ASTRONOMY 2017

AUSTRALIA

YOUR GUIDE TO THE NIGHT SKY

Ken Wallace
Glenn Dawes
Peter Northfield

CALENDAR 2017

JANUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5		7
8	9	10	11		13	14
15	16	17	18	19		21
22	23	24	25	26	27	
29	30	31				

FEBRUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	
5	6	7	8	9	10	
12	13	14	15	16	17	18
	20	21	22	23	24	25
26 WA		28				

MARCH

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
	6	7	8	9	10	11
12 WA		14	15	16	17	18
19	20 WA		22	23	24	25
26	27		29	30	31	

APRIL

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30						1
2	3		5	6	7	8
9	10		12	13	14	15
16	17	18		20	21	22
23	24	25		27	28	29

MAY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2		4	5	6
7	8	9	10		12	13
14	15	16	17	18		20
21	22	23	24	25		27
28	29	30	31			

JUNE

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					2	3
4	5	6	7	8		10
11	12	13	14	15	16	
18	19	20	21	22	23	
25	26	27	28	29	30	

JULY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30 WA						
2	3	4	5	6	7	8
	10	11	12	13	14	15
16		18	19	20	21	22
	24	25	26	27	28	29

AUGUST

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7		9	10	11	12
13	14		16	17	18	19
20	21		23	24	25	26
27	28		30	31		

SEPTEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5		7	8	9
10	11	12		14	15	16
17	18	19		21	22	23
24	25	26	27		29	30

OCTOBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5		7
8	9	10	11		13	14
15	16	17	18	19		21
22	23	24	25	26	27	
29	30	31				

NOVEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	
5	6	7	8	9	10	
12	13	14	15	16	17	
19	20	21	22	23	24	25
26		28	29	30		

DECEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31					1	2
3 WA		5	6	7	8	9
	11	12	13	14	15	16
17		19	20	21	22	23
24	25		27	28	29	30

ASTRONOMY 2017

AUSTRALIA

Glenn Dawes Peter Northfield Ken Wallace

Quasar Publishing 2016

Acknowledgements 2017

Some of the information for this yearbook was adapted from the following sources:

- Astronomical Almanac for the Year 2017 (US Naval Observatory and UK Hydrographic Office)
- Astronomical Tables of the Sun, Moon and Planets (Meeus)
- Atlas of the Moon (Rükl)
- Cambridge Guide to the Constelations (Bakich)
- Comet orbital elements (International Astronomical Union)
- Exploring the Moon (Massey)
- International Astronomical Union
- International Meteor Organisation Calendar
- Mathematical Astronomy Morsels series, volumes 1 to 5 (Meeus)
- NASA/JPL websites
- Stars (Jim Kaler)
- The Moon: A Biography (Whitehouse)
- Washington Double Star Catalog
- The American Association of Variable Star Observers (AAVSO) website
- Data was also prepared with the assistance of the following software:
- Multiyear Interactive Computer Almanac 1800–2050 version 2.22 (MICA) (US Naval Observatory)
- TheSky (Software Bisque)
- Occult version 4.2.2.1 (Herald)
- Voyager version 4.5 (Carina Software)
- Guide 9 (Project Pluto)
- Ephemeris Tool (Dings)

Thanks to John Sarkissian for 'The CSIRO Parkes Telescope: Fifty Years of Greatness', Greg Bryant for the monthly comet text in Part I and comet text Part II and Richard Jaworski for Double Stars monthly paragraphs.

We would like to acknowledge the following individuals for that vital job of proofreading. Our thanks go to Greg Bryant, Brenda McNamara and Geoff Smith.

We (the authors) are responsible for any remaining errors. (big sigh) Yes, we like to think we are infallible, meticulous to every detail and the font of all astronomical knowledge, but… self-delusion is good too!

Illustrations

Front cover image is NGC 7635, the Bubble Nebula in Cassiopeia, Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA).

p. 1:	Joe Cauchi, NGC 2442, Meathook Galaxy taken with his 16" f/4.5 Newtonian, 12 × 15 minute plus 15 × 15 minute exposures March 2013 and April 2016.
pp. 5–8:	Images supplied by John Sarkissian, see captions.
pp. 9–14:	Cartoon drawings by Ingrid Huibers.
p. 13:	Image of Celestron GoTo NexStar 6 supplied by Binocular and Telescope Shop (Bintel).
p. 21:	Murchison Meteorite at the Museum of Natural History—Wikimedia Commons.
p. 27:	Pioneer plaque—NASA, JPL
p. 42:	Twilight image from International Space Station, see caption
p. 56:	Big three craters from Consolidated Lunar Atlas
p. 60:	Herschel's drawing of 'lunar forest', Wikimedia Commons.
p. 61:	Franz Von Gruithuisen, Wikimedia Commons.
p. 61:	Gruithuisen's drawing of Wallwerk, Wikimedia Commons.
p. 92:	Solar active region 9933 in 2001, courtesy of SOHO/[MDI] consortium.
p. 93:	Eclipse predictions by Fred Espenak, NASA/GSFC.
pp. 100–101:	Texture maps of Moon, credit NASA/Naval Research.

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

Rear cover: A double rainbow appears over the refurbished Parkes Telescope—a bright future lies ahead. Image copyright: John Sarkissian.

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

ISBN 978-0-9924409-2-3

Published in October 2016 by:
Quasar Publishing
PO Box 85, Georges Hall NSW 2198 Australia
Fax: (02) 9012 0452
Email: info@quasarastronomy.com.au
Web: www.quasarastronomy.com.au

Additional copies of this book may be purchased directly from the publishers. Contact Quasar as above for further information.

Contents 2017

Introduction to the 2017 Edition

Welcome to Astronomy 2017, our 27th year of publishing this august tome (works in other months as well).

This year we would like to thank John Sarkissian for following up on his previous article (11 years ago) to update the achievements of the Parkes Radio Telescope and for giving us a glimpse into its exciting future. It's great to see him recognise the importance of the people involved and their talents that keep the instrumentation on the cutting edge of technology, which drives the discoveries. Its involvement in a revived effort to look for extra-terrestrial intelligence is fascinating. After so many years of failed attempts worldwide it's easy to get blasé, but such a discovery would have a staggering worldwide impact, crossing all political and social boundaries.

The yearbook contains much of its regular information, including our monthly features covering the usual diverse range of interests. Topics this year include:

- Just because a star is bright, does it mean it is close by?
- Australia's stunning meteorite fall in 1969!
- Forests and cities on the Moon?
- Are the Pioneer and Voyager probes really leaving the Solar System forever?
- The big three on the Moon.
- Earthly twilight as seen from space.
- There's much to consider when choosing an observing site.
- An update on spacecraft probing the depths of the Solar System.

Part I of Astronomy 2017 is intended as a general quick reference to finding and observing the planets. This section is ideal for those just starting to navigate the heavens. The All Sky Maps cover the entire Southern Hemisphere night sky in nine easy to use charts. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices; include sections on the constellations, bright stars and astronomical objects to observe as well as places of interest and amateur societies. You can also visit our website www.quasarastronomy.com.au where you will find links to all of the sites listed in Part III of this book.

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

At the time of writing the Rio Olympics were in full swing. Every time the Australian flag went up at a medal award ceremony we celebrated not only our national pride but also our heritage, the night skies, with the Southern Cross proudly on display. Traditionally, as a small nation we have punched above our weight on the world stage with astronomical achievements for many years. As John Sarkissian reminds us, 'The Dish' is a classic example. Unfortunately funding for scientific endeavours in Australia (like many countries) is continually under pressure. In this environment of belt tightening it is a tribute to see our nation supporting the Square Kilometre Array. Although the SKA has tremendous potential, it has stretched the already limited resources available for astronomical endeavours. Let us hope the fine work at Parkes and other excellent institutes such as the Australian Astronomical Observatory do not suffer. We shouldn't forget scientific discoveries only happen by keeping professional astronomers and associated engineers and staff employed and developing their skills into the future.

There is nothing more refreshing than the passion of a dedicated volunteer. Consider supporting your local astronomical society. For just a small fee to keep the wheels turning, they are an invaluable source of advice based on many years of hands on experience. You may also get to use equipment you could never afford or have the remote dark sky site to keep it. Finally, don't underestimate the importance of making life long friends bonded with a common interest—the authors can attest to this!

Wishing you clear skies and see you next year.

Glenn Dawes   Peter Northfield   Ken Wallace

THE CSIRO PARKES TELESCOPE: FIFTY-FIVE YEARS OF GREATNESS

John Sarkissian, OAM, Operations Scientist, CSIRO Parkes Telescope

The CSIRO's 64-metre Parkes Radio Telescope was commissioned on 31 October 1961. At the time, it was the most advanced radio telescope in the world, incorporating many new innovative design features that have since become standard in all large dish antennas. Through its early discoveries (see Astronomy 2006), it quickly became the leading instrument of its kind in the world. Today, over 55 years later, it is still arguably the finest single-dish radio telescope in the world. It is still doing world-class science and making discoveries that are shaping our understanding of the Universe. We take a look at the reasons for the telescope's success and longevity and try to peer into the near future to see what may lie ahead for it.

The telescope was originally expected to have a lifetime of twenty years, so we have well and truly exceeded that expectation. There have been many reasons for this longevity. Its location in the Goobang Valley, just north of the town of Parkes in the Central West of NSW, was chosen for its lack of radio frequency interference (RFI). A large antenna like Parkes is incredibly sensitive to local radio interference. The region around the Goobang Valley shielded the telescope from the radio emissions from the larger population centres further east such as Orange, Bathurst, Lithgow and of course, Sydney. Today, the situation has worsened; it seems like everyone has mobile phones, digital cameras, GPS receivers, computers, microwave ovens, digital TV, wireless internet and much more. All of these devices emit radio signals that can easily overwhelm the faint signals the astronomers want to detect from space (RFI can be thought of as the radio equivalent of light pollution in optical astronomy). However, compared to other sites of similar vintage around the world, the Parkes site is still quite good and useful work is still being undertaken there. Another great advantage of the site is its location on the Earth's surface. As all astronomers are aware, from these latitudes the centre of the Milky Way passes almost directly overhead, so the richest and most interesting parts of the Galaxy are easily accessible from Parkes, giving it an advantage over almost all other large radio telescopes.

Another reason for its success was the design of the telescope. The famous British engineer, Barnes Wallis, of "Dambusters" fame, suggested many new, innovative design features. For example, it was the first large radio telescope to be mounted from the centre, like an inverted umbrella. All previous large antennas were mounted on the edges like inverted bridges, which made pointing the telescope very difficult. The Parkes design overcame this by incorporating a Barnes Wallis inspired master equatorial (ME) telescope at its centre. Essentially, a small equatorially mounted optical telescope was placed at the intersection of the altazimuth axes of the giant dish. The ME could be pointed very accurately (optical astronomers had been doing this for centuries). By using a powerful light beam and clever electronics, the dish was slaved to the ME via a servo loop, which allowed the dish to accurately follow the ME smoothly across the sky. The design was so successful that, up until the 1990s, it was incorporated in all subsequent large, single-dish antennas. Barnes Wallis also designed the dish surface to be extra rigid. This allowed the surface to remain accurate as the dish was tipped. The shape would deform, but to another parabola. This effectively meant that the focus position would move up and down. By knowing how much the focus position changed as a function of tip angle, the receivers in the focus cabin could be positioned to be at maximum focus at all times, thus maintaining their sensitivity.

These features alone do not explain the longevity of the telescope. Rather, the telescope has been constantly upgraded over the years. The most obvious upgrades have been to the dish surface. Originally, the entire surface was made of steel wire-mesh panels which extended all the way to the centre. However, beginning in 1970, the surface has been progressively upgraded, with the steel wire-mesh panels replaced by perforated aluminium panels. These have made the telescope more sensitive to the higher frequencies. The most recent surface upgrade was in 2003 when the aluminium panels were extended to the inner 55 metres of the dish. Another major upgrade was to the focus cabin. The old original cabin was only capable of housing a single receiver at the focus. Whenever astronomers wanted to change observing frequency they would have to dismantle the receiver and

The Parkes Telescope as it appears today with the new focus cabin and the inner 55 metres of the dish surface replaced by perforated aluminium panels. Image copyright: John Sarkissian.

bring it down in pieces and then take up the new receiver and assemble it on the focus. This process could take as long as a day to complete, sometimes longer. In mid-1995, a new, larger focus cabin was installed. This new cabin was twice the size and weight of the old cabin. It was capable of housing up to four receivers. Now, whenever an astronomer wanted to change observing frequency, a simple pressing of a button in the control room would move the selected receiver onto the focus within a minute. This made the telescope more frequency agile and efficient in the way it was used and it increased the productivity of the telescope many-fold. Consequently, many different types of observations could be scheduled within a short period, leading to more opportunities to do world-class science and to follow up observations of rapidly changing phenomena.

Another source of the telescope's success has been the constant upgrading of its processing instrumentation. When it was first commissioned, the most common recording device was a chart recorder and analysis was performed with a slide-rule. Eventually, the Observatory's first computer was installed in 1968. It was a PDP-9 with a paper tape output and was the same one featured in the film The Dish. Since then, every function of the telescope has been fully computerised. All of the data is digitised and stored onto magnetic disks before being transported around the country, and the world, via dedicated fibre-optic lines with a 1 Gbps capacity, and upgradable to 10 Gbps if required. This is essential because of the enormous volume of data being recorded. A typical observing session today can record several terrabytes of data. In fact, there is so much data being recorded that the archiving capacity is constantly being challenged. The new, innovative observations demand a vast amount of memory space and this will only increase further in the coming years. New data capture and processing equipment is constantly being designed and installed to meet this demand. We've moved from chart recorders to supercomputer clusters utilising the latest graphics processing unit (GPU) and radio frequency (RF) over fibre technologies. It's been an incredible transformation.

The telescope's receiving systems have also been extensively upgraded over the years. When commissioned, simple dipole receivers were used to detect the radio waves at the focus. These essentially operated at room temperatures and were not very sensitive. Eventually, cryogenically cooled receivers were developed that now operate at around 20 K (–253° C), vastly increasing their sensitivity. In 1997, this technology was further advanced when the 20 cm multi-beam (MB) receiver was commissioned. Up until then, conventional receivers could only detect radio signals coming from single points on the sky. These single feed receivers would sit at the focus of the parabolic dish, only detecting the signals focused at that point. However, the telescope has a focal plane, that is, a region around that focus point where the signal is still quite strong. It was realised that by placing several receivers on the focal plane, multiple radio beams can be projected on adjacent points on the sky. Consequently, a focal plane array receiver with 13 feeds was built and installed in January 1997. This allowed astronomers to 'see' 13 points simultaneously on the sky and to conduct surveys 13 times faster than in the past. You can think of it as a 13-pixel radio camera. It's not much compared to today's multi mega-pixel optical cameras, but it was a great improvement on the single pixel, conventional radio receivers. This MB receiver rejuvenated the Parkes telescope. It led to several ground breaking surveys that doubled the total known number of pulsars, including the discovery of the only known double pulsar system, in 2003. It also allowed astronomers to probe the Universe and plot the positions of galaxies out to 300 million light years and to peer through the Milky Way to see what lay behind, for the first time. It revolutionised the way radio telescopes conducted surveys. Several MB receivers were subsequently built by CSIRO for other observatories around the world including Jodrell Bank Observatory, Arecibo Observatory and the new FAST telescope in China.

The sum result of all these upgrades, both external and internal, is that today, the telescope is 10,000 times more sensitive than when it was built. In fact, the only parts of the telescope that are 55 years old are the concrete and steel it is made of. Everything else is much newer—in many ways it is a young telescope.

The way the telescope operates has also changed over time. At first, dedicated telescope drivers were employed to drive the telescope for the astronomers. The old control desk, with its dials and globes, which resembled something from the TV show, 'Thunderbirds', was too complicated to entrust to inexperienced astronomers. Over time this became a very inefficient and costly way of operating the telescope. With new equipment and observing techniques being developed, it was time for a change. In the early 1980s, the entire control system was replaced by a new computerised system. Now, astronomers could be trained to operate the telescope more efficiently, and conduct more complicated observations. It also helped that it kept the operating costs down, so that money was freed to develop new equipment and to build the Compact Array at Narrabri. This system was further upgraded and modernised in the late 1990s when the MB receiver came online. With the costs of building the Australian SKA Pathfinder (ASKAP) telescope escalating, it was decided in the late 2000s to further upgrade the operations and allow remote observing to be undertaken. The entire control system was modified so that astronomers could connect via the internet and safely control the telescope from a remote location such as their office or home, from anywhere in the world. This allowed further savings to be made and has increased the efficiency of the telescope further.

The improvements to the telescope have meant that new discoveries are being made all the time. One fine example is the discovery of Fast Radio Bursts (FRBs). These are sudden, single bursts of radio energy that last only a few milliseconds. Their origin is a complete mystery. From the nature of the signals detected so far, they appear to come from extragalactic sources, billions of light years from the Earth. This implies that the energy release is enormous. The first FRB was discovered at Parkes in 2007 by British astronomer Duncan Lorimer and his colleagues. He was searching through some archived data taken with the MB receiver in 2001, looking for giant pulses from pulsars. Instead, he came across this ultra-bright burst from a single point on the sky. The dispersion of the signal indicated it was very distant. When it was observed again, to see if it could be re-detected, nothing was ever seen of it. Then over the next few years, more of these were found

In September 1970, the Parkes Observatory director, John Bolton, is seen on the right installing the first of the new aluminium panels, with his staff. Image Copyright: CSIRO

In 1970, the inner 33 metres of the dish surface were replaced by perforated aluminium panels. They appear yellow in this picture but were later painted white to reflect the heat in order to minimise the surface deformation. The panels were later progressively extended to 37 metres, then 45 metres and finally to 55 metres in 2003. Image Copyright: CSIRO

in the archived data, coming from other points in the sky, and in new observations. Interest began to increase. The very first FRB, and all but two of the less than two dozen FRBs discovered to date, have been found at Parkes. The statistics suggest there should be thousands of these bursts every day, but you need to observe at the right point, at the right time, at the right frequency and with all the right equipment and processing software to detect them. With the MB surveys and with the right kind of equipment, Parkes was the ideal place to discover them. Are FRBs a new class of object? Are they formed by colliding neutron stars, black holes or some other cataclysmic event? Could they be signals from extraterrestrial civilisations? Or is there a more mundane explanation for them? No one knows, but it is fascinating to watch an entirely new field of astronomical research taking shape before our eyes. Stay tuned for more.

In order to further study these intriguing objects, and much more, a new suite of radio receivers is being planned and built for Parkes. The first is an ultra-wideband (UWB) receiver. It will operate over a very wide band of frequencies ranging from 700 MHz to 4 GHz. This is many times the frequency range of existing receivers. Together with the 20 cm MB receiver, this would allow more than 90% of current Parkes operations to be made with no receiver changes, greatly improving the efficiency of Parkes operations. It could be configured for all types of observations including pulsar, spectral line, polarisation and VLBI observations. The UWB receiver would make possible unique studies of frequency–dependent phenomena and allow the CSIRO engineering group to maintain their world-leading expertise in the Square Kilometre Array (SKA) era. The plan is to commission the receiver in late 2017.

Another new form of receiver being developed by CSIRO is a Phased Array Feed (PAF) receiver. PAFs are many little antennas placed on the focal plane of the telescope, in a checkerboard design. Each of the antennas can be linked together, or phased, in such a way that many radio beams can be projected on the sky. These PAFs are being developed by the CSIRO to operate on the next generation of radio telescopes as a pathfinder for the SKA and are being installed on the ASKAP antennas in WA. The PAFs are able to generate 36 beams simultaneously. This will greatly increase the speed that surveys will be conducted and they represent the future of radio astronomy. In February 2016, a PAF was installed on the Parkes telescope to test and commission the receiver for installation on the 100-metre radio telescope in Effelsberg, Germany, for the Max Planck Institute for Radio Astronomy. As a consequence of this, the Parkes telescope was granted the status of “SKA pathfinder” for the Square Kilometre Array Organisation. It is planned that soon after the UWB receiver is installed and commissioned on Parkes in late 2017, work would begin to build a cryogenically cooled PAF specifically for the Parkes telescope. This receiver will be even more sensitive than the existing PAFs and will be an ideal instrument in searching for FRBs.

On 21 July 2015, the Breakthrough Prize Foundation announced that a new Search for Extraterrestrial Intelligence (SETI) project will begin in 2016. It will incorporate the 110-metre radio telescope at Green Bank, West Virginia, USA, in the northern hemisphere and the 64-metre CSIRO Parkes telescope in the southern hemisphere. The Breakthrough Prizes were founded by well-known internet entrepreneurs, Sergey Brin, Jack Ma, Yuri Milner and Mark Zuckerberg. The prizes aim to celebrate scientists and generate excitement about the pursuit of science as a career. The SETI project is known as Breakthrough Listen. Over a ten year period, US $100 million will be invested by Breakthrough Listen on this global SETI initiative. The Parkes telescope is essential for the scientific integrity of the SETI program. It is ideally located and perfectly positioned to provide the best and most powerful view of our galactic plane. The $7.5 million contract began at Parkes in October 2016 and will run for five years to 2021, with a likely extension of another five years after that. Twenty five percent of the telescope time is contracted to the project. The program will not displace any high priority science programs or the existing scientific user base. The astronomy community will be supplied with greater scientific capability through long-term financial support. The program will ensure that the telescope is adequately and sustainably funded, and it will facilitate the delivery of world leading science outcomes.

The current plan for Breakthrough Listen is to utilise the 20 cm MB receiver in its initial search. Once the UWB receiver is commissioned in late 2017, it too will be used to increase the frequency coverage. Finally, when the Parkes PAF is commissioned, it too will be used to increase the search area and survey speed even further. Breakthrough Listen is an exciting project that inspires the public and ensures the future viability of Parkes. The chances of finding a SETI signal are very small, but the consequences would be enormous. For this reason it is an extremely worthwhile undertaking.

The great advantage of the Parkes telescope has been its incredible flexibility and versatility. Upgrading the telescope is relatively straightforward; you only need to build one piece of equipment. For an array, you need one for every antenna in the array; the more antennas, the more expensive it becomes. Parkes offers a less costly alternative and therefore is more likely to happen.

Although it was initially designed as a survey instrument, its versatility has meant that it is capable of performing many different types of observations. From discovering quasars, pulsars and molecular clouds to tracking spacecraft or searching for ET. It can do many things efficiently—and very well.

But in the end, what makes Parkes such a great instrument are the people who use it, the engineers and programmers who design and build the new equipment, and the people who maintain it. This attracts the very finest astronomers, who devise new observing techniques and clever ways to extract more information from the data. It is these people who realise that a new, unusual signal is interesting and worth following up on with a desire and curiosity to get to the bottom of the mystery. The Parkes telescope has been fortunate to have these inspiring people work on it.

Parkes has maintained its world-leading position in radio astronomy by constantly adapting and changing to meet new requirements. Today's improvements and upgrades are just the latest in a spectrum of change that has made the CSIRO's Parkes telescope Australia's premier scientific instrument. It is an iconic telescope with a great legacy of world-class science and discovery. The future looks bright for Parkes.

BIO: John Sarkissian is an Operations Scientist at the CSIRO Parkes Radio Observatory. His main responsibilities are the operation and systems development at the radio telescope, and the remote support and training of astronomers with their observations. In addition, he is involved in pulsar research—an exciting field of radio astronomy.

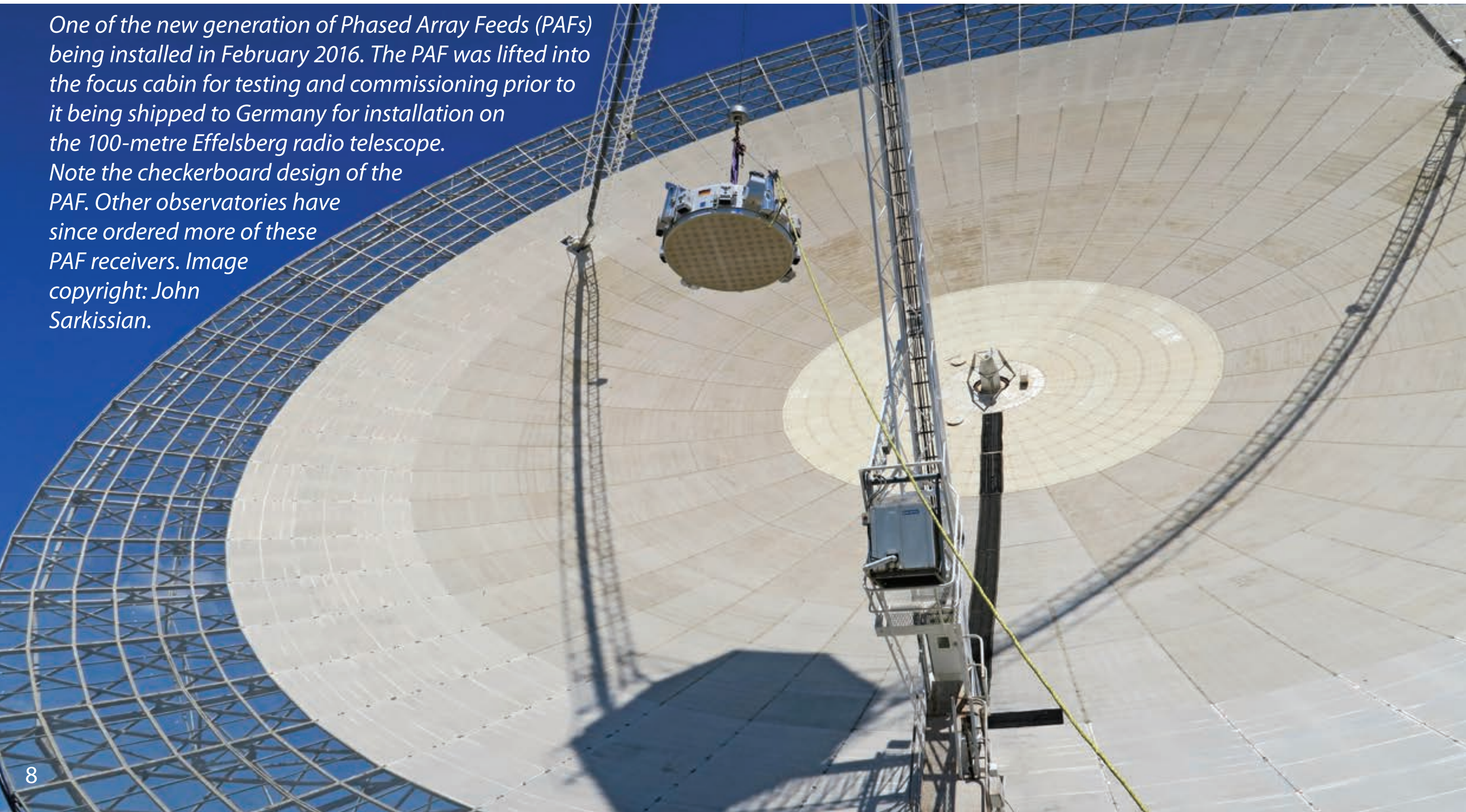
John is a member of the ATNF Science Operations Team which provides the front-line support for the Australia Telescope National Facility (ATNF) telescopes. He is one of four ATNF Operations Scientists who operate and troubleshoot the ATNF telescopes. In 2015, he joined the newly created ASKAP Operations Team. Overall, the team will operate ASKAP and support Parkes, ATCA and VLBI operations.

John is also a member of several precision pulsar timing projects including the Parkes Pulsar Timing Array (PPTA) team which is endeavouring to use precision pulsar timing to make a direct detection of gravitational waves.

Since 2003, John has been a member of the small, informal team searching for the missing Apollo 11 slow-scan TV tapes. From 1998-1999, John acted as a technical advisor for the feature film The DISH'. He came to Parkes in 1996 to support the Galileo Mission to Jupiter. He managed the Galileo spacecraft tracking operations at the observatory and performed one third of the daily tracking duties.

In June 2016, John received an Order of Australia Medal (OAM) in the Queens Birthday Honours List, for services to astronomy.

For more, visit: www.parkes.atnf.csiro.au/people/sar049/



One of the new generation of Phased Array Feeds (PAFs) being installed in February 2016. The PAF was lifted into the focus cabin for testing and commissioning prior to it being shipped to Germany for installation on the 100-metre Effelsberg radio telescope. Note the checkerboard design of the PAF. Other observatories have since ordered more of these PAF receivers. Image copyright: John Sarkissian.

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

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

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

A FEW TIPS FOR BEGINNERS

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

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

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

Location. Take a little time to plan where you will observe. Some handy, often just common sense advice can be found on page 73.

The Attraction of Dark Skies

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

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

DISTANCES ARE TRULY ASTRONOMICAL!

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

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

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

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

The distance to:

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

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

Dark skies also offer the opportunity to try and see the planet Uranus with the unaided eye. The All Sky Map No 3 (p. 79) and finder chart (p. 128) will help find this elusive distant member of the Solar System. Also, at some oppositions the minor planet Vesta can brighten sufficiently to be visible with the naked eye.

You can always go on a voyage of self-discovery. There is a good chance any fuzzy object (unless it is a comet) will be marked on the All Sky charts (see pp. 77-85).

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

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 brighter stars can make it easier to learn the major constellations. The many stars visible from the country, certainly more than those shown on the All Sky Maps, can swamp distinctive star patterns making them difficult to find.

Whether your skies are dark or flooded by light pollution it is still important to try and maintain dark adaption for your eyes and this makes reading star charts and making notes under red light important (see side bar, A Few Tips for Beginners, p. 9). As part of this avoid any direct lighting, even if it means sacrificing some horizon by hiding behind your home or fence. If you have the annoying neighbour with the constant backyard light on, invite them over to view the sky. Trying to see past their floodlight might give them the message.

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

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

When two celestial bodies are close together it's called a **conjunction**. They can be quite attractive, especially those involving the brightest planets. Conjunctions between the thin crescent Moon and Venus or Jupiter are spectacular. For example have a look at the close meeting between the Moon and Venus in the early evening sky on January 2 (see Sky View, page 24).

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

Meteors or shooting stars. These streaks or fireballs occur when particles burn up in the Earth's atmosphere. Most range from about the size of grains of sand up to a few millimetres (pea size) and are called meteoroids when in space. Those that survive to hit the ground are called meteorites. Around a half dozen meteors per hour can be seen under dark skies, with a tendency for more after midnight. These are the sporadics.

Meteors also occur in annual **'showers'**. This happens when a sudden increase in number are seen around the same time each year as the Earth passes through or near ancient debris trails left by passing comets. Part 1 discusses the favourable ones visible this year; also see the introduction page 17.

A WORD ABOUT BINOCULARS

Probably the most cost-effective accessory for the beginner are binoculars. A reasonable quality pair can be purchased for the same price as a cheap, sub-standard telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a low cost way of gauging your child's level of interest. We suggest they should be purchased from a reputable optics or telescope dealer. These people appreciate the quality required for stargazing. To observe detail on the Moon or look for Jupiter's moons, avoid just holding them in your hands. Try bracing yourself on something like the arms of a chair, a

USES FOR BINOCULARS

There are a multitude of uses for binoculars in amateur astronomy. Some of these include:

- Helping to find stars and planets in a bright twilight sky.
- Looking at the maria (seas), larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views, All Sky Maps and finder charts in this publication. Binoculars can help in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Contrast the yellow of Alpha (α) Centauri with the blue of Beta (β) Centauri.
- Stars and planets close to the horizon.
- Looking at artificial satellites in the early evening sky. You might find them with the naked eye, but binoculars will help; sometimes they vary in brightness as they tumble. You can follow them further into the Earth's shadow before disappearing.
- Lunar occultations of some of the brighter stars (see Part II). Small binoculars are well suited for magnitude four or brighter events, preferably on a dark limb.
- Searching out Uranus and Neptune, using the finder charts, see page 128 and All Sky Maps 3 and 8.
- Looking at bright, wide double stars.
- Observing bright comets.
- Observing the moons of Jupiter as they oscillate across the planet from night to night, see the diagrams on pages 113 to 118. The magnification of the binoculars will dictate how close to Jupiter you can see these satellites.
- Some of the bright deep sky objects such as star clusters, Milky Way regions, and the Magellanic Clouds. The galaxies M33 in Triangulum and NGC 253 in Sculptor are worth going after as well. Most Messier objects, marked as 'M__' on the All Sky Charts, are visible in binoculars, the galaxies may need a small telescope.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart to see which *star* has moved. Taking the coordinates of a minor planet from Part II, and plotting that position on the All Sky Maps, will help you find the correct area.
- Monitoring the change in magnitude of some of the brighter variable stars. There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society (p. 149) or organisations such as Variable Stars South www.variablestarssouth.org or AAVSO www.aavso.org. Examples of Mira (long period) variables ideal for binoculars are listed on page 36.

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.

A selection of binoculars. Clockwise from top we have 15 × 80, 7 × 50, 4 × 21 and 10 × 50.

fence or the roof of a car. Telescope dealers can assist with mounts to hold the binoculars steady. There are also brackets designed to attach binoculars to a camera tripod. This is probably the cheapest option, especially if you already have a tripod. Keeping the binoculars steady is important if the power of the binoculars is more than 10×. A power of 7× is a reasonable compromise. It can give a good field of view with adequate magnification to glimpse some of the moons of Jupiter. The size of the aperture normally comes down to what is comfortable for a person to hold in the hand and the budget; 7 × 50 binoculars (7 times magnification, 50 mm diameter objective lens) are fairly popular with amateurs.

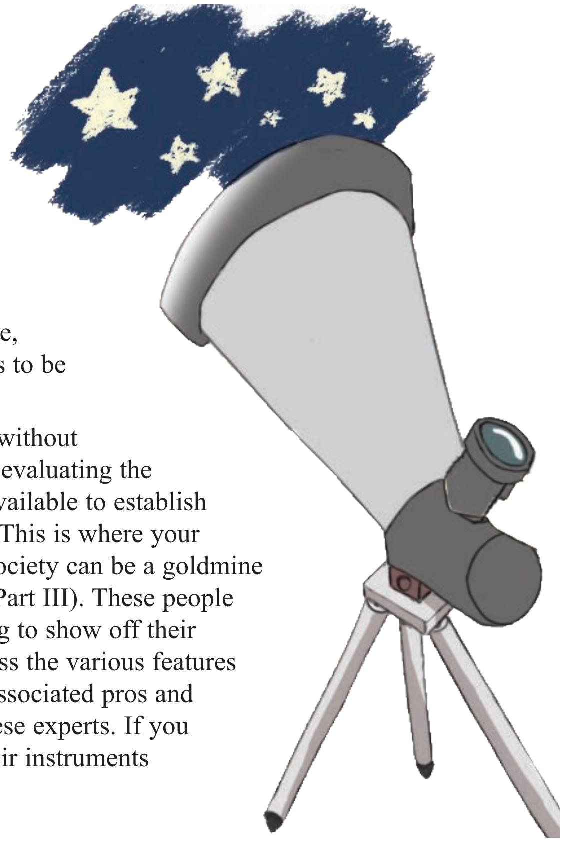
For the novice, finding your way around the sky is far easier with binoculars than with a telescope. Using a telescope is a bit like looking at the sky through a straw and the view is usually upside down and sometimes mirror-imaged! Even when using low power in a typical amateur telescope, the field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

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

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

Taking your binoculars out under dark country skies at some stage is a must. It has been said that one of the joys of the Milky Way's satellite galaxies, the Magellanic Clouds, is that they show as much detail through a moderate size amateur telescope as that seen by large professional telescopes looking at distant galaxies (outside our Local Group). This argument can be extended to our own Milky Way, but in this case the humble binoculars are sufficient. The wide field of binoculars is ideal to show detail in the complex dark lanes and star clouds running through our galaxy, especially around the central galactic bulge 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.

BUYING YOUR FIRST TELESCOPE



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

Don't buy anything without spending some time evaluating the various telescopes available to establish what suits you best. This is where your local astronomical society can be a goldmine of information (see Part III). These people are more than willing to show off their telescopes and discuss the various features available and their associated pros and cons. Learn from these experts. If you can look through their instruments

Typical commercial Dobsonian telescope.

under light polluted conditions as well as under dark, country skies, all the better. This gives you a realistic feel of what to expect. The telescope shops and public observatories also have many years of experience in this area, so draw on their advice as well. You might pick up a bargain through the amateur ranks, maybe checkout the IceInSpace website?

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

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

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

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

GoTos require some initial fiddling to get going, but after this you just select the object from a list in its on-board computer and the telescope automatically takes you there—magic! They are driven by a control paddle or even remotely via Wi-Fi by planetarium programs on tablets or smart phones. GoTos require very little knowledge of the sky, although when setting up most need the operator to help the electronics get its bearing by pointing to two bright stars in its memory bank. The GoTos are quite portable with most utilising the shorter

Celestron NexStar GoTo telescope.

Schmidt Cassegrain optics, which easily swing into their fork mount with the tripod quickly collapsible. Another advantage for these power-driven scopes is they compensate for the rotation of the Earth, keeping the object in the field of view.

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

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

USING THE BOOK

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

The Moon. The phase of the Moon is a good place to start, the inside front cover will help. Unless you wish to view our natural satellite, 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 generally Moon free as are evenings after Last Quarter. The Rise/Set diagram, which is on the first page of each monthly section, helps further define the ‘Moon observing’ and ‘dark’ windows. More specific times, on a day-by-day basis for each of the Australian capitals, are presented in Part II (starting page 94).

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

Lunar occultations, when the Moon passes in front of stars, are very time and location dependent and these can be found for the cities starting on page 103 with the formula for adjusting for other locations on page 102. Events, either disappearances or reappearances, are best on dark limbs, which are also identified. Optimum times for **librations** are presented in the monthly sections, allowing the observer to glimpse features that temporarily appear on the limb as our satellite seems to wobble in its orbit.

The Planets. Mercury, Venus, Mars, Jupiter and Saturn are naked eye objects with Uranus and Neptune requiring at least binoculars. To get a quick overview of what is on offer tonight start with the **Visibility of the Planets** (p. 19).

As an example looking around mid-June, Saturn, Jupiter and Mars are visible in the evening sky with Mercury, Venus, Uranus, Neptune and Pluto in the morning. You will notice that Saturn is near the midnight line and likely to be close to opposition and up the whole night, see the specific June monthly Rise/Set (p. 45). Although the ‘Visibility’ shows Mercury in the morning it is also near the Sun line and once again the ‘Rise/Set’ shows it rising well into the dawn sky and difficult to observe.

The **Appearance of the Planets** diagram (first page on each monthly section) gives the relative sizes and phases (where relevant) for planets. Saturn’s rings are wide open this year and should be spectacular in any small telescope. It is fascinating to watch **Mercury** in particular as it quickly zips around the Sun. At superior conjunction, behind the Sun and out of sight (e.g. March 7), this inner world is small with a full phase. It then enters the evening sky growing in size but its phase waning as it approaches inferior conjunction for example April 20 (between us and the Sun). Mercury then enters the morning sky and the process reverses until superior conjunction is reached again (June 21). Its fellow inner world **Venus** goes through the same process but much slower, being further from the Sun. In fact, 2017 sees only an inferior conjunction, March 25, and spends the rest of the year reducing in size towards superior conjunction in 2018. When it comes to Mercury it is best to observe it around times of maximum elongation (conjunctions are too close to the solar glare). This is the time of greatest angular distance from the Sun and highest in the sky, for example Mercury in the evening sky on July 30.

Mars only achieves a reasonable size when at opposition which does not happen in 2017 (the next is in July 2018). Although its reddish disc remains small and possibly featureless you may occasionally see a polar ice cap or other surface marking.

Jupiter, like any of the outer planets, is best observed when the planet transits the meridian (is due north). The ideal time is at opposition when the widest observing window is available with the planet transiting around midnight. The Rise/Set (page 35) and page 19, confirms this happens for Jupiter in early April. Besides observing its atmospheric belts, the **Great Red Spot (GRS)** is worthwhile looking for, see the table and explanation on pages 110–111. An example is the evening of April 25 around 9:54 pm (EST).

Pages 112–118 cover the **Jovian Satellite Phenomena** as the four major moons shuffle back and forth crossing in front and passing behind the planet. Sometimes looking for days on the diagram when more than one moon is close to Jupiter such as on the evening of May 24 (page 115) is a good indication of many events. The table on the same page confirms this with three moons involved in a number of events before midnight.

Saturn, with its impressive ring system, is visible in any small telescope, and has six moons that are considered observable in amateur equipment. However, with the exception of 'bright' Titan, they are much fainter than the Jovian satellites. Page 122–123 shows a worked example of how to identify their configuration for your date and time.

Uranus and **Neptune** can be challenging but still considered visible in binoculars provided you know where to look. That is why the separate finder charts (see page 128) are needed for these distant planets. To identify four of Uranus's moons and Neptune's Triton a similar calculation to Saturn is used, see page 125.

Minor Bodies of the Solar System.

The monthly sections give predicted dates for opposition of the brighter **minor and dwarf planets**. Observing notes are also presented for the prominent **comets**. Positions in the sky of the brightest minor planet and comets are presented on pages 136 and 133–135 respectively. These can be plotted on the All Sky Maps to get an approximate position. For example, the February monthly text (p. 27) has minor planet 15 Eunomia reaching opposition on the 20th at magnitude 9.2 in Sextans. Page 138 tells you Sextans is on All Sky Map No 4. The ephemerides (page 136) when plotted on this map gives the location on this date very close to the RA 10 hr line approximately 2° west of Alpha Sextantis. Page 28 also tells you that Comet 41P/Tuttle-Giacobini-Kresak is in Cancer in February. Carrying out the same exercise with its position (p. 133) it is located on Map No 5 heading due north along the border with Leo and on the 20th about 2° east of Xi Cancri.

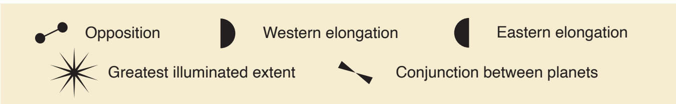
Meteors (Shooting Stars) can be seen sporadically at any time of the night, mostly after midnight. However, they do occur in annual showers with the Geminids being one of the finest. They are expected to peak on December 14 when the early hours should be Moon free (see the December monthly text page 75). Watching for meteors can always be a fun pastime. So, when taking a coffee break, sit back and relax. Who knows when an impressive fireball might light up the sky. If you don't go to sleep, you may be the only person to see it. Awesome!

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 and you will see from the specific rise and set times in Part II that there is variation from city to city. If more accurate times are required, see the tables for the object of interest in Part II. For regional locations use the appendix on page 142.

Highlights

This lists a few interesting events during the month.

Constellations

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

Appearance of the Planets

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

The Moon

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

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

Lunar Libration is a complicated mix of three different effects. 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 fast enough

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

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

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

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

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

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

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

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

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

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

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

to maintain the same face to us, giving us a view around its eastern limb. Then as the Moon moves slower, approaching apogee, it turns a little too much to keep facing us, giving a view beyond the western limb.

The second type of libration is a latitudinal nod and is caused by the slight tilt of the Moon's axis. We can see a little over the south pole during one half of each revolution with the north pole hidden; during the other half of its orbit we see over the northern limb while the south pole is hidden from view.

The last effect is minor, but nonetheless real. It's termed diurnal libration. As the Moon is so close to Earth we see further over the limb when observing near the horizon than when the Moon is overhead. No account is made for diurnal libration in this publication.

The Planets

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

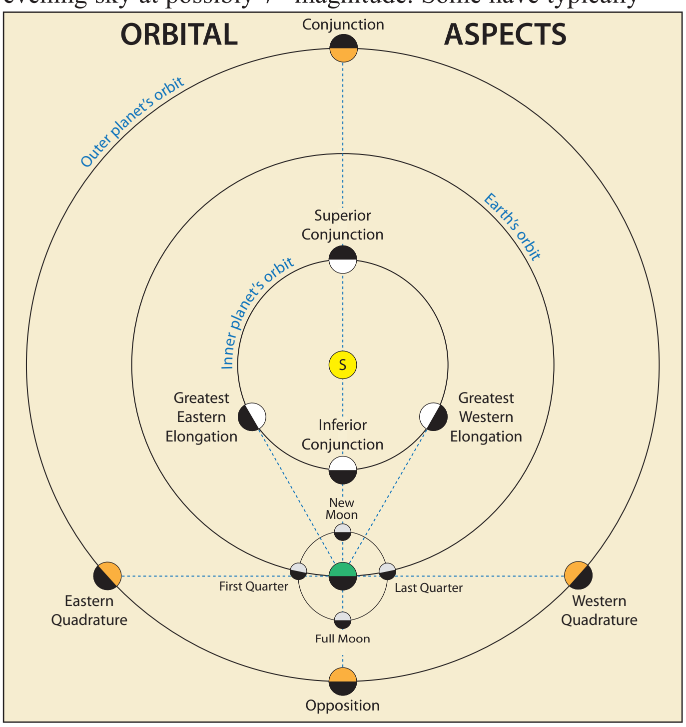
Dwarf Planets and Small Solar System Bodies

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

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

Comets

This section deals with the brightest comets expected to be visible during the year. Note that most of the known comets are relatively faint and need a telescope. However, 2017 is looking good for periodic comets with four that may reach binocular visibility. Comet Johnston (C/2015 V2) may be visible for most of the year and is well placed in the June evening sky at possibly 7th magnitude. Some have typically narrow windows to catch them at their best, such as Encke in the dawn sky in late March or Tuttle-Giacobini-Kresak in late April/early May, low in the northern morning sky.



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 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.

Meteor Showers

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

Double Stars

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

Feature Article

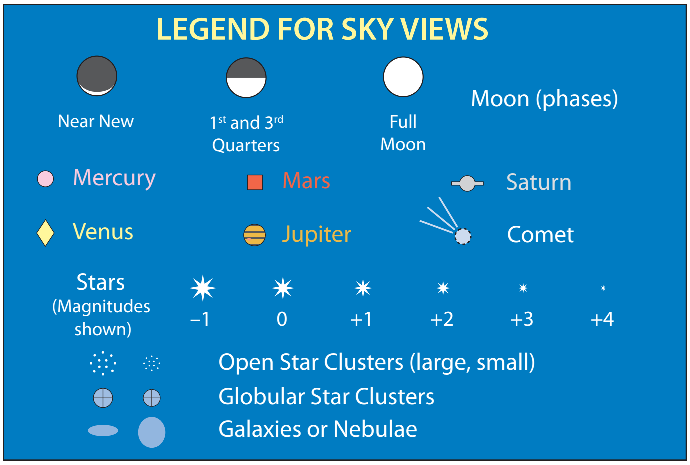
This section concentrates on some topics in popular astronomy. It can include observation, events, history, profiles of astronomy enthusiasts, astronomical equipment and techniques.

Diary

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

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

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



Abbreviations. These include:

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

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

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

Sky Views

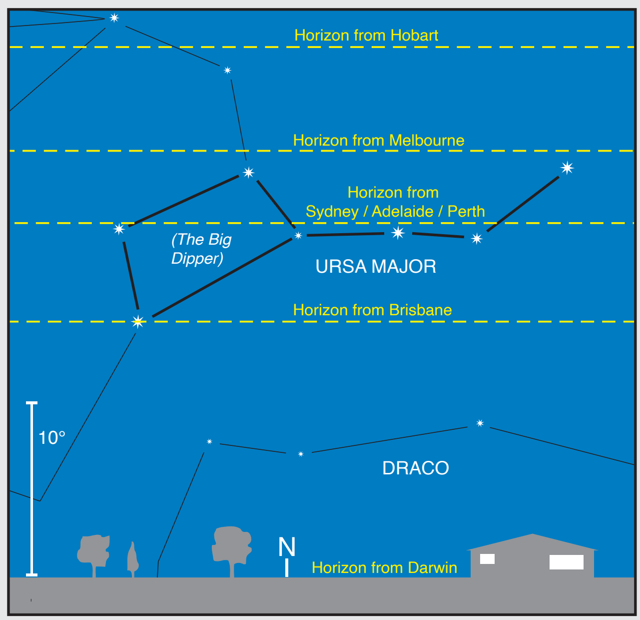
These diagrams are designed to help you find the naked eye planets. The date and time chosen give the most interesting patterns of the planets and Moon. Sometimes the times correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although this is twilight, it is sometimes necessary to catch a glimpse of the planets when close to the Sun. This is especially needed for Mercury as it never wanders more than 28° from the Sun. Sky Views which show a twilight view after sunset are called *Evening Twilight* and morning twilights are *Dawn Sky*. Those before midnight are *Evening Sky* and after midnight, *Morning Sky*.

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

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

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

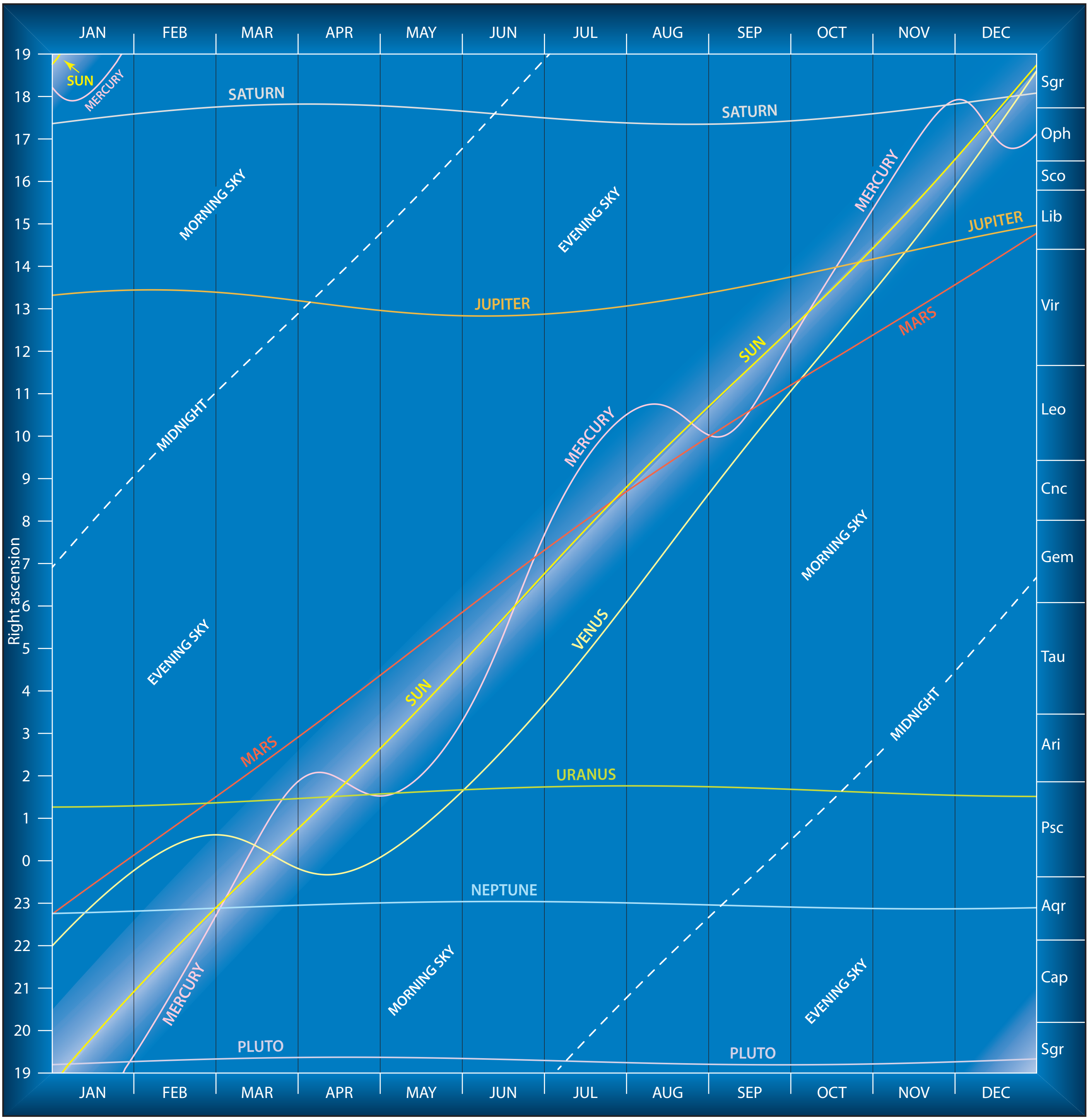
Uranus, Neptune and Pluto have been excluded from the Sky Views, as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20 cm telescope to glimpse this faint dwarf planet. In any case,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



EFFECT OF LATITUDE

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

VISIBILITY OF THE PLANETS



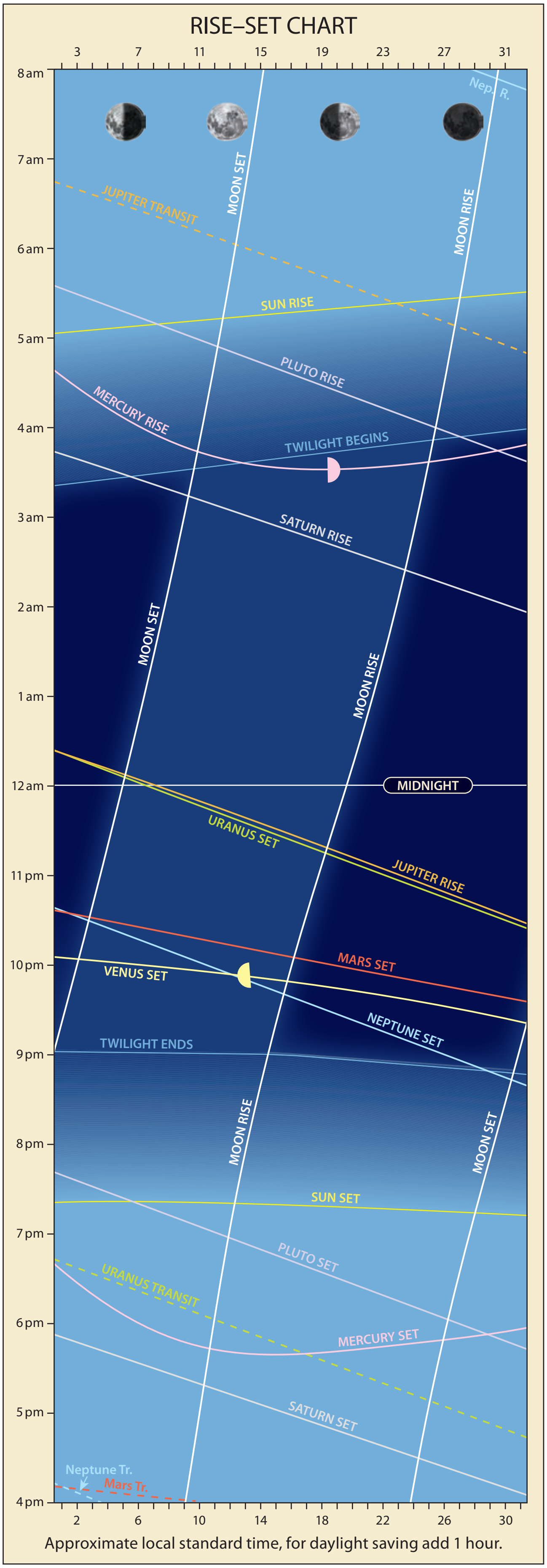
This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point, a horizontal line to the right vertical axis will show which constellation the planet is in. Jupiter for example will be in Virgo in the June evening sky (also see All Sky Map No. 6).

Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best time to observe these inner planets is when their paths extend beyond the twilight. For Mercury, the optimum period in the evening sky is from mid July to August and in the mornings from May to early June. Venus is visible from January until early March in the evening sky. It then becomes too close to the Sun for observation until April when it reappears in the morning sky.

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

The diagram also shows when conjunctions between the planets occur. When two or more planet lines cross or are close, they will be near each other in the sky. A fine example this year is the appearance of Mars and Jupiter in the late December morning sky. Another instance is shown when the Mercury and Saturn lines intersect in the late November evening sky.

JANUARY

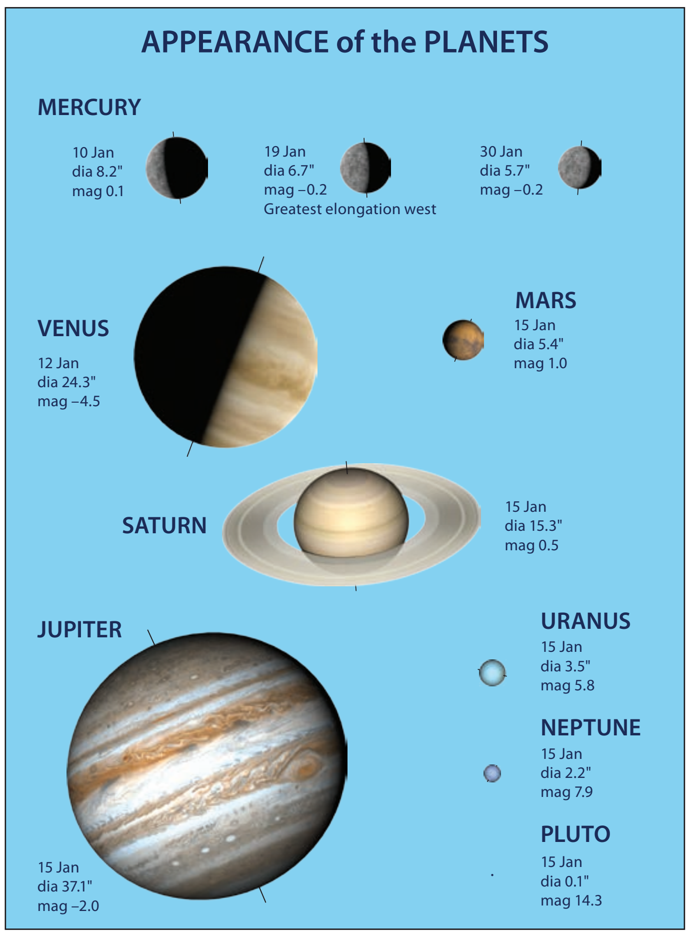


HIGHLIGHTS

- Venus and Neptune close.
- Mars and Neptune very close.
- Jupiter close to Spica.

CONSTELLATIONS

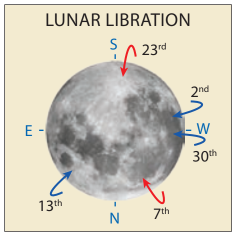
High in the northern evening sky is Orion the Hunter (All Sky Map 2). Based on ancient mythology, Orion was one of the original constellations listed by Ptolemy in the 2nd century AD, but its placement in the heavens dates back hundreds of years before Christ. His northern origin is obvious when you see the traditional depiction of him appearing upside down from Australia (see page 29), compared to standing prominently over the southern horizon as viewed from Northern Hemisphere mid-latitudes. The three belt stars are quite distinctive followed by Orion's two zero magnitude stars, almost equidistant on either side of the belt; Rigel (Beta Orionis) is above with Betelgeuse (Alpha Orionis) below. Both stars are classed as supergiants but that is where the similarity ends. The differences are even visible to the unaided eye, with Rigel being a blue/white colour and Betelgeuse orange/red. Following a line drawn along the 'belt' to the lower left (northwest) finds another red giant, 1st magnitude Aldebaran, representing the right eye to the face of Taurus the Bull (the 'V' shaped Hyades open cluster)–All Sky Map 3. The tip of its left horn (to the lower right) is marked by 1.6 magnitude star Elnath (Beta Tauri), which incidentally links Taurus to Auriga. This constellation is easily recognised by a pentagon of stars, with Elnath at the top and at the bottom the brightest, most



northerly member, zero magnitude Capella. It is visible from anywhere in Australia with a low horizon.

Beta Tauri is approximately 130 light years from Earth and the brightest star closest to the galactic anti-centre, the point in the heavens directly opposite the centre of the Milky Way. Any Elnathian looking towards the star-rich galactic hub would see our home star reduced to 7.8 magnitude, roughly halfway between Sagittarius's Teapot spout and Antares—a real needle in a stellar haystack!

THE MOON



2nd 8 am (6 am WST) Minimum Libration (5.8°), dark SW limb.

3rd 2 pm (noon WST) Occultation of Neptune by the Moon, visible from Indonesia, New Guinea, Hawaii and extreme W North America. From Australia the planet will be close to the Moon in the early evening.

3rd 5 pm (3 pm WST) Occultation of Mars by the Moon, visible from S Asia, Indonesia & New Guinea. From Australia the planet will be close to the Moon in the early evening.

6th 6 am (4 am WST) First Quarter.

7th 10 pm (8 pm WST) Maximum Libration (7°), dark NW limb. North pole favoured including the 124 km walled plain Goldschmidt.

10th 1 am (11 pm previous day WST) Occultation of Aldebaran by the Moon, visible from E & NE Africa, Arabia, Asia, Japan & NW Pacific. From Australia the pair appear close during the night. This is the 27th in a series of 49 occultations that began in January 2015 and ends in September 2018.

10th 4 pm (2 pm WST) Moon at perigee (closest to Earth at 363,238 km).

12th 10 pm (8 pm WST) Full Moon.

13th 5 am (3 am WST) Minimum Libration (6°), Full Moon.

15th 3 pm (1 pm WST) Occultation of Regulus by the Moon, visible from Central & S. South America, S. Antarctic Ocean & small part of the Antarctic. This is the 2nd in a series of 19 occultations of Regulus that began in December 2016 and ends in April 2018.

20th 8 am (6 am WST) Last Quarter.

22nd 10 am (8 am WST) Moon at apogee (furthest from Earth at 404,914 km).

23rd 5 pm (3 pm WST) Maximum Libration (6.8°), bright SW limb. Southwestern region favoured including the huge 311 km walled plain Bailly.

28th 10 am (8 am WST) New Moon.

30th 9 pm (7 pm WST) Occultation of Neptune by the Moon, visible from Africa, S Arabia & S Asia. From Australia the planet appears near our satellite in the western evening twilight just before moonset.

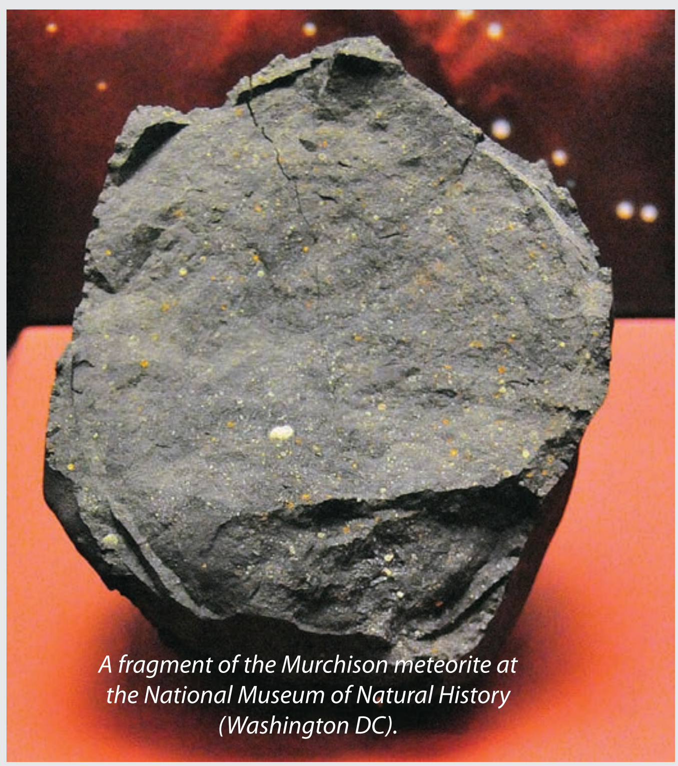
30th Noon (10 am WST) Minimum Libration (5°), dark NW limb.

Rock On

On July 24 1969, Apollo 11 returned to Earth landing in the North Pacific Ocean after its historic eight day mission to the Moon and back. One of the crew's mission objectives was to conduct selenological inspection and sampling. To this aim they returned a total of 21.5 kilograms of lunar material. Over the course of the six landings between 1969 and 1972 a total of 382 kilograms of rocks, core samples, pebbles and dust was collected by Apollo astronauts. From studies of these rocks most scientists are in agreement that the Moon formed around 4.5 billion years ago when another large planetary body collided with the proto-Earth. Almost identical oxygen isotopes can be found in both the lunar samples and terrestrial rocks supporting this hypothesis.

Two months after Apollo 11's return we were gifted with the oldest known remnant of the pre-Earth Solar System when it came crashing through the Earth's atmosphere. On 28th September 1969 around 11 am a fireball exploded in the sky near Murchison, a small village 167 km north of Melbourne, Victoria. Witnesses described a bright orange fireball with a dull orange conical tail leaving behind a blue smoke trail that lasted several minutes. Some reported a hissing sound like "truck tyres on a wet pavement" before it separated into three main pieces followed by several loud explosions and a smell of methyl alcohol. The event was observed from places as far away as Canberra (360 km north) and Mildura (410 km west).

Fortunately the Murchison meteorite fell in the daytime near a populated area and those that did not see it visually were alerted by its thunderous approach. Local residents were soon collecting pieces from a fall area 11 km long by 3.2 km wide. The largest piece found weighed 7 kg and in total, more than 100 kg was located. After the meteor broke up at high speed,



A fragment of the Murchison meteorite at the National Museum of Natural History (Washington DC).

THE PLANETS

Mercury returns to the morning sky after inferior conjunction (between the Earth and the Sun) in late December. On the 19th, the planet reaches its greatest western elongation (24°) then makes a gradual descent back toward the Sun. The slender fingernail crescent of the 27-day old Moon (just 5% illuminated by the Sun) appears near the planet on the 26th (see Sky View).

Venus is a brilliant object in the evening sky from the beginning of the year until early March when it becomes too close to the Sun for observation. The planet travels across Aquarius before joining Mars in Pisces during the last week of January (see Sky View). On the 2nd, the 4-day old waxing crescent Moon appears 3° to the north of the dazzling Venus, making a pleasing vista in the summer sky (see Sky View). On the 12th and 13th, Venus and Neptune will be less than 1° apart, making an attractive uneven pair in a low power telescope field. The Moon has a second rendezvous with Venus when the 3-day old crescent appears around 5° away on the 31st (see Sky View). The planet is at its greatest elongation (47°) east of the Sun on the 12th.

The **Earth** is at perihelion on the 4th, the closest point in its orbit to the Sun (147,100,933 km or 0.983309 au distant).

Mars watchers (using optical aid) are in for a treat on the 1st day of the New Year when the Red Planet has a close rendezvous with the outer gas giant Neptune. Around the end of astronomical twilight the pair will be approximately 7 arcminutes apart in the western sky! Earlier in the day (around 5 pm) they will be even closer, less than 1 arcminute. If using binoculars (properly braced) the two will be unmistakable but Neptune will lack colour. A telescope with an aperture of 100 mm or more under about 200 magnification will provide the most stunning view, bringing out the blue hue of Neptune contrasting against the orange Mars. On the 3rd, the 5-day old waxing crescent Moon appears close to the planet (see Sky View). Mars spends the first half of the month in Aquarius before moving into Pisces.

Jupiter is visible in the eastern morning sky meandering through Virgo, its apparent sluggish movement due to nearing a stationary point in its orbit (as we see it from Earth—refer Retrograde Motion page 86) early next month. Throughout January the gas giant is positioned within 4° of the 1st magnitude star Spica (Alpha Virginis), the constellation's brightest. The waxing gibbous Moon, just past Last Quarter appears near the planet on the morning of the 19th and 20th (see Sky View).

Saturn, in Ophiuchus, rises shortly before dawn (midmonth) in the east. Since 2009, when the planet's splendid ring system was edge-on, it has been gradually widening with respect to Earth. In October this year, the rings will reach their maximum openness and then they will begin to close until the Earth passes through the ring plane in 2025 when they again appear edge-on.

Uranus can be located in the northwestern evening sky in Pisces at the end of astronomical twilight. The constellation of The Fishes will remain home to the green planet until early 2019 when it moves into Aries (The Ram). Over the course

individual fragments continued through the atmosphere—most of their surfaces melting, creating a fusion crust that effectively created a seal against internal contamination. This crust, coupled with the speed of recovery, providing pieces of meteorite that were as pristine as you can get.

The Murchison meteorite is classified as a rare carbonaceous chondrite (meaning it was rich in carbon compounds), type CM2, and the largest fall of its kind. To date it has been the subject of more scientific papers than any other meteorite. It predates the Apollo rocks, with its age estimated to be around 4.95 billion years—close to 500 million years older than Earth! Unlike iron meteorites, chondrites are stony and have a very low iron and nickel content. They formed in the very early Solar System as material began to be accreted into small primordial asteroids. Since they did not experience melting or differentiation these meteorites provide an unspoiled snapshot of the raw materials in the early Solar System.

Analysis of the samples produced the first direct evidence of extraterrestrial amino acids—over 90 different types of which 19 are found in Earth life. The Murchison meteorite also contains tiny (a few nanometres in size) presolar grains or stardust (diamond, silicon carbide, graphite etc.) that originated from red giant stars and supernova explosions, billions of years ago. These particles of stardust would become the molecular cloud from which our Solar System would eventually form.

The discovery of stardust in the chondrites has opened up a whole new branch of astronomy where microanalytical techniques have replaced the telescope. It's also very likely that organic material brought to Earth by meteorite bombardment supplied the simple chemical building blocks essential for terrestrial life.

of the month Uranus will be within 1° of the double star Zeta Piscium. This pair of 5th and 6th magnitude suns is separated by a wide 23 arcseconds and is considered the best in the constellation for small instruments and well worth a look.

Neptune, in the western evening sky in Aquarius, sets around 9:30 pm midmonth. On the 1st, Neptune will have a very close encounter with the Red Planet as detailed under Mars. This conjunction, at least for the telescope user, should rate as one of the most ascetically appealing of this type of event. Another conjunction occurs on the 12th and 13th, this time with the brightest planet (see Venus).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet **Pluto** is in conjunction with the Sun on the 7th and will return to the morning skies in February.

Minor Planets. Two of the brighter minor planets reach opposition this month in Cancer, 4 Vesta on 18th at magnitude 6.2 and 54 Alexandra on 30th at magnitude 12.0. Others at opposition include 13 Egeria on 8th at magnitude 10.1 in Lynx, 21 Lutetia on 11th at magnitude 10.9 in Gemini and 121 Hermione on 17th at magnitude 12.3 near the Cancer/Gemini border.

COMETS

Comet C/2015 ER_{61} (PANSTARRS) should brighten from 13th to 12th magnitude this month. Rising shortly after midnight, comet PANSTARRS spends most of January in Libra before moving into Scorpius and then ending the month in Ophiuchus.

41P/Tuttle-Giacobini-Kresak may brighten to 13th magnitude by the first week of January and then to 11th magnitude by the end of the month. Located in Cancer throughout January, the comet is rising early in the evening and is visible until dawn.

Comet 45P/Honda-Mrkos-Pajdusakova opens the year at 7th magnitude in Capricornus. Early January sees the comet setting shortly after the end of evening twilight for a few days before it is lost in the glare of the Sun, returning to the morning sky next month. Having just passed perihelion (New Year's Eve 2016), Honda-Mrkos-Pajdusakova is moving away from the Sun but its distance to Earth is decreasing.

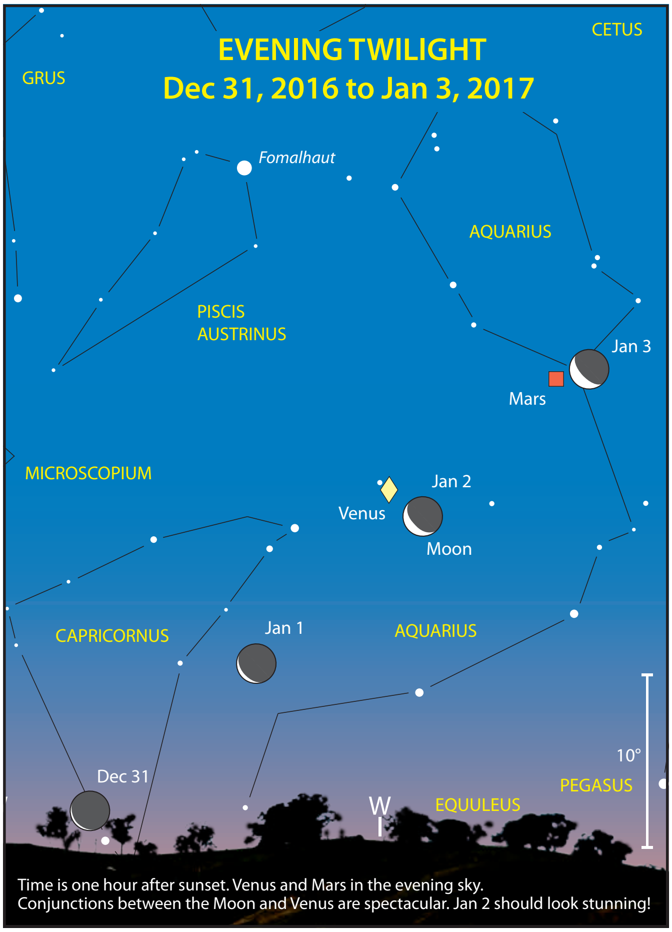
Comet 73P/Schwassmann-Wachmann 3, rising one to two hours before dawn, is expected to brighten from 13th to 12th magnitude this month. Beginning January in Libra, the comet moves into Scorpius briefly midmonth before finishing January in Ophiuchus.

DOUBLE STARS

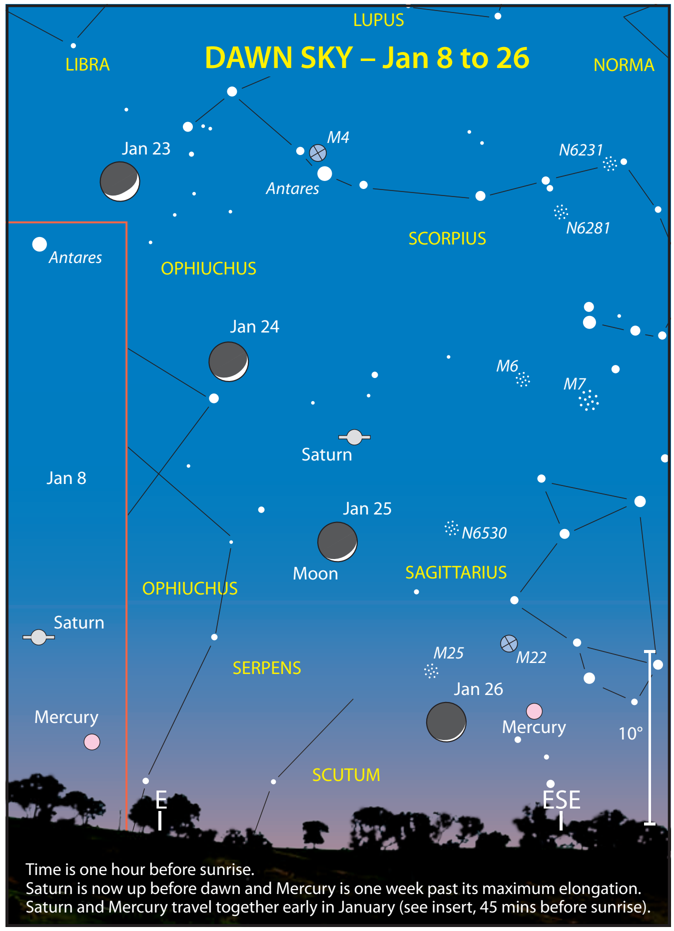
Located just south of the most eastern of the belt stars of Orion (Alnitak) is the complex multiple star system **Sigma Orionis** (All Sky Map 2). The naked eye primary star (magnitude 3.8) and three companions (C, D and E) form a lovely irregular line of stars. The stars are magnitudes 8.8 (C), 6.6 (D) and 6.3 (E) with separations of AC 11.2, AD 12.9 and AE 41.2 arcseconds and are easily seen in a small telescope. All the stars are hot blue-white O and B-type stars; however interestingly Sigma is often described as a colourful multiple. Adding to the scene is a nearby fainter triple star system (Struve 761) located 3.5 arcminutes to the northwest, with stars of magnitudes 7.9, 8.4 and 8.6 separated by 67.7 and 8.6 arcseconds forming a narrow triangle.

DIARY

Sun	1st		Uranus 0.6°E of star Zeta Piscium
Sun	1st	5 pm	(3 pm WST) Neptune 0.02° N of Mars
Mon	2nd	7 pm	(5 pm WST) Venus 1.9° S of Moon
Mon	2nd	8 pm	(6 pm WST) m.p. 2 Pallas 5° N of Moon
Tue	3rd	am	m.p. 9 Metis 0.6°N of NGC 3489 (G) in Leo
Tue	3rd	2 pm	(Noon WST) Neptune 0.4° S of Moon
Tue	3rd	5 pm	(3 pm WST) Mars 0.2° S of Moon
Wed	4th	Midnight	(10 pm WST) Earth at perihelion, 0.983309436 au
Wed	4th		Mars 0.5°SE of star Lambda Aquarii
Wed	4th		Mercury at greatest latitude north
Wed	4th	3 am	(1 am WST) m.p. 14 Irene 0.1°E of star 51 Leonis
Thu	5th		Comet 45P/Honda-Mrkos-Pajdusakova 0.5°S of star Theta Capricorni
Fri	6th		Mercury 1.2°S of M23 (OC) in Sagittarius
Fri	6th		Comet C/2015 ER_{61} (PANSTARRS) 0.6°N of NGC 5897 (GC) in Libra
Fri	6th	5:47 am	(3:47 am WST) First Quarter Moon
Fri	6th	Noon	(10 am WST) Uranus 3° N of Moon
Fri	6th	9 pm	(7 pm WST) d.p. 1 Ceres 3° S of Moon
Sat	7th	5 pm	(3 pm WST) d.p. Pluto in conjunction with Sun
Sun	8th	8 pm	(6 pm WST) Mercury stationary
Tue	10th	1 am	(11 pm WST, prev day) star Aldebaran 0.4° S of Moon
Tue	10th	4 pm	(2 pm WST) Moon at perigee, 363,238 km
Wed	11th		Comet 71P/Clark 0.2°NE of star Iota Virginis
Thu	12th	9:34 pm	(7:34 pm WST) Full Moon (366,879 km)
Thu	12th	11 pm	(9 pm WST) Venus at greatest elongation East (47.1°)
Fri	13th	2 am	(Midnight WST, prev day) star Pollux 10° N of Moon
Fri	13th	Noon	(10 am WST) Neptune 0.4° S of Venus
Sat	14th		Venus 0.2°W of star Lambda Aquarii
Sun	15th	3 pm	(1 pm WST) star Regulus 0.8° N of Moon
Tue	17th		Mercury 0.7°SW of star Mu Sagittarii
Tue	17th		Comet 71P/Clark 1.0°SW of NGC 5634 (GC) in Virgo
Tue	17th		Venus at ascending node
Tue	17th	4 am	(2 am WST) Mercury 0.2°W of NGC 6568 (OC) in Sagittarius
Wed	18th	am	m.p. 12 Victoria 0.3°N of NGC 5247 (G) in Virgo
Wed	18th	11 am	(9 am WST) m.p. 4 Vesta at opposition
Thu	19th	3 pm	(1 pm WST) Jupiter 3° S of Moon
Thu	19th	4 pm	(2 pm WST) star Spica 6° S of Moon
Thu	19th	8 pm	(6 pm WST) Mercury at greatest elongation West (24.1°)
Fri	20th		Mercury 1.1°S of d.p. Pluto
Fri	20th	8:13 am	(6:13 am WST) Last Quarter Moon
Sat	21st	7 am	(5 am WST) star Spica 4° S of Jupiter
Sun	22nd	10 am	(8 am WST) Moon at apogee, 404,914 km
Mon	23rd		Comet C/2015 ER_{61} (PANSTARRS) 0.2°N of star Delta Scorpii
Mon	23rd	2 pm	(Noon WST) star Antares 10° S of Moon
Tue	24th	8 pm	(6 pm WST) Saturn 4° S of Moon
Thu	26th		Comet 2P/Encke 0.6°SE of star Theta Piscium
Thu	26th	11 am	(9 am WST) Mercury 4° S of Moon
Thu	26th	8 pm	(6 pm WST) d.p. Pluto 3° S of Moon
Sat	28th		Mars 0.7°S of NGC 524 (G) in Pisces
Sat	28th		d.p. 1 Ceres 0.8°SE of NGC 676 (G) in Pisces
Sat	28th		Mercury at descending node
Sat	28th	10:07 am	(8:07 am WST) New Moon
Sun	29th	3 am	(1 am WST) Comet C/2015 ER_{61} (PANSTARRS) 0.05°NW of M80 (GC) in Scorpius
Mon	30th	3 am	(1 am WST) d.p. Pluto 1.2° N of Mercury
Mon	30th	6 pm	(4 pm WST) m.p. 2 Pallas 3° N of Moon
Mon	30th	9 pm	(7 pm WST) Neptune 0.2° S of Moon
Tue	31st	3 am	(1 am WST) Saturn 0.025°NW of star 52 Ophiuchi

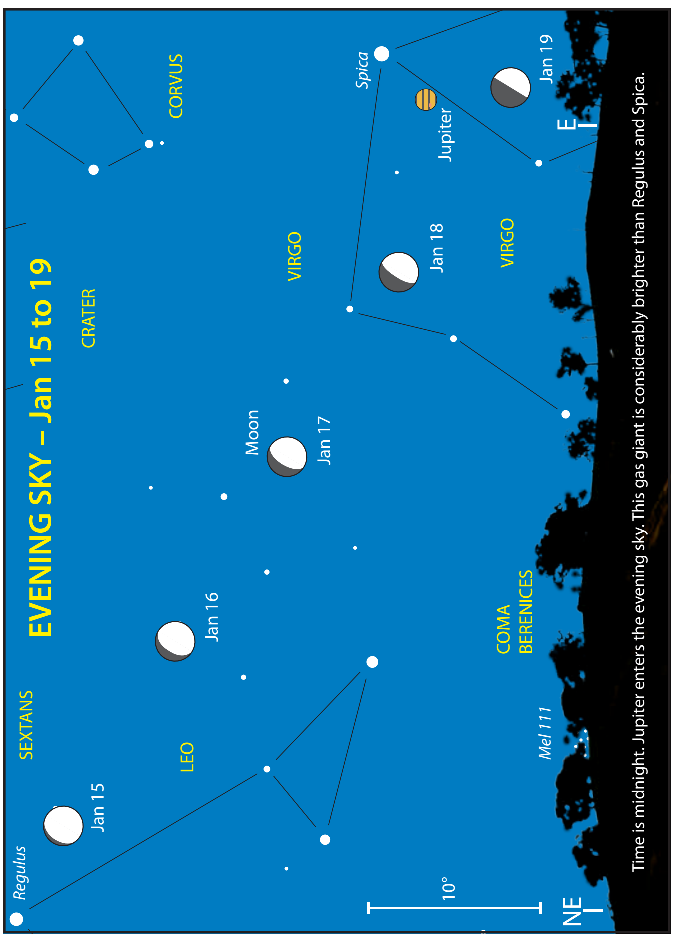


Time is one hour after sunset. Venus and Mars in the evening sky.
Conjunctions between the Moon and Venus are spectacular. Jan 2 should look stunning!

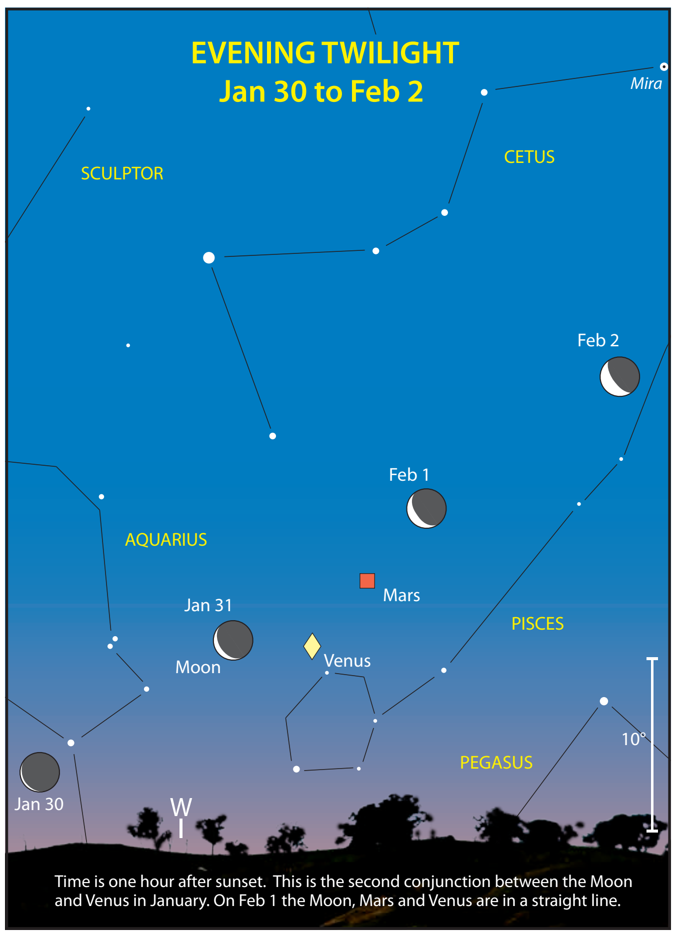


Time is one hour before sunrise.
Saturn is now up before dawn and Mercury is one week past its maximum elongation.
Saturn and Mercury travel together early in January (see insert, 45 mins before sunrise).

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

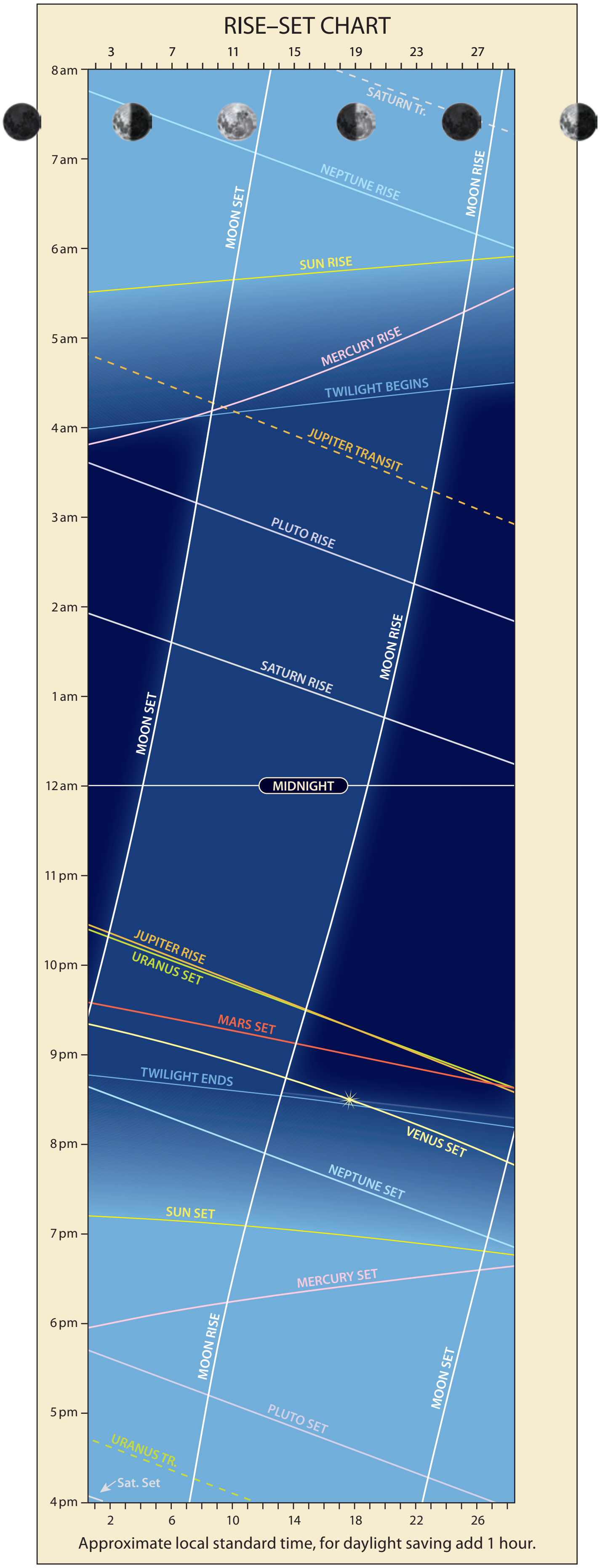


Time is midnight. Jupiter enters the evening sky. This gas giant is considerably brighter than Regulus and Spica.



Time is one hour after sunset. This is the second conjunction between the Moon and Venus in January. On Feb 1 the Moon, Mars and Venus are in a straight line.

FEBRUARY



HIGHLIGHTS

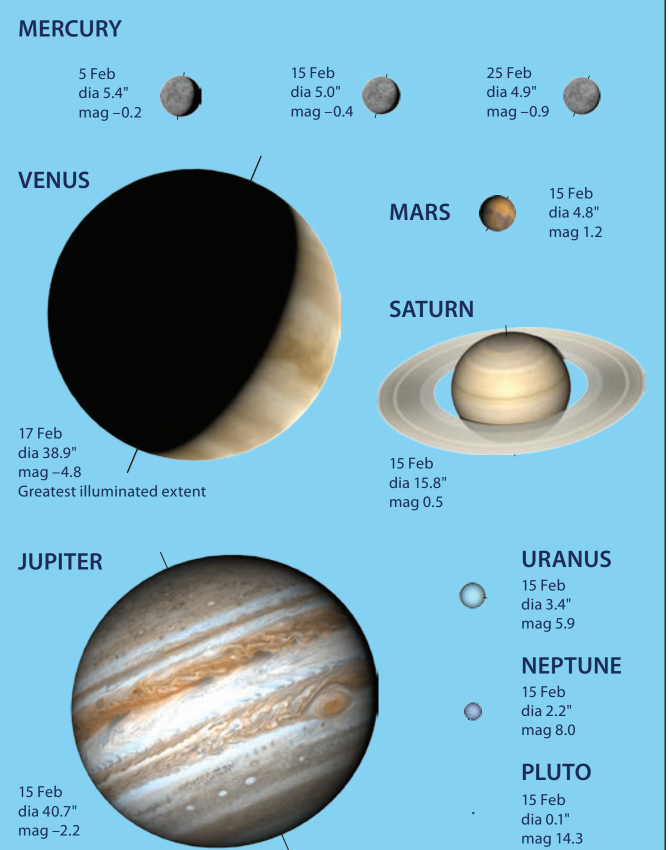
- Venus, Mars and crescent Moon form a line.
- Mars and Uranus close.
- Jupiter close to Spica.
- Comet 45P/Honda-Mrkos-Pajdusakova close to Earth at magnitude 7.

CONSTELLATIONS

Orion continues to dominate the northern evening sky (All Sky Map 2). The mythology surrounding Orion influences the night sky well beyond this hunter's constellation. Possibly the best known examples are his hunting dogs, with the most prominent being the larger dog, known to us as the constellation of Canis Major (All Sky Map 4). Sirius, the brightest star in the heavens, dominates this constellation. Sirius is also a very challenging binary. At magnitude –1.5 its blue/white glare normally swamps its close 8.5 magnitude companion. However over the next 10 years the amateur has the best chance of observing Sirius B (sometimes called the Pup). They will be at a maximum separation of approximately 11 arcseconds ("), an opening that will not reoccur until around 2070. In the course of their 50-year orbit the stars will again be closest at only 3" in 2043 and very difficult to resolve.

Returning to Orion mythology, the second hunting dog's constellation, Canis Minor (Lesser Dog) is anything but impressive, best recognised by a single bright (0.4 magnitude) naked eye star, Procyon (All Sky Map 4). It is interesting the name comes from the Greek for 'before the dog', referring to rising slightly before the Dog Star Sirius. This is true for locations north of the equator, but from *down under* Procyon's

APPEARANCE of the PLANETS

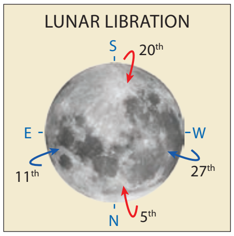


more southerly and brilliant canine companion definitely leads the way.

Perhaps the least known Orion connection is Lepus the Hare. Lying just below Orion's feet (above for us), it represents the hunter's favourite prey and is seen being chased by his two dogs. The constellation is quite faint with its brightest or Alpha star being 2.5 magnitude Arneb that in Arabic means 'hare'.

Orion's influence also extends across to the opposite side of the sky. The hunter was placed in the heavens after being killed by a scorpion. This creature can be interpreted as the constellation of Scorpius. So throughout eternity Orion is destined to flee (set) in the west as his predator rises in the east.

THE MOON



- 3rd Noon (10 am WST) Occultation of dwarf planet Ceres by the Moon, visible from E Siberia, Alaska, N Canada and Greenland.
- 4th 2 pm (noon WST) First Quarter.
- 5th 8 am (6 am WST) Maximum Libration (6.9°), dark NW limb. Craters in the north pole region at their best including 124 km Goldschmidt and 53 km Anaxagoras.
- 6th 8 am (6 am WST) Occultation of Aldebaran by the Moon, visible from Central America, Caribbean & S Europe.
- 6th Midnight (10 pm WST) Moon at perigee (closest to Earth at 368,816 km).
- 11th 8 am (6 am WST). Minimum Libration (5°), bright NE limb.
- 11th 11 am (9 am WST) Full Moon. Penumbral lunar eclipse, not visible from Australia see Part II for details.
- 11th Midnight (10 pm WST) Occultation of Regulus by the Moon, visible across Australia & New Zealand (see Sky View). Refer to the Lunar Occultation Tables in part II for times from your location.
- 19th 6 am (4 am WST) Last Quarter.
- 19th 7 am (5 am WST) Moon at apogee (furthest from Earth at 404,376 km).
- 20th 1 pm (11 am WST) Maximum Libration (6.9°), bright SW limb. Heavily cratered region of the south pole favoured such as Crater Drygalski.
- 27th 1 am (11 pm previous day WST) New Moon. Annular eclipse of the Sun, not visible from Australia, see Part II for details.
- 27th 6 pm (4 pm WST). Minimum Libration (5°), too close to New Moon.

THE PLANETS

Mercury is visible for the first half of the month in the eastern morning twilight. It then becomes lost in the bright dawn as it moves closer to the rising Sun.

Venus spends the month in the early western evening sky in Pisces. On the 1st a pleasant sight occurs with Venus, Mars and the 4-day old waxing crescent Moon forming a straight line. At this time Venus and the Moon will be 10° apart with Mars directly between them (see Sky View for January, p. 24). With the planet shining like a searchlight, observers will note that Venus appears progressively lower in the sky each evening as it makes its way toward inferior conjunction. Venus reaches its greatest brilliancy on the 17th at –4.8 magnitude. Known as

These are the Voyages …

What do the NASA probes Pioneers 10 and 11, Voyagers 1 and 2 and New Horizons have in common? They are all in the process of permanently leaving the Solar System. The two Pioneer craft were our first explorers to visit any of the gas giant planets. They were the precursors to the higher profile Voyagers. The story of these four craft dates back to the 1960s when NASA first conceived of the 'Planetary Grand Tour mission'. This was a recognition that in the late 70s a rare alignment of the outer planets would take place and if the timing of the launch was just right, using planetary gravity assist, spacecraft could potentially tour Jupiter, Saturn, Uranus, Neptune and Pluto, all previously unvisited.

Pioneer 10 was our first visitor to Jupiter. Being launched in March 1972, the closest approach to the planet was in December 1973. It radioed back hundreds of images and its on-board instruments measured the main asteroid belt and Jovian environment including its magnetosphere and intense radiation field. It then commenced a very long haul with contact finally lost in January 2003, when its power finally died, at a distance of 80 au (double the average distance to the dwarf planet Pluto).

Pioneer 11 followed in the footsteps of Pioneer 10 being launched in April 1973 and flying by Jupiter a year after its brother. Five years later it became the first visitor to Saturn capturing close up images of its famous rings. The probe also observed its largest moon, Titan, detecting a significant atmosphere, a key observation that would influence the ultimate destination of Voyager 1. Pioneer 11 was truly a pathfinder being sent deliberately on a trajectory close to the rings similar to that needed for Voyager. If Pioneer encountered dense particles that could damage spacecraft, then the Voyagers' orbits would be set to an encounter at a safer distance but in doing so would miss the necessary gravity assistance needed to fly onto Uranus and Neptune.

Voyager 1 and 2 were launched in late 1977. Their list of achievements is significant and there is no room to go into detail here. Voyager 1 achieved its primary objectives with the successful flyby of Jupiter (1979) and Saturn and its satellite Titan (1980). This final close encounter resulted in the probe being thrown at high speed out of the plane of the Solar System ending its tour of the outer planets. Without this phase Voyager 1 could have potentially gone on to Pluto in 1986. The exploration of Titan was considered so vital, if Voyager 1 had failed Voyager 2 would have had to complete the mission, terminating its further explorations. Voyager 2 visited Jupiter (1979), Saturn (1981) and went on to write the textbooks on Uranus (1986) and Neptune (1989), being the only probe to visit these ice giants to date.

As some may have surmised, the title has been borrowed from the Star Trek world. Unfortunately we don't have access to 'warp' speed (if achievable at all) and these craft are definitely restricted to sub (sub-sub-sub) light speed.

greatest illuminated extent by astronomers, it happens when the planet's illuminated portion or day side covers the greatest area of our sky. At this time Venus's crescent appears like a 3 or 4 day old Moon.

Mars opens the month situated between Venus and the 4-day old waxing crescent Moon in the early western evening sky in Pisces (see Sky View for January). The rest of February is rather uneventful for the Red Planet until the last week when it first passes an excellent double star and an outer planet—both events occur low to the horizon so observation should begin as soon as the sky darkens. Firstly on the 24th, the planet will be just 0.3° from Zeta Piscium, a splendid pair of 5th and 6th magnitude suns suitable for small apertures at a wide 23 arcseconds. There is some conjecture on their colours, what do you see? On the 26th and 27th Mars will be less than 1° from the 6th magnitude greenish outer planet Uranus, providing a pleasant colour contrast in a low power telescope field.

Jupiter rises around 10 pm midmonth and is located in central Virgo within 4° of the 1st magnitude star Spica (Alpha Virginis). It is interesting to note that Spica is believed to be the star that supplied Hipparchus with the data that gave evidence of the procession of the equinoxes. A temple at Thebes was built and aligned with reference to Spica in 3200 BC. Over time it was noticed that there was a slow but real change in the stars location relative to the temple.

The planet appears stationary on the 7th marking the beginning of four months retrograde motion, when Jupiter moves from east to west across the sky. On the 15th, the 19-day old waning gibbous Moon will be near the gas giant (see Sky View). On the 17th, Jupiter reaches aphelion, the point in its orbit furthest from the Sun at 5.46 astronomical units.

Saturn, rising after midnight, is a morning object during February. In the east, the planet spends most of the month in Ophiuchus before passing into Sagittarius. Its sojourn into the constellation of the Archer is short lived with retrograde motion bringing it back into Ophiuchus in May. On the 21st, the 24-day old waning crescent Moon will be near Saturn (see Sky View).

Uranus, in Pisces, is low in the early western evening sky during February. Before we lose Uranus as it nears the Sun and conjunction, it appears within 1° of Mars on the 26th and 27th, the pair however will be close to the horizon at the end of astronomical twilight.

Neptune is visible early in the month low in the western evening sky in Aquarius. By month's end the planet becomes lost in the evening twilight and reappears in the morning sky late March after its conjunction with the Sun.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

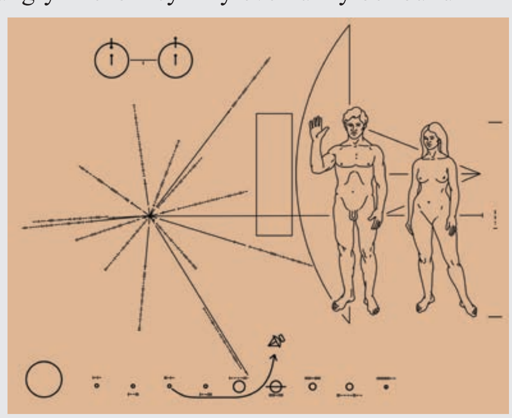
Dwarf Planet Pluto, in Sagittarius, returns to the predawn eastern sky after its conjunction with the Sun last month. The constellation of the Archer will be home to this slow moving dwarf until 2023 when it moves into Capricornus.

Minor Planets. Five of the brighter minor planets reach opposition this month in Leo. They are: 103 Hera on 10th at magnitude 11.5, 39 Laetitia on 14th at magnitude 10.0, 14 Irene on 18th at magnitude 9.0, 9 Metis on 22nd at magnitude 9.0 and 26 Proserpina on 22nd at magnitude 10.8. Others at opposition include 471 Papagena on 19th at magnitude 11.1 in Leo Minor and 15 Eunomia on 20th at magnitude 9.2 in Sextans.

Voyager 1 overtook Pioneer 10 in 1998 at a distance of 69 au, becoming the most distant probe. Moving at a speed of approximately 17 km per second (in 2012) it has sustained the lead, becoming the first to pass through the heliopause around 2010 (Voyager 2 is expected to be passing through this barrier now). This is the boundary in space where the solar wind crashes into the interstellar medium. Even New Horizons, which was the fastest spacecraft to leave the Earth, is travelling at around 13 km/s so will never catch up. Earlier this year Voyager 1 had reached a distance of 135 au from the Sun with its signals taking 19 hours to return to Earth! Contrary to some comments in the media the probe has not left the Solar System, its outer reaches now defined as the Oort Cloud. This is the distant cloud of bodies that are believed to be the source of long period comets. Voyager 1 won't hit that for another 300 years and will take over 20,000 years to pass through!

These probes have been described as our ambassadors to the stars. But is wandering around the Milky Way really their destinies? Many would say the main box has been ticked, they have reached the Sun's escape velocity; a simplistic view ignoring Man's curiosity. In the Air and Space Museum in Washington a full-scale model of a Voyager hangs in the displays. How do we know, one day it might be replaced with the actual Voyager 1 or 2? It's easy to speculate on the future, but just like Apollo 12 retrieved parts from Surveyor 3, to examine the long-term effects of being on the Moon, how do we know this isn't the future for these envoys? If the technology and opportunity arose, could Mankind resist retrieving them to investigate the long-term impact of the interstellar environment on spacecraft?

There are plaques on the Pioneer spacecraft designed to send greetings to any extraterrestrials who may come across them. One criticism was directed to the map showing the relative position of the Earth to the centre of the galaxy and to pulsars (this is also stamped on the Voyager records). Each of these pulsing stars have their unique periods encoded, creating effectively a street directory to the birth place of Man. Do we want to potentially invite an ET invasion in the future? This may all be irrelevant. Instead of ending up being drooled over by some war-hungry aliens they may eventually be found in a glass display case, with future Homo sapiens glancing at them as they hurry to meet their friends in the gift shop!



Drawing of the plaque on Pioneer 10 and 11

COMETS

Comet C/2015 ER_{61} (PANSTARRS) is rising around midnight throughout February. Predicted to brighten from 12th to 10th magnitude, PANSTARRS spends most of the month in Ophiuchus before moving into Sagittarius. Over February and March the comet tours a number of bright deep sky objects in these constellations, see the diary for further details.

Comet C/2015 V2 (Johnson) should first be sighted this month, rising about an hour before dawn. Predicted to brighten from 10th to 9th magnitude during February, comet Johnson begins the month in Bootes and then moves into Hercules early on for the remainder of the month. From mid February until late April it will be within 3° of 4th magnitude star Tau Herculis.

Comet 41P/Tuttle-Giacobini-Kresak is expected to continue to brighten this month, from 11th to 8th magnitude, ahead of April's perihelion passage and close approach to Earth. Visible from the end of evening twilight until just before dawn, the comet remains in Cancer throughout the month.

Comet 45P/Honda-Mrkos-Pajdusakova is at its closest to Earth this month, passing just 0.08 au on 11 February. Re-emerging in the morning sky during the first half of the month, as it initially moves through Aquila and Hercules, HMP will move very rapidly across the sky. By midmonth, the comet is rising around midnight, and by the end of February the comet will be visible throughout the night. A peak brightness of slightly better than 7th magnitude is expected during the first half of February, but the diffuseness of the comet due to its proximity to Earth will make it harder to observe. By month's end, it will have faded to around 10th magnitude.

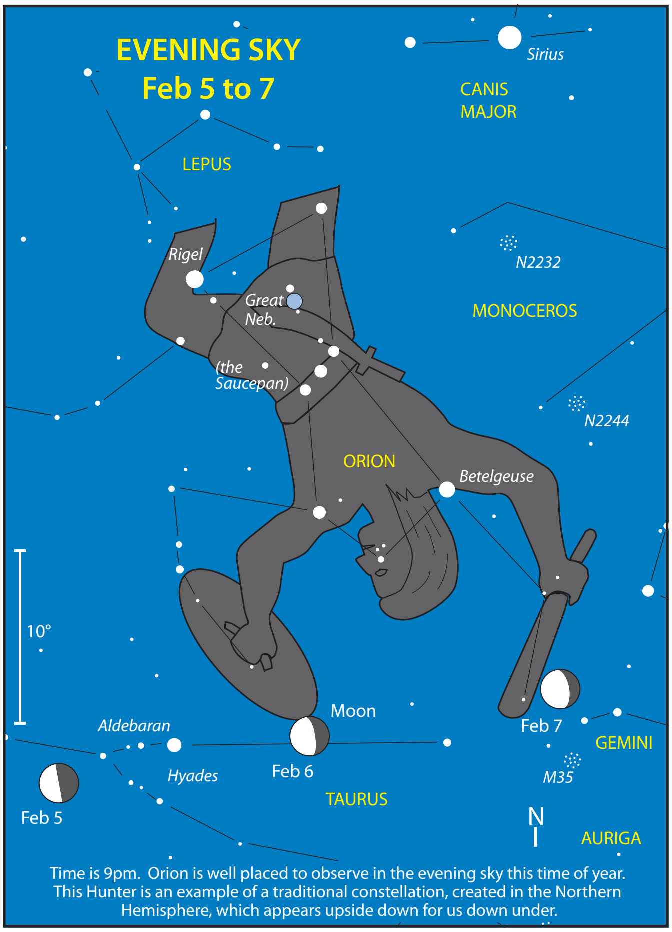
Comet 71P/Clark should be at 12th magnitude throughout February. Rising late in the evening, Clark is in Libra throughout the month.

