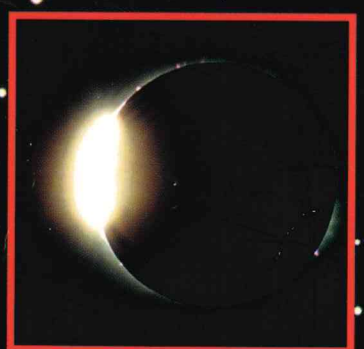
# ASTRONOMY 2002

WESTERN AUSTRALIAN EDITION



Total Solar Eclipse in South Australia this Year!

PERTH OBSERVATORY

## A PRACTICAL GUIDE TO THE NIGHT SKY

Glenn Dawes Peter Northfield Ken Wallace

# 2002

### January

| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 ◐ | 7 | 8 | 9 | 10 | 11 | 12 |
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| 26 ○ | 27 | 28 | 29 | 30 | 31 | |

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| 30 | | | | | | |

### July

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### December

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| 15 | 16 | 17 | 18 | 19 | 20 ○ | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 ◐ | 28 |
| 29 | 30 | 31 | | | | |

● New Moon ◑ First Quarter ○ Full Moon ◐ Last Quarter

# ASTRONOMY 2002

## WESTERN AUSTRALIAN EDITION

A PRACTICAL
GUIDE TO
THE NIGHT
SKY

GLENN DAWES
KEN WALLACE
PETER NORTHFIELD

QUASAR PUBLISHING
2001

ISBN 0 9585906 7 2

First published November 2001 by:

Quasar Publishing
PO Box 85
Georges Hall NSW 2198
Australia

Fax: (02) 9636 9097
email: info@quasarastronomy.com.au
web: www.quasarastronomy.com.au

Additional copies of this **Western Australian Edition** may be purchased directly from Perth Observatory Phone (08) 9293 8255 or Fax (08) 9293 8138

For more information on, or copies of **ASTRONOMY 2001 Eastern Australian Edition**; contact Quasar Publishing (as above).

# TABLE OF CONTENTS

# INTRODUCTION TO THE 2002 EDITION

Welcome to Astronomy 2002.

Our lead article this year is a guide to the total solar eclipse visible from South Australia in December. Although being far from ideal, including a little isolated, it is still a rare event to most of us. Unless of course you have lots of money and are willing to travel anywhere in the world. Whether you see totality for half a minute, as from Ceduna, or 7 minutes (an ideal eclipse) it can be a magic and very personal experience. For those 'chasing the shadow' we wish you good luck and no clouds!

A positive aspect of doing this yearbook is the opportunity it presents to highlight the excellent work being done by fellow Australian enthusiasts. Sydney astrophotographer, Joe Cauchi, gives us a feel for his background in this technically demanding area of our hobby. There is also a taste for how a normal 35mm camera can be used to make real discoveries. Just when you thought you knew the constellations, we introduce the Emu?

Throughout this publication you will find various internet addresses. You will find links to many of these on the recently upgraded Quasar Publishing web site:

www.quasarastronomy.com.au

In fact many of the various astronomical institutions and societies listed in the appendices have web pages which may or may not be included here. Links to these can be found on our site as well.

With regards to observing in 2002:

- The Total Solar Eclipse in South Australia must take top billing (see article commencing next page)
- The continual dance of the planets across the sky culminates in May this year with an early evening spectacular conjunction of all 5 naked eye planets.

This edition has been designed for observers in Western Australia. A separate Eastern Australian edition is also available from the publishers.

Part I 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 your way around the night sky. The planets can be identified and 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.

As in previous editions of this yearbook, the authors 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.

Wishing you clear skies and many hours of enjoyable observing.

*Glenn Dawes* *Peter Northfield* *Ken Wallace*

# ACKNOWLEDGEMENTS

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

- Astronomical Almanac for the Year 2002 (US Naval and Royal Greenwich Observatories)
- Astronomical Tables of the Sun, Moon and Planets (Jean Meeus)
- Comet orbital elements courtesy International Astronomical Union
- Fifty Year Canon of Lunar Eclipses 1986 - 2035 (NASA RP1216)
- Fifty Year Canon of Solar Eclipses 1986 - 2035 (NASA RP1178)
- Eclipse information based on predictions courtesy of Fred Espenak, NASA/GSFC
- Institut de Mecanique Celeste (IMCCE) - Paris Observatory for Jupiter satellite events
- Burnham's Celestial Handbook (Robert Burnham Jnr.)
- Dawes Meteorological Journal
- Guide to Observing the Moon (BAA)
- Moon Observers Handbook (Price)
- International Meteor Organisation Calendar

Data was also prepared with the assistance of the following computer software:

- MICA ver 1.5 (US Naval Observatory)
- Occult ver 4.2 (David Herald)
- Deep Space ver 5.56 (David Chandler Company)
- Voyager II, the Interactive Desktop Planetarium ver 2 (Carina Software)
- TheSky for Mac ver 5 (Software Bisque)

Special thanks are extended to Daniel Tickell for his contribution. Also to Greg Bryant for the comet text and monthly comet highlights.

We would also like to thank the following for assistance in proofreading (certainly an important part of this complex publication): Greg Bryant, Brenda McNamara, Richard Jaworski, Rob McIntyre, Elise Dott and Sue Dawes (typing and proofreading).

**Illustrations**

- The front cover is the Hydra Cluster of Galaxies (Abell 1060). Photographed by David Malin at the Anglo-Australian Observatory © AAO/D. Malin.
- Photographs by Sydney amateur, Joe Cauchi.
  - Page 17 the images of the Trifid Nebula (250mm $f/4$, 12 mins, hypered 2415) and the Orion Nebula (250mm $f/5$, 12 mins, 103aE film).
- Photo of Joe Cauchi (p. 21) supplied by Joe.
- Solar eclipse photographs by Peter Anderson, Queensland, from northern Zimbabwe 21 June 2001, using a Meade ETX 90 at $f/14$. Kodak ISO 100 print film and aluminised filter (partial phase, p. 7) and Kodak ISO 400 print film for the diamond ring, (front cover) and the total phase (p. 5)
- Comet C/2001 A2 (LINEAR) image (p. 33) by Gordon Garradd.
- Rear cover photo is Comet C/2001 A2 (LINEAR) by Roger North, Kings Tableland Observatory (Takahashi 106mm $f/5$ refractor, 15 mins using Fuji 400).

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

# IN THE SHADOW OF THE MOON - December 4th 2002

## (A Guide to Observing the South Australian Total Solar Eclipse)

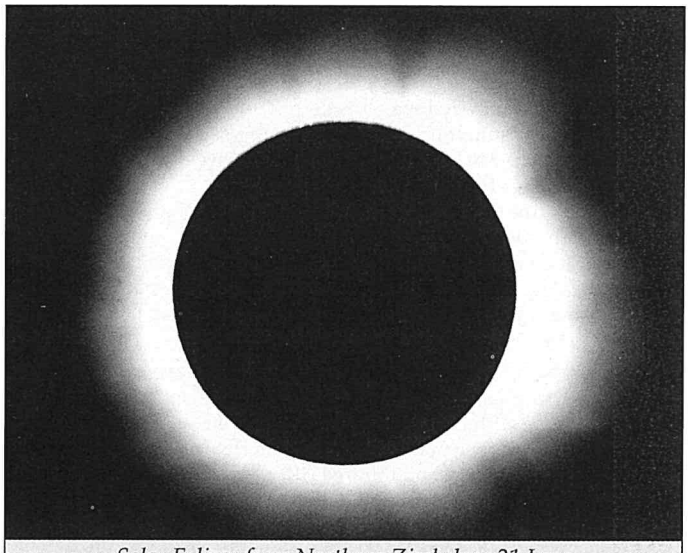
On the 4th December 2002, the Sun will be totally eclipsed by the Moon. This total eclipse is special in that it is visible from Australia, the first in over a quarter of a century. As the shadow of the Moon sweeps across the Earth at around 1600 km per hour, people from the far reaches of our planet will gather under the narrow path of totality to witness one of nature's most extraordinary and exquisite events.

The path of totality begins off the West Coast of Southern Africa and makes first landfall over Angola. Briefly crossing Zambia and Namibia, the path follows the Zimbabwe-Botswana border and exits the continent at Mozambique.

The track then begins the long journey across the Indian Ocean before reaching the South Australian coastal town of Ceduna. This historic moment marks the first time since 23rd October 1976 that the path of totality has touched Australian soil. The shadow continues beyond Ceduna across predominantly inhospitable outback terrain, passing just north of Woomera and finally ending in Queensland when the Sun sets, just beyond where the Queensland, New South Wales and South Australian borders meet (see figure 1).

Figuratively speaking this eclipse is in our own backyard, however there are some vast distances to be covered; the township of Ceduna for example is 775 km from Adelaide, a good day's drive. If motoring from interstate we would advise some careful planning before the trip. The main viewing sites, although remote for the majority of the Australian population, are at least accessible.

The Australian outback is a harsh and arid environment, and even in early summer temperatures of 40°C and over are possible. The following simple rules for outback travel should be observed: stay on main roads, carry ample water, check road and weather conditions before travel, do not leave your vehicle if a breakdown occurs, and with service stations few and far between make sure you have sufficient fuel.



*Solar Eclipse from Northern Zimbabwe 21 June 2001 (Total Phase) by Peter Anderson, Queensland*

In addition, you should leave details of your travel plans with someone else, particularly if travelling off the main roads.

From South Australia, this sunset eclipse is short and low to the horizon. These two factors do not make for a perfect eclipse, but arguably even 30 seconds of totality at any altitude is better than nothing. Another quandary with this eclipse is that there are only three locations easily accessed for viewing. Should the weather deteriorate at a particular spot, there will not be enough time to reach another site on the day, the distances are simply too vast.

Accommodation near the path has been booked out for over a year, so late planners may need to search further afield. This is perhaps not a bad thing and accommodation near the Port Augusta region, at the head of Spencer's Gulf, will at least place the eclipse chaser at the crossroads to each of the possible viewing sites. A base such as this will provide time to evaluate the weather conditions and make a final dash to your preferred site. Many will simply choose to 'rough it' in tent or vehicle, ready and mobile for a quick departure to the clearest skies.

The coastal town of Ceduna (figure 3) will probably entice most eclipse watchers, particularly those from overseas. Ceduna is located on the eastern side of the Great Australian Bight on the attractive shores of Murat Bay, around 470 km from Port Augusta and 775 km from Adelaide. To the west, the next major town, Norseman is 1200 km away, and Perth 1960 km. Ceduna is a stopover en-route to Western Australia, and caters well to travellers with all facilities available.

Woomera (figure 4) is another option lying 485 km from Adelaide and 180 km from Port Augusta. However, the path does not directly pass over Woomera, but rather about 70 km west of the town along the Stuart Highway near Wirraminna, a rail siding on the Trans-Australian Railway. An alternative site is on the Roxby Downs Road about 45 km north of Woomera near Purple Downs station. The nearest facilities to Wirraminna and Purple Downs are back at Woomera, where all

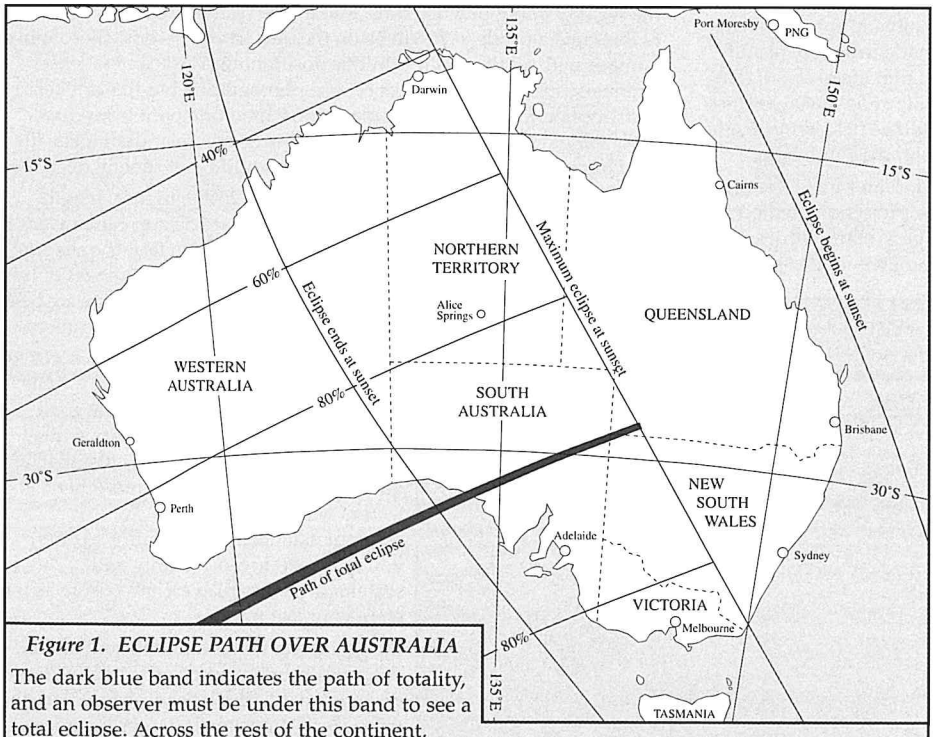



***Figure 1. ECLIPSE PATH OVER AUSTRALIA***

The dark blue band indicates the path of totality, and an observer must be under this band to see a total eclipse. Across the rest of the continent, varying degrees of a partial eclipse will be seen. For the partial phases; If situated left (west) of the 'Eclipse ends at sunset' line, the eclipse will be seen in its entirety. If on the 'Maximum eclipse at sunset' line, an observer will see the eclipsed Sun set during maximum or mid-eclipse. Between this line and the 'Eclipse ends at sunset' line the Sun will set before the partial phases are over. On the 'Eclipse begins at sunset' line, no part of the eclipse can be seen. If left (west) of this line (and before the 'Maximum eclipse at sunset' line) the partial phases prior to maximum or mid-eclipse will be seen before the Sun sets. The lines running parallel to the total path indicate the percentage of the Sun's diameter eclipsed by the Moon. The further from the total path, the less of the Sun is covered by the Moon.

facilities are available. The final possibility is just north of the small town of Lyndhurst, 290 km north of Port Augusta. At the start of the Strzelecki Track, the Lyndhurst area is the least favoured site with the eclipse at very low altitude.

As the crow flies, from Ceduna, the distance to Wirraminna is 260 km, Purple Downs 340 km, and Lyndhurst 500 km. The further from the coast, the lower the Sun and Moon to the horizon: from Ceduna 9° altitude, Wirraminna and Purple Downs 6°, and Lyndhurst 4°. The duration of totality also reduces further inland, but is of less concern than the altitude loss. From Ceduna, you can expect 33 seconds of totality and from the Lyndhurst region 27 seconds (see table 'Eclipse Mapping Coordinates' on p. 7).

Figure 2. The partial phase of the eclipse from outside of the totality zone for various locations. The appearance from Sydney and Brisbane are shown 10 mins before sunset, prior to mid-eclipse, other locations are at mid-eclipse when the maximum amount of the solar disk is covered. For Perth 4th contact (end of eclipse) is 6:09pm WAST.

| City | Perth | Darwin | Adelaide | Melbourne | Hobart | Sydney | Brisbane |
|---|---|---|---|---|---|---|---|
| 1st contact | 4:02pm WAST | 6:06pm ACST | 5:42pm ACST | 6:12pm AEST | 6:09pm AEST | 6:15pm AEST | 6:17pm AEST |
| mid eclipse | 5:07pm WAST | 6:57pm ACST | 6:39pm ACST | 7:03pm AEST | 6:57pm AEST | 6:42pm AEST | 6:22pm AEST |

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

Avoid the use of photographic neutral density filters (of *any* density), smoked glass and exposed photographic film; these can transmit UV and IR radiation. Perfectly safe for the partial phases are purpose made, hand held aluminium coated Mylar filters, which can be purchased already supported in a cardboard frame, and even 'spectacles' are available. A number 14 welder's filter also will work. These products are useful for checking the Sun at any time for large sunspots.

A very simple and safe method to watch the partial progress of the eclipse is to project the Sun's image through a small hole onto a screen. A hole 1 to 5 millimeters in diameter should be made in a piece of stiff paper or card (alternately drill a hole in a piece of thin metal sheet). The image of the Sun is then projected through this hole and viewed against a screen of white paper or board. The screen should be held about 20 cm behind a 1 mm hole, and about 1 to 1.5 meters behind a 5 mm hole.

Along the same theme, but with a magnified and clearer image, is the eyepiece projection method with a telescope. The projection method is low-cost and easy (providing you have a telescope to start with), and enables more than one observer to monitor the progress of the eclipse.

It is preferable to use a Ramsden or Huygenian eyepiece or any old cheap unwanted eyepiece. The intense heat at the focal point can damage eyepieces with cemented elements. Detail in sunspots can be discerned with this method, and a projected image around twice the diameter of the objective provides excellent results.

Direct observation through an instrument using filters is quite safe, provided the filters are specifically designed for this purpose. These filters are fitted to the *front* of the telescope, and are usually either aluminium coated Mylar or nickel chromium coated glass. The economical Mylar filters do show the Sun in an unusual blue light, whereas the expensive glass filters provide a pleasant yellow/orangish image.

If you intend watching the evolution of sunspots across the solar disk as a future long-term interest, the nickel chromium coated glass filters are recommended. **NEVER** use filters that go over the eyepiece, they can crack with the now focussed intense heat, allowing the highly magnified Sun's heat through. Ensure any filter is fastened securely, and do not forget to cap the objective lens of the finderscope, a likely source of a nasty burn!

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

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

Telephoto lenses and telescopes in the 200 to 2000 mm focal length range will give good results, and even a standard 50 mm camera lens is useful for photographing the changing landscape. In fact, the shadow bands and projected crescent images of the eclipse through gaps in tree foliage are best with the 'standard' lens on a SLR camera.

Allow a few seconds between exposures to let vibration dampen out, and use a cable release. It is best to settle for a few good shots than numerous blurred exposures. The exposure guide (page 8) is just that, a guide. Natural sky filtering and other factors will influence these recommendations. With totality so brief, you will need to work calmly and systematically, so plan each exposure as if it were your last frame.

Image size on film is all-important and is determined by the focal length of the lens or telescope used. The longer the focal length, the larger the image, the larger the image the better it is for blowing up. To determine the image size, simply multiply the effective focal length of your instrument, in millimetres, by the diameter of the Sun/Moon in seconds of arc (1,800"), then divide the result by 202,265; the resultant answer is the image size in millimetres.

If applying the above formula to a 50mm lens, we get an image on film a little less than

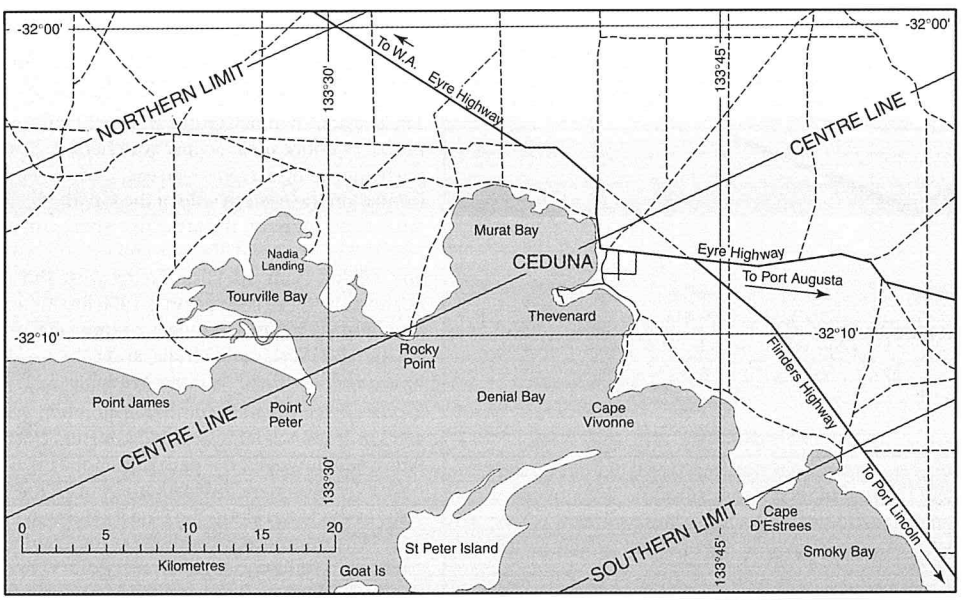



*Figure 3. Ceduna and surrounds. Roads shown as solid lines are sealed main roads, dashed are unsealed main and minor roads. The centre line passes almost directly through the centre of Ceduna and there are many vantage points including several with scenic views across the bay.*

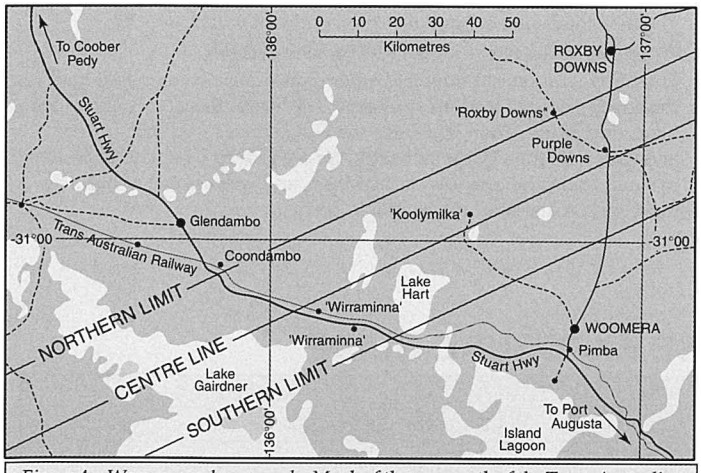


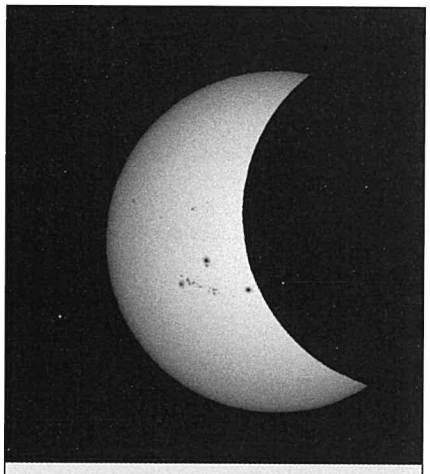

*Figure 4. Woomera and surrounds. Much of the area north of the Trans Australian Railway and west of the Woomera/Roxby Downs road is the Woomera Prohibited area.*

half a millimetre (50 x 1,800/202,265 = 0.44mm); certainly not an acceptable size for detail or enlargement. Moving up to a 500 mm lens things improve (500 x 1,800/202,265 = 4.45mm), and a 15 times enlargement will deliver an image about 68 mm in diameter. Working with the popular 2,000mm Schmidt-Cassegrain telescopes we achieve (2,000 x 1,800/202,265 = 17.80mm), an ample image size for enlargement.

While we are talking about trial runs, if possible, it might be advisable to find your observing site a day or two before the event. With the eclipse occurring so low in the sky, it is not a good time to discover 30 minutes before totality that the Sun is going behind a hill! Take careful note of the where the Sun will be relative to the horizon and its local altitude at the time of totality. The Sun during totality will be very close to WSW (also see Sky View p. 63). This can be an opportunity to be a little artistic, especially if you are including a reasonably wide-angle lens in your arsenal of cameras e.g., put the Sun below the limbs of a dead tree? Can you get the eclipsed Sun and its reflection in a lake? Your imagination is the limit.

What can you expect to see? Firstly, the eclipse begins as the Moon makes a slight indentation on the western limb of the Sun (point of first contact). From Ceduna this will occur about 5:43pm ACST (6:43pm daylight saving time). For the next hour, the Sun's disk diminishes steadily as the black body of the Moon passes over it. Nervous watchers waiting for the ephemeral moment of totality will be making last minute checks of cameras and telescopes.

Near totality, with the Moon covering most of the Sun, the surrounding landscape starts to turn an eerie gray, with shadows disappearing. The temperature begins to drop and a breeze develops. With solar eclipses, higher in the sky than the Australian one, it is normally worthwhile looking for thousands of tiny crescents visible on the ground beneath the trees. The small gaps in the foliage act in the same manner as a pinhole camera. Perhaps in December it might be worthwhile looking for the effect in shadows of trees on nearby walls of buildings? Gray shadow bands rippling across the ground are also seen during eclipses. This is an effect of atmospheric turbulence.



*Solar Eclipse from Northern Zimbabwe 21 June 2001 (Partial Phase) by Peter Anderson, Queensland*

Only seconds before totality, the umbra of the Moon's shadow can be seen racing across the countryside. The Sun's limb abruptly breaks into a series of tiny bright beads. Known as Baily's Beads, they are formed as the Sun shines between mountain peaks and craters on the lunar limb. A phenomenon known as the diamond-ring effect appears as the last bead appears ring-like together with the Sun's inner corona.

After the beads vanish (second contact), the Sun's inner atmosphere, the chromosphere (meaning 'colour sphere') appears for a few seconds as a reddish zone around the lunar limb. At this point, when totality begins, it is safe to view the Sun without any filters. The elusive prominences are now easily seen, projecting out from the limb in all their red and pink splendour. Then the Sun's faint tenuous outer atmosphere, the corona, appears, surrounding the Moon's black silhouette. The pearly white corona displays a petal structure, much like a flower.

# Eclipse Mapping Coordinates

| Longitude | LATITUDE | | | CIRCUMSTANCES ON CENTRE LINE | | | | |
|---|---|---|---|---|---|---|---|---|
| | Northern Limit | Southern Limit | Centre Line | Universal Time | Sun Alt | Sun Azi | Path Width | Central Duration |
| 130° 00.0' | 33° 21.38' | 33° 45.68' | 33° 33.49' | 09:09:11 | 12° | 251° | 41km | 37.4s |
| 130° 15.0' | 33° 15.67' | 33° 39.81' | 33° 27.69' | 09:09:17 | 12° | 251° | 41km | 37.0s |
| 130° 30.0' | 33° 09.93' | 33° 33.92' | 33° 21.88' | 09:09:23 | 12° | 251° | 40km | 36.7s |
| 130° 45.0' | 33° 04.18' | 33° 28.01' | 33° 16.05' | 09:09:29 | 12° | 251° | 40km | 36.4s |
| 131° 00.0' | 32° 58.42' | 33° 22.09' | 33° 10.21' | 09:09:34 | 11° | 251° | 40km | 36.0s |
| 131° 15.0' | 32° 52.64' | 33° 16.15' | 33° 04.35' | 09:09:40 | 11° | 251° | 39km | 35.7s |
| 131° 30.0' | 32° 46.84' | 33° 10.19' | 32° 58.47' | 09:09:45 | 11° | 250° | 39km | 35.4s |
| 131° 45.0' | 32° 41.03' | 33° 04.22' | 32° 52.58' | 09:09:51 | 11° | 250° | 39km | 35.1s |
| 132° 15.0' | 32° 29.37' | 32° 52.24' | 32° 40.76' | 09:10:01 | 10° | 250° | 38km | 34.4s |
| 132° 30.0' | 32° 23.52' | 32° 46.22' | 32° 34.83' | 09:10:06 | 10° | 250° | 38km | 34.1s |
| 132° 45.0' | 32° 17.65' | 32° 40.20' | 32° 28.88' | 09:10:11 | 10° | 250° | 38km | 33.8s |
| 133° 00.0' | 32° 11.77' | 32° 34.15' | 32° 22.92' | 09:10:16 | 9° | 249° | 37km | 33.5s |
| 133° 15.0' | 32° 05.88' | 32° 28.10' | 32° 16.95' | 09:10:20 | 9° | 249° | 37km | 33.1s |
| 133° 30.0' | 31° 59.97' | 32° 22.03' | 32° 10.96' | 09:10:25 | 9° | 249° | 37km | 32.8s |
| 133° 45.0' | 31° 54.05' | 32° 15.95' | 32° 04.96' | 09:10:29 | 9° | 249° | 37km | 32.5s |
| 134° 00.0' | 31° 48.12' | 32° 09.85' | 31° 58.95' | 09:10:33 | 8° | 249° | 36km | 32.2s |
| 134° 15.0' | 31° 42.18' | 32° 03.74' | 31° 52.92' | 09:10:37 | 8° | 249° | 36km | 31.9s |
| 134° 30.0' | 31° 36.22' | 31° 57.62' | 31° 46.88' | 09:10:41 | 8° | 249° | 36km | 31.6s |
| 134° 45.0' | 31° 30.25' | 31° 51.49' | 31° 40.83' | 09:10:45 | 8° | 248° | 35km | 31.3s |
| 135° 00.0' | 31° 24.27' | 31° 45.34' | 31° 34.77' | 09:10:49 | 7° | 248° | 35km | 31.0s |
| 135° 15.0' | 31° 18.28' | 31° 39.19' | 31° 28.69' | 09:10:52 | 7° | 248° | 35km | 30.6s |
| 135° 30.0' | 31° 12.28' | 31° 33.02' | 31° 22.61' | 09:10:56 | 7° | 248° | 35km | 30.3s |
| 135° 45.0' | 31° 06.27' | 31° 26.84' | 31° 16.51' | 09:10:59 | 7° | 248° | 34km | 30.0s |

| Longitude | LATITUDE | | | CIRCUMSTANCES ON CENTRE LINE | | | | |
|---|---|---|---|---|---|---|---|---|
| | Northern Limit | Southern Limit | Centre Line | Universal Time | Sun Alt | Sun Azi | Path Width | Central Duration |
| 136° 00.0' | 31° 00.24' | 31° 20.65' | 31° 10.40' | 09:11:02 | 6° | 248° | 34km | 29.7s |
| 136° 15.0' | 30° 54.20' | 31° 14.44' | 31° 04.28' | 09:11:05 | 6° | 248° | 34km | 29.4s |
| 136° 30.0' | 30° 48.16' | 31° 08.23' | 30° 58.16' | 09:11:08 | 6° | 248° | 33km | 29.1s |
| 136° 45.0' | 30° 42.10' | 31° 02.01' | 30° 52.02' | 09:11:11 | 6° | 247° | 33km | 28.8s |
| 137° 00.0' | 30° 36.04' | 30° 55.77' | 30° 45.87' | 09:11:14 | 5° | 247° | 33km | 28.5s |
| 137° 15.0' | 30° 29.96' | 30° 49.53' | 30° 39.71' | 09:11:16 | 5° | 247° | 33km | 28.2s |
| 137° 30.0' | 30° 23.87' | 30° 43.27' | 30° 33.54' | 09:11:19 | 5° | 247° | 32km | 27.9s |
| 137° 45.0' | 30° 17.78' | 30° 37.01' | 30° 27.36' | 09:11:21 | 5° | 247° | 32km | 27.6s |
| 138° 00.0' | 30° 11.67' | 30° 30.73' | 30° 21.17' | 09:11:24 | 4° | 247° | 32km | 27.3s |
| 138° 15.0' | 30° 05.56' | 30° 24.45' | 30° 14.97' | 09:11:26 | 4° | 247° | 31km | 27.0s |
| 138° 30.0' | 29° 59.44' | 30° 18.16' | 30° 08.76' | 09:11:28 | 4° | 246° | 31km | 26.7s |
| 138° 45.0' | 29° 53.31' | 30° 11.86' | 30° 02.55' | 09:11:29 | 4° | 246° | 31km | 26.4s |
| 139° 00.0' | 29° 47.17' | 30° 05.55' | 29° 56.32' | 09:11:31 | 3° | 246° | 31km | 26.1s |
| 139° 15.0' | 29° 41.02' | 29° 59.23' | 29° 50.09' | 09:11:33 | 3° | 246° | 30km | 25.8s |
| 139° 30.0' | 29° 34.87' | 29° 52.91' | 29° 43.85' | 09:11:34 | 3° | 246° | 30km | 25.6s |
| 139° 45.0' | 29° 28.70' | 29° 46.58' | 29° 37.60' | 09:11:36 | 3° | 246° | 30km | 25.3s |
| 140° 00.0' | 29° 22.53' | 29° 40.23' | 29° 31.35' | 09:11:37 | 2° | 246° | 30km | 25.0s |
| 140° 15.0' | 29° 16.35' | 29° 33.89' | 29° 25.09' | 09:11:38 | 2° | 246° | 29km | 24.7s |
| 140° 30.0' | 29° 10.17' | 29° 27.53' | 29° 18.82' | 09:11:39 | 2° | 245° | 29km | 24.4s |
| 140° 45.0' | 29° 03.98' | 29° 21.17' | 29° 12.54' | 09:11:40 | 2° | 245° | 29km | 24.1s |
| 141° 00.0' | 28° 57.78' | 29° 14.80' | 29° 06.26' | 09:11:41 | 1° | 245° | 28km | 23.8s |
| 141° 15.0' | 28° 51.57' | 29° 08.42' | 28° 59.96' | 09:11:41 | 1° | 245° | 28km | 23.6s |
| 141° 30.0' | 28° 45.36' | 29° 02.04' | 28° 53.67' | 09:11:42 | 1° | 245° | 28km | 23.3s |

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

The next total solar eclipse over our continent will be on 13th November 2012, passing over Cairns, Queensland.

The Earth's Moon is unique; no other planet has a satellite that matches the angular size of the Sun so closely. The Sun's diameter is about 400 times that of the Moon, but since the Sun is about 400 times further away their diameters match neatly. We are indeed fortunate to be able to stand under the shadow of the Moon, and witness one of nature's most spectacular and unforgettable events.

## TOTAL SOLAR ECLIPSE EXPOSURE GUIDE

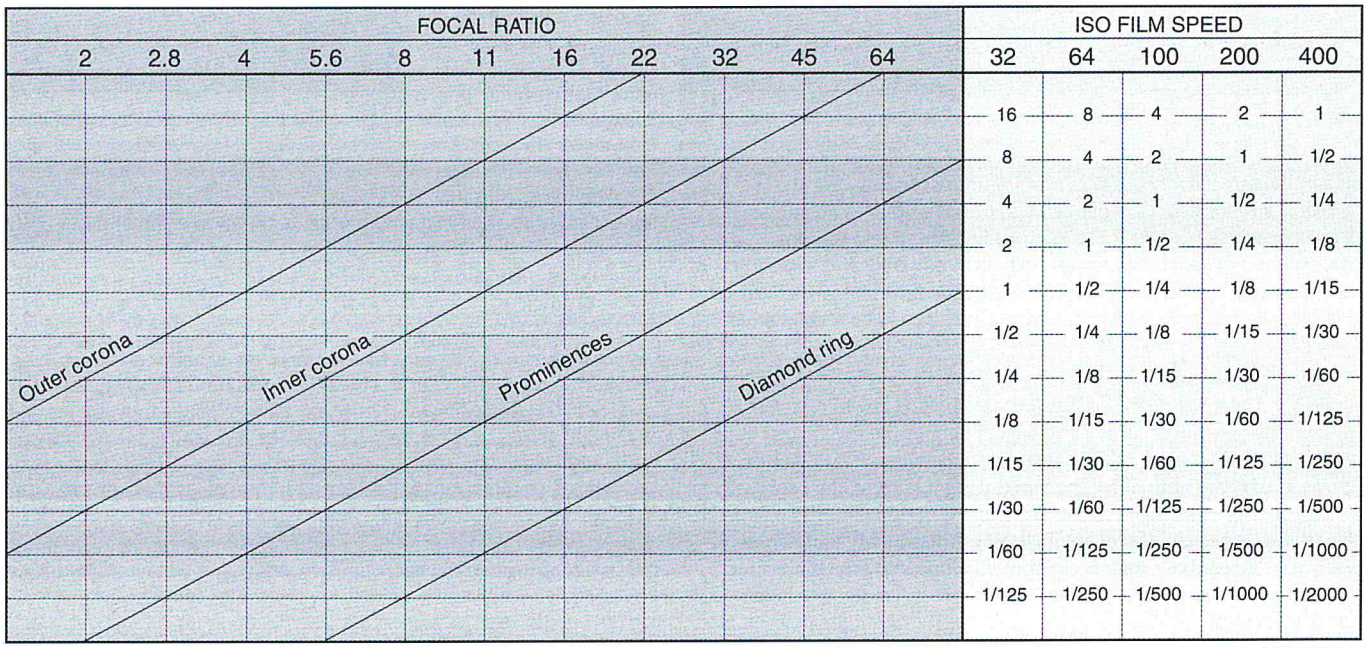



*FIGURE 3. Select the focal ratio that nearest matches your camera/telephoto/telescope combination from the grey section of the guide. Draw a vertical line until it meets a diagonal line that represents the part of the eclipse to be photographed. Then follow the horizontal line at the intersection point to the blue section to determine the exposure required with various speed films.*

# OTHER SOLAR AND LUNAR ECLIPSES FOR 2002

During 2002 there are four other eclipses, one of the Sun and three of the Moon. The other solar eclipse is annular and the three lunar eclipses are all penumbral. 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.

Please note, all times listed below are in UT.

**PENUMBRAL LUNAR ECLIPSE - 26th May 2002**

The first of the lunar eclipses is visible over the Pacific region and Australia. The penumbra magnitude at mid-eclipse is 0.71, just deep enough to subtlety shade the Moon's far southern regions. Observers will need to look carefully, as anything less than 0.7 is generally considered too difficult to see. Binoculars will help in detecting the faint penumbral portion of the Earth's shadow.

| | |
|---|---|
| Moon enters penumbra | 26d 10h 12.7m UT |
| Middle of eclipse | 26d 12h 03.3m |
| Moon leaves penumbra | 26d 13h 53.8m |

**ANNULAR SOLAR ECLIPSE – 10/11th June 2002**

With the exception of some small Indonesian islands, the path of annularity of this eclipse is solely over water. The track starts just north of the equator in the Celebes Sea, and then crosses the Pacific Ocean, ending just off the Mexican coast. From parts of the northern regions of Australia the partially eclipsed Sun will be seen at sunrise on the 11th. From Broome, Alice Springs and Darwin the partial phases begin before sunrise, from Cairns the partial eclipse is visible in its entirety.

**PENUMBRAL LUNAR ECLIPSE - 24th June 2002**

Technically this eclipse is visible from Europe, Africa, Asia and Australia. In reality, with the penumbra magnitude at mid-eclipse only 0.23 (just under a quarter of the Moon's diameter), this is not deep enough for the Earth's shadow to be noticed against the lunar surface.

| | |
|---|---|
| Moon enters penumbra | 24d 20h 18.4m UT |
| Middle of eclipse | 24d 21h 27.1m |
| Moon leaves penumbra | 24d 22h 35.4m |

**PENUMBRAL LUNAR ECLIPSE - 19/20th November 2002**

The last penumbral eclipse this year is not visible from Australia. From Europe, Africa, and the Americas, observers will see some darkening on the Moon's northern limb as it dips in the penumbral shadow with a magnitude of 0.89.

| | |
|---|---|
| Moon enters penumbra | 19d 23h 32.0m UT |
| Middle of eclipse | 20d 01h 46.5m |
| Moon leaves penumbra | 20d 04h 01.1m |

# 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', for this area has the most to offer the novice.

## IS THIS USEFUL FOR WHERE I LIVE?

Although the information in Part I has been calculated for Perth, WA (latitude 31° 57'S, longitude 115° 51'E) it is useful for anywhere in western Australia (some of it is common for the world). The change in the appearance of the sky between cities and towns - even across a country as vast as Australia - is not large (see also 'Effect of Latitude' on the next page). The rise/set graphs are useful since they give an approximate local time of rising and setting – no matter where you live!

**Times are given in Western Australian Standard Time (in Part I).**

Part I is designed as a quick reference section for anyone who wants a summary of tonight's sky, without having to refer to lengthy, complicated tables. Precise data, like the exact rise/set time or position (RA and Declination) of the planets is in Part II.

## 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 Moon, Saturn and Aldebaran on March 20 (see Sky View p. 27). These celestial dwellers all lie within a 5 degree circle in the NW evening twilight 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 1 second to reach us, Saturn 78 minutes and Aldebaran 60 years. If you include the open star cluster, the Pleiades, we are out to 400 years. Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, this cluster 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 5-6 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 Sky View 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 Sky View. 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.

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 January 18, the Moon and Mars set together around 10.30pm. 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 (see p. 19)

Each of these monthly sections also has diagrams 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 some 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 (see p. 25). 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. A good companion to this publication would be a basic star atlas or a planisphere. These will show 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. Once you start to look around the sky with a planisphere, you may be pleasantly surprised how easy it is to recognise a few of the constellations. These star patterns will quickly become familiar and will soon be like old friends.

Part II of Astronomy 2002 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 the authors 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. They are people who 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 hand hold 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 the bright twilight sky.
- Looking at the craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views 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. Also, the contrast between the yellow of Alpha Centauri and the blue of Beta Centauri is interesting.
- 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 (see the 'Mira' example on p. 45). There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society.
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on pages 87-89). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites (pp. 85-86) as the moon passes into or out of the shadow of the planet.
- 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 one should not time the event as described on page 76.
- 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.
- Searching out Uranus and Neptune, see finder charts, p. 94.

Most of the above can be done from a typical suburban backyard. It is not necessary to drive for an hour to reach dark skies. Also scanning the skies for satellites can open up a whole new Universe of discovery as various star clusters and nebulae drift through your field of view.

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 2002, 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 planet out from the Sun. The diagram on page 15 gives a good overview. There are also a number (actually tens 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. A star is an enormous sphere 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.

**Time.** The times used in Part I are in Western Australian Standard Time (WAST). WAST is the mean solar time on the meridian of longitude of 120°E.

**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!

**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 predictions in this book.

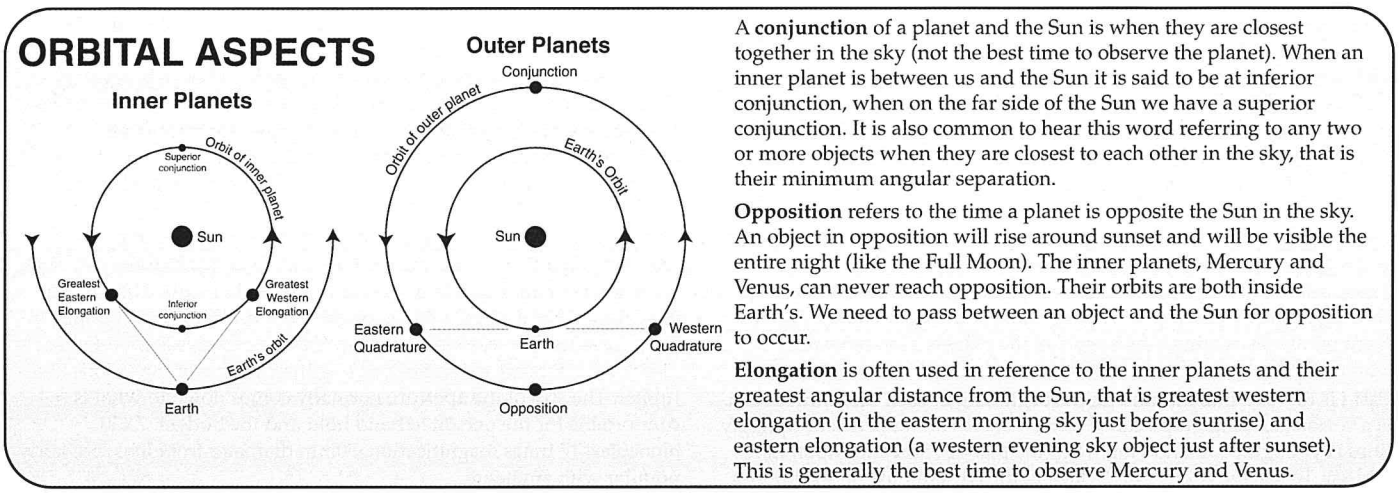
**Twilight** does not really end until the Sun is 18 degrees below the horizon; this is called 'astronomical twilight'. This happens about 90 minutes after sunset (or before sunrise) and is different from what people would normally call the end of twilight. This would be civil twilight, which begins 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!). But 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.

**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 (assuming it's night). 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 the book we will work through an example.

You are planning to go out and observe on the evening of June 14 (for once the weather is looking OK). A good place to start is the 'Visibility of the Planets' chart (p. 14). Looking around mid June, the diagram is showing Mars, Jupiter, Venus and Pluto in the evening sky, with Mercury, Uranus and Neptune in the morning. A quick check of the




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, that is 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.

'Rise/Set Chart' for June (p. 36) certainly shows Mars, Jupiter and Venus setting in the early evening sky. Venus and the Moon are setting close together which would indicate a conjunction and there may be a sky view for this date. On p. 39 there is indeed a sky view, 'Jun. 12 to 15' showing not only Venus with the Moon but also Mars and Jupiter in the early evening twilight sky. Venus is rising in the evening sky, heading towards its greatest eastern elongation in August. Although Venus currently shows only a small gibbous disk of around 13 arc seconds (see 'Appearance of the Planets' diagram p. 36) it is also heading towards inferior conjunction in October so its size will grow. Unfortunately Jupiter is quite low in the evening twilight, and will soon set. There are no Jupiter moon events visible this evening but it is always worthwhile checking p. 85-86 before going out to observe.

With the Moon setting early in the evening (8.30pm) there is little opportunity to spot any occultations of stars by our satellite during this evening. It is better to wait until the Moon spends more time in the night sky. For example on June 17, in the early evening, there is an occultation of 3.9 magnitude star ZC1651. There is an opportunity to spot this star reappear, during twilight, on the bright limb of the Moon (the time from Perth is 5.56pm, see p. 77).

Back to the evening of June 14, a look at the 'Diary' for June (p. 38) indicates that the minor planet 654 Zelinda makes a close approach to the spiral galaxy NGC 2974 in Sextans this evening. A check with a planisphere tells us this constellation sets around 10pm this evening so one should get onto this event as early as possible. This conjunction may attract the astrophotographer wishing to catch a minor planet next to a deep sky object. While we are talking faint objects, the comet C/2000 WM1 (LINEAR), at magnitude 12, is in the constellation of Hercules making a close approach to the globular cluster M13 on the 18th (refer comet text and diary p. 38).

For those wishing to chase our most distant and faint planet Pluto, it is rising at sunset and hence is visible the entire night. You will need at least a 20cm telescope and the finder charts on pp. 94, 95 to find this world (not an exercise for the beginner).

Both Uranus and Neptune rise during the evening. It is always a good idea to wait a couple of hours, when possible, so the planet is higher and you are not looking through a lot of atmosphere. Therefore an early morning timeframe may be best to observe these distant bodies (as per the 'Visibility' recommendations on p. 14). Finder charts for these planets are located on p. 94.

For those looking for an 'all nighter', let's look at the next morning (15th). Mercury is reasonably placed, rising just before the start of dawn. (See Rise/Set, p. 36 and the 'Movement of the Planets' diagram, 'DAWN SKY – Jun. To Sep. 2002' on p. 13). Through even a small telescope it will show a thin crescent as shown in the 'Appearance' diagram on p. 36. Unfortunately, Saturn has just gone through conjunction with the Sun, moving into the morning sky but is still too close to the Sun to observe its spectacular rings. It is probably best to wait until July for Saturn when it will be rising before dawn.

This is an example 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. 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 103.

### 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.

### MONTHLY HIGHLIGHTS

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

### THE MOON

This provides information on any 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 will be no occultations of bright stars by the Moon during 2002, the next bright star occultation will be in January 2005 when the 1st magnitude star Antares passes behind the lunar limb. There will be 19 planet and major asteroid occultations this year (somewhere in the world) plus the usual multitude of fainter star events (see also Lunar Occultations in Part II for details).

### 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.

### MINOR PLANETS (or Asteroids)

This section deals with the 20 brightest asteroids that reach opposition this year. An entry is included if the asteroid reaches opposition during that month, when it is brightest. It lists the magnitude and constellation the asteroid is in at the time of opposition.

### 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, 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. We have seen some spectacular ones in recent years, including Comet C/2001 A2 (LINEAR) (see p. 33). Let's hope the trend continues this 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. More details for all showers are 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, comets, minor planets (asteroids), brighter stars and deep sky objects (see also page 102 for descriptions of some of the brighter non stellar 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 Western 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 'occultation'. 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 which is for a galaxy (SG - spiral, IG - irregular, EG - elliptical).
- OC represents an open cluster
- GC is a globular cluster
- PN is a planetary nebula
- m.p. equals a minor planet

There are also some astronomical catalogues including:

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

**FEATURE ARTICLE**

This section concentrates on some topics in popular astronomy. This can include observational, historical, profiles of astronomy enthusiasts, astronomical equipment and techniques.

**SKY VIEWS**

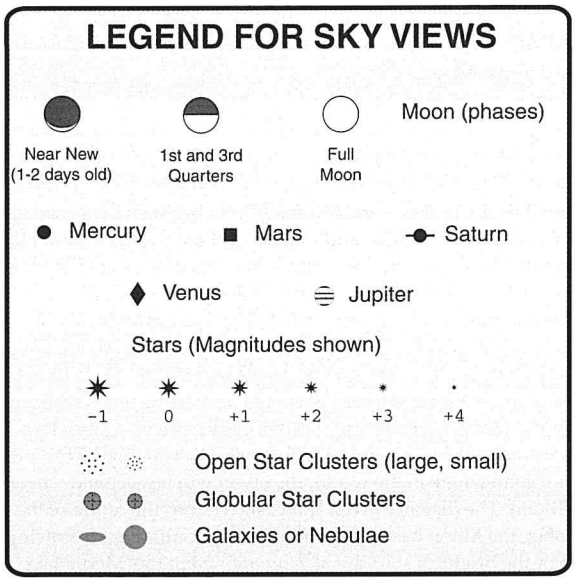
These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although, 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. Many of these deep sky objects are also listed on page 102 in 'Non Stellar Objects'.
- Constellations are labelled (capital letters) and have black lines joining key stars.

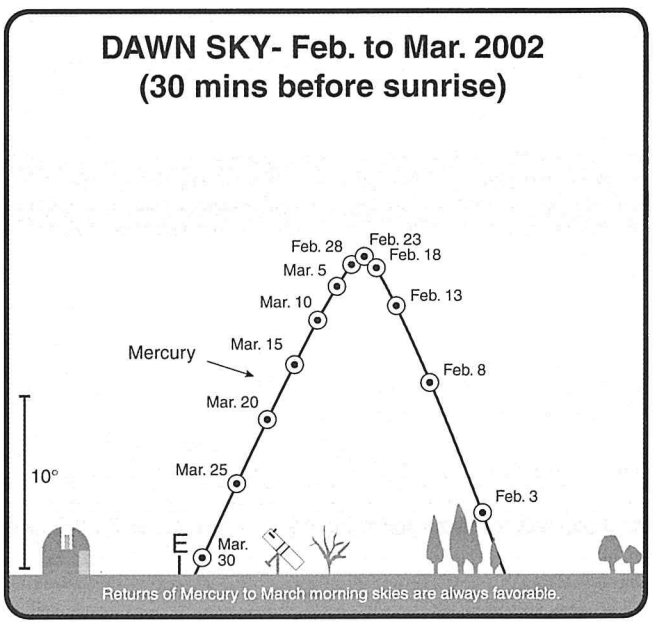
When using these 'windows to the sky' it is important to keep in mind that the horizon shown is theoretical, like looking out over the ocean. You will soon learn to make mental adjustments for local hills, trees and buildings etc. The scale has been kept constant and a 10° reference bar is marked. Sometimes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

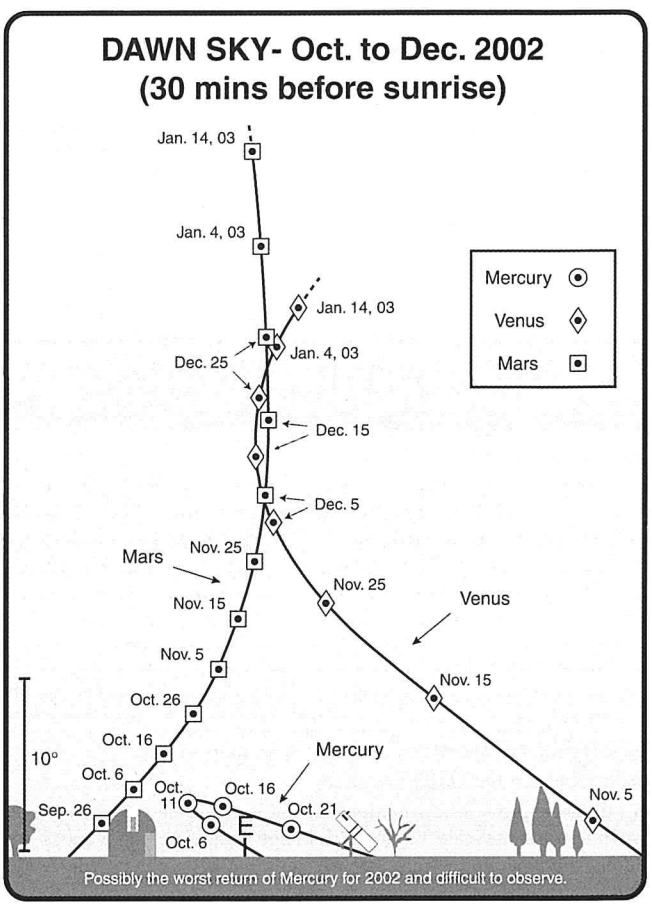
The Sky Views are useful for more than just the date and time shown. The pattern of stars relative to the horizon will appear the same one month later, but 2 hours earlier. Of course the planets and the Moon will have moved. Compare the Sky Views for Aug. 4 to 6 (5am) with Aug. 31 to Sep. 2 (3am), see page 47. A few minutes playing with a planisphere will also show this yearly motion of the stars.



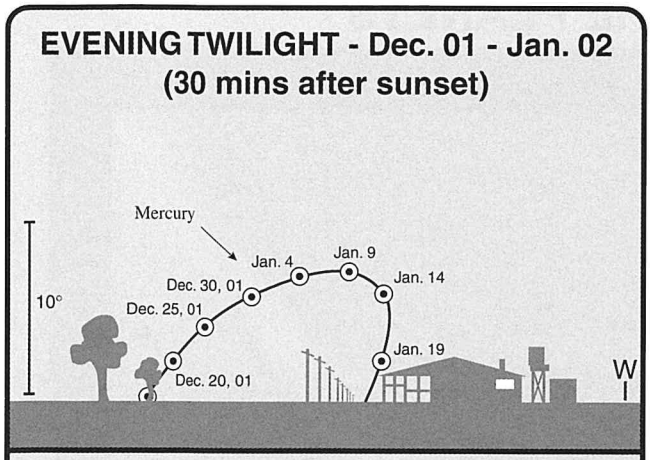

Uranus, Neptune and Pluto have been excluded from the Sky Views as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. 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 pp 94-95.

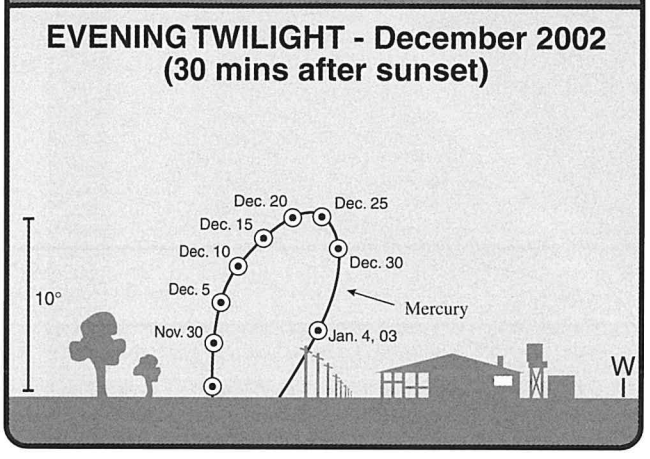
## MOVEMENT OF THE PLANETS

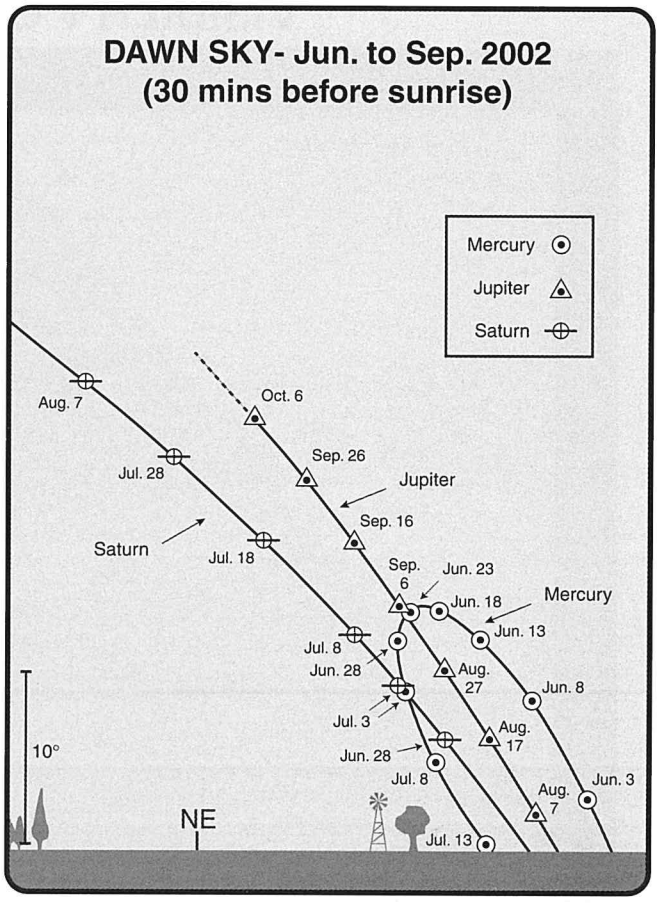


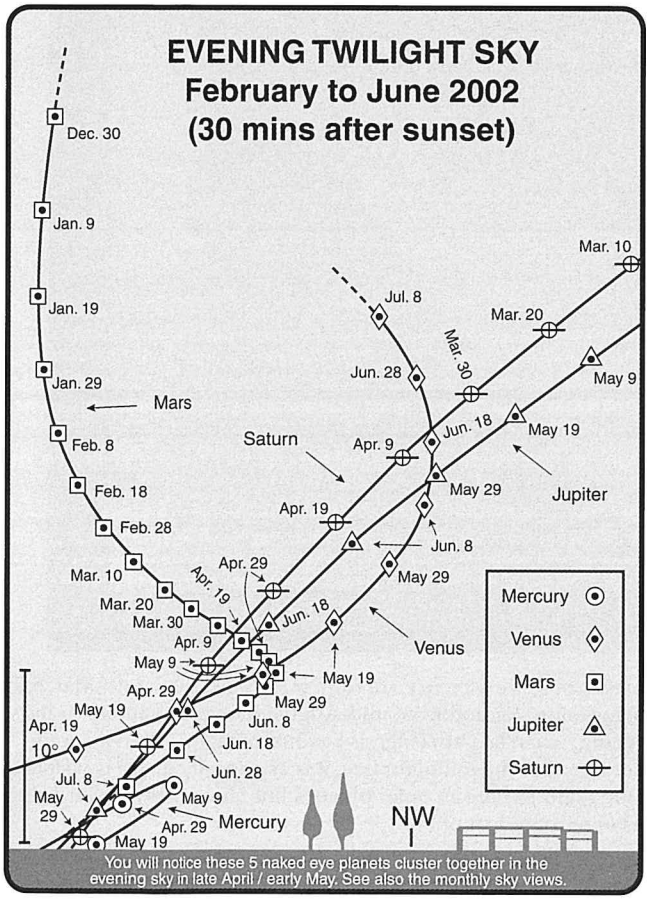



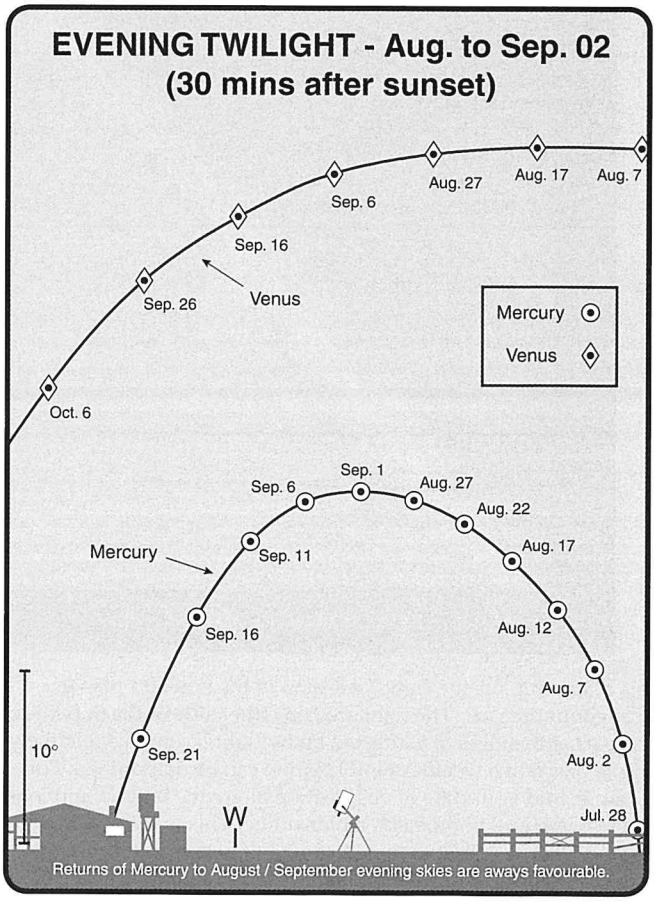
# MOVEMENT OF THE PLANETS



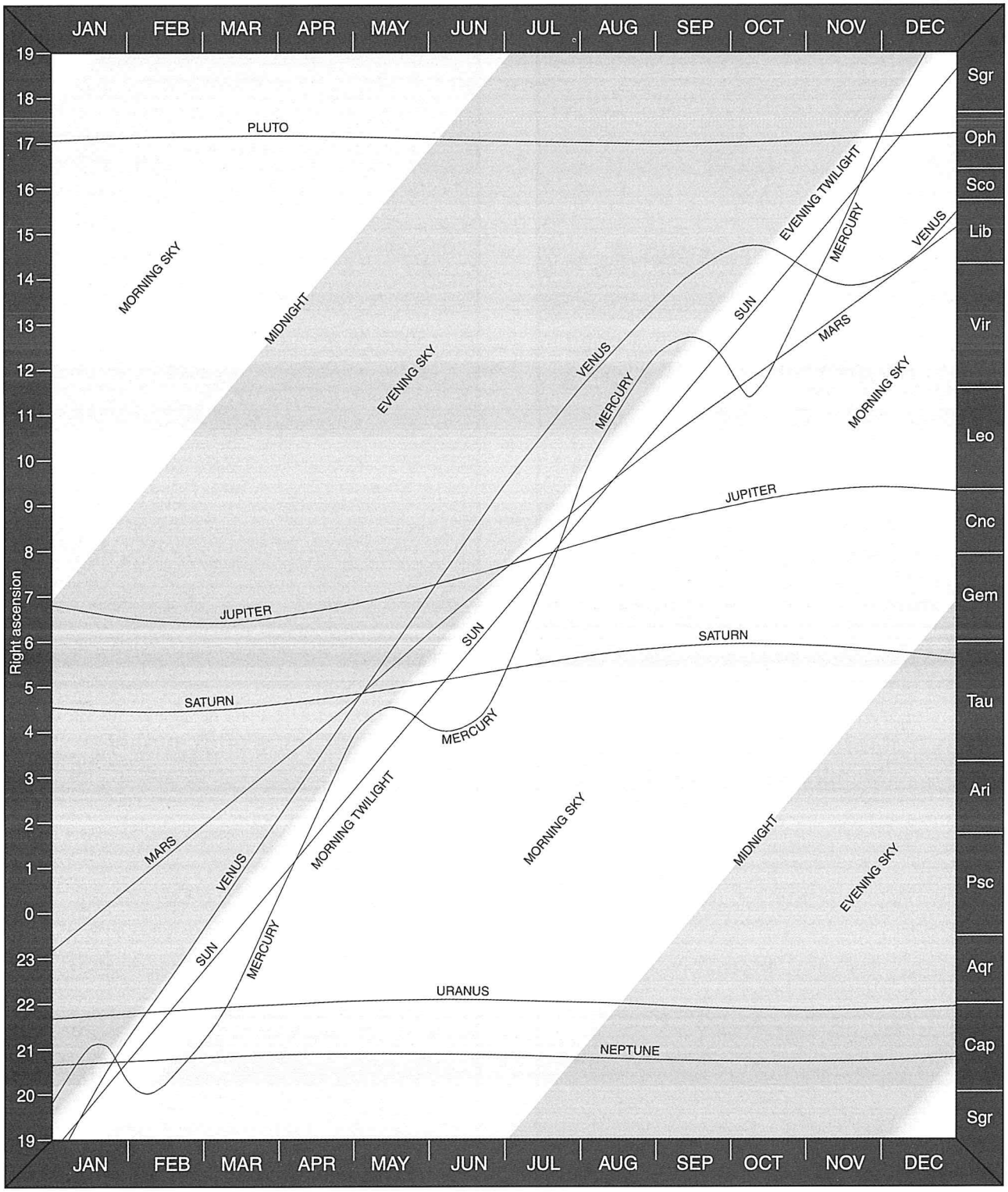




These diagrams are designed to help observers know when the planets first become observable after being in conjunction with the Sun, or when they are about to go into conjunction with our star. The drawings are particularly useful as an observing guide for Mercury. In addition, the Visibility of the Planets diagram (p. 14), allows you to see at a glance whether an object is in the morning or evening sky.

# VISIBILITY OF THE PLANETS



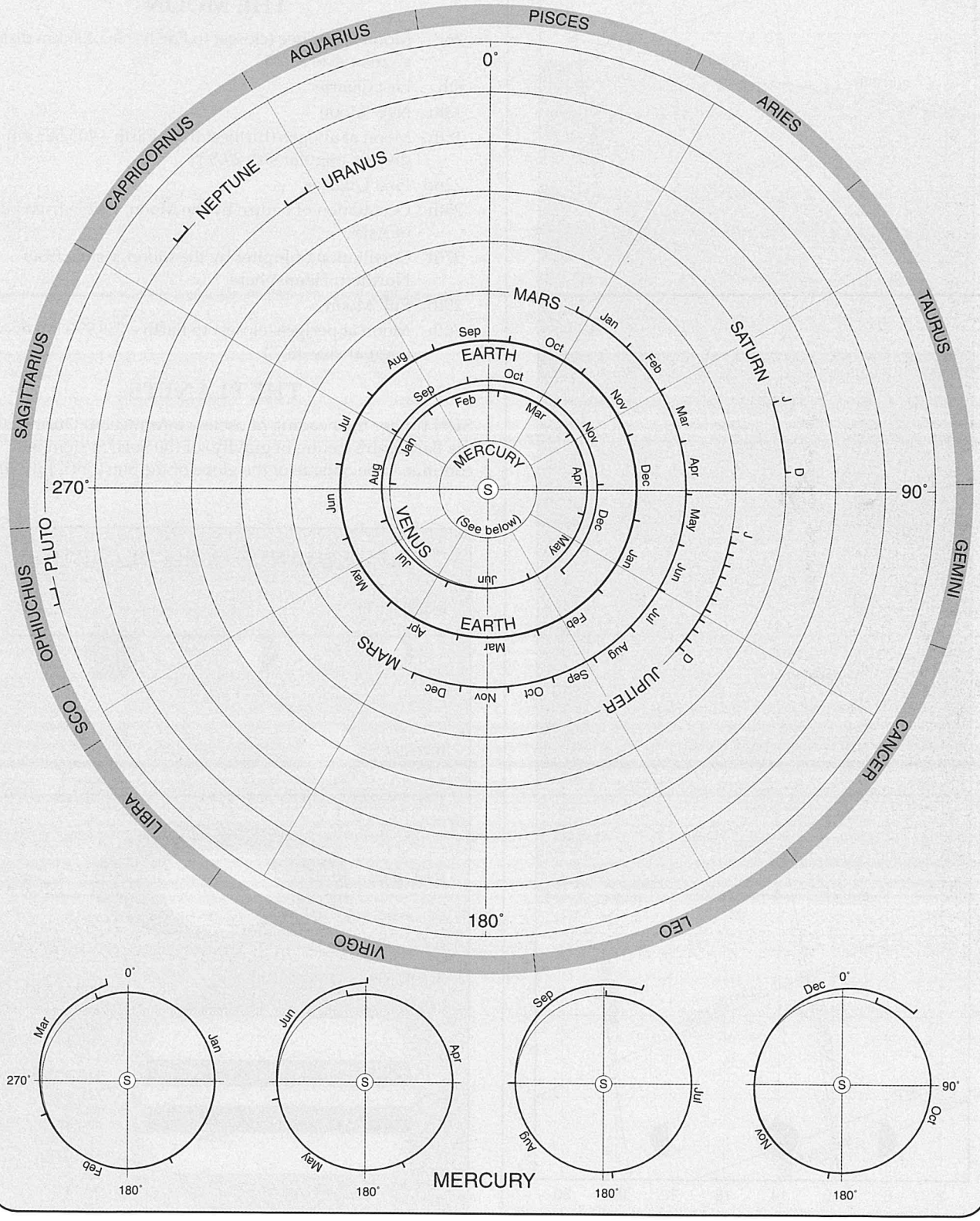

This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation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

Mercury and Venus 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 mid-February to mid-March for the morning sky, and from mid-August to mid-September 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 Venus, Mars and Saturn is clearly shown where their paths cross in the early May evening sky.

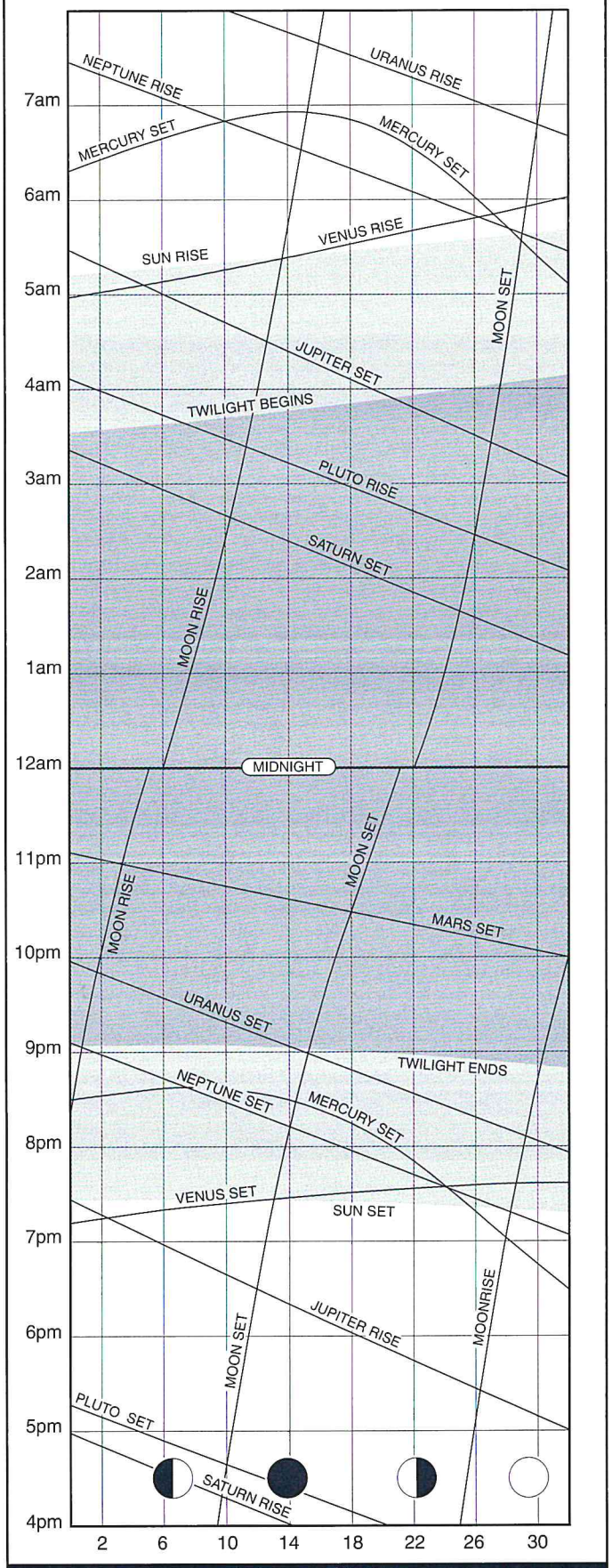
# PLANET POSITIONS

This diagram illustrates the relative positions of the planets during the course of their orbits in 2002. The relationship between the major solar system bodies is clearly shown. For example, this year's opposition of Jupiter occurs very early in January when the Earth appears closest. A line extended from Earth, through and beyond Jupiter shows that the planet is located in Gemini 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 distances are not drawn to scale. The thirteen constellations named are those that are situated on the ecliptic. If a planet is off the ecliptic it may in fact be in a neighbouring constellation, Saturn for instance appears in Orion from September to mid-November, whereas our diagram indicates Taurus during this period. A small section of Orion comes within 1° of the ecliptic.



# JANUARY

## RISE/SET CHART




All times are WAST.

## JANUARY HIGHLIGHTS

- Mercury and Neptune close in the evening sky
- Mercury and crescent Moon close in evening twilight
- Jupiter at opposition
- Saturn near Aldebaran

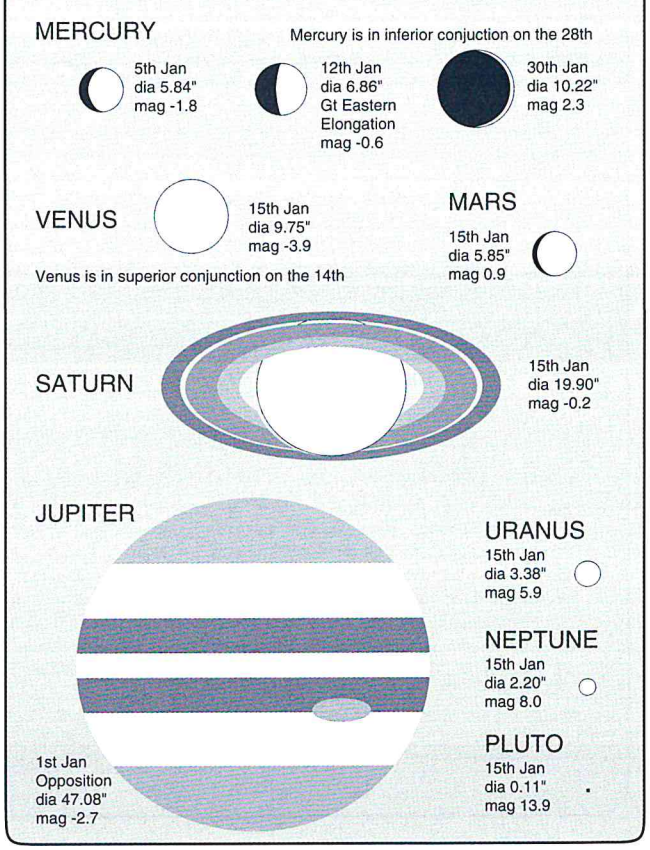
## THE MOON

| | |
|---|---|
| 2nd | Moon at perigee (closest to Earth – 365,406 km distant, angular size 32.2′) |
| 6th | Last Quarter |
| 13th | New Moon |
| 18th | Moon at apogee (furthest from Earth – 405,505 km distant, angular size 29.8′) |
| 22nd | First Quarter |
| 25th | Occultation of Saturn by the Moon, visible from parts of Asia |
| 27th | Occultation of Jupiter by the Moon, visible from Northern Hemisphere |
| 29th | Full Moon |
| 30th | Moon at perigee (closest to Earth – 359,996 km distant, angular size 33.0′) |

## THE PLANETS

**SUN** (under the heading of useless information) During 2002 the Barycentre (centre of gravity) of the Solar System will continue to be outside of the globe of the Sun (until July 2003).

## APPEARANCE of the PLANETS



# JANUARY

**MERCURY**, for the first half of January, is located in the western evening twilight, setting about an hour after the Sun. The planet's greatest elongation east of the Sun (19°) occurs on the 12th, and then it races back toward the Sun and inferior conjunction (between Earth and Sun) on the 28th. Moving from Sagittarius into Capricornus early in the month, Mercury passes less than 0.5° from the globular cluster M75 (NGC6864). An encounter between the Sun's nearest planet and one of its most distant, Neptune, occurs on the 9th when the two are 1.3° apart. On the 15th, the very thin crescent 2-day old Moon appears 4.3° above the planet (see Sky View).

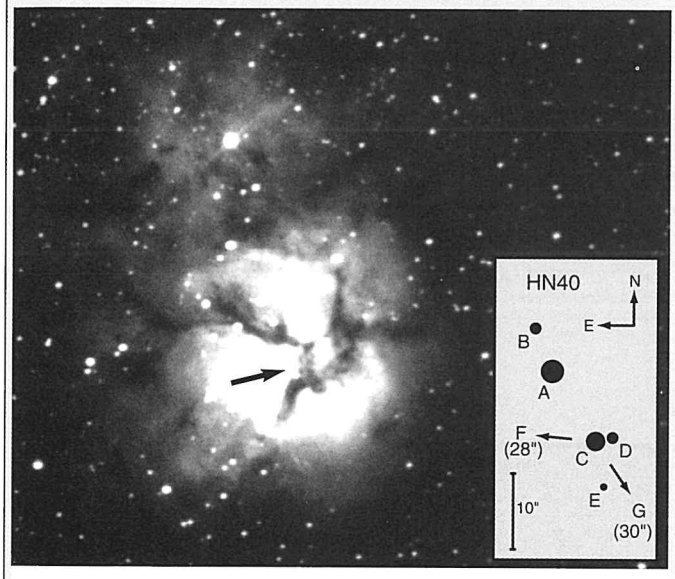
**VENUS** is too close to the Sun for observation this month. In superior conjunction on the 14th (Venus and Earth on opposite sides of the Sun), the planet remains near the Sun until its debut in the evening sky in late February.

The **EARTH** is at perihelion (the closest point in its orbit to the Sun) on the 2nd. The Earth/Sun distance is 0.98329 astronomical units, which is equivalent to about 147 million km.

**MARS** is visible in the western evening sky, setting around 10.30pm. After the June 2001 favourable opposition, the planet has now diminished substantially in size and brightness. For most of the year Mars will remain below 1st magnitude and present a disk size of less than 5 arc seconds. Hardly an exciting telescopic object. On the 18th, the 4-day old Moon will be 8.5° south of the planet, and on the following evening 5.7° above (see Sky View).

**JUPITER** begins the year in opposition, visible for the entire night in Gemini. Although the planet is a worthy telescopic object at any time of the year, opposition provides a good-sized disk that is around 50% larger than when near conjunction

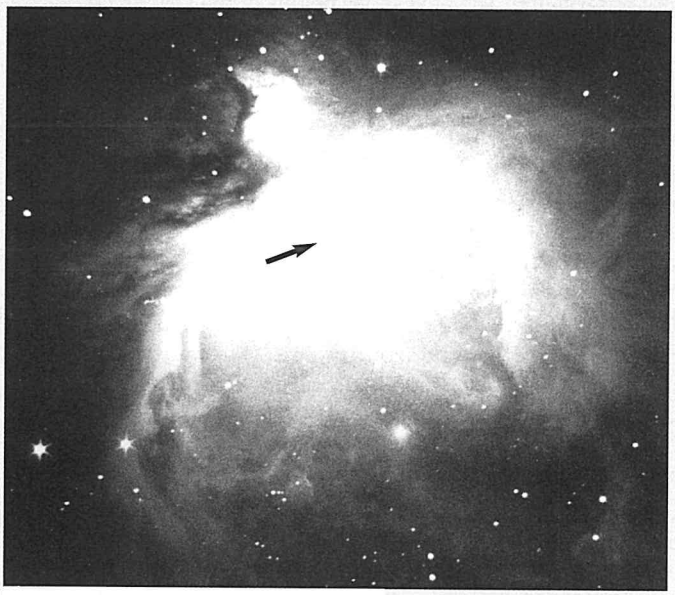
## MULTIPLE STARS IN WELL KNOWN NEBULAE



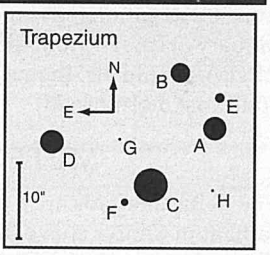

*Multiple Star HN40 in the Trifid Nebula. Photograph by J. Cauchi*

The casual observer, when looking at nebulae, tends to stay with low power eyepieces. It is worthwhile going to a higher power. Not only does this have the potential of increasing the contrast of the nebulosity, but it may also reveal some surprises in their central star systems (if present). Two famous examples are given here. With photographs of the Trifid and Orion nebulae, even short exposures with amateur equipment, the central stars will easily burn out. The positions of the multiple stars are arrowed. The photos and inserts are positioned with north to the top.

