ASTRONOMY 2004 AUSTRALIA

Includes the rare transit of Venus – last seen in 1882

A PRACTICAL GUIDE TO THE NIGHT SKY

Glenn Dawes Peter Northfield Ken Wallace

CALENDAR 2004

JANUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
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29						

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14	15	16	17	18		20
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28	29	30				

DECEMBER

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	13	14	15	16	17	18
	20	21	22	23	24	25
WA 26		28	29	30	31	

New Moon First Quarter Full Moon Last Quarter

ASTRONOMY 2004

AUSTRALIA

A Practical Guide
to the Night Sky

Glenn Dawes
Peter Northfield
Ken Wallace

Quasar Publishing 2003

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- The Messier Album – Mallas and Kreimer
- Catalogue of Supernovae - Karpowicz and Rudnicki.
- Sky & Telescope Magazine, March 1999
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- International Astronomical Union Web site
- Mathematical Astronomy Morsels - Meeus
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Illustrations

- The front cover is the Pleiades Star Cluster (M45) in Taurus, photographed by David Malin at the Anglo-Australian Observatory © AAO / D. Malin
- Inside front cover is the Hubble Deep Field (north), Jon Morse (University of Colorado), and NASA
- Page 1 image of M83 was taken by Joe Cauchi (Sydney, NSW) using 250mm *f*4 reflector with an exposure of 30 minutes. The film was Hypered Kodak 2415.
- Mt Stromlo article images: page 5 aerial shot by Geoscience Australia, page 6 image of 74" instrument before the fire by Bob Cooper, Coombes Photography, Australian National University. After fire image of 74" by Kim Rawlings, Mt Stromlo Observatory, Australian National University.
- Page 11 Homunculus Nebula, Hubble Space Telescope Jon Morse (University of Colorado), and NASA.
- Page 33 double star tables by Richard Jaworski.
- Page 42 image of NGC 2997 was taken by Joe Cauchi (Sydney, NSW) using 250mm *f*4 reflector with an exposure of 40 minutes with Hypered Kodak 2415 film.
- The two images on pages 50 and 68 were taken using Kodak 400ASA T-Max film through a 55mm lens. The 35mm camera was piggy-backed on an equatorially tracking telescope and the exposures were 6 minutes each. The authors.
- Page 53 image, NASA archives.
- Page 57 image was taken by the authors. Kodak 400ASA Tri X film through a 200mm lens. The 35mm camera was piggy-backed on an equatorially tracking telescope, exposure was 10 minutes.
- Page 65. Mosaic of lunar images taken by Robert Price, Bethanga Victoria using an SBIG ST7 camera through a Celestron 11.
- Rear cover photo is a wide angle shot of the Eta Carinae region by S. Quirk (Mudgee, NSW). A 20 minute exposure using Hypered Kodak Ektar 1000 through a 31.5cm *f*/4.5 Newtonian with coma corrector.

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INTRODUCTION TO THE 2004 EDITION

Welcome to Astronomy 2004.

On the afternoon of Saturday January 18, 2003, Australian astronomy suffered a blow with the devastating fires that swept through Mt. Stromlo in Canberra. With this in mind it was appropriate we acknowledge the contribution that our national observatory has made to our knowledge of the heavens. We thank Don Faulkner, who has just had a book published on Stromlo, for giving a brief overview of its history and the work of this establishment and for leaving us feeling optimistic about Stromlo's future.

David Frew presents a history of Eta Carinae, which is probably the most famous and perplexing star in the southern skies. Who knows, perhaps Eta will be the next supernova we have been waiting for?

With regard to observing, there are two rare events in 2004. For the first time since 1882, we will see the disc of Venus pass (transit) in front of the Sun. A transit of Venus in 1769 eventually lead to James Cook's discovery of the east coast of Australia (see p. 105). The other treat is the apparition of two bright comets in the May evening sky. There is a good chance that C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) will reach naked-eye visibility. If so, this will be the first time two comets will have reached this brightness together, in the sky at the same time, for nearly a century. This is certainly an event worth escaping the city lights for. The May evening sky will also host the Moon, Venus, Mars, Saturn and Jupiter! (see the May pages in Part I and the Comet section in Part II). If the opposition of Mars in August 2003 is any indication, we can probably expect good media coverage for both of these events. The various observatories and amateur astronomical societies (see Part III) across the country are likely to run public observing sessions.

As usual, our monthly feature articles cover quite a diverse range of interests. We introduce you to Messier, the man who created the most famous astronomical catalogue. We also encourage you to have a bit of fun and undertake a marathon to observe his celestial objects — galaxies, nebulae and star clusters that are visible in the smallest of telescopes or binoculars. This year sees the 400th anniversary of the last supernova seen in the Milky Way and we wonder when the next will blaze forth. Other topics include: the Blue Moon, a daytime occultation of Venus, our brightness scale and naming convention for stars, plus, plus …

In this edition we have included All Sky Maps to cover the entire wonderful night sky we live under in the Southern Hemisphere. These pages compress the night sky into only nine maps and the beginner can gain some confidence finding his or her way around the sky without having to buy a separate star atlas (well … not straight away). Also, when you look at the finder charts, especially those for the fainter outer planets of Uranus, Neptune and Pluto, you previously needed a good knowledge of the sky or an atlas to find these fields. The All Sky Maps now make this much easier. These maps have now superseded our traditional separate finder chart for Mars.

Part I of Astronomy 2004 is intended as a general quick reference section for those wishing to see which planets are up tonight and when, during the year, is the best time to observe them. This section, in particular, is ideal for those just starting their exploration of the night sky. The Sky View diagrams are an easy way for you to find the brighter planets and constellations. The planets can be followed throughout the year as these wanderers journey through the constellations. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, includes sections on astronomical places of interest and the amateur societies, ideal for the beginner. We also would like to recommend to readers our website www.quasarastronomy.com.au. There are links to all of the sites listed in Part III of this book, as well as monthly updates.

As in previous editions of this yearbook, we would like to conclude this introduction with a brief word to the novice. Astronomy, like any science, may seem to be swamped in jargon. Unfortunately, it is impossible to avoid such words. However, where necessary, astronomical terms have been explained in the text or covered in the glossary. To a beginner, some of this information (especially the tables of numbers) may seem difficult to understand. It is important not to allow yourself to become overwhelmed. Understanding will come with experience and when there is a need to know.

The night sky is the last great natural wilderness. Man may be able to dim our views, with his ever-expanding urban sprawl, but he can't destroy it.

Keep looking up and enjoy your heritage.

Glenn Dawes Peter Northfield Ken Wallace

MOUNT STROMLO OBSERVATORY — EIGHTY YEARS ON

Don Faulkner

The year 2004 marks the eightieth anniversary of the establishment of an observatory on Mount Stromlo. It was on 1 January 1924 that Walter Geoffrey Duffield was appointed the founding Director of the Commonwealth Solar Observatory (CSO), as it was first named.

The Observatory has been much in the news this last year. In January 2003 it suffered from a devastating bushfire. The original heritage buildings and all of the major domes were consumed, causing irreparable damage to some of Australia's most historically significant telescopes. Fortunately, several of the more recent buildings were spared, and, of course, the ANU's other major site at Siding Spring was entirely unaffected. The computer environment was another survivor, so the damage could have been much worse.

Nevertheless, the tragedy was a significant one, and this seems a good time to take stock. This article traces the development of Stromlo over the last eighty years—its successes and achievements; its place within Australian scientific endeavour—in the hope that reflecting on its journey to date will provide us with useful pointers for the future.

* * *

Duffield showed great perseverance in founding his observatory. It was in 1905 that it occurred to him that eastern Australia would be ideal for filling the longitude gap between India and the US West Coast when attempting continuous solar observations. His proposal received much support. In 1911 the Oddie 9-inch Refractor was brought from Melbourne to the newly designated 'Federal Capital Territory' for a year-long site-testing operation. The building constructed to house it on Stromlo thus became one of the earliest Commonwealth establishments in the Territory. In 1991 the Oddie Telescope was thoroughly restored, with a heritage grant, so it was in excellent condition prior to the 2003 fire. While its value was primarily historical rather than scientific, it was a significant landmark on the Stromlo scene.

World War I caused a decade-long delay in Duffield's campaign. It wasn't until 1923 that the Government finally approved funding for the CSO. Duffield arrived in Canberra in December 1924 to find that building work on Stromlo had scarcely begun. In fact, his Observatory spent the first few years of its life working in temporary laboratories set up in the Hotel Canberra. Duffield's tenure as Director was all too brief. In the winter of 1929 he succumbed to an influenza attack and after a nine-day illness, died on Mount Stromlo on 1 August. He is buried on the mountain.

Duffield's loss was a sad blow to the infant observatory, but another was soon to follow when the Wall Street stock market crash of October 1929 precipitated the Great Depression. In a mood of general economic pessimism, the Government declined to appoint a replacement Director, instead asking Bill Rimmer, the Observatory's most senior staff member, to serve as Officer-in-Charge for the next ten years. This left the Observatory under-staffed and under-resourced. Nevertheless, research work proceeded along the lines envisaged by Duffield, with an emphasis on solar work and atmospheric physics.

The Sun Telescope was completed in 1931 and did excellent work, particularly in the hands of Cla Allen, whose measurements of the strengths of some 2,700 Fraunhofer lines was internationally acclaimed, and paved the way for the 'curve-of-growth' technique for deriving chemical abundances in stellar atmospheres. Allen's atlas was considered Stromlo's most important achievement during its first 15 years.

Other scientific programmes conducted by the infant CSO included: sunspot records; spectroscopic parallaxes of southern stars; the luminosity of the night sky; the electrical properties of the Earth's atmosphere; radio soundings of the ionosphere; meteorological observations; cosmic ray studies; and laboratory spectroscopy—a truly amazing undertaking given the adverse staffing conditions. By 1932 Rimmer also managed to complete the assembly of the largest of the original telescope donations to the CSO, the Reynolds 30-inch Reflector, although it saw little use until after World War II.

By 1937, the Government felt able to initiate a search for a new Director to succeed Duffield. Richard van der Reit Woolley was offered the appointment—at the youthful age of thirty-three. He had, however, already achieved considerable distinction within British astronomical circles, having held the posts of Chief Assistant at the Royal Observatory, Greenwich, and John Couch Adams Astronomer at Cambridge. He had also spent two years at Mount Wilson during his Cambridge doctoral studies. He arrived, on 4 December 1939, with the clear intention of changing the focus of the Observatory's research work from solar and atmospheric studies to stellar and galactic astrophysics. In the event, his plans were thwarted for several years by the outbreak of World War II.

Australia entered the war immediately after Great Britain, and staff at the Observatory became intimately involved in technical support activities. Australia's remoteness dictated that it should be as self-sufficient as possible in producing its own weapons. But weapons are only as good as the gun-sights, range-finders, etc., used to aim them, and Australia had no capacity for manufacturing such optical systems. Indeed it did not even produce the type of high-quality optical glass from which they must be made.

In 1940 an Optical Munitions Panel (OMP) was formed to address this emergency. The armed services needed a dozen different instruments immediately—over 15,000 items in all, costing £750,000. The OMP coordinated the work of scientists in more than 25 institutions—chemists, physicists, astronomers, instrument-makers, engineers, etc.

Woolley proved both able and hard-working in addressing the nation's wartime needs. He served on the OMP and in 1942, was appointed head of the Army Inventions Directorate. The Observatory itself played a key role, being virtually transformed into an optical munitions factory. Its staff increased rapidly from 10 to over 70. Contrary to the pessimistic predictions of Australia's former optical suppliers in the UK, this national effort was an outstanding success. The first large-scale batch of optical glass was poured in September 1941 and by war's end, a total of 43 different instrument systems had been produced.

In addition, Australia's radar research activities during the war led directly to the formation of CSIRO's Division of Radiophysics—one of the world's first, and best, radio astronomical research groups. Radio astronomy was, in fact, born out of the radar research done by the allies during the war years. It can fairly be claimed that World War II launched Australia as one of the world's leading nations in astronomical technology, both optical and radio.

Some purely scientific activities proved possible during the war. Cla Allen and Arthur Higgs mounted a solar eclipse expedition to South Africa in October 1940, from which much was learned, not least relating to the Sun's effects on the earth's ionosphere. Further investigation of these effects, particularly by Allen, led to a better understanding of the nature and causes of the 'fade-outs' which affect long-distance radio communications. This also proved of great military benefit in the latter stages of the war in the Pacific.

Following the war, Woolley implemented his new vision for his institution. Even its name was changed—to simply the Commonwealth Observatory. The Reynolds 30-inch Reflector, the largest of the Observatory's original instruments, then came into its own. Donated by John Henry Reynolds of Birmingham, it had been installed during 1927-32, but it had seen little service during the next two decades, since solar research was given priority. Now, however, it began to play a major role in the Observatory's new programme, as the horizons of observation were pushed beyond our Solar System into the Universe at large.

The Reynolds was equipped both with a spectrograph and in 1951, with a state-of-the-art photoelectric photometer brought to Stromlo from the Lick Observatory in California. Ben Gascoigne used this to observe variable

Aerial photo of Mt Stromlo observatory.

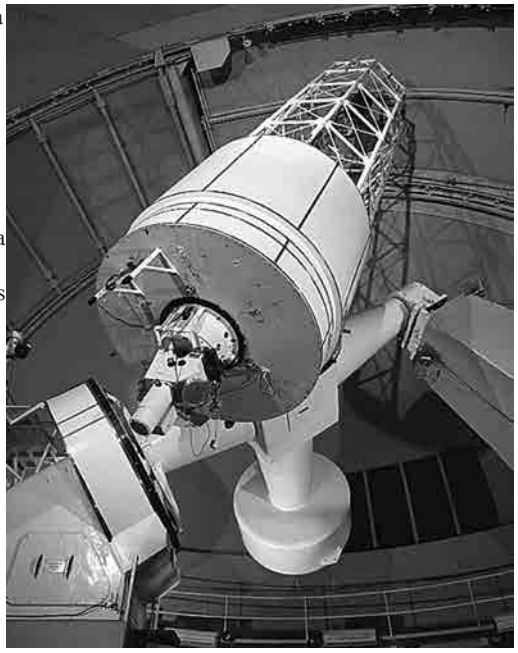
stars in our neighbouring galaxies, the Magellanic Clouds, providing confirmation that the distance scale of the Universe was twice as large as had previously been thought. Gerard de Vaucouleurs surveyed the brighter southern galaxies, discovering that many of them are grouped into an enormous structure—the Local Supercluster—which is some hundred million light years in size.

Woolley's instrumental ambitions for Mount Stromlo went far beyond a rejuvenated 30-inch. The mid-1950s saw another four major telescopes arrive. The largest was the 74-inch Reflector. The campaign for its funding and construction started in 1947 with a visit from the Astronomer Royal, Sir Harold Spencer Jones, and concluded with its official opening by the Governor-General on 8 November 1955. A month later Woolley left Canberra to become Astronomer Royal. Equipped with a magnificent coudé spectrograph, the 74-inch remained the largest optical telescope in the country, and equal largest in the Southern Hemisphere, for almost two decades.

The year 1955 also saw the installation of the Great Melbourne Telescope and the Yale-Columbia 26-inch Refractor, relocated from Victoria and South Africa respectively. The fourth arrival was a new 26-inch Schmidt camera commissioned by the Swedish University of Uppsala and completed in 1957.

By organising this amazing wave of telescope acquisition in the mid 1950s, Woolley bequeathed to Stromlo a handsome legacy of world-class instrumentation, well capable of supporting the Observatory's entry into the new era of stellar astrophysics that was revolutionising the study of astronomy in the mid-twentieth century. The Uppsala Schmidt was relocated to Siding Spring Observatory in 1981 but, sadly, all of Woolley's other acquisitions fell victim to the January 2003 bushfires, as did the Reynolds and the Oddie Telescopes.

Woolley also deserves credit for orchestrating another far-reaching change at Mount Stromlo—the Observatory's transfer from the Commonwealth public service to the Australian National University (ANU). The University was founded in 1946 and Woolley was one of the prime movers in designing the new institution. Although not initially a part of the University, the Observatory had close links with it. Woolley became an Honorary Professor, courses were taught and students accommodated. The first PhD degree and the first (non-honorary) DSc degree awarded by the ANU were both won by astronomers. Woolley's goal was that Stromlo should join the University in a formal way, and this was achieved, after some debate, when the Observatory became a department of the Research School of Physical Sciences on 3 January 1957. Astronomy has flourished in the University environment and many consider this accomplishment one of Woolley's greatest.



The 74" instrument before the fire.

Woolley's successor as director was Bart Jan Bok, a Dutch-born astronomer who had spent his previous career at Harvard. His appointment commenced on 7 March 1957, and he immediately set about building on Woolley's foundation by establishing a vigorous graduate school at Stromlo. Since then the quality of the Observatory's PhD education has become internationally famous. There are now well over one hundred Stromlo graduates working at observatories in all six continents, and many have achieved the highest accolades of the scientific world.

By the late 1950s, Canberra's growing light pollution had begun to make life difficult for the astronomers working on Stromlo and Bok initiated a site-testing project to find a new and better site where the most light-sensitive observations could be made. After several years of testing, Siding Spring Mountain (west of Coonabarabran in central NSW) emerged as the best of the locations examined.

The ANU approved the establishment of a new observatory there and funded an initial suite of three telescopes, the largest a 40-inch reflector completed in 1964. It was due largely to Bart Bok's great energy and enthusiasm that these developments took place. He was a keen observer throughout his career, and he and Priscilla Bok, also an astronomer, frequently went observing together. They spent the Christmas of 1964 at Siding Spring, prior to the official opening of the new observatory in April 1965.

At the time, it wasn't apparent just how significant an achievement the establishment of Siding Spring was destined to become. It has now developed into one of the world's truly great optical observatories—the home of the Anglo-Australian Telescope, as well as the ANU's own 2.3-m Advanced Technology Telescope. Every year dozens of astronomers from around the world travel to Siding Spring to make use of the leading-edge instruments located there.

When Olin Eggen became Mount Stromlo's fourth Director in 1966, he had already published what has now been named as one of the fifty-odd seminal astronomical papers of the twentieth century, "Evidence from the Motions of Old Stars that the Galaxy Collapsed" (Eggen, Lynden-Bell and Sandage, 1962).

Eggen was a dedicated observer who specialised in measuring the brightness of stars by photo-electric techniques and he used these observations to investigate the orbits of stars within our Milky Way galaxy. It became apparent to him that stars of different ages have different motions—the oldest stars travel in a large, spherical volume of space, while those born more recently form a flat, rotating disc. Thus Eggen realised that our Galaxy hasn't always been as we see it today. It began in a sort of giant collapse, with the shrinking gas cloud forming into generations of stars as time went by.

This was a revolutionary idea at the time, but the fact that we live in an evolving Galaxy is now accepted by everyone. The picture has become a bit more complex, however, since we have also discovered that our Galaxy has swallowed other smaller ones along the way, probably contributing a fair amount of material to the old, spherical component. This process continues even today.

It was during Olin Eggen's time at Stromlo that the bi-national Anglo-Australian Telescope (AAT) was built at Siding Spring, although his own participation in this project proved a rather turbulent one. Nevertheless, Stromlo staff were intimately involved, particularly Herman Wehner, who was the fourth and final AAT Project Manager, and Ben Gascoigne, who served as Commissioning Astronomer.

Eggen's successor as Director, Don Mathewson, was responsible for commissioning another large and innovative reflector at Siding Spring, the ANU's 2.3-metre Advanced Technology Telescope. This instrument features three novel design concepts—a thin mirror, an altitude-azimuth mount, and a rotating building. This was the first time that all these innovations had been included in a single instrument and also the first time that control computers were employed in such a comprehensive way. The entire project was undertaken by the Observatories' own technical staff, an achievement of great pride. Today the 2.3-metre is doing ground-breaking work solving some of the most intriguing problems in the Universe, but equally important was its role as a prototype for the advances in telescope design and engineering that have revolutionised optical astronomy over the last couple of decades.

The term of office of Mount Stromlo's sixth Director, Alex Rodgers, (1986-92) was distinguished by the Observatory's participation in a major international experiment to address one of the most baffling astronomical puzzles of the day—the fact that 90 per cent of the matter in the Universe is entirely unseen.

This 'missing' mass betrays its existence because of the gravitational pull it exerts on other material around it, but its nature was (and is) a matter of speculation. It could, for instance, consist of bodies the size of planets, or perhaps very faint, low-mass stars. The MACHO Project was designed to look for such objects—Massive Astronomical Compact Halo Objects (MACHOs)—in the Halo of our own Galaxy. If such a compact body were to pass between us and a more distant star, the brightness of the star would be temporarily enhanced because of the warping of space by the MACHO.

This lensing effect is a consequence of Einstein's theory of relativity, and the demonstration that our Sun warps the space around it provided one of the early confirmations that Einstein's theory is right.

The MACHO team spent eight years monitoring the brightness of several million stars in the Magellanic Clouds, looking for such lensing events. They detected their first in 1993, and its announcement attracted world-wide attention. In all, they recorded about 15, and were able to deduce that about 20 per cent of the Galaxy's missing mass can be accounted for by typically half-solar-mass objects in its Halo. These could be white dwarf stars but, if so, their existence so far out in our Galaxy poses yet another mystery.

The MACHO Experiment was undertaken using the 50-inch Great Melbourne Telescope, which was extensively refurbished for the task.

* * *

Jeremy Mould succeeded Alex Rodgers as Director in 1993. His term was marked by a significant focus of the Observatory's research endeavour on cosmological questions. Mould was himself a co-leader of the Hubble Space Telescope (HST) Key Project to establish the value of Hubble's Constant to a precision of ten per cent. In spite of the best efforts of the world's astronomers in the half-century following Hubble's 1929 discovery of the expansion of the Universe, its size and age still remained uncertain by a factor of two. It was to remedy this that the HST Key Project was devised. Culminating in 1998, it was entirely successful.

While it was in progress, however, great changes were occurring in our understanding of the nature of the Universe in which we live. Two other Stromlo staff members were also co-leaders of large international studies which brought this about. Brian Schmidt founded the High-z Supernova Search team, which has studied supernovae in distant galaxies, some so remote that the light we see from them started its journey when the Universe was less than 40 per cent of its current size. Matthew Colless was a co-leader of the Two-Degree-Field Galaxy Redshift Survey which, during 1997-2001, used the magnificent new spectral facility on the AAT to map the distribution of over 220,000 galaxies in two fan-shaped slices of the Universe, stretching out to about 2,500 million light years.

The result of all this work is that we now have quite a good idea of the scale and the age of the Universe—it is about 14,000 million years old. But the greatest surprise to emerge is that, instead of its expansion slowing down as expected, it seems to be accelerating. In order to explain this, cosmologists have resurrected something that Einstein once called his 'greatest blunder'. His original equations contained provision for a mysterious 'vacuum energy', which could serve to push or to pull on the material of the Universe, even though it wasn't itself associated with any material whatsoever. Working before Hubble's discovery that the Universe is expanding, Einstein introduced this term into his equations to force his model Universe to be a stationary system. Following Hubble's work, he simply crossed the term out. Now, it seems, we once again need to use 'Einstein's blunder' to account for the newly discovered acceleration of the Universe's expansion. In fact, it seems that there is about three times as much of this 'vacuum energy' in the Universe as there is of the normal 'matter energy' with which we are so familiar.

* * *

On 18 January 2003, the Observatory at Mount Stromlo suffered massive damage in the bushfires that also devastated several Canberra suburbs—a very unwelcome blow so early in the directorship of Penny Sackett, who had arrived just six months earlier. The domes of all of the major telescopes were consumed, as were the workshops, and the old heritage buildings—the entire quadrangle suite of the original Commonwealth Solar Observatory, the Director's Residence, and several other houses. Perhaps the most heart-breaking single loss was that of the Near-Infrared Field Spectrograph (NIFS), four years in the building, and undergoing final testing in the workshops prior to its delivery to Gemini North in Hawaii in just six months time. Fortunately, most of the astronomer offices are in the Woolley and Duffield Buildings, which survived, along with the new Visitor Centre. All the computer servers are housed in the Woolley Building as well, so the entire electronic environment was virtually unaffected. One sad loss was the Library, which contained many irreplaceable items, all now gone forever.

It is worth noting, however, that Mount Stromlo is home to only half of the ANU's investment in astronomical instrumentation. Everything acquired since the 1950s has been located at Siding Spring, and is entirely unaffected. It should also be said that the last decade or so has seen a notable decrease in the Observatory's reliance on its own telescope resources. Large team projects using the HST, the major ground-based facilities of Gemini and ESO, and so on, now figure much more prominently in Stromlo's research agenda. Nevertheless, the loss of such iconic instruments as the 74-inch and the Great Melbourne Telescope, and the other heritage damage on Stromlo, were sad indeed.

Everyone is quite determined to re-establish the Observatory on Mount Stromlo. Indeed most staff are already back at work there following the erection of several demountable buildings. The Observatory has been absolutely overwhelmed by the expressions of concern, and offers of help, that have arrived from all over the globe. In particular, workshop facilities made available elsewhere in Canberra have allowed work on the NIFS and the Gemini South Adaptive Optics Imager contracts to proceed with a minimum of disruption. The ANU and the Commonwealth Government have been particularly supportive.

At the time of writing (June 2003) reconstruction plans are still far from complete, but already some things are becoming apparent. One is that the original CSO buildings occupied a place of such significance in the heritage

After fire image of the 74".

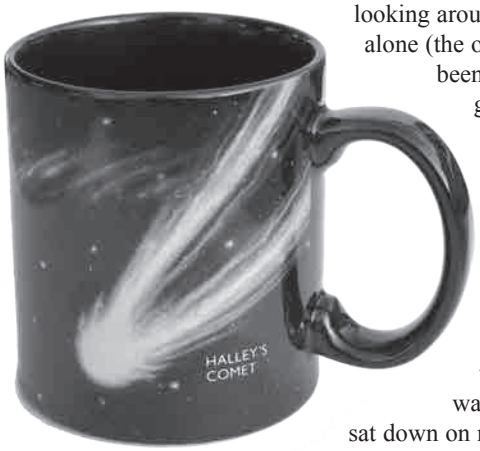
of early Canberra that they ought to be restored, although, of course, with due deference to modern building codes—particularly regarding fire protection! Certainly enough restoration will occur to leave no one in any doubt that it is still the same Observatory. On the other hand, sentiment alone could scarcely justify the replication, in the twenty-first century, of a 1950s-era, 74-inch telescope in the Grubb-Parsons mould! The telescopes that replace those destroyed will obviously be built to modern specifications, with due attention to the scientific programmes they are to support, and to the limitations of the site, particularly in terms of sky brightness. It is entirely likely that one replacement, at least, will be located at Siding Spring.

On the Monday after the fire a meeting of all Stromlo staff was held in the ANU Chancelry. Penny Sackett's first words were inspirational: 'Fortunately, the Research School's three most valuable assets remain entirely intact—its people, its reputation, and its spirit'. Indeed they do, and everyone is quite determined that Mount Stromlo Observatory will rise from the ashes stronger and better than ever.

Don Faulkner spent virtually his whole career working at Mount Stromlo Observatory, retiring in 1998 as Associate Director for Education and Outreach. Born in Brisbane in 1937, he was educated at the University of Queensland (DSc) and the Australian National University (PhD). His main research interest is the internal workings of stars, and how the physical processes taking place inside them determine the way they are born, live their lives, and die. He is an enthusiastic exponent of astronomy; his evening lecture series Astronomy for Fun ran at Mount Stromlo for twenty years. He served as the President of the Astronomical Society of Australia during 1989-91. He lives in Canberra with his wife June, and still attends the Observatory quite frequently as a Visiting Fellow. With historian Tom Frame, he has co-authored a book on the history of Mount Stromlo Observatory ('STROMLO An Australian Observatory'), which is to appear in late 2003.

COFFEE CUP DISCOVERIES

Glenn Dawes

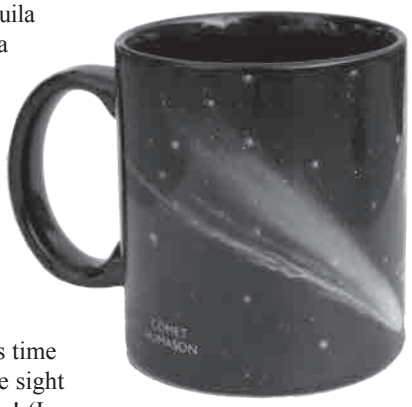


Twilight ended just as I arrived and looking around I realised I was alone (the others must have been slower than me getting out of town). The magnificent sky called to me to have a rest, grab a coffee, and sit back and take in the grandeur. The neatly packed telescope could wait 20 minutes. As I sat down on my camping chair, under the starry sky, I reminded myself that I was not looking at just a static painting, but a live telecast of our corner of the Universe. This included a unique opportunity for discovery, different to that through the light intensified narrow field of my telescope. The faint flash as a meteor crossed the sky and the slow-moving, eerie silence of a satellite, as it dissected some of my favourite constellations, was a good start for the evening. It made me reflect on previous visits my coffee cup and I had with the night sky (did I mention my mug is a Messier one?). I remembered the brilliant flash of what must have been a –4 magnitude point meteor — as bright as Venus — as it betrayed the location of the radiant of the Leonid meteor shower back in 1999. I know point meteors can be sporadic, as well as members of an annual stream. However, I've always remembered to take note of the position and the date of such events to see if they coincide with the radiant of a known shower.

I also recalled my impressive introduction to an Iridium Satellite a number of years ago. This short, brilliant (-7 magnitude) flare, as the sunlight briefly reflected off its solar panels, was totally unexpected. Fortunately at that time I hadn't discovered the 'Heavens Above' website (www.heavens-above.com/), with its predictions for such events, so I definitely enjoyed the surprise.

I reflected on my youth. Long before the 'Iridium' experience and even before I had a car, I had spent many evenings confined to my parents' backyard, following satellites with a second-hand pair of binoculars. I used to watch them dim and brighten as different aspects of these unmanned wanderers presented themselves to the Sun. Following them, even under the light polluted suburban skies, began a personal voyage of discovery as a multitude of wide double stars and open star clusters drifted through my binocular field. I used to dream of seeing one make a dramatic right-angle turn, revealing it may not have had a terrestrial origin. I'm afraid, today, even in this relaxed state of mind, my 30-something years of watching the sky has made me somewhat sceptical about UFOs. I'm not saying there isn't life out there; in fact that's probably a real certainty. But whether they are visiting us is a very different matter. The lack of sightings by credible witnesses who know the sky, such as fellow amateur astronomers, doesn't help the case. Also, having gathered an appreciation over the years for the sheer distances our interstellar friends would have to travel to visit us, makes it a little too hard to swallow. However I'm not totally a lost cause. If they want to land in front of me and extend a three fingered hand in the name of friendship, that's all right by me. Just wait until my friends arrive so I'm not carted off to some loony bin for the astronomically insane!

That was enough of this alien theme. It was time to return to astronomy and let my imagination run wild and dream of glimpsing an event of literally stellar proportions. How about a nova bright enough to see with the unaided eye! (The coffee must have been stronger than I thought). This is not beyond the realms of possibility for novae this luminous are seen about two or three times per decade. As recently as 1999 Nova Aquilae (No. 2) shone briefly at just under 4th magnitude, easily visible under dark skies. Such discoveries have been made by determined naked-eye and binocular observers. It takes some dedication and lots of observing to achieve the knowledge of the star patterns required to pick them. Let's face it, another 5th magnitude star could be easily overlooked. I suppose the nova could always reach negative magnitude? You might think I'm stretching it and you are right to think that's got to be rare. Back in 1918, the constellation Aquila produced another nova with a brilliance rivalling the star Alpha Centauri!



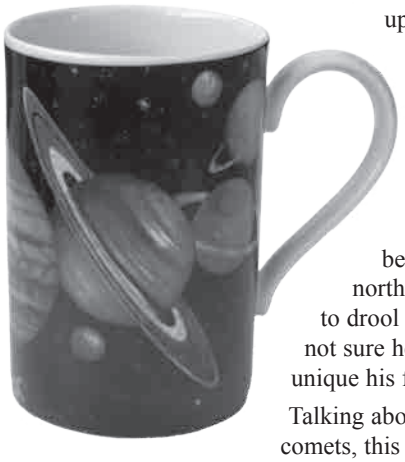
Looking at the multitude of faint but clearly visible stars painted across the southern Milky Way, I knew there was a good chance I'd overlook a 'garden variety' nova. Perhaps it was time to guarantee an unforgettable sight and start thinking supernovae! (I should really listen to my wife and switch to 'decaf') The last supernova found in the Milky Way was back in 1604 (in fact 400 years ago this October). There had been four others in the 600 years prior to this object, which is now known as Kepler's Star (see p. 57). We are certainly long overdue for another (did I hear a groan from a statistician hiding in the bushes?) All of these supernovae were at least as bright as Venus; a couple may have reached magnitude -8 and were well and truly visible in broad daylight! Now Venus wasn't around that evening, but looking at Jupiter I would even settle for –2 magnitude, why be greedy?

It is worthwhile pointing out the difference between a nova and a supernova. A nova is a brilliant flash from a star as it blows off an outer shell of material. This event can even recur during this turbulent period of the star's life. A supernova is an intrinsically much brighter event, which occurs when a large mass star blows itself apart as it reaches old age.

The beauty of daydreaming (but hang on, it's night!) is you don't worry about the odds. Why not go after something even rarer than a galactic supernova. How about a sight that has never really been confirmed in recorded history — a naked-eye impact on the Moon! It doesn't matter what the phase of the Moon is when you look, but such an event would be easier to view on the unlit side (unless of course you're hoping to read the newspaper by its flash!) So the thin crescent Moon I could see perched on the western horizon would be an ideal hunting ground (oh well,

nothing tonight). We know significant impacts are still happening today in the Solar System (even if only visible in a telescope). It was amazing to see Comet Shoemaker-Levy 9 give Jupiter a series of black eyes back in 1994. In fact I wouldn't mind seeing one of the planets suddenly brighten due to one of these Solar System bingles, as long as it wasn't Earth! I bet NASA would be thrilled to explore a nice fresh impact zone on Mars, especially if when the dust settled the crater has a lake in the centre of it (no matter how temporary). Probably one of the most dramatic discoveries about Mars has been how much of its landscape has been carved by water. Just how much water and where it is now is still a hot topic for debate.

While exploring the western evening sky I wondered whether it would offend the gods to ask for a magnificent comet, complete with a sweeping tail. I'm not necessarily asking to be the first, but an independent naked-eye discovery would be fantastic. Back in 1996, an old friend rang me excitedly to report a bright comet with a search-beam-like tail. It was standing upright, stretching half way to the zenith, just above the northern horizon. This was Comet Hyakutake and his description was exactly how it appeared from Australia just before it became an object only for northern hemisphere observers to drool over. To this day I'm not sure he really appreciated how unique his find was.



Talking about rare events involving comets, this year may see an unusual apparition, which is far from wild speculation. In late May 2004, Comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) will be in the evening sky (see May monthly section). At this time both comets are expected to be near maximum brightness and possibly 2nd magnitude (yes, I know nothing is certain but remember this is my dream). Having two naked-eye comets above the horizon at the same time is a very rare event, but one which was previously witnessed in the early 20th century. To top this off, we will also have Mars, Saturn, Venus, Jupiter and the Moon in the west. Now that's what I call a grand conjunction (see Sky View on p. 39)! Now it's true that professional search programmes like LINEAR and NEAT have recently made it difficult for amateur comet hunters, but in this case, having found them a couple of years before their spectacular visit to the inner Solar System, I like to think they have given us plenty of warning and time for the anticipation to build.

I mentioned above the spectacle of point meteors. These days we have a new recognised contender in the 'flashing' stakes — Gamma Ray Bursters (GRB). Gamma radiation is at the very short wavelength end of the spectrum, and is very high in energy. It seems that long duration bursts that last from 2 seconds to several minutes have been finally linked to supernova explosions of massive stars. The recently detected GRB 030329 was found 90 minutes after the event, still shining at 12th magnitude. Some astronomers believe that it may have been visible to the naked-eye when it first appeared! The spectra of the object showed it was *only* 2 billion light years away, quite close compared to the 5–10 billion for normal GRBs. It would be amazing to look up and see an event whose light commenced its voyage before life even started its journey on earth (did I hear a creationist join the statistician in the bushes, harmonising their moans?) I thought the next time I saw a point meteor, especially if it lasted more than a few seconds, I should take note of the time, its duration, position and magnitude. You never know, such a simple observation could make a significant contribution to astronomy and possibly smash the naked-eye distance scale, a new world (err… universal?) record unlikely to be broken.

For those who feel my wish list is pretty far fetched, let's look at the situation Oscar Duhalde found himself in, back in 1987. It was the night of February 24, Oscar had taken a break from his job as a night assistant at the Las Campanas Observatory in Chile and strolled outside. He casually looked up and *saw* a supernova — a visual event that hadn't been witnessed in over 3 centuries! He had discovered SN 1987A in the Large Magellanic Cloud. New Zealand amateur astronomer, Albert Jones, also made his independent discovery that evening.

My musings were interrupted by the sound of a car pulling up. This was shortly followed by the words "who's the lazy observer?"

I turned to my newly arrived companion and answered, "What do you mean lazy, I'm doing some serious CCD!"

I'm glad in the dark I couldn't see the roll of his eyes as he turned and walked away. I smiled. He didn't know I meant 'Coffee Cup Discoveries'. I leaned forward as if to get up but instead grabbed my thermos flask. Umm… two more cups left and Sagittarius is rising. I think I'll stay here a little longer.

ETA CARINAE, THE WONDER STAR

David J. Frew

When I was asked to write a short contribution on Eta Carinae for this book, I knew it would be a difficult task. I was faced with the voluminous scientific literature of nearly 1000 papers, and I would need to combine the long historical record with a summary of the recent discoveries made from ground-based and space-based telescopes. So the first question I faced was where to begin, and I immediately thought of the late Gerard de Vaucouleurs, who in 1952 called it the 'Wonder Star,' in his paper published by the Astronomical Society of the Pacific. This prescient appellation has stuck in my mind ever since I read his little pamphlet in the seventies, so I entitled this article in homage to his original work.

Much of Eta Carinae's fame stems from its nova-like outburst in the 1840s, now often referred to as the 'Great Eruption.' For a few years, Eta Carinae rivalled Sirius and Canopus as one of the brightest stars in the sky, and it must have presented a wonderful sight with its reddish hue, embedded in one of the richest parts of the southern Milky Way. For the last few years, as time has allowed, I have revised all the published estimates of Eta's brightness, as well as gleaning new data from unpublished manuscripts to better define the light curve of this exceptional star (see figure 2 opposite).

It is not mentioned in Ptolemy's Almagest, but neighbouring stars of the third magnitude were also omitted from this catalogue. It seems the first record is due to the Dutch navigator Peter Keyser around 1596, when the magnitude was probably between 3 and 4. Over the next two centuries it was recorded intermittently by Halley, Noel and Lacaille, and was probably varying between the 2nd and 3rd magnitudes. Eta was around magnitude 2 in the early 1800s before it brightened markedly in the famous 'Great Eruption' of 1838 to 1856, when it peaked at magnitude –1 in 1843, and again in 1845.

Eta faded rather slowly over the next decade and was still a star of the first magnitude in early 1858, before the rate of fading suddenly increased, most likely due to the onset of dust condensation from the prodigious stellar wind. It faded to sixth magnitude by 1868, before gradually dimming further to magnitude 7.4 by 1886. In 1887 another brightening occurred, the 'Lesser Eruption', with Eta reaching magnitude 6.2 and remaining around that level until early 1895, when the star dimmed rather abruptly to magnitude 7.5. The backbone of the 19th century light-curve is a legacy of dedicated Australian observers, with John Tebbutt providing significant observations, having monitored the star for over half a century.

Since the beginning of the 20th century, Eta has partly recovered in brightness as the ejecta (now seen as the Homunculus nebula, fig 1) has expanded and become more transparent. Eta reached magnitude 6.5 in 1952, and magnitude 5.6 by 1997, before an unanticipated brightening occurred in 1998 when the star rose by about 0.3 magnitude in less than a year — the star is close to magnitude 5.0 at present.

From the 1960s on, astronomers have regularly measured the star with photoelectric photometers and most recently with CCDs, and the light curve is much more precise. Visual observations confirm the long-term brightening, with stalwarts such as Albert Jones, a New Zealand amateur astronomer, rivalling Tebbutt's 50-year monitoring program. However, as Chris Sterken has pointed out, various professional photometric programs have ceased in recent years for a number of reasons, including the decommissioning of several smaller telescopes. Any amateur photometrist who wants to make an important scientific contribution to the wider community should seriously consider beginning a long-term monitoring programme of this famous star.

For the casual telescopic user, Eta lies in the magnificent Eta Carina Nebula, NGC 3372, which is easily visible to the naked-eye as a brightening in the Milky Way (see back cover). On a clear night the nebula is remarkable, with mottled masses of bluish-grey nebulosity rifted by dark dust-lanes and patches, and highlighted by crowds of faint stars. Several small clusters and groups are obvious, and these contain numerous hot O- and B-type stars which provide the ionization for the nebula. The distance to the whole complex is now fairly well determined at 2,300 parsecs (7,500 light-years), being one of the more significant star-forming regions in the Milky Way.

Near the centre of the nebula, southeast of the brightest portion of the nebulosity, is the orange form of the Homunculus, surrounding Eta itself. This is the dusty cocoon which formed in the 'Great Eruption', and is currently about 17" x 12" in size, readily visible through backyard telescopes at quite modest magnifications. The nebulous appearance of the star was first noted by R.T.A. Innes in 1914, and the shell was later named the Homunculus by the Argentine astronomer Enrique Gaviola, due to its resemblance to a stubby mannequin.

Closely preceding Eta is the dark Keyhole nebula, first delineated by Sir John Herschel, and later given this title by Richard Proctor in allusion to its shape. A bright patch of nebulosity on the southeast edge of the Keyhole has been shown to reflect the peculiar emission-line spectrum of Eta, showing that Eta is indeed a bona fide member of the star-forming complex. Furthermore, Sir John Herschel's drawings from the late 1830s, when Eta was near maximum light, show the southern edge of the Keyhole to be far more prominent then it is today, and indeed a star six magnitudes brighter than at present would be expected to illuminate any surrounding dust much more distinctly.

However, in 1969, astronomers looked at Eta Carinae in the mid-infrared for the first time, and were surprised to discover that it is still emitting as much energy as it did before the 1840s outburst. In fact, at a wavelength of 20 microns, Eta is the brightest star in the sky. Inside the obscuring Homunculus, Eta Carinae still glows brightly, with most of the star's energy being used to heat up the dust which then emits copious amounts of infrared radiation. The absolute bolometric magnitude (which measures the energy emitted over all wavelengths) is close to –12.0, equal to a luminosity of more than 4 million suns, while the estimated mass is about 100 solar masses, making Eta one of the most massive stars known anywhere.

Recent images from the Hubble Space Telescope (HST) reveal much intricate detail within the Homunculus, showing a two-lobed (bipolar) morphology with equatorial jets, and including a bright star-like core about 1" across. Only HST, however, has managed to resolve clearly the features in the bright inner core. There is a 7th magnitude central object, with four close 'companions', within 0.2" of the star. These are the so-called Weigelt blobs, and are almost stellar-appearing, high-density gaseous knots which show a bewildering variety of emission lines.

Some of the internal structure near the perimeter of the Homunculus shown by HST, including the brighter knots, is visible through larger backyard telescopes in good seeing conditions. Most of these knots were thought to be stellar companions by Innes, van den Bos and others in the early years of the 20th century, and hence given letter designations in the double star catalogues. Gaviola took the first high resolution photographs of the Homunculus in the 1940s and, after matching the knots to the companions measured by the early double star observers, showed that they were expanding outward from the central object. Eventually (over the next century or two) the dust will disperse into the surrounding medium, when Eta should again shine around third magnitude. The Homunculus nebula now spans some 40,000 AU (0.2 light-year), and its expansion is readily obvious to anyone who compares large-scale images taken at different epochs.

Some faint outer wisps and knots outside the Homunculus are also seen on deep images, and are most likely ejecta from even older eruptions, leading to the conclusion that Eta has had a long and complex history of light variations. Such behaviour, with irregular light variations and 'giant eruptions' at much rarer intervals, is typical of a class of stars now known as Luminous Blue Variables or LBVs. The first known example and a prototype of the class is P Cygni, which had outbursts in 1600 and 1655, peaking at 3rd magnitude, before fading to below naked-eye visibility. The star over the last three

hundred years has gradually brightened to its present magnitude of 4.8. The famous star S Doradus in the LMC, and AG Carinae and HR Carinae in our own galaxy, are other examples of the class, though Eta Carinae seems the most extreme member by any standard.

An important discovery was announced by the Brazilian astronomer Augusto Damineli in 1996. Based on archival spectra, dating back to the 1940s, he discovered that Eta Carinae underwent a recurring 'spectroscopic event' every 5.52 years. For a few months, the intensity of the high-excitation emission lines in the spectrum is greatly reduced, and this is coincident with variations in the light curve, which take the form of brief dips superposed on broad photometric maxima. These 'eclipse-like' events of a few weeks duration occur in both the optical and infrared, though theorists are still trying to model the observations.

Damineli's pronouncement renewed professional interest in the star, especially when Eta experienced its predicted event at the close of 1997, with remarkable changes occurring all across the electromagnetic spectrum, from X-rays to the radio region. The clockwork behaviour, extending back over decades, is readily explained if Eta is part of a binary system, with a hot (T = 40,000 K) secondary star of perhaps 30 solar masses in an eccentric orbit around the luminous primary star, which is thought to be somewhat cooler (T = 30,000 K). In one model, the separation between the two stars varies from 2 AU at periastron (the point in their orbits where the two stars are closest) to around 30 AU at apastron, when the apparent separation as seen from Earth is still only 0.01". This is far too close for even HST to resolve and, until detailed interferometric studies are implemented in the future, we can only speculate on the physical parameters of the secondary star.

In the binary hypothesis, the X-rays are produced in the collisional shock between the stellar winds of the primary and secondary stars. Around periastron the X-ray flux plummets to near zero, which suggests the X-rays are attenuated as the shock is enveloped by the primary star's dense wind. Alternatively, the primary's wind, which is almost certainly non-spherical, is altered by increased radiation and/or tidal effects from the secondary. Much of the ultraviolet flux (presumably from the secondary) that escapes the core region also drops, reducing the ionization level of the clumps of dense gas in the vicinity of the primary star, and causing the observed spectral changes.

While writing this article, another periastron event was underway. By the end of June 2003, the X-ray flux reached a minimum, the high-excitation emission lines had faded out, and the infrared JHKL and optical photometry revealed that another 'eclipse' had commenced. Using the most recent observations, and comparing them with earlier data sets, the best period for the orbit is now refined slightly upwards to about 2022 days (5.536 years) with an estimated error of less than a week.

A large multinational team of astronomers is currently using the Space Telescope Imaging Spectrograph on HST to obtain the most detailed spectroscopic data set ever taken, and it will literally take years to properly reduce all the observations. While a consensus has already developed that Eta is a massive 'colliding-wind' binary, the devil is in the detail, and we expect vigorous debate between astronomers for the foreseeable future. Many of them are already planning for the next event, due at the beginning of 2009.

David Frew is an experienced amateur astronomer who has written extensively for several publications, including Southern Astronomy and Sky & Space magazines. He is a co-author, with David Malin, of "Hartung's Astronomical Objects for Southern Telescopes", which has become a standard reference for Australian amateurs.

He has interests in variable star observing and the history of astronomy, and he has recently commenced a PhD at Macquarie University, working on new evolved planetary nebulae discovered from the AAO/UKST H-alpha Survey.

Further Reading:

Davidson, K. 2003. *The Eta Carinae HST Treasury Project.* Online at http://www.astro.umn.edu/~kd/Etacar/

Davidson, K. & Humphreys, R.M. 1997. Eta Carinae and its environment. *Ann. Rev. Astron. Astrophys.* 35, 1–32

Damineli, A. 1996. The 5.52-year cycle of Eta Carinae. *ApJ* 460, L49–52

de Vaucouleurs, G. 1952. The wonder star: Eta Carinae. *ASP Leaflet* 281, 8 pp.

Feast, M., Whitelock, P. & Marang, F. 2001. Variability of η Carinae – III. *MNRAS* 322, 741–748

Roth, J. 2003. Eta Carinae's Year of Glory. *Sky & Telescope* 106 (1), 30–35

Sterken, C. 2000. The drama of η Carinae. *IBVS* 5000

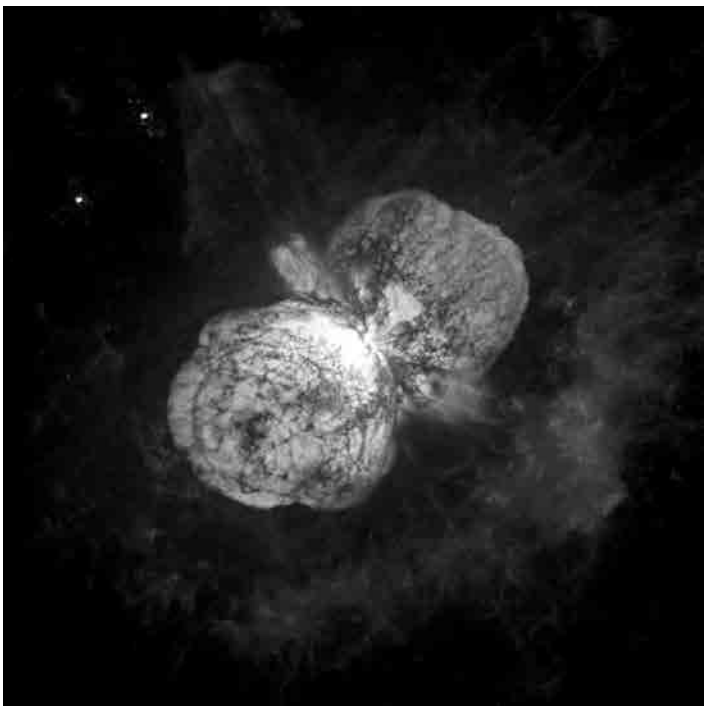


Figure 1. The Homunculus Nebula surrounding Eta Carinae, formed in the Great Eruption of the 1840s (HST).

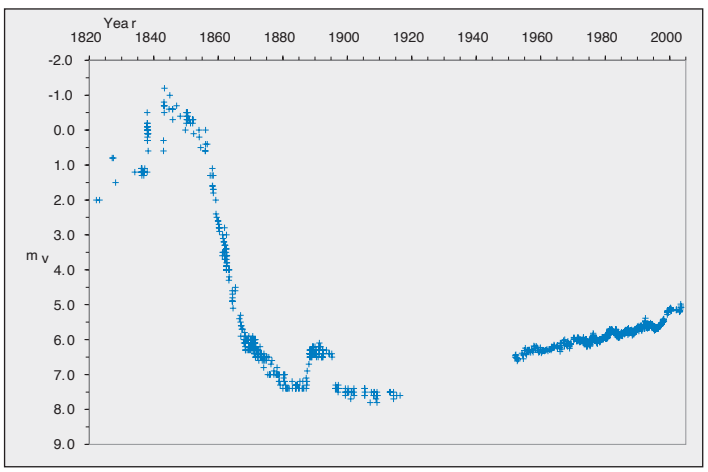


Figure 2. Detailed light curve for Eta Carinae based on visual and recent PEP/CCD photometric measures. Note the smaller eruption around 1890 and the gap in the light-curve between 1915 and 1952.

GETTING STARTED

If you are a beginner, this page is for you. If the tables of numbers in the back of this book seem a little daunting, forget them. You don't need them (yet). Nor do you need a telescope to discover the most spectacular show nature has to offer, the night sky. You just need this book to guide you along on your voyage of discovery of the Universe.

This page will concentrate on the first part of this book, the 'Monthly Sections', as this area has the most to offer the novice.

Is this useful for where I live?

Part I is designed as a quick reference section for anyone who wants a summary of tonight's sky — no matter where you live in Australia.

No adjustment has been made for daylight saving time. When in force you will need to add one hour to get your local time.

So what can this book help me see?

The night sky regularly puts on displays for us called conjunctions. Since the planets, including Earth, are moving round the Sun, their positions change constantly with respect to the background stars. As seen in the sky, the planets seem to pass by each other and bright stars. When a planet is near another, the Moon or a star, it's called a conjunction. When the Moon is included, it's a wonderful sight.

Conjunctions can be spectacular events. An example of a good conjunction this year is the one between the Moon, Venus and Aldebaran on July 14 (see Sky View p. 47). These celestial dwellers all lie within a 9-degree circle in the northeast morning sky. This is simply a chance alignment of these celestial bodies. They only look close together; in space they are still separated by enormous distances. When talking distances beyond the Earth, it is difficult to use normal scales such as metres or kilometres because the numbers would be so large. Instead, let's use the time it takes for light to travel from these objects to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over one second to reach us, Venus 3.7 minutes and Aldebaran 60 years. Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, this star is just in our neighbourhood!

Conjunctions are fun to watch, free, and entertaining. The equipment needed to see conjunctions? You guessed it… nothing!

The best times to see conjunctions are shown in the Sky View diagrams (there are usually five such drawings for each month). Each Sky View shows you an area of the sky that contains a conjunction or another interesting feature. The horizon is shown at the bottom of most Sky Views along with any useful notes. At the top of each is the date you should look. Since the planets move fairly slowly in the sky, many conjunctions occur over a number of days. This means you can often see the planets and stars starting to take their 'places' days before, and then drift apart for days after the event. The Moon is the only exception. It moves quite a bit each day against the background stars. This is why the Moon's position for more than one day is often shown on the same diagram. All the planets visible in a Sky View are labelled, as are the brighter stars.

To use a Sky View, simply go outside under the night sky at the time given and face the direction shown on the diagram. What you see in the Sky View will be a temporary map of the sky in front of you. Incidentally, if you don't know the directions around your house, use a street directory to show you which way is north (it is always towards the top of the page).

There is more to the night sky than conjunctions. There are meteor showers, comets, minor planets (asteroids) and constellations. Not to mention the fascinating movements of the planets as they wander against the background stars. All are described in Part I.

Part I is divided into months. At the beginning of each monthly section is a curious looking graph called a rise/set chart. This series of squiggly lines is your guide to knowing when the planets, Sun and Moon rise and set. To use the chart, simply look at the current date on the bottom of the chart and follow that line upward until it intersects the object of interest. The rise or set time of the object can now be read on the left-hand edge of the chart. For example, on February 8, the Moon and Jupiter rise together during twilight, about 8:30pm. Incidentally, when you see objects rising or setting together, look for a Sky View on that date. There is a Sky View for this conjunction for later that evening (see p. 27).

Each of these monthly sections also has a diagram showing the relative size and appearance of each planet, as seen through a telescope. There is also a description of celestial happenings and highlights — kind of like a celestial moviegoer's guide — and in plain English! Want to know what Venus is up to in March? The description will tell you. A diary of events is also included that summarises the month's features. To see many of these celestial events, you'll need a pair of binoculars or a telescope.

There is one piece of equipment that every sky watcher should have — a red tinted torch. Any torch will do. Simply tape some red cellophane over the end of the torch so that it gives off a dull red glow. The aim is to preserve your night vision, or 'dark adaptation'. When your eyes become used to the dark, they won't react to a red light and so you can use the charts and illustrations and still enjoy the night sky.

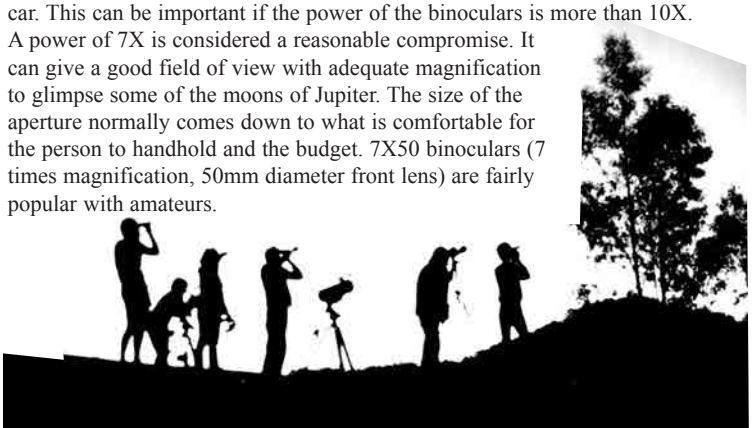
While on the subject of lights, make sure as many lights as possible near your observing site are turned off. The less glare around you, the easier it will be to enjoy the night sky. Encourage neighbours to turn off their outside lights and invite them to enjoy the night sky as well. A major modern threat to the night sky is light pollution; stray light scatters upward into the night sky where it drowns out the stars. So, the more lights we all turn off, the less light pollution, the more power we save and the less natural resources we consume. Perhaps it is time the environmentalists had a look at this. After all, it is the only form of pollution that costs less to fix!

The Sky Views don't show all the sky. By their very nature they mostly concentrate on the ecliptic or zodiac regions of the sky, where the planets and Moon wander. This is why we have re-introduced the All Sky Maps this year. Also, a good companion to this publication would be a planisphere. This shows all of the sky, but not the Sun, Moon and planets because they move. The planisphere is useful by showing at a glance all of the constellations visible at the time you are observing. An example is shown on page 15. Once you start to look around the sky using a planisphere or the All Sky Maps, you may be pleasantly surprised how easy it is to recognise some of the constellations. These star patterns will quickly become familiar and will soon be like old friends.

Part II contains specialised data designed for the experienced enthusiast. The novice, however, should not miss the appendices in Part III. If you wish to pursue the hobby further, we strongly recommend that beginners check out the local amateur community. Learn from these experts and look through their equipment, before spending hundreds or thousands of dollars on a telescope that may not suit your needs. The public observatories, planetariums and courses can also be great resources. Use them.

A word about binoculars

Probably the most cost-effective accessory for the beginner are binoculars. Good quality binoculars can be purchased at the same cost as a cheap, low quality 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 cheap way of gauging their level of dedication. This does not mean we are suggesting the quality of the binoculars should be poor. It is recommended that even binoculars should be purchased from a reputable optics or telescope dealer (see the Quasar Publishing website). These people appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. Such shops can also assist with mounts to hold the binoculars steady. These are often brackets designed to attach to a tripod (sorry, another possible expense). To observe details on the Moon or look for Jupiter's moons, it is recommended that binoculars are not hand held. Sometimes you can brace yourself on the arms of a chair or the roof of a car. This can be important if the power of the binoculars is more than 10X. A power of 7X is considered 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 the person to handhold and the budget. 7X50 binoculars (7 times magnification, 50mm diameter front lens) are fairly popular with amateurs.



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 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. This can be important 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 Centauri with the blue of Beta Centauri.
- The crescent phases of Venus.
- Stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky.
- 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.
- Looking at wide double stars (p. 33).
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on pp. 114-115). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites as the moon passes into or out of the shadow of the planet. The magnification of the binoculars will dictate how close to Jupiter you can see such an event.
- Lunar occultations of some of the brighter stars (see also Part II). Small binoculars are well suited for magnitude 4 or brighter events, preferably on a dark limb. There is no reason why you should not time the event as described on page 92.
- Looking for bright comets (from dark skies).
- Some of the bright deep sky objects such as the star clusters, Milky Way regions and the Magellanic Clouds.
- 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 and see which 'star' has moved. Taking the co-ordinates of a minor planet from Part II, pp. 128-129, and plotting that position on the All Sky Charts will help you find the correct area.
- Searching out Uranus and Neptune, see finder charts, page 124.

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

Finally, it is worth remembering that a pair of binoculars is prone to dewing just like a refracting telescope. A couple of cardboard tubes on the front, sticking out about 75mm, can prevent dew and also help eliminate stray light.

Some Astronomical Terms To Get You Started

There are several astronomical terms you'll come across in Astronomy 2004, many of which are defined in the glossary at the end of the book. Here are a few of the more common ones, just to get you started.

Planet. Just like the Earth! A planet is a sphere of either rock or gas that orbits the Sun or another star. There are nine planets in our Solar System, and the Earth is the third from the Sun. The diagram on page 19 gives a good overview. There are also a number (actually hundreds of thousands) of 'minor planets' that move around the Sun, mostly between the orbits of Mars and Jupiter. The Moon and all the planets we see in the sky do not glow in their own right. They are only visible because of reflected sunlight.

Star. Just like the Sun. Stars are enormous spheres of glowing gas that gives off tremendous amounts of light and heat. They shine by their own light caused by nuclear reactions going on deep inside them. It's a testament to the enormous distances between the stars when you realise that the Sun is a relatively average star, while some stars visible in the night sky are tens or hundreds of times larger and brighter, yet in our sky look so faint.

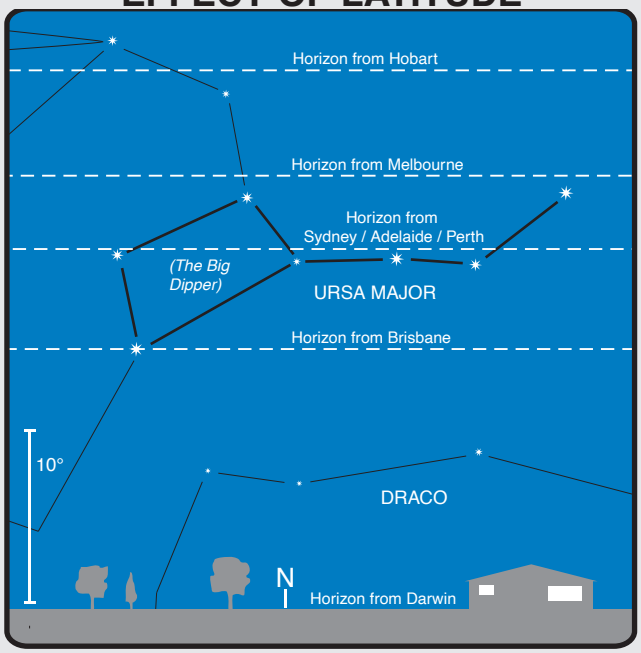
Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'mag.'). The numbers work backwards. The faintest star you're likely to see with the naked-eye is about 6.0 magnitude (under country skies), while the brightest stars are -1.0 magnitude. Planets can be much brighter. Venus, for example, can be as bright as -4.0 magnitude, the Full Moon, -12 magnitude!

Waxing, waning, gibbous and crescent. These terms are normally used to describe the Moon. It is 'waxing' between New and Full Moon, 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 third 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. It is an interesting exercise to go out on nights when there are conjunctions and do your own measurements of the objects' separations and compare your results with the diagrams in this book. Always measure from the centres of the objects — the Moon in the Sky Views is not drawn to scale.

Twilight does not really end until the Sun is 18° below the horizon; this is called astronomical twilight. This happens about 90 minutes after sunset (or before sunrise) and is different from what people normally call the end of twilight. This is civil twilight, which begins or ends when the Sun is 6° below the horizon (about 30 minutes before sunrise or after sunset). Only when astronomical twilight has ended is the sky considered truly dark (assuming the Moon isn't above the horizon!) Keep in mind that many celestial features can be seen even during twilight; binoculars can also help. The actual time between sunset and end of twilight (and the beginning of dawn and sunrise) does vary with latitude. The further south, the longer the time of twilight. Compare the twilight and rise/set times in Part II between Darwin and Hobart.

EFFECT OF LATITUDE



The Sky Views (see the monthly sections) 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 latitude. 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. You may have first heard about this in books written in England or America. This group of stars is part of a larger group known as the constellation Ursa Major, the Great Bear. From Darwin the group is clearly visible above the horizon (but upside down). 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 9pm (mid-June, 7pm). Also from the south we see very little of the constellation Draco. The diagram (above) is drawn to the same scale as a Sky View.

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. For the planets, this is normally when they are due north.

How do I use this book to plan my observing?

This publication was never intended to be read from cover to cover (but we don't mind if you do!) It is a reference work which, if you look closely enough, gives you a number of pieces of the picture. Also, the picture is quite different depending on whether you are using your eyes, binoculars, or a telescope. The data that an astrophotographer would find useful could again differ. To illustrate how to use this book we will work through an example.

You live near Melbourne, Victoria and are planning to go out and observe on the evening of May 22 and hoping to push on all night (for once the infamous Melbourne weather is looking OK). Being in an eastern state you will use times in EST, when given. A good place to start is the Visibility of the Planets chart (p. 18). Looking around mid-May, the diagram is showing Venus, Mars, Saturn and Jupiter in the evening sky, with Mercury, Pluto, Uranus and Neptune in the morning. A quick check of the Rise/Set Chart for May (p. 36) shows the Moon, Mars and Saturn setting together in the early evening (around 7:30–8pm) which would indicate a conjunction and there may be a Sky View for this date. On page 39 there is indeed a Sky View showing Saturn, Mars and the Moon low in the northwest twilight sky, one hour after sunset.

With the Moon being up, it is worthwhile checking for any occultations on this evening. With the Moon setting just a couple of hours after sunset today, there is a limited opportunity to see any occultations and a check of the Melbourne table (p. 96) shows no events for May 22. In fact no events are seen until May 25 at 7:54pm when 7.5 magnitude star SAO 80615 disappears behind the dark limb of the Moon.

The Moon text, page 36, shows it is only 3 days past New, so a thin crescent Moon is visible.

The Rise/Set diagram shows that Venus is setting around the end of twilight, so you need to start early and have a flat western horizon to glimpse its thin crescent shape (see Appearance of the Planets diagram p. 36).

This same diagram shows that Saturn's rings are still relatively wide open (as they are for the whole year). A check of Satellites of Saturn (p. 118) shows its brightest moon, Titan, to be approximately 6 days past an eastern elongation. Its position can be read directly off the diagram on page 118. Going back to the appearance diagram this places the moon to the upper right (2 o'clock position) of Saturn, but a fair distance from the rings. Note this is on the opposite side as the appearance diagrams are drawn with north up, whereas the diagram on page 118 is drawn with south up. Titan can be seen in a small telescope.

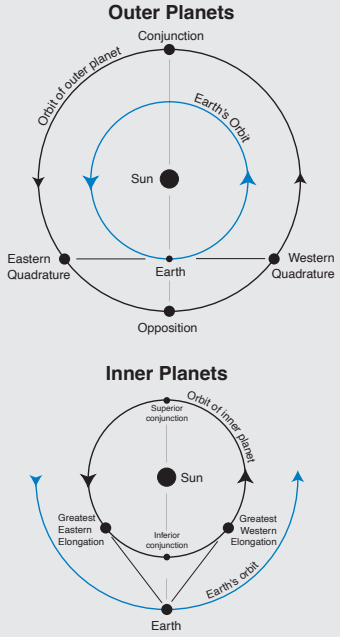
Jupiter doesn't set until just after midnight, so it is well placed in the evening sky for observations. Besides its famous cloud bands and Great Red Spot, the satellites put on a show for the evening. Satellite II (Europa) is transiting across the disk early in the evening with its shadow passing onto the disk at 7:56pm (19:56) and 17 minutes later the moon leaves the disk (20:13). The shadow eventually leaves (egresses) the planet some 2 hours later (22:45, see Jupiter Moon Events p. 112). Later in the morning (23rd) Europa passes close to Io, with satellite III (Ganymede) being the only satellite, of the main four, on the eastern side of Jupiter (see diagram on p. 114).

Returning to the Sky View on page 39, the possibility of seeing two naked-eye comets in the sky is the real drawcard. For such a unique event, you must give yourself the opportunity of seeing this under dark skies, well away from the city. The Moon will not present any problems with it setting so early in the evening. Not only is Comet 2002 T7 (LINEAR) going to be at maximum brightness but it will be only 3.5° from Sirius, the brightest star in the sky (see the diary p. 37). Even if the comet is not visible to the naked-eye they should both fit easily in the field of view of a low power pair of binoculars.

There is another, much fainter comet visible on this night. The monthly comet text, page 37, mentions that C/2003 K4 (LINEAR):

'... is moving northwest through Cygnus and Lyra. Low in the northern sky, the 10th magnitude comet is best observed in the early hours of the morning.'

ORBITAL ASPECTS



Looking at Part II, Comets

A **conjunction** of a planet and the Sun is when they are closest together in the sky (not the best time to observe the planet). When an inner planet is between us and the Sun it is said to be at inferior conjunction, when on the far side of the Sun we have a superior conjunction. It is also common to hear this word referring to any two or more objects when they are closest to each other in the sky, i.e., when they at their minimum angular separation.

Opposition refers to the time a planet is opposite the Sun in the sky. An object in opposition will rise around sunset and will be visible the entire night (like the Full Moon). The inner planets, Mercury and Venus, can never reach opposition. Their orbits are both inside Earth's. We need to pass between an object and the Sun for opposition to occur.

Elongation is often used in reference to the inner planets and their greatest angular distance from the Sun, that is greatest western elongation (in the eastern morning sky just before sunrise) and eastern elongation (a western evening sky object just after sunset). This is generally the best time to observe Mercury and Venus.

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for 2004 (p. 132) shows the position for this comet on May 22 as RA 19hr 36.4m, Dec. +38° 21' (if there isn't a position for the date you will have to interpolate). An approximate location in the sky can then be determined on the appropriate All Sky Map (in this case No. 9). Take the half-way point between the stars Vega and Sadr. The comet is about 3 degrees south (above) this point. A planisphere (see example opposite) shows this position to be due north (i.e., its highest point) at around 3am.

The Rise/Set chart shows Neptune rising before 11pm with Uranus less than 2 hours behind. This confirms the Visibility Chart indicating these planets are best visible in the morning sky (allowing a couple of hours for them to get away from the horizon). Finder charts for these distant members of our Solar System can be found on page 124. Their general location in the sky is marked on All Sky Map No. 8.

If you wish to observe through to dawn, you should be rewarded with an excellent view of a half-moon shaped Mercury (see Appearance of the Planets, p. 36). It is about as well placed as Mercury can get in the morning sky, with the planet rising about 30 minutes before the start of dawn.

These are just a few examples of the way to apply the information within this book and how it can be a lot of fun planning an observing session.

THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

RISE/SET CHART

This will enable the reader 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 morning sky above. The two bands of 'lighter' shading show the times of morning and evening astronomical twilight. If you are using a telescope you'll soon learn to avoid trying to observe a planet near the horizon (close to rise or set times). Turbulence in the much thicker atmosphere (at low altitude) gives very poor 'boiling' images.

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. There are no adjustments made for Daylight Saving (or Summer Time) anywhere in this publication. When Daylight Saving is in force you will need to add one hour to times given here. For example, any rise/set time read off the charts will need to have one hour added to it 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). They are the mean solar time on the meridian of longitudes of 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from the EST times given. Any times specifically given for Darwin or Adelaide are CST.

Queensland, NSW, ACT, Victoria and Tasmania use EST as their time zone. South Australia and the Northern Territory use CST and Western Australia uses WST.

These charts only give an approximate local standard time and you will see from the specific rise/set times in Part II there is variation from city to city. This reflects the effects of position relative to the standard meridian and differing latitudes. The chart indicates the time to within plus/minus 30 minutes for all capital cities (except Darwin). Darwin, because of its extreme latitude compared to the more populated southern regions of the continent, can differ by up to 90 minutes. If more accurate rise/set times are required, you will need to refer to the specific tables for the object of interest in Part II of this publication. You can also adjust for rural locations using the appendix on page 138.

HIGHLIGHTS

This lists a few of the more interesting events during the month.

APPEARANCE OF THE PLANETS

This diagram provides the reader with a telescopic view of each planet drawn to the same scale. Under each image is the date, the planet's angular diameter and magnitude. Phases are also shown for Mercury, Venus and Mars. Each planet is presented with the north pole to the top.

THE MOON

This provides information on major events relating to the Moon. The data includes the Moon's phases, apogee, perigee, occultations of planets or bright stars and lunar and solar eclipses. The event does not have to be visible from Australia to be included. The description will normally indicate whether or not it can be seen. Throughout the monthly section the Earth–Moon distance quoted is between the centres of the two bodies.

There are no occultations of bright stars by the Moon during 2004. The next bright star occultation will be in January 2005, when the 1st magnitude star Antares passes behind the lunar limb. There will be ten planet and major asteroid occultations this year, somewhere in the world, plus the usual multitude of fainter star events (see Lunar Occultations in Part II).

THE PLANETS

Presented are general notes on each planet. Emphasis is placed on their suitability for observation and any interesting conjunctions and patterns between the Moon, other planets and bright stars. Any times given for specific locations assumes local standard time.

MINOR PLANETS (or Asteroids)

This section deals with the brightest asteroids that reach opposition this year (approximately 11th magnitude or brighter). An entry includes the date of opposition (i.e., when it is brightest), its magnitude and the constellation the asteroid is in at the time of opposition. Ephemerides for the brightest 16 of these, plus 4 others that reach opposition in either late 2003 or early 2005, are included in Part II.

COMETS

This section deals with the comets expected to be visible during the year. It points out those that are observable during the month and includes any interesting conjunctions. Note, with the possible exceptions of C/2002 T7 and C/2001 Q4, most of the known comets this year are relatively faint and will need a telescope. It is likely that many other comets will be discovered during the year.

METEOR SHOWERS

On any clear night we can sometimes 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 the radiant lies near. For example, the radiant for the Leonids lies within the constellation of Leo. The monthly section lists the major showers for this year that are suitable for observation. These selected showers are those largely unaffected by moonlight during their peak period. Information for all the known showers is given in Part II. It takes great patience to watch for meteors, but the occasional fireball makes it all worthwhile. It is best to do your searching on moonless nights, away from light polluted cities. As a general rule, more meteors are seen after midnight.

DIARY OF EVENTS

This is a list of all general phenomena associated with the planets and Moon. The presentation is keyed to those people who would like to know 'what's happening tonight (astronomically speaking)?' 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. Differences will be often found between the separation distances (and times quoted) and those found in the remainder of Part I. Conjunctions involving only the bright stars, the planets and the Moon are geocentric. This is how they would look from a position corresponding to the centre of the Earth. The exact time of closest approach may be in daylight from Australia, or the objects of interest may not be above the horizon for us. The planetary text and Sky Views have been tailor-made to suit Australia. Hence the times and angles given in the Diary of Events could differ from those on a Sky View. Sometimes a lunar conjunction is followed by 'Occn'. This indicates that from somewhere in the world the object will be occulted (covered) by the Moon. The distance given is measured from the centre of the Moon (remember, the Moon has a diameter of 0.5°). Occultations involving the planets or the brightest stars are also mentioned in the 'Moon' text.

Abbreviations. These include:

- G is galaxy (SG spiral, IG irregular, EG elliptical, LG lenticular)
- OC represents an open cluster
- GC is a globular cluster
- DS is a double star
- N is nebula (PN planetary, BN bright and DN dark nebula)
- m.p. refers to a minor planet

There are also some astronomical catalogues including:

- NGC – New General Catalogue
- IC – Index Catalogue
- M – Messier catalogue

Time. When times are given, both EST and WST are presented. As these times are rounded to the nearest hour, it is unnecessary to include a separate entry for CST seeing there is only a 30 minute difference to EST. The remaining entries are less time sensitive and either have no time (i.e., 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 2am) for EST, the WST conversion (subtracting 2 hours) takes it into the previous day — shown as 'prev. day'.

FEATURE ARTICLE

This section concentrates on some topics in popular astronomy. This can include observation, history, profiles of astronomy enthusiasts, astronomical equipment and techniques. Some of these are written specifically for beginners.

SKY VIEWS

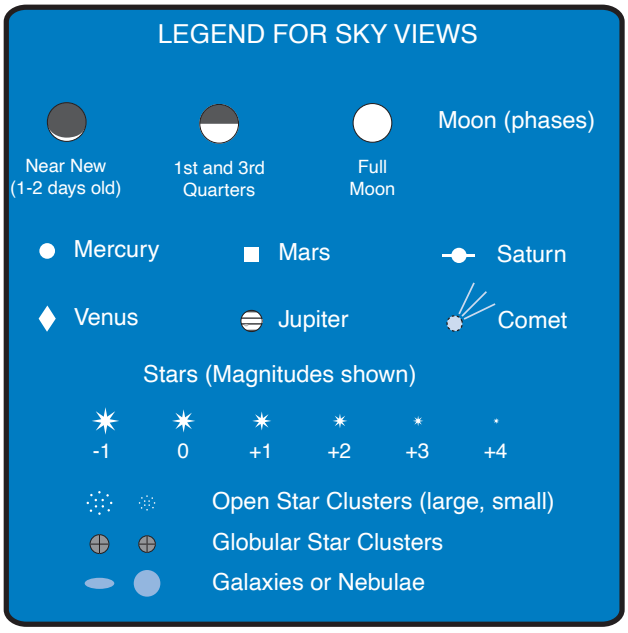
These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although, astronomically speaking, this would still be considered twilight, this is sometimes necessary to catch a glimpse of the planets when they are close to the Sun. This is especially needed for Mercury, because 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 below) include:

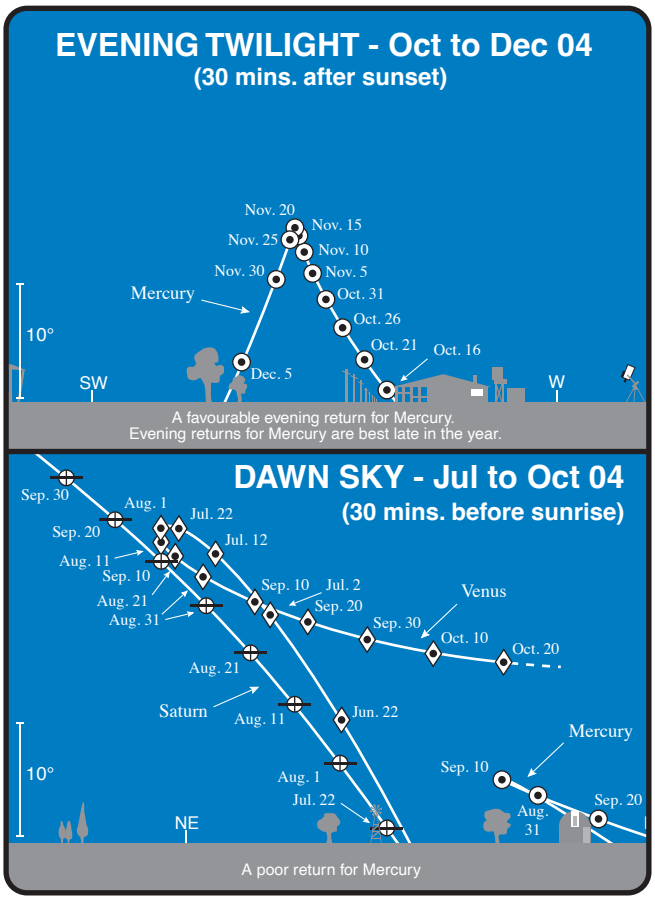
- The Moon (showing approximate phase) and the planets visible with the naked-eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies (down to approximately 5.5 magnitude). These objects are named using the following codes. A prefix of '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.

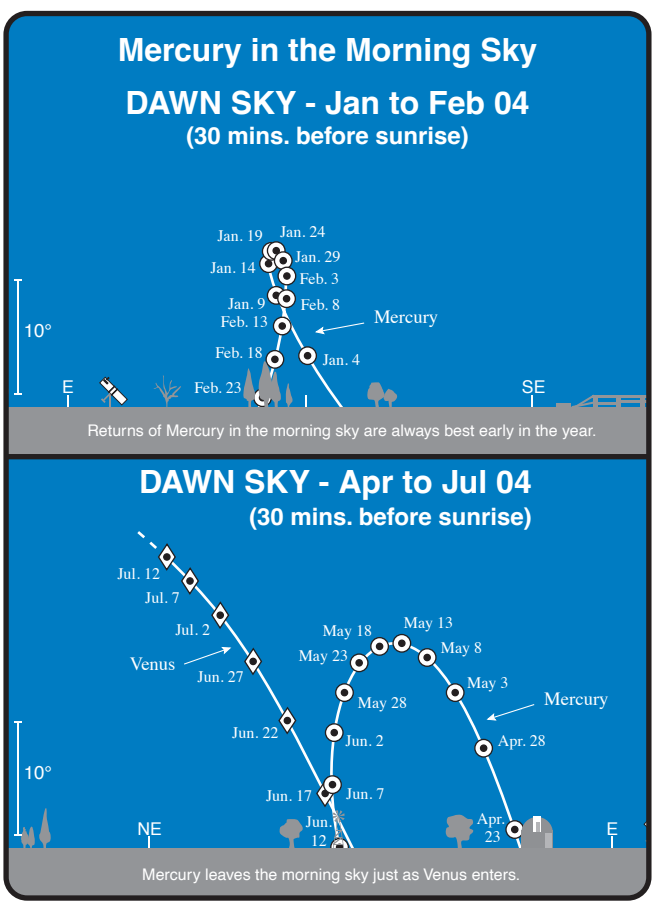
When using these 'windows to the sky' it is important to keep in mind that the horizon shown is theoretical, like looking out over the ocean. You will soon learn to make mental adjustments for local hills, trees and buildings etc. The scale has been kept constant and a 10° reference bar is marked. Sometimes the object of interest is so high, the field of view is not large enough to include the horizon.

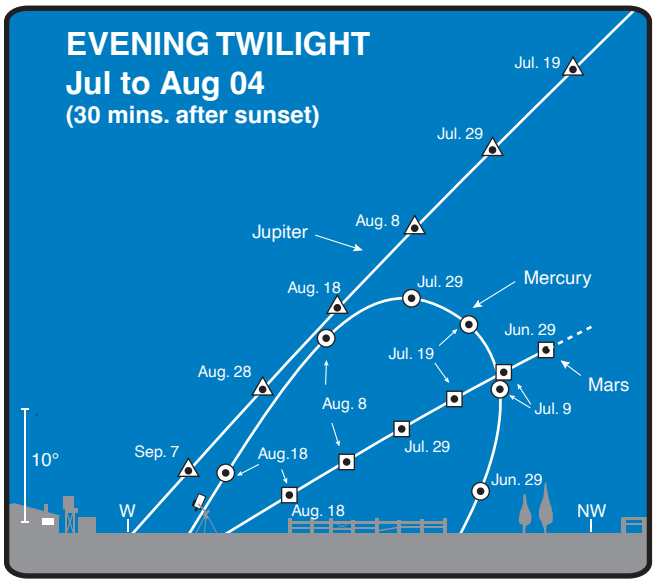
Uranus, Neptune and Pluto have been excluded from the Sky Views as they are not generally visible to the naked-eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. In any case, because of the many faint stars of similar brightness close-by, finder charts would be needed to identify these outer worlds. Charts for these planets are on pages 124-125.

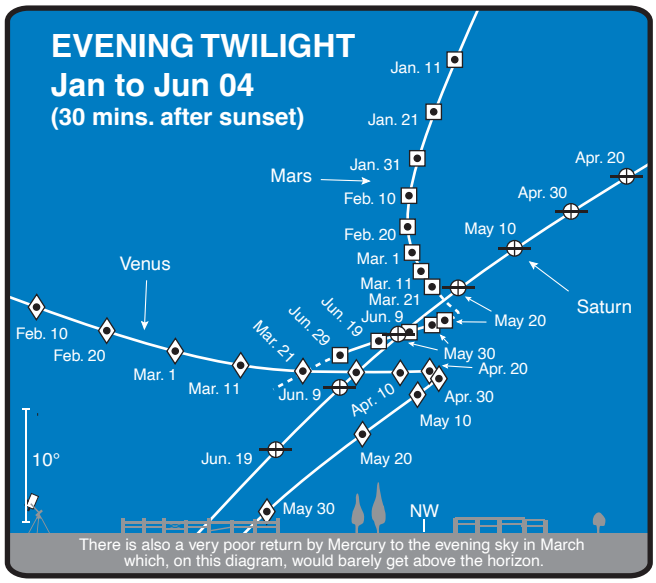


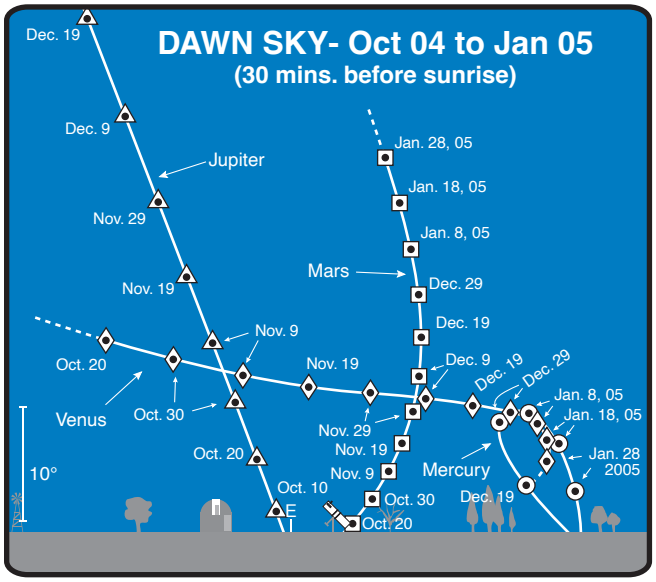
MOVEMENT OF THE PLANETS





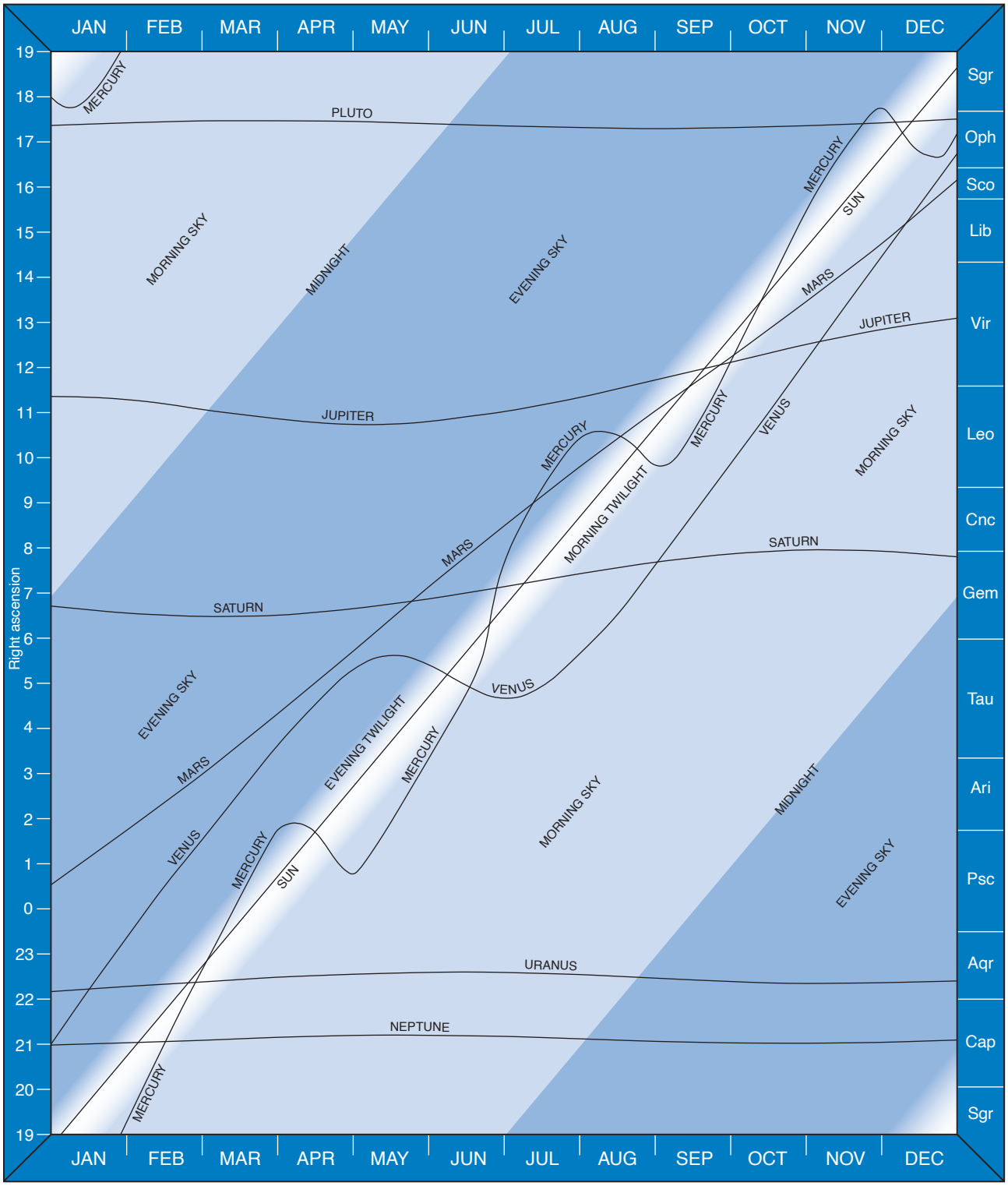






These diagrams are designed to help observers know when the planets first become observable after being in conjunction with the Sun, or when they are about to go into conjunction with our star. The drawings are particularly useful as an observing guide for Mercury. In addition, the Visibility of the Planets diagram (p. 18), allows you to see at a glance whether an object is in the morning or evening sky.

VISIBILITY OF THE PLANETS

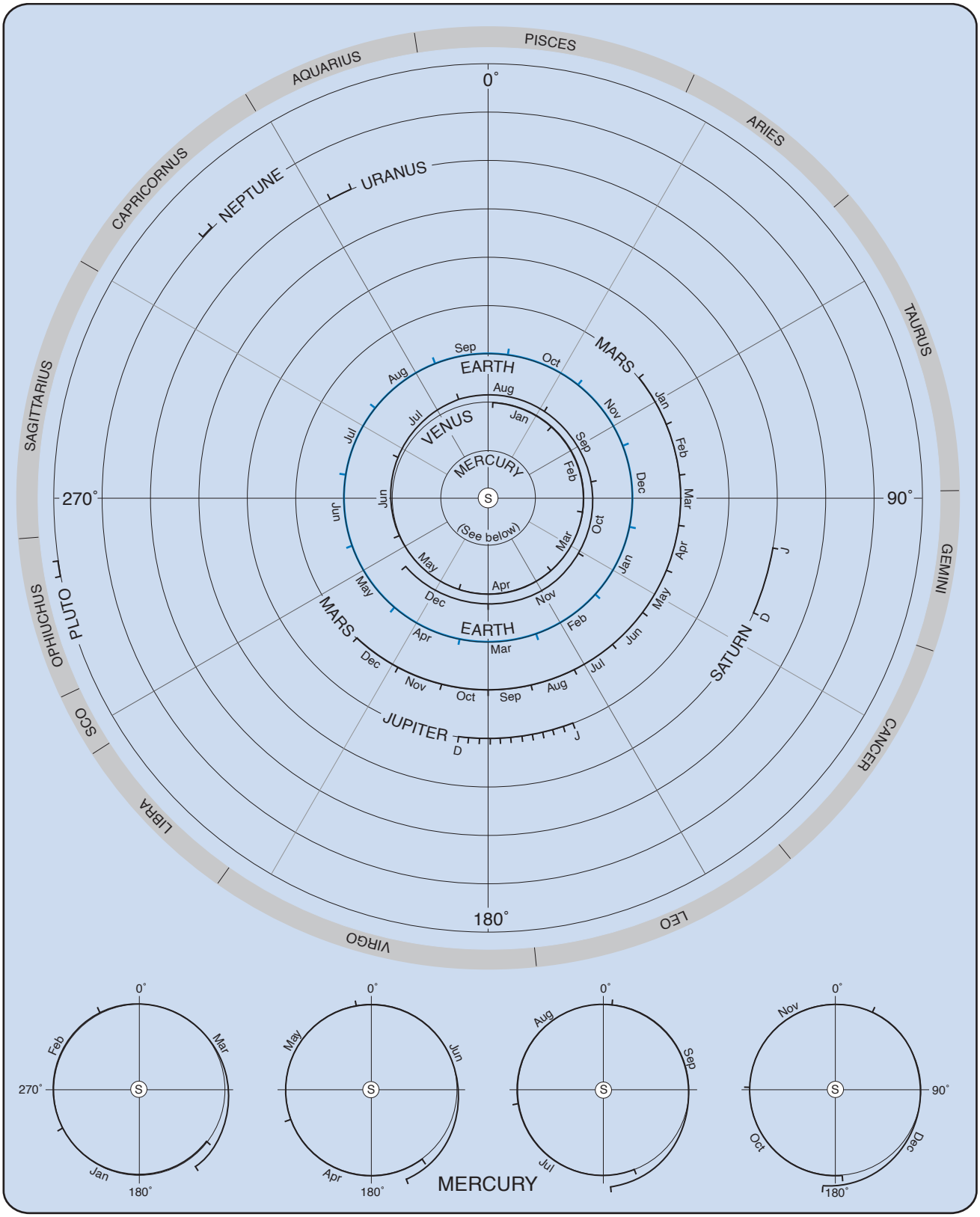


This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation 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, in the latter third of the year, is visible in the morning sky in Virgo).

Mercury and Venus (and the rest of the planets) are in conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best times to observe Mercury are from late April to early June for the morning sky, and from early July to mid-August in the evening, when its path extends beyond twilight. When an outer planet crosses the midnight line, it is at opposition and is visible the entire night. Where an outer planet's line shows a downward slope, it is in retrograde motion.

The diagram also shows when conjunctions between the planets occur. When two or more lines cross, the planets will be close together in the sky. This year's conjunction between Mercury and Mars is clearly shown where their paths cross in the July early evening sky (see Sky View p. 46).

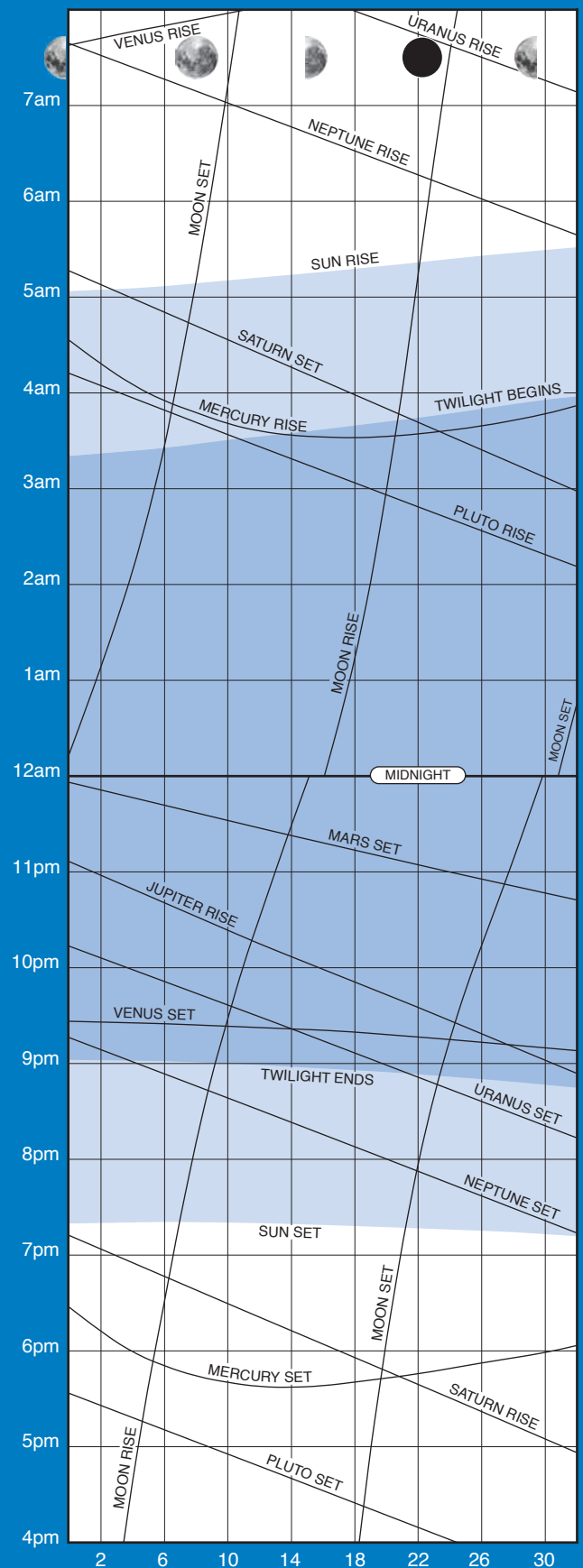
PLANET POSITIONS



This diagram illustrates the relative positions of the planets during the course of their orbits in the year 2004. The relationships between the major Solar System bodies are clearly shown. For example, this year's opposition of Jupiter occurs early in March when the Earth appears closest. A line extended from Earth, through and beyond Jupiter shows that the planet is located in Leo at this time. The diagram is drawn as viewed from below (south of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the sun and planet distances are not drawn to scale. The thirteen constellations named are those that are situated on the ecliptic.

JANUARY

RISE/SET CHART



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

HIGHLIGHTS

- Mercury returns to the morning sky
- Venus and Uranus close together
- Saturn at opposition

THE MOON

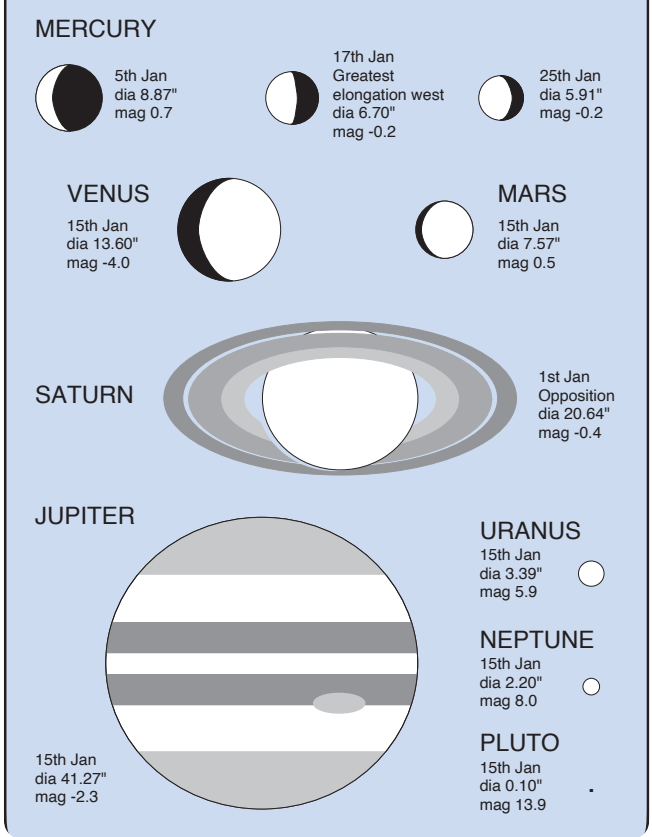
4th	Moon at apogee (furthest from Earth – 405,707 km distant, angular size 29.1')
8th	Full Moon
15th	Last Quarter
20th	Moon at perigee (closest to Earth – 362,770 km distant, angular size 33.2')
22nd	New Moon
29th	First Quarter
31st	Moon at apogee (furthest from Earth – 404,807 km distant, angular size 29.7')

THE PLANETS

MERCURY, in Sagittarius, is too close to the Sun for observation early in the month. The planet quickly moves away from the Sun and into the morning twilight, reaching its greatest elongation west of the Sun on the 17th (24°). Throughout the month Mercury moves past many of the Messier objects within the Sagittarius Star Cloud, but twilight hinders observations of these gems. The slender crescent Moon makes a fine sight above the planet on the 20th (see Sky View).

VENUS is visible in the early western evening sky, moving from Capricornus into Aquarius mid-month. After a close rendezvous with

APPEARANCE of the PLANETS



Neptune late in December, Venus moves towards the next most distant planet, Uranus; the pair will be less than 1° apart on the 15th. On the 24th, the 3-day old thin crescent Moon appears near Venus (see Sky View). With optical aid, the 15-arc second diameter gibbous phase of the planet can be seen. When nearing inferior conjunction (and transit) this year, Venus grows much larger in angular size than Jupiter!

The **EARTH** is at perihelion (the closest point in its orbit to the Sun) on the 5th. The Earth/Sun distance is 0.983265 astronomical units, which is equivalent to about 147,096,000 km.

MARS, in Pisces all month, can be seen setting just before midnight in the west. Currently Mars is at its brightest this year, and also at its largest angular diameter, although a far cry from the magnificent sight presented to us last August during the planet's favourable perihelic opposition. The Red Planet remains visible in the evening sky for the first seven months of the year before coming too close to the Sun for observation, it then reappears in the late October morning sky. On the 28th, the first quarter Moon appears close to Mars (see Sky View).

JUPITER, in the constellation of Leo, rises in the mid-evening eastern sky. Jupiter remains an evening object until September when it moves too close to the Sun for observation. The planet then becomes a morning object from October through to year-end. On the 13th, the 19-day old Moon can be seen near the planet (see Sky View).

SATURN is at opposition on the 1st day of the New Year, and for the next month or so will be well placed for observation of this most exquisite planet at its brightest and largest. Observers will note a gradual closing of the planet's rings over the course of the year. This trend continues until the Earth passes through the ring plane in 2009, when they will appear edge on. The planet lingers in the constellation of Gemini throughout the year and is an evening object for the next six months. On the 6th and 7th, the Full Moon appears near the planet (see Sky Views).

URANUS in Aquarius and **NEPTUNE** in Capricornus remain in their respective constellations during the year. Both planets begin the year low in the early western evening sky, moving toward solar conjunction next month. Venus will come within 1° of Uranus on the 15th.

PROBING THE PLANETS – UPDATE 2004

Over the last 40 years or so we have been enthralled by the stunning images returned by the various robotic probes sent into the Solar System. There is no doubt we rely on these spacecraft heavily for our knowledge of the Solar System, having now nearly exhausted what can be learned from Earth bound observatories.

Back in 1974, Mariner 10 took pictures that revealed the inner world of Mercury to have a surface very moon-like, complete with multitudes of craters.

The Earth's sister planet Venus has always been a source of curiosity with its surface hidden from us by its permanent, globe-encircling layers of clouds. In 1990 a real breakthrough was made when the orbiter Magellan made detailed radar maps of 98% of the Venusian surface. This data showed that, like the Earth, little evidence remains of any ancient impact craters, proving that the planet has been volcanically active or there has been significant plate tectonic movement.

Mars had been extensively studied from Earth but it only took a handful of pictures by Mariner 4 in 1965 to shatter forever the myth of the Martian vegetation and canals. Mars was shown to be very much like the Moon with a meteorite-pounded surface. Subsequent orbital missions have revealed a much more varied and exciting red planet including four enormous volcanoes, a giant canyon Vallas Marineris and a surface that has been moulded by running water in the past. This exciting fact has re-ignited the interest in finding evidence of life (at least in the distant past) and missions to Mars have been planned for the next 10 years. In 1976 the Viking landers came along and delivered crystal clear images of the red rocky plains of Mars. In more recent times the Pathfinder lander gave us a fascinating travelogue as we watched the breadbox-sized Sojourner rover drive a few metres and photograph, sample and test the Martian rocks and soil. In 2001 the Mars Odyssey spacecraft went into orbit and has been making detailed maps of the planet — survey work that will set the targets for the next generation of landers.

The Pioneer and Voyager flybys showed us an unprecedented complex cloud structure on Jupiter, as well as discovering the planet's rings. These probes also introduced us to Jupiter's extremely diverse family of satellites, from the volcanically active Io to the ice-enshrouded Europa. In 1995 Galileo became the first spacecraft to orbit Jupiter and its probe was the first to sample the atmosphere of this gas giant. Over many orbits Galileo studied Jupiter's atmosphere and the four largest moons. It ended its mission by plunging into Jupiter's atmosphere in September 2003 as planned.

Pioneer 11 and both Voyagers (1 and 2) also made brief calls on Saturn. During these flybys they discovered unusual detailed structure in the rings, storms in Saturn's atmosphere and many of its satellites were studied and imaged.

Voyager 2 went on to streak past Uranus and Neptune and overnight rewrote the textbooks on what we know of these distant gas giants. Unfortunately, Pluto still remains unvisited and will continue like this until at least 2006 when NASA hopes to launch 'New Horizons'. Assuming adequate funding can be found for the mission it should arrive around 2015.

Milestones for 2004

In either March or May NASA is expected to launch 'Messenger'. Thirty years after Mariner, a probe is finally returning to Mercury. After two flybys of Venus and one of Mercury it will finally enter orbit in 2009. Messenger stands for **ME**rcury **S**urface, **S**pace **EN**vironment, **GE**ochemistry and **R**anging mission. The orbital phase is expected to last for one year.

H.G. Wells may have had the Martians invading Earth, but 2004 will see Earth get its revenge when a truly international armada descends on the Red Planet early in the year. The European Space Agency's Mars Express will arrive in December 2003 with a Christmas landing of Beagle 2. The plan is for the lander to conduct exobiology and geochemistry research until March while it is hoped the orbiter will operate until November 2005. The Japanese probe NOZOMI will enter orbit in January to study the upper atmosphere and its interaction with the solar wind. NASA's Mars Explorer programme is on track to deliver its Spirit (MER-A) and Opportunity (MER-B) probes to the surface in January. These two identical robotic field geologists will hopefully operate for three months with their primary mission to look for water.

In 2004 Saturn will get its first artificial satellite when Cassini goes into orbit in July. In December it will release the Huygens probe which will, a month later, enter the atmosphere of the moon Titan and parachute its laboratory to the ground. For four hours it will study the surface structure and the weather of Titan, relaying its data back to Earth via the orbiter. Cassini is expected to spend four years studying Saturn's rings and atmosphere, the moons and the magnetosphere.

Although not related to the exploration of the planets there are two significant events involving the study of comets this year. In January 'Stardust' will collect samples of dust and gas from the coma of Comet Wild 2. It will return this material to Earth in 2006. Also in January it is hoped 'Deep Impact' will be launched. This unique mission will send a 350-kilogram projectile crashing into Comet Tempel 1 in 2005. It is expected to blast out a crater 200 metres across. The resulting debris will be studied by the probe and from ground-based observatories.

PLUTO, in Serpens Cauda, returns to the morning sky after solar conjunction late last year.

MINOR PLANETS at opposition this month include: 10 Hygiea on the 7th at magnitude 10.0 in Gemini, 1 Ceres on the 9th at magnitude 6.8 in Gemini and 6 Hebe on the 12th at magnitude 8.6 in Canis Minor.

COMETS

Comet C/2001 HT50 (LINEAR-NEAT) is an evening object in Pisces, setting before midnight. During the first half of January, it is within two degrees of 4th magnitude Delta Piscium. It should fade from 12th to 13th magnitude by month's end.

Comet C/2001 Q4 (NEAT) opens the year perhaps as bright as 10th magnitude in Octans. Visible all night, although best observed in the evening, NEAT moves northward into Indus during January and may end the month at 9th magnitude.

Comet C/2002 T7 (LINEAR) begins January in the northern half of the evening sky. Possibly as bright as 9th magnitude, LINEAR briefly passes through Andromeda before returning to Pisces as it moves southwest. By month's end, LINEAR will be setting mid-evening and may have brightened to 8th magnitude.

Comet C/2003 H1 (LINEAR) could be 13th magnitude at the beginning of January, brightening to 12th magnitude by month's end as it moves through the morning sky constellation of Libra.

Comet 2P/Encke is a difficult sight this month, rising around the beginning of astronomical twilight in the morning sky. It could be fading from 8th to 10th magnitude as it moves through Ophiuchus and Sagittarius.

Comet 43P/Wolf-Harrington should brighten from 13th to 12th magnitude this month. It is an early evening object, moving through Pegasus and Pisces.

Comet 81P/Wild 2 may be sighted in the pre-dawn skies of the second half of January as a 13th magnitude object in Ophiuchus, passing near a number of globular clusters.

Comet 88P/Howell should first become visible to amateurs from mid-January onwards, when it has brightened to 13th magnitude and is moving southeast through Ophiuchus before ending the month in neighbouring Sagittarius.

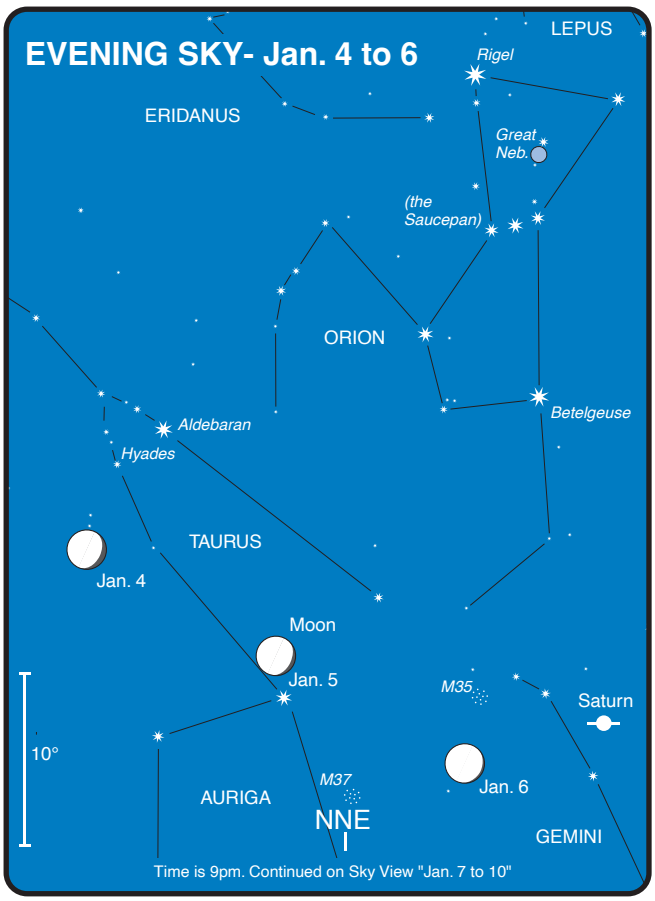
Comet 123P/West-Hartley is a morning object of 13th magnitude in Virgo, near the Virgo cluster of galaxies. During the first half of the month, it is within three degrees of 3rd magnitude Epsilon Virginis.

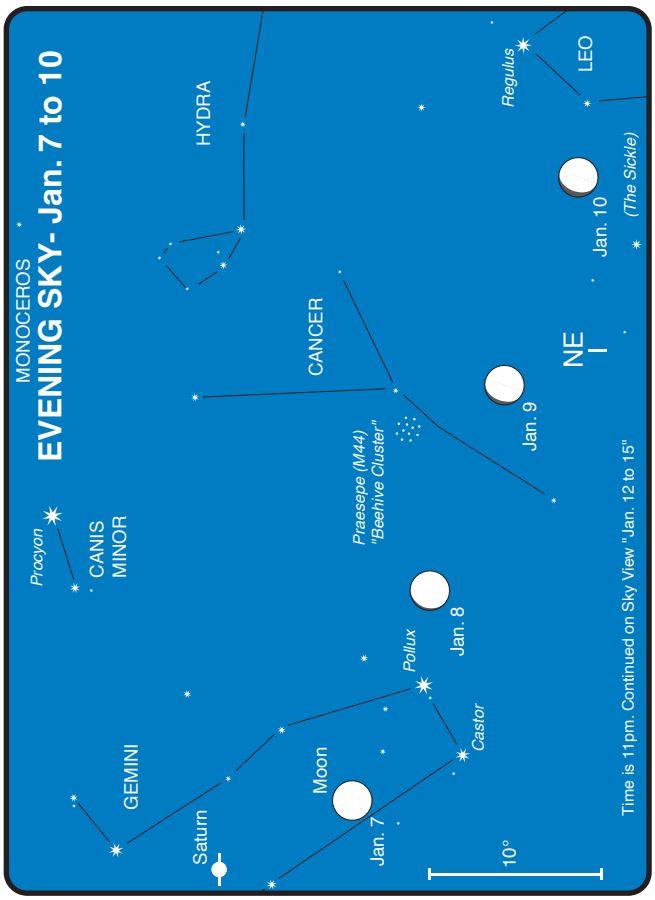
METEOR SHOWERS

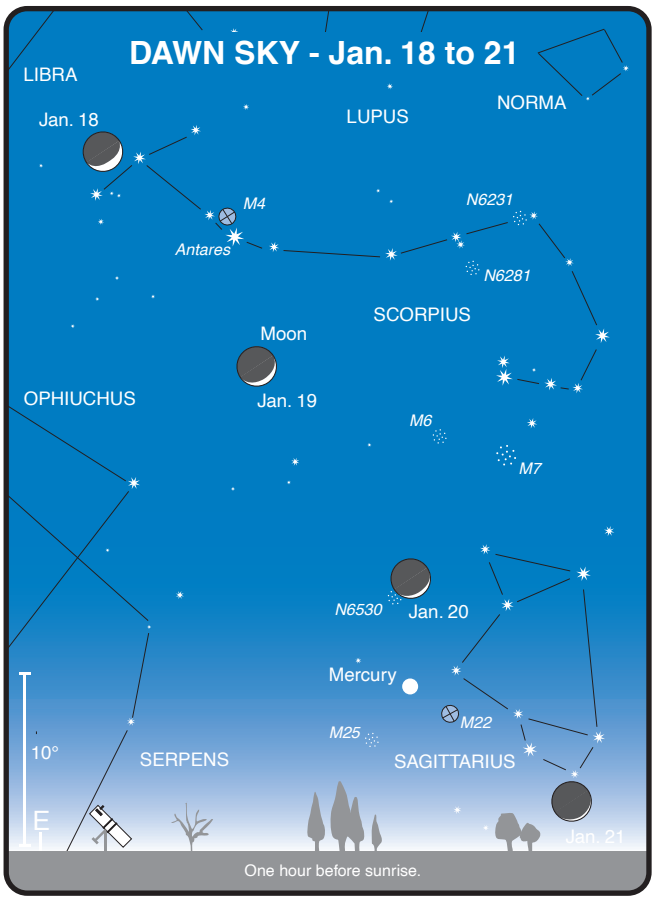
The **delta-Cancrids** are a minor meteor shower, with the radiant in Cancer above the horizon for most of the night. Typically faint, the zenith hourly rate is unlikely to rise above 3 to 4. The shower's duration is from the 1st to 24th January with maximum on the 17th.

DIARY

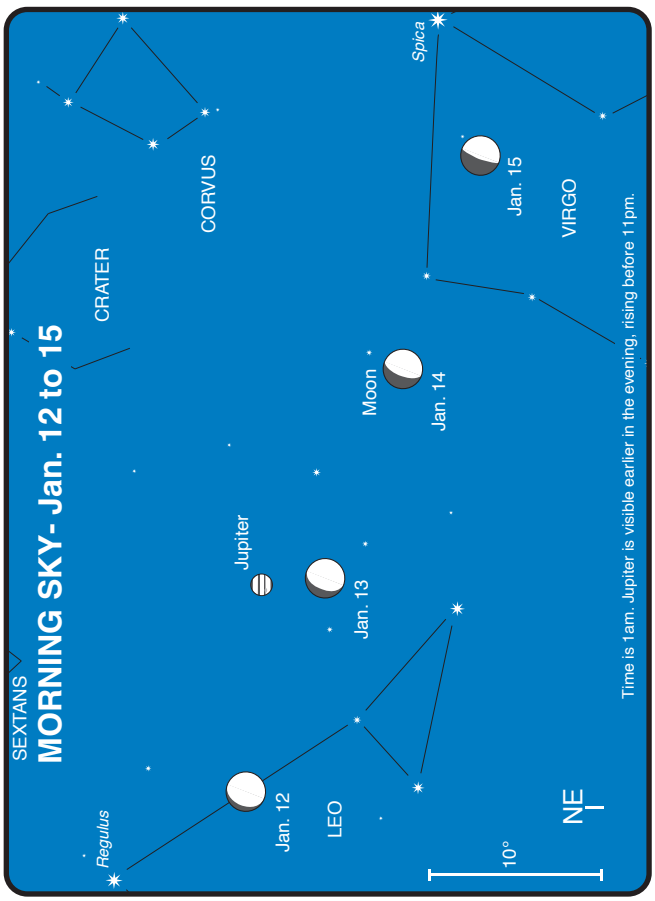
1st	7 am	(5 am WST) Saturn at opposition
3rd		Comet 2P/Encke 0.3°S of star Theta Ophiuchi
3rd		Mercury at greatest latitude North
4th	6 am	(4 am WST) Moon at apogee
4th		Comet 2P/Encke 0.8°NE of NGC 6355 (GC) in Ophiuchus
5th	1 am	(11 pm WST, prev day) Jupiter stationary
5th	4 am	(2 am WST) Earth at perihelion
6th	Midnight	(10 pm WST) Mercury stationary
7th	10 am	(8 am WST) Saturn 5°S of Moon
8th	2 am	(Midnight WST, prev day) Full Moon
8th		m.p. 20 Massalia 0.4°SW of star Alpha Librae
9th		Venus 0.9°NW of star Delta Capricorni
9th		Comet 123P/West-Hartley 0.6°N of star Epsilon Virginis
9th	Midnight	(10 pm WST) m.p. 1 Ceres at opposition
10th		Mercury 0.6°SW of NGC 6440 (GC) in Sagittarius
11th		Comet 2P/Encke 0.4°N of NGC 6520 (OC) in Sagittarius
12th	9 pm	(7 pm WST) Jupiter 3°S of Moon
15th		Comet 88P/Howell 0.3°SE of NGC 6235 (GC) in Ophiuchus
15th	11 am	(9 am WST) Venus 0.9°S of Uranus
15th	3 pm	(1 pm WST) Last Quarter Moon
16th		Mercury 0.8°N of M21 (OC) in Sagittarius
17th	8 pm	(6 pm WST) Mercury greatest elongation West (24°)
18th		Mercury 0.4°S of NGC 6568 (OC) in Sagittarius
18th		Comet 88P/Howell 0.3°W of NGC 6287 (GC) in Ophiuchus
19th		Mercury 0.4°E of NGC 6583 (OC) in Sagittarius
19th		Comet 2P/Encke 1°S of star Phi Sagittarii
20th	5 am	(3 am WST) Moon at perigee
20th		m.p. 324 Bamberga 0.5°N of M6 (OC) in Scorpius
20th	1 pm	(11 am WST) Mercury 5°N of Moon
22nd	7 am	(5 am WST) New Moon
22nd		Mercury 1.0°N of NGC 6642 (OC) in Sagittarius
22nd		m.p. 8 Flora 0.3°SE of star Delta Capricorni
22nd		m.p. 324 Bamberga 0.6°NW of NGC 6416 (OC) in Scorpius
23rd		Mercury 1.4°N of M22 (GC) in Sagittarius
23rd		Comet 88P/Howell 0.8°NE of NGC 6325 (GC) in Ophiuchus
23rd	9 pm	(7 pm WST) Mars 0.2°SW of NGC 524 (LG) in Pisces
24th	4 am	(2 am WST) Comet 2P/Encke 0.05°E of star Tau Sagittarii
24th	7 am	(5 am WST) Uranus 4°N of Moon
24th		m.p. 324 Bamberga 0.3°S of NGC 6425 (OC) in Scorpius
25th	2 am	(Midnight WST, prev day) Venus 4°N of Moon
26th		Mercury at descending node
28th	1 pm	(11 am WST) Mars 3°N of Moon
29th		Comet 88P/Howell 0.5°NE of NGC 6401 (GC) in Ophiuchus
29th	4 pm	(2 pm WST) First Quarter Moon
31st	Midnight	(10 pm WST) Moon at apogee

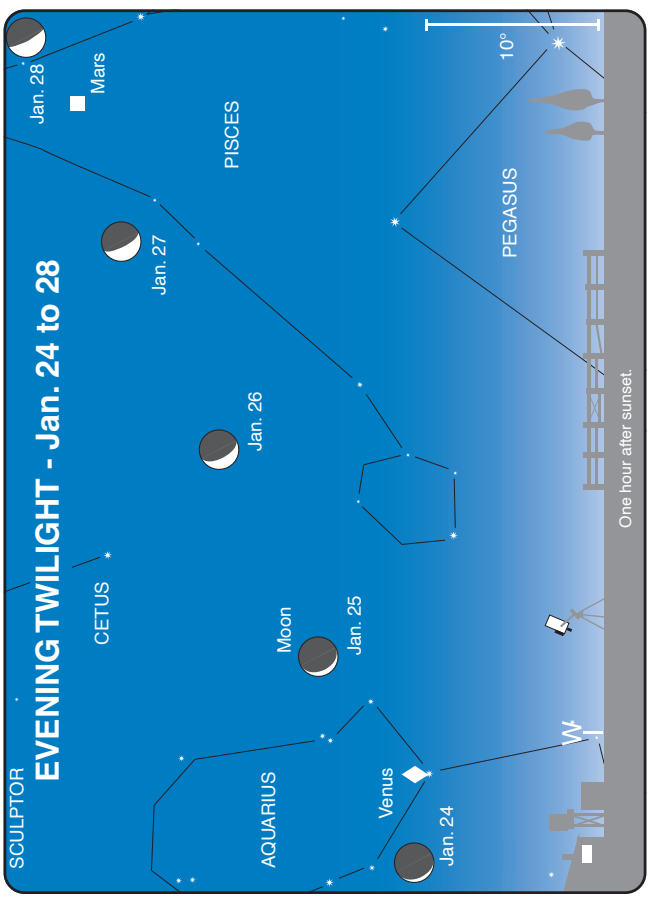






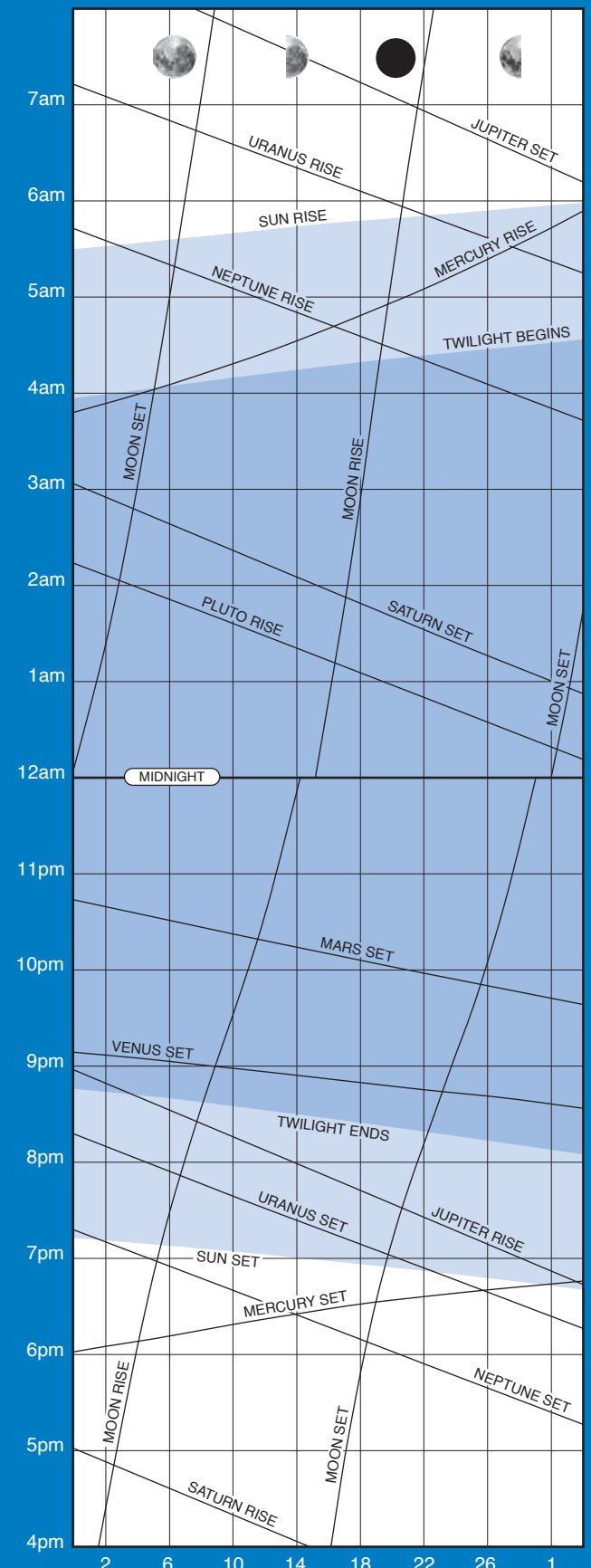
Approximate local standard time, for daylight saving add 1 hour.