Comet 73P/Schwassmann-Wachmann 3 should remain around 12th magnitude during February. Beginning the month in Ophiuchus, and rising about 2 am, the comet moves into Sagittarius early on, and resides there for the remainder of February. SW3 has a number of close meetings with bright stars and deep sky objects in these constellations during the month (see diary).

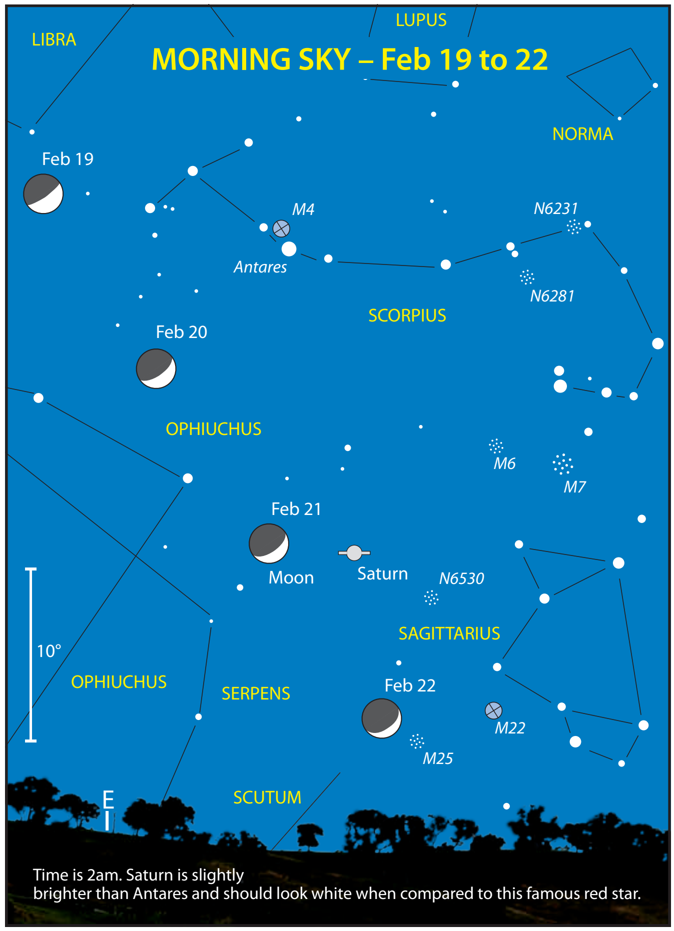
DOUBLE STARS

Located not far from Betelgeuse and near the Rosette Nebula, **Epsilon Monocerotis** (All Sky Maps 4 and 5) is a beautiful pair of pale yellow stars or golden yellow and lilac stars, depending on the observer, set in a rich field of stars (open star cluster Dolidze 22) containing several wide pairs and triples. The stars, magnitudes 4.4 and 6.6, are separated by 12.3 arcseconds. To add to the scene there is a red star 5 arcminutes away.

DIARY			
Wed	1st		d.p. 1 Ceres 0.5°NW of NGC 741 (G) in Pisces
Wed	1st		Comet 73P/Schwassmann-Wachmann 3, 0.5°NW of M9 (GC) in Ophiuchus
Wed	1st		Comet C/2015 ER_{61} (PANSTARRS) 0.3°N of star Rho Ophiuchi
Wed	1st	1 am	(11 pm WST, prev day) Venus 4° N of Moon
Wed	1st	11 am	(9 am WST) Mars 2° N of Moon
Thu	2nd		Comet 2P/Encke 0.9°S of star Iota Piscium
Thu	2nd		Comet 73P/Schwassmann-Wachmann 3, 0.7°SW of NGC 6356 (GC) in Ophiuchus
Thu	2nd	6 pm	(4 pm WST) Uranus 3° N of Moon
Thu	2nd	pm	m.p. 4 Vesta 0.5°NE of star Kappa Geminorum
Fri	3rd	Noon	(10 am WST) d.p. 1 Ceres 1.0° S of Moon
Sat	4th	2:19 pm	(12:19 pm WST) First Quarter Moon
Sun	5th		Comet 45P/Honda-Mrkos-Pajdusakova 0.7°SW of star Delta Aquilae
Mon	6th	Midnight	(10 pm WST) Moon at perigee, 368,816 km
Mon	6th		Comet 45P/Honda-Mrkos-Pajdusakova 1.2°N of NGC 6755 (OC) in Aquila
Mon	6th	4 am	(2 am WST) m.p. 2 Pallas 3° N of Neptune
Mon	6th	8 am	(6 am WST) star Aldebaran 0.2° S of Moon
Tue	7th		Mercury 0.5°NW of M75 (GC) in Sagittarius
Tue	7th		Mercury at aphelion
Tue	7th	5 am	(3 am WST) Jupiter stationary
Wed	8th		Comet 73P/Schwassmann-Wachmann 3, 1.0°NE of NGC 6440 (GC) in Sagittarius
Thu	9th		Comet 73P/Schwassmann-Wachmann 3, 0.8°S of M23 (OC) in Sagittarius
Thu	9th	Noon	(10 am WST) star Pollux 10° N of Moon
Sat	11th	Midnight	(10 pm WST) star Regulus 0.8° N of Moon
Sat	11th	10:33 am	(8:33 am WST) Full Moon (377,420 km)
Sat	11th	pm	m.p. 15 Eunomia 0.3°N of star Alpha Sextantis
Sun	12th		Comet 73P/Schwassmann-Wachmann 3, 0.9°N of star Mu Sagittarii
Mon	13th		Comet C/2015 ER_{61} (PANSTARRS) 0.9°N of NGC 6284 (GC) in Ophiuchus
Wed	15th	Midnight	(10 pm WST) star Spica 6° S of Moon
Wed	15th		Comet 2P/Encke 0.7°N of star Omega Piscium
Wed	15th		Comet 45P/Honda-Mrkos-Pajdusakova 0.7°N of star Rho Bootis
Wed	15th	am	Comet 71P/Clark 1.0°SW of star Beta Librae
Thu	16th	1 am	(11 pm WST, prev day) Jupiter 3° S of Moon
Fri	17th		Jupiter at aphelion
Fri	17th	3 am	(1 am WST) Comet C/2015 ER_{61} (PANSTARRS) 0.1°S of NGC 6325 (GC) in Ophiuchus
Sat	18th	10 pm	(8 pm WST) m.p. 41 Daphne 0.2°E of star Phi Leonis
Sun	19th		d.p. 1 Ceres 0.2°SE of star Xi Ceti
Sun	19th	5:33 am	(3:33 am WST) Last Quarter Moon
Sun	19th	7 am	(5 am WST) Moon at apogee, 404,376 km
Sun	19th	10 pm	(8 pm WST) star Antares 10° S of Moon
Mon	20th		Venus at perihelion
Tue	21st		Comet 45P/Honda-Mrkos-Pajdusakova 4.0°N of Mel 111 (OC) in Coma Berenices
Tue	21st		Comet 73P/Schwassmann-Wachmann 3, 0.5°E of star Xi 2 Sagittarii
Tue	21st	4 am	(2 am WST) Comet 45P/Honda-Mrkos-Pajdusakova 0.3°N of NGC 4314 (G) in Coma Berenices
Tue	21st	9 am	(7 am WST) Saturn 4° S of Moon
Wed	22nd		Mercury 0.8°NE of star Gamma Capricorni
Wed	22nd		Comet 73P/Schwassmann-Wachmann 3, 0.6°N of star Omicron Sagittarii
Wed	22nd		Comet C/2015 ER_{61} (PANSTARRS) 0.5°W of NGC 6401 (GC) in Ophiuchus
Thu	23rd		Mercury 0.8°NE of star Delta Capricorni
Thu	23rd	3 am	(1 am WST) Comet 73P/Schwassmann-Wachmann 3, 0.2°E of star Pi Sagittarii
Thu	23rd	6 am	(4 am WST) d.p. Pluto 3° S of Moon
Fri	24th		Mars 0.3°N of star Zeta Piscium
Fri	24th	2 am	(Midnight WST, prev day) star Spica 4° S of Jupiter
Sat	25th		Comet 73P/Schwassmann-Wachmann 3, 0.5°E of d.p. Pluto
Sun	26th	pm	Comet 41P/Tuttle-Giacobini-Kresak 1.0°W of star Kappa Leonis
Mon	27th		Mercury at greatest latitude south
Mon	27th		Mars at ascending node
Mon	27th	12:58 am	(10:58 pm WST, prev day) New Moon
Mon	27th	6 pm	(4 pm WST) Uranus 0.6° S of Mars

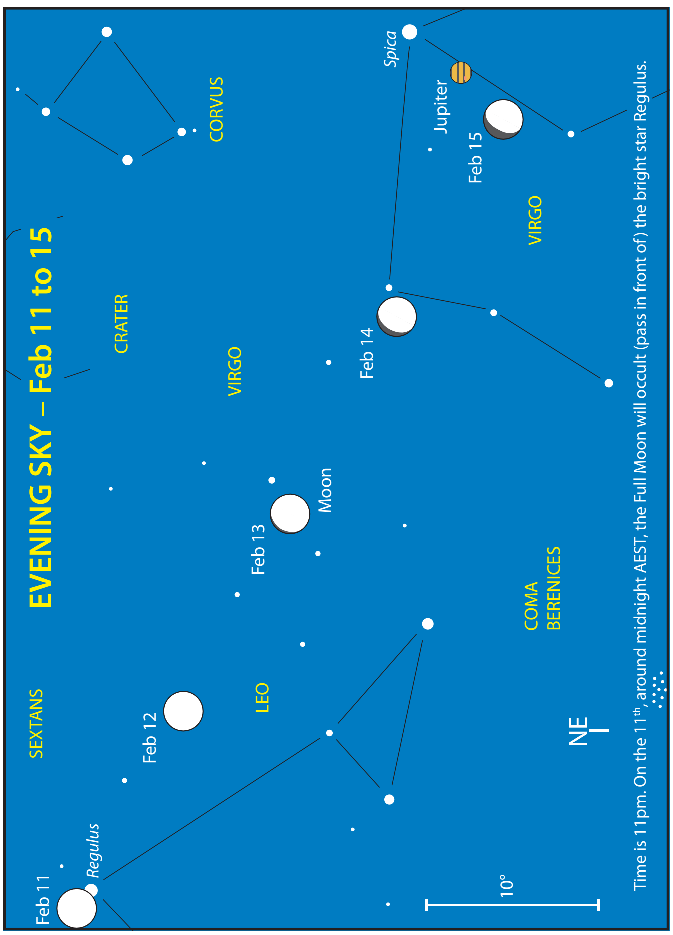


Time is 9pm. Orion is well placed to observe in the evening sky this time of year. This Hunter is an example of a traditional constellation, created in the Northern Hemisphere, which appears upside down for us down under.

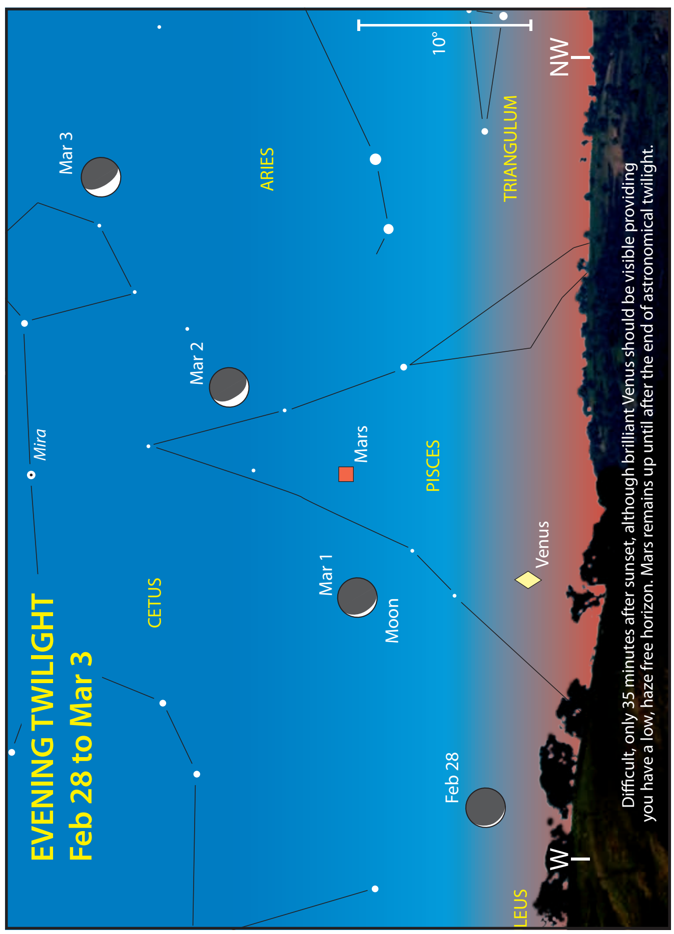


Time is 2am. Saturn is slightly brighter than Antares and should look white when compared to this famous red star.

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

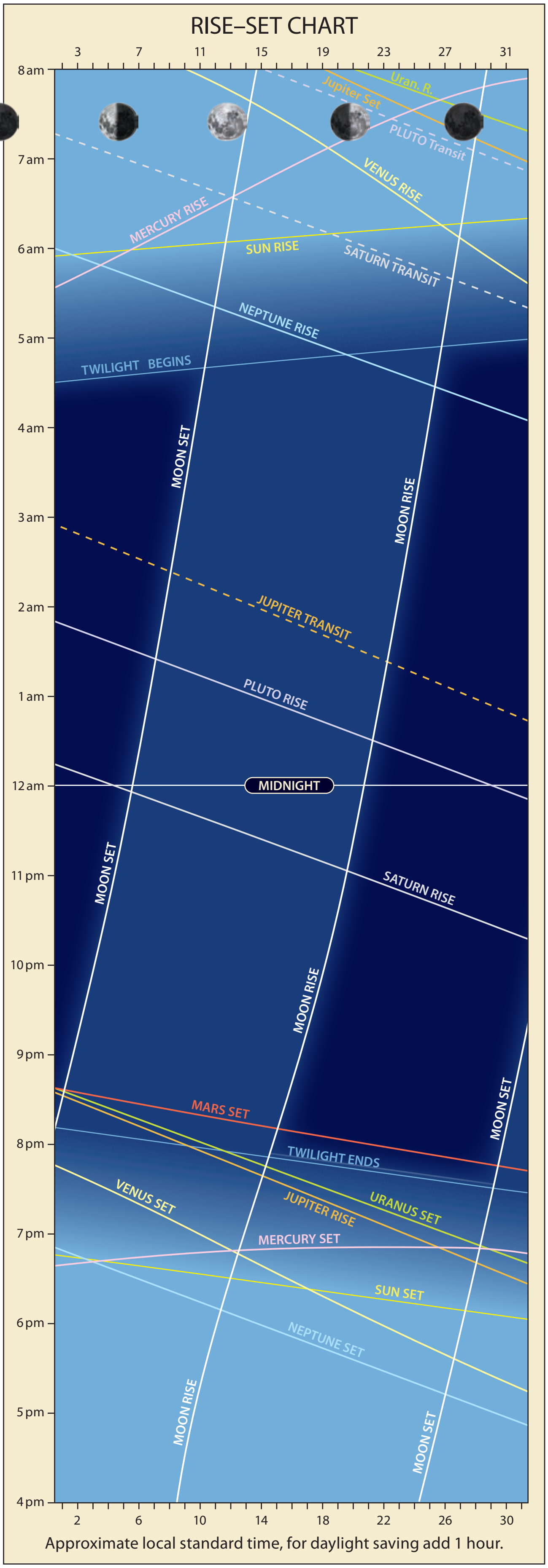


Time is 11pm. On the 11th, around midnight AEST, the Full Moon will occult (pass in front of) the bright star Regulus.



Difficult, only 35 minutes after sunset, although brilliant Venus should be visible providing you have a low, haze free horizon. Mars remains up until after the end of astronomical twilight.

MARCH



HIGHLIGHTS

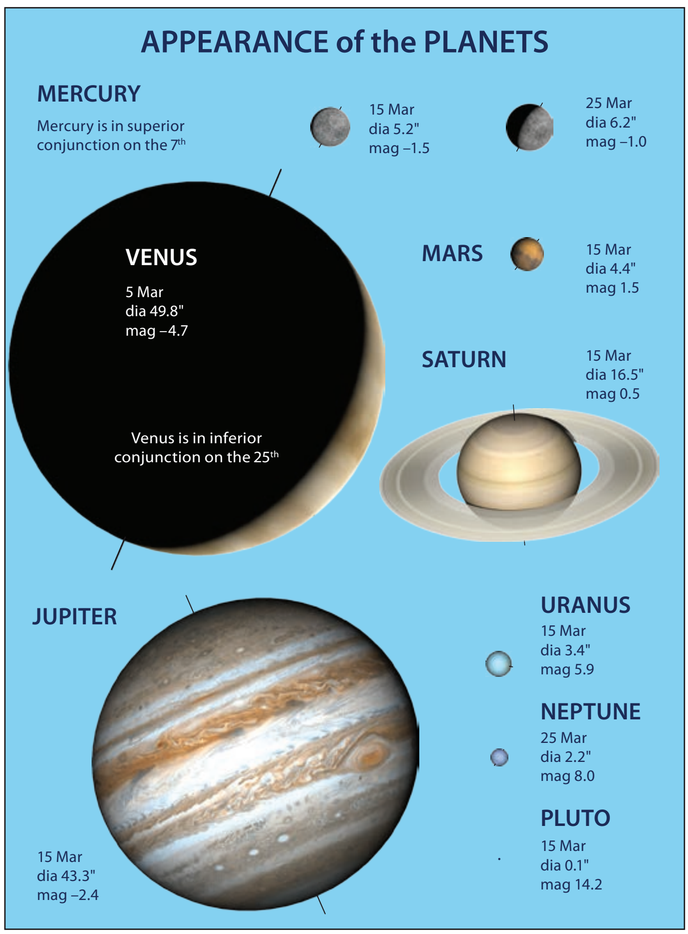
- Jupiter close to opposition.
- Mars visited by the Moon twice.
- Comet 2P/Encke in morning sky.

CONSTELLATIONS

The mythical ship Argo Navis, as per Jason and the Argonauts fame, sails high in the southern evening sky, of course better know today as the constellations of Carina (Keel), Puppis (Stern) and Vela (Sails)—All Sky Map 1. Puppis is situated between the bright stars Canopus and Sirius (All Sky Map 4). Lying in the plane of the Milky Way it is home to numerous open star clusters. There are many visible in binoculars with three making the Messier catalogue. M46 and M47 are certainly highlights appearing in the same binocular field. M46 is a real gem with the planetary nebula NGC 2438 superimposed on the cluster visible through a small telescope. The third Messier object is M93.

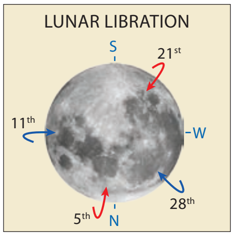
Two nearby lesser-known, faint constellations have been loosely connected with, but not part of the original Argo. In the 'water' below (south of) the Keel (Carina) lies Pisces Volans, the flying fish, in modern times shortened to just Volans or 'flying'. It consists of six scattered 4th magnitude stars. North of Vela (above the Argo) lies a similar obscure stellar collection, Pyxis, the ship's compass (All Sky Map 4). Its Alpha star is only magnitude 3.7 and is sometimes referred to by the Arabic 'Al Sumut' or 'the compass bearing'.

Vela may be famous for being the sail of the ship Argo Navis, however, there is another unofficial but more prominent sail nearly overhead in the mid-evening. Corvus is the constellation



of the Crow, with three of its brightest stars attesting to this (All Sky Map 4). Mintar (Epsilon Corvi) is a contraction of an Arabic phrase meaning the Raven's Beak. Glenah (Gamma) and Algorab (Delta) both relate to a Raven's wing. With these two stars pointing towards Alpha Virginis the main stars of Corvus are sometimes referred to as Spica's Spanker, a type of ship's sail. When it comes to asterisms the only limitation is your imagination. To us, Musca (All Sky Map 1), under the Southern Cross, looks much more like a sail than a fly.

THE MOON



- 3rd 7 am (5 am WST) Occultation of dwarf planet Ceres by the Moon, visible from Antarctic Peninsula and South Georgia.
- 3rd 6 pm (4 pm WST) Moon at perigee (closest to Earth at 369,062 km).
- 5th 10 am (8 am WST) Maximum Libration (6.9°), bright NE limb. The 165 km Mare Humboldtianum comes into view.
- 5th 1 pm (11 am WST) Occultation of Aldebaran by the Moon, visible from Solomon Islands, Micronesia, Hawaii & Central America.
- 5th 10 pm (8 pm WST) First Quarter.
- 11th 9 am (7 am WST) Occultation of Regulus by the Moon, visible from S South America & S tip of S Africa.
- 11th 1 pm (11 am WST) Minimum Libration (4.7°), bright SE limb.
- 13th 1 am (11 pm previous day WST) Full Moon.
- 19th 3 am (1 am WST) Moon at apogee (furthest from Earth at 404,650 km)
- 21st 2 am (midnight previous day WST) Last Quarter.
- 21st 8 am (6 am WST) Maximum Libration (6.9°), bright SW limb. North pole craters west of the terminator favoured such as Crater Hausen (167 km).
- 26th 6 pm (4 pm WST) Occultation of Neptune by the Moon, visible from S Africa, Yemen, Oman & SW Asia.
- 28th 1 pm (11 am WST) New Moon.
- 28th 1 pm (11 am WST) Minimum Libration (5.9°), too close to New Moon.
- 30th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 363,854 km).

Bright Doesn't Mean Close!

Looking up at the night sky you would be forgiven thinking that the brightest stars must mean they are the nearest. After all we have grown to accept without questioning that larger looking trees are close by, as are the brightest streetlights. There are all sorts of subconscious clues we draw on to make these conclusions such as with the lighting example, the apparent size of the lamp housing or height of the poles. Gazing at the stars all we see is brightness and colour. The difference in colour does give a hint to fundamental differences between these heavenly bodies.

The tables on page 139 give a wealth of information. The first surprise is only 8 of the 22 closest stars are considered visible to the naked eye (brighter than 6th magnitude). The biggest shock might be that only 3 of the 30 brightest stars appear on the closest list! So there are big differences between their intrinsic brightness or luminosity. Going back to our streetlight analogy, we might have two side by side but differing in brightness because they have different intrinsic luminosities. One might be a quartz halogen and the other fluorescent where from a distance we may need to rely on their spectrum, or more practically their colour to distinguish them (blue and white respectively).

Ultimately the luminosity of a star is determined by its temperature and size (radiating surface area). How bright a star is depends on how much of that radiation falls in the visible part of the spectrum. Cool stars peak in the long wavelength end of the spectrum and appear red. However they may still have significant radiation falling in the infrared which is invisible to the eye. Hot stars are the opposite, peaking in the blue end and losing a lot to the ultraviolet.

To account for variations in brightness due to distance, astronomers use absolute magnitude, that is, how the stars would appear if all were placed at a standard distance.

It's interesting that traditional textbooks refer to the Sun as being a typical star (a vague comment anyway). As our technology has grown it's become apparent how many faint stars are nearby. The closer the star the larger the proper motion against background stars (the Hipparcos satellite delivered a treasure trove of such results). Looking at the absolute magnitude values in the Nearest Stars table, only three other stars come close to or exceed the Sun. The majority of the remainder are M class Red Dwarf stars, which includes the closest star Proxima Centauri. Such stars are typically 7% to 50% of the mass of the Sun. Proxima is only 12% the mass and only 14% the size (200,000 km in diameter).

Missing from this list are a few Brown Dwarfs, which have masses lower than 7%. If the table is fairly representative (yes, it is a small sample) then the Sun may deserve a higher ranking than just 'typical'. It is well above the median, but it is not in the same league as the monsters we are about to discuss.

This brings us to the Brightest Stars table. Every star listed except one has a considerably brighter absolute magnitude than the Sun. The only exception is Alpha Centauri and only through luck being close by. As mentioned above, the temperature of stars contributes to their brightness. As per the explanation on page 138, this is reflected directly in the spectral class and there are numerous hot O, B and A representatives on this list. In general their masses are considerably greater than the Sun, for example Sirius is double but still doesn't make it to a negative absolute magnitude.

The really interesting members of the 'brightest' club are the supergiants. Take Antares as an example, a red supergiant with a mass 15 to 18 times the Sun and a total luminosity of around 65,000 ×. Most is in the infrared, with around 10,000 × in the visible. It was mentioned above that the radiating

THE PLANETS

Mercury is in superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 7th and thereafter returns to the western evening sky for a rather poor apparition this month. At best, the planet gains just a couple of degrees of altitude above the horizon by the end of civil twilight at month's end (see Sky View).

Venus is visible in the western evening twilight early in the month, before moving too close to the Sun for observation. In the first few days of March a rapidly brightening comet Encke can be seen to the lower left of Venus (about 9° away), but a low horizon is needed. As the planet is heading toward Earth, and nearing inferior conjunction on the 25th, it appears at its brightest. A telescopic view will show the planet increasing in size as its crescent wanes (see also the Orbital Aspects diagram on page 17).

The **Earth** is at its autumnal equinox on the 20th. The Sun will rise and set due east and west. Day and night will be approximately equal.

Mars is visible low in the early western evening sky, spending the first week of the month in Pisces before crossing into neighbouring Aries. The 3-day old earthshine enhanced waxing crescent Moon appears to the south (left) of the Red Planet on the 1st and 30th (see Sky Views). Being a non-opposition year, Mars makes a rather poor target through telescopes with its disc under 5 arcseconds in diameter from now until the end of the year. We can look forward to a great opposition in 2018 when the Martian disc grows to 24 arcseconds. Considering it another way: the sunlight reflected off the planet back to Earth takes 22 minutes to reach us at conjunction this July, at opposition in 2018 it will take a little over 3 minutes.

Jupiter, at around –2.5 magnitude, rises in the eastern evening sky in Virgo. With opposition looming early next month the planet presents a 44 arcsecond diameter disc for observers (at its equator). Since Jupiter reached aphelion (the point in its orbit furthest from the Sun) in February, this opposition would generally be considered unfavourable. However, even small telescopes will show plenty of detail. Features like polar flattening on the rapidly spinning globe, distinctive ever-changing equatorial cloud bands, the Great Red Spot and the constant shuffling of the Galilean moons (see Sky View for some interesting configurations during the month). After this year's opposition we can look forward to seeing a slightly larger disc size at each subsequent apparition, leading up to the next perihelic (closest to the Sun) opposition in 2022. Over the course of the month Jupiter moves away from is companion of the past few months, the 1st magnitude star Spica (see Sky View), ending up less than 1° from the 4th magnitude binary star Theta Virginis.

Saturn drifts through Sagittarius not far from the photographic delights of the Lagoon and Trifid nebulae. Rising around 11 pm midmonth, it is still considered a morning object. On the 18th, Saturn is at its western quadrature where the Sun-Earth-Saturn angle is 90°, this configuration of the three bodies is shown on the Orbital Aspects diagram p. 17. It is during quadrature that we can see the maximum shadow of the planet cast onto the back of the rings, a sight that is not visible at opposition. On the 20th, the Last Quarter Moon appears near the planet (see Sky View).

Uranus sets in the western evening sky around the end of astronomical dusk during the first half of the month before it becomes too close to the Sun for observation.

Neptune is in conjunction with the Sun on the 2nd, and lost from view until its reappearance in the morning sky at the end of the month in Aquarius.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto, in Sagittarius, rises around 1 am in the east.

Minor Planets. Three of the brighter minor planets reach opposition this month in Leo. They are: 16 Psyche on 3rd at magnitude 10.3, 29 Amphitrite on 3rd at magnitude 9.1 and 41 Daphne on 8th at magnitude 9.6. There are two in Virgo, 192 Nausikaa on 18th at 11.1 and 423 Diotima on 27th at magnitude 11.7. Others at opposition include 409 Aspasia on 29th at magnitude 10.8 in Corvus, 43 Ariadne on 5th at magnitude 10.6 near the Leo/Sextans border and 88 Thisbe on 23rd at magnitude 11.2 near the Virgo/Crater border.

The minor planet 9 Metis visits a few galaxies in Leo in the next four months as it swings through its retrograde loop (see diary). In March a faint (11th magnitude) 10 Hygiea visits some notable deep sky objects in Sagittarius, including the spectacular globular M22 on 27th. Retrograde motion will see this minor planet make a much closer return to M22 in June (see diary). Also touring Sagittarius in March is 40 Harmonia.

COMETS

Comet C/2015 ER$_{61}$ (PANSTARRS) is expected to brighten from 10th to 9th magnitude this month. In Sagittarius for all but the last few days of March, when it moves into Capricornus, PANSTARRS is rising shortly after midnight. On 1st it passes between the Trifid and Lagoon nebulae in Sagittarius. An imaging opportunity?

Comet C/2015 V2 (Johnson) rises about two hours before dawn as March opens. Predicted to brighten from 9th to 8th magnitude, the comet is slowly moving through Hercules in the northern sky. On the morning of the 4th it will be extremely close to 4th magnitude star Tau Herculis.

Comet 2P/Encke is at perihelion on 10 March and should become visible in the dawn sky later in the month. By 20

surface area also contributes. Antares is well endowed in this area, having a diameter of approximately 900 × our Sun. If it replaced Sol, its outer surface would be between Mars and Jupiter!

The most luminous star on the list is the white supergiant Deneb (absolute magnitude –7). To be some 1600 light years distant and still glow at 1st magnitude it is a real powerhouse with high temperature, mass and size going for it! Its mass is around 19 ×, luminosity 200,000 × and size 200 × the Sun. If it replaced our star its surface would be around the position of the Earth! While playing God, let's move it to the distance of the brightest star, Sirius (8.6 light years). What a beacon it would make, being close to the brilliance of the Full Moon and clearly visible during the day. Something to contemplate when next looking at this Alpha star to Cygnus, forming the lower right star of the Summer Triangle (see All Sky Map No 9).

March, Encke could be around 6th magnitude and a few degrees high at the beginning of dawn. The comet will be in Aquarius throughout the second half of March and may have faded to 8th magnitude by month's end.

Comet 41P/Tuttle-Giacobini-Kresak may brighten from 8th to 6th magnitude this month. As the comet nears Earth, it is moving more quickly through the sky from night to night. Beginning March in Leo, it is moving north and by midmonth is passing through Ursa Major and below the northern horizon for many readers.

Comet 45P/Honda-Mrkos-Pajdusakova opens March on the border of Leo and Leo Minor, rising at the end of evening twilight and shining at 10th magnitude. Moving away from both the Sun and Earth, the comet will fade to 13th magnitude by late March.

Comet 71P/Clark is in Libra as March opens, rising late in the evening and shining at 12th magnitude. Midmonth sees it move into Scorpius, and by month's end the comet is predicted to have brightened to 11th magnitude.

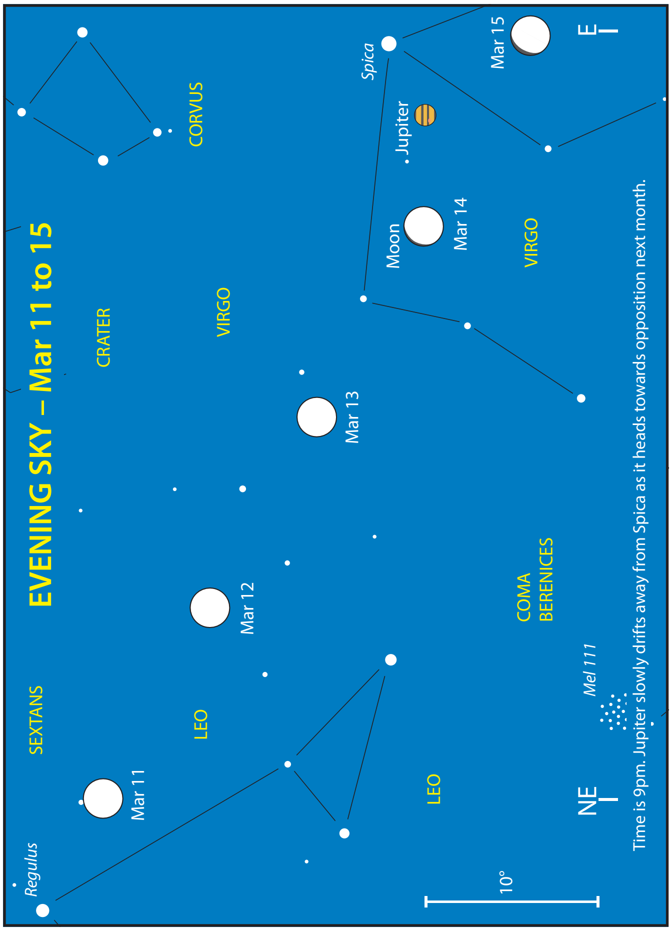
Comet 73P/Schwassmann-Wachmann 3 is predicted to hover around 12th magnitude this month. Rising around 2:30 am midmonth, the comet begins March in Sagittarius before moving quickly into Capricornus, and then into Aquarius late in the month.

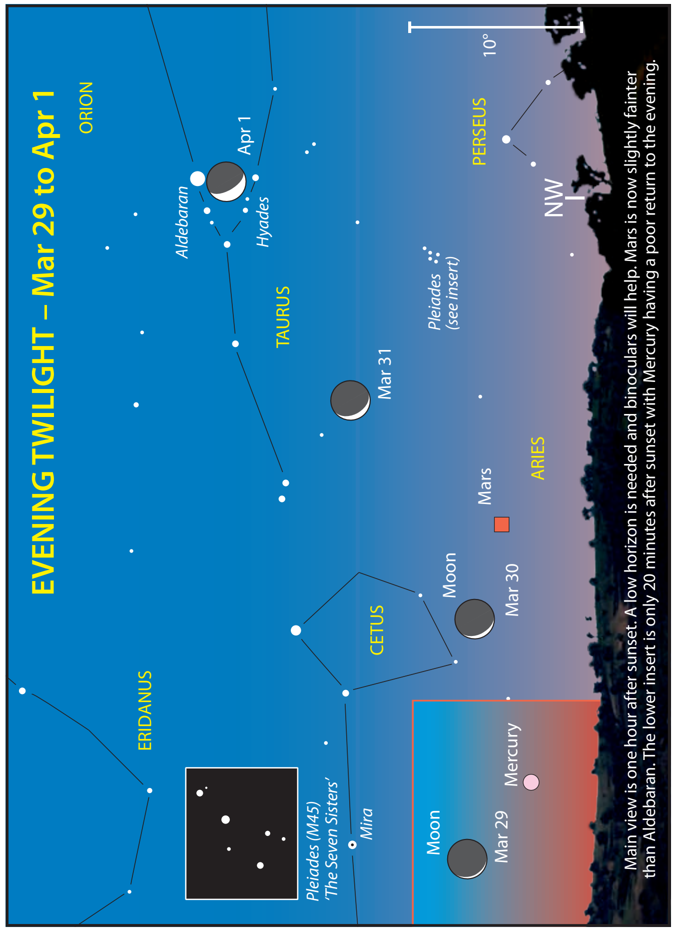
DOUBLE STARS

This month's double star, **Dunlop 70** (All Sky Map 1), is located in the southern constellation of Vela, the sails. Dunlop 70 is near the magnificent multiple star Gamma Velorum (Regor). The stars, magnitudes 5.2 and 7.0, are separated by 4.3 arcseconds and appear to be closing. Hartung described these stars as deep yellow and pale yellow. For those with larger telescopes (aperture of 25 cm and over), a dark sky and an OIII filter, a filament of the Vela supernova remnant (Gum 12) passes through the field of view.

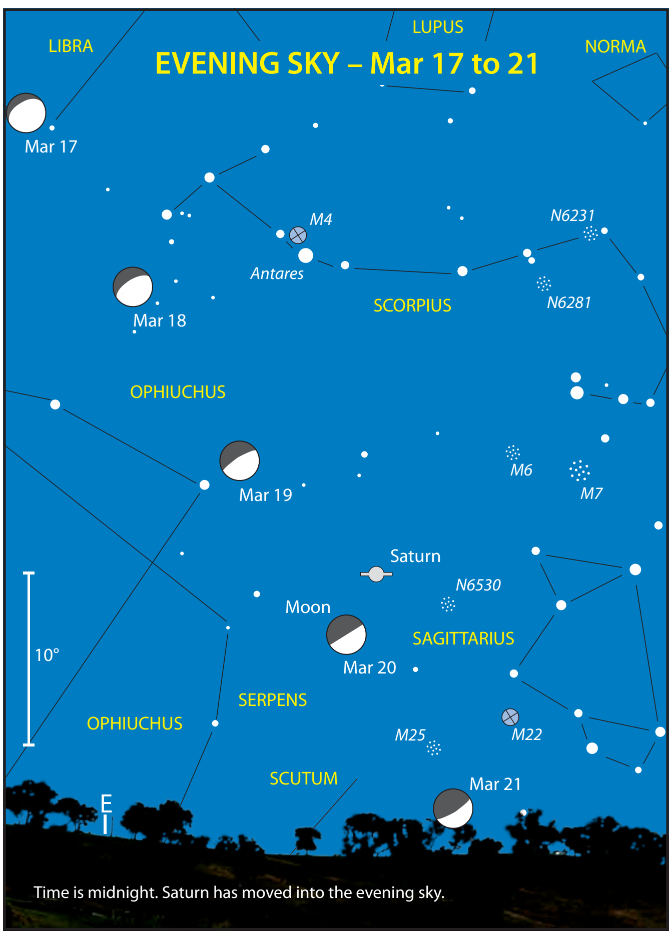
DIARY

Wed	1st		m.p. 10 Hygiea 0.9°S of M8 Lagoon Nebula (BN) in Sagittarius
Wed	1st		Comet C/2015 ER_{61} (PANSTARRS) 0.8°N of M8 Lagoon Nebula (BN) in Sagittarius
Wed	1st		Comet C/2015 ER_{61} (PANSTARRS) 0.7°SE of M20 Trifid Nebula (BN) in Sagittarius
Wed	1st	6 am	(4 am WST) Venus 10° N of Moon
Thu	2nd	Midnight	(10 pm WST) Venus stationary
Thu	2nd	2 am	(Midnight WST, prev day) Uranus 4° N of Moon
Thu	2nd	5 am	(3 am WST) Mars 4° N of Moon
Thu	2nd	1 pm	(11 am WST) Neptune in conjunction with Sun
Fri	3rd		m.p. 10 Hygiea 0.3°S of NGC 6544 (GC) in Sagittarius
Fri	3rd	7 am	(5 am WST) d.p. 1 Ceres 0.9° N of Moon
Fri	3rd	6 pm	(4 pm WST) Moon at perigee, 369,062 km
Sat	4th		m.p. 10 Hygiea 0.6°N of NGC 6553 (GC) in Sagittarius
Sat	4th	4 am	(2 am WST) Comet C/2015 V2 (Johnson) 0.03°S of star Tau Herculis
Sun	5th		Comet 73P/Schwassmann-Wachmann 3, 1.2°NW of M75 (GC) in Sagittarius
Sun	5th	1 pm	(11 am WST) star Aldebaran 0.2° S of Moon
Sun	5th	9:32 pm	(7:32 pm WST) First Quarter Moon
Sun	5th	pm	m.p. 9 Metis 0.5°NE of NGC 3227 (G) in Leo
Sun	5th	pm	m.p. 29 Amphitrite 0.2°SW of star Rho Leonis
Mon	6th	11 pm	(9 pm WST) Comet 45P/Honda-Mrkos-Pajdusakova 0.5°SE of star 54 Leonis
Mon	6th	pm	Comet 41P/Tuttle-Giacobini-Kresak 1.3°SE of star Alpha Lyncis
Tue	7th		Comet C/2015 ER_{61} (PANSTARRS) 0.7°NW of NGC 6642 (GC) in Sagittarius
Tue	7th		m.p. 4 Vesta stationary
Tue	7th	10 am	(8 am WST) Mercury in superior conjunction
Wed	8th		Comet C/2015 ER_{61} (PANSTARRS) 1.2°NW of M22 (GC) in Sagittarius
Wed	8th	am	m.p. 40 Harmonia 1.0°N of Saturn
Wed	8th	6 pm	(4 pm WST) star Pollux 10° N of Moon
Wed	8th	10 pm	(8 pm WST) m.p. 41 Daphne 0.1°NE of NGC 3521 (G) in Leo
Fri	10th	pm	m.p. 9 Metis 0.7°N of star Gamma Leonis
Sat	11th	am	m.p. 40 Harmonia 0.7°S of NGC 6440 (GC) in Sagittarius
Sat	11th	9 am	(7 am WST) star Regulus 0.8° N of Moon
Mon	13th	12:54 am	(10:54 pm WST, prev day) Full Moon (388,858 km)
Tue	14th		Venus at greatest latitude north
Wed	15th		Comet C/2015 ER_{61} (PANSTARRS) 0.2°E of star Omicron Sagittarii
Wed	15th	6 am	(4 am WST) Jupiter 2° S of Moon
Wed	15th	9 am	(7 am WST) star Spica 6° S of Moon
Wed	15th	1 pm	(11 am WST) m.p. 2 Pallas in conjunction with Sun
Thu	16th		m.p. 10 Hygiea 0.3°S of M28 (GC) in Sagittarius
Thu	16th		Comet C/2015 ER_{61} (PANSTARRS) 0.5°S of star Pi Sagittarii
Thu	16th	7 pm	(5 pm WST) d.p. 1 Ceres 0.03°S of star 38 Arietis
Sat	18th		Comet C/2015 ER_{61} (PANSTARRS) 0.4°NW of d.p. Pluto
Sat	18th		Mercury at ascending node
Sat	18th	11 pm	(9 pm WST) Comet 45P/Honda-Mrkos-Pajdusakova 0.4°SE of NGC 3301 (G) in Leo
Sun	19th		m.p. 10 Hygiea 0.3°N of star Lambda Sagittarii
Sun	19th		Comet 2P/Encke 0.5°E of star Tau 2 Aquarii
Sun	19th	3 am	(1 am WST) Moon at apogee, 404,650 km
Sun	19th	6 am	(4 am WST) star Antares 10° S of Moon
Mon	20th	8 pm	(6 pm WST) Equinox
Mon	20th	8 pm	(6 pm WST) Saturn 3° S of Moon
Tue	21st	1:58 am	(11:58 pm WST, prev day) Last Quarter Moon
Wed	22nd	am	m.p. 10 Hygiea 0.5°N of NGC 6638 (GC) in Sagittarius
Wed	22nd	4 pm	(2 pm WST) d.p. Pluto 3° S of Moon
Thu	23rd		Mercury at perihelion
Sat	25th	8 pm	(6 pm WST) Venus in inferior conjunction
Sun	26th	6 pm	(4 pm WST) Neptune 0.005° N of Moon
Mon	27th		Mercury 1.0°N of NGC 524 (G) in Pisces
Mon	27th	am	m.p. 10 Hygiea 1.0°S of M22 (GC) in Sagittarius
Mon	27th	4 pm	(2 pm WST) Uranus 2° S of Mercury
Tue	28th		m.p. 4 Vesta 0.7°S of star Upsilon Geminorum
Tue	28th	12:57 pm	(10:57 am WST) New Moon
Wed	29th	am	m.p. 40 Harmonia 0.4°N of NGC 6568 (OC) in Sagittarius
Wed	29th	1 pm	(11 am WST) Uranus 4° N of Moon
Wed	29th	5 pm	(3 pm WST) Mercury 7° N of Moon
Thu	30th	11 pm	(9 pm WST) Moon at perigee, 363,854 km
Thu	30th	11 pm	(9 pm WST) Mars 5° N of Moon
Fri	31st		Mercury 0.6°E of NGC 660 (G) in Pisces
Fri	31st		m.p. 3 Juno 1.0°SE of NGC 6712 (GC) in Scutum
Fri	31st	am	m.p. 40 Harmonia 0.9°N of NGC 6583 (OC) in Sagittarius
Fri	31st	3 am	(1 am WST) m.p. 40 Harmonia 0.1°S of star Mu Sagittarii
Fri	31st	6 am	(4 am WST) d.p. 1 Ceres 2° N of Moon





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

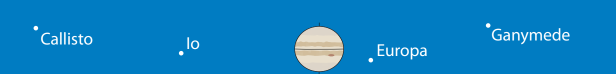


Jupiter's Satellites for March

1 arc min.

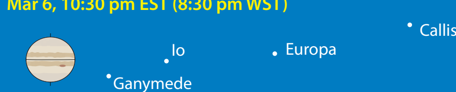
Jupiter's Moons can be followed with any small telescope. Here are a few interesting patterns that occur this month. Unless otherwise stated, events are suitable for all of Australia. Specific times of these events can be found in Part II, 'Jupiter Moon Events'. Drawn to normal sky, Jupiter's north pole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

Mar 4, 2:30 am EST (12:30 am WST)



Europa is about to go into eclipse.

Mar 6, 10:30 pm EST (8:30 pm WST)

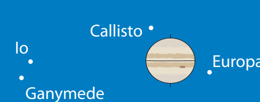


All four moons on the west side of Jupiter. Ganymede is about to be eclipsed and in the morning Io will follow suit with both moons reappearing before dawn.

Mar 14, 2:00 am EST (Midnight 13th WST)

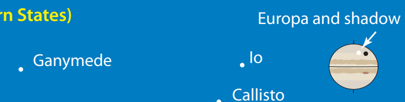
A rare event, two moons being eclipsed in the morning. Ganymede will disappear in the next hour, followed by Io two hours later, leaving Jupiter with only two moons visible for a brief time.

Mar 21, 9:00 pm EST (Eastern States)



From the eastern states Europa is about to be eclipsed, to reappear three hours later. Callisto will pass over (north) of Jupiter. The morning hours will see Io and its shadow complete a transit (the egress is better suited for WA).

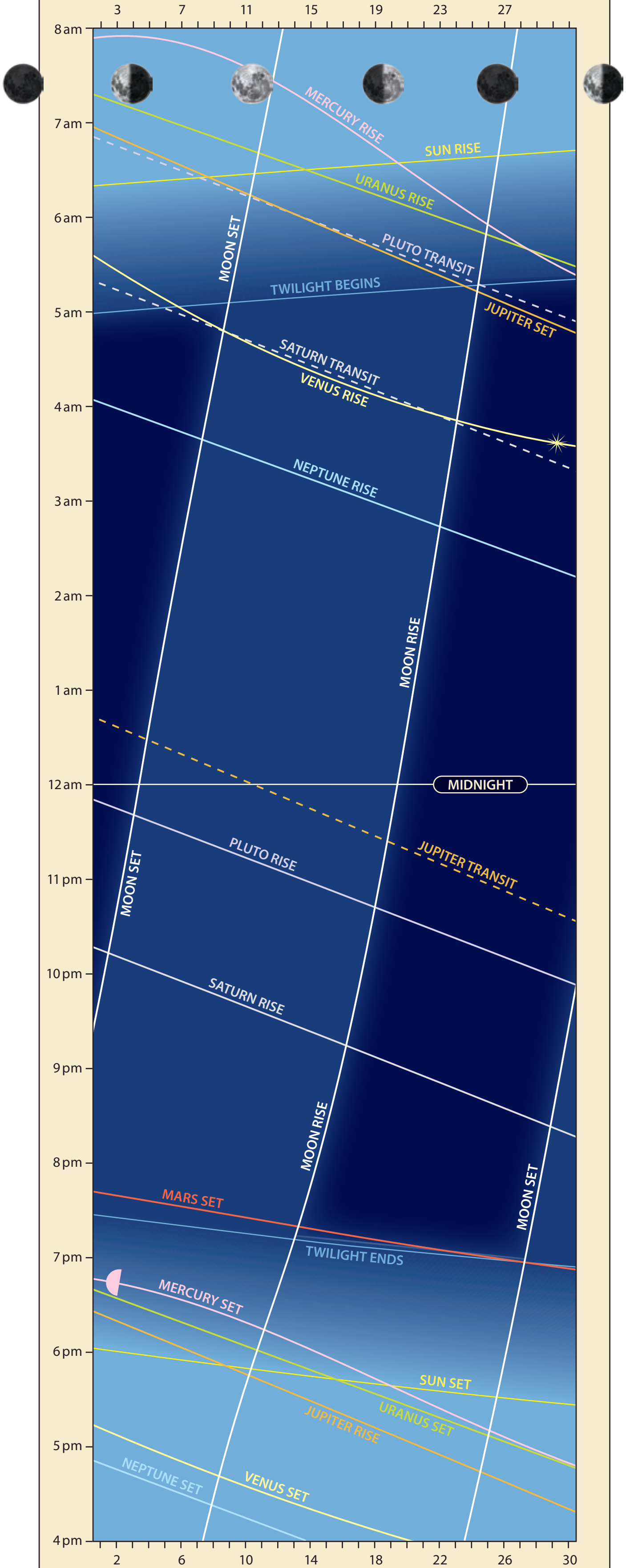
Mar 30, 8:00 pm EST (Eastern States)



Europa and its shadow are transiting and will egress in the next hour. During the night all of Australia will see a complete transit of Io and its shadow.

APRIL

RISE–SET CHART



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

HIGHLIGHTS

- Venus returns to the morning sky.
- Jupiter at opposition.
- Occultation of Neptune by the Moon.
- Comet 41P/Tuttle-Giacobini-Kresak in morning sky

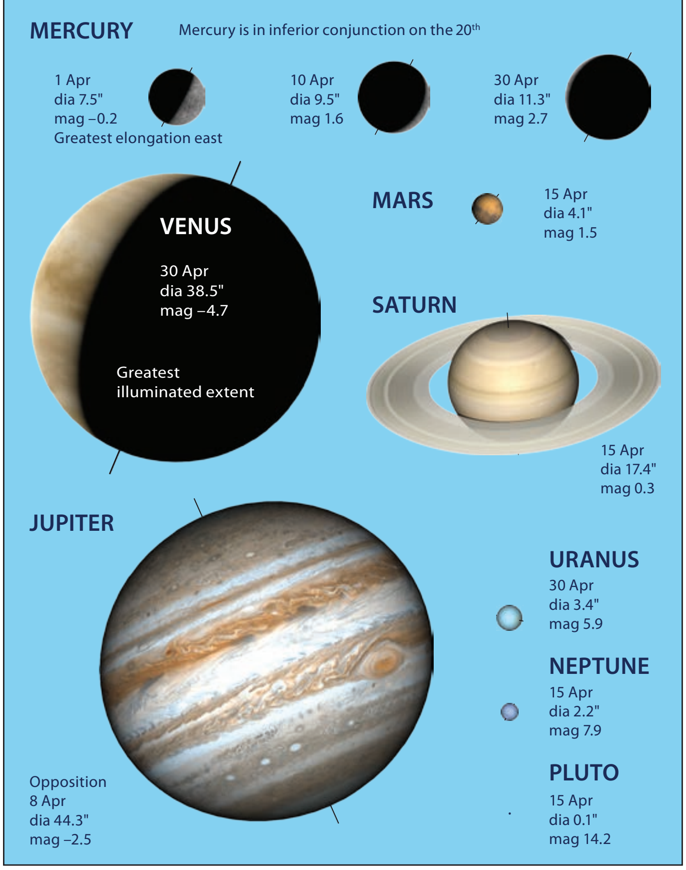
CONSTELLATIONS

Toliman, Bungula, Rigel Kent or Rigel Kentaurus are all names for the most famous Southern Hemisphere star, Alpha Centauri, currently high in the evening sky (All Sky Map 1). Considering its position on the traditional drawing of this half man-half horse creature in the heavens Rigel Kentaurus is possibly the most descriptive meaning 'foot of the centaur', although Bungula with its Latin derivation of 'hoof' isn't bad either. The view from low Northern Hemisphere latitudes helps explain its origin with the centaur standing on the southern horizon with the Pointers close to the ground, marking the front feet, with the beast straddling the Southern Cross.

As well as being the closest star to our Solar System, 4.4 light years away, Alpha Centauri is a well-known binary. Its primary components are magnitude 0.0 and 1.3 with an orbital period of 80 years. Earth sees an inclined view of the orbit and it's been fascinating watching these stars slowly move together from a maximum separation of 22 arcseconds in 1980 down to a close approach this year of 4.0 arcseconds. The brighter of the stars (Alpha Centauri A) resembles our Sun having the same spectral class (G2V) but slightly higher luminosity.

This system has a remote third component, Proxima Centauri, approximately 0.1 light years nearer. It is located 2° south of Alpha, which at that distance equals 15,000 au from its

APPEARANCE of the PLANETS

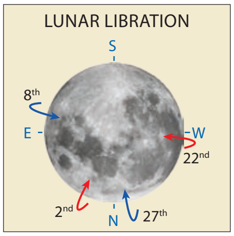


APRIL

companions. At only 11th magnitude this very low luminosity red dwarf star is only 15% the Sun's diameter and about one eighth of its mass. You may feel it is ironic that the truly closest star needs a telescope to see, however red dwarf stars are abundant (also see page 31).

Another irony is that although Alpha and Beta Centauri are known as the pointers (to the Southern Cross), a line drawn through them currently passes over Crux, but not for long (astronomically speaking). Proper motion is moving Alpha northward and towards Beta with the two forming a naked eye double star in about 4,000 years.

THE MOON



1st 7 pm (5 pm WST) Occultation of Aldebaran by the Moon, visible from NE Africa, Arabia, India, Mongolia, China & Japan. From Australia the 5-day old Moon appears close to the 1st magnitude star in the early evening western sky.

2nd 5 pm (3 pm WST) Maximum Libration (7°), bright NE limb. The libration favours the dark lava flooded Mare Humboldtianum.

4th 5 am (3 am WST) First Quarter.

7th 3 pm (1 pm WST) Occultation of Regulus by the Moon, visible from S Polynesia, Antarctic Peninsula & tip of S America.

8th 4 pm (2 pm WST) Minimum Libration (5.4°), bright SE limb.

11th 4 pm (2 pm WST) Full Moon.

15th 8 pm (6 pm WST) Moon at apogee (furthest from Earth at 405,475 km).

19th 8 pm (6 pm WST) Last Quarter.

22nd 6 pm (4 pm WST) Maximum Libration (7.4°), bright NW limb. The libration favours the 92 km wide Crater Schluter.

23rd 6 am (4 am WST) Occultation of Neptune by the Moon, visible across New Zealand and most of Australia, see details under Neptune on next page.

25th 2 am (midnight previous day WST) Occultation of minor planet Pallas by the Moon, visible from most of N America, Greenland, Iceland & Ireland.

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

27th 5 pm (3 pm WST) Minimum Libration (6.5°), too close to New Moon.

28th 2 am (midnight previous day WST) Moon at perigee (closest to Earth at 359,327 km).

29th 4 am (2 am WST) Occultation of Aldebaran by the Moon, visible from N America, Cuba, Europe & N Africa.

THE PLANETS

Mercury reaches its greatest elongation east (19°) of the Sun on the 1st. This is not a favourable elongation for viewing with the planet barely above the horizon at the end of civil twilight. Mercury then returns to the morning dawn after passing between the Earth and Sun (inferior conjunction) on the 20th. Although unobservable and immersed in the twilight sky, it is interesting to note that Mercury and the outer planet Uranus will be separated by just 10 arcminutes on the 29th.

Venus returns to the morning eastern dawn after inferior conjunction late last month. The planet will remain the Morning

Mira Variable Stars

The stars to most of us seem pretty constant and unchanging. We are not only talking over a human lifetime but, except for the odd supernovae, over recorded history and certainly to the naked eye view. For those relatively new to astronomy it may come as a surprise there are tens of thousands of stars known to significantly change brightness, many in a repeatable pattern. Amateurs have discovered a number of these and although the majority need a telescope to see, some only need binoculars or even the unaided eye to witness them. A very much naked eye example is mentioned in the December Constellations section (p. 72), the brightest eclipsing binary star, Algol. This is a relative rare type, where its dimming is caused by an external factor, when its fainter companion passes in front of (eclipses) the brighter primary on each orbit.

Pulsating Variables

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

The short period Cepheids are most famous for their period/luminosity relationship, a discovery made by Henrietta Swan

Bright Mira Type Variable Stars suitable for observing in 2017

Name	RA	Dec	Brightness range		Period	Approximate Dates of Predicted Maximum and Minimum					Months/Times of Culmination			All Sky Map	Notes (below)
			max	min	(days)	Min	Max	Min	Max	Min	1 am	11 pm	9 pm		
OMI CET (MIRA)	02h 19.3m	–02° 59'	3.4	9.3	332.0	26/10/16	23/02/17	22/09/17	20/01/18	20/08/18	Oct	Nov	Dec	2	1
T CEN	13h 41.8m	–33° 36'	5.5	9.0	90.6	25/12/16	6/02/17	25/03/17	7/05/17	24/06/17	Mar	Apr	May	6	2
S CAR	10h 09.4m	–61° 33'	5.7	8.5	149.5	6/08/16	2/11/16	3/01/17	31/03/17	1/06/17	Feb	Mar	Apr	1	3
R LEO	09h 47.6m	+11° 26'	5.8	10.0	310.0	19/02/16	25/06/16	25/12/16	30/04/17	30/10/17	Jan	Feb	Mar	5	4
RR SCO	16h 56.6m	–30° 35'	5.9	11.8	281.5	20/07/16	23/11/16	27/04/17	31/08/17	2/02/18	May	Jun	Jul	6	5
R HOR	02h 53.9m	–49° 53'	6.0	13.0	407.6	20/04/16	28/09/16	1/06/17	9/11/17	14/07/18	Oct	Nov	Dec	2	6

1 Watch Mira rise to maximum at the end of the year.

2 With its short period a good chance to see a full cycle early in the year (Max to Max).

3 With its short period and southern declination a good chance to see a full cycle (Min to Min) in the first half of the year.

4 5° due west of Regulus. Good opportunity to see it rise to maximum early in the year.

5 1°SW from M62. Watch it rise to maximum in the middle of the year.

6 AAVSO chart doesn't show magnitude sequence. Good opportunity to see it rise to maximum at the end of the year.

Star until November when it again becomes too close to the Sun for observation. On the 24th, the 26-day old waning crescent Moon appears 5° south of the planet—a very attractive sight for early morning risers (see Sky View). The view of Venus through any small telescope at this time will reveal the planet as a crescent closely matching that of the Moon. The planet reaches its *greatest illuminated extent* (see February Venus section for definition) on the 30th at -4.7 magnitude.

Mars is barely above the western evening horizon at the end of astronomical dusk this month. Being so low in altitude basically rules out any observation and since it is a non-opposition year the Martian disc barely averages 4 arcseconds in diameter from January to December—a disappointing target for small telescopes. The Red Planet spends the first third of April in Aries before crossing over into Taurus between the Pleiades and Hyades star clusters. On the 28th, soon after sunset you may be able to catch the planet with the 2-day waxing crescent Moon a few degrees to the south.

Jupiter is at opposition on the 8th, standing brilliantly above the eastern horizon after dusk. At –2.5 magnitude, the planet is the brightest object in the evening sky aside from the Moon. The equatorial diameter of the gas giant at this opposition is a little over 44 arcseconds. Oppositions repeat after one year and one month (398.9 days) and each subsequent apparition will be a little more favourable until 2022 when the diameter is at a maximum of 50 arcseconds. Even small telescopes show detail on the planet. Look for the polar flattening, changing cloud bands and the massive ancient storm known as the Great Red Spot (GRS). Keep in mind that with a 10-hour rotation period things move fast on Jupiter, and the GRS is best observed at the time of meridian passage or at most an hour on either side. See Part II for estimated date/times for these events. Never underestimate the fun of watching the Galilean moons as they shuffle back and forth undergoing satellite transits, shadow transits, occultations and eclipses—just like a miniature solar system (see Sky View for some interesting configurations during the month). From the 5th to 7th, the 4th magnitude star Theta Virginis will be in the same field as Jupiter at just 0.2° away. Theta is a spectroscopic binary that is orbited by a pair of 9th and 10th magnitude suns at a distance of 7 and 70 arcseconds respectively. On the 11th, the Full Moon forms an equilateral triangle with Jupiter and the 1st magnitude star Spica (see Sky View).

Saturn, in Sagittarius, nearing opposition in mid-June, rises around 9:30 pm midmonth. The planet appears stationary against the stellar backdrop on the 6th before beginning close to five months of retrograde motion, taking it back towards the constellation of the Serpent Bearer (Ophiuchus). On the 16th, the 20-day old waning crescent Moon will be near the ringed planet (see Sky View).

Uranus is in conjunction with the Sun on the 14th (the planet on the opposite side of the Sun from the Earth) and will not be observable until its reappearance in the morning eastern sky in May.

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 3 am midmonth. On the morning of the 23rd, the Moon occults Neptune. The event will not be visible from the extreme north of the continent for example, Cape York and Darwin plus the western half of Western Australia. The eastern states will get the best view of the occultation as the planet disappears behind the bright crescent of the 25-day old waning crescent Moon and egresses from the dark limb. The further west you are the lower the Moon will be to the horizon and from about half way across the continent (west of Adelaide)

Leavitt while studying these stars in the Large Magellanic Cloud. This established a key yardstick in determining extragalactic distances. By short period we are talking only days to pass through a full cycle. The long period type has cycles typically measured in months. They have been named after the brightest example known, Mira (Omicron Ceti). Miras can vary by 5 to 8 magnitudes. To get a feel for how extreme this is try comparing the brightest stars (even Sirius) to the faintest stars visible to the naked eye under country moonless nights—pretty dramatic!

Why Don't You Contribute to Science?

Measuring the brightness of variables is still a key area that amateurs can contribute to astronomy, having something professionals don't have, mainly strength in numbers of observers and instruments (telescopes/binoculars). No special measuring equipment such as CCD or digital camera is needed. With practice visual observers can make estimates to the closest tenth of a magnitude (0.1) by interpolating between reference stars in the same field. These are stars whose brightness has previously been accurately determined, often by professionals. There are a number of variable star associations who regularly receive amateur measurements such as the AAVSO and Variable Stars South (an Australia/New Zealand based organisation). Their websites typically alert observers to stars that need observations either due to unusual behaviour or just lack of current measurements. This isn't unusual, for stars in the deep south are inaccessible to the large number of observers in the Northern Hemisphere.

For those wishing a more complete overview of variables we recommend the article by Alan Plummer in Astronomy 2013.

The table shown left covers the brightest Miras with expected maxima visible in 2017. By brightest, much of their range should be within view of typical binoculars. The first three can be followed through their entire cycle using 7 × 50 binoculars. While at maximum all six stars might be glimpsed with the unaided eye. The Months/Times of Culmination columns are when the star is highest in the sky and is offered only as a broad guide to the observing season. The further south in the sky the longer they are accessible. Also winter months and the observer being able to work well into the morning offers a much wider window of opportunity. Positions for these stars have been marked on the All Sky Maps.

The predictions shown have been calculated from data on the American Association of Variable Star Observer (AAVSO) website. Variable star charts with reference magnitude stars marked can also be printed from this site. Go to the Variable Star Plotter (VSP), which is accessible from the home page from the drop down 'Observing' menu. In general this is an excellent place to start exploring the world of variables. Check out their 'Manual for Visual Observing of Variable Stars'.

the Moon rises with Neptune already in occultation (see Lunar Occultation Table pp. 102–106 for times from capital cities).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto rises in the late evening eastern sky in Sagittarius. It appears stationary on the 20th before beginning five months of retrograde motion, as the Earth overtakes the slow-moving dwarf in its orbit.

Minor Planets. Three of the brighter minor planets reach opposition this month in Virgo. They are: 63 Ausonia on 11th at magnitude 10.1, 230 Athamantis on 13th at magnitude 10.6 and 12 Victoria on 19th at magnitude 9.8. Also 387 Aquitania reaches opposition on 5th at magnitude 11.2 in Bootes and 702 Alauda on 14th at magnitude 12.1 in Centaurus. On 24th 4 Vesta passes between the components of the wide double star Omega Cancri.

COMETS

Comet C/2015 ER$_{61}$ (PANSTARRS) should be around 9th magnitude throughout April. Rising in the early hours of the morning, PANSTARRS moves between Capricornus and Aquarius throughout the month, finishing in Pisces.

Comet C/2015 V2 (Johnson) could brighten from 8th to 7th magnitude during April. Rising around the middle of the night, Johnson is located in Hercules.

Comet 2P/Encke is in the morning sky as April opens, shining at 9th magnitude and rising two hours before dawn. Located in Aquarius throughout all of April, it will fade quickly, dropping to 11th magnitude by month's end.

Comet 41P/Tuttle-Giacobini-Kresak should become visible in the northern morning sky towards the end of April. Shining at perhaps 6th magnitude, the comet will be moving through Hercules.

Comet 71P/Clark is rising mid-evening at the start of April, and is forecast to shine at 11th magnitude, brightening to 10th magnitude by the end of the month. Initially located in Scorpius, the comet moves into Ophiuchus early in the month where it resides for the remainder of April.

Comet 73P/Schwassmann-Wachmann 3 is expected to fade from 12th to 13th magnitude this month. Rising around 3 am, the comet begins April in Aquarius where it resides until crossing into Cetus just before month's end.

METEOR SHOWERS

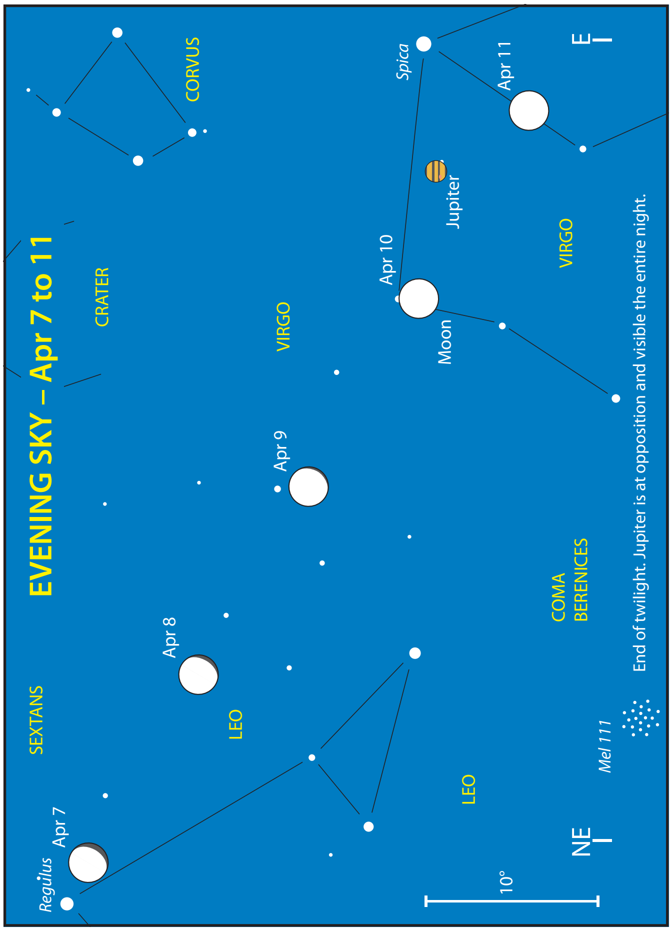
The **Lyrids** are a Northern Hemisphere shower, but they are visible south of the equator. They are best seen well past midnight in the Southern Hemisphere from the 16th to 25th, with maximum on the 22nd. High rates may only last an hour or so, and typically the zenith hourly rate is around 18. The Lyrids have on occasion produced higher rates, and because of their erratic nature, they are a shower to be watched. In 1982, American observers noticed a short peak of 90 per hour.

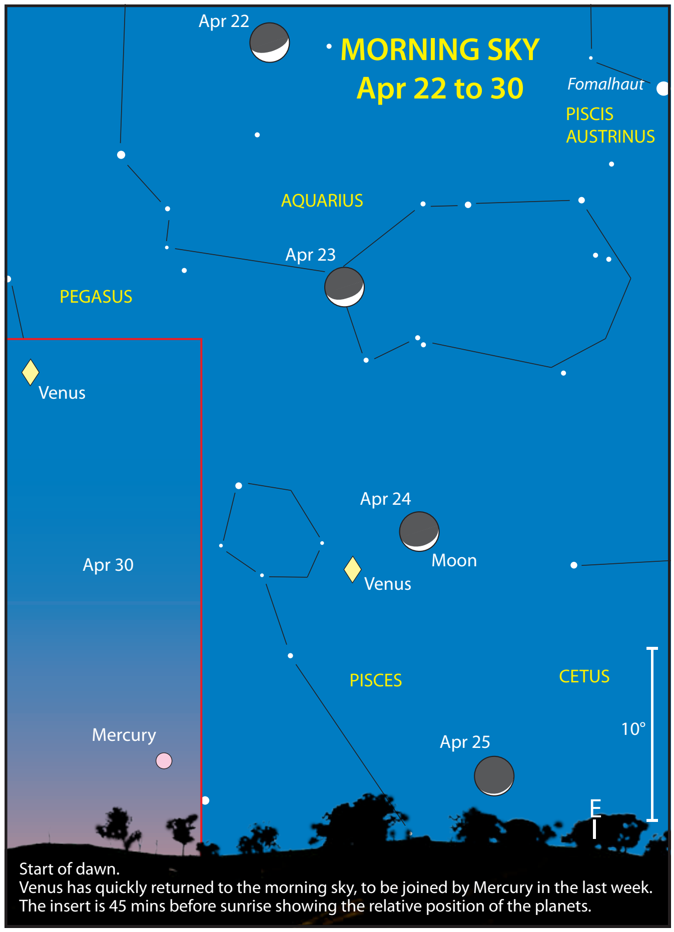
The **pi-Puppids** are a young southern shower first observed in 1972, and produced by Comet 26P/Grigg-Skjellerup. Best seen from 15th to 28th, with maximum activity on the 23rd. Leading up to and after maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly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

DIARY			
Sat	1st	7 pm	(5 pm WST) star Aldebaran 0.3° S of Moon
Sat	1st	8 pm	(6 pm WST) Mercury at greatest elongation East (19.0°)
Sun	2nd		Mercury at greatest latitude north
Sun	2nd	10 pm	(8 pm WST) m.p. 41 Daphne 0.15°NE of NGC 3423 (G) in Sextans
Mon	3rd	am	m.p. 6 Hebe 0.5°NW of NGC 6539 (GC) in Serpens
Tue	4th	Midnight	(10 pm WST) star Pollux 10° N of Moon
Tue	4th	4:39 am	(2:39 am WST) First Quarter Moon
Wed	5th		Saturn 0.8°W of NGC 6469 (OC) in Sagittarius
Wed	5th	11 pm	(9 pm WST) Jupiter 0.2°S of star Theta Virginis
Thu	6th	3 pm	(1 pm WST) Saturn stationary
Fri	7th	3 pm	(1 pm WST) star Regulus 0.7° N of Moon
Sat	8th	8 am	(6 am WST) Jupiter at opposition
Sun	9th	10 pm	(8 pm WST) star Pollux 2° N of m.p. 4 Vesta
Mon	10th		Comet 73P/Schwassmann-Wachmann 3, 0.5°E of star Tau 2 Aquarii
Mon	10th	11 am	(9 am WST) Mercury stationary
Tue	11th	am	m.p. 6 Hebe 0.9°NW of IC 1276 (GC) in Serpens
Tue	11th	7 am	(5 am WST) Jupiter 2° S of Moon
Tue	11th	4 pm	(2 pm WST) star Spica 6° S of Moon
Tue	11th	4:08 pm	(2:08 pm WST) Full Moon (398,715 km)
Thu	13th	3 am	(1 am WST) d.p. 1 Ceres 3° S of Mars
Thu	13th	10 am	(8 am WST) Venus stationary
Fri	14th	4 pm	(2 pm WST) Uranus in conjunction with Sun
Sat	15th	2 pm	(Noon WST) star Antares 10° S of Moon
Sat	15th	8 pm	(6 pm WST) Moon at apogee, 405,475 km
Sat	15th	11 pm	(9 pm WST) Jupiter 0.4°NE of NGC 4941 (G) in Virgo
Mon	17th	4 am	(2 am WST) Saturn 3° S of Moon
Wed	19th		Comet C/2015 V2 (Johnson) 0.7°NW of star Tau Herculis
Wed	19th	1 am	(11 pm WST, prev day) d.p. Pluto 3° S of Moon
Wed	19th	7:57 pm	(5:57 pm WST) Last Quarter Moon
Thu	20th		d.p. Pluto 1.1°NW of star 50 Sagittarii
Thu	20th		Pluto stationary
Thu	20th	4 pm	(2 pm WST) Mercury in inferior conjunction
Thu	20th	pm	m.p. 12 Victoria 0.6°NE of NGC 5247 (G) in Virgo
Sun	23rd	6 am	(4 am WST) Neptune 0.2° N of Moon
Mon	24th		m.p. 4 Vesta 0.2°S of star Omega 1 Cancri
Mon	24th		m.p. 4 Vesta 0.1°NW of star Omega 2 Cancri
Mon	24th	4 am	(2 am WST) Venus 5° N of Moon
Tue	25th	2 am	(Midnight WST, prev day) m.p. 2 Pallas 0.8° S of Moon
Wed	26th		Comet 41P/Tuttle-Giacobini-Kresak 1.0°SW of star Beta Draconis
Wed	26th		Mercury at descending node
Wed	26th	10:16 pm	(8:16 pm WST) New Moon
Fri	28th	2 am	(Midnight WST, prev day) Moon at perigee, 359,327 km
Fri	28th	9 am	(7 am WST) d.p. 1 Ceres 3° N of Moon
Fri	28th	5 pm	(3 pm WST) Mars 6° N of Moon
Sat	29th	4 am	(2 am WST) star Aldebaran 0.5° S of Moon
Sat	29th	6 am	(4 am WST) Mercury 0.1°S of Uranus

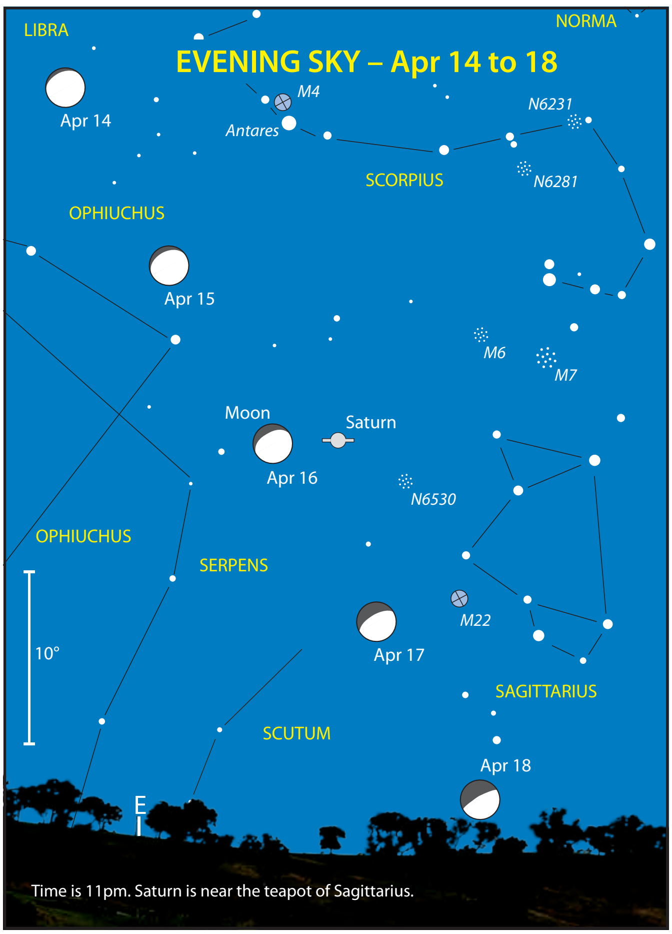
DOUBLE STARS

Located in Centaurus, the Centaur, **Q Centauri** (All Sky Maps 1 and 6) is a close double, easily located as it is situated just south of the bright star Epsilon Centauri. The white stars, magnitudes 5.2 and 6.5, form a tight pair separated by 5.4 arcseconds and are a fine site in a 15 cm *f*8 reflector at high power.





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



Jupiter's Satellites for April

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.

Apr 6, 10:00 pm EST (8:00 pm WST)

Europa and its shadow are in transit.
They will egress in the next hour. NB moons and their shadows appear close together when at opposition. Io and its shadow will transit completely later in the night.

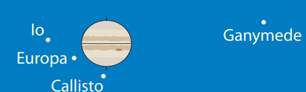
Apr 11, 3:00 am EST (1:00 am WST)

Interesting configuration with all four moons on the west side. Callisto is near a maximum elongation.

Apr 13, 11:30 pm EST (9:30 pm WST)

Europa and its shadow are currently in transit.
Later in the night they will egress. Io and its shadow will also complete a transit.

Apr 15, 9:00 pm EST (7:00 pm WST)

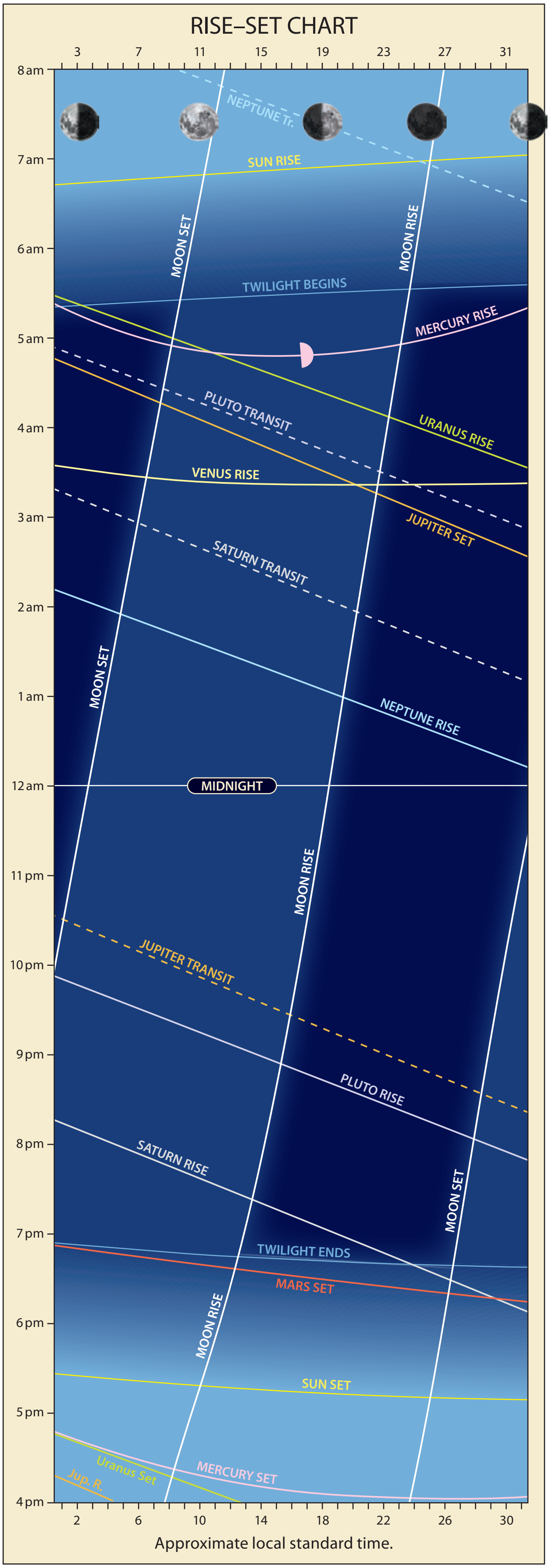


An attractive sight with three moons close to Jupiter. Europa has just reappeared from being eclipsed. Io and its shadow will transit during the night.

Apr 24, midnight EST (10:00 pm WST)

An attractive sight. All four moons have been on the west side since Io completed a transit earlier in the evening.

MAY



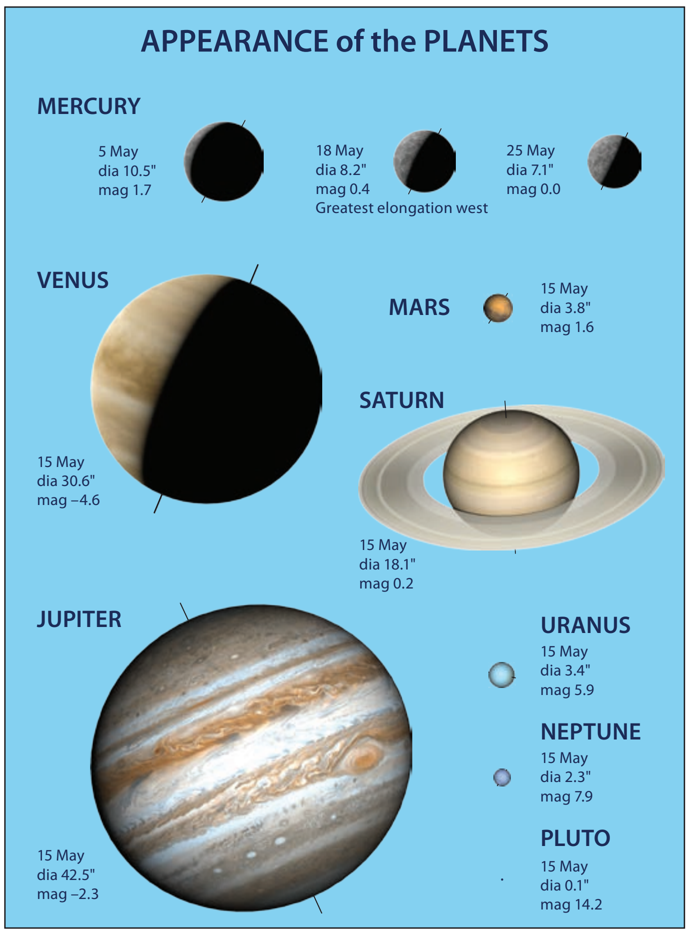
HIGHLIGHT

- Mercury at best for morning observation.
- Occultation of Regulus by the Moon.
- Mercury and Uranus close.
- Comet C/2015 V2 (Johnson) at 7th magnitude.

CONSTELLATIONS

May evenings put on a magnificent display of the far southern Milky Way. Crossing the meridian is the Southern Cross with Musca below, which along with Triangulum Australe (to its left or east) and the Carinae diamond cross (to the right or west) are the closest obvious Milky Way asterisms to the South Celestial Pole, coming within 20 degrees (All Sky Map 1). This is a view certainly envied by Northern Hemisphere astronomers that have been fortunate to make the pilgrimage down under. The galactic hub is rising in the east, with our galaxy flowing through the Pointers, Crux and into the naked eye brilliance of the Eta Carinae region, still high in the southwest.

What a feast is on offer this time of the year! The Milky Way environ mentioned above is a smorgasbord of bright/dark nebulae and open/globular clusters, but as they say in the classics, there's more! The northern sky presents a complete contrast. Here you are looking out and above (north) of the plane of our galaxy as you enter the realm of the galaxies. Only 10° east (right) of the star Beta Leonis or Denebola (from an abbreviated Arabic phrase meaning 'tail of the Lion') lies the centre of the Virgo super cluster of galaxies (All Sky Maps 6 and 7). This swarm, straddling the constellations of Virgo and Coma Berenices, contains hundreds of galaxies visible

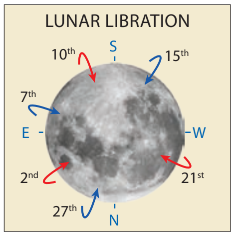


through amateur telescopes. This cluster is so far out of the plane of the Milky Way that Coma Berenices is home to the northern galactic pole (90 degrees from the galactic equator).

There is also great variety and extremes such as the cluster's largest member M87, a giant elliptical with a mass that exceeds the Milky Way and Andromeda combined! Following Markarian's chain of galaxies can be fun, especially viewing the pair of bright elliptical galaxies M84 and M86. In the southern extreme of Virgo is M104, the Sombrero Galaxy which looks, through small telescopes, just like the images with the dark equatorial band standing out.

The nearby constellation of Leo shouldn't be overlooked with 'must sees' as well, such as its famous triplet (M65, M66 and NGC 3627) and the pair of M95 and M96—All Sky Map 5.

THE MOON



2nd 1 am (11 pm previous day WST) Maximum Libration (7.1°), bright NE limb. The 129 km crater Endymion with its dark lava filled floor seen to best advantage.

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

4th 8 pm (6 pm WST) Occultation of Regulus by the Moon, visible from Australia and New Zealand (see Sky View). From eastern and central Australia Regulus disappears behind the dark limb of the 9-day old Moon and reappears from the bright limb around 1 hour 20 minutes later. From Perth the disappearance occurs before sunset with reappearance in twilight. Darwin sees the disappearance at sunset reappearing after the end of twilight (see pp. 103–106).

7th 1 am (11 pm previous day WST) Minimum Libration (6.5°), bright SE limb.

10th 1 pm (11 am WST) Maximum Libration (6.7°), bright SE limb. Too close to Full Moon.

11th 8 am (6 am WST) Full Moon.

13th 6 am (4 am WST) Moon at apogee (furthest from Earth at 406,210 km).

15th 2 am (midnight previous day WST) Minimum Libration (6.2°), bright SW limb.

19th 11 am (9 am WST) Last Quarter.

20th 4 pm (2 pm WST) Occultation of Neptune by the Moon, visible from S part of Africa, Madagascar and Maldives.

21st 10 pm (8 pm WST) Maximum Libration (8.3°), bright NW limb. Craters along the north western shores of Oceanus Procellarum brought into prominence.

26th 6 am (4 am WST) New Moon.

26th 11 am (9 am WST) Moon at perigee (closest to Earth at 357,207 km).

27th 1 pm (11 am WST) Minimum Libration (6.2°), bright NE limb.

MAY

Twilight

Unless you are an amateur astronomer or a keen photographer the mention of *twilight* would probably invoke thoughts of the popular novel series by Stephenie Meyer or of the films based upon her books. In fact, when you Google *twilight*, you get millions of hits and you need to sort through about 15 pages before you come to a definition of the time of day between daylight and total darkness, and vice-versa.

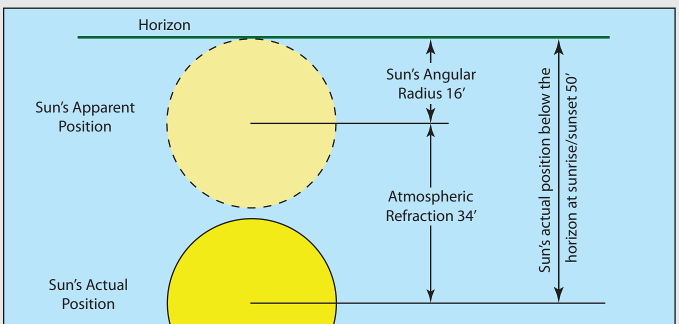


Figure 1: Sunrise/sunset is calculated when the upper limb of the Sun is coincident with the theoretical horizon.

So what is twilight? Simply put, twilight is the time between day and night when the Sun is below the horizon but it is neither completely light nor totally dark. Sunlight passing through the upper atmosphere is scattered and reflected which in turn illuminates the lower atmosphere—on a planet or moon without an atmosphere there can be no period of twilight.

Perhaps the most graphic example of twilight is shown in the image taken from the International Space Station in 2001 from an altitude of 391 km (see image next page). In this exquisite view of our planet, the terminator can be seen not as a sharp defined boundary between night and day, but as a gradual transition that is twilight. Note also the reddened cloud tops as sunlight is filtered through the dusty troposphere—down below on Earth a beautiful sunset is happening.

For simplicity, the following are for evening twilight, after sunset. The order should be reversed for morning sunrise. Firstly the time of sunset is calculated when the upper limb of the Sun's disc is coincident with the theoretical horizon. Taking into account the average amount of atmospheric refraction at the horizon (34 arcminutes) and apparent radius of the Sun (16 arcminutes), a figure of 50 arcminutes is obtained which is equivalent to 90.83° from the zenith (figure 1).

The state of the atmosphere, local weather conditions and an observer's geographic location can affect the length of twilight. That said, twilight has been categorised into three

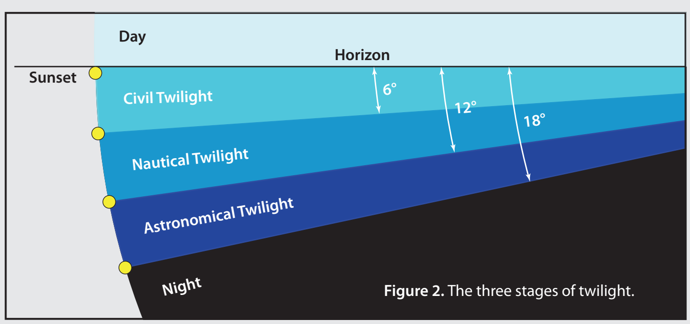


Figure 2. The three stages of twilight.

… continued next page.

THE PLANETS

Mercury, in the eastern sky, is at its best for morning observation this month as it reaches its greatest western elongation (26°) from the Sun on the 18th. With the angle of the ecliptic (plane of the planetary orbits) near perpendicular to the horizon, the planet is mostly visible in a dark sky for the entire month. On the 24th, the 27-day old waning crescent Moon appears a few degrees directly above Mercury (see Sky View). On the 1st, Mercury and Uranus will be just under 1° apart. You will need a telescope with low magnification and a low eastern horizon to see the pair before the sky brightens.

Venus wanders through Pisces in the eastern morning sky—rising around 3 am it is visible well before the beginning of civil dawn. The planet shares the constellation of The Fish with both Uranus and Mercury for the first half of the month (Mercury then moves into Cetus). On the 23rd, the 26-day old waning crescent Moon appears near the brilliant planet (see Sky View).

Mars continues its journey through Taurus this month, albeit low to the western evening horizon and only visible for a short period after the end of civil twilight.

Jupiter is visible in the eastern sky as twilight ends and is ideally positioned for evening viewing as it continues its western retrograde travel through Virgo. Now past opposition the gas giant's brightness begins to decrease slightly as too does its size, however, the planet is always a delight to observe. Well-suited for small telescopes at any time is the daily dance of its four major moons, their continuous motion provides a renewed and different view every time they are observed (see Sky View for some interesting configurations during the month). Watch as the Galilean satellites (Io, Europa, Ganymede and Callisto) undergo transits and shadow transits of the planet, occultations and eclipses. Predictions for these moon events can be found in Part II. On the 7th and 8th, the 12 to 13-day old waxing gibbous Moon will be near Jupiter—not real close, but nonetheless it's always an attractive sight when a bright planet is in the vicinity of our satellite (see Sky View).

Saturn rises in the east soon after the end of astronomical twilight. The planet moves from Sagittarius back into Ophiuchus in the second half of the month, where it remains until mid-November when it again visits the constellation of the Archer. With the planet approaching opposition in mid-

stages that are determined by how far below the horizon the Sun is (figure 2).

Civil twilight begins at sunset and ends when the Sun's centre is 6° below the horizon. At this time (assuming good weather conditions) the horizon is clearly defined and the brightest stars and planets are visible. At the end of civil twilight artificial illumination is usually required to carry on ordinary outdoor activities. A favourite time for landscape photographers when the lighting is soft, diffused and warm is the *golden hour* that begins just prior to sunset and the *blue hour* that overlaps with civil twilight.

Nautical Twilight begins at the end of civil twilight and ends when the centre of the Sun is 12° below the horizon. At the beginning of nautical twilight, general outlines of terrestrial objects are discernible, but outdoor operations are not possible without artificial lighting. The horizon is still visible allowing mariners to make reliable star sights for navigational purposes.

The final stage, **Astronomical Twilight**, begins at the end of nautical twilight and ends when the centre of the Sun is 18° below the horizon. During this time the illumination from scattered sunlight is less than that from starlight and other natural sources and the faintest stars (around 6th magnitude) are visible. The imaging purist may well wait until the end of astronomical twilight to begin their activities. In general through, many dimmer objects like nebulae and galaxies will be visible during the whole period of astronomical twilight.

There is no set rule when an amateur should begin observations, obviously the Moon, planets, double stars and bright star clusters can be viewed earlier than fainter deep sky objects. From the equatorial regions where the Sun sets near perpendicular to the horizon rather than at an angle the sky darkens the quickest. As you move to higher latitudes the process is slower, until you reach the polar circles where twilight can last for weeks.

Twilight image from the international space station. ISS nadir point: 47.5° S, 151.8° E (south of Hobart) Spacecraft Altitude: 211 nautical miles (391 km). Date taken 17 June 2001

http://eol.jsc.nasa.gov/DatabaseImages/ESC/large/ISS002/ISS002-E-7377.JPG

June, it's time to devote some telescope time to the *jewel* of the Solar System. The Saturnian moons are fun to track down and identify. The brightest and largest, Titan, can be seen in binoculars at 8.5 magnitude. Titan ranks as the second largest moon in the Solar System after Jupiter's Ganymede and is the only one with a substantial atmosphere. Four other moons, Enceladus, Tethys, Dione and Rhea can be seen in small telescopes but can be tricky to locate as they are scattered around the planet when the rings are open, unlike the neat orderly shuffling of Jupiter's Galilean moons. On the 13th, the 17-day old waning gibbous Moon is near the ringed planet (see Sky View).

Uranus returns to the eastern morning dawn sky in Pisces after its solar conjunction last month. An encounter with the innermost planet occurs on the 1st (see Mercury).

Neptune, in Aquarius, is only visible in the morning eastern sky, rising around 1 am midmonth. For the next three months, Neptune will be within 0.2° of the 6th magnitude star 81 Aquarii.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto, in Sagittarius, rises around 8:30 pm midmonth in the eastern evening sky.

Minor Planets. Four of the brighter minor planets reach opposition this month in Libra, 30 Urania on 6th at magnitude 11.0, 52 Europa on 12th at magnitude 10.9, 80 Sappho on 13th at magnitude 11.0 and 196 Philomela on 16th at magnitude 10.7. Two are in Scorpius, 27 Euterpe on 25th at magnitude 10.4 and 94 Aurora on 29th at magnitude 12.5. Others at opposition include 97 Klotho on 9th at magnitude 12.4 in Serpens and 115 Thyra on 9th at magnitude 11.6 in Centaurus.

COMETS

Comet C/2015 ER_{61} (PANSTARRS) reaches perihelion this month on the 10th and should be shining at around 9th magnitude. Rising approximately three hours before dawn, PANSTARRS will be found in Pisces throughout the month.

Comet C/2015 V2 (Johnson) is rising mid-evening as May opens. Shining at 7th magnitude, the comet spends the first two days in Hercules before moving into Bootes where it remains for the remainder of May. By month's end Johnson is rising around sunset.

Comet 41P/Tuttle-Giacobini-Kresak may become easier to observe this month as it moves south. Rising around the middle of the night initially and earlier as May progresses, the comet is expected to fade from 6th to 8th magnitude by month's end, but each night will see it reaching a higher altitude above the northern horizon as it moves through Hercules.

Comet 71P/Clark is rising early in the evening at May begins. Located in Ophiuchus until it moves into Scorpius in the second half of the month, it is expected to brighten from 10th to 9th magnitude during the month.

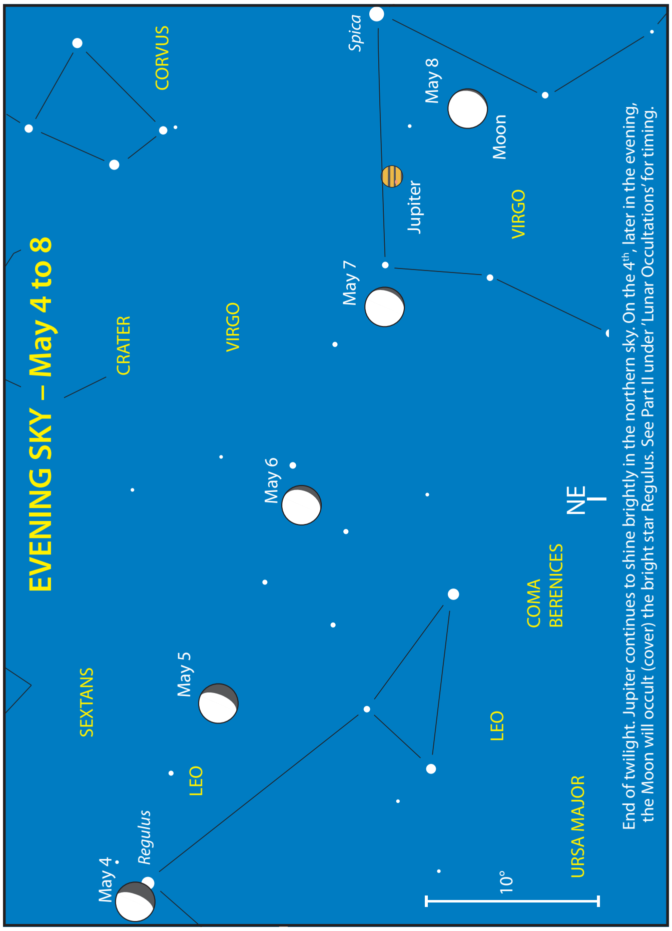
METEOR SHOWERS

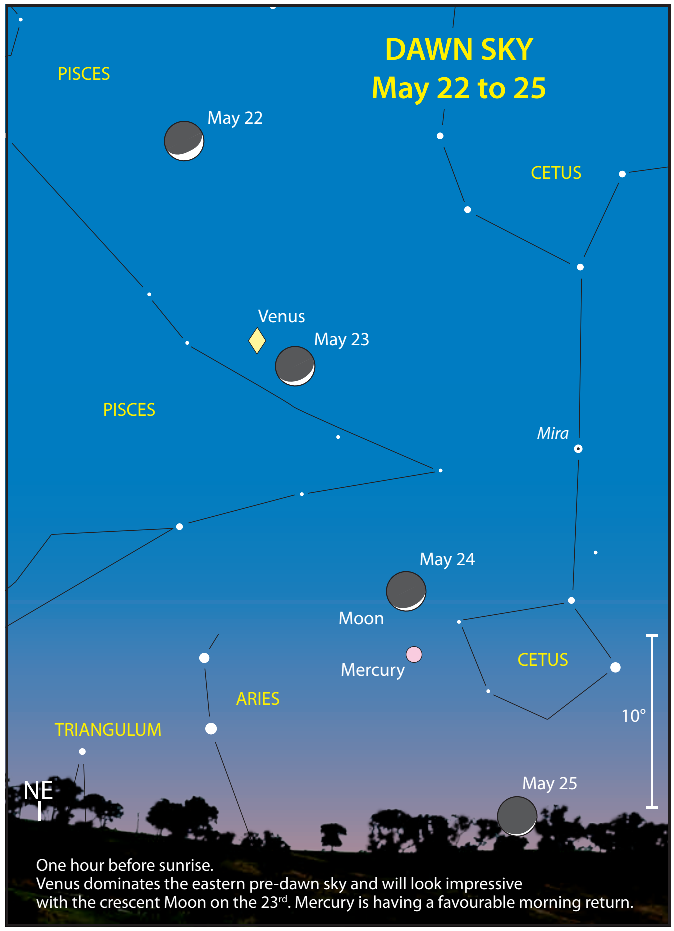
The **eta-Aquarids** are linked with Halley's Comet and rank as one of the most popular of the Southern Hemisphere showers. They are visible for a few hours before dawn, from 19 April to 28 May. The peak is around 6 May, but the rate can be above 30 over much of the period. The zenith hourly rate will often reach 70 or more meteors per hour (95 in 1975 and 110 in 1980). The Eta Aquarids are characterised by their high percentage of persistent trains. They are very swift and are a striking yellow colour. Early morning observers can enjoy Moon free skies up to the peak, but there will be lunar interference in the later half of the period of activity.

DOUBLE STARS

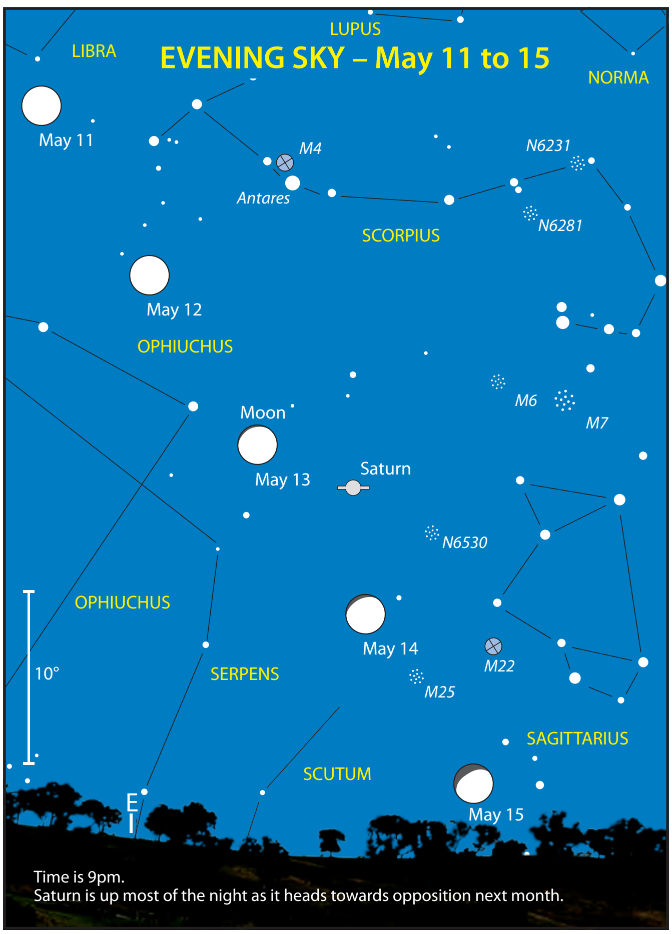
Xi Lupi (All Sky Map 6) is an excellent pair for small aperture telescopes. This is a slightly unequal pair of yellowish stars, magnitudes 5.1 and 5.6, separated by 10.2 arcseconds. Also, look for the fainter pair of stars (B1312, magnitudes 8.9 and 10.1) with similar position angle about 5 arcminutes away. For those with larger telescopes and an OIII filter have a look for the nearby planetary nebula NGC 6026.

DIARY			
Tue	2nd	Midnight	(10 pm WST) Mercury stationary
Tue	2nd	6 am	(4 am WST) star Pollux 10° N of Moon
Wed	3rd	12:47 pm	(10:47 am WST) First Quarter Moon
Thu	4th	8 pm	(6 pm WST) star Regulus 0.5° N of Moon
Thu	4th	pm	m.p. 14 Irene 0.2°SW of star Zeta Leonis
Sat	6th		Mercury at aphelion
Sun	7th	5 pm	(3 pm WST) star Aldebaran 6° S of Mars
Mon	8th		m.p. 3 Juno stationary
Mon	8th	am	Comet 41P/Tuttle-Giacobini-Kresak 1.5°NE of star Theta Herculis
Mon	8th	7 am	(5 am WST) Jupiter 2° S of Moon
Mon	8th	9 am	(7 am WST) Uranus 2° N of Mercury
Mon	8th	11 pm	(9 pm WST) star Spica 6° S of Moon
Tue	9th		m.p. 14 Irene 0.8°NE of NGC 3193 (G) in Leo
Tue	9th		Venus at descending node
Thu	11th	7:42 am	(5:42 am WST) Full Moon (404,917 km)
Fri	12th	5 am	(3 am WST) Venus 0.2°SW of NGC 128 (G) in Pisces
Fri	12th	8 pm	(6 pm WST) star Antares 10° S of Moon
Sat	13th	6 am	(4 am WST) Moon at apogee, 406,210 km
Sun	14th	9 am	(7 am WST) Saturn 3° S of Moon
Tue	16th		m.p. 9 Metis 0.6°SW of NGC 3239 (G) in Leo
Tue	16th	7 am	(5 am WST) d.p. Pluto 2° S of Moon
Wed	17th		Mars 0.3°SE of NGC 1746 (OC) in Taurus
Thu	18th	am	Comet 41P/Tuttle-Giacobini-Kresak 1.2°E of star Omicron Herculis
Thu	18th	9 am	(7 am WST) Mercury at greatest elongation West (25.8°)
Fri	19th	10:33 am	(8:33 am WST) Last Quarter Moon
Fri	19th	pm	m.p. 12 Victoria 0.5°W of NGC 5077 (G) in Virgo
Fri	19th	pm	Comet C/2015 V2 (Johnson) 1.0° NW of star Delta Bootis
Sat	20th	4 pm	(2 pm WST) Neptune 0.5° N of Moon
Mon	22nd		Neptune 0.2°SE of star 81 Aquarii
Mon	22nd	11 pm	(9 pm WST) Venus 2° N of Moon
Tue	23rd	6 am	(4 am WST) m.p. 2 Pallas 3° S of Moon
Tue	23rd	3 pm	(1 pm WST) Uranus 4° N of Moon
Wed	24th	11 am	(9 am WST) Mercury 1.6° N of Moon
Thu	25th	pm	Comet C/2015 V2 (Johnson) 1.6°SE of star Epsilon Bootis
Fri	26th		Mercury at greatest latitude south
Fri	26th	5:44 am	(3:44 am WST) New Moon
Fri	26th	11 am	(9 am WST) Moon at perigee, 357,207 km
Sat	27th	Noon	(10 am WST) Mars 5° N of Moon
Mon	29th	2 pm	(Noon WST) star Pollux 10° N of Moon
Tue	30th	11 pm	(9 pm WST) m.p. 6 Hebe 0.05°NW of star Zeta Serpentis
Wed	31st	am	m.p. 3 Juno 0.6°SW of star Lambda Aquilae





Approximate local standard time.



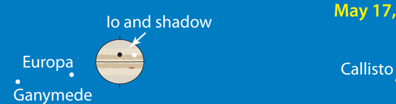
Jupiter's Satellites for May

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.

May 6, 9:30 pm EST (7:30 pm WST)

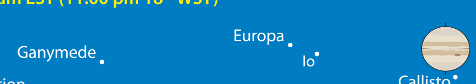
Ganymede's shadow will egress over the next hour, followed by Europa being occulted with an eclipse reappearance in the morning suiting WA observers.

May 17, 8:20 pm EST (6:20 pm WST)



Europa has just reappeared from eclipse and Io is about to egress from its transit.