**HN 40 and the Trifid Nebula**. Tucked into the fork of the dark rifts in the Trifid lies the multiple star system HN40 (the three dark rifts form the 'trifid' pattern). HN40 is thought to be the chief source of illumination for the Trifid, but there may be many hot stars hidden from view. The main three stars are easily visible in a small telescope, with 'D' presenting no real problems. It took S. W. Burnham, using the 36 inch Lick refractor, to detect the fainter components. Perhaps an interesting challenge for those large aperture scopes, fairly common with amateurs these days?



*Trapezium in Orion Nebula. Photograph by J. Cauchi.*




**The Trapezium in the Orion Nebula**. The Orion nebula is fluorescing due to the strong ultraviolet radiation from the Trapezium. These stars are likely to be a central core of a compact cluster of much fainter stars. The Trapezium is probably the best known multiple star system but many observers may only know of its four main components. The E star shouldn't be a problem in small instruments with F being a little more difficult. The G star is a real challenge considering it took the 36 inch refractor at Lick Observatory to detect it (A.G. Clark was the discoverer in 1888). While we are talking about tests, H has been shown to be a pair of 16th magnitude stars, separated by 1.3". Stars A and B have been found to be variable, both being eclipsing binary stars. 'A' was found in 1975 to have a period of 65 days with a range of 6.7 to 7.7 magnitude.

| Component | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| H40 | 7.4 | 10.5 | 8.5 | 10.5 | 12.4 | 13.8 | 13.2 | - |
| Trapezium | 6.8 | 7.9 | 5.4 | 6.8 | 11.1 | 11.5 | 16.7 | 15.8 |

**HN40 and Trapezium Magnitude Table**

# JANUARY

(compare the planet appearance diagrams for January and July). On the 26th, the 12-day old Moon appears 4.1° north of Jupiter and on the following evening 10° to the south (see Sky View). As a matter of interest, on the 1st January (the date of opposition) any Jovian residents looking sunwards will witness a transit of the Earth and the Moon across the face of the Sun. The next such transit occurs during the opposition of July 2008.

**SATURN**, in Taurus, remains within 4° of the 1st magnitude star Aldebaran throughout the month. Just one month past opposition, the planet makes a good telescopic target high in the mid-evening northern sky. On the 24th, the 10-day old Moon appears 2° from Saturn (see Sky View).

**URANUS** and **NEPTUNE** in Capricornus, both setting in evening twilight, will reappear late February in the morning sky. Neptune will be in conjunction with the Sun on the 29th. This is the 3rd in a series of eight annual Neptunian conjunctions, where the planet is occulted by the Sun's disk (not observable). The next series begins in the year 2080.

**PLUTO** rises in the morning sky in Ophiuchus. The slow moving planet will remain in this constellation until February 2003 when it moves into neighbouring Serpens.

**MINOR PLANETS** at opposition this month include 9 Metis on the 13th at magnitude 8.7 in Gemini and 654 Zelinda on the 10th at magnitude 9.8 in Gemini.

## COMETS

**Comet 19P/Borrelly** is low in the pre-dawn sky during January. The comet should fade from 12th to 13th magnitude as it sinks closer to the northern horizon, spending the entire month in the constellation of Canes Venatici. During the first week of January, Borrelly is about two degrees from 4th magnitude Beta Canum Venaticorum. On 7th January, the comet is a degree away from the 9th magnitude galaxy M94.

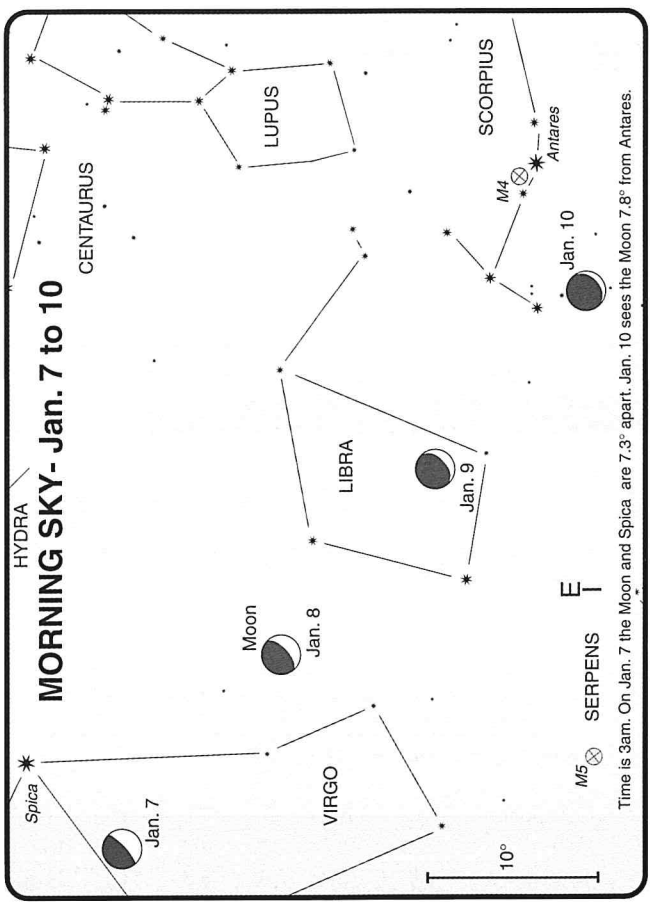
**Comet C/2000 WM1 (LINEAR)** should open the year at 6th magnitude in the evening sky, low in the southwest at the end of twilight. Moving quickly from Grus into Indus, and then into Telescopium, the comet will fade after perihelion on 22nd January at 0.6 AU from the Sun. By month's end, when LINEAR could be 7th magnitude, it is best observed in the southeast morning sky.

## METEOR SHOWERS

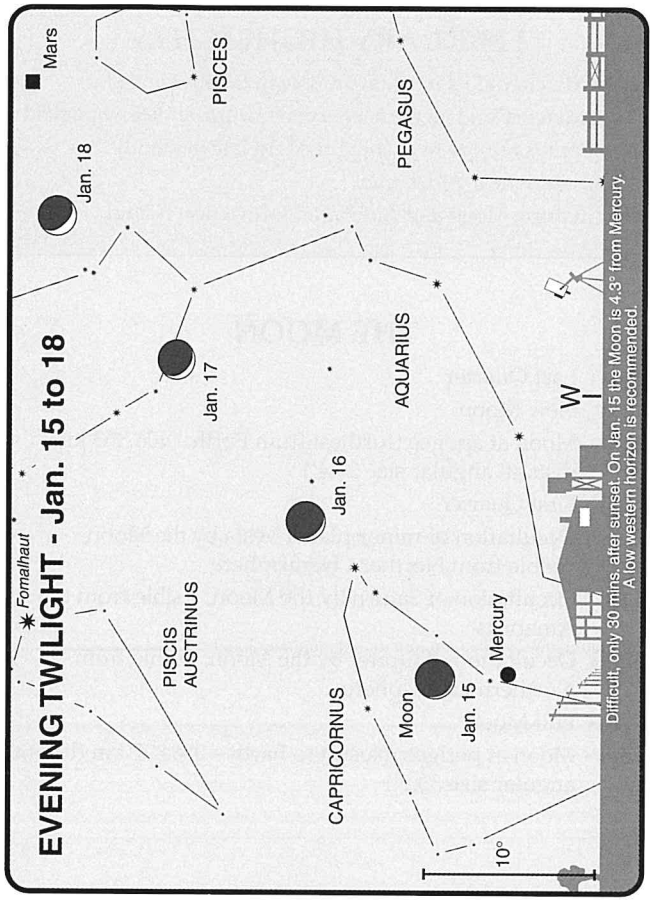
The **delta-Cancrids** are a minor meteor shower, with the radiant in Cancer above the horizon for most of the night. Typically faint, the zenith hourly rate is unlikely to rise above 3 to 5. The showers' duration is from the 1st to 24th. January 17th will be their maximum.

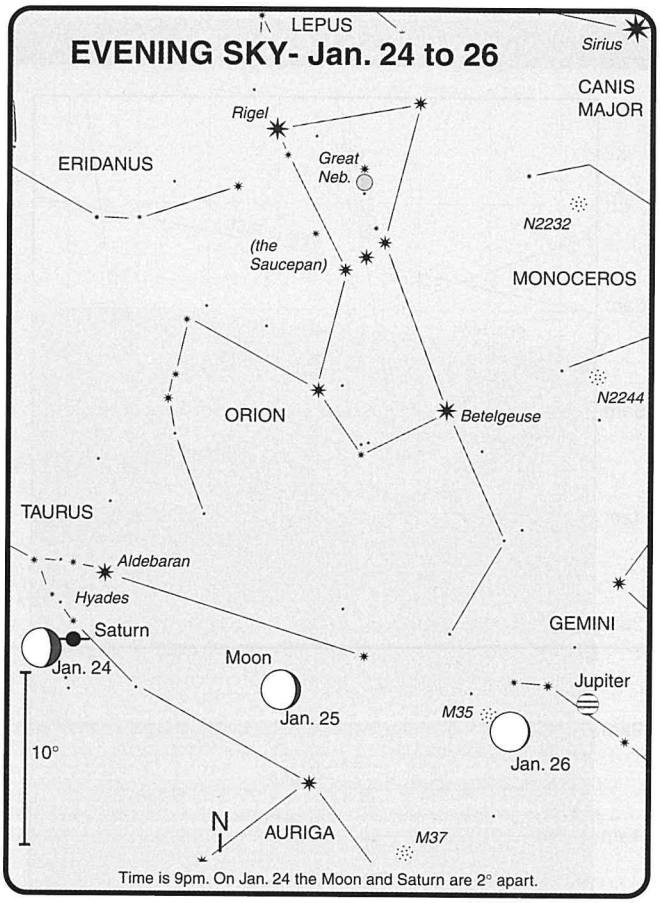
## DIARY

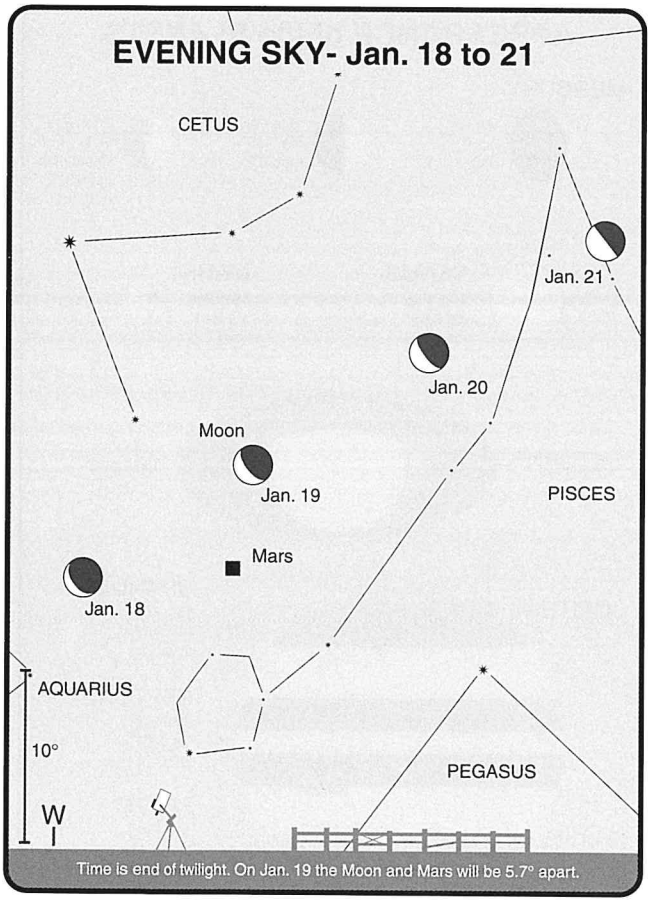
| | | |
|---|---|---|
| 1st | | m.p. 6 Hebe 0.1°W of star Zeta Ophiuchi |
| 1st | 2 PM | Jupiter at opposition |
| 2nd | 3 PM | Moon at perigee |
| 2nd | 10 PM | Earth at perihelion |
| 3rd | | Mercury 0.4°SE of M75 (GC) in Sagittarius |
| 6th | 11:55 AM | Last Quarter Moon |
| 7th | | Uranus 0.5°N of m.p. 44 Nysa |
| 7th | 7 PM | Comet C/2000 WM1 (LINEAR) 0.3°NW of NGC 7090 (SG) in Indus |
| 9th | 6 AM | Pallas in conjunction with Sun |
| 9th | 1 PM | Mercury 1.3°S of Neptune |
| 9th | 9 PM | m.p. 654 Zelinda 0.4°NW of NGC 2395 (OC) in Gemini |
| 9th | 9 PM | m.p. 9 Metis 0.2°N of star Pollux |
| 12th | 7 AM | Mercury greatest elongation E (19°) |
| 13th | 9:29 PM | New Moon |
| 14th | | Mercury at ascending node |
| 14th | 8 PM | Venus in superior conjunction |
| 15th | 10 AM | Mercury 4°N of Moon |
| 16th | 6 AM | Uranus 4°N of Moon |
| 17th | 1 AM | Vesta stationary |
| 18th | 5 PM | Mercury stationary |
| 18th | 5 PM | Moon at apogee |
| 19th | 6 AM | Mars 5° N of Moon |
| 19th | | Mercury at perihelion |
| 22nd | 1:46 AM | First Quarter Moon |
| 23rd | | m.p. 29 Amphitrite 0.3°S of NGC 6520 (OC) in Sagittarius |
| 24th | Midnight | Saturn 0.08°S of Moon; occultation |
| 25th | | Venus at aphelion |
| 27th | 3 AM | Jupiter 0.9°S of Moon; occultation |
| 28th | 3 AM | Mercury in inferior conjunction |
| 28th | 10 PM | Neptune in conjunction with Sun |
| 29th | 6:50 AM | Full Moon |
| 29th | | Mercury at greatest latitude North |
| 30th | | Mars 0.1°NW of NGC 128 (SG) in Pisces |
| 30th | 5 PM | Moon at perigee |

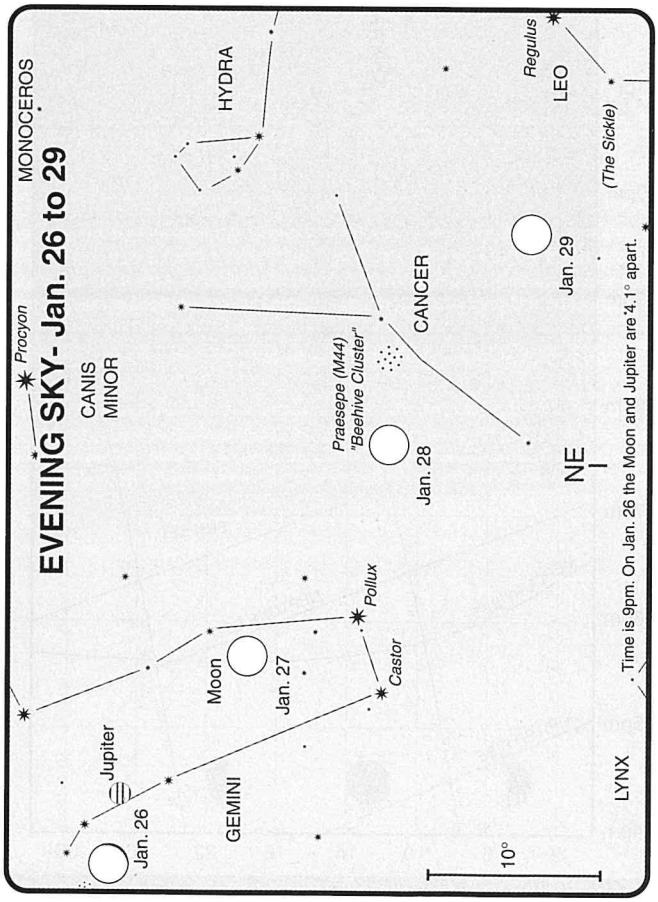


# JANUARY


EVENING TWILIGHT - Jan. 15 to 18
Mars
PISCES
PEGASUS
Jan. 18
Jan. 17
AQUARIUS
Jan. 16
Fomalhaut
PISCIS AUSTRINUS
CAPRICORNUS
Moon
Jan. 15
Mercury
W
10°
Difficult, only 30 mins. after sunset. On Jan. 15 the Moon is 4.3° from Mercury. A low western horizon is recommended.

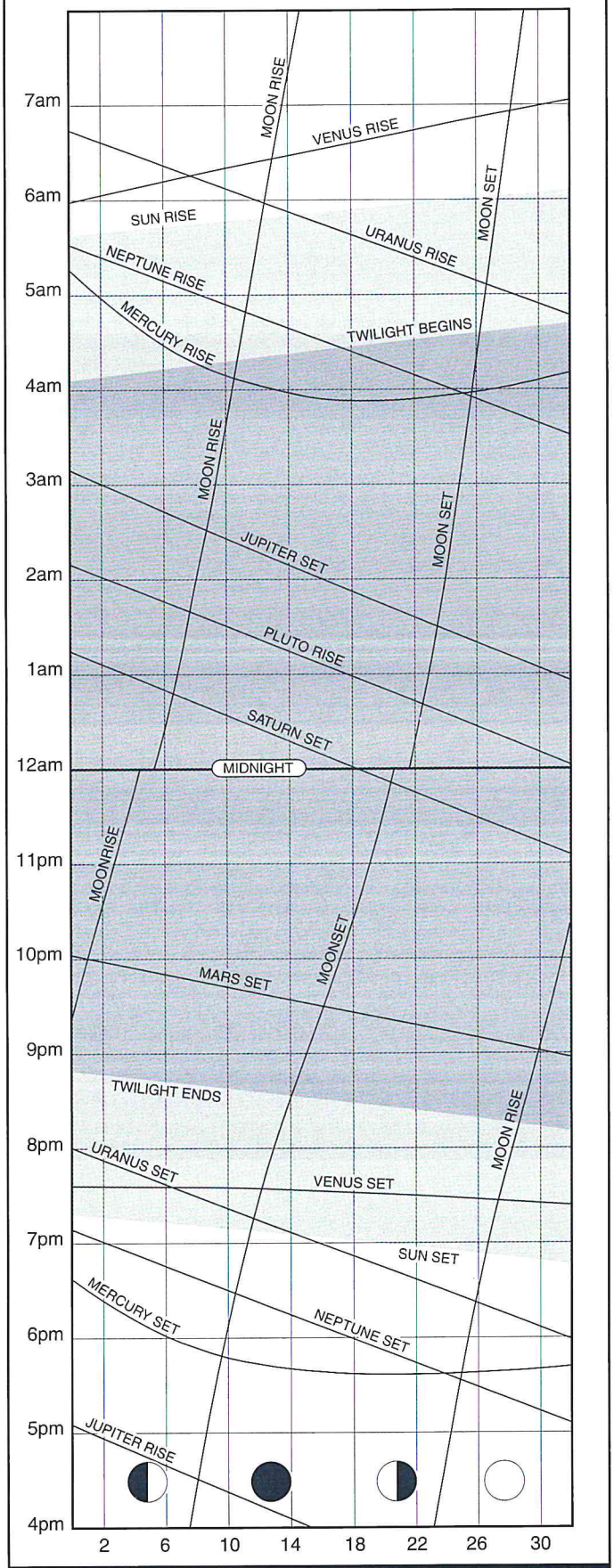

EVENING SKY- Jan. 24 to 26
LEPUS
Sirius
CANIS MAJOR
Rigel
ERIDANUS
Great Neb.
N2232
(the Saucepan)
MONOCEROS
N2244
ORION
Betelgeuse
TAURUS
Aldebaran
Hyades
Saturn
Jan. 24
GEMINI
Moon
Jan. 25
Jupiter
M35
Jan. 26
10°
N
AURIGA
M37
Time is 9pm. On Jan. 24 the Moon and Saturn are 2° apart.


EVENING SKY- Jan. 18 to 21
CETUS
Jan. 21
Jan. 20
Moon
Jan. 19
PISCES
Mars
Jan. 18
AQUARIUS
10°
W
PEGASUS
Time is end of twilight. On Jan. 19 the Moon and Mars will be 5.7° apart.


EVENING SKY- Jan. 26 to 29
MONOCEROS
HYDRA
Regulus
LEO
(The Sickle)
Procyon
CANIS MINOR
Jan. 29
CANCER
Praesepe (M44) "Beehive Cluster"
Jan. 28
NE
Pollux
Moon
Jan. 27
Castor
Jupiter
Jan. 26
GEMINI
LYNX
10°
Time is 9pm. On Jan. 26 the Moon and Jupiter are 4.1° apart.

# FEBRUARY

## RISE/SET CHART




All times are WAST.

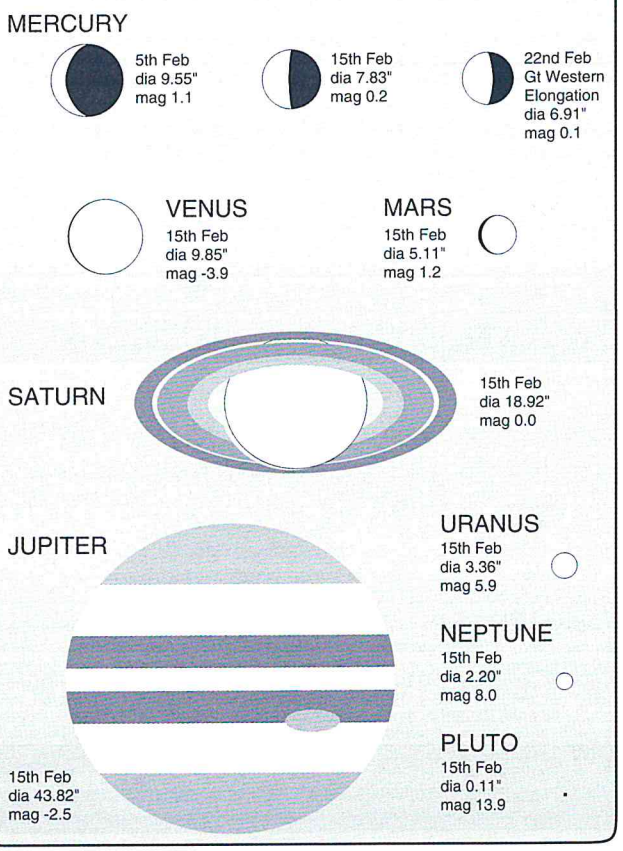
## FEBRUARY HIGHLIGHTS

- Mercury at its most favourable in the morning sky
- Mercury and Neptune in same low power telescope field
- Venus returns to evening twilight late in month
- Saturn near Aldebaran
- Saturn, Moon and Aldebaran form a neat triangle

## THE MOON

| | |
|---|---|
| 4th | Last Quarter |
| 12th | New Moon |
| 15th | Moon at apogee (furthest from Earth – 406,363 km distant, angular size 29.4′) |
| 20th | First Quarter |
| 20th | Occultation of minor planet Vesta by the Moon, visible from Northern Hemisphere |
| 21st | Occultation of Saturn by the Moon, visible from the Americas |
| 22nd | Occultation of Jupiter by the Moon, visible from Northern Hemisphere |
| 27th | Full Moon |
| 28th | Moon at perigee (closest to Earth – 356,897 km distant, angular size 33.5′) |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** will be at its most favourable in the morning sky this year from mid-February to mid-March. The planet reaches its greatest elongation west of the Sun on the 22nd (27°), providing an entire month with the planet in dark sky before twilight. On the 10th, the 27-day old thin crescent Moon will appear 6.4° above the planet (see Sky View). A rare opportunity to observe the Sun's closest planet and one of its most distant, Neptune, in the same low power field occurs on the 25th when they appear just 0.5° apart.

**VENUS** returns to the evening twilight this month, but remains too close to the Sun for observation. Keen observers with an unobstructed western horizon may try spotting the planet just after sunset towards month-end.

**MARS**, in Pisces, is visible in the early evening northwestern sky, setting around 9.30pm. On the 17th, the 4-day old crescent Moon will be situated 5° above the Red Planet (see Sky View).

**JUPITER** is prominent in the mid-evening northern sky in Gemini, setting around 2am mid-month. The 10-day old Moon appears 6° from the planet on the 23rd (see Sky View).

**SATURN** in Taurus again lingers within 4° of the 1st magnitude star Aldebaran during the month, in the NW evening sky. On the 20th, the First Quarter Moon will be 7° from the ringed planet, and on the following evening closer at 6.4° forming a right angle triangle with Aldebaran (see Sky View).

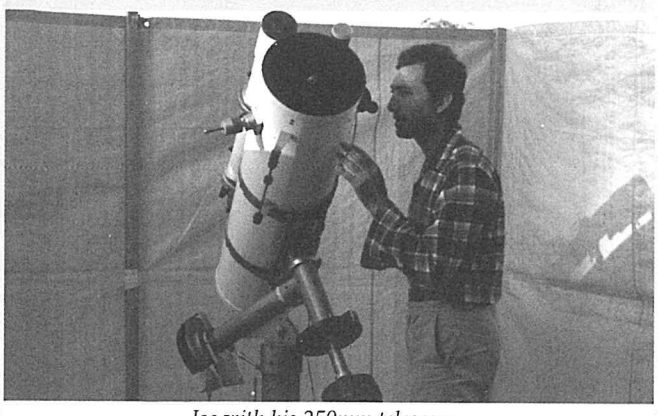
**URANUS** is in conjunction on the 14th, and moves into the morning twilight sky mid-month.

## ASTROPHOTOGRAPHER JOE CAUCHI

For a number of years we, at Quasar, have been displaying the magnificent astrophotography of Sydney amateur, Joe Cauchi. Joe started his passion for astronomy back in the early 70's with a 4.5 inch Tasco telescope. This soon gave way to a 200mm Newtonian. However, he soon lost interest having fallen into the common trap of knowing only a few well known objects and hence running out of things to observe! His flame was rekindled when he discovered the classic book 'Hartung's Astronomical Objects for Southern Telescopes' * and by joining the Astronomical Society of NSW. Hartung's pointed out a whole universe of new objects and the ASNSW brought the benefits of surrounding yourself with people with a common passion. Incidentally, this was the start of a long term association with the society, with Joe currently a vice-president. By the mid 70's, aperture fever had struck and he had built himself a home made mount and installed a 250mm *f*/5 reflector.

In 1979 fellow amateur Terry Clark first introduced Joe to the world of astrophotography. Terry showed him how to get great photos of the Moon. This work was easy, no guiding of the telescope was needed with the Moon and normal, fine grain films could be used. Unfortunately, our closest celestial neighbour only has so many phases to be 'snapped' and Joe was soon looking for further challenges. The next logical progression was to do 'piggy-back' work using a 200mm telephoto lens, but there were only so many wide field shots of the Milky Way he could do.

He soon made the jump to guided, prime focus, deep sky objects. It was now 1980 and Joe found he needed some very fast film. Initially he used black and white films such as Kodak Tri X or the spectroscopic 103ae or 103ao (the 103 films are no longer available). Being black and white he could easily process the film himself - which he continues to do today. These early films were fast, but very grainy. With the introduction of Kodak 2415, in combination with the gas hypersensitization (or hypered) process, there was at last a fast, fine grain film that didn't suffer from reciprocity failure (the film didn't get 'tired', compared to normal films, on long exposures). Kodak 2415 was also black and white but fortunately Joe was more interested in shooting galaxies, which really don't need colour. At the time he did experiment with hypered colour films but he was never really happy with the resulting colour balance. Joe found the combination of the fine grain film and the good seeing of the ASNSW's Bowen Mountain Observatory site produced sharp, detailed images.



*Joe with his 250mm telescope.*

In the late 80's, for about 3 years, he experimented with a Wright-Schmidt 5.5 inch *f*/3.8 camera. This gave very fast, sharp, 3° wide field views of the sky, but most objects, such as galaxies, were too small to see any detail in the photographs.

In the early 90's Joe changed his 250mm *f*/5 mirror to a 250mm *f*/4. He immediately saw a marked increase in speed with a wider field. Once again this suited the finer grain films with the now smaller images being able to take a lot of enlarging.

In 1999, in the tradition of a true deep sky fanatic that is 'too much aperture is never enough', Joe commenced his most ambitious project - a 400mm *f*/4.5 scope. It has taken 2 years to overcome the numerous teething problems. The telescope has great potential and he is planning to go after the faint Abell galaxy clusters in the future.

Does Joe see CCD cameras in his future? The answer is yes. Although this technology is easier to use compared to traditional films; he still has some technical problems to overcome.

In conclusion, Joe is the first to admit that astrophotography is a hard, expensive and frustrating hobby. Despite all this, he has taken hundreds of photographs over the years and the thing that really counts is that slight smile when Joe proudly pulls out a folder of prints.

* Hartung's book has been fully revised recently by Australia's famous astrophotographer, David Malin and David Frew.

# FEBRUARY

**NEPTUNE**, after conjunction last month, moves into the morning twilight. Late in the month, Neptune and Mercury have a close encounter (see Mercury).

**PLUTO** rises around 1am in Ophiuchus.

**MINOR PLANETS** at opposition this month include: 3 Juno on the 8th at magnitude 8.4 in Hydra, 8 Flora on the 26th at magnitude 9.2 in Leo and 28 Bellona on the 22nd at magnitude 10.1 in Leo. During the month 8 Flora visits the Leo group of galaxies.

## COMETS

**Comet C/2000 WM1 (LINEAR)** moves quickly from Telescopium into Sagittarius in the morning sky this month. On 18th February, LINEAR is about three degrees from the globular cluster M55. By month's end, the comet should have faded from 7th to 8th magnitude.

**Comet 7P/Pons-Winnecke** should first become visually observable in large telescopes this month as it brightens from 15th to 13th magnitude. The comet is located in the morning sky, initially only a few degrees from 3rd magnitude Alpha Serpentis. It then moves through Serpens, Hercules, and into Ophiuchus.

**Comet 19P/Borrelly** can only be observed from northern Australia as it fades from 13th to 14th magnitude during February. The comet moves from Canes Venatici into Ursa Major this month.

**Comet 96P/Machholz 1**, in all probability, will escape detection by amateurs at this return, particularly post-perihelion, although it will be in the field of the orbiting SOHO observatory in early January. Nevertheless, CCD users may like to start trying for the comet in early February, a month after perihelion, when it is 13th magnitude and rising around the beginning of astronomical twilight. Comet Machholz 1 spends February in the constellation of Aquila, and will be fainter than 15th magnitude by month's end.

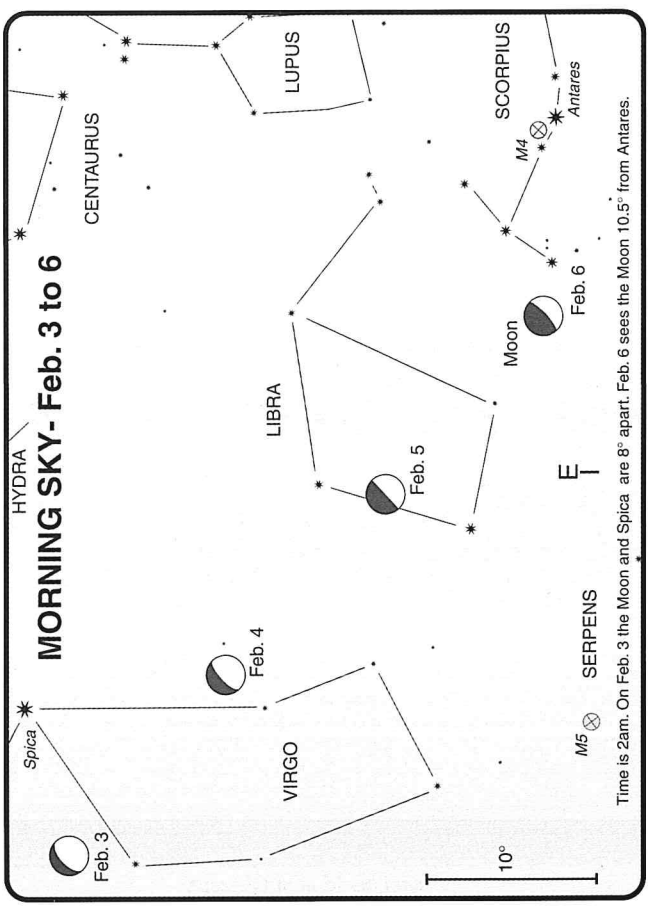
## METEOR SHOWERS

The **alpha Centaurids** are active from 28th January through to 21st February, with maximum on the 8th. Their zenith hourly rate is unpredictable, around 5 to 10 per hour at best, but high rates sometimes occur every 4 to 6 years. Most recently, in 1974 and 1980 the rate was 20 to 30 per hour. This increase is always temporary, lasting no more than 2 to 3 hours. The shower is noted for its brightly coloured fireballs that frequently reach negative magnitudes (up to –3 or more). They are predominantly yellow or blue, but their range can cover the entire spectrum. The alpha Centaurids are also well known for their long lasting trains (about 25 to 30 percent of the meteors) which may last from a few seconds to several minutes. Being circumpolar, the shower is visible throughout the night.

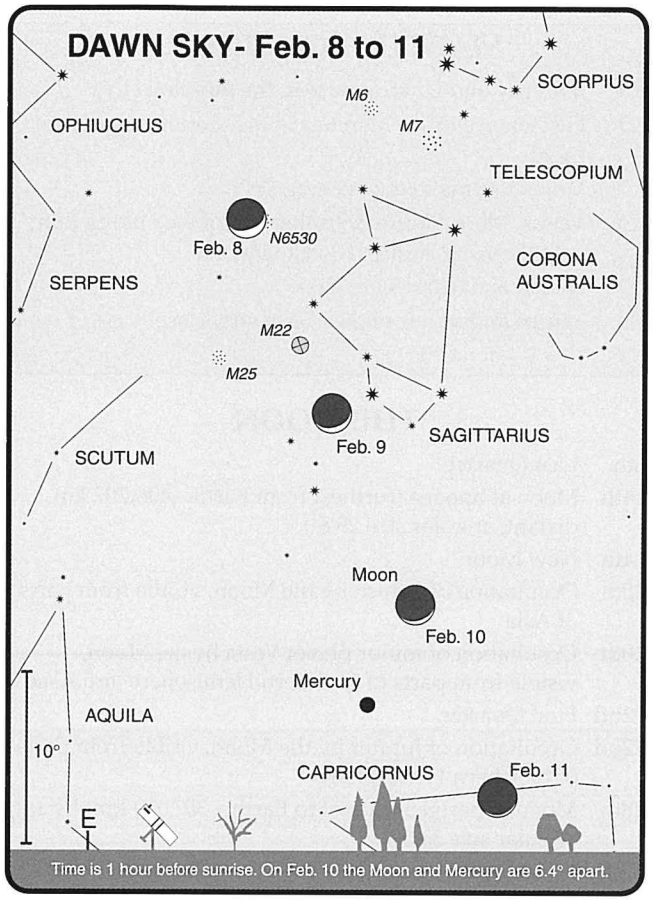
The **delta Leonids** are not well placed for southern observers, but with the radiant near the 'sickle' or 'head' of Leo, it will be above the northern horizon for a few hours late evening and early morning. With predominately faint meteors this shower is considered a minor one, active from 15th February to 10th March. Maximum is on the 24th but only a low zenith hourly rate of around 2 can be expected.

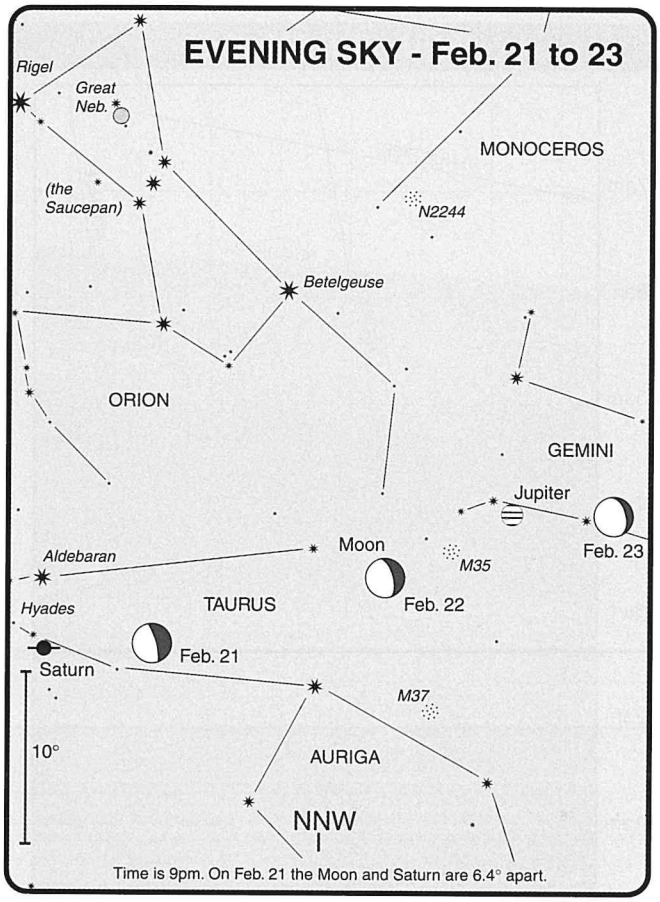
## DIARY

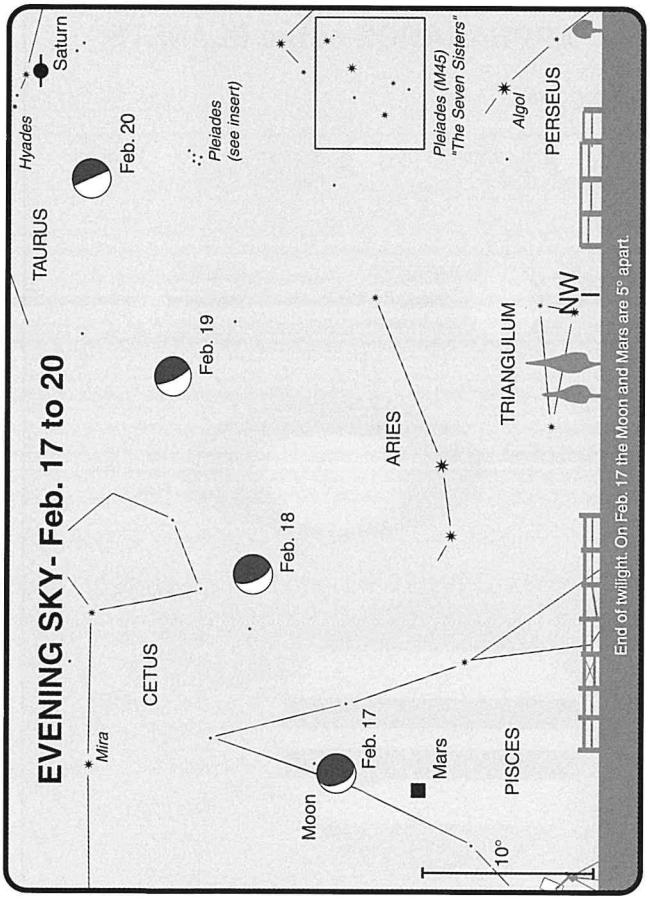
| | | |
|---|---|---|
| 4th | 9 PM | m.p. 8 Flora 0.9°SW of NGC 3489 (EG) in Leo |
| 4th | 9:33 PM | Last Quarter Moon |
| 8th | 6 PM | Mercury stationary |
| 8th | 6 PM | Saturn stationary |
| 9th | 9 PM | m.p. 8 Flora 0.9°NE of NGC 3412 (EG) in Leo |
| 10th | | Mars at ascending node |
| 10th | 1 PM | Mercury 5°N of Moon |
| 11th | 9 AM | Juno at opposition |
| 12th | 3:41 PM | New Moon |
| 13th | 9 PM | m.p. 8 Flora 0.8°NE of NGC 3377 (EG) in Leo |
| 14th | 1 AM | Uranus in conjunction with Sun |
| 15th | 6 AM | Moon at apogee |
| 16th | | Venus at greatest latitude South |
| 16th | | m.p. 18 Melpomene 0.7°S of NGC 6822 (IG) in Sagittarius |
| 16th | | m.p. 29 Amphitrite 1°S of star Phi Sagittarii |
| 16th | 9 PM | Ceres in conjunction with Sun |
| 17th | 8 AM | Mars 5°N of Moon |
| 20th | | Mars 0.6°SW of NGC 524 (EG) in Pisces |
| 20th | 8:02 PM | First Quarter Moon |
| 20th | 9 PM | Vesta 0.6°S of Moon; occultation |
| 21st | 8 AM | Saturn 0.2°S of Moon; occultation |
| 21st | | Mercury 0.2°E of m.p. 15 Eunomia |
| 21st | Midnight | Mercury greatest elongation W (27°) |
| 22nd | | Mercury at descending node |
| 23rd | 10 AM | Jupiter 0.9°S of Moon; occultation |
| 24th | 9 PM | Mercury 0.5°S of Neptune |
| 27th | 5:17 PM | Full Moon |
| 28th | 4 AM | Moon at perigee |
| 28th | | m.p. 3 Juno 0.3°NE of NGC 2775 (SG) in Cancer |

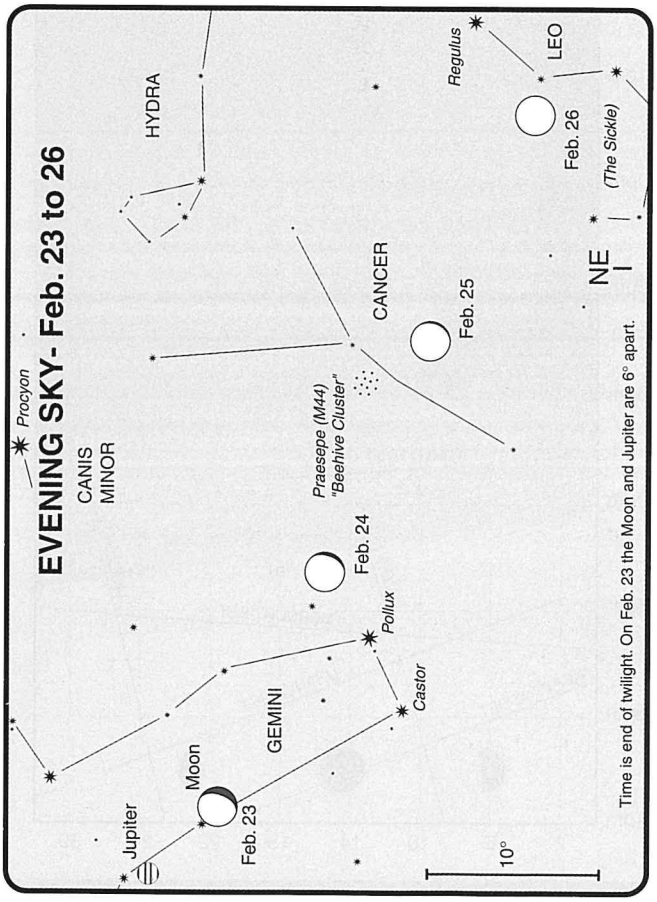


# FEBRUARY


DAWN SKY- Feb. 8 to 11
SCORPIUS
M6
M7
OPHIUCHUS
TELESCOPIUM
Feb. 8
N6530
CORONA AUSTRALIS
SERPENS
M22
M25
Feb. 9
SAGITTARIUS
SCUTUM
Moon
Feb. 10
Mercury
AQUILA
10°
CAPRICORNUS
Feb. 11
E
Time is 1 hour before sunrise. On Feb. 10 the Moon and Mercury are 6.4° apart.

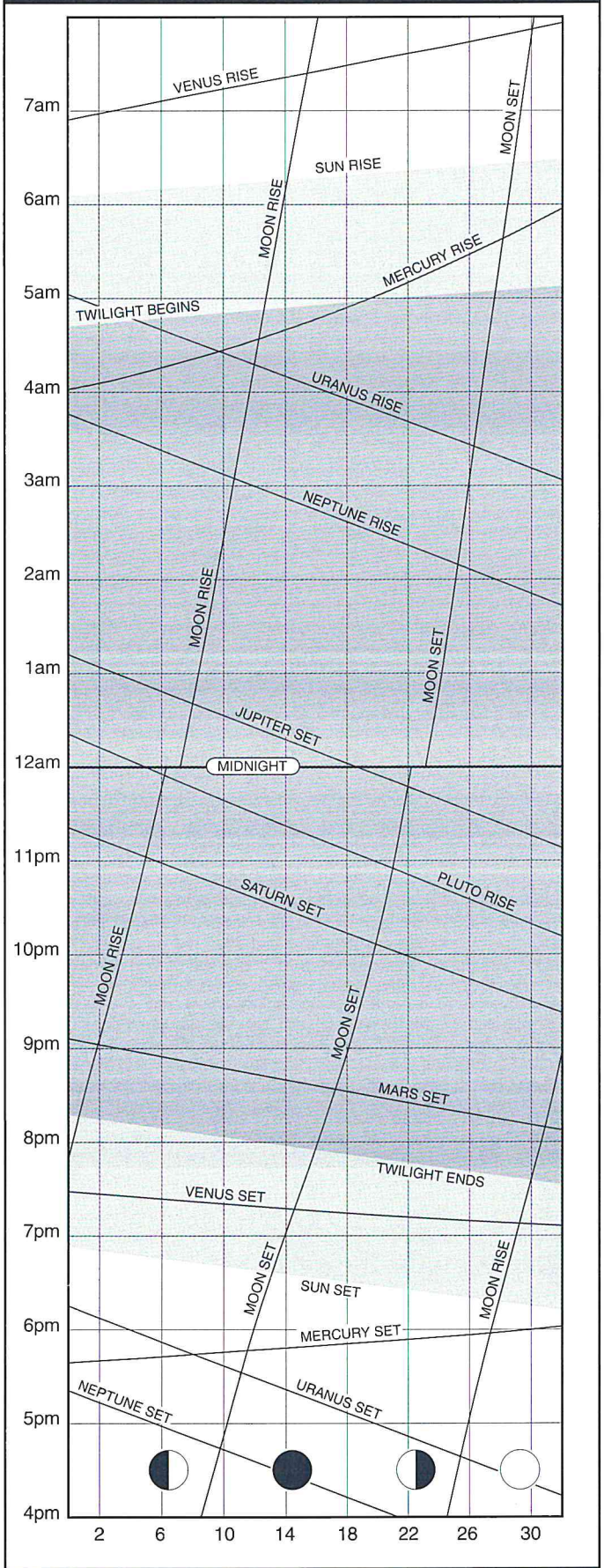

EVENING SKY - Feb. 21 to 23
Rigel
Great Neb.
MONOCEROS
(the Saucepan)
N2244
Betelgeuse
ORION
GEMINI
Jupiter
Feb. 23
Aldebaran
Moon
M35
Feb. 22
Hyades
TAURUS
Feb. 21
Saturn
M37
10°
AURIGA
NNW
Time is 9pm. On Feb. 21 the Moon and Saturn are 6.4° apart.


EVENING SKY- Feb. 17 to 20
Saturn
Hyades
Feb. 20
TAURUS
Pleiades (see insert)
Pleiades (M45) "The Seven Sisters"
Algol
PERSEUS
Feb. 19
TRIANGULUM
NW
ARIES
Feb. 18
CETUS
Mira
Feb. 17
Mars
PISCES
Moon
10°
End of twilight. On Feb. 17 the Moon and Mars are 5° apart.


EVENING SKY- Feb. 23 to 26
HYDRA
Regulus
LEO
Feb. 26
(The Sickle)
NE
CANCER
Feb. 25
Procyon
CANIS MINOR
Praesepe (M44) "Beehive Cluster"
Feb. 24
Pollux
Castor
GEMINI
Moon
Feb. 23
Jupiter
10°
Time is end of twilight. On Feb. 23 the Moon and Jupiter are 6° apart.

# MARCH

## RISE/SET CHART




All times are WAST.

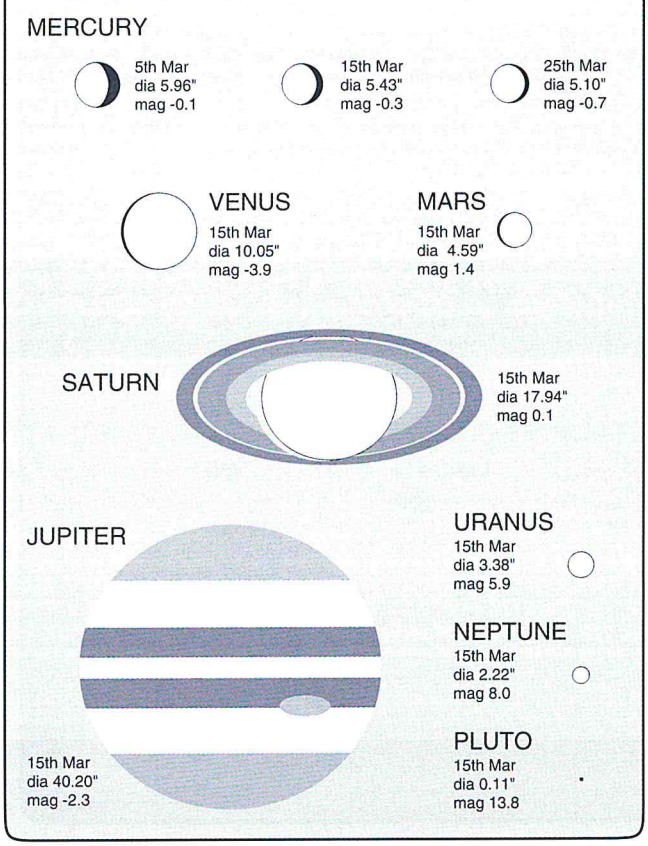
## MARCH HIGHLIGHTS

- Mercury and Uranus close in the morning sky
- Last chance to see Mercury in the morning sky (until June)
- Venus returns to the evening sky
- Venus, Mars, Saturn & Jupiter distributed along four neighbouring zodiacal constellations
- Saturn and Moon very close
- Saturn and minor planet Vesta very close

## THE MOON

| | |
|---|---|
| 6th | Last Quarter |
| 14th | Moon at apogee (furthest from Earth – 406,707 km distant, angular size 29.8′) |
| 14th | New Moon |
| 20th | Occultation of Saturn by the Moon, visible from parts of Asia |
| 20th | Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere and Asia |
| 22nd | First Quarter |
| 22nd | Occultation of Jupiter by the Moon, visible from parts of Northern Hemisphere |
| 28th | Moon at perigee (closest to Earth – 357,010 km distant, angular size 33.5′) |
| 29th | Full Moon |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY**, for the first half of March, maintains a good angular distance from the Sun, and remains easily visible in the eastern morning sky. On the 9th and 10th Mercury comes within 1.4° of Uranus (do not confuse Uranus with the brighter 5th magnitude star Mu Capricorni, situated just 0.3° from the greenish disk of the planet). On the 12th, the 27-day old thin crescent Moon appears 3° above the planet (see Sky View). During the course of March, Mercury travels from Capricornus to Aquarius and finally into Pisces at month-end.

**VENUS** is close to the Sun early in the month, but should not be difficult to detect in the western evening twilight from mid month onwards. On the Ides of March (15th), the slender crescent 1-day old Moon and Venus will make a splendid sight 3° apart, in the very early twilight. Interestingly at this time four planets are spread along four neighbouring zodiacal constellations as follows: (from west to north) Venus in Pisces, Mars in Aries, Saturn in Taurus, and Jupiter in Gemini.

The **EARTH** is at its autumnal equinox on the 21st. The Sun rises and sets due east and west and day and night are equal.

**MARS**, in Aries, is visible in the northwestern evening sky, setting about two hours after the Sun. On the 18th, the 4-day old crescent Moon will be 4.1° above the Red Planet.

**JUPITER** is situated in the mid-evening northern sky in Gemini, 4° from the rich compact star cluster Messier 35 (NGC2168), setting around midnight. On the 22nd, the First Quarter Moon appears only 1.7° from the planet (see Sky View). Incidentally, a few degrees from Jupiter's position (just over the border in Taurus) was where Sir William Herschel discovered Uranus 221 years ago this month.

**SATURN** is in Taurus, 4° below the first magnitude star Aldebaran in the northwestern evening sky. On the 20th, the 6-day old Moon appears 1.2° below the planet (see Sky View). On the 19th, there is an ideal chance to view an asteroid (minor planet), when Vesta is within only 0.1° of Saturn. Do not confuse Saturn's moon Titan with Vesta as both are of similar magnitude (around 8th), the moon is between the asteroid and the planet. On the following evening Vesta is now on the opposite side of Saturn and a little further away than on the 19th.

**URANUS** rises in the late morning eastern sky. Since 1996, Uranus has been confined within the boundaries of the constellation of Capricornus. At month-end the planet moves into Aquarius and remains there until mid-August when it returns to Capricornus. On the 9th, Uranus and Mercury have a close encounter (see Mercury).

**NEPTUNE** rises about an hour before and 16° above Uranus in the morning sky. Neptune, moving slower than Uranus, has resided in Capricornus since late 1998; it finally follows Uranus into Aquarius in 2010.

**PLUTO** now rises before midnight. The planet will be in retrograde motion from the end of the month until the end of August (see retrograde motion in Part II).

**MINOR PLANETS** at opposition this month include 27 Euterpe on the 12th at magnitude 9.4 in Leo. 18 Melpomene has some interesting deep sky encounters in Aquarius this month.

## COMETS

**Comet 7P/Pons-Winnecke** is a morning object in March, moving through the constellations of Ophiuchus and Serpens. Brightening from 13th to 12th magnitude as the month progresses, the comet is little more than a degree from 4th magnitude Sigma Ophiuchi around 11th March. A week later, Pons-Winnecke is less than a degree from Gamma Ophiuchi.

## A RED LIGHT DISTRICT?

*Daniel Tickell*

**Why Use a red torch.....**

The dark-adapted eye is insensitive to longer wavelengths of light and this is why the use of a red light when working at a telescope is so effective. The reason is the human eye is made up of sensors that react to different types of light. These sensors come in two types, rods and cones. Cones react primarily to colours and work best in bright conditions such as daylight. Rods on the other hand sense light in shades of black and white and continue to work well at low levels of light, Another way to help preserve dark adaptation, when taking a break from observing, is to wear red goggles. Although the pupils dilate relatively quickly it can take up to 20 minutes, depending on the individual, to achieve complete dark adaptation.

**How to make a red torch.....**

The simplest way to make a red torch is buy a torch from a supermarket, toy store or any other store that might take your fancy, and some red cellophane and a rubber band. Place the cellophane over the end of the torch and hold it in place with the rubber band.

One problem with this is that the cellophane will tear and the torch will not last. There are a few alternatives to the cellophane torch.

Buy a good quality torch, for example a Mini-Mag Light or similar. These torches are great, they take two AA batteries that last for ages. The torch will cost about $30-$50 and it really is worth it. The next step is to visit your local hobby shop and purchase a jar of clear red paint; this should cost you under $5. The next part can be done in two ways, both will require you to disassemble your torch and both will work on most torches, including the one from the toy store that costs $2. It's a good idea to have some blue tack or polystyrene handy for this. The globe in a Mag Light is a small glass bulb on the end of a two-wire element. Gently push the elements into the blue tack or polystyrene. Once firmly inserted dip the globe into the clear red paint, leave the globe to dry. This should be repeated 2 to 3 times, giving the globe plenty of time to dry. The advantage of doing this is that in the base of the Mag light there is a spare globe, so when you need red light, you have it and when you need white light swap the globe. Another advantage is that the Mag light has a removable reflector that makes the torch work like a candle. This is handy as it's not always practical to hold a torch, especially when you have lots of people that need it at the same time.

The other option is a bit harder; you will need the same ingredients as well as a hobby paintbrush. The idea here is that the glass that covers the globe in your torch is to be painted. If you are not worried about the torch, slap some paint on while the glass is in the torch. That way you might get some paint on the torch housing. The other way is to take the glass out and stick it on a piece of blue tack, paint one side and let it dry. It's important that it dries completely before sticking the painted surface on to the blue tack. Repeat 2 to 3 times as necessary.

Another alternative is to buy a torch that is specific for the purpose. Some of these have red LEDs instead of a globe. The commercially available 'Skylite' torch has 2 pairs of LEDs, one pair is red the other white which can easily be switched between. There is also a control to dim the torch.

# MARCH

**Comet C/2000 WM1 (LINEAR)** is rising higher in the sky each morning as it moves away from the Sun. The comet moves through Sagittarius into neighbouring Aquila. On 7th March, LINEAR is less then a degree from 4th magnitude Rho 1 Sagittarii. In March and April, LINEAR has a few encounters with star clusters in Aquila. By the end of March, the comet is similarly less than a degree from the globular cluster NGC 6760. During the month, LINEAR should fade from 8th to 10th magnitude.

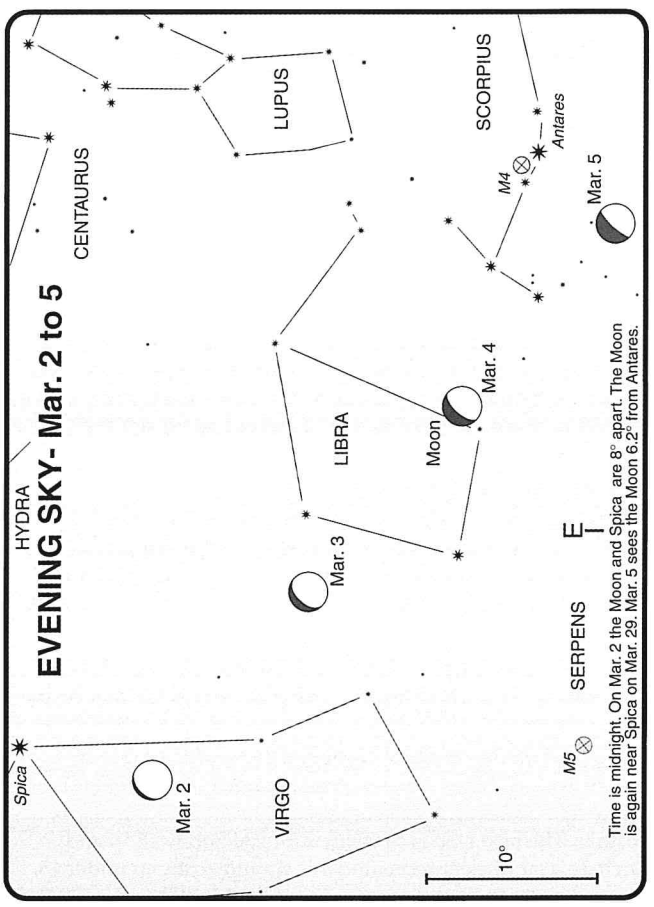
## METEOR SHOWERS

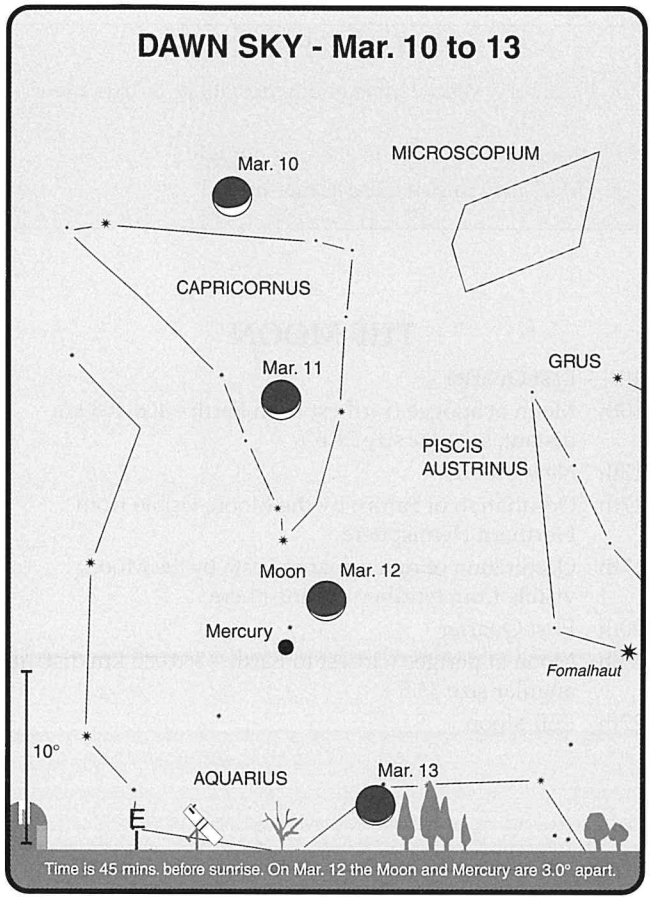
The **Gamma Normids** are active between 25th February and 22nd March. For most of the period the rate is low, and members are difficult to sort out from the background sporadic activity. The peak occurs on March 13, when rates can reach 3 to 8 per hour. Generally, the Gamma Normids are bright and chiefly yellow, white or orange with about 15% leaving trains. Since the constellation Norma doesn't reach a reasonable altitude until late evening, the shower is best viewed after midnight.

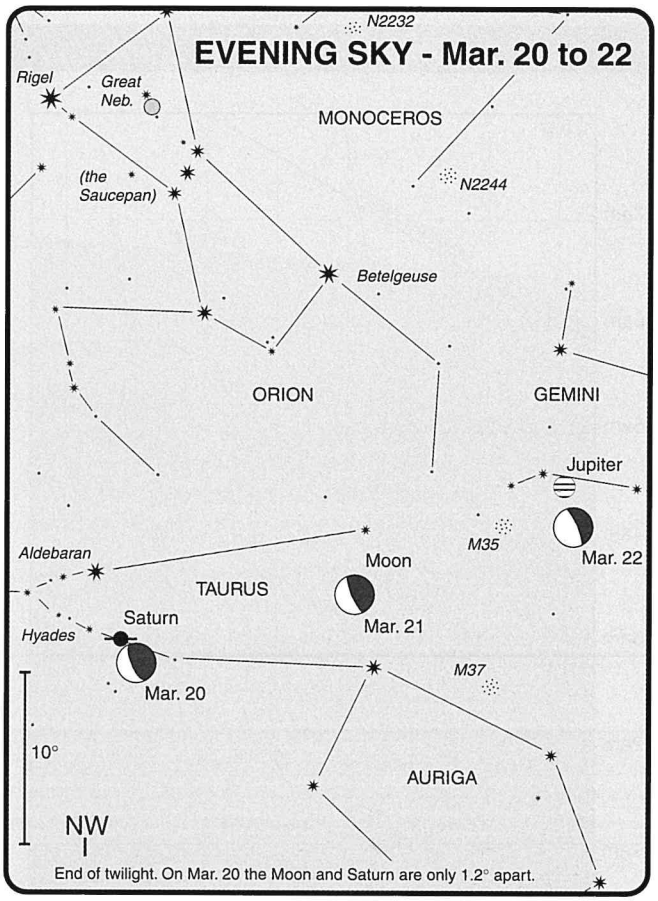
The **Virginids** are active from 25th January through to 15th April, with several peaks of maximum activity over the period. The radiant is near 1st magnitude Alpha Virginis (Spica), and the shower is best seen from late evening and into the morning hours. A zenith hourly rate of 5 slow meteors during peaks can be expected.

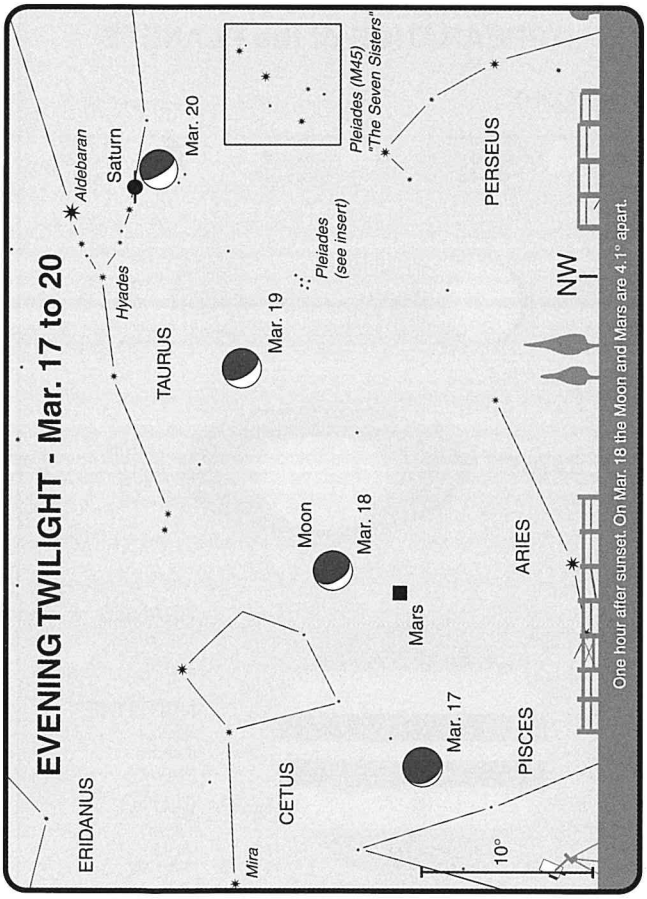
## DIARY

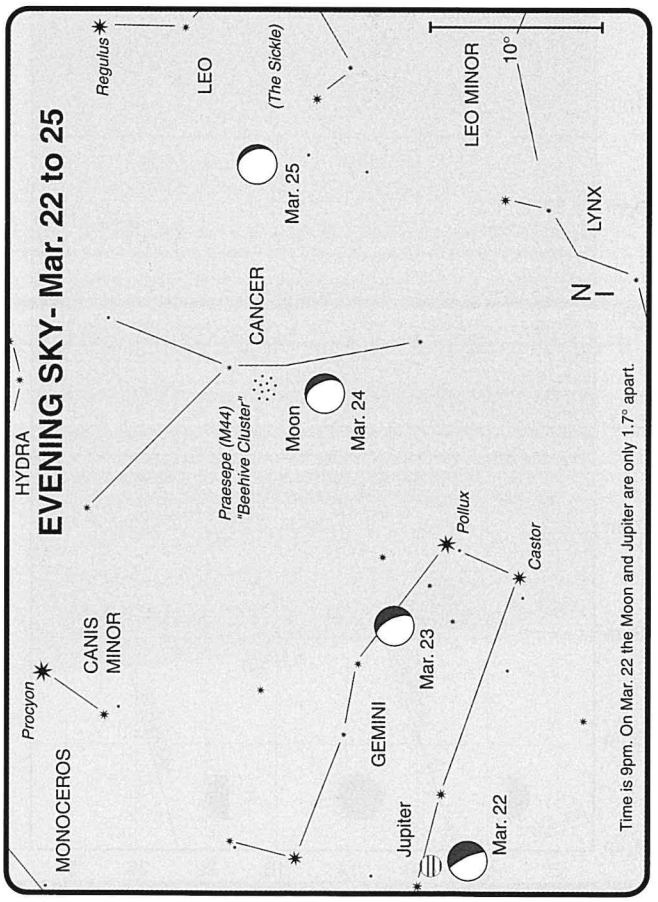
| | | |
|---|---|---|
| 1st | | m.p. 29 Amphitrite 0.2°SE of star Tau Sagittarii |
| 1st | 11 PM | Jupiter stationary |
| 4th | | Mercury at aphelion |
| 4th | | Neptune 0.5°S of m.p. 15 Eunomia |
| 5th | | m.p. 18 Melpomene 0.8°N of star Beta Capricorni |
| 6th | 1 AM | m.p. 25 Phocaea 0.6°S of star Eta Ophiuchi |
| 6th | 9:24 AM | Last Quarter Moon |
| 9th | 11 AM | Mercury 1.2°S of Uranus |
| 10th | 5 PM | Neptune 4°N of Moon |
| 11th | | m.p. 4 Vesta 0.1°N of NGC 1554 (Neb.) in Taurus |
| 12th | 1 AM | Uranus 4°N of Moon |
| 12th | 9 AM | Mercury 3°N of Moon |
| 13th | 1 AM | Comet 57P/du Toit-Neujmin-Delporte 0.7°S of NGC 6440 (GC) in Sagittarius |
| 14th | 9 AM | Moon at apogee |
| 14th | 10:02 AM | New Moon |
| 15th | 3 AM | Comet 46P/Wirtanen 0.02°W of m.p. 1 Ceres |
| 17th | | Comet 7P/Pons-Winnecke 0.5°S of NGC 6426 (GC) in Ophiuchus |
| 18th | | m.p. 18 Melpomene 0.3°NW of Aqr Dwarf (IG) in Aquarius |
| 18th | | m.p. 20 Massalia occulted by the Sun (not observable) |
| 18th | 9 AM | Mars 4°N of Moon |
| 19th | 7 PM | Saturn 0.1°NE of m.p. 4 Vesta |
| 20th | | m.p. 2 Pallas 0.3°SE of NGC 6934 (GC) in Delphinus |
| 20th | 6 PM | Saturn 0.5°S of Moon; occultation |
| 20th | 6 PM | Vesta 0.5°S of Moon; occultation |
| 21st | 3 AM | Equinox |
| 21st | 2 PM | Pluto stationary |
| 22nd | | m.p. 18 Melpomene 0.4°N of NGC 6981 (GC) in Aquarius |
| 22nd | 10:28 AM | First Quarter Moon |
| 22nd | 8 PM | Jupiter 1.1°S of Moon; occultation |
| 23rd | | Mercury 0.2°E of NGC 7596 (SG) in Aquarius |
| 23rd | 8 PM | Juno stationary |
| 24th | | Mercury at greatest latitude South |
| 24th | | m.p. 18 Melpomene 0.8°N of M73 (OC) in Aquarius |
| 27th | | m.p. 18 Melpomene 0.2°SW of Saturn Nebula (PN) in Aquarius |
| 28th | 4 PM | Moon at perigee |
| 29th | 2:25 AM | Full Moon |
| 29th | | m.p. 6 Hebe 1°SE of NGC 6664 (OC) in Scutum |
| 31st | 1 AM | Comet C/2000 WM1 (LINEAR) 0.5°E of NGC 6760 (GC) in Aquila |
| 31st | Midnight | Saturn 4°N of Aldebaran |




DAWN SKY - Mar. 10 to 13
Mar. 10
MICROSCOPIUM
CAPRICORNUS
Mar. 11
GRUS
PISCIS AUSTRINUS
Moon
Mar. 12
Mercury
Fomalhaut
10°
AQUARIUS
Mar. 13
E
Time is 45 mins. before sunrise. On Mar. 12 the Moon and Mercury are 3.0° apart.

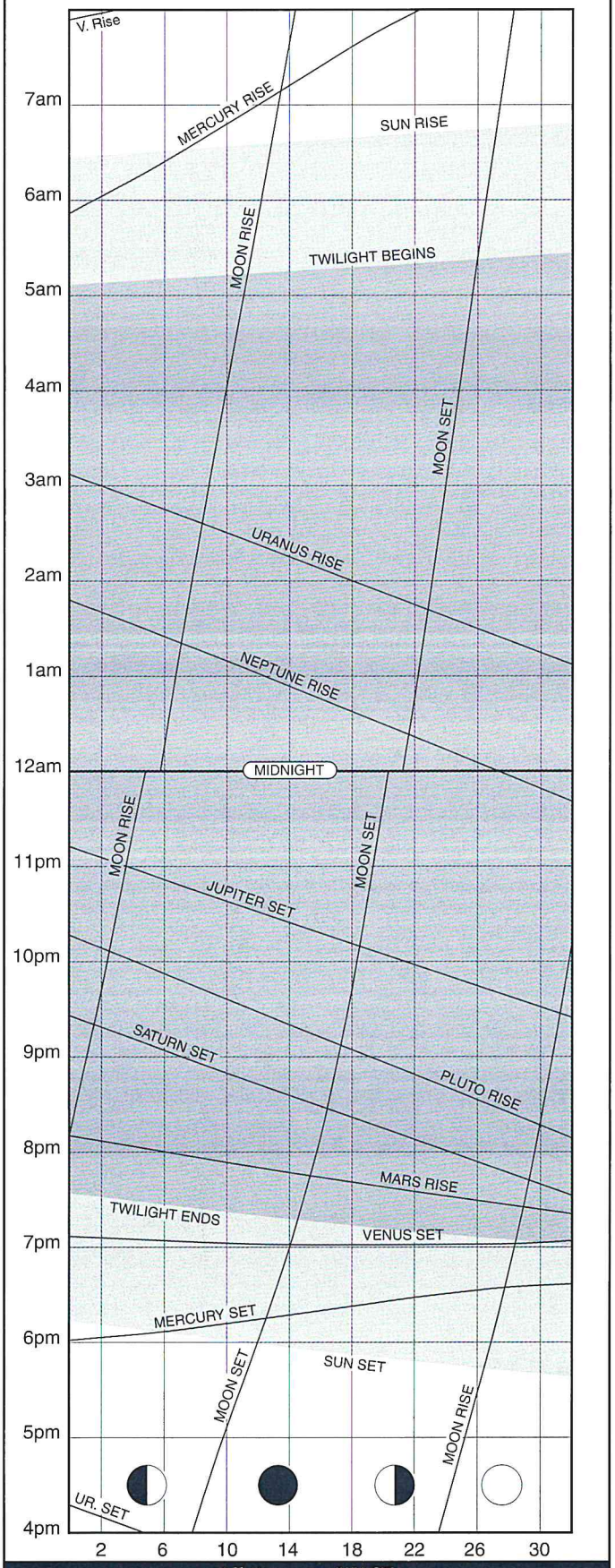

EVENING SKY - Mar. 20 to 22
N2232
Rigel
Great Neb.
MONOCEROS
(the Saucepan)
N2244
Betelgeuse
ORION
GEMINI
Jupiter
M35
Mar. 22
Aldebaran
Moon
TAURUS
Mar. 21
Saturn
Hyades
M37
Mar. 20
10°
AURIGA
NW
End of twilight. On Mar. 20 the Moon and Saturn are only 1.2° apart.


EVENING TWILIGHT - Mar. 17 to 20
Aldebaran
Saturn
Mar. 20
Hyades
Pleiades (M45) "The Seven Sisters"
TAURUS
Pleiades (see insert)
PERSEUS
Mar. 19
NW
Moon
Mar. 18
ARIES
Mars
ERIDANUS
Mar. 17
PISCES
CETUS
Mira
10°
One hour after sunset. On Mar. 18 the Moon and Mars are 4.1° apart.


EVENING SKY- Mar. 22 to 25
Regulus
LEO
(The Sickle)
LEO MINOR
10°
Mar. 25
LYNX
N
CANCER
HYDRA
Praesepe (M44) "Beehive Cluster"
Moon
Mar. 24
Pollux
Castor
Procyon
CANIS MINOR
GEMINI
Mar. 23
MONOCEROS
Jupiter
Mar. 22
Time is 9pm. On Mar. 22 the Moon and Jupiter are only 1.7° apart.

# APRIL

## RISE/SET CHART




All times are WAST.

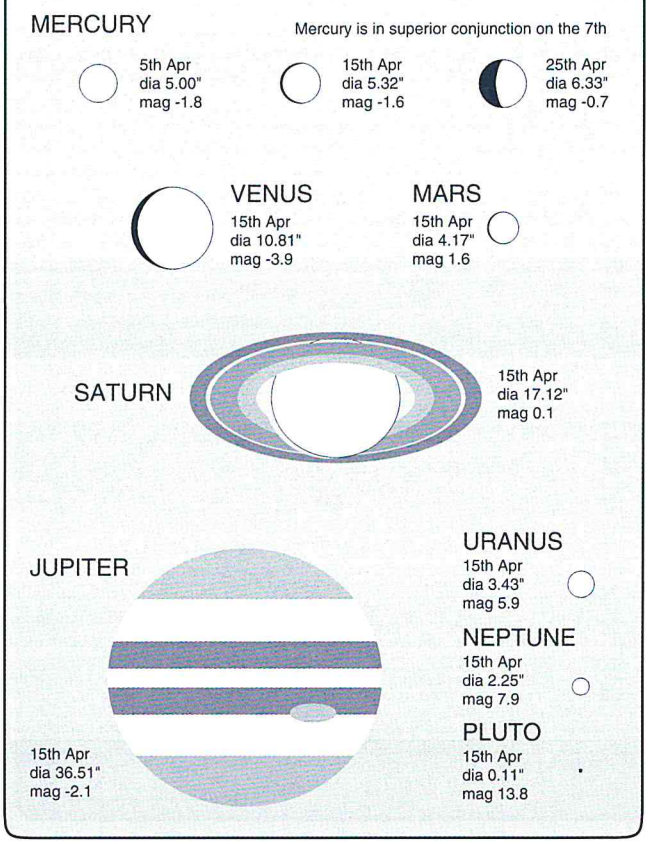
## APRIL HIGHLIGHTS

- Mercury, Venus, Mars and Saturn all in Taurus late in month
- Venus brilliant in the evening twilight
- Mars and Saturn close at month-end

## THE MOON

| | |
|---|---|
| 4th | Last Quarter |
| 10th | Moon at apogee (furthest from Earth – 406,408 km distant, angular size 29.6′) |
| 13th | New Moon |
| 17th | Occultation of Saturn by the Moon, visible from Northern Hemisphere |
| 17th | Occultation of minor planet Vesta by the Moon, visible from Northern Hemisphere |
| 20th | First Quarter |
| 25th | Moon at perigee (closest to Earth – 360,085 km distant, angular size 33.5′) |
| 27th | Full Moon |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 7th, and thereafter moves into the evening sky. Mercury steadily gains altitude after conjunction, but will be difficult to see in the twilight until month-end. After the 27th, with a good unobstructed northwestern horizon, Mercury may be glimpsed soon after sunset at low altitude. Strung along the ecliptic northwards above Mercury are Venus, Mars and Saturn, all four planets being in Taurus at this time.

**VENUS** is now easily visible in the evening twilight. The planet moves from Aries into Taurus late in the month, joining Mars and Saturn. Next month the trio provide some interesting and close conjunctions. On April 14th, the 1-day old thin crescent Moon appears 5° south of the planet, and on the following evening 6.6° to the north (see Sky View).

**MARS** is low in the early evening twilight, setting 30 minutes after the end of twilight. It moves from Aries into Taurus during the first week of April. On the 16th, the 3-day old crescent Moon appears 4.4° from Mars (see Sky View). By the 30th, the Red Planet will be located 3° below Saturn. Venus and Mercury are also nearby but lower in altitude and westward.

**JUPITER** can be found in the NW evening sky in Gemini, setting around 10pm mid-month. The 6 day old Moon will be 6.4° from Jupiter on the 19th (see Sky View).

**SATURN** is in the NW early evening sky, setting about 2 hours ahead of Jupiter. It begins April as the only planet in Taurus, but is joined by Mars, Venus and Mercury by month-end. On the 16th, the 3-day old crescent Moon is 6° south of Saturn (and a similar distance to Mars) and on the following evening 7° to the north (see Sky View).

**URANUS** and **NEPTUNE**, in Aquarius and Capricornus respectively, pass an uneventful month in the early morning eastern sky.

**PLUTO** rises in the mid-evening and transits the meridian (due north) around 4am mid-month.

## COMETS

**Comet 7P/Pons-Winnecke** brightens from 12th to 11th magnitude this month in the morning sky. Visible from shortly after midnight, the comet moves through Serpens and Aquila. On 11th April, Pons-Winnecke is two degrees from the globular cluster NGC 6760. A week later, the comet is a similar distance from 4th magnitude Iota Aquilae. In late April, the comet is less than four degrees from 3rd magnitude Theta Aquilae.

**Comet C/2000 WM1 (LINEAR)** rises before midnight during April as it moves from Aquila into Hercules. In March and April, LINEAR has a few encounters with star clusters in Aquila. During this month, the comet should fade from 10th to 11th magnitude.

## METEOR SHOWERS

The **Lyrids** are a northern shower, but can be observed south of the equator. They are best seen between 2am and dawn from the 16th to 25th April, with maximum on the 22nd. Maximum rates may only last an hour or so, and typically the zenith hourly rate is around 15. 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.

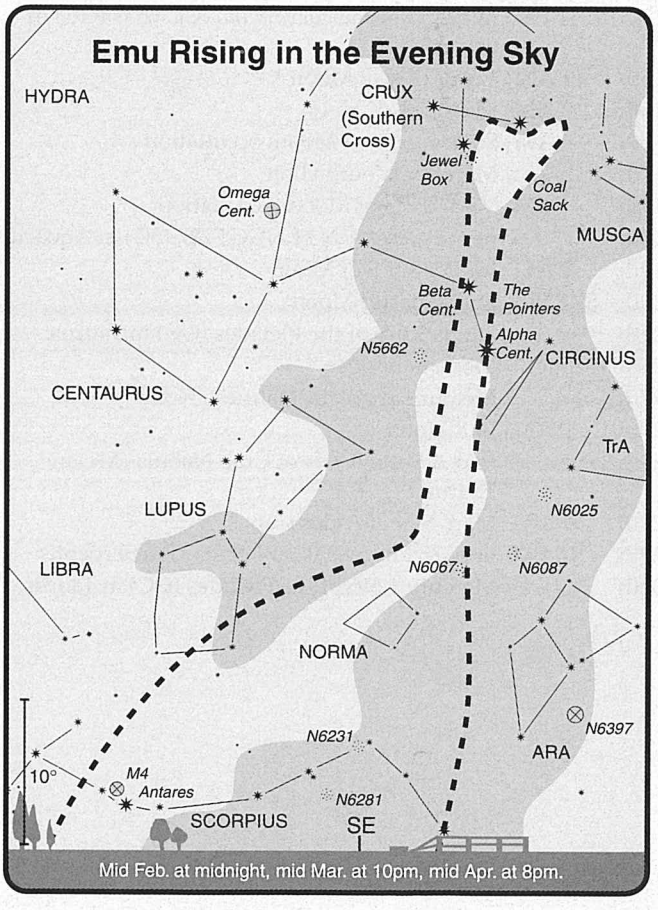
## THE CONSTELLATION OF THE EMU

The Australian aborigines had their own version of the zodiac thousands of years before the Europeans dreamed up our modern day interpretation of the constellations. The aborigines had a sky consisting of some 40 different native birds and animals which included eagles, parrots, lorikeets and dancing men. Probably the most conspicuous constellation was that of the Emu.