FEBRUARY

RISE/SET CHART



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

HIGHLIGHTS

- Jupiter close to opposition
- Saturn, just past opposition, is still excellent in small telescopes.

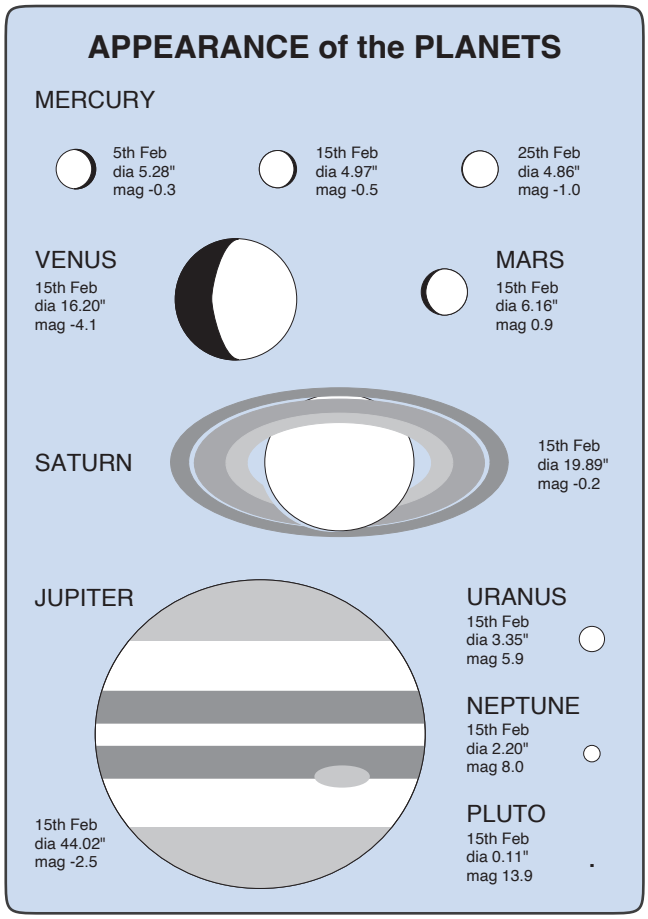
THE MOON

6th	Full Moon
13th	Last Quarter
16th	Moon at perigee (closest to Earth – 368,322 km distant, angular size 32.2')
20th	New Moon
26th	Occultation of Mars by the Moon (not visible from Australia)
28th	First Quarter
28th	Moon at apogee (furthest from Earth – 404,258 km distant, angular size 29.7')

THE PLANETS

MERCURY is visible in the dawn sky until late this month, the planet gradually moving toward the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) in March. On the 3rd and 4th, the 7.8 magnitude minor planet Vesta passes within 1° north of Mercury. As the planet slowly heads down toward the horizon it moves from Sagittarius into Capricornus, passing very close to the Messier globular M75 (on the 7th) and the outer planet Neptune (on the 15th). Both of these planets will be lost in the brightening sky.

APPEARANCE of the PLANETS



VENUS begins the month in Aquarius and quickly moves across into Pisces where it remains for the rest of February. The planet shines brilliantly in the western evening sky, setting about two hours after the Sun. On the 23rd and 24th the crescent Moon will be seen near the planet (see Sky View).

MARS moves from Pisces at the beginning of the month into Aries. Situated in the northwestern sky the Red Planet sets mid-evening. On the 26th, Mars and the 6-day old Moon appear close (see Sky View), after an occultation that occurred in daylight hours over the South Pacific Ocean.

JUPITER, in retrograde motion, spends the month above the hindquarters of Leo the Lion (the mythical figure is upside down from our viewpoint). Coming to opposition early next month the king of planets rises in the eastern twilight and is visible the entire night. On the 8th, the Moon, two days past full phase, appears near the planet (see Sky View).

SATURN, like Jupiter, is also in retrograde motion, moving slowly near the feet of the Gemini twins. Last month's opposition was at a time when Saturn was near perihelion, and consequently it was the best period to observe the ringed planet. Thirty years will lapse before it again comes to this orbital point, but the difference in angular size is

MESSIER AND HIS CATALOGUE

In the world of the 18th century, observational astronomy was in its infancy. The deep sky splendours we know of today were then just faint immoveable clouds or nebulae. The realisation that some of these 'fuzzies' were entire galaxies, just as grand as our own Milky Way, was still two centuries away. The scientists of the day had no large aperture telescopes to make them think these objects were anything special. Astrophotography, that would reveal the complex spiral structures of some of these 'clouds', was also well and truly a thing of the future.

Charles Messier was a French astronomer and commenced his observational career in the 1750's. At this time the world was fascinated with comets. It hadn't been long since these bodies had been considered to be signs from the gods proclaiming grand or disastrous events. Astronomers, like all true scientists, looked to bring order to their chaotic appearance by studying the mathematics of their orbits. Messier was also fashionably interested in comets. Although he is best known for his catalogue of deep sky objects, his comet achievements were considerable. Up to 1750 some 50 comets had been recorded in history. Messier alone would observe close to this number in the later half of the 18th century. He made an independent recovery of the first predicted return of the famous Halley's comet and during his career discovered some 20 comets. In fact from 1764 to 1779 most comets were discovered by Messier.

In 1758, while following a comet through the 'horns' of Taurus, he found what was to become the first object in his catalogue, M1, the Crab supernovae remnant. The first edition of his catalogue contained 40 objects. It is interesting that the last of these, M40, was frequently omitted in subsequent publications — being only a double star near 70 Ursa Majoris.

Although Messier had independently discovered the majority of his 'nebulae' quite a number had been previously found (M1 for example). In trying to make his catalogue as complete as possible he also conducted searches for objects tabulated by other observers. Not a lot of references existed at that time but he included the work of fellow Frenchman, La Caille, who had compiled a list of 42 southern nebulae during his time at the Cape of Good Hope in the early 1750's (see Astronomy 2003). Messier also drew on the work of Mechain who in the 1780's was the first to recognise the many nebulae in the Virgo and Coma Berenices regions. Messier's last published list brought the number up to 100 objects. Subsequent reviews of his observations and further contributions by such contemporaries as Mechain brought the total to 110 (see p. 136). Due to an 18th century error M102 has been found to be the same as M101, so that left 109.

Messier had stated that he had created his catalogue to help identify fixed nebulous objects that could otherwise be misidentified as comets by observers.

It is a shame that Messier spent his observing career based in France and missed out on the wonderful sky in the deep south. His most southerly objects are in Sagittarius. It would be interesting to speculate how many of the far southern objects, which we in Australia take for granted, would have made a 'Southern Extension' list. Certainly a lot more than 8 of La Caille's objects would have made the grade.

Observing Tips

The Messier Catalogue consists of: 39 galaxies, 29 globular clusters, 27 open star clusters, 6 bright nebulae, 4 planetary nebulae, 1 supernova remnant, 1 double star, 1 asterism (pattern of stars), 1 bright patch in the Milky Way and 1 duplication.

This is probably the most famous catalogue of its type and is well suited for the novice observer for most of the objects are visible through instruments as modest as the humble 60mm refractor. This is because Messier himself didn't use an instrument any bigger than the equivalent of a 90mm telescope.

Many of the open star clusters and some of the globulars and nebulae are clearly visible through binoculars, if not the naked-eye. The galaxies are a little more challenging, their observability varies quite a bit. The Andromeda Galaxy (M31) is visible to the naked-eye whereas nearby M33 in Triangulum is big and has a very low surface brightness. The galaxies and nebulae will need a dark, country sky and a 100 to 200mm telescope is recommended. This size telescope wouldn't have any problem in showing the dark rifts in the Trifid (M20) and will go someway towards resolving many of the globular clusters into a multitude of stars.

not huge compared to other times (about 10% less at aphelion). Still, capitalise on this apparition, as for many oppositions to come the disc will be slightly smaller.

URANUS is in conjunction with the Sun on the 22nd and will remain lost in the Sun's glare until its return to the morning sky next month.

NEPTUNE is in conjunction with the Sun on the 2nd, moving into the morning sky towards the end of February. While not observable, it is of interest to note that during this conjunction the planet is occulted by the Sun's disk. This is the 5th in a series of 8 annual Neptunian conjunctions where an occultation occurs; the next series begins in the year 2080.

PLUTO rises around 1am in Serpens.

MINOR PLANETS at opposition this month include: 15 Eunomia on the 11th at magnitude 9.0 in Hydra, 26 Proserpina on the 22nd at magnitude 10.9 in Leo and 349 Dembowska on the 28th at magnitude 10.3 in Leo.

4 Vesta has a close encounter with Mercury on the 3rd and 4th. 11th magnitude 11 Parthenope, during February and March, has a number of encounters with deep sky objects in Ophiuchus and Sagittarius. This month, a faint (12.5 magnitude) 324 Bamberga crosses the teapot of Sagittarius, visiting a few globular clusters along the way.

COMETS

Comet C/2001 Q4 (NEAT) could brighten from 9th to 8th magnitude this month. It moves northeast through Indus and into Tucana. Although observable all night, it will be higher in the southern sky early in the evening.

Comet C/2002 T7 (LINEAR) is visible briefly in Pisces in February's post-twilight evening skies. By mid-month, the comet, possibly at 8th magnitude, will be immersed in the twilight sky.

Comet C/2003 H1 (LINEAR), rising late in the evening, moves through Virgo and Hydra this month. It may brighten from 12th to 11th magnitude as it reaches perihelion.

Comet 2P/Encke is in the pre-dawn sky, moving through Sagittarius and Capricornus. Around two months after perihelion, the comet should be fading from 10th to 13th magnitude.

Comet 43P/Wolf-Harrington, at 12th magnitude, is visible early in the evening during February as it moves through Pisces and Aries.

Comet 88P/Howell should brighten from 13th to 12th magnitude as it moves eastward through Sagittarius in the morning sky. On February 13, Howell will pass very close to the globular cluster M22, possibly even crossing its face.

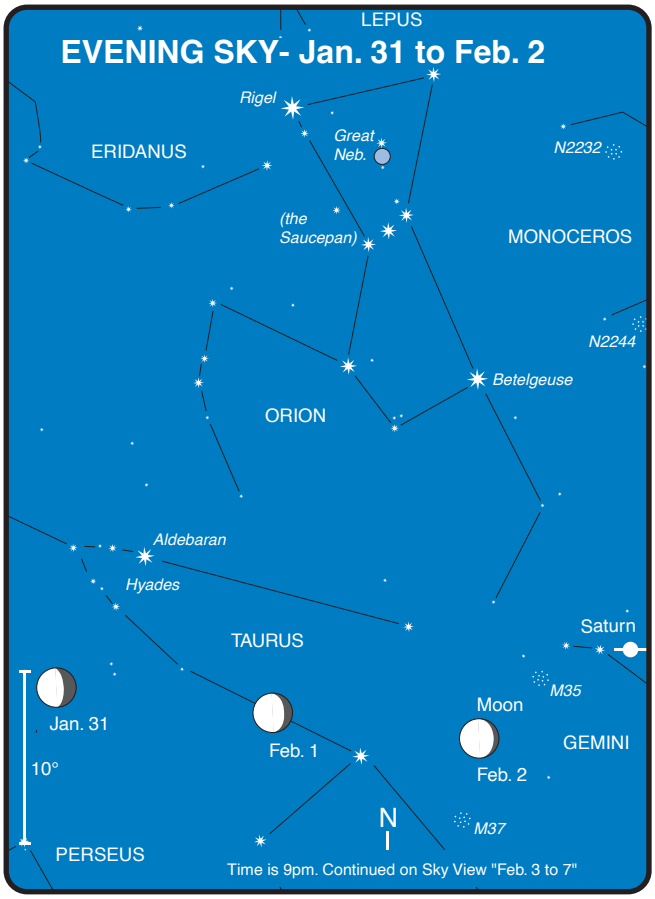
Comet 123P/West-Hartley is slowly moving through Virgo. Rising before midnight, the comet should be at 13th magnitude.

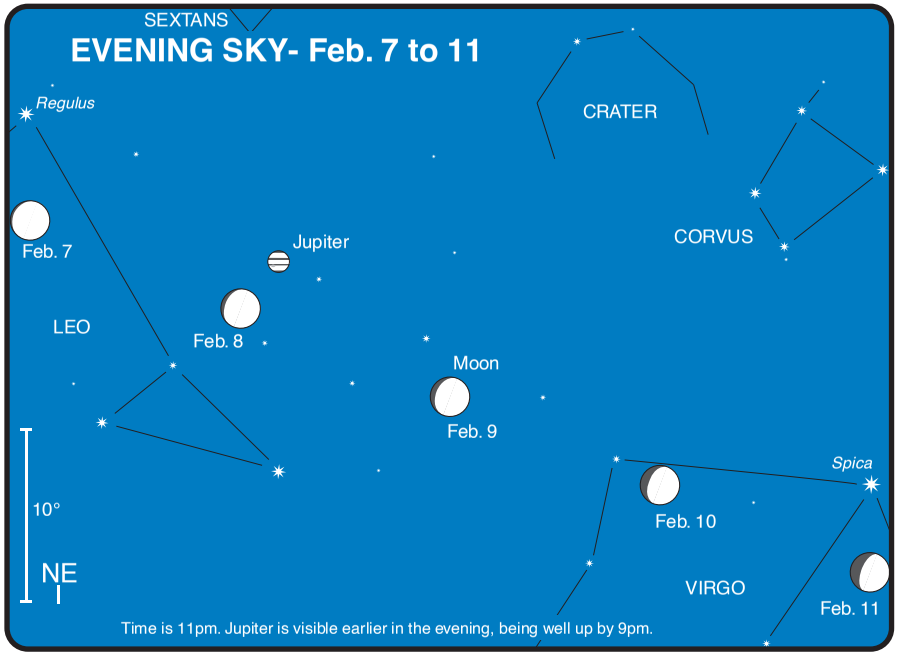
METEOR SHOWERS

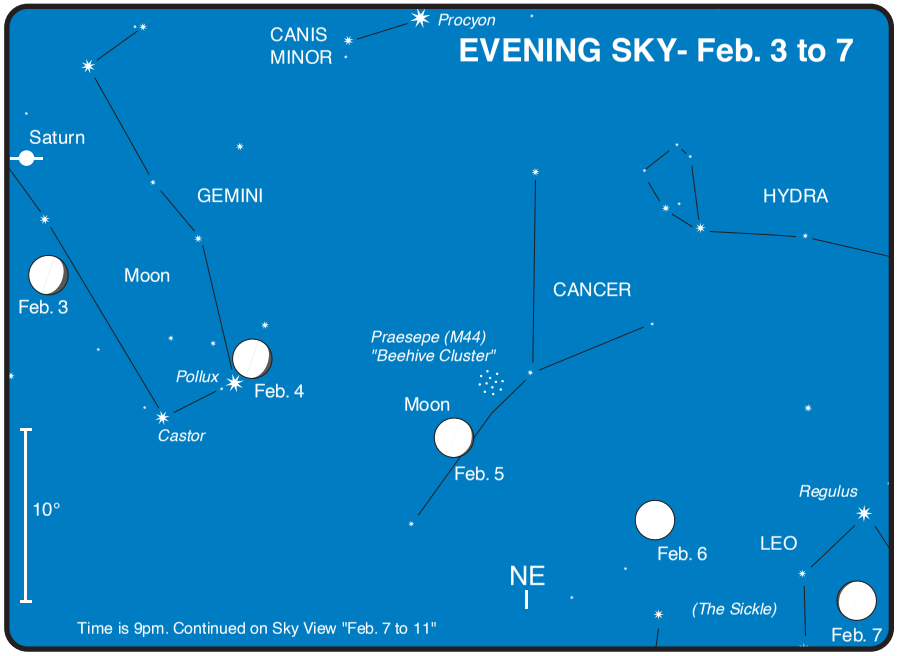
The **delta-Leonids** are reasonably placed for southern observers, with the radiant crossing the meridian around midnight. With predominately faint meteors this shower is considered a minor one, active from 15th February to 10th March, with maximum on the 25th; a low zenith hourly rate of around 2 can be expected.

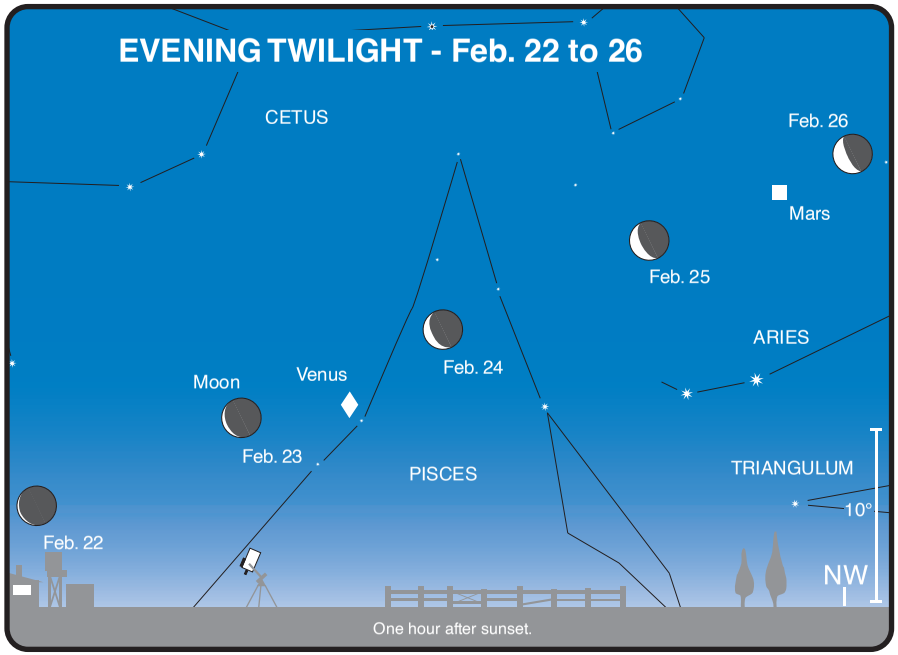
DIARY

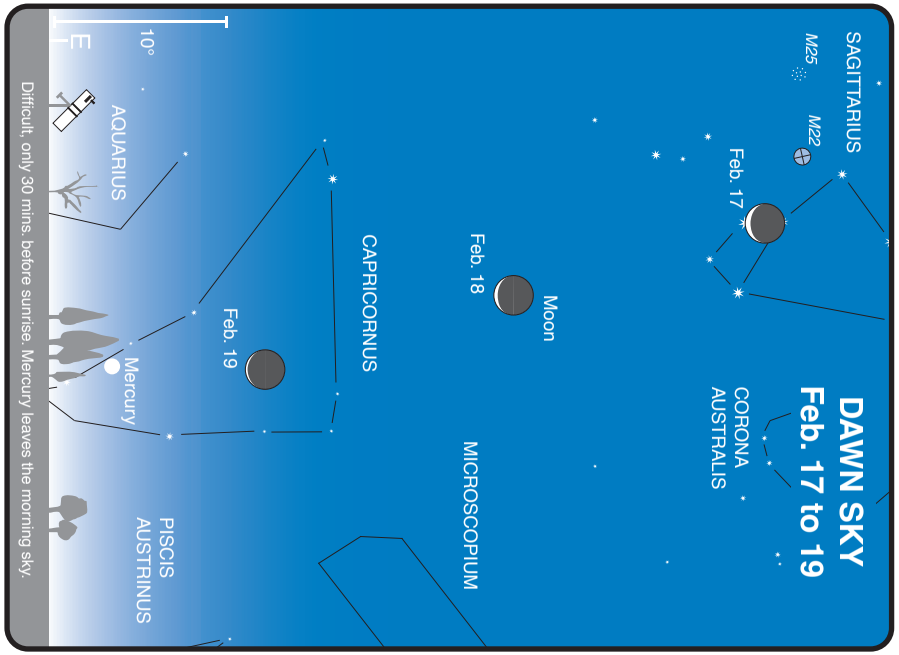
2nd		m.p. 11 Parthenope 1.2°S of M9 (GC) in Ophiuchus
2nd		m.p. 11 Parthenope 0.2°E of NGC 6342 (GC) in Ophiuchus
2nd		m.p. 16 Psyche 0.4°NW of star Xi2 Sagittarii
2nd	7 pm	(5 pm WST) Neptune in conjunction with Sun
3rd		Mercury 0.8°S of m.p. 4 Vesta
3rd	2 pm	(Noon WST) Saturn 4°S of Moon
4th		Comet 88P/Howell 0.9°S of Trifid Neb. (M20) in Sagittarius
5th		Comet 88P/Howell 0.5°N of Lagoon Neb. (M8) in Sagittarius
6th		Comet 81P/Wild 2 0.6°S of NGC 6440 (GC) in Sagittarius
6th		Mercury at aphelion
6th	7 pm	(5 pm WST) Full Moon
7th		Mercury 0.4°N of M75 (GC) in Sagittarius
7th		m.p. 3 Juno 1.2°N of Eagle Nebula (M16) in Serpens
8th		m.p. 324 Bamberga 0.2°SE of NGC 6569 (GC) in Sagittarius
8th	Midnight	(10 pm WST) Jupiter 3°S of Moon
10th		m.p. 16 Psyche 0.6°N of star Pi Sagittarii
11th		m.p. 3 Juno 0.4°S of NGC 6625 (OC) in Scutum
11th		Comet 88P/Howell 1°N of M28 (GC) in Sagittarius
13th		Comet 88P/Howell 0.5°SE of NGC 6642 (GC) in Sagittarius
13th	Midnight	(10 pm WST) Last Quarter Moon
14th		Mercury 0.5°SW of m.p. 40 Harmonia
14th		m.p. 3 Juno 0.3°S of NGC 6631 (OC) in Scutum
14th		m.p. 4 Vesta 1.2°N of M75 (GC) in Sagittarius
14th		Comet 88P/Howell 0.05°S of M22 (GC) in Sagittarius
15th	4 am	(2 am WST) Comet 2P/Encke 0.2°E of NGC 6907 (SG) in Capricornus
15th	7 pm	(5 pm WST) Mercury 2°S of Neptune
16th	6 pm	(4 pm WST) Moon at perigee
17th		m.p. 324 Bamberga 0.4°NW of M69 (GC) in Sagittarius
17th		Venus at ascending node
18th		m.p. 11 Parthenope 0.5°N of NGC 6440 (GC) in Sagittarius
19th		m.p. 387 Aquitania 0.5°S of NGC 6517 (GC) in Ophiuchus
19th	11 am	(9 am WST) Neptune 5°N of Moon
20th	7 pm	(5 pm WST) New Moon
22nd		m.p. 11 Parthenope 0.9°S of M23 (OC) in Sagittarius
22nd	Noon	(10 am WST) Uranus in conjunction with Sun
22nd	pm	Comet C/2003 H1 (LINEAR) 0.9°S of NGC 5085 (SG) in Hydra
24th	5 am	(3 am WST) Venus 3°N of Moon
24th		m.p. 324 Bamberga 0.4°N of M70 (GC) in Sagittarius
26th	6 am	(4 am WST) m.p. 1 Ceres stationary
26th		Mercury at greatest latitude South
26th	Noon	(10 am WST) Mars 0.9°N of Moon; Occn.
28th		Venus 0.5°E of NGC 524 (LG) in Pisces
28th	1 pm	(11 am WST) First Quarter Moon
28th	9 pm	(7 pm WST) Moon at apogee
28th	pm	m.p. 15 Eunomia 0.7°S of NGC 2775 (SG) in Cancer







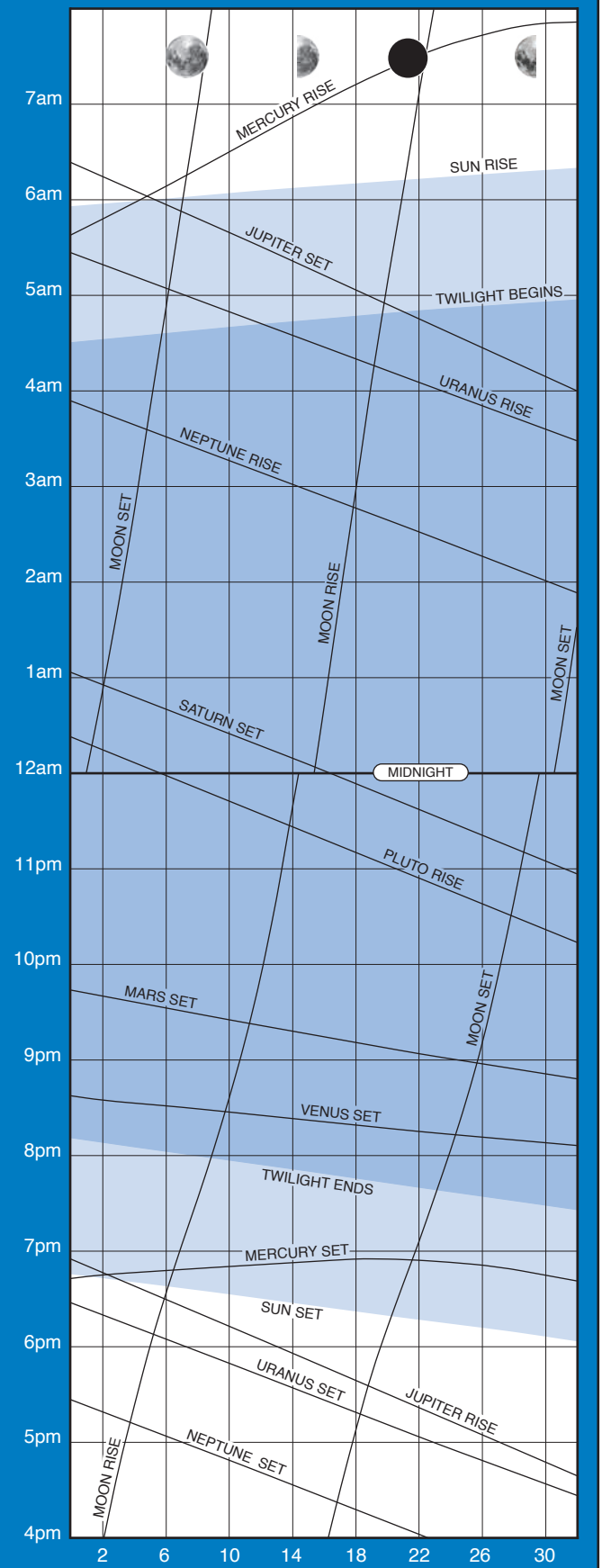




Approximate local standard time, for daylight saving add 1 hour.

MARCH

RISE/SET CHART



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

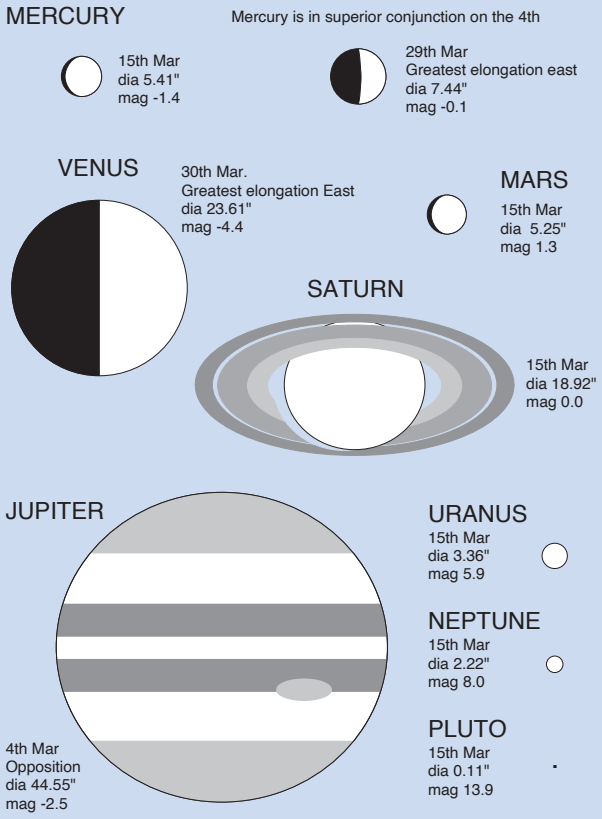
HIGHLIGHTS

- Venus at greatest elongation east of the Sun
- Venus close to the Pleiades at month's end
- Mars close to the Pleiades
- Jupiter at opposition
- Neptune and Vesta close

THE MOON

7th	Full Moon
12th	Moon at perigee (closest to Earth – 369,506 km distant, angular size 32.2')
14th	Last Quarter
21st	New Moon
26th	Occultation of Mars by the Moon (not visible from Australia)
27th	Moon at apogee (furthest from Earth – 404,521 km distant, angular size 29.8')
29th	First Quarter

APPEARANCE of the PLANETS



THE PLANETS

MERCURY emerges from superior conjunction on the 4th to appear in the evening twilight sky. The planet's greatest elongation east of the Sun (19°) occurs on the 29th. This is not a particularly favourable elongation, with the planet in the western twilight sky setting less than three-quarters of an hour after the Sun. Keen observers may detect Mercury a few degrees north of the thin crescent 2 day old Moon on the 22nd.

VENUS is very conspicuous in the western evening sky, beginning the month in Pisces, moving through Aries and into Taurus by months' end. On the 24th and 25th the thin crescent Moon appears nearby the planet (see Sky View). The planet is at its greatest elongation east of the Sun (46°) on the 30th, presenting a lunar quarter-like phase through a telescope and visually brilliant at –4.4 magnitude. At the end of March, Venus will be situated just 3° from the open star cluster M45, the Pleiades or Seven Sisters.

The **EARTH** is at its autumnal equinox on the 20th. This means by definition, the Sun rises and sets due east and west, and day and night are equal.

MARS is located in the northwestern evening sky (above left of Venus) and travels from Aries into Taurus mid-month. Around the 20th, Mars will pass within 5° of the Pleiades followed by Venus in early April. On the 25th and 26th, the crescent Moon appears close to the planet (see Sky View); from the northern hemisphere an occultation will occur.

JUPITER is at opposition on the 4th, and very noticeable in the east as the sky begins to darken after sunset. With Jupiter reaching aphelion (the most distant point in its orbit from the Sun) in April next year, this opposition is not the most favourable. The diameter of the planet's disc reaches 44.5 arc seconds this month, compared with 50 arc seconds when Jupiter is at perihelion (closest to the Sun); perihelic oppositions occur every twelve years, the next due in September 2010. Unlike Mars, there are really no bad or good oppositions of Jupiter, as its large angular size ensures even the smallest of telescopes can glimpse the cloud bands, polar flattening and Moons at any time. On the 6th, the Full Moon appears near Jupiter (see Sky View).

On the 28th a rare event happens involving Jupiter's moons. For a brief period three of the satellite's shadows will be seen on the planet's disc at once. Unfortunately we will not have a good view of the event with

THE MESSIER MARATHON

Firstly this is not some kind of astronomy 'get fit' programme and you don't have to be able to run 42 kilometres. However it does take some endurance and a touch of insomnia wouldn't go astray. The marathon is to observe every object in the Messier catalogue of deep sky objects in one night. This exercise is relatively straightforward from the Northern Hemisphere, assuming you pick the right time of the year, but is a different matter from the Southern Hemisphere.

Effect of Latitude. Living in the 'south' we need to consider the effects of latitude on observing these objects. With Messier doing his work from France there was of course a strong Northern Hemisphere bias in the objects he selected for his list. So you need to look where you are in Australia and give yourself some realistic limits. For example:

M81 and M82	visible only from the far north (e.g., Cairns, Darwin)
M40, M52 and M103	visible from the northern half of the continent only
M97, M101, M108 and M109	visible from mid-latitudes and further north
M39, M51, M76 and M106	mainland only, not visible from Tasmania

So if you lived in Hobart you wouldn't be able to see any of these 13 objects at any time of the year. Melbourne has 9 objects excluded. People living in the mid-latitudes, such as Sydney, Canberra, Adelaide and Perth, should be cautious trying to catch M97, M101, M108 and M109. Even if any of these objects was in theory visible above your horizon:

- You need a very low northern horizon
- It may only be visible for a short period, so plan your observing time well.
- All of these 4 deep sky objects are nebulous (1 planetary and 3 galaxies) and will be challenging through the extinction and atmospheric turbulence associated with observing close to the horizon.

The All Sky Charts (see pp. 68-77) have all the Messier objects marked, as well as the theoretical northern horizons for the capital cities.

The Marathon. The majority of astronomy magazines and books are written by and for Northern Hemisphere observers. You will hear them often refer to March being the time of the year to attempt a marathon. You start low in the west, as soon after sunset as possible, working on the objects that will set first which are those towards the south for Northern Hemisphere observers. The 'northern' marathon starts with M74 in Pisces, followed by M77 (Cetus) and M31/M110/M32 in Andromeda. You then work your way towards the east.

From the Southern Hemisphere you follow the same procedure above, except with the Earth tilted away from the northern skies, objects towards the north set first. Unfortunately for us at this so called optimum time, M2, M15, M29, M32, M39, M52, M76, M103 and M110 are already below the horizon at sunset from mid-Australian latitudes. M33 and M34 are setting during twilight, with Brisbane (and north) getting a better shot at them. Melbourne and further south can forget these objects as well. M74 is also low, setting around the end of twilight.

The morning sky also presents its challenges for those 'down under' with M30, M72, M73 and M92 being very low in the east at the start of dawn. Unfortunately, M27, M56 and M71 will definitely be dawn objects. This is probably not the news you would like to hear after spending an entire, tiring night observing.

The month you decide to attempt your marathon is not as critical for observers at Australian latitudes. There is no way you will see all of the Messier objects, available at your latitude, in one night anyway. However it is worthwhile noting there are two periods in the year that are exceptionally bad. They are:

1) When the Sun is passing across the galactic centre, taking out all the objects in Scorpius and Sagittarius. This is December and January. Also being summer you have less dark time to observe anyway.
2) When the Sun is close to the Virgo, Leo and the Coma galaxies. The worse months here are September and October.

November is also very difficult with the evening twilight cutting severely into Sagittarius and Scorpius and the dawn skies taking out much of Virgo. Even though August is ideal for the galactic centre, you will have to put on your running shoes to catch Virgo before the galaxies set in the early evening. In conclusion our best period is probably around February to July inclusive.

Remember to prepare yourself for the night. Map out the order in which you wish to observe the objects or at least the constellations and if you are star hopping familiarise yourself with your reference stars. Maybe even give yourself a timetable, which recognises when time critical far northern objects rise and set.

Good luck and remember, if you're having fun, who cares if you miss a few.

all three shadows already in transit at sunset. The satellites involved are Io (I), Ganymede (III) and Callisto (IV). From eastern Australia the shadow of Callisto leaves (egresses) the disc only a few minutes after sunset (6:17pm EST) and is very difficult to observe (Ganymede and Io themselves egress at 7:05pm and 7:14pm EST respectively). Io's shadow is the next to depart at 7:47pm EST followed by Ganymede's shadow at 9:23pm (see also Jupiter's Moons in Part II). Western Australia only sees the last of these events at 7:23pm WST. Although not a favourable 'triple shadow' event from Australia, we will have to wait until October 17, 2045 to see another one!

SATURN begins the month after sunset in the northern sky above the 9-day old gibbous Moon (see Sky View). Later in the month (28th) the First Quarter Moon appears below the ringed planet (see Sky View). Saturn sets around midnight and remains an evening object until June when it comes too close to the Sun for observation. Since October last year Saturn has been in retrograde motion, this month the planet reverses direction and begins its traverse across Gemini.

URANUS returns to the morning sky after being in conjunction with the Sun late last month.

NEPTUNE in the late morning sky in Capricornus is much higher than its sister planet Uranus. On the 13th and 14th, the minor planet Vesta speeds by the distant outer world, at a distance of 1.2°. This is a good opportunity to add this 540km diameter rock to your observing conquests. Vesta is at magnitude 7.9, Neptune at 8.0 and both the asteroid and planet form a triangle with 4th magnitude Theta Capricorni. The position of Vesta is marked on the Neptune finder chart on page 124; the position of Neptune at this time is just under the 'r' in 'Mar'.

PLUTO rises just prior to midnight in the east in Serpens.

MINOR PLANETS at opposition this month include: 7 Iris on the 11th at magnitude 9.0 in Leo, 18 Melpomene on the 13th at magnitude 10.1 in Virgo and 43 Ariadne on the 17th at magnitude 10.4 in Leo.

During March 11 Parthenope continues its tour of deep sky objects in Sagittarius.

COMETS

Comet C/2001 Q4 (NEAT) is visible all night for most Australian observers as it moves eastward through Tucana. As March opens, NEAT could be 8th magnitude, possibly brightening to 6th magnitude by the end of the month.

Comet C/2003 H1 (LINEAR) is visible all night, possibly at 11th magnitude, moving through the constellation of Hydra. In early March, LINEAR passes just to the south of M68.

Comet C/2003 K4 (LINEAR) should first become visible this month in the pre-dawn sky. Possibly as bright as 12th magnitude, LINEAR is moving north through Sagitta and Vulpecula. At the end of March, LINEAR is 3.5 degrees east of M27.

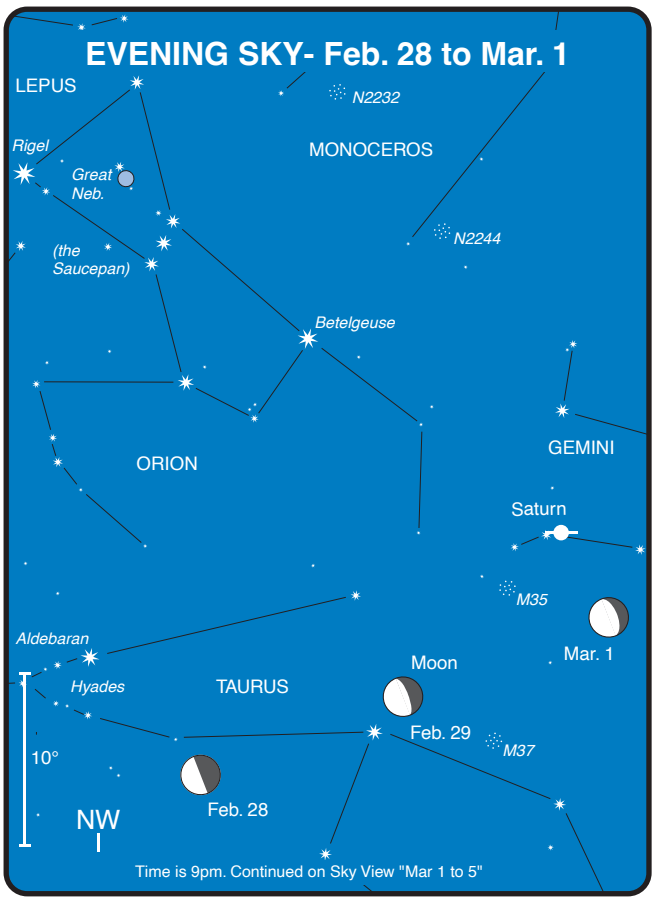
Comet 43P/Wolf-Harrington should be visible early in the evening as a 12th magnitude comet moving through Aries and Taurus. Perihelion occurs mid-month. By month's end, Wolf-Harrington is eight degrees south of M45 (the Pleiades).

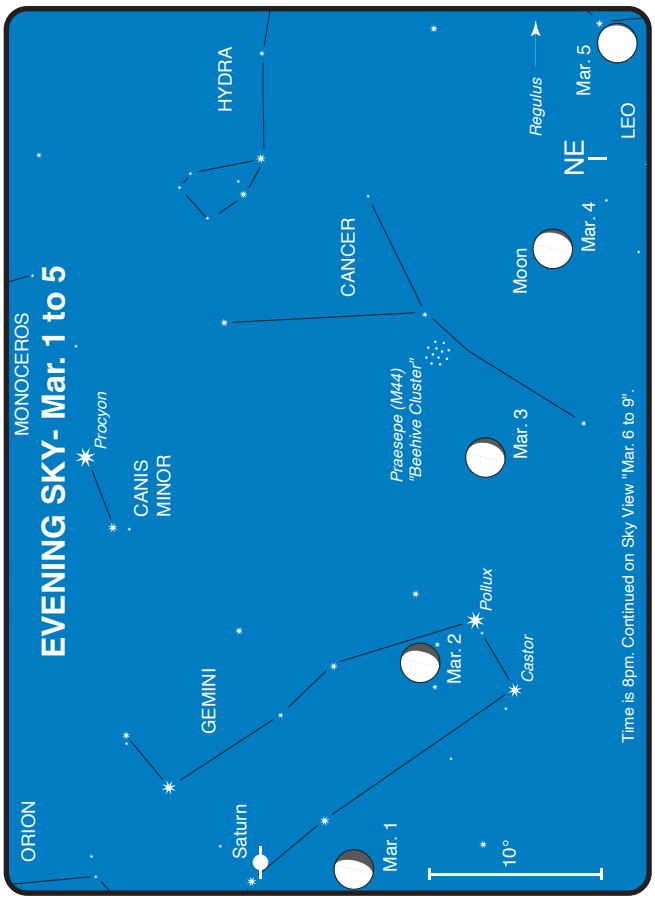
Comet 88P/Howell is in March's morning sky, moving through the constellations of Sagittarius and Capricornus. It should brighten from 11th to 10th magnitude by month's end.

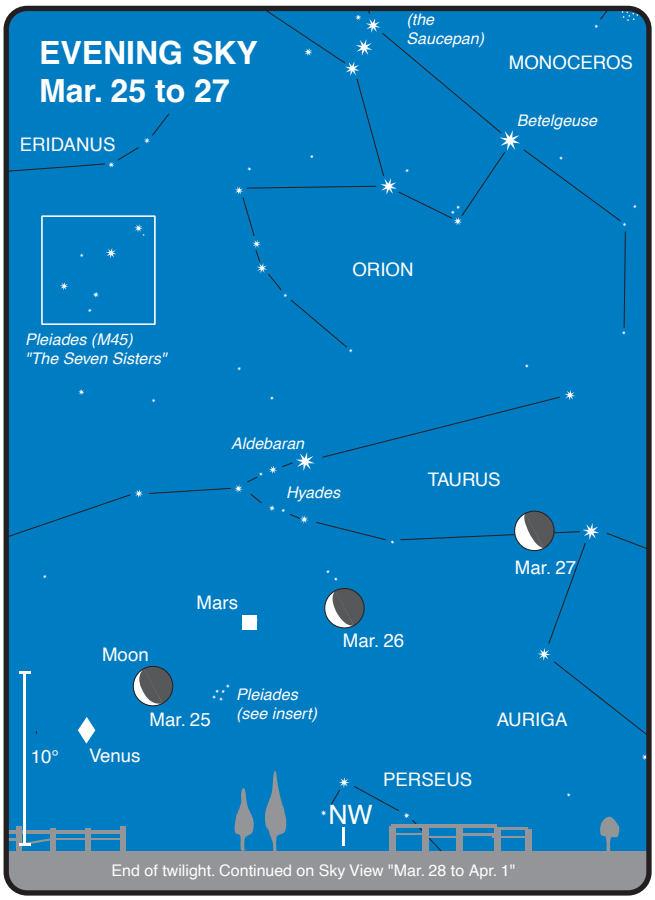
Comet 123P/West-Hartley should fade from 13th to 14th magnitude as it moves westward in Virgo. Rising early in the evening, the comet will be visible all night.

DIARY

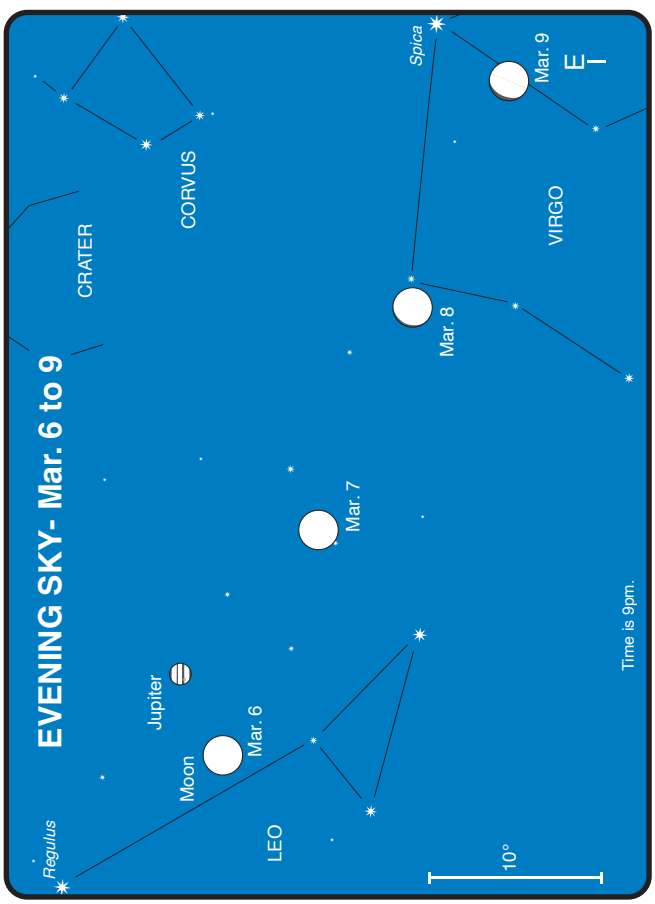
1st	8 pm	(6 pm WST) Saturn 5°S of Moon
2nd	pm	Comet C/2003 H1 (LINEAR) 0.3°SW of M68 (GC) in Hydra
4th	Noon	(10 am WST) Mercury in superior conjunction
4th	3 pm	(1 pm WST) Jupiter at opposition
5th		m.p. 11 Parthenope 0.1°N of NGC 6595 (OC) in Sagittarius
7th	2 am	(Midnight WST, prev day) Jupiter 3°S of Moon
7th	9 am	(7 am WST) Full Moon
8th	1 am	(11 pm WST, prev day) Saturn stationary
8th		Saturn 1.0°E of star Mu Geminorum
8th		m.p. 387 Aquitania 0.9°S of NGC 6664 (OC) in Scutum
9th		Comet 88P/Howell 0.5°SW of M75 (GC) in Sagittarius
10th		m.p. 40 Harmonia 0.7°NW of star Delta Capricorni
12th	2 pm	(Noon WST) Moon at perigee
13th		Neptune 1.2°N of m.p. 4 Vesta
13th		m.p. 387 Aquitania 0.5°N of M26 (OC) in Scutum
14th	7 am	(5 am WST) Last Quarter Moon
14th		m.p. 11 Parthenope 0.5°S of M25 (OC) in Sagittarius
16th		Mercury at ascending node
17th	7 pm	(5 pm WST) Neptune 5°N of Moon
17th	pm	Comet C/2003 H1 (LINEAR) 0.6°W of NGC 3585 (EG) in Hydra
18th		m.p. 387 Aquitania 0.2°W of NGC 6712 (GC) in Scutum
19th	6 am	(4 am WST) Uranus 4°N of Moon
20th	5 pm	(3 pm WST) Equinox
21st	9 am	(7 am WST) New Moon
21st		Mercury at perihelion
21st		Venus at perihelion
22nd	3 pm	(1 pm WST) Mercury 4°N of Moon
25th	7 am	(5 am WST) Venus 2°N of Moon
25th	9 am	(7 am WST) Pluto stationary
26th	10 am	(8 am WST) Mars 0.8°S of Moon; Occn.
27th	5 pm	(3 pm WST) Moon at apogee
29th	5 am	(3 am WST) Saturn 5°S of Moon
29th		m.p. 11 Parthenope 0.8°N of NGC 6716 (OC) in Sagittarius
29th		m.p. 324 Bamberga 0.2°SW of M55 (GC) in Sagittarius
29th	10 am	(8 am WST) First Quarter Moon
29th	10 pm	(8 pm WST) Mercury greatest elongation East (19°)
30th	3 am	(1 am WST) Venus greatest elongation East (46°)
31st		Mercury at greatest latitude North

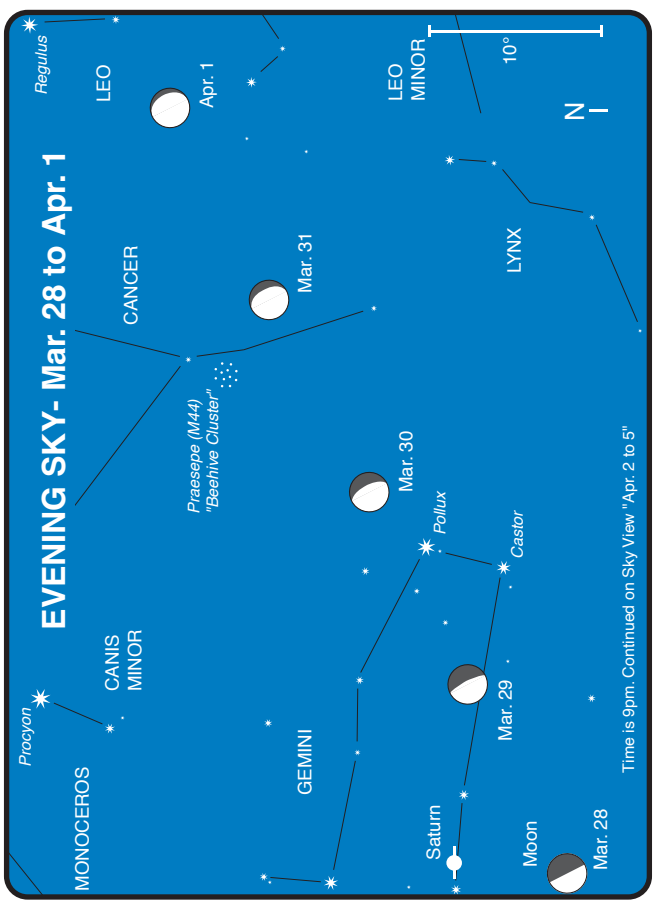






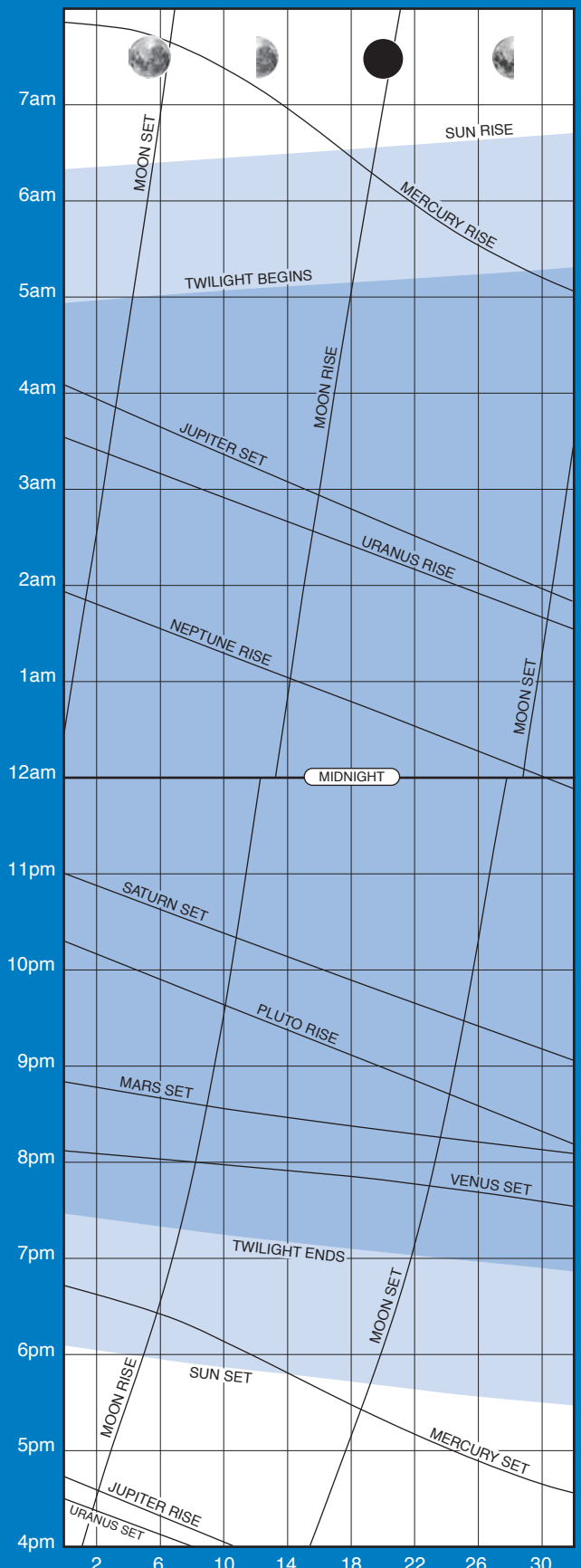
Approximate local standard time, for daylight saving add 1 hour.





APRIL

RISE/SET CHART



Approximate local standard time.

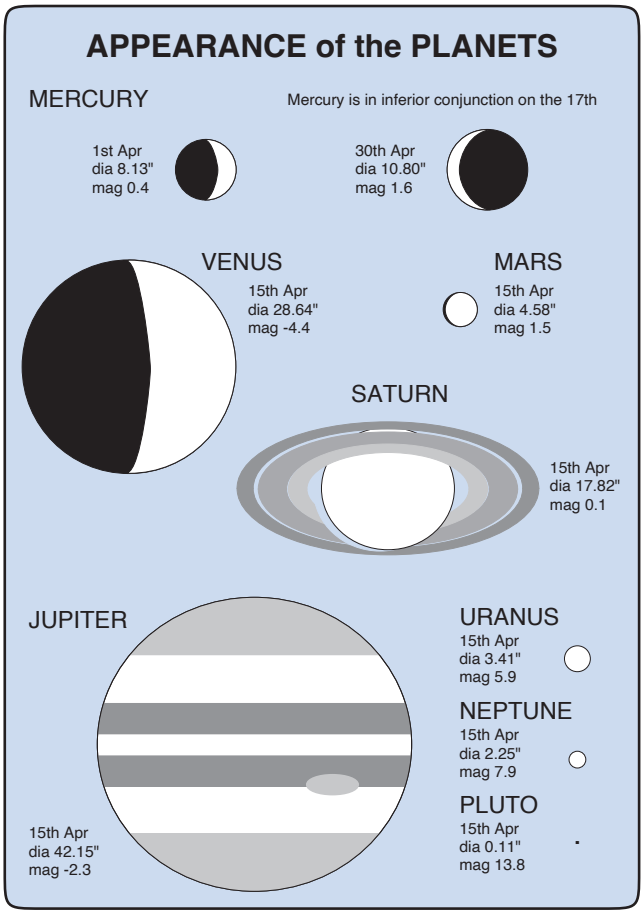
HIGHLIGHTS

- Comets C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT) approach naked-eye brightness, preparing for May's grand evening appearance!
- Mercury returns to the morning sky
- Venus close to the Pleiades (M45)
- Venus and crescent Moon close in evening sky

THE MOON

5th	Full Moon
8th	Moon at perigee (closest to Earth – 364,547 km distant, angular size 32.5')
12th	Last Quarter
19th	New Moon (Partial solar eclipse, not visible from Australia – see Part II)
24th	Moon at apogee (furthest from Earth – 405,403 km distant, angular size 29.4')
28th	First Quarter

APPEARANCE of the PLANETS



THE PLANETS

MERCURY's brief visit to the evening twilight last month is short lived as the planet moves into inferior conjunction on the 17th. Moving away from the Sun, Mercury reappears in Pisces in the morning twilight late in the month. This return marks the beginning of the best period to observe the planet in the morning sky this year, and for much of next month the planet rises two hours ahead of the Sun.

VENUS spends all of April in Taurus, setting around one hour after the end of twilight. It begins April close to the open cluster M45, The Pleiades. On the 3rd and 4th, Venus skims just above the naked-eye members of M45, the planet's brightness effectively overwhelming the delicate nature of the cluster. Our front cover this year features M45 (the Pleiades or commonly the Seven Sisters); with the unaided eye most people can see six or seven stars. A moderate sized telescope can reveal over a hundred stars, but the best view is afforded by binoculars. The associated wispy blue reflection nebulosity is best seen in photographs, as David Malin's cover image clearly shows. On the 23rd, the slender 3-day old Moon appears very close to Venus (see Sky View). During April, Venus appears to be closing in on Mars, but the pair only get as close as 6° at month's end, then drift apart in May as Venus heads for its solar rendezvous in June.

MARS, like Venus, remains within the confines of Taurus throughout the month, setting around 8:30pm. On the 23rd and 24th, the crescent Moon will be near the planet.

JUPITER, now one month past opposition, stands prominent in the early northeastern evening sky in Leo. On the 2nd and 3rd, the near Full Moon is situated in the vicinity of Jupiter (see Sky View), and on the 30th a 10-day old Moon appears closer (see Sky View).

SATURN, in Gemini, can be located in the early western evening sky, situated midway between the stars Betelgeuse and Castor. The planets Mars and Venus are further south and nearer the horizon. Late twilight is a good time to catch the three planets.

DOUBLE STARS FOR THE BEGINNER

Looking around the night sky even the most casual observer will notice that a number of stars occur in pairs. Some of these 'doubles' can appear quite attractive with features such as differences in brightness or colour between them. Binoculars, with their greater light gathering power compared to your eyes, can be used to display the colours better. The low power of binoculars, compared to a telescope, allows the stars to continue to appear close and maintain an attractive wide field of view. Theta 1 and 2 Tauri is a classic example. It consists of two stars, one white with the other yellow. Binoculars not only show the colours well but a low power pair (say 7X) exhibits the A-shaped Hyades star cluster at its best, including the brilliant orange/red colour of Aldebaran. There are a number of double and multiple stars in the Hyades waiting to be 'discovered' by astute binocular observers (see All Sky chart No. 3).

Most of the wide, naked-eye pairs in the sky are what is termed 'optical' double stars. They only appear close together because they happen to lie in the same direction in the sky as seen from Earth. Once you get down to the close doubles that need a small telescope to see them we start seeing binary stars. These are stars that lie the same distance from the Earth and are gravitationally linked or in orbit around each other. One of the wider binaries is Alpha Centauri. These two stars orbit each other in a pronounced ellipse, which is considerably tilted towards Earth (11° from edge-on). During their 80-year orbital period the separation varies from just under 2 arc seconds up to 21 arc seconds. As binary stars go, say with orbital periods under 200 years, this is fairly wide. This is only because of their proximity to Earth (only 4 light years). In reality the size of their orbits would easily fit inside our Solar System. At their closest they would be around the Sun/Saturn distance (11 AU). This would widen to the distance a little beyond the planet Neptune (35 AU).

It sometimes comes as a shock to the newcomer to learn that the Sun, being a single star, is in fact in a minority. It is likely that more than 50% of stars have binary companions. Distant doubles are too close together to resolve as a pair through traditional optical telescopes. Observing shifts in the lines of a star's spectrum can give away the presence of a companion. Also as interferometry techniques improve more binaries will be discovered. It is fortunate for us that the Sun, all those billions of years ago, took the evolutionary step of forming a solar system rather than having a fellow star condense out of its disk of gas and dust.

Stars	All Sky Map
Theta 1 & 2 Tauri	3
Mu 1 & 2 Scorpii	6,8
Omega 1 & 2 Scorpii	6
Beta 1 & 2 Sagittarii	6,8
Alpha 1 & 2 Capricorni	8
Delta 1 & 2 Gruis	1,8

Table 1: Naked-Eye Double Stars

Object	RA hr min	Dec deg min	Magnitudes	Separation arc seconds	All Sky Map
Gamma Leporis	05 44.5	-22 27	3.6, 6.3	97".0	2,4
Gamma Velorum	08 09.5	-47 20	1.8, 4.3	41".4	1,4
Alpha Crucis (AB-C)	12 26.6	-63 06	0.8, 4.9	89".8	1
Gamma Crucis	12 31.2	-57 07	1.6, 6.4	110".6	1
Alpha Librae	14 50.9	-16 03	2.8, 5.2	230".7	6
Beta Capricorni	20 21.0	-14 47	3.1, 6.1	205".2	8

Table 2: Double Stars Suitable for Binoculars

You may wonder for any particular double what instrument should be adequate to resolve or show them as a pair. In general 300 divided by the power of the instrument should give an approximate lower limit. For example a pair of 7X50 binoculars (i.e., 7 X power) should resolve down to 42 arc seconds. This assumes the optical quality of the instrument is adequate for the job and there isn't a large difference in brightness between the stars. Also it is a good idea to steady the binoculars to get optimum performance and comfort for the observer. This can be done by resting your elbows against a table or clamping the binoculars to a camera tripod. These clamps are readily available in camera stores.

Richard Jaworski, an amateur astronomer and dedicated double star observer, has supplied these tables.

Object	RA hr min	Dec deg min	Magnitudes	Separation arc seconds	All Sky Map
Gamma Arietis	01 53.5	+19 18	4.6, 4.7	7".7	3
Gamma Leonis	10 20.0	+19 50	2.0, 3.2	4".5	5
Alpha Crucis (AB)	12 26.6	-63 06	1.3, 1.7	4".0	1
Alpha Centauri	14 39.6	-60 50	0.0, 1.4	11".3	1
Beta Scorpii	16 05.4	-19 48	2.6, 4.9	13".6	6
Beta Cygni	19 30.7	+27 58	3.1, 5.1	34".3	9

Table 3: Bright Binary Stars for a Small Telescope

URANUS and **NEPTUNE** pass an uneventful month rising in the eastern morning sky. The minor planet Vesta, moving almost parallel to the ecliptic, passes Uranus at a distance of around 2.3° at the end of April (see last month for Vesta's encounter with Neptune).

PLUTO, nearing opposition in June, rises in the mid-evening eastern sky.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Virgo. They are: 39 Laetitia on the 17th at magnitude 10.5, 67 Asia on the 22nd at magnitude 11.0 and 5 Astraea on the 26th at magnitude 9.8.

COMETS

Comet C/2001 Q4 (NEAT) should become easily visible with the unaided eye this month. Predicted to brighten from 6th to 3rd magnitude, NEAT will move quickly across the southern sky — passing through Tucana, Hydrus, Horologium, Reticulum, Dorado, Pictor, and into Puppis. By the end of April, NEAT will be setting around midnight.

Comet C/2002 T7 (LINEAR) emerges in the pre-dawn sky in early April, possibly as bright as 5th magnitude. LINEAR will be moving south through Pisces, and may brighten to 3rd magnitude by month's end, a week after perihelion.

Comet C/2003 H1 (LINEAR) will probably fade from 11th to 12th magnitude this month. Moving northwest through Hydra, LINEAR will be visible until the early hours of the morning.

Comet C/2003 K4 (LINEAR) begins April 3.5 degrees east of M27 in the morning sky. Predicted to brighten from 12th to 11th magnitude, LINEAR spends April moving northwest through Vulpecula and Cygnus.

Comet 43P/Wolf-Harrington is visible early in the evening. Fading from 12th to 13th magnitude, the comet is moving through Taurus and Orion.

Comet 88P/Howell remains a morning object of 10th magnitude this month. It is moving through Capricornus and Aquarius and is at perihelion mid-month. On the 11th the comet is close to 4 Vesta.

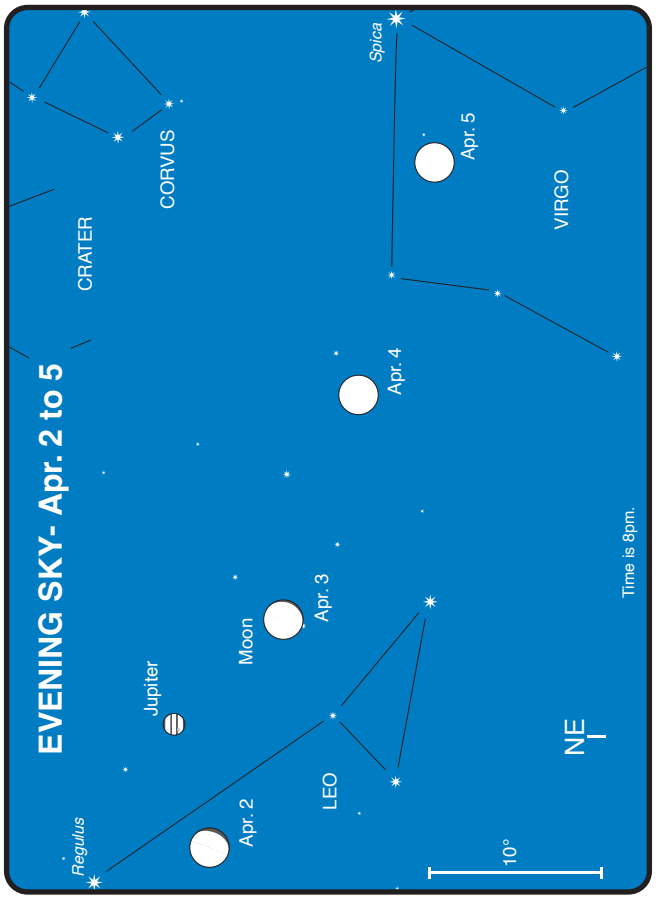
METEOR SHOWERS

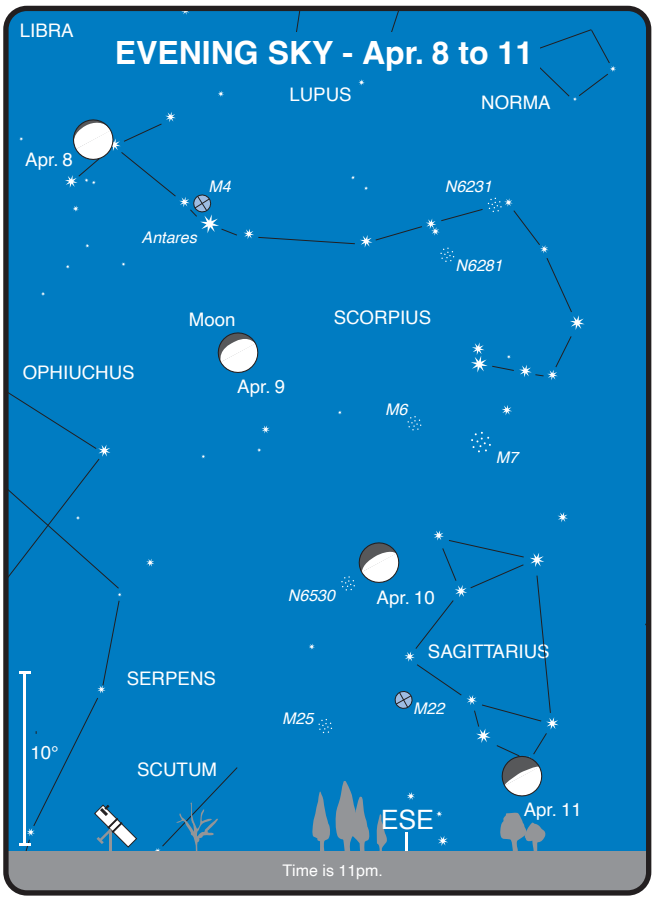
The **Lyrids** are a northern shower, but can be observed south of the equator. They are best seen in the mornings from the 16th to 25th April, with maximum on the 23rd. Maximum rates may only last an hour or so, and typically the zenith hourly rate is around 18. The Lyrids have on occasion produced higher rates, and because of their erratic nature, they are a shower to be watched. In 1982 American observers observed a short peak of 90 per hour.

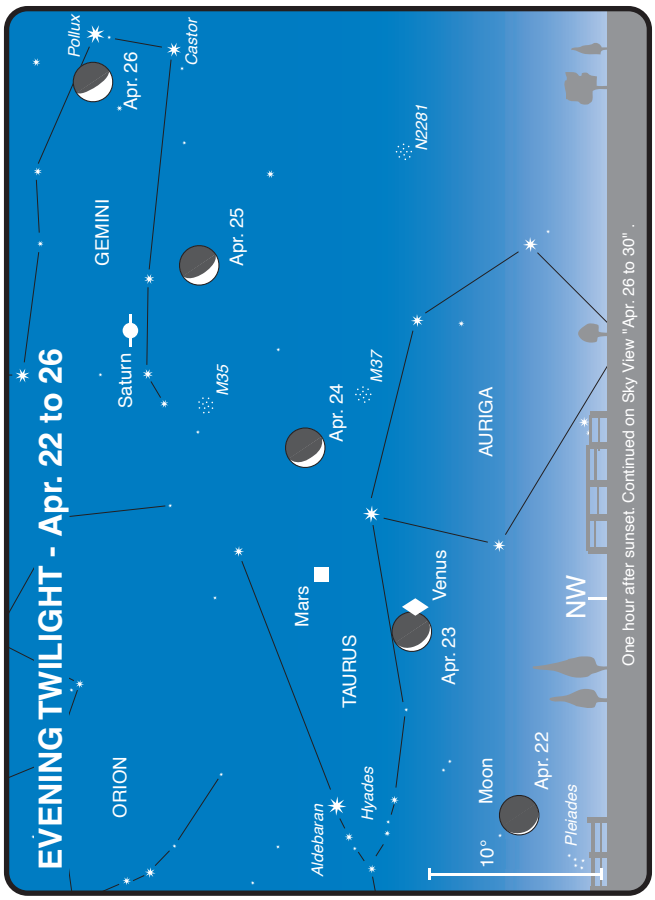
The **pi-Puppids** are a young southern shower first observed in 1972, and produced by Comet 26P/Grigg-Skjellerup. They are best seen in the evening sky from 15th to 28th April, with maximum activity on the 24th. Leading up to and after maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil, with occasionally 3 to 4 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.

DIARY

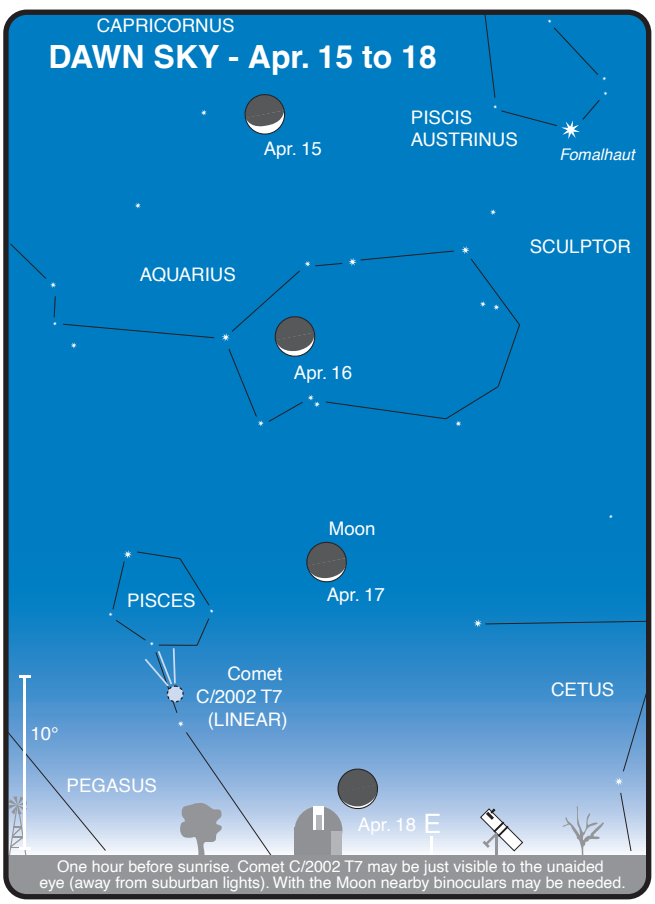
3rd	5 am	(3 am WST) Jupiter 3°S of Moon
3rd		Venus 0.6°S of The Pleiades (M45) in Taurus
3rd		m.p. 4 Vesta 0.7°N of star Delta Capricorni
3rd	pm	Comet C/2003 H1 (LINEAR) 0.5°SW of NGC 2986 (EG) in Hydra
5th	9 pm	(7 pm WST) Full Moon
5th	pm	Comet C/2003 H1 (LINEAR) 0.4°W of NGC 2935 (SG) in Hydra
6th		Comet 88P/Howell 0.4°SW of star Delta Capricorni
7th	7 am	(5 am WST) Mercury stationary
7th	3 pm	(1 pm WST) Mars 7°N of star Aldebaran
8th	Noon	(10 am WST) Moon at perigee
11th		m.p. 29 Amphitrite 0.2°S of star Beta Tauri
11th		Comet 88P/Howell 0.6°S of m.p. 4 Vesta
12th		m.p. 6 Hebe 0.5°S of Eskimo Nebula (PN) in Gemini
12th		Venus at greatest latitude North
12th	2 pm	(Noon WST) Last Quarter Moon
13th	11 pm	(9 pm WST) Comet 43P/Wolf-Harrington 0.3°E of star Aldebaran
14th	2 am	(Midnight WST, prev day) Neptune 5°N of Moon
15th	2 pm	(Noon WST) Uranus 4°N of Moon
16th	8 pm	(6 pm WST) Venus 10°N of Aldebaran
17th		Comet C/2003 K4 (LINEAR) 0.5°E of NGC 6885 (OC) in Vulpecula
17th	11 am	(9 am WST) Mercury in inferior conjunction
17th	pm	Mars 0.2°NE of NGC 1746 (OC) in Taurus
19th	11 pm	(9 pm WST) New Moon; eclipse
20th		m.p. 6 Hebe 0.9°S of NGC 2420 (OC) in Gemini
21st		m.p. 5 Astraea 0.6°NE of NGC 5634 (GC) in Virgo
22nd		Comet C/2001 Q4 (NEAT) 1°W of star Alpha Reticuli
23rd		Mercury at descending node
23rd	8 pm	(6 pm WST) Venus 1.5°N of Moon
24th	7 am	(5 am WST) Mars 2°S of Moon
24th		Comet 43P/Wolf-Harrington 0.4°S of NGC 1807 (OC) in Taurus
24th	10 am	(8 am WST) Moon at apogee
25th		Comet 43P/Wolf-Harrington 0.7°S of NGC 1817 (OC) in Taurus
25th	4 pm	(2 pm WST) Saturn 5°S of Moon
27th		m.p. 40 Harmonia 1.0°N of NGC 7606 (SG) in Aquarius
28th	4 am	(2 am WST) First Quarter Moon
29th	8 pm	(6 pm WST) Mercury stationary
30th	Noon	(10 am WST) Jupiter 4°S of Moon

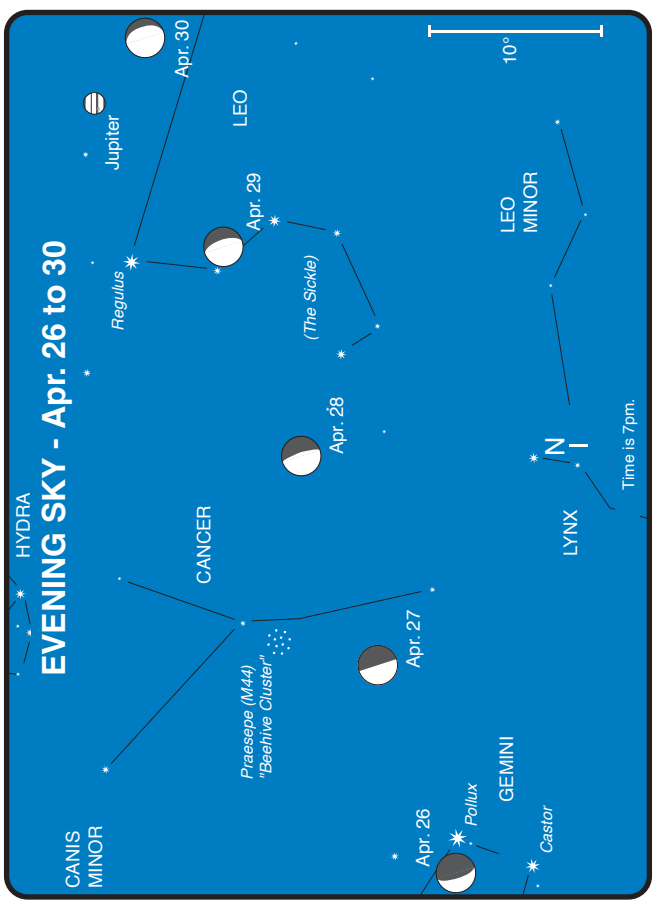






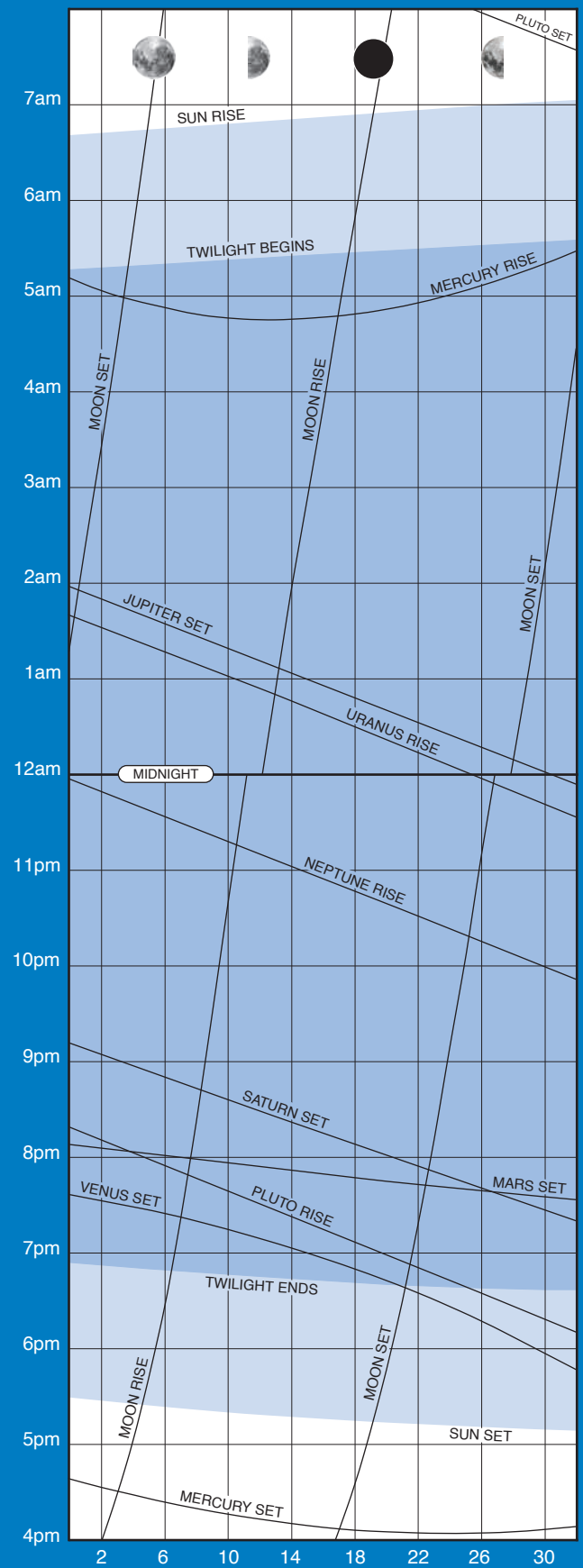
Approximate local standard time.





MAY

RISE/SET CHART



Approximate local standard time.

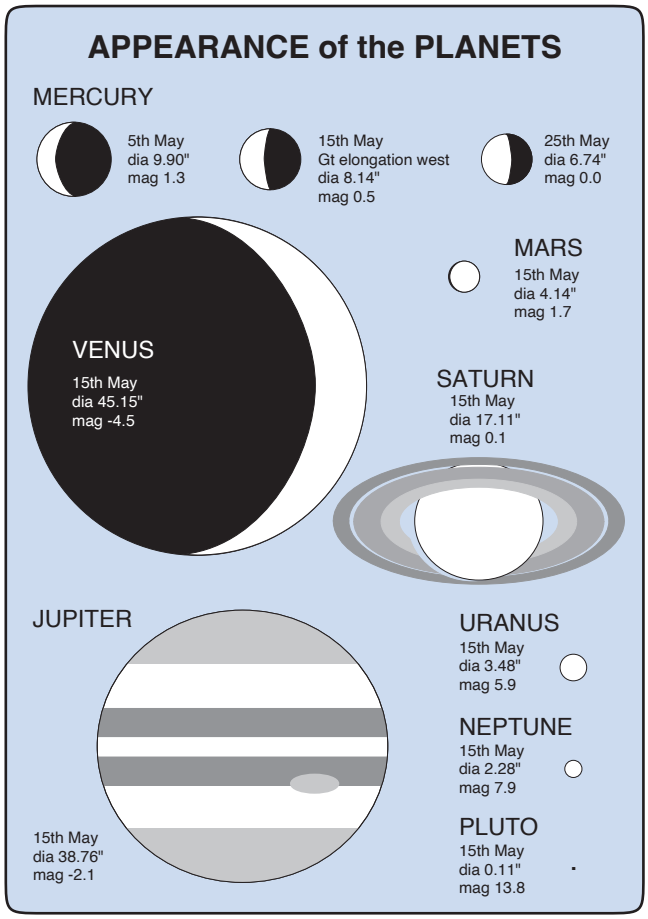
HIGHLIGHTS

- Comets C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT) together in the evening sky and could be naked-eye brightness!
- Mercury well placed for observing in the morning sky
- Venus at greatest brilliancy
- Venus close to crescent Moon in evening sky
- Mars, Saturn and the Moon in interesting alignment

THE MOON

5th	Full Moon (Total Lunar Eclipse, partially visible from Australia – see Part II p. 87)
6th	Moon at perigee (closest to Earth – 359,811 km distant, angular size 32.9')
11th	Last Quarter
13th	Occultation of minor planet Vesta by the Moon (visible from most of New Zealand)
19th	New Moon
21st	Moon at apogee (furthest from Earth – 406,264 km distant, angular size 29.3')
21st	Occultation of Venus by the Moon (visible from parts of Northern Hemisphere only)
27th	First Quarter

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is at its greatest elongation west of the Sun on the 15th (26°). This elongation is favourable, placing the planet almost as far from the Sun as possible (maximum 28°), providing this month with the best window to observe the planet in the morning sky this year. Mercury moves through Pisces, briefly into Cetus mid-month, then into Aries. On the 17th the planet is close to the 27-day old thin crescent Moon (see Sky View).

VENUS, setting in the early evening, begins a fairly rapid descent toward the northwestern horizon this month, leaving Saturn and Mars above (see Sky View). The planet is at its greatest brilliancy on the 2nd (magnitude –4.5), the brightest this year in the evening sky. On the 11th and 12th, Venus, Mars and Saturn are equally spaced forming a line. The 2-day old slender crescent Moon appears quite close to Venus on the 21st (see Sky View). Early next month is the eagerly awaited transit of Venus, an event so rare that not a soul alive has ever seen one and human eyes have only ever observed five. Be prepared!

MARS traverses the Milky Way this month, moving from Taurus into Gemini. On the 10th, the planet skims just below M35, a rich compact open star cluster. An interesting alignment occurs on the 22nd, with Mars 2° below Saturn and the 3-day old crescent Moon below the pair, all in a straight vertical line in the northwest early evening sky (see Sky View).

JUPITER transits the meridian around 7:30pm mid-month, placing it high in the northern sky just after the end of astronomical twilight. The First Quarter Moon appears nearby the planet on the 27th. In retrograde motion since early January and moving in the direction of Regulus, the planet now reverses direction this month and heads towards Spica in Virgo.

SATURN sets in the early evening sky, in the constellation of Gemini. This month is the last opportunity for telescopic observations of the ringed planet before too much altitude is lost as Saturn moves toward solar conjunction in July. In May there are also a couple of pleasing unaided-eye vistas that include Saturn, see Venus and Mars sections above.

URANUS and **NEPTUNE** spend an uneventful month in their respective constellations in the morning eastern sky. Neptune is now rising before midnight. With opposition in August, Neptune begins its retrograde motion mid-month.

PLUTO, in Serpens, rises in the early evening eastern sky. The constellation of Serpens 'the Serpent' is uniquely in two sections separated by Ophiuchus 'the Serpent Holder'. Pluto is in the half of Serpens known as Serpens Cauda 'the serpent's tail'; the other part is known as Serpens Caput 'the serpent's head'.

MINOR PLANETS at opposition this month include: 44 Nysa on the 5th at magnitude 10.1 in Libra, 20 Massalia on the 15th at magnitude 9.7 in Libra, 89 Julia on the 15th at magnitude 10.6 in Lupus and 51 Nemausa on the 26th at magnitude 10.3 in Ophiuchus.

COMETS

Comet C/2001 Q4 (NEAT) reaches perihelion this month and also makes its closest approach to the Earth. Visible in the evening sky, although setting earlier with each day, NEAT may peak at 2nd magnitude early in May before fading to 5th magnitude by month's end (see Sky View).

Comet C/2002 T7 (LINEAR), the second of this month's predicted bright comets, races through a myriad of constellations as it nears the Earth. Predicted to be initially 3rd magnitude in brightness, LINEAR passes south of the Sun in mid-May, when it will briefly be visible in both the evening twilight and morning skies. Around this time, LINEAR could peak in brightness between 1st and 2nd magnitude. Late May sees the comet in the evening sky, when it could still be 2nd magnitude, and sharing the sky with comet C/2001 Q4 (NEAT) (see Sky View). By month's end, LINEAR will be in Hydra, setting late in the evening and still possibly 4th magnitude.

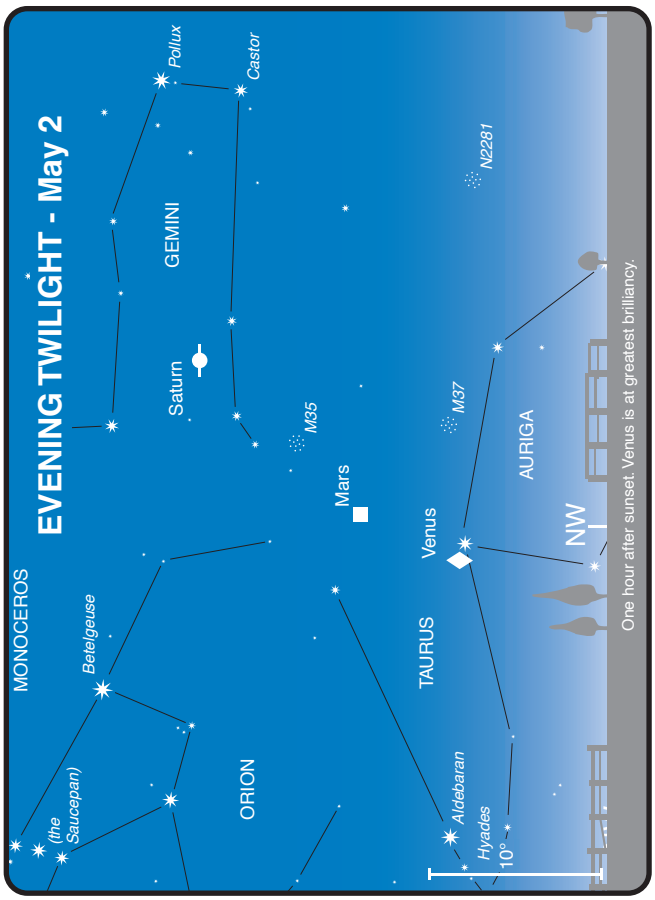
Comet C/2003 H1 (LINEAR) is an evening object, moving through Hydra and Puppis. It will probably fade from 12th to 13th magnitude.

Comet C/2003 K4 (LINEAR) is moving northwest through Cygnus and Lyra. Low in the northern sky, the 10th magnitude comet is best observed in the early hours of the morning. By late May, LINEAR is within a few degrees of 4th magnitude Eta Lyrae.

Comet 88P/Howell should fade this month from 10th to 11th magnitude as it moves through Aquarius, Pisces, and Cetus in the morning sky.

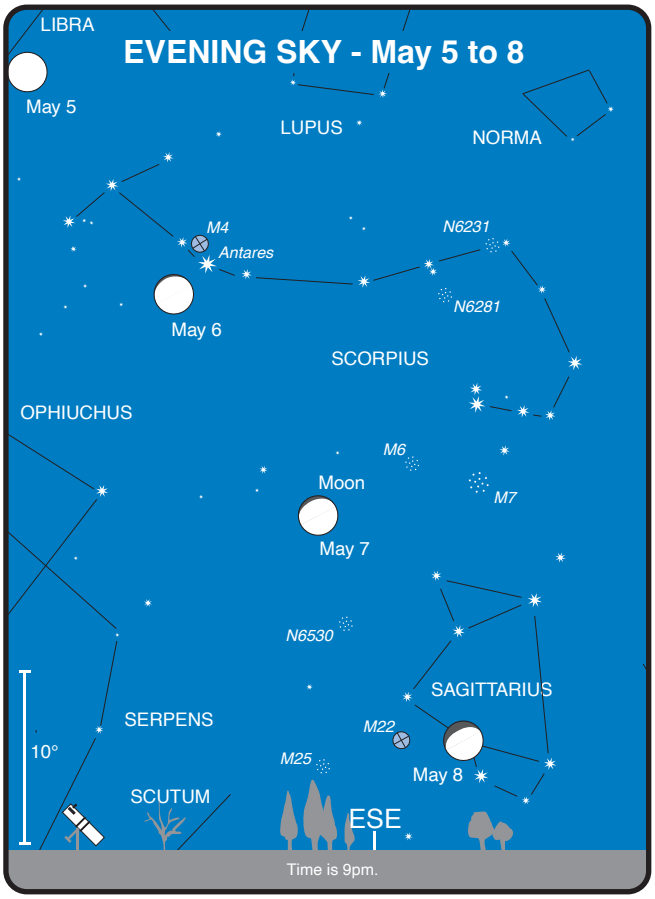
DIARY

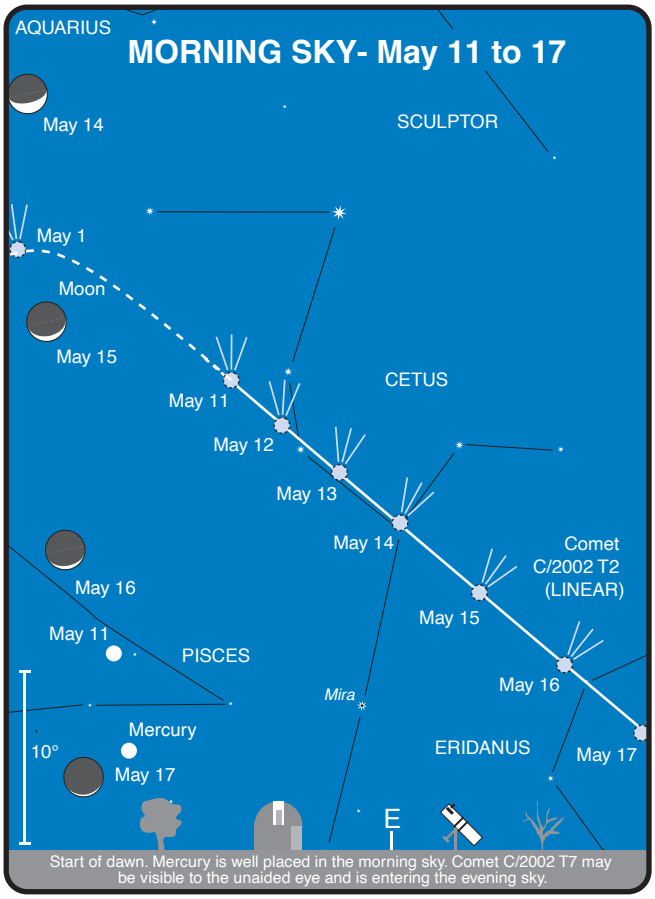
2nd	6 pm	(4 pm WST) Venus Greatest brilliancy
3rd		Venus 0.8°S of star Beta Tauri
3rd		Comet C/2002 T7 (LINEAR) 0.2°S of m.p. 27 Euterpe
4th		m.p. 15 Eunomia 0.3°SW of NGC 2775 (SG) in Cancer
4th		Mercury at aphelion
4th	pm	Comet C/2001 Q4 (NEAT) 0.6°S of star Epsilon Canis Majoris
5th	3 am	(1 am WST) Comet 88P/Howell 0.2°NW of NGC 7606 (SG) in Aquarius
5th	7 am	(5 am WST) Full Moon; eclipse
5th	11 pm	(9 pm WST) Jupiter stationary
6th	3 pm	(1 pm WST) Moon at perigee
7th	pm	Comet C/2001 Q4 (NEAT) 1°NW of M47 (OC) in Puppis
9th	7 pm	(5 pm WST) m.p. 2 Pallas 0.2°W of NGC 1637 (SG) in Eridanus
10th	8 pm	(6 pm WST) Mars 0.2°NW of M35 (OC) in Gemini
11th	8 am	(6 am WST) Neptune 5°N of Moon
11th	9 pm	(7 pm WST) Last Quarter Moon
12th	10 pm	(8 pm WST) Uranus 4°N of Moon
13th	8 am	(6 am WST) m.p. 4 Vesta 1.1°N of Moon; Occn.
15th	7 am	(5 am WST) Mercury greatest elongation West (26°)
15th	6 pm	(4 pm WST) m.p. 3 Juno stationary
15th	pm	Comet C/2001 Q4 (NEAT) 1°W of Beehive Cluster (M44) in Cancer
17th	9 am	(7 am WST) Mercury 3°S of Moon
18th	1 am	(11 pm WST, prev day) Neptune stationary
18th		Comet 88P/Howell 0.6°SE of m.p. 40 Harmonia
18th	10 am	(8 am WST) Venus stationary
19th	3 pm	(1 pm WST) New Moon
20th		Mercury 0.8°NW of m.p. 8 Flora
21st		m.p. 29 Amphitrite 0.4°NW of NGC 2266 (OC) in Gemini
21st	10 pm	(8 pm WST) Moon at apogee
21st	10 pm	(8 pm WST) Venus 0.3°S of Moon; Occn.
22nd	pm	Comet C/2002 T7 (LINEAR) 3.5°SE of star Sirius
23rd	2 am	(Midnight WST, prev day) Mars 3°S of Moon
23rd	4 am	(2 am WST) Saturn 5°S of Moon
23rd		Mars 0.9°S of star Epsilon Geminorum
23rd	pm	Comet C/2002 T7 (LINEAR) 2°S of star Alpha Hydrae
24th		Mercury at greatest latitude South
25th	9 am	(7 am WST) Mars 1.6°N of Saturn
27th	6 pm	(4 pm WST) First Quarter Moon
27th	10 pm	(8 pm WST) Jupiter 4°S of Moon



Approximate local standard time.

Comet Hale-Bopp taken in April 1997 *when near maximum brightness. It looked like this to the unaided eye. We can dream that Comets C/2001 Q4 (NEAT) and/or C/2002 T7 (LINEAR) might look like this!*

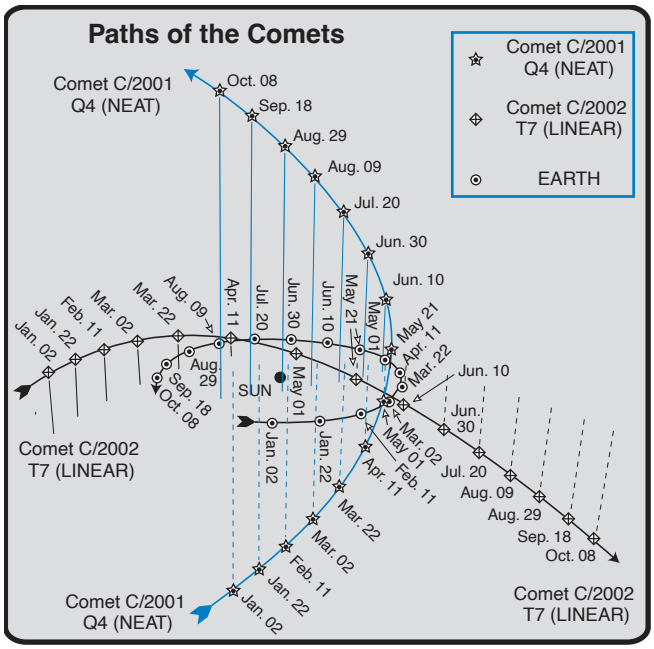




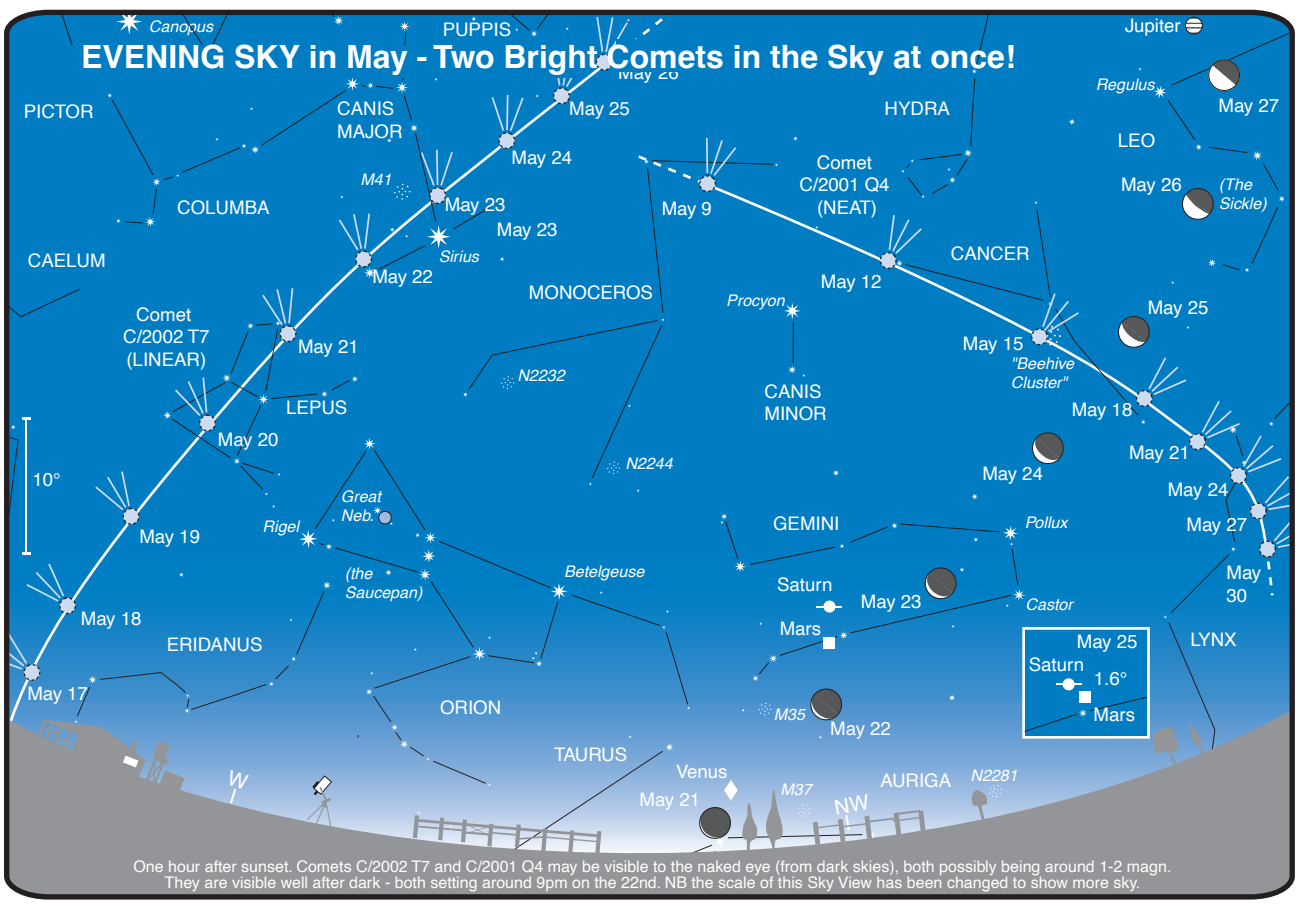
The Orbits of Comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR)

For those familiar with the orbits of bodies in the Solar System the behaviour of these comets may seem a little strange. Most of the planets and minor planets orbit within a fairly flat disc, that is within a few degrees of the plane of the ecliptic, or the Earth's orbit. Generally these bodies also orbit in the same direction which is anticlockwise as seen from above or north of the ecliptic. Both of these comets orbit in the opposite or retrograde direction (clockwise). C/2002 T7 (LINEAR)'s orbit is inclined or tilted to the Earth's by 20° where C/2001 Q4 (NEAT) is nearly perpendicular (81°) to us.

In April/early May, LINEAR is heading directly towards the Earth but from above our orbit. On April 23 it makes its closest approach to the Sun (perihelion) at 0.61AU. At this time the comet is in the late morning sky, rising about 4am or approximately 1 hour before the start of dawn. On May 1 it passes through the plane of the ecliptic at a distance of 0.63AU from the Sun (a little inside the orbit of Venus). Now below (south) of the ecliptic it makes its closest approach to Earth on the 19th at 0.26AU. So the comet comes closest to Earth nearly 4 weeks after perihelion. Considering its path, its rapid movement through the sky (see Sky View below) is not surprising. It is a little like passing an oncoming car on the freeway, relative to the background of buildings and trees the other vehicle appears to be moving rapidly just as it passes our car. Continuing this analogy NEAT on the other hand can be likened to looking over your shoulder and seeing a car crossing an overpass that you had passed under earlier. NEAT comes up from below our orbit, at a steep angle, making its closest approach to the Earth on May 7 at 0.32AU. It passes through the ecliptic on May 14 at a distance of 0.96AU from the Sun — very close to where the Earth is normally in its orbit on April 20. Then a day later, the 15th, it makes its closest approach to the Sun. This is only week after its close call with the Earth, so we are well positioned to see the comet at its brightest.

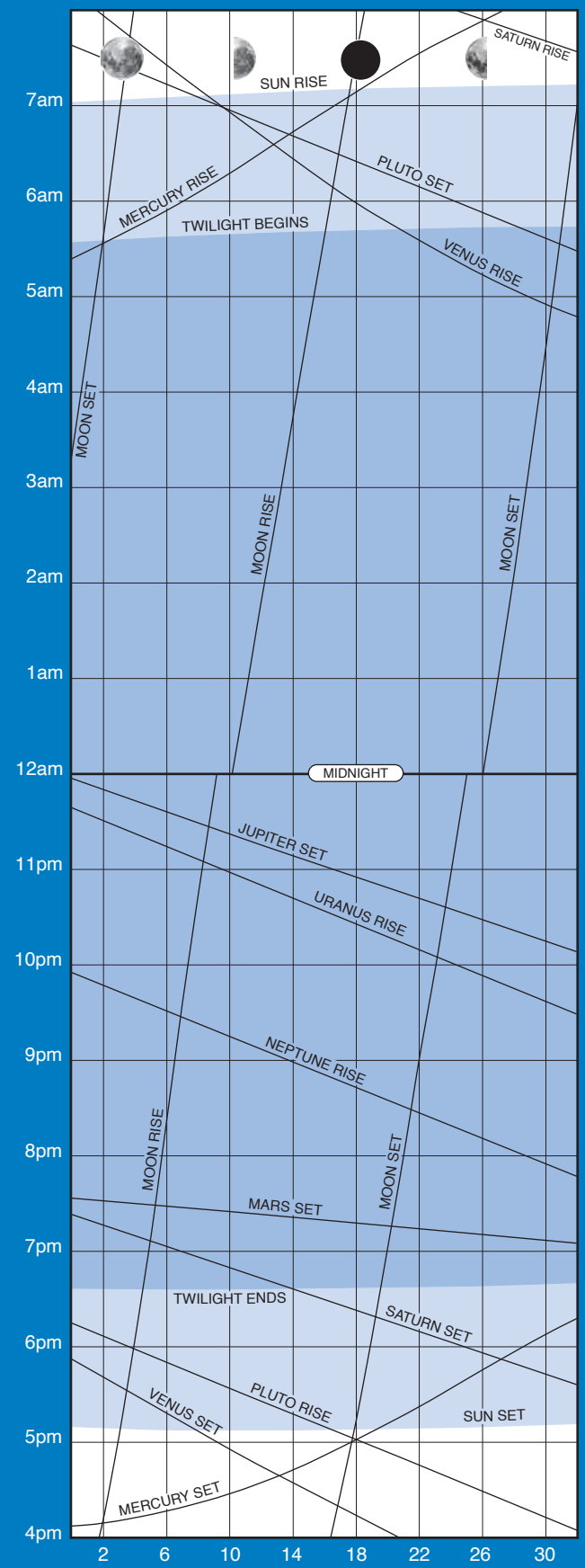


This simulated view shows the orbits of Earth and Comets LINEAR and NEAT. You are looking from well outside the orbit of the Earth and 20° above the plane of its orbit. Comet LINEAR is moving from left to right very close to the plane of the paper. The movement of NEAT is not that obvious. Its orbit is taking it up and out of the plane of the paper towards the reader. The vertical drop lines show to scale the distance above (solid) or below (dashed) the plane of the ecliptic.



JUNE

RISE/SET CHART



Approximate local standard time.

HIGHLIGHTS

- Comet 2002 T7 (LINEAR) is still bright, but fading quickly, in the western evening sky.
- Comet C/2001 Q4 is still bright but soon lost in twilight skies
- Mercury returns to the evening sky
- Transit of Venus across the Sun
- Mars and Saturn close
- Pluto at opposition

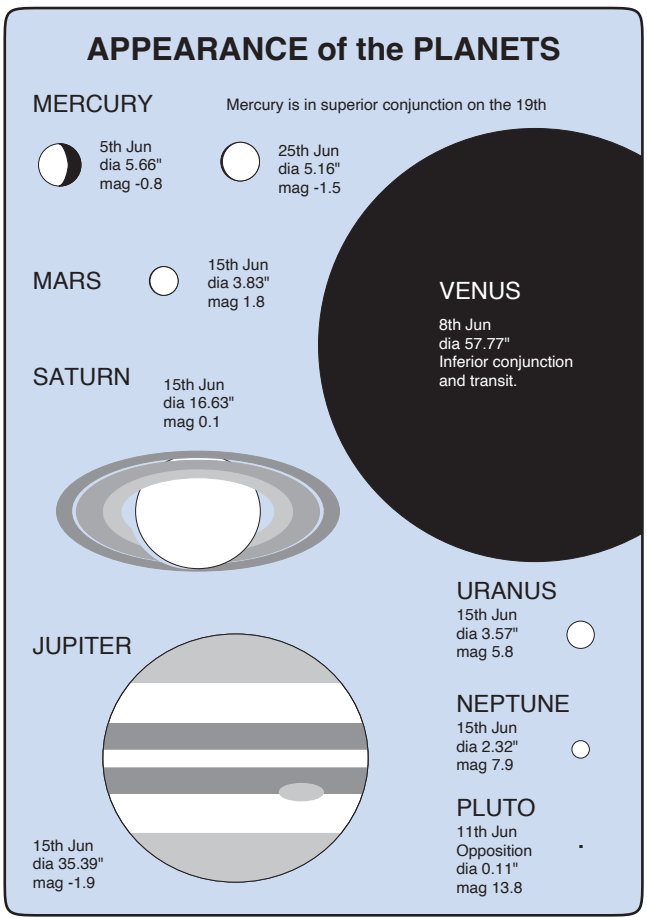
THE MOON

3rd	Full Moon
3rd	Moon at perigee (closest to Earth – 357,247 km distant, angular size 34.0')
10th	Last Quarter
10th	Occultation of minor planet Vesta by the Moon (visible only from Russia)
18th	Moon at apogee (furthest from Earth – 406,575 km distant, angular size 29.0')
18th	New Moon
26th	First Quarter

THE PLANETS

MERCURY, in the dawn sky, is only visible early in the month. The planet then rapidly loses altitude as it moves toward the Sun and

APPEARANCE of the PLANETS



superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 19th. The planet then moves east of the Sun to become an evening star until late August. This period, from early July to mid August, is the best time to see this sometimes difficult little planet in the evening sky.

VENUS, in Taurus for the entire month, undergoes its long awaited transit across the face of the Sun on the 8th. With the previous transit occurring 121.5 years ago, no person alive has ever witnessed one. This year's transit will only be the fifth to have ever been recorded, so although there are many astronomical events that one would consider more spectacular, the uniqueness and rarity makes the transit a must to observe. The beginnings of the transit will be visible Australia-wide (New Zealand just misses out with the event beginning at sunset). For those situated on the eastern seaboard, the Sun sets before Venus has reached mid-transit. Observers from places like Darwin, Perth and Alice Springs see at least until mid-transit, but the Sun sets before the planet's egress. **Warning, never look directly at the Sun with your eyes or without a suitability filtered instrument.** Viewing of the transit should be supervised by experienced solar observers, using safe solar observing techniques. If you are not sure, ring your local astronomical society (listed in the appendices) and join one of their observing groups. For full details of the transit see page 105. After transit the planet quickly climbs into the morning sky (see Sky View) where it remains for the rest of the year. At the end of June, Venus will be located just 1.5° from the 1st magnitude star Aldebaran, making an interesting additional member to the Hyades.

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

MARS, in the early western evening sky, begins the month just 4° from Saturn in Gemini, before moving into Cancer. On the 20th, the 2-day old slim crescent Moon appears near the Red Planet (see Sky View). At month's end Mars will be 3° from the open star cluster M44 (Praesepe of the Beehive cluster).

JUPITER is prominent in the northern sky in the early night sky, situated just above the upside down figure of Leo the lion. For the first time this year Jupiter drops below –2 magnitude, and will remain so until approaching opposition next year. On the 24th, the 6-day old Moon will be close to the planet (see Sky View).

SATURN is visible near Mars at the beginning of the month, but soon becomes lost in the evening twilight (see Sky View) as it moves toward conjunction with the Sun early next month.

URANUS in Aquarius and **NEPTUNE** in Capricornus both rise in the evening eastern sky. With opposition in August, Uranus begins its retrograde motion this month.

PLUTO is at opposition on the 11th, and is visible the entire night. Our most distant planet is currently 4,465,000,000 km from Earth (29.8 AU), with its light taking 248 minutes to reach us (a little over 4 hours).

MINOR PLANETS at opposition this month include: 19 Fortuna on the 3rd at magnitude 10.6 in Ophiuchus, 22 Kalliope on the 6th at magnitude 10.8 in Ophiuchus, 88 Thisbe on the 20th at magnitude 9.8 in

MAGNITUDE MADNESS — APPARENTLY

On learning of a new discovery, what is the first question an amateur astronomer is likely to ask? In most instances it will simply be 'how bright is it?' Rarely will the first utterance be concerned with the object's history, discoverer, or the how and when. Above all, the brightness of an object is the most important single piece of information one needs to know to determine its observability. The other questions will come, but there is always that immediate need to know if it's really worth getting excited about.

In astronomy the brightness of an object is measured using the *magnitude scale*, a system for describing the apparent brightness of things in the sky. The ancient Greeks were the first to record and catalogue the brightness of the stars. In those days they had a liking for the numbers six and sixty, and it's because of them we have sixty minutes in an hour. So when it came to describing the brightness of stars they chose six classes. They placed the brightest stars in the first class, the next brightest in the next class, and so on until the faintest stars were in the sixth class. The system worked fine until Galileo came along with his telescope and discovered stars fainter than sixth magnitude.

The magnitude system works contrary to the way we normally measure things. If we weigh or measure an item, its number increases the heavier or bigger it gets, and we are comfortable with this logic. The brighter a star is however, the smaller the number. It is less confusing if you substitute the word 'class' for 'magnitude', so it is easy to think of a *first class star* being brighter than a *second* or *third class star*.

It was known that a 1st magnitude star looked about 100 times brighter than one of 6th magnitude. In 1856, English astronomer Norman Pogson proposed that the system be redefined so that a difference of 5 magnitudes corresponds to a factor of 100 in brightness. So from one magnitude to the next the ratio of brightness is the 5th root of 100, or 2.511886432... lets round that to 2.51 for simplicity, For example, a fourth magnitude star is 2.51 times the brightness of a fifth magnitude one; and a first magnitude star is 6.30 (that's 2.51 x 2.51) times as bright as a third magnitude one.

The problem with becoming so precise is that some stars the Greeks classified as class one are much brighter than other class one stars — so scientists extended the range to zero magnitude (this does not mean no brightness at all) and some stars even have negative numbers. Sirius, the brightest star in the night sky, has a magnitude of –1.4, while the faintest objects seen by astronomers (using big telescopes, of course) are around 30th magnitude, four million million times fainter. The Sun, the brightest object in the sky by far, is –26.8 magnitude, so it is no wonder that you can't see the stars in the daytime.

In all there are four stars that shine above zero magnitude, Arcturus, Alpha Centauri, Canopus and Sirius. The Sun and Moon are certainly the brightest objects in the sky, and five of the planets have negative numbers (some planets will be fainter than zero at times e.g., Mars). Apart from the above eleven, and the occasional bright meteor or comet, everything else in the sky has a positive number.

The magnitude for diffuse or extended objects, nebulae or galaxies for example, is integrated and treated as if all their light was coming from a single starlike point. Integrated magnitude can be deceptive; a low number does not necessarily mean a bright object, as the brightness is 'smeared' across the angular size of the object.

So far we have discussed the *apparent magnitude* of an object, its apparent brightness in the sky from our viewpoint on Earth. An object's 'true' brightness is hidden by the effect of distance. So astronomers can compare the true brightness of stars, they created the *absolute magnitude scale*, which is the apparent magnitude a star would have if it were placed at a distance of 10 parsecs (32.6 light years). For comets and asteroids however, the absolute magnitude is calculated assuming the object is one astronomical unit from the Earth and the Sun.

From an imprecise and subjective beginning the modern day magnitude scale evolved. If you're a novice give it time, it's really not as bad as it sounds, and given a chance it will become second nature.

Sagittarius and 17 Thetis on the 23rd at magnitude 10.0 in Sagittarius. Early in the month 6 Hebe crosses the Beehive Cluster (M44).

COMETS

Comet C/2001 Q4 (NEAT) will be visible only briefly in early June's evening sky as it moves north through Ursa Major. Opening the month perhaps at 5th magnitude, the comet may have faded to 6th magnitude by mid-month.

Comet C/2002 T7 (LINEAR) could fade from 4th to 7th magnitude this month as it moves through Hydra and Sextans, setting by mid-evening.

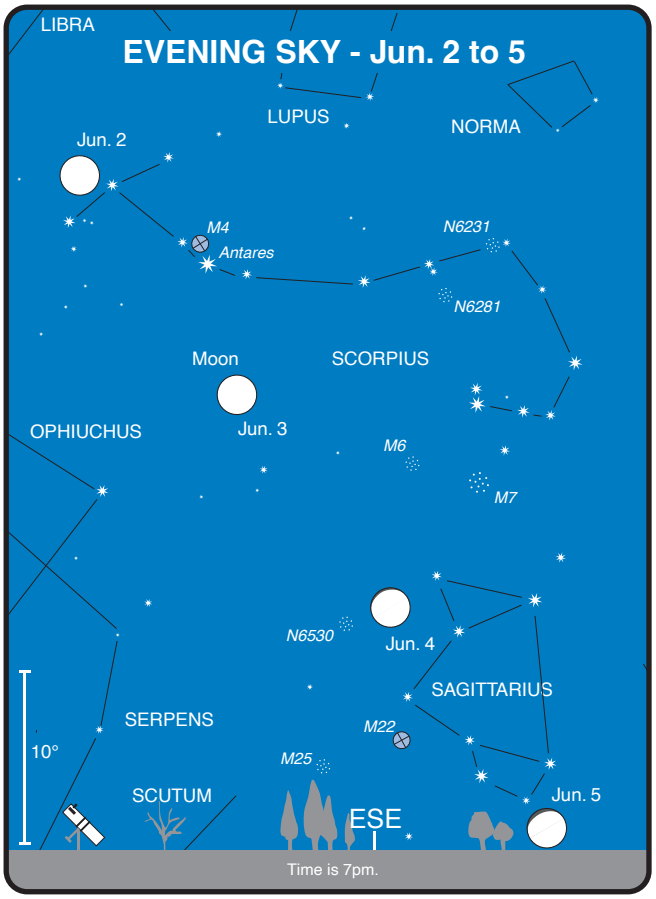
Comet C/2003 K4 (LINEAR) is very low in the northern sky this month, moving northwest through Lyra and Hercules. Possibly at 9th magnitude, the comet is only visible for a few hours as it rises and sets during the course of the night. By late June, LINEAR has reached the northernmost point of this apparition, and turns towards the south.