May 19, 1:00 am EST (11:00 pm 18th WST)

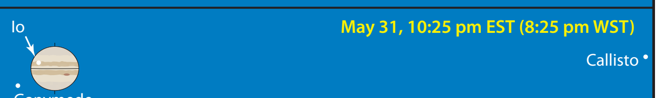


Nice configuration.
Callisto has no eclipses, occultations or transits during 2017, passing over the north and south poles when in conjunction.

May 24, 9:00 pm EST (7:00 pm WST)

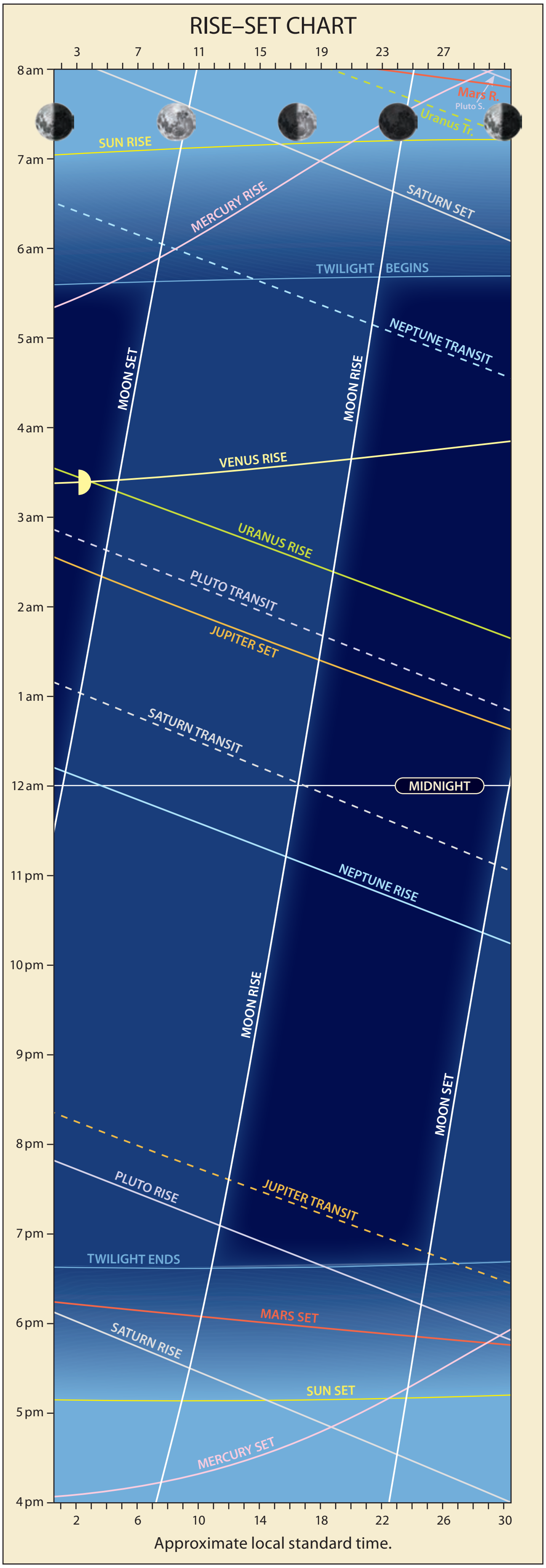
A busy evening.
Ganymede is currently reappearing from eclipse with Europa to do the same in about 90 minutes. Io will egress from transit later in the evening.

May 31, 10:25 pm EST (8:25 pm WST)



Io has commenced a transit just as Ganymede is about to disappear into eclipse. Europa is currently behind Jupiter. Later in the night Ganymede and then Europa will reappear from eclipse.

JUNE



HIGHLIGHTS

- Venus and Uranus close.
- Venus and Moon close.
- Saturn at opposition.
- Comet C/2015 V2 (Johnson) still near maximum brightness.

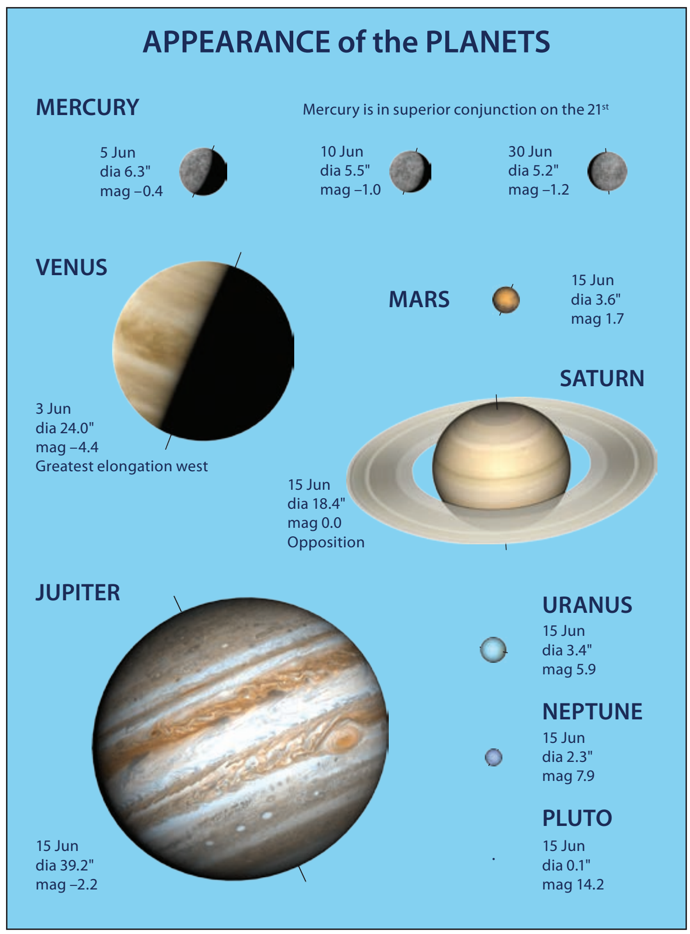
CONSTELLATIONS

High in the evening sky lies Scorpius the Scorpion (All Sky Map 6). It has the distinction of being one of a few constellations that actually resembles the object it represents.

Up until the first century BC the Greek-defined constellation of Scorpius was much larger than we know today. It not only had its obvious tail and body (the modern version) but also claws. The Romans then carved off the claws creating Libra the Scales. This is just as well for without this division there might have been only eleven signs of the Zodiac—twelve was good, for the signs divided nicely into 30 degree wide segments of the sky (2 hours in RA). Yes, the writers acknowledge that the Sun also spends time in Ophiuchus but a number of sources couldn't agree on a reason for its exclusion.

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

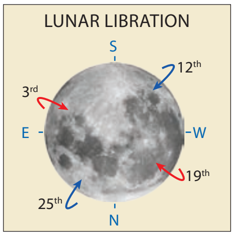
Returning to Scorpius, despite its obvious shape, not all cultures made the scorpion connection. The Chinese had



JUNE

a number of associations related to dragons. The four stars we know as the head (Beta, Delta, Pi and Rho) marked the stomach of the 'Blue Dragon' and Antares was called Huo, its heart. If you start at Epsilon Scorpii, the stars that sweep around to the stinger were known as Wei, the Chinese constellation of the dragon's tail.

THE MOON



1^{st} 3 am (1 am WST) Occultation of Regulus by the Moon, visible from E Brazil, Central and S Africa and Mauritius.

1^{st} 11 pm (9 pm WST) First Quarter.

3^{rd} 2 am (midnight previous day WST) Maximum Libration (7.6°), bright SE limb. Libration features along the bright limb brought into view such as the walled plain Hecataeus.

9^{th} 8 am (6 am WST) Moon at apogee (furthest from Earth at 406,401 km).

9^{th} 11 pm (9 pm WST) Full Moon.

12^{th} Noon (10 am WST) Minimum Libration (5.5°), bright SW limb.

16^{th} 11 pm (9 pm WST) Occultation of Neptune by the Moon, visible from W Antarctica and S half of South America.

17^{th} 10 pm (8 pm WST) Last Quarter.

19^{th} 9 am (7 am WST) Maximum Libration (8.6°), bright NW limb. Features around the western edge of Sinus Roris at their best, including the 70 km complex of lunar domes known as Mons Rumker.

23^{rd} 1 am (11 pm previous day WST) Occultation of Aldebaran by the Moon, visible from most of N America, most of Europe and NW part of Africa.

23^{rd} 9 pm (7 pm WST) Moon at perigee (closest to Earth at 357,937 km).

24^{th} 1 pm (11 am WST) New Moon.

25^{th} 6 am (4 am WST) Minimum Libration (5.4°), too close to New Moon.

28^{th} 11 am (9 am WST) Occultation of Regulus by the Moon, visible from Micronesia, Hawaii, Galapagos Is, Peru and Ecuador.

THE PLANETS

Mercury begins the month rising almost two hours ahead of the Sun in the eastern morning sky. The planet then rapidly moves toward the Sun and superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 21^{st}, returning to the western evening twilight in July.

Venus remains a brilliant beacon in the predawn eastern sky, travelling through Pisces, Aries and into Taurus over the course of the month. On the 3^{rd} and 4^{th} Venus will be a little less than 2° from the green ice giant Uranus—binoculars will easily show the fainter planet even under light polluted skies. On the 3^{rd}, Venus reaches its greatest elongation west of the Sun (46°). On the 21^{st}, the 26-day old waning crescent Moon will be around 2° from Venus, providing a pleasant sight in the morning sky (see Sky View).

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

Mars is only visible low in the western evening sky for a short period after the end of civil twilight early in the month. By the second week of June the planet will be close to the Sun and difficult to observe. The Red Planet is next seen in the morning sky in September.

Jupiter transits the meridian (is due north) around 7 pm midmonth in Virgo. On the 10^{th}, the planet appears stationary as it comes to the end of four months of retrograde motion; thereafter the planet moves from west to east across the sky instead of appearing to move backwards! On the 4^{th}, the 10-day old waxing gibbous Moon appears near the planet (see Sky View).

Saturn, in Ophiuchus, is at opposition on the 15^{th}, and can be seen low in the eastern evening sky after the end of astronomical twilight (see Sky View). A quick look through a telescope reveals why the 6^{th} planet from the Sun is called *The Jewel of the Solar System*—many amateur astronomers will tell you that it was that first glimpse of this globe with its majestic rings that got them hooked on astronomy. This year the planet's splendid ring system is at its widest as seen from Earth, exposing their northern side to the fullest (27°).

Large telescopes are not required to view this strikingly beautiful planet, and instruments in the 50 to 100 mm range will enable you to see the rings and the dark gap known as the Cassini Division. Moving to 150 mm and larger telescopes will reveal the Encke Gap in the outermost ring and the inner translucent Crepe Ring.

On the planet itself, all that most telescopes will reveal is the light coloured band around the equator, and a noticeable darkening and flattening at the poles.

Normally Saturn's ring system will be seen to be of similar brightness to the planet itself, however, around opposition time the planet's rings can brighten considerably. Known as the *opposition surge* or *Seeliger Effect* it occurs as the Sun illuminates the rings from directly behind us. Shadows projected from lumps and irregularities in the ring system will be hidden behind these particles—without shadows to darken the overall view, the rings surge dramatically in brightness.

Uranus, in the predawn eastern sky, has an encounter with the brightest planet (see Venus). If using binoculars to pick up Uranus, do not confuse the brighter 4^{th} magnitude Omicron Piscium with the planet. The finder chart in Part II will help confirm the star. For the next four months, the planet will be approximately 1° from Omicron.

Neptune rises around 11 pm in the evening eastern sky in Aquarius midmonth. The planet appears stationary on the 17^{th}, and thereafter will be in retrograde motion until late November.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto, in Sagittarius, rises at the end of astronomical dusk mid-June and is at opposition next month.

Minor Planets. Three of the brighter minor planets reach opposition this month in Sagittarius. They are: 346 Hermentaria on 21^{st} at magnitude 10.8, 40 Harmonia on 23^{rd}

at magnitude 9.3 and 10 Hygiea on 29th at magnitude 9.1. There are two in Ophiuchus, 389 Industria on 7th at 11.1 and 6 Hebe on 17th at magnitude 9.2. Others at opposition include 37 Fides on 2nd at magnitude 11.5 in Scorpius, 28 Bellona on 21st at magnitude 11.5 in Serpens and 324 Bamberga on 23rd at magnitude 10.3 in Crater.

The next four months will see 10 Hygiea visit a number of deep sky objects in Sagittarius, including a close approach to the globular M22 this month on 27th (see diary). Also in Sagittarius in June is 40 Harmonia while near opposition at 9th magnitude calls on a number of objects in the later half of the month, including going between the Trifid and Lagoon nebulae on 28th. Irene has spent all of 2017 so far in Leo. On 25th this month it passes the bright galaxy pair M65/66.

COMETS

Comet C/2015 ER$_{61}$ (PANSTARRS) spends the first half of June in Pisces before moving into Aries. Expected to fade from 9th to 10th magnitude, PANSTARRS is rising around 3 am.

Comet C/2015 V2 (Johnson) is visible throughout the night until shortly before dawn. Shining at 7th magnitude, the comet begins June in Bootes, moving into Virgo midmonth.

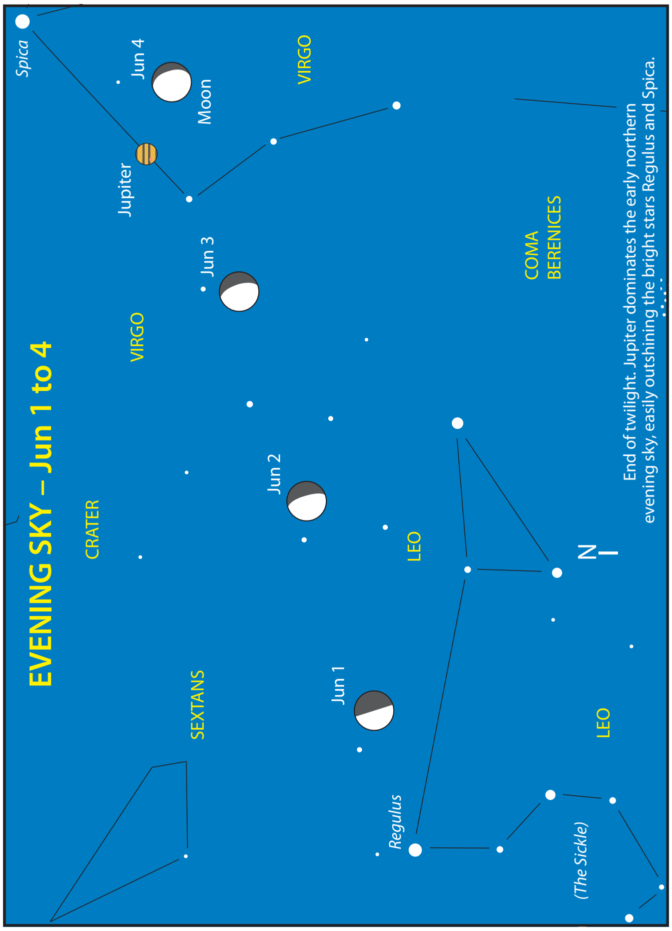
Comet 41P/Tuttle-Giacobini-Kresak begins June in Hercules and could be 8th magnitude in brightness. Rising early in the evening, the comet quickly travels into Ophiuchus where it remains until moving into Serpens in late June. By month's end, it should have faded to 11th magnitude. On the night of 21st TGK has a close approach to the double star 70 Ophiuchi and then on 26th passes the globular star cluster NGC 6535 in Serpens (see diary).

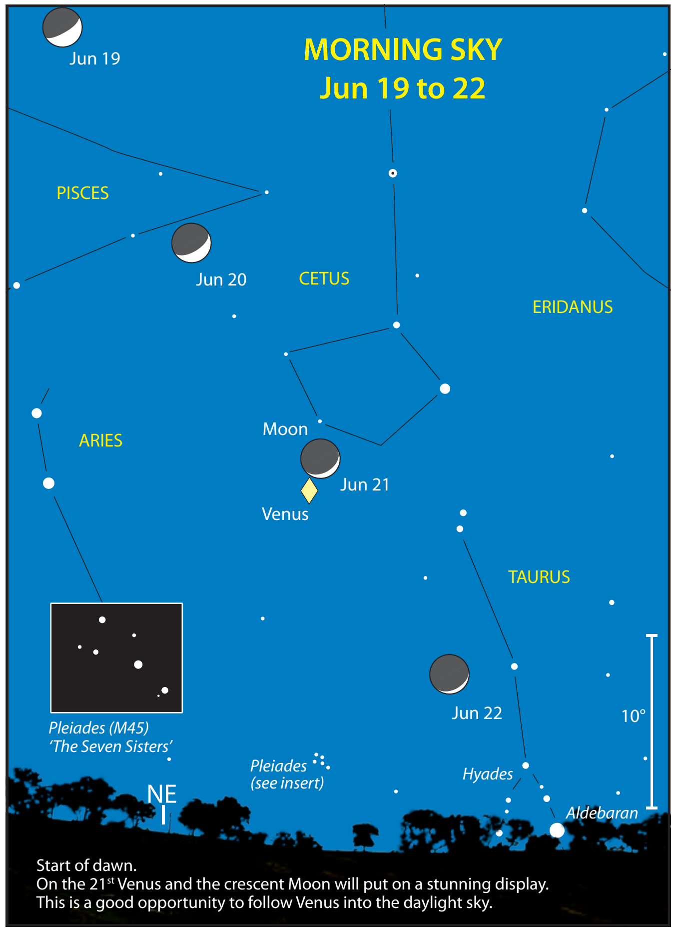
Comet 71P/Clark will be in Scorpius for all of June. The comet is visible the whole night, transiting in the late evening and should remain around 9th magnitude in brightness.

DOUBLE STARS

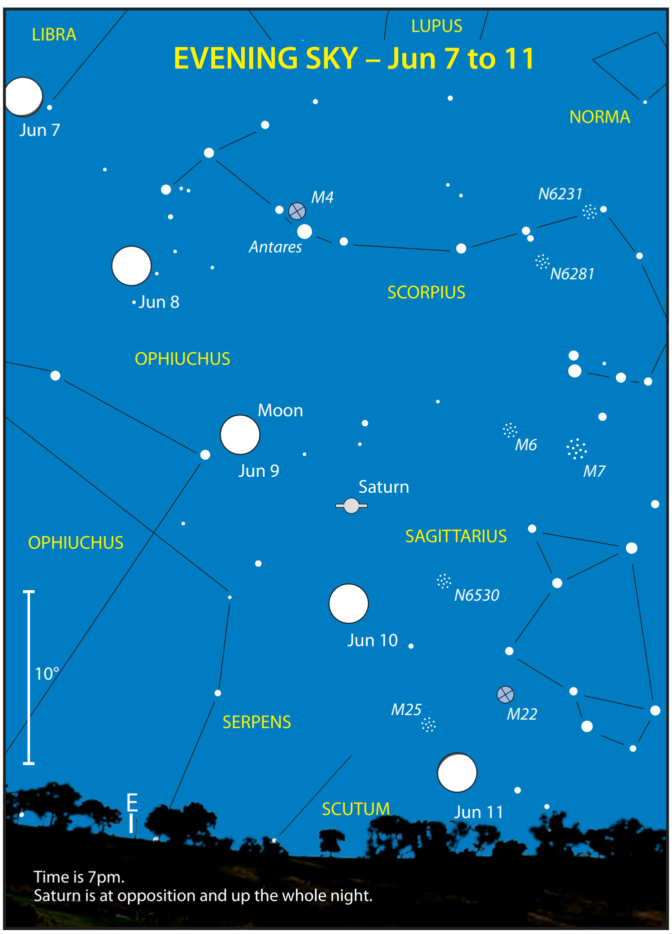
Norma, the Carpenter's Square, is a small constellation nestled between Scorpius, Lupus and Ara. It is home to **Epsilon Normae** (All Sky Map 6), a fine wide unequal double star, magnitudes 4.5 and 6.1 separated by 22.8 arcseconds. The pair is set in a fine field sprinkled with fainter stars. They are yellowish and bluish by contrast and there has been only slight change in relative positions since the measures of John Herschel in 1835.

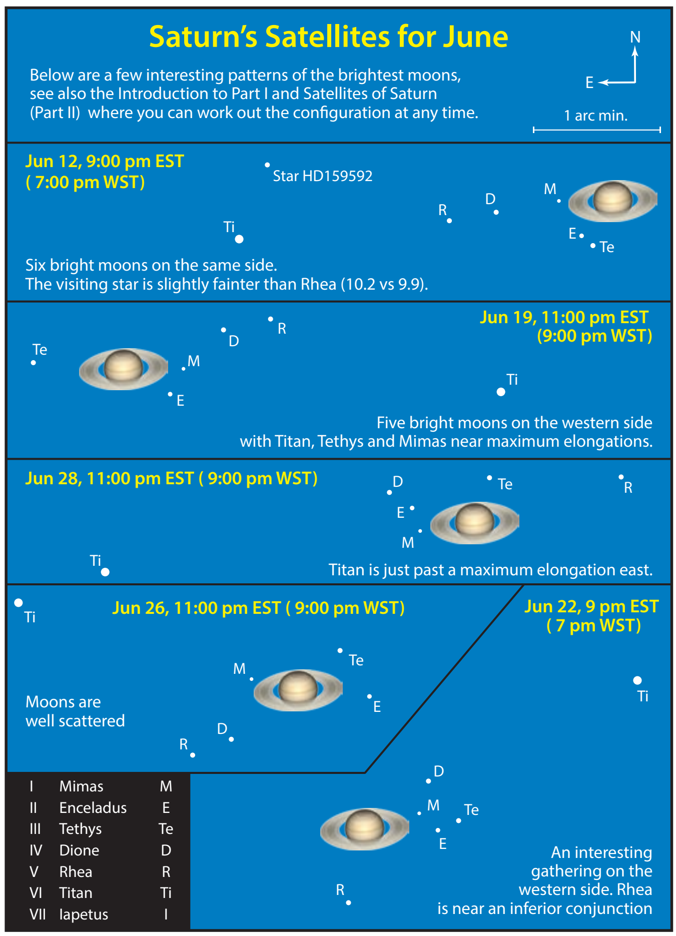
DIARY			
Thu	1st	3 am	(1 am WST) star Regulus 0.3° N of Moon
Thu	1st	10:42 pm	(8:42 pm WST) First Quarter Moon
Fri	2nd	pm	Comet 71P/Clark 2.0°SE of star Antares
Sat	3rd		m.p. 89 Julia 1.0°NW of star Lambda Aquarii
Sat	3rd	1 am	(11 pm WST, prev day) Uranus 1.8° N of Venus
Sat	3rd	10 pm	(8 pm WST) Venus at greatest elongation West (45.9°)
Sun	4th		m.p. 9 Metis 0.3°N of NGC 3338 (G) in Leo
Sun	4th		m.p. 41 Daphne 0.3°NE of star Iota Leonis
Sun	4th		Comet C/2015 V2 (Johnson) 5°E of star Arcturus
Sun	4th	10 am	(8 am WST) Jupiter 2° S of Moon
Sun	4th	11 pm	(9 pm WST) Comet 71P/Clark 0.1°N of star Tau Scorpii
Mon	5th	4 am	(2 am WST) star Spica 7° S of Moon
Tue	6th		Jupiter 0.7°SE of NGC 4691 (G) in Virgo
Tue	6th	10 am	(8 am WST) d.p. 1 Ceres in conjunction with Sun
Tue	6th	pm	m.p. 29 Amphitrite 0.5°NE of NGC 3423 (G) in Sextans
Thu	8th		m.p. 9 Metis 0.3°S of NGC 3367 (G) in Leo
Fri	9th		Comet C/2015 V2 (Johnson) 2.6°W of star Zeta Bootis
Fri	9th	2 am	(Midnight WST, prev day) star Antares 10° S of Moon
Fri	9th	8 am	(6 am WST) Moon at apogee, 406,401 km
Fri	9th	11:10 pm	(9:10 pm WST) Full Moon (406,272 km, furthest for this year)
Sat	10th	11 am	(9 am WST) Saturn 3° S of Moon
Sat	10th	3 pm	(1 pm WST) Jupiter stationary
Sat	10th	pm	Comet 41P/Tuttle-Giacobini-Kresak 0.8°E of star 72 Ophiuchi
Sun	11th		Venus 0.8°SE of NGC 821 (G) in Aries
Sun	11th		m.p. 9 Metis 0.6°NE of M105 (EG) in Leo
Sun	11th		m.p. 9 Metis 0.5°SW of NGC 3412 (G) in Leo
Sun	11th		Comet C/2015 ER$_{61}$ (PANSTARRS) 0.6°S of star Eta Piscium
Mon	12th		Venus at aphelion
Mon	12th	Noon	(10 am WST) d.p. Pluto 2° S of Moon
Tue	13th		Comet C/2015 ER$_{61}$ (PANSTARRS) 0.5°S of M74 (SG) in Pisces
Wed	14th		Mercury at ascending node
Wed	14th	pm	Comet 41P/Tuttle-Giacobini-Kresak 0.7°W of NGC 6572 (PN) in Ophiuchus
Thu	15th	8 pm	(6 pm WST) Saturn at opposition
Fri	16th	11 pm	(9 pm WST) Neptune 0.7° N of Moon
Fri	16th	pm	m.p. 40 Harmonia 0.7°S of NGC 6583 (OC) in Sagittarius
Sat	17th	9 am	(7 am WST) Neptune stationary
Sat	17th	9:33 pm	(7:33 pm WST) Last Quarter Moon
Sat	17th	pm	Comet C/2015 V2 (Johnson) 0.6°N of NGC 5566 (G) in Virgo
Mon	19th		m.p. 14 Irene 0.9°SW of star Theta Leonis
Mon	19th		Mercury at perihelion
Tue	20th	2 am	(Midnight WST, prev day) Uranus 4° N of Moon
Tue	20th	7 am	(5 am WST) m.p. 2 Pallas 5° S of Moon
Tue	20th	pm	m.p. 3 Juno 0.4°N of NGC 6704 (OC) in Scutum
Wed	21st	Midnight	(10 pm WST) Mercury in superior conjunction
Wed	21st	7 am	(5 am WST) Venus 2° N of Moon
Wed	21st	2 pm	(Noon WST) Solstice
Wed	21st	11 pm	(9 pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.15°NE of star 70 Ophiuchi
Fri	23rd	1 am	(11 pm WST, prev day) star Aldebaran 0.5° S of Moon
Fri	23rd	9 pm	(7 pm WST) Moon at perigee, 357,937 km
Fri	23rd	pm	m.p. 6 Hebe 0.9°S of M14 (GC) in Ophiuchus
Sat	24th	12:31 pm	(10:31 am WST) New Moon
Sat	24th	pm	m.p. 3 Juno 0.1°SE of star Beta Scuti
Sat	24th	pm	m.p. 40 Harmonia 0.1°N of NGC 6546 (OC) in Sagittarius
Sun	25th	Midnight	(10 pm WST) star Pollux 9° N of Moon
Sun	25th		m.p. 14 Irene 0.2°S of NGC 3628 (G) in Leo
Sun	25th		m.p. 14 Irene 0.4°N of M66 (SG) in Leo
Sun	25th		m.p. 14 Irene 0.5°NE of M65 (SG) in Leo
Mon	26th	11 pm	(9 pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.1°E NGC 6535 (GC) in Serpens
Mon	26th	pm	m.p. 40 Harmonia 0.7°S of M21 (OC) in Sagittarius
Tue	27th	10 pm	(8 pm WST) m.p. 4 Vesta 5° N of Moon
Tue	27th	10 pm	(8 pm WST) m.p. 10 Hygiea 0.15°NE of M22 (GC) in Sagittarius
Tue	27th	pm	m.p. 40 Harmonia 1.0°N of M8 Lagoon Nebula (BN) in Sagittarius
Tue	27th	pm	Comet C/2015 V2 (Johnson) 0.4°W of star Iota Virginis
Wed	28th	11 am	(9 am WST) star Regulus 0.03° N of Moon
Wed	28th	pm	m.p. 40 Harmonia 0.3°S of M20 Trifid Nebula (BN) in Sagittarius
Thu	29th		Mercury at greatest latitude north





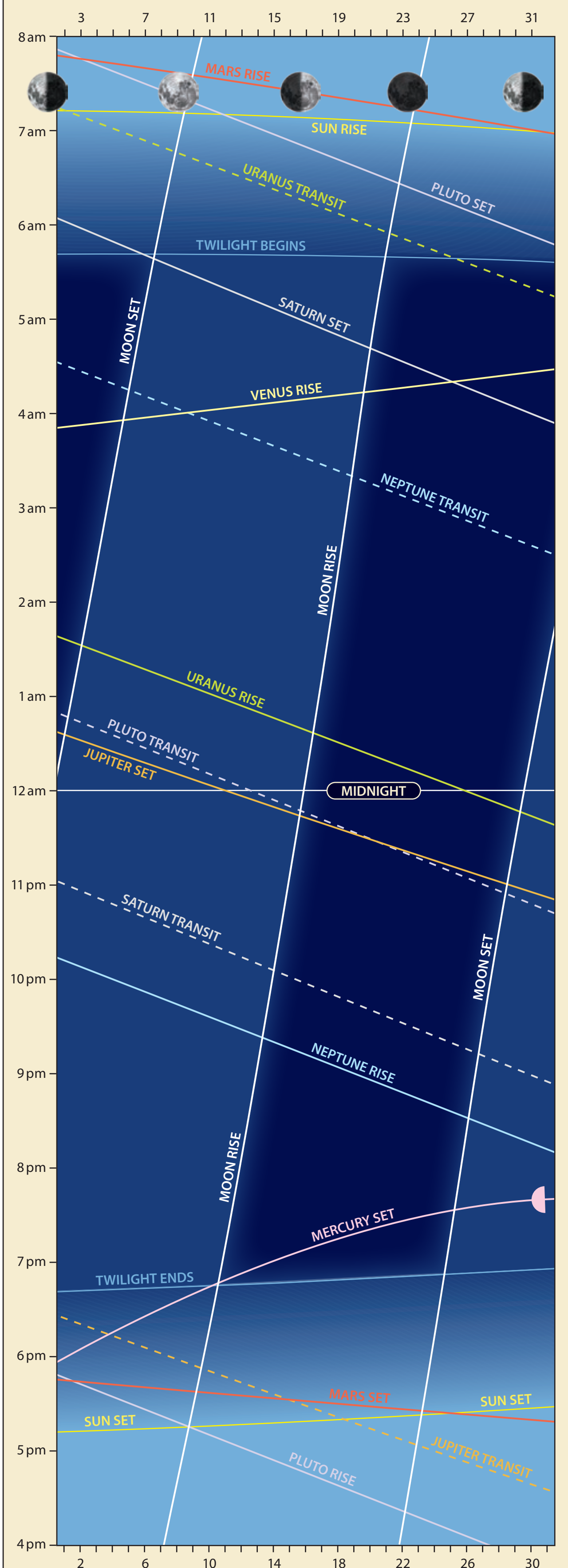
Approximate local standard time.





JULY

RISE–SET CHART



Approximate local standard time.

HIGHLIGHTS

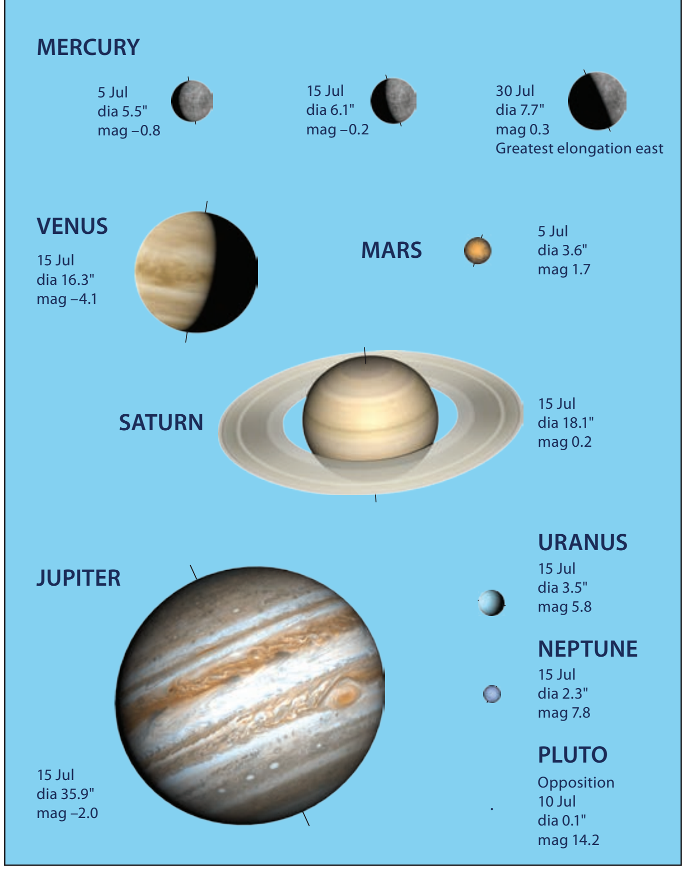
- Mercury at best in the evening sky.
- Mercury, Regulus and Moon close.
- Saturn ideally placed for observation.
- Neptune close to the Moon.
- Three meteor showers!

CONSTELLATIONS

The distinctive constellations of Scorpius and Sagittarius (All Sky Map 6) continue to ride high in July evenings, passing overhead for much of Australia. Nestled between these constellations lies the Galactic Centre. This also represents the centre of the magnificent central bulge in the Milky Way, called the hub. This is an interesting feature considering the bulk of the galaxy consists of a flattened disc. Go out and see how the milky region narrows, as you look westward towards Sirius. You will need to look early to catch this brightest star in the heavens for it is now out of season, setting in the twilight.

Being embedded in the plane of our galaxy, our view towards its centre is heavily obscured by massive dark clouds of gas and dust which can easily be seen with the naked eye under dark skies criss-crossing this 'milky river' as it flows through this region. Can you see the dark Pipe nebula, as in the smoking type? Its bowl is approximately halfway between the 'lid' star of Sagittarius's Teapot and the bright naked eye star Antares (Alpha Scorpii). The hub's generally broadened dark region also marks the body of the Australian aboriginal 'emu', a constellation made up entirely of dark nebulae (All Sky Maps 1 and 6). The lanes narrow down as they pass through Centaurus, forming the neck. Its head is the Coalsack on the

APPEARANCE of the PLANETS

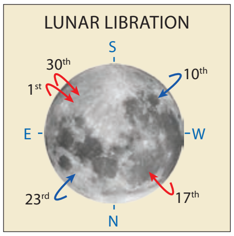


JULY

edge of the Southern Cross (Crux), which even has a beak and faint star for an eye! The complete animal is best recognised as it sits on the southeastern horizon in autumn evenings.

There is much more to the hub, with plentiful star-forming regions and star clusters visible. Sagittarius alone has numerous globular clusters, many making Messier's famous catalogue of bright deep sky objects. The glut of globulars is not surprising for unlike open star clusters, which reside in the plane of the galaxy, they congregate in a shell-like distribution around the galactic hub.

THE MOON



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

1st 6 pm (4 pm WST) Maximum Libration (8.2°), bright SE limb. Mare Australe and the walled plain of Lyot in the libration zone favoured.

6th 2 pm (noon WST) Moon at apogee (furthest from Earth at 405,934 km).

9th 2 pm (noon WST) Full Moon.

10th 2 pm (noon WST) Minimum Libration (4.7°), bright SW limb.

14th 4 am (2 am WST) Occultation of Neptune by the Moon, visible from most of Antarctica and New Zealand. From Australia Neptune appears close to the lunar limb (see Neptune on following page).

17th 5 am (3 am WST) Last Quarter.

17th 1 pm (11 am WST) Maximum Libration (8.4°), bright NW limb. Libration favours Crater Pythagoras with its lava filled flat floor with terraces and its double central mountain.

20th 10 am (8 am WST) Occultation of Aldebaran by the Moon, visible from India, Central and NE Asia and Hawaii.

22nd 3 am (1 am WST) Moon at perigee (closest to Earth at 361,236 km).

23rd 1 pm (11 am WST). Minimum Libration (4.4°), too close to New Moon.

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

25th 7 pm (5 pm WST) Occultation of Mercury by the Moon, visible from N Europe, British Isles, most of Greenland and N half of Asia.

25th 9 pm (7 pm WST) Occultation of Regulus by the Moon, visible from North half of Africa, Middle East, S India and Indonesia.

30th Midnight (10 pm WST) Maximum Libration (8.3°), bright SE limb. Mare Australe and the walled plain of Lyot in the libration zone favoured.

31st 1 am (11 pm previous day WST) First Quarter.

Bubble in Space

The object on the cover this year is NGC 7635, best known as the Bubble Nebula. This brilliant image was released to celebrate the 26th birthday of the Hubble Telescope. The nebula lies some 7,000 light years away in the constellation of Cassiopeia. This symmetrically shaped bubble is approximately 7 light years across. To help put this in perspective, this is nearly double the distance between the Sun and Alpha Centauri.

An 8.7 magnitude star, SAO 20575 (the bright star in the upper left quadrant) created the bubble. This is a rare, extremely hot, young star called a 'Wolf-Rayet' with only three hundred to date being found in the Milky Way. The initial material making up the bubble may have been created in a nova-type explosion and has since grown and expanded being fed by its intense relentless stellar wind. All this has happened in a brief life of only 20 million years. The bubble has ploughed into the surrounding nebulae forming a shock wave on the outer edge of the shell. The obvious question then is how do we see it? Now we find out just how incredible this star is. It is 45 times the mass and 15 times the diameter of the Sun. The star is spectral class O6.5 (see also discussions on pages 31 and 138) with a surface temperature of approximately 36,000K (where the Sun is a mere 5500K) and pumps out 400,000 times its luminosity! At this temperature much of this radiation is emitted in the UV part of the spectrum. This blast is so intense it causes not only the bubble to fluoresce but the surrounding gas as well. They are called emission nebulae. The colours indicate some of the elements present and their environment. The bubble's blue indicates it's hot enough to cause oxygen to emit light. More distant from the star, hence colder, nitrogen is seen as red and hydrogen, green. The pillars are yellow from a combination of elements.

There are different types of Wolf Rayet (WR) stars but they have much in common. Having used up the hydrogen in the core very early, WRs spend much of their lives burning helium and heavier elements. The stellar wind is so strong they can lose over two thirds of their total mass during their brief lives before going out as a supernova, quite a contrast to the mostly sedate 10 billion year life of our Sun (fortunately for us!). Good old Sol will definitely go out with a whimper rather than a bang.

The two brightest known WRs are conveniently placed in the southern sky with both easily accessible to small telescopes. The runner up is Theta Muscae on the edge of the Coalsack nebula. This is an impressive double star with components of magnitude 5.7 and 7.5 separated by a comfortable 5.4 arcseconds. The star of interest is the brighter primary one, consisting of a WR in a close orbit with an O6 type star only 0.5 au apart. There is a third companion, a blue supergiant star about 100 au away. All three are highly luminous, together expected to be around one million times the Sun!

And the winner is well known to the amateur community as a spectacular multiple star, not as the brightest WR known, Gamma Velorum. The bright, magnitude 1.8, Gamma 2 consists of a binary pair of supergiant stars, a blue (type O7) around 30 solar masses and a WR, which had commenced its life around 35 Sun masses but is now down to 9. They too are close with an orbital period of 78 days and an average separation of 1 au. At an approximate distance of 1,100 light years this WR is considered one of the closest supernova candidates in the sky. What a display that would be!

THE PLANETS

Mercury's best period for evening observation begins midmonth through mid-August, with the planet remaining well above the horizon after sunset. The planet's favourable apparitions are dependent on its angular distance from the Sun and the angle of the ecliptic relative to the horizon. If the angle is shallow, the planet remains in the bright twilight. When near vertical the planet can be observed in a dark sky when at its maximum angular distance from the Sun. On the evening of 10th this 'speedy messenger' is on the northern edge of the Beehive Cluster in Cancer. On the 25th and 26th Mercury will be just 1° from the 1st magnitude star Regulus (Alpha Leonis), the view enhanced on the 25th by the 2-day old Moon directly below the pair (see Sky View). On the 30th, the planet will be at its greatest elongation (27°) east of the Sun.

Venus spends the month cruising through Taurus in the eastern predawn sky. On the 13th, the planet will be 0.2° from Epsilon Tauri (Ain), the 4th magnitude star forming one of the Bull's eyes along with 1st magnitude Alpha Tauri (Aldebaran). At first glance, those used to the familiar look of the Hyades star cluster will be stunned to see the interloper seemingly replace and outshine its counterpart in this V-shaped asterism of stars representing the Bull's face. On the 21st, the 27-day old waning crescent Moon will be near the planet (see Sky View).

The **Earth** is at aphelion on the 4th, the furthest point in its orbit from the Sun (152,092,565 km or 1.016676 au distant).

Mars will be in conjunction with the Sun on the 27th and remains hidden from view until its reappearance in the morning eastern sky in mid-September.

Jupiter is visible in the northwestern sky in Virgo at the end of evening twilight and sets just before midnight. The planet has two lunar encounters this month, with the First Quarter Moon on the 1st (see Sky View) and on the 29th with a 6-day old waxing crescent, forming a triangle with the 1st magnitude star Spica (Alpha Virginis).

Saturn, now past opposition, transits the meridian around 10 pm midmonth—a great time to observe the ringed world while at maximum elevation above the horizon. The planet, located in Ophiuchus, continues its retrograde or east to west motion against the celestial sphere. Interestingly the term *retrograde* comes from the Latin word *retrogradus* or backward-step (see also explanation on p. 86). On the 7th, the 13-day old waxing gibbous Moon appears near Saturn (see Sky View).

Uranus rises around midnight midmonth and is situated in Pisces near the border with Aries. On the 9th the main belt asteroid (24) Themis sails past the planet at a distance of just 0.3°. Themis, one of the largest of the minor planets at approximately 200 km across, will be around 13th magnitude. Perhaps not that exciting, but of interest is the fact that NASA discovered the presence of water ice and organic compounds on Themis in 2009, using the 3-meter Infrared Telescope Facility at the Mauna Kea Observatory in Hawaii.

Neptune rises in the mid-evening eastern sky in Aquarius. On the 13th, the planet rises around 2° below the 19-day old waning gibbous Moon. As the night progresses the pair gradually move closer until 4 am on the following morning when the planet will be 0.2° from the lunar limb—from New Zealand there will be an occultation.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

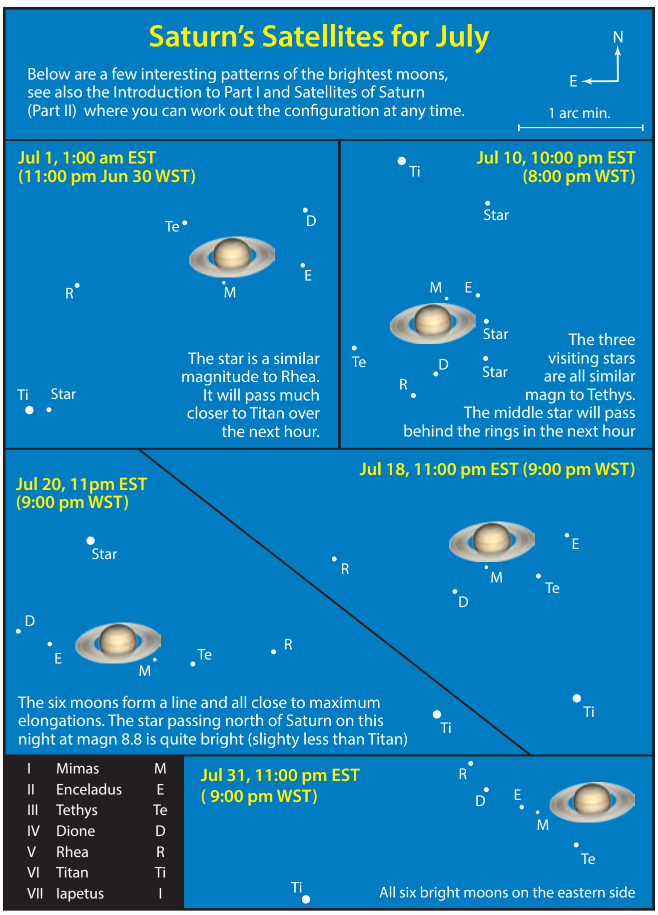
Dwarf Planet Pluto is at opposition on the 10th at magnitude 14.4 in Sagittarius and above the horizon the entire night. It is presently 4,839 million km (32.35 au) from Earth, with its light taking four hours and twenty-nine minutes to reach us. This month marks two years since the New Horizons flyby after its epic ten-year journey, and we are continuously awed at the spectacular images of this world that have exceeded all expectations.

Minor Planets. Four of the brighter minor planets reach opposition this month in Sagittarius. They are: 5 Astraea on 2nd at magnitude 10.8, 270 Anahita on 7th at magnitude 10.3, 654 Zelinda on 15th at magnitude 12.3 and 511 Davida on 15th at magnitude 11.3. Two are in Aquila, 69 Hesperia on 13th at magnitude 12.0 and 216 Kleopatra on 25th at magnitude 11.0. Others at opposition include 3 Juno on 2nd at magnitude 9.7 in Scutum and 128 Nemesis on 21st at magnitude 11.0 near the Capricornus/Sagittarius border. On the evening of 4th ninth magnitude 6 Hebe will be on the edge of the globular cluster NGC 6366 in Ophiuchus. In the last week of July, 7 Iris at 10th magnitude passes through the Hyades open cluster in Taurus.

COMETS

Comet C/2015 ER_{61} (PANSTARRS), rising around 2 am, is likely to fade from 10th to 11th magnitude during July, when it will be found in Aries.

Comet C/2015 V2 (Johnson) begins July in Virgo, moving into Hydra midmonth, and then Centaurus at month's end. It is



JULY

well placed in the early evening sky, setting around 2 am. The comet should fade from 7th to 8th magnitude this month.

Comet 41P/Tuttle-Giacobini-Kresak should fade from 11th to 13th magnitude this month. Beginning July in Serpens it is rising before sunset and transiting in the late evening. TGK quickly moves into Ophiuchus where it resides until returning to Serpens midmonth.

Comet 71P/Clark is in Scorpius throughout July. Visible until just before dawn, Clark should fade from 9th to 10th magnitude.

METEOR SHOWERS

This year the First Quarter Moon on the 31st will cause some grief, although each of these southern showers will be fine leading up to their peak for observers after midnight.

The **Piscis Austrinids** are visible from 15th July to 10th August, reaching their peak zenith hourly rate of 5 this month around the 28th. The Piscis Austrinids are generally blue, white or yellow in colour, with some leaving trains.

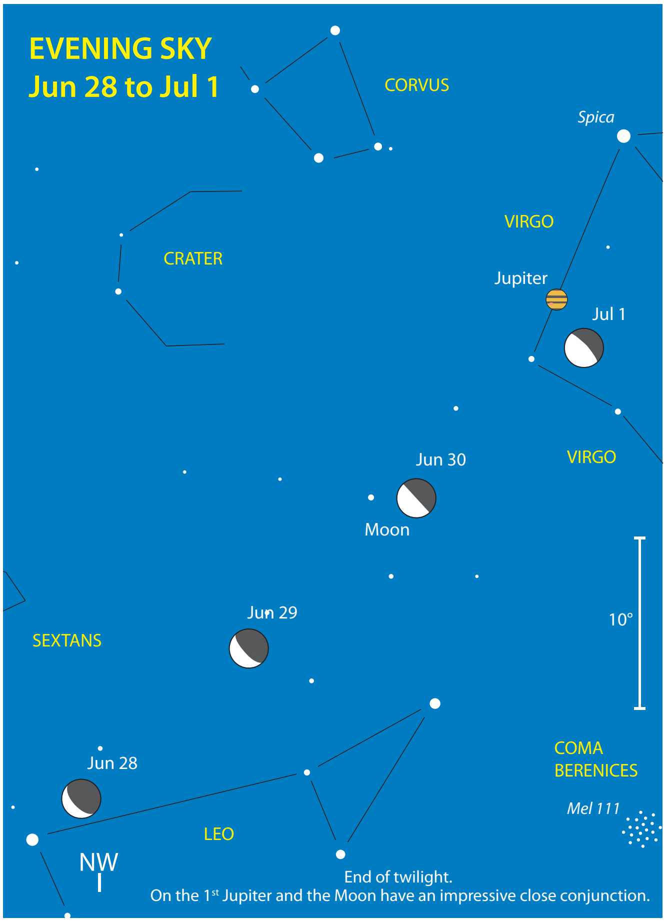
The **Southern delta-Aquarids** are one of the strongest and consistent of the southern showers. The range of activity of these medium speed meteors extends from 12 July through to 23 August, with maximum this month around the 30th, with a zenith hourly rate of 16. They are generally faint (bright meteors are the exception), typically white with some blue members, occasionally leaving trains.

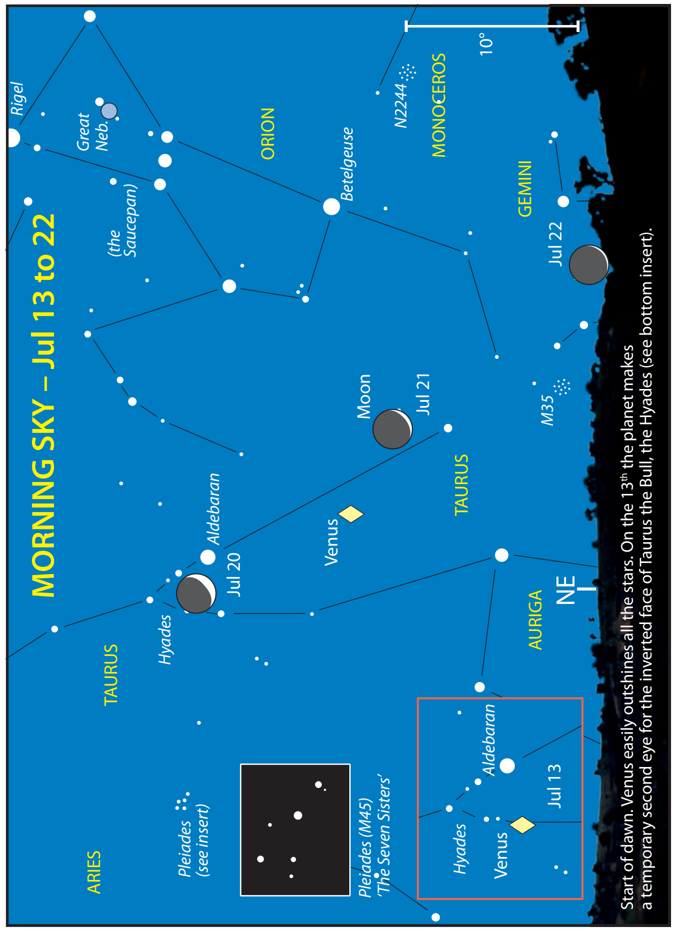
The **alpha-Capricornids** are noted for their bright, slow meteors with long paths and frequent fireballs. The shower is visible late evening until dawn, from 3rd July through to 15th August. Maximum activity occurs around the 30th, when a zenith hourly rate of 5 can be expected. Low hourly rates over the period are generally compensated by the spectacular nature of this shower.

DOUBLE STARS

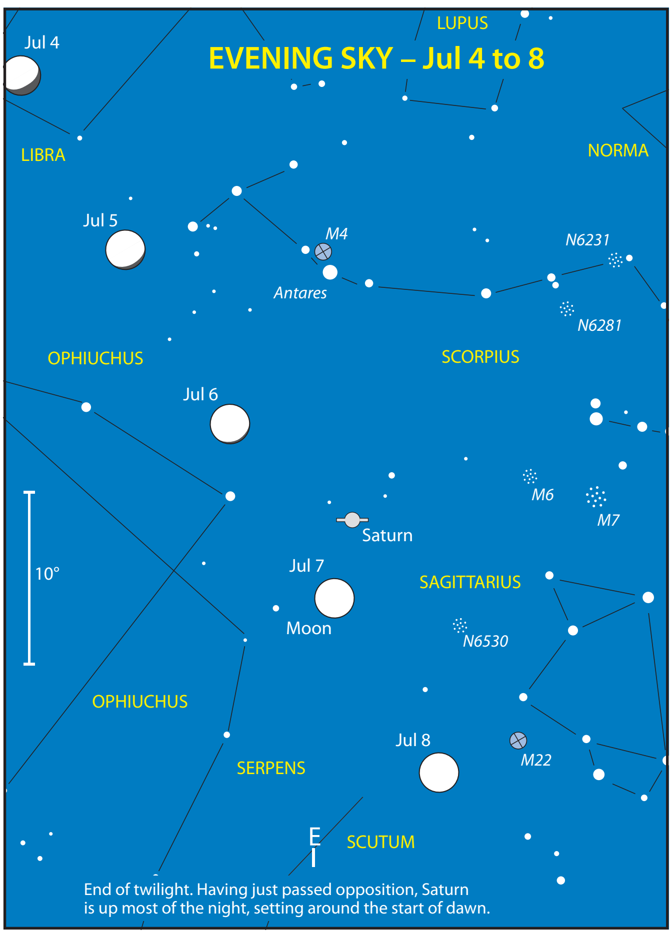
Located in a V-shaped group of stars in Ophiuchus is the beautiful double **70 Ophiuchi** (All Sky Maps 6 and 8). The pair is composed of bright orange and yellow stars, magnitudes 4.2 and 6.2 separated by 6.2 arcseconds. The effect of contrast makes the two a colourful pair with nineteenth-century observer Admiral Smythe calling them “pale topaz and violet.” The pair is also unusual in that it consists of two low mass, cool, yellow-orange class K dwarf stars; unusual as most naked eye stars are hotter and more luminous than our Sun. Located only 16.6 light years away (the 51st closest star system), 70 Ophiuchi is so close that its stars are easily separable with a small telescope and this lets one see nearly a full orbit over roughly a human lifetime. The duo swing from two to seven arcseconds apart and back over a period of 88.4 years. The last closest approach was in 1984 and the next widest separation will occur in 2028.

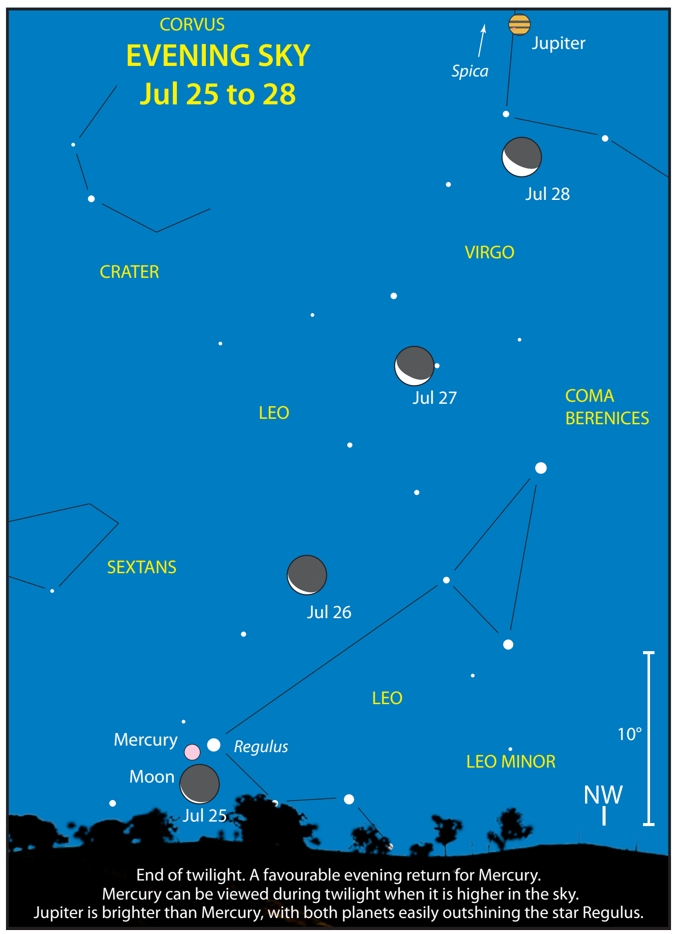
DIARY			
Sat	1st	10:51 am	(8:51 am WST) First Quarter Moon
Sat	1st	5 pm	(3 pm WST) Jupiter 3° S of Moon
Sat	1st	pm	Comet C/2015 V2 (Johnson) 0.4°N of star Kappa Virginis
Sun	2nd	10 am	(8 am WST) star Spica 7° S of Moon
Sun	2nd	11 pm	(9 pm WST) m.p. 3 Juno at opposition
Mon	3rd	10 am	(8 am WST) star Pollux 5° N of Mercury
Mon	3rd	8 pm	(6 pm WST) m.p. 15 Eunomia 0.1°NW of star Beta Sextantis
Mon	3rd	pm	m.p. 10 Hygiea 0.2°S of NGC 6642 (GC) in Sagittarius
Mon	3rd	pm	m.p. 29 Amphitrite 0.5°SW of NGC 3640 (G) in Leo
Tue	4th	6 am	(4 am WST) Earth at aphelion, 1.016675594 au
Tue	4th	10 pm	(8 pm WST) m.p. 6 Hebe 0.1°NW of NGC 6366 (GC) in Ophiuchus
Wed	5th		Venus at greatest latitude south
Thu	6th	8 am	(6 am WST) star Antares 10° S of Moon
Thu	6th	2 pm	(Noon WST) Moon at apogee, 405,934 km
Fri	7th	1 pm	(11 am WST) Saturn 3° S of Moon
Sat	8th		m.p. 347 Dembowska 0.5°N of m.p. 20 Massalia
Sat	8th	8 pm	(6 pm WST) m.p. 12 Victoria 0.2°NE of star 76 Virginis
Sun	9th	2:07 pm	(12:07 pm WST) Full Moon (402,624 km)
Sun	9th	5 pm	(3 pm WST) d.p. Pluto 2° S of Moon
Mon	10th		Mercury 0.3°N of M44 Beehive Cluster (OC) in Cancer
Mon	10th	3 pm	(1 pm WST) d.p. Pluto at opposition
Tue	11th		Neptune 0.2°SE of star 81 Aquarii
Tue	11th	10 pm	(8 pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.7°W of NGC 6539 (GC) in Serpens
Thu	13th		m.p. 4 Vesta 0.3°SW of star Eta Leonis
Thu	13th	5 am	(3 am WST) Venus 0.2°N of star Epsilon Tauri
Thu	13th	10 pm	(8 pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.3°W of star Tau Ophiuchi
Fri	14th		Uranus 1.1°N of star Omicron Piscium
Fri	14th	4 am	(2 am WST) Neptune 0.9° N of Moon
Fri	14th	9 pm	(7 pm WST) star Aldebaran 3° S of Venus
Sat	15th	10 pm	(8 pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.05°NE of NGC 6517 (GC) in Ophiuchus
Sun	16th		d.p. 1 Ceres 0.4°S of M35 (OC) in Gemini
Sun	16th		Comet C/2015 ER_{61} (PANSTARRS) 0.2°E of star Epsilon Arietis
Mon	17th		Venus 1.0°N of NGC 1647 (OC) in Taurus
Mon	17th	5:26 am	(3:26 am WST) Last Quarter Moon
Mon	17th	10 am	(8 am WST) Uranus 4° N of Moon
Mon	17th	pm	Comet 41P/Tuttle-Giacobini-Kresak 0.8°W of star Nu Ophiuchi
Tue	18th	am	m.p. 89 Julia 0.2°E of star Gamma Piscium
Thu	20th	10 am	(8 am WST) star Aldebaran 0.4° S of Moon
Thu	20th	9 pm	(7 pm WST) Venus 3° N of Moon
Sat	22nd		m.p. 9 Metis 0.7°SW of star Nu Virginis
Sat	22nd	2 am	(Midnight WST, prev day) d.p. 1 Ceres 5° N of Moon
Sat	22nd	3 am	(1 am WST) Moon at perigee, 361,236 km
Sun	23rd		m.p. 2 Pallas 0.8°SW of star Delta Ceti
Sun	23rd		Mercury at descending node
Sun	23rd	7:46 pm	(5:46 pm WST) New Moon
Tue	25th	7 pm	(5 pm WST) Mercury 0.9° S of Moon
Tue	25th	9 pm	(7 pm WST) star Regulus 0.07° S of Moon
Wed	26th		m.p. 2 Pallas 0.8°SW of M77 (SG) in Cetus
Wed	26th		m.p. 8 Flora 1.0°N of star Gamma Tauri
Wed	26th	5 am	(3 am WST) m.p. 4 Vesta 4° N of Moon
Wed	26th	7 pm	(5 pm WST) star Regulus 1.1° N of Mercury
Thu	27th		Venus 0.5°S of M1 Crab Nebula (PN) in Taurus
Thu	27th		Venus 0.7°NW of star Zeta Tauri
Thu	27th	3 am	(1 am WST) m.p. 2 Pallas 0.06°E of star 84 Ceti
Thu	27th	11 am	(9 am WST) Mars in conjunction with Sun
Thu	27th	pm	m.p. 40 Harmonia 0.4°S of NGC 6401 (GC) in Ophiuchus
Fri	28th		m.p. 8 Flora 0.8°S of star Delta 1 Tauri
Fri	28th	4 am	(2 am WST) m.p. 8 Flora 0.2°E of star 63 Tauri
Sat	29th	6 am	(4 am WST) Jupiter 3° S of Moon
Sat	29th	6 pm	(4 pm WST) star Spica 7° S of Moon
Sat	29th	pm	Comet 71P/Clark 1.0°NE of star Mu 2 Scorpii
Sun	30th		m.p. 2 Pallas 0.7°SW of NGC 1087 (G) in Cetus
Sun	30th		m.p. 8 Flora 1.0°N of star Theta 1 Tauri
Sun	30th	3 pm	(1 pm WST) Mercury at greatest elongation East (27.2°)
Mon	31st	1:23 am	(11:23 pm WST, prev day) First Quarter Moon





Approximate local standard time.

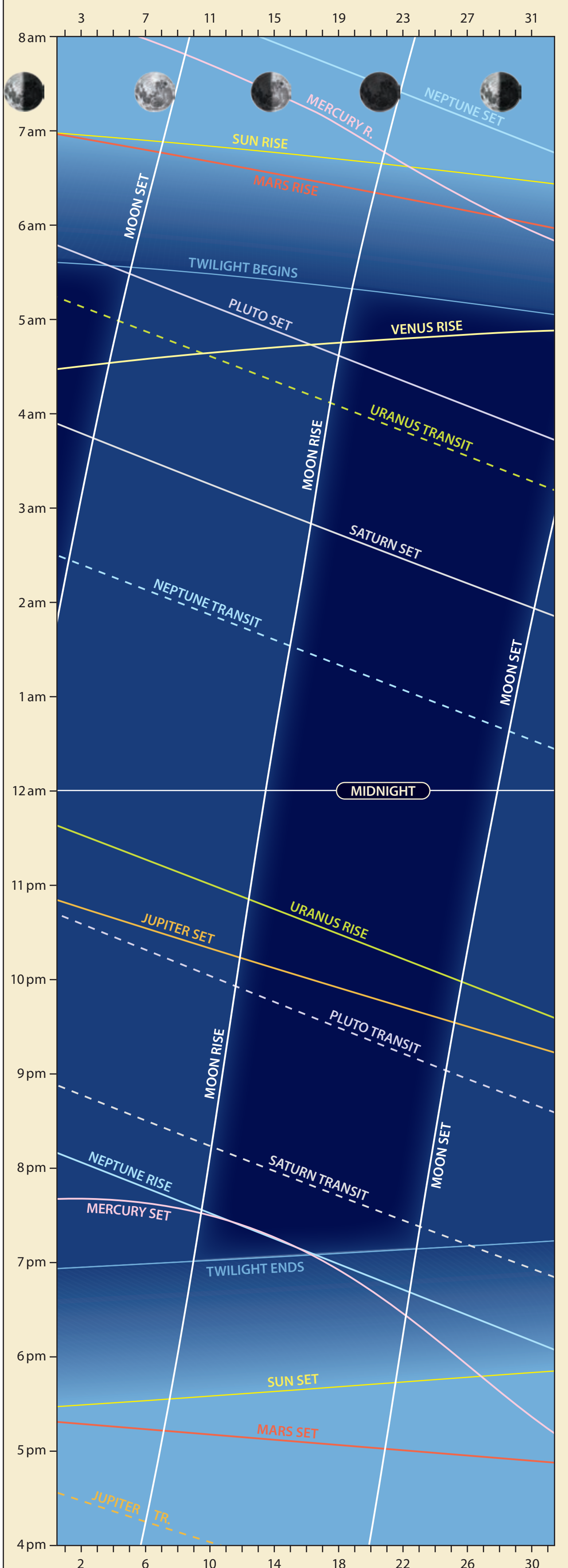




JULY

AUGUST

RISE–SET CHART



Approximate local standard time.

HIGHLIGHTS

- Mercury at best early this month in the evening sky.
- Jupiter, Moon and Spica make a pleasant conjunction.
- Jupiter and Spica close.

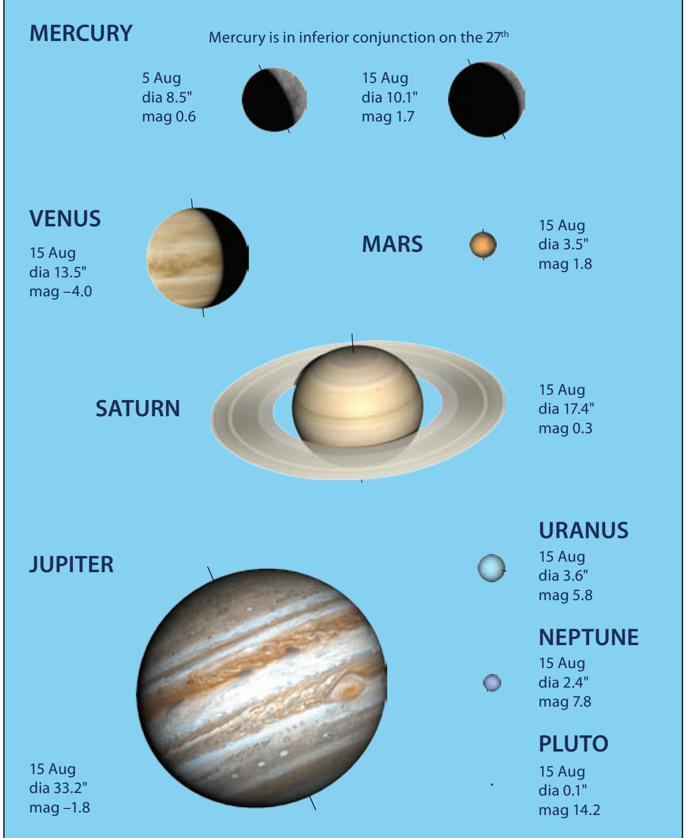
CONSTELLATIONS

In July Constellations we mentioned the famous emu dark cloud constellation of the Aborigines. This is just the southern part (west of the galactic centre) of what is a much larger collection called the Great Rift. The northern portion is conveniently placed in the evening sky this month.

A good place to start is to identify the Northern Cross asterism standing on the northern horizon (All Sky Map 9). It is quite large standing over 20° high representing the constellation of Cygnus the Swan with the head to the top, its neck stretched and wings spread. The lowest (most northerly) star is 1.3 magnitude Alpha Cygni or Deneb meaning ‘tail’. It is from here the rift starts as a dark bulbous shape called the Northern Coalsack. It narrows and heads up through Cygnus, passing the top star of the cross, the famous 3rd magnitude colourful double star, Beta Cygni, also known as Albireo.

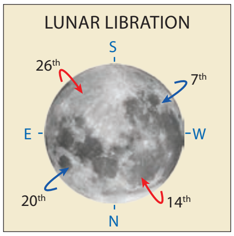
The rift widens as it passes through Vulpecula (the Fox), skirting the ‘arrow’ asterism of Sagitta. The distinctive binocular open star cluster known as the Coathanger is in the centre of this dark stream in Vulpecula. Up to this point the rift is nicely framed by the asterism known as the Summer Triangle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

APPEARANCE of the PLANETS



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

THE MOON



- 3rd 4 am (2 am WST) Moon at apogee (furthest from Earth at 405,025 km).
- 7th 9 am (7 am WST) Minimum Libration (4.1°), bright SW limb.
- 8th 4 am (2 am WST) Full Moon, Partial eclipse of the Moon visible from Western Pacific, Oceania, Australia, Asia Africa and Europe.
- 10th 9 am (7 am WST) Occultation of Neptune by the Moon, visible from most of Antarctica and W top of Australia (daylight event).
- 14th 9 am (7 am WST) Maximum Libration (7.8°), bright NW limb. Walled plains W Bond (163 km) and Goldschmidt (124 km) plus crater Barrow (95 km) at best during this libration.
- 15th 11 am (9 am WST) Last Quarter.
- 16th 5 pm (3 pm WST) Occultation of Aldebaran by the Moon, visible from Caribbean, Europe, Middle East and W Asia.
- 18th 11 pm (9 pm WST) Moon at perigee (closest to Earth at 366,121 km).
- 20th Noon (10 am WST) Minimum Libration (3.7°), too close to New Moon.
- 22nd 5 am (3 am WST) New Moon, Total Eclipse of the Sun visible from Hawaii, North America, W Europe and W Africa
- 26th 11 pm (9 pm WST) Maximum Libration (8.1°), bright SE limb. The 94 km crater Pontecoulant plus other southeastern highland features favoured.
- 29th 6 pm (4 pm WST) First Quarter.
- 30th 9 pm (7 pm WST) Moon at apogee (furthest from Earth at 404,308 km).

The Big Three

Around the time of the First Quarter Moon some very large craters become visible. A little south of the equator is the imposing and remarkable trio of Ptolemaeus, Alphonsus and Arzachel—the location near the centre of the lunar disc no doubt highlights their presence. The *big three* are all nicely lined up and make a wonderful sight as the terminator sweeps across them.

Named after the Greek astronomer, mathematician and geographer Claudius Ptolemy (c. 87-150 AD), the largest of the trio with a diameter of 154 km is Ptolemaeus. This large walled plain is hexagonal in shape with nearly straight sides. Formed during the Pre-Nectarian Age (4.55 to 3.92 billion years ago), its ancient walls have taken a beating by later impacts. Ptolemaeus is best viewed when the Sun is low, highlighting the many small craters on its lava-filled floor. The most prominent of the internal craters is Ammonius, a 9 km bowl-shaped feature. Just north of Ammonius lies the conspicuous 17 km *ghost crater* Ptolemaeus B, one of several that dot the floor.

On the northern rim of Ptolemaeus is the much younger 41 km crater Herschel. Its steep terraced inner walls and off-centre central peak make a wonderful sight although its larger neighbour tends to overshadow it.

Overlapping Ptolemaeus to the south is the slightly younger (3.92 to 3.85 billion years) Alphonsus, named after the 13th century Spanish King Alfonso of Castile. This 118 km crater with its 1.5 km high pyramid-shaped central mountain and complex walls is one of the most interesting craters on the Moon. One of its most intriguing features is the presence of dark patches inside its walls. Known as *dark halo craters* these were considered to be volcanic fumaroles. However, the Apollo 17 crew visited a similar crater named Shorty in the Taurus-Littrow valley and found it to be an impact crater where dark material was brought to the surface and covered the lighter regolith. The dark patches can be observed with a small telescope and are very conspicuous when the Sun is high in the lunar sky (near Full Moon). There have been several reports of *transient lunar phenomena* (mists and glows) emanating from Alphonsus, although no corroboration has come from the many lunar missions to date. In 1965 the Ranger 9 spacecraft returned spectacular images of the crater before impacting near the central mountain.

Before moving to the last of the *big three,* there is a 40 km crater named Alpetragius just to the southwest of Alphonsus that is worth a look. The most remarkable feature of this crater is its overly large 2 km high central mountain that covers most of the crater floor—unique among central peaks. It is interesting to compare Alpetragius with Herschel to the north; both craters are around the same diameter and depth yet Herschel's central peak is what you would consider average for craters of this size.

The last and smallest of the *big three* is the 98 km Arzachel, it is also the youngest at 3.85 to 3.80 billion years old. Named after Al Zarqali, an 11th century Arabian astronomer and mathematician, it is the best preserved of the trio. Its detailed inner terraced walls rise around 4 km above the surroundings and its conspicuous 1.5 km high central peak is noticeably offset to the west and has a small crater on its southern slopes. Its floor contains the 10 km bowl-shaped crater Arzachel A, plus hills and rilles.

Since the Moon wobbles around a bit as it orbits the Earth (librations in longitude and latitude) we actually see up to 59% of the lunar surface. This gentle oscillation means that a crater clearly visible on the terminator on a First Quarter

THE PLANETS

Mercury, in the western evening sky, is at its best for observation during the first half of August. Over the final fortnight the planet moves back toward the Sun and inferior conjunction (between the Earth and the Sun) on the 27th, thereafter returning to the morning dawn in September.

Venus, in the eastern predawn sky, travels across Gemini before moving into Cancer at month's end. On the 17th the brilliant planet will be 0.5° from the 4th magnitude star Delta Geminorum (Wasat). Delta is an interesting binary of unequal white and reddish suns; the companion, 6 arcseconds away is 8th magnitude, 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. On the 19th, the 26-day old waning crescent Moon appears near the planet (see Sky View). Also on the same day Venus is near the Eskimo Nebula (NGC 2392).

Mars remains hidden from view in the glare of the Sun after conjunction and will reappear in the morning sky mid-September in Leo.

Jupiter, in Virgo, can be seen in the western evening sky moving towards the 1st magnitude star Spica (Alpha Virginis). By month's end the star and planet will be less than 4° apart and a little closer next month. On the evening of the 2nd Jupiter is seen nearly on top of the galaxy NGC 4941 in Virgo. Due to the glare of the planet this faint spiral will be hard to see. On the 10th, Jupiter passes 0.6° from the 4th magnitude double star Theta Virginis, having had a closer approach to this sun last April whilst moving in retrograde. The 4-day old waxing crescent Moon, Jupiter and Spica make a pleasant sight on the evening of the 25th (see Sky View). This month is the last chance to view Jupiter at a practical altitude before it moves closer to the Sun and conjunction in October.

Saturn transits the meridian around 8 pm midmonth, placing it high in the northern sky and ideal for observation. The planet appears stationary on the 26th (coming close to the double star Xi Ophiuchi) as it comes to the end of its retrograde loop. It then resumes its west to east motion across the sky heading toward Sagittarius. Saturn has two close encounters with the waxing gibbous Moon this month, on the 3rd with an 11-day old Moon and on the 30th with the 8-day old Moon (see Sky Views).

Uranus rises in the late evening eastern sky and transits the meridian around 4 am. On the 3rd the planet appears stationary against the background stars and thereafter is in retrograde motion until early 2018.

Moon on a given date, may well be in shadow on the following First Quarter. Taking into account the lunar librations, the following dates in the evenings are when the *big three* are at their finest.

30 August
28 September
29 October
26 November
26 December
25 January 2018

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

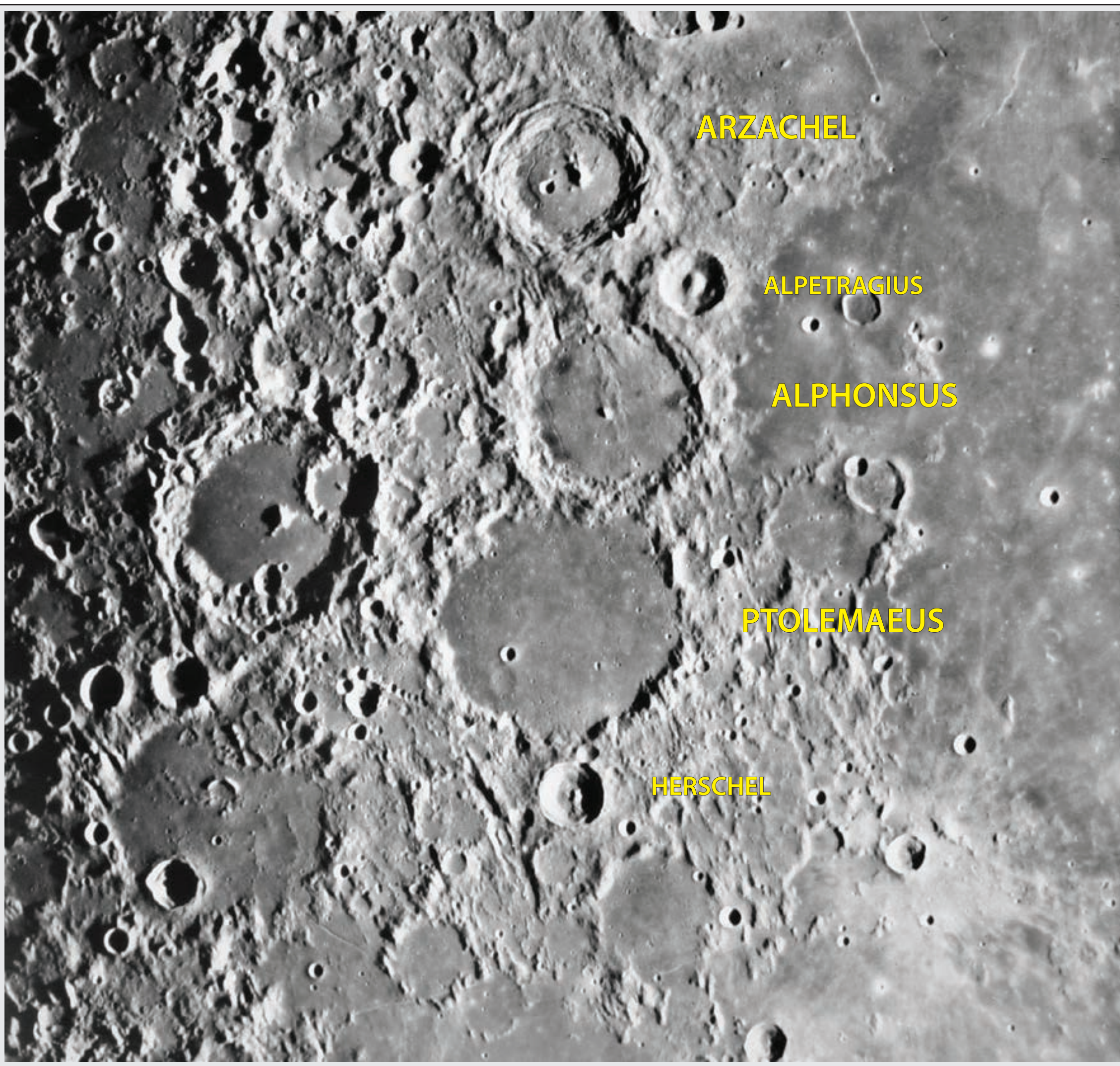


Image of the Big Three from the Consolidated Lunar Atlas. www.lpi.usra.edu/resources/cla/

Neptune, in Aquarius, rises at the end of astronomical twilight midmonth. At the end of August the planet will be 1.3° from the 4th magnitude star Lambda Aquarii (Hydor), a handy reference point to offset from if using binoculars to find Neptune.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto, now past opposition, transits the meridian (is due north) around 9 pm midmonth. For those interested in astroimaging, the ice dwarf will be just 3 arcminutes from the 6th magnitude star HR 7276 at the end of August—a perfect opportunity to take images over several days as the plutoid sails past this bright reference point.

Minor Planets. The brighter minor planets reaching opposition this month include 23 Thalia on 6th at magnitude 11.6 in Microscopium, 25 Phocaea on 11th at magnitude 10.0 in Vulpecula and 87 Sylvia on 31st at magnitude 11.5 in Aquarius. In mid-August 7 Iris passes by the bright stars of Gamma and Beta Arietis. Retrograde motion causes a return visit to these stars in November.

COMETS

Comet C/2015 ER_{61} (PANSTARRS), rising around 1 am midmonth, begins August in Aries and quickly crosses into Taurus where it resides for the remainder of the month. During this time, the comet remains around 11th magnitude. Here's an imaging opportunity. For all of August through until late October it will be within 5° of the Pleiades, with closest approach this month on the 17th (see diary).

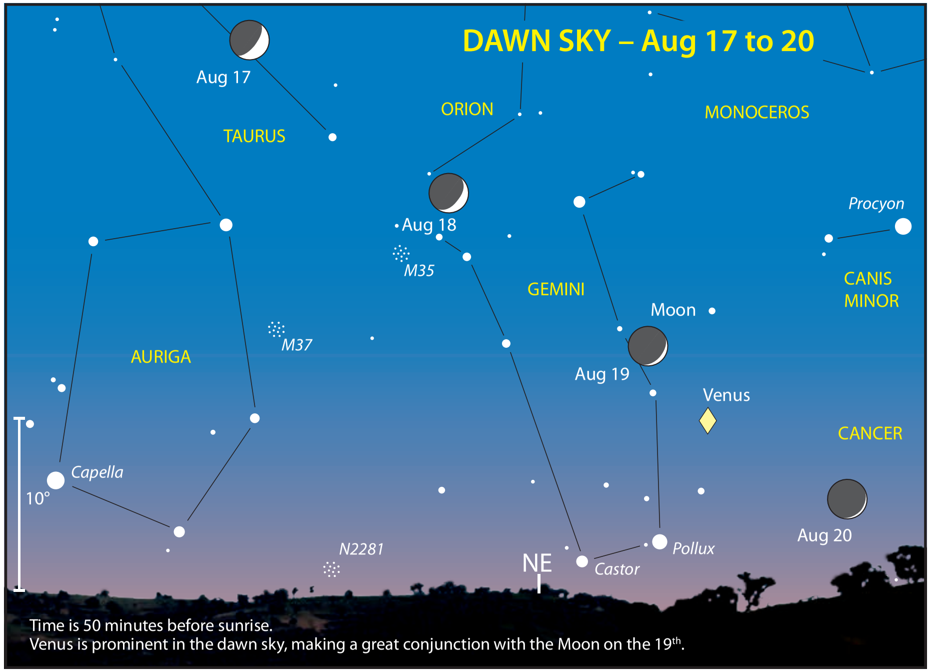
Comet C/2015 V2 (Johnson) is expected to fade from 8th to 9th magnitude this month. Moving through Centaurus until late August, when it enters Lupus, the comet sets around 1 am. On the evening of 24th it makes a close approach to 3rd magnitude Kappa Centauri.

Comet 71P/Clark will be moving through Scorpius throughout August until the last two nights when it enters Corona Australis. Around 10th magnitude in brightness, the comet will be visible until late morning. During the month it passes through the tail of Scorpius visiting a number of bright stars and deep sky objects along the way.

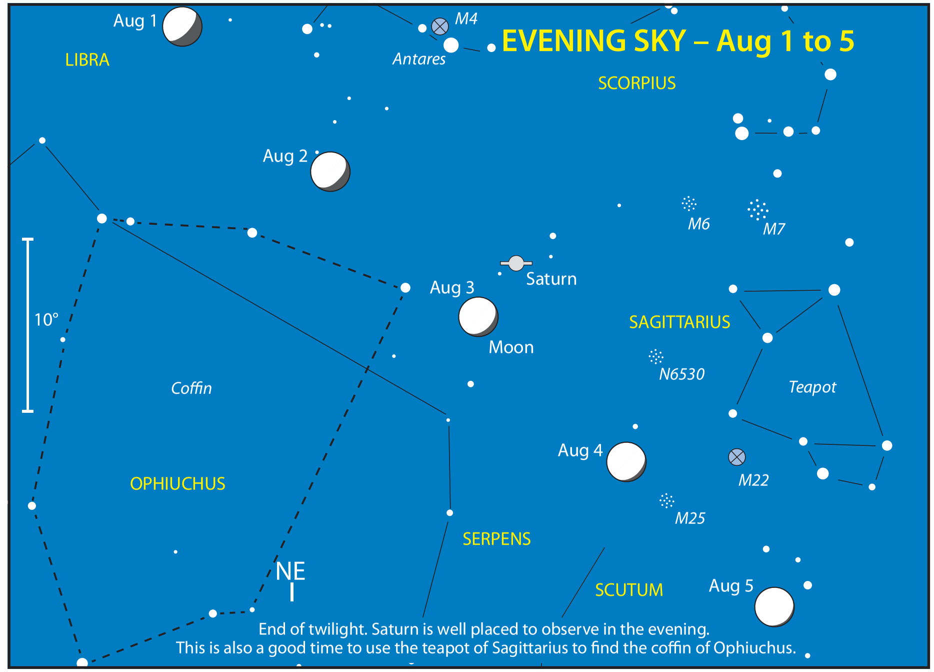
DOUBLE STARS

Situated near Corona Australis, **Beta1 Sagittarii** (All Sky Maps 1, 6 and 8) is an excellent telescopic double and forms a wide binocular pair with Beta 2. The stars, magnitudes 4.0 and 7.2, are separated by 28.7 arcseconds. Both are pale yellow and probably form a long period binary. The primary is a B8V main sequence dwarf whilst the companion is an F0V dwarf. The stars are separated by 3,300 astronomical units.

DIARY			
Tue	1st	pm	Comet 71P/Clark 0.3°S of NGC 6256 (GC) in Scorpius
Wed	2nd		m.p. 8 Flora 0.7°N of star Aldebaran
Wed	2nd		Mercury at aphelion
Wed	2nd	3 pm	(1 pm WST) star Antares 10° S of Moon
Wed	2nd	8 pm	(6 pm WST) Jupiter 0.025°SE of NGC 4941 (G) in Virgo
Thu	3rd	4 am	(2 am WST) Moon at apogee, 405,025 km
Thu	3rd	5 pm	(3 pm WST) Saturn 3° S of Moon
Thu	3rd	8 pm	(6 pm WST) Uranus stationary
Fri	4th		Venus 0.5°S of star Eta Geminorum
Fri	4th		d.p. 1 Ceres 0.9°S of star Epsilon Geminorum
Fri	4th	pm	Comet 71P/Clark 0.5°N of NGC 6281 (OC) in Scorpius
Sat	5th	10 pm	(8 pm WST) d.p. Pluto 2° S of Moon
Sun	6th		Venus 0.7°SE of star Mu Geminorum
Sun	6th		m.p. 347 Dembowska 0.2°NW of star 37 Tauri
Tue	8th	4:11 am	(2:11 am WST) Full Moon (394,795 km)
Wed	9th	pm	Comet 71P/Clark 0.6°S of NGC 6302 (PN) in Scorpius
Thu	10th		Jupiter 0.6°SW of star Theta Virginis
Thu	10th	9 am	(7 am WST) Neptune 0.9° N of Moon
Thu	10th	pm	m.p. 3 Juno 0.6°SE of IC 1276 (GC) in Serpens
Fri	11th		m.p. 20 Massalia 0.8°S of star Kappa Tauri
Fri	11th	3 am	(1 am WST) m.p. 7 Iris 0.2°N of star Gamma Arietis
Sat	12th	Midnight	(10 pm WST) d.p. 1 Ceres 2° N of Venus
Sat	12th	4 pm	(2 pm WST) Mercury stationary
Sun	13th	am	m.p. 7 Iris 1.0°NW of NGC 772 (G) in Aries
Sun	13th	3 pm	(1 pm WST) Uranus 4° N of Moon
Mon	14th	am	m.p. 7 Iris 1.0°SE of star Beta Arietis
Tue	15th	11:15 am	(9:15 am WST) Last Quarter Moon
Wed	16th	5 pm	(3 pm WST) star Aldebaran 0.4° S of Moon
Wed	16th	pm	m.p. 10 Hygiea 0.5°NE of NGC 6546 (OC) in Sagittarius
Thu	17th		Venus 0.5°S of star Delta Geminorum
Thu	17th		m.p. 10 Hygiea 1.4°E of M20 Trifid Nebula (BN) in Sagittarius
Thu	17th		Comet C/2015 ER_{61} (PANSTARRS) 0.7°S of M45 the Pleiades (OC) in Taurus
Fri	18th	11 pm	(9 pm WST) Moon at perigee, 366,121 km
Fri	18th	pm	Comet 71P/Clark 0.5°S of star Upsilon Scorpii
Sat	19th		Venus 0.4°NE of NGC 2392 (PN) in Gemini
Sat	19th	6 am	(4 am WST) d.p. 1 Ceres 5° N of Moon
Sat	19th	3 pm	(1 pm WST) Venus 2° N of Moon
Sat	19th	8 pm	(6 pm WST) star Pollux 9° N of Moon
Sat	19th	pm	Comet 71P/Clark 0.7°S of star Lambda Scorpii
Sun	20th		m.p. 20 Massalia 1.0°S of star Tau Tauri
Sun	20th	5 am	(3 am WST) d.p. 1 Ceres 0.1°W of star 48 Geminorum
Mon	21st		Venus 0.8°SE of NGC 2420 (OC) in Gemini
Mon	21st		Uranus 1.1°N of star Omicron Piscium
Tue	22nd		Saturn 0.8°S of star Xi Ophiuchi
Tue	22nd		Mercury at greatest latitude south
Tue	22nd	4:30 am	(2:30 am WST) New Moon
Tue	22nd	5 am	(3 am WST) star Pollux 7° N of Venus
Tue	22nd	pm	Comet 71P/Clark 0.8°S of NGC 6400 (OC) in Scorpius
Wed	23rd	2 pm	(Noon WST) m.p. 4 Vesta 3° N of Moon
Thu	24th		m.p. 347 Dembowska 1.0°N of star Upsilon Tauri
Thu	24th	8 pm	(6 pm WST) Comet C/2015 V2 (Johnson) 0.05°NW of star Kappa Centauri
Fri	25th	11 pm	(9 pm WST) Jupiter 3° S of Moon
Sat	26th		m.p. 3 Juno stationary
Sat	26th	1 am	(11 pm WST, prev day) Saturn stationary
Sat	26th	3 am	(1 am WST) star Spica 7° S of Moon
Sat	26th	pm	Comet 71P/Clark 0.6°S of NGC 6441 (GC) in Scorpius
Sat	26th	pm	Comet C/2015 V2 (Johnson) 0.8°NE of star Beta Lupi
Sun	27th	7 am	(5 am WST) Mercury in inferior conjunction
Tue	29th	6:13 pm	(4:13 pm WST) First Quarter Moon
Tue	29th	11 pm	(9 pm WST) star Antares 10° S of Moon
Wed	30th	Midnight	(10 pm WST) Saturn 4° S of Moon
Wed	30th		Venus at ascending node
Wed	30th		Mars at greatest latitude north
Wed	30th	9 pm	(7 pm WST) Moon at apogee, 404,308 km
Thu	31st	pm	d.p. Pluto 0.05°SE of star HR7276
Thu	31st	pm	m.p. 704 Interamnia, 0.3°SW of star Alpha Andromedae

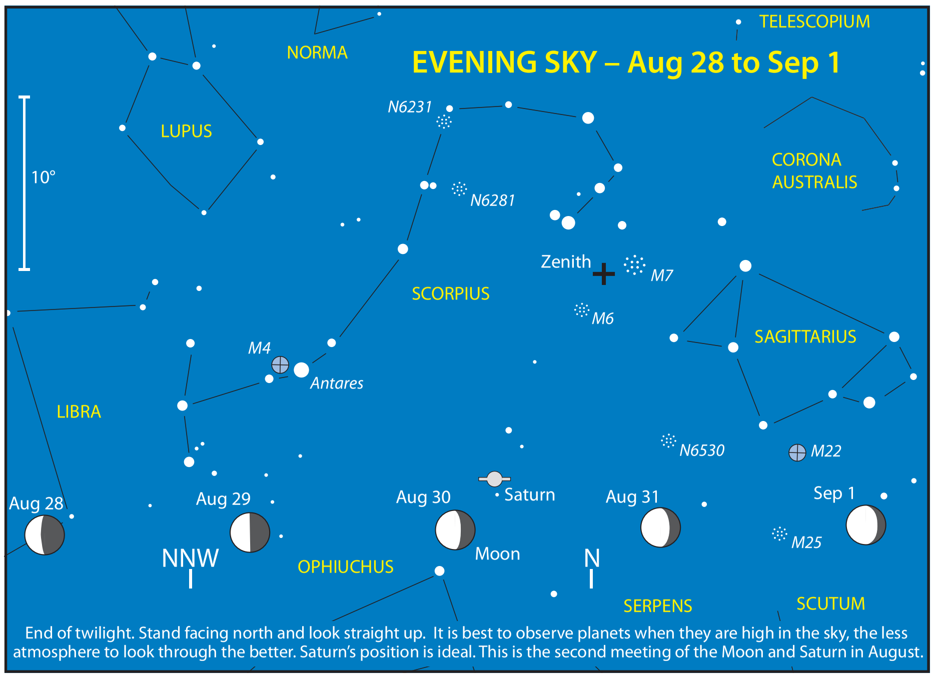


Time is 50 minutes before sunrise.
Venus is prominent in the dawn sky, making a great conjunction with the Moon on the 19th.

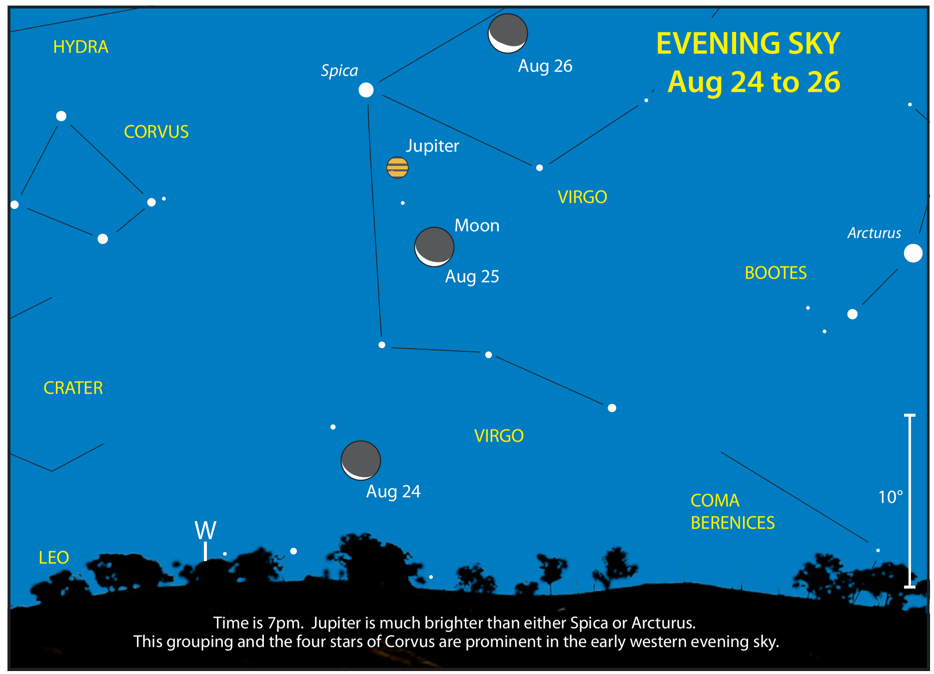


End of twilight. Saturn is well placed to observe in the evening.
This is also a good time to use the teapot of Sagittarius to find the coffin of Ophiuchus.

Approximate local standard time.

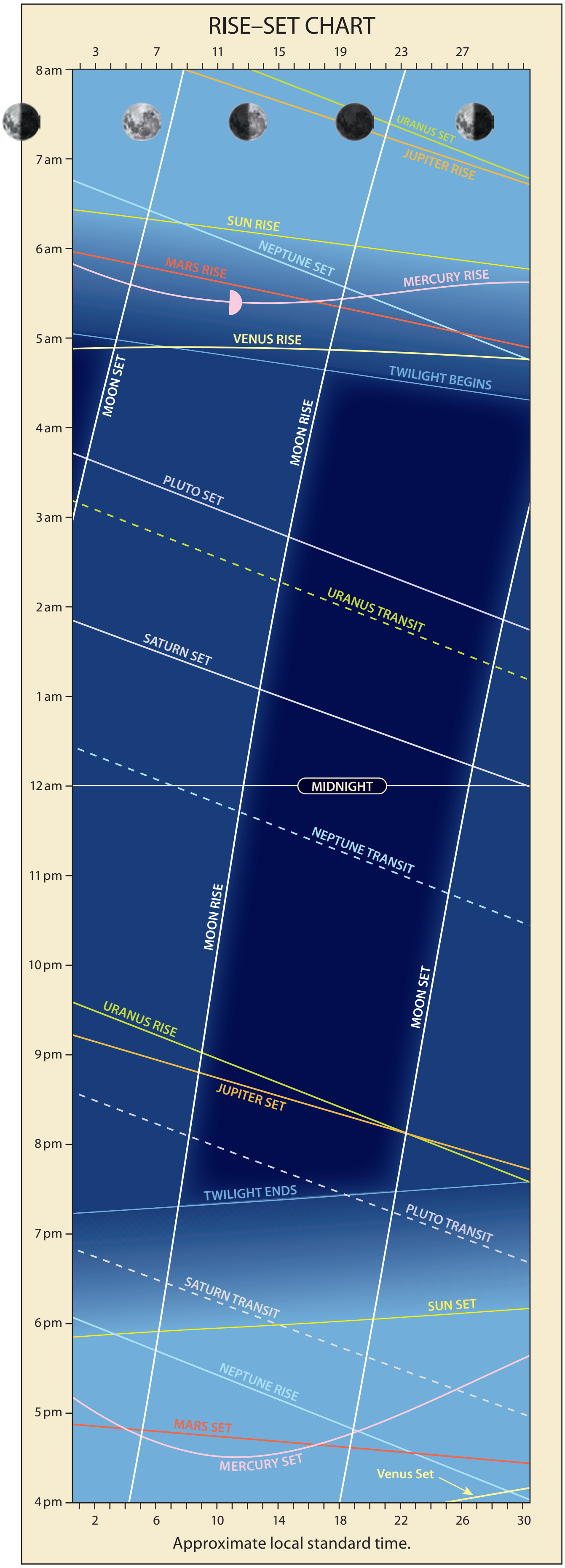


End of twilight. Stand facing north and look straight up. It is best to observe planets when they are high in the sky, the less atmosphere to look through the better. Saturn's position is ideal. This is the second meeting of the Moon and Saturn in August.



Time is 7pm. Jupiter is much brighter than either Spica or Arcturus.
This grouping and the four stars of Corvus are prominent in the early western evening sky.

SEPTEMBER



HIGHLIGHTS

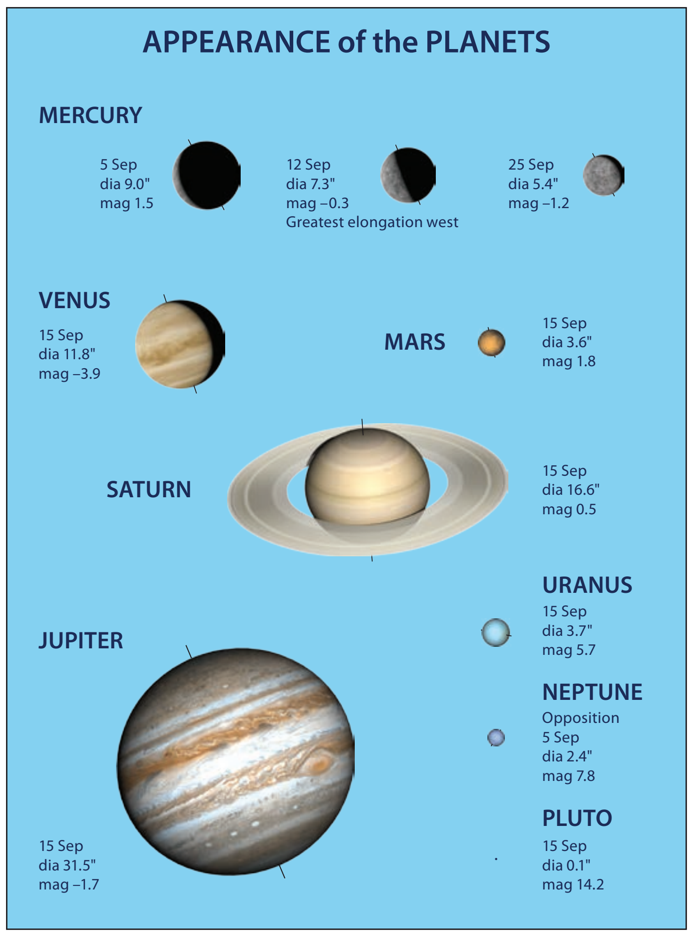
- Mercury, Mars and Moon close (difficult).
- Venus and Moon close.
- Venus and Regulus close.
- Venus and Mars close.
- Jupiter and Spica close.
- Neptune at opposition.

CONSTELLATIONS

This is a great time of the year to observe. Nights are long, getting warmer and as evening twilight ends the traditional winter gems are still well showcased. The Southern Cross and Centaurus are accessible low in the southwest (All Sky Map 1). It's not too late to catch highlights such as the Jewel Box, the double stars Alpha Crucis, Alpha Centauri and the globular cluster Omega Centauri, objects you may not think of when planning an observing session in September.

Scorpius and Sagittarius have commenced their journey towards the western horizon. The 'Scorpion' is already head down with the Teapot tilting over looking like it is getting ready to dispense some celestial tea. You'll have most of the evening to continue to enjoy the star clusters and nebulae associated with this central region of the Milky Way (All Sky Maps 6 and 8).

As early as midnight the sky is transforming into a more summer vista. Find bright Achernar (Alpha Eridani) high in the south and follow this winding river, Eridanus, comprised of around thirty 4th magnitude stars down to the eastern horizon, already heralding the return of Orion (All Sky Map No 2). Also by midnight the eastern half of the sky is now somewhat

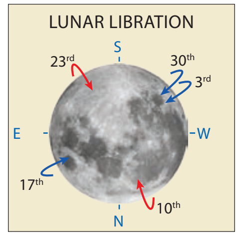


extragalactic, with the bright members of the local group of galaxies available (see November 'Constellations').

You don't have to move too far from the Milky Way for the constellations to lose their striking appearance. An example is Capricornus, high in the evening sky, next to brilliant Sagittarius (All Sky Map 8). It is almost invisible under light polluted suburbia, but obvious from moonless country skies. Known since antiquity as the Sea Goat, this triangular shaped group of 3rd and 4th magnitude stars resembles a house roof or an inverted smile. This part of the sky is rich in water-themed, faint constellations with Aquarius (The Water Bearer), Piscis Austrinus (The Southern Fish)—All Sky Map 8, Pisces (The Fish), Cetus (The Whale) (All Sky Map 2) and possibly the pick of the bunch and easiest to find the more distinctive Delphinus (The Dolphin)—All Sky Map 9.

THE MOON

- 3rd 3 pm (1 pm WST) Minimum Libration (4.2°), dark SW limb.
- 6th 3 pm (1 pm WA) Occultation of Neptune by the Moon, visible from Antarctica, SE South America and South Georgia.
- 6th 5 pm (3 pm WST) Full Moon.
- 10th 6 pm (4 pm WST) Maximum Libration (7.2°), bright NW limb. The libration favours Crater Xenophanes. Also a better view of Crater Pythagoras is on offer.
- 12th 11 pm (9 pm WST) Occultation of Aldebaran by the Moon, visible from Hawaii and Azores.
- 13th 4 pm (2 pm WST) Last Quarter.
- 14th 2 am (midnight previous day WST) Moon at perigee (closest to Earth at 369,860 km).
- 17th 3 am (1 am WST) Minimum Libration (3.7°), dark NE limb.
- 18th 11 am (9 am WST) Occultation of Venus by the Moon, visible from SE Asia, Australia and New Zealand. See Venus below.
- 18th 3 pm (1 pm WST) Occultation of Regulus by the Moon, visible from NE Africa, Middle East, SE Asia and N Australia (daytime event).
- 19th 6 am (4 am WST) Occultation of Mars by the Moon, visible from NE Micronesia, Hawaii, Galapagos Is and NW South America.
- 19th 9 am (7 am WST) Occultation of Mercury by the Moon, visible from Easternmost Asia, Micronesia and N Polynesia.
- 20th 4 pm (2 pm WST) New Moon.



Wallwerk – A City in the Moon

Today we see the Moon as a lifeless and unchanging place, however, throughout history there has been speculation on its habitability. To the Homeric Greeks, the Moon was a world *"inhabited and that it is a land of many cities and mountains"* (Xenophanes 570–475 BC). The Greek writer Plutarch (46–120 AD) also considered the possibility of life on the Moon. The discoverer of Uranus, William Herschel, in 1776 observed what he believed to be a *forest* consisting of *large growing substances* on Mare Humorum (figure 1). In a letter two years later to a friend, he described his conviction in the existence of lunarian cities and dwellings in the craters of the Moon. His later observations up to 1783 included *two small pyramids*, *vegetation* and *turnpike roads*. Other prominent 18th century scientists that supported extraterrestrial life on the Moon and elsewhere included Gottfried Leibniz and Edmond Halley.

Modern telescopic lunar exploration began when the Englishman Thomas Harriot made drawings of the Moon in early August 1609, preceding Galileo's observations by several months. It is interesting to note that by the time of Herschel's observations it had already been established that the Moon lacked an atmosphere, and therefore could not sustain life—as evidenced by the fact that stars occulted by the Moon remained steady and sharp right up to their disappearance behind the limb (a detail known to Herschel). This fact alone did not deter all astronomers from their belief in life on the Moon; some held the view that only direct telescopic observation would settle the question once and for all.

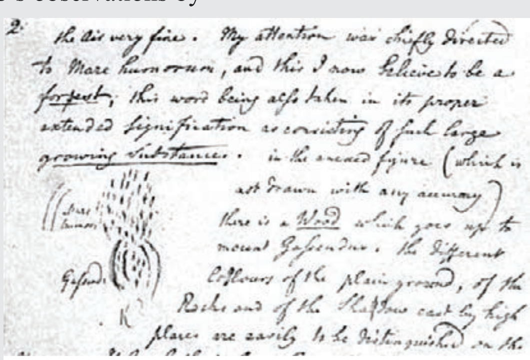


Figure 1. Herschel's drawing of the lunar forest he believed he observed.

This view that the Moon had vegetation and was populated by selenites persisted into the early 19th century. Noted German astronomers of this time who held this opinion included Carl Gauss (director of the Gottingen Observatory), Johann von Littrow (director of the Vienna Observatory) and Wilhelm Olbers. Proposals were even put forth to contact the inhabitants by constructing gigantic geometrical shapes on the Earth's surface.

