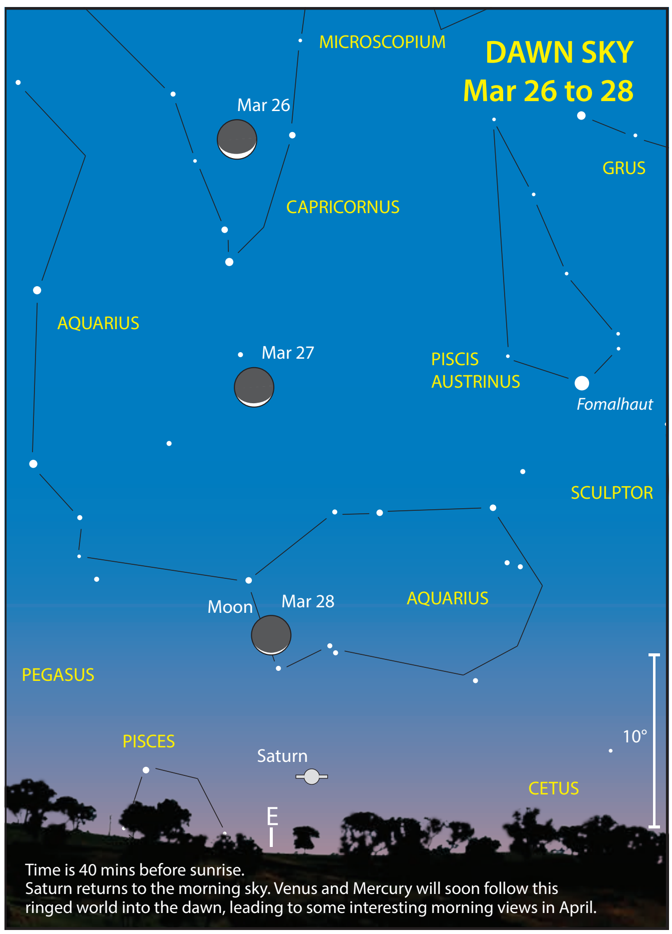
The Trifid Nebula M20 (NGC 6514)
Exposure 50 minutes, Seestar S50



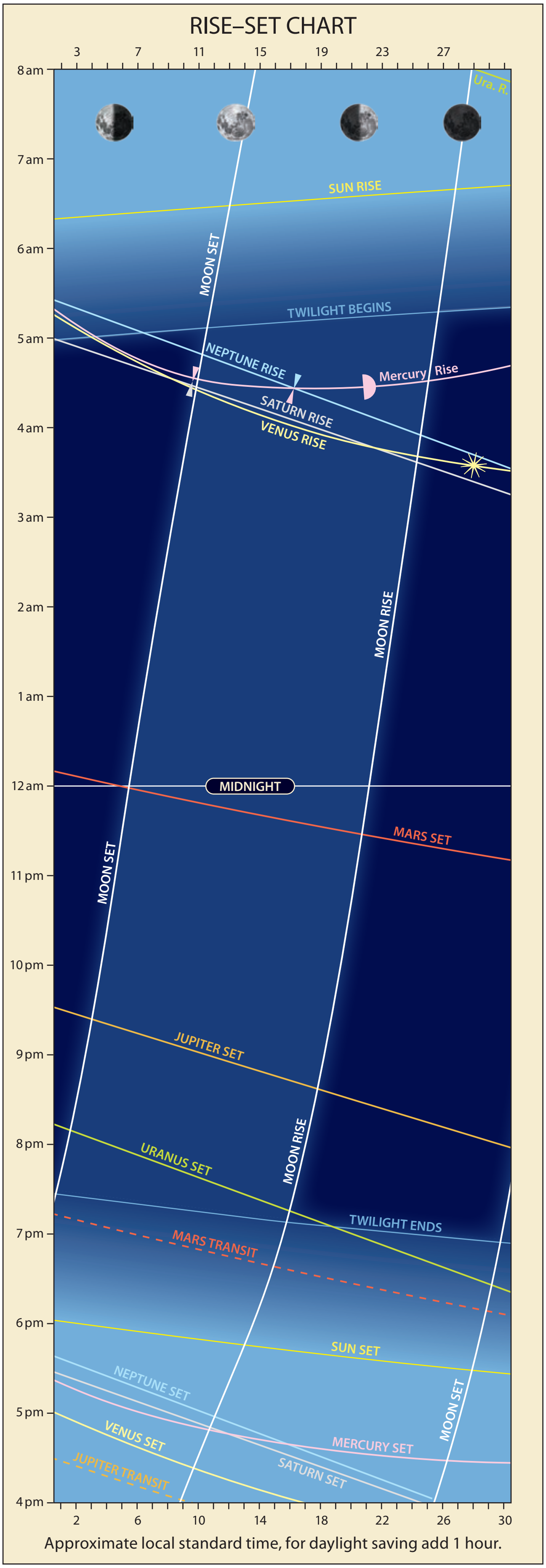


Approximate local standard time, for daylight saving add one hour.





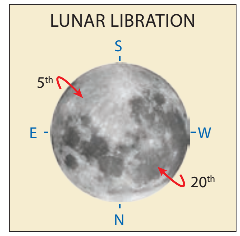
APRIL



HIGHLIGHTS

- Mercury at best in the pre-dawn sky this year.
- Mercury and Saturn close.
- Mercury and Neptune close.
- Mercury and the Moon close.
- Venus at its greatest brilliance.
- Four planets in Pisces.

THE MOON



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

5th Noon (10 am WST) First Quarter.

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

14th 9 am (7 am WST) Moon at apogee (furthest from Earth at 406,295 km).

20th Noon (10 am WST) Maximum Libration (9.6°), bright NW limb.

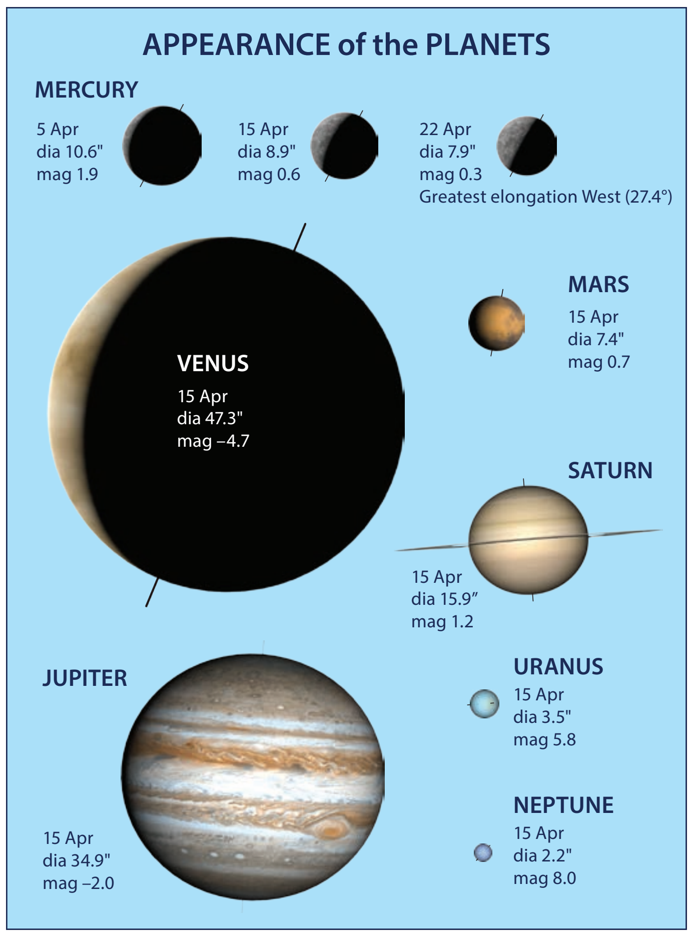
21st Noon (10 am WST) Last Quarter.

28th 2 am (Midnight WST, previous day) Moon at perigee (closest to Earth at 357,119 km).

28th 6 am (4 am WST) New Moon.

THE PLANETS

Mercury begins its best period for morning observation this month. The planet reaches its greatest elongation 27° west of the Sun on the 22nd. With the ecliptic (the plane of the planetary orbits) nearly vertical, this is an excellent



opportunity to glimpse this small world without interference from the brightening dawn. Mercury joins Venus, Saturn, and Neptune in the dawn sky and approaches within about 2° of the Ringed Planet from the 10th to 12th. At this time, both planets are of equal magnitude, and the best way to distinguish them is by noting Saturn is above Mercury. From the 17th to the 18th, Mercury will be less than 1° from the outermost planet, Neptune, although binoculars will be required to view the planetary duo. Finally, to end a busy month for the innermost planet, it appears just 4° south of the 27-day-old waning crescent Moon on the 26th, a pleasant visual sight in the pre-dawn sky (see Sky View).

After conjunction with the Sun last month, **Venus** joins Mercury, Saturn, and Neptune in the eastern morning dawn. The planet will now grace our skies as the Morning Star for the rest of the year. On the 25th, the 26-day-old waning crescent Moon appears above Venus and Saturn, forming a triangle. Venus is at its greatest illuminated extent (or greatest brilliancy) on the 27th at −4.8 magnitude (see explanation in February Venus section). In April, Venus will traverse the Circlet of Pisces.

In the early northern evening sky, **Mars** spends the first half of April in Gemini before moving into Cancer (see Sky View). Between the 1st and the 3rd, the planet will be within 30 arcminutes of the 4th magnitude star Kappa (κ) Geminorum. Kappa is a fine double star; the primary is a rich yellow, and its fainter 8th magnitude companion is slightly bluish. The delta magnitude (the difference in brightness between the two components of a double star system) is 4.7, indicating a substantial variation in brightness. Mars is at its eastern quadrature on the 21st, where the Sun-Earth-Mars angle is 90° (see Orbital Aspects diagram p. 16). At this time, Mars displays its minimum phase with 90% 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 the Full Moon.

This month, **Jupiter** is visible low in the north-western sky as twilight gives way to night (see Sky View). As the distance from Earth to Jupiter has increased since its December opposition, telescope users will note a substantial decrease in image size, down from 48 to 35 arcseconds. Less noticeable is its magnitude drop, from −2.8 to −2.0; despite this, it remains the brightest object in the evening sky aside from the Moon. The planet passes by NGC 1746 early in the month, a loose and irregularly scattered open cluster with many orange/red stars spanning 0.7°, best viewed with binoculars.

Saturn, now past conjunction, rises in the eastern morning sky around 4 am mid-month. Towards the end of the month, the planet moves from Aquarius and into Pisces, joining Venus, Mercury, and Neptune in that constellation for a brief period. The constellation of the Fishes will be the Ringed Planet's home until it moves into Cetus in April 2026 (aside from a little side excursion back into Aquarius later this year due to retrograde motion). The planet has a close visit by Mercury between the 10th and 12th (see Mercury). On the 25th, the 26-day-old waning crescent Moon will be 4° from the planet and form a triangle with Venus (see Sky View).

Uranus, in Taurus, is very low in the north-western sky at the end of astronomical twilight. Next month, it will be in conjunction with the Sun and will return to the morning skies in June.

Neptune, in Pisces, reappears in the eastern dawn sky after its conjunction with the Sun last month. From the 17th to the 18th, Neptune will be less than 1° from the innermost planet, Mercury (see Mercury).

DIARY

Tue	1st		Venus 0.3° W of star Iota Piscium
Wed	2nd		Mars 0.5° S of star Kappa Geminorum
Thu	3rd	7 pm	(5 pm WST) Jupiter 8° SW of Moon
Thu	3rd		star Pollux 4° N of Mars
Sat	5th		m.p. 11 Parthenope 0.1° N of star Epsilon Tauri
Sat	5th	5 am	(3 am WST) Maximum Libration (9.7°), bright SE limb.
Sat	5th	Noon	(10 am WST) First Quarter Moon.
Sat	5th	10 pm	(8 pm WST) star Pollux 4° E of Moon
Sat	5th	10 pm	(8 pm WST) Mars 6° SE of Moon
Sun	6th	pm	m.p. 28 Bellona 0.1° N of M44 Beehive Cluster (OC) in Cancer
Mon	7th	am	m.p. 9 Metis 0.6° S of star Gamma Librae
Wed	9th		m.p. 15 Eunomia 0.9° S of NGC 2158 (OC) in Gemini
Wed	9th	1 am	(11 pm WST, prev day) star Regulus 2° S of Moon
Thu	10th		Jupiter 1.2° S of NGC 1746 (OC) in Taurus
Thu	10th		m.p. 15 Eunomia 1.0° S of M35 (OC) in Gemini
Thu	10th	am	Comet C/2023 A3 (Tsuchinshan-ATLAS) 0.4° E of NGC 6905 (PN) in Delphinus
Thu	10th	10 pm	(8 pm WST) m.p. 8 Flora 0.1° E of NGC 3628 (G) in Leo
Thu	10th	pm	m.p. 8 Flora 0.6° N of M66 (SG) in Leo
Sun	13th	10 am	(8 am WST) Full Moon (406,006 km, furthest for this year).
Sun	13th	7 pm	(5 pm WST) star Spica 4° W of Moon
Sun	13th	pm	m.p. 8 Flora 0.6° N of M65 (SG) in Leo
Mon	14th	9 am	(7 am WST) Moon at apogee (furthest from Earth at 406,295 km).
Tue	15th		m.p. 14 Irene 1.0° S of star Tau Geminorum
Wed	16th		m.p. 15 Eunomia 0.8° S of Collinder 89 (OC) in Gemini
Thu	17th	5 am	(3 am WST) star Antares 2° E of Moon
Thu	17th		Neptune 0.5° N of Mercury
Sun	20th		d.p. 1 Ceres 0.7° NW of NGC 7727 (G) in Aquarius
Sun	20th	5 am	(3 am WST) m.p. 15 Eunomia 0.15° NW of star Nu Geminorum
Sun	20th	Noon	(10 am WST) Maximum Libration (9.6°), bright NW limb.
Mon	21st	Noon	(10 am WST) Last Quarter Moon.
Tue	22nd	am	Lyrids meteor shower, Apr 16–25, Moon affected.
Tue	22nd		Mercury at greatest elongation West (27.4°)
Wed	23rd		Venus 1.0° S of star Lambda Piscium
Thu	24th	pm	pi-Puppids meteor shower, Apr 15–28, Moon affected.
Fri	25th		m.p. 14 Irene 0.8° N of star Iota Geminorum
Fri	25th	5 am	(3 am WST) Saturn 4° E of Moon
Fri	25th	5 am	(3 am WST) Venus 4° NE of Moon
Sat	26th	5 am	(3 am WST) Neptune 8° SW of Moon
Sat	26th	5 am	(3 am WST) Mercury 4° SE of Moon
Sat	26th	pm	m.p. 4 Vesta 0.2° S of star 16 Librae
Mon	28th	2 am	(Midnight WST, prev day) Moon at perigee (closest to Earth at 357,119 km).
Mon	28th	6 am	(4 am WST) New Moon.
Tue	29th	am	m.p. 63 Ausonia 1.2° NW of star Psi Capricorni
Tue	29th		Saturn 4° S of Venus
Wed	30th	6 pm	(4 pm WST) Jupiter 9° SE of Moon

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

From mid-April, for around a month, Vesta will be brighter than 6th magnitude and considered to be visible to the naked eye (see plot on All Sky Map 6). This will need dark skies, however being this bright should make this minor planet easy to follow in binoculars. April and May will see Eunomia visit several bright stars and open clusters in Gemini, see Diary. From the 4th to 9th, a faint Bellona (11th magnitude) crosses M44 (the Beehive Cluster) in Cancer. On the night of 10th, Flora (10th magnitude) is on the western edge of the bright spiral galaxy NGC 3628. The following night, Flora is on the eastern edge. This is a member of the famous Leo Triplet, with the other members being M65 and M66, see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
10 Apr	389 Industria	Corvus	11.0
11 Apr	121 Hermione	Virgo	12.8
12 Apr	128 Nemesis	Virgo	12.0
17 Apr	37 Fides	Virgo	11.3
21 Apr	216 Kleopatra	Virgo	11.8
24 Apr	324 Bamberga	Hydra	12.1
28 Apr	451 Patientia	Virgo	11.6
29 Apr	192 Nausikaa	Virgo	11.4

COMET

Comet C/2023 A3 (Tsuchinshan-ATLAS) starts April in Delphinus about magnitude 12.5, rising in the eastern sky around 2:30 am. By mid-month it has moved into Vulpecula, rising in the north-eastern sky around 1:30 am and by month's end, transiting low in the northern sky shortly before sunrise having faded to magnitude 13.

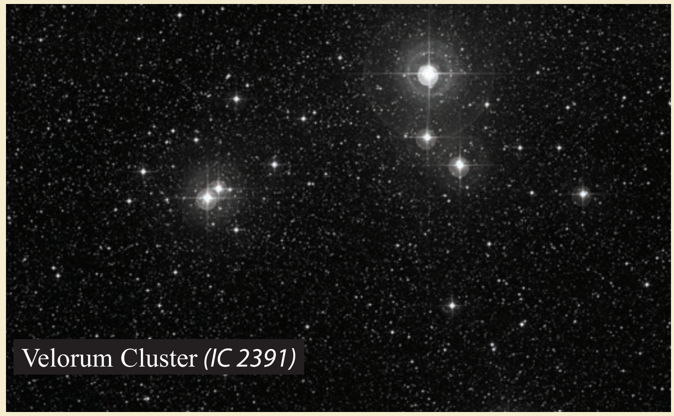
METEOR SHOWERS

The **Lyrids** are a Northern Hemisphere shower visible south of the equator. Best from April 16–25, with maximum rates expected late on the 22nd and into the morning hours of the 23rd when their radiant is highest. The peak may only last an hour; typically, the ZHR is around 18 (perhaps five or six from mid-Australian latitudes). The Lyrids have occasionally produced higher rates, and because of their erratic nature, they are a shower to keep an eye on. Unfortunately, the Last Quarter Moon on the 21st will cause significant interference during maximum.

The **pi-Puppids** are a young southern shower produced by Comet 26P/Grigg-Skjellerup. They are visible from April 15–28 and peak on the morning of the 24th. However, before and after the maximum, the rates are low and difficult to separate from sporadic meteors. The pi-Puppids are known for their slow speed, brightness, persistent trains, yellow meteors, and occasional fireballs. They are best seen from dusk to midnight but will suffer the same fate as the Lyrids this year with lunar interference.

CONSTELLATIONS

The constellation of **Vela**, The Sails (best seen on All Sky Map 4), being enriched by the Milky Way, has around 20 objects bright enough to be considered visible in binoculars. It's located north of Carina, with the False Cross asterism linking the constellations by borrowing two stars from each, Kappa (κ) and Delta (δ) Velorum plus Iota (ι) and Epsilon (ε) Carinae.


Velorum Cluster *(IC 2391)*

The Omicron (o) Velorum Cluster, IC 2391, is bright and scattered (1° across) making it an ideal binocular object. Located 2° north of 2nd mag Delta (δ) Velorum (a member of the False Cross asterism), the cluster has around 30 stars down to magnitude 11. However, it has six prominent members, 7th magnitude and brighter, which are dominated in the centre by naked-eye (3rd magnitude) Omicron. Only 5° north is another remarkable open star cluster, IC 2395. It shows two dominant 5th and 7th magnitude stars approximately 5 arcminutes apart, with an impressive arc of around 20 stars, 8th to 10th magnitude, joining them. The region just keeps on giving. Approximately 1° south-east of IC 2395 you will find the unusual open cluster NGC 2670. A 150 mm telescope shows a somewhat sparse cluster consisting of around thirty stars arranged in a distinct, equilateral, triangle shape, approximately 6 arcminutes across. Its members appear similar in colour and brightness (11th magnitude). One of the edges of the triangle runs north to south and has pretty triple and double stars included.

Now return to the False Cross. Starting with Kappa (κ) Velorum, scan 2.4° north-east to discover the open star cluster NGC 2910. It is a compact cluster (5 arcminutes across) composed of about 40 stars, mostly 10th to 12th magnitude, in a bright star field. It is distinctly crescent in appearance, with a more densely packed triangular shaped region.

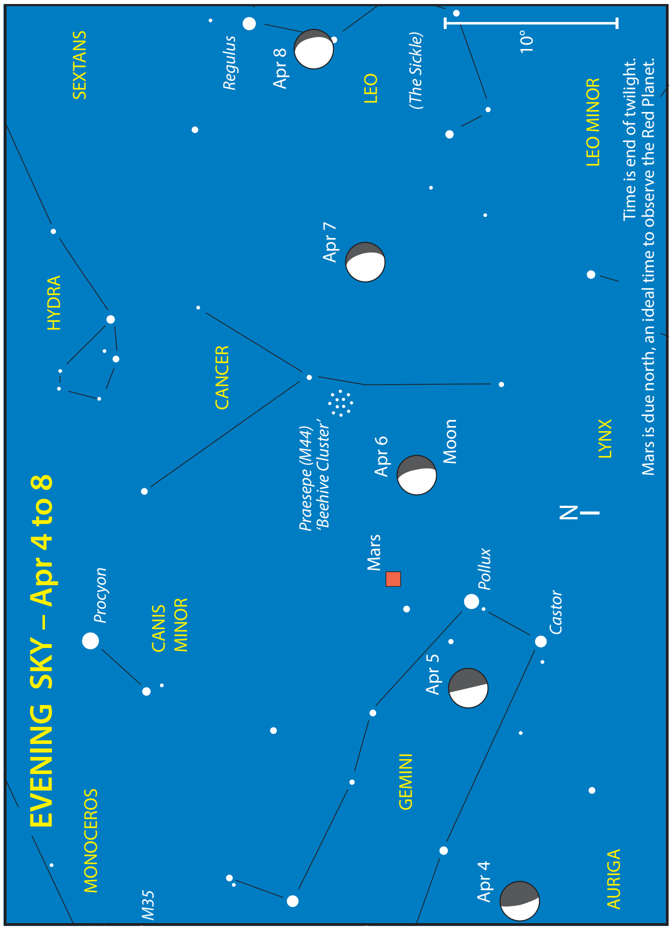
Vela's most famous and brightest double star is Gamma (γ) Velorum with binoculars showing two white stars of magnitude 1.8 and 4.2, separated by 41 arcseconds. However, a small telescope clearly shows two additional, slightly yellow, companions of magnitude 7.4 and 9.2 to the south-east, 60 and 90 arcseconds respectively from the main pair, a brilliant multiple star! Only 2° south, the binocular view of Gamma is enhanced by including the open cluster NGC 2547, showing its ten brightest (8th magnitude) members loosely scattering across a 0.5° field. It includes a distinctive curve of stars, running north-south, centred on a 6.4 magnitude white star. A small telescope reveals around 30 fainter members around 10 to 11th magnitude peppering the field.

The globular star cluster, NGC 3201 is quite bright at 6.7 magnitude and easily found in binoculars. It is diffuse, with a wide bright centre. Around a 150 mm instrument is needed to occasionally glimpse (resolve) some of its brighter stars, at magnitude 12.

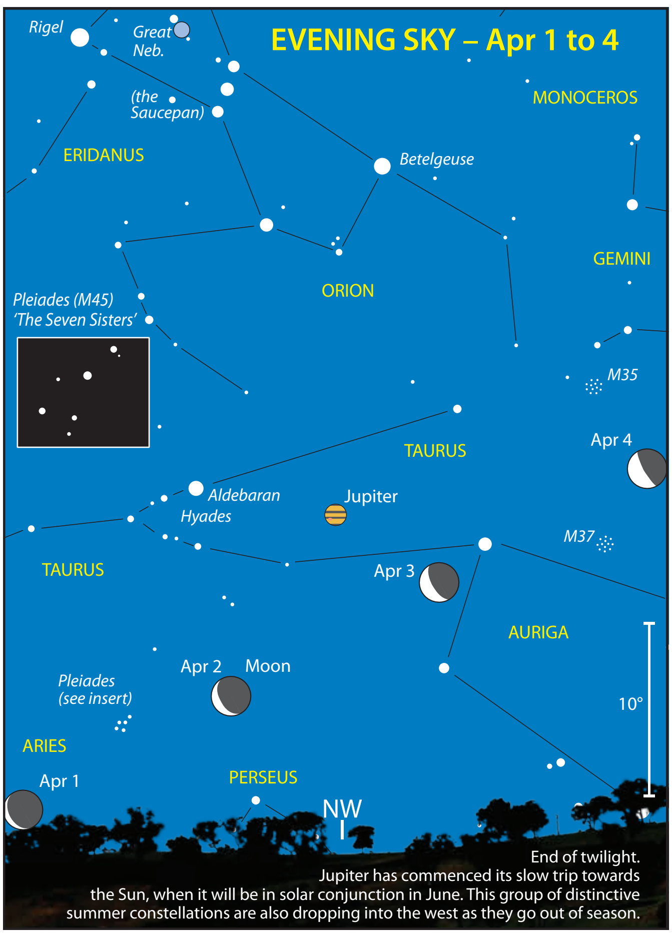
Near Vela's border with Antlia lies the 9th magnitude planetary nebula NGC 3132, better known as the Eight Burst Nebula. It is visible through any size telescope, with a 150 mm instrument showing a prominent 2-arcminute, slightly elliptical ring with a 10th magnitude central star. The interior nebula appears mottled.

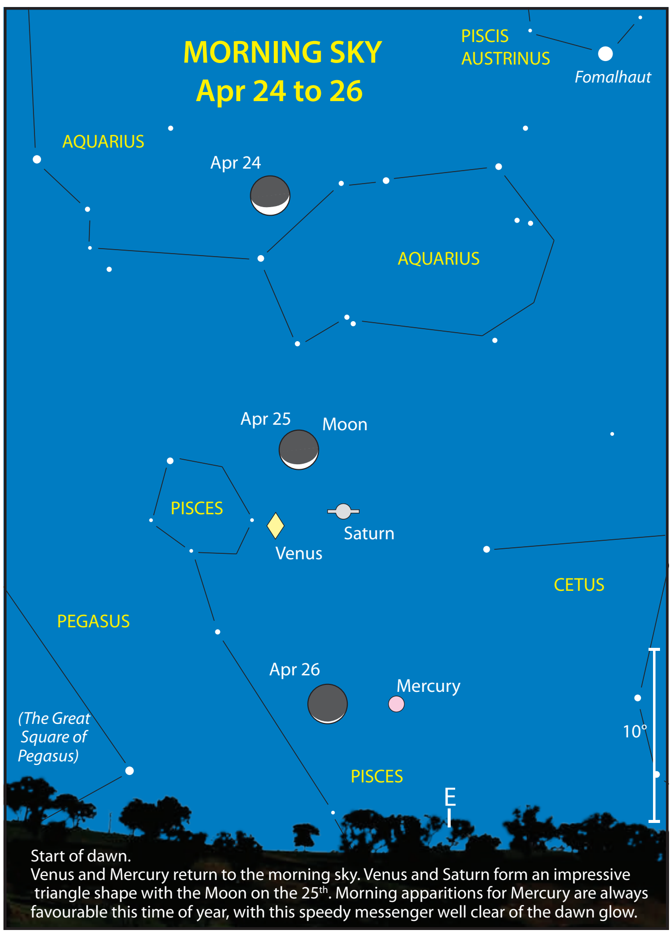
Antlia the Air Pump (All Sky Map 4) is an obscure southern constellation with its brightest star, Alpha (α) Antliae only magnitude 4.2. Alpha forms a nice naked-eye double with Delta (δ) Antliae, 0.7° to the north-east. Delta, itself, is a great double comprised of a 5.5 magnitude yellow primary with its fainter (9.8 magnitude) companion a comfortable 10 arcseconds away. Having now moved out of the plane of the Milky Way, Antlia is best known for its galaxy cluster. For a large face-on spiral galaxy, 10th magnitude, NGC 2997 has a reasonable surface brightness showing a haze (5 × 4 arcminutes), with an obvious almost stellar nucleus. At least a 250 mm telescope is needed to glimpse some of the spiral structure.

Globular cluster NGC 3201

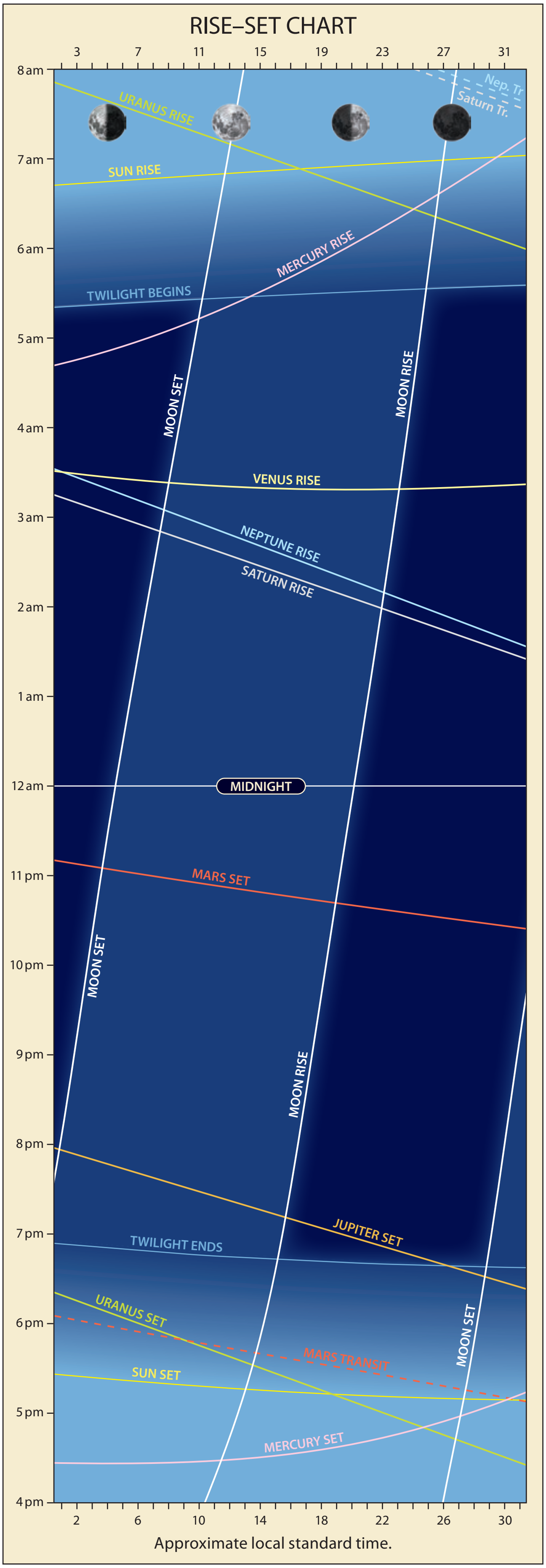


Approximate local standard time, for daylight saving add one hour.





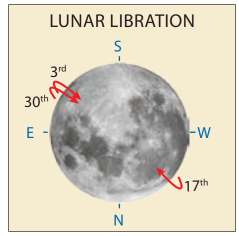
MAY



HIGHLIGHT

- Venus and Moon close.
- Mars near the Beehive cluster.
- Mars and Moon close.
- Saturn and Neptune close.
- The eta-Aquarids meteor shower.

THE MOON



3rd 2 am (Midnight WST, previous day) Maximum Libration (9.6°), bright SE limb.

4th Midnight (10 pm WST) First Quarter.

11th 11 am (9 am WST) Moon at apogee (furthest from Earth at 406,244 km).

13th 3 am (1 am WST) Full Moon.

17th 7 pm (5 pm WST) Maximum Libration (8.7°), bright NW limb.

20th 10 pm (8 pm WST) Last Quarter.

26th Noon (10 am WST) Moon at perigee (closest to Earth at 359,022 km).

27th 1 pm (11 am WST) New Moon.

30th 11 pm (9 pm WST) Maximum Libration (8.8°), bright SE limb. The 114 km crater Lyot is ideally suited for observation as it emerges from the libration zone.

APPEARANCE of the PLANETS

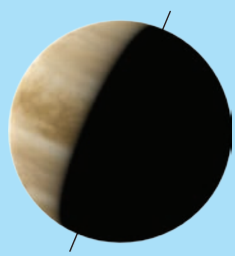
MERCURY Mercury is in superior conjunction on the 30th

1 May
dia 6.8"
mag 0.0

10 May
dia 6.0"
mag –0.4

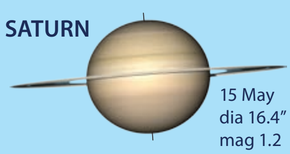
20 May
dia 5.3"
mag –1.1

VENUS
15 May
dia 29.6"
mag –4.6



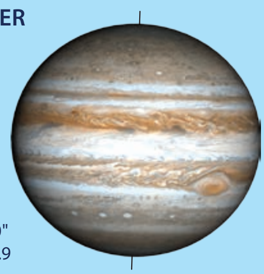
MARS
15 May
dia 6.1"
mag 1.1

SATURN



15 May
dia 16.4"
mag 1.2

JUPITER



15 May
dia 33.0"
mag –1.9

URANUS
1 May
dia 3.4"
mag 5.8
Conjunction on 18th

NEPTUNE
15 May
dia 2.2"
mag 7.9

THE PLANETS

Mercury is readily visible in the eastern pre-dawn sky during the first half of the month. However, it becomes increasingly difficult to see as it journeys back towards the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 30th.

Venus is brilliant in the eastern dawn sky in Pisces. On the 24th, the planet will be 4° from the 26-day-old waning crescent Moon, two gems in an otherwise barren part of the sky (see Sky View).

Mars, in the early northern evening sky, spends most of the month in Cancer before moving into Leo. In early May, the Red Planet will be within a few degrees of the Beehive (M44) and will skim past the cluster's outliers on the 5th (see Sky View). The planet should make a nice colour contrast between the brighter cluster members of about a dozen yellow-white suns brighter than 7th magnitude. Even a small telescope or binoculars will show around 75 members in this cluster, which Galileo first resolved into stars in 1610. On the 4th, the First Quarter Moon will be within 5° of Mars.

The King of Planets, **Jupiter**, is in Taurus in the early western evening sky (see Sky Views). It becomes increasingly difficult to see late in the month as it moves into the brighter dusk sky and conjunction next month. Callisto, the outermost of the planet's four Galilean Moons, is the only one not eclipsed by Jupiter's shadow on each orbit about the planet. Instead, Callisto's eclipses occur in a series every six years. The next series begins on May 29 and continues until June 2028 for a total of 67 eclipses. See Jupiter Moon

Great Observatory for Long Wavelengths (GO-LoW)

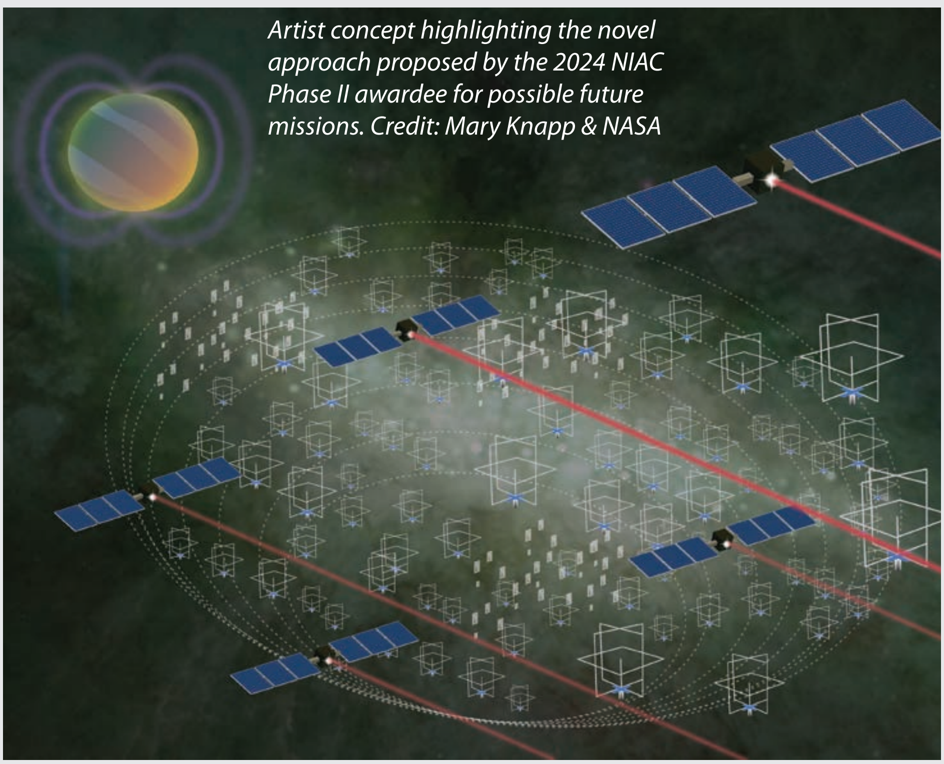
Humankind has never before seen the low frequency radio sky. It is hidden from ground-based telescopes by the Earth's ionosphere and challenging to access from space with traditional missions because the long wavelengths involved (metre to kilometre-scale) require infeasibly massive telescopes to see clearly. Electromagnetic radiation at these low frequencies carries crucial information about exoplanetary and stellar magnetic fields (a key ingredient to habitability), the interstellar/intergalactic medium, and the earliest stars and galaxies.

GO-LoW proposes an interferometric array of thousands of identical SmallSats at an Earth-Sun Lagrange Point (e.g. L5) to measure the magnetic fields of terrestrial exoplanets via detections of their radio emissions at frequencies between 100 kHz and 15 MHz. Each spacecraft will carry an innovative Vector Sensor Antenna, which will enable the first survey of exoplanetary magnetic fields within five parsecs.

In a departure from the traditional approach of a single large and expensive spacecraft (e.g. HST, Chandra, JWST), they propose an interferometric Great Observatory comprised of thousands of small, cheap, and easily replaceable nodes. Interferometry, a technique that combines signals from many spatially separated receivers to form a large 'virtual' telescope, is ideally suited to long wavelength astronomy. The individual antenna/receiver systems are simple, no large structures are required, and the very large spacing between nodes provides high spatial resolution.

Early studies found that a hybrid constellation architecture was most efficient. Small and simple listener nodes (LNs) collect raw radio data using a deployable vector sensor antenna. A small number of larger, more capable communication and computation nodes (CCNs) collect data from LNs via a local radio network, perform beamforming processing to reduce the data volume, and then transmit the data to Earth via free space optics (lasercomm). Cross correlation of the beamformed data is performed on Earth, where computational resources are not tightly constrained. The CCNs are also responsible for constellation management, including timing distribution and ranging.

In the study, that NASA has now funded, they will (1) develop a simulation of the GO-LoW constellation that demonstrates the autonomous operations architecture required to achieve a large (up to 100 k) constellation outside of Earth's orbit, (2) continue to refine the science case and requirements by simulating science output from the constellation, (3) develop appropriate orbital modelling to assess propulsion requirements for station keeping at a stable Lagrange point, and (4) further refine the technology road map required to make GO-LoW feasible in the next 10–20 years.



Artist concept highlighting the novel approach proposed by the 2024 NIAC Phase II awardee for possible future missions. Credit: Mary Knapp & NASA

Events, page 117 for all upcoming transits, shadow transits, occultations and eclipses once the planet is favourable for viewing again.

Saturn begins May with brilliant Venus 4° away in the eastern dawn sky. The pair of unequal-magnitude planets quickly separate early in the month. Saturn and Neptune are also preparing to meet up for a rendezvous and, at month's end, will be 1.5° apart. By the end of June, these two giants will be within a degree of each other and look excellent in a telescope with a wide field of view. By mid-month, Saturn is rising around 2 am, and on the 23rd, the 25-day-old waning crescent Moon will be 4° from the planet (see Sky View).

Uranus is in conjunction with the Sun on the 18th, after which it reappears in the eastern dawn sky in early June. It is interesting to note (although unobservable) that the Sun occults Uranus at this conjunction. These occultations occur near when Uranus passes through the nodes of its orbit, resulting in a series of 10 annual occultations. The last series, each year from 1980 to 1989, was on the descending node. On the ascending node, this current series began last year and will end in 2033. With an 84-year orbital period, the next set of 10 starts in 2113.

Early in the month, **Neptune**, Venus, and Saturn all fit within a 4° circle in the morning eastern sky in Pisces (binoculars will be required to include the fainter outermost ice giant). By the end of the month, the planet will be 1.5° from Saturn, making a neat wide-field telescopic view.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
1 May	372 Palma	Centaurus	13.1
2 May	4 Vesta	Libra	5.8
5 May	31 Euphrosyne	Libra	11.9
9 May	9 Metis	Libra	9.7
12 May	349 Dembowska	Libra	10.2
15 May	3 Juno	Serpens	10.1
20 May	354 Eleonora	Hercules	10.3

METEOR SHOWER

The **eta-Aquarids** are linked with Halley's Comet and are among the most popular Southern Hemisphere showers. They are visible from April 19 to May 28, with the peak expected during the morning of the 6th. The maximum rate of 40 or more will likely be seen before dawn since the radiant in Aquarius reaches its highest altitude a little after sunrise. Their high percentage of persistent trains characterises the eta-Aquarids. They are very swift and are a striking yellow colour. With the 9-day-old Moon setting around midnight, morning observations will be free of moonlight.

CONSTELLATIONS

The Southern Cross (Crux) and the Pointers are iconic to the southern skies (All Sky Map 1). The bottom star in **Crux** is Alpha (α) Crucis or Acrux. Binoculars show this 0.8 magnitude star to have a 5th magnitude companion 90 arcseconds away. The smallest telescope reveals the main star as a pair of nearly matched blue/white 1st magnitude (1.4, 1.9) stars, only 5 arcseconds apart. Also in Crux is the 5th magnitude open cluster NGC 4755, the Jewel Box. Through binoculars this tight, 10-arcminute arrowhead shaped group is in the same field as Beta (β) Crucis. A small telescope shows a collection of blue/white stars with a central red star appearing like a ruby in a diamond setting. Just 2 arcminutes west of Beta is one of the reddest stars known, Ruby (DY) Crucis. A 100 mm telescope shows this 9th mag gem well (move Beta out of the field to avoid the glare).

Head to the south-east corner of Crux to discover the prominent, naked-eye dark nebulae, the Coalsack. This large (7° wide) irregularly shaped dark gaseous cloud is only visible because it is silhouetted against the glow of our galaxy. It also forms the head of the Aboriginal constellation of the Emu. Can you spot its beak and 5th magnitude eye (star)?

Although **Centaurus**, the Centaur (see All Sky Maps 1 and 6) is mostly recognised for the two pointer stars (Map 1), down under amateurs know the constellation as home to a few of the brightest and most popular deep sky objects. It is a large constellation with a presence, not only within the plane of the Milky Way, containing numerous open star clusters and nebulae, but extending well beyond and showcasing impressive galaxies and galaxy clusters.

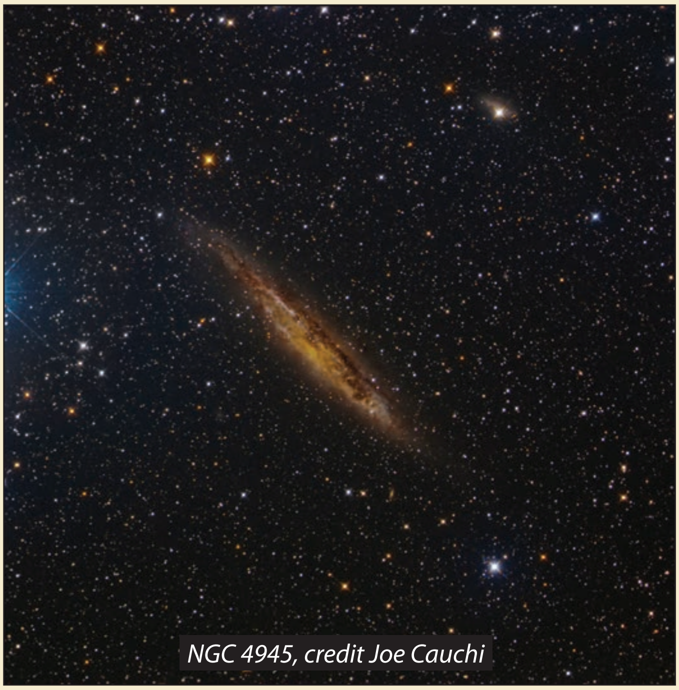
Alpha (α) Centauri, the yellow-coloured left pointer is the third brightest star in the sky. The smallest of telescopes reveals it's the brightest double star as well with magnitudes of −0.1 and 1.3, currently 9 arcseconds apart (it is also a binary star with its stars orbiting each other every 80 years). Being only 4.3 light-years from the Solar System, Alpha used to be considered our nearest neighbour until its faint (10.5 magnitude) third component, Proxima Centauri (2° south of Alpha) was found to be slightly closer.

Our next stop is the brightest globular cluster in the sky NGC 5139, Omega (ω) Centauri (Map 6). Even to the naked eye it appears fuzzy. You can find this 3rd magnitude object by drawing a line from beta (β) to Eta (η) Centauri

Jewel Box NGC 4755, credit Joe Cauchi

and extending it the same distance. This city of stars, 0.5 degrees across, is impressive but needs a 150 mm telescope to resolve it as a condensed myriad of stars showing fine lacy patterns. Heading 4° east-south-east from Omega there is a triangle of stars, which includes the 4th magnitude Xi (ξ) Centauri wide double star. A 150 mm telescope reveals the galaxy, NGC 4945 (Map 6), slashing across one corner. This distinctive 9th magnitude, edge-on spiral, at low power looks like a white streak (22' × 2'). Its surface appears mottled, which brightens towards its equator. Some dark lanes are present and 4945 has an ill-defined bright core.

In contrast, 7th magnitude peculiar galaxy NGC 5128 (also known as Cen A) Map 6, appears roughly circular (15' across) with a prominent wide, dark equatorial band, clearly seen through small telescopes, cutting the galaxy in half, leading to its nickname the Hamburger Galaxy. It is located 5° north of Omega Centuari.



NGC 4945, credit Joe Cauchi

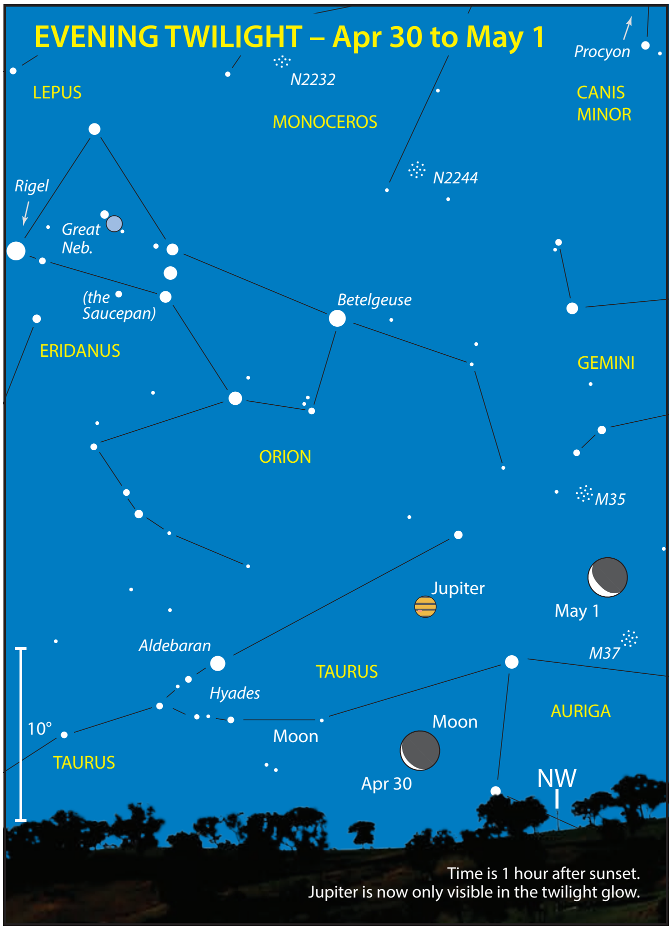
The naked-eye (3rd magnitude) star Lambda (λ) Centauri (Map 1) is located on the north-western edge of a large, sparse open star cluster IC 2944. Its most distinctive feature is an alignment of around a dozen stars appearing to flow away from Lambda towards the south-east, all fitting in a 0.5° field. IC 2944 also has a nebula component, the visually challenging Running Chicken Nebula. Just 1.5° north of Lambda is an impressive open cluster NGC 3766. Binoculars show a distinctive hazy patch standing out in a rich Milky Way region. Telescopes show a compact (10 arcminute), fan-shaped array of mostly 9th to 11th magnitude white stars, hence, the Pearl Cluster. Enjoy the complex arrangement of interlocked curved lines of stars.

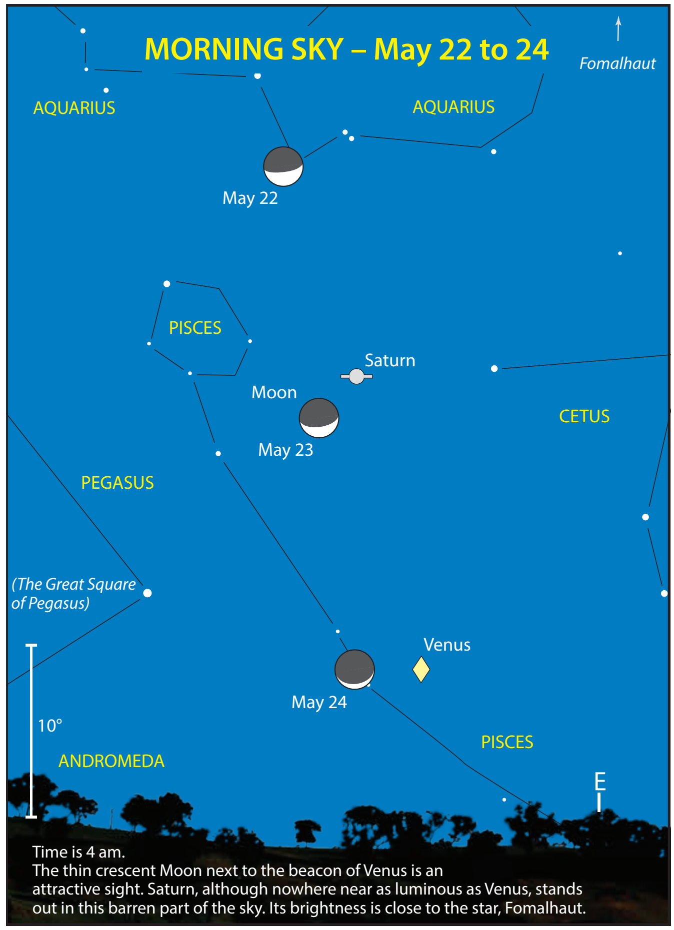
The constellation of **Musca** the Fly (All Sky Map 1) lies beneath (south of) Crux and is marked by four naked-eye (3rd and 4th magnitude) stars arranged in the shape of a trapezium. Musca is best known for two globular clusters, both easy to find, being about 40 arcminutes (a low power eyepiece field) from 4th magnitude stars, both suitable for 150 mm telescopes. NGC 4372, south-west of gamma (γ), is large and faint, but resolved into stars with no obvious central brightening. In contrast, NGC 4833, north of delta (δ), noticeably brightens towards the centre.

Heading to northern Musca, take a brief visit to planetary nebula NGC 5189, 5° north-east from Beta (β) Muscae. This is quite an unusual planetary. Photographically, it resembles a barred spiral galaxy, but visually through 150–200 mm instruments, only the central bar is visible, an oval measuring 1 × 2 arcminutes.

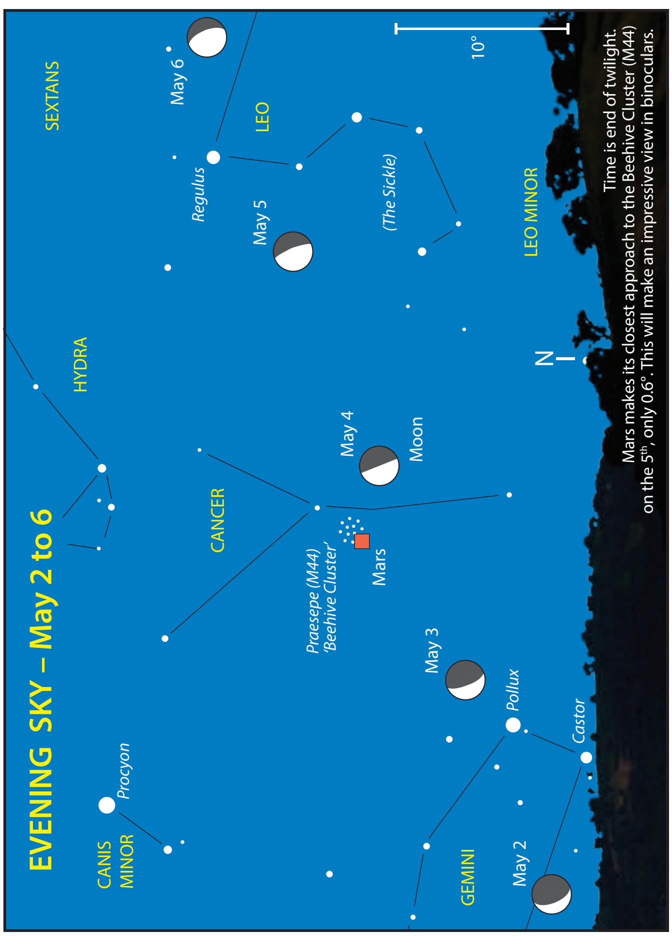
DIARY			
Fri	2nd		Vesta at opposition
Fri	2nd	pm	m.p. 532 Herculina 0.9° S of NGC 5897 (GC) in Libra
Sat	3rd	2 am	(Midnight WST, prev day) Maximum Libration (9.6°), bright SE limb.
Sat	3rd	7 pm	(5 pm WST) star Pollux 5° NW of Moon
Sun	4th		Neptune 2° S of Venus
Sun	4th	7 pm	(5 pm WST) Mars 6° W of Moon
Sun	4th	Midn	(10 pm WST) First Quarter Moon.
Mon	5th		Mars 0.5° N of M44 Beehive Cluster (OC) in Cancer
Mon	5th		Mercury 0.4° NW of NGC 488 (G) in Pisces
Mon	5th	11 pm	(9 pm WST) star Regulus 5° SE of Moon
Mon	5th	pm	m.p. 3 Juno 0.2° N of star Mu Serpentis
Tue	6th		m.p. 14 Irene 0.3° W of star Pollux
Tue	6th	am	eta-Aquarids meteor shower, Apr 19 to May 28.
Sat	10th	am	m.p. 129 Antigone 1.0° NW of Saturn Nebula (NGC 7009) in Aquarius
Sat	10th	6 pm	(4 pm WST) star Spica 0.5° W of Moon
Sun	11th	11 am	(9 am WST) Moon at apogee (furthest from Earth at 406,244 km).
Sun	11th	pm	m.p. 8 Flora 0.2° NE of NGC 3593 (G) in Leo
Mon	12th	am	m.p. 89 Julia 0.3° N of star Zeta Capricorni
Tue	13th	3 am	(1 am WST) Full Moon (405,279 km).

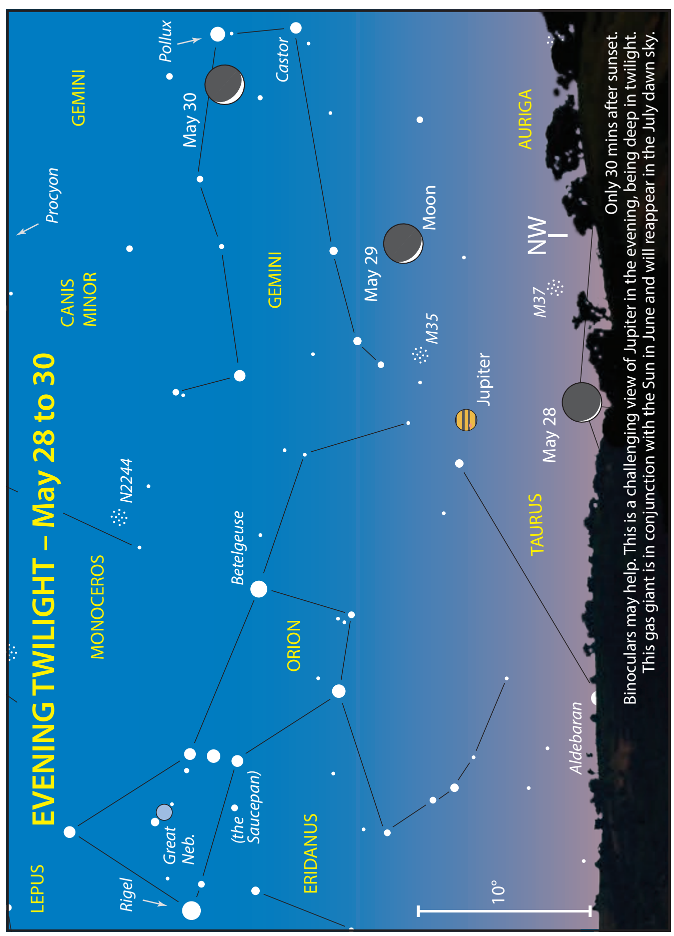
Wed	14th	am	m.p. 532 Herculina 1.0° NW of Comet 210P/Christensen
Wed	14th	7 pm	(5 pm WST) star Antares 3° W of Moon
Thu	15th		m.p. 15 Eunomia 0.3° NE of star Zeta Geminorum
Thu	15th		Juno at opposition
Thu	15th	pm	m.p. 8 Flora 0.7° SW of M65 (SG) in Leo
Fri	16th		Jupiter 1.0° N of M1 Crab Nebula (PN) in Taurus
Sat	17th		Uranus in conjunction with Sun
Sat	17th	7 pm	(5 pm WST) Maximum Libration (8.7°), bright NW limb.
Mon	19th	pm	m.p. 8 Flora 0.9° SW of M66 (SG) in Leo
Tue	20th		d.p. 1 Ceres 0.8° NW of star Iota Ceti
Tue	20th	10 pm	(8 pm WST) Last Quarter Moon.
Fri	23rd	3 am	(1 am WST) Saturn 3° S of Moon
Fri	23rd	4 am	(2 am WST) Neptune 2° S of Moon
Sat	24th	6 am	(4 am WST) Venus 4° S of Moon
Mon	26th	Noon	(10 am WST) Moon at perigee (closest to Earth at 359,022 km).
Tue	27th	1 pm	(11 am WST) New Moon.
Thu	29th		m.p. 15 Eunomia 1.3° S Eskimo Nebula (NGC 2392) in Gemini
Fri	30th		Mercury in superior conjunction
Fri	30th	7 pm	(5 pm WST) star Pollux 2° NE of Moon
Fri	30th	11 pm	(9 pm WST) Maximum Libration (8.8°), bright SE limb.



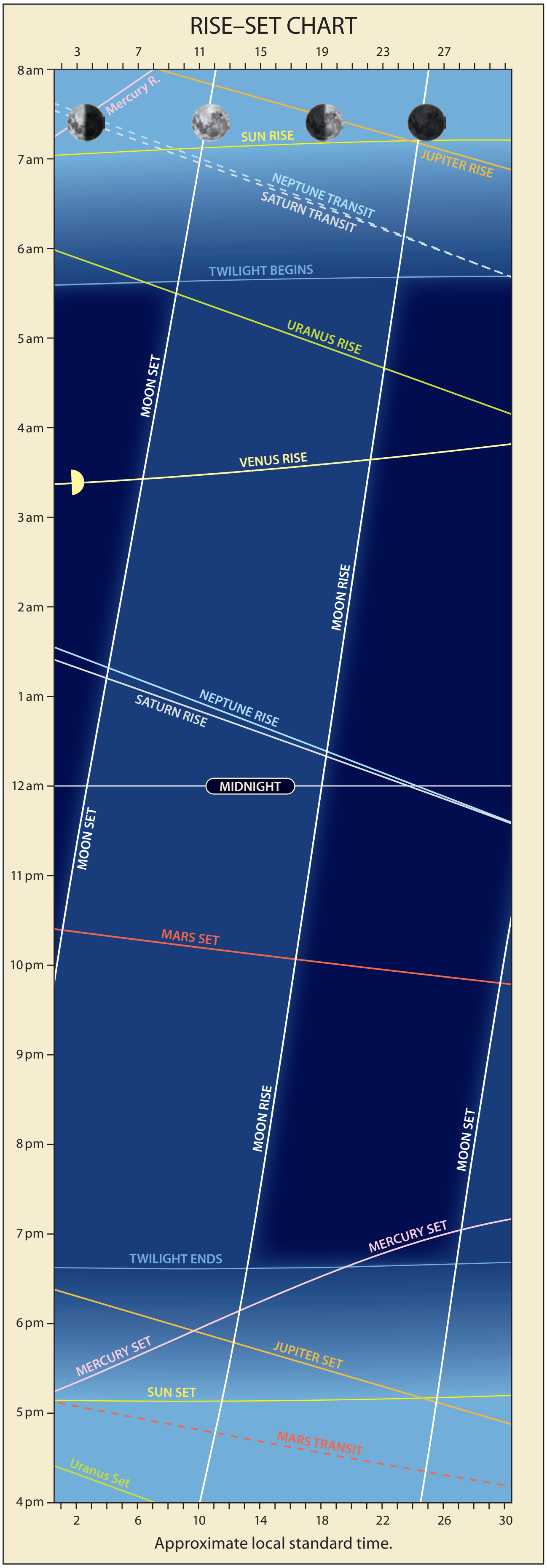


Approximate local standard time.





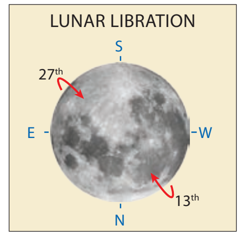
JUNE



HIGHLIGHTS

- Mercury and the Moon close.
- Saturn and Neptune close.

THE MOON



3rd 2 pm (Noon WST) First Quarter.

7th 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 405,553 km).

11th 6 pm (4 pm WST) Full Moon.

13th 10 am (8 am WST) Maximum Libration (7.9°), bright NW limb.

19th 5 am (3 am WST) Last Quarter.

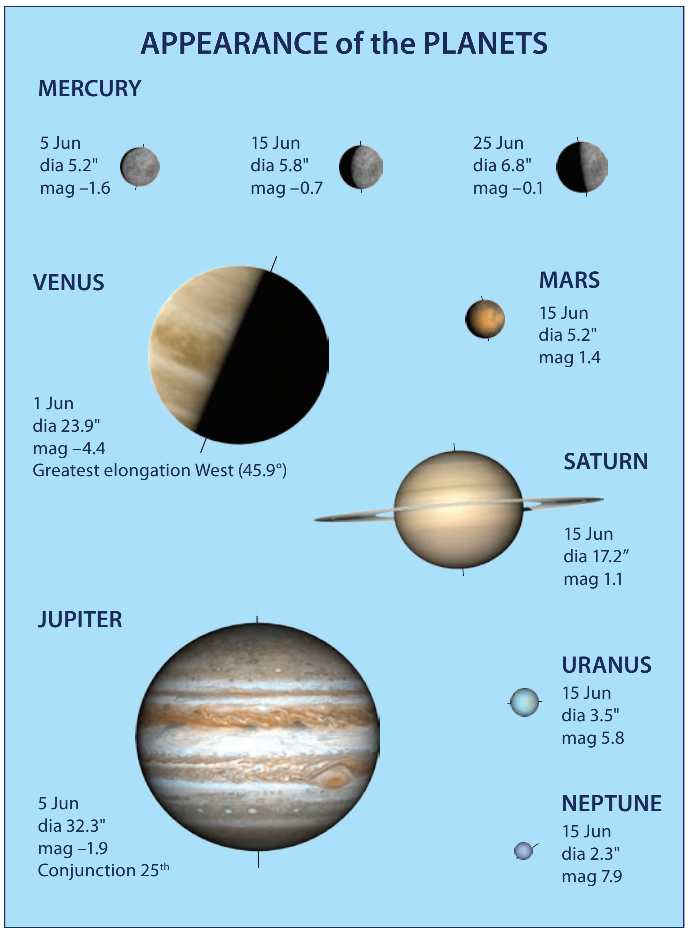
23rd 3 pm (1 pm WST) Moon at perigee (closest to Earth at 363,178 km).

25th 9 pm (7 pm WST) New Moon.

27th 9 am (7 am WST) Maximum Libration (7.8°), bright SE limb. This slender crescent Moon is ideal for hunting down libration features. To name a few, there are the craters Lyot (114 km), Hamilton (58 km), Abel (114 km) and Barnard (101 km).

THE PLANETS

Mercury returns to the western dusk sky this month after its solar conjunction in late May. Late June through to mid-July marks an excellent period for evening observation of the planet. An attractive conjunction occurs on the 27th between Mercury and the 2-day-old waxing crescent Moon, with the pair less than 4° apart (see Sky View). As always, binoculars will help locate objects in a twilight sky.



Venus reaches its greatest elongation 45° west of the Sun on the 1st. The planet is visible, shining brilliantly in a dark sky well before the arrival of civil dawn (see Sky View). Venus moves from Pisces early in the month, across Aries, and finally into Taurus at the end of the month.

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

Mars, in Leo for the entire month, is visible in the early north-western evening sky. On the 17th and 18th, the Red Planet will be a little less than 1° from Regulus (Alpha (α) Leonis), the brightest of Leo's stars and the 21st brightest star in the night sky. At this time, both star and planet will be 1.4 magnitude, but Mars' colour will give it away. Regulus appears as the handle of the asterism known as the Sickle (or Backwards Question Mark). The planet has two encounters within 3° of the waxing crescent Moon this month: on the 1st, with a 6-day-old Moon and on the 30th, when the Moon is five days old (see Sky Views).

Jupiter will be lost in the glare of the Sun this month as it moves into solar conjunction on the 25th. It reappears in the eastern morning dawn sky in late July. It is interesting to note (although unobservable) that during this conjunction, the planet will be occulted by the Sun.

Saturn, in Pisces (see Sky View), rises around midnight mid-month in the eastern morning sky. On the 23rd, the planet is at the point in its orbit known as its western quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 16). At this time, Saturn will be at its highest altitude as the Sun rises in the east. The planet's rings have opened slightly since the ring plane crossing in March with an inclination of a little under 4°. However, this will narrow again towards the end of the year. The two giants, Saturn and Neptune, creep slowly together, and by month's end, they will be just 1° apart, a separation they maintain until early August.

After its solar conjunction last month, **Uranus** returns to the early morning eastern sky in Taurus. Currently, the planet is just a few degrees from the Pleiades star cluster.

Neptune, in Pisces, rises around midnight in the eastern morning sky. The planet and Saturn remain close, providing a neat wide-view field in small telescopes.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

After Flora's encounter with the Leo Triplet of Galaxies in May, retrograde motion causes the minor planet to loop around the group (see Diary). On the early evening of the 9th, 11th magnitude Amphitrite is very close to the bright star Regulus, followed by a not-so-close encounter with Rho Leonis on the 28th, see Diary. This month 10th magnitude Niobe, while at opposition, passes across the main asterism of stars making up the constellation of Ara. It enters between the close, bright (naked-eye) pair of stars, Beta and Gamma, on the 11th, see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
6 Jun	5 Astraea	Ophiuchus	10.6
15 Jun	71 Niobe	Ara	10.3

CONSTELLATIONS

In May we covered the brilliant double star, Alpha (α) Centauri. Moving 4° south from this Pointer, you will cross over into the obscure constellation of **Circinus** the Drawing Compass (All Sky Map 1) to discover naked-eye Alpha (α) Circini. This 3.2 magnitude white star has an 8.5 magnitude orange companion 16 arcseconds away, easily visible in a small telescope. Here's something unusual, Circinus is also

DIARY

Sun	1st		Venus at greatest elongation West (45.9°)
Sun	1st	8 pm	(6 pm WST) Mars 2° S of Moon
Mon	2nd		m.p. 8 Flora 0.6° NE of star Iota Leonis
Mon	2nd	7 pm	(5 pm WST) star Regulus 3° W of Moon
Mon	2nd	pm	m.p. 532 Herculina 0.8° W of m.p. 89 Julia
Tue	3rd		d.p. 1 Ceres 1.2° N of NGC 157 (G) in Cetus
Tue	3rd	2 pm	(Noon WST) First Quarter Moon.
Thu	5th		Venus 0.9° SE of star Omicron Piscium
Sat	7th	2 am	(Midnight WST, prev day) star Spica 0.5° NE of Moon
Sat	7th	9 pm	(7 pm WST) Moon at apogee (furthest from Earth at 405,553 km).
Sat	7th	pm	m.p. 6 Hebe 1.3° N of star Theta Aquarii
Mon	9th	7 pm	(5 pm WST) m.p. 29 Amphitrite 0.03° NE of star Regulus
Tue	10th	8 pm	(6 pm WST) star Antares 0.02° S of Moon
Wed	11th		m.p. 8 Flora 0.8° NE of NGC 3705 (G) in Leo
Wed	11th		Venus 0.9° SE of NGC 821 (G) in Aries
Wed	11th	6 pm	(4 pm WST) Full Moon (399,741 km).
Wed	11th	pm	m.p. 71 Niobe 0.3° S of star Beta Arae
Wed	11th	pm	m.p. 71 Niobe 0.4° N of star Gamma Arae
Thu	12th	am	m.p. 63 Ausonia 0.8° NW of star Zeta Capricorni
Thu	12th	7 pm	(5 pm WST) m.p. 18 Melpomene 0.15° NW of star Omicron Virginis
Fri	13th	10 am	(8 am WST) Maximum Libration (7.9°), bright NW limb.
Tue	17th		star Regulus 1° S of Mars
Thu	19th	5 am	(3 am WST) Saturn 5° E of Moon
Thu	19th	5 am	(3 am WST) Neptune 5° E of Moon
Thu	19th	5 am	(3 am WST) Last Quarter Moon.
Fri	20th	pm	m.p. 354 Eleonora 1.0° E of star Alpha Serpentis
Sat	21st		Solstice
Sun	22nd	6 am	(4 am WST) Venus 8° SE of Moon
Sun	22nd		star Pollux 5° N of Mercury
Mon	23rd	5 am	(3 am WST) Uranus 6° SE of Moon
Mon	23rd	3 pm	(1 pm WST) Moon at perigee (closest to Earth at 363,178 km).
Mon	23rd	pm	m.p. 4 Vesta 1.5° E of star Iota Virginis
Mon	23rd	pm	m.p. 4 Vesta 1.6° W of NGC 5634 (GC) in Virgo
Wed	25th		Jupiter in conjunction with Sun
Wed	25th	9 pm	(7 pm WST) New Moon.
Fri	27th	9 am	(7 am WST) Maximum Libration (7.8°), bright SE limb.
Fri	27th	6 pm	(4 pm WST) Mercury 3° S of Moon
Sat	28th	8 pm	(6 pm WST) m.p. 29 Amphitrite 0.15° SW of star Rho Leonis
Sun	29th		m.p. 8 Flora 1.2° NE of star Nu Virginis
Sun	29th	am	m.p. 2 Pallas 1.0° N of NGC 7006 (GC) in Delphinus
Sun	29th	8 pm	(6 pm WST) star Regulus 3° SE of Moon
Sun	29th	pm	m.p. 71 Niobe 0.4° E of NGC 6253 (OC) in Ara
Mon	30th		Neptune 1° N of Saturn
Mon	30th	7 pm	(5 pm WST) Mars 3° W of Moon

home to the Horseshoe asterism, an object for binoculars. Look 1.5° south-east of alpha and you'll find a dozen 7th and 8th magnitude stars arranged in a 1° diameter semicircle. The western edge is comprised of five stars forming a distinctive straight line. The star at its eastern end is 6th magnitude Zeta (ζ) Circini.

Adjacent to Circinus is **Triangulum Australe** the Southern Triangle (All Sky Map 1), with its three naked-eye (3rd magnitude) stars arranged in an obvious isosceles triangle shape. The open star cluster NGC 6025 is a collection of around twenty 8th to 10th magnitude white stars arranged in a curvy 'S' shape. Binoculars show an obvious haze (20 × 15 arcminutes) standing out in a rich star field with naked-eye (3rd magnitude) Beta (β) Trianguli Australis, 3° to the south.

Directly below (south of) Triangulum Australe is the faint constellation of **Apus** the Bird of Paradise (All Sky Map 1). Gamma (γ) Apodis is a naked-eye (3.9 magnitude) yellow star, which forms a wide binocular double with Delta (δ) Apodis, 40' westward. Delta itself is double and well suited for binoculars with δ^2 approximately 2 arcminutes north of δ^1 (mag 5.3 and 4.7 respectively).

The constellation of **Lupus** the Wolf (All Sky Map 6) lies to the east of Centaurus and, like its neighbour, ranges across the Milky Way environ out to the realm of the galaxies. Unfortunately, Lupus doesn't have the brilliant showcase examples of deep sky objects like Centaurus. However, it is a bright constellation presenting to the unaided eye numerous 2nd and 3rd magnitude stars. Many of these belong to the

Mirror Size Comparison

In the last fifty years we have seen a huge growth in mirror size. Technology now allows for the adjustment of a mirror's curvature as it flexes in various positions. This is also used for adaptive optics to compensate for the boiling affect of the atmosphere. In addition we can now *combine* multiple mirrors as if they are one.

The diagram opposite shows a comparison of nominal sizes of primary mirrors of notable optical reflecting telescopes, and a few other objects. Dotted lines show sizes of round mirrors that would have had equivalent light-gathering ability.

Largest refractors (for comparison):

- Yerkes Observatory's 40-inch (1.02 m) refractor, 1893 (largest refractor consistently used for scientific observations)
- Great Paris Exhibition Telescope, 49 inches (1.24 m), 1900 (largest refractor ever built; had practically no scientific usage)

Ground-based reflectors:

- Hooker Telescope, 100 inches (2.54 m), 1917; world's largest telescope from 1917 to 1949
- Australian Astronomical Telescope (3.9 m) Siding Spring, 1974
- Multiple Mirror Telescope, 186 inches (4.72 m) effective, 1979–1998; 6.5 m, from 1998
- LAMOST (Large sky Area Multi-Object fiber Spectroscopic Telescope), 4.9 m effective at best, 2009
- Hale Telescope, 200 inches (5.1 m), 1949; world's largest telescope from 1949 to 1975
- BTA-6, 6 m, 1975; world's largest telescope from 1975 to 1990 (when it was surpassed by the partially completed Keck I telescope)
- Large Zenith Telescope, 6 m, 2003; largest liquid-mirror telescope ever built; decommissioned in 2019
- Magellan Telescopes, two 6.5 m individual telescopes, 2000 and 2002
- Vera C. Rubin Observatory (formerly Large Synoptic Survey Telescope), 6.68 m effective (8.4 m mirror, but with a big hole in the middle), planned 2025
- Gemini Observatory, 8.1 m, 1999 and 2001
- Subaru Telescope, 8.2 m, 1999; largest single mirror in an optical telescope from 1999 to 2005
- SALT (Southern African Large Telescope), 9.2 m effective, 2005 (largest optical telescope in the Southern Hemisphere)
- Hobby–Eberly Telescope, 10 m effective, 1996
- Gran Telescopio Canarias, 10.4 m, 2007 (world's largest single-aperture optical telescope)
- Large Binocular Telescope, 11.8 m effective (two 8.4 m telescopes on a common mount), 2005 and 2006; each individual telescope has the largest monolithic (i.e. non-segmented) mirror in an optical telescope, while the combined effective light collecting area is the largest for any optical telescope in non-interferometric mode
- Keck Telescopes, 14 m effective (two 10 m individual telescopes), 1993 and 1996; similarly to VLT, the two telescopes were combined only for interferometric observations rather than to simply achieve larger light collecting area; furthermore, this mode has been discontinued
- Very Large Telescope, 16.4 m effective (four 8.2 m individual telescopes), 1998, 1999, 2000, and 2000; total effective light collecting area would have been world's largest for any present-day optical telescope, but the instrumentation required to obtain a combined coherent focus was not built
- Giant Magellan Telescope, 22.0 m effective, planned for early 2030s
- Thirty Meter Telescope, 30 m effective, planned (no specific dates yet)
- Extremely Large Telescope, 39.3 m effective, planned 2028

Space telescopes:

- Gaia, 1.45 m × 0.5 m (area equivalent to a 0.96-m round mirror), 2013
- Kepler, 1.4 m, 2009
- Hubble Space Telescope, 2.4 m, 1990
- James Webb Space Telescope, 6.5 m effective, 2022 (largest space optical telescope to date)

Other objects for comparison:

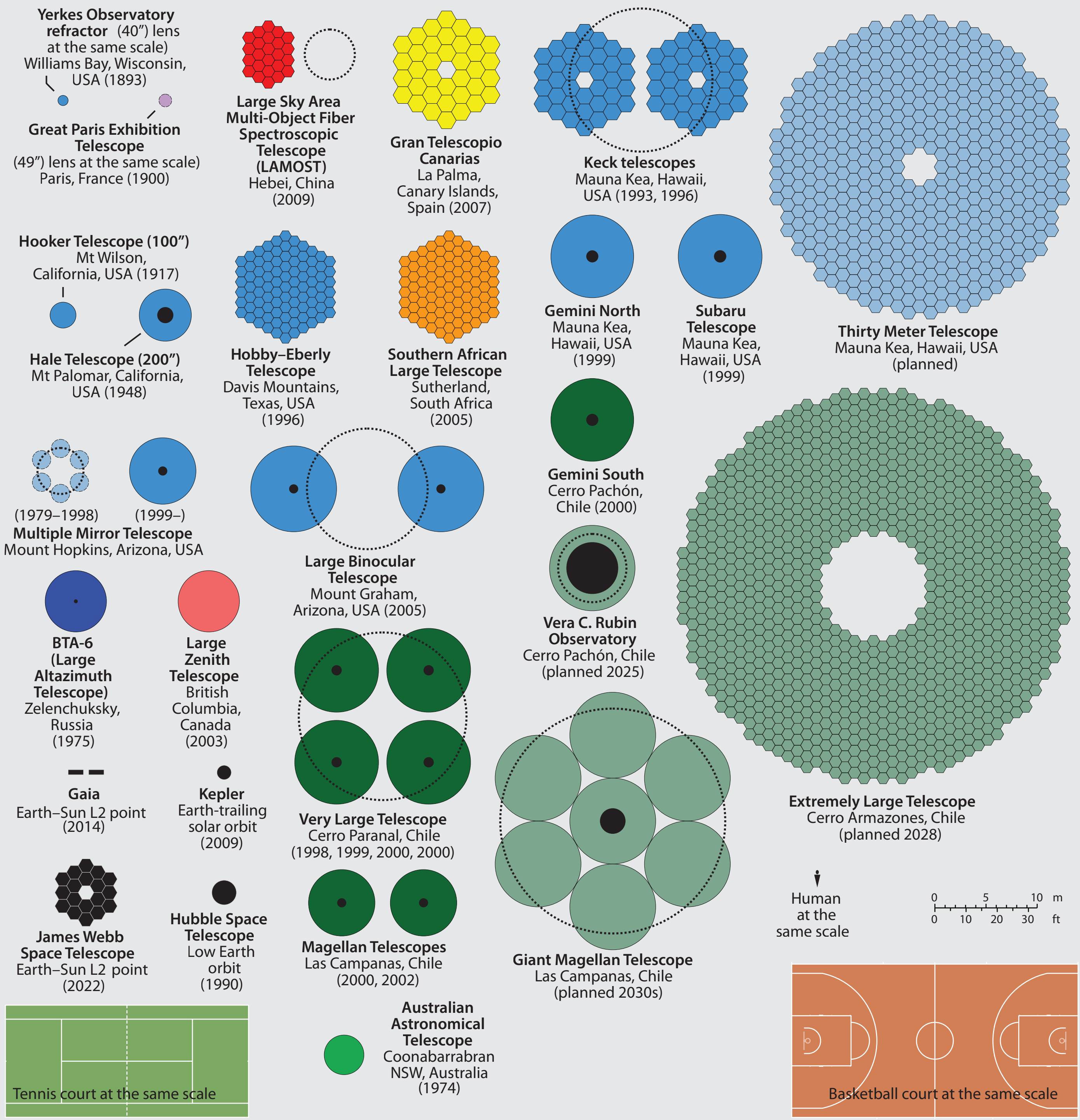
- Average human height
- Tennis court, 78 × 36 ft (23.77 × 10.97 m)
- Basketball court, 94 × 50 ft (28.7 × 15.2 m)

Scorpio-Centaurus Stellar Association which are rich in hot (blue coloured) double/binary stars.