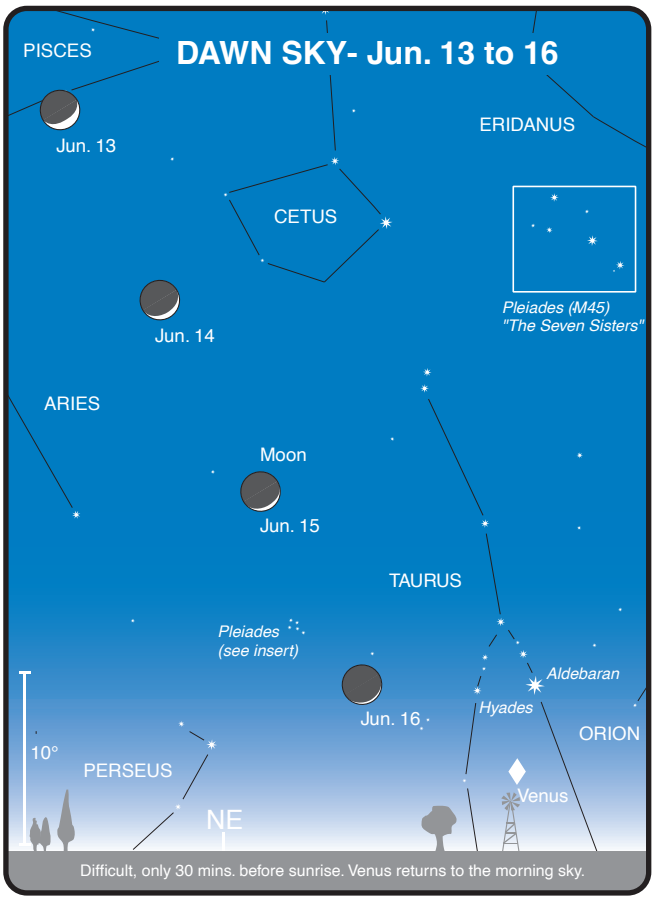
Comet 88P/Howell is moving northeast through Cetus and Pisces in July's morning sky. During the month, it should fade from 11th to 12th magnitude.

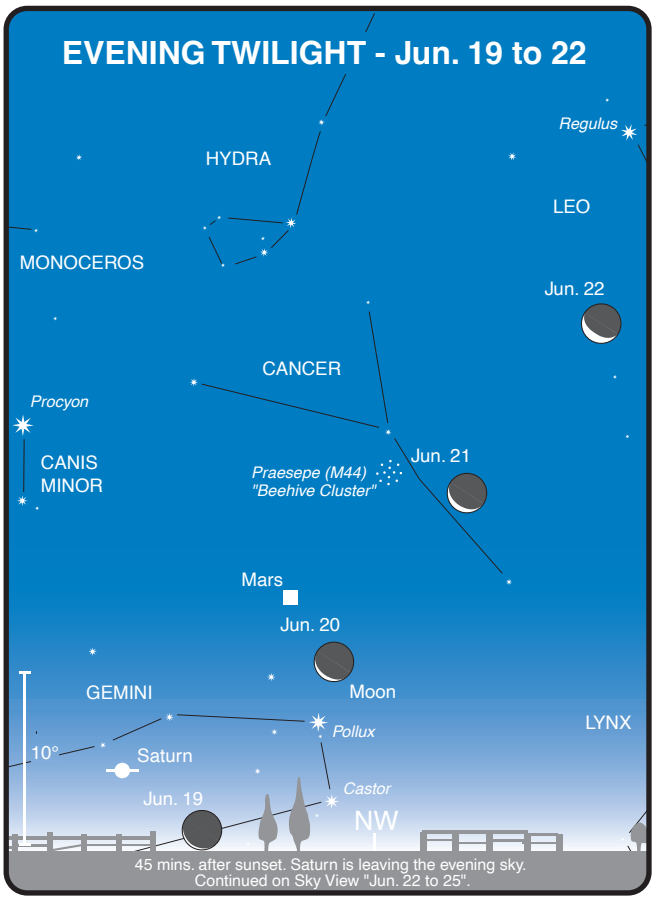
DIARY

2nd		m.p. 29 Amphitrite 0.8°S of NGC 2331 (OC) in Gemini
3rd		m.p. 6 Hebe 0.1°S of Beehive Cluster (M44) in Cancer
3rd	2 pm	(Noon WST) Full Moon
3rd	11 pm	(9 pm WST) Moon at perigee
4th		m.p. 2 Pallas 0.4°N of star Epsilon Orionis
6th		m.p. 7 Iris 0.3°SW of NGC 3521 (SG) in Leo
6th	pm	Comet C/2002 T7 (LINEAR) 2°SE of star Beta Canis Majoris
7th		Venus at descending node
7th	4 pm	(2 pm WST) Neptune 5°N of Moon
8th	7 pm	(5 pm WST) Venus in inferior conjunction, transit over Sun!
9th	5 am	(3 am WST) Uranus 4°N of Moon
9th		m.p. 6 Hebe 0.5°N of NGC 2672 (EG) in Cancer
10th	6 am	(4 am WST) Last Quarter Moon
10th	9 am	(7 am WST) Vesta 1.2°S of Moon; Occn.
11th	10 am	(8 am WST) Uranus stationary
11th	10 pm	(8 pm WST) Pluto at opposition
12th		Mercury at ascending node
15th	4 am	(2 am WST) Mars 6°S of star Pollux
15th		Comet 88P/Howell 0.2°N of IC 1613 (IG) in Cetus
17th		Mercury at perihelion
18th	2 am	(Midnight WST, prev day) Moon at apogee
18th	6 am	(4 am WST) New Moon
19th	7 am	(5 am WST) Mercury in superior conjunction
19th		Venus 1.0°NW of NGC 1647 (OC) in Taurus
19th	5 pm	(3 pm WST) Saturn 5°S of Moon
20th	7 pm	(5 pm WST) Mars 4°S of Moon
21st		Comet C/2002 T7 (LINEAR) 0.2°S of NGC 3115 (LG) in Hydra
21st	11 am	(9 am WST) Solstice
24th	9 am	(7 am WST) Jupiter 3°S of Moon
25th	7 am	(5 am WST) Venus 2°N of star Aldebaran
26th	5 am	(3 am WST) First Quarter Moon
26th		m.p. 532 Herculina 0.8°S of NGC 1807 (OC) in Taurus
26th	pm	Comet C/2003 K4 (LINEAR) 0.9°S of NGC 6229 (GC) in Hercules
27th		m.p. 532 Herculina 0.9°S of NGC 1817 (OC) in Taurus
27th		Mercury at greatest latitude North
29th	Midnight	(10 pm WST) Venus stationary

***Galaxy NGC2997 in Antlia**, a very distinctive face-on spiral galaxy that can be observed in the SW evening sky in June.*

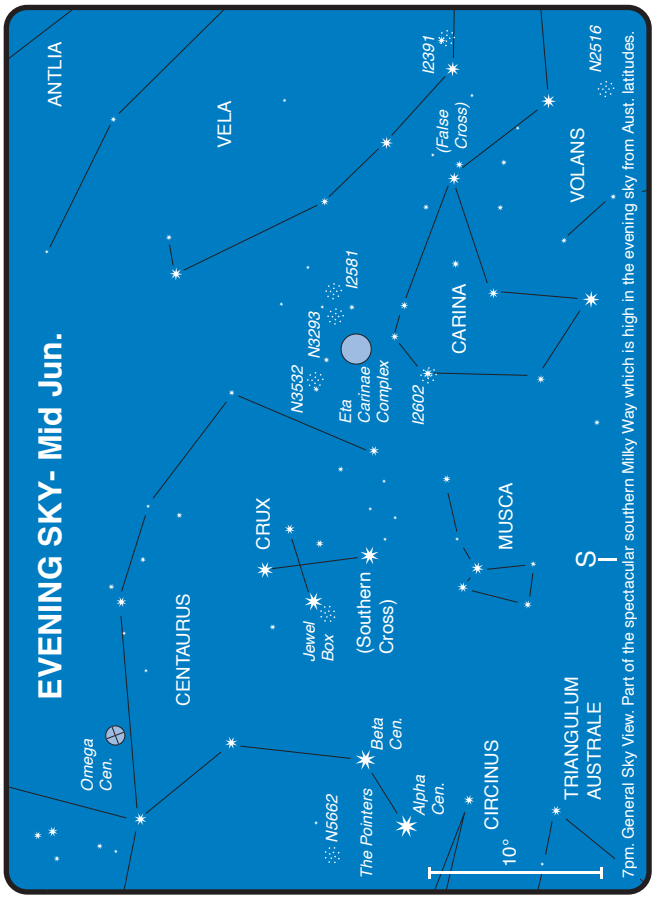


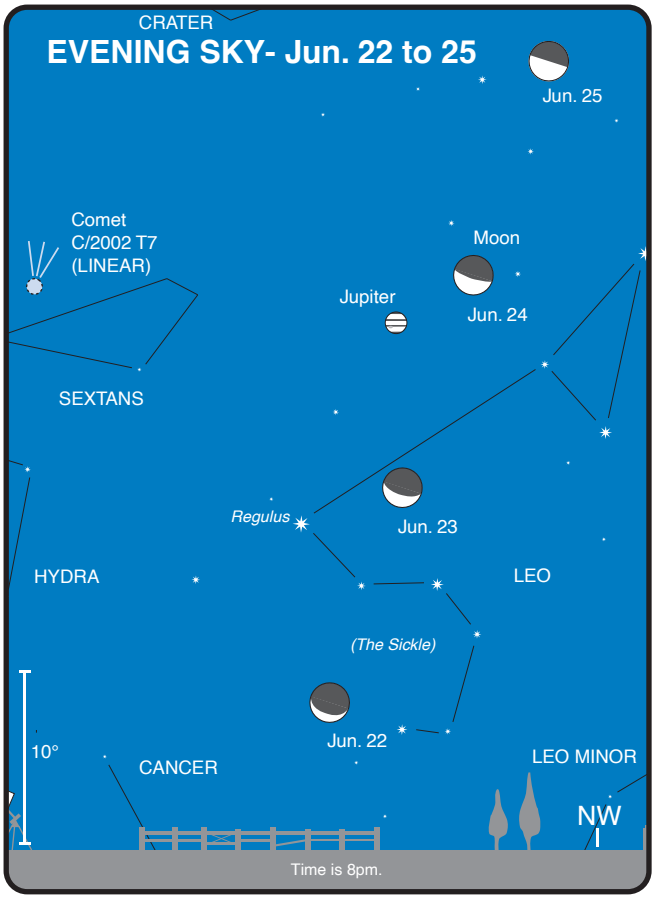




JUNE

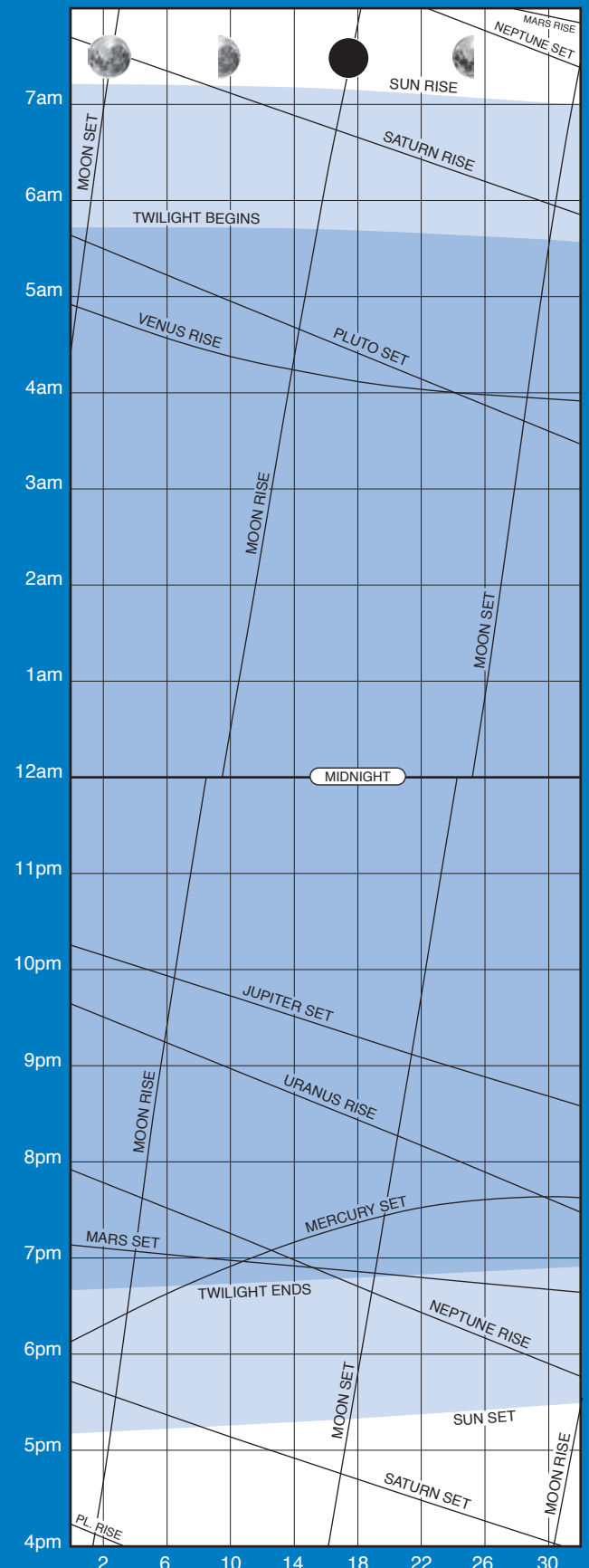
Approximate local standard time.





JULY

RISE/SET CHART



Approximate local standard time.

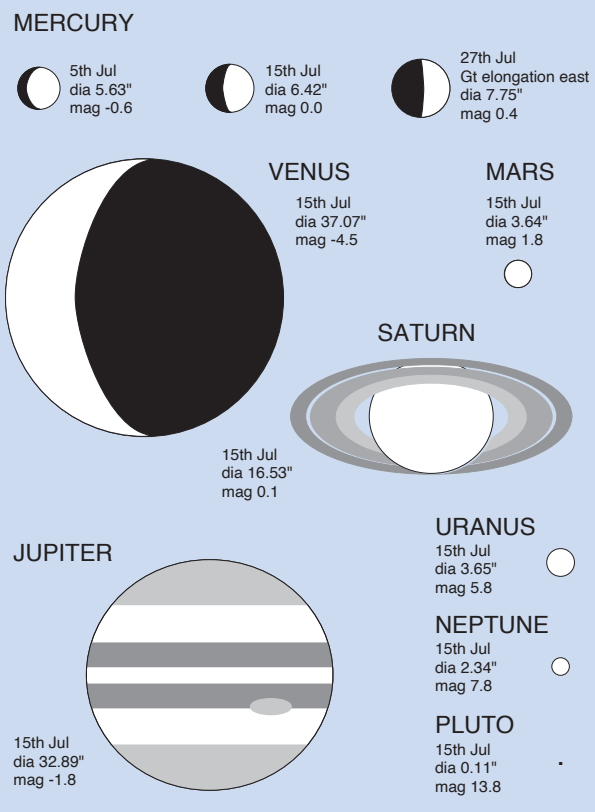
HIGHLIGHTS

- Mercury close to the open cluster M44
- Mercury and Mars very close
- Venus at greatest brilliancy
- Mars crosses the open cluster M44
- Seven of the brightest minor planets reach opposition
- Minor planets Vesta and Metis have a close encounter

THE MOON

2nd	Moon at perigee (closest to Earth – 357,448 km distant, angular size 33.2')
2nd	Full Moon
9th	Last Quarter
15th	Moon at apogee (furthest from Earth – 406,192 km distant, angular size 29.5')
17th	New Moon
25th	First Quarter
30th	Moon at perigee (closest to Earth – 360,324 km distant, angular size 33.2')

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is best in the evening sky from early July to mid August, and rewards us with some interesting events. Mercury chases and overtakes Mars as it moves from Gemini, into Cancer and finally Leo. On the 8th, Mercury will be located on the outer fringes of the open star cluster M44, the Beehive (see Sky View), a few days after Mars traversed the cluster (see Mars section). Mercury crosses directly through M44's centre but it is below the horizon when this occurs. On the following evening the planet appears on the opposite side of M44. On the 10th, Mercury and Mars will be 0.6° apart and on the following evening a close 0.4°, Mercury is the brighter of the two (see Sky View). On the 25th, Mercury will be 1.3° from the 1st magnitude star Regulus (Alpha Leonis). Mercury is a little brighter than Regulus and to the south (see Sky View). On the 27th, the planet is at its greatest elongation east of the Sun at an angular distance of 27°.

VENUS, in Taurus, is located between the eyes of the bull at the start of the month, in the morning eastern sky. The planet is at its greatest brilliancy on the 15th (magnitude –4.5), the brightest this year in the morning sky. Between the 3rd and 5th, the planet will be around 1.1° from the 1st magnitude star Aldebaran, the brightest star of the Hyades (see Sky View). Continuing its path through the constellation, Venus at month's end will be near 3rd magnitude Zeta Tauri, the star marking the tip of the right hand horn of the bull.

The **EARTH** is at aphelion (the furthermost point in its orbit from the Sun) on the 5th. The Earth/Sun distance is 1.016694 astronomical units, which is equivalent to about 152,097,000 km.

MARS is located in the early evening western sky, setting at the end of astronomical twilight. Mars and Mercury have a race (speedy little Mercury wins) and end up very close on the 11th (see Mercury section and Sky View). Between the 4th and 6th, Mars crosses over the open star cluster M44 (the Beehive), and near the end of the month joins Mercury and Jupiter in Leo. On the 19th, the 2-day old crescent Moon will be just to the north (right) of the Red Planet (see Sky View). It is interesting to note that the angular size of Mars is only 3.6 arc seconds this month (less than that of Uranus), compared with the planet's opposition size of 26 arc seconds last August.

MAGNITUDE MADNESS
IT'S ALL GREEK TO ME

Most of the brighter stars in the sky have proper names of some historical and mythological significance. There was a need however for an orderly method of identification and in 1603 the German uranographer Johann Bayer introduced such a system. The Bayer system classifies the stars within a constellation according to their brightness, by labelling them with a Greek letter: Alpha for the brightest star, Beta for the next and so on to Omega for the 24th brightest. The Greek letter is then attached to the genitive case of the Latin name for the constellation. Thus, the brightest star in the constellation of Andromeda would be Alpha Andromedae, or α And. The sixth brightest star would be Zeta Andromedae, or ζ And.

Of course many constellations have more than 24 stars, and we naturally run out of Greek letters. The solution put forward by English astronomer John Flamsteed, was to number the stars, not by their brightness but from their nearness to the western edge of their respective constellations. In this system a star is given a numeral indicating its order from the western boundary, followed by the constellation's Latin genitive case. Astronomers adopted this new numbering scheme, but retained the Bayer Greek letters for stars that already had them. Therefore, the 50th star from the western edge of Cygnus is identified as 50 Cygni; it is also known by its Arabic name Deneb. Since Deneb is the brightest star in the constellation it also goes by its Bayer description of Alpha Cygni (α Cyg). And if that is not enough, it is also designated by many other numbers in numerous other modern standard catalogues.

A classical example of the Bayer system is the main stars of our own Southern Cross. Starting from Alpha Crucis at 0.74 magnitude and working clockwise we have, Beta Cru (1.26 mag), Gamma Cru (1.63 mag), Delta Cru (2.80 mag) and Epsilon Cru (3.59 mag). All neatly descending in order of brightness, as they should. Quite a clean and simple system really, well, maybe not that clear-cut when you start looking at anomalies in other constellations.

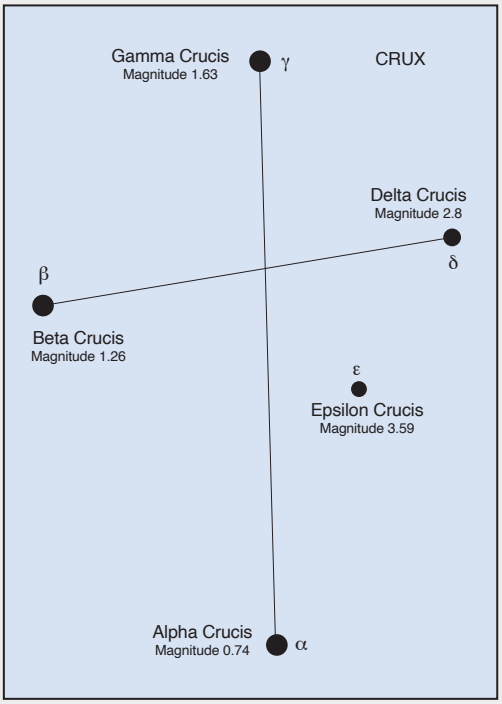
The famous Gemini twins, Castor and Pollux, are stars that have about a half magnitude difference in brightness, however the fainter of the pair, Castor is designated by the Greek letter Alpha. The northern constellation of Ursa Major is a strange case, where Bayer himself chose to label the stars of the Big Dipper by their position, and not by their relative brightness.

Readers may think that these little peculiarities are not all that common, but 34 of the 88 constellations have stars brighter than their Alpha (if they have one), and that's close to 40%! In 13 of the 34 constellations Beta and no other star is brighter than Alpha. In 3 cases a star other than Alpha or Beta is the brightest. Furthermore, 14 constellations have two or more Bayer stars brighter than Alpha.

Vulpecula's Alpha is surpassed not by another Greek letter but by 13 Vul, a Flamsteed number. In Sagittarius, 13 Bayer stars are brighter than its Alpha with Epsilon and Sigma being the constellation's brightest stars. Pisces is interesting; its Alpha could not even exceed its Omega, the star at the far end of the Bayer scale.

There are four constellations that have no Alpha star at all, namely Leo Minor, Norma, Puppis and Vela. Leo Minor has a Beta but no Alpha, the only constellation where an Alpha absence cannot be explained. Norma's Alpha disappeared when the official International Astronomical Union's constellation boundaries were set, it is now known as Eta Scorpii. When the old and substantial constellation of Argo Navis was divided into the constellations of Carina (the Ship's Keel), Puppis (the Ship's Stern), and Vela (the Ship's Sails), there was only one Alpha to go around. The star Alpha of Argo Navis, Canopus, became Alpha Carinae, and Puppis and Vela missed out.

Why not start afresh and adopt one single catalogue as a means of identification and save all the confusion? Naming a star 252838 (from the Smithsonian Astrophysical Catalog) instead of Alpha Centauri, somehow removes some of the romance and mystique from our hobby.



JUPITER sets mid-evening in the western sky. July and early August is the last chance for telescopic observations before the planet loses too much altitude. The 4-day old Moon appears below the planet on the 21st (see Sky View).

SATURN is in conjunction with the Sun on the 9th, and will be too close to the Sun for observation this month. The planet returns to grace the morning sky early next month.

URANUS and **NEPTUNE** both come to opposition next month and are rising in the eastern evening sky. Mid-month Neptune rises around the end of twilight with Uranus 2 hours later.

PLUTO, now past opposition, is still visible throughout most of the night in Serpens Cauda, setting late in the morning.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Sagittarius. They are: 11 Parthenope on the 9th at magnitude 8.9, 270 Anahita on the 16th at magnitude 10.2 and 324 Bamberga on the 23rd at magnitude 9.2. Another three reach opposition in Capricornus: 92 Undina on the 21st at magnitude 10.6, 387 Aquitania on the 23rd at magnitude 9.5 and 79 Eurynome on the 29th at magnitude 11.0. On July 9th 3 Juno reaches opposition at magnitude 9.6 in Aquila.

On the 26th, 3 Juno, near opposition, crosses over the Wild Duck Cluster (M11) in Scutum. This would make an interesting photographic/imaging target. During July, 4 Vesta and 9 Metis are no more than 0.5 degrees apart, being closest on the 15th at only 4 arc minutes. Mid-month, 8 Flora passes through the Hyades Cluster in Taurus. On the morning of the 18th 192 Nausikaa can be seen on the Pleiades in Taurus.

COMETS

Comet C/2002 T7 (LINEAR) can be found in Sextans, in the evening sky, setting a few hours after twilight has ended. The comet will probably be fading from 7th to 9th magnitude this month.

Comet C/2003 K4 (LINEAR) begins July midway between the two 4th magnitude stars Tau and Phi Herculis, low in the northern sky and setting around midnight, before moving into neighbouring Bootes a few days later. On July 28, LINEAR (perhaps at 8th magnitude) will pass quite close to the 9th magnitude globular cluster NGC 5466.

Comet 78P/Gehrels 2 may brighten to 13th magnitude this month. Rising in the morning sky, the comet is moving northeast through Pisces and Aries. Mid-month, Gehrels 2 is less than three degrees from the galaxy M74.

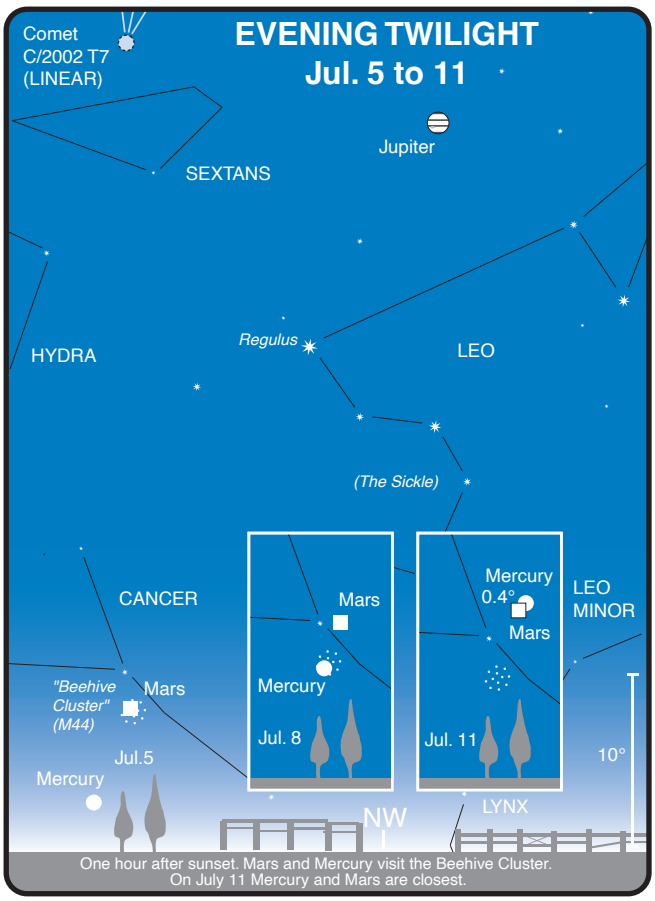
Comet 88P/Howell is a morning object of between 12th and 13th magnitude, moving though Pisces and Cetus, and ending the month near the border with Aries.

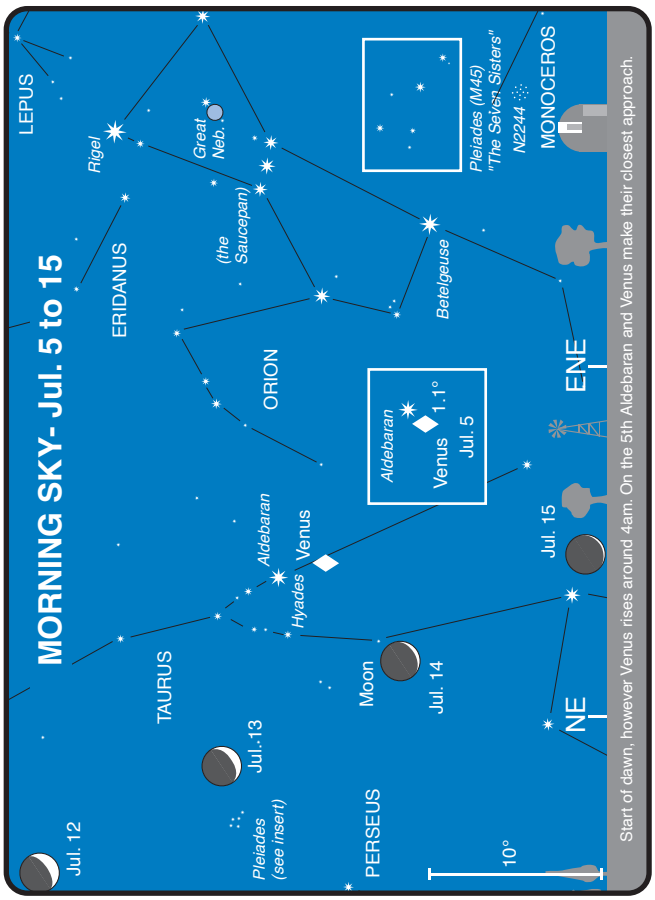
METEOR SHOWERS

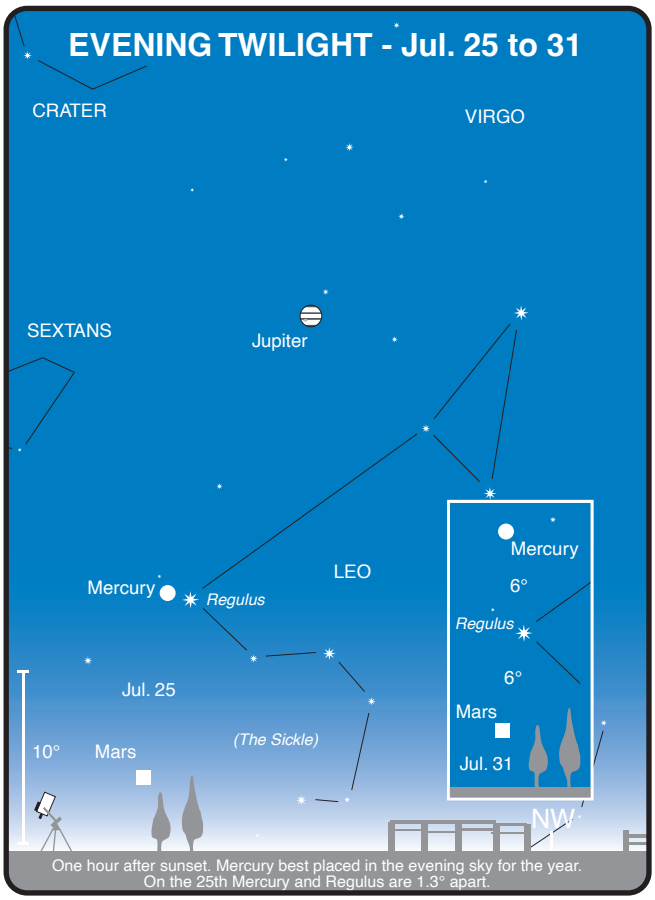
The **Phoenicids** (**July**) are a Southern Hemisphere shower and are best seen after midnight when the radiant is at its highest altitude. The Phoenicids are active from the 10th to 16th, with maximum on the 13th. Activity is variable, but zenith hourly rates of 3-10 have been recorded, although in more recent years the rate has been less than 4 per hour.

DIARY

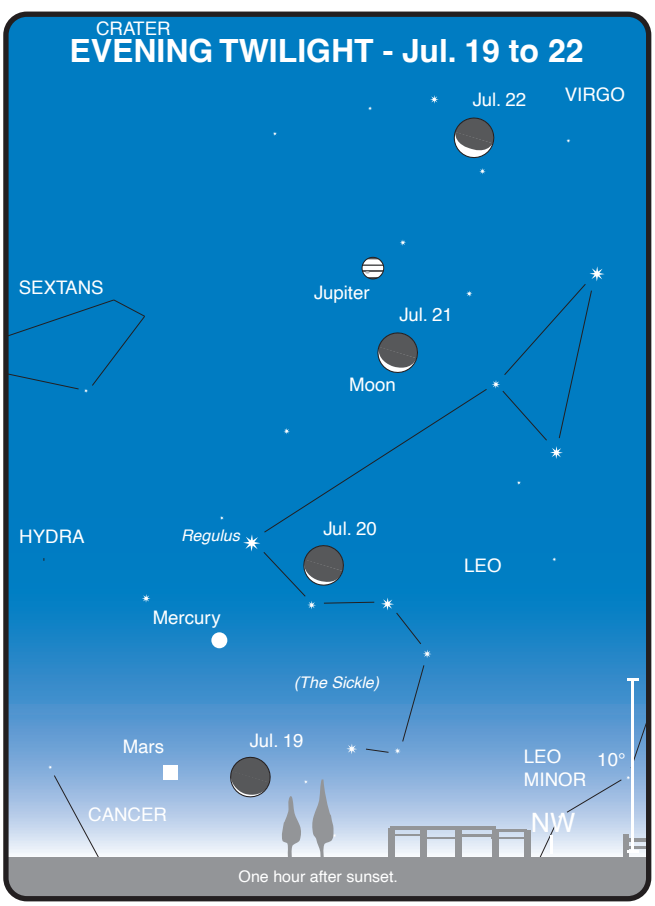
1st	6 am	(4 am WST) m.p. 2 Pallas in conjunction with Sun
1st		Mars at greatest latitude North
1st	9 pm	(7 pm WST) Mercury 5°S of star Pollux
2nd	9 am	(7 am WST) Moon at perigee
2nd	9 pm	(7 pm WST) Full Moon
2nd	pm	m.p. 5 Astraea 0.8°NE of NGC 5427 (SG) in Virgo
2nd	11 pm	(9 pm WST) m.p. 5 Astraea 0.1°SW of NGC 5468 (SG) in Virgo
4th	8 pm	(6 pm WST) Venus 1.1°N of star Aldebaran
5th	1 am	(11 pm WST, prev day) Neptune 5°N of Moon
5th		Venus 1.1°N of star Aldebaran
5th		Mars 0.3°S of Beehive Cluster (M44) in Cancer
5th	9 pm	(7 pm WST) Earth at aphelion
6th		Comet 88P/Howell 0.7°NW of NGC 676 (SG) in Pisces
6th	1 pm	(11 am WST) Uranus 4°N of Moon
8th		Mercury 0.7°W of Beehive Cluster (M44) in Cancer
8th	pm	m.p. 3 Juno 0.4°S of star Lambda Aquilae
9th	3 am	(1 am WST) Saturn in conjunction with Sun
9th		m.p. 2 Pallas 0.5°S of NGC 2301 (OC) in Monoceros
9th	2 pm	(Noon WST) m.p. 3 Juno at opposition
9th	6 pm	(4 pm WST) Last Quarter Moon
11th	9 am	(7 am WST) Mercury 0.2°N of Mars
12th		Venus at aphelion
14th		m.p. 8 Flora 0.3°SW of star Delta Tauri
14th	10 am	(8 am WST) Venus 8°S of Moon
15th	7 am	(5 am WST) Moon at apogee
15th		m.p. 4 Vesta 0.1°E of m.p. 9 Metis
15th		m.p. 40 Harmonia 0.7°SE of NGC 474 (LG) in Pisces
15th	11 am	(9 am WST) Venus Greatest brilliancy
15th	pm	m.p. 11 Parthenope 1.0°N of star Pi Sagittarii
17th	9 pm	(7 pm WST) New Moon
18th		m.p. 192 Nausikaa is on the Pleiades in Taurus (0.2°NE of the star Electra)
19th	Noon	(10 am WST) Mars 4°S of Moon
20th	1 am	(11 pm WST, prev day) Mercury 5°S of Moon
20th		m.p. 8 Flora 1.5°N of star Aldebaran
20th		Mercury at descending node
21st	11 pm	(9 pm WST) Jupiter 3°S of Moon
24th		m.p. 8 Flora 0.9°S of NGC 1647 (OC) in Taurus
25th	2 pm	(Noon WST) First Quarter Moon
26th	10 am	(8 am WST) Mercury 1.5°S of star Regulus
26th	11 pm	(9 pm WST) m.p. 3 Juno 0.1°N of M11 (OC) in Scutum
27th	1 pm	(11 am WST) Mercury greatest elongation East (27°)
28th		m.p. 1 Ceres 1.1°SW of star Gamma Leonis
28th	pm	Comet C/2003 K4 (LINEAR) 0.4°N of NGC 5466 (GC) in Bootes
30th	4 pm	(2 pm WST) Moon at perigee
31st		Mercury at aphelion

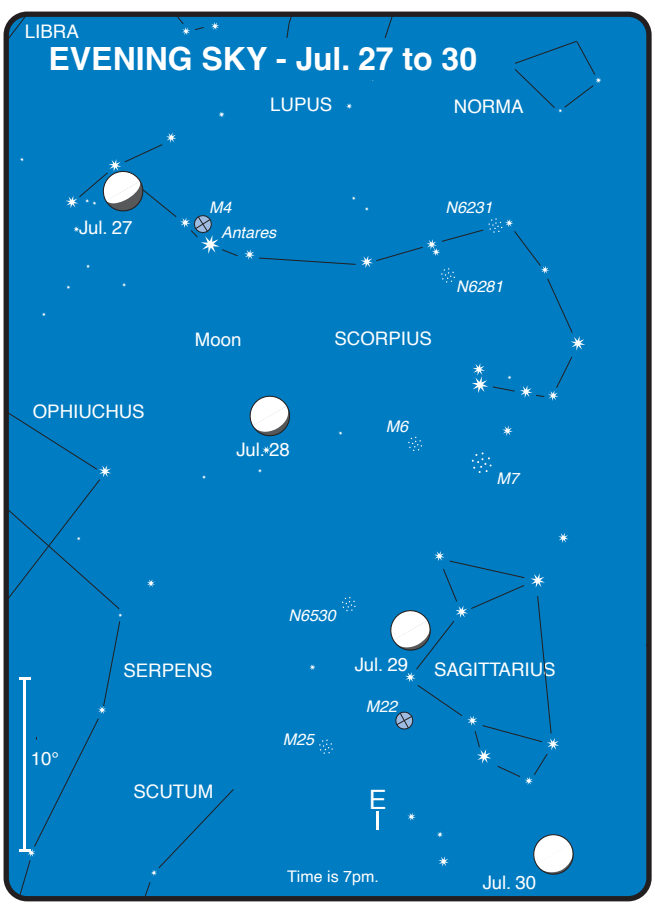






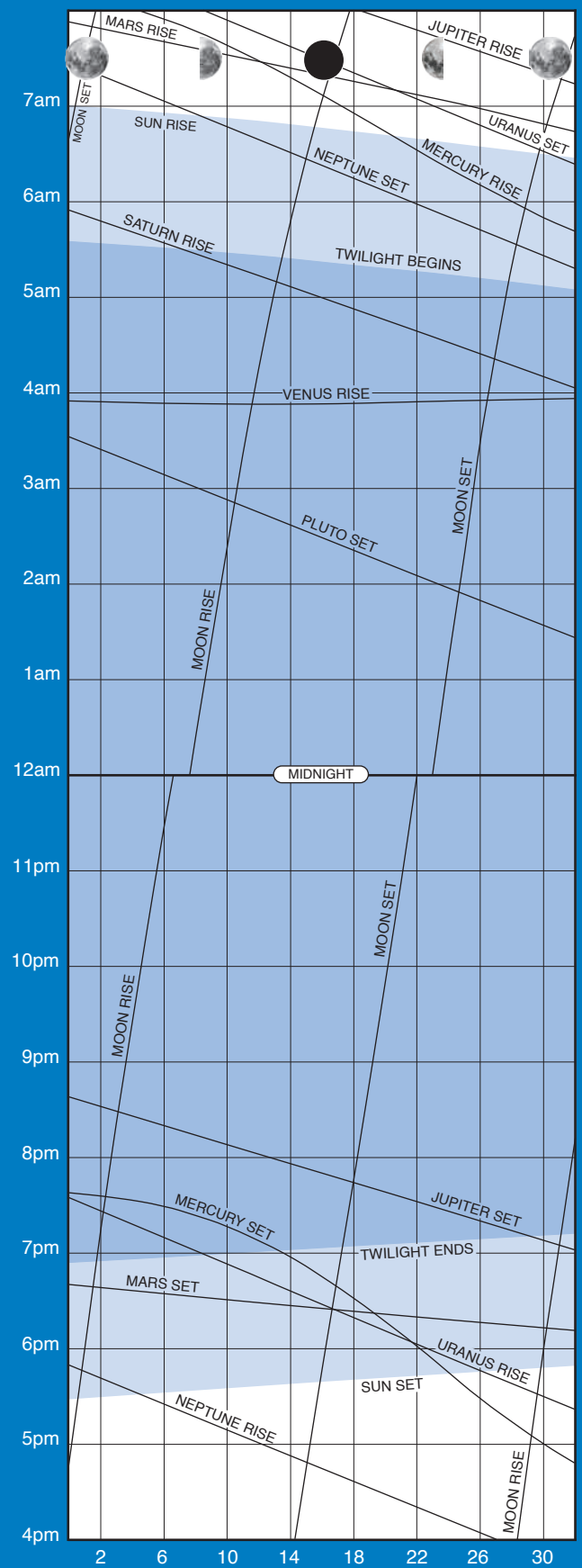
Approximate local standard time.





AUGUST

RISE/SET CHART



Approximate local standard time.

HIGHLIGHTS

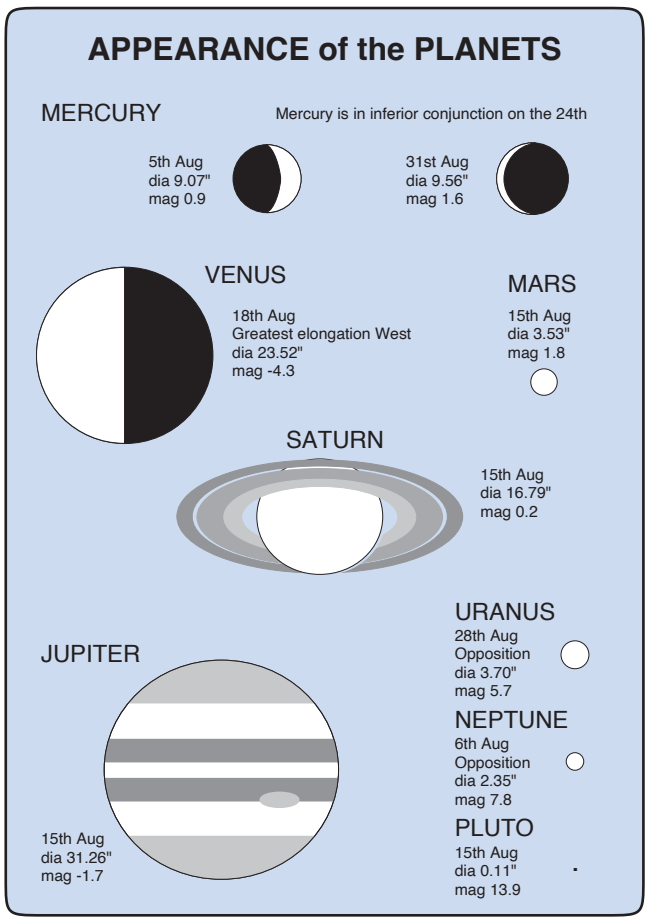
- Mercury favourable for observation in the evening early in the month
- Venus at greatest elongation west
- Venus and Saturn close in the morning sky
- Earth transits the Sun (for Neptunian observers)
- Uranus at opposition
- Neptune at opposition

THE MOON

This month features a 'Blue Moon' (see article on next page for explanation)

1st	Full Moon
8th	Last Quarter
11th	Moon at apogee (furthest from Earth – 405,292 km distant, angular size 29.0')
16th	New Moon
23rd	First Quarter
27th	Moon at perigee (closest to Earth – 365,105 km distant, angular size 32.9')
30th	Full Moon, Blue Moon

APPEARANCE of the PLANETS



THE PLANETS

MERCURY begins the month midway between Mars and Jupiter in Leo, and is very favourable for observation during the first half of August (see Sky View). In the month's second half the planet will be too close to the Sun for observation, with inferior conjunction (between Earth and the Sun) occurring on the 24th.

VENUS, at its greatest elongation (46°) west of the Sun on the 18th, shines brilliantly high in the pre-dawn morning sky. It moves from Taurus, into Orion and finally across to Gemini for the final two weeks of August. On its journey across Gemini, Venus heads in the direction of Saturn and at month's end the pair are 2° apart. At this time, both planets are also close to the planetary nebula NGC 2392 (the Eskimo or Clown Face Nebula).

MARS succumbs to the western evening twilight sky in August, and by month's end the planet will be too close to the Sun for observation.

JUPITER in Leo since July last year, moves into Virgo late in the month. The planet is visible in the early western evening sky, but its low altitude will generally rule out telescope observation. On the 18th, Jupiter and the 2-day old thin crescent Moon will be quite close (see Sky View).

SATURN makes its debut in the eastern morning sky this month, rising above and south of the stars Castor and Pollux, shortly before dawn. On the 31st, Saturn will be 2° from Venus, with Venus at this time 40 times brighter than the ringed planet (see September Sky View).

URANUS and **NEPTUNE** are both at opposition this month (28th and 6th respectively). There is a special treat for any Neptunians that may be looking our way on the 6th; they will witness a transit of the Earth and Moon across the face of the Sun. This rare series of transits began in 2000, and will continue at each opposition until the year 2006.

PLUTO, now two months past opposition, transits the meridian around 7.30pm (mid-month).

MINOR PLANETS at opposition this month include 16 Psyche on the 4th at magnitude 9.3 in Capricornus and 41 Daphne on the 8th at magnitude 10.7 in Aquarius.

BLUE MOON

In August we have two Full Moons, one on the 1st and the other on the 30th. People in other parts of the world may already have had their pair of Full Moons last month; it all depends on your local clock. For some strange reason the second of a pair of Full Moons that occur in the same calendar month has become known as a *blue moon*. This calendar meaning of the term does not, as one would imagine, go back into ancient folklore, but more on that later.

What does the term *blue moon* conjure up in your mind; a song crooned by Elvis Presley, a symbol of sadness and loneliness, a cocktail of Curacao and gin, the Moon's colour or an expression rating something as rare.

The earliest known reference to a blue moon goes back to the sixteenth century, when somebody penned the lines in quaint Elizabethan English: 'Yf they saye the mone is belewe, We must believe it is true'. A year later in 1529, another writer came back with: 'they woulde make men beleue … that ye Moone is made of grene cheese'. A bit of fun between satirists perhaps. In essence by saying that the Moon was blue or was made of green cheese was an obvious absurdity, akin to our more modern saying 'he would argue that black is white'.

When the Indonesian volcano Krakatoa erupted in 1883, blue and green Suns and Moons were seen for some time in many tropical countries. Dust from large sandstorms, smoke from forest fires, atmospheric ice crystals and even industrial pollution can also turn the Moon blue. If the particles in the atmosphere are large enough (around 0.85 microns) light is scattered in such a way as to turn the Sun and Moon blue or green. It is from infrequent conditions like these that the expression 'once in a blue moon' probably evolved, implying a fairly rare event.

For a long time the term blue moon was a colloquial expression meaning infrequent. Somehow it developed a formal calendrical meaning, and nobody really knows why or when. The first known reference to a calendar blue moon comes from an obscure American farmers calendar, the Maine Farmer's Almanac of 1937. The blue moon mentioned here was a seasonal one, as distinct from the second Full Moon in a given month. Each season had three full moons, each clearly defined by name, Harvest Moon, Hunter's Moon etc. According to the almanac, when a fourth Full Moon happened in a season, it was called a blue moon.

It was briefly noted in Sky & Telescope magazine in 1943 as a quiz question, the reference source being the 1937 Maine almanac. In 1980 Deborah Byrd mentioned the term on her national radio program *Star Date*, her source being S&T magazine. *The Kid's World Almanac (of Records and Facts)* of 1985 mentioned the expression, and perhaps the biggest boost was its inclusion as a question in Trivial Pursuit in the following year. Under Science and Nature, the question 'What's a second full moon in a month called', the answer of course being 'A blue moon'. If you had any difficulty with that one, on the same card is the question 'what country would you be in if you wiled away the time playing a didgeridoo in Wagga Wagga'.

In 1988, when a second Full Moon fell in May, newspapers and radio stations across the United States carried the blue moon story describing it as old folklore. This recent calendrical meaning to the blue moon seemed to capture the public imagination (at least in the United States), but like an urban myth out of control, it gained momentum and now we are stuck with it.

Is the calendar blue moon at all rare? Not really, as the lunar month is 29.53 days in length and the average month 30.44 days we often find that a month can have two lunar phases. From this year to the year 2020, there are 28 instances where a month has more than one phase, and 8 of these are Full or blue moons. February is the only month that cannot accommodate a blue moon, it being shorter than the lunar cycle.

The astonishing rise to prominence from a minor reference in an obscure and very localised publication is at best weird. I guess it could only happen *once in a blue moon*.

COMETS

Comet C/2002 T7 (LINEAR) moves closer to the solar glare this month. Perhaps fading from 9th to 10th magnitude, LINEAR will be moving through Sextans and Crater, and may be lost from sight by month's end.

Comet C/2003 K4 (LINEAR) is an early evening object in August, possibly at 8th magnitude. It is moving southwest through Bootes, Coma Berenices, and Virgo, and ends the month near the Virgo cluster of galaxies.

Comet 78P/Gehrels 2 should brighten from 13th to 12th magnitude this month. Moving slowly through Aries, Gehrels 2 will be rising around the middle of the night and is best observed in the morning.

METEOR SHOWERS

The **Perseids** unfortunately are not easily observable for most southern observers, for many the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17th July through to 24th August, with maximum on the 12th. The zenith hourly rate is variable and has in the past been exceptional, over 400 in 1991/1992, and down to 100 – 120 by the late 1990s. Since 2000, the peak has failed to appear; this was not unanticipated as the parent comet 109P/Swift-Tuttle passed perihelion in 1992 and is now moving back into the outer Solar System. There are predictions however that the peak may return in 2004.

The **Piscis Austrinids** and **Aquarid/Capricornid Complex** are both conglomerates of many individual meteor showers. In 2004, only two of the less active are favourable moon-wise, and are summarised below.

The **Northern delta-Aquarids** are active from 15th July to 25th August and a maximum activity on the 8th with a zenith hourly rate of 4.

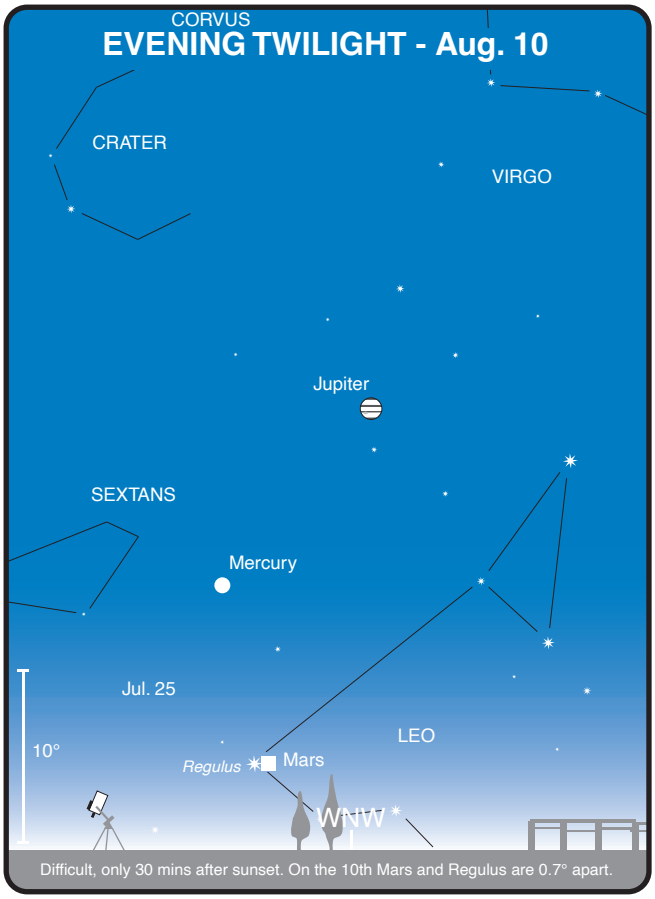
The **Northern iota-Aquarids** are active for the period of 11th to 31st August and a maximum activity expected on the 19th with a zenith hourly rate of 3.

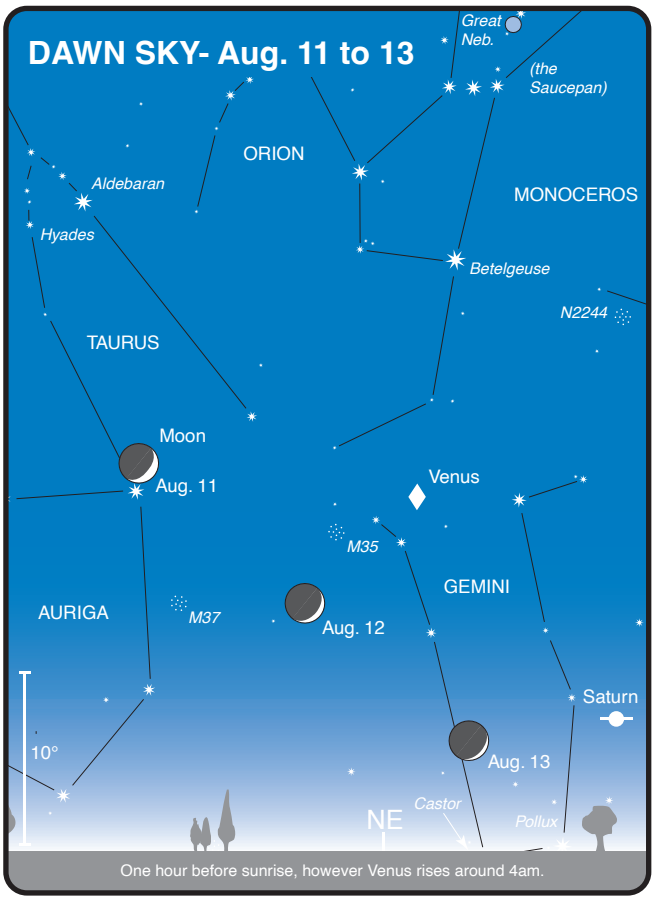
DIARY

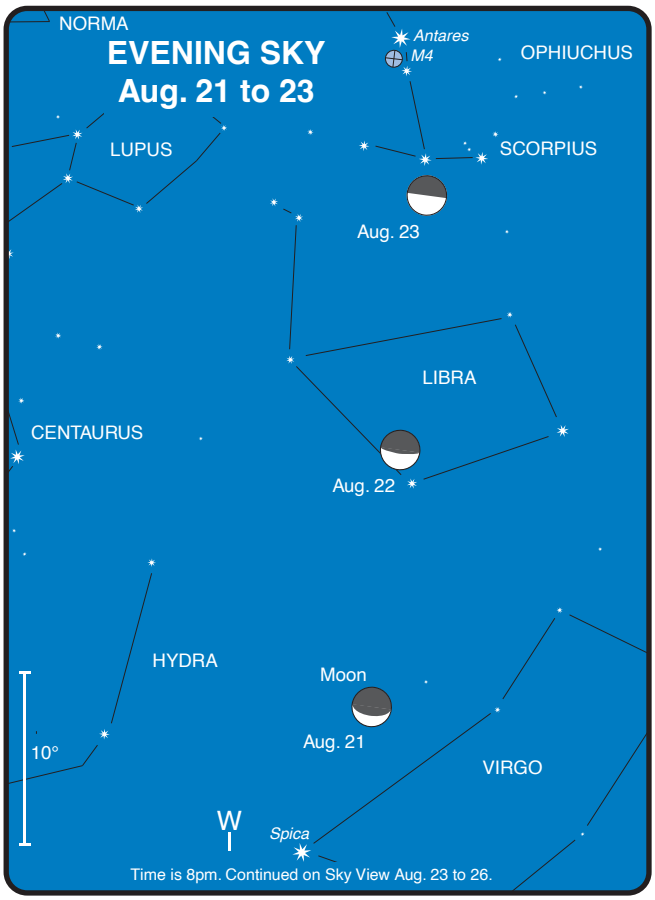
1st	4 am	(2 am WST) Full Moon
1st	10 am	(8 am WST) Neptune 5°N of Moon
2nd	3 am	(1 am WST) m.p. 4 Vesta stationary
2nd	10 pm	(8 pm WST) Uranus 4°N of Moon
3rd		Venus at greatest latitude South
6th	1 pm	(11 am WST) Neptune at opposition
7th		Mars at aphelion
8th	8 am	(6 am WST) Last Quarter Moon
9th	3 pm	(1 pm WST) Mercury stationary
11th	8 pm	(6 pm WST) Moon at apogee
12th	9 am	(7 am WST) Venus 8°S of Moon
13th	7 pm	(5 pm WST) Saturn 5°S of Moon
16th	11 am	(9 am WST) New Moon
17th	1 pm	(11 am WST) Mercury 6°S of Mars
18th	5 am	(3 am WST) Venus greatest elongation West (46°)
18th	3 pm	(1 pm WST) Jupiter 3°S of Moon
19th	11 pm	(9 pm WST) m.p. 3 Juno 0.3°SE of NGC 6664 (OC) in Scutum
20th		m.p. 532 Herculina 1.0°N of star Gamma Geminorum
20th		Mercury at greatest latitude South
23rd		m.p. 7 Iris 0.1°E of NGC 4504 (SG) in Virgo
23rd		m.p. 7 Iris 0.6°NE of NGC 4487 (SG) in Virgo
23rd	8 pm	(6 pm WST) First Quarter Moon
24th	7 am	(5 am WST) Mercury in inferior conjunction
27th		Saturn 0.2°S of NGC 2420 (OC) in Gemini
27th	4 pm	(2 pm WST) Moon at perigee
28th	5 am	(3 am WST) Uranus at opposition
28th	7 pm	(5 pm WST) Neptune 5°N of Moon
30th	6 am	(4 am WST) Uranus 4°N of Moon
30th		m.p. 8 Flora 0.8°S of NGC 2175 (OC) in Orion
30th	Noon	(10 am WST) Full Moon
31st		m.p. 192 Nausikaa 1.0°N of star Beta Tauri
31st	Midnight	(10 pm WST) m.p. 3 Juno stationary

Southern Cross and Pointers

Crux and the Pointers are in August starting to go down in the southwest evening sky. The photograph shows the distinctive Coal Sack nebula to the lower left of Crux. This dark nebula, sitting in front of the bright band of the Milky Way, is the head in the aboriginal 'constellation' of the Emu. North is towards the top of the page.







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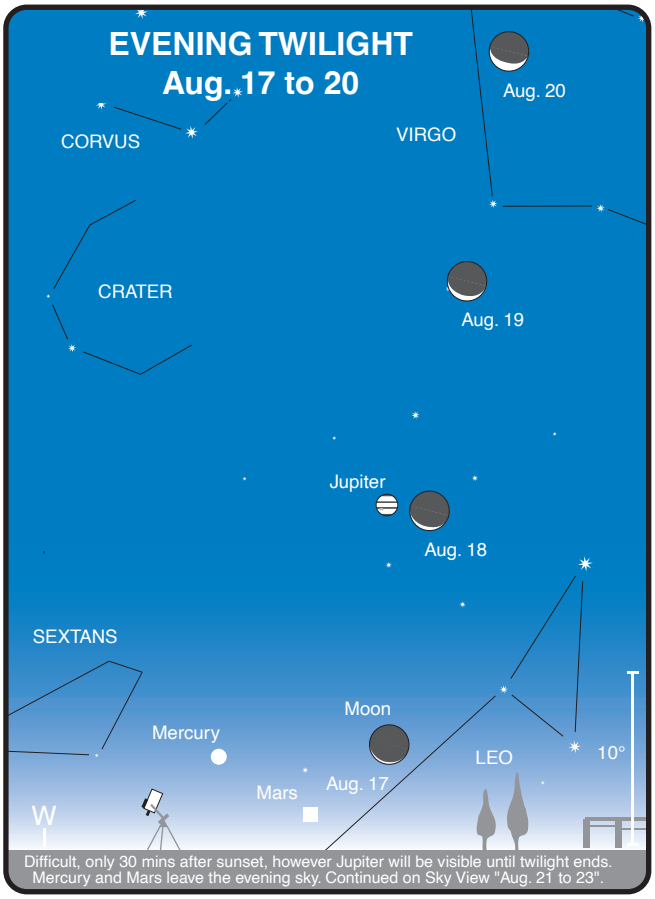
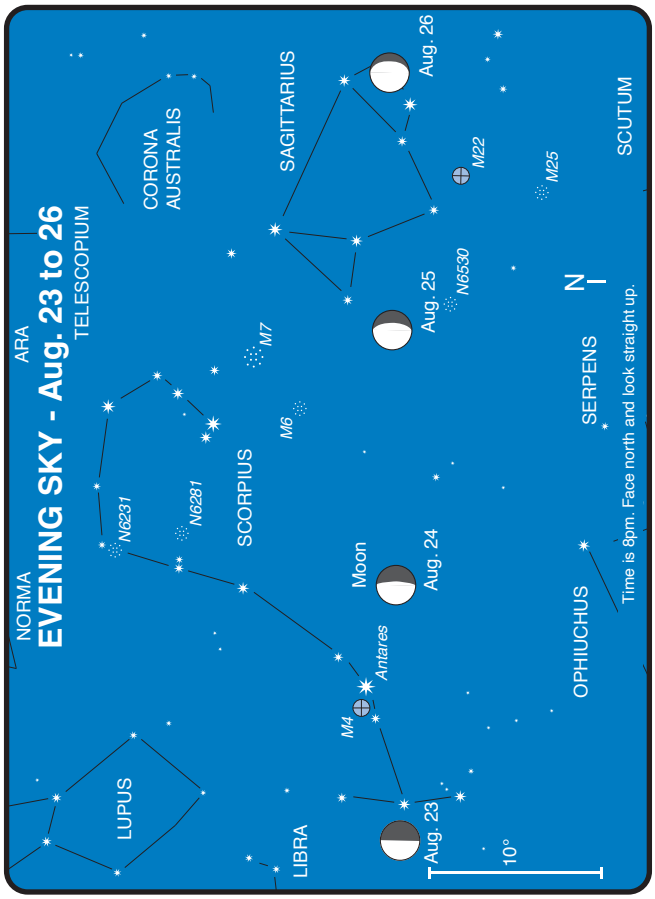
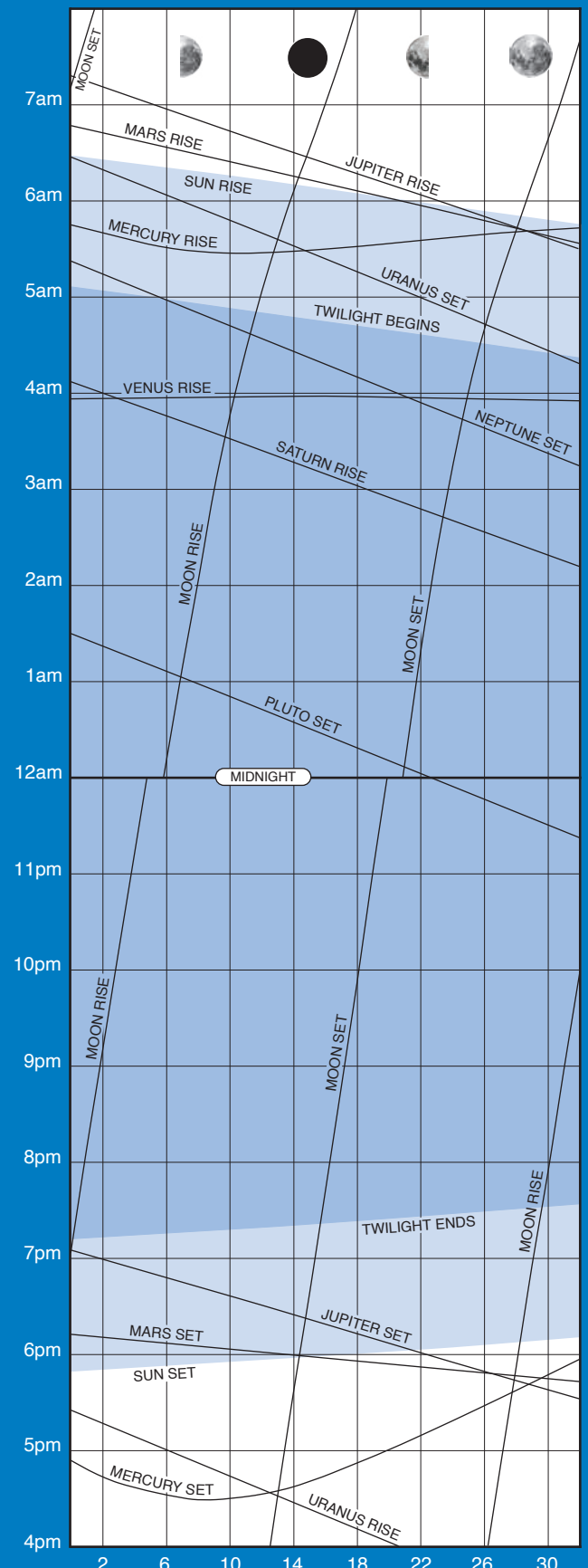




SEPTEMBER

RISE/SET CHART



Approximate local standard time.

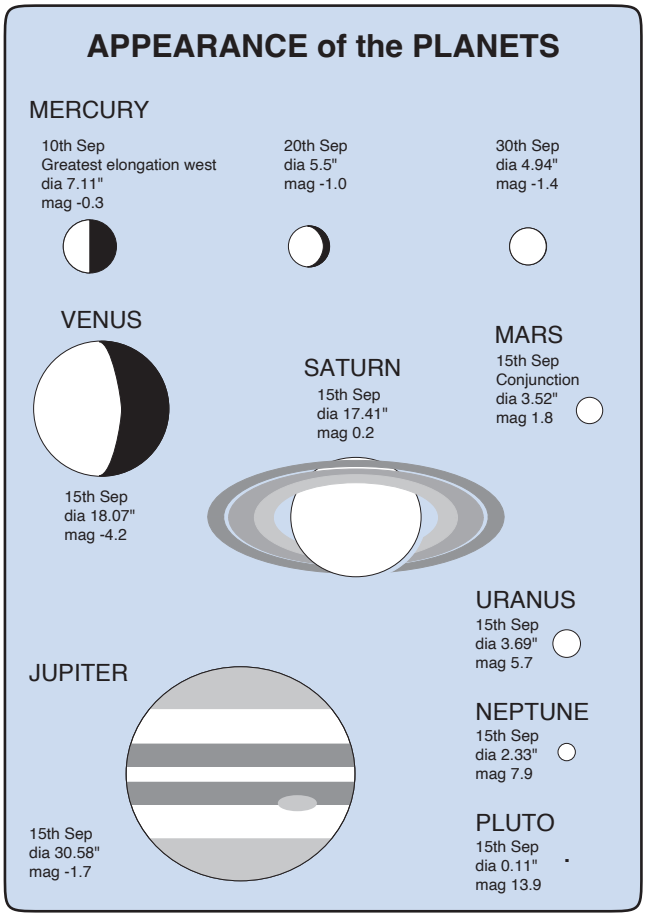
HIGHLIGHTS

- Venus and Saturn close in morning sky
- Venus and Regulus close

THE MOON

7th	(6th WST) Last Quarter
8th	Moon at apogee (furthest from Earth – 404,464 km distant, angular size 29.4')
15th	(14th WST) New Moon
22nd	(21st WST) First Quarter
23rd	Moon at perigee (closest to Earth – 369,589 km distant, angular size 31.7')
28th	Full Moon

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is at its greatest elongation west of the Sun on the 9th, but the angular distance of 18˚ does not make for a good elongation with the Sun rising 3/4 hour after the planet. Due to the high eccentricity of Mercury's orbit, the angular distance from the Sun at an elongation can be as close as 18˚ or as far as 27˚. A more favourable period for observation occurs in November when Mercury is in the evening sky. As the Sky View shows, Mercury and the 1st magnitude star Regulus are close in the dawn sky on the 10th. Unobservable, but of interest is that later in the day the two will be just 4 arc minutes apart. The next similar event occurs in July 2036, and an actual occultation will happen in August 2253.

THE APOLLO LEGACY

At the time of publication NASA was suffering the backlash of a damaging report on the outcome of the investigation into the loss of a second shuttle. Recommendations like scrapping the existing space shuttle fleet, if acted upon, would be a near fatal blow to the American manned space programme. NASA has nothing that can replace the shuttle at least in the medium term. This has serious potential fallout considering the ultimate fate of the current space telescope, and to a lesser extent the ISS (International Space Station) is based upon servicing by the shuttle. Fortunately, there is a reliable fleet of rockets that have been used successfully for solar system probes, such as those mentioned on page 21. So unmanned exploration should continue as is.

The loss of the astronauts was not only felt deeply within the NASA and scientific communities but has left some people wondering about whether it is worth the risk. At this low point it is difficult to remember the wonderful legacy that NASA has left the world – the Apollo Programme. It is now more than 30 years since Eugene Cernan left the last human foot prints on the Moon. Unfortunately, for today's young enthusiasts, this is just history. They didn't have the thrill of gazing in awe at the poor television image of Armstrong taking that historic step, live. It is little wonder we now have the urban myths materialising like it was all a hoax or the Americans just went to the Moon to prove to the Russians, once and for all, who was the most technologically superior country in the world.

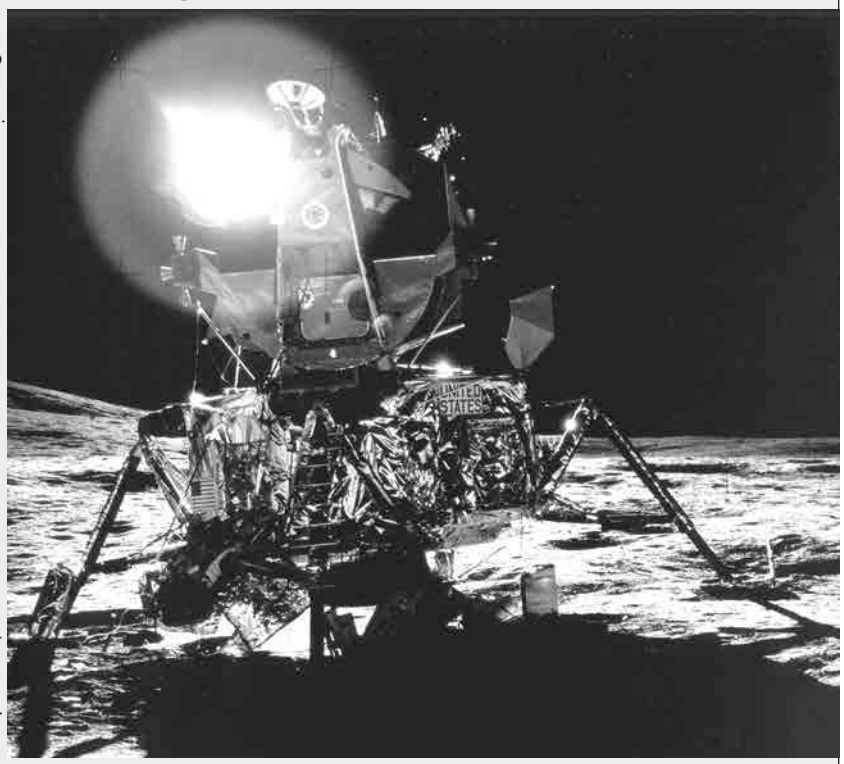
The hoax rumours would be laughable if it wasn't for the fact that so many people have taken them seriously. The TV programme 60 Minutes certainly did NASA no favours by giving the conspiracy theorists air-time. It must have been a 'no news' week! These guys must have watched the movie Capricorn One too many times. At the time of Apollo there were tens of thousands of people involved all over the world. A good number of these were closely monitoring the signals and tracking the spacecraft such as the Australian scientists working at the Parkes Radio Telescope in NSW. To pull off such a deception would have been nearly impossible or would have been a conspiracy of monumental proportions. Also the cover-up would have to be continued today by the current generation of scientists who still delicately dissect and study the returned Moon rocks. These geologically unique samples were all hand-selected, and in many cases their terrains photographically documented, by the Moon walkers.

Although there is some merit in the comment that the programme was just another cog in the American cold war propaganda machine, this very much undersells the contributions that were made to engineering developments and the quantum leap in the understanding of the Moon's geology. Apollo finally answered questions such as why the grey coloured smooth, sometimes featureless, 'seas' are so distinctive compared to the rest of the mountainous, crater-infested surface. There is no doubt that volcanic activity filled in many of these low lying plains judging from the variety of basalts returned from these 'mare'. The debate over whether the origin of the lunar craters was meteoritic or volcanic was finally resolved — there is evidence for both.

The political side did made one very significant contribution. Considering how primitive the technology was (by today's standards), it was amazing what NASA could achieve when given a blank cheque. One can only wonder whether many of the errors, blamed on NASA management for the recent shuttle disasters, would have been there if not for continual budget cuts.

Once the politically driven Apollo 11 ('One small step for man, one giant leap for mankind') landing was out of the way, NASA got down to some serious scientific work. It might also come as a surprise to some how extensive the program was. There were six successful moon landings plus the famous failed attempt — see the movie Apollo 13 if you wish to know more. Twelve men spent over 160 hours on the surface. During fourteen separate excursions (extravehicular activities or EVAs) they traversed 94 kilometres of the lunar landscape, helped in the last three missions by the 2-man lunar rover vehicle. Over 400 kilograms of rocks and soil were returned, including core samples of the lunar crust. A number of surface experiments were conducted as well as scientific instruments left on the surface such as seismometers and the Lunar Ranging Experiments. Earth bound observatories still bounce lasers off these special arrays of glass prisms to determine the distance to the Moon to within a few centimetres. (Here's some more conspirators for you, all the observatories that have taken part in this experiment!) The landing sites were quite diverse, from the lowland 'mare', like Apollo 11's Sea of Tranquility, to the rugged lunar highlands such as Apollo 17's Taurus-Littrow landing site.

In closing, we shouldn't forget the intangible contribution Apollo made to the human spirit — the need for adventure. These highly skilled test pilots and scientists were bringing to life Buck Rogers and the writings of Jules Verne. It is unfortunate that the scientific work carried out in recent years in Earth orbit doesn't fire the imagination as the voyages to the Moon did. Like James Cook discovering the east coast of Australia, they were true pioneers, knowing and accepting the high risks. Dangers will always be present with space travel, no matter how complacent we become.



The Lunar Module Antares at Fra Mauro (Apollo 14).

VENUS, rising 1 hour before dawn, appears 2° above Saturn in the eastern sky in Gemini at the start of the month (see Sky View). The planets quickly separate and Venus crosses over to Cancer and finally into Leo. On the 14th, Venus passes 3° above M44, the Beehive Cluster (see Sky View); being close to the ecliptic this famous open cluster regularly has planets paying a visit. After the M44 encounter, Venus makes a beeline (pardon the pun) for the brightest of Leo's stars, 1st magnitude Regulus. At the end of September the planet and star will be 4.3° apart, and a great deal closer early next month.

The **EARTH** is at its vernal (spring) equinox on the 23rd. The Sun rises and sets due east and west and day and night are equal.

MARS is totally out of action for observing over the next few months, eventually returning to our morning sky in December. On the 15th, the Red Planet will be in conjunction with the Sun. Of interest but unobservable (as the Sun will be just 5° away) is the close proximity of Mars, Mercury and Jupiter on the 29th, as all these planets fit in a circle less than 1° in diameter.

JUPITER can be seen early in the month in the western evening twilight, setting about an hour after the Sun. On the 22nd, the planet will be in conjunction with the Sun, reappearing in the morning twilight in late October.

SATURN in the morning eastern sky, in Gemini, begins the month 2° from Venus (see Sky View). On the 10th, the 25-day old crescent Moon (just over a degree above Pollux) will be near and north of Saturn (see Sky View).

URANUS in Aquarius and **NEPTUNE** in Capricornus are both now just past opposition and are visible for most of the night.

PLUTO, in the evening sky in Serpens, sets around midnight and is only available to keen observers with large telescopes (see finder chart on page 125).

MINOR PLANETS. Two of the brighter minor planets reach opposition this month in Aquarius. They are 4 Vesta on the 13th at magnitude 6.1 and 9 Metis on the 14th at magnitude 9.1.

COMETS

Comet C/2003 K4 (LINEAR) will be lost from view after mid-month when it becomes immersed in the evening twilight. In the first half of September, LINEAR will be in Virgo, near 3rd magnitude Delta Virginis, and perhaps brighter than 8th magnitude.

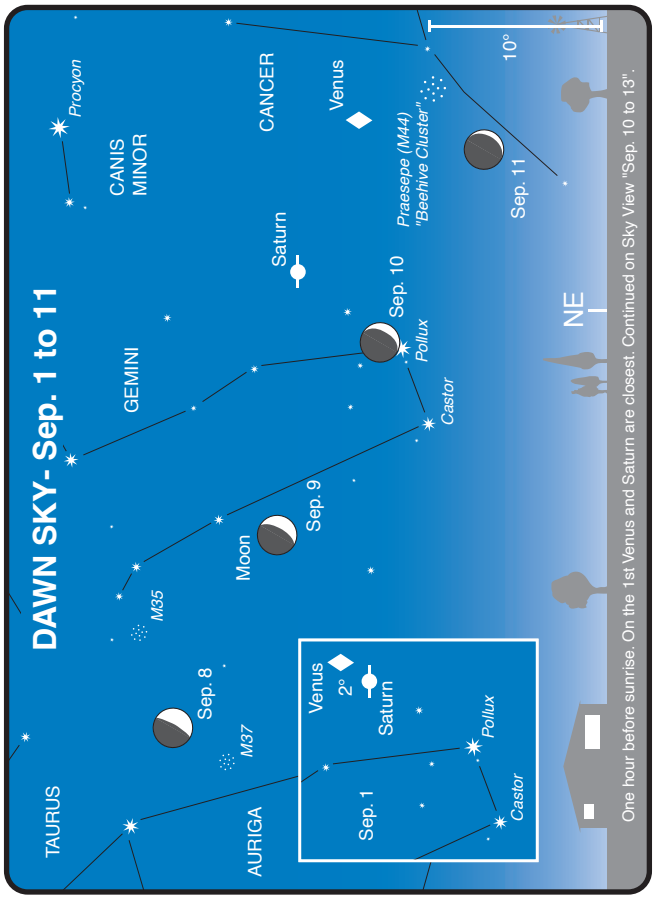
Comet 78P/Gehrels 2 is rising late in the evening in Aries, and should brighten from 12th to 11th magnitude.

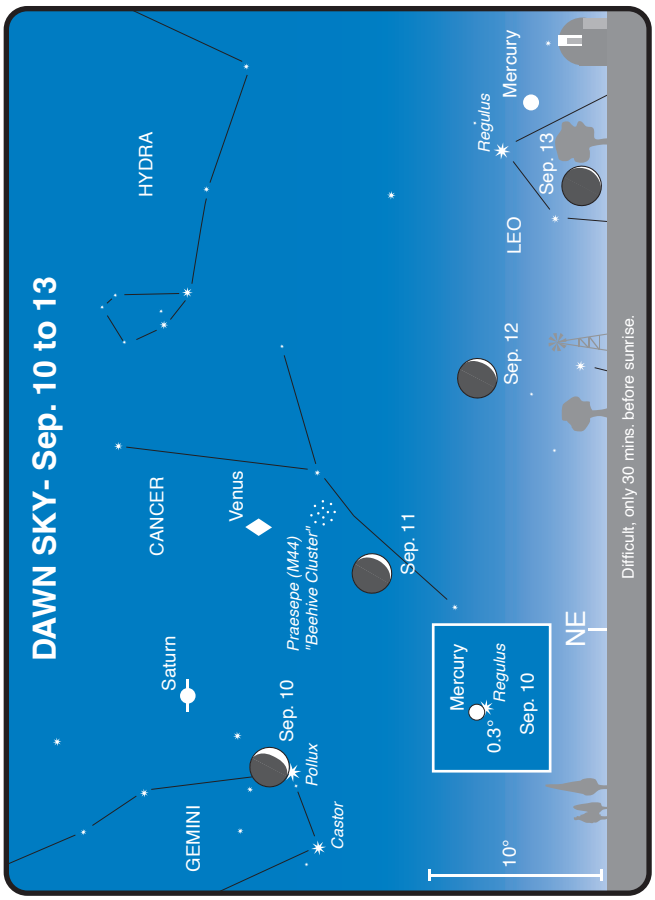
METEOR SHOWERS

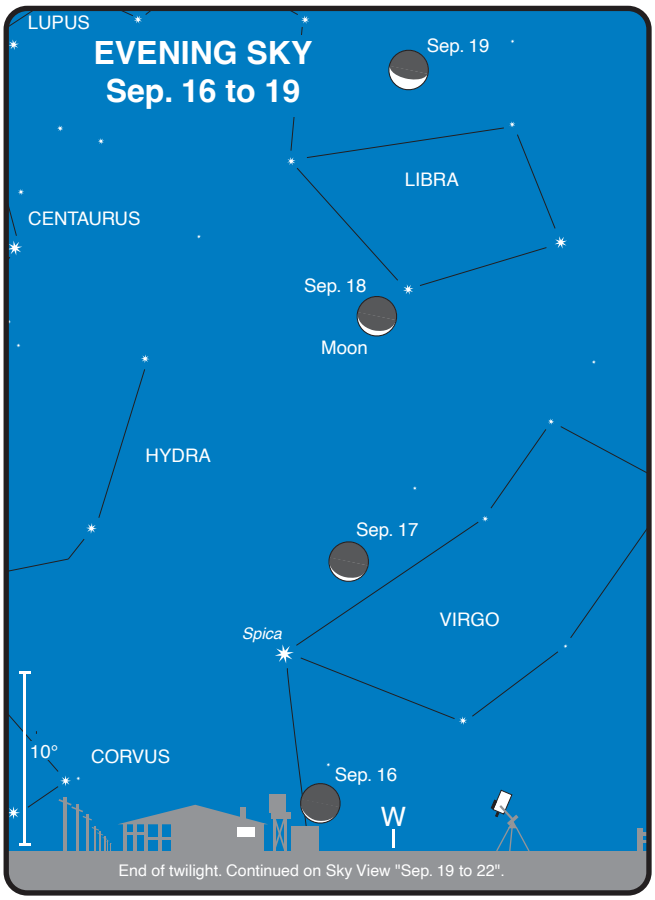
The **Piscids** are a minor shower that little is known about. They are active from 1st to 30th September, maximum is on the 19th and we can expect a zenith hourly rate of 3.

DIARY

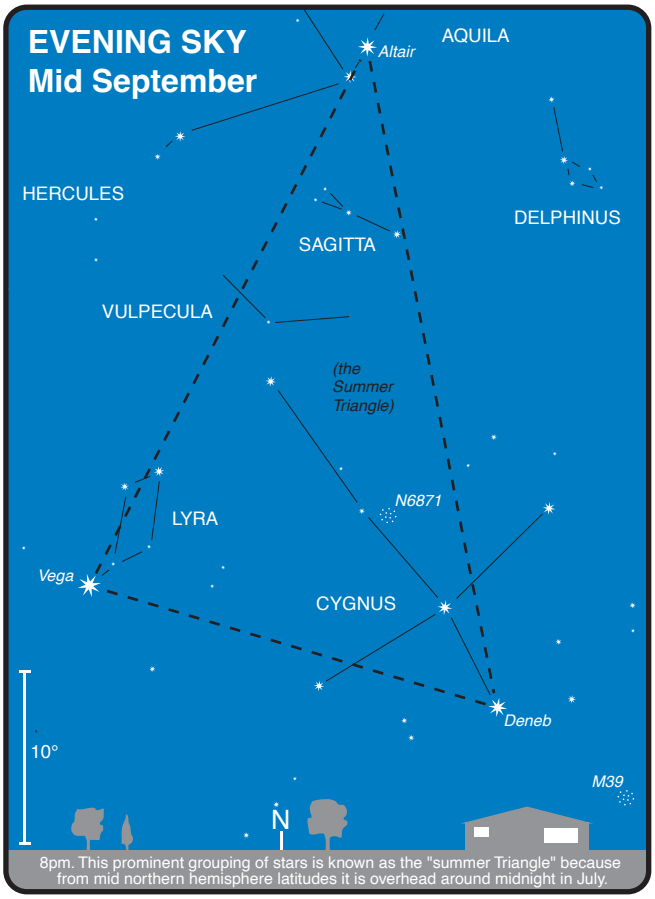
1st	3 am	(1 am WST) Pluto stationary
1st		m.p. 532 Herculina 0.6°S of NGC 2304 (OC) in Gemini
1st	11 am	(9 am WST) Venus 1.9°S of Saturn
2nd	4 am	(2 am WST) Mercury stationary
2nd	Noon	(10 am WST) Venus 9°S of star Pollux
4th		m.p. 7 Iris 0.4°S of NGC 4699 (SG) in Virgo
4th	pm	m.p. 324 Bamberga 1.6°SW of m.p. 387 Aquitania
4th	11 pm	(9 pm WST) m.p. 40 Harmonia 0.15°W of NGC 718 (SG) in Pisces
6th	11 pm	(9 pm WST) m.p. 3 Juno 0.3°SE of NGC 6649 (OC) in Scutum
7th	1 am	(11 pm WST, prev day) Last Quarter Moon
8th		Mercury at ascending node
8th	1 pm	(11 am WST) Moon at apogee
9th	Midnight	(10 pm WST) Mercury greatest elongation West (18°)
10th	8 am	(6 am WST) Saturn 5°S of Moon
10th	3 pm	(1 pm WST) Mercury 0.06°S of star Regulus
11th	2 am	(Midnight WST, prev day) Venus 7°S of Moon
12th	2 pm	(Noon WST) Saturn 7°S of star Pollux
13th		Mercury at perihelion
13th	11 am	(9 am WST) Mercury 4°S of Moon
13th	3 pm	(1 pm WST) m.p. 1 Ceres in conjunction with Sun
13th	5 pm	(3 pm WST) m.p. 4 Vesta at opposition
14th	Midnight	(10 pm WST) New Moon
15th		m.p. 7 Iris 0.2°S of NGC 4939 (SG) in Virgo
15th	11 pm	(9 pm WST) Mars in conjunction with Sun
18th	11 pm	(9 pm WST) m.p. 9 Metis 0.3°SE of NGC 7727 (SG) in Aquarius
20th	11 pm	(9 pm WST) m.p. 9 Metis 0.3°N of NGC 7723 (SG) in Aquarius
21st		m.p. 8 Flora 1.1°N of NGC 2304 (OC) in Gemini
21st		Comet C/2003 K4 (LINEAR) 0.3°SE of NGC 4753 (SG) in Virgo
22nd	2 am	(Midnight WST, prev day) First Quarter Moon
22nd		m.p. 20 Massalia 0.5°SW of star Beta Scorpii
22nd	10 am	(8 am WST) Jupiter in conjunction with Sun
23rd	2 am	(Midnight WST, prev day) Equinox
23rd	7 am	(5 am WST) Moon at perigee
23rd		Mercury at greatest latitude North
25th	1 am	(11 pm WST, prev day) Neptune 5°N of Moon
25th		Comet C/2003 K4 (LINEAR) 0.6°E of NGC 4691 (SG) in Virgo
26th	1 pm	(11 am WST) Uranus 4°N of Moon
28th		m.p. 7 Iris 1.2°SW of star Spica
28th		Venus at ascending node
28th	11 pm	(9 pm WST) Full Moon

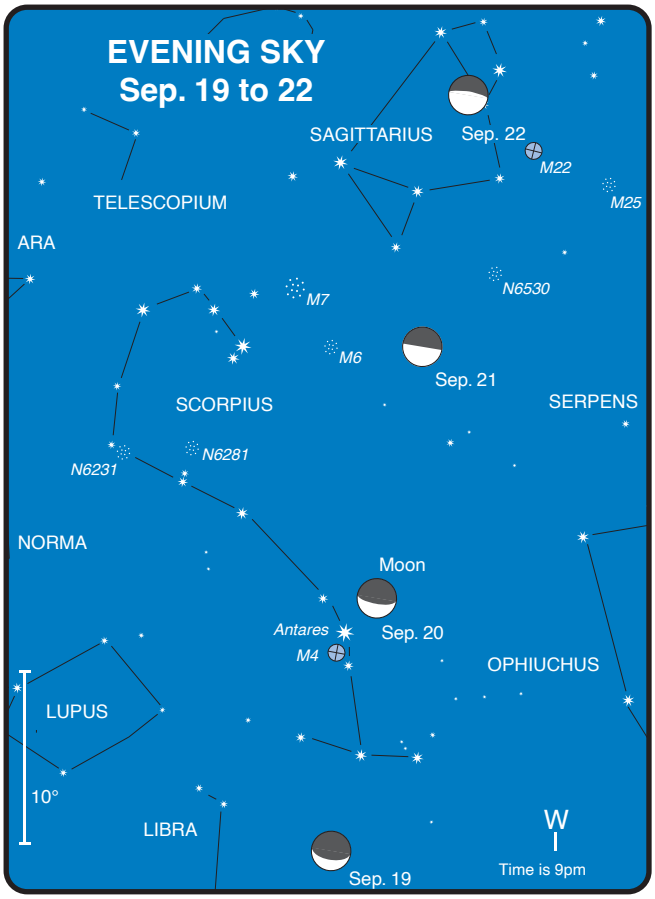






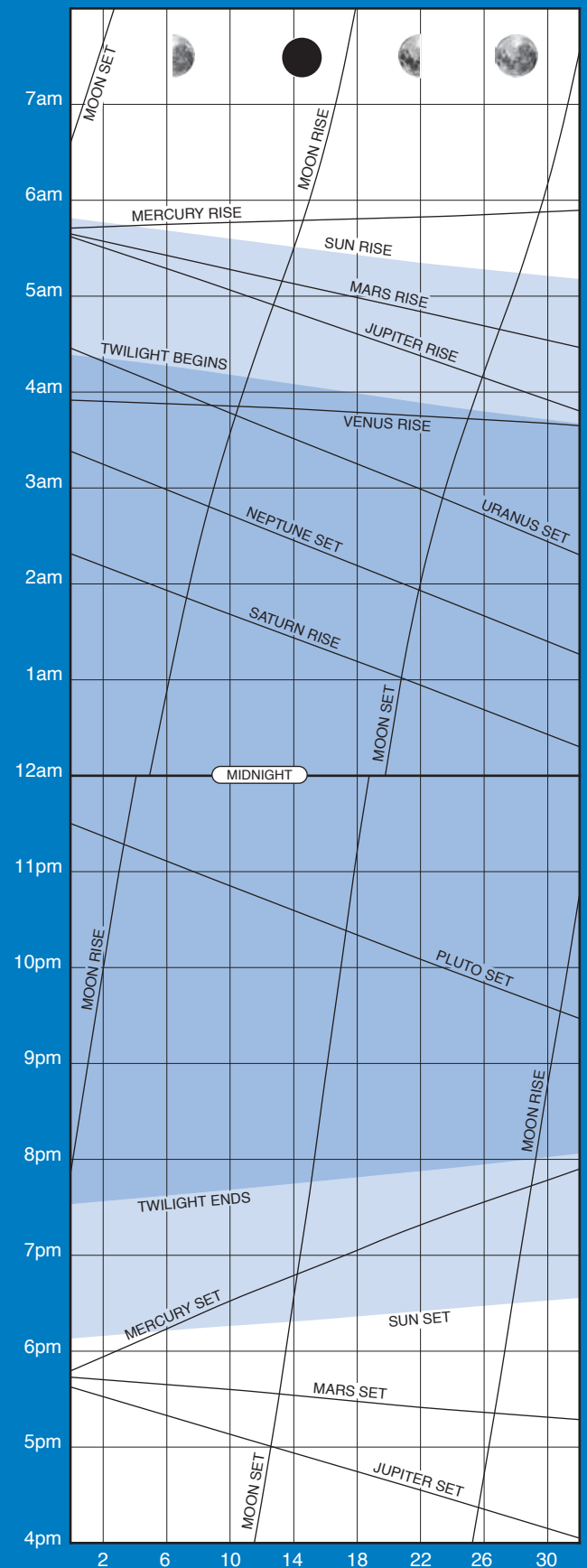
Approximate local standard time.





OCTOBER

RISE/SET CHART



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

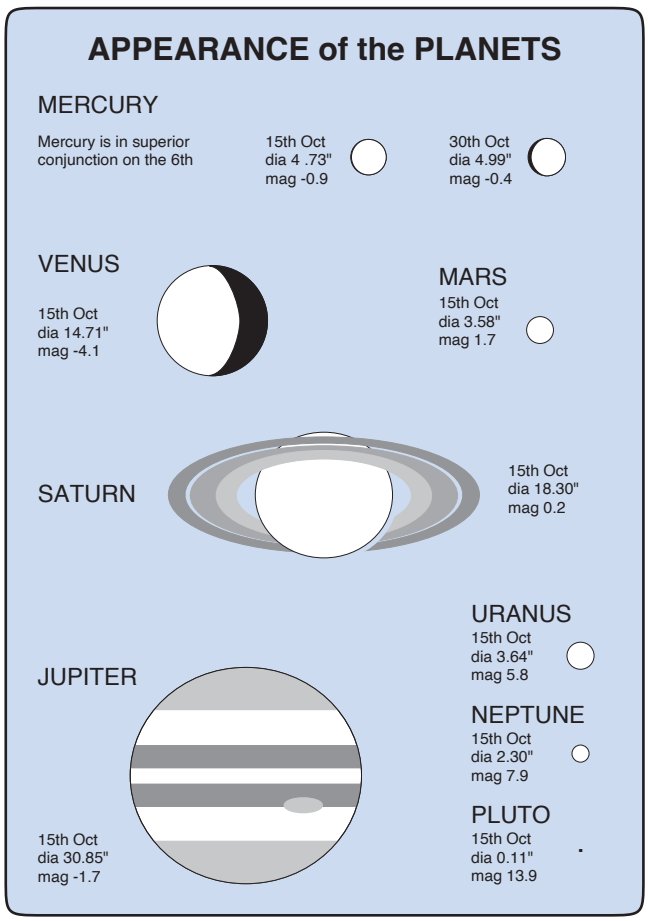
HIGHLIGHTS

- Mercury returns to the evening sky
- Venus and Regulus close
- Venus and Jupiter together in the dawn sky.

THE MOON

6th	Moon at apogee (furthest from Earth – 404,326 km distant, angular size 29.7')
6th	Last Quarter
14th	New Moon (Partial solar eclipse, not visible from Australia – see Part II)
18th	Moon at perigee (closest to Earth – 367,758 km distant, angular size 32.7')
21st	First Quarter
28th	Full Moon (Total lunar eclipse, not visible from Australia – see Part II)

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 6th, the planet then returns to the evening sky. Late in the month, after moving from Virgo into Libra, Mercury can be seen in the western twilight sky setting just over an hour after the Sun.

VENUS begins the month 3.2° from the 1st magnitude Regulus (Alpha Leonis) in the late morning eastern sky. On the 4th, the pair will be a close 0.3° apart (see Sky View). On the 11th, the 26-day old Moon will be near Venus. Jupiter rises up to meet Venus, and by month-end the two bright planets will be 5.5° apart (see Sky View).

MARS, after solar conjunction last month, is now west of the Sun in the dawn sky but lingers too close to our 'star' for observation.

JUPITER, like Mars, reappears in the morning twilight after its solar conjunction late last month. The two brightest planets, Jupiter and Venus appear around 5.5° apart on the 31st (see Sky View), and a great deal closer early in November.

SATURN in Gemini rises just ahead of the constellation's main stars, Castor and Pollux, in the early morning sky. On the 8th, the 23-day old Moon will be located below the planet, forming a triangle with Pollux (see Sky View). Incidentally, although Pollux is designated Beta Geminorum it is actually brighter than its twin, Castor or Alpha Geminorum.

URANUS and **NEPTUNE** transit the meridian early evening allowing plenty of time to locate and view these distant worlds. Now well past opposition, Neptune ends its retrograde travel this month, returning to a west/east path across the sky.

PLUTO, moving toward conjunction in mid December, sets in the evening around 10:30pm mid-month.

MINOR PLANETS at opposition this month include: 135 Hertha on the 7th at magnitude 10.1 in Pisces, 40 Harmonia on the 13th at magnitude 9.4 in Cetus, 246 Hermentaria on the 20th at magnitude 10.5 in Cetus and 128 Nemesis on the 23rd at magnitude 10.5 in Pisces.

NAKED EYE SUPERNOVAE

Four hundred years ago this month, a brilliant 'guest star', rivalling the brightness of Venus, appeared in the constellation of Ophiuchus — the last time a supernova has been seen in the Milky Way. Before you go looking for a 'Catalogue of Naked Eye Supernovae' in your local astronomy shop you need to know this club is very exclusive, having only six members!

A supernova (SN) is the most cataclysmic event in the life of a star and for a number of months can shine as bright as the sum of all the stars in its host galaxy. These cataclysmic explosions, which are thought to destroy the host star completely (or at least change it into something quite different like a pulsar or black hole), occur around once or twice in each galaxy per century (not all stars end their existence so dramatically). These events should not be confused with normal novae, which have a much lower intensity and don't lead to the star's destruction. In fact a nova can sometimes recur as the star, from time to time, blows off its outer layers as it continues to accumulate mass from a companion star. You may ask why so few supernovae have been sighted in our own galaxy, for certainly a lot more supernova remnants (gas clouds) have been found than that identified with historical sightings. This is mainly due to the high dust and gas levels in the plane of the Milky Way. The same dark clouds that shroud what should be a spectacular view of the centre of our galaxy. All of the following supernovae, except for 1987A, were stars exploding within our Milky Way and for some period were likely to be visible in daylight.

SN 1006 was in the constellation of Lupus and was discovered by the Arabs on April 30 with Japanese and Chinese observers finding it the day after. It was thought to have reached magnitude –7.5 and remained visible until sometime in 1009 AD.

SN 1054 was in Taurus and was the event that spawned the well-known Crab Nebula (M1). Chinese observers found the star in the eastern morning sky on July 4, 1054. It is thought the supernova reached –6 magnitude and was visible for 2 years.

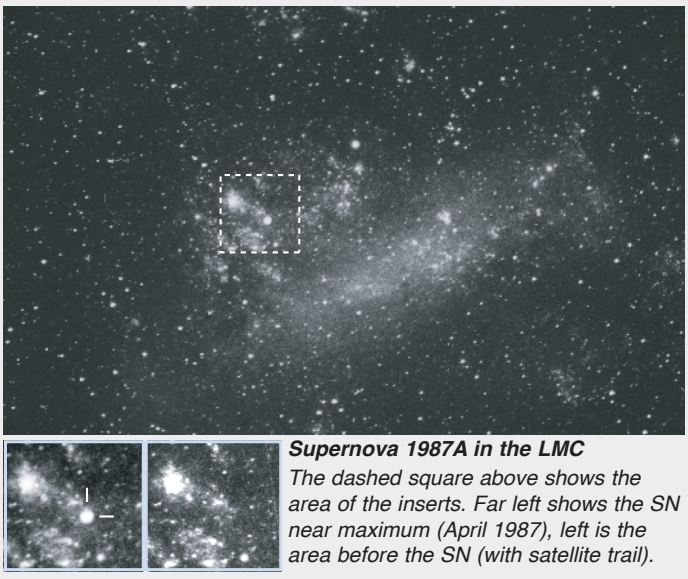
SN 1181. The Chinese and Japanese extensively observed this object in Cassiopeia. It was first seen in China on August 6, 1181 AD and remained visible for 6 months.

SN 1572, like the supernova in 1181, was also in Cassiopeia. It is often referred to as Tycho's Supernova due to Tycho Brahe's extensive observations. The Koreans compared its brilliance to Venus with it reaching –4 magnitude. It was visible for 18 months.

SN 1604 has been called Kepler's Star. During the year it was visible, Kepler, who is better known for his laws of planetary motion, kept it under close observation. It was about –4th magnitude at its brightest.

SN 1987A. This one was located in a satellite galaxy to our Milky Way, the Large Magellanic Cloud (LMC). It was discovered on the night of February 24, 1987 by Oscar Duhalde, Las Campanas Observatory (Chile), and independently by New Zealand amateur astronomer, Albert Jones. It was found at magnitude 5, after rising some 8 magnitudes in the previous 24 hours. The knowledge of this rise was due to photographic records by Sheldon (also at Las Campanas) and McNaught (Siding Spring Observatory, Australia). The supernova peaked at magnitude 2.9 and remained visible in amateur telescopes for over 2 years.

There is a lesser-known candidate that can consider itself unlucky not to make this list. On August 20, 1885, Ernest Hartwig (Tartu Observatory, Estonia) observed a 6th magnitude star-like object near the nucleus of the Andromeda Galaxy (M31). Professor L. Gully (Rouen, France) had observed the object 3 days earlier but had thought it was a defect in his new telescope! Historical records have since shown the supernova had likely peaked on the day of Gully's observation at around magnitude 5.5. This would certainly have made this 'guest star' a naked-eye object, close to the nucleus of M31, but the authors are unaware of any such observations being reported.



Supernova 1987A in the LMC
The dashed square above shows the area of the inserts. Far left shows the SN near maximum (April 1987), left is the area before the SN (with satellite trail).

COMETS

Comet C/2002 T7 (LINEAR) re-emerges in the pre-dawn sky, possibly at 11th magnitude. The comet will be moving southeast through Crater, and perhaps fading to 12th magnitude by month's end.

Comet C/2003 K4 (LINEAR) emerges from the solar glare in late October as a pre-dawn sight in Corvus, possibly at 7th magnitude. It reaches perihelion this month.

Comet 62P/Tsuchinshan 1 is a morning object in October. By month's end, when it is in the constellation of Cancer, it should have brightened to 13th magnitude.

Comet 78P/Gehrels 2 begins October about eight degrees southwest of M45 (the Pleiades). Rising mid-evening, 11th magnitude Gehrels 2 moves along the border of Aries and Taurus and is at perihelion in late October.

METEOR SHOWERS

The **epsilon-Geminids** are a weak minor shower that is active from 14th to 27th October with maximum on the 18th, a low hourly rate of 2 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 2nd October through to 7th November. Maximum activity is on 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. They 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.

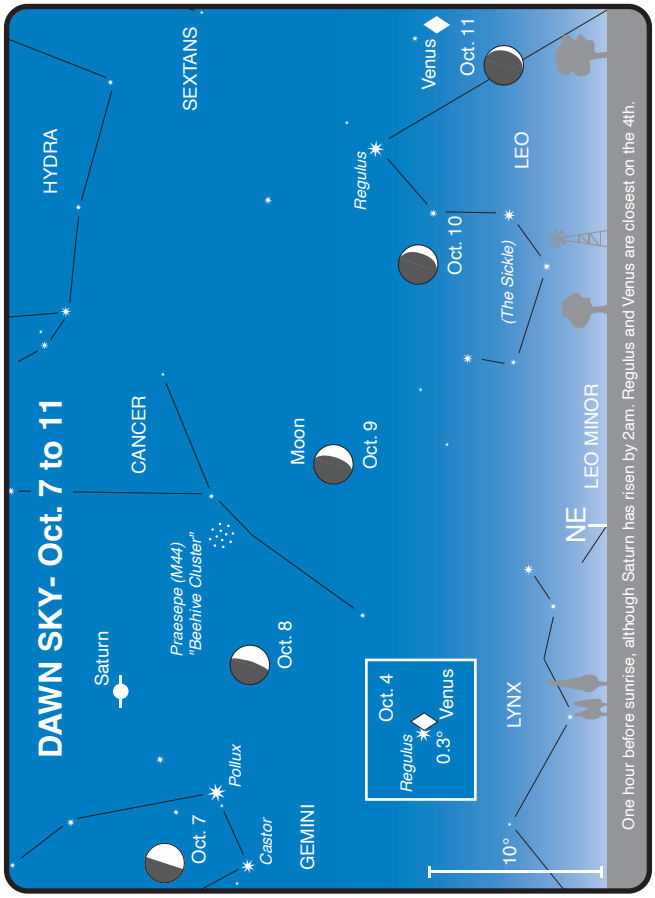
The **Taurids (North and South)** are composed of a main double radiant which is visible from 1st October through to 25th November (see next month for details).

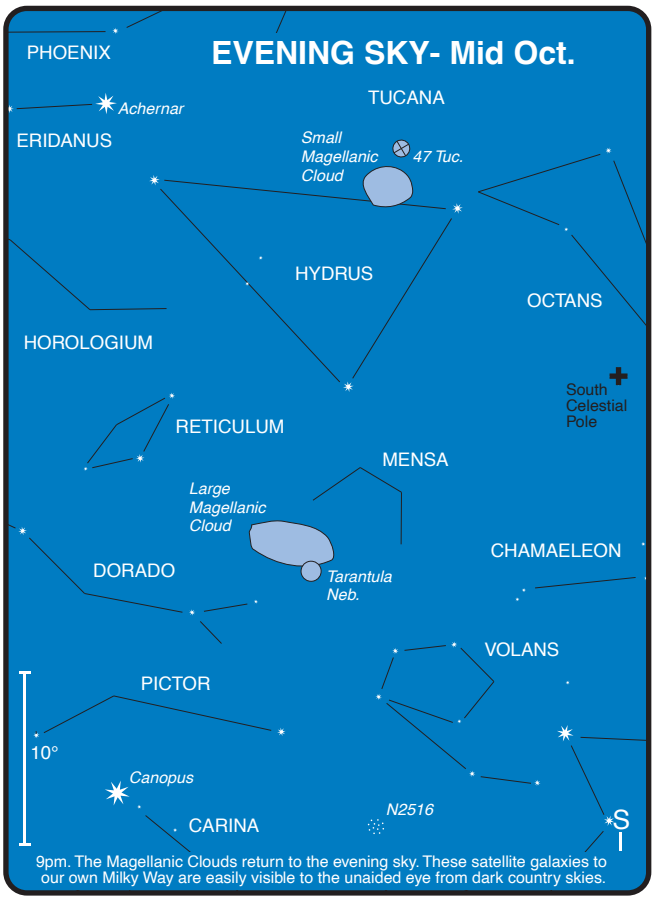
DIARY

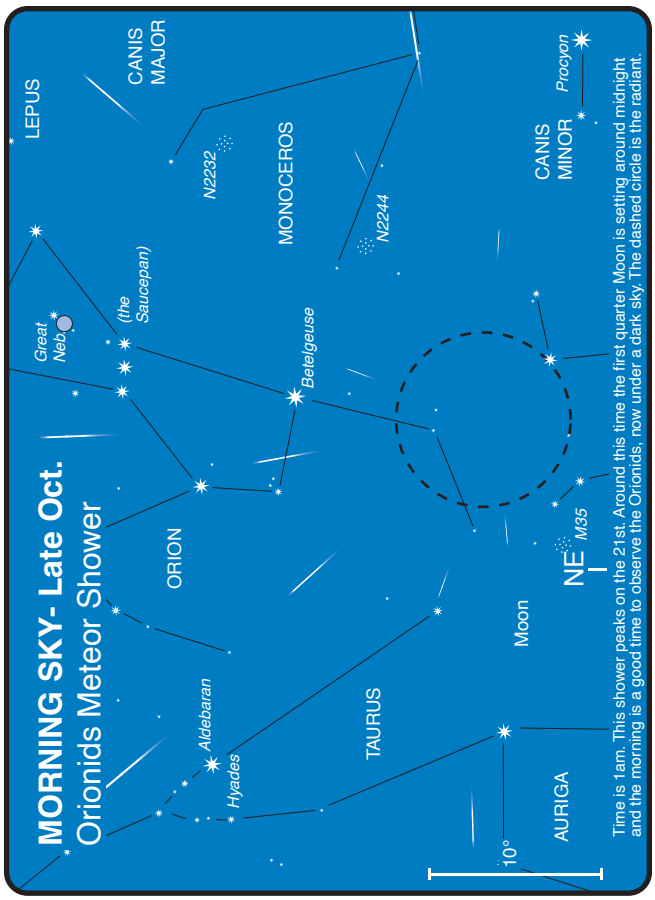
4th	2 am	(Midnight WST, prev day) Venus 0.2°S of star Regulus
6th	5 am	(3 am WST) Mercury in superior conjunction
6th	8 am	(6 am WST) Moon at apogee
6th	8 pm	(6 pm WST) Last Quarter Moon
7th	8 pm	(6 pm WST) Saturn 5°S of Moon
8th		m.p. 1 Ceres 0.4°NE of NGC 4261 (EG) in Virgo
10th		m.p. 2 Pallas 1.0°N of NGC 3115 (LG) in Sextans
11th	5 am	(3 am WST) Venus 4°S of Moon
13th	5 am	(3 am WST) Jupiter 1.6°S of Moon
14th	1 pm	(11 am WST) New Moon; eclipse
16th		Mercury at descending node
18th		Venus 0.9°S of m.p. 29 Amphitrite
18th	10 am	(8 am WST) Moon at perigee
21st	8 am	(6 am WST) First Quarter Moon
22nd	7 am	(5 am WST) Neptune 5°N of Moon
23rd	6 pm	(4 pm WST) Uranus 4°N of Moon
24th	8 pm	(6 pm WST) Neptune stationary
25th		m.p. 20 Massalia 0.2°NE of NGC 6235 (GC) in Ophiuchus
25th		Comet C/2003 K4 (LINEAR) 0.2°W of star Delta Corvi
26th	pm	m.p. 40 Harmonia 1.0°NW of NGC 428 (SG) in Cetus
27th		Mercury at aphelion
28th	1 pm	(11 am WST) Full Moon; eclipse
31st	6 pm	(4 pm WST) Mars 3°N of star Spica
31st	9 pm	(7 pm WST) m.p. 4 Vesta stationary

Orion and Barnard's Loop

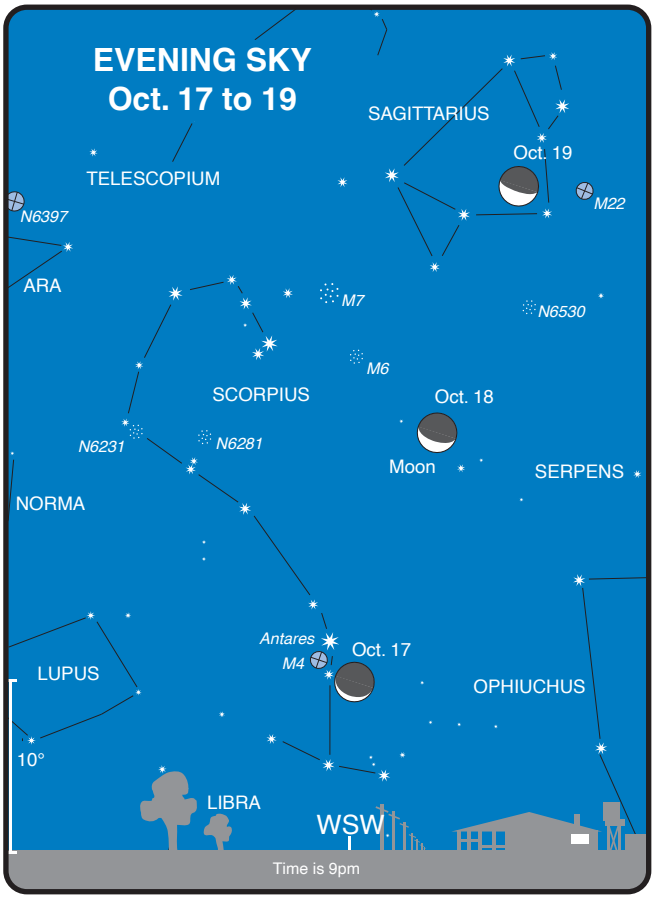
Orion is now returning to the evening sky, rising mid-month around 10pm in October. This is a wide field image using a 55mm ƒ2.8 lens on a 35mm camera using hypered Kodak 2415 film. The exposure was 10 minutes with the camera piggybacked on an equatorially tracking telescope. The red sensitivity of this film shows the very faint nebula called Barnard's Loop. South is towards the top of the page.

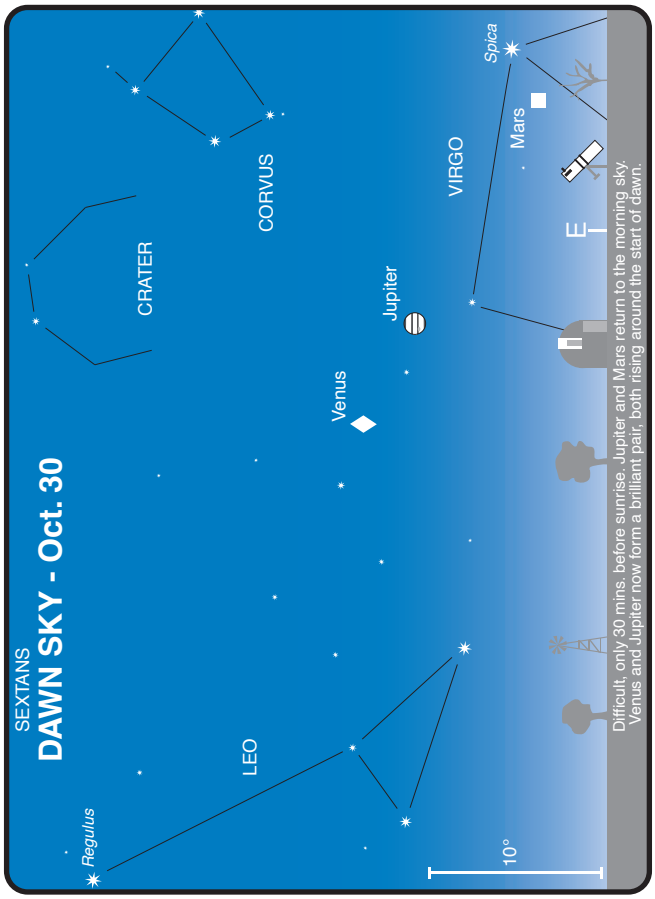






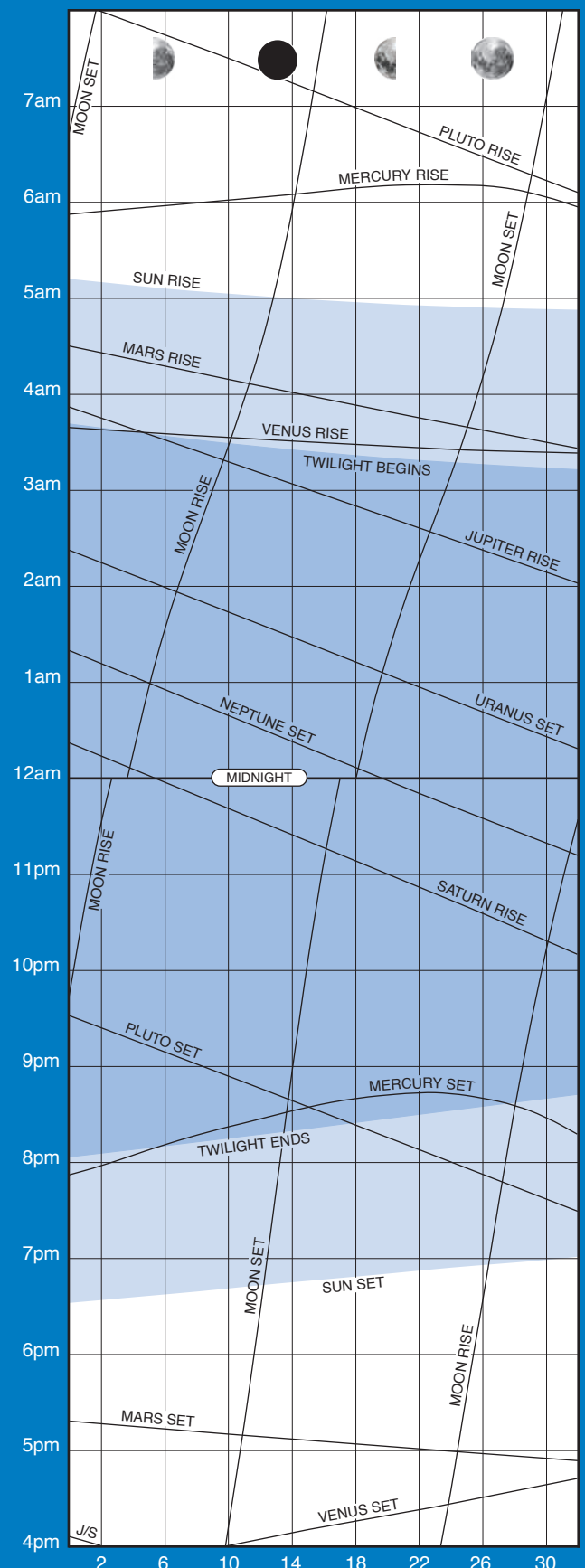
Approximate local standard time, for daylight saving add 1 hour.





NOVEMBER

RISE/SET CHART



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

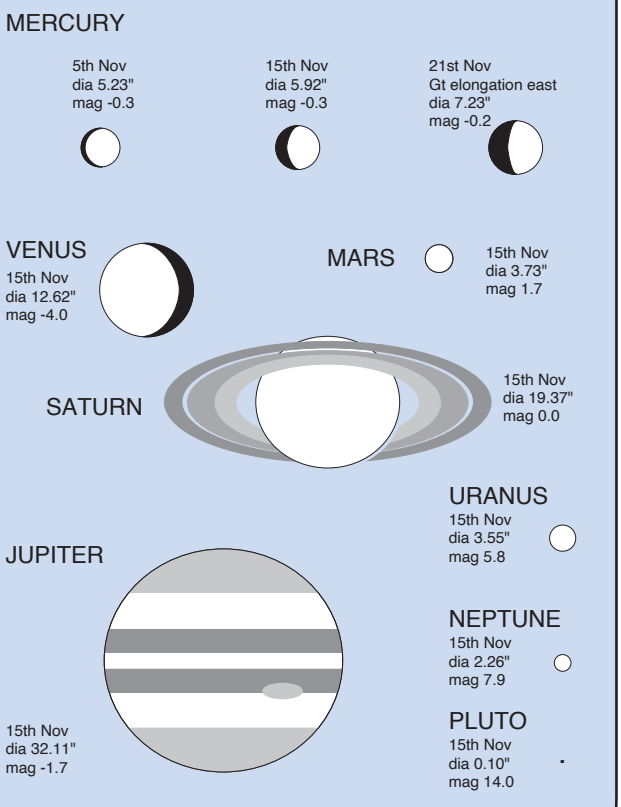
HIGHLIGHTS

- Mercury in favourable evening position for observation
- Planets Venus, Mars and Jupiter together in Virgo (plus minor planet Ceres)
- Venus and Jupiter close in the dawn sky
- Venus and Mars close at end of month
- Daytime occultation of Venus by the Moon
- Venus, Jupiter and Moon close together

THE MOON

3rd	Moon at apogee (furthest from Earth – 404,998 km distant, angular size 29.7')
5th	Last Quarter
10th	Occultation of Jupiter by the Moon (not visible from Australia)
10th	Occultation of Venus by the Moon (daylight event — visible from Australia. See Venus next page)
11th	Occultation of Mars by the Moon (daylight event — Melbourne, Tasmania and New Zealand)
13th	(12th WST) New Moon
14th	Occultation of Mercury by the Moon (only visible from Antarctica)
15th	Moon at perigee (closest to Earth – 362,311 km distant, angular size 32.7')
19th	First Quarter
27th	Full Moon
30th	Moon at apogee (furthest from Earth – 405,953 km distant, angular size 29.3')

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is in a good position to observe in the western evening sky all month. It will be at its greatest elongation east of the Sun on the 21st (22°), and although not the best of elongations, observers should have no difficulty picking out the planet in the late twilight. On the 14th, Mercury will be close and below the slender crescent of a 2-day old Moon (see Sky View). During the course of November, Mercury moves through Libra, Scorpius, Ophiuchus and finally into Sagittarius. It has various 'deep sky' encounters in these constellations (see Diary).