Franz Gruithuisen (figure 2) was a German physician-turned astronomer who was noted for his belief in the plurality of inhabited worlds and his far-fetched ideas regarding the Moon and planets. He studied philosophy and medicine and graduated from university as a Doctor of General Medicine in 1808. He lectured on physics and chemistry, zoology and anthropology. As a physician he led the way in the field of lithotrity and developed safer methods to remove bladder stones transurethrally.

Whilst he had a boyhood interest in astronomy, it was the Great Comet of 1811 (C/1811 F1) that rekindled Franz's curiosity in the science. He obtained 2.4 and 4-inch refracting telescopes from the famous optician Joseph von Fraunhofer and began an examination of the lunar surface. On 12 July 1822, while observing the Moon with his 2.4-inch refractor he noticed a regular herringbone pattern of ridges arranged with geometric

SEPTEMBER

23rd 4 pm (2 pm previous day WST) Maximum Libration (7.7°), bright SE limb. Southern highland craters Neumayer (78 km), Helmholtz (99 km), Lyot (145 km) and Pontecoulant (94 km) are favoured.

27th 5 pm (3 pm WST) Moon at apogee (furthest from Earth at 404,348 km).

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

30th 9 am (7 am WST) Minimum Libration (4.5°), dark SW limb.

THE PLANETS

Mercury, in the eastern morning sky will be at its greatest elongation (18°) west of the Sun on the 12th. This is a rather poor apparition with the planet barely above the horizon at the time of civil dawn. On the 17th, Mercury and Mars will be just 4 arcminutes apart although the low altitude and bright twilight sky will make any observation of the pair extremely difficult. Two days later on the 19th, the 28-day old slender crescent Moon joins the planetary pair, again a challenging conjunction to view (see Sky View).

Venus moves from Cancer into Leo in the first week of September, in the eastern morning dawn. For the trivia aficionados out there the brightest of planets will be 0.1° from the 4th magnitude orange giant star Delta Cancri (Asellus Australis) on the 3rd. Delta itself is unremarkable but it does have the distinction of having the longest of all known star names, Arkushanangarushashutu, meaning the southeast star in the crab from the ancient Babylonian. Delta is a very handy marker for locating M44 (the Beehive Cluster) and X Cancri, one of the reddest stars in the sky (a semi-regular variable ranging from 5.6 to 7.3 magnitude)—both in the same binocular field as Delta. On the 18th, the slender crescent of the 27-day old waning crescent Moon will be just 2.5° from the planet (see Sky View). The Alpha star in Leo, 1st magnitude Regulus, will be just over 0.5° from Venus on the 20th.

On the 18th there will be a daytime occultation of Venus by the Moon, at this time the Moon is a little over two days from New and just 28° from the Sun.

Warning! Observing objects near the Sun is extremely dangerous and should not be attempted unless the observer is fully experienced and aware of the dangers. Instant blindness can result through carelessness and lack of understanding. As a minimum safety precaution the Sun must be blocked from the observer by a building or similar structure.

From Sydney Venus will disappear behind the 27-day old waning crescent Moon around 10:49 am (AEST) and seemingly reappear in a clear blue sky at 12:17 pm (AEST) as it clears the unseen dark limb. At ingress the Sun's altitude

accuracy. He believed this to be a *"colossal structure, not dissimilar to one of our cities"* and he named his city Wallwerk (figure 3).

In 1824 he published a paper entitled *"Discovery of Many Distinct Traces of Lunar Inhabitants, Especially of One of Their Colossal Buildings"* detailing his observational evidence of an inhabited Moon. He claimed to have seen fortifications, walls, roads, cities and a huge star-shaped 'temple'. He also saw different shades of colour that he attributed to vegetation and climate zones.

Such was the impact of his ideas he was appointed Professor of Astronomy at Munich University in 1826, where he was freed from all administrative work and allowed to continue his research. He was the first to identify the bright cusp caps of Venus and was one of the first to suggest an impact origin for the craters on the Moon. Eventually his vivid imagination and inadequate telescope resolution caught up with him and

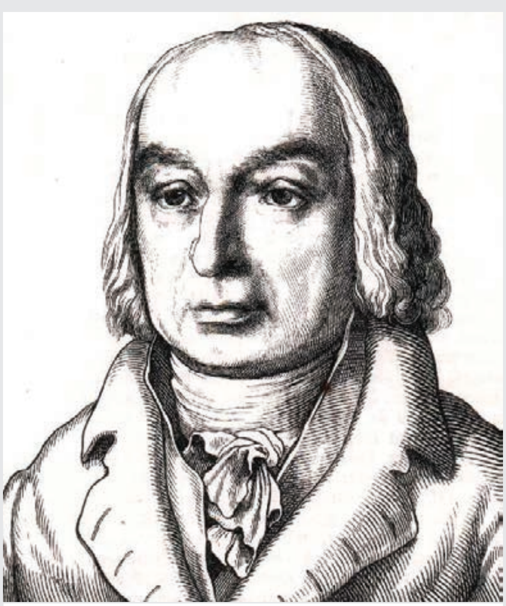


Figure 2, Franz von Gruithuisen (1774–1852)

it wasn't long before larger telescopes were able to disprove his claims, rendering him the object of ridicule by astronomers.

Figure 3. Gruithuisen's drawing of Wallwerk – a city in the Moon

If you wish to see Gruithuisen's Wallwerk, virtually any telescope will do; remember he was using a 60 mm refractor. It is located roughly midway between the craters Eratosthenes and Mosting and a little north of the degraded crater Schroter. It is best observed when the Sun angle is low over Schroter around one day after First Quarter or Last Quarter. If you have Rukl's *Atlas of the Moon* you can distinctly see the herringbone pattern on chart #32 at 8°W and 6°N.

Since the Moon wobbles around a bit as it orbits the Earth (librations in longitude and latitude) we actually see up to 59% of the lunar surface. This gentle oscillation means that a crater clearly visible on the terminator on a First Quarter Moon on a given date, may well be in shadow on the following First Quarter. Taking into account the Lunar Librations, the best time to look for the city would be on the following dates: 29 September morning, 28 October evening, 26 December evening and in 2018 25 January evening, 24 February morning and 25 March evening.

DIARY			
Fri	1st	pm	m.p. 6 Hebe 0.4°SW of star Nu Serpentis
Fri	1st	pm	Comet C/2015 V2 (Johnson) 0.9°NE of star Lambda Lupi
Sat	2nd		Venus 1.2°S of M44 Beehive Cluster (OC) in Cancer
Sat	2nd	5 am	(3 am WST) d.p. Pluto 3° S of Moon
Sun	3rd		Venus 0.1°E of star Delta Cancri
Tue	5th	2 am	(Midnight WST, prev day) Mercury stationary
Tue	5th	3 pm	(1 pm WST) Neptune at opposition
Tue	5th	9 pm	(7 pm WST) star Spica 3° S of Jupiter
Wed	6th	3 pm	(1 pm WST) Neptune 0.8° N of Moon
Wed	6th	5:03 pm	(3:03 pm WST) Full Moon (384,378 km)
Thu	7th	pm	Comet 71P/Clark 0.3°S of star Eta Sagittarii
Fri	8th		d.p. 1 Ceres 0.6°S of star Kappa Geminorum
Fri	8th	3 am	(1 am WST) m.p. 2 Pallas 0.1°E of star Zeta Eridani
Fri	8th	pm	m.p. 89 Julia 0.1°N of star Zeta Pegasi
Sat	9th	8 pm	(6 pm WST) Uranus 4° N of Moon
Sun	10th		Mercury at ascending node
Sun	10th	10 pm	(8 pm WST) star Regulus 0.6° N of Mercury
Sun	10th	pm	m.p. 10 Hygiea 0.5°S of NGC 6583 (OC) in Sagittarius
Mon	11th		Mercury 1.0°S of Leo 1 (G) in Leo
Tue	12th	8 pm	(6 pm WST) Mercury at greatest elongation West (17.9°)
Tue	12th	11 pm	(9 pm WST) star Aldebaran 0.4° S of Moon
Wed	13th	4:25 pm	(2:25 pm WST) Last Quarter Moon
Thu	14th	2 am	(Midnight WST, prev day) Moon at perigee, 369,860 km
Fri	15th		Mercury at perihelion
Sat	16th	3 am	(1 am WST) star Pollux 9° N of Moon
Sat	16th	8 am	(6 am WST) d.p. 1 Ceres 5° N of Moon
Sun	17th	4 am	(2 am WST) Mars 0.06° S of Mercury
Mon	18th	11 am	(9 am WST) Venus 0.6° N of Moon
Mon	18th	3 pm	(1 pm WST) star Regulus 0.09° S of Moon
Tue	19th	6 am	(4 am WST) Mars 0.1° S of Moon
Tue	19th	9 am	(7 am WST) Mercury 0.03° N of Moon
Tue	19th	pm	m.p. 40 Harmonia 1.0°S of M8 Lagoon Nebula (BN) in Sagittarius
Wed	20th		Venus 0.3°NW of Leo 1 (G) in Leo
Wed	20th		m.p. 6 Hebe 0.3°SW of star Xi Serpentis
Wed	20th	9 am	(7 am WST) star Regulus 0.5° S of Venus
Wed	20th	3:30 pm	(1:30 pm WST) New Moon
Thu	21st	pm	m.p. 40 Harmonia 0.5°S of NGC 6544 (GC) in Sagittarius
Fri	22nd	Noon	(10 am WST) star Spica 7° S of Moon
Fri	22nd	6 pm	(4 pm WST) Jupiter 4° S of Moon
Sat	23rd		m.p. 20 Massalia 0.9°N of M1 Crab Nebula (PN) in Taurus
Sat	23rd	6 am	(4 am WST) Equinox
Sat	23rd	pm	m.p. 40 Harmonia 0.4°N of NGC 6553 (GC) in Sagittarius
Sun	24th		Mercury 0.2°N of star Sigma Leonis
Sun	24th		m.p. 3 Juno 0.6°NE of NGC 6604 (OC) in Serpens
Sun	24th	pm	Comet 71P/Clark 1.1°N of NGC 6723 (GC) in Sagittarius
Mon	25th		m.p. 2 Pallas stationary
Mon	25th		Mercury at greatest latitude north
Tue	26th		Venus 1.0°NE of star Rho Leonis
Tue	26th	7 am	(5 am WST) star Antares 10° S of Moon
Wed	27th	Midnight	(10 pm WST) m.p. 4 Vesta in conjunction with Sun
Wed	27th	10 am	(8 am WST) Saturn 3° S of Moon
Wed	27th	5 pm	(3 pm WST) Moon at apogee, 404,348 km
Thu	28th		m.p. 3 Juno 0.2°SW of NGC 6625 (OC) in Scutum
Thu	28th		Pluto stationary
Thu	28th	12:54 pm	(10:54 am WST) First Quarter Moon
Fri	29th	1 pm	(11 am WST) d.p. Pluto 2° S of Moon

will be 51° with an azimuth of 25°, the Moon and Venus will be at an altitude of 42° and an azimuth of 346°. A pair of binoculars will be essential to detect the occulting pair from the bright sky. See Lunar occultation (pp 103-106) for timings for other capitals.

The **Earth** is at its spring equinox on the 23rd. The Sun will rise and set due east and west. Day and night will be approximately equal.

Mars reappears midmonth in the morning eastern dawn after a lengthy sojourn behind the Sun. Mercury and the Moon both have close encounters with the Red Planet as outlined in the Mercury paragraph, although difficult to observe (see Sky View). Venus, on its way back toward the Sun, ends up less than 4° from Mars at month's end and even closer in October for an outstanding conjunction.

Jupiter opens the month close to the 1st magnitude star Spica (Alpha Virginis) in the early western evening sky. From the 5th to 16th the planet and star will be 3° apart, a little closer than at the beginning of the year. On the 22nd, Jupiter will be near the slender crescent of the 2-day old waxing Moon (see Sky View). By month's end, the gas-giant is only visible low to the horizon prior to the end of astronomical dusk as it moves toward the Sun and conjunction next month.

Saturn, in Ophiuchus, appears high in the northwestern evening sky at the end of astronomical twilight. On the 14th, Saturn is at its eastern quadrature where the Sun-Earth-Saturn angle is 90°, this configuration of the three bodies is shown on the Orbital Aspects diagram p. 17. It is during quadrature that we see the maximum shadow of the planet cast onto the back of the rings, which helps give the planet a real 3-D look through a telescope. On the 27th the near First Quarter Moon will be in the ringed planet's vicinity (see Sky View).

Uranus comes to opposition next month, rising in the mid-evening eastern sky in Pisces near the border with Aries.

Neptune is at opposition on the 5th and is visible in the eastern sky after the end of astronomical twilight in Aquarius. Even at opposition, this distant outer world only appears as a bright 8th magnitude *star* in small telescopes. Instruments larger than 100 mm and moderate to high magnification will easily resolve the Solar System's most distant planet into a small bluish disc.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

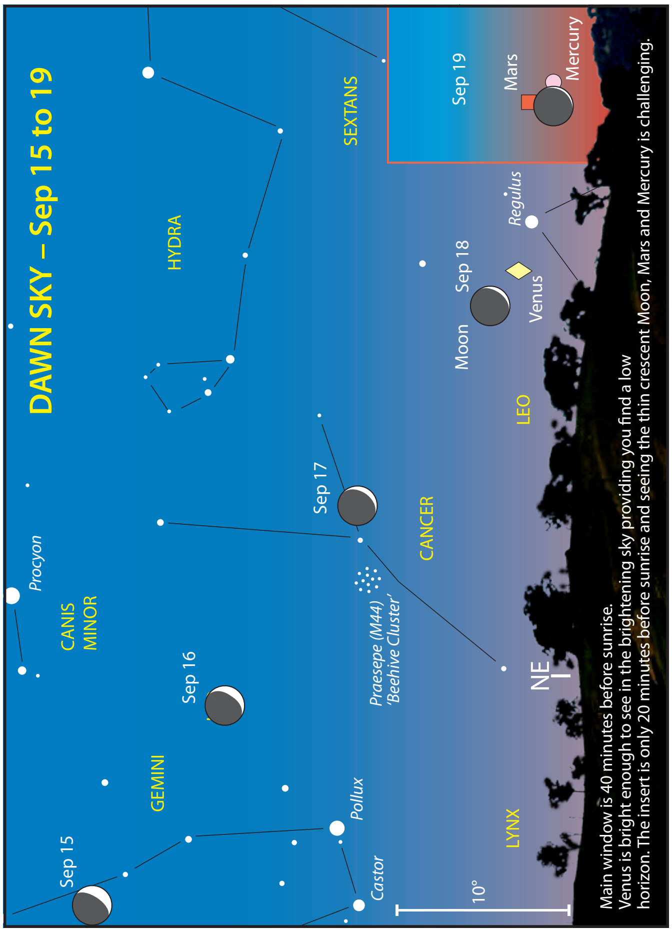
Dwarf Planet Pluto appears stationary on the 28th as it ends five months of retrograde motion. The icy dwarf is visible in the evening sky, crossing the meridian (is due north) around 7:30 pm, setting 2:30 am midmonth.

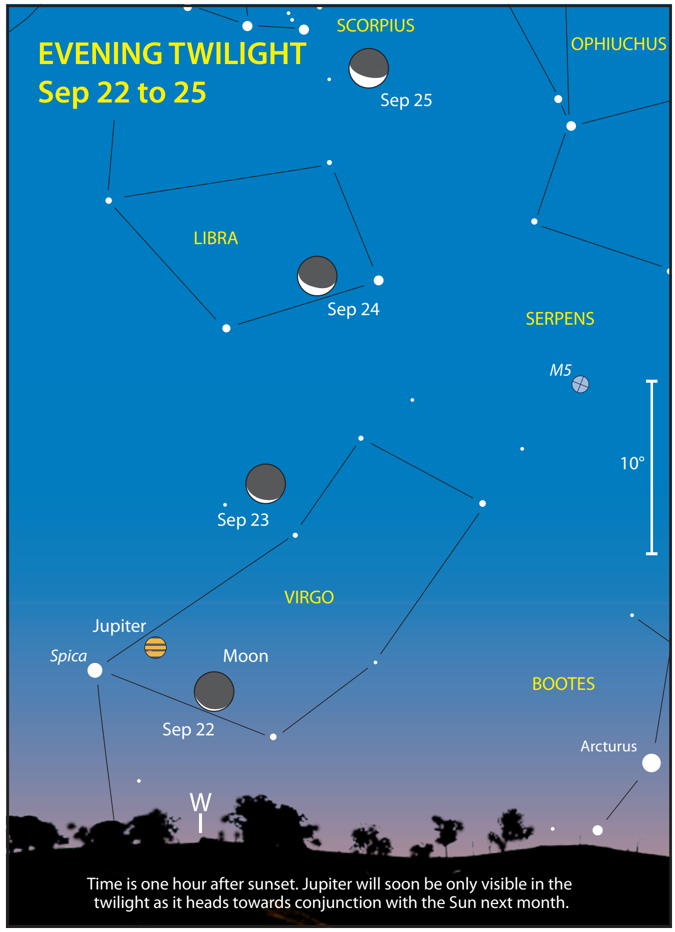
Minor Planets. The brighter minor planets reaching opposition this month include 89 Julia on 8th at magnitude 9.0 in Pegasus, 354 Eleonora on 11th at magnitude 10.8 in Aquarius and 107 Camilla on 13th at magnitude 12.0 near the Aquarius/Pisces border.

COMETS

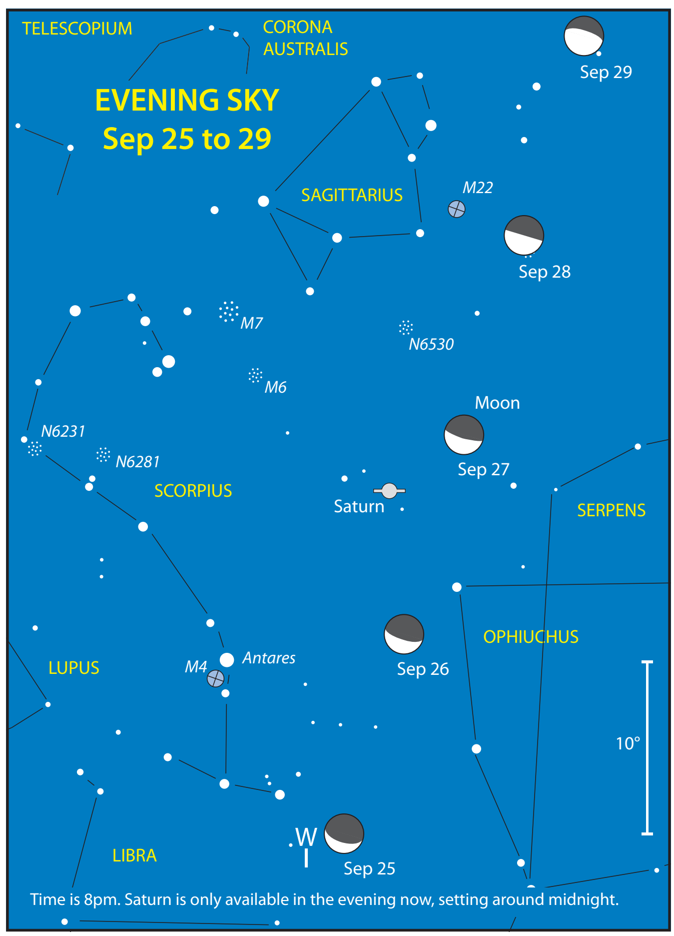
Comet C/2015 ER$_{61}$ (PANSTARRS) is in Taurus throughout September, rising by late evening by month's end. During the month, the comet should be around 12th magnitude.

Comet C/2015 V2 (Johnson) is predicted to fade from 9th to 10th magnitude this month. Setting around 1 am midmonth,





Approximate local standard time.



it is well placed to observe in the early evening. In mid September the comet moves from Lupus into Norma.

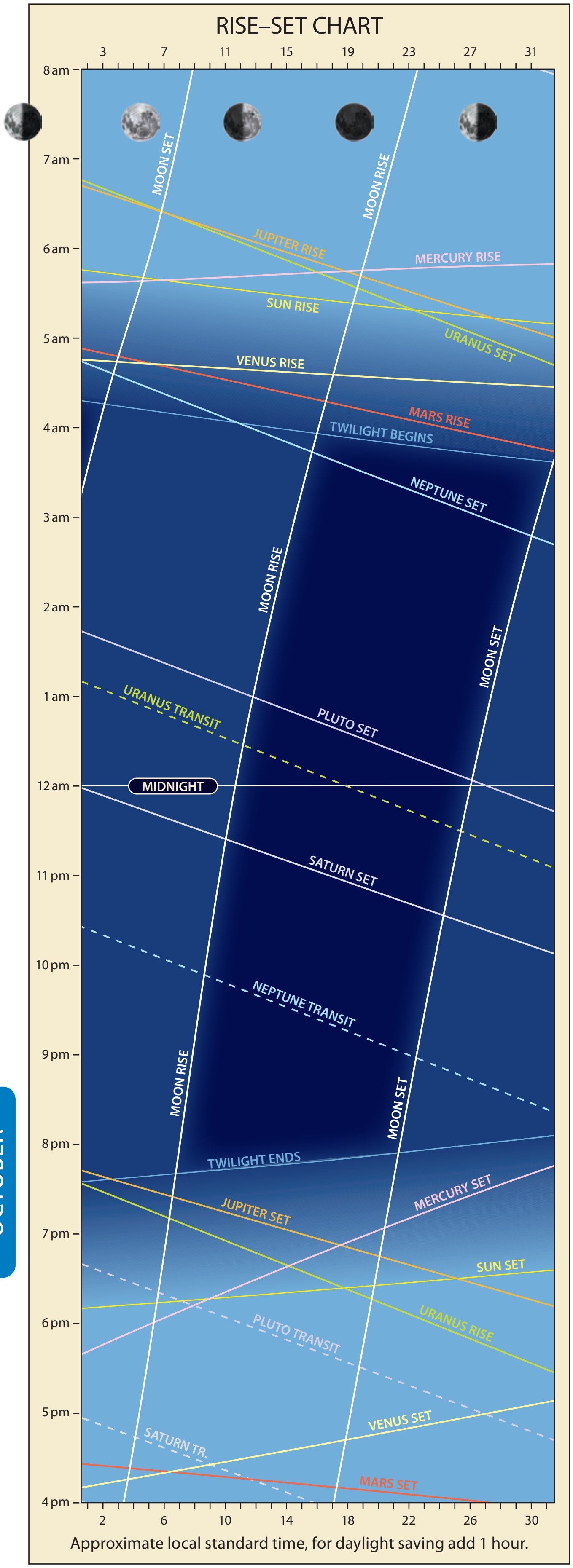
Comet 71P/Clark spends the first week of September in Corona Australis before moving into Sagittarius where it resides for the remainder of the month. Setting a few hours before dawn, the comet is expected to fade from 10th to 11th magnitude by month's end.

Comet 96P/Machholz 1. Up until the last week of the month the comet will be circumpolar for much of Australia. It is visible after the end of evening twilight and towards the end of September for only a brief period before dawn. The month opens with Machholz in Circinus, moving into Centaurus after the first week. It should brighten to 12th magnitude by month's end.

DOUBLE STARS

Located in Piscis Austrinus, the Southern Fish, **Beta Piscis Austrini** (All Sky Map 8) is another excellent double for small telescopes. The stars, magnitudes 4.3 and 7.1, are separated by 30.6 arcseconds. The stars appear pale yellow and white although some describe the companion as reddish. Common proper motion suggests a binary system. Beta Piscis Austrini is like Fomalhaut (its more famous neighbour) a white class A dwarf, but at A0 it is a bit hotter than its bright class A4 neighbour. It appears fainter because it is located at a much greater distance of 142 light years, more than five times that of Fomalhaut. Whilst in the area also check out nearby Dunlop 241 (1.3° northeast), a wide pair of stars magnitudes 5.9 and 7.6 separated by 93.4 arcseconds.

OCTOBER



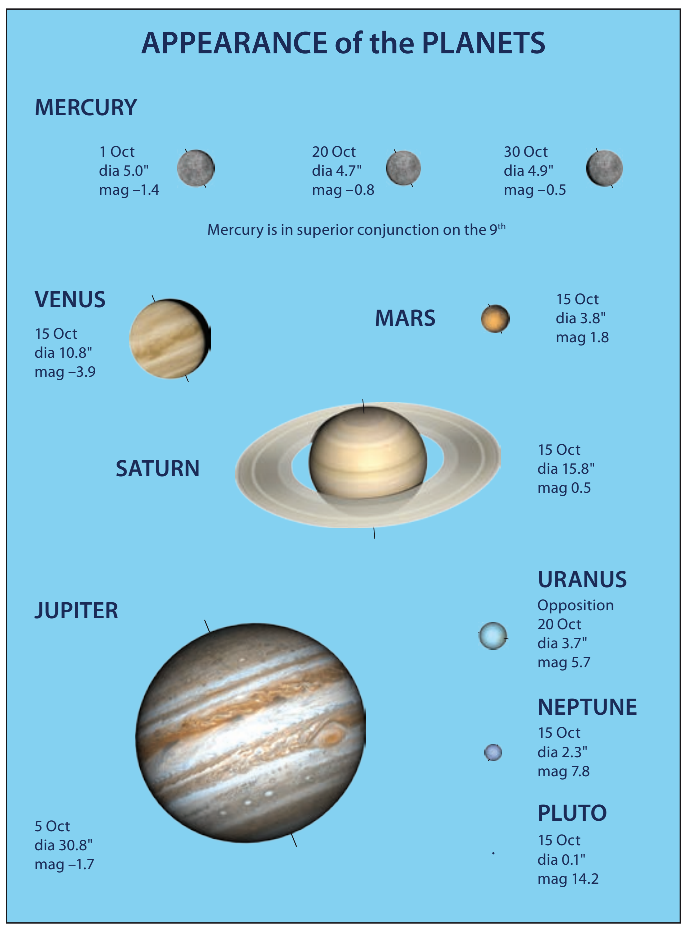
HIGHLIGHTS

- Venus and Mars very close.
- Uranus at opposition.
- Occultation of Neptune by the Moon.
- The Orionids Meteor Shower.

CONSTELLATIONS

The majority of constellations look nothing like the often legendary figures that mankind has assigned to them. For example, the northern evening sky is supposed to present an equestrian treat with two constellations related to horses, but you wouldn't know it. The more famous is Pegasus with its most recognisable feature being the body marked by the Great Square of Pegasus—All Sky Map 9. For us down under this winged creature is drawn standing upright. The square's top left (southwest) star is Alpha Pegasi or Markab in Arabic meaning shoulder or saddle of the horse. Moving 20° west (left) is Epsilon or Enif meaning the nose. Further westward lies Equuleus or the Little Horse—an obscure, small constellation representing just the head, with its most 'distinguishing' feature being a lowly 4th magnitude alpha star called Kitalpha, a contraction of 'part of a horse'.

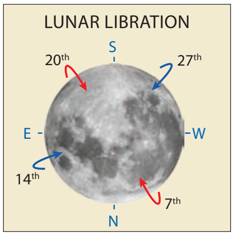
Above the square lies Pisces with its distinctive circlet of six 4th and 5th magnitude stars, however we struggle to see a fish in this! Continuing the trend and fishy theme, moving eastward (to the right) you enter the large constellation of Cetus (All Sky Map 2). Here's another circle (well… pentagon), which looks nothing like a whale's head. Although, the constellation was originally called 'the Sea Monster' and if you compare



its drawing in Bayer's Uranometria star atlas to this asterism it fits quite well with its dragon-like head and the curvature of the upper neck.

There is at least a clue to the placement of the modern 'whale' in its star names. The brightest member of the pentagon is 2.5 magnitude Alpha Ceti also known as Menkar with an original Arabic derivation meaning Nostril. Heading towards the bright star Fomalhaut, near Cetus's southern boundary with Sculptor, is a somewhat isolated 2.0 magnitude star, Beta Ceti also known as Deneb Kaitos. It translates to 'whale's tail'. While on the subject of distinctive objects in this otherwise unimpressive constellation, we would like to invent an asterism. Magnitude 3.5 Eta Ceti is the brightest and most eastern member of an obvious arc of four stars (0.7° across). The other members of this semi-circular shaped asterism are around 6th magnitude, making it ideal for binoculars. We call it the blowhole.

THE MOON



3rd 10 pm (8 pm WST) Occultation of Neptune by the Moon, visible from SE tip of Australia, New Zealand and SW Polynesia. See Neptune below.

6th 5 am (3 am WST) Full Moon.

7th 7 am (5 am WST) Maximum Libration (7.0°), bright NW limb. Too close to Full Moon.

9th 4 pm (2 pm WST) Moon at perigee (closest to Earth at 366,855 km).

10th 5 am (3 am WST) Occultation of Aldebaran by the Moon, visible from Central and NE Asia, Alaska and NW Canada.

12th 10 pm (8 pm WST) Last Quarter.

14th 7 am (5 am WST) Minimum Libration (4.6°), dark NE limb.

15th 9 pm (7 pm WST) Occultation of Regulus by the Moon, visible from N. America except Canada, most of Caribbean, Cape Verde and W Africa. From Australia, Regulus will be approximately 5° from the Moon shortly after it rises on the morning of 16th.

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

20th 8 pm (6 pm WST) Maximum Libration (7.6°), too close to New Moon.

25th Noon (10 am WST) Moon at apogee (furthest from Earth at 405,154 km).

27th 3 am (1 am WST) Minimum Libration (4.4°), dark SW limb.

28th 8 am (6 am WST) First Quarter.

31st 7 am (5 am WST) Occultation of Neptune by the Moon, visible from most of Antarctica and S tip of Africa.

Probing the Solar System (Part 1)

MARS

Opportunity is wrapping up exploration of Marathon Valley on the rim of Endeavour Crater. The long-lived rover is driving to an alternative hillside target after a climb on the steepest slope ever tackled by any Mars rover, its tilt hit 32 degrees but it could not quite get within reach of the target near the crest of Knudsen Ridge. Both the intended target and the current target area further west are on the hillside forming the southern edge of Marathon Valley, which slices east-west across the raised western rim of Endeavour Crater. Both targets are in areas where mineral-mapping observations by NASA's Mars Reconnaissance Orbiter have identified clay minerals, which form in the presence of water. Total odometry as of 15 August 2016 is 43.10 km. www.nasa.gov/mission_pages/mer/

Curiosity is now in its fifth year of exploring Mars. It is continuing to climb to progressively higher and younger strata on Mount Sharp, investigating how long the ancient, water-rich environments found so far persisted as Mars dried out. A recent extension to the program has operations planned until October 2018. mars.jpl.nasa.gov/msl/

In October 2016 ***Mars Express*** will act as a relay for the landing of ESO's Schiaparelli lander, part of the ExoMars Trace Gas Orbiter mission. www.esa.int/esaMI/Mars_Express/

More than ten years after launch, ***Mars Reconnaissance Orbiter*** still returns more data about Mars every week than all other Mars missions combined. New findings show that gullies on modern Mars are likely not being formed by flowing liquid water. mars.jpl.nasa.gov/mro/

Mars Odyssey, now in its 15th year of operation, continues to be the longest serving of the Martian missions. With its recent change of orbit, it is now concentrating on observing Mars in the early morning period. There is sufficient fuel for it to operate for several more years. mars.jpl.nasa.gov/odyssey/

MAVEN (Mars Atmosphere and Volatile EvolutioN) has returned significant measurements of solar wind erosion at Mars, observing ions in the upper atmosphere as they pick up energy from the electric field of the solar wind and escape to space. www.nasa.gov/mission_pages/maven/

Launched 14 March 2016 ***ExoMars Trace Gas Orbiter*** (TGO) is on route to Mars, arriving in October 2016. The first in a series of Mars missions to be undertaken jointly by ESA and Roscosmos. A key goal of this mission is to gain a better understanding of methane and other atmospheric gases that are present in small concentrations (less than 1% of the atmosphere) but nevertheless could be evidence for possible biological or geological activity. exploration.esa.int/mars/46475-trace-gas-orbiter/

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

JUPITER

Juno arrived at Jupiter on 4 July 2016 and as of 20 August is nearing the end of the first of two 58 day orbits and about to have its first close encounter with Jupiter with all its *science eyes* open. www.nasa.gov/juno/

… continued next month, page 69.

THE PLANETS

Mercury moves from the morning to the evening sky after superior conjunction (Earth and Mercury on opposite sides of the Sun) on the 9th. The best time to track the planet down is during the last week of the month when it is several degrees above the horizon at the end of civil dusk.

Venus, whilst still visible in the eastern morning sky, will be low to the horizon as civil dawn begins. Of particular interest this month will be the close conjunction of Venus and Mars when they are just 0.2° apart on the 6th, a fine visual sight made even better in binoculars or small telescope (see Sky View). A good horizon is needed to see the 28-day old waning crescent Moon just north (left) of the planet on the 18th (see Sky View).

Mars rises a little before civil dawn in the eastern morning sky. The planet spends the first half of October in Leo before moving into Virgo. From the 5th to 7th brilliant Venus will be less than 1° from Mars and closest on the 6th when they are just 0.2° apart (see Sky View). This is one of those conjunctions that may not be that spectacular visually until you train binoculars or a telescope on the pair. It is interesting to note that Venus is approximately 200 times brighter than Mars at this time.

Jupiter can only be seen at the beginning of the month low in the western dusk sky in Virgo. The planet will be in conjunction on the 27th and too close to the Sun for observation until its reappearance in the morning sky next month.

Saturn, setting around 11 pm midmonth, is located in Ophiuchus near the border of Sagittarius. On the 24th, the 4-day old waxing crescent Moon will be near the planet (see Sky View). October will be the last month that Saturn will be at a reasonable altitude for telescopic observation in the evening sky, as it heads towards conjunction with the Sun in December.

Uranus is at opposition on the 20th, rising in the early evening eastern sky in Pisces and visible the entire night. At 5.7 magnitude the planet is technically visible to the unaided eye, although you will need to be away from city lights (see our finder p. 128). It's a good idea to first use binoculars and star-hop or sweep from a known star. Any telescope under moderate magnification will reveal this greenish world as a disc, easily identifying it from the background stars. On the 28th, the main belt asteroid Themis returns to the planet's vicinity—this time at a distance of 0.4° and slightly brighter at 12th magnitude (see also July).

Neptune, in Aquarius, is now past opposition and transits the meridian (is due north) around 9 pm midmonth. On the 3rd, the 12-day old waxing gibbous Moon will occult the planet. The occultation will only be seen approximately south of a line drawn from the eastern most point of the NSW/Vic border to Cape Otway. From the rest of the continent the Moon will appear close to the planet, with a near miss from Melbourne. The occultation is visible from Tasmania (see Lunar Occultation Tables p. 105 for Hobart) and New Zealand. For the remainder of the year the planet never strays more than 0.6° from the 4th magnitude star Lambda Aquarii (Hydor).

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto, in Sagittarius, transits the meridian (due north) around 5:30 pm midmonth. Eris, in Cetus, is at opposition on the 16th. This 18.7 magnitude trans-Neptunian object, discovered in 2005, is three times the distance that Pluto is from the Sun. Apart from long period comets and spacecraft, Eris and its moon, Dysnomia, are currently one of the most distant natural objects in the Solar System.

DIARY

Tue	3rd		Venus at perihelion
Tue	3rd	10 pm	(8 pm WST) Neptune 0.8° N of Moon
Wed	4th	pm	Comet C/2015 V2 (Johnson) 0.4°SW of NGC 6152 (OC) in Norma
Thu	5th		Mars 0.5°SW of star Sigma Leonis
Thu	5th		Comet 62P/Tsuchinshan 1, 1.4°S of M44 Beehive Cluster (OC) in Cancer
Thu	5th	11 pm	(9 pm WST) Mars 0.2° S of Venus
Fri	6th		Venus 0.5°SE of star Sigma Leonis
Fri	6th		Comet 62P/Tsuchinshan 1, 0.4°W of star Delta Cancri
Fri	6th	4:40 am	(2:40 am WST) Full Moon (373,412 km)
Sat	7th		Neptune 0.6°SE of star Lambda Aquarii
Sat	7th		Mars at aphelion
Sat	7th	2 am	(Midnight WST, prev day) Uranus 4° N of Moon
Mon	9th	7 am	(5 am WST) Mercury in superior conjunction
Mon	9th	4 pm	(2 pm WST) Moon at perigee, 366,855 km
Tue	10th	5 am	(3 am WST) star Aldebaran 0.6° S of Moon
Tue	10th	pm	Comet C/2015 V2 (Johnson) 0.3°SW of NGC 6208 (OC) in Ara
Thu	12th		Venus 1.0°N of star Beta Virginis
Thu	12th	10:25 pm	(8:25 pm WST) Last Quarter Moon
Thu	12th	pm	m.p. 2 Pallas 0.7°W of NGC 1300 (G) in Eridanus
Fri	13th	8 am	(6 am WST) star Pollux 9° N of Moon
Sun	15th	3 am	(1 am WST) m.p. 8 Flora 0.1°NE of NGC 2304 (OC) in Gemini
Sun	15th	9 pm	(7 pm WST) star Regulus 0.2° S of Moon
Mon	16th		Comet 24P/Schaumasse 0.6°W of star Eta Leonis
Tue	17th	8 pm	(6 pm WST) Mars 1.8° S of Moon
Wed	18th	10 am	(8 am WST) Venus 2° S of Moon
Wed	18th	pm	m.p. 2 Pallas 1.0°SE of NGC 1232 (G) in Eridanus
Thu	19th		Venus 0.4°E of star Eta Virginis
Thu	19th		Mars 0.5°NE of star Beta Virginis
Thu	19th		Mercury at descending node
Thu	19th	am	m.p. 20 Massalia 0.5°S of NGC 2129 (OC) in Gemini
Fri	20th	4 am	(2 am WST) Uranus at opposition
Fri	20th	5:12 am	(3:12 am WST) New Moon
Sun	22nd	10 pm	(8 pm WST) Comet C/2015 V2 (Johnson) 0.1°W of star Beta Arae
Mon	23rd		Venus 1.2°S of star Gamma Virginis
Mon	23rd	3 pm	(1 pm WST) star Antares 10° S of Moon
Tue	24th		Venus at greatest latitude north
Tue	24th	am	m.p. 20 Massalia 0.5°S of star 1 Geminorum
Tue	24th	10 pm	(8 pm WST) Saturn 3° S of Moon
Wed	25th		Venus 0.3°SE of NGC 4691 (G) in Virgo
Wed	25th		Comet 24P/Schaumasse 0.6°N of NGC 3338 (G) in Leo
Wed	25th	Noon	(10 am WST) Moon at apogee, 405,154 km
Thu	26th		Comet 24P/Schaumasse 0.5°W of NGC 3377 (G) in Leo
Thu	26th	9 pm	(7 pm WST) d.p. Pluto 2° S of Moon
Fri	27th		Comet 24P/Schaumasse 0.5°NW of NGC 3412 (G) in Leo
Fri	27th	4 am	(2 am WST) Jupiter in conjunction with Sun
Sat	28th	8:22 am	(6:22 am WST) First Quarter Moon
Sun	29th		Mercury at aphelion
Sun	29th	10 am	(8 am WST) m.p. 2 Pallas at opposition
Sun	29th	pm	m.p. 2 Pallas 0.9°SE of star Tau 3 Eridani
Mon	30th	pm	m.p. 44 Nysa 1.0°S of star Mu Ceti
Tue	31st		Mars 0.2°SW of star Eta Virginis
Tue	31st	7 am	(5 am WST) Neptune 0.9° N of Moon

Minor Planets. Two of the brighter minor planets reach opposition this month in Pisces, 24 Themis on 19th at magnitude 11.5 and 64 Angelina on 21st at magnitude 11.1. Others at opposition include 704 Interamnia on 1st at magnitude 9.9 in Pegasus, 7 Iris on 30th at magnitude 6.9 in Aries, 71 Niobe on 6th at magnitude 12.0 near the Pegasus/ Andromeda border and 2 Pallas on 29th at magnitude 8.2 near the Fornax/Eridanus border.

COMETS

Comet C/2015 ER$_{61}$ (PANSTARRS) is expected to fade from 12th to 13th magnitude this month. Rising mid-evening, PANSTARRS resides in Taurus until late October when it moves into Aries.

Comet 96P/Machholz 1 may be visible briefly in the evening during the first half of October. Brightening from 12th to 9th magnitude by midmonth, when it is setting at the end of evening twilight, Machholz 1 is in Centaurus where it remains until late October, shortly before reaching perihelion on the 27th.

Comet 62P/Tsuchinshan 1 should brighten from 13th to 12th magnitude this month. Rising in the morning sky just over an hour before dawn, Tsuchinshan 1 moves through the constellations of Cancer then Leo.

Comet 71P/Clark is predicted to fade from 11th to 12th magnitude during October. In Sagittarius throughout the month, the comet is setting around 2 am.

Comet C/2015 V2 (Johnson) begins October in Norma, setting around 2 am. As the month progresses, the comet continues its passage south, moving into Ara on the 6th. By month's end it will be circumpolar for much of Australia and visible throughout the night. During October Johnston is likely to fade from 10th to 11th magnitude.

METEOR SHOWERS

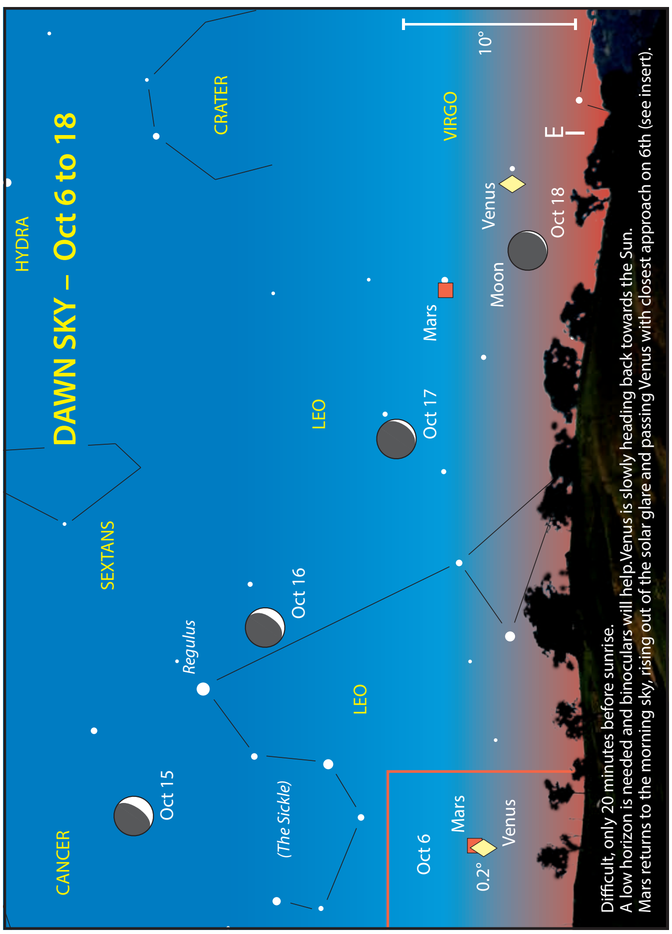
With New Moon on the 20th, both the following showers will be Moon-free for their peak activity.

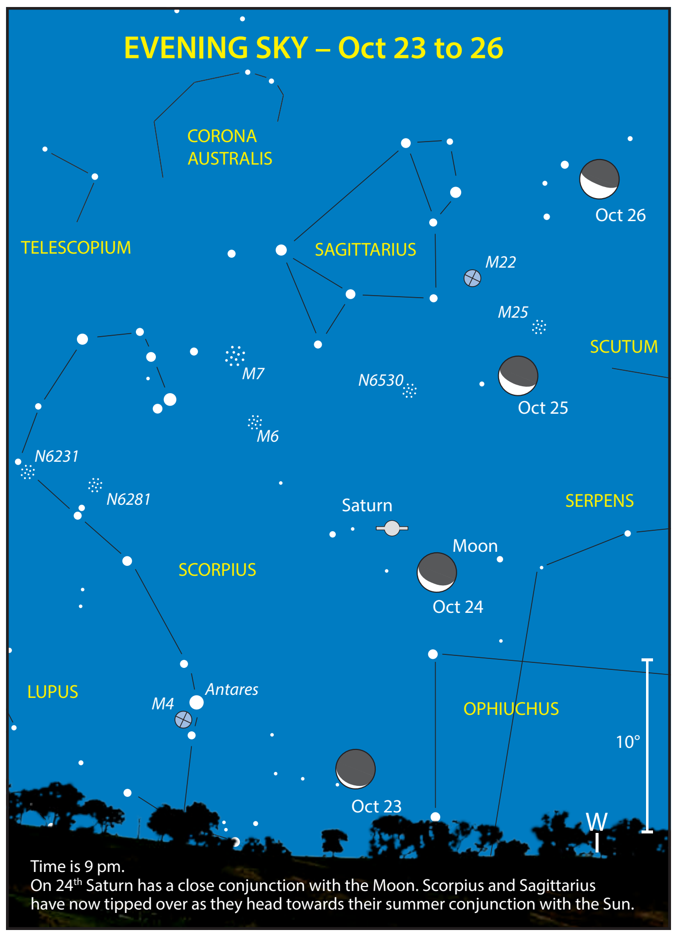
The **epsilon-Geminids** are a weak minor shower that is active from 14th to 27th with maximum on the 18th, a low hourly rate of 3 can be expected. As this shower is near the Orionids that are active at the same time, it may be difficult to distinguish them.

The **Orionids** are best seen from late evening until dawn and are visible from 2 October through to 7 November. Maximum activity is expected around the 21st, but with many sub-maxima, good rates can be observed on several consecutive nights around this date. The Orionids provide a prominent display that has, over the past twenty years produced rates of 14 to 31 meteors per hour. Both 2006 and 2007 were strong, with zenith hourly rates better than the normal peak seen on two or three consecutive nights, at best 50–70. The Orionids are typically very swift and often bright, with some leaving trains. The shower was first recorded by Chinese observers in 288 AD, and is associated with Halley's Comet.

DOUBLE STARS

Located in the far southern circumpolar constellation of Tucana, the Toucan, is the very unequal pair **Delta Tucanae** (All Sky Map 1). The stars, magnitudes 4.5 and 8.7, are separated by 7.0 arcseconds. The companion, located to the west, has a reddish hue compared to the bright white primary. Little has changed since the measurements taken in 1835 and similar proper motion suggests a long period binary. The system is located 267 light years away.

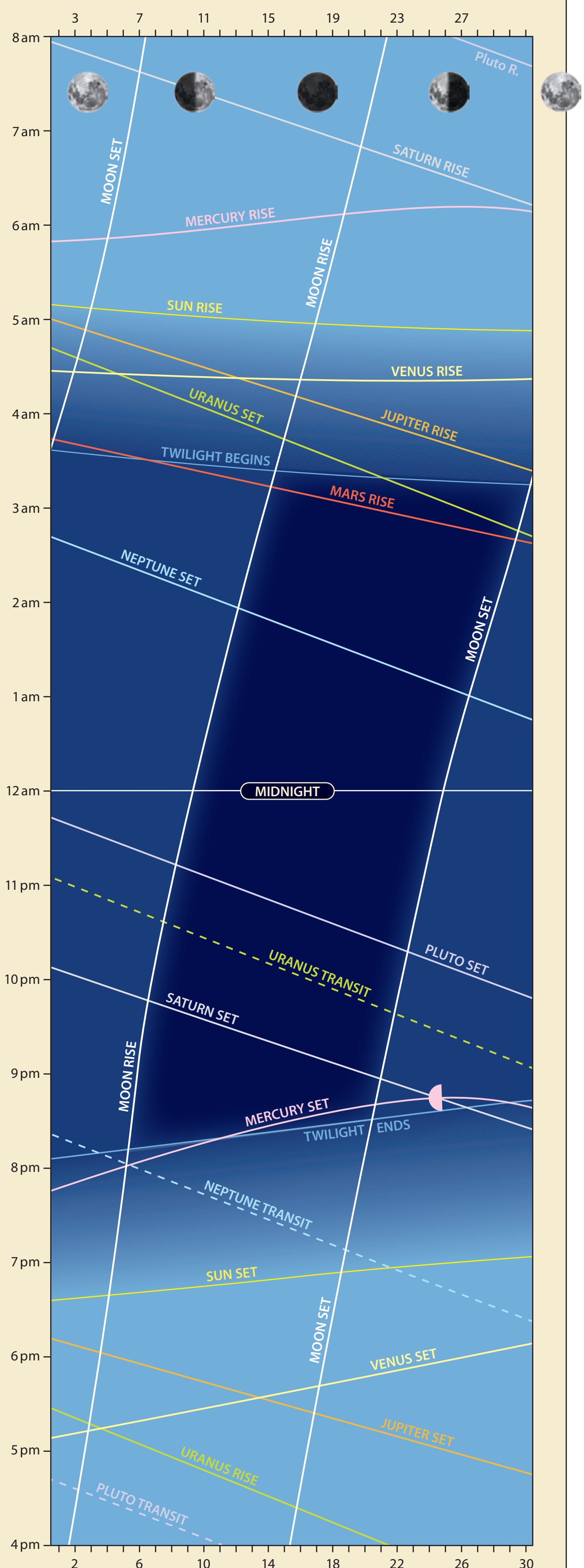




Approximate local standard time, for daylight saving add one hour.

NOVEMBER

RISE–SET CHART



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

HIGHLIGHTS

- Mercury and Saturn close.
- Venus and Jupiter close.
- Leonid meteor shower.

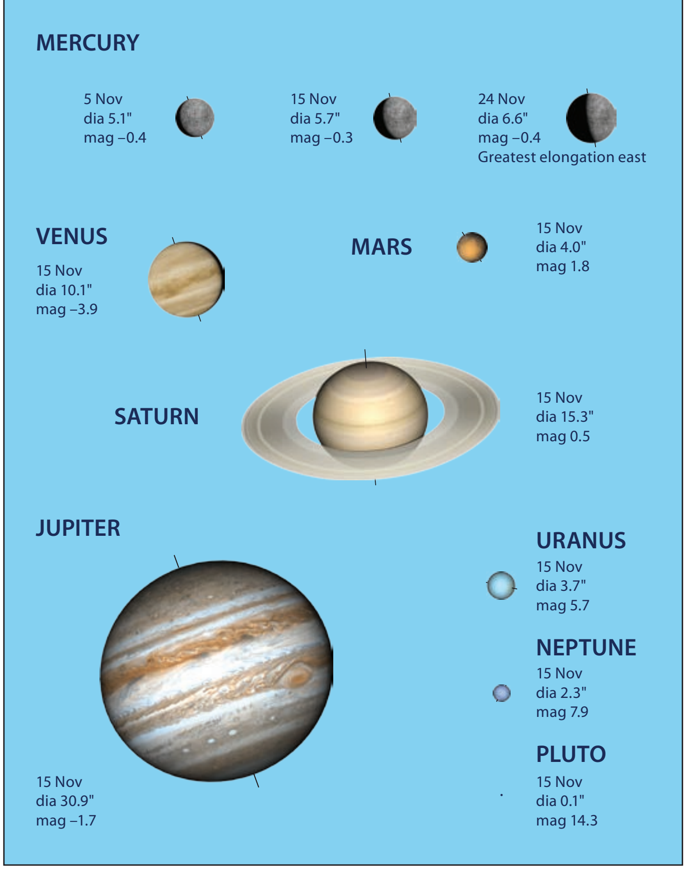
CONSTELLATIONS

In May Constellations we described how the southern Milky Way was high in the southern evening sky with the north giving a great view above the plane of our galaxy. It is not surprising that six months later the reverse has happened, with the Milky Way now low, revealing the Universe below (south) of our galaxy. In fact, if you choose the right time and latitude the galactic equator coincides with the horizon, so given an absence of trees or hills you can find the Milky Way hugging the horizon forming an almost uninterrupted ring around you! An example would be mid-November around 9 pm EST from Brisbane. At this time/place the south galactic pole, which is in the constellation of Sculptor (All Sky Map 2), would be at the zenith (overhead). As you head further south in Australia, you'll start to lose a bit from the far north, but it is still impressive. The visible 'band' around Perseus and adjoining Cassiopeia is pretty thin anyway.

As you look higher in the sky (higher galactic latitude) fewer stars are seen. In fact, the bright stars of Fomalhaut (All Sky Map 8) and Achernar (All Sky Map 2) almost look out of place. This is just because they are nearby galactically speaking, being only 25 and 143 light years away respectively.

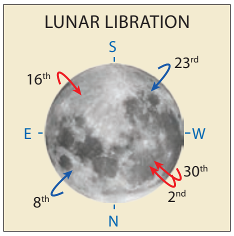
The local group of galaxies, which has over 50 members, is approximately 10 million light years in diameter with its centre between Andromeda and the Milky Way. Most of them

APPEARANCE of the PLANETS



are nearby, low mass, low luminosity dwarf galaxies and difficult to see (big and faint). However, we are fortunate to have all the brightest members on the south side of the Milky Way and on display in the evening. Besides our home galaxy the next three brightest members are clearly visible to the naked eye under dark skies. The Small and Large Magellanic Clouds (All Sky Map 1) are high in the south and southeast respectively and low in the north dwells the Andromeda Galaxy (M31)—All Sky Map 3. Using binoculars you can add NGC 253 in Sculptor, All Sky Map 8 (near the zenith hence passing overhead) and M33 in Triangulum (near M31)—All Sky Map 3.

THE MOON



- 2nd 1 pm (11 am WST) Maximum Libration (7.9°), dark NW limb. Northern region around the 133 km crater Pythagoras, with its double central mountain, at best.
- 4th 3 pm (1 pm WST) Full Moon.
- 6th 1 pm (11 am WST) Occultation of Aldebaran by the Moon, visible from North America except westernmost part, N Europe and NW Asia.
- 6th 10 am (8 am WST) Moon at perigee (closest to Earth at 361,438 km).
- 8th 10 pm (8 pm WST) Minimum Libration (5.4°), dark NE limb.
- 11th 7 am (5 am WST) Last Quarter.
- 12th 3 am (1 am WST) Occultation of Regulus by the Moon, visible from Japan, E Asia, SW North America and Central America.
- 16th 10 am (8 am WST) Maximum Libration (8.0°), too close to New Moon.
- 16th 7 pm (5 pm WST) Occultation of minor planet Vesta by the Moon, visible from E Brazil, and SW Africa.
- 18th 10 pm (8 pm WST) New Moon.
- 22nd 5 am (3 am WST) Moon at apogee (furthest from Earth at 406,132 km).
- 23rd 11 am (9 am WST) Minimum Libration (4.0°), dark SW limb.
- 27th 3 am (1 am WST) First Quarter.
- 27th 3 pm (1 pm WST) Occultation of Neptune by the Moon, visible from West and Central Antarctica.
- 30th 5 am (3 am WST) Maximum Libration (9.1°), dark NW limb. Dark limb event therefore no libration features brought into view. Its effects can be seen as the eastern Mare (Crisium and Fecunditatis) are as close to the eastern limb as they can be.

THE PLANETS

Mercury, in the early western evening sky, reaches its greatest elongation (22°) east of the Sun on the 24th, providing a favourable opportunity to view the speedy little planet in the late twilight. On the 13th, Mercury will be 2° north (right) of the 1st magnitude star Antares (Alpha Scorpii), at this time the planet will be the brighter of the two. From the 25th until month's end Mercury and Saturn appear less than 4° apart. The innermost planet is only slightly brighter than the gas giant at this time but can easily be identified as the *star* to the south (left) of Saturn (see Sky View). During November, Mercury visits a few globular clusters in Scorpius and Ophiuchus. As with most conjunctions with Mercury they are challenging, being in twilight and close to the horizon.

Venus is only visible in the eastern morning sky for a short period before sunrise. For those desperate souls that would do anything for a good conjunction, Venus and Jupiter will be less than 1° apart on the 13th and 14th. However, you will need to view them just prior to sunup, when they are only a few degrees above the horizon (see Sky View). **Warning! The planetary pair are around 13° from the Sun and we do not recommend following them into the daylight after sunrise.**

Probing the Solar System (Part 2)

SATURN

After almost 20 years in space, 13 of them orbiting Saturn, the ***Cassini*** mission will end on 15 September 2017 at 10:07 pm EST. Beginning 30 November 2016, Cassini will repeatedly climb high above Saturn's north pole, then descend to a point just outside the narrow F ring (the edge of the main rings), completing 22 such orbits. Then, on 22 April 2017, Cassini will leap over the rings to begin its final series of daring dives between the planet and the inner edge of the rings. After 22 of these orbits, the spacecraft will enter the upper atmosphere of Saturn, where it will burn up, ending the epic mission to the Saturn system. saturn.jpl.nasa.gov

DWARF PLANETS

In July 2015, the ***New Horizons*** probe made its much anticipated flyby of Pluto and Charon. It is still returning encounter data to Earth, completion is expected by December 2016. The probe is still enroute to Kuiper Belt Object 2014 MU69, scheduled for arrival January 2019. pluto.jhuapl.edu

The ***Dawn*** space probe, having completed its primary mission in June 2016, is now operating an extended mission collecting new Ceres data as it orbits the dwarf planet every 5.4 hours at an altitude of 385 km. Consideration was given to moving on to a third asteroid, Adeona, but the final decision was to remain at Ceres for further observations. dawn.jpl.nasa.gov

COMETS

Two years have passed since **Rosetta** arrived at Comet 67P/Churyumov-Gerasimenko on 6 August 2014. During that time Rosetta has mapped the comet's curious shape and given us awe-inspiring views from near and far, spotting changes in its surface features and watching as jets of gas and dust stream out in to space. With Rosetta still flying alongside, the comet is now heading back towards the outer Solar System. Power is falling, and Rosetta's mission will soon conclude in a controlled impact onto the surface of the comet on 30 September 2016. www.esa.int/SPECIALS/Rosetta/

MINOR PLANETS

The OSIRIS-REx (Origins Spectral Interpretation Resource Identification Security—Regolith Explorer) spacecraft will travel to a near-Earth asteroid, Bennu, and bring a small sample back to Earth for study. Successfully launched in September 2016, it should reach its target in 2018 and return a sample to Earth in 2023. www.nasa.gov/osiris-rex

DIARY			
Thu	2nd		Comet 24P/Schaumasse 0.7°S of NGC 3593 (G) in Leo
Thu	2nd	1 am	(11 pm WST, prev day) star Spica 4° S of Venus
Fri	3rd		Comet 24P/Schaumasse 1.2°S of M66 (SG) in Leo
Fri	3rd		Comet 24P/Schaumasse 1.2°S of M65 (SG) in Leo
Fri	3rd	11 am	(9 am WST) Uranus 4° N of Moon
Fri	3rd	7 pm	(5 pm WST) m.p. 4 Vesta 4° N of Venus
Sat	4th	3:23 pm	(1:23 pm WST) Full Moon (364,002 km)
Sun	5th		Comet 24P/Schaumasse 0.9°NE of star Iota Leonis
Sun	5th	pm	m.p. 2 Pallas 0.9°NW of NGC 1201 (G) in Fornax
Mon	6th	10 am	(8 am WST) Moon at perigee, 361,438 km
Mon	6th	1 pm	(11 am WST) star Aldebaran 0.8° S of Moon
Tue	7th		Mercury 0.6°W of star Delta Scorpii
Wed	8th	pm	m.p. 7 Iris 1.0°SE of star Beta Arietis
Thu	9th	2 pm	(Noon WST) star Pollux 9° N of Moon
Fri	10th		Mercury 0.6°SW of M80 (GC) in Scorpius
Fri	10th		Comet 62P/Tsuchinshan 1, 0.8°N of M95 (SG) in Leo
Fri	10th	pm	m.p. 7 Iris 0.9°NW of NGC 772 (G) in Aries
Sat	11th		Comet 62P/Tsuchinshan 1, 0.6°NE of M96 (SG) in Leo
Sat	11th		Comet 62P/Tsuchinshan 1, 0.2°S of M105 (EG) in Leo
Sat	11th		Comet 71P/Clark 0.7°S of star Omega Capricorni
Sat	11th	6:36 am	(4:36 am WST) Last Quarter Moon
Sun	12th		Mercury 0.8°SE of star Rho Ophiuchi
Sun	12th		Mars 0.6°S of NGC 4691 (G) in Virgo
Sun	12th	3 am	(1 am WST) star Regulus 0.5° S of Moon
Mon	13th	1 am	(11 pm WST, prev day) star Antares 2° S of Mercury
Tue	14th	pm	m.p. 7 Iris 0.3°SE of star Gamma Arietis
Wed	15th		d.p. Pluto 0.2°N of star HD179609
Wed	15th		Comet 24P/Schaumasse 0.6°S of star Omicron Virginis
Wed	15th	11 am	(9 am WST) Mars 3° S of Moon
Thu	16th	2 am	(Midnight WST, prev day) star Spica 7° S of Moon
Thu	16th	7 pm	(5 pm WST) m.p. 4 Vesta 0.4° N of Moon
Fri	17th	7 am	(5 am WST) Jupiter 4° S of Moon
Fri	17th	pm	m.p. 44 Nysa 0.7°S of star Xi 2 Ceti
Sat	18th		Mercury 0.7°SW of NGC 6284 (GC) in Ophiuchus
Sat	18th		Mercury 0.9°N of M19 (GC) in Ophiuchus
Sat	18th		Mercury at greatest latitude south
Sat	18th	9:42 pm	(7:42 pm WST) New Moon
Sun	19th		Mars 0.2°W of NGC 4941 (G) in Virgo
Mon	20th		Venus 0.8°N of star Alpha 1 Librae
Mon	20th		Comet 24P/Schaumasse 0.7°S of NGC 4365 (G) in Virgo
Mon	20th	7 pm	(5 pm WST) Mercury 7° S of Moon
Tue	21st	10 am	(8 am WST) Saturn 3° S of Moon
Wed	22nd		Mercury 0.8°SE of star Theta Ophiuchi
Wed	22nd		Mercury 0.7°N of NGC 6355 (GC) in Ophiuchus
Wed	22nd		Comet 62P/Tsuchinshan 1, 0.3°S of star Iota Leonis
Wed	22nd	5 am	(3 am WST) Moon at apogee, 406,132 km
Thu	23rd	6 am	(4 am WST) d.p. Pluto 2° S of Moon
Thu	23rd	7 am	(5 am WST) Neptune stationary
Thu	23rd	11 am	(9 am WST) m.p. 3 Juno 5° N of Moon
Fri	24th	10 am	(8 am WST) Mercury at greatest elongation East (22.0°)
Fri	24th	pm	Comet C/2015 V2 (Johnson) 0.2°W of NGC 6753 (G) in Pavo
Sun	26th	pm	m.p. 2 Pallas 0.8°N of NGC 1079 (G) in Fornax
Mon	27th		m.p. 89 Julia 0.5°N of star Zeta Pegasi
Mon	27th	3:03 am	(1:03 am WST) First Quarter Moon
Mon	27th	3 pm	(1 pm WST) Neptune 1.2° N of Moon
Tue	28th	10 am	(8 am WST) star Spica 3° S of Mars
Tue	28th	7 pm	(5 pm WST) Saturn 3° N of Mercury
Wed	29th		Comet 24P/Schaumasse 0.5°NE of star Delta Virginis
Thu	30th	8 pm	(6 pm WST) Uranus 4° N of Moon

Mars, low to the horizon, wanders through Virgo in the pre-dawn eastern morning sky during November. At month's end the Red Planet will be around 3° to the lower left of Virgo's alpha star, Spica—Mars will be a little fainter than the star at this time (see Sky View).

Jupiter reappears in the eastern dawn sky midmonth after its conjunction with the Sun late in October. Whilst hidden from view the gas giant moved from Virgo, its home of the past 15 months, into Libra. Jupiter and Venus appear close on the 13th and 14th (see Sky View). Unfortunately the conjunction occurs just prior to sunrise when the planets are low to the horizon (see Venus for details)—unlike the spectacular pairing of the two in August 2016.

Saturn moves from Ophiuchus into Sagittarius midmonth, its low altitude in the western sky at the end of astronomical dusk essentially rules out anything but the unaided eye or binocular view. On the 21st, the 3-day old waxing crescent Moon will be above and to the north (right) of the planet (see Sky View). By month's end Saturn will only be visible in the brightening twilight.

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

Neptune is high in the early northwestern evening sky at the end of astronomical dusk midmonth, in Aquarius. The planet remains within 0.6° of the 4th magnitude star Lambda Aquarii (Hydor) as it comes to the end of five months in retrograde on the 23rd.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet. Pluto, in the western evening sky in Sagittarius, sets around 10:30 pm midmonth.

Minor Planets. The brighter minor planets reaching opposition this month include 532 Herculina on 2nd at magnitude 10.4 in Eridanus, 44 Nysa on 3rd at magnitude 9.6 in Cetus, 42 Isis on 17th at magnitude 10.4 in Taurus and 48 Doris on 8th at magnitude 10.9 near the Aries/Cetus border. In November, 7 Iris passes by the bright stars of Gamma and Beta Arietis (see diary)

COMETS

Comet C/2015 V2 (Johnson) is visible throughout the night in November. It makes its way through the constellations of Ara and Telescopium finishing the month in Pavo. The comet is predicted to fade from 11th to 12th magnitude.

Comet 62P/Tsuchinshan 1 reaches perihelion this month, at 1.38 au from the Sun on the 16th. Located in Leo for all but the last few days of November, when it moves into Virgo, the comet is rising a little over an hour before dawn and should remain around 11th magnitude. On the mornings of 2nd it is 3° below Regulus and on the 10th and 11th visits the galaxy trio of M95, M96 and M105 in Leo (see diary).

METEOR SHOWERS

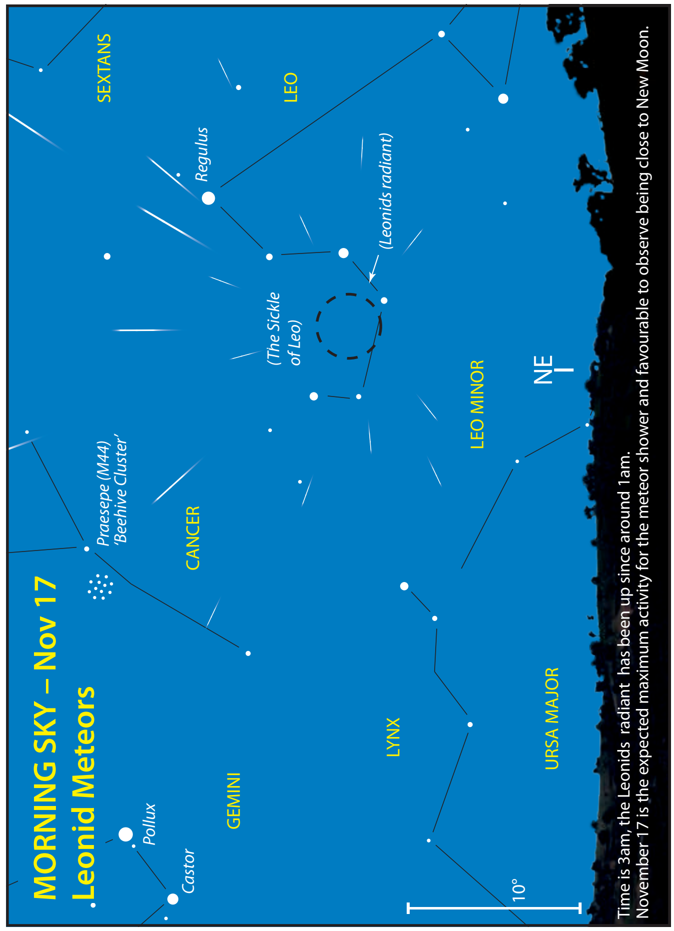
Both showers listed this month will be Moon free during their expected peaks.

The **Leonids**, after a storm of unbelievable intensity in 1833, were responsible for the change in scientists' attitudes that meteors were not purely an atmospheric event. The shower is associated with the periodic comet 55P/Tempel-Tuttle and is best about every 33 years when the comet returns to perihelion. The Leonids are active from the 6th to the 30th, with maximum on the morning of the 17th (see Sky View). Between 1998 and 2002, the Leonids put on spectacular displays, and since then activity has been variable from year to year. Early predictions for 2017 are indicating a zenith hourly rate of around 10, although it is still early days and this could well change. We would encourage observers to be on the lookout for updates nearer the time of the shower as this is not one to be missed if active.

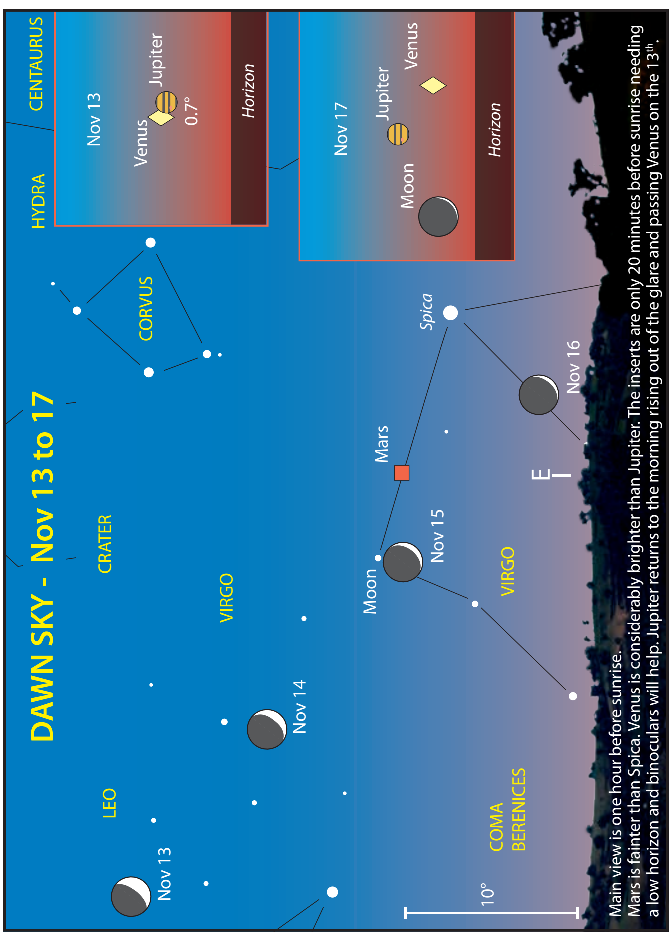
The **Alpha-Monocerotids** is a minor shower, with unusual short-lived outbursts. Active from 15th to 25th, they are expected to peak around the 21st and are best seen after midnight. While the zenith hourly rate is variable, high rates were seen in the years 1925, 1935, 1985 and 1995. The 1995 rate reached an estimated 420, and lasted just 5 minutes, the entire shower was over in 30 minutes. The unpredictability of the Alpha-Monocerotids could produce a surprise at any return and reward the patient observer.

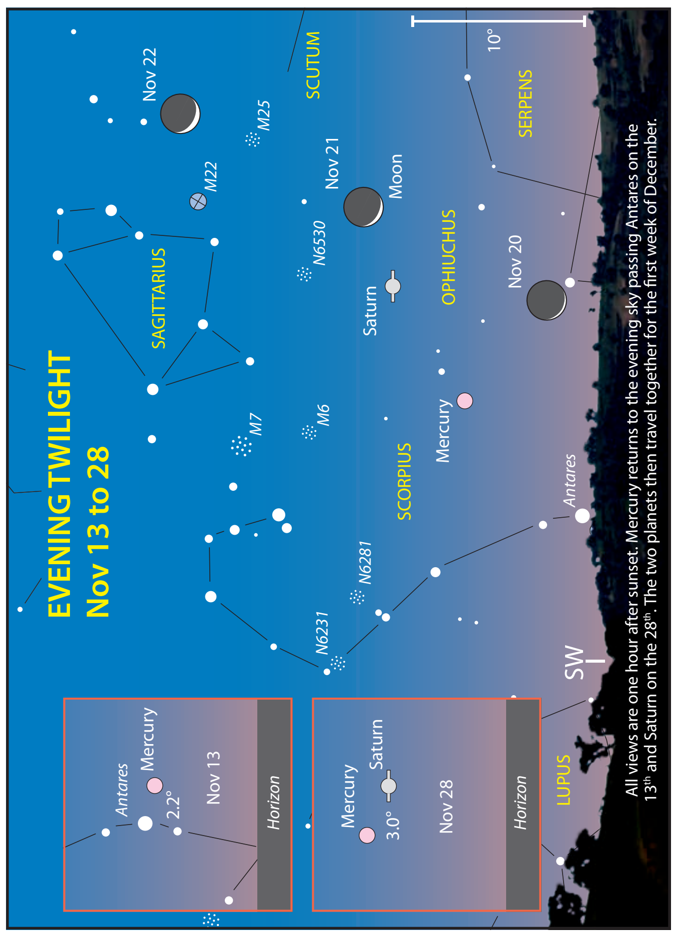
DOUBLE STARS

This month's double star is the attractive, but little known pair **32 Eridani** (All Sky Map 2), located in the fainter reaches of the large constellation of Eridanus, the river, just to the west of Orion and to the south of the Hyades. The stars, magnitudes 4.8 and 5.9, are separated by 6.9 arcseconds and have been described as topaz-yellow and greenish.



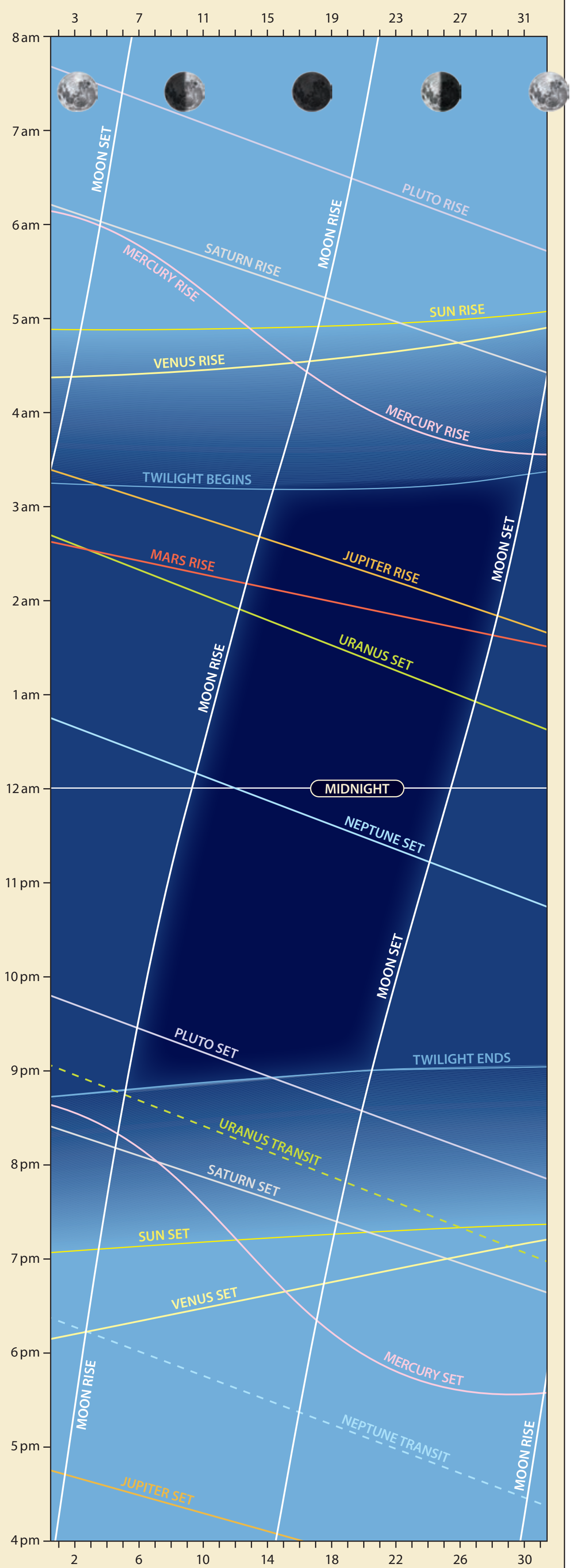
Approximate local standard time, for daylight saving add one hour.





DECEMBER

RISE–SET CHART



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

HIGHLIGHTS

- Mars and Jupiter becoming close.
- The Geminids meteor shower

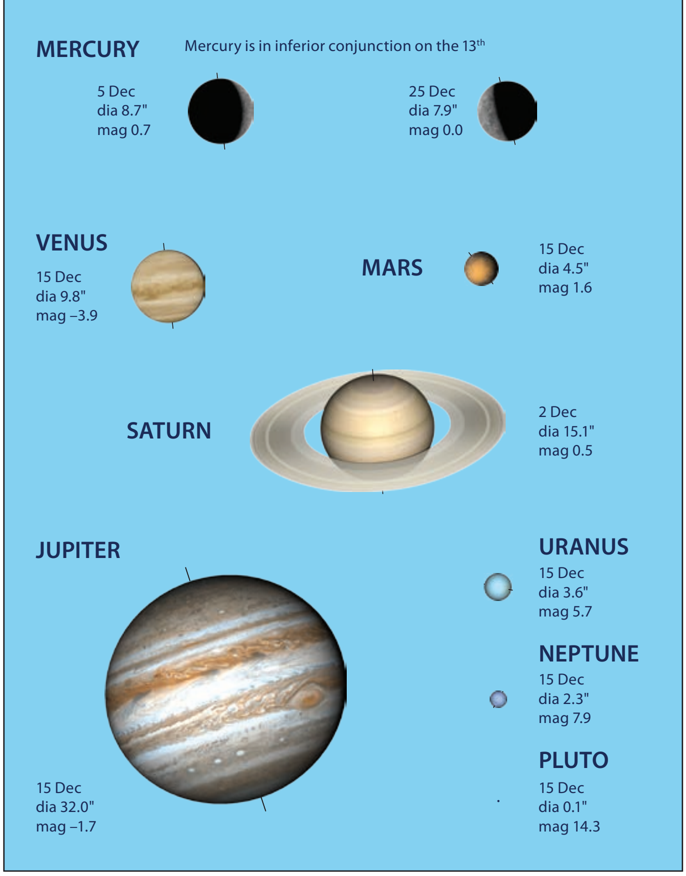
CONSTELLATIONS

Sitting on the northern evening horizon is Perseus (All Sky Map 3). Under dark skies its main stars resemble a lower case 'y'. The constellation marks the northwestern extreme of the Milky Way easily visible from anywhere on the mainland. As mentioned in November Constellations, people from mid to low latitudes down under can just see our galaxy as a full circle.

Perseus is referred to as 'the Rescuer of Andromeda'. He is indeed placed in the heavens adjacent to (the right of) this maiden's constellation who is shown lying down and chained to the rocks.

The celestial connection to Perseus goes much further. Andromeda is linked to Pegasus by the bright star Alpheratz, which is part of the Great Square of Pegasus now getting low in the northwest. Perseus was riding this flying horse when he swooped in and slayed Cetus (All Sky Map 2), which was threatening to kill Andromeda. Cetus is high in the north (also see October Constellations). Perseus killed Cetus by turning it to stone with the head of the Gorgon Medusa, who he had previously slain. The representation in the sky sees this hero holding the head by the hair in his left hand. It is interesting to note one of Medusa's eyes is occupied by Beta Persei, also known as Algol, which is derived from an Arabic phrase meaning 'head of the ghoul'. The star has a long history of being associated with evil, sometimes called the Demon

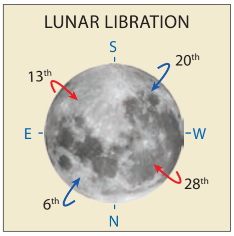
APPEARANCE of the PLANETS



Star, not because of the mythology but because the ancients couldn't explain its periodic changing in brightness and colour. Today we know it as the most famous example of an eclipsing binary as its fainter orange companion star partially eclipses the hot blue primary every 2.9 days. Anyone can watch this normally constant magnitude 2.1 star drop to 3.4 and recover over a period of 10 hours.

THE MOON

- 3rd 11 pm (9 pm WST) Occultation of Aldebaran by the Moon, visible from Central and N Asia, N Greenland and NW North America.
- 4th 2 am (midnight previous day WST) Full Moon. Astrologers also call this a Super Moon as the Full Moon happens about the same time as perigee.
- 4th 7 pm (5 pm WST) Moon at perigee (closest to Earth at 357,492 km).
- 6th 3 am (1 am WST) Minimum Libration (4.7°), dark NE limb.
- 9th 9 am (7 am WST) Occultation of Regulus by the Moon, visible from NE and Central Europe, N Greenland, N Asia and N parts of Micronesia.



- 10th 6 pm (4 pm WST) Last Quarter.
- 13th 1 am (11 pm previous day WST) Maximum Libration (8.9°), dark SE limb. Dark limb event therefore no libration features brought into view.
- 15th 5 am (3 am) Occultation of minor planet Vesta by the Moon, visible from Central Polynesia and parts of Chile and Argentina.
- 18th 5 pm (3 pm WST) New Moon.

Location, Location, Location

Whether you are using a telescope, binoculars or just looking up, there are a number of things to consider when selecting an observing site. Much of what follows may seem pretty straightforward, but having to move in the middle of the night might be a real challenge especially if you have already set up and aligned a telescope.

Also remember your security, especially if on your own, which is never recommended. Being out of sight can have its advantages. Letting someone know where you are going and when you'll be back is always good advice. It's fortunate the mobile telephone networks have continued to reach further into the outback (also good insurance).

In theory having a low horizon in every direction might sound ideal but can be fraught with problems. One way to achieve this might be in flat lowlands but such areas often come with nearby rivers or lakes, which can lead to fog as the temperature drops. The other extreme on mountaintops or ridges can be great but can expose you to rising winds. Not the time to discover the uncomfortable effect called the wind chill factor. There are many *exposures* that need consideration. Having well-placed buildings, trees or even hills can protect you from a lot more than just wind. Blocking out various sources of light such as cars and street lights come to mind.

Over the years we have stressed the importance of planning your observing session and this extends to choice of location. For example having a poor southern horizon may not be a problem provided you have time to wait for objects to rise. However if you are chasing far northern objects a low northern horizon is essential. If you look at the All Sky Maps the theoretical horizon is marked for the latitudes corresponding to Australian cities. The closer to the relevant line the less time it spends above the horizon. For example, looking on All Sky Map No 9, the star Deneb is only just above the Hobart line. No matter which celestial object is being considered the maximum altitude is achieved when crossing the meridian, so from Hobart this bright star will be visible only briefly and only when close to due north. The importance of the horizon also goes for objects setting early, such as planets approaching conjunction where an unobstructed western outlook is important during twilight. The same applies to the morning just before sunrise to the east with planets post conjunction. Either dawn or dusk circumstance could apply when trying to catch a comet near the Sun when its tail is most likely to develop.

If for whatever reason you have to observe an object close to the horizon the view will be far from ideal. You are not just looking through much thicker and turbulent air, but light pollution often from unknown sources could make low altitude haze as bad as thin cloud.

If possible, check out the site and the surrounding area beforehand during the day and night, especially if you will be setting up a telescope, which is not as easy to move as grabbing your binoculars and jumping in the car. The middle of the night is not the time to discover you have gone though a national park gate that is locked at night! Also, during the day you may not notice security lighting. In one case a group of amateurs thought they had done well avoiding streetlights in a small town to find out the hard way they had set up behind a car yard!

Going to new locations can at times be as unpredictable as the weather. Get a group of seasoned amateur astronomers around a campfire and listen to the stories, often punctuated with roaring laughter. Grazing lunar occultations, where the location is critical, have always been a rich source of tales. Over the years, the writers have had 'interesting' chats with the police, milkmen and the occasional security guard in the middle of the night. One milkman said, "I've been doing this run for 30 years and I've never seen so many telescopes, what's going on!" Also try explaining to the concerned occupant what you are doing in front of their home at 3 am! Other experiences have been at an amateur convention where it was thought a local sports ground was a good site to check out the sky. This went well until the automatic sprinklers came on! Luckily, there were no telescopes on the field. Another story (perhaps urban legend) related to a convenient nice flat, cleared area in the country away from everything. The observing session was going great until the automated lights came on for an aircraft approaching—yep, a bush landing strip!

All such incidents can be amusing to look back on, but at the time could have been avoided with a little planning.

19th 11 am (9 am WST) Moon at apogee (furthest from Earth at 406,603 km).

20th Midnight (10 pm WST) Minimum Libration (3.4°), dark SW limb.

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

28th 4 am (2 am WST) Maximum Libration (9.9°), dark NW limb. No libration features visible.

31st 11 am (9 am WST) Occultation of Aldebaran by the Moon, visible from most of North America, Greenland, Europe except S and W Russia.

THE PLANETS

Mercury is visible in the western evening twilight for about the first week in the month. It then descends back toward the Sun and inferior conjunction (between the Earth and the Sun) on the 13th before its return to the eastern morning dawn late in December (see Sky View).

Venus is all but lost this month as it moves too close to the Sun for observation. The planet will be in superior conjunction (Earth and Venus on opposite sides of the Sun) on January 9th. On its reappearance from behind the Sun it will remain as the 'evening star' in the western evening sky until October 2018.

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

Mars, rising around 2 am midmonth, moves from Virgo and joins Jupiter in Libra in the last week of December. Early risers should keep an eye on this pair in the east as they draw closer together and end up 3° apart at month's end (see Sky View). It will be even better next year when they will be 0.2° apart on the 7th January. On the 14th, the 25-day old waning crescent Moon will be near the planet.

Jupiter can be located low in the eastern morning sky at the beginning of astronomical dawn. On the 15th, the 26-day old waning crescent Moon will be near the planet (see Sky View). For a week beginning on the 19th Jupiter will be 1° or less from Libra's duo of Alpha stars. Alpha^1 and Alpha^2 form a splendid wide double pair of 3rd and 5th magnitude suns at a wide 4 arcminutes apart, with a contrasting yellow and pale blue colour contrast. As the month progresses, Mars and Jupiter gradually move together, culminating in a close conjunction early next year (see Sky View).

Saturn, immersed in the evening twilight, is in conjunction with the Sun on the 22nd. This effectively rules out any observation of the planet until its reappearance in the morning skies in late January 2018.

Uranus, in Pisces, transits the meridian around 8 pm midmonth. The planet appears to be moving very slowly as it nears the end of four months in retrograde, resuming its west to east direction across the sky early next month.

Neptune can only be seen in the evening sky, setting around 11:30 pm midmonth in Aquarius.

DWARF PLANETS and SMALL SOLAR SYSTEM BODIES

Dwarf Planet Pluto is in conjunction with the Sun early in January, and will be lost from view from midmonth in December until its return to the morning skies in February 2018.

Minor Planets. Five of the brighter minor planets reach opposition this month in Taurus. They are: 349 Dembowska on 1st at magnitude 9.6, 451 Patientia on 11th at magnitude 10.4, 65 Cybele on 13th at magnitude 12.0, 20 Massalia on 17th at magnitude 8.4 and 92 Undina on 18th at magnitude 11.1. Two are in Orion, 129 Antigone on 11th at magnitude 12.0 and 85 Io on 26th at magnitude 11.8. Others at opposition include 17 Thetis on 10th at magnitude 11.5 near the Taurus/Orion border, 31 Euphrosyne on 23rd at magnitude 10.5 near the Camelopardalis/Lynx border and 372 Palma on 28th at magnitude 10.9 near the Lynx/Auriga border.

DIARY			
Sat	2nd		m.p. 89 Julia 0.6°S of star Xi Pegasi
Sun	3rd	6 pm	(4 pm WST) Mercury stationary
Sun	3rd	11 pm	(9 pm WST) star Aldebaran 0.8° S of Moon
Mon	4th		Comet 71P/Clark 0.3°N of M30 (GC) in Capricornus
Mon	4th	am	d.p. 1 Ceres 0.5°NW of star Lambda Leonis
Mon	4th	1:47 am	(11:47 pm WST, prev day) Full Moon (357,983 km, closest for this year)
Mon	4th	7 pm	(5 pm WST) Moon at perigee, 357,492 km
Wed	6th	10 pm	(8 pm WST) Saturn 1.4° N of Mercury
Wed	6th	11 pm	(9 pm WST) star Pollux 9° N of Moon
Thu	7th		Mercury at ascending node
Fri	8th	10 am	(8 am WST) m.p. 4 Vesta 4° N of Jupiter
Sat	9th	9 am	(7 am WST) star Regulus 0.7° S of Moon
Sun	10th	5:51 pm	(3:51 pm WST) Last Quarter Moon
Mon	11th		Comet 24P/Schaumasse 1.0°NE of star Zeta Virginis
Mon	11th		Comet 62P/Tsuchinshan 1, 1.0°SW of NGC 4365 (G) in Virgo
Tue	12th		Mercury at perihelion
Wed	13th	7 am	(5 am WST) star Spica 7° S of Moon
Wed	13th	Noon	(10 am WST) Mercury in inferior conjunction
Thu	14th	Midnight	(10 pm WST) Jupiter 4° S of Moon
Thu	14th	2 am	(Midnight WST, prev day) Mars 4° S of Moon
Fri	15th		m.p. 89 Julia 0.2°NW of NGC 7479 (G) in Pegasus
Fri	15th		Comet 71P/Clark 0.4°NW of NGC 7184 (G) in Aquarius
Fri	15th	5 am	(3 am WST) m.p. 4 Vesta 0.2° N of Moon
Sun	17th	4 am	(2 am WST) star Antares 9° S of Moon
Mon	18th	4:30 pm	(2:30 pm WST) New Moon
Mon	18th	pm	Comet C/2015 V2 (Johnson) 0.9°N of star Alpha Pavonis
Tue	19th		Venus at descending node
Tue	19th	11 am	(9 am WST) Moon at apogee, 406,603 km
Wed	20th	1 pm	(11 am WST) d.p. Pluto 1.9° S of Moon
Thu	21st		d.p. 1 Ceres stationary
Thu	21st	2 pm	(Noon WST) m.p. 3 Juno 5° N of Moon
Thu	21st	pm	m.p. 20 Massalia 1.0°N of star Zeta Tauri
Fri	22nd		Mercury at greatest latitude north
Fri	22nd	2 am	(Midnight WST, prev day) Solstice
Fri	22nd	7 am	(5 am WST) Saturn in conjunction with Sun
Sat	23rd	1 pm	(11 am WST) Mercury stationary
Sun	24th		m.p. 2 Pallas stationary
Sun	24th	11 pm	(9 pm WST) Neptune 1.4° N of Moon
Sun	24th	11 pm	(9 pm WST) m.p. 20 Massalia 0.15°NW of M1 Crab Nebula (PN) in Taurus
Sun	24th	pm	m.p. 8 Flora 0.5°SW of star Zeta Geminorum
Mon	25th		Jupiter 0.8°NE of star Alpha 1 Librae
Tue	26th	7:20 pm	(5:20 pm WST) First Quarter Moon
Thu	28th	4 am	(2 am WST) Uranus 5° N of Moon
Sun	31st		Neptune 0.5°SE of star Lambda Aquarii
Sun	31st	11 am	(9 am WST) star Aldebaran 0.8° S of Moon
Sun	31st	10 pm	(8 pm WST) m.p. 20 Massalia 0.15°NW of star 114 Tauri

COMETS

Comet 24P/Schaumasse, in early December, is visible close to the horizon at the beginning of dawn following its perihelion passage last month. It then steadily climbs, rising over an hour before dawn by month's end. Spending December in Virgo, Schaumasse should fade from 11th to 12th magnitude.

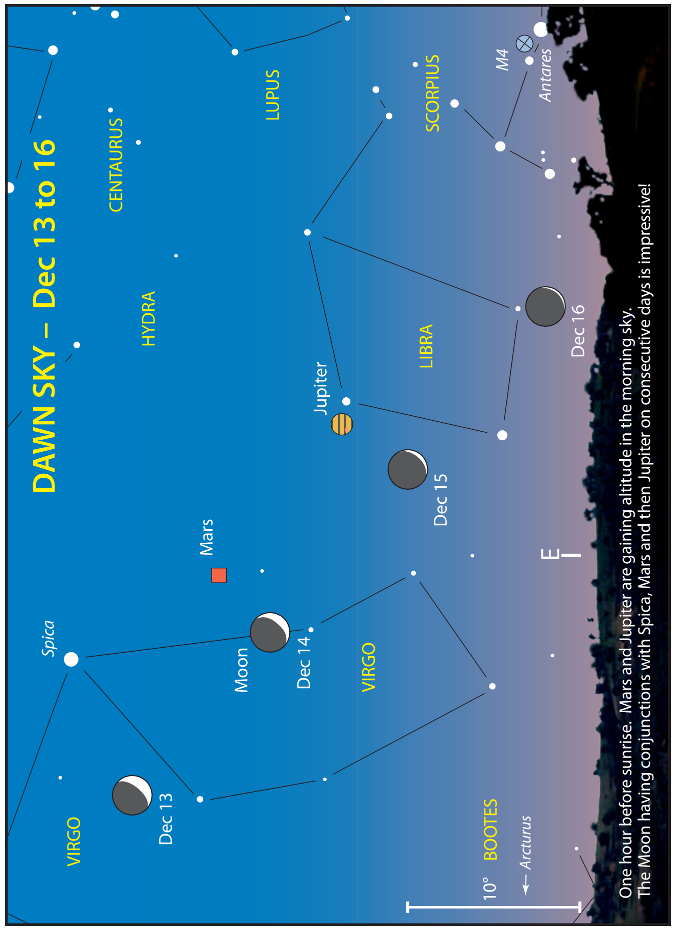
Comet 62P/Tsuchinshan 1 is expected to fade from 11th to 12th magnitude as it moves away from the Sun following last month's perihelion passage. Spending all of December in Virgo, the comet will be rising a little over two hours before dawn by the end of the month.

METEOR SHOWERS

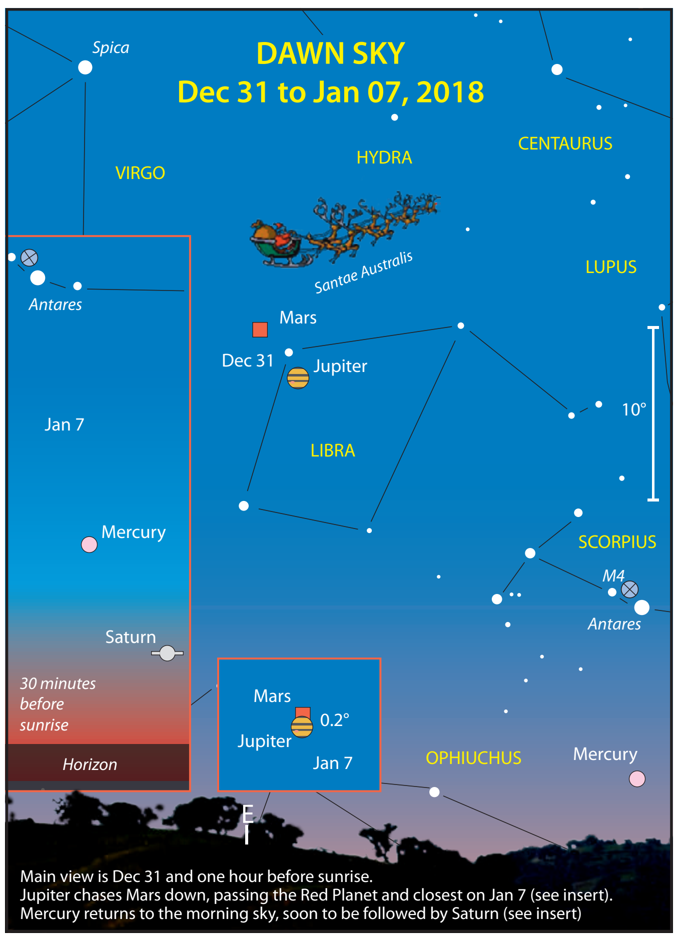
The **Geminids** are one of the finest and reliable of the major annual showers. Visible from the 4th to 17th, with maximum predicted on the 14th, the Geminids often produce bright, medium-speed meteors. The zenith hourly rate is variable but around 120 are possible. Even though our northern counterparts will see the best of the Geminids, they can still provide a spectacular display for us down under. Conditions are perfect for this year's Geminids with New Moon on the 18th.

DOUBLE STARS

This month's double star comes with an added treat. **HJ 3752** (All Sky Map 2) is located in Lepus the Hare. It is a lovely pair of deep yellow stars, magnitudes 5.4 and 6.6, separated by 3.5 arcseconds. The 9.2 magnitude star located about 1 arcminute southeast appears to have no connection with the pair. The additional treat is the nearby globular cluster Messier 79 (only 0.6° northeast).



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



ALL SKY MAPS

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

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

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

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

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

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

The seasonal views are a little arbitrary. As you will see in the Notes section on the maps, an evening view around the relevant time of the year was chosen. However, if you are willing to stay up all night there is only a small part of the entire sky not available to you, especially in winter. For example, suppose it is around mid-to-late June. At 9 pm the sky will look like the winter pair. By 3 am the sky will be showing the spring view. Around dawn, the Earth will have rotated further, where the sky is now half spring (to the left or west if you are facing north and half summer (towards the right or east). A planisphere illustrates this quite well (p. 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 (as an aside this is also the definition of the local sidereal time, see page 142). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1 am) the star Alpha (α) Pegasi (Markab), with an RA close to 23 hours, will culminate.

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

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

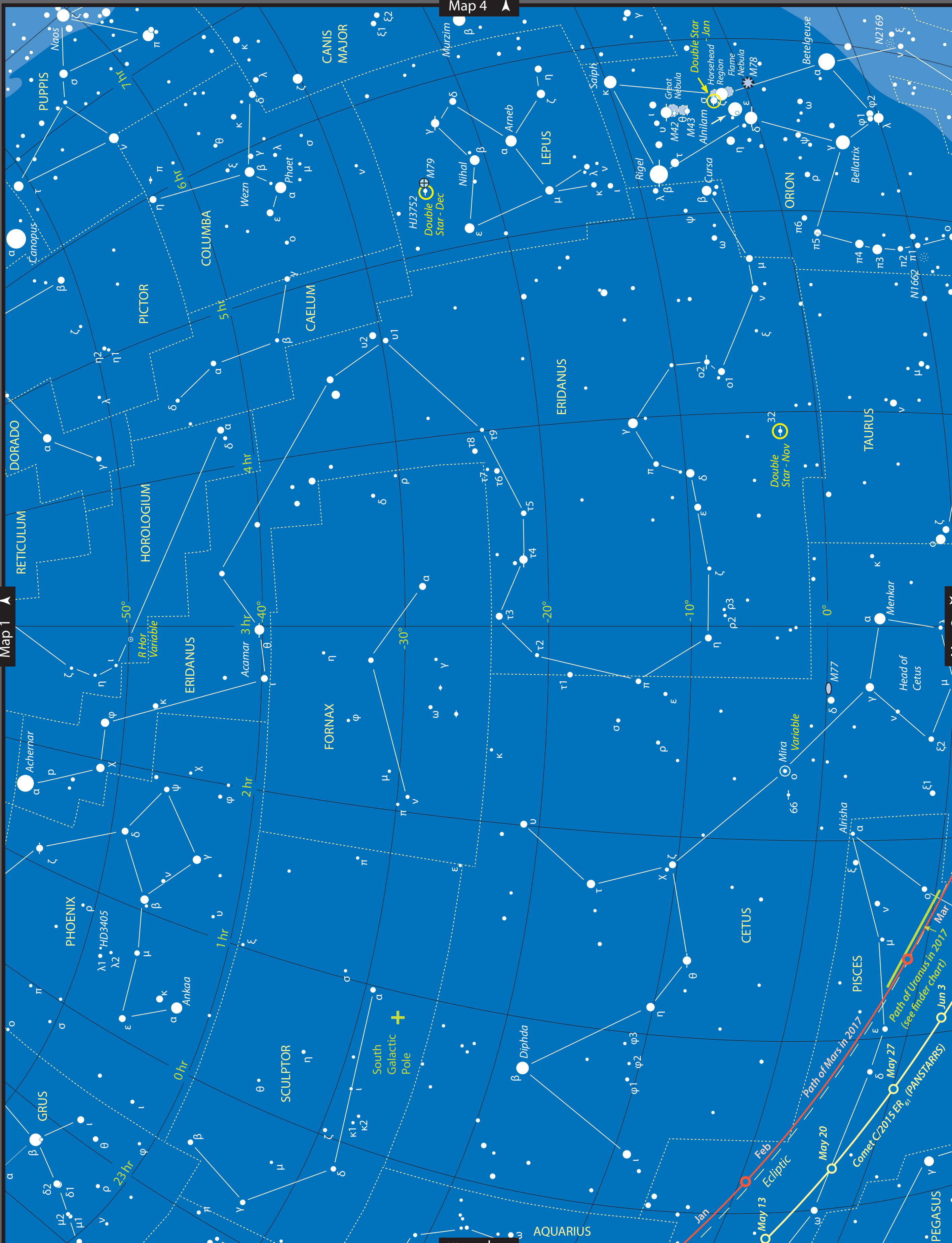
What are the planet lines? Lines are shown to indicate the approximate path in the sky for Mars, Jupiter, Saturn, Uranus, Neptune and Pluto for the year. With the exception of Mars, once you have found the general area you can go to the relevant finder chart. The path for Mars has the position marked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

What else is shown on the maps?

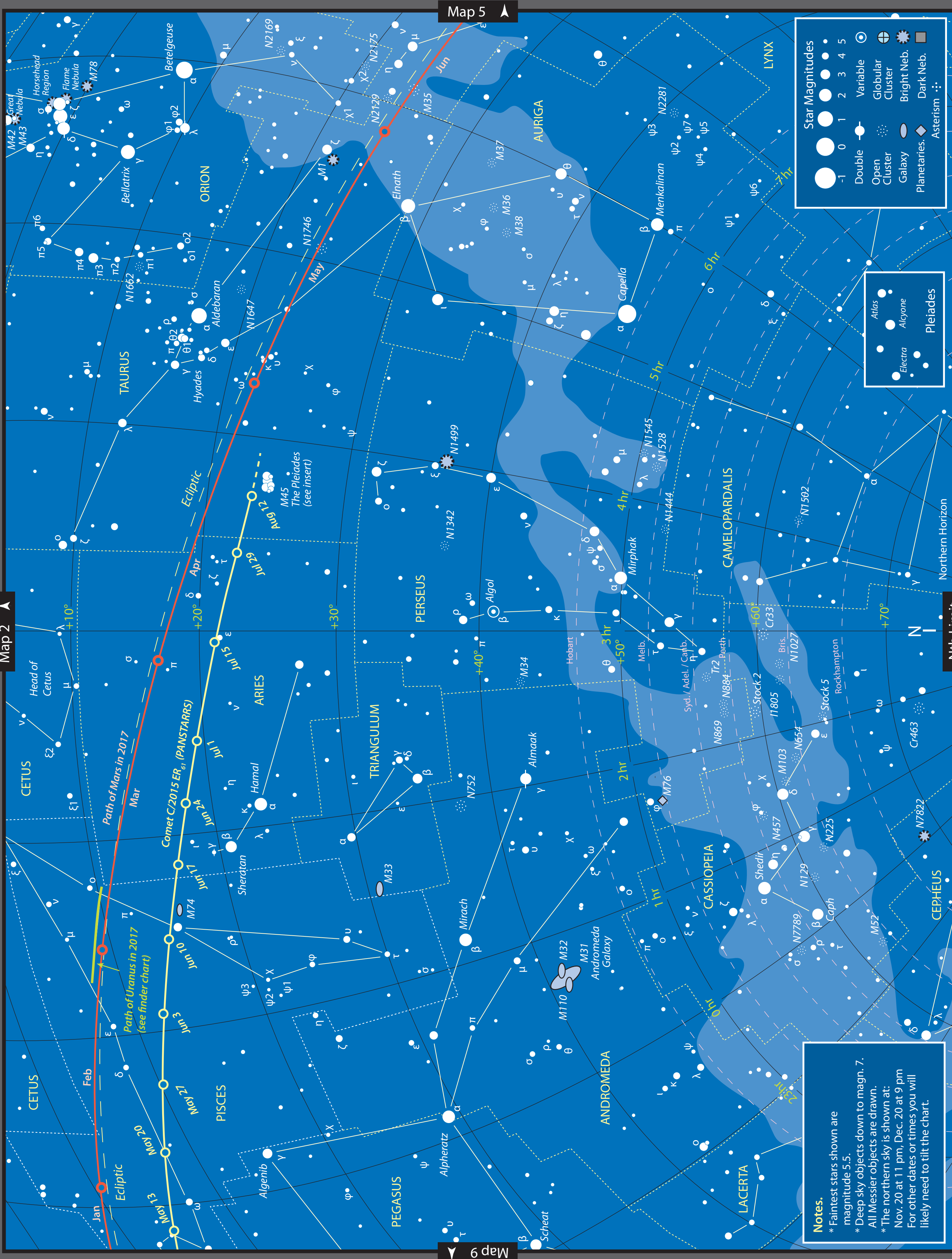
- Deep sky objects down to magnitude 7 and all of the Messier objects (see the legend). These objects are identified by their common names (such as asterisms), Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope. There are occasionally other objects included when referred to elsewhere in the book.
- Constellation lines. The yellow dotted lines are the boundaries and the solid lines joining some of the brighter stars help recognise the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A few of the brighter variable and double stars, including those specifically mentioned in the Part 1 monthly sections. Double stars from part 1 are labelled with the month they are mentioned in and circled.
- A light blue shading shows the Milky Way and Magellanic Clouds.
- The path for two comets have been included this year, C/2015 V2 (Johnson) and C/2015 ER_{61} (PANSTARRS). Positions are given for 0hr UT on each Saturday they are expected to be brighter than approximately 10^{th} magnitude.