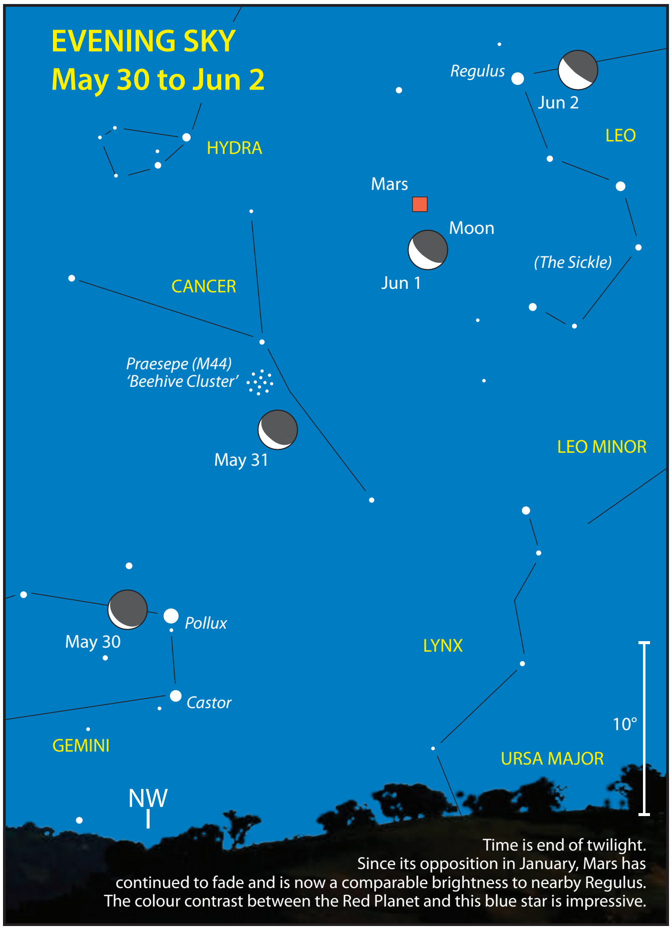
The naked-eye Eta (η) Lupi is a double star with a 3.4 magnitude white primary and a 7.5 magnitude blue companion, 14 arcseconds away. They are visible through any small telescope. Moving 3° west finds the attractive, 7.5 magnitude, globular star cluster, NGC 5986. It is 6 arcminutes in diameter with a broad, bright nucleus and a narrow, faint halo of stars. A 150 mm telescope resolves a smattering of stars across its hazy bright background.

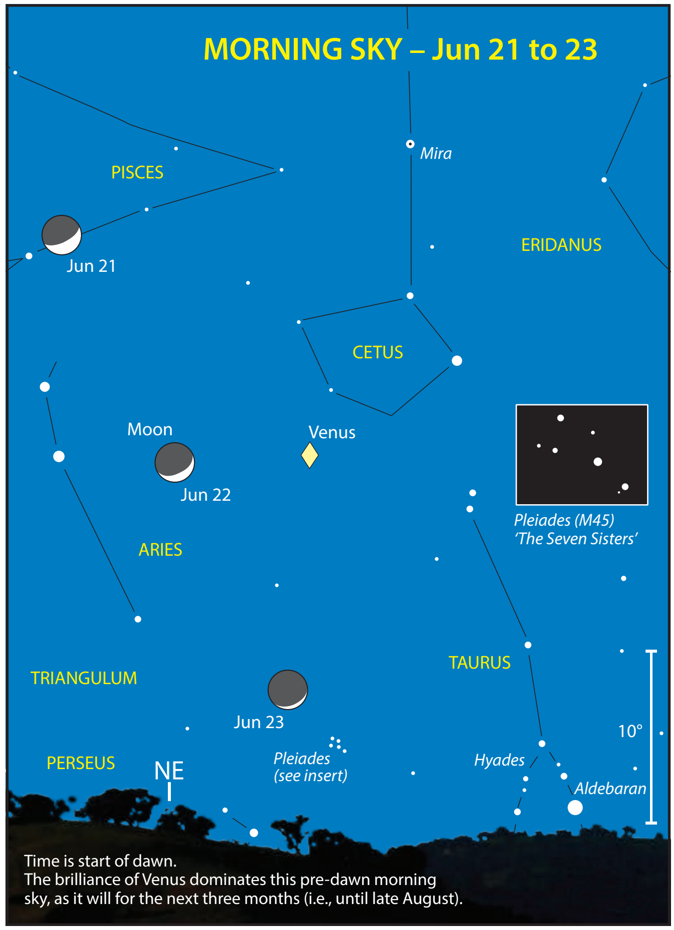
Now for a binocular triple star comprised of 5th magnitude Nu^1 (ν^1) Lupi, 5.5 magnitude ν^2 (0.4° south) and 4th magnitude Mu (μ) Lupi (0.6° west of ν^1). Mu is itself a telescopic triple star with two easily visible in small telescopes. This white, 5th magnitude star has a yellowish 7th magnitude component 23 arcseconds away. Returning to Nu^2 Lupi, shift 2.5° south-south-east to find globular star cluster NGC 5927. It is 8th magnitude and around 4 arcminutes in diameter, with a gradual brightening to its 1-arcminute core. Using a 150–200 mm telescope, under great seeing conditions, individual stars can be glimpsed in the globular.

Naked-eye (4th magnitude) Kappa (κ) is a pair of white stars with a 5.6 magnitude companion, 27 arcseconds away. It is ideal for a small telescope (60 mm) and has an attractive star field.

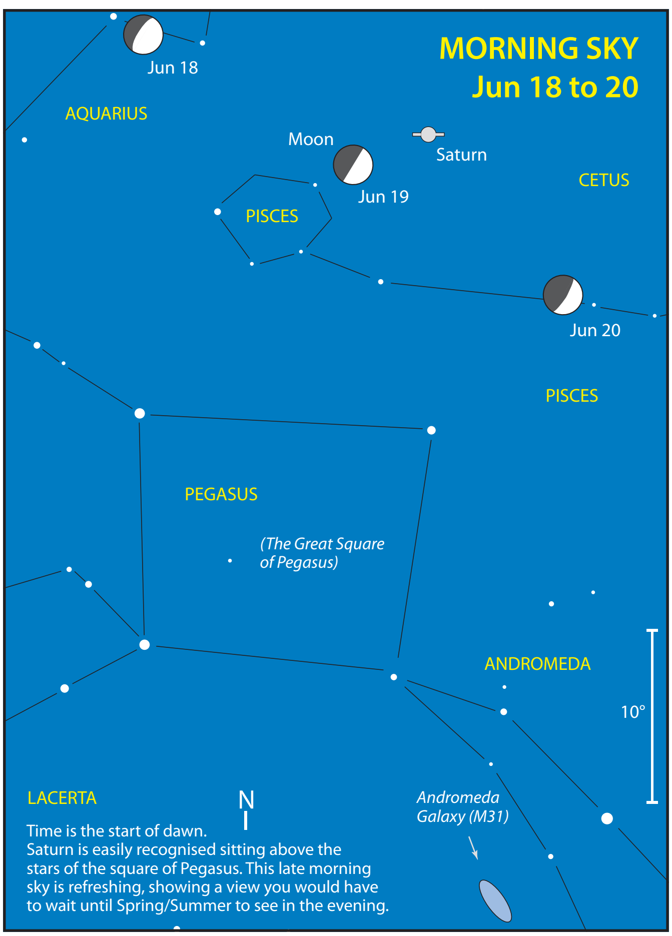


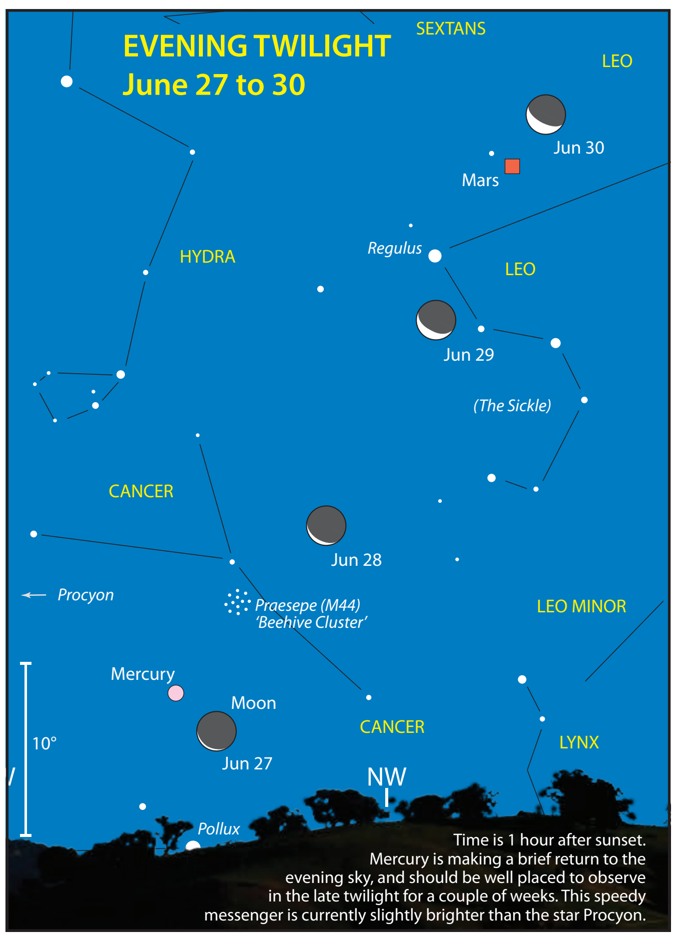
JUNE



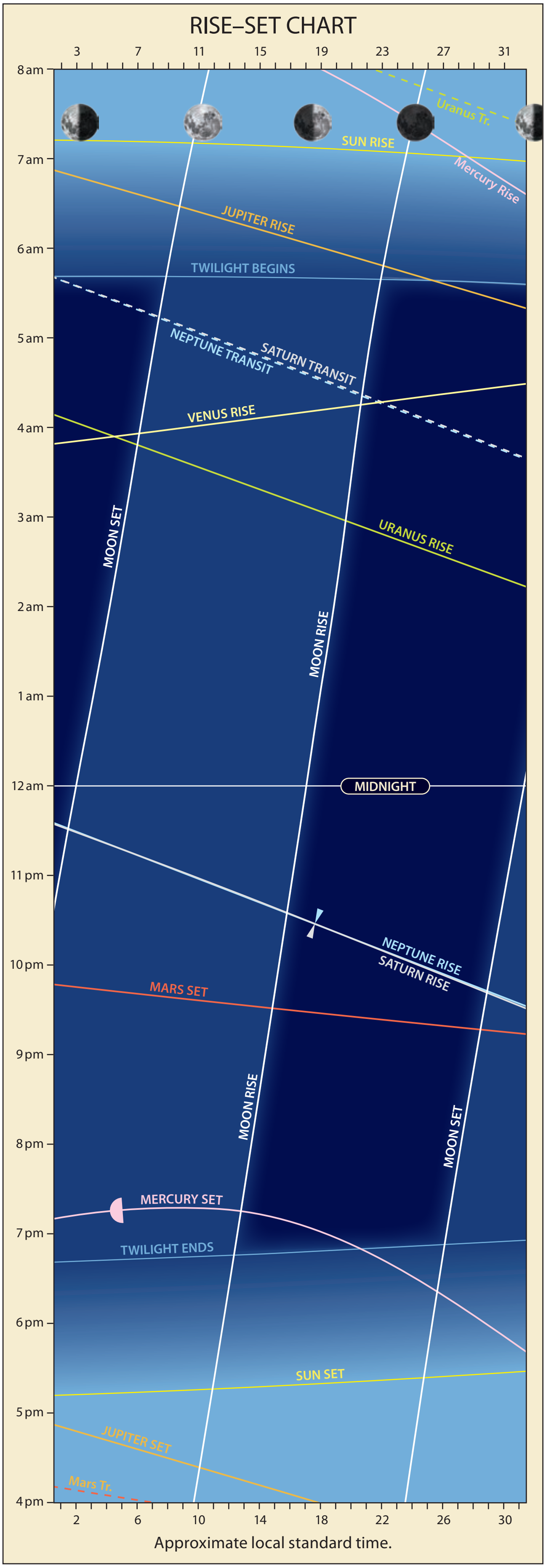


Approximate local standard time.





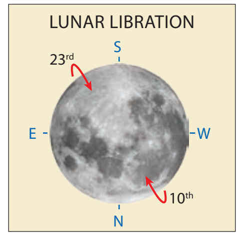
JULY



HIGHLIGHTS

- Venus and Aldebaran close.
- Saturn and Neptune close
- Mercury excellent evening return.

THE MOON



3rd 6 am (4 am WST) First Quarter.

5th Noon (10 am WST) Moon at apogee (furthest from Earth at 404,627 km).

10th 4 am (2 am WST) Maximum Libration (7.6°), Full Moon.

11th 7 am (5 am WST) Full Moon.

18th 11 am (9 am WST) Last Quarter.

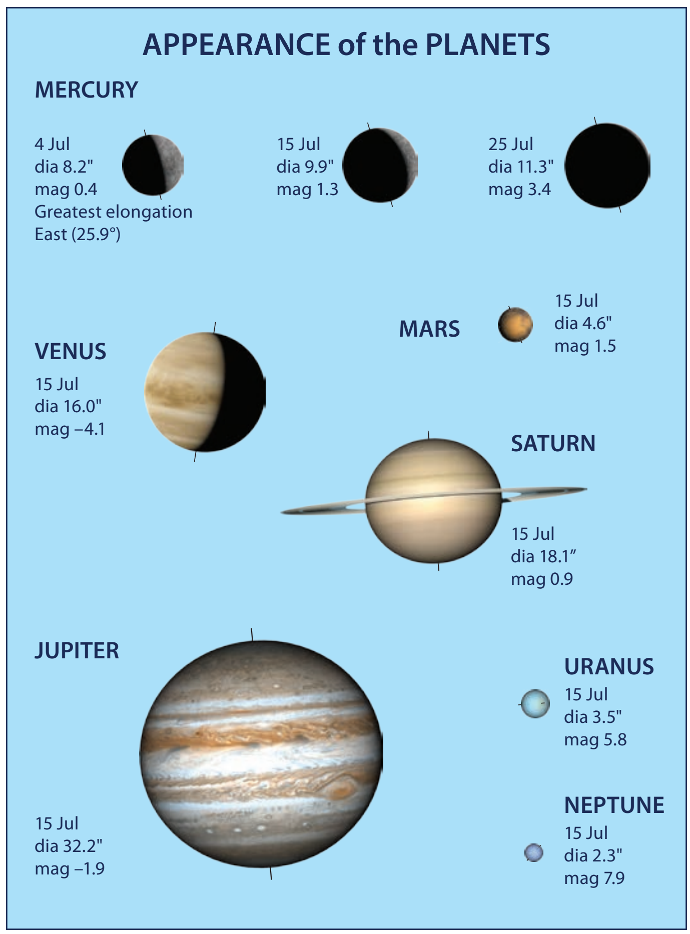
20th Midnight (10 pm WST) Moon at perigee (closest to Earth at 368,041 km).

23rd 9 pm (7 pm WST) Maximum Libration (7.3°), too close to New Moon.

25th 5 am (3 am WST) New Moon.

THE PLANETS

In the western evening sky, **Mercury** is in an ideal position for observation until mid-month as it meanders through Cancer. The smallest of planets reaches its greatest elongation 26° east of the Sun on the 4th, then gradually moves into Sol's glare and inferior conjunction (Mercury between the Earth and the Sun) on August 1. On the 3rd, during a favourable evening return, Mercury has a meeting with the Beehive Cluster (M44), see Diary.



The dazzling planet **Venus** is visible in the pre-dawn eastern sky in Taurus (see Sky View). On its journey across the constellation, the planet will pass within 3° of the 1st magnitude star Aldebaran, the fiery eye of the Bull and the brightest star in the Hyades star cluster (a foreground star, not a genuine member of the cluster). At this time, Venus will be close to and overshadowing the 3.5 magnitude star known as Ain (Epsilon (ε) Tauri), the northernmost eye of the Bull. The celestial conjunction between Venus and Aldebaran makes a striking sight in the pre-dawn sky. On its way toward the Hyades, Venus passes within 3° of the fainter outer planet Uranus between the 3rd and 6th.

On the 4th, the **Earth** is at aphelion, the furthest point in its orbit from the Sun at 1.017 au.

Mars is visible in the early north-western evening sky, setting around 9 pm mid-month (see Sky Views). The planet continues its trek across Leo and finally enters Virgo at month's end.

After its solar conjunction in June, **Jupiter** joins Venus in the morning north-eastern dawn sky in Gemini late this month (see Sky View). The brilliant pair will be together for an excellent conjunction next month.

Saturn, in Pisces, rises around 10:30 pm mid-month in the eastern evening sky (see Sky View). The Ringed Planet's apparent path against the starfield reverses on the 14th as the world begins its retrograde track ahead of its September opposition (see Retrograde Motion p 92). Saturn and Neptune remain within 1° of each other over the entire month. This planetary duo presents an attractive imaging opportunity for astroimagers: Saturn with a slim slither of rings and the bluish disc of Neptune nearby.

Uranus is in the early morning north-eastern pre-dawn sky in Taurus, within a few degrees of the Pleiades star cluster. Venus passes by the planet between the 3rd and the 6th, at a distance of 3°.

Neptune, in Pisces, rises in the late evening eastern sky. On the 5th, the planet begins five months in retrograde motion, appearing to travel westward against the stellar background (see retrograde motion p. 92). Its close planetary companion, Saturn, remains within 1° over the month.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

While near opposition, in late July/early August, minor planet Pallas has a close encounter with some of the bright stars in the faint, but obvious constellation of Delphinus. On the night of 8th, 10th magnitude Herculina is on the western edge of the globular cluster M30 in Capricornus. On the 21st and 22nd, 10th magnitude Papagena has a close encounter with the bright galaxy pair, NGC 1055 and M77 in Cetus, see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
2 Jul	23 Thalia	Sagittarius	11.5
3 Jul	230 Athamantis	Scutum	10.3
14 Jul	115 Thyra	Sagittarius	10.8

METEOR SHOWERS

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

The **alpha-Capricornids** are known for their bright, slow meteors, long paths, and frequent fireballs. From dusk

DIARY

Thu	3rd		Mercury 1.0° SW of M44 Beehive Cluster (OC) in Cancer
Thu	3rd	6 am	(4 am WST) First Quarter Moon.
Thu	3rd	Midn	(10 pm WST) star Spica 5° E of Moon
Fri	4th		Uranus 2° N of Venus
Fri	4th		Earth at aphelion, 1.016643732 au
Fri	4th		Mercury at greatest elongation East (25.9°)
Sat	5th	Noon	(10 am WST) Moon at apogee (furthest from Earth at 404,627 km).
Mon	7th	pm	m.p. 89 Julia 1.4° NE of star Delta Capricorni
Tue	8th	4 am	(2 am WST) star Antares 1° E of Moon
Tue	8th	pm	m.p. 532 Herculina 0.05° E of M30 (GC) in Capricornus
Thu	10th	4 am	(2 am WST) Maximum Libration (7.6°), Full Moon.
Fri	11th		m.p. 471 Papagena 0.6° NW of NGC 936 (G) in Cetus
Fri	11th	7 am	(5 am WST) Full Moon (390,732 km).
Sun	13th		Venus 0.4° N of star Epsilon Tauri
Tue	15th	am	m.p. 30 Urania 0.4° N of star Theta Capricorni
Tue	15th		star Aldebaran 3° S of Venus
Wed	16th		Venus 1.0° NW of NGC 1647 (OC) in Taurus
Wed	16th	Midn	(10 pm WST) Neptune 5° SW of Moon
Wed	16th	Midn	(10 pm WST) Saturn 6° SW of Moon
Fri	18th	11 am	(9 am WST) Last Quarter Moon.
Sun	20th		m.p. 471 Papagena 0.2° SE of star Delta Ceti
Sun	20th		Mars 0.9° SW of star Sigma Leonis
Sun	20th	Midn	(10 pm WST) Moon at perigee (closest to Earth at 368,041 km).
Sun	20th	pm	m.p. 71 Niobe 1.0° E of NGC 6200 (OC) in Ara
Mon	21st		m.p. 471 Papagena 0.3° S of NGC 1055 (G) in Cetus
Mon	21st		m.p. 471 Papagena 0.5° SE of star Delta Ceti
Mon	21st	4 am	(2 am WST) Uranus 7° SW of Moon
Tue	22nd		m.p. 471 Papagena 0.3° N of M77 (SG) in Cetus
Tue	22nd	6 am	(4 am WST) Venus 8° S of Moon
Wed	23rd	6 am	(4 am WST) Jupiter 7° E of Moon
Wed	23rd	9 pm	(7 pm WST) Maximum Libration (7.3°), too close to New Moon.
Wed	23rd	pm	m.p. 2 Pallas 0.4° NW of star Gamma Delphini
Fri	25th	5 am	(3 am WST) New Moon.
Sun	27th		Venus 0.5° N of star Zeta Tauri
Sun	27th		Venus 0.7° NW of M1 Crab Nebula (PN) in Taurus
Sun	27th	pm	m.p. 71 Niobe 1.3° W of NGC 6250 (OC) in Ara
Mon	28th	7 pm	(5 pm WST) Mars 6° E of Moon
Wed	30th		Southern delta-Aquarids meteor shower, Jul 12 to Aug 23.
Wed	30th		alpha-Capricornids meteor shower, Jul 3 to Aug 15.
Wed	30th	pm	m.p. 2 Pallas 0.2° SE of star Alpha Delphini
Thu	31st	7 pm	(5 pm WST) star Spica 1.5° NW of Moon
Thu	31st	pm	m.p. 71 Niobe 0.3° E of NGC 6216 (C) in Scorpius

till dawn, the shower is visible from July 3 to August 15. Maximum activity occurs around the 30th, with a zenith hourly rate of around five. Their spectacular nature generally makes up for the low hourly rates. As with the Southern delta-Aquarids, there will be minimal lunar interference after midnight.

CONSTELLATIONS

Norma the Carpenter's Square (All Sky Map 6) is a faint constellation nestled between Lupus and Scorpius. The brightest members are four 4th magnitude stars arranged in a distorted square, two of them being double. Its lucida is a yellow coloured, Gamma^2 (γ^2) forming a naked-eye double with its white companion, 5th magnitude Gamma^1 (γ^1), 0.5° west. Binoculars show the colour contrast well. The other is Epsilon (ε) Normae, a pretty double composed of a 4.5 magnitude blue-white star and 6.1 magnitude white companion, 23 arcseconds away.

Moving southward you'll come to Norma's jewel, the open star cluster NGC 6067. It is just 0.4° north of 5th magnitude Kappa (κ) Normae and embedded in a bright knot of the Milky Way, hence its brilliant star field. This 5.6-magnitude, irregularly shaped cluster is approximately 15 arcminutes in diameter with dozens of stars visible in telescopes as small as 100 mm. The star count increases dramatically as you move to larger instruments. NGC 6067 is awash with doubles and curved lines of stars. Near its centre lies its brightest member, an 8.6 and 9.1 magnitude double star, separated by 9.4 arcseconds.

Continue your southerly trek 4° to find Iota (ι) Normae. Its primary, ι^1, is 4.6 mag, with its companion ι^2 a good test for the naked eye at mag 5.6 (easy in binoculars), 0.8° east. Iota^1 is itself a great double for small telescopes having an 8th mag component 11 arcseconds south-west.

A short 1° hop east of Iota^2 is the open star cluster NGC 6087. Its main two-dozen stars (7th to 11th magnitude) are loosely scattered over 12 arcminutes in a pretty star field. The cluster's 6.5-magnitude brightest member really stands out.

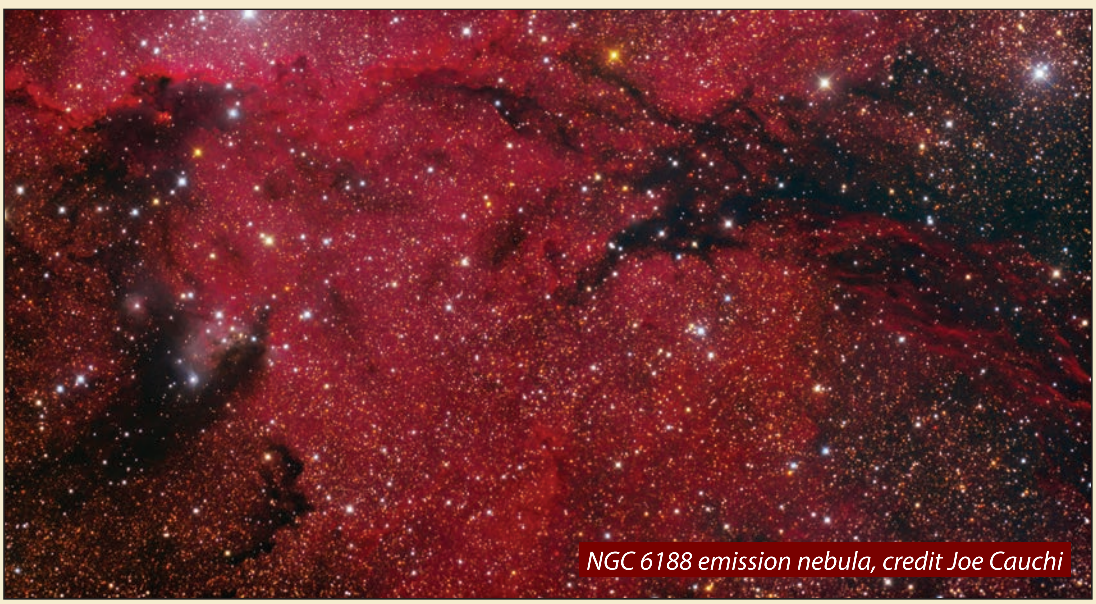
Now make a brief visit to southern **Scorpius** the Scorpion (best seen on Map 6), starting where the tail of the Scorpion makes a near 90° bend. Look for the obvious binocular triple star formed by Zeta (ζ^1), (ζ^2) and HR6266. Only 0.5° north of 4th magnitude Zeta is NGC 6231. This 2.6 magnitude open cluster, comprised of some 40 stars, is dominated by around a dozen 6th to 4th magnitude blue/white stars and has been called the Northern Jewel Box. A further 4° northward finds a double you shouldn't miss, naked-eye Mu (μ^1 and μ^2) Scorpii with its 3.0 and 3.6 magnitude blue components, 5 arcminutes apart. The triple star, NGC 6231 and Mu all fit within the same low power binocular field—very attractive. While drinking in this view, move one field (5°) to the west to discover the open star cluster NGC 6124. This nearly 0.5° diameter, 5.8 magnitude cluster is good in binoculars (but faint) or small rich field telescopes. Approximately 50 stars of magnitudes 9 to 11 are easily seen in this well scattered field. Larger telescopes start to reveal fainter members making numerous curved lines.

Near the stinger of the scorpion is the naked-eye (3rd magnitude) star G Scorpii. Only 4 arcminutes east lies the globular cluster NGC 6441. This bright (magnitude 7) cluster plus this dazzling orange star look great in the same telescopic field of view. The globular is compact (3 arcminutes across) with a broad intense nucleus.

Nestled between Scorpius and Triangulum Australe, lies the constellation of **Ara** the Altar (best seen on All Sky Map 6). Being embedded in the Milky Way, it has no shortage of star clusters. Ara's pattern is obvious with seven stars ranging from mag 2.8 to 4.0 arranged in an open book shape (maybe a bat?). Ara's most distinctive naked-eye feature is the pair of 3rd magnitude stars forming the southern end of the spine. Separated by only 1°, Beta (β) and Gamma (γ) Arae are distinctively yellow and white respectively. Binoculars are recommended to show this colour contrast. Gamma is a wonderful telescopic multiple star with its main components being magnitudes 3.3 and 10.0, separated by 18 arcseconds. There is also a more distant 12th magnitude companion, 40 arcseconds from the primary.

The outstanding gem of Ara is the globular cluster, NGC 6397. Although not as famous as some, at magnitude 5.9 it is considered the 4th brightest globular in the heavens! At reasonable power it is stunning, showing a bright halo rising to a brilliant core. Look for lines of stars appearing to radiate from the centre. This relatively loosely packed globular is easy to locate, being in the same binocular field as Beta (β) Arae (3 degrees north-east of the star).

Ara has another globular cluster that shouldn't be missed in its southern regions close to the border with Apus.



NGC 6188 emission nebula, credit Joe Cauchi

The Allure of Europa

By Greg Bryant

When the Italian astronomer Galileo Galilei discovered the four largest moons of Jupiter in 1610, he didn't just shake up our understanding of the Solar System, and indeed the Universe, we were presented with enticing worlds to fuel our imagination. Every night, when Jupiter is visible in the night sky, we can turn our telescopes towards it and watch the Galilean Moons, Io, Europa, Ganymede and Callisto are known, as they move in their orbit around the gas giant. Pinpoints of light, they make a fascinating sight to follow throughout the night and indeed over many nights (see Jupiter Moons p. 117).

While professional telescopes were used to gather basic data, and amateurs assisted with visual timings to improve orbital parameters (Europa has a diameter of 3,120 km, slightly smaller than our Moon, and orbits Jupiter twice every week), it would take nearly four centuries to get up close by way of planetary space probes, and those encounters opened our eyes to new worlds to explore. One of Jupiter's moons in particular, Europa, has planetary scientists pondering the possibility of a subsurface ocean and the potential for life.

The flybys of the Pioneer 10 and 11 spacecraft in 1973 and 1974 respectively showed Europa as a seemingly barren and icy world, with a smooth and relatively featureless surface dominated by shades of white and grey. Closer images taken by the Voyager 1 and 2 spacecraft in 1979 revealed a landscape unlike any other in the Solar System. Europa's surface is crisscrossed by a network of long, linear fractures known as 'lineae', as well as numerous ridges, cracks, and terrain best described as chaotic.

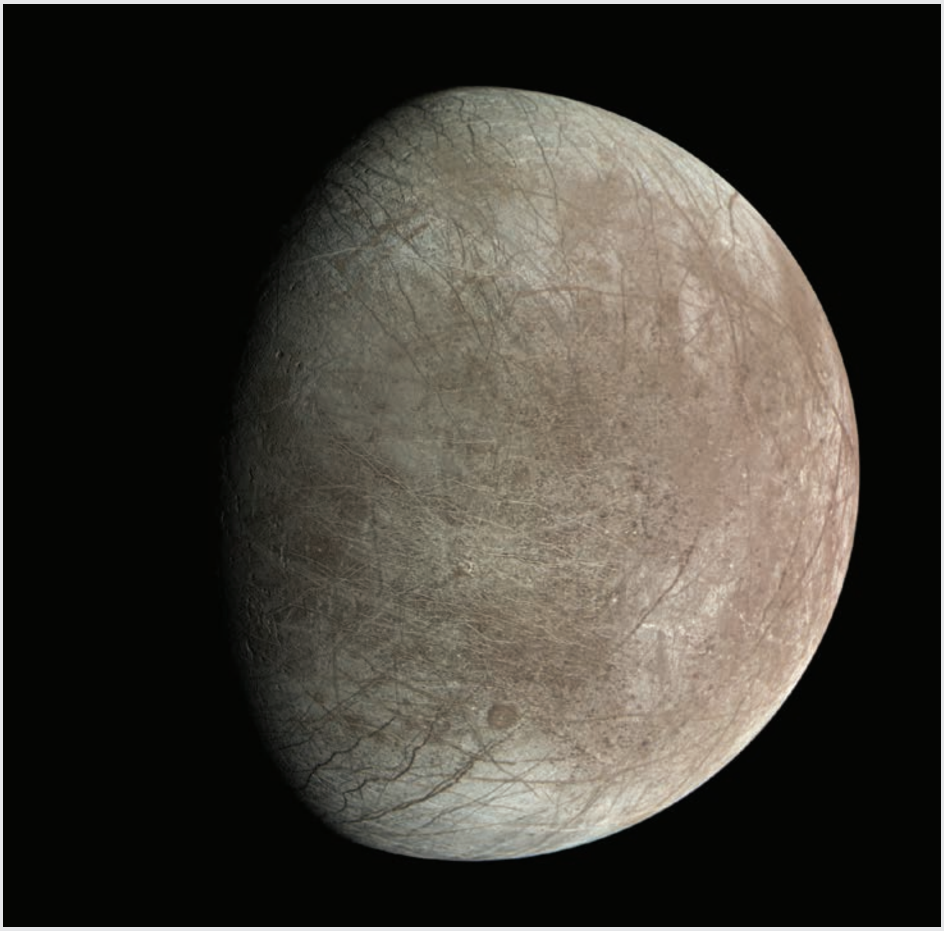
Thirty years ago, in 1995, NASA's Galileo spacecraft arrived in orbit around Jupiter. Its mission was to send a probe into Jupiter's atmosphere, study the planet itself, and make multiple flybys of Jupiter's larger satellites. Of the latter targets, it was Europa's findings that stood out as one of the mission's highlights. The higher-resolution images taken by Galileo of Europa suggest a dynamic and geologically active world, where processes such as tectonics, possibly cryovolcanism, and the shifting of ice plates continually reshape the landscape.

The above-mentioned lineae stretch for hundreds of kilometres across Europa's icy crust. They're thought to result from the tidal forces exerted by Jupiter's immense gravity, which flex and stretch Europa's icy shell, causing it to crack and fracture. The presence of these fractures indicates that Europa is not a static world but rather one that is undergoing constant change and evolution.

In addition to lineae, Europa's surface is also marked by a variety of other intriguing features, including ridges that rise several kilometres above the surrounding terrain and dark spots that may be areas where material from beneath the surface has welled up and refrozen. These features provide clues about the geologic processes at work on Europa and hint at the presence of a subsurface ocean beneath the moon's icy crust.

Indeed, one of the most compelling reasons why Europa is so interesting is the strong evidence for the existence of a global subsurface ocean of liquid water. This evidence comes from multiple sources, including the above, as well as observations made by the Galileo spacecraft which detected fluctuations in Europa's magnetic field consistent with the presence of a conductive layer beneath the surface, a layer that is believed to be a salty, liquid ocean.

The existence of a subsurface ocean on Europa has significant implications for our understanding of the moon's potential habitability. Liquid water is a critical ingredient for



This image of Europa, taken by NASA's Juno spacecraft as it came to within 360 km of the moon in September 2022, shows the side of Europa that always faces Jupiter. This was the first high-resolution image taken of Europa since Galileo's last flyby in 2000 and highlights the lineae and ridges that riddle the surface.

Credit: NASA/JPL-Caltech/SwRI/MSSS/Björn Jónsson

NGC 6362 lies 1.1° north-east from the yellow, naked-eye (4.8 magnitude) star Zeta (ζ) Apodis. The globular is reasonably bright (7.5 magnitude) and 4 arcminutes in diameter. Although basically circular in shape, it gives a hint of being triangular with a slight brightening towards the centre. A 150 mm telescope resolves it into a scattering of stars on a bright background haze.

The open cluster IC 4651 is easy to find being only 1° west of naked-eye Alpha (α) Arae. A small telescope shows about sixty 10–11th mag stars, forming several lines, scattered across 12 arcminutes. While in the area, move 1.5° north to find the globular cluster, NGC 6352. It shows as a round bright haze standing out in a rich star field. Unfortunately, the stars are quite faint with the haze at its best remaining textured.

Even galaxies pierce their way through the Milky Way barrier. The face on, 10th magnitude, peculiar spiral galaxy NGC 6221, is only 0.4° east of the naked-eye (4th magnitude) orange star, Eta (η) Arae. What makes this 2-arcminute, slightly oval shaped blob attractive is the surrounding star-rich Milky Way field.

The open star cluster NGC 6193 is in an isolated region, near the border with Norma. Only a small aperture (60 mm) instrument is needed to reveal around 20 scattered 10th magnitude stars covering around 10 arcminutes. The brightest member, on the western edge, is an impressive multiple star h4876. Its main components are magnitudes 5.7 and 6.8, separated by 9 arcseconds. How many other companions can you see? Bright and dark nebulae surround this cluster, the brightest being NGC 6188 (image p. 53). The most obvious portion of NGC 6188 can be found by looking 10 arcminutes west of h4876. Given good dark skies and reasonable aperture (200 mm minimum), a bright bar, approximately 10 arcminutes long, can be glimpsed running north to south as it comes up against a dark nebula.

life as we know it, and Europa's ocean is thought to be in direct contact with its rocky mantle. The presence of essential chemical elements and a source of energy from the moon's internal heat bolster the case for Europa's habitability.

Europa's subsurface ocean offers a tantalising opportunity to search for signs of life beyond Earth. On our own planet, life thrives in some of the most extreme environments, from deep-sea hydrothermal vents to acidic hot springs, leading scientists to speculate that similar environments could exist beneath the icy crust of Europa. Furthermore, Europa's subsurface ocean offers a unique environment for studying astrobiology and the limits of life in extreme conditions.

Beyond its potential for life, Europa is also of scientific interest due to the processes that shape its surface and interior. The dynamic interactions between Europa and Jupiter's powerful gravitational forces drive a range of geological processes, including the formation of surface features such as lineae and ridges. Studying these mechanisms on Europa can provide valuable insights into the geophysical dynamics of icy moons and other planetary bodies.

Future Missions to Europa

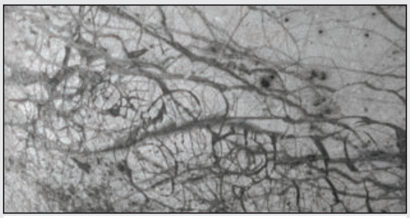
At present, NASA's Juno spacecraft has been orbiting Jupiter since 2016. Its prime mission is studying the planet itself, but there have been several flybys of the larger moons, including Europa. The potential for Europa to be an abode for extraterrestrial life has seen several missions proposed since the 1990s but only two have "gotten off the ground". The first, Europe's Jupiter Icy Moons Explorer (Juice – previously known as JUICE), launched in 2023 and will reach Jupiter in 2031. The mission will only have two close flybys of Europa as it orbits Jupiter before ultimately settling into orbit around the moon Ganymede.

The second mission, NASA's Europa Clipper mission, is scheduled for launch in October 2024 and will arrive at Jupiter in 2030. Europa Clipper aims to conduct detailed reconnaissance of Europa's surface, ice shell, subsurface ocean, and geology. Earlier proposals for NASA's next mission to study Europa considered an orbiter around the moon. However, due to the high levels of radiation at Europa's distance from Jupiter (around 100 times more intense than at Ganymede's distance), it was concluded that Europa Clipper would instead undertake several dozen flybys of Europa approximately every two weeks as it moves through an elliptical orbit of Jupiter, thereby extending the mission's operational life span.

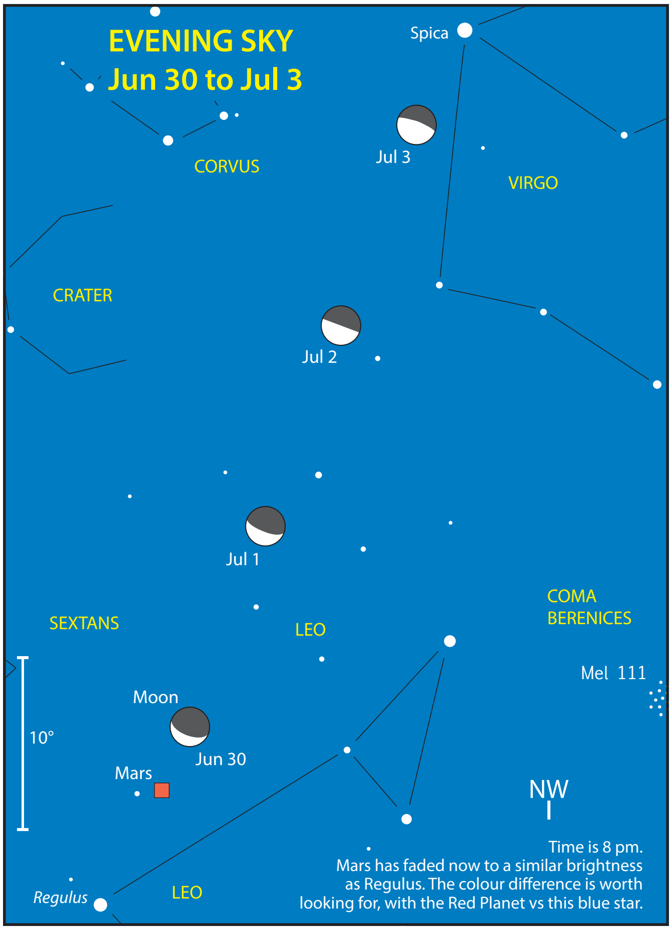
The largest planetary spacecraft that NASA has built, Europa Clipper is equipped with numerous scientific instruments to probe the icy moon:

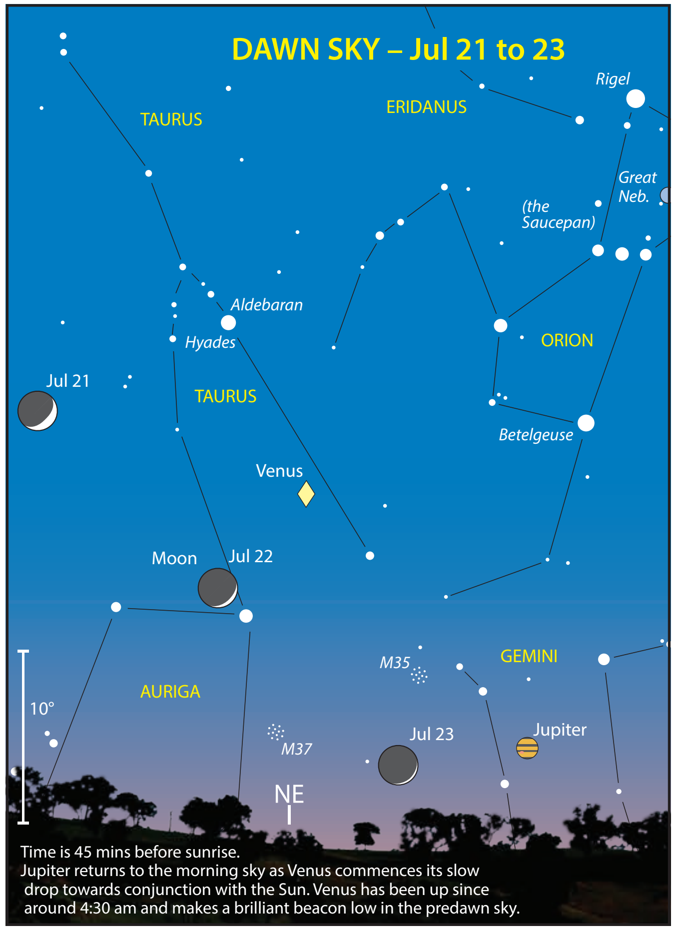
- Cameras imaging at visual and infrared wavelengths will capture detailed images of Europa's surface and map its temperature, looking for variations in the icy surface that might suggest different icy crust thicknesses.
- Spectrometers will analyse the composition of Europa's surface and any plumes that the spacecraft may fly through.
- An ice-penetrating radar will map the thickness of Europa's ice shell and the subsurface ocean below.
- A magnetometer will measure Europa's magnetic field to provide insights on the physical and chemical properties of the subsurface ocean.

By mapping the ice thickness, identifying surface compositions, detecting potential plumes, and understanding the moon's magnetic and thermal properties, Europa Clipper will hopefully answer many compelling questions surrounding Europa's potential habitability. Additionally, the data gathered will be invaluable for planning future missions, including potential landers that could directly sample Europa's ice and subsurface ocean. For followers of planetary exploration, the 2030s promises many new insights into Europa and a bounty of new images to enjoy.



Europa's icy crust has been considerably fractured, as shown by the dark lines in this image taken by Galileo in 1996. The scene bears a resemblance to icy floes found in Earth's polar regions. Credit: NASA/JPL





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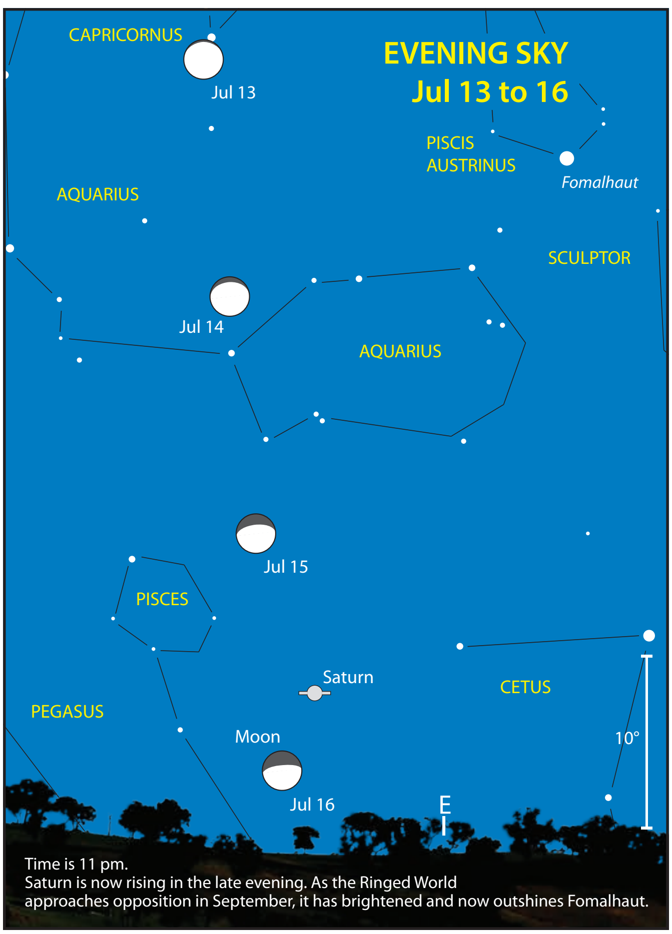
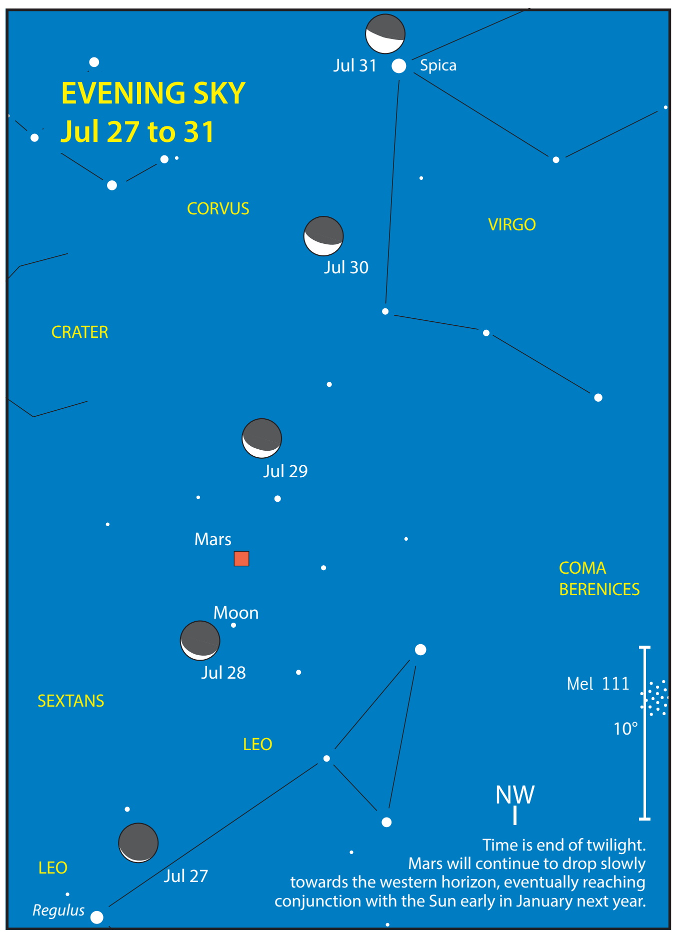
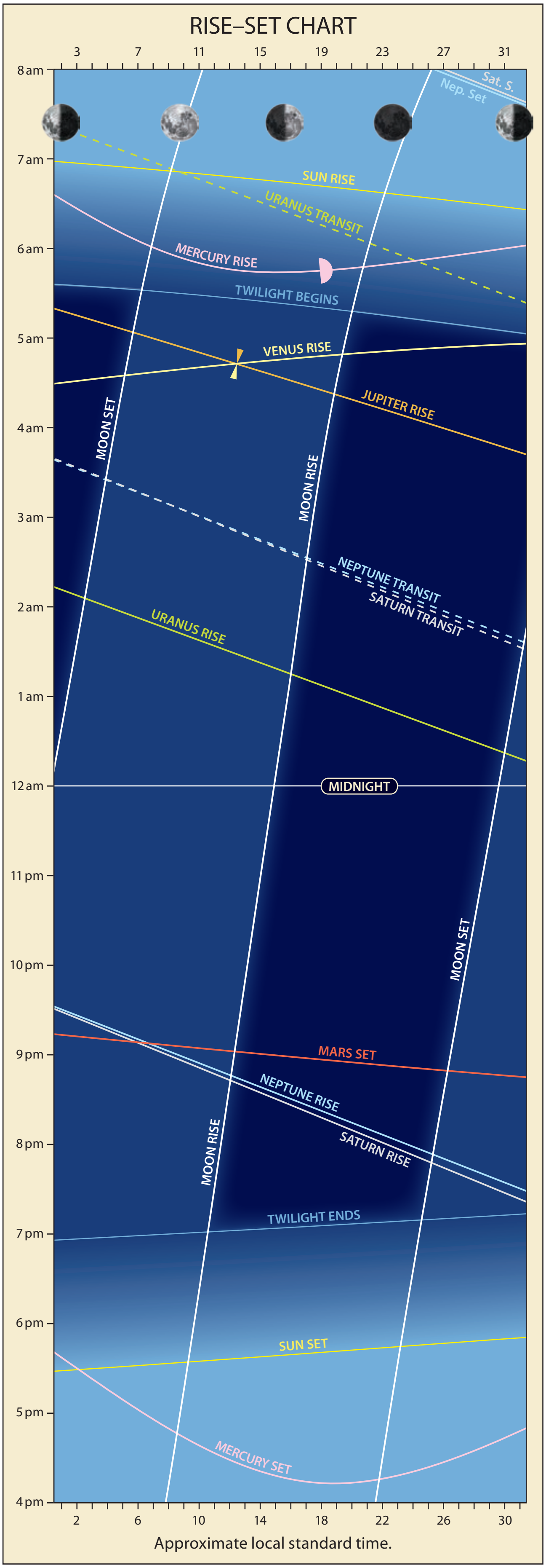




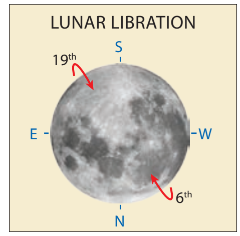
AUGUST



HIGHLIGHTS

- Venus and Jupiter close.
- Saturn and Neptune close.

THE MOON



1st 11 pm (9 pm WST) First Quarter.

2nd 7 am (5 am WST) Moon at apogee (furthest from Earth at 404,161 km).

6th 11 am (9 am WST) Maximum Libration (7.8°), dark NW limb.

9th 6 pm (4 pm WST) Full Moon.

15th 4 am (2 am WST) Moon at perigee (closest to Earth at 369,288 km).

16th 3 pm (1 pm WST) Last Quarter.

19th 2 pm (Noon WST) Maximum Libration (7.6°), dark SE limb.

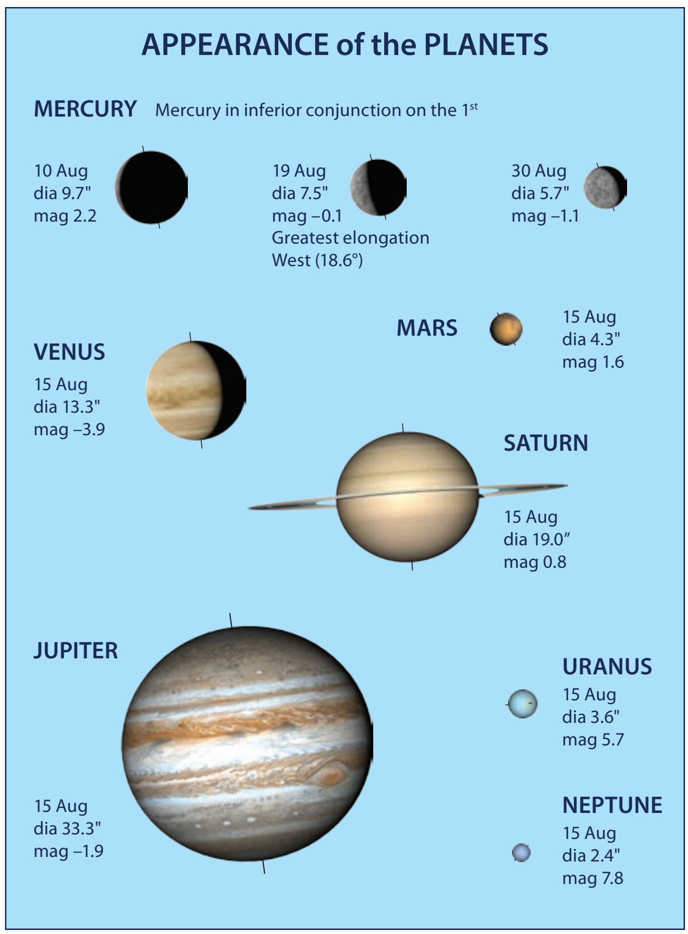
23rd 4 pm (2 pm WST) New Moon.

30th 2 am (Midnight WST, previous day) Moon at apogee (furthest from Earth at 404,548 km).

31st 4 pm (2 pm WST) First Quarter.

THE PLANETS

Mercury is in inferior conjunction (between the Earth and the Sun) on the 1st. It then joins Venus and Jupiter in the eastern morning dawn sky; this is a relatively poor apparition of the planet. It reaches its greatest elongation 28° west of the Sun on the 19th, just 6° above the horizon at civil dawn.



Brilliant **Venus** is visible in the pre-dawn eastern sky. The planet spends most of the month in Gemini before moving into Cancer. On the 3rd and 4th, Venus will be within 1° of the 3rd magnitude star Propus (Eta (η) Geminorum). Propus lies near the ecliptic and can be occulted by the Moon and rarely by a planet. In 1837, it was occulted by Mercury and then in 1910 by Venus, but it is best known as the star nearest to Uranus when that planet was discovered in 1781. An excellent conjunction occurs between the brightest planets, Venus and Jupiter, when they will be just 1° apart on the 12th and 13th (see Sky View). The spectacular meet-ups between these two are reasonably common, occurring roughly 13 months apart (although not always visible if close to the Sun).

Mars, in Virgo, is visible in the early western evening sky setting around 9 pm mid-month. On the 26th, the planet will be 4° from the 3-day-old waxing crescent Moon, forming a triangle with the 3rd magnitude star Gamma (γ) Virginis (Porrima), the second brightest star in Virgo (see Sky View).

Jupiter, low in the pre-dawn eastern sky in Gemini, has a very close encounter with Venus on the 12th and 13th (see Venus and Sky View). On the 20th, the planet will be around 5° from the 26-day-old waning crescent Moon.

Saturn, just south of the asterism the Circlet of Pisces, rises around 8:30 pm mid-month in the eastern sky. The planet's rings continue to narrow down to an inclination of 3°. During Saturn's journey around the Sun, observers can marvel at the beauty of the planet's splendid ring system. Alas, around the time of a ring plane crossing, they appear as slim protrusions extending from either side of the planet. On the plus side, this opens opportunities to view the planet's disc without ring interference and its major moons as they are strung out in line on either side of the planet (like how we see Jupiter's Galilean Moons, only fainter). The outermost planet, Neptune, has remained within 1° of Saturn since mid-June, but this month, they slowly separate until they are 1.7° apart at month's end. On the 12th, the 18-day-old waning gibbous Moon will be 4° from the planet (see Sky View). Next month, we will see Saturn at its best when it comes to opposition.

Uranus remains an object for morning observers, rising around 1 am mid-month in Taurus.

Neptune, in Pisces, rises in the mid-evening eastern sky around 8:30 pm mid-month. The planet and Saturn finally begin to separate (see Saturn).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

For the next two months, Niobe will visit some of the brighter stars in Scorpius, see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
2 Aug	30 Urania	Capricornus	9.9
3 Aug	63 Ausonia	Capricornus	9.6
6 Aug	129 Antigone	Capricornus	10.1
6 Aug	532 Herculina	Capricornus	10.2
8 Aug	2 Pallas	Delphinus	9.5
11 Aug	89 Julia	Aquarius	9.0
13 Aug	64 Angelina	Capricornus	11.6
14 Aug	27 Euterpe	Capricornus	10.2
27 Aug	6 Hebe	Aquarius	7.6

METEOR SHOWER

The famous **Perseids** are not readily observable, and the radiant will be below the horizon for many southern observers. The Perseids are the most dependable of the showers, with

AUGUST

DIARY			
Fri	1st		Mercury in inferior conjunction
Fri	1st	11 pm	(9 pm WST) First Quarter Moon.
Sat	2nd	7 am	(5 am WST) Moon at apogee (furthest from Earth at 404,161 km).
Sun	3rd		Mars 0.3° SE of star Beta Virginis
Mon	4th		Venus 0.4° SE of star Eta Geminorum
Mon	4th		Venus 1.8° S of Collinder 89 (OC) in Gemini
Mon	4th	7 pm	(5 pm WST) star Antares 4° W of Moon
Mon	4th	pm	m.p. 2 Pallas 0.6° NW of star Beta Delphini
Mon	4th	pm	m.p. 27 Euterpe 0.9° NW of star Delta Capricorni
Tue	5th		Venus 0.6° SW of star Mu Geminorum
Tue	5th	pm	m.p. 9 Metis 0.2° SW of star Alpha 2 Librae
Wed	6th	11 am	(9 am WST) Maximum Libration (7.8°), dark NW limb.
Wed	6th		Neptune 1° N of Saturn
Wed	6th	pm	m.p. 2 Pallas 0.2° NW of star Zeta Delphini
Fri	8th		m.p. 16 Psyche 0.8° N of star Delta³ Tauri
Fri	8th		Pallas at opposition
Sat	9th	6 pm	(4 pm WST) Full Moon (380,056 km).
Sun	10th	pm	m.p. 27 Euterpe 0.7° NW of star Gamma Capricorni
Sun	10th	pm	m.p. 71 Niobe 0.3° E of star Zeta² Scorpii
Mon	11th		m.p. 16 Psyche 0.3° S of star Epsilon Tauri
Mon	11th	pm	m.p. 71 Niobe 0.6° SE of NGC 6231 (OC) in Scorpius
Tue	12th	am	Perseids meteor shower, Jul 17 to Aug 24, Moon affected.
Tue	12th		Jupiter 1° NE of Venus
Tue	12th	11 pm	(9 pm WST) Saturn 4° S of Moon
Tue	12th	11 pm	(9 pm WST) Neptune 3° S of Moon
Thu	14th		Mars 1.0° SW of star Eta Virginis
Fri	15th	4 am	(2 am WST) Moon at perigee (closest to Earth at 369,288 km).
Sat	16th	3 pm	(1 pm WST) Last Quarter Moon.
Sun	17th		Venus 0.7° SE of star Delta Geminorum
Sun	17th	4 am	(2 am WST) Uranus 6° S of Moon
Mon	18th		Venus 0.6° NW of Eskimo Neb (NGC 2392, PN) in Gemini
Mon	18th	pm	m.p. 89 Julia 0.5° NE of star Nu Aquarii
Tue	19th	2 pm	(Noon WST) Maximum Libration (7.6°), dark SE limb.
Tue	19th		Mercury at greatest elongation West (18.6°)
Wed	20th	6 am	(4 am WST) Jupiter 6° S of Moon
Thu	21st	6 am	(4 am WST) Venus 7° SW of Moon
Thu	21st		star Pollux 7° N of Venus
Thu	21st	pm	m.p. 71 Niobe 0.6° SE of NGC 6268 (OC) in Scorpius
Fri	22nd	pm	m.p. 89 Julia 1.0° NE of Saturn Nebula (NGC 7009) in Aquarius
Sat	23rd	4 pm	(2 pm WST) New Moon.
Sun	24th		m.p. 16 Psyche 0.2° N of NGC 1647 (OC) in Taurus
Mon	25th	pm	m.p. 27 Euterpe 0.7° SE of star Iota Capricorni
Tue	26th	7 pm	(5 pm WST) Mars 4° E of Moon
Wed	27th	9 pm	(7 pm WST) star Spica 2° E of Moon
Thu	28th		Mars 0.8° N of NGC 4697 (G) in Virgo
Thu	28th	pm	d.p. 1 Ceres 1.5° NW of star Theta Ceti
Sat	30th	2 am	(Midnight WST, prev day) Moon at apogee (furthest from Earth at 404,548 km).
Sun	31st	4 pm	(2 pm WST) First Quarter Moon.
Sun	31st	10 pm	(8 pm WST) star Antares 0.5° N of Moon

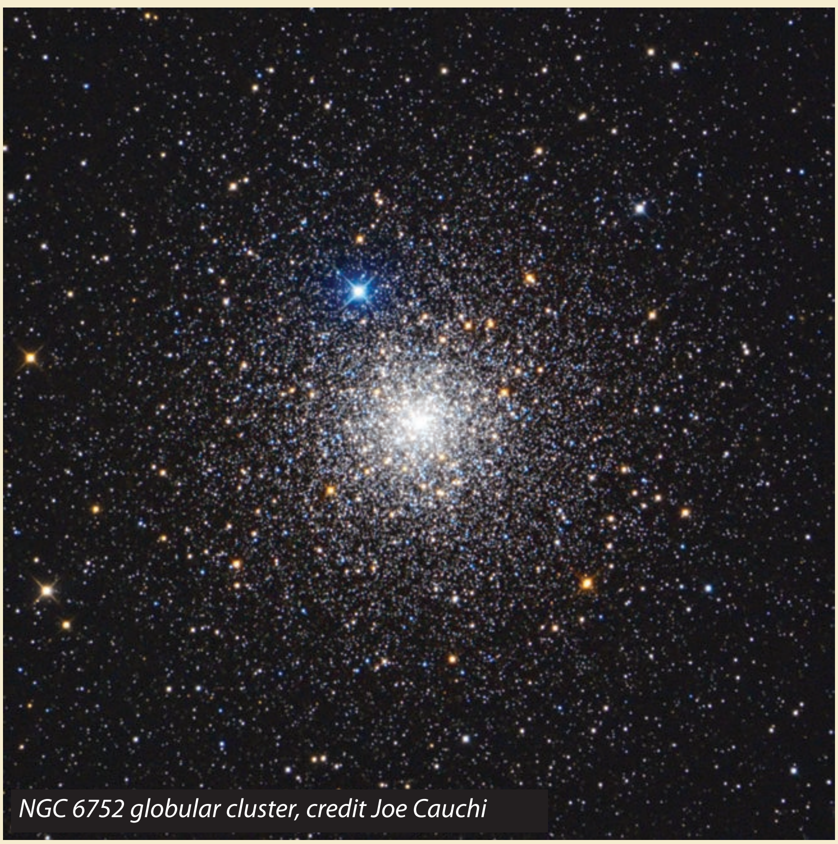
records of their activity going back over 1,000 years. Their duration is from July 17 to August 24. Their maxima are expected around the 12th and the morning of the 13th. This shower has produced exceptional rates, but a ZHR of 100 is generally possible. There would be considerably less activity from mid-Australian latitudes except for a few that may appear over the northern horizon. In his song, Rocky Mountain High, John Denver immortalised this spectacular shower when he sang, "I've seen it rainin' fire in the sky." The waning gibbous Moon will interfere with the Perseids this year.


NGC 6726/27 complex in Corona Australis, credit Joe Cauchi

CONSTELLATIONS

Beneath (south of) the Teapot of Sagittarius, there is a semicircle of stars marking the constellation of **Corona Australis** the Southern Crown (all Sky Map 8). Although made up of mostly 4th to 5th magnitude stars this asterism stands out well to the unaided eye under dark skies. The arc is around 8° in diameter and a good binocular object. At its eastern end, between Epsilon (ε) and Gamma (γ) Coronae Australis, sitting on the border with Sagittarius, are two impressive bright and dark nebulae (NGC 6726 and 6729 respectively) and a star complex. North (0.5°) of Epsilon lies the bright star cluster NGC 6723 which is just across the border in Sagittarius. This 7th magnitude globular has a bright 4-arcminute diameter halo with a broad core, showing slight brightening towards the centre. In the same low power (50 ×) field, 0.5° south-east, is an impressive double-double star. One pair (HD176386) consists of 7.3 and 9.4 mag components, 57 arcseconds apart. The other is two nearly matched 6th mag stars HR7169/70, separated by 13 arcseconds. These doubles are 0.2° apart forming a nice narrow triangle with the cluster. Each of the doubles lies in bright reflection nebulae and, commencing between these glowing gas clouds and extending to the south-east, is a dark nebula, visible by an absence of stars in an otherwise rich field. Overall, a stunning sight!

At magnitude 6.3 the spectacular star cluster NGC 6541 is one of the brightest globulars to reside in the hub of our galaxy. Low power binoculars show an obvious circular glow, 5° west of the semicircle star Theta (θ) Coronae Australis. Any size telescope reveals its highly condensed centre with a ragged edge on its halo. A darker region is seen on the globular towards its southern edge.


NGC 6752 globular cluster, credit Joe Cauchi

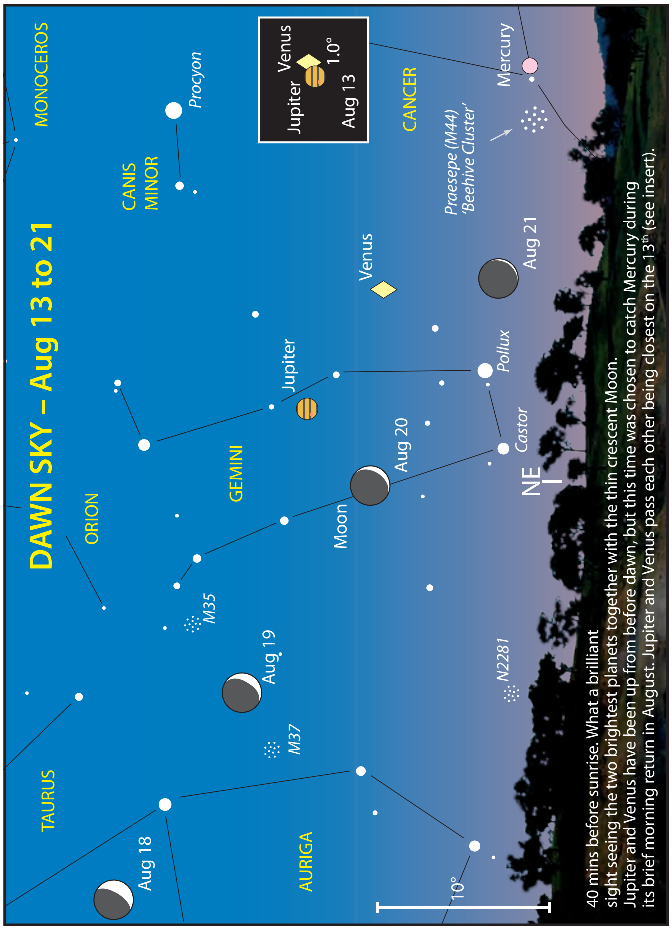
Finally, to round off our look at Corona Australis, are a couple of great double stars. Lambda (λ) Coronae Australis has a 5.1 magnitude white primary with a 10.0 mag yellow companion, 29 arcseconds away. A short hop 2° west-south-west finds Kappa (κ) Corona Australis. What a brilliant double with nearly matching white stars (mag 5.6 and 6.2) separated by 21 arcseconds on a rich star field.

Next, jump to the far south to the large, isolated constellation of **Pavo** the Peacock (all Sky Map 1). It certainly has no obvious naked-eye asterism. Except for naked-eye (2nd magnitude) Alpha (α) Pavonis, its brightest luminaries drop quickly to 4th magnitude. Being in the deep south, Pavo is well away from the Milky Way, hence known for numerous (mostly faint) galaxies and a globular cluster.

The globular star cluster NGC 6752, at magnitude 5.3, is the fifth brightest globular and offers excellent views through binoculars or telescopes. It is 29 arcminutes in diameter and a 150 mm telescope resolves the brighter 10th to 11th magnitude stars, which are arranged in various patterns, appearing to overlay the haze of the cluster. It has an obvious bright centre a few arcminutes in diameter.

The only other deep sky object in Pavo, visible in binoculars, conveniently lies only 5° south of NGC 6752 (or 2.5° south-east of 4^{th} magnitude Lambda (λ) Pavonis). The face-on, barred spiral galaxy NGC 6744, is impressive. Although bright at 8.3 magnitude, the arms are not easy to see having a low surface brightness, the light being spread over 20×13 arcminutes. The galaxy can be glimpsed as a hazy patch through binoculars but ideal dark skies with no haze are needed. The telescope shows a bright, non-stellar core, surrounded by a large tenuous halo whose brightness drops away quickly as you leave the core.

Here's the path to two more interesting galaxies. First, find the naked-eye (3.4 magnitude) star Beta (β) Pavonis. A short jump of 2.5° south finds Sigma (σ) Pavonis. Yellow (5.4 magnitude) Sigma is easily recognised in binoculars having the white 7^{th} magnitude star HD197569 only 2 arcminutes away. Only 0.4° west of the star lies the spiral galaxy NGC 6943. At first glance this 11.4 magnitude oval (3×2 arcminute) halo appears as a white homogeneous glow, which on increasing power (150 ×) shows a brightening towards a non-stellar nucleus. Return to Sigma and make a small 0.5° hop south-east to the challenging IC 5052. Edge-on spiral galaxies can always be fun to tease out of the background sky but when you see this 11.2 magnitude ghostly white streak (5×0.5 arcminute) it's worth the search.



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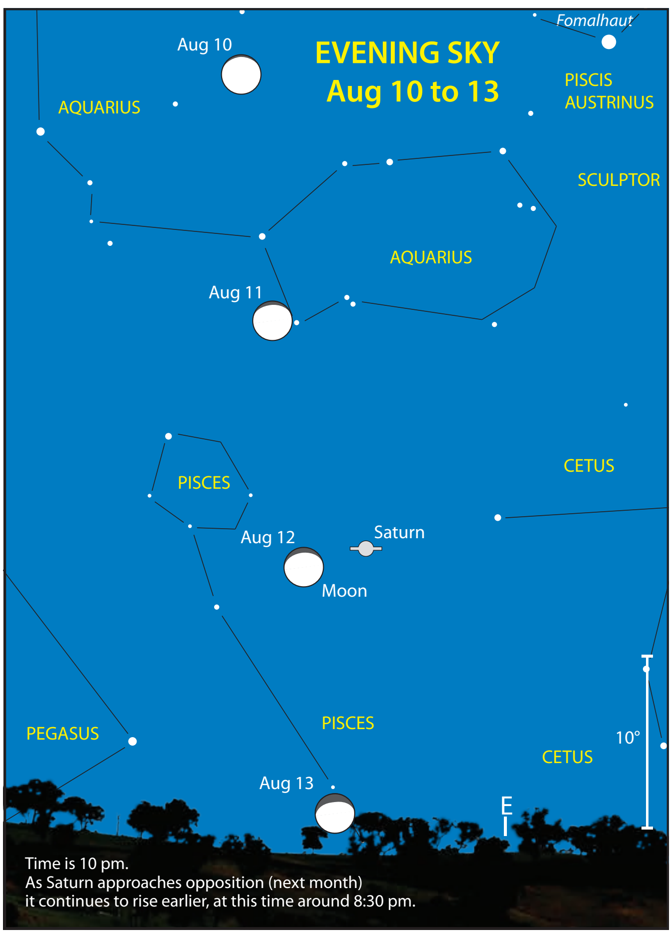
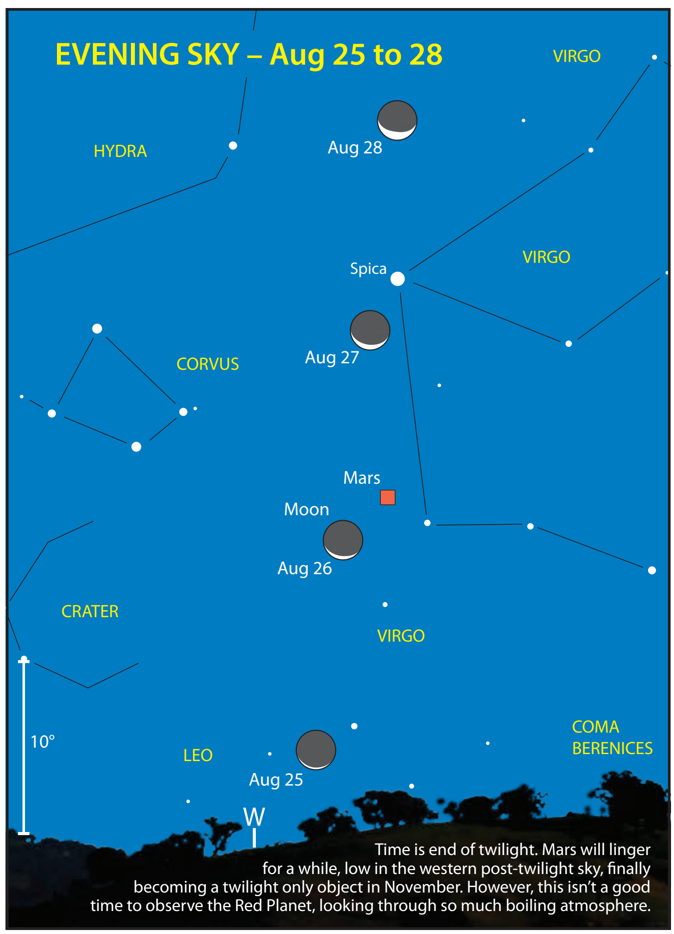
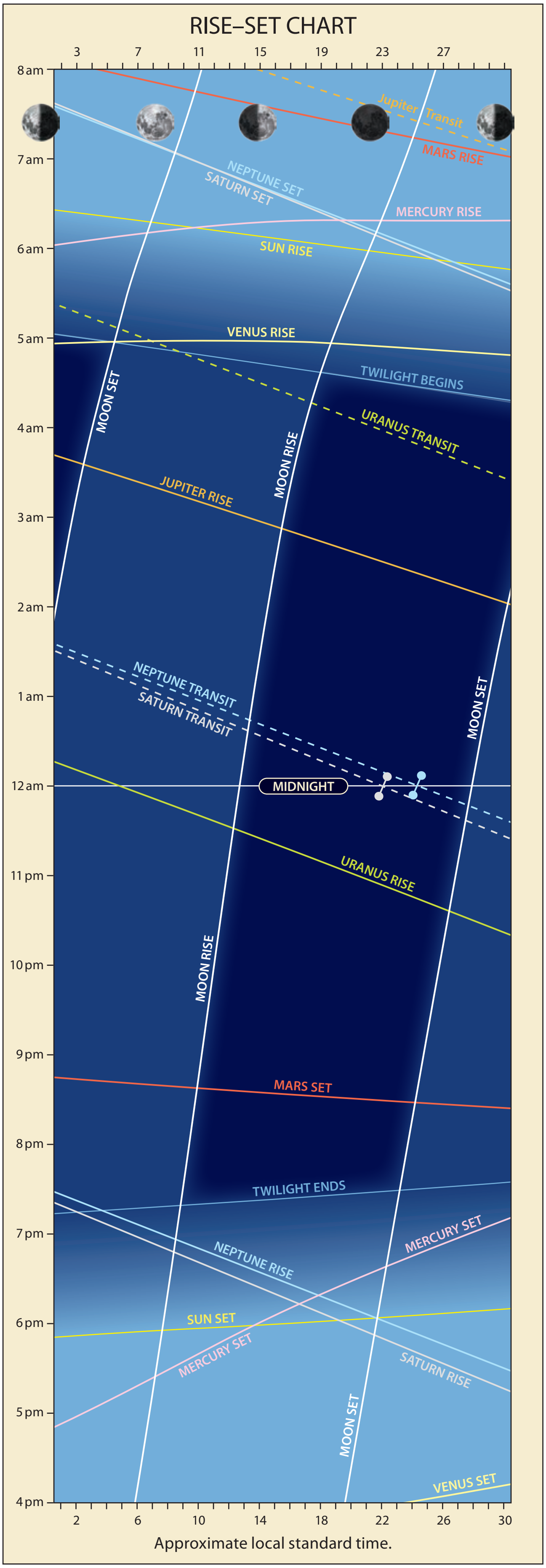




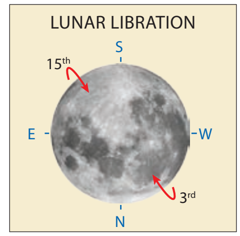
SEPTEMBER



HIGHLIGHTS

- ❍ Jupiter near the Eskimo Nebula.
- ❍ Saturn at opposition.
- ❍ Total lunar eclipse.