VENUS begins an interesting month 5.5° from Jupiter in the eastern dawn sky. By the 5th the separation of the two brightest planets (Venus –4.0 magnitude and Jupiter –1.7 at this time) decreases to a close 0.6° — an exceptional sight (see Sky View). For those patient people, an exceedingly rare event occurs when Venus actually passes in front of Jupiter in November 2065 (see Astronomy 2065 for more details). The last such occultation was in January 1818. Another exceptional sight this month is on the 10th when the 26-day old crescent Moon appears close to Venus and Jupiter (see Sky View). During the daylight Venus will be occulted by the Moon (see below and lunar occultations in Part II). On the 30th, Venus will be 3.6° from Mars, and even closer early next month.

MARS returns to the dawn sky, having been too close to the Sun for observation since late August. The planet moves from Virgo into Libra, and on the 30th will be 3.6° from Venus. There is a daylight occultation of Mars by the Moon on the afternoon of the 11th. While it is above the horizon from Melbourne, Hobart and New Zealand, the planet is too faint, too close to the Sun and unobservable. It would be an extremely dangerous exercise to attempt any observations, even scattered light in a telescope tube can cause permanent eye damage.

JUPITER is visible in the late morning sky rising a little before the beginning of twilight. Jupiter and the brighter Venus appear very close on the 5th (see Venus section and Sky View). On the 10th, the 26-day old Moon appears just below Jupiter with Venus also in the picture to the right (see Sky View).

SATURN rises in the late evening northeastern sky to the right of Castor and Pollux. On the 4th, the 21-day old waning gibbous Moon will be near the planet.

URANUS and **NEPTUNE** in Aquarius and Capricornus respectively, are high in the northwestern sky after the end of astronomical twilight. Uranus ends its retrograde travel this month, returning to a west/east path across the sky. On the 8th Neptune has a close encounter with the minor planet 16 Psyche (see diary).

PLUTO, in conjunction in early December, becomes lost in the evening twilight late in the month, returning to the morning sky in the New Year.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Aries. They are: 21 Lutetia on the 2nd at magnitude 9.8, 27 Euterpe on the 7th at magnitude 8.8 and 64 Angelina on the 10th at magnitude 10.8. 80 Sappho also reaches opposition on the 25th at magnitude 10.0 in Taurus.

On the 21st, 3 Juno, now down to 10.7 magnitude, is close to Barnard's Galaxy (NGC 6822) in Sagittarius. This presents an interesting photo opportunity and we are not necessarily referring to using telescopes either. This large irregular galaxy has the distinction of being one of the few galaxies that can be photographed with only a 50mm camera. Long exposures (in the minutes) and fast film are still required so your camera platform (telescope?) will need to be tracking the stars.

VENUS THE DAY STAR

Observing the occultation of Venus by the Moon on November 10th 2004.

Venus is commonly known as the *Morning Star* or *Evening Star*, it is the first 'star' visible after sunset or the last seen before sunrise. Blazing gloriously in the twilight, there would be few people who had not noticed Venus. It may surprise some that Venus is bright enough to be visible in the middle of the day with the unaided eye, provided you know precisely where to look.

Under normal circumstances the best time to track down Venus in daylight is at or near an elongation, when it is at its greatest angular distance from the Sun. The next elongations of the planet will be November 2005 and March 2006, however the occultation on November 10th will provide an opportunity to see Venus in the daytime. The event occurs around lunchtime for the eastern states and mid-morning for Western Australia. See the Lunar Occultation Tables in Part II for times and duration.

WARNING: exercise extreme caution when using optical instruments near the Sun. Serious eye damage will result from even a momentary glance.

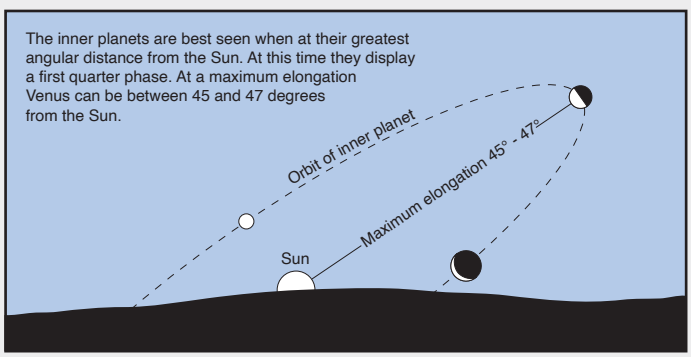
By using the Moon as a reference point, the task of finding Venus will be easier. You will need low power binoculars mounted on a tripod and focused on infinity. Located 34° west (left as you face northwest) of the Sun and at a lower altitude, the 27-day old Moon will appear as a slender crescent just 9% illuminated.

First shield the Sun with a building or wall (this should be to your right as you face northwest) and sweep the sky with the binoculars. You can use the scale on the rear cover of this book to determine the approximate offset from the Sun. The altitude of the Moon at the time will be nearly half that of the Sun. Once found you will be able to see the Moon with the unaided eye by sighting over the binocular. Having found the Moon, Venus will be just east (above right) of the crescent if you start your search a little before the occultation is due. It is amazing just how easy Venus can be seen with the unaided eye when looking directly at it.

Venus will be occulted by the sunlit lunar crescent and reappear from behind the 'dark side' sometime (about an hour) later. As the lunar limb will be invisible against the bright sky, the reappearance should prove interesting with Venus materializing in a blue sky.

If you have an equatorially mounted telescope, correctly polar aligned with setting circles, you can 'dial up' Venus. With a filter specifically made for solar viewing the Sun should be centred and the setting circles adjusted to the right ascension and declination of the Sun. Then swing the telescope until the circles match the position of Venus, take off the filter and the planet should be within a low-power eyepiece field. See Part II for the R.A. and Dec of the Sun and Venus.

Now that you have conquered Venus in the daytime, how would you like another challenge? Jupiter at the time of the occultation is about 5° west (lower left) of the Moon, try spotting it with binoculars or a telescope. Good luck!



COMETS

Comet C/2002 T7 (LINEAR) is a morning object, perhaps of 12th magnitude, moving south through Crater.

Comet C/2003 K4 (LINEAR) can initially be found rising in the morning sky in Corvus. The comet should maintain a brightness of around 7th magnitude this month as it moves southwest into Hydra and Centaurus. By month's end, it is rising well before midnight.

Comet 62P/Tsuchinshan 1 is moving eastward through the constellations of Cancer and Leo. Visible in the morning sky, the comet may be 13th magnitude in brightness.

Comet 78P/Gehrels should be 11th magnitude and moving southwest through Aries this month, visible all night.

METEOR SHOWERS

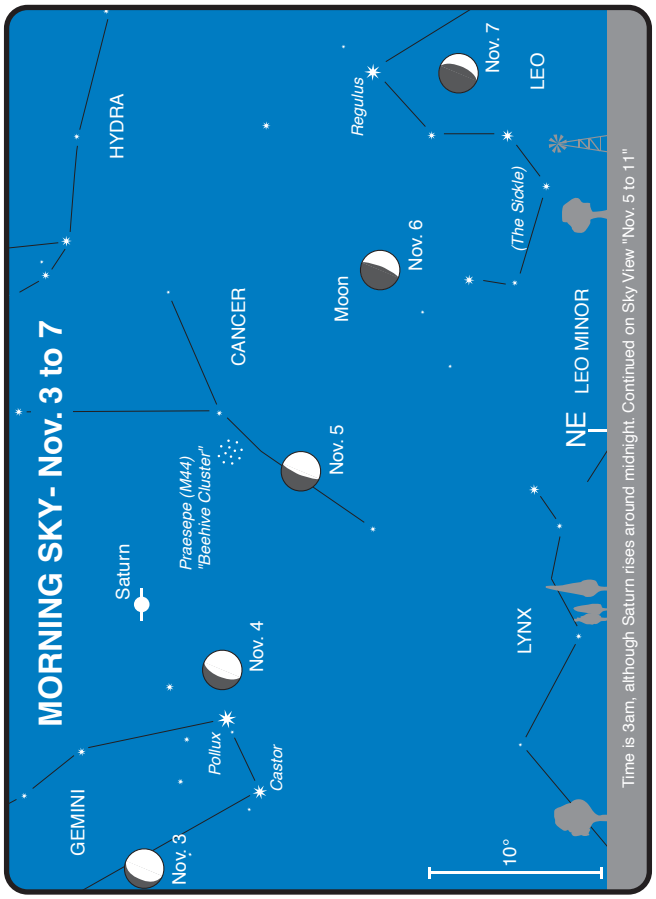
The **Taurids** (**North and South**) are associated with Comet 2P/Encke, and can be seen from late evening to early morning. The shower is composed of a main double radiant which is visible from 1st October through to 25th November. The Taurids do not have a well-defined sharp peak in activity, but rather plateau for about ten days in early November. Maxima occur on the 5th November for the Taurids South (ZHR of 5) and on the 12th November for the Taurids North (ZHR of 5). Both maxima last for about a week and provide nearly constant rates. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs. The International Meteor Organisation recommends the Taurids to newcomers as their slow speed allows them to practice their visual meteor plotting techniques. The Taurids brightness also makes them an ideal target for astrophotography.

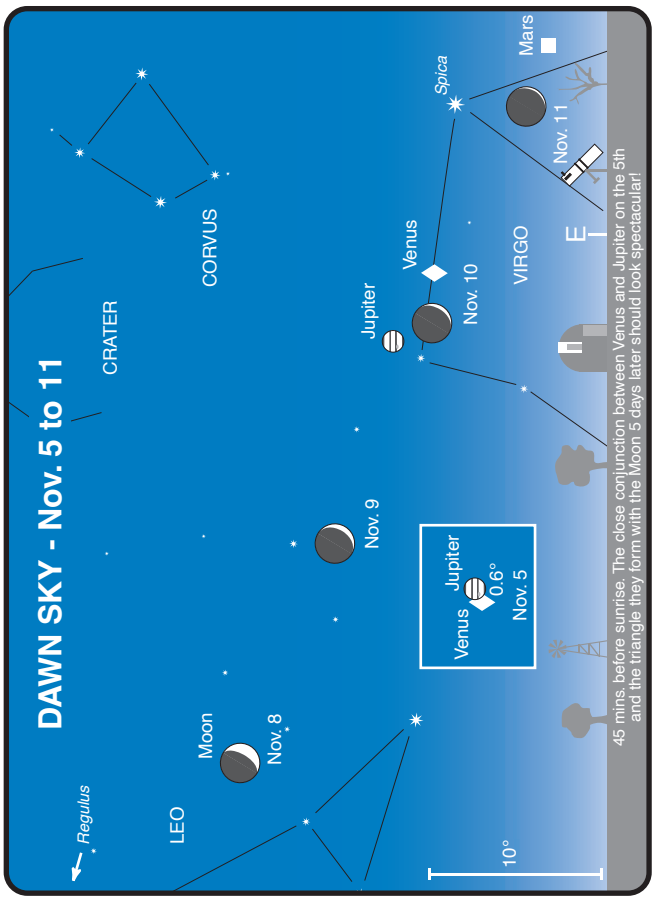
The **Leonids**, after a storm of unbelievable intensity in 1833, were responsible for the change in scientists' attitudes that meteors were not purely an atmospheric event. The shower is associated with the periodic comet 55P/Tempel-Tuttle and is best about every 33 years when the comet returns to perihelion. Between 1998 and 2002 the Leonids put on spectacular displays. Alas, predictions for this year are for a return to past zenith hourly rates around 10 to 15. They are active from 14th to 21st November, with maximum on the 17th. It will be worth watching; you never know when something unexpected will happen. The sight of a Leonid fireball coming from near the horizon and passing overhead is really something else!

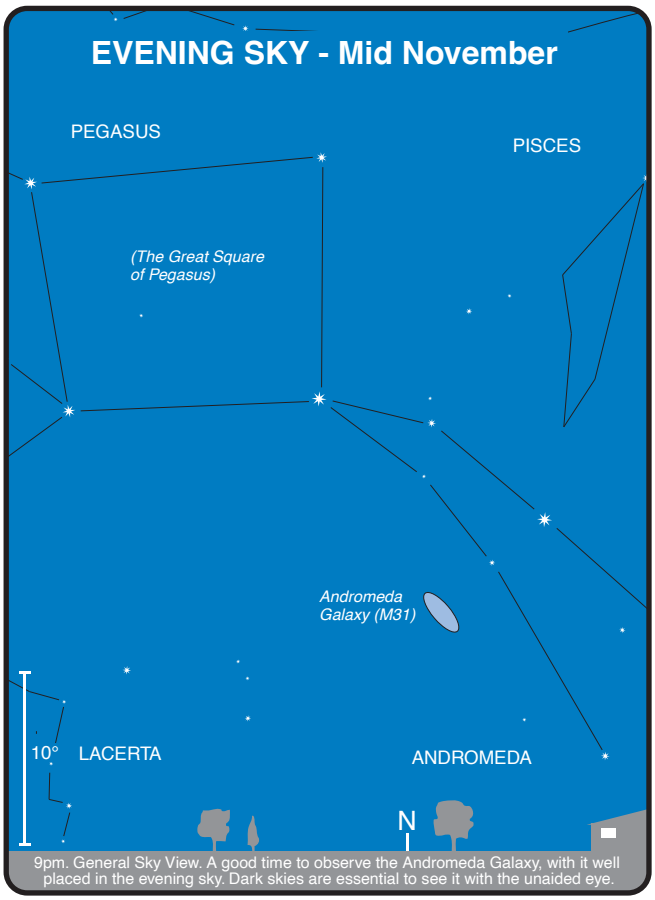
The **alpha-Monocerotids** is a minor shower, with unusual short-lived bursts of high rates. Active from 15th to 25th November, they peak on the 21st and are best seen during the late evening. While the zenith hourly rate is normally around 5, high rates were seen in the years 1925, 1935, 1985 and 1995. The 1995 rate reached an estimated 420, and lasted just 5 minutes, the entire shower was over in 30 minutes. There is some speculation of a 10-year cycle (due in 2005), but who knows what this year has in store?

DIARY

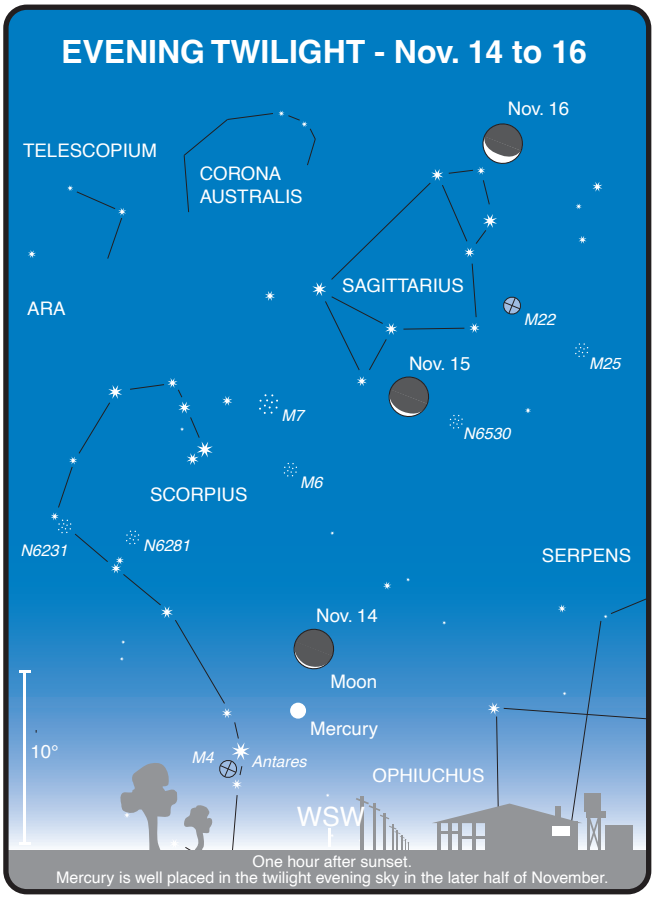
1st		m.p. 20 Massalia 0.4°N of NGC 6287 (GC) in Ophiuchus
1st		Venus at perihelion
2nd		m.p. 6 Hebe 0.7°NE of NGC 4457 (SG) in Virgo
2nd		m.p. 6 Hebe 0.2°NW of NGC 4496A (SG) in Virgo
3rd	4 am	(2 am WST) Moon at apogee
4th	6 am	(4 am WST) Saturn 5°S of Moon
5th	7 am	(5 am WST) Venus 0.6°N of Jupiter
5th		m.p. 11 Parthenope 0.2°NW of M75 (GC) in Sagittarius
5th	4 pm	(2 pm WST) Last Quarter Moon
6th		m.p. 15 Eunomia 1.0°SW of NGC 4856 (SG) in Virgo
6th	7 pm	(5 pm WST) Mercury 0.2°SW of star Delta Scorpii
8th		Venus 0.6°NW of NGC 4691 (SG) in Virgo
8th		Neptune 0.2°NW of m.p. 16 Psyche
8th	9 pm	(7 pm WST) Saturn stationary
9th		Mercury 0.7°S of M80 (GC) in Scorpius
10th	2 am	(Midnight WST, prev day) Jupiter 1.0°S of Moon; Occn.
10th	Noon	(10 am WST) Venus 0.2°N of Moon; Occn.
11th		m.p. 6 Hebe 0.5°NE of NGC 4636 (EG) in Virgo
11th	2 pm	(Noon WST) Mars 0.5°N of Moon; Occn.
11th	8 pm	(6 pm WST) Mercury 2°N of star Antares
12th	am	m.p. 6 Hebe 0.1°N of NGC 4636 (EG) in Virgo
12th	Noon	(10 am WST) Uranus stationary
12th	Midnight	(10 pm WST) New Moon
14th	1 pm	(11 am WST) Mercury 0.9°N of Moon; Occn.
14th	Midnight	(10 pm WST) Moon at perigee
16th		m.p. 324 Bamberga 0.7°NW of M73 (OC) in Aquarius
16th		Comet C/2003 K4 (LINEAR) 0.9°W of NGC 4105 (EG) in Hydra
16th		Mercury at greatest latitude South
16th	7 pm	(5 pm WST) Venus 4°N of star Spica
17th		Mercury 0.8°SW of NGC 6284 (GC) in Ophiuchus
17th		Mercury 0.9°N of M19 (GC) in Ophiuchus
17th		m.p. 8 Flora 1.5°W of m.p. 532 Herculina
18th	1 pm	(11 am WST) Neptune 5°N of Moon
19th	4 pm	(2 pm WST) First Quarter Moon
19th	11 pm	(9 pm WST) Uranus 4°N of Moon
20th		m.p. 20 Massalia 1.1°N of NGC 6401 (GC) in Ophiuchus
21st		m.p. 3 Juno 0.4°N of NGC 6822 (IG) in Sagittarius
21st	11 am	(9 am WST) Mercury greatest elongation East (22°)
22nd		Mercury 0.8°NE of NGC 6355 (GC) in Ophiuchus
22nd		m.p. 2 Pallas 1.0°SW of NGC 3672 (SG) in Crater
23rd		Venus at greatest latitude North
25th		Jupiter 0.6°SW of NGC 4691 (SG) in Virgo
27th	6 am	(4 am WST) Full Moon
30th	9 pm	(7 pm WST) Moon at apogee
30th	11 pm	(9 pm WST) Mercury stationary

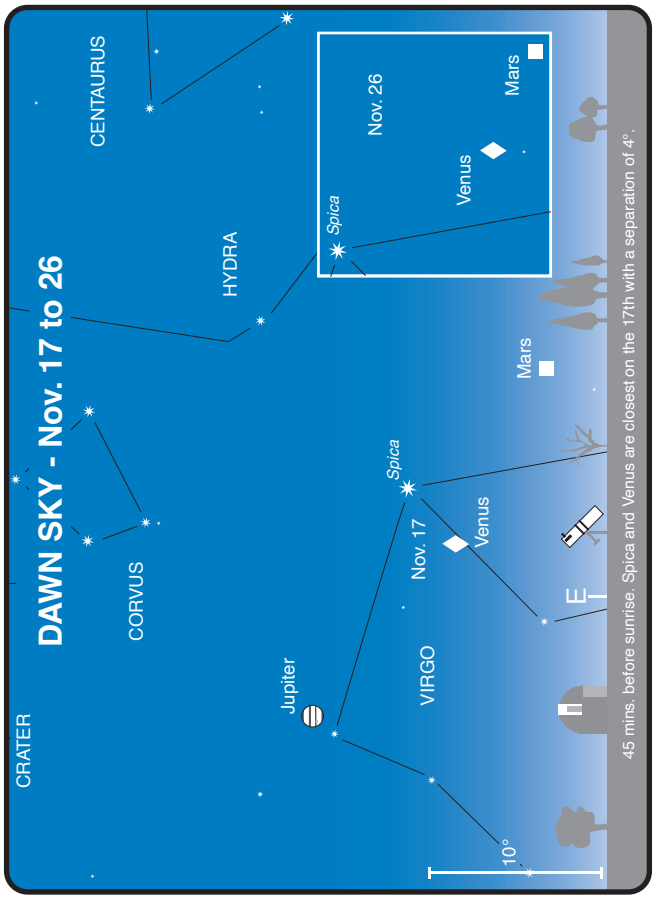






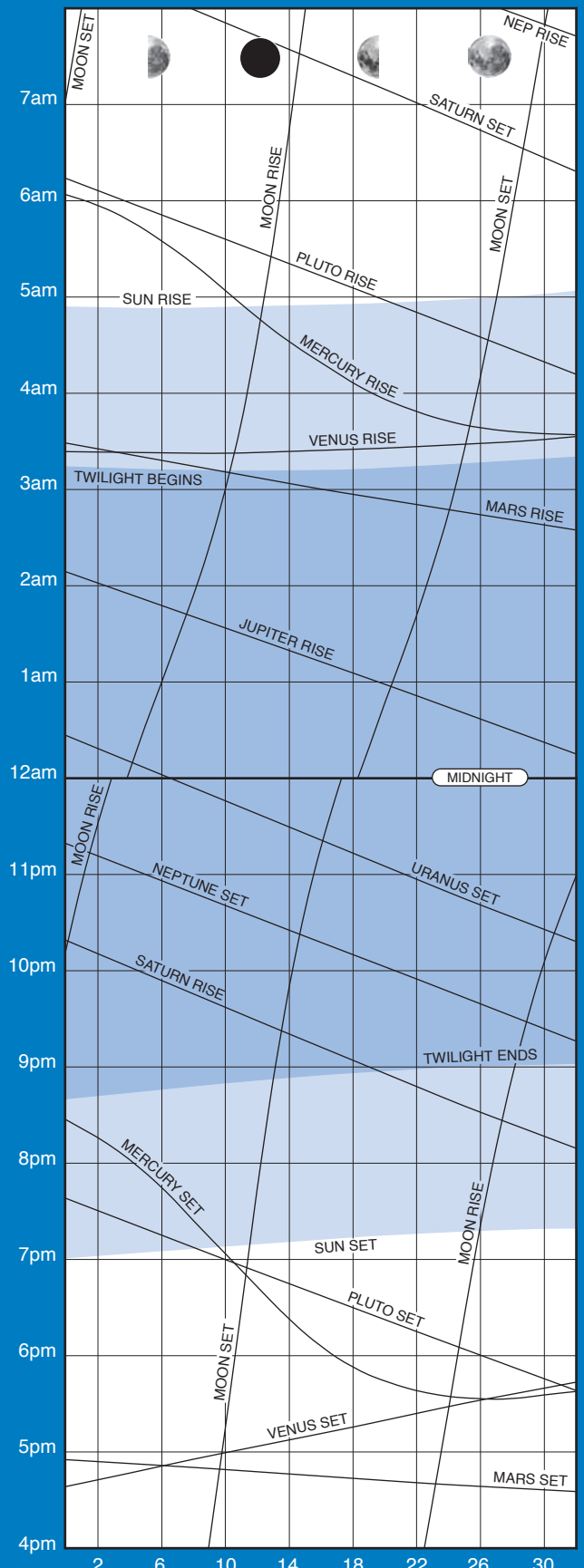
Approximate local standard time, for daylight saving add 1 hour.





DECEMBER

RISE/SET CHART



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

HIGHLIGHTS

- Mercury and Venus close
- Venus and Mars close
- Mars very close to Alpha Librae
- Saturn nearing opposition

THE MOON

5th	Last Quarter
12th	New Moon
13th	Moon at perigee (closest to Earth – 357,983 km distant, angular size 33.6')
19th	First Quarter
27th	(26th WST) Full Moon
28th	Moon at apogee (furthest from Earth – 406,489 km distant, angular size 29.4')

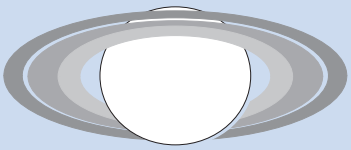
APPEARANCE of the PLANETS

MERCURY Mercury is in inferior conjunction on the 10th

VENUS
15th Dec
dia 11.34"
mag -4.0

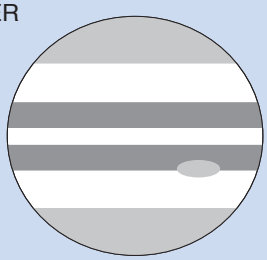
MARS
15th Dec
dia 3.98"
mag 1.6

SATURN



15th Dec
dia 20.23"
mag -0.2

JUPITER



15th Dec
dia 34.32"
mag -1.9

URANUS
15th Dec
dia 3.46"
mag 5.9

NEPTUNE
15th Dec
dia 2.23"
mag 8.0

PLUTO
15th Dec
dia 0.10"
mag 14.0

THE PLANETS

MERCURY rapidly moves from the evening twilight toward the Sun and inferior conjunction (between Earth and Sun) on the 10th. Then swinging west of the Sun, Mercury returns to the morning twilight from mid-month, reaching its greatest elongation west of the Sun (22°) on the 30th. Mercury and Venus become companions late in the month and on the 29th the pair will be 1.2° apart (see Sky View). Remaining together for the next four weeks, the planets will be at their closest at 0.3° on the 14th January next year.

VENUS begins the month in the morning sky just over 3° from Mars. The two planets move closer together and on the 6th they will be 1.2° apart (see Sky View). On the 10th there is a pretty sight with the 27-day old Moon above Venus with Mars between the two (see Sky View). After separating from Mars, Venus moves onto its rendezvous with Mercury (detailed above).

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

MARS in the late morning sky (rising around the start of dawn) is in Libra until late in December when it moves into Scorpius ending up 1° from Beta Scorpii. While the attention during the first week of this month will be on Mars and Venus (see above), Mars will also have a close encounter of the stellar kind on the 4th. The Red Planet will be just 6 arc minutes from both components of the wide double star system Alpha Librae on the 4th. The pair of suns at 3rd and 5th magnitude is separated by 4 arc minutes; theoretically the stars are at the limit of the human eye's resolution. Anyone care to test his or her eyesight? On the 10th, the 27-day old crescent Moon is a little above the planet with Venus below (see Sky View).

JUPITER, rising around 1:30am mid-month, is high in the northeastern sky by the beginning of dawn. On the 7th and 8th, the 25-day old waning crescent Moon will be close to the planet (see Sky View). On the 8th they form a triangle with Spica.

SATURN rises in the mid-evening eastern sky in Gemini. The ringed planet reaches opposition on the 14th of January next year. The period from December through February is the optimum period for observation of this most exquisite planet at its brightest and largest. On the 28th, the Moon, just past full phase will be nearby the planet (see Sky View).

URANUS and **NEPTUNE** are setting in the evening with both moving toward solar conjunction early next year. January will see Neptune setting before twilight ends.

PLUTO, in conjunction with the Sun on the 14th, returns to the morning sky in January.

MINOR PLANETS at opposition this month include: 320 Athamantis on the 14th at magnitude 10.0 in Taurus, 12 Victoria on the 18th at magnitude 10.8 in Taurus, 354 Eleonora on the 18th at magnitude 10.1 in Orion, 192 Nausikaa on the 25th at magnitude 9.7 in Auriga and 30 Urania on the 31st at magnitude 9.9 in Gemini.

A faint 387 Aquitania sits on the northeast edge of the Helix Nebula, in Aquarius, on the 30th.

COMETS

Comet C/2002 T7 (LINEAR), now rising before midnight, should be 12th magnitude in Crater. In late December, the comet passes within a degree of Gamma Crateris.

Comet C/2003 K4 (LINEAR) is visible all night in December as it moves southwest through Centaurus, Vela, Carina, and Pictor. Possibly at 7th magnitude throughout the month, LINEAR reaches the southern most point of this apparition in late December.

MOON WATCHER

SUNRISE ON MARE IMBRIUM

The Apennine mountain range and the three prominent craters of Archimedes, Autolycus and Aristillus probably make this region one of the most distinctive areas on the Moon. The best time to observe this area is around First Quarter Moon. The lunar features described below should be visible through a small amateur telescope.

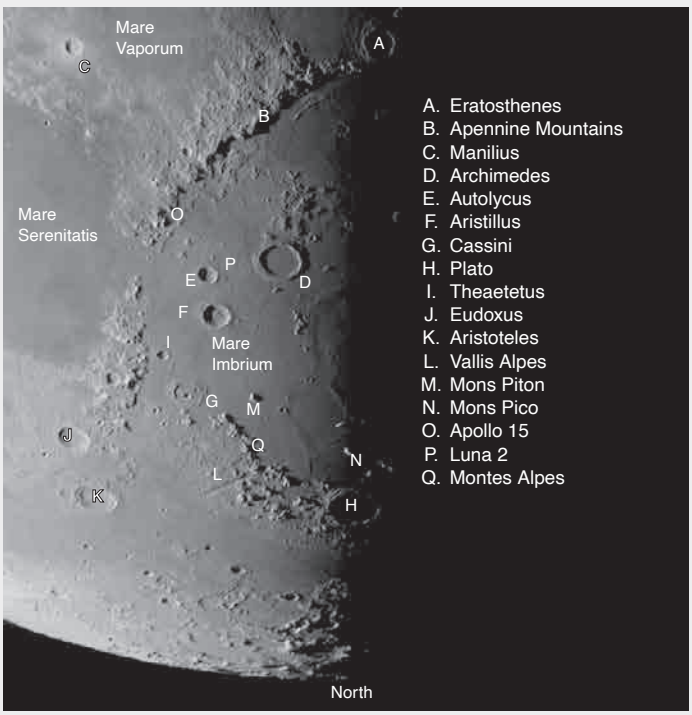
The Apennines form the southeast corner of Mare Imbrium commencing near Eratosthenes and stretching in a gentle curve for a distance of 600 kilometres. In fact Mare Imbrium is surrounded by a number of mountain ranges making the 'sea' look like a great walled plain. Another part of this ring is Montes Alpes (The Alps) which runs approximately 250 kilometres starting near Cassini and running towards Plato. While in this area check out the unusual feature, Vallis Alpes or Alpine Valley. This is probably the best-known lunar valley and appears like a straight slash, cutting its way into the Alps.

As well as being an impressive string of some 3,000 mountains, the Apennines also hold a special place in the history of Man's exploration of the Moon — the landing site of Apollo 15. Nestled between two peaks, that towered 4,000 metres above the lander, Apollo 15 set down next to an unusually narrow valley called Hadley Rille. For those trivia buffs, this was the first mission to use the buggy-like 'Rover' vehicle, which the astronauts used to explore the foothills of the mountains. Also, under the heading of useless information, Apollo 15 touched down about 150 kilometres from the crash site of the unmanned Luna 2 probe.

Mare Imbrium has the distinction of being the home to two of the tallest isolated peaks on the surface of the Moon. The best known is Pico which rises 2,400 metres above the plain. In this First Quarter Moon photo the mountain is well lit with its base having just emerged from shadow. The other peak is Piton which rises 2,100 metres. It can be seen over near Cassini, displaying an impressive early morning shadow.

The crater Archimedes is some 80 kilometres across and its almost featureless floor gives it a distinctive look. This is probably due to lava flows filling the basin in ancient times. The nearby crater, Aristillus, presents quite a contrast to Archimedes, with a rugged floor including three peaks (quite different to the typical single, central peak).

At the time this image was taken the Sun's rays were just starting to hit the rim of the crater Plato. When the angle of the Sun is just right, Plato shows a brilliant, complete ring while its floor remains dark.



Comet 62P/Tsuchinshan 1 should brighten from 13th to 12th magnitude this month as it reaches perihelion. Rising around midnight and visible during the morning, Tsuchinshan 1 is moving eastward through Leo, passing near a number of relatively bright galaxies.

Comet 78P/Gehrels 2 is visible in the evening and early morning, and it should end the year slowly fading from 11th to 12th magnitude as it moves along the border of Aries and Cetus.

METEOR SHOWERS

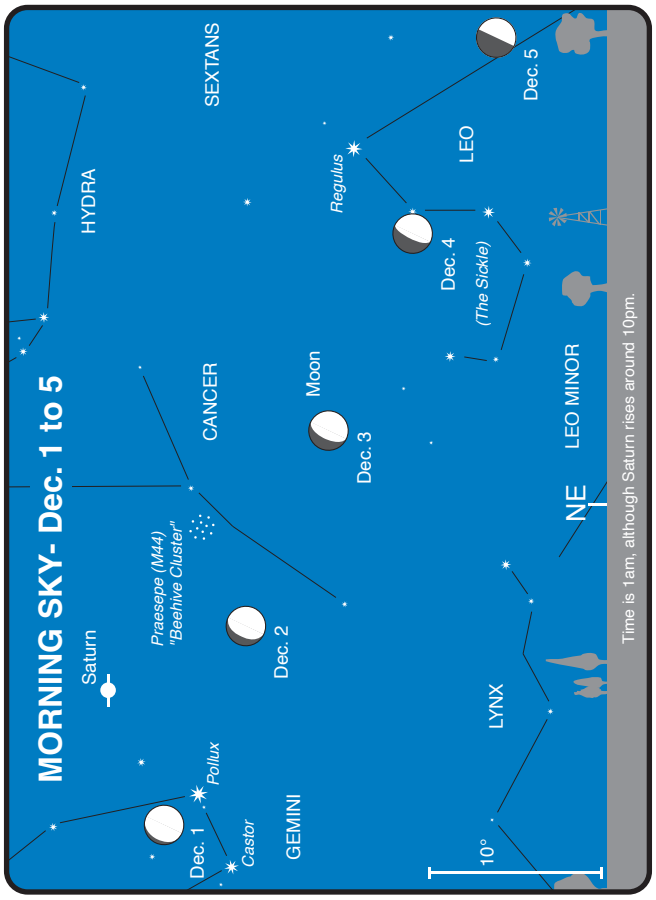
The **Phoenicids** (**Dec**.) are a southern shower that was discovered in 1956, when a zenith hourly rate of around 100 was observed. There have been three minor bursts in activity since 1956, but in recent years the shower seems nonexistent. There is a possibility that this may be a periodic shower, so observations should still be carried out in case of a return. The period of activity appears to be 28th November through 9th December, with the 6th being the maximum.

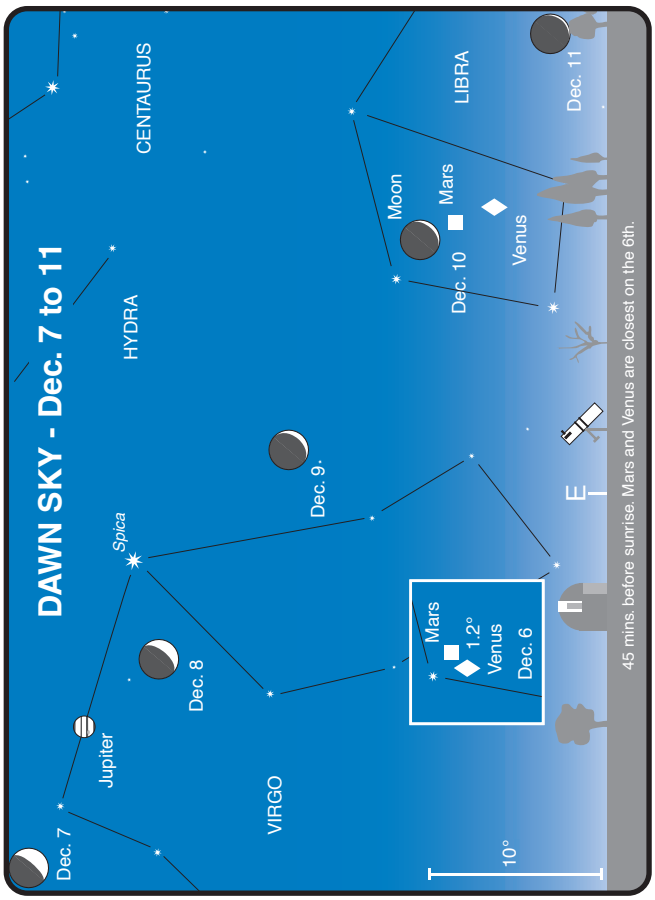
The **Geminids** are one of the best annual showers observable, but for some southern observers the radiant is below or low on the horizon until late evening. Visible from the 7th to 17th, with maximum on the 13th, the Geminids often produce bright, medium-speed meteors. The zenith hourly rate is variable but around 120 are possible. Even though our Northern Hemisphere counterparts will see the best of the Geminids, they can still provide a spectacular display for us 'down under'.

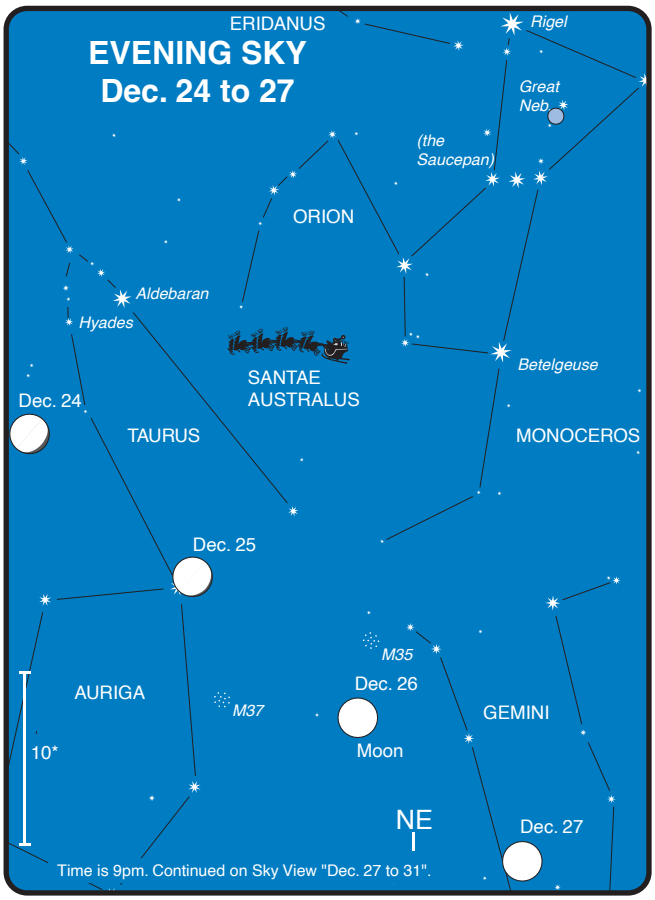
The **Puppid-Velids** are a very complex system of around ten showers; with each radiant so close that visual observation cannot easily separate them. Some of the showers are thought to be visible from late October to early January, but have been so poorly observed (a reflection on the number of southern meteor observers perhaps?) that the International Meteor Organisation can only confirm high activity from December 1st to 15th, with a peak zenith hourly rate of 10 on the 6th. Most of the Puppid-Velids are faint but occasional bright fireballs, particularly around the peak, have been observed.

DIARY

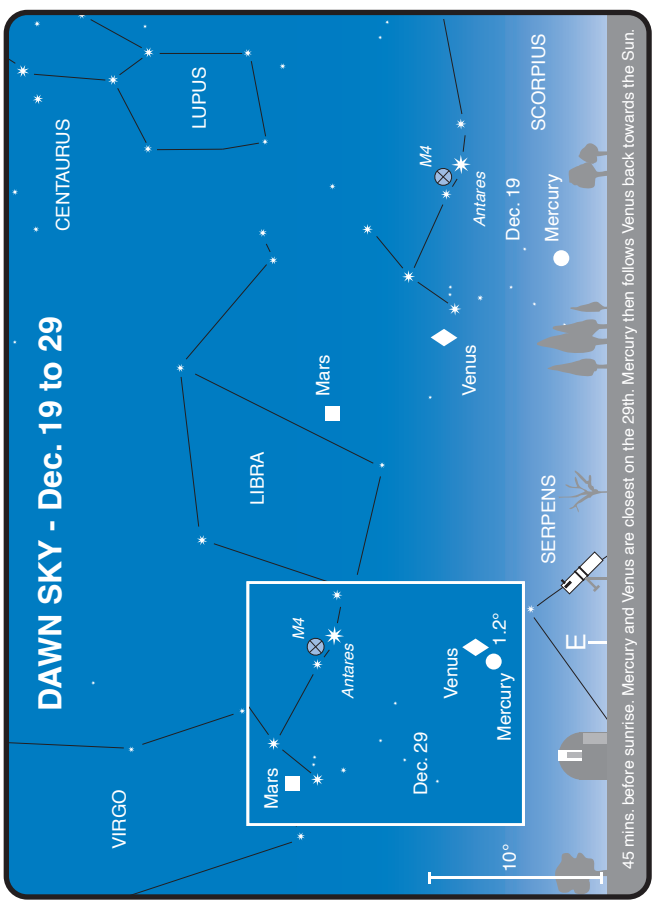
1st	Noon	(10 am WST) Saturn 5°S of Moon
1st	pm	Comet C/2003 K4 (LINEAR) 0.9°NW of NGC 3680 (OC) in Centaurus
3rd		m.p. 387 Aquitania 1.2°S of M30 (GC) in Capricornus
3rd		Comet 62P/Tsuchinshan 1 0.4°S of NGC 3338 (SG) in Leo
4th		Mars 0.1°S of star Alpha Librae
5th		Comet 62P/Tsuchinshan 1 0.7°N of M105 (EG) in Leo
5th		Mercury at ascending node
5th	11 am	(9 am WST) Last Quarter Moon
5th	5 pm	(3 pm WST) Venus 1.3°N of Mars
6th		Comet 62P/Tsuchinshan 1 0.2°N of NGC 3412 (LG) in Leo
7th	9 pm	(7 pm WST) Jupiter 0.3°S of Moon; Occn.
8th	11 pm	(9 pm WST) Comet C/2003 K4 (LINEAR) 0.1°SE of star Mu Velorum
10th		Mercury at perihelion
10th	10 am	(8 am WST) Mars 2°N of Moon
10th	3 pm	(1 pm WST) Venus 4°N of Moon
10th	6 pm	(4 pm WST) Mercury in inferior conjunction
11th	pm	Comet C/2003 K4 (LINEAR) 1°SE of NGC 3228 (OC) in Vela
12th	11 am	(9 am WST) New Moon
13th	7 am	(5 am WST) Moon at perigee
14th	3 am	(1 am WST) Pluto in conjunction with Sun
14th		m.p. 3 Juno 1.0°N of NGC 4261 star Beta Capricorni
14th	pm	Comet C/2003 K4 (LINEAR) 0.4°SE of NGC 3105 (OC) in Vela
15th		Comet 62P/Tsuchinshan 1 0.2°SE of NGC 3593 (SG) in Leo
15th	9 pm	(7 pm WST) Neptune 5°N of Moon
16th		m.p. 40 Harmonia 0.2°S of IC 1613 (IG) in Cetus
16th		Comet 62P/Tsuchinshan 1 0.5°S of M65 (SG) in Leo
16th	pm	Comet C/2003 K4 (LINEAR) 0.7°W of NGC 3033 (OC) in Vela
17th	7 am	(5 am WST) Uranus 4°N of Moon
17th		Comet 62P/Tsuchinshan 1 0.4°S of M66 (SG) in Leo
17th	pm	Comet C/2003 K4 (LINEAR) 0.8°SE of IC 2488 (OC) in Vela
19th	3 am	(1 am WST) First Quarter Moon
20th		Venus 0.6°E of star Beta Scorpii
20th		Mercury at greatest latitude North
20th	5 pm	(3 pm WST) Mercury stationary
21st	11 pm	(9 pm WST) Solstice
23rd	pm	Comet C/2003 K4 (LINEAR) 0.9°S of star Epsilon Carinae
24th	7 am	(5 am WST) Venus 6°N of star Antares
25th	pm	Comet C/2003 K4 (LINEAR) 0.7°W of NGC 2516 (OC) in Carina
27th	1 am	(11 pm WST, prev day) Full Moon
28th	5 am	(3 am WST) Moon at apogee
28th	4 pm	(2 pm WST) Saturn 5°S of Moon
29th	3 am	(1 am WST) m.p. 1 Ceres 0.1°NW of NGC 5634 (GC) in Virgo
29th		Venus 0.7°N of NGC 6287 (GC) in Ophiuchus
29th	3 pm	(1 pm WST) Mercury 1.2°N of Venus
30th	7 am	(5 am WST) Mercury greatest elongation West (22°)
30th		m.p. 11 Parthenope 0.4°N of star Delta Capricorni
30th	9 pm	(7 pm WST) m.p. 387 Aquitania 0.1°NE of Helix Nebula (NGC 7293) in Aquarius
31st		Venus 0.7°NE of NGC 6235 (GC) in Ophiuchus
31st		Mars 0.9°S of star Beta Scorpii

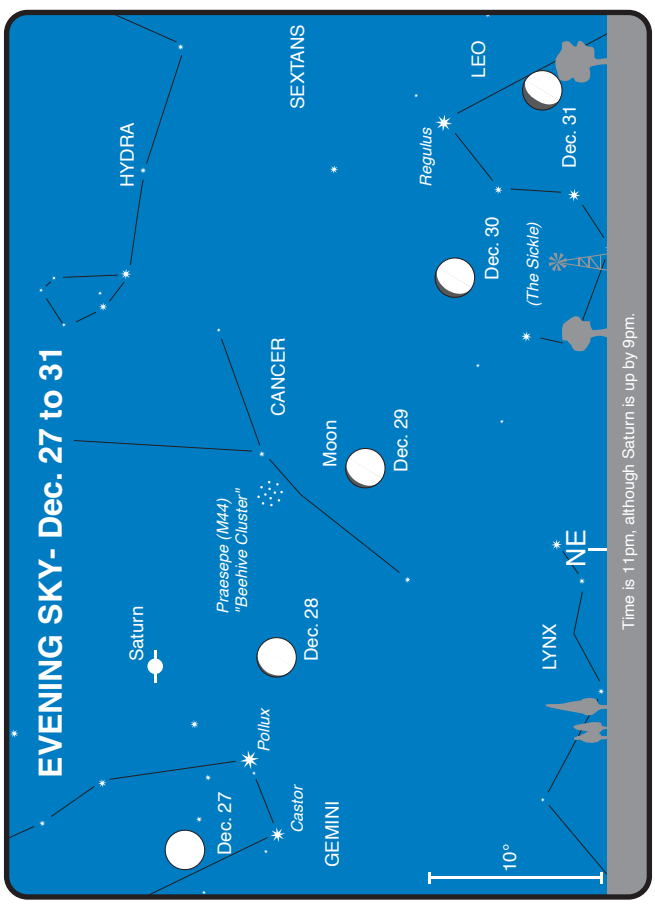






Approximate local standard time, for daylight saving add 1 hour.





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 probably more accurate to say they are useful for anywhere in the Southern Hemisphere with latitudes similar to Australia. This includes most of New Zealand, South Africa and parts of South America.

Who can use them?

Anyone, and you don't even need binoculars or a telescope to become completely at ease finding your way around the sky and recognising all of the constellations.

The limiting magnitude of the charts is 5.5. This means, if you live in a suburban area you will not see the faint stars marked on the maps, just with your eyes. Some of the less conspicuous constellations may not be visible at all (a low power pair of binoculars will help). Under dark, country skies, where you can see the Milky Way, you will be able to see numerous fainter stars that are not marked on the maps.

HOW DO I USE THEM?

There are 9 maps. Map 1 is the far southern sky called 'Looking South'. Then there are 4 pairs of maps, one pair for each season i.e., a 'Centre' and a 'North' map.

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 to help. From mid Australian latitudes, and further south, Crux is circumpolar and 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. For example suppose it is around mid to late June. At 9pm the sky will look like the 'Winter' pair. By 3am the sky will be showing the 'Spring' view. Around dawn the earth would have rotated further to the point where the sky is now half 'Spring' (to the left or towards the west) and half 'Summer' (towards the right or east). Using a planisphere (p. 15) illustrates this quite well.

What does the fine black grid represent?

These are the right ascension (RA) and declination (Dec.) lines. They are the celestial equivalent to longitude and latitude respectively. RA is expressed as hours/minutes/seconds. Also the line, which starts on the due north point ('N' on the 'North' charts) and running 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 11pm on August 20 is approximately 21 hours (as an aside this is also the definition of the local sidereal time, see page 139). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1am) the star Alpha Pegasi (Markab), with an RA close to 23 hours, will culminate.

The declination also indicates which areas of the charts will pass directly overhead. This is 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 March 20 at 9pm 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 black dashed lines, labelled with city names, on the 'North' maps mean? As previously mentioned in the introduction to Part I, 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 may only be above the northern horizon briefly. 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?

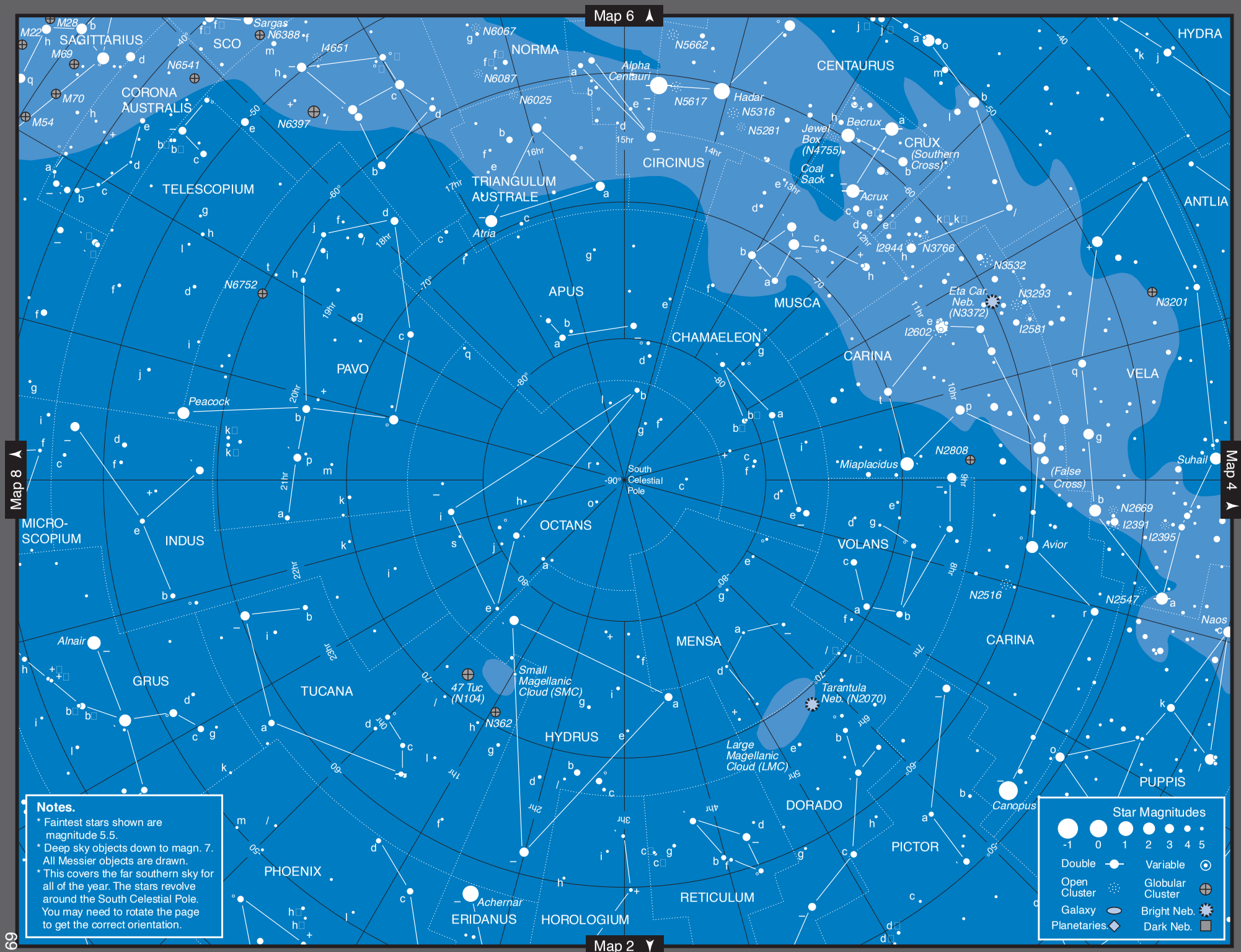
Lines are shown to indicate the approximate path in the sky for **Jupiter, Saturn, Uranus, Neptune and Pluto** for the year. You can then go to the relevant finder chart. The path for **Mars** has the position marked for each month and this replaces our traditional finder chart. The Moon, Mercury and 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?

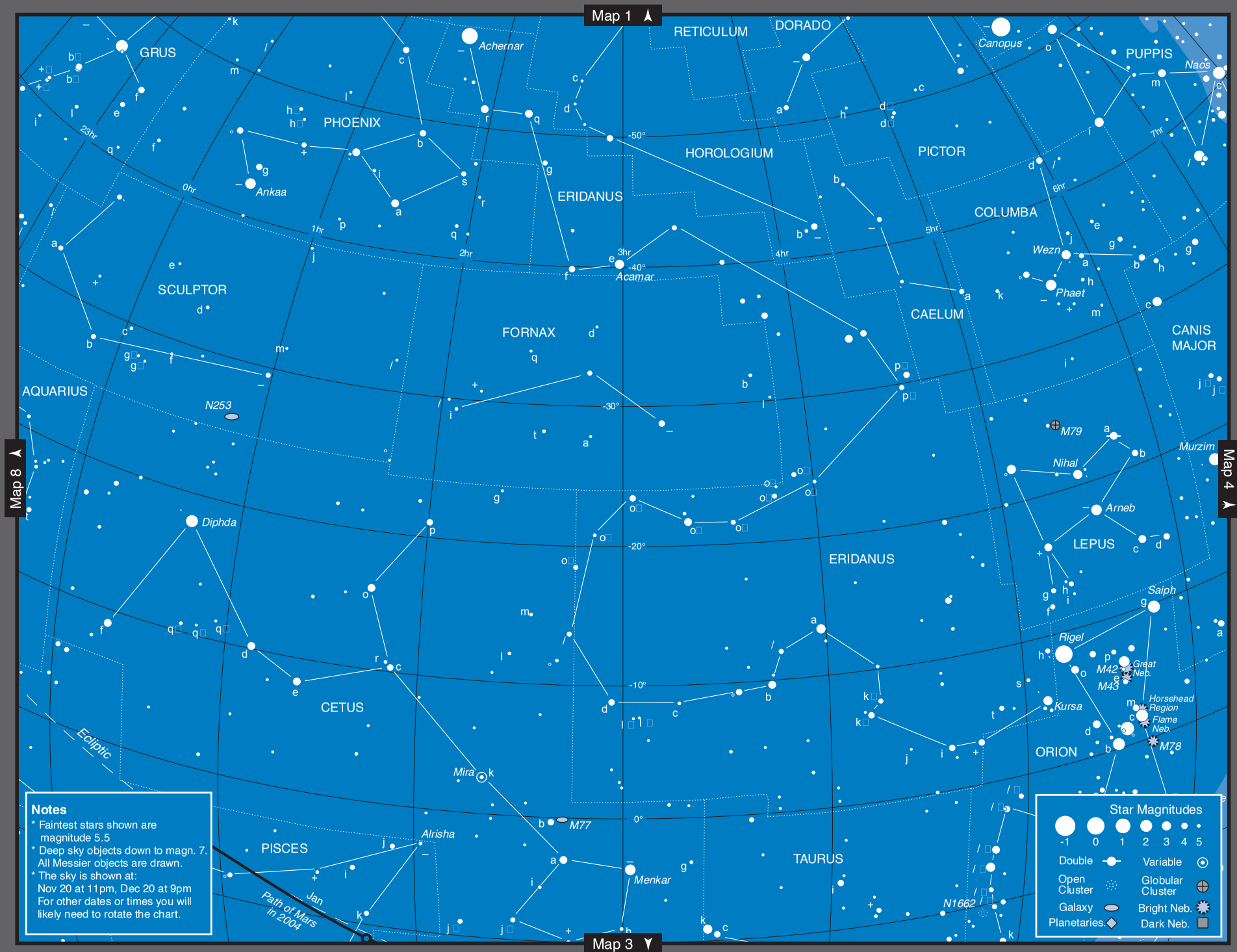
- **Deep sky objects** down to magnitude 7 and all of the Messier objects (see the legend). Most of these objects are identified by their common names, Messier number ('M'), NGC ('N') or IC ('I') catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope.
- **Constellation lines.** The white dotted lines are the boundaries and the solid white lines join some of the brighter stars to help in recognising the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A few of the brighter **Double Stars** (see p. 33) and **Variables**.
- A light blue shading shows the **Milky Way** and **Magellanic Clouds.**

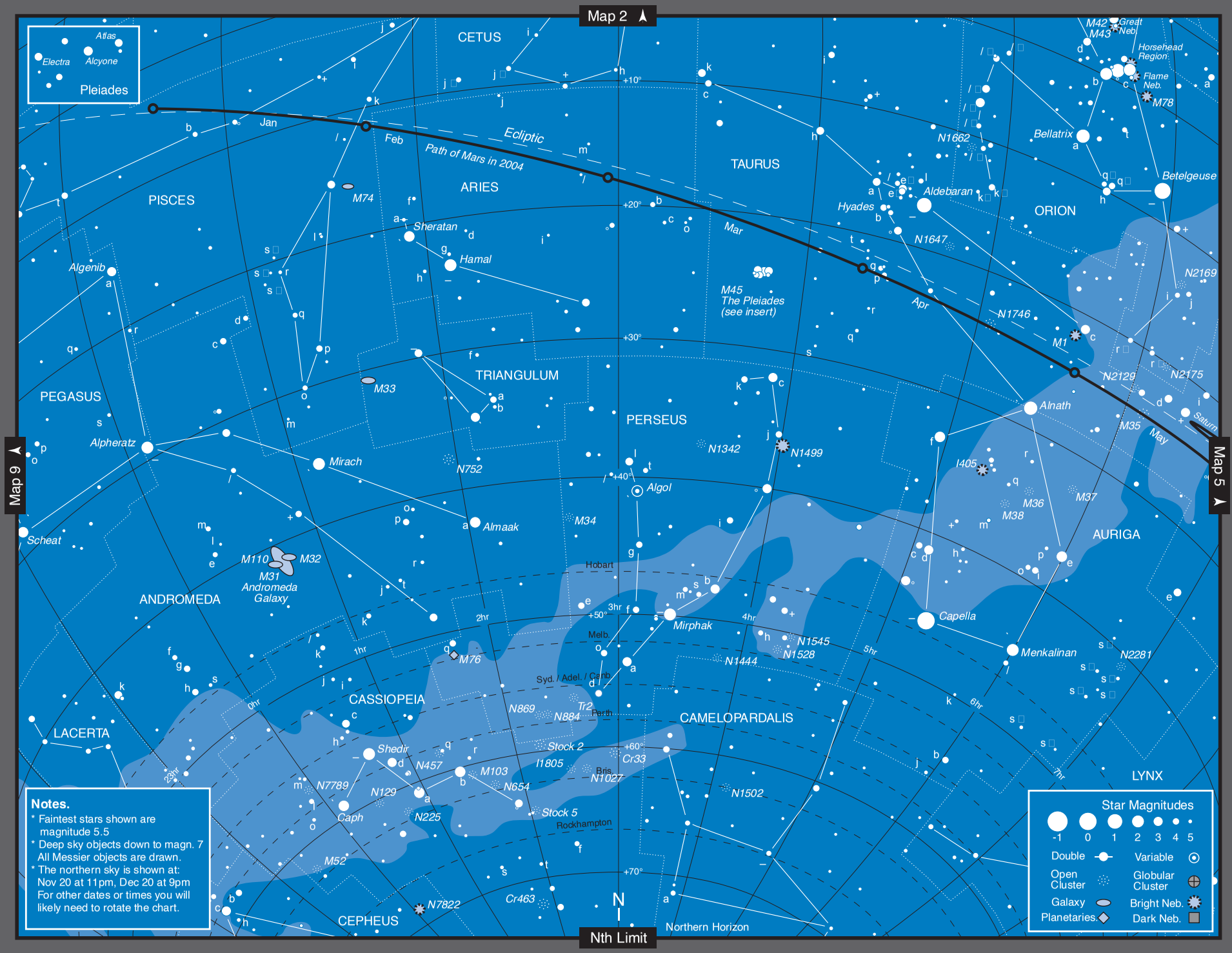
The Centre of the Milky Way in Ophiuchus.

A complex of dark nebula lanes is shown here against the bright band of the Milky Way. The bright star on the right edge, slightly below half way up, is Antares. The bright 'star' half way between Antares and the top right corner is Saturn as it was on March 14, 1986. North is towards the top of the page.


Map 6
Map 8
Map 4
Map 2
SAGITTARIUS
SCO
CORONA AUSTRALIS
TELESCOPIUM
NORMA
CIRCINUS
TRIANGULUM AUSTRALE
CENTAURUS
HYDRA
CRUX (Southern Cross)
ANTLIA
APUS
MUSCA
CHAMAELEON
CARINA
VELA
PAVO
Peacock
INDUS
MICRO-SCOPIUM
OCTANS
South Celestial Pole
VOLANS
Avior
(False Cross)
Miaplacidus
Suhail
MENSA
GRUS
Alnair
TUCANA
47 Tuc (N104)
Small Magellanic Cloud (SMC)
HYDRUS
Large Magellanic Cloud (LMC)
Tarantula Neb. (N2070)
DORADO
Canopus
PUPPIS
Naos
PICTOR
PHOENIX
ERIDANUS
Achernar
HOROLOGIUM
RETICULUM
Alpha Centauri
Hadar
Becrux
Acrux
Atria
Jewel Box (N4755)
Coal Sack
Eta Car. Neb. (N3372)
Notes.
* Faintest stars shown are magnitude 5.5.
* Deep sky objects down to magn. 7. All Messier objects are drawn.
* This covers the far southern sky for all of the year. The stars revolve around the South Celestial Pole. You may need to rotate the page to get the correct orientation.
Star Magnitudes
-1 0 1 2 3 4 5
Double
Variable
Open Cluster
Globular Cluster
Galaxy
Bright Neb.
Planetaries
Dark Neb.

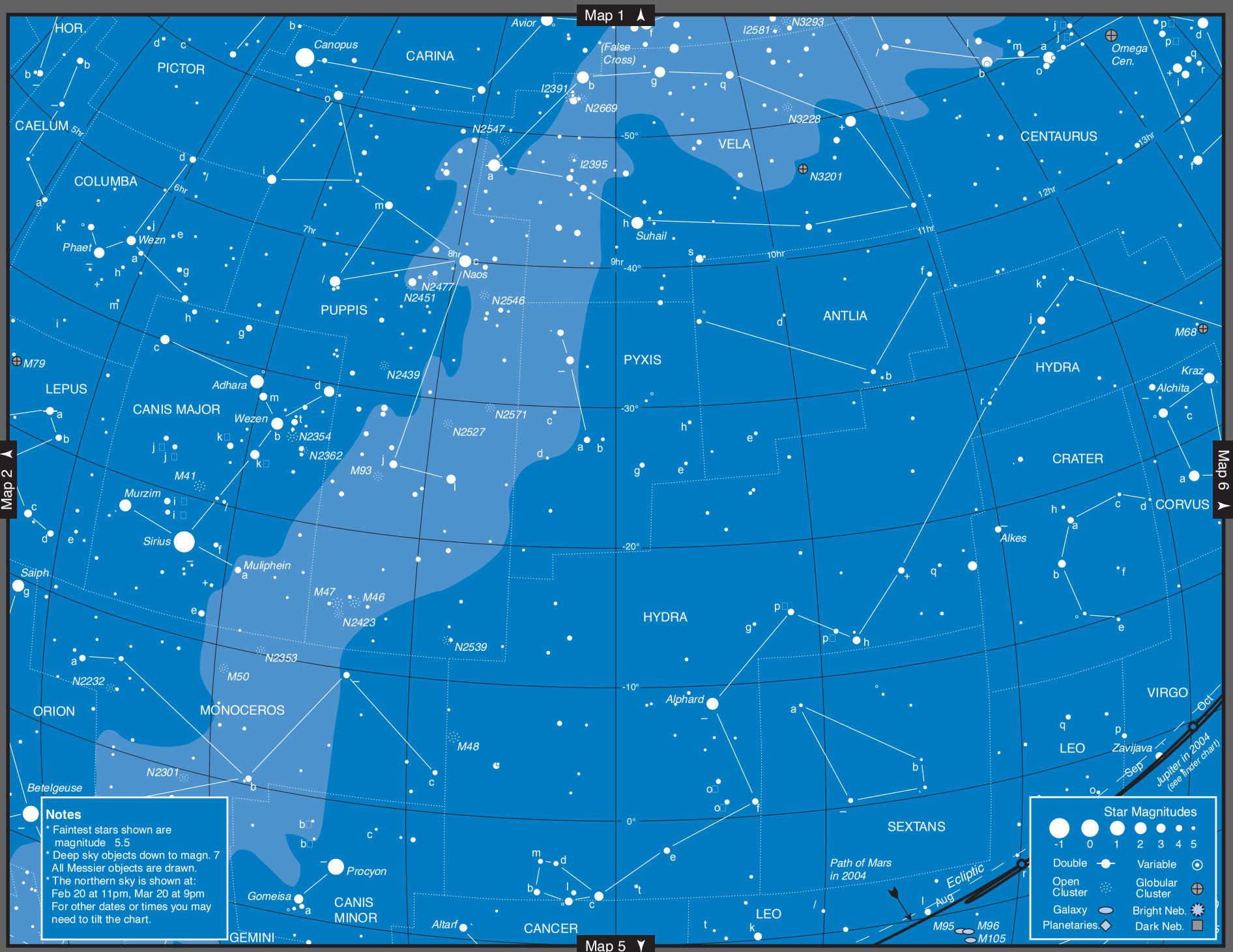
Map 2 - Summer (Centre)

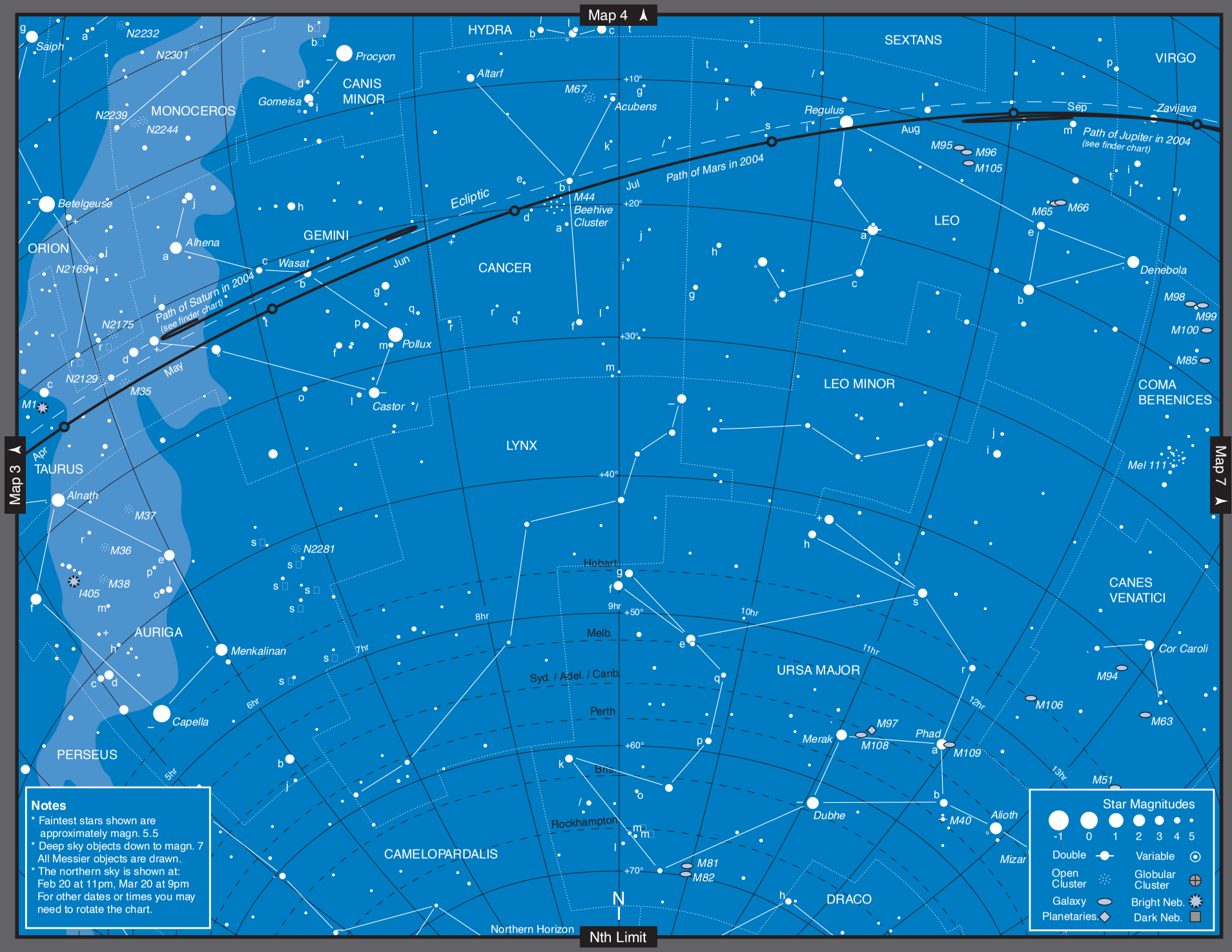




Map 3 - Summer (North)

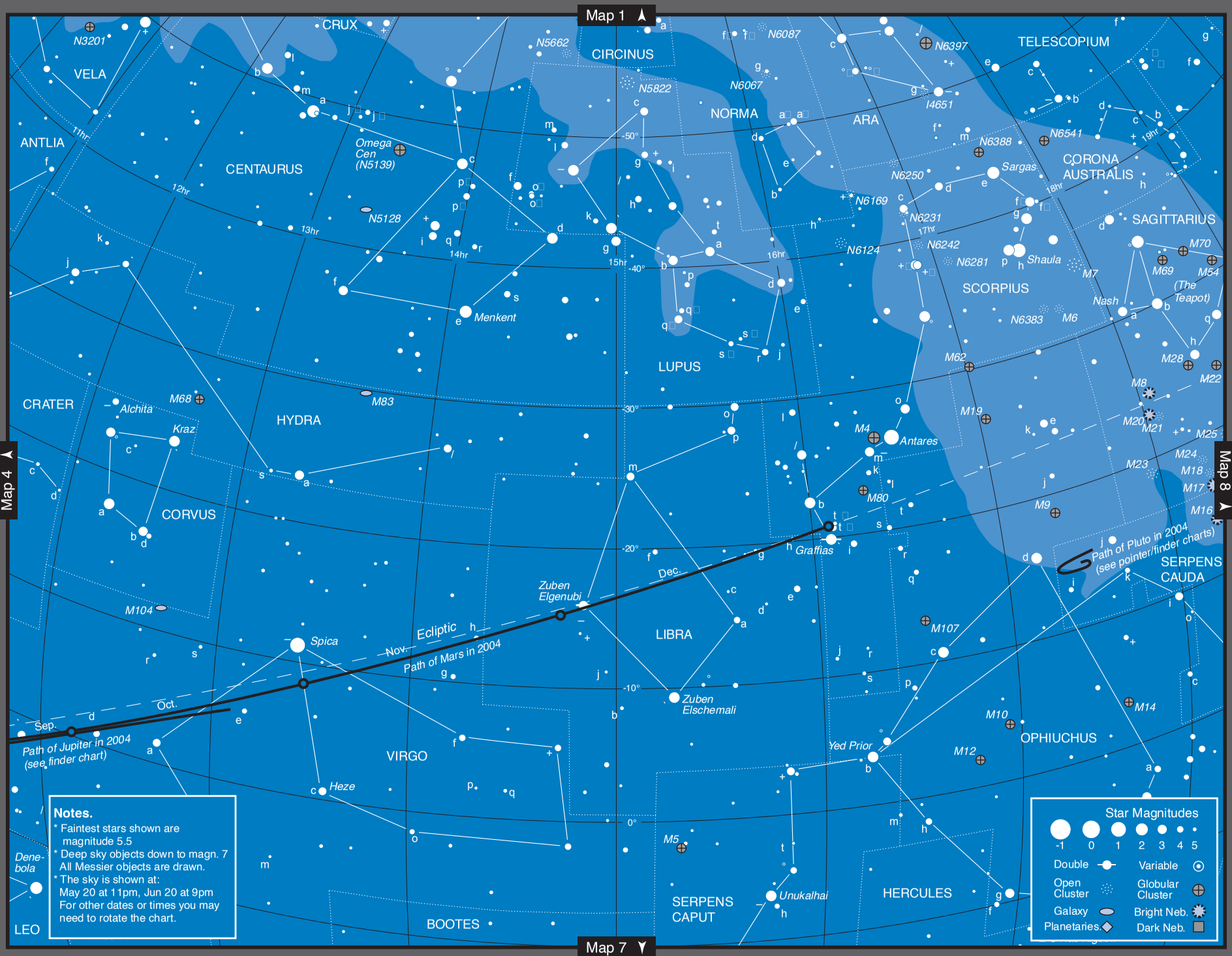
Map 4 - Autumn (Centre)

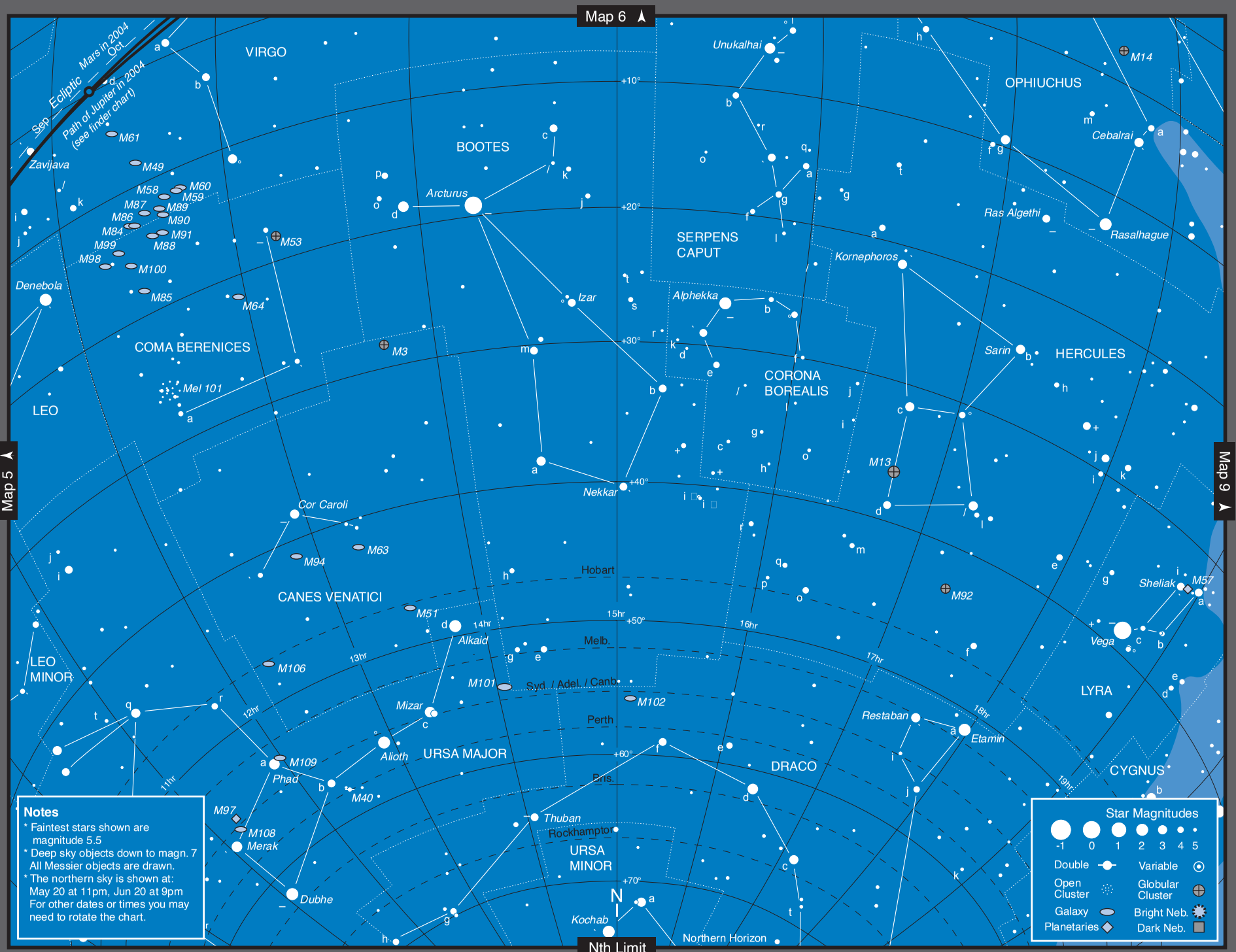




Map 5 - Autumn (North)

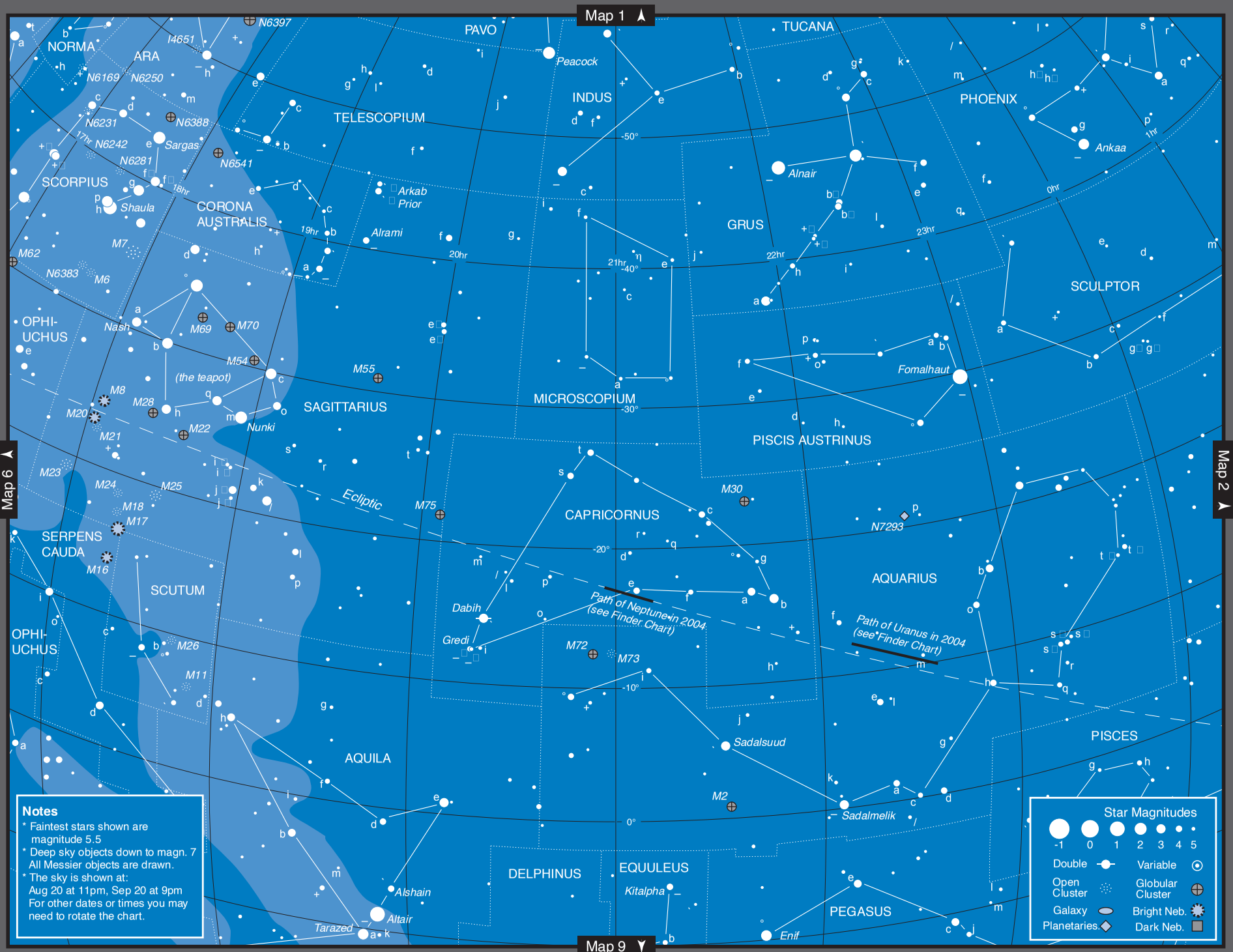
Map 6 - Winter (Centre)

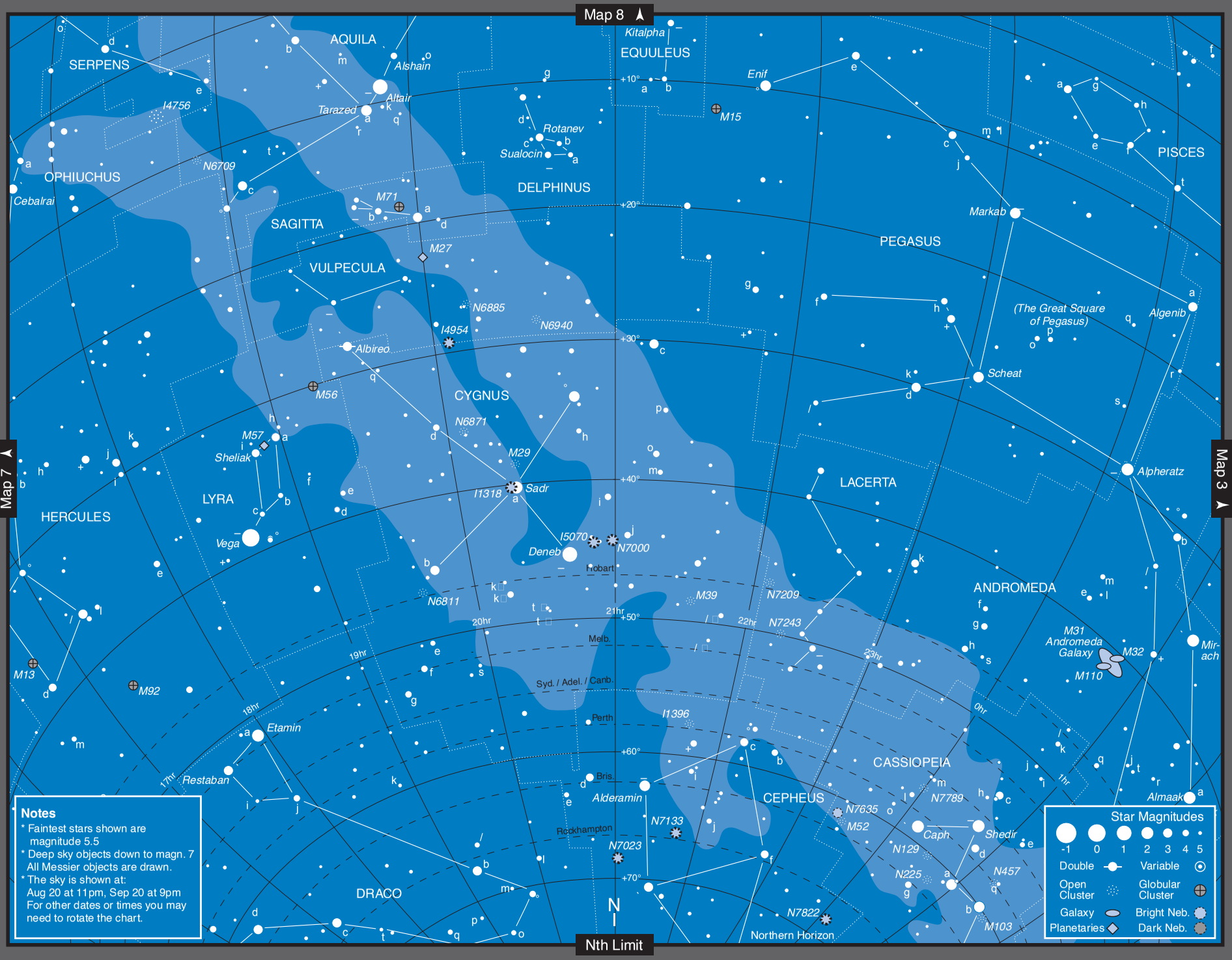




Map 7 - Winter (North)

Map 8 - Spring (Centre)





Map 9 - Spring (North)

PART II
THE SOLAR SYSTEM

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

Time. There are four zones used in Part II. They are: Eastern Standard Time (EST), Central Standard Time (CST), Western Standard Time (WST) and Universal Time (UT).

Time Zones. The local Australian standard zones are used where ever they involve location specific data, such as rise/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 need to add one hour to the times given here. Information related to Jupiter's moons (pp. 111-115) is given in EST and WST. Remaining data in Part II is presented in UT.

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 10:00hr (10:00am) EST, 9:30hr (9:30am) CST and 8:00hr (8:00am) WST.

The 24 hr clock is often used in astronomy e.g., 16:00 hr is the same as 4:00pm. This avoids having to distinguish between 'am' and 'pm'. The 24hr approach is frequently used in Part II of this book e.g., for rise/set times. In some areas, it is convenient to use decimal hours e.g., 5.3hr is the same as 5hr 18min or 5:18hr. The satellite data for Saturn, Uranus and Neptune use decimal hours.

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 Co-ordinates or Positions. The astronomical positions are given in equatorial co-ordinates. 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, 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 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 Map 1 in the All Sky Maps). The Northern 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 have been calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. This means they have been calculated for a position at the centre of the Earth. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Except for the Moon, this slight shift is insignificant. Positions for the outer planets are given in weekly intervals and correspond to Saturdays; those for the Sun, Moon, Venus and Mercury are daily.

Rise and Set Times. Those given are when the upper limb of the object is coincident with the theoretical horizon. The data is adjusted for atmospheric refraction. The intervals used for rise/sets are weekly, the dates corresponding to Saturdays. The exception is the Moon, which is presented for each day. Also see note on time zones (above).

Use of Star Atlases. As the Earth orbits the Sun, the polar axis remains fixed relative to the stars. The points, around which the stars appear to rotate (the celestial poles), appear to never change no matter what time of the year one is observing. However, the positions of the celestial 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.

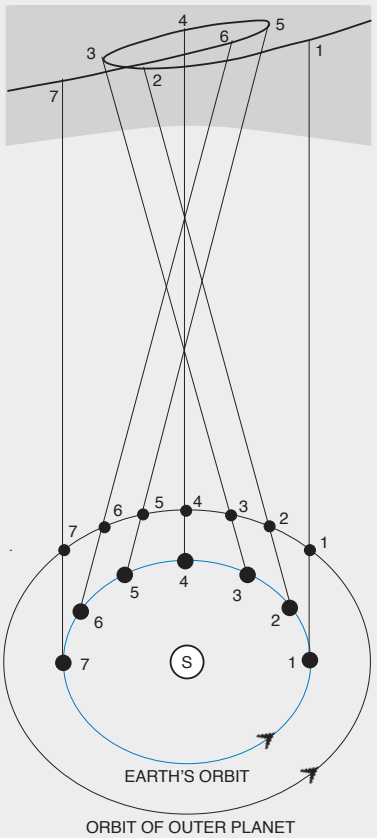
Field of View in a Telescope. All the satellite diagrams and finder charts in this book are drawn to correct or normal sky orientation, i.e., east to the left, and north to the top (in the sky, east and west are opposite to what is seen on terrestrial maps). Telescope systems that use an odd number of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

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 it was decided that the All Sky Maps gave adequate detail to easily find the red planet, so its traditional finder has been included on the All Sky Charts.

RETROGRADE MOTION

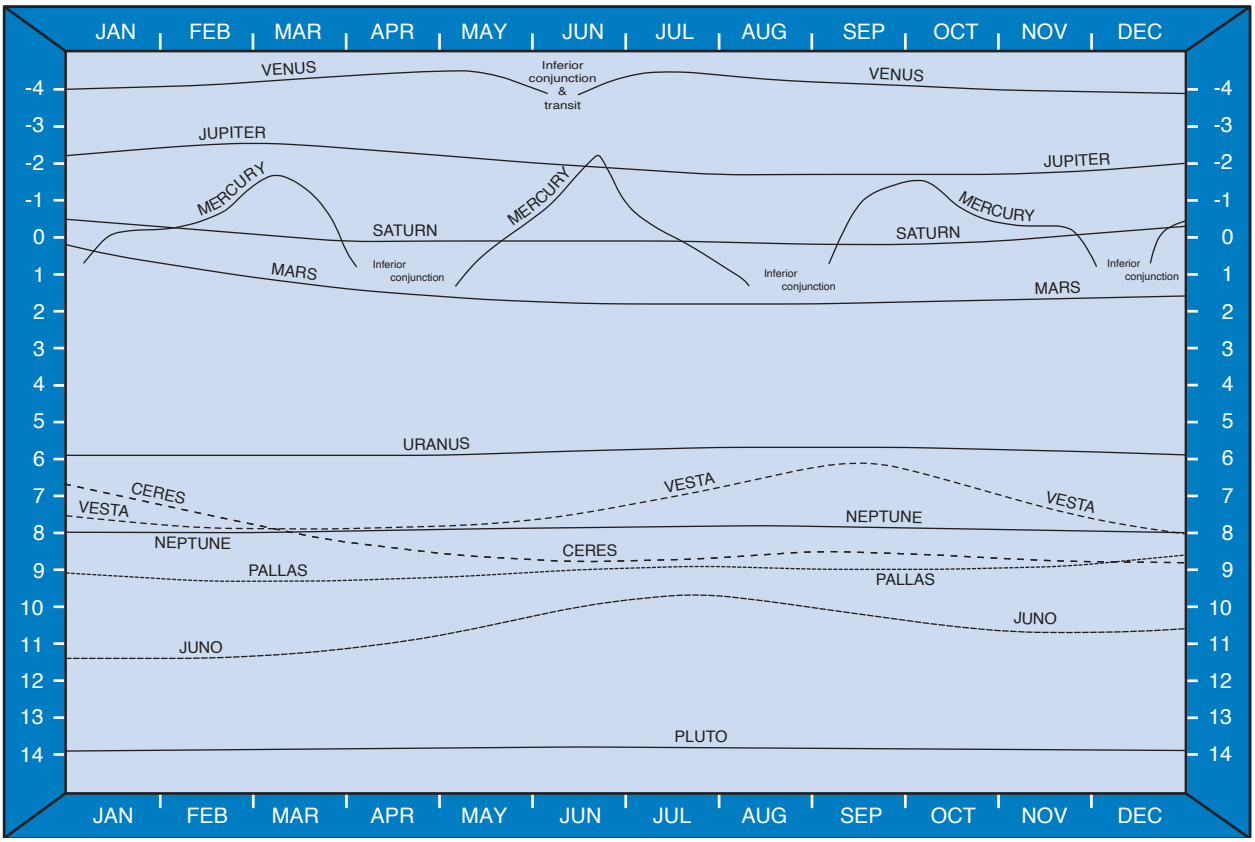
The finder charts for the outer planets have one thing in common – an apparent motion with a loop shape. This only applies to the period during opposition. Note that Mars does not reach opposition every year. The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

In the diagram, the shaded area represents the path of an outer planet against the celestial sphere. 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 this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet appears to move from east to west instead of from 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 (i.e., moving east to west) 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.



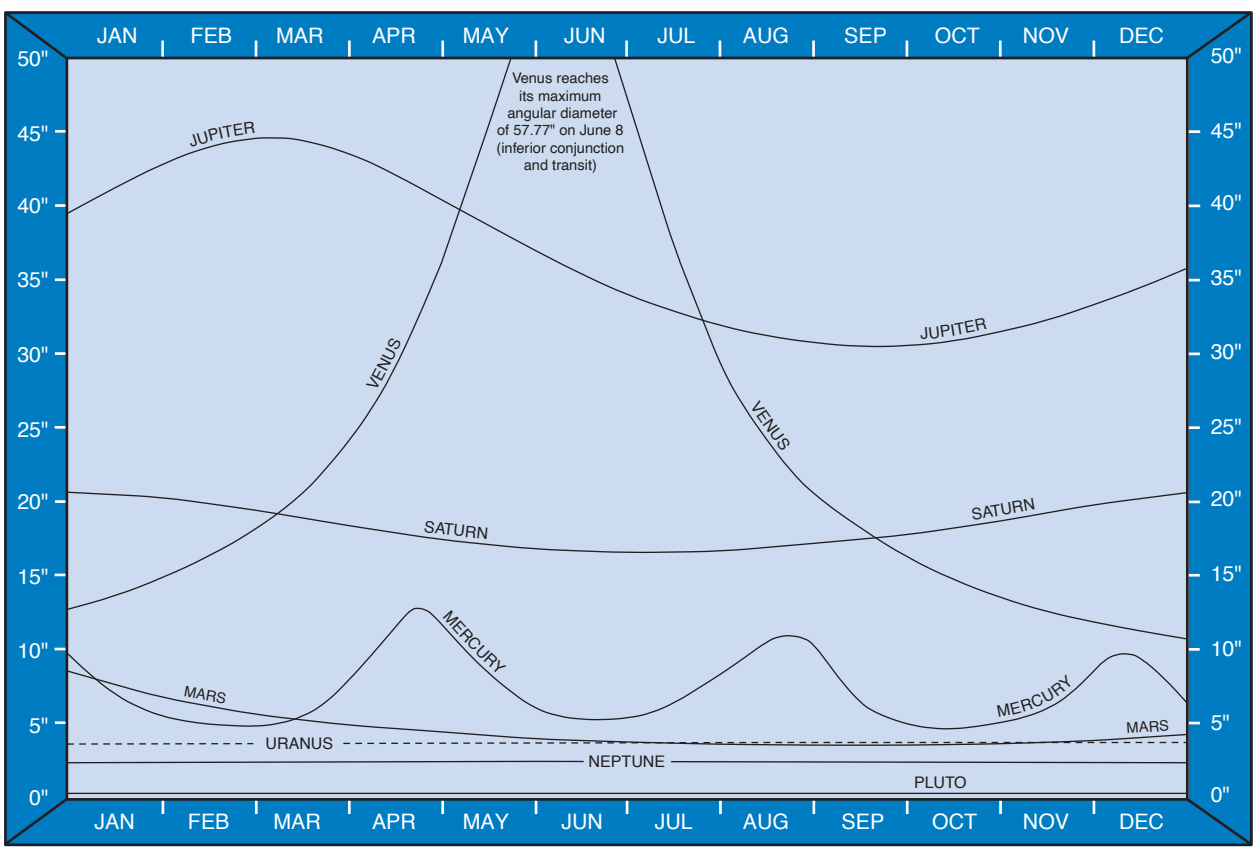
Because the orbits of the outer planets are inclined to that of the Earth's, the path can never be a straight line. It will always be a loop or an S-bend.

MAGNITUDES of the PLANETS and MAJOR ASTEROIDS



The magnitude plots for Mercury and Venus are not shown when the planets are near inferior conjunction, as they are too close to the Sun for observation.

PLANETARY ANGULAR SIZE



GEOCENTRIC PHENOMENA (UT)

Planet	Stationary	Greatest Elongation West	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction
Mercury	Jan 6, 14h	Jan 17, 10h (24°)	Mar 4, 2h	Mar 29, 12h (19°)	Apr 6, 21h	Apr 17, 1h
	Apr 29, 10h	May 14, 21h (26°)	Jun 18, 21h	Jul 27, 3h (27°)	Aug 9, 5h	Aug 23, 21h
	Sep 1, 18h	Sep 9, 14h (18°)	Oct 5, 19h	Nov 21, 1h (22°)	Nov 30, 13h	Dec 10, 8h
	Dec 20, 7h	Dec 29, 21h (22°)				
Venus				Mar 29, 17h (46°)	May 18, 0h	Jun 8, 9h
	Jun 29, 14h	Aug 17, 19h (46°)				
Planet	**Conjunction**	**Stationary**	**Opposition**	**Stationary**	**EARTH**	
Mars	Sep 15, 13h				Perihelion	Jan 4, 18h
Jupiter	Sep 22, 00h	Jan 4, 15h	Mar 4, 5h	May 5, 13h	Equinox	Mar 20 06:49
Saturn	Jul 8, 17h	Nov 8, 11h	Dec 31 2003	Mar 7, 15h	Solstice	Jun 21 00:57
Uranus	Feb 22, 2h	Jun 11, 0h	Aug 27, 19h	Nov 12, 2h	Aphelion	July 5, 11h
Neptune	Feb 2, 9h	May 17, 15h	Aug 6, 3h	Oct 24, 10h	Equinox	Sep 22 16:30
Pluto	Dec 13, 17h	Mar 24, 23h	Jun 11, 12h	Aug 31, 17h	Solstice	Dec 21 12:42

HELIOCENTRIC PHENOMENA (UT)

Planet	Aphelion	Perihelion	Greatest Latitude North	Descending Node	Greatest Latitude South	Ascending Node
Mercury	6-Feb	21-Mar	3-Jan	26-Jan	26-Feb	16-Mar
	4-May	17-Jun	31-Mar	23-Apr	24-May	12-Jun
	31-Jul	13-Sep	27-Jun	20-Jul	20-Aug	8-Sep
	27-Oct	10-Dec	23-Sep	16-Oct	16-Nov	5-Dec
	-	-	20-Dec	-	-	-
Venus	-	21-Mar	12-Apr	7-Jun	3-Aug	17-Feb
	12-Jul	1-Nov	23-Nov	-	-	28-Sep
Mars	7-Aug	-	1-Jul	-	-	-
Jupiter, Saturn, Uranus, Neptune and Pluto have no events in 2004						

SOLAR SYSTEM DATA – SUN, MOON AND THE PLANETS

NAME	MEAN DISTANCE FROM SUN (x 10^3 km)	(Earth = 1)	MAG at OPP	EQUATORIAL DIAMETER (km).	FLATTENING [1]	No of MOONS	MASS (x10^{24} kg)	(Earth = 1)
Sun	-		-26.8	1392530	0	-	1989085	332946
Moon	-		-12.74 [11]	3475	0	-	0.073483	0.0123
Mercury	57856	0.387	0.16 [12]	4879	0	0	0.33022	0.055
Venus	108132	0.723	-4.07 [12]	12104	0	0	4.8690	0.816
Earth	149492	1.000	-3.5 [13]	12756	0.00335364	1	5.9742	1.000
Mars	227780	1.524	-2.01	6794	0.006476	2	0.64191	0.107
Jupiter	777776	5.203	-2.70	142984	0.064874	61	1898.8	317.900
Saturn	1425983	9.540	0.67	120536	0.097962	31	568.50	95.200
Uranus	2867760	19.180	5.52	51118	0.022927	25	86.625	14.500
Neptune	4492800	30.700	7.84	49528	0.017081	13	102.78	17.400
Pluto	5745000	39.670	13.7	2302	0	1	0.015	0.003

NAME	VOLUME (Earth = 1)	SIDEREAL PERIOD [2]	SYNODIC PERIOD (days) [3]	AXIAL ROTATION (days) [4]	ALBEDO [5]	ECCEN-TRICITY [6]	INCLINATION [7]	OBLIQUITY [8]
Sun	1300000	-	-	25.38 [9]	-	-	-	7° 15' [10]
Moon	0.02	27.32 d	29.4	27.32166	0.12	0.0549	5° 08' 40"	6° 41'
Mercury	0.06	87.97 d	115.8	58.6462	0.106	0.20562	7° 00' 00"	0° 00'
Venus	0.86	224.7 d	583.9	-243.0187	0.65	0.00681	3° 23' 38"	92° 00'
Earth	1	365.256 d	-	0.99726968	0.367	0.01681	0° 00' 00"	23° 26'
Mars	0.15	687 d	779.8	1.02595675	0.150	0.09333	1° 51' 01"	25° 10'
Jupiter	1323	11.86 y	398.8	0.41354 [14]	0.52	0.04837	1° 18' 28"	3° 07'
Saturn	752	29.46 y	378.0	0.44401 [14]	0.47	0.05582	2° 29' 29"	26° 45'
Uranus	64	84.01 y	369.7	-0.71833	0.51	0.0471	0° 46' 22"	98° 00'
Neptune	54	164.8 y	367.5	0.67125	0.41	0.00855	1° 46' 38"	29° 00'
Pluto	0.007	249.9 y	366.7	-6.3872	0.30	0.2486	17° 09' 00"	118° 00'

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 (the polar areas of the Sun rotate in a period of 29 to 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 used as the reference point.

SOLAR SYSTEM DATA — SATELLITES

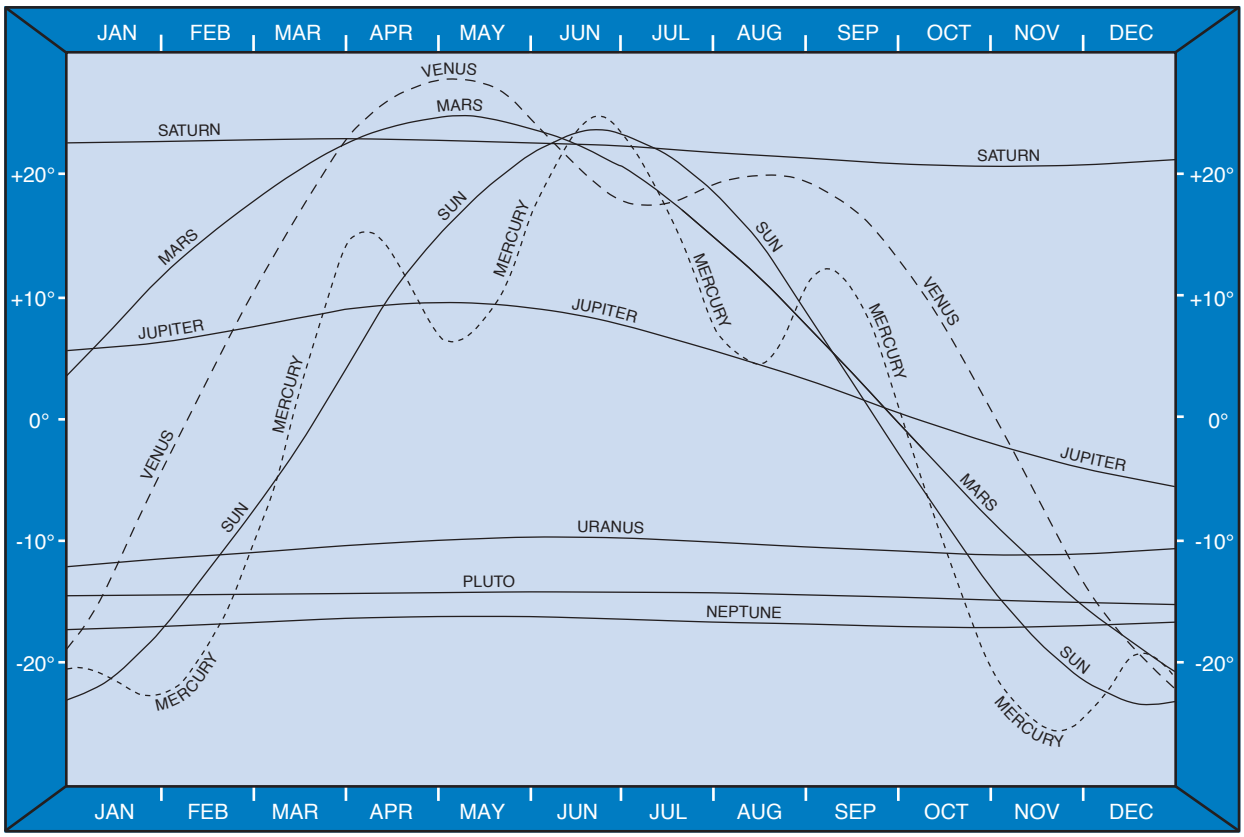
PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (x10³ km)	DIAMETER (km)	MAGNITUDE AT OPPOSITION
Earth	Moon	27.321661		384.400		-12.74
Mars	Phobos	0.31891023	25"	9.378		11.3
	Deimos	1.2624407	1' 02"	23.459		12.40
Jupiter	Metis	0.30	0' 42"	128	43	17.5
	Adrastea	0.30	0' 42"	129	16	18.7
	Amalthea	0.50	0' 59"	181	167	14.1
	Thebe	0.68	1' 13"	222	99	16.0
	Io	1.77	2' 18"	422	3,643	5.1
	Europa	3.55	3' 40"	671	3,122	5.3
	Ganymede	7.16	5' 51"	1,070	5,262	4.6
	Callisto	16.69	10' 18"	1,883	4,821	5.7
	Themisto	130.02		7,507	8	21.0
	Leda	240.92	1° 00' 39"	11,094	20	19.5
	Himalia	250.56	1° 02' 46"	11,480	170	14.6
	Lysithea	259.20	1° 04' 04"	11,720	36	18.3
	Elara	259.64	1° 04' 10"	11,737	86	16.3
	S/2000 J 11	286.95		12,555	4	22.4R
	S/2003 J 20	454.13		17,033	3	23.0R
	S/2003 J 3	490.45		17,929	2	23.4R
	S/2003 J 18	511.75		18,445	2	23.4R
	S/2003 J 12	536.23		19,028	1	23.9R
	S/2003 J 4	547.50		19,294	2	23.0R
	Euporie	550.67		19,302	2	23.1R
	S/2003 J 16	598.04		20,464	2	23.3R
	Orthosie	622.58		20,721	2	23.1R
	Euanthe	620.55		20,799	3	22.8R
	S/2003 J 21	613.40		20,813	2	23.3R
	S/2003 J 6	616.82		20,890	4	22.6R
	Thyone	627.26		20,940	4	22.3R
	S/2003 J 8	623.39		21,038	3	22.9R
	S/2003 J 10	625.16		21,078	2	23.6R
	Harpalyke	623.34		21,105	4	22.2
	Hermippe	633.91		21,131	4	22.1R
	Praxidike	625.30		21,147	7	21.2
	Ananke	629.77	1° 55' 52"	21,200	28	18.8
	Iocaste	631.49		21,269	5	21.8
	S/2003 J 15	678.19		22,253	2	23.5R
	Carme	734.17	2° 03' 31"	22,600	46	17.6
	S/2003 J 11	702.95		22,792	2	23.7R
	Eurydome	717.31		22,865	3	22.7R
	S/2003 J 17	708.81		22,918	2	23.4R
	S/2002 J 1	723.90		22,931	3	22.8R
	S/2003 J 9	713.51		23,020	1	23.7R
	S/2003 J 7	714.00		23,030	4	22.5R
	Autonoe	762.70		23,039	4	22.0R
	Pasithee	719.48		23,096	2	23.2R
	Chaldene	723.78		23,179	4	22.5
	Isonoe	725.52		23,217	4	22.5
	Kale	729.47		23,217	2	23.0R
	Aitne	730.22		23,231	3	22.7R
	Erinome	728.26		23,279	3	22.8
	S/2003 J 19	728.84		23,348	2	23.7R
	Taygete	732.24		23,360	5	21.9
	Sponde	748.33		23,487	2	23.0R
	Pasiphae	743.63	2° 08' 26"	23,500	60	17.0
	Kalyke	742.98		23,583	5	21.8
	S/2003 J 13	742.93		23,648	2	23.2R
	Sinope	758.90	2° 09' 31"	23,700	38	18.1
	S/2003 J 1	747.70		23,749	4	22.6R
	Megaclite	752.82		23,806	5	21.7
	S/2003 J 14	761.45		24,039	2	23.6R
	Callirrhoe	758.77		24,102	9	20.7
	S/2003 J 5	781.03		24,450	4	22.4R
	S/2003 J 2	889.20		26,658	2	23.2R
Saturn	Pan	0.58	0' 21"	134	20	19.4
	Atlas	0.60	0' 22"	138	32	19.0
	Prometheus	0.61	0' 23"	139	100	15.8
	Pandora	0.63	0' 23"	142	84	16.4
	Epimetheus	0.69	0' 24"	151	119	15.6
	Janus	0.70	0' 24"	152	178	14.4
	Mimas	0.94	0' 30"	186	397	12.8
	Enceladus	1.37	0' 38"	238	499	11.8
	Calypso	1.89	0' 48"	295	19	18.7
	Telesto	1.89	0' 48"	295	24	18.5
	Tethys	1.89	0' 48"	295	1,060	10.2
	Dione	2.74	1' 01"	377	1,118	10.4
	Helene	2.74	1' 01"	377	32	18.4
	Rhea	4.52	1' 25"	527	1,528	9.6
	Titan	15.95	3' 17"	1,222	5,150	8.4
	Hyperion	21.28	3' 59"	1,464	266	14.4
	Iapetus	79.33	9' 35"	3,561	1,436	11.0
	Kiviuq	449.22		11,365	14	22.0R
	Ijiraq	451.47		11,442	10	22.6R
	Phoebe	548.21	34' 51"	12,944	220	16.4
	Paaliaq	686.94		15,198	19	21.3R
	Skadi	728.18		15,641	6	23.6R
	Albiorix	783.47		16,394	26	20.5R
	Erriapo	871.25		17,604	9	23.0R
	Siarnaq	895.55		18,195	32	20.1R
	Tarvos	926.13		18,239	13	22.1R
	S/2003 S 1	956.19		18,719	7	24.0
	Mundilfari	951.56		18,722	6	23.8R
	Suttung	1,016.51		19,465	6	23.9R
	Thrym	1,091.76		20,219	6	23.9R
	Ymir	1,315.33		23,130	16	21.7R
Uranus	Cordelia	0.34	0' 04"	50	40	23.6
	Ophelia	0.38	0' 04"	54	43	23.3
	Bianca	0.44	0' 04"	59	51	22.5
	Cressida	0.46	0' 05"	62	80	21.6
	Desdemona	0.47	0' 05"	63	64	22.0
	Juliet	0.49	0' 05"	64	94	21.1
	Portia	0.51	0' 05"	66	135	20.4
	Rosalind	0.56	0' 05"	70	72	21.8
	S/2003 U 2	-		75	20	
	Belinda	0.62	0' 06"	75	81	21.5
	S/1986 U 10	0.64		76	40	
	Puck	0.76	0' 07"	86	162	19.8
	S/2003 U 1	-		98	20	
	Miranda	1.41	0' 10"	130	472	15.8
	Ariel	2.52	0' 14"	191	1,158	13.7
	Umbriel	4.14	0' 20"	266	1,097	14.5
	Titania	8.71	0' 33"	436	1,578	13.5
	Oberon	13.46	0' 44"	584	1,523	13.7
	Caliban	579.73	8' 56"	7,231	98	22.4
	Stephano	677.37		8,004	20	24.1
	Trinculo	759.03		8,578	-	25.4R
	Sycorax	1,288.28	15' 26"	12,179	190	20.8
	Prospero	1,977.29		16,243	30	23.2
	Setebos	2,234.77		17,501	30	23.3
	S/2001 U 2	2,823.40		21,000	24	
Neptune	Naiad	0.29	0' 02"	48	66	23.9
	Thalassa	0.31	0' 02"	50	82	23.3
	Despina	0.34	0' 02"	53	150	22.0
	Galatea	0.43	0' 03"	62	176	21.9
	Larissa	0.56	0' 03"	74	194	21.5
	Proteus	1.12	0' 06"	118	420	19.8
	Triton	5.88	0' 17"	355	2,707	13.5
	Nereid	360.14	4' 21"	5,513	340	19.7
	S/2002 N 1	1,874.83		15,686	48	25.0R
	S/2002 N 2	2,405.98		19,345	48	25.0R
	S/2002 N 3	2,674.87		20,723	48	25.0R
	S/2003 N 1	9,136.11		46,738	28	26.0R
	S/2002 N 4	9,007.10		47,280	120	
Pluto	Charon	6.39	<1"	19	1,186	17.3

The table covers the currently known satellites of the Solar System (as of October 2003). Note a number of the satellites above are recent discoveries and have not yet been named. Instead they have a preliminary designation such as S/2003 J 2.

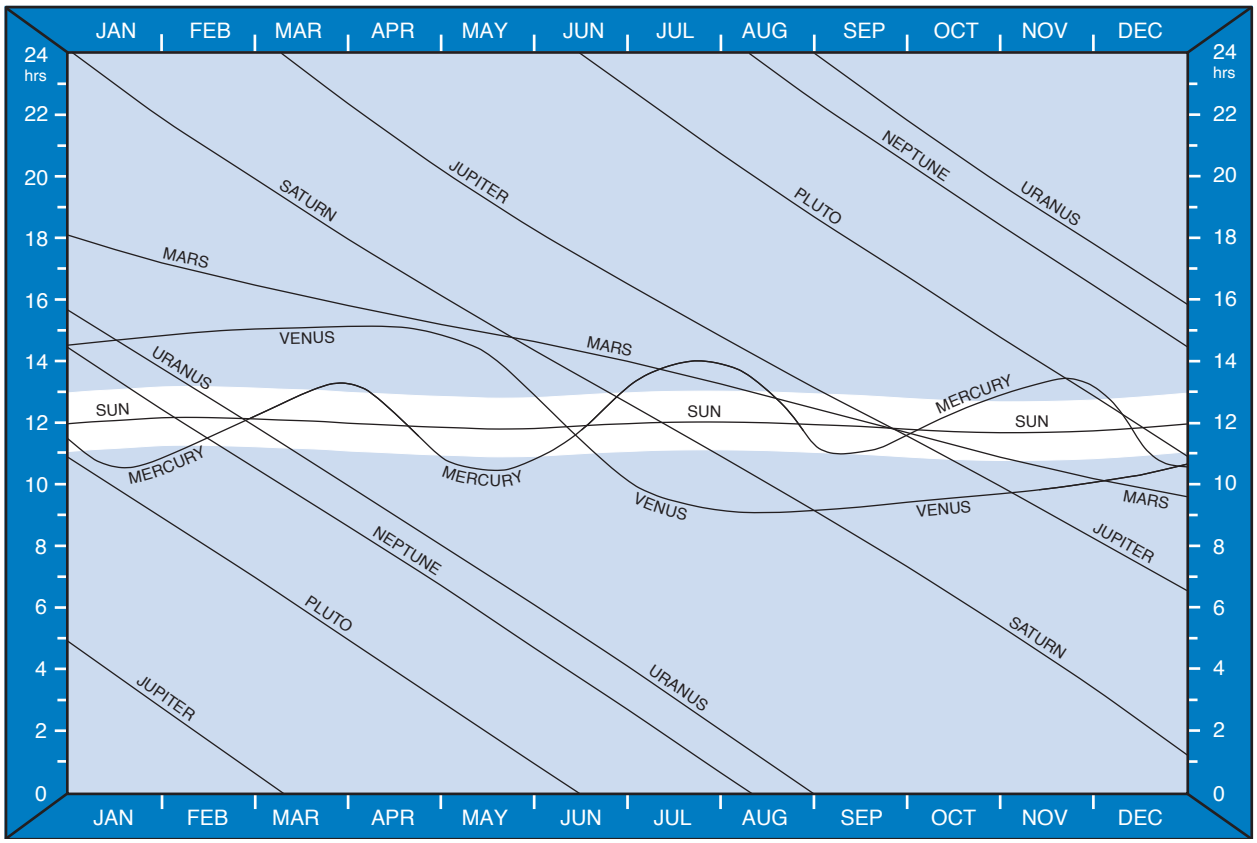
Note: magnitudes followed by R are red magnitudes.

DECLINATIONS of the SUN and PLANETS

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 (less prone to turbulence). This can be particularly relevant when trying to observe a planet under high magnification.



MERIDIAN PASSAGE of the SUN and PLANETS



The time of meridian passage for a planet is when it is due north and at its highest point in the sky. For the outer planets this is certainly looked upon as the best time to observe when you are looking through the least amount of atmosphere. The time for the Sun is close to midday (12hrs). When a planet crosses from the bottom of the diagram (0 hours) to the top (24 hours) it is at opposition and visible the whole night.