Map 1 - Looking South

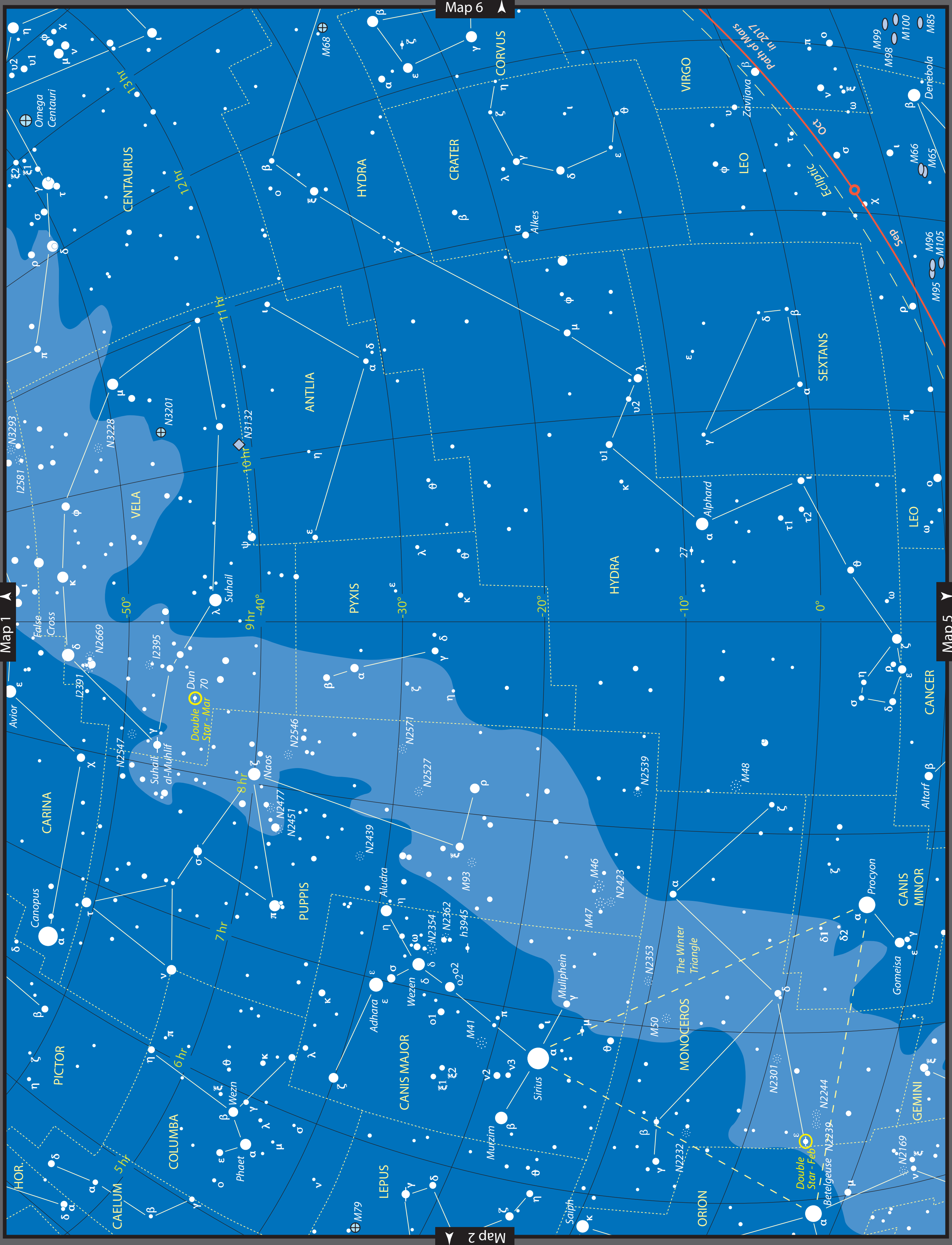
Map 2 - Summer (Centre)



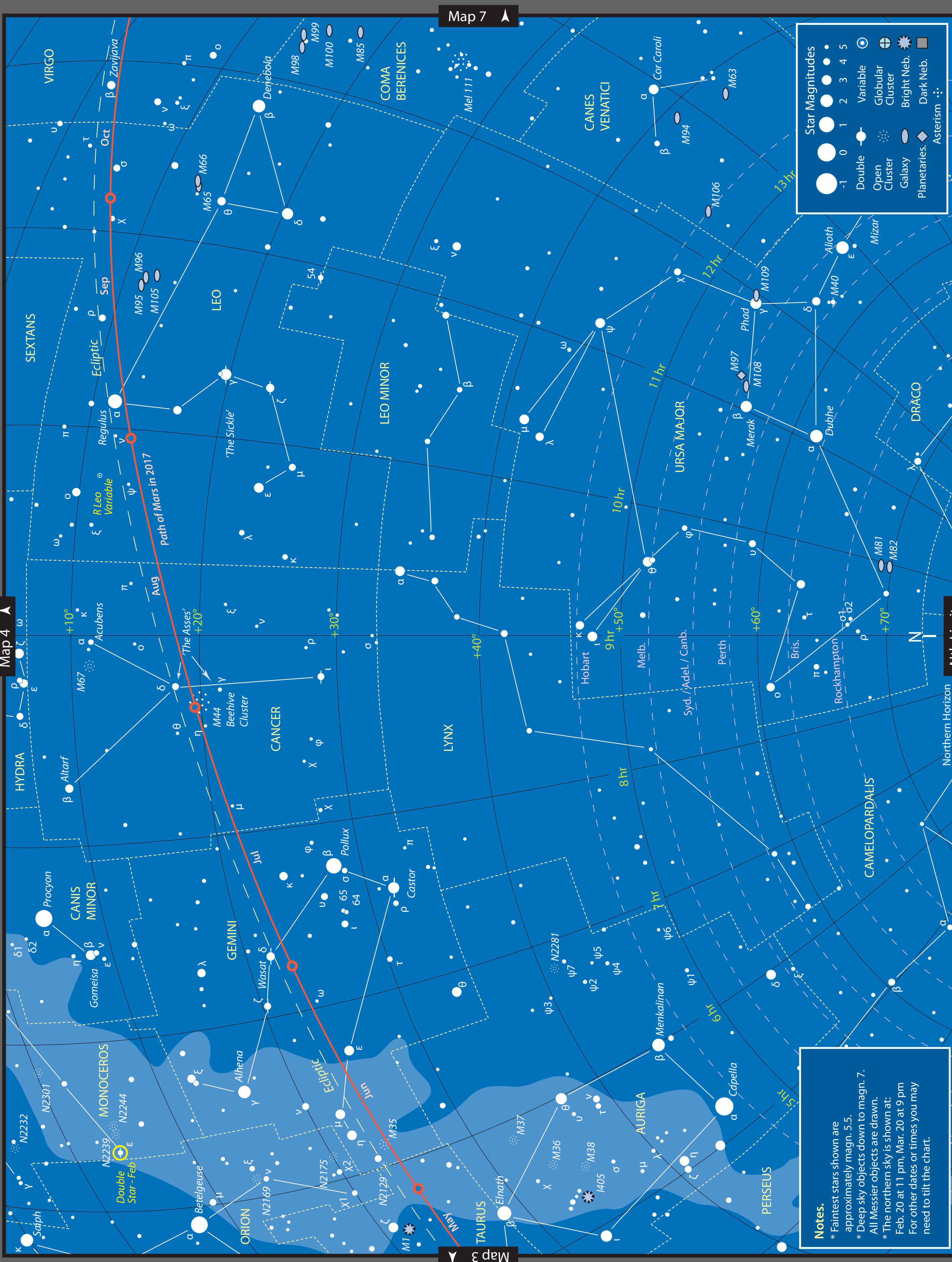
Map 3 - Summer (North)



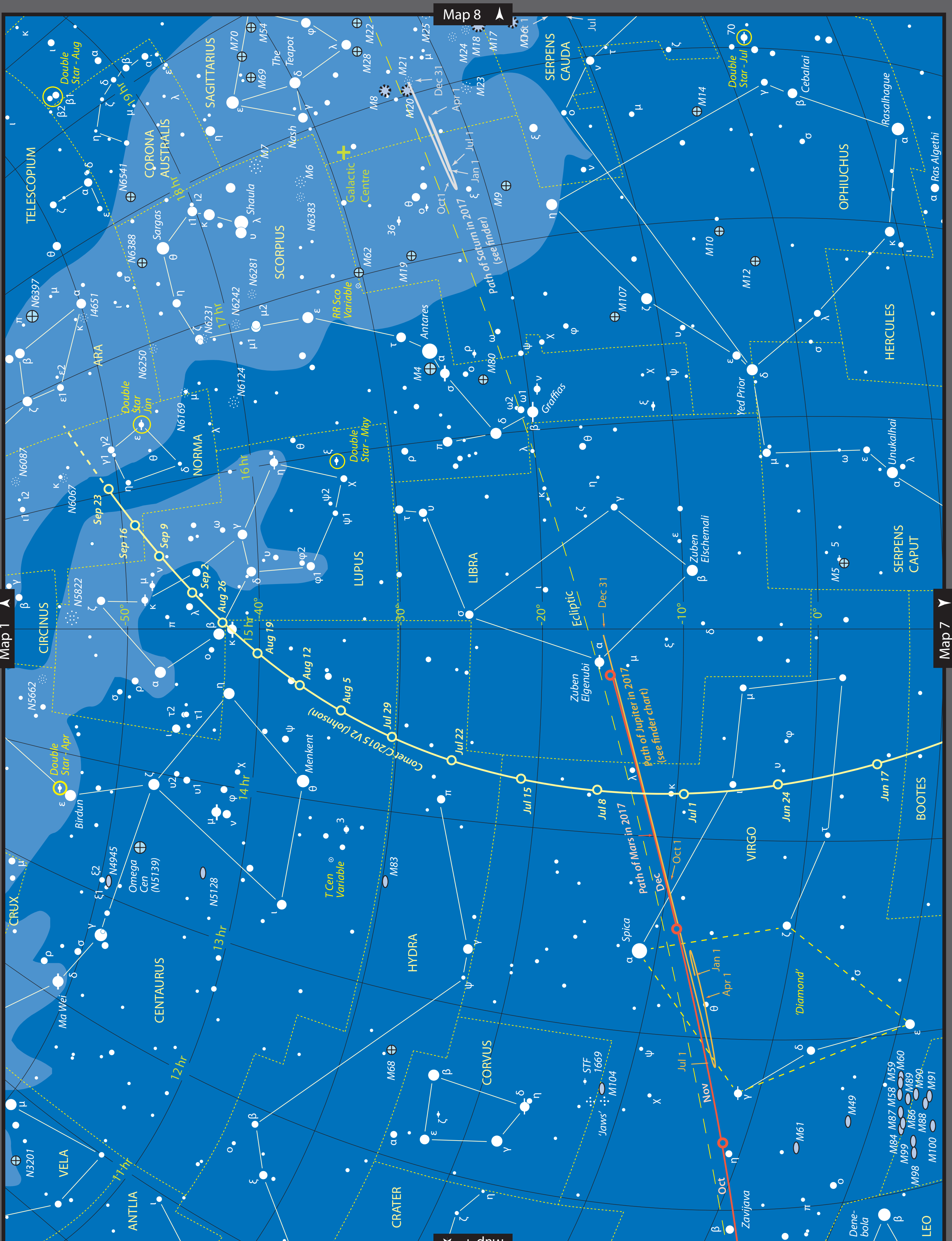
Map 4 - Autumn (Centre)



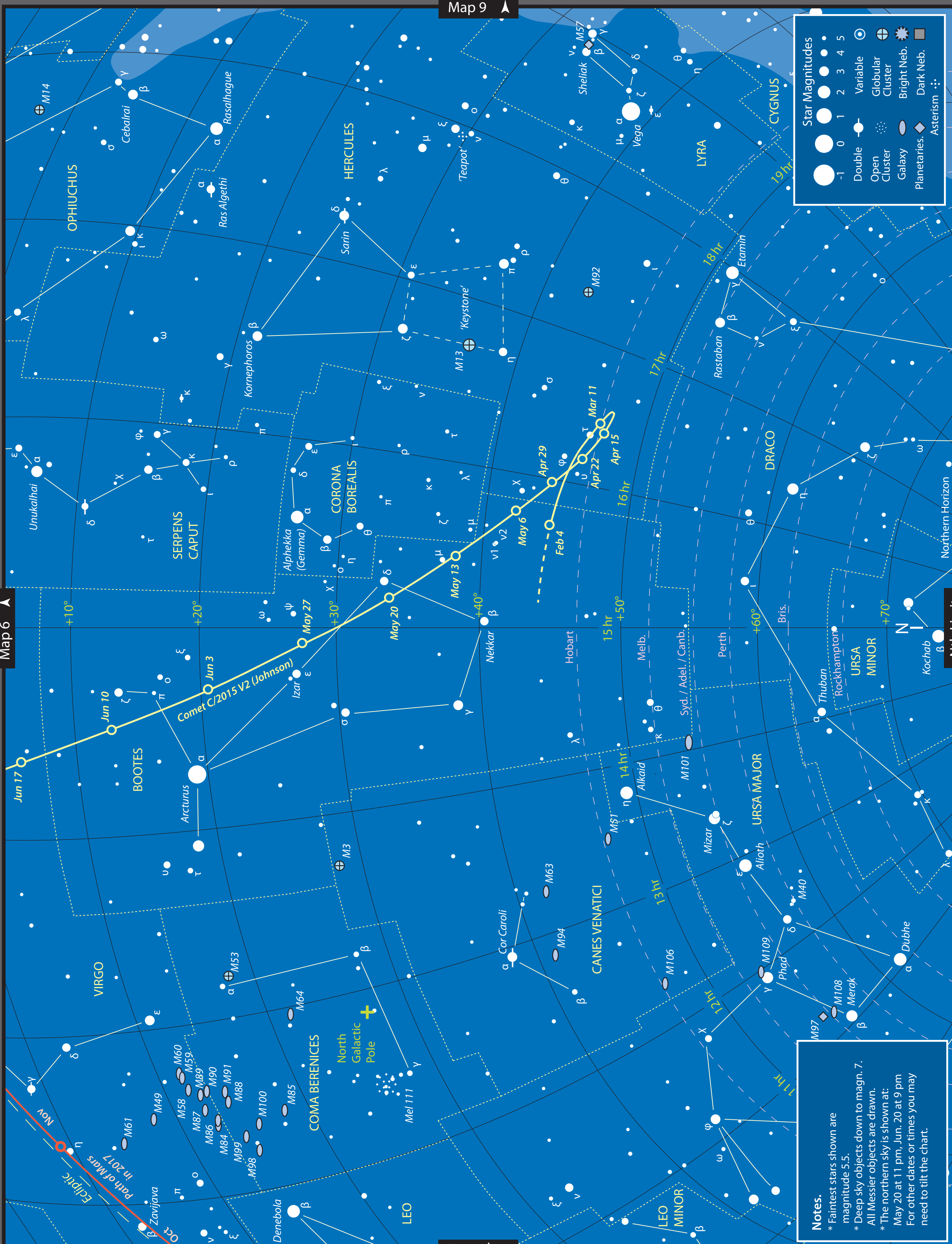
Map 5 - Autumn (North)



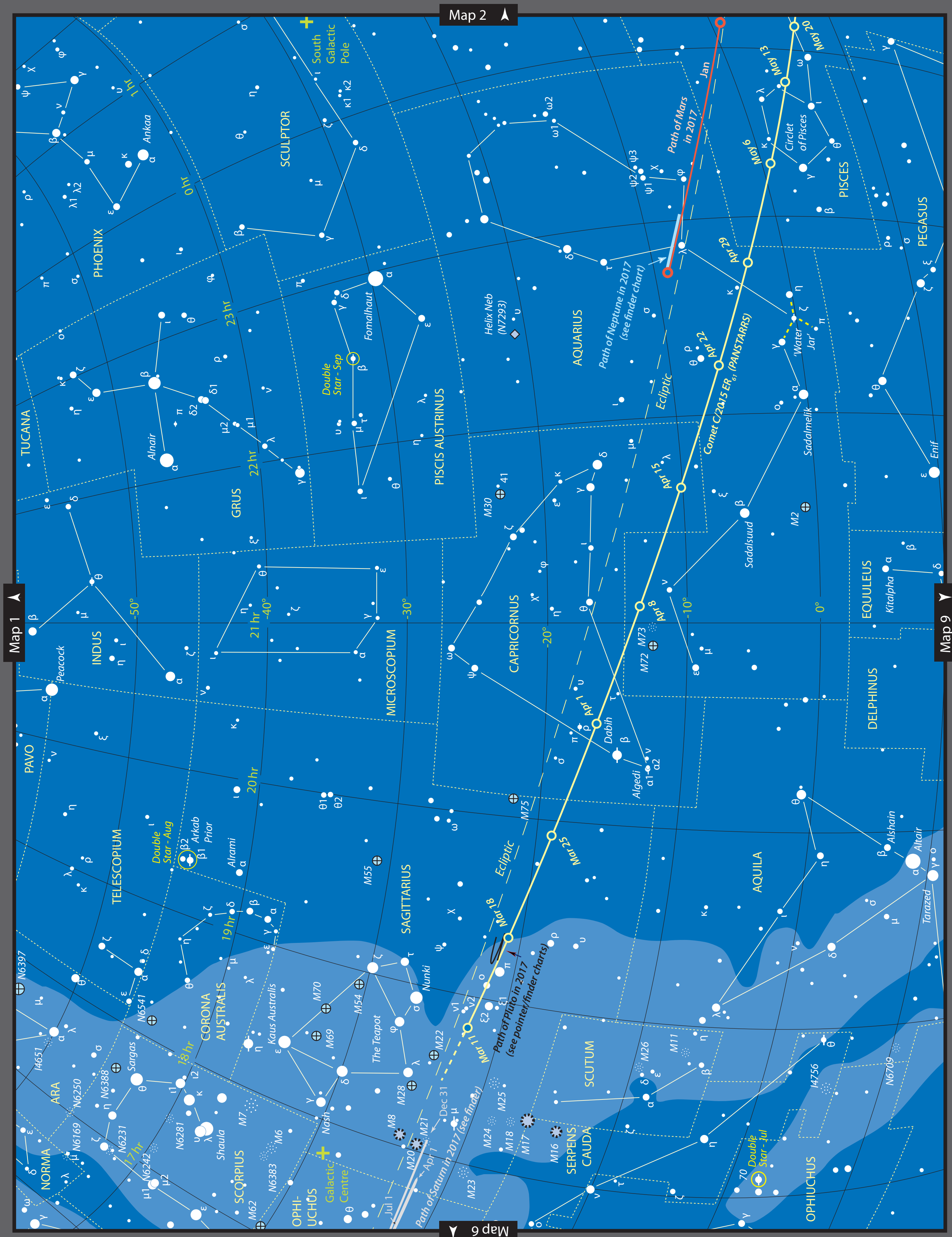
Map 6 - Winter (Centre)



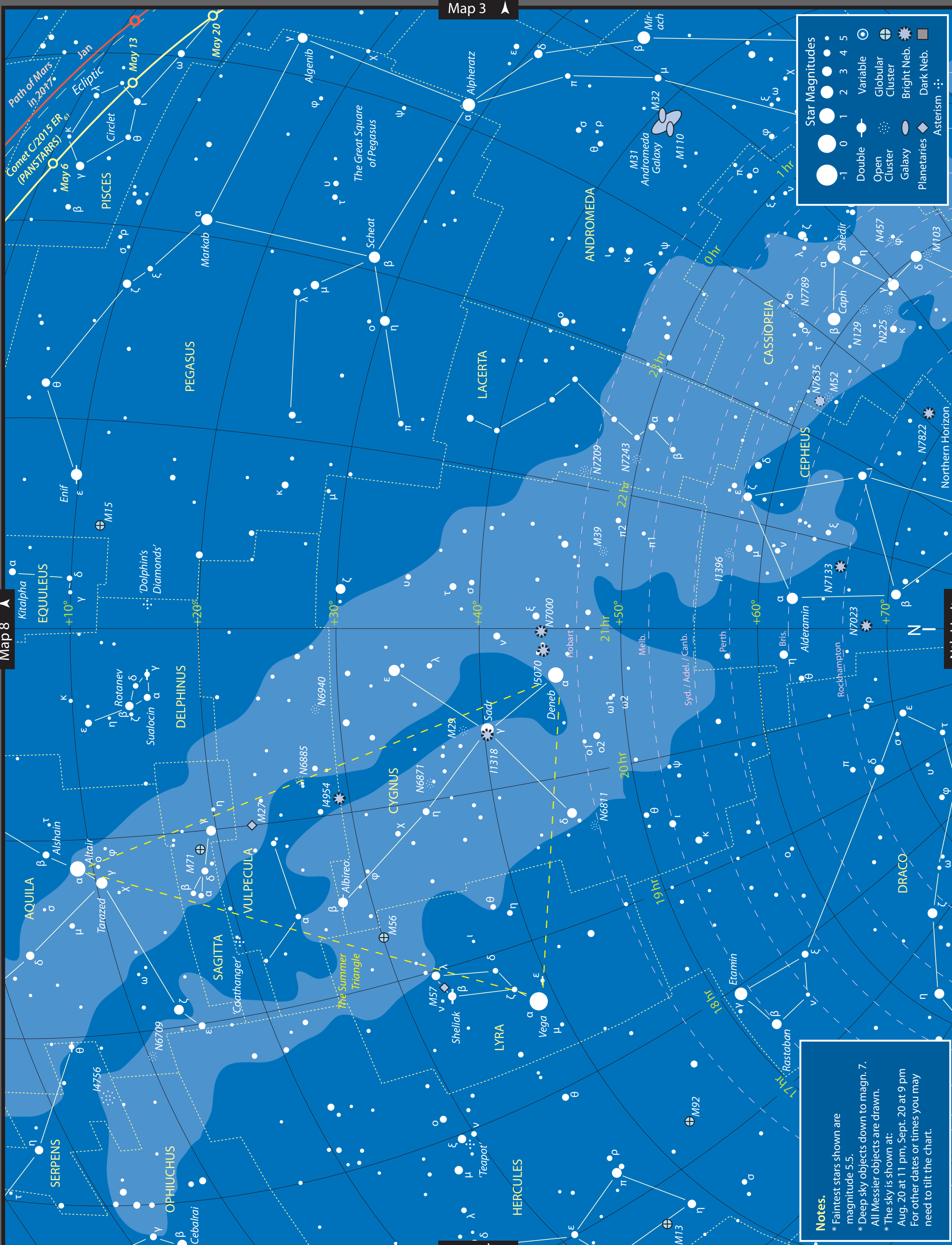
Map 7 - Winter (North)



Map 8 - Spring (Centre)



Map 9 - Spring (North)



PART II — THE SOLAR SYSTEM

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

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

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

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

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

Locations. Rise and set times and lunar occultation data are given for specific cities. The latitudes and longitudes used are:

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

Astronomical Coordinates or Positions. The astronomical positions are given in equatorial coordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one-hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations, those south have negative (–). The Right Ascension and Declination grid has been marked on the All Sky Maps (see previous pages). The RA has a line for each hour and the Declination has a line every 10°. The finders also have them marked. The Earth’s daily rotation on its polar axis causes the stars to appear to rotate around a point in the sky. From southern latitudes, including Australia, this point is called the South Celestial Pole and is at declination –90° (see All Sky Map 1 in the All Sky Maps). The North Celestial Pole, not visible from the Southern Hemisphere, is at +90°. The celestial equator and poles can be described as projections on the sky of their terrestrial counterparts.

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

Rise and Set Times. Those given are when the upper limb of the object is coincident with the theoretical horizon. The times are adjusted for atmospheric refraction. The intervals used for Moon rise and set are daily, the remainder are weekly and correspond to Saturdays. Also see note on time zones (above).

Use of Star Atlases. As the Earth orbits the Sun the polar axis, around which the stars rotate (the celestial poles) appears to never change no matter what time of the year you are observing. However, the positions of the poles do slowly move against the star field. This is called precession and is caused by the Earth’s axis slowly wobbling, like a spinning top, over thousands of years. ‘Epoch 2000.0’ refers to an object’s position relative to where the celestial poles (+ /–90° in declination) were in the year 2000. The All Sky Maps are Epoch 2000.0.

Field of View in a Telescope. All the satellite diagrams and finder charts in this book are drawn to correct or normal sky orientation, that is east to the left, and north to the top (in the sky, east and west are opposite to terrestrial maps). Binoculars (and the eyes) or straight Newtonians show this appearance (the Newtonian image will be upside down). Telescope systems that use an odd number of mirrors will reverse the image. The common use of star diagonals in Schmidt-Cassegrains or traditional refractors causes this reversal.

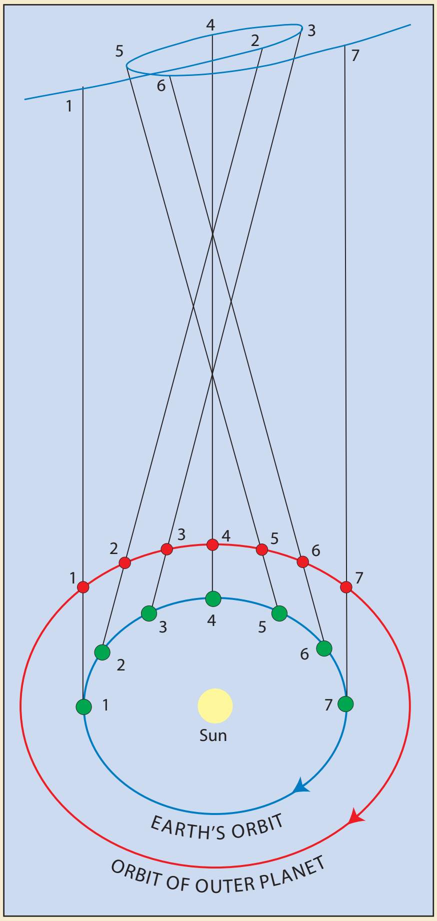
Finder Charts. No finder charts are presented for the Moon, Mercury, Venus or Mars. Their rapid motion during the year causes them to cover a very large section of the sky, which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams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

RETROGRADE MOTION

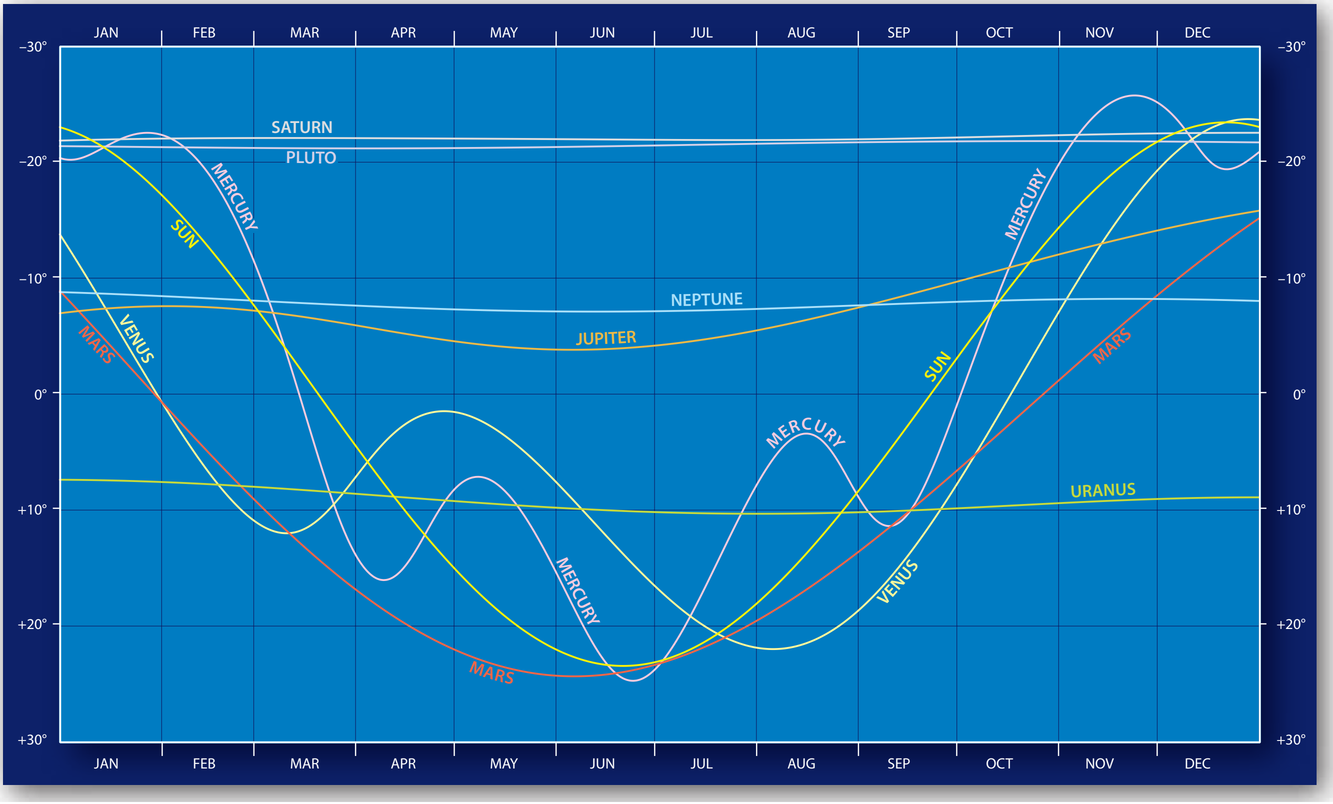
The finder charts for the outer planets have one thing in common, an apparent motion with a loop or ‘S’ shape. This only applies to the period during opposition. See the All Sky Maps or the Finder Charts for examples. The diagram below illustrates the combined effects of the orbital motions of Earth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

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

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

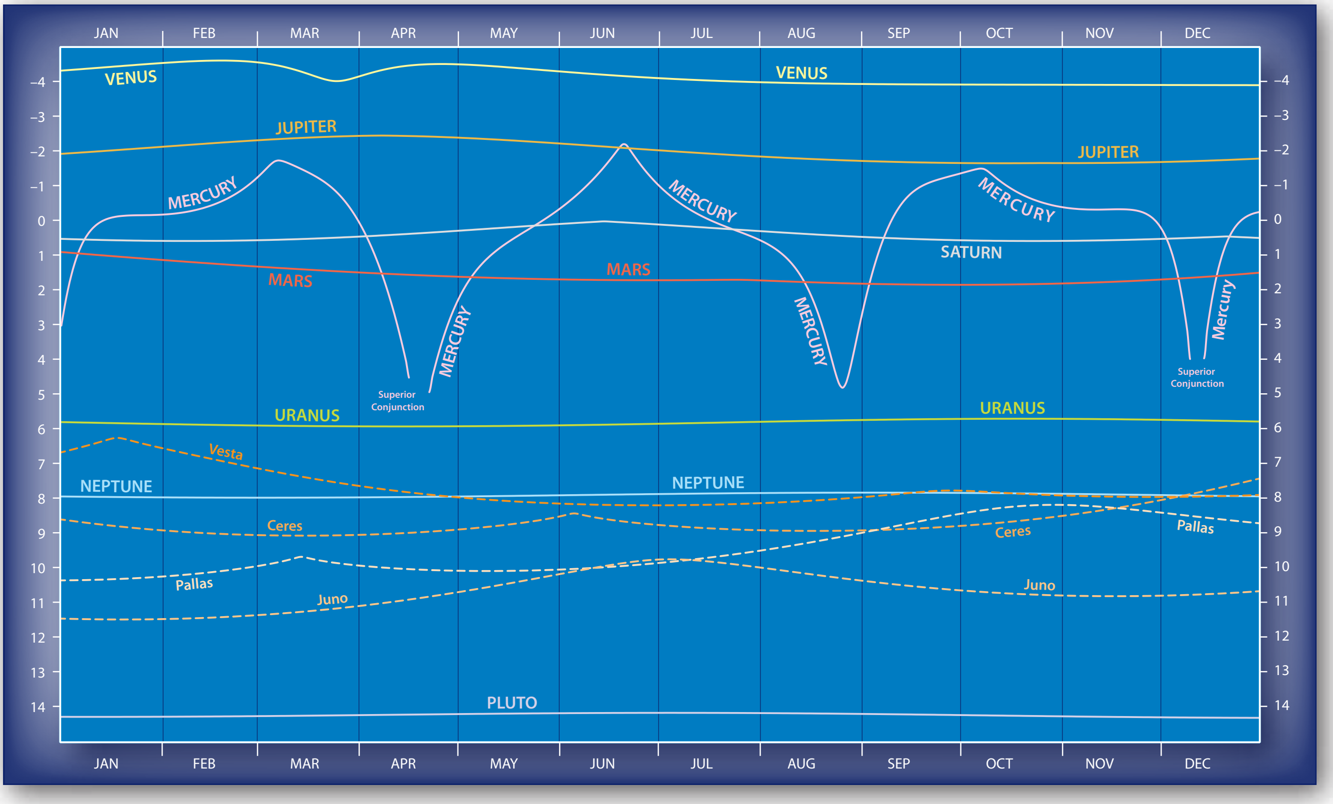


DECLINATIONS of the SUN, PLANETS and PLUTO



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

MAGNITUDES of the PLANETS, BRIGHT DWARF and MINOR PLANETS



GEOCENTRIC PHENOMENA (UT)

Planet	Stationary	Greatest Elongation West	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction
Mercury	8 Jan, 10h 2 May, 14h 4 Sep, 16h 23 Dec, 3h	19 Jan, 10h (24.1°) 17 May, 23h (25.8°) 12 Sep, 10h (17.9°)	7 Mar, 0h 21 Jun, 14h 8 Oct, 21h	1 Apr, 10h (19.0°) 30 Jul, 5h (27.2°) 24 Nov, 0h (22.0°)	10 Apr, 1h 12 Aug, 6h 3 Dec, 8h	20 Apr, 6h 26 Aug, 21h 13 Dec, 2h
Venus	 13 Apr, 0h	 3 Jun, 12h (45.9°)		12 Jan, 13h (47.1°)	2 Mar, 14h	25 Mar, 10h

Planet	Conjunction	Stationary	Opposition	Stationary	Conjunction	EARTH	
Mars	27 Jul, 1h					Perihelion	4 Jan, 14h
Jupiter		6 Feb, 19h	7 Apr, 22h	10 Jun, 5h	26 Oct, 18h	Equinox	20 Mar, 10h
Saturn		6 Apr, 5h	15 Jun, 10h	25 Aug, 15h	21 Dec, 21h	Solstice	21 Jun, 4h
Uranus	14 Apr, 6h	3 Aug, 10h	19 Oct, 18h			Aphelion	3 Jul, 20h
Neptune	2 Mar, 3h	16 Jun, 23h	5 Sep, 5h	22 Nov, 21h		Equinox	22 Sep, 20h
Pluto	7 Jan, 7h	20 Apr	10 Jul, 5h	28 Sep		Solstice	21 Dec, 16h

HELIOCENTRIC PHENOMENA (UT)

Planet	Aphelion	Perihelion	Descending Node	Greatest Latitude South	Ascending Node	Greatest Latitude North
Mercury	Feb 7 May 6 Aug 2 Oct 29	Mar 23 Jun 19 Sep 15 Dec 12	Jan 28 Apr 26 Jul 23 Oct 19	Feb 27 May 26 Aug 22 Nov 18	Mar 18 Jun 14 Sep 10 Dec 7	Jan 4 Apr 2 Jun 29 Sep 25 Dec 22
Venus	 Jun 12	Feb 20 Oct 3	May 9 Dec 19	Jul 5	Jan 17 Aug 30	Mar 14 Oct 24
Mars	Oct 7				Feb 27	Aug 30
Jupiter	Feb 17					
Saturn, Uranus, and Neptune have no events in 2017						

SOLAR SYSTEM DATA – SUN, MOON, PLANETS and PLUTO

	Sun	Moon	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mean Distance from Sun ($\times 10^3$ km)	-	-	57856	108132	149492	227780	777776	1425983	2867760	4492800	5745000
Mean Distance from Sun (Earth = 1)	-	-	0.387	0.723	1.000	1.524	5.203	9.540	19.180	30.700	39.670
Magnitude at Opposition	–26.8	–12.74 [11]	0.16 [12]	–4.07 [12]	–3.5 [13]	–2.01	–2.70	0.67	5.52	7.84	13.7
Equatorial Diameter (km)	1392530	3474.8	4879.4	12103.6	12756.3	6792.4	142984	120536	51118	49528	2370
Flattening [1]	0	0	0	0	0.00335281	0.005886	0.064874	0.097962	0.022927	0.017081	0
No of Moons	-	-	0	0	1	2	67	62	27	14	5
Mass ($\times 10^{24}$ kg)	1.9884×10^{30}	0.073458	0.3301	4.8673	5.9721986	0.64169	1898.1	568.31	86.809	102.41	0.013041
Mass (Earth = 1)	332946	0.012300	0.0553	0.8150	1.0000000	0.10745	317.8	95.16	14.536	17.148	0.002184
Volume (Earth = 1)	1300000	0.02	0.06	0.86	1	0.15	1323	752	64	54	0.007
Sidereal Period [2]	-	27.32 d	87.97 d	224.7 d	365.256 d	687 d	11.86 y	29.46 y	84.01 y	164.8 y	249.9 y
Synodic Period (Days) [3]	-	29.4	115.8	583.9	-	779.8	398.8	378.0	369.7	367.5	366.7
Axial Rotation (Days) [4]	25.38 [9]	27.32166	58.6462	–243.0185	0.99726963	1.02595676	0.41354 [14]	0.44401 [14]	–0.71833	0.67125	–6.3872
Albedo [5]	-	0.12	0.106	0.65	0.367	0.150	0.52	0.47	0.51	0.41	0.3
Eccentricity [6]	-	0.0549	0.20562	0.00681	0.01681	0.09333	0.04837	0.05582	0.0471	0.00855	0.2486
Inclination [7]	-	5° 08' 40"	7° 00' 00"	3° 23' 38"	0° 00' 00"	1° 51' 01"	1° 18' 28"	2° 29' 29"	0° 46' 22"	1° 46' 38"	17° 09' 00"
Obliquity [8]	7° 15' [10]	6° 41'	0° 01'	2° 38'	23° 26'	25° 11'	3° 07'	26° 45'	82° 14'	28° 20'	60° 25'

Notes:

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

The satellite table (right) covers those currently known (as of August 2016). Some are not yet named, instead they have a preliminary designation such as S/2007 S3.

SOLAR SYSTEM DATA — SATELLITES

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (× 10³ km)	RADIUS (km)	MAG AT OPP
Earth	Moon	27.321661		384.400	1,737.4	–12.74
Mars	Phobos	0.31891023	25"	9.380	13.4 × 11.2 × 9.2	11.9
	Deimos	1.2624407	1' 02"	23.460	7.5 × 6.1 × 5.2	13.0
Jupiter	Metis	0.295	42"	127.98	22	17.5
	Adrastea	0.298	42"	128.98	10 × 8 × 7	18.7
	Amalthea	0.49817905	59"	181.20	125 × 73 × 64	14.1
	Thebe	0.675	1' 13"	221.90	58 × 49 × 42	16.0
	Io	1.769137786	2' 18"	422.0	1829 × 1819 × 1816	5.0
	Europa	3.551181041	3' 40"	671.0	1,562	5.3
	Ganymede	7.15455296	5' 51"	1,070.0	2,632	4.6
	Callisto	16.6890184	10' 18"	1,883.0	2,409	5.7
	Themisto	130.0	40' 44"	7,450.00	2 [15]	20.3
	Leda	240.5	1° 00' 58"	11,150.00	10 [15]	19.0
	Himalia	250.1	1° 02' 34"	11,443.00	85	14.6
	Lysithea	258.5	1° 03' 58"	11,700.00	18 [15]	18.3
	Elara	259.1	1° 04' 03"	11,716.00	43 [15]	16.3
	Dia	287		12,555	2	22.4
	Carpo	455.07	1° 33' 14"	17,056.04	1.5 [15]	23.0
	S/2003 J3	505	1° 44' 24"	18,290.718	0.5	23.6
	S/2003 J12	533	1° 49' 12"	18,951.537	0.7	23.8
	Euporie	555.2 [16]	1° 46' 38"	19,509.12	1 [15]	23.1
	S/2011 J1	580.7[16]		20,155.29	1	23.6
	Chaldene	591.7 [16]	1° 50' 57"	20,299.46	1.5 [15]	22.5
	Jupiter LII	588.1		20,307.15	0.5	23.9
	S/2003 J16	596.76	1° 58' 48"	20,434.426	0.8	23.0
	Mneme	599.65 [16]	1° 52' 03"	20,500.28	1 [15]	23.3
	Helike	601.40 [16]	1° 52' 16"	20,540.27	2 [15]	22.6
	Iocaste	606.3 [16]	1° 52' 50"	20,642.86	2 [15]	22.5
	S/2003 J18	607.68	2°	20,682.998	1	23.0
	Thyone	610.0 [16]	1° 53' 31"	20,769.90	1.5 [15]	22.3
	Orthosie	613.6 [16]	1° 53' 58"	20,849.89	1 [15]	23.1
	Harpalyke	617.3 [16]	1° 54' 20"	20,917.72	1.5 [15]	23.0
	Euanthe	620.9 [16]	1° 54' 41"	20,983.14	1.5 [15]	22.8
	Hermippe	624.6 [16]	1° 55' 26"	21,047.99	2 [15]	22.1
	Ananke	624.1 [16]	1° 55' 03"	21,048.00	14 [15]	18.8
	Praxidike	624.6 [16]	1° 55' 19"	21,098.10	2.5 [15]	22.5
	Thelxinoe	635.82 [16]	1° 56' 31"	21,316.68	1 [15]	23.5
	Taygete	650.1 [16]	1° 58' 27"	21,671.85	2 [15]	22.9
	Erinome	661.1 [16]	1° 59' 31"	21,867.75	1.5 [15]	22.8
	S/2003 J15	667.17	2° 7' 48"	22,011.816	0.7	23.3
	Aitne	679.3 [16]	2° 01' 44"	22,274.41	1.5 [15]	22.7
	Kale	679.4 [16]	2° 01' 53"	22,300.64	1 [15]	23.0
	Kallichore	681.94 [16]	2° 02' 04"	22,335.35	1 [15]	23.7
	S/2003 J9	684	2° 9' 36"	22,381.517	0.7	23.6
	Herse	689.98	2° 10' 12"	22,510.605	1	23.0
	Sponde	690.3 [16]	2° 03' 14"	22,548.24	1 [15]	23.0
	S/2003 J19	700.83	2° 12' 0"	22,745.922	0.8	23.5
	Isonoe	704.9 [16]	2° 04' 38"	22,804.70	1.5 [15]	22.5
	Hegemone	715 [16]	2° 05' 44"	23,006.33	1.5 [15]	22.8
	S/2003 J4	722	2° 14' 24"	23,195.569	1	22.7
	Carme	726.3 [16]	2° 07' 14"	23,280.00	23 [15]	17.6
	Jupiter LI	723.2		23,314.335	1	22.3
	S/2011 J2	726.8[16]		23,329.71	1	23.6
	Megaclite	734.1 [16]	2° 08' 06"	23,439.08	2 [15]	22.1
	Eukelade	735.27 [16]	2° 08' 21"	23,485.28	2 [15]	22.6
	Cyllene	737.80 [16]	2° 08' 41"	23,544.84	1 [15]	23.2
	Pasiphae	744.2 [16]	2° 09' 18"	23,658.00	30 [15]	17.0
	Aoede	747 [16]	2° 09' 46"	23,743.83	2 [15]	22.5
	Arche	748.7 [16]	2° 09' 53"	23,765.12	1.5 [15]	22.8
	Pasithee	748.76 [16]	2° 09' 58"	23,780.14	1 [15]	23.2
	Eurydome	752.4 [16]	2° 10' 14"	23,830.94	1.5 [15]	22.7
	Sinope	753.2 [16]	2° 10' 20"	23,848.00	19 [15]	18.1
	S/2003 J23	759.15	2° 19' 12"	23,991.011	0.7	23.6
	S/2003 J5	761	2° 19' 12"	24,019.614	1.8	22.0
	Kalyke	767 [16]	2° 11' 54"	24,135.61	2 [15]	21.8
	S/2003 J10	768.4	2° 19' 48"	24,184.59	0.9	23.6
	Autonoe	778.0 [16]	2° 13' 25"	24,413.09	1.5 [15]	22.0
	Callirrhoe	736 [16]	2° 14' 25"	24,596.24	3.5 [15]	20.7
	Kore	807.20 [16]	2° 16' 29"	24,974.03	1 [15]	23.6
	S/2003 J2	983	2° 42' 36"	28,493.817	1	23.2
Saturn	S/2009 S1	0.4715	19"	117	0.15	
	Pan	0.575	22"	133.58	14.2	19.4
	Daphnis	0.594	22"	136.50	3.9	23.4
	Atlas	0.602	22"	137.67	20.9 × 18.1 × 8.9	19.0
	Prometheus	0.613	22"	139.38	66.3 × 39.5 × 30.7	15.8
	Pandora	0.629	23"	141.72	51.6 × 39.8 × 32.0	16.4
	Epimetheus	0.694	24"	151.41	58.0 × 58.7 × 53.2	15.6
	Janus	0.695	24"	151.46	97.4 × 96.9 × 77.2	14.4
	Aegaeon	0.8081	27" [15]	167.5	0.25	27R
	Mimas	0.942421813	30"	185.54	207 × 197 × 191	12.8
	Methone	1.01	31"	194.44	1.6	25.1
	Anthe	1.037	32"	197.70	1 [15]	26 [15]
	Pallene	1.14	34"	212.28	2.2	24.5
	Enceladus	1.370217855	38"	238.20	257 × 251 × 248	11.8
	Calypso	1.888	48"	294.71	15.0 × 11.5 × 7	18.7
	Telesto	1.888	48"	294.71	15.7 × 11.7 × 10.4	18.5
	Tethys	1.887802160	48"	294.99	540 × 531 × 528	10.3
	Polydeuces	2.74	1' 01"	377.20	1.3	24.8
	Helene	2.737	1' 01"	377.42	16.5	18.4
	Dione	2.736914742	1' 01"	377.65	562	10.4
	Rhea	4.517500436	1' 25"	527.37	764	9.7
	Titan	15.94542068	3' 17"	1,221.80	2,575	8.4
	Hyperion	21.2766088	3' 59"	1,481.10	164 × 130 × 107	14.4
	Iapetus	79.3301825	9' 35"	3,561.85	736	11.0
	Kiviuq	449.2	30' 27"	11,319.01	8 [15]	22.7
	Ijiraq	451.4	30' 33"	11,359.25	6 [15]	22.6
	Phoebe	548.2 [16]	34' 41"	12,893.24	110	16.7
	Paaliaq	686.9	40' 18"	14,985.05	13 [15]	21.0
	Skathi	728.2 [16]	41' 37"	15,471.94	4 [15]	23.6
	Albiorix	783.5	44' 22"	16,495.93	16 [15]	20.5
	S/2007 S2	799.8975	0° 46' 48"	16,560	3	24.4
	Bebhionn	834.8	45' 36"	16,950.00	3 [15]	24.1
	Skoll	878.3 [16]	47' 22"	17,610.00	3 [15]	24.5
	Erriapus	871.2	47' 54"	17,807.71	5 [15]	23.9
	Tarqeq	887.5	48' 12"	17,920.00	3.5 [15]	23.9
	Tarvos	926.2	48' 21"	17,977.24	7 [15]	22.3
	Greip	921.2 [16]	48' 42"	18,105.00	3 [15]	24.4
	Siarnaq	895.6	48' 57"	18,201.44	21 [15]	20.4
	Hyrrokkin	931.8 [16]	49' 00"	18,217.13	4 [15]	23.5
	Mundilfari	952.6 [16]	49' 32"	18,412.67	3 [15]	23.8
	S/2004 S13	905.82	0° 52' 48"	18,450	3	24.5
	S/2004 S17	913.125	0° 53' 24"	18,600	2	25.2
	Bergelmir	1,005.9 [16]	50' 26"	18,750.00	3 [15]	24.2
	S/2006 S1	971.565	0° 54' 0"	18,981.135	3	24.6
	Narvi	1,003.9 [16]	51' 29"	19,140.48	2.5 [15]	23.8
	Suttungr	1,016.7 [16]	51' 36"	19,185.70	4 [15]	23.9
	Aegir	1,116.5 [16]	52' 03"	19,350.00	3 [15]	24.4
	S/2004 S12	1,048.2675	0° 57' 0"	19,650	2.5	24.8
	Bestla	1,083.6 [16]	52' 51"	19,650.00	3.5 [15]	23.8
	S/2004 S7	1,103.055	0° 57' 0"	19,800	3	24.5
	Farbauti	1,086.1 [16]	53' 15"	19,800.00	2.5 [15]	24.7
	Hati	1,038.7 [16]	53' 40"	19,950.00	3 [15]	24.4
	Thrymr	1,094.3 [16]	53' 41"	19,957.54	4 [15]	23.9
	S/2007 S3	1,099.4025	0° 58' 48"	20,578	2.5	24.9
	S/2006 S3	1,143.2325	1° 0' 0"	21,132	3	24.6
	Fenrir	1,260.3 [16]	59' 43"	22,200.00	2 [15]	25.0
	Fornjot	1,490.9 [16]	59' 43"	22,200.00	3 [15]	24.6
	Surtur	1,297.7 [16]	59' 57"	22,290.00	3 [15]	24.8
	Kari	1,233.6 [16]	1° 00' 07"	22,350.00	3.5 [15]	23.9
	Jarnsaxa	964.7 [16]	1° 02' 22"	23,190.00	3 [15]	24.7
	Loge	1,312.0 [16]	1° 02' 22"	23,190.00	3 [15]	24.6
	Ymir	1,315.4 [16]	1° 02' 41"	23,305.87	10 [15]	22.4
Uranus	Cordelia	0.335	4"	49.75	25 × 18 × 18	23.1
	Ophelia	0.376	4"	53.76	27 × 19 × 19	22.8
	Bianca	0.435	4"	59.17	27	22.0
	Cressida	0.46356960	5"	61.77	41	21.1
	Desdemona	0.47364960	5"	62.66	35	21.5
	Juliet	0.49306549	5"	64.36	53	20.6
	Portia	0.51319592	5"	66.10	70	19.9
	Rosalind	0.55845953	5"	69.93	36	21.3
	Cupid	0.616	6"	74.80	8.9	25.9
	Belinda	0.62352747	6"	75.26	45	21.0
	Perdita	0.638	6"	76.42	13.3	24.0
	Puck	0.76183287	7"	86.00	81	19.2
	Mab	0.923	7"	97.73	12.4	25.4
	Miranda	1.41347925	10"	129.87	240 × 234 × 233	15.3
	Ariel	2.52037935	14"	190.95	581 × 578 × 578	13.2
	Umbriel	4.1441772	20"	266.00	585	14.0
	Titania	8.7058717	33"	436.30	789	13.0
	Oberon	13.4632389	44"	583.52	761	13.2
	Francisco	266.6 [16]	5' 24"	4,276.00	7 [15]	25.0
	Caliban	579.6 [16]	9' 03"	7,170.00	49	22.4
	Stephano	675.7 [16]	10' 19"	7,942.00	10 [15]	24.1
	Trinculo	759.7 [16]	10' 50"	8,571.02	7 [15]	25.4
	Sycorax	1,289.0 [16]	15' 24"	12,216.00	95	20.8
	Margaret	1,694.8	18' 07"	14,345.00	7.5 [15]	25.2
	Prospero	1,948.1 [16]	20' 19"	16,089.00	15 [15]	23.2
	Setebos	2,303.1 [16]	22' 43"	17,988.00	17.5 [15]	23.3
	Ferdinand	2,823.4 [16]	26' 24"	20,901.00	8 [15]	25.1
Neptune	Naiad	0.294	2"	48.227	33	23.9
	Thalassa	0.311	2"	50.075	41	23.3
	Despina	0.334655	2"	52.526	75	22.0
	Galatea	0.428745	3"	61.953	88	21.9
	Larissa	0.554654	3"	73.548	97	21.5
	S/2004 N1	0.950	5"	105.284	9	26.5
	Proteus	1.122315	6"	117.647	210	19.8
	Triton	5.8768541 [16]	17"	354.759	1,353	13.0
	Nereid	360.13	4' 22"	5,513.4	170	19.7
	Halimede	1,881.00	12' 26"	15,728.00	25 [15]	24.5
	Sao	2,914.63	17' 44"	22,422.00	13.5 [15]	25.4
	Laomedeia	3,166.65	18' 38"	23,571.00	16.5 [15]	25.4
	Psamathe	9,116.45	36' 55"	46,695.00	18 [15]	25.6
	Neso	9,737.36	38' 15"	48,387.00	21.5 [15]	24.6
Pluto	Charon	6.38723	1"	19.571	604	17.3
	Styx	20.16	2"	42.393	10	27.0
	Nix	24.8562	2"	48.671	13	23.4
	Kerberos	32.17	2"	57.729	14	26.1
	Hydra	38.2065	2"	64.698	30.5	22.9

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

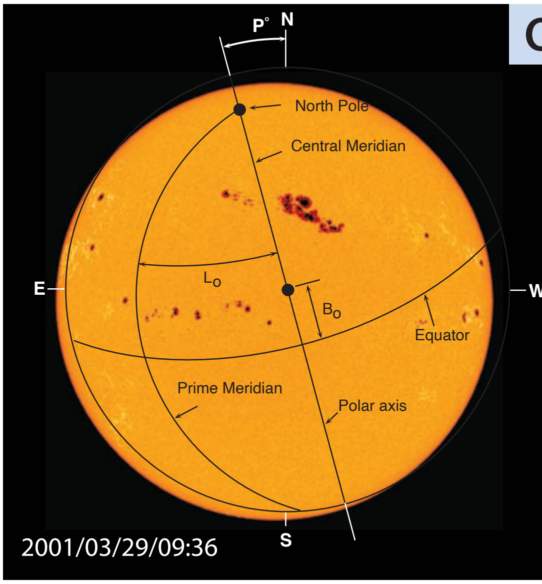
	ADELAIDE (CST)				BRISBANE (EST)				CANBERRA (EST)				DARWIN (CST)				
	Twilight Begin	Sun Rise	Sun Set	Twilight End	Twilight Begin	Sun Rise	Sun Set	Twilight End	Twilight Begin	Sun Rise	Sun Set	Twilight End	Twilight Begin	Sun Rise	Sun Set	Twilight End	
Jan 7	03:26	05:10	19:33	21:18	03:29	05:00	18:48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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN

ORIENTATION OF THE SUN



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

SYNODIC ROTATION NUMBERS (UT)

Rotation	Month	d.dd
2186	Jan	10.38
2187	Feb	6.72
2188	Mar	6.06
2189	Apr	2.36
2190	Apr	29.63
2191	May	26.85
2192	Jun	23.05
2193	Jul	20.25
2194	Aug	16.47
2195	Sep	12.73
2196	Oct	10.00
2197	Nov	6.30
2198	Dec	3.61
2199	Dec	30.94

VARIATION OF L_o

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

Date		P°	B_o°	L_o°
Jan	7	- 0.9	- 3.7	044.5
	14	- 4.3	- 4.5	312.3
	21	- 7.5	- 5.1	220.2
	28	- 10.6	- 5.7	128.0
Feb	4	- 13.4	- 6.2	035.8
	11	- 16.1	- 6.7	303.7
	18	- 18.4	- 7.0	211.5
	25	- 20.5	- 7.2	119.3
Mar	4	- 22.3	- 7.3	027.1
	11	- 23.7	- 7.2	294.9
	18	- 24.9	- 7.1	202.6
	25	- 25.7	- 6.9	110.3
Apr	1	- 26.2	- 6.5	018.0
	8	- 26.3	- 6.1	285.6
	15	- 26.0	- 5.6	193.2
	22	- 25.4	- 5.0	100.8
	29	- 24.4	- 4.4	008.3
May	6	- 23.1	- 3.7	275.8
	13	- 21.5	- 2.9	183.2
	20	- 19.5	- 2.1	090.6
	27	- 17.2	- 1.3	358.0
Jun	3	- 14.6	- 0.4	265.4
	10	- 11.8	+ 0.4	172.8
	17	- 8.9	+ 1.3	080.1
	24	- 5.8	+ 2.1	347.4
Jul	1	- 2.6	+ 2.9	254.8
	8	+ 0.5	+ 3.6	162.1
	15	+ 3.7	+ 4.3	069.5
	22	+ 6.7	+ 5.0	336.9
	29	+ 9.7	+ 5.6	244.3
Aug	5	+ 12.4	+ 6.1	151.7
	12	+ 15.0	+ 6.5	059.1
	19	+ 17.4	+ 6.8	326.6
	26	+ 19.5	+ 7.1	234.1
Sep	2	+ 21.3	+ 7.2	141.6
	9	+ 22.9	+ 7.3	049.2
	16	+ 24.2	+ 7.2	316.8
	23	+ 25.2	+ 7.0	224.4
	30	+ 25.9	+ 6.8	132.0
Oct	7	+ 26.2	+ 6.4	039.6
	14	+ 26.2	+ 6.0	307.3
	21	+ 25.8	+ 5.4	214.9
	28	+ 25.1	+ 4.8	122.6
Nov	4	+ 23.9	+ 4.1	030.3
	11	+ 22.4	+ 3.3	298.0
	18	+ 20.5	+ 2.5	205.7
	25	+ 18.2	+ 1.6	113.5
Dec	2	+ 15.7	+ 0.8	021.2
	9	+ 12.8	- 0.1	289.0
	16	+ 9.7	- 1.0	196.7
	23	+ 6.4	- 1.9	104.5
	30	+ 3.1	- 2.8	012.3

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

B_o° Heliocentric Latitude of centre of Sun

L_o° Heliocentric Longitude of centre of Sun

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

Example for Calculating Heliocentric Longitude

You wish to calculate the L_o value for 10 March at 2 pm WST.

2 pm WST is 6 hours UT (0 hr UT is 8 am WST). To get the value for 10 March (0 hr UT) start with the value from the main table for 4 March (27.1°) 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:

27.1° + (–79.1°) + (–3.3°) = –55.3° (If result negative, add 360°, if > 360, subtract 360) so –55.3° + 360° = 304.7°

MOON PERIGEE AND APOGEE (UT)

Perigee			Apogee		
Date	Time	Distance (km)	Date	Time	Distance (km)
Jan 10	06:01	363,238	Jan 22	00:14	404,914
Feb 6	14:02	368,816	Feb 18	21:14	404,376
Mar 3	07:33	369,062	Mar 18	17:25	404,650
Mar 30	12:32	363,854	Apr 15	10:05	405,475
Apr 27	16:15	359,327	May 12	19:51	406,210
May 26	01:21	357,207	Jun 8	22:21	406,401
Jun 23	10:52	357,937	Jul 6	04:28	405,934
Jul 21	17:12	361,236	Aug 2	17:55	405,025
Aug 18	13:18	366,121	Aug 30	11:25	404,308
Sep 13	16:06	369,860	Sep 27	06:50	404,348
Oct 9	05:55	366,855	Oct 25	02:26	405,154
Nov 6	00:10	361,438	Nov 21	18:53	406,132
Dec 4	08:46	357,492	Dec 19	01:26	406,603

MOON PHASE (UT)

Lunation	New Moon		First Quarter		Full Moon		Last Quarter	
1163			Jan 5	19:47	Jan 12	11:34	Jan 19	22:13
1164	Jan 28	00:07	Feb 4	04:19	Feb 11	00:33	Feb 18	19:33
1165	Feb 26	14:58	Mar 5	11:32	Mar 12	14:54	Mar 20	15:58
1166	Mar 28	02:57	Apr 3	18:39	Apr 11	06:08	Apr 19	09:57
1167	Apr 26	12:16	May 3	02:47	May 10	21:42	May 19	00:33
1168	May 25	19:44	Jun 1	12:42	Jun 9	13:10	Jun 17	11:33
1169	Jun 24	02:31	Jul 1	00:51	Jul 9	04:07	Jul 16	19:26
1170	Jul 23	09:46	Jul 30	15:23	Aug 7	18:11	Aug 15	01:15
1171	Aug 21	18:30	Aug 29	08:13	Sep 6	07:03	Sep 13	06:25
1172	Sep 20	05:30	Sep 28	02:54	Oct 5	18:40	Oct 12	12:25
1173	Oct 19	19:12	Oct 27	22:22	Nov 4	05:23	Nov 10	20:36
1174	Nov 18	11:42	Nov 26	17:03	Dec 3	15:47	Dec 10	07:51
1175	Dec 18	06:30	Dec 26	09:20				

SOLAR AND LUNAR ECLIPSES

During 2017 there are four eclipses, two of the Sun and two of the Moon. One solar eclipse is annular and the other total, one lunar eclipse is penumbral and the other partial. Only the partial lunar eclipse is visible from Australia.

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

The magnitudes quoted for the lunar eclipses below relate to the percentage of the lunar diameter that is immersed in the Earth's penumbral or umbral shadow. It is not a measure of brightness.

11 February – Penumbral eclipse of the Moon

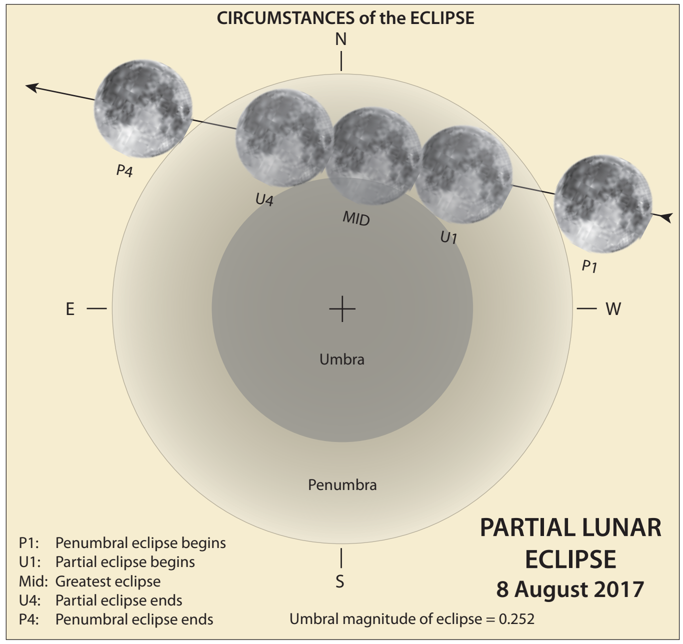
The first eclipse of the year is a penumbral lunar eclipse. It will be seen across the Americas, Europe, Africa and western Asia. It will not be visible from Australia, New Zealand, Papua New Guinea and eastern Asia. The penumbral magnitude of the eclipse is 1.014 resulting in a total immersion in the Earth's penumbral shadow, with the Moon's northern half noticeably darkened.

27 February – Annular eclipse of the Sun

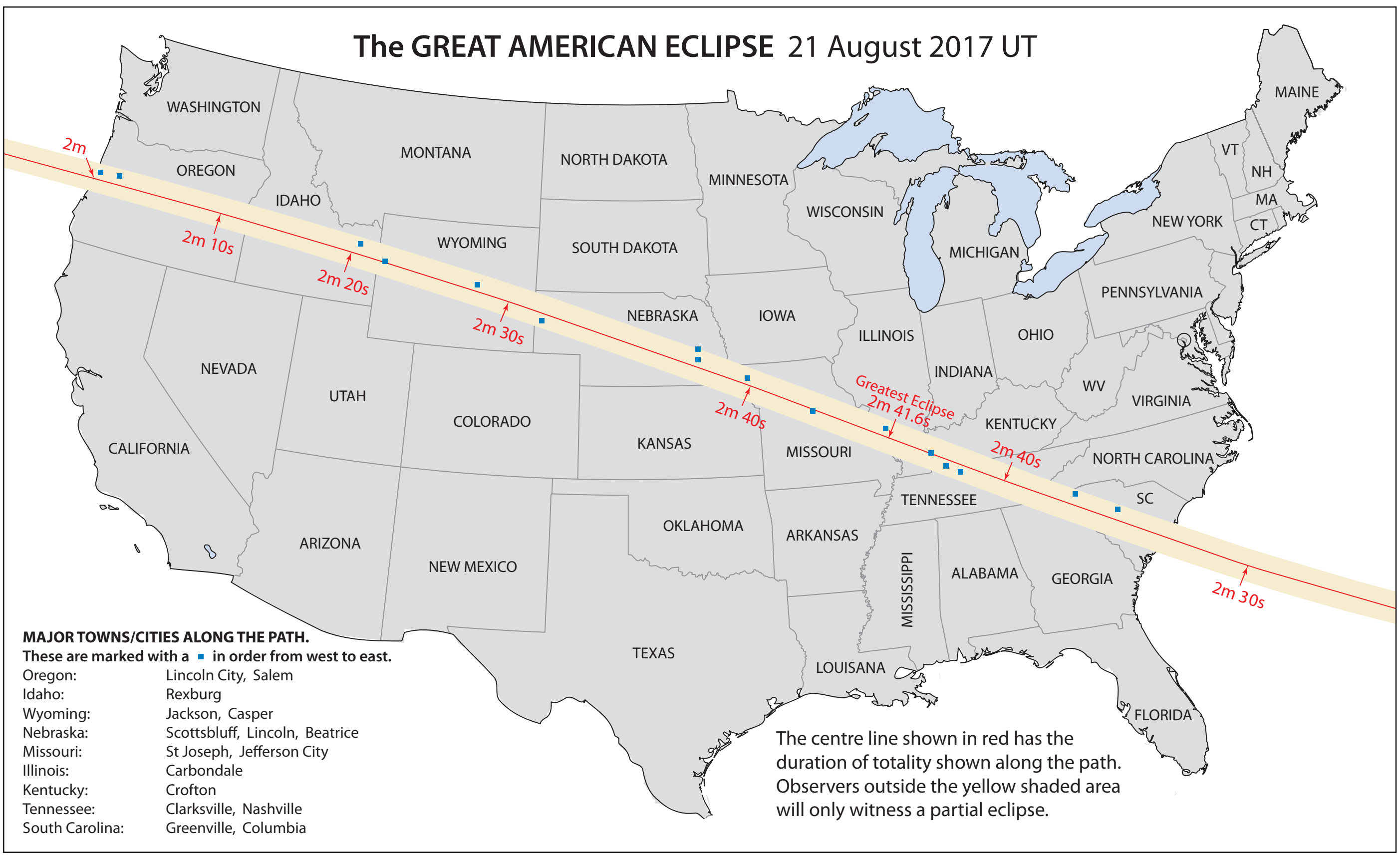
The first solar eclipse of 2017 is annular. The path of annularity begins in the southeastern Pacific Ocean with first landfall over Chile and Argentina. It then travels across the Atlantic Ocean touching down on the African continent in Angola, crosses the very north western part of Zambia before ending at sunset in the south east of the Democratic Republic of the Congo near the city of Likasi.

8 August – Partial eclipse of the Moon

		UT (7th)	EST	CST	WST
Penumbral eclipse begins	P1	15:48	1:48 am	1:18 am	11:48 pm (7th)
Umbral eclipse begins	UI	17:22	3:22 am	2:52 am	1:22 am
Mid eclipse	Mid	18:21	4:21 am	3:51 am	2:21 am
Umbral eclipse ends	U4	19:19	5:19 am	4:49 am	3:19 am
Penumbral eclipse ends	P4	20:53	6.53 am	6:23 am	4:53 am



The third eclipse is a partial lunar event that is visible across Australia and central Asia. The magnitude of maximum eclipse will be 0.25 with the southern quarter of the Moon immersed in the umbral shadow. From eastern and central Australia the Moon sets or is in twilight by the time of last contact (P4).



22 August – Total eclipse of the Sun

The last eclipse of the year has been billed the Great American Eclipse and it is easy to understand why. The path of totality will sweep across the North American continent from Oregon to South Carolina in the afternoon and will be within a day's drive for most Americans. Millions of people across the USA (and visitors from around the world) will see nature's most wondrous spectacle. The Moon's shadow first strikes the Earth in the North Pacific Ocean before crossing the Oregon coast where eclipse chasers will experience 1 minute 55 seconds of totality. Greatest eclipse occurs in Kentucky at 2 minutes 40 seconds, the shadow exits the continent soon after on the coast of South Carolina, where spectators can enjoy 1 minute 28 seconds of totality.

MOON RISE AND SET

ADELAIDE (CST)

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

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

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

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

BRISBANE (EST)

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

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

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

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

CANBERRA (EST)

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

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

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

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

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

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

MOON RISE AND SET

HOBART (EST)

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

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

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

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

MELBOURNE (EST)

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

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

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

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

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

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

SYDNEY (EST)

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

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

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

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.

OBSERVING THE MOON

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

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

The Table

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

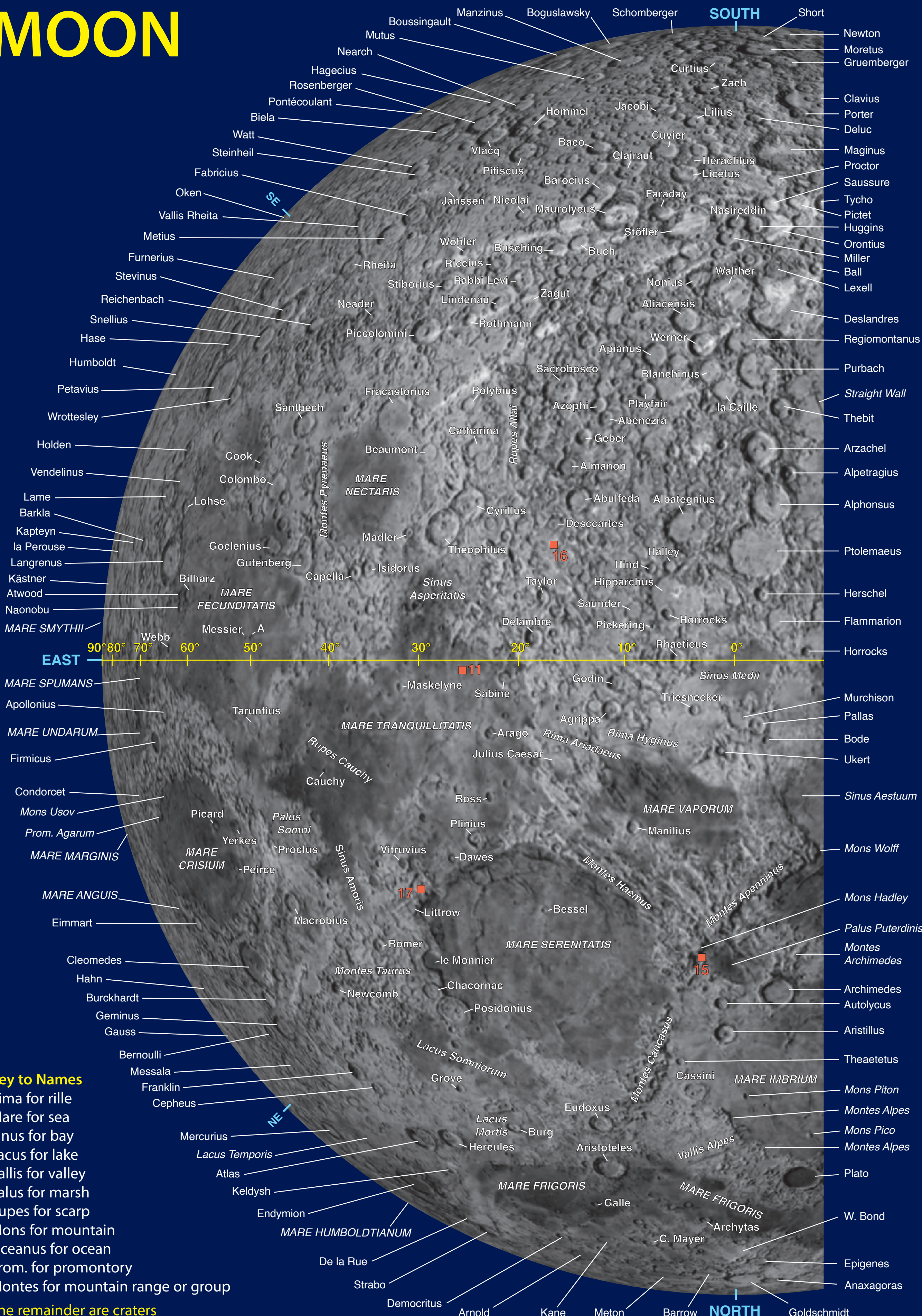
FEATURE	NOTES
Day 3 (48° E)	
Biela (76 km)	three central peaks
Furnerius, Petavius, Vendelinus and Langrenus	easily recognised row of four craters
Furnerius (130 km)	look for small crater on floor
Petavius (177 km)	central mountain and rille
Vendelinus (150 km) and Lame (84 km)	merged craters (Lame was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

FEATURE	NOTES
Posidonius (101 km)	impressive, circular walled plain
Lacus Somniorum	Lake of Dreams
Atlas (87 km) and Hercules (67 km)	prominent pair of craters near Mare Frigoris
Mare Frigoris	Sea of Cold
Day 6 (20° E)	
Manzinus (97 km)	deep crater with small craters on floor
Mutus (76 km)	paired with Manzinus with three small craters nearby
Hommel (120 km)	south of Pitiscus, with two obvious internal craters
Pitiscus (82 km)	prominent crater with central peak
Maurolycus (116 km)	old, heavily cratered floor
Catharina (101 km), Cyrillus (93 km) and Theophilus (104 km)	Theophilus and Cyrillus are overlapping craters, these three make a very distinctive group
Delambre (46 km)	near equator
Arago (26 km), Ross (27 km) and Plinius (43 km)	three distinctive, isolated craters on western Mare Tranquillitatis
Bessel (16 km)	small isolated crater on Mare Serenitatis
Mare Serenitatis	Sea of Serenity
Eudoxus (67 km) and Aristoteles (88 km)	an impressive pair of craters near Mare Frigoris
Day 7 (4° E) — First Quarter	
Curtius (95 km)	contains three small mountain peaks
Lilius (62 km)	prominent central peak (casts a long spire shadow at low Sun angles)
Cuvier (78 km), Heraclitus (97 km) and Licetus (76 km)	three craters in obvious triangle
Stofler (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 (northeast 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 southeast edge of Mare Imbrium
Mare Imbrium	Sea of Rains, eastern part in view
Autolycus (39 km)	makes a distinctive pair with Aristillus to the north
Aristillus (56 km)	three central mountain peaks
Cassini (57 km)	crater in northern Mare Imbrium, with two smaller craters on floor
Vallis Alpes (Alpine Valley)	cuts through Montes Alpes
Montes Alpes	northern edge of Mare Imbrium
Day 9 (15° W)	
Moretus (117 km)	not far from the south pole, another distinctive crater with a central mountain that casts eye-catching shadows
Clavius (232 km)	a number of smaller craters are on the floor (location of Clavius Base, from where TMA-1 was discovered—for those Sci-Fi fans)
Rays extending to the east from Tycho	these develop as the Moon gets closer to full
Tycho (87 km)	prominent crater in the southern uplands, at low Sun angles its central peak casts a *witch's hat* shadow (location of TMA-1, see Clavius above)
Hell (35 km)	well defined crater in flat plain of Deslandres
Pitatus (88 km)	on southern edge of Mare Nubium, a flat lava filled crater with central peak
Mare Nubium	Sea of Clouds, eastern portion
Nicollet	small distinctive crater in the middle of Mare Nubium
Rupes Recta (Straight Wall)	running north-south (120 km) on eastern edge of Mare Nubium, small crater Birt is just west
Eratosthenes (58 km)	at the western end of the Apennines, has terraced walls and a central peak
Mones Apennine	the mountain range is now in full sunlight
Archimedes (80 km)	distinctive, flat floored crater in Mare Imbrium
Mons Piton and Mons Pico	two obvious isolated mountains in northern Mare Imbrium, both cast long shadows at low Sun angles
Plato (101 km)	at the northern end of Mare Imbrium, casts interesting shadows from its jagged crater walls and has challenging 1 km diameter craters on its floor
Day 10 (27° W)	
Longomontanus (149 km)	a walled plain with several craters around the edge of the floor plus some peaks
Mare Nubium	now in full sunlight
Bullialdus A, B and Konig (23 km)	a group of three craters, just south of Bullialdus, standing out well against the dark floor of Mare Nubium
Bullialdus (60 km)	prominent crater in Mare Nubium with terraced walls and multiple peaked central mountain
Lansberg (39 km)	isolated crater with central peak in Mare Insularum
Reinhold (45 km)	distinctive crater, near Lansberg in Mare Insularum

FEATURE	NOTES
Copernicus (91 km)	possibly the most recognisable crater on the Moon. It has terraced walls and a prominent central peak with surrounding ejector rays, standing out well against the dark floored mare. Located on the border of Mare Insularum and Mare Imbrium
Crater chain	a challenge, this string of craters (4–7 km) is between Copernicus and Eratosthenes, running roughly towards the southeast
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 northwest 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, Schroter's, extends from Herodotus towards the north.
Day 13 and 14 (about 70°–80° W)	
Bailly (295 km)	a large, foreshortened crater near the south pole limb, presents great views with favourable librations
Wargentin (84 km)	was once a crater but now filled with lava to the brim forming a plateau, that appears to stand above the surface with the right Sun angle
Mersenius (84 km)	west of Mare Humorum, has a lava flooded floor with small crater pits
Billy (46 km)	prominent crater with a dark floor
Grimaldi (228 km)	large, foreshortened, dark floored crater is an obvious signpost
Hevelius (109 km) and Cavalerius (60 km)	a distinctive pair near western limb. Hevelius is a walled plain with a small central peak and crisscross pattern of rilles
Cardanus (51 km) and Krafft (53 km)	impressive pair near limb against backdrop of dark plain of Oceanus Procellarum
Struve (175 km) and Russell (105 km)	both are extremely foreshortened limb features, appearing to merge
Mons Rumker	a well known lunar dome (mound-like), isolated in Sinus Roris
Pythagoras (129 km)	very close to the northern pole limb, is extremely foreshortened but displays good terraced walls and twin central peaks
Day 15 — Full Moon	
Bright Rays from craters	the most prominent example is Tycho (dominates the southern hemisphere). The rays of Copernicus, Aristarchus and Kepler form a triangle. Also worthwhile looking at are Stevinus, Proclus (fan shaped ejecta) and Anaxagoras
Bright craters	there are a number of these which include Dionysius, Byrgius, and Censorinus
Dark features	all the seas and walled plains of Grimaldi, Endymion and Plato
Day 16 to 17 (about 70°–80° E)	
Furnerius, Petavius, Vendelinus and Langrenus	seen at best (better view than day 3)
Mare Crisium	best phase to see the wrinkled ridges on floor

MOON



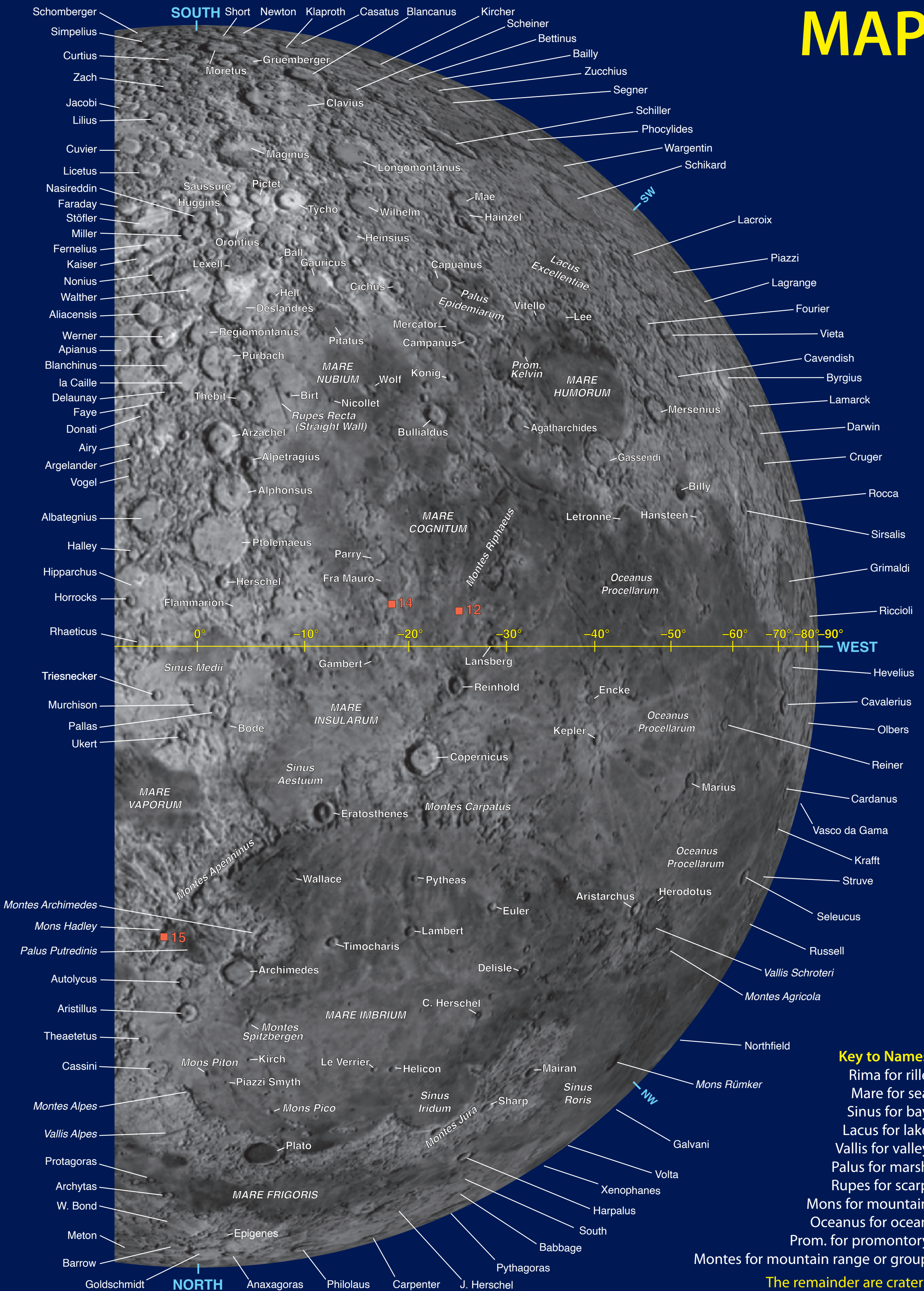
Key to Names

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

The remainder are craters

Orange squares are Apollo landing sites

MAP



Key to Names

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

The remainder are craters

Orange squares are Apollo landing sites

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 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 way of saying the edge of the Moon. After Full Moon a star disappears on the bright limb and reappears on the dark limb. There is no dark limb at Full Moon.

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

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

THE TIMING OF OCCULTATIONS.

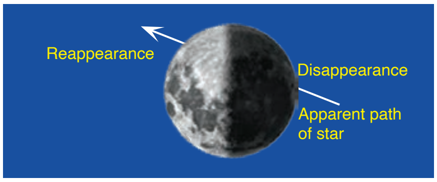
Besides being a spectacular event, the observation of occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

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

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

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

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



LUNAR OCCULTATION TABLES

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

EXPLANATION

EST	the date and time of the occultation, hr and min are in EST except Adelaide and Darwin using CST and Perth using WST.	
OBJECT	n, nn, nnn, nnnn	ZC catalogue number
	ggg ccc	Greek letter and constellation abbreviation
	n ccc	Flamsteed number and constellation
	name of planet, satellite or deep sky object.	
PD	event, consisting of two letters. The first letter is the type of Event: D = Disappearance and R = Reappearance. The second letter represents: D = Dark limb, B = a bright limb event. G indicates a graze at or near the location. M means a miss with a graze nearby.	
Mag	magnitude of the star.	
Elg	elongation or separation of the Moon from the Sun as measured in degrees.	
Alt	altitude of the Moon during the occultation.	
PA	position angle is the position the event occurs on the limb of the Moon (measured as degrees east of north).	
A	coefficient of longitude (see below)	
B	coefficient of latitude (see below)	
	NB. For some stars, close to grazing, A and B values would be useless, and no values are shown.	

CALCULATING EVENT TIME FOR OTHER LOCATIONS

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

Predicted Time at your location

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

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

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

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

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

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

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the reappearance of Regulus on May 4th for their location in Albury NSW (146° 55' E, 36° 05' S), see page 142. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

$$= 149.13° - 146.92° = -2.21° \quad — \quad \text{‘n’ } (-)$$

The change in latitude from Canberra (decimal degrees)

$$= 35.25° - 36.08° = -0.83° \quad — \quad \text{‘p’ } (-)$$

From the Canberra table, the time of the event is 21:31 EST and the values of A and B are + 1.8 and + 0.5 respectively.

Therefore the equation becomes:

$$21{:}31 + (+1.8 \times -2.21°) + (+0.5 \times -0.83°)$$
$$= 21{:}31 + (-4.0) + (-0.4)$$
$$= 21{:}31 + (-4.4) = 21{:}27$$

The event will be visible from Albury approximately four minutes earlier than Canberra, i.e., about 9:27 pm (EST) on May 4th.

Lunar occultation predictions calculated using Occult version 4.2.1 by D. Herald.

LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 20:26	20 Psc	RB	5.5	72	34	227	0.9	2.2
Feb 06 20:26	104 Tau	RB	4.9	120	37	281	2.3	-0.3
Feb 07 21:25	68 Ori	DD	5.8	134	35	54	2.2	1.2
Feb 09 22:16	1241	DD	6.5	161	36	141	1.9	-2.0
Feb 11 00:22	Pi Cnc	DD	5.4	175	40	141	1.6	-1.5
Feb 11 22:43	Regulus	DB	1.4	173	33	105	1.8	-1.3
Feb 12 00:05	Regulus	RD	1.4	173	42	296	2.0	-1.1
Feb 19 01:45	2266	RD	6.2	91	27	297	0.4	-1.9
Feb 19 04:15	2279	DB	6.1	90	56	163	0.5	-4.4
Feb 19 04:33	2278	RD	6.3	90	59	336	0.9	-3.8
Feb 23 05:34	Rho 1 Sgr	DB	3.9	45	36	18	2.8	5.6
Feb 23 05:55	Rho 1 Sgr	RD	3.9	45	40	345	-0.5	-8.3
Mar 10 01:37	Omi 2 Cnc	DD	5.7	143	19	155	0.1	-1.4
Mar 11 00:31	23 Leo	DD	6.5	155	37	68	2.7	1.8
Mar 22 05:11	2764	RD	6.4	77	58	253	2.1	0.0
Apr 09 02:11	Sig Leo	DD	4.1	150	24	131	0.7	-0.4
Apr 09 03:15	Sig Leo	RB	4.1	150	11	277	0.5	0.9
Apr 10 02:17	10 Vir	DD	6.0	161	34	142	0.9	-1.0
Apr 17 22:50	2686	RD	5.1	110	7	326	-0.7	-2.7
Apr 21 02:24	3100	RD	6.5	74	19	257	0.5	-0.7
Apr 23 04:19	Neptune	RD	7.9	49	18	236	0.5	0.0
Apr 23 05:24	81 Aqr	RD	6.2	49	30	273	1.1	-1.3
May 04 19:24	Regulus	DD	1.4	106	43	147	1.5	-2.0
May 04 20:39	Regulus	RB	1.4	106	41	263	2.6	0.8
May 10 20:03	Xi Lib	DD	5.5	173	32	189	-1.8	-7.0
May 10 20:21	Xi Lib	RD	5.5	173	35	219	3.7	3.6
May 14 21:56	2640	RD	6.1	140	21	314	-0.1	-2.4
May 15 00:26	2658	DB	5.8	139	51	59	2.2	0.6
May 15 01:36	2658	RD	5.8	138	64	315	1.8	-3.2
May 15 22:37	2787	RD	6.3	128	20	259	0.5	-0.8
May 19 04:25	3196	RD	6.3	92	56	217	1.7	1.9
May 22 05:47	10 Cet	RD	6.4	54	36	261	1.4	-0.6
Jun 07 04:13	Xi Lib	DD	5.5	148	6	112	0.1	0.4
Jun 09 03:20	Phi Oph	DD	4.3	169	38	96	1.2	0.9
Jun 09 04:32	Phi Oph	RB	4.3	170	23	274	0.5	1.1
Jun 12 02:15	2763	RD	6.5	156	74	218	2.2	3.7
Jun 12 05:02	2774	RD	6.4	155	47	232	1.0	2.6
Jun 13 22:28	3005	RD	6.2	135	22	284	0.4	-1.7
Jun 28 19:25	1529	DD	6.6	58	26	51	2.7	4.1
Jun 29 20:49	1645	DD	6.7	71	23	138	0.6	-0.7
Jul 02 18:57	1965	DD	6.5	105	60	121	2.1	-1.4
Jul 07 03:57	2460	DD	6.0	152	16	56	-0.1	2.2
Jul 08 02:27	2578	DD	6.5	163	44	75	1.2	1.7
Jul 08 23:26	2715	DD	6.3	172	73	107	2.5	-1.1
Jul 09 00:25	2718	DD	6.7	173	73	117	2.6	-1.3
Jul 11 22:50	29 Cap	DB	5.3	153	40	151	0.8	-7.8
Jul 11 23:15	29 Cap	RD	5.3	152	45	187	1.8	6.9
Jul 13 01:27	38 Aqr	DB	5.4	140	58	74	2.1	0.1
Jul 13 02:56	38 Aqr	RD	5.4	140	67	240	2.1	1.3
Jul 15 03:38	24 Psc	DB	5.9	115	55	5	0.4	4.1
Jul 15 04:26	24 Psc	RD	5.9	115	58	296	3.6	-2.0
Aug 01 23:07	2279	DD	6.1	111	38	106	1.3	0.5
Aug 04 19:48	2658	DD	5.8	143	60	28	3.7	5.7
Aug 04 20:21	2658	RB	5.8	143	65	346	0.8	-8.3
Aug 05 02:44	2687	DD	6.6	145	25	122	1.0	0.1
Aug 05 22:51	43 Sgr	DD	4.9	155	74	103	2.6	-0.6
Aug 06 00:18	43 Sgr	RB	4.9	155	63	241	1.8	2.1
Aug 13 00:08	89 Psc	DB	5.1	121	22	131	1.7	-4.6
Aug 13 00:36	89 Psc	RD	5.1	120	27	179	-0.3	4.3
Aug 14 01:50	64 Cet	RD	5.6	107	28	285	1.7	-1.8
Aug 14 02:14	Xi 1 Cet	DB	4.4	107	31	358	-0.6	4.3
Aug 14 02:45	Xi 1 Cet	RD	4.4	107	36	308	3.4	-4.1
Aug 15 05:16	464	RD	6.1	93	41	257	2.1	0.2
Aug 17 03:41	104 Tau	DB	4.9	67	12	72	0.6	-0.5
Aug 17 04:48	104 Tau	RD	4.9	66	22	257	1.2	-0.5
Aug 18 05:29	68 Ori	DB	5.8	52	19	133	2.0	-2.7
Aug 18 06:13	68 Ori	RD	5.8	52	25	209	0.7	1.5
Sep 04 19:51	3152	DD	6.6	158	44	116	1.5	-2.5
Sep 06 04:01	3313	DD	6.5	173	28	85	0.8	1.3
Sep 07 02:18	3432	RD	6.2	175	52	274	2.2	0.6
Sep 07 22:38	5 Psc	RD	6.2	164	41	190	0.5	3.1
Sep 14 04:57	888	RD	6.0	82	30	267	1.9	-0.5
Sep 14 05:12	57 Ori	DB	5.9	82	32	124	2.5	-1.8
Sep 16 04:09	1186	RD	6.0	56	8	298	1.0	-1.9
Sep 18 09:58	Venus	DB	-3.9	28	42	151	1.7	-2.4
Sep 18 11:15	Venus	RD	-3.9	28	41	258	3.0	1.0
Sep 29 00:13	2715	DD	6.3	95	14	160	2.6	-5.3
Sep 30 01:37	2865	DD	5.7	106	7	58	-0.4	1.7
Oct 05 01:25	24 Psc	DD	5.9	165	46	58	1.4	1.7
Oct 10 03:14	684	RD	6.2	127	37	315	3.3	-2.6
Oct 26 20:30	2791	RB	5.6	73	42	255	1.1	1.7
Nov 03 22:08	308	DD	6.3	170	43	82	2.0	-0.3
Nov 04 02:48	Xi 1 Cet	DB	4.4	172	27	145	2.2	-3.4
Nov 04 03:06	Xi 1 Cet	RB	4.4	172	24	174	0.5	6.3
Nov 05 01:09	454	RD	5.6	173	41	279	2.4	0.0
Nov 09 03:40	56 Gem	DB	5.1	117	34	74	2.2	0.1
Nov 27 21:45	83 Aqr	DD	5.5	99	43	72	1.4	1.6
Nov 27 22:57	83 Aqr	RB	5.5	99	29	235	0.6	2.0
Dec 03 20:42	684	DD	6.2	175	19	38	0.4	0.6
Dec 07 02:02	85 Gem	RD	5.4	137	33	276	2.0	-0.6
Dec 10 01:51	53 Leo	RD	5.3	98	17	291	1.0	-1.6
Dec 28 22:25	64 Cet	DD	5.6	116	35	89	1.8	0.9
Dec 28 23:29	Xi 1 Cet	DD	4.4	117	24	67	1.1	1.6
Dec 29 00:36	Xi 1 Cet	RB	4.4	117	12	255	0.6	1.5
Dec 29 22:42	454	DD	5.6	130	35	4	0.9	4.2
Dec 30 01:05	464	DD	6.1	131	14	132	0.7	-0.4

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 20:09	78 Aqr	RB	6.2	59	26	225	0.4	2.1
Jan 04 20:15	20 Psc	DD	5.5	72	33	80	1.2	1.2
Jan 04 21:21	20 Psc	RB	5.5	72	19	233	0.5	1.9
Jan 06 19:18	Mu Psc	RB	4.8	97	53	308	4.3	-2.7
Jan 13 03:06	81 Gem	DB	4.9	176	27	92	1.5	0.7
Jan 13 04:13	81 Gem	RD	4.9	176	15	298	0.5	0.0
Feb 04 21:05	464	DD	6.1	93	30	127	1.6	-0.8
Feb 06 20:15	104 Tau	DD	4.9	120	44	48	2.3	1.7
Feb 06 21:27	104 Tau	RB	4.9	120	38	297	2.1	-0.5
Feb 09 22:03	Zet 1 Cnc	DD	5.1	160	44	143	2.1	-2.4
Feb 09 22:03	97646	DD	6.2	160	44	143	2.1	-2.3
Feb 09 22:03	X108006	DD	6.2	160	44	144	2.1	-2.4
Feb 09 23:11	Zet 1 Cnc	RB	5.1	161	45	243	3.0	1.4
Feb 11 01:14	Pi Cnc	DD	5.4	174	42	102	2.1	0.1
Feb 11 23:41	Regulus	DB	1.4	173	49	75	3.0	0.4
Feb 12 00:50	Regulus	RD	1.4	173	50	334	1.3	-2.5
Feb 13 02:57	Chi Leo	DB	4.6	160	49	133	1.6	-1.2
Feb 13 04:15	Chi Leo	RD	4.6	159	36	283	1.5	0.3
Feb 17 23:20	18 Lib	RD	5.9	103	10	275	0.2	-1.1
Feb 19 01:13	2266	DB	6.2	91	26	64	1.2	0.0
Feb 19 02:02	2266	RD	6.2	91	37	337	0.1	-3.5
Mar 10 02:09	Omi 2 Cnc	DD	5.7	143	11	110	0.5	0.3
Mar 19 23:45	2460	RD	6.0	101	16	209	2.4	4.3
Apr 09 02:53	Sig Leo	DD	4.1	150	12	93	0.6	0.8
Apr 10 02:59	10 Vir	DD	6.0	161	23	103	0.9	0.5
Apr 17 22:51	2680	RD	5.6	110	12	271	0.1	-0.9
Apr 18 23:17	45 Sgr	RD	5.8	99	7	267	0.0	-0.8
Apr 23 04:58	Neptune	RD	7.9	49	33	262	1.2	-0.6
Apr 23 05:12	81 Aqr	DB	6.2	49	36	20	0.9	2.7
Apr 24 04:53	24 Psc	RD	5.9	36	19	225	0.5	0.7
Apr 30 18:17	68 Ori	RB	5.8	53	27	264	1.6	0.9
May 03 20:55	Pi Cnc	DD	5.4	94	33	159	0.4	-2.2
May 03 21:46	Pi Cnc	RB	5.4	94	24	246	1.9	2.1
May 04 20:14	Regulus	DD	1.4	106	48	107	2.3	-0.3
May 04 21:36	Regulus	RB	1.4	106	37	307	1.3	-0.7
May 06 00:29	Chi Leo	DD	4.6	119	16	134	0.4	-0.7
May 10 20:08	Xi Lib	DD	5.5	173	40	135	0.8	-2.4
May 10 21:26	Xi Lib	RB	5.5	173	56	277	2.2	-1.1
May 12 19:21	Phi Oph	DD	4.3	162	12	172	-1.1	-4.3
May 12 19:47	Phi Oph	RD	4.3	162	18	222	1.5	1.7
May 13 22:06	2508	RD	6.3	151	39	223	2.7	2.2
May 16 05:34	43 Sgr	DB	4.9	127	61	137	3.6	-3.1
Jun 09 04:10	Phi Oph	DD	4.3	169	21	81	0.4	1.3
Jun 12 05:34	2773	RD	6.2	156	34	192	-0.9	5.7
Jun 13 22:41	3005	RD	6.2	135	30	335	-0.2	-6.5
Jul 10 02:45	2863	RD	6.1	174	54	180	9.9	9.9
Jul 11 23:16	29 Cap	DB	5.3	153	53	106	2.0	-1.7
Jul 12 00:35	29 Cap	RD	5.3	152	69	224	2.2	2.1
Jul 13 02:36	38 Aqr	DB	5.4	140	74	66	2.4	1.2
Jul 13 04:08	38 Aqr	RD	5.4	140	63	241	1.9	1.8
Jul 15 04:45	24 Psc	DB	5.9	115	64	8	0.5	4.2
Jul 15 05:39	24 Psc	RD	5.9	115	58	291	3.4	-0.7
Jul 20 04:09	63 Tau	RD	5.6	50	15	249	0.6	-0.2
Jul 31 18:01	18 Lib	RB	5.9	98	74	315	2.0	-2.3
Aug 01 23:57	2279	DD	6.1	111	22	88	0.6	1.1
Aug 05 23:59	43 Sgr	DD	4.9	155	64	87	2.3	0.8
Aug 06 01:24	43 Sgr	RB	4.9	155	45	248	1.2	1.7
Aug 07 21:05	3064	DD	5.9	177	52	95	1.9	-1.1
Aug 07 22:32	3064	RB	5.9	177	70	239	2.4	1.2
Aug 13 00:42	89 Psc	DB	5.1	121	37	111	2.2	-2.2
Aug 13 01:33	89 Psc	RD	5.1	120	46	193	0.5	3.0
Aug 14 01:47	64 Cet	DB	5.6	107	36	15	0.3	2.6
Aug 14 02:40	64 Cet	RD	5.6	107	45	289	2.9	-1.8
Aug 14 03:10	Xi 1 Cet	DB	4.4	107	49	356	-0.6	5.1
Aug 14 03:46	Xi 1 Cet	RD	4.4	107	52	305	4.6	-3.5
Aug 15 04:57	464	DB	6.1	93	49	56	2.0	1.1
Aug 17 04:22	104 Tau	DB	4.9	67	28	69	1.3	-0.1
Aug 17 05:39	104 Tau	RD	4.9	66	38	259	2.0	-0.1
Sep 07 03:21	3432	RD	6.2	175	39	272	1.6	0.8
Sep 07 19:54	29 Psc	RD	5.1	165	17	237	0.5	0.2
Sep 07 23:42	5 Psc	RD	6.2	164	60	199	1.1	2.9
Sep 14 04:32	888	DB	6.0	83	37	68	1.9	0.2
Sep 16 04:44	1186	RD	6.0	56	23	307	1.7	-2.1
Sep 18 10:47	Venus	DB	-3.9	28	48	111	2.5	-0.6
Sep 18 12:20	Venus	RD	-3.9	28	37	302	1.6	-0.6
Oct 03 02:55	38 Aqr	DD	5.4	141	9	149	2.0	-5.5
Oct 05 02:25	24 Psc	DD	5.9	165	33	58	0.9	1.8
Oct 09 22:21	63 Tau	RD	5.6	129	10	222	0.1	0.7
Oct 10 03:49	684	DB	6.2	127	44	359	0.4	8.8
Oct 10 04:08	684	RD	6.2	127	42	334	3.8	-7.3
Oct 12 00:40	Nu Gem	RD	4.1	101	12	279	0.9	-1.1
Oct 14 02:23	The Cnc	RD	5.3	74	11	288	0.9	-1.4
Oct 21 18:28	Xi Lib	DD	5.5	18	9	103	0.2	0.5
Oct 26 20:10	2791	DD	5.6	73	41	77	1.2	1.4
Oct 26 21:23	2791	RB	5.6	73	25	259	0.5	1.3
Nov 04 03:29	Xi 1 Cet	DD	4.4	172	17	117	0.8	0.0
Nov 05 01:07	454	DB	5.6	173	46	34	1.7	2.3
Nov 05 02:12	454	RD	5.6	173	38	285	2.1	0.1
Nov 27 22:42	83 Aqr	DD	5.5	99	27	72	0.8	1.5
Dec 03 21:29	684	DD	6.2	175	36	38	1.0	1.2
Dec 07 01:38	85 Gem	DB	5.4	138	40	80	2.3	0.0
Dec 07 02:59	85 Gem	RD	5.4	137	43	298	2.2	-0.8
Dec 10 01:16	53 Leo	DB	5.3	98	19	87	1.0	-0.9
Dec 10 02:25	53 Leo	RD	5.3	98	32	311	1.5	-2.1
Dec 28 23:24	64 Cet	DD	5.6	116	23	79	1.1	1.2
Dec 29 00:25	Xi 1 Cet	DD	4.4	117	11	50	0.6	1.9

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 20:01	20 Psc	DD	5.5	72	36	94	1.5	0.9
Jan 04 21:02	20 Psc	RB	5.5	72	24	216	0.5	2.4
Feb 06 19:58	104 Tau	DD	4.9	120	36	66	2.1	0.6
Feb 06 21:19	104 Tau	RB	4.9	120	33	278	2.1	0.3
Feb 07 22:18	68 Ori	DD	5.8	134	32	53	2.3	1.7
Feb 09 23:07	1241	DD	6.5	161	37	135	1.8	-1.3
Feb 11 01:10	Pi Cnc	DD	5.4	175	37	128	1.6	-0.7
Feb 11 23:34	Regulus	DB	1.4	173	40	99	2.1	-0.8
Feb 12 00:56	Regulus	RD	1.4	173	43	307	1.8	-1.1
Feb 13 03:06	Chi Leo	DB	4.6	160	43	166	0.6	-2.7
Feb 13 03:58	Chi Leo	RD	4.6	159	36	248	2.4	2.2
Feb 17 23:26	18 Lib	RD	5.9	103	9	252	0.2	-0.7
Feb 19 02:22	2266	RD	6.2	91	37	309	0.7	-2.3
Feb 19 04:35	2278	DB	6.3	90	61	44	4.3	3.9
Mar 10 02:09	Omi 2 Cnc	DD	5.7	143	11	141	0.2	-0.6
Mar 11 01:31	23 Leo	DD	6.5	155	27	42	3.8	6.0
Mar 22 04:38	2764	DB	6.4	77	53	106	1.7	-1.6
Apr 09 02:48	Sig Leo	DD	4.1	150	14	123	0.5	0.0
Apr 10 02:56	10 Vir	DD	6.0	161	24	133	0.7	-0.5
Apr 17 22:55	2680	RD	5.6	110	11	244	0.3	-0.4
Apr 17 23:13	2686	RD	5.1	110	14	343	-1.1	-4.4
Apr 18 23:21	45 Sgr	RD	5.8	99	7	239	0.2	-0.2
Apr 21 03:02	3100	RD	6.5	74	29	261	0.8	-0.9
Apr 23 04:56	Neptune	RD	7.9	49	28	235	0.9	0.2
Apr 23 04:59	81 Aqr	DB	6.2	49	28	52	0.9	0.3
Apr 24 04:40	24 Psc	RD	5.9	36	12	186	0.3	3.3
Apr 30 18:00	68 Ori	RB	5.8	53	26	239	1.9	1.7
May 04 20:11	Regulus	DD	1.4	106	42	133	1.6	-1.1
May 04 21:31	Regulus	RB	1.4	106	34	279	1.8	0.5
May 06 00:40	Chi Leo	DD	4.6	119	15	175	-0.3	-3.2
May 10 20:29	Xi Lib	DD	5.5	173	39	164	0.1	-3.6
May 13 19:44	2495	RD	6.0	152	7	303	-0.4	-1.8

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
May 14 22:26	2640	RD	6.1	140	30	327	-0.1	-3.3
May 15 01:22	2658	DB	5.8	139	64	49	2.8	2.0
May 15 02:29	2658	RD	5.8	138	73	320	2.3	-3.6
May 15 23:14	2787	RD	6.3	128	30	268	0.8	-1.1
May 15 23:55	2794	RD	6.6	128	38	215	2.1	2.1
May 19 04:09	3196	DB	6.3	93	55	115	2.3	-2.4
May 19 05:12	3196	RD	6.3	92	64	205	1.5	3.1
May 20 01:20	3313	RD	6.5	82	12	227	0.4	0.3
May 22 05:19	10 Cet	DB	6.4	55	33	59	1.1	0.1
Jun 09 04:00	Phi Oph	DD	4.3	169	27	103	0.8	0.7
Jun 10 19:07	2578	RD	6.5	169	15	247	0.4	-0.5
Jun 12 03:03	2763	RD	6.5	156	66	207	1.4	5.0
Jun 12 05:38	2774	RD	6.4	155	37	216	0.2	3.2
Jun 13 23:05	3005	RD	6.2	135	32	291	0.7	-2.0
Jul 02 19:50	1965	DD	6.5	105	59	106	2.3	-0.4
Jul 07 04:25	2460	DD	6.0	152	8	68	-0.3	1.7
Jul 08 03:07	2578	DD	6.5	163	33	85	0.8	1.3
Jul 09 00:23	2715	DD	6.3	172	72	110	2.6	-0.8
Jul 11 23:37	29 Cap	DB	5.3	153	52	152	9.9	9.9
Jul 11 23:59	29 Cap	RD	5.3	152	56	181	9.9	9.9
Jul 13 02:22	38 Aqr	DB	5.4	140	65	86	2.5	0.0
Jul 13 03:45	38 Aqr	RD	5.4	140	63	225	1.6	2.2
Jul 15 04:16	24 Psc	DB	5.9	115	58	28	1.2	2.4
Jul 15 05:28	24 Psc	RD	5.9	115	55	273	2.5	0.4
Jul 20 04:08	63 Tau	RD	5.6	50	8	229	0.2	0.2
Jul 31 18:04	18 Lib	RB	5.9	98	66	286	2.4	-0.9
Aug 01 23:48	2279	DD	6.1	111	27	112	0.9	0.4
Aug 05 02:46	2680	DD	5.6	145	22	12	-1.3	5.9
Aug 05 23:48	43 Sgr	DD	4.9	155	66	111	2.5	-0.5
Aug 06 01:02	43 Sgr	RB	4.9	155	52	228	1.1	2.7
Aug 14 01:33	64 Cet	DB	5.6	107	27	39	0.7	0.8
Aug 14 02:39	64 Cet	RD	5.6	107	37	267	1.9	-0.7