THE MOON



3rd 4 am (2 am WST) Maximum Libration (8.2°), dark NW limb.

8th 4 am (2 am WST) Full Moon, total lunar eclipse, Europe, Africa, Asia, Australia.

10th 10 pm (8 pm WST) Moon at perigee (closest to Earth at 364,777 km).

14th 9 pm (7 pm WST) Last Quarter.

15th 10 pm (8 pm WST) Maximum Libration (8.3°), dark SE limb.

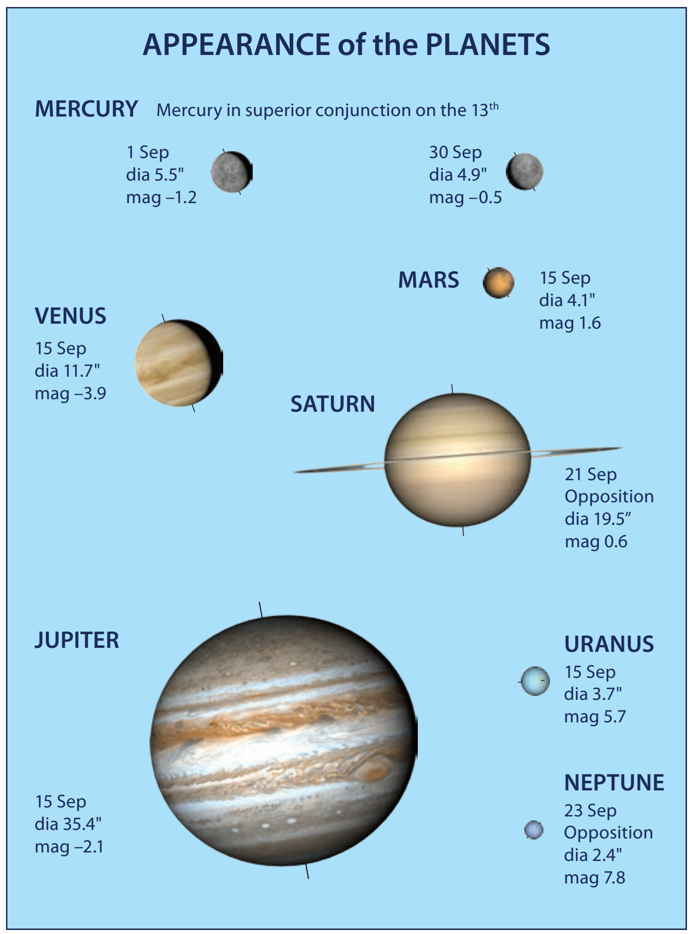
22nd 6 am (4 am WST) New Moon, partial solar eclipse, s Pacific, N.Z., Antarctica.

26th 8 pm (6 pm WST) Moon at apogee (furthest from Earth at 405,548 km).

30th 10 am (8 am WST) First Quarter.

THE PLANETS

Mercury, in the eastern morning sky, is too close to the Sun for observation. The planet is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 13th and then returns to the western dusk sky, albeit still close to the Sun. Next month will provide an excellent opportunity to follow this elusive planet.



Venus is now only visible in the eastern dawn sky (see Sky View). Viewing will become more challenging as the planet moves lower in the sky each morning and closer to the Sun. By the end of the month, it will be so low at the beginning of civil twilight that it will require an unobstructed horizon to observe it.

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

Mars, in Virgo, is visible low in the early western evening sky. On the 24th, the planet will be 4° from the slender crescent of the 2-day-old waxing Moon (see Sky View). By the end of the month, Mars' angular size is just 4 arcseconds, and its brightness is now 1.6 magnitude, compared to 14 arcseconds and −1.4 magnitude at opposition last January.

Jupiter, rising around 3 am mid-month, is visible in the eastern morning sky in Gemini (see Sky View). From the 4th to the 10th, the planet will be 0.5° or less from the 4th magnitude star Delta (δ) Geminorum (Wasat) and closest on the 7th at 0.2°. Delta is an interesting binary of unequal white and reddish suns; the companion is 8th magnitude, and the pair make an easy double in small telescopes. Delta very closely marks the point where Pluto crosses the ecliptic on its way north; in fact, the dwarf planet was only 0.2° from this star when found by Clyde Tombaugh in 1930. From the 19th to the 24th, Jupiter will be 1° from the Eskimo Nebula NGC 2392 (also known as the Clown Face Nebula). It is visible in telescopes as a small greenish ball with a central star.

Saturn comes to opposition on the 21st and is visible the entire night. By mid-month, the inclination of the planet's rings to the plane of the Earth's orbit is just 2°. This narrow aspect of the rings gives a near-unobstructed view of both hemispheres of the globe. Using filters over the eyepiece (orange or blue) will enhance details in the bands and the polar regions. Look for the light-coloured equatorial band and the noticeable darkening and flattening at the poles.

It's fun to track down and identify some of the planet's satellites (about six are readily visible in amateur telescopes). Except for 8th magnitude Titan, the others are a little more difficult, and 'Saturn's Moons' p. 126. will greatly assist. With its moons orbiting roughly in the plane of the rings, they are visible shuttling back and forth across Saturn (like Jupiter and its satellites) when the rings are near edge-on. On the 8th, the Full Moon rises with the planet in the early eastern sky (see Sky View).

Uranus, in Taurus, rising around 11 pm mid-month, is still essentially a morning object. On the 6th, the planet begins five months in retrogression, appearing to travel westward against the stars (see retrograde motion p. 92).

Neptune, the only planet not visible to the unaided eye from Earth, comes to opposition on the 23rd, rising in the east during astronomical twilight. At 7.8 magnitude and 2.4 arcseconds in diameter, it requires at least a 100 mm telescope, 200 magnification, and good seeing to resolve into a featureless bluish disc. Since mid-June, Neptune has been close to Saturn, and this month, the pair draws apart from 1.7° to 3° by month's end.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Hygiea visits three open star clusters during September and, due to retrograde motion, will visit the same three in December, but in reverse order, see Diary. Brightest minor planets at opposition this month include:

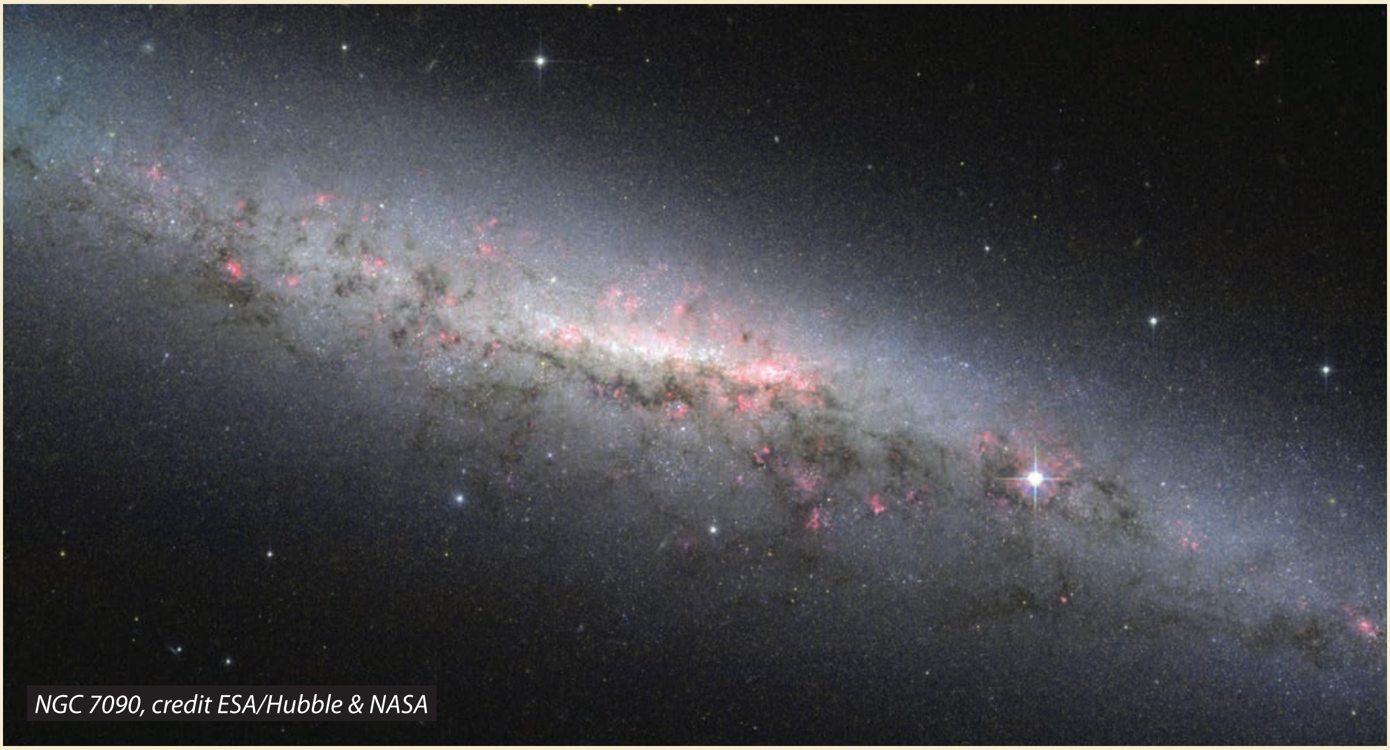
Date	Minor Planet	Constellation	Mag.
1 Sep	185 Eunike	Aquarius	10.6
14 Sep	22 Kalliope	Cetus	10.6

CONSTELLATIONS

The constellation of **Microscopium** the Microscope (All Sky Map 8), located south of Capricornus, can easily be missed having no stars brighter than magnitude 4.9. It's home to several faint galaxies and some interesting double stars. Its brightest star, Alpha (α) Microscopii is

DIARY

Mon	1st		Venus 1.3° SW of M44 Beehive Cluster (OC) in Cancer
Tue	2nd		Mars 1.0° SW of NGC 4941 (G) in Virgo
Wed	3rd	4 am	(2 am WST) Maximum Libration (8.2°), dark NW limb.
Fri	5th		Mars 1.0° NE of NGC 4958 (G) in Virgo
Sat	6th		Mars 0.6° NE of NGC 4995 (G) in Virgo
Sun	7th	5 am	(3 am WST) Jupiter 0.2° N of star Delta Geminorum
Mon	8th	4 am	(2 am WST) Full Moon (369,671 km), total lunar eclipse, Europe, Africa, Asia, Australia.
Tue	9th	3 am	(1 am WST) Saturn 4° SE of Moon
Tue	9th	4 am	(2 am WST) Neptune 4° SE of Moon
Tue	9th	pm	m.p. 6 Hebe 1.6° W of Helix Neb (NGC 7293) in Aquarius
Tue	9th	pm	m.p. 71 Niobe 1.2° NW of star Upsilon Scorpii
Wed	10th		m.p. 10 Hygiea 1.1° N of NGC 2158 (OC) in Gemini
Wed	10th	10 pm	(8 pm WST) Moon at perigee (closest to Earth at 364,777 km).
Thu	11th	pm	m.p. 89 Julia 0.8° NE of star Epsilon Aquarii
Fri	12th		m.p. 10 Hygiea 0.8° N of M35 (OC) in Gemini
Fri	12th		m.p. 4 Vesta 1.3° SW of star Theta Librae
Fri	12th		star Spica 2° S of Mars
Fri	12th	pm	m.p. 71 Niobe 1.2° NW of star Lambda Scorpii
Sat	13th	4 am	(2 am WST) Uranus 7° SE of Moon
Sat	13th		Mercury in superior conjunction
Sun	14th	9 pm	(7 pm WST) Last Quarter Moon.
Mon	15th	10 pm	(8 pm WST) Maximum Libration (8.3°), dark SE limb.
Wed	17th	4 am	(2 am WST) Jupiter 6° SW of Moon
Wed	17th	4 am	(2 am WST) star Pollux 1.5° N of Moon
Fri	19th		m.p. 44 Nysa 0.8° S of star Zeta Geminorum
Fri	19th	pm	m.p. 129 Antigone 2.4° E of m.p. 63 Ausonia
Sat	20th		Jupiter 1.0° N of Eskimo Neb (NGC 2392, PN) in Gemini
Sat	20th		star Regulus 0.5° SW of Venus
Sun	21st		m.p. 4 Vesta 0.8° S of star Beta Scorpii
Sun	21st		Saturn at opposition
Mon	22nd	6 am	(4 am WST) New Moon, partial solar eclipse, s Pacific, N.Z., Antarctica.
Tue	23rd		Equinox
Tue	23rd		Neptune at opposition
Tue	23rd	pm	d.p. 1 Ceres 1.0° NW of star Eta Ceti
Wed	24th		m.p. 10 Hygiea 1.4° N of Collinder 89 (OC) in Gemini
Wed	24th	7 pm	(5 pm WST) star Spica 5° NW of Moon
Wed	24th	7 pm	(5 pm WST) Mars 4° NE of Moon
Thu	25th		m.p. 4 Vesta 0.1° SE of star Nu Scorpii
Fri	26th	8 pm	(6 pm WST) Moon at apogee (furthest from Earth at 405,548 km).
Sat	27th	10 pm	(8 pm WST) star Antares 4° E of Moon
Tue	30th	10 am	(8 am WST) First Quarter Moon.


NGC 7090, credit ESA/Hubble & NASA

an impressive double, displaying an obvious 5th magnitude yellow primary with a 10th magnitude white secondary, 20 arcseconds away.

Move 3.7° north-west of Alpha to find the galaxy NGC 6925. This 11th magnitude, near edge-on spiral, has an obvious (3 × 1 arcminute) halo with a bright elongated core and star-like nucleus. Compare this galaxy to NGC 6958, located 4.2° south of Alpha. It's also an 11th magnitude galaxy, but elliptical in nature, showing a near circular halo (2' wide) with a broad core which brightens slightly towards the centre. It resembles an unresolved globular cluster.

Moving southward we cross the border into **Indus**, the Indian (best seen on All Sky Map 1). Except for Alpha (α) Indi at magnitude 3.2, it is like Microscopium, made up of faint stars and being, located away from the Milky Way, is known for several galaxies and double stars.

Here's a couple of doubles. Starting at naked-eye (4.4 magnitude) Delta (δ) Indi, move 3° south-west to discover a brilliant binocular triple star, JC 25 (HD 206429), arranged in a dogleg shape. From its central 6.5 magnitude star, one companion is 6.9 magnitude, 2.5 arcminutes north, with the other star, 7.3 magnitude located 3.1 arcminutes south-west. All three components are distinctly yellow.

Naked-eye Theta (θ) Indi is a great double for any small telescope, comprising 4.5 and 6.9 magnitude stars, 6 arcseconds apart. The primary is white with its companion yellowish orange.

From Theta, move 5° north to uncover the galaxy NGC 7049. This 10.7 magnitude spiral has a prominent, slightly oval core surrounded by a faint narrow halo. Only 0.4° to the west-north-west lies another spiral, NGC 7041, showing an obvious oval core, surrounded by a faint spindle-shaped halo.

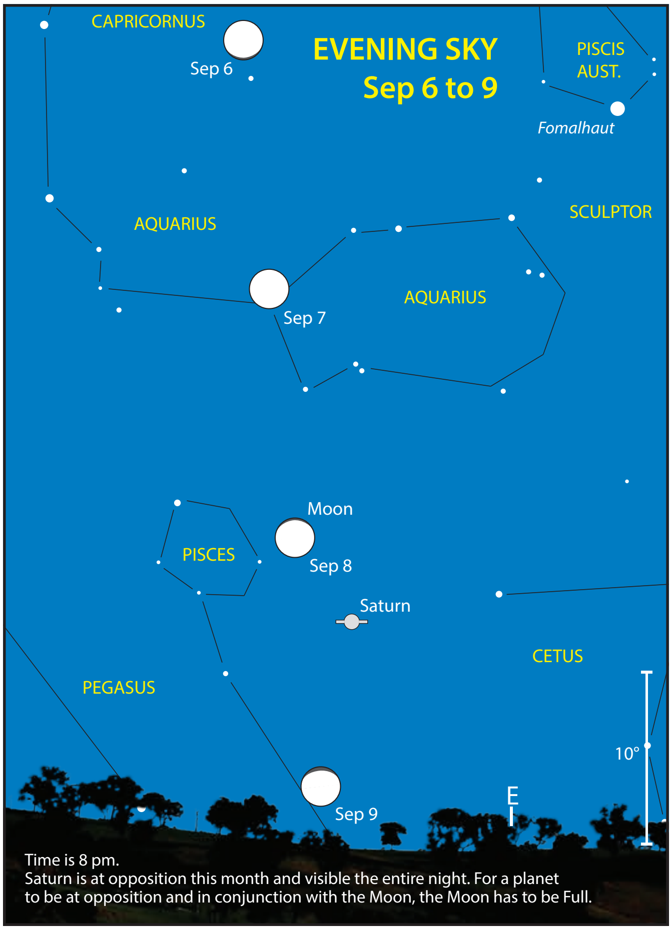
Returning to Delta, move 3.8° north to uncover the 9.9 magnitude irregular galaxy, IC 5152. Its claim to fame is being a member of the local group of galaxies. The galaxy is an oval shaped (1.5 × 3.0 arcminute) obvious haze appearing evenly lit. Avoid the glare from the bright (7.8 magnitude) star on its north-west edge by pushing it out of the field.

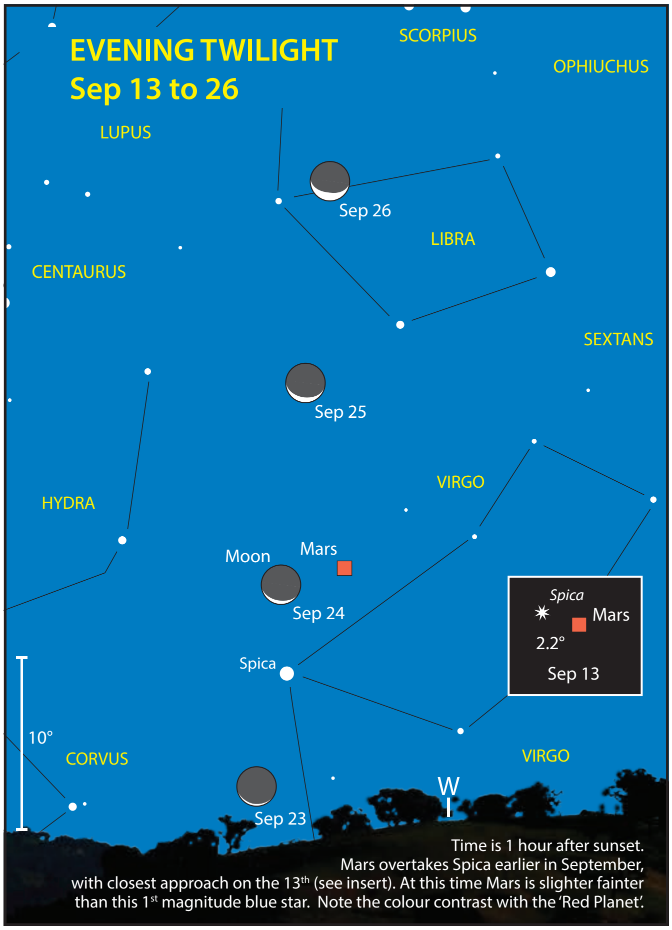
The edge-on spiral galaxy NGC 7090 is halfway between 4th magnitude Delta (δ) Indi and Theta (θ) Indi, the stars being 6° apart. A 150–200 mm telescope is needed for this 10th magnitude ghostly streak, 3–4 arcminutes long.

To the west of Indus (east of Ara) lies another faint constellation, **Telescopium**, the Telescope (best seen on All Sky Map 1). Except for naked-eye (4th magnitude) Zeta (ζ) and Epsilon (ε) plus magnitude 3.5, Alpha (α) Telescopii, the remaining stars are 5th magnitude and fainter. These three stars form a right-angled triangle (Alpha is the 90°) nestled into the north-east corner of the constellation (near the semicircle asterism of Corona Australis). The star Delta, δ^1 and δ^2, (only 1° west of Alpha) makes a great binocular (naked-eye) double with nearly matched 5th magnitude blue stars, separated by 9 arcminutes.

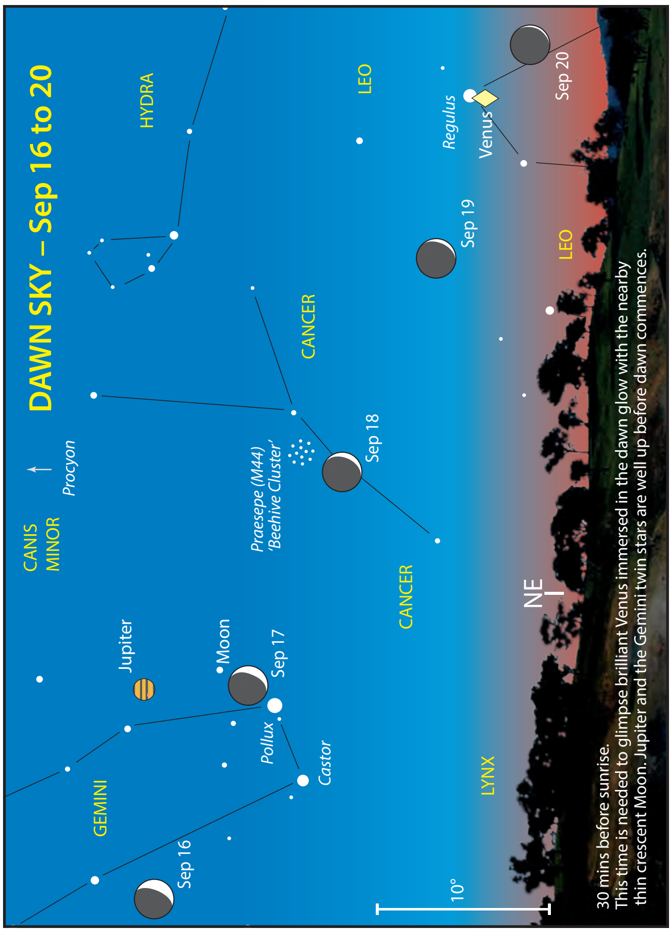
Telescopium's only globular cluster is worth a look. NGC 6584 (3.5° south-south-west from Zeta (ζ)) is bright (magnitude 7.9), showing a 3-arcminute halo with a rich concentrated centre. Some of its brightest stars are well resolved, especially at the edge in 150–200 mm instruments.

The brightest galaxy in Telescopium is NGC 6868. It's in the north-east, somewhat barren corner of the constellation, 5° west of Alpha (α) Indi. This 10.7 magnitude elliptical galaxy is nearly circular (3 arcminutes across) with a bright central non-stellar core, dropping away in brightness into the halo. A 150 mm minimum sized telescope is recommended. It has a fainter, smaller companion NGC 6870, 6 arcminutes to the north-east, which in contrast is distinctly oval. For those with larger instruments, NGC 6868 lies on the eastern edge of the small, faint Abell S851 galaxy cluster, which extends westward by around 1°, have fun looking around.

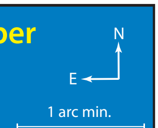




Approximate local standard time.



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.

Sep 4, 10 pm EST (8 pm WST)

Having an orbital period of 16 days, Titan only has a close approach to Saturn every 8 days. Here, Titan was at inferior conjunction (making a close approach to Saturn's northern pole) about 3 hours earlier.

Sep 5, 11 pm EST (9 pm WST)

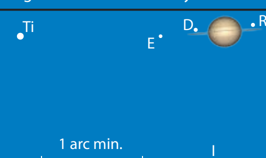
A nice gathering of the moons on the western side and a good time to observe them. Mimas and Enceladus are already at maximum elongation and Dione and Rhea reach maximum in a few hours.

Sep 16, 9 pm EST (9 pm WST)

This diagram illustrated well how far Saturn's brightest moon, Titan, wanders when near a maximum elongation. Enceladus is close to a western maximum. Being so close to the rings this is not the best time to go after Mimas or Tethys.

Sep 18, 11 pm EST (9 pm WST)

The distant moon Iapetus, having an orbital period of 79 days, only makes a 'close' approach to Saturn about every 39 days. Here, the moon is close to a superior conjunction. Having a highly inclined orbit compared to the other moons it rarely gets closer. (Note the change of scale)

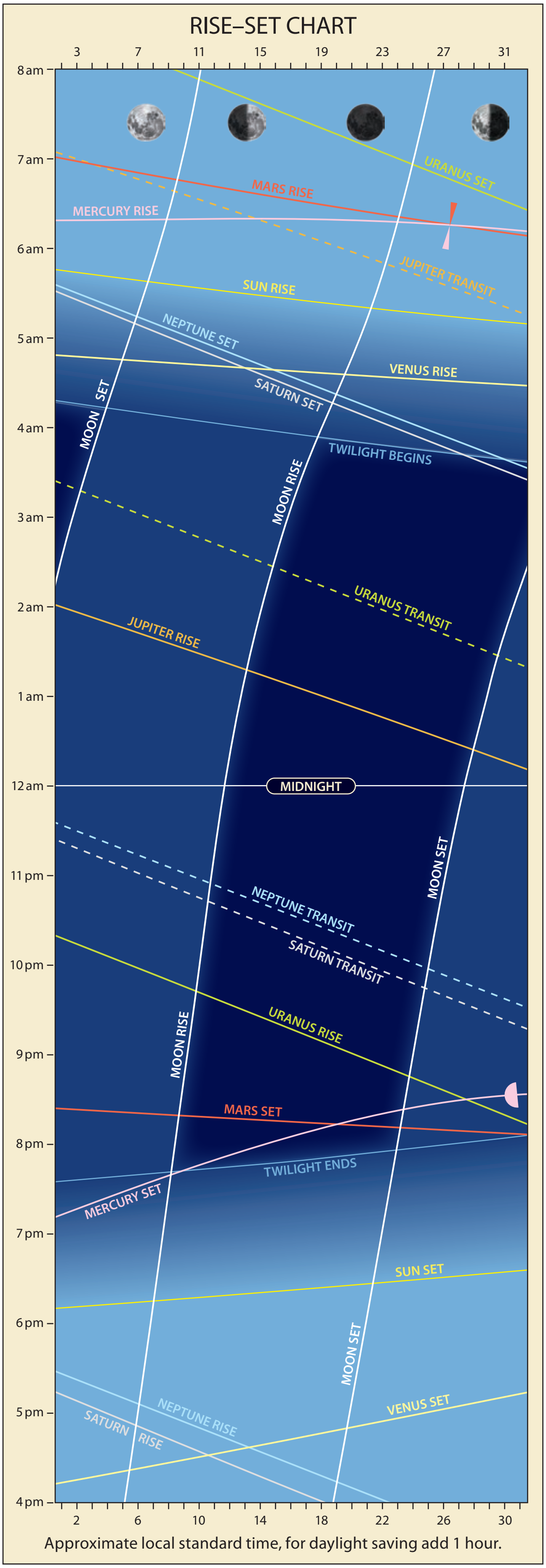


I	Mimas	M
II	Enceladus	E
III	Tethys	Te
IV	Dione	D
V	Rhea	R
VI	Titan	Ti
VII	Iapetus	I

Sep 22, midnight EST (10 pm WST)

The moons are flying in tight formation!

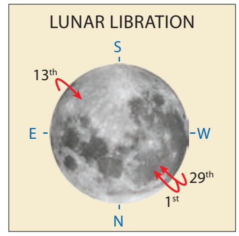
OCTOBER



HIGHLIGHTS

- Mercury and Mars close.
- Moon, Mercury, and Mars close.
- The Orionids meteor shower.

THE MOON



1st 4 am (2 am WST) Maximum Libration (8.5°), dark NW limb.

7th 2 pm (Noon WST) Full Moon, supermoon.*

8th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 359,819 km).

13th 6 pm (4 pm WST) Maximum Libration (8.9°), dark SE limb.

14th 4 am (2 am WST) Last Quarter.

21st 10 pm (8 pm WST) New Moon.

24th 10 am (8 am WST) Moon at apogee (furthest from Earth at 406,444 km).

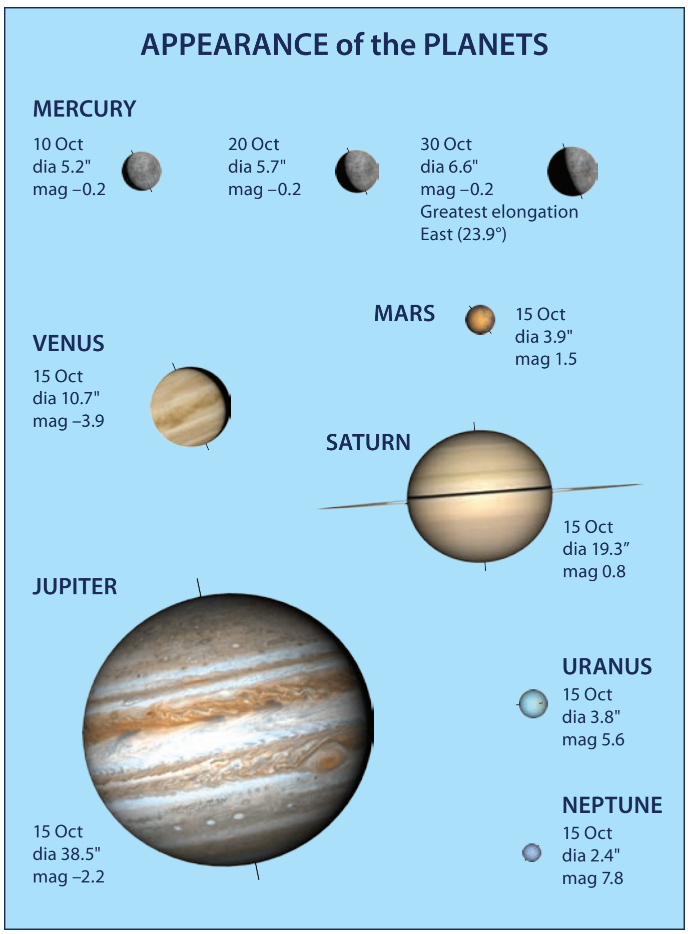
29th 11 am (9 am WST) Maximum Libration (8.3°), dark NW limb.

30th 2 am (Midnight WST, previous day) First Quarter.

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

THE PLANETS

This month provides an good opportunity to see **Mercury** in the western evening sky. The planet reaches its greatest



elongation, 24° from the Sun, on the 30th and can be seen at the end of civil twilight as the sky darkens. As Mercury gains altitude, it passes by Mars as that world heads toward its solar conjunction. From the 19th to the 22nd, the planetary duo will be just 2° apart, but making this view special is the inclusion of the 2-day-old waxing crescent Moon on the 23rd (see Sky View). At this time, Mercury is brighter than Mars, although the colour of the Red Planet should be a giveaway. Try viewing the triplet in binoculars to enhance the view.

Venus remains just a few degrees above the eastern horizon throughout the month at the beginning of civil dawn.

In Libra, **Mars** meets Mercury in the early western evening sky. From the 19th to the 22nd, Mars and Mercury will be just 2° apart. Although further apart on the 23rd, the inclusion of the slender crescent of the 2-day-old Moon creates an attractive conjunction (see Sky View).

Jupiter rises around 1 am mid-month in the eastern morning sky in Gemini (see Sky View). After last month's meeting with the Eskimo Nebula, the King of Planets' path takes it directly across the open star cluster NGC 2420 (closest on the 7th). This cluster comprises fifty 11th to 13th magnitude stars, loosely spread across a 10-arcminute area.

Saturn, just past opposition, rises around 4 pm mid-month and is visible in the eastern sky at the end of twilight (see Sky View). The planet's rings continue to narrow and, by the 15th, will be inclined to us just at 1°. They reach their narrowest in November (since the March ring-plane crossing) before gradually widening again. Over the year, one of the

Fluidic Telescope (FLUTE)

Enabling the Next Generation of Large Space Observatories

The future of space-based UV/optical/IR astronomy requires ever larger telescopes. The highest priority astrophysics targets, including Earth-like exoplanets, first generation stars, and early galaxies, are all extremely faint, which presents an ongoing challenge for current missions and is the opportunity space for next generation telescopes: larger telescopes are the primary way to address this issue.

With mission costs depending strongly on aperture diameter, scaling current space telescope technologies to aperture sizes beyond 10 m does not appear economically viable. Without a breakthrough in scalable technologies for large telescopes, future advances in astrophysics may slow down or even completely stall. Thus, there is a need for cost-effective solutions to scale space telescopes to larger sizes.

The FLUTE project (jointly led by NASA and Technion – Israel Institute of Technology) aims to overcome the limitations of current approaches by paving a path towards space observatories with large aperture, unsegmented liquid primary mirrors, suitable for a variety of astronomical applications. Such mirrors would be created in space via a novel approach based on fluidic shaping in microgravity, which has already been successfully demonstrated in a laboratory neutral buoyancy environment, in parabolic microgravity flights, and aboard the International Space Station (ISS). Theoretically scale-invariant, this technique has produced optical components with superb, sub-nanometre (RMS) surface quality. In order to make the concept feasible to implement in the next 15–20 years with near-term technologies and realistic cost, the diameter of the primary mirror is limited to 50 metres.

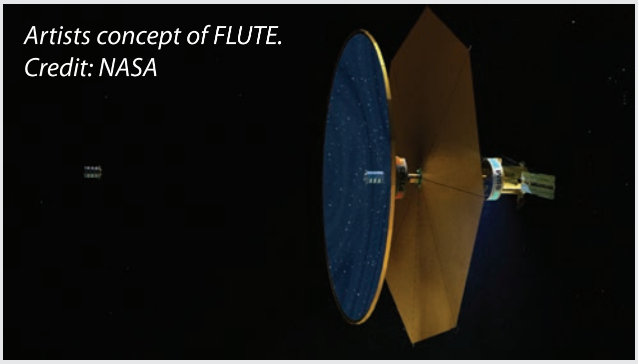
In the Phase I study, they:

- explored choices of mirror liquids, deciding to focus on ionic liquids
- conducted an extensive study of ionic liquids with suitable properties
- worked on techniques for ionic liquid reflectivity enhancement
- analysed several alternative architectures for the main mirror frame
- conducted modelling of the effects of slewing manoeuvres and temperature variations on the mirror surface
- developed a detailed mission concept for a 50 m fluidic mirror observatory
- created a set of initial concepts for a subscale small spacecraft demonstration in low Earth orbit.

In Phase II, that has now received funding, they will continue maturing the key elements of the mission concept.

- Continue their analysis of suitable mirror frame architectures and modelling of their dynamic properties.
- Take next steps in machine learning-based modelling and experimental work to develop reflectivity enhancement techniques for ionic liquids.
- Further advance the work of modelling liquid mirror dynamics. In particular, focus on modelling the effects from other types of external disturbances (spacecraft control accelerations, tidal forces, and micrometeorite impacts).
- Create a model of the optical chain from the liquid mirror surface to the science instruments.
- Further develop the mission concept for a larger-scale, 50 m aperture observatory, focusing on its highest-risk elements.

Finally, they will mature the concept for a small spacecraft technology demonstration mission in low Earth orbit, incorporating the knowledge gained in other parts of this work.


Artists concept of FLUTE. Credit: NASA

OCTOBER

most conspicuous things that observers would have noted is the planet's polar flattening. When the rings are wide open, they tend to divert the mind away from the planet's shape. The degree of Saturn's polar flattening is quantified by its equatorial bulge, which is the difference between its equatorial and polar diameters. This difference is 10% for Saturn, making it the most oblate (pumpkin-shaped) of all the planets in the Solar System.

Uranus, in Taurus, rises in the eastern evening sky around 9 pm mid-month. The planet comes to opposition next month.

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

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

As Vesta drops lower in the early western evening sky, it has some interesting conjunctions with several globular clusters in Ophiuchus, see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
3 Oct	1 Ceres	Cetus	7.8
17 Oct	85 Io	Pisces	10.2
19 Oct	702 Alauda	Andromeda	12.3
28 Oct	654 Zelinda	Andromeda	11.8
30 Oct	433 Eros	Andromeda	10.1

COMET

Comet 210P/Christensen begins October in Corona Australis about magnitude 13, rising in daylight and setting in the south-western sky around 2:30 am. On the 12th, it moves into Scorpius, having brightened to magnitude 11.5 and setting around 12:30 am. By month's end, the comet is rising about 6 pm and possibly 10th magnitude. In the latter half of October, Christensen traverses the stinger region of Scorpius' scorpion. On the 29th it's close to the impressive naked-eye double star Mu Scorpii, see Diary.

METEOR SHOWERS

The **Southern Taurids** are active from September 10 through to November 20. The shower comprises two radiants of nearly equal activity ten degrees apart. The Southern Taurids should peak late evening on October 10 through to dawn, with about five meteors per hour. The Taurids are frequently bright, slow-moving, and noted for occasionally producing colourful fireballs. They are associated with Comet 2P/Encke and are visible from late evening to early morning. During the shower's peak this year, the waning gibbous Moon will have a severe impact.

The **Orionids** are best seen from late evening until dawn and are visible from October 2 to November 7. Maximum activity is expected from the late evening of the 21st through to dawn. Over the past twenty years, the Orionids have produced around 20 meteors per hour. With many sub-maxima, reasonable rates can occur several nights around the peak. The Orionids are typically very swift and often bright, with some leaving trains. Chinese observers recorded this shower in 288 CE, associated with Halley's Comet. This year's peak occurs around New Moon, so moonlight will not be an issue.

CONSTELLATIONS

The constellation of **Grus** the Crane (best seen on All Sky Map 8) is now riding high in the southern evening sky. Grus is the most recognisable constellation in the deep south, away from the Milky Way. It's certainly a landmark constellation in an otherwise dull section of the sky. Grus's neck of curved stars points towards Capricornus to the north and the rising Clouds of Magellan in the south. Looking out of the plane of our galaxy, it is a feast for extragalactic hunters, with plenty of great galaxies and no open star clusters.

We'll whet your appetite by starting with a couple of bright double stars, both in the curved neck line of stars making an impressive naked-eye double-double. Mu (μ) Grus is comprised of magnitude 4.8 (Mu^1) and 5.1 (Mu^2) members, 19 arcminutes apart. Moving 3° south-east you'll find Delta (δ) Gruis with components of magnitude 4.0 ($Delta^1$) and 4.1 ($Delta^2$), separated by 16 arcminutes. Binoculars show both Mu stars and $Delta^1$ as yellow in contrast to $Delta^2$'s orange. The Mu and Delta pairs are 3° apart.

From Delta scroll 2.8° south-south-west to discover the brilliant binocular double Pi (π) Gruis, with 6.6 magnitude (π^1) and 5.8 magnitude (π^2), separated by 4 arcminutes. Closer inspection with a telescope (under high power and good seeing) reveals Pi to be a double-double! Pi^1 consists of magnitude 6.6 and 10.8 components, coloured red and yellow respectively, only 2.7 arcseconds apart. Pi^2 has two yellow stars of magnitude 5.8 and 11.2, separated by an easier 4.8 arcseconds.

Switching to galaxies, we return to Delta (δ) and track 6° north-east to discover the galaxy NGC 7410. This 10.3 magnitude spiral is large (6 × 2 arcminutes) with a bright stellar nucleus and an obvious central bar (3 × 1 arcminutes) with a mottled surface. The limits of the halo are less defined, gradually fading towards the edge.

Now we look to the *big guns*, Grus' triplet of galaxies: NGC 7582 (10th magnitude) and 7590 / 7599 (both 11th magnitude). They are 2.5° north-east of naked-eye (4th magnitude) Theta (θ) Gruis. These edge-on spirals, which need at least a 150 mm telescope to observe, are arranged in a triangle 15 arcminutes across. They resemble the Leo Triplet of M65, M66 and NGC 3628, but the Grus group is fainter and more compact. NGC 7582 is not only the brightest member but has a more pronounced ovality in the halo (3.0 × 0.5 arcminutes) and a small non-stellar nucleus. If you go to a wider field (0.7°) the Grus trio becomes a quartet with another spiral (10.6 magnitude) NGC 7552 in the south-west. It shows an obvious narrow bar (3.0 × 0.3 arcminutes) with a stellar nucleus.

Now take a trip up (north) in Grus' neck to observe its only planetary nebula IC 5148. It's a challenging object but easy to find, being only 1.3° west of naked-eye (4.5 magnitude) Lambda (λ) Gruis. IC 5148 consists of an 11.0 magnitude, 2-arcminute diameter, circular ring. Its surface appears slightly mottled, with a dark central region. The nebula lies in a pretty star field with a prominent (10.3 magnitude) star close to the southern edge.

North of Grus is **Pisces Austrinus**, whose main marker is the 1st magnitude alpha star Fomalhaut. Moving east from this bright star you enter the visually unimpressive constellation of **Sculptor** (the Sculptor) best seen on All Sky Map 2. There is no obvious asterism, with all its stars fainter than 4th magnitude. Being well outside the plane of the Milky Way, Sculptor is an extragalactic treasure chest of galaxies. In fact, the South Galactic Pole lies within the constellation, only a few degrees from naked-eye (4.3 magnitude) Alpha (α) Sculptoris. Although there are many galaxies, most are quite distant and faint for amateur telescopes. However, the members of the Sculptor Galaxy group are the exception. The group is approximately eight million light-years away and likely to be the closest such gathering to our local group of galaxies. This group's most outstanding galaxy is the magnificent near-edge-on, NGC 253, near the South Galactic Pole and the globular NGC 288. Other bright members, suitable for amateur telescopes, include NGC 247 in Cetus, NGC 7793 in Sculptor and NGC 625 in Phoenix. It was thought at one time the two other bright galaxies in Sculptor, NGC 300 and NGC 55, were associated with this group, but are now considered unrelated, foreground galaxies.

NGC 300, despite being 8.2 magnitude, it is a near face-on spiral with a low surface brightness, having its light smeared across 20 × 15 arcminutes. A telescope shows a much smaller oval core with a slight central brightening. Through a 250 mm telescope you might get a hint of its two major arms.

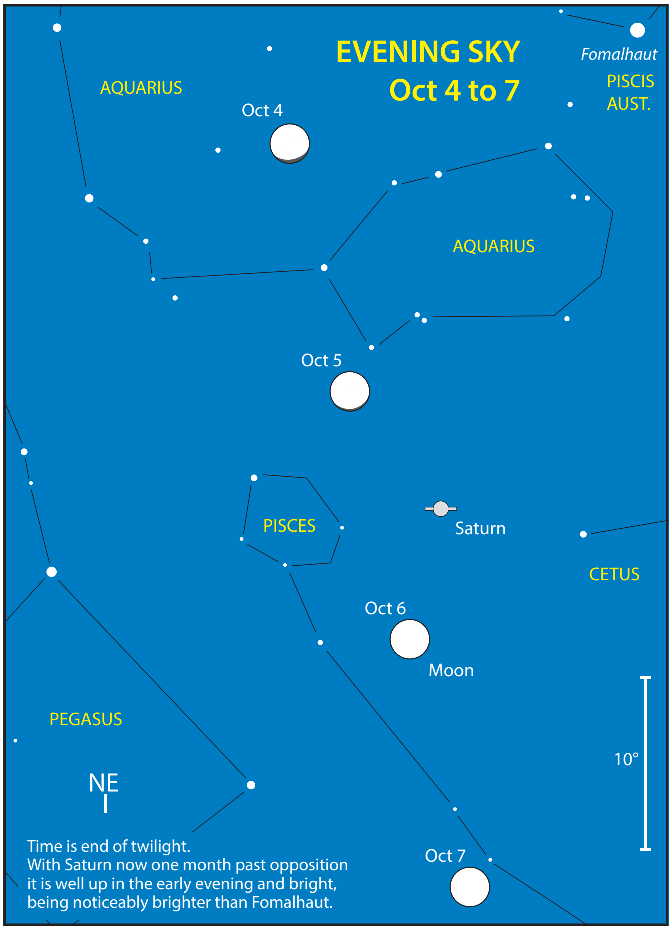
NGC 55 is a great contrast to NGC 300! Although it's considered to be a similar overall brightness to NGC 300, being a near-edge-on spiral galaxy (20 × 4 arcminute) it is easier to see having its light more concentrated over a smaller area. Its elongated nucleus is visible in the smallest of telescopes. The western half of the galaxy is distinctly brighter than the wispier eastern regions. Only a 200 mm telescope is needed to show distinct bright regions and a mottled surface. Larger amateur instruments show some fine dark lanes.

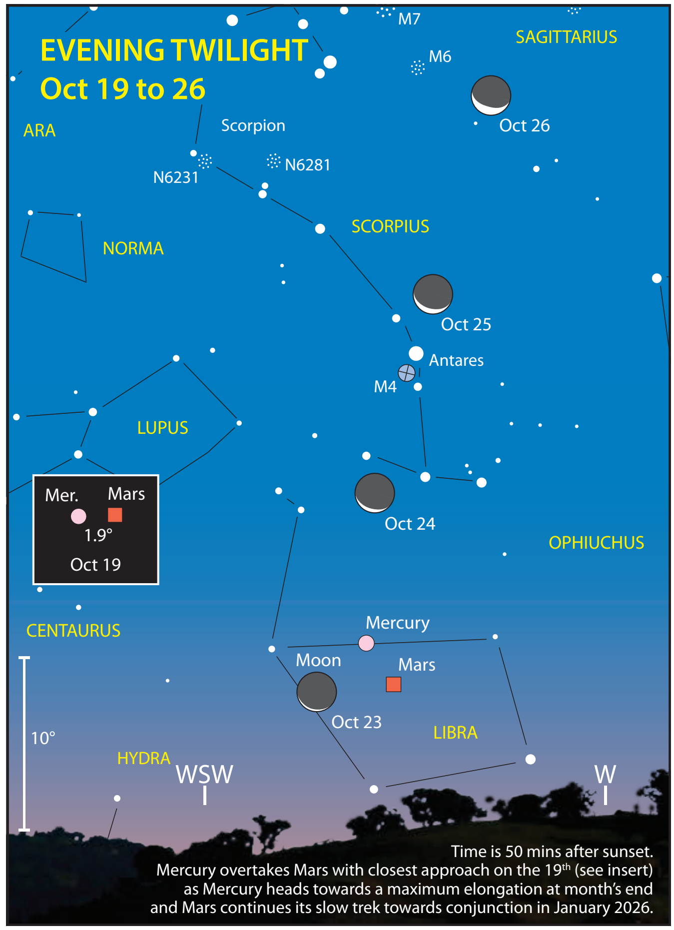
NGC 55 is very close to the border with **Phoenix**. So, let's continue further south for a brief visit to Pheonix's member of the Sculptor Group. Like Sculptor, Phoenix, the Phoenix Bird (best seen in All Sky Map 2) also offers an extragalactic feast (lots of faint galaxies), with NGC 625 being the standout. Located 2.2° north-east of naked-eye (3.4 magnitude) Gamma (γ) Phoenicis, NGC 625 is a near-edge-on 11th magnitude spiral displaying a bright oval core measuring 2.0 × 0.5 arcminutes with some irregular mottling visible. It is surrounded by a large faint halo (5 × 1 arcminutes).

NGC 253 Silver Coin Galaxy, credit Joe Cauchi

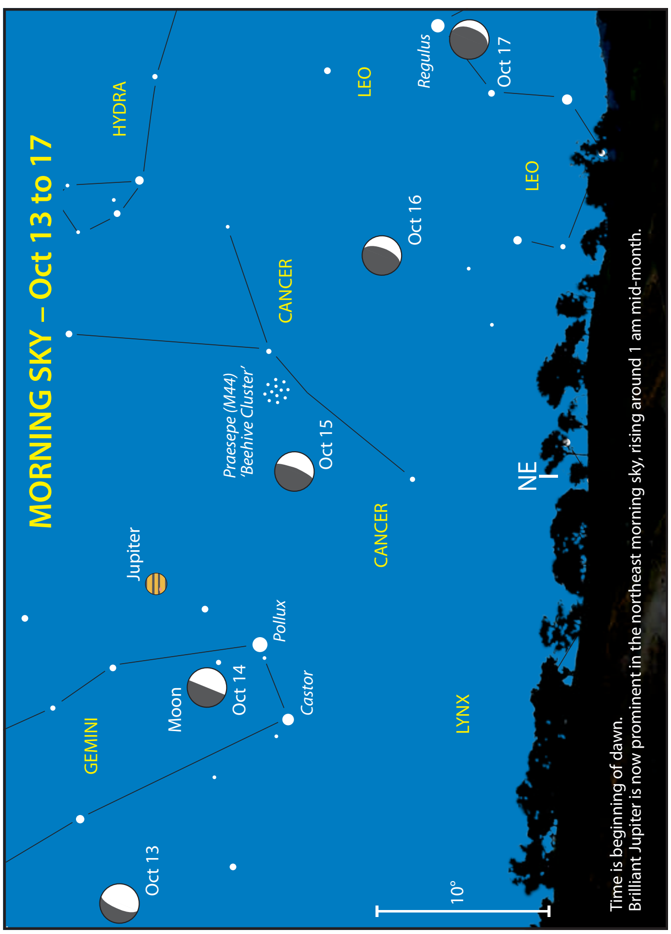
DIARY

Wed	1st		m.p. 4 Vesta 0.2° SW of star Psi Ophiuchi
Wed	1st	4 am	(2 am WST) Maximum Libration (8.5°), dark NW limb.
Thu	3rd		Ceres at opposition
Fri	3rd		Mercury 1.8° NE of star Spica
Mon	6th		m.p. 4 Vesta 0.7° N of star Omega Ophiuchi
Mon	6th	7 pm	(5 pm WST) Saturn 7° SW of Moon
Mon	6th	8 pm	(6 pm WST) Neptune 5° SW of Moon
Tue	7th	2 pm	(Noon WST) Full Moon (361,456 km), supermoon.
Wed	8th	11 pm	(9 pm WST) Moon at perigee (closest to Earth at 359,819 km).
Thu	9th	pm	Comet 210P/Christensen 1.7° N of NGC 6541 (GC) in Corona Australis
Fri	10th	am	Southern Taurids meteor shower, Sep 10 to Nov 20, Moon affected.
Fri	10th	11 pm	(9 pm WST) Uranus 7° SW of Moon
Mon	13th	6 pm	(4 pm WST) Maximum Libration (8.9°), dark SE limb.
Tue	14th		Mars 0.7° SW of star Alpha 1 Librae
Tue	14th	4 am	(2 am WST) Jupiter 6° S of Moon
Tue	14th	4 am	(2 am WST) star Pollux 3° E of Moon
Tue	14th	4 am	(2 am WST) Last Quarter Moon.
Wed	15th		m.p. 40 Harmonia 0.7° N of star Zeta Geminorum
Wed	15th		m.p. 7 Iris 0.7° N of star Omicron Leonis
Thu	16th		m.p. 4 Vesta 0.4° N of NGC 6235 (GC) in Ophiuchus
Thu	16th		Mercury 0.5° S of NGC 5728 (G) in Libra
Thu	16th	pm	Comet 210P/Christensen 1.2° S of star Iota^1 Scorpii
Thu	16th	pm	m.p. 12 Victoria 0.4° NW of star Epsilon Arietis
Fri	17th	4 am	(2 am WST) star Regulus 2° SW of Moon
Sun	19th		Comet 210P/Christensen 1.9° N of star Theta Scorpii
Sun	19th		d.p. 1 Ceres 1.0° NW of Skull Nebula (NGC 246) in Cetus
Mon	20th	5 am	(3 am WST) Venus 3° N of Moon
Tue	21st		Mars 2° N of Mercury
Tue	21st	10 pm	(8 pm WST) New Moon.
Tue	21st	pm	Orionids meteor shower, Oct 2 to Nov 7.
Wed	22nd		m.p. 4 Vesta 0.5° NE of NGC 6287 (GC) in Ophiuchus
Thu	23rd		Mercury 0.3° NE of NGC 5897 (GC) in Libra
Thu	23rd	7 pm	(5 pm WST) Mars 4° NE of Moon
Thu	23rd	7 pm	(5 pm WST) Mercury 4° E of Moon
Thu	23rd	pm	m.p. 27 Euterpe 1.2° SE of star Theta Capricorni
Fri	24th	10 am	(8 am WST) Moon at apogee (furthest from Earth at 406,444 km).
Sat	25th	8 pm	(6 pm WST) star Antares 4° W of Moon
Mon	27th		Comet 210P/Christensen 0.2° NE of NGC 6268 (OC) in Scorpius
Tue	28th		Comet 210P/Christensen 0.5° E of NGC 6242 (OC) in Scorpius
Tue	28th		Comet 210P/Christensen 1.6° N of Collinder 316 (OC) in Scorpius
Tue	28th		m.p. 4 Vesta 1.0° N of NGC 6325 (GC) in Ophiuchus
Tue	28th		star Pollux 7° N of Jupiter
Wed	29th		Comet 210P/Christensen 1.0° S of star Mu Scorpii
Wed	29th	11 am	(9 am WST) Maximum Libration (8.3°), dark NW limb.
Thu	30th	2 am	(Midnight WST, prev day) First Quarter Moon.
Thu	30th		Mercury at greatest elongation East (23.9°)
Fri	31st		m.p. 44 Nysa 0.5° S of star Zeta Cancri





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



Saturn's Satellites for October

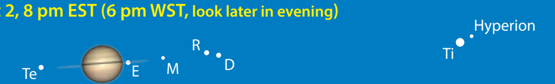
Below are a few interesting patterns of the brightest moons, see also the Introduction to Part I and Satellites of Saturn (Part II) where you can work out the configuration at any time.

N
E
1 arc min.

Oct 2, 11 pm EST (9 pm WST)

Titan is at a maximum elongation east and Rhea is approaching a maximum elongation west (the next day).

Oct 2, 8 pm EST (6 pm WST, look later in evening)



Hyperion is extremely faint (14 magn - needing large scopes) so difficult to find in star fields. Here, Titan is used as a finder. The gap increases as the evening progresses.

Oct 14, 4 am EST (2 am WST)

Titan continues to approach Saturn with superior conjunction due in the daylight. FYI, with the rings so close to edge-on, Titan will pass behind Saturn and out of view (is occulted).

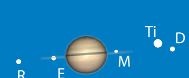
Oct 21, 11 pm EST (9 pm WST)

Few moons are visible with Tethys, Dione and Mimas currently transiting Saturn. All three will egress in the next few hours. FYI, Titan will transit in daytime on the 22nd.

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

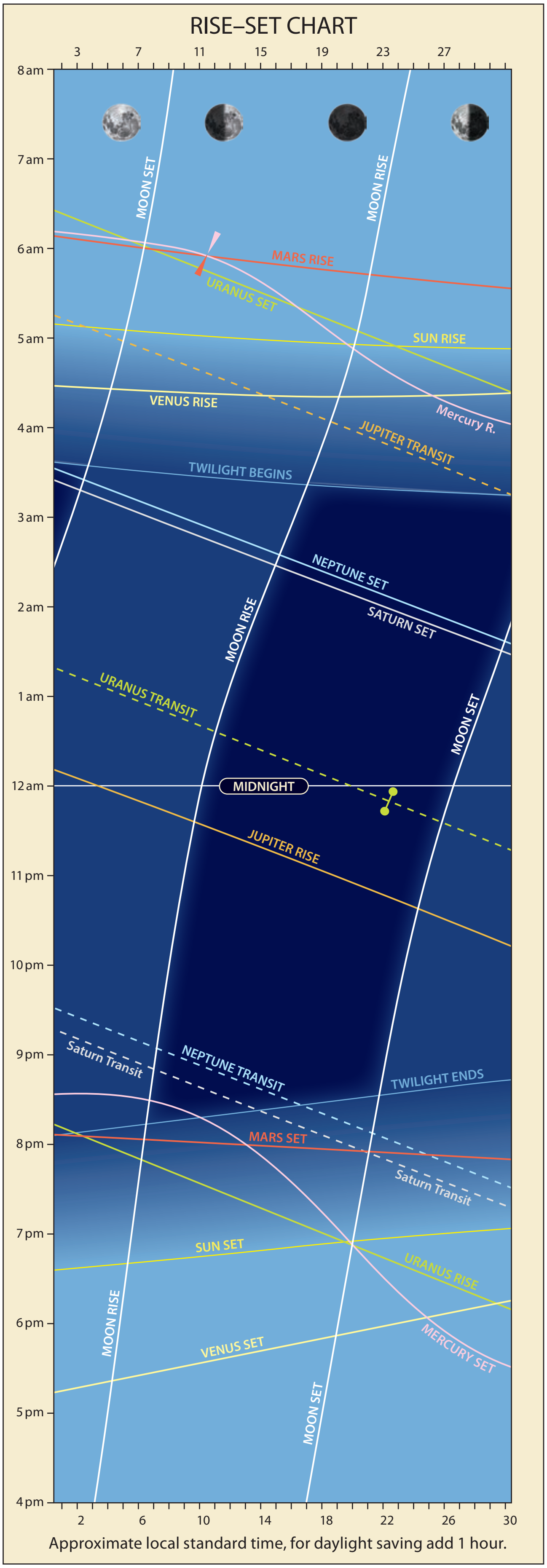
Oct 22, 11 pm EST (9 pm WST)

This drawing is 24 hours later than the one directly above. This shows how quickly Titan appears to move around the time of a conjunction.



OCTOBER

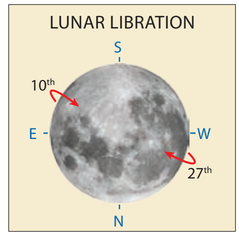
NOVEMBER



HIGHLIGHTS

❍ Mercury and Mars close.

THE MOON



5th 11 pm (9 pm WST) Full Moon, supermoon. *

6th 8 am (6 am WST) Moon at perigee (closest to Earth at 356,833 km).

10th 11 pm (9 pm WST) Maximum Libration (9.0°), dark SE limb.

12th 3 pm (1 pm WST) Last Quarter.

20th 1 pm (11 am WST) Moon at apogee (furthest from Earth at 406,691 km).

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

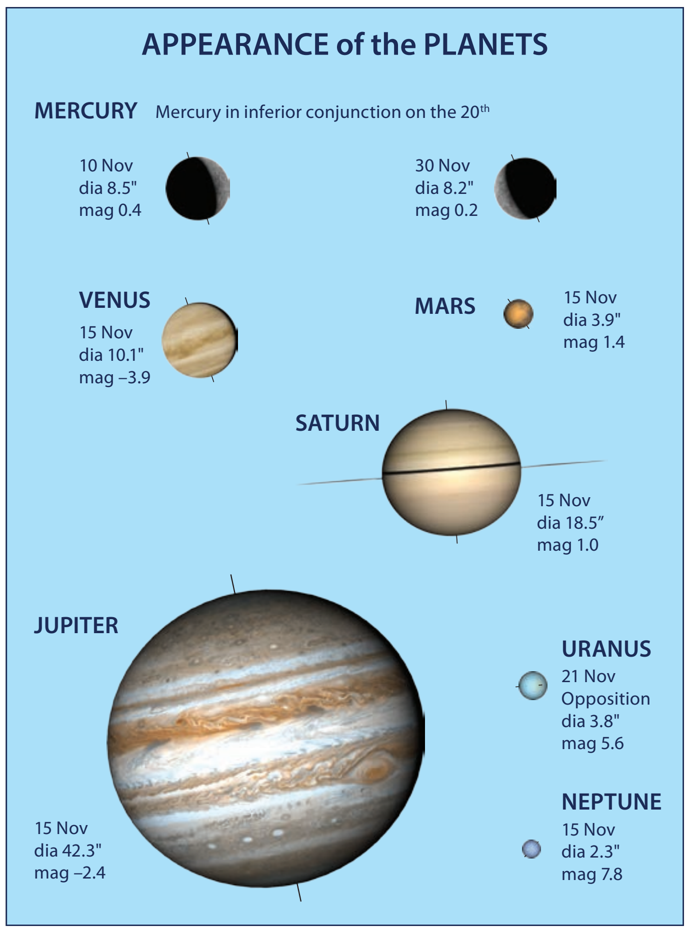
27th 6 am (4 am WST) Maximum Libration (7.6°), dark NW limb.

28th 5 pm (3 pm WST) First Quarter.

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

THE PLANETS

After its greatest elongation late last month, **Mercury** begins its descent back toward the Sun. It again passes Mars to the south at a separation of 1.3° on the 13th; this time, the planetary duo will be evenly matched in magnitude (see Sky View). Mercury is in inferior conjunction (between the Earth and the Sun) on the 20th. The planet then emerges into the



morning dawn for a poor return only a couple of degrees above the eastern horizon at the beginning of civil twilight.

Venus, in the eastern dawn sky, remains too close to the Sun this month for viewing.

This month will be the last chance to see **Mars** before it moves into conjunction with the Sun. The innermost planet, Mercury, passes within 1.3° of the Red Planet on the 13th (see Mercury and Sky View). Located in the western dusk sky, a pair of binoculars will help you pick up the pair in the twilight.

Jupiter rises around 11 pm mid-month in the eastern evening sky in Gemini (see Sky View). The planet begins its retrograde path against the starfield early in the month. It's interesting to note that retrograde motion was a puzzle for early astronomers until the heliocentric (Sun centred) model of the Solar System was proposed by Copernicus. This easily explained retrograde motion because of the Earth's orbital motion around the Sun combined with the slower orbital motions of the outer planets (see Retrograde Motion p. 92).

Saturn transits the meridian (is due north) around 8 pm mid-month, a convenient time to observe the planet at its highest in the sky. The planet's rings continue to narrow and by mid-month, will be inclined to us at just 0.4°; they then begin to widen slightly again in December. This narrow aspect of the rings gives a near-unobstructed view of both hemispheres. Filters (orange or blue) will enhance details in the bands and the polar regions. The light-coloured equatorial band and the noticeable darkening and flattening at the poles are things to look for. Twice this month, the planet is visited by the waxing gibbous Moon, on the 2nd by the 11-day-old Moon and on the 29th by the 9-day-old Moon (see Sky Views). On the 29th, Saturn ends 4.5 months in retrograde motion, resuming its west-to-east motion in the sky. In October, the planet moved into Aquarius from Pisces; now, as it resumes its regular path, it will return to the constellation of the Fishes at the end of January 2026 (see also Retrograde Motion p. 92, and the Saturn Finder chart p. 128).

Uranus comes to opposition on the 21st, rising in the early evening eastern sky and is visible the entire night. This outer ice giant has an axial tilt of 98°, meaning it practically spins on its side as it orbits the Sun; presently, and until 2030, the planet's south pole is pointed toward Earth. Uranus' apparent diameter is a little less than 4 arcseconds at opposition, and at 5.6 magnitude, it is within naked-eye visibility under dark skies. Even in light-polluted areas, you should be able to locate the planet with binoculars a few degrees from the Pleiades star cluster in Taurus. Uranus shows no distinguishable atmospheric features through a telescope, but all observers will immediately notice its disc and blue-green colour.

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

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Before vanishing into the evening twilight glow, Vesta continues its crossing of the galactic hub, passing through Sagittarius in November. It visits a few well-known deep sky objects, including passing between the Trifid and Lagoon Nebulae mid-month, see Diary. From around 11th to 16th, Leto will be close to the Pleiades star cluster (M45), see Diary. Brightest minor planets at opposition this month include:

Date	Minor Planet	Constellation	Mag.
6 Nov	12 Victoria	Aries	9.9
11 Nov	471 Papagena	Cetus	9.3
14 Nov	423 Diotima	Taurus	11.7
15 Nov	52 Europa	Taurus	10.5
21 Nov	68 Leto	Taurus	10.1
23 Nov	25 Phocaea	Taurus	11.4

COMETS

Comet 210P/Christensen is about 10th magnitude and moves through several constellations this month. Starting in Scorpius followed by Lupus on the 6th, Libra on the 12th, Hydra on the 15th, Libra on the 16th and finally Virgo on the 27th. It starts the month setting in the south-western sky around 10 pm, by mid-month rising just before sunrise and setting just after sunset and by month's end, is rising about 3 am.

Comet 24P/Schaumasse begins the month in Cancer about magnitude 12.5, rising in the north-eastern sky around midnight. On the 20th it moves into Leo and ends the month at about magnitude 10. On the morning of the 10th, while still only 11th magnitude, Schaumasse is close to the Beehive Cluster in Cancer, an astroimager's dream? (see Diary). The comet goes on to cross the Sickle of Leo in the last week of November.

METEOR SHOWERS

The **Northern Taurids** are bright, slow meteors active from October 20 to December 10, with their peak late evening around November 12 and through to dawn. Taurids are frequently bright, slow-moving, and noted for producing colourful fireballs (although not yearly). The zenith hourly rate is 5, although, from Australia's latitudes, it will be considerably lower. They are associated with Comet 2P/Encke and are visible from late evening to early morning. The Last Quarter Moon during the peak will interfere with observations after midnight.

The **Leonids** are one of the better-known showers. It is associated with the periodic comet 55P/Tempel-Tuttle and is best every 33 years when it returns to perihelion (last in 2001). The Leonids are active from November 6 to 30, reaching a maximum peak of around 15 meteors per hour (possibly about 5–6 from mid-Australian latitudes) for the morning of the 18th. Since Leo rises after midnight, observation will only be available briefly before dawn. A slender, waning crescent Moon will present minimal interference this year.

CONSTELLATIONS

The far southern constellation of **Tucana** the Toucan (All Sky Map 1) is well known as the home to the Small Magellanic Cloud. Tucana has no obvious asterism with only two stars brighter than 4th magnitude. To find Tucana, the SMC is in its south-east corner, with the bulk stretching off towards the obvious asterism of Grus to the north-west. Tucana also can boast having one of the finest globular clusters, 47 Tucanae (NGC 104) in the sky, second only to Omega Centauri.

Gaia – Mining the Universe

In January 2022, the James Webb Space Telescope made its much-anticipated arrival to its solar orbit, near the Sun-Earth L2 Lagrange point. What wasn't mentioned was that the JWST had joined another space telescope in the same orbit, Gaia. This probe doesn't deliver spectacular images, but over its 10 years of service has been compiling an unprecedented map of the Milky Way. It too is a technological marvel, created by the European Space Agency (we warn you, be prepared to hear some impressive numbers and achievements).

Gaia is a dedicated astrometric telescope. Astrometry is precise measurement of the positions, distances and motions of stars. Its predecessor was the Hipparcos Telescope, which was also purely an astrometric instrument. Its work from 1989 to 1993, resulted in the Hipparcos Catalogue (1997), a high precision catalogue of 118,200 stars, and the Tycho catalogues (1997 and 2000) covering 2.5 million stars.

Since entering orbit in 2013 Gaia has monitored around 2,000 million objects, mostly stars, down to a limiting magnitude of around 20. This is measured over a broad spectral band running from the near infrared to near UV. Its initial mission, (the first 5 years) it compiled around 70 measurements of each object. Its harvest included many thousands of galaxies and quasars and thousands of variable/double stars, planets/asteroids and it is expected to detect similar numbers of Jupiter sized exoplanets. The probe's stellar haul is about 1% of the total number of stars in the Milky Way. This percentage may not sound like much but is expected to improve our understanding of the dynamics of our galaxy astronomically (pun intended). Although stars move in various directions and speeds for many reasons, there is still a component common to most in our galaxy, that is caused by them orbiting the galactic centre. Just like the Sun orbits every 220 million years. It's a bit like measuring the speed and direction of horses on an enormous merry-go-round from the perspective of one of these horses. With Gaia we can measure many more horses with a lot on the opposite side to ours.

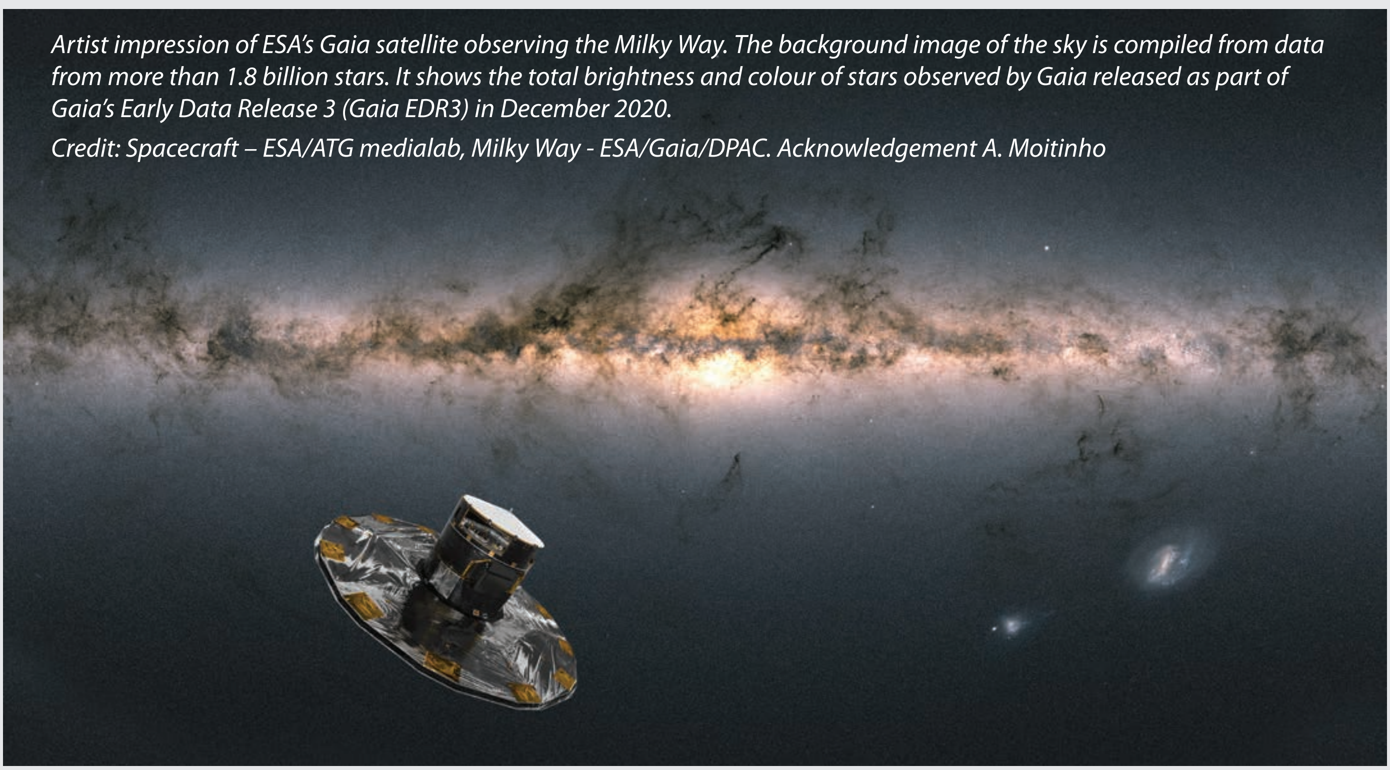
In reading this article keep in mind that ESA's objective is to supply researchers with an enormous database to process, so many of its discoveries still lie in the future. Below is just a taste of some already identified or definitely expected.

What does Gaia measure?

The principles used by Gaia for its astrometry are the same that have been in use for many years from the ground.

The direction and speed need two measurements taken. First, the proper motion, or angular speed and direction across our line of sight. It was known that stars moved as early as 1718 when Edmund Halley noted that the bright stars, Arcturus and Sirius were moving against the background of more distant stars. This observation was helped by both being close bright stars, now known to be 36.7 and 8.5 light-years away respectively. Such shifts of more distant stars can be so small it can take many years to measure, or need Gaia's tremendously impressive resolution.

The other measurement needed is what speed the object is moving towards or away from us. This is determined by spectroscopy, looking at known lines in the star's spectrum to see how far the wavelength has shifted from normal, e.g. if it's at a longer wavelength, the star is showing a red shift and moving away from us. How far the line has shifted (the Doppler shift) tells us its radial velocity. This technique has been around for many years with William Huggins in 1868 measuring the radial velocity of Sirius. Not all stars in Gaia's database have accurate radial velocities measured, for its



Artist impression of ESA's Gaia satellite observing the Milky Way. The background image of the sky is compiled from data from more than 1.8 billion stars. It shows the total brightness and colour of stars observed by Gaia released as part of Gaia's Early Data Release 3 (Gaia EDR3) in December 2020.

Credit: Spacecraft – ESA/ATG medialab, Milky Way - ESA/Gaia/DPAC. Acknowledgement A. Moitinho high-resolution spectrometer has a limiting magnitude of around 16.

The star's distance is determined by its parallax shift. Once again, the star's movement is measured against more distant stars but this time determining how much is purely caused by the Earth's annual orbit of the Sun. Think of it as constructing a giant triangle with a short side, being the diameter of the Earth's orbit, with two very long sides being the distance to the star. Calculating the angle where they join allows the distance to be determined using nothing more than basic high school mathematics. This miniscule angle can be challenging for Earth-bound telescopes to measure precisely due to the blurring caused by the boiling atmosphere, a telescope in space doesn't have this problem. To get an idea of the magnitude of this angular shift even the closest star, the Alpha Centauri system, around 4.2 light-years away, has a shift of only a little less than 1 arcsecond. Despite various technical innovations developed over the years to minimise the effect of the atmosphere, Earth-based instruments are still restricted to a maximum of around 300 to 400 light-years distant before the shift becomes too small and hence, inaccurate to measure. When one considers the Milky Way has a diameter of around 100 thousand light-years, ground-based instruments haven't been able to get much of a 3D picture of the Milky Way, well… at least from parallax measures alone.

Having the distance and apparent magnitude allows the absolute brightness to be calculated. The apparent magnitude is measured in two colour ranges, splitting the light and sending it through blue and red photometers. So included in this vast database is the means to determine each star's temperature, mass, age and chemical composition. Having such information across such an enormous sampling of stars has the potential to revolutionise our knowledge of stellar evolution and has already refined the Hertzsprung-Russell diagram.

How does Gaia work?

The probe is located 1.5 million km from the Earth in the opposite direction to the Sun (the L2 point) and maintains this position relative to the Sun and Earth as it orbits the Sun approximately once a year. As you can see from the illustration, it is roughly the shape of a top hat, with its brim constantly pointing at the Sun gathering power from solar cells on its underside. It slowly revolves around its axis, about every 6 hours, with Gaia's attitude, including this precise rotation, controlled by small cold gas thrusters.

Gaia constantly observes the heavens through two wide slits, perpendicular to its axis, with the light bouncing off two mirrors and directed to the instruments. Because this axis is always pointing away from the Sun, these 360° slices of the sky are not only perpendicular to its axis but also roughly perpendicular to the direction of the Sun. We say 'roughly' for its thrusters not only rotate the instrument but also impart a deliberate precession or wobble. Gaia works with a wide field with each of its slices being an impressive 0.7° wide.

Gaia's effective light gathering power is not impressive by modern standards consisting of two 1.49 metre telescopes and considered about equivalent to the Hubble Space Telescope. The fact that it is constantly scanning the sky (not doing fixed exposures) and can still measure stars as faint as 20th magnitude, is a testament to the sensitivity of its instruments.

The other key feature is its resolving power, with its best performance achieving around 7 micro arcseconds (0.000007"). This angular size would be similar to a small coin at the distance of the Moon! This ability contributes greatly to all aspects of its discoveries, not only measuring proper motion and parallax of stars, but 'visually' seeing close binaries and some large exoplanets. Given this high-resolution, shapes of galaxies have been measured contributing to refining their classification and evolution.

Its original mission's duration was set at five years which meant each object was scanned around 70 times during this period. The telescope is now well into an expanded mission, having had three data releases to date. Although its instruments are still performing well, Gaia will unfortunately cease operating, as its supply of gas for the thrusters, controlling its attitude and rotation, will be exhausted in 2025.

A Few Interesting Highlights, to date

Detailed measurements of the proper motion of stars within the Sculptor Dwarf galaxy has shown it orbits the Milky Way in a highly elliptical orbit, ranging from its current distance of 272,000 light-years out to around 720,000 light-years.

Many runaway stars have been detected i.e. those being ejected from the Milky Way due to having had near collisions with other bodies. Six of them have been traced back to being expelled by the black hole at the centre of our galaxy. Ongoing measurements of the deceleration of runaway stars help to refine the mass of our galaxy.

Gaia has found that the Sun is currently accelerating in its orbit around the centre of the galaxy by around 100 km per year (talk about precision!).

Analysis of Gaia data in 2022 revealed a Sun-like star in orbit around a black hole. Being only 1,600 light-years away, it's the closest known black hole to Earth. Another system was discovered showing a red giant star orbiting another black hole.

Gaia has demonstrated its ability to detect distinct groups of stars, which today could have members well scattered across the sky, but have a common origin from perhaps a specific star-forming region, like the Scorpio-Centaurus Stellar Association mentioned in June's constellations. A group could also originate from historic mergers between dwarf galaxies and the Milky Way. In 2018 data from Gaia revealed a galactic population, called Gaia-Enceladus, which includes at least 13 globular clusters appearing to have come from a major merger with a now defunct Enceladus dwarf galaxy around 10 billion years ago.

As mentioned, this year Gaia will stop its observations, ultimately generating over 10 years of data. Today we are seeing just the start of Gaia's contributions, for as long as mankind still has imagination and wonderment, its data will continue to enrich our astronomical knowledge for many years to come.