SUN

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	18 42 51	- 23 04 25	20 55 27	- 17 21 31	22 48 44	- 07 33 25	00 42 29	+ 04 34 09	02 33 56	+ 15 05 55	04 36 49	+ 22 03 45
2	18 47 16	- 22 59 40	20 59 32	- 17 04 35	22 52 28	- 07 10 33	00 46 08	+ 04 57 15	02 37 46	+ 15 23 55	04 40 55	+ 22 11 40
3	18 51 40	- 22 54 27	21 03 36	- 16 47 21	22 56 12	- 06 47 36	00 49 47	+ 05 20 16	02 41 36	+ 15 41 40	04 45 01	+ 22 19 13
4	18 56 04	- 22 48 47	21 07 39	- 16 29 49	22 59 56	- 06 24 33	00 53 26	+ 05 43 11	02 45 26	+ 15 59 09	04 49 07	+ 22 26 21
5	19 00 28	- 22 42 40	21 11 42	- 16 12 00	23 03 39	- 06 01 25	00 57 05	+ 06 05 59	02 49 17	+ 16 16 22	04 53 14	+ 22 33 06
6	19 04 52	- 22 36 06	21 15 43	- 15 53 54	23 07 22	- 05 38 12	01 00 44	+ 06 28 42	02 53 09	+ 16 33 19	04 57 21	+ 22 39 28
7	19 09 15	- 22 29 05	21 19 44	- 15 35 32	23 11 04	- 05 14 54	01 04 24	+ 06 51 18	02 57 01	+ 16 49 59	05 01 29	+ 22 45 26
8	19 13 37	- 22 21 37	21 23 44	- 15 16 54	23 14 46	- 04 51 32	01 08 03	+ 07 13 46	03 00 54	+ 17 06 23	05 05 37	+ 22 51 00
9	19 17 59	- 22 13 44	21 27 43	- 14 58 00	23 18 28	- 04 28 07	01 11 43	+ 07 36 08	03 04 47	+ 17 22 29	05 09 45	+ 22 56 10
10	19 22 21	- 22 05 24	21 31 42	- 14 38 52	23 22 09	- 04 04 37	01 15 24	+ 07 58 22	03 08 41	+ 17 38 19	05 13 53	+ 23 00 55
11	19 26 42	- 21 56 38	21 35 39	- 14 19 28	23 25 50	- 03 41 05	01 19 04	+ 08 20 28	03 12 36	+ 17 53 50	05 18 02	+ 23 05 17
12	19 31 02	- 21 47 26	21 39 36	- 13 59 50	23 29 30	- 03 17 30	01 22 45	+ 08 42 26	03 16 31	+ 18 09 04	05 22 11	+ 23 09 14
13	19 35 22	- 21 37 49	21 43 33	- 13 39 58	23 33 11	- 02 53 53	01 26 26	+ 09 04 15	03 20 27	+ 18 24 00	05 26 20	+ 23 12 47
14	19 39 41	- 21 27 47	21 47 28	- 13 19 53	23 36 51	- 02 30 14	01 30 08	+ 09 25 56	03 24 23	+ 18 38 37	05 30 29	+ 23 15 55
15	19 44 00	- 21 17 20	21 51 23	- 12 59 34	23 40 31	- 02 06 33	01 33 49	+ 09 47 27	03 28 20	+ 18 52 55	05 34 38	+ 23 18 39
16	19 48 18	- 21 06 29	21 55 17	- 12 39 03	23 44 10	- 01 42 51	01 37 32	+ 10 08 48	03 32 18	+ 19 06 54	05 38 48	+ 23 20 57
17	19 52 36	- 20 55 13	21 59 10	- 12 18 19	23 47 50	- 01 19 07	01 41 14	+ 10 30 00	03 36 16	+ 19 20 34	05 42 57	+ 23 22 51
18	19 56 52	- 20 43 33	22 03 03	- 11 57 24	23 51 29	- 00 55 24	01 44 57	+ 10 51 01	03 40 14	+ 19 33 54	05 47 07	+ 23 24 21
19	20 01 08	- 20 31 29	22 06 55	- 11 36 17	23 55 08	- 00 31 40	01 48 41	+ 11 11 51	03 44 14	+ 19 46 55	05 51 17	+ 23 25 25
20	20 05 24	- 20 19 02	22 10 46	- 11 14 59	23 58 47	- 00 07 56	01 52 24	+ 11 32 31	03 48 13	+ 19 59 34	05 55 26	+ 23 26 05
21	20 09 38	- 20 06 12	22 14 36	- 10 53 30	00 02 26	+ 00 15 47	01 56 09	+ 11 52 59	03 52 14	+ 20 11 54	05 59 36	+ 23 26 20
22	20 13 52	- 19 53 00	22 18 26	- 10 31 51	00 06 04	+ 00 39 29	01 59 53	+ 12 13 15	03 56 15	+ 20 23 53	06 03 46	+ 23 26 10
23	20 18 05	- 19 39 25	22 22 16	- 10 10 02	00 09 43	+ 01 03 10	02 03 38	+ 12 33 19	04 00 16	+ 20 35 30	06 07 55	+ 23 25 35
24	20 22 18	- 19 25 28	22 26 04	- 09 48 04	00 13 22	+ 01 26 48	02 07 24	+ 12 53 11	04 04 18	+ 20 46 47	06 12 05	+ 23 24 35
25	20 26 29	- 19 11 10	22 29 52	- 09 25 57	00 17 00	+ 01 50 25	02 11 10	+ 13 12 49	04 08 20	+ 20 57 42	06 16 14	+ 23 23 11
26	20 30 40	- 18 56 30	22 33 40	- 09 03 42	00 20 38	+ 02 13 59	02 14 56	+ 13 32 15	04 12 23	+ 21 08 15	06 20 23	+ 23 21 22
27	20 34 50	- 18 41 30	22 37 27	- 08 41 19	00 24 17	+ 02 37 30	02 18 43	+ 13 51 27	04 16 26	+ 21 18 26	06 24 32	+ 23 19 08
28	20 38 59	- 18 26 09	22 41 13	- 08 18 48	00 27 55	+ 03 00 58	02 22 31	+ 14 10 26	04 20 30	+ 21 28 15	06 28 41	+ 23 16 30
29	20 43 07	- 18 10 29	22 44 58	- 07 56 10	00 31 34	+ 03 24 22	02 26 19	+ 14 29 10	04 24 34	+ 21 37 41	06 32 50	+ 23 13 27
30	20 47 14	- 17 54 29			00 35 12	+ 03 47 42	02 30 07	+ 14 47 40	04 28 39	+ 21 46 45	06 36 58	+ 23 10 00
31	20 51 21	- 17 38 09			00 38 51	+ 04 10 58			04 32 44	+ 21 55 27		

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

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

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

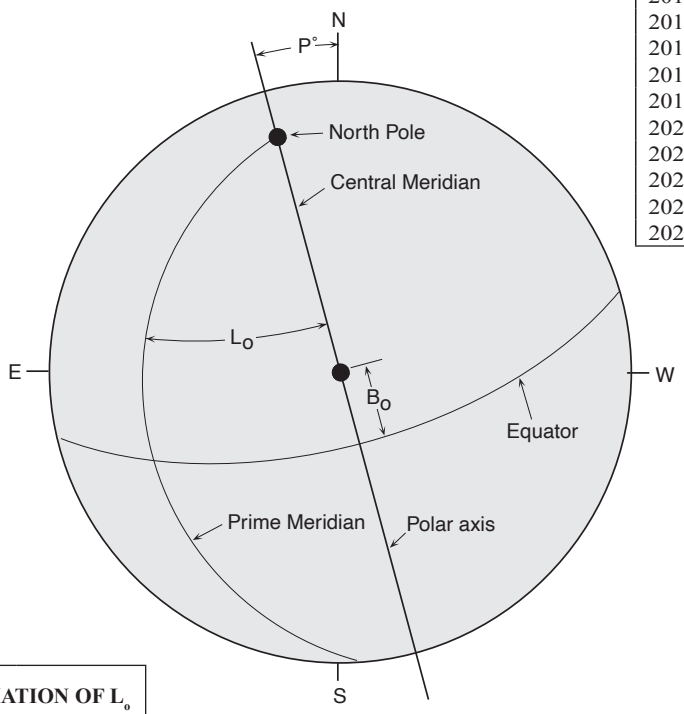
	HOBART (EST)				MELBOURNE (EST)				PERTH (WST)				SYDNEY (EST)				
	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	
	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	
Jan 3	2:23	4:37	19:53	22:07	3:08	5:02	19:46	21:39	3:36	5:15	19:26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

ORIENTATION OF THE SUN

Date		P°	B_o°	L_o°
Jan	3	+ 1.39	– 3.19	138.24
	10	– 1.99	– 3.97	046.05
	17	– 5.30	– 4.69	313.88
	24	– 8.49	– 5.34	221.71
	31	– 11.50	– 5.91	129.55
Feb	7	– 14.29	– 6.38	037.38
	14	– 16.84	– 6.76	305.21
	21	– 19.12	– 7.03	213.03
	28	– 21.10	– 7.20	120.84
Mar	6	– 22.79	– 7.25	028.62
	13	– 24.15	– 7.20	296.38
	20	– 25.19	– 7.04	204.12
	27	– 25.89	– 6.77	111.81
Apr	3	– 26.25	– 6.41	019.47
	10	– 26.25	– 5.96	287.09
	17	– 25.89	– 5.42	194.67
	24	– 25.17	– 4.81	102.22
May	1	– 24.09	– 4.14	009.72
	8	– 22.66	– 3.41	277.18
	15	– 20.89	– 2.63	184.62
	22	– 18.80	– 1.82	092.02
	29	– 16.42	– 0.99	359.41
Jun	5	– 13.79	– 0.14	266.77
	12	– 10.94	+ 0.70	174.12
	19	– 7.93	+ 1.53	081.46
	26	– 4.81	+ 2.35	348.81
Jul	3	– 1.64	+ 3.13	256.15
	10	+ 1.52	+ 3.86	163.50
	17	+ 4.64	+ 4.55	070.87
	24	+ 7.66	+ 5.18	338.26
	31	+ 10.54	+ 5.73	245.66
Aug	7	+ 13.25	+ 6.21	153.09
	14	+ 15.76	+ 6.61	060.55
	21	+ 18.05	+ 6.91	328.03
	28	+ 20.09	+ 7.12	235.54
Sep	4	+ 21.88	+ 7.23	143.07
	11	+ 23.38	+ 7.24	050.63
	18	+ 24.59	+ 7.15	318.21
	25	+ 25.49	+ 6.95	225.82
Oct	2	+ 26.06	+ 6.66	133.44
	9	+ 26.29	+ 6.26	041.08
	16	+ 26.16	+ 5.77	308.75
	23	+ 25.66	+ 5.20	216.42
	30	+ 24.77	+ 4.55	124.11
Nov	6	+ 23.51	+ 3.83	031.80
	13	+ 21.86	+ 3.04	299.52
	20	+ 19.84	+ 2.21	207.24
	27	+ 17.48	+ 1.35	114.98
Dec	4	+ 14.80	+ 0.46	022.72
	11	+ 11.85	– 0.44	290.49
	18	+ 8.68	– 1.33	198.26
	25	+ 5.38	– 2.20	106.05

SYNODIC ROTATION NUMBERS (UT)

Rotation	Month	d.dd
2012	Jan	13.50
2013	Feb	9.84
2014	Mar	8.18
2015	Apr	4.48
2016	May	1.74
2017	May	28.96
2018	Jun	25.16
2019	Jul	22.36
2020	Aug	18.58
2021	Sep	14.84
2022	Oct	12.12
2023	Nov	8.42
2024	Dec	5.73



VARIATION OF L_o

DAILY	
1	– 13.18
2	– 26.37
3	– 39.55
4	– 52.73
5	– 65.91
6	– 79.10
HOURLY	
1	– 0.55
2	– 1.10
3	– 1.65
4	– 2.20
5	– 2.75
6	– 3.30
7	– 3.84
8	– 4.39
9	– 4.94
10	– 5.49
11	– 6.04
12	– 6.59
13	– 7.14
14	– 7.69
15	– 8.24
16	– 8.79
17	– 9.34
18	– 9.89
19	– 10.43
20	– 10.98
21	– 11.53
22	– 12.08
23	– 12.63
24	– 13.18

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 Lo is zero; that is, the prime meridian passes through the central point of the disk.

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 Aug 20 at 2pm WST.

2pm WST is 6 hours UT (0 hr UT is 8am WST). From the table the value for Aug 20 (0 hr UT) is the value for Aug 14 (60.55°) plus 6 days which from the daily variation table is –79.10°. Then you add the value for 6 hours, which is –3.30°. The calculation becomes:

$$60.55° + (–79.10°) + (–3.30°) = –21.85°$$

If negative you need to add 360° so the result is 338.15° for Aug 20 @ 2pm WST.

SOLAR AND LUNAR ECLIPSES

During 2004 there are four eclipses, two of the Sun and two of the Moon. Both solar eclipses are partial and both lunar eclipses are total. Of the four eclipses, only the May total eclipse of the Moon will be visible from Australia, although not in its entirety.

Magnitudes quoted for lunar eclipses relate to the percentage of the lunar diameter that is either immersed in the Earth's umbral shadow (total and partial eclipses), or the penumbral shadow (penumbral eclipse). It is not a measure of brightness.

April 19th Partial eclipse of the Sun

The first eclipse of the year, a partial solar, is visible from southern Africa and parts of Antarctica. Greatest eclipse occurs at a point off the coast of Antarctica where the Moon will cover 74% of the Sun's diameter. The southern portion of Africa, below a line from Angola to Mozambique will witness a shallow eclipse. Further south near Cape Town, the Moon will cover about half of the solar disk.

	Time UT	Longitude	Latitude
Eclipse begins	11h29.9m	-49°58.4'	-69°34.3'
Greatest eclipse	13h33.9m	+49°13.5'	-61°43.5'
Eclipse ends	15h38.5m	+30°53.2'	-20°01.5'

October 14th Partial eclipse of the Sun

The second partial solar eclipse of the year is a northern hemisphere event. The Moon's penumbral shadow passes over northeastern Asia (including Japan, northeast Mongolia, China, and most of Siberia), the Pacific Ocean and parts of Alaska. The point of greatest eclipse is southwest of Anchorage, where the Moon will cover 93% of the Sun's diameter.

	Time UT	Longitude	Latitude
Eclipse begins	0h54.5m	+94°04.3'	+68°15.3'
Greatest eclipse	2h59.2m	-153°42.3'	+61°23.8'
Eclipse ends	5h04.2m	-171°40.6'	+14°15.1'

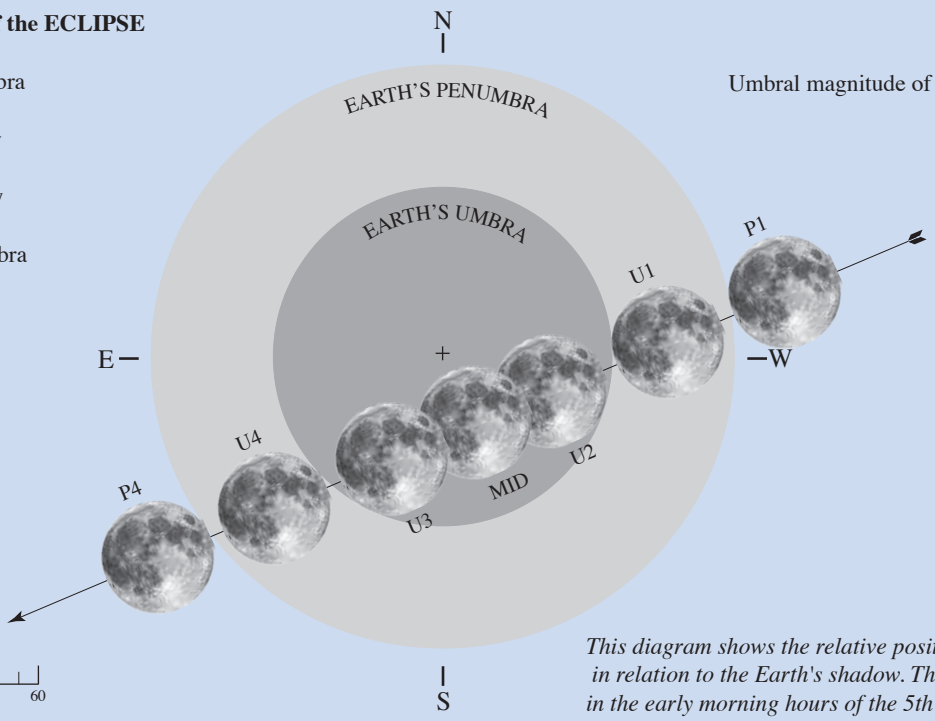
October 28th Total eclipse of the Moon

The last eclipse of the year and the second total lunar eclipse. Not visible from Australia, but observers from Western Europe, Africa, South America and portions of North America are favoured.

TOTAL LUNAR ECLIPSE of 5th May 2004

CIRCUMSTANCES of the ECLIPSE

P1: Moon enters penumbra
U1: Moon enters umbra
U2: Moon enters totality
MID: Mid eclipse
U3: Moon leaves totality
U4: Moon leaves umbra
P4: Moon leaves penumbra



This diagram shows the relative position of the Moon in relation to the Earth's shadow. The eclipse is visible in the early morning hours of the 5th May from Australia.

A morning eclipse for Australia (5th May). Unfortunately from the east coast only the mundane penumbral stages will be visible before the beginning of astronomical twilight. From the west coast the penumbral and most of the total phases can be seen prior to twilight. From Adelaide astronomical twilight begins at the beginning of totality with the Moon just immersed in the umbra. For those on the west coast, a large variation in brightness across the disk can be expected during totality, as the Moon does not pass centrally over the umbral shadow.

Time	UT (4th)	EST (5th)	WST (5th)
Moon enters penumbra	17h50.8m	03h50.8m	01h50.8m
Moon enters umbra	18h48.2m	04h48.2m	02h48.2m
Moon enters totality	19h52.0m	05h52.0m	03h52.0m
Middle of eclipse	20h30.1m	06h30.1m	04h30.1m
Moon leaves totality	21h08.3m	—	05h08.3m
Moon leaves umbra	22h12.1m	—	—
Moon leaves penumbra	23h09.5m	—	—

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

LUNAR OCCULTATIONS 2004

INTRODUCTION

An occultation is 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 from day to day. From just after New Moon to just before Full Moon, stars being occulted will 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 will disappear on the bright limb and reappear on the dark limb. There is no dark limb at the time of 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 2004 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, 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. For a single event, such as a normal occultation, a stop-watch and the telephone time signal as a reference are required. For multiple events, the amateur may tape record simultaneously a shortwave radio time signal with his own voice calling out the events (e.g., star gone … now!) The tape would be later played back (often at a slower speed) and the precise times determined. An accuracy of within 0.2 seconds is not unusual for the experienced observer.

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).

LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 7th 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
nnnnn or nnnnnn SAO catalogue number
X nnnnn USNO XZ catalogue number
name of planet, satellite or deep sky object.

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

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.

P.A. 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 become useless, and no values are recorded.

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 500km 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 'n' and 'p' are the **change** in longitude and latitude respectively (in decimal degrees).

'n' is positive (+) if east, negative (-) if west

'p' is positive (+) if north, negative (-) if south.

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 ZC3164 on August 1st for their location in Albury NSW (146° 55' E, 36° 05' S), see page 138. 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 — 'n' (-)

The change in latitude from Canberra (decimal degrees)

= 35°.25 - 36°.08 = –0°.83 — 'p' (–)

From the Canberra table, the time of the event is 21:34 EST and the values of A and B are +1.4 and +4.6 respectively.

Therefore the equation becomes:

21:34 + (1.4 * -2°.21) + (4.6 * -0°.83)

= 21:34 + (-3.1) + (-3.8)

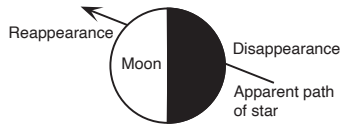
=

Th

ap

Ca

Au



Lunar occultation predictions were calculated using Win Occult version 3 by D. Herald, PO Box 254 Woden ACT 2606. heraldd@canberra.DIALix.oz.au

LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:34	525	DD	6.5	135	34	91	+2.8	+0.2
Jan 03 23:25	76070	DD	7.2	135	25	7	+1.6	+4.0
Jan 09 02:39	79987	RD	7.5	167	26	243	+3.1	+1.7
Jan 09 02:49	1232	RD	6.4	167	25	320	+1.2	-0.8
Jan 09 03:11	1233	RD	5.7	167	24	248	+2.7	+1.7
Jan 10 03:31	80615	RD	7.5	156	29	339	+0.6	-1.6
Jan 18 04:04	2282	DB	5.8	56	31	87	+0.8	-1.0
Jan 20 04:18	2605	RD	7.3	28	13	271	0.0	-1.0
Jan 30 22:36	489	DD	6.8	104	16	119	+1.2	+0.3
Jan 31 22:11	76499	DD	7.3	114	22	86	+2.0	+1.1
Jan 31 23:33	624	DD	6.8	115	11	81	+1.3	+1.4
Feb 01 23:58	762	DD	6.6	126	12	36	+2.2	+3.0
Feb 02 21:04	890	RB	4.6	136	28	268	+2.6	-0.1
Feb 02 21:11	77724	DD	7.0	136	27	69	+2.4	+0.5
Feb 02 23:36	77804	DD	7.3	136	21	112	+1.7	+0.3
Feb 03 00:46	909	DD	6.0	137	12	102	+1.2	+0.8
Feb 05 00:38	1181	DD	7.0	159	25	180	-1.3	-4.4
Feb 09 04:11	1647	RD	6.7	151	39	295	+1.6	-0.2
Feb 11 03:15	1864	RD	6.7	126	57	307	+1.6	-1.5
Feb 14 03:39	2230	RD	6.7	87	51	325	+0.5	-2.4
Feb 17 03:27	2721	DD	3.2	47	17	179	-4.1	-8.4
Feb 17 03:36	2721	RD	3.2	47	19	197	+4.2	+6.3
Feb 27 20:47	76283	DD	7.6	82	18	46	+1.7	+2.2
Feb 29 21:31	840	DD	6.3	104	20	32	+2.9	+3.2
Mar 01 21:21	996	DD	6.9	115	25	71	+2.6	+1.1
Mar 02 20:47	1119	DD	5.8	126	28	64	+2.7	+0.7
Mar 02 22:59	79402	DD	7.3	127	22	105	+1.8	+0.4
Mar 03 21:44	1252	DD	7.3	138	30	123	+2.1	-0.9
Mar 06 23:58	1598	DD	6.5	173	43	181	0.0	-3.0
Mar 07 20:45	1702	DB	4.0	172	17	132	+0.7	-2.0
Mar 07 21:53	1702	RD	4.0	171	30	291	+1.3	-1.6
Mar 09 04:00	1825	RD	5.9	157	45	274	+2.0	+0.7
Mar 10 02:59	1947	RD	7.0	145	62	304	+1.7	-1.1
Mar 11 00:28	2061	RD	7.7	132	45	8	-1.0	-4.0
Mar 11 01:54	2065	RD	6.5	132	60	332	+0.8	-2.4
Mar 11 22:21	2182	RD	6.2	120	12	356	-0.8	-2.8
Mar 12 23:23	2333	RD	7.4	106	15	348	-0.9	-2.6
Mar 13 01:13	184305	RD	7.5	105	37	220	+3.8	+2.7
Mar 13 04:41	2357	RD	6.8	104	76	360	-0.3	-6.5
Mar 14 04:45	185404	RD	7.5	91	69	279	+1.9	-1.0
Mar 16 03:42	188263	RD	7.7	65	32	339	-1.1	-5.2
Apr 01 20:22	1432	DD	6.7	129	33	46	+5.1	+3.0
Apr 03 21:59	1659	DD	6.7	154	45	167	+0.7	-2.4
Apr 06 20:02	1997	RD	6.9	166	16	331	-0.1	-2.1
Apr 07 03:46	2025	RD	6.8	163	50	357	+0.6	-3.7
Apr 07 20:12	2117	RD	5.2	153	11	270	+0.1	-1.1
Apr 07 20:17	2118	RD	2.8	153	12	266	+0.1	-1.0
Apr 07 22:58	2132	RD	7.3	151	44	268	+1.5	-1.0
Apr 08 03:07	2147	RD	6.9	150	69	308	+1.7	-1.2
Apr 08 23:13	2281	RD	7.1	137	38	358	-1.0	-3.7
Apr 09 23:28	2443	RD	5.7	123	31	356	-1.4	-4.0
Apr 09 23:41	2442	RD	5.9	123	33	321	-0.1	-2.2
Apr 10 01:53	2452	RD	6.7	122	60	268	+1.8	-0.7
Apr 10 02:14	2455	RD	6.6	122	64	290	+1.5	-1.4
Apr 10 23:52	186222	RD	7.5	110	24	303	-0.1	-1.7
Apr 11 04:40	2634	RD	7.2	108	80	251	+2.3	+0.7
Apr 11 23:45	187716	RD	7.2	96	12	259	0.0	-0.8
Apr 12 02:09	2805	RD	7.1	95	39	272	+0.9	-1.1
Apr 28 19:45	1389	DD	7.7	98	33	152	+1.1	-1.5
May 03 20:16	1947	DD	7.0	161	43	172	+0.1	-2.8
May 03 22:41	1951	DD	7.1	162	62	53	+6.8	+5.0
May 04 01:26	1962	DD	5.0	163	49	77	+2.3	+1.8
May 04 04:41	1973	DD	6.2	164	12	125	+0.3	0.0
May 05 23:44	2214	RD	6.3	170	69	274	+2.1	-0.6
May 06 03:34	2228	RD	5.8	168	53	248	+1.6	+2.1
May 06 19:29	184381	RD	5.7	157	10	270	-0.1	-1.0
May 06 19:29	2359	RD	5.0	157	10	270	-0.1	-1.0
May 08 01:53	185716	RD	7.4	140	74	285	+1.9	-1.0
May 08 03:08	2558	RD	6.3	140	82	302	+2.0	-1.5
May 08 04:13	2564	RD	7.0	139	73	291	+2.1	-0.5
May 08 05:50	2575	RD	6.9	139	54	243	+1.1	+1.9
May 08 21:35	2721	DB	3.2	128	11	74	+0.1	-0.6
May 08 22:25	2721	RD	3.2	128	21	300	-0.2	-1.7
May 09 00:03	187318	RD	7.7	127	40	296	+0.5	-1.8
May 09 00:53	187363	RD	7.2	127	50	297	+0.9	-1.9
May 12 02:52	3214	RD	6.8	86	34	238	+1.1	+0.1
May 13 05:48	3356	DB	5.8	72	55	4	+0.6	+3.7
May 25 19:15	80615	DD	7.5	67	25	92	+2.1	+0.8
May 30 20:37	139195	DD	7.7	129	60	145	+1.2	-1.9
May 31 00:13	1903	DD	7.7	130	37	90	+1.4	+1.1
May 31 01:51	139272	DD	7.6	131	18	134	+0.5	-0.4
May 31 20:33	2013	DD	7.6	142	61	56	+5.3	+2.9
Jun 01 18:40	2132	DD	7.3	155	36	147	+0.1	-2.2
Jun 01 22:25	2147	DD	6.9	157	73	107	+2.0	-0.8
Jun 02 18:35	2281	DD	7.1	169	25	71	+0.8	-0.6
Jun 02 20:53	184043	DD	7.2	170	53	53	+3.2	+1.4
Jun 03 18:37	2443	RD	5.7	176	16	307	-0.3	-1.6
Jun 04 21:35	2650	DB	4.7	160	38	59	+1.4	0.0
Jun 04 22:24	2650	RD	4.7	160	47	322	+0.3	-2.8
Jun 04 22:30	186606	RD	7.2	160	49	254	+1.5	-0.4
Jun 04 23:42	186671	RD	7.3	159	63	262	+1.8	-0.4
Jun 06 21:39	2985	RD	6.8	132	13	266	0.0	-0.9
Jun 07 02:54	3018	RD	6.4	130	73	209	+1.6	+2.8
Jun 08 00:31	3164	DB	4.5	117	32	70	+0.9	-0.4
Jun 08 01:42	3164	RD	4.5	117	46	254	+1.4	-0.4
Jun 08 01:58	164528	RD	7.5	116	50	296	+1.7	-2.7
Jun 08 03:49	164567	RD	7.3	116	69	302	+3.3	-3.3
Jun 08 03:55	3175	DB	4.7	116	70	56	+1.8	+1.1
Jun 08 05:17	3175	RD	4.7	115	73	244	+1.9	+1.3
Jun 09 00:46	3304	RD	6.4	104	22	201	+0.8	+1.8
Jun 10 01:30	3434	RD	7.5	91	19	219	+0.5	+0.7
Jun 10 02:44	X185486	RD	7.6	91	33	187	+0.6	+3.0
Jun 10 02:44	3446	RD	7.2	91	33	188	+0.6	+3.0
Jun 11 01:51	13	RD	6.2	79	11	275	+0.4	-1.5
Jun 11 02:28	128618	RD	6.8	79	18	201	+0.4	+1.6
Jun 12 05:27	109568	RD	7.6	66	38	249	+1.6	-0.1
Jun 23 19:34	1532	DD	7.6	61	25	185	-0.9	-3.3
Jun 25 20:41	1741	DD	7.1	85	37	75	+2.5	+2.3
Jun 28 00:04	1973	DD	6.2	112	25	83	+0.8	+1.5
Jun 29 19:44	2214	DD	6.3	137	65	111	+1.6	-1.3
Jun 29 23:51	2228	DD	5.8	139	55	129	+1.6	-0.8
Jul 01 03:22	184678	DD	7.6	154	27	95	+0.5	+0.9
Jul 01 21:44	185716	DD	7.4	166	67	101	+1.7	-1.0
Jul 01 23:00	2558	DD	6.3	167	80	80	+2.2	+0.3
Jul 01 23:59	2564	DD	7.0	167	79	88	+2.1	+0.3
Jul 02 01:48	2575	DD	6.9	168	59	133	+2.1	-1.4
Jul 02 17:49	2721	DB	3.2	176	10	101	-0.3	-1.1
Jul 02 18:41	2721	RD	3.2	176	19	273	+0.1	-1.1
Jul 05 03:00	3106	DB	5.2	148	75	7	+0.3	+4.3
Jul 05 03:46	3106	RD	5.2	147	69	295	+3.2	-1.1
Jul 05 05:28	3116	RD	6.6	147	50	278	+1.8	+0.7
Jul 06 00:18	3243	RD	7.3	135	44	225	+1.3	+0.8
Jul 06 04:04	3265	RD	6.6	134	70	193	+0.5	+3.2
Jul 10 03:33	214	RD	6.2	84	30	202	+0.4	+1.5
Jul 13 06:04	76283	RD	7.6	50	21	250	+1.3	-0.4
Jul 22 18:29	1709	DD	6.6	55	37	113	+1.5	0.0
Jul 25 22:16	X 37784	DD	7.4	94	33	93	+1.0	+1.1
Jul 26 21:21	2171	DD	6.5	107	57	136	+1.6	-1.3
Jul 26 22:30	159116	DD	7.2	107	43	59	+1.3	+3.1
Jul 27 01:08	2189	DD	7.1	108	13	110	+0.2	+0.5
Jul 28 01:57	184337	DD	7.0	122	16	82	0.0	+1.3
Jul 28 21:03	2478	DD	7.6	134	81	141	+1.7	-2.6
Jul 28 21:20	2479	DD	5.1	134	81	162	+1.5	-4.9
Jul 28 21:21	2480	DD	5.2	134	81	162	+1.5	-5.0
Jul 28 21:33	2482	DD	6.3	134	80	134	+1.9	-2.0
Jul 28 21:59	2480	RB	5.2	134	75	218	+2.3	+4.6
Jul 28 22:00	2479	RB	5.1	134	75	219	+2.3	+4.5
Jul 28 22:25	2488	DD	6.9	135	71	142	+2.1	-2.3
Jul 28 23:42	185282	DD	7.1	135	56	109	+1.7	+0.1
Jul 29 00:07	185305	DD	7.5	135	51	97	+1.4	+0.6
Jul 29 02:31	185404	DD	7.5	136	23	65	0.0	+1.7
Jul 29 19:33	186671	DD	7.3	147	56	95	+1.4	-1.0
Aug 01 20:49	3164	RB	4.5	168	31	179	+1.9	+6.6
Aug 01 21:35	164528	RD	7.5	168	40	235	+1.2	+0.3
Aug 01 23:14	3175	DB	4.7	167	59	105	+2.1	-1.7
Aug 01 23:19	164567	RD	7.3	167	60	246	+1.8	+0.3
Aug 02 00:13	3175	RD	4.7	167	69	202	+1.2	+2.7
Aug 02 03:09	164637	RD	7.5	166	60	274	+2.2	+0.6
Aug 03 02:50	165243	RD	7.4	153	66	205	+0.9	+2.4
Aug 06 01:03	167	RD	5.5	115	28	196	+0.2	+1.8
Aug 07 01:03	284	RD	7.1	104	16	223	+0.4	+0.5
Aug 07 04:48	290	RD	6.1	102	43	209	+1.1	+1.7
Aug 08 03:32	407	RD	7.2	91	28	177	-0.8	+3.0
Aug 20 18:43	1891	RB	4.4	51	37	339	+0.7	-1.9
Aug 23 22:06	2274	DD	6.9	91	36	162	+1.7	-3.0
Aug 24 00:17	2290	DD	2.3	92	11	74	-0.2	+1.5
Aug 24 19:46	2424	DD	6.9	103	76	73	+2.3	+1.2
Aug 24 20:57	2427	DD	7.2	103	63	103	+1.9	+0.2
Aug 24 23:08	184849	DD	7.4	104	37	138	+1.5	-0.9
Aug 26 00:31	186271	DD	7.3	118	34	117	+1.1	+0.2
Aug 26 21:23	187672	DD	7.4	131	81	94	+2.2	0.0
Aug 26 23:14	2796	DD	6.9	131	61	91	+1.7	+0.7
Aug 27 01:15	2805	DD	7.1	132	37	96	+0.9	+0.9
Aug 27 20:30	2939	DD	7.5	144	68	112	+2.0	-1.8
Aug 28 22:59	3106	DD	5.2	159	76	17	+0.9	+3.4
Aug 29 00:36	3116	DD	6.6	159	65	30	+0.8	+2.6
Aug 30 23:17	146509	RD	7.1	172	58	259	+2.1	-0.1
Sep 01 01:08	147015	RD	7.1	159	57	226	+1.5	+1.4
Sep 01 22:57	109427	RD	7.7	148	30	283	+1.8	-2.1
Sep 05 00:52	465	RD	4.4	111	15	222	+0.3	+0.4
Sep 06 02:52	598	RD	5.5	99	22	272	+2.0	-1.1
Sep 18 19:14	2091	DD	7.7	47	32	61	+0.8	+3.0
Sep 18 19:30	158720	DD	7.2	47	29	51	+0.5	+4.0
Sep 22 00:03	2558	DD	6.3	88	15	24	-1.2	+3.2
Sep 22 20:42	2723	DD	6.6	100	66	49	+1.3	+2.4
Sep 22 23:28	187363	DD	7.2	101	33	31	-0.4	+2.8
Sep 24 23:44	3062	DD	7.5	128	51	38	+0.5	+2.3
Sep 25 19:14	3191	DD	7.4	140	53	43	+1.5	+1.2
Sep 25 20:06	164674	DD	7.6	140	62	119	+2.8	-3.1
Sep 26 19:34	165243	DD	7.4	153	43	50	+1.3	+0.6
Sep 27 00:34	165316	DD	7.6	155	55	53	+1.3	+1.8
Sep 29 23:49	184	RD	6.0	167	45	197	+0.6	+2.0
Sep 30 21:42	290	RD	6.1	155	17	208	+0.2	+1.0
Oct 03 01:00	76088	RD	7.4	131	25	282	+2.5	-1.5
Oct 03 03:43	76156	RD	6.9	130	32	258	+2.5	+0.6
Oct 07 04:14	79295	RD	7.2	86	19	285	+2.1	-1.3
Oct 09 04:26	80615	RD	7.5	64	12	264	+1.1	-1.1
Oct 17 20:04	2347	DD	4.6	43	23	67	+0.1	+1.8
Oct 17 20:54	2347	RB	4.6	43	13	305	+0.4	+0.1
Oct 22 22:39	164516	DD	6.9	111	49	13	-0.1	+3.0
Oct 23 23:09	165149	DD	7.7	124	50	108	+2.6	+0.2
Oct 25 01:58	3449	DD	7.3	138	22	59	+0.4	+1.8
Oct 29 23:28	486	RD	5.3	163	30	272	+2.4	-0.8
Nov 01 02:31	773	RD	7.0	139	28	251	+2.4	+0.4
Nov 02 01:37	77883	RD	7.6	128	21	264	+2.0	-0.6
Nov 02 03:40	77949	RD	7.5	128	26	306	+2.7	-1.0
Nov 10 11:33	Venus	DB	-4.0	34	52	144	+1.3	-1.6
Nov 10 12:55	Venus	RD	-4.0	33	38	295	+1.4	0.0
Nov 15 20:35	186361	DD	7.2	39	17	150	+1.6	-1.6
Nov 18 20:05	3116	DD	6.6	79	55	14	0.0	+3.2
Nov 19 20:36	164948	DD	7.2	93	56	20	+0.4	+2.7
Nov 19 22:13	3271	DD	7.2	93	37	10	-0.3	+2.9
Nov 20 20:23	146509	DD	7.1	105	61	93	+2.8	+0.4
Dec 08 02:54	1891	RD	4.4	58	10	222	+1.3	+2.1
Dec 20 20:40	180	RB	5.2	111	45	256	+2.3	+1.0
Dec 21 20:58	299	DD	6.0	123	41	60	+2.0	+1.2
Dec 23 22:56	76088	DD	7.4	146	30	112	+2.9	-0.2
Dec 24 01:23	76156	DD	6.9	147	13	89	+1.3	+1.2
Dec 28 00:36	1103	RD	5.8	168	27	242	+2.7	+0.6
Dec 29 01:45	1232	RD	6.4	157	29	243	+3.2	+0.9

LUNAR OCCULTATION TABLE

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 22:47	525	DD	6.5	135	32	90	+2.4	+0.8
Jan 09 04:12	1233	RD	5.7	167	18	296	+0.9	0.0
Jan 29 20:24	374	DD	6.0	92	33	114	+2.7	-0.2
Jan 30 21:13	93394	DD	6.9	103	29	39	+1.9	+2.5
Jan 31 23:17	76499	DD	7.3	114	13	64	+1.4	+1.8
Feb 01 20:16	745	DD	7.3	124	37	88	+3.0	+0.2
Feb 02 20:35	890	DD	4.6	135	35	68	+2.7	+0.6
Feb 02 22:13	890	RB	4.6	136	32	282	+2.6	+0.1
Feb 02 22:29	77724	DD	7.0	136	31	52	+3.0	+2.0
Feb 02 23:43	77753	DD	7.2	136	22	154	+0.2	-2.4
Feb 03 00:35	77804	DD	7.3	136	14	77	+1.5	+1.4
Feb 05 01:07	1181	DD	7.0	159	26	125	+1.2	-0.4
Feb 08 22:32	99505	RD	7.5	153	29	275	+1.6	-1.1
Feb 11 03:44	1864	RD	6.7	126	65	360	0.0	-3.6
Feb 14 01:25	2217	RD	5.5	88	30	261	+1.0	-0.7
Feb 17 03:28	2721	DB	3.2	48	20	115	-0.1	-1.5
Feb 17 04:26	2721	RD	3.2	47	32	263	+0.9	-0.6
Feb 24 19:31	214	DD	6.2	48	16	123	+1.0	-0.5
Feb 27 20:07	566	DD	6.1	82	25	94	+1.9	+0.8
Feb 27 20:28	563	DD	7.0	82	21	16	+2.2	+4.3
Feb 28 19:26	703	DD	6.2	92	33	106	+2.8	0.0
Mar 03 00:07	79402	DD	7.3	127	15	56	+2.5	+2.7
Mar 03 22:46	1252	DD	7.3	138	34	88	+2.7	+0.6
Mar 07 00:28	1598	DD	6.5	173	50	130	+1.7	-1.2
Mar 07 21:16	1702	DB	4.0	172	32	110	+1.4	-1.5
Mar 07 22:30	1702	RD	4.0	172	45	322	+1.3	-2.1
Mar 09 01:27	138889	RD	7.2	159	63	276	+2.9	-0.3
Mar 09 02:35	1821	DB	2.8	158	59	164	+0.7	-2.5
Mar 09 02:35	X 54027	DB	3.5	158	59	164	+0.7	-2.5
Mar 09 03:40	1821	RD	2.8	158	48	276	+2.1	+0.5
Mar 09 03:40	X 54027	RD	3.5	158	48	276	+2.1	+0.4
Mar 09 04:48	1825	RD	5.9	157	35	319	+0.9	-1.0
Mar 10 03:31	1947	RD	7.0	145	62	357	+0.3	-3.6
Mar 11 22:18	2173	RD	6.9	120	16	263	+0.4	-0.7
Mar 11 23:13	2181	RD	6.8	120	28	245	+1.4	0.0
Mar 13 02:08	184305	RD	7.5	105	55	283	+1.5	-1.2
Mar 13 03:54	184337	RD	7.0	105	77	262	+2.8	+0.1
Mar 30 18:25	1189	DD	5.0	105	35	94	+2.8	-0.4
Mar 30 20:02	1189	RB	5.0	105	34	299	+2.2	-0.6
Apr 03 22:36	1659	DD	6.7	154	54	121	+2.0	-1.1
Apr 04 02:02	1669	DD	6.7	155	28	190	-0.9	-4.3
Apr 07 19:46	2118	DB	2.8	153	10	123	-0.2	-1.4
Apr 07 20:34	2117	RD	5.2	153	20	299	+0.2	-1.5
Apr 07 20:40	2118	RD	2.8	153	22	295	+0.2	-1.4
Apr 07 23:36	2132	RD	7.3	151	60	312	+1.1	-1.9
Apr 08 00:59	2136	RD	6.6	151	76	265	+2.9	0.0
Apr 08 03:38	2147	RD	6.9	150	62	0	+0.7	-5.5
Apr 09 01:36	2290	DB	2.3	137	75	164	+0.5	-3.6
Apr 09 02:32	2290	RD	2.3	136	85	251	+3.2	+1.2
Apr 09 03:47	184045	RD	7.3	136	74	279	+2.4	-0.1
Apr 10 02:37	2452	RD	6.7	122	76	314	+1.6	-2.3
Apr 10 02:45	2455	RD	6.6	122	78	341	+0.9	-4.3
Apr 11 01:04	186271	RD	7.3	109	43	219	+3.1	+2.5
Apr 12 00:06	187716	RD	7.2	97	18	300	-0.2	-1.6
Apr 12 00:47	2796	RD	6.9	96	27	247	+0.9	-0.1
Apr 12 02:37	2805	RD	7.1	95	49	318	+0.7	-3.2
Apr 15 02:51	3243	RD	7.3	57	14	313	-0.3	-3.6
Apr 25 19:18	1026	DD	6.5	64	19	95	+1.6	+0.7
May 02 22:38	1825	DD	5.9	148	62	145	+1.3	-1.8
May 03 20:40	1947	DD	7.0	161	56	128	+1.4	-1.8
May 04 18:53	2065	DD	6.5	174	26	102	+0.6	-1.2
May 06 00:31	2214	RD	6.3	170	82	322	+1.6	-2.2
May 06 04:33	2228	RD	5.8	168	35	274	+1.0	+0.7
May 06 19:46	2357	RD	6.8	157	17	297	-0.1	-1.3
May 06 19:46	184383	RD	7.3	157	17	311	-0.2	-1.6
May 06 19:49	184381	RD	5.7	157	18	303	-0.1	-1.4
May 06 19:49	2359	RD	5.0	157	18	303	-0.1	-1.4
May 07 20:09	2524	RD	6.0	143	10	288	-0.2	-1.1
May 08 02:38	185716	RD	7.4	140	87	326	+2.1	-3.3
May 08 03:49	2558	RD	6.3	140	73	343	+3.0	-7.4

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 08 05:08	2564	RD	7.0	139	56	310	+2.3	-1.3
May 08 23:03	2723	RD	6.6	128	32	236	+1.4	+0.4
May 12 03:41	3214	RD	6.8	86	51	265	+1.9	-0.6
May 17 05:13	92688	RD	6.8	26	10	227	+0.2	+0.5
May 24 18:11	1232	DD	6.4	56	27	112	+1.6	0.0
May 27 22:52	1569	DD	6.9	91	11	163	-0.2	-1.7
Jun 01 17:19	2118	RB	2.8	154	25	304	+0.2	-1.6
Jun 01 19:06	2132	DD	7.3	155	48	108	+1.2	-1.3
Jun 01 20:34	2136	DD	6.6	156	67	154	+0.7	-2.6
Jun 02 21:28	2290	DB	2.3	170	68	185	-1.2	-5.7
Jun 02 21:58	2290	RB	2.3	170	75	232	+4.5	+3.1
Jun 02 22:04	184045	DD	7.3	170	75	141	+1.3	-2.3
Jun 03 18:54	2442	RD	5.9	176	23	322	-0.3	-2.0
Jun 03 21:09	2455	RD	6.6	175	51	294	+1.1	-1.5
Jun 04 21:25	2634	RD	7.2	160	41	229	+2.1	+1.1
Jun 04 23:15	186606	RD	7.2	160	64	297	+1.6	-1.7
Jun 05 00:34	186671	RD	7.3	159	81	300	+2.1	-1.7
Jun 06 00:43	2848	RD	5.6	145	68	206	+2.6	+4.2
Jun 06 21:56	2985	RD	6.8	132	19	312	-0.3	-2.5
Jun 06 21:58	2984	RD	7.1	132	20	271	+0.3	-0.9
Jun 07 04:05	3018	RD	6.4	130	80	219	+1.5	+2.4
Jun 08 01:23	3164	DB	4.5	117	49	38	+1.6	+1.6
Jun 08 02:34	3164	RD	4.5	117	65	276	+2.5	-1.0
Jun 08 03:17	164544	RD	7.3	116	73	201	+1.4	+3.1
Jun 08 04:55	164567	RD	7.3	116	78	304	+5.1	-3.4
Jun 08 05:03	3175	DB	4.7	116	78	56	+1.8	+1.7
Jun 09 01:38	3304	RD	6.4	104	40	234	+1.3	+0.6
Jun 10 00:11	3425	RD	4.4	92	8	223	+0.3	+0.7
Jun 10 03:44	3446	RD	7.2	91	53	203	+1.1	+2.3
Jun 11 01:59	12	RD	6.4	79	19	298	+1.0	-3.2
Jun 11 02:11	13	RD	6.2	79	22	312	+1.8	-6.9
Jun 11 03:17	128618	RD	6.8	79	35	218	+0.9	+1.2
Jun 13 03:57	110063	RD	7.3	55	20	182	-0.4	+3.0
Jun 29 18:12	2207	DD	7.0	136	55	166	-0.1	-3.1
Jun 29 20:58	2214	DD	6.3	137	82	45	+6.1	+7.2
Jun 30 00:40	2228	DD	5.8	139	38	104	+1.2	+0.4
Jul 01 22:48	185716	DD	7.4	166	87	59	+2.7	+1.8
Jul 02 00:13	2558	DD	6.3	167	73	46	+1.9	+3.0
Jul 02 01:05	2564	DD	7.0	167	62	67	+1.6	+1.6
Jul 02 02:39	2575	DD	6.9	168	42	123	+1.7	-0.5
Jul 02 18:16	2721	DD	3.2	176	17	59	+0.7	+0.1
Jul 02 19:00	2721	RD	3.2	176	26	317	-0.2	-2.2
Jul 05 04:53	3106	RD	5.2	147	52	283	+2.2	+0.2
Jul 05 21:52	164829	RD	7.1	137	20	281	+0.4	-1.4
Jul 05 21:52	3228	RD	7.2	137	20	281	+0.4	-1.4
Jul 06 01:17	3243	RD	7.3	135	64	242	+2.0	+0.7
Jul 06 05:01	3265	RD	6.6	134	61	178	-0.6	+4.0
Jul 07 04:28	146509	DD	7.1	121	70	335	-3.8	+8.0
Jul 07 04:50	146509	RD	7.1	121	68	303	+7.1	-4.0
Jul 10 04:24	214	RD	6.2	84	47	196	+0.5	+2.3
Jul 12 04:03	442	RD	6.7	62	23	190	-0.4	+2.3
Jul 13 05:06	566	RD	6.1	50	23	218	+0.5	+0.9
Jul 13 05:08	563	RD	7.0	50	23	290	+2.6	-2.2
Jul 13 05:27	76254	RD	7.3	50	26	289	+2.8	-2.1
Jul 20 18:36	1499	DD	7.1	32	12	90	+0.9	+1.0
Jul 25 23:07	X 37784	DD	7.4	94	16	64	+0.2	+2.3
Jul 26 22:11	2171	DD	6.5	107	42	106	+1.4	+0.2
Jul 28 22:02	2479	DD	5.1	134	71	121	+2.3	-1.1
Jul 28 22:02	2480	DD	5.2	134	71	121	+2.3	-1.1
Jul 28 22:27	2482	DD	6.3	134	66	104	+2.2	-0.1
Jul 28 23:14	2479	RB	5.1	134	55	248	+1.5	+1.7
Jul 28 23:14	2480	RB	5.2	134	55	248	+1.5	+1.7
Jul 28 23:16	2488	DD	6.9	134	55	117	+2.0	-0.5
Jul 29 00:35	185282	DD	7.1	135	38	99	+1.1	+0.5
Jul 29 18:56	2643	DD	6.7	147	55	146	+0.5	-3.2
Jul 29 19:12	186606	DD	7.2	147	58	57	+2.4	+1.0
Jul 29 20:34	186671	DD	7.3	147	76	51	+2.7	+2.0
Aug 01 20:50	3164	DB	4.5	168	36	95	+1.1	-1.1
Aug 01 21:56	3164	RD	4.5	168	51	225	+1.6	+1.2
Aug 02 00:13	3175	DB	4.7	167	78	93	+2.8	-0.4

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 02 00:22	164567	RD	7.3	167	80	255	+2.4	+0.6
Aug 02 01:20	3175	RD	4.7	167	79	203	+0.9	+2.9
Aug 03 03:34	3327	RD	6.8	153	60	298	+4.4	-1.5
Aug 03 03:48	165243	RD	7.4	153	57	191	+0.1	+3.0
Aug 06 01:53	167	RD	5.5	115	45	195	+0.5	+2.3
Aug 06 23:36	272	RD	5.9	104	8	276	+0.6	-1.3
Aug 07 01:46	284	RD	7.1	104	33	224	+0.9	+0.9
Aug 21 18:48	2000	DD	7.0	63	45	166	+1.0	-2.9
Aug 23 22:43	2274	DD	6.9	90	21	142	+1.1	-1.1
Aug 24 21:05	2424	DD	6.9	103	55	37	+1.1	+4.7
Aug 24 21:55	2427	DD	7.2	103	44	86	+1.3	+1.0
Aug 24 23:51	184849	DD	7.4	104	20	132	+1.0	-0.6
Aug 26 01:14	186271	DD	7.3	118	17	119	+0.6	0.0
Aug 26 22:27	187672	DD	7.4	131	65	83	+1.9	+0.9
Aug 27 00:11	2796	DD	6.9	131	43	92	+1.2	+0.8
Aug 27 02:01	2805	DD	7.1	132	20	101	+0.5	+0.6
Aug 29 00:03	3106	DD	5.2	159	69	21	+0.6	+3.0
Aug 29 01:33	3116	DD	6.6	159	49	40	+0.6	+2.2
Aug 30 01:11	164948	DD	7.2	172	63	360	-0.4	+3.9
Aug 31 00:23	146509	RD	7.1	172	72	253	+2.4	+0.8
Sep 01 02:11	147015	RD	7.1	159	61	213	+1.2	+2.2
Sep 05 00:08	460	RD	6.9	112	17	213	+0.1	+1.0
Sep 05 00:25	465	DB	4.4	112	19	75	+1.0	-0.4
Sep 05 01:35	465	RD	4.4	111	31	216	+0.7	+1.1
Sep 06 03:51	598	RD	5.5	99	37	261	+2.7	-0.1
Sep 20 18:33	2371	RB	4.8	72	60	266	+2.0	+0.9
Sep 22 21:43	2723	DD	6.6	100	47	45	+0.5	+2.4
Sep 23 00:09	187363	DD	7.2	101	17	36	-0.6	+2.2
Sep 25 20:21	3191	DD	7.4	140	74	29	+1.5	+2.5
Sep 26 20:33	165243	DD	7.4	153	63	40	+1.6	+1.7
Sep 30 00:43	184	RD	6.0	167	55	179	0.0	+3.4
Sep 30 22:26	290	RD	6.1	155	34	207	+0.5	+1.5
Oct 03 02:03	76088	RD	7.4	131	39	268	+3.0	-0.2
Oct 07 02:09	1103	RD	5.8	87	12	240	+0.6	0.0
Oct 17 18:57	2336	DD	6.7	42	28	107	+0.8	+0.3
Oct 17 20:43	2347	DD	4.6	43	7	62	-0.5	+1.6
Oct 20 18:54	2848	DD	5.6	83	69	85	+2.2	+0.7
Oct 20 20:09	2848	RB	5.6	83	53	237	+1.0	+1.9
Oct 22 23:27	164516	DD	6.9	111	33	25	-0.1	+2.4
Oct 26 20:10	109522	DD	7.3	160	45	75	+2.0	0.0
Oct 30 00:34	486	RD	5.3	163	41	259	+2.8	+0.4
Nov 01 03:43	773	RD	7.0	139	31	259	+2.7	+0.9
Nov 04 03:32	1189	DB	5.0	106	33	157	+2.6	-3.5
Nov 10 03:52	1825	RD	5.9	37	9	333	+0.1	-2.2
Nov 10 12:24	Venus	DB	-4.0	34	42	96	+2.0	+0.7
Nov 10 13:33	Venus	RD	-4.0	33	27	335	+0.6	-1.8
Nov 14 19:18	184849	DD	7.4	24	10	94	0.0	+0.7
Nov 15 18:58	NGC6520	DD	9.0	38	28	144	+2.0	-1.8
Nov 15 19:54	186271	DD	7.3	38	16	68	-0.1	+1.3
Nov 16 20:25	2805	DD	7.1	52	23	49	-0.2	+1.8
Nov 18 19:33	3106	DD	5.2	79	57	4	-0.5	+3.9
Nov 18 20:15	3106	RB	5.2	79	48	292	+2.5	-0.2
Nov 18 20:56	3116	DD	6.6	79	39	26	0.0	+2.5
Nov 19 21:31	164948	DD	7.2	92	41	33	+0.4	+2.3
Nov 19 22:59	3271	DD	7.2	93	22	18	-0.3	+2.4
Nov 20 21:38	146509	DD	7.1	105	47	116	+3.6	-0.8
Nov 24 19:40	325	DD	7.1	153	39	103	+3.2	-1.7
Nov 30 23:23	1132	RD	6.4	138	18	246	+1.2	-0.2
Dec 08 02:45	1891	DB	4.4	58	15	159	0.0	-2.4
Dec 08 03:36	1891	RD	4.4	57	26	267	+1.0	-1.0
Dec 20 20:28	180	DD	5.2	111	50	37	+1.5	+2.1
Dec 20 20:29	181	DD	6.3	111	49	37	+1.5	+2.1
Dec 20 21:49	180	RB	5.2	111	37	246	+1.7	+1.6
Dec 21 22:09	299	DD	6.0	123	37	68	+2.0	+1.5
Dec 22 20:43	415	DD	5.8	134	44	57	+2.3	+1.2
Dec 23 21:22	524	DD	6.7	145	40	51	+2.2	+1.3
Dec 24 00:03	76088	DD	7.4	146	26	102	+2.0	+0.5
Dec 28 01:52	1103	RD	5.8	168	32	271	+2.7	+0.5
Dec 28 21:48	1213	RD	7.1	159	16	284	+1.6	-1.4
Dec 29 03:01	1232	RD	6.4	157	32	284	+2.2	+0.1

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 22:33	525	DD	6.5	135	29	104	+2.6	+0.4
Jan 04 00:12	76070	DD	7.2	135	16	8	+1.9	+4.4
Jan 08 01:21	1093	DD	6.6	175	25	173	-0.2	-4.1
Jan 09 04:03	1233	RD	5.7	167	16	268	+1.6	+1.1
Jan 29 20:21	374	DD	6.0	92	30	140	+5.2	-4.7
Jan 30 20:50	93394	DD	6.9	103	28	52	+1.9	+1.8
Jan 31 22:59	76499	DD	7.3	114	14	83	+1.4	+1.4
Feb 02 20:24	890	DD	4.6	135	26	80	+2.4	-0.1
Feb 02 22:00	890	RB	4.6	136	26	266	+2.5	+0.5
Feb 02 22:07	77724	DD	7.0	136	26	71	+2.5	+0.9
Feb 05 01:09	1181	DD	7.0	159	21	153	+0.5	-1.1
Feb 07 00:42	1416	DD	7.0	174	35	191	-1.4	-4.8
Feb 07 01:11	1416	RD	7.0	174	34	230	+5.4	+3.6
Feb 08 22:33	99505	RD	7.5	153	22	256	+1.4	-0.8
Feb 11 04:01	1864	RD	6.7	126	57	327	+1.2	-1.8
Feb 14 01:21	2217	RD	5.5	88	27	224	+2.5	+1.5
Feb 14 04:14	2230	RD	6.7	87	60	346	+0.1	-3.4
Feb 17 03:44	2721	DB	3.2	47	23	146	-0.6	-2.6
Feb 17 04:24	2721	RD	3.2	47	30	230	+1.3	+0.3
Feb 27 19:55	566	DD	6.1	82	23	112	+2.0	+0.4
Feb 27 19:57	563	DD	7.0	82	22	38	+1.9	+2.3
Feb 27 20:20	76254	DD	7.3	82	19	30	+1.9	+2.7
Mar 01 22:17	996	DD	6.9	115	18	60	+2.4	+1.9
Mar 02 21:47	1119	DD	5.8	126	26	54	+3.2	+1.8
Mar 02 23:46	79402	DD	7.3	127	15	89	+1.5	+1.1
Mar 03 22:35	1252	DD	7.3	138	28	111	+2.0	-0.1
Mar 07 00:34	1598	DD	6.5	173	43	156	+0.9	-1.7
Mar 07 21:25	1702	DB	4.0	172	27	126	+1.0	-1.8
Mar 07 22:38	1702	RD	4.0	172	39	302	+1.5	-1.6
Mar 09 04:46	1825	RD	5.9	157	35	288	+1.3	+0.3
Mar 10 03:45	1947	RD	7.0	145	57	321	+1.3	-1.4
Mar 11 02:30	2065	RD	6.5	132	66	356	+0.1	-3.6
Mar 11 22:20	2173	RD	6.9	120	15	235	+0.8	-0.1
Mar 13 02:08	184305	RD	7.5	105	51	253	+1.9	-0.3
Mar 30 19:55	1189	RB	5.0	105	28	279	+2.4	0.0
Apr 03 22:40	1659	DD	6.7	154	46	146	+1.2	-1.6
Apr 06 20:32	1997	RD	6.9	166	25	341	0.0	-2.4
Apr 07 20:00	2118	DB	2.8	153	11	141	-0.3	-1.8
Apr 07 20:44	2117	RD	5.2	153	20	280	+0.3	-1.3
Apr 07 20:50	2118	RD	2.8	153	21	276	+0.4	-1.3
Apr 07 23:44	2132	RD	7.3	151	55	287	+1.5	-1.3
Apr 08 03:54	2147	RD	6.9	150	59	318	+1.5	-1.4
Apr 09 03:30	184045	RD	7.3	136	75	242	+2.8	+2.1
Apr 10 00:10	2442	RD	5.9	123	42	341	-0.4	-3.2
Apr 10 02:43	2452	RD	6.7	122	72	283	+1.9	-1.0
Apr 10 03:01	2455	RD	6.6	122	75	304	+1.6	-1.8
Apr 11 00:21	186222	RD	7.5	110	33	319	-0.1	-2.4
Apr 12 00:16	187716	RD	7.2	97	20	273	+0.1	-1.1
Apr 12 00:36	2796	RD	6.9	96	24	202	+2.5	+3.2
Apr 12 02:50	2805	RD	7.1	95	50	284	+1.2	-1.5
Apr 15 03:07	3243	RD	7.3	57	15	273	+0.2	-1.3
Apr 25 19:10	1026	DD	6.5	64	16	119	+1.2	+0.2
May 02 22:52	1825	DD	5.9	148	55	178	+0.1	-3.0
May 03 20:51	1947	DD	7.0	161	51	151	+0.7	-2.2
May 04 02:16	1962	DD	5.0	163	38	62	+1.8	+3.3
May 04 19:03	2065	DD	6.5	174	25	121	+0.3	-1.7
May 06 00:35	2214	RD	6.3	170	75	291	+1.9	-0.9
May 06 04:18	2228	RD	5.8	168	42	245	+1.0	+2.3
May 06 19:55	2357	RD	6.8	157	18	276	+0.1	-1.1
May 06 19:58	184383	RD	7.3	157	19	290	0.0	-1.4
May 06 19:59	184381	RD	5.7	157	19	282	+0.1	-1.2
May 06 19:59	2359	RD	5.0	157	19	282	+0.1	-1.2
May 07 20:17	2524	RD	6.0	143	12	266	-0.1	-0.9
May 08 02:45	185716	RD	7.4	140	81	291	+2.1	-0.9
May 08 04:01	2558	RD	6.3	140	72	301	+2.1	-1.0
May 08 05:04	2564	RD	7.0	139	60	283	+1.8	+0.2
May 08 22:08	2721	DB	3.2	128	20	59	+0.6	-0.2
May 08 22:53	2721	RD	3.2	128	29	317	-0.2	-2.4
May 09 01:35	187363	RD	7.2	127	61	308	+1.2	-2.5
May 12 03:35	3214	RD	6.8	86	46	237	+1.4	+0.3

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 24 18:08	1232	DD	6.4	56	22	138	+1.0	-0.6
May 25 20:07	80615	DD	7.5	67	16	67	+2.3	+2.4
May 27 18:44	99249	DD	7.6	90	41	125	+1.8	-0.9
Jun 01 17:29	2118	RB	2.8	154	24	285	+0.4	-1.4
Jun 01 19:15	2132	DD	7.3	155	45	131	+0.7	-1.9
Jun 01 23:17	2147	DD	6.9	157	69	92	+2.3	+0.3
Jun 02 19:21	2281	DD	7.1	169	37	42	+3.6	+2.5
Jun 03 19:04	2443	RD	5.7	176	24	322	-0.3	-2.0
Jun 03 19:08	2442	RD	5.9	176	24	297	0.0	-1.5
Jun 04 22:25	2650	DB	4.7	160	50	36	+2.8	+2.5
Jun 04 22:56	2650	RD	4.7	160	57	343	-0.2	-5.2
Jun 04 23:17	186606	RD	7.2	160	61	267	+1.7	-0.6
Jun 05 00:33	186671	RD	7.3	159	75	269	+2.0	-0.3
Jun 06 22:01	2984	RD	7.1	132	19	241	+0.5	-0.2
Jun 06 22:10	2985	RD	6.8	132	21	278	+0.2	-1.3
Jun 07 03:36	3018	RD	6.4	130	78	193	+0.9	+4.4
Jun 08 01:13	3164	DB	4.5	117	43	68	+1.3	-0.2
Jun 08 02:29	3164	RD	4.5	117	58	250	+1.8	+0.1
Jun 08 02:51	164528	RD	7.5	116	62	287	+2.3	-1.8
Jun 08 04:45	3175	DB	4.7	116	74	71	+2.1	+0.8
Jun 08 04:51	164567	RD	7.3	116	73	277	+2.7	-0.3
Jun 08 06:02	3175	RD	4.7	115	65	224	+1.2	+2.1
Jun 09 01:25	3304	RD	6.4	104	33	202	+1.0	+1.9
Jun 10 02:06	3434	RD	7.5	91	28	215	+0.8	+1.0
Jun 10 03:16	X185486	RD	7.6	91	41	169	-0.2	+6.1
Jun 10 03:16	3446	RD	7.2	91	42	170	-0.1	+5.8
Jun 11 02:10	12	RD	6.4	79	17	262	+0.6	-1.0
Jun 11 02:27	13	RD	6.2	79	20	269	+0.8	-1.3
Jun 11 03:01	128618	RD	6.8	79	27	191	+0.4	+2.4
Jun 28 00:40	1973	DD	6.2	112	15	85	+0.3	+1.4
Jun 29 20:35	2214	DD	6.3	137	74	93	+2.3	-0.3
Jun 30 00:36	2228	DD	5.8	139	43	131	+1.3	-0.6
Jul 01 22:34	185716	DD	7.4	166	79	92	+2.1	-0.3
Jul 01 23:52	2558	DD	6.3	167	78	79	+2.1	+0.8
Jul 02 00:50	2564	DD	7.0	167	68	92	+1.9	+0.5
Jul 02 03:46	2579	DD	7.4	168	33	43	-0.1	+2.5
Jul 02 18:18	2721	DD	3.2	176	17	87	+0.1	-0.9
Jul 02 19:13	2721	RD	3.2	176	28	287	+0.2	-1.4
Jul 05 04:41	3106	RD	5.2	147	57	269	+1.8	+0.9
Jul 05 06:11	3116	RD	6.6	147	39	258	+0.8	+1.4
Jul 05 21:58	164829	RD	7.1	137	19	250	+0.5	-0.5
Jul 05 21:58	3228	RD	7.2	137	19	250	+0.5	-0.5
Jul 06 01:02	3243	RD	7.3	135	55	218	+1.4	+1.4
Jul 07 04:44	146509	RD	7.1	121	63	281	+3.2	-0.4
Jul 10 04:04	214	RD	6.2	84	36	177	-0.4	+3.2
Jul 13 04:57	566	RD	6.1	50	14	201	-0.2	+1.3
Jul 13 05:13	563	RD	7.0	50	16	271	+1.5	-1.2
Jul 13 05:30	76254	RD	7.3	50	18	271	+1.7	-1.2
Jul 20 18:29	1499	DD	7.1	32	13	122	+0.5	+0.1
Jul 22 19:14	1709	DD	6.6	55	27	97	+1.3	+0.9
Jul 25 22:54	X 37784	DD	7.4	94	23	95	+0.6	+1.0
Jul 26 22:07	2171	DD	6.5	107	45	135	+1.4	-0.9
Jul 26 23:10	159116	DD	7.2	107	33	64	+0.7	+2.4
Jul 28 21:54	2478	DD	7.6	134	74	138	+2.0	-2.1
Jul 28 22:11	2479	DD	5.1	134	71	160	+2.1	-4.7
Jul 28 22:12	2480	DD	5.2	134	71	160	+2.1	-4.8
Jul 28 22:25	2482	DD	6.3	134	69	134	+2.1	-1.7
Jul 28 22:47	2480	RB	5.2	134	64	213	+1.3	+5.2
Jul 28 22:47	2479	RB	5.1	134	64	213	+1.3	+5.1
Jul 28 23:18	2488	DD	6.9	135	58	150	+2.3	-2.8
Jul 29 00:28	185282	DD	7.1	135	44	121	+1.5	-0.2
Jul 29 00:51	185305	DD	7.5	135	40	110	+1.2	+0.4
Jul 29 19:06	186606	DD	7.2	147	54	91	+1.4	-0.9
Jul 29 20:21	186671	DD	7.3	147	69	85	+1.9	-0.4
Aug 01 21:06	3164	DB	4.5	168	37	137	+0.6	-5.0
Aug 01 21:34	3164	RD	4.5	168	42	185	+1.4	+4.6
Aug 01 22:19	164528	RD	7.5	168	51	234	+1.5	+0.6
Aug 02 00:08	164567	RD	7.3	167	70	235	+1.8	+1.1
Aug 02 00:13	3175	DB	4.7	167	70	122	+3.4	-3.3
Aug 02 00:50	3175	RB	4.7	167	73	178	0.0	+5.1

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 02 03:56	164637	RD	7.5	166	49	253	+1.2	+1.4
Aug 03 03:23	165243	RD	7.4	153	60	178	-0.4	+3.7
Aug 03 03:24	3327	RD	6.8	153	60	280	+2.7	+0.1
Aug 06 01:32	167	RD	5.5	115	34	171	-0.7	+3.9
Aug 07 01:36	284	RD	7.1	104	24	206	+0.3	+1.2
Aug 07 05:25	290	RD	6.1	102	42	184	+0.3	+2.8
Aug 20 18:31	1891	DD	4.4	50	36	77	+1.8	+2.1
Aug 20 19:20	1891	RB	4.4	51	27	348	+0.5	-2.3
Aug 24 00:43	2290	DD	2.3	92	4	88	-0.3	+1.0
Aug 24 20:37	2424	DD	6.9	103	64	74	+1.8	+1.5
Aug 24 21:45	2427	DD	7.2	103	51	109	+1.5	+0.2
Aug 24 22:42	184805	DD	7.6	104	39	30	-0.2	+4.8
Aug 24 23:58	184849	DD	7.4	104	24	167	+3.1	-5.2
Aug 25 18:46	2575	DD	6.9	116	76	67	+2.4	+0.8
Aug 26 01:13	186271	DD	7.3	118	23	140	+1.3	-0.8
Aug 26 22:16	187672	DD	7.4	131	70	105	+2.2	-0.1
Aug 26 23:33	187716	DD	7.2	131	54	26	+0.2	+3.5
Aug 27 00:01	2796	DD	6.9	132	49	109	+1.6	+0.3
Aug 27 01:54	2805	DD	7.1	132	27	116	+0.9	+0.4
Aug 27 21:25	2939	DD	7.5	144	79	120	+2.6	-2.1
Aug 28 23:39	3106	DD	5.2	159	72	38	+1.2	+2.2
Aug 29 01:14	3116	DD	6.6	159	56	51	+0.9	+1.9
Aug 30 00:44	164948	DD	7.2	172	66	15	+0.5	+2.9
Aug 30 02:23	3271	DD	7.2	173	49	5	-0.2	+3.2
Aug 31 00:07	146509	RD	7.1	172	64	239	+1.8	+1.0
Sep 01 01:50	147015	RD	7.1	159	57	204	+0.9	+2.2
Sep 05 00:28	465	DB	4.4	112	13	94	+1.2	-1.4
Sep 05 01:25	465	RD	4.4	111	21	200	+0.1	+1.3
Sep 06 03:43	598	RD	5.5	99	28	251	+1.9	-0.1
Sep 18 20:02	158720	DD	7.2	47	19	61	+0.1	+2.6
Sep 21 23:34	185716	DD	7.4	88	17	32	-0.8	+2.7
Sep 22 21:24	2723	DD	6.6	100	55	64	+1.1	+1.8
Sep 22 23:55	187363	DD	7.2	101	25	51	-0.2	+1.9
Sep 25 00:19	3062	DD	7.5	128	42	57	+0.6	+1.8
Sep 25 20:01	3191	DD	7.4	140	63	52	+1.7	+1.1
Sep 26 20:19	165243	DD	7.4	153	54	61	+1.6	+0.5
Sep 27 01:17	165316	DD	7.6	155	45	73	+1.3	+1.5
Sep 30 22:12	290	RD	6.1	155	24	187	-0.2	+2.1
Oct 03 01:54	76088	RD	7.4	131	30	258	+2.2	-0.1
Oct 03 04:37	76156	RD	6.9	130	28	248	+2.2	+1.2
Oct 17 20:33	2347	DD	4.6	43	15	81	-0.1	+1.3
Oct 20 19:49	2848	RB	5.6	83	61	219	+0.8	+2.7
Oct 22 23:09	164516	DD	6.9	111	40	35	+0.2	+2.3
Oct 26 20:07	109522	DD	7.3	160	37	95	+2.2	-1.4
Oct 30 00:22	486	RD	5.3	163	33	250	+2.1	+0.3
Nov 01 03:26	773	RD	7.0	139	26	244	+2.4	+1.0
Nov 04 01:30	79729	RD	6.9	107	10	350	+4.5	-7.4
Nov 10 04:08	1825	RD	5.9	37	9	316	+0.1	-1.9
Nov 10 12:18	Venus	DB	-4.0	34	42	129	+1.4	-0.7
Nov 10 13:37	Venus	RD	-4.0	33	28	303	+0.9	-0.1
Nov 16 20:12	2805	DD	7.1	52	31	63	+0.2	+1.7
Nov 18 20:04	3106	RB	5.2	79	53	277	+1.9	+0.7
Nov 18 20:37	3116	DD	6.6	79	47	37	+0.4	+2.3
Nov 19 21:12	164948	DD	7.2	92	47	42	+0.7	+2.1
Nov 19 22:42	3271	DD	7.2	93	29	29	0.0	+2.3
Nov 21 20:56	3514	DD	5.9	118	55	349	-0.8	+4.0
Nov 30 23:21	1132	RD	6.4	138	10	231	+0.6	0.0
Nov 30 23:52	1137	RD	5.0	138	14	328	+2.7	-3.4
Dec 01 00:26	1139	RD	7.1	138	18	327	+2.7	-3.0
Dec 08 03:07	1891	DB	4.4	58	16	184	-0.4	-3.2
Dec 08 03:37	1891	RD	4.4	58	22	242	+1.3	-0.3
Dec 13 19:46	2721	DD	3.2	19	10	36	-0.8	+2.0
Dec 20 20:08	180	DD	5.2	111	46	44	+1.5	+1.7
Dec 20 21:30	180	RB	5.2	111	37	239	+1.6	+1.7
Dec 21 21:50	299	DD	6.0	123	35	77	+2.1	+1.2
Dec 22 20:27	415	DD	5.8	134	36	65	+2.1	+0.6
Dec 23 21:07	524	DD	6.7	145	32	60	+2.0	+0.6
Dec 23 23:53	76088	DD	7.4	146	24	120	+2.1	0.0
Dec 28 01:36	1103	RD	5.8	168	26	249	+2.9	+1.0
Dec 29 02:47	1232	RD	6.4	157	27	260	+2.8	+0.9

LUNAR OCCULTATION TABLE

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 22:21	525	DD	6.5	135	29	105	+2.7	+0.2
Jan 03 23:55	76070	DD	7.2	135	19	17	+1.7	+3.1
Jan 09 03:27	1232	RD	6.4	167	20	324	+0.8	-0.6
Jan 09 03:52	1233	RD	5.7	167	17	253	+2.1	+1.6
Jan 18 04:43	2282	DB	5.8	56	38	82	+1.1	-1.0
Jan 31 22:49	76499	DD	7.3	114	16	89	+1.6	+1.2
Feb 02 20:15	890	DD	4.6	135	23	81	+2.1	-0.3
Feb 02 21:49	890	RB	4.6	136	24	262	+2.4	+0.4
Feb 02 21:55	77724	DD	7.0	136	24	75	+2.4	+0.6
Feb 03 00:14	77804	DD	7.3	136	14	111	+1.3	+0.5
Feb 05 01:13	1181	DD	7.0	159	20	172	-0.5	-2.5
Feb 11 03:59	1864	RD	6.7	126	55	313	+1.5	-1.4
Feb 14 04:20	2230	RD	6.7	87	57	329	+0.6	-2.6
Feb 17 03:57	2721	DB	3.2	47	23	171	-2.2	-5.4
Feb 17 04:14	2721	RD	3.2	47	26	204	+2.6	+3.1
Feb 27 20:06	76254	DD	7.3	82	21	36	+1.8	+2.3
Feb 27 21:21	76283	DD	7.6	82	11	49	+1.5	+2.2
Feb 29 22:10	840	DD	6.3	104	14	31	+2.7	+3.3
Mar 01 22:03	996	DD	6.9	115	19	71	+2.3	+1.3
Mar 02 21:32	1119	DD	5.8	126	24	65	+2.7	+0.9
Mar 02 23:38	79402	DD	7.3	127	16	102	+1.5	+0.7
Mar 03 22:28	1252	DD	7.3	138	26	121	+1.9	-0.5
Mar 07 00:36	1598	DD	6.5	173	40	172	+0.3	-2.3
Mar 07 21:26	1702	DB	4.0	172	23	133	+0.9	-2.0
Mar 07 22:36	1702	RD	4.0	171	34	293	+1.5	-1.5
Mar 09 04:39	1825	RD	5.9	157	38	273	+1.6	+1.0
Mar 10 03:42	1947	RD	7.0	145	57	307	+1.6	-1.0
Mar 11 02:36	2065	RD	6.5	132	63	338	+0.7	-2.6
Mar 11 22:54	2182	RD	6.2	120	18	359	-0.9	-3.0
Mar 12 23:56	2333	RD	7.4	106	22	352	-0.9	-2.9
Mar 13 01:58	184305	RD	7.5	105	46	232	+2.7	+0.9
Mar 14 00:04	2483	RD	7.1	93	14	351	-1.3	-3.1
Mar 16 04:22	188263	RD	7.7	65	39	336	-0.5	-5.1
Mar 30 19:45	1189	RB	5.0	105	26	271	+2.4	0.0
Apr 03 22:40	1659	DD	6.7	154	43	160	+0.8	-2.0
Apr 06 20:38	1997	RD	6.9	166	22	332	0.0	-2.1
Apr 07 04:30	2025	RD	6.8	163	42	348	+0.8	-2.6
Apr 07 20:06	2118	DB	2.8	153	10	149	-0.4	-1.9
Apr 07 20:46	2117	RD	5.2	153	17	271	+0.3	-1.2
Apr 07 20:51	2118	RD	2.8	153	18	267	+0.3	-1.1
Apr 07 23:41	2132	RD	7.3	151	51	273	+1.6	-1.1
Apr 08 03:50	2147	RD	6.9	150	61	305	+1.6	-0.8
Apr 10 00:18	2442	RD	5.9	123	40	324	0.0	-2.4
Apr 10 02:37	2452	RD	6.7	122	67	269	+1.9	-0.6
Apr 10 02:58	2455	RD	6.6	122	70	290	+1.7	-1.3
Apr 11 00:27	186222	RD	7.5	110	31	305	+0.1	-1.9
Apr 11 05:21	2634	RD	7.2	108	79	242	+2.2	+1.5
Apr 12 00:18	187716	RD	7.2	96	18	261	+0.2	-0.9
Apr 12 02:48	2805	RD	7.1	95	46	271	+1.1	-1.1
Apr 15 03:09	3243	RD	7.3	57	13	261	+0.2	-0.9
Apr 25 19:05	1026	DD	6.5	64	17	131	+1.1	-0.1
May 03 20:55	1947	DD	7.0	161	48	165	+0.3	-2.6
May 04 02:03	1962	DD	5.0	163	42	81	+1.7	+1.6
May 04 19:06	2065	DD	6.5	174	22	130	+0.1	-1.8
May 06 00:29	2214	RD	6.3	170	71	276	+2.0	-0.5
May 06 04:06	2228	RD	5.8	168	47	232	+1.2	+3.6
May 06 19:58	2357	RD	6.8	157	16	266	+0.1	-1.0
May 06 20:02	184383	RD	7.3	157	17	280	0.0	-1.2
May 06 20:02	184381	RD	5.7	157	17	272	+0.1	-1.1
May 06 20:02	2359	RD	5.0	157	17	272	+0.1	-1.1
May 07 20:19	2524	RD	6.0	143	10	255	0.0	-0.8
May 08 02:38	185716	RD	7.4	140	78	279	+2.0	-0.6
May 08 03:54	2558	RD	6.3	140	75	292	+2.0	-0.6
May 08 04:56	2564	RD	7.0	139	65	277	+1.8	+0.4
May 08 22:08	2721	DB	3.2	128	18	73	+0.3	-0.7
May 08 22:59	2721	RD	3.2	128	27	302	0.0	-1.9
May 09 00:43	187318	RD	7.7	127	47	295	+0.8	-1.9
May 09 01:35	187363	RD	7.2	127	57	294	+1.2	-1.8
May 12 03:29	3214	RD	6.8	86	41	228	+1.2	+0.6
May 13 06:16	3356	DB	5.8	72	56	27	+1.2	+2.0

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 25 19:54	80615	DD	7.5	67	18	86	+1.8	+1.3
May 27 18:40	99249	DD	7.6	90	38	137	+1.5	-1.3
May 30 21:20	139195	DD	7.7	129	57	139	+1.3	-1.5
Jun 01 00:44	2025	DD	6.8	143	44	53	+2.2	+4.8
Jun 01 17:31	2118	RB	2.8	154	22	275	+0.4	-1.3
Jun 01 19:18	2132	DD	7.3	155	42	143	+0.4	-2.1
Jun 01 23:09	2147	DD	6.9	157	69	107	+1.9	-0.5
Jun 02 19:13	2281	DD	7.1	169	32	66	+1.2	-0.5
Jun 02 21:41	184043	DD	7.2	170	60	43	+4.7	+4.0
Jun 03 19:10	2443	RD	5.7	176	22	310	-0.2	-1.8
Jun 04 22:14	2650	DB	4.7	160	45	58	+1.6	+0.1
Jun 04 23:05	2650	RD	4.7	160	55	321	+0.6	-2.9
Jun 04 23:11	186606	RD	7.2	160	56	253	+1.7	-0.2
Jun 05 00:25	186671	RD	7.3	159	70	257	+1.9	0.0
Jun 06 21:59	2984	RD	7.1	132	17	226	+0.6	+0.1
Jun 06 22:12	2985	RD	6.8	132	19	265	+0.2	-1.0
Jun 07 03:20	3018	RD	6.4	130	74	183	+0.6	+6.5
Jun 08 01:09	3164	DB	4.5	117	39	78	+1.1	-0.7
Jun 08 02:22	3164	RD	4.5	117	53	242	+1.6	+0.2
Jun 08 02:46	164528	RD	7.5	116	57	279	+1.9	-1.4
Jun 08 04:35	3175	DB	4.7	116	70	73	+2.0	+0.6
Jun 08 04:42	164567	RD	7.3	116	71	275	+2.5	-0.4
Jun 08 05:52	3175	RD	4.7	115	67	225	+1.3	+2.0
Jun 09 01:14	3304	RD	6.4	104	27	186	+1.0	+3.4
Jun 10 02:01	3434	RD	7.5	91	24	206	+0.6	+1.3
Jun 11 02:10	12	RD	6.4	79	13	254	+0.4	-0.7
Jun 11 02:27	13	RD	6.2	79	17	261	+0.6	-1.0
Jun 11 02:42	15	RD	7.1	79	19	299	+1.1	-3.7
Jun 11 02:53	128618	RD	6.8	79	21	180	+0.1	+3.3
Jun 12 06:06	109568	RD	7.6	66	41	229	+1.3	+0.7
Jun 23 20:08	1532	DD	7.6	61	18	182	-0.7	-2.9
Jun 25 21:19	1741	DD	7.1	85	30	75	+1.9	+2.3
Jun 28 00:35	1973	DD	6.2	112	19	95	+0.5	+1.1
Jun 29 20:29	2214	DD	6.3	137	69	108	+1.8	-1.0
Jun 30 00:33	2228	DD	5.8	139	46	140	+1.4	-1.1
Jul 01 03:53	184678	DD	7.6	154	22	112	+0.5	+0.5
Jul 01 22:28	185716	DD	7.4	166	73	104	+1.8	-1.0
Jul 01 23:42	2558	DD	6.3	167	79	89	+2.0	+0.2
Jul 02 00:41	2564	DD	7.0	167	71	100	+1.9	+0.1
Jul 02 03:39	2579	DD	7.4	168	38	46	+0.1	+2.5
Jul 02 18:21	2721	DB	3.2	176	16	99	-0.1	-1.2
Jul 02 19:15	2721	RD	3.2	176	26	275	+0.3	-1.2
Jul 05 03:26	3106	DB	5.2	148	70	32	+1.0	+2.5
Jul 05 04:31	3106	RD	5.2	147	61	270	+1.9	+0.7
Jul 05 06:04	3116	RD	6.6	147	44	259	+1.0	+1.3
Jul 05 21:57	164829	RD	7.1	137	16	238	+0.4	-0.2
Jul 05 21:57	3228	RD	7.2	137	16	238	+0.4	-0.2
Jul 06 00:52	3243	RD	7.3	135	49	211	+1.2	+1.6
Jul 07 04:32	146509	RD	7.1	121	62	283	+3.2	-0.8
Jul 10 03:57	214	RD	6.2	84	31	176	-0.5	+3.2
Jul 13 05:11	563	RD	7.0	50	11	271	+1.2	-1.3
Jul 13 05:27	76254	RD	7.3	50	14	272	+1.4	-1.3
Jul 20 18:27	1499	DD	7.1	32	14	136	+0.4	-0.3
Jul 22 19:07	1709	DD	6.6	55	30	112	+1.2	+0.3
Jul 25 22:49	X 37784	DD	7.4	94	27	104	+0.8	+0.7
Jul 26 22:05	2171	DD	6.5	107	49	146	+1.4	-1.5
Jul 26 23:01	159116	DD	7.2	107	38	75	+1.0	+1.9
Jul 28 02:24	184337	DD	7.0	122	13	98	0.0	+0.9
Jul 28 21:53	2478	DD	7.6	134	75	152	+1.8	-3.4
Jul 28 22:22	2482	DD	6.3	134	71	146	+2.0	-2.7
Jul 28 23:19	2488	DD	6.9	135	61	165	+2.6	-6.1
Jul 29 00:23	185282	DD	7.1	135	49	126	+1.6	-0.5
Jul 29 00:45	185305	DD	7.5	135	45	114	+1.3	+0.2
Jul 29 02:57	185404	DD	7.5	136	20	82	+0.1	+1.3
Jul 29 19:04	186606	DD	7.2	147	50	104	+1.0	-1.4
Jul 29 20:15	186671	DD	7.3	147	64	98	+1.6	-1.0
Aug 01 22:12	164528	RD	7.5	168	46	224	+1.3	+0.8
Aug 01 23:58	164567	RD	7.3	167	64	230	+1.6	+1.1
Aug 02 00:09	3175	DB	4.7	167	65	132	+3.6	-5.3
Aug 02 00:36	3175	RB	4.7	167	69	172	-0.4	+6.7

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 02 03:47	164637	RD	7.5	166	53	254	+1.3	+1.4
Aug 03 00:01	165197	RD	7.5	154	52	309	+3.2	-5.6
Aug 03 03:13	3327	RD	6.8	153	61	283	+2.9	-0.2
Aug 03 03:14	165243	RD	7.4	153	62	181	-0.1	+3.5
Aug 06 01:24	167	RD	5.5	116	29	167	-1.0	+4.7
Aug 07 01:32	284	RD	7.1	104	19	203	+0.2	+1.2
Aug 07 05:17	290	RD	6.1	102	40	188	+0.4	+2.4
Aug 20 18:20	1891	DD	4.4	50	40	93	+1.7	+1.0
Aug 20 19:22	1891	RB	4.4	51	29	333	+0.7	-1.3
Aug 24 00:42	2290	DD	2.3	92	8	91	-0.2	+1.0
Aug 24 20:26	2424	DD	6.9	103	68	83	+2.0	+0.9
Aug 24 21:38	2427	DD	7.2	103	55	116	+1.7	-0.1
Aug 24 22:30	184805	DD	7.6	104	45	39	+0.4	+3.9
Aug 26 01:09	186271	DD	7.3	118	28	142	+1.5	-0.9
Aug 26 22:08	187672	DD	7.4	131	73	110	+2.2	-0.5
Aug 26 23:23	187716	DD	7.2	131	60	29	+0.5	+3.4
Aug 26 23:54	2796	DD	6.9	132	54	110	+1.8	+0.2
Aug 27 01:49	2805	DD	7.1	132	32	115	+1.0	+0.4
Aug 27 21:21	2939	DD	7.5	144	74	130	+2.5	-3.2
Aug 28 23:28	3106	DD	5.2	159	72	39	+1.3	+2.1
Aug 29 01:05	3116	DD	6.6	159	59	49	+1.0	+1.9
Aug 30 00:35	164948	DD	7.2	172	66	14	+0.5	+3.0
Aug 30 02:16	3271	DD	7.2	173	53	2	-0.3	+3.4
Aug 30 23:58	146509	RD	7.1	172	59	239	+1.7	+0.8
Sep 01 01:41	147015	RD	7.1	159	55	206	+1.0	+2.0
Sep 05 01:21	465	RD	4.4	111	17	200	0.0	+1.2
Sep 06 03:36	598	RD	5.5	99	23	253	+1.7	-0.3
Sep 18 19:55	158720	DD	7.2	47	24	71	+0.5	+2.2
Sep 21 23:30	185716	DD	7.4	88	22	34	-0.7	+2.8
Sep 22 00:20	2558	DD	6.3	88	13	48	-0.6	+2.0
Sep 22 21:14	2723	DD	6.6	100	60	67	+1.3	+1.7
Sep 22 23:50	187363	DD	7.2	101	30	51	0.0	+2.0
Sep 24 19:39	3037	DD	7.3	126	68	2	+0.8	+6.6
Sep 25 00:12	3062	DD	7.5	128	46	56	+0.7	+1.9
Sep 25 19:52	3191	DD	7.4	140	58	57	+1.6	+0.6
Sep 26 20:12	165243	DD	7.4	153	48	65	+1.5	+0.1
Sep 27 01:07	165316	DD	7.6	155	49	71	+1.4	+1.5
Sep 30 22:07	290	RD	6.1	155	19	184	-0.3	+2.2
Oct 03 01:46	76088	RD	7.4	131	26	260	+2.0	-0.4
Oct 03 04:25	76156	RD	6.9	130	27	247	+2.1	+1.0
Oct 17 20:30	2347	DD	4.6	43	19	84	+0.1	+1.3
Oct 20 19:38	2848	RB	5.6	83	65	217	+0.9	+2.8
Oct 22 23:02	164516	DD	6.9	111	44	33	+0.3	+2.3
Oct 25 02:25	3449	DD	7.3	138	17	68	+0.4	+1.6
Oct 26 20:03	109522	DD	7.3	160	33	97	+1.9	-1.7
Oct 30 00:13	486	RD	5.3	163	30	252	+2.0	+0.1
Nov 01 03:14	773	RD	7.0	139	24	242	+2.2	+0.8
Nov 02 02:21	77883	RD	7.6	128	21	252	+2.0	-0.2
Nov 10 12:15	Venus	DB	-4.0	34	44	143	+1.2	-1.2
Nov 10 13:32	Venus	RD	-4.0	33	31	291	+1.1	+0.4
Nov 11 15:20	Mars	DB	1.7	19	24	48	+0.8	+5.6
Nov 11 15:46	Mars	RD	1.7	19	19	3	+0.7	-4.6
Nov 18 19:54	3106	RB	5.2	79	57	279	+2.0	+0.5
Nov 18 20:29	3116	DD	6.6	79	51	35	+0.5	+2.4
Nov 19 21:03	164948	DD	7.2	92	51	39	+0.7	+2.2
Nov 19 22:36	3271	DD	7.2	93	34	27	+0.1	+2.3
Nov 20 21:19	146509	DD	7.1	105	52	132	+8.3	-5.3
Nov 20 21:32	146509	RD	7.1	105	50	151	-5.7	+8.8
Nov 21 20:50	3514	DD	5.9	118	54	342	-1.5	+4.8
Dec 08 03:21	1891	DD	4.4	58	15	205	-2.4	-7.7
Dec 08 03:29	1891	RD	4.4	58	16	219	+3.2	+4.2
Dec 13 19:44	2721	DD	3.2	19	15	36	-0.7	+2.0
Dec 13 20:20	2721	RB	3.2	19	8	302	+0.1	+0.3
Dec 20 21:19	180	RB	5.2	111	39	241	+1.7	+1.5
Dec 21 21:38	299	DD	6.0	123	36	75	+2.1	+1.1
Dec 22 20:18	415	DD	5.8	134	33	63	+1.8	+0.4
Dec 23 20:58	524	DD	6.7	145	28	58	+1.7	+0.4
Dec 23 23:44	76088	DD	7.4	146	24	125	+2.4	-0.3
Dec 28 01:21	1103	RD	5.8	168	24	239	+2.8	+1.0
Dec 29 02:33	1232	RD	6.4	157	26	246	+3.1	+1.1

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 07 22:24	1093	RD	6.6	175	24	204	+0.8	+2.7
Jan 08 23:55	79987	RD	7.5	167	29	214	+2.7	+2.8
Jan 09 00:33	1232	RD	6.4	167	31	299	+2.4	-1.1
Jan 10 01:23	80615	RD	7.5	156	34	308	+2.1	-1.3
Jan 10 04:47	1363	RD	5.2	155	24	256	+2.3	+1.6
Jan 18 03:19	2282	RD	5.8	55	21	299	0.0	-1.5
Jan 18 03:26	183983	RD	7.3	55	23	336	-0.4	-2.3
Jan 27 21:45	167	DD	5.5	71	13	28	+0.5	+2.5
Jan 28 20:45	92669	DD	7.4	82	29	55	+1.4	+2.0
Jan 31 21:24	624	DD	6.8	115	30	80	+2.5	+1.0
Feb 01 21:41	762	DD	6.6	126	30	43	+2.5	+1.9
Feb 01 22:55	76970	DD	7.6	126	24	85	+2.1	+1.0
Feb 02 21:12	77804	DD	7.3	136	31	112	+2.9	-0.8
Feb 02 22:38	909	DD	6.0	137	28	117	+2.3	-0.4
Feb 05 00:26	79777	DD	7.6	159	29	48	+4.1	+2.9
Feb 09 01:39	1647	RD	6.7	151	48	243	+4.7	+1.6
Feb 11 01:00	1864	RD	6.7	126	40	269	+1.8	-1.0
Feb 11 02:24	1869	RD	6.2	126	54	249	+3.8	+0.6
Feb 11 04:45	1875	RD	6.7	125	60	330	+1.2	-1.9
Feb 13 03:55	2105	RD	6.3	99	62	301	+1.5	-1.7
Feb 14 01:47	X 39791	RD	7.6	87	28	346	-0.5	-2.7
Feb 14 01:52	2230	RD	6.7	87	29	293	+0.4	-1.5
Feb 17 04:15	2735	RD	7.2	46	24	274	+0.3	-1.1
Feb 17 04:54	2740	RD	6.3	46	32	312	0.0	-2.3
Mar 01 21:22	78496	DD	7.5	116	28	121	+2.2	-0.4
Mar 01 22:19	1008	DD	5.3	116	23	101	+1.9	+0.5
Mar 02 20:40	79402	DD	7.3	127	31	122	+2.5	-1.1
Mar 02 21:22	1132	DD	6.4	127	30	48	+3.5	+2.0
Mar 02 23:38	79479	DD	7.2	128	21	101	+1.6	+0.6
Mar 07 19:58	1702	RD	4.0	171	9	285	+0.5	-1.4
Mar 10 00:36	1947	RD	7.0	145	53	260	+2.6	-0.4
Mar 10 05:12	1962	DB	5.0	143	49	75	+2.4	+2.0
Mar 10 23:58	2065	RD	6.5	132	39	297	+0.8	-1.7
Mar 13 01:21	2351	RD	7.6	104	38	333	-0.1	-2.5
Mar 13 01:52	2359	DB	5.0	104	44	85	+1.3	-0.8
Mar 13 02:45	184383	RD	7.3	104	55	336	+0.2	-3.0
Mar 13 02:49	2357	RD	6.8	104	56	319	+0.7	-2.4
Mar 13 02:51	184381	RD	5.7	104	56	327	+0.6	-2.6
Mar 13 02:52	2359	RD	5.0	104	56	326	+0.6	-2.6
Mar 14 02:17	2514	RD	6.4	91	38	338	-0.4	-3.1
Mar 14 02:35	185404	RD	7.5	91	42	250	+1.5	-0.3
Mar 14 04:45	2524	RD	6.0	90	68	343	+0.4	-4.8
Mar 15 01:22	2673	RD	6.3	78	15	332	-0.9	-2.6
Mar 18 04:12	3164	DB	4.5	38	10	85	+0.1	-0.8
Mar 18 05:12	3164	RD	4.5	37	23	249	+0.6	-0.3
Mar 30 21:59	1213	DD	7.1	107	24	93	+2.0	+0.8
Apr 02 23:17	99249	DD	7.6	143	42	105	+2.2	-0.1
Apr 06 22:27	2013	RD	7.6	164	45	311	+0.9	-1.9
Apr 07 01:48	2025	RD	6.8	163	69	328	+1.3	-2.1
Apr 08 00:50	2147	RD	6.9	150	66	278	+2.1	-0.8
Apr 08 21:46	2281	RD	7.1	137	19	321	-0.3	-1.9
Apr 08 23:53	184043	RD	7.2	136	45	333	+0.1	-2.6
Apr 09 22:06	2443	RD	5.7	123	13	318	-0.5	-1.8
Apr 09 22:09	2442	RD	5.9	123	14	293	-0.2	-1.3
Apr 09 23:43	2452	RD	6.7	122	33	227	+2.1	+1.0
Apr 10 00:11	2455	RD	6.6	122	38	260	+1.1	-0.7
Apr 10 05:36	2478	RD	7.6	120	72	208	+2.1	+7.7
Apr 11 02:19	2634	RD	7.2	108	52	235	+2.2	+0.8
Apr 11 04:22	186606	RD	7.2	107	77	297	+2.0	-1.6
Apr 12 00:23	2805	RD	7.1	95	16	248	+0.4	-0.4
Apr 14 03:55	190252	RD	7.2	68	33	268	+0.9	-1.0
Apr 14 04:25	3130	DB	5.4	68	39	112	+1.0	-2.2
Apr 14 05:25	3130	RD	5.4	67	51	214	+1.7	+1.9
Apr 15 05:25	164984	RD	7.1	55	39	225	+1.2	+0.9
Apr 16 04:47	3392	RD	7.3	43	19	266	+0.5	-1.0
Apr 24 18:23	885	DD	5.6	53	21	99	+1.8	+0.6
May 03 20:11	1951	DD	7.1	162	43	109	+1.3	-1.5
May 03 23:04	1962	DD	5.0	163	67	112	+2.1	-0.9
May 04 02:55	1973	DD	6.2	164	35	116	+1.1	0.0
May 06 01:15	2228	RD	5.8	168	78	237	+3.6	+2.9
May 07 00:19	2398	RD	6.1	154	67	354	-0.3	-4.9
May 07 05:06	184678	RD	7.6	152	50	321	+1.9	-1.5
May 07 23:44	185716	RD	7.4	140	47	263	+1.4	-0.7
May 08 00:53	2558	RD	6.3	140	62	292	+1.4	-1.5
May 08 01:53	2564	RD	7.0	139	74	293	+1.8	-1.4
May 08 03:43	2575	RD	6.9	139	80	268	+2.2	+0.3
May 08 23:04	187363	RD	7.2	126	27	274	+0.4	-1.1
May 12 01:06	3214	RD	6.8	86	12	234	+0.4	+0.1
May 13 04:04	3358	RD	6.9	72	35	178	+0.7	+5.0
May 25 20:43	1363	DD	5.2	69	16	170	-0.5	-2.0
May 25 21:06	1365	DD	6.0	69	13	148	0.0	-0.9
May 31 00:01	139272	DD	7.6	131	41	136	+1.1	-0.9
May 31 21:33	2025	DD	6.8	143	70	90	+2.7	-0.1
Jun 01 03:54	2053	DD	4.5	146	8	113	+0.2	+0.3
Jun 01 20:18	2147	DD	6.9	157	55	142	+0.7	-2.2
Jun 02 02:54	159116	DD	7.2	159	34	123	+1.0	-0.2
Jun 02 18:50	184043	DD	7.2	170	27	95	+0.5	-1.1
Jun 04 02:21	185282	RD	7.1	171	69	252	+1.9	+1.4
Jun 04 02:51	185305	RD	7.5	171	63	266	+1.8	+0.8
Jun 04 05:14	185404	RD	7.5	170	34	307	+1.2	-0.3
Jun 04 20:28	186606	RD	7.2	160	23	216	+1.8	+1.5
Jun 04 20:42	2650	RD	4.7	160	26	294	+0.1	-1.5
Jun 04 21:35	186671	RD	7.3	159	37	236	+1.5	+0.3
Jun 07 00:48	3018	RD	6.4	130	48	224	+1.7	+1.1
Jun 07 05:51	3037	RD	7.3	128	64	294	+2.9	-0.6
Jun 07 23:47	3164	RD	4.5	117	22	255	+0.6	-0.6
Jun 07 23:59	164528	RD	7.5	116	25	301	+0.2	-2.6
Jun 08 00:07	164544	RD	7.3	116	26	181	+2.0	+6.2
Jun 08 01:52	3175	DB	4.7	116	47	28	+1.5	+2.1
Jun 08 02:54	3175	RD	4.7	115	60	286	+2.3	-1.8
Jun 10 01:06	3446	RD	7.2	91	13	208	+0.4	+1.3
Jun 14 05:21	374	RD	6.0	42	16	172	-1.2	+4.0
Jun 25 18:19	1741	DD	7.1	85	54	119	+2.1	-1.0
Jun 26 23:39	1866	DD	5.8	100	18	78	+0.7	+1.8
Jun 27 19:00	1962	RB	5.0	111	65	335	+1.0	-2.4
Jun 27 22:07	1973	DD	6.2	112	49	87	+2.1	+1.1
Jun 29 21:37	2228	DD	5.8	139	79	136	+1.6	-1.9
Jul 01 01:39	184678	DD	7.6	155	48	61	+1.0	+2.2
Jul 01 19:44	185716	DD	7.4	166	42	125	+0.5	-1.9
Jul 01 20:45	2558	DD	6.3	167	55	96	+1.4	-1.0
Jul 01 21:41	2564	DD	7.0	167	66	93	+1.8	-0.7
Jul 01 23:26	2575	DD	6.9	168	85	113	+2.1	-1.1
Jul 02 04:44	186222	DD	7.5	170	25	41	-0.4	+2.4
Jul 03 03:12	187716	RD	7.2	174	56	291	+2.0	-0.1
Jul 03 23:55	2939	RD	7.5	162	66	220	+2.0	+1.9
Jul 05 22:27	3243	RD	7.3	135	21	232	+0.7	+0.3
Jul 06 02:08	3265	RD	6.6	134	64	242	+1.9	+0.7
Jul 07 00:36	3392	RD	7.3	121	34	196	+0.8	+2.4
Jul 08 02:17	3526	DB	4.9	108	40	62	+1.4	+0.2
Jul 08 03:34	3526	RD	4.9	107	54	222	+1.4	+1.3
Jul 08 04:47	3535	DB	5.1	107	60	84	+2.8	+0.1
Jul 08 05:54	3535	RD	5.1	107	60	191	+0.5	+2.9
Jul 10 01:54	214	RD	6.2	84	13	242	+0.4	-0.1
Jul 21 19:37	1612	DD	7.3	45	17	117	+0.6	+0.1
Jul 24 22:57	1946	DD	7.4	82	13	106	+0.4	+0.5
Jul 25 20:11	X 37784	DD	7.4	94	59	97	+2.2	+0.4
Jul 26 19:11	2171	DD	6.5	107	77	154	+1.2	-2.7
Jul 26 20:18	159116	DD	7.2	107	70	62	+3.3	+2.9
Jul 26 23:30	2189	DD	7.1	109	32	82	+0.8	+1.4
Jul 28 00:22	2347	DD	4.6	122	35	159	+1.9	-3.0
Jul 28 00:32	184337	DD	7.0	122	33	39	0.0	+4.0
Jul 28 00:53	2347	RB	4.6	123	29	215	-0.4	+4.2
Jul 28 19:00	2478	DD	7.6	134	62	166	-0.1	-4.4
Jul 28 19:21	2482	DD	6.3	134	66	149	+0.8	-3.1
Jul 28 20:06	2488	DD	6.9	135	75	145	+1.3	-3.0
Jul 28 21:26	185282	DD	7.1	135	83	95	+2.3	-0.1
Jul 28 21:58	185305	DD	7.5	135	78	77	+2.3	+0.9
Jul 30 05:13	2721	DD	3.2	153	6	99	-0.2	+0.7
Aug 01 21:15	164567	RD	7.3	167	35	260	+1.0	-0.6
Aug 01 22:14	3175	RD	4.7	167	47	231	+1.4	+0.7
Aug 02 01:30	3191	RD	7.4	166	76	236	+1.8	+1.4
Aug 03 00:47	165243	RD	7.4	153	62	255	+2.1	+0.1
Aug 03 05:38	165316	RD	7.6	151	40	240	+0.9	+1.7
Aug 05 23:28	167	RD	5.5	115	10	232	+0.3	+0.2
Aug 06 04:23	184	RD	6.0	114	51	250	+2.3	+0.7
Aug 07 02:43	290	RD	6.1	102	33	264	+1.9	-0.7
Aug 07 05:01	92761	RD	6.9	102	45	224	+1.6	+1.4
Aug 08 02:01	407	RD	7.2	91	16	234	+0.5	+0.1
Aug 08 03:10	416	DB	5.3	91	26	86	+1.8	-0.9
Aug 08 04:17	416	RD	5.3	90	35	200	+0.5	+1.7
Aug 09 05:15	76050	RD	7.3	79	32	199	+0.5	+1.8
Aug 23 19:51	2274	DD	6.9	90	64	139	+1.9	-1.8
Aug 24 20:58	184849	DD	7.4	104	64	107	+2.0	-0.1
Aug 25 21:06	2601	DD	6.8	118	76	149	+2.7	-4.1
Aug 25 22:35	186271	DD	7.3	118	57	76	+1.5	+1.3
Aug 26 02:11	2634	DD	7.2	120	14	137	+0.9	-0.6
Aug 26 19:03	187672	DD	7.4	131	64	85	+1.9	-0.4
Aug 26 21:03	2796	DD	6.9	132	85	58	+2.1	+1.5
Aug 26 23:27	2805	DD	7.1	132	60	51	+1.1	+2.2
Aug 29 04:35	3150	DD	6.6	162	19	57	0.0	+1.6
Aug 30 20:56	146509	RD	7.1	172	32	306	+1.6	-4.6
Aug 31 04:39	3421	RD	4.9	170	33	275	+1.3	+1.0
Aug 31 22:53	147015	RD	7.1	159	42	280	+2.2	-1.7
Sep 01 00:19	3537	RD	6.9	159	55	201	+0.9	+2.2
Sep 03 00:31	110020	RD	7.6	134	34	225	+1.0	+0.7
Sep 05 04:44	486	DB	5.3	109	37	36	+1.6	+1.6
Sep 20 22:47	2411	DD	6.7	75	17	98	+0.2	+0.8
Sep 22 00:15	2575	DD	6.9	89	12	84	-0.1	+1.0
Sep 22 22:29	2743	DD	7.6	102	45	154	+5.6	-7.0
Sep 26 22:54	165316	DD	7.6	155	69	352	-0.6	+4.6
Sep 29 21:56	184	RD	6.0	167	32	249	+1.3	-0.1
Sep 30 21:48	92761	RD	6.9	155	19	227	+0.5	+0.4
Oct 01 00:52	92795	RD	7.2	153	43	225	+1.5	+1.1
Oct 03 03:06	556	RD	5.4	130	35	296	+3.9	-1.4
Oct 06 04:10	78431	RD	7.5	96	25	273	+2.4	-0.8
Oct 07 04:11	1122	DB	3.8	85	21	127	+2.4	-2.1
Oct 07 05:31	1122	RD	3.8	85	28	241	+2.6	+0.5
Oct 21 20:39	3018	DD	6.4	98	66	132	+4.8	-3.4
Oct 22 00:43	3037	DD	7.3	100	16	105	+0.4	+0.7
Oct 22 19:49	3164	DD	4.5	111	77	104	+3.2	-0.9
Oct 22 20:14	164528	DD	7.5	111	76	72	+2.2	+1.0
Oct 22 20:45	3164	RB	4.5	111	72	190	+0.3	+3.6
Oct 22 22:14	164567	DD	7.3	111	56	100	+2.3	+0.5
Oct 23 01:27	164637	DD	7.5	113	15	75	+0.1	+1.3
Oct 24 00:16	165197	DD	7.5	125	38	91	+1.4	+1.1
Oct 24 21:55	3447	DD	7.6	137	65	99	+3.5	-0.3
Oct 25 00:21	3449	DD	7.3	138	43	24	+0.5	+2.5
Oct 25 02:48	3463	DD	6.4	139	13	118	+0.7	+0.2
Oct 25 22:13	22	DD	7.2	150	59	111	+4.9	-1.9
Oct 29 21:42	487	RD	5.2	162	18	195	-0.3	+1.7
Oct 29 22:25	75906	RD	7.5	162	24	226	+0.8	+0.5
Oct 31 04:23	647	RD	5.4	149	23	284	+2.0	+0.5
Nov 01 00:05	773	RD	7.0	139	19	292	+2.5	-1.9
Nov 06 04:08	1424	RD	6.8	83	25	314	+1.8	-2.1
Nov 10 09:41	Venus	DB	-4.0	33	62	193	-1.0	-4.6
Nov 10 10:30	Venus	RD	-4.0	33	61	258	+4.4	+1.4
Nov 15 20:40	2634	DD	7.2	40	16	80	-0.1	+1.1
Nov 17 22:42	2985	DD	6.8	68	15	122	+0.7	+0.1
Nov 21 01:25	3421	DD	4.9	108	6	54	-0.1	+1.6
Nov 25 23:09	93309	DD	7.5	166	38	103	+3.5	-0.6
Nov 28 00:32	732	RD	7.5	170	31	234	+2.2	+1.0
Dec 05 02:38	1586	RD	7.5	93	22	335	+1.1	-2.7
Dec 11 04:25	2290	RD	2.3	16	5	274	-0.2	-0.9
Dec 23 23:12	76156	DD	6.9	147	32	82	+2.5	+0.8
Dec 24 01:06	556	DD	5.4	147	18	64	+1.7	+1.7
Dec 27 22:18	1103	RD	5.8	168	18	259	+1.6	-0.7
Dec 28 04:00	1122	DB	3.8	166	19	40	+4.8	+5.2
Dec 28 04:23	1119	RD	5.8	166	16	289	+1.1	+0.4
Dec 28 04:27	1122	RB	3.8	166	15	1	-2.3	-4.5
Dec 28 23:19	1232	RD	6.4	157	21	243	+1.7	-0.1

LUNAR OCCULTATION TABLE

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 22:39	525	DD	6.5	135	29	102	+2.5	+0.5
Jan 08 01:17	1093	DD	6.6	175	26	162	+0.7	-2.4
Jan 29 20:25	374	DD	6.0	92	29	138	+4.1	-3.4
Jan 30 20:56	93394	DD	6.9	103	27	51	+1.9	+1.9
Jan 31 23:04	76499	DD	7.3	114	13	79	+1.4	+1.5
Feb 01 20:12	745	DD	7.3	124	30	99	+2.9	-0.3
Feb 02 20:29	890	DD	4.6	135	28	80	+2.5	0.0
Feb 02 22:06	890	RB	4.6	136	27	269	+2.5	+0.5
Feb 02 22:14	77724	DD	7.0	136	26	67	+2.5	+1.1
Feb 05 01:09	1181	DD	7.0	159	21	145	+0.7	-0.8
Feb 07 01:24	1416	RD	7.0	174	34	245	+3.8	+1.9
Feb 08 22:35	99505	RD	7.5	153	25	261	+1.5	-0.9
Feb 11 04:01	1864	RD	6.7	126	58	335	+1.0	-2.1
Feb 14 01:25	2217	RD	5.5	88	29	238	+1.6	+0.1
Feb 14 04:09	2230	RD	6.7	87	62	358	-0.4	-4.2
Feb 17 03:40	2721	DB	3.2	47	23	137	-0.4	-2.3
Feb 17 04:26	2721	RD	3.2	47	32	239	+1.2	0.0
Feb 27 19:59	566	DD	6.1	82	22	109	+1.9	+0.5
Feb 27 20:04	563	DD	7.0	82	21	35	+1.9	+2.5
Feb 27 20:28	76254	DD	7.3	82	18	26	+1.9	+3.0
Mar 01 22:25	996	DD	6.9	115	18	53	+2.6	+2.4
Mar 02 21:58	1119	DD	5.8	126	26	45	+3.8	+2.8
Mar 03 22:40	1252	DD	7.3	138	29	105	+2.1	+0.1
Mar 07 00:34	1598	DD	6.5	173	44	148	+1.1	-1.5
Mar 07 21:24	1702	DB	4.0	172	29	122	+1.2	-1.8
Mar 07 22:39	1702	RD	4.0	172	41	308	+1.5	-1.7
Mar 09 01:17	138889	RD	7.2	159	57	246	+4.7	+2.0
Mar 09 02:57	X 54027	DD	3.5	158	52	198	-1.6	-5.8
Mar 09 02:58	1821	DD	2.8	158	52	199	-1.7	-6.0
Mar 09 03:24	1821	RD	2.8	158	48	240	+4.2	+4.5
Mar 09 03:25	X 54027	RD	3.5	158	48	240	+4.1	+4.3
Mar 09 04:49	1825	RD	5.9	157	34	295	+1.1	+0.1
Mar 10 03:46	1947	RD	7.0	145	57	329	+1.2	-1.8
Mar 11 02:23	2065	RD	6.5	132	67	10	-0.9	-5.0
Mar 11 22:21	2173	RD	6.9	120	16	244	+0.6	-0.4
Mar 13 02:11	184305	RD	7.5	105	54	262	+1.8	-0.6
Mar 13 03:40	184337	RD	7.0	105	71	226	+4.6	+3.9
Mar 30 20:00	1189	RB	5.0	105	29	284	+2.3	-0.1
Apr 03 22:41	1659	DD	6.7	154	48	139	+1.4	-1.4
Apr 06 20:28	1997	RD	6.9	166	26	347	-0.1	-2.6
Apr 07 19:57	2118	DB	2.8	153	12	137	-0.2	-1.7
Apr 07 20:43	2117	RD	5.2	153	21	285	+0.3	-1.4
Apr 07 20:49	2118	RD	2.8	153	23	281	+0.4	-1.3
Apr 07 23:45	2132	RD	7.3	151	58	294	+1.4	-1.5
Apr 08 03:55	2147	RD	6.9	150	58	325	+1.4	-1.7
Apr 09 03:38	184045	RD	7.3	136	74	252	+2.6	+1.4
Apr 10 00:04	2442	RD	5.9	123	42	353	-1.0	-4.1
Apr 10 02:45	2452	RD	6.7	122	74	290	+1.9	-1.2
Apr 10 03:02	2455	RD	6.6	122	77	311	+1.6	-2.1
Apr 11 00:18	186222	RD	7.5	110	33	328	-0.3	-2.7
Apr 12 00:15	187716	RD	7.2	97	21	279	+0.1	-1.2
Apr 12 00:43	2796	RD	6.9	96	26	218	+1.5	+1.1
Apr 12 02:50	2805	RD	7.1	95	51	291	+1.2	-1.7
Apr 15 03:05	3243	RD	7.3	57	16	280	+0.2	-1.5
Apr 25 19:13	1026	DD	6.5	64	16	113	+1.2	+0.4
May 01 17:48	1702	RB	4.0	133	29	276	+1.4	-1.3
May 02 22:49	1825	DD	5.9	148	55	167	+0.6	-2.5
May 03 20:50	1947	DD	7.0	161	53	144	+0.9	-2.1
May 04 02:26	1962	DD	5.0	163	34	48	+2.1	+6.6
May 04 19:01	2065	DD	6.5	174	26	117	+0.4	-1.6
May 06 00:38	2214	RD	6.3	170	76	298	+1.9	-1.1
May 06 04:23	2228	RD	5.8	168	39	250	+0.9	+2.0
May 06 19:54	2357	RD	6.8	157	19	281	+0.1	-1.2
May 06 19:56	184383	RD	7.3	157	20	295	0.0	-1.4
May 06 19:58	184381	RD	5.7	157	20	287	0.0	-1.3
May 06 19:58	2359	RD	5.0	157	20	287	0.0	-1.3
May 07 20:16	2524	RD	6.0	143	13	272	-0.1	-1.0
May 08 02:48	185716	RD	7.4	140	82	297	+2.1	-1.2
May 08 04:04	2558	RD	6.3	140	71	306	+2.2	-1.3
May 08 05:08	2564	RD	7.0	139	58	286	+1.8	+0.1

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 08 22:10	2721	DB	3.2	128	22	50	+0.9	+0.2
May 08 22:49	2721	RD	3.2	128	29	326	-0.4	-2.8
May 09 01:34	187363	RD	7.2	127	62	317	+1.2	-3.0
May 12 03:39	3214	RD	6.8	86	48	242	+1.5	+0.3
May 24 18:09	1232	DD	6.4	56	23	131	+1.1	-0.4
May 25 20:17	80615	DD	7.5	67	15	52	+3.3	+4.4
Jun 01 17:28	2118	RB	2.8	154	26	289	+0.4	-1.4
Jun 01 19:15	2132	DD	7.3	155	47	124	+0.8	-1.8
Jun 01 20:54	2136	DD	6.6	156	66	181	-0.4	-4.1
Jun 01 23:23	2147	DD	6.9	157	68	84	+2.4	+0.8
Jun 03 19:01	2443	RD	5.7	176	24	329	-0.4	-2.2
Jun 03 19:05	2442	RD	5.9	176	25	303	0.0	-1.6
Jun 03 21:15	2455	RD	6.6	175	51	273	+1.3	-1.0
Jun 04 23:20	186606	RD	7.2	160	63	274	+1.7	-0.8
Jun 05 00:37	186671	RD	7.3	159	78	275	+2.1	-0.5
Jun 06 22:01	2984	RD	7.1	132	21	248	+0.5	-0.4
Jun 06 22:09	2985	RD	6.8	132	22	285	+0.2	-1.5
Jun 07 03:44	3018	RD	6.4	130	79	196	+0.9	+4.0
Jun 08 01:15	3164	DB	4.5	117	45	63	+1.4	+0.1
Jun 08 02:33	3164	RD	4.5	117	61	254	+1.9	0.0
Jun 08 02:53	164528	RD	7.5	116	64	292	+2.6	-2.2
Jun 08 04:51	3175	DB	4.7	116	74	71	+2.1	+1.0
Jun 08 04:57	164567	RD	7.3	116	74	278	+2.8	-0.2
Jun 08 06:08	3175	RD	4.7	115	64	224	+1.1	+2.1
Jun 09 01:29	3304	RD	6.4	104	36	208	+1.1	+1.6
Jun 10 00:02	3425	RD	4.4	92	6	192	+0.4	+2.3
Jun 10 02:09	3434	RD	7.5	91	31	220	+0.9	+0.9
Jun 10 03:23	3446	RD	7.2	91	45	176	+0.2	+4.6
Jun 11 02:10	12	RD	6.4	79	19	267	+0.7	-1.1
Jun 11 02:27	13	RD	6.2	79	22	274	+0.9	-1.5
Jun 11 03:05	128618	RD	6.8	79	30	195	+0.5	+2.1
Jun 28 00:42	1973	DD	6.2	112	13	80	+0.2	+1.6
Jun 29 20:40	2214	DD	6.3	137	76	85	+2.5	+0.2
Jun 30 00:38	2228	DD	5.8	139	41	126	+1.3	-0.4
Jul 01 22:38	185716	DD	7.4	166	81	86	+2.2	+0.1
Jul 01 23:58	2558	DD	6.3	167	76	74	+2.0	+1.1
Jul 02 00:54	2564	DD	7.0	167	65	88	+1.8	+0.7
Jul 02 03:49	2579	DD	7.4	168	31	42	-0.2	+2.5
Jul 02 18:18	2721	DD	3.2	176	18	81	+0.2	-0.8
Jul 02 19:12	2721	RD	3.2	176	29	294	+0.2	-1.6
Jul 05 04:46	3106	RD	5.2	147	55	269	+1.7	+0.9
Jul 05 21:58	164829	RD	7.1	137	21	256	+0.5	-0.6
Jul 05 21:58	3228	RD	7.2	137	21	256	+0.5	-0.6
Jul 06 01:07	3243	RD	7.3	135	58	221	+1.5	+1.4
Jul 07 04:50	146509	RD	7.1	121	63	279	+3.1	-0.1
Jul 10 04:07	214	RD	6.2	84	39	177	-0.4	+3.3
Jul 13 04:59	566	RD	6.1	50	16	201	-0.1	+1.3
Jul 13 05:15	563	RD	7.0	50	18	271	+1.6	-1.2
Jul 13 05:32	76254	RD	7.3	50	21	271	+1.8	-1.1
Jul 20 18:30	1499	DD	7.1	32	11	115	+0.5	+0.3
Jul 22 19:19	1709	DD	6.6	55	26	89	+1.4	+1.3
Jul 25 22:56	X 37784	DD	7.4	94	21	91	+0.5	+1.1
Jul 26 22:09	2171	DD	6.5	107	43	129	+1.4	-0.6
Jul 26 23:15	159116	DD	7.2	107	30	59	+0.5	+2.8
Jul 28 21:56	2478	DD	7.6	134	73	131	+2.1	-1.6
Jul 28 22:11	2479	DD	5.1	134	70	151	+2.2	-3.3
Jul 28 22:11	2480	DD	5.2	134	70	151	+2.2	-3.3
Jul 28 22:27	2482	DD	6.3	134	67	129	+2.1	-1.3
Jul 28 22:56	2480	RB	5.2	134	61	220	+1.2	+3.9
Jul 28 22:56	2479	RB	5.1	134	61	220	+1.3	+3.9
Jul 28 23:20	2488	DD	6.9	135	56	144	+2.2	-2.2
Jul 29 00:31	185282	DD	7.1	135	42	119	+1.4	-0.1
Jul 29 00:54	185305	DD	7.5	135	38	108	+1.1	+0.4
Jul 29 19:08	186606	DD	7.2	147	56	84	+1.6	-0.6
Jul 29 20:25	186671	DD	7.3	147	71	79	+2.1	0.0
Aug 01 21:02	3164	DB	4.5	168	38	126	+0.8	-3.4
Aug 01 21:41	3164	RD	4.5	168	46	195	+1.4	+3.1
Aug 01 22:23	164528	RD	7.5	168	54	238	+1.6	+0.5
Aug 02 00:13	164567	RD	7.3	167	72	236	+1.8	+1.2
Aug 02 00:16	3175	DB	4.7	167	73	119	+3.4	-2.7