Unlike many of the Greek and Roman figures allotted to the star patterns, the Emu really does resemble this Australian native creature. The animal is made up of many dark bands of nebulae that are silhouetted against the glow of our own galaxy, the Milky Way.

To see this bird you need to be well away from the light polluted skies of large towns and cities (if you can't see the Milky Way - forget about finding this animal). The Emu can be seen sitting on the southeastern horizon in the late summer and autumn evening sky. It is quite large - extending half way up the sky. Its head consists of what is probably the most distinctive dark nebula in the southern skies, the Coal Sack, near the Southern Cross. It is well shaped, even showing a beak, and a fairly conspicuous 6th magnitude star for an eye. From there the neck runs down through the pointers and then widens out to the body in Scorpius.

It is unique. For example, none of the modern day constellations are made up entirely of nebulae i.e., no stars! Considering its terrestrial counterpart is very much earth-bound, the Emu has no problems taking flight, passing overhead, as the Southern Hemisphere moves into its brilliant, early evening winter skies.

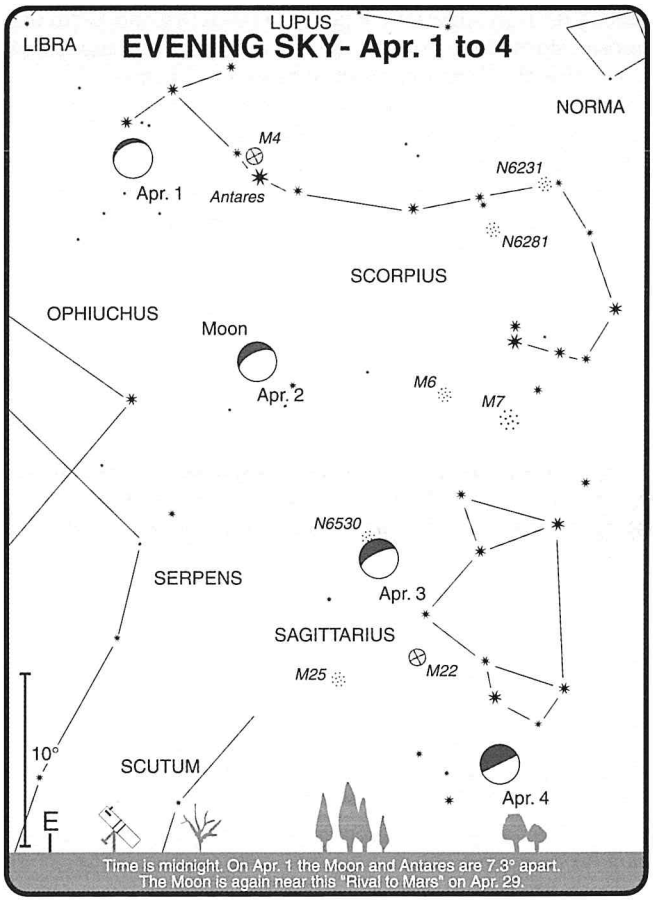


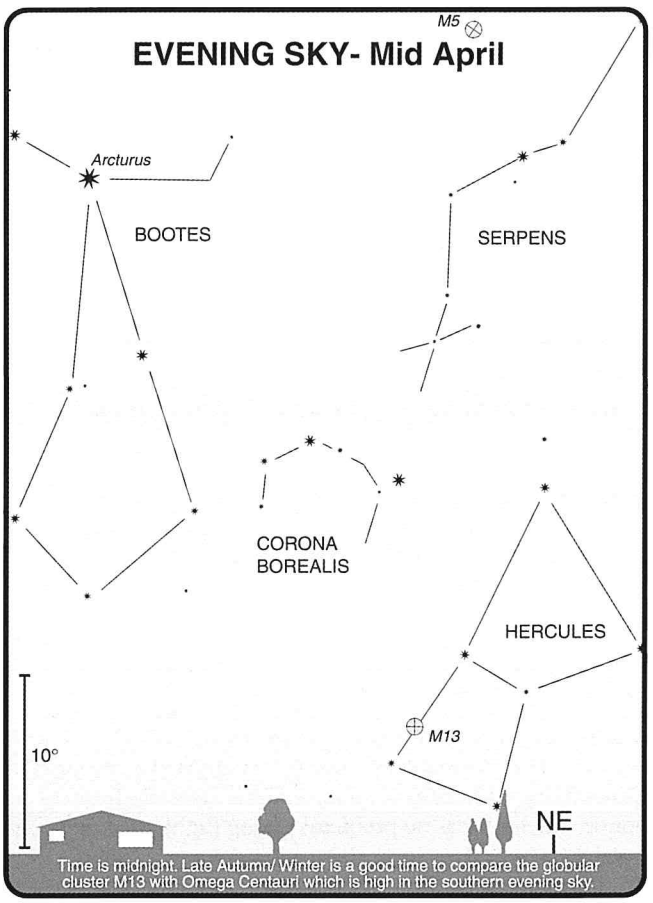
# APRIL

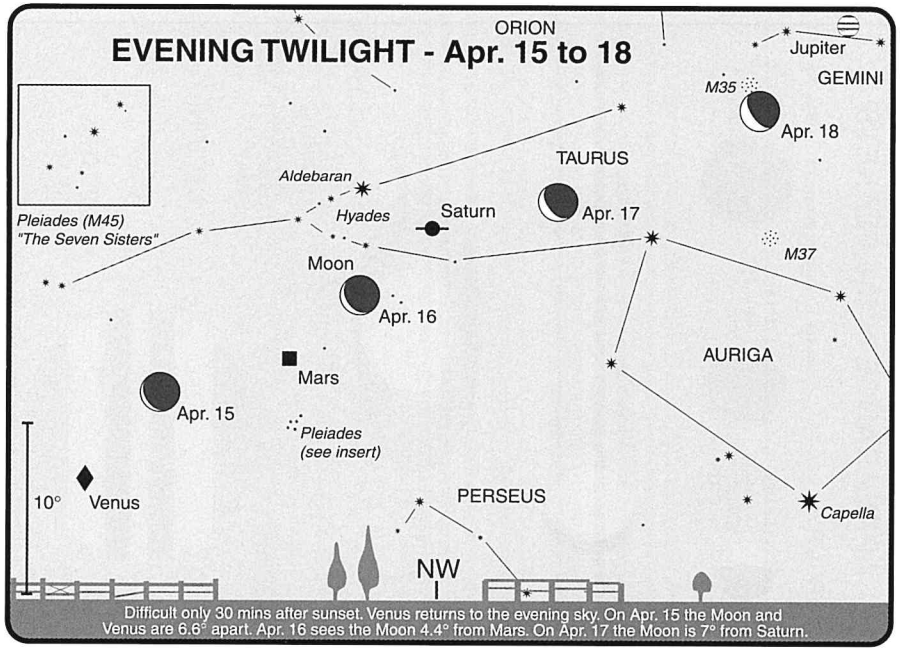
The **pi Puppids** or **Grigg-Skjellerupids** (after the short period comet that produced the stream) is a very young southern shower first observed in 1972. They are best seen in the evening sky from 15th to 28th April, with maximum activity on the 23rd. Leading up to and after the maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil and occasionally 3 to 4 per hour or more (13 in 1983, 40 in 1982 and 1977). The pi Puppids are noted for their very slow speed, brightness, persistent trains, and large proportion of yellow meteors and occasional fireballs.

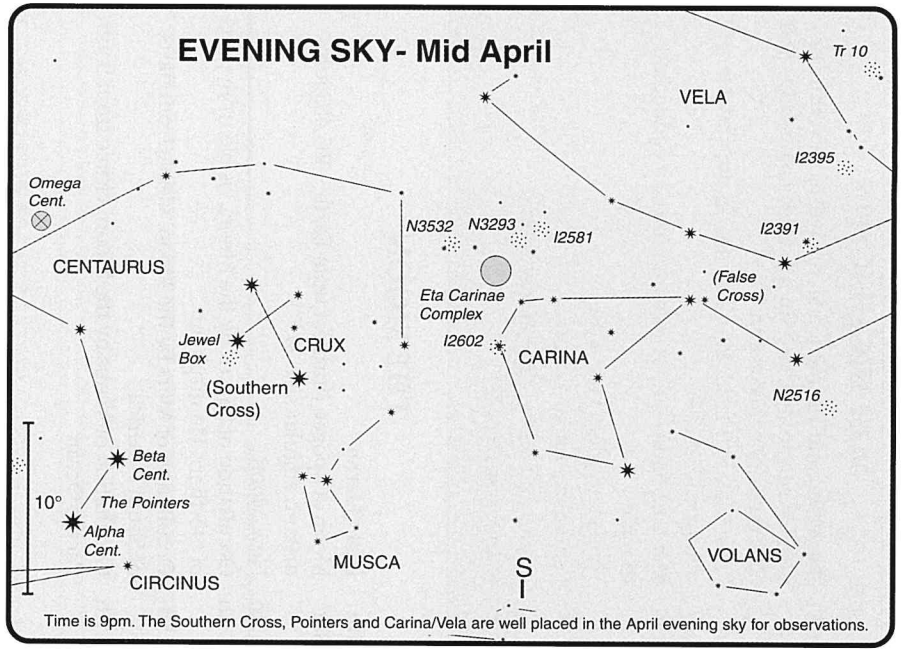
## DIARY

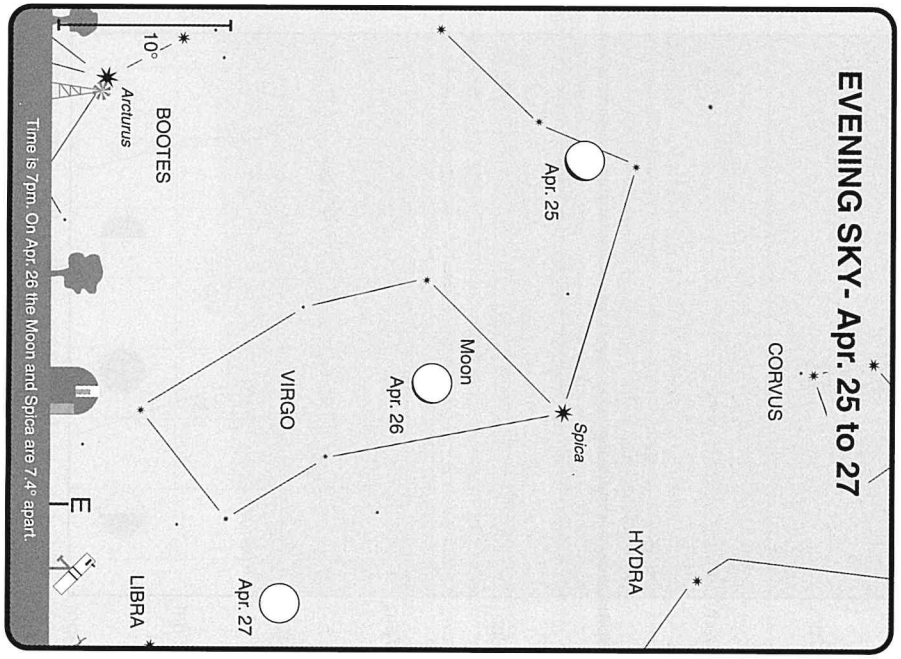
| | | |
|---|---|---|
| 3rd | 1 AM | m.p. 6 Hebe 0.7°NW of M26 (OC) in Scutum |
| 4th | 1 AM | Comet C/2000 WM1 (LINEAR) 0.5°E of NGC 6755 (OC) in Aquila |
| 4th | 10 PM | Comet 57P/du Toit-Neujmin-Delporte 0.9°S of M25 (OC) in Sagittarius |
| 4th | 11:29 PM | Last Quarter Moon |
| 6th | Midnight | Neptune 4°N of Moon |
| 7th | 5 PM | Mercury in superior conjunction |
| 8th | 9 AM | Uranus 4°N of Moon |
| 9th | 2 AM | Comet 7P/Pons-Winnecke 0.1°W of NGC 6741 (PN) in Aquila |
| 9th | | m.p. 9 Metis 0.6°S of star Pollux |
| 10th | 1 PM | Moon at apogee |
| 12th | | Mercury at ascending node |
| 12th | | Mars 3.5°S of Pleiades M45 (OC) in Taurus |
| 12th | Midnight | m.p. 6 Hebe 0.6°N of NGC 6712 (GC) in Scutum |
| 13th | 3:21 AM | New Moon |
| 13th | | Venus at ascending node |
| 13th | 11 PM | m.p. 25 Phocaea 0.5°SE of NGC 6539 (GC) in Serpens |
| 15th | 1 AM | Venus 3°N of Moon |
| 16th | 7 AM | Mars 2°N of Moon |
| 17th | 4 AM | Saturn 0.8°S of Moon; occultation |
| 17th | | Mercury at perihelion |
| 17th | 6 PM | Vesta 0.7°S of Moon; occultation |
| 18th | | m.p. 1 Ceres 1°N of NGC 7727 (SG) in Aquarius |
| 19th | 7 AM | Jupiter 1.6°S of Moon |
| 20th | 8:48 PM | First Quarter Moon |
| 25th | | Venus 3.6°S of the Pleiades (OC) in Taurus |
| 25th | Midnight | Moon at perigee |
| 27th | | Mercury at greatest latitude North |
| 27th | 11:00 AM | Full Moon |
| 29th | | m.p. 4 Vesta 0.9°N of Crab Nebula (M1) in Taurus |
| 29th | 9 PM | Mars 6°N of Aldebaran |
| 29th | 10 PM | m.p. 25 Phocaea 0.6°W of star Eta Serpentis |
| 30th | | Mercury 1.5°S of the Pleiades (OC) in Taurus |

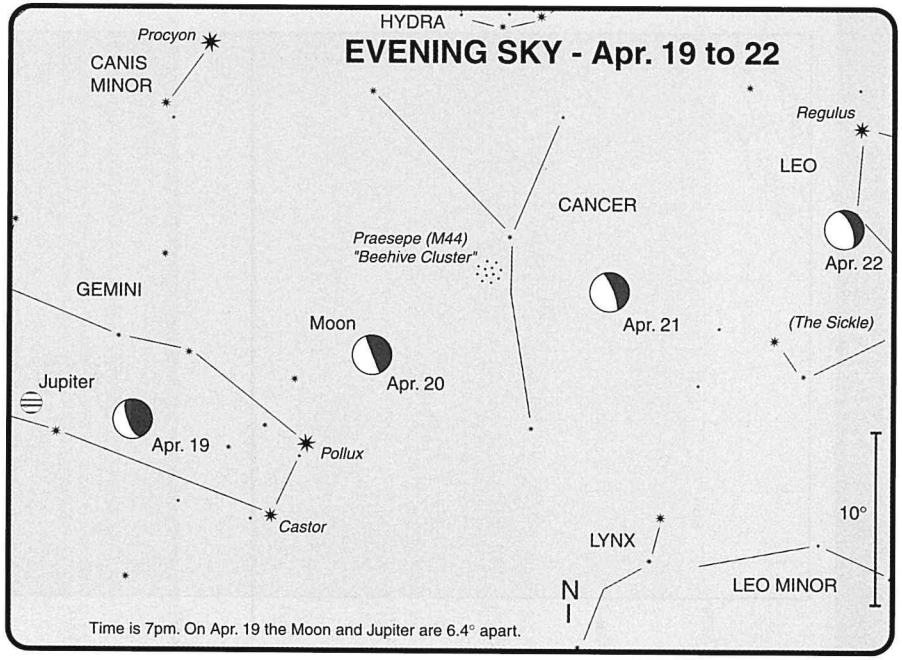



EVENING TWILIGHT - Apr. 15 to 18
ORION
Jupiter
GEMINI
M35
Apr. 18
TAURUS
Aldebaran
Hyades
Saturn
Apr. 17
Pleiades (M45)
"The Seven Sisters"
M37
Moon
Apr. 16
AURIGA
Mars
Apr. 15
Pleiades
(see insert)
10°
Venus
PERSEUS
Capella
NW
Difficult only 30 mins after sunset. Venus returns to the evening sky. On Apr. 15 the Moon and Venus are 6.6° apart. Apr. 16 sees the Moon 4.4° from Mars. On Apr. 17 the Moon is 7° from Saturn.

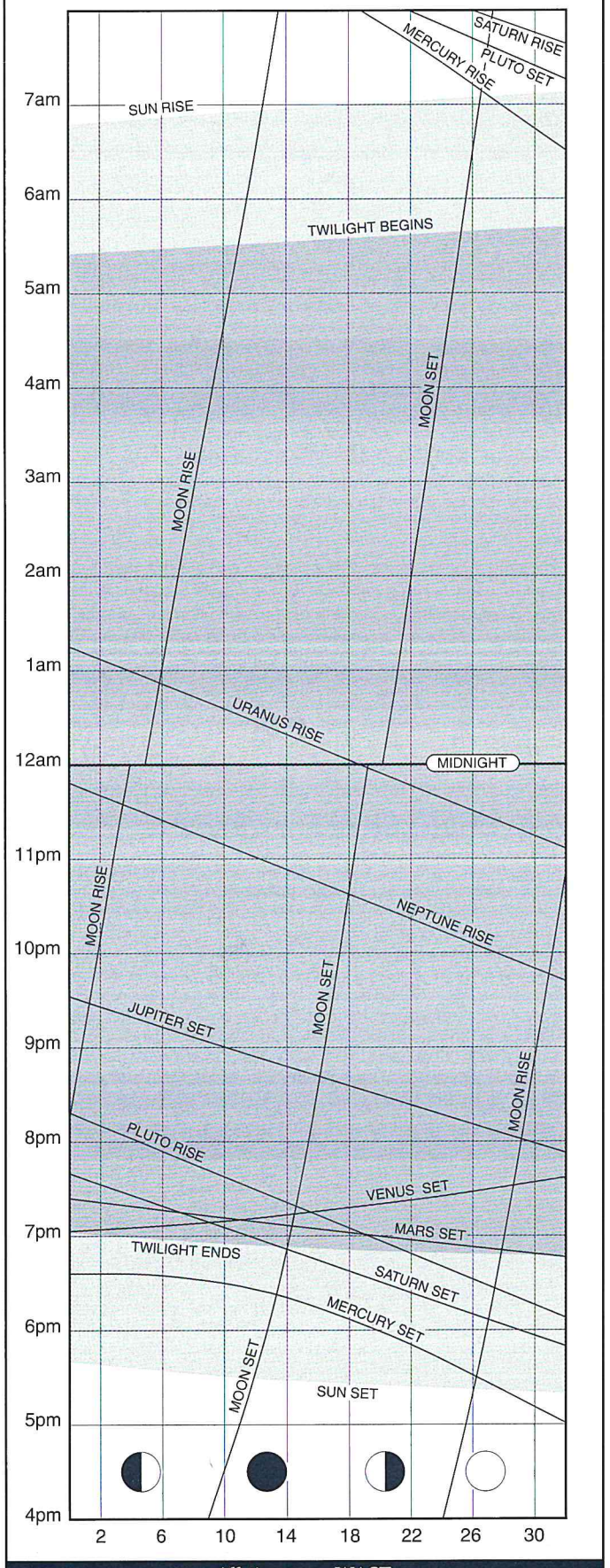

EVENING SKY- Mid April
Tr 10
VELA
I2395
Omega
Cent.
N3532
N3293
I2581
I2391
CENTAURUS
(False
Cross)
Eta Carinae
Complex
Jewel
Box
CRUX
I2602
CARINA
(Southern
Cross)
N2516
Beta
Cent.
10°
The Pointers
Alpha
Cent.
MUSCA
VOLANS
CIRCINUS
S
Time is 9pm. The Southern Cross, Pointers and Carina/Vela are well placed in the April evening sky for observations.


EVENING SKY- Apr. 25 to 27
10°
Arcturus
BOOTES
Apr. 25
CORVUS
Moon
Apr. 26
VIRGO
Spica
HYDRA
LIBRA
Apr. 27
Time is 7pm. On Apr. 26 the Moon and Spica are 7.4° apart.


HYDRA
Procyon
CANIS
MINOR
EVENING SKY - Apr. 19 to 22
Regulus
LEO
CANCER
Praesepe (M44)
"Beehive Cluster"
Apr. 22
GEMINI
Apr. 21
(The Sickle)
Moon
Apr. 20
Jupiter
Apr. 19
Pollux
Castor
10°
LYNX
N
LEO MINOR
Time is 7pm. On Apr. 19 the Moon and Jupiter are 6.4° apart.

# MAY

## RISE/SET CHART




All times are WAST.

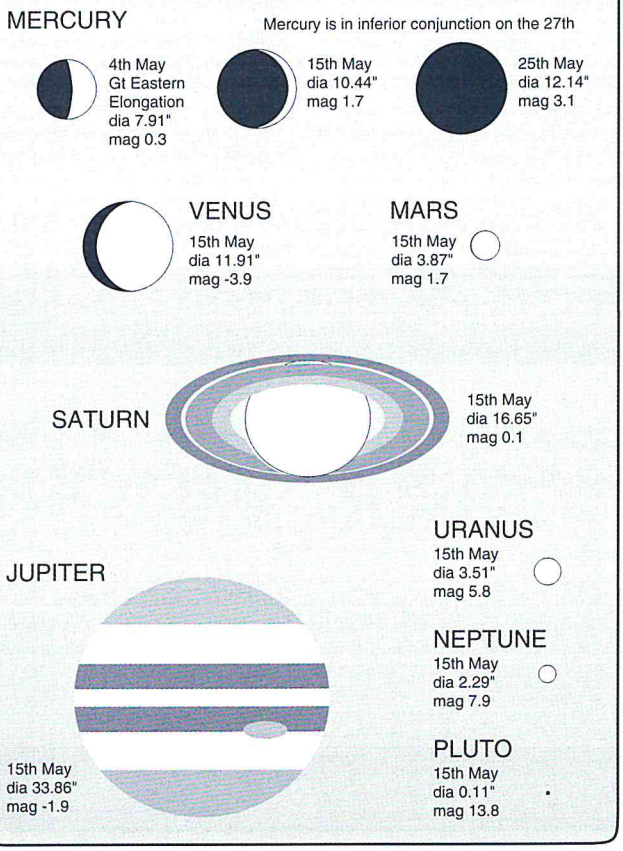
## MAY HIGHLIGHTS

- The Moon and the planets in the western evening sky provide several weeks of interesting conjunctions and configurations this month
- From May 5 to 11 Mercury, Venus, Saturn and Mars fit within a 10° circle.
- Mercury, Saturn and Aldebaran form an equilateral triangle
- Venus and Mars very close
- Penumbral Lunar Eclipse
- Jupiter and Venus close at month-end
- Mars passes by M35

## THE MOON

| | |
|---|---|
| 4th | Last Quarter |
| 8th | Moon at apogee (furthest from Earth – 405,483 km distant, angular size 29.7′) |
| 12th | New Moon |
| 14th | Occultation of Saturn by the Moon, visible from parts of Northern Hemisphere |
| 15th | Occultation of Mars by the Moon, visible from parts of South America |
| 15th | Occultation of Venus by the Moon, visible from South Pacific Ocean |

## APPEARANCE of the PLANETS



15th Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere
20th First Quarter
23rd Moon at perigee (closest to Earth – 364,984 km distant, angular size 32.9')
26th Full Moon. Penumbral Lunar Eclipse, visible from Australia (see p. 8)

## THE PLANETS

**MERCURY** reaches its greatest elongation east of the Sun (21°) on the 4th (see Sky View). This is not a particularly favourable elongation, with the planet remaining in the twilight sky and setting about an hour after the Sun during the first half of the month. Mercury then moves back toward the Sun and inferior conjunction (between Earth and Sun) on the 27th; before reappearing in the June morning sky. For a day or two either side of the 15th, Mercury, Saturn and Aldebaran form an equilateral triangle (see Sky View).

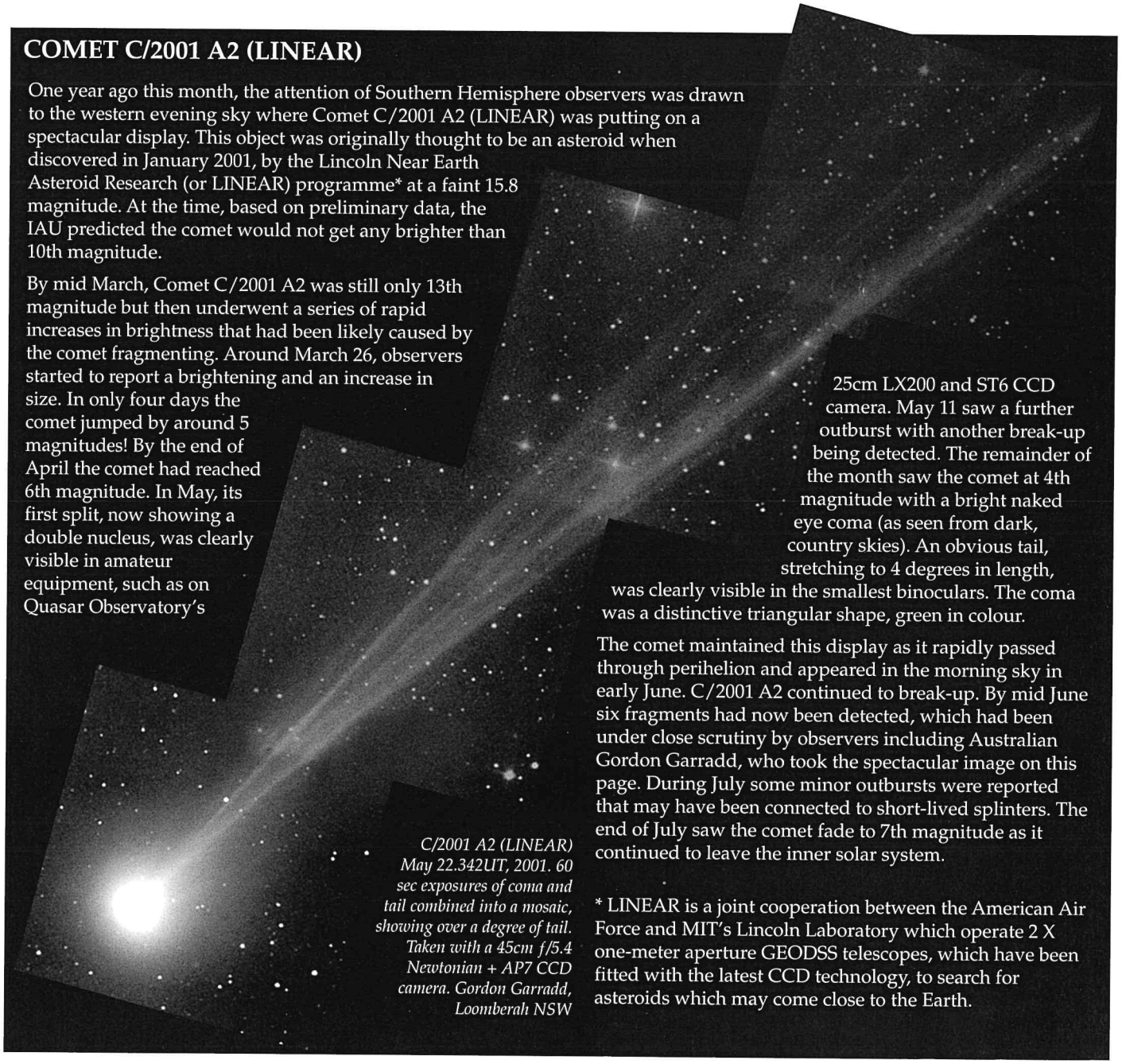
**VENUS**, low in the NW evening twilight, forms an equilateral triangle with Mars and Saturn on the 6th, with sides measuring 2.5°. On the 10th and 11th, Venus and Mars appear a close 0.4° apart (see Sky View). The 3-day old crescent Moon enters the picture on the 15th, 4.4° from Venus (see Sky View). Leaving Taurus in the last week of May, Venus moves into Gemini and on the 22nd comes within 0.7° from the heart of the open cluster M35. On the 23rd and 24th the asteroid Vesta (magnitude 8.4) is 1.5° from the planet. While Venus gains altitude as it moves toward its greatest elongation from the Sun in late August, it passes by Jupiter. At month-end, the two planets are 4° apart.

**MARS** and **SATURN**, low in the NW evening twilight, are less than 2.3° apart from the 3rd to the 5th (see Sky View). Mars and Venus appear close at 0.4° apart on the 10th and 11th (see Sky View). At the end of May, Mars follows Venus into Gemini, and on the 31st the Red Planet passes across the outer limits of the open star cluster M35. This is a rich star cluster composed of

## COMET C/2001 A2 (LINEAR)

One year ago this month, the attention of Southern Hemisphere observers was drawn to the western evening sky where Comet C/2001 A2 (LINEAR) was putting on a spectacular display. This object was originally thought to be an asteroid when discovered in January 2001, by the Lincoln Near Earth Asteroid Research (or LINEAR) programme* at a faint 15.8 magnitude. At the time, based on preliminary data, the IAU predicted the comet would not get any brighter than 10th magnitude.

By mid March, Comet C/2001 A2 was still only 13th magnitude but then underwent a series of rapid increases in brightness that had been likely caused by the comet fragmenting. Around March 26, observers started to report a brightening and an increase in size. In only four days the comet jumped by around 5 magnitudes! By the end of April the comet had reached 6th magnitude. In May, its first split, now showing a double nucleus, was clearly visible in amateur equipment, such as on Quasar Observatory's 25cm LX200 and ST6 CCD camera. May 11 saw a further outburst with another break-up being detected. The remainder of the month saw the comet at 4th magnitude with a bright naked eye coma (as seen from dark, country skies). An obvious tail, stretching to 4 degrees in length, was clearly visible in the smallest binoculars. The coma was a distinctive triangular shape, green in colour.



*C/2001 A2 (LINEAR) May 22.342UT, 2001. 60 sec exposures of coma and tail combined into a mosaic, showing over a degree of tail. Taken with a 45cm f/5.4 Newtonian + AP7 CCD camera. Gordon Garradd, Loomberah NSW*

The comet maintained this display as it rapidly passed through perihelion and appeared in the morning sky in early June. C/2001 A2 continued to break-up. By mid June six fragments had now been detected, which had been under close scrutiny by observers including Australian Gordon Garradd, who took the spectacular image on this page. During July some minor outbursts were reported that may have been connected to short-lived splinters. The end of July saw the comet fade to 7th magnitude as it continued to leave the inner solar system.

* LINEAR is a joint cooperation between the American Air Force and MIT's Lincoln Laboratory which operate 2 X one-meter aperture GEODSS telescopes, which have been fitted with the latest CCD technology, to search for asteroids which may come close to the Earth.

# MAY

about 200 stars of magnitude 8 to 16. It is visible to the unaided eye under dark skies as a hazy patch, almost Moon sized.

**JUPITER** in Gemini, is slightly removed from the events happening in neighbouring Taurus (see above), but nonetheless forms a part of the overall picture. On the 16th, the 4-day old crescent Moon is located 3.4° below Jupiter (see Sky View). Jupiter and Venus appear 4° from each other at the end of May, the brilliance of the two planets making a striking sight in the early evening sky.

**URANUS** and **NEPTUNE** now rise before midnight mid month. On the early morning of the 4th, the 22-day old Moon is 5° from Neptune and on the morning of the 6th, the Moon is 6° from Uranus.

**PLUTO** rises around 7pm mid-month and is visible most of the month. This distant world is at opposition early next month.

## COMETS

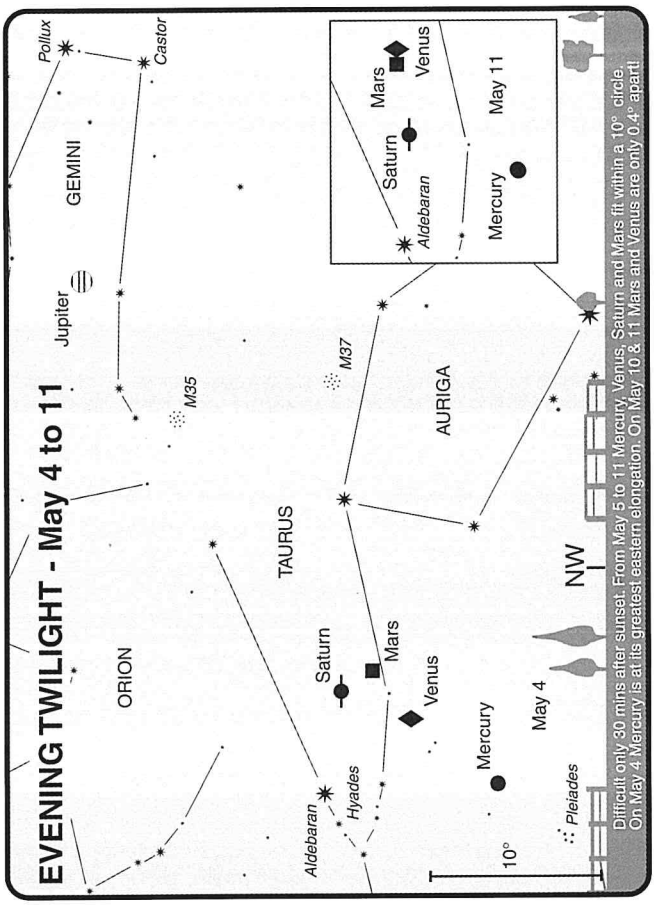
**Comet 7P/Pons-Winnecke** reaches its peak brightness of around 11th magnitude this month. The comet also reaches perihelion on the 15th at 1.3 AU from the Sun. Pons-Winnecke moves through Aquila, Aquarius, Capricornus, and back into Aquarius again, and is rising before midnight. In late May, the comet is less than a degree from Uranus.

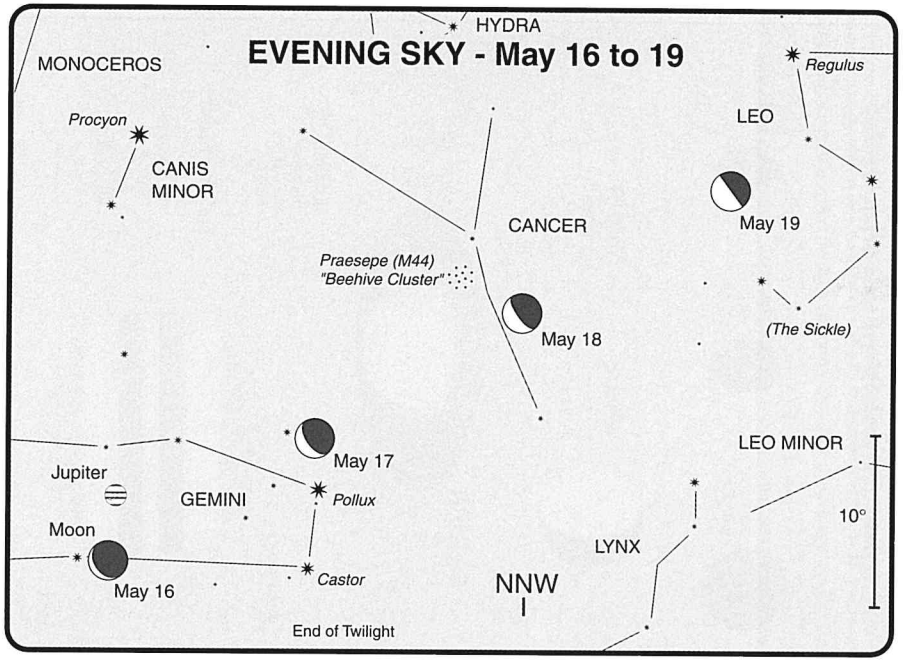
**Comet P/1992 Q1 (Brewington),** brightening from 14th to 13th magnitude, rises late in the evening. The comet can be found all month in the constellation of Microscopium. At the beginning of the month, Brewington is about a degree from 5th magnitude Alpha Microscopii.

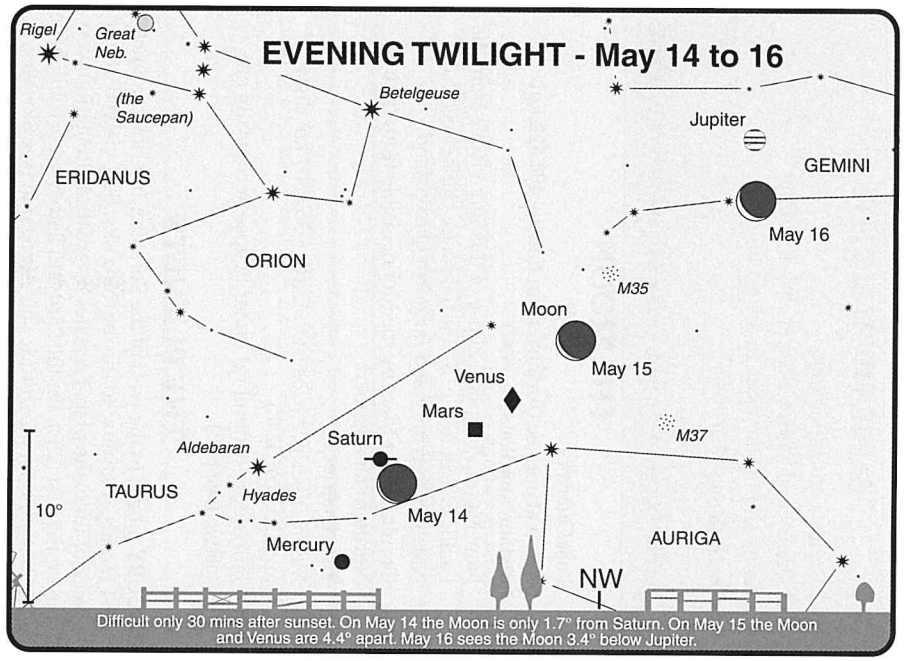
**Comet C/2000 WM1 (LINEAR)** spends May moving through the constellation of Hercules, rising late in the evening. The comet is expected to fade in brightness from 11th to 12th magnitude during the month. On 10th May, LINEAR is less than a degree from 4th magnitude Omicron Herculis.

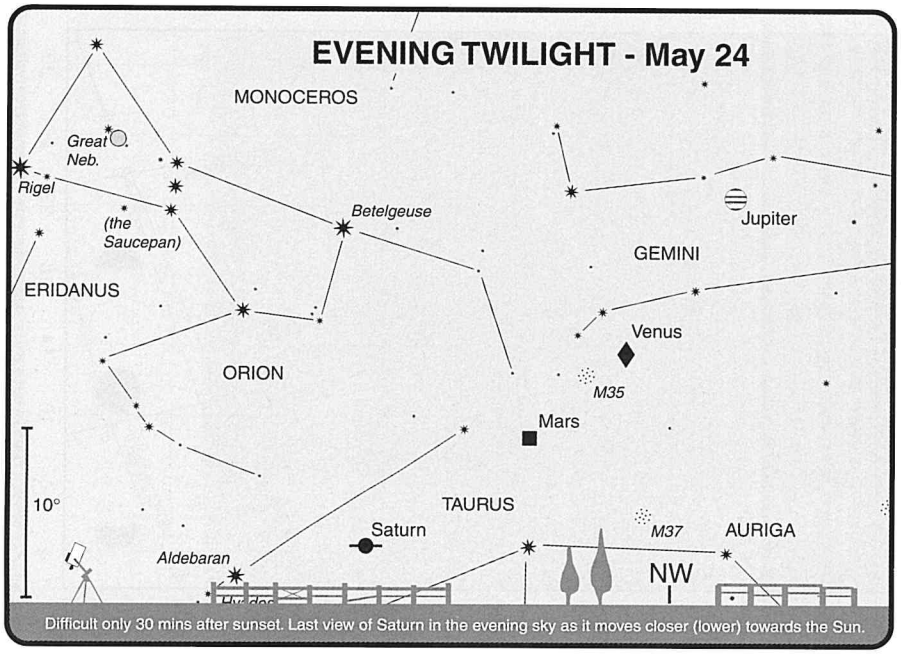
## DIARY

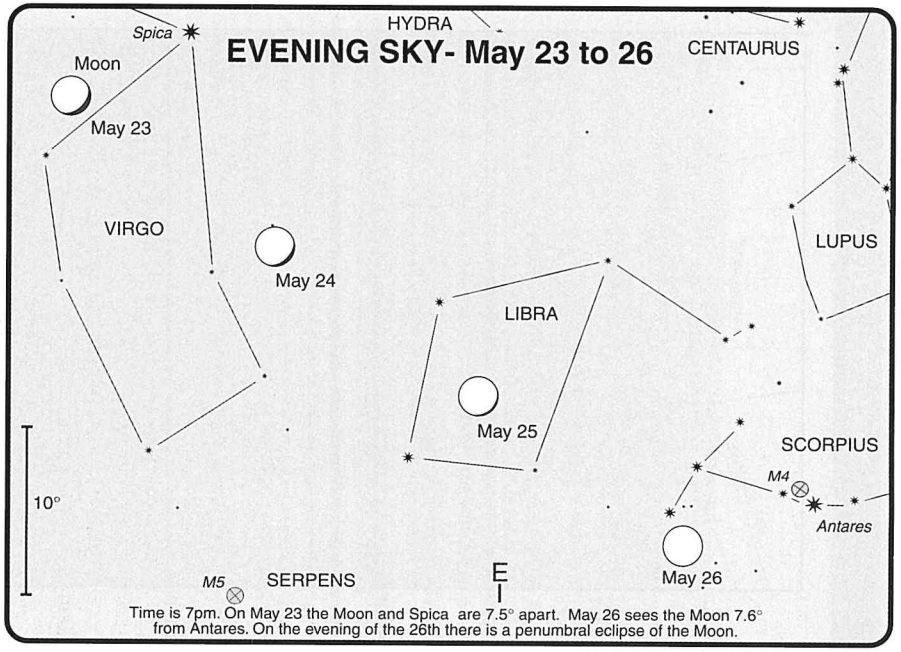
| | | |
|---|---|---|
| 4th | 8 AM | Neptune 4°N of Moon |
| 4th | Noon | Mercury greatest elongation E (21°) |
| 4th | 3:16 PM | Last Quarter Moon |
| 4th | 10 PM | Venus 6°N of Aldebaran |
| 5th | 1 AM | Mars 2°N of Saturn |
| 5th | 6 PM | Uranus 4°N of Moon |
| 8th | 2 AM | Venus 2°N of Saturn |
| 8th | 3 AM | Moon at apogee |
| 9th | | Mars 0.2°SE of NGC 1746 (OC) in Taurus |
| 9th | | Venus 0.6°W of NGC 1746 (OC) in Taurus |
| 11th | 5 AM | Venus 0.3°N of Mars |
| 12th | | m.p. 15 Eunomia 0.9°NE of m.p. 18 Melpomene |
| 12th | | m.p. 20 Massalia 0.5°S of NGC 524 (EG) in Pisces |
| 12th | 6:45 PM | New Moon |
| 13th | 10 PM | Neptune stationary |
| 14th | 5 AM | Mercury 3°N of Moon |
| 14th | | m.p. 4 Vesta 0.2°NW of NGC 2129 (OC) in Gemini |
| 14th | 4 PM | Saturn 1.1°S of Moon; occultation |
| 15th | 3 AM | Mars 0.6°N of Moon; occultation |
| 15th | 7 AM | Venus 0.8°N of Moon; occultation |
| 15th | 8 PM | Vesta 1.1°S of Moon; occultation |
| 16th | 1 PM | Mercury stationary |
| 16th | 8 PM | Jupiter 2°S of Moon |
| 17th | | Venus at perihelion |
| 17th | | m.p. 8 Flora 0.5°N of m.p. 28 Bellona |
| 19th | | m.p. 4 Vesta 0.8°S of M35 (OC) in Gemini |
| 20th | 3:42 AM | First Quarter Moon |
| 20th | | m.p. 5 Astraea 0.1°SW of NGC 4887 (SG) in Pisces |
| 21st | | Mercury at descending node |
| 22nd | | m.p. 44 Nysa 0.8°NW of NGC 488 (SG) in Pisces |
| 22nd | | Venus 0.7°N of M35 (OC) in Gemini |
| 23rd | Midnight | Moon at perigee |
| 25th | | m.p. 4 Vesta 0.3°N of IC 444 (Bright Neb) in Gemini |
| 26th | 7:51 PM | Full Moon; penumbral eclipse |
| 27th | 1 AM | Comet 7P/Pons-Winnecke 1°SW of Uranus |
| 27th | 3 PM | Mercury in inferior conjunction |
| 30th | | Mars 0.4°N of IC 2157 (OC) in Gemini |
| 31st | | Mercury at aphelion |
| 31st | | Mars 0.1°NW of M35 (OC) in Gemini |
| 31st | 4 PM | Neptune 4°N of Moon |




EVENING SKY - May 16 to 19
HYDRA
MONOCEROS
Regulus
Procyon
LEO
CANIS MINOR
May 19
CANCER
Praesepe (M44)
"Beehive Cluster"
May 18
(The Sickle)
May 17
LEO MINOR
Jupiter
GEMINI
Pollux
10°
Moon
LYNX
May 16
Castor
NNW
End of Twilight

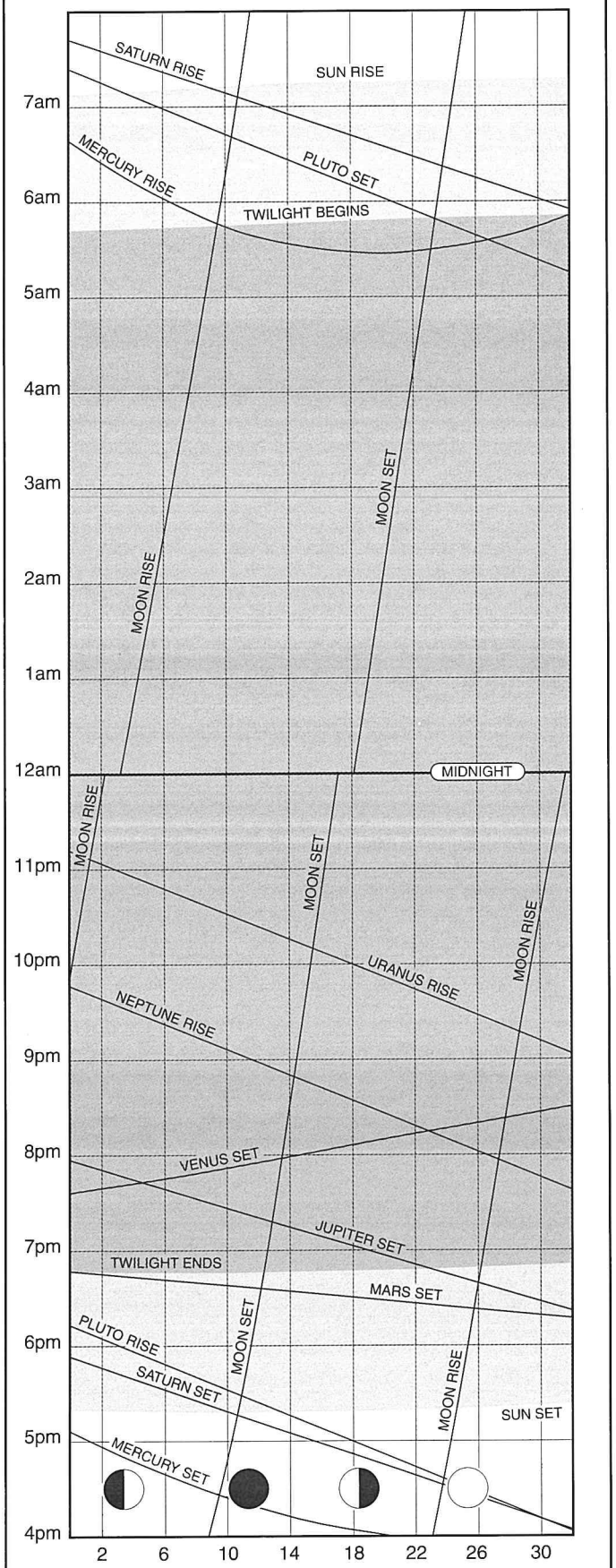

EVENING TWILIGHT - May 14 to 16
Rigel
Great Neb.
(the Saucepan)
Betelgeuse
Jupiter
ERIDANUS
GEMINI
May 16
ORION
M35
Moon
May 15
Venus
Mars
M37
Aldebaran
Saturn
TAURUS
Hyades
10°
May 14
AURIGA
Mercury
NW
Difficult only 30 mins after sunset. On May 14 the Moon is only 1.7° from Saturn. On May 15 the Moon and Venus are 4.4° apart. May 16 sees the Moon 3.4° below Jupiter.


EVENING TWILIGHT - May 24
MONOCEROS
Great Neb.
Rigel
(the Saucepan)
Betelgeuse
Jupiter
GEMINI
ERIDANUS
Venus
ORION
M35
Mars
10°
TAURUS
Saturn
M37
AURIGA
Aldebaran
NW
Difficult only 30 mins after sunset. Last view of Saturn in the evening sky as it moves closer (lower) towards the Sun.


EVENING SKY- May 23 to 26
HYDRA
Spica
CENTAURUS
Moon
May 23
VIRGO
LUPUS
May 24
LIBRA
May 25
SCORPIUS
M4
10°
Antares
May 26
M5
SERPENS
E
Time is 7pm. On May 23 the Moon and Spica are 7.5° apart. May 26 sees the Moon 7.6° from Antares. On the evening of the 26th there is a penumbral eclipse of the Moon.

# JUNE

## RISE/SET CHART




All times are WAST.

## JUNE HIGHLIGHTS

- Mercury near Aldebaran
- Mercury and Saturn close at end of month
- Venus and Jupiter close in the evening sky
- Venus passes near M44
- Pluto at opposition
- Partial eclipse of the Sun, visible from northern Australia

## THE MOON

3rd Last Quarter

4th Moon at apogee (furthest from Earth – 404,522 km distant, angular size 29.4′)

11th New Moon. Annular Eclipse of the Sun, visible from the Pacific Ocean (see p. 8). Partial phase can be seen from Northern Territory and far north Queensland.

12th Occultation of Mars by the Moon, visible from parts of Northern Hemisphere

18th First Quarter

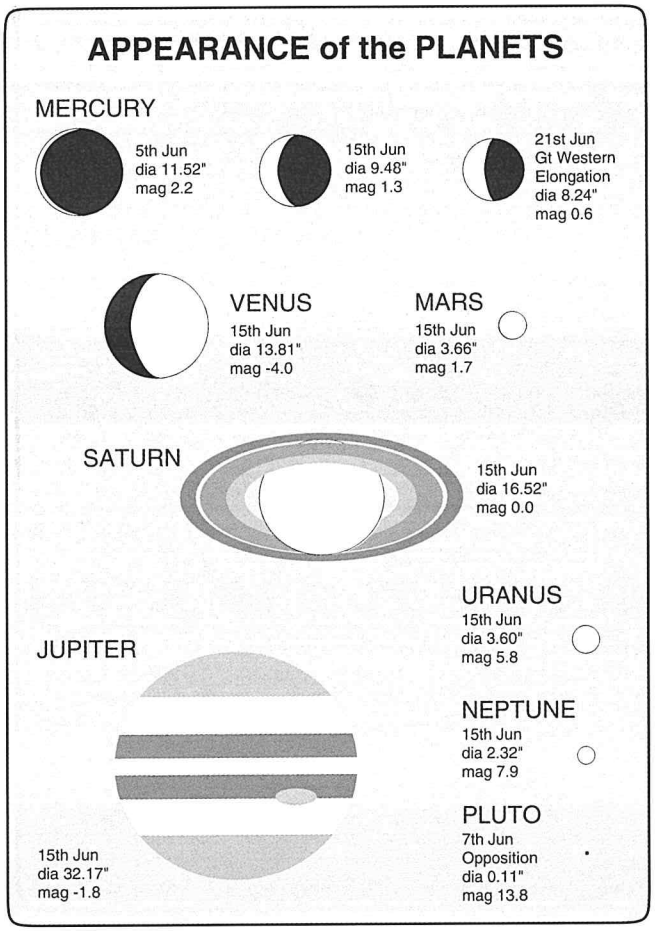
19th Moon at perigee (closest to Earth – 369,309 km distant, angular size 32.8′)

25th Full Moon. Penumbral Lunar Eclipse, technically not visible (see p. 8)

## THE PLANETS

**MERCURY** moves to the west of the Sun after inferior conjunction late last month, returning to the morning sky. Best viewed after the first week of June, the planet reaches its greatest elongation west of the Sun on the 21st (23°). On the 23rd and 24th Mercury will be less than 2.5° from the 1st magnitude star Aldebaran (see Sky View). At the end of the month, this speedy little planet will be found 3.7° from the rising Saturn.

## APPEARANCE of the PLANETS



**VENUS** begins the month 4° below Jupiter in Gemini, rising up in the NW evening sky. It moves into Cancer mid-month and finally over to Leo at month-end. From the 3rd to the 5th, the two brightest planets will be less than 2° from each other, a magnificent sight in the evening sky (see Sky View). The 3-day old crescent Moon will be 5.8° from the planet on the 14th (see Sky View). On the 21st, Venus will be within 0.5° from the famous M44, the Beehive or Praesepe. M44 is a cluster of about 200 stars, 80 or so of the brightest are visible in small telescopes. At 3rd magnitude the cluster is easily visible to the unaided eye from dark skies. In fact it is collectively brighter than any of the stars that make up the constellation of Cancer!

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

**MARS**, in Gemini, now sets about an hour after the Sun and is no longer visible outside of the twilight glow. The Red Planet is moving slowly toward inferior conjunction in August. On the 30th, a good unobstructed western horizon will reveal Mars 1.6° below Jupiter in the twilight.

## PROXIMA CENTAURI

High in the early evening sky this month lies the spectacular constellation of Centaurus, wrapped around the Southern Cross and partly lying along bright and dark rifts of the Milky Way. Within its boundary lies nine stars brighter than 3rd magnitude, two well known galaxies (Centaurus A and NGC4945), arguably the best globular cluster in the sky (Omega Centauri) and a particular 10.7 magnitude star. Did I hear someone say 'what?' Well this star is certainly ordinary, by probably any astronomer's definition, except that it has the distinction of being the closest star to our Solar System - Proxima Centauri.

Everyone who has looked through a telescope has seen the brilliant double star Alpha Centauri. This is in fact a true binary, with the two components orbiting each other in an eccentric orbit every 80 years. Alpha is in fact a triple star with its much more distant, faint companion being Proxima. It is located approximately 2° SW of Alpha and a little closer to us than its much brighter brothers. It was discovered by measurements of its proper motion by R.T. Innes in 1915. The star is believed to be gravitationally linked to Alpha Centauri but 400 times further away than the mean separation of the main pair and taking some 500,000 to a million years (depending on which reference you quote) to complete one orbit. Proxima's distance from Alpha is approximately 10,000 times greater than the distance from the Earth to the Sun (about 1/6 of a light year). Innes measured the parallax as 0.762" and the annual proper motion of 3.85", both values being slightly larger (hence closer) than Alpha. The proper motions of Proxima and Alpha are moving them westward towards the companion pointer, Beta. In fact, Alpha will make its closest approach to Beta around 6200AD when it will be 23' north - less than the diameter of the Moon away! At this time, Beta will actually pass between Alpha and the distant Proxima.

Being so close and faint it comes as no surprise to learn it is one of the least luminous stars ever found. Its absolute magnitude is only +15.1 and its real luminosity is 13,000 times less than the Sun. It is a little ironic that, with all the thousands of naked eye stars in the heavens, a small telescope and a good finder chart is needed to see the closest star of them all (excluding the Sun). If it replaced the Sun it would only be as bright as 45 Full Moons and about 1/20 of its diameter.

Probably the most interesting aspect of Proxima is that this red dwarf (spectral class dM5e) is also a flare star. It can increase in brightness by up to a magnitude in only a few minutes. These temporary flashes occur at irregular intervals and the star returns to its normal brightness in less than 30 minutes. Harlow Sharpley, studying Harvard plates, detected 48 flares during the interval of 1925 to 1950. Back in the 60's a number of Australian amateurs took part in a program to monitor Proxima for flares.

For such an insignificant star, on the galactic scale, Proxima certainly holds a special place in our knowledge of our stellar neighbourhood.

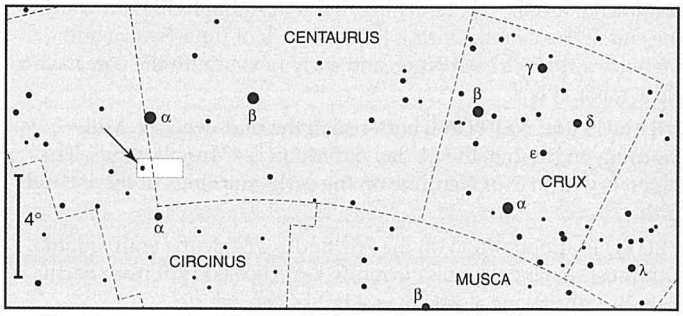



*Chart 1. Locate the 5th magnitude star (arrowed) mid-way between Alpha Centauri and Alpha Circini. Faintest stars shown are approximately 6th magnitude. The white block represents the area covered below in chart 2.*

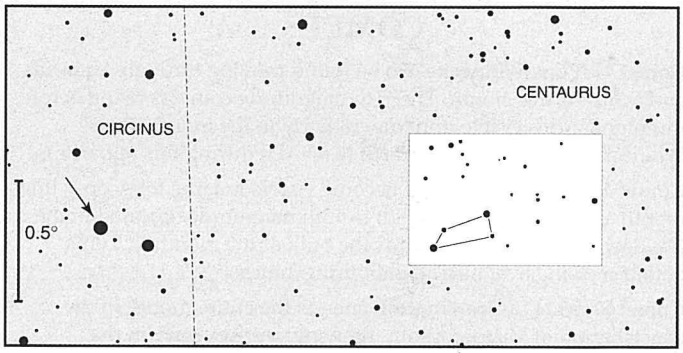



*Chart 2. From the 5th magnitude star (arrowed), track west just under 2° to a trapezium made up of 8th and 9th magnitude stars. The faintest stars shown are approximately 10.5 magnitude. The white block represents the area covered below in chart 3.*

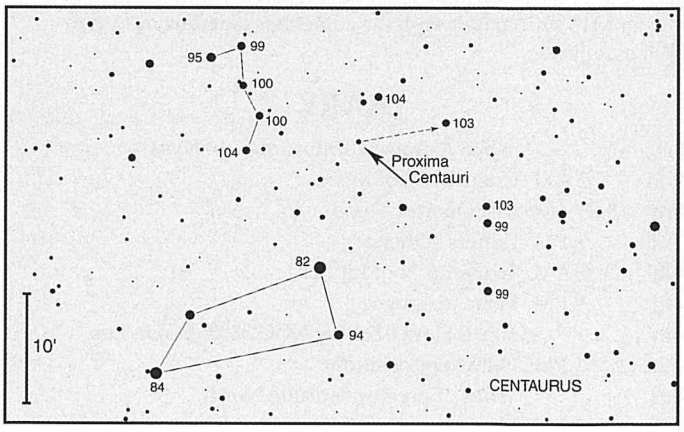



*Chart 3. From the trapezium, it is easy to star-hop to Proxima. Another prominent landmark in the field is the 'W' of 9 and 10th magnitude stars. Numbers next to stars are the magnitudes (104 = 10.4 magnitude). Stars are shown down to approximately 13th magnitude. The dashed arrow extending from Proxima shows the direction and distance that proper motion will take the star over the next 100 years.*

# JUNE

**JUPITER** is low in the NW evening twilight sky. Along with Venus, Castor and Pollux it forms a lopsided rectangle in Gemini on the 1st of the month. On the 13th, the 2-day old thin crescent Moon appears 3.8° from the planet (see Sky View). From the 9th to the 11th, Jupiter will be less than 0.5° from a 3.5 magnitude star known as Wasat or Delta Geminorum. The significance of Delta Gem is that it was the guide star that Clyde Tombaugh centred his telescope on 72 years ago, when taking the discovery plates of Pluto. Jupiter at this time is very close to the original discovery position of the most distant planet.

**SATURN** is lost from the evening sky when it moves into solar conjunction on the 9th, returning to the morning twilight towards the end of the month. During the last week of June, Saturn and Mercury approach each other, and early next month the pair have a close rendezvous.

**URANUS** and **NEPTUNE** both rise in the mid-evening. Mid-morning on the 2nd, the 21-day old Moon is 4° from Uranus. The Moon is within 6° of Neptune on the early mornings of the 1st and 28th.

**PLUTO** is at opposition on the 7th, and is visible the entire night. Our most distant planet is currently 4,416,000,000 km from Earth, with its light taking a little over 4 hours to reach us.

**MINOR PLANETS** at opposition this month include 6 Hebe on the 30th at magnitude 8.9 in Scutum and 25 Phocaea on the 23rd at magnitude 10.0 in Hercules. 8 Flora and 28 Bellona visit the Leo group of galaxies in June.

## COMETS

**Comet 7P/Pons-Winnecke** can be found moving through Aquarius and Sculptor this month. The 11th magnitude comet is rising before midnight and is visible until dawn. Early in the month, Pons-Winnecke is at its closest to Earth (0.63 AU) during this apparition.

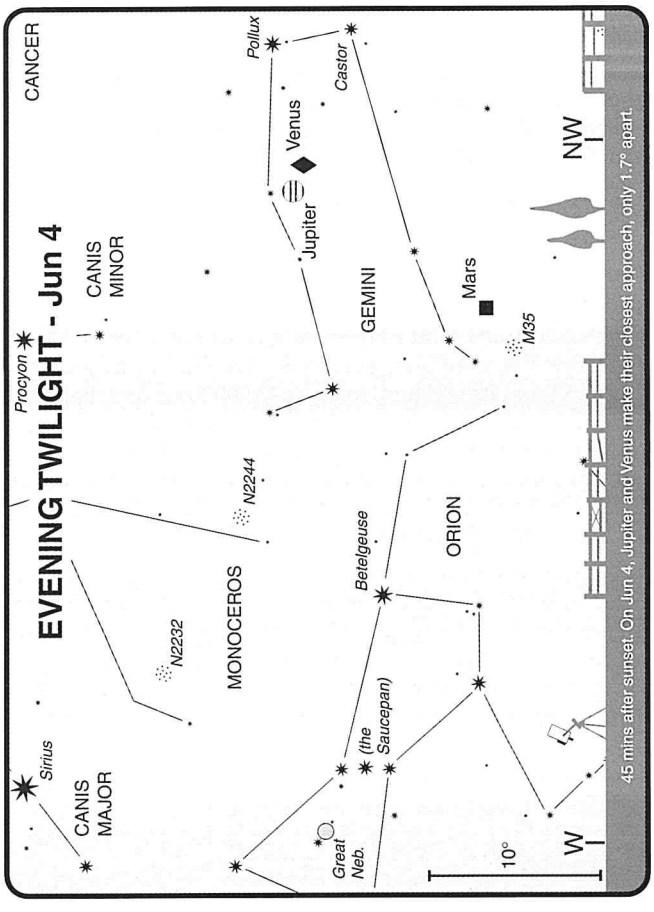
**Comet 46P/Wirtanen** should become visible in large telescopes this month as it brightens from 15th to 13th magnitude. Located in the pre-dawn sky, Wirtanen spends the bulk of the month in Cetus before crossing over into neighbouring Taurus.

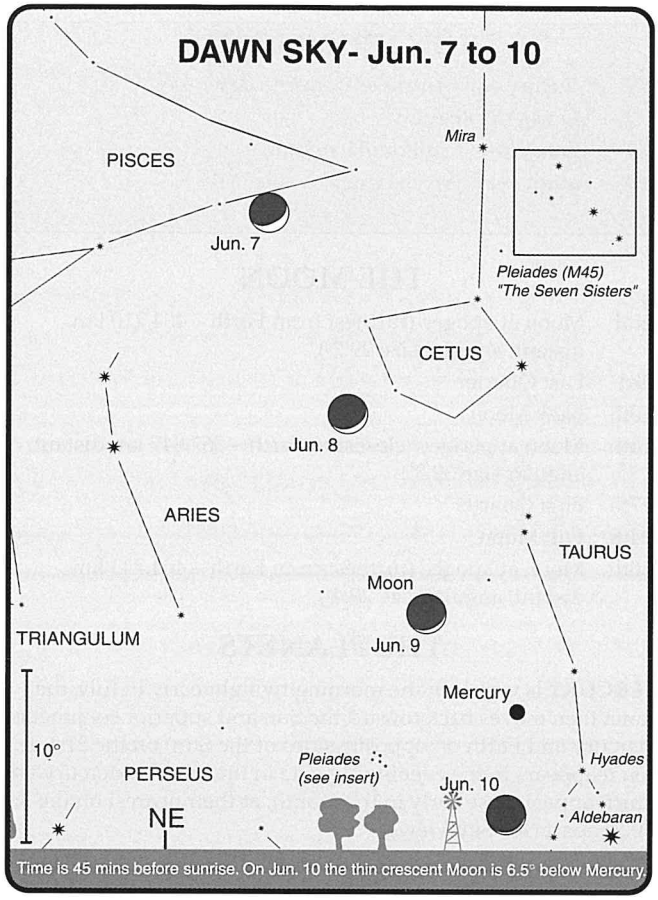
**Comet P/1992 Q1 (Brewington)** spends the entire month in the constellation of Microscopium. Brewington rises early in the evening and is visible all night. During the month, the comet should brighten from 13th to 12th magnitude.

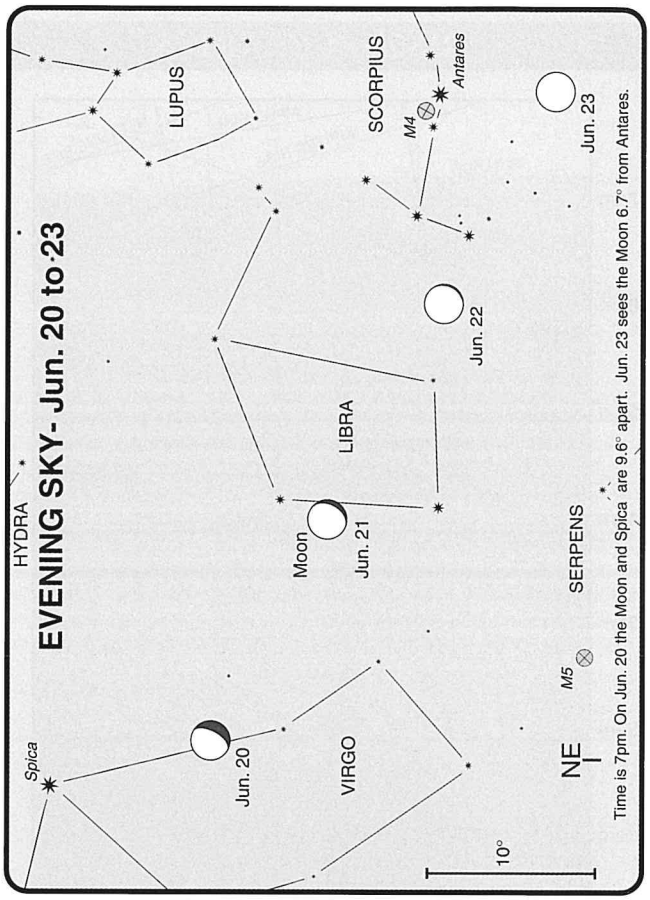
**Comet C/2000 WM1 (LINEAR)** begins June located midway between the 3rd magnitude stars Pi Herculis and 68 Herculis. On 18th June, LINEAR will be less than a degree from the globular cluster M13. By month's end, the comet has faded from 12th to 13th magnitude.

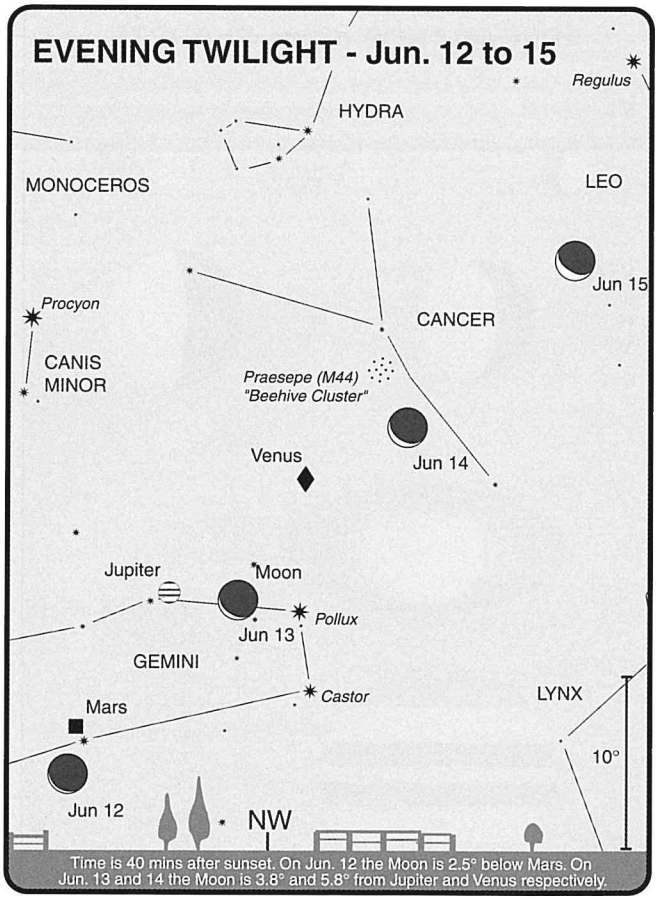
## DIARY

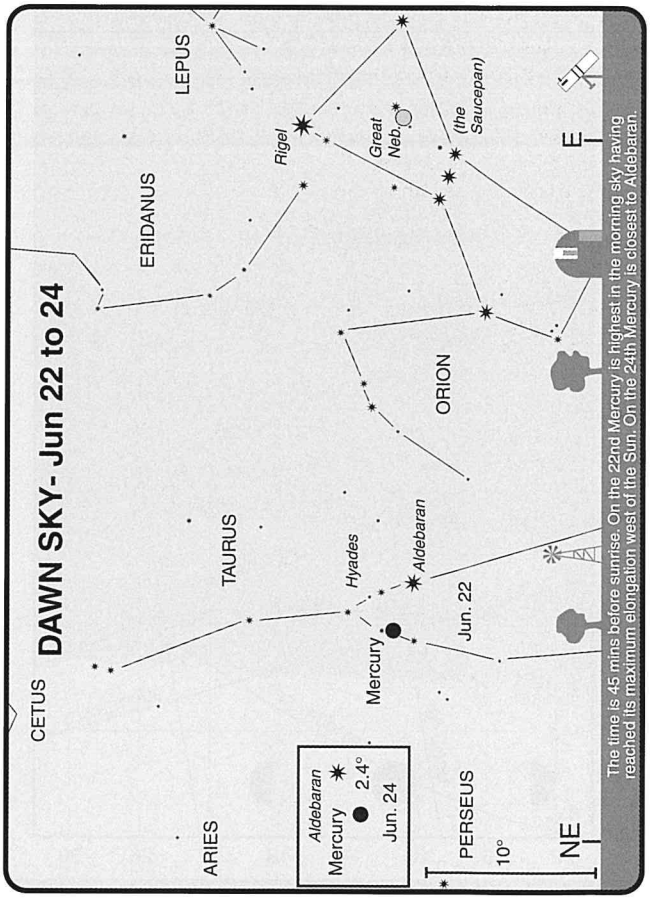
| | | |
|---|---|---|
| 1st | | m.p. 5 Astraea 0.8°SE of m.p. 44 Nysa |
| 2nd | 2 AM | Uranus 4°N of Moon |
| 3rd | 8:05 AM | Last Quarter Moon |
| 3rd | 3 PM | Uranus stationary |
| 4th | 2 AM | Venus 1.6°N of Jupiter |
| 4th | 9 PM | Moon at apogee |
| 6th | | m.p. 8 Flora 0.5°N of NGC 3338 (SG) in Leo |
| 7th | 1 PM | Pluto at opposition |
| 8th | | Venus at greatest latitude North |
| 8th | 7 PM | Mercury stationary |
| 8th | 7 PM | m.p. 28 Bellona 0.1°S of NGC 3377 (EG) in Leo |
| 9th | 7 AM | Pallas stationary |
| 9th | 7 PM | Saturn in conjunction with Sun |
| 9th | 10 PM | Mercury 3°S of Moon |
| 10th | 4 AM | Venus 5°S of Pollux |
| 10th | | Jupiter 0.4°N of star Delta Geminorum |
| 10th | | m.p. 8 Flora 0.3°S of NGC 3377 (EG) in Leo |
| 11th | 7:46 AM | New Moon; eclipse |
| 11th | 7 PM | m.p. 28 Bellona 0.2°NE of NGC 3412 (EG) in Leo |
| 12th | | m.p. 3 Juno 0.6°SW of star Regulus |
| 12th | 8 PM | Mars 0.9°S of Moon; occultation |
| 13th | | m.p. 8 Flora 0.1°S of NGC 3412 (EG) in Leo |
| 13th | Noon | Jupiter 2°S of Moon |
| 14th | 5 AM | Venus 1.5°S of Moon |
| 14th | | m.p. 654 Zelinda 0.2°S of NGC 2974 (SG) in Sextans |
| 17th | 7 PM | m.p. 6 Hebe 0.4°N of M11 (OC) in Scutum |
| 18th | 8:29 AM | First Quarter Moon |
| 18th | 8 PM | Comet C/2000 WM1 (LINEAR) 0.3°S of M13 (GC) in Hercules |
| 19th | 3 PM | Moon at perigee |
| 20th | | Mercury at greatest latitude South |
| 21st | | Venus 0.6°NE of Beehive Cluster M44 (OC) in Cancer |
| 21st | 9 PM | Solstice |
| 21st | 11 PM | Mercury greatest elongation W (23°) |
| 22nd | | m.p. 44 Nysa 1°S of NGC 821 (EG) in Aries |
| 24th | Noon | Mercury 2°N of Aldebaran |
| 25th | 5:42 AM | Full Moon; penumbral eclipse |
| 26th | | Mercury 0.7°NW of NGC 1647 (OC) in Taurus |
| 27th | Midnight | Neptune 4°N of Moon |
| 29th | 10 AM | Uranus 4°N of Moon |




DAWN SKY- Jun. 7 to 10
PISCES
Mira
Jun. 7
Pleiades (M45)
"The Seven Sisters"
CETUS
Jun. 8
ARIES
TAURUS
Moon
Jun. 9
TRIANGULUM
Mercury
10°
PERSEUS
Pleiades
(see insert)
Jun. 10
Hyades
Aldebaran
NE
Time is 45 mins before sunrise. On Jun. 10 the thin crescent Moon is 6.5° below Mercury.

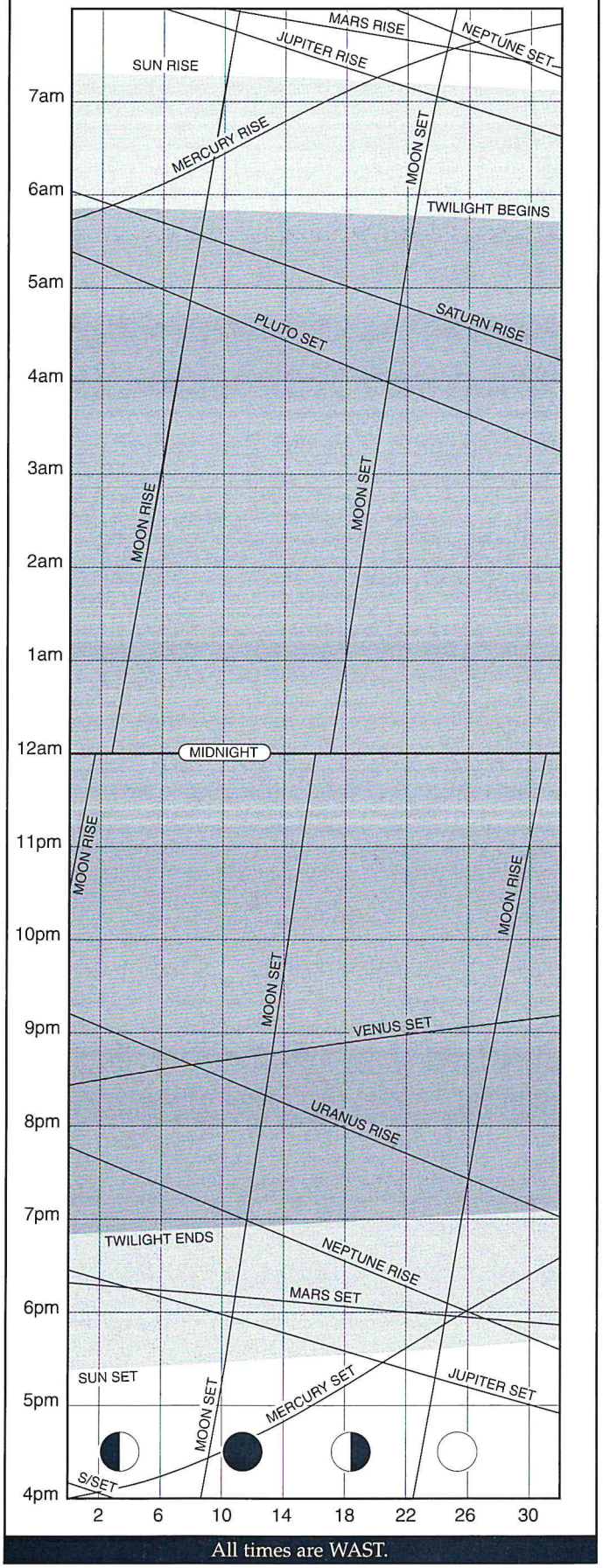

EVENING SKY- Jun. 20 to 23
LUPUS
SCORPIUS
Antares
M4
Jun. 23
Jun. 22
LIBRA
HYDRA
Moon
Jun. 21
SERPENS
M5
Spica
Jun. 20
VIRGO
NE
10°
Time is 7pm. On Jun. 20 the Moon and Spica are 9.6° apart. Jun. 23 sees the Moon 6.7° from Antares.


EVENING TWILIGHT - Jun. 12 to 15
Regulus
HYDRA
MONOCEROS
LEO
Jun 15
Procyon
CANCER
CANIS
MINOR
Praesepe (M44)
"Beehive Cluster"
Venus
Jun 14
Jupiter
Moon
Pollux
Jun 13
GEMINI
Castor
Mars
LYNX
10°
Jun 12
NW
Time is 40 mins after sunset. On Jun. 12 the Moon is 2.5° below Mars. On
Jun. 13 and 14 the Moon is 3.8° and 5.8° from Jupiter and Venus respectively.


DAWN SKY- Jun 22 to 24
LEPUS
Rigel
Great
Neb.
(the
Saucepan)
E
ERIDANUS
ORION
TAURUS
Hyades
Aldebaran
Jun. 22
CETUS
Mercury
Aldebaran
Mercury
2.4°
Jun. 24
ARIES
PERSEUS
10°
NE
The time is 45 mins before sunrise. On the 22nd Mercury is highest in the morning sky having
reached its maximum elongation west of the Sun. On the 24th Mercury is closest to Aldebaran.

# JULY

## RISE/SET CHART




All times are WAST.