For more information, some in an interactive way, we highly recommend the app "Gaia Mission". Enjoy.

47 Tuc is a spectacular globular, lying approximately 1° west of the SMC. At magnitude 4.0 it is certainly a naked-eye object and even binoculars will show you a bright, condensed centre. The view is brilliant in any size telescope but to resolve some stars you need around a 150 mm instrument. It has a large halo, around 20 arcminutes in diameter. The inner core, which is around 10 arcminutes, is a prominent haze which rises in brightness towards a small, non-stellar nucleus. Many stars can be seen scattered across this brilliant haze, especially towards the less populated edge. Although adjacent to the SMC, 47 Tucanae is not part of the Cloud. Being only 15,000 light-years away it belongs to the Milky Way.

Another impressive globular is NGC 362, easily visible in binoculars. By traditional standards, at 7th magnitude it would be considered a brilliant globular (which it is!) but lying very close to the cloud (less than a degree from the northern edge) it tends to be overshadowed by this extragalactic neighbour and 47 Tucanae. The cluster is 12 arcminutes in diameter and has a dense core (5 arcminutes) but resolvable in 150–200 mm instruments. NGC 362's smaller size, compared to 47 Tuc, is mostly due to its remoteness, being nearly twice as far away, 28,000 ly.

The SMC to the naked eye appears as an irregularly shaped, 4° diameter blob. Binoculars reveal no structure (like the LMC's bar) but several bright knots, with around six of them forming a curved line starting around 1° south of the globular NGC 362, running into the south-west for nearly the length (diameter?) of the SMC.

One of the knots close to this globular is noticeably brighter than the others, NGC 346. This is the most active star forming region in the SMC, similar to what the Tarantula region is to the LMC. Telescopes show NGC 346 as a compact open star cluster, imbedded in a wispy oval-shaped nebula, roughly 5 arcminutes long. Also, in the same (wide) field of view, lies the open cluster NGC 371 (0.5° to the east). Compared to 346 it is larger, more diffuse and made up of fainter stars. Lying 20 arcminutes south-west of NGC 346 is the open cluster NGC 330. It is bright and compact, around 1 arcminute across, in a rich but faint star field. Whatever the size of your telescope, enjoy exploring the knots.

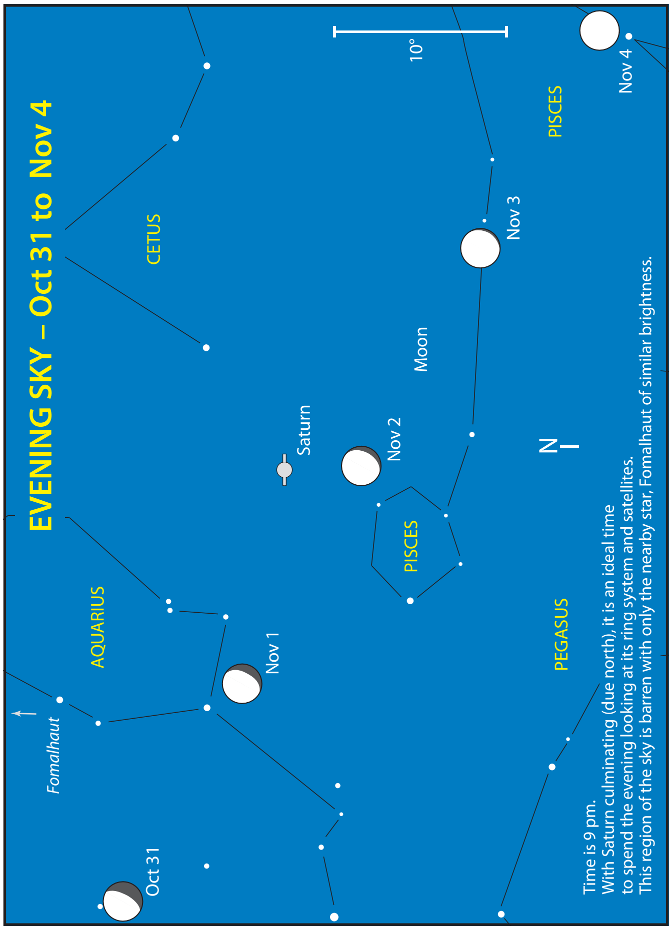
As mentioned in January Constellations, many of the star clusters in the SMC are less than 1 arcminute across and can easily be missed. Their diminutive stature reflects the cloud's distance, around 190,000 light-years away, and a high magnification is recommended (150 × or greater). To see individual cluster stars, you'll often need a larger telescope (250 mm plus). To learn more about the SMC, see the references given in the introduction in January constellations, beginning on page 25.

Considering how faint the stars of Tucana are it has a couple of bright and impressive double stars. The naked-eye star Beta (β^1 and β^2) Tucanae consists of two nearly matched 4th magnitude, pale yellow components, separated by 27 arcseconds. They have a fainter 5th magnitude companion (β^3), 9 arcminutes away making Beta also a good binocular double.

Naked-eye Kappa (κ) (around 2° north-east of NGC 362) is a pair of yellow stars of magnitudes 4.2 and 7.7, the fainter being 5 arcseconds to the north-west. Continue in this direction for a further 5 arcminutes and you'll find a third component, a 7.2 magnitude orange/red star, making Kappa a good binocular double as well.

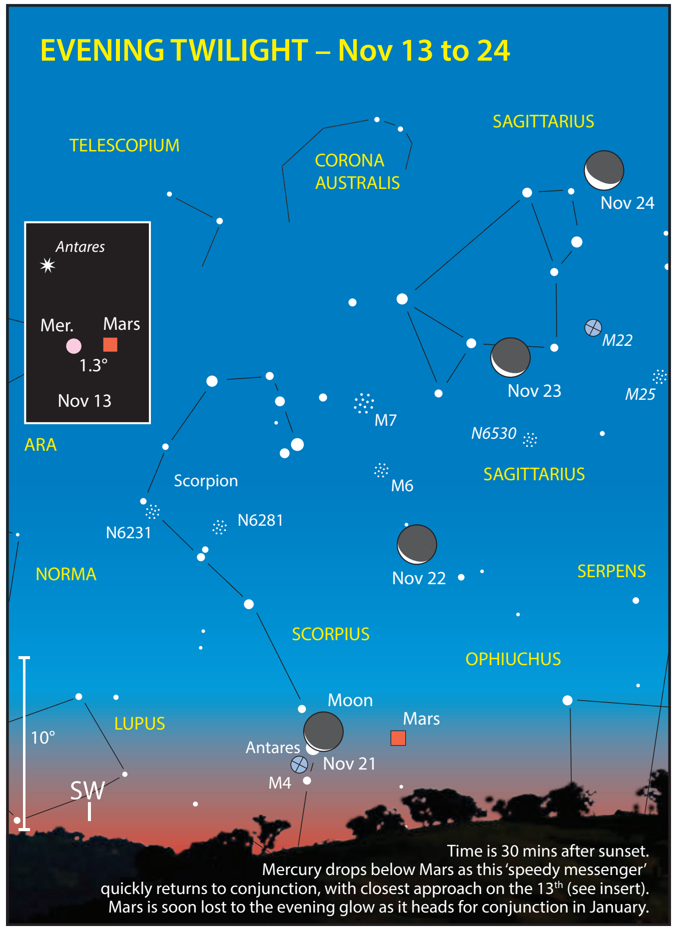
DIARY			
Sat	1st		Mercury 0.9° S of star Delta Scorpii
Sun	2nd	8 pm	(6 pm WST) Saturn 4° S of Moon
Mon	3rd	1 am	(11 pm WST, prev day) Neptune 3° SE of Moon
Tue	4th		m.p. 40 Harmonia 0.8° S of star Delta Geminorum
Wed	5th		m.p. 63 Ausonia 0.8° N of star Theta Capricorni
Wed	5th	11 pm	(9 pm WST) Full Moon (356,978 km, closest for this year), supermoon.
Thu	6th		m.p. 4 Vesta 0.7° N of NGC 6401 (GC) in Ophiuchus
Thu	6th	8 am	(6 am WST) Moon at perigee (closest to Earth at 356,833 km).
Thu	6th	11 pm	(9 pm WST) Uranus 6° SE of Moon
Sat	8th		Comet 210P/Christensen 0.8° NW of star Chi Lupi
Mon	10th		Comet 210P/Christensen 1.5° SW of star Tau Librae
Mon	10th		Comet 24P/Schaumasse 0.5° N of M44 Beehive Cluster (OC) in Cancer
Mon	10th	11 pm	(9 pm WST) Maximum Libration (9.0°), dark SE limb.
Mon	10th	pm	m.p. 27 Euterpe 0.3° SE of star Iota Capricorni
Tue	11th	1 am	(11 pm WST, prev day) star Pollux 6° NW of Moon
Tue	11th	1 am	(11 pm WST, prev day) Jupiter 6° SW of Moon
Wed	12th		Mercury 0.5° SW of M80 (GC) in Scorpius
Wed	12th		Northern Taurids meteor shower, Oct 20 to Dec 10, Moon affected after midnight.
Wed	12th	3 pm	(1 pm WST) Last Quarter Moon.
Thu	13th	3 am	(1 am WST) star Regulus 4° SE of Moon
Thu	13th		Mars 1° N of Mercury
Fri	14th	pm	m.p. 68 Leto 1.3° S of M45 the Pleiades (OC) in Taurus
Mon	17th		m.p. 4 Vesta 0.6° N of M8 Lagoon Nebula (BN) in Sagittarius
Mon	17th		m.p. 4 Vesta 0.6° S of M20 Trifid Nebula (BN) in Sagittarius
Mon	17th		m.p. 4 Vesta 1.2° S of M21 (OC) in Sagittarius
Tue	18th	am	Leonids meteor shower, Nov 6–30.
Wed	19th		m.p. 4 Vesta 0.4° S of NGC 6546 (OC) in Sagittarius
Thu	20th	1 pm	(11 am WST) Moon at apogee (furthest from Earth at 406,691 km).
Thu	20th	5 pm	(3 pm WST) New Moon.
Thu	20th		Mercury in inferior conjunction
Thu	20th	9 pm	(7 pm WST) m.p. 6 Hebe 0.05° S of NGC 7377 (G) in Aquarius
Fri	21st		Uranus at opposition
Sat	22nd		Comet 24P/Schaumasse 1.5° SW of NGC 2905 in Leo
Sat	22nd		m.p. 27 Euterpe 1.2° NW of star Gamma Capricorni
Mon	24th		m.p. 89 Julia 1.0° SE of M2 (GC) in Aquarius
Thu	27th		m.p. 4 Vesta 1.0° N of M28 (GC) in Sagittarius
Thu	27th		star Pollux 7° N of Jupiter
Thu	27th	6 am	(4 am WST) Maximum Libration (7.6°), dark NW limb.
Fri	28th	5 pm	(3 pm WST) First Quarter Moon.
Sat	29th	11 pm	(9 pm WST) Saturn 5° SE of Moon
Sun	30th	9 pm	(7 pm WST) Neptune 7° SW of Moon
Sun	30th	pm	m.p. 471 Papagena 0.3° SW of star Alpha Ceti

EVENING SKY – Oct 31 to Nov 4



Time is 9 pm.
With Saturn culminating (due north), it is an ideal time to spend the evening looking at its ring system and satellites.
This region of the sky is barren with only the nearby star, Fomalhaut of similar brightness.

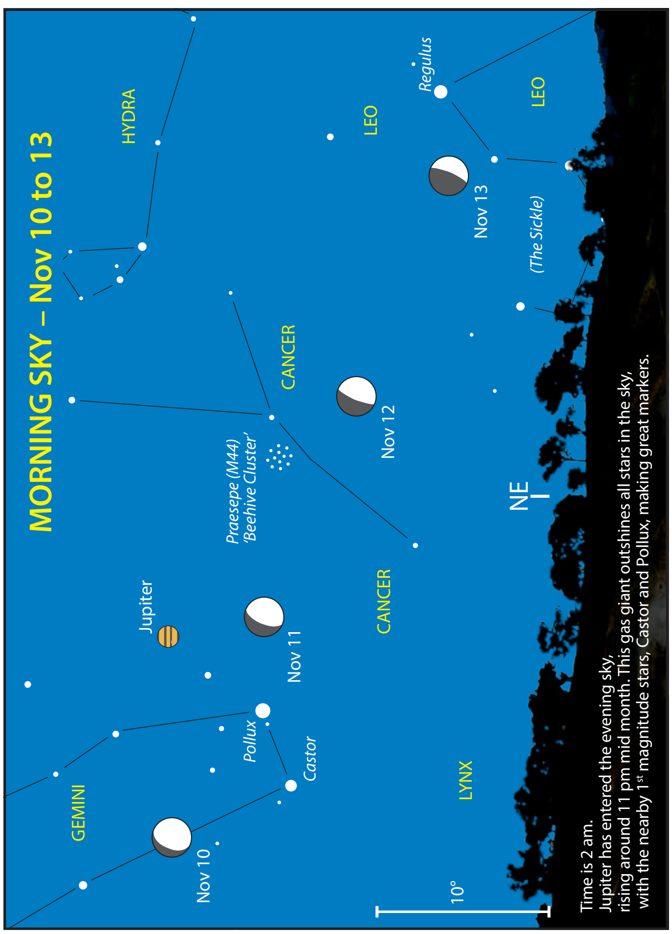
EVENING TWILIGHT – Nov 13 to 24



Time is 30 mins after sunset.
Mercury drops below Mars as this 'speedy messenger' quickly returns to conjunction, with closest approach on the 13th (see insert).
Mars is soon lost to the evening glow as it heads for conjunction in January.

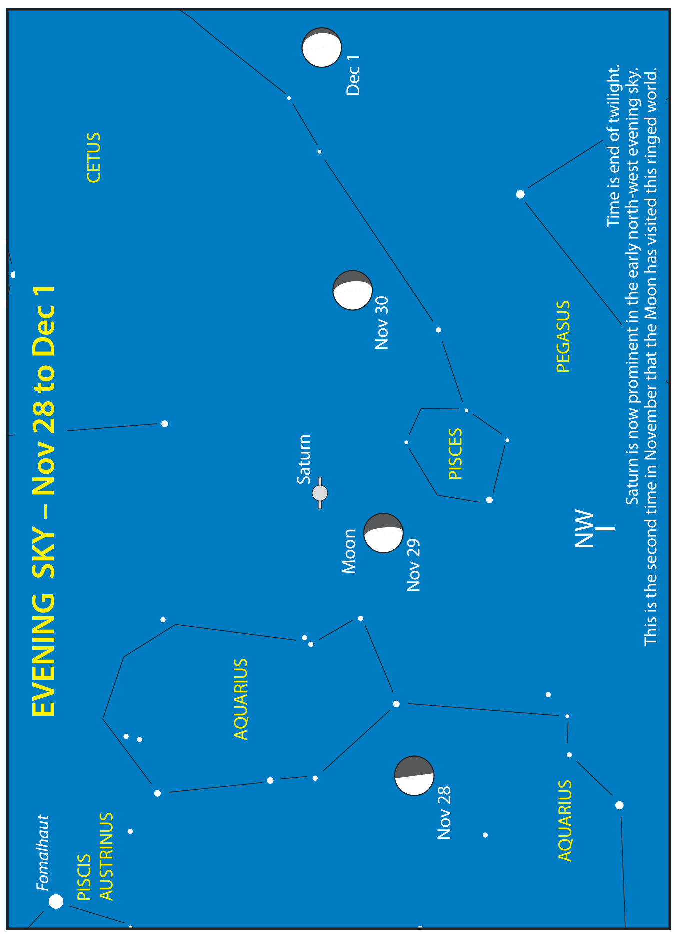
Approximate local standard time, for daylight saving add one hour.

MORNING SKY – Nov 10 to 13



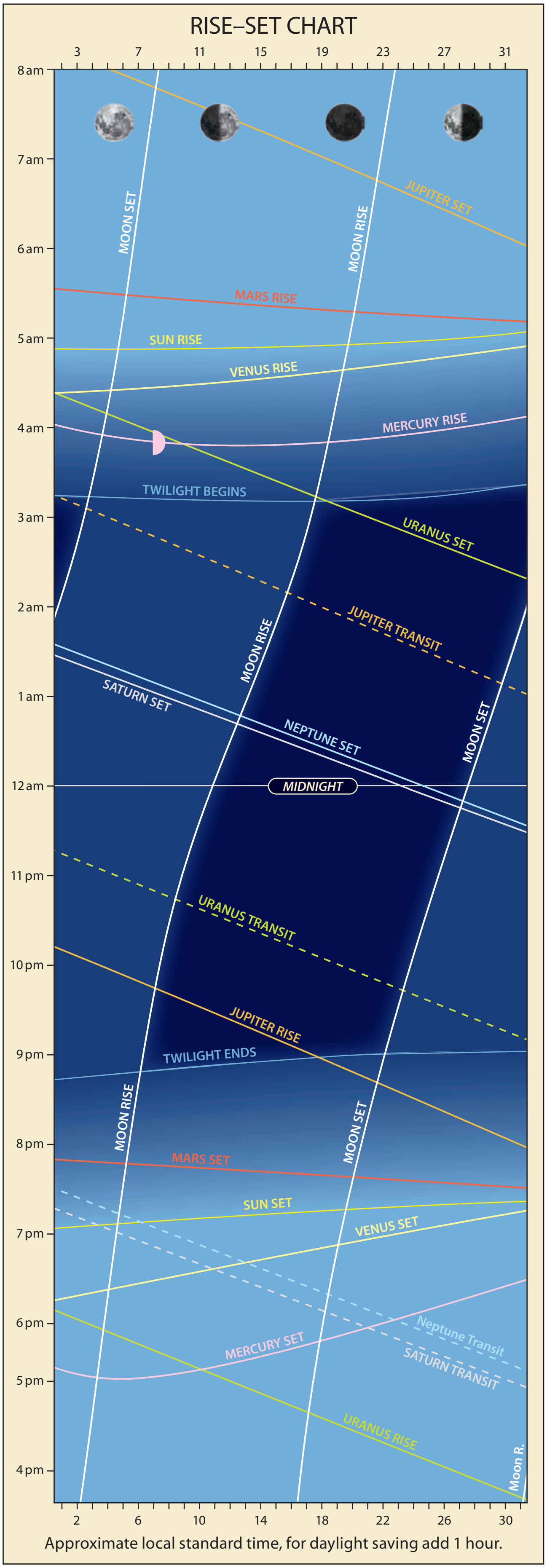
Time is 2 am.
Jupiter has entered the evening sky, rising around 11 pm mid month. This gas giant outshines all stars in the sky, with the nearby 1st magnitude stars, Castor and Pollux, making great markers.

EVENING SKY – Nov 28 to Dec 1



Time is end of twilight.
Saturn is now prominent in the early north-west evening sky.
This is the second time in November that the Moon has visited this ringed world.

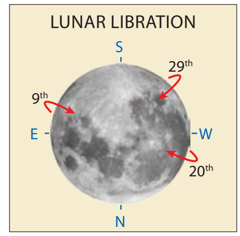
DECEMBER



HIGHLIGHTS

- Jupiter is approaching opposition.
- The Geminids meteor shower.

THE MOON



4th 9 pm (7 pm WST) Moon at perigee (closest to Earth at 356,963 km).

5th 9 am (7 am WST) Full Moon, supermoon. *

9th 11 am (9 am WST) Maximum Libration (8.3°), dark SE limb.

12th 7 am (5 am WST) Last Quarter.

17th 4 pm (2 pm WST) Moon at apogee (furthest from Earth at 406,322 km).

20th Noon (10 am WST) New Moon.

20th 4 pm (2 pm WST) Maximum Libration (6.7°), too close to New Moon.

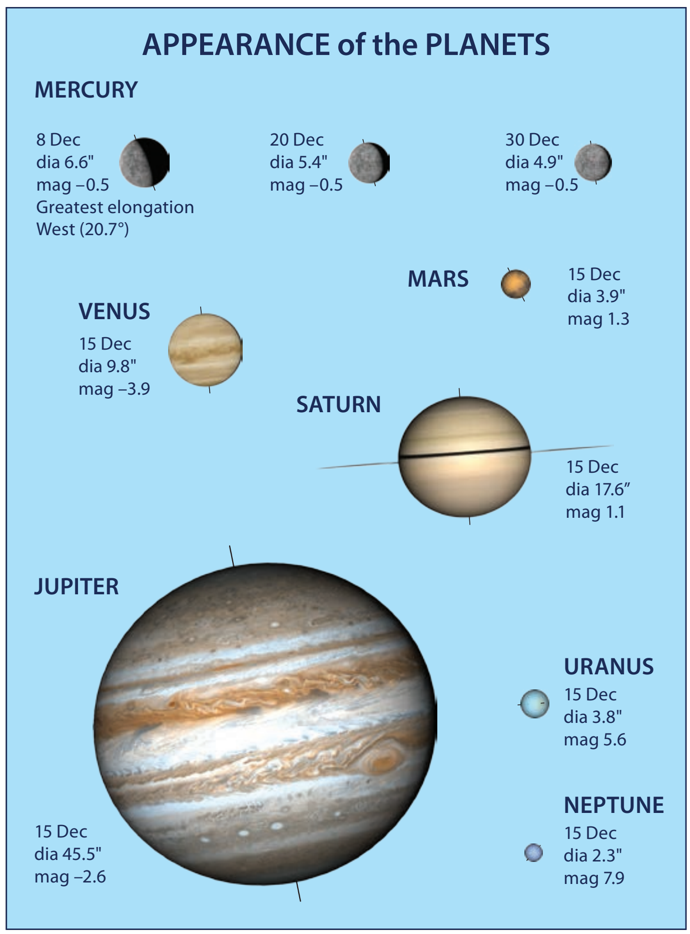
28th 5 am (3 am WST) First Quarter.

29th 5 pm (3 pm WST) Maximum Libration (7.1°), dark SW limb.

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

THE PLANETS

Mercury presents a disappointing target in the morning dawn sky this month. It is at its greatest elongation, 21° from



the Sun on the 8th, but at best, is around 7° above the horizon at the beginning of civil twilight (see Sky View).

Venus succumbs to the bright early morning eastern sky as it moves toward superior conjunction (Venus and Earth on opposite sides of the Sun) early in the new year. It will then transition to the Evening Star for the next ten months.

The **Earth's** summer solstice (Southern Hemisphere) occurs on the 22nd when the days are the longest. On this day, the Sun is at its most southerly position, with a declination of −23.5°.

Mars is too close to the Sun to observe this month, it will be in conjunction on January 9 and reappear in the morning skies in late February 2026.

Jupiter is visible, rising in the eastern evening sky around astronomical dusk mid-month. On the 7th, the planet will be 4° from the 18-day-old waning gibbous Moon (see Sky View). Moving in retrograde in Gemini, Jupiter again passes the open star cluster NGC 2420, which it crossed last October. This time it just misses the cluster on the 17th, 0.2° north.

With Jupiter at opposition on January 10 next year, it's time to devote some attention to the gas giant. By the end of the month, it reaches a brilliant −2.7 magnitude with an angular disc diameter of just over 46 arcminutes. Under steady seeing, telescopes of all sizes can study the changes in the belts and zones that appear laterally across the planet. The most obvious and easiest to identify are the darker north and south equatorial belts separated by the lighter area known as the equatorial zone. The famous Great Red Spot (GRS) is not always visible unless you look for it at the right time. With the planet's fast 10-hour rotation period, there is only a narrow window to observe. By the way, the GRS is more pinkish than red. 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 the Great Red Spot and moon events are in Part II).

Saturn, in Aquarius, is visible in the western sky at the end of astronomical twilight (see Sky View). On the 17th, the planet is at a point in its orbit known as its eastern quadrature, where the Sun-Earth-Saturn angle is 90° (see Orbital Aspects diagram p. 16). As a result, Saturn will be at its highest altitude as the Sun sets in the west. The planet's rings widen a little this month to almost 1°. For those missing Saturn with his splendid rings on show, the good news is that from now on, they begin expanding. They will be next at a maximum tilt of 27° in 2032 before closing and appearing edge-on again in 2038.

Uranus, now past opposition, is in the northern evening sky at the end of astronomical twilight in Taurus. If scanning for the planet with binoculars from mid-month on, do not confuse the stars 13 Tauri (5.7 magnitude) and 14 Tauri (6th magnitude) with Uranus (see Uranus Finder Chart p. 129). Interestingly, Uranus is the only planet named after a Greek god (all the others are named after Roman gods). In recent years, there has been a push to rename the planet, Caelus, the Roman equivalent of Uranus, although the authors are happy with the status quo. It could have been worse; when Sir William Herschel discovered it, he wanted to name it "Georgium Sidus" (George's Star) in honour of his patron, King George III.

Neptune, in Pisces, comes to the end of five months in retrograde on the 11th and appears 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.
8 Dec	16 Psyche	Taurus	9.5
8 Dec	32 Pomona	Taurus	11.2
9 Dec	43 Ariadne	Taurus	11.1
11 Dec	196 Philomela	Taurus	10.8
13 Dec	94 Aurora	Auriga	11.7
14 Dec	45 Eugenia	Orion	11.7
17 Dec	80 Sappho	Orion	10.6
20 Dec	87 Sylvia	Taurus	11.9
22 Dec	10 Hygiea	Gemini	10.2
22 Dec	107 Camilla	Orion	12.0
26 Dec	42 Isis	Gemini	11.1
31 Dec	17 Thetis	Gemini	11.4

COMETS

Comet 210P/Christensen begins the month about magnitude 10, rising in the eastern sky around 3 am and ends December rising a little earlier, having faded to magnitude 13. During the month the comet moves from Virgo then into Libra on the 5th, back to Virgo on the 20th and returning to Libra on the 21st.

Comet 24P/Schaumasse starts the month about magnitude 10, rising in the eastern sky around midnight. Beginning in Leo, the comet moves into Coma Berenices on the 22nd. The last week of December finds Schaumasse in the morning sky, crossing the Virgo/Coma Berenices Cluster of Galaxies. Having achieved close to its maximum brightness (8th magnitude), the comet spends this time on the Coma side of the border, having some conjunctions with several of its brighter members (see Diary) and passing around 2° north of Markarian's Chain.

METEOR SHOWERS

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

The **Puppid-Velids** is a vastly complex system of showers active during November and December. Each radiant is so close that visual observation cannot easily separate them. Active from December 1–15, a ZHR of 6 is possible around the evening of the 7th through dawn on the 8th. The radiant is highest from mid-Australian latitudes around 4 am. The Full Moon on the 5th will interfere this year.

The **Geminid**s are among the finest and most reliable of the major annual showers. They are visible from the 4th to the 17th, with their maximum predicted late evening on the 14th

DIARY			
Tue	2nd		Comet 24P/Schaumasse 0.5° S of star Gamma Leonis
Tue	2nd	pm	Phoenicids meteor shower, Nov 28 to Dec 9, Moon affected.
Wed	3rd	am	m.p. 10 Hygiea 1.0° N of Collinder 89 (OC) in Gemini
Wed	3rd	am	m.p. 40 Harmonia 0.05° NE of star Delta Geminorum
Thu	4th	9 pm	(7 pm WST) Moon at perigee (closest to Earth at 356,963 km).
Fri	5th	9 am	(7 am WST) Full Moon (357,218 km), supermoon.
Sun	7th		Puppid-Velids meteor shower, Dec 1–15, Moon affected.
Mon	8th	2 am	(Midnight WST, prev day) star Pollux 2° N of Moon
Mon	8th	3 am	(1 am WST) Jupiter 4° S of Moon
Mon	8th		Mercury at greatest elongation West (20.7°)
Tue	9th	11 am	(9 am WST) Maximum Libration (8.3°), dark SE limb.
Thu	11th	1 am	(11 pm WST, prev day) star Regulus 5° W of Moon
Fri	12th	7 am	(5 am WST) Last Quarter Moon.
Sat	13th		Comet 24P/Schaumasse 0.6° W of NGC 3607 (G) in Leo
Sat	13th		Comet 24P/Schaumasse 2.4° S of star Delta Leonis
Sat	13th		Comet 24P/Schaumasse 2.6° N of star Theta Leonis
Sun	14th		Comet 24P/Schaumasse 0.5° SW of NGC 3626 (G) in Leo
Sun	14th		Geminids meteor shower, Dec 4–17, Moon affected after midnight.
Sun	14th	pm	m.p. 10 Hygiea 0.2° N of M35 (OC) in Gemini
Mon	15th	2 am	(Midnight WST, prev day) star Spica 0.5° N of Moon
Tue	16th	pm	m.p. 10 Hygiea 0.6° N of NGC 2158 (OC) in Gemini
Wed	17th		Juno in conjunction with Sun
Wed	17th	4 pm	(2 pm WST) Moon at apogee (furthest from Earth at 406,322 km).
Thu	18th	pm	d.p. 1 Ceres 1.2° NW of NGC 157 (G) in Cetus
Fri	19th	4 am	(2 am WST) Mercury 7° NW of Moon
Fri	19th	4 am	(2 am WST) star Antares 3° W of Moon
Sat	20th		Comet 24P/Schaumasse 2.4° N of star Beta Leonis
Sat	20th		star Antares 6° S of Mercury
Sat	20th	Noon	(10 am WST) New Moon.
Sat	20th	4 pm	(2 pm WST) Maximum Libration (6.7°), too close to New Moon.
Mon	22nd		Solstice
Thu	25th		Comet 24P/Schaumasse 1.3° N of M98 (SG) in Coma Berenices
Thu	25th		Uranus 0.2° S of star 13 Tauri
Fri	26th		Comet 24P/Schaumasse 1.5° of M99 (SG) in Coma Berenices
Fri	26th		m.p. 16 Psyche 1.2° S of NGC 1647 (OC) in Taurus
Sat	27th	3 am	(1 am WST) Comet 24P/Schaumasse 0.1° W of M100 (SG) in Coma Berenices
Sat	27th	9 pm	(7 pm WST) Saturn 7° SW of Moon
Sat	27th	9 pm	(7 pm WST) Neptune 4° S of Moon
Sun	28th	5 am	(3 am WST) First Quarter Moon.
Mon	29th		Comet 24P/Schaumasse 1.0° N of M88 (SG) in Coma Berenices
Mon	29th	5 pm	(3 pm WST) Maximum Libration (7.1°), dark SW limb.
Tue	30th		Comet 24P/Schaumasse 0.7° N of M91 (SG) in Coma Berenices
Wed	31st	am	m.p. 7 Iris 1.2° SW of NGC 3521 (G) in Leo
Wed	31st	9 pm	(7 pm WST) Uranus 6° S of Moon

Cover Story – Pillars of Creation

The Eagle Nebula was discovered in 1745 by Jean-Philippe Cheseaux. The name reflects the visual appearance of its prominent dark silhouettes. Charles Messier made it number 16 (M16) in his famous catalogue of deep sky objects. M16 is a young active star forming region still embedded in gas and dust involved in its creation. The star cluster associated with the nebula numbers around 8,100 stars, aged around 1 to 2 million years old, very young by stellar standards.

An image taken by the Hubble Space Telescope in 1995 made famous the phrase, Pillars of Creation referring to this large region of star formation enshrouded by dust showing up as these dark columns. A later image taken by Hubble in 2014 in visible light, showed an expanded and much sharper view of the region than Hubble had previously produced (see lower left image).

The Hubble image shows how impenetrable the dust cloud is to visible wavelengths of light and identified small dark pockets believed to be protostars (Bok Globules) in M16. In contrast the right image taken by the James Webb Space Telescope (JWST) in near-infrared (NIR) light does an

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 (with a ZHR of around 40–50 from mid-Australian latitudes). Unfortunately, the waning crescent Moon could cause problems after midnight this year.

CONSTELLATIONS

This month, we'll be looking at an area roughly between the 1st magnitude stars, Canopus and Achernar.

The constellation of **Reticulum** the Net (All Sky Map 1) lies to the upper right of the LMC. If you zero in on its brightest star, naked-eye (3.3 magnitude) Alpha (α) Reticuli, a low power eyepiece finds the spiral galaxy NGC 1559 only 0.5° to the south-east. This obvious narrow 2-arcminute long, 11th magnitude oval has a slightly brighter centre. A further 0.5° south finds the nice double star, Theta (θ) Reticuli, with components of 6.0 and 7.7 magnitudes, separated by 4.3 arcseconds.

Through a 150 mm telescope, the 9th magnitude barred-spiral galaxy NGC 1313 shows an obvious central bar (1.5 × 0.5 arcminutes) and a bright nucleus. The galaxy shares a low power eyepiece field with a 6th magnitude star (HR 1014) 0.5° to the south. To find NGC 1313, move 3° south-west of 4th magnitude Beta (β) Reticuli. This star is easily recognisable through binoculars, being a double with an 8th magnitude companion 16 arcminutes to the east.

From Reticulum, head towards Achernar and you'll stumble into the lesser-known constellation of **Horologium** the Clock (best seen on All Sky Map 2). With its brightest star, Alpha (α) being 3.8 magnitude and the rest dropping to 5th magnitude and lower, it can be a bit challenging. The double star CorO-14 (All Sky Map 2) is easy to find being only 0.5° south-south-east of naked-eye (magnitude 5.3) star, Eta (η) Horologii. CorO-14 has components magnitude 7.9 and 8.7, being white and yellow respectively, separated by a comfortable 9 arcseconds. As a bonus CorO-14 forms an easy binocular double with a brighter (magnitude 6.8) star 4 arcminutes eastward.

The globular cluster NGC 1261 is located 4.5° east of naked-eye (5th magnitude) Zeta (ζ) Horologii. Although its magnitude is listed as only 8.3, it is very compact with a high surface brightness right to the edges of this 2-arcminute city of stars. It is obvious in any sized telescope but needs

amazing job allowing us to see through this veil. If you can pull your gaze away from the pillars, and compare the images, it's staggering how much of the surrounding nebula, seen in the Hubble image as shades of green and yellow, obscures dozens of other stars. The colour is indicative of the amount of dust surrounding the pillars. The background (sky) in the JWST image being blue shows just hydrogen.

M16 is a relatively nearby achievement for the JWST, with the nebula only some 5,700 light-years from Earth (in our backyard if you like). The telescope has also shown us new views of other famous stellar nurseries, including the Tarantula Nebula in the large Magellanic Cloud (see Astronomy 2024), the Orion Nebula, Rho Ophiuchi (the closest stellar nursery to Earth, only 400 light-years away) and this one in Cassiopeia.

Similar pillars of star formation (but much larger than M16's) have also been found in the 'Soul Nebula of Cassiopeia', also composed of hydrogen gas and dust, which are incubators for new stars. This was confirmed by the Spitzer Space Telescope, another, but now inoperative, IR telescope. Inside the columns astronomers have found knots of denser gas called EGGs (Evaporating Gaseous Globules).

Telescopes working in other regions of the spectrum have also contributed to our knowledge of these birth places of stars. An example being X-ray images from the Chandra Observatory of these EGGs in Cassiopeia, failed to 'see' any X-ray sources present, but instead are scattered across the nebula, demonstrating any protostars present in the EGG's are not hot enough (yet?) to emit X-rays.

Infrared observations have many applications, with Webb's basic design catering for:

- Objects with high red shifts used for observations of the early Universe. The further we look into space the larger the redshift caused by the expansion of the Universe. Visible light has a limitation to how far back we can see with the previous record having been just under 1 billion years after the big bang. Objects beyond (earlier than this period) are mostly visible only in the infrared, with Webb having now pushed to earlier than 500,000 years after the big bang.
- Infrared light passes through dust clouds when visible doesn't, as we've seen above. This will likely pay real dividends when looking through the dark clouds that obscure the central region of the Milky Way.
- Infrared light is difficult to study from the ground, with atmospheric water absorbing much of the IR light, hence Webb being in space.

How Does Webb 'see' Colour?

When looking at JWST images (including the above) they are all false colour, because we can't see infrared light. This still delivers information and not just pretty pictures. The colours are assigned in chromatic order, just like visible light. The near IR (or short wavelength end) is treated as blue (just like blue is the short wavelength end of the visible spectrum) and progresses through the visible spectrum right up to red being some of the longest wavelengths monitored by JWST. All images taken by Webb are black and white, but taken through specific narrow-band IR filters, each of which has a predetermined colour assigned when being processed.

Webb has two main cameras on board, the Near-Infrared Camera (NIRCam) which captures the short wavelengths of light and its Mid-Infrared Instrument (MIRI) for longer wavelengths. The various wavelengths are monitored quite precisely, with NIRCam having 29 filters and MIRI having nine available. When wishing to generate 'full' coloured images (including the pretty ones we see) MIRI has three or four filters which are assembled as a composite.

200 mm or larger to resolve. There is a distinctive 9^{th} mag star just outside its north-east edge.

Here's an isolated barred spiral galaxy, NGC 1433, but worth the hunt (7° south-west from Alpha). Images of this 10.0 magnitude galaxy show a bright core and bar with two bright spiral arms extending from the ends, almost circling the galaxy. Visually NGC 1433 shows an obvious bright halo (approximately. 3' × 2') with a hint of a central core with a star-like nucleus, still impressive.

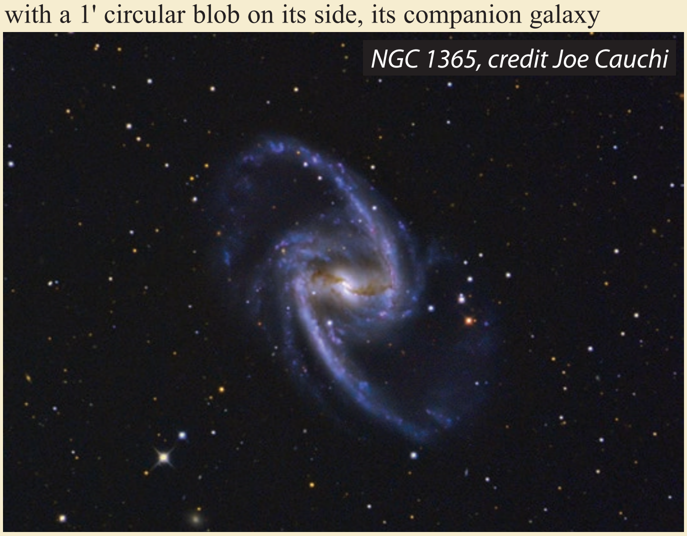
Next stop is the constellation of **Eridanus** (All Sky Map 2). Known since antiquity as the river, it's well named being one of the longest constellations. Brilliant Achernar, Alpha (α) Eridani, north of the Small Magellanic Cloud is its mouth, with its headwater being 3^{rd} magnitude star Cursa, Beta (β) Eridani, near Rigel in Orion. It then snakes its way south. Tracing the river is a good test for the darkness of your observing location, consisting of around two dozen 4^{th} to 5^{th} magnitude stars. Looking at its path on All Sky Map 2, the constellation is well away from the Milky Way, so it's not surprising that Eridanus is deep sky heaven, being the home for numerous galaxies.

Eridanus is also renowned for double stars. Here are a couple suited for 60 mm telescopes. First, just 1° north of Achernar lies the brilliant double p Eridani, two nearly matched mag 6 yellow stars, separated by 11 arcseconds. Second, move 20° to the north-east (or just follow the river) to naked-eye Theta (θ) Eridani (Acamar). This pale blue pair, of magnitudes 3.2 and 4.3, are 8 arcseconds apart, and 100 × power gives a pleasing view.

The lenticular galaxy NGC 1291 is 3.7° east and slightly south of Acamar. It is magnitude 9 and about 2 arcminutes across. A 150 mm telescope shows the galaxy's most distinctive feature, a remarkably bright nucleus that looks like an unresolved globular cluster.

Continue swimming upstream (a jump of 16° to the north-east) to the obvious naked-eye double-double of 4^{th} magnitude stars made up of two pairs, each 1° apart, Upsilon (υ^1 and υ^2, Theemin) then 5° away, Upsilon (υ^4) plus d Eridani. They are a binocular treat with Upsilon^4 being blue-white with the other three yellow. From υ^4 move 1.5° north-west to uncover a true gem, the edge-on spiral galaxy NGC 1532. A 150 mm telescope shows a 5' × 1' haze with a 1' circular blob on its side, its companion galaxy NGC 1531. To its west lie two 10^{th} magnitude stars, and eastward a distinctive 7^{th} magnitude star, all fitting in a 0.5° field.


NGC 1532, credit Joe Cauchi


NGC 1365, credit Joe Cauchi

This is as far north as our brief survey goes, however there is a further feast of galaxies in Eridanus, many associated with the Eridanus Cluster centred around RA 3 hr 30 min, Dec −20°. However, this is not the end of our extragalactic voyage.

Heading back towards Acamar we encounter a nice naked-eye triangle of 4^{th} magnitude stars, g, h and f Eridani, fitting in a 2° circle. Moving 4° west (in the same binocular field as this triangle in Eridanus) there's another distinctive triangle, Chi (χ^1, χ^2 and χ^3) Fornacis; we have now crossed into the constellation of **Fornax**. Chi is an eye-catching binocular group of three 6^{th} magnitude stars, arranged in the shape of a right-angled triangle. They fit in a 0.5° eyepiece field.

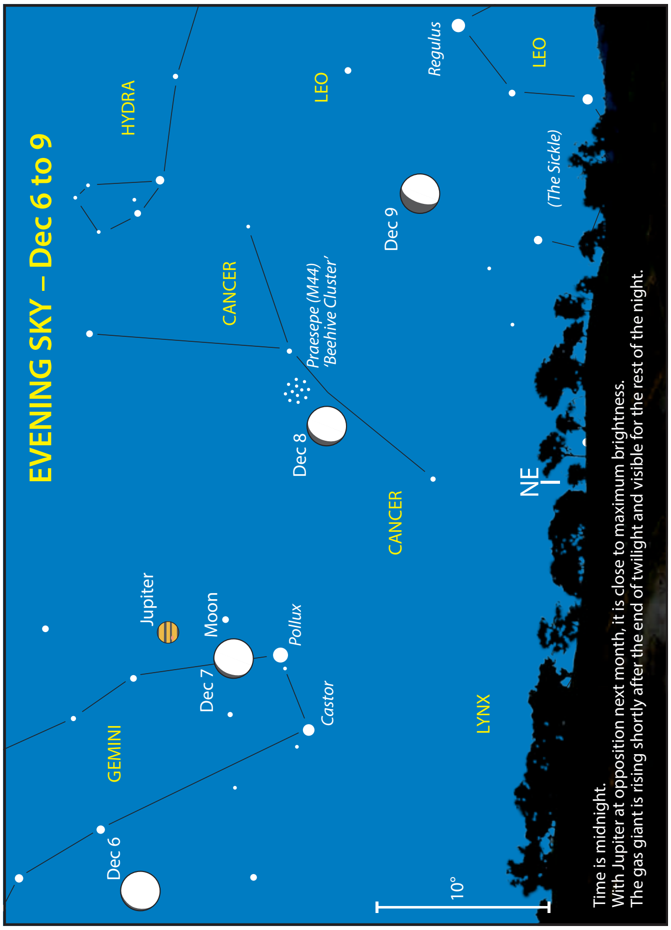
Although attractive in their own right, we are using these two triangles as markers, for between them lies the bulk of the Fornax Cluster of Galaxies. This cluster lies around 60 light-years distant and includes around a dozen galaxies many amateurs would consider bright.

Starting from the Chi triangle, move 1.5° south-west to find the impressive (magnitude 8.5) lenticular galaxy NGC 1316. A 150 mm instrument shows a 2 × 3 arcminute halo with a brighter elongated central core and star-like nucleus. Only 5 arcminutes north lies its companion, NGC 1317. It too is bright, appearing as a well-defined, 0.5 arcminute, circular cloud.

Only 1.3° east of Chi lies the well-known barred spiral galaxy NGC 1365. It is a great object for 150–200 mm telescopes showing the central bar, with larger instruments showing the ghostly arms radiating from its ends giving a distorted S shape.

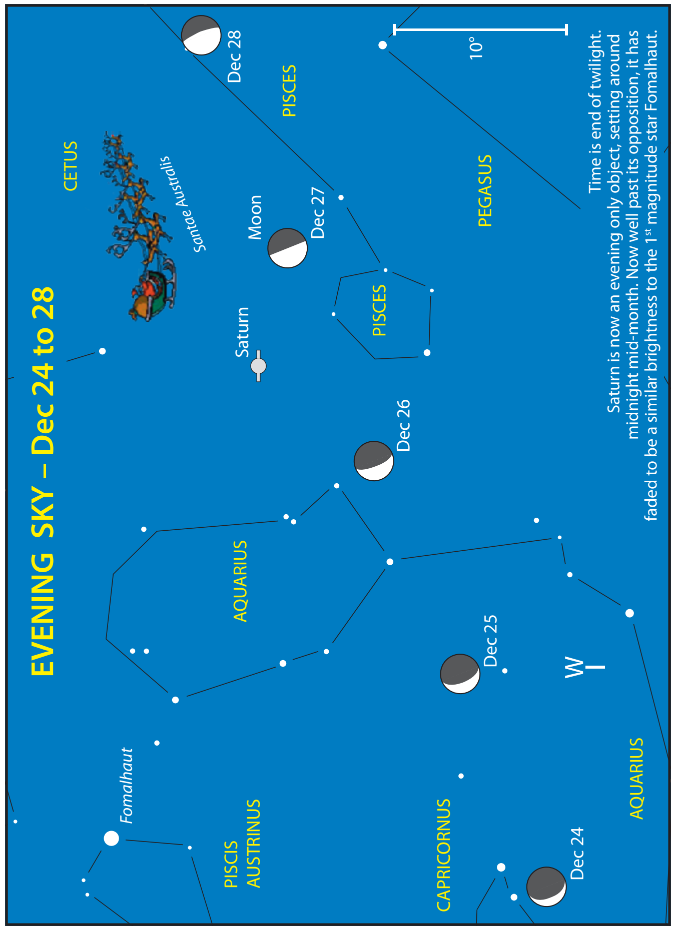
Just 1° north-east of NGC 1365 is a small group of extragalactic treasures. This collection of nine galaxies lie within a 1° circle and at 10^{th} to 11^{th} magnitude are within reach of a 150 mm instrument. The northernmost member of this tight group is the edge-on spiral galaxy NGC 1380. Glowing at a respectable magnitude 9.9, it has a bright halo (3' × 1'), showing a non-stellar nucleus imbedded in a prominent circular core, impressive.

EVENING SKY – Dec 6 to 9



Time is midnight.
With Jupiter at opposition next month, it is close to maximum brightness.
The gas giant is rising shortly after the end of twilight and visible for the rest of the night.

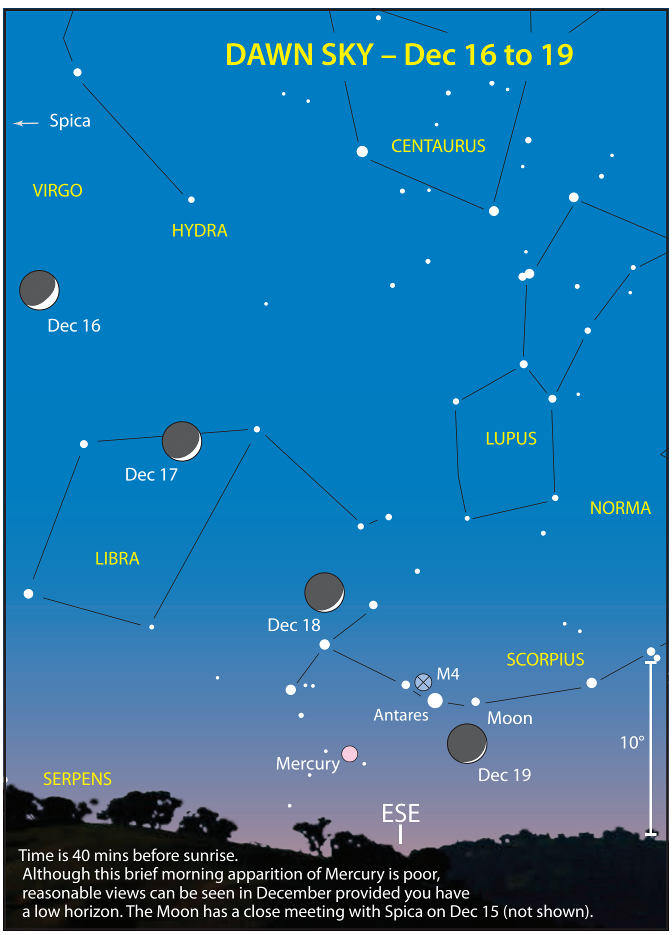
EVENING SKY – Dec 24 to 28



Time is end of twilight.
Saturn is now an evening only object, setting around midnight mid-month. Now well past its opposition, it has faded to be a similar brightness to the 1st magnitude star Fomalhaut.

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

DAWN SKY – Dec 16 to 19



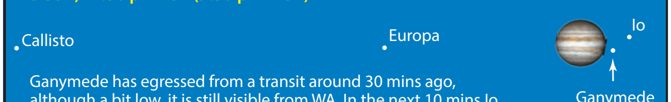
Time is 40 mins before sunrise.
Although this brief morning apparition of Mercury is poor, reasonable views can be seen in December provided you have a low horizon. The Moon has a close meeting with Spica on Dec 15 (not shown).

Jupiter's Satellites for December

1 arc min.

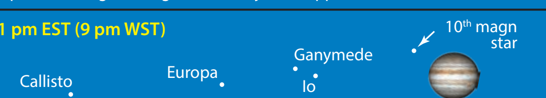
Jupiter's moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole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

Dec 2, 11:30 pm EST (9:30 pm WST)



Ganymede has egressed from a transit around 30 mins ago, although a bit low, it is still visible from WA. In the next 10 mins Io will be eclipsed. It's magic seeing the moons just disappear!

Dec 6, 11 pm EST (9 pm WST)



All four moons on the eastern side of Jupiter.
NB the faint interloper close to the glare of Jupiter.

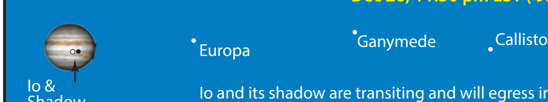
Dec 16, 11 pm EST (9 pm WST)

Earlier in the evening a rare event is seen as Callisto reappears from being occulted. Later in the night a full transit of Ganymede and its shadow are visible.

Dec 24, midnight EST (11 pm WST)

Callisto's shadow is currently transiting. Later in the morning this outer moon's shadow will egress, followed by the satellite ingressing. The morning hours will also see Io and its shadow transit.

Dec 26, 11:30 pm EST (9:30 pm WST)



Io and its shadow are transiting and will egress in the morning. The wee hours also sees Europa eclipsed (pass into Jupiter's shadow)

ALL SKY MAPS 2025

Introduction These maps have been created to show you the entire night sky at any time of the year from anywhere in Australia, New Zealand, South Africa, and parts of South America.

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

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

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

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

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

The seasonal views are a little arbitrary. As you will see in the Notes section on the maps, an evening view around the relevant time of the year was chosen. However, if you are willing to stay up all night there is only a small part of the entire sky not available to you, especially in winter. Rotating a planisphere illustrates this quite well (p. 15).

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

The declination indicates which areas of the charts will pass directly overhead. This happens when an object has the same declination as your latitude. Let's take an example for Hobart (latitude around 43° S). Looking at the Autumn (Centre) map on 20 March at 9 pm the star Suhail, with a declination close to −43°, will pass overhead.

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

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

What else is shown on the maps?

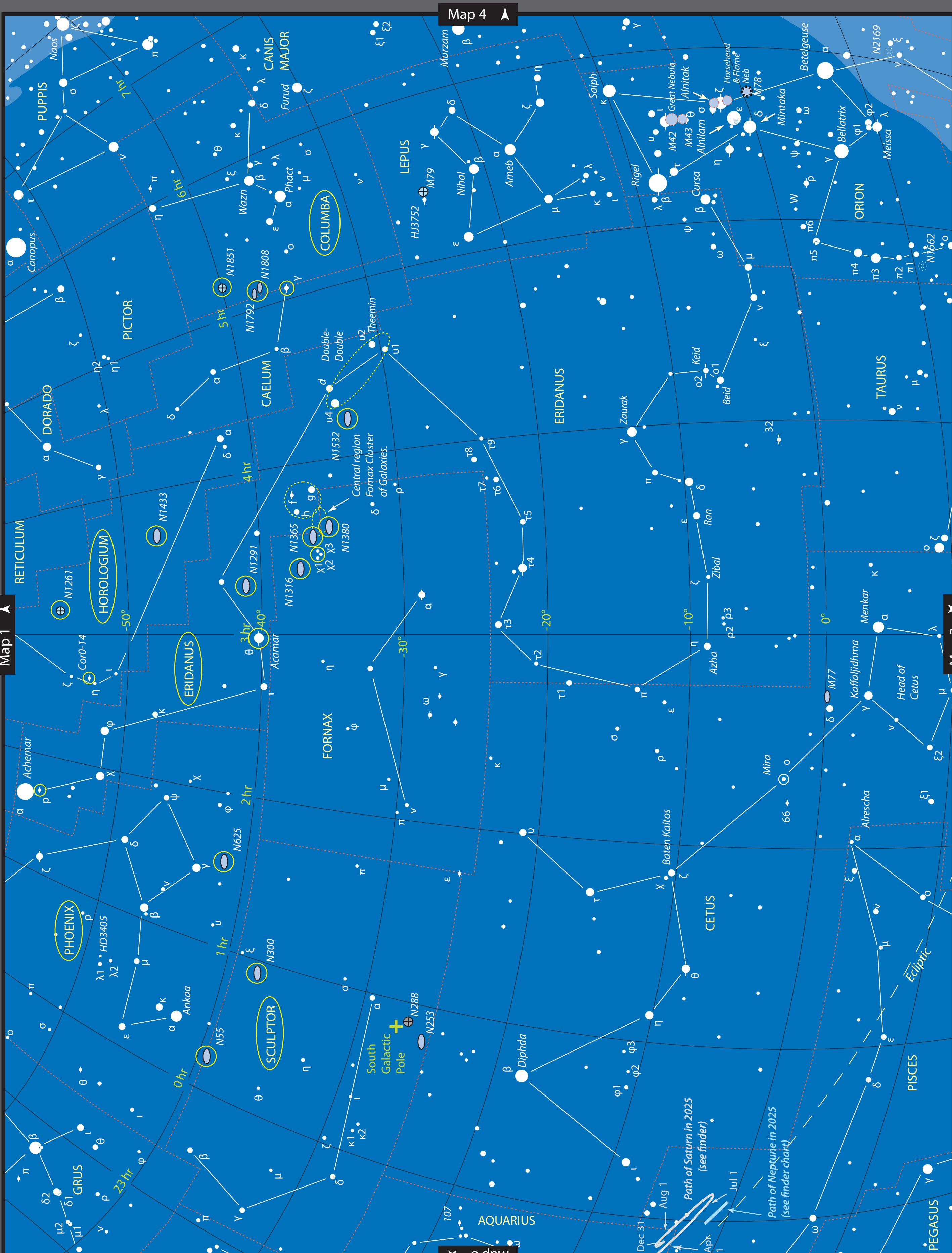
- Deep sky objects down to magnitude 7 and all the Messier objects (see the legend). These objects are identified by their common names (such as asterisms), Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope.
- Constellation lines. The orange dotted lines are the boundaries and the solid lines joining some of the brighter stars help us to recognise the constellation's pattern.
- A light blue shading shows the Milky Way and Magellanic Clouds.

Special objects marked this year include constellations, deep sky objects and double stars mentioned in the monthly Constellations section. Because the maps have a generous overlap in places, we have only marked these on the maps referred to in the monthly text. Also, included are the locations of the known bright comets for 2025 during their most favourable passage (see ephemerides in Part II), and the location of minor planet, Vesta, during its brightest, naked-eye period (i.e. when brighter than 6^{th} magnitude) All Sky Map No 6).

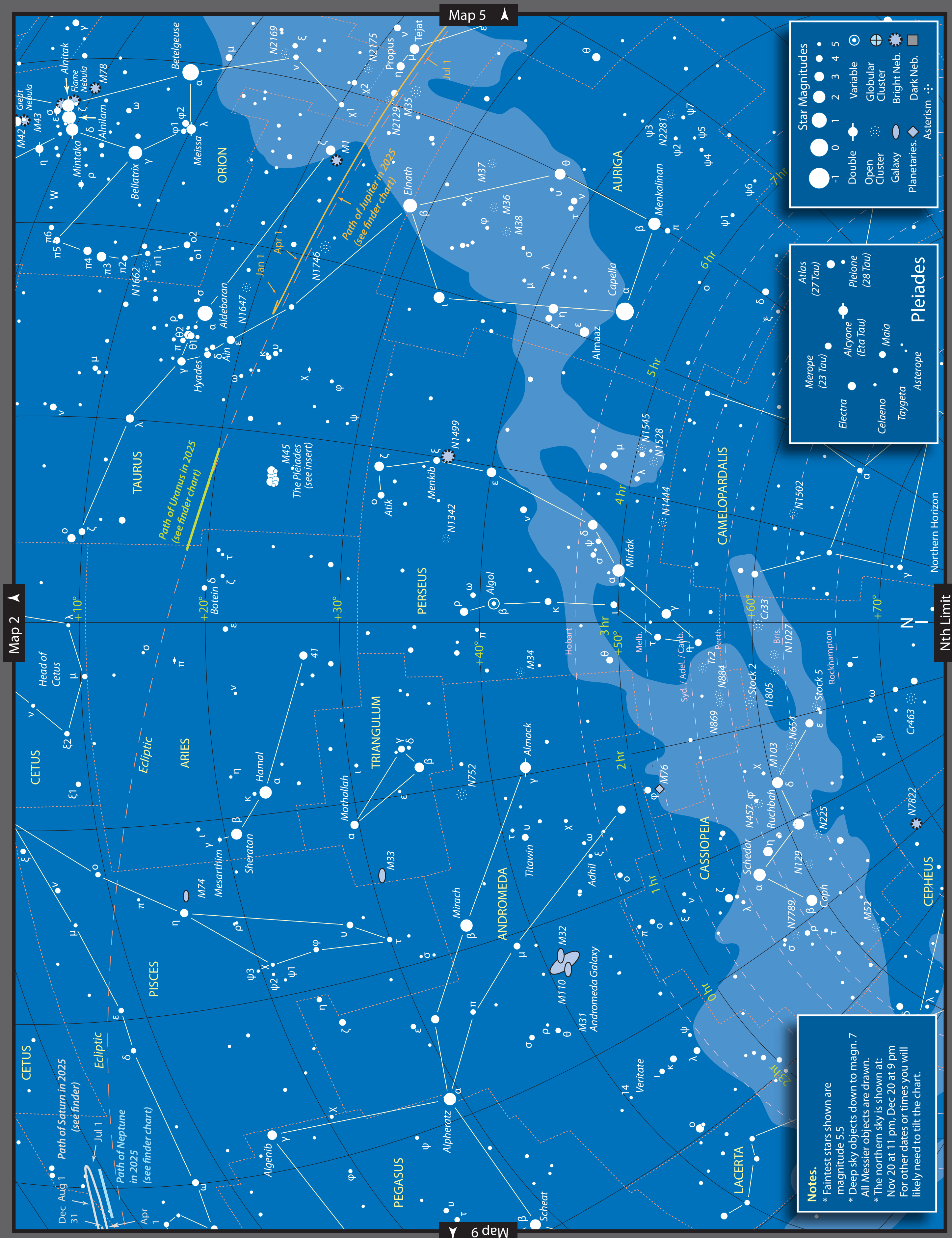
Southern celestial pole on a Full Moon night. Taken at Hanging Rock on the western edge of Rudall River (Karlamilyi) National Park WA 12 Sep 2022. The west side of the rock was illuminated by campfire. A 2–3 hour exposure started shortly after moonrise. Credit John Beadle.

Map 1 - Looking South

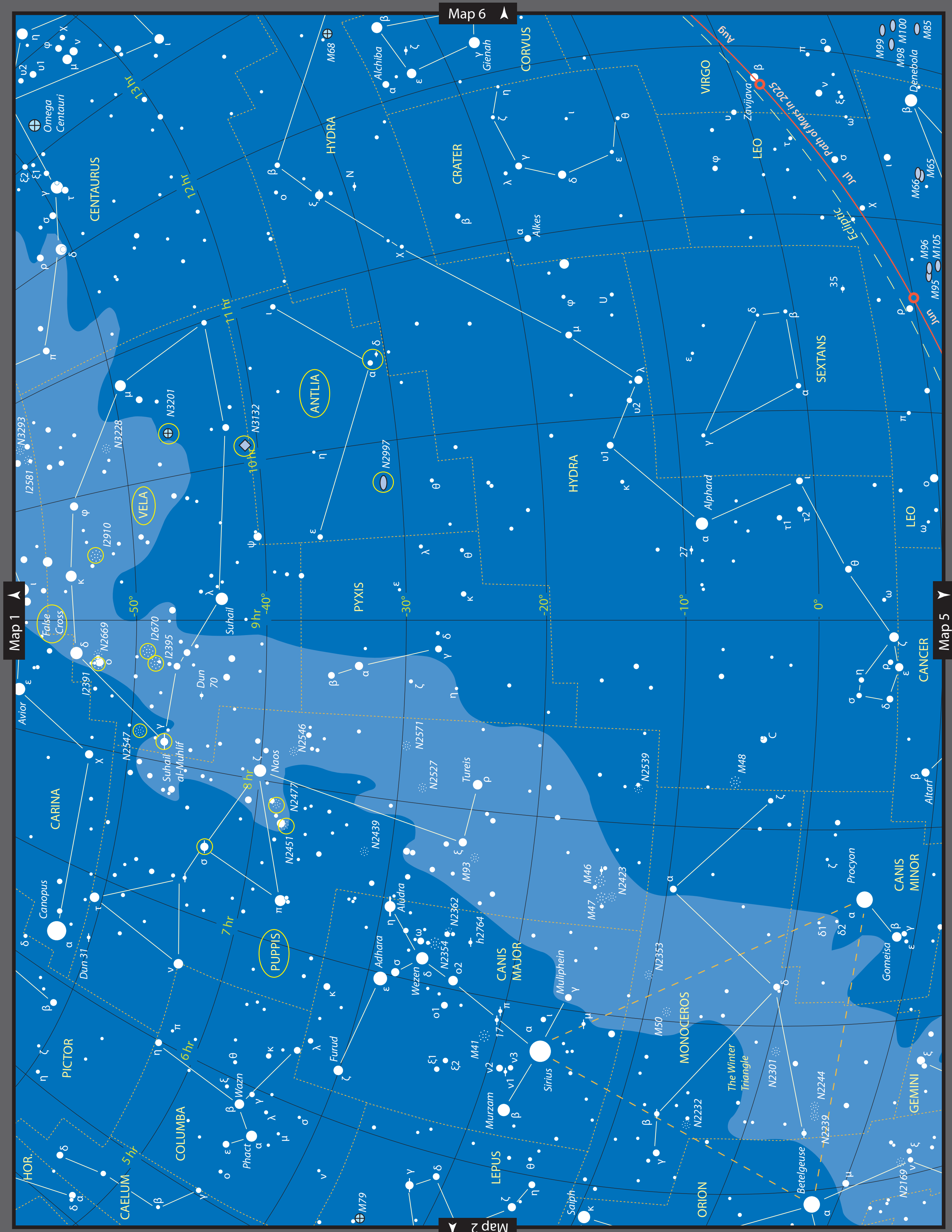
Map 2 - Summer (Centre)



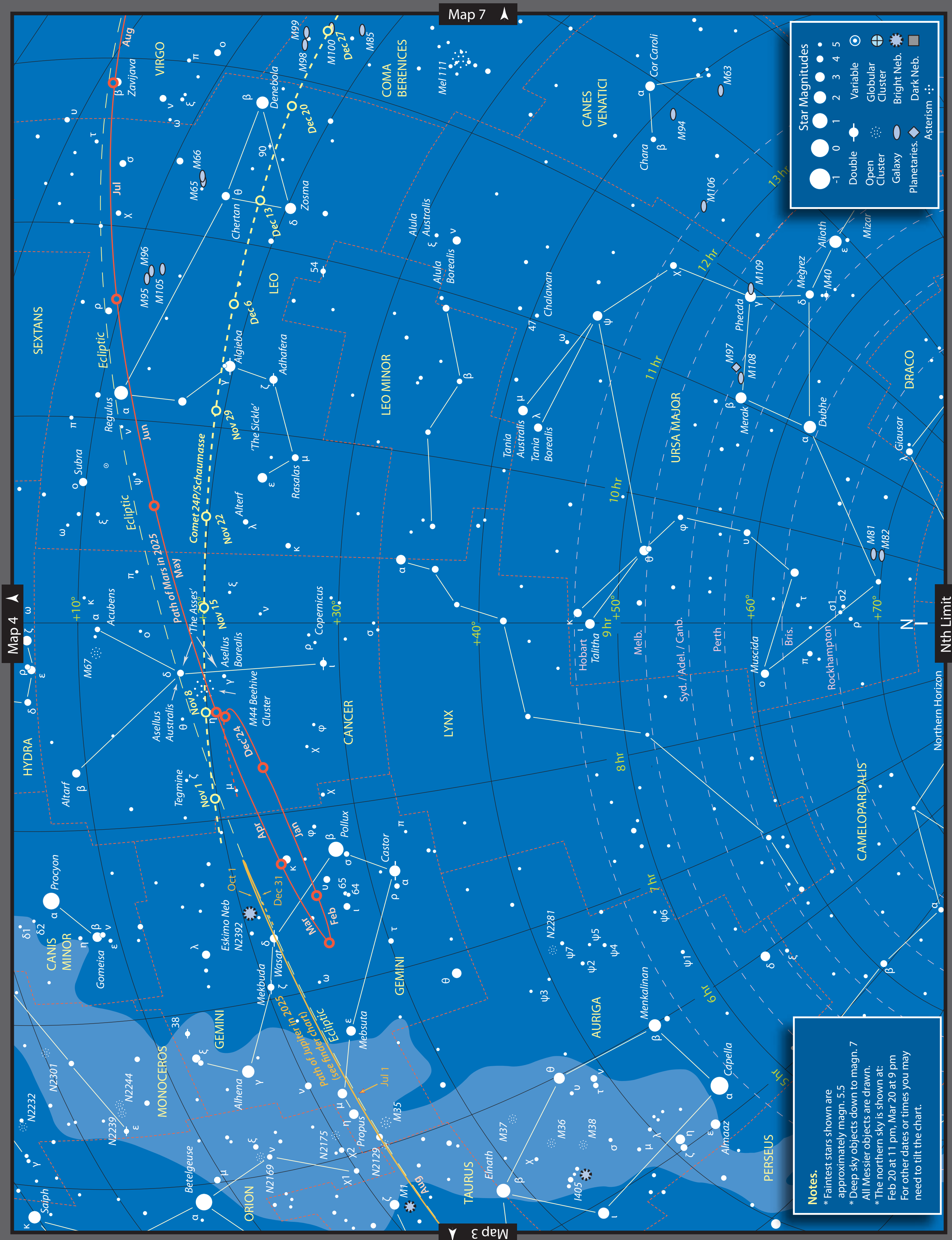
Map 3 - Summer (North)



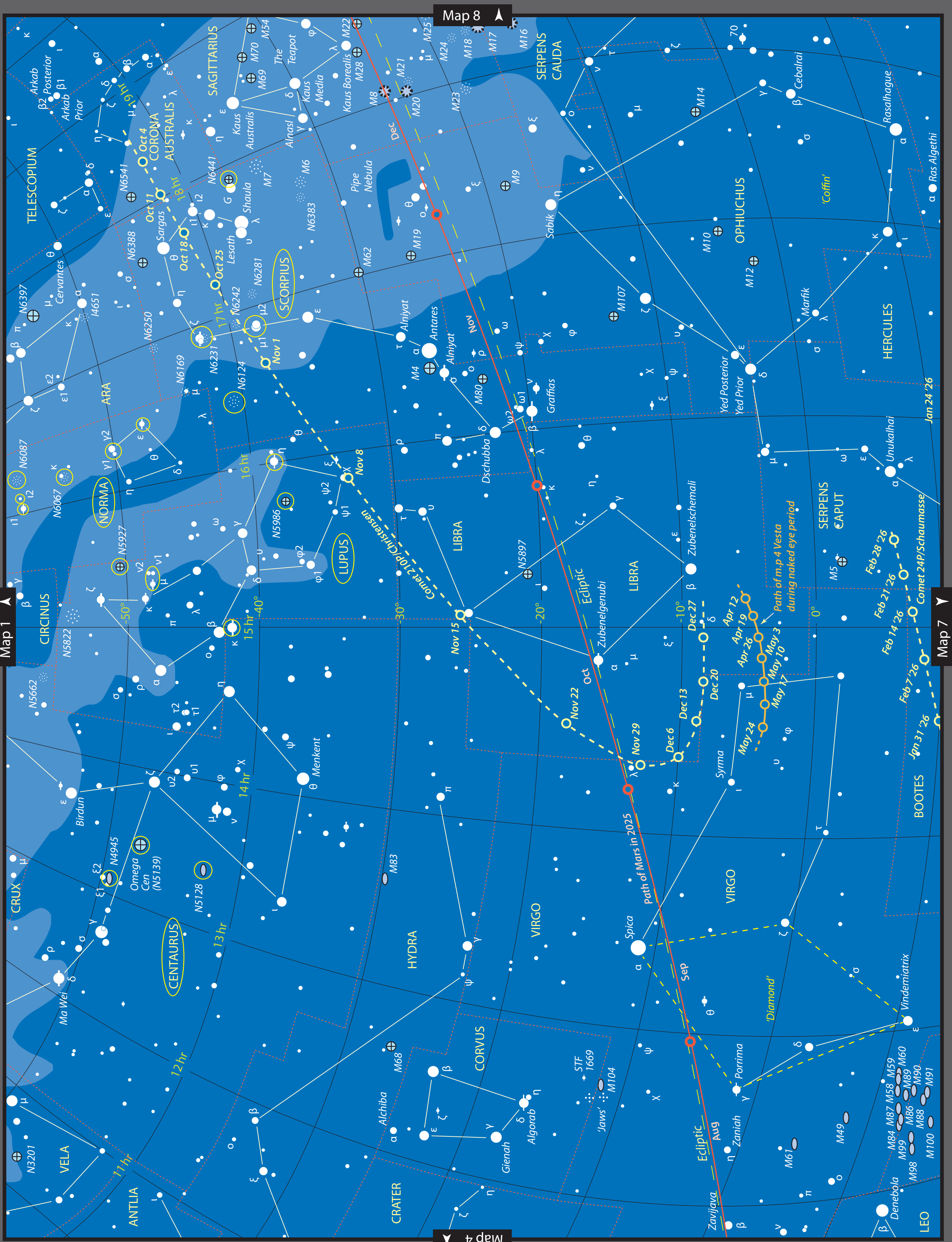
Map 4 - Autumn (Centre)



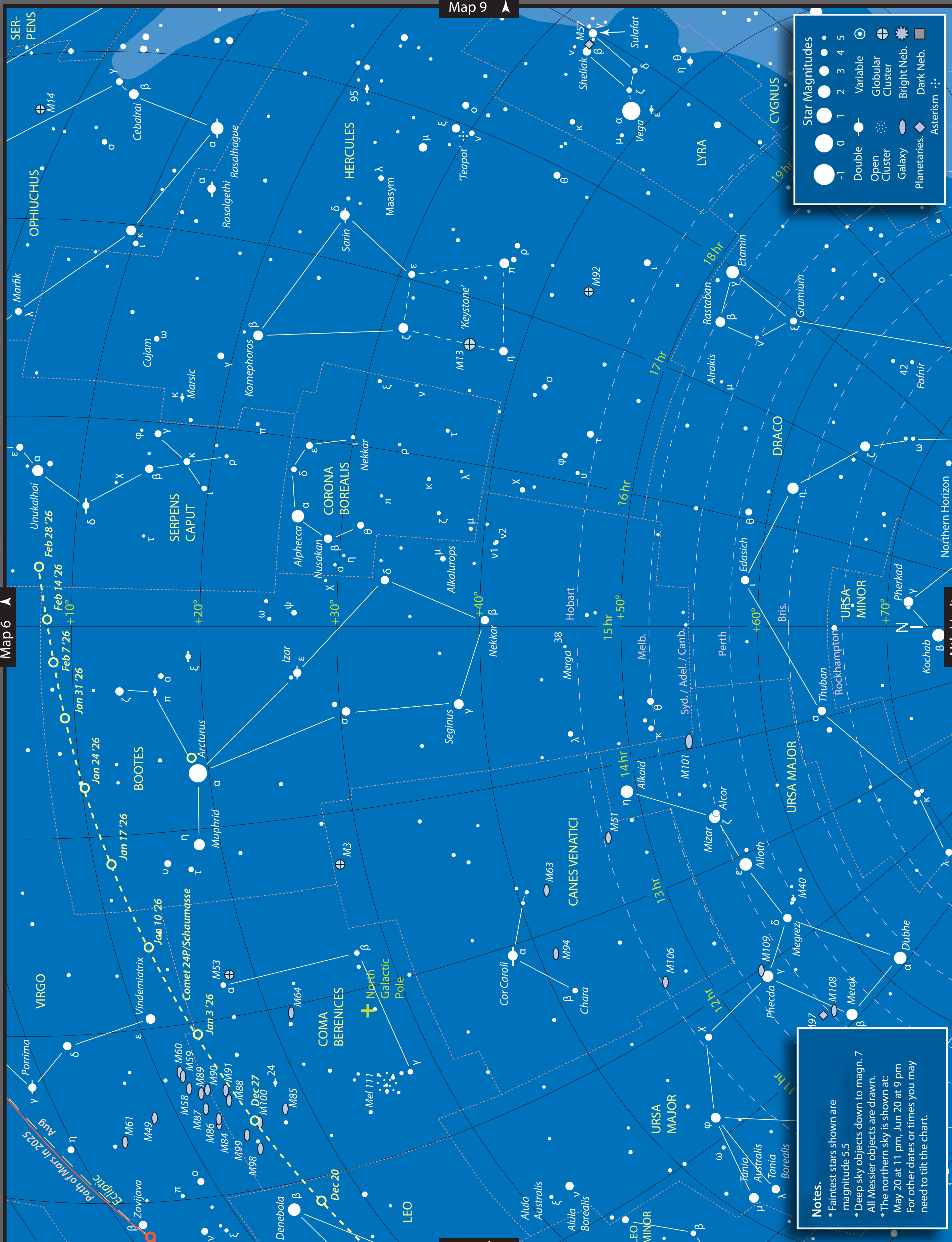
Map 5 - Autumn (North)



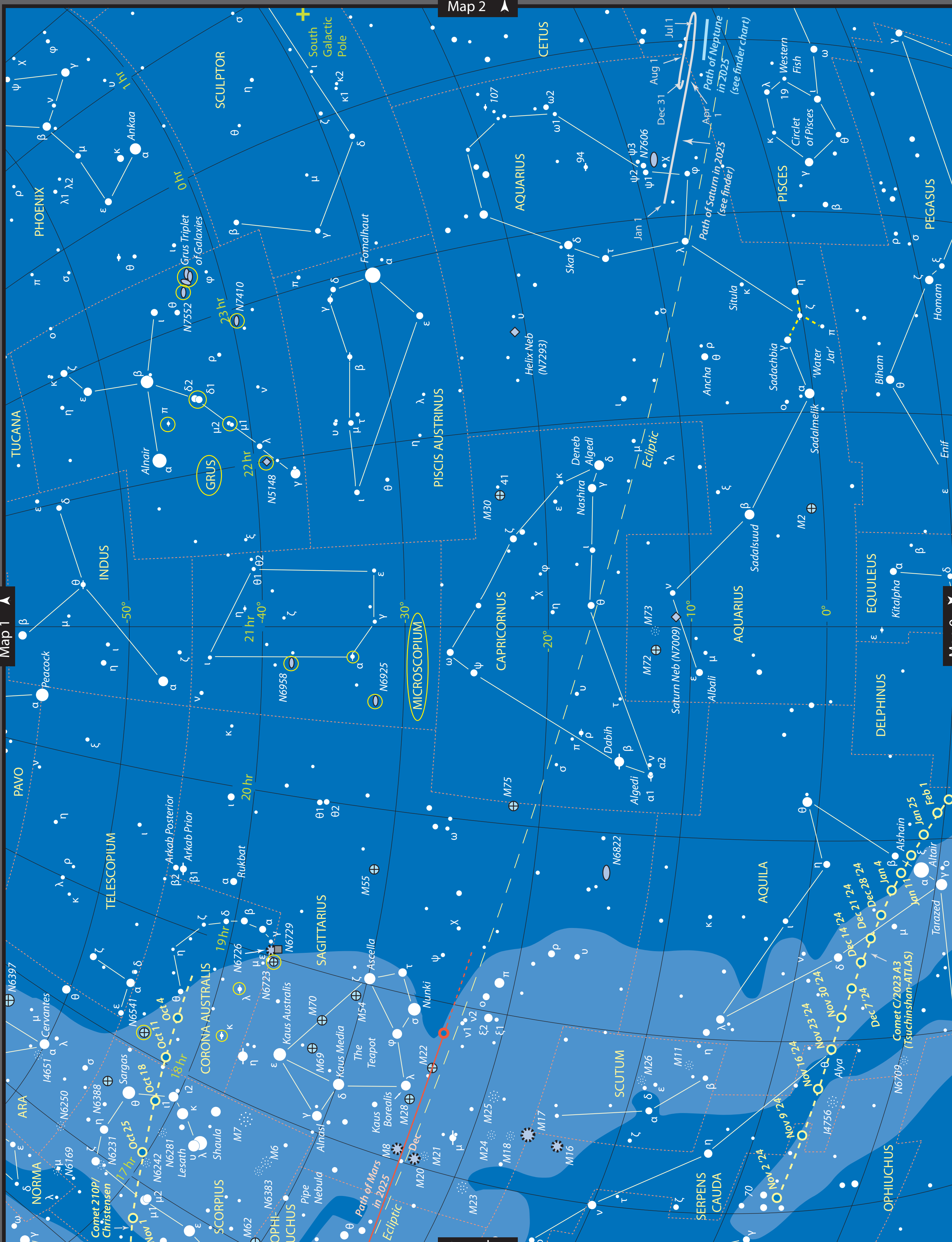
Map 6 - Winter (Centre)



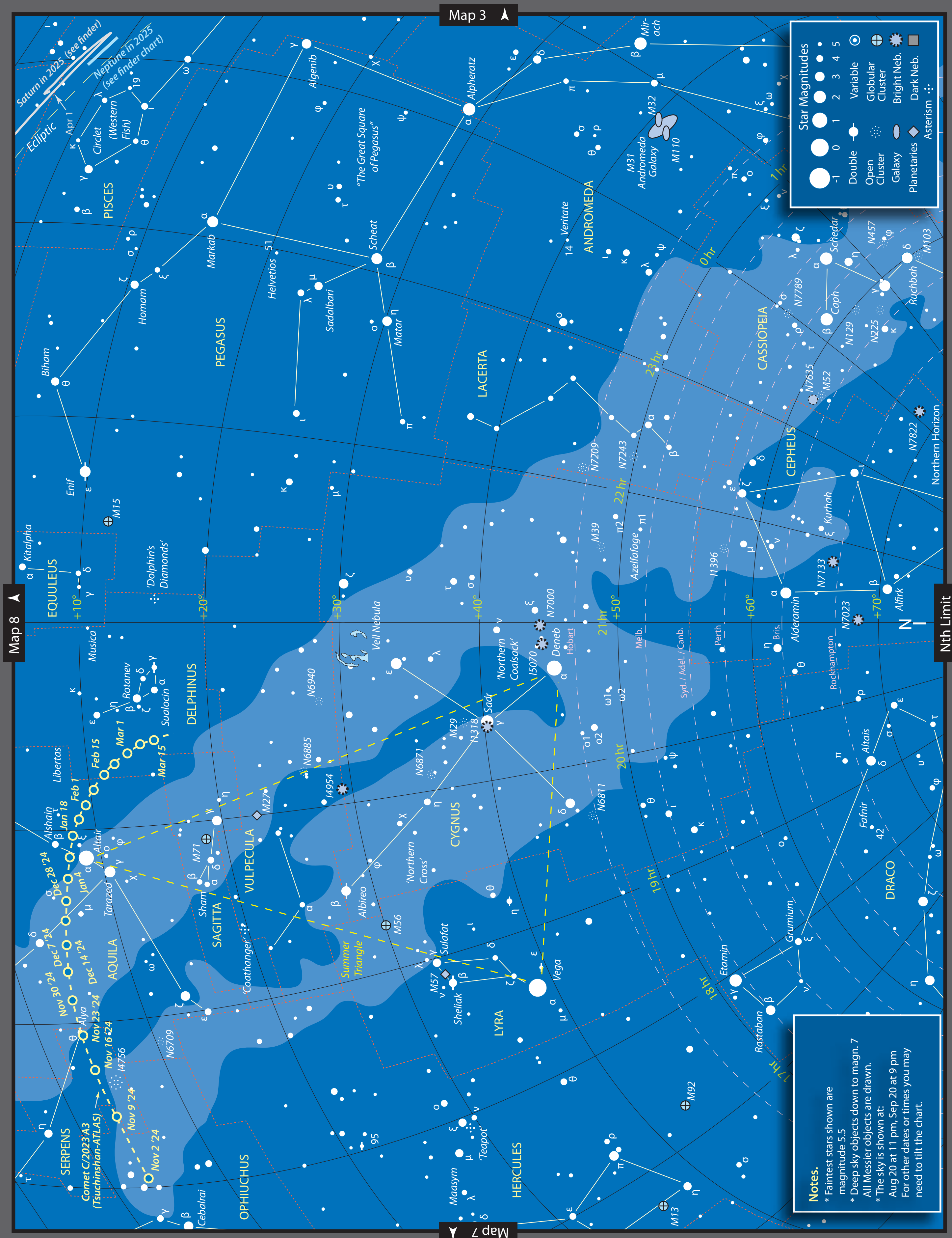
Map 7 - Winter (North)



Map 8 - Spring (Centre)



Map 9 - Spring (North)



PART II — THE SOLAR SYSTEM

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

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

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

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

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

Locations: Rise and set times for the Sun and Moon are given for specific cities. The latitudes and longitudes used are:

Adelaide	34° 54' S	138° 36' E	Brisbane	27° 30' S	153° 01' E
Canberra	35° 15' S	149° 08' E	Darwin	12° 23' S	130° 44' E
Hobart	42° 48' S	147° 13' E	Melbourne	37° 50' S	145° 00' E
Perth	31° 57' S	115° 51' E	Sydney	33° 54' S	151° 15' E

Astronomical Coordinates or Positions. The astronomical positions are given in equatorial coordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360°, for once around the sky, are divided into 24 one-hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations; those south have negative (–). The Right Ascension and Declination grid has been marked on the All Sky Maps (see previous pages). The RA has a line for each hour and the Declination has a line every 10°. The finders also have them marked.