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 02 00:56	3175	RB	4.7	167	75	180	0.0	+4.7
Aug 02 04:00	164637	RD	7.5	166	46	252	+1.1	+1.5
Aug 03 03:30	3327	RD	6.8	153	58	279	+2.6	+0.3
Aug 06 01:36	167	RD	5.5	115	37	172	-0.6	+3.8
Aug 07 01:38	284	RD	7.1	104	26	207	+0.4	+1.2
Aug 07 05:30	290	RD	6.1	102	43	182	+0.2	+3.0
Aug 20 18:38	1891	DD	4.4	50	34	66	+1.8	+3.2
Aug 20 19:18	1891	RB	4.4	51	26	358	+0.3	-3.3
Aug 24 20:43	2424	DD	6.9	103	61	69	+1.7	+1.8
Aug 24 21:48	2427	DD	7.2	103	48	106	+1.5	+0.3
Aug 24 23:57	184849	DD	7.4	104	22	163	+2.4	-3.7
Aug 25 18:52	2575	DD	6.9	116	79	59	+2.5	+1.5
Aug 26 01:15	186271	DD	7.3	118	21	140	+1.2	-0.8
Aug 26 22:21	187672	DD	7.4	131	67	102	+2.1	+0.1
Aug 26 23:38	187716	DD	7.2	131	52	25	+0.1	+3.5
Aug 27 00:05	2796	DD	6.9	132	46	108	+1.6	+0.3
Aug 27 01:56	2805	DD	7.1	132	25	116	+0.8	+0.3
Aug 27 21:28	2939	DD	7.5	144	81	115	+2.7	-1.6
Aug 28 23:45	3106	DD	5.2	159	71	38	+1.1	+2.3
Aug 29 01:19	3116	DD	6.6	159	53	51	+0.9	+1.9
Aug 30 00:49	164948	DD	7.2	172	65	16	+0.5	+2.9
Aug 30 02:27	3271	DD	7.2	173	47	7	-0.2	+3.1
Aug 31 00:13	146509	RD	7.1	172	66	239	+1.8	+1.1
Sep 01 01:55	147015	RD	7.1	159	58	202	+0.9	+2.3
Sep 05 00:00	460	RD	6.9	112	11	192	-0.5	+1.8
Sep 05 00:28	465	DB	4.4	112	15	93	+1.3	-1.3
Sep 05 01:27	465	RD	4.4	111	24	200	+0.1	+1.4
Sep 06 03:47	598	RD	5.5	99	30	250	+2.0	+0.1
Sep 18 20:06	158720	DD	7.2	47	17	55	0.0	+3.0
Sep 20 18:19	2371	RB	4.8	72	64	239	+2.0	+2.7
Sep 21 23:35	185716	DD	7.4	88	15	32	-0.9	+2.7
Sep 22 21:28	2723	DD	6.6	100	52	63	+1.0	+1.8
Sep 22 23:57	187363	DD	7.2	101	23	51	-0.2	+1.9
Sep 25 00:23	3062	DD	7.5	128	39	58	+0.5	+1.8
Sep 25 20:06	3191	DD	7.4	140	66	49	+1.7	+1.3
Sep 26 20:23	165243	DD	7.4	153	57	59	+1.7	+0.6
Sep 30 22:14	290	RD	6.1	155	27	188	-0.1	+2.2
Oct 01 01:19	299	RD	6.0	154	43	308	+8.3	-5.3
Oct 03 01:59	76088	RD	7.4	131	32	257	+2.3	0.0
Oct 17 20:35	2347	DD	4.6	43	12	80	-0.1	+1.2
Oct 20 19:54	2848	RB	5.6	83	58	220	+0.7	+2.6
Oct 22 23:13	164516	DD	6.9	111	38	36	+0.2	+2.2
Oct 26 20:10	109522	DD	7.3	160	40	94	+2.3	-1.3
Oct 30 00:27	486	RD	5.3	163	35	249	+2.2	+0.5
Nov 01 03:32	773	RD	7.0	139	27	246	+2.5	+1.1
Nov 04 01:30	79729	RD	6.9	107	12	352	+5.5	-9.5
Nov 10 12:20	Venus	DB	-4.0	34	41	122	+1.5	-0.4
Nov 10 13:38	Venus	RD	-4.0	33	26	310	+0.8	-0.4
Nov 15 19:46	186271	DD	7.3	38	22	83	+0.1	+1.2
Nov 16 20:14	2805	DD	7.1	52	28	63	+0.1	+1.6
Nov 18 20:09	3106	RB	5.2	79	50	276	+1.8	+0.8
Nov 18 20:41	3116	DD	6.6	79	44	38	+0.4	+2.2
Nov 19 21:16	164948	DD	7.2	92	45	43	+0.6	+2.1
Nov 19 22:45	3271	DD	7.2	93	27	29	0.0	+2.2
Nov 21 21:00	3514	DD	5.9	118	55	352	-0.6	+3.8
Nov 30 23:22	1132	RD	6.4	138	12	232	+0.8	+0.1
Nov 30 23:54	1137	RD	5.0	138	16	329	+2.8	-3.5
Dec 01 00:28	1139	RD	7.1	138	20	328	+2.8	-3.1
Dec 08 03:02	1891	DB	4.4	58	17	177	-0.2	-2.9
Dec 08 03:39	1891	RD	4.4	58	24	249	+1.3	-0.6
Dec 13 19:47	2721	DD	3.2	19	8	36	-0.8	+1.9
Dec 20 20:13	180	DD	5.2	111	46	45	+1.6	+1.7
Dec 20 20:14	181	DD	6.3	111	46	45	+1.6	+1.7
Dec 20 21:35	180	RB	5.2	111	36	238	+1.6	+1.8
Dec 21 21:56	299	DD	6.0	123	35	77	+2.1	+1.2
Dec 22 20:33	415	DD	5.8	134	38	66	+2.2	+0.7
Dec 23 21:12	524	DD	6.7	145	33	61	+2.1	+0.7
Dec 23 23:57	76088	DD	7.4	146	23	117	+2.0	+0.1
Dec 28 01:43	1103	RD	5.8	168	27	254	+2.8	+0.9
Dec 29 02:54	1232	RD	6.4	157	28	266	+2.6	+0.7

LUNAR OCCULTATION TABLE

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:43	525	DD	6.5	135	57	26	+1.7	+3.0
Jan 09 03:02	1233	RD	5.7	167	48	295	+2.4	-0.8
Jan 19 04:37	2442	RD	5.9	41	14	224	+1.9	+2.3
Jan 19 04:50	2443	RD	5.7	41	17	260	+0.6	-0.1
Jan 27 21:48	155	DD	6.4	70	23	67	+1.0	+1.3
Feb 03 00:22	906	DD	6.6	137	37	130	+1.6	-1.5
Feb 03 01:00	909	DD	6.0	137	31	49	+3.1	+2.8
Feb 11 04:00	1869	RD	6.2	126	79	340	+1.0	-2.9
Feb 15 05:15	2398	RD	6.1	73	51	299	+1.3	-1.4
Mar 04 03:08	1270	DD	6.1	140	13	147	-0.3	-1.5
Mar 06 22:50	1598	DD	6.5	173	52	140	+1.8	-2.2
Mar 07 21:02	1702	RD	4.0	172	21	335	+0.7	-2.5
Mar 09 01:08	X 54027	DB	3.5	158	69	182	-0.2	-3.9
Mar 09 01:09	1821	DB	2.8	158	69	182	-0.2	-3.9
Mar 09 02:05	1821	RD	2.8	158	78	267	+3.9	+0.1
Mar 09 02:05	X 54027	RD	3.5	158	78	267	+3.9	+0.1
Mar 09 03:27	1825	RD	5.9	157	71	327	+1.4	-2.2
Mar 18 05:22	3158	RD	5.7	38	14	225	+0.9	+1.2
Mar 26 20:54	652	DD	6.4	62	21	134	+0.4	-1.9
Apr 07 23:28	2136	RD	6.6	151	43	252	+2.5	+0.6
Apr 09 00:16	2290	DB	2.3	137	41	170	-0.6	-3.2
Apr 09 01:01	2290	RD	2.3	136	51	252	+2.8	+0.6
Apr 10 01:15	2455	RD	6.6	122	40	352	-1.0	-4.0
May 02 02:08	1733	DD	5.4	137	28	133	+0.7	-1.1
May 02 21:07	1825	DD	5.9	148	63	161	+0.8	-2.8
May 05 23:00	2214	RD	6.3	170	55	320	+0.9	-2.0
May 06 03:11	2228	RD	5.8	168	64	333	+1.9	-2.9
May 10 00:49	2914	DB	4.8	113	22	140	-0.3	-2.6
May 10 01:32	2914	RD	4.8	112	32	220	+2.1	+2.0
May 12 05:34	3227	RD	6.3	85	62	204	+1.7	+3.1
May 25 22:15	1363	DD	5.2	69	15	72	+1.4	+1.5
Jun 01 19:19	2136	DD	6.6	156	36	164	-0.2	-2.6
Jun 02 03:49	2171	DD	6.5	159	25	121	+1.0	-0.7
Jun 02 20:19	2290	DB	2.3	170	36	199	-5.2	-9.2
Jun 02 20:31	2290	RB	2.3	170	39	220	+6.9	+6.9
Jun 04 01:40	2479	RD	5.1	172	74	279	+2.7	-0.4
Jun 04 01:40	2480	RD	5.2	172	74	279	+2.8	-0.3
Jun 04 02:06	2482	RD	6.3	172	71	298	+2.6	-1.2
Jun 05 23:45	2848	RD	5.6	145	38	249	+1.7	+0.4
Jun 07 02:41	3018	RD	6.4	130	63	304	+2.8	-2.8
Jun 08 00:02	3158	RD	5.7	117	15	235	+0.7	+0.8
Jun 09 00:44	3304	RD	6.4	104	12	286	+0.2	-1.1
Jun 23 21:34	1544	DD	5.4	62	20	109	+0.7	-0.3
Jun 26 21:45	1849	DD	6.1	98	53	152	+1.1	-2.3
Jun 29 19:22	2214	DD	6.3	137	54	50	+6.2	+4.5
Jun 29 19:43	2214	RD	6.3	138	59	18	-3.7	-7.9
Jul 06 04:23	3265	RD	6.6	134	84	280	+4.0	-0.7
Jul 08 04:37	3526	DB	4.9	108	72	28	+1.3	+2.5
Jul 08 06:02	3526	RD	4.9	107	80	241	+2.5	+1.5
Jul 10 03:20	214	RD	6.2	84	31	306	+4.3	-6.0
Jul 26 21:11	2171	DD	6.5	107	67	50	+4.7	+5.4
Jul 26 22:06	2175	DD	6.1	107	55	142	+2.0	-2.1
Jul 28 01:55	2347	DD	4.6	122	16	98	+0.5	+0.1
Jul 28 20:28	2479	DD	5.1	134	68	82	+2.9	+0.2
Jul 28 20:28	2480	DD	5.2	134	69	83	+2.9	+0.2
Jul 28 21:10	2482	DD	6.3	134	74	52	+3.9	+2.7
Jul 28 21:50	2479	RB	5.1	134	75	309	+2.5	-2.0
Jul 28 21:51	2480	RB	5.2	134	75	309	+2.5	-2.0
Jul 30 19:50	2848	DD	5.6	162	34	114	+0.8	-1.3
Aug 01 21:00	3164	RD	4.5	168	22	274	+0.7	-0.6
Aug 01 23:21	3175	DB	4.7	167	54	8	+1.4	+4.7
Aug 02 00:07	3175	RD	4.7	167	65	300	+3.6	-3.0
Aug 06 00:59	167	RD	5.5	115	28	295	+2.2	-2.6
Aug 07 04:08	290	DD	6.1	102	56	337	-3.3	+6.8
Aug 07 04:40	290	RD	6.1	102	61	295	+7.1	-3.5
Aug 08 05:12	416	DB	5.3	91	55	64	+2.4	+1.0
Aug 10 03:21	652	RD	6.4	69	14	216	-0.2	+1.4
Aug 25 19:30	2583	DD	5.8	117	69	146	+1.8	-3.5
Aug 26 21:25	2784	DD	3.3	131	75	92	+2.9	-0.1
Aug 26 22:54	2784	RB	3.3	131	66	246	+2.2	+1.3
Aug 29 23:03	3265	DD	6.6	172	69	38	+1.8	+2.1
Aug 31 23:49	3526	RD	4.9	160	55	223	+1.5	+1.7
Sep 01 02:05	3535	RD	5.1	159	81	184	+0.3	+3.5
Sep 08 03:18	885	RD	5.6	77	17	276	+1.2	-0.7
Sep 21 21:47	2545	DD	6.4	87	41	124	+2.3	-1.2
Sep 21 23:52	2554	DD	4.5	88	14	146	+2.0	-2.6
Sep 29 23:52	184	RD	6.0	167	59	284	+4.5	-1.6
Oct 01 22:27	416	RD	5.3	143	18	247	+0.5	+0.4
Oct 02 02:45	432	RD	5.8	142	59	178	-0.2	+4.4
Oct 21 22:39	3018	DD	6.4	98	43	95	+1.8	+0.2
Oct 22 22:07	3164	DD	4.5	110	63	75	+2.2	+1.0
Oct 22 23:17	3164	RB	4.5	111	47	212	+0.4	+2.2
Oct 25 20:04	12	DD	6.4	148	51	126	+6.5	-7.4
Oct 25 20:28	13	DD	6.2	148	56	127	+8.6	-9.0
Oct 29 23:49	487	RD	5.2	162	48	221	+1.3	+1.6
Nov 04 01:39	1189	DB	5.0	106	18	89	+1.1	-0.4
Nov 04 03:06	1189	RD	5.0	106	35	274	+2.3	-0.6
Nov 10 10:47	Venus	DB	-4.0	34	80	99	+3.9	-0.5
Nov 10 12:03	Venus	RD	-4.0	33	64	356	+0.3	-3.9
Nov 19 19:56	3265	DD	6.6	92	77	70	+2.6	+1.1
Nov 29 22:01	1008	RD	5.3	149	10	201	-1.2	+2.8
Nov 30 00:57	1022	RD	6.0	148	41	221	+1.7	+2.2
Dec 21 21:46	299	DD	6.0	123	60	345	-1.4	+6.1
Dec 26 04:45	840	DD	6.3	169	11	125	+0.1	-0.8
Dec 28 00:07	1103	RD	5.8	168	44	295	+3.3	-1.5
Dec 29 01:18	1232	RD	6.4	157	48	290	+3.2	-1.2

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 22:26	525	DD	6.5	135	23	116	+2.5	+0.1
Feb 02 21:52	890	RB	4.6	136	19	255	+2.1	+0.6
Feb 11 04:09	1864	RD	6.7	126	50	305	+1.5	-1.0
Feb 29 22:01	840	DD	6.3	104	10	42	+2.1	+2.4
Mar 02 21:33	1119	DD	5.8	126	19	71	+2.3	+0.7
Mar 07 00:48	1598	DD	6.5	173	35	181	-0.2	-2.5
Mar 07 21:37	1702	DB	4.0	172	24	138	+0.8	-2.0
Mar 07 22:46	1702	RD	4.0	171	33	289	+1.5	-1.4
Mar 09 04:35	1825	RD	5.9	157	34	255	+1.8	+2.2
Mar 11 02:49	2065	RD	6.5	132	60	329	+0.9	-2.1
Mar 11 23:06	2182	RD	6.2	120	23	350	-0.5	-2.6
Mar 13 04:59	2359	DB	5.0	104	70	62	+2.5	+1.6
Mar 17 02:26	2985	RD	6.8	53	10	217	+0.4	+0.3
Mar 30 19:50	1189	RB	5.0	105	20	266	+2.2	+0.2
Apr 01 21:13	1432	DD	6.7	129	27	49	+4.6	+2.5
Apr 03 22:51	1659	DD	6.7	154	39	166	+0.5	-1.9
Apr 07 04:40	2025	RD	6.8	163	37	327	+0.9	-1.0
Apr 07 20:15	2118	DB	2.8	153	14	155	-0.3	-2.0
Apr 07 20:53	2117	RD	5.2	153	21	266	+0.4	-1.3
Apr 07 20:58	2118	RD	2.8	153	22	261	+0.5	-1.2
Apr 10 00:19	2443	RD	5.7	123	42	347	-0.6	-3.5
Apr 10 00:30	2442	RD	5.9	123	44	315	+0.3	-2.2
Apr 10 02:43	2452	RD	6.7	122	66	255	+2.0	0.0
Apr 10 03:07	2455	RD	6.6	122	69	277	+1.7	-0.7
Apr 25 19:07	1026	DD	6.5	64	11	138	+0.8	-0.1
May 04 02:01	1962	DD	5.0	163	39	99	+1.3	+0.8
May 04 19:15	2065	DD	6.5	174	25	134	+0.2	-1.9
May 06 00:34	2214	RD	6.3	170	67	263	+2.1	+0.2
May 06 20:03	2357	RD	6.8	157	20	260	+0.3	-1.1
May 06 20:08	184381	RD	5.7	157	21	266	+0.2	-1.2
May 06 20:08	2359	RD	5.0	157	21	266	+0.2	-1.2
May 07 03:33	2398	RD	6.1	154	62	337	+1.6	-3.1
May 07 20:23	2524	RD	6.0	143	15	248	+0.1	-0.8
May 08 03:59	2558	RD	6.3	140	70	274	+1.7	+0.3
May 08 22:13	2721	DB	3.2	128	22	82	+0.2	-1.0
May 08 23:08	2721	RD	3.2	128	32	292	+0.2	-1.7
May 12 03:26	3214	RD	6.8	86	41	207	+1.1	+1.6
May 24 18:12	1232	DD	6.4	56	16	161	+0.2	-1.1
Jun 01 00:34	2025	DD	6.8	143	42	80	+1.5	+1.7
Jun 01 17:38	2118	RB	2.8	154	25	270	+0.5	-1.3
Jun 03 19:19	2443	RD	5.7	176	27	303	0.0	-1.7
Jun 04 22:19	2650	DB	4.7	160	47	72	+1.3	-0.5
Jun 04 23:19	2650	RD	4.7	160	58	306	+1.0	-2.1
Jun 06 22:18	2985	RD	6.8	132	23	253	+0.4	-0.8
Jun 08 01:16	3164	DB	4.5	117	41	96	+1.1	-1.5
Jun 08 02:22	3164	RD	4.5	117	52	223	+1.4	+1.0
Jun 08 04:38	3175	DB	4.7	116	66	93	+2.2	-0.2
Jun 08 05:43	3175	RD	4.7	115	63	207	+0.8	+2.5
Jun 11 02:13	12	RD	6.4	79	15	235	+0.4	-0.2
Jun 11 02:32	13	RD	6.2	79	18	242	+0.6	-0.4
Jun 27 21:07	1962	DD	5.0	110	50	67	+2.7	+2.6
Jun 27 21:48	1962	RB	5.0	111	44	1	+0.3	-3.6
Jun 28 00:31	1973	DD	6.2	112	18	113	+0.5	+0.6
Jun 29 20:38	2214	DD	6.3	137	66	119	+1.5	-1.3
Jun 30 00:45	2228	DD	5.8	139	42	167	+1.3	-3.1
Jul 01 00:27	2398	DD	6.1	153	57	39	+1.3	+4.5
Jul 01 04:07	2417	DD	6.7	155	19	22	-1.4	+4.9
Jul 01 23:47	2558	DD	6.3	167	73	106	+1.8	-0.5
Jul 02 18:28	2721	DB	3.2	176	20	107	-0.1	-1.5
Jul 02 19:22	2721	RB	3.2	176	30	265	+0.5	-1.1
Jul 05 00:18	3089	RD	5.3	149	55	306	+1.7	-3.4
Jul 05 04:30	3106	RD	5.2	147	57	254	+1.3	+1.3
Jul 05 05:58	3116	RD	6.6	147	42	246	+0.7	+1.7
Jul 22 19:09	1709	DD	6.6	55	26	125	+0.9	0.0
Jul 25 22:36	2053	DD	4.5	94	27	54	+0.7	+4.0
Jul 25 23:09	2053	RB	4.5	94	21	352	+0.8	-2.6
Jul 26 22:18	2171	DD	6.5	107	43	172	+1.2	-3.7
Jul 29 19:27	2650	DD	4.7	147	55	44	+2.1	+1.4
Jul 29 20:10	2650	RB	4.7	147	63	330	+0.8	-3.8
Aug 03 03:16	3327	RD	6.8	153	56	264	+1.9	+0.8
Aug 06 00:05	153	RD	6.0	116	15	279	+0.9	-2.0
Aug 07 05:02	290	RD	6.1	102	35	166	-1.2	+3.8
Aug 20 19:28	1891	RB	4.4	51	25	315	+0.7	-0.3
Aug 24 00:37	2290	DD	2.3	92	9	107	0.0	+0.8
Aug 25 01:41	2452	DD	6.7	105	10	82	-0.3	+1.3
Aug 25 18:42	2575	DD	6.9	116	69	95	+1.7	-0.7
Aug 28 19:35	3089	DD	5.3	157	44	30	+1.3	+1.5
Aug 28 23:23	3106	DD	5.2	159	67	57	+1.5	+1.4
Aug 29 00:59	3116	DD	6.6	159	56	65	+1.2	+1.5
Sep 05 01:11	465	RD	4.4	111	13	173	-1.3	+3.2
Sep 06 03:40	598	RD	5.5	99	20	240	+1.4	-0.1
Sep 22 00:10	2558	DD	6.3	88	15	64	-0.3	+1.6
Sep 22 21:10	2723	DD	6.6	100	58	85	+1.4	+1.1
Oct 01 01:18	299	RD	6.0	154	34	286	+3.1	-0.9
Oct 17 20:25	2347	DD	4.6	43	20	101	+0.2	+1.0
Oct 17 21:20	2347	RB	4.6	43	10	272	-0.2	+1.1
Oct 30 00:16	486	RD	5.3	163	25	240	+1.6	+0.3
Nov 10 12:24	Venus	DB	-4.0	34	38	157	+0.8	-1.6
Nov 10 13:30	Venus	RD	-4.0	33	28	274	+1.2	+1.4
Nov 11 15:06	Mars	DB	1.7	19	25	78	+0.7	+2.1
Nov 11 15:58	Mars	RD	1.7	19	15	333	+0.5	-0.9
Nov 30 01:20	1018	RD	5.8	149	17	337	+2.7	-2.7
Dec 20 21:14	180	RB	5.2	111	34	231	+1.4	+1.6
Dec 21 21:38	299	DD	6.0	123	30	85	+2.1	+0.9
Dec 28 01:22	1103	RD	5.8	168	19	232	+2.7	+1.1
Dec 29 02:33	1232	RD	6.4	157	21	239	+3.0	+1.4

MOON

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

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

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

MOON PHASES (UT)

Lunation	New Moon		First Quarter	
1002				
1003	Jan 21	21:05	Jan 29	06:03
1004	Feb 20	09:18	Feb 28	03:24
1005	Mar 20	22:41	Mar 28	23:48
1006	Apr 19	13:21	Apr 27	17:32
1007	May 19	04:52	May 27	07:57
1008	Jun 17	20:27	Jun 25	19:08
1009	Jul 17	11:24	Jul 25	03:37
1010	Aug 16	01:24	Aug 23	10:12
1011	Sep 14	14:29	Sep 21	15:54
1012	Oct 14	02:48	Oct 20	21:59
1013	Nov 12	14:27	Nov 19	05:50
1014	Dec 12	01:29	Dec 18	16:40
	Full Moon		Last Quarter	
1002	Jan 7	15:40	Jan 15	04:46
1003	Feb 6	08:47	Feb 13	13:40
1004	Mar 6	23:14	Mar 13	21:01
1005	Apr 5	11:03	Apr 12	03:46
1006	May 4	20:33	May 11	11:04
1007	Jun 3	04:20	Jun 9	20:02
1008	Jul 2	11:09	Jul 9	07:34
1009	Jul 31	18:05	Aug 7	22:01
1010	Aug 30	02:22	Sep 6	15:11
1011	Sep 28	13:09	Oct 6	10:12
1012	Oct 28	03:07	Nov 5	05:53
1013	Nov 26	20:07	Dec 5	00:53
1014	Dec 26	15:06		

PERIGEE AND APOGEE OF THE MOON (UT)

PERIGEE						APOGEE					
Date	hr	km	Date	hr	km	Date	hr	km	Date	hr	km
Jan 19	19	362,770	Jul 30	06	360,324	Jan 03	20	405,707	Jul 14	21	406,192
Feb 16	08	368,322	Aug 27	06	365,105	Jan 31	14	404,807	Aug 11	10	405,292
Mar 12	04	369,506	Sep 22	21	369,589	Feb 28	11	404,258	Sep 08	03	404,464
Apr 08	02	364,547	Oct 18	00	367,758	Mar 27	07	404,521	Oct 05	22	404,326
May 06	05	359,811	Nov 14	14	362,311	Apr 24	00	405,403	Nov 02	18	404,998
Jun 03	13	357,247	Dec 12	21	357,983	May 21	12	406,264	Nov 30	11	405,953
Jul 01	23	357,448				Jun 17	16	406,575	Dec 27	19	406,489

MERCURY

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

MERCURY

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	17 54 44	- 20 17 40	19 30 58	- 22 27 43	22 41 41	- 10 21 50	01 47 01	+ 14 06 43	01 20 34	+ 06 34 31	03 19 33	+ 16 15 53
2	17 51 09	- 20 14 26	19 37 07	- 22 21 11	22 48 34	- 09 36 42	01 49 17	+ 14 26 09	01 21 09	+ 06 25 05	03 26 24	+ 16 50 56
3	17 48 17	- 20 13 12	19 43 19	- 22 13 24	22 55 29	- 08 50 17	01 51 07	+ 14 41 58	01 22 01	+ 06 18 14	03 33 26	+ 17 25 58
4	17 46 09	- 20 13 55	19 49 34	- 22 04 22	23 02 24	- 08 02 40	01 52 31	+ 14 54 07	01 23 09	+ 06 13 55	03 40 41	+ 18 00 51
5	17 44 44	- 20 16 26	19 55 52	- 21 54 03	23 09 21	- 07 13 51	01 53 30	+ 15 02 34	01 24 33	+ 06 12 06	03 48 08	+ 18 35 26
6	17 44 01	- 20 20 36	20 02 12	- 21 42 28	23 16 18	- 06 23 54	01 54 04	+ 15 07 15	01 26 11	+ 06 12 43	03 55 48	+ 19 09 34
7	17 43 57	- 20 26 11	20 08 34	- 21 29 34	23 23 16	- 05 32 51	01 54 13	+ 15 08 12	01 28 05	+ 06 15 43	04 03 40	+ 19 43 05
8	17 44 30	- 20 32 59	20 14 59	- 21 15 22	23 30 15	- 04 40 49	01 53 59	+ 15 05 26	01 30 13	+ 06 21 01	04 11 45	+ 20 15 48
9	17 45 38	- 20 40 46	20 21 25	- 20 59 51	23 37 14	- 03 47 50	01 53 21	+ 14 59 00	01 32 35	+ 06 28 31	04 20 02	+ 20 47 34
10	17 47 16	- 20 49 19	20 27 53	- 20 43 01	23 44 13	- 02 54 00	01 52 23	+ 14 48 59	01 35 11	+ 06 38 10	04 28 31	+ 21 18 09
11	17 49 24	- 20 58 26	20 34 23	- 20 24 50	23 51 12	- 01 59 27	01 51 05	+ 14 35 32	01 37 59	+ 06 49 50	04 37 12	+ 21 47 22
12	17 51 57	- 21 07 54	20 40 54	- 20 05 19	23 58 10	- 01 04 18	01 49 30	+ 14 18 50	01 40 59	+ 07 03 28	04 46 04	+ 22 15 01
13	17 54 53	- 21 17 33	20 47 27	- 19 44 28	00 05 07	- 00 08 41	01 47 40	+ 13 59 08	01 44 12	+ 07 18 58	04 55 06	+ 22 40 54
14	17 58 10	- 21 27 13	20 54 01	- 19 22 15	00 12 01	+ 00 47 13	01 45 38	+ 13 36 41	01 47 37	+ 07 36 15	05 04 17	+ 23 04 49
15	18 01 47	- 21 36 44	21 00 36	- 18 58 41	00 18 52	+ 01 43 14	01 43 26	+ 13 11 50	01 51 13	+ 07 55 13	05 13 36	+ 23 26 35
16	18 05 41	- 21 45 58	21 07 13	- 18 33 46	00 25 40	+ 02 39 10	01 41 08	+ 12 44 59	01 55 00	+ 08 15 47	05 23 03	+ 23 46 01
17	18 09 50	- 21 54 48	21 13 51	- 18 07 28	00 32 22	+ 03 34 46	01 38 46	+ 12 16 30	01 58 58	+ 08 37 52	05 32 34	+ 24 02 58
18	18 14 13	- 22 03 08	21 20 30	- 17 39 49	00 38 58	+ 04 29 49	01 36 23	+ 11 46 51	02 03 07	+ 09 01 23	05 42 10	+ 24 17 19
19	18 18 49	- 22 10 52	21 27 10	- 17 10 48	00 45 26	+ 05 24 05	01 34 03	+ 11 16 29	02 07 26	+ 09 26 16	05 51 48	+ 24 28 57
20	18 23 37	- 22 17 54	21 33 51	- 16 40 25	00 51 45	+ 06 17 17	01 31 47	+ 10 45 51	02 11 56	+ 09 52 25	06 01 26	+ 24 37 48
21	18 28 35	- 22 24 10	21 40 33	- 16 08 39	00 57 54	+ 07 09 10	01 29 38	+ 10 15 24	02 16 36	+ 10 19 46	06 11 04	+ 24 43 50
22	18 33 42	- 22 29 36	21 47 16	- 15 35 32	01 03 51	+ 07 59 28	01 27 39	+ 09 45 33	02 21 27	+ 10 48 13	06 20 39	+ 24 47 02
23	18 38 58	- 22 34 09	21 54 00	- 15 01 03	01 09 34	+ 08 47 56	01 25 51	+ 09 16 43	02 26 27	+ 11 17 43	06 30 10	+ 24 47 25
24	18 44 21	- 22 37 44	22 00 46	- 14 25 11	01 15 03	+ 09 34 20	01 24 16	+ 08 49 13	02 31 39	+ 11 48 10	06 39 35	+ 24 45 02
25	18 49 52	- 22 40 21	22 07 32	- 13 47 59	01 20 14	+ 10 18 26	01 22 56	+ 08 23 22	02 37 00	+ 12 19 29	06 48 54	+ 24 39 58
26	18 55 29	- 22 41 54	22 14 20	- 13 09 25	01 25 08	+ 11 00 00	01 21 51	+ 07 59 26	02 42 32	+ 12 51 36	06 58 05	+ 24 32 18
27	19 01 12	- 22 42 24	22 21 08	- 12 29 31	01 29 42	+ 11 38 50	01 21 02	+ 07 37 39	02 48 15	+ 13 24 25	07 07 07	+ 24 22 09
28	19 07 00	- 22 41 47	22 27 58	- 11 48 16	01 33 55	+ 12 14 47	01 20 29	+ 07 18 09	02 54 08	+ 13 57 51	07 16 00	+ 24 09 37
29	19 12 53	- 22 40 02	22 34 49	- 11 05 42	01 37 47	+ 12 47 41	01 20 14	+ 07 01 05	03 00 12	+ 14 31 49	07 24 42	+ 23 54 50
30	19 18 51	- 22 37 07			01 41 16	+ 13 17 23	01 20 15	+ 06 46 31	03 06 28	+ 15 06 13	07 33 14	+ 23 37 57
31	19 24 53	- 22 33 01			01 44 21	+ 13 43 46			03 12 55	+ 15 40 57		
	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	07 41 34	+ 23 19 05	10 25 56	+ 07 31 32	09 49 19	+ 10 47 46	12 18 20	- 00 16 20	15 27 39	- 20 32 22	17 45 19	- 24 40 14
2	07 49 43	+ 22 58 23	10 28 04	+ 07 05 52	09 49 12	+ 11 08 30	12 24 49	- 01 03 03	15 33 38	- 20 59 01	17 44 36	- 24 25 13
3	07 57 41	+ 22 35 58	10 29 57	+ 06 41 34	09 49 36	+ 11 26 26	12 31 16	- 01 49 41	15 39 36	- 21 24 39	17 43 05	- 24 08 28
4	08 05 27	+ 22 12 00	10 31 35	+ 06 18 47	09 50 33	+ 11 41 19	12 37 40	- 02 36 10	15 45 35	- 21 49 13	17 40 47	- 23 49 59
5	08 13 01	+ 21 46 35	10 32 57	+ 05 57 39	09 52 03	+ 11 52 56	12 44 02	- 03 22 27	15 51 33	- 22 12 42	17 37 40	- 23 29 47
6	08 20 23	+ 21 19 51	10 34 02	+ 05 38 17	09 54 06	+ 12 01 04	12 50 21	- 04 08 27	15 57 30	- 22 35 05	17 33 48	- 23 07 57
7	08 27 34	+ 20 51 56	10 34 51	+ 05 20 52	09 56 40	+ 12 05 37	12 56 38	- 04 54 07	16 03 26	- 22 56 20	17 29 16	- 22 44 41
8	08 34 32	+ 20 22 56	10 35 22	+ 05 05 31	09 59 46	+ 12 06 28	13 02 53	- 05 39 24	16 09 21	- 23 16 25	17 24 09	- 22 20 15
9	08 41 20	+ 19 52 58	10 35 35	+ 04 52 25	10 03 21	+ 12 03 35	13 09 06	- 06 24 16	16 15 15	- 23 35 19	17 18 38	- 21 55 03
10	08 47 55	+ 19 22 09	10 35 30	+ 04 41 41	10 07 23	+ 11 56 57	13 15 16	- 07 08 39	16 21 06	- 23 53 01	17 12 52	- 21 29 37
11	08 54 20	+ 18 50 35	10 35 06	+ 04 33 30	10 11 51	+ 11 46 36	13 21 25	- 07 52 33	16 26 55	- 24 09 28	17 07 04	- 21 04 35
12	09 00 33	+ 18 18 22	10 34 22	+ 04 28 00	10 16 43	+ 11 32 35	13 27 33	- 08 35 54	16 32 42	- 24 24 40	17 01 25	- 20 40 38
13	09 06 35	+ 17 45 36	10 33 20	+ 04 25 18	10 21 56	+ 11 15 02	13 33 39	- 09 18 41	16 38 24	- 24 38 33	16 56 06	- 20 18 26
14	09 12 26	+ 17 12 21	10 31 59	+ 04 25 33	10 27 27	+ 10 54 05	13 39 43	- 10 00 52	16 44 02	- 24 51 08	16 51 16	- 19 58 38
15	09 18 06	+ 16 38 44	10 30 19	+ 04 28 49	10 33 15	+ 10 29 54	13 45 47	- 10 42 26	16 49 35	- 25 02 21	16 47 03	- 19 41 42
16	09 23 35	+ 16 04 50	10 28 21	+ 04 35 10	10 39 16	+ 10 02 41	13 51 49	- 11 23 21	16 55 03	- 25 12 12	16 43 32	- 19 28 00
17	09 28 53	+ 15 30 43	10 26 07	+ 04 44 38	10 45 29	+ 09 32 39	13 57 51	- 12 03 36	17 00 23	- 25 20 39	16 40 45	- 19 17 41
18	09 34 01	+ 14 56 29	10 23 37	+ 04 57 10	10 51 52	+ 09 00 03	14 03 52	- 12 43 09	17 05 34	- 25 27 41	16 38 44	- 19 10 48
19	09 38 57	+ 14 22 13	10 20 54	+ 05 12 43	10 58 22	+ 08 25 06	14 09 52	- 13 21 59	17 10 36	- 25 33 16	16 37 28	- 19 07 15
20	09 43 43	+ 13 48 00	10 18 00	+ 05 31 07	11 04 58	+ 07 48 04	14 15 52	- 14 00 05	17 15 27	- 25 37 23	16 36 55	- 19 06 50
21	09 48 18	+ 13 13 54	10 14 57	+ 05 52 11	11 11 37	+ 07 09 10	14 21 51	- 14 37 25	17 20 05	- 25 40 00	16 37 03	- 19 09 16
22	09 52 42	+ 12 40 01	10 11 50	+ 06 15 38	11 18 20	+ 06 28 40	14 27 50	- 15 13 59	17 24 28	- 25 41 06	16 37 49	- 19 14 16
23	09 56 55	+ 12 06 24	10 08 40	+ 06 41 07	11 25 04	+ 05 46 46	14 33 49	- 15 49 45	17 28 33	- 25 40 41	16 39 10	- 19 21 28
24	10 00 56	+ 11 33 10	10 05 32	+ 07 08 16	11 31 48	+ 05 03 41	14 39 48	- 16 24 42	17 32 19	- 25 38 44	16 41 03	- 19 30 33
25	10 04 47	+ 11 00 24	10 02 31	+ 07 36 37	11 38 32	+ 04 19 37	14 45 47	- 16 58 48	17 35 43	- 25 35 12	16 43 24	- 19 41 12
26	10 08 25	+ 10 28 10	09 59 39	+ 08 05 42	11 45 15	+ 03 34 45	14 51 45	- 17 32 03	17 38 42	- 25 30 06	16 46 12	- 19 53 06
27	10 11 52	+ 09 56 35	09 57 01	+ 08 35 00	11 51 56	+ 02 49 14	14 57 44	- 18 04 25	17 41 12	- 25 23 24	16 49 23	- 20 06 00
28	10 15 07	+ 09 25 43	09 54 40	+ 09 04 02	11 58 36	+ 02 03 15	15 03 43	- 18 35 53	17 43 10	- 25 15 06	16 52 55	- 20 19 36
29	10 18 09	+ 08 55 40	09 52 41	+ 09 32 17	12 05 13	+ 01 16 55	15 09 42	- 19 06 27	17 44 33	- 25 05 09	16 56 46	- 20 33 42
30	10 20 58	+ 08 26 33	09 51 06	+ 09 59 17	12 11 47	+ 00 30 21	15 15 41	- 19 36 03	17 45 17	- 24 53 32	17 00 54	- 20 48 05
31	10 23 34	+ 07 58 29	09 49 58	+ 10 24 35			15 21 40	- 20 04 42			17 05 18	- 21 02 33

VENUS

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	21 04 44	- 18 36 52	23 27 46	- 04 30 54	01 29 49	+ 10 24 57	03 37 22	+ 22 50 25	05 20 07	+ 27 43 54	05 25 41	+ 24 43 18
2	21 09 41	- 18 15 07	23 32 05	- 03 59 51	01 33 58	+ 10 54 00	03 41 22	+ 23 07 41	05 22 29	+ 27 45 46	05 23 23	+ 24 28 17
3	21 14 36	- 17 52 53	23 36 24	- 03 28 42	01 38 07	+ 11 22 49	03 45 20	+ 23 24 28	05 24 44	+ 27 47 10	05 20 59	+ 24 12 43
4	21 19 30	- 17 30 09	23 40 42	- 02 57 28	01 42 16	+ 11 51 23	03 49 17	+ 23 40 44	05 26 53	+ 27 48 04	05 18 30	+ 23 56 41
5	21 24 22	- 17 06 58	23 44 59	- 02 26 10	01 46 25	+ 12 19 41	03 53 13	+ 23 56 29	05 28 54	+ 27 48 30	05 15 58	+ 23 40 12
6	21 29 13	- 16 43 18	23 49 15	- 01 54 49	01 50 33	+ 12 47 43	03 57 08	+ 24 11 44	05 30 48	+ 27 48 27	05 13 23	+ 23 23 21
7	21 34 02	- 16 19 13	23 53 31	- 01 23 25	01 54 42	+ 13 15 28	04 01 00	+ 24 26 27	05 32 35	+ 27 47 54	05 10 46	+ 23 06 11
8	21 38 50	- 15 54 41	23 57 46	- 00 51 59	01 58 51	+ 13 42 55	04 04 52	+ 24 40 40	05 34 13	+ 27 46 54	05 08 08	+ 22 48 46
9	21 43 37	- 15 29 45	00 02 01	- 00 20 32	02 02 59	+ 14 10 04	04 08 41	+ 24 54 21	05 35 44	+ 27 45 24	05 05 31	+ 22 31 12
10	21 48 22	- 15 04 24	00 06 15	+ 00 10 56	02 07 08	+ 14 36 55	04 12 28	+ 25 07 31	05 37 06	+ 27 43 25	05 02 55	+ 22 13 32
11	21 53 06	- 14 38 40	00 10 29	+ 00 42 24	02 11 16	+ 15 03 26	04 16 14	+ 25 20 09	05 38 19	+ 27 40 58	05 00 22	+ 21 55 53
12	21 57 48	- 14 12 33	00 14 42	+ 01 13 51	02 15 25	+ 15 29 38	04 19 57	+ 25 32 17	05 39 23	+ 27 38 01	04 57 52	+ 21 38 18
13	22 02 30	- 13 46 05	00 18 55	+ 01 45 17	02 19 33	+ 15 55 29	04 23 38	+ 25 43 52	05 40 18	+ 27 34 34	04 55 27	+ 21 20 54
14	22 07 09	- 13 19 15	00 23 07	+ 02 16 41	02 23 41	+ 16 20 59	04 27 17	+ 25 54 56	05 41 03	+ 27 30 38	04 53 06	+ 21 03 45
15	22 11 48	- 12 52 05	00 27 19	+ 02 48 02	02 27 49	+ 16 46 07	04 30 53	+ 26 05 29	05 41 39	+ 27 26 11	04 50 52	+ 20 46 57
16	22 16 25	- 12 24 35	00 31 30	+ 03 19 19	02 31 57	+ 17 10 54	04 34 26	+ 26 15 30	05 42 05	+ 27 21 13	04 48 44	+ 20 30 33
17	22 21 01	- 11 56 46	00 35 42	+ 03 50 32	02 36 05	+ 17 35 18	04 37 57	+ 26 25 00	05 42 21	+ 27 15 44	04 46 43	+ 20 14 38
18	22 25 35	- 11 28 40	00 39 53	+ 04 21 41	02 40 13	+ 17 59 19	04 41 24	+ 26 33 58	05 42 26	+ 27 09 43	04 44 50	+ 19 59 17
19	22 30 09	- 11 00 16	00 44 03	+ 04 52 44	02 44 21	+ 18 22 56	04 44 48	+ 26 42 25	05 42 21	+ 27 03 09	04 43 06	+ 19 44 32
20	22 34 41	- 10 31 36	00 48 14	+ 05 23 41	02 48 28	+ 18 46 09	04 48 09	+ 26 50 21	05 42 05	+ 26 56 02	04 41 30	+ 19 30 28
21	22 39 12	- 10 02 40	00 52 24	+ 05 54 31	02 52 35	+ 19 08 58	04 51 26	+ 26 57 46	05 41 39	+ 26 48 20	04 40 03	+ 19 17 06
22	22 43 42	- 09 33 29	00 56 34	+ 06 25 13	02 56 42	+ 19 31 21	04 54 39	+ 27 04 39	05 41 02	+ 26 40 03	04 38 45	+ 19 04 29
23	22 48 11	- 09 04 04	01 00 44	+ 06 55 48	03 00 49	+ 19 53 18	04 57 48	+ 27 11 02	05 40 14	+ 26 31 11	04 37 37	+ 18 52 39
24	22 52 39	- 08 34 26	01 04 54	+ 07 26 13	03 04 55	+ 20 14 50	05 00 53	+ 27 16 54	05 39 16	+ 26 21 42	04 36 38	+ 18 41 38
25	22 57 06	- 08 04 35	01 09 03	+ 07 56 28	03 09 01	+ 20 35 55	05 03 53	+ 27 22 16	05 38 07	+ 26 11 36	04 35 50	+ 18 31 26
26	23 01 31	- 07 34 32	01 13 13	+ 08 26 34	03 13 06	+ 20 56 32	05 06 49	+ 27 27 07	05 36 48	+ 26 00 52	04 35 10	+ 18 22 04
27	23 05 56	- 07 04 19	01 17 22	+ 08 56 28	03 17 10	+ 21 16 42	05 09 40	+ 27 31 28	05 35 19	+ 25 49 30	04 34 41	+ 18 13 33
28	23 10 20	- 06 33 55	01 21 31	+ 09 26 10	03 21 14	+ 21 36 24	05 12 25	+ 27 35 19	05 33 41	+ 25 37 31	04 34 21	+ 18 05 51
29	23 14 43	- 06 03 22	01 25 40	+ 09 55 40	03 25 18	+ 21 55 38	05 15 05	+ 27 38 40	05 31 53	+ 25 24 53	04 34 10	+ 17 59 00
30	23 19 05	- 05 32 40			03 29 20	+ 22 14 23	05 17 39	+ 27 41 32	05 29 57	+ 25 11 38	04 34 10	+ 17 52 57
31	23 23 26	- 05 01 50			03 33 22	+ 22 32 39			05 27 53	+ 24 57 46		
	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	04 34 18	+ 17 47 43	05 37 06	+ 19 03 32	07 40 36	+ 19 17 10	09 56 16	+ 12 43 15	12 15 30	+ 00 02 58	14 34 03	- 13 19 20
2	04 34 35	+ 17 43 16	05 40 27	+ 19 08 20	07 45 01	+ 19 11 03	10 00 48	+ 12 23 09	12 19 59	- 00 24 32	14 38 52	- 13 43 16
3	04 35 02	+ 17 39 35	05 43 52	+ 19 13 00	07 49 28	+ 19 04 27	10 05 19	+ 12 02 40	12 24 29	- 00 52 06	14 43 43	- 14 06 53
4	04 35 37	+ 17 36 38	05 47 20	+ 19 17 30	07 53 55	+ 18 57 22	10 09 51	+ 11 41 47	12 28 59	- 01 19 44	14 48 36	- 14 30 11
5	04 36 21	+ 17 34 24	05 50 52	+ 19 21 50	07 58 23	+ 18 49 47	10 14 22	+ 11 20 33	12 33 29	- 01 47 24	14 53 29	- 14 53 07
6	04 37 14	+ 17 32 51	05 54 27	+ 19 25 58	08 02 51	+ 18 41 42	10 18 53	+ 10 58 56	12 38 00	- 02 15 05	14 58 23	- 15 15 42
7	04 38 14	+ 17 31 56	05 58 04	+ 19 29 53	08 07 21	+ 18 33 07	10 23 24	+ 10 36 59	12 42 31	- 02 42 48	15 03 19	- 15 37 55
8	04 39 22	+ 17 31 38	06 01 45	+ 19 33 35	08 11 51	+ 18 24 03	10 27 55	+ 10 14 41	12 47 02	- 03 10 31	15 08 15	- 15 59 44
9	04 40 39	+ 17 31 55	06 05 28	+ 19 37 01	08 16 21	+ 18 14 28	10 32 25	+ 09 52 03	12 51 34	- 03 38 13	15 13 13	- 16 21 10
10	04 42 02	+ 17 32 45	06 09 14	+ 19 40 12	08 20 52	+ 18 04 24	10 36 55	+ 09 29 05	12 56 06	- 04 05 54	15 18 12	- 16 42 10
11	04 43 33	+ 17 34 06	06 13 03	+ 19 43 05	08 25 23	+ 17 53 50	10 41 25	+ 09 05 48	13 00 39	- 04 33 32	15 23 13	- 17 02 45
12	04 45 11	+ 17 35 55	06 16 54	+ 19 45 41	08 29 55	+ 17 42 47	10 45 55	+ 08 42 14	13 05 12	- 05 01 08	15 28 14	- 17 22 54
13	04 46 55	+ 17 38 11	06 20 48	+ 19 47 58	08 34 27	+ 17 31 13	10 50 25	+ 08 18 21	13 09 46	- 05 28 41	15 33 17	- 17 42 35
14	04 48 46	+ 17 40 51	06 24 44	+ 19 49 55	08 38 59	+ 17 19 10	10 54 54	+ 07 54 12	13 14 20	- 05 56 08	15 38 21	- 18 01 49
15	04 50 43	+ 17 43 54	06 28 42	+ 19 51 32	08 43 32	+ 17 06 38	10 59 24	+ 07 29 46	13 18 55	- 06 23 31	15 43 26	- 18 20 33
16	04 52 47	+ 17 47 17	06 32 42	+ 19 52 48	08 48 05	+ 16 53 37	11 03 53	+ 07 05 04	13 23 31	- 06 50 48	15 48 32	- 18 38 49
17	04 54 56	+ 17 50 59	06 36 44	+ 19 53 43	08 52 37	+ 16 40 07	11 08 22	+ 06 40 07	13 28 07	- 07 17 58	15 53 39	- 18 56 34
18	04 57 11	+ 17 54 57	06 40 49	+ 19 54 14	08 57 10	+ 16 26 09	11 12 50	+ 06 14 56	13 32 44	- 07 45 00	15 58 48	- 19 13 48
19	04 59 32	+ 17 59 10	06 44 55	+ 19 54 23	09 01 43	+ 16 11 42	11 17 19	+ 05 49 31	13 37 22	- 08 11 54	16 03 57	- 19 30 30
20	05 01 57	+ 18 03 36	06 49 03	+ 19 54 08	09 06 16	+ 15 56 47	11 21 48	+ 05 23 52	13 42 00	- 08 38 39	16 09 08	- 19 46 41
21	05 04 28	+ 18 08 13	06 53 13	+ 19 53 28	09 10 50	+ 15 41 24	11 26 16	+ 04 58 01	13 46 40	- 09 05 15	16 14 20	- 20 02 18
22	05 07 04	+ 18 13 00	06 57 24	+ 19 52 24	09 15 23	+ 15 25 33	11 30 44	+ 04 31 59	13 51 20	- 09 31 39	16 19 32	- 20 17 22
23	05 09 45	+ 18 17 54	07 01 37	+ 19 50 54	09 19 56	+ 15 09 15	11 35 13	+ 04 05 44	13 56 01	- 09 57 53	16 24 46	- 20 31 52
24	05 12 31	+ 18 22 54	07 05 52	+ 19 48 58	09 24 29	+ 14 52 31	11 39 41	+ 03 39 20	14 00 43	- 10 23 54	16 30 01	- 20 45 46
25	05 15 21	+ 18 27 59	07 10 08	+ 19 46 36	09 29 01	+ 14 35 19	11 44 09	+ 03 12 45	14 05 25	- 10 49 43	16 35 17	- 20 59 06
26	05 18 15	+ 18 33 07	07 14 26	+ 19 43 47	09 33 34	+ 14 17 42	11 48 38	+ 02 46 01	14 10 09	- 11 15 17	16 40 34	- 21 11 49
27	05 21 13	+ 18 38 16	07 18 44	+ 19 40 31	09 38 07	+ 13 59 39	11 53 06	+ 02 19 08	14 14 54	- 11 40 38	16 45 52	- 21 23 55
28	05 24 16	+ 18 43 25	07 23 04	+ 19 36 47	09 42 39	+ 13 41 10	11 57 35	+ 01 52 08	14 19 39	- 12 05 43	16 51 11	- 21 35 24
29	05 27 23	+ 18 48 32	07 27 26	+ 19 32 36	09 47 12	+ 13 22 16	12 02 03	+ 01 25 00	14 24 26	- 12 30 32	16 56 31	- 21 46 16
30	05 30 33	+ 18 53 37	07 31 48	+ 19 27 56	09 51 44	+ 13 02 58	12 06 32	+ 00 57 45	14 29 14	- 12 55 05	17 01 51	- 21 56 29
31	05 33 48	+ 18 58 37	07 36 11	+ 19 22 47			12 11 01	+ 00 30 24			17 07 13	- 22 06 04

VENUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

ACROSS the FACE of the SUN

The Transit of Venus — 8th June 2004

On June 8th 2004, the Earth's sister planet, Venus, will cross the face of the Sun. The last transit of Venus occurred on December 6th 1882, one of only five such events of its kind ever viewed by humankind. Although there are many astronomical phenomena that one would consider more spectacular and exciting, the uniqueness and rarity of this transit will mean mandatory viewing by amateurs worldwide.

Johannes Kepler, discoverer of the laws of planetary motion, predicted a transit of Mercury on November 7th, 1631 and just one month later a transit of Venus on December 6th. Pierre Cassendi and two other individuals are known to have seen the Mercurian transit; inclement weather across Europe no doubt prevented more observations. The Venus event, not visible from Europe, passed by without a single recorded sighting. Kepler died just over a year prior to his forecasted transits.

Two persons, a young English astronomer Jeremiah Horrocks, and a friend William Crabtree observing 40 km apart saw the Venus transit of December 4th, 1639. As far as is known, they were the only people in the world to see this event. It was Horrocks' own calculations that predicted this transit, which due to a minor parallax error was missed by Kepler. Kepler did however correctly forecast the upcoming 1761 transit.

Edmond Halley, after observing the transit of Mercury in November 1677 (only the fourth ever seen, and the first to be followed from beginning to end), proposed that the infrequent transits of Venus could be used to determine the distances of the planets. Mercury was not a suitable candidate, even thought transits of this planet were more common, as it was too close to the Sun for accurate parallax measurements. If the distance of one planet from the Sun was known, then the other planets distances could be determined by applying Kepler's third law. So began the challenge to determine the Earth-Sun distance (the astronomical unit – 149,597,870 km), the key to the scale of the Solar System.

Prior to Halley's suggestion, it was a simple matter to calculate the relative sizes of the orbits of Venus and the Earth, by knowing the angle of greatest elongation from the Sun; without any further information it was impossible to calculate a size in actual kilometres. By observing a transit of Venus from two separated positions on the Earth, it is possible to calculate the distance from Earth to Venus, and hence the size of the Earth's orbit and from there the sizes of the orbits of all the other planets.

1631	Dec	7
1639	Dec	4
1761	Jun	6
1769	Jun	3
1874	Dec	9
1882	Dec	6
2004	Jun	8
2012	Jun	6
2117	Dec	11
2125	Dec	8

Table 1. Transits of Venus 1631 to 2125 AD

The next four transits, in 1761, 1769, 1874 and 1882, were large international affairs, with expeditions being dispatched around the globe. Over 120 observing sites were set up for the 1761 occasion; even Captain James Cook, on his first voyage of discovery in the Endeavour, was given the task of observing the June 3rd, 1769 transit. Cook and Charles Green successfully saw the transit in Tahiti from Point Venus. They then sailed to New Zealand, where a transit of Mercury was observed on November 9th, 1769. After mapping New Zealand, Cook sailed further westwards and discovered the East Coast of Australia.

The 1761/1769 pair of transits gave astronomers their first fairly good value of the Sun's distance, although the precision required for exact calculations, was fraught by several factors (see below). Better observations came from the 1874/1882 transits, but again not anywhere near as exact as they could be. Modern radar methods gave much more accurate distances to the planets than any observation of a transit could, and future transit observations will be enjoyed for what they are, rather than a method to scale the Solar System.

Observers at the 1761 transit were expecting a clean separation of Venus from the solar limb, an abrupt break where one could definitely say that the planet had entered the solar disc. Precise timing was critical here, the instant of separation had to be known for Halley's proposal to provide good results.

Imagine the dismay of the observers when instead of a clean break, the planet's trailing edge elongated and seemed to hang on to the solar limb (diagram 1). It was seen without exception at all observing stations, at ingress and egress, and reportedly lasted from a few seconds to a minute. The effect is not clearly understood, but refraction through Venus' thick atmosphere (discovered at the 1761 transit) and contrast effects are probable factors. It is this *black drop effect*, combined with turbulence in our own atmosphere, which spoiled the attempts of astronomers at the 1761 and later transits to make meaningful measurements that would provide precise data for the calculation of the size of the Solar System.

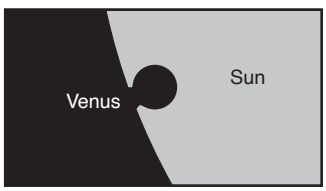


DIAGRAM 1. The Black drop effect

Transits of Venus occur in a 243 year cycle; a pair of transit events separated by 8 years, with these pairs separated by 121.5 years for half a cycle and 105.5 years for the next half (see table 1). Why doesn't a transit occur each time the planet is at inferior conjunction, when the planet is between the Earth and Sun? It is the same reason that a total solar eclipse does not occur at every New Moon – the Moon and Venus have orbits that are inclined to the plane of the ecliptic and mostly they will pass below or above the Sun at these times (diagram 2).

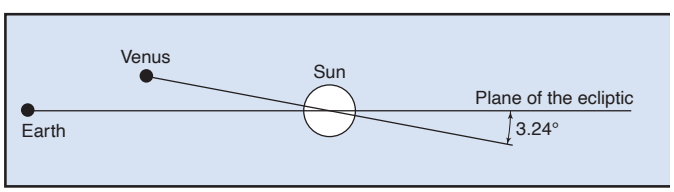


DIAGRAM 2. Venus' orbital tilt to the plane of the ecliptic.

A transit of Venus (for simplicity, we will mostly refer to Venus — but in general the same applies to Mercury unless noted) is only possible when the planet crosses the ecliptic, or the nodes (the intersection points of the planet's orbit with the plane of the Earth's orbit) of its orbit at inferior conjunction (diagram 3). In the diagram, the line joining the points where the plane of Venus's orbit intersects that of the Earth, is known as the line of nodes. During the course of an orbit, Venus will cross the line of nodes twice; once going from south to north, known as the ascending node, and the other going from north to south, the descending node. A transit can only occur if the Earth crosses the line of nodes at the same time as Venus, and this is exactly what happens in June on Venus's descending node.

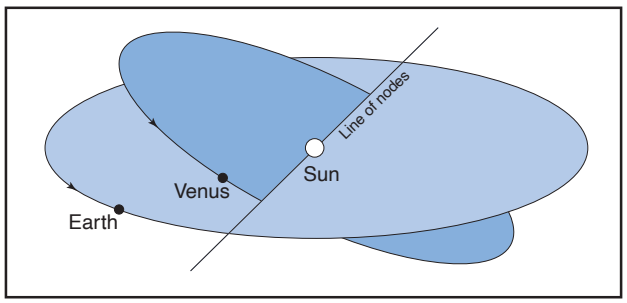


Diagram 3. A transit is only possible when inferior conjunction occurs as the Earth and Venus cross the line of nodes at the same time.

During a solar or lunar eclipse, the event advances from west to east against the eclipsed body. The opposite is seen during a transit when an inner planet crosses the Sun from east to west. Venus is in inferior conjunction when a transit occurs, and is between the Sun and Earth. As Venus moves more rapidly in its orbit than we do, it will approach the Sun's eastern limb and move ahead of us as it passes across the disc, finally exiting from the western limb.

What can an observer expect at this transit? To begin with, the entire transit (lasting over six hours) will only be visible from Europe, the

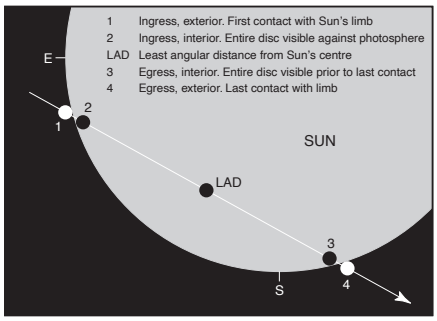
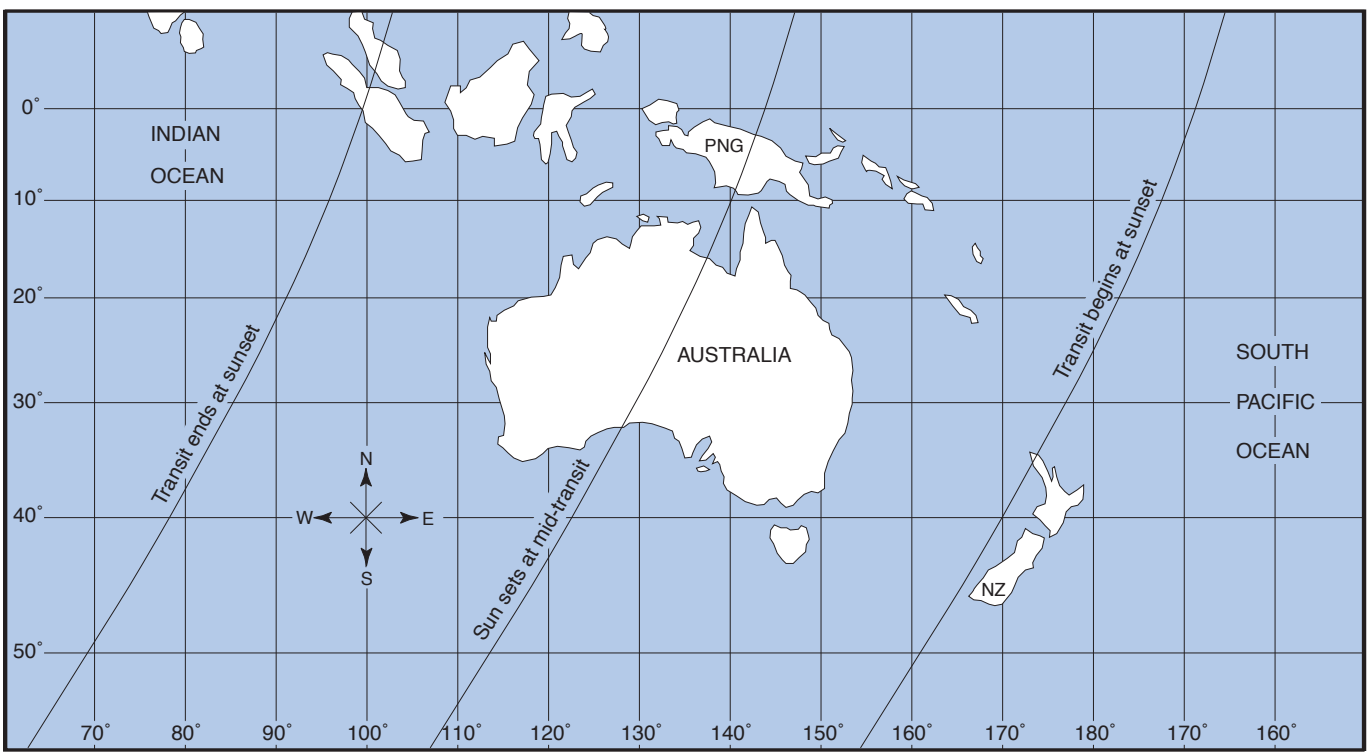


DIAGRAM 4. Path and contacts of the transit.

Middle East, and most of Asia and Africa. The Sun will set with the transit still in progress from Australia, and unfortunately our Kiwi friends across the Tasman just miss out on any of the transit. The beginning of the event starts around 3pm local time in the eastern states, and about 1pm in the west (see table 2). The Sun sets before mid-transit over the eastern half of the continent, while the western half will see more than half of the passage. Locations on the western coast, like Perth, will experience 4 hours of transit before sunset, or two thirds of the total event (see map below).

On the 8th June 2004, the first indication of the beginnings of the transit will be a small notch in the Sun's southeast limb. How soon after the predicted time Venus will be seen, is to a large extent, dependant upon the seeing at the observers location, as a 'boiling' limb will make it difficult to see the initial indentation. Around nineteen minutes later, contact two occurs, but instead of the separation of planet and solar limb, the legendary *black drop effect*

TRANSIT of VENUS - JUNE 8th 2004



The further west of the 'Transit begins at sunset' line, the more will be seen of the transit before sunset. From the east coast of Australia the Sun sets before mid-transit, while the western half of the continent will see beyond this point, with the Sun setting before the end of the transit.

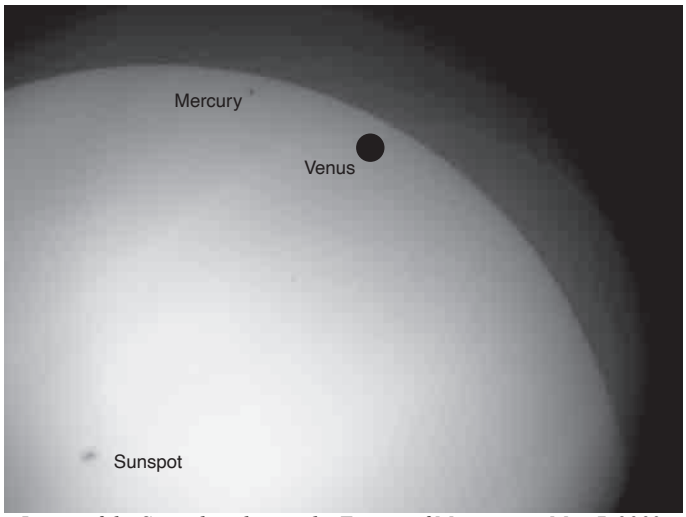


Image of the Sun taken during the Transit of Mercury on May 7, 2003. NB. The inserted circle shows Venus as it will appear during this year's transit drawn to the same scale as the photograph.

will happen. Venus' black disc then continues its traverse of the Sun for the next five hours and thirty minutes, before the egress contacts begin (diagram 4). With the unaided eye (suitably solar-filtered of course) Venus will be visible only if you have excellent eyesight. The planet at this time will be close to 58 arc seconds in diameter, or about 1/32 the diameter of the Sun.

We are also fortunate that the next transit occurs in eight years time, on June 6th 2012, and then begins a 105.5-year drought until the next pair. The 2012 transit is more favoured for Australian observers than the current one. The 6 hour 40 minute journey over the solar disc will be visible in its entirety from the eastern and central parts of the continent. Western Australia, however misses the beginning.

As mentioned at the start, there are many astronomical events that one would consider more spectacular, a bright comet or total solar eclipse for example. But still, the transit will have a beauty of its own for those who appreciate the marvels of our Universe. It will be a chance to contemplate the mechanics of the Solar System, the early attempts to measure it, and the rather fortunate timing that enables us to experience something that no living person has ever seen. In essence the transit is like an annular solar eclipse, but instead of our Moon, a much smaller body (in angular size) will be silhouetted against the Sun. Interestingly there will be an effective 0.001 magnitude drop (albeit, very insignificant and unnoticeable) due to the passage of the planet across the face of the Sun. Enjoy the transit!

OBSERVING THE SUN SAFELY

Looking at the Sun at any time can cause serious eye damage or blindness. Even glancing with the unaided eye can cause permanent damage and it is strongly advised that children be supervised by an adult. However, there are safe ways to view the Sun and this does not necessarily have to be expensive.

The safest way to observe is by *eyepiece projection*. This might give a new lease of life to that old department store 60mm refractor that has been under the bed for years. You don't look through the telescope, at any time, but instead project the image of the Sun from the eyepiece onto a flat white card and look at the solar image on the card. Make sure the small finder scope on the side of the tube is capped to avoid unexpected burns. Larger instruments may need to be stopped down to prevent eyepiece damage.

There are also inexpensive *aluminium coated Mylar filters*. These have been designed to let through a fraction of a percent of the sunlight. They can be just held up to the sun and looked through, mounted in front of the two main lenses of a pair of binoculars or in front of a small telescope.

NOTE The filter has to be mounted *before* the sunlight enters the binoculars or telescope, i.e., the end facing the Sun, NOT over the eyepieces you look through!

It is important:

1) You **buy only Mylar designed specifically for solar observing**.

2) If you are using it on a small telescope or binoculars **ensure it is securely mounted** so that they will not blow off with a gust of wind.

3) Get advice on its use. Purchase the Mylar from only a dedicated telescope dealer and definitely ask them how to use it. (The Quasar Publishing website has links to many such Australian shops)

Another option to observe the event, and probably the safest, is to get in touch with your local amateur astronomical society or public observatory and view with them on the day. Based on the media reaction to the opposition of Mars in August 2003 it is highly likely many of these organizations will run public education and viewing sessions. Watch the media as the time approaches or contact the societies/observatories directly. See places or society sections in Part III for contact details or the Quasar website for appropriate links.

Location	Time Zone	1st Contact Ingress Exterior h:m:s	PA (°) 1st Contact*	Altitude of the Sun (°) 1st Contact	2nd Contact Ingress Interior h:m:s	Altitude of the Sun (°) 2nd Contact	Least angular distance h:m:s
Adelaide	CST	02:37:53 PM	114.8	23.0	02:56:26 PM	20.7	-
Alice Springs	CST	02:38:16 PM	115.0	34.5	02:56:48 PM	31.9	05:44:19 PM
Brisbane	EST	03:07:02 PM	114.9	20.3	03:25:42 PM	17.1	-
Canberra	EST	03:07:18 PM	114.8	17.2	03:25:55 PM	14.5	-
Darwin	CST	02:38:46 PM	115.2	45.2	02:57:20 PM	42.3	05:43:56 PM
Hobart	EST	03:07:33 PM	114.7	12.6	03:26:09 PM	10.3	-
Melbourne	EST	03:07:33 PM	114.8	17.6	03:26:08 PM	15.1	-
Perth	WST	01:09:37 PM	114.9	33.7	01:28:04 PM	32.5	04:15:50 PM
Sydney	EST	03:07:10 PM	114.8	17.0	03:25:48 PM	14.2	-

* The position angle (PA) of the 1st point of contact measured from the north point of the solar limb towards the east.

Table 2. Local time of transit from various locations

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
00 37 48	+ 04 11 18
00 53 27	+ 06 00 02
01 09 25	+ 07 47 24
01 25 41	+ 09 32 46
01 42 17	+ 11 15 27
01 59 10	+ 12 54 39
02 16 20	+ 14 29 40
02 33 48	+ 15 59 54
02 51 35	+ 17 24 46
03 09 38	+ 18 43 33
03 27 57	+ 19 55 39
03 46 32	+ 21 00 35
04 05 22	+ 21 57 53
04 24 25	+ 22 47 03
04 43 38	+ 23 27 42
05 02 59	+ 23 59 34
05 22 28	+ 24 22 25
05 42 00	+ 24 36 04
06 01 32	+ 24 40 29
06 21 03	+ 24 35 40
06 40 29	+ 24 21 45
06 59 48	+ 23 58 52
07 18 58	+ 23 27 19
07 37 56	+ 22 47 24
07 56 42	+ 21 59 29
08 15 14	+ 21 03 57
08 33 31	+ 20 01 18
08 51 34	+ 18 52 00
09 09 22	+ 17 36 29
09 26 56	+ 16 15 17
09 44 17	+ 14 48 57
10 01 25	+ 13 17 57
10 18 23	+ 11 42 48
10 35 11	+ 10 03 58
10 51 52	+ 08 22 02
11 08 27	+ 06 37 29
11 24 58	+ 04 50 46
11 41 28	+ 03 02 26
11 57 58	+ 01 13 00
12 14 30	- 00 36 59
12 31 08	- 02 27 02
12 47 53	- 04 16 37
13 04 47	- 06 05 06
13 21 53	- 07 51 54
13 39 13	- 09 36 26
13 56 48	- 11 18 07
14 14 42	- 12 56 13
14 32 54	- 14 30 02
14 51 27	- 15 58 56
15 10 22	- 17 22 11
15 29 39	- 18 39 03
15 49 19	- 19 48 47

JUPITER

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

0hrs UT Epoch 2000.0

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11 20 45	+ 05 35 09
11 20 00	+ 05 41 56
11 18 41	+ 05 52 16
11 16 50	+ 06 05 51
11 14 30	+ 06 22 15
11 11 46	+ 06 40 59
11 08 42	+ 07 01 25
11 05 25	+ 07 22 50
11 02 02	+ 07 44 27
10 58 39	+ 08 05 30
10 55 25	+ 08 25 19
10 52 26	+ 08 43 12
10 49 47	+ 08 58 37
10 47 34	+ 09 11 09
10 45 50	+ 09 20 31
10 44 38	+ 09 26 31
10 43 59	+ 09 29 03
10 43 54	+ 09 28 08
10 44 23	+ 09 23 50
10 45 24	+ 09 16 17
10 46 56	+ 09 05 34
10 48 58	+ 08 51 54
10 51 27	+ 08 35 28
10 54 22	+ 08 16 27
10 57 40	+ 07 55 00
11 01 19	+ 07 31 21
11 05 17	+ 07 05 41
11 09 32	+ 06 38 11
11 14 03	+ 06 09 00
11 18 47	+ 05 38 21
11 23 42	+ 05 06 26
11 28 47	+ 04 33 23
11 34 01	+ 03 59 23
11 39 22	+ 03 24 38
11 44 48	+ 02 49 18
11 50 18	+ 02 13 34
11 55 50	+ 01 37 36
12 01 24	+ 01 01 37
12 06 57	+ 00 25 47
12 12 28	- 00 09 42
12 17 55	- 00 44 40
12 23 18	- 01 18 53
12 28 34	- 01 52 08
12 33 41	- 02 24 14
12 38 38	- 02 55 00
12 43 23	- 03 24 11
12 47 53	- 03 51 33
12 52 07	- 04 16 55
12 56 02	- 04 40 04
12 59 35	- 05 00 45
13 02 45	- 05 18 47

JUPITER'S MOONS 2004

Jupiter and its moons can be likened to a miniature solar system with its many moons orbiting the planet. Also, like the planets, these moons all lie in a similar plane. Although there are currently 61 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo (who suggested calling them the 'Medicean Stars'), 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 the monthly 'Jupiter's Moons' on pages 114-115. All the moons orbit in roughly the same plane, which is very close to the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From our perspective on Earth, we see four types of events. They are:

1 The satellite passes in front of Jupiter. This is called a Satellite Transit.

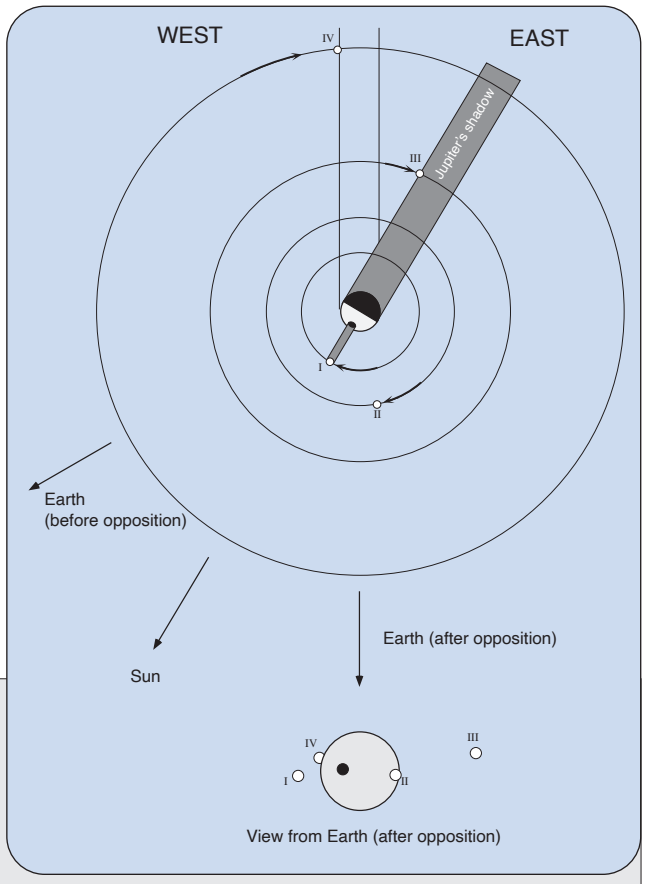
2 The shadow of a satellite can move across the 'surface' of the planet. This is called a Satellite Shadow Transit. The start of a satellite or shadow transit is called its ingress, the finish, its egress.

   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 2004 is March 4th.

3 A satellite can go into occultation i.e., 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. In fact, Io is so close to Jupiter, it is impossible to see both the disappearance and reappearance for the same eclipse. 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 (7X power 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 every 8 days approximately; an example would be the evening of January 9th. 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's	(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 (pp. 111-113)

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.

ECLIPSE POSITIONS

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

These diagrams shows the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse is 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

January

1	03:00	01:00	I	Ec	D	
	06:27	04:27	I	Oc	R	W
2	00:21	22:21(p)	I	Sh	I	
	01:30	23:30(p)	I	Tr	I	
	02:37	00:37	I	Sh	E	
	03:45	01:45	I	Tr	E	
	23:04	21:04	III	Tr	I	E
3	00:54	22:54(p)	I	Oc	R	
	02:23	00:23	III	Tr	E	
5	00:56	22:56(p)	IV	Sh	E	
	05:03	03:03	II	Sh	I	
7	00:10	22:10(p)	II	Ec	D	
	05:11	03:11	II	Oc	R	
8	04:54	02:54	I	Ec	D	
	23:22	21:22	II	Tr	E	E
9	02:14	00:14	I	Sh	I	
	03:19	01:19	I	Tr	I	
	04:31	02:31	I	Sh	E	
	05:34	03:34	I	Tr	E	W
	22:20	20:20	III	Sh	I	E
	23:22	21:22	I	Ec	D	E
10	01:49	23:49(p)	III	Sh	E	
	02:43	00:43	I	Oc	R	
	02:44	00:44	III	Tr	I	
	06:03	04:03	III	Tr	E	W
	22:59	20:59	I	Sh	E	E
11	00:01	22:01(p)	I	Tr	E	
13	05:27	03:27	IV	Ec	D	
14	02:44	00:44	II	Ec	D	
15	06:47	04:47	I	Ec	D	W
	22:58	20:58	II	Tr	I	E
	23:47	21:47	II	Sh	E	
16	01:47	23:47(p)	II	Tr	E	
	04:07	02:07	I	Sh	I	
	05:07	03:07	I	Tr	I	
	06:24	04:24	I	Sh	E	W
17	01:16	23:16(p)	I	Ec	D	
	02:18	00:18	III	Sh	I	
	04:31	02:31	I	Oc	R	
	05:47	03:47	III	Sh	E	W
	06:21	04:21	III	Tr	I	W
	22:35	20:35	I	Sh	I	E
	23:34	21:34	I	Tr	I	
18	00:52	22:52(p)	I	Sh	E	
	01:49	23:49(p)	I	Tr	E	
	22:58	20:58	I	Oc	R	
20	23:30	21:30	III	Oc	R	
21	05:18	03:18	II	Ec	D	
22	00:00	22:00(p)	IV	Tr	I	
	02:43	00:43	IV	Tr	E	
	23:31	21:31	II	Sh	I	
23	01:21	23:21(p)	II	Tr	I	
	02:23	00:23	II	Sh	E	
	04:10	02:10	II	Tr	E	
	06:00	04:00	I	Sh	I	W
	06:54	04:54	I	Tr	I	W
24	03:09	01:09	I	Ec	D	
	06:16	04:16	III	Sh	I	W
	06:18	04:18	I	Oc	R	W
	23:06	21:06	II	Oc	R	
25	00:29	22:29(p)	I	Sh	I	
	01:21	23:21(p)	I	Tr	I	
	02:45	00:45	I	Sh	E	
	03:36	01:36	I	Tr	E	
	21:37	19:37	I	Ec	D	E
26	00:45	22:45(p)	I	Oc	R	
	21:13	19:13	I	Sh	E	E
	22:02	20:02	I	Tr	E	E
28	02:59	00:59	III	Oc	R	
29	23:28	21:28	IV	Ec	D	
30	02:06	00:06	II	Sh	I	
	03:17	01:17	IV	Ec	R	
	03:42	01:42	II	Tr	I	
	04:58	02:58	II	Sh	E	
	06:31	04:31	II	Tr	E	W
31	05:03	03:03	I	Ec	D	
	21:08	19:08	II	Ec	D	E

February

1	01:24	23:24(p)	II	Oc	R	
	02:22	00:22	I	Sh	I	
	03:06	01:06	I	Tr	I	
	04:38	02:38	I	Sh	E	
	05:21	03:21	I	Tr	E	
	23:31	21:31	I	Ec	D	
2	02:31	00:31	I	Oc	R	
	20:50	18:50	I	Sh	I	E
	21:32	19:32	I	Tr	I	E
	23:06	21:06	I	Sh	E	
	23:47	21:47	I	Tr	E	
3	20:57	18:57	I	Oc	R	E
4	00:17	22:17(p)	III	Ec	D	
	06:24	04:24	III	Oc	R	W
6	04:42	02:42	II	Sh	I	
	06:01	04:01	II	Tr	I	W
7	06:57	04:57	I	Ec	D	W
	23:42	21:42	II	Ec	D	
8	03:40	01:40	II	Oc	R	
	04:15	02:15	I	Sh	I	
	04:51	02:51	I	Tr	I	
	06:31	04:31	I	Sh	E	W
	07:06	05:06	I	Tr	E	W
9	01:25	23:25(p)	I	Ec	D	
	04:16	02:16	I	Oc	R	
	20:51	18:51	II	Sh	E	E
	21:58	19:58	II	Tr	E	
	22:44	20:44	I	Sh	I	
	23:17	21:17	I	Tr	I	
10	01:00	23:00(p)	I	Sh	E	
	01:32	23:32(p)	I	Tr	E	
	22:42	20:42	I	Oc	R	
11	04:16	02:16	III	Ec	D	
	19:58	17:58	I	Tr	E	E
13	07:18	05:18	II	Sh	I	W
14	20:02	18:02	III	Tr	I	E
	21:36	19:36	III	Sh	E	
	23:18	21:18	III	Tr	E	
15	02:15	00:15	II	Ec	D	
	05:55	03:55	II	Oc	R	
	06:09	04:09	I	Sh	I	W
	06:35	04:35	I	Tr	I	W
	21:11	19:11	IV	Ec	R	
	22:03	20:03	IV	Oc	D	
16	00:42	22:42(p)	IV	Oc	R	
	03:19	01:19	I	Ec	D	
	06:01	04:01	I	Oc	R	W
	20:36	18:36	II	Sh	I	E
	21:26	19:26	II	Tr	I	
	23:27	21:27	II	Sh	E	
17	00:15	22:15(p)	II	Tr	E	
	00:37	22:37(p)	I	Sh	I	
	01:01	23:01(p)	I	Tr	I	
	02:53	00:53	I	Sh	E	
	03:16	01:16	I	Tr	E	
	21:48	19:48	I	Ec	D	
18	00:27	22:27(p)	I	Oc	R	
	19:27	17:27	I	Tr	I	E
	21:22	19:22	I	Sh	E	
	21:42	19:42	I	Tr	E	
21	22:07	20:07	III	Sh	I	
	23:19	21:19	III	Tr	I	
22	01:33	23:33(p)	III	Sh	E	
	02:36	00:36	III	Tr	E	
	04:49	02:49	II	Ec	D	
23	05:13	03:13	I	Ec	D	
	23:12	21:12	II	Sh	I	
	23:42	21:42	II	Tr	I	
24	02:04	00:04	II	Sh	E	
	02:31	00:31	II	Tr	E	
	02:31	00:31	I	Sh	I	
	02:45	00:45	I	Tr	I	
	02:57	00:57	IV	Sh	I	
	04:47	02:47	I	Sh	E	
	05:00	03:00	I	Tr	E	
	05:29	03:29	IV	Tr	I	
	06:32	04:32	IV	Sh	E	W
	23:42	21:42	I	Ec	D	
25	02:11	00:11	I	Oc	R	
	20:59	18:59	I	Sh	I	
	21:11	19:11	I	Tr	I	
	21:16	19:16	II	Oc	R	
	23:15	21:15	I	Sh	E	
	23:26	21:26	I	Tr	E	
26	20:37	18:37	I	Oc	R	E
29	02:05	00:05	III	Sh	I	
	02:35	00:35	III	Tr	I	
	05:31	03:31	III	Sh	E	
	05:53	03:53	III	Tr	E	
	07:22	05:22	II	Ec	D	W

March

1	07:07	05:07	I	Ec	D	W
2	01:48	23:48(p)	II	Sh	I	
	01:57	23:57(p)	II	Tr	I	
	04:24	02:24	I	Sh	I	
	04:28	02:28	I	Tr	I	
	04:40	02:40	II	Sh	E	
	04:46	02:46	II	Tr	E	
	06:40	04:40	I	Sh	E	W
	06:43	04:43	I	Tr	E	W
3	01:36	23:36(p)	I	Ec	D	
	03:55	01:55	I	Oc	R	
	19:39	17:39	III	Oc	R	E
	20:39	18:39	II	Ec	D	
	22:53	20:53	I	Sh	I	
	22:54	20:54	I	Tr	I	
	23:29	21:29	II	Oc	R	
4	01:09	23:09(p)	I	Sh	E	
	01:09	23:09(p)	I	Tr	E	
	20:05	18:05	I	Oc	D	E
	22:22	20:22	I	Ec	R	
5	19:35	17:35	I	Tr	E	E
	19:37	17:37	I	Sh	E	E
7	05:51	03:51	III	Tr	I	W
	06:04	04:04	III	Sh	I	W
9	04:12	02:12	II	Tr	I	
	04:25	02:25	II	Sh	I	
	06:12	04:12	I	Tr	I	W
	06:18	04:18	I	Sh	I	W
	07:02	05:02	II	Tr	E	W
	07:16	05:16	II	Sh	E	W
10	03:23	01:23	I	Oc	D	
	05:48	03:48	I	Ec	R	W
	19:35	17:35	III	Oc	D	E
	22:55	20:55	II	Oc	D	
	23:36	21:36	III	Ec	R	
11	00:38	22:38(p)	I	Tr	I	
	00:47	22:47(p)	I	Sh	I	
	02:02	00:02	II	Ec	R	
	02:53	00:53	I	Tr	E	
	03:02	01:02	I	Sh	E	
	19:35	17:35	IV	Tr	I	E
	20:57	18:57	IV	Sh	I	
	21:49	19:49	I	Oc	D	
	22:28	20:28	IV	Tr	E	
12	00:16	22:16(p)	I	Ec	R	
	00:25	22:25(p)	IV	Sh	E	
	19:03	17:03	I	Tr	I	E
	19:15	17:15	I	Sh	I	E
	20:10	18:10	II	Tr	E	E
	20:35	18:35	II	Sh	E	
	21:19	19:19	I	Tr	E	
	21:31	19:31	I	Sh	E	
13	18:45	16:45	I	Ec	R	E
16	06:28	04:28	II	Tr	I	W
17	05:07	03:07	I	Oc	D	W
	22:52	20:52	III	Oc	D	
18	01:09	23:09(p)	II	Oc	D	
	02:21	00:21	I	Tr	I	
	02:41	00:41	I	Sh	I	
	03:34	01:34	III	Ec	R	
	04:35	02:35	II	Ec	R	
	04:37	02:37	I	Tr	E	
	04:56	02:56	I	Sh	E	W
	23:33	21:33	I	Oc	D	
19	02:11	00:11	I	Ec	R	
	19:36	17:36	II	Tr	I	E
	20:21	18:21	II	Sh	I	
	20:47	18:47	I	Tr	I	
	21:09	19:09	I	Sh	I	
	22:26	20:26	II	Tr	E	
	23:03	21:03	I	Tr	E	
	23:12	21:12	II	Sh	E	
	23:25	21:25	I	Sh	E	
20	02:12	00:12	IV	Oc	D	
	05:13	03:13	IV	Oc	R	W
	05:35	03:35	IV	Ec	D	W
	17:59	15:59	I	Oc	D	E
	20:39	18:39	I	Ec	R	
21	17:52	15:52	II	Ec	R	E
	17:53	15:53	I	Sh	E	E

JUPITER MOON EVENTS

25	02:10	00:10	III	Oc	D	
	03:24	01:24	II	Oc	D	
	04:06	02:06	I	Tr	I	
	04:35	02:35	I	Sh	I	W
26	01:18	23:18(p)	I	Oc	D	
	04:05	02:05	I	Ec	R	W
	21:54	19:54	II	Tr	I	
	22:32	20:32	I	Tr	I	
	22:58	20:58	II	Sh	I	
	23:03	21:03	I	Sh	I	
27	00:44	22:44(p)	II	Tr	E	
	00:47	22:47(p)	I	Tr	E	
	01:19	23:19(p)	I	Sh	E	
	01:49	23:49(p)	II	Sh	E	
	19:44	17:44	I	Oc	D	E
	22:34	20:34	I	Ec	R	
28	18:00	16:00	III	Sh	I	E
	18:17	16:17	IV	Sh	E	E
	19:05	17:05	III	Tr	E	E
	19:14	17:14	I	Tr	E	E
	19:47	17:47	I	Sh	E	E
	20:26	18:26	II	Ec	R	
	21:23	19:23	III	Sh	E	

April

1	05:32	03:32	III	Oc	D	W
	05:39	03:39	II	Oc	D	W
2	03:04	01:04	I	Oc	D	
3	00:12	22:12(p)	II	Tr	I	
	00:17	22:17(p)	I	Tr	I	
	00:57	22:57(p)	I	Sh	I	
	01:35	23:35(p)	II	Sh	I	
	02:33	00:33	I	Tr	E	
	03:03	01:03	II	Tr	E	
	03:13	01:13	I	Sh	E	
	04:26	02:26	II	Sh	E	W
	21:30	19:30	I	Oc	D	
4	00:29	22:29(p)	I	Ec	R	
	18:44	16:44	I	Tr	I	E
	18:48	16:48	II	Oc	D	E
	19:06	17:06	III	Tr	I	E
	19:26	17:26	I	Sh	I	E
	20:59	18:59	I	Tr	E	
	21:42	19:42	I	Sh	E	
	21:58	19:58	III	Sh	I	
	22:28	20:28	III	Tr	E	
	23:00	21:00	II	Ec	R	
5	01:20	23:20(p)	III	Sh	E	
	18:58	16:58	I	Ec	R	E
	19:56	17:56	IV	Oc	R	
	23:39	21:39	IV	Ec	D	
6	02:56	00:56	IV	Ec	R	
	17:44	15:44	II	Sh	E	E
9	04:50	02:50	I	Oc	D	W
10	02:03	00:03	I	Tr	I	
	02:33	00:33	II	Tr	I	
	02:52	00:52	I	Sh	I	
	04:12	02:12	II	Sh	I	W
	04:19	02:19	I	Tr	E	W
	23:17	21:17	I	Oc	D	
11	02:24	00:24	I	Ec	R	
	20:30	18:30	I	Tr	I	
	21:07	19:07	II	Oc	D	
	21:20	19:20	I	Sh	I	
	22:32	20:32	III	Tr	I	
	22:46	20:46	I	Tr	E	
	23:36	21:36	I	Sh	E	
12	01:34	23:34(p)	II	Ec	R	
	01:55	23:55(p)	III	Tr	E	
	01:57	23:57(p)	III	Sh	I	
	17:44	15:44	I	Oc	D	E
	20:53	18:53	I	Ec	R	
13	17:30	15:30	II	Sh	I	E
	18:04	16:04	I	Sh	E	E
	18:34	16:34	II	Tr	E	E
	20:21	18:21	II	Sh	E	
14	00:44	22:44(p)	IV	Tr	I	
	04:04	02:04	IV	Tr	E	W
15	19:29	17:29	III	Ec	R	
17	03:51	01:51	I	Tr	I	W
18	01:05	23:05(p)	I	Oc	D	
	04:19	02:19	I	Ec	R	W
	22:18	20:18	I	Tr	I	
	23:15	21:15	I	Sh	I	
	23:27	21:27	II	Oc	D	
19	00:33	22:33(p)	I	Tr	E	
	01:30	23:30(p)	I	Sh	E	
	02:02	00:02	III	Tr	I	
	04:09	02:09	II	Ec	R	W
	19:32	17:32	I	Oc	D	
	22:48	20:48	I	Ec	R	
20	17:43	15:43	I	Sh	I	E
	18:07	16:07	II	Tr	I	E
	19:00	17:00	I	Tr	E	E
	19:59	17:59	I	Sh	E	
	20:08	18:08	II	Sh	I	
	20:58	18:58	II	Tr	E	
	22:58	20:58	II	Sh	E	
21	17:16	15:16	I	Ec	R	E
22	17:26	15:26	II	Ec	R	E
	17:44	15:44	IV	Ec	D	E
	19:24	17:24	III	Oc	R	
	20:06	18:06	III	Ec	D	
	20:52	18:52	IV	Ec	R	
	23:28	21:28	III	Ec	R	
25	02:54	00:54	I	Oc	D	W
26	00:06	22:06(p)	I	Tr	I	
	01:09	23:09(p)	I	Sh	I	
	01:50	23:50(p)	II	Oc	D	
	02:22	00:22	I	Tr	E	W
	03:25	01:25	I	Sh	E	W
	21:22	19:22	I	Oc	D	
27	00:43	22:43(p)	I	Ec	R	
	18:34	16:34	I	Tr	I	E
	19:38	17:38	I	Sh	I	
	20:33	18:33	II	Tr	I	
	20:50	18:50	I	Tr	E	
	21:53	19:53	I	Sh	E	
	22:45	20:45	II	Sh	I	
	23:24	21:24	II	Tr	E	
28	01:35	23:35(p)	II	Sh	E	
	19:11	17:11	I	Ec	R	E
29	19:35	17:35	III	Oc	D	
	20:00	18:00	II	Ec	R	
	23:01	21:01	III	Oc	R	
30	00:05	22:05(p)	III	Ec	D	
	03:26	01:26	III	Ec	R	W
	19:59	17:59	IV	Tr	E	

May

1	03:02	01:02	IV	Sh	I	W
3	01:56	23:56(p)	I	Tr	I	W
	03:04	01:04	I	Sh	I	W
	17:15	15:15	III	Sh	E	E
	23:12	21:12	I	Oc	D	
4	02:38	00:38	I	Ec	R	W
	20:24	18:24	I	Tr	I	
	21:32	19:32	I	Sh	I	
	22:40	20:40	I	Tr	E	
	23:01	21:01	II	Tr	I	
	23:48	21:48	I	Sh	E	
5	01:22	23:22(p)	II	Sh	I	W
	01:52	23:52(p)	II	Tr	E	W
	17:40	15:40	I	Oc	D	E
	21:07	19:07	I	Ec	R	
6	17:07	15:07	I	Tr	E	E
	17:28	15:28	II	Oc	D	E
	18:16	16:16	I	Sh	E	E
	22:35	20:35	II	Ec	R	
	23:17	21:17	III	Oc	D	
7	02:44	00:44	III	Oc	R	W
8	17:31	15:31	II	Sh	E	E
9	00:09	22:09(p)	IV	Oc	D	
10	17:54	15:54	III	Sh	I	E
	21:13	19:13	III	Sh	E	
11	01:04	23:04(p)	I	Oc	D	W
	22:15	20:15	I	Tr	I	
	23:27	21:27	I	Sh	I	
12	00:31	22:31(p)	I	Tr	E	
	01:31	23:31(p)	II	Tr	I	W
	01:42	23:42(p)	I	Sh	E	W
	19:32	17:32	I	Oc	D	
	23:02	21:02	I	Ec	R	
13	17:56	15:56	I	Sh	I	E
	18:59	16:59	I	Tr	E	E
	19:56	17:56	II	Oc	D	
	20:11	18:11	I	Sh	E	
14	01:09	23:09(p)	II	Ec	R	W
	17:30	15:30	I	Ec	R	E
15	17:18	15:18	II	Sh	I	E
	17:39	15:39	II	Tr	E	E
	20:08	18:08	II	Sh	E	
17	16:49	14:49	III	Tr	I	E
	20:16	18:16	III	Tr	E	
	21:05	19:05	IV	Sh	I	
	21:53	19:53	III	Sh	I	
	23:57	21:57	IV	Sh	E	
18	01:11	23:11(p)	III	Sh	E	W
19	00:07	22:07(p)	I	Tr	I	
	01:22	23:22(p)	I	Sh	I	W
	02:23	00:23	I	Tr	E	W
	21:25	19:25	I	Oc	D	
20	00:57	22:57(p)	I	Ec	R	W
	18:36	16:36	I	Tr	I	E
	19:51	17:51	I	Sh	I	
	20:52	18:52	I	Tr	E	
	22:06	20:06	I	Sh	E	
	22:27	20:27	II	Oc	D	
21	19:26	17:26	I	Ec	R	
22	17:21	15:21	II	Tr	I	E
	19:56	17:56	II	Sh	I	
	20:13	18:13	II	Tr	E	
	22:45	20:45	II	Sh	E	
24	17:02	15:02	II	Ec	R	E
	20:42	18:42	III	Tr	I	
25	00:09	22:09(p)	III	Tr	E	W
	01:52	23:52(p)	III	Sh	I	W
	17:21	15:21	IV	Oc	D	E
	21:02	19:02	IV	Oc	R	
26	02:01	00:01	I	Tr	I	W
	23:19	21:19	I	Oc	D	
27	20:29	18:29	I	Tr	I	
	21:45	19:45	I	Sh	I	
	22:45	20:45	I	Tr	E	
28	00:01	22:01(p)	I	Sh	E	W
	01:00	23:00(p)	II	Oc	D	W
	17:48	15:48	I	Oc	D	E
	19:22	17:22	III	Ec	R	
	21:21	19:21	I	Ec	R	
29	17:14	15:14	I	Tr	E	E
	18:29	16:29	I	Sh	E	E
	19:57	17:57	II	Tr	I	
	22:33	20:33	II	Sh	I	
	22:48	20:48	II	Tr	E	
30	01:22	23:22(p)	II	Sh	E	W
31	19:37	17:37	II	Ec	R	

June

1	00:39	22:39(p)	III	Tr	I	W
3	01:14	23:14(p)	I	Oc	D	W
	17:50	15:50	IV	Sh	E	E
	22:24	20:24	I	Tr	I	
	23:40	21:40	I	Sh	I	W
4	00:40	22:40(p)	I	Tr	E	W
	18:18	16:18	III	Oc	R	E
	19:43	17:43	I	Oc	D	
	20:04	18:04	III	Ec	D	
	23:16	21:16	I	Ec	R	
	23:21	21:21	III	Ec	R	W
5	16:53	14:53	I	Tr	I	E
	18:09	16:09	I	Sh	I	E
	19:09	17:09	I	Tr	E	
	20:24	18:24	I	Sh	E	
	22:34	20:34	II	Tr	I	
6	01:10	23:10(p)	II	Sh	I	W
	17:45	15:45	I	Ec	R	E
7	16:53	14:53	II	Oc	D	E
	22:12	20:12	II	Ec	R	
9	17:16	15:16	II	Sh	E	E
11	00:20	22:20(p)	I	Tr	I	W
	18:53	16:53	III	Oc	D	E
	21:39	19:39	I	Oc	D	
	22:21	20:21	III	Oc	R	
12	00:03	22:03(p)	IV	Ec	D	W
	00:03	22:03(p)	III	Ec	D	W
	18:49	16:49	I	Tr	I	E
	20:04	18:04	I	Sh	I	
	21:05	19:05	I	Tr	E	
	22:19	20:19	I	Sh	E	
13	19:40	17:40	I	Ec	R	

JUPITER MOON EVENTS

14	16:48	14:48	I	Sh	E	E
	19:30	17:30	II	Oc	D	
15	00:47	22:47(p)	II	Ec	R	W
	17:06	15:06	III	Sh	E	E
16	17:04	15:04	II	Sh	I	E
	17:25	15:25	II	Tr	E	E
	19:53	17:53	II	Sh	E	
18	22:59	20:59	III	Oc	D	W
	23:36	21:36	I	Oc	D	W
19	20:45	18:45	I	Tr	I	
	21:18	19:18	IV	Tr	I	
	21:59	19:59	I	Sh	I	
	23:02	21:02	I	Tr	E	W
20	00:14	22:14(p)	I	Sh	E	W
	18:05	16:05	I	Oc	D	E
	21:35	19:35	I	Ec	R	
21	17:31	15:31	I	Tr	E	E
	18:42	16:42	I	Sh	E	E
	22:09	20:09	II	Oc	D	
22	17:50	15:50	III	Sh	I	E
	21:05	19:05	III	Sh	E	
23	17:15	15:15	II	Tr	I	E
	19:41	17:41	II	Sh	I	
	20:06	18:06	II	Tr	E	
	22:29	20:29	II	Sh	E	W
25	16:40	14:40	II	Ec	R	E
26	22:43	20:43	I	Tr	I	W
	23:53	21:53	I	Sh	I	W
27	20:03	18:03	I	Oc	D	
	23:30	21:30	I	Ec	R	W
28	17:12	15:12	I	Tr	I	E
	18:10	16:10	IV	Ec	D	E
	18:22	16:22	I	Sh	I	E
	19:28	17:28	I	Tr	E	
	20:31	18:31	IV	Ec	R	
	20:37	18:37	I	Sh	E	
29	17:04	15:04	III	Tr	I	E
	17:58	15:58	I	Ec	R	E
	20:30	18:30	III	Tr	E	
	21:49	19:49	III	Sh	I	
30	19:57	17:57	II	Tr	I	
	22:17	20:17	II	Sh	I	W
	22:48	20:48	II	Tr	E	W

July

2	19:16	17:16	II	Ec	R	
4	22:02	20:02	I	Oc	D	W
5	19:10	17:10	I	Tr	I	
	20:17	18:17	I	Sh	I	
	21:27	19:27	I	Tr	E	
	22:32	20:32	I	Sh	E	W
6	19:53	17:53	I	Ec	R	
	20:00	18:00	IV	Tr	E	
	21:17	19:17	III	Tr	I	
7	17:01	15:01	I	Sh	E	E
	22:41	20:41	II	Tr	I	W
9	16:54	14:54	II	Oc	D	E
	21:51	19:51	II	Ec	R	W
10	19:15	17:15	III	Ec	R	
11	16:59	14:59	II	Sh	E	E
12	21:09	19:09	I	Tr	I	
	22:12	20:12	I	Sh	I	W
13	18:31	16:31	I	Oc	D	E
	21:48	19:48	I	Ec	R	W
14	17:55	15:55	I	Tr	E	E
	18:56	16:56	I	Sh	E	E
16	19:39	17:39	II	Oc	D	
17	19:21	17:21	III	Oc	R	
	20:00	18:00	III	Ec	D	
18	17:39	15:39	II	Tr	E	E
	19:35	17:35	II	Sh	E	
20	20:30	18:30	I	Oc	D	
21	17:38	15:38	I	Tr	I	E
	18:35	16:35	I	Sh	I	E
	19:55	17:55	I	Tr	E	
	20:50	18:50	I	Sh	E	W
22	18:11	16:11	I	Ec	R	E
23	21:22	19:22	IV	Sh	I	W
	22:24	20:24	II	Oc	D	W
24	20:15	18:15	III	Oc	D	
25	17:35	15:35	II	Tr	I	E
	19:23	17:23	II	Sh	I	
	20:25	18:25	II	Tr	E	
	22:10	20:10	II	Sh	E	W
27	22:30	20:30	I	Oc	D	W
28	16:56	14:56	III	Sh	E	E
	19:38	17:38	I	Tr	I	
	20:30	18:30	I	Sh	I	W
	21:55	19:55	I	Tr	E	W
29	17:00	15:00	I	Oc	D	E
	20:06	18:06	I	Ec	R	
30	17:14	15:14	I	Sh	E	E
31	21:54	19:54	IV	Oc	D	W

August

1	20:22	18:22	II	Tr	I	W
	21:59	19:59	II	Sh	I	W
3	18:57	16:57	II	Ec	R	E
4	17:45	15:45	III	Sh	I	E
	17:58	15:58	III	Tr	E	E
	20:55	18:55	III	Sh	E	W
	21:39	19:39	I	Tr	I	W
5	19:00	17:00	I	Oc	D	E
	22:00	20:00	I	Ec	R	W
6	18:25	16:25	I	Tr	E	E
	19:08	17:08	I	Sh	E	E
9	17:14	15:14	IV	Sh	E	E
10	17:22	15:22	II	Oc	D	E
	21:33	19:33	II	Ec	R	W
11	18:59	16:59	III	Tr	I	E
	21:45	19:45	III	Sh	I	W
12	21:01	19:01	I	Oc	D	W
13	18:10	16:10	I	Tr	I	E
	18:48	16:48	I	Sh	I	E
	20:26	18:26	I	Tr	E	W
	21:03	19:03	I	Sh	E	W
14	18:23	16:23	I	Ec	R	E
17	18:19	16:19	IV	Oc	D	E
	20:11	18:11	II	Oc	D	W
	21:23	19:23	IV	Oc	R	W
19	18:09	16:09	II	Tr	E	E
	19:12	17:12	II	Sh	E	E
20	20:11	18:11	I	Tr	I	W
	20:43	18:43	I	Sh	I	W
21	17:32	15:32	I	Oc	D	E
	20:18	18:18	I	Ec	R	W
22	17:26	15:26	I	Sh	E	E
	19:03	17:03	III	Ec	R	E
26	18:08	16:08	II	Tr	I	E
	19:01	17:01	II	Sh	I	E
	20:56	18:56	II	Tr	E	W
28	19:33	17:33	I	Oc	D	W
29	18:16	16:16	III	Oc	D	E
	18:58	16:58	I	Tr	E	E

September

3	17:43	15:43	IV	Oc	R	E
	18:46	16:46	IV	Ec	D	E
	19:51	17:51	IV	Ec	R	W
4	18:40	16:40	II	Ec	R	E
5	18:44	16:44	I	Tr	I	E
	19:00	17:00	I	Sh	I	E
6	18:34	16:34	I	Ec	R	E

October

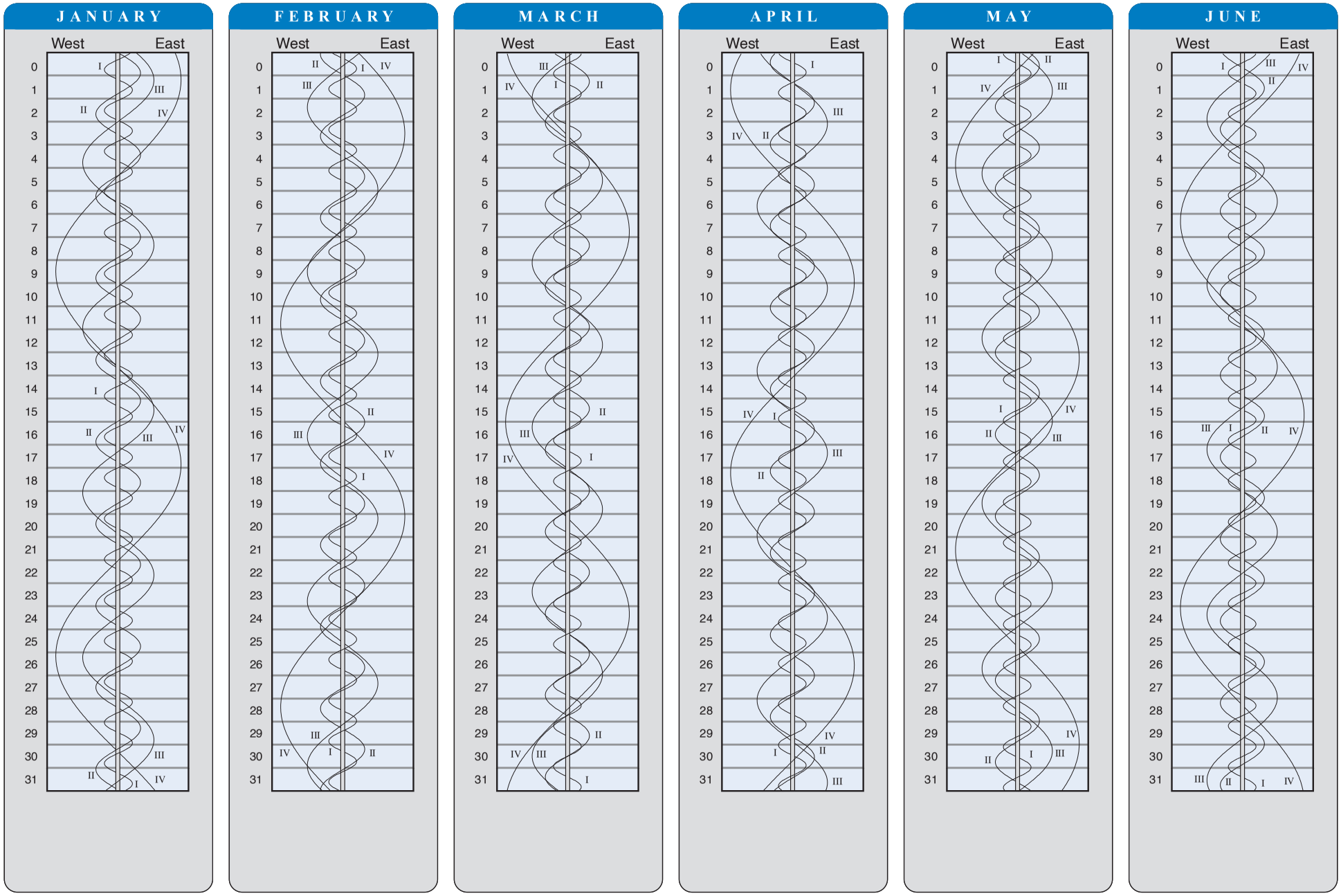
18	06:26	04:26	I	Sh	I	W
	06:52	04:52	I	Tr	I	W
19	04:31	02:31	III	Oc	R	E
	04:59	02:59	II	Sh	E	E
	05:51	03:51	II	Tr	E	W
	06:22	04:22	I	Oc	R	W
26	04:48	02:48	II	Sh	I	E
	05:35	03:35	I	Ec	D	W
	05:53	03:53	II	Tr	I	W
27	05:03	03:03	I	Sh	E	E
	05:37	03:37	I	Tr	E	W

November

3	04:42	02:42	I	Sh	I	E
	05:23	03:23	I	Tr	I	W
	06:57	04:57	I	Sh	E	W
4	04:51	02:51	I	Oc	R	
	06:11	04:11	II	Oc	R	W
6	03:16	01:16	III	Tr	E	E
10	06:36	04:36	I	Sh	I	W
11	03:50	01:50	I	Ec	D	E
	04:37	02:37	II	Ec	D	
	06:50	04:50	I	Oc	R	W
12	03:19	01:19	I	Sh	E	E
	04:07	02:07	I	Tr	E	E
13	03:29	01:29	II	Tr	E	E
	04:24	02:24	III	Sh	E	
	04:44	02:44	III	Tr	I	
18	05:43	03:43	I	Ec	D	W
19	02:59	00:59	I	Sh	I	E
	03:52	01:52	I	Tr	I	E
	05:13	03:13	I	Sh	E	W
	06:06	04:06	I	Tr	E	W
20	03:18	01:18	I	Oc	R	E
	03:30	01:30	II	Tr	I	E
	04:27	02:27	II	Sh	E	
	05:24	03:24	III	Sh	I	W
	06:12	04:12	II	Tr	E	W
24	02:11	00:11	III	Oc	R	E
26	04:52	02:52	I	Sh	I	
	05:51	03:51	I	Tr	I	W
27	02:04	00:04	I	Ec	D	E
	04:17	02:17	II	Sh	I	
	05:15	03:15	I	Oc	R	W
	06:13	04:13	II	Tr	I	W
28	02:34	00:34	I	Tr	E	E
29	03:54	01:54	II	Oc	R	

December

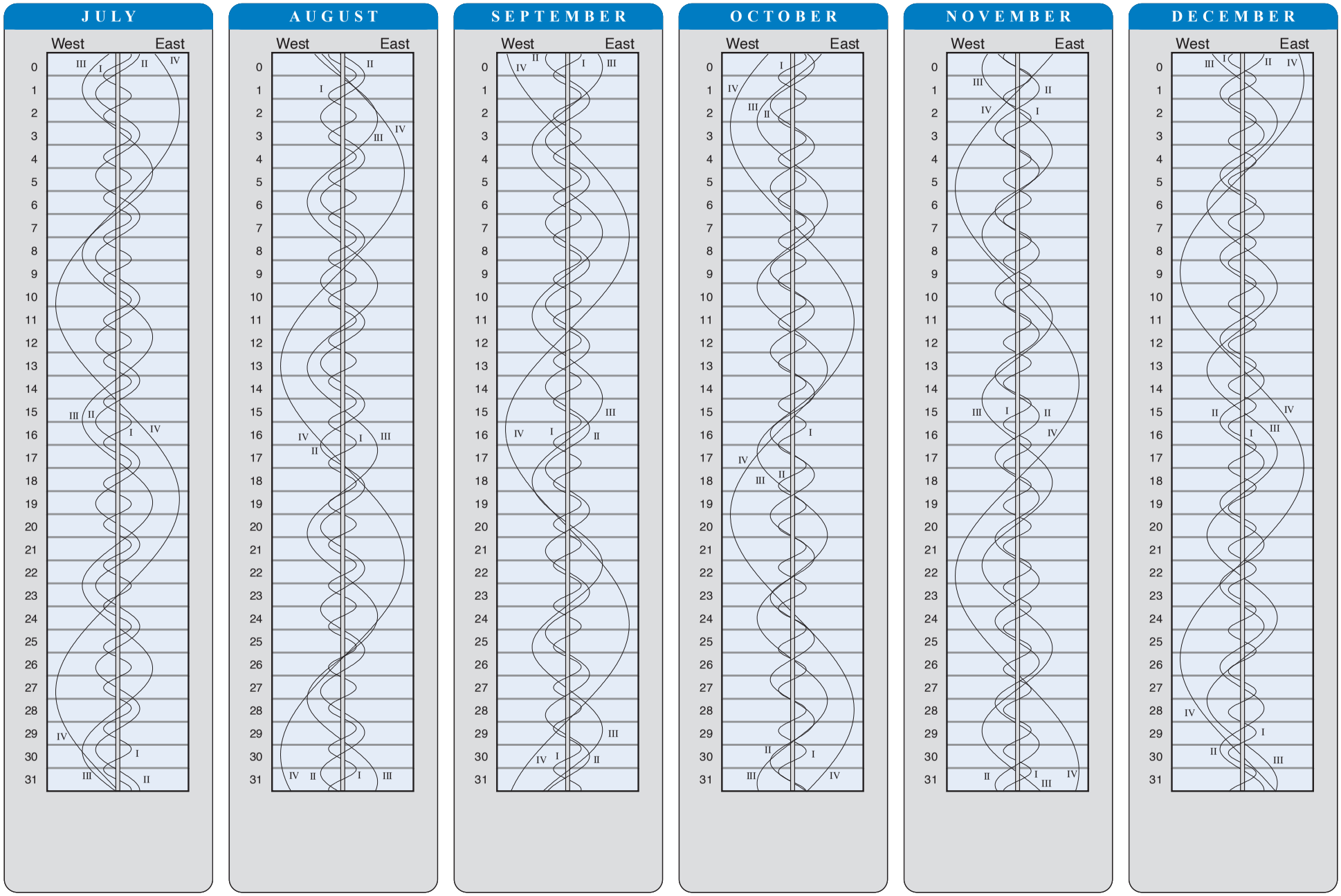
1	02:24	00:24	III	Ec	R	E
	03:40	01:40	III	Oc	D	
	06:26	04:26	III	Oc	R	W
3	06:46	04:46	I	Sh	I	W
4	03:57	01:57	I	Ec	D	
5	02:18	00:18	I	Tr	I	E
	03:28	01:28	I	Sh	E	
	04:31	02:31	I	Tr	E	
6	01:42	23:42(p)	I	Oc	R	E
	01:43	23:43(p)	II	Ec	D	E
	06:37	04:37	II	Oc	R	W
8	03:27	01:27	III	Ec	D	
	06:22	04:22	III	Ec	R	W
11	05:50	03:50	I	Ec	D	W
12	03:08	01:08	I	Sh	I	
	04:15	02:15	I	Tr	I	
	05:22	03:22	I	Sh	E	W
	06:28	04:28	I	Tr	E	W
13	03:38	01:38	I	Oc	R	
	04:19	02:19	II	Ec	D	
15	01:22	23:22(p)	II	Sh	E	E
	03:36	01:36	II	Tr	E	
19	02:05	00:05	III	Tr	I	E
	04:42	02:42	III	Tr	E	
	05:01	03:01	I	Sh	I	
	06:12	04:12	I	Tr	I	W
20	02:11	00:11	I	Ec	D	
	05:34	03:34	I	Oc	R	W
	06:54	04:54	II	Ec	D	W
21	00:41	22:41(p)	I	Tr	I	E
	01:43	23:43(p)	I	Sh	E	E
	02:53	00:53	I	Tr	E	
22	01:12	23:12(p)	II	Sh	I	E
	03:34	01:34	II	Tr	I	
	03:55	01:55	II	Sh	E	
	06:14	04:14	II	Tr	E	W
24	01:20	23:20(p)	II	Oc	R	E
26	01:13	23:13(p)	III	Sh	I	E
	04:04	02:04	III	Sh	E	
	06:13	04:13	III	Tr	I	W
	06:55	04:55	I	Sh	I	W
27	04:04	02:04	I	Ec	D	
28	01:23	23:23(p)	I	Sh	I	E
	02:36	00:36	I	Tr	I	
	03:37	01:37	I	Sh	E	
	04:49	02:49	I	Tr	E	
29	01:57	23:57(p)	I	Oc	R	
	03:45	01:45	II	Sh	I	
	06:11	04:11	II	Tr	I	W
	06:28	04:28	II	Sh	E	W
31	03:57	01:57	II	Oc	R	



JUPITER'S MOONS

Jupiter is like a miniature solar system with many moons orbiting the planet. As seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing in front of or behind the planet. The diagrams here show the patterns the four major moons of Jupiter make as they move from side-to-side. 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 (14hr UT), the bottom edge of the line is midnight WST (16hr 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 (pp. 111-113). 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.



JUPITER – LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	265.0	123.1	026.3	244.3	301.3	152.8	204.1	051.9	259.4	309.8	159.0	212.2	1
2	063.0	281.1	184.3	042.3	099.1	310.5	001.8	209.5	057.1	107.5	316.8	010.1	2
3	220.9	079.2	342.3	200.2	257.0	108.3	159.5	007.2	214.7	265.2	114.5	167.9	3
4	018.9	237.2	140.4	358.2	054.8	266.0	317.1	164.9	012.4	062.9	272.3	325.7	4
5	176.9	035.2	298.4	156.1	212.6	063.7	114.8	322.5	170.1	220.6	070.0	123.5	5
6	334.9	193.3	096.4	314.1	010.5	221.5	272.5	120.2	327.8	018.3	227.8	281.3	6
7	132.8	351.3	254.5	112.0	168.3	019.2	070.2	277.8	125.4	176.0	025.5	079.1	7
8	290.8	149.3	052.5	269.9	326.1	176.9	227.9	075.5	283.1	333.7	183.3	237.0	8
9	088.8	307.4	210.5	067.9	123.9	334.6	025.5	233.2	080.8	131.4	341.0	034.8	9
10	246.8	105.4	008.5	225.8	281.7	132.4	183.2	030.8	238.4	289.1	138.8	192.6	10
11	044.8	263.5	166.5	023.7	079.5	290.1	340.9	188.5	036.1	086.8	296.6	350.4	11
12	202.8	061.5	324.6	181.6	237.4	087.8	138.6	346.1	193.8	244.5	094.3	148.3	12
13	000.8	219.6	122.6	339.5	035.2	245.5	296.2	143.8	351.5	042.2	252.1	306.1	13
14	158.8	017.6	280.6	137.4	193.0	043.2	093.9	301.5	149.1	199.9	049.9	103.9	14
15	316.8	175.6	078.6	295.3	350.7	200.9	251.6	099.1	306.8	357.7	207.6	261.8	15
16	114.8	333.7	236.6	093.3	148.5	358.7	049.2	256.8	104.5	155.4	005.4	059.6	16
17	272.8	131.7	034.6	251.1	306.3	156.4	206.9	054.4	262.2	313.1	163.2	217.5	17
18	070.8	289.8	192.6	049.0	104.1	314.1	004.6	212.1	059.9	110.8	321.0	015.3	18
19	228.8	087.8	350.6	206.9	261.9	111.8	162.2	009.8	217.5	268.5	118.7	173.2	19
20	026.8	245.9	148.6	004.8	059.7	269.5	319.9	167.4	015.2	066.3	276.5	331.0	20
21	184.8	043.9	306.6	162.7	217.4	067.2	117.6	325.1	172.9	224.0	074.3	128.9	21
22	342.8	202.0	104.6	320.6	015.2	224.9	275.2	122.8	330.6	021.7	232.1	286.7	22
23	140.8	360.0	262.6	118.5	173.0	022.6	072.9	280.4	128.3	179.4	029.9	084.6	23
24	298.9	158.0	060.6	276.3	330.8	180.3	230.6	078.1	286.0	337.2	187.7	242.5	24
25	096.9	316.1	218.6	074.2	128.5	338.0	028.2	235.7	083.6	134.9	345.5	040.3	25
26	254.9	114.1	016.5	232.1	286.3	135.7	185.9	033.4	241.3	292.6	143.2	198.2	26
27	052.9	272.2	174.5	029.9	084.0	293.3	343.6	191.1	039.0	090.4	301.0	356.1	27
28	211.0	070.2	332.5	187.8	241.8	091.0	141.2	348.7	196.7	248.1	098.8	153.9	28
29	009.0	228.2	130.4	345.6	039.5	248.7	298.9	146.4	354.4	045.8	256.6	311.8	29
30	167.0		288.4	143.5	197.3	046.4	096.6	304.1	152.1	203.6	054.4	109.7	30
31	325.1		086.4		355.0		254.2	101.7		001.3		267.6	31

SYSTEM II (° at 0hr UT)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	257.8	239.3	281.2	262.8	090.9	065.8	248.3	219.5	190.5	012.0	344.7	169.0	1
2	048.1	029.7	071.6	053.1	241.1	215.9	038.3	009.6	340.6	162.1	134.9	319.2	2
3	198.5	180.1	222.1	203.4	031.3	006.1	188.4	159.6	130.6	312.2	285.0	109.4	3
4	348.8	330.5	012.5	353.7	181.5	156.2	338.4	309.6	280.7	102.2	075.1	259.6	4
5	139.1	121.0	162.9	144.1	331.7	306.3	128.5	099.7	070.7	252.3	225.2	049.8	5
6	289.5	271.4	313.3	294.4	121.9	096.4	278.5	249.7	220.7	042.4	015.3	199.9	6
7	079.8	061.8	103.7	084.7	272.1	246.5	068.6	039.7	010.8	192.5	165.5	350.1	7
8	230.2	212.2	254.0	235.0	062.3	036.6	218.6	189.8	160.8	342.5	315.6	140.3	8
9	020.6	002.6	044.4	025.3	212.5	186.7	008.7	339.8	310.9	132.6	105.7	290.5	9
10	170.9	153.0	194.8	175.6	002.6	336.8	158.7	129.8	100.9	282.7	255.8	080.7	10
11	321.3	303.4	345.2	325.9	152.8	126.8	308.8	279.9	251.0	072.8	046.0	230.9	11
12	111.6	093.8	135.6	116.1	303.0	276.9	098.8	069.9	041.0	222.8	196.1	021.1	12
13	262.0	244.2	286.0	266.4	093.2	067.0	248.9	219.9	191.0	012.9	346.2	171.3	13
14	052.4	034.7	076.4	056.7	243.3	217.1	038.9	009.9	341.1	163.0	136.4	321.5	14
15	202.7	185.1	226.8	207.0	033.5	007.2	188.9	160.0	131.1	313.1	286.5	111.7	15
16	353.1	335.5	017.1	357.3	183.7	157.3	339.0	310.0	281.2	103.2	076.7	261.9	16
17	143.5	125.9	167.5	147.5	333.8	307.4	129.0	100.0	071.2	253.3	226.8	052.2	17
18	293.9	276.3	317.9	297.8	124.0	097.4	279.1	250.1	221.3	043.3	016.9	202.4	18
19	084.2	066.7	108.3	088.0	274.1	247.5	069.1	040.1	011.3	193.4	167.1	352.6	19
20	234.6	217.1	258.6	238.3	064.3	037.6	219.1	190.1	161.4	343.5	317.2	142.8	20
21	025.0	007.6	049.0	028.6	214.4	187.6	009.2	340.2	311.4	133.6	107.4	293.0	21
22	175.4	158.0	199.3	178.8	004.6	337.7	159.2	130.2	101.5	283.7	257.5	083.3	22
23	325.8	308.4	349.7	329.1	154.7	127.8	309.2	280.2	251.6	073.8	047.7	233.5	23
24	116.2	098.8	140.1	119.3	304.8	277.9	099.3	070.3	041.6	223.9	197.9	023.7	24
25	266.6	249.2	290.4	269.5	095.0	067.9	249.3	220.3	191.7	014.0	348.0	174.0	25
26	056.9	039.6	080.8	059.8	245.1	218.0	039.3	010.3	341.7	164.1	138.2	324.2	26
27	207.3	190.0	231.1	210.0	035.2	008.0	189.4	160.4	131.8	314.2	288.4	114.5	27
28	357.7	340.4	021.4	000.2	185.4	158.1	339.4	310.4	281.8	104.3	078.5	264.7	28
29	148.1	130.8	171.8	150.4	335.5	308.2	129.4	100.4	071.9	254.4	228.7	054.9	29
30	298.5		322.1	300.7	125.6	098.2	279.5	250.5	222.0	044.5	018.9	205.2	30
31	088.9		112.4		275.7		069.5	040.5		194.6		355.4	31

Unlike Mars, Jupiter (and Saturn) are gas giants and we can only view their upper atmospheric features. Only a small telescope (even a 60mm instrument) is required to view the equatorial belts and the Great Red Spot. When seeing is good, numerous breaks can be glimpsed in the bands as well as many minor spots. There is no single correct rotation period for the features of Jupiter. The speed of movement 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 often measure the time a feature crosses the central meridian of the planet.