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 14 02:45	Xi 1 Cet	DB	4.4	107	37	23	0.7	1.8
Aug 14 03:47	Xi 1 Cet	RD	4.4	107	44	281	2.6	-1.0
Aug 15 04:44	464	DB	6.1	93	40	70	1.9	0.3
Aug 17 04:21	104 Tau	DB	4.9	67	20	86	1.2	-0.8
Aug 17 05:33	104 Tau	RD	4.9	66	29	244	1.5	0.0
Aug 31 00:44	2495	DD	6.0	103	11	34	-0.7	3.3
Sep 06 04:38	3313	DD	6.5	173	18	96	0.5	1.0
Sep 07 03:07	3432	RD	6.2	175	42	258	1.5	1.4
Sep 07 19:47	29 Psc	RD	5.1	165	11	206	0.3	1.3
Sep 14 04:26	888	DB	6.0	83	28	84	1.7	-0.5
Sep 16 04:52	1186	RD	6.0	56	17	288	1.3	-1.5
Sep 18 10:47	Venus	DB	-3.9	28	41	137	1.8	-1.4
Sep 18 12:12	Venus	RD	-3.9	28	34	274	2.1	0.7
Oct 05 02:08	24 Psc	DD	5.9	165	36	71	1.2	1.5
Oct 10 04:14	684	RD	6.2	127	36	302	2.4	-0.8
Oct 12 00:45	Nu Gem	RD	4.1	101	6	261	0.6	-0.8
Oct 14 02:30	The Cnc	RD	5.3	74	6	271	0.6	-1.1
Oct 24 19:29	2508	RB	6.3	51	32	292	1.1	0.4
Oct 26 19:55	2791	DD	5.6	73	47	96	1.6	0.9
Oct 26 20:47	2794	DD	6.6	73	36	6	-1.5	7.4
Oct 26 21:08	2791	RB	5.6	73	32	242	0.5	2.0
Oct 30 23:03	3313	DD	6.5	119	42	6	-0.2	4.1
Nov 03 23:02	308	DD	6.3	170	46	101	2.6	-0.6
Nov 05 02:01	454	RD	5.6	173	35	269	1.9	0.7
Nov 27 22:27	83 Aqr	DD	5.5	99	32	86	1.1	1.3
Dec 03 01:31	523	DD	6.4	165	27	4	1.3	5.1
Dec 07 01:33	85 Gem	DB	5.4	138	32	98	2.0	-0.7
Dec 07 02:54	85 Gem	RD	5.4	137	35	278	2.1	-0.2
Dec 10 02:33	53 Leo	RD	5.3	98	27	292	1.4	-1.6
Dec 28 23:11	64 Cet	DD	5.6	116	25	96	1.3	0.9
Dec 29 00:09	Xi 1 Cet	DD	4.4	117	15	69	0.8	1.6
Dec 29 23:23	454	DD	5.6	130	28	15	1.2	3.3

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 14:58	Mars	DD	0.9	58	63	120	4.1	-3.3
Jan 03 15:53	Mars	RB	0.9	58	76	185	0.7	5.9
Jan 04 19:56	20 Psc	DD	5.5	72	55	360	-0.2	5.4
Jan 04 20:35	20 Psc	RB	5.5	72	45	303	3.1	-2.1
Jan 13 01:56	81 Gem	DB	4.9	176	57	74	3.1	0.9
Jan 13 03:10	81 Gem	RD	4.9	176	46	315	1.4	-1.6
Feb 04 21:15	464	RB	6.1	94	48	256	2.2	0.9
Feb 07 23:02	71 Ori	DD	5.2	134	54	136	2.3	-2.3
Feb 08 00:07	71 Ori	RB	5.2	135	44	232	2.8	2.3
Feb 09 20:22	Zet 1 Cnc	DD	5.1	160	32	92	1.6	-0.5
Feb 09 20:22	97646	DD	6.2	160	32	92	1.6	-0.5
Feb 09 20:22	X108006	DD	6.2	160	32	93	1.6	-0.5
Feb 09 21:44	Zet 1 Cnc	RB	5.1	161	48	278	2.4	-0.6
Feb 10 23:41	Pi Cnc	DD	5.4	175	59	87	3.0	0.0
Feb 11 22:40	Regulus	MD	1.4	173	42	18	9.9	9.9
Feb 13 01:16	Chi Leo	DB	4.6	160	65	127	2.3	-1.9
Feb 13 02:50	Chi Leo	RD	4.6	159	69	293	2.7	-1.1
Feb 16 04:35	80 Vir	DB	5.7	123	83	102	3.3	-0.7
Feb 16 06:10	80 Vir	RD	5.7	123	67	320	2.0	-2.4
Feb 19 03:12	2279	DB	6.1	90	37	104	1.3	-1.0
Feb 19 04:36	2279	RD	6.1	90	58	303	1.8	-1.9
Feb 22 05:17	2680	DB	5.6	56	33	66	1.7	0.7
Feb 23 05:59	45 Sgr	RD	5.8	45	32	292	0.9	-1.4
Mar 10 01:18	Omi 2 Cnc	DD	5.7	143	41	92	2.0	0.3
Mar 10 01:29	Omi 1 Cnc	DD	5.2	143	39	154	0.5	-2.5
Mar 10 02:24	Omi 1 Cnc	RB	5.2	143	27	250	1.7	1.4
Mar 19 06:22	Phi Oph	DB	4.3	110	77	80	3.6	0.8
Apr 08 03:25	Rho Leo	DD	3.8	138	10	149	0.0	-1.7
Apr 09 02:18	Sig Leo	DD	4.1	150	38	49	3.6	5.0
Apr 09 02:47	Sig Leo	RB	4.1	150	31	5	-0.8	-6.2
Apr 10 02:04	10 Vir	DD	6.0	161	53	70	3.3	1.9
Apr 11 19:48	80 Vir	RD	5.7	175	12	223	1.1	3.3

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Apr 22 04:56	38 Aqr	DB	5.4	61	31	142	1.0	-5.1
Apr 22 05:26	38 Aqr	RD	5.4	61	38	188	1.5	5.9
May 02 23:24	25 Cnc	DD	6.1	82	12	111	0.3	-0.3
May 03 19:21	Pi Cnc	DD	5.4	94	63	146	2.0	-2.7
May 03 20:41	Pi Cnc	RB	5.4	94	56	262	3.2	0.7
May 04 18:33	Regulus	DD	1.4	106	56	96	2.9	-0.6
May 04 20:05	Regulus	RB	1.4	106	66	315	2.3	-2.1
May 05 23:27	Chi Leo	DD	4.6	119	48	111	1.9	-0.6
May 06 00:45	Chi Leo	RB	4.6	120	30	306	0.9	-1.0
May 10 19:01	Xi Lib	DD	5.5	173	10	118	0.0	-1.3
May 13 21:18	2508	RD	6.3	150	11	248	0.6	0.4
May 16 03:51	43 Sgr	DB	4.9	127	78	58	3.4	1.9
May 16 05:32	43 Sgr	RD	4.9	126	74	286	3.6	-0.8
May 18 02:11	3064	DB	5.9	105	34	128	1.0	-2.6
May 18 03:09	3064	RD	5.9	104	48	216	2.3	2.8
May 31 22:34	Nu Leo	DD	5.3	77	20	104	0.7	-0.1
Jun 12 05:11	2773	RD	6.2	155	51	284	2.5	-0.3
Jun 18 04:55	5 Psc	RD	6.2	85	55	226	1.7	1.7
Jul 10 02:12	2863	RD	6.1	174	74	279	3.4	-0.3
Jul 11 23:19	29 Cap	RD	5.3	152	40	285	1.6	-1.2
Jul 14 04:33	83 Aqr	DB	5.5	127	85	65	2.8	1.3
Jul 14 06:06	83 Aqr	RD	5.5	127	65	231	1.9	2.0
Jul 18 03:59	368	RD	6.2	77	32	261	1.3	-0.1
Aug 06 01:48	2825	DD	6.3	156	52	123	3.2	-1.8
Aug 13 00:46	89 Psc	RD	5.1	120	30	280	1.4	-1.0
Aug 18 05:04	68 Ori	DB	5.8	52	21	46	0.3	1.2
Aug 18 06:03	68 Ori	RD	5.8	52	33	291	2.0	-1.3
Aug 30 00:32	Phi Oph	DD	4.3	92	7	81	0.0	0.7
Sep 02 01:16	2773	DD	6.2	125	30	93	1.2	0.3
Sep 07 22:41	5 Psc	RD	6.2	163	42	287	2.1	-1.5
Sep 14 04:48	57 Ori	DB	5.9	82	42	47	1.4	1.5
Sep 14 06:02	57 Ori	RD	5.9	82	54	291	3.1	-1.2

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 18 08:58	Venus	DB	-3.9	28	51	97	2.8	-0.7
Sep 18 10:41	Venus	RD	-3.9	28	64	309	2.8	-2.1
Oct 01 23:41	29 Cap	DD	5.3	128	56	78	2.2	0.9
Oct 02 01:00	29 Cap	RB	5.3	129	37	233	0.8	1.8
Oct 03 02:09	38 Aqr	DD	5.4	141	32	61	0.8	1.4
Oct 07 22:30	368	RD	6.2	155	31	247	1.0	0.5
Oct 26 20:35	2798	DD	6.1	73	47	150	5.6	-7.9
Oct 26 20:58	2798	RB	6.1	73	41	182	-2.2	9.4
Oct 29 00:31	3064	DD	5.9	97	14	65	0.1	1.2
Oct 29 19:42	42 Cap	DD	5.2	107	86	70	3.1	1.1
Oct 29 21:22	42 Cap	RB	5.2	107	69	237	2.2	1.9
Oct 30 20:05	Sig Aqr	RB	4.8	119	81	266	3.3	0.1
Nov 04 01:25	64 Cet	DD	5.6	171	61	77	2.6	0.8
Nov 04 02:37	Xi 1 Cet	DD	4.4	171	47	62	1.9	1.4
Nov 04 03:53	Xi 1 Cet	RB	4.4	172	30	254	1.3	1.0
Nov 05 03:57	464	RD	6.1	172	40	228	1.7	2.0
Nov 06 22:33	104 Tau	DB	4.9	147	19	84	0.8	-0.2
Nov 06 23:39	104 Tau	RD	4.9	146	33	241	1.1	0.7
Nov 10 03:45	20 Cnc	DB	5.9	104	46	134	2.5	-2.4
Nov 10 05:00	20 Cnc	RD	5.9	103	57	245	3.1	1.2
Dec 05 05:07	888	RD	6.0	164	31	210	2.7	4.2
Dec 05 05:20	Chi 1 Ori	DB	4.4	164	28	53	1.9	2.0
Dec 06 23:18	1186	RD	6.0	138	19	207	-0.3	3.1
Dec 08 01:25	1335	RD	6.2	123	34	235	1.4	1.3
Dec 15 05:16	18 Lib	RD	5.9	37	18	313	0.2	-1.8
Dec 27 21:46	89 Psc	DD	5.1	103	55	72	2.3	1.1
Dec 27 23:06	89 Psc	RB	5.1	104	36	232	1.3	1.8
Dec 28 22:51	64 Cet	DD	5.6	117	49	22	1.4	3.4
Dec 28 23:49	64 Cet	RB	5.6	117	36	291	1.9	-0.6
Dec 30 01:08	464	DD	6.1	131	29	65	1.4	1.3
Dec 31 21:33	104 Tau	DD	4.9	157	50	157	9.9	9.9
Dec 31 21:42	104 Tau	RB	4.9	157	51	168	9.9	9.9

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 20:42	20 Psc	RB	5.5	72	27	200	0.4	2.8
Jan 17 00:02	1645	RD	6.7	128	19	315	0.8	-2.2
Feb 06 21:12	104 Tau	RB	4.9	120	27	263	1.8	0.6
Feb 07 22:05	68 Ori	DD	5.8	134	26	70	1.9	0.8
Feb 09 23:16	1241	DD	6.5	161	30	157	1.2	-2.0
Feb 11 01:14	Pi Cnc	DD	5.4	175	30	150	1.0	-1.2
Feb 11 23:37	Regulus	DB	1.4	173	33	115	1.7	-1.1
Feb 12 00:58	Regulus	RD	1.4	173	35	288	1.8	-0.4
Feb 17 23:29	18 Lib	RD	5.9	103	9	229	0.4	-0.1
Feb 19 02:36	2266	RD	6.2	91	36	289	0.9	-1.8
Feb 19 04:23	2278	DB	6.3	90	53	79	2.1	-0.5
Mar 06 21:54	57 Ori	DD	5.9	103	17	23	2.4	4.3
Mar 11 01:08	23 Leo	DD	6.5	155	26	80	1.7	1.4
Mar 22 04:53	2764	DB	6.4	77	52	135	1.2	-3.3
Apr 07 22:43	1522	DD	6.8	136	34	168	0.5	-2.3
Apr 09 02:50	Sig Leo	DD	4.1	150	13	153	0.2	-0.9
Apr 10 03:03	10 Vir	DD	6.0	161	21	167	0.3	-2.1
Apr 17 22:55	2680	RD	5.6	110	12	215	0.7	0.7
Apr 17 23:36	2686	RD	5.1	110	19	310	-0.1	-2.4
Apr 18 00:17	2690	RD	6.8	109	26	338	-0.5	-4.3
Apr 18 23:09	Rho 1 Sgr	RD	3.9	99	5	342	-1.3	-4.4
Apr 18 23:18	45 Sgr	RD	5.8	99	7	207	0.7	1.3
Apr 19 02:28	2846	RD	6.7	98	41	200	2.4	4.4
Apr 21 03:04	3100	RD	6.5	74	27	235	0.8	-0.1
Apr 23 04:49	Neptune	RD	7.9	49	24	204	0.6	1.4
May 04 20:19	Regulus	DD	1.4	106	34	156	0.9	-1.7
May 04 21:19	Regulus	RB	1.4	106	30	253	2.2	1.6
May 12 05:41	2279	RD	6.1	169	23	298	0.6	0.5
May 13 19:57	2495	RD	6.0	151	10	285	-0.2	-1.5
May 14 22:46	2640	RD	6.1	140	32	300	0.4	-2.2
May 15 00:14	2649	RD	6.7	139	48	286	1.3	-1.7
May 15 01:14	2658	DB	5.8	139	57	79	1.9	-0.4
May 15 02:40	2658	RD	5.8	138	66	289	2.1	-1.1
May 15 23:19	2787	RD	6.3	128	30	244	0.9	-0.5
May 19 02:39	3186	RD	6.7	93	35	242	1.1	-0.2
Jun 09 03:55	Phi Oph	DD	4.3	169	29	128	1.0	0.0
Jun 09 04:52	Phi Oph	RB	4.3	170	19	242	0.0	2.3
Jun 10 19:07	2578	RD	6.5	169	15	218	0.9	0.6
Jun 13 23:15	3005	RD	6.2	135	32	265	0.8	-1.2
Jun 14 01:38	3019	DB	5.8	134	55	9	1.5	6.4
Jun 14 02:09	3019	RD	5.8	134	59	327	2.6	-6.9
Jun 28 19:49	1529	DD	6.6	58	17	74	1.2	2.0
Jun 29 21:30	1645	DD	6.7	71	12	162	0.1	-1.5
Jul 02 19:53	1965	DD	6.5	105	52	131	1.6	-1.2
Jul 07 04:13	2460	DD	6.0	152	13	88	0.0	1.4
Jul 08 02:57	2578	DD	6.5	163	36	106	1.1	0.8
Jul 09 00:32	2715	DD	6.3	173	65	143	2.4	-3.4
Jul 13 02:22	38 Aqr	DB	5.4	140	58	111	2.5	-1.5
Jul 13 03:23	38 Aqr	RD	5.4	140	58	203	1.0	3.0
Jul 14 04:14	Neptune	MD	7.8	127	54	333	9.9	9.9
Jul 15 04:00	24 Psc	DB	5.9	115	50	47	1.5	1.2
Jul 15 05:19	24 Psc	RD	5.9	115	49	256	1.9	0.8
Jul 31 18:02	18 Lib	RB	5.9	98	58	261	2.5	0.2
Aug 01 23:46	2279	DD	6.1	111	28	139	1.0	-0.6
Aug 04 20:23	2658	DD	5.8	143	61	61	2.2	0.8
Aug 04 21:39	2658	RB	5.8	143	66	306	2.1	-1.9
Aug 05 02:19	2680	DD	5.6	145	29	44	0.1	2.8
Aug 05 02:45	2685	DD	6.8	145	24	95	0.5	1.2
Aug 05 23:55	43 Sgr	DD	4.9	155	61	145	2.9	-3.8
Aug 06 00:33	43 Sgr	RB	4.9	155	55	197	0.4	5.7
Aug 06 02:46	45 Sgr	DD	5.8	156	32	14	-0.6	4.9
Aug 08 22:59	3196	RD	6.3	170	51	286	1.9	-1.7
Aug 14 02:36	Xi 1 Cet	DB	4.4	107	29	45	0.9	0.5
Aug 14 02:40	64 Cet	RD	5.6	107	30	248	1.3	-0.2
Aug 14 03:47	Xi 1 Cet	RD	4.4	107	36	263	1.8	-0.3
Aug 15 05:56	464	RD	6.1	93	34	230	1.5	1.0
Aug 17 04:27	104 Tau	DB	4.9	67	15	104	1.3	-1.5
Aug 17 05:29	104 Tau	RD	4.9	66	22	227	1.0	0.2
Aug 31 00:25	2495	DD	6.0	103	17	60	-0.1	2.2
Sep 01 22:00	2755	DD	6.6	124	59	2	9.9	9.9
Sep 06 04:29	3313	DD	6.5	173	20	111	0.7	0.9
Sep 07 02:53	3432	RD	6.2	175	41	245	1.2	1.6
Sep 16 05:00	1186	RD	6.0	56	12	273	1.0	-1.2
Sep 18 10:57	Venus	DB	-3.9	28	34	160	1.0	-2.1
Sep 18 11:58	Venus	RD	-3.9	28	30	248	2.6	1.9
Sep 28 19:54	2699	DD	6.8	93	59	117	2.1	-0.6
Sep 30 01:53	2865	DD	5.7	106	6	83	-0.3	1.3
Oct 03 21:58	Neptune	DD	7.8	151	55	18	0.9	2.9
Oct 05 01:55	24 Psc	DD	5.9	165	36	84	1.3	1.3
Oct 07 22:26	25 Cet	RD	6.5	156	22	310	2.3	-4.0
Oct 10 04:13	684	RD	6.2	127	29	285	2.0	0.0
Oct 21 19:17	18 Lib	DD	5.9	18	6	63	-0.2	2.3
Oct 26 19:48	2791	DD	5.6	73	48	118	1.8	0.0
Oct 26 20:15	2794	DD	6.6	73	43	40	0.6	3.1
Oct 26 20:48	2791	RB	5.6	73	37	222	0.3	2.9
Oct 30 22:38	3313	DD	6.5	119	44	27	0.6	2.8
Nov 05 01:51	454	RD	5.6	173	31	256	1.6	0.9
Nov 27 22:16	83 Aqr	DD	5.5	99	33	100	1.3	1.1
Nov 27 23:12	83 Aqr	RB	5.5	99	23	211	0.2	2.5
Dec 03 01:05	523	DD	6.4	165	25	29	1.3	2.1
Dec 07 02:51	85 Gem	RD	5.4	137	27	263	1.9	0.0
Dec 10 02:42	53 Leo	RD	5.3	98	22	278	1.2	-1.4
Dec 28 23:02	64 Cet	DD	5.6	117	23	112	1.4	0.7
Dec 28 23:56	Xi 1 Cet	DD	4.4	117	15	83	0.8	1.4
Dec 29 23:01	454	DD	5.6	130	26	34	1.2	2.1
Jan 01 21:52	935	DD	6.8	171	22	59	1.3	0.0

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 20:54	20 Psc	RB	5.5	72	28	214	0.6	2.5
Jan 16 23:49	1645	RD	6.7	128	17	325	0.8	-2.5
Feb 06 21:09	104 Tau	RB	4.9	120	33	273	2.1	0.3
Feb 07 22:05	68 Ori	DD	5.8	134	32	61	2.1	1.1
Feb 09 23:04	1241	DD	6.5	161	35	145	1.7	-1.8
Feb 11 01:06	Pi Cnc	DD	5.4	175	36	140	1.4	-1.1
Feb 11 23:28	Regulus	DB	1.4	173	36	107	1.9	-1.1
Feb 12 00:51	Regulus	RD	1.4	173	40	296	1.9	-0.8
Feb 13 03:18	Chi Leo	DB	4.6	159	41	195	-2.8	-9.2
Feb 13 03:35	Chi Leo	RD	4.6	159	39	219	5.9	8.7
Feb 17 23:27	18 Lib	RD	5.9	103	6	242	0.2	-0.5
Feb 19 02:24	2266	RD	6.2	91	34	298	0.7	-2.0
Feb 19 04:17	2278	DB	6.3	90	54	66	2.6	0.3
Mar 10 02:11	Omi 2 Cnc	DD	5.7	143	12	157	-0.1	-1.3
Mar 11 01:11	23 Leo	DD	6.5	155	30	67	2.3	2.0
Mar 22 04:37	2764	DB	6.4	77	49	118	1.3	-2.2
Apr 07 22:31	1522	DD	6.8	136	40	155	1.0	-1.9
Apr 09 02:46	Sig Leo	DD	4.1	150	17	136	0.5	-0.4
Apr 10 02:55	10 Vir	DD	6.0	161	26	146	0.6	-1.0
Apr 17 22:55	2680	RD	5.6	110	9	231	0.3	0.0
Apr 17 23:24	2686	RD	5.1	110	14	324	-0.5	-2.8
Apr 19 02:34	2846	RD	6.7	97	41	226	1.7	0.9
Apr 21 03:00	3100	RD	6.5	74	25	251	0.7	-0.6
Apr 23 04:52	Neptune	RD	7.9	49	23	225	0.7	0.4
May 04 20:09	Regulus	DD	1.4	106	40	146	1.4	-1.6
May 04 21:21	Regulus	RB	1.4	106	35	265	2.2	1.0
May 10 20:42	Xi Lib	DD	5.5	173	38	186	-1.3	-6.1
May 12 05:39	2279	RD	6.1	169	25	318	0.9	-0.7
May 14 22:34	2640	RD	6.1	140	28	312	0.2	-2.6
May 15 00:02	2649	RD	6.7	139	45	299	1.1	-2.2
May 15 01:09	2658	DB	5.8	139	57	64	2.2	0.4
May 15 02:27	2658	RD	5.8	138	69	306	2.2	-2.4
May 15 23:14	2787	RD	6.3	128	27	256	0.7	-0.8
May 19 02:34	3186	RD	6.7	93	34	258	1.1	-0.8
May 19 04:57	3196	RD	6.3	92	58	197	1.3	3.7
Jun 09 03:54	Phi Oph	DD	4.3	169	31	109	1.0	0.6
Jun 09 05:01	Phi Oph	RB	4.3	170	18	259	0.2	1.6
Jun 10 19:06	2578	RD	6.5	169	12	233	0.5	-0.1
Jun 11 20:33	2733	RD	6.8	158	19	214	1.3	1.4
Jun 12 02:41	2763	RD	6.5	156	70	192	1.2	9.4
Jun 12 05:28	2774	RD	6.4	155	42	212	0.3	3.6
Jun 13 23:06	3005	RD	6.2	135	29	279	0.7	-1.6
Jun 28 19:59	1529	DD	6.6	58	19	54	2.0	3.6
Jun 29 21:24	1645	DD	6.7	71	17	143	0.4	-0.7
Jul 02 19:43	1965	DD	6.5	105	58	119	2.0	-1.1
Jul 07 04:21	2460	DD	6.0	152	12	72	-0.1	1.7
Jul 08 03:00	2578	DD	6.5	163	38	89	1.0	1.3
Jul 08 19:33	2699	DD	6.8	171	32	159	-0.4	-4.6
Jul 09 00:15	2715	DD	6.3	172	71	119	2.5	-1.5
Jul 09 01:17	2718	DD	6.7	173	65	134	2.7	-2.2
Jul 09 04:42	2733	DD	6.8	174	27	133	1.3	-0.5
Jul 13 02:12	38 Aqr	DB	5.4	140	61	90	2.3	-0.4
Jul 13 03:33	38 Aqr	RD	5.4	140	63	223	1.6	2.1
Jul 15 04:06	24 Psc	DB	5.9	115	54	29	1.2	2.1
Jul 15 05:17	24 Psc	RD	5.9	115	55	272	2.5	0.2
Aug 01 23:43	2279	DD	6.1	111	31	119	1.0	0.2
Aug 04 20:26	2658	DD	5.8	143	64	39	2.9	3.1
Aug 04 21:19	2658	RB	5.8	143	70	330	2.0	-4.7
Aug 05 02:37	2680	DD	5.6	145	27	19	-0.7	4.7
Aug 05 02:50	2685	DD	6.8	145	25	80	0.4	1.5
Aug 05 03:21	2687	DD	6.6	145	19	144	1.2	-1.2
Aug 05 23:39	43 Sgr	DD	4.9	155	67	118	2.6	-1.1
Aug 06 00:50	43 Sgr	RB	4.9	155	56	224	1.2	3.0
Aug 08 22:41	3196	RD	6.3	171	50	312	2.1	-4.3
Aug 14 02:34	64 Cet	RD	5.6	107	32	265	1.6	-0.8
Aug 14 02:38	Xi 1 Cet	DB	4.4	107	32	26	0.6	1.4
Aug 14 03:39	Xi 1 Cet	RD	4.4	107	39	280	2.3	-1.1
Aug 15 05:57	464	RD	6.1	93	39	242	1.8	0.8
Aug 17 04:18	104 Tau	DB	4.9	67	15	88	1.0	-1.0
Aug 17 05:27	104 Tau	RD	4.9	66	25	242	1.2	-0.1
Aug 31 00:38	2495	DD	6.0	103	16	40	-0.4	3.0
Sep 04 20:42	3152	DD	6.6	158	52	133	2.0	-4.3
Sep 06 04:33	3313	DD	6.5	173	22	98	0.7	1.1
Sep 07 02:58	3432	RD	6.2	175	45	258	1.6	1.3
Sep 16 04:51	1186	RD	6.0	56	13	285	1.1	-1.5
Sep 18 10:44	Venus	DB	-3.9	28	39	149	1.5	-2.0
Sep 18 12:00	Venus	RD	-3.9	28	35	260	2.6	1.2
Sep 28 19:49	2699	DD	6.8	93	64	98	2.3	0.2
Oct 05 01:59	24 Psc	DD	5.9	165	40	72	1.4	1.5
Oct 10 04:06	684	RD	6.2	127	34	298	2.4	-0.7
Oct 26 19:46	2791	DD	5.6	73	51	99	1.8	0.7
Oct 26 20:35	2794	DD	6.6	73	42	14	-0.5	5.8
Oct 26 21:00	2791	RB	5.6	73	37	239	0.6	2.2
Oct 30 22:53	3313	DD	6.5	119	45	7	0.0	4.1
Nov 03 22:53	308	DD	6.3	170	43	101	2.5	-0.8
Nov 05 01:51	454	RD	5.6	173	36	266	1.9	0.6
Nov 09 04:23	56 Gem	DB	5.1	117	32	80	2.1	0.2
Nov 27 22:19	83 Aqr	DD	5.5	99	36	86	1.3	1.3
Nov 27 23:23	83 Aqr	RB	5.5	99	24	223	0.3	2.2
Dec 03 01:15	523	DD	6.4	165	30	14	1.3	3.3
Dec 07 02:46	85 Gem	RD	5.4	137	32	271	2.0	-0.2
Dec 10 02:32	53 Leo	RD	5.3	98	22	286	1.2	-1.5
Dec 28 23:03	64 Cet	DD	5.6	117	28	100	1.5	0.8
Dec 29 00:01	Xi 1 Cet	DD	4.4	117	18	74	0.9	1.5
Dec 29 23:10	454	DD	5.6	130	30	21	1.2	2.7
Jan 01 21:50	935	DD	6.8	171	25	46	1.1	0.5

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:07	82 Aqr	DD	6.2	61	20	119	1.0	0.0
Jan 13 00:02	81 Gem	DB	4.9	177	39	142	2.1	-2.1
Jan 13 01:05	81 Gem	RD	4.9	176	39	238	2.7	1.5
Feb 10 03:00	25 Cnc	DD	6.1	163	19	125	0.7	-0.2
Feb 10 22:07	Pi Cnc	DD	5.4	175	35	153	1.7	-3.0
Feb 11 20:39	Regulus	DB	1.4	173	14	101	0.8	-1.3
Feb 11 21:50	Regulus	RD	1.4	173	27	289	1.4	-1.5
Feb 19 02:36	2278	RD	6.3	90	37	310	0.6	-2.3
Feb 22 04:07	2680	DB	5.6	56	28	156	-0.5	-4.2
Feb 22 04:31	2686	DB	5.1	56	32	62	1.3	0.0
Feb 22 04:43	2680	RD	5.6	56	36	219	2.1	1.8
Feb 22 05:32	2686	RD	5.1	56	46	313	0.9	-2.9
Feb 23 03:37	Rho 1 Sgr	DB	3.9	45	11	44	0.6	0.6
Feb 23 04:17	Rho 1 Sgr	RD	3.9	45	20	322	-0.3	-3.0
Mar 11 03:04	Nu Leo	DD	5.3	157	17	51	1.9	3.7
Mar 19 05:00	Phi Oph	DB	4.3	109	75	184	9.9	9.9
Mar 19 05:19	Phi Oph	RD	4.3	109	74	206	9.9	9.9
Mar 20 03:19	2495	DB	6.0	99	54	84	2.0	-0.6
Mar 20 04:46	2495	RD	6.0	99	70	303	2.2	-2.1
Mar 22 03:03	2764	RD	6.4	77	31	242	1.2	0.0
Apr 04 22:56	81 Gem	DD	4.9	100	16	110	0.8	0.4
Apr 09 00:17	Sig Leo	DD	4.1	150	45	152	1.0	-1.9
Apr 09 01:24	Sig Leo	RB	4.1	150	34	264	1.8	1.3
Apr 10 00:19	10 Vir	DD	6.0	161	53	166	0.8	-3.2
Apr 19 04:26	2865	DB	5.7	96	64	104	2.3	-1.4
Apr 19 05:57	2865	RD	5.7	96	76	244	2.5	1.4
May 04 18:01	Regulus	RB	1.4	106	41	234	3.0	1.3
May 09 02:55	80 Vir	DD	5.7	155	26	115	0.9	0.1
May 14 23:30	2658	RD	5.8	138	39	301	0.8	-2.2
May 16 02:00	43 Sgr	DB	4.9	127	60	142	1.6	-4.3
May 16 02:57	43 Sgr	RD	4.9	126	71	215	2.7	3.6
May 19 02:25	3196	RD	6.3	92	33	233	1.1	0.5
May 22 03:50	10 Cet	RD	6.4	54	14	289	0.6	-1.9
Jun 07 02:35	Xi Lib	DD	5.5	149	27	92	0.8	1.1
Jun 09 01:12	Phi Oph	DD	4.3	169	64	80	2.5	1.2
Jun 09 02:38	Phi Oph	RB	4.3	170	47	298	1.8	-0.3
Jun 10 05:02	2508	RD	6.3	174	28	249	0.5	1.8
Jun 12 02:43	2773	RD	6.2	155	74	229	2.3	2.7
Jun 12 05:33	2787	RD	6.3	155	41	317	2.4	-1.7
Jun 17 04:29	3432	DB	6.2	97	57	39	1.6	1.7
Jun 17 05:51	3432	RD	6.2	97	64	264	2.6	0.2
Jun 27 19:35	7 Leo	DD	6.3	46	15	111	0.7	0.3
Jul 08 21:05	2715	DD	6.3	173	50	111	1.4	-1.8
Jul 09 23:31	2863	RD	6.1	174	69	207	2.6	4.5
Jul 11 05:25	3005	RD	6.2	161	36	275	1.2	0.9
Jul 11 21:19	29 Cap	RD	5.3	152	21	189	1.9	5.8
Jul 12 23:21	38 Aqr	DB	5.4	140	35	56	1.2	0.4
Jul 13 00:37	38 Aqr	RD	5.4	140	50	270	1.9	-0.9
Jul 14 02:21	83 Aqr	DB	5.5	127	57	111	2.9	-2.2
Jul 14 03:20	83 Aqr	RD	5.5	127	64	195	1.0	3.6
Aug 01 20:55	2279	DD	6.1	111	65	98	2.5	0.2
Aug 05 20:24	43 Sgr	DD	4.9	155	57	95	2.0	-1.1
Aug 05 21:57	43 Sgr	RB	4.9	155	74	263	2.6	0.1
Aug 12 23:07	89 Psc	RD	5.1	120	10	218	0.2	0.8
Aug 15 02:50	464	RD	6.1	93	27	309	2.8	-3.9
Aug 18 04:29	68 Ori	RD	5.8	52	10	249	0.5	-0.4
Aug 29 22:52	Phi Oph	DD	4.3	92	26	139	1.2	-1.1
Aug 29 23:40	Phi Oph	RB	4.3	93	16	229	-0.2	2.8
Sep 02 01:39	2787	DD	6.3	126	22	64	0.2	1.8
Sep 07 20:35	4 Psc	RD	6.4	164	18	210	0.4	1.3
Sep 07 20:57	5 Psc	RD	6.2	163	22	223	0.6	0.7
Sep 14 02:44	888	RD	6.0	83	14	305	1.6	-2.4
Sep 14 04:09	57 Ori	RD	5.9	82	27	250	1.4	-0.2
Sep 18 07:41	Venus	DB	-3.9	28	30	163	1.6	-4.2
Sep 18 08:33	Venus	RD	-3.9	28	37	232	2.9	1.4
Sep 28 22:10	2715	DD	6.3	95	39	105	1.4	0.5
Sep 30 00:23	2865	DD	5.7	106	21	20	-0.6	3.7
Oct 01 21:31	29 Cap	DD	5.3	128	71	125	3.8	-2.5
Oct 01 22:20	29 Cap	RB	5.3	128	64	191	0.3	4.9
Oct 02 23:54	38 Aqr	DD	5.4	141	53	94	2.1	0.7
Oct 03 01:01	38 Aqr	RB	5.4	141	40	215	0.6	2.6
Oct 04 23:32	24 Psc	DD	5.9	165	61	13	0.7	3.4
Oct 26 22:53	43 Sgr	DD	4.9	75	14	73	0.0	1.5
Oct 28 22:31	3064	DD	5.9	97	37	101	1.4	0.7
Oct 29 23:57	3196	DD	6.3	109	27	21	-0.1	3.1
Nov 02 02:15	10 Cet	DD	6.4	146	22	33	0.5	2.4
Nov 03 20:09	308	DD	6.3	170	27	41	0.7	0.8
Nov 04 00:19	Xi 1 Cet	DD	4.4	172	48	98	2.6	-0.1
Nov 04 01:25	Xi 1 Cet	RB	4.4	172	42	210	1.3	2.4
Nov 09 01:31	56 Gem	DB	5.1	117	23	55	1.1	0.2
Nov 09 02:36	56 Gem	RD	5.1	117	31	303	2.2	-1.7
Nov 27 19:48	83 Aqr	DD	5.5	99	63	30	1.3	2.8
Nov 27 21:02	83 Aqr	RB	5.5	99	52	270	2.2	0.8
Dec 05 03:14	Chi 1 Ori	DB	4.4	164	31	125	1.6	-0.5
Dec 05 04:15	Chi 1 Ori	RD	4.4	163	23	236	1.7	1.9
Dec 06 23:49	85 Gem	RD	5.4	137	19	292	1.4	-1.5
Dec 07 02:38	1205	RD	6.3	136	38	298	2.2	-1.1
Dec 15 04:02	18 Lib	RD	5.9	37	10	244	0.4	-0.3
Dec 22 21:31	29 Cap	DD	5.3	46	7	29	-0.5	2.4
Dec 27 20:27	89 Psc	RB	5.1	104	50	195	0.9	3.2
Dec 28 20:13	64 Cet	DD	5.6	117	49	56	1.9	1.2
Dec 28 21:31	Xi 1 Cet	DD	4.4	117	44	44	1.6	1.9
Dec 28 21:36	64 Cet	RB	5.6	117	43	249	2.0	1.3
Dec 28 22:45	Xi 1 Cet	RB	4.4	117	34	267	1.7	1.0
Dec 29 23:01	464	DD	6.1	131	36	118	2.2	-0.4
Jan 01 02:52	798	DD	6.2	160	14	46	1.4	2.3

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 04 20:06	20 Psc	DD	5.5	72	34	94	1.4	1.0
Jan 04 21:06	20 Psc	RB	5.5	72	22	218	0.5	2.3
Jan 13 03:01	81 Gem	DB	4.9	176	24	113	1.2	0.2
Feb 06 20:04	104 Tau	DD	4.9	120	38	64	2.1	0.8
Feb 06 21:24	104 Tau	RB	4.9	120	34	281	2.0	0.2
Feb 07 22:25	68 Ori	DD	5.8	134	32	48	2.4	2.1
Feb 07 23:21	68 Ori	RB	5.8	134	26	319	1.1	-0.9
Feb 09 22:20	97646	DD	6.2	160	38	171	1.2	-5.0
Feb 09 22:21	Zet 1 Cnc	DD	5.1	160	38	172	1.2	-5.2
Feb 09 22:21	X108006	DD	6.2	160	38	172	1.2	-5.2
Feb 09 22:50	Zet 1 Cnc	RB	5.1	161	39	212	3.7	4.4
Feb 11 01:12	Pi Cnc	DD	5.4	174	37	122	1.6	-0.5
Feb 11 23:37	Regulus	DB	1.4	173	42	94	2.3	-0.5
Feb 12 00:58	Regulus	RD	1.4	173	44	313	1.7	-1.3
Feb 13 03:04	Chi Leo	DB	4.6	160	43	157	0.9	-2.1
Feb 13 04:06	Chi Leo	RD	4.6	159	35	258	2.0	1.6
Feb 17 23:26	18 Lib	RD	5.9	103	11	257	0.3	-0.8
Feb 19 01:15	2266	DB	6.2	91	25	86	0.7	-1.1
Feb 19 02:20	2266	RD	6.2	91	38	315	0.6	-2.5
Mar 10 02:09	Omi 2 Cnc	DD	5.7	143	10	133	0.2	-0.3
Apr 09 02:49	Sig Leo	DD	4.1	150	13	117	0.4	0.2
Apr 10 02:57	10 Vir	DD	6.0	161	23	127	0.7	-0.2
Apr 17 22:55	2680	RD	5.6	110	13	251	0.3	-0.6
Apr 18 23:21	45 Sgr	RD	5.8	99	8	246	0.2	-0.4
Apr 23 04:58	Neptune	RD	7.9	49	30	239	1.0	0.1
Apr 23 05:01	81 Aqr	DB	6.2	49	30	48	0.9	0.6
Apr 24 04:44	24 Psc	RD	5.9	36	15	195	0.3	2.3
Apr 30 18:06	68 Ori	RB	5.8	53	25	245	1.8	1.6
May 04 20:14	Regulus	DD	1.4	106	42	126	1.7	-0.8
May 04 21:35	Regulus	RB	1.4	106	33	286	1.6	0.3
May 06 00:37	Chi Leo	DD	4.6	119	14	164	0.0	-2.0
May 10 20:25	Xi Lib	DD	5.5	173	40	156	0.4	-3.2
May 10 21:26	Xi Lib	RB	5.5	173	52	255	2.5	-0.2
May 13 19:41	2495	RD	6.0	152	8	308	-0.4	-1.9
May 14 22:21	2640	RD	6.1	140	30	337	-0.4	-4.2
May 15 01:32	2658	DB	5.8	139	68	39	3.1	3.4
May 15 02:28	2658	RD	5.8	138	75	328	2.4	-4.8
May 15 23:14	2787	RD	6.3	128	32	274	0.8	-1.3
May 19 04:11	3196	DB	6.3	93	58	110	2.4	-2.0
May 19 05:19	3196	RD	6.3	92	67	209	1.6	2.9
Jun 09 04:02	Phi Oph	DD	4.3	169	25	101	0.7	0.8
Jun 12 05:42	2774	RD	6.4	155	34	218	0.2	3.0
Jun 13 23:03	3005	RD	6.2	135	34	298	0.8	-2.4
Jul 09 00:28	2715	DD	6.3	172	71	106	2.6	-0.4
Jul 10 03:05	2865	DB	5.7	174	50	354	9.9	9.9
Jul 10 03:17	2865	RB	5.7	174	48	338	9.9	9.9
Jul 11 23:32	29 Cap	DB	5.3	153	53	139	2.1	-5.5
Jul 12 00:11	29 Cap	RD	5.3	152	60	192	1.6	5.4
Jul 13 02:27	38 Aqr	DB	5.4	140	67	84	2.5	0.2
Jul 13 03:52	38 Aqr	RD	5.4	140	63	225	1.6	2.2
Jul 15 04:22	24 Psc	DB	5.9	115	59	27	1.3	2.6
Jul 15 05:34	24 Psc	RD	5.9	115	54	273	2.5	0.4
Jul 20 04:09	63 Tau	RD	5.6	50	10	231	0.3	0.1
Jul 31 18:08	18 Lib	RB	5.9	98	67	293	2.3	-1.2
Aug 01 23:50	2279	DD	6.1	111	25	109	0.8	0.5
Aug 05 23:53	43 Sgr	DD	4.9	155	64	108	2.5	-0.3
Aug 06 01:08	43 Sgr	RB	4.9	155	49	230	1.0	2.6
Aug 07 21:14	3064	DD	5.9	177	51	122	1.7	-2.9
Aug 07 22:17	3064	RB	5.9	177	63	214	2.0	2.6
Aug 14 01:35	64 Cet	DB	5.6	107	29	37	0.7	0.9
Aug 14 02:43	64 Cet	RD	5.6	107	40	268	2.0	-0.7
Aug 14 02:49	Xi 1 Cet	DB	4.4	107	40	22	0.7	2.0
Aug 14 03:51	Xi 1 Cet	RD	4.4	107	46	282	2.8	-0.9
Aug 15 04:49	464	DB	6.1	93	42	69	2.0	0.4
Aug 17 04:22	104 Tau	DB	4.9	67	22	84	1.3	-0.8
Aug 17 05:36	104 Tau	RD	4.9	66	32	245	1.6	0.1
Aug 31 00:47	2495	DD	6.0	103	8	31	-0.8	3.5
Sep 07 03:12	3432	RD	6.2	175	40	259	1.4	1.4
Sep 07 19:49	29 Psc	RD	5.1	165	14	212	0.4	1.1
Sep 14 04:29	888	DB	6.0	83	31	82	1.8	-0.4
Sep 16 04:53	1186	RD	6.0	56	19	290	1.4	-1.5
Sep 18 10:49	Venus	DB	-3.9	28	42	130	1.9	-1.2
Sep 18 12:17	Venus	RD	-3.9	28	34	281	1.9	0.5
Oct 05 02:13	24 Psc	DD	5.9	165	35	71	1.1	1.6
Oct 10 03:23	684	DB	6.2	127	38	28	1.6	2.2
Oct 10 04:18	684	RD	6.2	127	36	305	2.4	-0.9
Oct 12 00:45	Nu Gem	RD	4.1	101	8	262	0.7	-0.8
Oct 14 02:29	The Cnc	RD	5.3	74	8	273	0.7	-1.1
Oct 24 19:32	2508	RB	6.3	51	30	295	1.0	0.2
Oct 26 20:00	2791	DD	5.6	73	44	94	1.5	0.9
Oct 26 21:12	2791	RB	5.6	73	29	243	0.4	2.0
Nov 03 23:07	308	DD	6.3	170	48	101	2.7	-0.5
Nov 04 03:33	Xi 1 Cet	DB	4.4	172	16	146	0.8	-2.9
Nov 05 00:52	454	DB	5.6	173	42	48	1.7	1.5
Nov 05 02:06	454	RD	5.6	173	35	270	1.9	0.7
Nov 27 22:31	83 Aqr	DD	5.5	99	30	85	1.0	1.3
Nov 27 23:34	83 Aqr	RB	5.5	99	17	227	0.2	2.1
Dec 03 21:22	684	DD	6.2	175	29	54	1.1	0.3
Dec 07 01:36	85 Gem	DB	5.4	138	34	95	2.1	-0.6
Dec 07 02:59	85 Gem	RD	5.4	137	36	282	2.1	-0.3
Dec 10 01:22	53 Leo	DB	5.3	98	16	102	0.9	-1.4
Dec 10 02:34	53 Leo	RD	5.3	98	29	296	1.4	-1.7
Dec 28 21:23	308	RB	6.3	116	41	264	2.0	0.9
Dec 28 23:15	64 Cet	DD	5.6	116	23	94	1.2	1.0
Dec 29 00:12	Xi 1 Cet	DD	4.4	117	13	66	0.7	1.6
Dec 29 23:30	454	DD	5.6	130	26	11	1.2	3.9

MERCURY

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

VENUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

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	217.1	072.6	176.4	035.6	096.0	311.4	005.6	215.1	063.0	112.8	320.7	012.0	1
2	015.0	230.5	334.5	193.7	254.0	109.3	163.4	012.7	220.6	270.5	118.4	169.8	2
3	172.9	028.5	132.5	351.7	051.9	267.1	321.2	170.4	018.3	068.1	276.1	327.5	3
4	330.8	186.5	290.5	149.7	209.9	065.0	118.9	328.1	176.0	225.8	073.8	125.2	4
5	128.6	344.4	088.5	307.8	007.8	222.8	276.7	125.8	333.6	023.5	231.5	283.0	5
6	286.5	142.4	246.6	105.8	165.8	020.7	074.4	283.5	131.3	181.1	029.2	080.7	6
7	084.4	300.4	044.6	263.8	323.8	178.5	232.2	081.2	288.9	338.8	186.9	238.5	7
8	242.3	098.4	202.6	061.9	121.7	336.4	029.9	238.9	086.6	136.5	344.6	036.2	8
9	040.2	256.3	000.7	219.9	279.7	134.2	187.6	036.5	244.3	294.1	142.3	194.0	9
10	198.1	054.3	158.7	017.9	077.6	292.0	345.4	194.2	041.9	091.8	300.0	351.7	10
11	356.0	212.3	316.8	176.0	235.5	089.8	143.1	351.9	199.6	249.5	097.7	149.5	11
12	153.9	010.3	114.8	334.0	033.5	247.7	300.8	149.6	357.2	047.1	255.4	307.2	12
13	311.8	168.3	272.8	132.0	191.4	045.5	098.6	307.3	154.9	204.8	053.1	105.0	13
14	109.7	326.3	070.9	290.0	349.3	203.3	256.3	104.9	312.6	002.5	210.8	262.7	14
15	267.6	124.3	228.9	088.0	147.3	001.1	054.0	262.6	110.2	160.1	008.5	060.5	15
16	065.6	282.3	027.0	246.1	305.2	158.9	211.8	060.3	267.9	317.8	166.2	218.2	16
17	223.5	080.3	185.0	044.1	103.1	316.7	009.5	218.0	065.5	115.5	323.9	016.0	17
18	021.4	238.3	343.0	202.1	261.0	114.5	167.2	015.6	223.2	273.2	121.6	173.8	18
19	179.3	036.3	141.1	000.1	058.9	272.3	324.9	173.3	020.9	070.8	279.3	331.5	19
20	337.2	194.3	299.1	158.1	216.8	070.1	122.6	331.0	178.5	228.5	077.1	129.3	20
21	135.2	352.3	097.2	316.1	014.7	227.9	280.3	128.6	336.2	026.2	234.8	287.1	21
22	293.1	150.3	255.2	114.1	172.6	025.7	078.0	286.3	133.8	183.9	032.5	084.9	22
23	091.0	308.3	053.3	272.1	330.5	183.5	235.8	084.0	291.5	341.6	190.2	242.6	23
24	249.0	106.3	211.3	070.1	128.4	341.3	033.5	241.6	089.2	139.2	347.9	040.4	24
25	046.9	264.4	009.3	228.1	286.3	139.0	191.2	039.3	246.8	296.9	145.6	198.2	25
26	204.9	062.4	167.4	026.1	084.2	296.8	348.9	197.0	044.5	094.6	303.4	356.0	26
27	002.8	220.4	325.4	184.1	242.1	094.6	146.6	354.6	202.1	252.3	101.1	153.8	27
28	160.8	018.4	123.5	342.0	040.0	252.4	304.3	152.3	359.8	050.0	258.8	311.6	28
29	318.7		281.5	140.0	197.8	050.1	102.0	310.0	157.5	207.7	056.6	109.3	29
30	116.7		079.5	298.0	355.7	207.9	259.7	107.6	315.1	005.3	214.3	267.1	30
31	274.6		237.6		153.6		057.4	265.3		163.0		064.9	31

SYSTEM II (° at 0 hr UT)													
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	335.1	314.0	204.2	186.8	018.3	357.2	182.6	155.5	126.9	307.8	279.2	101.6	1
2	125.3	104.3	354.6	337.2	168.6	147.4	332.7	305.5	276.9	097.8	069.2	251.7	2
3	275.6	254.6	145.0	127.6	319.0	297.7	122.8	095.6	066.9	247.9	219.3	041.8	3
4	065.8	045.0	295.4	278.1	109.3	087.9	272.9	245.6	217.0	037.9	009.4	191.9	4
5	216.1	195.3	085.8	068.5	259.6	238.1	063.1	035.7	007.0	187.9	159.4	342.0	5
6	006.3	345.7	236.2	218.9	050.0	028.3	213.2	185.8	157.0	338.0	309.5	132.1	6
7	156.6	136.0	026.6	009.3	200.3	178.5	003.3	335.8	307.0	128.0	099.6	282.2	7
8	306.8	286.4	177.0	159.7	350.6	328.7	153.4	125.9	097.1	278.0	249.6	072.4	8
9	097.1	076.7	327.4	310.1	140.9	118.9	303.5	275.9	247.1	068.1	039.7	222.5	9
10	247.4	227.1	117.8	100.5	291.2	269.1	093.6	066.0	037.1	218.1	189.8	012.6	10
11	037.6	017.4	268.2	250.9	081.6	059.3	243.7	216.0	187.2	008.2	339.8	162.7	11
12	187.9	167.8	058.6	041.2	231.9	209.5	033.8	006.1	337.2	158.2	129.9	312.8	12
13	338.2	318.1	209.0	191.6	022.2	359.7	183.9	156.1	127.2	308.2	280.0	103.0	13
14	128.5	108.5	359.4	342.0	172.5	149.9	334.0	306.2	277.3	098.3	070.1	253.1	14
15	278.8	258.9	149.8	132.4	322.8	300.1	124.1	096.2	067.3	248.3	220.1	043.2	15
16	069.0	049.2	300.2	282.8	113.1	090.3	274.2	246.2	217.3	038.4	010.2	193.4	16
17	219.3	199.6	090.7	073.2	263.3	240.4	064.3	036.3	007.4	188.4	160.3	343.5	17
18	009.6	350.0	241.1	223.6	053.6	030.6	214.4	186.3	157.4	338.5	310.4	133.6	18
19	159.9	140.3	031.5	014.0	203.9	180.8	004.5	336.4	307.4	128.5	100.5	283.8	19
20	310.2	290.7	181.9	164.3	354.2	330.9	154.6	126.4	097.4	278.6	250.6	073.9	20
21	100.5	081.1	332.3	314.7	144.5	121.1	304.7	276.5	247.5	068.6	040.6	224.0	21
22	250.8	231.5	122.7	105.1	294.7	271.3	094.7	066.5	037.5	218.6	190.7	014.2	22
23	041.1	021.8	273.1	255.4	085.0	061.4	244.8	216.5	187.5	008.7	340.8	164.3	23
24	191.4	172.2	063.5	045.8	235.3	211.6	034.9	006.6	337.6	158.7	130.9	314.5	24
25	341.7	322.6	214.0	196.2	025.5	001.7	185.0	156.6	127.6	308.8	281.0	104.6	25
26	132.0	113.0	004.4	346.5	175.8	151.9	335.0	306.6	277.6	098.9	071.1	254.8	26
27	282.4	263.4	154.8	136.9	326.0	302.0	125.1	096.7	067.7	248.9	221.2	044.9	27
28	072.7	053.8	305.2	287.2	116.3	092.2	275.2	246.7	217.7	039.0	011.3	195.1	28
29	223.0		095.6	077.6	266.5	242.3	065.3	036.8	007.7	189.0	161.4	345.3	29
30	013.3		246.0	227.9	056.8	032.4	215.3	186.8	157.8	339.1	311.5	135.4	30
31	163.6		036.4		207.0		005.4	336.8		129.1		285.6	31

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

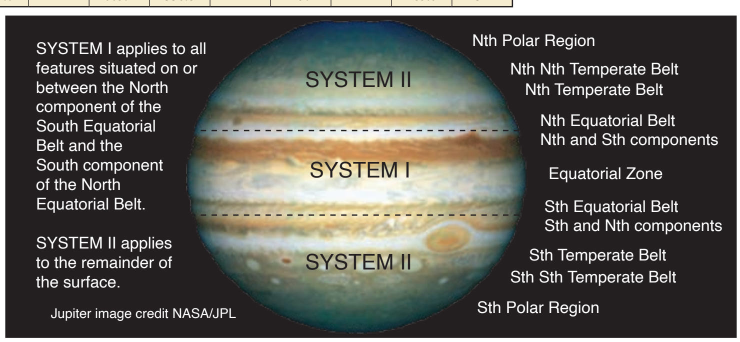
There is no single correct rotation period for the features of Jupiter. The speed of any feature on the surface depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs record the time a feature crosses the central meridian of 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 29 June at 2:20 am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on June 28. From the table, the longitude on 28 June is 252.4°. 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 489.9°, less 360° gives a final answer of 129.9°.

GREAT RED SPOT TRANSIT TIME

The GRS can best be seen from about one hour before transiting the central meridian to one hour after. During this two-hour period it will move approximately 70% of the width of Jupiter at its latitude. It can be seen a further 30 minutes either side of this period, but it tends to appear foreshortened and merging with the limb. The longitude of the GRS (System II) does drift over the years. In recent times it shows an average increase of about 17° to 20° per annum. The following are some actual values for June: 2012 (180°), 2013 (197°), 2014 (214°), 2015 (227°) and 2016 about 248°. The table data (opposite) has been based on 268°. For every degree of longitude greater than 268° it will transit 1.6 minutes later than shown (for every degree less than 268°, transit is 1.6 minutes earlier). If this trend continues the value could range from about 14 minutes earlier than shown here as the year opens to 14 minutes later by the end of 2017. This is an estimated midpoint of the GRS. The spot is about 15° in diameter, so it takes around 24 minutes to transit. The longitude of the GRS was obtained from the JUPOS website. jupos.privat.t-online.de/

Increase In Longitude SYSTEM I Rotation: 9 h 50 m 30.003 s					
hr	deg°	hr	deg°	min	deg°
1	036.6	13	115.5	5	03.0
2	073.2	14	152.1	10	06.1
3	109.7	15	188.7	15	09.1
4	146.3	16	225.3	20	12.2
5	182.9	17	261.8	25	15.2
6	219.5	18	298.4	30	18.3
7	256.1	19	335.0	35	21.3
8	292.6	20	011.6	40	24.4
9	329.2	21	048.2	45	27.4
10	005.8	22	084.7	50	30.5
11	042.4	23	121.3	55	33.5
12	079.0	24	157.9	60	36.6



Increase In Longitude SYSTEM II Rotation: 9 h 55 m 40.062 s					
hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

JUPITER – GREAT RED SPOT

Date	1st	2nd	3rd
Jan 2	4:00 *		
Jan 4	(3:38)		
Jan 5	1:30		
Jan 6	(5:17)		
Jan 7	3:08 *		
Jan 9	4:47 *		
Jan 10	0:38		
Jan 11	(4:25)		
Jan 12	2:16 *		
Jan 14	3:55 *		23:46
Jan 16	(3:33)		
Jan 17	1:24		
Jan 18	(5:11)		
Jan 19	3:03 *		
Jan 21	4:41 *		
Jan 22	0:32		
Jan 23	(4:19)		
Jan 24	2:10 *		
Jan 25	(5:57)		
Jan 26	3:49 *		23:40
Jan 28	5:27 *		(23:18)
Jan 29	1:18		
Jan 30	(5:05)		
Jan 31	2:56 *		22:48
Feb 2	4:35 *		
Feb 3	0:26		
Feb 4	(4:13)		
Feb 5	2:04 *		
Feb 6	(5:51)		
Feb 7	3:42 *		23:34
Feb 9	5:20 *		(23:12)
Feb 10	1:12		
Feb 11	(4:58)		
Feb 12	2:50 *		22:41
Feb 14	4:28 *		(22:19)
Feb 15	0:19		
Feb 16	(4:06)		(23:57)
Feb 17	1:57		21:48
Feb 18	(5:44)		
Feb 19	3:35 *		23:26 *
Feb 21	5:13 *		(23:05)
Feb 22	1:04		20:56
Feb 23	(4:51)		
Feb 24	2:42 *		22:34

Date	1st	2nd	3rd
Feb 25	(6:29)		
Feb 26	4:20 *		(22:12)
Feb 27	0:11		
Feb 28	5:58 *		(23:50)
Mar 1	1:49		21:41
Mar 2	(5:36)		
Mar 3	3:27 *		23:19 *
Mar 5	5:05 *		(22:57)
Mar 6	0:56		20:48
Mar 7	(4:43)		
Mar 8	2:34 *		22:26 *
Mar 9	(6:21)		
Mar 10	4:12 *		(22:04)
Mar 11	0:03		19:55
Mar 12	5:50 *		(23:42)
Mar 13	1:41		21:33
Mar 14	(5:28)		
Mar 15	3:19 *		23:11 *
Mar 17	4:57 *		(22:49)
Mar 18	0:48		20:40
Mar 19	(4:35)		
Mar 20	2:26 *		22:18 *
Mar 21	(6:13)		
Mar 22	4:04 *		23:56 *
Mar 23		19:47	
Mar 24	5:42 *		(23:34)
Mar 25	1:33	(19:25)	21:25
Mar 26	(5:20)		
Mar 27	3:11 *		23:03 *
Mar 28		18:54	
Mar 29	4:49 *		(22:40)
Mar 30	0:40		20:32
Mar 31	6:27 *		
Apr 1	2:18 *		22:10 *
Apr 2	(6:05)		
Apr 3	3:56 *		23:47 *
Apr 4		19:39	
Apr 5	5:34 *		(23:25)
Apr 6	1:25	(19:17)	21:17
Apr 7	(5:12)		
Apr 8	3:03 *		22:54 *
Apr 9		18:46	
Apr 10	4:41 *		(22:32)
Apr 11	0:32	(18:24)	20:24

Date	1st	2nd	3rd
Apr 12	(4:19)		
Apr 13	2:10 *		22:02 *
Apr 14	(5:57)	17:53	
Apr 15	3:48 *		23:40 *
Apr 16		19:31 *	
Apr 17	5:26 *		(23:18)
Apr 18	1:17	(19:09)	21:09
Apr 19	(5:04)	17:00	
Apr 20	2:55 *		22:47 *
Apr 21		18:38	
Apr 22	4:33 *		(22:25)
Apr 23	0:25	(18:16)	20:16
Apr 24	(4:11)		
Apr 25	2:03 *		21:54 *
Apr 26		17:45	
Apr 27	3:41 *		23:32 *
Apr 28		19:23 *	
Apr 29	(3:19)		(23:10)
Apr 30	1:10	(19:02)	21:02
May 1		16:53	
May 2	2:48 *		22:40 *
May 3		18:31	
May 4	(2:26)		(22:18)
May 5	0:18	(18:09)	20:09
May 6	(4:05)		(23:56)
May 7	1:56	(19:47)	21:47
May 8		17:39	
May 9	3:34 *		23:25 *
May 10		19:17 *	
May 11	(3:12)		(23:04)
May 12	1:04	(18:55)	20:55
May 13		16:46	
May 14	2:42 *		22:33 *
May 15		18:25	
May 16	(2:20)		(22:12)
May 17	0:11	(18:03)	20:03
May 18			(23:50)
May 19	1:50	(19:41)	21:41
May 20		17:33	
May 21	(1:28)		23:20 *
May 22		19:11 *	
May 23	(3:07)		(22:58)
May 24	0:58	(18:49)	20:49
May 25		16:41	

Date	1st	2nd	3rd
May 26	2:36 *		22:28 *
May 27		18:19	
May 28	(2:15)		(22:06)
May 29	0:06	(17:58)	19:58
May 30			(23:45)
May 31	1:45	(19:36)	21:36
Jun 1		17:28	
Jun 2	(1:23)		23:15 *
Jun 3		19:06 *	
Jun 4			(22:53)
Jun 5	0:53	(18:45)	20:45
Jun 6		16:36	
Jun 7	(0:32)		22:23 *
Jun 8		18:15	
Jun 9			(22:02)
Jun 10	0:02	(17:53)	19:53
Jun 11			(23:41)
Jun 12		(19:32)	21:32
Jun 13		17:23	
Jun 14	(1:19)		23:11 *
Jun 15		19:02 *	
Jun 16			(22:49)
Jun 17	0:49	(18:41)	20:41
Jun 18		16:32	
Jun 19	(0:28)		22:20 *
Jun 20		18:11	
Jun 21			23:58 *
Jun 22		19:50 *	
Jun 23			(23:37)
Jun 24		(19:29)	21:29
Jun 25		17:20	
Jun 26			23:07 *
Jun 27		18:59 *	
Jun 28			(22:46)
Jun 29		(18:38)	20:38
Jun 30		16:29	
Jul 1	(0:25)		22:17 *
Jul 2		18:08	
Jul 3			23:55 *
Jul 4		19:47 *	
Jul 5			(23:34)
Jul 6		(19:26)	21:26
Jul 7		17:18	
Jul 8			23:05 *

Date	1st	2nd	3rd
Jul 9		18:56	
Jul 10			(22:44)
Jul 11		(18:35)	20:35
Jul 13			22:14 *
Jul 14		18:06	
Jul 15			(21:53)
Jul 16		19:45 *	
Jul 17			(23:32)
Jul 18		(19:24)	21:24
Jul 19		17:16	
Jul 20			23:03 *
Jul 21		18:55	
Jul 22			(22:42)
Jul 23		(18:34)	20:34
Jul 25			22:13 *
Jul 26		18:04	
Jul 27			(21:52)
Jul 28		19:43 *	
Jul 30		(19:22)	21:22
Jul 31		17:14	
Aug 1			(21:01)
Aug 2		18:53	
Aug 3			(22:41)
Aug 4		(18:32)	20:32
Aug 6			22:11 *
Aug 7		18:03	
Aug 8			(21:50)
Aug 9		19:42 *	
Aug 11		(19:21)	21:21
Aug 12		17:13	
Aug 13			(21:00)
Aug 14		18:52	
Aug 16		(18:31)	20:31
Aug 18			(20:10)
Aug 19		18:02	
Aug 20			(21:50)
Aug 21		19:41 *	
Aug 23		(19:20)	21:20
Aug 24		17:12	
Aug 25			(21:00)
Aug 26		18:51	
Aug 28		(18:30)	20:30
Aug 30			(20:10)
Aug 31		18:01	

Date	1st	2nd	3rd
Sep 2		19:41 *	
Sep 4		(19:20)	
Sep 5		17:11	
Sep 6			(20:59)
Sep 7		18:51	
Sep 9		(18:30)	20:30
Sep 11			(20:09)
Sep 12		18:01	
Sep 14		19:40 *	
Sep 16		(19:19)	
Sep 19		18:50	
Sep 21		(18:29)	
Sep 23			(20:08)
Sep 24		18:00	
Sep 26		19:39	
Sep 28		(19:18)	
Oct 1		18:49	
Oct 3		(18:29)	
Nov 16	(5:10)		
Nov 19	4:41		
Nov 21	(4:20)		
Nov 24	3:51		
Nov 28	(5:09)		
Dec 1	4:39		
Dec 3	(4:18)		
Dec 6	3:49		
Dec 8	(3:28)		
Dec 10	(5:06)		
Dec 11	2:58		
Dec 13	4:37		
Dec 15	(4:16)		
Dec 18	3:46		
Dec 20	(3:25)		
Dec 22	(5:04)		
Dec 23	2:55		
Dec 25	4:34 *		
Dec 27	(4:13)		
Dec 28	2:04		
Dec 30	3:43		

1st, 2nd or 3rd GRS

h:mm EST (Eastern only)
h:mm* EST (All States)
(h:mm) WST (WA only)

Predictions are shown for transit times for Sydney and Perth (giving a reasonable indication for eastern and western Australia). Times have been excluded when Jupiter is near conjunction (within 18° of the Sun) or below the horizon. If a transit is predicted when Jupiter is close to the horizon, the GRS may still be seen at least one hour before or after the time (allowing it to have some altitude). Predictions during daylight hours have also been omitted, except for those within 30 minutes after sunrise or 30 minutes before sunset. Even if there is a transit close to sunrise or sunset, the GRS can be seen well into the twilight period. For places that have extreme latitudes (such as Darwin or Hobart) you may need to check the GRS times against your local rise and set times for the Sun and Jupiter.

With a transit occurring every 9 hours 55 min 40 secs, two or three transits will occur every day, but a maximum of two are visible from most places. The three columns represent the 1st, 2nd and 3rd (when applicable) transits for each day for the relevant time zone. 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 21 May the first transit is only visible from WA at 1:28 am WST. The 3rd transit for the day is visible Australia wide at 23:20 EST or 11:20 pm EST (9:20 pm WST).

JUPITER'S MOONS

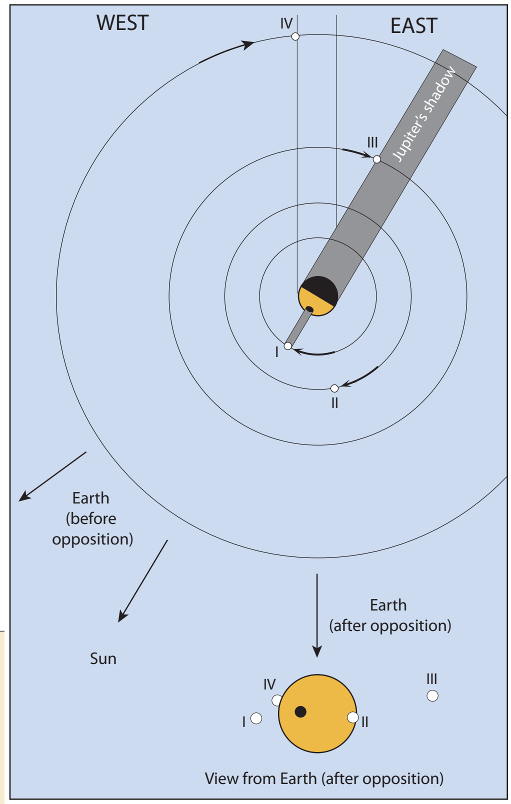
Jupiter, with its many moons, can be likened to a miniature Solar System. Like the planets, these moons all lie in a similar plane. Although there are 67 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo, are bright enough to be visible in small telescopes or moderate-sized binoculars. The dance of these moons, as they pass back and forth across Jupiter, is illustrated in *Jupiter Moon Events* on the following pages. All the moons orbit in roughly the same plane, which is very close to the plane of the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From Earth, we see four types of events. They are:

1. The satellite passes in front of Jupiter. This is called a satellite transit.
2. The shadow of a satellite can move across the *surface* of the planet. This is called a satellite shadow transit. The start of a satellite or shadow transit is called its ingress; the finish, its egress.

   Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter's opposition date in 2017 is 8 April.
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 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 January 18.

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.

Viewed from the Earth (after opposition):

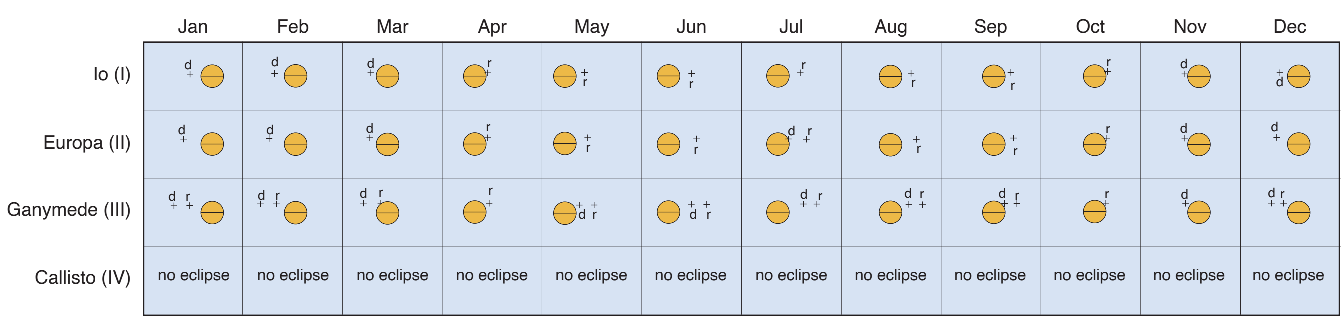
Satellite I	(Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.
Satellite II	(Europa) has just commenced a satellite transit (ingress).
Satellite III	(Ganymede) is about to be eclipsed (disappear).
Satellite IV	(Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

JUPITER'S MOON EVENTS Legend (following pages)

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

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

ECLIPSE POSITIONS



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

JUPITER MOON EVENTS

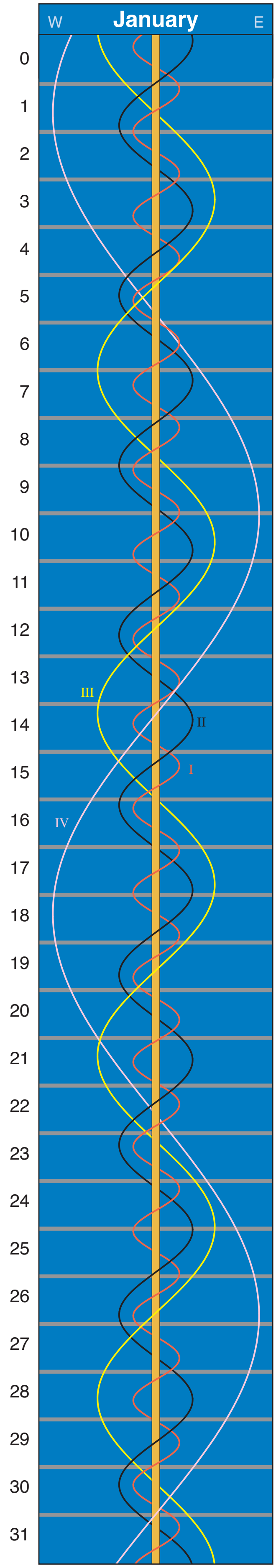
The diagrams here show the patterns the four major moons of Jupiter make as they shuffle back and forth. Each complete period represents one orbit of the satellite. Each horizontal grey date line represents midnight; the top edge of the line is midnight EST (14 hr UT), the bottom edge of the line is midnight WST (16 hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times. The same can be done with the occultation times, that is when the line disappears behind Jupiter. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.

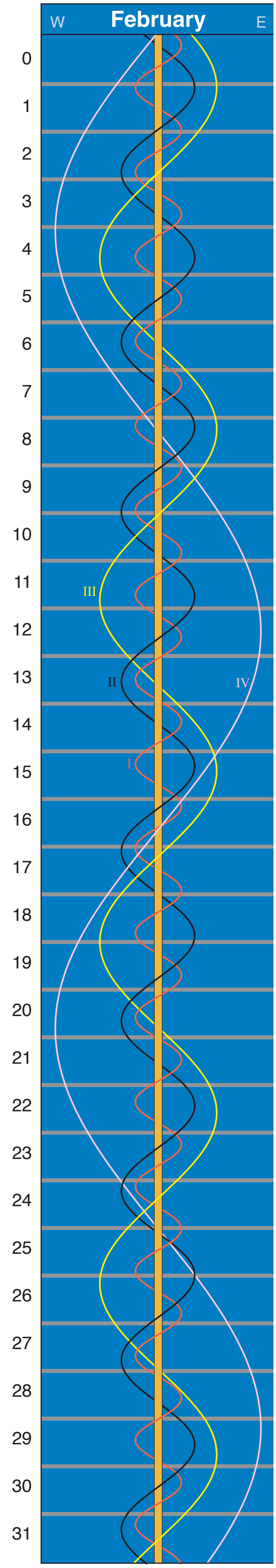
January

Day	EST	WST	Sat	Event	Vis
1	02:40	00:40	II	Tr E	
4	04:35	02:35	I	Ec D	
5	00:59	22:59(p)	III	Sh I	E
	01:55	23:55(p)	I	Sh I	E
	03:09	01:09	I	Tr I	
	03:38	01:38	III	Sh E	
	04:08	02:08	I	Sh E	
	05:20	03:20	I	Tr E	W
	06:05	04:05	III	Tr I	W
6	02:28	00:28	I	Oc R	
	06:09	04:09	II	Ec D	W
8	00:21	22:21(p)	II	Sh I	E
	02:50	00:50	II	Tr I	
	02:52	00:52	II	Sh E	
	05:15	03:15	II	Tr E	W
10	00:24	22:24(p)	II	Oc R	E
11	06:28	04:28	I	Ec D	W
12	03:48	01:48	I	Sh I	
	04:57	02:57	III	Sh I	
	05:03	03:03	I	Tr I	W
	06:01	04:01	I	Sh E	W
	07:14	05:14	I	Tr E	W
13	00:56	22:56(p)	I	Ec D	E
	04:22	02:22	I	Oc R	
	23:31	21:31	I	Tr I	E
14	00:29	22:29(p)	I	Sh E	E
	01:42	23:42(p)	I	Tr E	E
15	02:54	00:54	II	Sh I	
	05:25	03:25	II	Tr I	W
	05:26	03:26	II	Sh E	W
16	00:13	22:13(p)	III	Oc D	E
	02:25	00:25	III	Oc R	
17	00:33	22:33(p)	II	Ec R	E
	00:33	22:33(p)	II	Oc D	E
	02:57	00:57	II	Oc R	
19	05:41	03:41	I	Sh I	W
	06:55	04:55	I	Tr I	W
20	02:49	00:49	I	Ec D	
	06:14	04:14	I	Oc R	W
21	00:10	22:10(p)	I	Sh I	E
	01:23	23:23(p)	I	Tr I	E
	02:22	00:22	I	Sh E	
	03:34	01:34	I	Tr E	
22	00:42	22:42(p)	I	Oc R	E
	05:28	03:28	II	Sh I	W
	23:00	21:00	III	Ec D	E
23	01:36	23:36(p)	III	Ec R	
	04:08	02:08	III	Oc D	
	06:16	04:16	III	Oc R	W
24	00:36	22:36(p)	II	Ec D	E
	05:29	03:29	II	Oc R	W
25	23:35	21:35	II	Tr E	E
27	04:42	02:42	I	Ec D	
28	02:03	00:03	I	Sh I	
	03:15	01:15	I	Tr I	
	04:15	02:15	I	Sh E	
	05:26	03:26	I	Tr E	W
	23:11	21:11	I	Ec D	E
29	02:33	00:33	I	Oc R	
	22:44	20:44	I	Sh E	E
	23:53	21:53	I	Tr E	E
30	02:57	00:57	III	Ec D	
	05:32	03:32	III	Ec R	W
31	03:11	01:11	II	Ec D	

February

Day	EST	WST	Sat	Event	Vis
1	23:42	21:42	II	Tr I	E
	23:50	21:50	II	Sh E	E
2	02:04	00:04	II	Tr E	
	23:47	21:47	III	Tr E	E
3	06:35	04:35	I	Ec D	W
4	03:56	01:56	I	Sh I	
	05:05	03:05	I	Tr I	
	06:08	04:08	I	Sh E	W
	07:16	05:16	I	Tr E	W
5	01:04	23:04(p)	I	Ec D	
	04:23	02:23	I	Oc R	
	22:24	20:24	I	Sh I	E
	23:33	21:33	I	Tr I	E
6	00:37	22:37(p)	I	Sh E	
	01:43	23:43(p)	I	Tr E	
	06:54	04:54	III	Ec D	W
	22:50	20:50	I	Oc R	E
7	05:45	03:45	II	Ec D	W
8	23:53	21:53	II	Sh I	E
9	02:10	00:10	II	Tr I	
	02:23	00:23	II	Sh E	
	04:31	02:31	II	Tr E	
	23:21	21:21	III	Sh E	E
10	01:28	23:28(p)	III	Tr I	
	03:27	01:27	III	Tr E	
	23:38	21:38	II	Oc R	E
11	05:49	03:49	I	Sh I	W
	06:55	04:55	I	Tr I	W
12	02:57	00:57	I	Ec D	
	06:12	04:12	I	Oc R	W
13	00:18	22:18(p)	I	Sh I	
	01:22	23:22(p)	I	Tr I	
	02:30	00:30	I	Sh E	
	03:32	01:32	I	Tr E	
14	00:39	22:39(p)	I	Oc R	
	21:59	19:59	I	Tr E	E
16	02:28	00:28	II	Sh I	
	04:35	02:35	II	Tr I	
	04:58	02:58	II	Sh E	
	06:55	04:55	II	Tr E	W





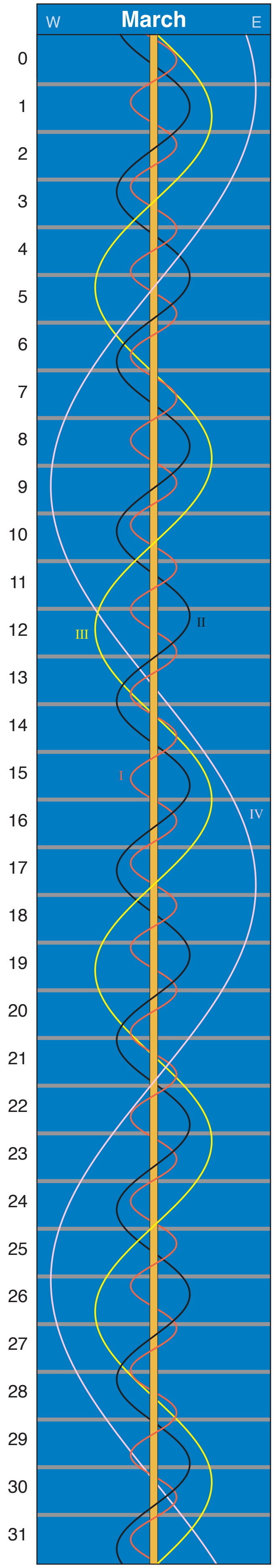
JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
17	00:46	22:46(p)	III	Sh	I	
	03:17	01:17	III	Sh	E
	05:06	03:06	III	Tr	I
	07:03	05:03	III	Tr	E W
	21:37	19:37	II	Ec	D E
18	02:02	00:02	II	Oc	R
	07:43	05:43	I	Sh	I W
19	04:50	02:50	I	Ec	D
20	02:11	00:11	I	Sh	I
	03:10	01:10	I	Tr	I
	04:23	02:23	I	Sh	E
	05:20	03:20	I	Tr	E
	23:18	21:18	I	Ec	D E
21	02:27	00:27	I	Oc	R
	21:36	19:36	I	Tr	I E
	22:51	20:51	I	Sh	E E
	23:46	21:46	I	Tr	E
22	20:54	18:54	I	Oc	R E
23	05:02	03:02	II	Sh	I
	06:58	04:58	II	Tr	I W
	07:32	05:32	II	Sh	E W
24	04:43	02:43	III	Sh	I
	07:14	05:14	III	Sh	E W
25	00:12	22:12(p)	II	Ec	D
	04:23	02:23	II	Oc	R
26	06:43	04:43	I	Ec	D W
	20:49	18:49	II	Sh	E E
	22:28	20:28	II	Tr	E E
27	04:04	02:04	I	Sh	I
	04:56	02:56	I	Tr	I
	06:16	04:16	I	Sh	E W
	07:06	05:06	I	Tr	E W
	21:20	19:20	III	Ec	R E
	22:31	20:31	III	Oc	D E
28	00:27	22:27(p)	III	Oc	R
	01:12	23:12(p)	I	Ec	D
	04:14	02:14	I	Oc	R
	22:33	20:33	I	Sh	I E
	23:23	21:23	I	Tr	I

March

Day	EST	WST	Sat	Event	Vis
1	00:45	22:45(p)	I	Sh E	
	01:33	23:33(p)	I	Tr E	
	22:40	20:40	I	Oc R	E
2	07:37	05:37	II	Sh I	W
4	02:46	00:46	II	Ec D	
	06:43	04:43	II	Oc R	W
5	20:55	18:55	II	Sh I	E
	22:29	20:29	II	Tr I	
	23:24	21:24	II	Sh E	
6	00:48	22:48(p)	II	Tr E	
	05:58	03:58	I	Sh I	W
	06:42	04:42	I	Tr I	W
	08:09	06:09	I	Sh E	W
	22:47	20:47	III	Ec D	
7	01:17	23:17(p)	III	Ec R	
	01:58	23:58(p)	III	Oc D	
	03:05	01:05	I	Ec D	
	03:54	01:54	III	Oc R	
	06:00	04:00	I	Oc R	W
8	00:26	22:26(p)	I	Sh I	
	01:09	23:09(p)	I	Tr I	
	02:38	00:38	I	Sh E	
	03:18	01:18	I	Tr E	
	21:34	19:34	I	Ec D	E
9	00:26	22:26(p)	I	Oc R	
	21:06	19:06	I	Sh E	E
	21:45	19:45	I	Tr E	E

Day	EST	WST	Sat	Event	Vis
11	05:20	03:20	II	Ec D	
12	23:30	21:30	II	Sh I	
13	00:47	22:47(p)	II	Tr I	
	01:58	23:58(p)	II	Sh E	
	03:06	01:06	II	Tr E	
	07:51	05:51	I	Sh I	W
14	02:45	00:45	III	Ec D	
	04:59	02:59	I	Ec D	
	05:14	03:14	III	Ec R	
	05:21	03:21	III	Oc D	
	07:17	05:17	III	Oc R	W
	07:45	05:45	I	Oc R	W
	22:08	20:08	II	Oc R	
15	02:19	00:19	I	Sh I	
	02:54	00:54	I	Tr I	
	04:31	02:31	I	Sh E	
	05:03	03:03	I	Tr E	
	23:27	21:27	I	Ec D	
16	02:11	00:11	I	Oc R	
	20:48	18:48	I	Sh I	E
	21:20	19:20	I	Tr I	E
	22:59	20:59	I	Sh E	
	23:29	21:29	I	Tr E	
17	20:37	18:37	I	Oc R	E
	20:49	18:49	III	Tr E	E
18	07:54	05:54	II	Ec D	W
20	02:05	00:05	II	Sh I	
	03:04	01:04	II	Tr I	
	04:34	02:34	II	Sh E	
	05:24	03:24	II	Tr E	
21	06:42	04:42	III	Ec D	W
	06:53	04:53	I	Ec D	W
	21:12	19:12	II	Ec D	E
22	00:24	22:24(p)	II	Oc R	
	04:13	02:13	I	Sh I	
	04:38	02:38	I	Tr I	
	06:25	04:25	I	Sh E	W
	06:48	04:48	I	Tr E	W
23	01:21	23:21(p)	I	Ec D	
	03:55	01:55	I	Oc R	
	22:41	20:41	I	Sh I	
	23:04	21:04	I	Tr I	
24	00:53	22:53(p)	I	Sh E	
	01:14	23:14(p)	I	Tr E	
	19:50	17:50	I	Ec D	E
	20:35	18:35	III	Sh I	E
	22:12	20:12	III	Tr I	
	22:22	20:22	I	Oc R	
	23:01	21:01	III	Sh E	
25	00:08	22:08(p)	III	Tr E	
	19:21	17:21	I	Sh E	E
	19:39	17:39	I	Tr E	E
27	04:41	02:41	II	Sh I	
	05:20	03:20	II	Tr I	
	07:09	05:09	II	Sh E	W
	07:40	05:40	II	Tr E	W
28	23:46	21:46	II	Ec D	
29	02:39	00:39	II	Oc R	
	06:07	04:07	I	Sh I	
	06:22	04:22	I	Tr I	W
	08:18	06:18	I	Sh E	W
30	03:15	01:15	I	Ec D	
	05:40	03:40	I	Oc R	
	18:28	16:28	II	Tr I	E
	20:27	18:27	II	Sh E	E
	20:48	18:48	II	Tr E	

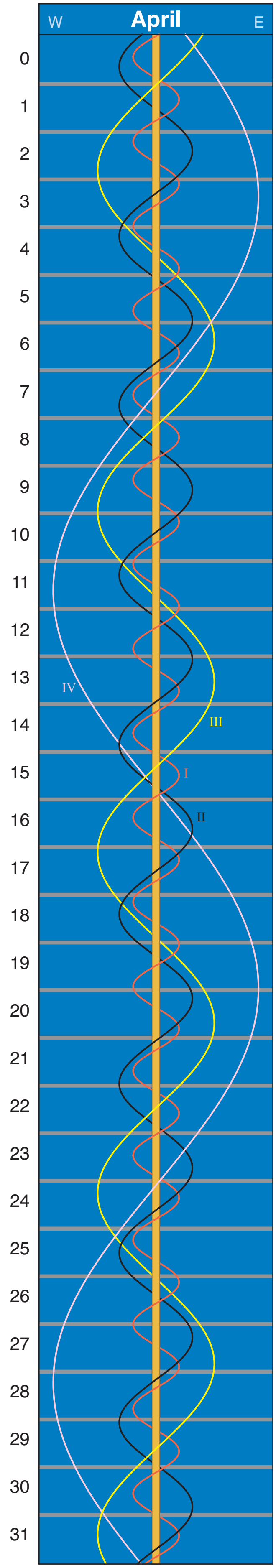


Day	EST	WST	Sat	Event	Vis
31	00:35	22:35(p)	I	Sh I	
	00:48	22:48(p)	I	Tr I	
	02:46	00:46	I	Sh E	
	02:57	00:57	I	Tr E	
	21:44	19:44	I	Ec D	

April

Day	EST	WST	Sat	Event	Vis
1	00:06	22:06(p)	I	Oc R	
	00:34	22:34(p)	III	Sh I	
	01:29	23:29(p)	III	Tr I	
	02:59	00:59	III	Sh E	
	03:27	01:27	III	Tr E	
	19:03	17:03	I	Sh I	E
	19:13	17:13	I	Tr I	E
	21:15	19:15	I	Sh E	
	21:23	19:23	I	Tr E	
2	18:32	16:32	I	Oc R	E
3	07:17	05:17	II	Sh I	W
	07:35	05:35	II	Tr I	W
5	02:20	00:20	II	Ec D	
	04:53	02:53	II	Oc R	
	08:00	06:00	I	Sh I	W
	08:05	06:05	I	Tr I	W
6	05:09	03:09	I	Ec D	
	07:24	05:24	I	Oc R	W
	20:35	18:35	II	Sh I	
	20:42	18:42	II	Tr I	
	23:03	21:03	II	Sh E	
	23:04	21:04	II	Tr E	
7	02:29	00:29	I	Sh I	
	02:31	00:31	I	Tr I	
	04:40	02:40	I	Sh E	
	04:41	02:41	I	Tr E	
	23:38	21:38	I	Ec D	
8	01:50	23:50(p)	I	Ec R	
	04:32	02:32	III	Sh I	
	04:44	02:44	III	Tr I	
	06:44	04:44	III	Tr E	W
	06:56	04:56	III	Sh E	W
	18:04	16:04	II	Ec R	E
	20:57	18:57	I	Tr I	
	20:57	18:57	I	Sh I	
	23:07	21:07	I	Tr E	
	23:09	21:09	I	Sh E	
9	18:05	16:05	I	Oc D	E
	20:19	18:19	I	Ec R	
11	18:29	16:29	III	Oc D	E
	21:03	19:03	III	Ec R	
12	04:45	02:45	II	Oc D	
	07:21	05:21	II	Ec R	W
13	06:57	04:57	I	Oc D	W
	22:57	20:57	II	Tr I	
	23:12	21:12	II	Sh I	
14	01:19	23:19(p)	II	Tr E	
	01:39	23:39(p)	II	Sh E	
	04:15	02:15	I	Tr I	
	04:23	02:23	I	Sh I	
	06:25	04:25	I	Tr E	W
	06:34	04:34	I	Sh E	W
15	01:23	23:23(p)	I	Oc D	
	03:44	01:44	I	Ec R	
	07:58	05:58	III	Tr I	W
	17:52	15:52	II	Oc D	E
	20:38	18:38	II	Ec R	
	22:41	20:41	I	Tr I	
	22:51	20:51	I	Sh I	
16	00:51	22:51(p)	I	Tr E	
	01:02	23:02(p)	I	Sh E	
	19:49	17:49	I	Oc D	E
	22:13	20:13	I	Ec R	
17	19:17	17:17	I	Tr E	E
	19:31	17:31	I	Sh E	E

JUPITER MOON EVENTS

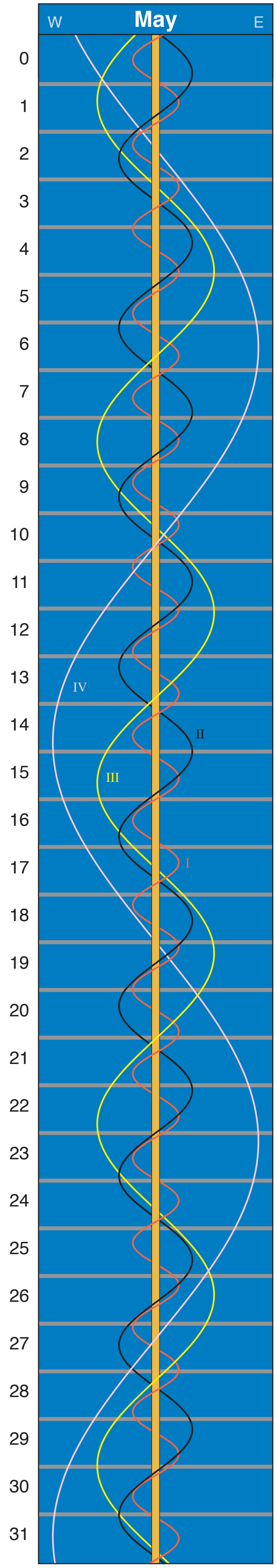


Day	EST	WST	Sat	Event		Vis
18	21:44	19:44	III	Oc	D	
19	01:01	23:01(p)	III	Ec	R	
	06:59	04:59	II	Oc	D	W
21	01:13	23:13(p)	II	Tr	I	
	01:48	23:48(p)	II	Sh	I	
	03:36	01:36	II	Tr	E	
	04:15	02:15	II	Sh	E	
	05:59	03:59	I	Tr	I	W
	06:16	04:16	I	Sh	I	W
22	03:07	01:07	I	Oc	D	
	05:39	03:39	I	Ec	R	W
	20:06	18:06	II	Oc	D	
	23:11	21:11	II	Ec	R	
23	00:25	22:25(p)	I	Tr	I	
	00:45	22:45(p)	I	Sh	I	
	02:35	00:35	I	Tr	E	
	02:56	00:56	I	Sh	E	
	21:33	19:33	I	Oc	D	
24	00:07	22:07(p)	I	Ec	R	
	17:33	15:33	II	Sh	E	E
	18:51	16:51	I	Tr	I	E
	19:13	17:13	I	Sh	I	E
	21:01	19:01	I	Tr	E	
	21:25	19:25	I	Sh	E	
25	18:36	16:36	I	Ec	R	E
26	01:01	23:01(p)	III	Oc	D	
	04:59	02:59	III	Ec	R	
28	03:29	01:29	II	Tr	I	
	04:25	02:25	II	Sh	I	
	05:53	03:53	II	Tr	E	W
	06:52	04:52	II	Sh	E	W
29	04:52	02:52	I	Oc	D	W
	18:47	16:47	III	Sh	E	E
	22:21	20:21	II	Oc	D	
30	01:45	23:45(p)	II	Ec	R	
	02:09	00:09	I	Tr	I	
	02:39	00:39	I	Sh	I	
	04:19	02:19	I	Tr	E	
	04:50	02:50	I	Sh	E	W
	23:18	21:18	I	Oc	D	

May

Day	EST	WST	Sat	Event		Vis
1	02:02	00:02	I	Ec	R	
	17:43	15:43	II	Sh	I	E
	19:02	17:02	II	Tr	E	E
	20:09	18:09	II	Sh	E	
	20:35	18:35	I	Tr	I	
	21:08	19:08	I	Sh	I	
	22:46	20:46	I	Tr	E	
	23:19	21:19	I	Sh	E	
2	17:45	15:45	I	Oc	D	E
	20:31	18:31	I	Ec	R	
3	04:20	02:20	III	Oc	D	
	06:33	04:33	III	Oc	R	W
	06:36	04:36	III	Ec	D	W
	17:47	15:47	I	Sh	E	E
5	05:47	03:47	II	Tr	I	W
6	06:38	04:38	I	Oc	D	W
	17:52	15:52	III	Tr	I	E
	20:06	18:06	III	Tr	E	
	20:26	18:26	III	Sh	I	
	22:46	20:46	III	Sh	E	
7	00:37	22:37(p)	II	Oc	D	
	03:54	01:54	I	Tr	I	
	04:19	02:19	II	Ec	R	W
	04:33	02:33	I	Sh	I	W
	06:05	04:05	I	Tr	E	W

Day	EST	WST	Sat	Event		Vis
8	01:04	23:04(p)	I	Oc	D	
	03:57	01:57	I	Ec	R	
	18:56	16:56	II	Tr	I	E
	20:20	18:20	II	Sh	I	
	21:21	19:21	II	Tr	E	
	22:21	20:21	I	Tr	I	
	22:46	20:46	II	Sh	E	
	23:02	21:02	I	Sh	I	
9	00:31	22:31(p)	I	Tr	E	
	01:13	23:13(p)	I	Sh	E	
	19:31	17:31	I	Oc	D	E
	22:25	20:25	I	Ec	R	
10	17:30	15:30	I	Sh	I	E
	17:36	15:36	II	Ec	R	E
	18:58	16:58	I	Tr	E	E
	19:41	17:41	I	Sh	E	
13	21:16	19:16	III	Tr	I	
	23:33	21:33	III	Tr	E	
14	00:25	22:25(p)	III	Sh	I	
	02:44	00:44	III	Sh	E	
	02:55	00:55	II	Oc	D	
	05:40	03:40	I	Tr	I	W
15	02:51	00:51	I	Oc	D	
	05:52	03:52	I	Ec	R	W
	21:16	19:16	II	Tr	I	
	22:57	20:57	II	Sh	I	
	23:43	21:43	II	Tr	E	
16	00:07	22:07(p)	I	Tr	I	
	00:56	22:56(p)	I	Sh	I	
	01:23	23:23(p)	II	Sh	E	
	02:18	00:18	I	Tr	E	
	03:07	01:07	I	Sh	E	
	21:18	19:18	I	Oc	D	
17	00:20	22:20(p)	I	Ec	R	
	18:34	16:34	I	Tr	I	E
	19:25	17:25	I	Sh	I	E
	20:10	18:10	II	Ec	R	
	20:45	18:45	I	Tr	E	
	21:36	19:36	I	Sh	E	
18	18:49	16:49	I	Ec	R	E
21	00:43	22:43(p)	III	Tr	I	
	03:04	01:04	III	Tr	E	
	04:24	02:24	III	Sh	I	W
	05:14	03:14	II	Oc	D	W
22	04:39	02:39	I	Oc	D	W
	23:39	21:39	II	Tr	I	
23	01:35	23:35(p)	II	Sh	I	
	01:55	23:55(p)	I	Tr	I	
	02:06	00:06	II	Tr	E	
	02:50	00:50	I	Sh	I	
	04:00	02:00	II	Sh	E	W
	04:06	02:06	I	Tr	E	W
	05:01	03:01	I	Sh	E	W
	23:06	21:06	I	Oc	D	
24	02:15	00:15	I	Ec	R	
	18:25	16:25	II	Oc	D	E
	18:33	16:33	III	Ec	D	E
	20:22	18:22	I	Tr	I	
	20:51	18:51	III	Ec	R	
	21:19	19:19	I	Sh	I	
	22:33	20:33	I	Tr	E	
	22:44	20:44	II	Ec	R	
	23:30	21:30	I	Sh	E	
25	17:33	15:33	I	Oc	D	E
	20:44	18:44	I	Ec	R	
26	17:19	15:19	II	Sh	E	E
	17:59	15:59	I	Sh	E	E
28	04:15	02:15	III	Tr	I	W



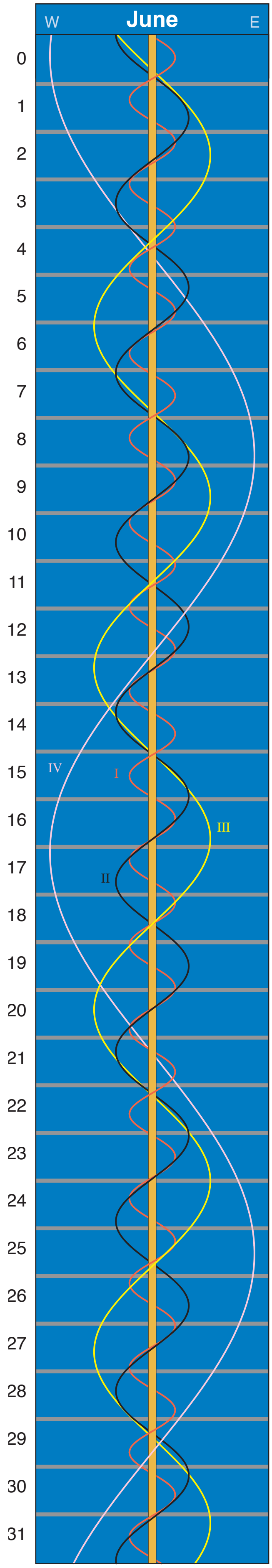
JUPITER

JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
30	02:03	00:03	II	Tr I	
	03:43	01:43	I	Tr I	W
	04:12	02:12	II	Sh I	W
	04:31	02:31	II	Tr E	W
	04:45	02:45	I	Sh I	W
31	00:55	22:55(p)	I	Oc D	
	04:10	02:10	I	Ec R	W
	18:11	16:11	III	Oc D	E
	20:37	18:37	III	Oc R	
	20:47	18:47	II	Oc D	
	22:10	20:10	I	Tr I	
	22:33	20:33	III	Ec D	
	23:13	21:13	I	Sh I	

June

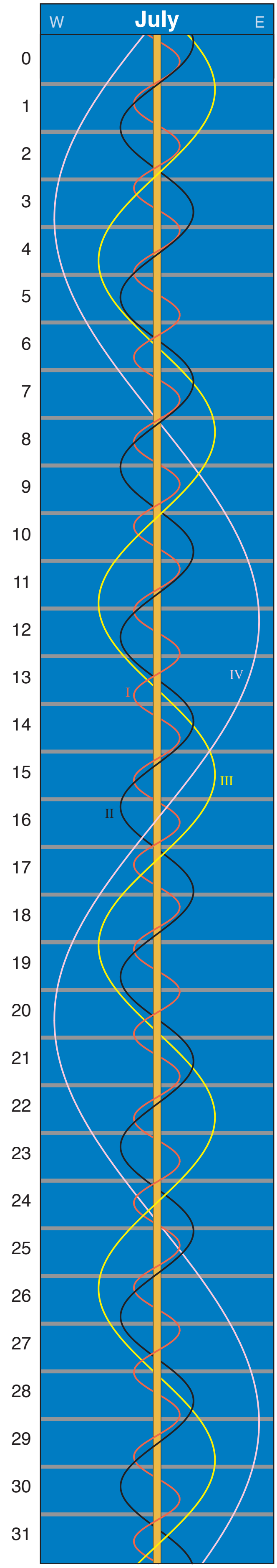
Day	EST	WST	Sat	Event	Vis
1	00:21	22:21(p)	I	Tr E	
	00:50	22:50(p)	III	Ec R	
	01:18	23:18(p)	II	Ec R	
	01:24	23:24(p)	I	Sh E	
	19:22	17:22	I	Oc D	
	22:39	20:39	I	Ec R	
2	17:31	15:31	II	Sh I	E
	17:42	15:42	I	Sh I	E
	17:45	15:45	II	Tr E	E
	18:49	16:49	I	Tr E	E
	19:53	17:53	I	Sh E	
	19:56	17:56	II	Sh E	
3	17:08	15:08	I	Ec R	E
6	04:30	02:30	II	Tr I	W
7	02:45	00:45	I	Oc D	W
	21:50	19:50	III	Oc D	
	23:12	21:12	II	Oc D	
8	00:00	22:00(p)	I	Tr I	
	00:18	22:18(p)	III	Oc R	
	01:08	23:08(p)	I	Sh I	
	02:11	00:11	I	Tr E	W
	02:33	00:33	III	Ec D	W
	03:19	01:19	I	Sh E	W
	03:52	01:52	II	Ec R	W
	21:13	19:13	I	Oc D	
9	00:34	22:34(p)	I	Ec R	
	17:45	15:45	II	Tr I	E
	18:28	16:28	I	Tr I	E
	19:37	17:37	I	Sh I	
	20:09	18:09	II	Sh I	
	20:14	18:14	II	Tr E	
	20:39	18:39	I	Tr E	
	21:47	19:47	I	Sh E	
	22:33	20:33	II	Sh E	
10	19:03	17:03	I	Ec R	E
11	17:09	15:09	II	Ec R	E
	18:35	16:35	III	Sh E	E
15	01:34	23:34(p)	III	Oc D	
	01:39	23:39(p)	II	Oc D	W
	01:51	23:51(p)	I	Tr I	W
	03:03	01:03	I	Sh I	W
	23:04	21:04	I	Oc D	
16	02:29	00:29	I	Ec R	W
	20:15	18:15	II	Tr I	
	20:19	18:19	I	Tr I	
	21:31	19:31	I	Sh I	
	22:31	20:31	I	Tr E	
	22:45	20:45	II	Tr E	
	22:46	20:46	II	Sh I	
	23:42	21:42	I	Sh E	
17	01:11	23:11(p)	II	Sh E	
	17:33	15:33	I	Oc D	E
	20:58	18:58	I	Ec R	



Day	EST	WST	Sat	Event	Vis
18	16:59	14:59	I	Tr E	E
	17:47	15:47	III	Tr E	E
	18:11	16:11	I	Sh E	E
	19:44	17:44	II	Ec R	
	20:20	18:20	III	Sh I	
	22:33	20:33	III	Sh E	
23	00:57	22:57(p)	I	Oc D	
	22:11	20:11	I	Tr I	
	22:48	20:48	II	Tr I	
	23:26	21:26	I	Sh I	
24	00:23	22:23(p)	I	Tr E	
	01:18	23:18(p)	II	Tr E	W
	01:24	23:24(p)	II	Sh I	W
	01:36	23:36(p)	I	Sh E	W
	19:26	17:26	I	Oc D	
	22:53	20:53	I	Ec R	
25	17:24	15:24	II	Oc D	E
	17:54	15:54	I	Sh I	E
	18:51	16:51	I	Tr E	E
	19:07	17:07	III	Tr I	E
	19:53	17:53	II	Oc R	
	19:55	17:55	II	Ec D	
	20:05	18:05	I	Sh E	
	21:39	19:39	III	Tr E	
	22:18	20:18	II	Ec R	
26	00:20	22:20(p)	III	Sh I	
	02:32	00:32	III	Sh E	W
	17:22	15:22	I	Ec R	E
27	17:06	15:06	II	Sh E	E
30	02:51	00:51	I	Oc D	W

July

Day	EST	WST	Sat	Event	Vis
1	00:05	22:05(p)	I	Tr I	
	01:20	23:20(p)	I	Sh I	W
	01:23	23:23(p)	II	Tr I	W
	02:16	00:16	I	Tr E	W
	21:20	19:20	I	Oc D	
2	00:49	22:49(p)	I	Ec R	W
	18:33	16:33	I	Tr I	E
	19:49	17:49	I	Sh I	
	19:56	17:56	II	Oc D	
	20:45	18:45	I	Tr E	
	22:00	20:00	I	Sh E	
	22:25	20:25	II	Oc R	
	22:30	20:30	II	Ec D	
	23:02	21:02	III	Tr I	
3	00:52	22:52(p)	II	Ec R	W
	01:34	23:34(p)	III	Tr E	W
	19:17	17:17	I	Ec R	E
4	17:11	15:11	II	Tr E	E
	17:20	15:20	II	Sh I	E
	19:43	17:43	II	Sh E	
6	18:31	16:31	III	Ec D	E
	20:43	18:43	III	Ec R	
8	01:59	23:59(p)	I	Tr I	W
	23:15	21:15	I	Oc D	
9	20:28	18:28	I	Tr I	
	21:44	19:44	I	Sh I	
	22:31	20:31	II	Oc D	
	22:40	20:40	I	Tr E	
	23:54	21:54	I	Sh E	
10	01:00	23:00(p)	II	Oc R	W
	01:04	23:04(p)	II	Ec D	W
	17:44	15:44	I	Oc D	E
	21:13	19:13	I	Ec R	