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

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

Rise and Set Times. Those given are when the upper limb of the object is coincident with the theoretical horizon. The times are adjusted for atmospheric refraction. The intervals used for Moon rise and set are daily with the Sun weekly and corresponding to Saturdays. Also see note on time zones under Time (above). Rise and set times for the planets are on our website. www.quasarastronomy.com.au

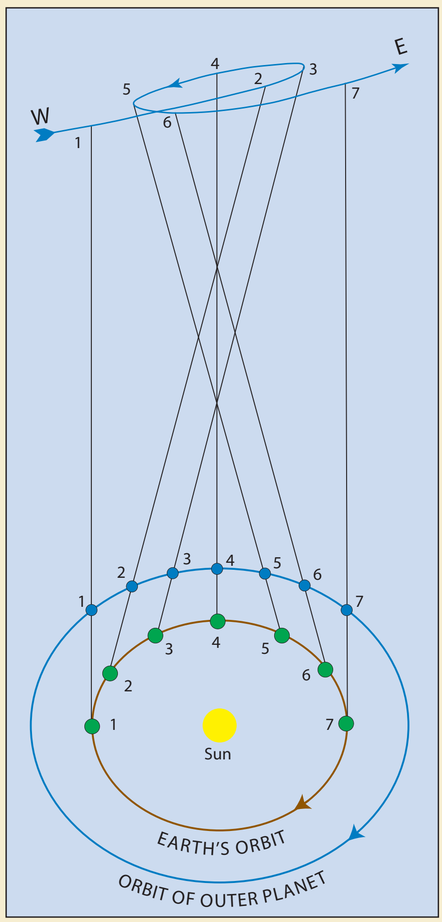
Use of Star Atlases. As the Earth orbits the Sun the polar axis, around which the stars appear to rotate (the celestial poles) appears to never change no matter what time of the year you are observing. However, the positions of the poles do slowly move against the star field. This is called precession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

RETROGRADE MOTION

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

In the diagram, the top section represents the path of an outer planet against the celestial sphere with south up. As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is a loop in its path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and during this time the planet appears to move among the stars from east to west, instead of west to east. At positions 1 and 2, Uranus continues its west to east path and begins to slow to position 3 as the Earth catches up. Between 3 and 5, Uranus is in retrograde motion and it is at opposition (in line with the Earth and the Sun) at 4. At points 3 and 5, the planet is said to be stationary. After 5, as the Earth passes the slower planet, Uranus continues its west to east direction.

Because the orbits of the outer planets are inclined to that of the Earth's, thus having some north/south motion, the path can never be a straight line. It will always be a loop or an S-bend.



2000.0' refers to an object's position relative to where the celestial poles (+/–90° in declination) were on 1 Jan in the year 2000. The All Sky Maps and finder charts are Epoch 2000.0.

Field of View in a Telescope. The All Sky Maps and the finder charts are drawn with South up and east to the right to match the view from the Southern Hemisphere (in the sky, east and west are opposite to terrestrial maps). The satellite diagrams are drawn to traditional sky orientation, that is east to the left, and north to the top. Binoculars, the eyes and straight Newtonians show this orientation, although the Newtonian image will be upside down. Telescope systems that use an odd number of mirrors will reverse the orientation of the image. The common use of star diagonals in Schmidt-Cassegrain or traditional refractors causes this reversal.

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

Supermoons The table below shows the so called supermoons for 2025. They occur when the time of the Moon's perigee (the point in its orbit when closest to the Earth) happens close to the time of Full Moon. This can be observed by comparing the dates (below) to those of perigee and Full Moon for the month of interest (see Moon section in Part I). As you can see, the Moon is not exactly super large and the effect is possibly enhanced by having the impressive fully illuminated globe close to the horizon with surrounding trees and buildings. This is known as the Moon Illusion.

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

FULL MOON at PERIGEE (Supermoon, UT)

Date of FM [7]	Time of FM [1]	Geocentric Distance (km)	Geocentric Diameter (arcminutes)	Relative Distance [2]	Relative Brightness [3]	Date of Perigee [4]	Time of Perigee [1]	Nearest Perigee [5]
Oct 07	03:48	361,458	33.06	0.964	1.259/1.131	Oct 08	12:38	1.367
Nov 05	13:19	356,980 [6]	33.47	0.997	1.296/1.160	Nov 05	22:27	0.382
Dec 04	23:14	357,219	33.45	0.995	1.294/1.158	Dec 04	11:07	−0.506

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	
1262			Jan 6	23:56	Jan 13	22:27	Jan 21	20:31
1263	Jan 29	12:36	Feb 5	08:02	Feb 12	13:53	Feb 20	17:32
1264	Feb 28	00:45	Mar 6	16:32	Mar 14	06:55	Mar 22	11:29
1265	Mar 29	10:58	Apr 5	02:15	Apr 13	00:22	Apr 21	01:36
1266	Apr 27	19:31	May 4	13:52	May 12	16:56	May 20	11:59
1267	May 27	03:02	Jun 3	03:41	Jun 11	07:44	Jun 18	19:19
1268	Jun 25	10:32	Jul 2	19:30	Jul 10	20:37	Jul 18	00:38
1269	Jul 24	19:11	Aug 1	12:41	Aug 9	07:55	Aug 16	05:12
1270	Aug 23	06:06	Aug 31	06:25	Sep 7	18:09	Sep 14	10:33
1271	Sep 21	19:54	Sep 29	23:54	Oct 7	03:48	Oct 13	18:13
1272	Oct 21	12:25	Oct 29	16:21	Nov 5	13:19	Nov 12	05:28
1273	Nov 20	06:47	Nov 28	06:59	Dec 4	23:14	Dec 11	20:52
1274	Dec 20	01:43	Dec 27	19:10				

PERIGEE AND APOGEE (UT)

Perigee			Apogee		
Date	Time	Distance (km)	Date	Time	Distance (km)
Jan 8	00:01	370,171	Jan 21	04:54	404,298
Feb 2	02:47	367,457	Feb 18	01:10	404,882
Mar 1	21:21	361,964	Mar 17	16:37	405,754
Mar 30	05:25	358,128	Apr 13	22:48	406,295
Apr 27	16:18	357,119	May 11	00:47	406,244
May 26	01:34	359,022	Jun 7	10:44	405,553
Jun 23	04:44	363,178	Jul 5	02:29	404,627
Jul 20	13:55	368,041	Aug 1	20:36	404,161
Aug 14	17:59	369,288	Aug 29	15:34	404,548
Sep 10	12:10	364,777	Sep 26	09:46	405,548
Oct 8	12:38	359,819	Oct 23	23:30	406,444
Nov 5	22:27	356,833	Nov 20	02:48	406,691
Dec 4	11:07	356,963	Dec 17	06:09	406,322

GEOCENTRIC PHENOMENA (UT)

Planet	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary	Greatest Elongation West
Mercury	9 Feb, 12h	8 Mar, 06h (18.2°)	14 Mar, 21h	24 Mar, 20h	6 Apr, 6h	21 Apr, 19h (27.4°)
	30 May, 04h	4 Jul, 05h (25.9°)	17 Jul, 7h	31 Jul, 24h	10 Aug, 18h	19 Aug, 10h (18.6°)
	13 Sep, 11h	29 Oct, 22h (23.9°)	9 Nov, 23h	20 Nov, 09h	29 Nov, 15h	7 Dec, 21h (20.7°)
Venus		10 Jan, 05h (47.2°)	28 Feb, 3h	23 Mar, 01h	10 Apr, 15h	1 Jun, 03h (45.9°)

Planet	Stationary	Conjunction	Stationary	Opposition	Stationary
Mars				16 Jan, 03h	24 Feb, 10h
Jupiter	4 Feb, 13h	24 Jun, 15h	11 Nov, 20h		
Saturn		12 Mar, 10h	14 Jul, 8h	21 Sep, 06h	29 Nov, 1h
Uranus	30 Jan, 19h	17 May, 24h	6 Sep, 5h	21 Nov, 12h	
Neptune		19 Mar, 23h	5 Jul, 15h	23 Sep, 13h	11 Dec, 0h

Earth	
Perihelion	4 Jan, 13h
Equinox	20 Mar, 09h
Solstice	21 Jun, 03h
Aphelion	3 Jul, 20h
Equinox	22 Sep, 18h
Solstice	21 Dec, 15h

HELIOCENTRIC PHENOMENA (UT)

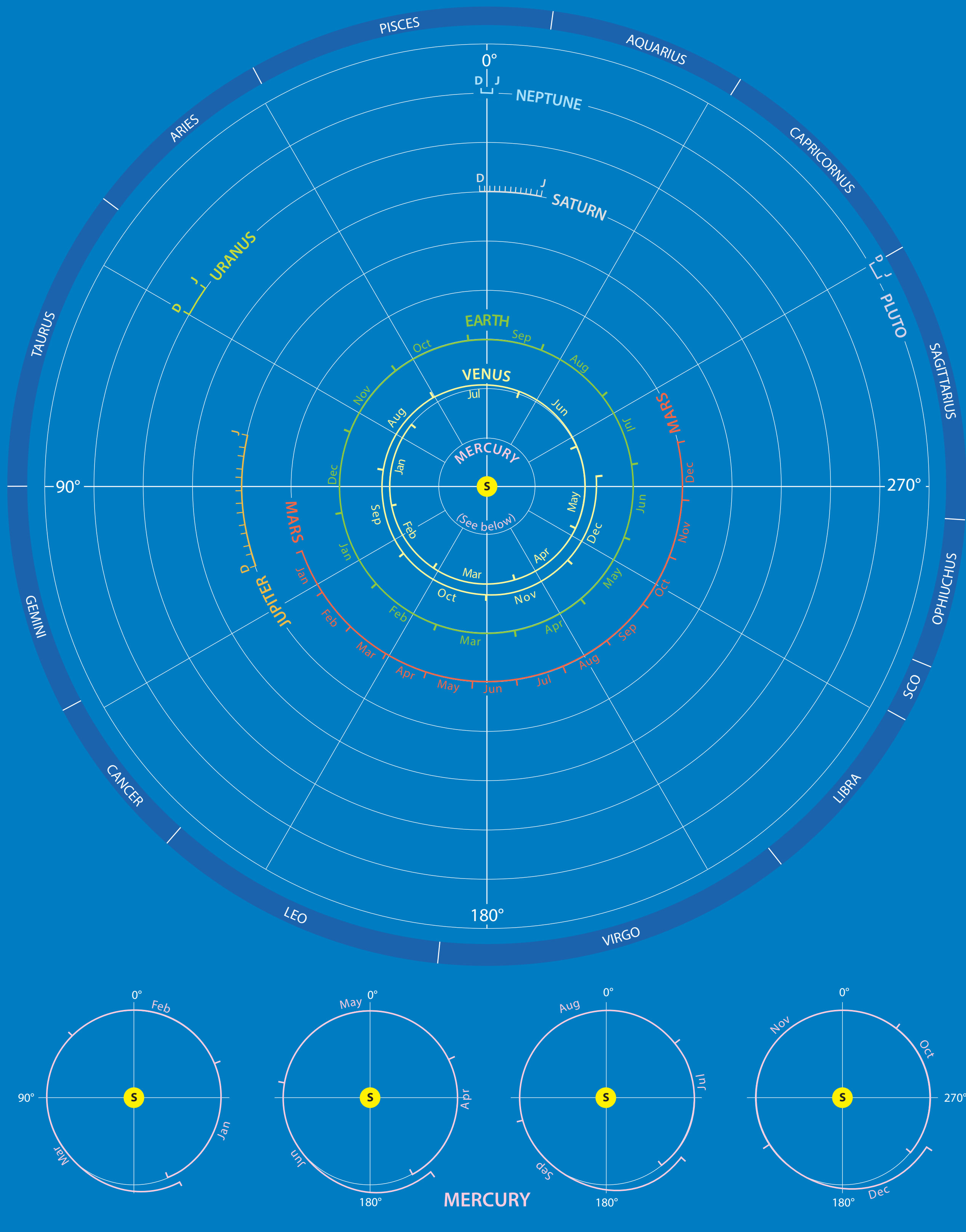
Planet	Aphelion	Perihelion	Descending Node	Greatest Latitude South	Ascending Node	Greatest Latitude North
Mercury	Jan 19	Mar 4	Jan 9	Feb 8	Feb 27	Mar 14
Mercury	Apr 17	May 31	Apr 7	May 7	May 26	Jun 10
Mercury	Jul 14	Aug 27	Jul 4	Aug 3	Aug 22	Sep 6
Mercury	Oct 10	Nov 23	Sep 30	Oct 30	Nov 18	Dec 3
Mercury			Dec 27			
Venus	Jun 12	Feb 19	May 8	Jul 4	Jan 16	Mar 13
Venus		Oct 2	Dec 19		Aug 29	Oct 24
Mars	Apr 16		Sep 23			Mar 9
Jupiter					Sep 19	
Saturn, Uranus, and Neptune have no events in 2025						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Mean Distance from Sun ($\times 10^3$ km)	-	-	57856	108132	149492	227780	777776	1425983	2867760	4492800
Mean Distance from Sun (Earth = 1)	-	-	0.387	0.723	1.000	1.524	5.203	9.540	19.180	30.700
Magnitude at Opposition	–26.8	–12.74 [11]	0.16 [12]	–4.07 [12]	–3.5 [13]	–2.01	–2.70	0.67	5.52	7.84
Equatorial Diameter (km)	1392530	3474.8	4879.4	12103.6	12756.3	6792.4	142984	120536	51118	49528
Flattening [1]	0	0	0	0	0.00335281	0.005886	0.064874	0.097962	0.022927	0.017081
No of Moons	-	-	0	0	1	2	95	146	28	16
Mass ($\times 10^{24}$ kg)	1.9884×10^{30}	0.073458	0.3301	4.8673	5.9721986	0.64169	1898.1	568.31	86.809	102.41
Mass (Earth = 1)	332946	0.012300	0.0553	0.8150	1.0000000	0.10745	317.8	95.16	14.536	17.148
Volume (Earth = 1)	1300000	0.02	0.06	0.86	1	0.15	1323	752	64	54
Sidereal Period [2]	-	27.32 d	87.97 d	224.7 d	365.256 d	687 d	11.86 y	29.46 y	84.01 y	164.8 y
Synodic Period (Days) [3]	-	29.4	115.8	583.9	-	779.8	398.8	378.0	369.7	367.5
Axial Rotation (Days) [4]	25.38 [9]	27.32166	58.6462	–243.0185	0.99726963	1.02595676	0.41354 [14]	0.44401 [14]	–0.71833	0.67125
Albedo [5]	-	0.12	0.106	0.65	0.367	0.150	0.52	0.47	0.51	0.41
Eccentricity [6]	-	0.0549	0.20562	0.00681	0.01681	0.09333	0.04837	0.05582	0.0471	0.00855
Inclination [7]	-	5° 08' 40"	7° 00' 00"	3° 23' 38"	0° 00' 00"	1° 51' 01"	1° 18' 28"	2° 29' 29"	0° 46' 22"	1° 46' 38"
Obliquity [8]	7° 15' [10]	6° 41'	0° 01'	2° 38'	23° 26'	25° 11'	3° 07'	26° 45'	82° 14'	28° 20'

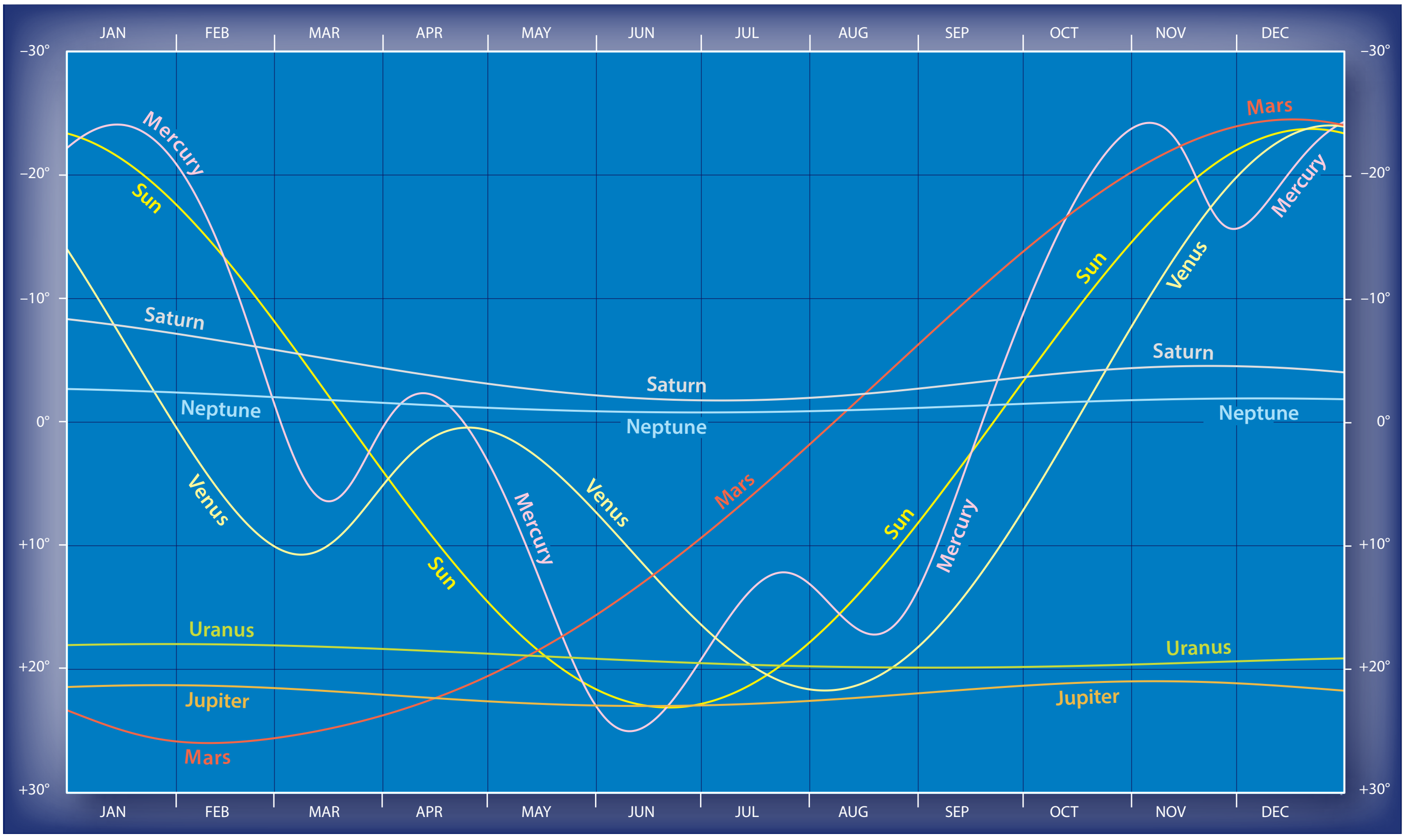
Notes:
1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
5 The ratio of the sunlight 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.

PLANET POSITIONS



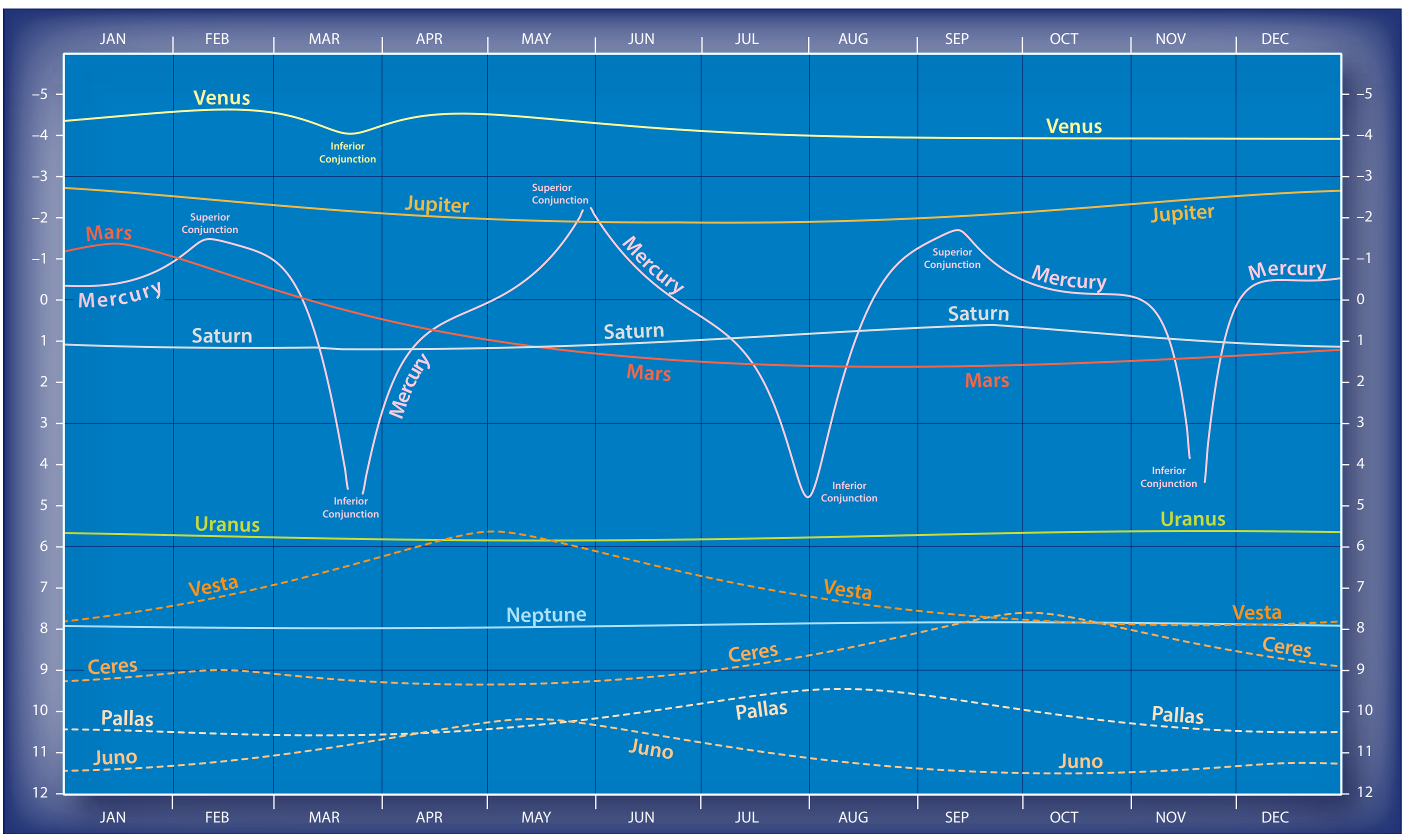
This diagram illustrates the relative positions of the planets during the course of their orbits in 2025. The relationships between the major Solar System bodies are clearly shown. The diagram is drawn as viewed from above (north of) the Solar System. The drawing has been simplified in that the planetary 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.

DECLINATIONS of the SUN and PLANETS



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

MAGNITUDES of the PLANETS, BRIGHT DWARF and MINOR PLANETS



SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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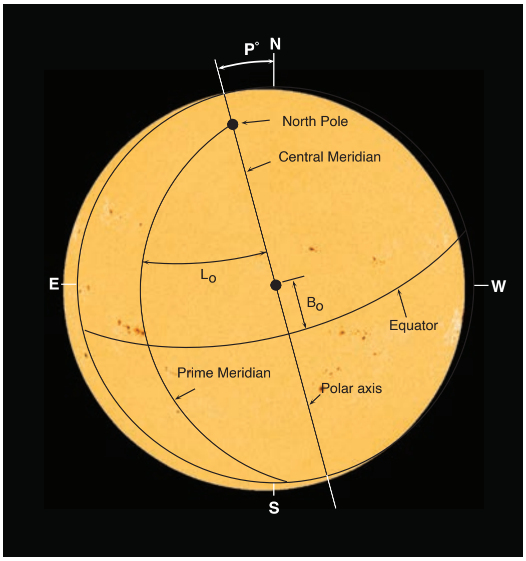
ORIENTATION OF THE SUN



Sun image courtesy of SOHO/HMI 220240717-000000

SYNODIC ROTATION NUMBERS (UT)

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2294	Feb	3.17
2295	Mar	2.50
2296	Mar	29.81
2297	Apr	26.09
2298	May	23.31
2299	Jun	19.51
2300	Jul	16.71
2301	Aug	12.93
2302	Sep	9.18
2303	Oct	6.45
2304	Nov	2.75
2305	Nov	30.06
2306	Dec	27.38

Date (0 h UT)		P°	B_0°	L_0°
Jan	4	+ 0.5	−3.4	037.2
	11	−2.9	−4.1	305.0
	18	−6.2	−4.9	212.8
	25	−9.3	−5.5	120.6
Feb	1	−12.3	−6.0	028.5
	8	−15.0	−6.5	296.3
	15	−17.5	−6.8	204.1
	22	−19.7	−7.1	112.0
Mar	1	−21.6	−7.2	019.8
	8	−23.2	−7.3	287.5
	15	−24.4	−7.2	195.3
	22	−25.4	−7.0	103.0
	29	−26.0	−6.7	010.7
Apr	5	−26.3	−6.3	278.4
	12	−26.2	−5.8	186.0
	19	−25.7	−5.3	093.5
	26	−24.9	−4.7	001.1
May	3	−23.7	−4.0	268.6
	10	−22.2	−3.2	176.0
	17	−20.3	−2.4	083.5
	24	−18.2	−1.6	350.9
	31	−15.7	−0.8	258.2
Jun	7	−13.0	+ 0.1	165.6
	14	−10.1	+ 0.9	072.9
	21	−7.1	+ 1.7	340.3
	28	−4.0	+ 2.5	247.6

Date (0 h UT)		P°	B_0°	L_0°
Jul	5	−0.8	+ 3.3	155.0
	12	+ 2.4	+ 4.0	062.3
	19	+ 5.5	+ 4.7	329.7
	26	+ 8.4	+ 5.3	237.1
Aug	2	+ 11.3	+ 5.9	144.5
	9	+ 13.9	+ 6.3	051.9
	16	+ 16.4	+ 6.7	319.4
	23	+ 18.6	+ 7.0	226.9
	30	+ 20.6	+ 7.2	134.4
Sep	6	+ 22.3	+ 7.3	041.9
	13	+ 23.7	+ 7.2	309.5
	20	+ 24.8	+ 7.1	217.1
	27	+ 25.6	+ 6.9	124.7
Oct	4	+ 26.1	+ 6.6	032.3
	11	+ 26.3	+ 6.2	300.0
	18	+ 26.0	+ 5.7	207.6
	25	+ 25.4	+ 5.1	115.3
Nov	1	+ 24.5	+ 4.4	023.0
	8	+ 23.1	+ 3.7	290.7
	15	+ 21.3	+ 2.9	198.4
	22	+ 19.2	+ 2.0	106.1
	29	+ 16.8	+ 1.1	013.9
Dec	6	+ 14.0	+ 0.3	281.6
	13	+ 11.0	−0.6	189.4
	20	+ 7.8	−1.5	097.2
	27	+ 4.5	−2.4	005.0

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

B_0° Heliocentric Latitude of centre of Sun

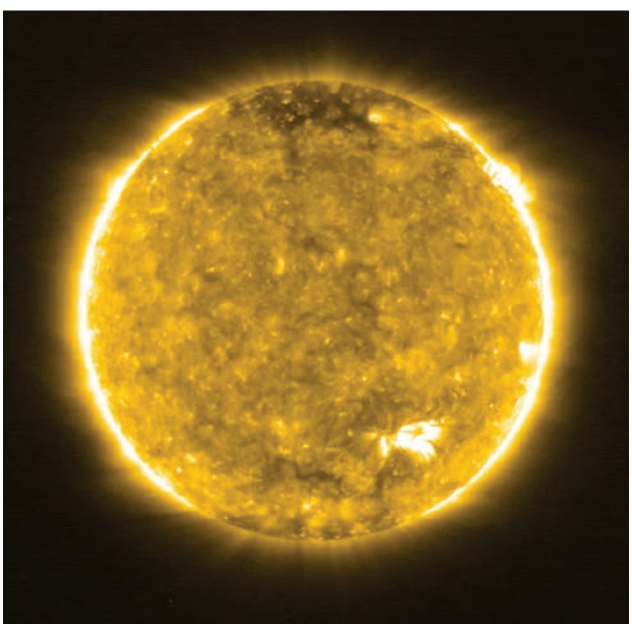
L_0° Heliocentric Longitude of centre of Sun

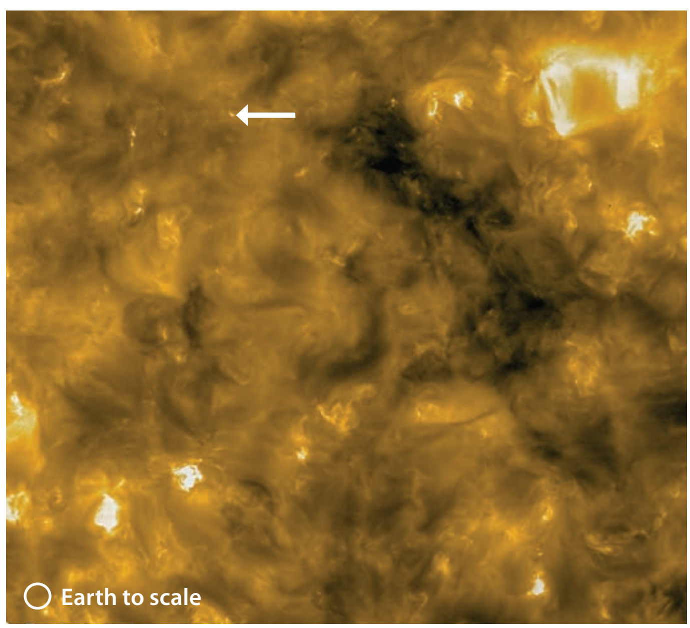
At the date of commencement of each synodic rotation period the value of L_0° is zero; that is, the prime meridian passes through the central point of the disc. The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is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

Example: Heliocentric Longitude value for 14 March at 2 pm WST. 2 pm WST is 6 hours UT (0 hr UT is 8 am WST). To get the value for 14 March (0 hr UT) start with the value from the main table for 8 March (287.5°) plus 6 days which from the daily variation table is −79.1°. Then you add the value for 6 hours, which is −3.3°. The calculation becomes: 287.5° + (–79.1°) + (–3.3°) = 205.1° (If negative, add 360°, if > 360°, subtract 360°).

VARIATION OF L_0°

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





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 2025, there will be four eclipses: two of the Sun and two of the Moon. Both solar eclipses are partial, and both lunar eclipses are total.

The magnitudes provided in this section are not a measure of brightness. For solar eclipses, it is the fraction of the Sun's diameter occulted by the Moon. It is strictly a ratio of diameters and should not be confused with eclipse obscuration, a measure of the Sun's surface area occulted by the Moon. For lunar eclipses, it is the fraction of the Moon's diameter occulted by the Earth's penumbral or umbral shadow. By convention, the magnitude of all eclipses is given at the instant of the greatest eclipse.

To accommodate all observers, we use four time zones in the eclipse section: UT, EST, CST, and WST. No account is made for daylight saving time (add one hour if applicable). Therefore, carefully check the data you are using when planning your observations.

14 March: Total Eclipse of the Moon

A total lunar eclipse will be visible from the USA, Canada, and the western half of South America. A partial eclipse occurs over the eastern states of Australia, although not under ideal circumstances and will suffer from twilight interference. The eclipse begins with the Moon below the horizon in the eastern states. The umbral stages then end when the Moon is only 8.5° above the horizon for Brisbane, 6° for Sydney, 1° for Melbourne and 2° for Hobart. The relatively mundane penumbral stages can then be followed as the sky darkens. Should you wish to observe the eclipse, check the Moon Rise and Set tables for your location pages 106–109.

29 March: Partial Eclipse of the Sun

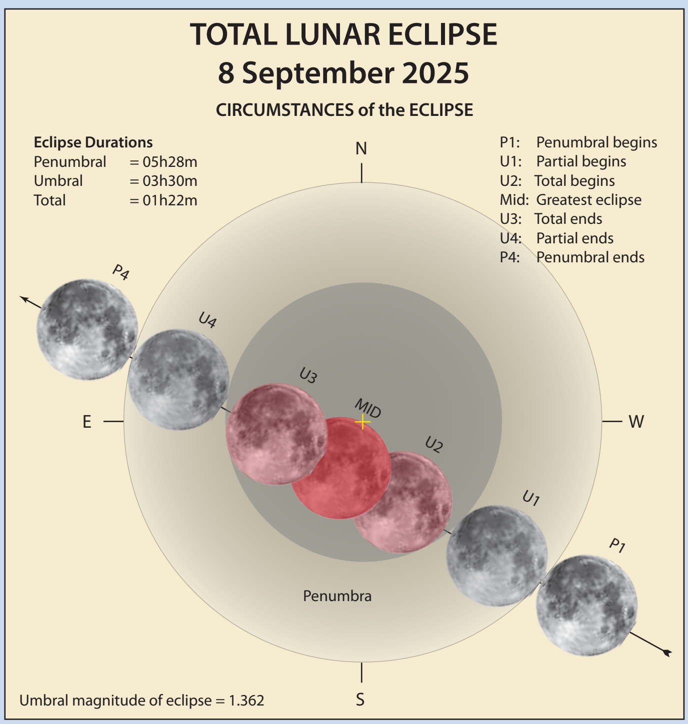
The Moon will pass in front of the Sun, causing a partial eclipse visible from Canada, Greenland, Great Britain, Iceland, Europe, and Western Russia. This is a very deep partial eclipse with a magnitude of 0.94%. The maximum eclipse will occur at 10:47 UT 61.1004° N 77.0888° W in Canada.

21 September: Partial Eclipse of the Sun

The last eclipse of the year is a partial solar eclipse visible from the South Pacific, New Zealand, and Antarctica. From the east coast of Australia, the eclipse ends at or just before sunrise. Our friends across the Tasman in New Zealand will have a grand view.

8 September: Total Eclipse of the Moon

		UT (7th)	EST	CST	WST
Penumbral begins	P1	15:28	1:28 am	12:58 am	11:28 pm (7th)
Partial begins	U1	16:27	2:27 am	1:57 am	12:27 am
Total begins	U2	17:31	3:31 am	3:01 am	1:31 am
Greatest eclipse	Mid	18:12	4:12 am	3:42 am	2:12 am
Total ends	U3	18:53	4:53 am	4:23 am	2:53 am
Partial ends	U4	19:57	5:57 am	5:27 am	3:57 am
Penumbral ends	P4	20:56	6:56 am	6:26 am	4:56 am



This total lunar eclipse is the first to be visible in its entirety across Australia since 2022. It will also be visible over Europe, Africa, and Asia. This early morning eclipse has an umbral magnitude of 1.362. With the northern limb of the Moon just touching the centre of the umbral shadow, we should see a moderately dark eclipse highlighted by a bright southern lunar limb.

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 2025 as predicted for **Adelaide**, **Brisbane**, **Canberra**, **Darwin**, **Hobart**, **Melbourne**, **Perth** and **Sydney**. Both events, the disappearance and reappearance, are not necessarily included. An event may not be present because:

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

THE TIMING OF OCCULTATIONS.

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

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

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

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

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

LUNAR OCCULTATION TABLES

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

EXPLANATION

EST the date and time of the occultation, hr and min are in EST except for Adelaide and Darwin which use CST and Perth which uses WST.

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

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

Mag magnitude of the star.

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

Alt altitude of the Moon during the occultation.

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

A coefficient of longitude (see below)

B coefficient of latitude (see below)
NB. For some stars (including those close to a graze) A and B would be useless, so no values are shown.

CALCULATING EVENT TIME FOR OTHER LOCATIONS

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

The predicted time at your location is given by

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

where A and B are taken from the tables for your nearest city and n and p are given by

n = your longitude – reference longitude

p = reference latitude – your latitude

you need to preserve the signs of n and p, that is, whether they are positive or negative and it is best to use your closest city.

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the reappearance of Antares on March 21 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 01:57 EST and the values of A and B are + 0.4 and −3.0 respectively.

Therefore the equation becomes:

01:57 + (+0.4 × −2.21°) + (–3.0 × −0.83°)
= 01:57 + (–0.9) + (+2.5)
= 01:57 + (+1.6) = 01:59

The event will be visible from Albury approximately two minutes later than Canberra, i.e. about 1:59 am (EST) on March 21.

Lunar occultation predictions calculated using Occult version 4.2024.2.10 by D. Herald.

LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 20:53	Eta Cap	RB	4.9	31	7	234	−0.4	1.5
Jan 10 20:54	44 Tau	RB	5.4	136	29	234	1.8	0.7
Jan 13 22:21	59 Gem	DD	5.8	173	23	111	2.1	−1.2
Jan 13 23:04	Iot Gem	DD	3.8	173	26	66	2.3	0.2
Jan 14 00:13	Iot Gem	RB	3.8	173	28	322	1.7	−1.2
Jan 15 03:14	28 Cnc	RD	6.1	170	24	324	0.7	−0.7
Jan 21 04:26	1886	DB	5.6	101	61	183	−0.3	−3.9
Jan 25 02:18	2332	RD	6.1	58	15	269	0.0	−1.1
Feb 09 00:29	921	DD	6.0	131	10	38	3.0	3.6
Feb 14 22:32	Sig Leo	DB	4.1	157	27	84	1.6	−1.2
Feb 14 23:29	Sig Leo	RD	4.1	157	36	349	0.6	−2.8
Feb 21 01:23	2269	RD	5.4	90	29	292	0.3	−1.6
Feb 21 02:53	2286	DB	5.4	90	46	69	2.1	−0.3
Feb 21 03:45	2286	RD	5.4	89	57	345	−0.1	−3.8
Mar 08 19:50	28 Gem	DD	5.4	112	26	116	2.2	−0.6
Mar 08 21:16	28 Gem	RB	5.4	112	24	267	2.2	0.6
Mar 14 22:53	Bet Vir	DB	3.6	177	46	101	2.3	−1.2
Mar 15 00:05	Bet Vir	RD	3.6	177	53	346	0.7	−2.6
Mar 20 02:14	42 Lib	DB	5.0	121	63	47	5.5	3.9
Mar 20 02:41	42 Lib	RD	5.0	121	68	11	−2.3	−8.2
Mar 21 00:15	Antares	DB	1.1	110	31	97	0.5	−1.4
Mar 21 01:21	Antares	RD	1.1	110	44	308	0.5	−2.2
Mar 21 02:24	2373	RD	6.1	110	57	327	0.5	−3.1
Mar 22 00:10	43 Oph	DB	5.3	99	21	135	−0.4	−2.1
Mar 22 01:04	43 Oph	RD	5.3	99	31	256	0.9	−0.8
Mar 23 01:57	2660	RD	6.2	87	31	231	1.4	0.3
Apr 05 18:39	59 Gem	RB	5.8	93	28	241	2.9	0.8
Apr 05 19:26	Iot Gem	RB	3.8	94	27	296	2.0	−0.3
Apr 06 22:06	28 Cnc	DD	6.1	107	22	79	2.3	1.4
Apr 18 21:59	2583	RD	5.8	119	10	285	−0.3	−1.3
Apr 19 02:39	2617	DB	4.6	117	64	86	2.1	−0.6
Apr 19 04:11	2617	RD	4.6	116	82	280	2.5	−0.7
Apr 20 04:27	Tau Sgr	DB	3.3	105	75	158		
Apr 20 04:48	Tau Sgr	RD	3.3	105	78	183		
Apr 23 01:53	Del Cap	DB	2.9	69	8	52	0.2	0.1
Apr 23 02:50	Del Cap	RD	2.9	69	19	269	0.4	−1.2
May 09 19:39	1836	DD	6.3	145	48	156	0.7	−2.6
May 13 21:16	2269	RD	5.4	170	44	299	0.7	−1.9
May 13 23:51	2286	RD	5.4	169	74	359	−0.5	−6.5
May 16 06:19	2583	RD	5.8	145	43	310	2.1	−0.8
Jun 03 17:50	Chi Leo	RB	4.6	92	47	281	2.6	−0.8
Jun 04 21:08	1716	DD	6.3	104	46	114	1.9	−0.3
Jun 09 20:40	42 Lib	DD	5.0	159	61	82	2.4	−0.5
Jun 09 21:51	42 Lib	RB	5.0	159	74	334	1.0	−3.4
Jun 10 05:27	2269	DD	5.4	162	8	60	−0.6	1.9
Jun 10 18:55	Antares	DD	1.1	169	31	141	−0.2	−2.3
Jun 10 19:52	2373	DD	6.1	170	43	125	0.5	−2.1
Jun 10 19:54	Antares	RB	1.1	170	43	263	1.4	−0.9
Jun 17 00:07	Iot Aqr	DB	4.3	117	25	115	0.6	−2.8
Jun 17 00:51	Iot Aqr	RD	4.3	116	34	194	0.9	2.5
Jun 18 04:36	82 Aqr	DB	6.2	103	59	72	2.1	0.4
Jun 18 05:49	82 Aqr	RD	6.2	102	62	205	0.9	2.3
Jul 01 18:58	89 Leo	RB	5.8	74	45	329	1.0	−1.5
Jul 08 04:48	Antares	DD	1.1	144	3	109	−0.2	0.6
Jul 08 22:23	2470	DD	6.1	153	83	49	2.8	3.0
Jul 09 21:40	2617	DD	4.6	164	69	144	1.4	−4.2
Jul 09 22:35	2617	RB	4.6	164	80	219	2.6	3.4
Jul 21 04:51	44 Tau	RD	5.4	52	9	208	−0.1	0.8
Jul 31 22:17	1949	DD	5.9	78	19	120	0.6	0.1
Aug 02 21:21	2157	DD	6.1	100	52	87	1.8	1.2
Aug 03 19:01	2 Sco	DD	4.5	110	80	143	1.6	−2.8
Aug 03 19:31	3 Sco	DD	5.9	111	80	103	2.5	−0.6
Aug 03 20:23	2 Sco	RB	4.5	111	74	258	2.7	1.2
Aug 03 21:06	3 Sco	RB	5.9	111	66	292	2.2	−0.4
Aug 06 02:50	2583	DD	5.8	136	20	84	0.1	1.2
Aug 17 02:41	569	RD	5.3	83	10	217	0.1	0.4
Sep 01 20:16	43 Oph	DD	5.3	103	72	44	1.9	3.6
Sep 01 21:21	43 Oph	RB	5.3	103	59	311	2.6	−1.4
Sep 02 21:45	2660	DD	6.2	115	65	140	3.7	−3.5
Sep 05 18:58	Eta Cap	RB	4.9	150	43	239	1.3	0.2
Sep 06 02:40	30 Cap	DD	5.4	153	33	72	0.6	1.5
Sep 07 19:59	Lam Aqr	DD	3.7	177	28	44	0.8	0.6
Sep 07 21:06	Lam Aqr	RB	3.7	177	41	250	1.4	−0.2
Sep 12 00:31	26 Ara	RD	6.1	127	22	253	1.1	−0.4
Sep 14 04:25	707	DB	5.7	98	25	6	−0.1	3.0
Sep 14 04:55	707	RD	5.7	98	26	323	3.7	−2.9
Oct 11 03:45	Phi Tau	DB	5.0	129	28	132	2.8	−1.3
Oct 11 04:32	Phi Tau	RD	5.0	129	26	202	1.9	2.4
Oct 14 04:44	Ups Gem	DB	4.1	89	24	100	2.1	−0.9
Oct 24 19:18	2 Sco	DD	4.5	31	22	179		
Oct 24 19:25	2 Sco	RD	4.5	31	21	189		
Oct 24 19:26	3 Sco	DD	5.9	31	21	130	0.8	−0.2
Oct 26 22:36	3 Sgr	DD	4.5	54	6	70	−0.5	1.3
Oct 30 21:05	30 Cap	DD	5.4	99	57	68	1.5	1.6
Oct 30 22:16	30 Cap	RB	5.4	100	43	222	0.5	2.2
Nov 06 23:02	11 Tau	RD	6.1	164	24	262	1.7	−0.5
Nov 26 20:21	20 Cap	DB	6.3	68	42	342	−3.0	6.1
Nov 26 20:39	20 Cap	RB	6.3	68	38	312	4.0	−2.0
Nov 27 22:27	Mu Cap	DD	5.1	80	23	28	−0.1	2.3
Nov 27 23:19	Mu Cap	RB	5.1	81	13	269	0.2	1.2
Dec 05 01:03	Phi Tau	DD	5.0	172	25	98	2.0	0.3
Dec 06 02:19	824	RD	6.2	168	23	292	1.7	0.1
Dec 07 02:21	54 Aur	RD	6.0	155	27	203	4.6	5.6
Dec 08 01:36	1169	DD	5.3	142	27	190		
Dec 08 01:44	1169	RD	5.3	142	27	203		
Dec 18 04:14	2269	DB	5.4	25	12	73	0.2	−0.7

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 21:07	64	DD	6.5	83	25	79	1.1	1.3
Jan 10 20:37	44 Tau	DD	5.4	135	36	88	2.6	0.0
Jan 10 22:02	44 Tau	RB	5.4	135	33	237	2.3	1.4
Jan 13 23:19	59 Gem	DD	5.8	173	35	95	2.6	−0.3
Jan 14 00:34	Iot Gem	MB	3.8	173	33	20		
Jan 25 02:38	2332	RD	6.1	58	22	304	−0.1	−1.7
Jan 26 03:38	2470	RD	6.1	46	24	258	0.7	−0.6
Jan 31 19:10	Sig Aqr	DD	4.8	24	11	71	0.1	1.3
Feb 06 19:29	569	RB	5.3	104	35	242	2.3	1.1
Feb 06 20:11	579	DD	6.4	104	32	112	2.5	−0.2
Feb 10 01:12	1081	DD	6.5	144	14	64	2.1	2.1
Feb 15 20:56	1730	RD	6.2	147	11	264	0.5	−0.9
Feb 17 01:39	1836	RD	6.3	134	63	287	2.6	−1.3
Feb 21 00:46	2269	DB	5.4	91	25	81	0.8	−0.7
Feb 21 01:39	2269	RD	5.4	90	36	333	−0.2	−2.7
Mar 07 19:57	855	DD	6.4	99	29	77	2.5	0.9
Mar 08 20:53	28 Gem	DD	5.4	112	30	89	2.4	0.5
Mar 08 22:12	28 Gem	RB	5.4	112	21	305	1.0	−0.3
Mar 12 19:58	37 Leo	DD	5.4	159	32	179	0.7	−3.9
Mar 15 04:36	1716	RD	6.3	175	21	300	0.7	−0.2
Mar 21 01:14	Antares	MB	1.1	110	48	24		
Mar 22 00:28	43 Oph	DB	5.3	99	27	94	0.5	−1.0
Mar 22 01:36	43 Oph	RD	5.3	99	42	300	0.7	−1.9
Mar 23 00:24	2644	RD	6.4	88	16	276	0.1	−1.0
Mar 23 02:40	2660	RD	6.2	87	44	279	1.2	−1.3
Apr 05 18:24	59 Gem	DD	5.8	93	35	122	2.3	−0.9
Apr 05 19:09	Iot Gem	DD	3.8	93	34	66	3.3	1.3
Apr 05 19:52	59 Gem	RB	5.8	93	31	279	2.2	0.2
Apr 05 20:09	Iot Gem	RB	3.8	94	29	338	0.4	−1.8
Apr 05 21:06	1132	DD	6.4	94	23	56	3.3	2.8
Apr 18 22:09	2583	RD	5.8	119	14	328	−0.9	−2.5
Apr 19 03:55	2617	DB	4.6	117	87	47	2.9	2.9
Apr 19 05:12	2617	RD	4.6	117	76	304	3.2	−1.9
Apr 20 05:09	Tau Sgr	DB	3.3	105	89	118	3.4	−1.9
Apr 23 02:44	Del Cap	DB	2.9	69	23	2	1.3	4.8
Apr 23 03:10	Del Cap	RD	2.9	69	29	315	0.6	−5.4
May 09 20:14	1836	DD	6.3	144	63	112	2.4	−1.5
May 13 21:31	2269	RD	5.4	170	53	350	−0.5	−4.0
May 21 00:28	42 Aqr	RD	5.3	88	9	244	0.3	−0.1
Jun 03 18:38	Chi Leo	RB	4.6	92	55	329	1.3	−2.0
Jun 05 23:26	25 Vir	DD	5.9	116	30	186	0.2	−5.1
Jun 10 19:17	Antares	DD	1.1	169	40	99	1.0	−1.2
Jun 10 20:31	Antares	RB	1.1	169	56	309	1.1	−2.2
Jun 10 20:31	2373	DD	6.1	169	56	78	2.4	−0.2
Jun 17 00:40	Iot Aqr	DB	4.3	117	38	83	1.4	−0.7
Jun 17 01:52	Iot Aqr	RD	4.3	116	54	217	1.5	1.7
Jul 06 17:39	2183	RB	5.5	129	56	306	1.2	−2.1
Jul 09 22:25	2617	DD	4.6	164	85	104	2.8	−0.9
Jul 09 23:57	2617	RB	4.6	164	74	245	2.3	1.7
Jul 18 00:53	173	RD	6.5	94	16	188	−0.3	2.2
Jul 19 03:52	317	RD	6.4	80	34	199	0.3	1.7
Jul 21 04:41	44 Tau	DB	5.4	53	17	112	2.0	−1.8
Jul 21 05:29	44 Tau	RD	5.4	52	24	199	−0.1	1.7
Aug 02 22:24	2157	DD	6.1	100	33	63	0.7	2.5
Aug 03 19:54	2 Sco	DD	4.5	110	76	101	2.8	−0.2
Aug 03 20:47	3 Sco	DD	5.9	111	65	64	2.5	2.5
Aug 03 21:31	2 Sco	RB	4.5	111	55	287	2.1	0.0
Aug 03 22:01	3 Sco	RB	5.9	111	49	317	2.2	−1.7
Aug 17 02:22	569	DB	5.3	83	16	96	1.4	−1.1
Aug 17 03:20	569	RD	5.3	83	25	210	0.3	1.2
Sep 01 21:32	43 Oph	DD	5.3	103	50	26	0.0	4.8
Sep 01 22:17	43 Oph	RB	5.3	103	40	318	2.6	−1.8
Sep 02 19:41	2645	DD	6.2	114	85	133	3.4	−3.2
Sep 02 19:44	2644	DD	6.4	114	85	43	2.3	3.1
Sep 02 20:41	2645	RB	6.2	114	72	208	1.2	4.5
Sep 02 22:47	2660	DD	6.2	115	45	140	3.8	−3.0
Sep 05 18:34	Eta Cap	DD	4.9	150	44	52	1.5	0.8
Sep 05 19:53	Eta Cap	RB	4.9	150	61	262	2.2	−0.3
Sep 06 03:26	30 Cap	DD	5.4	153	17	78	0.2	1.2
Sep 07 20:51	Lam Aqr	DD	3.7	177	46	29	1.0	1.7
Sep 07 22:02	Lam Aqr	RB	3.7	177	60	254	2.2	0.2
Sep 12 01:20	26 Ara	RD	6.1	127	37	243	1.6	0.3
Sep 15 02:36	850	RD	6.0	86	16	262	1.2	−0.6
Sep 15 03:34	855	RD	6.4	86	24	304	2.7	−1.9
Sep 27 19:52	2312	DD	5.4	61	33	169	4.3	−7.9
Sep 27 20:10	2312	RB	5.4	61	29	195	−2.7	9.3
Oct 05 00:26	3313	DD	6.5	145	45	85	1.7	1.1
Oct 06 03:20	11 Psc	DD	6.4	160	14	22	0.1	2.3
Oct 11 04:43	Phi Tau	DB	5.0	129	29	117	2.0	−0.3
Oct 12 03:43	22 Aur	RD	6.5	116	34	191	1.5	5.4
Oct 24 19:50	2 Sco	DD	4.5	31	7	165	2.1	−4.0
Oct 30 22:06	30 Cap	DD	5.4	99	40	80	1.2	1.3
Oct 30 23:05	30 Cap	RB	5.4	100	27	212	−0.1	2.2
Nov 01 18:35	Lam Aqr	RB	3.7	123	62	223	1.6	1.5
Nov 06 20:28	7 Tau	RD	6.0	166	14	230	0.3	0.3
Nov 06 23:59	11 Tau	RD	6.1	164	37	253	2.2	0.3
Nov 08 23:52	897	RD	6.4	136	22	232	1.0	0.4
Nov 26 21:01	20 Cap	DD	6.3	68	27	3	−0.9	3.3
Nov 27 23:10	Mu Cap	DD	5.1	80	7	28	−0.4	2.1
Nov 29 22:45	11 Psc	DD	6.4	105	27	80	1.0	1.3
Dec 05 02:04	Phi Tau	DD	5.0	173	22	78	1.7	1.0
Dec 06 00:04	22 Aur	RD	6.5	169	34	262	2.4	0.2
Dec 08 02:04	1169	DB	5.3	142	37	144	1.8	−1.7
Dec 08 03:17	1169	RD	5.3	142	36	261	2.8	0.6
Dec 11 01:47	1529	RD	6.6	104	30	301	1.4	−1.8
Dec 31 21:25	11 Tau	DD	6.1	139	37	116	3.0	−0.8

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 20:29	Eta Cap	DD	4.9	31	9	83	−0.1	1.2
Jan 10 20:29	44 Tau	DD	5.4	135	28	99	2.5	−0.4
Jan 10 21:43	44 Tau	RB	5.4	135	27	224	1.9	1.3
Jan 13 23:14	59 Gem	DD	5.8	173	27	111	2.2	−0.7
Jan 14 00:01	Iot Gem	DD	3.8	173	27	59	2.9	1.0
Jan 14 00:57	Iot Gem	RB	3.8	173	26	337	0.9	−1.5
Jan 25 02:49	2332	RD	6.1	58	23	283	0.2	−1.4
Jan 26 03:36	2470	RD	6.1	46	23	224	1.5	0.6
Feb 14 23:26	Sig Leo	DB	4.1	157	37	65	3.4	0.1
Feb 15 00:02	Sig Leo	RD	4.1	157	42	14	−0.8	−4.0
Feb 17 01:32	1836	RD	6.3	134	54	254	3.7	0.1
Feb 21 00:53	2269	DB	5.4	91	25	104	0.2	−1.5
Feb 21 01:57	2269	RD	5.4	90	38	308	0.3	−2.1
Feb 23 01:31	2545	RD	6.4	68	15	345	−1.5	−3.4
Mar 07 19:44	855	DD	6.4	99	24	94	2.2	0.3
Mar 08 20:43	28 Gem	DD	5.4	112	25	109	2.0	0.0
Mar 14 23:56	Bet Vir	DB	3.6	177	53	71	4.7	1.2
Mar 15 00:35	Bet Vir	RB	3.6	177	53	18	−1.5	−4.7
Mar 21 00:55	Antares	DB	1.1	110	41	79	1.4	−0.8
Mar 21 01:57	Antares	RD	1.1	110	54	327	0.4	−3.0
Mar 21 02:15	2373	DB	6.1	110	57	54	3.3	1.4
Mar 21 02:59	2373	RD	6.1	110	66	351	−0.2	−5.4
Mar 22 00:38	43 Oph	DB	5.3	99	29	119	0.1	−1.8
Mar 22 01:45	43 Oph	RD	5.3	99	42	273	1.0	−1.2
Mar 23 00:30	2644	RD	6.4	88	17	249	0.4	−0.6
Mar 23 02:41	2660	RD	6.2	87	42	249	1.4	−0.4
Apr 05 18:25	59 Gem	DD	5.8	93	27	141	1.8	−1.3
Apr 05 18:53	Iot Gem	DD	3.8	93	27	89	2.4	0.2
Apr 05 19:38	59 Gem	RB	5.8	93	26	255	2.6	0.9
Apr 05 20:13	Iot Gem	RB	3.8	94	23	311	1.3	−0.4
Apr 05 20:45	1132	DD	6.4	94	21	89	1.9	0.8
Apr 06 23:05	28 Cnc	DD	6.1	107	12	42	5.5	7.9
Apr 18 22:26	2583	RD	5.8	119	18	299	−0.3	−1.7
Apr 19 03:34	2617	DB	4.6	117	77	80	2.5	0.2
Apr 19 05:08	2617	RD	4.6	116	79	276	2.5	0.0
Apr 20 05:29	Tau Sgr	MB	3.3	105	82	166		
Apr 23 02:27	Del Cap	DB	2.9	69	17	46	0.6	0.4
Apr 23 03:27	Del Cap	RD	2.9	69	29	272	0.8	−1.3
May 09 20:21	1836	DD	6.3	144	56	135	1.4	−2.1
May 13 21:54	2269	RD	5.4	170	54	317	0.7	−2.5
May 21 00:24	42 Aqr	RD	5.3	88	6	212	0.3	0.9
Jun 03 18:43	Chi Leo	RB	4.6	92	47	303	1.9	−1.0
Jun 04 21:57	1716	DD	6.3	104	37	97	1.8	0.9
Jun 09 21:43	42 Lib	DD	5.0	159	75	57	4.1	2.5
Jun 09 22:31	42 Lib	RB	5.0	159	79	355	0.4	−5.9
Jun 10 19:27	Antares	DD	1.1	169	40	124	0.4	−2.0
Jun 10 20:32	2373	DD	6.1	169	53	108	1.3	−1.6
Jun 10 20:40	Antares	RB	1.1	170	55	281	1.5	−1.4
Jun 17 00:48	Iot Aqr	DB	4.3	117	36	118	1.3	−3.3
Jun 17 01:30	Iot Aqr	RD	4.3	117	44	186	0.8	3.6
Jun 18 05:33	82 Aqr	DB	6.2	102	61	99	3.3	−0.4
Jul 01 18:32	89 Leo	DD	5.8	73	46	95	2.5	0.5
Jul 01 19:36	89 Leo	RB	5.8	74	37	348	0.3	−2.2
Jul 06 17:47	2183	RB	5.5	129	54	281	1.6	−1.4
Jul 08 23:18	2470	DD	6.1	153	74	50	2.1	3.0
Jul 09 22:31	2617	DD	4.6	164	81	139	2.3	−3.7
Jul 09 23:29	2617	RB	4.6	164	81	215	2.0	3.9
Jul 19 03:38	317	RD	6.4	80	24	180	−0.6	2.5
Jul 21 05:13	44 Tau	RD	5.4	52	14	174	−2.4	4.4
Jul 31 22:52	1949	DD	5.9	78	10	127	0.3	0.0
Aug 02 22:06	2157	DD	6.1	100	41	91	1.2	1.2
Aug 03 19:53	2 Sco	DD	4.5	110	77	132	2.1	−1.9
Aug 03 20:27	3 Sco	DD	5.9	111	71	97	2.4	0.2
Aug 03 21:17	2 Sco	RB	4.5	111	61	259	2.1	1.5
Aug 03 21:58	3 Sco	RB	5.9	111	53	289	1.8	0.2
Aug 06 03:20	2583	DD	5.8	136	13	100	0.0	0.8
Aug 17 03:10	569	RD	5.3	83	15	192	−0.4	1.6
Sep 01 21:02	43 Oph	DD	5.3	103	60	56	1.4	2.6
Sep 01 22:14	43 Oph	RB	5.3	103	45	293	1.7	0.2
Sep 02 19:20	2644	DD	6.4	114	82	73	2.5	0.8
Sep 05 18:29	Eta Cap	DD	4.9	150	39	81	1.2	−0.8
Sep 05 19:44	Eta Cap	RB	4.9	150	54	236	1.7	0.6
Sep 06 03:15	30 Cap	DD	5.4	153	24	88	0.5	1.2
Sep 07 20:39	Lam Aqr	DD	3.7	177	38	53	1.1	0.4
Sep 07 21:51	Lam Aqr	RB	3.7	177	51	236	1.5	0.6
Sep 12 01:12	26 Ara	RD	6.1	127	28	232	1.1	0.3
Sep 14 05:04	707	DB	5.7	98	26	27	1.5	1.6
Sep 15 02:36	850	RD	6.0	86	8	249	0.8	−0.5
Sep 15 03:38	855	RD	6.4	86	16	289	1.9	−1.4
Oct 06 03:03	11 Psc	DD	6.4	160	20	34	0.3	2.1
Oct 11 04:40	Phi Tau	DB	5.0	129	24	139	1.9	−1.0
Oct 24 20:05	3 Sco	DD	5.9	31	11	151	1.0	−1.3
Oct 26 21:16	2545	DD	6.4	53	18	61	−0.3	1.8
Oct 30 21:51	30 Cap	DD	5.4	99	46	90	1.6	1.2
Oct 30 22:47	30 Cap	RB	5.4	100	34	203	−0.1	2.5
Nov 06 23:49	11 Tau	RD	6.1	164	28	244	1.7	0.3
Nov 08 23:46	897	RD	6.4	136	13	217	0.4	0.5
Nov 26 20:40	20 Cap	DD	6.3	68	35	16	−0.3	2.8
Nov 27 22:56	Mu Cap	DD	5.1	80	15	40	−0.1	2.0
Nov 29 22:31	11 Psc	DD	6.4	105	31	90	1.3	1.2
Dec 05 01:52	Phi Tau	DD	5.0	172	19	96	1.6	0.7
Dec 06 03:04	824	RD	6.2	168	17	301	1.1	0.1
Dec 07 03:28	54 Aur	RD	6.0	155	22	230	2.8	2.1
Dec 08 02:15	1169	DB	5.3	142	29	171	1.0	−2.7
Dec 08 02:56	1169	RD	5.3	142	29	230	3.5	1.8
Dec 31 21:22	11 Tau	DD	6.1	139	29	134	3.4	−1.9

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 20:42	Eta Cap	DD	4.9	31	9	7	−0.9	2.8
Jan 10 19:50	44 Tau	DD	5.4	135	43	0	−1.1	4.6
Jan 10 20:28	44 Tau	RB	5.4	136	48	307	5.0	−3.2
Jan 12 02:38	Bet Tau	DD	1.7	150	21	107	0.9	−0.1
Jan 12 03:44	Bet Tau	RB	1.7	151	8	270	0.5	0.4
Jan 21 03:12	1886	DB	5.6	102	50	148	0.8	−2.5
Jan 21 04:37	1886	RD	5.6	101	71	303	2.3	−1.8
Jan 31 19:47	Sig Aqr	RB	4.8	24	14	281	0.6	0.0
Feb 21 00:46	2269	RD	5.4	90	7	333	−0.8	−2.1
Feb 21 05:51	2298	DB	5.0	88	71	120	2.5	−1.7
Mar 02 19:39	Del Psc	DD	4.4	32	17	71	0.7	1.0
Mar 02 19:58	62 Psc	RB	5.9	32	12	177	0.5	4.3
Mar 08 20:50	28 Gem	RB	5.4	112	48	310	2.6	−1.7
Mar 14 22:31	Bet Vir	MB	3.6	177	48	42		
Mar 21 00:06	Antares	DB	1.1	110	15	35	4.2	5.7
Mar 21 00:19	Antares	RB	1.1	110	17	11	−4.4	−8.0
Mar 22 00:39	43 Oph	RD	5.3	99	11	302	−0.3	−1.3
Mar 23 01:41	2660	RD	6.2	87	13	288	0.0	−0.9
Mar 24 05:59	2848	DB	5.6	73	55	70	2.6	0.7
Apr 03 21:43	Bet Tau	MB	1.7	69	16	189		
Apr 20 03:33	Tau Sgr	DB	3.3	105	52	62	2.7	1.1
Apr 20 05:05	Tau Sgr	RD	3.3	105	69	288	3.3	−1.3
Apr 29 19:10	569	DD	5.3	22	7	40	1.3	2.2
May 13 20:27	2269	RD	5.4	170	21	343	−0.8	−2.7
May 14 02:31	2298	DB	5.0	168	69	119	3.1	−1.4
May 14 04:08	2298	RD	5.0	168	49	266	2.2	0.6
May 22 02:34	Phi Aqr	DB	4.2	74	8	86	0.3	−0.3
May 22 03:30	Phi Aqr	RD	4.2	73	22	216	0.7	1.5
May 22 05:51	96 Aqr	DB	5.6	72	55	68	2.0	0.7
May 30 19:59	1169	DD	5.3	44	21	138	0.1	−1.1
Jun 05 21:50	25 Vir	DD	5.9	116	69	163	1.0	−3.2
Jun 05 23:09	25 Vir	RB	5.9	116	50	282	2.3	−0.3
Jun 09 02:15	2134	DD	5.9	150	37	115	1.8	−0.7
Jun 10 19:20	2373	DD	6.1	169	22	81	0.9	−0.1
Jun 10 19:21	Antares	RB	1.1	169	23	306	0.0	−1.5
Jun 16 23:58	Iot Aqr	DB	4.3	117	13	29	0.8	2.0
Jun 17 00:51	Iot Aqr	RD	4.3	116	26	286	1.0	−1.3
Jun 18 04:48	81 Aqr	RD	6.2	102	70	249	2.6	0.9
Jun 18 05:22	82 Aqr	DD	6.2	102	78	334	−3.4	7.8
Jun 18 05:51	82 Aqr	RD	6.2	102	83	295	7.5	−3.7
Jun 19 06:33	3520	DB	5.8	89	76	92	4.0	−0.3
Jul 04 00:50	50 Vir	DD	6.0	98	7	113	0.3	−0.4
Jul 09 04:44	43 Oph	DD	5.3	155	10	94	0.2	0.3
Jul 09 20:53	2617	DD	4.6	164	47	71	2.4	0.5
Jul 09 22:16	2617	RB	4.6	164	64	304	2.4	−2.2
Jul 10 22:23	Tau Sgr	MB	3.3	174	55	177		
Jul 13 02:35	Eta Cap	DB	4.9	157	82	32	1.6	2.7
Jul 13 03:58	Eta Cap	RD	4.9	157	68	253	2.4	1.0
Jul 13 20:56	Del Cap	RD	2.9	147	0	200	0.7	2.5
Jul 15 06:55	Lam Aqr	DB	3.7	131	49	81	2.0	0.8
Jul 21 04:40	44 Tau	RD	5.4	52	15	298	1.8	−1.9
Aug 03 19:34	2 Sco	RB	4.5	111	76	332	1.8	−3.6
Aug 03 23:23	Pi Sco	MD	2.9	112	40	185		
Aug 04 01:16	2298	DD	5.0	112	16	87	0.4	0.6
Aug 09 02:58	17 Cap	DD	5.9	171	52	115	4.0	−1.5
Aug 11 01:48	Sig Aqr	DB	4.8	163	86	80	3.2	0.5
Aug 11 02:58	Sig Aqr	RD	4.8	162	76	191	0.4	3.2
Aug 17 02:05	569	DD	5.3	83	10	344	−4.9	9.2
Aug 17 02:16	569	RD	5.3	83	12	323	5.5	−8.6
Sep 02 19:31	2645	RB	6.2	114	70	281	3.2	−0.8
Sep 02 21:35	2660	DD	6.2	115	67	40	2.0	3.1
Sep 06 03:23	30 Cap	DD	5.4	153	28	5	−0.7	3.1
Sep 13 02:08	7 Tau	RD	6.0	112	35	217	0.6	1.4
Sep 27 19:49	2312	RB	5.4	61	41	296	2.2	−0.8
Sep 29 19:44	2586	DD	6.0	83	63	80	2.8	0.8
Sep 29 21:18	2586	RB	6.0	84	44	253	1.5	1.1
Oct 02 20:51	17 Cap	DD	5.9	119	81	52	2.3	1.9
Oct 02 22:22	17 Cap	RB	5.9	119	66	237	1.9	1.7
Oct 03 21:18	Gam Cap	DD	3.7	131	83	100	4.3	−0.9
Oct 03 22:14	Gam Cap	RB	3.7	132	80	179	−0.3	4.3
Oct 04 20:20	Sig Aqr	DD	4.8	144	59	45	1.7	1.7
Oct 04 21:44	Sig Aqr	RB	4.8	144	80	234	2.2	1.6
Oct 10 23:21	44 Tau	RD	5.4	131	16	266	0.8	−0.3
Oct 11 03:17	Phi Tau	DB	5.0	129	49	65	2.4	0.8
Oct 11 04:47	Phi Tau	RD	5.0	129	48	261	2.8	0.5
Oct 14 04:33	Ups Gem	DB	4.1	89	38	34	1.6	3.9
Oct 14 05:10	Ups Gem	RD	4.1	89	43	347	2.7	−5.5
Oct 24 19:48	3 Sco	DD	5.9	31	15	37	−0.8	3.2
Oct 24 20:05	2 Sco	RB	4.5	31	11	298	0.7	−0.6
Oct 29 23:17	2991	DD	6.1	88	25	102	1.2	0.0
Oct 30 22:01	30 Cap	DD	5.4	99	53	344	−2.5	5.8
Oct 30 22:31	30 Cap	RB	5.4	100	46	299	4.3	−2.1
Nov 07 02:55	569	DB	5.3	163	47	124	2.9	−1.7
Nov 07 03:51	569	RB	5.3	162	39	208	2.4	3.2
Nov 08 00:27	731	RD	6.0	149	40	186	−1.0	4.7
Nov 30 00:57	14 Psc	DD	5.9	106	12	71	0.4	1.0
Dec 05 01:03	Phi Tau	DD	5.0	173	49	45	2.5	1.9
Dec 05 02:14	Phi Tau	RB	5.0	173	41	295	2.1	−0.7
Dec 05 22:51	Bet Tau	DB	1.7	169	36	107	2.4	−1.0
Dec 06 00:02	Bet Tau	RD	1.7	169	45	229	1.9	1.4
Dec 07 02:30	54 Aur	RD	6.0	155	49	269	2.9	0.0
Dec 08 00:21	1169	DB	5.3	142	31	107	1.9	−1.0
Dec 08 01:45	1169	RD	5.3	142	45	275	2.6	−0.5
Dec 26 22:11	3416	DD	5.6	74	23	75	0.8	1.0
Dec 31 20:08	11 Tau	DD	6.1	139	45	36	1.1	1.7
Jan 01 01:46	569	DD	5.3	141	23	138	0.4	−1.9