## JULY HIGHLIGHTS

- Mercury and Saturn very close in dawn sky
- Venus near Regulus
- Venus close to minor planet Juno
- Saturn very near the Crab Nebula (M1)

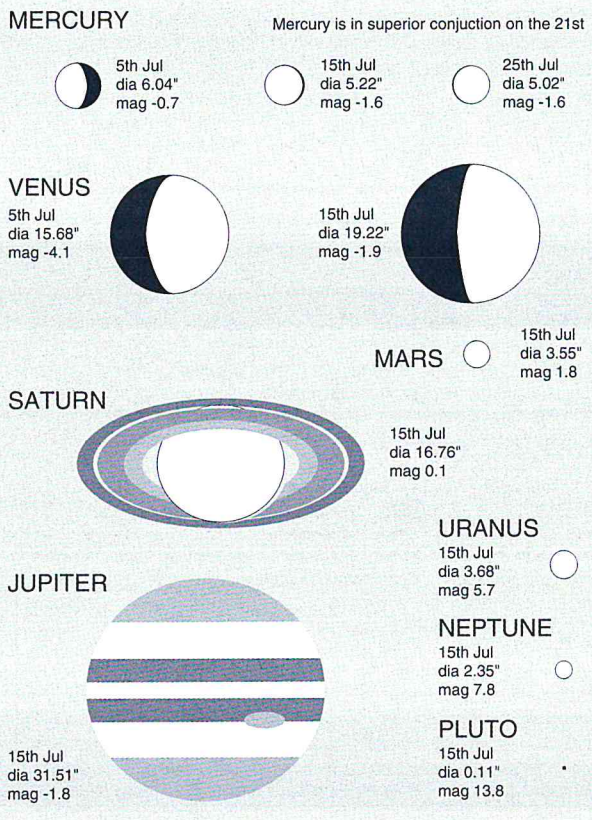
## THE MOON

| | |
|---|---|
| 2nd | Moon at apogee (furthest from Earth – 404,210 km distant, angular size 29.2′) |
| 3rd | Last Quarter |
| 10th | New Moon |
| 14th | Moon at perigee (closest to Earth – 367,847 km distant, angular size 32.3′) |
| 17th | First Quarter |
| 24th | Full Moon |
| 30th | Moon at apogee (furthest from Earth – 404,743 km distant, angular size 29.4′) |

## THE PLANETS

**MERCURY** is visible in the morning twilight early in July, the planet then moves back toward the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 21st. It then reappears in the evening sky late in the month. Mercury and Saturn appear close early in the month, at their nearest on the 3rd at 0.5° apart (see Sky View).

## APPEARANCE of the PLANETS



**VENUS**, residing in the constellation of Leo during the month, is very conspicuous in the western evening sky. Between the 8th and the 13th the planet will be within 3° of the 1st magnitude star Regulus (Alpha Leonis); closest approach of 1.1° occurs on the 10th and 11th. On the 13th, the 3-day old Moon is 5° from Venus, the pair forming a triangle with Regulus (see Sky View).

The **EARTH** is at aphelion (the furthermost point in its orbit from the Sun) on the 6th. The Earth/Sun distance is 1.016688 astronomical units, which is equivalent to about 152,096,000 km.

**MARS** can be seen early in the month in the evening twilight, but comes too close to the Sun for observation by mid-month. Between the 2nd and 5th Mars and Jupiter are less than 1° apart. You will need a good unobstructed western horizon to see the pair as they are only 3° above the horizon 30 minutes after sunset.

**JUPITER** makes a last show in the evening twilight with the Red Planet (see Mars). Jupiter will be in conjunction with the Sun on the 20th, returning to the morning sky in mid-August.

**SATURN** rises around 5am mid-month in Taurus. Saturn and Mercury appear close early in the month, at their nearest on the 3rd at 0.5° (see Sky View). The thin waning crescent Moon appears 6.5° below the ringed planet on the 9th (see Sky View). In the latter part of the month, Saturn comes very close to the Crab Nebula. First in Messier's catalogue, the Crab Nebula or M1 is the remnant of the supernova of 1054AD. From the 21st to the 30th the planet will be less than 0.5° from M1, and on the 25th the pair are closest, at only 0.03°. M1 is a little closer to the planet than Saturn's moon Titan! If this visitation is beyond your normal observing hours, another very similar circumstance presents itself in the evening sky early next January.

## A Picture Worth A Thousand Stars – The Joys of 35mm Astrophotography

*Glenn Dawes*

Many people think that astrophotography is an expensive, specialist area. A hobby that soaks up as much money as you would like to throw at it. In some cases this is true but you may be amazed to learn what can be achieved with just a normal camera. I'm not just talking about breath-taking, wide-angle views of the Milky Way, but having the opportunity to make a real contribution to science!

**What Equipment is needed?** In the simplest case, all that you need is a second-hand 35mm camera with a fast lens, a cable release and a way to mount it. It is important that the camera have a manual 'B' setting to allow the shutter to be locked open with a cable release, without drawing on a lot of battery power to keep it open. The lens should be as fast as possible. A speed of $f/1.2$ to 1.8 would be ideal. Often lenses at this 'wide open' setting show poor star images in the corners. A star field is the most severe test for any optics. I have found that stopping these down to $f/2.8$ can sometimes help greatly without losing much speed.

A high-speed film is needed, at least 400 ASA. Fast modern films are much finer grained compared to their counterparts of the 70's and 80's. With this combination of camera, lens and film, mounted on a tripod, you can capture the brightest stars with a 30-second exposure. Beyond this the movement of the stars will cause trails. Star trails can also have their attractions. Sometimes it is difficult to get colours on the brightest stars because they can burnout. Letting them trail can show the colours quite well. Also wide angle (say 16mm lens) can be effectively used to patrol for fireball meteors, even though there are very long star trails over a couple of hours. To help avoid dew on the front of the lens it is a good idea to leave a neutral filter (such as a UV) and the sun hood on.

To go further we need to move the camera slowly to follow the stars, this is referred to as 'equatorial tracking'. Those who already have a telescope with an equatorial mount can mount the camera on the side of the telescope and let its drive follow the stars for you (while you have a coffee break).

**A Photographic Patrol.** Once you can guide the camera for say 5 to 10 minutes, a whole new world (Universe?) of discovery opens up. During the 80's and 90's I conducted a nova search programme in the southern Milky Way. In fact, it only takes around 20 fields with a 50mm lens, to cover all of the Milky Way regions visible from our mid-southern latitude. On a good, transparent night (out in the country) it was not unusual to get stars down to 11th magnitude. The programme consisted of taking photos of the sky and comparing them to identical images, taken some months before, looking for 'new' stars. With today's technology it is easy to enlist the help of a computer to help you search your photos. I recently experimented with 'Photoshop' to superimpose two scanned prints. Another method uses two slide projectors to merge the images on a screen and then 'blinking' one of them.

**What can be Found?** When searching the films it was rare to not find at least one variable star per field. Some of these soon became old friends as they were picked up on each cycle. This is especially the case if my favourite reference slide showed the star near a minimum. There is no shortage of relatively bright Mira type variables to re-discover or maybe a new variable? In fact, this technique lead to my discovery of V854 Cen in 1986. A 'variable' which turned out to be the third brightest R Coronae Borealis star (but that's another story).

This technique is also well suited for finding minor planets . All of the minor planets, mentioned in this publication, should be easily within reach when they are near their brightest i.e., at opposition. The monthly sections even tell you the constellation they are in during opposition, so all that you need is a planisphere to help you point your camera. Two photos, a week apart, should be sufficient to see the asteroid move. Of course a nova is also not out of the question. Statistically, there should be one or two each year easily within reach of this set-up. If you are going searching always take two images of the field. This helps eliminate confusion from film or developing flaws. Good luck!

*Southern Cross and Pointers. 50mm lens @f/2.8. A 5 min exposure using Kodak T-Max 400. NB the dark nebula or the 'Coal Sack' (slightly below and left of the Cross). This is also the head of the 'Emu' (see p. 29).*

# JULY

**URANUS** and **NEPTUNE** in Aquarius and Capricornus respectively, rise in the early evening eastern sky. Both planets will be at opposition next month.

**PLUTO**, just past opposition, is visible throughout the night until around 4am.

**MINOR PLANETS** at opposition this month include 29 Amphitrite on the 23rd at magnitude 9.4 in Sagittarius. Towards the end of July 9 Metis visits the M95, 96, 105 trio of galaxies in Leo.

## COMETS

**Comet 7P/Pons-Winnecke** resides in the constellation of Sculptor throughout July. Rising late in the evening, the comet should fade from 11th to 12th magnitude by month's end. Towards the end of July, Pons-Winnecke lies midway between the galaxies NGC 55 and NGC 300.

**Comet 22P/Kopff** is well placed in the evening sky, brightening from 14th to 13th magnitude as it moves through the constellation of Virgo. Around mid-month, Kopff is two degrees from the 10th magnitude galaxy M61.

**Comet 46P/Wirtanen** can be found in the pre-dawn sky this month in the constellation of Taurus. Brightening from 13th to 11th magnitude, the comet will pass across the Hyades around mid-month, and will be close to Comet 67P/Churyumov-Gerasimenko. On the morning of the 15th, comet Wirtanen is close to Aldebaran.

**Comet 67P/Churyumov-Gerasimenko** brightens from 14th to 13th magnitude this month as it approaches perihelion in August. The comet is rising a few hours before dawn and spends all of July in Taurus. Around mid-month, Churyumov-Gerasimenko passes near the Hyades and Comet 46P/Wirtanen.

**Comet P/1992 Q1 (Brewington)** is visible all night throughout July at about 12th magnitude. The comet is in Microscopium throughout the month.

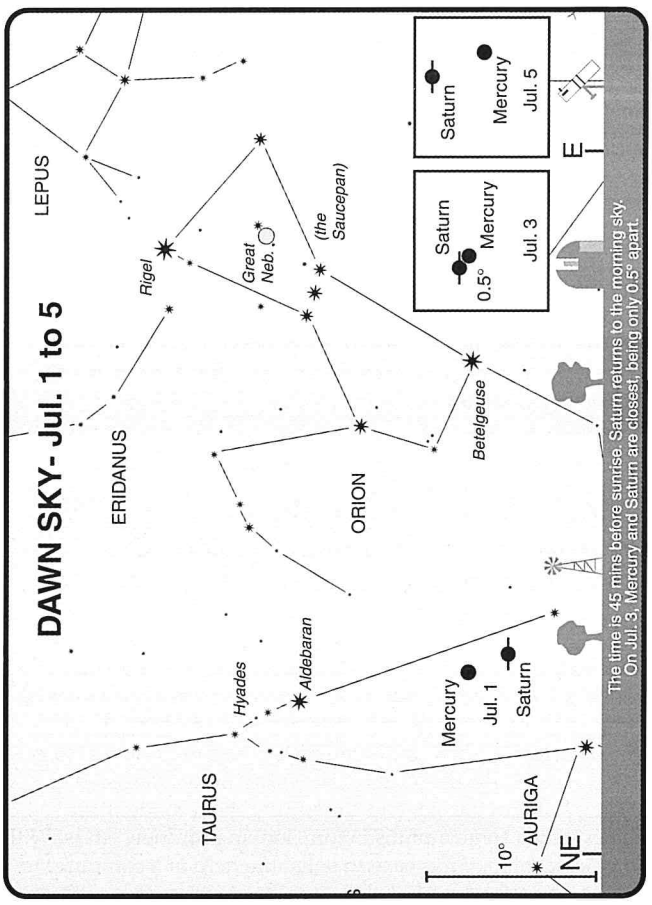
## METEOR SHOWERS

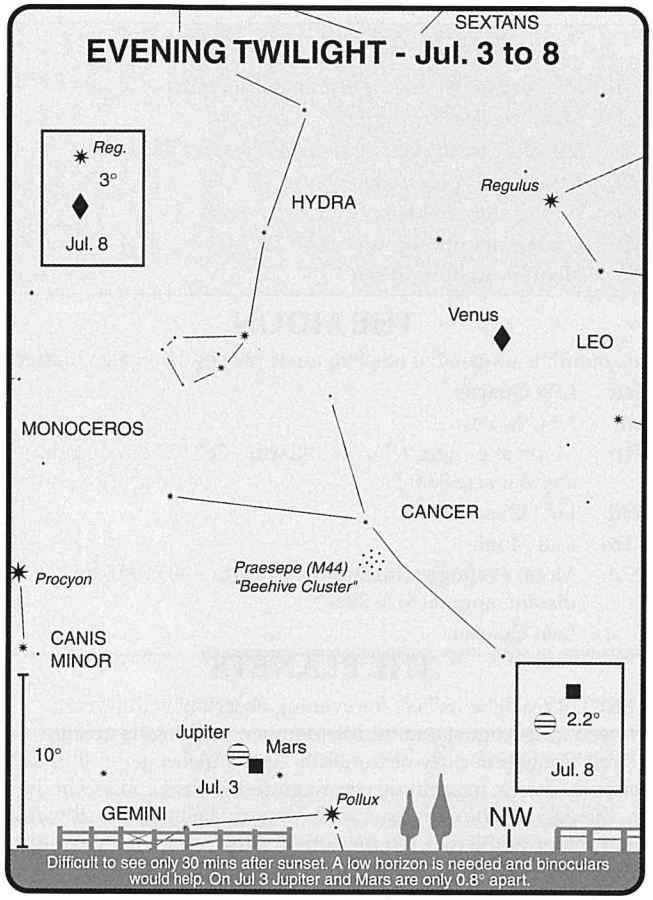
The **Pegasids** are a short-lived shower, lasting only from the 7th to 13th, with maximum on the 9th. The shower is best viewed during the second half of the night, and produces faint, swift meteors. The zenith hourly rate is low, and about 3 can be expected. The radiant is on the western side of the Great Square of Pegasus, near 3rd magnitude Alpha Pegasi.

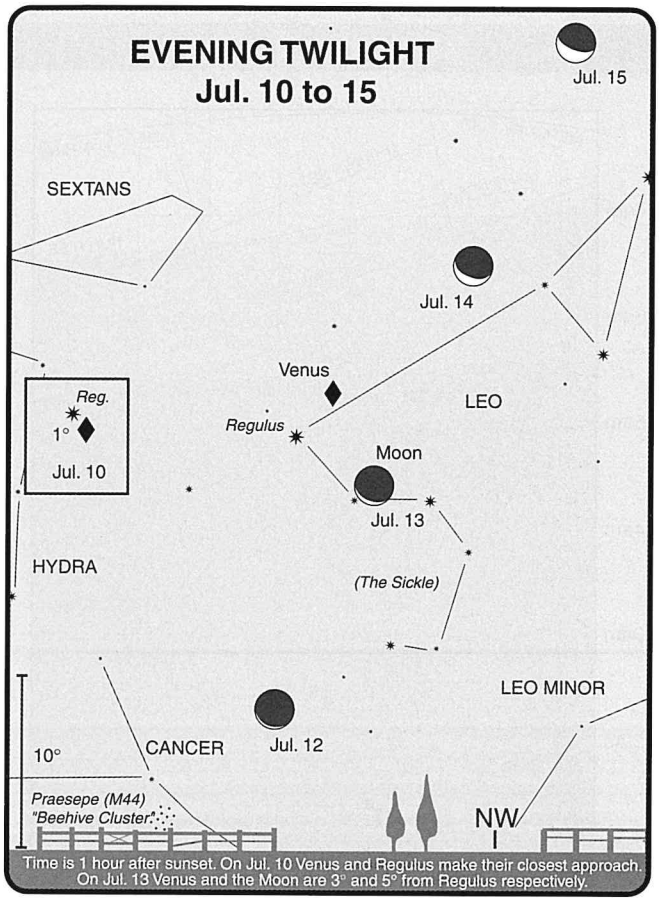
The **Phoenicids** (July) are a Southern Hemisphere shower, and are best seen after midnight until dawn, when the radiant is at its highest altitude. The Phoenicids are active from the 10th to 16th, with maximum on the 13th. Activity is variable, but zenith hourly rates of 3-10 have been recorded, although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

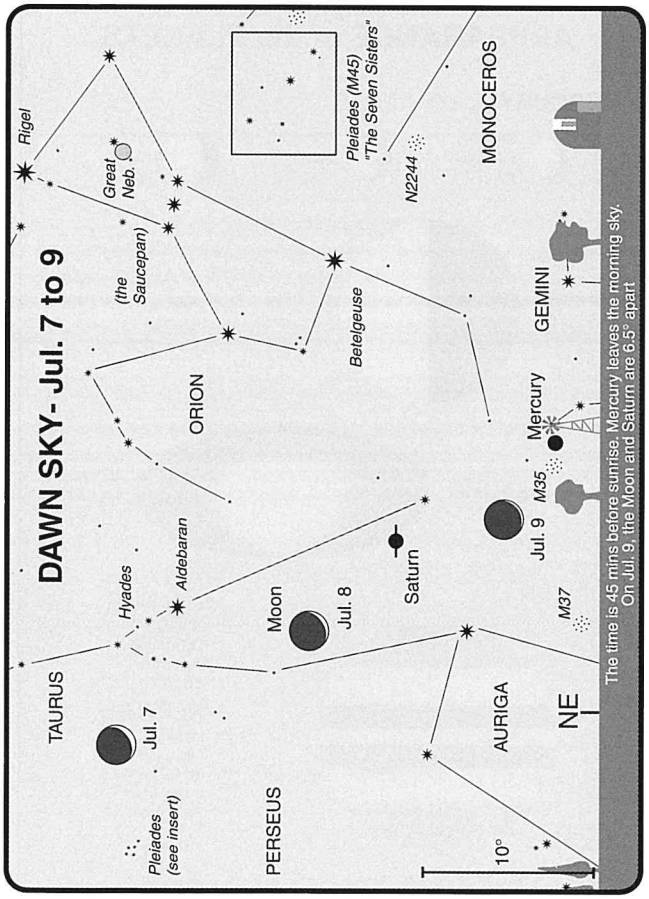
## DIARY

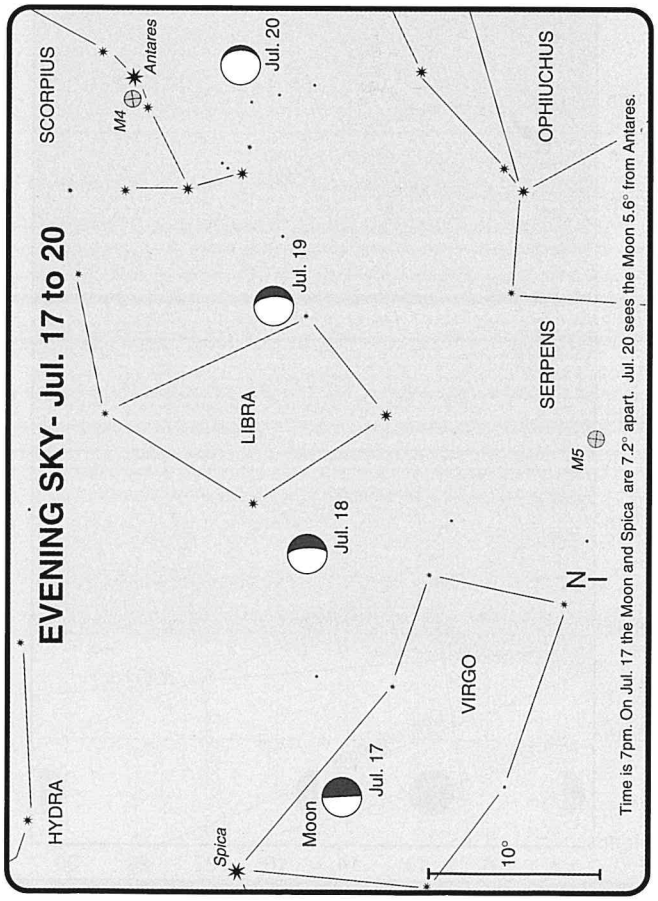
| | | |
|---|---|---|
| 2nd | 4 PM | Moon at apogee |
| 2nd | 7 PM | Mercury 0.2°S of Saturn |
| 3rd | 1:19 AM | Last Quarter Moon |
| 3rd | 2 PM | Mars 0.8°N of Jupiter |
| 4th | | Mercury 0.4°W of M1 (neb) in Taurus |
| 5th | 1 AM | Mars 6°S of Pollux |
| 5th | 10 PM | Comet 7P/Pons-Winnecke 0.3°NE of Blanco 1 (OC) in Sculptor |
| 6th | Noon | Earth at aphelion |
| 8th | 9 PM | Saturn 1.7°S of Moon |
| 9th | | Mercury at ascending node |
| 10th | 6 PM | Venus 1.1°N of Regulus |
| 10th | 6:26 PM | New Moon |
| 11th | | m.p. 28 Bellona 0.4°N of NGC 3705 (SG) in Leo |
| 13th | | m.p. 8 Flora 0.5°SW of NGC 3705 (SG) in Leo |
| 13th | 8 PM | Venus 4°S of Moon |
| 14th | | Mercury at perihelion |
| 14th | 9 PM | Moon at perigee |
| 16th | 3 AM | Comet 46P/Wirtanen 0.7°S of Aldebaran |
| 17th | 12:47 PM | First Quarter Moon |
| 20th | | Venus 0.7°S of NGC 3429 (SG) in Leo |
| 20th | 9 AM | Jupiter in conjunction with Sun |
| 21st | 10 AM | Mercury in superior conjunction |
| 23rd | | Venus 0.6°S of m.p. 3 Juno |
| 23rd | 4 PM | Vesta in conjunction with Sun |
| 24th | | Mercury at greatest latitude North |
| 24th | | Comet 46P/Wirtanen 1°N of NGC 1817 (OC) in Taurus |
| 24th | 5:07 PM | Full Moon |
| 25th | 7 AM | Neptune 4°N of Moon |
| 25th | | Saturn 0.03°N of Crab Nebula M1 (Neb) in Taurus |
| 26th | 5 PM | Uranus 4°N of Moon |
| 29th | | m.p. 9 Metis 0.6°SW of M105 (EG) in Leo |
| 29th | | m.p. 9 Metis 0.7°NE of M95 (SG) in Leo |
| 30th | | m.p. 9 Metis 0.3°NE of M96 (SG) in Leo |
| 30th | 10 AM | Moon at apogee |




EVENING TWILIGHT - Jul. 3 to 8
SEXTANS
Reg.
3°
Jul. 8
HYDRA
Regulus
Venus
LEO
MONOCEROS
CANCER
Procyon
Praesepe (M44)
"Beehive Cluster"
CANIS
MINOR
10°
Jupiter
Mars
Jul. 3
GEMINI
Pollux
NW
2.2°
Jul. 8
Difficult to see only 30 mins after sunset. A low horizon is needed and binoculars would help. On Jul 3 Jupiter and Mars are only 0.8° apart.

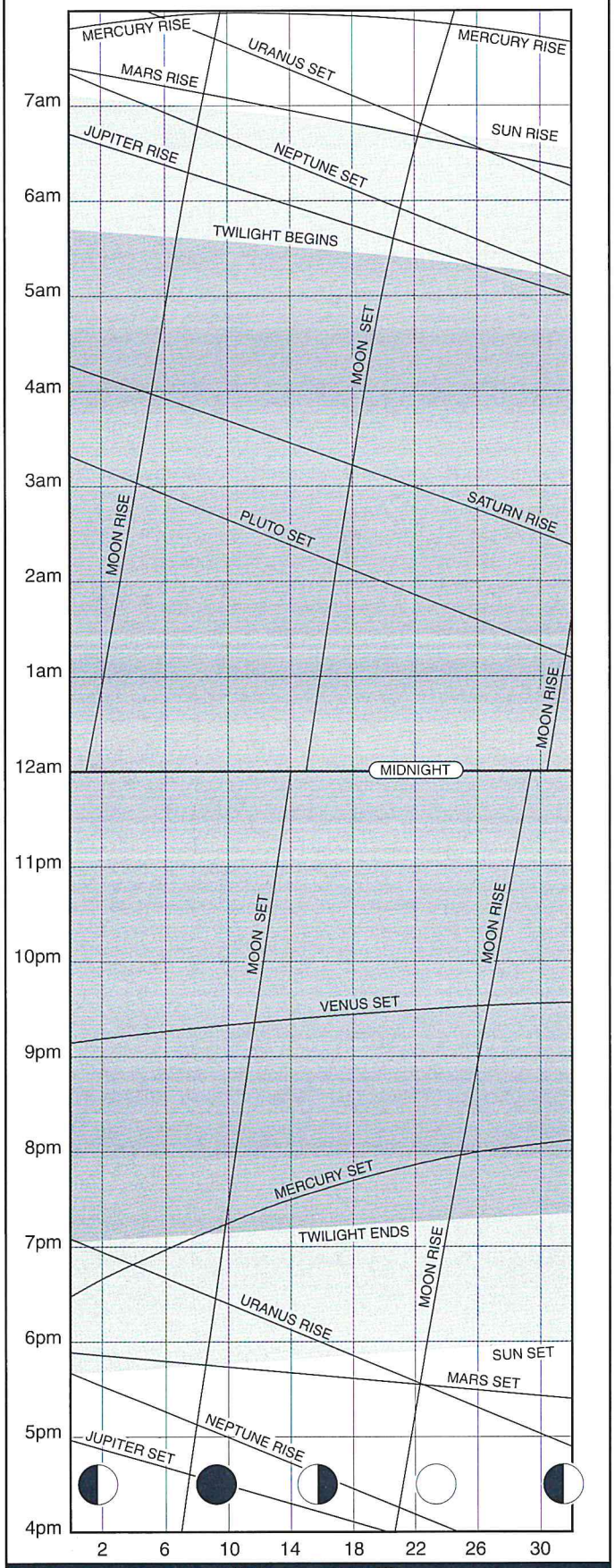

EVENING TWILIGHT
Jul. 10 to 15
Jul. 15
SEXTANS
Jul. 14
Venus
LEO
Reg.
1°
Jul. 10
Regulus
Moon
Jul. 13
HYDRA
(The Sickle)
LEO MINOR
10°
CANCER
Jul. 12
Praesepe (M44)
"Beehive Cluster"
NW
Time is 1 hour after sunset. On Jul. 10 Venus and Regulus make their closest approach. On Jul. 13 Venus and the Moon are 3° and 5° from Regulus respectively.


DAWN SKY- Jul. 7 to 9
Rigel
Great
Neb.
(the
Saucepan)
Pleiades (M45)
"The Seven Sisters"
N2244
MONOCEROS
Betelgeuse
GEMINI
ORION
Mercury
M35
Jul. 9
Hyades
Aldebaran
Moon
Jul. 8
Saturn
M37
TAURUS
Jul. 7
AURIGA
NE
Pleiades
(see insert)
PERSEUS
10°
The time is 45 mins before sunrise. Mercury leaves the morning sky. On Jul. 9, the Moon and Saturn are 6.5° apart


EVENING SKY- Jul. 17 to 20
SCORPIUS
Antares
M4
Jul. 20
OPHIUCHUS
Jul. 19
LIBRA
SERPENS
M5
Jul. 18
N
HYDRA
VIRGO
Jul. 17
Moon
Spica
10°
Time is 7pm. On Jul. 17 the Moon and Spica are 7.2° apart. Jul. 20 sees the Moon 5.6° from Antares.

# AUGUST

## RISE/SET CHART




All times are WAST.

## AUGUST HIGHLIGHTS

- Mercury at its best for evening observation
- Mercury close to Regulus
- Venus at greatest elongation (46°) east of the Sun
- Venus and Spica close
- Jupiter close to M44
- Uranus at opposition
- Neptune at opposition

## THE MOON

This month is unusual, it has five lunar phases (two Last Quarters)

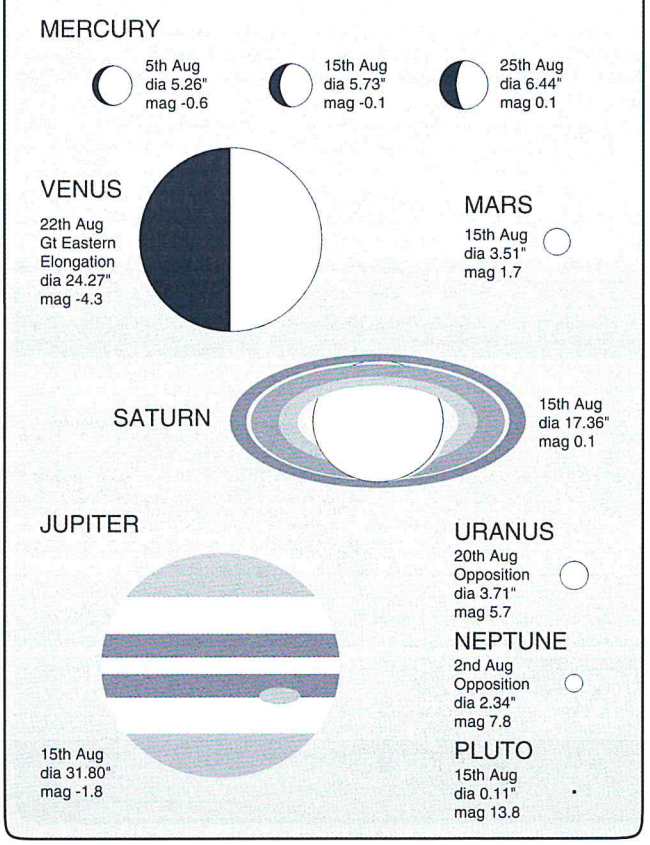
| | |
|---|---|
| 1st | Last Quarter |
| 9th | New Moon |
| 11th | Moon at perigee (closest to Earth – 362,927 km distant, angular size 33.0′) |
| 15th | First Quarter |
| 23rd | Full Moon |
| 27th | Moon at apogee (furthest from Earth – 405,695 km distant, angular size 29.8′) |
| 31st | Last Quarter |

## THE PLANETS

**MERCURY** will be its best for evening observation this year between mid-August and mid-September, reaching its greatest eastern elongation early next month. As the planet gains altitude it passes by the 1st magnitude star Regulus (Alpha Leonis). On the 6th, the pair will be 0.8° apart with Mercury being the northward and brighter of the two. On the 10th, the thin crescent 2-day old Moon will be 4.8° from the planet (see Sky View).

**VENUS** is at its greatest elongation (46°) east of the Sun on the 22nd, and spends the month high in the western evening sky in

## APPEARANCE of the PLANETS



Virgo. The 4-day old crescent Moon will be 6.5° north of the planet on the 12th (see Sky View). Venus increases altitude a little during the month, meeting up with the setting 1st magnitude star Spica (Alpha Virginis). The pair are closest on the 31st and 1st September at just under 1° apart (see Sky View next month). Also during August, Venus visits a number of galaxies in the Virgo cluster.

**MARS**, in conjunction with the Sun on the 11th, will remain lost in the Sun's glare until its return to the morning sky in October.

**JUPITER** returns to the morning eastern dawn sky after its solar conjunction last month. On the 31st, Jupiter will be 1.5° above the famous Beehive cluster or Praesepe (M44), an open cluster of about 200 stars visible to the unaided eye from dark skies (closest approach is next month).

**SATURN**, rising around 3am, begins the month 0.7° below M1, the Crab Nebula in Taurus. Closest approach occurred last month at 0.03°, which at the time was nearer to the planet than Saturn's satellite Titan. On the 5th, the 25-day old Moon will be 4° from the planet (see Sky View).

**URANUS** is at opposition on the 20th and is visible the entire night. On the 22nd, in the early evening the Full Moon will be 4° from the planet (closer as the night progresses). Uranus has been in Aquarius since the end of March, now its retrograde motion brings the planet back across the border into Capricornus on the 10th. It will remain now in Capricornus until late January 2003.

**NEPTUNE** is at opposition on the 2nd, and on this day, if any Neptunians happen to be looking our way, they will witness a transit of the Earth and Moon across the face of the Sun. This rare series of transits began in 2001, and will continue at each opposition until the year 2006. On the 21st, in the early evening the Full Moon will be 5.5° from the planet (further as the night progresses).

**PLUTO**, now two months past opposition, transits the meridian around 7pm.

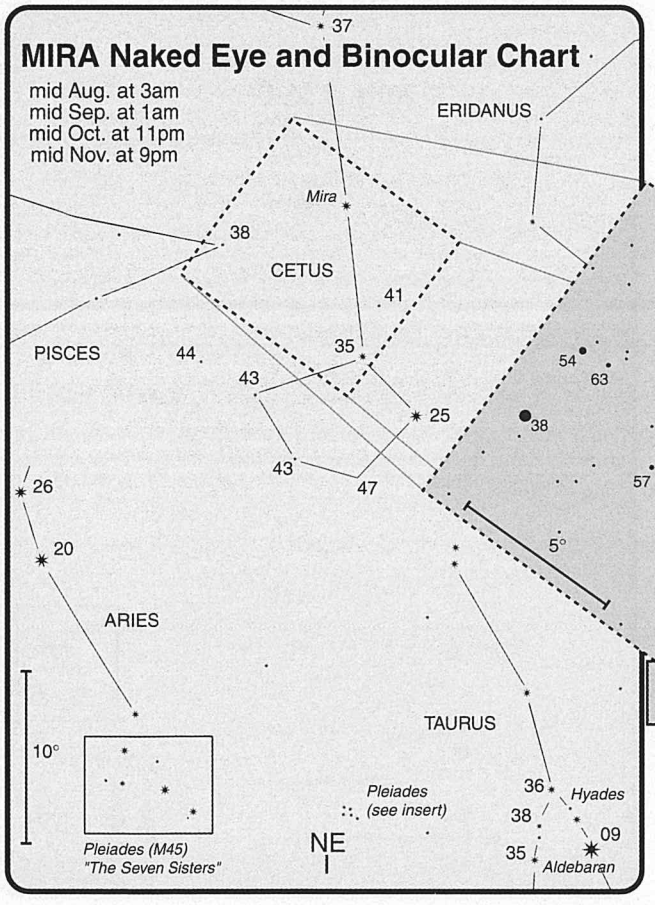
**MINOR PLANETS** at opposition this month include: 2 Pallas on the 4th at magnitude 9.4 in Delphinus, 7 Iris on the 24th at magnitude 7.8 in Aquarius and 532 Herculina on the 16th at magnitude 10.2 in Piscis Austrinus. A faint 28 Bellona visits the Virgo cluster of galaxies this month.

## COMETS

**Comet 7P/Pons-Winnecke** moves through Phoenix during August, and is visible for most of the month. On 10th August, the comet is

## MIRA - A VARIABLE STAR FOR BEGINNERS

To the casual stargazer it may come as a surprise to learn that the brightness of all stars is not as constant as they seem. It fact, astronomers (many of them amateurs) have discovered tens of thousands of stars whose brightness varies over periods ranging from minutes to years. The amplitude (how much they change in brightness or their range of magnitudes) and how long it takes for one cycle (to be bright, fade and brighten again) varies greatly from star to star. Most of these objects are faint and require a telescope to observe them. However, there are a number of these stars that are quite bright. Brilliant enough for people to observe them go through their cycle of fading, and then brightening again, with only binoculars or even the naked eye. These few stars are ideal for the beginner. Some stars only vary by a fraction of a magnitude but it is not unusual for others to change by at least 4 to 6 magnitudes. To visualise 6 magnitudes try looking at the brightest star, Sirius (mag. -1), and compare it to the faintest stars you can see (around mag. 5 to 6).




Variable stars are split into a number of classes. The most common variables are the long period pulsating types. Thousands of these 'Mira' variables have now been catalogued. Mira, itself, was discovered back in 1596 by Fabricus, but he thought it was a nova. Bayer even included it in his star catalogue in 1603 thinking it was a normal 4th magnitude star, calling it Omicron Ceti. However, its strange nature was soon discovered. Being the first variable discovered it was considered appropriate to name it Mira, 'The Wonderful'.

Mira is an excellent variable for beginners and this article is a guide to observing the star in 2002. At its brightest the star averages around 3rd magnitude (although historically it has peaked anywhere from 4th to 2nd) - definitely a naked eye star even from a suburban location. The star then fades to around 9th magnitude, now a binocular or small telescope object. A full cycle from peak to peak is 330 days. Therefore the star reaches maximum about one month earlier than the previous year. The 2001 peak was in the first week of September. In 2002 it will reach maximum in early August. The star is in conjunction with the Sun in April/May and then moves into the morning sky. It is easiest for a beginner to pick it up at maximum and follow its decline. By mid August the star is rising before midnight, but it is best to wait 2-3 hours to allow it to gain altitude before attempting any magnitude estimates. Mira is in an area devoid of bright stars, so binoculars will help from light polluted skies. If you wait for Taurus to rise, the arrowhead of the Hyades will point you in the right direction. Based on 400 years of observations, the star is expected to fade to its minimum 200 days after maximum (it fades slower than it brightens). The minimum is therefore expected around March 2003. It will be possible to follow the star until February when it will start to get lost in the western evening twilight sky.

# AUGUST

just over two degrees from 2nd magnitude Alpha Phoenicis. By month's end, the comet has faded from 12th to 13th magnitude.

**Comet 22P/Kopff** can be found in Virgo in the evening sky, visible for a few hours after the end of twilight. It should brighten from 13th to 12th magnitude. In early August, the comet is less than two degrees from 3rd magnitude Gamma Virginis.

**Comet 46P/Wirtanen** reaches its peak brightness of 10th magnitude this month. Wirtanen also reaches perihelion this month on 26th August at 1.1 AU from the Sun, and mid-month it is at its closest to Earth during this apparition - a distant 1.6 AU. The comet is very low in the morning sky before dawn, moving through the constellations of Taurus, Orion, Gemini, and Cancer. On the 9th and 10th of August, Wirtanen is very close to the 4th magnitude star Nu Geminorum.

**Comet 67P/Churyumov-Gerasimenko** reaches perihelion this month on 18th August at 1.3 AU from the Sun. The comet should stay around 13th magnitude. On the morning of 5th August, the comet will be very near Saturn and the supernova remnant M1, with a crescent Moon nearby. A week later, the comet has crossed over into the constellation of Gemini and is less than a degree from the open cluster M35. Capping off an interesting month of conjunctions, Churyumov-Gerasimenko is about a degree from 3rd magnitude Epsilon Geminorum on 21st August and less than half a degree from 5th magnitude Omega Geminorum on 26th August.

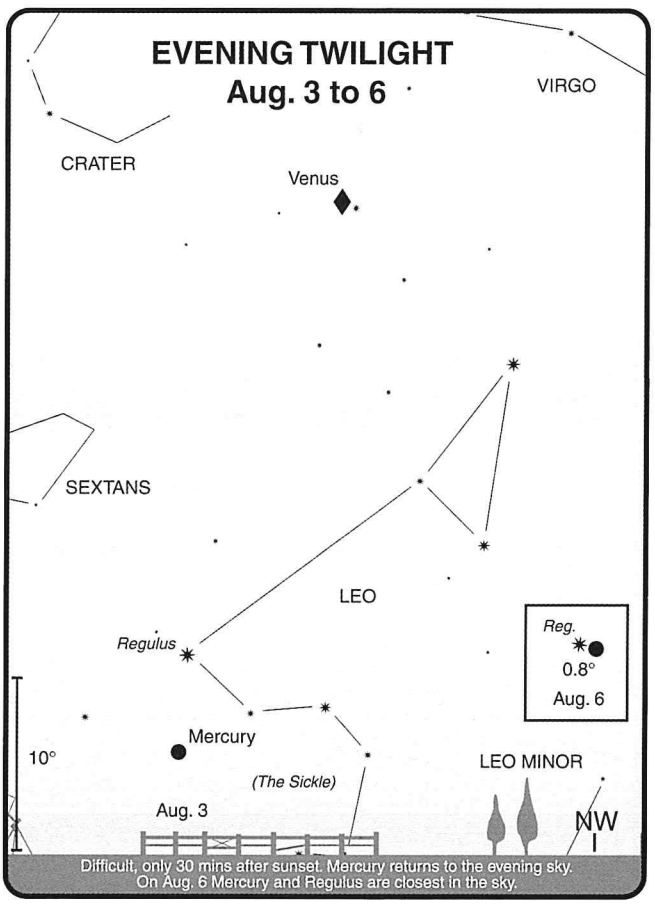
**Comet P/1992 Q1 (Brewington)** should brighten from 12th to 11th magnitude this month. The comet is visible all night and moves from Microscopium into Sagittarius. In late August, Brewington is at its closest to Earth during this apparition (1.56 AU), even though perihelion isn't until February 2003.

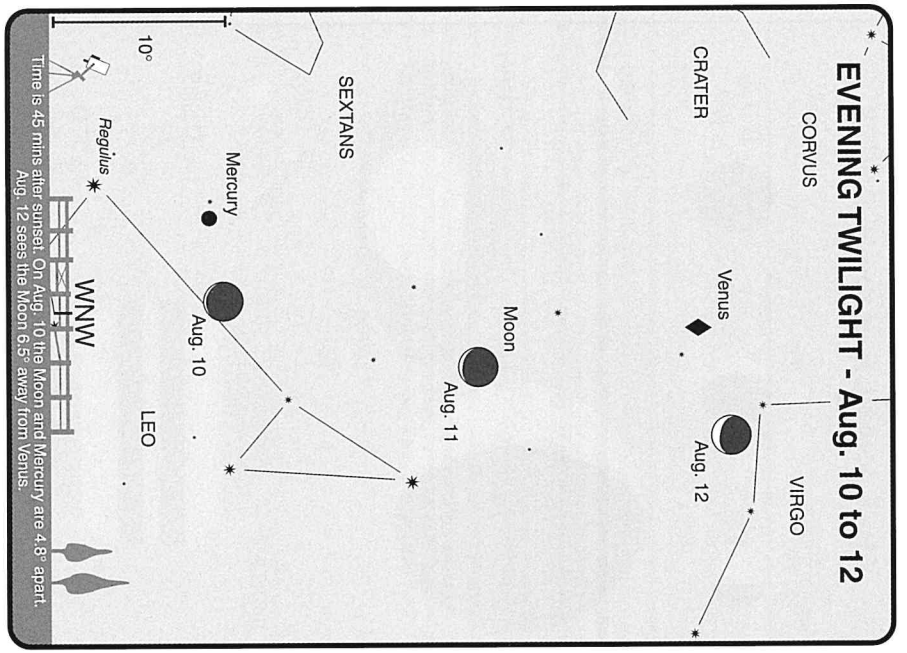
## METEOR SHOWERS

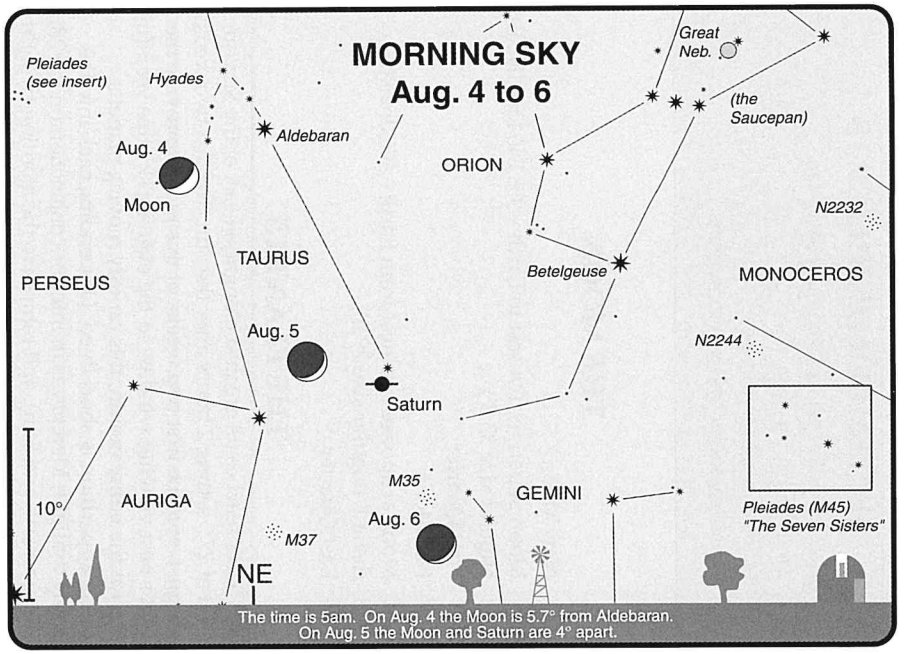
The **Perseids** unfortunately are not easily observable for most southern observers, and for southern Australia the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17th July through to 24th August, with maximum on the 12th August. The zenith hourly rate is variable and has in the past being exceptional; 1991 and 1992 saw over 400, in 1993 around 300 and 1994 was 220. Since then respectable rates of between 120-160 have occurred. There could still be some surprises in the shower activity, but the rates have gradually declined since 1992 when the Perseids parent comet Swift-Tuttle reached perihelion.

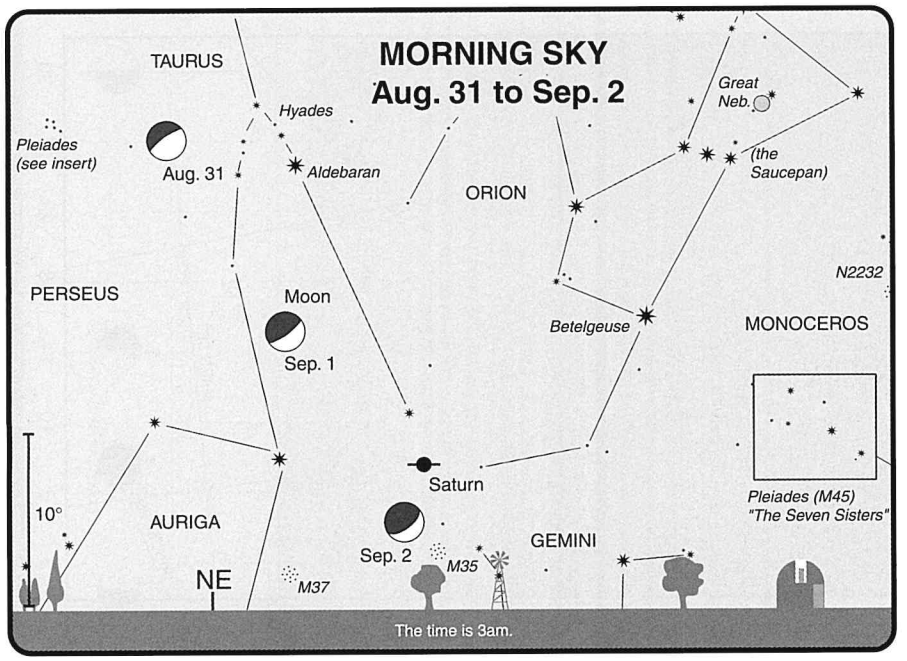
## DIARY

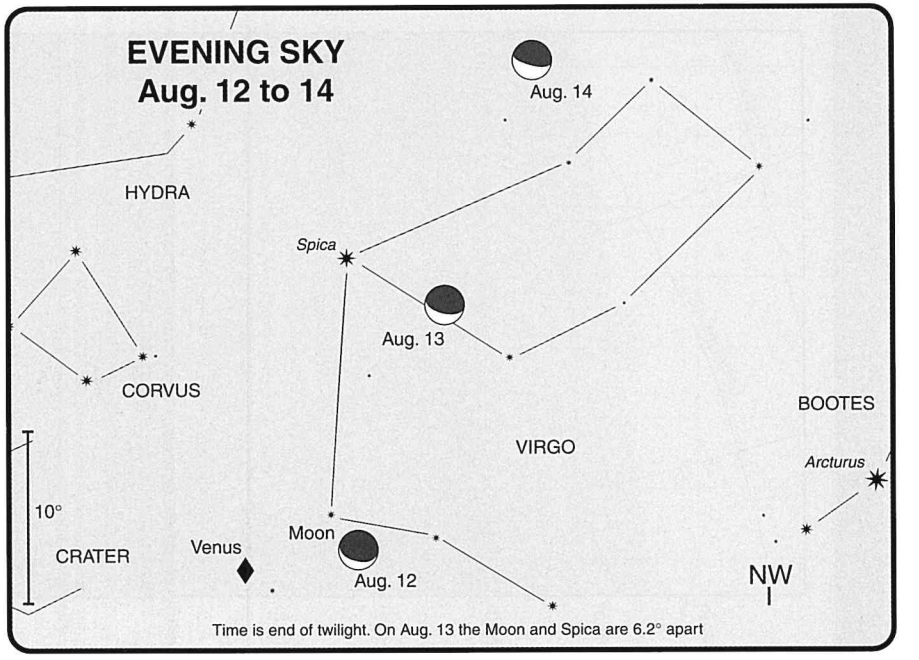
| | | |
|---|---|---|
| 1st | 6:22 PM | Last Quarter Moon |
| 2nd | 9 AM | Neptune at opposition |
| 3rd | | Venus at descending node |
| 3rd | 6 PM | Comet 22P/Kopff 0.03°N of NGC 4666 (SG) in Virgo |
| 5th | Noon | Saturn 2°S of Moon |
| 6th | | Comet 46P/Wirtanen 0.5°S of NGC 2175 (OC) in Orion |
| 6th | Noon | Mercury 0.9°N of Regulus |
| 7th | 6 PM | Comet 22P/Kopff 0.2°W of NGC 4753 (IG) in Virgo |
| 8th | | Venus 0.7°NE of NGC 4030 (SG) in Virgo |
| 9th | 3:15 AM | New Moon |
| 10th | | m.p. 27 Euterpe 0.5°SW of NGC 4691 (SG) in Virgo |
| 10th | 9 AM | Mercury 4°S of Moon |
| 11th | 6 AM | Mars in conjunction with Sun |
| 11th | 7 AM | Moon at perigee |
| 12th | 6 AM | Venus 6°S of Moon |
| 12th | 8 PM | Pallas at opposition |
| 14th | | Mars at greatest latitude North |
| 14th | | m.p. 28 Bellona 0.2°S of M61 (SG) in Virgo |
| 15th | | m.p. 654 Zelinda 0.2°SE of NGC 3962 (EG) in Crater |
| 15th | 6:12 PM | First Quarter Moon |
| 17th | | Mercury at descending node |
| 17th | 11 PM | Ceres stationary |
| 18th | | Venus 0.4°SW of NGC 4593 (SG) in Virgo |
| 19th | | m.p. 28 Bellona 0.2°SE of NGC 4457 (EG) in Virgo |
| 19th | | Mercury 0.7°NE of NGC 3640 (EG) in Leo |
| 20th | | Venus 1°SW of NGC 4697 (EG) in Virgo |
| 20th | 9 AM | Uranus at opposition |
| 21st | | Venus 0.8°SW of NGC 4731 (SG) in Virgo |
| 21st | Noon | Neptune 4°N of Moon |
| 22nd | | m.p. 27 Euterpe 0.1°S of NGC 4941 (SG) in Virgo |
| 22nd | | m.p. 28 Bellona 0.3°N of NGC 4527 (SG) in Virgo |
| 22nd | 9 PM | Venus greatest elongation E (46°) |
| 22nd | 10 PM | Uranus 4°N of Moon |
| 23rd | 3 AM | Comet 46P/Wirtanen 0.2°SW of Eskimo Nebula (PN) in Gemini |
| 23rd | 6:29 AM | Full Moon |
| 23rd | | Venus 0.5°N of NGC 4818 (SG) in Virgo |
| 25th | | Comet 46P/Wirtanen 0.9°S of NGC 2420 (OC) in Gemini |
| 26th | | m.p. 28 Bellona 0.7°SW of NGC 4636 (EG) in Virgo |
| 26th | | m.p. 8 Flora 1°SW of NGC 4536 (SG) in Virgo |
| 26th | | Venus 1°NE of NGC 4939 (SG) in Virgo |
| 27th | 2 AM | Moon at apogee |
| 27th | | Mercury at aphelion |
| 27th | | Mercury 0.6°S of NGC 4030 (SG) in Virgo |
| 28th | 4 AM | Pluto stationary |
| 28th | 5 PM | m.p. 28 Bellona 0.05°S of NGC 4643 (SG) in Virgo |
| 29th | 7 PM | m.p. 7 Iris 0.4°S of star Alpha Aquarii |
| 31st | | m.p. 654 Zelinda 0.4°S of star Delta Corvi |
| 31st | 10:31 AM | Last Quarter Moon |




EVENING TWILIGHT - Aug. 10 to 12
Time is 45 mins after sunset. On Aug. 10 the Moon and Mercury are 4.8° apart. Aug. 12 sees the Moon 6.5° away from Venus.
10°
WNW
Regulus
Mercury
Aug. 10
Moon
Aug. 11
Venus
Aug. 12
SEXTANS
CRATER
CORVUS
LEO
VIRGO

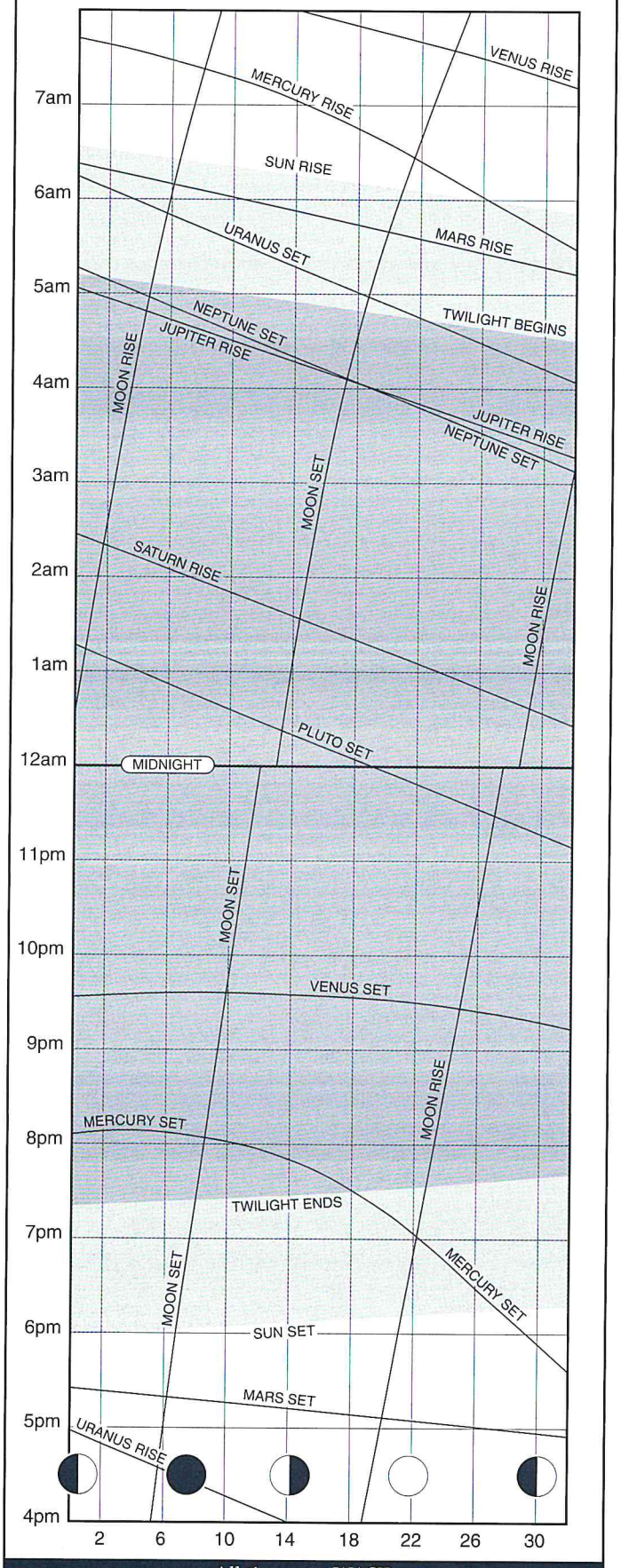

MORNING SKY
Aug. 4 to 6
Pleiades (see insert)
Hyades
Aldebaran
Great Neb.
(the Saucepan)
Aug. 4
Moon
ORION
N2232
TAURUS
Betelgeuse
PERSEUS
MONOCEROS
Aug. 5
N2244
Saturn
M35
10°
AURIGA
GEMINI
Aug. 6
Pleiades (M45) "The Seven Sisters"
M37
NE
The time is 5am. On Aug. 4 the Moon is 5.7° from Aldebaran. On Aug. 5 the Moon and Saturn are 4° apart.


MORNING SKY
Aug. 31 to Sep. 2
TAURUS
Hyades
Great Neb.
Pleiades (see insert)
Aug. 31
Aldebaran
(the Saucepan)
ORION
N2232
PERSEUS
Moon
Sep. 1
Betelgeuse
MONOCEROS
Saturn
Pleiades (M45) "The Seven Sisters"
10°
AURIGA
Sep. 2
M35
GEMINI
NE
M37
The time is 3am.


EVENING SKY
Aug. 12 to 14
Aug. 14
HYDRA
Spica
Aug. 13
CORVUS
BOOTES
VIRGO
Arcturus
10°
Moon
Venus
CRATER
Aug. 12
NW
Time is end of twilight. On Aug. 13 the Moon and Spica are 6.2° apart

# SEPTEMBER

## RISE/SET CHART




All times are WAST.

## SEPTEMBER HIGHLIGHTS

- Mercury at its best for evening observation
- Venus and Spica close
- Venus at greatest brilliancy
- Jupiter passes by M44's outer regions

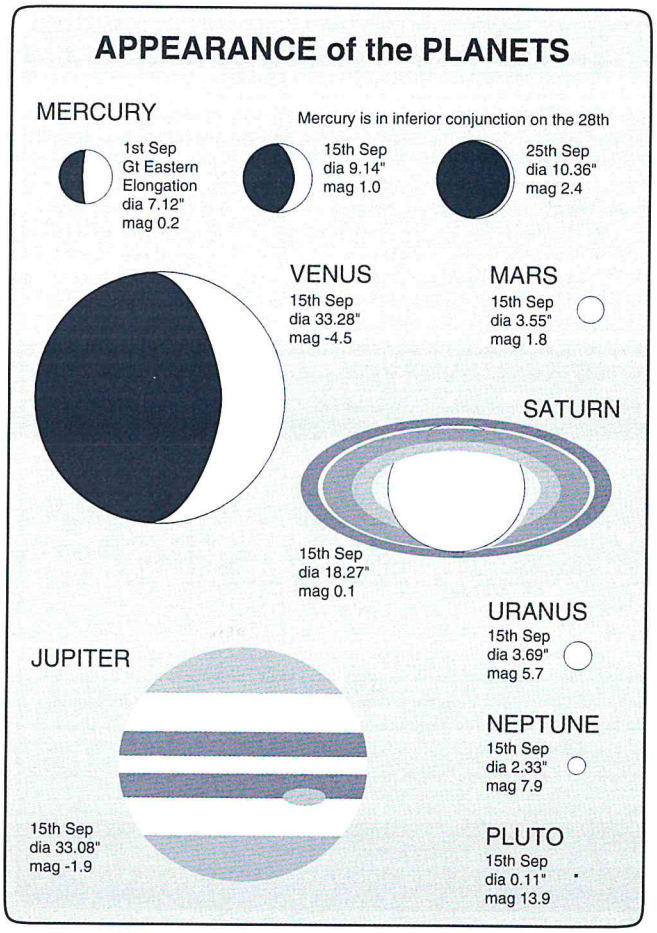
## THE MOON

| | |
|---|---|
| 7th | New Moon |
| 8th | Moon at perigee (closest to Earth – 358,746 km distant, angular size 33.8′) |
| 14th | First Quarter |
| 21st | Full Moon |
| 23rd | Moon at apogee (furthest from Earth – 406,352 km distant, angular size 29.0′) |
| 30th | Last Quarter |

## THE PLANETS

**MERCURY** reaches its greatest elongation east of the Sun on the 1st at 27°, setting 2 hours after the Sun. The last two weeks of August, and the first two weeks of this month, provide the planet's best viewing window in the evening sky this year. In Virgo for the entire month, this rapidly moving planet's evening apparition is short lived. Descending back into the evening twilight, Mercury is in inferior conjunction on the 28th (between Earth and Sun), and returns to the morning twilight next month.

## APPEARANCE of the PLANETS



# SEPTEMBER

**VENUS**, in the western evening sky, begins the month just 1° from the 1st magnitude star Spica (Alpha Virginis). The separation from Spica increases throughout the month and during the last week the planet moves from Virgo into Libra. On the 10th, the 4-day-old crescent Moon appears 7.5° north of the planet (see Sky View). Venus attains its greatest brilliancy (magnitude –4.6) in the evening sky at month-end, outshining the brightest star Sirius (Alpha Canis Majoris) by a factor of 12. Interestingly, the planet is so bright that it can cast a perceptible shadow, visible only under good dark skies away from city lights. Venus' prominence as the Evening Star over the past six months is ending, with the planet in conjunction with the Sun late 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** returns to the morning sky after its solar conjunction last month, albeit remaining close to the Sun and making observations difficult until late October.

**JUPITER**, rising about 30 minutes (mid-month) before the commencement of dawn, starts the month in Cancer just 1.5° from the famous Beehive cluster or Praesepe (M44) The planet passes by the cluster's outer fringes on the 6th. The thin crescent Moon will be 5.7° below the planet on the 5th (see Sky View).

## TRANSIENT LUNAR PHENOMENA

For a lot of amateur astronomers the Moon is something they may only occasionally look at, or be the trump card to be wheeled out at public field nights to ensure a high wow factor! Very few would look at our celestial neighbour as a target for a serious, long term observing project. One such area is looking for Transient Lunar Phenomena (TLPs). For hundreds of years observers have reported strange, short-term changes on the Moon. These reports have even come from Apollo astronauts and the great observer Herschel who once described Aristarchus - "like a nebula - like glowing coals". These events fit into four broad categories: brightness variation, obscurations (such as fogs or mists), star-like flashes and colour abnormalities. They are by no means randomly distributed across the surface but tend to re-occur in specific lunar features. This is just as well for it would be impossible to learn the entire visible surface of the Moon to the level needed to make meaningful observations.

**What do TLPs look like?**

*Brightening*. This effect is mostly seen on crater rims or highland areas. Seen in Aristarchus, Proclus and Censorinus.

*Gaseous*. This is when an object looks diffused and can appear obscured. This may be associated with an outgassing from the Moon's interior. This has been seen by many observers in the Mare Crisium basin. Also small craters on the interior of Plato have been 'missing' for short periods.

*Darkening*. This can have the dramatic appearance of black ink flowing across the lunar surface. Aristarchus, Linnie and Plato have been known to show this feature.

*Colour effects*. A 'bluish' glow has been seen during the crescent phase but on the darkened, or earthshine, portion of the Moon. Aristarchus is the most common site. The rim of Aristarchus and the inside of the crater Gassendi have been the sites for a strange red colour.

*Shadow and Contrast Effect*. This can be the appearance of a shadow on the surface where one shouldn't be. Also the normal stark boundary between light and dark at sunset or sunrise can appear to be 'greyed'.

*Star-like Flashes*. Unlike most TLPs the cause of these are likely to be impacting particles related to a meteor storm. A recent example was the reporting of flashes during the Leonids peak in 1999.

*Star-like Lights*. A stellar point of light is observed and can last for several minutes up to an hour. These are mostly seen on the dark portion of the Moon when the Moon is 3 to 4 days old.

**What causes TLPs?**

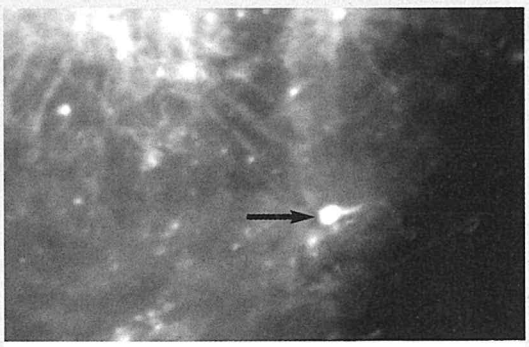
There are many and varied theories of which there is little space to go into here. A commonly believed contributor is the tidal pull of the Earth, which does strain the lunar crust and may release trapped gases. See also the discussion on the ALPO web site (below).

**How and where does one look for TLPs?**

A good approach would be to pick 5 or 6 regions, including 3 known TLP sites, and observe them under all possible levels of illumination. This would include, the terminator crossing the feature from both directions i.e., local sunrise and sunset, at Full Moon and only earthshine (no direct sunlight). The size of the telescope is not critical, although it is recommended that reflectors to be at least 20cm. There is no doubt that observers using larger scopes (such as 30cm) report more such phenomena. A high contrast is also considered desirable so a refractor may offer some advantages. It is important, when one detects a TLP, to look at a number of other features across the lunar disk. If they all show the same event you may be seeing an effect from local atmospheric seeing and not a lunar feature at all.

With regards to which features to observe, Aristarchus, as well as being the brightest feature on the Moon, has been by far, the most prolific TLP site. Plato would be the next most active area, followed by Proclus.

The British Astronomical Association (BAA) and the Association of Lunar and Planetary Observers (ALPO) have active TLP sections. They would be pleased to receive any such observations and have available guides to observing and reporting such events. The following web site, which includes TLP alerts, would be a good start (www.ltpresearch.org/nav.htm).



*Aristarchus (arrowed) is the brightest region on the Moon and the most common location for TLPs (south is up).*

# SEPTEMBER

**SATURN**, rising around 1.30am mid-month, moves into Orion in September after spending more than 2 years in Taurus. It will be a brief sojourn however, as the planets retrograde motion returns it to Taurus in November. The Moon has close approaches to the planet twice this month, on the 2nd the 24-day old Moon will be 3.7° below Saturn (see Sky View) and on the 29th, 5.8° away (see Sky View).

**URANUS** and **NEPTUNE** in Capricornus are now one month past opposition and are visible for virtually the entire night.

**PLUTO** is only available to keen observers (with large enough telescopes and our finder chart on page 95), in the evening sky, setting around midnight.

**MINOR PLANETS** at opposition this month include 15 Eunomia on the 7th at magnitude 8.1 in Pegasus.

## COMETS

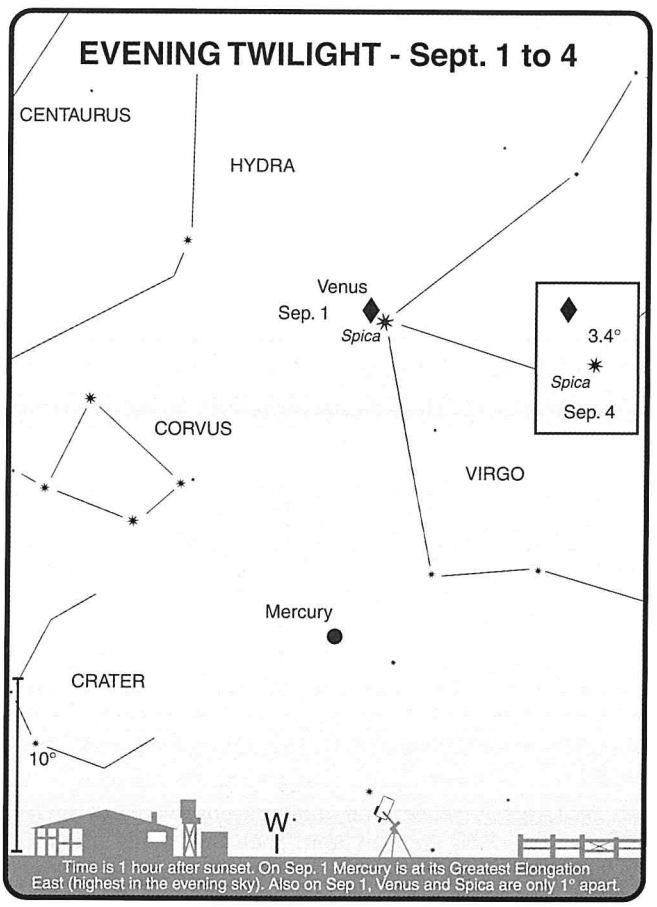
**Comet 22P/Kopff** is low in the western evening sky after the end of astronomical twilight. Kopff should brighten from 12th to 11th magnitude during the month as it moves from Virgo into Libra. In mid-September, the comet is about a degree from 4th magnitude Kappa Virginis.

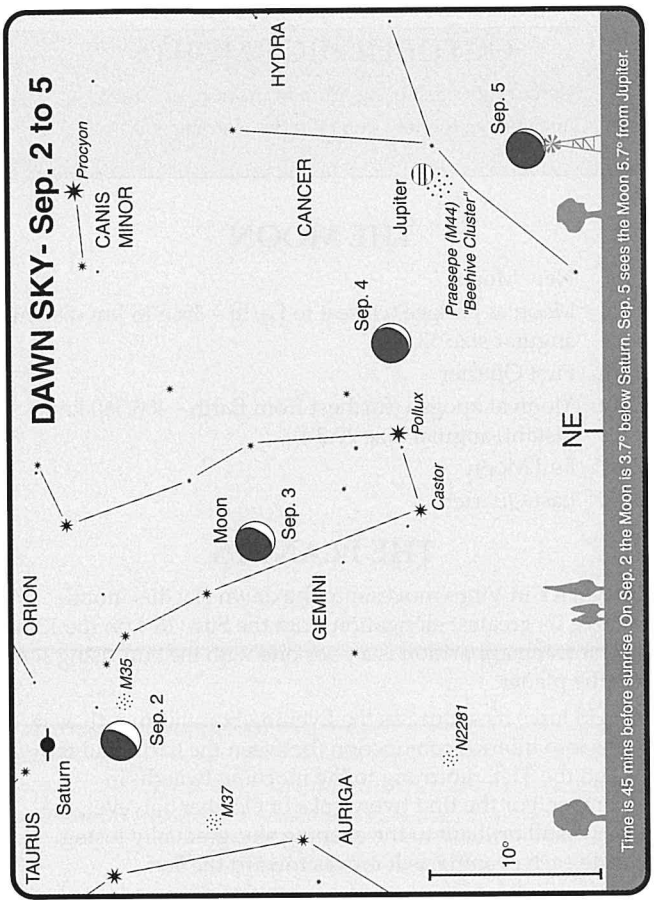
**Comet 46P/Wirtanen** will be difficult to observe this month, rising around the time of morning twilight. The comet should fade from 10th to 11th magnitude as it moves away from both the Earth and the Sun. Wirtanen moves from Cancer into Leo during this time, ending the month about a degree from 4th magnitude Eta Leonis. The 8th September sees the comet pass in front of the open cluster M44, with Jupiter 1° away.

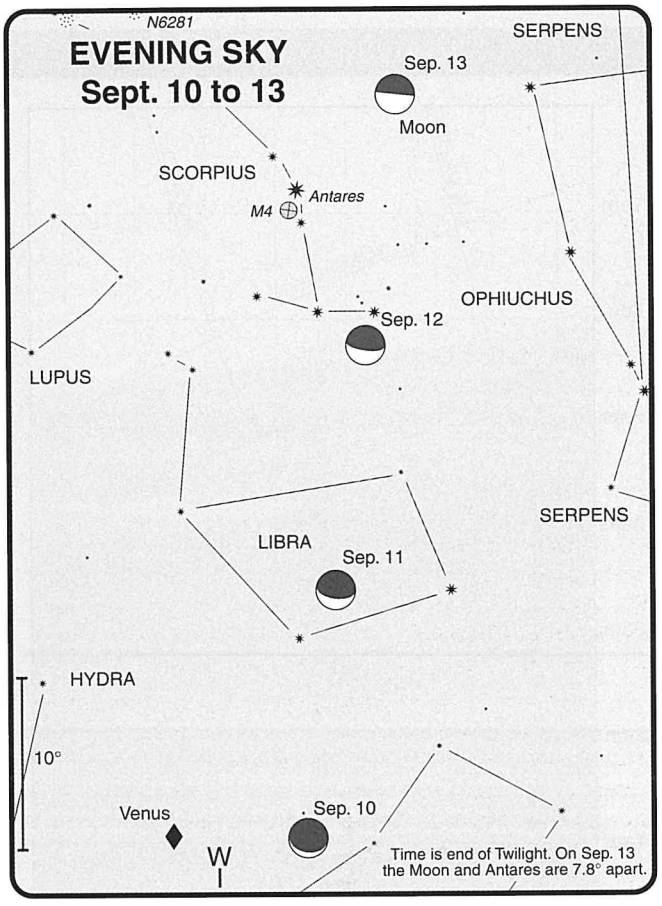
**Comet P/1992 Q1 (Brewington)** is high in the eastern sky when evening twilight concludes this month. The 11th magnitude comet can be found in Sagittarius and sets a few hours before dawn. On 3rd September, the comet is less than a degree from 4th magnitude Theta 1 Sagittarii. Three days later, the comet glides past 5th magnitude Theta 2 Sagittarii. In late September, Brewington is less than 4° from the globular cluster M55.

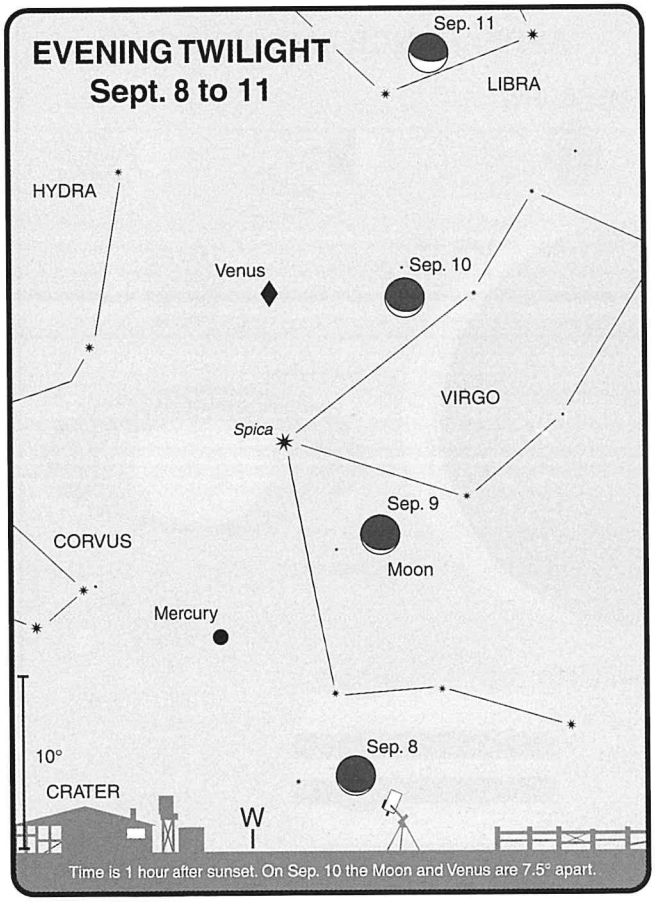
## DIARY

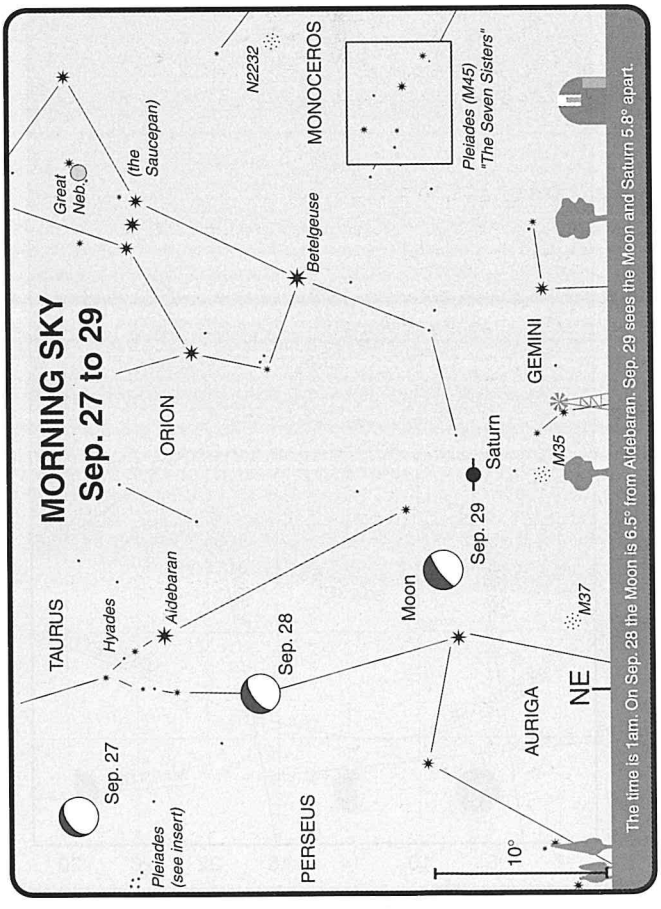
| | | |
|---|---|---|
| 1st | 2 PM | Venus 0.9°S of Spica |
| 1st | 6 PM | Mercury greatest elongation E (27°) |
| 2nd | 1 AM | Saturn 2°S of Moon |
| 4th | | m.p. 8 Flora 0.4°NE of NGC 4666 (SG) in Virgo |
| 4th | 9 PM | Jupiter 4°S of Moon |
| 6th | | Jupiter 1°S of Beehive Cluster M44 (OC) in Cancer |
| 7th | | Venus at aphelion |
| 7th | | Mercury 0.7°NE of NGC 4504 (SG) in Virgo |
| 7th | 11:10 AM | New Moon |
| 7th | 9 PM | m.p. 15 Eunomia 0.7°N of NGC 7479 (SG) in Pegasus |
| 8th | | Comet 46P/Wirtanen 0.2°S of Beehive Cluster M44 (OC) in Cancer |
| 8th | | Comet 46P/Wirtanen 1°N of Jupiter |
| 8th | | m.p. 8 Flora 0.3°N of NGC 4753 (IG) in Virgo |
| 8th | | Saturn 0.4°N of Berk 21 (OC) in Orion |
| 8th | 11 AM | Moon at perigee |
| 9th | 1 AM | Mercury 9°S of Moon |
| 10th | 10 AM | Venus 8°S of Moon |
| 11th | 7 PM | m.p. 2 Pallas 0.3°W of NGC 6934 (GC) in Delphinus |
| 14th | 2:08 AM | First Quarter Moon |
| 14th | 10 PM | Mercury stationary |
| 15th | 7 PM | m.p. 6 Hebe 0.6°SW of M18 (OC) in Sagittarius |
| 16th | | Mercury at greatest latitude South |
| 17th | 5 PM | Neptune 4°N of Moon |
| 19th | 2 AM | Uranus 4°N of Moon |
| 19th | | m.p. 654 Zelinda 0.6°SW of NGC 5018 (SG) in Virgo |
| 21st | | Mars at aphelion |
| 21st | | Mercury 0.4°SE of NGC 4504 (SG) in Virgo |
| 21st | 9:59 PM | Full Moon |
| 23rd | | m.p. 654 Zelinda 0.5°NE of NGC 5068 (SG) in Virgo |
| 23rd | 11 AM | Moon at apogee |
| 23rd | 1 PM | Equinox |
| 25th | | m.p. 25 Phocaea 0.1°SE of IC 4756 (OC) in Serpens |
| 26th | 7 PM | Venus greatest brilliancy |
| 28th | 3 AM | Mercury in inferior conjunction |
| 29th | | Venus at greatest latitude South |
| 29th | 11 AM | Saturn 3°S of Moon |
| 29th | 9 PM | m.p. 6 Hebe 0.3°N of M25 (OC) in Sagittarius |
| 30th | 1:03 AM | Last Quarter Moon |
| 30th | 8 AM | Pallas stationary |




DAWN SKY- Sep. 2 to 5
HYDRA
Procyon
CANIS MINOR
CANCER
Jupiter
Sep. 5
Praesepe (M44) "Beehive Cluster"
Sep. 4
Pollux
Castor
Moon
Sep. 3
ORION
GEMINI
M35
Sep. 2
Saturn
N2281
M37
AURIGA
TAURUS
NE
10°
Time is 45 mins before sunrise. On Sep. 2 the Moon is 3.7° below Saturn. Sep. 5 sees the Moon 5.7° from Jupiter.

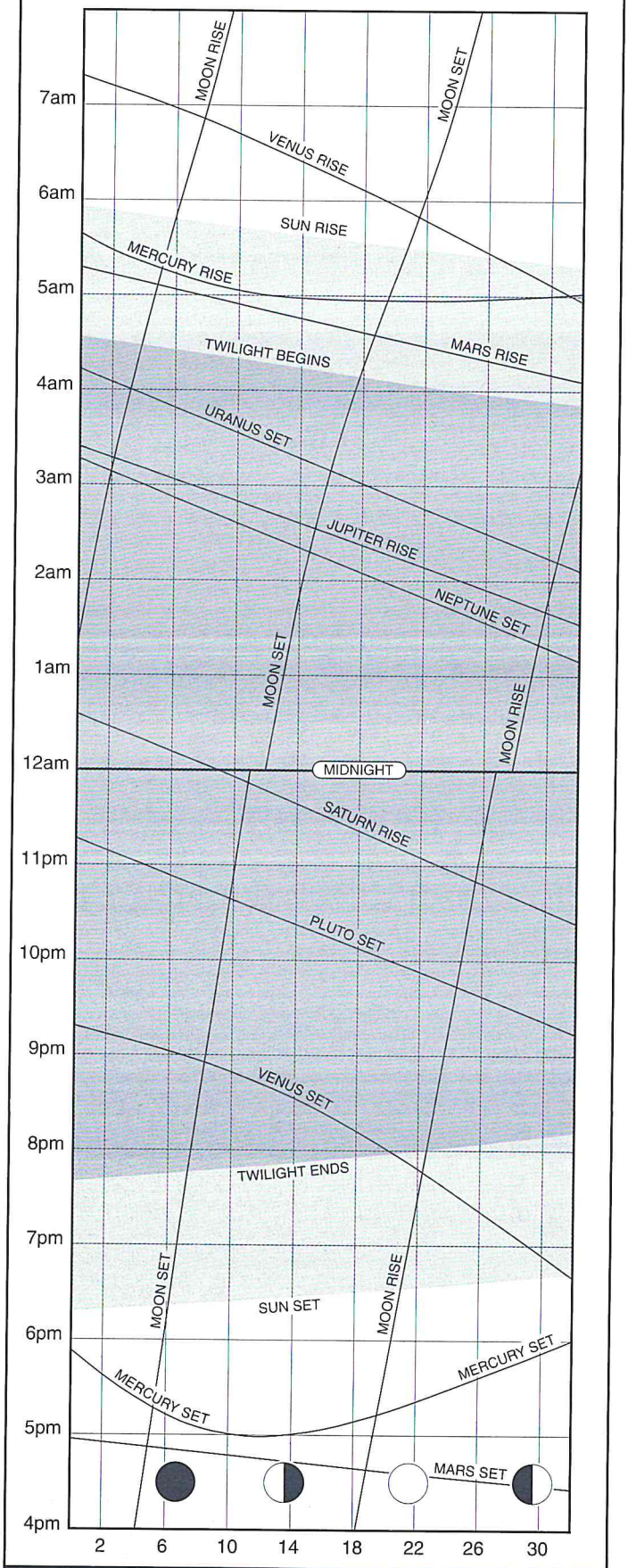

N6281
SERPENS
EVENING SKY
Sept. 10 to 13
Sep. 13
Moon
SCORPIUS
Antares
M4
OPHIUCHUS
Sep. 12
LUPUS
SERPENS
LIBRA
Sep. 11
HYDRA
10°
Venus
Sep. 10
W
Time is end of Twilight. On Sep. 13 the Moon and Antares are 7.8° apart.