The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0hr 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 June 27 at 2:20am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on June 26. From the table, the longitude on June 26 is 135.7°. 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 373.2°; less 360° gives a final answer of 13.2°.

Finding the Great Red Spot (GRS)

At the time of publication the GRS was located at 84° longitude using System II (it slowly drifts over the years e.g., at the end of 1999 its longitude was 66°). For all features visible on Jupiter they are best observed from about one hour before crossing the central meridian to one hour after. Based on System II this results in plus/minus about 36° (see correction table below) or in the case of the GRS about 48° to 120°.

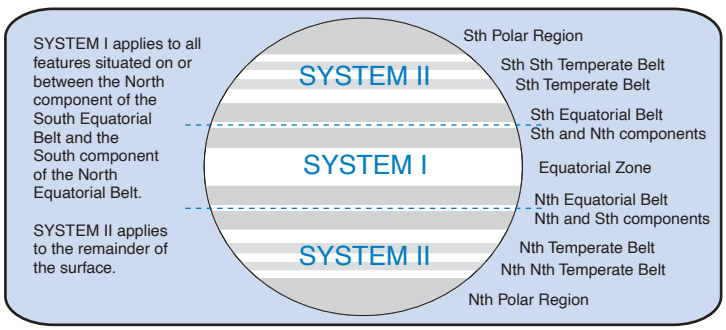
Repeating the calculation for the example above i.e., June 27 at 2:20am but using the data and correction tables for System II gives a value of 450.3°. Subtracting 360° gives a final result of 90.3°. The GRS should be transiting at this time. The Great Red Spot in recent years has lost a lot of its red colouration and now looks more pale orange or tan.

The longitude of the GRS was obtained from the web site below, as calculated by John W. McAnally of the Association of Lunar and Planetary Observers (ALPO). Updates for its longitude and predicted times (in UT) for the GRS crossing the central meridian can be found at:
http://ncastro.org/juptrans.html

SYSTEM I
Rotation: 9h 50m 30.003s

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

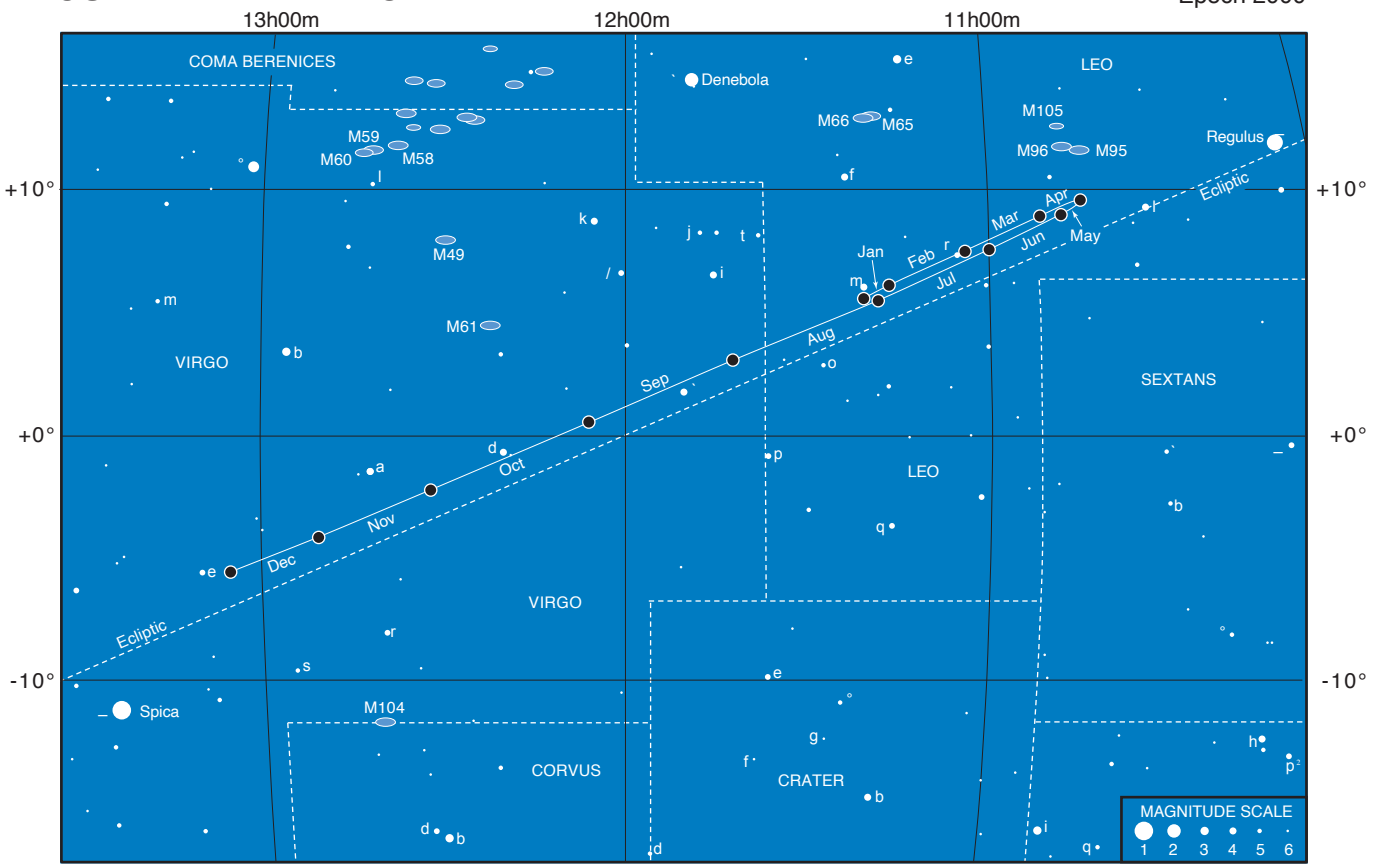


SYSTEM II
Rotation: 9h 55m 40.062s

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

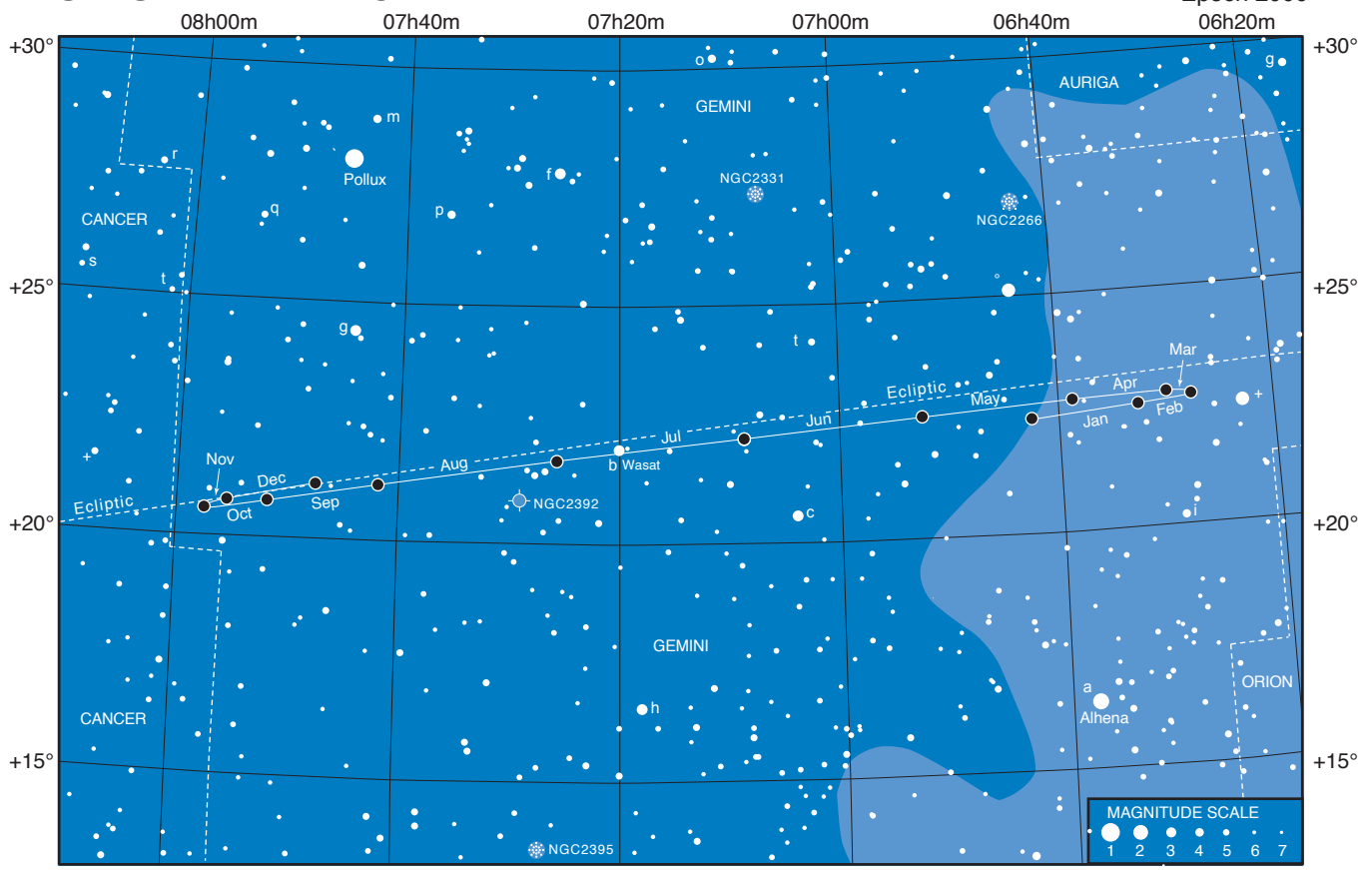
Increase in longitude

JUPITER FINDER CHART



Stationary 5th January, Opposition 4th March, Stationary 5th May, Conjunction 22nd September.

SATURN FINDER CHART



Opposition 1st January, Stationary 8th March, Conjunction 9th July, Stationary 8th November

SATELLITES OF SATURN

SATURN'S RINGS

Date	Major "	Minor "	U °	B °
Jan 4	46.8	20.2	331.97	-25.60
Jan 12	46.7	20.3	331.26	-25.73
Jan 20	46.5	20.3	330.59	-25.85
Jan 28	46.2	20.2	329.98	-25.96
Feb 5	45.8	20.1	329.45	-26.06
Feb 13	45.3	20.0	329.02	-26.14
Feb 21	44.7	19.8	328.71	-26.20
Feb 29	44.1	19.5	328.52	-26.25
Mar 8	43.5	19.3	328.46	-26.28
Mar 16	42.9	19.0	328.53	-26.29
Mar 24	42.2	18.7	328.74	-26.28
Apr 1	41.6	18.4	329.07	-26.26
Apr 9	41.0	18.1	329.52	-26.21
Apr 17	40.5	17.8	330.08	-26.15
Apr 25	39.9	17.5	330.74	-26.06
May 3	39.5	17.3	331.50	-25.96
May 11	39.0	17.0	332.33	-25.84
May 19	38.6	16.8	333.24	-25.71
May 27	38.3	16.5	334.21	-25.55
Jun 4	38.0	16.3	335.22	-25.38
Jun 12	37.8	16.1	336.28	-25.19
Jun 20	37.7	15.9	337.36	-24.99
Jun 28	37.6	15.7	338.46	-24.77
Jul 6	37.5	15.6	339.57	-24.55
Jul 14	37.5	15.4	340.68	-24.31
Jul 22	37.6	15.3	341.78	-24.07
Jul 30	37.7	15.2	342.86	-23.82
Aug 7	37.9	15.1	343.91	-23.57
Aug 15	38.1	15.1	344.92	-23.33
Aug 23	38.4	15.1	345.89	-23.08
Aug 31	38.7	15.0	346.79	-22.85
Sep 8	39.1	15.1	347.63	-22.63
Sep 16	39.6	15.1	348.40	-22.42
Sep 24	40.1	15.2	349.08	-22.24
Oct 2	40.6	15.3	349.67	-22.08
Oct 10	41.2	15.4	350.16	-21.94
Oct 18	41.8	15.5	350.54	-21.84
Oct 26	42.4	15.7	350.80	-21.77
Nov 3	43.0	15.9	350.94	-21.74
Nov 11	43.7	16.2	350.97	-21.75
Nov 19	44.3	16.4	350.87	-21.79
Nov 27	44.8	16.7	350.65	-21.87
Dec 5	45.4	17.0	350.31	-21.98
Dec 13	45.8	17.3	349.88	-22.13
Dec 21	46.2	17.5	349.35	-22.30
Dec 29	46.5	17.8	348.75	-22.48

The 'Appearance of the Planets' diagrams in Part I show how open the rings are for 2004. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. The planet'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 7 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 edge-on during 1995 and will be again in 2009. During 2004 they are still quite open at just over 20°.

Major and minor axes (in arc seconds) 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.

TITAN (UT) Mean Synodic Period 15d 23.3h

Greatest Eastern Elongation date	hr	Inferior Conjunction date	hr	Greatest Western Elongation date	hr	Superior Conjunction date	hr
				Jan 1	22	Jan 5	20
Jan 10	0	Jan 14	0	Jan 17	19	Jan 21	17
Jan 25	21	Jan 29	22	Feb 2	16	Feb 6	15
Feb 10	19	Feb 14	19	Feb 18	14	Feb 22	13
Feb 26	17	Mar 1	18	Mar 5	13	Mar 9	11
Mar 13	16	Mar 17	16	Mar 21	12	Mar 25	10
Mar 29	15	Apr 2	16	Apr 6	11	Apr 10	10
Apr 14	15	Apr 18	16	Apr 22	11	Apr 26	10
Apr 30	15	May 4	16	May 8	11	May 12	11
May 16	16	May 20	16	May 24	12	May 28	11
Jun 1	17	Jun 5	17	Jun 9	13	Jun 13	12
Jun 17	18	Jun 21	18	Jun 25	14	Jun 29	13
Jul 3	19	Jul 7	19	Jul 11	14	Jul 15	15
Jul 19	20	Jul 23	20	Jul 27	15	Jul 31	16
Aug 4	21	Aug 8	21	Aug 12	16	Aug 16	17
Aug 20	22	Aug 24	22	Aug 28	17	Sep 1	17
Sep 5	22	Sep 9	22	Sep 13	17	Sep 17	18
Sep 21	23	Sep 25	22	Sep 29	17	Oct 3	18
Oct 7	23	Oct 11	22	Oct 15	17	Oct 19	17
Oct 23	22	Oct 27	21	Oct 31	16	Nov 4	16
Nov 8	21	Nov 12	20	Nov 16	15	Nov 20	15
Nov 24	19	Nov 28	18	Dec 2	13	Dec 6	13
Dec 10	17	Dec 14	16	Dec 18	11	Dec 22	11
Dec 26	15	Dec 30	13				

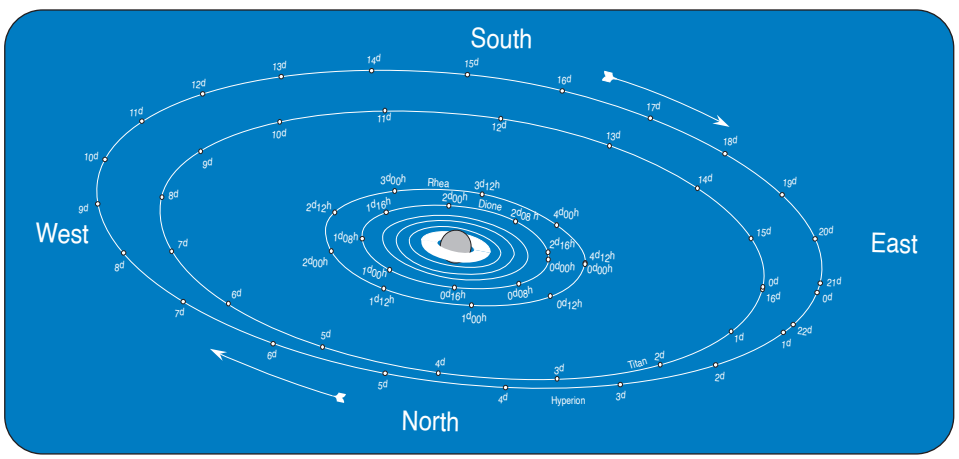
IAPETUS (UT) Mean Synodic Period 79d 22.1h

Greatest Eastern Elongation date	hr	Inferior Conjunction date	hr	Greatest Western Elongation date	hr	Superior Conjunction date	hr
				Jan 2	6	Jan 21	1
Feb 10	7	Mar 1	18	Mar 20	22	Apr 9	5
Apr 30	2	May 21	2	Jun 9	16	Jun 29	9
Jul 20	15	Aug 10	14	Aug 30	1	Sep 18	18
Oct 9	19	Oct 30	6	Nov 18	5	Dec 7	10
Dec 27	20						

HYPERION (UT) Mean Synodic Period 21d 7.6h

Greatest Eastern Elongation date	hr	Inferior Conjunction date	hr	Greatest Western Elongation date	hr	Superior Conjunction date	hr
				Jan 5	6	Jan 11	2
Jan 17	12	Jan 22	6	Jan 26	13	Feb 1	8
Feb 7	18	Feb 12	12	Feb 16	20	Feb 22	16
Feb 29	2	Mar 4	20	Mar 9	4	Mar 14	24
Mar 21	10	Mar 26	4	Mar 30	13	Apr 5	9
Apr 11	19	Apr 16	12	Apr 20	22	Apr 26	20
May 3	4	May 7	21	May 12	7	May 18	7
May 24	14	May 29	6	Jun 2	17	Jun 8	18
Jun 14	24	Jun 19	14	Jun 24	3	Jun 30	5
Jul 6	9	Jul 10	23	Jul 15	12	Jul 21	15
Jul 27	17	Aug 1	6	Aug 5	21	Aug 12	1
Aug 18	2	Aug 22	13	Aug 27	5	Sep 2	10
Sep 8	9	Sep 12	20	Sep 17	12	Sep 23	18
Sep 29	15	Oct 4	1	Oct 8	18	Oct 15	0
Oct 20	20	Oct 25	6	Oct 29	24	Nov 5	6
Nov 11	1	Nov 15	10	Nov 20	4	Nov 26	10
Dec 2	4	Dec 6	13	Dec 11	7	Dec 17	12
Dec 23	7	Dec 27	16				

To estimate the configuration or positions of the satellites, the Apparent Orbits diagram and the times of Greatest Eastern Elongation are needed. For each satellite, take the previous (most recent) date of greatest eastern elongation and work out the period that has elapsed (in days and hours) since this time. Locate this time on the relevant orbit on the diagram and that gives the moon's position directly.



Apparent orbits of the satellites on July 1. Only the inner satellites are shown. The orbits of Iapetus and Phoebe are too large to show on the above diagram.

RHEA (UT) Mean Synodic Period 4d 12.5h

JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
4	8.1	4	22.3	3	0.6	3	15.9	5	7.6	1	11.1	3	3.4	3	19.6	4	11.7	1	14.8	2	6.1	3	20.8
8	20.4	9	10.7	7	13.0	8	4.4	9	20.2	5	23.7	7	16.0	8	8.2	9	0.2	6	3.3	6	18.5	8	9.2
13	8.7	13	23.1	12	1.5	12	16.9	14	8.8	10	12.3	12	4.6	12	20.8	13	12.8	10	15.8	11	6.9	12	21.5
17	21.0	18	11.4	16	13.9	17	5.4	18	21.4	15	1.0	16	17.2	17	9.4	18	1.3	15	4.3	15	19.3	17	9.8
22	9.4	22	23.8	21	2.4	21	18.0	23	9.9	19	13.6	21	5.8	21	22.0	22	13.8	19	16.8	20	7.7	21	22.1
26	21.7	27	12.2	25	14.9	26	6.5	27	22.5	24	2.2	25	18.4	26	10.5	27	2.3	24	5.2	24	20.1	26	10.5
31	10.0			30	3.4	30	19.1			28	14.8	30	7.0	30	23.1			28	17.7	29	8.5	30	22.8

DIONE (UT) Mean Synodic Period 2d 17.7h

JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
1	4.4	3	0.1	1	8.8	3	5.3	3	8.3	2	11.5	2	14.8	1	18.1	3	15.0	1	0.3	2	20.7	2	23.1
3	22.0	5	17.8	4	2.5	5	23.0	6	2.0	5	5.3	5	8.6	4	11.9	6	8.8	3	18.0	5	14.4	5	16.7
6	15.6	8	11.4	6	20.2	8	16.7	8	19.8	7	23.0	8	2.4	7	5.6	9	2.5	6	11.7	8	8.1	8	10.4
9	9.3	11	5.1	9	13.9	11	10.4	11	13.5	10	16.8	10	20.1	9	23.4	11	20.2	9	5.4	11	1.7	11	4.1
12	2.9	13	22.8	12	7.6	14	4.2	14	7.3	13	10.6	13	13.9	12	17.1	14	14.0	11	23.1	13	19.4	13	21.7
14	20.6	16	16.4	15	1.3	16	21.9	17	1.0	16	4.3	16	7.6	15	10.9	17	7.7	14	16.8	16	13.1	16	15.4
17	14.2	19	10.1	17	19.0	19	15.6	19	18.8	18	22.1	19	1.4	18	4.6	20	1.4	17	10.5	19	6.8	19	9.0
20	7.9	22	3.8	20	12.7	22	9.4	22	12.5	21	15.8	21	19.1	20	22.4	22	19.1	20	4.2	22	0.4	22	2.7
23	1.5	24	21.5	23	6.4	25	3.1	25	6.3	24	9.6	24	12.9	23	16.1	25	12.9	22	21.9	24	18.1	24	20.3
25	19.2	27	15.2	26	0.1	27	20.8	28	0.0	27	3.3	27	6.6	26	9.8	28	6.6	25	15.6	27	11.8	27	13.9
28	12.8			28	17.8	30	14.6	30	17.8	29	21.1	30	0.4	29	3.6			28	9.3	30	5.4	30	7.6
31	6.5			31	11.5									31	21.3			31	3.0				

TETHYS (UT) Mean Synodic Period 1d 21.3h

JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
1	1.2	2	3.1	1	10.6	2	13.0	2	18.3	1	23.7	2	5.1	1	10.5	2	13.2	2	18.4	1	23.4	2	4.2
2	22.5	4	0.4	3	7.9	4	10.3	4	15.6	3	21.0	4	2.5	3	7.9	4	10.5	4	15.7	3	20.7	4	1.5
4	19.8	5	21.7	5	5.2	6	7.6	6	12.9	5	18.3	5	23.8	5	5.2	6	7.9	6	13.0	5	18.0	5	22.8
6	17.0	7	19.0	7	2.5	8	5.0	8	10.3	7	15.7	7	21.1	7	2.6	8	5.2	8	10.4	7	15.3	7	20.1
8	14.3	9	16.3	8	23.9	10	2.3	10	7.6	9	13.0	9	18.5	8	23.9	10	2.5	10	7.7	9	12.6	9	17.4
10	11.6	11	13.6	10	21.2	11	23.6	12	4.9	11	10.4	11	15.8	10	21.2	11	23.9	12	5.0	11	9.9	11	14.7
12	8.9	13	10.9	12	18.5	13	20.9	14	2.3	13	7.7	13	13.2	12	18.6	13	21.2	14	2.3	13	7.2	13	11.9
14	6.2	15	8.2	14	15.8	15	18.3	15	23.6	15	5.0	15	10.5	14	15.9	15	18.5	15	23.6	15	4.5	15	9.2
16	3.5	17	5.5	16	13.1	17	15.6	17	21.0	17	2.4	17	7.8	16	13.2	17	15.8	17	20.9	17	1.8	17	6.5
18	0.8	19	2.8	18	10.4	19	12.9	19	18.3	18	23.7	19	5.2	18	10.6	19	13.2	19	18.2	18	23.1	19	3.8
19	22.1	21	0.1	20	7.7	21	10.3	21	15.6	20	21.1	21	2.5	20	7.9	21	10.5	21	15.6	20	20.4	21	1.1
21	19.3	22	21.4	22	5.1	23	7.6	23	13.0	22	18.4	22	23.9	22	5.2	23	7.8	23	12.9	22	17.7	22	22.4
23	16.6	24	18.7	24	2.4	25	4.9	25	10.3	24	15.8	24	21.2	24	2.6	25	5.1	25	10.2	24	15.0	24	19.7
25	13.9	26	16.0	25	23.7	27	2.3	27	7.6	26	13.1	26	18.5	25	23.9	27	2.4	27	7.5	26	12.3	26	17.0
27	11.2	28	13.3	27	21.0	28	23.6	29	5.0	28	10.4	28	15.9	27	21.2	28	23.8	29	4.8	28	9.6	28	14.3
29	8.5			29	18.3	30	20.9	31	2.3	30	7.8	30	13.2	29	18.6	30	21.1	31	2.1	30	6.9	30	11.5
31	5.8			31	15.7									31	15.9								

ENCELADUS (UT) Mean Synodic Period 1d 8.9h

JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
2	2.7	1	5.9	1	0.5	1	13.0	1	16.7	2	5.4	1	0.4	1	13.2	2	1.8	2	5.5	1	9.0	1	12.4
3	11.6	2	14.8	2	9.4	2	21.9	3	1.6	3	14.3	2	9.3	2	22.1	3	10.7	3	14.4	2	17.9	2	21.3
4	20.5	3	23.7	3	18.3	4	6.8	4	10.5	4	23.2	3	18.2	4	7.0	4	19.6	4	23.3	4	2.8	4	6.2
6	5.4	5	8.6	5	3.2	5	15.7	5	19.4	6	8.1	5	3.1	5	15.9	6	4.5	6	8.2	5	11.7	5	15.1
7	14.3	6	17.5	6	12.1	7	0.6	7	4.3	7	17.0	6	12.0	7	0.8	7	13.4	7	17.1	6	20.6	6	24.0
8	23.0	8	2.3	7	20.9	8	9.4	8	13.2	9	2.0	7	20.9	8	9.7	8	22.3	9	1.9	8	5.4	8	8.8
10	7.9	9	11.2	9	5.8	9	18.3	9	22.1	10	10.9	9	5.8	9	18.6	10	7.2	10	10.8	9	14.3	9	17.7
11	16.8	10	20.1	10	14.7	11	3.2	11	7.0	11	19.8	10	14.7	11	3.5	11	16.1	11	19.7	10	23.2	11	2.6
13	1.7	12	5.0	11	23.6	12	12.1	12	15.9	13	4.7	11	23.6	12	12.4	13	1.0	13	4.6	12	8.1	12	11.5
14	10.6	13	13.9	13	8.5	13	21.0	14	0.8	14	13.6	13	8.5	13	21.3	14	9.9	14	13.5	13	17.0	13	20.4
15	19.4	14	22.7	14	17.3	15	5.9	15	9.7	15	22.5	14	17.4	15	6.1	15	18.8	15	22.4	15	1.8	15	5.1
17	4.3	16	7.6	16	2.2	16	14.8	16	18.6	17	7.4	16	2.3	16	15.0	17	3.7	17	7.3	16	10.7	16	14.0
18	13.2	17	16.5	17	11.1	17	23.7	18	3.5	18	16.3	17	11.2	17	23.9	18	12.6	18	16.2	17	19.6	17	22.9
19	22.1	19	1.4	18	20.0	19	8.6	19	12.4	20	1.2	18	20.1	19	8.8	19	21.5	20	1.1	19	4.5	19	7.8
21	7.0	20	10.3	20	4.9	20	17.5	20	21.3	21	10.1	20	5.0	20	17.7	21	6.4	21	10.0	20	13.4	20	16.7
22	15.8	21	19.2	21	13.8	22	2.4	22	6.2	22	19.0	21	13.9	22	2.6	22	15.2	22	18.8	21	22.2	22	1.5
24	0.7	23	4.1	22	22.7	23	11.3	23	15.1	24	3.9	22	22.8	23	11.5	24	0.1	24	3.7	23	7.1	23	10.4
25	9.6	24	13.0	24	7.6	24	20.2	24	24.0	25	12.8	24	7.7	24	20.4	25	9.0	25	12.6	24	16.0	24	19.3
26	18.5	25	21.9	25	16.5	26	5.1	26	8.9	26	21.7	25	16.6	26	5.3	26	17.9	26	21.5	26	0.9	26	4.2
28	3.4	27	6.8	27	1.4	27	14.0	27	17.8	28	6.6	27	1.5	27	14.2	28	2.8	28	6.4	27	9.8	27	13.1
29	12.3	28	15.7	28	10.3	28	22.9	29	2.7	29	15.5	28	10.4	28	23.1	29	11.7	29	15.3	28	18.7	28	22.0
30	21.2			29	19.2	30	7.8	30	11.6			29	19.3	30	8.0	30	20.6	31	0.2	30	3.6	30	6.9
				31	4.1			31	20.5			31	4.2	31	16.9							31	15.8

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
06 41 16	+ 22 25 52
06 38 48	+ 22 29 03
06 36 25	+ 22 32 04
06 34 12	+ 22 34 53
06 32 12	+ 22 37 28
06 30 29	+ 22 39 48
06 29 04	+ 22 41 52
06 28 01	+ 22 43 40
06 27 20	+ 22 45 13
06 27 03	+ 22 46 30
06 27 09	+ 22 47 30
06 27 39	+ 22 48 15
06 28 33	+ 22 48 41
06 29 49	+ 22 48 49
06 31 26	+ 22 48 37
06 33 23	+ 22 48 04
06 35 39	+ 22 47 07
06 38 12	+ 22 45 45
06 41 01	+ 22 43 57
06 44 03	+ 22 41 41
06 47 17	+ 22 38 56
06 50 42	+ 22 35 41
06 54 16	+ 22 31 57
06 57 57	+ 22 27 43
07 01 43	+ 22 23 00
07 05 34	+ 22 17 48
07 09 27	+ 22 12 10
07 13 21	+ 22 06 08
07 17 14	+ 21 59 44
07 21 05	+ 21 53 02
07 24 52	+ 21 46 06
07 28 34	+ 21 39 00
07 32 10	+ 21 31 49
07 35 37	+ 21 24 38
07 38 54	+ 21 17 33
07 41 59	+ 21 10 41
07 44 52	+ 21 04 07
07 47 30	+ 20 58 00
07 49 52	+ 20 52 25
07 51 57	+ 20 47 29
07 53 42	+ 20 43 19
07 55 08	+ 20 40 00
07 56 12	+ 20 37 38
07 56 55	+ 20 36 18
07 57 14	+ 20 36 01
07 57 10	+ 20 36 50
07 56 44	+ 20 38 44
07 55 54	+ 20 41 41
07 54 44	+ 20 45 37
07 53 14	+ 20 50 24
07 51 26	+ 20 55 57
07 49 23	+ 21 02 04

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

POSITION

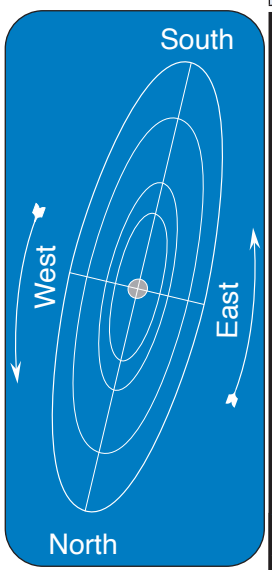
0hr UT Epoch 2000.0

RA	DEC
h m s	Set
22 09 48	- 12 07 18
22 10 59	- 12 00 31
22 12 17	- 11 53 13
22 13 39	- 11 45 28
22 15 04	- 11 37 22
22 16 33	- 11 28 58
22 18 04	- 11 20 23
22 19 36	- 11 11 42
22 21 08	- 11 02 59
22 22 39	- 10 54 22
22 24 08	- 10 45 55
22 25 35	- 10 37 42
22 26 58	- 10 29 50
22 28 16	- 10 22 24
22 29 30	- 10 15 27
22 30 38	- 10 09 05
22 31 39	- 10 03 21
22 32 33	- 09 58 20
22 33 19	- 09 54 04
22 33 57	- 09 50 36
22 34 27	- 09 47 58
22 34 48	- 09 46 13
22 35 00	- 09 45 21
22 35 03	- 09 45 21
22 34 57	- 09 46 13
22 34 42	- 09 47 57
22 34 19	- 09 50 30
22 33 48	- 09 53 48
22 33 09	- 09 57 48
22 32 24	- 10 02 25
22 31 33	- 10 07 34
22 30 38	- 10 13 08
22 29 38	- 10 19 01
22 28 36	- 10 25 06
22 27 33	- 10 31 14
22 26 30	- 10 37 20
22 25 28	- 10 43 16
22 24 28	- 10 48 53
22 23 32	- 10 54 06
22 22 41	- 10 58 48
22 21 57	- 11 02 53
22 21 19	- 11 06 16
22 20 48	- 11 08 53
22 20 27	- 11 10 41
22 20 14	- 11 11 37
22 20 11	- 11 11 39
22 20 17	- 11 10 47
22 20 33	- 11 09 00
22 20 58	- 11 06 21
22 21 32	- 11 02 49
22 22 15	- 10 58 27
22 23 06	- 10 53 18

SATELLITES OF URANUS

Titania (III) and Oberon (IV) are the easiest to observe visually. However, at least a 20cm telescope, under dark skies, is needed to glimpse these distant bodies. The inner satellites, Ariel and Umbriel, are harder to observe and they would be a real test for a 40cm telescope. The orbits of the satellites are only partly open as seen from Earth. The orbits' apparent minor axis (running east/west) is 29% of the apparent major axis (north/south). For example, Oberon, at opposition, has a maximum elongation of 44" (p. 81). Its minimum elongation would be 29% of this or 13". To locate the approximate position angle (degrees east of north) for a satellite, at your time of observation:

1. Work out how long since the satellite's most recent greatest northern elongation.
2. Express this as a fraction of the sidereal orbital period. Satellites I, II, III, and IV have periods of 2.52, 4.14, 8.71 and 13.46 days respectively.
3. Multiply the result by 360°.



Apparent orbit of satellites I-IV at date of opposition, August 27th.

ARIEL (UT) Mean Sidereal Period 2d 12.489h

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
1	16.9	3	11.2	2	4.6	1	10.4	1	16.2	3	10.5	1	3.8	2	22.2	2	4.1	2	9.9	1	15.9	1	21.9
4	5.4	5	23.7	4	17.1	3	22.9	4	4.7	5	23.0	3	16.3	5	10.7	4	16.6	4	22.4	4	4.4	4	10.4
6	17.9	8	12.2	7	5.6	6	11.4	6	17.2	8	11.5	6	4.8	7	23.2	7	5.1	7	10.9	6	16.9	6	22.9
9	6.4	11	0.7	9	18.1	8	23.9	9	5.7	10	24.0	8	17.3	10	11.7	9	17.6	9	23.4	9	5.4	9	11.4
11	18.9	13	13.2	12	6.6	11	12.4	11	18.2	13	12.5	11	5.8	13	0.2	12	6.1	12	11.9	11	17.9	11	23.9
14	7.4	16	1.7	14	19.1	14	0.9	14	6.7	16	0.9	13	18.3	15	12.6	14	18.5	15	0.5	14	6.4	14	12.3
16	19.9	18	14.2	17	7.6	16	13.4	16	19.2	18	13.4	16	6.8	18	1.1	17	7.0	17	13.0	16	18.9	17	0.8
19	8.4	21	2.7	19	20.1	19	1.9	19	7.7	21	1.9	18	19.3	20	13.6	19	19.5	20	1.5	19	7.4	19	13.3
21	20.9	23	15.2	22	8.6	21	14.4	21	20.2	23	14.4	21	7.8	23	2.1	22	8.0	22	14.0	21	19.9	22	1.8
24	9.4	26	3.7	24	21.1	24	2.9	24	8.7	26	2.9	23	20.3	25	14.6	24	20.5	25	2.5	24	8.4	24	14.3
14	21.5	28	16.2	27	9.6	26	15.4	26	21.2	28	15.4	26	8.8	28	3.1	27	9.0	27	15.0	26	20.9	27	2.8
29	10.3			29	22.0	29	3.8	29	9.6			28	21.2	30	15.5	29	21.4	30	3.4	29	9.3	29	15.2
31	22.8							31	22.1			31	9.7										

UMBRIEL (UT) Mean Sidereal Period 4d 3.460h

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
1	18.0	3	21.6	3	21.8	1	22.1	5	1.5	3	1.6	2	1.8	4	5.6	2	5.9	1	6.0	3	9.7	2	10.2
5	21.5	8	1.1	8	1.3	6	1.6	9	5.0	7	5.1	6	5.3	8	9.1	6	9.4	5	9.5	7	13.2	6	13.7
10	0.9	12	4.5	12	4.7	10	5.0	13	8.4	11	8.5	10	8.7	12	12.5	10	12.8	9	12.9	11	16.6	10	17.1
14	4.4	16	8.0	16	8.2	14	8.5	17	11.9	15	12.0	14	12.2	16	16.0	14	16.3	13	16.4	15	20.1	14	20.6
18	7.8	20	11.4	20	11.6	18	11.9	21	15.3	19	15.4	18	15.6	20	19.4	18	19.7	17	19.8	19	23.5	19	0.0
22	11.3	24	14.9	24	15.1	22	15.4	25	18.8	23	18.9	22	19.1	24	22.9	22	23.2	21	23.3	24	3.0	23	3.5
26	14.7	28	18.3	28	18.5	26	18.8	29	22.2	27	22.3	26	22.5	29	2.3	27	2.6	26	2.7	28	6.4	27	6.9
30	18.2					30	22.3					31	2.0					30	6.2			31	10.4

TITANIA (UT) Mean Sidereal Period 8d 16.941h

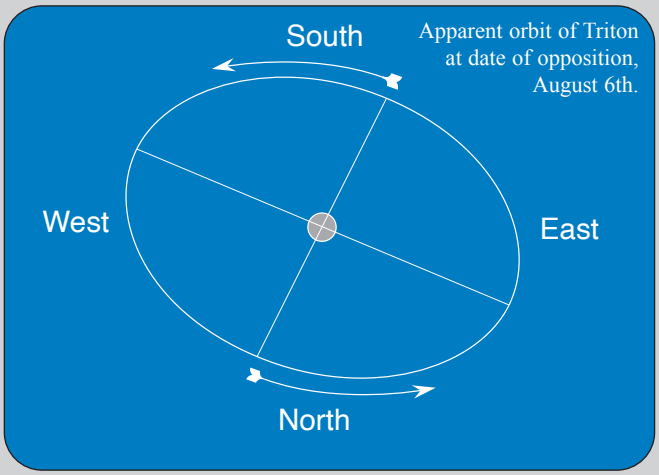
Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
7	11.4	2	14.1	8	9.7	3	12.3	8	7.9	3	10.7	8	6.4	3	9.3	7	5.2	3	8.1	7	3.9	3	6.7
16	4.3	11	7.1	17	2.6	12	5.3	17	0.9	12	3.7	16	23.4	12	2.3	15	22.2	12	1.1	15	20.9	11	23.7
24	21.3	20	0.0	25	19.6	20	22.2	25	17.8	20	20.6	25	16.3	20	19.2	24	15.1	20	18.0	24	13.8	20	16.6
		28	17.0			29	15.2			29	13.6			29	12.2			29	11.0			29	9.6

OBERON (UT) Mean Sidereal Period 13d 11.118h

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
12	1.3	7	23.5	5	21.5	1	19.5	12	4.6	8	2.7	5	1.0	14	10.3	10	8.7	7	7.2	3	5.6	13	15.0
25	12.3	21	10.5	19	8.5	15	6.5	25	15.6	21	13.7	18	12.0	27	21.3	23	19.7	20	18.2	16	16.6	27	2.0
						28	17.6					31	23.1							30	3.7		

SATELLITE OF NEPTUNE

With typical amateur telescopes, Triton (I) is the only observable moon. To find Triton, use the approach as described above for the satellites of Uranus. Note that in this case, the apparent major axis is in the east/west direction. The orbits of the Neptunian satellites are currently relatively open. In 2004, Triton's apparent orbit as seen from Earth is an ellipse with the minor axis being 71% of the major axis. Therefore Triton, at opposition, varies from 17" (p. 81) down to 12". To find the approximate position angle of Triton, the same approach is used as above for Uranus. The sidereal orbital period for Triton is 5.88 days and after step 3 add 90° to get the position angle from north. If greater than 360°, subtract 360°.



Apparent orbit of Triton at date of opposition, August 6th.

TRITON Mean Sidereal Period 5d 21.044h

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h	d	hh.h
5	14.6	3	23.2	4	7.8	2	16.5	2	1.3	6	7.5	5	17.0	4	2.7	2	12.4	1	22.0	6	4.4	5	13.4
11	11.5	9	20.1	10	4.7	8	13.4	7	22.2	12	4.4	11	13.9	9	23.6	8	9.3	7	18.9	12	1.3	11	10.3
17	8.5	15	17.1	16	1.7	14	10.4	13	19.2	18	1.4	17	10.9	15	20.6	14	6.3	13	15.9	17	22.3	17	7.3
23	5.4	21	14.0	21	22.6	20	7.3	19	16.1	23	22.3	23	7.8	21	17.5	20	3.2	19	12.8	23	19.2	23	4.2
29	2.4	27	11.0	27	19.6	26	4.3	25	13.1	29	19.3	29	4.8	27	14.5	26	0.2	25	9.8	29	16.2	29	1.2
								31	10.0									31	6.7				

NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

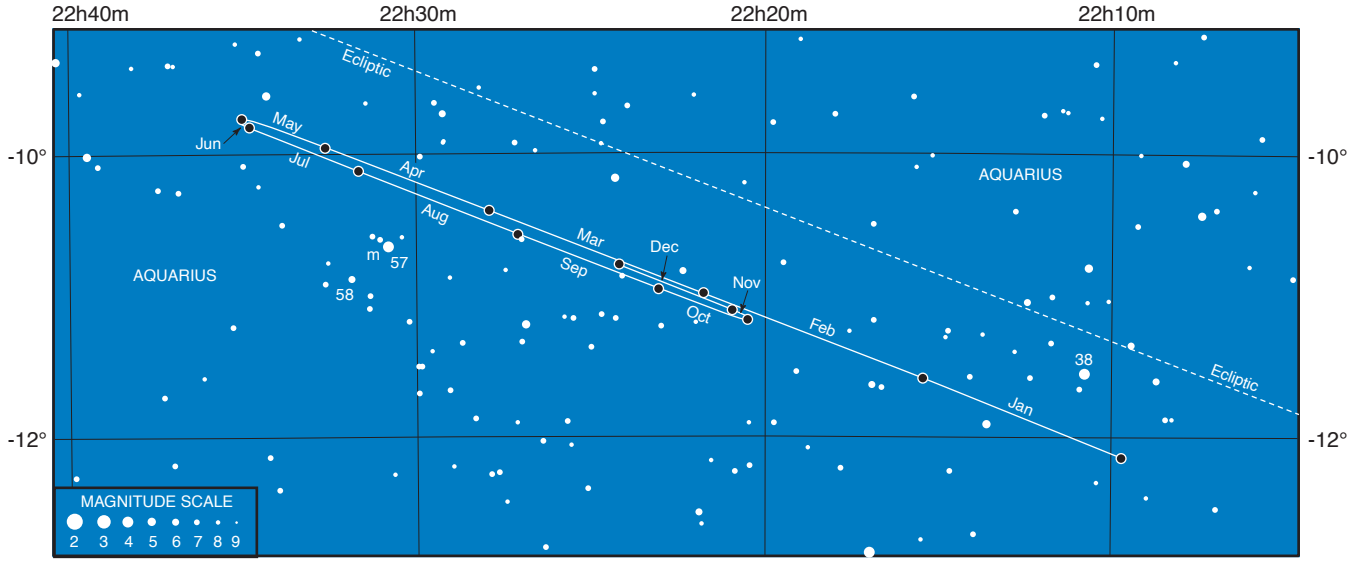
POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
20 56 42	- 17 18 00
20 57 41	- 17 14 01
20 58 42	- 17 09 50
20 59 45	- 17 05 32
21 00 49	- 17 01 08
21 01 53	- 16 56 42
21 02 56	- 16 52 16
21 03 58	- 16 47 55
21 04 59	- 16 43 41
21 05 56	- 16 39 36
21 06 51	- 16 35 45
21 07 41	- 16 32 10
21 08 28	- 16 28 53
21 09 09	- 16 25 57
21 09 45	- 16 23 24
21 10 15	- 16 21 15
21 10 40	- 16 19 33
21 10 58	- 16 18 18
21 11 09	- 16 17 31
21 11 15	- 16 17 13
21 11 14	- 16 17 23
21 11 07	- 16 18 01
21 10 53	- 16 19 06
21 10 34	- 16 20 37
21 10 09	- 16 22 31
21 09 40	- 16 24 47
21 09 06	- 16 27 22
21 08 28	- 16 30 13
21 07 47	- 16 33 18
21 07 04	- 16 36 32
21 06 19	- 16 39 51
21 05 34	- 16 43 14
21 04 48	- 16 46 35
21 04 04	- 16 49 52
21 03 21	- 16 53 00
21 02 40	- 16 55 56
21 02 04	- 16 58 37
21 01 31	- 17 01 01
21 01 03	- 17 03 04
21 00 40	- 17 04 44
21 00 23	- 17 06 00
21 00 12	- 17 06 50
21 00 07	- 17 07 12
21 00 09	- 17 07 07
21 00 18	- 17 06 34
21 00 34	- 17 05 32
21 00 56	- 17 04 03
21 01 24	- 17 02 07
21 01 58	- 16 59 45
21 02 38	- 16 56 59
21 03 23	- 16 53 50
21 04 13	- 16 50 21

URANUS FINDER CHART

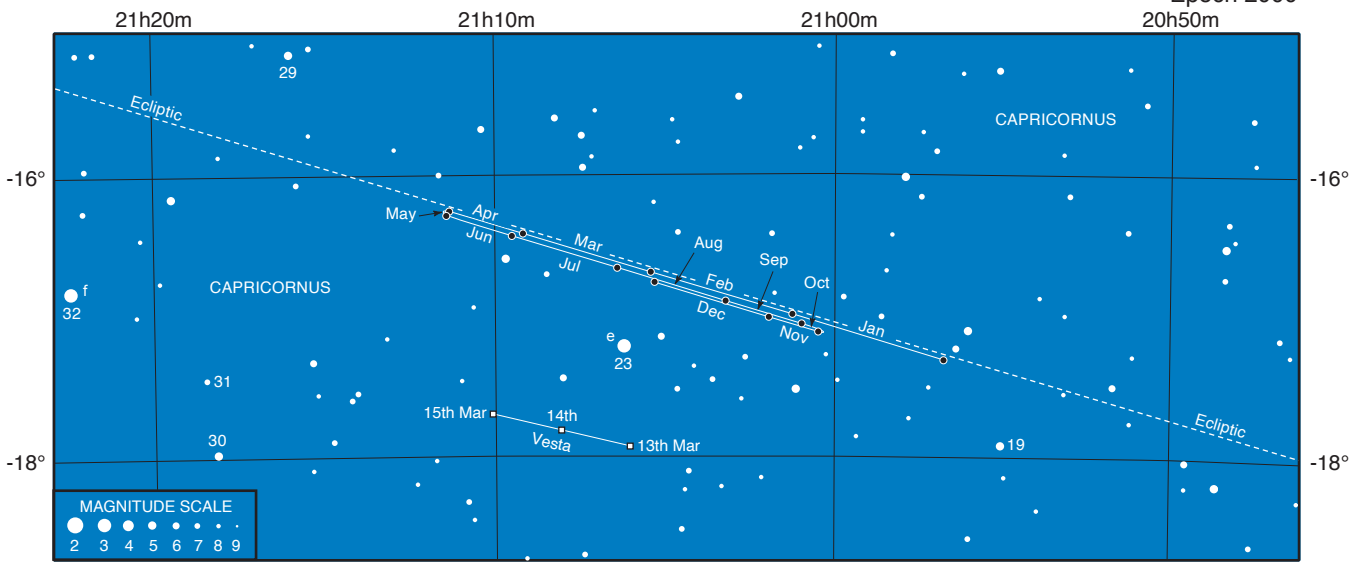
Epoch 2000



Conjunction 22nd February, Stationary 11th June, Opposition 28th August, Stationary 12th November.

NEPTUNE FINDER CHART

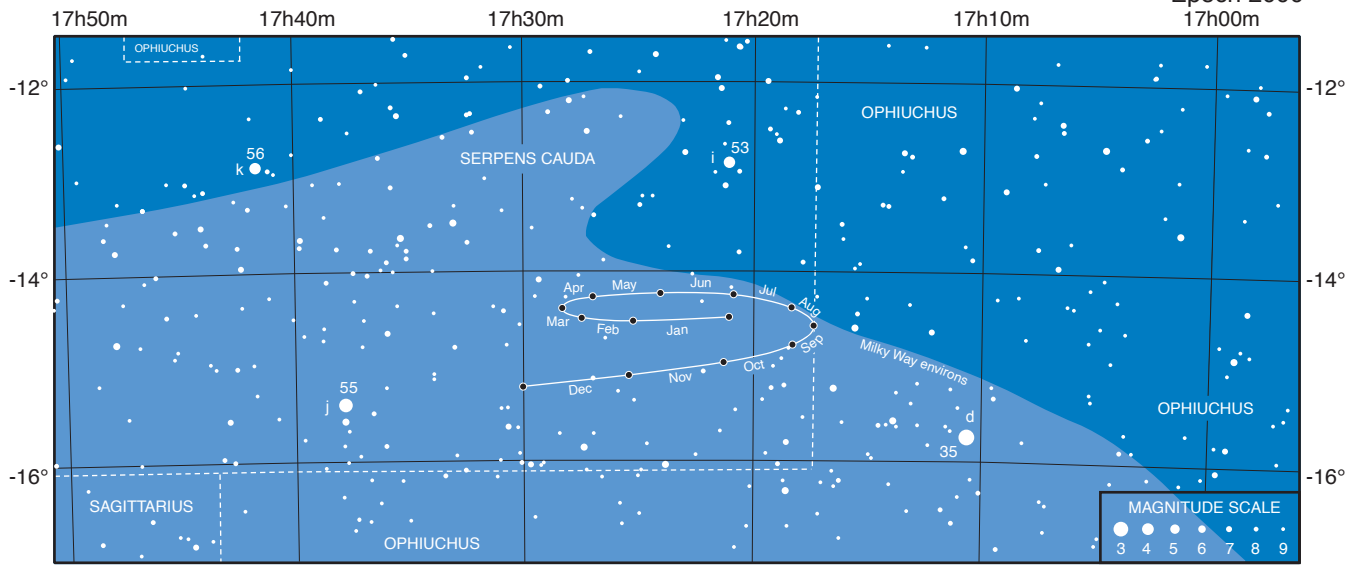
Epoch 2000



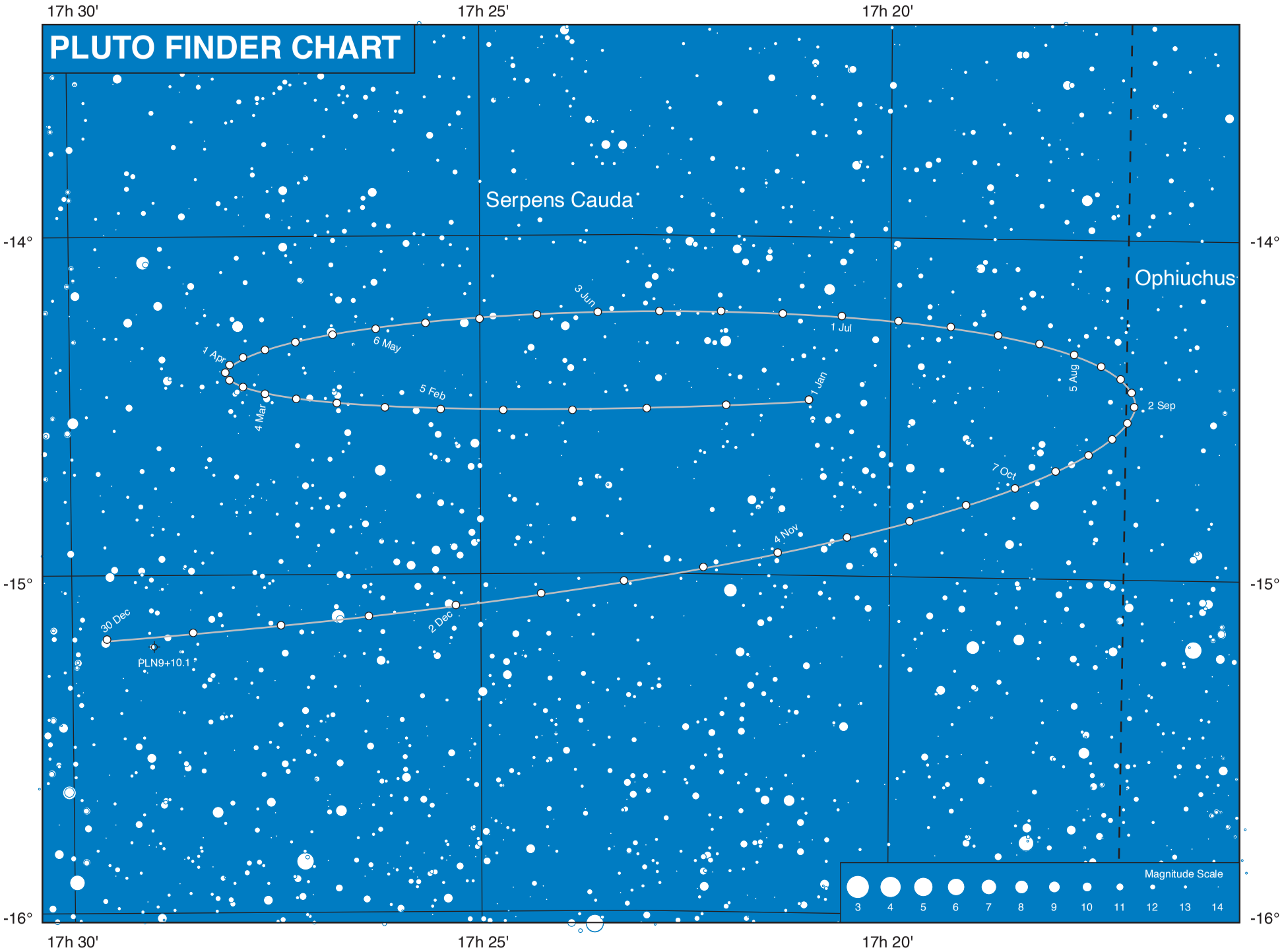
Conjunction 2nd February, Stationary 18th May, Opposition 6th August, Stationary 24th October.

PLUTO POINTER CHART

Epoch 2000



Stationary 25th March, Opposition 11th June, Stationary 1st September, Conjunction 14th December.


PLUTO FINDER CHART
17h 30'
17h 25'
17h 20'
-14°
-15°
-16°
Serpens Cauda
Ophiuchus
1 Apr
6 May
3 Jun
1 Jul
5 Aug
2 Sep
7 Oct
4 Nov
2 Dec
30 Dec
1 Jan
5 Feb
4 Mar
PLN9+10.1
Magnitude Scale
3 4 5 6 7 8 9 10 11 12 13 14

PLUTO

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

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

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
17 21 16	- 14 29 34
17 22 16	- 14 30 22
17 23 14	- 14 30 54
17 24 07	- 14 31 09
17 24 57	- 14 31 08
17 25 41	- 14 30 52
17 26 21	- 14 30 23
17 26 54	- 14 29 41
17 27 22	- 14 28 49
17 27 43	- 14 27 46
17 27 58	- 14 26 36
17 28 05	- 14 25 20
17 28 07	- 14 24 00
17 28 01	- 14 22 38
17 27 50	- 14 21 15
17 27 32	- 14 19 54
17 27 08	- 14 18 37
17 26 40	- 14 17 25
17 26 06	- 14 16 20
17 25 29	- 14 15 24
17 24 49	- 14 14 38
17 24 06	- 14 14 04
17 23 21	- 14 13 43
17 22 36	- 14 13 35
17 21 50	- 14 13 41
17 21 06	- 14 14 03
17 20 23	- 14 14 41
17 19 42	- 14 15 34
17 19 05	- 14 16 42
17 18 31	- 14 18 07
17 18 02	- 14 19 45
17 17 38	- 14 21 38
17 17 20	- 14 23 45
17 17 07	- 14 26 03
17 17 01	- 14 28 32
17 17 01	- 14 31 11
17 17 07	- 14 33 57
17 17 20	- 14 36 49
17 17 40	- 14 39 46
17 18 05	- 14 42 44
17 18 37	- 14 45 44
17 19 14	- 14 48 42
17 19 57	- 14 51 36
17 20 45	- 14 54 26
17 21 37	- 14 57 08
17 22 33	- 14 59 42
17 23 31	- 15 02 06
17 24 33	- 15 04 18
17 25 36	- 15 06 18
17 26 40	- 15 08 04
17 27 45	- 15 09 35
17 28 49	- 15 10 52

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris a comet. A comet has been best described as a 'dirty snowball', a conglomerate of ice, gases, 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 wind to form the classical 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 tugs from the planets will over time break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

Incredible velocities such as these (a bullet from a rifle travels at about 1 km 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.

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		DIA	VEL km/s	ZHR
				R.A.	Dec			
Quadrantids	FQ	Jan 01-Jan 05	Jan 04	230°	+49°	5˚	41	120
delta-Cancrids	LQ	Jan 01-Jan 24	Jan 17	130°	+20°	10˚-5˚	28	4
alpha-Centaurids	FM	Jan 28-Feb 21	Feb 08	210°	-59°	4˚	56	6
delta-Leonids	NM	Feb 15-Mar 10	Feb 25	168°	+16°	5˚	23	2
gamma-Normids	LQ	Feb 25-Mar 22	Mar 13	249°	-51°	5˚	56	8
Virginids	NM	Jan 25-Apr 15	Mar 24	195°	-04°	15˚-10˚	30	5
Lyrids	NM	Apr 16-Apr 25	Apr 23	271°	+34°	5˚	49	18
pi-Puppids*	FQ	Apr 15 - Apr 28	Apr 24	110°	-45°	5˚	18	var
eta-Aquarids	FM	Apr 19-May 28	May 05	338°	-01°	4˚	66	60
Sagittarids	NM	Apr 15-Jul 15	May 19	247°	-22°	15˚-10˚	30	5
Bootids (June)*	FQ	Jun 26 - Jul 02	Jun 27	224°	+48°	5˚	18	var
Pegasids	LQ	Jul 07-Jul 13	Jul 09	340°	+15°	5˚	70	3
Phoenicids (July)*	LQ	Jul 10 - Jul 16	Jul 13	032°	-48°	7˚	47	var
Pisces Austrinids	FQ	Jul 15-Aug 10	Jul 27	341°	-30°	15˚-10˚	35	5
Southern delta-Aquarids	FQ	Jul 12-Aug 19	Jul 27	339°	-16°	5˚	41	20
alpha-Capricornids	FM	Jul 03-Aug 15	Jul 29	307°	-10°	8˚	23	4
Southern iota-Aquarids	FM	Jul 25-Aug 15	Aug 04	334°	-15°	5˚	34	2
Northern delta-Aquarids	LQ	Jul 15-Aug 25	Aug 08	335°	-05°	5˚	42	4
Perseids	NM	Jul 17-Aug 24	Aug 12	046°	+58°	5˚	59	110
kappa-Cygnids	NM	Aug 03-Aug 25	Aug 17	286°	+59°	6˚	25	3
Northern iota-Aquarids	NM	Aug 11-Aug 31	Aug 19	327°	-06°	5˚	31	3
alpha-Aurigids	FM	Aug 25-Sep 08	Aug 31	084°	+42°	5˚	66	7
delta-Aurigids	LQ	Sep 05-Oct 10	Sep 09	060°	+47°	5˚	64	5
Piscids	FQ	Sep 01-Sep 30	Sep 19	005°	-01°	5˚	26	3
Draconids*	LQ	Oct 06 - Oct 10	Oct 08	262°	+54°	2˚	20	var
Epsilon Geminids	FQ	Oct 14-Oct 27	Oct 18	102°	+27°	5˚	70	2
Orionids	FQ	Oct 02-Nov 07	Oct 21	095°	+16°	10˚	66	23
Southern Taurids	LQ	Oct 01-Nov 25	Nov 05	052°	+13°	10˚-5˚	27	5
Northern Taurids	NM	Oct 01-Nov 25	Nov 12	058°	+22°	10˚-5˚	29	5
Leonids	FQ	Nov 14-Nov 21	Nov 17	153°	+22°	5˚	71	50+
alpha-Monocerotids	FQ	Nov 15-Nov 25	Nov 21	117°	+01°	5˚	65	Var
chi-Orionids	FM	Nov 26-Dec 15	Dec 01	082°	+23°	8˚	28	3
Phoenicids	LQ	Nov 28-Dec 09	Dec 06	018°	-53°	5˚	22	Var
Puppid-Velids	LQ	Dec 01-Dec 15	Dec 06	123°	-45°	10˚	40	10
Monocerotids (Dec)	NM	Nov 27-Dec 17	Dec 08	100°	+08°	5˚	42	3
sigma-Hydrids	NM	Dec 03-Dec 15	Dec 11	127°	+02°	5˚	58	2
Geminids	NM	Dec 07-Dec 17	Dec 13	112°	+33°	5˚	35	120
Coma Berenicids	FQ	Dec 12-Jan 23	Dec 19	175°	+25°	5˚	65	5
Ursids	FQ	Dec 17-Dec 26	Dec 22	217°	+76°	5˚	33	10

Individual meteors during a shower appear to originate from a common point in the sky known as the radiant. This focal point is named after the constellation in which the meteors appear or the comet that is associated with the shower. Members of meteoroid streams travel though space in parallel paths. The apparent divergence from the radiant is only an illusion, due simply 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 Organisation (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 the monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic meteors (originating from random points in the sky) 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 Organisation. They can be reached on the Web: www.imo.net/ or by writing to Ina Rendtel, IMO Treasurer, Mehlbeerenweg 5, D-14469 Potsdam, Germany. You can also email to treasurer@imo.net for details on IMO membership. Please enclose return postage if writing. International Reply Coupons are available from Australia Post outlets.

NOTES ON THE TABLE ABOVE

SHOWER NAME The shower is named after the constellation that the radiant appears in 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, R.A. and Dec: The position of the shower radiant in right ascension and declination (R.A. is expressed in degrees). These co-ordinates refer to the radiant position on the date of maximum activity.

DIA The radiant diameter. When two figures are given, the first is the spread in R.A. and the second the spread in Dec.

VEL km/s The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11km/s (very slow) to 71km/s (very fast), medium speed is about 40km/s.

ZHR Zenith Hourly Rate, a theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

	1 CERES			2 PALLAS			3 JUNO			4 VESTA			5 ASTRAEA			6 HEBE		
	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag
Jan 3	07 32.1	+ 29 28	6.9	01 31.1	- 21 25	9.1	17 31.7	- 13 07	11.4	18 31.5	- 22 29	7.6	13 46.6	- 07 24	11.4	07 37.8	+ 08 46	8.7
10	07 25.1	+ 30 11	6.8	01 35.9	- 20 33	9.2	17 41.4	- 13 07	11.4	18 47.8	- 22 25	7.6	13 57.1	- 08 04	11.4	07 30.7	+ 09 44	8.6
17	07 17.8	+ 30 48	6.9	01 41.7	- 19 36	9.2	17 51.1	- 13 04	11.4	19 04.0	- 22 15	7.7	14 07.1	- 08 38	11.3	07 23.5	+ 10 49	8.7
24	07 10.9	+ 31 19	7.1	01 48.3	- 18 35	9.2	18 00.5	- 12 57	11.4	19 20.1	- 21 59	7.7	14 16.3	- 09 06	11.3	07 16.7	+ 11 56	8.8
31	07 04.8	+ 31 42	7.2	01 55.8	- 17 31	9.3	18 09.8	- 12 47	11.4	19 36.0	- 21 37	7.8	14 24.7	- 09 26	11.2	07 10.8	+ 13 05	9.0
Feb 7	06 59.9	+ 31 59	7.4	02 04.1	- 16 25	9.3	18 18.9	- 12 33	11.4	19 51.7	- 21 11	7.8	14 32.2	- 09 40	11.1	07 06.1	+ 14 11	9.2
14	06 56.4	+ 32 08	7.5	02 13.0	- 15 17	9.3	18 27.8	- 12 17	11.4	20 07.2	- 20 39	7.9	14 38.5	- 09 46	11.0	07 02.8	+ 15 15	9.4
21	06 54.4	+ 32 12	7.7	02 22.5	- 14 08	9.3	18 36.3	- 11 57	11.4	20 22.4	- 20 03	7.9	14 43.7	- 09 45	10.9	07 01.0	+ 16 13	9.6
28	06 54.1	+ 32 11	7.8	02 32.7	- 12 59	9.3	18 44.4	- 11 34	11.3	20 37.4	- 19 23	7.9	14 47.6	- 09 37	10.8	07 00.8	+ 17 07	9.7
Mar 6	06 55.4	+ 32 06	7.9	02 43.3	- 11 50	9.3	18 52.2	- 11 09	11.3	20 52.0	- 18 40	7.9	14 50.1	- 09 21	10.7	07 02.1	+ 17 54	9.9
13	06 58.2	+ 31 58	8.0	02 54.5	- 10 42	9.3	18 59.5	- 10 42	11.3	21 06.3	- 17 54	7.9	14 51.1	- 08 58	10.5	07 04.8	+ 18 36	10.1
20	07 02.4	+ 31 46	8.2	03 06.2	- 09 35	9.3	19 06.3	- 10 12	11.2	21 20.4	- 17 06	7.9	14 50.5	- 08 29	10.4	07 08.7	+ 19 11	10.2
27	07 07.8	+ 31 32	8.3	03 18.3	- 08 30	9.3	19 12.6	- 09 41	11.1	21 34.0	- 16 17	7.9	14 48.4	- 07 54	10.3	07 13.8	+ 19 41	10.3
Apr 3	07 14.4	+ 31 15	8.3	03 30.8	- 07 27	9.3	19 18.2	- 09 09	11.1	21 47.3	- 15 26	7.9	14 44.9	- 07 15	10.1	07 19.8	+ 20 05	10.5
10	07 22.0	+ 30 56	8.4	03 43.6	- 06 27	9.2	19 23.2	- 08 36	11.0	22 00.2	- 14 35	7.9	14 40.2	- 06 34	10.0	07 26.8	+ 20 23	10.6
17	07 30.4	+ 30 33	8.5	03 56.9	- 05 30	9.2	19 27.4	- 08 02	10.9	22 12.8	- 13 44	7.9	14 34.7	- 05 53	9.9	07 34.5	+ 20 36	10.7
24	07 39.5	+ 30 07	8.6	04 10.5	- 04 37	9.2	19 30.8	- 07 29	10.8	22 24.9	- 12 53	7.9	14 28.6	- 05 14	9.8	07 42.9	+ 20 43	10.8
May 1	07 49.3	+ 29 38	8.6	04 24.4	- 03 47	9.2	19 33.3	- 06 56	10.7	22 36.6	- 12 04	7.8	14 22.3	- 04 40	9.8	07 51.8	+ 20 45	10.8
8	07 59.7	+ 29 06	8.7	04 38.6	- 03 02	9.1	19 34.8	- 06 25	10.6	22 47.8	- 11 18	7.8	14 16.5	- 04 13	10.0	08 01.2	+ 20 43	10.9
15	08 10.4	+ 28 31	8.7	04 53.0	- 02 21	9.1	19 35.4	- 05 56	10.5	22 58.6	- 10 33	7.7	14 11.2	- 03 53	10.2	08 11.0	+ 20 35	11.0
22	08 21.5	+ 27 52	8.7	05 07.7	- 01 45	9.1	19 34.9	- 05 31	10.4	23 08.8	- 09 53	7.7	14 06.9	- 03 43	10.4	08 21.1	+ 20 23	11.0
29	08 33.0	+ 27 09	8.8	05 22.6	- 01 14	9.1	19 33.4	- 05 09	10.2	23 18.5	- 09 16	7.6	14 03.8	- 03 42	10.6	08 31.4	+ 20 07	11.1
Jun 5	08 44.6	+ 26 24	8.8	05 37.6	- 00 49	9.0	19 30.7	- 04 52	10.1	23 27.5	- 08 44	7.6	14 01.8	- 03 49	10.8	08 42.0	+ 19 46	11.1
12	08 56.5	+ 25 34	8.8	05 52.8	- 00 28	9.0	19 27.1	- 04 41	10.0	23 35.9	- 08 17	7.5	14 01.2	- 04 05	10.9	08 52.7	+ 19 22	11.2
19	09 08.5	+ 24 42	8.8	06 08.1	- 00 14	9.0	19 22.5	- 04 37	9.9	23 43.4	- 07 57	7.4	14 01.8	- 04 28	11.1	09 03.6	+ 18 54	11.2
26	09 20.6	+ 23 46	8.8	06 23.5	- 00 05	9.0	19 17.2	- 04 39	9.7	23 50.2	- 07 44	7.3	14 03.5	- 04 58	11.3	09 14.5	+ 18 22	11.2
Jul 3	09 32.8	+ 22 48	8.8	06 38.9	- 00 01	9.0	19 11.4	- 04 49	9.7	23 56.0	- 07 38	7.2	14 06.4	- 05 33	11.4	09 25.5	+ 17 48	11.2
10	09 44.9	+ 21 46	8.8	06 54.4	- 00 03	9.0	19 05.2	- 05 06	9.6	00 00.8	- 07 41	7.1	14 10.3	- 06 12	11.5	09 36.5	+ 17 10	11.2
17	09 57.2	+ 20 42	8.7	07 09.8	- 00 11	8.9	18 59.0	- 05 30	9.6	00 04.4	- 07 53	7.0	14 15.0	- 06 55	11.7	09 47.6	+ 16 30	11.2
24	10 09.4	+ 19 36	8.7	07 25.2	- 00 23	8.9	18 53.1	- 05 59	9.7	00 06.8	- 08 14	6.9	14 20.6	- 07 41	11.8	09 58.6	+ 15 47	11.2
31	10 21.6	+ 18 27	8.7	07 40.5	- 00 41	8.9	18 47.8	- 06 34	9.7	00 07.8	- 08 44	6.8	14 27.0	- 08 29	11.9	10 09.7	+ 15 02	11.2
Aug 7	10 33.8	+ 17 17	8.7	07 55.8	- 01 03	8.9	18 43.3	- 07 13	9.8	00 07.4	- 09 23	6.6	14 34.0	- 09 19	12.0	10 20.7	+ 14 16	11.2
14	10 46.0	+ 16 04	8.6	08 10.9	- 01 29	8.9	18 39.7	- 07 54	9.9	00 05.6	- 10 10	6.5	14 41.6	- 10 09	12.1	10 31.6	+ 13 28	11.2
21	10 58.1	+ 14 51	8.6	08 25.8	- 01 59	8.9	18 37.3	- 08 37	10.0	00 02.5	- 11 02	6.4	14 49.8	- 11 00	12.1	10 42.5	+ 12 38	11.1
28	11 10.1	+ 13 36	8.5	08 40.6	- 02 33	9.0	18 36.1	- 09 20	10.1	23 58.0	- 11 58	6.3	14 58.5	- 11 50	12.2	10 53.4	+ 11 48	11.1
Sep 4	11 22.2	+ 12 20	8.5	08 55.3	- 03 10	9.0	18 36.0	- 10 02	10.2	23 52.6	- 12 55	6.2	15 07.6	- 12 40	12.3	11 04.2	+ 10 56	11.0
11	11 34.1	+ 11 04	8.4	09 09.7	- 03 49	9.0	18 37.2	- 10 43	10.2	23 46.5	- 13 49	6.1	15 17.2	- 13 29	12.3	11 14.9	+ 10 05	11.1
18	11 46.1	+ 09 48	8.5	09 23.9	- 04 30	9.0	18 39.6	- 11 21	10.3	23 40.1	- 14 37	6.1	15 27.1	- 14 16	12.4	11 25.6	+ 09 13	11.1
25	11 57.9	+ 08 31	8.5	09 37.9	- 05 13	9.0	18 43.1	- 11 57	10.4	23 33.8	- 15 15	6.3	15 37.3	- 15 02	12.4	11 36.1	+ 08 22	11.2
Oct 2	12 09.7	+ 07 16	8.5	09 51.6	- 05 57	9.0	18 47.6	- 12 30	10.4	23 28.1	- 15 43	6.4	15 47.9	- 15 46	12.4	11 46.6	+ 07 31	11.3
9	12 21.5	+ 06 00	8.6	10 05.2	- 06 40	9.0	18 53.1	- 12 59	10.5	23 23.3	- 15 59	6.6	15 58.8	- 16 27	12.5	11 57.0	+ 06 42	11.3
16	12 33.2	+ 04 46	8.6	10 18.4	- 07 24	9.0	18 59.5	- 13 24	10.5	23 19.7	- 16 02	6.7	16 09.9	- 17 05	12.5	12 07.2	+ 05 53	11.3
23	12 44.8	+ 03 34	8.7	10 31.4	- 08 07	9.0	19 06.7	- 13 45	10.6	23 17.4	- 15 55	6.9	16 21.2	- 17 41	12.5	12 17.4	+ 05 06	11.4
30	12 56.4	+ 02 22	8.7	10 44.0	- 08 48	9.0	19 14.7	- 14 02	10.6	23 16.4	- 15 36	7.0	16 32.8	- 18 13	12.5	12 27.4	+ 04 22	11.4
Nov 6	13 07.8	+ 01 13	8.8	10 56.3	- 09 26	9.0	19 23.3	- 14 14	10.6	23 16.8	- 15 09	7.2	16 44.5	- 18 42	12.5	12 37.2	+ 03 39	11.4
13	13 19.2	+ 00 07	8.8	11 08.3	- 10 02	8.9	19 32.6	- 14 21	10.7	23 18.5	- 14 33	7.3	16 56.4	- 19 08	12.5	12 46.9	+ 02 59	11.4
20	13 30.4	- 00 58	8.8	11 19.9	- 10 33	8.9	19 42.3	- 14 24	10.7	23 21.3	- 13 50	7.4	17 08.3	- 19 30	12.4	12 56.3	+ 02 23	11.4
27	13 41.5	- 01 59	8.8	11 31.0	- 11 00	8.9	19 52.6	- 14 22	10.7	23 25.3	- 13 01	7.6	17 20.4	- 19 48	12.4	13 05.6	+ 01 50	11.4
Dec 4	13 52.4	- 02 57	8.8	11 41.7	- 11 21	8.8	20 03.3	- 14 14	10.7	23 30.3	- 12 07	7.7	17 32.5	- 20 02	12.4	13 14.5	+ 01 21	11.4
11	14 03.2	- 03 52	8.8	11 51.8	- 11 34	8.8	20 14.4	- 14 02	10.6	23 36.1	- 11 08	7.8	17 44.6	- 20 12	12.3	13 23.2	+ 00 57	11.4
18	14 13.7	- 04 43	8.8	12 01.3	- 11 40	8.7	20 25.8	- 13 45	10.6	23 42.7	- 10 05	7.9	17 56.8	- 20 19	12.2	13 31.5	+ 00 37	11.3
25	14 23.9	- 05 30	8.8	12 10.1	- 11 37	8.6	20 37.5	- 13 23	10.6	23 49.9	- 08 59	8.0	18 08.9	- 20 21	12.2	13 39.3	+ 00 23	11.3

	7 IRIS			8 FLORA			9 METIS			11 PARTHENOPE			15 EUNOMIA			16 PSYCHE		
Jan 3	11 43.9	- 05 18	10.1	21 04.4	- 19 22	11.0	19 13.7	- 24 58	11.4	16 23.9	- 18 12	11.7	09 58.3	+ 06 16	9.6	18 07.4	- 21 22	11.6
10	11 46.2	- 05 55	10.0	21 20.0	- 18 20	10.9	19 27.1	- 24 37	11.3	16 37.4	- 18 40	11.7	09 54.7	+ 05 56	9.5	18 19.1	- 21 19	11.6
17	11 47.2	- 06 24	9.9	21 35.5	- 17 13	10.9	19 40.6	- 24 13	11.3	16 50.7	- 19 04	11.7	09 50.0	+ 05 42	9.3	18 30.8	- 21 12	11.7
24	11 46.8	- 06 44	9.8	21 51.1	- 16 01	10.8	19 53.9	- 23 45	11.4	17 04.0	- 19 23	11.7	09 44.2	+ 05 36	9.2	18 42.3	- 21 03	11.7
31	11 45.0	- 06 54	9.7	22 06.7	- 14 44	10.8	20 07.2	- 23 13	11.5	17 17.1	- 19 37	11.7	09 37.6	+ 05 36	9.1	18 53.8	- 20 50	11.7
Feb 7	11 41.9	- 06 55	9.5	22 22.3	- 13 24	10.7	20 20.4	- 22 37	11.5	17 30.1	- 19 47	11.7	09 30.6	+ 05 41	9.0	19 05.2	- 20 34	11.7
14	11 37.6	- 06 45	9.4	22 37.9	- 11 59	10.7	20 33.4	- 21 59	11.6	17 42.8	- 19 53	11.6	09 23.6	+ 05 51	9.0	19 16.3	- 20 15	11.7
21	11 32.2	- 06 24	9.3	22 53.5	- 10 32	10.6	20 46.3	- 21 18	11.6	17 55.3	- 19 54	11.6	09 16.8	+ 06 04	9.1	19 27.3	- 19 54	11.7
28	11 26.0	- 05 55	9.1	23 09.0	- 09 01	10.5	20 59.0	- 20 34	11.6	18 07.4	- 19 52	11.5	09 10.7	+ 06 18	9.3	19 38.0	- 19 30	11.7
Mar 6	11 19.3	- 05 17	9.0	23 24.5	- 07 29	10.5	21 11.5	- 19 48	11.6	18 19.1	- 19 46	11.5	09 05.6	+ 06 33	9.5	19 48.4	- 19 04	11.7
13	11 12.6	- 04 33	9.0	23 40.1	- 05 54	10.4	21 23.8	- 19 01	11.6	18 30.3	- 19 38	11.4	09 01.6	+ 06 46	9.6	19 58.5	- 18 36	11.7
20	11 06.2	- 03 47	9.1	23 55.6	- 04 18	10.4	21 35.9	- 18 11	11.6	18 41.0	- 19 26	11.3	08 58.8	+ 06 58	9.8	20 08.3	- 18 07	11.6
27	11 00.4	- 03 00	9.3	00 11.2	- 02 42	10.5	21 47.8	- 17 21	11.6	18 51.2	- 19 13	11.3	08 57.4	+ 07 07	9.9	20 17.7	- 17 37	11.6
Apr 3	10 55.6	- 02 15	9.5	00 26.8	- 01 05	10.5	21 59.4	- 16 30	11.6	19 00.6	- 18 58	11.2	08 57.2	+ 07 12	10.1	20 26.6	- 17 06	11.6
10	10 51.9	- 01 35	9.7	00 42.4	+ 00 31	10.6	22 10.7	- 15 39	11.6	19 09.2	- 18 43	11.1	08 58.2	+ 07 14	10.2	20 35.1	- 16 35	11.5
17	10 49.4	- 01 00	9.9	00 58.2	+ 02 06	10.6	22 21.8	- 14 48	11.6	19 17.1	- 18 27	11.0	09 00.3	+ 07 12	10.3	20 43.0	- 16 04	11.4
24	10 48.2	- 00 32	10.0	01 13.9	+ 03 40	10.6	22 32.5	- 13 57	11.5	19 23.9	- 18 13	10.8	09 03.4	+ 07 05	10.5	20 50.4	- 15 35	11.4
May 1	10 48.3	- 00 11	10.2	01 29.8	+ 05 13	10.6	22 42.9	- 13 08	11.5	19 29.7	- 18 00	10.7	09 07.4	+ 06 55	10.6	20 57.1	- 15 07	11.3
8	10 49.5	+ 00 02	10.3	01 45.8	+ 06 42	10.7	22 53.0	- 12 20	11.4	19 34.3	- 17 49	10.6	09 12.2	+ 06 40	10.7	21 03.2	- 14 40	11.2
15	10 51.8	+ 00 09	10.4	02 01.8	+ 08 09	10.7	23 02.7	- 11 34	11.4	19 37.6	- 17 42	10.4	09 17.8	+ 06 21	10.7	21 08.4	- 14 17	11.1
22	10 55.0	+ 00 08	10.6	02 18.0	+ 09 32	10.7	23 12.0	- 10 51	11.3	19 39.6	- 17 40	10.3	09 23.9	+ 05 59	10.8	21 12.9	- 13 57	11.0
29	10 59.2	+ 00 00	10.7	02 34.2	+ 10 51	10.7	23 20.8	- 10 11	11.2	19 40.0	- 17 42	10.1	09 30.5	+ 05 32	10.9	21 16.4	- 13 41	10.9
Jun 5	11 04.1	- 00 13	10.8	02 50.6	+ 12 05	10.7	23 29.1	- 09 34	11.2	19 39.0	- 17 50	9.9	09 37.7	+ 05 02	11.0	21 19.0	- 13 29	10.7
12	11 09.7	- 00 32	10.9	03 07.1	+ 13 15	10.7	23 36.8	- 09 02	11.1	19 36.4	- 18 03	9.7	09 45.2	+ 04 28	11.0	21 20.5	- 13 23	10.6
19	11 15.9	- 00 56	11.0	03 23.6	+ 14 19	10.7	23 43.9	- 08 35	11.0	19 32.4	- 18 22	9.5	09 53.1	+ 03 51	11.1	21 20.8	- 13 23	10.5
26	11 22.6	- 01 25	11.0	03 40.2	+ 15 18	10.7	23 50.3	- 08 14	10.8	19 27.2	- 18 46	9.3	10 01.2	+ 03 10	11.1	21 20.1	- 13 28	10.3
Jul 3	11 29.8	- 01 58	11.1	03 56.8	+ 16 11	10.7	23 55.8	- 07 59	10.7	19 21.1	- 19 13	9.1	10 09.6	+ 02 27	11.1	21 18.2	- 13 40	10.2
10	11 37.4	- 02 35	11.2	04 13.4	+ 16 58	10.7	00 00.5	- 07 50	10.6	19 14.5	- 19 43	8.9	10 18.2	+ 01 40	11.2	21 15.1	- 13 58	10.0
17	11 45.3	- 03 15	11.2	04 30.0	+ 17 38	10.7	00 04.1	- 07 49	10.5	19 07.8	- 20 13	9.1	10 27.0	+ 00 51	11.2	21 11.1	- 14 21	9.8
24	11 53.6	- 03 59	11.3	04 46.4	+ 18 12	10.7	00 06.6	- 07 56	10.3	19 01.6	- 20 43	9.3	10 35.9	- 00 01	11.2	21 06.3	- 14 48	9.7
31	12 02.2	- 04 44	11.3	05 02.8	+ 18 40	10.7	00 07.9	- 08 11	10.1	18 56.2	- 21 11	9.5	10 44.9	- 00 54	11.2	21 00.9	- 15 18	9.5
Aug 7	12 11.0	- 05 32	11.3	05 19.0	+ 19 01	10.6	00 07.8	- 08 34	10.0	18 52.1	- 21 37	9.7	10 54.1	- 01 51	11.2	20 55.2	- 15 50	9.4
14	12 20.0	- 06 22	11.3	05 34.9	+ 19 16	10.6	00 06.3	- 09 04	9.8	18 49.5	- 22 00	9.8	11 03.4	- 02 49	11.2	20 49.5	- 16 22	9.6
21	12 29.3	- 07 14	11.3	05 50.6	+ 19 25	10.6	00 03.5	- 09 40	9.6	18 48.5	- 22 20	10.0	11 12.7	- 03 48	11.2	20 44.3	- 16 52	9.7
28	12 38.7	- 08 06	11.3	06 05.9	+ 19 29	10.6	23 59.3	- 10 22	9.4	18 49.2	- 22 37	10.2	11 22.0	- 04 50	11.1	20 39.7	- 17 19	9.9
Sep 4	12 48.3	- 09 00	11.3	06 20.8	+ 19 27	10.5	23 54.0	- 11 05	9.2	18 51.5	- 22 50	10.3	11 31.5	- 05 52	11.1	20 36.1	- 17 42	10.0
11	12 58.1	- 09 54	11.3	06 35.2	+ 19 21	10.5	23 47.9	- 11 47	9.1	18 55.3	- 23 01	10.4	11 40.9	- 06 56	11.1	20 33.7	- 18 00	10.1
18	13 08.0	- 10 49	11.3	06 49.1	+ 19 12	10.4	23 41.3	- 12 26	9.1	19 00.5	- 23 07	10.6	11 50.4	- 08 01	11.0	20 32.5	- 18 14	10.2
25	13 18.0	- 11 44	11.3	07 02.3	+ 18 59	10.4	23 34.7	- 12 57	9.2	19 07.1	- 23 09	10.7	11 59.9	- 09 06	11.0	20 32.7	- 18 22	10.4
Oct 2	13 28.2	- 12 38	11.2	07 14.7	+ 18 44	10.3	23 28.5	- 13 20	9.3	19 14.8	- 23 08	10.8	12 09.3	- 10 12	11.0	20 34.1	- 18 25	10.5
9	13 38.5	- 13 33	11.2	07 26.4	+ 18 27	10.2	23 23.1	- 13 32	9.5	19 23.5	- 23 01	10.9	12 18.8	- 11 19	11.1	20 36.8	- 18 23	10.6
16	13 48.8	- 14 26	11.1	07 37.2	+ 18 11	10.2	23 18.9	- 13 32	9.6	19 33.1	- 22 51	11.0	12 28.2	- 12 25	11.1	20 40.7	- 18 16	10.7
23	13 59.3	- 15 19	11.0	07 46.9	+ 17 55	10.1	23 16.1	- 13 22	9.8	19 43.4	- 22 35	11.1	12 37.6	- 13 32	11.2	20 45.6	- 18 03	10.8
30	14 09.9	- 16 10	11.0	07 55.5	+ 17 42	10.0	23 14.7	- 13 01	9.9	19 54.5	- 22 14	11.1	12 47.0	- 14 38	11.2	20 51.5	- 17 46	10.8
Nov 6	14 20.5	- 17 00	11.0	08 02.8	+ 17 32	9.9	23 14.9	- 12 30	10.1	20 06.1	- 21 49	11.2	12 56.2	- 15 44	11.2	20 58.3	- 17 24	10.9
13	14 31.1	- 17 48	11.1	08 08.7	+ 17 27	9.8	23 16.5	- 11 50	10.2	20 18.2	- 21 18	11.3	13 05.4	- 16 50	11.3	21 05.9	- 16 57	11.0
20	14 41.8	- 18 35	11.2	08 13.1	+ 17 28	9.6	23 19.4	- 11 03	10.3	20 30.6	- 20 42	11.3	13 14.5	- 17 54	11.3	21 14.2	- 16 26	11.0
27	14 52.5	- 19 19	11.3	08 15.7	+ 17 36	9.5	23 23.7	- 10 08	10.4	20 43.4	- 20 01	11.3	13 23.3	- 18 58	11.3	21 23.1	- 15 50	11.1
Dec 4	15 03.2	- 20 01	11.3	08 16.5	+ 17 53	9.4	23 29.1	- 09 08	10.5	20 56.4	- 19 15	11.4	13 32.0	- 20 00	11.3	21 32.5	- 15 10	11.1
11	15 13.8	- 20 40	11.3	08 15.3	+ 18 18	9.2	23 35.4	- 08 03	10.6	21 09.6	- 18 24	11.4	13 40.5	- 21 02	11.3	21 42.4	- 14 25	11.2
18	15 24.4	- 21 17	11.4	08 12.2	+ 18 51	9.1	23 42.7	- 06 52	10.7	21 23.0	- 17 29	11.4	13 48.7	- 22 02	11.3	21 52.6	- 13 37	11.2
25	15 34.8	- 21 52	11.4	08 07.4	+ 19 32	8.9	23 50.8	- 05 38	10.8	21 36.4	- 16 29	11.5	13 56.6	- 23 00	11.3	22 03.2	- 12 44	11.2

MINOR PLANET POSITIONS

(0HR UT, EPOCH 2000.0)

As well as the nine planets, their moons and the comets, the Solar System contains numerous smaller bodies known as the 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 photographing 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.

The ephemerides are for the twenty brightest minor planets for 2004. Sixteen of these reach opposition in 2004, three early in 2005 and one is at opposition late in 2003. These selected asteroids all get brighter than 10th magnitude around the time of opposition.

	20 MASSALIA			27 EUTERPE			29 AMPHITRITE		
	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag
Jan 3	14 42.8	- 15 50	11.5	20 42.8	- 19 02	12.4	03 44.6	+ 29 14	9.5
10	14 53.3	- 16 35	11.5	20 55.0	- 18 15	12.3	03 43.5	+ 28 52	9.7
17	15 03.4	- 17 17	11.5	21 07.2	- 17 24	12.3	03 44.1	+ 28 33	9.8
24	15 13.0	- 17 54	11.4	21 19.5	- 16 31	12.2	03 46.3	+ 28 19	10.0
31	15 22.1	- 18 27	11.4	21 31.8	- 15 34	12.1	03 50.1	+ 28 09	10.1
Feb 7	15 30.4	- 18 56	11.3	21 44.1	- 14 34	12.0	03 55.2	+ 28 03	10.2
14	15 38.0	- 19 21	11.3	21 56.3	- 13 31	11.9	04 01.6	+ 28 01	10.3
21	15 44.7	- 19 41	11.2	22 08.6	- 12 26	11.9	04 09.1	+ 28 01	10.4
28	15 50.4	- 19 57	11.1	22 20.8	- 11 19	12.0	04 17.6	+ 28 04	10.5
Mar 6	15 55.0	- 20 09	11.0	22 33.0	- 10 10	12.0	04 26.9	+ 28 08	10.6
13	15 58.4	- 20 17	10.9	22 45.1	- 08 59	12.1	04 37.0	+ 28 12	10.7
20	16 00.5	- 20 21	10.8	22 57.2	- 07 47	12.1	04 47.8	+ 28 16	10.8
27	16 01.1	- 20 21	10.7	23 09.2	- 06 33	12.2	04 59.2	+ 28 20	10.8
Apr 3	16 00.3	- 20 16	10.6	23 21.2	- 05 19	12.2	05 11.1	+ 28 22	10.9
10	15 58.0	- 20 07	10.5	23 33.1	- 04 05	12.2	05 23.4	+ 28 22	10.9
17	15 54.4	- 19 54	10.3	23 45.0	- 02 50	12.2	05 36.1	+ 28 19	11.0
24	15 49.4	- 19 36	10.2	23 56.8	- 01 35	12.2	05 49.1	+ 28 13	11.0
May 1	15 43.4	- 19 15	10.0	00 08.5	- 00 21	12.2	06 02.4	+ 28 04	11.0
8	15 36.7	- 18 51	9.9	00 20.2	+ 00 53	12.2	06 15.9	+ 27 52	11.0
15	15 29.7	- 18 24	9.7	00 31.8	+ 02 06	12.1	06 29.5	+ 27 36	11.1
22	15 22.8	- 17 58	9.9	00 43.4	+ 03 18	12.1	06 43.2	+ 27 15	11.1
29	15 16.3	- 17 32	10.1	00 54.9	+ 04 27	12.1	06 57.1	+ 26 51	11.1
Jun 5	15 10.6	- 17 09	10.3	01 06.2	+ 05 36	12.0	07 10.9	+ 26 22	11.1
12	15 06.0	- 16 50	10.4	01 17.5	+ 06 42	12.0	07 24.7	+ 25 50	11.0
19	15 02.6	- 16 35	10.6	01 28.6	+ 07 45	11.9	07 38.5	+ 25 13	11.0
26	15 00.5	- 16 27	10.7	01 39.6	+ 08 46	11.9	07 52.2	+ 24 32	11.0
Jul 3	14 59.7	- 16 23	10.9	01 50.4	+ 09 44	11.8	08 05.8	+ 23 48	11.0
10	15 00.2	- 16 26	11.0	02 00.9	+ 10 38	11.7	08 19.3	+ 23 00	10.9
17	15 01.8	- 16 33	11.2	02 11.2	+ 11 29	11.6	08 32.6	+ 22 08	10.9
24	15 04.7	- 16 45	11.3	02 21.1	+ 12 16	11.5	08 45.9	+ 21 13	10.8
31	15 08.5	- 17 02	11.4	02 30.5	+ 12 59	11.4	08 58.9	+ 20 15	10.8
Aug 7	15 13.4	- 17 21	11.5	02 39.5	+ 13 38	11.3	09 11.8	+ 19 14	10.7
14	15 19.0	- 17 44	11.6	02 47.8	+ 14 12	11.2	09 24.5	+ 18 11	10.8
21	15 25.5	- 18 08	11.7	02 55.4	+ 14 41	11.1	09 37.0	+ 17 05	10.9
28	15 32.8	- 18 35	11.7	03 02.1	+ 15 05	10.9	09 49.3	+ 15 58	10.9
Sep 4	15 40.6	- 19 02	11.8	03 07.8	+ 15 24	10.8	10 01.5	+ 14 48	11.0
11	15 49.1	- 19 29	11.9	03 12.3	+ 15 38	10.6	10 13.4	+ 13 38	11.0
18	15 58.1	- 19 57	11.9	03 15.5	+ 15 46	10.4	10 25.1	+ 12 26	11.1
25	16 07.6	- 20 24	12.0	03 17.1	+ 15 48	10.2	10 36.6	+ 11 13	11.1
Oct 2	16 17.6	- 20 50	12.0	03 17.1	+ 15 44	10.0	10 47.9	+ 10 00	11.2
9	16 28.0	- 21 14	12.0	03 15.5	+ 15 35	9.8	10 58.9	+ 08 47	11.2
16	16 38.8	- 21 37	12.0	03 12.1	+ 15 20	9.6	11 09.8	+ 07 33	11.2
23	16 49.9	- 21 57	12.0	03 07.2	+ 15 00	9.4	11 20.3	+ 06 21	11.2
30	17 01.2	- 22 15	12.0	03 01.2	+ 14 36	9.1	11 30.6	+ 05 09	11.2
Nov 6	17 12.9	- 22 30	12.0	02 54.3	+ 14 10	8.8	11 40.6	+ 03 58	11.2
13	17 24.8	- 22 41	12.0	02 47.3	+ 13 44	9.0	11 50.3	+ 02 49	11.2
20	17 36.9	- 22 50	12.0	02 40.6	+ 13 21	9.2	11 59.6	+ 01 42	11.2
27	17 49.1	- 22 55	12.0	02 34.8	+ 13 03	9.4	12 08.5	+ 00 37	11.1
Dec 4	18 01.5	- 22 56	12.0	02 30.4	+ 12 52	9.6	12 17.0	- 00 26	11.1
11	18 14.0	- 22 54	11.9	02 27.6	+ 12 49	9.7	12 25.0	- 01 26	11.1
18	18 26.5	- 22 48	11.8	02 26.6	+ 12 55	9.9	12 32.5	- 02 22	11.0
25	18 39.0	- 22 38	11.8	02 27.4	+ 13 10	10.1	12 39.3	- 03 15	10.9

	40 HARMONIA			192 NAUSIKAA			324 BAMBERGA			387 AQUITANIA			532 HERCULINA		
Jan 3	19 21.7	- 23 01	11.6	20 12.5	- 22 42	11.7	17 09.0	- 31 15	12.6	16 27.9	- 08 08	12.4	01 48.2	- 06 52	11.3
10	19 37.3	- 22 34	11.5	20 28.8	- 21 36	11.6	17 21.8	- 31 30	12.6	16 42.1	- 08 35	12.4	01 50.3	- 05 54	11.4
17	19 52.9	- 22 01	11.4	20 45.2	- 20 24	11.5	17 34.6	- 31 41	12.6	16 56.4	- 08 57	12.4	01 53.2	- 04 52	11.5
24	20 08.3	- 21 23	11.5	21 01.5	- 19 06	11.4	17 47.5	- 31 50	12.6	17 10.6	- 09 13	12.3	01 57.0	- 03 49	11.5
31	20 23.7	- 20 40	11.6	21 17.8	- 17 42	11.3	18 00.3	- 31 56	12.6	17 24.7	- 09 24	12.3	02 01.5	- 02 44	11.6
Feb 7	20 38.9	- 19 53	11.6	21 34.0	- 16 13	11.2	18 13.1	- 31 58	12.6	17 38.8	- 09 30	12.3	02 06.7	- 01 37	11.6
14	20 53.9	- 19 01	11.7	21 50.1	- 14 39	11.0	18 25.7	- 31 58	12.5	17 52.6	- 09 31	12.2	02 12.6	- 00 31	11.7
21	21 08.7	- 18 06	11.7	22 06.2	- 13 00	11.1	18 38.2	- 31 55	12.5	18 06.3	- 09 27	12.2	02 19.0	+ 00 36	11.7
28	21 23.4	- 17 06	11.8	22 22.1	- 11 17	11.2	18 50.5	- 31 50	12.4	18 19.7	- 09 19	12.1	02 25.9	+ 01 43	11.7
Mar 6	21 37.8	- 16 04	11.8	22 38.0	- 09 30	11.3	19 02.6	- 31 42	12.4	18 32.7	- 09 07	12.1	02 33.4	+ 02 48	11.7
13	21 52.1	- 14 59	11.8	22 53.8	- 07 40	11.3	19 14.3	- 31 32	12.3	18 45.5	- 08 51	12.0	02 41.2	+ 03 53	11.7
20	22 06.1	- 13 52	11.9	23 09.6	- 05 47	11.4	19 25.7	- 31 20	12.2	18 57.8	- 08 33	12.0	02 49.5	+ 04 57	11.7
27	22 19.9	- 12 43	11.9	23 25.4	- 03 52	11.4	19 36.7	- 31 07	12.1	19 09.6	- 08 13	11.9	02 58.1	+ 05 59	11.7
Apr 3	22 33.4	- 11 33	11.9	23 41.1	- 01 55	11.4	19 47.3	- 30 53	12.0	19 20.9	- 07 51	11.8	03 07.0	+ 07 00	11.7
10	22 46.8	- 10 21	11.9	23 56.8	+ 00 03	11.5	19 57.3	- 30 38	11.9	19 31.6	- 07 29	11.7	03 16.3	+ 07 58	11.7
17	22 59.9	- 09 10	11.9	00 12.5	+ 02 01	11.5	20 06.7	- 30 23	11.8	19 41.6	- 07 07	11.6	03 25.8	+ 08 55	11.6
24	23 12.8	- 07 58	11.9	00 28.3	+ 04 00	11.5	20 15.5	- 30 09	11.7	19 50.9	- 06 48	11.5	03 35.6	+ 09 49	11.6
May 1	23 25.4	- 06 47	11.9	00 44.1	+ 05 57	11.5	20 23.5	- 29 56	11.6	19 59.4	- 06 31	11.4	03 45.6	+ 10 40	11.6
8	23 37.8	- 05 38	11.8	01 00.0	+ 07 54	11.5	20 30.7	- 29 45	11.4	20 06.9	- 06 19	11.3	03 55.8	+ 11 29	11.5
15	23 50.0	- 04 29	11.8	01 15.9	+ 09 49	11.6	20 36.8	- 29 35	11.3	20 13.4	- 06 12	11.2	04 06.2	+ 12 15	11.5
22	00 01.9	- 03 22	11.8	01 32.0	+ 11 41	11.6	20 41.9	- 29 28	11.1	20 18.8	- 06 14	11.0	04 16.8	+ 12 58	11.4
29	00 13.4	- 02 18	11.7	01 48.2	+ 13 30	11.6	20 45.8	- 29 23	10.9	20 22.9	- 06 25	10.9	04 27.5	+ 13 38	11.4
Jun 5	00 24.7	- 01 17	11.7	02 04.4	+ 15 16	11.6	20 48.3	- 29 22	10.7	20 25.8	- 06 47	10.7	04 38.3	+ 14 15	11.4
12	00 35.6	- 00 18	11.6	02 20.8	+ 16 57	11.6	20 49.3	- 29 23	10.5	20 27.2	- 07 22	10.5	04 49.3	+ 14 48	11.4
19	00 46.1	+ 00 36	11.6	02 37.3	+ 18 34	11.6	20 48.6	- 29 26	10.3	20 27.2	- 08 11	10.4	05 00.3	+ 15 18	11.4
26	00 56.2	+ 01 26	11.5	02 53.8	+ 20 06	11.6	20 46.3	- 29 30	10.1	20 25.7	- 09 14	10.2	05 11.4	+ 15 45	11.4
Jul 3	01 05.7	+ 02 12	11.4	03 10.4	+ 21 32	11.6	20 42.3	- 29 34	9.8	20 23.0	- 10 33	10.0	05 22.5	+ 16 08	11.5
10	01 14.7	+ 02 52	11.3	03 27.1	+ 22 52	11.6	20 36.7	- 29 35	9.6	20 19.1	- 12 04	9.8	05 33.7	+ 16 29	11.5
17	01 23.0	+ 03 27	11.2	03 43.7	+ 24 06	11.6	20 29.7	- 29 32	9.3	20 14.3	- 13 45	9.6	05 44.8	+ 16 46	11.5
24	01 30.5	+ 03 55	11.1	04 00.2	+ 25 14	11.6	20 21.8	- 29 21	9.2	20 09.1	- 15 32	9.5	05 55.9	+ 16 59	11.5
31	01 37.2	+ 04 17	11.0	04 16.7	+ 26 16	11.5	20 13.5	- 29 02	9.2	20 03.9	- 17 22	9.6	06 06.9	+ 17 10	11.5
Aug 7	01 42.8	+ 04 32	10.9	04 32.9	+ 27 11	11.5	20 05.4	- 28 33	9.3	19 59.2	- 19 08	9.9	06 17.8	+ 17 18	11.5
14	01 47.3	+ 04 39	10.8	04 48.8	+ 28 00	11.5	19 58.1	- 27 55	9.4	19 55.4	- 20 47	10.1	06 28.6	+ 17 23	11.4
21	01 50.5	+ 04 38	10.6	05 04.4	+ 28 44	11.5	19 52.2	- 27 09	9.6	19 52.8	- 22 16	10.3	06 39.2	+ 17 25	11.4
28	01 52.3	+ 04 30	10.5	05 19.5	+ 29 21	11.4	19 48.0	- 26 17	9.7	19 51.7	- 23 35	10.5	06 49.6	+ 17 25	11.4
Sep 4	01 52.6	+ 04 14	10.3	05 34.0	+ 29 54	11.4	19 45.7	- 25 20	9.8	19 52.2	- 24 41	10.7	06 59.8	+ 17 24	11.3
11	01 51.3	+ 03 50	10.1	05 47.8	+ 30 23	11.3	19 45.4	- 24 21	10.0	19 54.3	- 25 35	10.9	07 09.7	+ 17 21	11.3
18	01 48.5	+ 03 19	9.9	06 00.9	+ 30 48	11.3	19 47.1	- 23 19	10.1	19 57.9	- 26 17	11.0	07 19.2	+ 17 17	11.2
25	01 44.2	+ 02 44	9.8	06 12.9	+ 31 10	11.2	19 50.7	- 22 15	10.2	20 02.9	- 26 49	11.2	07 28.4	+ 17 12	11.2
Oct 2	01 38.6	+ 02 06	9.6	06 23.8	+ 31 31	11.2	19 56.0	- 21 10	10.3	20 09.3	- 27 10	11.3	07 37.1	+ 17 08	11.1
9	01 32.2	+ 01 28	9.4	06 33.5	+ 31 51	11.1	20 02.8	- 20 04	10.4	20 16.8	- 27 21	11.5	07 45.2	+ 17 05	11.0
16	01 25.4	+ 00 52	9.4	06 41.7	+ 32 11	11.0	20 11.0	- 18 55	10.5	20 25.3	- 27 24	11.6	07 52.8	+ 17 02	10.9
23	01 18.6	+ 00 22	9.5	06 48.3	+ 32 31	10.9	20 20.4	- 17 44	10.6	20 34.7	- 27 18	11.8	07 59.8	+ 17 03	10.8
30	01 12.4	+ 00 01	9.7	06 53.1	+ 32 54	10.8	20 30.9	- 16 30	10.6	20 44.9	- 27 04	11.9	08 06.0	+ 17 06	10.7
Nov 6	01 07.2	- 00 11	9.9	06 55.9	+ 33 17	10.6	20 42.3	- 15 12	10.7	20 55.6	- 26 43	12.0	08 11.3	+ 17 14	10.6
13	01 03.3	- 00 12	10.1	06 56.6	+ 33 42	10.5	20 54.4	- 13 51	10.7	21 06.9	- 26 15	12.1	08 15.6	+ 17 27	10.5
20	01 00.8	- 00 03	10.3	06 55.0	+ 34 07	10.3	21 07.2	- 12 26	10.8	21 18.5	- 25 41	12.2	08 18.9	+ 17 47	10.3
27	00 59.9	+ 00 17	10.5	06 51.2	+ 34 31	10.2	21 20.6	- 10 57	10.8	21 30.5	- 25 01	12.2	08 21.0	+ 18 13	10.2
Dec 4	01 00.5	+ 00 46	10.6	06 45.4	+ 34 50	10.0	21 34.4	- 09 24	10.9	21 42.7	- 24 15	12.3	08 21.8	+ 18 48	10.0
11	01 02.5	+ 01 23	10.8	06 37.8	+ 35 03	9.9	21 48.7	- 07 47	10.9	21 55.0	- 23 25	12.4	08 21.3	+ 19 30	9.8
18	01 05.9	+ 02 07	10.9	06 29.1	+ 35 08	9.8	22 03.3	- 06 06	10.9	22 07.5	- 22 31	12.4	08 19.3	+ 20 21	9.7
25	01 10.6	+ 02 58	11.1	06 19.8	+ 35 02	9.7	22 18.2	- 04 21	11.0	22 20.1	- 21 32	12.5	08 15.9	+ 21 20	9.5

COMETS FOR 2004

WHAT IS A COMET? It is a member of the Solar System which is normally in a very eccentric orbit around the Sun. The orbits of periodic, or regularly reappearing comets are quite elongated or oval compared to those of the planets. Comets also differ from the planets by being far less massive and mainly composed 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, Encke, takes just over 3 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 a number of new comets that have not been recorded before. The majority of these have either open-ended orbits (they are believed to be making their only visit to the Solar System and are not expected to return) or have extremely long orbital periods measured in thousands of years.

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 ionized 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 the direction of 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 2P/Encke indicates Encke was the 2nd comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. Interestingly, Halley's Comet's prefix is 1P/ because it was the first comet shown to be periodic. In fact Halley did not find the comet. It was named after him after he successfully predicted its return. You will also see references to another naming system. It is best to explain this with an example. You will notice one of the Comet LINEARs is referred to as 'C/2003 L2'. 2003 refers to the year, L refers to the 11th half month period ('I' is not used) during the year and 2 shows it was the 2nd discovery in this half of the month. Therefore LINEAR was the 2nd comet discovered in the first half of June 2003.

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 from even 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 comets that are expected to be observable during 2004. The table (opposite) lists these objects as well as their orbital elements. This is the data required to calculate their locations in the sky. It lists all the known comets expected to be visible that reach perihelion (closest approach to the Sun) during 2004. There are also a few included that are bright during 2004 but have a perihelion date in 2003. The elements are followed by 'ephemerides' (a list of expected positions in the sky and magnitude estimates for different dates) for some of the brighter comets. 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 have it too close to the Sun or on the opposite side of the Sun from Earth. This would likely be considered unfavourable.

Many of the comets expected in 2004 are extremely faint and would require professional-size telescopes or long exposure astrophotographs to detect them. But, as we have previously mentioned, we have 2 comets, C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) that could potentially put on spectacular displays in May.

NOTES ON SELECTED COMETS FOR 2004 – *by Greg Bryant*

Comet 43P/Wolf-Harrington: German astronomer Max Wolf discovered this comet on photographs taken on 22nd December 1924. The comet was quickly identified as periodic, but the short arc of observations, and a close approach to Jupiter in 1936, rendered the comet subsequently lost. On 4th October 1951, Robert Harrington discovered a faint comet during the course of the National Geographic Society – Palomar Observatory Sky Survey. A month later, it was suspected it might be the lost comet Wolf, but it wasn't until the following return in 1957 that the identity was confirmed. This year Wolf-Harrington will be visible early in the evening during January – April as a comet of 12th – 13th magnitude.

Comet 62P/Tsuchinshan 1: Discovered in January 1965, and named after the Purple Mountain Observatory in China at which it was first spotted, Tsuchinshan 1 is making its 7th observed apparition. In 2004, Tsuchinshan 1 reaches perihelion in December and should be between 12th and 13th magnitude in the morning skies of October – December. Prior to its discovery, Tsuchinshan 1 made a close approach (0.14 AU) to Jupiter in December 1960, reducing its perihelion distance by nearly 0.6 AU and its period by more than a year.

Comet 78P/Gehrels 2: During the course of a minor planet survey, Tom Gehrels discovered this comet on photographic plates taken with Palomar's 1.2m Schmidt telescope in the United States in 1973 between September 29 and October 5. At its last return, in 1997, Gehrels 2 was observed quite favourably. This year, Gehrels 2 will be a telescopic object visible in the second half of 2004.

Comet 88P/Howell: Ellen Howell discovered this comet on photographic plates taken on 29th August, 1981, with the 0.46m Schmidt telescope at Palomar. Within a fortnight, the periodic nature of the comet was confirmed. This is the 4th observed apparition of comet Howell, and it may reach 10th magnitude in Autumn's morning sky.

Comet C/2001 Q4 (NEAT): The NEAT asteroid survey program reported what appeared to be just another comet discovery on 24th August 2001 (it's worth noting that NEAT discovered an additional five comets in the few months prior to this), and a somewhat uncertain orbit announced several days later suggested it would reach a distant perihelion in 2005.

In early September 2001, word began to circulate that revised orbit calculations indicated a much more promising set of orbital circumstances. On 10th September, it was officially announced that the comet would reach perihelion in May 2004 (still with an uncertainty of a few weeks) and much closer to both the Sun and Earth. Within a week, additional measurements of the comet's movement by observers had narrowed down the uncertainty in our favour.

Prospects look good for the comet to be visible to the naked-eye in Autumn of 2004, well placed in the southern sky, but as the comet has been discovered to be a first-time visitor to the inner Solar System, a slow rate of brightening should be anticipated.

Comet C/2002 T7 (LINEAR): On October 14th, 2002, the LINEAR program discovered what was apparently an asteroidal object but was revealed subsequently to be a comet, one making its first trip to the inner

Solar System. LINEAR reaches perihelion in April 2004 and is predicted to be visible to the naked-eye. In May, it will be visible in the evening sky at the same time as comet C/2001 Q4 (NEAT). Both comets may display good tails and the Moon is conveniently well-placed.

Interestingly, whilst the prospect of seeing two potentially bright comets at the same time might initially be thought to be unique, it is only so for today's generation of observers. In October 1911, comets Beljawsky and Brooks were 1st and 2nd magnitude respectively in the evening sky. A third comet, Quenisset, was hovering near 6th magnitude at the same time as the above two and was also sighted naked-eye!

Comet C/2003 H1 (LINEAR): Another apparent asteroidal object unearthed by LINEAR, this time on 24th April, 2003, revealed itself to be a comet, reaching perihelion in February 2004. It may brighten to 11th magnitude by the beginning of Autumn.

Comet C/2003 K4 (LINEAR): This comet was discovered on 28th May, 2003, by the LINEAR program, and an initial preliminary orbit suggested that it would not enter the inner Solar System. Shortly afterwards, orbital calculators noted that additional measured positions suggested a vastly different orbit, reaching perihelion in late 2004, and this was confirmed a few days later by the Central Bureau. A first-time visitor to the inner Solar System, comet LINEAR may brighten to 7th magnitude or better in Spring. Interestingly, if the comet had arrived just six months earlier, it would have passed very close to Earth and been easily visible to the naked-eye… around the time of comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR)!

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COMETS FOR 2004 – ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q AU	e	Period years	ω °	Ω °	Incl. °	H1	K1
C/2001 HT50 (LINEAR-NEAT)	2003 07 09.0076	2.792093	0.997654	-	324.0671	042.9133	163.2120	4.5	10.0
81P/Wild 2	2003 09 25.9385	1.590365	0.538789	6.4	041.7514	136.1415	003.2403	7.0	15.0
123P/West-Hartley	2003 12 09.1212	2.128691	0.448506	7.6	102.9165	046.6199	015.3467	4.0	25.0
2P/Encke	2003 12 29.8768	0.338461	0.847339	3.3	186.4985	334.5876	011.7696	9.8	*
58P/Jackson-Neujmin	2004 01 09.9944	1.388664	0.660469	8.3	200.4388	160.6152	013.4560	11.5	25.0
C/2003 L2 (LINEAR)	2004 01 15.6410	2.900080	1.0		118.6010	273.8670	082.1710		
40P/Vaisala 1	2004 01 22.8965	1.795919	0.633073	10.8	047.1890	134.7335	011.5385	5.5	30.0
C/2003 E1 (NEAT)	2004 02 13.6399	3.245129	0.763463	50.8	103.8619	137.0695	033.5380		
C/2003 H1 (LINEAR)	2004 02 22.5142	2.240829	1.0		196.0796	018.9884	138.6705	8.0	7.5
43P/Wolf-Harrington	2004 03 17.8530	1.578633	0.544593	6.5	187.2755	254.6942	018.5204	6.5	21.0
C/2002 L9 (NEAT)	2004 04 06.1537	7.031604	0.998516		231.4486	110.4558	068.4364	5.5	8.0
88P/Howell	2004 04 12.5677	1.367516	0.561155	5.5	235.8395	056.8257	004.3828	5.5	27.0
C/2002 T7 (LINEAR)	2004 04 23.0600	0.614500	1.000499		157.7392	094.8569	160.5809	5.0	7.5
104P/Kowal 2	2004 05 09.7402	1.395925	0.585488	6.2	192.0430	246.0858	015.4894	10.0	13.0
C/2001 Q4 (NEAT)	2004 05 15.9337	0.961876	1.000766		001.2064	210.2782	099.6424	5.0	7.5
103P/Hartley 2	2004 05 17.9811	1.036282	0.699503	6.4	180.8067	219.8984	013.6021	8.0	20.0
P/1996 R2 (P/Lagerkvist)	2004 06 07.3568	2.623007	0.308434	7.4	334.2502	040.2230	002.6022	11.0	10.0
29P/Schwassmann-Wachmann 1	2004 07 10.8283	5.723578	0.044170	14.7	048.9562	312.7156	009.3921	4.0	7.5
42P/Neujmin 3	2004 07 15.9577	2.014907	0.585066	10.7	147.1582	150.3536	003.9854		
121P/Shoemaker-Holt 2	2004 09 01.7136	2.648121	0.338458	8.0	006.2293	099.6700	017.7177	6.5	20.0
120P/Mueller 1	2004 09 30.1527	2.746803	0.336767	8.4	030.1767	004.4594	008.7866	5.0	25.0
48P/Johnson	2004 10 11.9689	2.309978	0.366506	7.0	207.6950	117.3296	013.6583	4.5	25.0
130P/McNaught-Hughes	2004 10 23.2861	2.104250	0.405889	6.7	224.1202	089.8867	007.3070		
C/2003 K4 (LINEAR)	2004 10 13.7760	1.022940	1.0		198.4630	018.6588	134.2504	5.5	7.5
78P/Gehrels 2	2004 10 27.0835	2.008166	0.462537	7.2	192.9576	210.5479	006.2528	1.5	30.0
69P/Taylor	2004 11 30.4111	1.941847	0.466923	7.0	355.5291	108.7970	020.5632		
62P/Tsuchinshan 1	2004 12 07.9463	1.489255	0.577811	6.6	022.8480	096.7684	010.5023		
131P/Mueller 2	2004 12 17.5867	2.424069	0.342225	7.1	179.8479	214.2291	007.3490		
111P/Helin-Roman-Crockett	2004 12 27.1442	3.473362	0.140269	8.1	010.5657	091.9365	004.2328	3.0	25.0

Perihelion Date 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 one would indicate an open orbit which means it is a once only visitor to the Solar System, or it has a very long period (thousands of years) or the comet is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period in years. The time it takes to complete one orbit of the Sun.

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. If the value is greater than 90°, the comets direction of orbit is retrograde i.e., moving 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 was one AU from the Sun and the Earth.

K1 A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' for further details)

The maths used to calculate ephemerides from these elements is complex (but not difficult, with the power of home computers) but is beyond the scope of this publication.