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 10 20:28	44 Tau	DD	5.4	135	20	111	2.3	−0.7	Apr 06 22:41	28 Cnc	DD	6.1	107	12	84	1.5	1.4	Aug 02 21:58	2157	DD	6.1	100	43	117	1.3	0.2
Jan 13 23:16	59 Gem	DD	5.8	173	19	122	1.8	−0.8	Apr 13 03:52	1886	RD	5.6	176	29	71	1.2	2.8	Aug 03 20:14	2 Sco	DD	4.5	110	69	171	1.2	−5.9
Jan 13 23:53	Iot Gem	DD	3.8	173	20	74	2.1	0.2	Apr 16 20:11	2299	RD	6.2	142	12	331	−0.7	−2.1	Aug 03 20:27	3 Sco	DD	5.9	111	68	125	1.9	−1.1
Jan 14 01:02	Iot Gem	RB	3.8	173	18	319	1.2	−0.4	Apr 18 05:01	2470	RD	6.1	128	68	320	2.2	−2.4	Aug 03 20:52	2 Sco	RB	4.5	111	64	221	2.2	5.6
Jan 25 02:59	2332	RD	6.1	58	26	266	0.4	−1.3	Apr 18 22:38	2583	RD	5.8	119	21	280	0.0	−1.5	Aug 03 21:49	3 Sco	RB	5.9	111	55	263	1.6	1.5
Feb 14 23:27	Sig Leo	DB	4.1	157	31	85	1.9	−1.2	Apr 19 03:34	2617	DB	4.6	117	72	108	1.9	−1.3	Aug 06 03:14	2583	DD	5.8	136	18	114	0.3	0.8
Feb 15 00:24	Sig Leo	RD	4.1	157	37	351	0.5	−2.4	Apr 19 04:59	2617	RD	4.6	116	75	250	2.0	1.2	Sep 01 20:44	43 Oph	DD	5.3	103	63	81	1.7	1.3
Feb 21 01:05	2269	DB	5.4	91	27	119	0.1	−1.9	Apr 23 02:29	Del Cap	DB	2.9	69	17	73	0.3	−0.8	Sep 01 22:06	43 Oph	RB	5.3	103	49	272	1.2	1.2
Feb 21 02:10	2269	RD	5.4	90	39	290	0.6	−1.8	Apr 23 03:32	Del Cap	RD	2.9	69	28	244	0.7	−0.5	Sep 02 19:15	2644	DD	6.4	114	75	101	2.1	−0.7
Feb 21 03:45	2286	DB	5.4	90	56	74	2.1	−0.5	May 09 20:35	1836	DD	6.3	144	50	153	0.8	−2.3	Sep 05 18:38	Eta Cap	DD	4.9	150	39	112	1.0	−2.5
Feb 21 04:47	2286	RD	5.4	89	66	335	0.7	−3.4	May 13 22:09	2269	RD	5.4	170	54	296	1.1	−1.9	Sep 05 19:32	Eta Cap	RB	4.9	150	48	206	1.3	1.9
Feb 23 01:52	2545	RD	6.4	68	20	317	−0.5	−2.2	May 14 01:04	2286	RD	5.4	169	72	333	1.4	−3.2	Sep 06 03:05	30 Cap	DD	5.4	153	28	98	0.7	1.3
Feb 26 04:46	17 Cap	DB	5.9	29	16	17	1.0	1.8	May 15 22:41	2545	RD	6.4	148	43	319	0.2	−2.9	Sep 07 20:38	Lam Aqr	DD	3.7	177	34	78	1.1	−0.8
Feb 27 04:33	Gam Cap	RD	3.7	16	2	276	−0.3	−1.3	May 18 22:33	2991	RD	6.1	113	11	341	−3.2	−9.4	Sep 07 21:43	Lam Aqr	RB	3.7	177	44	214	0.9	1.1
Mar 08 20:40	28 Gem	DD	5.4	112	18	122	1.6	−0.1	Jun 03 17:31	Chi Leo	DD	4.6	92	38	158	0.9	−2.0	Sep 11 02:14	101 Psc	RD	6.2	140	33	310	5.6	−3.7
Mar 14 23:51	Bet Vir	DB	3.6	177	45	97	2.3	−0.7	Jun 03 18:45	Chi Leo	RB	4.6	92	40	284	2.1	−0.3	Sep 12 01:08	26 Ara	RD	6.1	127	20	218	0.6	0.4
Mar 15 00:58	Bet Vir	RD	3.6	177	45	347	0.5	−2.2	Jun 04 21:52	1716	DD	6.3	104	34	125	1.1	−0.1	Sep 29 19:45	2583	DD	5.8	83	60	18	0.1	6.0
Mar 20 03:02	42 Lib	DB	5.0	121	67	63	3.1	1.2	Jun 07 02:15	Spica	MD	1.0	128	11	23			Sep 29 20:21	2583	RB	5.8	83	54	324	2.9	−2.6
Mar 20 03:55	42 Lib	RD	5.0	120	71	347	0.7	−4.4	Jun 08 02:43	2029	DD	4.9	139	17	53	−0.1	3.6	Oct 06 02:47	11 Psc	DD	6.4	160	22	42	0.5	1.9
Mar 20 21:45	Sig Sco	RD	2.9	112	8	343	−1.0	−2.3	Jun 09 21:34	42 Lib	DD	5.0	159	67	91	2.1	−0.6	Oct 26 21:03	2545	DD	6.4	53	24	75	0.0	1.6
Mar 21 01:02	Antares	DB	1.1	110	42	100	0.8	−1.6	Jun 09 22:55	42 Lib	RB	5.0	160	71	318	1.6	−2.1	Oct 26 22:52	3 Sgr	DD	4.5	54	6	95	−0.4	1.0
Mar 21 02:11	2373	DB	6.1	110	54	85	1.6	−1.0	Jun 10 05:42	2269	DD	5.4	162	8	93	−0.3	1.1	Oct 28 23:42	52 Sgr	DD	4.6	77	13	21	−0.8	2.3
Mar 21 02:15	Antares	RD	1.1	110	55	303	1.0	−2.1	Jun 10 19:44	Antares	DD	1.1	169	42	145	0.0	−2.7	Oct 30 21:40	30 Cap	DD	5.4	99	47	103	1.9	0.8
Mar 21 03:25	2373	RD	6.1	110	66	316	1.2	−2.6	Jun 10 20:44	Antares	RB	1.1	170	53	256	1.8	−0.6	Oct 30 22:28	30 Cap	RB	5.4	99	39	191	−0.3	2.8
Mar 22 00:55	43 Oph	DB	5.3	99	32	140	−0.2	−2.5	Jun 10 20:45	2373	DD	6.1	170	53	130	0.8	−2.4	Nov 06 23:45	11 Tau	RD	6.1	164	20	234	1.2	0.2
Mar 22 01:50	43 Oph	RD	5.3	99	42	249	1.3	−0.6	Jun 17 23:56	Lam Aqr	MD	3.7	105	12	333			Nov 10 02:07	1081	RD	6.5	122	14	337	2.0	−2.3
Mar 23 00:32	2644	RD	6.4	88	19	223	0.8	0.0	Jul 01 18:28	89 Leo	DD	5.8	73	41	120	1.5	−0.4	Nov 27 22:41	Mu Cap	DD	5.1	80	20	48	0.1	1.9
Mar 23 02:36	2660	RD	6.2	87	41	215	2.1	1.5	Jul 01 19:45	89 Leo	RB	5.8	74	32	319	0.9	−0.6	Nov 29 22:19	11 Psc	DD	6.4	105	31	100	1.5	1.1
Apr 05 18:32	59 Gem	DD	5.8	93	20	157	1.3	−1.4	Jul 06 17:52	2183	RB	5.5	129	51	258	1.9	−0.8	Nov 30 00:01	13 Psc	DD	6.4	106	13	45	0.3	2.0
Apr 05 18:49	Iot Gem	DD	3.8	93	20	102	1.9	−0.1	Jul 08 05:15	Antares	DD	1.1	144	2	143	0.2	−0.2	Dec 05 01:44	Phi Tau	DD	5.0	172	14	108	1.4	0.5
Apr 05 20:11	Iot Gem	RB	3.8	94	17	294	1.4	0.2	Jul 08 23:01	2470	DD	6.1	153	73	81	2.1	0.8	Dec 05 23:49	22 Aur	RD	6.5	169	18	239	1.5	0.1
Apr 05 20:37	1132	DD	6.4	94	15	107	1.4	0.5	Jul 31 22:55	1949	DD	5.9	78	12	155	0.5	−1.1	Dec 06 02:58	824	RD	6.2	168	12	286	1.2	0.6

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B	EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 20:26	Eta Cap	DD	4.9	31	14	83	0.0	1.3	Apr 19 03:24	2617	DB	4.6	117	72	91	2.2	−0.6	Aug 03 20:18	3 Sco	DD	5.9	111	74	108	2.3	−0.5
Jan 10 20:21	44 Tau	DD	5.4	135	25	98	2.3	−0.6	Apr 19 04:57	2617	RD	4.6	116	80	269	2.4	0.2	Aug 03 21:04	2 Sco	RB	4.5	111	66	248	2.3	2.1
Jan 13 23:07	59 Gem	DD	5.8	173	23	116	2.0	−1.0	Apr 20 05:19	Tau Sgr	MB	3.3	105	79	168			Aug 03 21:49	3 Sco	RB	5.9	111	57	281	1.9	0.5
Jan 13 23:49	Iot Gem	DD	3.8	173	24	68	2.4	0.3	Apr 23 02:25	Del Cap	DB	2.9	69	14	58	0.3	−0.2	Aug 06 03:18	2583	DD	5.8	136	17	100	0.1	1.0
Jan 14 00:56	Iot Gem	RB	3.8	173	24	324	1.3	−0.9	Apr 23 03:27	Del Cap	RD	2.9	69	26	261	0.7	−1.0	Aug 17 03:08	569	RD	5.3	83	11	193	−0.5	1.4
Jan 25 02:52	2332	RD	6.1	58	21	272	0.2	−1.3	May 09 20:21	1836	DD	6.3	144	52	148	1.0	−2.3	Sep 01 20:49	43 Oph	DD	5.3	103	66	62	1.7	2.2
Feb 14 23:17	Sig Leo	DB	4.1	157	32	81	2.1	−1.0	May 13 21:57	2269	RD	5.4	170	51	304	0.9	−2.1	Sep 01 22:06	43 Oph	RB	5.3	103	50	290	1.7	0.3
Feb 15 00:11	Sig Leo	RD	4.1	157	39	356	0.3	−2.8	May 14 00:39	2286	RD	5.4	169	77	358	0.1	−6.9	Sep 02 19:09	2644	DD	6.4	114	77	83	2.3	0.0
Feb 21 00:57	2269	DB	5.4	91	23	114	0.0	−1.7	May 15 22:26	2545	RD	6.4	148	38	332	−0.4	−3.5	Sep 05 19:35	Eta Cap	RB	4.9	150	49	227	1.4	0.8
Feb 21 02:00	2269	RD	5.4	90	36	296	0.4	−1.8	Jun 03 18:37	Chi Leo	RB	4.6	92	45	289	2.2	−0.7	Sep 06 03:10	30 Cap	DD	5.4	153	28	86	0.6	1.3
Feb 21 03:39	2286	DB	5.4	90	54	62	2.7	0.4	Jun 04 21:49	1716	DD	6.3	104	39	112	1.6	0.1	Sep 07 20:34	Lam Aqr	DD	3.7	177	33	59	1.0	0.0
Feb 21 04:27	2286	RD	5.4	89	63	350	−0.1	−4.5	Jun 09 21:28	42 Lib	DD	5.0	159	68	78	2.7	0.0	Sep 07 21:44	Lam Aqr	RB	3.7	177	46	233	1.3	0.5
Feb 23 01:43	2545	RD	6.4	68	15	326	−0.8	−2.3	Jun 09 22:38	42 Lib	RB	5.0	159	76	334	1.3	−3.4	Sep 12 01:08	26 Ara	RD	6.1	127	24	234	0.9	0.1
Mar 08 20:35	28 Gem	DD	5.4	112	23	117	1.9	−0.3	Jun 10 05:49	2269	DD	5.4	162	6	77	−0.4	1.4	Sep 14 05:49	707	RD	5.7	98	24	307	2.4	−0.8
Mar 14 23:42	Bet Vir	DB	3.6	177	48	92	2.7	−0.7	Jun 10 19:31	Antares	DD	1.1	169	38	137	0.1	−2.4	Sep 15 03:34	855	RD	6.4	86	12	290	1.7	−1.5
Mar 15 00:45	Bet Vir	RD	3.6	177	51	355	0.3	−2.8	Jun 10 20:33	2373	DD	6.1	170	50	121	0.8	−2.1	Oct 06 02:56	11 Psc	DD	6.4	160	24	34	0.4	2.1
Mar 20 03:10	42 Lib	DB	5.0	121	71	33			Jun 10 20:37	Antares	RB	1.1	170	51	266	1.6	−1.0	Oct 11 04:36	Phi Tau	DB	5.0	129	23	147	2.2	−1.8
Mar 20 03:19	42 Lib	RB	5.0	121	72	21			Jun 17 00:55	Iot Aqr	DB	4.3	117	34	138	1.4	−8.1	Oct 11 05:06	Phi Tau	RD	5.0	129	21	192	2.1	3.4
Mar 20 21:35	Sig Sco	RD	2.9	112	2	354	−1.5	−2.8	Jun 17 01:14	Iot Aqr	RD	4.3	117	37	168	0.4	8.0	Oct 24 20:04	3 Sco	DD	5.9	31	15	155	1.2	−1.6
Mar 21 00:53	Antares	DB	1.1	110	38	93	0.9	−1.3	Jun 18 05:22	82 Aqr	DB	6.2	102	59	96	2.9	−0.5	Oct 26 21:12	2545	DD	6.4	53	23	61	−0.2	1.9
Mar 21 02:02	Antares	RD	1.1	110	52	312	0.7	−2.4	Jun 18 06:15	82 Aqr	RD	6.2	102	58	181	0.0	3.2	Oct 28 23:57	52 Sgr	DD	4.6	77	10	2	−1.5	3.3
Mar 21 02:04	2373	DB	6.1	110	52	74	1.9	−0.5	Jul 01 18:22	89 Leo	DD	5.8	73	47	112	2.0	−0.3	Oct 30 21:41	30 Cap	DD	5.4	99	50	87	1.6	1.2
Mar 21 03:08	2373	RD	6.1	110	64	330	0.7	−3.4	Jul 01 19:38	89 Leo	RB	5.8	74	38	331	0.8	−1.3	Oct 30 22:41	30 Cap	RB	5.4	100	39	205	0.0	2.5
Mar 22 00:44	43 Oph	DB	5.3	99	27	131	−0.2	−2.1	Jul 08 05:15	Antares	DD	1.1	144	0	125	−0.1	0.2	Nov 06 23:42	11 Tau	RD	6.1	164	24	245	1.5	0.0
Mar 22 01:43	43 Oph	RD	5.3	99	39	259	1.1	−0.9	Jul 08 23:03	2470	DD	6.1	153	78	62	2.3	2.0	Nov 26 20:34	20 Cap	DD	6.3	68	40	13	−0.3	2.9
Mar 23 00:29	2644	RD	6.4	88	15	235	0.5	−0.3	Jul 09 22:36	2617	DD	4.6	164	77	159	1.7	−7.8	Nov 27 22:51	Mu Cap	DD	5.1	80	19	40	0.0	2.0
Mar 23 02:35	2660	RD	6.2	87	38	233	1.6	0.2	Jul 09 23:07	2617	RB	4.6	164	80	199	2.2	7.6	Nov 29 22:21	11 Psc	DD	6.4	105	34	88	1.5	1.3
Apr 05 18:44	Iot Gem	DD	3.8	93	25	97	2.2	−0.2	Jul 19 03:34	317	RD	6.4	80	19	179	−0.7	2.4	Nov 30 00:10	13 Psc	DD	6.4	106	14	37	0.3	2.1
Apr 05 20:08	Iot Gem	RB	3.8	94	22	300	1.6	−0.1	Jul 21 05:11	44 Tau	RD	5.4	52	10	176	−2.1	3.8	Dec 05 01:43	Phi Tau	DD	5.0	172	19	102	1.6	0.5
Apr 05 20:35	1132	DD	6.4	94	21	102	1.7	0.4	Jul 31 22:51	1949	DD	5.9	78	14	134	0.4	−0.2	Dec 06 02:58	824	RD	6.2	168	17	292	1.4	0.3
Apr 06 22:45	28 Cnc	DD	6.1	107	16	73	2.1	1.9	Aug 02 21:58	2157	DD	6.1	100	45	99	1.5	0.8	Dec 07 03:06	54 Aur	RD	6.0	155	22	207	4.5	4.6
Apr 18 22:31	2583	RD	5.8	119	17	287	−0.2	−1.5	Aug 03 19:51	2 Sco	DD	4.5	110	77	146	1.8	−2.9	Dec 31 21:13	11 Tau	DD	6.1	139	27	133	3.5	−2.0

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 13 20:58	Iot Gem	DB	3.8	173	15	46	0.7	0.5
Jan 13 21:50	Iot Gem	RB	3.8	173	22	324	2.3	−2.4
Jan 14 03:04	Ups Gem	DD	4.1	174	20	116	1.1	0.1
Jan 15 01:07	28 Cnc	RD	6.1	169	34	290	2.3	−0.6
Jan 17 03:55	37 Leo	DB	5.4	146	42	123	1.8	−0.7
Jan 25 02:39	Sig Sco	DB	2.9	57	16	56	0.8	0.0
Jan 25 03:12	Sig Sco	RD	2.9	57	23	347	−1.0	−3.1
Feb 08 22:07	921	DD	6.0	131	27	69	2.6	0.9
Feb 14 21:35	Sig Leo	RD	4.1	157	17	330	0.6	−2.4
Feb 20 23:47	2269	RD	5.4	90	8	267	−0.1	−0.9
Feb 21 00:59	2286	DB	5.4	90	22	105	0.2	−1.4
Feb 21 02:02	2286	RD	5.4	89	35	306	0.3	−2.0
Feb 27 05:20	Del Cap	RD	2.9	15	5	285	−0.3	−1.5
Mar 14 20:45	Bet Vir	DB	3.6	177	25	128	0.8	−2.0
Mar 14 22:01	Bet Vir	RD	3.6	176	40	307	1.4	−2.0
Mar 17 04:51	Spica	MB	1.0	152	46	34		
Mar 19 23:54	42 Lib	DB	5.0	121	34	98	0.8	−1.4
Mar 20 01:01	42 Lib	RD	5.0	120	48	319	0.5	−2.5
Mar 20 22:41	Antares	DB	1.1	110	11	124	−0.5	−1.6
Mar 20 23:37	Antares	RD	1.1	110	22	277	0.2	−1.2
Mar 21 00:36	2373	RD	6.1	109	34	293	0.4	−1.7
Mar 21 23:14	43 Oph	RD	5.3	99	9	212	1.5	1.8
Mar 27 05:16	42 Aqr	RD	5.3	35	19	301	0.3	−3.0
Apr 02 19:22	Phi Tau	RB	5.0	56	13	259	1.3	1.2
Apr 05 22:15	Ups Gem	DD	4.1	95	15	131	0.5	−0.2
Apr 06 19:46	28 Cnc	DD	6.1	107	34	116	2.2	−0.7
Apr 13 01:03	1886	DD	5.6	176	63	69	4.7	2.9
Apr 18 01:28	2470	RD	6.1	128	60	348	−0.4	−5.7
Apr 19 00:34	2617	DB	4.6	117	38	107	0.7	−1.6
Apr 19 01:50	2617	RD	4.6	116	54	272	1.7	−1.0
Apr 20 02:18	Tau Sgr	DB	3.3	105	48	168		
Apr 20 02:34	Tau Sgr	RD	3.3	105	51	190		

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
May 13 19:29	2269	RD	5.4	170	21	268	0.4	−1.1
May 13 22:00	2286	RD	5.4	169	52	316	0.7	−2.4
May 19 04:46	17 Cap	DB	5.9	110	78	35	1.7	2.4
May 19 06:06	17 Cap	RD	5.9	109	75	263	2.5	0.7
May 20 05:32	Gam Cap	DB	3.7	97	73	62	2.1	1.1
May 20 06:56	Gam Cap	RD	3.7	97	71	224	1.4	2.0
May 21 05:53	Sig Aqr	DB	4.8	84	65	3	0.3	3.6
Jun 09 18:37	42 Lib	DD	5.0	159	35	118	0.4	−1.8
Jun 09 19:49	42 Lib	RB	5.0	160	50	298	1.0	−1.9
Jun 10 17:39	Antares	DB	1.1	169	15	191	−4.3	−7.5
Jun 10 17:49	Antares	RB	1.1	170	17	209	4.2	4.9
Jun 16 23:08	Iot Aqr	RD	4.3	116	12	202	0.6	1.6
Jun 23 06:00	7 Tau	RD	6.0	34	12	266	0.9	−0.8
Jul 08 03:24	Antares	DD	1.1	144	17	69	−0.1	1.6
Jul 08 04:20	Antares	RB	1.1	144	7	289	0.0	0.5
Jul 08 19:51	2470	DD	6.1	153	57	69	2.4	0.1
Jul 09 03:01	43 Oph	DD	5.3	155	33	132	1.7	−0.7
Jul 13 00:03	Eta Cap	DB	4.9	158	61	75	2.1	0.0
Jul 13 01:27	Eta Cap	RD	4.9	157	76	227	1.8	1.7
Jul 15 04:34	Lam Aqr	DB	3.7	131	63	94	3.0	0.2
Jul 15 05:27	Lam Aqr	RD	3.7	131	55	182	−0.1	3.2
Jul 31 20:24	1949	DD	5.9	78	43	111	1.6	0.1
Jul 31 21:42	1949	RB	5.9	79	27	303	0.9	−0.2
Aug 02 18:56	2157	DD	6.1	100	80	94	2.9	−0.1
Aug 02 20:25	2157	RB	6.1	100	65	318	2.1	−1.9
Aug 03 18:39	3 Sco	RB	5.9	111	78	283	2.4	−1.0
Aug 03 23:30	2298	DD	5.0	112	38	136	1.7	−1.0
Aug 04 00:25	2298	RB	5.0	113	27	232	−0.1	2.7
Aug 06 01:24	2583	DD	5.8	136	37	39	−0.1	2.8
Aug 10 23:50	Sig Aqr	DB	4.8	163	59	131		-
Aug 11 00:06	Sig Aqr	RB	4.8	163	61	153		
Sep 01 18:35	43 Oph	RB	5.3	103	84	345	1.5	−8.1

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 06 01:01	30 Cap	DD	5.4	153	54	26	0.4	2.6
Sep 06 02:02	30 Cap	RB	5.4	153	42	264	1.2	1.2
Sep 07 19:10	Lam Aqr	RB	3.7	177	18	275	0.6	−1.4
Sep 13 00:08	7 Tau	RD	6.0	112	7	177	−1.6	3.3
Sep 13 04:02	11 Tau	RD	6.1	111	32	213	1.3	1.3
Sep 28 22:49	2470	DD	6.1	74	16	58	−0.4	1.8
Oct 02 19:43	17 Cap	RB	5.9	119	77	207	1.5	2.9
Oct 04 19:16	Sig Aqr	RB	4.8	144	48	195	0.8	2.5
Oct 06 03:12	14 Psc	DD	5.9	161	22	46	0.5	1.9
Oct 11 01:14	Phi Tau	DB	5.0	129	24	88	1.8	−0.7
Oct 11 02:28	Phi Tau	RD	5.0	129	30	230	1.6	0.7
Oct 12 04:23	824	RD	6.2	115	29	240	2.3	0.7
Oct 13 05:06	53 Aur	DB	5.8	101	29	74	2.5	0.3
Oct 14 02:35	Ups Gem	DB	4.1	89	10	82	1.0	−0.8
Oct 14 03:49	Ups Gem	RD	4.1	89	21	292	1.9	−1.4
Oct 26 21:27	3 Sgr	DD	4.5	54	18	23	−1.2	3.2
Oct 26 22:00	3 Sgr	RB	4.5	55	11	315	0.8	−0.5
Oct 27 23:03	Phi Sgr	DD	3.2	66	9	31	−0.9	2.1
Oct 29 21:26	2991	DD	6.1	88	47	142		
Oct 29 21:35	2991	RD	6.1	88	45	156		
Oct 30 19:14	30 Cap	DD	5.4	99	76	13	0.6	3.5
Oct 30 20:18	30 Cap	RB	5.4	100	67	274	2.8	0.4
Nov 15 04:02	89 Leo	RD	5.8	59	21	326	0.6	−2.3
Nov 29 22:57	14 Psc	DD	5.9	106	30	107	1.7	0.6
Dec 04 22:45	Phi Tau	DD	5.0	173	29	76	1.9	0.0
Dec 05 21:29	Bet Tau	DD	1.7	169	14	156	5.5	−7.6
Dec 05 21:42	Bet Tau	RD	1.7	169	16	179	−3.4	6.4
Dec 07 00:07	54 Aur	RD	6.0	155	25	210	1.2	1.8
Dec 07 23:45	1169	RD	5.3	142	17	225	0.9	0.6
Dec 24 21:46	44 Cap	DD	5.9	50	8	37	−0.3	1.9
Dec 26 20:01	3416	DD	5.6	74	41	100	2.3	0.7
Dec 26 20:49	3416	RB	5.6	74	32	184	0.0	3.0

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 02 20:30	Eta Cap	DD	4.9	31	7	83	−0.2	1.1
Jan 10 20:33	44 Tau	DD	5.4	135	30	99	2.5	−0.3
Jan 10 21:49	44 Tau	RB	5.4	135	28	225	2.0	1.4
Jan 13 23:18	59 Gem	DD	5.8	173	28	108	2.3	−0.6
Jan 14 00:10	Iot Gem	DB	3.8	173	28	52	3.3	1.6
Jan 14 00:56	Iot Gem	RB	3.8	173	26	346	0.4	−2.0
Jan 25 02:48	2332	RD	6.1	58	24	288	0.1	−1.5
Jan 26 03:39	2470	RD	6.1	46	25	235	1.1	0.0
Feb 06 20:10	579	DD	6.4	104	27	128	2.5	−0.8
Feb 14 23:37	Sig Leo	DB	4.1	157	41	49	9.0	5.4
Feb 14 23:49	Sig Leo	RB	4.1	157	43	32	−6.4	−9.4
Feb 17 01:39	1836	RD	6.3	134	57	266	3.2	−0.5
Feb 21 00:52	2269	DB	5.4	91	26	98	0.4	−1.3
Feb 21 01:54	2269	RD	5.4	90	39	314	0.3	−2.2
Mar 07 19:49	855	DD	6.4	99	24	91	2.2	0.5
Mar 08 20:47	28 Gem	DD	5.4	112	25	104	2.0	0.1
Mar 15 00:16	Bet Vir	MB	3.6	177	55	45		
Mar 15 04:32	1716	RD	6.3	175	22	274	1.0	1.1
Mar 21 00:57	Antares	DB	1.1	110	43	70	1.8	−0.4
Mar 21 01:53	Antares	RD	1.1	110	55	336	0.1	−3.5
Mar 21 02:29	2373	DB	6.1	110	62	33	8.1	9.5
Mar 21 02:45	2373	RB	6.1	110	66	11		
Mar 22 00:36	43 Oph	DB	5.3	99	30	112	0.2	−1.7
Mar 22 01:45	43 Oph	RD	5.3	99	44	280	1.0	−1.4
Mar 23 00:30	2644	RD	6.4	88	19	256	0.3	−0.7
Mar 23 02:44	2660	RD	6.2	87	44	257	1.4	−0.6
Apr 05 18:27	59 Gem	DD	5.8	93	29	136	1.9	−1.1
Apr 05 18:59	Iot Gem	DD	3.8	93	28	84	2.6	0.4
Apr 05 19:45	59 Gem	RB	5.8	93	26	262	2.4	0.8
Apr 05 20:15	Iot Gem	RB	3.8	94	23	317	1.1	−0.6
Apr 05 20:50	1132	DD	6.4	94	20	82	2.0	1.1
Apr 18 22:23	2583	RD	5.8	119	18	306	−0.4	−1.9

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Apr 19 03:39	2617	DB	4.6	117	81	74	2.6	0.6
Apr 19 05:13	2617	RD	4.6	116	77	280	2.6	−0.1
Apr 20 05:34	Tau Sgr	MB	3.3	105	82	165		
Apr 23 02:29	Del Cap	DB	2.9	69	19	39	0.7	0.7
Apr 23 03:26	Del Cap	RD	2.9	69	31	278	0.9	−1.6
May 09 20:21	1836	DD	6.3	144	58	129	1.6	−1.9
May 13 21:52	2269	RD	5.4	170	56	325	0.6	−2.8
May 21 00:25	42 Aqr	RD	5.3	88	8	219	0.3	0.6
Jun 03 18:46	Chi Leo	RB	4.6	92	48	311	1.7	−1.2
Jun 04 22:03	1716	DD	6.3	104	35	87	1.9	1.4
Jun 09 22:03	42 Lib	DD	5.0	159	79	34		
Jun 09 22:16	42 Lib	RD	5.0	159	80	17		
Jun 10 19:25	Antares	DD	1.1	169	41	117	0.6	−1.9
Jun 10 20:33	2373	DD	6.1	169	55	101	1.5	−1.4
Jun 10 20:41	Antares	RB	1.1	169	57	288	1.5	−1.6
Jun 17 00:47	Iot Aqr	DB	4.3	117	37	111	1.4	−2.6
Jun 17 01:36	Iot Aqr	RD	4.3	117	47	191	0.9	3.1
Jun 18 05:40	82 Aqr	DB	6.2	102	62	101	3.5	−0.5
Jul 01 18:39	89 Leo	DD	5.8	73	46	84	2.9	1.3
Jul 01 19:33	89 Leo	RB	5.8	74	37	358	0.0	−3.0
Jul 06 17:48	2183	RB	5.5	129	56	288	1.5	−1.6
Jul 08 23:27	2470	DD	6.1	153	71	45	1.9	3.6
Jul 09 22:31	2617	DD	4.6	164	83	132	2.5	−2.9
Jul 09 23:38	2617	RB	4.6	164	79	220	1.9	3.4
Jul 19 03:40	317	RD	6.4	80	26	179	−0.6	2.6
Jul 21 04:55	44 Tau	DB	5.4	53	14	140	4.3	−5.5
Jul 21 05:14	44 Tau	RB	5.4	53	16	173	−2.6	4.8
Jul 31 22:52	1949	DD	5.9	78	8	123	0.2	0.1
Aug 02 22:10	2157	DD	6.1	100	38	87	1.1	1.3
Aug 03 19:55	2 Sco	DD	4.5	110	76	125	2.3	−1.5
Aug 03 20:33	3 Sco	DD	5.9	111	69	91	2.4	0.6
Aug 03 21:23	2 Sco	RB	4.5	111	58	264	2.0	1.2

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 03 22:02	3 Sco	RB	5.9	111	50	293	1.8	0.0
Aug 06 03:21	2583	DD	5.8	136	10	100	−0.1	0.8
Aug 17 03:11	569	RD	5.3	83	18	192	−0.4	1.7
Sep 01 21:08	43 Oph	DD	5.3	103	57	53	1.2	2.7
Sep 01 22:18	43 Oph	RB	5.3	103	43	294	1.6	0.1
Sep 02 19:26	2644	DD	6.4	114	85	69	2.5	1.2
Sep 05 18:31	Eta Cap	DD	4.9	150	41	75	1.3	−0.5
Sep 05 19:48	Eta Cap	RB	4.9	150	57	240	1.8	0.6
Sep 06 03:18	30 Cap	DD	5.4	153	21	88	0.4	1.2
Sep 07 20:42	Lam Aqr	DD	3.7	177	41	50	1.1	0.6
Sep 07 21:55	Lam Aqr	RB	3.7	177	54	237	1.6	0.7
Sep 12 01:15	26 Ara	RD	6.1	127	30	232	1.2	0.4
Sep 14 05:10	707	DB	5.7	98	28	26	1.6	1.9
Sep 15 02:37	850	RD	6.0	86	11	249	0.9	−0.5
Sep 15 03:40	855	RD	6.4	86	18	289	2.0	−1.3
Sep 16 03:15	28 Gem	RD	5.4	73	8	347	5.5	−8.5
Oct 06 03:06	11 Psc	DD	6.4	160	18	33	0.3	2.1
Oct 24 20:06	3 Sco	DD	5.9	31	9	150	0.9	−1.2
Oct 26 21:17	2545	DD	6.4	53	15	61	−0.4	1.7
Oct 30 21:56	30 Cap	DD	5.4	99	43	91	1.5	1.1
Oct 30 22:50	30 Cap	RB	5.4	100	32	202	−0.2	2.5
Nov 06 20:25	7 Tau	RD	6.0	166	8	213	−0.1	0.6
Nov 06 23:53	11 Tau	RD	6.1	164	30	243	1.7	0.4
Nov 08 23:48	897	RD	6.4	136	15	217	0.5	0.6
Nov 26 20:43	20 Cap	DD	6.3	68	33	17	−0.3	2.7
Nov 27 22:58	Mu Cap	DD	5.1	80	12	39	−0.2	1.9
Nov 29 22:35	11 Psc	DD	6.4	105	29	90	1.2	1.2
Dec 05 01:56	Phi Tau	DD	5.0	172	19	92	1.5	0.8
Dec 05 23:58	22 Aur	RD	6.5	169	27	250	2.0	0.3
Dec 08 02:14	1169	DB	5.3	142	30	163	1.2	−2.2
Dec 08 03:05	1169	RD	5.3	142	30	239	3.2	1.4
Dec 31 21:27	11 Tau	DD	6.1	139	30	133	3.3	−1.7

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

ADELAIDE (CST)

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

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

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

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

BRISBANE (EST)

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

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

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

MOON RISE AND SET

CANBERRA (EST)

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

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

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

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

DARWIN (CST)

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

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

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

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

HOBART (EST)

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

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

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

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

MELBOURNE (EST)

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

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

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

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

PERTH (WST)

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

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

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

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

SYDNEY (EST)

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

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

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

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 to see these features return to the terminator under dark, night skies.

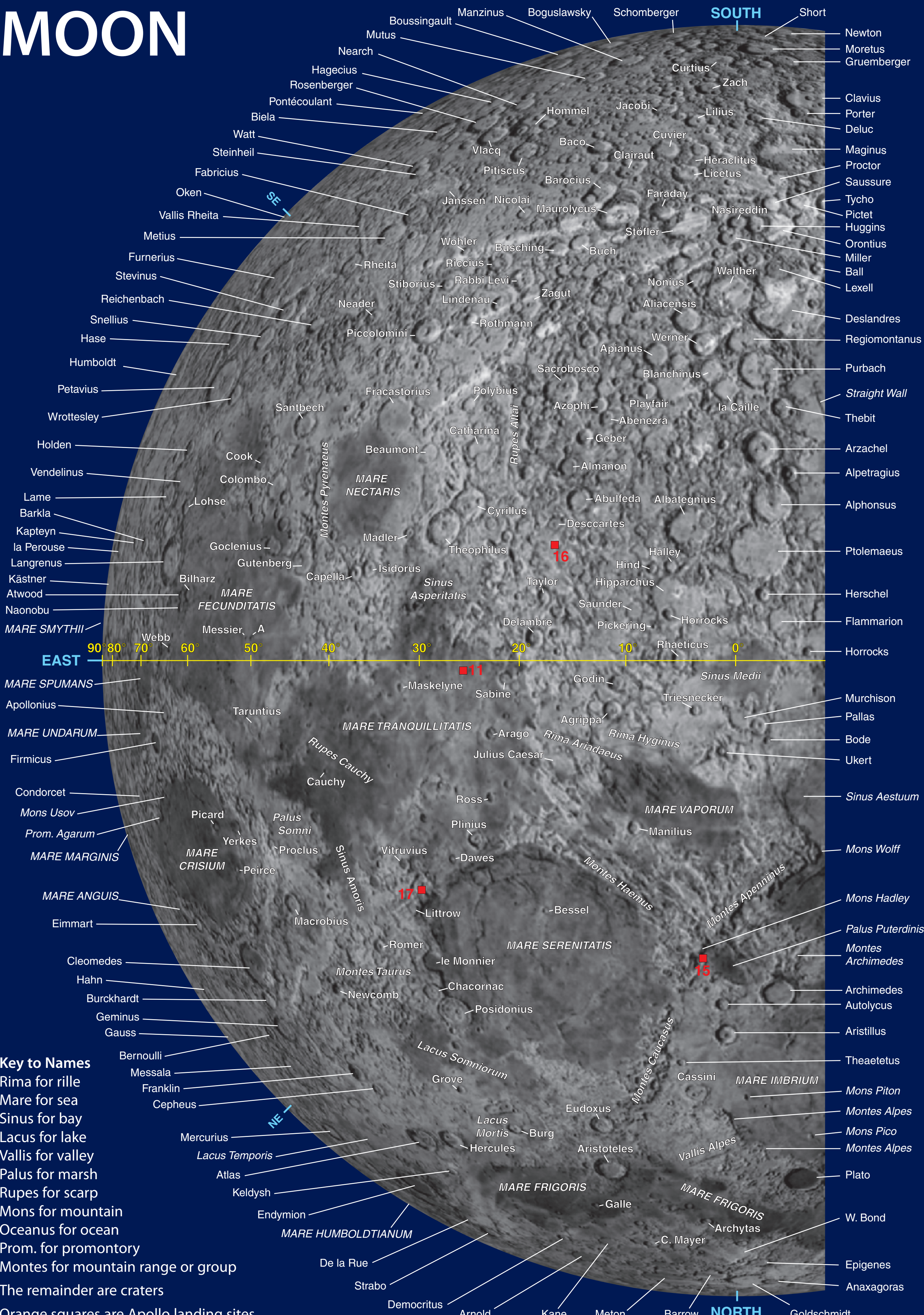
The Table: The lunar features listed are those on the terminator (the day/night line) for the age of the Moon, that is the number of days after New Moon. The presumed position of the terminator is only approximate for this can vary depending on the libration or even the time of day. Objects on the terminator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

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

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

MOON

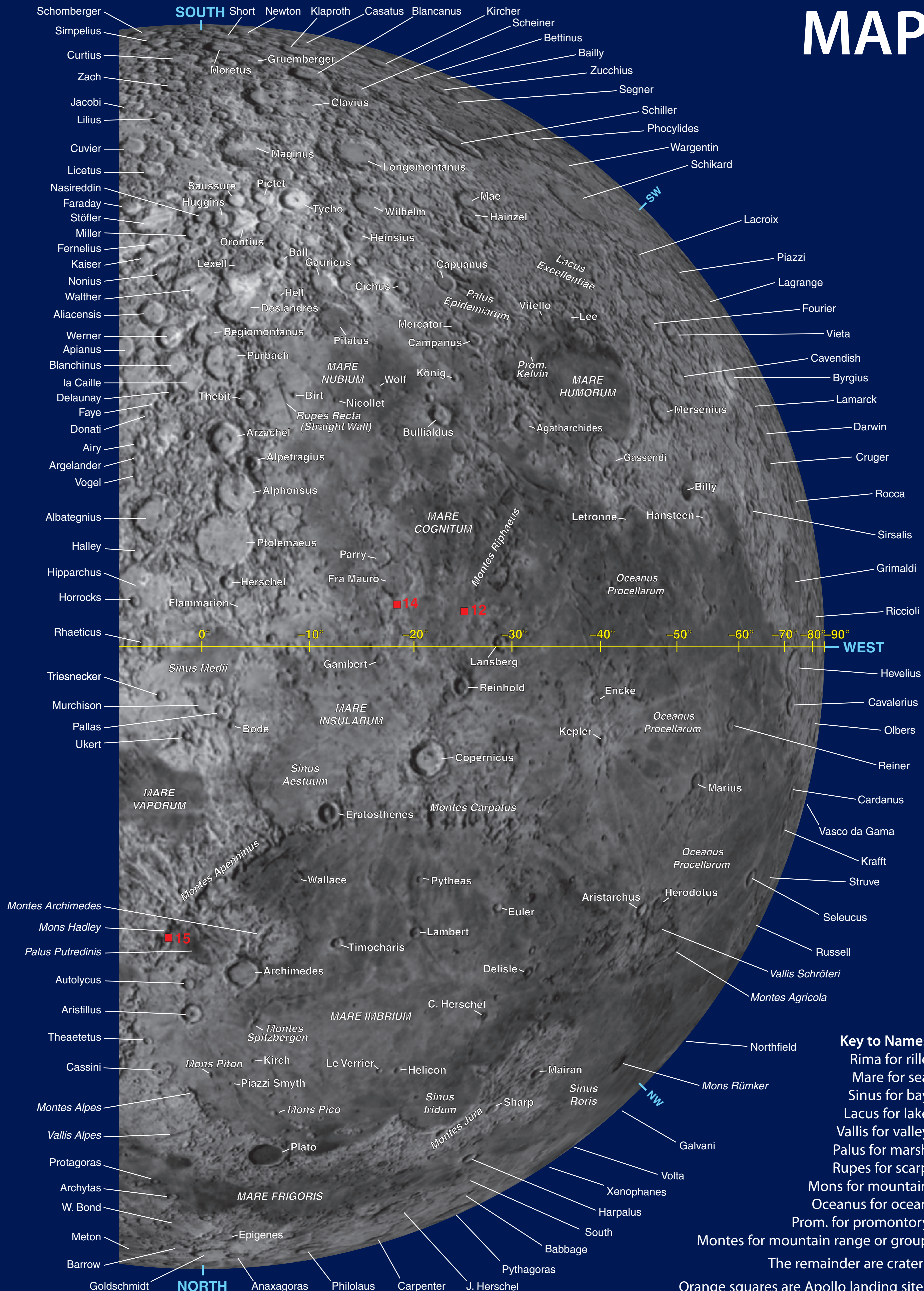


Key to Names
Rima for rille
Mare for sea
Sinus for bay
Lacus for lake
Vallis for valley
Palus for marsh
Rupes for scarp
Mons for mountain
Oceanus for ocean
Prom. for promontory
Montes for mountain range or group

The remainder are craters

Orange squares are Apollo landing sites

MAP



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OPPOSITION OF MARS 2025

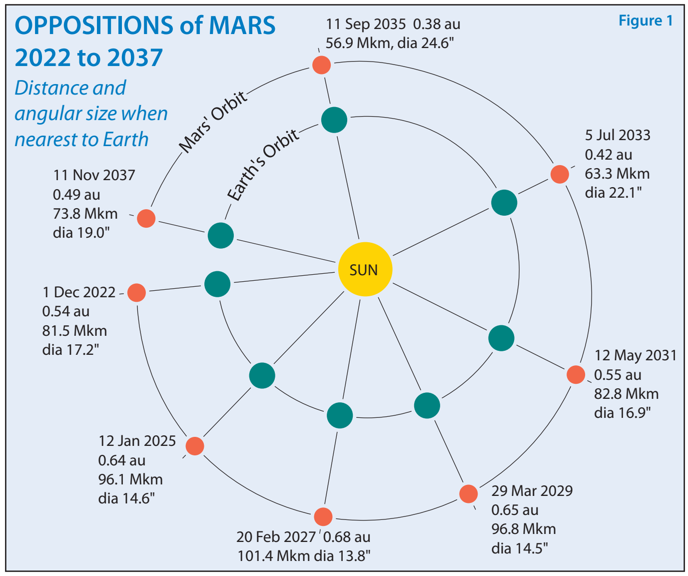
Mars has long been the most fascinating of all the planets in the Solar System. Others are bigger, prettier, closer or brighter, but Mars holds a place in people's imaginations. Only on Mars will you see thawing and growing polar caps, great planet-wide dust storms, clouds forming downwind from the largest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

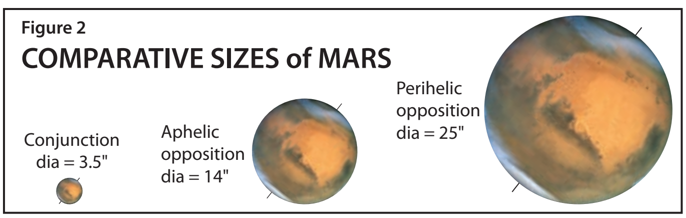
Mars comes to opposition on January 16, 2025, four days after its closest approach to Earth at 96.1 million km (Mkm) (0.6423 au). The timing of opposition and closest approach can vary by up to two weeks since the orbits of Mars and Earth are eccentric and inclined to each other. These events would coincide if the orbits were circular and coplanar (in the same geometric plane).

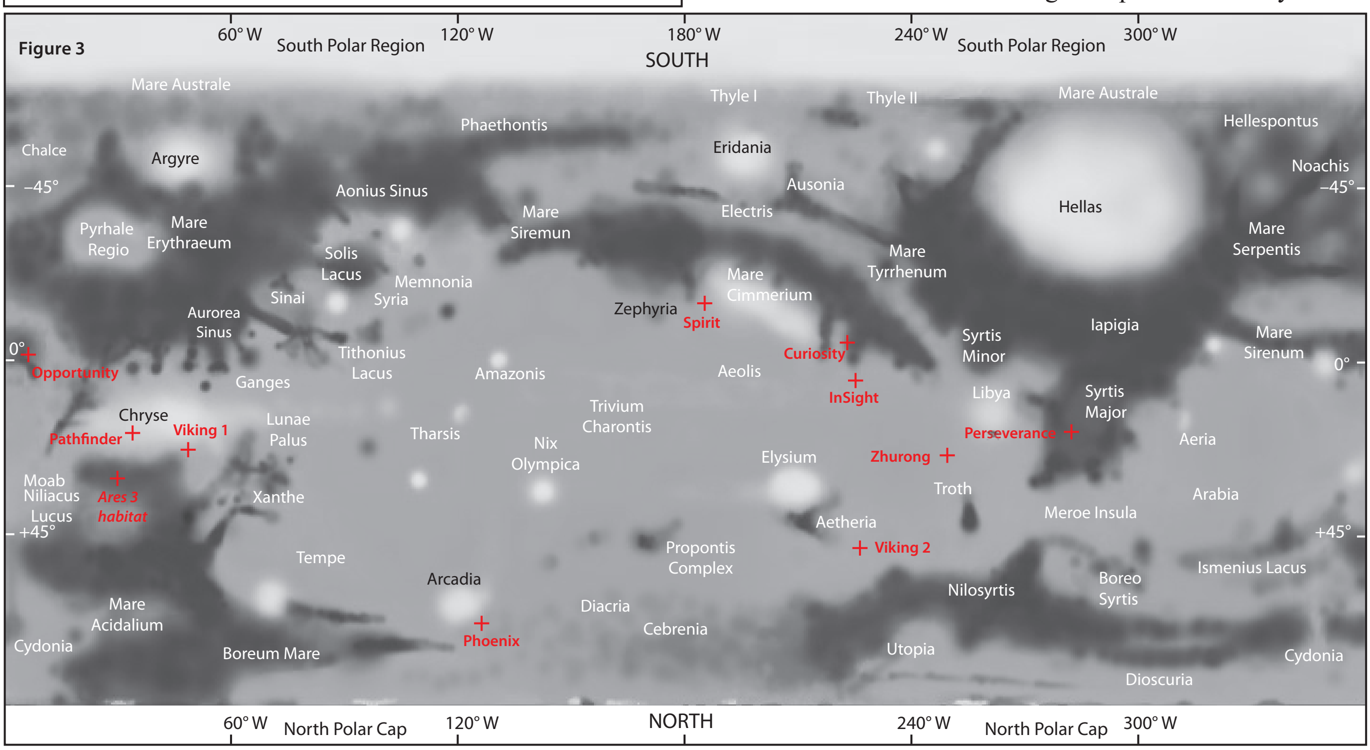
Not all oppositions of Mars are favourable; some give a better perspective than others. When the Earth passes Mars in its orbit every 26 months, we get a close view of it (Figure 1). When Mars is also at or near its perihelion, we get an excellent view, for example, the outstanding 2003 opposition. The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

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

At this year's opposition, the size of the Martian disc is just 15" in angular size. This is one of several relatively poor oppositions, with the disc being under 20". The nearest approach in 2020 was the last of the previous good perihelic oppositions until the next series of three in 2033, 35, and 37. December 2024 to February 2025 will be the prime time to train large and small telescopes on the Red Planet. The detail you observe at opposition will depend on telescope size and those moments when the seeing magically settles down for a few seconds. With good optics and steady skies





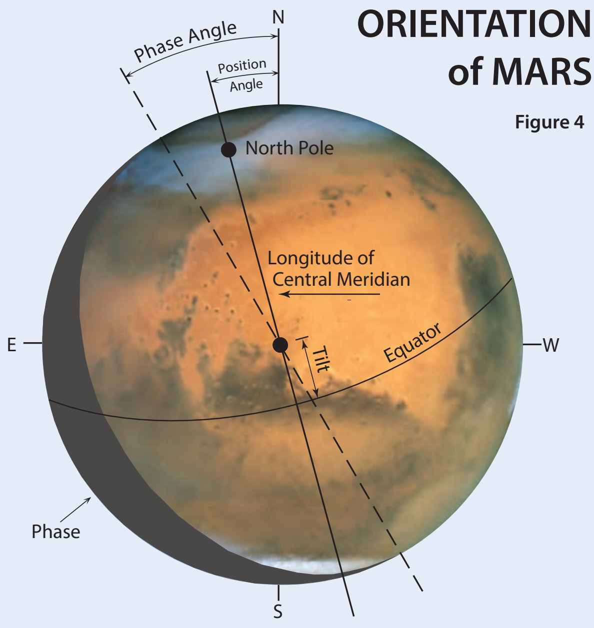


(and no Martian dust storms), try pushing the telescope to its maximum usable magnification—considered twice the aperture in millimetres (for an 80 mm telescope, this will be 160×). With modern-day imaging technology, the study of Martian surface features is no longer solely restricted to favourable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

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

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

Mars can be fun to observe at any opposition through a telescope. The view, however, can be significantly improved by using filters that can bring hard-to-detect areas into prominence.



ORIENTATION of MARS

Figure 4

NOTES on the Physical Ephemeris Table (next page).

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

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

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

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

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

Diagram does not represent any particular date.

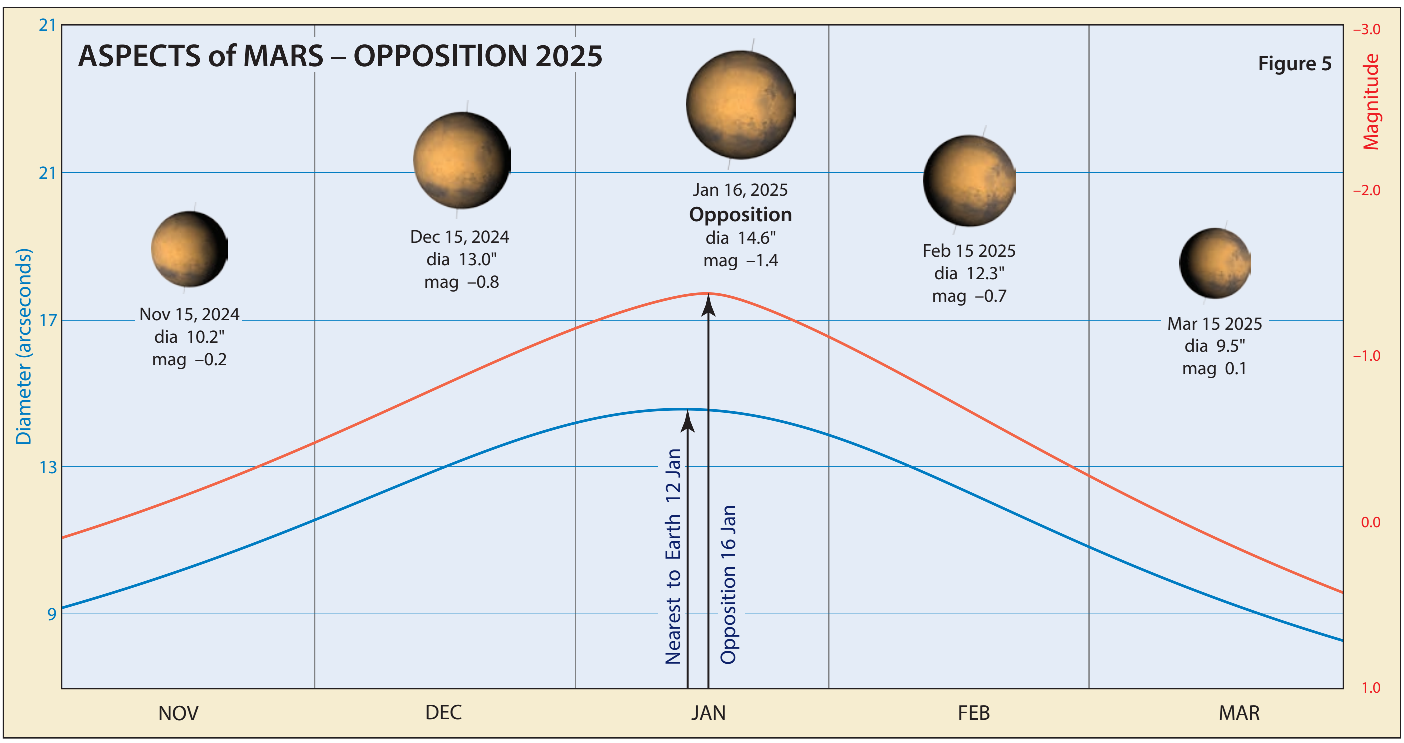


Table 1 Physical Ephemeris (0 hr UT).

See Figure 4 for description.

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Dec 1 '24	006.5	15.5	0.927	31.5	354.5
Dec 2 '24	357.3	15.5	0.928	31.0	354.5
Dec 3 '24	348.2	15.5	0.930	30.6	354.6
Dec 4 '24	339.0	15.5	0.932	30.2	354.6
Dec 5 '24	329.9	15.5	0.934	29.7	354.6
Dec 6 '24	320.7	15.4	0.936	29.3	354.7
Dec 7 '24	311.6	15.4	0.938	28.8	354.7
Dec 8 '24	302.5	15.3	0.940	28.3	354.7
Dec 9 '24	293.4	15.3	0.942	27.8	354.7
Dec 10 '24	284.3	15.2	0.944	27.3	354.7
Dec 11 '24	275.3	15.2	0.946	26.8	354.6
Dec 12 '24	266.2	15.1	0.948	26.2	354.6
Dec 13 '24	257.2	15.0	0.951	25.7	354.6
Dec 14 '24	248.1	14.9	0.953	25.1	354.5
Dec 15 '24	239.1	14.9	0.955	24.6	354.5
Dec 16 '24	230.1	14.8	0.957	24.0	354.4
Dec 17 '24	221.1	14.7	0.959	23.4	354.3
Dec 18 '24	212.2	14.6	0.961	22.7	354.3
Dec 19 '24	203.2	14.5	0.963	22.1	354.2
Dec 20 '24	194.3	14.4	0.965	21.5	354.1
Dec 21 '24	185.3	14.3	0.967	20.8	354.0
Dec 22 '24	176.4	14.2	0.969	20.2	353.8
Dec 23 '24	167.5	14.1	0.971	19.5	353.7
Dec 24 '24	158.6	13.9	0.973	18.8	353.6
Dec 25 '24	149.7	13.8	0.975	18.1	353.4
Dec 26 '24	140.8	13.7	0.977	17.4	353.3
Dec 27 '24	132.0	13.6	0.979	16.7	353.1
Dec 28 '24	123.1	13.4	0.981	15.9	352.9
Dec 29 '24	114.3	13.3	0.983	15.2	352.8
Dec 30 '24	105.5	13.1	0.984	14.4	352.6
Dec 31 '24	096.6	13.0	0.986	13.7	352.4
Jan 1	087.8	12.8	0.987	12.9	352.2
Jan 2	079.0	12.7	0.989	12.1	352.0
Jan 3	070.3	12.5	0.990	11.3	351.8
Jan 4	061.5	12.4	0.992	10.5	351.6
Jan 5	052.7	12.2	0.993	9.7	351.3
Jan 6	043.9	12.0	0.994	8.9	351.1
Jan 7	035.2	11.9	0.995	8.2	350.9
Jan 8	026.4	11.7	0.996	7.4	350.6
Jan 9	017.7	11.5	0.997	6.6	350.4
Jan 10	008.9	11.4	0.997	5.8	350.2
Jan 11	000.2	11.2	0.998	5.1	349.9
Jan 12	351.4	11.0	0.999	4.4	349.7
Jan 13	342.7	10.9	0.999	3.7	349.4
Jan 14	333.9	10.7	0.999	3.1	349.2
Jan 15	325.2	10.5	0.999	2.8	348.9
Jan 16	316.5	10.4	0.999	2.6	348.7
Jan 17	307.7	10.2	0.999	2.7	348.4
Jan 18	299.0	10.0	0.999	3.1	348.2
Jan 19	290.2	9.9	0.999	3.6	348.0
Jan 20	281.5	9.7	0.999	4.2	347.7
Jan 21	272.7	9.6	0.998	4.9	347.5
Jan 22	264.0	9.4	0.998	5.6	347.2
Jan 23	255.2	9.3	0.997	6.4	347.0
Jan 24	246.4	9.1	0.996	7.1	346.8
Jan 25	237.7	9.0	0.995	7.9	346.5
Jan 26	228.9	8.8	0.994	8.7	346.3
Jan 27	220.1	8.7	0.993	9.4	346.1
Jan 28	211.3	8.6	0.992	10.2	345.9
Jan 29	202.5	8.4	0.991	11.0	345.7
Jan 30	193.7	8.3	0.990	11.7	345.5

Date	Cent Mer°	Tilt°	Phase	Phase Angle	P.A.°
Jan 31	184.9	8.2	0.988	12.5	345.3
Feb 1	176.0	8.1	0.987	13.2	345.1
Feb 2	167.2	8.0	0.985	13.9	344.9
Feb 3	158.3	7.9	0.984	14.6	344.8
Feb 4	149.5	7.8	0.982	15.3	344.6
Feb 5	140.6	7.7	0.981	16.0	344.4
Feb 6	131.7	7.6	0.979	16.7	344.3
Feb 7	122.8	7.6	0.977	17.4	344.1
Feb 8	113.9	7.5	0.975	18.0	344.0
Feb 9	105.0	7.4	0.974	18.7	343.9
Feb 10	096.0	7.4	0.972	19.3	343.8
Feb 11	087.1	7.3	0.970	19.9	343.7
Feb 12	078.1	7.3	0.968	20.5	343.6
Feb 13	069.2	7.2	0.966	21.1	343.5
Feb 14	060.2	7.2	0.965	21.7	343.4
Feb 15	051.2	7.2	0.963	22.2	343.3
Feb 16	042.2	7.1	0.961	22.8	343.2
Feb 17	033.2	7.1	0.959	23.3	343.2
Feb 18	024.1	7.1	0.957	23.9	343.1
Feb 19	015.1	7.1	0.955	24.4	343.1
Feb 20	006.0	7.1	0.954	24.9	343.0
Feb 21	356.9	7.1	0.952	25.4	343.0
Feb 22	347.9	7.1	0.950	25.8	343.0
Feb 23	338.8	7.2	0.948	26.3	343.0
Feb 24	329.7	7.2	0.947	26.7	343.0
Feb 25	320.6	7.2	0.945	27.2	343.0
Feb 26	311.4	7.3	0.943	27.6	343.0
Feb 27	302.3	7.3	0.941	28.0	343.0
Feb 28	293.1	7.3	0.940	28.4	343.0
Mar 1	284.0	7.4	0.938	28.8	343.0
Mar 2	274.8	7.4	0.937	29.2	343.1
Mar 3	265.6	7.5	0.935	29.5	343.1
Mar 4	256.4	7.6	0.934	29.9	343.2
Mar 5	247.2	7.6	0.932	30.2	343.2
Mar 6	238.0	7.7	0.931	30.5	343.3
Mar 7	228.8	7.8	0.929	30.9	343.3
Mar 8	219.6	7.9	0.928	31.2	343.4
Mar 9	210.3	8.0	0.926	31.5	343.5
Mar 10	201.1	8.0	0.925	31.8	343.6
Mar 11	191.8	8.1	0.924	32.0	343.7
Mar 12	182.5	8.2	0.923	32.3	343.8
Mar 13	173.3	8.3	0.921	32.6	343.9
Mar 14	164.0	8.4	0.920	32.8	344.0
Mar 15	154.7	8.6	0.919	33.1	344.1
Mar 16	145.4	8.7	0.918	33.3	344.2
Mar 17	136.1	8.8	0.917	33.5	344.3
Mar 18	126.7	8.9	0.916	33.7	344.5
Mar 19	117.4	9.0	0.915	33.9	344.6
Mar 20	108.1	9.1	0.914	34.1	344.8
Mar 21	098.7	9.3	0.913	34.3	344.9
Mar 22	089.4	9.4	0.912	34.5	345.0
Mar 23	080.0	9.5	0.911	34.7	345.2
Mar 24	070.6	9.7	0.910	34.8	345.4
Mar 25	061.3	9.8	0.910	35.0	345.5
Mar 26	051.9	9.9	0.909	35.2	345.7
Mar 27	042.5	10.1	0.908	35.3	345.9
Mar 28	033.1	10.2	0.907	35.4	346.0
Mar 29	023.7	10.4	0.907	35.6	346.2
Mar 30	014.3	10.5	0.906	35.7	346.4
Mar 31	004.9	10.7	0.905	35.8	346.6

A red or orange filter will highlight dark features; green or red filters are best for seeing the projections and boundaries of the polar caps. Yellow and green filters can distinguish surface frost and fog from lower-level clouds, while blue or violet filters show higher-altitude clouds. Using yellow, orange, and red filters will highlight dust storms.

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

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

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

For example an observation at 1:20 am EST on January 27, converts to 15:20 UT on January 26. From the tables here our calculation is 228.9° + 219.3° + 4.9° = 453.1° Subtracting 360° to get a result less than 360° gives us a longitude of central meridian of 93.1°. The longitudes are shown on the map (Fig. 3). Around this time Solis Lacus will be crossing the central meridian.

Table 2: Central Meridian – Increase in Longitude

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

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

JUPITER'S MOONS

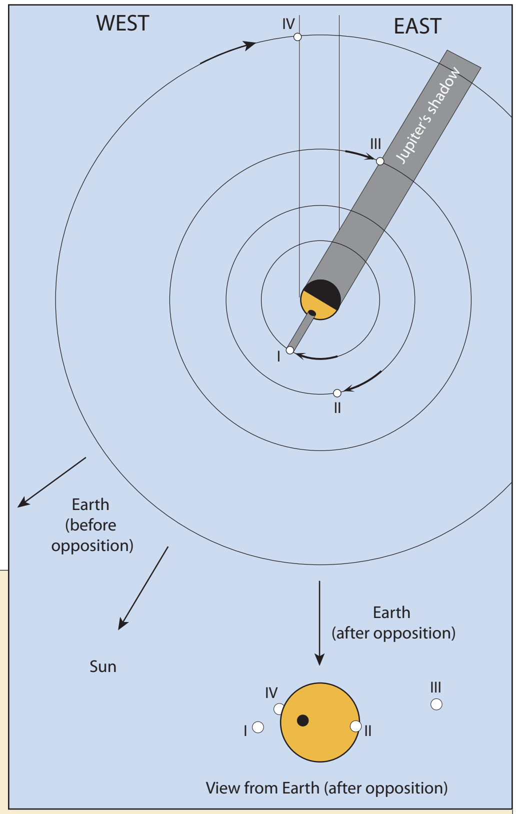
Jupiter, with its many moons, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are 95 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo, are bright enough to be visible in small telescopes or moderate-sized binoculars. The dance of these moons, as they pass back and forth across Jupiter, is illustrated in *Jupiter Moon Events* on the following pages. All the moons orbit in roughly the same plane, which is very close to the plane of the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From Earth, we see four types of events. They are:

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

   Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter does not have an opposition in 2025, the last was 8 Dec 24, the next is 11 Jan 2026.
3. A satellite can go into occultation, that is, pass behind the disc of Jupiter.
4. A satellite can be eclipsed as it passes into Jupiter's shadow. The closer Jupiter is to opposition (or conjunction), the more likely that the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7× or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation). This happens approximately every eight days; an example would be 10 January.

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



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

Viewed from the Earth (after opposition):

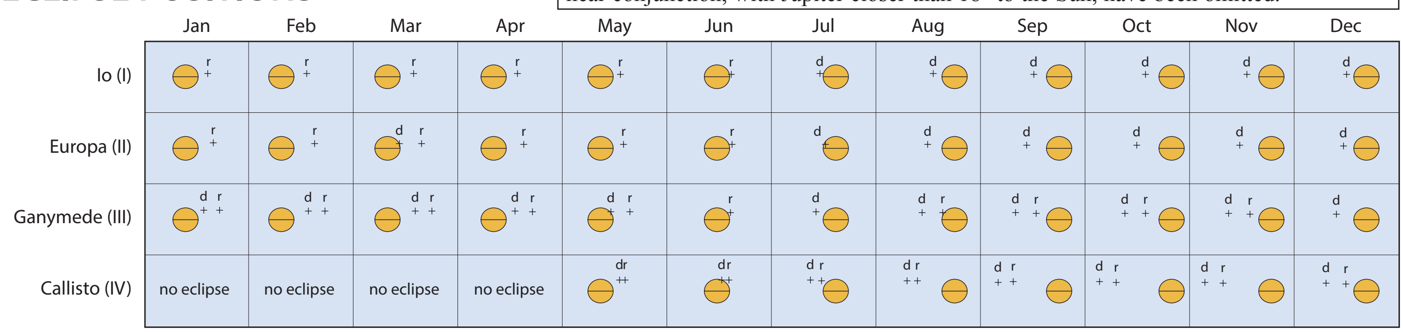
Satellite I	(Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.
Satellite II	(Europa) has just commenced a satellite transit (ingress).
Satellite III	(Ganymede) is about to be eclipsed (disappear).
Satellite IV	(Callisto) may be about to move out of sight as it is occulted by Jupiter's disc.

JUPITER'S MOON EVENTS Legend (following pages)

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

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

ECLIPSE POSITIONS



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

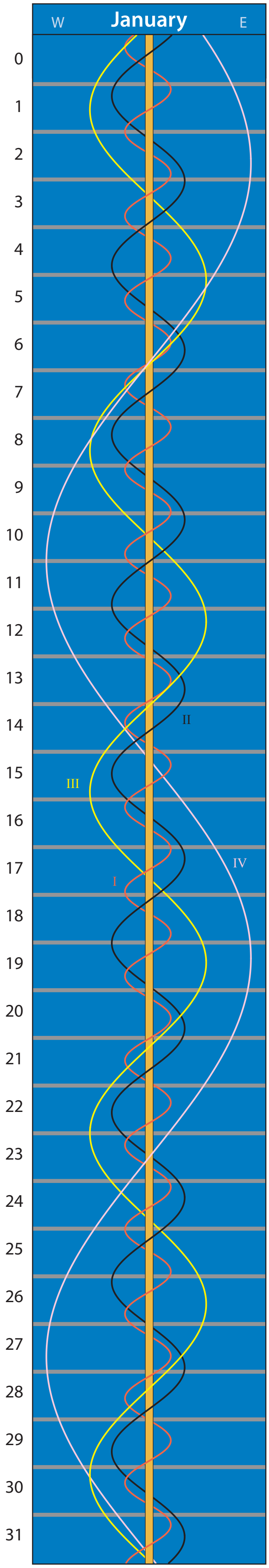
JUPITER MOON EVENTS

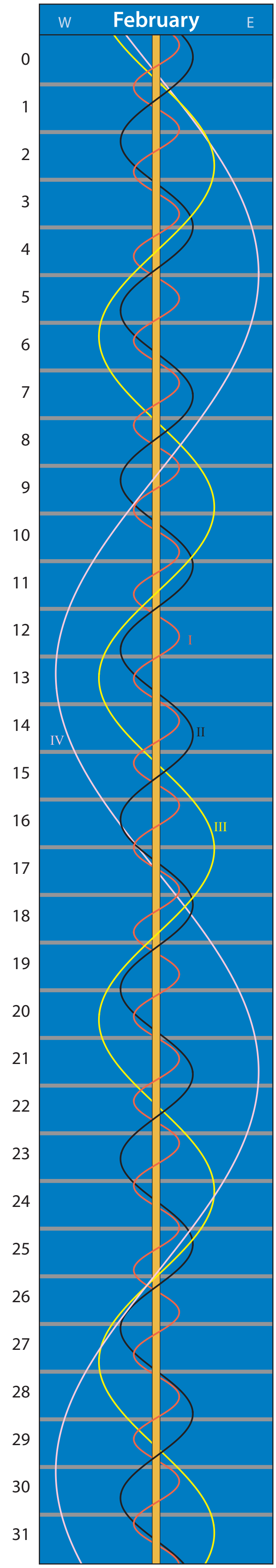
The diagrams here show the patterns that the four major moons of Jupiter make as they shuttle back and forth. Each complete period represents one orbit of the satellite. Each horizontal grey date line represents midnight; the top edge of the line is midnight EST (14 hr UT), the bottom edge of the line is midnight WST (16 hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times. The same can be done with the occultation times, that is when the line disappears behind Jupiter.

Satellite:

- **I** is **Io**
- **II** is **Europa**
- **III** is **Ganymede**
- **IV** is **Callisto.**

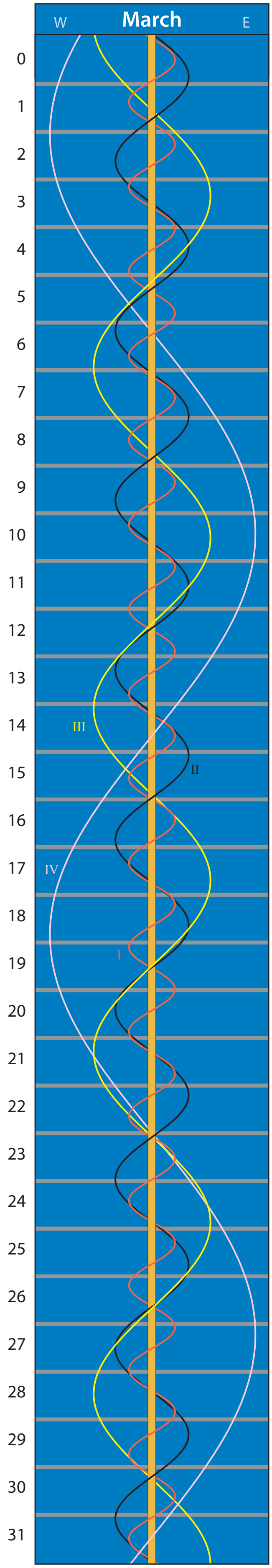
Day	EST	WST	Sat	Event	Vis
January					
2	03:15	01:15	II	Oc D	W
3	22:18	20:18	II	Tr I	
	23:35	21:35	II	Sh I	
4	00:49	22:49(p)	II	Tr E	
	02:10	00:10	II	Sh E	
5	02:28	00:28	I	Tr I	
	03:09	01:09	I	Sh I	W
	04:39	02:39	I	Tr E	W
	20:24	18:24	II	Ec R	E
	23:47	21:47	I	Oc D	
6	02:41	00:41	I	Ec R	
	20:54	18:54	I	Tr I	E
	21:38	19:38	I	Sh I	
	21:45	19:45	III	Tr I	
	23:06	21:06	I	Tr E	
	23:50	21:50	I	Sh E	
	23:50	21:50	III	Tr E	
7	00:37	22:37(p)	III	Sh I	
	02:53	00:53	III	Sh E	W
	21:10	19:10	I	Ec R	E
11	00:36	22:36(p)	II	Tr I	
	02:11	00:11	II	Sh I	
	03:07	01:07	II	Tr E	W
	04:45	02:45	II	Sh E	W
12	04:14	02:14	I	Tr I	W
	23:02	21:02	II	Ec R	
13	01:33	23:33(p)	I	Oc D	
	04:36	02:36	I	Ec R	W
	22:41	20:41	I	Tr I	
	23:33	21:33	I	Sh I	
14	00:53	22:53(p)	I	Tr E	
	01:10	23:10(p)	III	Tr I	
	01:46	23:46(p)	I	Sh E	
	03:17	01:17	III	Tr E	W
	20:00	18:00	I	Oc D	E
	23:04	21:04	I	Ec R	
15	19:20	17:20	I	Tr E	E
	20:14	18:14	I	Sh E	E
17	20:47	18:47	III	Ec R	E
18	02:56	00:56	II	Tr I	W
19	21:06	19:06	II	Oc D	E
20	01:40	23:40(p)	II	Ec R	
	03:21	01:21	I	Oc D	W
21	00:29	22:29(p)	I	Tr I	
	01:29	23:29(p)	I	Sh I	
	02:41	00:41	I	Tr E	W
	03:41	01:41	I	Sh E	W
	20:39	18:39	II	Sh E	E
	21:48	19:48	I	Oc D	
22	01:00	23:00(p)	I	Ec R	
	19:57	17:57	I	Sh I	E
	21:08	19:08	I	Tr E	E
	22:10	20:10	I	Sh	E
23	19:28	17:28	I	Ec R	E
24	20:29	18:29	III	Oc R	E
	22:28	20:28	III	Ec D	
25	00:49	22:49(p)	III	Ec R	
26	23:30	21:30	II	Oc D	
28	02:18	00:18	I	Tr I	W
	03:24	01:24	I	Sh I	W
	20:40	18:40	II	Sh I	E
	21:02	19:02	II	Tr E	E
	23:15	21:15	II	Sh E	
	23:37	21:37	I	Oc D	
29	02:55	00:55	I	Ec R	W
	20:46	18:46	I	Tr I	E
	21:53	19:53	I	Sh I	
	22:58	20:58	I	Tr E	
30	00:06	22:06(p)	I	Sh E	
	21:23	19:23	I	Ec R	E
31	21:53	19:53	III	Oc D	
February					
1	00:07	22:07(p)	III	Oc R	
	02:28	00:28	III	Ec D	W
3	01:58	23:58(p)	II	Oc D	W
4	20:56	18:56	II	Tr I	E
	23:16	21:16	II	Sh I	
	23:29	21:29	II	Tr E	



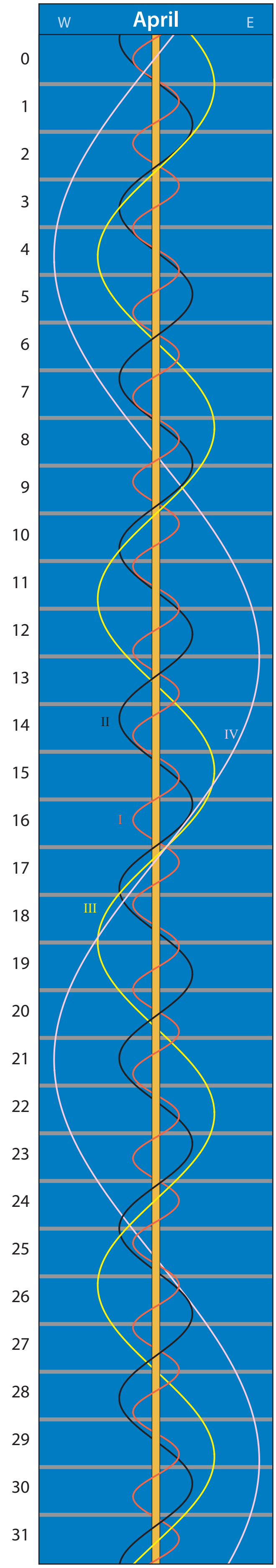


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
5	01:27	23:27(p)	I	Oc D	W
	01:51	23:51(p)	II	Sh E	W
	22:36	20:36	I	Tr I	
	23:49	21:49	I	Sh I	
6	00:49	22:49(p)	I	Tr E	W
	02:01	00:01	I	Sh E	W
	19:55	17:55	I	Oc D	E
	20:17	18:17	II	Ec R	E
	23:19	21:19	I	Ec R	
7	19:17	17:17	I	Tr E	E
	20:30	18:30	I	Sh E	E
8	01:35	23:35(p)	III	Oc D	W
11	20:40	18:40	III	Sh I	E
	23:03	21:03	III	Sh E	
	23:24	21:24	II	Tr I	
12	01:51	23:51(p)	II	Sh I	W
	01:57	23:57(p)	II	Tr E	W
13	00:28	22:28(p)	I	Tr I	W
	01:44	23:44(p)	I	Sh I	W
	21:46	19:46	I	Oc D	
	22:56	20:56	II	Ec R	
14	01:14	23:14(p)	I	Ec R	W
	18:57	16:57	I	Tr I	E
	20:13	18:13	I	Sh I	E
	21:09	19:09	I	Tr E	E
	22:26	20:26	I	Sh E	
15	19:43	17:43	I	Ec R	E
18	19:30	17:30	III	Tr I	E
	21:48	19:48	III	Tr E	
19	00:41	22:41(p)	III	Sh I	W
	01:55	23:55(p)	II	Tr I	W
20	20:17	18:17	II	Oc D	E
	22:53	20:53	II	Oc R	
	22:56	20:56	II	Ec D	
	23:39	21:39	I	Oc D	W
21	01:34	23:34(p)	II	Ec R	W
	20:50	18:50	I	Tr I	E
	22:09	20:09	I	Sh I	
	23:03	21:03	I	Tr E	
22	00:22	22:22(p)	I	Sh E	W
	20:21	18:21	II	Sh E	E
	21:38	19:38	I	Ec R	
23	18:51	16:51	I	Sh E	E
25	23:24	21:24	III	Tr I	W
27	22:53	20:53	II	Oc D	
28	01:30	23:30(p)	II	Oc R	W
	01:33	23:33(p)	I	Oc D	W
	01:34	23:34(p)	II	Ec D	W
	22:45	20:45	I	Tr I	

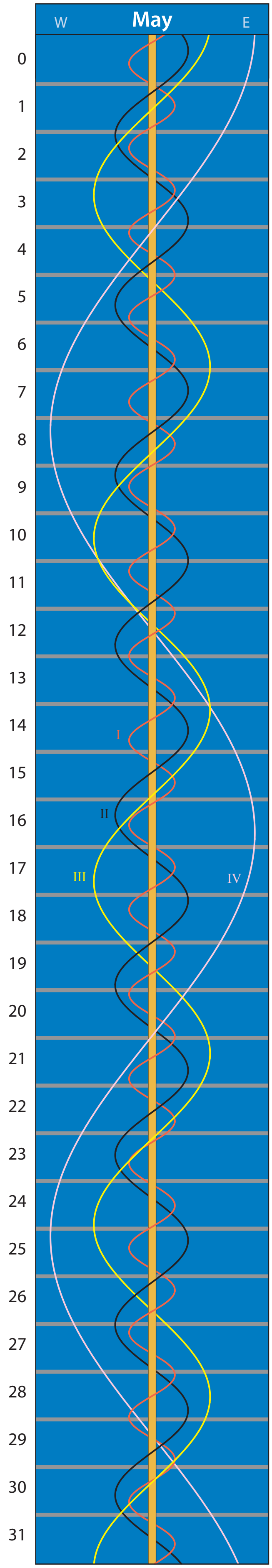


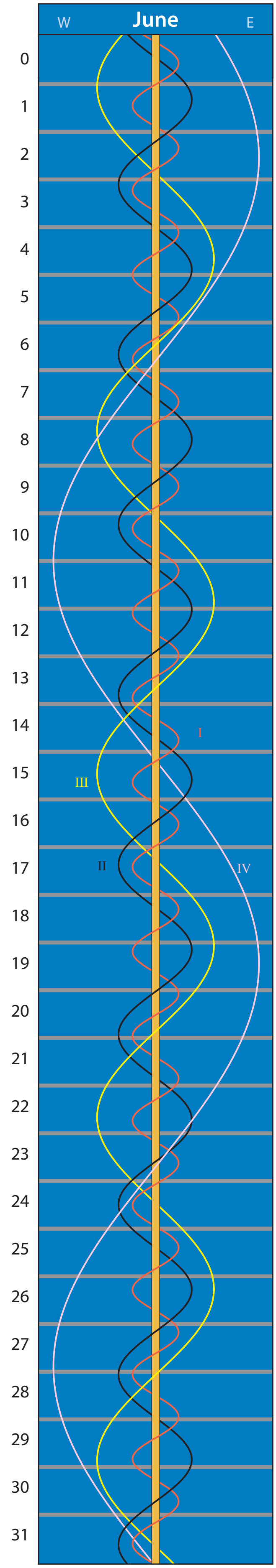
Day	EST	WST	Sat	Event	Vis
March					
1	00:05	22:05(p)	I	Sh I	W
	00:58	22:58(p)	I	Tr E	W
	20:02	18:02	I	Oc D	E
	20:19	18:19	II	Tr E	E
	20:20	18:20	II	Sh I	E
	20:57	18:57	III	Ec R	
	22:56	20:56	II	Sh E	
	23:33	21:33	I	Ec R	W
2	19:27	17:27	I	Tr E	E
	20:47	18:47	I	Sh E	E
8	00:41	22:41(p)	I	Tr I	W
	19:36	17:36	III	Oc R	E
	20:20	18:20	II	Tr I	E
	21:57	19:57	I	Oc D	
	22:30	20:30	III	Ec D	
	22:55	20:55	II	Tr E	W
	22:55	20:55	II	Sh I	W
9	00:59	22:59(p)	III	Ec R	W
	19:10	17:10	I	Tr I	E
	20:30	18:30	I	Sh I	E
	21:23	19:23	I	Tr E	
	22:43	20:43	I	Sh E	W
10	19:57	17:57	I	Ec R	E
	20:11	18:11	II	Ec R	E
15	21:17	19:17	III	Oc D	
	22:58	20:58	II	Tr I	W
	23:42	21:42	III	Oc R	W
	23:54	21:54	I	Oc D	W
16	21:07	19:07	I	Tr I	
	22:25	20:25	I	Sh I	W
	23:20	21:20	I	Tr E	W
17	18:23	16:23	I	Oc D	E
	21:52	19:52	I	Ec R	
	22:50	20:50	II	Ec R	W
18	19:08	17:08	I	Sh E	E
19	19:13	17:13	III	Sh E	E
23	23:05	21:05	I	Tr I	W
24	20:15	18:15	II	Oc D	E
	20:20	18:20	I	Oc D	E
	23:47	21:47	I	Ec R	W
25	18:50	16:50	I	Sh I	E
	19:48	17:48	I	Tr E	E
	21:04	19:04	I	Sh E	
26	18:11	16:11	III	Tr E	E
	18:16	16:16	I	Ec R	E
	20:01	18:01	II	Sh E	E
	20:45	18:45	III	Sh I	
	23:15	21:15	III	Sh E	W
31	22:18	20:18	I	Oc D	W
	23:00	21:00	II	Oc D	W