EVENING TWILIGHT
Sept. 8 to 11
Sep. 11
LIBRA
HYDRA
Venus
Sep. 10
VIRGO
Spica
Sep. 9
Moon
CORVUS
Mercury
10°
Sep. 8
CRATER
W
Time is 1 hour after sunset. On Sep. 10 the Moon and Venus are 7.5° apart.


MORNING SKY
Sep. 27 to 29
N2232
MONOCEROS
Pleiades (M45) "The Seven Sisters"
Great Neb.
(the Saucepan)
Betelgeuse
GEMINI
ORION
Saturn
M35
Sep. 29
Moon
Aldebaran
Hyades
TAURUS
Sep. 28
M37
AURIGA
NE
Sep. 27
Pleiades (see insert)
PERSEUS
10°
The time is 1am. On Sep. 28 the Moon is 6.5° from Aldebaran. Sep. 29 sees the Moon and Saturn 5.8° apart.

# OCTOBER

## RISE/SET CHART




All times are WAST.

## OCTOBER HIGHLIGHTS

- Mercury greatest elongation in morning twilight
- Last chance to view Venus in the evening sky

## THE MOON

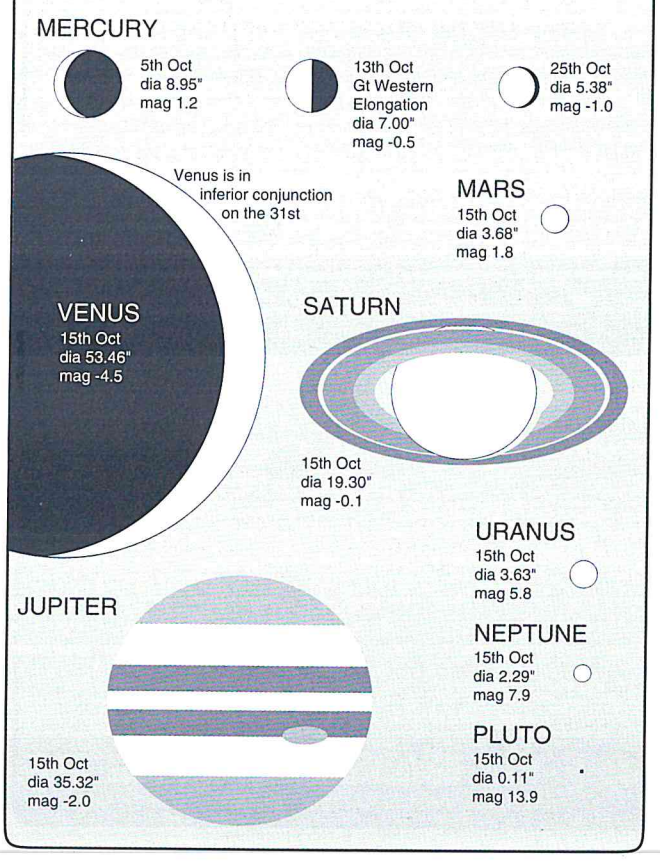
| | |
|---|---|
| 6th | New Moon |
| 6th | Moon at perigee (closest to Earth – 356,918 km distant, angular size 33.0′) |
| 13th | First Quarter |
| 20th | Moon at apogee (furthest from Earth – 406,360 km distant, angular size 29.2′) |
| 21st | Full Moon |
| 29th | Last Quarter |

## THE PLANETS

**MERCURY** in Virgo moves into the dawn sky this month, reaching its greatest elongation from the Sun (18°) on the 13th. This morning apparition is a poor one with the Sun rising soon after the planet.

**VENUS** loses its stature as the Evening Star this month as it moves into inferior conjunction (between the Earth and the Sun) on the 31st, returning to the morning twilight in November. For the first two weeks of October however, the planet is still brilliant in the evening sky, gradually losing altitude each evening as it moves toward the Sun.

## APPEARANCE of the PLANETS



**MARS** rises an hour before the Sun in the morning twilight. The Red Planet resides in Leo for the first week of October before moving into Virgo.

**JUPITER** rises in the NE sky around 2.30am in the constellation of Cancer. On the 30th, the Last Quarter Moon will be 6.2° from the planet.

**SATURN** rises around 11.30pm and is located in a corner of Orion near the tip of the hunter's sword. On the 26th, the 20-day old Moon will be 5.7° below Saturn (see Sky View).

**URANUS** and **NEPTUNE**, in Capricornus, transit the meridian in the early evening.

## A CHEAP EQUATORIAL CAMERA PLATFORM

*Glenn Dawes*

In the astrophotography article on page 41, it was mentioned that even with a 50mm lens, if the exposure goes beyond about 30 seconds, you need to track the stars to avoid 'trailing' of the image. Unfortunately a 30-second exposure doesn't get one anywhere near the potential described in this previous article. It is certainly convenient to hang the camera off a telescope and let it guide. Figure 1 is the telescope with the camera I used to do all my patrol photography. This is ideal but we don't always have the thousands of dollars to invest in such equipment.

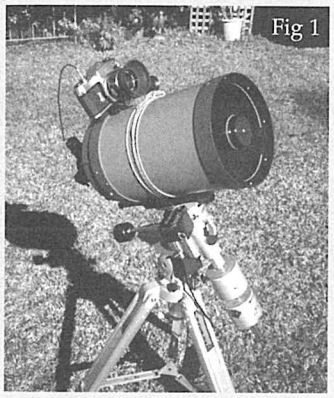


Fig 1

This article offers a possible, much cheaper alternative (figure 2). I originally dreamed up the idea for portability when travelling overseas. Besides your camera and cable lock all that is needed is a sturdy tripod, a camera slow motion control (available from telescope suppliers for around $100), a right angle mount, a small spirit level and a compass (the straight edged type, used on maps would be ideal). The 'right angle mount' was the only engineering involved. I used a section of 50mm, square rolled hollow section (RHS) steel. However, any channel will do as long as the camera is mounted at 90 degrees to the top of the slow motion control and the camera is able to swing freely.

**An Equatorial Head**. Set up the tripod, keeping the head low and the legs wide to improve stability. Level the tripod with the spirit level at point C (fig. 3). Then point the camera platform south by using a compass or the map compass placed on the edge D. You can even offset for the difference between the magnetic and true poles with a compass, however this isn't that critical for 5 minute shots. Tilt the tripod head back to line up the axis A, with the South Pole. This can be helped the first time by placing the straight edge of a vertically held protractor, along edge D and hanging a string with a weight and setting this to your latitude (e.g., 32° if you live in Perth). Mark the position at point E to avoid this step in the future. Then tilt the tripod forward elevating the head to the same angle but now pointing in the opposite direction (mark another point F). Tilt it back to E again. Mount the slow motion control where the camera normally goes. The goal then is to ensure the A and B axes are parallel. In this set up I found that lining up the front edge of the slow motion control to that of the camera platform (edge J) was sufficient (move the second axis, which is not used, to the centre position). We now have our makeshift equatorial mount. By unlocking the knob G we can swing the mount in right ascension (R.A.) Movement in declination is achieved by moving the camera itself on the right angle mount.

**Calibrating the 'Tracking'.** Finally we need to determine the speed in which knob H is turned to follow the stars. This can be done by centring the camera on a bright star and leaving it for an hour and seeing how many turns is needed to catch up to the

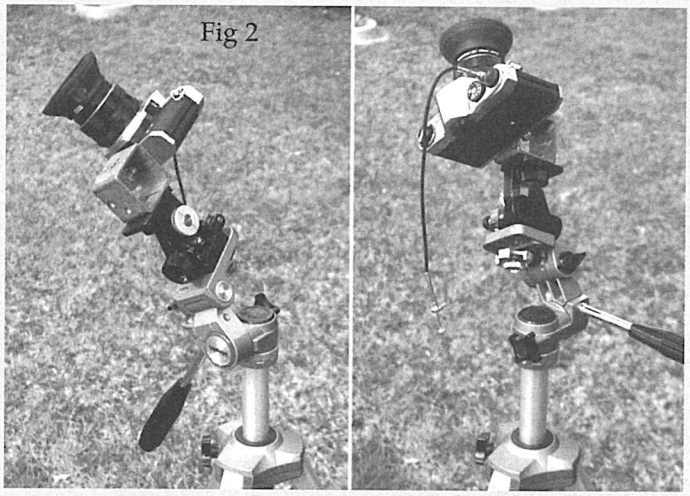


Fig 2

star (note which direction you had to turn the knob). Work out how many minutes per turn is needed. In practice while guiding, continuous turning of the knob isn't needed, as long as it is 'tweaked' the correct amount every 20 seconds or so. You will settle into your own style, maybe even setting up some audible signal every 20 seconds? The slow motion control, in this example needed only one full turn per 8 minutes. To help with the fine movement needed I have successfully experimented with putting a mark on the edge of the knob and placing a scale behind it.

**Photographing the Whole Sky**. The way it is shown in figure 3, i.e., south to the right, the tripod platform can only tilt towards the reader so you can only work on the western half of the sky (assuming Southern Hemisphere). To get to the eastern half you tilt the tripod head to point F and swing the entire tripod head around 180°. Fig. 2 shows the tripod in both configurations. You will need to go through the exercise again of pointing to the south. Now you can resume your photography immediately. Note the direction that you have been turning knob H now needs to be reversed.

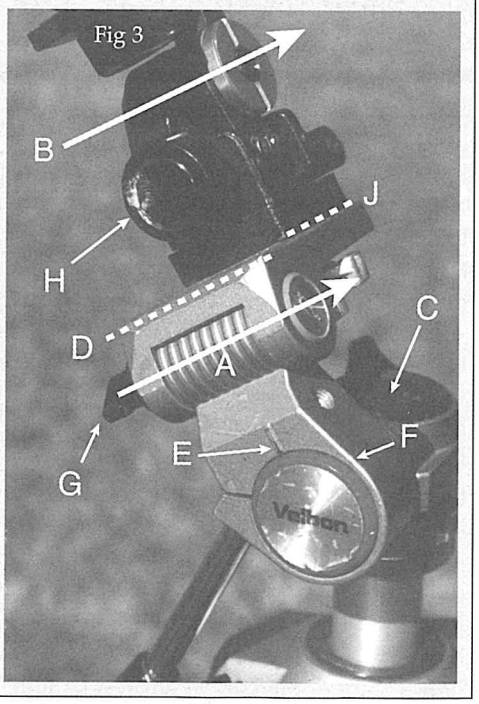


Fig 3

# OCTOBER

**PLUTO**, moving toward conjunction in early December, sets in the evening around 10pm.

**MINOR PLANETS** at opposition this month include 1 Ceres on the 9th at magnitude 7.6 in Cetus and 18 Melpomene on the 2nd at magnitude 7.8 in Cetus.

## COMETS

**Comet 22P/Kopff** continues to slowly brighten this month, from 11th to nearly 10th magnitude, but it is sinking closer to the western evening horizon with each night. In late October, the comet is only a few degrees from 4th magnitude Theta Librae. Kopff doesn't reach perihelion until 12th December, but after this month it will be too close to the Sun for observation again until late autumn 2003.

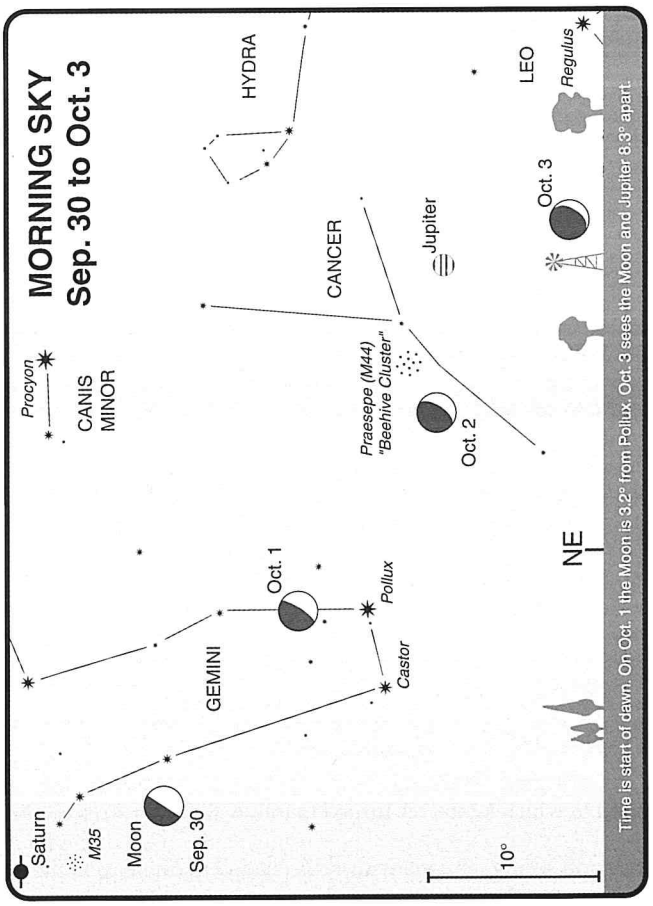
**Comet 46P/Wirtanen** fades from 11th to 13th magnitude this month. Although the comet does gain some altitude as its declination moves south, whilst traversing the constellations of Leo and Virgo, it will be a difficult object to observe. Early in the month, Wirtanen crosses the Leo group of galaxies.

**Comet C/2001 HT50 (LINEAR-NEAT)** can be found low in the eastern morning sky, brightening from 14th to 13th magnitude. LINEAR-NEAT spends the entire month in Sextans, moving quite slowly.

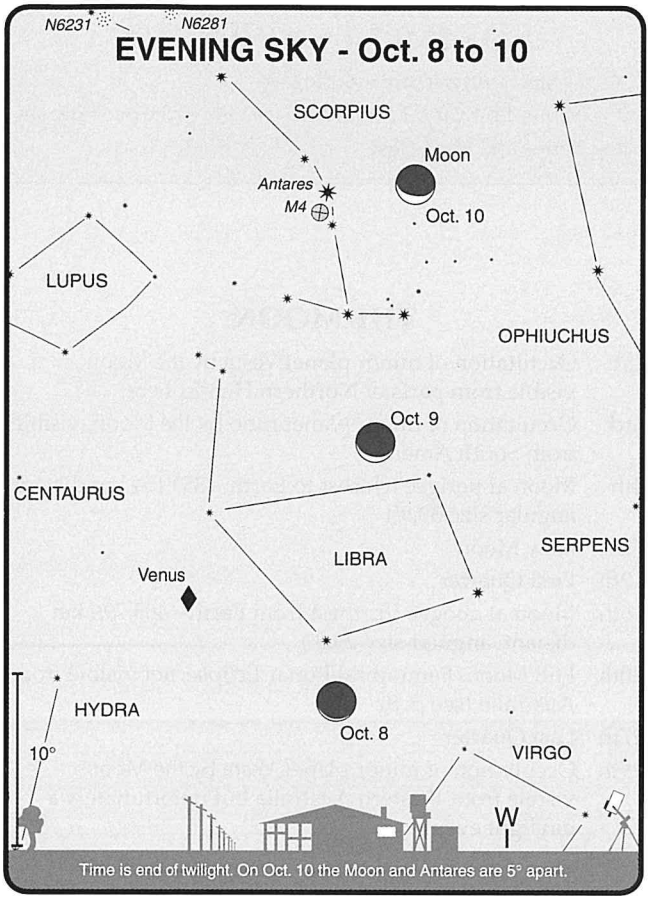
**Comet P/1992 Q1 (Brewington)** remains at 11th magnitude during October, and is high in the western evening sky following the end of astronomical twilight. During this month, the comet moves through the constellations of Sagittarius and Capricornus, and is setting shortly after midnight.

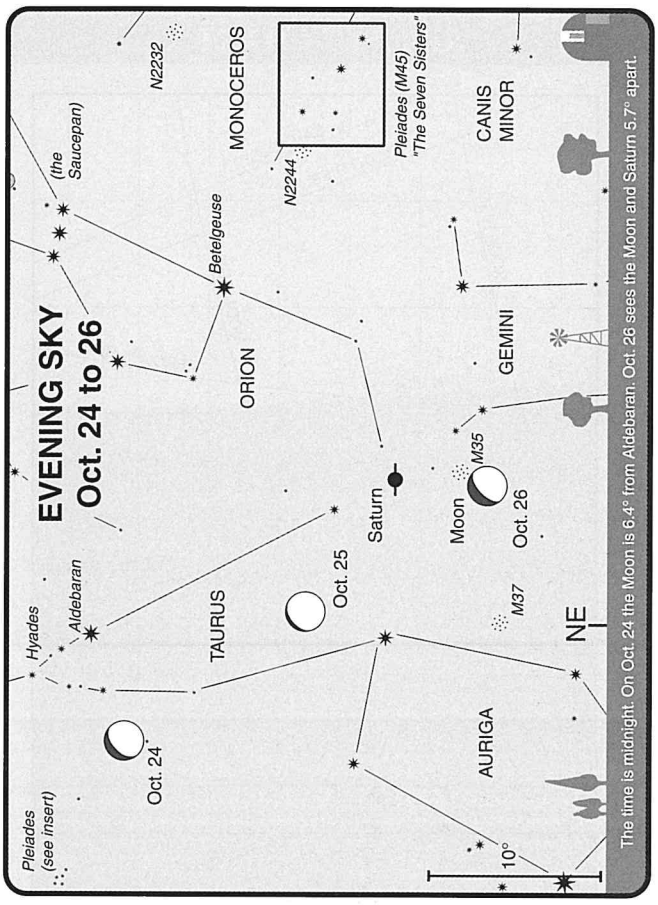
## DIARY

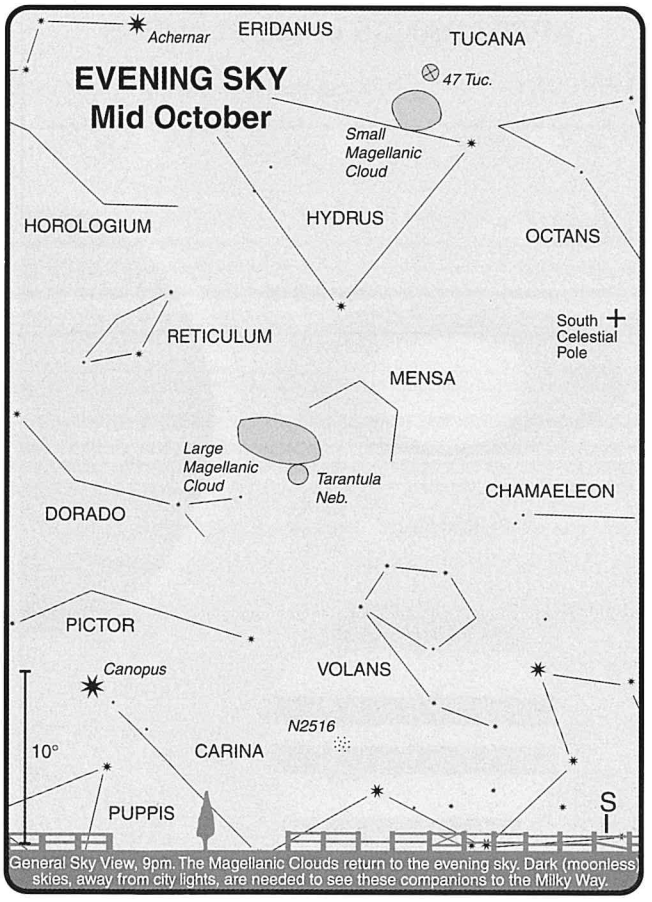
| | | |
|---|---|---|
| 2nd | | Venus 0.2°NE of IC 4468 (SG) in Libra |
| 2nd | 3 PM | Jupiter 4°S of Moon |
| 4th | 6 AM | Juno in conjunction with Sun |
| 4th | 4 PM | Ceres at opposition |
| 5th | | Mercury at ascending node |
| 5th | 9 AM | Mars 4°S of Moon |
| 6th | 10 AM | Mercury stationary |
| 6th | 7:18 PM | New Moon |
| 6th | 9 PM | Moon at perigee |
| 8th | | Jupiter 0.5°N of NGC 2734 (SG) in Cancer |
| 8th | 6 PM | Venus 10°S of Moon |
| 10th | | Mercury at perihelion |
| 10th | | Comet 46P/Wirtanen 0.2°N of NGC 3338 (SG) in Leo |
| 10th | 5 PM | Venus stationary |
| 11th | 9 PM | Saturn stationary |
| 12th | | Comet 46P/Wirtanen 0.4°SE of NGC 3377 (EG) in Leo |
| 13th | | Comet 46P/Wirtanen 0.2°E of NGC 3412 (EG) in Leo |
| 13th | | Mars 1°N of NGC 4546 (EG) in Virgo |
| 13th | 1:33 PM | First Quarter Moon |
| 13th | 4 PM | Mercury greatest elongation W (18°) |
| 14th | 10 PM | Neptune 5°N of Moon |
| 16th | 6 AM | Uranus 4°N of Moon |
| 16th | | m.p. 4 Vesta 0.1°N of M95 (SG) in Leo |
| 18th | | m.p. 4 Vesta 0.3°S of M96 (SG) in Leo |
| 19th | | Venus 0.5°SW of IC 4468 (SG) in Libra |
| 20th | | Mercury at greatest latitude North |
| 20th | | Comet 46P/Wirtanen 1°S of NGC 3593 (SG) in Leo |
| 20th | 1 PM | Moon at apogee |
| 20th | 7 PM | Neptune stationary |
| 21st | 3:20 PM | Full Moon |
| 26th | 5 PM | Saturn 3°S of Moon |
| 27th | 5 PM | Mercury 4°N of Spica |
| 29th | | m.p. 20 Massalia 0.6°N of M1 (Neb) in Taurus |
| 29th | 1:28 PM | Last Quarter Moon |
| 30th | 6 AM | Jupiter 4°S of Moon |
| 31st | 8 PM | Venus in inferior conjunction |

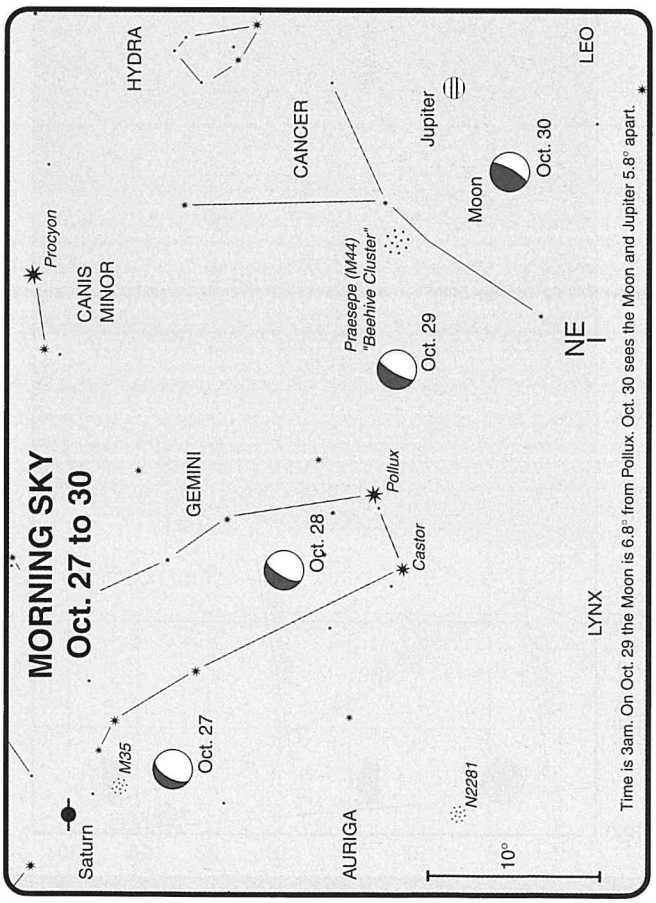


# OCTOBER


N6231
N6281
EVENING SKY - Oct. 8 to 10
SCORPIUS
Moon
Antares
M4
Oct. 10
LUPUS
OPHIUCHUS
Oct. 9
CENTAURUS
SERPENS
LIBRA
Venus
HYDRA
Oct. 8
VIRGO
10°
W
Time is end of twilight. On Oct. 10 the Moon and Antares are 5° apart.

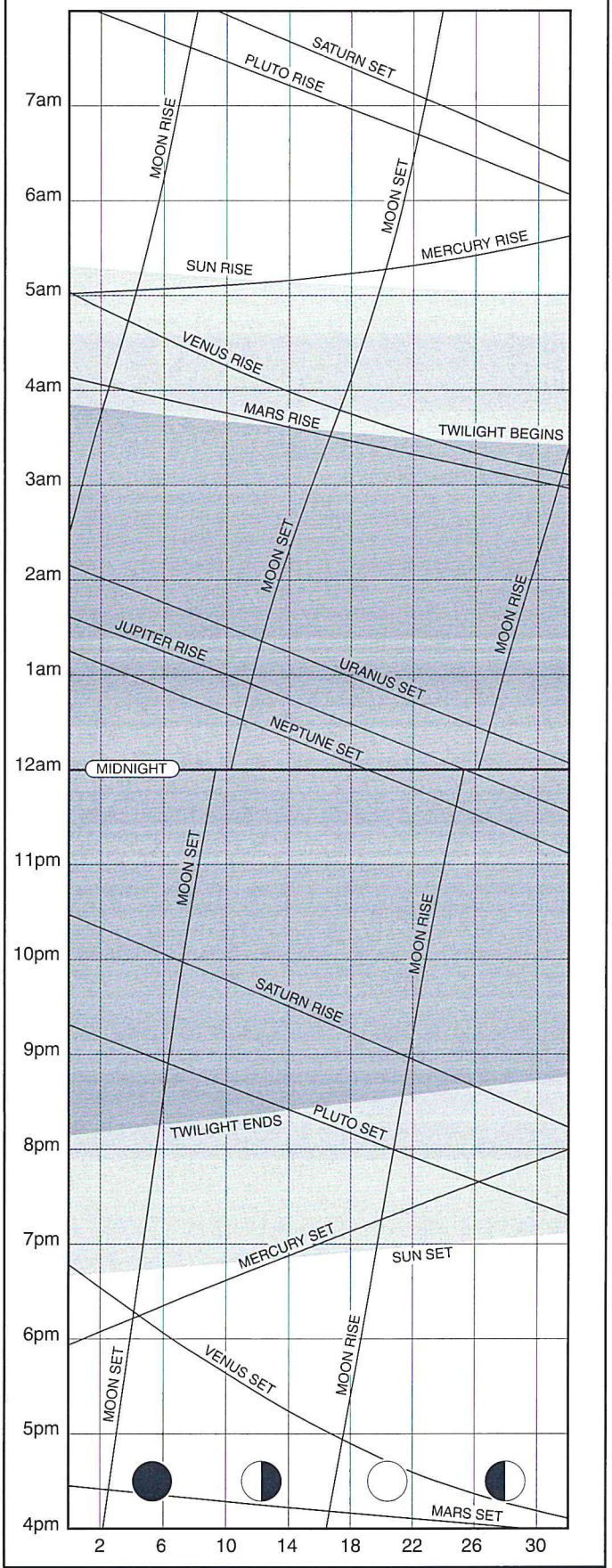

EVENING SKY
Oct. 24 to 26
N2232
MONOCEROS
Pleiades (M45)
"The Seven Sisters"
CANIS
MINOR
(the
Saucepan)
N2244
Betelgeuse
ORION
GEMINI
Saturn
Moon
M35
Oct. 26
Oct. 25
Hyades
Aldebaran
TAURUS
M37
NE
Pleiades
(see insert)
Oct. 24
AURIGA
10°
The time is midnight. On Oct. 24 the Moon is 6.4° from Aldebaran. Oct. 26 sees the Moon and Saturn 5.7° apart.


Achernar
ERIDANUS
TUCANA
EVENING SKY
Mid October
47 Tuc.
Small
Magellanic
Cloud
HOROLOGIUM
HYDRUS
OCTANS
South
Celestial
Pole
RETICULUM
MENSA
Large
Magellanic
Cloud
Tarantula
Neb.
CHAMAELEON
DORADO
PICTOR
Canopus
VOLANS
N2516
10°
CARINA
PUPPIS
S
General Sky View, 9pm. The Magellanic Clouds return to the evening sky. Dark (moonless) skies, away from city lights, are needed to see these companions to the Milky Way.


MORNING SKY
Oct. 27 to 30
HYDRA
LEO
CANCER
Jupiter
Moon
Oct. 30
Procyon
CANIS
MINOR
Praesepe (M44)
"Beehive Cluster"
Oct. 29
NE
GEMINI
Pollux
Oct. 28
Castor
LYNX
M35
Oct. 27
Saturn
N2281
AURIGA
10°
Time is 3am. On Oct. 29 the Moon is 6.8° from Pollux. Oct. 30 sees the Moon and Jupiter 5.8° apart.

# NOVEMBER

## RISE/SET CHART




All times are WAST.

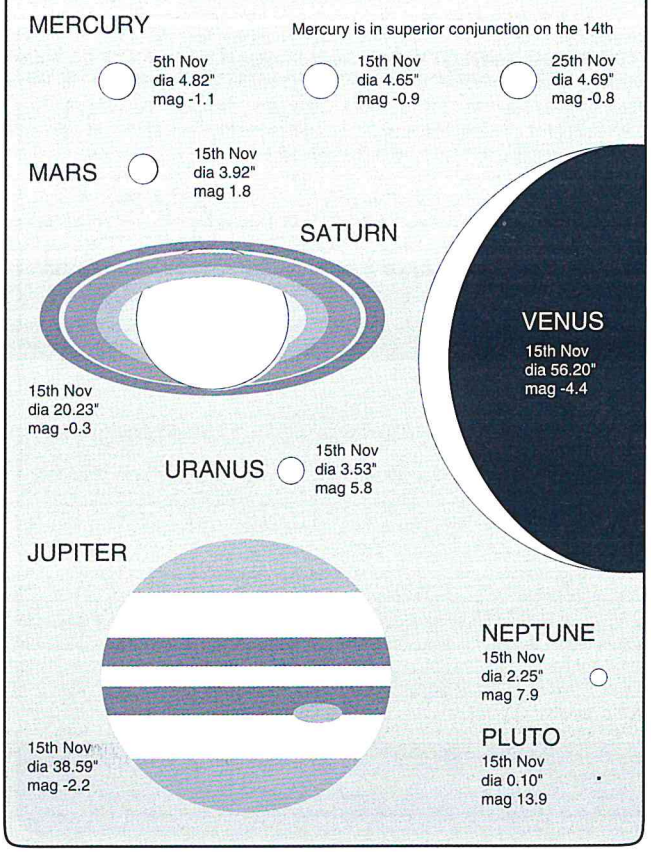
## NOVEMBER HIGHLIGHTS

- Venus returns to the morning sky
- Venus, Spica and Mars form a triangle in the morning sky
- Venus and Mars close

## THE MOON

| | |
|---|---|
| 1st | Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere |
| 3rd | Occultation of minor planet Juno by the Moon, visible from South America |
| 4th | Moon at perigee (closest to Earth – 358,154 km distant, angular size 33.9′) |
| 5th | New Moon |
| 12th | First Quarter |
| 16th | Moon at apogee (furthest from Earth – 405,796 km distant, angular size 29.8′) |
| 20th | Full Moon. Penumbral Lunar Eclipse, not visible from Australia (see p. 8) |
| 27th | Last Quarter |
| 29th | Occultation of minor planet Vesta by the Moon, visible from Western Australia but unfortunately a daylight event. |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 14th, and then moves east of the Sun into the evening sky. At this conjunction the planet is occulted by the Sun's disk (not exactly observable). The next such conjunction/occultation occurs in May 2007.

**VENUS** makes its debut as the Morning Star in November following its inferior conjunction last month. In Virgo for the entire month, Venus rises up toward the 1st magnitude star Spica (Alpha Virginis) and Mars and on the 22nd the trio form a neat triangle (see Sky View). By the 30th, Venus and Mars will be 2.6° apart.

**MARS** has gained sufficient altitude to be easily visible in the morning twilight before sunrise. On the 3rd, the thin lunar crescent appears 4.2° below the planet (see Sky View). After gradually nearing the 1st magnitude star Spica (Alpha Virginis) during the month, Mars will be at its closest at 3° on the 22nd (see Sky View). On the 30th, Mars and Venus will be 2.6° apart.

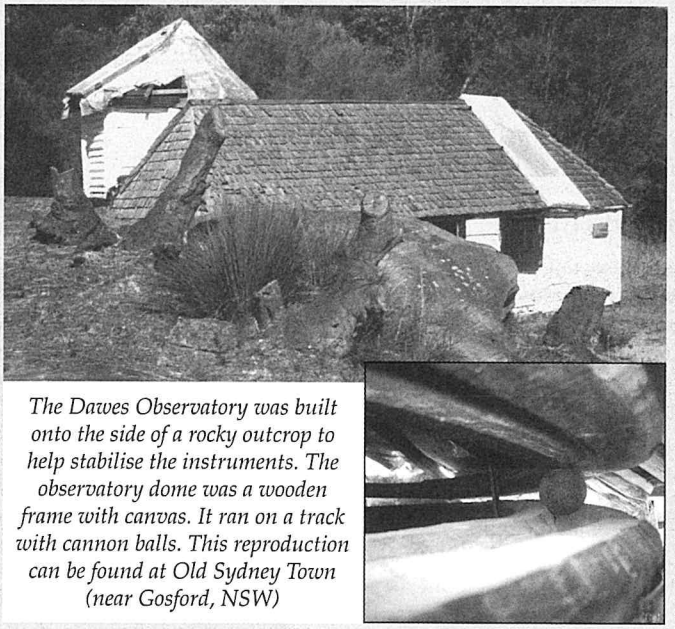
**JUPITER** spends the first half of November in Cancer before crossing over into Leo. The 21-day old waning gibbous Moon appears 6.9° from the planet on the 27th (see Sky View).

**SATURN** rises around 9pm in the eastern evening sky. Since September the planet has been in Orion (near the tip of the hunter's sword), its retrograde motion now swings it back into

## AUSTRALIA'S FIRST OBSERVATORY

A lot of people, when asked what was Australia's first observatory might answer Sydney, Melbourne, Parramatta or even Tebbutt's (at Windsor, NSW). Although the first observatory was on Dawes Point we are not talking about Sydney Observatory. 'Sydney', and the others mentioned above, didn't come along until the 19th century.

In 1788 the First Fleet arrived in Sydney Cove. On board the Sirius, along with Arthur Phillip was a young astronomer, Lieutenant William Dawes. The Board of Longitude, in England, had given Dawes instruments to establish the fledgling colony's observatory. The purpose of the observatory was to measure the longitude of Sydney, to provide a time service for the colony and to service the maritime needs of the fleet. Dawes had also been given the task, by the Government Astronomer at the time, Neville Maskeylene, to try and recover Halley's Comet. This would have been the second recovery of the comet, after Halley successfully predicted its previous return. Dawes looked intensely for the comet during 1788, unfortunately he failed to find it.



*The Dawes Observatory was built onto the side of a rocky outcrop to help stabilise the instruments. The observatory dome was a wooden frame with canvas. It ran on a track with cannon balls. This reproduction can be found at Old Sydney Town (near Gosford, NSW)*

On arrival in Sydney he immediately set out to build the observatory with the aid of convicts and marines. The building was located where the southern pylon of the Harbour Bridge now stands and approximately 500 metres from the current Sydney Observatory. Clearing the land was hard work and the structure was finally completed in August 1788. It was a small building; the lower rectangular section was Dawes' living quarters and study. The upper, octagonal shaped room housed the astronomical and meteorological equipment. The instruments included a sextant, a barometer, thermometers, a telescope and an astronomical quadrant. He later added a homemade hydrometer. Astronomical observations were made through a rectangular canvas shutter.

Dawes was a very talented, versatile and respected individual. As well as his astronomical interests, his duties as a marine officer also placed him in charge of engineering and artillery. He even tried his hand at surveying when it turned out the official surveyor for the colony was not very good at his job. He also had the distinction of being Australia's first (if not official) meteorologist. In 1977 there was a chance discovery of a 182-page book written by Dawes detailing his weather observations. He made 5 to 6 daily recordings of the wind, temperature, rain and barometric pressure as well as his comments.

Dawes was also one of the first, along with Captain Watkin Trench, to attempt a crossing of the Blue Mountains in 1789. They, like many to follow, were driven back by the rugged terrain of cliffs and ravines.

Dawes' original tour of duty was for 3 years. After a while he showed interest in applying for a permanent position as the colony's astronomer. Or at least, if he couldn't stay, he pushed for his instruments to remain in Sydney and for someone else to take up the work. Unfortunately he had a falling out with Governor Phillip.

Phillip's gamekeeper had been killed by some Aborigines. Dawes was ordered by Phillip to join a party to put ten natives to death and return their heads in a bag. Dawes believed the gamekeeper had provoked the attack. The expedition was a failure and on returning to Sydney, Dawes told Phillip he would not obey such an order again. When his application to stay came up for review in 1791, he was told he must apologise to Phillip first. He refused and within a short time he and his instruments were on a ship heading back to England. The observatory was never used again for astronomical observations and quickly fell into disrepair. For a while it was used as a sentry post.

The French explorer, La Perouse, also established a tent observatory in 1788 at Botany Bay. Unfortunately there are no records remaining of any work done there following their loss in a shipwreck.

It would be 30 years before Sir Thomas Brisbane established Australia's next observatory at Parramatta (a western suburb of Sydney).

# NOVEMBER

Taurus, where it remains until May next year. The 17-day old Moon will be 4° from the ringed planet on the 22nd (see Sky View).

**URANUS** and **NEPTUNE** in Capricornus transit the meridian in the early evening.

**PLUTO**, in conjunction in early December, becomes lost in the evening twilight this month, returning to the morning sky in the new year.

**MINOR PLANETS** at opposition this month include 5 Astraea on the 10th at magnitude 10.2 in Cetus and 44 Nysa on the 19th at magnitude 9.4 in Taurus.

## COMETS

**Comet P/1986 A1 (Shoemaker 3)** should first become visible to observers this month as it brightens from 14th to 13th magnitude. Around mid-month, the comet is less than two degrees from the Beehive Cluster (M44) in Cancer, rising around midnight.

**Comet C/2001 HT50 (LINEAR-NEAT)** is a morning object in the constellation of Sextans. Still more than 3 AU from the Sun and Earth, the comet should be around 13th magnitude in brightness.

**Comet 116P/Wild 4** can be found in Virgo in the morning sky, rising before dawn and brightening from 14th to 13th magnitude. Around 8th November, Comet Wild 4 is about 0.2° from 4th magnitude Eta Virginis. Ten days later, the comet is less than 2° from 3rd magnitude Gamma Virginis.

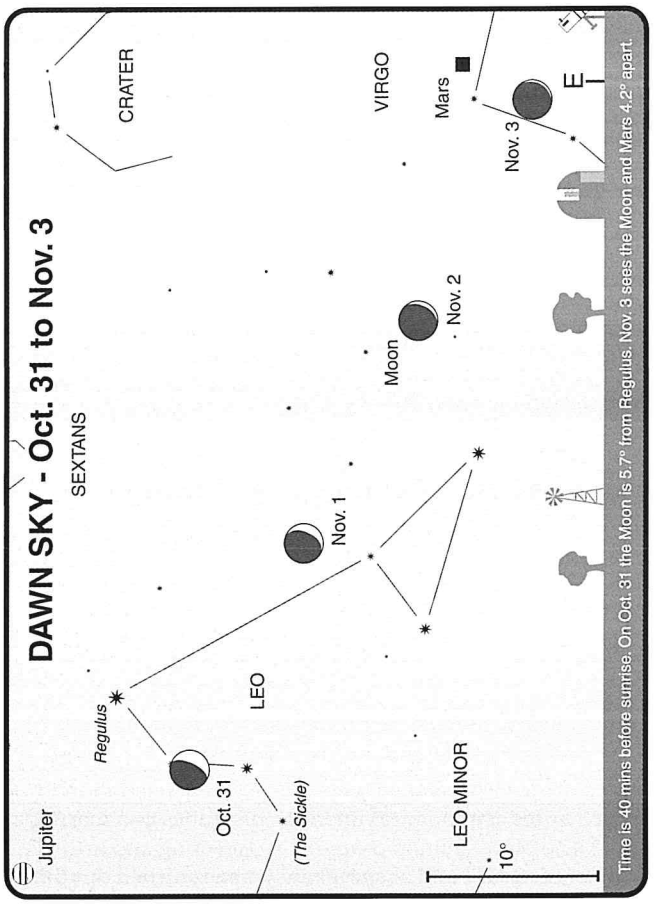
**Comet P/1992 Q1 (Brewington)** is well placed for observation early in the evening, setting around midnight. The 11th magnitude comet spends November residing in Capricornus. Mid-month Brewington is only a few degrees from Neptune.

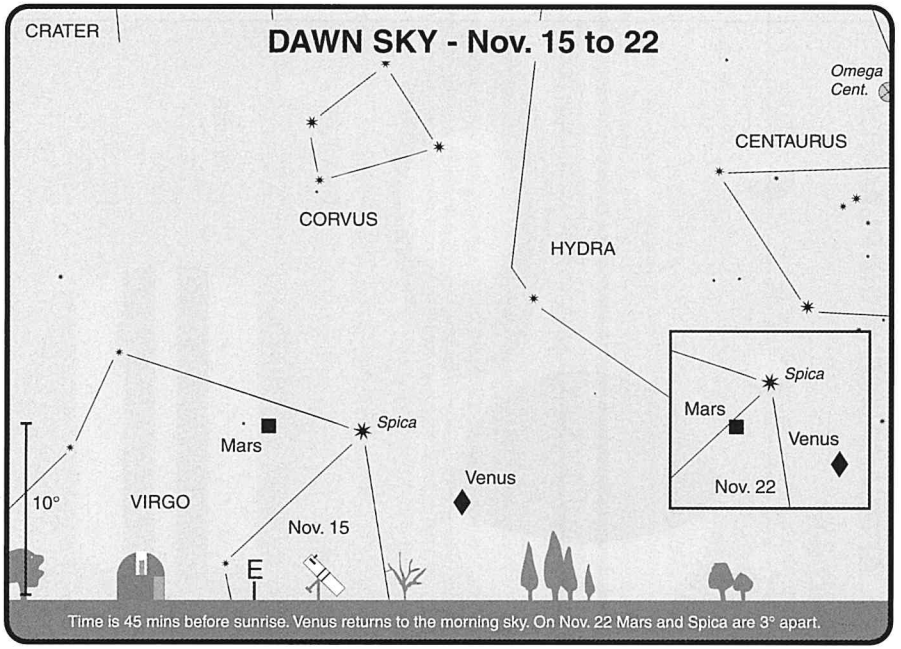
## METEOR SHOWERS

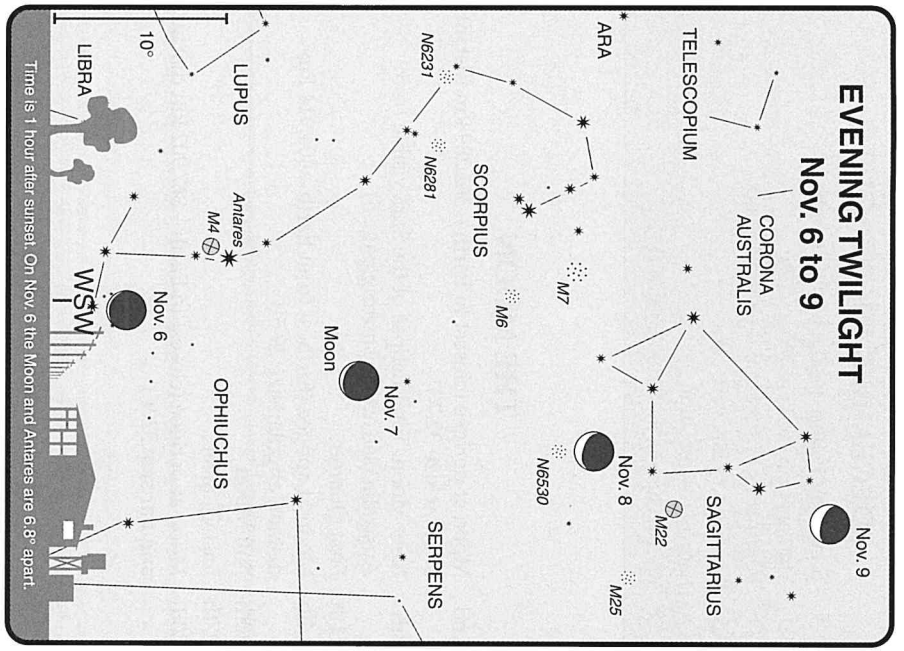
The **Taurids** (**North and South**) are associated with the short period Comet 2P/Encke, and can be seen from late evening to early morning. The shower is composed of a main double radiant, north and south. They are visible from 1st October through to 25th November. The Taurids do not have a well defined sharp peak in activity, but rather plateau for about ten days in early November. Maxima occurs on the 5th November for the Taurids South (Zenith Hourly Rate 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 ZHRs. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs. The International Meteor Organisation recommends the Taurids to newcomers. This allows them to practice their visual meteor plotting techniques, because of their slow speed and steady activity. Their brightness also makes them an ideal target for astrophotography.

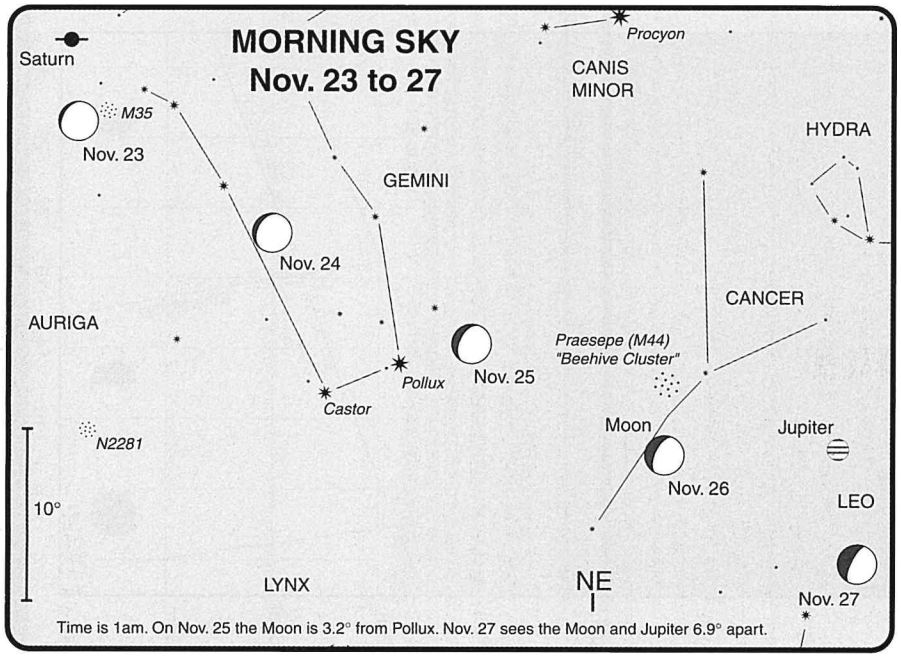
## DIARY

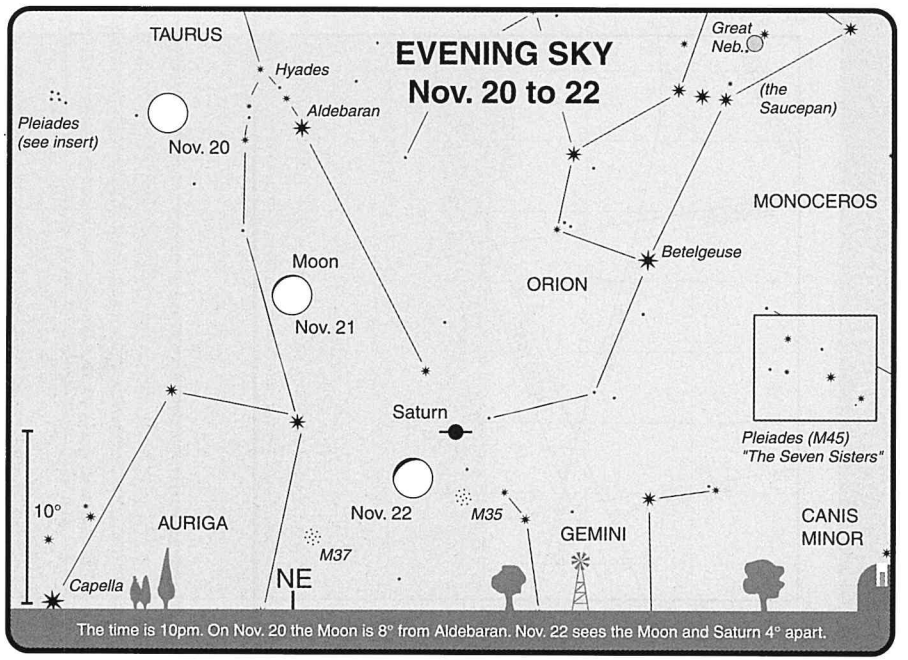
| | | |
|---|---|---|
| 1st | 8 AM | Vesta 1.3°S of Moon; occultation |
| 3rd | 2 AM | Mars 4°S of Moon |
| 3rd | 8 PM | Juno 0.6°N of Moon; occultation |
| 4th | | Mars 0.7°SW of NGC 4691 (SG) in Virgo |
| 4th | 9 AM | Moon at perigee |
| 4th | 8 PM | Uranus stationary |
| 5th | 4:34 AM | New Moon |
| 9th | | m.p. 25 Phocaea 0.3°N of star Theta Aquilae |
| 11th | 6 AM | Neptune 5°N of Moon |
| 11th | | Mars 0.3°SW of NGC 4941 (SG) in Virgo |
| 12th | 4:52 AM | First Quarter Moon |
| 12th | 1 PM | Uranus 5°N of Moon |
| 13th | | Mercury at descending node |
| 14th | 1 PM | Mercury in superior conjunction |
| 15th | | Comet 46P/Wirtanen 0.7°SW of NGC 4365 (EG) in Virgo |
| 15th | | Saturn 0.3°N of Berk 21 (OC) in Orion |
| 16th | 7 PM | Moon at apogee |
| 19th | Noon | Venus stationary |
| 20th | 9:34 AM | Full Moon; penumbral eclipse |
| 20th | 1 PM | Mars 3°N of Spica |
| 22nd | 8 PM | Saturn 3°S of Moon |
| 23rd | | Mercury at aphelion |
| 24th | | Venus at ascending node |
| 24th | | m.p. 6 Hebe 0.7°N of M75 (GC) in Sagittarius |
| 26th | 3 PM | Jupiter 4°S of Moon |
| 27th | 11:46 PM | Last Quarter Moon |
| 29th | 11 AM | Vesta 0.04°N of Moon; occultation |
| 30th | 2 AM | Ceres stationary |




DAWN SKY - Nov. 15 to 22
CRATER
Omega Cent.
CENTAURUS
CORVUS
HYDRA
Spica
Mars
Venus
Nov. 22
Nov. 15
VIRGO
10°
E
Time is 45 mins before sunrise. Venus returns to the morning sky. On Nov. 22 Mars and Spica are 3° apart.

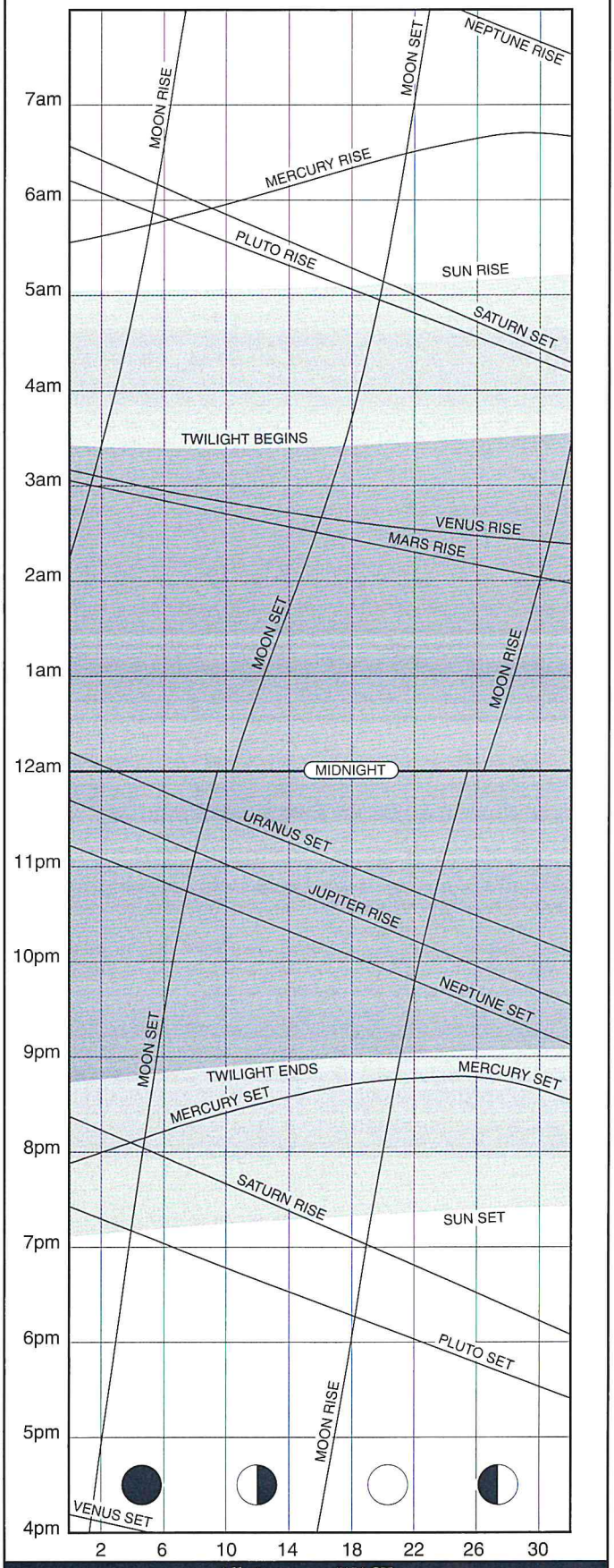

EVENING TWILIGHT
Nov. 6 to 9
LIBRA
LUPUS
N6231
ARA
TELESCOPIUM
CORONA AUSTRALIS
N6281
SCORPIUS
Antares
M4
M7
M6
WSW
Nov. 6
Moon
Nov. 7
OPHIUCHUS
N6530
Nov. 8
M22
SAGITTARIUS
Nov. 9
SERPENS
M25
10°
Time is 1 hour after sunset. On Nov. 6 the Moon and Antares are 6.8° apart.


MORNING SKY
Nov. 23 to 27
Saturn
Procyon
CANIS MINOR
M35
Nov. 23
HYDRA
GEMINI
Nov. 24
AURIGA
CANCER
Praesepe (M44)
"Beehive Cluster"
Pollux
Nov. 25
Castor
N2281
Moon
Jupiter
Nov. 26
LEO
10°
LYNX
NE
Nov. 27
Time is 1am. On Nov. 25 the Moon is 3.2° from Pollux. Nov. 27 sees the Moon and Jupiter 6.9° apart.


EVENING SKY
Nov. 20 to 22
TAURUS
Hyades
Great Neb.
(the Saucepan)
Pleiades
(see insert)
Aldebaran
Nov. 20
MONOCEROS
Betelgeuse
Moon
ORION
Nov. 21
Saturn
Pleiades (M45)
"The Seven Sisters"
10°
Nov. 22
M35
CANIS MINOR
AURIGA
GEMINI
M37
Capella
NE
The time is 10pm. On Nov. 20 the Moon is 8° from Aldebaran. Nov. 22 sees the Moon and Saturn 4° apart.

# DECEMBER

## RISE/SET CHART




All times are WAST.

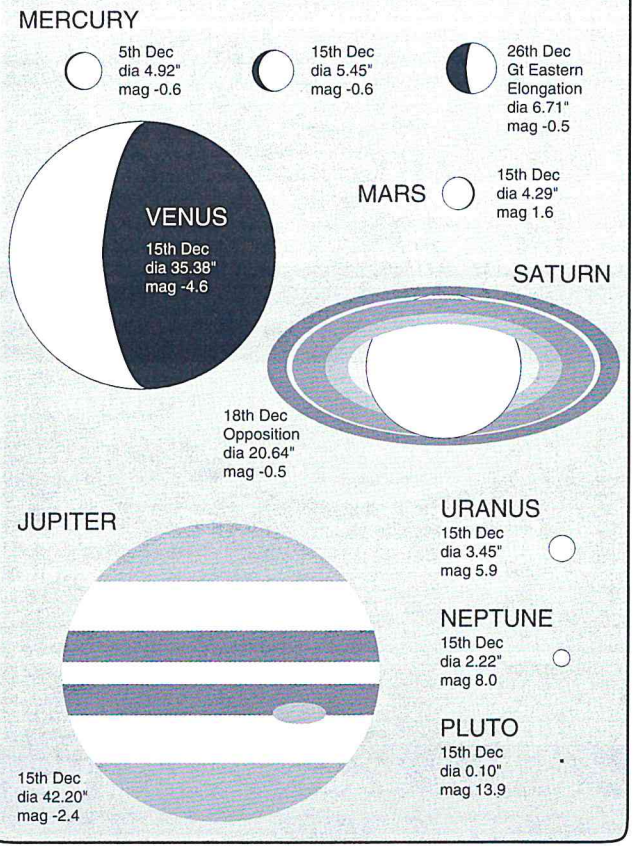
## DECEMBER HIGHLIGHTS

- Total Solar Eclipse visible from Australia
- Mercury and crescent Moon close
- Venus at its brightest in the morning sky
- Venus and Mars very close
- Saturn at opposition
- Saturn close to the Crab Nebula (M1)

## THE MOON

| | |
|---|---|
| 2nd | Moon at perigee (closest to Earth – 362,289 km distant, angular size 32.7′) |
| 4th | New Moon. Total Eclipse of the Sun, visible from Australia (see article starting page 5). |
| 11th | First Quarter |
| 14th | Moon at apogee (furthest from Earth – 404,914 km distant, angular size 29.5′) |
| 20th | Full Moon |
| 27th | Last Quarter |
| 30th | Moon at perigee (closest to Earth – 367,902 km distant, angular size 32.9′) |

## APPEARANCE of the PLANETS



## THE PLANETS

**MERCURY** reaches its greatest elongation east of the Sun (20°) on the 26th. This evening apparition is not a particularly good one, although Mercury will be easily seen in the twilight. On the 5th, the very slender 25-hour old crescent Moon will be 3° above and northwards of the planet. An unobstructed western horizon will be required to view Mercury and the Moon, as they set an hour after the Sun.

**VENUS** rises around 3am in Virgo, moving onto Libra half way through the month. In the first week of December, Venus is at its brightest in the morning sky for the next six months (magnitude –4.7). On the 2nd, the 27-day old crescent Moon is 4.3° from the planet (see Sky View). At month-end the waning crescent Moon again is nearby the planet, on the 30th, at 6.3° separation and on the following evening at 7.3° (see Sky View). Venus and Mars remain within 2° of each other between the 2nd and 14th, closest approach of 1.5° occurs on the 7th (see Sky View).

**EARTH**, at Solstice on the 22nd, marks when the Southern Hemisphere days are longest. On this day at noon, the Sun is at its most southerly position with a declination of -23.5°.

**MARS** is in the morning sky, rising about an hour before the start of dawn. During December it is never more than 4.7° from Venus and begins the month in Virgo and follows the brighter planet into Libra mid-month. These two planets are closest at 1.5° apart on the 7th (see Sky View). The crescent Moon is near Mars twice during the month, on the 2nd at 6.5° apart (see Sky View), and on the 30th at 3.7° separation (see Sky View).

**JUPITER** rises around 10.30pm mid-month. Its trip into Leo last month is short lived when it returns to Cancer on the 15th. On the 23rd, the 19-day old gibbous Moon will be 5° from the planet (see Sky View). Jupiter is at opposition in early February next year, and the period from December through March will provide the best evening viewing of this the largest of the planets.

**SATURN** reaches opposition this month on the 18th, visible the whole night. The warm summer evenings are an ideal time to observe this most exquisite planet at its brightest and largest this year. Overall the planet's size has increased by 25% since conjunction. The distance along the length of the rings is 47 arc seconds, and the minor axis is at its widest at 21 arc seconds, slightly broader than Saturn's polar diameter. The Full Moon appears 3.6° from the planet on the 19th (see Sky View). During the month Saturn moves directly toward the Crab Nebula. First in Messier's catalogue, the Crab Nebula or M1 is the remnant of the supernova of 1054AD. This is the second such approach this year, the other in July, occurred in the cold early morning hours. By the 31st the planet will be less than 0.4° from M1, and on the 5th January 2003 the pair are closest at just 0.03°. At this time M1 will be a little closer to the planet than Saturn's moon Titan!

**URANUS** and **NEPTUNE** are both moving toward solar conjunction early next year, and this month is the last chance to sight the pair in the evening sky.

**PLUTO**, at conjunction on the 10th, returns to the morning sky in the new year.

**MINOR PLANETS** at opposition this month include 20 Massalia on the 10th at magnitude 8.7 in Taurus and 349 Dembowska on the 1st at magnitude 9.7 in Taurus. 4 Vesta visits the Virgo cluster of galaxies in December and January.

## WHY IS THE SKY BLUE?

This is a fascinating question that children love to ask their parents. The then supposed, all seeing, all knowing grown-ups realise they have been shot down in flames. They have no idea why! There are a few legends around such as the sky reflects the colour of the ocean. This doesn't work very well because the sky is just as blue even if you are in a desert thousands of miles from the nearest ocean. Anyway, why should the ocean be blue in the first place when the water, like the air is clear? (a future topic?). Not only is the sky blue but the Sun, which from space looks white, is slightly yellow when viewed from the ground. CAUTION never look directly at the Sun.

Anyone who has ever looked at a rainbow, or played with a prism, will know that light is made up of a continuous spectrum i.e., violet then blue, green, yellow, orange and red. The closer to the blue end the shorter the wavelength of the light. The oxygen and nitrogen molecules in the atmosphere (which make up 99% of the air) will readily scatter the higher energy, higher frequency, short wavelength blue end of the spectrum, in all directions. That is why when you look at part of the sky, away from the Sun, you see the light as blue. These bundles of energy before finally ending their existence in your eyes have been through a somewhat tortured, convoluted path through the atmosphere. The effect of this scattering is accentuated when the Sun is low in the sky, such as at sunrise or sunset. The sunlight needs to travel through a much thicker atmosphere and the air molecules and dust particles now scatter nearly all the light leaving only the longest wavelength light to make the direct trip, making the Sun look red.

This atmospheric effect can be simulated by a simple experiment. All you need is an aquarium, a torch, a card with a hole and some milk. Add a few drops of milk to the water and shine the torch through the card and into the tank. Please ensure the tank contains only water, we are not sure how well fish would like a change to a milk diet! As an alternative you could use a glass casserole dish or similar. Position the light so that it shines through the length of the tank. The milk particles will simulate the effect of the air molecules in the atmosphere. The more drops of milk the more yellow, yellow/red and finally red will the direct light appear. Looking in the tank from the sides, at the scattered light, you may see a blue tinge.

Why is Mars different? It is true that the blue sky effect would apply to any planet that has a clear atmosphere of roughly Earth's size and density. However, as NASA's Mars Pathfinder and Viking landers showed, the sky on Mars is a strange mixture of pink, orange and gray. This is because the light scattering is not dominated by air (which for Mars is carbon dioxide). The atmosphere on Mars is very thin and the scattering is mainly caused by suspended dust particles, which are reddened by iron oxide. A similar effect is seen on Earth when we see the brilliant red sunsets when there has been a volcanic eruption or a local bush fire. In this case, the level of dust particles in the air is much higher than normal.

# DECEMBER

## COMETS

**Comet P/1986 A1 (Shoemaker 3)** reaches perihelion on 15th December at 1.8 AU from the Sun. The 13th magnitude comet is visible for most of the night, rising late in the evening. During the first half of December, Comet Shoemaker 3 is only a few degrees away from the planet Jupiter. By mid-month, the comet has moved from the constellation of Cancer into neighbouring Leo.

**Comet C/2001 HT50 (LINEAR-NEAT)** should brighten from 13th to 12th magnitude this month. Moving from Sextans into Hydra, the comet is now rising before midnight. Around mid-December, LINEAR-NEAT is less than three degrees from 2nd magnitude Alpha Hydrae. The comet reaches perihelion in July of 2003.

**Comet 116P/Wild** 4 reaches perihelion next month at 2.2 AU from the Sun, and should be around 13th magnitude for all of this month, though it is still a morning object. Around mid-December, Comet Wild 4 is about three degrees from 1st magnitude Spica (Alpha Virginis).

**Comet P/1992 Q1 (Brewington)** brightens from 11th to 10th magnitude this month as it approaches perihelion in February 2003. Visible only in the evening sky, the comet is less than 3 degrees from 4th magnitude Iota Capricorni in early December. Around the middle of the month, Brewington is less than 4 degrees from Uranus. By month's end, the comet has moved from Capricornus into Aquarius and is less than two degrees from 4th magnitude Theta Aquarii.

## METEOR SHOWERS

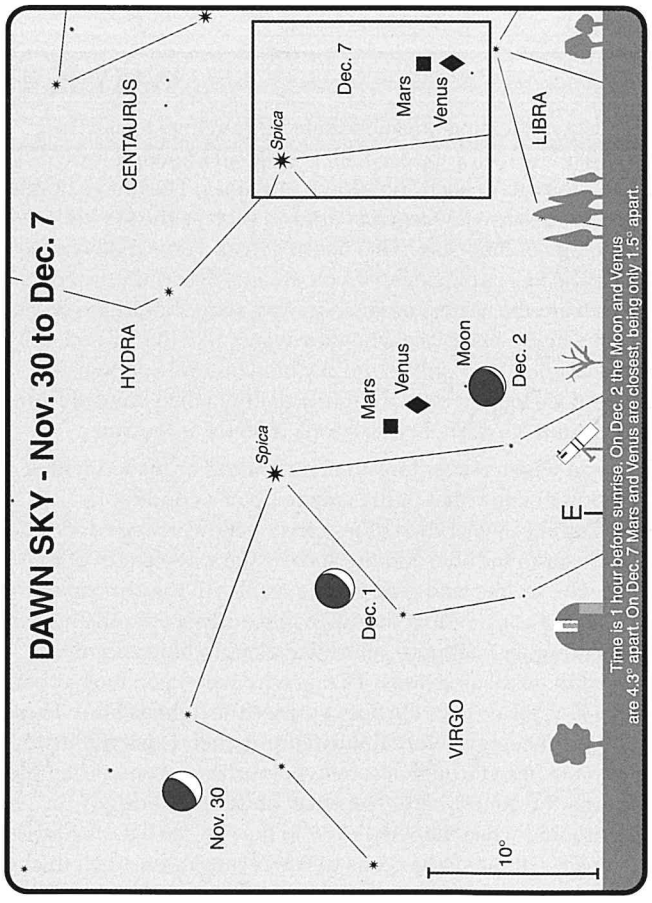
The **chi-Orionids** are active from 26th November through to 15th December. Their peak is on December 2nd, with a low zenith hourly rate of 3. While generally a weak stream visually, a number of bright meteors have been recorded.

The **Phoenicids** 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.

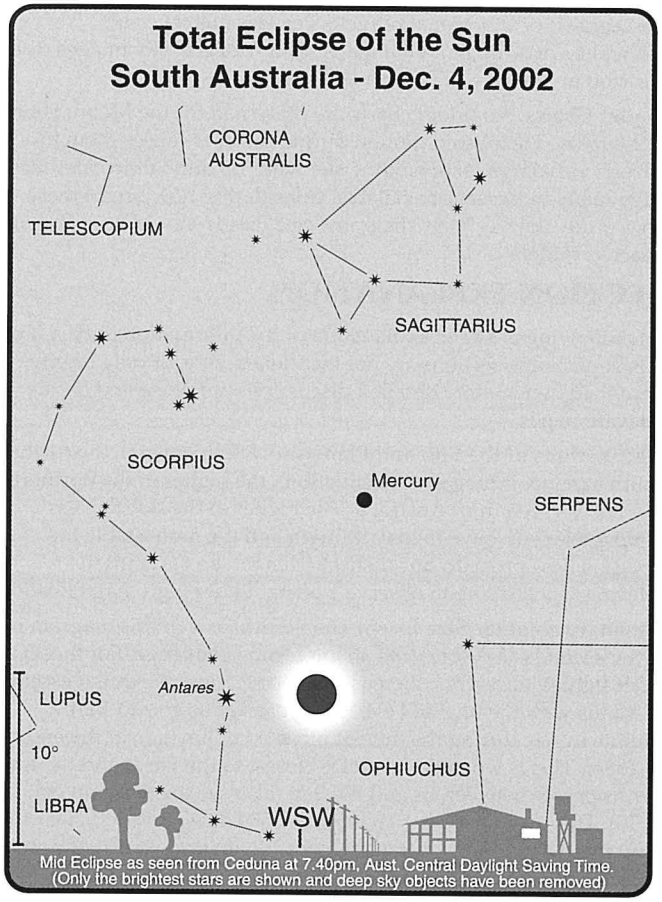
The **Geminids** are one of the best annual showers observable, but for southern observers the radiant is below or close to the horizon until after midnight. Visible from the 7th to 17th, with maximum on the 14th, the Geminids produce often bright, medium speed meteors. The zenith hourly rate is variable but around 110 is normal, and worth watching for in the morning hours, even though our northern counterparts will see the best of the Geminids.

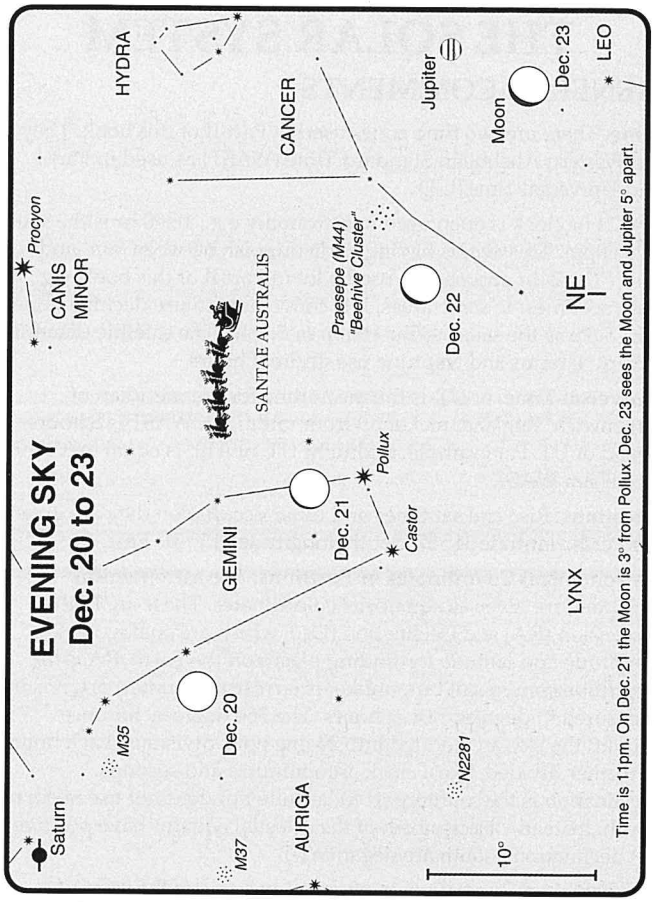
## DIARY

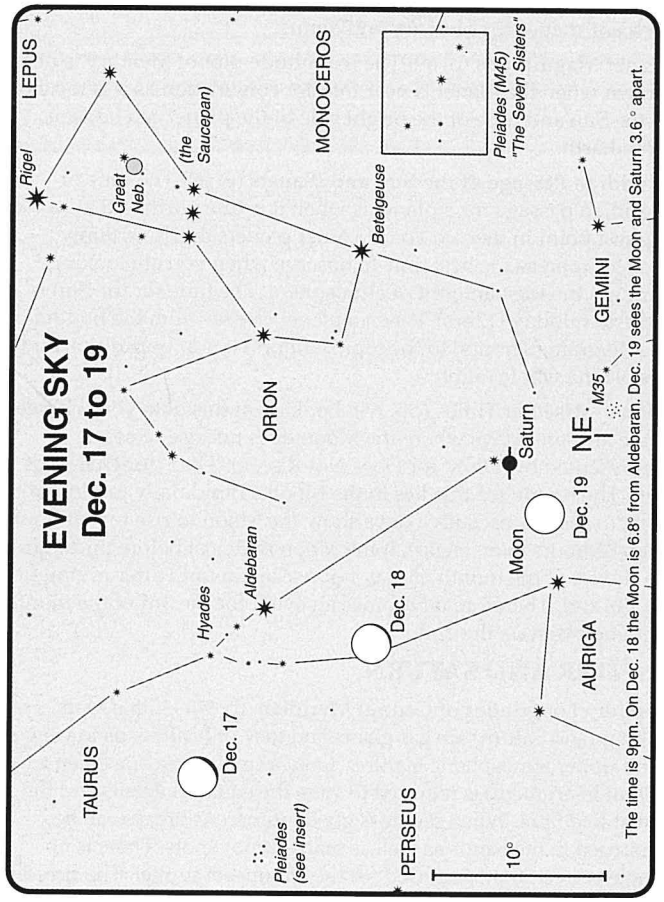
| | | |
|---|---|---|
| 1st | 6 PM | Mars 3°S of Moon |
| 1st | 9 PM | Venus 2°S of Moon |
| 2nd | 5 PM | Moon at perigee |
| 4th | 3:34 PM | New Moon; eclipse |
| 4th | 8 PM | m.p. 1 Ceres 0.5°W of NGC 157 (SG) in Cetus |
| 5th | 5 AM | Jupiter stationary |
| 7th | | Comet 22P/Kopff 0.1°N of M21 (OC) in Sagittarius |
| 7th | 9 AM | Venus greatest brilliancy |
| 8th | 4 PM | Neptune 5°N of Moon |
| 9th | 10 PM | Uranus 5°N of Moon |
| 10th | 1 AM | Pluto in conjunction with Sun |
| 10th | | Mercury 0.3°NE of NGC 6553 (GC) in Sagittarius |
| 11th | 11:49 PM | First Quarter Moon |
| 12th | | Mercury 0.7°S of M28 (GC) in Sagittarius |
| 13th | | Mercury at greatest latitude South |
| 13th | | Mercury 0.1°W of NGC 6638 (GC) in Sagittarius |
| 14th | Noon | Moon at apogee |
| 14th | 7 PM | m.p. 25 Phocaea 0.1°W of M2 (GC) in Aquarius |
| 18th | 1 AM | Saturn at opposition |
| 19th | 1 AM | Venus 0.1°N of m.p. 9 Metis |
| 19th | 11 PM | Saturn 3°S of Moon |
| 20th | 3:10 AM | Full Moon |
| 21st | | m.p. 4 Vesta 0.1°S of M61 (SG) in Virgo |
| 22nd | 9 AM | Solstice |
| 23rd | 8 PM | Jupiter 4°S of Moon |
| 25th | | Mars 0.4°N of star Alpha 2 Librae |
| 25th | | Venus 0.4°NE of NGC 5803 (SG) in Libra |
| 26th | | m.p. 2 Pallas 0.8°N of star Beta Aquarii |
| 26th | 1 PM | Mercury greatest elongation E (20°) |
| 27th | | m.p. 4 Vesta 0.4°N of NGC 4457 (SG) in Virgo |
| 27th | 8:31 AM | Last Quarter Moon |
| 28th | 7 PM | m.p. 25 Phocaea 0.2°N of star Alpha Aquarii |
| 29th | | m.p. 4 Vesta 0.1°SW of NGC 4496A (SG) in Virgo |
| 29th | | Venus 0.4°E of NGC 5883 (SG) in Libra |
| 30th | 9 AM | Mars 1.2°S of Moon; occultation |
| 30th | 9 AM | Moon at perigee |
| 30th | 5 PM | Venus 2°N of Moon |

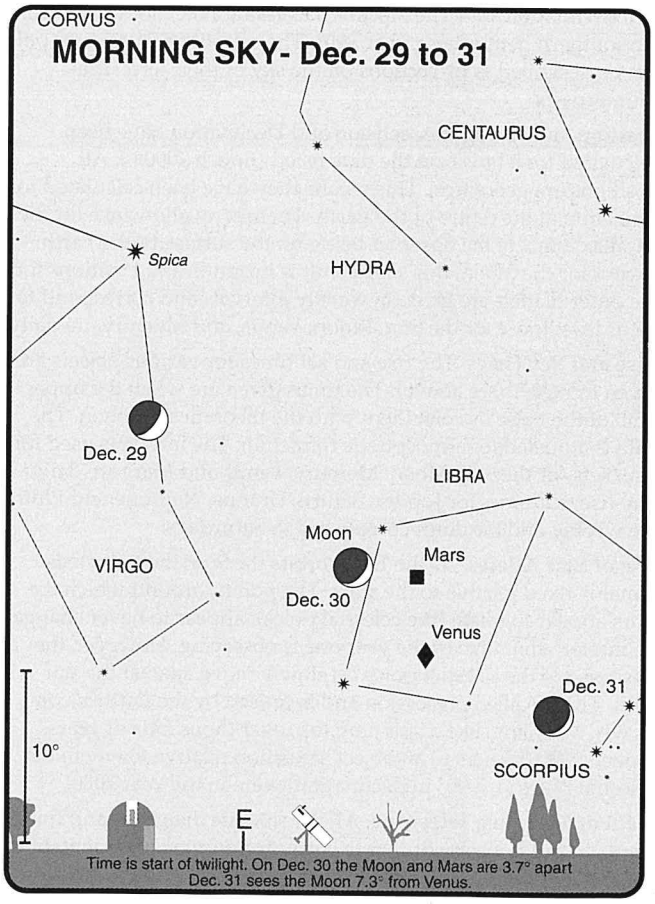


# DECEMBER


Total Eclipse of the Sun
South Australia - Dec. 4, 2002
CORONA AUSTRALIS
TELESCOPIUM
SAGITTARIUS
SCORPIUS
Mercury
SERPENS
LUPUS
Antares
10°
LIBRA
OPHIUCHUS
WSW
Mid Eclipse as seen from Ceduna at 7.40pm, Aust. Central Daylight Saving Time.
(Only the brightest stars are shown and deep sky objects have been removed)


EVENING SKY
Dec. 20 to 23
HYDRA
CANCER
Jupiter
Moon
Dec. 23
LEO
Procyon
CANIS MINOR
SANTAE AUSTRALIS
Praesepe (M44)
"Beehive Cluster"
Dec. 22
NE
Pollux
Castor
GEMINI
Dec. 21
LYNX
M35
Dec. 20
N2281
Saturn
AURIGA
M37
10°
Time is 11pm. On Dec. 21 the Moon is 3° from Pollux. Dec. 23 sees the Moon and Jupiter 5° apart.


EVENING SKY
Dec. 17 to 19
LEPUS
Rigel
Great Neb.
(the Saucepan)
MONOCEROS
Pleiades (M45)
"The Seven Sisters"
Betelgeuse
GEMINI
ORION
Saturn
NE
M35
Hyades
Aldebaran
Moon
Dec. 19
Dec. 18
AURIGA
TAURUS
Dec. 17
Pleiades
(see insert)
PERSEUS
10°
The time is 9pm. On Dec. 18 the Moon is 6.8° from Aldebaran. Dec. 19 sees the Moon and Saturn 3.6 ° apart.