Comet 88P/Howell

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2004 Jan 31	17 48.1	-23 42	2.143	1.575	43	12.5
2004 Feb 7	18 12.4	-23 56	2.077	1.540	45	12.2
2004 Feb 14	18 37.4	-23 56	2.016	1.508	46	11.8
2004 Feb 21	19 02.9	-23 41	1.959	1.478	47	11.5
2004 Feb 28	19 28.7	-23 11	1.906	1.452	48	11.3
2004 Mar 6	19 54.7	-22 25	1.859	1.428	49	11.0
2004 Mar 13	20 20.5	-21 25	1.817	1.408	50	10.8
2004 Mar 20	20 46.2	-20 10	1.780	1.392	51	10.6
2004 Mar 27	21 11.4	-18 42	1.748	1.380	52	10.5
2004 Apr 3	21 36.1	-17 03	1.721	1.372	53	10.4
2004 Apr 10	22 00.1	-15 15	1.698	1.368	54	10.3
2004 Apr 17	22 23.4	-13 21	1.679	1.368	55	10.3
2004 Apr 24	22 45.9	-11 22	1.663	1.373	56	10.3
2004 May 1	23 07.5	-09 22	1.650	1.382	57	10.4
2004 May 8	23 28.3	-07 21	1.639	1.396	58	10.5
2004 May 15	23 48.2	-05 22	1.629	1.413	59	10.6
2004 May 22	00 07.2	-03 26	1.619	1.434	61	10.8
2004 May 29	00 25.3	-01 35	1.609	1.458	63	11.0
2004 Jun 5	00 42.6	+00 10	1.599	1.486	65	11.2
2004 Jun 12	00 58.9	+01 49	1.588	1.516	67	11.4
2004 Jun 19	01 14.3	+03 20	1.575	1.549	70	11.6
2004 Jun 26	01 28.8	+04 44	1.560	1.585	72	11.9
2004 Jul 3	01 42.2	+06 00	1.543	1.622	76	12.1
2004 Jul 10	01 54.6	+07 08	1.524	1.661	79	12.4

Comet 78P/Gehrels 2

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2004 Aug 7	02 24.5	+17 01	1.763	2.115	95	12.5
2004 Aug 14	02 35.0	+17 36	1.677	2.098	100	12.3
2004 Aug 21	02 44.9	+18 05	1.593	2.082	104	12.1
2004 Aug 28	02 54.1	+18 26	1.513	2.068	109	11.9
2004 Sep 4	03 02.4	+18 39	1.436	2.055	113	11.7
2004 Sep 11	03 09.7	+18 44	1.363	2.044	118	11.5
2004 Sep 18	03 15.8	+18 41	1.295	2.034	124	11.3
2004 Sep 25	03 20.5	+18 29	1.233	2.026	130	11.2
2004 Oct 2	03 23.8	+18 08	1.176	2.019	136	11.0
2004 Oct 9	03 25.5	+17 38	1.127	2.014	143	10.9
2004 Oct 16	03 25.7	+17 00	1.087	2.010	150	10.8
2004 Oct 23	03 24.5	+16 16	1.055	2.008	157	10.7
2004 Oct 30	03 22.1	+15 26	1.034	2.008	164	10.7
2004 Nov 6	03 18.8	+14 34	1.024	2.010	172	10.6
2004 Nov 13	03 15.1	+13 42	1.025	2.013	176	10.7
2004 Nov 20	03 11.5	+12 55	1.038	2.018	170	10.7
2004 Nov 27	03 08.3	+12 13	1.062	2.024	162	10.8
2004 Dec 4	03 06.1	+11 41	1.097	2.032	155	10.9
2004 Dec 11	03 05.1	+11 19	1.142	2.042	147	11.1
2004 Dec 18	03 05.4	+11 07	1.197	2.053	140	11.3
2004 Dec 25	03 07.2	+11 06	1.260	2.066	134	11.5

Comet 2P/Encke

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag *
2003 Nov 1	23 47.9	+44 00	0.341	1.259	136	8.7
2003 Nov 8	22 21.8	+41 44	0.287	1.153	118	7.8
2003 Nov 15	20 49.6	+33 42	0.262	1.042	94	7.1
2003 Nov 22	19 32.9	+21 28	0.268	0.925	69	6.6
2003 Nov 29	18 35.6	+09 06	0.304	0.803	46	6.4
2003 Dec 6	17 52.5	-01 18	0.366	0.677	26	6.4
2003 Dec 13	17 20.2	-09 35	0.460	0.548	14	6.5
2003 Dec 20	17 00.2	-16 13	0.597	0.428	14	6.7
2003 Dec 27	16 59.4	-21 34	0.791	0.347	19	7.2
2004 Jan 3	17 22.9	-25 26	1.021	0.356	20	7.7
2004 Jan 10	17 59.5	-27 24	1.231	0.448	20	8.3
2004 Jan 17	18 35.9	-27 56	1.406	0.571	19	9.0
2004 Jan 24	19 08.2	-27 40	1.555	0.699	19	9.6
2004 Jan 31	19 36.3	-26 57	1.684	0.825	20	10.2
2004 Feb 7	20 00.7	-25 59	1.796	0.946	21	10.8
2004 Feb 14	20 22.1	-24 55	1.895	1.062	23	11.5

Comet C/2003 K4 (LINEAR)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2004 Mar 6	20 06.9	+18 40	3.844	3.306	51	12.3
2004 Mar 13	20 09.7	+19 37	3.697	3.228	55	12.2
2004 Mar 20	20 12.2	+20 41	3.542	3.149	59	12.0
2004 Mar 27	20 14.0	+21 55	3.380	3.070	64	11.8
2004 Apr 3	20 15.0	+23 18	3.211	2.990	68	11.6
2004 Apr 10	20 15.2	+24 51	3.038	2.910	73	11.4
2004 Apr 17	20 14.1	+26 36	2.862	2.829	78	11.2
2004 Apr 24	20 11.6	+28 32	2.683	2.748	83	10.9
2004 May 1	20 07.3	+30 41	2.506	2.666	88	10.7
2004 May 8	20 00.5	+33 03	2.331	2.584	93	10.4
2004 May 15	19 50.5	+35 38	2.161	2.502	98	10.2
2004 May 22	19 36.4	+38 21	1.999	2.419	102	9.9
2004 May 29	19 17.0	+41 09	1.849	2.335	106	9.6
2004 Jun 5	18 50.9	+43 47	1.715	2.251	108	9.3
2004 Jun 12	18 17.0	+45 55	1.601	2.167	110	9.0
2004 Jun 19	17 35.5	+47 04	1.512	2.083	109	8.8
2004 Jun 26	16 49.1	+46 46	1.451	1.999	107	8.6
2004 Jul 3	16 02.7	+44 48	1.420	1.915	102	8.4
2004 Jul 10	15 21.1	+41 20	1.419	1.831	96	8.2
2004 Jul 17	14 46.7	+36 53	1.445	1.747	89	8.1
2004 Jul 24	14 19.6	+31 59	1.494	1.665	81	8.0
2004 Jul 31	13 58.8	+27 04	1.558	1.583	73	8.0
2004 Aug 7	13 42.8	+22 20	1.633	1.504	64	7.9
2004 Aug 14	13 30.5	+17 56	1.712	1.426	56	7.8
2004 Aug 21	13 20.7	+13 50	1.791	1.352	49	7.7
2004 Aug 28	13 12.8	+10 04	1.864	1.282	41	7.7
2004 Sep 4	13 06.2	+06 32	1.929	1.217	33	7.6
2004 Sep 11	13 00.5	+03 12	1.981	1.159	26	7.5
2004 Sep 18	12 55.3	+00 01	2.018	1.109	18	7.4
2004 Sep 25	12 50.4	-03 05	2.037	1.068	11	7.3
2004 Oct 2	12 45.5	-06 10	2.036	1.040	4	7.2
2004 Oct 9	12 40.5	-09 16	2.014	1.024	5	7.1
2004 Oct 16	12 35.3	-12 29	1.971	1.022	13	7.0
2004 Oct 23	12 29.6	-15 52	1.908	1.034	20	7.0
2004 Oct 30	12 23.2	-19 30	1.827	1.059	28	7.0
2004 Nov 6	12 15.6	-23 31	1.730	1.096	36	7.0
2004 Nov 13	12 06.1	-27 60	1.624	1.143	44	7.0
2004 Nov 20	11 53.5	-33 05	1.511	1.199	52	7.0
2004 Nov 27	11 35.8	-38 51	1.400	1.263	61	7.0
2004 Dec 4	11 09.6	-45 17	1.299	1.331	70	7.0
2004 Dec 11	10 28.9	-51 58	1.217	1.405	79	7.0
2004 Dec 18	09 25.2	-57 45	1.165	1.481	87	7.1
2004 Dec 25	07 56.6	-60 33	1.152	1.560	94	7.3

EXPLANATION OF COMET EPHEMERIDES

Date is for 0 hr UT (10am EST, 9:30am CST and 8am WST) of date.

R.A., 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.

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 invariably based on the behaviour of its brightness during previous return(s).

Comet C/2001 Q4 (NEAT)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2003 Nov 1	04 02.0	-74 28	2.886	3.051	90	10.9
2003 Nov 8	03 36.7	-76 32	2.855	2.970	87	10.8
2003 Nov 15	03 02.0	-78 09	2.828	2.889	84	10.7
2003 Nov 22	02 18.4	-79 11	2.803	2.806	80	10.6
2003 Nov 29	01 30.7	-79 30	2.777	2.724	77	10.5
2003 Dec 6	00 46.0	-79 12	2.751	2.640	73	10.4
2003 Dec 13	00 09.6	-78 23	2.721	2.556	70	10.2
2003 Dec 20	23 43.0	-77 14	2.688	2.472	67	10.1
2003 Dec 27	23 24.9	-75 56	2.648	2.387	64	9.9
2004 Jan 3	23 13.5	-74 33	2.602	2.301	62	9.8
2004 Jan 10	23 07.1	-73 11	2.548	2.216	59	9.6
2004 Jan 17	23 04.5	-71 52	2.485	2.129	58	9.4
2004 Jan 24	23 04.9	-70 38	2.413	2.043	57	9.2
2004 Jan 31	23 07.5	-69 29	2.330	1.956	56	9.0
2004 Feb 7	23 11.9	-68 28	2.236	1.869	56	8.8
2004 Feb 14	23 18.0	-67 34	2.131	1.782	56	8.5
2004 Feb 21	23 25.7	-66 49	2.014	1.696	57	8.2
2004 Feb 28	23 34.9	-66 14	1.886	1.610	59	7.9
2004 Mar 6	23 46.0	-65 48	1.745	1.526	61	7.6
2004 Mar 13	23 59.4	-65 33	1.594	1.443	63	7.2
2004 Mar 20	00 16.0	-65 30	1.431	1.362	65	6.8
2004 Mar 27	00 37.5	-65 38	1.258	1.285	68	6.3
2004 Apr 3	01 06.7	-65 54	1.076	1.212	71	5.8
2004 Apr 10	01 49.1	-66 03	0.888	1.145	74	5.2
2004 Apr 17	02 53.9	-65 12	0.698	1.085	77	4.5
2004 Apr 24	04 28.2	-60 28	0.516	1.035	79	3.7
2004 May 1	06 14.2	-44 26	0.369	0.997	78	2.8
2004 May 8	07 37.8	-11 28	0.323	0.972	74	2.5
2004 May 15	08 32.1	+18 26	0.415	0.962	71	3.0
2004 May 22	09 06.8	+34 09	0.580	0.968	69	3.7
2004 May 29	09 30.2	+42 19	0.765	0.989	66	4.4
2004 Jun 5	09 47.2	+47 08	0.952	1.024	63	5.0
2004 Jun 12	10 00.6	+50 16	1.132	1.071	60	5.5
2004 Jun 19	10 12.0	+52 29	1.302	1.128	57	6.0
2004 Jun 26	10 22.6	+54 10	1.458	1.193	54	6.4
2004 Jul 3	10 32.8	+55 31	1.602	1.265	52	6.8
2004 Jul 10	10 43.3	+56 39	1.731	1.341	51	7.1
2004 Jul 17	10 54.2	+57 38	1.847	1.421	50	7.5
2004 Jul 24	11 05.8	+58 33	1.949	1.503	50	7.8
2004 Jul 31	11 18.2	+59 25	2.039	1.587	50	8.1
2004 Aug 7	11 31.6	+60 17	2.117	1.673	51	8.3
2004 Aug 14	11 46.0	+61 09	2.184	1.759	52	8.5
2004 Aug 21	12 01.8	+62 03	2.240	1.846	54	8.7
2004 Aug 28	12 19.1	+62 58	2.288	1.932	57	8.9
2004 Sep 4	12 38.1	+63 55	2.328	2.019	60	9.1
2004 Sep 11	12 59.1	+64 54	2.362	2.106	63	9.3
2004 Sep 18	13 22.4	+65 54	2.391	2.192	66	9.4
2004 Sep 25	13 48.3	+66 52	2.417	2.278	70	9.6
2004 Oct 2	14 17.1	+67 48	2.441	2.364	74	9.7
2004 Oct 9	14 49.0	+68 37	2.466	2.449	77	9.9
2004 Oct 16	15 24.1	+69 17	2.492	2.534	81	10.0
2004 Oct 23	16 01.9	+69 44	2.523	2.618	84	10.1
2004 Oct 30	16 41.7	+69 53	2.559	2.701	87	10.3
2004 Nov 6	17 22.4	+69 44	2.601	2.784	90	10.4
2004 Nov 13	18 02.6	+69 14	2.652	2.866	92	10.5
2004 Nov 20	18 41.0	+68 27	2.712	2.948	94	10.7
2004 Nov 27	19 16.9	+67 26	2.782	3.029	95	10.8
2004 Dec 4	19 49.7	+66 13	2.861	3.110	95	11.0
2004 Dec 11	20 19.5	+64 54	2.951	3.190	95	11.1
2004 Dec 18	20 46.4	+63 33	3.050	3.269	94	11.3
2004 Dec 25	21 10.8	+62 12	3.159	3.348	93	11.4

Comet C/2002T7 (LINEAR)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2003 Nov 1	04 54.0	+36 56	2.113	2.939	140	10.1
2003 Nov 8	04 35.2	+37 31	1.956	2.850	149	9.9
2003 Nov 15	04 12.1	+37 48	1.821	2.760	157	9.6
2003 Nov 22	03 45.1	+37 38	1.711	2.669	162	9.4
2003 Nov 29	03 15.4	+36 51	1.630	2.577	159	9.1
2003 Dec 6	02 44.7	+35 23	1.580	2.484	150	9.0
2003 Dec 13	02 15.2	+33 17	1.560	2.390	139	8.8
2003 Dec 20	01 48.6	+30 46	1.568	2.294	127	8.7
2003 Dec 27	01 25.8	+28 04	1.600	2.197	114	8.6
2004 Jan 3	01 07.1	+25 26	1.648	2.099	103	8.5
2004 Jan 10	00 52.0	+22 59	1.707	1.999	92	8.4
2004 Jan 17	00 40.2	+20 48	1.772	1.898	82	8.3
2004 Jan 24	00 31.0	+18 55	1.837	1.796	72	8.2
2004 Jan 31	00 23.9	+17 18	1.896	1.692	63	8.1
2004 Feb 7	00 18.4	+15 56	1.948	1.587	54	8.0
2004 Feb 14	00 14.1	+14 46	1.987	1.480	46	7.8
2004 Feb 21	00 10.8	+13 45	2.011	1.373	38	7.5
2004 Feb 28	00 08.0	+12 51	2.018	1.264	30	7.3
2004 Mar 6	00 05.6	+12 02	2.004	1.156	23	7.0
2004 Mar 13	00 03.3	+11 14	1.967	1.048	16	6.6
2004 Mar 20	00 00.9	+10 24	1.904	0.942	11	6.2
2004 Mar 27	23 58.4	+09 29	1.811	0.842	9	5.7
2004 Apr 3	23 55.7	+08 25	1.684	0.751	14	5.2
2004 Apr 10	23 53.3	+07 07	1.520	0.677	20	4.6
2004 Apr 17	23 52.2	+05 29	1.316	0.629	28	4.1
2004 Apr 24	23 54.8	+03 24	1.078	0.615	34	3.6
2004 May 1	00 06.1	+00 38	0.815	0.639	39	3.1
2004 May 8	00 38.4	-03 47	0.548	0.695	41	2.5
2004 May 15	02 16.7	-12 43	0.323	0.774	36	1.7
2004 May 22	06 14.2	-19 56	0.288	0.868	53	1.8
2004 May 29	08 34.0	-14 29	0.481	0.970	71	3.3
2004 Jun 5	09 23.3	-10 59	0.732	1.077	74	4.6
2004 Jun 12	09 47.0	-09 10	0.992	1.185	72	5.5
2004 Jun 19	10 01.6	-08 10	1.248	1.293	69	6.3
2004 Jun 26	10 12.1	-07 36	1.497	1.402	65	7.0
2004 Jul 3	10 20.5	-07 19	1.737	1.509	60	7.5
2004 Jul 10	10 27.8	-07 14	1.967	1.615	55	8.0
2004 Jul 17	10 34.3	-07 16	2.186	1.720	50	8.5
2004 Jul 24	10 40.3	-07 26	2.393	1.823	45	8.9
2004 Jul 31	10 46.0	-07 40	2.587	1.925	40	9.2
2004 Aug 7	10 51.4	-07 58	2.769	2.026	35	9.5
2004 Aug 14	10 56.6	-08 19	2.937	2.125	30	9.8
2004 Aug 21	11 01.5	-08 44	3.092	2.223	26	10.1
2004 Aug 28	11 06.3	-09 10	3.232	2.319	21	10.3
2004 Sep 4	11 10.8	-09 39	3.358	2.415	17	10.5
2004 Sep 11	11 15.1	-10 09	3.470	2.509	15	10.7
2004 Sep 18	11 19.2	-10 40	3.566	2.602	14	10.9
2004 Sep 25	11 23.0	-11 13	3.648	2.693	15	11.0
2004 Oct 2	11 26.4	-11 46	3.715	2.784	19	11.2
2004 Oct 9	11 29.6	-12 20	3.768	2.874	23	11.3
2004 Oct 16	11 32.3	-12 54	3.807	2.962	28	11.4
2004 Oct 23	11 34.6	-13 28	3.832	3.050	33	11.5
2004 Oct 30	11 36.4	-14 01	3.843	3.137	39	11.6
2004 Nov 6	11 37.7	-14 34	3.843	3.223	45	11.7
2004 Nov 13	11 38.4	-15 05	3.831	3.308	52	11.8
2004 Nov 20	11 38.4	-15 35	3.809	3.392	58	11.9
2004 Nov 27	11 37.6	-16 02	3.778	3.475	65	11.9
2004 Dec 4	11 36.0	-16 27	3.740	3.558	72	12.0
2004 Dec 11	11 33.5	-16 48	3.697	3.640	79	12.0
2004 Dec 18	11 30.0	-17 04	3.651	3.721	86	12.1
2004 Dec 25	11 25.6	-17 15	3.603	3.801	94	12.1

The estimate of total magnitude is normally calculated using the formula:

$$\text{Mag.} = H1 + 5 \log (\Delta) + K1 \log R.$$

* The brightness of Comet Encke behaves a little differently from the standard formula. 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 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. 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.

PART III – APPENDICES

CONSTELLATIONS – Abbreviations and Culmination at 9pm

Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.
Andromeda	Andromedae	And	Nov 23	Crux	Crucis	Cru	May 12	Orion	Orionis	Ori	Jan 27
Antlia	Antliae	Ant	Apr 10	Cygnus	Cygni	Cyg	Sep 13	Pavo	Pavonis	Pav	Aug 29
Apus	Apodis	Aps	Jul 5	Delphinus	Delphini	Del	Sep 14	Pegasus	Pegasi	Peg	Oct 16
Aquarius	Aquarii	Aqr	Oct 9	Dorado	Doradus	Dor	Jan 31	Perseus	Persei	Per	Dec 22
Aquila	Aquilae	Aql	Aug 30	Draco	Draconis	Dra	Jul 8	Phoenix	Phoenicis	Phe	Nov 18
Ara	Arae	Ara	Jul 25	Equuleus	Equulei	Equ	Sep 22	Pictor	Pictoris	Pic	Jan 30
Aries	Arietis	Ari	Dec 14	Eridanus	Eridani	Eri	Dec 25	Pisces	Piscium	Psc	Nov 11
Auriga	Aurigae	Aur	Feb 4	Fornax	Fornacis	For	Dec 17	Piscis Austrinus	Piscis Austrini	PsA	Oct 9
Bootes	Bootis	Boo	Jun 16	Gemini	Geminorum	Gem	Feb 19	Puppis	Puppis	Pup	Feb 22
Caelum	Caeli	Cae	Jan 15	Grus	Gruis	Gru	Oct 12	Pyxis	Pyxidis	Pyx	Mar 21
Camelopardus	Camelopardi	Cam	Feb 6	Hercules	Herculis	Her	Jul 28	Reticulum	Reticuli	Ret	Jan 3
Cancer	Cancri	Cnc	Mar 16	Horologium	Horologii	Hor	Dec 25	Sagitta	Sagittae	Sge	Aug 30
Canes Venatici	Canum Venaticorum	CVn	May 22	Hydra	Hydrae	Hya	Apr 29	Sagittarius	Sagittarii	Sgr	Aug 21
				Hydrus	Hydri	Hyi	Dec 10	Scorpius	Scorpii	Sco	Jul 18
Canis Major	Canis Majoris	CMa	Feb 16	Indus	Indi	Ind	Sep 26	Sculptor	Sculptoris	Scl	Nov 10
Canis Minor	Canis Minoris	CMi	Feb 28	Lacerta	Lacertae	Lac	Oct 12	Scutum	Scuti	Sct	Aug 15
Capricornus	Capricorni	Cap	Sep 22	Leo	Leonis	Leo	Apr 15	Serpens	Serpentis	Ser	Jul 21
Carina	Carinae	Car	Mar 17	Leo Minor	Leonis Minoris	LMi	Apr 9	Sextans	Sextantis	Sex	Apr 8
Cassiopeia	Cassiopeiae	Cas	Nov 23	Lepus	Leporis	Lep	Jan 28	Taurus	Tauri	Tau	Jan 14
Centaurus	Centauri	Cen	May 14	Libra	Librae	Lib	Jun 23	Telescopium	Telescopii	Tel	Aug 24
Cepheus	Cephei	Cep	Nov 13	Lupus	Lupi	Lup	Jun 23	Triangulum	Trianguli	Tri	Dec 7
Cetus	Ceti	Cet	Nov 29	Lynx	Lyncis	Lyn	Mar 5	Triangulum Australe	Trianguli Australis	TrA	Jul 7
Chamaeleon	Chamaeleontis	Cha	Apr 15	Lyra	Lyrae	Lyr	Aug 18				
Circinus	Circini	Cir	Jun 14	Mensa	Mensae	Men	Jan 28	Tucana	Tucanae	Tuc	Nov 1
Columba	Columbae	Col	Feb 1	Microscopium	Microscopii	Mic	Sep 18	Ursa Major	Ursae Majoris	UMa	Apr 25
Coma Berenices	Comae Berenices	Com	May 17	Monoceros	Monocerotis	Mon	Feb 19	Ursa Minor	Ursae Minoris	UMi	Jun 27
Corona Australis	Coronae Australis	CrA	Aug 14	Musca	Muscae	Mus	May 14	Vela	Velorum	Vel	Mar 30
Corona Borealis	Coronae Borealis	CrB	Jul 3	Norma	Normae	Nor	Jul 3	Virgo	Virginis	Vir	May 26
Corvus	Corvi	Crv	May 12	Octans	Octantis	Oct	Circum	Volans	Volantis	Vol	Mar 4
Crater	Crateris	Crt	Apr 26	Ophiuchus	Ophiuchi	Oph	Jul 26	Vulpecula	Vulpeculae	Vul	Sep 8

BRIGHTEST and NEAREST STARS

The column descriptions are:

Designation The name of the star in the system created by Bayer. He 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.

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 and
(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 now 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, the Sun and Arcturus)
- 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 in 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 (i.e., no colour).

The colours of stars can be photographed simply. Mount your normal 35mm camera on a tripod and take a time exposure (some minutes) using a fast film. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., 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 burn out on the negative. All such photography should be conducted in country areas, away from city lights.

THE BRIGHTEST STARS

Designation		Name	Constellation	R.A. (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	El Nath	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

No	Star Name		Constellation	R.A. 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

MESSIER OBJECTS (Epoch 2000.0)

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M1	NGC1952	05 34.5	+ 22° 01'	6	Tau	SNR	8.4	5,3	Crab Nebula, remnant from supernova of A.D. 1054
M2	NGC7089	21 33.5	- 00° 49'	12.9	Aqr	GC	6.5	8	
M3	NGC5272	13 42.2	+ 28° 23'	16.2	CVn	GC	6.4	7	Large bright globular, brightens suddenly towards the middle
M4	NGC6121	16 23.6	- 26° 32'	26.3	Sco	GC	5.9	6	Conspicuous globular near Antares
M5	NGC5904	15 18.6	+ 02° 05'	17.4	Ser	GC	5.8	6	Bright, large very compressed in middle, slightly oval in shape
M6	NGC6405	17 40.1	- 32° 13'	15	Sco	OC	4.2	6,8	Butterfly Cluster, 80 stars
M7	NGC6475	17 53.9	- 34° 49'	80	Sco	OC	3.3	6,8	Ptolemy's Cluster, 80 stars brighter than 10th magnitude
M8	NGC6523	18 03.8	- 24° 23'	90	Sgr	BN	3.5	6,8	Lagoon Nebula, densest section known as the Hourglass, dark lane
M9	NGC6333	17 19.2	- 18° 31'	9.3	Oph	GC	7.9	6	
M10	NGC6254	16 57.1	- 04° 06'	15.1	Oph	GC	6.6	6	
M11	NGC6705	18 51.1	- 06° 16'	14	Sct	OC	5.8	8	Wild Duck Cluster, rich and compact open cluster
M12	NGC6218	16 47.2	- 01° 57'	14.5	Oph	GC	6.6	6	
M13	NGC6205	16 41.7	+ 36° 28'	16.6	Her	GC	5.9	7,9	Great Hercules Cluster, showpiece of northern skies
M14	NGC6402	17 37.6	- 03° 15'	11.7	Oph	GC	7.6	6,7	
M15	NGC7078	21 30.0	+ 12° 10'	12.3	Peg	GC	6.4	9	Bright, irregularly round, well resolved into faint stars
M16	NGC6611	18 18.8	- 13° 47'	35	Ser	BN	6	6,8	Associated with Eagle Nebula
M17	NGC6618	18 20.8	- 16° 11'	46	Sgr	BN	6	6,8	Omega or Swan Nebula
M18	NGC6613	18 19.9	- 17° 08'	9	Sgr	OC	6.9	6,8	
M19	NGC6273	17 02.6	- 26° 16'	13.5	Oph	GC	7.2	6	
M20	NGC6514	18 02.3	- 23° 02'	29	Sgr	BN	6.3	6,8	Trifid Nebula, emission and reflection nebulosity cut by dark lanes
M21	NGC6531	18 04.6	- 22° 30'	13	Sgr	OC	5.9	6,8	
M22	NGC6656	18 36.4	- 23° 54'	24	Sgr	GC	5.1	1,6,8	Fine globular, only Omega Centauri and 47 Tucanae are brighter
M23	NGC6494	17 56.8	- 19° 01'	27	Sgr	OC	5.5	6,8	150 stars, moderate brightness range, lies in good star field
M24	NGC6603	18 18.4	- 18° 25'	5	Sgr	OC		6,8	Sagittarius Star Cloud, Delle Caustiche
M25	IC4725	18 31.6	- 19° 15'	32	Sgr	OC	4.6	6,8	30 stars loosely scattered
M26	NGC6694	18 45.2	- 09° 24'	15	Sct	OC	8	8	
M27	NGC6853	19 59.6	+ 22° 43'	15.2	Vul	PN	7.3	9	Dumbbell Nebula, bright dumbbell shaped, 14th mag. central star
M28	NGC6626	18 24.5	- 24° 52'	11.2	Sgr	GC	6.9	1,6,8	Large, round, increasingly compressed in the middle
M29	NGC6913	20 23.9	+ 38° 32'	7	Cyg	OC	6.6	9	
M30	NGC7099	21 40.4	- 23° 11'	11	Cap	GC	7.5	8	
M31	NGC224	00 42.7	+ 41° 16'	178	And	SG	3.5	3,9	Andromeda Galaxy
M32	NGC221	00 42.7	+ 40° 52'	7.6	And	EG	8.2	3,9	
M33	NGC598	01 33.9	+ 30° 39'	62	Tri	SG	5.7	3	Triangulum or Pinwheel Galaxy, member of Local Group
M34	NGC1039	02 42.0	+ 42° 47'	35	Per	OC	5.2	3	
M35	NGC2168	06 08.9	+ 24° 20'	28	Gem	OC	5.1	3,5	200 stars, magnitude 9 to 16
M36	NGC1960	05 36.1	+ 34° 08'	12	Aur	OC	6	3,5	60 stars, magnitude 9 to 14
M37	NGC2099	05 52.4	+ 32° 33'	24	Aur	OC	5.6	3,5	150 stars, magnitude range 9 to 12.5
M38	NGC1912	05 28.7	+ 35° 50'	21	Aur	OC	6.4	3,5	100 stars, mag 9.5 in splendid field
M39	NGC7092	21 32.2	+ 48° 26'	32	Cyg	OC	4.6	9	
M40	WNC 4	12 22.4	+ 58° 05'	0	UMa	DS	-	5,7	Double Star WNC4
M41	NGC2287	06 46.0	- 20° 44'	38	CMa	OC	4.5	4	80 stars, 7th magnitude and fainter, with 6.9 mag. red star near centre
M42	NGC1976	05 35.4	- 05° 27'	66	Ori	BN	3.7	2,3	Orion Nebula, emission and reflection nebula
M43	NGC1982	05 35.6	- 05° 16'	20	Ori	BN		1,3	de Mairan's nebula; part of Orion Nebula
M44	NGC2632	08 40.1	+ 19° 59'	95	Cnc	OC	3.1		Praesepe or Beehive Cluster, very large cluster, 50 stars
M45	Pleiades	03 47.0	+ 24° 07'	120	Tau	OC	1.2	3	Seven Sisters. naked-eye cluster
M46	NGC2437	07 41.8	- 14° 49'	27	Pup	OC	6.1	4	Rich open cluster, 100 stars, planetary nebula NGC2438 in same field
M47	NGC2422	07 36.6	- 14° 30'	30	Pup	OC	4.4	4	Large coarse cluster with 30 stars
M48	NGC2548	08 13.8	- 05° 48'	54	Hya	OC	5.8	4	Large cluster of 80 stars 8 to 13th mag.
M49	NGC4472	12 29.8	+ 08° 00'	8.9	Vir	EG	8.4	7	
M50	NGC2323	07 03.2	- 08° 20'	16	Mon	OC	5.9	4	Rich cluster, 80 stars mags 8 to 12
M51	NGC5194	13 29.9	+ 47° 12'	11	CVn	SG	8.4	5	Whirlpool Galaxy
M52	NGC7654	23 24.2	+ 61° 35'	13	Cas	OC	6.9	3,9	
M53	NGC5024	13 12.9	+ 18° 10'	12.6	Com	GC	7.7	7	Bright centre region, very compressed
M54	NGC6715	18 55.1	- 30° 29'	9.1	Sgr	GC	7.7	1,6,8	
M55	NGC6809	19 40.0	- 30° 58'	19	Sgr	GC	6.3	8	
M56	NGC6779	19 16.6	+ 30° 11'	7.1	Lyr	GC	8.3	9	Irregularly round, compressed in the middle
M57	NGC6720	18 53.6	+ 33° 02'	2.5	Lyr	PN	8.6	7,9	Ring Nebula, ring structure
M58	NGC4579	12 37.7	+ 11° 49'	5.4	Vir	SG	9.8	7	Bright diffuse nucleus, dark lanes
M59	NGC4621	12 42.0	+ 11° 39'	5.1	Vir	EG	9.8	7	
M60	NGC4649	12 43.7	+ 11° 33'	7.2	Vir	EG	8.8	7	
M61	NGC4303	12 21.9	+ 04° 28'	6	Vir	SG	9.7	7	
M62	NGC6266	17 01.2	- 30° 07'	14.1	Oph	GC	6.6	6,8	
M63	NGC5055	13 15.8	+ 42° 02'	12.3	CVn	SG	8.6	5,7	Sunflower Galaxy
M64	NGC4826	12 56.7	+ 21° 41'	9.3	Com	SG	8.5	7	Blackeye Galaxy
M65	NGC3623	11 18.9	+ 13° 05'	10	Leo	SG	9.3	5	
M66	NGC3627	11 20.2	+ 12° 59'	8.7	Leo	SG	9	5	
M67	NGC2682	08 50.4	+ 11° 49'	30	Cnc	OC	6.9	5	200 stars mag. 10-15, large and rich
M68	NGC4590	12 39.5	- 26° 45'	12	Hya	GC	8.2	4,6	Rich and compressed
M69	NGC6637	18 31.4	- 32° 21'	7.1	Sgr	GC	7.7	1,6,8	
M70	NGC6681	18 43.2	- 32° 18'	7.8	Sgr	GC	8.1	1,6,8	
M71	NGC6838	19 53.8	+ 18° 47'	7.2	Sge	GC	8.3	9	
M72	NGC6981	20 53.5	- 12° 32'	5.9	Aqr	GC	9.4	8	

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M73	NGC6994	20 59.0	- 12° 38'	3	Aqr	OC	9	8	
M74	NGC628	01 36.7	+ 15° 47'	10.2	Psc	SG	9.2	3	
M75	NGC6864	20 06.1	- 21° 55'	6	Sgr	GC	8.6	8	
M76	NGC650	01 42.3	+ 51° 34'	4.8	Per	PN	10.2	3,9	Little Dumbbell Nebula, Cork Nebula
M77	NGC1068	02 42.7	- 00° 01'	6.9	Cet	SG	8.8	2	Seyfert type with very bright nucleus
M78	NGC2068	05 46.7	+ 00° 03'	8	Ori	BN	8	2,3	Brightest & largest in group of 4 nebulae
M79	NGC1904	05 24.5	- 24° 33'	8.7	Lep	GC	8	2,4	Rich and compressed, well resolved
M80	NGC6093	16 17.0	- 22° 59'	8.9	Sco	GC	7.2	6	Strong central concentration, bright & large
M81	NGC3031	09 55.6	+ 69° 04'	25.7	UMa	SG	6.9	5	Bode's Galaxy
M82	NGC3034	09 55.8	+ 69° 41'	11.2	UMa	IG	8.4	5	Cigar Galaxy
M83	NGC5236	13 37.0	- 29° 52'	11.2	Hya	SG	7.6	6	Southern Pinwheel Galaxy
M84	NGC4374	12 25.1	+ 12° 53'	5	Vir	EG	9.3	7	Bright centre, in same field as M86
M85	NGC4382	12 25.4	+ 18° 11'	7.1	Com	EG	9.2	5,7	
M86	NGC4406	12 26.2	+ 12° 57'	7.4	Vir	EG	9.2	7	
M87	NGC4486	12 30.8	+ 12° 24'	7.2	Vir	EG	8.6	7	Virgo A., bright, smooth & featureless
M88	NGC4501	12 32.0	+ 14° 25'	6.9	Com	SG	9.5	7	
M89	NGC4552	12 35.7	+ 12° 33'	4.2	Vir	EG	9.8	7	
M90	NGC4569	12 36.8	+ 13° 10'	9.5	Vir	SG	9.5	7	
M91	NGC4548	12 35.4	+ 14° 30'	5.4	Com	SG	10.2	7	
M92	NGC6341	17 17.1	+ 43° 08'	11.2	Her	GC	6.5	7,9	
M93	NGC2447	07 44.6	- 23° 52'	22	Pup	OC	6.2	4	80 stars magnitude 8 to 13
M94	NGC4736	12 50.9	+ 41° 07'	11	CVn	SG	8.2	5,7	
M95	NGC3351	10 44.0	+ 11° 42'	7.4	Leo	SG	9.7	4,5	
M96	NGC3368	10 46.8	+ 11° 49'	7.1	Leo	SG	9.2	4,5	
M97	NGC3587	11 14.8	+ 55° 01'	3.2	UMa	PN	9.7	5,7	Owl Nebula
M98	NGC4192	12 13.8	+ 14° 54'	9.5	Com	SG	10.1	5,7	
M99	NGC4254	12 18.8	+ 14° 25'	5.4	Com	SG	9.8	5,7	
M100	NGC4321	12 22.9	+ 15° 49'	6.9	Com	SG	9.4	5,7	
M101	NGC5457	14 03.2	+ 54° 21'	26.9	UMa	SG	7.7	7	Pinwheel Galaxy
M102									Same as M101
M103	NGC581	01 33.2	+ 60° 42'	6	Cas	OC	7.4	3,9	
M104	NGC4594	12 40.0	- 11° 37'	8.9	Vir	SG	8.3	6	Sombrero Galaxy
M105	NGC3379	10 47.8	+ 12° 35'	4.5	Leo	EG	9.3	4,5	
M106	NGC4258	12 19.0	+ 47° 18'	18.2	CVn	SG	8.3	5,7	
M107	NGC6171	16 32.5	- 13° 03'	10	Oph	GC	8.1	6	
M108	NGC3556	11 11.5	+ 55° 40'	8.3	UMa	SG	10.1	5,7	
M109	NGC3992	11 57.6	+ 53° 23'	7.6	UMa	SG	9.8	5,7	
M110	NGC205	00 40.4	+ 41° 41'	17.4	And	EG	8	3,9	

LEGEND

Other Ref/ Cat Catalogue number (NGC New General Catalogue, IC Index Catalog, 'M' Messier number)

R.A. Right Ascension (hh mm.m, Epoch 2000.0)

Dec Declination (° ', Epoch 2000.0)

Size In arc minutes

Con. Constellation

Type Object type (see intro part 1 page 16)

Mag Magnitude of object

Map All Sky Map number (pp. 68-77)

Notes Common name and/or description

OTHER NON-STELLAR OBJECTS (Epoch 2000.0)

Cat	R.A.	Dec	Size	Con.	Type	Mag	Notes
SMC	00 52.7	-72° 30'	5°x4°	Tuc	IG	2.3	Small Magellanic Cloud. Visible to unaided eye from dark sky
NGC55	00 14.9	-39° 11'	30'x6.3'	Scl	SG	8.1	A bright galaxy in the Sculptor Group
NGC104	00 24.1	-72° 05'	30.9'	Tuc	GC	3.8	47 Tucanae, one of the finest globulars
NGC253	00 47.6	-25° 17'	30'x6.9'	Scl	SG	7.6	Silver Coin galaxy. Large, bright edge-on spiral
Hyades	04 27.0	+16° 00'	6°	Tau	OC	0.5	Naked-eye, V-shaped cluster. 28 stars, the brighter mag. 3 and 4
LMC	05 23.6	-69° 45'	9°x10°	Dor	IG	0.1	Large Magellanic Cloud. Visible to unaided eye from dark sky
NGC2070	05 38.6	-69° 05'	30'x20'	Dor	BN	5.4	30 Doradus, Tarantula Nebula, complex structure
NGC2169	06 08.4	+13° 57'	6'	Ori	OC	5.9	Rich loose cluster, 30 stars magnitude 7 and fainter
NGC2244	06 32.4	-04° 52'	23'	Mon	OC	4.8	100 stars, with nebulosity (Rosette Nebula)
NGC2264	06 41.1	+09° 53'	20'	Mon	OC	3.9	Christmas Tree cluster
NGC2301	06 51.8	+00° 28'	12'	Mon	OC	6.0	Rich cluster, 80 stars, large magnitude range
NGC2362	07 18.8	-24° 57'	8'	CMa	OC	4.1	60 stars, large brightness range (4th mag. down)
NGC2451	07 45.4	-37° 58'	45'	Pup	OC	2.8	Rich in stars with slight central concentration
NGC2477	07 52.3	-38° 33'	27'	Pup	OC	5.8	160 stars, mag. 10 to 12, central concentration
NGC2516	07 58.3	-60° 52'	29'	Car	OC	3.8	80 stars 6th mag. and fainter, central concentration
NGC2547	08 10.7	-49° 16'	74'	Vel	OC	4.7	Rich in stars with strong central concentration
IC2391	08 40.2	-53° 04'	50'	Vel	OC	2.5	Moderately rich in bright and faint stars
IC2395	08 41.1	-48° 12'	7'	Vel	OC	4.6	40 stars 6th magnitude and fainter
NGC2808	09 12.0	-64° 52'	13.8'	Car	GC	6.1	Large and rich, compressed centre, mag 13 - 15
NGC3114	10 02.7	-60° 07'	35'	Car	OC	4.2	Rich cluster, stars 9 to 14th magnitude
NGC3132	10 07.1	-40° 26'	30"	Vel	PN	8.2	The Eight Burst Nebula, ring and disk
IC2602	10 43.2	-64° 24'	50'	Car	OC	1.9	Central concentration, brightest mag. 3
NGC3372	10 43.8	-59° 52'		Car	BN	2.5	Eta Carinae Nebula, bright, prominent dark lanes
NGC3532	11 06.4	-58° 40'	55'	Car	OC	3.0	Rich and large, 150 stars 7 to 12th magnitude
NGC3766	11 36.1	-61° 37'	12'	Cen	OC	5.3	Rich cluster, 100 stars magnitude range 7 to 12th
NGC4755	12 53.6	-60° 20'	10'	Cru	OC	4.2	Jewel Box, rich in stars, large brightness range
NGC4945	13 05.4	-49° 28'	23'x5.9'	Cen	SG	9.0	Big edge on spiral, small galaxy in same field
NGC5128	13 25.5	-43° 01'	31'x23'	Cen	G	6.7	Centaurus A, bright sphere crossed by dark lane
NGC5139	13 26.8	-47° 29'	36'	Cen	GC	3.5	Omega Centauri, perhaps the finest globular cluster
NGC5281	13 46.6	-62° 54'	5'	Cen	OC	5.9	40 stars, moderately rich in bright and faint stars
NGC5617	14 29.8	-60° 43'	10'	Cen	OC	6.3	80 stars, large brightness range, central conc.
NGC6025	16 03.7	-60° 30'	12'	TrA	OC	5.1	60 stars, large brightness range
NGC6067	16 13.2	-54° 13'	12'	Nor	OC	5.6	100 stars, large brightness range, central conc.
NGC6087	16 18.9	-57° 54'	12.5'	Nor	OC	5.4	40 stars, moderate brightness range
NGC6124	16 25.6	-40° 40'	29'	Sco	OC	5.8	100 stars, large brightness range
NGC6193	16 41.3	-48° 46'	14'	Ara	OC	5.2	Few stars, large brightness range
NGC6231	16 54.0	-41° 48'	14'	Sco	OC	2.6	A few stars with strong central concentration
NGC6397	17 40.7	-53° 40'	25.7'	Ara	GC	5.8	Loose structure, possibly the nearest globular
NGC7009	21 04.2	-11° 22'	25"	Aqr	PN	7.9	Saturn Nebula, ring structure in a larger faint halo
NGC7293	22 29.6	-20° 48'	12'	Aqr	PN	7.3	Helix Nebula, ring structure in large, fainter disk

RISE/SET TIME CORRECTIONS FOR OTHER LOCATIONS

As mentioned previously in this book, the rise/set tables for the Sun, Moon and planets in Part II are calculated for Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney.

This page is designed to help people who live outside these cities make corrections to determine the rise/set times for their specific location. There are two corrections needed, they are:

1. An adjustment 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**. Examples of corrections for various towns and cities are given in table 1.
2. An adjustment for the difference in latitude also requires the declination for the object of interest. Table 2 presents these corrections (southern latitudes are negative). NB. **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.

In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example of rise/set time corrections:

Calculate the rise/set times for the Sun on January 17 for Albury (36° 05'S, 146° 55'E)

	Rise	Set
From page 85 the rise/set values for Sydney are:	5:01	19:09
Adjust for longitude (151.25–146.92) x 4 (table 1)	+ :17	+ :17
(value is positive due to Albury being west of Sydney)		
Adjust for latitude and declination of the Sun from table 2. Sun's declination is –20° 55' (p. 83)	– :05	+ :05
Rise/Set times for Albury are:	5:13	19:31

If your local time is Central Standard Time, **subtract** 30 minutes, if your local time is Western Standard Time, **subtract** 2 hours

If daylight saving is in force, **add** 60 minutes.

TABLE 2 – RISE/SET CORRECTIONS FOR LATITUDE/ DECLINATION (from Sydney)

South Latitude (negative)	Declination 30°	25°	20°	15°	10°	5°	0°	-5°	-10°	-15°	-20°	-25°	-30°
-12°	-63	-50	-39	-28	-19	-9	0	9	19	28	39	50	63
-14°	-58	-46	-36	-26	-17	-8	0	8	17	26	36	46	58
-16°	-53	-42	-33	-24	-16	-8	0	8	16	24	33	42	53
-18°	-48	-38	-29	-22	-14	-7	0	7	14	22	29	38	48
-20°	-43	-34	-26	-19	-13	-6	0	6	13	19	26	34	43
-22°	-37	-30	-23	-17	-11	-5	0	5	11	17	23	30	37
-24°	-32	-25	-19	-14	-9	-5	0	5	9	14	19	25	32
-26°	-26	-20	-16	-11	-7	-4	0	4	7	11	16	20	26
-28°	-20	-16	-12	-9	-6	-3	0	3	6	9	12	16	20
-30°	-13	-11	-8	-6	-4	-2	0	2	4	6	8	11	13
-32°	-7	-5	-4	-3	-2	-1	0	1	2	3	4	5	7
-34°	0	0	0	0	0	0	0	0	0	0	0	0	0
-36°	8	6	5	3	2	1	0	-1	-2	-3	-5	-6	-8
-38°	16	12	9	7	4	2	0	-2	-4	-7	-9	-12	-16
-40°	25	19	15	10	7	3	0	-3	-7	-10	-15	-19	-25
-42°	34	26	20	14	9	5	0	-5	-9	-14	-20	-26	-34
-44°	44	34	26	18	12	6	0	-6	-12	-18	-26	-34	-44

Table 1 **LONGITUDE ADJUSTMENTS FOR SOME TOWNS AND CITIES RELATIVE TO SYDNEY**

Location	Latitude (° ' S)	Longitude ° ' E)	Change in Longitude (decimal °)	correction (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	32 0	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
Ayers Rock	25 11	130 58	20.3	8
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
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
Warnambool	38 27	142 30	8.8	35
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
WEST 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
Denmark	34 58	117 21	33.90	136
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
Kellerberrin	31 38	117 43	33.53	134
Lake Grace	33 06	118 28	32.78	131
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
Onslow	21 38	115 07	36.13	145
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
Wiluna	26 35	120 14	31.02	124
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

JULIAN DATE – 2004

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 0hr 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 wish to know the Julian date at 23:00 EST on July 17th 2004. Subtract 10 hours to get UT.

23 – 10 = 13:00 hrs UT

From the table the JD for July is 2453186.5
Add the day of month, 17 gives us 2453203.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 23:00hr 17 July 2004 EST is 2453204.042

JULIAN DATE at 0hr UT	
Month	Julian Date
Jan 0	2453004.5
Feb 0	2453035.5
Mar 0	2453064.5
Apr 0	2453095.5
May 0	2453125.5
Jun 0	2453156.5
Jul 0	2453186.5
Aug 0	2453217.5
Sep 0	2453248.5
Oct 0	2453278.5
Nov 0	2453309.5
Dec 0	2453339.5

Hours as decimal of a day.			
01	0.042	13	0.542
02	0.083	14	0.583
03	0.125	15	0.625
04	0.167	16	0.667
05	0.208	17	0.708
06	0.250	18	0.750
07	0.292	19	0.792
08	0.333	20	0.833
09	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 – 2004

Jan 0 6.6009	May 0 14.5518	Sep 0 22.6341
Feb 0 8.6379	Jun 0 16.5888	Oct 0 0.6054
Mar 0 10.5435	Jul 0 18.5601	Nov 0 2.6424
Apr 0 12.5805	Aug 0 20.5971	Dec 0 4.6137

Greenwich mean sidereal time (GMST) at 0hr UT

You can 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 0hr UT (from table above) + 0.06571 *d* + 1.00274 *t*

To convert this to local mean sidereal time (LMST) we use

LMST = GMST + east longitude (or – west longitude)

where longitude is expressed in HOURS (not degrees!)

To convert longitude from degrees to hours, just divide by 15.

Example:

Find LMST at 23 hours Sydney time (EST) on 17th July 2004.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5601 hours.

GMST = 18.5601 + (0.06571 x 17) + (1.00274 x 13) = 32.7127

Sydney's longitude is 151.25°, which is 10.0833 hrs so

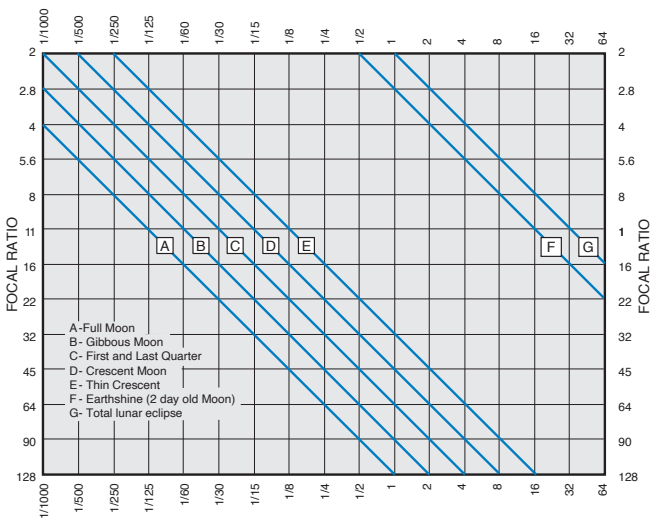
LMST = 32.7127 + 10.0833 = 42.7961

Subtract from this multiples of 24 until it is in the range of 0 to 24

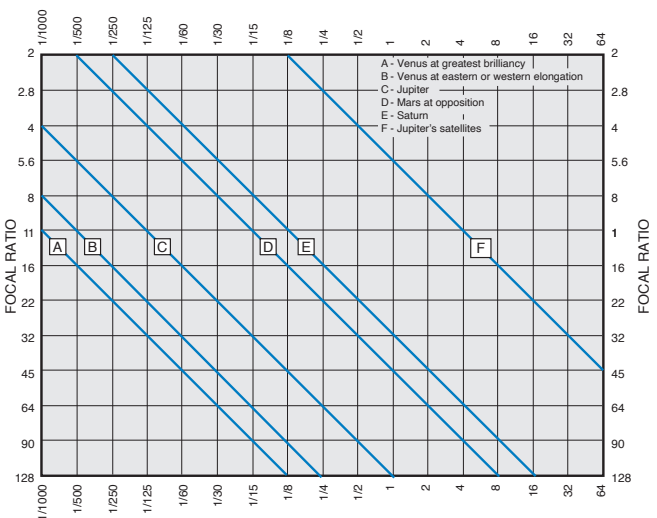
42.7961 – 24 = 18.7961 hrs or 18h 47m 46s

PHOTOGRAPHIC EXPOSURE GUIDES

MOON



PLANETS



These charts provide recommended photographic exposures for the Moon (left) and selected planets (right) using 100 ISO film. The charts should only be treated as a guide, as many factors will influence the exposure time.

Follow a horizontal line nearest to your systems focal ratio to the oblique line that represents the Moon aspect or planet required, then follow the intersecting vertical line down to find the correct exposure.

For the best result, always take one photo at the recommended speed and follow up with one at half and one at twice the exposure (bracketing). This will help smooth out variables and should provide at least one image at the required density.

Film Speed	Multiply By	Film Speed	Divide By	*For ISO values other than 100, apply the above factors to the exposure time.*
32 ISO	4	200 ISO	2	
64 ISO	2	400 ISO	4	

Places of Astronomical Interest

Following is a list of places of astronomical interest. These facilities cater to the public in regards to tours and/or displays. Prices are subject to change. Links to all of the web sites listed in the following Places, Courses and Societies sections can be found on the Quasar Publishing site: www.quasarastronomy.com.au

NEW SOUTH WALES and ACT

BATHURST OBSERVATORY

This observatory is located 10 kilometres from Bathurst. Their dome houses a 14-inch telescope to view the dark rural skies. They also have a radio telescope for listening to signals from the Milky Way. Accommodation for individuals or groups is available at the adjacent Rossmore Park. The local Centaurus Astronomical Society has regular meetings at the observatory as well.

Address: Rossmore Park, 624 Limekilns Road, Bathurst 2795
Times: The observatory is open every clear night of the year (except Christmas Eve, Christmas Day and Boxing Day) with tour times varying depending on the season.
Contact: Ray and Cindy Pickard on (02) 6337-3988
Email: info@bathurstobservatory.com.au
Web: bathurstobservatory.com.au/

BOWEN MOUNTAIN OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (north west of Sydney). It houses a 40cm Dobsonian telescope. The observatory is open on Friday and Saturday nights (not every week). Visitors are most welcome.

Contact: Adrian Saw (02) 4572-1568
Email: secretary@asnsw.com

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The complex is located 40km 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. The centrepiece is the 70-metre antenna. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is a Moon rock. There is also the Moon Rock Cafe and Giftshop, where meals and souvenirs are available.

Address: Tourist Drive 5, Discovery Drive (off Paddy's River Rd), Tidbinbilla
Times: 9am to 5pm, 7 days per week (8pm daylight saving time).
Cost: Entry to the Canberra Space Centre is free.
Contact: (02) 6201-7880
Email: cdscc-prc@anbe.cdscc.nasa.gov
Web: www.cdscc.nasa.gov/

CHESLEIGH HOMESTEAD

The homestead offers accommodation for couples to large groups. Chesleigh offers observing to its patrons through its 12-inch reflector telescope taking full advantage of its clean, dark sky site.

Address: Chesleigh Homestead, 319 Hill End Road Sofala, NSW 2795
Cost: Included with accommodation costs.
Contact: Mike & Jan Cody Ph: (02) 6337 7077 Fax: (02) 6337 7092
Email: cody@ix.net.au
Web: www.sofala.net.au/astronomy.html

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. The observatory offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments, a 6 inch refractor and a flat screen planetarium.

Times: Winter: 7-10pm, Summer: 8:30-11pm, or by appointment. Coaches and schools welcome.
Contact: Mark Monk (02) 6345-1900 or fax (02) 6345-1920
Email: darbysob@tpg.com.au

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. Stage one of the observatory is running, which includes viewing the night sky through 3 x 300 mm Schmidt Cassegrain telescopes and large binoculars. Slides of the Universe, displays, videos and a well-stocked gift shop are available.

Address: 13L Camp Rd. PO Box 308 Dubbo NSW 2830
Times: Open daily (except Christmas) from 10am until late. Bookings essential for night sessions.
Cost: Adults $13.50; family of four $38.50 concession, school groups, tour groups and interested amateur astronomers.
Contact: Peter Neilson (manager) (02) 6885 3022 Fax (02) 6885 3012
Email: dubbobs@hwy.com.au
Web: www.hwy.com.au/~dubbobs/

GILGANDRA OBSERVATORY

The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It provides a 31cm Newtonian reflector for public use. Tours of the night sky are held each night except Sundays. During NSW school holidays; Sunday nights and daytime by appointment. Booking is advised.

Address: Willie Street, Gilgandra 2827
Times: 7pm to 10pm (daylight saving 8:30pm to 10pm)
Cost: Adults $9, pensioners $7, children $6, family $25.
Contact: (02) 6847-2646 fax: (02) 6847-2845
Email: mail@gilobs.com.au
Web: www.gilobs.com.au/

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two buildings house 41cm and 35cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also runs regular open nights for the general public. In 2004, open nights are tentatively scheduled for the First Quarter Moon weekend in August.

Address: Cnr Green Point & Caravan Head Roads, Oyster Bay (PO Box 31 Sutherland 1499)
Cost: no charge for visitors
Contact: Secretary (02) 9589-1014 (voicemail phone/fax)
Email: sasi@sasi.net.au
Web: www.sasi.net.au

GROVE CREEK OBSERVATORY

This observatory is located 60km south of Bathurst. The facility caters for amateur astronomers who are looking to use large aperture telescopes under very dark skies. The facility boasts a C-14, two 12.5 inch Newtonians and a Meade 10 inch LX-200 with astrophotography and CCD equipment. The observatory has on-site accommodation, sleeping up to 10 people.

Cost: $120 per person/per night all inclusive (conditions apply).
Contact: Steven Williams on (02) 6368-8611
Email: info@gco.org.au
Web: www.gco.org.au/

KOOLANG OBSERVATORYAND SPACE SCIENCE CENTRE

Located on the border of the Central Coast and Lower Hunter; the centre is no more than 2 hours from most Sydney and Newcastle suburbs. Koolang's telescopes operate 7 days and nights a week. Bookings are essential. Koolang staff have also developed curriculum and theme based presentations to cover all school levels.

Address: Koolang Observatory, George Downes Drive, Bucketty
Times: Daytime solar viewing shows and display centre visits 6 days (closed Wednesday), 10am to 1pm and 3pm to 5pm. Night shows (2 hours) - Friday and Saturday nights (7 nights for groups.) Night shows start about an hour after sunset. Starting times vary, and booking is essential.
Cost: Public night shows: adults $11; concession; $9.50; child $8. Day shows: Adults $5; group (15 or more) discounts available. Special prices and hours for schools. These prices may change slightly.
Contact: (02) 4998 8216, fax (02) 4998 8580
Email: staff@koolang.com.au

Web: www.koolang.com.au

KINGS TABLELAND OBSERVATORY

The observatory is located in the Blue Mountains at Wentworth Falls. It offers dark skies while still close to Sydney. It is open to any interested people or groups. There is a flat screen planetarium and two modern telescopes, housed in a dome. Classes for the Nepean Community College are also conducted including workshops on the night sky, use of star charts, astrophotography and telescopes. It is also open on Saturday and Sunday from 10am to 4pm for Solar Observing.

Times: Flexible to meet demand
Contact: Roger North, Sybil Barber (02) 4757-2954
Email: north.barber@bigpond.com

MACQUARIE UNIVERSITY OBSERVATORY

Located on the Macquarie University Campus at North Ryde, this observatory is open to the public every Friday night. Astronomy students will guide you with a range of telescopes. On cloudy nights their program includes slide shows and Solar System demonstrations.

Times: 8:30pm to 10pm summer (Nov - Mar); 7pm to 8:30pm winter (Apr - Oct)
Cost: $5 per person (subject to variation)
Contact: Lesa Moore (Mob) 0427 4333 88
Email: StarryLady@hotmail.com
Web: members.ozemail.com.au/~starrylady/

PARKES CSIRO RADIO TELESCOPE

The observatory is located on the western plains of NSW, 20km north of Parkes (just off the Newell Highway). This landmark radio telescope is just over 40 years old, but still considered to be one of the best single dish radio telescopes in the world. It also functions as part of the CSIRO Australia Telescope Array. As well as a great view of the telescope, the visitor's centre has displays, audiovisual and 3D presentations. There is also the Dish Café and a public picnic area with free gas barbecues. Souvenirs and educational material are available.

Address: Radio Telescope Visitors Centre, Telescope Rd (PO Box 276), Parkes NSW 2870
Times: 8:30am to 4:15pm - daily except Christmas and Boxing Day
Cost: Admission to the visitor's centre is free. A modest charge is made for the audio visual and 3D presentations.
Contact: (02) 6861-1777
Email: parkes-vdc@csiro.au
Web: www.parkes.atnf.csiro.au/visitors_centre/

MAGELLAN OBSERVATORY

This facility is at Lake Bathurst, which is 30km south of Goulburn. This well equipped observatory has accommodation and a variety of telescopes, which includes a computerised 46cm telescope (NGT18) in a dome. It also has some CCD equipment and a Hydrogen Alpha filter for viewing the Sun. An astrophotography rig is available for hire. For those travelling by train, your hosts will even pick you up from Goulburn station.

Address: Lot 48 Covan Creek Rd, Lake Bathurst 2580
Contact: (02) 4849-4489
Email: magellan@goulburn.net.au
Web: home.goulburn.net.au/~magellan/

MT. STROMLO OBSERVATORY

The oldest fully operational research observatory in Australia, Mt Stromlo Observatory (along with its sister observatory at Siding Springs) is part of the Research School of Astronomy and Astrophysics at the Australian National University. Once housing telescopes dating back to 1868, Mt Stromlo Observatory was devastated by the fire storms on 18 January 2003. Through the dedication of the staff, government and public, Mt Stromlo Observatory is rebuilding and hopes to offer site visits to the public and school groups in the near future. See their website or contact them for continued updates.

Address: 15 minutes from Canberra City, Mt Stromlo Observatory, off Cotter Road, Weston Creek, ACT (On Tourist Drive 5)
Contact: Visitors' Centre (02) 6125-0232; Fax (02) 6125-8045
Star Wares Gifts (02) 6125-8903
Red Belly Black Cafe (02) 6287-1518
Email: msovc@mso.anu.edu.au
Web: www.mso.anu.edu.au/msovc/

NEPEAN OBSERVATORY

The Nepean Observatory of the University of Western Sydney is open to both the public and to school groups. Their hands-on programs cover astronomy, space, model rocketry and general science. The observatory is located at Werrington North on the Penrith Campus. It has a research telescope, which is a computer controlled 0.6m telescope. Nepean also has a range of smaller telescopes for public viewing.

Cost: $10 per adult; $5 per child/concession; $20 family (2 adults + 2 children)
Contact: Phone Roslyn McCourt on (02) 4736 0135
Email: r.mccourt@uws.edu.au
Web: www.uws.edu.au/observatory/

LINDEN OBSERVATORY

WSAAG (Western Sydney Amateur Astronomy Group) holds two observing nights a month, where anyone can drop in and look through their telescopes. Observing nights are usually held on Saturdays closest to the New Moon. Dates can be obtained by contacting Brett White or by visiting the WSAAG website.

Address: 105 Glossop Road, Linden 2778
Cost: Donation to Linden Trust @ $5 per person.
Contact: Brett White
Email: bwhite@acay.com.au
Web: www4.tpgi.com.au/users/wsaag/FindUs.html

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association, is situated in Rotary Park (opposite Town Beach) Port Macquarie. It is open to the public on Wednesday & Sunday evenings at 7:30 pm (8:15pm, daylight savings). Lectures are given plus viewing of celestial objects. Special nights can be arranged for groups. They own two Celestron telescopes. Adult Education Classes are also held (contact Dave Reneke (02) 6585-2260).

Address: Port Macquarie Astronomical Association Inc, PO Box 1453, Port Macquarie NSW 2444
Cost: Donation asked for is $5 adults $4 for kids $15 family (2+2)
Contact: Jim Daniel (02) 6583-1933 or Peter Hall (02) 6586-1095
Email: jaidanl@bigpond.com.au
Web: www.users.bigpond.net.au/esther/

SIDING SPRING OBSERVATORY

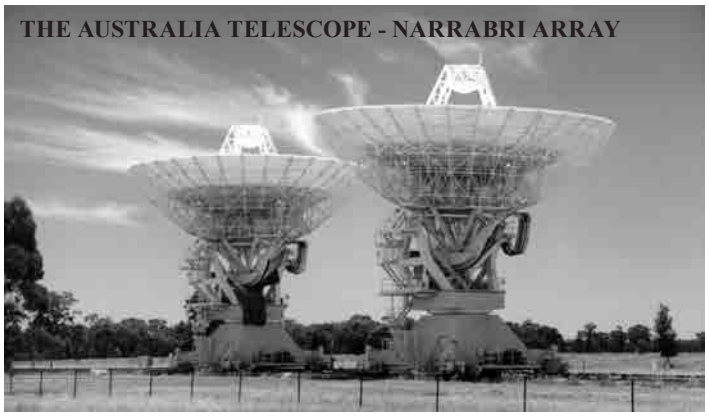
Siding Spring is home to eight telescopes, including the Anglo-Australian Telescope with a 3.9 metre mirror - the largest in Australia. Siding Spring nestles into the Warrumbungle's at the entrance to the national park, 30 minutes west of Coonabarabran. The exploratory at Siding Spring offers scale models, videos and interactive computers and much more. Guided tours are available most school holidays. Bus tours are available on bookings. An open day is generally held in October.

Times: 9:30am to 4:00pm daily except Christmas Day.
Cost: Exploratory: adult $5.50, child/pensioners $3.50, family $13.50
Tours: adult $11.00, child/pensioner $9, family $27
Contact: Ph (02) 6842-6211, Fax (02) 6842-6226
Email: juls@mso.anu.edu.com.au
Web: www.sidingspringexploratory.com.au/

SKYWATCH OBSERVATORY AND ASTRO GOLF

This public observatory is in Coonabarabran, which is also the home of the Siding Spring Observatory. It is on Timor Rd, 2km west of the clock tower. During the day the exhibition features hands on activities, a theatrette, computers and displays. At night there is guided telescope viewing, with up to five telescopes. There is also Astro Golf, an 18 hole mini golf course and light refreshments are available. In cloudy weather a planetarium and slide-show is featured.

Times: 2pm to 5pm (closed during the day in February) Night-time hours vary throughout the year as the daylight hours change, so it is always a good idea to call ahead. Bookings not required, but appreciated. Groups welcome but please book ahead. Open every day except Christmas day.
Cost: Adult $14; Child/pensioner $9; Family $38
Contact: Marcus Donnelly (02) 6842-3303 Fax: (02) 6842-2978
Email: astro@skywatchobservatory.com
Web: hwy.com.au/~skywatch/index.html



The Australia Telescope operates in the radio region of the spectrum. It essentially uses high technology to combine the signals from a number of dishes, or elements, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array, located at the CSIRO's Paul Wild Observatory near Narrabri, is the heart of the telescope. It consists of six 22m dishes five of which are spaced along a 3km 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: Locked Bag 194, Narrabrai NSW 2390
Times: 8am to 4pm daily (not staffed weekends, except school holidays).
Cost: No charge to visit the centre. Bookings appreciated for groups.
Contact: Tim Kennedy (02) 6790-4070
Email: Tim.Kennedy@csiro.au
Web: wwwnar.atnf.csiro.au/

THE CANBERRA SPACE DOME AND OBSERVATORY

The Canberra Space Dome (Planetarium) is a virtual reality star theatre. Experience night sky simulations, interplanetary space flight, and explore the night sky. The observatory features research-grade telescopes under domes.

Address: Hawdon Place, Dickson (off Antil Street)
Times: Tuesday to Saturday evenings (phone for session times), bookings essential.
Cost: Per facility: $8.50 adult, $6 child/student/senior $24 family (2 + 2, extra child $4 each)
Contact: Phone: (02) 6248-5333 fax: (02) 6249-7238
Email: planetarium@ctuc.asn.au
Web: www.ctuc.asn.au/planetarium/

THE UNIVERSITY OF NSW OBSERVATORY

The University opens its observatory to the general public several times a year on Friday nights. These are usually accompanied by an astronomy talk and a visit to Starlab, our portable planetarium. Activities are generally geared to a wide age range. Starlab is also available for school visits and these can be arranged through the Outreach Centre in the Science Student Centre.

Address: UNSW Kensington
Cost: Details available on website.
Contact: Outreach (02) 9385 7311
Email: outreach@science.unsw.edu.au
Web: www.science.unsw.edu.au/school/student/events.asp

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive exhibits, demonstration theatre, and a gift and resource shop. The BHP Steel Star Theatre has a state of the art Zeiss ZKP3 star projector. The Duke Energy Observatory houses a computer controlled telescope under a dome which is used to observe the Sun and stars.

Address: Science Centre, Squires Way, Wollongong NSW 2522
Times: 10 am to 4 pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Cost: Child $6, concession $8, adult $9.50. Discount on Planetarium Shows tickets when purchased with general entry
Contact: (02) 4286-5000, fax: (02) 4283-6665
Email: Kim_Noble@uow.edu.au
Web: www.uow.edu.au/science_centre/

SYDNEY OBSERVATORY

This is Australia's oldest existing observatory — being used to view the southern sky for over 140 years. Situated on Observatory Hill, and overlooking Sydney Harbour, the observatory is an important site in the nation's early scientific history. It is now part of the Powerhouse Museum. There are interactive displays and films on astronomy as well as the exhibition 'By the light of the Southern Stars'. Night tours include exhibitions, lectures, films and stargazing through the Observatory's telescopes. On weekends, visitors can observe the Sun through a safely filtered telescope (weather permitting).

Address: Watson Road, Observatory Hill, The Rocks Sydney
Times: 10am to 5pm, except Christmas Day. Night sessions are held every night of the week. Bookings required for evening tours.
Cost: Daytime entry free (Telescope & 3D Theatre: $6 adult, $4 child, $16 family). Night time entry: $12 adult, $8 student/concession, $32 family. Day tours can be arranged, a fee applies.
Contact: (02) 9217-0485
Email: observatory@phm.gov.au
Web: www.phm.gov.au/observe/

QUEENSLAND

ALLOWAY OBSERVATORY

The observatory, which is 6 km outside of Bundaberg, is operated by the Bundaberg Astronomical Society. The dome houses a 480mm telescope. A recent update has included computerised CCD imaging technology. As well as regular Friday night viewing and information evenings, interested persons or groups can visit any suitable night by prior arrangement.

Address: PO box 4221 South Bundaberg Qld 4670
Times: Every Friday night, other nights by appointment.
Cost: $12 family, $6 adult and $3 child; discount for groups.
Contact: Trish Gibson (07) 4156-5278 or (07) 4159-7232 (ans service)
Email: iluka@widebay.net.au
Web: www.angelfire.com/al/AstronDirectory/

COSMOS CENTRE CHARLEVILLE

The public observatory is located on Cunnamulla Rd, near the airport. The Centre includes an observatory, two theatre presentations and seven interactive displays.

Address: PO Box 681, Charleville, 4470
Contact: Jane Morgan (07) 4654-3057
Email: cosmoscentre@bigpond.com
Web: www.cosmocentre.com/

SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is only a 45-minute drive from Surfers Paradise. The observatory is open to the general public, astronomical groups, schools, and researchers by appointment. This facility has a C14, C11, 4.5-inch refractor, CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing. A new observatory is opening in January 2004, contact them for details.

Address: 2319 Springbrook Road, Springbrook 4213
Contact: Andre Clayden (07) 5533-5200, fax (07) 5533-5457
Email: springbrook@iprimus.com.au
Web: www.maguires.com/astronomy/

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Brisbane Botanic Gardens at Toowong in Brisbane. Programs are presented in the 'Cosmic Skydome' which has an artificial sky projected onto the interior of a 12.5m dome. The Planetarium is undergoing a major upgrade in early 2004. The foyer and gallery areas contain interesting astronomical displays and a shop. The planetarium also has an observatory equipped with a variety of telescopes. Observatory sessions must be pre-booked.

Address: Brisbane Botanic Gardens Mt Coot-tha, Mt Coot-tha Rd, Toowong, Brisbane 4066
Times: Both public and school shows are presented. Not recommended for children under 6. School shows are on a booking basis only. Admission charges apply to shows.
Contact: (07) 3403-2578
Email: ACBP@brisbane.qld.gov.au
www.brisbane.qld.gov.au/community/facilities/planetarium.shtml

SUNDOWN OBSERVATORY

The observatory is approximately 250 kilometres southwest of Brisbane, on a dark sky site 4 km off the New England Highway. The main instrument is a 46-cm telescope. The visitor's centre has space for visitor's telescopes. Bookings are essential.

Address: 389 Sundown Road, Ballandean Qld 4382
Times: Open nightly from 8pm (subject to weather)
Cost: Adults $8 each; groups of 10 or more $7 each
School children (primary & high) $5 each; supervising teachers free
Contact: phone/fax (07) 4684-1192
Email: sundownobservatory@bigpond.com
Web: users.bigpond.com/sundownobservatory/

THE GREAT BARRIER REEF OBSERVATORY

Situated on Hamilton Island, the observatory is open to the public during the dry months from April to November. Sessions are held on Tuesday, Thursday and Sunday evenings. Special openings on request. The observatory enjoys dark skies, operates five telescopes, and is staffed by members of the island's astronomical group. Viewing is complimentary.

Address: PO Box 40 Hamilton Island Qld 4803
Contact: Ray Johnston (07) 4946-8686
Email: star@whitsunday.net.au

SOUTH AUSTRALIA

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

The Arkaroola Resort and Wildlife Sanctuary is a 610 square kilometre property of spectacular rugged mountains in South Australia's remote outback which offers a unique range of nature and science based tours and activities. A large computer driven astronomical observatory offers an expert nightly tour through the universe. They now have two observatories and three starchairs for viewing.

Address: Arkaroola Wilderness Sanctuary, Northern Flinders Ranges. PMB 106 Port Augusta SA 5710
Contact: Ph (08) 8648-4848 Fax (08) 8648-4846
Email: res@arkaroola.on.net
Web: www.arkaroola.on.net/index.htm

INTERNATIONAL CANGAROO PROJECT

The CANGAROO III telescopes are used for high-energy astrophysical studies of pulsars, supernovae, gamma ray bursts and black holes. There are four 10m diameter light collecting telescopes which are used for detecting optical light which is produced when very high energy gamma-rays reach our atmosphere. The telescopes are located inside the Woomera Security Area. There is a display in the Woomera Heritage Centre. An idea of the activities, including a picture gallery, is available on the web site.

Contact: Dr Roger Clay, University of Adelaide (08) 8303 5113
Fax (08) 8303 4380
Email: rclay@physics.adelaide.edu.au
Web: www.physics.adelaide.edu.au/astrophysics/cangaroo.html

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury (Adelaide). It was formed primarily for students of the school with an interest in astronomy, but anyone interested in astronomy is encouraged to join. There are two main telescopes and a classroom. During the day solar observations are made.

Email: rperkins@theheights.sa.edu.au
Web: www.theheights.sa.edu.au/

UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM

The planetarium has sessions for primary/secondary schools as well as the general public. Sessions are by appointment only. An open to the public session is available on the first Saturday of the month at 3pm.

Address: University of South Australia,
Building P, Mowson Lakes Campus
Cost: $4.40 adults, $3.30 students and concession
Contact: (08) 8302-3138
Email: Christine.Moore@unisa.edu.au
Web: www.unisa.edu.au/planetarium/

TASMANIA

KING ISLAND OBSERVATORY

Take advantage of King Island's beautiful dark nights to enjoy a guided tour of the heavens. A 6-inch refracting telescope is used for observing.

Address: Rifle Range Road, Currie, King Island 7256
Times: Shows are nightly (except Wednesdays) when the sky is clear and run for about 60 minutes
Cost: $10
Contact: (03) 6462-1319
Email: kiobservatory@bigpond.com.au

LAUNCESTON PLANETARIUM

The planetarium is in the Queen Victoria Museum, Wellington St.

Address: Queen Victoria Museum, Wellington St, Launceston, 7250
Times: Tuesday to Friday 3pm, Saturday 2pm and 3pm. During government school holidays, shows run Monday to Saturday 2pm and 3pm. Group bookings by arrangement.
Cost: $3 children (under 15), $5 adults and $12 family (children under 5 years old are not admitted). 50% discounts available to Museum admission ticket holders.
Contact: (03) 6323-3777
Email: martin@qvmag.tas.gov.au
Web: www.qvmag.tas.gov.au/planetarium.html

PLANETARIUM IN HOBART

This planetarium is in Antarctic Adventure, Salamanca Square, Hobart. It consists of a 6-metre geodesic dome, seating 30 people. There is no age limit on entry. Shows run hourly 6 times per day. Antarctic Adventure offers educational and astronomical presentations for school groups. Also the Antarctic Gift Shop sells astronomy-related items.

Address: 2 Salamanca Square, Hobart Tas 7000
Times: Open every day (except Christmas Day) from 10am to 5pm. Shows are hourly and run for about 40 minutes.
Cost: Entry (to centre) adult $17.50, concession $14, child $9 (4 & under free), and family $44, school group $6.60
Contact: (03) 6220-8220
Email: sales@antarctic.com.au
Web: www.antarctic.com.au/

VICTORIA

ASTROTOURS

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 the school holidays.

Address: The theatre is located in room AS406 on the fourth floor of the Applied Science building. Enter from Burwood Road.
Contact: Sarah Maddison, phone 9214-5971 , fax 9214-8797
Email: astrotour@swin.edu.au
Web: astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The Observatory contains three historic telescopes: The Jelbart - a 125 mm refractor, the Oddie - a 220 mm Newtonian and the Baker Great Equatorial Telescope - a 650 mm Newtonian, which was commissioned in 1886. There are a number of other telescopes including a computer-enhanced, disabled-access 406mm Cassegrain. The observatory is open most Friday and some Saturday nights. Daytime tours can also be arranged by appointment.

Contact: (03) 5332-7526
Email: bas@cbl.com.au
Web: observatory.ballarat.net/

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages. The planetarium is open 7 days a week from 10am and runs special evening sessions from January to April.

Address: 2 Booker St, Spotswood, Victoria
Cost: See web site
Contact: (03) 9392-4800
Email: mvplanet@museum.vic.gov.au
Web: www.museum.vic.gov.au/planetarium/index.html

MELBOURNE OBSERVATORY

The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. There is a self guided tour available from Friday to Monday. There are also Tuesday evening presentations 'The Night Sky Experience'. Bookings are essential for both programs (03) 9252-2429. The Royal Botanic Gardens Melbourne has a visitor centre, function rooms, Observatory Cafe and a Gardens' Shop.

Address: Birdwood Avenue, South Yarra 3141
Times: Day tour, 10am-4pm Fri-Mon. Night 7:30-9:00pm Tuesdays.
Cost: Day tour: $4.50 adult, $3.50 concession, $12 family (2+2)
Night tour: $15.50 adult $11 concession, $37.50 family (2+2)
Contact: Visitor Centre, Observatory Gate (03) 9252-2429
Email: rbg@rbg.vic.gov.au
Web: www.rbg.vic.gov.au/visinfo/whatson/index.html

WESTERN AUSTRALIA

PERTH OBSERVATORY

Situated in the Darling Ranges, 40km inland from the West Coast, Perth Observatory conducts astronomical research and educational activities. As part of the observatory public education program, several telescopes from 10 inch to 16 inch are available for use by visitors. Astronomers also take telescopes to conduct Field Nights at various locations. A portable display is often used at public libraries and schools. There is a museum displaying instruments, from the old observatory (founded in 1896), paintings and current photographs.

Times: Normal office hours : 8am - 5pm
Star Viewing Nights: Times vary during the year. No tours May - Sep. inclusive, bookings essential. Tour lasts 1.5 hours approx.
Daytime Guided Tours: 10am, 12:30pm, or by appointment - bookings essential. 1st Sunday of the month 2pm, no booking needed. Astronomy Field Night: Telescopes at remote locations.
Cost: All services attract charges, contact the observatory for details.
Contact: Phone: (08) 9293-8255 fax: (08) 9293-8138
Info Line: (08) 9293-8109
Email: perthobs@iinet.net.au
Web: www.wa.gov.au/perthobs/

PINGELLY HEIGHTS OBSERVATORY (ASTRO VENTURES)

An Educational Facility specialising in the presentation of astronomical information and the viewing of the night sky. They provide a wide range of talks and observing experiences through their telescopes. The observatory is one and a half hours drive from the Perth metropolitan area. The property is 'Sunarise', Lot 11 Pingelly Heights (off Aldersyde Road), Pingelly. Astro Ventures caters especially for: primary and secondary schools, youth groups, scout and guide units, recreational and sporting groups, community organisations, private parties and others on request.

Address: PO Box 512 Pingelly WA 6308
Times: Night Programme starts summer: 7.30 pm; winter: 7pm Friday, Saturday and Sunday (other nights by appointment)
Cost: Adults $20, children/pensioner/concession $10, family $50
Contact: For further information and reservations ring Susie or Trevor on (08) 9887 0088, 0407 380 922 or write to Astro Ventures.
Email: astroventures@westnet.com.au
Web: www.westnet.com.au/astroventures/

SOUTHERN CROSS COSMOS CENTRE

Astro Nights (formerly of the Golden Grove Observatory) now operates the Southern Cross Cosmos Centre (SCCC), situated in the Shire of Gingin, an hour north of Perth. Each evening session starts with a short presentation, followed by an hour of viewing through a number of different instruments including the 25 inch Brodie-Hall telescope.

Times: The observatory is open each Friday and Saturday from October to April, (inclusive) with the evenings running from 7:30pm to 10pm. Other evenings are available on request but minimum charges apply. Bookings are essential and can be made by contacting Astro Nights.
Cost: $25 adult, $10 children, $15 concession $60 family
Contact: (08) 9307-1353 or (08) 9246-5782
Email: sccc@bigpond.net.au
Web: www.sccc.asn.au

ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following lists astronomy courses, events, magazines and radio programs for 2004. This list is by no means intended to be exhaustive. Across the country there are no doubt many other evening courses held at various universities and colleges. Enquiries from the general public are most welcome. A number of the amateur astronomical societies also provide an invaluable service to public education by their lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change.

GENERAL

FUNDING FOR ASTRONOMICAL RESEARCH

The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateur astronomers and students. No grant is being made available in 2004, however grants will be made available in future years. Further information concerning eligibility of applicants and obligations of successful applicants are available from the contact below.

Address: PO Box 6101, St. Lucia. Qld 4067
Contact: The General Secretary, Astronomical Association of Queensland

INTERNATIONAL DARK-SKY ASSOCIATION

IDA's goal is to preserve and protect the night-time environment and our heritage of dark skies through quality outdoor lighting.

Address: 32 Carina Road, Turramurra, NSW 2074
Contact: Reg. R. Wilson (Director, Australian Representative)
Phone/Fax: 61 (02) 9488-7078
Email: regrw@tpg.com.au
Web: www.Darksky.org/

NACAA 2004

The National Australian Convention of Amateur Astronomers is a biennial meeting normally held over Easter. The 2004 gathering will be in Hobart at the Wrest Point Casino, hosted by the Astronomical Society of Tasmania. Contact the society for details.

Email: nacaa2004@emailgroups.net
Web: www.nacaa.has.it/

SPACE ASSOCIATION OF AUSTRALIA INC

Activities include monthly free public meetings, public displays, radio programme and newsletter to promote understanding of astronautics.

Address: PO Box 351, Mulgrave North, Victoria 3170
Contact: Andrew Rennie
Web: www.space.asn.au

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia has instituted a new website to provide links for Australian astronomy, both professional and amateur, including links to educational material.

Web: www.astronomy.org.au

THE PLANETARY SOCIETY AUSTRALIAN VOLUNTEER CO-ORDINATORS

An Australian based space exploration lobby group linked to The Planetary Society. It contains information of relevance to the Australian scene.

Web: www4.tpg.com.au/users/tps-seti/index.html

LABNOTES - TIPS FOR TEACHERS - ASTRONOMY AND SPACE

Articles are listed and tips have been written for these articles. These tips will help you run learning activities, set homework, and guide student research. For educational purposes, you may print off pages, photocopy them and hand them to your students.

Web: www.abc.net.au/labnotes/read/default.htm#astronomy

TUTORIALFIND - ASTRONOMY TUTORIALS

Web page that is a search engine for tutorials - in this case astronomical tutorials.

Web: www.find.com.au/tutorials/education/astronomy/

U3A ONLINE - INTRODUCTION TO ASTRONOMY

University of the third age (U3A) now offer an astronomy course online. For extra details contact Byron via jump.to/lunar-eclipse/

Contact: Byron Soulsby
Email: info@u3aonline.org.au
Web: u3aonline.edna.edu.au/course_summaries/astronomy_summ.html

QUESTACON STARLAB

Starlab is an inflatable planetarium which can accommodate up to 30 students. Starlab presentations are available in Canberra, Sydney, Melbourne, Brisbane, Wollongong in collaboration with other science centres.

Address: National Science and Technology Centre, Canberra ACT 2600
Contact: Outreach Programs Bookings Coordinator
(02) 6270-2800 fax: 1 800 641 171
Email: gsmith@questacon.edu.au
Web: www.questacon.edu.au/html/starlab_planatarium.html

The questacon science centre in Canberra

PUBLICATIONS

ASTROCARDS

The Astronomical Society of NSW runs an information service called Astrocards. This service alerts subscribers to new observable discoveries such as comets, novae, supernovae, bright near-Earth asteroids, or unusual planetary phenomena. The service is available via email or letter and is open to all amateurs.

Address: 7 Richards Close, Berowra 2081
Fees: $10 for 10 - subscriptions payable to the ASNSW
Contact: Greg Bryant
Email: gchbryant@hotmail.com
Web: gchbryant.tripod.com/

COMET TALES

This quarterly publication covers a variety of topics including the latest information on comets. Deep-sky observing, monthly sky highlights, and Australian astronomy news (including amateur) are broadly covered.

Address: 7 Richards Close, Berowra, 2081
Fees: $14 for one year (payable to Greg Bryant, credit card accepted)
Contact: Greg Bryant
Email: gchbryant@hotmail.com
Web: gchbryant.tripod.com/

PERIHELION COMET QUARTERLY

This bulletin, for comet observers, is published by David Seargent. It is a 16-page newsletter that carries articles of interest to the comet enthusiast, plus new discoveries and ephemerides of comets appropriate to southern hemisphere observers. There are also special bulletins which give discovery details for bright comets, visible from Australia.

Address: PO Box 204, The Entrance NSW 2261
Fees: $12 (for 4 issues per year), $15 also includes special mail notices for new discoveries (cheques payable to Karagi Publication).
Contact: David Seargent
Email: seargent@ozemail.com.au

SKY AND SPACE MAGAZINE

This astronomy and space exploration magazine is produced for Australia and New Zealand. The full-colour magazine is bi-monthly and available through newsagencies or by subscription. Sky & Space also produce a magazine called Southern Astronomy. It is available only by subscription.

Address: Sky and Space Publishing,
PO Box 1690 Bondi Junction NSW 1355
Contact: (02) 9369-3344 fax (02) 9369-3366
Email: info@skyandspace.com.au
Web: www.skyandspace.com.au/public/home.ehtml

NEW SOUTH WALES and ACT

ASTROFEST - COONABARABRAN

Activities on this weekend include: observing, lectures, tour of Siding Spring and Skywatch Observatories, and Science in the Pub (subject to availability). This event is hosted by the Warrumbungle Mountain Motel. Dates for 2004 were uncertain at time of publication.

Contact: Mark Boyd (02) 6842-1832
Email: warrumbunglelodge@bigpond.com.au

ASTRONOMY COURSES - COONABARABRAN

At the time of publication, it was unknown whether these courses would be held in 2004 (they are dependent on the level of interest). Contact Mark for details. They are organised by the Warrumbungle Mountain Motel.

Contact: Mark Boyd at the motel on (02) 6842-1832
Email: warrumbunglelodge@bigpond.com.au

INTRODUCTION TO AMATEUR ASTRONOMY

A six week beginners course run by WEA Illawarra. This course will aim to convey an understanding of the objects that can be seen in the night sky, an appreciation of their nature and the equipment amateur astronomers use to observe them. In addition to the 6 x 2 hour classroom sessions are two 2 hour field trips. Tutor is Andrew Wood BSc, PhD. There is a possibility that this course will also be run at Macarthur Community College from Term 1, 2004.

Fees: Course is held at Ballarang Public School, Shellharbour
Contact: (02) 4226-1622
Email: bandawood@bigpond.com
Web: www.weaillawarra.com.au/

FESTIVAL OF ASTRONOMY 2004

FANS (Festival of Astronomy at North Sydney) was held at the North Sydney football ground in June 2002 and July 2003 (where it was part of the IAU Symposium held in Sydney). FANS 2004 is in the early stages of planning as this book went to print. For more details see our web site or contact one of the Sydney societies.

Setting up for the FANS 2003 open night.

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. There are two such nights held each year normally in March-April and September-October (a Saturday night around First Quarter Moon). The venue is Macquarie University (off Epping Rd, North Ryde, Sydney) and commences around 6.30pm.

Address: Dept of Physics, Macquarie Uni, NSW 2109
Fees: Adults $8, Children $4, Family $20
Contact: Dr Alan Vaughan
Email: alanv@ics.mq.edu.au
Web: www.ics.mq.edu.au/~alanv/mqastro.htm

MACQUARIE UNIVERSITY FOUNDATION FOR ASTRONOMY

The FFA acts as a support group for astronomy activities at Macquarie University. Membership subscription is $20 per year (students $10). Through its activities it supports community education in astronomy.

Address: Dept of Physics, Macquarie Uni, NSW 2109
Fees: $20 ($10 students)
Contact: Dr Alan Vaughan
Email: alanv@ics.mq.edu.au
Web: www.ics.mq.edu.au/~alanv/ffa.htm

MACQUARIE UNIVERSITY PLANETARIUM

Macquarie University now operates a mobile planetarium. The planetarium simulates the appearance of the stars in the night sky. It can be set up on campus or can be taken to schools. The planetarium seats a maximum of 20 adults.

Address: Dept of Physics, Macquarie Uni, NSW 2109
Contact: Dr Alan Vaughan (02) 9850-8904
Email: alanv@ics.mq.edu.au

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an 8 week course conducted by Sutherland Astronomical Society (SAS) during Spring. Each lecture is followed by observations with the society's equipment (weather permitting).

Address: Green Point Observatory (Sutherland, Sydney)
Fees: $120 per student.
Contact: The Education Officer (02) 9589-1014 (voicemail phone/fax)
Email: education@sasi.net.au
Web: www.sasi.net.au

SKYWORKS PLANETARIUM

Skyworks is a travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. It is authorised by the Department of Education and was recently presented with the Frater Award. Programs are curriculum based to suit years K-12.

Contact: Geoff Zenner / Diana Zenner (02) 9610-2899,
0427 112 899, fax (02) 9753-1898
Email: sky-works@bigpond.com
Web: www.users.bigpond.com/sky-works/

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 400 people. The 2004 SPSP will be held from 19-21 March. Contact the ASNSW for details.

Email: secretary@asnsw.com
Web: www.asnsw.com/

STAR CLASS - ASTRONOMY EDUCATION

This part-time, home-based business offers 'Star Kids', an astronomy & space club for upper-primary aged children and includes a membership kit. Star Class also provides free regular online astronomy chats, a free email based astronomy discussion forum, and is the Australian National Centre for the Red Rover Goes to Mars project. Visit our website for the latest pricing and information

Address: GPO Box 271 Canberra ACT 2601
Fees: Visit our website for the latest pricing and information
Contact: Michael and Leonie MacDonald (02) 6161 0471
Email: info@starclass.com.au
Web: www.starclass.com.au/

NEPEAN COMMUNITY COLLEGE COURSES

Run at the Kings Tableland Observatory in Wentworth Falls (Blue Mountains).

Contact: (02) 4721-5368 (College)

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY

SOLIS is an active group with the aim of bringing the ever increasing sky glow to a standstill.

Address: PO Box 3002, North Turramurra NSW 2074
Contact: Ken Petersen (02) 9634-1736
Email: solissydney@telstra.com
Web: solis.org.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. Contact the university's Centre for Continuing Education on (02) 9351 2907 to enrol.

Address: Centre for Continuing Education, University of Sydney
Fees: Approximately $180 for 10 weeks
Contact: John O'Byrne
Email: j.obyrne@physics.usyd.edu.au
Web: www.physics.usyd.edu.au/~obyrne/cep/cep.html

WEA - SYDNEY OBSERVATORY COURSE

Sydney Observatory and the WEA are likely to run some beginner astronomy courses, based at the observatory, during 2004.

Contact: WEA (02) 9264-2781 for cost and timetable details.
Web: www.weasydney.com.au

QUEENSLAND

ASTROFEST - QUEENSLAND

The Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours northwest of Brisbane. It has a dark sky with accommodation and a C14 telescope (Stewart Observatory). Activities include: presentations from professional astronomers, awards, swap and sell, barbecue, slide shows and light sports. The 2004 Astrofest is scheduled for 16-22 August.

Contact: (07) 3274-5073 Tony Surma-Hawes (registrar)
Email: firstlight@optushome.com.au
Web: members.optushome.com.au/earthlight/astrofest.htm

BRISBANE FIELD NIGHTS

The Brisbane Astronomical Society (BAS) holds a free public Field Night on the Saturday nearest to the First Quarter Moon (weather permitting) at Mt Coot-tha Lookout, from 7pm to 9pm.

Address: Brisbane Astronomical Society Inc
PO Box 892, Brisbane Albert St Qld 4002
Contact: BAS Infoline (07) 3321-8511 (recorded club information service)
Email: basmail@bas.asn.au
Web: www.bas.asn.au/

STARGAZERS WEEK 2004

O'Reilly's Rainforest Guesthouses will likely run its annual Stargazers Week towards the end of July. Programme includes telescopic views of the winter Milky Way under dark skies and solar observing. Contact O'Reilly's for more information.

Contact: (07) 5544-0644
Web: members.optushome.com.au/firstlight/stargazers/stargazers.htm

SOUTH AUSTRALIA

STARLORE AND SOLAR SYSTEM ASTRONOMY

This is a one night course conducted at the Adelaide Planetarium around 5-6 times a year. The course emphasises how other cultures see the night sky including indigenous Australians.

Fees: $20
Contact: Paul Curnow
Email: paulc@ching.apana.org.au
Web: ching.apana.org.au/~paulc/index.html

WEA COURSES

Astronomy courses are run in March, May, August and October.

Address: 223 Angas Street, Adelaide, 5000
Contact: (08) 8223-1272
Email: enrolments@wea-sa.com.au
Web: www.wea-sa.com.au/

TASMANIA

INTRODUCTION TO ASTRONOMY - HOBART

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Canopus Hill Optical Observatory site, usually twice a year in April/May and October/November.

Address: Canopus Hill Observatory
Fees: $40 per participant
Contact: Greg Burns (03) 6278-2184
Email: joroco@trump.net.au
Web: www.southcom.com.au/~shevillm/ast/

VICTORIA

AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. The net, conducted by Russell Ward, commences each Friday evening at 10pm EST on 3.543 MHz (LSB). New stations and shortwave listeners are most welcome.

Email: mockrdge@alphalink.com.au
Web: www.asv.org.au/

ASTRONOMY SHOW ON RADIO KLFM

The Bendigo District Astronomical Society has a fortnightly segment on Radio KLFM. This goes to air at 5:30pm on two Saturdays each month. KLFM can be found on 96.5 FM Bendigo and 106.3 FM Castlemaine (Victoria, Australia). The segment can be accessed online.

Contact: Bendigo District Astronomical Society
Web: www.klfm.com.au/audiovault.html

INTRODUCTION TO ASTRONOMY

This course is a hands on introduction to the sky and all manner of astronomy subjects. Viewing sessions are included every week (equipment supplied). Held at Chisholm & Holmesglen TAFE Institutes.

Contact: The TAFE's, or Cris Ellis on 0412 318125
Email: ngc4755@i.net.au

SKYLINE

A pre-recorded information service, run by the Astronomical Society of Victoria, to cover the latest astronomical discoveries. Cost is only the phone call. Updated weekly or more frequently as required.

Contact: (03) 9888-7130
Email: mockrdge@alphalink.com.au
Web: www.asv.org.au/

THE SPACE SHOW

This show is broadcast on radio station 88.3 Southern FM; (88.3 MHz), 7 to 8 pm every Wednesday. Presented by Andrew Rennie.

Contact: (03) 9553 5444
Email: webmaster@southernfm.org.au
Web: www.southernfm.org.au/

VASTROC

Victorian Amateur Astronomical Society's Conventions (VASTROC's) are held every second year (alternating years with NACAA Conventions). Activities include speakers, workshops, poster displays, observing and the convention dinner. For information regarding the 2005 event contact a Melbourne based society.

WESTERN AUSTRALIA

ASTRO TOURS OF THE KIMBERLEY

Since 1995 Astro Tours has offered Astronomy Experiences catering for anyone who has ever looked up in the sky and wondered. They are in Broome from April to December and on Rottnest Island January through March. Two hour shows are run for the general public, schools, community and private groups using a selection of telescopes and binoculars under some of the best skies on the planet.

Address: PO Box 2537 Broome 6725
Contact: Greg Quicke Ph: 0500 831 111 Fax (08) 6210 1468
Email: info@astrotours.net
Web: www.astrotours.net/

ASTRO GUIDES

Astro Guides run regular courses for beginners in Perth, telescopic viewing nights for Schools, groups and parties, packages for schools (including a 114mm telescope and instructions) and directions to build a home for your telescope. All services available outside the metro area by arrangement.

Contact: Keith Galbraith (08) 9307-1353 phone/fax

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. Where given, annual fees are subject to change. We are keen to keep the information in this section 'evergreen'. It would be appreciated if you could keep us informed of any changes (see p. 2 for contact details). The deadline for Astronomy 2005 will be August 1, 2004.

Please note that many societies now have web sites. Links to these can be found on the Quasar web site: www.quasarastronomy.com.au

NEW SOUTH WALES and ACT

ASTRONOMICAL SOCIETY OF COONABARABRAN

Meets on the third Wednesday of each month at 7:30pm at the Imperial Hotel, John Street, Coonabarabran.

Address: c/- AAO Private Bag, Coonabarabran NSW 2357
Fees: $1 joining fee plus $20 annual subscription
Contact: Paul Cass (02) 6842-2994
Email: cpc@aaocbn.aao.gov.au

ASTRONOMICAL SOCIETY OF NSW

The society holds meetings twice per month at the CSIRO, Division of Radio Physics, Pembroke Rd (cnr Vimera Rd), Marsfield.

Address: GPO Box 1123, Sydney, NSW, 2001
Fees: $43 full, $10 juniors (under 18) and $32 student (over 18), $12 for each additional family member. There is no joining fee.
Contact: Adrian Saw (Treasurer) (02) 4572-1568
Email: secretary@asnsw.com
Web: www.asnsw.com/

ASTRONOMICAL SOCIETY OF THE HUNTER

Meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday of each month at 7:30pm.

Address: PO Box 69, Kurri Kurri NSW 2327
Fees: $20 adult, $25 family
Contact: Col Maybury (02) 4937-4664 (ph/fax)
Email: colmay@kooee.com.au

BRITISH ASTRONOMICAL ASSOCIATION - NSW BRANCH

The BAA meets at Sydney Observatory on the third Wednesday of each month, commencing at 7:30pm.

Address: Sydney Observatory, Watson Rd, The Rocks, Sydney 2000
Fees: $40 full, $20 junior/concession and there are family concessions for $60. There is a joining fee.
Contact: Elizabeth Cocking (02) 9398-9705
Email: honsecretary@baansw.asn.au
Web: www.baansw.asn.au

CANBERRA ASTRONOMICAL SOCIETY

CAS meetings are held on the 3rd Thursday of every month (except July and December) starting at 8:00pm. Due to the fire at Mt Stromlo, the society is temporarily meeting at the CSIRO headquarters. Contact John (below) for details.

Address: PO Box 1338, Woden ACT 2606
Contact: John Howard (02) 6248-0552
Web: www.mso.anu.edu.au/cas/

CENTAURUS ASTRONOMICAL SOCIETY

The society is located in Bathurst and hold regular meetings at the Bathurst Observatory.

Fees: Adult $20, family $30, concession & student $15
Contact: Ray Pickard (Bathurst Observatory) (02) 6337-3988
Email: info@bathurstobservatory.com.au
Web: www.bathurstobservatory.com.au

CENTRAL WEST ASTRONOMICAL SOCIETY INC (PARKES)

Meetings are held on the first Friday of the month at the Parkes Observatory Discovery Centre, commencing 7:30pm, visitors welcome.

Address: PO Box 819, Parkes 2870
Fees: $30 adults, $20 students
Contact: John Sarkissian (Pres.)
Email: John.Sarkissian@csiro.au

HAWKESBURY ASTRONOMICAL ASSOCIATION

Meetings are held monthly on the 2nd Wednesday, commencing 7:45pm, in the Tebbutt Rooms at the Windsor Library, Dight St Windsor.

Address: PO Box 670 Windsor NSW 2756
Fees: $20 adult, $30 family and $10 junior.
Contact: Adrian Saw (02) 4572-1568
Email: haa@panthers.net.au
Web: jigsaw.panthers.net.au/haa.html

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC

The society meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus.

Address: PO Box 400, Kingswood NSW 2747
Fees: $30 full, $20 student/concession, $40 family/school groups and $10 for newsletter only.
Contact: Dave Gault (02) 4754-4351
Ted Dobosz (Pres.) (02) 9708-3163
Email: daveg@tpg.com.au
Web: www4.tpgi.com.au/users/wsaag/

WOLLONGONG AMATEUR ASTRONOMY CLUB

Holds monthly meetings on the first Thursday of each month, commencing 7:30pm, at the Unanderra Community Centre, Princess Highway, Unanderra. Visitors are welcome to attend.

Address: PO Box 398, Unanderra NSW 2526
Fees: Membership is $10 per year.
Contact: Andrew Wood (02) 4272-4505
Email: bandawood@bigpond.com
Web: www.users.bigpond.com/paul.b/index.htm

MACARTHUR ASTRONOMICAL SOCIETY

The MAS holds meetings, with guest speakers and workshops, every 3rd Monday of the month at 7:30pm at the University of Western Sydney - Macarthur, Building 22, Room 5.

Address: c/- Secretary, PO Box 17, Minto NSW 2566
Contact: Ian Cook 0415 915 771 Mobile
Email: skyview@zipworld.com.au

SUTHERLAND ASTRONOMICAL SOCIETY

The SAS meets every Thursday at 8pm at the Green Point Observatory near Sutherland (visitors welcome), with the main meeting and guest speaker on the 1st & 4th Thursdays.

Address: PO Box 31, Sutherland NSW 1499
Fees: $40 full, $30 student/associate, $15 junior/pensioners and $50 for families plus joining fee - full/family $25, others $15
Contact: Secretary (02) 9589-1014 (voicemail phone/fax)
Email: sasi@sasi.net.au
Web: www.sasi.net.au/

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC.

Meets at the Port Macquarie Observatory (in Rotary Park, opposite Town Beach) contact for dates and times.

Address: Port Macquarie Astronomical Association Inc
PO Box 1453, Port Macquarie NSW 2444
Contact: Jim Daniel (02) 6583-1933
Email: jaidanl@bigpond.com.au
Web: www.usersbigpond.net.au/esther/

SHOALHAVEN ASTRONOMERS

Meet at the Nowra Hill School on the third Friday of each month at 7:30pm.

Address: PO Box 1053, Nowra NSW 2541
Fees: $25 full membership.
Contact: Jack Apfelbaum (president) (02) 4423-2255
Email: Editor@shoalhavenastronomers.asn.au
Web: www.shoalhavenastronomers.asn.au/index.html

THE NEWCASTLE ASTRONOMICAL SOCIETY

Meetings are held on the last Friday of each month (except December), at the University of Newcastle, Lecture Theatre GP, first floor of Linguistics Building at 7:30pm.

Address: c/- Dept. Physics, University of Newcastle Callaghan NSW 2308
Fees: Adult $25, Child/Pensioner $15, Family $30
Contact: Ghul Hussain (02) 4963 4529; or George Barnes (02) 4967-1057
Email: ggbarnes@idl.net.au or ghulhussain1@bigpond.com
Web: www.newcastle.edu.au/school/math-physical-sci/nas/

UNIVERSITY OF NEW ENGLAND AND NTH. TABLELANDS AS

Meetings are held once per month at the Kirby Observatory on Thursday evenings close to New Moon. Meetings commence 6.30pm (Dec and Jan 8pm).

Address: Ms Anne Parnell, 81 Perrott St Armidale 2350
Fees: $10
Contact: Anne Parnell (02) 6772-1859
Email: msharpe@metz.une.edu.au
charlie@phoenixfoundry.com.au

ILLAWARRA ASTRONOMICAL SOCIETY

Meetings are held at the Wollongong Science Centre and Planetarium on the second Tuesday of each month (except January) at 8pm.

Address: PO Box 1814, Wollongong NSW 2500
Contact: Dave Wheeler (02) 4226-3584
Email: IllawarraAstro@optusnet.com.au
Web: members.optusnet.com.au/~smr/

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC

Meetings are held at the Sports Pavilion, St Ignatius College, Lane Cove on the 3rd Tuesday of each month at 7:30pm.

Address: PO Box 3002, North Turramurra NSW 2074
Fees: $40 adult, $20 student/pensioner and $60 family
Contact: Ron Washington (President) (02) 9949-3544
Email: info@nsas.ozau.net
Web: www.nsas.ozau.net/

NORTHERN TERRITORY

ALICE SPRINGS ASTRONOMICAL SOCIETY

The society holds meetings on the 2nd Monday of each month at the Motor Registry Office, METEL Centre, Nth Stuart Hwy.

Address: Box 739, Alice Springs NT 0871
Fees: $30
Contact: Dan Barnett, President (08) 8953-8039
Bob Oostergaard, Sec (08) 8953-0811
Email: barnett.downunder@bigpond.com
Web: members.ozemail.com.au/~asasinc/

DARWIN ASTRONOMY GROUP

Monthly viewing nights are held during the dry season plus special astronomical events.

Contact: Phillip Smith (08) 8945-9450
Email: hapchap@ozemail.com.au
Web: members.ozemail.com.au/~hapchap/

GOVE AMATEUR ASTRONOMERS

Meets monthly for viewing nights on a Friday close to the New Moon at the local Speedway track, as announced in the local paper the Arafura Times and as shown in our web calendar of events.

Address: PO Box 178 Nhulunbuy NT 0881
Fees: $30 family, $20 single and $15 student
Contact: Ian Maclean 0417 601 490
Email: goveastronomers@yahoo.com.au
Web: au.calendar.yahoo.com/goveastronomers.

QUEENSLAND

ASTRONOMICAL ASSOCIATION OF QUEENSLAND

Meetings are held on the afternoon of the second Saturday of the month at 2:30pm in the lecture theatre of the Sir Thomas Brisbane Planetarium, Mt Coot-tha Botanic Gardens.

Address: PO Box 6101, St. Lucia Qld 4067
Fees: $35 adult, $50 family, $23 student and pensioner.
Contact: Peter Hall (07) 3378-1173
Email: info@aaq.org.au
Web: www.aaq.org.au/

BRISBANE ASTRONOMICAL SOCIETY

Meets on the second Friday of each month at 7:30pm at the Kelvin Grove State High School Library.

Address: Brisbane Astronomical Society Inc
PO Box 892, Brisbane Albert Street Qld 4002
Fees: $30 full, $18 pensioner, $26.50 country, $18 junior, $36 family, $32.50 country family and $50 international, also $5 joining fee.
Contact: BAS Infoline (07) 3321-8511 (recorded club information service)
Email: basmail@bas.asn.au
Web: www.bas.asn.au/

BUNDABERG ASTRONOMICAL SOCIETY

Meetings are held at Alloway Observatory on every Friday at 7:30pm. The first Friday of the month are general meetings and are not held in January.

Address: PO box 4221 South Bundaberg Qld 4670
Fees: $30 adult, $15 junior and $20 country, no joining fee required
Contact: Trish Gibson (07) 4156-5278 or
(07) 4159-7232 (answering service)
Email: iluka@widebay.net.au
Web: www.angelfire.com/al/AstronDirectory/

CAIRNS ASTRONOMY GROUP

Holds monthly meetings from June to November, on the first Saturday of the month, at Bob's place, starting at 7:30pm.

Address: 18 Yurongi St, Caravonica Qld 4878
Fees: $12 per year
Contact: Bob Dollery (07) 4058-1180
Email: jamesbak@bigpond.com
Web: www.users.bigpond.com/jamesbak.htm

MT. ISA ASTRONOMY GROUP

The society meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17km outside of Mount Isa). Meetings are held monthly, usually near the New Moon.

Address: PO Box 1556, Mount Isa Qld 4825
Fees: $40 per year
Contact: Len Fulham (07) 4743-5385 (AH), fax (07) 4743-3381
Email: lfulham@tpgi.com.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY

The society meets on the third Tuesday of the month at Chirmside Library from February to November. Meetings commence at 7:30pm and visitors are welcome.

Address: PO Box 60, Everton Park Qld 4053
Fees: $25 for adults and concession $15, no joining fees are applicable.
Contact: David Larkin (07) 3844-7904
Julie Straayer (07) 3325-2479
Email: dclarkin@optusnet.com.au
Web: homepage.powerup.com.au/~mcerlean/index.html

REDLANDS ASTRONOMICAL SOCIETY

Meets at Ormiston College, Ormiston (27km SE of Brisbane) on the 2nd Tuesday of the month.

Address: PO Box 2048, Wellington Point Qld 4160
Fees: $35 single, $50 family, $20 student (under 18)
Contact: Steve Nissen (President) (07) 3829-0971
Email: snissen@powerup.com.au

BUNDABERG SKYWATCHERS

Meets every Friday night at 7pm, two field nights and one training night each month.

Address: 534 Moorlands Road, Bundaberg Qld 4670
Fees: $10 per year
Contact: Karlene Galway (07) 4159-9674
Email: karlene@interworx.com.au
Web: www.interworx.com.au/users/karlene/

SOUTHERN ASTRONOMICAL SOCIETY

Monthly meetings are held at Pimpama State School, at Hotham Creek Road, Pimpama, on Saturdays (date varies with Moon phase), commencing at 7pm.

Address: PO Box 867, Beenleigh Qld 4207
Fees: $28 adult and $21 student, discount for additional family members
Contact: Kevin Dixon (07) 5537-3852
Web: www.sas.org.au/

SUN COAST ASTRONOMICAL SOCIETY

Meetings are held on the first Saturday of each month at 7pm. Please contact Glen for meeting nights and locations.

Address: 5 Tibrogargan Drive , Beerburrum Qld 4517
Fees: $30 single $40 family
Contact: Glen Lang (07) 5496-0310
Email: langfamily@itconnect.net.au
Web: suncoastastronomy.homestead.com/News.html

TOWNSVILLE ASTRONOMY GROUP

Observe on the Saturday closest to New Moon at Alligator Creek (20km south of Townsville) or at Kelso Dam.

Address: 96 Stagpole St, West End, Townsville QLD 4810
Contact: Murray Gibson Ph. (07) 4772-1339
Email: mgib@tpg.com.au

TROPICAL STARGAZERS

Tropical Stargazers have two branches. The Hamilton Island based group meets regularly during April to December and operates the Great Barrier Reef Observatory. The Mackay section holds regular meetings and viewing nights.

Address: PO Box 40 Hamilton Island Qld 4803
Contact: Ray Johnston (Hamilton Is) (07) 4946-8686
Michael Benedetti (Mackay) 0407 969 889
Email: star@whitsunday.net.au

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA

Meetings are held on the 1st Wednesday of each month (except January) at the University of Adelaide, North Terrace Campus.

Address: GPO Box 199, Adelaide SA 5001
Fees: Full $45, country or concession $35, spouse $25
Contact: (08) 8338-1231
Email: info@assa.org.au
Web: www.assa.org.au/

TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA (AST)

General Meetings are held at either the Canopus Observatory Site at Cambridge or the Hutchins School Conference Centre, Sandy Bay on the last Tuesday of each month except December.

Address: Secretary, Mr. Laurie Priest, PO Box 1654, Hobart Tas 7001
Fees: $45 family, $40 Full Adult Member, Town & Country and $20 Junior (up to age 18 years.)
Contact: Hobart (03) 6244-3476
Launceston - Karenne Barnes (03) 6344-7100
Devonport - Peter Sayers (03) 6424-2588
Email: shevillm@southcom.com.au
Web: www.ast.n3.net

VICTORIA

ASTRONOMICAL SOCIETY OF ALBURY WODONGA

The society meets regularly on the first Wednesday of each month (except January) at Victory Primary School, Drages Road, Wodonga at 8pm.

Address: 1 Poplar St, Wodonga Vic 3690
Fees: $25 Single, $30 Family and $15 Student/Concession
Contact: David Thurley (02) 6040-3704
Email: astronomy@tpg.com.au
Web: www.asaw.tripod.com/

ASTRONOMICAL SOCIETY OF FRANKSTON (ASF)

Meetings are held on the 3rd Wednesday of each month (except December) at 8pm, at the senior school theatrette, Peninsula School, Wooralla Drive, Mt Eliza. Visitors are welcome.

Address: PO Box 596, Frankston Vic 3199
Fees: $35 adult, $30 concession, $25 student, $45 family, $40 family concession, $16 newsletter only, $50 international.
Contact: Peter Skilton (mobile) 0419 253 252
Email: skywatch@iprimus.com.au
Web: www.ASFnet.20m.com/

ASTRONOMICAL SOCIETY OF GEELONG

Meets every Friday at 8:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong.

Address: PO Box 1799, Geelong Vic 3220
Fees: $50 adult, $25 junior/concession.
Contact: Frank Baker Secretary 0407 345 070
Email: robmarineowl@bigpond.com

ASTRONOMICAL SOCIETY OF MELBOURNE

They hold regular club nights and have a dark sky observing site.

Address: PO Box 92, Bentleigh, Vic 3204
Contact: Chris Ellis 0412 318 125 (recorded info line (03) 9517-9250)
Email: ngc4755@i.net.au
Web: www.astromelb.i.net.au/

ASTRONOMICAL SOCIETY OF VICTORIA

Visitors are welcome at the society's general meetings, held at 8pm on the 2nd Wednesday of each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. ASV specialist sections also hold regular meetings.

Address: GPO Box 1059J, Melbourne, Vic 3001
Fees: Metropolitan $48 (family $55); junior (under 18) $30; country/interstate $30 (family $38); seniors $30 (family $38). A joining fee of $20 applies to all categories except Juniors.
Contact: Linda Mockridge (Public Relations Officer) (03) 9888-7130
Email: mockrdge@alphalink.com.au
Web: www.asv.org.au/

BALLARAT ASTRONOMICAL SOCIETY

The BAS holds a general meeting on the second Friday of each month.

Address: PO Box 284, Ballarat Vic 3353
Fees: $30 full, $50 family, $20 associate, junior and pensioner, $10 subscriber (joining fee $5 junior, $10 associate).
Contact: (03) 5332-7526 (society information)
Email: bas@cbl.com.au
Web: observatory.ballarat.net/

LATROBE VALLEY ASTRONOMICAL SOCIETY

The society meets each month (except December and January) at the Wirilda Park and Conference Centre, Tyers, call for details.

Address: PO Box 1298, Traralgon BC, Victoria 3844
Fees: $25 adult, $13 associate $38 family (members living more than 50km from Morwell)
Contact: Gavan Dinsdale (03) 5174 6453
Email: gdinsdal@hotmail.com
Web: home.vicnet.net.au/~lvas/

OASIS STARGAZERS CLUB MILDURA INC

Oasis conduct regular viewing nights, which are open to the public, and once a month have a public activity night.

Address: PO Box 378CP, Mildura Vic 3500
Contact: Kerry Needs (03) 5021-1330 or 0414 535 122
Email: kelpie41@yahoo.com.au
Web: mc2.vicnet.net.au/home/astrogroup/web/index.html

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND

Meetings and dark sky observations are held at 10 Waterholes Rd, Bairnsdale Vic 3875.

Address: 53 Riley St, Bairnsdale Vic 3875
Contact: Mike Finn (03) 5153 2802
Web: www.geocities.com/asegastronomy/Home.html

THE BENDIGO DISTRICT ASTRONOMICAL SOCIETY

The Society meets at the BRiT building (3rd floor of the McCrae Street Campus) at 7.30pm on the fourth Wednesday of each month (excluding January).

Address: PO Box 164 Bendigo Vic 3550
Fees: $28 adult, $15 concession and $40 family
Contact: Neil Linton 03 5448-8352
Email: bdas@astromail.com
Web: www.bendigo.net.au/~rbath/bdas

WESTERN AUSTRALIA

ASTRONOMICAL GROUP OF WA (AGWA)

The group meets at 7pm on the first Tuesday of every month (see address below). Visitors are welcome.

Address: 159A Scarborough Beach Rd Mount Hawthorn WA 6016
Contact: Keith Williams (08) 9201-0895
Email: btow@iinet.net.au

ASTRONOMICAL SOCIETY OF THE SOUTH WEST

Observing nights are held at their observatory south of Bunbury on the two Fridays before the new moon.

Address: PO Box 1100, Bunbury, WA 6231
Fees: Ordinary $25, Junior/Concession $10, Family $40.
Contact: Phil Smith (08) 9721 1586
Email: asthecrowflieswest@hotmail.com

THE ASTRONOMICAL SOCIETY OF WA

The society meets at 8pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como.

Address: PO Box 421 Subiaco WA 6008
Fees: Ordinary Member: $20 Nomination $50 Subscription
Associate Member:$15 Nomination $30 Subscription
Junior Member (U18):$15 Nomination $20 Subscription
(Approx. 20% discount for Country Members)
Contact: (08) 9299 6347
Email: aswa@aswa.info
Web: aswa.info/

THE MURDOCH ASTRONOMICAL SOCIETY

Meetings are conducted each month at the University and consist of informal talks, guest speakers, slide shows and observation reports.

Address: c/- Murdoch Uni. Physics and Energy Studies, Murdoch WA 6150
Fees: $30 per year
Email: mas@science.murdoch.edu.au
Web: wwwscience.murdoch.edu.au/interest/mas/

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. (A complete reflection gives an albedo of 1.0 or 100%).

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 co-ordinates 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 or radians.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a comet, planet or minor planet 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***

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See ***Minor Planet***.

Astrology A complete waste of time. See ***rubbish.***

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 AU.

Azimuth Horizontal co-ordinate 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 and 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.

Comet Small icy body that orbits the Sun and produces 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 the Earth, an ***inferior planet*** (Mercury or Venus) and the Sun are in a line in that order.

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 gods, people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the whole 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 observers horizon.

Declination (Dec) One part of the equatorial co-ordinate 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 similar 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 into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow cone 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 elongation of Mercury and Venus occur when the planets are at their most 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 co-ordinate 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 21st, and autumnal or fall equinox about March 22nd.

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 disk 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 the reference is the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is Mercury and Venus.

Julian date The number of days since noon on 1st 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***.

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 2.512. 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 apparent magnitude a star would have if it were placed at 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 of an 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 Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Minute of arc An angular measure (each degree is divided in 60 minutes of arc).

Mira A variable star in the ***constellation*** of Cetus, with a range in brightness from 2nd to 10th ***magnitude***, and a mean period of 331 days. Known as Mira the Wonderful, it is the brightest and most famous of the long period pulsating variables.

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 a planet's polar to its equatorial diameter.

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.

Omega Centauri A globular star cluster in the ***constellation*** of Centaurus. Globulars are made up of tens of thousands of stars and form a shell around our galaxy. Omega Centauri and 47 Tucanae are two of the finest examples of these objects.

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.

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 arc second.

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.

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. Thought to be the outer layers of a red giant during its latter stages of 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 A configuration that 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 which occurs near opposition (outer planets) or near inferior conjunction (inner planets).

Right ascension (R.A.) Part of the equatorial co-ordinate 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 similar to lines of longitude on the Earth but is measured in hours (24hrs = 360°).

Rubbish See ***astrology***

Second of arc An angular measure. Each degree contains 3600 seconds of arc, and each ***minute of arc*** contains 60 seconds.

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23hrs 56m 4s of normal solar time.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way system, 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 June 21st marks the shortest day of the year, and around December 21st 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 period of a planet's orbit with respect to the 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

A, α	Alpha	E, ε	Epsilon	I, ι	Iota	N, ν	Nu	P, ρ	Rho	Φ,φ	Phi
B, β	Beta	Z, ζ	Zeta	K, κ	Kappa	Ξ, ξ	Xi	Σ, σ	Sigma	X, χ	Chi
Γ, γ	Gamma	H, η	Eta	Λ, λ	Lambda	O, o	Omicron	T, τ	Tau	Ψ, ψ	Psi
Δ, δ	Delta	Θ,θ, ϑ	Theta	M, μ	Mu	Π, π	Pi	Y, υ	Upsilon	Ω, ω	Omega

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Have you ever gazed at the beauty of the night sky and wondered:

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Which constellation is that?

Why do some 'stars' move from night to night?

Which planet is that?

Where is the Moon?

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