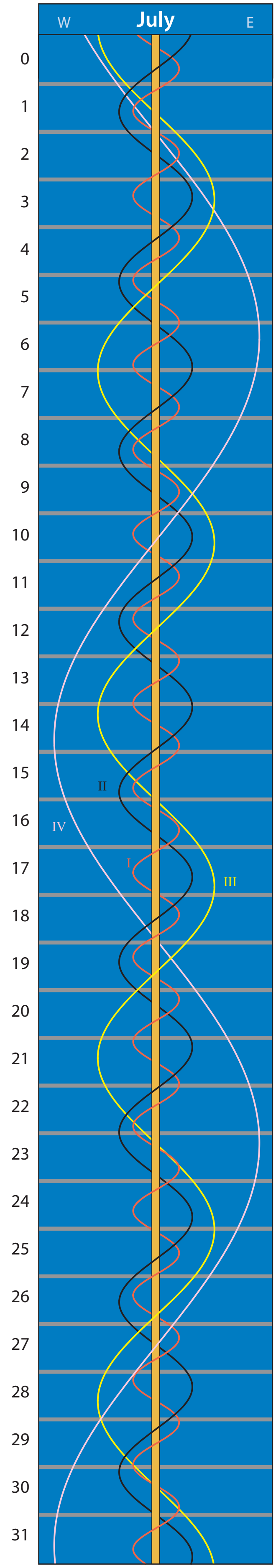


I – Io   II – Europa   III – Ganymede   IV – Callisto

Day	EST	WST	Sat	Event	Vis
April					
1	19:34	17:34	I	Tr I	E
	20:46	18:46	I	Sh I	
	21:47	19:47	I	Tr E	W
	22:59	20:59	I	Sh E	W
2	19:59	17:59	III	Tr I	E
	19:59	17:59	II	Sh I	E
	20:11	18:11	I	Ec R	E
	20:16	18:16	II	Tr E	
	22:27	20:27	III	Tr E	W
	22:37	20:37	II	Sh E	W
8	21:33	19:33	I	Tr I	W
	22:42	20:42	I	Sh I	W
9	18:47	16:47	I	Oc D	E
	20:22	18:22	II	Tr I	
	22:06	20:06	I	Ec R	W
	22:34	20:34	II	Sh I	W
	22:59	20:59	II	Tr E	W
10	18:16	16:16	I	Tr E	E
	19:24	17:24	I	Sh E	E
11	20:06	18:06	II	Ec R	
13	18:31	16:31	III	Ec D	E
	21:06	19:06	III	Ec R	W
16	20:46	18:46	I	Oc D	W
17	18:03	16:03	I	Tr I	E
	19:06	17:06	I	Sh I	E
	20:17	18:17	I	Tr E	
	21:20	19:20	I	Sh E	W
18	17:57	15:57	II	Oc D	E
	18:30	16:30	I	Ec R	E
20	18:30	16:30	III	Oc D	E
	21:03	19:03	III	Oc R	W
	22:32	20:32	III	Ec D	W
24	20:04	18:04	I	Tr I	W
	21:01	19:01	I	Sh I	W
	22:18	20:18	I	Tr E	W
25	20:25	18:25	I	Ec R	W
	20:46	18:46	II	Oc D	W
26	17:44	15:44	I	Sh E	E
27	17:53	15:53	II	Tr E	E
	19:42	17:42	II	Sh E	E
May					
1	19:23	17:23	III	Sh E	E
2	19:17	17:17	I	Oc D	E
3	17:26	15:26	I	Sh I	E
	18:49	16:49	I	Tr E	E
	19:39	17:39	I	Sh E	W
4	18:01	16:01	II	Tr I	E
	19:38	17:38	II	Sh I	W
	20:40	18:40	II	Tr E	W
6	17:19	15:19	II	Ec R	E

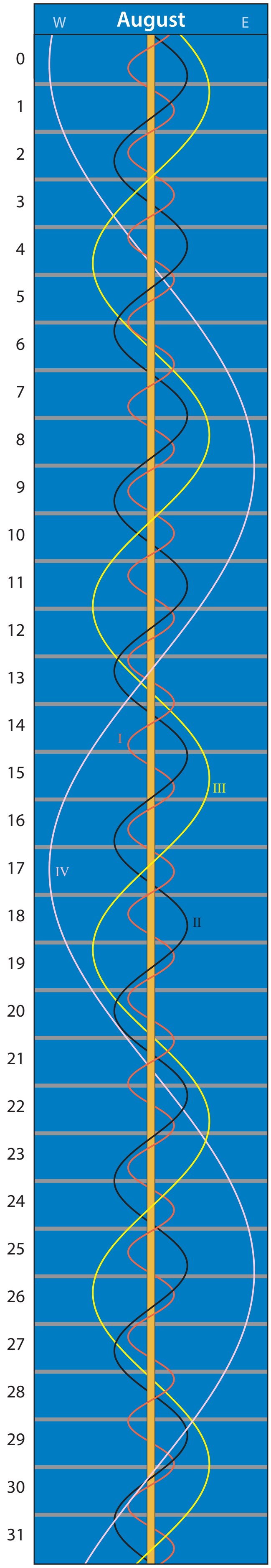




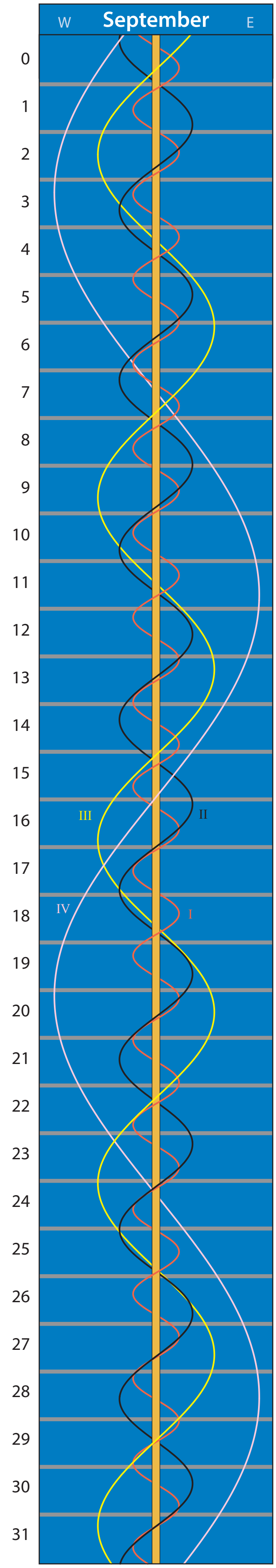


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
8	17:42	15:42	III	Tr I	E
	20:19	18:19	III	Tr E	W
	20:46	18:46	III	Sh I	W
9	21:17	19:17	I	Oc D	W
10	18:37	16:37	I	Tr I	E
	20:51	18:51	I	Tr E	W
11	18:44	16:44	I	Ec R	E
	20:48	18:48	II	Tr I	W
13	19:56	17:56	II	Ec R	W
17	20:38	18:38	I	Tr I	W
18	17:49	15:49	I	Oc D	E
	20:39	18:39	I	Ec R	W
19	17:12	15:12	III	Ec R	E
	17:23	15:23	I	Tr E	E
	17:59	15:59	I	Sh E	E
20	18:40	16:40	II	Oc D	E
25	19:50	17:50	I	Oc D	W
26	17:11	15:11	I	Tr I	E
	17:40	15:40	I	Sh I	E
	19:25	17:25	I	Tr E	W
	19:54	17:54	I	Sh E	W
27	17:02	15:02	I	Ec R	E
29	19:23	17:23	II	Sh E	W
June					
Events difficult to observe, too close to conjunction					
July					
20	05:58	03:58	II	Ec D	E
22	08:56	06:56	I	Sh I	W
23	06:04	04:04	I	Ec D	E
	08:47	06:47	I	Oc R	W
24	06:08	04:08	I	Tr E	E
27	08:32	06:32	II	Ec D	W
29	05:30	03:30	II	Sh E	E
	06:39	04:39	II	Tr E	E
30	06:26	04:26	III	Ec D	E
	07:58	05:58	I	Ec D	W
31	05:54	03:54	I	Tr I	E
	08:09	06:09	I	Tr E	W
August					
5	05:20	03:20	II	Sh I	E
	06:41	04:41	II	Tr I	E
	08:06	06:06	II	Sh E	W
7	07:54	05:54	I	Tr I	W
8	07:19	05:19	I	Oc R	W
10	06:36	04:36	III	Tr E	E
12	07:56	05:56	II	Sh I	W
13	06:24	04:24	IV	Tr I	E
14	07:20	05:20	II	Oc R	W



Day	EST	WST	Sat	Event	Vis
15	06:15	04:15	I	Ec D	E
16	05:49	03:49	I	Sh E	E
	06:39	04:39	I	Tr E	E
17	04:37	02:37	III	Sh I	E
	07:33	05:33	III	Sh E	W
	07:58	05:58	III	Tr I	W
21	05:33	03:33	II	Ec D	E
	06:21	04:21	IV	Ec D	E
22	08:09	06:09	I	Ec D	W
23	04:31	02:31	II	Tr E	E
	05:28	03:28	I	Sh I	E
	06:23	04:23	I	Tr I	E
	07:43	05:43	I	Sh E	W
	08:38	06:38	I	Tr E	W
24	05:49	03:49	I	Oc R	E
	08:36	06:36	III	Sh I	W
28	05:22	03:22	III	Oc R	E
	08:07	06:07	II	Ec D	W
30	04:29	02:29	II	Tr I	E
	05:14	03:14	II	Sh E	E
	05:36	03:36	IV	Tr E	E
	07:18	05:18	II	Tr E	W
	07:22	05:22	I	Sh I	W
	08:22	06:22	I	Tr I	W
31	04:32	02:32	I	Ec D	E
	07:49	05:49	I	Oc R	W
September					
1	04:05	02:05	I	Sh E	E
	05:06	03:06	I	Tr E	E
4	05:19	03:19	III	Ec R	E
	06:34	04:34	III	Oc D	W
6	05:03	03:03	II	Sh I	E
	07:14	05:14	II	Tr I	W
	07:51	05:51	II	Sh E	W
7	06:26	04:26	I	Ec D	W
8	03:44	01:44	I	Sh I	E
	04:49	02:49	I	Tr I	E
	04:55	02:55	II	Oc R	E
	05:58	03:58	I	Sh E	
	07:04	05:04	I	Tr E	W
9	04:17	02:17	I	Oc R	E
11	06:18	04:18	III	Ec D	W
13	07:39	05:39	II	Sh I	W
14	08:19	06:19	I	Ec D	W
15	04:18	02:18	III	Tr E	E
	05:37	03:37	I	Sh I	
	06:46	04:46	I	Tr I	W
	07:36	05:36	II	Oc R	W
	07:52	05:52	I	Sh E	W
16	06:15	04:15	I	Oc R	W
17	03:31	01:31	I	Tr E	E



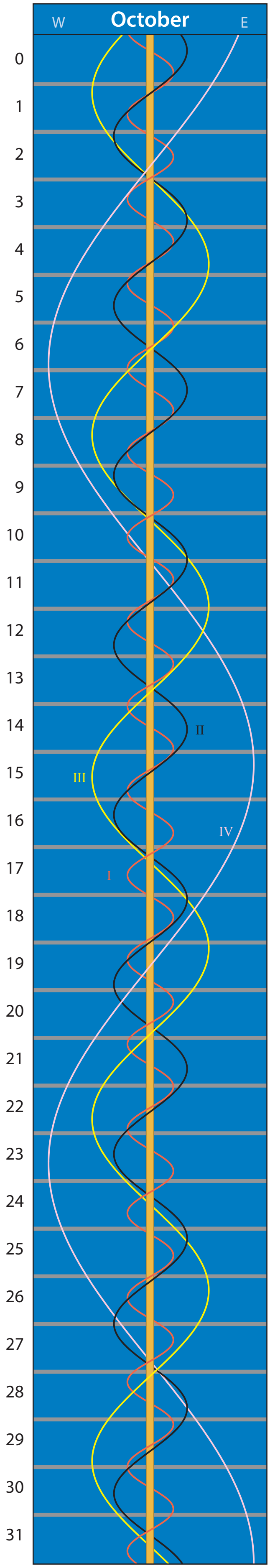
JUPITER

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

Day	EST	WST	Sat	Event	Vis
22	03:30	01:30	III	Sh E	E
	05:05	03:05	II	Ec D	
	05:19	03:19	III	Tr I	
	07:30	05:30	I	Sh I	W
23	04:42	02:42	I	Ec D	E
24	03:12	01:12	I	Tr I	E
	04:13	02:13	I	Sh E	E
	04:54	02:54	II	Tr E	
	05:27	03:27	I	Tr E	
	05:41	03:41	IV	Oc D	
25	02:41	00:41	I	Oc R	E
29	04:27	02:27	III	Sh I	E
	07:29	05:29	III	Sh E	W
	07:38	05:38	II	Ec D	W
30	06:36	04:36	I	Ec D	W

October

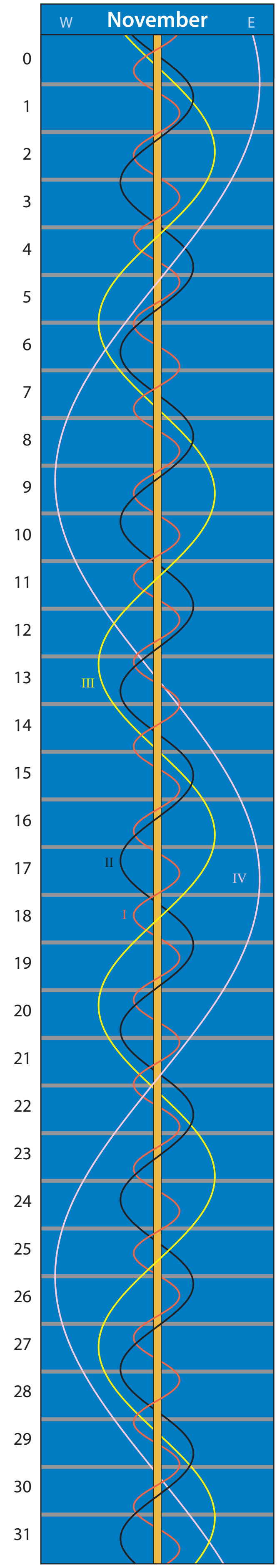
Day	EST	WST	Sat	Event	Vis
1	02:10	00:10	II	Sh I	E
	03:52	01:52	I	Sh I	E
	04:44	02:44	II	Tr I	
	04:58	02:58	II	Sh E	
	05:07	03:07	I	Tr I	
	06:06	04:06	I	Sh E	W
	07:23	05:23	I	Tr E	W
	07:36	05:36	II	Tr E	W
2	04:38	02:38	I	Oc R	
	05:08	03:08	IV	Sh I	
3	02:14	00:14	II	Oc R	E
	02:36	00:36	III	Oc R	E
8	04:46	02:46	II	Sh I	
	05:45	03:45	I	Sh I	W
	07:02	05:02	I	Tr I	W
	07:24	05:24	II	Tr I	W
	07:35	05:35	II	Sh E	W
9	02:58	00:58	I	Ec D	E
	06:33	04:33	I	Oc R	W
10	01:30	23:30(p)	I	Tr I	E
	02:28	00:28	I	Sh E	E
	03:25	01:25	III	Oc D	E
	03:46	01:46	I	Tr E	E
	04:50	02:50	II	Oc R	
	06:40	04:40	III	Oc R	W
11	04:04	02:04	IV	Oc R	
15	07:22	05:22	II	Sh I	W
	07:38	05:38	I	Sh I	W
16	04:52	02:52	I	Ec D	



Day	EST	WST	Sat	Event	Vis
17	02:01	00:01	II	Ec D	E
	02:06	00:06	I	Sh I	E
	02:11	00:11	III	Ec D	E
	03:24	01:24	I	Tr I	E
	04:21	02:21	I	Sh E	
	05:17	03:17	III	Ec R	
	05:39	03:39	I	Tr E	W
	07:24	05:24	II	Oc R	W
	07:25	05:25	III	Oc D	W
18	02:56	00:56	I	Oc R	E
19	02:12	00:12	II	Tr E	E
	02:17	00:17	IV	Sh E	E
23	06:46	04:46	I	Ec D	W
24	04:00	02:00	I	Sh I	
	04:34	02:34	II	Ec D	
	05:16	03:16	I	Tr I	W
	06:10	04:10	III	Ec D	W
	06:14	04:14	I	Sh E	W
25	01:14	23:14(p)	I	Ec D	E
	04:49	02:49	I	Oc R	
26	00:43	22:43(p)	I	Sh E	E
	01:54	23:54(p)	II	Tr I	E
	02:00	00:00	I	Tr E	E
	02:07	00:07	II	Sh E	E
	04:46	02:46	II	Tr E	
27	06:14	04:14	IV	Ec D	W
28	01:25	23:25(p)	III	Tr I	E
	04:41	02:41	III	Tr E	
31	05:53	03:53	I	Sh I	W
	07:08	05:08	II	Ec D	W
	07:08	05:08	I	Tr I	W

November

Day	EST	WST	Sat	Event	Vis
1	03:08	01:08	I	Ec D	
	06:41	04:41	I	Oc R	W
2	00:21	22:21(p)	I	Sh I	E
	01:36	23:36(p)	I	Tr I	E
	01:53	23:53(p)	II	Sh I	E
	02:36	00:36	I	Sh E	
	03:51	01:51	I	Tr E	
	04:26	02:26	II	Tr I	
	04:43	02:43	II	Sh E	
	07:18	05:18	II	Tr E	W
3	01:09	23:09(p)	I	Oc R	E
4	00:17	22:17(p)	III	Sh I	E
	01:40	23:40(p)	II	Oc R	E
	03:25	01:25	III	Sh E	
	05:14	03:14	III	Tr I	W
5	04:31	02:31	IV	Tr I	
8	05:02	03:02	I	Ec D	W



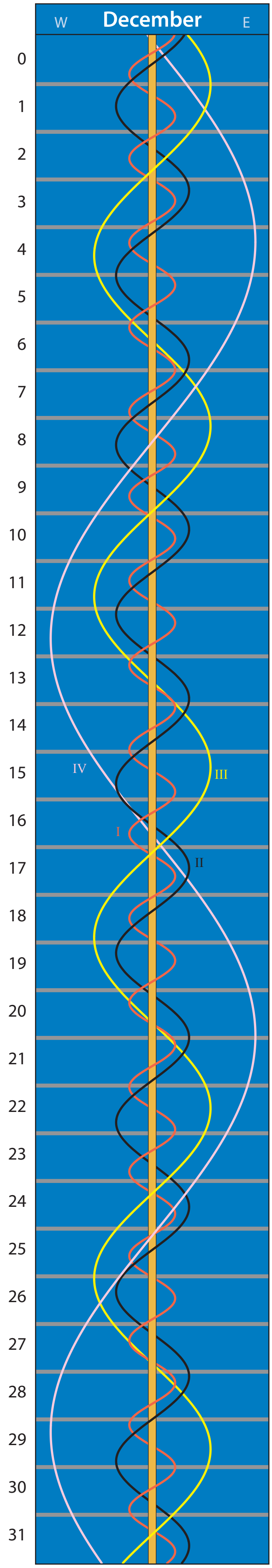
JUPITER

JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
9	02:14	00:14	I	Sh I	
	03:26	01:26	I	Tr I	
	04:29	02:29	I	Sh E	
	04:30	02:30	II	Sh I	
	05:41	03:41	I	Tr E	W
	06:56	04:56	II	Tr I	W
10	02:59	00:59	I	Oc R	
11	00:09	22:09(p)	I	Tr E	E
	04:07	02:07	II	Oc R	
	04:15	02:15	III	Sh I	
13	00:13	22:13(p)	IV	Ec D	E
	03:41	01:41	IV	Ec R	
15	02:01	00:01	III	Oc R	
	06:56	04:56	I	Ec D	W
16	04:08	02:08	I	Sh I	
	05:15	03:15	I	Tr I	W
	06:23	04:23	I	Sh E	W
	07:06	05:06	II	Sh I	W
17	01:24	23:24(p)	I	Ec D	E
	04:49	02:49	I	Oc R	W
	23:42	21:42	I	Tr I	E
18	00:51	22:51(p)	I	Sh E	E
	01:31	23:31(p)	II	Ec D	
	01:58	23:58(p)	I	Tr E	
	06:32	04:32	II	Oc R	W
	23:16	21:16	I	Oc R	E
19	23:14	21:14	II	Sh E	E
20	01:28	23:28(p)	II	Tr E	
22	00:48	22:48(p)	IV	Tr E	E
	01:16	23:16(p)	III	Ec R	
	02:19	00:19	III	Oc D	
	05:38	03:38	III	Oc R	W
23	06:01	04:01	I	Sh I	W
	07:03	05:03	I	Tr I	W
24	03:18	01:18	I	Ec D	
	06:37	04:37	I	Oc R	W
25	00:29	22:29(p)	I	Sh I	E
	01:30	23:30(p)	I	Tr I	
	02:44	00:44	I	Sh E	
	03:45	01:45	I	Tr E	
	04:05	02:05	II	Ec D	
26	01:04	23:04(p)	I	Oc R	
	23:00	21:00	II	Sh I	E
27	01:00	23:00(p)	II	Tr I	
	01:50	23:50(p)	II	Sh E	
	03:52	01:52	II	Tr E	
29	02:02	00:02	III	Ec D	
	05:15	03:15	III	Ec R	W
	05:51	03:51	III	Oc D	W
30	02:55	00:55	IV	Oc D	
	06:54	04:54	IV	Oc R	W

December

Day	EST	WST	Sat	Event	Vis
1	05:12	03:12	I	Ec D	W
2	02:23	00:23	I	Sh I	
	03:16	01:16	I	Tr I	
	04:38	02:38	I	Sh E	
	05:32	03:32	I	Tr E	W
	06:38	04:38	II	Ec D	W
	23:01	21:01	III	Tr E	E
	23:40	21:40	I	Ec D	E
3	02:51	00:51	I	Oc R	
	23:06	21:06	I	Sh E	E
	23:58	21:58	I	Tr E	E
4	01:36	23:36(p)	II	Sh I	
	03:22	01:22	II	Tr I	
	04:27	02:27	II	Sh E	
	06:13	04:13	II	Tr E	W
6	00:24	22:24(p)	II	Oc R	
	06:01	04:01	III	Ec D	W
8	05:03	03:03	IV	Sh I	W
9	04:16	02:16	I	Sh I	
	05:02	03:02	I	Tr I	W
	06:31	04:31	I	Sh E	W
	23:09	21:09	III	Tr I	E
	23:21	21:21	III	Sh E	E
10	01:35	23:35(p)	I	Ec D	
	02:26	00:26	III	Tr E	
	04:36	02:36	I	Oc R	
	22:44	20:44	I	Sh I	E
	23:28	21:28	I	Tr I	E
11	01:00	23:00(p)	I	Sh E	
	01:44	23:44(p)	I	Tr E	
	04:13	02:13	II	Sh I	
	05:41	03:41	II	Tr I	W
	23:03	21:03	I	Oc R	E
12	22:29	20:29	II	Ec D	E
13	02:41	00:41	II	Oc R	
14	21:42	19:42	II	Tr E	E
16	06:10	04:10	I	Sh I	W
	06:47	04:47	I	Tr I	W
	21:52	19:52	IV	Oc R	E
17	00:07	22:07(p)	III	Sh I	
	02:31	00:31	III	Tr I	
	03:20	01:20	III	Sh E	
	03:29	01:29	I	Ec D	
	05:48	03:48	III	Tr E	W
	06:22	04:22	I	Oc R	W
18	00:38	22:38(p)	I	Sh I	
	01:13	23:13(p)	I	Tr I	
	02:54	00:54	I	Sh E	
	03:29	01:29	I	Tr E	
	06:49	04:49	II	Sh I	W
	21:57	19:57	I	Ec D	E



Day	EST	WST	Sat	Event	Vis
19	00:48	22:48(p)	I	Oc R	
	21:22	19:22	I	Sh E	E
	21:55	19:55	I	Tr E	E
20	01:03	23:03(p)	II	Ec D	
	04:57	02:57	II	Oc R	W
21	21:07	19:07	II	Tr I	E
	22:58	20:58	II	Sh E	
	23:58	21:58	II	Tr E	
24	04:05	02:05	III	Sh I	
	05:23	03:23	I	Ec D	W
	05:49	03:49	III	Tr I	W
	23:03	21:03	IV	Sh I	
25	02:32	00:32	I	Sh I	
	02:48	00:48	IV	Sh E	
	02:53	00:53	IV	Tr I	
	02:57	00:57	I	Tr I	
	04:48	02:48	I	Sh E	W
	05:13	03:13	I	Tr E	W
	06:49	04:49	IV	Tr E	W
	23:51	21:51	I	Ec D	
26	02:32	00:32	I	Oc R	
	21:00	19:00	I	Sh I	E
	21:23	19:23	I	Tr I	E
	23:16	21:16	I	Sh E	
	23:38	21:38	I	Tr E	
27	03:38	01:38	II	Ec D	
	20:58	18:58	I	Oc R	E
	22:41	20:41	III	Oc R	
28	22:43	20:43	II	Sh I	
	23:23	21:23	II	Tr I	
29	01:34	23:34(p)	II	Sh E	
	02:14	00:14	II	Tr E	
30	20:19	18:19	II	Oc R	E

JUPITER — LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0 hr UT)													
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	215.8	070.8	168.9	017.6	067.3	274.3	324.1	172.7	023.0	077.5	292.3	351.7	1
2	013.8	228.7	326.6	175.3	224.9	071.9	121.8	330.5	180.8	235.3	090.2	149.7	2
3	171.7	026.5	124.3	332.9	022.5	229.6	279.5	128.2	338.5	033.2	248.2	307.8	3
4	329.7	184.3	282.1	130.6	180.2	027.2	077.2	285.9	136.3	191.0	046.1	105.8	4
5	127.6	342.2	079.8	288.3	337.8	184.9	234.8	083.6	294.1	348.9	204.1	263.8	5
6	285.6	140.0	237.5	085.9	135.5	342.5	032.5	241.4	091.9	146.8	002.0	061.8	6
7	083.5	297.8	035.2	243.6	293.1	140.2	190.2	039.1	249.7	304.6	160.0	219.9	7
8	241.5	095.6	193.0	041.3	090.8	297.8	347.9	196.8	047.5	102.5	317.9	017.9	8
9	039.4	253.4	350.7	198.9	248.4	095.5	145.6	354.6	205.3	260.4	115.9	175.9	9
10	197.4	051.2	148.4	356.6	046.1	253.2	303.3	152.3	003.1	058.3	273.8	334.0	10
11	355.3	209.0	306.1	154.2	203.7	050.8	101.0	310.0	160.9	216.1	071.8	132.0	11
12	153.2	006.8	103.8	311.9	001.3	208.5	258.6	107.8	318.7	014.0	229.8	290.0	12
13	311.1	164.6	261.5	109.6	159.0	006.1	056.3	265.5	116.5	171.9	027.8	088.1	13
14	109.1	322.4	059.2	267.2	316.6	163.8	214.0	063.3	274.3	329.8	185.7	246.1	14
15	267.0	120.2	216.9	064.9	114.3	321.4	011.7	221.0	072.1	127.7	343.7	044.2	15
16	064.9	278.0	014.6	222.5	271.9	119.1	169.4	018.8	229.9	285.6	141.7	202.2	16
17	222.8	075.8	172.3	020.2	069.6	276.8	327.1	176.5	027.8	083.5	299.7	000.2	17
18	020.7	233.6	330.0	177.8	227.2	074.4	124.8	334.3	185.6	241.4	097.7	158.3	18
19	178.6	031.3	127.7	335.5	024.9	232.1	282.5	132.0	343.4	039.3	255.7	316.3	19
20	336.5	189.1	285.4	133.1	182.5	029.8	080.2	289.8	141.2	197.2	053.7	114.4	20
21	134.4	346.9	083.1	290.8	340.1	187.4	237.9	087.5	299.1	355.1	211.6	272.4	21
22	292.2	144.6	240.8	088.4	137.8	345.1	035.6	245.3	096.9	153.0	009.6	070.5	22
23	090.1	302.4	038.5	246.1	295.4	142.8	193.3	043.0	254.7	310.9	167.6	228.5	23
24	248.0	100.1	196.2	043.7	093.1	300.4	351.0	200.8	052.5	108.8	325.6	026.6	24
25	045.9	257.9	353.9	201.4	250.7	098.1	148.7	358.6	210.4	266.7	123.7	184.6	25
26	203.7	055.6	151.5	359.0	048.4	255.8	306.5	156.3	008.2	064.7	281.7	342.6	26
27	001.6	213.4	309.2	156.7	206.0	053.4	104.2	314.1	166.1	222.6	079.7	140.7	27
28	159.5	011.1	106.9	314.3	003.7	211.1	261.9	111.9	323.9	020.5	237.7	298.7	28
29	317.3		264.6	112.0	161.3	008.8	059.6	269.6	121.8	178.5	035.7	096.8	29
30	115.2		062.3	269.6	319.0	166.5	217.3	067.4	279.6	336.4	193.7	254.8	30
31	273.0		219.9		116.6		015.0	225.2		134.3		052.9	31

SYSTEM II (° at 0 hr UT)													
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	358.8	337.4	221.8	194.0	014.8	345.3	166.2	138.3	112.0	297.6	275.8	106.4	1
2	149.2	127.6	011.9	344.0	164.8	135.3	316.3	288.4	262.1	087.8	066.1	256.7	2
3	299.5	277.8	162.0	134.1	314.8	285.3	106.3	078.5	052.3	238.0	216.4	047.1	3
4	089.8	068.0	312.1	284.1	104.8	075.3	256.4	228.6	202.5	028.2	006.8	197.5	4
5	240.2	218.2	102.2	074.1	254.8	225.3	046.4	018.7	352.6	178.5	157.1	347.9	5
6	030.5	008.4	252.3	224.2	044.8	015.4	196.5	168.8	142.8	328.7	307.4	138.3	6
7	180.8	158.6	042.4	014.2	194.9	165.4	346.5	318.9	292.9	118.9	097.7	288.7	7
8	331.1	308.7	192.5	164.2	344.9	315.4	136.6	109.0	083.1	269.2	248.0	079.1	8
9	121.4	098.9	342.6	314.3	134.9	105.4	286.6	259.1	233.3	059.4	038.4	229.5	9
10	271.7	249.1	132.6	104.3	284.9	255.5	076.7	049.2	023.4	209.7	188.7	019.9	10
11	062.0	039.3	282.7	254.3	074.9	045.5	226.7	199.3	173.6	359.9	339.1	170.3	11
12	212.3	189.4	072.8	044.4	224.9	195.5	016.8	349.4	323.8	150.2	129.4	320.7	12
13	002.6	339.6	222.9	194.4	014.9	345.6	166.9	139.5	114.0	300.4	279.7	111.1	13
14	152.9	129.8	013.0	344.4	165.0	135.6	316.9	289.6	264.1	090.7	070.1	261.5	14
15	303.2	279.9	163.0	134.4	315.0	285.6	107.0	079.7	054.3	240.9	220.4	052.0	15
16	093.5	070.1	313.1	284.5	105.0	075.6	257.1	229.9	204.5	031.2	010.8	202.4	16
17	243.7	220.2	103.2	074.5	255.0	225.7	047.1	020.0	354.7	181.5	161.1	352.8	17
18	034.0	010.4	253.2	224.5	045.0	015.7	197.2	170.1	144.9	331.7	311.5	143.2	18
19	184.3	160.5	043.3	014.5	195.0	165.7	347.3	320.2	295.1	122.0	101.9	293.6	19
20	334.5	310.7	193.4	164.6	345.0	315.8	137.3	110.3	085.3	272.3	252.2	084.0	20
21	124.8	100.8	343.4	314.6	135.1	105.8	287.4	260.5	235.5	062.6	042.6	234.4	21
22	275.1	250.9	133.5	104.6	285.1	255.8	077.5	050.6	025.6	212.8	192.9	024.8	22
23	065.3	041.1	283.5	254.6	075.1	045.9	227.6	200.7	175.9	003.1	343.3	175.3	23
24	215.6	191.2	073.6	044.6	225.1	195.9	017.6	350.9	326.1	153.4	133.7	325.7	24
25	005.8	341.3	223.7	194.7	015.1	346.0	167.7	141.0	116.3	303.7	284.1	116.1	25
26	156.0	131.4	013.7	344.7	165.1	136.0	317.8	291.1	266.5	094.0	074.4	266.5	26
27	306.3	281.5	163.8	134.7	315.2	286.0	107.9	081.3	056.7	244.3	224.8	056.9	27
28	096.5	071.7	313.8	284.7	105.2	076.1	258.0	231.4	206.9	034.6	015.2	207.3	28
29	246.7		103.9	074.7	255.2	226.1	048.0	021.5	357.1	184.9	165.6	357.8	29
30	036.9		253.9	224.7	045.2	016.2	198.1	171.7	147.3	335.2	316.0	148.2	30
31	187.2		043.9		195.2		348.2	321.8		125.5		298.6	31

Jupiter is a gas giant and we can only view the upper atmospheric features. Only a small telescope (even a 60 mm instrument) is needed 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 77.2°. 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 314.7°. (if greater than 360°, subtract 360°).

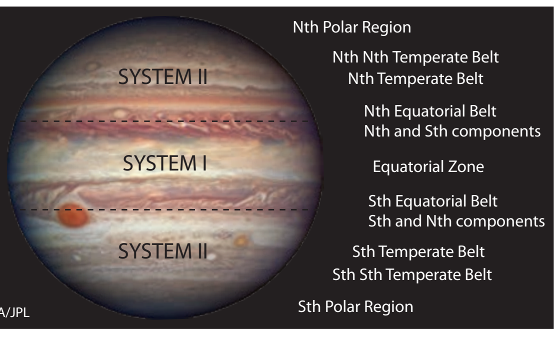
GREAT RED SPOT TRANSIT TIME

The GRS can best be seen from about one hour before transiting the central meridian to one hour after. During this two-hour period it will move approximately 70% of the width of Jupiter at its latitude. It can be seen a further 30 minutes either side of this period, but it tends to appear foreshortened and merging with the limb. The longitude of the GRS (System II) does drift inconsistently over the years. For example the following are some actual values for June: 2017 (274°), 2018 (290°), 2019 (312°), 2020 (339°), 2021 (359°), 2022 (22°), 2023 (45°) and 2024 (59°). The table of data for 2025 (opposite) has been based on 80°. For every degree of longitude greater than 80° it will transit 1.6 minutes later than shown (for every degree less than 80°, 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 2025. This is an estimated midpoint of the GRS. The spot is about 15° in diameter, so it takes around 24 minutes to transit.

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

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

SYSTEM II applies to the remainder of the surface.



Jupiter image credit NASA/JPL

Increase In Longitude SYSTEM II Rotation: 9 h 55 m 40.062 s					
hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

JUPITER — GREAT RED SPOT

Date	1st	2nd	3rd
Jan 1	2:18 *		22:10 *
Jan 3	(1:56)		23:48 *
Jan 4		19:39	
Jan 5			(23:26)
Jan 6	1:26	(19:17)	21:17
Jan 8	(1:04)		22:55 *
Jan 9		18:47	
Jan 10	(2:42)		(22:34)
Jan 11	0:34		20:25
Jan 13	(0:12)		22:03 *
Jan 15	(1:50)		23:42 *
Jan 16		19:33	
Jan 17			(23:20)
Jan 18	1:20	(19:11)	21:11
Jan 20	(0:58)		22:50 *
Jan 21		18:41	
Jan 22			(22:28)
Jan 23	0:28		20:20
Jan 25	(0:07)		21:58 *
Jan 27			23:37 *
Jan 28		19:28	
Jan 29			(23:15)
Jan 30		(19:07)	21:07
Feb 1	(0:54)		22:45 *
Feb 2		18:37	
Feb 3			(22:24)
Feb 4	0:24		20:15
Feb 6	(0:02)		21:54 *
Feb 8			23:32 *
Feb 9		19:24	
Feb 10			(23:11)
Feb 11		(19:03)	21:03
Feb 13			22:41 *
Feb 14		18:33	
Feb 15			(22:20)
Feb 16			20:12
Feb 17			(23:59)
Feb 18		(19:50)	21:50
Feb 20			23:29 *
Feb 21		19:21	
Feb 22			(23:08)
Feb 23		(19:00)	21:00

Date	1st	2nd	3rd
Feb 25			22:39 *
Feb 26		18:30	
Feb 27			(22:17)
Feb 28			20:09
Mar 2		(19:48)	21:48
Mar 4			(21:27)
Mar 5		19:19	
Mar 6			(23:06)
Mar 7		(18:57)	20:57
Mar 9			(20:36)
Mar 10		18:28	
Mar 11			(22:15)
Mar 12			20:07
Mar 14		(19:46)	21:46
Mar 16			(21:25)
Mar 17		19:17	
Mar 19		(18:56)	20:56
Mar 21			(20:35)
Mar 22		18:27	
Mar 24		(18:06)	20:06
Mar 26		(19:45)	
Mar 27		17:37	
Mar 28			(21:24)
Mar 29		19:16	
Mar 31		(18:55)	20:55
Apr 2			(20:34)
Apr 3		18:26	
Apr 5		(18:05)	20:05
Apr 7		(19:44)	
Apr 8		17:36	
Apr 10		19:15	
Apr 12		(18:54)	
Apr 14			(20:33)
Apr 15		18:25	
Apr 17		(18:04)	20:04
Apr 19		(19:44)	
Apr 20		17:35	
Apr 22		19:15	
Apr 24		(18:54)	
Apr 27		18:25	
Apr 29		(18:04)	
May 1		(19:43)	

Date	1st	2nd	3rd
May 2		17:35	
May 4		19:14 *	
May 6		(18:53)	
May 7		16:45	
May 9		18:24	
May 11		(18:04)	
May 14		17:35	
May 16		(17:14)	
May 18		(18:53)	
May 19		16:45	
May 21		18:24	
May 23		(18:03)	
May 26		17:34	
May 28		(17:14)	
Jul 20	(6:25)		
Jul 23	5:55		
Jul 27	(7:13)		
Jul 30	6:44		
Aug 1	(6:23)		
Aug 4	5:54		
Aug 6	(5:33)		
Aug 8	(7:12)		
Aug 9	5:03		
Aug 11	6:42		
Aug 13	(6:21)		
Aug 16	5:52		
Aug 18	(5:30)		
Aug 20	(7:09)		
Aug 21	5:01		
Aug 23	6:40 *		
Aug 25	(6:19)		
Aug 26	4:10		
Aug 28	5:49		
Aug 30	(5:28)		
Sep 2	4:58		
Sep 4	6:37 *		
Sep 6	(6:16)		
Sep 7	4:07		
Sep 9	5:46 *		
Sep 11	(5:25)		
Sep 12	3:16		
Sep 14	4:55		

Date	1st	2nd	3rd
Sep 16	(4:33)		
Sep 18	(6:12)		
Sep 19	4:04		
Sep 21	5:42 *		
Sep 23	(5:21)		
Sep 24	3:12		
Sep 26	4:51 *		
Sep 28	(4:30)		
Sep 29	2:21		
Sep 30	(6:08)		
Oct 1	3:59		
Oct 3	5:38 *		
Oct 5	(5:17)		
Oct 6	3:08		
Oct 8	4:46 *		
Oct 10	(4:25)		
Oct 11	2:16		
Oct 12	(6:03)		
Oct 13	3:55 *		
Oct 15	5:33 *		
Oct 16	1:25		
Oct 17	(5:12)		
Oct 18	3:03		
Oct 20	4:41 *		
Oct 22	(4:20)		
Oct 23	2:11		
Oct 25	3:49 *		
Oct 27	5:28 *		
Oct 28	1:19		
Oct 29	(5:06)		
Oct 30	2:57 *		
Nov 1	4:35 *		
Nov 2	0:27		
Nov 3	(4:14)		
Nov 4	2:05 *		
Nov 6	3:43 *		
Nov 8	(3:21)		
Nov 9	1:13		
Nov 10	(5:00)		
Nov 11	2:51 *		
Nov 13	4:29 *		
Nov 14	0:20		

Date	1st	2nd	3rd
Nov 15	(4:07)		(23:59)
Nov 16	1:58		
Nov 18	3:36 *		23:28
Nov 20	(3:15)		(23:06)
Nov 21	1:06		
Nov 22	(4:53)		
Nov 23	2:44 *		22:35
Nov 25	4:22 *		
Nov 26	0:13		
Nov 27	(4:00)		(23:51)
Nov 28	1:51		
Nov 30	3:29 *		23:20
Dec 2	(3:07)		(22:59)
Dec 3	0:58		
Dec 4	(4:45)		
Dec 5	2:36 *		22:28
Dec 7	4:14 *		(22:06)
Dec 8	0:05		
Dec 9	(3:52)		(23:44)
Dec 10	1:43		21:35
Dec 11	(5:30)		
Dec 12	3:21 *		23:13
Dec 14	4:59 *		(22:51)
Dec 15	0:50		
Dec 16	(4:37)		
Dec 17	2:28 *		22:20
Dec 19	4:06 *		23:57 *
Dec 21	(3:44)		(23:35)
Dec 22	1:35		21:27
Dec 23	(5:22)		
Dec 24	3:13 *		23:04 *
Dec 26	4:51 *		(22:42)
Dec 27	0:42		20:33
Dec 28	(4:29)		
Dec 29	2:20 *		22:11
Dec 31	3:58 *		23:49 *

1st, 2nd or 3rd GRS

h:mm EST (Eastern only)
h:mm* EST (All States)
(h:mm) WST (WA only)

JUPITER

Predictions are shown for transit times for Sydney and Perth (giving a reasonable indication for eastern and western Australia). Times have been excluded when Jupiter is near conjunction (within 18° of the Sun) or below the horizon. If a transit is predicted when Jupiter is close to the horizon, the GRS may still be seen at least one hour before or after the time (allowing it to have some altitude). Predictions during daylight hours have also been omitted, except for those within 30 minutes after sunrise or before sunset. Even if there is a transit close to sunrise or sunset, the GRS can be seen well into the twilight period.

With a transit occurring every 9 hours 55 min 40 seconds, two or three transits will occur every day, but a maximum of two are visible from any location. The three columns represent the 1st, 2nd and 3rd transits for each day. Note if the first transit for the day in EST is before 2 am, the event will be the last transit (3rd) for the previous day in WST (assuming Jupiter is visible). When the same transit is visible across the country, only the EST time is given followed by an asterisk (*). To get the WST time subtract two hours from the EST. For CST subtract 30 minutes from EST. For an event only visible from WA the time is given in brackets (WST). Daylight Saving is not allowed for, you will need to add one hour to the times in the table when in effect.

For example, on 3 January the first transit is only visible from WA at 1:56 am WST. The 3rd transit for the day is visible Australia wide at 23:48 EST or 11:48 pm EST (11:18 pm CST, 9:48 pm WST).

SATURN'S MOONS

These pages help you find the position of Saturn's major satellites. Note that dates and times here are given in days and fractions of a day in UT. You will need to convert your local time to this format first. Table 3 will help.

The worked examples here are based on a diagram of the satellite's configuration for 22 September midnight EST (p. 64).

Rhea and Dione

Table 1 presents the times of the first greatest elongation to the east for each month. This location is the day 0 point on the Apparent Orbits diagram (below). The procedure is to work out how many orbits have elapsed since the first elongation of the month, then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram below. You wish to determine the position of Rhea for the date above.

1. Convert to UT as a fractional day (table 3) to get 22.583 UT.
2. Subtract the date of the greatest elongation east for Rhea for September, i.e. 22.583 −3.727 = 18.856
3. Express this as the number of orbits by dividing by the period i.e. 18.856 / 4.518 = 4.174
4. Discard any complete orbits (4 in this case) leaving 0.174
5. Multiply by the period, 0.174 × 4.518 = 0.786 days or about 19 hours after elongation east.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is east of Saturn, approaching inferior conjunction.

Mimas, Enceladus and Tethys

The procedure is similar to Rhea and Dione with the times of the first greatest elongation east for each month also being listed in Table 1. However, these inner moons are so close to Saturn that while the orbits are represented on the diagram, it is difficult to put the day markers on and still have it readable. As above we calculate the fraction of the orbit and then estimate its position. Like the other major moons, these three still orbit in the same direction (anticlockwise), so three quarters of an orbit (0.75) would place it north of Saturn.

Estimate the position for Tethys using the same date, September 22.583 UT; 10.873 orbits have elapsed since the first greatest elongation east for September on 2.056 UT. Discarding the completed orbits leaves 0.873 of an orbit. This is east of Saturn approaching its next elongation east.

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	1.176	1.162	1.465	3.628	2.618
February	1.286	1.689	2.574	2.755	3.276
March	1.569	1.106	1.018	2.147	2.418
April	1.679	1.634	2.129	1.278	3.083
May	1.843	1.789	2.348	1.405	4.743
June	1.004	2.310	1.563	3.265	5.392
July	1.161	1.087	1.771	3.377	2.507
August	1.256	1.598	2.860	2.479	3.125
September	1.348	2.106	2.056	1.573	3.727
October	1.499	2.243	2.250	1.663	5.322
November	1.596	1.383	1.447	3.493	1.409
December	1.755	1.528	1.651	3.598	3.027

Notes 1. When at opposition 2. Mean Synodic Period

Titan and Hyperion

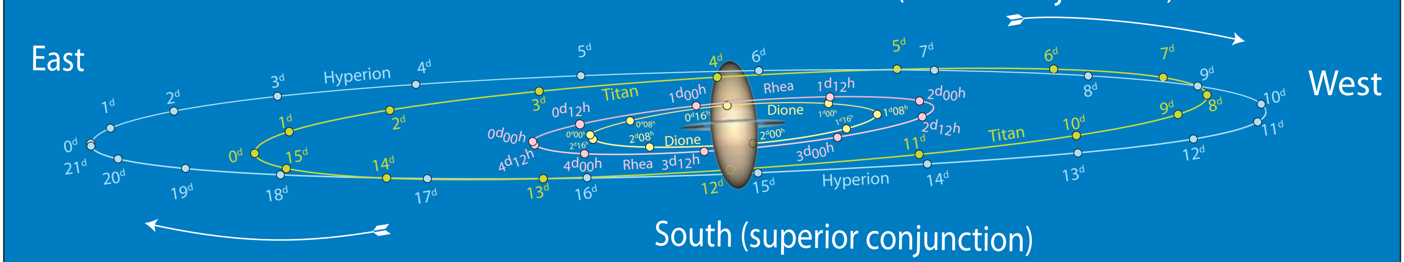
Because of their long orbital periods, compared to the moons shown opposite, it is possible to list all of their greatest eastern elongations for the year (see Table 2). Therefore, all you need to do is work out the number of days that have elapsed since the most recent elongation and read this position directly off the diagram.

Using our previous example 22 September midnight EST (22.583 UT), Titan is about 6.4 days past its most recent greatest elongation east (September 16.203 UT), which puts it west of Saturn. The diagrams below and on page 64 show this very well.

Iapetus

This moon's orbit is too large to place on the Apparent Orbits diagram. The shape of its orbit is similar to the others but more inclined and over twice the diameter of Hyperion's. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from stars of similar brightness. Table 4 shows this moon's greatest elongations east, inferior conjunctions (due south of Saturn), greatest elongations west and superior conjunctions (north of Saturn) for the year. Taking the same example date and time as above, 22 September midnight EST (22.583 UT), the most recent event was a superior conjunction on September 18.688 (UT). Iapetus is 3.9 days past this time, heading towards an elongation east, so it is to the east of the planet.

APPARENT ORBITS OF SATURN'S SATELLITES



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

Apparent orbits of the satellites on 21 September at 5 hrs UT. Only four of the inner satellites are shown. The orbits of Iapetus and Phoebe are too large to show.

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	3.506	19.726
	19.510	
February	4.523	10.251
	20.545	
March	8.570	3.769
	24.595	25.286
April	9.619	15.771
	25.637	
May	11.646	7.212
	27.645	28.608
June	12.630	18.94
	28.600	
July	14.552	10.201
	30.486	31.402
August	15.404	21.545
	31.308	
September	16.203	11.63
October	2.097	2.704
	17.995	23.799
November	2.904	13.9
	18.830	
December	4.773	5.06
	20.735	26.304

Notes 1. When at opposition
2. Mean Synodic Period

The Appearance of the Planets diagrams in Part I show how open the rings are for 2025. 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 are edge-on during 2025, next time will be 2038.

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.

SATURN'S RINGS 2025

Date	Major "	Minor "	B °
Jan 1	37.6	2.8	4.3
Jan 9	37.2	2.6	3.9
Jan 17	36.8	2.3	3.6
Jan 25	36.5	2.0	3.2
Feb 2	36.2	1.8	2.8
Feb 10	36.0	1.5	2.4
Feb 18	35.8	1.2	1.9
Feb 26	35.7	0.9	1.5
Mar 6	35.6	0.6	1.0
Mar 14	35.6	0.3	0.6
Mar 22	35.6	0.1	0.1
Mar 30	35.7	−0.2	−0.3
Apr 7	35.9	−0.5	−0.8
Apr 15	36.1	−0.8	−1.2
Apr 23	36.3	−1.0	−1.6
May 1	36.6	−1.3	−2.0
May 9	37.0	−1.5	−2.3
May 17	37.3	−1.7	−2.6
May 25	37.8	−1.9	−2.9
Jun 2	38.2	−2.1	−3.1
Jun 10	38.8	−2.2	−3.3
Jun 18	39.3	−2.4	−3.5
Jun 26	39.8	−2.5	−3.6
Jul 4	40.4	−2.5	−3.6
Jul 12	41.0	−2.6	−3.6
Jul 20	41.5	−2.6	−3.6
Jul 28	42.1	−2.5	−3.5
Aug 5	42.6	−2.5	−3.3
Aug 13	43.0	−2.3	−3.1
Aug 21	43.4	−2.2	−2.9
Aug 29	43.7	−2.0	−2.7
Sep 6	44.0	−1.8	−2.4
Sep 14	44.1	−1.6	−2.1
Sep 22	44.1	−1.4	−1.8
Sep 30	44.1	−1.2	−1.5
Oct 8	43.9	−0.9	−1.2
Oct 16	43.7	−0.8	−1.0
Oct 24	43.3	−0.6	−0.8
Nov 1	42.9	−0.4	−0.6
Nov 9	42.5	−0.3	−0.5
Nov 17	41.9	−0.3	−0.4
Nov 25	41.4	−0.3	−0.4
Dec 3	40.8	−0.3	−0.4
Dec 11	40.3	−0.3	−0.5
Dec 19	39.7	−0.4	−0.6
Dec 27	39.2	−0.6	−0.8

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**

Max Elong. [1] 9' 35"

Magnitude [1] 11.0 Period (days) [2] 79.331

SuperiorConjunction		**Elongation East**		**Inferior Conjunction**		**Elongation West**	
Jan	21.136	Feb	9.705	Mar	2.201	Mar	23.208
Apr	12.405	May	2.395	May	22.579	Jun	12.471
Jul	1.977	Jul	21.646	Aug	10.273	Aug	30.43
Sep	18.688	Oct	7.63	Oct	27.406	Nov	16.317
Dec	6.299	Dec	25.465				

Notes 1. When at opposition 2. Mean Synodic Period

SATELLITE EVENTS

As Saturn is going through a ring crossing this year, satellite events similar to Jupiter (p. 117) can be seen. Shown here are satellite events (below) and mutual events (right) for 2025. We have only included events for Titan (Sat 6) while Saturn is up and it is night.

Date	EST	WST	Sat	Event	Vis
Mar 29	05:34	03:34	6	Tr E	E
Apr 14	05:45	03:45	6	Tr E	E
22	04:23	02:23	6	Oc R	E
30	05:16	03:16	6	Tr E	E
May 8	03:30	01:30	6	Oc R	E
Sep 20	18:27	16:27	6	Tr E	E

Date	EST Start	EST End	WST Start	WST End	Vis	Event	Kind	Mag Drop	% Illuminate	Sep	PA°	Min Dist
30 Apr	06:00	06:07	04:00	04:07	W	Titan ECL Tethys	T	9.9	0	19.1	271	0.134
30 Apr	07:35	07:42	05:35	05:42	W	Titan ECL Enceladus	T	9.9	0	22.5	272	0.056
6 Jun	07:40	07:55	05:40	05:55	W	Hyperion ECL Titan	E	0	99.7	153.3	272	0.295

Event The first mentioned moon either eclipses (ecl) or occults (occ) the second mentioned moon.

Kind E = Penumbral eclipse, T = Total eclipse, where the eclipsed moon is fully obscured

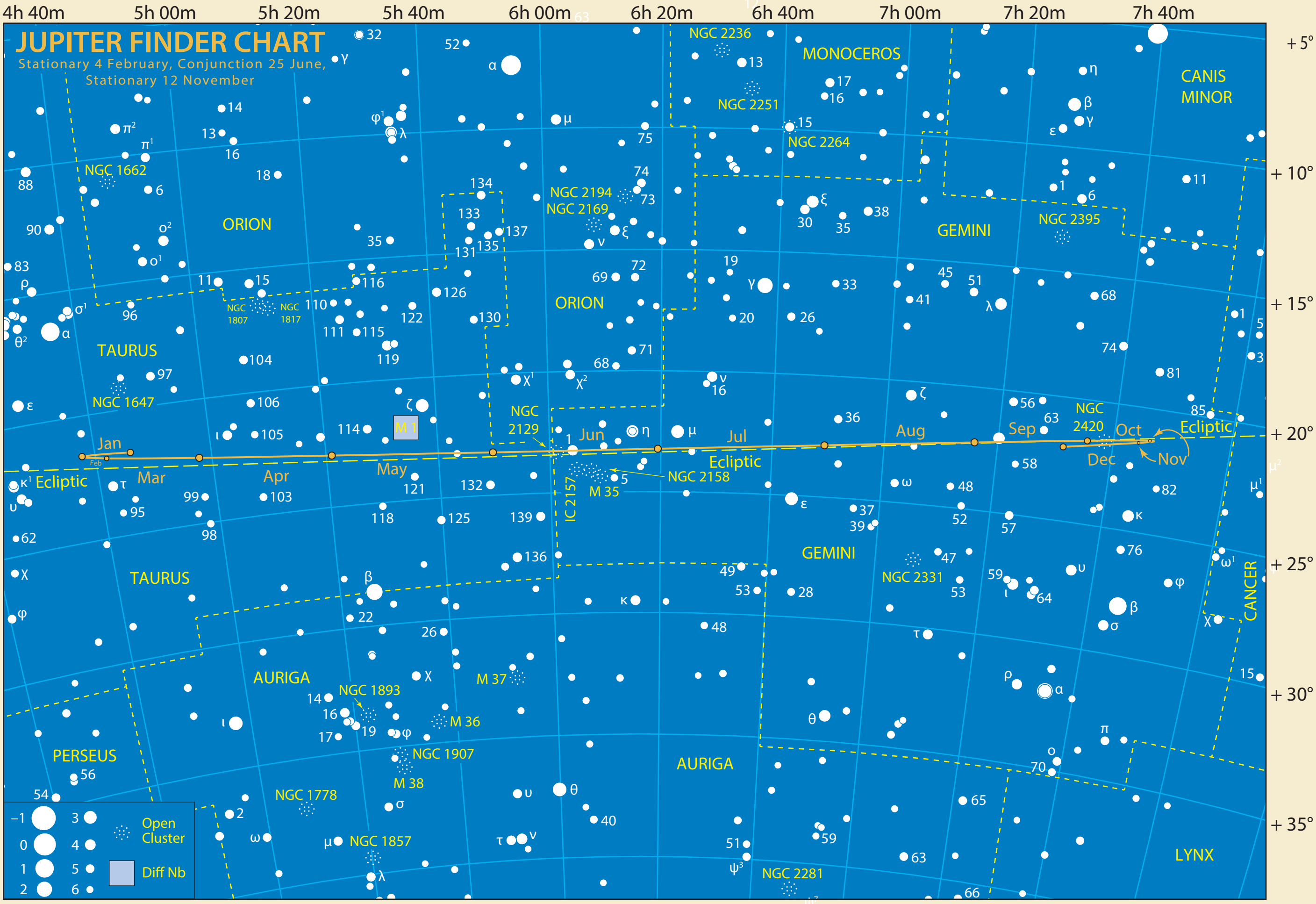
Mag Drop The magnitude drop. In the case of occultations, it is in comparison to the combined magnitude of the two moons. A value of 9.9 indicates a total eclipse.

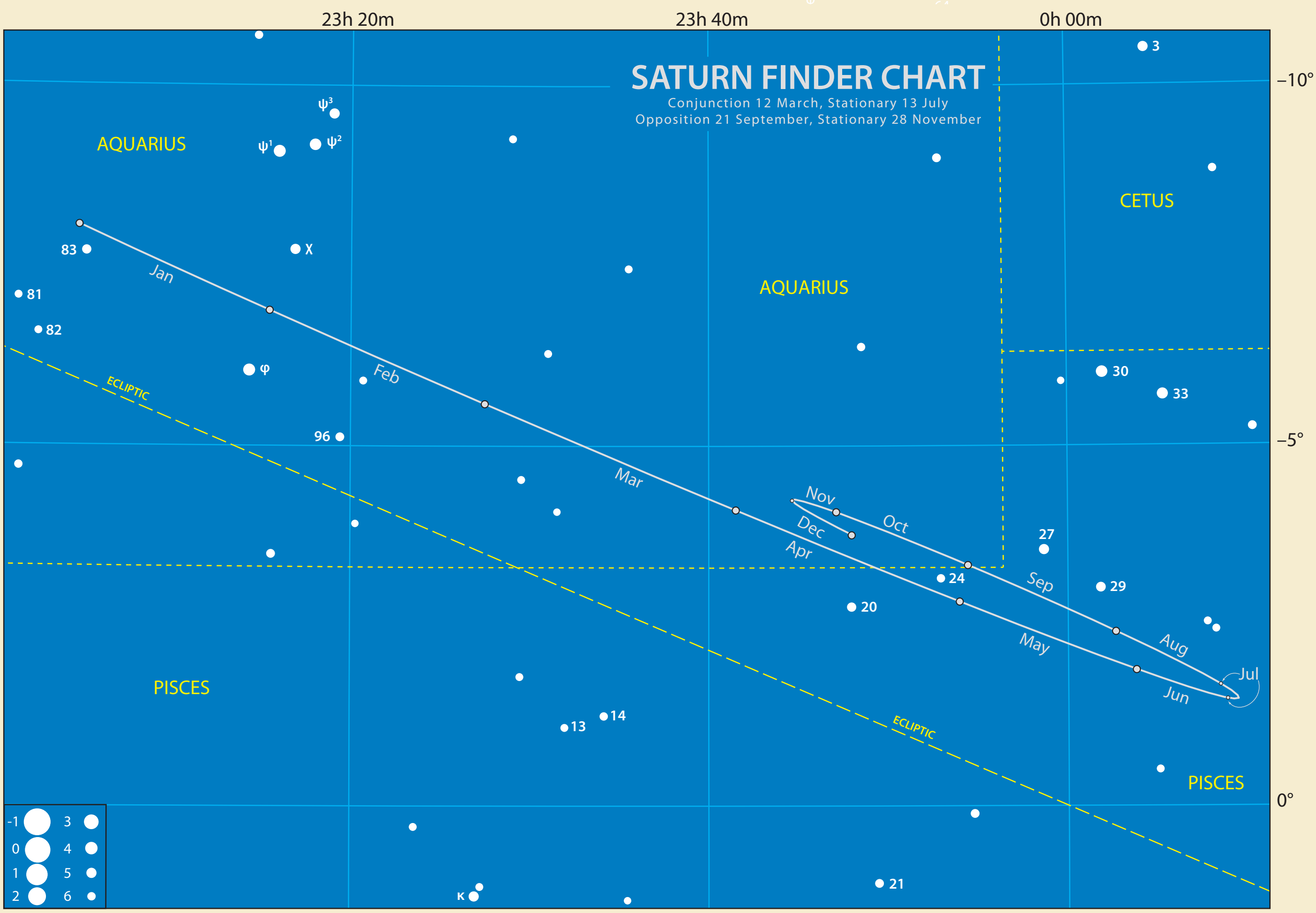
% Illuminate The illumination at maximum eclipse or occultation, as a percentage of the full illumination of the moon alone (eclipses) or of both moons (occultations).

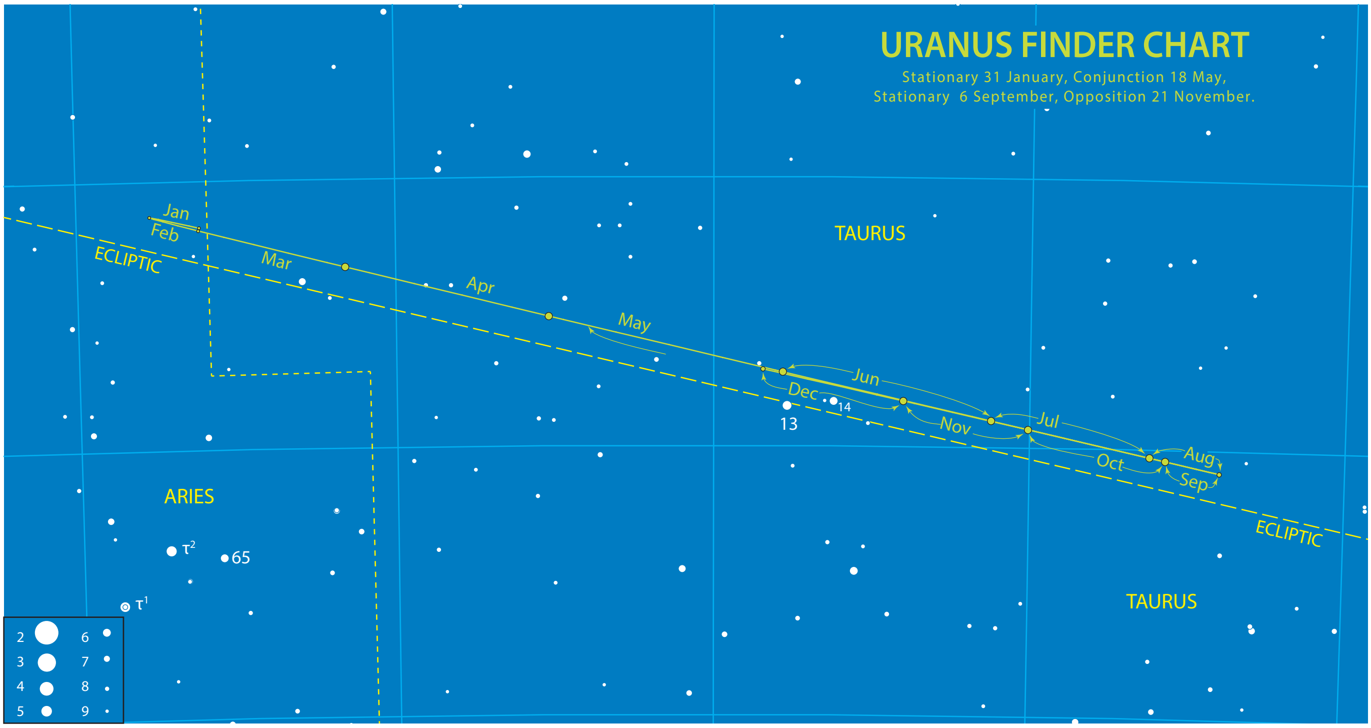
Sep Distance (arcsecs) of the eclipsed/occulted satellite from the centre of the planet.

PA PA (deg) of the eclipsed/occulted satellite with respect to the planet.

Min Dist The minimum separation of the centres of the satellites, or satellite and shadow, in arcseconds


JUPITER FINDER CHART
Stationary 4 February, Conjunction 25 June,
Stationary 12 November
4h 40m
5h 00m
5h 20m
5h 40m
6h 00m
6h 20m
6h 40m
7h 00m
7h 20m
7h 40m
+ 5°
+ 10°
+ 15°
+ 20°
+ 25°
+ 30°
+ 35°
ORION
TAURUS
MONOCEROS
CANIS MINOR
GEMINI
AURIGA
PERSEUS
CANCER
LYNX
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
NGC 1662
NGC 1807
NGC 1817
NGC 1647
NGC 2236
NGC 2251
NGC 2264
NGC 2194
NGC 2169
NGC 2129
NGC 2158
IC 2157
M 35
M 1
NGC 2395
NGC 2420
NGC 2331
NGC 1893
M 37
M 36
NGC 1907
M 38
NGC 1778
NGC 1857
NGC 2281
Open Cluster
Diff Nb


SATURN FINDER CHART
Conjunction 12 March, Stationary 13 July
Opposition 21 September, Stationary 28 November
23h 20m
23h 40m
0h 00m
−10°
−5°
0°
AQUARIUS
CETUS
PISCES
ECLIPTIC
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



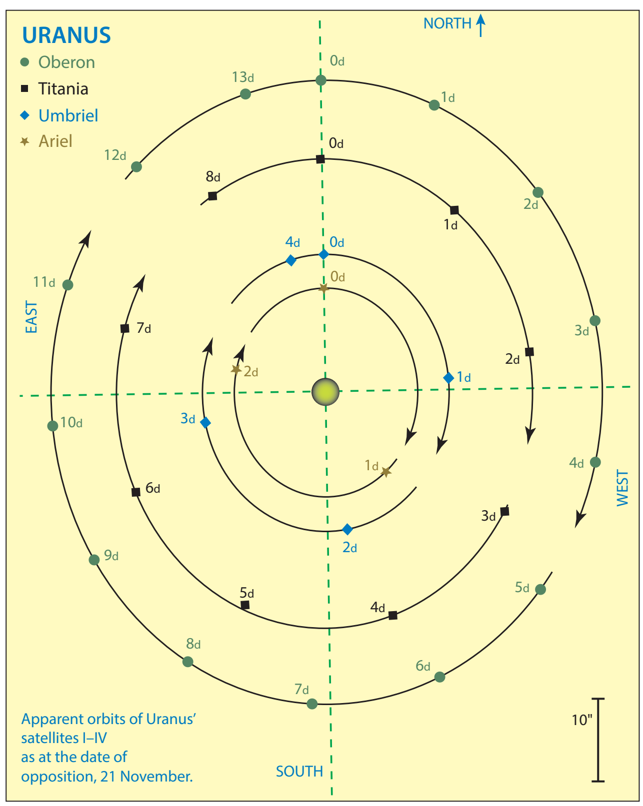
URANUS' MOONS

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 21 November at 1 am (WST).

1. Convert to UT as a fractional day. 21 November at 1 am (WST) = 20.708 UT (refer table 1 next page).

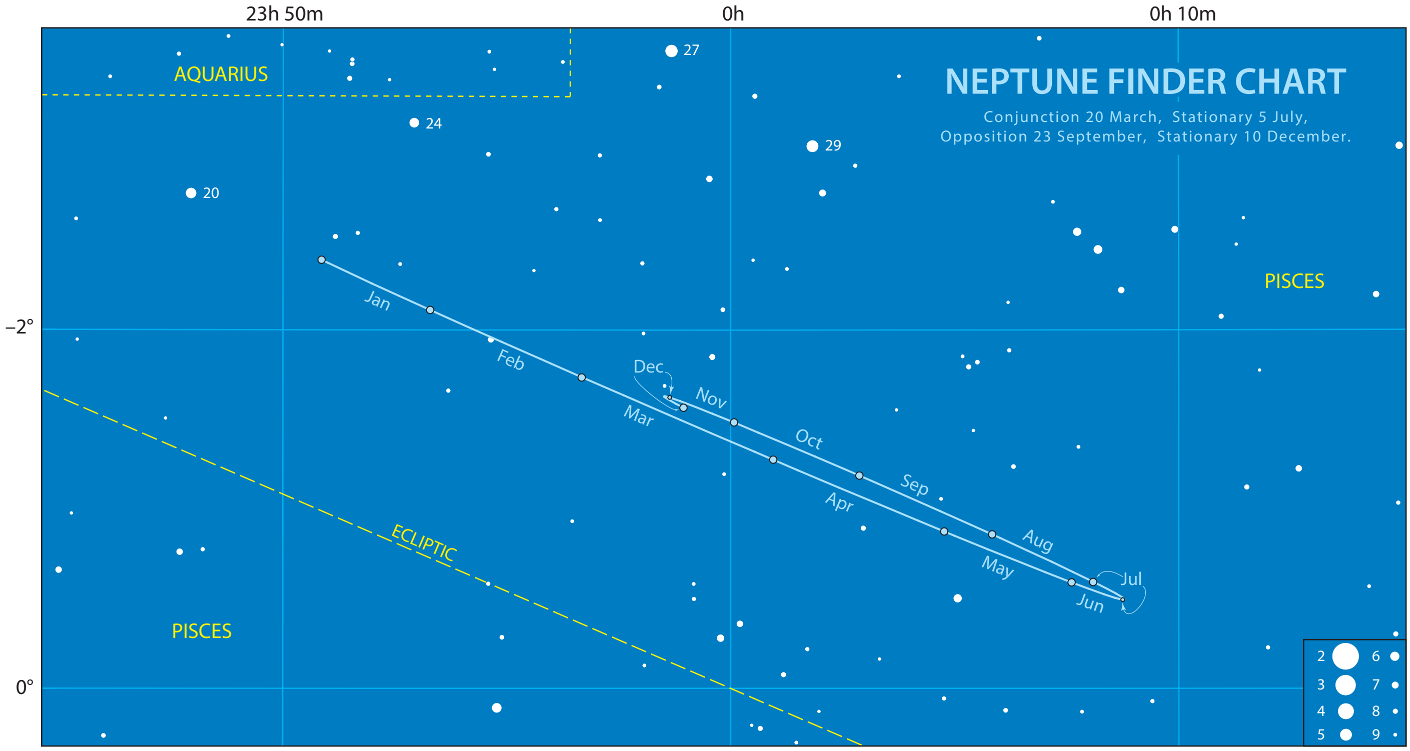
Table 2a: **Time of Greatest Elongation North** (UT)				
Planet	**Uranus**			
Moon	**Ariel**	**Umbriel**	**Titania**	**Oberon**
Magnitude [1]	13.7	14.5	13.5	13.7
Max Elong. [1]	0' 14"	0' 20"	0' 33"	0' 44"
Period (days) [2]	2.520	4.144	8.706	13.463
Month	**Elongation North (d.ddd)**			
January	2.593	1.395	5.863	14.351
February	1.841	3.553	9.698	10.268
March	1.566	4.560	7.809	9.183
April	3.327	2.564	2.908	5.092
May	1.045	1.562	7.695	1.988
June	2.797	3.693	2.784	11.303
July	3.029	2.687	7.577	8.161
August	2.262	4.820	2.668	4.052
September	1.500	2.817	6.466	13.440
October	1.744	1.833	2.580	10.386
November	3.515	3.993	6.434	6.323
December	1.248	3.015	2.582	3.264
Notes 1. When at opposition	2. Sidereal Period			

2. Subtract the date of the greatest elongation north for November, i.e. 20.708 − 3.993 = 16.715 days.
3. Divide by the period to get the number of orbits, i.e. 16.715 / 4.144 = 4.034 orbits.
4. Discarding whole orbits leaves 0.034 (about 3% of an orbit)..
5. Multiply by the period, 0.034 × 4.144 = 0.141 days (3.4 hours).
6. Looking at its orbital path (see Apparent Orbits diagram), the satellite is just after the 0 day mark, just after a northern elongation.



Apparent orbits of Uranus' satellites I–IV as at the date of opposition, 21 November.

NEPTUNE



Uranus and Neptune are unusual in that they are the only planets that needed optical aids to discover them. The remaining planets, being naked-eye, do not have a recognised known discoverer.	The information on these pages help you find the position of Uranus' major satellites and Neptune's moon Triton. Dates and times are in days and fractions of a day in UT. You need to convert your local time to UT first. Table 1, will help.

NEPTUNE'S MOON

The procedure for finding Neptune's major satellite **Triton** is identical to that for Uranus, except the times of the first greatest elongation *east* for each month are listed in Table 2b. The orientation of Triton's orbit places this day 0 (zero) point closer to north-east of Neptune (see diagram).

Table 1: **Converting Time in Australia to Universal Time (UT)**

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

After midnight it is still the previous day in UT, e.g. 1 am (EST) on the 21st = 20.625 days UT

An example. Estimate the position for Triton for September 15 at 10 pm EST. 1.483 orbits have elapsed since its greatest elongation east on Sep 6.786 UT. Discarding the whole orbits leaves 0.483. Multiplying by 5.877 (its period) gives 2.839 days. From the diagram the moon is south of Neptune, approaching a greatest western elongation.

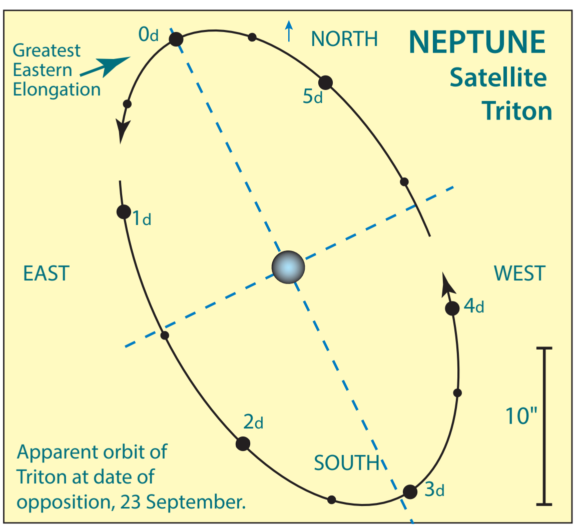


Table 2b: **Time of Greatest Elongation East** (UT)

Planet	**Neptune**
Moon	**Triton**
Magnitude [1]	13.5
Max Elong. [1]	0' 17"
Period (days) [2]	5.877
Month	**East** (d.ddd)
January	3.019
February	1.396
March	2.768
April	1.137
May	6.380
June	4.753
July	4.132
August	2.517
September	6.786
October	6.181
November	4.577
December	4.635

Notes 1. At opposition
2. Sidereal Period

COMETS FOR 2025

WHAT IS A COMET? It is usually a member of the Solar System, which is normally in a highly elongated orbit around the Sun. The orbits of periodic, or regularly reappearing comets, are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive and containing significant quantities of water (in the form of ice) and rocks/dust. The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. One of the shortest period comets, 2P/Encke, takes just over three years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds or even thousands of years. Each year sees the discovery of comets that have not been recorded before.

As a comet draws closer to the Sun, the nucleus heats up and the ice sublimates forming a cloud called a coma around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionised particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of dust grains that trail behind the comet along its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails, some may only show a coma.

Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets, you will see examples on the following pages. The prefix 'P/' means the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 2P/Encke indicates it was the 2nd comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. You will also see references to another naming system, best explained with an example. The Tsuchinshan-ATLAS comet, mentioned (next page), is referred to as 'C/2023 A3'. 2023 refers to the year of the discovery, A is the 1st 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/2023 A3 (Tsuchinshan-ATLAS) was the third comet discovered in the first half of January 2023.

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 2025. The table on page 133 lists comets that are expected to brighten to at least 13th magnitude sometime during the year, along with their orbital elements. This is the data required to calculate their locations in the sky. The elements are followed by ephemerides (a list of expected positions in the sky and magnitude estimates for different dates). These positions can be plotted on the All Sky Maps to get an idea of where they are in the sky. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could be too close to the Sun or on the opposite side of the Sun from Earth. This would be considered unfavourable.

There are many other comets not listed here expected in 2025, but are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

SELECTED NOTES ON COMETS FOR 2025 by Greg Bryant

24P/Schaumasse: French astronomer Alexandre Schaumasse (1882–1958) discovered this periodic comet on 1 December 1911 from Nice, France. 12th magnitude at the time, the comet brightened by another magnitude before fading. During January 1912, it became apparent that the comet was of short period, orbiting the Sun every eight years.

1919 saw comet Schaumasse recovered a week after its predicted perihelion passage. Future returns saw mixed results, but during the apparition of 1952, Schaumasse was brighter than 7th magnitude for two months as it passed within 0.3 au of Earth. At its most recent return, in 2017, the comet peaked at around 10th magnitude, though it was an unfavourable apparition for Australian observers. The comet next reaches perihelion in early January 2026. Observers will be able to follow the comet in the morning sky in November and December 2025 as it brightens to 9th magnitude.

210P/Christensen: American astronomer Eric Christensen discovered this comet on images taken on 26 May 2003 during the course of the Catalina Sky Survey in the United States. 14th magnitude at the time, it was soon realised to be of short period, orbiting the Sun every six years and reaching perihelion nearly 0.5 au from the Sun. In 2008, Australian amateur Alan Watson noticed a comet in images taken by the STEREO spacecraft. This was found to be a recovery of Christensen.