CORVUS
MORNING SKY- Dec. 29 to 31
CENTAURUS
Spica
HYDRA
Dec. 29
LIBRA
Moon
Mars
VIRGO
Dec. 30
Venus
Dec. 31
10°
SCORPIUS
E
Time is start of twilight. On Dec. 30 the Moon and Mars are 3.7° apart
Dec. 31 sees the Moon 7.3° from Venus.

# PART II

# THE SOLAR SYSTEM

## GENERAL COMMENTS

**Time**. There are two time zones used in Part II of this book. They are Western Australian Standard Time (WAST) as used in Part I and Universal Time (UT).

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 used a lot 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.

**Universal Time**, or UT, is the mean time for the meridian of Greenwich, England, reckoned from midnight. WAST is 8 hours ahead of UT. For example, midnight UT, or 0 hr, is equal to 8:00hr or 8:00am WAST.

**Locations**. Rise and set times and lunar occultation data are given for Perth: latitude 31° 57′ South, longitude 115° 51′ East.

**Astronomical Co-ordinates or Positions**. The astronomical positions are given as equatorial co-ordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude for finding places on the 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 are negative (-).

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°. 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**. The rise and set times for various objects are given in WAST (see above). The times 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 for the Sun, Moon, Mercury, Venus and Mars are daily. The rise/set times for Jupiter, Saturn, Uranus, Neptune and Pluto are weekly and the dates correspond to Saturdays.

**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.

**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 reflecting surfaces will mirror (or 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, Venus or Mercury. 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.

## SECTION EXPLANATION

The following is a brief explanation of the information in Part II of this book. Some sections are not mentioned here, or only briefly described, when more detailed discussions are presented on the relevant pages.

**Declinations of the Sun and Planets** (p. 68) In general, the further south a planet is (negative declination), the higher in the northern sky it is, as seen from 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.

**Planetary Angular Size** (p. 68) The vertical axis of this diagram is in arc seconds. 2002 presents an interesting challenge. For those keen sighted observers, there is a chance to view the thin crescent of Venus with the unaided eye. This year Venus gets to 1 arc minute in size during the time of inferior conjunction at the end of October. This is when the planet is closest to the Earth and the time Venus passes between us and the Sun (also see the diagram on p. 15). This event happens about every 580 days. It is only near this time that Venus shows a thin crescent. No matter what size Venus presents it is certainly worthwhile trying to observe it using binoculars (it helps to keep the binoculars steady by using a tripod). Looking during twilight can often help. There is less glare and the planet is higher in the sky. See Part I for the expected crescent shapes for Mercury and Venus.

**Planet Magnitudes** (p. 69) The magnitude plot of Mercury is not shown when the planet is near inferior conjunction as it is too close to the Sun and little of the bright side of the planet can be seen from Earth.

**Meridian Passage of the Sun and Planets** (p. 69) 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.

**Moon - Rise/Set Times** (pp. 75). Looking at this data you will see there are some days where the Moon does not rise or set (represented by 'DNR' for Does Not Rise, or 'DNS' for Does Not Set). 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.

### JUPITER AND SATURN

**Jupiter - Longitudes of Central Meridian**. (p. 90) Unlike Mars, Jupiter (and Saturn) are gas giants and they only allow us to view their upper atmospheric features. Only a small telescope (even a 50mm 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 Longitude of Central Meridian tables. All the times on the main tables are calculated for 0hrs UT (8:00am WAST) of date. You will need to add multiple hours and minutes from the small 'Increase in Longitude' tables. For example the longitude of central meridian for Jupiter (system I) for November 1 at 12:20am WAST would be calculated as follows. First subtract 8 hours to convert to UT i.e., 16:20 hrs on October 31. From the table, the longitude on October 31 is 192.4°. To this add an adjustment for the 16 hours, which is 225.3°, and finally for the 20 mins add 12.2°. These add up to 429.9°; less 360° gives a final answer of 69.9°.

**Jupiter's Moons** (pp. 84-89). Jupiter is like a miniature solar system with many moons orbiting the planet. Also, like the planets, these moons all lie in a similar plane. This plane is also very close to that of the Earth's orbit. Therefore, as seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing across (transiting) or behind (occulted by) the planet. The diagrams (pp. 87-89) 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 date line represents midnight WAST (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. 85-86). The same can be done with the occultation times, that is when the line disappears behind Jupiter.

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 26. 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.

**Eclipse Positions of Jupiter's Moons** (bottom of p. 84) 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.

**Jupiter's Moons - Mutual Events** (p. 86). It has already been stated above that the plane of Jupiter's moons is close to that of the Earth's orbit. About every 6 years the two planes cross and for a brief period we can see the moons eclipse and occult each other. The drop in brightness does not just depend on the relative magnitudes of the satellites. It also varies depending on whether the event is complete e.g., how much of the shadow (eclipse) or the moon (occultation) covers the other moon during an event.

## URANUS, NEPTUNE AND PLUTO

**Uranus and Neptune** (p. 94). These planets should be easily visible through binoculars. The finder charts will help identify the planets from nearby stars. Under dark skies, most of the stars shown here will be visible through binoculars. It is important to let your eyes adapt to the darkness.

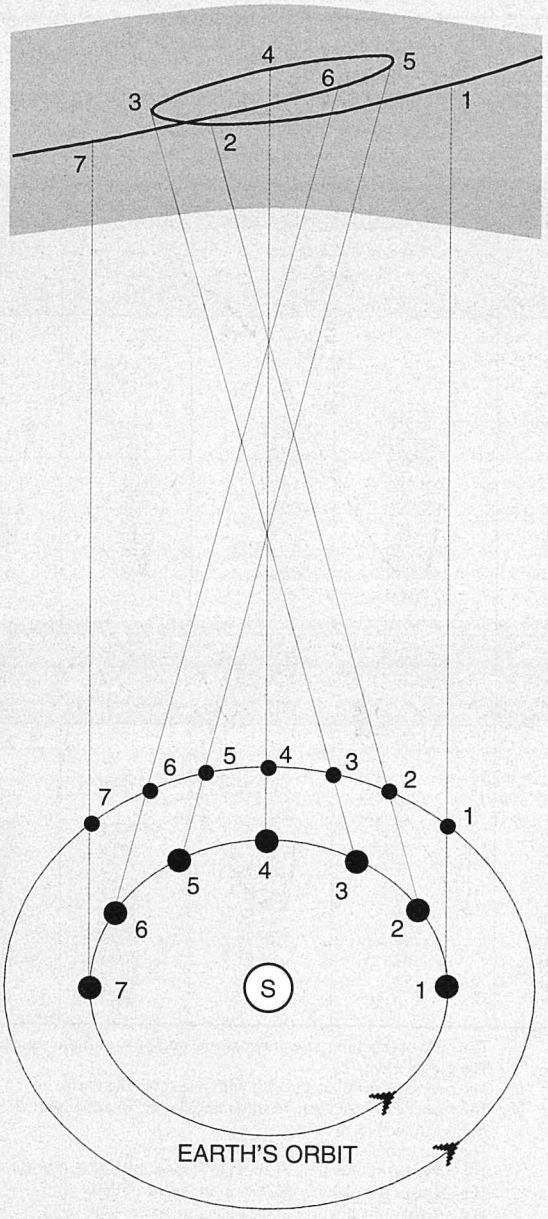
**Pluto** (pp. 94-95). The pointer chart is designed to help people find the general area for Pluto. The main finder chart shows stars down to approximately magnitude 14.5. This is necessary to pick out the faint star-like image of Pluto (magnitude 13.7) from other numerous faint stars in the field. Commonly available star atlases do not include stars down to anywhere near this magnitude.

## 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 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.

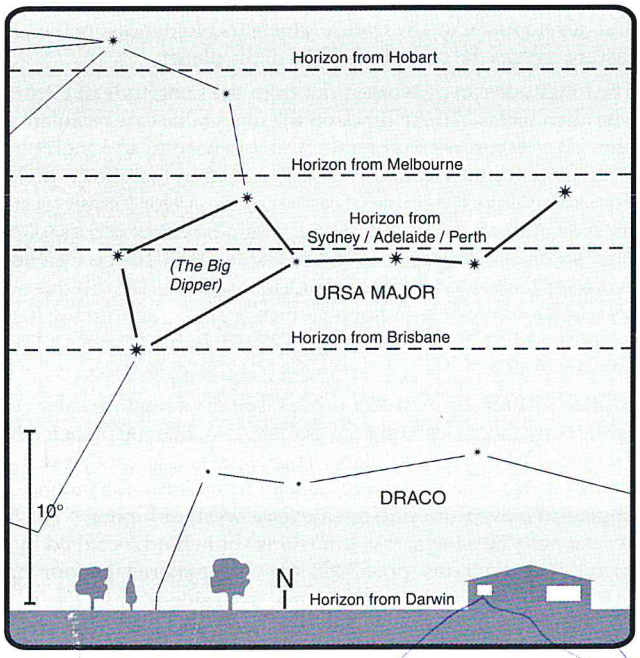
In the diagram, the shaded area represents the path of an outer planet against the celestial sphere. As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet moves 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.



# EFFECT OF LATITUDE

The Sky Views (see the monthly sections) have been drawn for a latitude of approximately 32° 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 one goes north the more stars we 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 say 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 (right) is drawn to the same scale as a Sky View.




## SOLAR SYSTEM DATA — 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 | 28 [15] | 1898.8 | 317.900 |
| Saturn | 1425983 | 9.540 | 0.67 | 120536 | 0.097962 | 30 [15] | 568.50 | 95.200 |
| Uranus | 2867760 | 19.180 | 5.52 | 51118 | 0.022927 | 20 [15] | 86.625 | 14.500 |
| Neptune | 4492800 | 30.700 | 7.84 | 49528 | 0.017081 | 8 | 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' |

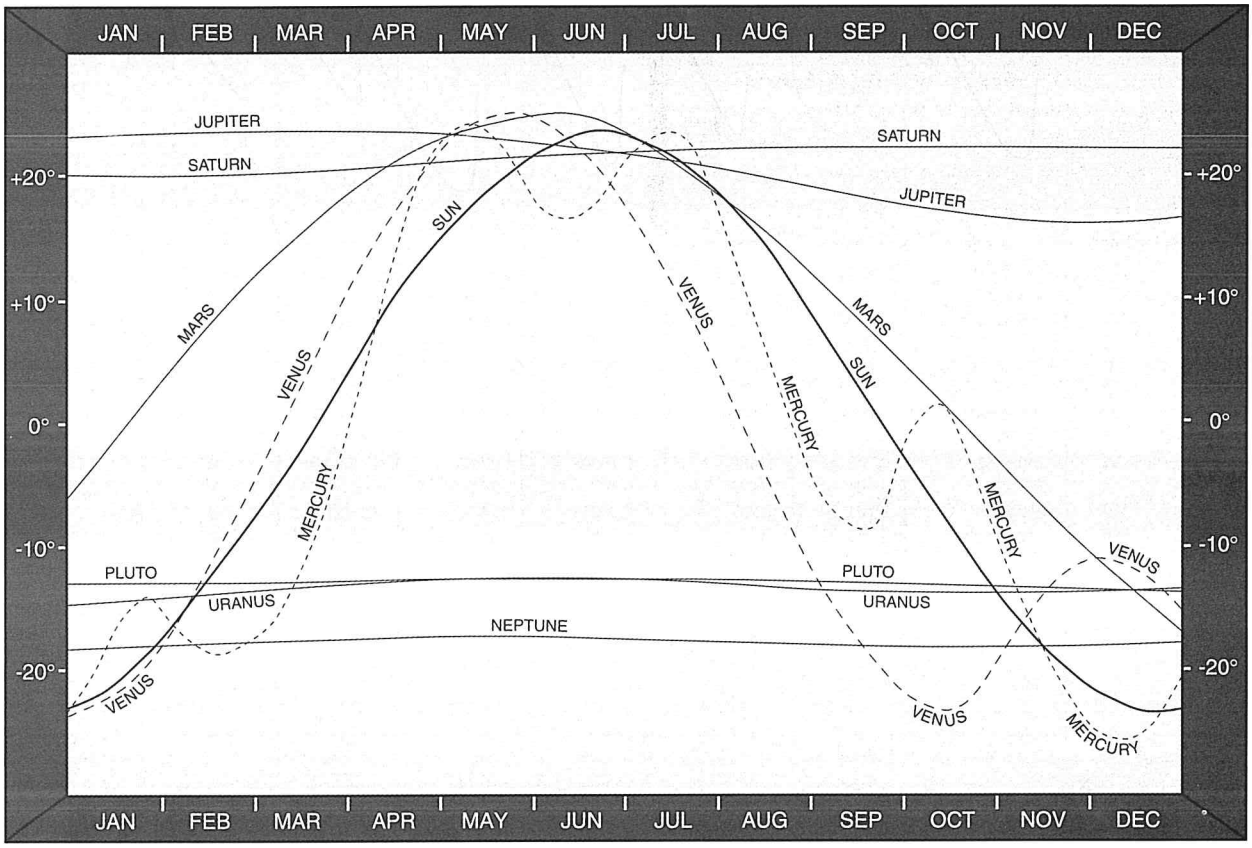
Notes:
1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the North pole.
5 The ratio of the sunlight 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.
15 There have been a number of recent discoveries with new satellites not yet named or their orbits fully determined.

# SOLAR SYSTEM DATA — SATELLITES

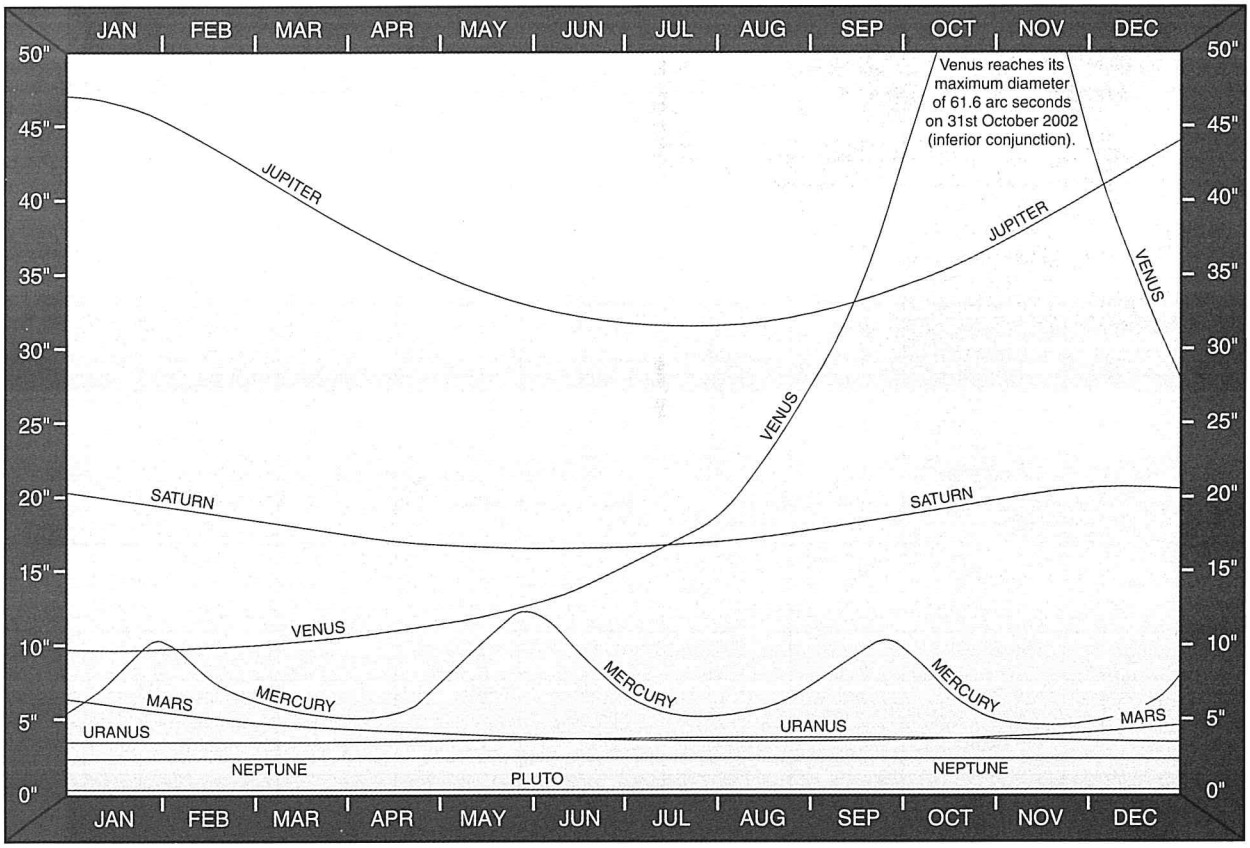
| PLANET / SATELLITE | | ORBITAL [1] PERIOD (days) (R=retrograde) | MAX. ELONG AT MEAN OPPOSITION | SEMIMAJOR AXIS ($x10^3$ km) | ORBITAL ECCENTRICITY | INCLINATION TO PLANET'S EQUATOR (°) | MASS (1/PLANET) | RADIUS (km) | SIDEREAL PERIOD OF ROTATION (days) | MAGNITUDE AT OPPOSITION |
|---|---|---|---|---|---|---|---|---|---|---|
| Earth | | | | | | | | | | |
| Moon | | 27.321661 | | 384.400 | 0.054900489 | 18.28-28.58 | 0.01230002 | 1737.4 | S | -12.74 |
| Mars | | | | | | | | | | |
| Phobos | I | 0.31891023 | 25" | 9.378 | 0.015 | 1.0 | $1.65x10^{-8}$ | 13.4x11.2x9.2 | S | 11.3 |
| Deimos | II | 1.2624407 | 1' 02" | 23.459 | 0.0005 | 0.9-2.7 | $3.71x10^{-9}$ | 7.5x6.1x5.2 | S | 12.40 |
| Jupiter | | | | | | | | | | |
| Metis | XVI | 0.294780 | 0' 42" | 128 | | | $0.5x10^{-10}$ | 20 | S | 17.5 |
| Adrastea | XV | 0.29826 | 0' 42" | 129 | | | $0.1x10^{-10}$ | 13x10x8 | S | 19.1 |
| Amalthea | V | 0.49817905 | 0' 59" | 181 | 0.003 | 0.40 | $38x10^{-10}$ | 131x73x67 | S | 14.1 |
| Thebe | XIV | 0.6745 | 1' 13" | 222 | 0.015 | 0.8 | $4x10^{-10}$ | 55x45 | S | 15.7 |
| Io | I | 1.769137786 | 2' 18" | 422 | 0.004 | 0.04 | $4.70x10^{-5}$ | 1830x1819x1815 | S | 5.02 |
| Europa | II | 3.551181041 | 3' 40" | 671 | 0.009 | 0.47 | $2.53x10^{-5}$ | 1565 | S | 5.29 |
| Ganymede | III | 7.15455296 | 5' 51" | 1070 | 0.002 | 0.21 | $7.80x10^{-5}$ | 2634 | S | 4.61 |
| Callisto | IV | 16.6890184 | 10' 18" | 1883 | 0.007 | 0.51 | $5.67x10^{-5}$ | 2403 | S | 5.65 |
| Leda | XIII | 238.72 | 1° 00' 39" | 11094 | 0.14762 | 26.07 | $0.03x10^{-10}$ | 5 | | 20.2 |
| Himalia | VI | 250.5662 | 1° 02' 46" | 11480 | 0.15798 | 27.63 | $50x10^{-10}$ | 85 | 0.4 | 14.84 |
| Lysithea | X | 259.22 | 1° 04' 04" | 11720 | 0.107 | 29.02 | $0.4x10^{-10}$ | 12 | 0.533 | 18.4 |
| Elara | VII | 259.6528 | 1° 04' 10" | 11737 | 0.20719 | 24.77 | $4x10^{-10}$ | 40 | | 16.77 |
| Ananke | XII | 631. R | 1° 55' 52" | 21200 | 0.16870 | 147 | $0.2x10^{-10}$ | 10 | 0.35 | 18.9 |
| Carme | XI | 692. R | 2° 03' 31" | 22600 | 0.20678 | 164 | $0.5x10^{-10}$ | 15 | 0.433 | 18.0 |
| Pasiphae | VIII | 735. R | 2° 08' 26" | 23500 | 0.378 | 145 | $1x10^{-10}$ | 18 | | 17.03 |
| Sinope | IX | 758. R | 2° 09' 31" | 23700 | 0.275 | 153 | $0.4x10^{-10}$ | 14 | 0.548 | 18.3 |
| Saturn | | | | | | | | | | |
| Pan | XVIII | 0.5750 | 0' 21" | 133.583 | | | | 10 | | |
| Atlas | XV | 0.6019 | 0' 22" | 137.670 | 0.000 | 0.3 | | 18.5x17.2x13.5 | | 18 |
| Prometheus | XVI | 0.6130 | 0' 23" | 139.353 | 0.003 | 0.0 | | 74x50x34 | | 16 |
| Pandora | XVII | 0.6285 | 0' 23" | 141.700 | 0.004 | 0.0 | | 55x44x31 | | 16 |
| Epimetheus | XI | 0.6942 | 0' 24" | 151.422 | 0.009 | 0.34 | $9.5x10^{-10}$ | 69x55x55 | S | 15 |
| Janus | X | 0.6945 | 0' 24" | 151.472 | 0.007 | 0.14 | $3.38x10^{-9}$ | 97x95x77 | S | 14 |
| Mimas | I | 0.942421813 | 0' 30" | 185.52 | 0.0202 | 1.53 | $6.60x10^{-8}$ | 209x196x191 | S | 12.9 |
| Enceladus | II | 1.370217855 | 0' 38" | 238.02 | 0.00452 | 0.00 | $1x10^{-7}$ | 256x247x245 | S | 11.7 |
| Telesto | XIII | 1.8878 | 0' 48" | 294.66 | | | | 15x12.5x7.5 | | 18.5 |
| Tethys | III | 1.887802160 | 0' 48" | 294.66 | 0.00000 | 1.86 | $1.10x10^{-6}$ | 536x528x526 | S | 10.2 |
| Calypso | XIV | 1.8878 | 0' 48" | 294.66 | | | | 15x8x8 | | 18.7 |
| Helene | XII | 2.7369 | 1' 01" | 377.40 | 0.005 | 0.0 | | 18x16x15 | | 18 |
| Dione | IV | 2.736914742 | 1' 01" | 377.40 | 0.002230 | 0.02 | $1.93x10^{-6}$ | 560 | S | 10.4 |
| Rhea | V | 4.517500436 | 1' 25" | 527.04 | 0.00100 | 0.35 | $4.06x10^{-6}$ | 764 | S | 9.7 |
| Titan | VI | 15.94542068 | 3' 17" | 1221.83 | 0.029192 | 0.33 | $2.37x10^{-4}$ | 2575 | S | 8.28 |
| Hyperion | VII | 21.2766088 | 3' 59" | 1481.1 | 0.104 | 0.43 | $4x10^{-8}$ | 180x140x113 | | 14.19 |
| Iapetus | VIII | 79.3301825 | 9' 35" | 3561.3 | 0.02828 | 14.72 | $2.8x10^{-6}$ | 718 | S | 11.1 |
| Phoebe | IX | 550.48 R | 34' 51" | 12952 | 0.16326 | 177 [2] | $7x10^{-10}$ | 110 | 0.4 | 16.45 |
| Uranus | | | | | | | | | | |
| Cordelia | VI | 0.3350338 | 0' 04" | 49.77 | 0.00026 | 0.08 | | 13 | | 24.1 |
| Ophelia | VII | 0.376400 | 0' 04" | 53.79 | 0.0099 | 0.10 | | 15 | | 23.8 |
| Bianca | VIII | 0.43457899 | 0' 04" | 59.17 | 0.009 | 0.19 | | 21 | | 23.0 |
| Cressida | IX | 0.46356960 | 0' 05" | 61.78 | 0.0004 | 0.01 | | 31 | | 22.2 |
| Desdemona | X | 0.47364960 | 0' 05" | 62.68 | 0.00013 | 0.11 | | 27 | | 22.5 |
| Juliet | XI | 0.49306549 | 0' 05" | 64.35 | 0.00066 | 0.07 | | 42 | | 21.5 |
| Portia | XII | 0.51319592 | 0' 05" | 66.09 | 0.0000 | 0.06 | | 54 | | 21.0 |
| Rosalind | XIII | 0.55845953 | 0' 05" | 69.94 | 0.0001 | 0.28 | | 27 | | 22.5 |
| Belinda | XIV | 0.62352747 | 0' 06" | 75.26 | 0.00007 | 0.03 | | 33 | | 22.1 |
| Puck | XV | 0.76183287 | 0' 07" | 86.01 | 0.00012 | 0.32 | | 77 | | 20.2 |
| Miranda | V | 1.41347925 | 0' 10" | 129.39 | 0.0027 | 4.2 | $0.08x10^{-5}$ | 240x234x233 | S | 16.3 |
| Ariel | I | 2.52037935 | 0' 14" | 191.02 | 0.0034 | 0.3 | $1.55x10^{-5}$ | 581x578x578 | S | 14.16 |
| Umbriel | II | 4.1441772 | 0' 20" | 266.30 | 0.0050 | 0.36 | $1.35x10^{-5}$ | 585 | S | 14.81 |
| Titania | III | 8.7058717 | 0' 33" | 435.91 | 0.0022 | 0.14 | $4.06x10^{-5}$ | 789 | S | 13.73 |
| Oberon | IV | 13.4632389 | 0' 44" | 583.52 | 0.0008 | 0.10 | $3.47x10^{-5}$ | 761 | S | 13.94 |
| Caliban | XVI | 579R | 8' 56" | 7,169 | 0.082 | 139.7 [2] | | 30 | | 22.4 |
| Sycorax | XVII | 1289R | 15' 26" | 12,214 | 0.509 | 152.7 [2] | | 60 | | 20.9 |
| Neptune | | | | | | | | | | |
| Naiad | III | 0.294396 | 0' 02" | 48.23 | 0.000 | 4.74 | | 29 | | 24.7 |
| Thalassa | IV | 0.311485 | 0' 02" | 50.07 | 0.000 | 0.21 | | 40 | | 23.8 |
| Despina | V | 0.334655 | 0' 02" | 52.53 | 0.000 | 0.07 | | 74 | | 22.6 |
| Galatea | VI | 0.428745 | 0' 03" | 61.95 | 0.000 | 0.05 | | 79 | | 22.3 |
| Larissa | VII | 0.554654 | 0' 03" | 73.55 | 0.00139 | 0.20 | | 104x89 | | 22.0 |
| Proteus | VIII | 1.122315 | 0' 06" | 117.65 | 0.0004 | 0.55 | | 218x208x201 | S | 20.3 |
| Triton | I | 5.8768541 R | 0' 17" | 354.76 | 0.000016 | 157.345 | $2.09x10^{-4}$ | 1353 | S | 13.47 |
| Nereid | II | 360.13619 | 4' 21" | 5513.4 | 0.7512 | 27.6 [3] | $2x10^{-7}$ | 170 | | 18.7 |
| Pluto | | | | | | | | | | |
| Charon | I | 6.38725 | <1" | 19.6 | <0.001 | 99 [3] | 0.125 | 593 | S | 16.8 |

Notes: **1** - Sidereal periods, except tropical periods are given for Saturn. **2** - Relative to the ecliptic plane. **3** - Referred to the equator of 1950.0
**4** - S = Synchronous, rotation period same as orbital period. i.e., keeps the same section of its surface facing its planet.

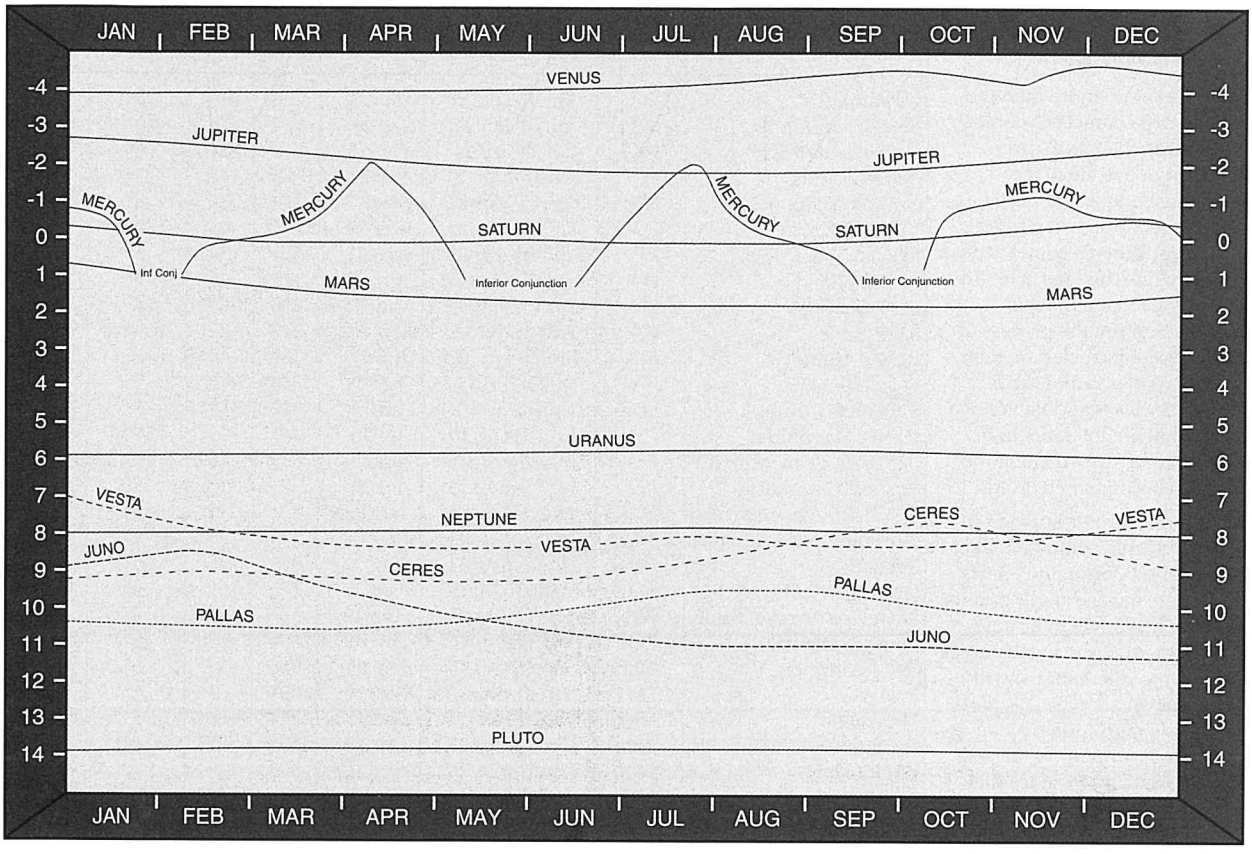
## DECLINATIONS of the SUN and PLANETS



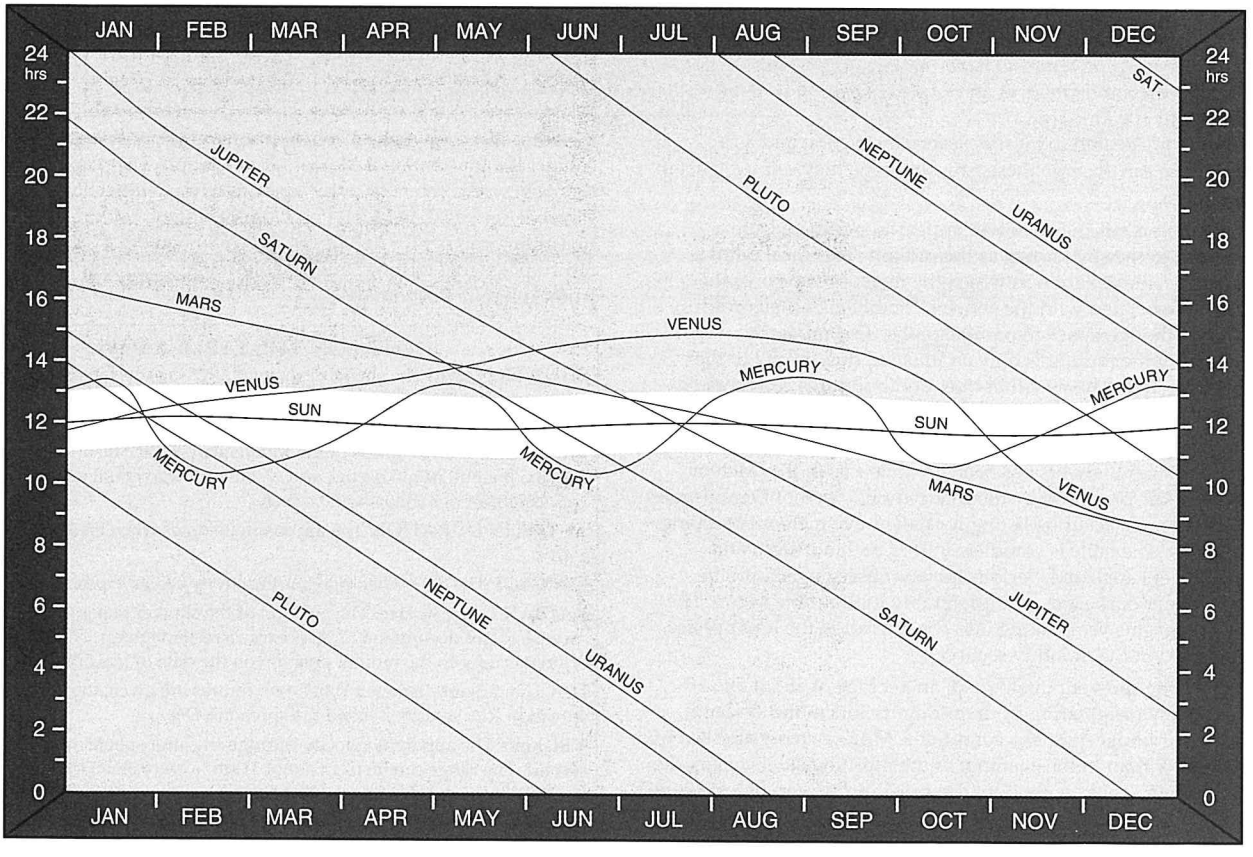

## PLANETARY ANGULAR SIZE



# MAGNITUDES of the PLANETS and MAJOR ASTEROIDS




# MERIDIAN PASSAGE of the SUN and PLANETS



# METEOR SHOWERS

## WHAT is a METEOR SHOWER?

A meteor shower is no more than the leftover debris from comets. A comet has been best described as a 'dirty snowball', a conglomerate of ice, frozen 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 (by the process of sublimation). 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 meteor of visual magnitude 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 stream, at 71 km/s, makes it 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 NAME | MOON PHASE | ACTIVITY DURATION | MAX ACT | RADIANT | | DIA | VEL km/s | ZHR |
|---|---|---|---|---|---|---|---|---|
| | | | | R.A. | Dec | | | |
| Quadrantids | LQ | Jan 01-Jan 05 | Jan 03 | 230° | +49° | 5° | 41 | 120 |
| delta-Cancrids | FQ | Jan 01-Jan 24 | Jan 17 | 130° | +20° | 10°-5° | 28 | 4 |
| alpha-Centaurids | NM | Jan 28-Feb 21 | Feb 08 | 210° | -59° | 4° | 56 | 6 |
| delta-Leonids | FQ | Feb 15-Mar 10 | Feb 24 | 168° | +16° | 5° | 23 | 2 |
| gamma-Normids | NM | Feb 25-Mar 22 | Mar 13 | 249° | -51° | 5° | 56 | 8 |
| Virginids | FQ | Jan 25-Apr 15 | Mar 24 | 195° | -04° | 15°-10° | 30 | 5 |
| Lyrids | FQ | Apr 16-Apr 25 | Apr 21 | 271° | +34° | 5° | 49 | 15 |
| pi-Puppids* | FQ | Apr 15 - Apr 28 | Apr 23 | 110° | -45° | 5° | 18 | * |
| eta-Aquarids | LQ | Apr 19-May 28 | May 05 | 338° | -01° | 4° | 66 | 60 |
| Sagittarids | FQ | Apr 15-Jul 15 | May 19 | 247° | -22° | 15°-10° | 30 | 5 |
| Bootids (June)* | FM | Jun 26 - Jul 02 | Jun 27 | 224° | +48° | 5° | 18 | * |
| Pegasids | NM | Jul 07-Jul 13 | Jul 09 | 340° | +15° | 5° | 70 | 3 |
| Phoenicids (July)* | NM | Jul 10 - Jul 16 | Jul 13 | 032° | -48° | 7° | 47 | * |
| Pisces Austrinids | FM | Jul 15-Aug 10 | Jul 28 | 341° | -30° | 15°-10° | 35 | 5 |
| Southern delta-Aquarids | FM | Jul 12-Aug 19 | Jul 28 | 339° | -16° | 5° | 41 | 20 |
| alpha-Capricornids | LQ | Jul 03-Aug 15 | Jul 30 | 307° | -10° | 8° | 23 | 4 |
| Southern iota-Aquarids | LQ | Jul 25-Aug 15 | Aug 04 | 334° | -15° | 5° | 34 | 2 |
| Northern delta-Aquarids | NM | Jul 15-Aug 25 | Aug 08 | 335° | -05° | 5° | 42 | 4 |
| Perseids | FQ | Jul 17-Aug 24 | Aug 12 | 046° | +58° | 5° | 59 | 140 |
| kappa-Cygnids | FQ | Aug 03-Aug 25 | Aug 17 | 286° | +59° | 6° | 25 | 3 |
| Northern iota-Aquarids | FM | Aug 11-Aug 31 | Aug 19 | 327° | -06° | 5° | 31 | 3 |
| alpha-Aurigids | LQ | Aug 25-Sep 05 | Sep 01 | 084° | +42° | 5° | 66 | 10 |
| delta-Aurigids | NM | Sep 05-Oct 10 | Sep 08 | 060° | +47° | 5° | 64 | 6 |
| Piscids | FM | Sep 01-Sep 30 | Sep 19 | 005° | -01° | 5° | 26 | 3 |
| Draconids* | NM | Oct 06 - Oct 10 | Oct 08 | 262° | +54° | 2° | 20 | * |
| Epsilon Geminids | FM | Oct 14-Oct 27 | Oct 18 | 102° | +27° | 5° | 70 | 2 |
| Orionids | FM | Oct 02-Nov 07 | Oct 21 | 095° | +16° | 10° | 66 | 20 |
| Southern Taurids | NM | Oct 01-Nov 25 | Nov 05 | 052° | +13° | 10°-5° | 27 | 5 |
| Northern Taurids | FQ | Oct 01-Nov 25 | Nov 12 | 058° | +22° | 10°-5° | 29 | 5 |
| Leonids | FM | Nov 14-Nov 21 | Nov 17 | 153° | +22° | 5° | 71 | 100+ |
| alpha-Monocerotids | FM | Nov 15-Nov 25 | Nov 21 | 117° | +01° | 5° | 65 | Var |
| chi-Orionids | NM | Nov 26-Dec 15 | Dec 02 | 082° | +23° | 8° | 28 | 3 |
| Phoenicids | NM | Nov 28-Dec 09 | Dec 06 | 018° | -53° | 5° | 18 | Var |
| Puppid-Velids | NM | Dec 01-Dec 15 | Dec 07 | 123° | -45° | 10° | 40 | 10 |
| Monocerotids (Dec) | FQ | Nov 27-Dec 17 | Dec 09 | 100° | +08° | 5° | 42 | 3 |
| sigma-Hydrids | FQ | Dec 03-Dec 15 | Dec 11 | 127° | +02° | 5° | 58 | 2 |
| Geminids | FQ | Dec 07-Dec 17 | Dec 14 | 112° | +33° | 5° | 35 | 120 |
| Coma Berenicids | FM | Dec 12-Jan 23 | Dec 19 | 175° | +25° | 5° | 65 | 5 |
| Ursids | FM | 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. & 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).

# SUN

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

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

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

# SUN – RISE, SET and TRANSIT (PERTH, WAST)

## JANUARY

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 03:34 | 05:14 | 118° | 12:20:08 | 81° | 19:26 | 242° | 21:05 |
| 2 | 03:35 | 05:15 | 118° | 12:20:36 | 81° | 19:26 | 242° | 21:05 |
| 3 | 03:36 | 05:15 | 118° | 12:21:03 | 81° | 19:26 | 242° | 21:05 |
| 4 | 03:37 | 05:16 | 118° | 12:21:31 | 81° | 19:26 | 242° | 21:05 |
| 5 | 03:38 | 05:17 | 118° | 12:21:58 | 81° | 19:27 | 242° | 21:05 |
| 6 | 03:39 | 05:18 | 117° | 12:22:24 | 81° | 19:27 | 243° | 21:05 |
| 7 | 03:40 | 05:18 | 117° | 12:22:50 | 80° | 19:27 | 243° | 21:05 |
| 8 | 03:41 | 05:19 | 117° | 12:23:16 | 80° | 19:27 | 243° | 21:05 |
| 9 | 03:42 | 05:20 | 117° | 12:23:41 | 80° | 19:27 | 243° | 21:05 |
| 10 | 03:43 | 05:21 | 117° | 12:24:05 | 80° | 19:27 | 243° | 21:04 |
| 11 | 03:44 | 05:22 | 117° | 12:24:29 | 80° | 19:27 | 243° | 21:04 |
| 12 | 03:45 | 05:23 | 116° | 12:24:53 | 80° | 19:27 | 244° | 21:04 |
| 13 | 03:46 | 05:24 | 116° | 12:25:16 | 80° | 19:26 | 244° | 21:03 |
| 14 | 03:48 | 05:24 | 116° | 12:25:38 | 79° | 19:26 | 244° | 21:03 |
| 15 | 03:49 | 05:25 | 116° | 12:26:00 | 79° | 19:26 | 244° | 21:02 |
| 16 | 03:50 | 05:26 | 116° | 12:26:20 | 79° | 19:26 | 245° | 21:02 |
| 17 | 03:51 | 05:27 | 115° | 12:26:41 | 79° | 19:26 | 245° | 21:01 |
| 18 | 03:52 | 05:28 | 115° | 12:27:00 | 79° | 19:25 | 245° | 21:01 |
| 19 | 03:53 | 05:29 | 115° | 12:27:19 | 78° | 19:25 | 245° | 21:00 |
| 20 | 03:55 | 05:30 | 115° | 12:27:37 | 78° | 19:25 | 246° | 21:00 |
| 21 | 03:56 | 05:31 | 114° | 12:27:54 | 78° | 19:24 | 246° | 20:59 |
| 22 | 03:57 | 05:32 | 114° | 12:28:10 | 78° | 19:24 | 246° | 20:58 |
| 23 | 03:58 | 05:33 | 114° | 12:28:26 | 78° | 19:24 | 246° | 20:58 |
| 24 | 04:00 | 05:34 | 114° | 12:28:41 | 77° | 19:23 | 247° | 20:57 |
| 25 | 04:01 | 05:35 | 113° | 12:28:55 | 77° | 19:23 | 247° | 20:56 |
| 26 | 04:02 | 05:36 | 113° | 12:29:08 | 77° | 19:22 | 247° | 20:55 |
| 27 | 04:03 | 05:37 | 113° | 12:29:20 | 77° | 19:22 | 248° | 20:54 |
| 28 | 04:05 | 05:38 | 112° | 12:29:32 | 76° | 19:21 | 248° | 20:54 |
| 29 | 04:06 | 05:38 | 112° | 12:29:42 | 76° | 19:20 | 248° | 20:53 |
| 30 | 04:07 | 05:39 | 112° | 12:29:52 | 76° | 19:20 | 249° | 20:52 |
| 31 | 04:08 | 05:40 | 111° | 12:30:01 | 75° | 19:19 | 249° | 20:51 |

## FEBRUARY

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 04:10 | 05:41 | 111° | 12:30:10 | 75° | 19:19 | 249° | 20:50 |
| 2 | 04:11 | 05:42 | 111° | 12:30:17 | 75° | 19:18 | 250° | 20:49 |
| 3 | 04:12 | 05:43 | 110° | 12:30:24 | 75° | 19:17 | 250° | 20:48 |
| 4 | 04:13 | 05:44 | 110° | 12:30:30 | 74° | 19:16 | 250° | 20:47 |
| 5 | 04:15 | 05:45 | 110° | 12:30:35 | 74° | 19:16 | 251° | 20:46 |
| 6 | 04:16 | 05:46 | 109° | 12:30:39 | 74° | 19:15 | 251° | 20:45 |
| 7 | 04:17 | 05:47 | 109° | 12:30:43 | 73° | 19:14 | 251° | 20:44 |
| 8 | 04:18 | 05:48 | 108° | 12:30:46 | 73° | 19:13 | 252° | 20:42 |
| 9 | 04:19 | 05:49 | 108° | 12:30:48 | 73° | 19:12 | 252° | 20:41 |
| 10 | 04:21 | 05:50 | 108° | 12:30:49 | 72° | 19:12 | 253° | 20:40 |
| 11 | 04:22 | 05:50 | 107° | 12:30:50 | 72° | 19:11 | 253° | 20:39 |
| 12 | 04:23 | 05:51 | 107° | 12:30:49 | 72° | 19:10 | 253° | 20:38 |
| 13 | 04:24 | 05:52 | 107° | 12:30:48 | 71° | 19:09 | 254° | 20:37 |
| 14 | 04:25 | 05:53 | 106° | 12:30:46 | 71° | 19:08 | 254° | 20:35 |
| 15 | 04:27 | 05:54 | 106° | 12:30:44 | 71° | 19:07 | 255° | 20:34 |
| 16 | 04:28 | 05:55 | 105° | 12:30:41 | 70° | 19:06 | 255° | 20:33 |
| 17 | 04:29 | 05:56 | 105° | 12:30:37 | 70° | 19:05 | 255° | 20:32 |
| 18 | 04:30 | 05:57 | 104° | 12:30:32 | 70° | 19:04 | 256° | 20:30 |
| 19 | 04:31 | 05:57 | 104° | 12:30:26 | 69° | 19:03 | 256° | 20:29 |
| 20 | 04:32 | 05:58 | 104° | 12:30:20 | 69° | 19:02 | 257° | 20:28 |
| 21 | 04:33 | 05:59 | 103° | 12:30:14 | 69° | 19:01 | 257° | 20:27 |
| 22 | 04:34 | 06:00 | 103° | 12:30:06 | 68° | 19:00 | 257° | 20:25 |
| 23 | 04:35 | 06:01 | 102° | 12:29:58 | 68° | 18:59 | 258° | 20:24 |
| 24 | 04:36 | 06:02 | 102° | 12:29:49 | 68° | 18:58 | 258° | 20:23 |
| 25 | 04:37 | 06:02 | 101° | 12:29:40 | 67° | 18:57 | 259° | 20:21 |
| 26 | 04:38 | 06:03 | 101° | 12:29:30 | 67° | 18:55 | 259° | 20:20 |
| 27 | 04:39 | 06:04 | 101° | 12:29:20 | 66° | 18:54 | 260° | 20:19 |
| 28 | 04:40 | 06:05 | 100° | 12:29:09 | 66° | 18:53 | 260° | 20:17 |

## MARCH

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 04:41 | 06:06 | 100° | 12:28:57 | 66° | 18:52 | 261° | 20:16 |
| 2 | 04:42 | 06:06 | 99° | 12:28:45 | 65° | 18:51 | 261° | 20:15 |
| 3 | 04:43 | 06:07 | 99° | 12:28:33 | 65° | 18:50 | 261° | 20:13 |
| 4 | 04:44 | 06:08 | 98° | 12:28:20 | 65° | 18:48 | 262° | 20:12 |
| 5 | 04:45 | 06:09 | 98° | 12:28:06 | 64° | 18:47 | 262° | 20:10 |
| 6 | 04:46 | 06:09 | 97° | 12:27:53 | 64° | 18:46 | 263° | 20:09 |
| 7 | 04:47 | 06:10 | 97° | 12:27:39 | 63° | 18:45 | 263° | 20:08 |
| 8 | 04:48 | 06:11 | 97° | 12:27:24 | 63° | 18:44 | 264° | 20:06 |
| 9 | 04:49 | 06:12 | 96° | 12:27:09 | 63° | 18:42 | 264° | 20:05 |
| 10 | 04:50 | 06:12 | 96° | 12:26:54 | 62° | 18:41 | 265° | 20:04 |
| 11 | 04:51 | 06:13 | 95° | 12:26:38 | 62° | 18:40 | 265° | 20:02 |
| 12 | 04:51 | 06:14 | 95° | 12:26:22 | 61° | 18:39 | 266° | 20:01 |
| 13 | 04:52 | 06:15 | 94° | 12:26:06 | 61° | 18:37 | 266° | 19:59 |
| 14 | 04:53 | 06:15 | 94° | 12:25:50 | 61° | 18:36 | 267° | 19:58 |
| 15 | 04:54 | 06:16 | 93° | 12:25:33 | 60° | 18:35 | 267° | 19:57 |
| 16 | 04:55 | 06:17 | 93° | 12:25:16 | 60° | 18:34 | 267° | 19:55 |
| 17 | 04:56 | 06:17 | 92° | 12:24:59 | 59° | 18:32 | 268° | 19:54 |
| 18 | 04:56 | 06:18 | 92° | 12:24:42 | 59° | 18:31 | 268° | 19:53 |
| 19 | 04:57 | 06:19 | 91° | 12:24:24 | 59° | 18:30 | 269° | 19:51 |
| 20 | 04:58 | 06:20 | 91° | 12:24:07 | 58° | 18:28 | 269° | 19:50 |
| 21 | 04:59 | 06:20 | 90° | 12:23:49 | 58° | 18:27 | 270° | 19:49 |
| 22 | 04:59 | 06:21 | 90° | 12:23:31 | 58° | 18:26 | 270° | 19:47 |
| 23 | 05:00 | 06:22 | 90° | 12:23:13 | 57° | 18:25 | 271° | 19:46 |
| 24 | 05:01 | 06:22 | 89° | 12:22:55 | 57° | 18:23 | 271° | 19:44 |
| 25 | 05:02 | 06:23 | 89° | 12:22:37 | 56° | 18:22 | 272° | 19:43 |
| 26 | 05:02 | 06:24 | 88° | 12:22:18 | 56° | 18:21 | 272° | 19:42 |
| 27 | 05:03 | 06:24 | 88° | 12:22:00 | 56° | 18:19 | 273° | 19:41 |
| 28 | 05:04 | 06:25 | 87° | 12:21:42 | 55° | 18:18 | 273° | 19:39 |
| 29 | 05:04 | 06:26 | 87° | 12:21:24 | 55° | 18:17 | 273° | 19:38 |
| 30 | 05:05 | 06:26 | 86° | 12:21:05 | 54° | 18:16 | 274° | 19:37 |
| 31 | 05:06 | 06:27 | 86° | 12:20:47 | 54° | 18:14 | 274° | 19:35 |

## APRIL

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:07 | 06:28 | 85° | 12:20:29 | 54° | 18:13 | 275° | 19:34 |
| 2 | 05:07 | 06:28 | 85° | 12:20:12 | 53° | 18:12 | 275° | 19:33 |
| 3 | 05:08 | 06:29 | 84° | 12:19:54 | 53° | 18:11 | 276° | 19:32 |
| 4 | 05:09 | 06:30 | 84° | 12:19:36 | 52° | 18:09 | 276° | 19:30 |
| 5 | 05:09 | 06:30 | 84° | 12:19:19 | 52° | 18:08 | 277° | 19:29 |
| 6 | 05:10 | 06:31 | 83° | 12:19:02 | 52° | 18:07 | 277° | 19:28 |
| 7 | 05:11 | 06:32 | 83° | 12:18:45 | 51° | 18:06 | 278° | 19:27 |
| 8 | 05:11 | 06:32 | 82° | 12:18:28 | 51° | 18:04 | 278° | 19:25 |
| 9 | 05:12 | 06:33 | 82° | 12:18:12 | 51° | 18:03 | 278° | 19:24 |
| 10 | 05:12 | 06:34 | 81° | 12:17:56 | 50° | 18:02 | 279° | 19:23 |
| 11 | 05:13 | 06:34 | 81° | 12:17:40 | 50° | 18:01 | 279° | 19:22 |
| 12 | 05:14 | 06:35 | 80° | 12:17:24 | 49° | 18:00 | 280° | 19:21 |
| 13 | 05:14 | 06:36 | 80° | 12:17:09 | 49° | 17:58 | 280° | 19:20 |
| 14 | 05:15 | 06:36 | 80° | 12:16:54 | 49° | 17:57 | 281° | 19:19 |
| 15 | 05:16 | 06:37 | 79° | 12:16:39 | 48° | 17:56 | 281° | 19:17 |
| 16 | 05:16 | 06:38 | 79° | 12:16:25 | 48° | 17:55 | 281° | 19:16 |
| 17 | 05:17 | 06:38 | 78° | 12:16:11 | 48° | 17:54 | 282° | 19:15 |
| 18 | 05:17 | 06:39 | 78° | 12:15:57 | 47° | 17:53 | 282° | 19:14 |
| 19 | 05:18 | 06:40 | 78° | 12:15:44 | 47° | 17:51 | 283° | 19:13 |
| 20 | 05:19 | 06:40 | 77° | 12:15:31 | 47° | 17:50 | 283° | 19:12 |
| 21 | 05:19 | 06:41 | 77° | 12:15:19 | 46° | 17:49 | 283° | 19:11 |
| 22 | 05:20 | 06:42 | 76° | 12:15:07 | 46° | 17:48 | 284° | 19:10 |
| 23 | 05:20 | 06:42 | 76° | 12:14:55 | 46° | 17:47 | 284° | 19:09 |
| 24 | 05:21 | 06:43 | 75° | 12:14:44 | 45° | 17:46 | 285° | 19:08 |
| 25 | 05:22 | 06:44 | 75° | 12:14:34 | 45° | 17:45 | 285° | 19:07 |
| 26 | 05:22 | 06:45 | 75° | 12:14:23 | 45° | 17:44 | 285° | 19:06 |
| 27 | 05:23 | 06:45 | 74° | 12:14:14 | 44° | 17:43 | 286° | 19:05 |
| 28 | 05:23 | 06:46 | 74° | 12:14:05 | 44° | 17:42 | 286° | 19:04 |
| 29 | 05:24 | 06:47 | 74° | 12:13:56 | 44° | 17:41 | 287° | 19:04 |
| 30 | 05:25 | 06:47 | 73° | 12:13:48 | 43° | 17:40 | 287° | 19:03 |

## MAY

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:25 | 06:48 | 73° | 12:13:40 | 43° | 17:39 | 287° | 19:02 |
| 2 | 05:26 | 06:49 | 72° | 12:13:33 | 43° | 17:38 | 288° | 19:01 |
| 3 | 05:26 | 06:49 | 72° | 12:13:27 | 42° | 17:37 | 288° | 19:00 |
| 4 | 05:27 | 06:50 | 72° | 12:13:21 | 42° | 17:36 | 288° | 19:00 |
| 5 | 05:27 | 06:51 | 71° | 12:13:16 | 42° | 17:36 | 289° | 18:59 |
| 6 | 05:28 | 06:51 | 71° | 12:13:11 | 42° | 17:35 | 289° | 18:58 |
| 7 | 05:29 | 06:52 | 71° | 12:13:07 | 41° | 17:34 | 289° | 18:57 |
| 8 | 05:29 | 06:53 | 70° | 12:13:03 | 41° | 17:33 | 290° | 18:57 |
| 9 | 05:30 | 06:54 | 70° | 12:13:00 | 41° | 17:32 | 290° | 18:56 |
| 10 | 05:30 | 06:54 | 70° | 12:12:58 | 41° | 17:31 | 290° | 18:55 |
| 11 | 05:31 | 06:55 | 69° | 12:12:56 | 40° | 17:31 | 291° | 18:55 |
| 12 | 05:31 | 06:56 | 69° | 12:12:55 | 40° | 17:30 | 291° | 18:54 |
| 13 | 05:32 | 06:56 | 69° | 12:12:54 | 40° | 17:29 | 291° | 18:54 |
| 14 | 05:33 | 06:57 | 69° | 12:12:54 | 39° | 17:29 | 292° | 18:53 |
| 15 | 05:33 | 06:58 | 68° | 12:12:54 | 39° | 17:28 | 292° | 18:52 |
| 16 | 05:34 | 06:58 | 68° | 12:12:55 | 39° | 17:27 | 292° | 18:52 |
| 17 | 05:34 | 06:59 | 68° | 12:12:57 | 39° | 17:27 | 292° | 18:51 |
| 18 | 05:35 | 07:00 | 67° | 12:12:59 | 39° | 17:26 | 293° | 18:51 |
| 19 | 05:35 | 07:00 | 67° | 12:13:02 | 38° | 17:25 | 293° | 18:51 |
| 20 | 05:36 | 07:01 | 67° | 12:13:05 | 38° | 17:25 | 293° | 18:50 |
| 21 | 05:36 | 07:02 | 67° | 12:13:08 | 38° | 17:24 | 293° | 18:50 |
| 22 | 05:37 | 07:02 | 66° | 12:13:13 | 38° | 17:24 | 294° | 18:49 |
| 23 | 05:37 | 07:03 | 66° | 12:13:17 | 38° | 17:23 | 294° | 18:49 |
| 24 | 05:38 | 07:04 | 66° | 12:13:22 | 37° | 17:23 | 294° | 18:49 |
| 25 | 05:38 | 07:04 | 66° | 12:13:28 | 37° | 17:23 | 294° | 18:48 |
| 26 | 05:39 | 07:05 | 66° | 12:13:34 | 37° | 17:22 | 295° | 18:48 |
| 27 | 05:39 | 07:05 | 65° | 12:13:41 | 37° | 17:22 | 295° | 18:48 |
| 28 | 05:40 | 07:06 | 65° | 12:13:48 | 37° | 17:21 | 295° | 18:47 |
| 29 | 05:40 | 07:07 | 65° | 12:13:56 | 36° | 17:21 | 295° | 18:47 |
| 30 | 05:41 | 07:07 | 65° | 12:14:04 | 36° | 17:21 | 295° | 18:47 |
| 31 | 05:41 | 07:08 | 65° | 12:14:12 | 36° | 17:20 | 296° | 18:47 |

## JUNE

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:42 | 07:08 | 64° | 12:14:21 | 36° | 17:20 | 296° | 18:47 |
| 2 | 05:42 | 07:09 | 64° | 12:14:31 | 36° | 17:20 | 296° | 18:46 |
| 3 | 05:43 | 07:09 | 64° | 12:14:40 | 36° | 17:20 | 296° | 18:46 |
| 4 | 05:43 | 07:10 | 64° | 12:14:50 | 36° | 17:20 | 296° | 18:46 |
| 5 | 05:44 | 07:10 | 64° | 12:15:01 | 36° | 17:19 | 296° | 18:46 |
| 6 | 05:44 | 07:11 | 64° | 12:15:12 | 35° | 17:19 | 296° | 18:46 |
| 7 | 05:45 | 07:11 | 64° | 12:15:23 | 35° | 17:19 | 297° | 18:46 |
| 8 | 05:45 | 07:12 | 63° | 12:15:34 | 35° | 17:19 | 297° | 18:46 |
| 9 | 05:45 | 07:12 | 63° | 12:15:46 | 35° | 17:19 | 297° | 18:46 |
| 10 | 05:46 | 07:13 | 63° | 12:15:58 | 35° | 17:19 | 297° | 18:46 |
| 11 | 05:46 | 07:13 | 63° | 12:16:10 | 35° | 17:19 | 297° | 18:46 |
| 12 | 05:46 | 07:14 | 63° | 12:16:23 | 35° | 17:19 | 297° | 18:46 |
| 13 | 05:47 | 07:14 | 63° | 12:16:35 | 35° | 17:19 | 297° | 18:46 |
| 14 | 05:47 | 07:14 | 63° | 12:16:48 | 35° | 17:19 | 297° | 18:46 |
| 15 | 05:47 | 07:15 | 63° | 12:17:01 | 35° | 17:19 | 297° | 18:46 |
| 16 | 05:48 | 07:15 | 63° | 12:17:14 | 35° | 17:19 | 297° | 18:47 |
| 17 | 05:48 | 07:15 | 63° | 12:17:27 | 35° | 17:19 | 297° | 18:47 |
| 18 | 05:48 | 07:16 | 63° | 12:17:40 | 35° | 17:19 | 297° | 18:47 |
| 19 | 05:49 | 07:16 | 63° | 12:17:53 | 35° | 17:20 | 297° | 18:47 |
| 20 | 05:49 | 07:16 | 63° | 12:18:06 | 35° | 17:20 | 297° | 18:47 |
| 21 | 05:49 | 07:17 | 63° | 12:18:19 | 35° | 17:20 | 297° | 18:47 |
| 22 | 05:49 | 07:17 | 63° | 12:18:32 | 35° | 17:20 | 297° | 18:48 |
| 23 | 05:50 | 07:17 | 63° | 12:18:45 | 35° | 17:20 | 297° | 18:48 |
| 24 | 05:50 | 07:17 | 63° | 12:18:58 | 35° | 17:21 | 297° | 18:48 |
| 25 | 05:50 | 07:17 | 63° | 12:19:10 | 35° | 17:21 | 297° | 18:48 |
| 26 | 05:50 | 07:17 | 63° | 12:19:23 | 35° | 17:21 | 297° | 18:49 |
| 27 | 05:50 | 07:18 | 63° | 12:19:35 | 35° | 17:22 | 297° | 18:49 |
| 28 | 05:50 | 07:18 | 63° | 12:19:48 | 35° | 17:22 | 297° | 18:49 |
| 29 | 05:50 | 07:18 | 63° | 12:20:00 | 35° | 17:22 | 297° | 18:50 |
| 30 | 05:50 | 07:18 | 63° | 12:20:12 | 35° | 17:23 | 297° | 18:50 |

# SUN – RISE, SET and TRANSIT (PERTH, WAST)

## JULY

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:51 | 07:18 | 63° | 12:20:23 | 35° | 17:23 | 297° | 18:50 |
| 2 | 05:51 | 07:18 | 63° | 12:20:35 | 35° | 17:23 | 297° | 18:51 |
| 3 | 05:51 | 07:18 | 63° | 12:20:46 | 35° | 17:24 | 297° | 18:51 |
| 4 | 05:51 | 07:18 | 63° | 12:20:57 | 35° | 17:24 | 297° | 18:51 |
| 5 | 05:51 | 07:18 | 63° | 12:21:08 | 35° | 17:25 | 297° | 18:52 |
| 6 | 05:51 | 07:17 | 63° | 12:21:18 | 35° | 17:25 | 296° | 18:52 |
| 7 | 05:50 | 07:17 | 64° | 12:21:28 | 35° | 17:26 | 296° | 18:53 |
| 8 | 05:50 | 07:17 | 64° | 12:21:37 | 36° | 17:26 | 296° | 18:53 |
| 9 | 05:50 | 07:17 | 64° | 12:21:47 | 36° | 17:27 | 296° | 18:53 |
| 10 | 05:50 | 07:17 | 64° | 12:21:55 | 36° | 17:27 | 296° | 18:54 |
| 11 | 05:50 | 07:17 | 64° | 12:22:04 | 36° | 17:28 | 296° | 18:54 |
| 12 | 05:50 | 07:16 | 64° | 12:22:12 | 36° | 17:28 | 296° | 18:55 |
| 13 | 05:50 | 07:16 | 65° | 12:22:19 | 36° | 17:29 | 295° | 18:55 |
| 14 | 05:49 | 07:16 | 65° | 12:22:26 | 36° | 17:29 | 295° | 18:56 |
| 15 | 05:49 | 07:15 | 65° | 12:22:32 | 37° | 17:30 | 295° | 18:56 |
| 16 | 05:49 | 07:15 | 65° | 12:22:38 | 37° | 17:30 | 295° | 18:57 |
| 17 | 05:49 | 07:15 | 65° | 12:22:44 | 37° | 17:31 | 295° | 18:57 |
| 18 | 05:48 | 07:14 | 65° | 12:22:48 | 37° | 17:32 | 294° | 18:57 |
| 19 | 05:48 | 07:14 | 66° | 12:22:53 | 37° | 17:32 | 294° | 18:58 |
| 20 | 05:48 | 07:13 | 66° | 12:22:56 | 37° | 17:33 | 294° | 18:58 |
| 21 | 05:47 | 07:13 | 66° | 12:22:59 | 38° | 17:33 | 294° | 18:59 |
| 22 | 05:47 | 07:12 | 66° | 12:23:02 | 38° | 17:34 | 294° | 18:59 |
| 23 | 05:46 | 07:12 | 67° | 12:23:04 | 38° | 17:35 | 293° | 19:00 |
| 24 | 05:46 | 07:11 | 67° | 12:23:05 | 38° | 17:35 | 293° | 19:00 |
| 25 | 05:46 | 07:11 | 67° | 12:23:06 | 38° | 17:36 | 293° | 19:01 |
| 26 | 05:45 | 07:10 | 67° | 12:23:06 | 39° | 17:37 | 293° | 19:01 |
| 27 | 05:45 | 07:09 | 68° | 12:23:06 | 39° | 17:37 | 292° | 19:02 |
| 28 | 05:44 | 07:09 | 68° | 12:23:05 | 39° | 17:38 | 292° | 19:02 |
| 29 | 05:44 | 07:08 | 68° | 12:23:03 | 39° | 17:38 | 292° | 19:03 |
| 30 | 05:43 | 07:07 | 68° | 12:23:01 | 40° | 17:39 | 291° | 19:03 |
| 31 | 05:42 | 07:07 | 69° | 12:22:58 | 40° | 17:40 | 291° | 19:04 |

## AUGUST

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:42 | 07:06 | 69° | 12:22:55 | 40° | 17:40 | 291° | 19:04 |
| 2 | 05:41 | 07:05 | 69° | 12:22:51 | 40° | 17:41 | 291° | 19:05 |
| 3 | 05:40 | 07:04 | 70° | 12:22:46 | 41° | 17:42 | 290° | 19:06 |
| 4 | 05:40 | 07:04 | 70° | 12:22:41 | 41° | 17:42 | 290° | 19:06 |
| 5 | 05:39 | 07:03 | 70° | 12:22:35 | 41° | 17:43 | 290° | 19:07 |
| 6 | 05:38 | 07:02 | 71° | 12:22:29 | 41° | 17:44 | 289° | 19:07 |
| 7 | 05:38 | 07:01 | 71° | 12:22:22 | 42° | 17:44 | 289° | 19:08 |
| 8 | 05:37 | 07:00 | 71° | 12:22:15 | 42° | 17:45 | 289° | 19:08 |
| 9 | 05:36 | 06:59 | 72° | 12:22:07 | 42° | 17:45 | 288° | 19:09 |
| 10 | 05:35 | 06:58 | 72° | 12:21:58 | 42° | 17:46 | 288° | 19:09 |
| 11 | 05:34 | 06:57 | 72° | 12:21:49 | 43° | 17:47 | 288° | 19:10 |
| 12 | 05:34 | 06:56 | 73° | 12:21:39 | 43° | 17:47 | 287° | 19:10 |
| 13 | 05:33 | 06:55 | 73° | 12:21:29 | 43° | 17:48 | 287° | 19:11 |
| 14 | 05:32 | 06:54 | 73° | 12:21:18 | 44° | 17:49 | 286° | 19:11 |
| 15 | 05:31 | 06:53 | 74° | 12:21:06 | 44° | 17:49 | 286° | 19:12 |
| 16 | 05:30 | 06:52 | 74° | 12:20:54 | 44° | 17:50 | 286° | 19:12 |
| 17 | 05:29 | 06:51 | 74° | 12:20:41 | 45° | 17:51 | 285° | 19:13 |
| 18 | 05:28 | 06:50 | 75° | 12:20:28 | 45° | 17:51 | 285° | 19:13 |
| 19 | 05:27 | 06:49 | 75° | 12:20:15 | 45° | 17:52 | 285° | 19:14 |
| 20 | 05:26 | 06:48 | 76° | 12:20:00 | 46° | 17:52 | 284° | 19:15 |
| 21 | 05:25 | 06:47 | 76° | 12:19:46 | 46° | 17:53 | 284° | 19:15 |
| 22 | 05:24 | 06:46 | 76° | 12:19:31 | 46° | 17:54 | 283° | 19:16 |
| 23 | 05:23 | 06:45 | 77° | 12:19:15 | 47° | 17:54 | 283° | 19:16 |
| 24 | 05:22 | 06:44 | 77° | 12:18:59 | 47° | 17:55 | 283° | 19:17 |
| 25 | 05:21 | 06:42 | 78° | 12:18:43 | 47° | 17:56 | 282° | 19:17 |
| 26 | 05:20 | 06:41 | 78° | 12:18:26 | 48° | 17:56 | 282° | 19:18 |
| 27 | 05:19 | 06:40 | 78° | 12:18:09 | 48° | 17:57 | 281° | 19:18 |
| 28 | 05:18 | 06:39 | 79° | 12:17:51 | 48° | 17:57 | 281° | 19:19 |
| 29 | 05:16 | 06:38 | 79° | 12:17:33 | 49° | 17:58 | 281° | 19:19 |
| 30 | 05:15 | 06:37 | 80° | 12:17:15 | 49° | 17:59 | 280° | 19:20 |
| 31 | 05:14 | 06:35 | 80° | 12:16:57 | 49° | 17:59 | 280° | 19:21 |

## SEPTEMBER

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 05:13 | 06:34 | 81° | 12:16:38 | 50° | 18:00 | 279° | 19:21 |
| 2 | 05:12 | 06:33 | 81° | 12:16:19 | 50° | 18:00 | 279° | 19:22 |
| 3 | 05:10 | 06:32 | 81° | 12:15:59 | 50° | 18:01 | 278° | 19:22 |
| 4 | 05:09 | 06:30 | 82° | 12:15:40 | 51° | 18:02 | 278° | 19:23 |
| 5 | 05:08 | 06:29 | 82° | 12:15:20 | 51° | 18:02 | 278° | 19:23 |
| 6 | 05:07 | 06:28 | 83° | 12:15:00 | 52° | 18:03 | 277° | 19:24 |
| 7 | 05:06 | 06:27 | 83° | 12:14:40 | 52° | 18:03 | 277° | 19:25 |
| 8 | 05:04 | 06:25 | 84° | 12:14:19 | 52° | 18:04 | 276° | 19:25 |
| 9 | 05:03 | 06:24 | 84° | 12:13:58 | 53° | 18:05 | 276° | 19:26 |
| 10 | 05:02 | 06:23 | 84° | 12:13:38 | 53° | 18:05 | 275° | 19:26 |
| 11 | 05:00 | 06:21 | 85° | 12:13:17 | 53° | 18:06 | 275° | 19:27 |
| 12 | 04:59 | 06:20 | 85° | 12:12:56 | 54° | 18:06 | 274° | 19:28 |
| 13 | 04:58 | 06:19 | 86° | 12:12:34 | 54° | 18:07 | 274° | 19:28 |
| 14 | 04:56 | 06:17 | 86° | 12:12:13 | 55° | 18:08 | 273° | 19:29 |
| 15 | 04:55 | 06:16 | 87° | 12:11:52 | 55° | 18:08 | 273° | 19:29 |
| 16 | 04:54 | 06:15 | 87° | 12:11:30 | 55° | 18:09 | 273° | 19:30 |
| 17 | 04:52 | 06:14 | 88° | 12:11:09 | 56° | 18:10 | 272° | 19:31 |
| 18 | 04:51 | 06:12 | 88° | 12:10:47 | 56° | 18:10 | 272° | 19:31 |
| 19 | 04:50 | 06:11 | 89° | 12:10:26 | 56° | 18:11 | 271° | 19:32 |
| 20 | 04:48 | 06:10 | 89° | 12:10:05 | 57° | 18:11 | 271° | 19:33 |
| 21 | 04:47 | 06:08 | 89° | 12:09:43 | 57° | 18:12 | 270° | 19:33 |
| 22 | 04:46 | 06:07 | 90° | 12:09:22 | 58° | 18:13 | 270° | 19:34 |
| 23 | 04:44 | 06:06 | 90° | 12:09:01 | 58° | 18:13 | 269° | 19:35 |
| 24 | 04:43 | 06:04 | 91° | 12:08:40 | 58° | 18:14 | 269° | 19:35 |
| 25 | 04:41 | 06:03 | 91° | 12:08:19 | 59° | 18:14 | 268° | 19:36 |
| 26 | 04:40 | 06:02 | 92° | 12:07:58 | 59° | 18:15 | 268° | 19:37 |
| 27 | 04:39 | 06:00 | 92° | 12:07:38 | 60° | 18:16 | 268° | 19:38 |
| 28 | 04:37 | 05:59 | 93° | 12:07:18 | 60° | 18:16 | 267° | 19:38 |
| 29 | 04:36 | 05:58 | 93° | 12:06:57 | 60° | 18:17 | 267° | 19:39 |
| 30 | 04:34 | 05:56 | 94° | 12:06:38 | 61° | 18:18 | 266° | 19:40 |

## OCTOBER

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 04:33 | 05:55 | 94° | 12:06:18 | 61° | 18:18 | 266° | 19:41 |
| 2 | 04:32 | 05:54 | 95° | 12:05:59 | 62° | 18:19 | 265° | 19:41 |
| 3 | 04:30 | 05:52 | 95° | 12:05:40 | 62° | 18:20 | 265° | 19:42 |
| 4 | 04:29 | 05:51 | 95° | 12:05:22 | 62° | 18:20 | 264° | 19:43 |
| 5 | 04:27 | 05:50 | 96° | 12:05:04 | 63° | 18:21 | 264° | 19:44 |
| 6 | 04:26 | 05:49 | 96° | 12:04:46 | 63° | 18:22 | 263° | 19:45 |
| 7 | 04:24 | 05:47 | 97° | 12:04:29 | 63° | 18:22 | 263° | 19:45 |
| 8 | 04:23 | 05:46 | 97° | 12:04:12 | 64° | 18:23 | 263° | 19:46 |
| 9 | 04:22 | 05:45 | 98° | 12:03:55 | 64° | 18:24 | 262° | 19:47 |
| 10 | 04:20 | 05:44 | 98° | 12:03:39 | 65° | 18:24 | 262° | 19:48 |
| 11 | 04:19 | 05:42 | 99° | 12:03:23 | 65° | 18:25 | 261° | 19:49 |
| 12 | 04:17 | 05:41 | 99° | 12:03:08 | 65° | 18:26 | 261° | 19:50 |
| 13 | 04:16 | 05:40 | 99° | 12:02:53 | 66° | 18:26 | 260° | 19:51 |
| 14 | 04:15 | 05:39 | 100° | 12:02:39 | 66° | 18:27 | 260° | 19:52 |
| 15 | 04:13 | 05:38 | 100° | 12:02:25 | 66° | 18:28 | 259° | 19:53 |
| 16 | 04:12 | 05:36 | 101° | 12:02:12 | 67° | 18:29 | 259° | 19:53 |
| 17 | 04:10 | 05:35 | 101° | 12:02:00 | 67° | 18:29 | 259° | 19:54 |
| 18 | 04:09 | 05:34 | 102° | 12:01:48 | 68° | 18:30 | 258° | 19:55 |
| 19 | 04:08 | 05:33 | 102° | 12:01:36 | 68° | 18:31 | 258° | 19:56 |
| 20 | 04:06 | 05:32 | 103° | 12:01:26 | 68° | 18:32 | 257° | 19:57 |
| 21 | 04:05 | 05:31 | 103° | 12:01:16 | 69° | 18:32 | 257° | 19:58 |
| 22 | 04:04 | 05:30 | 103° | 12:01:06 | 69° | 18:33 | 256° | 19:59 |
| 23 | 04:02 | 05:29 | 104° | 12:00:57 | 69° | 18:34 | 256° | 20:00 |
| 24 | 04:01 | 05:28 | 104° | 12:00:49 | 70° | 18:35 | 256° | 20:01 |
| 25 | 04:00 | 05:26 | 105° | 12:00:42 | 70° | 18:36 | 255° | 20:02 |
| 26 | 03:59 | 05:25 | 105° | 12:00:35 | 70° | 18:36 | 255° | 20:04 |
| 27 | 03:57 | 05:24 | 105° | 12:00:29 | 71° | 18:37 | 254° | 20:05 |
| 28 | 03:56 | 05:23 | 106° | 12:00:24 | 71° | 18:38 | 254° | 20:06 |
| 29 | 03:55 | 05:22 | 106° | 12:00:20 | 71° | 18:39 | 254° | 20:07 |
| 30 | 03:54 | 05:21 | 107° | 12:00:16 | 72° | 18:40 | 253° | 20:08 |
| 31 | 03:52 | 05:21 | 107° | 12:00:14 | 72° | 18:40 | 253° | 20:09 |

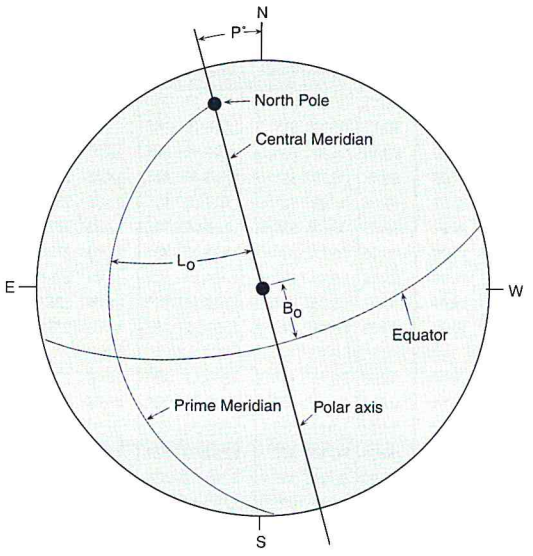
## NOVEMBER

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 03:51 | 05:20 | 107° | 12:00:12 | 72° | 18:41 | 252° | 20:10 |
| 2 | 03:50 | 05:19 | 108° | 12:00:11 | 73° | 18:42 | 252° | 20:11 |
| 3 | 03:49 | 05:18 | 108° | 12:00:10 | 73° | 18:43 | 252° | 20:12 |
| 4 | 03:48 | 05:17 | 109° | 12:00:11 | 73° | 18:44 | 251° | 20:14 |
| 5 | 03:46 | 05:16 | 109° | 12:00:12 | 74° | 18:45 | 251° | 20:15 |
| 6 | 03:45 | 05:15 | 109° | 12:00:14 | 74° | 18:46 | 250° | 20:16 |
| 7 | 03:44 | 05:15 | 110° | 12:00:17 | 74° | 18:46 | 250° | 20:17 |
| 8 | 03:43 | 05:14 | 110° | 12:00:21 | 75° | 18:47 | 250° | 20:18 |
| 9 | 03:42 | 05:13 | 110° | 12:00:26 | 75° | 18:48 | 249° | 20:19 |
| 10 | 03:41 | 05:12 | 111° | 12:00:31 | 75° | 18:49 | 249° | 20:21 |
| 11 | 03:40 | 05:12 | 111° | 12:00:37 | 75° | 18:50 | 249° | 20:22 |
| 12 | 03:39 | 05:11 | 111° | 12:00:44 | 76° | 18:51 | 248° | 20:23 |
| 13 | 03:38 | 05:10 | 112° | 12:00:52 | 76° | 18:52 | 248° | 20:24 |
| 14 | 03:37 | 05:10 | 112° | 12:01:01 | 76° | 18:53 | 248° | 20:25 |
| 15 | 03:36 | 05:09 | 112° | 12:01:11 | 76° | 18:54 | 247° | 20:27 |
| 16 | 03:35 | 05:09 | 113° | 12:01:21 | 77° | 18:55 | 247° | 20:28 |
| 17 | 03:35 | 05:08 | 113° | 12:01:33 | 77° | 18:55 | 247° | 20:29 |
| 18 | 03:34 | 05:07 | 113° | 12:01:45 | 77° | 18:56 | 247° | 20:30 |
| 19 | 03:33 | 05:07 | 114° | 12:01:58 | 77° | 18:57 | 246° | 20:31 |
| 20 | 03:32 | 05:07 | 114° | 12:02:11 | 78° | 18:58 | 246° | 20:33 |
| 21 | 03:32 | 05:06 | 114° | 12:02:26 | 78° | 18:59 | 246° | 20:34 |
| 22 | 03:31 | 05:06 | 114° | 12:02:41 | 78° | 19:00 | 245° | 20:35 |
| 23 | 03:30 | 05:05 | 115° | 12:02:58 | 78° | 19:01 | 245° | 20:36 |
| 24 | 03:30 | 05:05 | 115° | 12:03:14 | 79° | 19:02 | 245° | 20:37 |
| 25 | 03:29 | 05:05 | 115° | 12:03:32 | 79° | 19:03 | 245° | 20:39 |
| 26 | 03:28 | 05:04 | 115° | 12:03:51 | 79° | 19:03 | 244° | 20:40 |
| 27 | 03:28 | 05:04 | 116° | 12:04:10 | 79° | 19:04 | 244° | 20:41 |
| 28 | 03:27 | 05:04 | 116° | 12:04:30 | 79° | 19:05 | 244° | 20:42 |
| 29 | 03:27 | 05:04 | 116° | 12:04:51 | 79° | 19:06 | 244° | 20:43 |
| 30 | 03:26 | 05:04 | 116° | 12:05:12 | 80° | 19:07 | 244° | 20:44 |