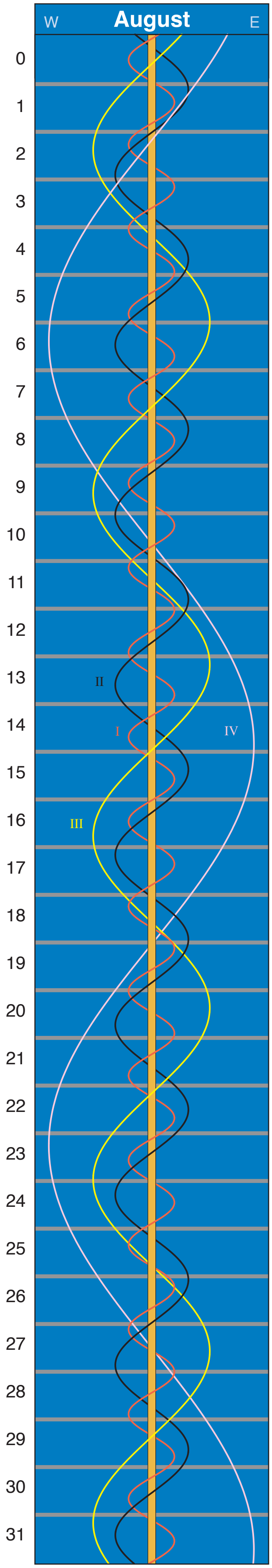


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
11	17:08	15:08	I	Tr E	E
	17:18	15:18	II	Tr I	E
	18:23	16:23	I	Sh E	E
	19:49	17:49	II	Tr E	
	19:57	17:57	II	Sh I	
	22:20	20:20	II	Sh E	
13	17:11	15:11	III	Oc D	E
	19:46	17:46	III	Oc R	
	22:31	20:31	III	Ec D	
14	00:41	22:41(p)	III	Ec R	W
16	01:11	23:11(p)	I	Oc D	W
	22:23	20:23	I	Tr I	
	23:38	21:38	I	Sh I	W
17	00:35	22:35(p)	I	Tr E	W
	01:07	23:07(p)	II	Oc D	W
	01:49	23:49(p)	I	Sh E	W
	19:40	17:40	I	Oc D	
	23:08	21:08	I	Ec R	
18	18:07	16:07	I	Sh I	E
	19:04	17:04	I	Tr E	E
	19:58	17:58	II	Tr I	
	20:18	18:18	I	Sh E	
	22:28	20:28	II	Tr E	
	22:34	20:34	II	Sh I	
19	00:57	22:57(p)	II	Sh E	W
	17:37	15:37	I	Ec R	E
20	19:18	17:18	II	Ec R	E
	21:17	19:17	III	Oc D	
	23:52	21:52	III	Oc R	W
24	00:19	22:19(p)	I	Tr I	W
	01:33	23:33(p)	I	Sh I	W
	18:25	16:25	III	Sh E	E
	21:37	19:37	I	Oc D	
25	01:03	23:03(p)	I	Ec R	W
	18:49	16:49	I	Tr I	E
	20:02	18:02	I	Sh I	
	21:01	19:01	I	Tr E	
	22:12	20:12	I	Sh E	
	22:39	20:39	II	Tr I	
26	01:10	23:10(p)	II	Tr E	W
	01:12	23:12(p)	II	Sh I	W
	19:32	17:32	I	Ec R	E
27	21:53	19:53	II	Ec R	
31	17:51	15:51	III	Tr E	E
	20:16	18:16	III	Sh I	
	22:23	20:23	III	Sh E	
	23:35	21:35	I	Oc D	W

August

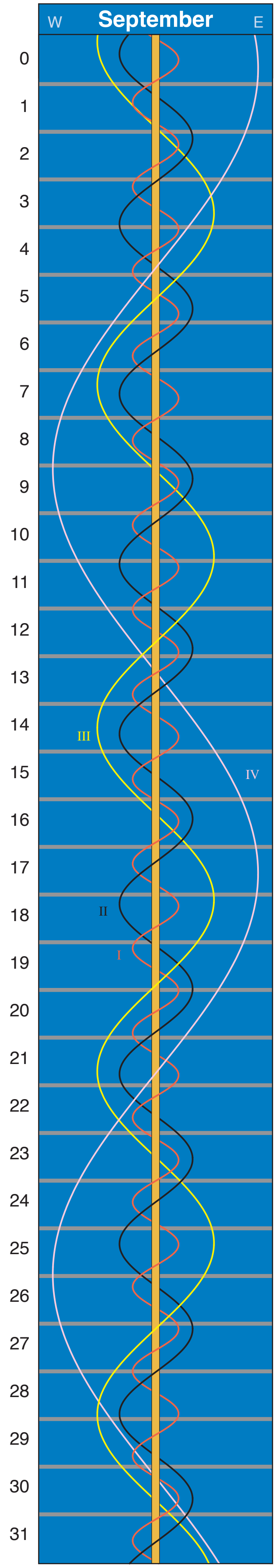
1	20:46	18:46	I	Tr I	
	21:56	19:56	I	Sh I	
	22:58	20:58	I	Tr E	W
2	00:07	22:07(p)	I	Sh E	W
	18:04	16:04	I	Oc D	E
	21:27	19:27	I	Ec R	
3	17:27	15:27	I	Tr E	E
	18:36	16:36	I	Sh E	E
	19:45	17:45	II	Oc D	
4	00:28	22:28(p)	II	Ec R	W
5	19:29	17:29	II	Sh E	E
7	19:29	17:29	III	Tr I	E
	22:02	20:02	III	Tr E	
8	00:15	22:15(p)	III	Sh I	W
	22:44	20:44	I	Tr I	W
	23:51	21:51	I	Sh I	W
9	20:03	18:03	I	Oc D	
	23:22	21:22	I	Ec R	W



Day	EST	WST	Sat	Event	Vis
10	18:20	16:20	I	Sh I	E
	19:25	17:25	I	Tr E	E
	20:30	18:30	I	Sh E	
	22:27	20:27	II	Oc D	W
11	17:51	15:51	I	Ec R	E
12	17:29	15:29	II	Tr I	E
	19:44	17:44	II	Sh I	E
	19:58	17:58	II	Tr E	
	22:06	20:06	II	Sh E	W
14	23:45	21:45	III	Tr I	W
16	22:02	20:02	I	Oc D	W
17	19:12	17:12	I	Tr I	E
	20:14	18:14	I	Sh I	
	21:24	19:24	I	Tr E	
	22:25	20:25	I	Sh E	W
18	18:29	16:29	III	Ec D	E
	19:46	17:46	I	Ec R	E
	20:35	18:35	III	Ec R	
19	20:14	18:14	II	Tr I	
	22:21	20:21	II	Sh I	W
	22:44	20:44	II	Tr E	W
21	18:55	16:55	II	Ec R	E
24	21:11	19:11	I	Tr I	
	22:09	20:09	I	Sh I	W
	23:23	21:23	I	Tr E	W
25	18:25	16:25	III	Oc D	E
	18:32	16:32	I	Oc D	E
	20:57	18:57	III	Oc R	
	21:40	19:40	I	Ec R	W
	22:28	20:28	III	Ec D	W
26	17:53	15:53	I	Tr E	E
	18:48	16:48	I	Sh E	E
	23:01	21:01	II	Tr I	W
28	21:30	19:30	II	Ec R	W
31	23:11	21:11	I	Tr I	W

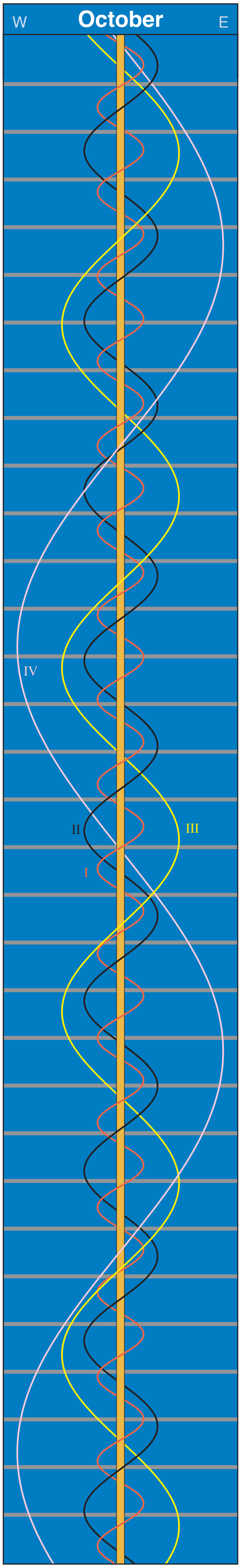
September

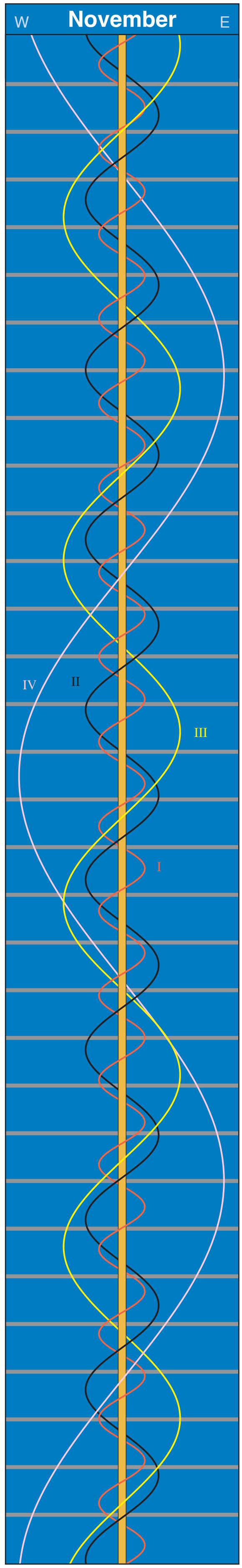
1	20:32	18:32	I	Oc D	
	22:46	20:46	III	Oc D	W
2	18:32	16:32	I	Sh I	E
	19:53	17:53	I	Tr E	E
	20:43	18:43	I	Sh E	
3	18:04	16:04	I	Ec R	E
4	20:03	18:03	II	Oc D	E
5	18:15	16:15	III	Sh E	E
6	19:12	17:12	II	Sh E	E
8	22:32	20:32	I	Oc D	W
9	19:41	17:41	I	Tr I	E
	20:27	18:27	I	Sh I	
	21:53	19:53	I	Tr E	W
	22:37	20:37	I	Sh E	W
10	19:58	17:58	I	Ec R	E
11	22:50	20:50	II	Oc D	W
12	19:34	17:34	III	Tr E	E
	20:11	18:11	III	Sh I	
	22:13	20:13	III	Sh E	W
13	18:00	16:00	II	Tr I	E
	19:27	17:27	II	Sh I	E
	20:27	18:27	II	Tr E	W
	21:47	19:47	II	Sh E	W
16	21:42	19:42	I	Tr I	W
	22:21	20:21	I	Sh I	W
17	19:03	17:03	I	Oc D	E
	21:53	19:53	I	Ec R	W
18	18:24	16:24	I	Tr E	E
	19:00	17:00	I	Sh E	E
19	21:32	19:32	III	Tr I	W

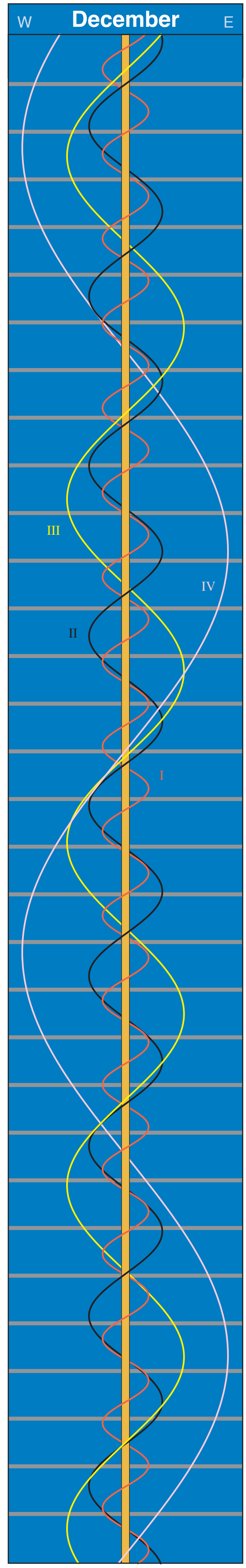


JUPITER MOON EVENTS

Day	EST	WST	Sat	Event	Vis
20	20:49	18:49	II	Tr I	W
	22:03	20:03	II	Sh I	W
22	18:33	16:33	II	Ec R	E
24	21:04	19:04	I	Oc D	W
25	18:13	16:13	I	Tr I	E
	18:44	16:44	I	Sh I	E
	20:25	18:25	I	Tr E	W
	20:55	18:55	I	Sh E	W
26	18:16	16:16	I	Ec R	E
29	21:08	19:08	II	Ec R	W
30	20:24	18:24	III	Ec R	W
October					
2	20:39	18:39	I	Sh I	W
November					
16	04:43	02:43	I	Sh E	E
23	04:26	02:26	I	Sh I	E
	06:37	04:37	I	Sh E	W
	07:04	05:04	I	Tr E	W
24	04:23	02:23	I	Oc R	E
27	04:05	02:05	III	Ec R	E
	04:12	02:12	III	Oc D	E
	06:13	04:13	III	Oc R	W
30	06:20	04:20	I	Sh I	W
	06:54	04:54	I	Tr I	W
December					
1	03:39	01:39	I	Ec D	E
	06:23	04:23	I	Oc R	W
2	03:35	01:35	I	Tr E	E
4	06:09	04:09	III	Ec D	W
8	03:41	01:41	II	Tr I	E
	04:38	02:38	II	Sh E	E
	05:32	03:32	I	Ec D	W
	05:58	03:58	II	Tr E	W
9	03:24	01:24	I	Tr I	E
	05:35	03:35	I	Tr E	W
10	02:52	00:52	I	Oc R	E
15	03:02	01:02	III	Tr I	E
	04:53	02:53	III	Tr E	W
	04:54	02:54	II	Sh I	W
	06:26	04:26	II	Tr I	W
16	04:36	02:36	I	Sh I	E
	05:24	03:24	I	Tr I	W
	06:47	04:47	I	Sh E	W
17	03:19	01:19	II	Oc R	E
	04:51	02:51	I	Oc R	W
22	03:51	01:51	III	Sh I	E
	05:41	03:41	III	Sh E	W
23	06:30	04:30	I	Sh I	W
24	03:46	01:46	I	Ec D	E
	06:06	04:06	II	Oc R	W
	06:49	04:49	I	Oc R	W
25	03:09	01:09	I	Sh E	E
	04:04	02:04	I	Tr E	E
31	04:35	02:35	II	Ec D	
	05:39	03:39	I	Ec D	W







JUPITER

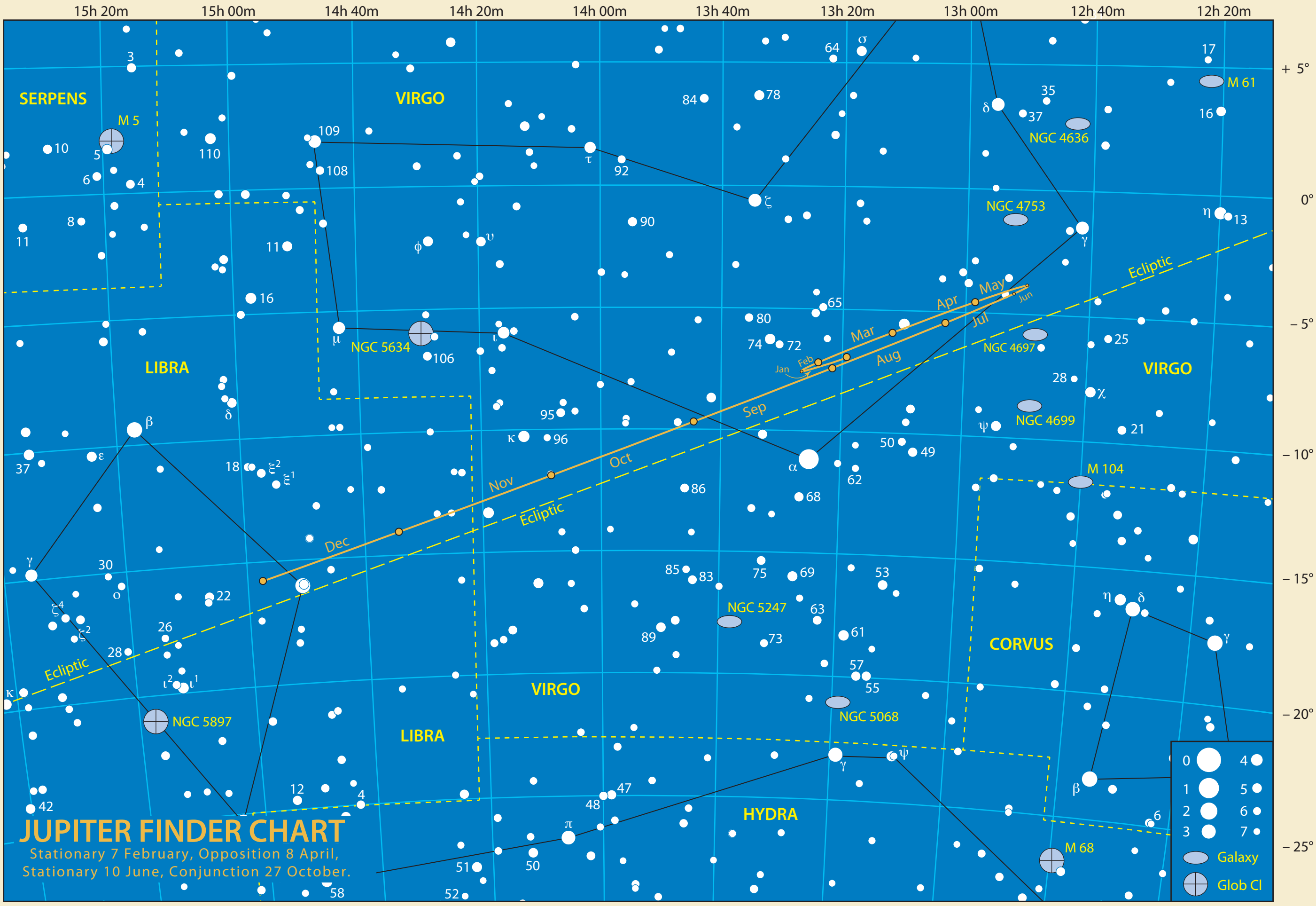
RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hrs UT Epoch 2000.0

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


JUPITER FINDER CHART
Stationary 7 February, Opposition 8 April,
Stationary 10 June, Conjunction 27 October.
15h 20m
15h 00m
14h 40m
14h 20m
14h 00m
13h 40m
13h 20m
13h 00m
12h 40m
12h 20m
+ 5°
0°
– 5°
– 10°
– 15°
– 20°
– 25°
SERPENS
VIRGO
LIBRA
CORVUS
HYDRA
M 5
M 61
M 104
M 68
NGC 4636
NGC 4753
NGC 4697
NGC 4699
NGC 5634
NGC 5247
NGC 5068
NGC 5897
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Galaxy
Glob Cl


SATURN
FINDER
CHART
Stationary 6 April,
Opposition 15 June,
Stationary 26 August,
Conjunction 22 December
18h 00m
17h 40m
17h 20m
–20°
–25°
SAGITTARIUS
OPHIUCHUS
NGC 6507
NGC 6356
M 9
M 23
NGC 6342
NGC 6440
NGC 6469
M 21
M 20
NGC 6546
M 8
NGC 6544
NGC 6553
NGC 6401
NGC 6325
NGC 6355
NGC 6293
Ecliptic
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Nebula
Open Cluster
Glob Cluster

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

SATELLITES OF SATURN

These pages help you find the position of Saturn's major satellites. Note that dates and times here are given in days and fractions 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 satellites configuration for 12 June 9 pm EST (see page 48).

Rhea and Dione

Table 1 presents the times of the first greatest elongation to the east for each month. This location is the day 0 (zero) point on the Apparent Orbits diagram (below). The procedure is to work out how many orbits have elapsed since the first elongation of the month, then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram below. You wish to determine the position of **Rhea** for the date above.

1. Convert to UT as a fractional day (table 3) = 12.458 UT.
2. Subtract the date of the greatest elongation east for Rhea for June, i.e., 12.458 – 3.379 = 9.079
3. Express this as the number of orbits by dividing by the period i.e., 9.079 / 4.518 = 2.01
4. Discard any complete orbits (2 in this case) leaves 0.01
5. Multiply by the period, 0.01 × 4.518 = 0.043 days or about 0 days 1 hr or 1 hour after elongation east.
6. Looking at the orbital path for Rhea (see Apparent Orbits diagram, below), the satellite is just below the 0d0h marker, almost due east of the planet.

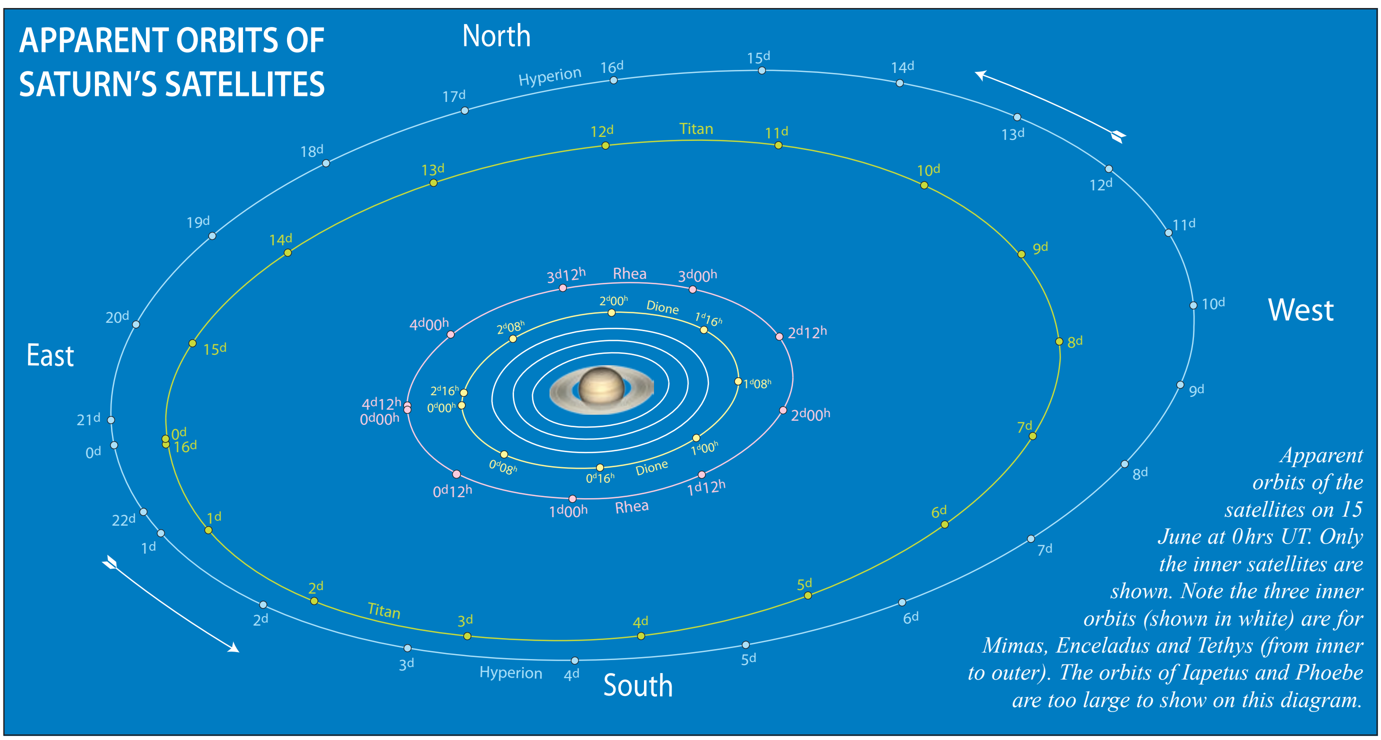
Table 1: **Saturn Satellites – Time of Greatest Elongation East** (dd.ddd UT)

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	1.425	1.542	2.600	1.967	5.263
February	1.538	2.067	1.821	1.096	1.404
March	1.813	1.479	2.146	3.221	5.058
April	1.917	1.996	1.354	2.329	1.171
May	1.129	2.133	1.554	2.429	2.783
June	1.221	1.271	2.633	1.521	3.379
July	1.371	1.408	2.829	1.608	4.967
August	1.467	1.917	2.025	3.438	1.054
September	1.567	1.063	1.229	2.542	1.675
October	1.729	1.217	1.442	2.658	3.317
November	1.838	1.742	2.554	1.788	3.975
December	1.067	1.904	2.779	1.925	1.121
Notes 1. When at opposition 2. Mean Synodic Period					

Mimas, Enceladus and Tethys

The procedure is similar to Rhea and Dione above with the times of the first greatest elongation east for each month also being listed in Table 1. However, these inner moons are so close to Saturn that while the orbits are represented on the diagram, it is difficult to put the day markers on and still have it readable. As above we calculate the fraction of the orbit and then estimate its position. Like the other major moons, these three still orbit in the same direction (anticlockwise), so three quarters of an orbit (0.75) would place it north of Saturn.

Estimate the position for **Enceladus** using the same date, June 12.458 UT; 8.166 orbits have elapsed since the first greatest elongation east for June on 1.271 UT. Discarding the 8 orbits leaves 0.166. This is about a sixth of its orbit, in the southeast quadrant.



Apparent orbits of the satellites on 15 June at 0hrs UT. Only the inner satellites are shown. Note the three inner orbits (shown in white) are for Mimas, Enceladus and Tethys (from inner to outer). The orbits of Iapetus and Phoebe are too large to show on this diagram.

Titan and Hyperion

Because of their long orbital periods, compared to the moons shown opposite, it is possible to list all of their greatest 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 12 June 9 pm EST (12.458 UT), Titan is fractionally past its most recent greatest elongation east (June 12.433 UT) which puts it due east of Saturn. The diagrams opposite and on page 48 show this very well.

Table 3
Converting Time in Australia to Universal Time (UT) *

EST	WST	Fraction of day (UT)
6 pm	4 pm	0.333
7 pm	5 pm	0.375
8 pm	6 pm	0.417
9 pm	7 pm	0.458
10 pm	8 pm	0.500
11 pm	9 pm	0.542
midnight	10 pm	0.583
1 am	11 pm	0.625
2 am	midnight	0.667
3 am	1 am	0.708
4 am	2 am	0.750
5 am	3 am	0.792
6 am	4 am	0.833
7 am	5 am	0.875
8 am	6 am	0.917

*After midnight it is still the previous day in UT, for example 1 am (EST) on the 21st = 20.625 days UT

Table 2
Time of Greatest Elongation East (UT)

Moon	Titan	Hyperion
Magnitude [1]	8.4	14.4
Max. Elong. [1]	3' 17"	3' 59"
Period (days) [2]	15.945	21.277
	Elongation (d.ddd)	
January	3.846	21.925
	19.875	
February	4.896	12.233
	20.904	
March	8.892	5.492
	24.863	26.688
April	9.813	16.921
	25.738	
May	11.650	8.088
	27.546	29.213
June	12.433	19.413
	28.317	
July	14.208	10.600
	30.113	31.804
August	15.038	22.142
	30.979	
September	15.946	12.508
October	1.929	3.904
	17.929	25.408
November	2.946	15.929
	18.975	
December	5.008	7.433
	21.050	28.988

Notes 1. When at opposition
2. Mean Synodic Period

Table 4: **Iapetus**

Magnitude [1]	11.0
Max Elong. [1]	9' 35"
Period (days) [2]	79.331

Elongation East		**Inferior Conjunction**		**Elongation West**		**Superior Conjunction**	
Jan	9.508	Jan	28.850	Feb	18.921	Mar	11.567
Mar	31.158	Apr	18.888	May	9.358	May	29.538
Jun	17.483	Jul	6.208	Jul	26.133	Aug	15.896
Sep	3.896	Sep	23.317	Oct	13.708	Nov	4.075
Nov	23.625	Dec	13.263				

Notes 1. When at opposition
2. Mean Synodic Period

Iapetus

This moon's orbit is too large to place on the Apparent Orbits diagram. The shape of its orbit is similar to the others but more inclined and over twice the diameter of Hyperion's. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from stars of similar brightness. Table 4 shows this moon's greatest elongations east, inferior conjunctions (due south of Saturn), greatest elongations west and superior conjunctions (north of Saturn) for the year. Taking the same example date and time as above 12 June 9 pm EST (12.458 UT). The most recent event was a superior conjunction on May 29.538 UT. Iapetus is 13.92 days past this time, heading towards an eastern elongation, so it's in the northwest quadrant.

SATURN'S RINGS

Date	Major "	Minor "	U °	B °
Jan 3	34.42	15.50	131.40	26.77
Jan 11	34.60	15.57	132.39	26.75
Jan 19	34.82	15.66	133.34	26.73
Jan 27	35.10	15.77	134.23	26.70
Feb 4	35.42	15.89	135.06	26.66
Feb 12	35.78	16.04	135.81	26.62
Feb 20	36.19	16.19	136.48	26.58
Feb 28	36.63	16.37	137.06	26.54
Mar 8	37.09	16.56	137.53	26.51
Mar 16	37.58	16.76	137.90	26.48
Mar 24	38.09	16.97	138.15	26.45
Apr 1	38.60	17.19	138.28	26.44
Apr 9	39.11	17.41	138.30	26.43
Apr 17	39.61	17.63	138.20	26.42
Apr 25	40.08	17.84	137.98	26.43
May 3	40.51	18.04	137.66	26.45
May 11	40.89	18.22	137.25	26.47
May 19	41.20	18.38	136.75	26.50
May 27	41.45	18.51	136.18	26.53
Jun 4	41.62	18.61	135.56	26.56
Jun 12	41.70	18.67	134.91	26.60
Jun 20	41.70	18.69	134.25	26.63
Jun 28	41.61	18.67	133.60	26.67
Jul 6	41.43	18.62	132.99	26.70
Jul 14	41.18	18.52	132.43	26.73
Jul 22	40.85	18.40	131.93	26.76
Jul 30	40.47	18.24	131.52	26.79
Aug 7	40.04	18.06	131.21	26.82
Aug 15	39.57	17.87	131.00	26.85
Aug 23	39.08	17.66	130.91	26.87
Aug 31	38.57	17.45	130.93	26.90
Sep 8	38.06	17.23	131.07	26.92
Sep 16	37.56	17.02	131.32	26.94
Sep 24	37.07	16.81	131.69	26.96
Oct 2	36.60	16.60	132.16	26.97
Oct 10	36.17	16.41	132.73	26.98
Oct 18	35.77	16.23	133.39	26.98
Oct 26	35.40	16.06	134.13	26.98
Nov 3	35.08	15.91	134.96	26.97
Nov 11	34.80	15.77	135.84	26.94
Nov 19	34.57	15.64	136.78	26.91
Nov 27	34.39	15.54	137.77	26.87
Dec 5	34.25	15.45	138.78	26.81
Dec 13	34.17	15.38	139.82	26.75
Dec 21	34.14	15.32	140.87	26.67
Dec 29	34.16	15.29	141.92	26.59

The Appearance of the Planets diagrams in Part I show how open the rings are for 2017. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every seven years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were last edge-on during 2009. During 2017 they are almost fully open, spending the year at almost 27°.

Major and minor axes (in arcseconds) are for the outer edge of the outer ring. To work out the size of the other rings, multiply by the following factors.

Inner edge of outer ring	0.8932
Outer edge of inner ring	0.8596
Inner edge of inner ring	0.6726
Inner edge of dusky ring	0.5477

U and B are the geocentric longitude and the tilt of the rings respectively.

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

SATELLITES OF URANUS AND NEPTUNE

This page helps you find the position of Uranus's major satellites and Neptune's moon Triton. Dates and times are in days and fractions of a day in UT. You need to convert your local time to UT first. Table 1 will help.

URANUS

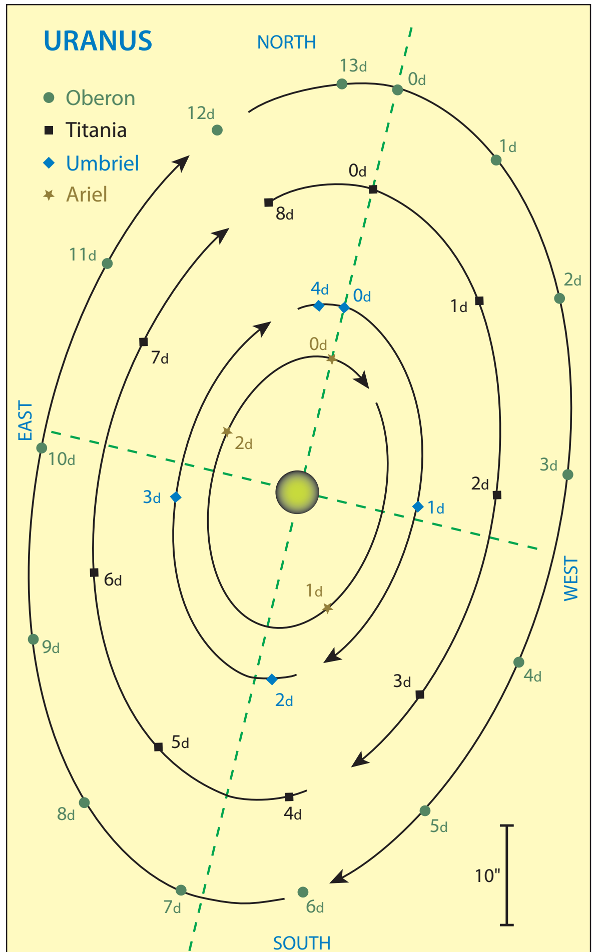
Table 2 presents the times of the first greatest elongation to the *north* for each month for **Ariel**, **Umbriel**, **Titania and Oberon**. This location is the day 0 (zero) point on the Apparent Orbits diagram. As with Saturn's satellites, the procedure is to work out how many orbits have elapsed since the first elongation of the month. Then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of **Umbriel** for 26 October at 1 am WST.

Table 1: **Converting Time in Australia to Universal Time (UT) ***

EST	WST	Fraction of day (UT)
6 pm	4 pm	0.333
7 pm	5 pm	0.375
8 pm	6 pm	0.417
9 pm	7 pm	0.458
10 pm	8 pm	0.500
11 pm	9 pm	0.542
midnight	10 pm	0.583
1 am	11 pm	0.625
2 am	midnight	0.667
3 am	1 am	0.708
4 am	2 am	0.750
5 am	3 am	0.792
6 am	4 am	0.833
7 am	5 am	0.875
8 am	6 am	0.917

* After midnight it is still the previous day in UT, e.g., 1 am (EST) on the 21st = 20.625 days UT

1. Convert to UT as a fractional day. 26 October at 1 am (WST) = 25.708 UT
2. Subtract the date of the greatest elongation north for October, i.e. 25.708 – 2.383 = 23.325 days
3. Divide by the period to get the number of orbits, i.e. 23.325 / 4.144 = 5.629
4. Discarding whole orbits leaves 0.629 (a little over half way around its orbit)
5. Multiply by the period, 0.629 × 4.144 = 2.607 days (2 days 14.6 hours)
6. Looking at the orbital path for Umbriel (see Apparent Orbits diagram), the satellite is just over half way between the 2-day and 3-day marks, placing it in the southeast quadrant.

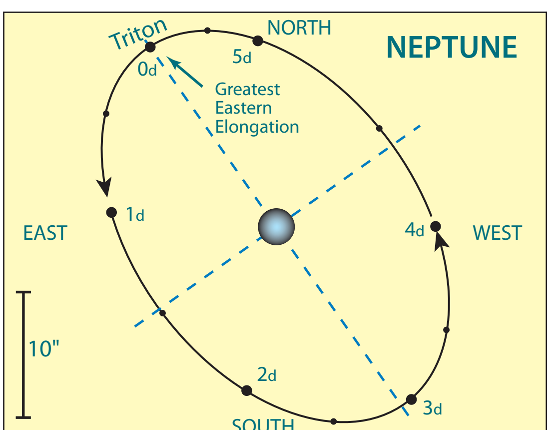


Apparent orbits of Uranus's satellites I–IV as at the date of opposition, 19 October.

NEPTUNE

The procedure for finding Neptune's major satellite **Triton** is identical to above, except the times of the first greatest elongation *east* for each month is listed in Table 2. The orientation of Triton's orbit places this day 0 (zero) point closer to northeast of Neptune (see diagram).

An example. Estimate the position for Triton for September 19 at 10 pm EST. 2.911 orbits have elapsed since its greatest elongation east on Sep 2.392 UT. Discarding the two orbits leaves 0.911. Multiplying by 5.877 (its period) gives 5.354 days. From the diagram the moon is northeast of Neptune approaching the next greatest elongation east.



Apparent orbit of Triton at date of opposition, 5 September.

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

Planet	Uranus				Neptune
Moon	**Ariel**	**Umbriel**	**Titania**	**Oberon**	**Triton**
Magnitude [1]	13.7	14.5	13.5	13.7	13.5
Max Elong. [1]	0' 14"	0' 20"	0' 33"	0' 44"	0' 17"
Period (days) [2]	2.520	4.144	8.706	13.463	5.877
Month	**Elongation North (d.ddd)**				**East** (d.ddd)
January	1.042	1.883	2.983	1.829	4.504
February	2.808	4.038	6.796	11.217	2.875
March	2.533	5.050	4.925	10.138	4.242
April	1.779	3.054	8.742	6.058	2.604
May	2.021	2.063	4.850	2.975	1.971
June	1.258	4.208	8.671	12.350	6.221
July	1.500	3.213	4.779	9.267	5.604
August	3.263	1.221	8.596	5.192	3.996
September	2.504	3.371	3.713	1.117	2.392
October	2.750	2.383	8.542	11.513	1.792
November	1.996	4.538	3.663	7.442	6.067
December	2.242	3.550	8.492	4.375	5.454

Notes 1. When at opposition 2. Sidereal Period

NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0 hr UT Epoch 2000.0

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

PLUTO

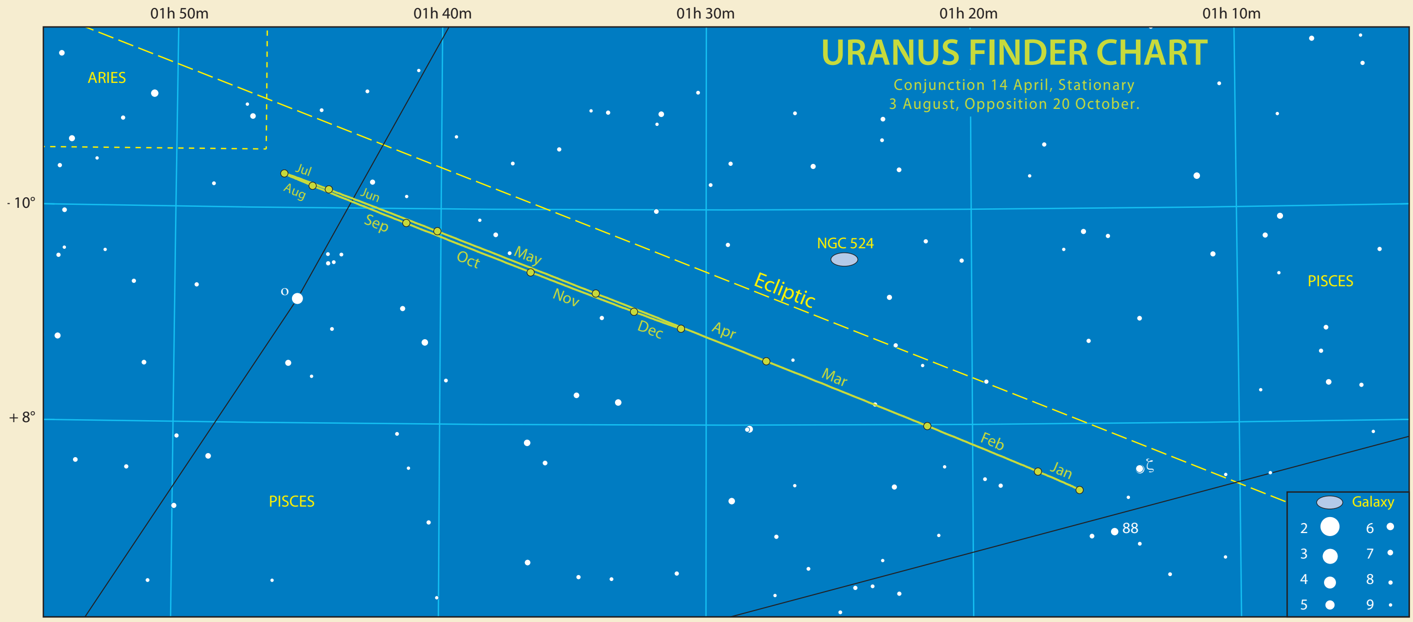
RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

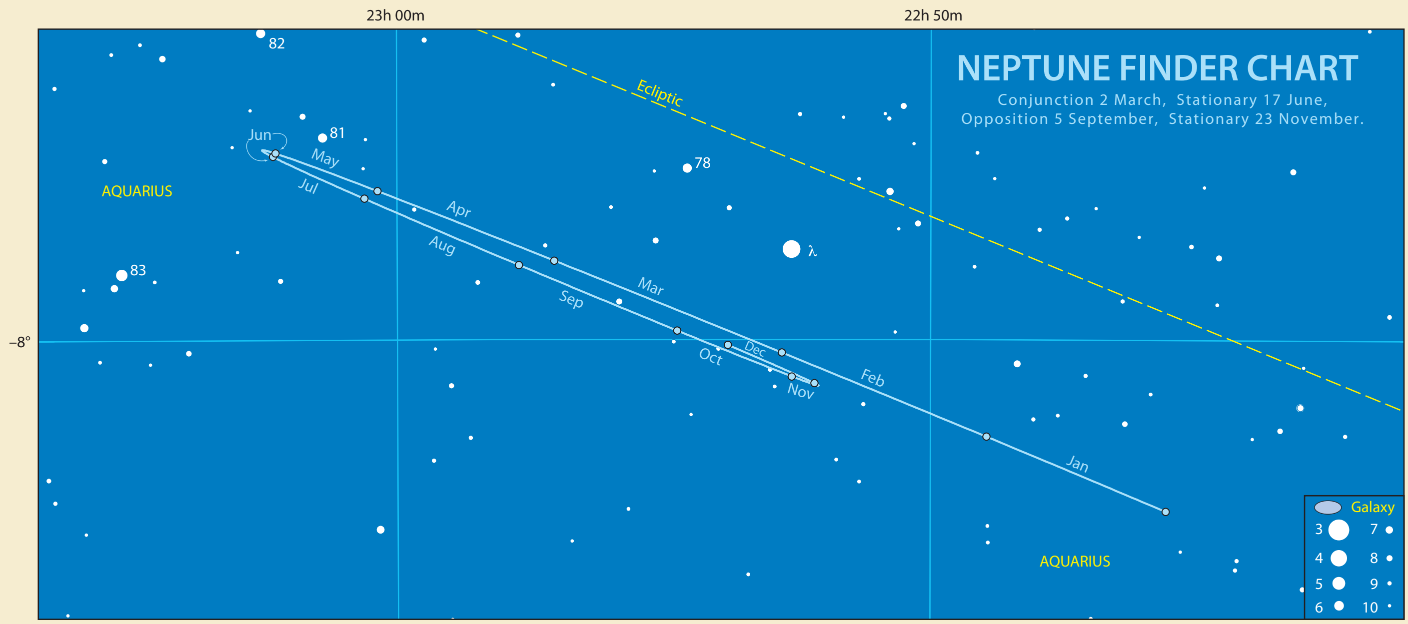
POSITION

0 hr UT Epoch 2000.0

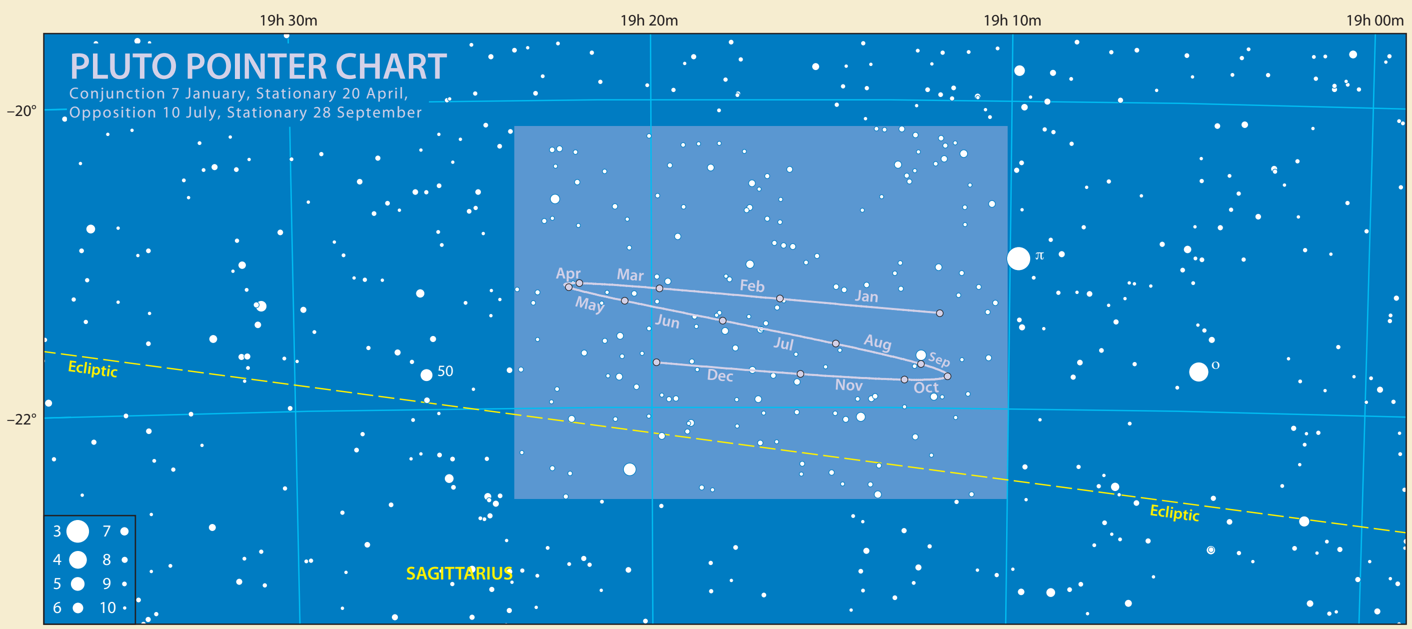
		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		RA	Dec
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h m s	° ' "
Jan	7	05:17	19:27	05:06	18:43	05:04	19:16	06:32	19:15	04:50	19:45	05:14	19:39	05:24	19:21	04:59	19:04	19 12 50	– 21 22 05
	14	04:50	19:01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



URANUS FINDER CHART
Conjunction 14 April, Stationary
3 August, Opposition 20 October.
01h 50m
01h 40m
01h 30m
01h 20m
01h 10m
10°
+ 8°
ARIES
PISCES
PISCES
NGC 524
Ecliptic
Jul
Aug
Jun
Sep
May
Oct
Nov
Dec
Apr
Mar
Feb
Jan
ο
ζ
88
Galaxy
2
3
4
5
6
7
8
9

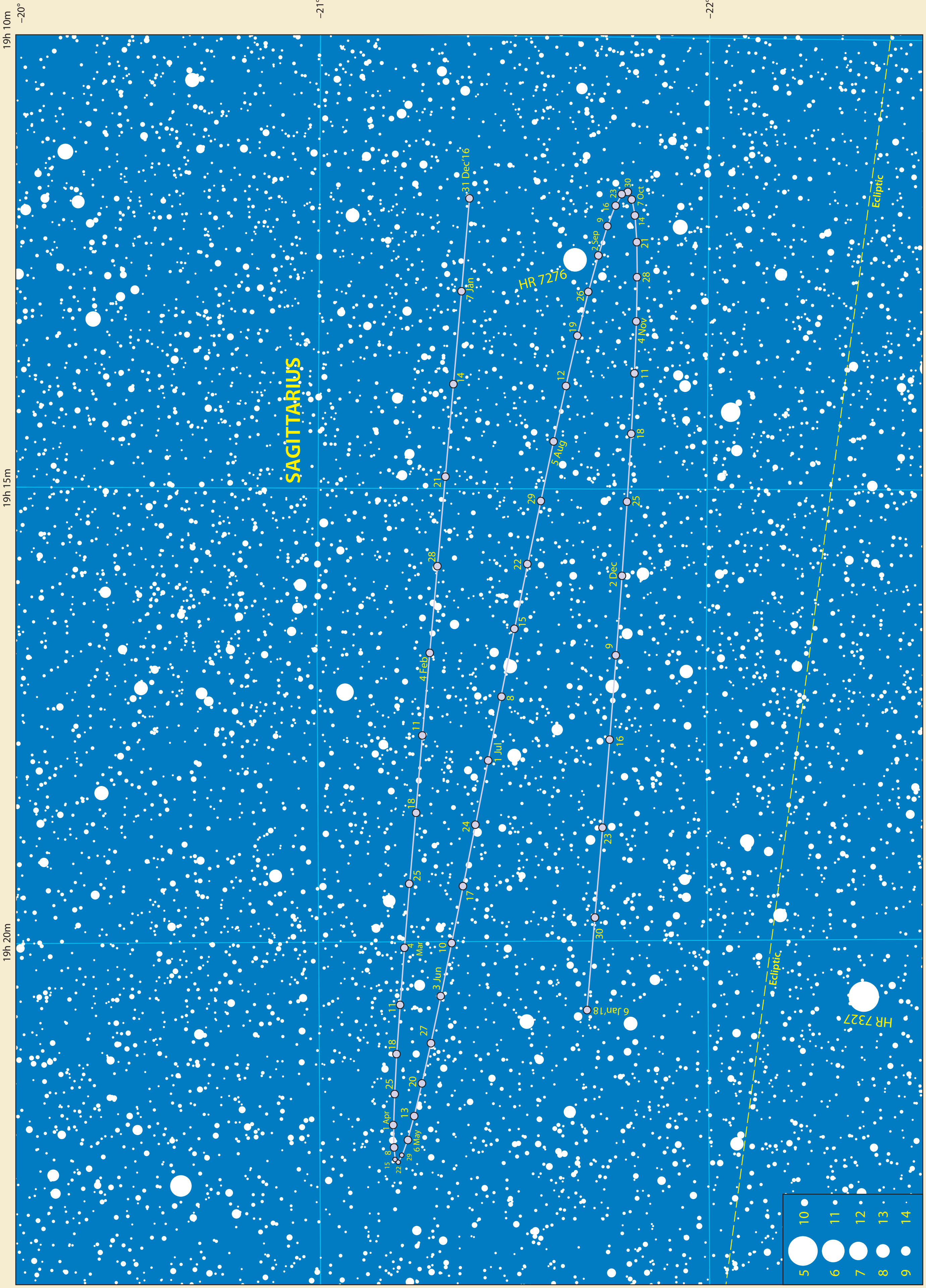


NEPTUNE FINDER CHART
Conjunction 2 March, Stationary 17 June,
Opposition 5 September, Stationary 23 November.
23h 00m
22h 50m
–8°
AQUARIUS
AQUARIUS
Ecliptic
82
81
78
83
λ
Jun
May
Jul
Apr
Aug
Mar
Sep
Dec
Oct
Nov
Feb
Jan
Galaxy
3
4
5
6
7
8
9
10



PLUTO POINTER CHART
Conjunction 7 January, Stationary 20 April,
Opposition 10 July, Stationary 28 September
19h 30m
19h 20m
19h 10m
19h 00m
–20°
–22°
Ecliptic
Ecliptic
SAGITTARIUS
50
π
ο
Apr
Mar
Feb
Jan
May
Jun
Jul
Aug
Sep
Dec
Nov
Oct
3
4
5
6
7
8
9
10

PLUTO



19h 10m
19h 15m
19h 20m
−20°
−21°
−22°
SAGITTARIUS
HR 7276
HR 7327
Ecliptic
31 Dec'16
7 Jan
14
21
28
4 Feb
11
18
25
4 Mar
11
18
25
1 Apr
8
15
22
29
6 May
13
20
27
3 Jun
10
17
24
1 Jul
8
15
22
29
5 Aug
12
19
26
2 Sep
9
16
23
30
7 Oct
14
21
28
4 Nov
11
18
25
2 Dec
9
16
23
30
6 Jan'18
5
6
7
8
9
10
11
12
13
14

PLUTO

COMETS FOR 2017

WHAT IS A COMET? It is a member of the Solar System, which is normally in a highly elongated orbit around the Sun. The orbits of periodic, or regularly reappearing comets, are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive and containing significant quantities of water (in the form of ice) and dust. A common analogy is a *dirty snowball* (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, 2P/Encke, which returns in 2017, takes just over three years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of comets that have not been recorded before.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a *coma* around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionised particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of dust grains that trail behind the comet along its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails. In fact some may only show the coma.

Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' means the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 24P/Schaumasse indicates Schaumasse was the 24th 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. Comet Johnson is referred to as 'C/2015 V2'. 2015 refers to the year of the discovery, V is the 21st half-month period ('I' is not used) during the year and 2 shows it was the second discovery in this half month. Therefore C/2015 V2 (Johnson) was the second comet discovered in the first half of November 2015.

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 2017, most of them passing through perihelion—closest approach to the Sun—during this year. The table on page 132 lists the comets along with their orbital elements that are expected to brighten to at least 13th magnitude sometime during 2017. This is the data required to calculate their locations in the sky. The elements are followed by *ephemerides* (a list of expected positions in the sky and magnitude estimates for different dates). These positions can be plotted on the All Sky Maps to get an idea of where they are in the sky. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could be too close to the Sun or on the opposite side of the Sun from Earth. This would be considered unfavourable.

There are many other comets not listed here that are expected in 2017, but they are extremely faint and would require large telescopes or long exposure images to detect them, but who knows what could be discovered tonight?

NOTES ON SELECTED COMETS FOR 2017

Greg Bryant

2P/Encke: One of the most well known comets to astronomers is Encke. This visitor enters our neighbourhood every 3.3 years, making it the shortest period of any known comet. In January 1786, the famous French comet hunter Pierre Mechain first sighted the comet. He notified fellow comet hunter Charles Messier of its discovery and both astronomers observed the comet two nights later. However, the comet was not sighted again during that apparition. Nearly ten years were to pass before the comet was seen again. English astronomer Caroline Herschel came across it in November 1795. Her brother, William Herschel, noted that it was visible to the naked eye. Yet another ten years were to pass before the comet was *discovered* again. This time, the comet was seen in October 1805 by European astronomers Jeans Pons, Johann Huth, and Alexis Bouvard. Huth estimated it to be 5th magnitude with a tail three degrees in length. At this time German astronomer Johann Encke entered the picture. Encke studied the positions that had been reported, and suggested (incorrectly) that they fitted an elliptical orbit with a period of 12.1 years.

It wasn't until 1818 that the comet was sighted again. Pons found it had brightened to display a similar appearance to its 1786 apparition. The comet remained observable for nearly seven weeks, enabling a good set of positions to be determined. Olbers was the first to suggest that this comet was the same as those observed in 1786, 1795, and 1805. However, it was Encke who proved mathematically that it was the same comet returning, with a period of 3.3 years. Encke then proceeded to predict the next return of the comet, with a perihelion date of 24 May, 1822. On 2 June, 1822, Carl Rumker recovered the comet whilst observing at the observatory of Sir Thomas Brisbane in Parramatta, New South Wales. This was only the second comet whose return had been successfully predicted, the first being Halley.

24P/Schaumasse: The French astronomer Alexandre Schaumasse discovered this comet on 1 December 1911 when it was 12th magnitude. By January 1912 it was recognised as being short-period in nature and was recovered in 1919. The comet was then seen again in 1927, missed in 1935, and then recovered in 1944. At its following return, Schaumasse was brighter than 7th magnitude for two months in early 1952, during which time it passed within 0.3 au of Earth. Although the comet was sighted in 1960, it was not seen during the course of its subsequent two returns (though it was belatedly found many years later on a 1976 exposure).

45P/Honda-Mrkos-Pajdusakova: Famed Japanese comet hunter Minora Honda discovered this comet just before dawn on 3 December, 1948. At the time, he reported it as 9th magnitude in brightness. Three days later, Ludmilla Pajdusakova (Skalnate Pleso Observatory) independently found HMP. However, twilight intervened and she could not confirm it until the following day. By this time, her colleague Antonin Mrkos had independently found the comet. It was soon recognised to be periodic, and that a close approach to Jupiter in 1935 had placed it in the current orbit. Its return in 1974/75 was very favourable. After reaching perihelion on 28 December, 1974, and shining slightly better than 8th magnitude for a few days, it passed Earth on 5 February 1975 at a distance of only 0.23 au and came within one degree of the South Celestial Pole.

A better appearance was at its return in 1995/96. Reaching perihelion on Christmas Day of 1995, Honda-Mrkos-Pajdusakova brightened to nearly 6th magnitude at the time before being lost in the Sun's glare. Emerging in January 1996, the comet approached Earth to about 0.17 au in early February. Queensland amateur Terry Lovejoy reported the comet to be 7th magnitude using 15 × 80 binoculars, two magnitudes brighter than predicted, with a coma diameter of 30 arcminutes. In 2011, HMP passed Earth at a distance of 0.06 au, its closest approach on record, and in the foreseeable future. The current return sees Honda-Mrkos-Pajdusakova reach perihelion on New Year's Eve, 2016, and in early 2017, the comet will pass Earth at a distance of only 0.08 au.

Comet 41P/Tuttle-Giacobini-Kresak: The American comet hunter Horace Tuttle discovered this on 3 May 1858. Tenth magnitude at the time of discovery, the comet was only observed for one month. Astronomers still calculated that it was periodic, although estimates of the comet's period ranged from 5.8 to 7.5 years. On 1 June 1907, Michel Giacobini was searching for comets and came across one at 13th magnitude, which was subsequently followed for only two weeks. A parabolic orbit was assumed for the comet, but in 1914, it was suggested that it might be related to Tuttle's comet of 1858, and Crommelin mathematically linked the two in 1928. He predicted that the comet would next return in November 1928, but no searches were conducted. Crommelin revisited the enigma of Tuttle-Giacobini in 1933 and found that perihelion was next expected to occur in March 1934, but searches by George van Biesbroeck at Yerkes Observatory revealed nothing, and the comet was assumed to be lost.

On 24 April 1951, Lubor Kresak discovered a 10th magnitude comet with 25 × 100 binoculars. It was well placed for observation and not only found to be of short period, was soon identified as a recovery of the lost Tuttle-Giacobini. Kresak's name was added to the comet.

In 1973, TGK surprised everyone. On May 20, ten days before perihelion, it was estimated at 13th magnitude. Six days later, S. Ako of Japan photographed an *unknown* comet of 8th magnitude, and the following day another Japanese astronomer independently detected it at 5th magnitude. The comet was actually Tuttle-Giacobini-Kresak undergoing a major outburst, and a photo later that day saw it at around 4th magnitude. TGK's outburst declined after a few days, but in the first week of July, it jumped again from 14th to 5th magnitude. Since then, the comet has been relatively well-behaved, although in August 1995, it did undergo a small outburst in brightness to 9th magnitude.

This year, the comet will pass just 0.14 au from Earth, the closest approach it has experienced since it was discovered, and is predicted to reach 6th magnitude—let's hope there's another huge outburst!

Comet 62P/Tsuchinshan 1 was discovered on a photograph taken on New Year's Day 1965 at the Purple Mountain Observatory in Nanking, China. It was several weeks before the comet was announced and within a few months it was determined to have a short period. A close approach within 0.15 au of Jupiter in 1960 brought the comet's perihelion distance from 2.1 au down to 1.5 au.

Comet 71P/Clark: During the course of a variable star photographic patrol at Mount John University Observatory in New Zealand, Michael Clark discovered this comet on 9 June 1973. At 13th magnitude it was confirmed as a short-period comet, returning to perihelion every 5.5 years. The orbit is such that its apparitions oscillate between favourable and unfavourable returns. Further returns will see the perihelion distance move further out, and by the mid-21st century, it will not pass any closer to the Sun than just under 2 au.

Comet 73P/Schwassmann-Wachmann 3: Arnold Schwassmann and Arno Arthur Wachmann, of Hamburg Observatory in Germany, discovered this on photographic plates taken on 2 May 1930, during the course of a minor planet survey. By the end of May it brightened to 6th magnitude as it passed just 0.06 au from Earth. It was followed for over three months and was recognised to be of short period, but uncertainties in its orbit meant that the comet became lost afterwards. In 1979, astronomers at Perth Observatory discovered a comet, which was soon recognised to be the return of SW3. It had been predicted that the 1979 return of this comet would be the most favourable since its discovery in 1930.

Being a relatively faint comet little was expected for its 1995 return, and an observation in August of that year showed it to be on track at 13th magnitude. In September, however, observations made at radio wavelengths revealed that there was an outburst occurring. This was soon backed up by visual observations, which saw the comet as bright as 8th magnitude. In early October 1995, many observers, including this writer, saw it brighter than 6th magnitude, with a dust tail in excess of one degree in length. Many amateurs, not expecting such a bright comet in the western evening sky, reported independent discoveries of a 'new' comet. At this time, it was nearly seven magnitudes brighter than predicted, and observations made at the European Southern Observatory in Chile revealed that the comet had split into several pieces. At the return in 2001, two of the fragments were still many magnitudes brighter than normal (a third appeared to dissipate during the apparition). At the two returns since, however, the comet has been significantly fainter.

96P/Machholz 1: American amateur Donald Machholz was one of the leading comet discoverers of the 1980s and 1990s, discovering nine in total—two of which were short-period in nature. More recently, comet C/2004 Q2 (Machholz) became visible to the naked eye in late 2004 and early 2005.

96P/Machholz 1, his first periodic comet find, was discovered on 12 May 1986. A parabolic orbit was calculated from observations over the first few days. The following month, astronomers were surprised to realise that it was in fact short period in nature, orbiting the Sun every 5.2 years. Studies of the orbit showed that it had been relatively stable for many centuries, so the most likely conclusion was the comet, after having been dormant and thus undetectable for some time, had just become active. Modelling also showed that the perihelion distance 1,300 years ago was 0.9 au. Today it is 0.12 au, and by 2450 it will get as close as 0.03 au to the Sun. Should Machholz 1 survive those increasingly close passages to the Sun, the perihelion distance will begin to move out again.

Another surprise came when observed in 1988 and 1989, around the time of aphelion when it was 5.9 au from the Sun. The images of the stellar nucleus were brighter than expected, leading some to believe that the comet was still showing some activity. The observing window for Machholz 1 is very short at each return.

C/2015 ER$_{61}$ (PANSTARRS): The Panoramic Survey Telescope And Rapid Response System (PANSTARRS) in Hawaii has discovered 131 comets as at the time of writing. This particular PANSTARRS was discovered on 15 March, 2015 when it was 8.4 au from the Sun.

C/2015 V2 (Johnson) was discovered by Jess Johnson on 3 November 2015 during the course of the Catalina Sky survey. At the time of writing, the survey has discovered 135 comets.

Greg Bryant is Sky & Telescope magazine's Southern Hemisphere contributing editor and can be reached at gchbryant@fastmail.fm. He has been following comets since the mid-1980s and enjoys noting each year's new comet discoveries.

BRIGHT COMETS FOR 2017 – ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q au	e	Period years	ω °	Ω °	i °	H1	K1
45P/Honda-Mrkos-Pajdusakova	2016 12 31.1582	0.532055	0.824035	5.3	326.2895	89.0043	4.2509	12.0	15.0
2P/Encke	2017 03 10.0861	0.335898	0.848345	3.3	186.5569	334.5644	11.7793		
C/2015 ER$_{61}$ (PANSTARRS)	2017 05 09.94920	1.042117	0.997292		68.1983	235.2173	6.3491	8.0	7.5
73P/Schwassmann-Wachmann 3	2017 03 16.8172	0.971880	0.685629	5.4	199.3878	69.6791	11.2368	11.2	6.5
41P/Tuttle-Giacobini-Kresak	2017 04 13.9594	1.045157	0.661152	5.4	62.1373	141.0765	9.2293	9.0	25.0
C/2015 V2 (Johnson)	2017 06 12.3790	1.636967	1.001544		164.9003	69.8563	49.8756	5.0	10.0
71P/Clark	2017 06 30.0079	1.585276	0.494711	5.6	208.9264	59.4726	9.4437	8.0	10.0
96P/Machholz 1	2017 10 27.8955	0.123759	0.959216	5.3	14.7739	94.3033	58.2414	12.7	12.0
24P/Schaumasse	2017 11 16.6088	1.206239	0.704850	8.3	57.9824	79.6799	11.7336	6.0	45.0
62P/Tsuchinshan 1	2017 11 15.8980	1.382933	0.597880	6.4	30.3056	90.2824	9.7106	6.5	30.0

COMET ELEMENTS (above)

Perihelion Date The Date of closest approach to the Sun.

q The perihelion distance in au (astronomical units).

e The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to or greater than one indicates: an open orbit (a once only visitor to the Solar System), it has a very long period (thousands of years) or it is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period (time taken for one orbit of the Sun) in years.

ω Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).

Ω Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (Ecliptic) as the comet moves north.

i Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. A value greater than 90° means the comet's orbit direction is retrograde (moves in the opposite direction to the planets).

H1 The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it were 1 au from the Sun and the Earth.

K1 A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' opposite for further details).

Calculation of ephemerides from these elements is complex (but not difficult, with the power of home computers) but beyond the scope of this book.

Comet 41P/Tuttle-Giacobini-Kresak

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
21 Jan	09 20.0	+09 04	0.533	1.497	19:34	01:15	06:53	160.4	12.0
28 Jan	09 20.5	+10 30	0.461	1.439	19:11	00:48	06:21	167.8	11.3
04 Feb	09 20.1	+12 36	0.397	1.382	18:49	00:20	05:48	175.6	10.5
11 Feb	09 19.4	+15 34	0.341	1.327	18:29	23:49	05:11	175.2	9.7
18 Feb	09 19.0	+19 31	0.293	1.275	18:13	23:21	04:31	166.3	9.0
25 Feb	09 19.8	+24 38	0.253	1.226	18:03	22:54	03:48	156.8	8.2
04 Mar	09 23.7	+31 01	0.219	1.182	18:02	22:31	03:02	146.9	7.5
11 Mar	09 33.3	+38 43	0.193	1.142	18:18	22:13	02:09	136.9	6.9
18 Mar	09 53.5	+47 35	0.172	1.107	19:08	22:05	01:05	127.0	6.3
Too far north to observe from Australia.									
22 Apr	17 05.3	+55 47	0.164	1.051	02:01	03:01	04:01	101.8	5.6
29 Apr	17 40.3	+47 33	0.178	1.065	00:12	03:09	06:05	104.3	5.9
06 May	17 59.2	+39 51	0.195	1.087	23:09	03:00	06:47	108.8	6.4
13 May	18 09.4	+32 52	0.215	1.117	22:18	02:43	07:02	114.6	6.9
20 May	18 14.0	+26 31	0.236	1.153	21:32	02:20	07:04	121.4	7.4
27 May	18 15.0	+20 38	0.261	1.194	20:46	01:54	06:57	128.9	8.0
03 Jun	18 13.7	+15 09	0.289	1.241	20:00	01:25	06:44	136.6	8.6
10 Jun	18 11.0	+10 03	0.323	1.290	19:16	00:54	06:28	144.0	9.3
17 Jun	18 08.0	+05 22	0.362	1.343	18:32	00:24	06:11	150.5	10.0
24 Jun	18 05.1	+01 08	0.409	1.399	17:51	23:50	05:52	155.4	10.7
01 Jul	18 02.9	−02 38	0.463	1.456	17:11	23:21	05:33	157.7	11.4
08 Jul	18 01.9	−05 55	0.526	1.514	16:33	22:52	05:13	156.9	12.1

COMET EPHEMERIDES

Date at 0 hr UT (10 am EST, 9:30 am CST and 8 am WST).

RA, Dec Right Ascension and Declination are for equinox 2000.0

Δ (delta) Geocentric distance (distance from the Earth) in au.

R Heliocentric distance (distance from the Sun) in au.

Rise, Transit, Set Times given are approximate and will vary between locations. Where no rise or set time is given, the comet is circumpolar.

Elg Elongation; angular distance of the comet from the Sun.

Mag This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is usually based on the behaviour of its brightness during previous return(s).

The estimate of total magnitude is normally calculated using:

$$\text{Mag} = H1 + 5 \log(\Delta) + K1 \log R$$

Comet Encke behaves a little differently, its magnitude estimate has been calculated using the following:

$$\text{Mag} = 9.8 + 5 \log(\Delta) + 2.5\,(R^{1.8} - 1)$$

See the table of elements opposite for the values of H1 and K1. For many comets the K1 value is equal to 10. For newly discovered comets the value of K1 is mostly assumed to be equal to 10 until its light curve can be studied in detail. The brightness of a comet is often very uncertain, especially for those newly discovered. In fact, it is now believed that comets making their first visit to the Sun have an average K1 value of approximately 7.5. Comets have also been known to suddenly flare up or fade away and some have even shown a different behaviour in their light curve (changed values for H1 and K1) after perihelion compared to before. There are also constants of H2 and K2 used by astronomers which refer to the absolute magnitude and the K constant for the nucleus of the comet. These are not used in this publication.

Comet C/2015 V2 (Johnson)

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
07 Jan	14 45.7	+44 03	2.392	2.587	04:12	07:35	10:57	90.1	11.0
14 Jan	15 00.2	+44 07	2.293	2.523	03:59	07:22	10:44	91.8	10.8
21 Jan	15 14.1	+44 16	2.197	2.460	03:47	07:08	10:29	93.4	10.6
28 Jan	15 27.5	+44 28	2.103	2.397	03:34	06:54	10:13	94.9	10.4
04 Feb	15 40.2	+44 44	2.013	2.336	03:21	06:39	09:57	96.3	10.2
11 Feb	15 51.9	+45 04	1.924	2.275	03:07	06:23	09:39	97.6	10.0
18 Feb	16 02.6	+45 27	1.837	2.216	02:53	06:06	09:19	98.8	9.8
25 Feb	16 12.0	+45 52	1.752	2.158	02:38	05:48	08:58	100.1	9.6
04 Mar	16 19.9	+46 18	1.668	2.102	02:22	05:29	08:35	101.4	9.3
11 Mar	16 26.1	+46 44	1.584	2.048	02:04	05:07	08:10	102.8	9.1
18 Mar	16 30.3	+47 08	1.502	1.995	01:44	04:44	07:44	104.3	8.9
25 Mar	16 32.1	+47 26	1.420	1.946	01:21	04:18	07:16	105.9	8.7
01 Apr	16 31.3	+47 36	1.338	1.898	00:53	03:50	06:46	107.7	8.4
08 Apr	16 27.5	+47 32	1.258	1.854	00:21	03:19	06:15	109.7	8.2
15 Apr	16 20.7	+47 07	1.179	1.813	23:40	02:44	05:44	112.0	7.9
22 Apr	16 10.7	+46 11	1.103	1.775	22:55	02:06	05:14	114.6	7.7
29 Apr	15 57.8	+44 34	1.031	1.741	22:03	01:26	04:45	117.4	7.5
06 May	15 42.7	+42 04	0.965	1.712	21:05	00:44	04:18	120.3	7.3
13 May	15 26.2	+38 27	0.907	1.687	20:01	23:57	03:55	123.2	7.1
20 May	15 09.7	+33 38	0.860	1.667	18:55	23:13	03:33	125.7	6.9
27 May	14 54.2	+27 36	0.827	1.652	17:49	22:30	03:13	127.4	6.8
03 Jun	14 40.6	+20 33	0.812	1.642	16:44	21:49	02:56	127.7	6.7
10 Jun	14 29.6	+12 53	0.817	1.637	15:43	21:10	02:40	126.4	6.7
17 Jun	14 21.4	+05 04	0.841	1.638	14:45	20:34	02:26	123.5	6.8
24 Jun	14 15.9	−02 28	0.885	1.644	13:52	20:01	02:13	119.6	6.9
01 Jul	14 13.1	−09 24	0.946	1.656	13:03	19:32	02:02	115.1	7.1
08 Jul	14 12.7	−15 37	1.020	1.673	12:17	19:03	01:52	110.4	7.3
15 Jul	14 14.4	−21 06	1.106	1.695	11:35	18:38	01:43	105.8	7.5
22 Jul	14 18.2	−25 54	1.201	1.721	10:55	18:14	01:36	101.5	7.8
29 Jul	14 23.7	−30 07	1.302	1.752	10:17	17:52	01:30	97.4	8.0
05 Aug	14 30.9	−33 49	1.409	1.787	09:41	17:32	01:25	93.6	8.3
12 Aug	14 39.7	−37 06	1.518	1.826	09:07	17:13	01:21	90.0	8.5
19 Aug	14 50.0	−40 02	1.631	1.868	08:34	16:56	01:20	86.6	8.8
26 Aug	15 01.6	−42 39	1.745	1.913	08:02	16:40	01:20	83.4	9.0
02 Sep	15 14.7	−45 00	1.860	1.961	07:32	16:25	01:22	80.3	9.3
09 Sep	15 29.0	−47 06	1.975	2.012	07:01	16:12	01:26	77.4	9.5
16 Sep	15 44.7	−48 59	2.091	2.065	06:31	16:01	01:32	74.6	9.8
23 Sep	16 01.6	−50 40	2.206	2.120	06:02	15:50	01:40	71.8	10.0
30 Sep	16 19.7	−52 09	2.321	2.177	05:32	15:40	01:51	69.2	10.2
07 Oct	16 38.9	−53 26	2.435	2.235	05:01	15:32	02:05	66.6	10.4
14 Oct	16 59.0	−54 31	2.548	2.294	04:27	15:25	02:24	64.0	10.6
21 Oct	17 20.1	−55 24	2.660	2.355	03:40	15:18	02:58	61.6	10.8
28 Oct	17 41.9	−56 06	2.771	2.417		15:12		59.2	11.0
04 Nov	18 04.1	−56 36	2.880	2.480		15:06		56.8	11.2
11 Nov	18 26.7	−56 55	2.987	2.543		15:01		54.5	11.4
18 Nov	18 49.4	−57 03	3.092	2.607		14:56		52.3	11.6
25 Nov	19 12.0	−57 01	3.195	2.672		14:51		50.1	11.8
02 Dec	19 34.3	−56 50	3.296	2.737		14:46		48.1	12.0
09 Dec	19 56.2	−56 30	3.394	2.803		14:40		46.1	12.1
16 Dec	20 17.5	−56 02	3.489	2.868		14:34		44.3	12.3
23 Dec	20 38.1	−55 27	3.582	2.935	02:52	14:27	02:06	42.6	12.4
30 Dec	20 58.0	−54 47	3.671	3.001	03:17	14:20	01:26	41.2	12.6

Comet 96P/Machholz 1

Date	RA (h m)	Dec (° ′)	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Elg (°)	Mag
16 Sep	13 49.5	−59 27	1.068	1.155		14:04		67.6	13.6
23 Sep	13 46.4	−55 13	1.048	1.017	02:06	13:35	01:06	59.4	12.9
30 Sep	13 43.9	−50 47	1.020	0.869	03:15	13:04	22:53	50.9	12.0
07 Oct	13 39.3	−45 27	0.978	0.700	03:35	12:32	21:29	41.4	10.8
14 Oct	13 35.7	−38 52	0.931	0.521	03:46	12:00	20:15	31.1	9.1
21 Oct	13 30.5	−28 22	0.885	0.313	04:00	11:28	18:55	18.0	6.4
28 Oct	13 46.1	−08 53	0.959	0.124	04:49	11:16	17:42	7.0	1.7
04 Nov	14 56.6	−05 10	1.227	0.320	05:43	11:59	18:14	11.3	7.2
11 Nov	15 42.0	−07 33	1.437	0.527	05:54	12:16	18:38	13.4	10.2
18 Nov	16 14.6	−09 45	1.624	0.705	05:53	12:21	18:50	13.8	11.9
25 Nov	16 41.0	−11 35	1.807	0.873	05:47	12:20	18:53	13.0	13.3

Comet 71P/Clark

Date	RA (h m)	Dec (° ′)	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Elg (°)	Mag
04 Feb	14 57.6	−09 04	1.809	2.068	23:26	05:57	12:23	90.5	12.4
11 Feb	15 09.2	−09 56	1.699	2.031	23:08	05:41	12:10	94.5	12.2
18 Feb	15 20.6	−10 45	1.591	1.995	22:49	05:25	11:56	98.6	12.0
25 Feb	15 31.7	−11 33	1.486	1.959	22:31	05:08	11:42	102.8	11.8
04 Mar	15 42.5	−12 19	1.385	1.925	22:12	04:52	11:27	107.0	11.6
11 Mar	15 52.8	−13 05	1.288	1.891	21:53	04:34	11:12	111.3	11.3
18 Mar	16 02.6	−13 51	1.195	1.858	21:33	04:16	10:57	115.8	11.1
25 Mar	16 11.7	−14 38	1.107	1.827	21:12	03:59	10:40	120.4	10.8
01 Apr	16 20.0	−15 28	1.024	1.797	20:50	03:39	10:23	125.2	10.6
08 Apr	16 27.2	−16 21	0.947	1.768	20:27	03:19	10:06	130.2	10.4
15 Apr	16 33.3	−17 20	0.877	1.740	20:03	02:57	09:48	135.5	10.1
22 Apr	16 38.1	−18 26	0.812	1.715	19:37	02:34	09:28	141.1	9.9
29 Apr	16 41.5	−19 40	0.755	1.691	19:09	02:10	09:08	147.0	9.7
06 May	16 43.2	−21 02	0.706	1.670	18:38	01:45	08:46	153.3	9.5
13 May	16 43.4	−22 34	0.665	1.650	18:06	01:17	08:24	159.8	9.3
20 May	16 42.1	−24 14	0.632	1.633	17:32	00:48	08:01	166.5	9.1
27 May	16 39.7	−25 58	0.608	1.618	16:56	00:18	07:37	172.7	9.0
03 Jun	16 36.5	−27 44	0.594	1.606	16:19	23:45	07:13	174.3	8.9
10 Jun	16 33.3	−29 28	0.588	1.597	15:42	23:14	06:48	169.1	8.9
17 Jun	16 30.7	−31 06	0.592	1.590	15:05	22:44	06:25	162.5	8.9
24 Jun	16 29.3	−32 34	0.603	1.586	14:30	22:15	06:02	155.9	8.9
01 Jul	16 29.8	−33 51	0.622	1.585	13:57	21:48	05:41	149.7	9.0
08 Jul	16 32.5	−34 57	0.649	1.587	13:28	21:23	05:21	143.9	9.1
15 Jul	16 37.5	−35 52	0.681	1.592	13:01	21:01	05:03	138.5	9.2
22 Jul	16 44.8	−36 36	0.719	1.599	12:37	20:40	04:46	133.6	9.3
29 Jul	16 54.3	−37 10	0.763	1.609	12:16	20:22	04:30	129.1	9.5
05 Aug	17 05.7	−37 33	0.811	1.622	11:58	20:06	04:16	125.0	9.6
12 Aug	17 18.7	−37 45	0.865	1.638	11:43	19:52	04:03	121.2	9.8
19 Aug	17 33.1	−37 48	0.923	1.655	11:29	19:39	03:50	117.5	10.0
26 Aug	17 48.5	−37 41	0.986	1.676	11:18	19:26	03:37	114.1	10.2
02 Sep	18 04.7	−37 24	1.053	1.698	11:08	19:15	03:25	110.8	10.4
09 Sep	18 21.5	−36 58	1.125	1.722	10:59	19:04	03:11	107.6	10.6
16 Sep	18 38.5	−36 23	1.200	1.748	10:51	18:54	02:58	104.5	10.8
23 Sep	18 55.7	−35 39	1.280	1.776	10:44	18:43	02:44	101.4	11.0
30 Sep	19 12.9	−34 49	1.365	1.805	10:38	18:33	02:29	98.3	11.2
07 Oct	19 30.0	−33 51	1.452	1.836	10:32	18:22	02:15	95.2	11.4
14 Oct	19 46.8	−32 47	1.544	1.868	10:26	18:11	01:59	92.0	11.7
21 Oct	20 03.3	−31 38	1.639	1.901	10:19	18:01	01:44	88.9	11.9
28 Oct	20 19.5	−30 23	1.737	1.935	10:13	17:49	01:27	85.7	12.1
04 Nov	20 35.3	−29 05	1.837	1.969	10:07	17:37	01:10	82.4	12.3
11 Nov	20 50.8	−27 44	1.940	2.005	10:00	17:25	00:53	79.1	12.5

Comet 45P/Honda-Mrkos-Pajdusakova

Date	RA (h m)	Dec (° ′)	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Elg (°)	Mag
07 Jan	21 08.5	−17 15	0.563	0.552	07:07	13:57	20:46	27.8	6.9
14 Jan	21 10.6	−15 13	0.428	0.607	06:47	13:32	20:15	21.7	6.9
21 Jan	21 01.0	−12 40	0.311	0.686	06:18	12:54	19:31	13.7	7.0
28 Jan	20 35.3	−08 27	0.211	0.778	05:37	12:01	18:25	9.9	7.0
04 Feb	19 34.0	+01 02	0.128	0.876	04:33	10:32	16:31	29.4	6.7
11 Feb	16 45.2	+23 13	0.086	0.977	02:21	07:17	12:12	80.8	6.5
18 Feb	13 07.7	+31 28	0.123	1.077	22:42	03:12	07:38	133.7	7.9
25 Feb	11 40.6	+28 02	0.202	1.177	20:35	01:18	05:57	155.2	9.6
04 Mar	11 05.4	+25 16	0.295	1.274	19:23	00:15	05:04	161.2	10.9
11 Mar	10 48.0	+23 18	0.396	1.369	18:31	23:27	04:25	158.6	12.0

Comet C/2015 ER_{61} (PANSTARRS)

Date	RA (h m)	Dec (° ′)	Δ (au)	R (au)	Rise (hh:mm)	Transit (hh:mm)	Set (hh:mm)	Elg (°)	Mag
14 Jan	15 37.3	−21 26	2.444	2.074	00:56	07:59	15:02	56.7	12.3
21 Jan	15 55.4	−22 12	2.300	1.991	00:44	07:50	14:55	59.6	12.1
28 Jan	16 14.8	−22 52	2.158	1.908	00:33	07:42	14:49	62.1	11.8
04 Feb	16 35.8	−23 24	2.020	1.825	00:25	07:35	14:44	64.4	11.5
11 Feb	16 58.4	−23 46	1.888	1.743	00:19	07:30	14:40	66.3	11.2
18 Feb	17 22.8	−23 55	1.762	1.662	00:15	07:27	14:38	67.8	10.9
25 Feb	17 49.3	−23 46	1.644	1.582	00:15	07:26	14:36	68.8	10.6
04 Mar	18 17.8	−23 17	1.535	1.504	00:17	07:27	14:35	69.3	10.3
11 Mar	18 48.4	−22 22	1.439	1.429	00:23	07:30	14:35	69.2	10.0
18 Mar	19 20.8	−20 58	1.355	1.357	00:33	07:35	14:35	68.5	9.7
25 Mar	19 54.7	−19 01	1.287	1.289	00:45	07:41	14:35	67.3	9.4
01 Apr	20 29.6	−16 31	1.235	1.226	01:00	07:48	14:35	65.6	9.1
08 Apr	21 04.8	−13 31	1.199	1.170	01:17	07:56	14:34	63.5	8.9
15 Apr	21 39.8	−10 08	1.181	1.123	01:34	08:02	14:31	61.2	8.7
22 Apr	22 13.8	−06 32	1.180	1.085	01:50	08:10	14:28	58.9	8.6
29 Apr	22 46.6	−02 51	1.193	1.058	02:05	08:15	14:23	56.8	8.6
06 May	23 17.9	+00 44	1.218	1.044	02:18	08:18	14:17	55.0	8.6
13 May	23 47.4	+04 07	1.253	1.043	02:29	08:20	14:10	53.6	8.6
20 May	00 15.3	+07 13	1.295	1.056	02:38	08:20	14:02	52.8	8.7
27 May	00 41.4	+10 00	1.341	1.081	02:44	08:19	13:53	52.4	8.9
03 Jun	01 05.8	+12 28	1.389	1.117	02:48	08:15	13:43	52.6	9.1
10 Jun	01 28.5	+14 36	1.436	1.164	02:49	08:10	13:32	53.4	9.3
17 Jun	01 49.6	+16 25	1.482	1.218	02:48	08:04	13:20	54.6	9.5
24 Jun	02 09.2	+17 58	1.524	1.280	02:44	07:57	13:08	56.4	9.7
01 Jul	02 27.1	+19 17	1.562	1.348	02:39	07:47	12:54	58.6	9.9
08 Jul	02 43.5	+20 21	1.595	1.419	02:31	07:36	12:39	61.2	10.2
15 Jul	02 58.4	+21 14	1.623	1.494	02:21	07:23	12:24	64.3	10.4
22 Jul	03 11.7	+21 57	1.645	1.572	02:09	07:09	12:07	67.8	10.6
29 Jul	03 23.4	+22 30	1.661	1.652	01:55	06:53	11:50	71.7	10.7
05 Aug	03 33.6	+22 55	1.672	1.733	01:39	06:35	11:32	76.0	10.9
12 Aug	03 42.1	+23 13	1.678	1.815	01:21	06:16	11:11	80.7	11.1
19 Aug	03 48.9	+23 24	1.680	1.897	01:01	05:56	10:50	85.8	11.2
26 Aug	03 54.0	+23 29	1.678	1.980	00:39	05:33	10:27	91.4	11.3
02 Sep	03 57.3	+23 29	1.674	2.063	00:14	05:09	10:03	97.4	11.5
09 Sep	03 58.9	+23 23	1.670	2.147	23:45	04:43	09:38	103.9	11.6
16 Sep	03 58.6	+23 11	1.665	2.230	23:16	04:15	09:10	110.8	11.7
23 Sep	03 56.5	+22 54	1.663	2.313	22:45	03:46	08:41	118.1	11.8
30 Sep	03 52.8	+22 31	1.666	2.395	22:13	03:14	08:11	125.9	12.0
07 Oct	03 47.5	+22 03	1.676	2.478	21:39	02:42	07:41	134.1	12.1
14 Oct	03 41.0	+21 29	1.694	2.560	21:03	02:07	07:08	142.6	12.2
21 Oct	03 33.6	+20 51	1.724	2.641	20:26	01:33	06:35	151.4	12.3
28 Oct	03 25.7	+20 09	1.766	2.722	19:49	00:57	06:02	160.3	12.5

Comet 2P/Encke

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
07 Jan	23 06.9	+04 22	1.412	1.308	10:05	15:55	21:45	63.2	12.1
14 Jan	23 13.9	+04 48	1.389	1.204	09:46	15:35	21:23	58.0	11.5
21 Jan	23 22.1	+05 21	1.354	1.095	09:28	15:16	21:02	53.0	10.9
28 Jan	23 31.3	+06 00	1.303	0.980	09:11	14:57	20:42	48.3	10.3
04 Feb	23 41.4	+06 42	1.234	0.861	08:56	14:40	20:22	43.9	9.7
11 Feb	23 52.0	+07 20	1.145	0.736	08:40	14:23	20:04	39.5	9.0
18 Feb	00 02.0	+07 39	1.034	0.607	08:23	14:04	19:46	34.8	8.4
25 Feb	00 08.6	+07 01	0.898	0.480	08:01	13:44	19:26	28.9	7.7
04 Mar	00 03.2	+03 45	0.751	0.374	07:19	13:11	19:02	19.1	7.1
11 Mar	23 32.8	–04 23	0.658	0.337	06:00	12:14	18:26	2.1	6.7
18 Mar	22 54.9	–12 51	0.696	0.397	04:31	11:08	17:45	18.1	7.0
25 Mar	22 36.5	–16 47	0.802	0.512	03:34	10:22	17:10	30.7	7.6
01 Apr	22 32.4	–18 00	0.907	0.641	02:58	09:51	16:42	38.9	8.2
08 Apr	22 34.5	–18 11	0.996	0.769	02:32	09:25	16:17	45.3	8.8
15 Apr	22 38.8	–17 58	1.065	0.893	02:09	09:02	15:53	51.0	9.5
22 Apr	22 43.5	–17 39	1.117	1.011	01:48	08:39	15:30	56.6	10.1
29 Apr	22 47.8	–17 21	1.153	1.124	01:26	08:16	15:06	62.3	10.7
06 May	22 51.3	–17 08	1.176	1.231	01:02	07:52	14:41	68.1	11.3
13 May	22 53.6	–17 03	1.188	1.334	00:37	07:26	14:15	74.3	11.9
20 May	22 54.5	–17 08	1.190	1.433	00:10	07:00	13:49	80.7	12.5

Hale-Bopp on 8 April 1997 from the VLA, New Mexico. Six minutes on Kodak Royal 1000, 135 mm ƒ/2.8 lens.

Comet 24P/Schaumasse

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
07 Oct	09 28.8	+18 28	1.603	1.317	03:11	08:22	13:32	55.1	12.4
14 Oct	09 57.5	+17 02	1.560	1.284	03:08	08:23	13:38	55.1	11.8
21 Oct	10 26.3	+15 22	1.525	1.256	03:04	08:24	13:44	55.0	11.4
28 Oct	10 54.9	+13 30	1.498	1.233	03:00	08:25	13:50	54.9	11.0
04 Nov	11 23.0	+11 29	1.480	1.218	02:55	08:25	13:56	54.8	10.7
11 Nov	11 50.6	+09 21	1.469	1.209	02:49	08:25	14:02	54.8	10.5
18 Nov	12 17.3	+07 10	1.464	1.206	02:42	08:25	14:07	54.9	10.5
25 Nov	12 43.2	+04 59	1.464	1.211	02:34	08:23	14:11	55.2	10.6
02 Dec	13 08.0	+02 52	1.468	1.223	02:25	08:20	14:14	55.7	10.8
09 Dec	13 31.7	+00 50	1.475	1.241	02:16	08:16	14:16	56.5	11.1
16 Dec	13 54.4	–01 04	1.483	1.266	02:06	08:11	14:16	57.6	11.5
23 Dec	14 15.8	–02 50	1.492	1.296	01:56	08:05	14:14	59.0	11.9
30 Dec	14 36.1	–04 25	1.500	1.331	01:44	07:58	14:11	60.7	12.5

Comet 73P/Schwassmann-Wachmann 3

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
14 Jan	15 58.6	–13 41	1.607	1.295	01:41	08:20	15:00	53.7	13.0
21 Jan	16 28.1	–15 38	1.540	1.237	01:37	08:22	15:07	53.4	12.7
28 Jan	16 59.7	–17 24	1.483	1.182	01:36	08:26	15:17	52.6	12.5
04 Feb	17 33.3	–18 56	1.438	1.131	01:37	08:32	15:28	51.6	12.3
11 Feb	18 08.7	–20 07	1.406	1.085	01:41	08:40	15:39	50.3	12.2
18 Feb	18 45.3	–20 53	1.387	1.045	01:48	08:49	15:50	48.7	12.0
25 Feb	19 22.6	–21 10	1.380	1.013	01:57	08:59	16:01	47.1	11.9
04 Mar	19 59.8	–20 56	1.385	0.989	02:07	09:08	16:09	45.6	11.9
11 Mar	20 36.2	–20 13	1.401	0.976	02:18	09:17	16:16	44.1	11.9
18 Mar	21 11.3	–19 05	1.426	0.972	02:29	09:25	16:19	42.9	11.9
25 Mar	21 44.5	–17 35	1.459	0.979	02:39	09:30	16:20	42.0	12.0
01 Apr	22 15.7	–15 50	1.497	0.996	02:48	09:34	16:19	41.3	12.1
08 Apr	22 44.7	–13 56	1.538	1.023	02:55	09:35	16:15	41.1	12.2
15 Apr	23 11.6	–11 56	1.582	1.058	03:00	09:35	16:08	41.2	12.4
22 Apr	23 36.6	–09 56	1.626	1.100	03:03	09:33	16:00	41.6	12.5
29 Apr	23 59.6	–07 58	1.668	1.148	03:04	09:27	15:50	42.4	12.7
06 May	00 21.0	–06 05	1.709	1.200	03:03	09:21	15:39	43.6	12.9
13 May	00 40.9	–04 18	1.746	1.256	03:00	09:13	15:26	45.1	13.1

Comet 62P/Tsuchinshan 1

Date	RA	Dec	Δ	R	Rise	Transit	Set	Elg	Mag
	h m	° '	au	au	hh:mm	hh:mm	hh:mm	°	
07 Oct	08 47.2	+18 02	1.573	1.454	02:28	07:41	12:52	64.4	12.4
14 Oct	09 11.7	+17 08	1.523	1.432	02:22	07:38	12:52	65.4	12.1
21 Oct	09 36.3	+16 06	1.477	1.413	02:16	07:34	12:52	66.4	11.9
28 Oct	10 00.7	+14 56	1.436	1.399	02:10	07:31	12:52	67.5	11.7
04 Nov	10 24.7	+13 40	1.400	1.390	02:03	07:28	12:52	68.6	11.5
11 Nov	10 48.4	+12 19	1.368	1.384	01:55	07:24	12:52	69.8	11.4
18 Nov	11 11.4	+10 57	1.339	1.383	01:47	07:19	12:51	71.1	11.4
25 Nov	11 33.7	+09 35	1.313	1.387	01:38	07:14	12:50	72.6	11.4
02 Dec	11 55.3	+08 15	1.290	1.395	01:28	07:08	12:47	74.3	11.4
09 Dec	12 15.9	+06 58	1.269	1.407	01:17	07:01	12:44	76.1	11.5
16 Dec	12 35.5	+05 47	1.249	1.424	01:06	06:53	12:39	78.3	11.6
23 Dec	12 54.0	+04 43	1.229	1.444	00:54	06:44	12:33	80.7	11.7
30 Dec	13 11.2	+03 47	1.210	1.469	00:41	06:33	12:25	83.4	11.9

BRIGHT DWARF AND MINOR PLANET POSITIONS (0 HR UT, EPOCH 2000.0)

As well as the planets, their moons and the comets, the Solar System contains numerous smaller bodies known as minor planets or asteroids. There are now hundreds of thousands of such bodies catalogued. Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe. Many can be found by imaging the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which *star* has moved. Be sure you have the right field of view. Only about sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

Included are ephemerides for the 14 brightest minor or dwarf planets reaching opposition in 2017, plus 8 Flora (opposition is 2 Jan 2018). Juno reaches magnitude 9.7 with the rest with a maximum of 9.5 or brighter. As only the 15 bright ones are considered here, 1 Ceres is the only dwarf planet that makes the grade. The period considered for the conjunctions was 3 months either side of opposition.

1 Ceres

Date	RA hh mm	Dec ° ′	Mag
Jul 15	06 07.4	+ 23 56	8.8
22	06 20.2	+ 24 05	8.9
29	06 33.0	+ 24 11	8.9
Aug 5	06 45.6	+ 24 14	8.9
12	06 58.1	+ 24 13	8.9
19	07 10.5	+ 24 10	8.9
26	07 22.7	+ 24 04	8.9
Sep 2	07 34.7	+ 23 56	8.9
9	07 46.4	+ 23 46	8.9
16	07 57.8	+ 23 35	8.9
23	08 08.9	+ 23 24	8.8
30	08 19.7	+ 23 12	8.8
Oct 7	08 30.0	+ 23 00	8.7
14	08 39.8	+ 22 50	8.7
21	08 49.1	+ 22 41	8.6
28	08 57.8	+ 22 35	8.5
Nov 4	09 05.8	+ 22 33	8.5
11	09 13.0	+ 22 35	8.4
18	09 19.4	+ 22 42	8.3
25	09 24.8	+ 22 55	8.2
Dec 2	09 29.1	+ 23 16	8.0
9	09 32.3	+ 23 43	7.9
16	09 34.2	+ 24 18	7.8
23	09 34.6	+ 25 01	7.6
30	09 33.6	+ 25 50	7.5

2 Pallas

Date	RA hh mm	Dec ° ′	Mag
Jul 15	02 28.1	+ 00 25	9.7
22	02 36.2	- 00 11	9.6
29	02 44.0	- 00 57	9.5
Aug 5	02 51.2	- 01 52	9.4
12	02 57.9	- 02 58	9.3
19	03 03.9	- 04 15	9.2
26	03 09.2	- 05 42	9.1
Sep 2	03 13.5	- 07 20	9.0
9	03 16.9	- 09 09	8.8
16	03 19.2	- 11 07	8.7
23	03 20.3	- 13 13	8.6
30	03 20.1	- 15 24	8.4
Oct 7	03 18.6	- 17 37	8.3
14	03 15.9	- 19 48	8.3
21	03 12.0	- 21 51	8.2
28	03 07.1	- 23 43	8.2
Nov 4	03 01.6	- 25 19	8.2
11	02 55.7	- 26 35	8.2
18	02 49.9	- 27 31	8.2
25	02 44.5	- 28 04	8.3
Dec 2	02 40.0	- 28 16	8.4
9	02 36.4	- 28 09	8.5
16	02 34.1	- 27 43	8.5
23	02 33.2	- 27 03	8.6
30	02 33.6	- 26 10	8.7

3 Juno

Date	RA hh mm	Dec ° ′	Mag
Apr 15	19 04.5	- 08 18	10.9
22	19 07.2	- 07 45	10.8
29	19 09.1	- 07 13	10.7
May 6	19 09.9	- 06 43	10.6
13	19 09.8	- 06 14	10.5
20	19 08.5	- 05 48	10.4
27	19 06.2	- 05 26	10.3
Jun 3	19 02.9	- 05 09	10.1
10	18 58.6	- 04 57	10.0
17	18 53.6	- 04 51	9.9
24	18 47.9	- 04 51	9.8
Jul 1	18 41.8	- 04 59	9.8
8	18 35.6	- 05 14	9.7
15	18 29.6	- 05 34	9.8
22	18 24.0	- 06 01	9.9
29	18 19.1	- 06 33	9.9
Aug 5	18 15.1	- 07 08	10.0
12	18 12.2	- 07 46	10.1
19	18 10.4	- 08 25	10.2
26	18 09.7	- 09 06	10.3
Sep 2	18 10.2	- 09 46	10.4
9	18 11.9	- 10 25	10.4
16	18 14.6	- 11 03	10.5
23	18 18.4	- 11 39	10.6
30	18 23.2	- 12 12	10.6

4 Vesta

Date	RA hh mm	Dec ° ′	Mag
Jan 7	08 13.7	+ 22 15	6.5
14	08 06.6	+ 22 59	6.3
21	07 59.0	+ 23 42	6.3
28	07 51.4	+ 24 21	6.5
Feb 4	07 44.4	+ 24 55	6.6
11	07 38.4	+ 25 23	6.7
18	07 33.7	+ 25 45	6.9
25	07 30.5	+ 26 00	7.0
Mar 4	07 29.0	+ 26 11	7.2
11	07 29.0	+ 26 16	7.3
18	07 30.7	+ 26 17	7.4
25	07 33.8	+ 26 13	7.5
Apr 1	07 38.3	+ 26 05	7.6
8	07 43.9	+ 25 53	7.7
15	07 50.7	+ 25 38	7.8
22	07 58.3	+ 25 19	7.9
29	08 06.8	+ 24 55	7.9
May 6	08 16.0	+ 24 28	8.0
13	08 25.7	+ 23 57	8.0
20	08 36.0	+ 23 22	8.1
27	08 46.7	+ 22 43	8.1
Jun 3	08 57.8	+ 22 00	8.1
10	09 09.2	+ 21 13	8.1
17	09 20.8	+ 20 22	8.2
24	09 32.6	+ 19 28	8.2

6 Hebe

Date	RA hh mm	Dec ° ′	Mag
Apr 1	18 02.6	- 07 19	10.6
8	18 06.8	- 06 48	10.5
15	18 10.0	- 06 16	10.4
22	18 12.0	- 05 44	10.2
29	18 12.8	- 05 12	10.1
May 6	18 12.3	- 04 43	9.9
13	18 10.5	- 04 18	9.8
20	18 07.3	- 03 57	9.6
27	18 03.0	- 03 43	9.5
Jun 3	17 57.6	- 03 36	9.4
10	17 51.3	- 03 38	9.2
17	17 44.5	- 03 50	9.2
24	17 37.5	- 04 11	9.2
Jul 1	17 30.7	- 04 42	9.2
8	17 24.5	- 05 22	9.3
15	17 19.2	- 06 09	9.4
22	17 15.1	- 07 02	9.5
29	17 12.3	- 08 00	9.6
Aug 5	17 10.9	- 09 01	9.7
12	17 11.0	- 10 03	9.8
19	17 12.5	- 11 05	9.9
26	17 15.4	- 12 07	10.0
Sep 2	17 19.7	- 13 08	10.1
9	17 25.2	- 14 06	10.1
16	17 31.8	- 15 02	10.2

7 Iris

Date	RA hh mm	Dec ° ′	Mag
Jul 15	01 15.9	+ 14 55	9.5
22	01 26.5	+ 16 14	9.4
29	01 36.6	+ 17 28	9.2
Aug 5	01 46.1	+ 18 38	9.1
12	01 54.9	+ 19 43	9.0
19	02 02.9	+ 20 43	8.8
26	02 09.8	+ 21 36	8.6
Sep 2	02 15.6	+ 22 22	8.5
9	02 20.0	+ 22 59	8.3
16	02 22.8	+ 23 26	8.1
23	02 24.0	+ 23 42	7.9
30	02 23.3	+ 23 46	7.7
Oct 7	02 21.0	+ 23 35	7.5
14	02 17.2	+ 23 11	7.3
21	02 12.2	+ 22 32	7.0
28	02 06.7	+ 21 41	6.9
Nov 4	02 01.2	+ 20 41	6.9
11	01 56.4	+ 19 37	7.1
18	01 52.8	+ 18 34	7.3
25	01 50.7	+ 17 36	7.5
Dec 2	01 50.4	+ 16 47	7.7
9	01 52.0	+ 16 10	7.9
16	01 55.3	+ 15 43	8.1
23	02 00.3	+ 15 29	8.3
30	02 06.7	+ 15 25	8.5

8 Flora

Date	RA hh mm	Dec ° ′	Mag
Jul 15	03 55.0	+ 15 35	10.6
22	04 11.1	+ 16 18	10.6
29	04 27.0	+ 16 55	10.6
Aug 5	04 42.7	+ 17 26	10.5
12	04 58.2	+ 17 50	10.5
19	05 13.4	+ 18 09	10.5
26	05 28.3	+ 18 22	10.4
Sep 2	05 42.7	+ 18 30	10.4
9	05 56.6	+ 18 34	10.3
16	06 09.8	+ 18 33	10.2
23	06 22.4	+ 18 29	10.2
30	06 34.1	+ 18 22	10.1
Oct 7	06 44.9	+ 18 13	10.0
14	06 54.6	+ 18 04	9.9
21	07 03.2	+ 17 56	9.8
28	07 10.3	+ 17 49	9.7
Nov 4	07 16.0	+ 17 46	9.6
11	07 20.0	+ 17 47	9.4
18	07 22.1	+ 17 54	9.3
25	07 22.3	+ 18 07	9.1
Dec 2	07 20.4	+ 18 27	9.0
9	07 16.6	+ 18 55	8.8
16	07 11.0	+ 19 28	8.7
23	07 04.0	+ 20 06	8.5
30	06 56.1	+ 20 46	8.3

9 Metis

Date	RA hh mm	Dec ° ′	Mag
Jan 7	11 01.0	+ 14 44	9.9
14	11 01.2	+ 15 11	9.8
21	10 59.9	+ 15 47	9.6
28	10 56.9	+ 16 30	9.5
Feb 4	10 52.4	+ 17 17	9.3
11	10 46.7	+ 18 06	9.2
18	10 40.1	+ 18 53	9.1
25	10 33.1	+ 19 35	9.1
Mar 4	10 26.2	+ 20 09	9.2
11	10 19.9	+ 20 32	9.4
18	10 14.5	+ 20 45	9.6
25	10 10.3	+ 20 47	9.8
Apr 1	10 07.6	+ 20 38	10.0
8	10 06.5	+ 20 20	10.1
15	10 06.7	+ 19 54	10.3
22	10 08.4	+ 19 21	10.4
29	10 11.3	+ 18 41	10.6
May 6	10 15.4	+ 17 56	10.7
13	10 20.4	+ 17 07	10.8
20	10 26.3	+ 16 13	11.0
27	10 32.9	+ 15 16	11.1
Jun 3	10 40.2	+ 14 15	11.1
10	10 48.1	+ 13 12	11.2
17	10 56.4	+ 12 06	11.3
24	11 05.1	+ 10 58	11.4

10 Hygiea

Date	RA hh mm	Dec ° ′	Mag
Apr 8	18 47.6	- 24 41	10.7
15	18 52.7	- 24 32	10.6
22	18 56.8	- 24 24	10.5
29	18 59.6	- 24 16	10.4
May 6	19 01.3	- 24 10	10.3
13	19 01.7	- 24 05	10.2
20	19 00.8	- 24 00	10.0
27	18 58.6	- 23 57	9.9
Jun 3	18 55.2	- 23 55	9.8
10	18 50.8	- 23 53	9.6
17	18 45.6	- 23 51	9.5
24	18 39.8	- 23 48	9.3
Jul 1	18 33.7	- 23 44	9.2
8	18 27.8	- 23 39	9.4
15	18 22.3	- 23 33	9.6
22	18 17.5	- 23 26	9.7
29	18 13.6	- 23 19	9.9
Aug 5	18 10.8	- 23 12	10.0
12	18 09.3	- 23 05	10.2
19	18 09.0	- 22 58	10.3
26	18 09.9	- 22 51	10.5
Sep 2	18 11.9	- 22 45	10.6
9	18 15.1	- 22 39	10.7
16	18 19.3	- 22 32	10.8
23	18 24.4	- 22 25	10.9

14 Irene

Date	RA hh mm	Dec ° ′	Mag
Jan 7	10 47.8	+ 19 11	9.9
14	10 48.8	+ 19 57	9.8
21	10 48.3	+ 20 52	9.6
28	10 46.2	+ 21 54	9.4
Feb 4	10 42.6	+ 22 59	9.2
11	10 37.8	+ 24 04	9.1
18	10 32.0	+ 25 05	9.0
25	10 25.7	+ 25 57	9.0
Mar 4	10 19.5	+ 26 37	9.1
11	10 13.8	+ 27 03	9.3
18	10 09.1	+ 27 14	9.4
25	10 05.7	+ 27 10	9.6
Apr 1	10 03.9	+ 26 53	9.7
8	10 03.7	+ 26 25	9.9
15	10 05.1	+ 25 46	10.0
22	10 07.9	+ 24 58	10.1
29	10 12.1	+ 24 02	10.2
May 6	10 17.6	+ 23 01	10.4
13	10 24.1	+ 21 53	10.5
20	10 31.5	+ 20 41	10.5
27	10 39.8	+ 19 24	10.6
Jun 3	10 48.7	+ 18 03	10.7
10	10 58.1	+ 16 39	10.8
17	11 08.1	+ 15 12	10.9
24	11 18.4	+ 13 42	10.9

15 Eunomia

Date	RA hh mm	Dec ° ′	Mag
Jan 7	10 32.3	+ 00 42	9.8
14	10 29.5	+ 00 17	9.7
21	10 25.6	+ 00 00	9.6
28	10 20.5	- 00 09	9.5
Feb 4	10 14.6	- 00 10	9.4
11	10 08.1	- 00 03	9.3
18	10 01.3	+ 00 10	9.2
25	09 54.6	+ 00 28	9.2
Mar 4	09 48.3	+ 00 50	9.4
11	09 42.7	+ 01 14	9.5
18	09 38.1	+ 01 37	9.7
25	09 34.6	+ 01 59	9.8
Apr 1	09 32.3	+ 02 18	10.0
8	09 31.2	+ 02 34	10.1
15	09 31.4	+ 02 45	10.2
22	09 32.6	+ 02 52	10.4
29	09 34.9	+ 02 54	10.5
May 6	09 38.1	+ 02 50	10.6
13	09 42.2	+ 02 42	10.7
20	09 47.0	+ 02 29	10.8
27	09 52.5	+ 02 12	10.9
Jun 3	09 58.6	+ 01 50	10.9
10	10 05.1	+ 01 24	11.0
17	10 12.1	+ 00 54	11.1
24	10 19.5	+ 00 20	11.1

20 Massalia

Date	RA hh mm	Dec ° ′	Mag
Jul 15	03 36.9	+ 19 17	11.3
22	03 49.9	+ 19 58	11.3
29	04 02.8	+ 20 34	11.2
Aug 5	04 15.6	+ 21 06	11.1
12	04 28.2	+ 21 34	11.1
19	04 40.5	+ 21 57	11.0
26	04 52.4	+ 22 16	10.9
Sep 2	05 03.9	+ 22 31	10.8
9	05 14.8	+ 22 42	10.7
16	05 25.1	+ 22 49	10.6
23	05 34.6	+ 22 53	10.5
30	05 43.3	+ 22 54	10.4
Oct 7	05 50.9	+ 22 53	10.3
14	05 57.3	+ 22 51	10.1
21	06 02.3	+ 22 47	10.0
28	06 05.8	+ 22 43	9.8
Nov 4	06 07.6	+ 22 39	9.6
11	06 07.7	+ 22 34	9.5
18	06 05.8	+ 22 30	9.3
25	06 02.2	+ 22 27	9.1
Dec 2	05 56.9	+ 22 23	8.9
9	05 50.4	+ 22 19	8.7
16	05 43.1	+ 22 14	8.4
23	05 35.6	+ 22 09	8.6
30	05 28.6	+ 22 03	8.8

29 Amphitrite

Date	RA hh mm	Dec ° ′	Mag
Jan 7	11 28.5	+ 07 19	10.3
14	11 29.2	+ 07 10	10.1
21	11 28.6	+ 07 08	10.0
28	11 26.6	+ 07 13	9.9
Feb 4	11 23.2	+ 07 26	9.7
11	11 18.6	+ 07 43	9.6
18	11 13.0	+ 08 05	9.4
25	11 06.7	+ 08 30	9.2
Mar 4	10 59.9	+ 08 54	9.1
11	10 53.2	+ 09 17	9.3
18	10 46.8	+ 09 36	9.5
25	10 41.3	+ 09 50	9.6
Apr 1	10 36.7	+ 09 58	9.8
8	10 33.3	+ 10 00	10.0
15	10 31.3	+ 09 54	10.1
22	10 30.5	+ 09 42	10.3
29	10 31.0	+ 09 24	10.4
May 6	10 32.7	+ 09 00	10.5
13	10 35.5	+ 08 31	10.6
20	10 39.3	+ 07 57	10.8
27	10 43.9	+ 07 18	10.9
Jun 3	10 49.4	+ 06 35	10.9
10	10 55.5	+ 05 49	11.0
17	11 02.2	+ 04 59	11.1
24	11 09.5	+ 04 05	11.2

40 Harmonia

Date	RA hh mm	Dec ° ′	Mag
Apr 1	18 16.2	- 21 12	11.4
8	18 23.0	- 21 12	11.3
15	18 28.8	- 21 13	11.2
22	18 33.3	- 21 15	11.1
29	18 36.4	- 21 18	10.9
May 6	18 38.0	- 21 24	10.8
13	18 38.1	- 21 32	10.6
20	18 36.5	- 21 44	10.4
27	18 33.3	- 21 58	10.2
Jun 3	18 28.6	- 22 14	10.0
10	18 22.5	- 22 32	9.8
17	18 15.5	- 22 51	9.6
24	18 07.8	- 23 09	9.3
Jul 1	18 00.2	- 23 26	9.6
8	17 53.0	- 23 41	9.8
15	17 46.8	- 23 55	10.0
22	17 41.9	- 24 08	10.2
29	17 38.5	- 24 19	10.4
Aug 5	17 36.8	- 24 30	10.5
12	17 36.9	- 24 41	10.7
19	17 38.6	- 24 51	10.8
26	17 42.0	- 25 01	10.9
Sep 2	17 46.8	- 25 10	11.1
9	17 52.9	- 25 17	11.2
16	18 00.3	- 25 24	11.3

89 Julia

Date	RA hh mm	Dec ° ′	Mag
Jun 17	23 03.3	- 03 35	10.7
24	23 08.7	- 02 00	10.6
Jul 1	23 12.9	- 00 25	10.4
8	23 15.9	+ 01 08	10.3
15	23 17.6	+ 02 39	10.1
22	23 17.9	+ 04 08	10.0
29	23 16.6	+ 05 32	9.8
Aug 5	23 13.7	+ 06 51	9.6
12	23 09.3	+ 08 02	9.4
19	23 03.5	+ 09 04	9.3
26	22 56.6	+ 09 54	9.1
Sep 2	22 48.9	+ 10 33	9.0
9	22 41.1	+ 10 59	9.0
16	22 33.6	+ 11 13	9.1
23	22 26.9	+ 11 17	9.2
30	22 21.6	+ 11 13	9.3
Oct 7	22 17.9	+ 11 05	9.5
14	22 15.9	+ 10 56	9.7
21	22 15.6	+ 10 47	9.8
28	22 17.1	+ 10 41	10.0
Nov 4	22 20.3	+ 10 40	10.1
11	22 24.9	+ 10 44	10.3
18	22 30.9	+ 10 54	10.4
25	22 38.0	+ 11 10	10.5
Dec 2	22 46.2	+ 11 32	10.6

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a *dirty snowball*, a conglomerate of ice, gas, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classic dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical-shaped donut. The effects of solar radiation and the slight gravity tug from the planets will, over time, break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand, up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		VEL km/s	ZHR
				RA	Dec		
Quadrantids (QUA)	FQ	Dec 28 – Jan 12	Jan 03	230°	+49°	41	120
alpha-Centaurids (ACE)	FM	Jan 28 – Feb 21	Feb 08	210°	-59°	56	6
gamma-Normids (GNO)	FM	Feb 25 – Mar 28	Mar 14	239°	-50°	56	6
Lyrids (LYR)	NM	Apr 16 – Apr 25	Apr 22	271°	+34°	49	18
pi-Puppids (PPU)*	NM	Apr 15 – Apr 28	Apr 23	110°	-45°	18	var
eta-Aquarids (ETA)	FQ	Apr 19 – May 28	May 06	338°	-01°	66	40
eta-Lyrids (ELY)	FM	May 03 – May 14	May 09	287°	+44°	43	3
June Bootids (JBO)*	NM	Jun 22 – Jul 02	Jun 27	224°	+48°	18	var
Piscis Austrinids (PAU)	FQ	Jul 15 – Aug 10	Jul 28	341°	-30°	35	5
Southern delta-Aquarids (SDA)	FQ	Jul 12 – Aug 23	Jul 30	340°	-16°	41	16
alpha-Capricornids (CAP)	FQ	Jul 03 – Aug 15	Jul 30	307°	-10°	23	5
Perseids (PER)	LQ	Jul 17 – Aug 24	Aug 12	048°	+58°	59	150
kappa-Cygnids (KCG)	LQ	Aug 03 – Aug 25	Aug 17	286°	+59°	25	3
Aurigids (AUR)	FQ	Aug 28 – Sep 05	Sep 01	091°	+39°	66	6
September Perseids (SPE)	FM	Sep 05 – Sep 21	Sep 09	048°	+40°	64	5
Draconids (DRA)*	FM	Oct 06 – Oct 10	Oct 08	262°	+54°	20	var
Southern Taurids (STA)	LQ	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	15
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 17	152°	+22°	71	15
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)	LQ	Dec 01 – Dec 15	Dec 07	123°	-45°	40	10
Monocerotids (MON)	LQ	Dec 05 – Dec 20	Dec 08	100°	+08°	42	2
sigma-Hydrids (HYD)	LQ	Dec 03 – Dec 15	Dec 11	127°	+02°	58	3
Geminids (GEM)	NM	Dec 04 – Dec 17	Dec 14	112°	+33°	35	120
Coma Berenicids (COM)	NM	Dec 12 – Dec 23	Dec 16	175°	+18°	65	3
Dec. Leonis Minorids (DLM)	NM	Dec 05 – Feb 04	Dec 20	161°	+30°	64	5
Ursids (URS)	FQ	Dec 17 – Dec 26	Dec 22	217°	+75°	33	10

Table Notes (above)

Shower Name The shower is named after the constellation in which the radiant appears, or a bright star near that point. A shower marked with an asterisk (*) is only occasionally active.