2025 sees the comet reach perihelion on 22 November. Observers will find it in the evening sky in October and early November as it hopefully brightens to 10th magnitude. During this time, the comet will pass within 0.4 au of Earth, its closest approach since before its discovery.

C/2023 A3 Tsuchinshan-ATLAS

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
02 Nov '24	18 03.9	+03 46	1.012	0.945	09:20	15:14	21:08	5.8	Oph
09 Nov '24	18 27.3	+03 56	1.255	1.078	09:16	15:09	21:02	6.7	Oph
16 Nov '24	18 43.5	+04 04	1.491	1.207	09:05	14:58	20:50	7.5	Ser
23 Nov '24	18 56.0	+04 14	1.715	1.333	08:51	14:43	20:35	8.1	Ser
30 Nov '24	19 06.4	+04 27	1.928	1.455	08:34	14:25	20:17	8.6	Aql
07 Dec '24	19 15.4	+04 44	2.129	1.574	08:16	14:07	19:57	9.1	Aql
14 Dec '24	19 23.5	+05 05	2.316	1.690	07:58	13:47	19:37	9.5	Aql
21 Dec '24	19 31.0	+05 31	2.490	1.804	07:39	13:27	19:16	9.9	Aql
28 Dec '24	19 37.9	+06 01	2.651	1.915	07:20	13:07	18:54	10.2	Aql
04 Jan	19 44.4	+06 35	2.797	2.023	07:00	12:45	18:31	10.5	Aql
11 Jan	19 50.4	+07 13	2.930	2.130	06:40	12:24	18:08	10.8	Aql
18 Jan	19 56.1	+07 55	3.049	2.234	06:20	12:02	17:44	11.0	Aql
25 Jan	20 01.3	+08 41	3.154	2.337	06:00	11:40	17:19	11.3	Aql
01 Feb	20 06.2	+09 31	3.245	2.438	05:40	11:17	16:54	11.5	Aql
08 Feb	20 10.6	+10 24	3.323	2.537	05:19	10:54	16:29	11.6	Aql
15 Feb	20 14.5	+11 21	3.389	2.634	04:58	10:30	16:02	11.8	Del
22 Feb	20 18.0	+12 21	3.441	2.731	04:37	10:06	15:36	12.0	Del
01 Mar	20 20.9	+13 25	3.482	2.825	04:15	09:42	15:08	12.1	Del
08 Mar	20 23.2	+14 31	3.512	2.919	03:53	09:16	14:39	12.2	Del
15 Mar	20 24.9	+15 40	3.532	3.011	03:30	08:50	14:10	12.3	Del
22 Mar	20 25.8	+16 51	3.542	3.102	03:07	08:24	13:40	12.4	Del
29 Mar	20 26.0	+18 05	3.545	3.192	02:44	07:57	13:09	12.5	Del
05 Apr	20 25.3	+19 20	3.541	3.280	02:19	07:28	12:37	12.6	Del
12 Apr	20 23.7	+20 35	3.532	3.368	01:54	06:59	12:04	12.7	Del
19 Apr	20 21.2	+21 50	3.519	3.455	01:28	06:29	11:30	12.8	Vul
26 Apr	20 17.6	+23 04	3.504	3.541	01:01	05:58	10:55	12.8	Vul
03 May	20 13.0	+24 15	3.489	3.626	00:33	05:26	10:19	12.9	Vul
10 May	20 07.2	+25 22	3.476	3.710	00:03	04:53	09:42	13.0	Vul
17 May	20 00.4	+26 23	3.467	3.793	23:28	04:19	09:04	13.0	Vul

24P/Schaumasse

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
01 Nov	08 06.3	+20 08	0.954	1.481	00:14	05:21	10:29	12.4	Cnc
08 Nov	08 33.1	+20 13	0.876	1.431	00:13	05:21	10:28	11.7	Cnc
15 Nov	09 01.9	+20 10	0.806	1.384	00:14	05:22	10:29	11.0	Cnc
22 Nov	09 32.9	+19 58	0.745	1.341	00:17	05:25	10:33	10.3	Leo
29 Nov	10 05.8	+19 35	0.694	1.301	00:21	05:30	10:40	9.7	Leo
06 Dec	10 40.1	+18 58	0.654	1.267	00:25	05:37	10:49	9.2	Leo
13 Dec	11 15.3	+18 06	0.623	1.237	00:30	05:44	10:59	8.7	Leo
20 Dec	11 50.2	+17 00	0.603	1.214	00:34	05:52	11:09	8.4	Leo
27 Dec	12 23.9	+15 45	0.591	1.198	00:37	05:58	11:19	8.1	Com
03 Jan '26	12 55.7	+14 24	0.586	1.188	00:37	06:02	11:27	8.0	Com
10 Jan '26	13 24.9	+13 01	0.587	1.185	00:35	06:04	11:33	7.9	Vir
17 Jan '26	13 51.1	+11 43	0.592	1.190	00:30	06:02	11:35	8.0	Boo
24 Jan '26	14 14.1	+10 31	0.599	1.202	00:22	05:58	11:34	8.2	Boo
31 Jan '26	14 34.0	+09 27	0.607	1.221	00:12	05:50	11:29	8.5	Boo
07 Feb '26	14 50.7	+08 33	0.616	1.246	23:57	05:39	11:20	8.8	Boo
14 Feb '26	15 04.2	+07 49	0.623	1.277	23:40	05:26	11:08	9.2	Boo
21 Feb '26	15 14.6	+07 13	0.630	1.314	23:21	05:08	10:53	9.6	Ser
28 Feb '26	15 21.8	+06 44	0.636	1.354	22:59	04:48	10:34	10.1	Ser
07 Mar '26	15 25.9	+06 20	0.642	1.399	22:35	04:25	10:11	10.6	Ser
14 Mar '26	15 26.9	+05 58	0.649	1.447	22:07	03:58	09:46	11.2	Ser
21 Mar '26	15 24.9	+05 37	0.658	1.498	21:36	03:29	09:17	11.7	Ser
28 Mar '26	15 20.2	+05 14	0.671	1.551	21:03	02:57	08:46	12.3	Ser

210P/Christensen

Date	RA h m	Dec ° '	Δ au	R au	Rise hh:mm	Transit hh:mm	Set hh:mm	Mag	Con
04 Oct	18 21.6	-41 58	0.566	1.096	08:52	17:25	02:05	12.7	CrA
11 Oct	18 02.3	-41 44	0.542	0.994	08:07	16:39	01:17	12.1	CrA
18 Oct	17 41.1	-41 14	0.513	0.892	07:21	15:50	00:26	11.6	Sco
25 Oct	17 14.4	-40 12	0.479	0.791	06:34	14:56	23:17	10.9	Sco
01 Nov	16 38.2	-37 57	0.446	0.696	05:42	13:52	22:00	10.2	Sco
08 Nov	15 51.5	-33 19	0.428	0.613	04:50	12:38	20:23	10.0	Lup
15 Nov	15 04.1	-25 54	0.446	0.552	04:04	11:23	18:40	9.0	Lib
22 Nov	14 32.1	-18 09	0.513	0.526	03:30	10:24	17:17	9.0	Lib
29 Nov	14 20.4	-12 48	0.619	0.543	03:06	09:45	16:23	9.8	Vir
06 Dec	14 23.0	-10 04	0.737	0.597	02:49	09:20	15:51	10.6	Lib
13 Dec	14 32.7	-08 54	0.848	0.676	02:34	09:02	15:30	11.4	Lib
20 Dec	14 44.9	-08 31	0.946	0.770	02:20	08:47	15:14	12.2	Vir
27 Dec	14 57.4	-08 27	1.028	0.869	02:05	08:32	14:58	13.0	Lib

C/2023 A3 (Tsuchinshan-ATLAS): This comet was discovered on images taken on 22 February 2023 by the ATLAS Survey program, and then linked to an apparent asteroid found a month earlier, but subsequently lost, at Purple Mountain Observatory (Tsuchinshan). At the time of writing (May 2024), the comet had brightened to 10th magnitude and hopes were high that the comet would be visible to the unaided eye in October 2024. Early 2025 should see the comet at 12th magnitude in the pre-dawn sky and fading.

Greg Bryant has been a contributing editor to *Sky & Telescope* magazine since 2001 and can be reached at *gchbryant@fastmail.fm.* He has been following comets since the mid-1980s and enjoys noting each year's new comet discoveries.

BRIGHT COMETS FOR 2025 — ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
C/2023 A3 (Tsuchinshan-ATLAS)	2024 09 27.7460	0.391453	1.000108		308.4901	21.5598	139.1123	6.0	7.5
210P/Christensen	2025 11 22.7737	0.526031	0.833690	5.6	345.8748	93.8309	10.2699	13.5	10.0
24P/Schaumasse	2026 01 8.8560	1.185286	0.707715	8.2	58.3485	78.4285	11.5081	6.5	35.0

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 below 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.

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. 136 for full name).

The estimate of total magnitude is normally calculated using:

$$Mag = H1 + 5 \log(\Delta) + K1 \log R$$

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.

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, minor and dwarf planets. 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 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 2025, plus Eunomia (14 Dec 2024), Harmonia (3 Jan 2026) and Nysa (24 Jan 2026). These include three of the four most well-known (Ceres, Pallas and Vesta) with the rest reaching magnitude 7.6 or brighter. As only 15 bright ones are considered here, Ceres is the only dwarf planet bright enough to qualify.

1 Ceres

Date		RA hh mm	Dec ° ′	Mag
Jul	12	01 09.0	−05 19	8.9
	19	01 13.3	−05 18	8.8
	26	01 16.8	−05 23	8.7
Aug	2	01 19.3	−05 35	8.6
	9	01 20.9	−05 52	8.5
	16	01 21.5	−06 16	8.4
	23	01 20.9	−06 45	8.2
	30	01 19.2	−07 18	8.1
Sep	6	01 16.4	−07 55	8.0
	13	01 12.6	−08 34	7.8
	20	01 07.9	−09 12	7.7
	27	01 02.5	−09 49	7.6
Oct	4	00 56.7	−10 20	7.6
	11	00 50.7	−10 45	7.6
	18	00 44.9	−11 02	7.7
	25	00 39.6	−11 10	7.9
Nov	1	00 35.0	−11 08	8.0
	8	00 31.3	−10 57	8.1
	15	00 28.6	−10 36	8.2
	22	00 27.1	−10 08	8.4
	29	00 26.7	−09 32	8.5
Dec	6	00 27.4	−08 50	8.6
	13	00 29.2	−08 02	8.7
	20	00 31.9	−07 09	8.8
	27	00 35.6	−06 13	8.8

2 Pallas

Date		RA hh mm	Dec ° ′	Mag
May	17	21 04.1	+14 22	10.3
	24	21 06.0	+15 04	10.2
	31	21 06.9	+15 43	10.1
Jun	7	21 07.0	+16 17	10.1
	14	21 06.1	+16 44	10.0
	21	21 04.3	+17 04	9.9
	28	21 01.6	+17 16	9.8
Jul	5	20 58.1	+17 17	9.7
	12	20 53.8	+17 07	9.6
	19	20 48.9	+16 46	9.6
	26	20 43.6	+16 12	9.5
Aug	2	20 38.1	+15 25	9.4
	9	20 32.6	+14 28	9.4
	16	20 27.5	+13 20	9.4
	23	20 22.7	+12 05	9.5
	30	20 18.7	+10 43	9.5
Sep	6	20 15.5	+09 17	9.6
	13	20 13.2	+07 51	9.7
	20	20 11.9	+06 25	9.8
	27	20 11.6	+05 02	9.9
Oct	4	20 12.3	+03 43	9.9
	11	20 14.0	+02 29	10.0
	18	20 16.6	+01 20	10.1
	25	20 20.0	+00 19	10.2
Nov	1	20 24.3	−00 36	10.2

4 Vesta

Date		RA hh mm	Dec ° ′	Mag
Feb	8	14 48.4	−07 21	7.3
	15	14 55.7	−07 31	7.2
	22	15 02.0	−07 34	7.1
Mar	1	15 07.1	−07 31	7.0
	8	15 11.1	−07 22	6.8
	15	15 13.6	−07 07	6.7
	22	15 14.7	−06 47	6.5
	29	15 14.1	−06 23	6.3
Apr	5	15 12.0	−05 56	6.2
	12	15 08.4	−05 27	6.0
	19	15 03.5	−04 58	5.9
	26	14 57.5	−04 32	5.7
May	3	14 50.9	−04 11	5.7
	10	14 44.1	−03 57	5.7
	17	14 37.7	−03 52	5.8
	24	14 32.0	−03 56	6.0
	31	14 27.4	−04 10	6.1
Jun	7	14 24.1	−04 33	6.2
	14	14 22.4	−05 06	6.4
	21	14 22.1	−05 46	6.5
	28	14 23.3	−06 33	6.7
Jul	5	14 25.9	−07 26	6.8
	12	14 29.9	−08 23	6.9
	19	14 35.0	−09 24	7.0
	26	14 41.3	−10 27	7.1

6 Hebe

Date		RA hh mm	Dec ° ′	Mag
May	31	22 09.1	−06 44	9.7
Jun	7	22 16.9	−06 30	9.6
	14	22 24.0	−06 24	9.4
	21	22 30.3	−06 27	9.3
	28	22 35.6	−06 41	9.1
Jul	5	22 39.8	−07 07	8.9
	12	22 42.9	−07 46	8.8
	19	22 44.8	−08 40	8.6
	26	22 45.3	−09 48	8.4
Aug	2	22 44.4	−11 12	8.2
	9	22 42.2	−12 48	7.9
	16	22 38.8	−14 33	7.7
	23	22 34.4	−16 23	7.6
	30	22 29.6	−18 13	7.6
Sep	6	22 24.7	−19 56	7.7
	13	22 20.1	−21 28	7.8
	20	22 16.5	−22 44	8.0
	27	22 14.1	−23 42	8.2
Oct	4	22 13.2	−24 23	8.3
	11	22 14.0	−24 46	8.5
	18	22 16.4	−24 52	8.6
	25	22 20.4	−24 44	8.7
Nov	1	22 25.9	−24 22	8.9
	8	22 32.8	−23 48	9.0
	15	22 40.7	−23 04	9.1

8 Flora

Date		RA hh mm	Dec ° ′	Mag
Jan	4	12 04.5	+05 03	10.8
	11	12 08.4	+05 05	10.7
	18	12 11.0	+05 16	10.5
	25	12 12.3	+05 38	10.4
Feb	1	12 12.0	+06 09	10.3
	8	12 10.3	+06 49	10.2
	15	12 07.1	+07 38	10.0
	22	12 02.5	+08 33	9.9
Mar	1	11 56.8	+09 31	9.7
	8	11 50.2	+10 29	9.6
	15	11 43.3	+11 24	9.6
	22	11 36.4	+12 12	9.7
	29	11 29.9	+12 51	9.9
Apr	5	11 24.3	+13 20	10.1
	12	11 19.7	+13 37	10.2
	19	11 16.5	+13 43	10.4
	26	11 14.6	+13 39	10.6
May	3	11 14.1	+13 25	10.7
	10	11 14.9	+13 02	10.8
	17	11 16.8	+12 32	11.0
	24	11 19.9	+11 56	11.1
	31	11 24.0	+11 13	11.2
Jun	7	11 28.9	+10 26	11.3
	14	11 34.6	+09 35	11.4
	21	11 41.0	+08 40	11.5

9 Metis

Date		RA hh mm	Dec ° ′	Mag
Feb	15	15 25.0	−14 40	11.3
	22	15 30.2	−14 58	11.2
Mar	1	15 34.4	−15 11	11.1
	8	15 37.3	−15 21	11.0
	15	15 39.1	−15 27	10.9
	22	15 39.4	−15 29	10.7
	29	15 38.4	−15 27	10.6
Apr	5	15 35.9	−15 22	10.5
	12	15 32.0	−15 13	10.3
	19	15 27.0	−15 01	10.2
	26	15 20.9	−14 48	10.0
May	3	15 14.1	−14 32	9.8
	10	15 07.0	−14 17	9.7
	17	14 59.9	−14 02	9.9
	24	14 53.2	−13 49	10.1
	31	14 47.4	−13 40	10.2
Jun	7	14 42.5	−13 35	10.4
	14	14 38.8	−13 35	10.5
	21	14 36.4	−13 40	10.7
	28	14 35.3	−13 51	10.8
Jul	5	14 35.5	−14 07	11.0
	12	14 36.9	−14 28	11.1
	19	14 39.5	−14 53	11.2
	26	14 43.1	−15 21	11.3
Aug	2	14 47.7	−15 53	11.4

14 Irene

Date		RA hh mm	Dec ° ′	Mag
Jan	4	06 56.8	+27 18	9.6
	11	06 49.1	+27 54	9.7
	18	06 41.8	+28 26	9.9
	25	06 35.2	+28 51	10.0
Feb	1	06 30.0	+29 12	10.2
	8	06 26.3	+29 27	10.3
	15	06 24.3	+29 38	10.5
	22	06 24.1	+29 46	10.6
Mar	1	06 25.7	+29 50	10.7
	8	06 28.9	+29 51	10.8
	15	06 33.7	+29 50	10.9
	22	06 39.8	+29 46	11.0
	29	06 47.2	+29 40	11.1
Apr	5	06 55.7	+29 30	11.2
	12	07 05.2	+29 16	11.2
	19	07 15.5	+29 00	11.3
	26	07 26.5	+28 39	11.4
May	3	07 38.2	+28 13	11.4
	10	07 50.4	+27 44	11.4
	17	08 03.0	+27 09	11.4
	24	08 16.0	+26 31	11.5
	31	08 29.2	+25 47	11.5
Jun	7	08 42.7	+24 58	11.5
	14	08 56.4	+24 05	11.5
	21	09 10.2	+23 07	11.5

15 Eunomia

Date		RA hh mm	Dec ° ′	Mag
Jan	4	05 03.7	+31 02	8.6
	11	04 59.6	+30 03	8.8
	18	04 57.3	+29 07	8.9
	25	04 56.8	+28 15	9.1
Feb	1	04 57.9	+27 29	9.3
	8	05 00.6	+26 48	9.4
	15	05 04.8	+26 13	9.6
	22	05 10.1	+25 42	9.7
Mar	1	05 16.5	+25 14	9.9
	8	05 24.0	+24 50	10.0
	15	05 32.2	+24 27	10.1
	22	05 41.1	+24 06	10.2
	29	05 50.6	+23 45	10.3
Apr	5	06 00.6	+23 24	10.4
	12	06 11.1	+23 02	10.5
	19	06 21.9	+22 39	10.5
	26	06 33.0	+22 14	10.6
May	3	06 44.3	+21 47	10.7
	10	06 55.8	+21 17	10.7
	17	07 07.4	+20 45	10.7
	24	07 19.0	+20 10	10.8
	31	07 30.8	+19 33	10.8
Jun	7	07 42.5	+18 52	10.8
	14	07 54.3	+18 08	10.8
	21	08 06.0	+17 22	10.8

16 Psyche

Date		RA hh mm	Dec ° ′	Mag
Jul	12	03 42.7	+17 13	11.5
	19	03 54.0	+17 43	11.5
	26	04 05.0	+18 10	11.5
Aug	2	04 15.6	+18 32	11.5
	9	04 25.9	+18 51	11.4
	16	04 35.7	+19 05	11.4
	23	04 45.0	+19 16	11.3
	30	04 53.6	+19 24	11.3
Sep	6	05 01.5	+19 28	11.2
	13	05 08.6	+19 30	11.1
	20	05 14.8	+19 29	11.1
	27	05 20.0	+19 25	11.0
Oct	4	05 24.0	+19 20	10.9
	11	05 26.8	+19 13	10.8
	18	05 28.3	+19 05	10.7
	25	05 28.3	+18 56	10.5
Nov	1	05 26.9	+18 47	10.4
	8	05 24.2	+18 37	10.3
	15	05 20.1	+18 28	10.1
	22	05 15.0	+18 18	10.0
	29	05 09.0	+18 10	9.8
Dec	6	05 02.6	+18 02	9.7
	13	04 56.1	+17 56	9.8
	20	04 49.9	+17 51	10.0
	27	04 44.5	+17 49	10.1

29 Amphitrite

Date		RA hh mm	Dec ° ′	Mag
Jan	4	10 20.3	+16 44	10.0
	11	10 18.1	+16 57	9.9
	18	10 14.5	+17 15	9.7
	25	10 09.6	+17 37	9.6
Feb	1	10 03.5	+18 00	9.4
	8	09 56.7	+18 24	9.2
	15	09 49.5	+18 45	9.2
	22	09 42.5	+19 02	9.4
Mar	1	09 35.9	+19 13	9.5
	8	09 30.3	+19 17	9.7
	15	09 25.8	+19 14	9.9
	22	09 22.7	+19 05	10.0
	29	09 21.0	+18 50	10.2
Apr	5	09 20.8	+18 29	10.3
	12	09 21.9	+18 03	10.5
	19	09 24.2	+17 33	10.6
	26	09 27.7	+16 58	10.7
May	3	09 32.1	+16 20	10.8
	10	09 37.5	+15 38	10.9
	17	09 43.6	+14 52	11.0
	24	09 50.4	+14 04	11.1
	31	09 57.8	+13 12	11.2
Jun	7	10 05.7	+12 18	11.2
	14	10 14.0	+11 21	11.3
	21	10 22.7	+10 21	11.3

40 Harmonia

Date		RA hh mm	Dec ° ′	Mag
Jul	12	04 26.3	+19 23	11.5
	19	04 40.2	+19 55	11.5
	26	04 54.0	+20 22	11.5
Aug	2	05 07.6	+20 44	11.4
	9	05 20.9	+21 02	11.4
	16	05 34.0	+21 16	11.4
	23	05 46.7	+21 26	11.4
	30	05 59.0	+21 32	11.3
Sep	6	06 10.9	+21 34	11.3
	13	06 22.2	+21 34	11.2
	20	06 32.9	+21 32	11.2
	27	06 42.9	+21 28	11.1
Oct	4	06 52.1	+21 23	11.0
	11	07 00.4	+21 18	10.9
	18	07 07.6	+21 14	10.8
	25	07 13.7	+21 11	10.7
Nov	1	07 18.5	+21 11	10.6
	8	07 21.9	+21 14	10.5
	15	07 23.7	+21 22	10.3
	22	07 23.8	+21 33	10.2
	29	07 22.2	+21 50	10.0
Dec	6	07 18.7	+22 11	9.8
	13	07 13.7	+22 35	9.7
	20	07 07.1	+23 02	9.5
	27	06 59.6	+23 30	9.2

44 Nysa

Date		RA hh mm	Dec ° ′	Mag
Jul	12	04 45.3	+19 36	11.4
	19	05 00.0	+19 59	11.3
	26	05 14.7	+20 17	11.3
Aug	2	05 29.4	+20 30	11.3
	9	05 44.0	+20 38	11.2
	16	05 58.5	+20 40	11.2
	23	06 12.8	+20 38	11.2
	30	06 26.9	+20 30	11.1
Sep	6	06 40.7	+20 18	11.0
	13	06 54.2	+20 02	11.0
	20	07 07.4	+19 42	10.9
	27	07 20.1	+19 20	10.8
Oct	4	07 32.2	+18 54	10.8
	11	07 43.8	+18 27	10.7
	18	07 54.8	+17 58	10.6
	25	08 04.9	+17 30	10.5
Nov	1	08 14.2	+17 02	10.4
	8	08 22.6	+16 36	10.2
	15	08 29.8	+16 13	10.1
	22	08 35.8	+15 55	10.0
	29	08 40.4	+15 42	9.8
Dec	6	08 43.6	+15 36	9.7
	13	08 45.1	+15 37	9.5
	20	08 44.8	+15 47	9.4
	27	08 42.9	+16 06	9.2

63 Ausonia

Date		RA hh mm	Dec ° ′	Mag
May	10	20 57.5	−23 27	11.0
	17	21 05.5	−23 00	10.9
	24	21 12.4	−22 36	10.7
	31	21 17.9	−22 17	10.6
Jun	7	21 22.0	−22 02	10.5
	14	21 24.5	−21 52	10.3
	21	21 25.4	−21 48	10.2
	28	21 24.6	−21 49	10.0
Jul	5	21 22.0	−21 54	9.9
	12	21 17.8	−22 03	9.7
	19	21 12.2	−22 13	9.6
	26	21 05.5	−22 22	9.4
Aug	2	20 58.3	−22 28	9.3
	9	20 50.9	−22 31	9.4
	16	20 44.1	−22 27	9.6
	23	20 38.3	−22 18	9.8
	30	20 33.7	−22 04	10.0
Sep	6	20 30.8	−21 44	10.2
	13	20 29.5	−21 19	10.3
	20	20 29.8	−20 51	10.5
	27	20 31.8	−20 19	10.7
Oct	4	20 35.2	−19 44	10.8
	11	20 39.9	−19 06	11.0
	18	20 45.7	−18 24	11.1
	25	20 52.6	−17 40	11.2

89 Julia

Date		RA hh mm	Dec ° ′	Mag
May	17	21 32.2	−21 24	10.8
	24	21 38.8	−20 28	10.6
	31	21 44.2	−19 33	10.5
Jun	7	21 48.5	−18 39	10.4
	14	21 51.5	−17 46	10.2
	21	21 53.1	−16 55	10.0
	28	21 53.2	−16 06	9.8
Jul	5	21 51.6	−15 19	9.7
	12	21 48.4	−14 33	9.5
	19	21 43.7	−13 49	9.3
	26	21 37.5	−13 07	9.0
Aug	2	21 30.1	−12 27	8.8
	9	21 22.1	−11 47	8.6
	16	21 13.9	−11 09	8.6
	23	21 06.1	−10 32	8.8
	30	20 59.1	−09 56	9.0
Sep	6	20 53.4	−09 21	9.2
	13	20 49.3	−08 47	9.4
	20	20 46.9	−08 13	9.5
	27	20 46.2	−07 39	9.7
Oct	4	20 47.3	−07 05	9.8
	11	20 50.1	−06 29	10.0
	18	20 54.2	−05 52	10.1
	25	20 59.8	−05 12	10.2
Nov	1	21 06.5	−04 30	10.3

471 Papagena

Date		RA hh mm	Dec ° ′	Mag
Jul	13	02 29.8	−00 26	10.8
	20	02 40.3	+00 07	10.8
	27	02 50.4	+00 35	10.7
Aug	3	03 00.0	+00 59	10.6
	10	03 09.0	+01 17	10.5
	17	03 17.2	+01 31	10.4
	24	03 24.6	+01 39	10.3
	31	03 31.0	+01 44	10.2
Sep	7	03 36.4	+01 45	10.1
	14	03 40.5	+01 42	9.9
	21	03 43.3	+01 37	9.8
	28	03 44.6	+01 30	9.7
Oct	5	03 44.3	+01 24	9.5
	12	03 42.4	+01 19	9.4
	19	03 39.0	+01 17	9.3
	26	03 34.2	+01 21	9.1
Nov	2	03 28.3	+01 32	9.0
	9	03 21.6	+01 52	9.0
	16	03 14.7	+02 20	9.0
	23	03 07.9	+02 58	9.1
	30	03 01.9	+03 46	9.2
Dec	7	02 56.9	+04 41	9.3
	14	02 53.2	+05 43	9.5
	21	02 51.0	+06 51	9.6
	28	02 50.3	+08 03	9.8

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a *dirty snowball*, a conglomerate of ice, gas, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classic dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical-shaped donut. The effects of solar radiation and the slight gravity tug from the planets will, over time, break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand, up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

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

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

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

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

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Quadrantids (QUA)	FQ	Dec 28 – Jan 12	Jan 03	230°	+49°	41	25
alpha-Centaurids (ACE)	FQ	Jan 28 – Feb 21	Feb 08	210°	−59°	58	6
gamma-Normids (GNO)	FM	Feb 25 – Mar 28	Mar 14	239°	−50°	56	6
Lyrids (LYR)	LQ	Apr 16 – Apr 25	Apr 22	271°	+34°	49	18
pi-Puppids (PPU)*	LQ	Apr 15 – Apr 28	Apr 24	110°	−45°	18	var
eta-Aquarids (ETA)	FQ	Apr 19 – May 28	May 06	338°	−01°	66	40
eta-Lyrids (ELY)	FM	May 03 – May 14	May 10	287°	+ 44°	43	3
June Bootids (JBO)*	NM	Jun 22 – Jul 02	Jun 27	224°	+48°	18	var
Pisces Austrinids (PAU)	FQ	Jul 15 – Aug 10	Jul 29	341°	–30°	35	5
Southern delta-Aquarids (SDA)	FQ	Jul 12 – Aug 23	Jul 30	340°	–16°	41	25
alpha-Capricornids (CAP)	FQ	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 28	Aug 17	286°	+59°	25	3
Aurigids (AUR)	FQ	Aug 28 – Sep 05	Aug 31	091°	+39°	66	6
September Perseids (SPE)	FM	Sep 05 – Sep 21	Sep 09	048°	+40°	64	8
Draconids (DRA)*	FM	Oct 06 – Oct 10	Oct 08	262°	+54°	20	5
Southern Taurids (STA)	FM	Sep 10 – Nov 20	Oct 10	032°	+09°	27	5
delta-Aurigids (DAU)	LQ	Oct 10 – Oct 18	Oct 11	084°	+44°	64	2
epsilon-Geminids (EGE)	NM	Oct 14 – Oct 27	Oct 18	102°	+27°	70	3
Orionids (ORI)	NM	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)	LQ	Oct 20 – Dec 10	Nov 12	058°	+22°	29	5
Leonids (LEO)	NM	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)	FM	Nov 28 – Dec 09	Dec 02	018°	−53°	18	Var
Puppid-Velids (PUP)	FM	Dec 01 – Dec 15	Dec 07	123°	−45°	40	6
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 17	Dec 14	112°	+33°	35	120
Coma Berenicids (COM)	LQ	Dec 05 – Dec 16	Dec 16	175°	+18°	65	3
Dec. Leonis Minorids (DLM)	NM	Dec 05 – Feb 04	Dec 19	161°	+30°	64	5
Ursids (URS)	NM	Dec 17 – Dec 26	Dec 22	217°	+75°	33	10

Table Notes (above)

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

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

Activity Duration The approximate dates when the shower is active.

Max Act The date when maximum activity can be expected.

Radiant The position of the shower radiant in right ascension and declination (RA is expressed in degrees). These coordinates refer to the radiant position on the date of maximum activity.

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

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

STARS

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

Milky Way, credit ESO & A. Fujii

PLACES OF ASTRONOMICAL INTEREST

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY RESEARCH FACILITY

They operate their 'Open Nights' public observatory tours on a regular basis, catering for school groups and the general public. The facility is also dedicated to meteorite research and the meteorite collection is open by request. Information on tour dates and times can be found on the website. Regular updates are also on their facebook page. Email <info@bathurstobservatory.com.au>
www.bathurstobservatory.com.au
www.facebook.com/BathurstObservatory

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The Complex, located 35 km 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 Café. The gift shop is open for space themed items and souvenirs. Contact Korinne McDonnell (02) 6201 7809, (02) 6201 7838, email <pr@cdscc.nasa.gov> www.cdscc.nasa.gov/
Also on Instagram, Twitter and YouTube. facebook.com/CanberraDSN

CSIRO PARKES OBSERVATORY

Located 20 km north of Parkes on Wiradjuri Country, is the home of Murriyang, CSIRO's Parkes radio telescope. The striking telescope at the heart of the observatory, owned and operated by Australia's national science agency, CSIRO, is a cutting-edge instrument used by astronomers all over the world. The observatory's visitor centre caters for those curious about radio astronomy, space technologies, and the history of this Australian science icon. There's also a 3D theatre, interactive exhibits, a playground, and souvenirs to collect.
Contact (02) 6861 1777 www.csiro.au/parkes

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the Western Plains Zoo. Sky presentations are projected in their theatrette, followed by viewing through their telescopes including a large 17". Bring your SLR camera to take astrophotos through this scope or over the internet with their CCD camera. Contact 0488 425 940, email <starr_peter@hotmail.com> www.dubboobservatory.com
www.facebook.com/DubboObservatory/

GREEN POINT OBSERVATORY

The observatory is operated by the volunteers of Sutherland Astronomical Society Inc (SASI) in Sydney. The building houses 41 cm and 35 cm telescopes. Visitors are welcome first three Thursdays of the month at 7:30 pm. Please contact the secretary by email before your visit. The society also runs regular open nights for the general public. Contact Secretary, Corinne Feldmann, email <honsecretary@sasi.net.au> www.sasi.net.au

MACQUARIE UNIVERSITY ASTRONOMICAL OBSERVATORY

Located at Macquarie University (North Ryde campus), this observatory is open to the public every Friday and Saturday night (weather permitting) throughout the year, see website for dates and ticket information. Their knowledgeable astronomy guides, who are typically astronomy students, will guide you through the Universe with a range of on-site telescopes. They also offer private events for schools, Scouts, or other interested groups on other nights of the week. Email <starinfo@mq.edu.au> www.mq.edu.au search 'Astronomical Observatory'
Also on Facebook, Instagram, Twitter and YouTube.

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. Also on TikTok as donnatheastronomer. Contact Donna 0428 288 244, email <donna@donnatheastronomer.com.au> www.donnatheastronomer.com.au
Also on Instagram and YouTube. www.facebook.com/milroyCoonabarabran

MUDGEE OBSERVATORY

Mudgee Observatory caters for school groups, organised tours and the general public. The observatory is situated 15 min west of Mudgee. The theatre and flat screen planetarium run features on the night sky and the Sun. A variety of telescopes and binoculars are available for visitors as well as conducted tours of the night sky. Bookings are essential. Contact (02) 6373 3431, 0428 560 039, email <john@mudgeeobservatory.com.au> www.mudgeeobservatory.com.au

PORT MACQUARIE OBSERVATORY

Please visit their website for more information.
Email <administration@pmasc.org.au> portastronomy.com.au
Also on Instagram. www.facebook.com/portobservatory

SCIENCE SPACE

Operated by the University of Wollongong, this public science centre includes the full dome planetarium, an observatory, exhibits and a gift and resource shop. The planetarium has the latest immersive full-dome technology. The observatory houses a telescope used to observe the Sun and stars. The Science Shop has a range of educational materials and telescopes. Contact (02) 4286 5000 (option 2), email <science-space@uow.edu.au> www.sciencespace.com.au

SIDING SPRING OBSERVATORY

Siding Spring Observatory (SSO) is Australia's premier optical astronomy research facility and is home to telescopes from many organisations within Australia and around the world. These include Australia's two largest optical telescopes, the Australian National University's 3.9 metre Anglo-Australian Telescope and the 2.3 metre Advanced Technology Telescope. Siding Spring nestles into the Warrumbungle mountains at the entrance to the Warrumbungle National Park, 30 minutes west of Coonabarabran. The Visitor Centre includes a café serving light meals, souvenir shop and an astronomy exhibit. From the Visitor Centre there is access to the viewing gallery of the 3.9 m AAT and special tours can be organised on request for groups, information can be found on their website. StarFest is a celebration of astronomy at SSO every October long weekend, more information on the web. www.sidingspring.com.au
www.starfest.org.au

SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a variety of tours and displays. See website for details. Sydney Observatory is part of the Museum of Applied Arts and Sciences. powerhouse.com.au/visit/sydney-observatory

TAMWORTH REGIONAL ASTRONOMY AND SCIENCE CENTRE

The Tamworth Regional Astronomy Club Inc runs the Tamworth Regional Astronomy and Science Centre, open to the general public (see website for days and times) to view the range of scientific displays, minerals and mega-fauna, planetarium, 34 inch Hewitt Camera and other large telescopes. It is adjacent to the Botanical Gardens, Piper St, Tamworth. Email <tracthestars@gmail.com>
www.tamworthastronomy.com.au

CSIRO PAUL WILD OBSERVATORY

Found just 25 km west of Narrabri on Gomeroi Country is the CSIRO Australia Telescope Compact Array. A world-class radio telescope operated by Australia's national science agency, CSIRO, it is made up of six identical dishes weighing around 270 tonnes each. Five dishes move along a three-kilometre railway track right in front of the observatory's visitors centre, creating an impressive sight of Australian engineering. Find out more about radio astronomy and the history of the site at the self-guided visitor's centre. Enjoy the garden displays, watch the kangaroos and stay for a picnic! Contact (02) 6861 1777 www.csiro.au/atca

QUEENSLAND

CHARLEVILLE COSMOS CENTRE

Unlock the Universe through a unique experience where the expanse of the cosmos meets the wild and natural beauty of Outback Queensland.

Through a combination of education and storytelling, the Charleville Cosmos Centre is dedicated to igniting curiosity, deepening understanding, and creating memories that reach beyond the stars. Defy logic while viewing the Sun directly through specialised telescopes, immerse yourself in Queensland's largest planetarium, look into the past at celestial objects thousands of light-years away and hear timeless stories that have shaped cultures around the globe. Prepare for launch. Next stop: Infinity, Contact (07) 4656 8377 www.cosmoscentre.com
Also on Facebook and Instagram. 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. They are open to the general public, astronomical groups, schools, and researchers by appointment. This facility houses a number of telescopes for night time viewing. See website or contact them on Facebook for details. www.springbrookobservatory.com.au

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located at the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs are presented in their Cosmic Skydome. All astronomy shows include a current night sky tour recreated in the dome. The Planetarium upgraded its digital projection system in 2019 and can now recreate the observable Universe at 7K resolution with many more astronomical features available. The display areas contain astronomical and space items including a large display concerning Aboriginal and Torres Strait Islander astronomy. The shop has educational products and souvenirs. School shows are also available during weekdays. Open Tuesday to Sunday (open on Monday during Qld school holidays). Contact (07) 3403 8888, email <bop@brisbane.qld.gov.au> www.brisbane.qld.gov.au/planetarium/
www.facebook.com/BrisbanePlanetarium

THE JUMP-UP DARK SKY SANCTUARY

The Jump-Up Dark-Sky Sanctuary, located on a 1,400-hectare mesa, 24 km south-east of Winton in Central West Queensland, is Australia's first International Dark-Sky Sanctuary and home to the Australian Age of Dinosaurs Museum of Natural History. This remote location offers pristine dark-sky conditions with minimal light pollution, making it ideal for stargazing due to clear skies, low humidity and the absence of urban and industrial pollutants. The Sanctuary aligns with the Museum's mission to safeguard natural history and enrich public understanding of the past. Featuring the free-access Star Gallery and the Gondwana Stars Observatory, the Museum advocates for and preserves dark skies, with sky quality often exceeding 21.5 MPSAS. Contact (07) 4657 0078, email <info@aaod.com.au> www.australianageofdinosaurs.com
Also on Instagram www.facebook.com/australianageofdinosaurs/

SOUTH AUSTRALIA

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

Located in the northern Flinders Ranges, Arkaroola has a range of accommodation and Advanced Ecotourism accredited products including three astronomy tours and the Ridgetop Tour. There are also many unguided bushwalks and driving tracks. Arkaroola has:

Two 3-metre dome observatories with equatorial fork mount Celestron C14 *f*/11 telescopes for eyepiece viewing.

One 3 metre robotic dome observatory for real time astro imaging. This observatory contains one Celestron C14 *f*/11 telescope with ZWO ASI186MC camera, a C14 *f*/2 FastStar telescope with ZWO ASI6200MC camera and a Coronado 60 mm Hydrogen Alpha telescope with ZWO ASI1600MC camera, all on a Software Bisque ME mount.

One roll-off roof observatory with a Skywatcher 150 mm *f*/7 ED refractor on a Losmandi G11 mount, a Skywatcher 16" *f*/4.5 GoTo Dobsonian and spare piers and wedges suitable for BYO telescopes. Contact (08) 8648 4848 www.arkaroola.com.au
Also on Instagram. www.facebook.com/arkaroola

STOCKPORT OBSERVATORY

Owned and operated by the Astronomical Society of South Australia (ASSA), the observatory is located in the small town of Stockport, approximately 80 km north of Adelaide. Public star parties are held in February, May, August and November. See website for details. Contact ASSA Info Line 0401 702 772, email <observatories@assa.org.au> www.assa.org.au/facilities/stockport/

THE BACKYARD UNIVERSE

Multicultural guided tours of South Australia's night sky with laser pointer and large telescope. Enjoy an evening of traditional stargazing and modern astronomy in a small group tour with an experienced local guide. Experience a night sky that's practically as dark as the outback but much closer to Adelaide. Also available for schools, events and private group tours at your venue. Bookings are essential, see website for details.
Email <tbu@thebackyarduniverse.com.au> www.thebackyarduniverse.com.au

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury Heights, Adelaide. There are two main telescopes, a 14" and a research quality 12.5" plus two Coronado solar scopes. Private bookings are accepted.
Ph (08) 8242 8900 Contact Meg Fay, email <Meg.Fay594@schools.sa.edu.au> www.theheights.sa.edu.au/observatory.html

THE RIVER MURRAY INTERNATIONAL DARK SKY RESERVE

The River Murray International Dark Sky Reserve consists of over 3300 km^2 of rural land within the Mid Murray Council area in South Australia, situated between the eastern slopes of the Adelaide Hills and the River Murray. It is Australia's first Dark Sky Reserve. The Reserve's core is in the Swan Reach Conservation Park, whilst its public Education centre is at Meldanda, a 100-acre property just outside the hamlet of Cambrai, where camping is available for a small fee per head. A well equipped hall is also available, and two large (300 m × 600 m) car-accessible flat astro paddocks, well away from any road, are available with very low horizons, along with a portable loo. A number of concrete telescope pads are provided throughout the Reserve. Contact Mid Murray Landcare SA (08) 8564 6044 www.rivermurraydarkskyreserve.org
www.facebook.com/RiverMurrayDarkSkyReserve/

UNIVERSITY OF SOUTH AUSTRALIA, ADELAIDE PLANETARIUM

The Adelaide Planetarium is open seven days a week by appointment for school, group and private bookings. Adult education courses are held throughout the year along with school holiday programs. Public Viewing sessions are held on the 1st and 3rd Saturday of the month. See website for session times and other information. Bookings essential. Contact (08) 8302 3138,
email <adelaide.planetarium@unisa.edu.au> www.unisa.edu.au/planetarium/
www.facebook.com/AdelaidePlanetarium

TASMANIA

LAUNCESTON PLANETARIUM

The Launceston Planetarium is at the Queen Victoria Museum's Inveresk site. See their website for details of shows. Contact (03) 6323 3777
www.qvmag.tas.gov.au/Planetarium
Also on Instagram, Twitter and YouTube. www.facebook.com/QVMAG/

VICTORIA

ASTROTOURS SWINBURNE

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during school holidays. AstroTour sessions can also be booked for school groups (Years 3–12) throughout the year.
Email <astrotour@astro.swin.edu.au> astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The observatory has several historic telescopes including the Jelbart (125 mm refractor), the Oddie (220 mm Newtonian), the Baker Great Equatorial Telescope (650 mm Newtonian) and a 300 mm Newtonian. The Adcock-Federation telescope (406 mm) has disabled-access. Observatory open Tuesday to Saturday. Bookings essential. See website for open times and calendar of events. Contact open hours (03) 5332 7526 or after hours for bookings 0429 199 312,
email <info@ballaratobservatory.org.au> ballaratobservatory.org.au
www.facebook.com/ObservatoryBAS/

BENDIGO PLANETARIUM @ DISCOVERY

This small planetarium inside The Discovery Science and Technology Centre, is interactive and engaging. www.discovery.asn.au

MELBOURNE PLANETARIUM

This planetarium is at Scienceworks in Spotswood. It regularly screens full-dome films for adults and families, as well as presenter-led tours through the night sky. See website for details.
museumsvictoria.com.au/scienceworks/visiting/melbourne-planetarium/

MOUNT BURNETT OBSERVATORY

Community Observatory and Science Organisation. New members are most welcome. Individuals and families wanting to look through the telescopes can join in one of their Public Events. School, scout and community events are also catered for. All sessions must be pre-booked. Email or phone for further details. Members' events include onsite and online events, dedicated sessions for young observers and a radio astronomy group. Email <info@mbo.org.au> mbo.org.au
Also on Instagram and Twitter. www.facebook.com/MtBurnettObservatory

WESTERN AUSTRALIA

GDC OBSERVATORY

The Gravity Discovery Centre Observatory is part of the Gravity Precinct and shares its bushland with the OzGrav research facilities, the Zadko Telescope Facility and the USAFA Falcon Telescope Network. The observatory boasts professional staff and five telescopes including one of the largest for public observing in WA. Along with regular night tours, other special events include, Local Aboriginal Astronomy nights, Tame Your Telescope and Astrophotography classes. Added to this is the annual Gingin Dark Sky Star Party, held under protected Dark Skies an hours drive north of Perth.
Contact (08) 9575 7577 (Office) www.gravitycentre.com.au/observatory

PERTH OBSERVATORY

Located in the breathtaking Perth Hills, a mere 40-minute drive east of Perth, lies the illustrious Perth Observatory. As Western Australia's oldest astronomical institution, it boasts a rich legacy of cutting-edge research and dedicated public outreach. Proudly managed by the Perth Observatory Volunteer Group, they provide a wide array of captivating night and daytime tours, catering even to school groups. Beyond the confines of its tranquil location, the Observatory hosts riveting stargazing events across WA, and they offer an enchanting star adoption program. For those eager to embark on a celestial journey, visit their website to book and for further information. Contact (08) 9293 8255,
email <info@perthobservatory.com.au> www.perthobservatory.com.au
Also on Instagram, Twitter and YouTube. facebook.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
Also on Instagram and Twitter. www.facebook.com/nationalscienceweek

NEW SOUTH WALES

CWAS ASTROFEST

The CWAS AstroFest is sponsored by the Central West Astronomical Society and held annually in July. The AstroFest incorporates a two day conference and related activities including the David Malin Astrophotography Exhibition and Competition which is open to all amateur astrophotographers. World-renowned professional and amateur astronomers also share their knowledge and experiences. Contact John Sarkissian (Local Organising Committee), email <astrofest@cwas.org.au> www.cwas.org.au/astrofest/
www.facebook.com/CWASAstroFest

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, commercial stands and telescopes operated by MQ academic/research staff and local amateurs. They are held once a year on a Saturday night around a First Quarter Moon. The venue is Macquarie University in North Ryde, Sydney. See website and search for 'Astronomy Open Night' for details. Email <astronomyopennight@mq.edu.au> mq.edu.au

NACAA

The National Australian Convention of Amateur Astronomers is a regular national forum at which amateur astronomers can exchange experiences, stay abreast of the latest trends, foster co-operative activities between individuals, societies and the professional sphere. They are held over Easter every two years. The 32nd NACAA will be held in Tamworth, NSW in 2026, hosted by the Tamworth Regional Astronomy Club. This is being planned as hybrid event, both at Tamworth and streamed online. See website for more details when available.
www.nacaa.org.au
www.facebook.com/NACAAInc

SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. It is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 300 people. Advance registrations required. See the society website for more details. Email <secretary@asnsw.com>
www.asnsw.com/spsp

QUEENSLAND

QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The 2025 Queensland Astrofest will be the 30th camp held annually at the Lions Club Camp Duckadang, situated at Linville, 160 km north-west of Brisbane. There is bunk house accommodation and limited sites for camping and caravans. Power is also available. Queensland Astrofest boasts a nine day format and will be held from Friday 23 May to morning Sunday 1 June 2025. Each Saturday has a guest speaker. Workshops throughout the event are run, covering various topics. The renowned Astro-Feast is held on the last Saturday Lunch. More details are on the website. Registration to open February 2025, early bookings are recommended. Contact registrar, email <registrar@qldastrofest.org.au>
www.qldastrofest.org.au www.facebook.com/QLDAstrofest

URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at the Barrett Street Reserve, Bracken Ridge (entry off Jude St) on the Saturday night around First Quarter Moon of each month (weather permitting). Special events are also organised. All welcome. Contact Julie Straayer 0411 047 439, email <seqldastro@gmail.com> www.seqas.org

SOUTH AUSTRALIA

VICSOUTH DESERT SPRING STAR PARTY

See entry for VicSouth under Victoria.

VICTORIA

VASTROC (VIC)

Victorian Amateur Astronomical Societies' Conventions (VASTROC) are held every second year (alternating years with NACAA). Activities include speakers, workshops, displays, observing and the convention dinner. Contact via website
vastroc.net

VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party is an annual weekend of astronomy, held at the Little Desert Nature Lodge about 16 km south of Nhill in western Victoria, roughly equidistant between Melbourne and Adelaide. It offers a weekend of social, astronomical and observing activities. See website for more details.
www.vicsouth.info

WESTERN AUSTRALIA

ASTROFEST WA

WA's biggest astronomy festival is held in Perth annually. 2019 was the 10th anniversary. It's free and great family fun with multiple telescopes to look through, special guest presenters, hands on activities for kids, astrophotography exhibition, space shows, space domes and information stalls. Discover more about astronomy and stargazing in WA and how you can get involved, start studying or begin a career. More details on the next one on their website when available. Hosted by Astronomy WA. Email <space@astronomywa.net.au>
www.astronomywa.net.au
Also on Twitter. www.facebook.com/AstronomyWA/

ORGANISATIONS

AUSTRALIA

AUSTRALASIAN DARK SKY ALLIANCE

ADSA promotes the preservation of the night environment, through the education of industry, community and policy makers. Contact Marnie Ogg, Director, email <secretary@ausdarksky.org> www.darksky.org IDA
Also on Twitter and YouTube www.australasiandarkskyalliance.org ADSA

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia is the society of professional astronomers in Australia. It has a Society website and a second Australian Astronomy site providing links, both professional and amateur, and including links to educational material. Contact the ASA Secretary (A/Prof. John O'Byrne), email <asa.secretary@sydney.edu.au> asa.astronomy.org.au ASA site
Also on Facebook and Twitter. 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

NEW SOUTH WALES

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY INC.

Since 1998 SOLIS has been working at protecting the view of the night sky by promoting better outdoor lighting. Find them on Facebook

COURSES

NEW SOUTH WALES & ACT

MSATT – ASTRONOMY PROJECTS FOR HIGH SCHOOL STUDENTS

MSATT is an educational facility designed for student-centred research projects in astronomy. The facility consists of two primary instruments (300 mm Schmidt-Cassegrain and 400 mm Newtonian) with auxiliary instruments and cameras for visual work, imaging, spectroscopy, photometry and astrometry. Students operate MSATT, a teaching telescope suite at ANU's historic Mount Stromlo Observatory, to complete extended investigations based on their own observations. In most cases, an astronomer is appointed as the student's mentor for the duration of the project. Students produce a referenced and refereed report which can often contribute to their formal school assessment. No experience with astronomy or telescopes is necessary and any Year 9 to 12 student from the ACT region is welcome to apply. Students wishing to visit MSATT or take on projects in 2025 should contact Geoff McNamara for a copy of the MSATT Student Guide. There is no cost for any MSATT activities. Contact Geoff McNamara, email <geoff.mcnamara@anu.edu.au> msatt.teamapp.com/
www.facebook.com/MSATTAustralia/

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an eight week course conducted by Sutherland Astronomical Society Inc (SASI). Each lecture is followed by observations with the society's equipment (weather permitting). Refer to website for course dates. Contact the Education Officer 0408 207 927, email <educationofficer@sasi.net.au> www.sasi.net.au
www.sasi.net.au/public-events/courses

SOUTH AUSTRALIA

ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

A variety of astronomy themed courses are conducted at the Adelaide Planetarium during the year. See their website for details.
www.unisa.edu.au search 'Astronomical Courses'

VICTORIA

ASTRONOMY PUBLIC LECTURES

The Centre for Astrophysics and Supercomputing have free public lectures on astronomy at the Hawthorn campus of Swinburne University of Technology. See website for details. astronomy.swin.edu.au/outreach/?topic=freelectures

MOBILE PLANETARIUMS

NEW SOUTH WALES

MACQUARIE UNIVERSITY MOBILE PLANETARIUM

Their planetarium projector system and portable dome is available, by arrangement, for groups of up to 35 people per session. The planetarium simulates the night sky. You will take a tour of the local Solar System and peer into the depths of our Galaxy and beyond. Presentations can be tailored to the interests and age of your groups, see the website for details. Email <starinfo@mq.edu.au>
Also on Facebook, Instagram and Twitter. www.mq.edu.au search 'Planetarium'

SKYWORKS PLANETARIUM

Skyworks Planetarium is a multi-award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools, libraries, vacation care centres and university open nights. Since starting in 2000, they have visited over 750 schools in greater Sydney. Programs are curriculum based to suit years K–12. Contact Geoff and Diana Zenner 0419 112 899, email <info@skyworks.net.au> www.skyworks.net.au
facebook.com/skyworksplanetarium

QUEENSLAND

NIGHT SKY SECRETS PLANETARIUM

Night Sky Secrets operate a Cosmodome Planetarium in North and Far North Queensland. They conduct both 3D Surround movies and Classic Planetarium presentations in schools, museums and events across Northern Queensland. Contact 1 300 843 759, email <sales@nightskysecrets.com.au>
www.nightskysecrets.com.au/planetarium/

STARLAB EDUCATION

Starlab Education provides astronomy and Earth science presentations throughout Queensland. Fully trained presenters visit your school or venue with a 'Cosmodome Science Theatre and Planetarium' to provide educational programs tailored to suit your level of interest and understanding. Contact Paul Tickner 0417 394 354, email <info@starlab.net.au> www.starlab.net.au

RESOURCES

AUSTRALIA

IS THE MOON UPSIDE DOWN?

Greg Quicke ran his Astro Tours of the Kimberly from Broome WA for many years. His book, 'Is The Moon Upside Down?' is an absorbing guided tour of the cosmos as seen through Greg's eyes. Unlike many of his peers who studied at university, he offers a unique and refreshing perspective on astronomy that was instead forged on cliff tops outside Alice Springs, in the endless expanse of the Great Sandy Desert, on the floor of the Indian Ocean and in his own front yard in Broome.

No matter what mysteries you've pondered about Earth's astral dance with the Sun, planets, Moon and the stars, it's guaranteed Greg has thought about them too, and the answers can be found in the pages of this book. Email <greg@astrotours.net>
www.astrotours.net/the-book www.astrotours.net/gregs-tv-shows
Also on Facebook, Instagram, Twitter and YouTube.

ICEINSPACE

IceInSpace is a community website dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers discover, discuss and enjoy the night sky. IceInSpace is free to join and use, all you need is a valid email address. By registering you will be able to post topics, upload content and images and access other features. IceInSpace is the largest and most active astronomy community in the Southern Hemisphere, with over 18,000 members.
www.iceinspace.com.au

WESTERN AUSTRALIA

ASTROTOURISM WA

Astrotourism WA is collaborating with local government to create a trail of welcoming dark sky places for stargazing, astrophotography and astronomy across country and outback WA. They're growing regional tourism and striving to reduce light pollution to maintain WA's pristine dark night sky as a world-class asset. Contact Carol Redford 0427 554 035, email <stars@astrotourismwa.com.au>www.astrotourismwa.com.au
Also on Instagram. www.facebook.com/AstrotourismWA

STARGAZERS CLUB WA

Stargazing and astronomy for beginners. Stargazers Club WA runs telescope classes, stargazing nights, astrophotography for beginners and hosts special trips to dark skies in country WA. See their website for costs and details.
Contact 0487 187 603, email <begin@stargazersclubwa.com.au>
www.stargazersclubwa.com.au
Also on Instagram. www.facebook.com/StargazersClub

SOCIETIES

NEW SOUTH WALES & ACT

The **ASTRONOMICAL SOCIETY OF ALBURY WODONGA** meets as advertised on their facebook page. Contact David Thurley 0418 690 142 <ASAWSecretary@gmail.com>.
www.facebook.com/AstronomicalSocietyAlburyWodonga Also on Twitter.

The **ASTRONOMICAL SOCIETY OF COONABARABRAN** meets on the third Wednesday each month at 7:30 pm at Room EG01, Coonabarabran TAFE campus, Robertson Street, Coonabarabran. Contact Donna Burton secretary 0428 288 244 <Donna@born2fly.com.au>.
www.facebook.com/AstronomicalSocietyofCoonabarabran/

The **ASTRONOMICAL SOCIETY OF NSW** holds two meetings per month at Epping and online, runs an observing site in NSW and publishes a monthly journal. The society welcomes members from all over Australia, as well as overseas. See their website for further details. Contact <secretary@asnsw.com>.
www.asnsw.com Also on Facebook.

The **CANBERRA ASTRONOMICAL SOCIETY** meetings are held on the 3rd Thursday of each month except June and December starting at 8 pm. An Introductory meeting begins one hour before the main meeting. The venue is usually the Duffield Lecture Theatre, Mt. Stromlo Observatory, ACT. Contact Secretary <secretary@casastronomy.org.au>.
casastronomy.org.au Also on Facebook.

The **CENTRAL WEST ASTRONOMICAL SOCIETY INC (PARKES)** meetings are held monthly. See the website for details. Visitors Welcome. Contact Secretary <secretary@cwas.org.au>.
www.cwas.org.au Also on Facebook.

The **CLARENCE VALLEY ASTRONOMICAL SOCIETY** Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>. Find them on Facebook.

The **COFFS HARBOUR ASTRONOMICAL SOCIETY INC** meets on the first Monday of each month (except January) at 7 pm at the Boambee East Community Centre, cnr. Bruce King Drive and Pacific Highway, Boambee East. Contact Win Howard (02) 6653 2742 <winhoward@iprimus.com.au>.
www.facebook.com/Coffsastro/

The **ILLAWARRA ASTRONOMICAL SOCIETY** meets at 7:30 pm, every second Tuesday of the month at the Wollongong Science Centre.
Contact <IAS.secretary@outlook.com>
iasenquiry.wixsite.com/website Also on Facebook.

The **MACARTHUR ASTRONOMICAL SOCIETY** meets monthly at Western Sydney University, Campbelltown, NSW, with guest speakers. Visitors welcome. See website for details. Contact <contact@macastro.org.au>.
www.macastro.org.au Also on Facebook and Twitter.

The **NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC** has regular meetings, see their website for details. Contact <nsas@nsas.org.au>.
www.nsas.org.au Also on Facebook and YouTube.

SHOALHAVEN ASTRONOMERS meet at the University Of Wollongong, Shoalhaven Campus, Library and Resources Centre, Seminar Room LG.25 on the third Friday of the month at 7 pm. Contact Andrew Wood (secretary) <astronomers@shoalhaven.net.au>. www.shoalhavenastronomers.asn.au

The **SUTHERLAND ASTRONOMICAL SOCIETY** meets first three Thursdays of the month at 7:30 pm at the Green Point Observatory Oyster Bay (cnr Green Point and Caravan Head Road), with guest speakers presenting on a range of fascinating topics every 1st Thursday of the month. Please email the secretary Corinne Feldmann at honsecretary@sasi.net.au before attending. Contact Corinne Feldmann (Sec) <honsecretary@sasi.net.au>.
www.sasi.net.au Also on Facebook.

SYDNEY CITY SKYWATCHERS meet at Sydney Observatory on the first Monday of the month (except January and December) at 6:30 pm. Contact Secretary, Elizabeth 0419 254 961 <sydneycityskywatchers@gmail.com>.
www.sydneycityskywatchers.org Also on Facebook and Twitter.

The **SYDNEY NORTHWEST ASTRONOMY GROUP (SNAG)** meets for viewing and imaging on Friday nights under clear skies at their Kenthurst site. Contact Geoff Bishop 0413 613 764 <snag.astronomy@gmail.com>.

The **TAMWORTH REGIONAL ASTRONOMY CLUB INC** holds meetings on the 1st Saturday of every month. The evening commences at 7 pm with an astronomy presentation (approximately. 30 minute talk) and then telescope viewing. Members Technical evenings and viewings are also held every Thursday, commencing from 5 pm. The Club also meets every Saturday morning 10 am to 1 pm for Solar and Radio Telescope operation. All sessions are open to the public to attend. They also operate the Astronomy and Science Centre, see entry under 'Places'. Contact Garry 0458 772 747 <tracthestars@gmail.com>. www.tamworthastronomy.com.au Also on Facebook.

THE NEWCASTLE ASTRONOMICAL SOCIETY meetings are held on the first Friday each month (except January), at the University of Newcastle, General Purpose building 1, level 1, at 7:30 pm. Contact Alan Meehan 0487 337 576 <starnut01@yahoo.com.au>. www.facebook.com/newcastleastrosociety/

The **UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY** meets on the first Wednesday of the month 6:30 for 7 pm start. Contact <unentas@gmail.com>. www.unentas.org.au Also on Facebook.

The **WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC** has club meetings with guest speakers at 7:30 pm on the 3rd Wednesday of the month. Contact <enquiry@wsaag.org>. wsaag.org Also on Facebook.

The **WOLLONGONG AMATEUR ASTRONOMY CLUB** has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Wests Illawarra Club, Unanderra. Visitors are most welcome to attend. Contact Jeff Poutney 0423 972 181 <jeff4@tpg.com.au>. waacers.org/index.php

NORTHERN TERRITORY

GOVE AMATEUR ASTRONOMERS meets as advised for viewing nights on a Saturday close to the New Moon at a local dark sky site. Their nights are announced on their Facebook page. www.facebook.com/GoveAstronomers

QUEENSLAND

The **ASTRONOMICAL ASSOCIATION OF QUEENSLAND** meetings will be on nominated Saturdays each month from February to December. The normal venue is Lecture Theatre 222, the Parnell Building (School of Maths and Physics), located on the south side of the Great Court, The University of Queensland, St Lucia Campus. Meetings generally commence at 4 pm. Dates of meetings and further details are published on their website. Contact the General Secretary via the 'Contact Us' form on their website. <info@aaq.org.au>. www.aaq.org.au Also on Facebook.

The **BRISBANE ASTRONOMICAL SOCIETY** hold meetings each month except January and December, see their website for meeting night details and live-stream options. Contact Peter Allison 0488 140 755 <President@bas.asn.au>. www.bas.asn.au Also on Facebook and YouTube.

The **BUNDABERG ASTRONOMICAL SOCIETY** has regular meetings, see website for details. Contact Mark Sugars 0409 697 734 alloway-observatory-bundaberg.webs.com

The **FNQ ASTRONOMERS GROUP** meet periodically in the Cairns region (Far North Qld) in conjunction with astronomical events as advised on the Facebook page. Contact Ian Maclean <ian@nightskysecrets.com.au>. nightskysecrets.com.au/tours/ Also on Facebook.

The **REDLANDS ASTRONOMICAL SOCIETY** meets via Zoom, see website for details. Contact President Janice 0411 627 610 <redlandsastronomicalsociety@gmail.com>. www.ras.org.au Also on Facebook.

The **SCENIC RIM ASTRONOMY ASSOCIATION** meets twice a month on Saturdays near the new Moon at their dark site at Laravale (under one hour south of Brisbane), often having a guest speaker or workshop before twilight ends. Contact Joel Bladen (President) 0431 436 500 <secretary@sraa.org.au>. sraa.org.au Also on Facebook.

The **SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY** meets third Tuesday of the month at Bracken Ridge Library from January to November. Meetings commence at 7:30 pm. Contact Julie Straayer 0411 047 439 <seqldastro@gmail.com>. www.seqas.org Also on Facebook.

The **SOUTHERN ASTRONOMICAL SOCIETY** has monthly meetings at 26–42 Charlies Crossing Road North, Upper Coomera Qld 4209, see website for details. Contact Caleb Kam (President) <calebkam.sas@gmail.com>. www.sas.org.au Also on Facebook and Instagram.

TOWNSVILLE ASTRONOMY GROUP INC meet monthly at the Aitkenvale Library for Club Meetings, fortnightly at the Strand, and weekly at their Oak Valley site for dark sky observing. www.astronomytsv.org.au Also on Facebook.

SOUTH AUSTRALIA

The **ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA** General Meetings are held at 8 pm on the 1st Wednesday each month (except January) in The Braggs Lecture Theatre, University of Adelaide, North Terrace Campus. Astronomy Education sessions at 7 pm precede the main meeting. The public are welcome to attend these meetings. Contact 0401 702 772 <info@assa.org.au>. www.assa.org.au Also on Facebook, Instagram and YouTube.

TASMANIA

The **ASTRONOMICAL SOCIETY OF TASMANIA** has regular meetings and observing activities throughout Tasmania. Contact Hobart – Steve Harvey 0419 341 469, Mark Rough – 0418 564 304, Devonport – Peter Sayers (03) 6424 2588 or email <info@astas.org.au>. www.astas.org.au Also on Facebook.

VICTORIA

The **ASTRONOMICAL SOCIETY OF VICTORIA** has monthly meetings, held at 8 pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. The ASV has 19 specialist sections that also hold regular meetings in the Ellery Suite at Melbourne Observatory. Contact Linda Richmond (Public Relations Officer) M: 0409 403 051 <publicrel@asv.org.au>. www.asv.org.au Also on Facebook, Instagram, Twitter and YouTube.

ASTRONOMY BENALLA meets on the 2nd Wednesday at 7:30 pm in Benalla, address varies, please consult their web page. Contact Peter Nankivell (President) 0428 308 234 <president@astronomybenalla.org.au>. www.astronomybenalla.org.au Also on Facebook.

The **BALLAARAT ASTRONOMICAL SOCIETY** holds members meetings, 2nd Friday of the month, beginning in February. Contact 0429 199 312 <bas@ballaratobservatory.org.au>. ballaratobservatory.org.au/bas

The **LATROBE VALLEY ASTRONOMICAL SOCIETY** meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers or via Zoom; call for details or check website. Contact Paul Odgers 0466 836 627 <info@LVAstro.org> www.LVAstro.org Also on Facebook.

The **MORNINGTON PENINSULA ASTRONOMICAL SOCIETY** meetings are held on the 3rd Wednesday of each month (except December) at 8 pm at The Briars Astronomy Centre, The Briars Historic Park, 450 Nepean Highway, Mount Martha. Contact Peter Skilton <welcome@mpas.asn.au>. www.mpas.asn.au Also on Facebook, Instagram, Twitter and YouTube.

The **MOUNT BURNETT ASTRONOMICAL SOCIETY** has regular meetings, see website for details. Contact <info@mbo.org.au>. mbo.org.au Also on Facebook, Instagram and Twitter.

The **SNAKE VALLEY ASTRONOMICAL ASSOCIATION** meet and observe at the SVAA Clubroom at 825 Linton-Carngham Rd Snake Valley on the closest Friday to the New Moon each month. ballaratman.wixsite.com/svastro

The **TALLANGATTA AND DISTRICT ASTRONOMY CLUB INC (TADAC)** get together once a month at the Tallangatta Showgrounds and various other locations for night sky observing. Contact Zachary West (president) 0438 863 739 <tallangattaastronomyclub@gmail.com>. www.tadac.info Also on Facebook.

WESTERN AUSTRALIA

The **ASTRONOMICAL SOCIETY OF THE SOUTH WEST** has regular meetings, see website for details. Contact <enquiries@assw.org.au>. www.assw.org.au Also on Facebook.

The **ASTRONOMICAL SOCIETY OF WESTERN AUSTRALIA** has regular meetings, see website for details. Contact <aswa.info@aswa-inc.org.au>. aswa-inc.org.au Also on Facebook.

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. A perfectly reflecting body has an albedo of 1.0 or 100%. The average lunar albedo is 0.12 or 12%.

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

Almanac A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an ***Ephemeris***.

Altazimuth coordinates The angular height (***altitude***) of an object above or below the horizon and its angular direction (***azimuth***) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a body most distant from the Sun. It is the opposite to ***perihelion***.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to ***perigee.***

Arcminute An angular measure (each degree is divided into 60 arcminutes).

Arcsecond An angular measure. Each degree contains 3600 arcseconds, and each ***arcminute*** contains 60 arcseconds.

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See ***Minor Planet***.

Astrology *See rubbish.*

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 au.

Azimuth Horizontal coordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the ***celestial sphere***.

Celestial poles Points on the ***celestial sphere*** directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth to which celestial bodies seem to be attached.

Circumpolar Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** it must have to be considered circumpolar.

Colour index The difference in the magnitude of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a ***comet***, usually the brightest part. Also a defect in an optical system.

Comet Small icy body that orbits the Sun and produces a coma and often tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least ***angular separation*** as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

Conjunction — Inferior When an ***inferior planet*** (Mercury or Venus) passes between the Sun and the Earth.

Conjunction — Superior When the Earth and an ***inferior planet*** (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the Universe.

CST Central Standard Time.

Culmination The instant when a celestial body crosses the ***meridian***; an object culminates when it reaches its highest point above the observer's horizon.

Declination (Dec) One part of the equatorial coordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (–) of the ***celestial equator*** and is analogous to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how long or thin an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

Eclipse When one object passes in front of or into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the ***umbra***, and penumbral if the Moon passes only through the ***penumbra*** of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. It is total when the Moon has a larger ***angular diameter*** than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

Ecliptic The plane of the Earth's orbit projected onto the ***celestial sphere***. It can also be defined as the Sun's path against the stars.

Ellipse A type of oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

Elongation The ***angular separation*** of two bodies. The greatest elongations of Mercury and Venus occur when the planets are at their largest angular distance from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all coordinate data and is compatible with modern star atlases.

Equinox The two times of the year when the Sun crosses the ***celestial equator***; vernal or spring equinox occurs about September 21, and autumnal equinox about March 22.

EST Eastern Standard Time.

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our ***galaxy***.

Galaxy A large disc or ball of billions of stars and ***nebulae***. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon with more than fifty percent, but less that one hundred percent illuminated. For example, aside from Full Moon, the Moon is gibbous between First and Last Quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our ***galaxy*** and are seen in other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local ***meridian***.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually in reference to the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is, Mercury or Venus.

Julian date The number of days since noon on 1 January 4713 BCE. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the ***constellation*** of Dorado. From mid southern latitudes the LMC is ***circumpolar***.

Libration The gentle rocking motion of the Moon as it orbits the Earth that allows observation of part of the side that normally faces away from our planet. In total, through this irregular motion fifty-nine percent of the Moon can be seen.

Light-year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.5. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude −1 (except for the Sun which is −26.7). The faintest visible to the unaided eye are magnitude 6 (under dark skies).

Magnitude — absolute The magnitude a star would have if it were viewed from a distance of 10 ***parsecs*** (32.6 ***light-years***).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The ***right ascension*** on the meridian equals local ***sidereal*** time.

Meteor (also shooting or falling star***)*** A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of ***meteors*** that appear to originate from a small region of the sky (the radiant).

Meteor swarm (or ***stream***) ***Meteoroids*** grouped in a localised region in orbit around the Sun (the source of ***meteor showers***).

Meteorite A ***meteor*** that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet (***Asteroid***) Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Nadir The point on the ***celestial sphere*** directly opposite the ***zenith.***

Nebula A cloud of interstellar gas and dust. See also ***emission, reflection*** and ***planetary nebula.***

Node One of two points at which an orbit passes through a reference plane (usually the ***ecliptic***).

Oblateness The ratio of the difference of equatorial and polar radii to equatorial radius.

Obliquity The degree of inclination (or tilt) of a planet's equator to its orbital plane.

Occultation The disappearance of one celestial body behind another.

Open star cluster A loose grouping of stars numbering from a few dozen to hundreds.

Opposition When a celestial body is opposite the Sun in the sky as viewed from Earth.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 ***light-years***. A parsec is defined as the distance to a celestial body whose ***parallax*** is one arcsecond.

Penumbra Area of partial illumination in the shadow of a planet surrounding the ***Umbra***. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth. It is opposite to ***apogee.***

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to ***aphelion***.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. The outer layers of a red giant during the latter stages of its evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of 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°).

Rubbish *See Astrology.*

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23 hrs 56 m 4 s.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid southern latitudes the SMC is ***circumpolar***.

Solstice The time when the Sun is farthest from the ***celestial equator***. In the Southern Hemisphere around 21 June marks the shortest day of the year, and around 21 December marks the longest day.

Spectral type A star's spectral classification determined by its ***spectrum***.

Spectrum The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The time that it takes for an object to reappear at the same point in the sky, relative to the Sun, as observed from Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the ***meridian***.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight — astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight — civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight — nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time (UT) A time system measured from the Meridian of Greenwich in England.

WST Western Standard Time.

Zenith The point directly overhead (90° in altitude).

Zenithal Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the ***zenith*** with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the ***ecliptic*** (astrologers ignore Ophiuchus, which also lies across the ecliptic).

GREEK ALPHABET (lower case)

α	Alpha	ε	Epsilon	ι	Iota	ν	Nu	ρ	Rho	φ	Phi
β	Beta	ζ	Zeta	κ	Kappa	ξ	Xi	σ	Sigma	χ	Chi
γ	Gamma	η	Eta	λ	Lambda	ο	Omicron	τ	Tau	ψ	Psi
δ	Delta	θ	Theta	μ	Mu	π	Pi	υ	Upsilon	ω	Omega

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- Astronomical Tables of the Sun, Moon and Planets (Meeus)
- Atlas of the Moon (Rükl)
- International Meteor Organization Calendar
- Mathematical Astronomy Morsels series, vol 1–5 (Meeus)
- The Night Sky Observer's Guide (Keppel/Sanner)
- Annals of the Night Sky vol 9 (Jeff Kanipe)
- Stars (Jim Kaler)
- Spectrum article (p. 5–10) some text credit:

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Some data prepared with the assistance of this software:

- Horizons System (JPL Solar System Dynamics)
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p. 99	Solar image, credit SOHO (ESA & NASA)
p. 99	EUV Sun images (Solar Orbiter/EUI Team/ESA & NASA; CSL, IAS, MPS, PMOD/WRC, ROB, UCL/MSSL)
p. 100	Full eclipse of the Moon, credit Sergei Mutovkin
p. 112	Texture maps of Moon, credit NASA/Naval Research
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p. 132	Background image, Comet Neowise (C/2020 F3), Benjamin Inouye, wikimedia commons.
p. 136	Milky Way, credit ESO & A. Fujii

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p. 24	NGC 1566 spiral galaxy in Dorado
p. 29	NGC 2442 Meathook galaxy in Volans
p. 29	NGC 1851 globular cluster in Columba
p. 33	NGC 3372 Eta Carina Nebula
p. 43	NGC 4755 Jewel Box
p. 44	NGC 4945 spiral galaxy in Centaurus
p. 53	NGC 6188/93 emission nebula & open cluster in Ara
p. 59	NGC 6726/27 complex in Corona Australis & NGC 6723 globular cluster
p. 59	NGC 6752 globular cluster in Pavo
p. 68	NGC 253 spiral galaxy in Sculptor
p. 80	NGC 1365 barred spiral galaxy in Fornax
p. 80	NGC 1532 spiral galaxy in Eridanus

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p. 24	NGC 1910/1903/1916
p. 39	IC 2391
p. 40	NGC 3201

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Index

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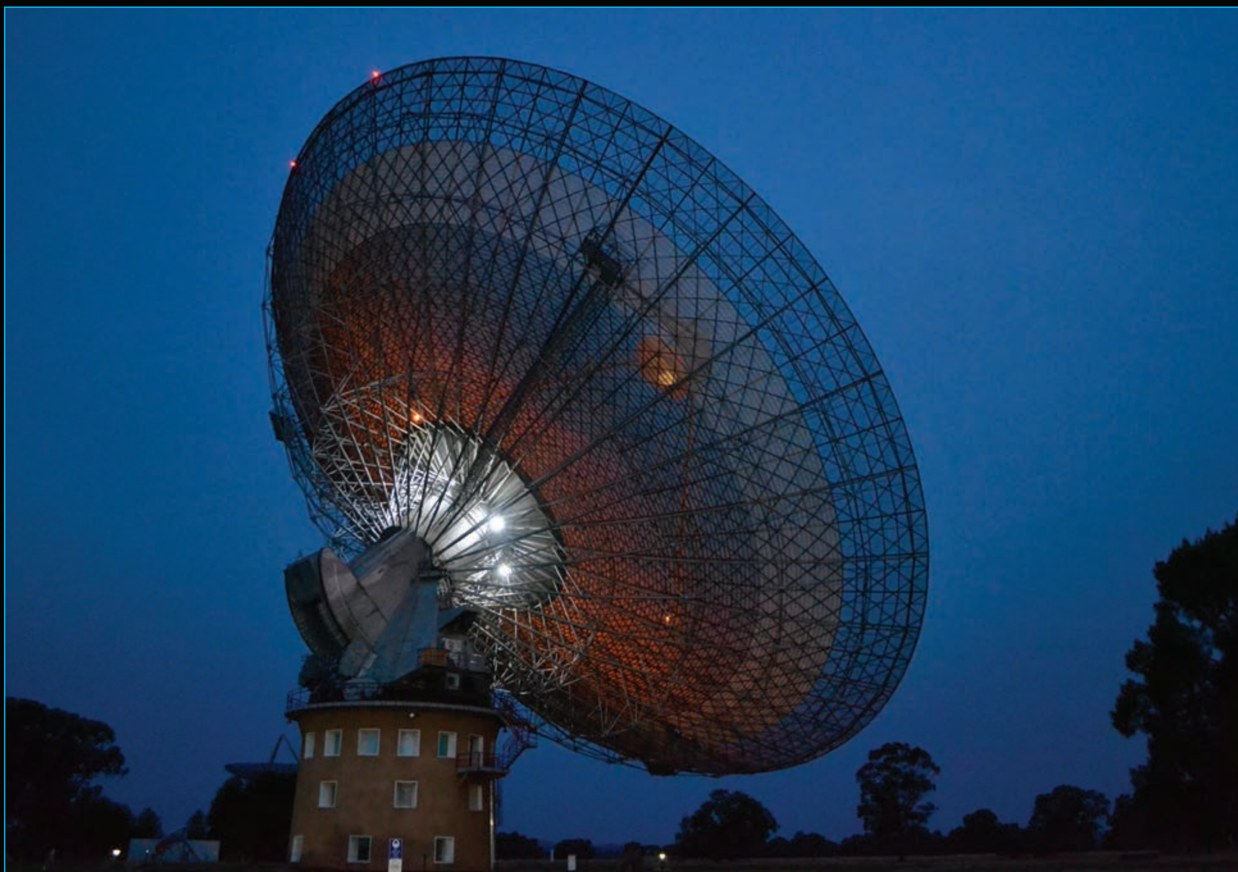

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