## DECEMBER

| | Twi | Rise | Azm | Transit | Alt | Set | Azm | Twi |
|---|---|---|---|---|---|---|---|---|
| 1 | 03:26 | 05:03 | 116° | 12:05:34 | 80° | 19:08 | 243° | 20:45 |
| 2 | 03:26 | 05:03 | 117° | 12:05:57 | 80° | 19:09 | 243° | 20:46 |
| 3 | 03:25 | 05:03 | 117° | 12:06:21 | 80° | 19:09 | 243° | 20:48 |
| 4 | 03:25 | 05:03 | 117° | 12:06:45 | 80° | 19:10 | 243° | 20:49 |
| 5 | 03:25 | 05:03 | 117° | 12:07:09 | 80° | 19:11 | 243° | 20:50 |
| 6 | 03:25 | 05:03 | 117° | 12:07:34 | 81° | 19:12 | 243° | 20:51 |
| 7 | 03:25 | 05:03 | 117° | 12:08:00 | 81° | 19:13 | 242° | 20:52 |
| 8 | 03:25 | 05:03 | 118° | 12:08:26 | 81° | 19:13 | 242° | 20:52 |
| 9 | 03:24 | 05:04 | 118° | 12:08:53 | 81° | 19:14 | 242° | 20:53 |
| 10 | 03:24 | 05:04 | 118° | 12:09:20 | 81° | 19:15 | 242° | 20:54 |
| 11 | 03:24 | 05:04 | 118° | 12:09:47 | 81° | 19:16 | 242° | 20:55 |
| 12 | 03:24 | 05:04 | 118° | 12:10:15 | 81° | 19:16 | 242° | 20:56 |
| 13 | 03:25 | 05:04 | 118° | 12:10:43 | 81° | 19:17 | 242° | 20:57 |
| 14 | 03:25 | 05:05 | 118° | 12:11:12 | 81° | 19:18 | 242° | 20:58 |
| 15 | 03:25 | 05:05 | 118° | 12:11:40 | 81° | 19:18 | 242° | 20:58 |
| 16 | 03:25 | 05:05 | 118° | 12:12:09 | 81° | 19:19 | 242° | 20:59 |
| 17 | 03:25 | 05:05 | 118° | 12:12:39 | 81° | 19:20 | 242° | 21:00 |
| 18 | 03:26 | 05:06 | 118° | 12:13:08 | 81° | 19:20 | 242° | 21:00 |
| 19 | 03:26 | 05:06 | 119° | 12:13:37 | 81° | 19:21 | 241° | 21:01 |
| 20 | 03:26 | 05:07 | 119° | 12:14:07 | 81° | 19:21 | 241° | 21:02 |
| 21 | 03:27 | 05:07 | 119° | 12:14:37 | 81° | 19:22 | 241° | 21:02 |
| 22 | 03:27 | 05:08 | 119° | 12:15:07 | 81° | 19:22 | 241° | 21:03 |
| 23 | 03:28 | 05:08 | 119° | 12:15:36 | 81° | 19:23 | 241° | 21:03 |
| 24 | 03:28 | 05:09 | 119° | 12:16:06 | 81° | 19:23 | 241° | 21:03 |
| 25 | 03:29 | 05:09 | 119° | 12:16:36 | 81° | 19:24 | 242° | 21:04 |
| 26 | 03:30 | 05:10 | 118° | 12:17:06 | 81° | 19:24 | 242° | 21:04 |
| 27 | 03:30 | 05:10 | 118° | 12:17:35 | 81° | 19:24 | 242° | 21:04 |
| 28 | 03:31 | 05:11 | 118° | 12:18:05 | 81° | 19:25 | 242° | 21:05 |
| 29 | 03:32 | 05:12 | 118° | 12:18:34 | 81° | 19:25 | 242° | 21:05 |
| 30 | 03:32 | 05:12 | 118° | 12:19:03 | 81° | 19:25 | 242° | 21:05 |
| 31 | 03:33 | 05:13 | 118° | 12:19:32 | 81° | 19:26 | 242° | 21:05 |

# ORIENTATION OF THE SUN




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

Bo° Heliocentric Latitude of centre of Sun

Lo° 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.

| DATE (0hr UT) | | P° | $B_o$° | $L_o$° |
|---|---|---|---|---|
| Jan | 5 | + 0.19 | - 3.47 | 027.03 |
| | 12 | - 3.18 | - 4.24 | 294.85 |
| | 19 | - 6.45 | - 4.93 | 202.68 |
| | 26 | - 9.58 | - 5.55 | 110.51 |
| Feb | 2 | - 12.51 | - 6.09 | 018.34 |
| | 9 | - 15.22 | - 6.53 | 286.18 |
| | 16 | - 17.68 | - 6.87 | 194.01 |
| | 23 | - 19.86 | - 7.10 | 101.82 |
| Mar | 2 | - 21.74 | - 7.23 | 009.62 |
| | 9 | - 23.31 | - 7.25 | 277.40 |
| | 16 | - 24.56 | - 7.15 | 185.15 |
| | 23 | - 25.48 | - 6.96 | 092.87 |
| | 30 | - 26.06 | - 6.66 | 000.55 |
| Apr | 6 | - 26.29 | - 6.26 | 268.19 |
| | 13 | - 26.16 | - 5.78 | 175.80 |
| | 20 | - 25.68 | - 5.21 | 083.37 |
| | 27 | - 24.83 | - 4.58 | 350.90 |
| May | 4 | - 23.62 | - 3.88 | 258.38 |
| | 11 | - 22.07 | - 3.13 | 165.84 |
| | 18 | - 20.19 | - 2.34 | 073.27 |
| | 25 | - 17.99 | - 1.52 | 340.66 |
| Jun | 1 | - 15.52 | - 0.69 | 248.04 |
| | 8 | - 12.80 | + 0.16 | 155.39 |
| | 15 | - 9.89 | + 1.00 | 062.75 |
| | 22 | - 6.83 | + 1.83 | 330.09 |
| | 29 | - 3.69 | + 2.63 | 237.43 |
| Jul | 6 | - 0.52 | + 3.40 | 144.78 |
| | 13 | + 2.64 | + 4.12 | 052.14 |
| | 20 | + 5.73 | + 4.78 | 319.51 |
| | 27 | + 8.70 | + 5.38 | 226.90 |
| Aug | 3 | + 11.52 | + 5.91 | 134.32 |
| | 10 | + 14.17 | + 6.36 | 041.76 |
| | 17 | + 16.60 | + 6.73 | 309.22 |
| | 24 | + 18.81 | + 7.00 | 216.71 |
| | 31 | + 20.76 | + 7.17 | 124.23 |
| Sep | 7 | + 22.45 | + 7.25 | 031.77 |
| | 14 | + 23.85 | + 7.22 | 299.34 |
| | 21 | + 24.95 | + 7.09 | 206.93 |
| | 28 | + 25.73 | + 6.86 | 114.54 |
| Oct | 5 | + 26.18 | + 6.53 | 022.17 |
| | 12 | + 26.28 | + 6.10 | 289.83 |
| | 19 | + 26.02 | + 5.58 | 197.49 |
| | 26 | + 25.39 | + 4.98 | 105.16 |
| Nov | 2 | + 24.37 | + 4.30 | 012.86 |
| | 9 | + 22.97 | + 3.55 | 280.56 |
| | 16 | + 21.19 | + 2.75 | 188.28 |
| | 23 | + 19.04 | + 1.91 | 096.00 |
| | 30 | + 16.56 | + 1.03 | 003.74 |
| Dec | 7 | + 13.78 | + 0.14 | 271.50 |
| | 14 | + 10.75 | - 0.76 | 179.26 |
| | 21 | + 7.53 | - 1.64 | 087.04 |
| | 28 | + 4.18 | - 2.51 | 354.83 |

## VARIATION OF $L_o$

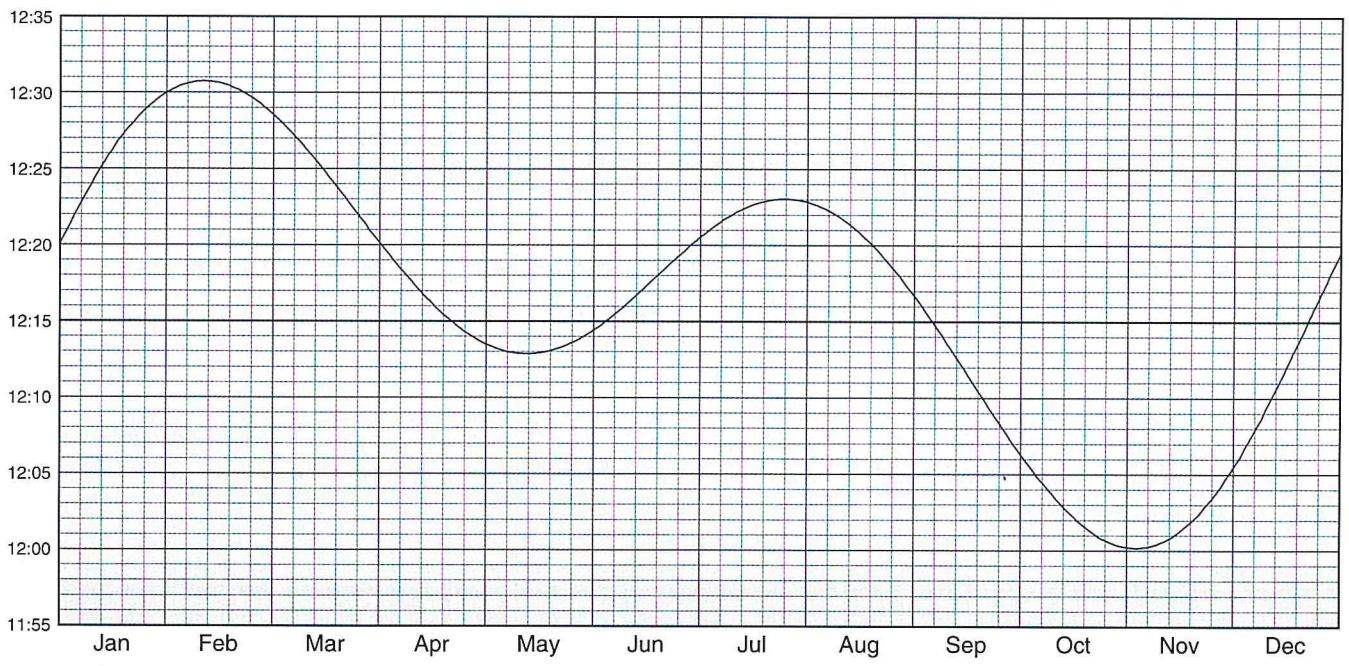
| DAILY | |
|---|---|
| 1 | - 13.18 |
| 2 | - 26.37 |
| 3 | - 39.55 |
| 4 | - 52.73 |
| 5 | - 65.91 |
| 6 | - 79.10 |

| 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 |

## SYNODIC ROTATION NUMBERS (UT)

| | | d.dd |
|---|---|---|
| 1985 | Jan | 7.06 |
| 1986 | Feb | 3.40 |
| 1987 | Mar | 2.73 |
| 1988 | Mar | 30.04 |
| 1989 | Apr | 26.31 |
| 1990 | May | 23.54 |
| 1991 | Jun | 19.74 |
| 1992 | Jul | 16.94 |
| 1993 | Aug | 13.16 |
| 1994 | Sep | 9.41 |
| 1995 | Oct | 6.68 |
| 1996 | Nov | 2.98 |
| 1997 | Nov | 30.29 |
| 1998 | Dec | 27.61 |

# TRANSIT TIME OF THE SUN AT PERTH (WAST)



# MOON RISE & SET PERTH, WAST

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm | h mm |
| 1 | 21 20 | 6 46 | 21 59 | 9 06 | 20 29 | 7 53 | 20 55 | 10 06 | 21 12 | 11 02 | 22 50 | 12 05 |
| 2 | 22 07 | 7 55 | 22 34 | 10 14 | 21 05 | 9 03 | 21 41 | 11 13 | 22 09 | 11 58 | 23 46 | 12 39 |
| 3 | 22 49 | 9 05 | 23 09 | 11 20 | 21 42 | 10 11 | 22 31 | 12 16 | 23 07 | 12 47 | DNR | 13 10 |
| 4 | 23 26 | 10 13 | 23 45 | 12 25 | 22 21 | 11 18 | 23 24 | 13 14 | DNR | 13 30 | 0 41 | 13 38 |
| 5 | DNR | 11 19 | DNR | 13 29 | 23 02 | 12 23 | DNR | 14 06 | 0 04 | 14 07 | 1 35 | 14 05 |
| 6 | 0 00 | 12 24 | 0 23 | 14 31 | 23 48 | 13 26 | 0 20 | 14 51 | 1 01 | 14 39 | 2 28 | 14 33 |
| 7 | 0 34 | 13 28 | 1 05 | 15 32 | DNR | 14 25 | 1 16 | 15 31 | 1 56 | 15 09 | 3 23 | 15 01 |
| 8 | 1 08 | 14 31 | 1 51 | 16 29 | 0 38 | 15 20 | 2 13 | 16 05 | 2 50 | 15 36 | 4 18 | 15 32 |
| 9 | 1 44 | 15 35 | 2 42 | 17 22 | 1 31 | 16 08 | 3 08 | 16 37 | 3 43 | 16 03 | 5 16 | 16 06 |
| 10 | 2 23 | 16 37 | 3 36 | 18 09 | 2 26 | 16 51 | 4 03 | 17 06 | 4 37 | 16 31 | 6 16 | 16 46 |
| 11 | 3 07 | 17 37 | 4 32 | 18 51 | 3 22 | 17 29 | 4 56 | 17 33 | 5 32 | 17 00 | 7 18 | 17 32 |
| 12 | 3 55 | 18 34 | 5 28 | 19 28 | 4 18 | 18 03 | 5 50 | 18 00 | 6 28 | 17 32 | 8 18 | 18 25 |
| 13 | 4 47 | 19 26 | 6 24 | 20 01 | 5 14 | 18 33 | 6 44 | 18 28 | 7 27 | 18 08 | 9 16 | 19 25 |
| 14 | 5 42 | 20 12 | 7 19 | 20 31 | 6 08 | 19 02 | 7 39 | 18 58 | 8 27 | 18 50 | 10 09 | 20 30 |
| 15 | 6 39 | 20 52 | 8 13 | 20 59 | 7 01 | 19 29 | 8 35 | 19 32 | 9 27 | 19 38 | 10 56 | 21 36 |
| 16 | 7 36 | 21 28 | 9 06 | 21 26 | 7 55 | 19 57 | 9 34 | 20 09 | 10 26 | 20 32 | 11 38 | 22 43 |
| 17 | 8 32 | 22 00 | 10 00 | 21 54 | 8 49 | 20 26 | 10 33 | 20 52 | 11 21 | 21 33 | 12 16 | 23 49 |
| 18 | 9 26 | 22 29 | 10 54 | 22 24 | 9 44 | 20 56 | 11 33 | 21 41 | 12 12 | 22 37 | 12 50 | DNS |
| 19 | 10 20 | 22 57 | 11 49 | 22 56 | 10 40 | 21 31 | 12 30 | 22 38 | 12 57 | 23 44 | 13 24 | 0 55 |
| 20 | 11 13 | 23 25 | 12 47 | 23 32 | 11 39 | 22 10 | 13 24 | 23 40 | 13 37 | DNS | 13 57 | 2 01 |
| 21 | 12 07 | 23 54 | 13 47 | DNS | 12 39 | 22 55 | 14 13 | DNS | 14 14 | 0 51 | 14 33 | 3 07 |
| 22 | 13 02 | DNS | 14 49 | 0 14 | 13 38 | 23 48 | 14 58 | 0 46 | 14 49 | 1 58 | 15 12 | 4 14 |
| 23 | 14 00 | 0 24 | 15 50 | 1 04 | 14 36 | DNS | 15 38 | 1 54 | 15 23 | 3 04 | 15 56 | 5 21 |
| 24 | 15 00 | 0 59 | 16 48 | 2 01 | 15 30 | 0 47 | 16 15 | 3 03 | 15 58 | 4 12 | 16 45 | 6 27 |
| 25 | 16 03 | 1 39 | 17 42 | 3 06 | 16 19 | 1 53 | 16 51 | 4 13 | 16 36 | 5 20 | 17 40 | 7 30 |
| 26 | 17 07 | 2 26 | 18 30 | 4 17 | 17 03 | 3 03 | 17 27 | 5 22 | 17 18 | 6 30 | 18 38 | 8 27 |
| 27 | 18 09 | 3 20 | 19 14 | 5 29 | 17 44 | 4 14 | 18 04 | 6 32 | 18 05 | 7 38 | 19 38 | 9 17 |
| 28 | 19 06 | 4 23 | 19 53 | 6 42 | 18 21 | 5 26 | 18 45 | 7 42 | 18 57 | 8 44 | 20 37 | 10 00 |
| 29 | 19 57 | 5 32 | | | 18 58 | 6 37 | 19 29 | 8 52 | 19 54 | 9 45 | 21 35 | 10 37 |
| 30 | 20 43 | 6 44 | | | 19 35 | 7 47 | 20 18 | 9 59 | 20 53 | 10 38 | 22 31 | 11 10 |
| 31 | 21 23 | 7 56 | | | 20 13 | 8 57 | | | 21 52 | 11 25 | | |

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 25 | 11 39 | DNR | 11 30 | 1 35 | 11 51 | 2 17 | 12 25 | 3 08 | 14 36 | 2 49 | 15 43 |
| 2 | DNR | 12 07 | 0 52 | 12 00 | 2 35 | 12 41 | 3 08 | 13 30 | 3 44 | 15 45 | 3 24 | 16 53 |
| 3 | 0 19 | 12 34 | 1 49 | 12 35 | 3 33 | 13 39 | 3 54 | 14 38 | 4 18 | 16 55 | 4 03 | 18 04 |
| 4 | 1 12 | 13 01 | 2 48 | 13 15 | 4 28 | 14 43 | 4 35 | 15 49 | 4 54 | 18 06 | 4 46 | 19 16 |
| 5 | 2 07 | 13 31 | 3 49 | 14 02 | 5 18 | 15 52 | 5 14 | 17 00 | 5 32 | 19 19 | 5 36 | 20 25 |
| 6 | 3 04 | 14 03 | 4 50 | 14 56 | 6 03 | 17 03 | 5 50 | 18 10 | 6 13 | 20 31 | 6 33 | 21 27 |
| 7 | 4 02 | 14 40 | 5 48 | 15 58 | 6 44 | 18 15 | 6 25 | 19 22 | 7 00 | 21 41 | 7 33 | 22 21 |
| 8 | 5 03 | 15 24 | 6 41 | 17 06 | 7 21 | 19 25 | 7 02 | 20 33 | 7 53 | 22 46 | 8 36 | 23 07 |
| 9 | 6 05 | 16 14 | 7 30 | 18 16 | 7 57 | 20 35 | 7 42 | 21 44 | 8 51 | 23 42 | 9 39 | 23 46 |
| 10 | 7 05 | 17 13 | 8 12 | 19 26 | 8 32 | 21 44 | 8 25 | 22 54 | 9 51 | DNS | 10 39 | DNS |
| 11 | 8 01 | 18 17 | 8 50 | 20 36 | 9 09 | 22 53 | 9 14 | 23 59 | 10 52 | 0 31 | 11 36 | 0 19 |
| 12 | 8 52 | 19 25 | 9 26 | 21 44 | 9 49 | DNS | 10 07 | DNS | 11 52 | 1 12 | 12 31 | 0 48 |
| 13 | 9 37 | 20 33 | 10 00 | 22 51 | 10 33 | 0 01 | 11 04 | 0 58 | 12 50 | 1 48 | 13 25 | 1 16 |
| 14 | 10 16 | 21 41 | 10 35 | 23 58 | 11 21 | 1 07 | 12 03 | 1 50 | 13 45 | 2 19 | 14 18 | 1 42 |
| 15 | 10 52 | 22 48 | 11 11 | DNS | 12 15 | 2 08 | 13 02 | 2 34 | 14 39 | 2 47 | 15 12 | 2 09 |
| 16 | 11 26 | 23 54 | 11 51 | 1 04 | 13 11 | 3 03 | 14 00 | 3 12 | 15 33 | 3 13 | 16 08 | 2 37 |
| 17 | 11 59 | DNS | 12 36 | 2 10 | 14 10 | 3 52 | 14 57 | 3 46 | 16 26 | 3 40 | 17 05 | 3 08 |
| 18 | 12 34 | 0 59 | 13 25 | 3 13 | 15 08 | 4 34 | 15 51 | 4 15 | 17 21 | 4 07 | 18 04 | 3 42 |
| 19 | 13 11 | 2 05 | 14 19 | 4 12 | 16 06 | 5 10 | 16 45 | 4 43 | 18 17 | 4 36 | 19 03 | 4 22 |
| 20 | 13 52 | 3 11 | 15 17 | 5 05 | 17 02 | 5 42 | 17 39 | 5 10 | 19 15 | 5 08 | 20 01 | 5 09 |
| 21 | 14 39 | 4 16 | 16 16 | 5 52 | 17 56 | 6 12 | 18 32 | 5 36 | 20 13 | 5 44 | 20 56 | 6 02 |
| 22 | 15 30 | 5 19 | 17 15 | 6 33 | 18 50 | 6 39 | 19 27 | 6 04 | 21 12 | 6 26 | 21 46 | 7 02 |
| 23 | 16 26 | 6 17 | 18 12 | 7 08 | 19 44 | 7 06 | 20 23 | 6 34 | 22 08 | 7 14 | 22 30 | 8 05 |
| 24 | 17 25 | 7 09 | 19 08 | 7 40 | 20 37 | 7 33 | 21 21 | 7 07 | 23 00 | 8 09 | 23 09 | 9 10 |
| 25 | 18 25 | 7 55 | 20 02 | 8 09 | 21 32 | 8 01 | 22 19 | 7 45 | 23 47 | 9 09 | 23 44 | 10 15 |
| 26 | 19 24 | 8 34 | 20 56 | 8 36 | 22 29 | 8 32 | 23 17 | 8 28 | DNR | 10 12 | DNR | 11 20 |
| 27 | 20 21 | 9 08 | 21 49 | 9 03 | 23 27 | 9 06 | DNR | 9 18 | 0 29 | 11 17 | 0 17 | 12 25 |
| 28 | 21 16 | 9 39 | 22 43 | 9 30 | DNR | 9 46 | 0 11 | 10 14 | 1 07 | 12 22 | 0 49 | 13 30 |
| 29 | 22 10 | 10 07 | 23 39 | 10 00 | 0 25 | 10 32 | 1 02 | 11 16 | 1 42 | 13 28 | 1 22 | 14 37 |
| 30 | 23 03 | 10 34 | DNR | 10 32 | 1 22 | 11 25 | 1 48 | 12 21 | 2 15 | 14 35 | 1 58 | 15 45 |
| 31 | 23 57 | 11 01 | 0 36 | 11 09 | | | 2 30 | 13 28 | | | 2 38 | 16 55 |

**Note:** DNR means Moon does not rise on that day, DNS means Moon does not set. See explanation p. 64.

## MOON DISTANCE (WAST)

| APOGEE | | PERIGEE | |
|---|---|---|---|
| | d hh | | d hh |
| Jan | 18 17 | Jan | 2 15 |
| Feb | 15 06 | Jan | 30 17 |
| Mar | 14 09 | Feb | 28 04 |
| Apr | 10 13 | Mar | 28 16 |
| May | 8 03 | Apr | 26 00 |
| Jun | 4 21 | May | 24 00 |
| Jul | 2 16 | Jun | 19 15 |
| Jul | 30 10 | Jul | 14 21 |
| Aug | 27 02 | Aug | 11 07 |
| Sep | 23 11 | Sep | 8 11 |
| Oct | 20 13 | Oct | 6 21 |
| Nov | 16 19 | Nov | 4 09 |
| Dec | 14 12 | Dec | 2 17 |
| | | Dec | 30 09 |

## MOON PHASES (WAST)

| Lunation | New Moon | | First Quarter | | Full Moon | | Last Quarter | |
|---|---|---|---|---|---|---|---|---|
| | d | h m | d | h m | d | h m | d | h m |
| 977 | | | | | | | Jan 06 | 11:55 |
| 978 | Jan 13 | 21:29 | Jan 22 | 01:46 | Jan 29 | 06:50 | Feb 04 | 21:33 |
| 979 | Feb 12 | 15:41 | Feb 20 | 20:02 | Feb 27 | 17:17 | Mar 06 | 09:24 |
| 980 | Mar 14 | 10:02 | Mar 22 | 10:28 | Mar 29 | 02:25 | Apr 04 | 23:29 |
| 981 | Apr 13 | 03:21 | Apr 20 | 20:48 | Apr 27 | 11:00 | May 04 | 15:16 |
| 982 | May 12 | 18:45 | May 20 | 03:42 | May 26 | 19:51 | Jun 03 | 08:05 |
| 983 | Jun 11 | 07:46 | Jun 18 | 08:29 | Jun 25 | 05:42 | Jul 03 | 01:19 |
| 984 | Jul 10 | 18:26 | Jul 17 | 12:47 | Jul 24 | 17:07 | Aug 01 | 18:22 |
| 985 | Aug 09 | 03:15 | Aug 15 | 18:12 | Aug 23 | 06:29 | Aug 31 | 10:31 |
| 986 | Sep 07 | 11:10 | Sep 14 | 02:08 | Sep 21 | 21:59 | Sep 30 | 01:03 |
| 987 | Oct 06 | 19:18 | Oct 13 | 13:33 | Oct 21 | 15:20 | Oct 29 | 13:28 |
| 988 | Nov 05 | 04:34 | Nov 12 | 04:52 | Nov 20 | 09:34 | Nov 27 | 23:46 |
| 989 | Dec 04 | 15:34 | Dec 11 | 23:49 | Dec 20 | 03:10 | Dec 27 | 08:31 |

# LUNAR OCCULTATIONS 2002

## 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 table presents the easier to observe occultations for 2002 as predicted for **Perth.** 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 (p. 109).

## LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following page, 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

**WAST** the date and time of the occultation, hr & min are in WAST

**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 Messier (Mnnn) 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 lunar 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 Perth. The formula is:

Predicted Time at your location

= Time from Table + ( A x n ) + ( B x 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 ZC 882 on February 22 for their location in Wagin (117° 20' E, 33° 19' S, see page 103).

-The change in longitude from Perth (decimal degrees)

= 115°.85 - 117°.33 = + 1°.48 — 'n' (+)

-The change in latitude from Perth (decimal degrees)

= 31°.95 - 33°.32 = - 1°.37 — 'p' (-)

From the table, the time of the event is 20:30 WAST and the values of A and B are +2.5 and –0.1 respectively.

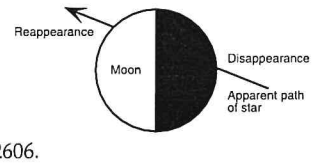
Therefore the equation becomes :-

20:30 + (+2.5 × 1°.48 ) + (–0.1 × –1°.37 )

= 20:30 + ( +3.7 ) + ( +0.1 )

= 20:30 + 3.8 = 20:34

The event will be visible from Wagin approximately 4 mins later than Perth, i.e., about 8:34pm (WAST) on February 22.




Lunar occultation predictions were calculated using Occult version 4 by D.Herald, PO Box 254 Woden ACT 2606. heraldd@canberra.DIALix.oz.au

# LUNAR OCCULTATION TABLE

# PERTH (31° 57' S, 115° 51'E)

| WAST | OBJECT | PD | Mag | Elg | Alt | PA | A | B |
|---|---|---|---|---|---|---|---|---|
| Jan 01 23:22 | 1334 | RD | 7.0 | 150 | 20 | 280 | +1.4 | -1.1 |
| Jan 05 04:05 | 119134 | RD | 7.3 | 107 | 48 | 359 | +0.2 | -3.5 |
| Jan 19 20:32 | 49 | DD | 6.1 | 65 | 29 | 67 | +1.0 | +1.8 |
| Jan 21 21:19 | 281 | DD | 7.4 | 88 | 30 | 94 | +1.7 | +1.0 |
| Jan 23 21:46 | 505 | DD | 7.0 | 111 | 32 | 100 | +2.2 | +0.5 |
| Jan 24 22:06 | 646 | DD | 6.1 | 123 | 32 | 21 | +1.8 | +3.0 |
| Jan 26 21:27 | 78231 | DD | 7.5 | 148 | 32 | 57 | +2.0 | +0.6 |
| Jan 27 00:20 | 977 | DD | 6.3 | 149 | 26 | 60 | +2.2 | +1.6 |
| Jan 27 21:31 | 1117 | DD | 5.0 | 161 | 28 | 51 | +1.6 | +0.6 |
| Feb 03 04:26 | 139336 | RD | 7.1 | 112 | 61 | 270 | +2.7 | -0.2 |
| Feb 04 00:51 | 2035 | RD | 7.2 | 100 | 21 | 266 | +0.7 | -1.0 |
| Feb 04 02:54 | 2043 | RD | 6.5 | 100 | 46 | 283 | +1.5 | -1.3 |
| Feb 04 03:18 | 2047 | RD | 6.6 | 99 | 50 | 274 | +1.9 | -1.0 |
| Feb 05 02:30 | 159050 | RD | 7.5 | 87 | 33 | 242 | +1.8 | +0.1 |
| Feb 07 04:25 | 2445 | RD | 7.3 | 61 | 39 | 274 | +1.1 | -1.2 |
| Feb 21 22:01 | 739 | DD | 7.2 | 102 | 21 | 83 | +1.7 | +1.1 |
| Feb 22 20:30 | 882 | RB | 5.0 | 114 | 33 | 281 | +2.5 | -0.1 |
| Feb 23 21:02 | 78827 | DD | 7.4 | 127 | 33 | 75 | +2.4 | +0.5 |
| Feb 23 22:31 | 1055 | DD | 5.7 | 127 | 29 | 50 | +2.7 | +2.0 |
| Feb 25 00:16 | 79868 | DD | 7.4 | 141 | 26 | 125 | +1.2 | -0.3 |
| Feb 27 01:12 | 1484 | DD | 3.5 | 169 | 38 | 181 | -0.5 | -3.4 |
| Feb 27 01:48 | 1484 | RB | 3.5 | 169 | 35 | 239 | +3.4 | +2.7 |
| Mar 01 01:18 | 1739 | RD | 6.4 | 160 | 52 | 265 | +2.7 | 0.0 |
| Mar 01 22:44 | 1854 | RD | 6.8 | 147 | 27 | 296 | +0.8 | -1.6 |
| Mar 05 01:04 | 2246 | RD | 7.3 | 106 | 32 | 299 | +0.5 | -1.7 |
| Mar 05 04:47 | 2259 | RD | 6.8 | 105 | 74 | 240 | +3.9 | +2.3 |
| Mar 06 01:26 | 2394 | RD | 6.2 | 93 | 28 | 327 | -0.2 | -2.4 |
| Mar 08 02:11 | 2689 | RD | 6.8 | 69 | 17 | 252 | +0.4 | -0.6 |
| Mar 08 02:30 | 2692 | RD | 5.5 | 69 | 21 | 277 | +0.2 | -1.2 |
| Mar 08 02:44 | 2694 | RD | 6.5 | 69 | 24 | 237 | +1.0 | 0.0 |
| Mar 23 23:24 | 79521 | DD | 7.4 | 108 | 13 | 68 | +1.6 | +1.8 |
| Mar 25 20:08 | 1408 | DD | 7.4 | 134 | 34 | 104 | +2.1 | -0.9 |
| Mar 25 20:21 | 80882 | DD | 7.3 | 134 | 35 | 34 | +4.2 | +4.9 |
| Mar 28 02:02 | 1689 | DD | 5.2 | 164 | 37 | 126 | +1.1 | -0.5 |
| Mar 29 23:43 | 139336 | RD | 7.1 | 166 | 54 | 314 | +1.3 | -1.8 |
| Mar 30 20:40 | 2043 | RD | 6.5 | 154 | 13 | 327 | -0.1 | -2.0 |
| Mar 30 21:02 | 2047 | RD | 6.6 | 154 | 17 | 314 | +0.1 | -1.8 |
| Apr 01 00:56 | 159188 | RD | 7.4 | 139 | 57 | 312 | +1.1 | -2.0 |
| Apr 01 01:09 | 2193 | RD | 6.1 | 139 | 60 | 282 | +1.8 | -1.1 |
| Apr 02 02:01 | 159860 | RD | 7.4 | 125 | 61 | 251 | +2.7 | +0.3 |
| Apr 02 03:17 | 2353 | DB | 4.5 | 124 | 75 | 57 | +3.7 | +2.3 |
| Apr 02 04:04 | 2353 | RD | 4.5 | 124 | 78 | 350 | +0.8 | -5.0 |
| Apr 03 05:04 | 2504 | RD | 7.4 | 111 | 81 | 308 | +2.2 | -1.9 |
| Apr 05 01:11 | 187779 | RD | 7.4 | 88 | 19 | 294 | -0.1 | -1.7 |
| Apr 05 03:16 | 2811 | RD | 6.2 | 88 | 45 | 330 | +0.1 | -4.2 |
| Apr 19 19:10 | 1085 | DD | 7.1 | 76 | 28 | 58 | +2.7 | +1.7 |
| Apr 21 22:19 | 1373 | DD | 6.5 | 103 | 23 | 54 | +3.1 | +3.2 |
| Apr 23 23:43 | 1621 | DD | 7.2 | 130 | 35 | 113 | +1.4 | 0.0 |
| Apr 24 22:17 | 1739 | DD | 6.4 | 144 | 53 | 144 | +1.3 | -1.7 |
| Apr 25 19:46 | 1854 | DD | 6.8 | 157 | 35 | 95 | +1.4 | -1.1 |
| Apr 25 23:28 | 1867 | DD | 7.5 | 158 | 59 | 172 | +0.4 | -2.9 |
| Apr 27 02:13 | 2008 | DD | 6.6 | 173 | 51 | 155 | +1.0 | -2.0 |
| Apr 28 23:48 | 2259 | RD | 6.8 | 159 | 61 | 298 | +1.4 | -1.6 |
| Apr 29 01:24 | 159551 | RD | 7.2 | 158 | 76 | 252 | +3.0 | +0.9 |
| Apr 30 00:01 | 2415 | RD | 7.3 | 145 | 54 | 244 | +2.5 | +0.4 |
| Apr 30 21:42 | 185674 | RD | 7.3 | 133 | 15 | 255 | +0.3 | -0.6 |
| May 02 03:32 | 187431 | RD | 7.3 | 119 | 75 | 287 | +2.3 | -1.3 |
| May 02 04:24 | 187465 | RD | 7.4 | 118 | 83 | 222 | +2.6 | +3.2 |
| May 02 04:44 | 2756 | RD | 7.5 | 118 | 82 | 330 | +2.8 | -5.4 |
| May 03 05:30 | 2907 | RD | 6.2 | 106 | 82 | 264 | +2.6 | +0.3 |
| May 04 03:39 | 189680 | RD | 7.3 | 95 | 54 | 204 | +2.3 | +3.7 |
| May 05 03:38 | 164516 | RD | 6.9 | 84 | 42 | 304 | +1.3 | -3.3 |
| May 05 05:48 | 164567 | RD | 7.3 | 83 | 68 | 193 | +1.4 | +4.7 |
| May 18 21:37 | 1334 | DD | 7.0 | 73 | 10 | 147 | 0.0 | -0.8 |
| May 20 18:59 | 1570 | DD | 5.5 | 98 | 44 | 93 | +2.6 | -0.2 |
| May 20 20:09 | 1570 | RB | 5.5 | 99 | 42 | 334 | +0.9 | -1.7 |
| May 21 18:57 | 118986 | DD | 7.3 | 112 | 47 | 87 | +2.6 | -0.3 |
| May 21 23:45 | 119038 | DD | 6.9 | 113 | 25 | 200 | -2.3 | -8.5 |
| May 22 19:48 | 119485 | DD | 7.0 | 126 | 53 | 113 | +1.9 | -1.2 |
| May 22 22:06 | 1813 | DD | 5.7 | 126 | 52 | 72 | +3.3 | +1.8 |
| May 24 00:53 | 1950 | DD | 5.7 | 141 | 39 | 153 | +0.9 | -1.6 |
| May 25 20:36 | 159188 | DD | 7.4 | 167 | 48 | 79 | +1.9 | -0.5 |
| May 25 20:40 | 2193 | DD | 6.1 | 167 | 49 | 112 | +1.2 | -1.5 |
| May 26 01:42 | 2209 | DD | 5.6 | 169 | 57 | 149 | +1.5 | -2.0 |
| May 26 02:49 | 2213 | DD | 5.8 | 170 | 44 | 81 | +1.4 | +1.4 |
| May 26 03:59 | 2218 | DD | 5.5 | 170 | 29 | 97 | +0.8 | +0.8 |
| May 26 05:05 | 159358 | DD | 7.2 | 171 | 16 | 130 | +0.5 | -0.3 |
| May 28 04:39 | 185466 | RD | 7.4 | 163 | 47 | 223 | +0.7 | +3.4 |
| May 29 03:20 | 186864 | RD | 7.6 | 150 | 75 | 227 | +2.1 | +2.9 |
| May 30 00:15 | 2834 | DB | 5.0 | 139 | 50 | 64 | +1.9 | +0.2 |
| May 30 01:17 | 2835 | RD | 7.3 | 139 | 63 | 330 | +1.2 | -5.2 |
| May 30 01:29 | 2834 | RD | 5.0 | 139 | 66 | 300 | +1.9 | -2.2 |
| Jun 01 00:39 | 3106 | DB | 5.2 | 115 | 32 | 143 | 0.0 | -4.8 |
| Jun 01 01:14 | 3106 | RD | 5.2 | 115 | 40 | 198 | +2.0 | +3.8 |
| Jun 01 03:33 | 3116 | RD | 6.6 | 114 | 68 | 239 | +2.2 | +1.0 |
| Jun 01 23:54 | 164829 | RD | 7.1 | 104 | 12 | 276 | +0.1 | -1.3 |
| Jun 01 23:55 | 3228 | RD | 7.2 | 104 | 12 | 276 | +0.1 | -1.3 |
| Jun 02 03:42 | 3243 | RD | 7.3 | 103 | 58 | 273 | +2.4 | -1.0 |
| Jun 04 03:23 | 3490 | RD | 7.2 | 80 | 32 | 186 | +0.6 | +3.8 |
| Jun 07 05:17 | 281 | RD | 7.4 | 47 | 22 | 244 | +0.8 | -0.1 |
| Jun 17 17:56 | 1651 | RB | 3.9 | 82 | 48 | 348 | +0.6 | -2.5 |
| Jun 19 21:19 | 139236 | DD | 7.1 | 110 | 53 | 157 | +0.9 | -2.1 |
| Jun 25 21:27 | 187431 | RD | 7.3 | 171 | 44 | 277 | +1.1 | -1.2 |
| Jun 25 22:06 | 187465 | RD | 7.4 | 171 | 52 | 218 | +2.8 | +2.6 |
| Jun 25 22:24 | 2756 | RD | 7.5 | 171 | 55 | 332 | +0.5 | -4.4 |
| Jun 25 23:46 | 2761 | RD | 6.6 | 170 | 72 | 275 | +2.2 | -0.7 |
| Jun 26 01:06 | 2767 | RD | 6.3 | 170 | 83 | 261 | +2.5 | +0.5 |
| Jun 26 02:26 | 2771 | RD | 5.6 | 169 | 70 | 273 | +2.3 | +0.4 |
| Jun 26 04:18 | 187660 | RD | 7.3 | 169 | 48 | 284 | +1.6 | +0.4 |
| Jun 26 05:39 | 2790 | RD | 6.3 | 168 | 31 | 259 | +0.5 | +1.3 |
| Jun 26 22:22 | 2907 | RD | 6.2 | 158 | 43 | 270 | +1.2 | -1.0 |
| Jun 29 02:16 | 3191 | RD | 7.4 | 133 | 67 | 253 | +2.4 | +0.3 |
| Jun 30 03:36 | 3323 | RD | 7.5 | 122 | 69 | 207 | +1.5 | +2.8 |
| Jul 16 20:25 | 1867 | DD | 7.5 | 80 | 40 | 119 | +1.3 | -0.3 |
| Jul 18 21:59 | 2110 | DD | 6.3 | 107 | 49 | 77 | +1.9 | +1.7 |
| Jul 23 03:03 | 2719 | DD | 5.8 | 160 | 37 | 159 | +4.9 | -7.2 |
| Jul 26 03:11 | 3150 | RD | 6.6 | 163 | 65 | 270 | +2.4 | +0.7 |
| Jul 26 03:52 | 164449 | RD | 7.2 | 163 | 57 | 214 | +0.7 | +2.8 |
| Jul 26 22:55 | 3265 | RD | 6.5 | 153 | 42 | 297 | +1.5 | -3.0 |
| Jul 27 00:25 | 164984 | RD | 7.1 | 153 | 60 | 188 | +1.1 | +4.7 |
| Jul 27 05:38 | 3284 | RD | 7.0 | 151 | 42 | 222 | +0.6 | +2.3 |
| Jul 29 00:04 | 3506 | RD | 6.1 | 130 | 34 | 308 | +2.2 | -5.6 |
| Jul 29 23:41 | 66 | RD | 7.1 | 119 | 18 | 221 | +0.5 | +0.7 |
| Jul 30 05:28 | 83 | RD | 6.6 | 118 | 55 | 244 | +2.2 | +1.5 |
| Jul 31 00:36 | 192 | DB | 5.1 | 108 | 18 | 92 | +0.9 | -1.4 |
| Jul 31 01:36 | 192 | RD | 5.1 | 108 | 30 | 203 | +0.5 | +1.8 |
| Aug 01 02:48 | 300 | RD | 7.5 | 96 | 32 | 278 | +2.2 | -1.6 |
| Aug 04 05:26 | 76645 | RD | 7.1 | 62 | 25 | 197 | +0.1 | +1.9 |
| Aug 13 18:48 | 1950 | DD | 5.7 | 63 | 47 | 99 | +1.8 | +0.4 |
| Aug 13 19:55 | 1950 | RB | 5.7 | 64 | 34 | 323 | +0.9 | -1.1 |
| Aug 15 18:58 | 2197 | DD | 7.6 | 90 | 70 | 153 | +1.4 | -2.6 |
| Aug 15 21:38 | 2209 | DD | 5.6 | 91 | 40 | 84 | +1.3 | +1.3 |
| Aug 15 22:42 | 2209 | RB | 5.6 | 92 | 27 | 310 | +0.9 | -0.4 |
| Aug 18 22:23 | 2659 | DD | 6.2 | 129 | 68 | 94 | +2.2 | +0.4 |
| Aug 19 20:14 | 187895 | DD | 7.5 | 141 | 69 | 55 | +2.6 | +1.4 |
| Aug 20 01:56 | 2834 | DD | 5.0 | 142 | 36 | 88 | +0.9 | +1.1 |
| Aug 20 02:02 | 2835 | DD | 7.3 | 143 | 35 | 68 | +0.5 | +1.7 |
| Aug 21 22:45 | 3092 | DD | 6.2 | 165 | 75 | 44 | +2.1 | +2.1 |
| Aug 24 04:07 | 3356 | DD | 5.8 | 169 | 43 | 341 | -3.0 | +7.1 |
| Aug 24 04:25 | 3356 | RD | 5.8 | 169 | 39 | 312 | +4.6 | -2.9 |
| Aug 25 01:20 | 146786 | RD | 7.4 | 159 | 65 | 266 | +3.0 | +0.1 |
| Aug 25 01:38 | 3478 | RD | 6.4 | 159 | 66 | 303 | +6.7 | -4.8 |
| Aug 26 02:01 | 128698 | RD | 7.0 | 148 | 60 | 272 | +3.3 | -0.3 |
| Aug 27 04:49 | 157 | RD | 7.3 | 137 | 47 | 285 | +3.4 | +0.1 |
| Aug 28 03:17 | 269 | RD | 7.0 | 126 | 50 | 206 | +1.1 | +2.2 |
| Sep 01 04:41 | NGC174 | RD | 8.0 | 81 | 27 | 275 | +2.3 | -1.0 |
| Sep 01 05:40 | 76952 | RD | 7.3 | 81 | 32 | 241 | +2.0 | +0.5 |
| Sep 03 05:01 | 1062 | RD | 6.4 | 57 | 14 | 266 | +1.2 | -0.9 |
| Sep 10 19:52 | 2032 | DD | 7.2 | 47 | 22 | 113 | +0.6 | +0.2 |
| Sep 12 19:54 | 2302 | DD | 2.6 | 73 | 49 | 91 | +1.6 | +0.9 |
| Sep 12 19:54 | 2303 | DD | 4.8 | 73 | 49 | 90 | +1.5 | +0.9 |
| Sep 12 20:11 | 159684 | DD | 7.5 | 74 | 45 | 56 | +1.2 | +3.0 |
| Sep 12 21:05 | 2303 | RB | 4.8 | 74 | 34 | 296 | +1.1 | +0.1 |
| Sep 12 21:05 | 2302 | RB | 2.6 | 74 | 33 | 296 | +1.1 | +0.1 |
| Sep 13 19:44 | 2450 | DD | 7.5 | 86 | 63 | 116 | +2.1 | -0.5 |
| Sep 14 21:32 | 186240 | DD | 7.3 | 99 | 53 | 44 | +1.0 | +3.2 |
| Sep 15 22:24 | 2780 | DD | 7.1 | 112 | 54 | 120 | +2.4 | -0.6 |
| Sep 16 00:33 | 2790 | DD | 6.3 | 113 | 28 | 22 | -0.7 | +3.4 |
| Sep 16 00:40 | 2792 | DD | 6.9 | 113 | 26 | 139 | +1.8 | -1.3 |
| Sep 18 23:08 | 164637 | DD | 7.5 | 147 | 71 | 15 | +0.6 | +3.9 |
| Sep 18 23:41 | 3191 | DD | 7.4 | 147 | 66 | 124 | +4.8 | -2.5 |
| Sep 19 19:03 | 3304 | DD | 6.4 | 157 | 35 | 63 | +1.2 | 0.0 |
| Sep 20 21:08 | 3428 | DD | 5.0 | 168 | 49 | 52 | +1.6 | +0.8 |
| Sep 20 22:36 | 3428 | RB | 5.0 | 169 | 64 | 241 | +2.2 | +1.0 |
| Sep 21 02:21 | 3446 | DD | 7.2 | 170 | 46 | 349 | -1.2 | +4.9 |
| Sep 22 21:23 | 95 | RD | 7.0 | 168 | 30 | 241 | +1.1 | +0.1 |
| Sep 23 21:02 | 212 | RD | 7.2 | 158 | 15 | 263 | +0.7 | -0.9 |
| Sep 24 04:24 | 237 | RD | 7.0 | 155 | 36 | 200 | +1.0 | +2.9 |
| Sep 25 23:07 | 445 | RD | 7.3 | 135 | 17 | 175 | -1.1 | +3.9 |
| Sep 26 02:49 | 450 | RD | 6.4 | 134 | 42 | 225 | +1.8 | +1.4 |
| Sep 28 00:47 | 709 | DB | 4.3 | 112 | 13 | 42 | +0.3 | +0.5 |
| Sep 28 01:56 | 709 | RD | 4.3 | 112 | 24 | 267 | +1.8 | -0.8 |
| Sep 28 01:56 | 76720 | RD | 7.0 | 112 | 24 | 267 | +1.8 | -0.8 |
| Sep 28 02:53 | 76729 | RD | 6.9 | 112 | 30 | 227 | +1.4 | +0.7 |
| Oct 13 20:05 | 2879 | DD | 6.7 | 93 | 68 | 110 | +2.7 | -0.5 |
| Oct 14 20:40 | 3009 | DD | 7.4 | 105 | 70 | 5 | -0.2 | +5.9 |
| Oct 15 21:33 | 164449 | DD | 7.2 | 117 | 68 | 28 | +1.0 | +3.1 |
| Oct 16 00:55 | 164516 | DD | 6.9 | 118 | 27 | 77 | +0.5 | +1.4 |
| Oct 16 01:30 | 164524 | DD | 7.2 | 118 | 19 | 20 | -0.5 | +2.6 |
| Oct 16 23:41 | 3284 | DD | 7.0 | 129 | 49 | 55 | +1.1 | +2.0 |
| Oct 18 02:54 | 3409 | DD | 7.0 | 141 | 16 | 355 | -0.8 | +4.0 |
| Oct 19 22:27 | 76 | DD | 5.9 | 161 | 58 | 26 | +1.1 | +2.3 |
| Oct 21 01:35 | 109832 | DD | 7.5 | 173 | 44 | 57 | +1.8 | +1.8 |
| Oct 22 01:59 | 110326 | RD | 7.0 | 175 | 42 | 246 | +2.1 | +1.5 |
| Oct 23 03:00 | 422 | RD | 5.5 | 164 | 35 | 271 | +2.5 | +0.8 |
| Oct 24 22:46 | 76593 | RD | 7.1 | 143 | 14 | 201 | -0.2 | +1.5 |
| Oct 24 23:10 | 656 | DB | 4.2 | 143 | 18 | 6 | -0.8 | +2.6 |
| Oct 24 23:52 | 656 | RD | 4.2 | 143 | 24 | 299 | +3.1 | -2.8 |
| Oct 24 23:59 | 657 | RD | 5.3 | 143 | 25 | 271 | +2.0 | -1.0 |
| Oct 28 04:21 | 79243 | RD | 7.3 | 107 | 31 | 284 | +2.5 | -0.7 |
| Oct 30 03:02 | 1365 | RD | 6.0 | 82 | 13 | 274 | +1.1 | -1.1 |
| Nov 01 04:15 | 1608 | RD | 6.9 | 56 | 12 | 330 | +0.8 | -2.4 |
| Nov 07 19:59 | 2491 | DD | 6.6 | 35 | 18 | 149 | +1.2 | -1.5 |
| Nov 11 21:12 | 3106 | DD | 5.2 | 86 | 48 | 102 | +2.0 | +0.5 |
| Nov 11 22:07 | 3106 | RB | 5.2 | 86 | 36 | 203 | -0.2 | +2.8 |
| Nov 11 22:52 | 3116 | DD | 6.6 | 87 | 27 | 107 | +1.0 | +0.6 |
| Nov 12 22:51 | 3243 | DD | 7.3 | 98 | 35 | 102 | +1.5 | +0.7 |
| Nov 13 21:52 | 3358 | DD | 6.9 | 109 | 54 | 67 | +1.7 | +1.7 |
| Nov 15 19:59 | 128698 | DD | 7.0 | 130 | 57 | 2 | +0.2 | +3.7 |
| Nov 16 22:41 | 157 | DD | 7.3 | 142 | 52 | 29 | +1.3 | +2.4 |
| Nov 18 02:22 | 283 | DD | 6.6 | 154 | 20 | 117 | +1.4 | +0.2 |
| Nov 22 23:30 | 900 | RD | 4.8 | 150 | 21 | 256 | +1.5 | -0.5 |
| Nov 22 23:34 | 902 | RD | 6.6 | 150 | 22 | 196 | -0.2 | +2.3 |
| Nov 28 03:02 | 1570 | DB | 5.5 | 88 | 21 | 157 | +1.1 | -2.7 |
| Nov 28 03:58 | 1570 | RD | 5.5 | 88 | 30 | 253 | +2.0 | -0.4 |
| Nov 29 03:18 | 1687 | RD | 6.2 | 75 | 19 | 294 | +0.9 | -1.6 |
| Dec 06 20:28 | 187465 | DD | 7.4 | 28 | 10 | 27 | -1.0 | +2.6 |
| Dec 09 21:03 | 3191 | DD | 7.4 | 66 | 32 | 92 | +1.0 | +1.1 |
| Dec 13 00:02 | 20 | DD | 6.7 | 101 | 15 | 69 | +0.4 | +1.7 |
| Dec 14 23:47 | 237 | DD | 7.0 | 122 | 28 | 117 | +2.1 | 0.0 |
| Dec 18 19:41 | 709 | DD | 4.3 | 166 | 16 | 97 | +1.5 | -1.3 |
| Dec 18 20:44 | 709 | RB | 4.3 | 166 | 25 | 212 | +0.6 | +1.1 |
| Dec 18 22:22 | 716 | DD | 6.3 | 166 | 33 | 32 | +1.3 | +1.5 |
| Dec 23 00:15 | 1283 | RD | 7.0 | 145 | 23 | 297 | +1.9 | -1.6 |
| Dec 23 02:00 | 1290 | RD | 6.9 | 144 | 33 | 245 | +2.7 | +0.5 |
| Dec 24 03:58 | 1424 | RD | 6.8 | 131 | 38 | 341 | +1.0 | -2.2 |
| Dec 26 01:28 | 1651 | DB | 3.9 | 106 | 20 | 89 | +1.1 | -1.1 |
| Dec 26 02:32 | 1651 | RD | 3.9 | 106 | 31 | 326 | +1.2 | -2.3 |
| Dec 29 03:35 | 2008 | RD | 6.6 | 66 | 27 | 271 | +0.9 | -1.1 |
| Dec 31 03:49 | 159551 | RD | 7.2 | 39 | 13 | 349 | -0.7 | -2.7 |

# MOON – GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

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

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

# MERCURY

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

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

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

# MERCURY RISE AND SET TIMES FOR PERTH (WAST)

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

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

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

# VENUS

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

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

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

# VENUS

## GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

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

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

# RISE AND SET TIMES WAST MARS

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

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

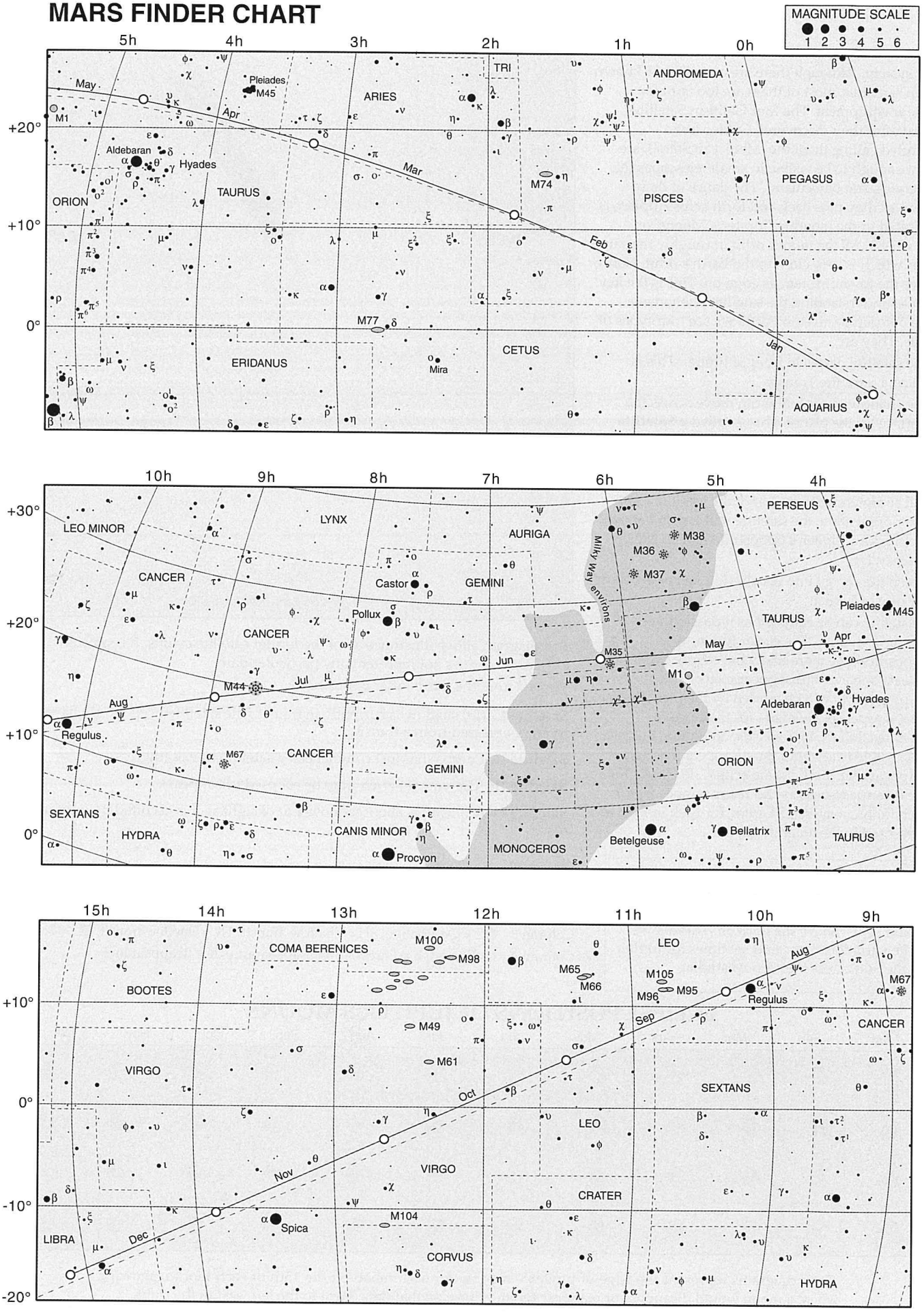
| | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|
| 1 | 6:20 | 17:24 | 5:15 | 16:56 | 4:06 | 16:26 | 3:00 | 15:58 |
| 2 | 6:18 | 17:23 | 5:13 | 16:55 | 4:04 | 16:25 | 2:58 | 15:57 |
| 3 | 6:16 | 17:23 | 5:11 | 16:54 | 4:01 | 16:24 | 2:56 | 15:57 |
| 4 | 6:14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

# POSITION

0 hrs UT
Epoch 2000.0

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

# MARS FINDER CHART



# JUPITER'S MOONS 2002

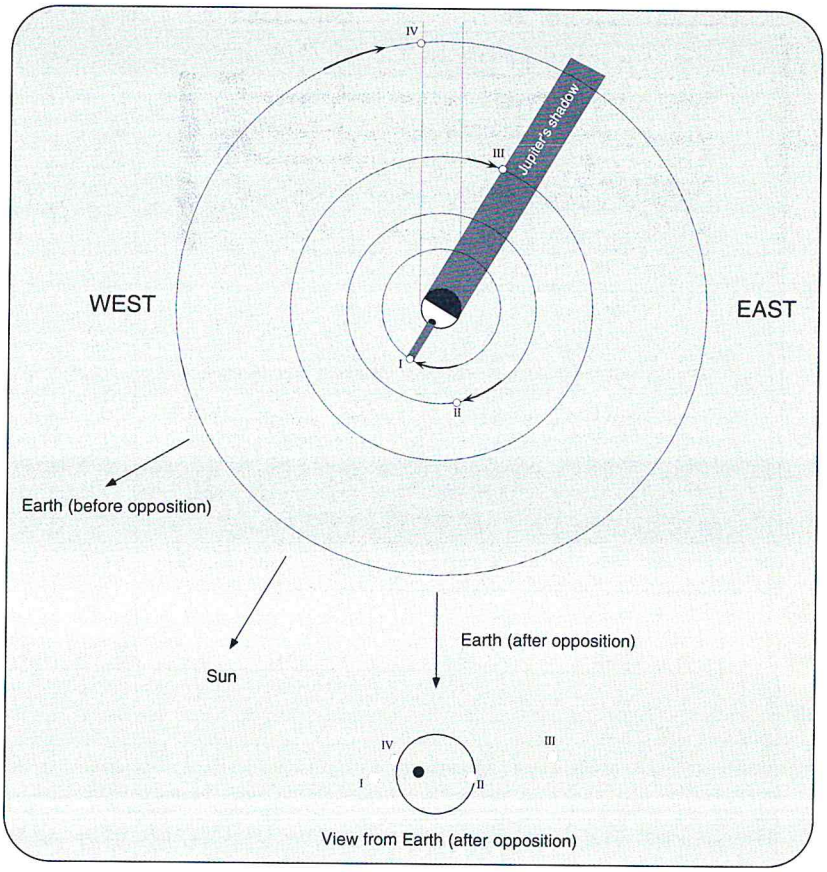
Jupiter and its moons can be likened to a miniature solar system. Although there are currently 28 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo (who suggested calling them the 'Medicean Stars'), are bright 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 87-89. 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 2002 is January 1st.

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, 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 diagram above 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).

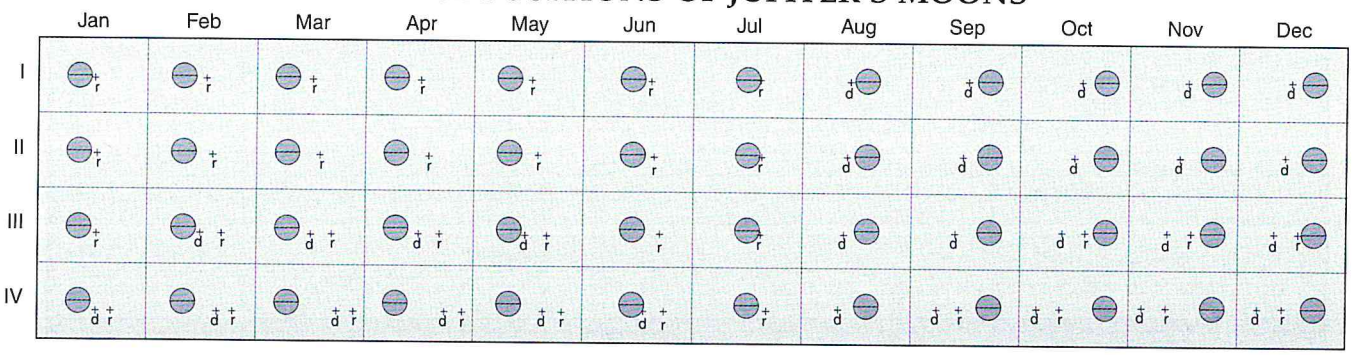
**Satellite IV** (Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

**Note:** In the tables on pages 85 to 86, 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 Western Australia.

**JUPITER'S MOONS Legend (pp. 85-86)**

Column 1 Date & time (in WAST). Date only appears for the first event each day.
Column 2 I = Io, II = Europa, III = Ganymede, IV = Callisto
Column 3 OC = Occultation, SH = Shadow Transit, TR = Satellite Transit, EC = Eclipse
Column 4 I = Ingress, E = Egress, D = Disappearance, R = Reappearance

## ECLIPSE POSITIONS OF JUPITER'S MOONS




These diagrams represent the edge of Jupiter's shadow for each moon on the 15th of each month, showing where a moon would disappear or reappear for an eclipse on that date. West to the left, east to the right.

# JUPITER'S MOONS (WAST)

## January

| | | | |
|---|---|---|---|
| 1 | 01:51 | I | SHE |
| | 01:52 | I | TRE |
| | 20:55 | I | OCD |
| | 21:19 | III | TRE |
| | 21:21 | III | SHE |
| | 23:11 | I | ECR |
| | 23:11 | III | SHI |
| | 23:11 | II | ECD |
| 2 | 20:17 | I | TRE |
| | 20:19 | I | SHE |
| 3 | 00:26 | II | TRI |
| | 00:31 | II | SHI |
| | 03:14 | II | TRE |
| | 03:19 | II | SHE |
| 4 | 21:33 | II | ECR |
| 6 | 01:08 | IV | OCD |
| | 04:59 | IV | ECR |
| 7 | 04:13 | I | OCD |
| 8 | 01:20 | I | TRI |
| | 01:30 | I | SHI |
| | 03:35 | I | TRE |
| | 03:45 | I | SHE |
| | 21:33 | III | TRI |
| | 22:18 | III | SHI |
| | 22:39 | I | OCD |
| 9 | 00:35 | III | TRE |
| | 01:06 | I | ECR |
| | 01:22 | III | SHE |
| | 19:46 | I | TRI |
| | 19:59 | I | SHI |
| | 22:01 | I | TRE |
| | 22:14 | I | SHE |
| 10 | 02:41 | II | TRI |
| | 03:07 | II | SHI |
| | 19:34 | I | ECR |
| 11 | 20:49 | II | OCD |
| 12 | 00:08 | II | ECR |
| 13 | 19:15 | II | SHE |
| 15 | 03:04 | I | TRI |
| | 03:25 | I | SHI |
| 16 | 00:23 | I | OCD |
| | 00:49 | III | TRI |
| | 02:18 | III | SHI |
| | 03:01 | I | ECR |
| | 03:51 | III | TRE |
| | 21:30 | I | TRI |
| | 21:53 | I | SHI |
| | 23:45 | I | TRE |
| 17 | 00:08 | I | SHE |
| | 21:29 | I | ECR |
| 18 | 23:04 | II | OCD |
| 19 | 02:44 | II | ECR |
| | 19:25 | III | ECR |
| 20 | 19:03 | II | SHI |
| | 20:52 | II | TRE |
| | 21:51 | II | SHE |
| 22 | 20:13 | IV | ECD |
| | 23:11 | IV | ECR |
| 23 | 02:07 | I | OCD |
| | 23:15 | I | TRI |
| | 23:48 | I | SHI |
| 24 | 01:30 | I | TRE |
| | 02:03 | I | SHE |
| | 20:34 | I | OCD |
| | 23:24 | I | ECR |
| 25 | 19:56 | I | TRE |
| | 20:32 | I | SHE |
| 26 | 01:20 | II | OCD |
| | 23:26 | III | ECR |
| 27 | 20:22 | II | TRI |
| | 21:40 | II | SHI |
| | 23:10 | II | TRE |
| 28 | 00:28 | II | SHE |
| 31 | 00:29 | IV | TRI |
| | 01:01 | I | TRI |
| | 01:43 | I | SHI |
| | 03:09 | IV | TRE |
| | 22:20 | I | OCD |

## February

| | | | |
|---|---|---|---|
| 1 | 01:19 | I | ECR |
| | 19:27 | I | TRI |
| | 20:11 | I | SHI |
| | 21:42 | I | TRE |
| | 22:26 | I | SHE |
| 2 | 19:48 | I | ECR |
| | 21:14 | III | OCD |
| 3 | 00:17 | III | OCR |
| | 00:19 | III | ECD |
| | 22:41 | II | TRI |
| 4 | 00:16 | II | SHI |
| | 01:29 | II | TRE |
| 5 | 21:14 | II | ECR |
| 8 | 00:07 | I | OCD |
| | 21:14 | I | TRI |
| | 22:06 | I | SHI |
| | 23:28 | I | TRE |
| 9 | 00:21 | I | SHE |
| | 21:43 | I | ECR |
| 10 | 00:41 | III | OCD |
| | 18:50 | I | SHE |
| 11 | 01:03 | II | TRI |
| 12 | 19:08 | II | OCD |
| | 23:51 | II | ECR |
| 13 | 21:23 | III | SHE |
| 14 | 18:59 | II | SHE |
| 15 | 01:54 | I | OCD |
| | 23:02 | I | TRI |
| 16 | 00:01 | I | SHI |
| | 01:17 | I | TRE |
| | 20:22 | I | OCD |
| | 23:38 | I | ECR |
| 17 | 01:03 | IV | SHI |
| | 19:44 | I | TRE |
| | 20:45 | I | SHE |
| 19 | 21:31 | II | OCD |
| 20 | 21:02 | III | TRE |
| | 22:16 | III | SHI |
| 21 | 01:24 | III | SHE |
| | 18:47 | II | SHI |
| | 19:25 | II | TRE |
| | 21:35 | II | SHE |
| 23 | 00:52 | I | TRI |
| | 22:11 | I | OCD |
| 24 | 19:19 | I | TRI |
| | 20:25 | I | SHI |
| | 21:33 | I | TRE |
| | 21:53 | IV | OCD |
| | 22:40 | I | SHE |
| 25 | 00:41 | IV | OCR |
| | 20:02 | I | ECR |
| 26 | 23:57 | II | OCD |
| 27 | 21:40 | III | TRI |
| 28 | 00:43 | III | TRE |
| | 19:05 | II | TRI |
| | 21:24 | II | SHI |
| | 21:52 | II | TRE |

## March

| | | | |
|---|---|---|---|
| 1 | 00:11 | II | SHE |
| 2 | 18:23 | II | ECR |
| 3 | 00:02 | I | OCD |
| | 19:30 | III | ECR |
| | 21:10 | I | TRI |
| | 22:21 | I | SHI |
| | 23:24 | I | TRE |
| 4 | 00:35 | I | SHE |
| | 18:30 | I | OCD |
| | 21:57 | I | ECR |
| 5 | 19:04 | I | SHE |
| | 19:04 | IV | SHI |
| | 22:25 | IV | SHE |
| 7 | 21:35 | II | TRI |
| 8 | 00:00 | II | SHI |
| | 00:21 | II | TRE |
| 9 | 21:01 | II | ECR |
| 10 | 18:24 | III | OCR |
| | 20:19 | III | ECD |
| | 23:02 | I | TRI |
| | 23:31 | III | ECR |
| 11 | 00:16 | I | SHI |
| | 20:22 | I | OCD |
| | 23:53 | I | ECR |
| 12 | 18:45 | I | SHI |
| | 19:45 | I | TRE |
| | 21:00 | I | SHE |
| 13 | 18:21 | I | ECR |
| 15 | 00:06 | II | TRI |
| 16 | 18:13 | II | OCD |
| | 23:38 | II | ECR |
| 17 | 19:09 | III | OCD |
| | 22:16 | III | OCR |
| 18 | 18:42 | II | SHE |
| | 22:15 | I | OCD |
| 19 | 19:24 | I | TRI |
| | 20:40 | I | SHI |
| | 21:38 | I | TRE |
| | 22:55 | I | SHE |
| 20 | 20:17 | I | ECR |
| 23 | 20:48 | II | OCD |
| 24 | 23:06 | III | OCD |
| 25 | 18:31 | II | SHI |
| | 18:43 | II | TRE |
| | 21:18 | II | SHE |
| 26 | 21:19 | I | TRI |
| | 22:36 | I | SHI |
| 27 | 18:38 | I | OCD |
| | 22:12 | I | ECR |
| 28 | 18:02 | I | TRE |
| | 18:15 | III | SHI |
| | 19:20 | I | SHE |
| | 21:27 | III | SHE |
| 30 | 20:24 | IV | ECD |

## April

| | | | |
|---|---|---|---|
| 1 | 18:33 | II | TRI |
| | 21:06 | II | SHI |
| | 21:19 | II | TRE |
| 3 | 18:12 | II | ECR |
| | 20:34 | I | OCD |
| 4 | 17:43 | I | TRI |
| | 19:00 | I | SHI |
| | 19:58 | I | TRE |
| | 20:12 | III | TRE |
| | 21:15 | I | SHE |
| | 22:16 | III | SHI |
| 5 | 18:36 | I | ECR |
| 7 | 19:19 | IV | TRI |
| | 22:23 | IV | TRE |
| 8 | 21:11 | II | TRI |
| 10 | 20:50 | II | ECR |
| | 22:30 | I | OCD |
| 11 | 19:40 | I | TRI |
| | 20:55 | I | SHI |
| | 21:12 | III | TRI |
| | 21:55 | I | TRE |
| 12 | 20:31 | I | ECR |
| 13 | 17:40 | I | SHE |
| 15 | 19:36 | III | ECR |
| 16 | 18:13 | IV | ECR |
| 17 | 18:05 | II | OCD |
| 18 | 21:38 | I | TRI |
| 19 | 18:23 | II | SHE |
| | 18:57 | I | OCD |
| 20 | 17:20 | I | SHI |
| | 18:22 | I | TRE |
| | 19:35 | I | SHE |
| 22 | 18:37 | III | OCR |
| | 20:18 | III | ECD |
| 24 | 17:27 | IV | TRE |
| | 20:49 | II | OCD |
| 26 | 18:11 | II | SHI |
| | 18:39 | II | TRE |
| | 20:55 | I | OCD |
| | 20:58 | II | SHE |
| 27 | 18:06 | I | TRI |
| | 19:15 | I | SHI |
| | 20:21 | I | TRE |
| | 21:31 | I | SHE |
| 28 | 18:50 | I | ECR |
| 29 | 19:41 | III | OCD |

## May

| | | | |
|---|---|---|---|
| 3 | 17:33 | III | SHE |
| | 18:35 | II | TRI |
| | 20:46 | II | SHI |
| 4 | 20:05 | I | TRI |
| | 21:11 | I | SHI |
| 5 | 17:23 | I | OCD |
| | 18:04 | II | ECR |
| | 20:44 | I | ECR |
| 6 | 17:56 | I | SHE |
| 10 | 17:17 | III | TRE |
| | 18:16 | III | SHI |
| 11 | 19:15 | IV | SHI |
| 12 | 19:22 | I | OCD |
| | 20:42 | II | ECR |
| 13 | 17:35 | I | SHI |
| | 18:50 | I | TRE |
| | 19:51 | I | SHE |
| 14 | 17:08 | I | ECR |
| 17 | 18:25 | III | TRI |
| 19 | 17:49 | IV | OCD |
| | 18:32 | II | OCD |
| 20 | 18:35 | I | TRI |
| | 19:30 | I | SHI |
| 21 | 18:02 | II | SHE |
| | 19:03 | I | ECR |
| 28 | 17:15 | IV | SHE |
| | 17:49 | II | SHI |
| | 17:52 | I | OCD |
| | 19:00 | II | TRE |
| | 19:39 | III | ECR |
| 29 | 17:22 | I | TRE |
| | 18:11 | I | SHE |

## June

| | | | |
|---|---|---|---|
| 4 | 17:22 | III | OCD |
| | 18:58 | II | TRI |
| 5 | 17:07 | I | TRI |
| | 17:46 | IV | OCR |
| | 17:50 | I | SHI |
| | 19:23 | I | TRE |
| 6 | 17:21 | I | ECR |
| | 17:54 | II | ECR |

# JUPITER'S MOONS (WAST)

| | | | |
|---|---|---|---|
| 12 | 19:08 | I | TR I |
| 13 | 19:15 | I | EC R |
| 15 | 17:38 | III | SH E |
| 20 | 18:24 | I | OCD |
| 21 | 17:57 | I | TR E |
| | 18:26 | I | SH E |
| 22 | 17:39 | II | SH E |
| | 18:15 | III | SH I |
| 28 | 17:42 | I | TR I |
| | 18:04 | I | SH I |
| 29 | 17:24 | II | SH I |
| | 17:32 | I | EC R |

## July

| | | | |
|---|---|---|---|
| 6 | 16:57 | I | OCD |
| 8 | 17:44 | II | EC R |
| 15 | 17:19 | II | OCD |
| 18 | 07:34 | I | TR E |
| | 07:36 | I | SH E |
| 24 | 17:15 | II | SH E |
| 25 | 07:14 | I | SH I |
| | 07:19 | I | TR I |

## August

| | | | |
|---|---|---|---|
| 4 | 06:46 | II | TR I |
| 18 | 07:19 | I | OCR |
| 20 | 06:31 | II | EC D |
| 25 | 06:28 | I | EC D |
| 26 | 06:05 | I | SH E |
| | 06:06 | III | SH I |
| | 06:41 | I | TR E |
| 29 | 06:09 | II | SH E |

## September

| | | | |
|---|---|---|---|
| 2 | 05:42 | I | SH I |
| | 06:24 | I | TR I |
| 3 | 05:50 | I | OCR |
| 5 | 05:52 | II | SH I |
| 6 | 05:48 | IV | SH E |
| | 06:38 | III | OCR |
| 7 | 05:26 | II | OCR |
| 10 | 04:43 | I | EC D |
| 11 | 05:10 | I | TR E |
| 17 | 06:37 | I | EC D |
| 18 | 04:53 | I | TR I |
| | 06:15 | I | SH E |
| 19 | 04:19 | I | OCR |
| 21 | 06:10 | II | EC D |
| 23 | 04:21 | IV | TR I |
| | 05:08 | II | TR E |
| 24 | 05:30 | III | TR E |
| 25 | 05:52 | I | SH I |
| 26 | 06:17 | I | OCR |
| 27 | 03:37 | I | TR E |
| 30 | 05:00 | II | TR I |
| | 05:46 | II | SH E |

## October

| | | | |
|---|---|---|---|
| 1 | 05:29 | III | SH E |
| | 06:13 | III | TR I |
| 3 | 04:52 | I | EC D |
| 4 | 03:18 | I | TR I |
| | 04:31 | I | SH E |
| | 05:35 | I | TR E |
| 7 | 05:29 | II | SH I |
| 8 | 05:57 | III | SH I |
| 9 | 05:46 | II | OCR |
| 10 | 04:37 | IV | TR E |
| 11 | 04:08 | I | SH I |
| | 05:15 | I | TR I |
| 12 | 04:12 | III | OCR |
| | 04:42 | I | OCR |
| 16 | 03:11 | II | EC D |
| 18 | 02:38 | II | TR E |
| | 06:01 | I | SH I |
| 19 | 03:08 | I | EC D |
| | 03:25 | III | EC R |
| | 04:44 | III | OCD |
| 20 | 02:46 | I | SH E |
| | 03:57 | I | TR E |
| 23 | 05:45 | II | EC D |
| 25 | 02:26 | II | TR I |
| | 02:49 | II | SH E |
| | 05:19 | II | TR E |
| 26 | 03:49 | III | EC D |
| | 05:01 | I | EC D |
| 27 | 02:23 | I | SH I |
| | 03:36 | I | TR I |
| | 04:39 | I | SH E |
| | 05:52 | I | TR E |
| 28 | 03:03 | I | OCR |
| 30 | 02:27 | III | TR E |

## November

| | | | |
|---|---|---|---|
| 1 | 02:32 | II | SH I |
| | 05:04 | II | TR I |
| | 05:24 | II | SH E |
| 3 | 03:00 | II | OCR |
| | 04:16 | I | SH I |
| | 05:30 | I | TR I |
| 4 | 01:23 | I | EC D |
| | 02:51 | IV | OCD |
| | 04:58 | I | OCR |
| 5 | 02:15 | I | TR E |
| 6 | 01:21 | III | SH E |
| | 02:54 | III | TR I |
| 8 | 05:08 | II | SH I |
| 10 | 05:33 | II | OCR |
| 11 | 03:17 | I | EC D |
| 12 | 01:14 | IV | SH I |
| | 01:52 | I | TR I |
| | 02:53 | I | SH E |
| | 04:08 | I | TR E |
| 13 | 01:20 | I | OCR |
| | 01:47 | III | SH I |
| | 05:19 | III | SH E |
| 17 | 02:43 | II | EC D |
| 18 | 05:10 | I | EC D |
| 19 | 02:26 | II | TR E |
| | 02:30 | I | SH I |
| | 03:44 | I | TR I |
| | 04:47 | I | SH E |
| 20 | 03:13 | I | OCR |
| 21 | 00:28 | I | TR E |
| | 01:32 | IV | OCR |
| 24 | 00:41 | III | OCD |
| | 04:20 | III | OCR |
| | 05:17 | II | EC D |
| 26 | 02:05 | II | TR I |
| | 02:30 | II | SH E |
| | 04:24 | I | SH I |
| | 04:58 | II | TR E |
| 27 | 01:32 | I | EC D |
| | 05:04 | I | OCR |
| 28 | 00:03 | I | TR I |
| | 01:08 | I | SH E |
| | 02:19 | I | TR E |
| | 23:53 | IV | SH E |
| 30 | 23:41 | III | EC D |

## December

| | | | |
|---|---|---|---|
| 1 | 03:17 | III | EC R |
| | 04:28 | III | OCD |
| 3 | 02:12 | II | SH I |
| | 04:34 | II | TR I |
| | 05:06 | II | SH E |
| 4 | 03:26 | I | EC D |
| 5 | 00:45 | I | SH I |
| | 01:52 | I | TR I |
| | 02:15 | II | OCR |
| | 03:01 | I | SH E |
| | 04:09 | I | TR E |
| 6 | 01:22 | I | OCR |
| 7 | 02:45 | IV | EC D |
| 8 | 03:39 | III | EC D |
| 10 | 04:48 | II | SH I |
| 11 | 05:20 | I | EC D |
| | 23:40 | II | EC D |
| 12 | 01:31 | III | TR E |
| | 02:38 | I | SH I |
| | 03:41 | I | TR I |
| | 04:39 | II | OCR |
| | 04:54 | I | SH E |
| | 23:48 | I | EC D |
| 13 | 03:11 | I | OCR |
| | 23:07 | II | TR E |
| | 23:22 | I | SH E |
| 14 | 00:24 | I | TR E |
| 15 | 22:41 | IV | TR I |
| 16 | 03:27 | IV | TR E |
| 19 | 01:09 | III | SH E |
| | 01:30 | III | TR I |
| | 02:13 | II | EC D |
| | 04:31 | I | SH I |
| | 05:06 | III | TR E |
| | 05:28 | I | TR I |
| 20 | 01:42 | I | EC D |
| | 04:59 | I | OCR |
| | 22:37 | II | TR I |
| | 22:59 | I | SH I |
| | 23:35 | II | SH E |
| | 23:55 | I | TR I |
| 21 | 01:16 | I | SH E |
| | 01:31 | II | TR E |
| | 02:11 | I | TR E |
| | 23:25 | I | OCR |
| 24 | 01:36 | IV | EC R |
| | 05:19 | IV | OCD |
| 26 | 01:33 | III | SH I |
| | 04:46 | II | EC D |
| | 05:00 | III | TR I |
| | 05:08 | III | SH E |
| 27 | 03:36 | I | EC D |
| | 23:18 | II | SH I |
| 28 | 00:52 | I | SH I |
| | 00:59 | II | TR I |
| | 01:41 | I | TR I |
| | 02:12 | II | SH E |
| | 03:09 | I | SH E |
| | 03:53 | II | TR E |
| | 03:58 | I | TR E |
| | 22:04 | I | EC D |
| 29 | 01:12 | I | OCR |
| | 22:24 | I | TR E |
| | 22:25 | III | OCR |
| | 22:29 | II | OCR |

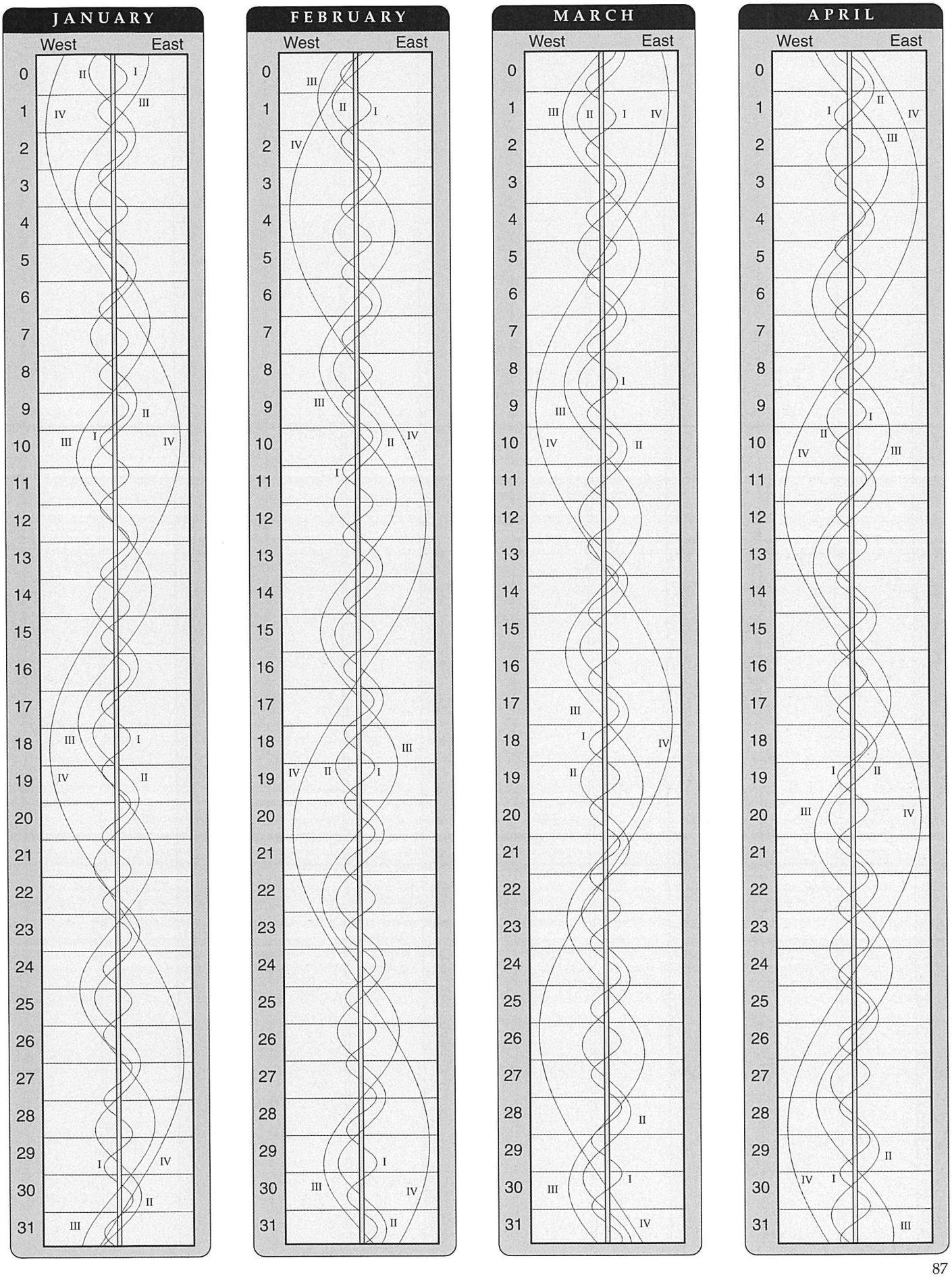
# Mutual Events (WAST) (see page 65)

| Date | Start | End | Dur | Event | Type | Mag Drop | Jup Dist | Sat Sep |
|---|---|---|---|---|---|---|---|---|
| Oct 14 | 04:27 | 04:31 | 00:03 | II Oc I | 0.10 | 4.8 | 0.6 | P |
| Nov 11 | 03:46 | 03:57 | 00:10 | IV Oc III | 0.12 | 14.0 | 1.0 | P |
| Nov 15 | 02:57 | 03:03 | 00:06 | II Oc I | 0.23 | 5.6 | 0.4 | P |
| Nov 22 | 03:11 | 03:17 | 00:05 | II Ec I | 0.13 | 5.0 | 35.9 | P |
| Nov 29 | 01:45 | 01:51 | 00:05 | IV Oc I | 0.56 | 2.9 | 0.3 | P |

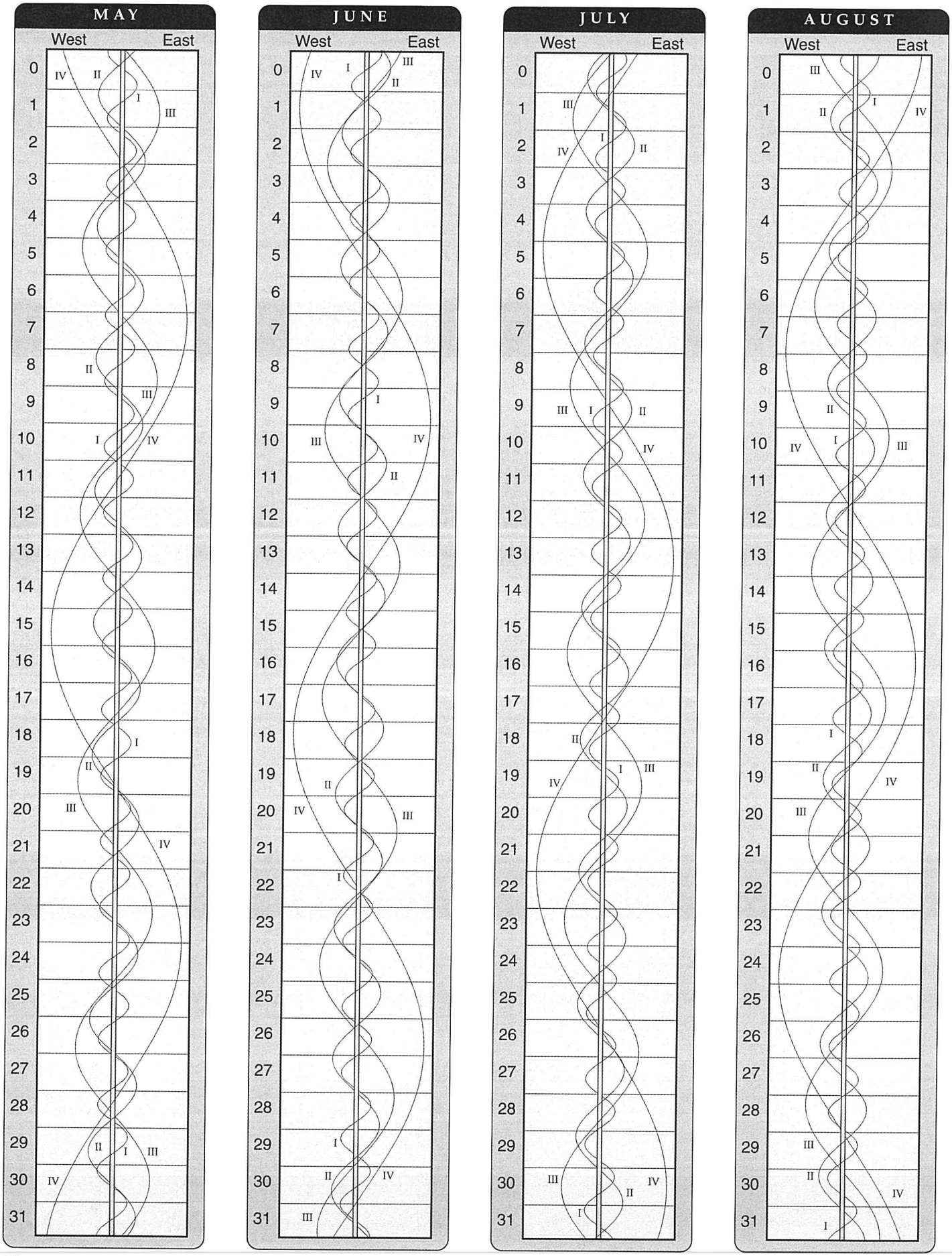
| Date Mth dd | Time Start | End | Dur | Event | Type | Mag Drop | Jup Dist | Sat Sep |
|---|---|---|---|---|---|---|---|---|
| Dec 06 | 04:09 | 04:24 | 00:15 | III Oc IV | 0.23 | 13.9 | 0.1 | P |
| Dec 16 | 23:31 | 23:41 | 00:09 | II Ec I | 0.63 | 5.7 | 26.0 | A |
| Dec 23 | 00:47 | 01:53 | 01:06 | II Oc III | 0.18 | 4.4 | 0.5 | P |
| Dec 24 | 02:02 | 02:13 | 00:11 | II Ec I | 0.66 | 5.8 | 22.0 | A |
| Dec 31 | 04:38 | 04:51 | 00:13 | II Ec I | 0.58 | 5.9 | 17.7 | P |

The mutual events table above has the following information:
**Date** of the event (month and day)
**Start, end** and **dur**ation times of the events (hh:mm).
**Event** description e.g., II Oc I. This means satellite II occults (passes in front of) satellite I (see p. 84 for satellite number).
Event **type** where 'P' is partial, 'A' is annular.
**Mag Drop** is the maximum drop in magnitude at mid event.
**Jup Dist** is the distance from Jupiter's centre (in Jupiter radii).
**Sat Sep** is the separation between the two satellites in arc seconds at closest approach.