Moon Phase The phase of the Moon nearest the date of maximum activity. If a Full Moon occurs near a shower's maximum period, only the very brightest of meteors will be seen.

Activity Duration The approximate dates when the shower is active.

Max Act The date when maximum activity can be expected.

Radiant The position of the shower radiant in right ascension and declination (RA is expressed in degrees). These coordinates refer to the radiant position on the date of maximum activity.

Vel The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11 km/s (very slow) to 71 km/s (very fast), medium speed is about 40 km/s.

ZHR Zenith Hourly Rate at peak period. A theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

Incredible velocities such as these (a bullet from a rifle travels at about one kilometre per second) result in the meteor's kinetic energy being converted to heat when it strikes the atmosphere at an altitude of about 100 km. The surrounding air is heated to incandescence by friction and as a consequence we can observe these tiny bodies as they self-destruct in our atmosphere.

Individual meteors during a shower appear to originate from a common point in the sky, known as the radiant. This focal point is often named after the constellation in which the meteors appear. The particles of meteoroid streams travel though space in parallel paths. The apparent divergence from the radiant is only an illusion, due to the effect of perspective. The way that trees and buildings converge on either side of a long straight road is the same effect that is seen when a meteor shower occurs far above an observer.

The table of Meteor Showers has been compiled from the Meteor Shower Calendar produced by the International Meteor Organization (IMO). It is the most accurate listing for naked eye meteor observing available today. The table is complete in that both northern and southern showers are listed. Serious meteor observing should be carried out under dark skies, and preferably without the Moon. The best showers for this year, taking into consideration the lunar phase, are summarised in each monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic or random meteors are visible per hour under dark sky conditions. More meteors are seen in the morning sky than in the evening; as the morning sky is facing the Earth's motion in space we tend to *run into* and *sweep up* meteors, whereas evening meteors must have sufficient velocity to catch up to the speeding Earth. Amateurs wishing to follow up an interest in meteors, and even make a contribution to meteor science, should contact the International Meteor Organization. www.imo.net/

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
Bootes	Bootis	Boo	7	Jun 16
Caelum	Caeli	Cae	2, 4	Jan 15
Camelopardalis	Camelopardalis	Cam	3, 5	Feb 6
Cancer	Cancri	Cnc	5, 4	Mar 16
Canes Venatici	Canum Venaticorum	CVn	5, 7	May 22
Canis Major	Canis Majoris	CMa	4, 2	Feb 16
Canis Minor	Canis Minoris	CMi	5, 4	Feb 28
Capricornus	Capricorni	Cap	8	Sep 22
Carina	Carinae	Car	1, 4	Mar 17
Cassiopeia	Cassiopeiae	Cas	3, 9	Nov 23
Centaurus	Centauri	Cen	1, 6	May 14
Cepheus	Cephei	Cep	9, 3	Nov 13
Cetus	Ceti	Cet	2, 3	Nov 29
Chamaeleon	Chamaeleontis	Cha	1	Apr 15
Circinus	Circini	Cir	1, 6	Jun 14
Columba	Columbae	Col	4, 2	Feb 1
Coma Berenices	Comae Berenices	Com	7, 5	May 17
Corona Australis	Coronae Australis	CrA	8, 6	Aug 14
Corona Borealis	Coronae Borealis	CrB	7	Jul 3
Corvus	Corvi	Crv	6, 4	May 12

Name	Genitive	Abr.	Map	Cul.
Crater	Crateris	Crt	4, 6	Apr 26
Crux	Crucis	Cru	1	May 12
Cygnus	Cygni	Cyg	9	Sep 13
Delphinus	Delphini	Del	9, 8	Sep 14
Dorado	Doradus	Dor	2, 1	Jan 31
Draco	Draconis	Dra	7, 9	Jul 8
Equuleus	Equulei	Equ	9, 8	Sep 22
Eridanus	Eridani	Eri	2, 1	Dec 25
Fornax	Fornacis	For	2	Dec 17
Gemini	Geminorum	Gem	5, 4	Feb 19
Grus	Gruis	Gru	8, 1	Oct 12
Hercules	Herculis	Her	7, 9	Jul 28
Horologium	Horologii	Hor	2, 1	Dec 25
Hydra	Hydrae	Hya	4, 6	Apr 29
Hydrus	Hydri	Hyi	1	Dec 10
Indus	Indi	Ind	1, 8	Sep 26
Lacerta	Lacertae	Lac	9	Oct 12
Leo	Leonis	Leo	5, 7	Apr 15
Leo Minor	Leonis Minoris	LMi	5, 7	Apr 9
Lepus	Leporis	Lep	2, 4	Jan 28
Libra	Librae	Lib	6	Jun 23
Lupus	Lupi	Lup	6	Jun 23
Lynx	Lyncis	Lyn	5, 3	Mar 5
Lyra	Lyrae	Lyr	9, 7	Aug 18
Mensa	Mensae	Men	1	Jan 28
Microscopium	Microscopii	Mic	8	Sep 18
Monoceros	Monocerotis	Mon	4, 5	Feb 19
Musca	Muscae	Mus	1	May 14
Norma	Normae	Nor	6, 1	Jul 3
Octans	Octantis	Oct	1	Circum
Ophiuchus	Ophiuchi	Oph	6, 7	Jul 26

Name	Genitive	Abr.	Map	Cul.
Orion	Orionis	Ori	2, 3	Jan 27
Pavo	Pavonis	Pav	1, 8	Aug 29
Pegasus	Pegasi	Peg	9, 3	Oct 16
Perseus	Persei	Per	3	Dec 22
Phoenix	Phoenicis	Phe	2, 8	Nov 18
Pictor	Pictoris	Pic	1, 2	Jan 30
Pisces	Piscium	Psc	3, 9	Nov 11
Piscis Austrinus	Piscis Austrini	PsA	8	Oct 9
Puppis	Puppis	Pup	4, 2	Feb 22
Pyxis	Pyxidis	Pyx	4	Mar 21
Reticulum	Reticuli	Ret	1	Jan 3
Sagitta	Sagittae	Sge	9	Aug 30
Sagittarius	Sagittarii	Sgr	8, 6	Aug 21
Scorpius	Scorpii	Sco	6, 8	Jul 18
Sculptor	Sculptoris	Scl	2, 8	Nov 10
Scutum	Scuti	Sct	8	Aug 15
Serpens	Serpentis	Ser	6, 7	Jul 21
Sextans	Sextantis	Sex	4	Apr 8
Taurus	Tauri	Tau	3, 5	Jan 14
Telescopium	Telescopii	Tel	8, 1	Aug 24
Triangulum	Trianguli	Tri	3	Dec 7
Triangulum Australe	Trianguli Australis	TrA	1	Jul 7
Tucana	Tucanae	Tuc	1	Nov 1
Ursa Major	Ursae Majoris	UMa	5, 7	Apr 25
Ursa Minor	Ursae Minoris	UMi	7	Jun 27
Vela	Velorum	Vel	4, 1	Mar 30
Virgo	Virginis	Vir	6, 7	May 26
Volans	Volantis	Vol	1	Mar 4
Vulpecula	Vulpeculae	Vul	9	Sep 8

BRIGHTEST and NEAREST STARS (opposite)

The column descriptions are:

Designation The name of the star in the system created by Bayer, who numbered the stars in the constellations using Greek letters (p. 152). They were usually ordered by their brightness, Alpha being the brightest in most cases.

Name Common name for each star.
Constellation The star's constellation.
RA and Dec. The position of the star, epoch 2000.0.
Magnitude App. The apparent magnitude as seen in the sky.
Magnitude Abs. The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light years) from Earth.
Spectral Type The spectral classification of the star (see below).
Parallax see glossary.
Proper Motion see glossary.
Distance, ly is light year and **pc** is parsec, see glossary.
Note (d) is a visual double star.
(sb) is a spectroscopic binary.
(eb) is an eclipsing binary.
(v) indicates the star is variable.

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O**, **B**, **A**, **F**, **G**, **K** and **M**, remembered by the mnemonic **O**h **B**e **A** **F**ine **G**irl(Guy) **K**iss **M**e.

There are also the *colder* star classes **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel).
- **F** and **G** are yellow (e.g., Capella, and the Sun).
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (that is no colour).

The colours of stars can be imaged simply. Mount a camera on a tripod and take a time exposure of several minutes. The resulting star trails often show the colours very well. An equatorially tracked time exposure (for example piggy-backed on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images can saturate the detector. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation		Name	Constellation	RA (2000.0)	Dec (2000.0)	Magnitude App	Abs	Spectral Type	Parallax	Distance pc	ly	Note
1	α CMa	Sirius	Canis Major	06 45.1	–16 43	–1.44	1.5	A1 V	0.3800	2.63	8.58	d
2	α Car	Canopus	Carina	06 23.9	–52 42	–0.74	–5.6	F0 Ib	0.0104	96	310	
3	α Cen	Rigil Kent	Centaurus	14 39.6	–60 50	–0.28	4.1	G2V + K0V	0.7472	1.34	4.37	d
4	α Boo	Arcturus	Bootes	14 15.7	+19 11	–0.05	–0.3	K2 III	0.0889	11.3	36.7	
5	α Lyr	Vega	Lyra	18 36.9	+38 47	0.03	0.6	A0 V	0.1289	7.76	25.3	v
6	α Aur	Capella	Auriga	05 16.7	+46 00	0.08	–0.5	G8III + G0III	0.0773	12.9	42.2	sb, v
7	β Ori	Rigel	Orion	05 14.5	–08 12	0.15	–6.8	B8 Ia	0.0042	240	780	d, v
8	α CMi	Procyon	Canis Minor	07 39.3	+05 14	0.38	2.7	F5 IV–V	0.2861	3.50	11.4	d
9	α Eri	Achernar	Eridanus	01 37.7	–57 14	0.45	–2.8	B5 IV	0.0227	44.1	144	v
10	α Ori	Betelgeuse	Orion	05 55.2	+07 24	0.50	–5.2	M2 Iab	0.0076	131	430	v
11	β Cen	Hadar	Centaurus	14 03.8	–60 22	0.61	–5.4	B1 II + B	0.0062	161	525	d, v
12	α Cru	Acrux	Crux	12 26.6	–63 06	0.74	–4.2	B0.5IV + B0.5V	0.0102	98	320	d
13	α Aql	Altair	Aquila	19 50.8	+08 52	0.76	2.2	A7 IV–V	0.1950	5.13	16.7	
14	α Tau	Aldebaran	Taurus	04 35.9	+16 31	0.87	–0.6	K5 III	0.0501	20.0	65	v
15	α Sco	Antares	Scorpius	16 29.4	–26 26	0.96	–5.1	M1.5Iab + B4V	0.0067	150	490	d, v
16	α Vir	Spica	Virgo	13 25.2	–11 10	0.98	–3.5	B1III–IV + B2V	0.0124	80	262	sb, v
17	β Gem	Pollux	Gemini	07 45.3	+28 02	1.15	1.1	K0 III	0.0967	10.3	33.7	
18	α PsA	Fomalhaut	Piscis Austrinus	22 57.7	–29 37	1.16	1.7	A3 V	0.1301	7.69	25.1	
19	α Cyg	Deneb	Cygnus	20 41.4	+45 17	1.25	–7.2	A2 Ia	0.0020	500	1600	v
20	β Cru	Mimosa	Crux	12 47.7	–59 41	1.26	–3.9	B0.5 III	0.0093	108	353	v
21	α Leo	Regulus	Leo	10 08.4	+11 58	1.36	–0.5	B7 V	0.0421	23.8	78	d
22	ε CMa	Adhara	Canis Major	06 58.6	–28 58	1.50	–4.1	B2 II	0.0076	132	430	d
23	α Gem	Castor	Gemini	07 34.6	+31 53	1.58	0.6	A1V + Am	0.0633	15.8	52	d, sb
24	λ Sco	Shaula	Scorpius	17 33.6	–37 06	1.62	–5.0	B1.5 III	0.0046	215	700	sb, v
25	γ Cru	Gacrux	Crux	12 31.2	–57 07	1.63	–0.5	M3 III	0.0371	27.0	88	v
26	γ Ori	Bellatrix	Orion	05 25.1	+06 21	1.64	–2.7	B2 III	0.0134	75	243	
27	β Tau	Elnath	Taurus	05 26.3	+28 36	1.65	–1.4	B7 III	0.0249	40.2	131	
28	β Car	Miaplacidus	Carina	09 13.2	–69 43	1.67	–1.0	A0 III	0.0293	34.1	111	
29	ε Ori	Alnilam	Orion	05 36.2	–01 12	1.69	–6.4	B0 Ia	0.0024	410	1340	
30	γ Vel	Regor	Vela	08 09.5	–47 20	1.70	–5.4	O9Ib + WC8	0.0039	258	840	sb, v

THE NEAREST STARS

Note, this list does not include some recently discovered brown dwarf stars.

No	Star Name		Constellation	RA 2000.0 hh mm.m	Dec ° '	Magnitude Apparent	Absolute	Spect Type	Parallax "	Proper Motion "/yr	Distance pc	ly
--	Sun					–26.72	4.85	G2 V				
1	Proxima Centauri		Centaurus	14 29.7	–62 40	11.09	15.53	M5.5 V	0.7720	3.85	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	–60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		B				1.34	5.71	K0 V				
2	Barnard's Star		Ophiuchus	17 57.8	+04 41	9.53	13.22	M4.0 V	0.5470	10.36	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	–16 43	–1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		B				8.44	11.34	DA2				
6	L 726-8 (UV Ceti)	A	Cetus	01 39.0	–17 57	12.54	15.40	M5.5 V	0.3737	3.37	2.68	8.73
		B				12.99	15.85	M6.0 V				
7	Ross 154		Sagittarius	18 49.8	–23 50	10.43	13.07	M3.5 V	0.3369	0.67	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	–09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	–35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	–15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		B				13.27	15.58	M				
		C				14.03	16.34	M				
13	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.66	F5 IV–V	0.2861	1.26	3.50	11.40
		B				10.70	12.98	DA				
14	61 Cygni	A	Cygnus	21 06.9	+38 45	5.21	7.49	K5.0 V	0.2860	5.28	3.50	11.40
		B				6.03	8.31	K7.0 V				
15	Σ 2398	A	Draco	18 42.8	+59 38	8.90	11.16	M3.0 V	0.2830	2.24	3.53	11.53
		B				9.69	11.95	M3.5 V				
16	Groombridge 34	A	Andromeda	00 18.4	+44 01	8.08	10.32	M1.5 V	0.2806	2.92	3.56	11.63
		B				11.06	13.30	M3.5 V				
17	Epsilon Indi		Indus	22 03.4	–56 47	4.69	6.89	K5 Ve	0.2758	4.70	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	–15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	–44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	–17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten's Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

DEEP SKY OBJECTS

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 55	G	Scl	7.9	31.2	00 14.9	−39 11	10		A bright galaxy in the Sculptor Group
NGC 104	GC	Tuc	4.0	30	00 24.1	−72 05	10	1	47 Tucanae
NGC 205	G	And	8.1	19.5	00 40.4	+41 41	10	3,9	M110
NGC 221	G	And	8.1	8.5	00 42.7	+40 52	10	3,9	M32
NGC 224	G	And	3.4	189	00 42.7	+41 16	10	3,9	M31, Andromeda Galaxy
NGC 253	G	Scl	7.2	26.4	00 47.6	−25 18	10		Silver Coin galaxy. Large, bright edge-on spiral
SMC	G	Tuc	2.3	319	00 52.6	−72 48	10	1	Small Magellanic Cloud
NGC 288	GC	Scl	8.1	13.8	00 52.8	−26 35	10		Near galaxy NGC 253
NGC 346	BN	Tuc	10.3	5.2	00 59.1	−72 11	10		Nebula in the SMC
NGC 362	GC	Tuc	6.8	12.9	01 03.2	−70 51	11	1	
NGC 598	G	Tri	5.7	68.7	01 33.9	+30 39	11	3	M33, Triangulum Galaxy
NGC 628	G	Psc	9.4	10	01 36.7	+15 47	11	3	M74
NGC 891	G	And	9.9	13.1	02 22.6	+42 21	11		
NGC 1039	OC	Per	5.2	35	02 42.1	+42 47	11	3	M34
NGC 1068	G	Cet	8.9	7.3	02 42.7	−00 01	11	2	M77, Cetus A
NGC 1097	G	For	9.5	9.4	02 46.3	−30 17	11		
NGC 1261	GC	Hor	8.4	6.9	03 12.3	−55 13	12		
NGC 1269	G	Eri	8.5	9.7	03 17.3	−41 06	12		
NGC 1313	G	Ret	8.7	9.2	03 18.3	−66 30	12		
NGC 1316	G	For	8.5	11.2	03 22.7	−37 13	12		
NGC 1360	PN	For	9.4	360	03 33.2	−25 52	12		
NGC 1365	G	For	9.6	11	03 33.6	−36 08	12		
NGC 1399	G	For	9.6	6.6	03 38.5	−35 27	12		In Fornax galaxy group
Pleiades	OC	Tau	1.2	100	03 47.0	+24 07	12	3	M45, Contains Merope Nebula
NGC 1532	G	Eri	9.9	11.6	04 12.1	−32 52	12		
NGC 1535	PN	Eri	9.4	20	04 14.3	−12 44	12		
NGC 1553	G	Dor	9.4	5	04 16.2	−55 47	12		Near galaxy NGC 1549
NGC 1566	G	Dor	9.7	8.2	04 20.0	−54 56	12		
NGC 1808	G	Col	9.9	6.3	05 07.7	−37 31	1		Near galaxy NGC 1792
NGC 1851	GC	Col	7.1	11	05 14.1	−40 03	1		
LMC	G	Dor	0.4	550	05 23.6	−69 45	1	1	Large Magellanic Cloud
NGC 1904	GC	Lep	7.7	7.8	05 24.2	−24 31	1	2	M79, Rich and compressed, well resolved
NGC 1912	OC	Aur	6.4	21	05 28.7	+35 51	1	3,5	M38, 100 stars, magnitude 9.5 in splendid field
NGC 1952	BN	Tau	8.4	8	05 34.5	+22 01	1	5,3	M1, Crab Nebula
NGC 1976	BN	Ori	4.0	90	05 35.3	−05 23	1	2	M42, Orion Nebula
NGC 1982	BN	Ori	7.0	20	05 35.5	−05 16	1	2	M43, de Mairan's Nebula; part of Orion Nebula
NGC 1960	OC	Aur	6.0	12	05 36.3	+34 08	1	3,5	M36, 60 stars, magnitude 9 to 14
NGC 2070	BN	Dor	8.3	20	05 38.6	−69 06	1	1	Tarantula Nebula
NGC 2068	BN	Ori	8.0	8	05 46.8	+00 05	1	2,3	M78, Brightest and largest in group of four nebulae
NGC 2099	OC	Aur	5.6	24	05 52.3	+32 33	1	3,5	M37, 150 stars, magnitude 9 to 12.5
NGC 2168	OC	Gem	5.1	28	06 08.9	+24 21	1	3,5	M35, 200 stars, magnitude 9 to 16
NGC 2174	BN	Ori		40	06 09.4	+20 40	1		Near open cluster M35
NGC 2237	BN	Mon	5.5	80	06 30.9	+05 03	1		Rosette Nebula
NGC 2287	OC	CMa	4.5	38	06 46.0	−20 45	1	4	M41, 80 stars, magnitude 7 and fainter, with magnitude 6.9 red star near centre
NGC 2323	OC	Mon	5.9	16	07 02.5	−08 23	2	4	M50, Rich cluster, 80 stars magnitude 8 to 12
NGC 2362	OC	CMa	4.1	8	07 18.7	−24 57	2	4	Tau Canis Majoris
NGC 2392	PN	Gem	8.6	47	07 29.2	+20 55	2		Eskimo Nebula
NGC 2422	OC	Pup	4.4	30	07 36.6	−14 29	2	4	M47, Large coarse cluster with 30 stars

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 2438	PN	Pup	11.0	65	07 41.8	−14 44	2		In M46
NGC 2437	OC	Pup	6.1	27	07 41.8	−14 49	2	4	M46, Rich open cluster, 100 stars, planetary nebula NGC 2438 in same field
NGC 2440	PN	Pup	9.3	54	07 41.9	−18 13	2		
NGC 2447	OC	Pup	6.2	22	07 44.5	−23 51	2	4	M93, 80 stars magnitude 8 to 13
NGC 2477	OC	Pup	5.8	27	07 52.2	−38 32	2	4	160 stars, magnitude 10 to 12, central concentration
NGC 2467	BN	Pup	7.1	15	07 52.5	−26 26	2		Near open cluster M93
NGC 2516	OC	Car	3.8	21	07 58.1	−60 45	2	1	80 stars 6th mag. and fainter, central concentration
NGC 2547	OC	Vel	4.7	20	08 10.2	−49 12	2	4	Rich in stars with strong central concentration
NGC 2548	OC	Hya	5.8	54	08 13.7	−05 45	2	4	M48, Large cluster of 80 stars magnitude 8 to 13
NGC 2632	OC	Cnc	3.1	95	08 40.0	+19 40	2	5	M44, Beehive Cluster
NGC 2682	OC	Cnc	6.9	30	08 51.4	+11 49	2	5	M67, 200 stars magnitude 10 to 15, large and rich
NGC 2808	GC	Car	6.3	13.8	09 12.0	−64 52	3	1	Large and rich, compressed centre, mag. 13 to 15
NGC 2903	G	Leo	9.0	12	09 32.2	+21 30	3		
NGC 2997	G	Ant	9.4	9.2	09 45.6	−31 11	3		
NGC 3114	OC	Car	4.2	35	10 02.5	−60 08	3		Rich cluster, stars magnitude 9 to 14
NGC 3115	G	Sex	8.9	7.3	10 05.2	−07 43	3		
NGC 3132	PN	Vel	8.2	84	10 07.0	−40 26	3	4	Eight-burst Nebula
NGC 3201	GC	Vel	6.8	18.2	10 17.6	−46 25	3	4	
NGC 3242	PN	Hya	8.6	40	10 24.8	−18 39	3		Ghost of Jupiter
NGC 3293	OC	Car	4.7	40	10 35.8	−58 13	3	1	
NGC 3351	G	Leo	9.7	7.3	10 44.0	+11 42	3	5	M95
NGC 3372	BN	Car	3.0	120	10 45.1	−59 52	3	1	Eta Carinae
NGC 3368	G	Leo	9.3	7.8	10 46.8	+11 49	3	5	M96
NGC 3379	G	Leo	9.3	5.3	10 47.8	+12 35	3	5	M105, in group of three galaxies
NGC 3532	OC	Car	3.0	50	11 05.2	−58 44	4	1	Rich and large, 150 stars magnitude 7 to 12
NGC 3521	G	Leo	9.0	11.2	11 05.8	−00 02	4		
NGC 3623	G	Leo	9.3	9	11 18.9	+13 05	4	5	M65
NGC 3627	G	Leo	8.9	9.1	11 20.2	+13 00	4	5	M66
NGC 3628	G	Leo	9.5	13.1	11 20.3	+13 35	4		Near galaxies M65/66
NGC 3766	OC	Cen	5.3	12	11 36.2	−61 37	4	1	Rich cluster, 100 stars magnitude 7 to 12
IC 2948	BN	Cen	7.0	75	11 39.4	−63 28	4		Running Chicken Nebula
NGC 3918	PN	Cen	8.4	12	11 50.3	−57 11	4		
NGC 4192	G	Com	10.1	9.4	12 13.8	+14 54	4	7	M98
NGC 4216	G	Vir	10.0	7.8	12 15.9	+13 09	4		Edge-on galaxy
NGC 4254	G	Com	9.9	5.3	12 18.8	+14 25	4	7	M99
NGC 4258	G	CVn	8.4	17.4	12 19.0	+47 18	4	5,7	M106
NGC 4303	G	Vir	9.6	6.5	12 21.9	+04 28	4	6,7	M61
NGC 4321	G	Com	9.4	7.5	12 22.9	+15 49	4	7	M100
NGC 4361	PN	Crv	10.9	80	12 24.5	−18 47	4		
NGC 4374	G	Vir	9.1	6.7	12 25.1	+12 53	4	7	M84, Bright centre, in same field as M86
NGC 4382	G	Com	9.1	7.4	12 25.4	+18 11	4	7	M85
NGC 4406	G	Vir	8.9	9.8	12 26.2	+12 57	4	7	M86
NGC 4472	G	Vir	8.4	9.8	12 29.8	+08 00	4	7	M49
NGC 4486	G	Vir	8.6	8.7	12 30.8	+12 23	4	7	M87, Virgo A
NGC 4501	G	Com	9.6	6.8	12 32.0	+14 25	4	7	M88
NGC 4548	G	Com	10.1	5.2	12 35.4	+14 30	4	7	M91
NGC 4552	G	Vir	9.8	5.3	12 35.7	+12 33	4	7	M89
NGC 4565	G	Com	9.6	14.9	12 36.3	+25 59	4		

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 4569	G	Vir	9.5	9.9	12 36.8	+13 10	4	7	M90
NGC 4579	G	Vir	9.7	6	12 37.7	+11 49	4	7	M58, Bright diffuse nucleus, dark lanes
NGC 4590	GC	Hya	7.3	9.8	12 39.5	−26 45	4	6	M68, Rich and compressed
NGC 4594	G	Vir	8.0	8.6	12 40.0	−11 37	4	6	M104, Sombrero Galaxy
NGC 4621	G	Vir	9.6	5.3	12 42.0	+11 39	4	7	M59
NGC 4631	G	CVn	9.2	15.2	12 42.1	+32 32	4		Whale Galaxy
NGC 4649	G	Vir	8.8	7.6	12 43.7	+11 33	4	7	M60
NGC 4736	G	CVn	8.2	12.3	12 50.9	+41 07	4	5,7	M94
NGC 4755	OC	Cru	4.2	10	12 53.6	−60 21	4	1	Jewel Box
NGC 4826	G	Com	8.5	10.3	12 56.7	+21 41	4	7	M64, Black Eye Galaxy
NGC 4833	GC	Mus	8.4	13.5	12 59.6	−70 52	4		Near globular cluster NGC 4372
NGC 4945	G	Cen	8.6	19.8	13 05.4	−49 28	5	6	Big edge on spiral, small galaxy in same field
NGC 5024	GC	Com	7.7	14.4	13 12.9	+18 10	5	7	M53, Bright centre region, very compressed
NGC 5055	G	CVn	8.6	12.6	13 15.8	+42 02	5	5,7	M63, Sunflower Galaxy
NGC 5128	G	Cen	6.8	27.6	13 25.5	−43 01	5		Centaurus A (radio source)
NGC 5139	GC	Cen	3.9	36.3	13 26.8	−47 29	5	6	Omega Centauri
NGC 5194	G	CVn	8.4	10.8	13 29.9	+47 12	5	7	M51, Whirlpool Galaxy
NGC 5189	PN	Mus	10.3	140	13 33.5	−65 58	5	1	Dunlop’s best planetary nebula
NGC 5236	G	Hya	7.5	13.1	13 37.0	−29 52	5	6	M83, Southern Pinwheel Galaxy
NGC 5272	GC	CVn	6.3	18.6	13 42.2	+28 23	5	7	M3, Large bright globular, brightens suddenly towards the middle
NGC 5286	GC	Cen	7.4	9.1	13 46.4	−51 22	5		
IC 4406	PN	Lup	11.0	46	14 22.4	−44 09	5		Retina Nebula
NGC 5904	GC	Ser	5.7	19.9	15 18.6	+02 05	6	6	M5, Bright, large very compressed in middle, slightly oval in shape
NGC 5986	GC	Lup	7.6	9.8	15 46.1	−37 47	6		
NGC 6067	OC	Nor	5.6	13	16 13.2	−54 13	6	6	100 stars, large brightness range, central conc.
NGC 6093	GC	Sco	7.3	5.1	16 17.0	−22 59	6	6	M80, Strong central concentration, bright & large
NGC 6121	GC	Sco	5.4	26.3	16 23.6	−26 32	6	6	M4, Near Antares
NGC 6124	OC	Sco	5.8	29.0	16 25.3	−40 39	6	6	Near planetary nebula NGC 6153
NGC 6171	GC	Oph	7.8	3.3	16 32.5	−13 03	6	6	M107
NGC 6193	OC	Ara	5.2	15	16 41.3	−48 46	6		In nebula NGC 6188
NGC 6205	GC	Her	5.8	23.2	16 41.7	+36 28	6	7	M13, Great Hercules Cluster
NGC 6218	GC	Oph	6.1	14.5	16 47.2	−01 57	6	6	M12
NGC 6231	OC	Sco	2.6	15	16 54.2	−41 49	6	6	A few stars with strong central concentration
IC 4628	BN	Sco		90	16 57.0	−40 27	6		Prawn Nebula
NGC 6254	GC	Oph	6.6	12.2	16 57.1	−04 06	6	6	M10
NGC 6266	GC	Oph	6.4	14.1	17 01.2	−30 07	7	6	M62
NGC 6273	GC	Oph	6.8	5.3	17 02.6	−26 16	7	6	M19
NGC 6302	PN	Sco	9.7	72	17 13.7	−37 06	7		Bug Nebula
NGC 6341	GC	Her	6.5	11.2	17 17.1	+43 08	7	7,9	M92
NGC 6333	GC	Oph	7.9	5.5	17 19.2	−18 31	7	6	M9
NGC 6402	GC	Oph	7.6	6.7	17 37.6	−03 15	7	6,7	M14
NGC 6405	OC	Sco	4.2	20	17 40.3	−32 15	7	6,8	M6, Butterfly Cluster
NGC 6397	GC	Ara	5.3	25.7	17 40.7	−53 40	7	1,6	Loose structure, possibly the nearest globular
NGC 6441	GC	Sco	7.4	7.8	17 50.2	−37 03	7		
NGC 6475	OC	Sco	3.3	80	17 53.9	−34 48	7	6,8	M7, Ptolemy’s Cluster
NGC 6494	OC	Sgr	5.5	27	17 57.1	−18 59	7	6,8	M23, 150 stars, moderate brightness range, lies in good star field
NGC 6514	BN	Sgr	6.3	28	18 02.7	−22 58	7	6,8	M20, Trifid Nebula
NGC 6520	OC	Sgr	7.6	6	18 03.4	−27 53	7		Near Barnard 86
NGC 6523	BN	Sgr	5.0	45	18 03.7	−24 23	7	6,8	M8, Lagoon Nebula

Catalogue #	Type	Con	Mag	Size' (PN")	RA	Dec	Mth 10pm	Map	Notes
NGC 6531	OC	Sgr	5.9	13	18 04.2	−22 29	7	6,8	M21
NGC 6541	GC	Cra	6.3	13.1	18 08.0	−43 42	7	8	
NGC 6572	PN	Oph	8.0	15	18 12.1	+06 51	7		
NGC 6611	BN	Ser	6.0	7	18 18.8	−13 47	7	8	M16, Eagle Nebula
NGC 6613	OC	Sgr	6.9	9	18 19.9	−17 08	7	8	M18
NGC 6618	BN	Sgr	6.0	11	18 20.8	−16 11	7	8	M17, Swan Nebula
NGC 6626	GC	Sgr	6.9	15	18 24.5	−24 52	7	6,8	M28, Large, round, increasingly compressed in the middle
		Sgr	3	95	18 19	−18 10	7	6,8	M24, Small Sagittarius Star Cloud
NGC 6633	OC	Oph	4.6	27	18 27.3	+06 31	7		Near open cluster IC 4756
NGC 6637	GC	Sgr	7.7	7.1	18 31.4	−32 21	7	1,6,8	M69
IC 4725	OC	Sgr	4.6	29	18 31.8	−19 07	7	8	M25, 30 stars loosely scattered
NGC 6656	GC	Sgr	5.2	24	18 36.4	−23 54	7	8	M22, Fine globular, only Omega Centauri and 47 Tucanae are brighter
NGC 6681	GC	Sgr	7.8	7.8	18 43.2	−32 18	7	1,6,8	M70
NGC 6694	OC	Sct	8.0	15	18 45.2	−09 24	7	8	M26
NGC 6705	OC	Sct	5.8	14	18 51.1	−06 16	7	8	M11, Wild Duck Cluster
NGC 6720	PN	Lyr	9.4	86	18 53.6	+33 02	7	7,9	M57, Ring Nebula
NGC 6715	GC	Sgr	7.7	9.1	18 55.1	−30 29	7	8	M54
NGC 6723	GC	Sgr	6.8	11	18 59.6	−36 38	7		
NGC 6726	BN	CrA		2	19 01.7	−36 53	8		
NGC 6744	G	Pav	8.3	20.2	19 09.8	−63 51	8	1	
NGC 6752	GC	Pav	5.4	20.4	19 10.9	−59 59	8	1	Starfish Cluster
NGC 6779	GC	Lyr	8.3	5	19 16.6	+30 11	8	9	M56, Irregularly round, compressed in the middle
NGC 6809	GC	Sgr	6.3	19	19 40.0	−30 58	8	8	M55
NGC 6818	PN	Sgr	10.0	22	19 44.0	−14 09	8		Near galaxy NGC 6822
NGC 6838	GC	Sge	8.3	6.1	19 53.8	+18 47	8	9	M71
NGC 6853	PN	Vul	7.3	480	19 59.6	+22 43	8	9	M27, Dumbbell Nebula
NGC 6864	GC	Sgr	8.6	6	20 06.1	−21 55	8	8	M75
NGC 6913	OC	Cyg	6.6	7	20 23.9	+38 32	8	9	M29
NGC 6981	GC	Aqr	9.2	5.9	20 53.5	−12 32	8	8	M72
NGC 6992	BN	Cyg	7.0	60	20 56.4	+31 43	8		Part of Veil Nebula
NGC 7000	BN	Cyg	4.0	120	21 01.8	+44 12	9	9	North American Nebula
NGC 7009	PN	Aqr	8.3	28	21 04.2	−11 22	9		Saturn Nebula
NGC 7078	GC	Peg	6.4	12.3	21 30.0	+12 10	9	9	M15, Bright, irregularly round, well resolved into faint stars
NGC 7092	OC	Cyg	4.6	32	21 32.2	+48 26	9	9	M39, Northern limit
NGC 7089	GC	Aqr	6.5	11.7	21 33.5	−00 49	9	8	M2
NGC 7099	GC	Cap	6.9	8.9	21 40.4	−23 11	9	8	M30
NGC 7293	PN	Aqr	6.3	960	22 29.6	−20 50	9	8	Helix Nebula
NGC 7662	PN	And	8.6	17	23 25.9	+42 32	10		Snowball Nebula
NGC 7793	G	Scl	9.1	9.6	23 57.8	−32 36	10		

LEGEND

Catalog Catalogue number (NGC New General Catalogue, IC Index Catalogue)

Type Object type:
- G Galaxy
- GC Globular Cluster
- OC Open Cluster
- BN Bright Nebula
- PN Planetary Nebula

Con Constellation
Mag Magnitude of object
Size In arcminutes (PN in arcseconds)
RA Right Ascension (hh mm.m, Epoch 2000.0)
Dec Declination (° ', Epoch 2000.0)
Mth 10 pm Month the object is highest at 10 pm.
Map All Sky Map number
Notes Common name and/or description

RISE & SET TIME ADJUSTMENTS FOR OTHER LOCATIONS

The rise and set tables for the Sun, Moon and planets in Part II are given for our capital cities. Here we help people who live outside these cities to make adjustments to determine the rise and set times for their specific location. There are two adjustments needed.

1. Adjust for the difference in longitude. **For every degree of longitude east or west of Sydney, subtract or add respectively 4 minutes to both the rise and set times**. Adjustments for various towns and cities are given in Table 1.
2. Adjust for the difference in latitude, that also requires the declination for the object of interest. Table 2 presents these adjustments (southern latitudes are negative). Note, **for rise times you add these values, for set you subtract**. For your specific latitude it is normally sufficient to interpolate these figures.

It is important that rise and set times for Sydney are used, irrespective of which town in Australia the calculations are for, when using these tables. If your local time is CST, **subtract** 30 minutes, if WST, **subtract** 2 hours. If daylight saving, **add** 60 minutes. In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example Calculate the rise and set times for Jupiter on 8 April for Albury (36° 05'S, 146° 55'E)	**Rise**	**Set**
Rise and set values for Sydney (p. 119):	17:39	6:18
Adjust for longitude (Table 1) positive as Albury is west of Sydney.	+ :17	+ :17
Adjust for latitude and declination of Jupiter from Table 2. Jupiter's declination is –5° 36' (p. 119)	– :01	+ :01
Rise and set times for Albury are:	17:55	6:36

Table 1 **Longitude adjustments for some places relative to Sydney**

Location	Lat. (° ' S)	Longitude (° ' E)	Long. dif (dec. °)	correct. (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	31 57	141 27	9.8	39
Coffs Harbour	30 13	153 08	–1.9	–8
Dubbo	32 15	148 37	2.6	11
Goulburn	34 45	149 43	1.5	6
Katoomba	33 42	150 18	0.9	4
Newcastle	32 55	151 45	–0.5	–2
Parkes	33 05	148 10	3.1	12
Tamworth	31 03	151 02	0.2	1
Wagga Wagga	35 05	147 20	3.9	16
Wollongong	34 25	150 52	0.4	2
NORTHERN TERRITORY				
Alice Springs	23 42	133 56	17.3	69
Uluru	25 11	130 58	20.3	81
QUEENSLAND				
Bundaberg	24 52	152 21	–1.1	–4
Cairns	16 55	145 49	5.4	22
Longreach	23 22	144 09	7.1	28
Mackay	21 08	149 10	2.1	8
Mount Isa	20 38	139 28	11.8	47
Rockhampton	23 21	150 28	0.8	3
Surfers Paradise	28 00	153 26	–2.2	–9
Toowoomba	27 33	151 58	–0.7	–3
Townsville	19 10	146 49	4.4	18
SOUTH AUSTRALIA				
Port Augusta	32 30	137 52	13.4	54
Port Lincoln	34 42	135 59	15.3	61
Mount Gambier	37 41	140 49	10.4	42
Whyalla	33 02	137 34	13.7	55
TASMANIA				
Launceston	41 20	147 08	4.1	16
Stanley	40 40	145 08	6.1	24
VICTORIA				
Ballarat	37 25	143 55	7.3	29
Benalla	36 30	146 01	5.2	21
Bendigo	36 46	144 17	7.1	28
Geelong	38 09	144 10	7.1	28
Morwell	38 12	146 21	4.9	20
Shepparton	36 13	145 25	5.8	23
Swan Hill	35 13	143 30	7.8	31
Wangaratta	36 17	146 13	5.0	20
Warrnambool	38 27	142 30	8.8	35
WESTERN AUSTRALIA				
Albany	35 01	117 53	33.37	133
Broome	17 58	122 14	29.02	116
Bunbury	33 20	115 38	35.62	142
Carnarvon	24 53	113 40	37.58	150
Derby	17 19	123 38	27.62	110
Esperance	33 52	121 54	29.35	117
Eucla	31 41	128 53	22.37	89
Fitzroy Crossing	18 11	125 36	25.65	103
Geraldton	28 46	114 37	36.63	147
Kalgoorlie	30 45	121 28	29.78	119
Marble Bar	21 10	119 45	31.50	126
Meekatharra	26 36	118 28	32.78	131
Mount Barker	34 38	117 40	33.58	134
Mount Magnet	28 04	117 51	33.40	134
Mount Newman	23 19	119 45	31.50	126
Mount Tom Price	22 41	117 47	33.47	134
Norseman	32 12	121 47	29.47	118
Northam	31 39	116 40	34.58	138
Port Hedland	20 18	118 35	32.67	131
Rawlinna	31 01	125 20	25.92	104
Southern Cross	31 14	119 19	31.93	128
Wagin	33 19	117 20	33.92	136
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

Table 2 **Rise and set corrections for latitude and declination (from Sydney)**

Declination	South Latitude (negative) –12°	–14°	–16°	–18°	–20°	–22°	–24°	–26°	–28°	–30°	–32°	–34°	–36°	–38°	–40°	–42°	–44°
30°	–63	–58	–53	–48	–43	–37	–32	–26	–20	–13	–7	0	8	16	25	34	44
25°	–50	–46	–42	–38	–34	–30	–25	–20	–16	–11	–5	0	6	12	19	26	34
20°	–39	–36	–33	–29	–26	–23	–19	–16	–12	–8	–4	0	5	9	15	20	26
15°	–28	–26	–24	–22	–19	–17	–14	–11	–9	–6	–3	0	3	7	10	14	18
10°	–19	–17	–16	–14	–13	–11	–9	–7	–6	–4	–2	0	2	4	7	9	12
5°	–9	–8	–8	–7	–6	–5	–5	–4	–3	–2	–1	0	1	2	3	5	6
0°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
–5°	9	8	8	7	6	5	5	4	3	2	1	0	–1	–2	–3	–5	–6
–10°	19	17	16	14	13	11	9	7	6	4	2	0	–2	–4	–7	–9	–12
–15°	28	26	24	22	19	17	14	11	9	6	3	0	–3	–7	–10	–14	–18
–20°	39	36	33	29	26	23	19	16	12	8	4	0	–5	–9	–15	–20	–26
–25°	50	46	42	38	34	30	25	20	16	11	5	0	–6	–12	–19	–26	–34
–30°	63	58	53	48	43	37	32	26	20	13	7	0	–8	–16	–25	–34	–44

JULIAN DATE

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 10 hrs from EST, 9.5 hrs from CST or 8 hrs from WST, correcting the date if necessary. Next find the Julian date given in the table (below left) for the month you are interested in. Now add the day of the month. This will give you JD for 0 hr UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you need the Julian date at 23:00 EST on 17 July 2017. Subtract 10 hours to get UT.

23 – 10 = 13:00 hrs UT

From the table the JD for July 0 is 2457934.5

Add the day of month, 17 gives us 2457951.5

Now add the hours as a fraction of a day from the 2nd table. 13 hr is 0.542. Thus JD at 23:00 17 July 2017 EST is 2457952.042

Julian Date (0 hr UT)

Month		Julian Date
Jan	0	2457753.5
Feb	0	2457784.5
Mar	0	2457812.5
Apr	0	2457843.5
May	0	2457873.5
Jun	0	2457904.5
Jul	0	2457934.5
Aug	0	2457965.5
Sep	0	2457996.5
Oct	0	2458026.5
Nov	0	2458057.5
Dec	0	2458087.5

Hours as decimal of a day.

1	0.042	13	0.542
2	0.083	14	0.583
3	0.125	15	0.625
4	0.167	16	0.667
5	0.208	17	0.708
6	0.250	18	0.750
7	0.292	19	0.792
8	0.333	20	0.833
9	0.375	21	0.875
10	0.417	22	0.917
11	0.458	23	0.958
12	0.500	24	1.000

SIDEREAL TIME

Jan	0	6.6568	Jul	0	18.5503
Feb	0	8.6938	Aug	0	20.5873
Mar	0	10.5337	Sep	0	22.6243
Apr	0	12.5707	Oct	0	0.5956
May	0	14.5420	Nov	0	2.6326
Jun	0	16.5790	Dec	0	4.6039

Greenwich mean sidereal time (GMST) at 0 hr UT

Use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to UT. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day d of month at hour t UT

= GMST at 0 hr UT (from table above) + 0.06571 d + 1.00274 t

To convert to local mean sidereal time (LMST)

LMST = GMST + east longitude (or – west)

where longitude is expressed in HOURS (not degrees!) To convert to hours, just divide by 15.

Example: Find LMST at 23 hours Sydney time (EST) on the 17th July 2017.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5503 hours.

$$\begin{aligned} \text{GMST} &= 18.5503 + \\ &\quad (0.06571 \times 17) + \\ &\quad (1.00274 \times 13) \\ &= 32.7030 \end{aligned}$$

Sydney's longitude (151.25°) is 10.0833 hrs so

$$\begin{aligned} \text{LMST} &= 32.7030 + \\ &\quad 10.0833 \\ &= 42.7863 \end{aligned}$$

Subtract from this multiples of 24 until it is in the range of 0 to 24

42.7863 – 24 = 18.7863 hrs or 18 h 47 m 11 s

PLACES OF ASTRONOMICAL INTEREST

Following is a list of places of astronomical interest. These facilities cater to the public with tours and/or displays. Information is subject to change. Links to the websites here can be found on the Quasar site: www.quasarastronomy.com.au

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY RESEARCH FACILITY

They operate their 'Open Nights' public observatory tours on a regular basis. School groups and general public tours a speciality. They are also dedicated to meteorite research, and the meteorite collection is open by request. Information on tour dates and times can be found on the web site. They also have a Facebook page. Contact (02) 6337 3988, email <info@bathurstobservatory.com.au>.

Address: 624 Limekilns Road, Bathurst NSW 2795
Web www.bathurstobservatory.com.au

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The complex is located 35 km southwest of Canberra (Tourist Drive 5) and is a major link in NASA's Deep Space Network. Tidbinbilla sends and receives radio signals from distant spacecraft as they explore our Solar System and beyond. The centrepiece is the 70-metre antenna, the largest in Australia. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is an actual Moon rock. The MoonRock Cafe and gift shop is available for meals and souvenirs. Contact Korinne McDonnell (02) 6201 7809, (02) 6201 7838, email <pr@cdscc.nasa.gov>.

Address: Discovery Drive (off Paddy's River Rd), Tidbinbilla
Web www.cdscc.nasa.gov/
twitter.com/CanberraDSN

CRAGO OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (northwest of Sydney). It houses a 40 cm Dobsonian telescope. Due to a lack of local light pollution, the observatory enjoys the darkest sky in the Sydney region and is open on Saturday nights nearest to Last Quarter Moon. Visitors most welcome. Contact Paul Hatchman 0413 047 782, email <VP_Crago@asnsw.com>.

Address: Burralow Fire Trail, Bowen Mountain
Web www.asnsw.com/crago/index.html

CSIRO PARKES RADIO TELESCOPE

The famous Parkes Observatory, 'The Dish', is located 20 km north of Parkes (just off the Newell Highway). This landmark radio telescope is over 50 years old, but still considered to be one of the best single dish radio telescopes in the world. As well as a great view of the telescope, the visitors centre has displays and a 3D Theatre. There is also the Dish Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available. Contact (02) 6861 1777, email <VCStaff-PA@csiro.au>.

Address: CSIRO Parkes radio telescope, Newell Hwy
(PO Box 276), Parkes NSW 2870
Web www.csiro.au/parkes

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. Contact Mark Monk (02) 6345 1900, email <darbysob@gmail.com>.

Address: 23 Observatory Road, Darbys Falls, NSW 2793

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. An entertaining presentation with live images of the Moon and planets are projected in their theatrette, followed by viewing of the planets, stars, and galaxies through up to six telescopes including their large 17" planewave telescope. Bring your SLR camera to take astrophotos through the 17" scope. There is a gift shop full of astronomy books and an 18 hole themed mini golf course including Stonehenge and Dr Who's Tardis. Astronomy for beginners course are also conducted. Contact 0488 425 940.

Address: 17L Camp Rd, Dubbo NSW 2830
Web www.tenbyobservatory.com/dubbo_observatory

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The building houses 41 cm and 35 cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also run regular open nights for the general public. Contact secretary (voicemail) 0408 832 408, email <info@sasi.net.au>.

Address: Cnr Green Point & Caravan Head Roads,
Oyster Bay (PO Box 31, Sutherland NSW 1499)
Web www.sasi.net.au

LINDEN OBSERVATORY

WSAAG (Western Sydney Amateur Astronomy Group) holds observing Nights at Linden Observatory. These are usually held on Saturdays closest to the New Moon. Visits by members of the public are welcome but strictly by appointment only.
Email <enquiry@wsaag.org>.

Address: 105 Glossop Road, Linden NSW 2778
Web wsaag.org

MACQUARIE UNIVERSITY ASTRONOMICAL OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on various nights unless raining for several months during the year, check web site for dates and status. Astronomy students will guide you with a range of telescopes.

Address: Macquarie University via Culloden Rd
Web physics.mq.edu.au/community/observatory/

MACQUARIE UNIVERSITY PLANETARIUM

Their Digitarium Epsilon planetarium projector system and portable 7m GoDome (see also entry under Mobile Planetariums, page 148) also run public sessions during the month, in the early evening, see website for details. Bookings are essential.

Address: Dept of Physics, Macquarie Uni NSW 2109
Web physics.mq.edu.au/community/planetarium/

MUDGEE OBSERVATORY

Mudgee Observatory is located just outside the town of Mudgee NSW. A private observatory for the past ten years, it is now open to the general public, catering for school groups, organised tours and any member of the general public who wishes to attend. The observatory is situated 15 minutes drive west of Mudgee in a location with extremely dark skies away from the town lights and the lights of Ulan mines. The theatre and flat screen planetarium runs several features on the night sky and the Sun as well. A variety of telescopes and binoculars are available for visitors to use as well as conducted tours of the night sky. Bookings are essential. Contact (02) 6373 3431, 0428 560 039,
email <john@mudgeeobservatory.com.au>.

Address: 961 Old Grattai Rd Mudgee NSW 2850
Web www.mudgeeobservatory.com.au

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association Inc, is situated in Rotary Park (opposite Town Beach) Port Macquarie. Contact Kevin Gallagher,
email <pmobs50@gmail.com>.

Address: PO Box 1453, Port Macquarie NSW 2444
Web www.pmobs.org.au

SIDING SPRING OBSERVATORY

Siding Spring Observatory 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 3.9 metre Anglo-Australian Telescope and the 2.3 metre Advanced Technology Telescope. Organisations currently operating telescopes at Siding Spring include the Australian National University, the Australian Astronomical Observatory, the University of New South Wales, the University of North Carolina, Polish Academy of Sciences, Princeton University, iTelescope.Net, Korean Astronomy and Space Science Institute and the Las Cumbres Observatory Global Telescope Network. LCOGTN now have five telescopes operating at Siding Spring, a 2 metre, two advanced 1 metre telescopes and two 0.4 m telescopes, all of which are available for web based education and research work. iTelescope.Net have 20 telescopes housed at Siding Spring, and they operate a global network of telescopes available online to the public. The Australian National University's robotic survey telescope SkyMapper sits on the top of the Mountain, surveying the Southern Sky, while the remotely operated and robotic telescopes of the HAT-South network and Project Solaris search for planets around other stars. PROMPT, operated by UNC as part of SKYNET, searches the sky for Gamma Ray Bursts, the most powerful explosions in the universe, while the Korean Microlensing Telescope observes the faint flicker of objects moving between us and a faraway star, and there are still more telescopes to come. The Japanese Aerospace Exploration Agency (JAXA) are to arrive in 2017.

Siding Spring is nestled 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, morning and afternoon teas, souvenir shop and an astronomy exhibit with displays, 3D movies and much more. From the Visitor Centre, there is access to the viewing gallery of the 3.9 m Anglo-Australian Telescope and special tours of the site can be organised on request for school and other groups.

StarFest, a celebration of astronomy and the observatory is held on the long weekend in October in conjunction with the Warrumbungle Festival of the Stars. More information can be found at www.starfest.org.au. Contact Amanda Wherrett (Public enquiries and tour information, Outreach Officer) (02) 6842 6363, email <amanda.wherrett@anu.edu.au>.

Address: Observatory Rd, Coonabarabran NSW 2357
Web www.sidingspring.com.au

SYDNEY OBSERVATORY

This historic observatory is situated near The Rocks on Observatory Hill, overlooking Sydney Harbour. It offers a Space Theatre, Digital planetarium, daytime telescope tours, fascinating historic and interactive displays and night telescope tours (which include stargazing through the observatory's telescopes). The planetarium is also used during wet weather at night. Reconstruction of the astrographic East dome with fully accessible DFM telescope was completed and opened in March 2015. Day tours are either the Space theatre or a planetarium show with a dome tour and solar viewing (weather permitting). Sydney Observatory is part of the Museum of Applied Arts and Sciences. Contact (02) 9217 0111, email <observatory@phm.gov.au>.

Address: 1003 Upper Fort St, Millers Point NSW 2000
Web www.maas.museum/Sydney-observatory

THE AUSTRALIA TELESCOPE COMPACT ARRAY – NARRABRI

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22 m dishes, five of which are spaced along a 3 km track with the sixth a further 3 km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations.

Address: 1828 Yarrie Lake Road, Narrabri NSW 2390
Web www.narrabri.atnf.csiro.au

WARRUMBUNGLE OBSERVATORY

The observatory is located at Coonabarabran and is open to the public for night viewing through a number of telescopes. Visitors are encouraged to bring DSLR cameras (Canon, Nikon, Pentax) to take astrophotographs of star clusters, nebulae and galaxies. The observatory can be hired by the more serious amateur astronomer to take advantage of the 51 cm telescope and CCD for astrophotography and photometry. There are piers available for Meade and Celestron telescopes if amateurs wish to bring them along. The site also hosts remote observatories utilised by our Northern Hemisphere cousins and is part of the Sierra Stars Observatory Network providing quality data for customers around the world. Contact Peter Starr 0488 425 112, email <starr_peter@hotmail.com>.

Address: 841 Timor Rd, Coonabarabran NSW 2357
Web www.tenbyobservatory.com

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes the BlueScope Steel Planetarium, observatory, laser light shows, extensive interactive exhibits, demonstration theatre (South32 Science Theatre), and a gift and resource shop. The Planetarium has a Zeiss ZKP3 star projector, laser projector and a full-dome projection system. The observatory houses a high quality computer controlled telescope which is used to observe the Sun and stars. The Science Shop has one of the most extensive ranges of science educational materials in Australia, including telescopes. Contact (02) 4286 5000 (option 2), Fax (02) 4283 6665, email <science_centre@uow.edu.au>.

Address: Science Centre & Planetarium, Innovation Campus,
60 Squires Way, North Wollongong 2500
Web www.sciencecentre.com.au

QUEENSLAND

ALLOWAY OBSERVATORY

The observatory, situated approximately 6 km south of Bundaberg, is operated by the Bundaberg Astronomical Society. The 6 metre dome houses a 480 mm Newtonian telescope and a 12 inch Meade ACF telescope with CCD imaging using various astronomical cameras. The observatory opens to the public on Friday nights. Midweek opening also arranged for large groups. Contact Lonnie Smilas 0418 868 695, email <lonnie37@me.com>.

Address: PO Box 4221, South Bundaberg Qld 4670
Web alloway-observatory-bundaberg.webs.com

COSMOS CENTRE AND OBSERVATORY CHARLEVILLE

The public observatory is located on Cunnamulla Rd, near the Charleville airport. The Centre includes an observatory for night viewing of the stars and planets. There is a general observatory session available, Introduction to the Night Sky, Aboriginal Night Sky Stories or a 1.5 hr small and personalised session. Minimum numbers apply to all sessions

During the day the Sun Viewing sessions operate, using a solar telescope, Astronomy by Day includes a theatre presentation, seven interactive displays and two mini-talks—an update on dwarf planets and a meteorite talk where the collection is taken out of the cabinet for you to hold. Special programmes arranged for groups and schools. Bookings are essential for the Observatory, Small and Personal and Sun Viewing Sessions.
Contact (07) 4654 7771, email <enquires@cosmoscentre.com>.

Address: PO Box 63 Charleville 4470
Web www.cosmoscentre.com

KINGAROY OBSERVATORY

Kingaroy Observatory (formerly known as the Maidenwell Observatory) is now located in Geoff Raph Drive at the Kingaroy airport, a five minute drive from the town's CBD. Their night shows consist of a planetarium presentation of the skies in the 77 seat Star Theatre before stargazing session outside, under the dark, night skies. Once seated on the 45 seat Observation Deck, owner/operator/astronomer James Barclay, points out various constellations and stars with his registered green laser pointer, whilst giving an ongoing commentary of what you're looking at.

Night shows begin at 7 pm in the Autumn/Winter period and 7:30 pm during Spring and Summer. All shows run for two hours. They have three Meade LX200 GPS 14 inch telescopes on the observation deck. Minimum number for a night show is four adults or six pensioners.

They also conduct Day Shows where the Sun is projected from a Solar telescope and its colour video camera, onto a cinema screen in the air conditioned Star Theatre. You also get to see the latest astro videos. Night show dates and prices are listed on their website, bookings are essential. Contact (07) 4164 6194 or 0427 961 391, email <mao123@bigpond.com>.

Address: 45 Geoff Raph Drive, Taabinga, (Kingaroy airport) Qld 4610
Web www.kingaroyobservatory.com

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs presented in the Cosmic Skydome have various themes and are projected onto the interior of a 12.5 m dome. All shows include a current night sky tour recreated in the Skydome. The Planetarium is one of the most advanced and versatile planetariums in the Southern Hemisphere equipped with both a digital fulldome system and an optical star projector. The display areas contain astronomical and space items, while short videos and space news updates run in two small theatres. The shop has a wide range of astronomical and educational products, as well as souvenirs. The Planetarium observatory has a variety of telescopes and sessions must be pre-booked. School shows are also available during weekdays and are available to the public on a space-available basis. Contact (07) 3403 2578, email <bop@brisbane.qld.gov.au>.

Address: Brisbane Botanic Gardens Mt Coot-tha,
Mt Coot-tha Rd, Toowong Qld 4066
Web www.brisbane.qld.gov.au/planetarium/
www.facebook.com/BrisbanePlanetarium

SOUTH AUSTRALIA

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

Located in the heart of the northern Flinders Ranges, Arkaroola have a total of eleven Advanced Ecotourism accredited products including Ridgetop, Astronomy and Waterholes tours. There are also many guided and unguided bushwalks. They have three astronomical observatories offering two Celestron 360 mm and three Meade Maksutov-Cassegrain computer assisted telescopes. There are also spare piers and wedges suitable for BYO telescopes and astrophotography/CCD equipment. Contact (08) 8648 4848, Fax (08) 8648 4846, email <res@arkaroola.com.au>.

Address: Private Bag 106, Port Augusta SA 5710
Web www.arkaroola.com.au

STOCKPORT OBSERVATORY

Owned and operated by the Astronomical Society of South Australia (ASSA), the observatory is located in the small town of Stockport (6 km north-east of Hamley Bridge) approximately 80 km north of Adelaide. It provides a convenient astronomical facility away from the light pollution which surrounds Adelaide. Public star parties are held at Stockport in February, May, August and November. See web site for details. Contact ASSA Info Line (08) 8338 1231, email <observatories@assa.org.au>.

Address: Observatory Road, Stockport SA 5410
Web www.assa.org.au/facilities/stockport/

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury Heights, Adelaide. There are two main telescopes, 14" LX200ACF and research quality 12.5" RC OGS plus 60 mm and 40 mm Coronado solar scopes. Private bookings are accepted. Ph 8263 6244. Contact Andrew Cool, email <andrew@cool.id.au>.

Address: Brunel Drive, Modbury Heights
Web www.theheights.sa.edu.au/observatory.html
www.adelaideobservatory.org

UNIVERSITY OF SOUTH AUSTRALIA, ADELAIDE PLANETARIUM

The Adelaide Planetarium is open seven days a week by appointment for group and private bookings. Adult education courses are held throughout the year along with school holiday programs. General public sessions are held on the first and third Saturday of the month at 1 pm that combines a full dome movie with a condensed Night Sky session and a 2.45 pm one hour Night Sky Presentation session. Bookings essential. Contact (08) 8302 3138, email <adelaide.planetarium@unisa.edu.au>.

Address: University of South Australia, Building P,
Mawson Lakes Campus
Web www.unisa.edu.au/planetarium/

TASMANIA

LAUNCESTON PLANETARIUM

The Launceston Planetarium is at the Queen Victoria Museum's Inveresk site. See their web site for details of shows. Contact (03) 6323 3777.

Address: Queen Victoria Museum,
2 Invermay Road Launceston Tas 7250
Web www.qvmag.tas.gov.au

VICTORIA

ASTROTOURS SWINBURNE

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during school holidays. AstroTour sessions can also be booked for school groups (Years 3-12) throughout the year. Contact Dr Christopher Fluke (school group enquiries) (03) 9214 5828 or Elizabeth Thackray (bookings) (03) 9214 5569, email <astrotour@swin.edu.au>.

Address: The Virtual Reality theatre is located on the ground floor of the AR building in room AR104, Hawthorn campus, Swinburne University of Technology.
Web astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The observatory has several historic telescopes including the Jelbart (a 125 mm refractor), the Oddie (a 220 mm Newtonian), the Baker Great Equatorial Telescope (a 650 mm Newtonian, commissioned in 1886) and a 300 mm Newtonian. The Adcock-Federation telescope (406 mm Cassegrain-Springfield) has disabled-access. Observatory open Tuesday to Saturday. Bookings essential. See website for times and events. Astrotour 3D Movies are available in conjunction with Swinburne University of Technology. Contact open hours (03) 5332 7526 or after hours for bookings 0429 199 312, email <bas@cbl.com.au>.

Address: 439 Cobden Street, Mount Pleasant, Vic 3352
PO Box 284 Ballarat 3353
Web observatory.ballarat.net

BENDIGO PLANETARIUM @ DISCOVERY

Part of the Discovery Science and Technology Centre, see web site for details. Contact (03) 5444 4400, email <planetarium@discovery.asn.au>.

Address: Discovery Science and Technology Centre
7 Railway Place Bendigo

Web www.discovery.asn.au

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 150 and produces shows for all ages. The planetarium is open seven days a week from 10 am see website for details.

Address: 2 Booker St, Spotswood Vic 3015

Web museumvictoria.com.au/planetarium/

MOUNT BURNETT OBSERVATORY

Visitors are most welcome at MBO, individuals and families wanting to look through our telescopes can join in one of their Public Viewing Nights. These run approximately once a month subject to the weather. They are very popular and must be pre-booked. To enquire about the next available date or to book please email or phone. Contact Mount Burnett Observatory hotline 0490 130 153, email <info@mtburnettobservatory.org>.

Address: 420 Paternoster Road, Mt Burnett, VIC 3781

Web mtburnettobservatory.org/index.php/visit
www.facebook.com/MtBurnettObservatory

WESTERN AUSTRALIA

ASTRO TOURS OF THE KIMBERLEY

Broome's Astronomy Experience is a 2-hour educational and entertaining mind bender using big telescopes and lasers at an open bush site under dark skies. They operate in Broome from April to November running shows for the general public, schools, community and corporate groups six nights a week. Greg Quicke's Astro Tours is also a Facebook Page.
Contact Greg Quicke 0417 949 958, email <greg@astrotours.net>.

Address: PO Box 2537 Broome WA 6725

Web www.astrotours.net

GDC OBSERVATORY

The GDC Observatory is part of the Gravity Precinct and shares this special piece of pristine bushland with the Gravity Discovery Centre, AIGO research centre and the famous Zadko Telescope enable visitors to experience science in an extraordinary number of ways. The observatory boasts professional staff, a fully retractable roof, four state of the art telescopes plus the largest telescope for public viewing in WA. Add to this the WA dark skies gives visitors a world class astronomy experience. Special events such as our Monster Telescope Nights, Indigenous Astronomy Nights and their Specialised Astronomy Sessions. Located about an hours drive north of Perth, it's well away from any light pollution.
Contact (08) 9575 7577 (Office).

Address: 1098 Military Road, Yeal 6503

Web www.gravitycentre.com.au/observatory

THE SPACE PLACE OBSERVATORY & "TRAVELLING TELESCOPES"

The observatory moved from Gingin late 2015. See their web site for information.
Contact (08) 9574 2295, email <stars@thespaceplace.com.au>.

Address: 163 Howard Rd, Julimar WA 6567
PO Box 1216, Toodyay WA 6566

Web www.thespaceplace.com.au

PERTH OBSERVATORY

The Perth Observatory is situated in the Darling Ranges about 25 km east of Perth CBD and 15 minutes from the town of Kalamunda. The observatory is WA's oldest and has a long tradition of public outreach. This provides opportunities for a wide variety of night and daytime tours. The public outreach program is managed by the Perth Observatory Volunteer Group Inc on behalf of the Department of Parks and Wildlife. Tours can be booked online through their web site. Contact (08) 9293 8255, Fax (08) 9293 8138, email <info@perthobservatory.com.au>.

Address: 337 Walnut Road, Bickley WA 6076
End of Walnut Road in Bickley, WA,
15 minutes east of Kalamunda.

Web www.perthobservatory.com.au

EVENTS

AUSTRALIA

NATIONAL SCIENCE WEEK

Held in August each year, the aim of this week is a nationwide celebration of Australian science and has the objective 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 fascinated by the world we live in. Astronomy is always a key component, and amateur societies are ideally placed for such outreach. Support is available for event holders in each state and territory. See the web site for more information.

Web www.scienceweek.net.au

NEW SOUTH WALES

CWAS ASTROFEST

The CWAS AstroFest is sponsored by the Central West Astronomical Society and was first held in July 2004. 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 share their knowledge and experience in an exciting amateur astronomy festival. The CWAS AstroFest is held annually in July. Contact John Sarkissian (Local Organising Committee), email <astrofest@cwas.org.au>.

Address: CWAS AstroFest, PO Box 819 Parkes NSW 2870

Web www.cwas.org.au/astrofest/

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, telescopes operated by local amateurs and commercial stands. They are held once a year, normally in March–May (a Saturday night around First Quarter Moon). The venue is Macquarie University (off Epping Rd, North Ryde, Sydney), commencing around 6:30 pm. See website for details.

Address: Dept of Physics, Macquarie Uni NSW 2109

Web physics.mq.edu.au/community-schools/afa/opennight/

VICTORIA

NACAA

The National Australian Convention of Amateur Astronomers Inc was started in 1967 and since has become 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, and network amongst their peers throughout Australia and beyond. They are held over Easter every two years. The 28th NACAA will be held at Ballarat, 30 March–2 April 2018, hosted by the Ballaarat Astronomical Society.

Web www.nacaa.org.au

NEW SOUTH WALES

SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. This is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 300 people. Advance registrations required. See the society web site for more details. Email <president@asnsw.com>.

Web www.asnsw.com/node/712

QUEENSLAND

BAS MOON & PLANET TELESCOPE VIEWING NIGHTS

The Brisbane Astronomical Society (BAS) holds regular free public viewing nights at Mt Coot-tha Lookout on certain Saturdays nearest First Quarter Moon from 7–9 pm, check website for dates. Email <info@bas.asn.au>.

Address: Brisbane Astronomical Society Inc
PO Box 15892, City East Qld 4002

Web www.bas.asn.au/index.php/events/4-public-viewing-nights

QUEENSLAND ASTROFEST (DUCKADANG, QLD)

The Queensland Astrofest, rated in the Top Ten of the world's best astrocamps (BBC Sky at Night 2007), is held annually at the Lions Club Camp Duckadang, situated at Linville 160 km northwest of Brisbane. It has a dark sky with bunk house accommodation. They have rooms for families with young children and plenty of room for camping and caravans. There is 240 volt power available for telescopes. Catered meals are available twice a day (about $9 per meal) from the camp managers; self-catering facilities will be available.

Queensland Astrofest boasts a nine day format, Friday 18 to Sunday 27 August 2017. Each Saturday will have vendor sales and talks from major speakers. Workshops will be run each day covering various topics such as how to polar align, and colour balancing in Photoshop. The renowned Astro-Feast is held on the last Saturday night of the camp.

Entries for the Erwin van der Velden Photography Awards can be lodged any time, but if it is after the start of the camp, you will lose votes from earlier visitors. More details are on the Web site. Qld Astrofest is a great environment for exchanging ideas and techniques.

Registration opens April/May, early registration and payment is recommended. Cancellations with 100% refund less an administrative fee of $5 at least two weeks before the start, after that the amount refunded will be at the discretion of the committee depending upon the reason.

Contact registrar, email <registrar@qldastrofest.org.au>.

Address: Lions Camp Duckadang, 117 Avoca Creek Rd,
Linville Qld 4306

Web www.qldastrofest.org.au

URBAN OBSERVERS

The South East Queensland Astronomical Society holds free public viewing nights 'Urban Observers' at the Barrett Street Reserve, Bracken Ridge (entry off Jude St) on the first and third Sunday of each month (weather permitting). All welcome. Contact Julie Straayer (07) 3325 2479, email <urbanobs@seqas.org>.

Address: SEQAS, PO Box 60, Everton Park Qld 4053

Web www.seqas.org

VICTORIA

VASTROC (VIC)

Victorian Amateur Astronomical Societies' Conventions (VASTROC) are held every second year (alternating years with NACAA Conventions). Activities include speakers, workshops, poster displays, observing and the convention dinner. Mt Burnet Observatory are hosting the 2017 Vastroc and Mornington Peninsula Astronomical Society will host the 2019 one. More details on the VASTROC web site when available.

Web 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 the town of Nhill in western Victoria. Jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, it offers a great weekend of social, astronomical and observing activities. VicSouth 2016 is from Friday October 28 to Monday November 1 (cup weekend) while VicSouth 2017 is scheduled for Friday October 20 to Monday October 23. See website for more details.

Web www.vicsouth.info

ORGANISATIONS

AUSTRALIA

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia is the society of professional astronomers in Australia. It has a Society website and a second Australian Astronomy site providing links, both professional and amateur, and including links to educational material. Contact A/Prof. John O'Byrne, email <john.obyrne@sydney.edu.au>.

Web asa.astronomy.org.au ASA site
www.astronomy.org.au Australian Astronomy site

VARIABLE STARS SOUTH

VSS is an international association of astronomers, amateur and professional, interested in researching the rich and under-explored realm of southern variable stars. VSS covers most techniques of variable star research: visual observing with binoculars or telescopes, imaging with DSLRs and astronomical CCD cameras, and even spectrography. Its research work is project-oriented, often involving professional/amateur collaboration. VSS is directed by Stan Walker of Awanui, New Zealand, but its 'home' is its website, visit it for further information and contacts.

Email <director@variablestarssouth.org>.

Web www.variablestarssouth.org

COURSES

NEW SOUTH WALES

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is a nine week course conducted by Sutherland Astronomical Society Inc (SASI). Each lecture is followed by observations with the society's equipment (weather permitting). Refer to website for course dates. Contact the Education Officer 0422 902 730, email <info@sasi.net.au>.

Address: Green Point Observatory (Sutherland, Sydney)

Web www.sasi.net.au

SYDNEY UNIVERSITY ASTRONOMY COURSES

The University of Sydney Centre for Continuing Education runs regular astronomy courses on the main Sydney University campus, with occasional bus tours to NSW observatories. See website for more information.

Web www.physics.usyd.edu.au/about/cep.shtml

TASMANIA

NIGHT SKY EXPLORER COURSE (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Mt. Pleasant site, usually twice a year in March/April and October/

November; six hours total (two by three hour sessions). Contact Richard Grudzien 0400 585 037, email <regulus1951@gmail.com>.
Address: Mt. Pleasant
Web ast.n3.net

VICTORIA

ASTRONOMY PUBLIC LECTURES

The Centre for Astrophysics & Supercomputing have free public lectures on astronomy at the Hawthorn campus of Swinburne University of Technology. See web site for details.
Web astronomy.swin.edu.au/outreach/?topic=freelectures

MOBILE PLANETARIUMS

NEW SOUTH WALES

MACQUARIE UNIVERSITY PLANETARIUM

Their Digitarium Epsilon planetarium projector system and portable 7m GoDome is available, by arrangement, for groups of up to 50 people per session. The planetarium simulates the night sky, including special events such as the transit of Venus or an eclipse of the sun. It allows an up-close look at the motions of celestial objects, the surfaces of planets, deep sky objects, and constellations. You can take a tour of the local Solar System, peer into the depths of the galaxy, or watch amazing new planetarium movies. Presentations can be tailored to the interests and age of your groups.
Address: Dept of Physics, Macquarie Uni NSW 2109
Web physics.mq.edu.au/community/planetarium/

SKYWORKS PLANETARIUM

Skyworks Planetarium is a multi award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. Since starting in 2000, Skyworks has become the most active planetarium in greater Sydney. Programs are curriculum based to suit years K-12. Contact Geoff & Diana Zenner (02) 9610 2899, 0419 112 899, Fax (02) 9753 1898, email <info@skyworks.net.au>.
Web www.skyworks.net.au

QUEENSLAND

STARLAB EDUCATION

Starlab Education provides astronomy and earth science presentations throughout Queensland. Fully trained presenters visit your school or venue with a 'Cosmodome Science Theatre & Planetarium' or a 'Starlab Planetarium' to provide educational programs tailored to suit your level of interest and understanding. Contact Paul Tickner 0417 394 354, email <info@starlab.net.au>.
Address: PO Box 1656, Noosaville BC QLD 4566
Web www.starlab.net.au

RESOURCES

AUSTRALIA

AUSTRALIAN SKY & TELESCOPE MAGAZINE

Australian Sky & Telescope is a world-class magazine about the science and hobby of astronomy. Combining the formidable worldwide resources of its venerable parent magazine with the talents of the best science writers and photographers in Australia, Australian Sky & Telescope is a magazine produced specifically for Southern Hemisphere astronomers.

Consistently delivering the latest news and developments in astronomy eight times a year, Australian Sky & Telescope caters for everyone with an interest in space and astronomy, from the absolute beginner looking to buy their first telescope to the seasoned observer wanting to expand their collection of equipment or acquire new skills.

With its thorough equipment reviews, detailed sky maps, up-to-date news, and knowledgeable advice on observing the southern skies, Australian Sky & Telescope is a powerful source of inspiration to get out and see the wonders of the universe. Contact (02) 9439 1955, Fax (02) 9439 1977, email <info@skyandtelescope.com.au>.
Address: PO Box 81 St Leonards NSW 1590
Web www.skyandtelescope.com.au

ICEINSPACE

IceInSpace is a community Web site dedicated to promoting amateur astronomy in the Southern Hemisphere. They aim to help stargazers from around the world discover, discuss and enjoy the beauty of our 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 on the IceInSpace Forum, communicate privately with other members (PM), respond to polls, upload content and images and access many other special features. IceInSpace is eight years old and is the largest and most active astronomy community in the southern hemisphere, with over 13,500 members.
Contact Mike Salway, email <mike@iceinspace.com.au>.
Address: PO Box 9127, Wyoming NSW 2250
Web www.iceinspace.com.au

WESTERN AUSTRALIA

ASTRONOMY EDUCATION SERVICES

Resource Astronomy Education Services AES grew from over 16 years experience at places like the Perth Observatory, Edith Cowan University School of Science and now, managing the GDC Observatory in Gingin. Their activities include day presentations with safe viewing of the Sun (for students of any age) and Astronomy Field Nights with telescopes. AES also conduct public astronomy and astrophotography courses at various institutions. See their web site and FaceBook Page for more details. Contact Richard Tonello 0417 961 357, email <richard@astro-ed-services.com>.
Address: PO Box 271, Dianella WA 6059
Web www.astro-ed-services.com

STARGAZERS CLUB

Stargazers Club holds special events and sends regular news that includes information on stargazing and astronomy for beginners. See website for costs and details. Contact Carol 0427 554 035, email <info@stargazersclubwa.com.au>.
Web www.stargazersclubwa.com.au

ASTRONOMICAL SOCIETIES

The following is a list of amateur societies in Australia. A common philosophy within these organisations is the emphasis they place on public education. Enquires from anyone are most welcome, as are visitors to most meetings. Most societies now have websites, links to these can be found on the Quasar website:
www.quasarastronomy.com.au/society.htm

NEW SOUTH WALES & ACT

ASTRONOMICAL SOCIETY OF ALBURY WODONGA meets regularly on the first Wednesday of each month (except January) at La Trobe University, Wodonga at 7 pm.
Contact David Thurley (02) 6040 3704 <enquiries@asaw.org.au>.
PO Box 1500, Lavington NSW 2641 www.asaw.org.au

ASTRONOMICAL SOCIETY OF NSW meets twice per lunar month where professional and amateur astronomers are invited to talk. See their website for details. Contact <president@asnsw.com>.

PO Box 870, Epping NSW 1710 www.asnsw.com

ASTRONOMICAL SOCIETY OF THE HUNTER meets at The Billabong Restaurant, East Maitland Bowling Club on the 1st Friday each even month at 6:30 PM. Contact Col Maybury (02) 4937 4664 or 0427 889 653 <cma45714@bigpond.net.au>.

21 Brooks St, Kurri Kurri NSW 2327

CANBERRA ASTRONOMICAL SOCIETY meetings are held on the 3rd Thursday of each month except June and December starting at 8 pm. An Introductory meeting begins one hour before the main meeting. The venue is usually the Duffield Lecture Theatre, Mt. Stromlo Observatory, Weston, ACT.
Contact Fay Neil (02) 6231 0851 <casadmin@gmail.com>.

PO Box 1338, Woden ACT 2606 casastronomy.org.au

CENTRAL WEST ASTRONOMICAL SOCIETY INC (PARKES) meetings are held on the first Friday of the month except January, at the Parkes Observatory Visitors Centre, commencing 7:30 pm, visitors welcome. Contact Secretary <secretary@cwas.org.au>.

PO Box 819, Parkes NSW 2870 www.cwas.org.au

CLARENCE VALLEY ASTRONOMICAL SOCIETY Contact Steve Fletcher (02) 6643 3288 <arrowdodgerfletch@hotmail.com>.

97 Skinner St, South Grafton NSW 2460

COFFS HARBOUR ASTRONOMICAL SOCIETY INC meets on the first Monday of each month (except January) at 7 pm at the Boambee East Community Centre, cnr. Bruce King Drive and Pacific Highway, Boambee East. Contact Win Howard (02) 6653 2742 <winhoward@iprimus.com.au>.

ILLAWARRA ASTRONOMICAL SOCIETY

Contact <wanglese@bigpond.net.au>.

PO Box 1814, Wollongong NSW 2500

illawarraastronomicalsociety.hostoi.com

MACARTHUR ASTRONOMICAL SOCIETY meet in Campbelltown, NSW, on the 3rd Monday of the month (Jan-Nov), with guest speakers and workshops. They also schedule three dark-sky observing nights per month. Contact <contact@macastro.org.au>.

PO Box 17, Minto NSW 2566 www.macastro.org.au

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC meets at St Ignatius College at Lane Cove third Tuesday of every month, runs a course each year for New Astronomer's Group on the fourth Tuesday of the month, and conducts regular observing nights at Terrey Hills. Contact <nsas@nsas.org.au>.

PO Box 56, Lane Cove NSW 1595 www.nsas.org.au

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC members meetings are held once a month, contact them for dates. Contact Kevin Gallagher (President) <pmobs50@gmail.com>.

PO Box 1453, Port Macquarie NSW 2444 www.pmobs.org.au

SHOALHAVEN ASTRONOMERS meet at the University Of Wollongong, ShoalHaven Campus, Library and Resources Centre, Seminar Room LG.25 on the third Friday of the month at 7 for 7:30 pm. Contact Jack Apfelbaum (Pres.) (02) 4423 2255

PO Box 1053, Nowra NSW 2541 www.shoalhavenastronomers.asn.au

SUTHERLAND ASTRONOMICAL SOCIETY meets every Thursday at 7:30 pm at the Green Point Observatory near Sutherland, with the main meeting and guest speaker on the 1st Thursdays. Junior Section meets 2nd Thursdays Feb–Nov at 6:30 pm.
Contact Secretary 0408 832 408 (voicemail) <info@sasi.net.au>.

PO Box 31, Sutherland NSW 1499 www.sasi.net.au

SYDNEY CITY SKYWATCHERS meet at Sydney Observatory on the first Monday of the month (except January) at 6:30 pm. Contact Secretary, Elizabeth (02) 9398 9705 <president@sydneycityskywatchers.asn.au>.

Sydney Observatory, 1003 Upper Fort St, Millers Point NSW 2000

www.sydneycityskywatchers.asn.au

THE NEWCASTLE ASTRONOMICAL SOCIETY meetings are held on the first Friday each month (except January), at the University of Newcastle, Lecture Theatre GP 2.1 (room 1, 2nd floor) of Linguistics Building at 7:30 pm. Contact NAS president Dr Richard Brown 0407 302 162 <moreinfo@nas.org.au>.

c/- Dept. Physics, University of Newcastle Callaghan NSW 2308

www.nas.org.au

UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY meetings are held once per month at the Kirby Observatory on Wednesday evenings close to New Moon at 7 for 7:30 pm.
Contact Anne Parnell (02) 6772 1958 <parnellansw@gmail.com>.

Ms Anne Parnell, 81 Perrott St Armidale NSW 2350

www.unentas.org.au

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC meets at 7:30 pm on the 3rd Wednesday of the month at Penrith Observatory, Western Sydney University, Werrington Campus. Hear Interesting guest speakers and attend Astronomy Workshops.
Contact <enquiry@wsaag.org>.

PO Box 400, Kingswood NSW 2747 wsaag.org

WOLLONGONG AMATEUR ASTRONOMY CLUB has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra. Visitors are most welcome to attend. Contact Jeff Pountney (02) 4283 4486 or Warren Norrie (02) 4234 2371

waacers.createmybb3.com

NORTHERN TERRITORY

GOVE AMATEUR ASTRONOMERS meets as advised for viewing nights on a Saturday close to the New Moon at a local dark sky site. Their nights are announced on their Facebook page.

www.facebook.com/GoveAstronomers

QUEENSLAND

ASTRONOMICAL ASSOCIATION OF QUEENSLAND meetings in 2017 will be on nominated Saturdays each month from February to December. The normal venue is Lecture Theatre 222, the Parnell Building (School of Maths and Physics), located on the south side of the Great Court, The University of Queensland, St Lucia Campus. Meetings generally commence at 4 pm. Dates of meetings and further details are published on their website. Contact the General Secretary via the ‘email us’ link on the Contact page of their web site.

PO Box 6101, St Lucia Qld 4067 www.aaq.org.au

BRISBANE ASTRONOMICAL SOCIETY hold meetings each month except January, see their web site for meeting night details. Contact Chris Landman 0419 861 689 <President@bas.asn.au>.

PO Box 15892, City East Qld 4002 www.bas.asn.au

BUNDABERG ASTRONOMICAL SOCIETY meetings are held at Alloway Observatory every Friday at 7:30 pm. The second Friday of the month are general meetings and are not held in January. Contact Lonnie Smilas 0418 868 695 <lonnie37@me.com>.

PO Box 4221, South Bundaberg Qld 4670

alloway-observatory-bundaberg.webs.com

FNQ ASTRONOMERS GROUP meet periodically in the Cairns region (Far North Qld) in conjunction with astronomical events as advised on the FaceBook Page. Contact Ian Maclean 0417 601490

www.facebook.com/FNQAstronomers

MOUNT ISA ASTRONOMY GROUP meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17 km outside of Mount Isa). Meetings are held monthly, usually the Saturday preceding New Moon. Contact Len Fulham (07) 0437 833 331 (AH), (07) 4743 2955 (W) <lfulham@tpgi.com.au>.

PO Box 1556, Mount Isa Qld 4825

REDLANDS ASTRONOMICAL SOCIETY meets on the second Tuesday of the month at Ormiston College, Ormiston (27 km SE of Brisbane), see web site for details. Contact President: Chris Tacke 0410 444 702 <redlandsastronomicalsociety@gmail.com>.

PO Box 2048, Wellington Point Qld 4160 www.ras.org.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY meets third Tuesday of the month at Bracken Ridge Library from January to November. Meetings commence at 7:30 pm. Contact Julie Straayer (07) 3325 2479 <juliestraayer@hotmail.com>.

PO Box 60, Everton Park Qld 4053 www.seqas.org

SOUTHERN ASTRONOMICAL SOCIETY has monthly meetings at The Pimpama Space Flight Academy, 1 Pimpama-Jacobs Well Road, Pimpama QLD 4209. Contact Joe Zerafa 0421 866 376

PO Box 867, Beenleigh Qld 4207 www.sas.org.au

TOWNSVILLE ASTRONOMY GROUP INC holds a weekly public viewing at the Strand in Townsville. In addition there is a monthly viewing at a dark site further inland, usually on the Saturday closest to New Moon. Details and updates can be found on their website and in their Facebook group. Contact Bob Bartlett 0407 747 297 <info@astronomytsv.org.au>. www.astronomytsv.org.au

WIDE BAY ASTRONOMICAL SOCIETY meet at 7 pm Wednesday nights at the University of Sunshine Coast, Pialba, two weeks after our monthly dark sky viewing nights in Takura (see website for details).
Contact Joe Mather 0477 194 277 <president@wbastro.org>.

President, Wide Bay Astronomical Society
Unit 88 34-56 Elizabeth Street, Urangan Qld 4655 www.wbastro.org

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA meetings are held on the 1st Wednesday each month (except January) at the University of Adelaide, North Terrace Campus.
Contact <secretary@assa.org.au>.

GPO Box 199, Adelaide SA 5001 www.assa.org.au

"TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA has general meetings at the Rosny LINC, Bligh St, Rosny Park on the last Tuesday each month except December.
Contact Hobart – Steve Harvey 0419 341 469,
Launceston – Michael Booth 0408 240 576,
Devonport – Peter Sayers (03) 6424 2588 or secretary,
Brian Garland <ingridbrian@iice.net.au.>.

GPO Box 1654, Hobart Tas 7001 ast.n3.net

VICTORIA

ASTRONOMICAL SOCIETY OF VICTORIA has monthly meetings, held at 8 pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. ASV has 18 specialist sections that also hold regular meetings. Contact Linda Mockridge (Public Relations Officer) (03) 9888 7130

GPO Box 1059, Melbourne Vic 3001 www.asv.org.au

ASTRONOMY BENALLA meets on the third Wednesday of each month at 7:30 pm at Benalla Hockey Club Room, Churchill Park, Waller St Benalla.
Contact Jeff Knight (President) (03) 5762 5429 or 0407 532 674

128 Cowan St, Benalla Vic 3672 www.astronomybenalla.org.au

BALLAARAT ASTRONOMICAL SOCIETY holds bi-monthly general meetings, 2nd Friday of the month, beginning in February.
Contact 0429 199 312 <bas@cbl.com.au>.

PO Box 284, Ballarat Vic 3353 observatory.ballarat.net

BENDIGO DISTRICT ASTRONOMICAL SOCIETY arranges Astronomy and Science Presentations at the Discovery Centre, Bendigo, 7:30 pm, on the first Wednesday of each month. Contact president Michael Goodwin 0448 402 032 <president@bdas.net>.

PO Box 164, Bendigo Vic 3552 www.bdas.net

BRIGHT ASTRONOMY CLUB INC is small group who meet at the Porepunkah airfield once a month or on special astronomical events and outreach works. Contact president Zachary 0438 863 739, secretary Rob <rob.kau@gmail.com> or treasurer Sean 0411 797 714 <brightastronomyclub@gmail.com>.
brightastronomy.webs.com/

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND meetings are held at Bairnsdale and Perry Bridge. Dark sky site near Bairnsdale airport. Contact Mike Finn (03) 5153 2802, 0422 904 238 <mikef1@iprimus.com.au>.

53 Riley St, Bairnsdale Vic 3875

LATROBE VALLEY ASTRONOMICAL SOCIETY meets on the second Tuesday each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers; call for details. Contact John Sunderland (03) 5122 3014 <info@LVastro.org>.

PO Box 459, Moe Vic 3825 www.LVastro.org

MORNINGTON PENINSULA ASTRONOMICAL SOCIETY meetings are held on the 3rd Wednesday of each month (except December) at 8 pm, at the modern senior school theatrette, Building T, Peninsula School, Wooralla Drive, Mt Eliza.
Contact Peter Skilton 0419 253 252 <welcome@mpas.asn.au>.

PO Box 596, Frankston Vic 3199 www.mpas.asn.au

MOUNT BURNETT ASTRONOMICAL SOCIETY is open for members every Friday night from 7:30 pm.
Contact Mount Burnett Observatory hotline 0490 130 153 <info@mtburnettobservatory.org>.

420 Paternoster Road, Mt Burnett, VIC 3781 mtburnettobservatory.org

SNAKE VALLEY ASTRONOMICAL ASSOCIATION meet and observe at the SVAA Clubroom at 825 Linton-Carngham Rd Snake Valley on the closest Friday to the New Moon each month.

c/o Snake Valley Post Office, Snake Valley Vic 3351
ballaratman.wix.com/svaa

WEST AUSTRALIA

ASTRONOMICAL SOCIETY OF WESTERN AUSTRALIA meets at 8 pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como. Visitors most welcome. Contact <aswa@aswa.info>.

PO Box 421, Subiaco WA 6904 aswa.info

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. A perfectly reflecting body has an albedo of 1.0 or 100%. The average lunar albedo is 0.12 or 12%.

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

Almanac A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an ***Ephemeris***.

Altazimuth coordinates The angular height (***altitude***) of an object above or below the horizon and its angular direction (***azimuth***) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a body most distant from the Sun. It is the opposite to ***perihelion***.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to ***perigee.***

Arcminute An angular measure (each degree is divided into 60 arcminutes).

Arcsecond An angular measure. Each degree contains 3600 arcseconds, and each ***arcminute*** contains 60 arcseconds.

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See ***Minor Planet***.

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 au.

Azimuth Horizontal coordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the ***celestial sphere***.

Celestial poles Points on the ***celestial sphere*** directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth to which celestial bodies seem to be attached.

Circumpolar Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** it must have to be considered circumpolar.

Colour index The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a ***comet***, usually the brightest part. Also a defect in an optical system.

Comet Small icy body that orbits the Sun and produces a coma and often tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least ***angular separation*** as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

Conjunction — Inferior When an ***inferior planet*** (Mercury or Venus) passes between the Sun and the Earth.

Conjunction — Superior When the Earth and an ***inferior planet*** (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the Universe.

CST Central Standard Time.

Culmination The instant when a celestial body crosses the ***meridian***; an object culminates when it reaches its highest point above the observer's horizon.

Declination (Dec) One part of the equatorial coordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (–) of the ***celestial equator*** and is analogous to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how long or thin an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

Eclipse When one object passes in front of or into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the ***umbra***, and penumbral if the Moon passes only through the ***penumbra*** of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. It is total when the Moon has a larger ***angular diameter*** than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

Ecliptic The plane of the Earth's orbit projected onto the ***celestial sphere***. It can also be defined as the Sun's path against the stars.

Ellipse An oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

Elongation The ***angular separation*** of two bodies. The greatest elongations of Mercury and Venus occur when the planets are at their largest angular distance from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all coordinate data and is compatible with modern star atlases.

Equation of Time The difference between apparent and mean solar time.

Equinox The two times of the year when the Sun crosses the ***celestial equator***; vernal or spring equinox occurs about September 21, and autumnal equinox about March 22.

EST Eastern Standard Time.

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our ***galaxy***.

Galaxy A large disc or ball of billions of stars and ***nebulae***. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between First and Last Quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our ***galaxy*** and are seen in other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local ***meridian***.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually in reference to the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is, Mercury or Venus.

Julian date The number of days since noon on 1 January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the ***constellation*** of Dorado. From mid-southern latitudes the LMC is ***circumpolar***.

Librations The gentle rocking motion of the Moon as it orbits the Earth that allows observation of the side that normally faces away from our planet. In total, through this irregular motion fifty-nine percent of the Moon can be seen.

Light year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.5. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude –1 (except for the Sun which is –26.7). The faintest visible to the unaided eye are magnitude 6 (under dark skies).

Magnitude — absolute The magnitude a star would have if it were viewed from a distance of 10 ***parsecs*** (32.6 ***light years***).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The ***right ascension*** on the meridian equals local ***sidereal*** time.

Meteor (also shooting or falling star***)*** A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of ***meteors*** that appear to originate from a small region of the sky (the radiant).

Meteor swarm (or ***stream***) ***Meteoroids*** grouped in a localised region in orbit around the Sun (the source of ***meteor showers***).

Meteorite A ***meteor*** that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet (***Asteroid***) Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Nadir The point on the ***celestial sphere*** directly opposite the ***zenith.***

Nebula A cloud of interstellar gas and dust. See also ***emission, reflection*** and ***planetary nebula.***

Node One of two points at which an orbit passes through a reference plane (usually the ***ecliptic***).

Oblateness The ratio of the difference of equatorial and polar radii to equatorial radius.

Obliquity The degree of inclination (or tilt) of a planet's equator to its orbital plane.

Occultation The disappearance of one celestial body behind another.

Open star cluster A loose grouping of stars numbering from a few dozen to hundreds.

Opposition When a celestial body is opposite the Sun in the sky as viewed from Earth.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 ***light years***. A parsec is defined as the distance to a celestial body whose ***parallax*** is one arcsecond.

Penumbra Area of partial illumination in the shadow of a planet surrounding the ***Umbra***. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth. It is opposite to ***apogee.***

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to ***aphelion***.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. The outer layers of a red giant during the latter stages of its evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

Quadrature When two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

Reflection nebula A gas cloud illuminated by a nearby star.

Retrograde motion 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.

2. Apparent retrograde motion is the westward motion of a planet with respect to the stars. This occurs near ***opposition*** for the outer planets and near ***inferior conjunction*** for the inner planets.

Right ascension (RA) Part of the equatorial coordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is analogous to lines of longitude on the Earth but is measured in hours (24 hrs = 360°).

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23 hrs 56 m 4 s.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is ***circumpolar***.

Solstice The time when the Sun is farthest from the ***celestial equator***. In the Southern Hemisphere around 21 June marks the shortest day of the year, and around 21 December marks the longest day.

Spectral type A star's spectral classification determined by its ***spectrum***.

Spectrum The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The time that it takes for an object to reappear at the same point in the sky, relative to the Sun, as observed from Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the ***meridian***.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight — astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight — civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight — nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time (UT) A time system measured from the Meridian of Greenwich in England.

WST Western Standard Time.

Zenith The point directly overhead (90° in altitude).

Zenith Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the ***zenith*** with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the ***ecliptic*** (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

GREEK ALPHABET

α	Alpha	ε	Epsilon	ι	Iota	ν	Nu	ρ	Rho	φ	Phi
β	Beta	ζ	Zeta	κ	Kappa	ξ	Xi	σ	Sigma	χ	Chi
γ	Gamma	η	Eta	λ	Lambda	ο	Omicron	τ	Tau	ψ	Psi
δ	Delta	θ	Theta	μ	Mu	π	Pi	υ	Upsilon	ω	Omega

INDEX

Step outside and look up at the night sky. We are fortunate to live in Australia, where the stars of the Southern Hemisphere are spectacular. Does it leave you with a sense of wonder, wanting to know more about the heavens above? Then this book is for you.

Whatever your level of interest this publication has much to offer. Even if you are a beginner just starting your astronomical voyage, using nothing but your eyes, let this be your guide to:

What is that bright star?

Which constellation is that?

Which planet is that moving against the star field?

When will the Moon rise or set?

Astronomy 2017 includes all the regular features people have come to depend on from this book series over the years, including:

Beginner friendly Moon Maps

Amateur Astronomical societies

Observatories open to the public

The best times to observe the planets

Where to find the brighter comets for the year

Easy to use star maps, designed for Australia

When and where to look for shooting stars

Easy to read monthly rise and set charts

Drawings to easily identify the planets and stars

From its humble beginnings in 1990 to the splendid edition you hold today, this Yearbook has always been the outstanding Australian guide to the night sky. It's the perfect reference for newcomers and seasoned observers alike.

Fred Watson
Australian Astronomical Observatory

Quasar Publishing has been producing yearbooks since 1991. Astronomy 2017, the 27th edition, continues with the high standard established over the years. The authors have many years experience in observational astronomy, astronomical publications, public education and the amateur astronomical community. In 2009 the Astronomical Society of NSW awarded the authors McNiven Medals for excellence in astronomy.

QUASAR PUBLISHING

ISBN 978-0-9924409-2-3

9 780992 440923

ESTIMATING ANGLES IN THE SKY When 0.5m (20 inches) from the eye, each division on this scale corresponds to 1° of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°