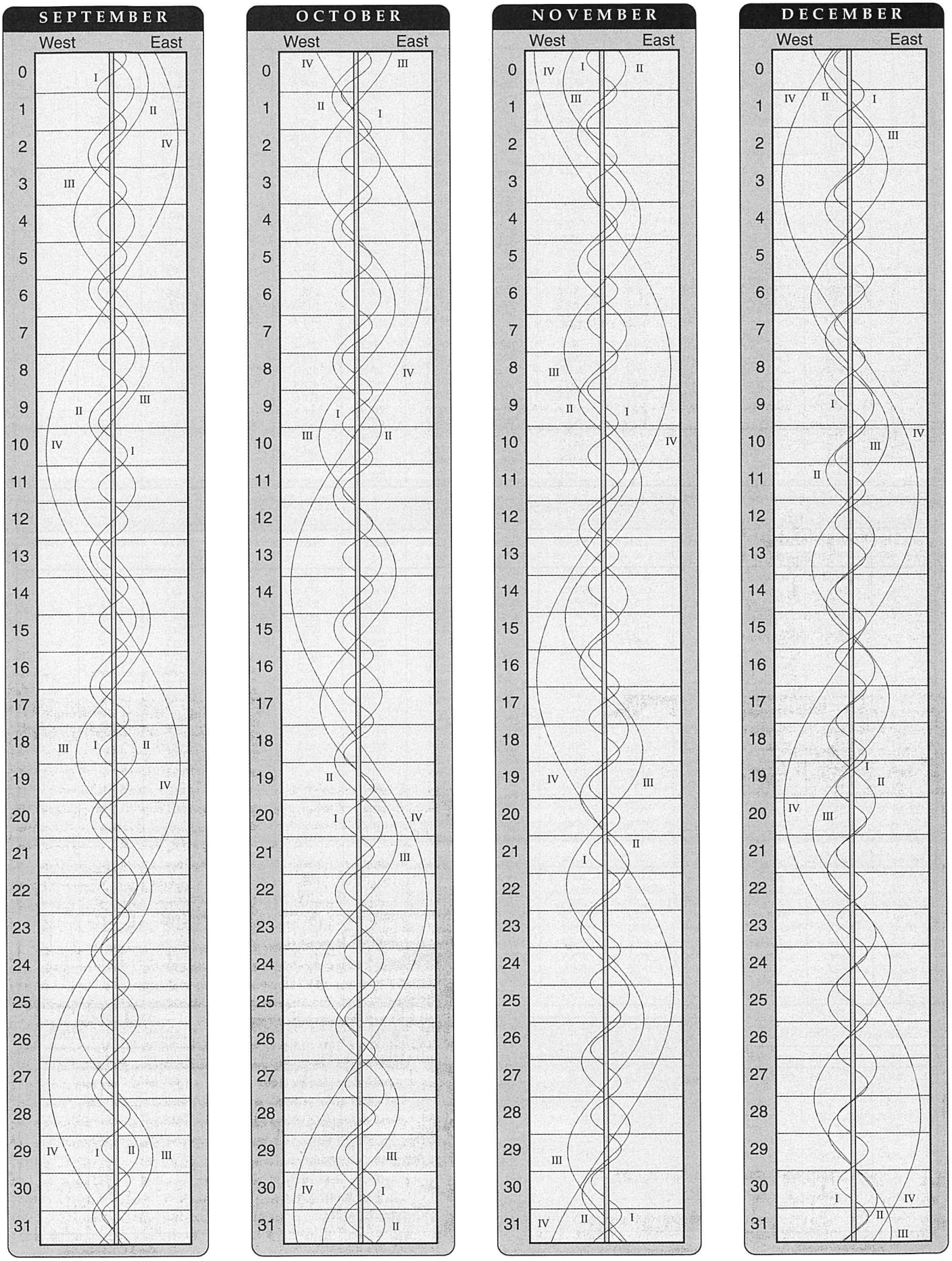
# JUPITER'S MOONS (WAST)



# JUPITER'S MOONS (WAST)



# JUPITER'S MOONS (WAST)



# JUPITER — LONGITUDE OF CENTRAL MERIDIAN

## SYSTEM I (0hr UT)

| DATE | JAN ° | FEB ° | MAR ° | APR ° | MAY ° | JUN ° | JUL ° | AUG ° | SEP ° | OCT ° | NOV ° | DEC ° | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 270.1 | 127.9 | 228.7 | 079.6 | 130.5 | 337.8 | 027.4 | 235.3 | 084.3 | 137.3 | 350.3 | 047.9 | 1 |
| 2 | 068.1 | 285.8 | 026.5 | 237.4 | 288.1 | 135.5 | 185.1 | 033.0 | 242.1 | 295.1 | 148.1 | 205.8 | 2 |
| 3 | 226.1 | 083.8 | 184.3 | 035.1 | 085.8 | 293.1 | 342.7 | 190.6 | 039.8 | 092.9 | 306.0 | 003.8 | 3 |
| 4 | 024.2 | 241.7 | 342.1 | 192.8 | 243.5 | 090.8 | 140.4 | 348.3 | 197.5 | 250.7 | 103.9 | 161.8 | 4 |
| 5 | 182.2 | 039.6 | 140.0 | 350.5 | 041.1 | 248.4 | 298.1 | 146.0 | 355.3 | 048.5 | 261.8 | 319.7 | 5 |
| 6 | 340.2 | 197.6 | 297.8 | 148.2 | 198.8 | 046.1 | 095.7 | 303.7 | 153.0 | 206.3 | 059.7 | 117.7 | 6 |
| 7 | 138.2 | 355.5 | 095.6 | 306.0 | 356.5 | 203.7 | 253.4 | 101.4 | 310.8 | 004.1 | 217.6 | 275.7 | 7 |
| 8 | 296.3 | 153.4 | 253.4 | 103.7 | 154.1 | 001.4 | 051.0 | 259.1 | 108.5 | 162.0 | 015.5 | 073.7 | 8 |
| 9 | 094.3 | 311.3 | 051.2 | 261.4 | 311.8 | 159.0 | 208.7 | 056.8 | 266.3 | 319.8 | 173.4 | 231.7 | 9 |
| 10 | 252.3 | 109.2 | 209.0 | 059.1 | 109.5 | 316.7 | 006.4 | 214.5 | 064.0 | 117.6 | 331.3 | 029.6 | 10 |
| 11 | 050.3 | 267.1 | 006.8 | 216.8 | 267.1 | 114.3 | 164.0 | 012.2 | 221.8 | 275.4 | 129.2 | 187.6 | 11 |
| 12 | 208.3 | 065.0 | 164.6 | 014.5 | 064.8 | 272.0 | 321.7 | 169.9 | 019.5 | 073.2 | 287.1 | 345.6 | 12 |
| 13 | 006.3 | 222.9 | 322.3 | 172.2 | 222.4 | 069.6 | 119.4 | 327.6 | 177.3 | 231.1 | 085.0 | 143.6 | 13 |
| 14 | 164.3 | 020.8 | 120.1 | 329.9 | 020.1 | 227.3 | 277.0 | 125.3 | 335.1 | 028.9 | 242.9 | 301.6 | 14 |
| 15 | 322.3 | 178.7 | 277.9 | 127.6 | 177.7 | 024.9 | 074.7 | 283.0 | 132.8 | 186.7 | 040.8 | 099.6 | 15 |
| 16 | 120.3 | 336.6 | 075.7 | 285.3 | 335.4 | 182.6 | 232.4 | 080.8 | 290.6 | 344.6 | 198.7 | 257.6 | 16 |
| 17 | 278.3 | 134.4 | 233.4 | 083.0 | 133.1 | 340.2 | 030.1 | 238.5 | 088.4 | 142.4 | 356.7 | 055.6 | 17 |
| 18 | 076.3 | 292.3 | 031.2 | 240.6 | 290.7 | 137.9 | 187.7 | 036.2 | 246.1 | 300.2 | 154.6 | 213.6 | 18 |
| 19 | 234.3 | 090.2 | 189.0 | 038.3 | 088.4 | 295.5 | 345.4 | 193.9 | 043.9 | 098.1 | 312.5 | 011.6 | 19 |
| 20 | 032.3 | 248.1 | 346.7 | 196.0 | 246.0 | 093.2 | 143.1 | 351.6 | 201.7 | 255.9 | 110.5 | 169.6 | 20 |
| 21 | 190.3 | 045.9 | 144.5 | 353.7 | 043.7 | 250.9 | 300.8 | 149.3 | 359.4 | 053.8 | 268.4 | 327.7 | 21 |
| 22 | 348.3 | 203.8 | 302.3 | 151.4 | 201.3 | 048.5 | 098.4 | 307.0 | 157.2 | 211.6 | 066.3 | 125.7 | 22 |
| 23 | 146.3 | 001.6 | 100.0 | 309.1 | 359.0 | 206.2 | 256.1 | 104.8 | 315.0 | 009.5 | 224.3 | 283.7 | 23 |
| 24 | 304.2 | 159.5 | 257.8 | 106.8 | 156.6 | 003.8 | 053.8 | 262.5 | 112.8 | 167.3 | 022.2 | 081.7 | 24 |
| 25 | 102.2 | 317.3 | 055.5 | 264.4 | 314.3 | 161.5 | 211.5 | 060.2 | 270.6 | 325.2 | 180.1 | 239.7 | 25 |
| 26 | 260.2 | 115.2 | 213.2 | 062.1 | 111.9 | 319.1 | 009.2 | 217.9 | 068.4 | 123.0 | 338.1 | 037.7 | 26 |
| 27 | 058.1 | 273.0 | 011.0 | 219.8 | 269.6 | 116.8 | 166.8 | 015.7 | 226.1 | 280.9 | 136.0 | 195.8 | 27 |
| 28 | 216.1 | 070.8 | 168.7 | 017.5 | 067.2 | 274.4 | 324.5 | 173.4 | 023.9 | 078.8 | 294.0 | 353.8 | 28 |
| 29 | 014.0 | | 326.5 | 175.1 | 224.9 | 072.1 | 122.2 | 331.1 | 181.7 | 236.6 | 092.0 | 151.8 | 29 |
| 30 | 172.0 | | 124.2 | 332.8 | 022.5 | 229.8 | 279.9 | 128.9 | 339.5 | 034.5 | 249.9 | 309.9 | 30 |
| 31 | 329.9 | | 281.9 | | 180.2 | | 077.6 | 286.6 | | 192.4 | | 107.9 | 31 |

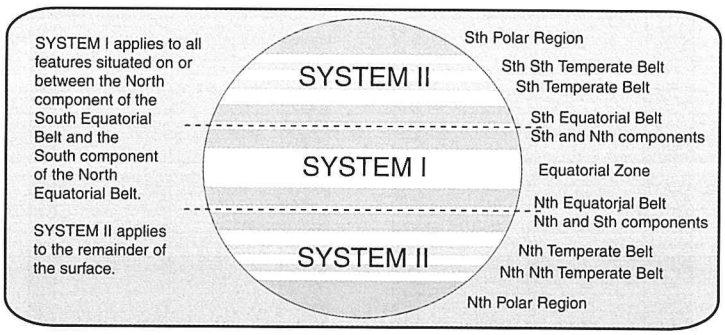
## SYSTEM II (0hr UT)

| DATE | JAN ° | FEB ° | MAR ° | APR ° | MAY ° | JUN ° | JUL ° | AUG ° | SEP ° | OCT ° | NOV ° | DEC ° | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 072.7 | 054.0 | 301.2 | 275.7 | 097.6 | 068.5 | 249.1 | 220.5 | 193.0 | 017.1 | 353.5 | 182.1 | 1 |
| 2 | 223.1 | 204.3 | 091.4 | 065.7 | 247.6 | 218.5 | 039.2 | 010.5 | 343.1 | 167.2 | 143.7 | 332.5 | 2 |
| 3 | 013.5 | 354.7 | 241.6 | 215.8 | 037.7 | 008.5 | 189.2 | 160.6 | 133.2 | 317.4 | 294.0 | 122.8 | 3 |
| 4 | 163.9 | 145.0 | 031.8 | 005.9 | 187.7 | 158.5 | 339.2 | 310.6 | 283.3 | 107.6 | 084.2 | 273.2 | 4 |
| 5 | 314.3 | 295.3 | 182.0 | 156.0 | 337.7 | 308.5 | 129.3 | 100.7 | 073.4 | 257.8 | 234.5 | 063.5 | 5 |
| 6 | 104.7 | 085.5 | 332.1 | 306.1 | 127.8 | 098.6 | 279.3 | 250.8 | 223.5 | 047.9 | 024.7 | 213.8 | 6 |
| 7 | 255.1 | 235.8 | 122.3 | 096.2 | 277.8 | 248.6 | 069.3 | 040.8 | 013.7 | 198.1 | 175.0 | 004.2 | 7 |
| 8 | 045.5 | 026.1 | 272.5 | 246.3 | 067.9 | 038.6 | 219.4 | 190.9 | 163.8 | 348.3 | 325.3 | 154.5 | 8 |
| 9 | 195.9 | 176.4 | 062.7 | 036.3 | 217.9 | 188.6 | 009.4 | 341.0 | 313.9 | 138.5 | 115.5 | 304.9 | 9 |
| 10 | 346.3 | 326.7 | 212.8 | 186.4 | 007.9 | 338.6 | 159.4 | 131.0 | 104.0 | 288.7 | 265.8 | 095.2 | 10 |
| 11 | 136.7 | 117.0 | 003.0 | 336.5 | 157.9 | 128.7 | 309.5 | 281.1 | 254.1 | 078.9 | 056.1 | 245.6 | 11 |
| 12 | 287.1 | 267.2 | 153.1 | 126.6 | 308.0 | 278.7 | 099.5 | 071.2 | 044.3 | 229.1 | 206.3 | 036.0 | 12 |
| 13 | 077.4 | 057.5 | 303.3 | 276.6 | 098.0 | 068.7 | 249.5 | 221.3 | 194.4 | 019.2 | 356.6 | 186.3 | 13 |
| 14 | 227.8 | 207.8 | 093.5 | 066.7 | 248.0 | 218.7 | 039.6 | 011.3 | 344.5 | 169.4 | 146.9 | 336.7 | 14 |
| 15 | 018.2 | 358.0 | 243.6 | 216.8 | 038.1 | 008.7 | 189.6 | 161.4 | 134.7 | 319.6 | 297.2 | 127.1 | 15 |
| 16 | 168.6 | 148.3 | 033.7 | 006.8 | 188.1 | 158.8 | 339.7 | 311.5 | 284.8 | 109.8 | 087.5 | 277.4 | 16 |
| 17 | 318.9 | 298.5 | 183.9 | 156.9 | 338.1 | 308.8 | 129.7 | 101.6 | 074.9 | 260.1 | 237.8 | 067.8 | 17 |
| 18 | 109.3 | 088.8 | 334.0 | 307.0 | 128.1 | 098.8 | 279.7 | 251.7 | 225.1 | 050.3 | 028.1 | 218.2 | 18 |
| 19 | 259.7 | 239.0 | 124.2 | 097.0 | 278.2 | 248.8 | 069.8 | 041.7 | 015.2 | 200.5 | 178.4 | 008.6 | 19 |
| 20 | 050.0 | 029.2 | 274.3 | 247.1 | 068.2 | 038.9 | 219.8 | 191.8 | 165.3 | 350.7 | 328.7 | 158.9 | 20 |
| 21 | 200.4 | 179.5 | 064.4 | 037.1 | 218.2 | 188.9 | 009.9 | 341.9 | 315.5 | 140.9 | 119.0 | 309.3 | 21 |
| 22 | 350.7 | 329.7 | 214.6 | 187.2 | 008.2 | 338.9 | 159.9 | 132.0 | 105.6 | 291.1 | 269.3 | 099.7 | 22 |
| 23 | 141.1 | 119.9 | 004.7 | 337.2 | 158.3 | 128.9 | 310.0 | 282.1 | 255.8 | 081.3 | 059.6 | 250.1 | 23 |
| 24 | 291.4 | 270.1 | 154.8 | 127.3 | 308.3 | 279.0 | 100.0 | 072.2 | 045.9 | 231.6 | 209.9 | 040.5 | 24 |
| 25 | 081.8 | 060.4 | 304.9 | 277.3 | 098.3 | 069.0 | 250.1 | 222.3 | 196.1 | 021.8 | 000.2 | 190.9 | 25 |
| 26 | 232.1 | 210.6 | 095.0 | 067.4 | 248.3 | 219.0 | 040.1 | 012.4 | 346.2 | 172.0 | 150.5 | 341.3 | 26 |
| 27 | 022.4 | 000.8 | 245.1 | 217.4 | 038.3 | 009.0 | 190.2 | 162.5 | 136.4 | 322.3 | 300.8 | 131.6 | 27 |
| 28 | 172.8 | 151.0 | 035.2 | 007.5 | 188.4 | 159.1 | 340.2 | 312.6 | 286.6 | 112.5 | 091.2 | 282.0 | 28 |
| 29 | 323.1 | | 185.4 | 157.5 | 338.4 | 309.1 | 130.3 | 102.7 | 076.7 | 262.7 | 241.5 | 072.4 | 29 |
| 30 | 113.4 | | 335.5 | 307.6 | 128.4 | 099.1 | 280.3 | 252.8 | 226.9 | 053.0 | 031.8 | 222.8 | 30 |
| 31 | 263.7 | | 125.6 | | 278.4 | | 070.4 | 042.9 | | 203.2 | | 013.2 | 31 |

### SYSTEM I
Rotation: 9h 50m 30.003s

| hr | deg° | hr | deg° | min | deg° |
|---|---|---|---|---|---|
| 01 | 036.6 | 13 | 115.5 | 05 | 03.0 |
| 02 | 073.2 | 14 | 152.1 | 10 | 06.1 |
| 03 | 109.7 | 15 | 188.7 | 15 | 09.1 |
| 04 | 146.3 | 16 | 225.3 | 20 | 12.2 |
| 05 | 182.9 | 17 | 261.8 | 25 | 15.2 |
| 06 | 219.5 | 18 | 298.4 | 30 | 18.3 |
| 07 | 256.1 | 19 | 335.0 | 35 | 21.3 |
| 08 | 292.6 | 20 | 011.6 | 40 | 24.4 |
| 09 | 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



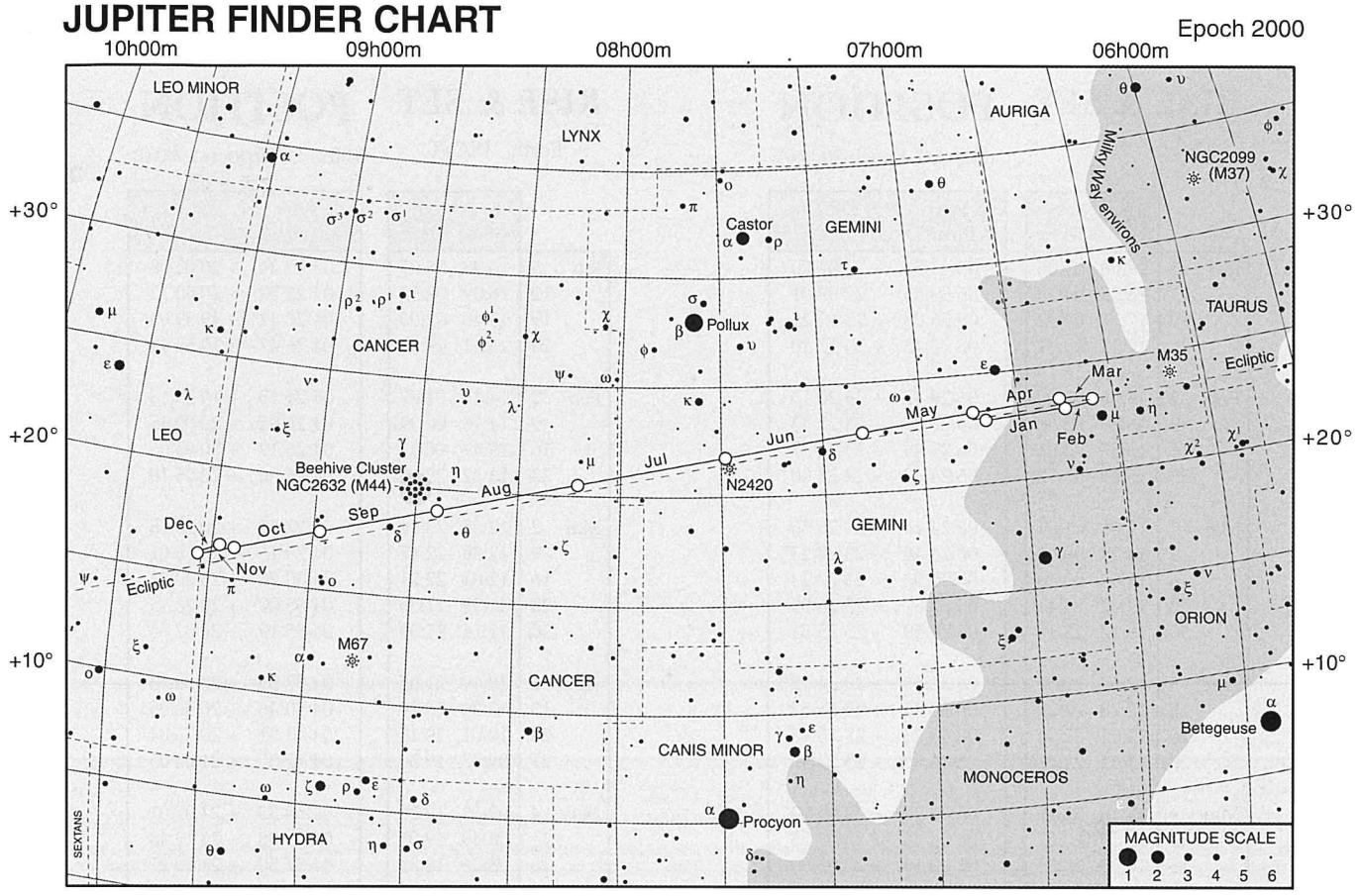

### SYSTEM II
Rotation: 9h 55m 40.062s

| hr | deg° | hr | deg° | min | deg° |
|---|---|---|---|---|---|
| 01 | 036.3 | 13 | 111.4 | 05 | 03.0 |
| 02 | 072.5 | 14 | 147.7 | 10 | 06.0 |
| 03 | 108.8 | 15 | 183.9 | 15 | 09.1 |
| 04 | 145.0 | 16 | 220.2 | 20 | 12.1 |
| 05 | 181.3 | 17 | 256.5 | 25 | 15.1 |
| 06 | 217.6 | 18 | 292.7 | 30 | 18.1 |
| 07 | 253.8 | 19 | 329.0 | 35 | 21.2 |
| 08 | 290.1 | 20 | 005.2 | 40 | 24.2 |
| 09 | 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

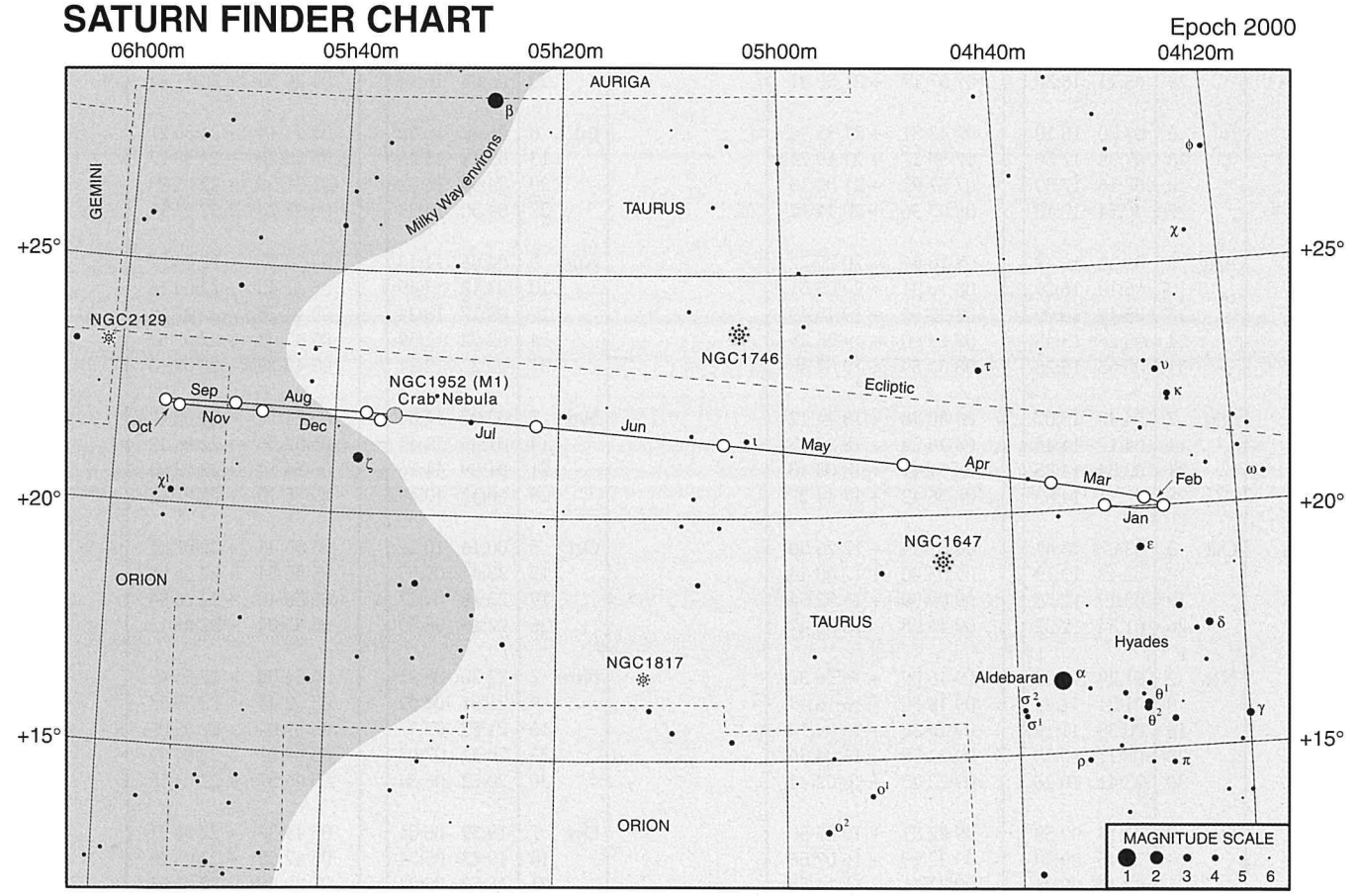
For further explanation see page 64

## JUPITER FINDER CHART




Opposition 1st January, Stationary 2nd March, Conjunction 20th July, Stationary 5th December.

## SATURN FINDER CHART




Stationary 8th February, Conjunction 9th June, Stationary 11th October, Opposition 18th December.

# JUPITER

## RISE & SET

Perth WAST

## POSITION

(0hrs UT Epoch 2000.0)

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

# SATURN

## RISE & SET

Perth WAST

## POSITION

(0hrs UT Epoch 2000.0)

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

# URANUS, NEPTUNE AND PLUTO

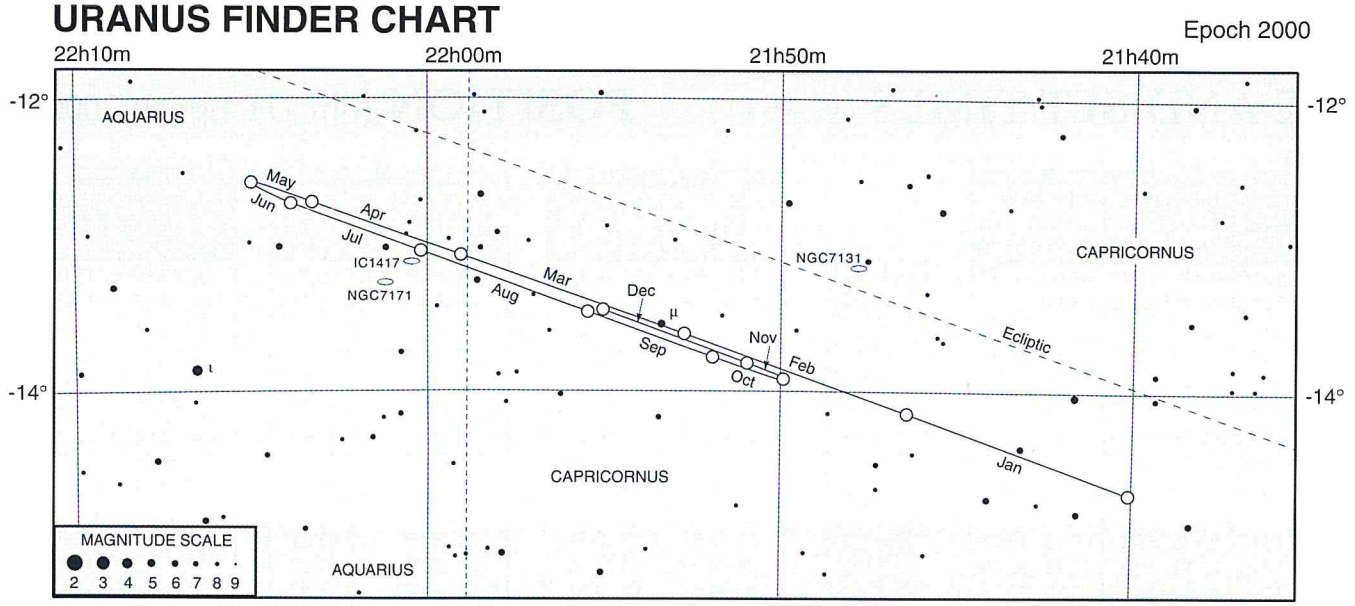
## RISE AND SET TIMES (WAST)

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

## POSITION (0hr UT Epoch 2000.0)

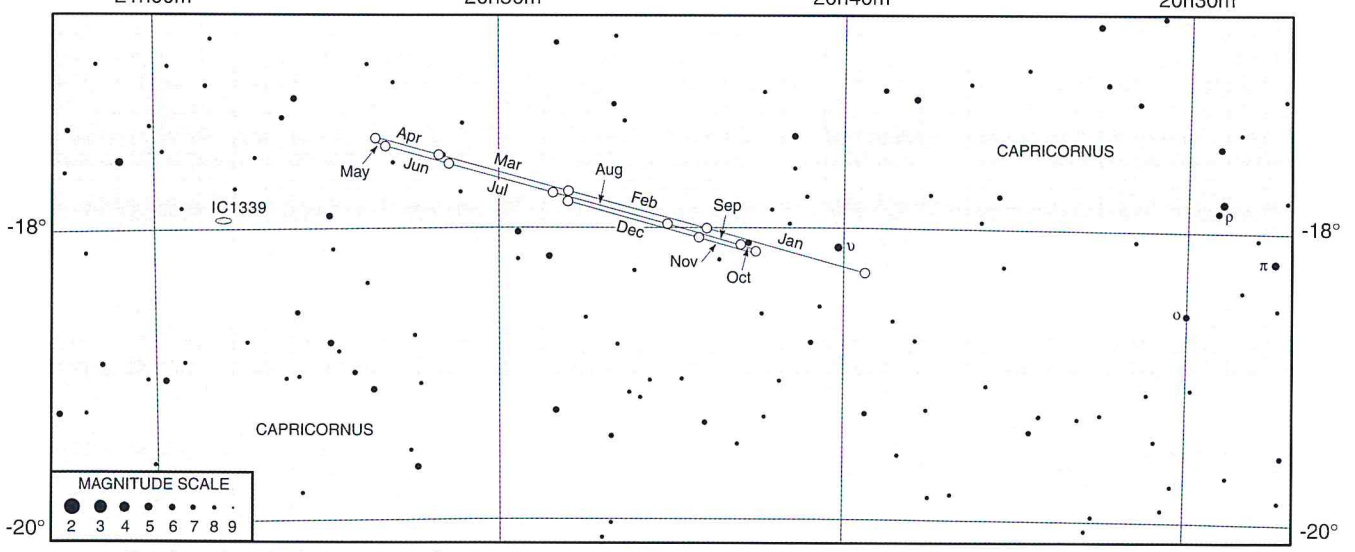
| | URANUS RA h m s | URANUS DEC ° ' " | NEPTUNE RA h m s | NEPTUNE DEC ° ' " | PLUTO RA h m s | PLUTO DEC ° ' " |
|---|---|---|---|---|---|---|
| Jan 5 | 21 40 52 | - 14 38 03 | 20 39 47 | - 18 16 39 | 17 03 59 | - 13 00 10 |
| 12 | 21 42 13 | - 14 31 04 | 20 40 49 | - 18 12 51 | 17 04 57 | - 13 00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

## URANUS FINDER CHART



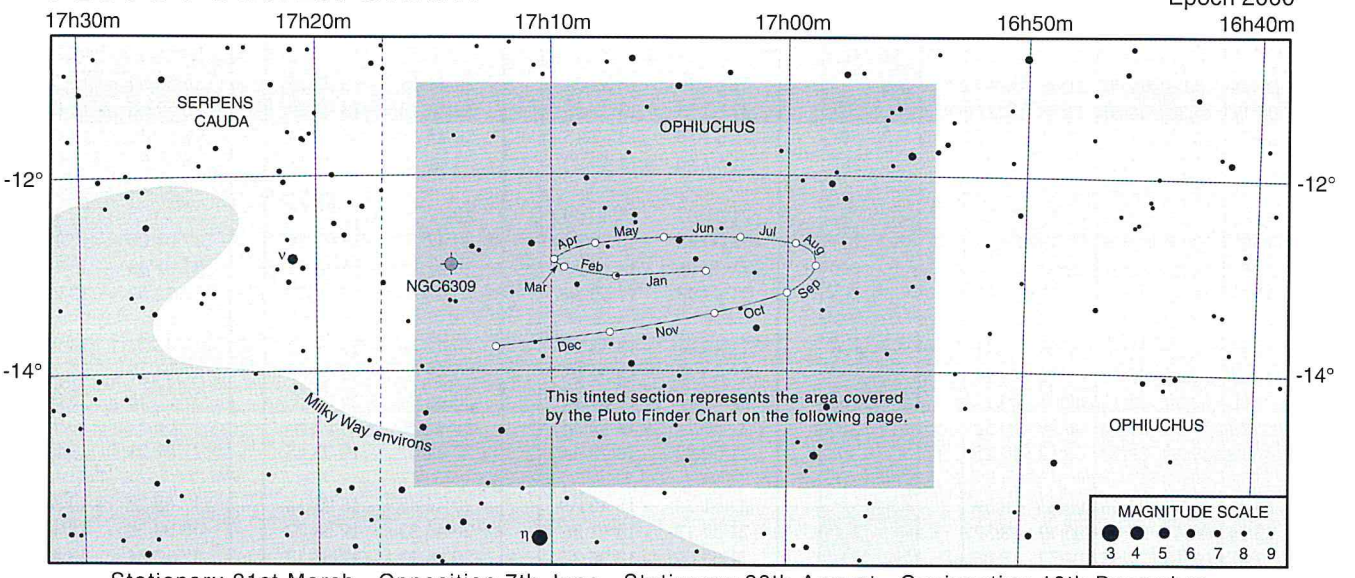

Conjunction 14th February, Stationary 3rd June, Opposition 20th August, Stationary 4th November.

## NEPTUNE FINDER CHART




Conjunction 28th January, Stationary 13th May, Opposition 2nd August, Stationary 20th October.

## PLUTO POINTER CHART

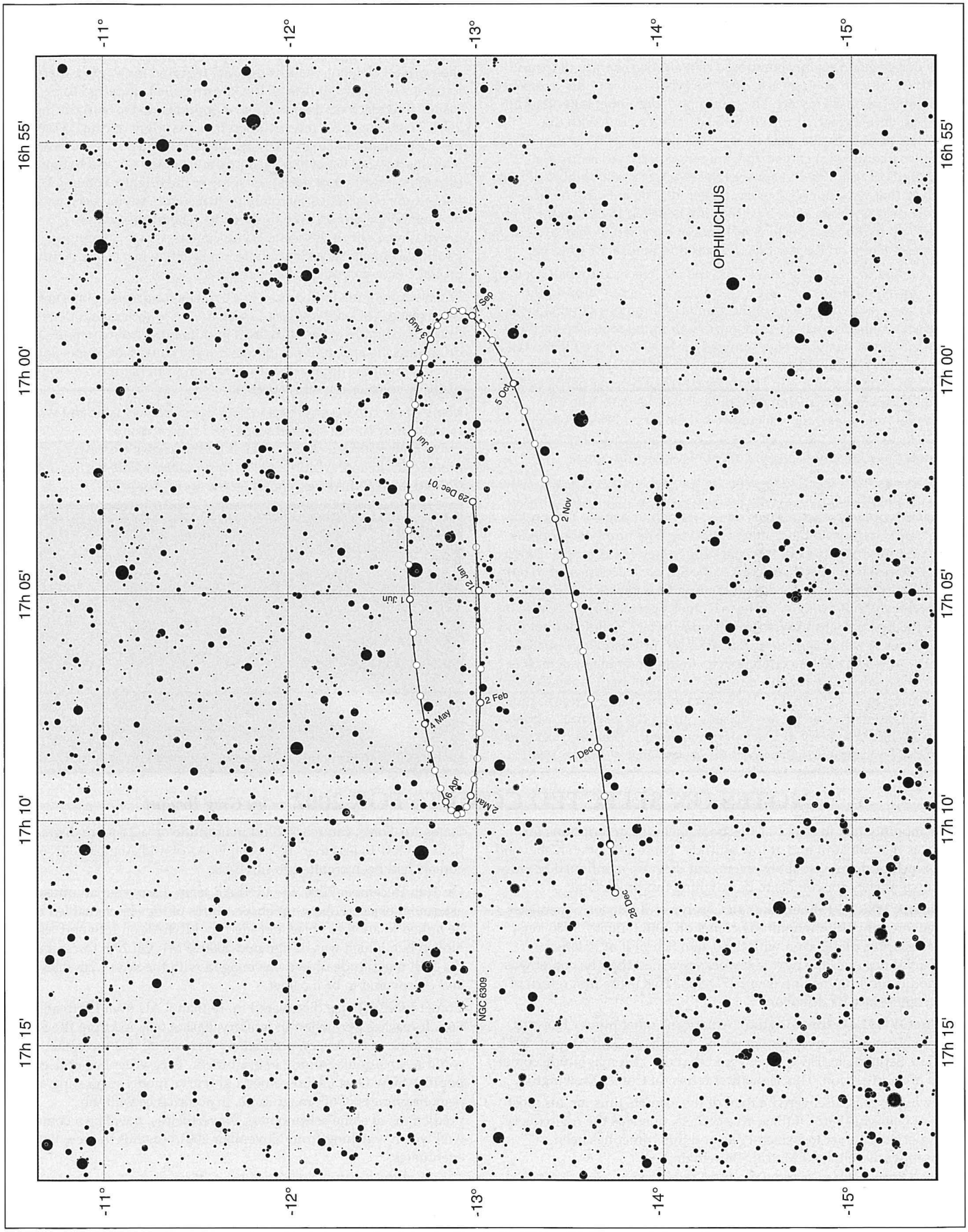



Stationary 21st March, Opposition 7th June, Stationary 28th August, Conjunction 10th December.

See introduction to Part II (p. 65) for more information.

# PLUTO FINDER CHART 2002

## Epoch 2000.0




Pluto is shown at weekly intervals. See introduction to Part II (p. 65) for more information.

# COMETS FOR 2002

**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 'egg shaped' compared to those of the planets. They 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 sublimes 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 heavier particles 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.

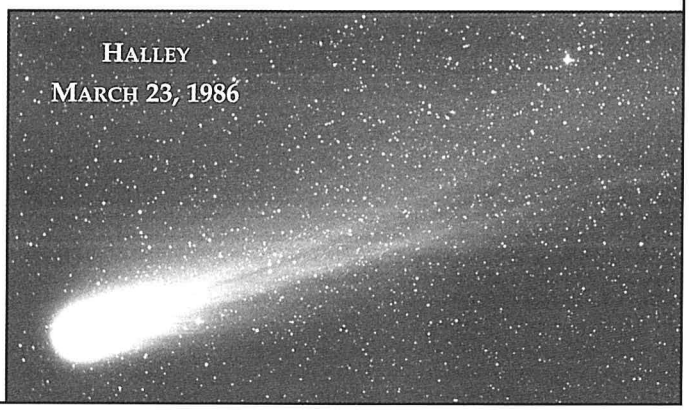
Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' refers to the fact the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 6P/d'Arrest indicates d'Arrest was the 6th 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 Comet Catalina is referred to as 'C/1999 F1'. 1999 refers to the year, F refers to the 6th half month period ('I' is not used) during the year and 1 shows it was the first discovery in this half of the month. Therefore Catalina was the first comet discovered in the second half of March 1999.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbits, the overall brightness, the size of the coma and the 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 2002. The table (p. 98) 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 2002. There are also a few included that are bright during 2002 but have a perihelion date in 2001 or 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. 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 2002 are extremely faint and would require professional size telescopes or long exposure astrophotographs to detect them. But who knows what new discoveries lie in the future! (2001 was looking a little boring until C/2001 A2 (LINEAR) exploded on the scene, see p. 33).




## NOTES ON SELECTED COMETS FOR 2002 – *by Greg Bryant*

The monthly text in Part 1 of this book includes descriptions for comets that are faint and at low altitude. These will often be beyond the reach of many visual observers, but they are mentioned because of the tendency for comets to be anything but predictable.

**Comet P/1986 A1 (Shoemaker 3):** Carolyn and Eugene Shoemaker discovered this 13th magnitude comet on 10th January, 1986, on a photographic plate taken with the 0.46m Schmidt at Palomar. Observations over the next few weeks revealed that the comet was periodic, orbiting the Sun every 17 years. This is the first return of the comet since its discovery.

**Comet P/1992 Q1 (Brewington)**: American comet hunter Howard Brewington discovered this comet, his fourth, on 28th August, 1992. By late September, it was discovered that the 11th magnitude comet was of short-period. This is the first return of Comet Brewington.

Brewington has discovered a total of five comets thus far, his most recent being in 1996. Of those five comets, one was the rediscovery of a periodic comet lost since 1906, and this comet has been subsequently renamed Metcalf-Brewington.

**Comet C/2000 WM1 (LINEAR)**: The LINEAR (Lincoln Near Earth Asteroid Research) program has discovered many objects since its inception a few years ago. The survey, largely funded by the United States Air Force, can reach 22nd magnitude on a 2 square degree field of view in less than 100 seconds. As of mid-August 2001, 62 comets had been credited to LINEAR.

On 16th December 2000, the LINEAR team discovered an unusual asteroidal object. Follow-up observations of the object enabled it to be linked to another object detected by LINEAR on 16th and 18th November, which was designated 2000 WM1. On 20th December, the 18th magnitude object was imaged with the SAO 1.2m telescope and discovered to be a comet.

Comet LINEAR was discovered more than 5 AU from Earth and the Sun. It reaches perihelion in January 2002 at 0.56 AU from the Sun. At the time of discovery, predictions were made that the comet could reach 4th magnitude in brightness. This writer has utilised a popular 'new Oort Cloud comet' lightcurve model suggesting a peak brightness of 6th magnitude, in accordance with the predictions of some astronomers. Nevertheless, it will be a comet well worth watching from November 2001 onwards to see what eventuates.

**Comet 7P/Pons-Winnecke**: Jean Louis Pons, the most successful amateur comet hunter in history, discovered this comet on 12th June, 1819. Eighth magnitude at the time, the comet brightened further as

it neared both the Earth and the Sun. By late July, shortly after perihelion, it was reported to be between 5th and 6th magnitude, but immersed in twilight skies. The comet was lost from sight afterwards - a pity as in late August, it passed 0.13 AU from Earth.

Johann Encke (of Comet Encke fame) believed that Pons' comet was periodic, but although he calculated an orbital period of 5.62 years, the comet was not recovered at subsequent returns and was considered lost. In 1858, Friedrich Winnecke accidentally rediscovered the comet on 9th March as an 8th magnitude object in the morning sky. Orbital calculations within a few days of the comet's discovery revealed a similarity to Pons' comet of 1819, and this was confirmed by the time the comet was last observed in June of that year. Although the observing geometry for the comet's next return, in 1863, was very poor (and the comet was indeed missed), it was recovered at the return of 1869.

Close encounters with Jupiter have steadily increased Pons-Winnecke's orbital period and perihelion distance since 1869; from 5.59 years and 0.78 AU to 6.38 years and 1.26 AU respectively. In 1927, the comet passes just 0.04 AU from Earth (the 7th closest known approach by any comet), and displayed a brightness of better than 4th magnitude. For now, because of Pons-Winnecke's perihelion distance being somewhat greater than the extent of Earth's orbit, such close approaches can not occur. In 2062, however, the comet is predicted to pass 0.17 AU from Earth.

**Comet 19P/Borrelly**: Alphonse Borrelly, a comet hunter of the late 19th and early 20th centuries, discovered this comet on the night of 28th December, 1904 from Marseilles in France. Of the ten comets that bear Borrelly's name, only this one is short-period in nature. Following its discovery, the comet was widely observed during January 1905, at which time it peaked at 9th magnitude in brightness. It was observed until May of that year, and during its time, its periodic nature was revealed - perihelion was calculated to have occurred on 17th January and the orbital period was 6.9 years.

Search ephemerides calculated by G. Fayet enabled H. Knox Shaw and Alexandre Schaumasse to independently recover the comet on 20th September 1911. That return of Comet Borrelly was particularly favourable, with the comet's brightness approaching 8th magnitude. Since then, the apparitions of Borrelly have been good and bad, with an approach near Jupiter slightly altering its orbit, and locking it into a set of bad returns (period of 7 years) in the mid 20th Century. Another Jupiter encounter enabled Borrelly's period to be shortened from 7 to 6.8 years, enabling better apparitions to occur. In 1987, the comet peaked at magnitude 7.5.

During the 1994 return, the Hubble Space Telescope obtained images of the comet, and the nucleus was measured to be 8.3 x 3.3 km. Comet Borrelly was the target of the Deep Space 1 mission, which was launched in October 1998 and encountered the comet in September 2001 as this book was going to press. Borrelly was expected to peak at 9th magnitude around this time.

**Comet 22P/Kopff**: August Kopff, an astronomer who would later become director of an astronomy institute in Germany, photographically discovered this comet on 23rd August, 1906. The 12th magnitude comet was revealed to be periodic within a few weeks, although the return of 1912/13 was predicted to be too unfavourable for recovery. The subsequent return of 1919 saw the comet recovered by Max Wolf quite close to the predicted position.

Since 1919, Kopff has been seen at every apparition. Its most recent return, in 1996, was extremely favourable, with the comet's closest approach to Earth (0.57 AU) occurring just days after perihelion. As a result, the comet rose to better than 8th magnitude in brightness.

**46P/Wirtanen** was discovered on 17th January 1948, on a photographic plate by Carl Wirtanen of Lick Observatory, whilst conducting a program of studying the proper motion of stars. The 16th magnitude comet was more than six weeks past perihelion at discovery, fading as it moved away from both Earth and the Sun. In 1954, Carl Wirtanen himself recovered the comet at its next return.

Prior to 1986, Wirtanen never became brighter than 15th magnitude, making it too faint for the amateur visual observer. However, a combination of close approaches to Jupiter in 1972 and 1984 reduced Wirtanen's perihelion distance from 1.61 AU to 1.26 AU and finally to 1.08 AU. This enabled Wirtanen to be observed by amateurs at its returns in 1986, 1991, and 1997.

Comet Wirtanen is the target of Europe's Rosetta mission. Scheduled for launch in January 2003, the Rosetta probe will rendezvous with the comet some eight years later.

Wirtanen is also one of several periodic comets that can make close approaches to Earth. In December 2018, Wirtanen will pass less than 0.1 AU from Earth, and it should be visible to the naked-eye.

**Comet 67P/Churyumov-Gerasimenko**: On 20th September, 1969, Klim Churyumov examined a photographic plate taken by Svetlana Gerasimenko on 11th September at Alma-Ata Observatory in Russia during the course of a survey of comets. Churyumov identified a 13th magnitude comet that he believed was periodic comet Comas Sola, which was the target of the photograph. However, the following month, he discovered that the comet was in the wrong position for Comas Sola, and a new discovery was recognised.

Churyumov-Gerasimenko is a classic example of how Jupiter can bring new periodic comets into the inner Solar System, and into range for amateurs. In 1840, a close approach to Jupiter reduced the comet's perihelion distance from 4.0 AU to 3.0 AU, and another close approach in 1959 brought it down to 1.3 AU.

**Comet 96P/Machholz 1**: Donald Machholz was one of the top comet discoverers of the 1980s and 1990s, discovering nine in total, two of which were short-period in nature. This comet, his first periodic, was discovered on 12th May 1986. Brightness estimates at the time were between 10th and 11th magnitude. A parabolic orbit was calculated from observations over the first few days. In June, astronomers were very surprised to learn that the comet was in fact short-period in nature, orbiting the Sun every 5.2 years. Its exceedingly small perihelion distance, large eccentricity, and high inclination were nothing like any other member of the Jupiter family of comets.

Studies of the comet's orbit showed that it had been relatively stable for many centuries, so it became apparent that the most likely conclusion was that the comet, after having been dormant and thus undetectable for some time, had just become active. Modelling also showed that the comet's perihelion distance 1300 years ago was 0.9 AU. Today, it is 0.12 AU, and by 2450 will be as close as 0.03 AU to the Sun. Should the comet survive those increasingly close passages to the Sun, the perihelion distance will begin to move out again.

Another surprise came when the comet was observed in 1988 and 1989, around the time of aphelion when the it was 5.9 AU from the Sun. Images of the stellar nucleus were brighter than expected, leading some to believe the comet was still showing some activity.

The observing window for Comet Machholz 1 is very short at each return, and this return is less favourable than most. At its last return in 1996, the comet was not visually observed by amateurs (Andrew Pearce from Western Australia reported several negative observations) but it was captured by the orbiting SOHO spacecraft around the time of perihelion - its images showed the comet at between 3rd and 4th magnitude.

**Comet 116P/Wild 4**: This comet was discovered by Paul Wild on 21st January 1990. The 14th magnitude object was found on a photographic plate and it was soon revealed that the comet was periodic in nature. Calculations in early February revealed that the comet had previously been in a low-eccentricity (e = 0.17) orbit with a perihelion distance of 3.8 AU before a close approach to Jupiter in July 1987 moved the comet much closer to the Sun.

At both its discovery apparition and its subsequent return in 1996, observers have seen the comet peak in brightness at 12th magnitude. A similar performance is expected for this return, which sees Wild 4 reach perihelion in January 2003.

***BIOGRAPHICAL NOTE:*** *Greg Bryant has been an astronomy writer, active observer, and member of the amateur astronomical community since the mid-1980s. He is publisher of the quarterly newsletter Comet Tales (p. 108) which provides updates on old and newly discovered comets. In 2000, he was honoured by the International Astronomical Union with the naming of minor planet (9984) Gregbryant.*

# COMET EPHEMERIDES 2002

### EXPLANATION OF COMET EPHEMERIDES

**Date** is for 0 hr UT or 8am WAST 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).

The estimate of total magnitude is normally calculated using the formula: Mag. = H1 + 5 log (Δ) + K1 log R.

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 nearly always 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.

## Comet 22P/Kopff

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Aug 3 | 12 44.3 | +00 20 | 2.333 | 2.025 | 60 | 12.8 |
| 2002 Aug 10 | 12 56.0 | -01 43 | 2.358 | 1.987 | 56 | 12.6 |
| 2002 Aug 17 | 13 08.3 | -03 09 | 2.380 | 1.949 | 53 | 12.4 |
| 2002 Aug 24 | 13 21.4 | -04 38 | 2.399 | 1.913 | 50 | 12.2 |
| 2002 Aug 31 | 13 35.2 | -06 09 | 2.415 | 1.877 | 47 | 12.0 |
| 2002 Sep 7 | 13 49.7 | -07 41 | 2.428 | 1.843 | 44 | 11.8 |
| 2002 Sep 14 | 14 04.9 | -09 14 | 2.439 | 1.810 | 41 | 11.6 |
| 2002 Sep 21 | 14 20.8 | -10 47 | 2.447 | 1.779 | 39 | 11.4 |
| 2002 Sep 28 | 14 37.5 | -12 18 | 2.454 | 1.750 | 36 | 11.3 |
| 2002 Oct 5 | 14 54.9 | -13 48 | 2.459 | 1.722 | 34 | 11.1 |
| 2002 Oct 12 | 15 13.1 | -15 14 | 2.464 | 1.697 | 32 | 10.9 |
| 2002 Oct 19 | 15 32.1 | -16 36 | 2.467 | 1.673 | 29 | 10.8 |
| 2002 Oct 26 | 15 51.8 | -17 53 | 2.471 | 1.652 | 27 | 10.6 |
| 2002 Nov 2 | 16 12.2 | -19 02 | 2.475 | 1.634 | 25 | 10.5 |
| 2002 Nov 9 | 16 33.3 | -20 04 | 2.479 | 1.618 | 23 | 10.4 |
| 2002 Nov 16 | 16 55.1 | -20 56 | 2.484 | 1.605 | 22 | 10.3 |
| 2002 Nov 23 | 17 17.3 | -21 37 | 2.490 | 1.595 | 20 | 10.3 |
| 2002 Nov 30 | 17 40.1 | -22 07 | 2.498 | 1.588 | 18 | 10.2 |
| 2002 Dec 7 | 18 03.1 | -22 24 | 2.507 | 1.584 | 16 | 10.2 |
| 2002 Dec 14 | 18 26.3 | -22 29 | 2.519 | 1.584 | 14 | 10.2 |
| 2002 Dec 21 | 18 49.6 | -22 21 | 2.532 | 1.586 | 13 | 10.2 |
| 2002 Dec 28 | 19 12.7 | -22 00 | 2.547 | 1.592 | 11 | 10.3 |

## COMETS FOR 2002 — ORBITAL ELEMENTS (EQUINOX 2000.0)

| Comet Name | Perihelion Date yy mm d.dd | q A.U. | e | Period years | ω deg | Ω deg | i deg | H1 | K1 |
|---|---|---|---|---|---|---|---|---|---|
| 19P/Borrelly | 2001 09 14.7334 | 1.358200 | 0.623896 | 6.9 | 353.3759 | 075.4249 | 030.3247 | 5.0 | 25.0 |
| 96P/Machholz 1 | 2002 01 08.6337 | 0.124105 | 0.958812 | 5.2 | 014.5807 | 094.6084 | 060.1866 | 13.0 | 12.0 |
| 31P/Schwassmann-Wachmann 2 | 2002 01 18.5163 | 3.408579 | 0.195287 | 8.7 | 018.4031 | 114.1943 | 004.5497 | 5.0 | 20.0 |
| C/2000 WM1 (LINEAR) | 2002 01 22.6656 | 0.555386 | 1.000299 | | 276.7671 | 237.8988 | 072.5473 | 8.0 | 7.5 |
| 125P/Spacewatch | 2002 01 28.0513 | 1.528592 | 0.511540 | 5.5 | 087.3013 | 153.2367 | 009.9815 | 13.0 | 15.0 |
| 6P/d'Arrest | 2002 02 03.5918 | 1.352768 | 0.612809 | 6.5 | 178.1117 | 138.9440 | 019.4973 | 15.0 | 7.5 |
| 15P/Finlay | 2002 02 07.1675 | 1.034099 | 0.710510 | 6.8 | 323.6382 | 041.9643 | 003.6745 | 12.0 | 10.0 |
| C/1999 F1 (Catalina) | 2002 02 13.7405 | 5.786986 | 0.998887 | | 255.1658 | 020.0125 | 092.0300 | 4.0 | 10.0 |
| 89P/Russell 2 | 2002 03 22.9086 | 2.290067 | 0.397912 | 7.4 | 249.2165 | 042.4840 | 012.0279 | 11.5 | 15.0 |
| C/2001 C1 (LINEAR) | 2002 03 28.3037 | 5.104696 | 0.999785 | | 219.9358 | 033.7113 | 068.9514 | 6.0 | 10.0 |
| C/2000 SV74 (LINEAR) | 2002 04 30.4781 | 3.541380 | 1.005072 | | 076.2330 | 024.1852 | 075.2412 | 4.5 | 10.0 |
| 7P/Pons-Winnecke | 2002 05 15.7228 | 1.258149 | 0.634076 | 6.4 | 172.2915 | 093.4504 | 022.2848 | 10.0 | 15.0 |
| 90P/Gehrels 1 | 2002 06 23.0188 | 2.965533 | 0.508858 | 14.8 | 028.1966 | 013.5283 | 009.6163 | 9.5 | 10.0 |
| 124P/Mrkos | 2002 07 27.0306 | 1.467056 | 0.542643 | 5.7 | 181.2447 | 001.3902 | 031.3522 | 13.5 | 7.5 |
| 57P/du Toit-Neujmin-Delporte | 2002 07 31.1636 | 1.729518 | 0.499103 | 6.4 | 115.2389 | 188.9317 | 002.8442 | 5.5 | 20.0 |
| 54P/de Vico-Swift | 2002 08 07.4524 | 2.146053 | 0.430565 | 7.3 | 002.1374 | 358.9324 | 006.0925 | 10.0 | 15.0 |
| 67P/Churyumov-Gerasimenko | 2002 08 18.3101 | 1.292339 | 0.631528 | 6.6 | 011.4520 | 050.9685 | 007.1204 | 11.0 | 10.0 |
| 46P/Wirtanen | 2002 08 26.9664 | 1.058778 | 0.657885 | 5.4 | 356.4001 | 082.1739 | 011.7381 | 8.5 | 27.0 |
| 77P/Longmore | 2002 09 04.7225 | 2.309541 | 0.358190 | 6.8 | 196.4466 | 014.9767 | 024.4034 | 9.0 | 14.0 |
| 18P/Perrine-Mrkos | 2002 09 10.3965 | 1.287243 | 0.639515 | 6.8 | 166.6442 | 240.5570 | 017.8644 | 11.5 | 20.0 |
| 92P/Sanguin | 2002 09 23.0561 | 1.807428 | 0.663372 | 12.4 | 163.0502 | 182.3498 | 018.7644 | 12.0 | 15.0 |
| C/2001 K5 (LINEAR) | 2002 10 11.9362 | 5.184540 | 1.000000 | | 047.0686 | 237.4667 | 072.6252 | 2.5 | 10.0 |
| 26P/Grigg-Skjellerup | 2002 11 29.7204 | 1.117878 | 0.632709 | 5.3 | 001.6241 | 211.7398 | 022.3473 | 12.0 | 40.0 |
| 22P/Kopff | 2002 12 12.0763 | 1.583608 | 0.543307 | 6.5 | 162.7536 | 120.9290 | 004.7185 | 3.0 | 26.0 |
| P/1986 A1 (Shoemaker 3) | 2002 12 15.0206 | 1.813723 | 0.726794 | 17.1 | 014.9411 | 097.2704 | 006.3862 | 10.0 | 12.0 |
| 39P/Oterma | 2002 12 21.7164 | 5.470734 | 0.244575 | 19.5 | 056.3664 | 331.5834 | 001.9432 | 5.0 | 15.0 |
| P/1993 K2 (Helin-Lawrence) | 2002 12 22.4478 | 3.110104 | 0.307738 | 9.5 | 163.6906 | 092.0158 | 009.8713 | 10.0 | 8.5 |
| 115P/Maury | 2002 12 23.8741 | 2.041656 | 0.520806 | 8.8 | 119.8758 | 176.7557 | 011.6826 | 11.5 | 15.0 |
| 30P/Reinmuth 1 | 2002 12 24.3991 | 1.877508 | 0.502115 | 7.3 | 013.2867 | 119.7568 | 008.1306 | 9.5 | 15.0 |
| 28P/Neujmin 1 | 2002 12 27.3786 | 1.552051 | 0.775627 | 18.2 | 346.9190 | 347.0339 | 014.1853 | 11.5 | 6.0 |
| 116P/Wild 4 | 2003 01 21.7803 | 2.169793 | 0.375570 | 6.5 | 173.4160 | 021.0752 | 003.6160 | 2.5 | 25.0 |
| P/1992 Q1 (Brewington) | 2003 02 18.8430 | 1.590355 | 0.671624 | 10.7 | 048.0058 | 343.6435 | 018.0596 | 6.5 | 10.0 |
| C/2001 HT50 (LINEAR-NEAT) | 2003 07 08.7975 | 2.804298 | 1.000000 | | 323.8007 | 042.8812 | 163.2401 | 4.5 | 10.0 |

**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 7P/Pons-Winnecke

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Mar 2 | 16 58.4 | +03 43 | 1.202 | 1.538 | 89 | 13.2 |
| 2002 Mar 9 | 17 19.8 | +03 10 | 1.126 | 1.494 | 90 | 12.9 |
| 2002 Mar 16 | 17 41.8 | +02 34 | 1.055 | 1.453 | 90 | 12.5 |
| 2002 Mar 23 | 18 04.5 | +01 52 | 0.989 | 1.414 | 91 | 12.2 |
| 2002 Mar 30 | 18 28.0 | +01 02 | 0.928 | 1.379 | 91 | 11.9 |
| 2002 Apr 6 | 18 52.2 | +00 03 | 0.873 | 1.347 | 92 | 11.6 |
| 2002 Apr 13 | 19 17.1 | -01 07 | 0.823 | 1.319 | 92 | 11.4 |
| 2002 Apr 20 | 19 42.8 | -02 31 | 0.778 | 1.296 | 92 | 11.1 |
| 2002 Apr 27 | 20 09.0 | -04 09 | 0.740 | 1.279 | 93 | 10.9 |
| 2002 May 4 | 20 35.7 | -06 02 | 0.707 | 1.266 | 94 | 10.8 |
| 2002 May 11 | 21 02.7 | -08 09 | 0.680 | 1.259 | 94 | 10.7 |
| 2002 May 18 | 21 29.7 | -10 29 | 0.658 | 1.258 | 96 | 10.6 |
| 2002 May 25 | 21 56.3 | -12 60 | 0.643 | 1.263 | 97 | 10.6 |
| 2002 Jun 1 | 22 22.1 | -15 40 | 0.633 | 1.274 | 99 | 10.6 |
| 2002 Jun 8 | 22 46.8 | -18 25 | 0.628 | 1.290 | 101 | 10.6 |
| 2002 Jun 15 | 23 09.9 | -21 15 | 0.629 | 1.311 | 103 | 10.8 |
| 2002 Jun 22 | 23 30.9 | -24 06 | 0.633 | 1.337 | 106 | 10.9 |
| 2002 Jun 29 | 23 49.6 | -26 58 | 0.641 | 1.367 | 109 | 11.1 |
| 2002 Jul 6 | 00 05.7 | -29 48 | 0.653 | 1.401 | 112 | 11.3 |
| 2002 Jul 13 | 00 18.9 | -32 35 | 0.668 | 1.439 | 116 | 11.5 |
| 2002 Jul 20 | 00 28.8 | -35 18 | 0.687 | 1.479 | 119 | 11.7 |
| 2002 Jul 27 | 00 35.5 | -37 53 | 0.710 | 1.523 | 123 | 12.0 |
| 2002 Aug 3 | 00 38.9 | -40 17 | 0.736 | 1.568 | 126 | 12.3 |
| 2002 Aug 10 | 00 38.8 | -42 25 | 0.767 | 1.615 | 130 | 12.5 |
| 2002 Aug 17 | 00 35.6 | -44 12 | 0.803 | 1.664 | 133 | 12.8 |

## Comet C/2000 WM1 (LINEAR)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2001 Nov 3 | 04 25.9 | +48 43 | 0.793 | 1.674 | 139 | 9.2 |
| 2001 Nov 10 | 03 59.7 | +45 37 | 0.631 | 1.565 | 149 | 8.5 |
| 2001 Nov 17 | 03 21.5 | +39 14 | 0.487 | 1.455 | 160 | 7.7 |
| 2001 Nov 24 | 02 31.2 | +26 27 | 0.374 | 1.343 | 159 | 6.8 |
| 2001 Dec 1 | 01 33.5 | +04 55 | 0.318 | 1.230 | 135 | 6.2 |
| 2001 Dec 8 | 00 36.8 | -18 47 | 0.340 | 1.116 | 104 | 6.0 |
| 2001 Dec 15 | 23 47.1 | -35 21 | 0.420 | 1.002 | 80 | 6.1 |
| 2001 Dec 22 | 23 04.7 | -45 00 | 0.527 | 0.889 | 64 | 6.2 |
| 2001 Dec 29 | 22 26.4 | -50 37 | 0.643 | 0.782 | 53 | 6.2 |
| 2002 Jan 5 | 21 48.6 | -53 42 | 0.759 | 0.684 | 44 | 6.2 |
| 2002 Jan 12 | 21 09.9 | -54 38 | 0.870 | 0.607 | 38 | 6.1 |
| 2002 Jan 19 | 20 32.9 | -53 19 | 0.972 | 0.562 | 33 | 6.1 |
| 2002 Jan 26 | 20 03.2 | -49 51 | 1.058 | 0.561 | 32 | 6.2 |
| 2002 Feb 2 | 19 43.7 | -44 54 | 1.125 | 0.604 | 32 | 6.6 |
| 2002 Feb 9 | 19 33.0 | -39 15 | 1.173 | 0.680 | 35 | 7.1 |
| 2002 Feb 16 | 19 27.7 | -33 25 | 1.205 | 0.777 | 40 | 7.6 |
| 2002 Feb 23 | 19 25.2 | -27 38 | 1.224 | 0.884 | 46 | 8.0 |
| 2002 Mar 2 | 19 23.9 | -21 55 | 1.234 | 0.996 | 52 | 8.4 |
| 2002 Mar 9 | 19 22.6 | -16 16 | 1.237 | 1.110 | 59 | 8.8 |
| 2002 Mar 16 | 19 20.8 | -10 38 | 1.238 | 1.224 | 66 | 9.1 |
| 2002 Mar 23 | 19 17.9 | -05 02 | 1.237 | 1.338 | 73 | 9.4 |
| 2002 Mar 30 | 19 13.6 | +00 34 | 1.239 | 1.449 | 80 | 9.7 |
| 2002 Apr 6 | 19 07.5 | +06 06 | 1.246 | 1.560 | 87 | 9.9 |
| 2002 Apr 13 | 18 59.4 | +11 28 | 1.260 | 1.668 | 94 | 10.2 |
| 2002 Apr 20 | 18 49.2 | +16 36 | 1.283 | 1.775 | 101 | 10.4 |
| 2002 Apr 27 | 18 36.9 | +21 19 | 1.318 | 1.880 | 107 | 10.7 |
| 2002 May 4 | 18 22.6 | +25 30 | 1.365 | 1.984 | 113 | 10.9 |
| 2002 May 11 | 18 06.7 | +29 02 | 1.425 | 2.086 | 117 | 11.2 |
| 2002 May 18 | 17 49.9 | +31 51 | 1.499 | 2.186 | 120 | 11.4 |
| 2002 May 25 | 17 32.8 | +33 55 | 1.586 | 2.285 | 122 | 11.7 |
| 2002 Jun 1 | 17 16.2 | +35 16 | 1.685 | 2.382 | 122 | 12.0 |
| 2002 Jun 8 | 17 00.9 | +36 01 | 1.795 | 2.478 | 121 | 12.2 |
| 2002 Jun 15 | 16 47.2 | +36 13 | 1.915 | 2.573 | 120 | 12.5 |
| 2002 Jun 22 | 16 35.6 | +36 01 | 2.044 | 2.666 | 117 | 12.7 |

## Comet 46P/Wirtanen

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Jul 6 | 03 57.3 | +13 19 | 1.773 | 1.262 | 44 | 12.5 |
| 2002 Jul 13 | 04 25.4 | +15 10 | 1.727 | 1.216 | 44 | 12.0 |
| 2002 Jul 20 | 04 54.9 | +16 51 | 1.690 | 1.174 | 43 | 11.5 |
| 2002 Jul 27 | 05 25.6 | +18 17 | 1.662 | 1.138 | 42 | 11.1 |
| 2002 Aug 3 | 05 57.2 | +19 26 | 1.644 | 1.107 | 41 | 10.8 |
| 2002 Aug 10 | 06 29.4 | +20 14 | 1.634 | 1.083 | 40 | 10.5 |
| 2002 Aug 17 | 07 01.8 | +20 40 | 1.632 | 1.067 | 40 | 10.3 |
| 2002 Aug 24 | 07 34.1 | +20 44 | 1.639 | 1.060 | 39 | 10.3 |
| 2002 Aug 31 | 08 05.8 | +20 27 | 1.651 | 1.060 | 38 | 10.3 |
| 2002 Sep 7 | 08 36.5 | +19 49 | 1.670 | 1.069 | 38 | 10.4 |
| 2002 Sep 14 | 09 06.0 | +18 55 | 1.692 | 1.086 | 38 | 10.6 |
| 2002 Sep 21 | 09 34.0 | +17 47 | 1.717 | 1.111 | 38 | 10.9 |
| 2002 Sep 28 | 10 00.6 | +16 28 | 1.745 | 1.143 | 38 | 11.3 |
| 2002 Oct 5 | 10 25.6 | +15 03 | 1.772 | 1.180 | 39 | 11.7 |
| 2002 Oct 12 | 10 49.1 | +13 34 | 1.800 | 1.223 | 40 | 12.1 |
| 2002 Oct 19 | 11 11.2 | +12 04 | 1.826 | 1.270 | 42 | 12.6 |

## Comet 57P/du Toit-Neujmin-Delporte

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Mar 2 | 17 28.3 | -21 07 | 2.152 | 2.184 | 79 | 13.9 |
| 2002 Mar 9 | 17 42.1 | -21 06 | 2.042 | 2.149 | 82 | 13.7 |
| 2002 Mar 16 | 17 55.7 | -20 59 | 1.934 | 2.116 | 86 | 13.4 |
| 2002 Mar 23 | 18 09.1 | -20 47 | 1.828 | 2.083 | 90 | 13.2 |
| 2002 Mar 30 | 18 22.2 | -20 30 | 1.725 | 2.051 | 94 | 12.9 |
| 2002 Apr 6 | 18 35.1 | -20 08 | 1.624 | 2.019 | 98 | 12.7 |
| 2002 Apr 13 | 18 47.4 | -19 41 | 1.527 | 1.989 | 102 | 12.4 |
| 2002 Apr 20 | 18 59.3 | -19 11 | 1.434 | 1.960 | 106 | 12.1 |
| 2002 Apr 27 | 19 10.6 | -18 37 | 1.344 | 1.932 | 110 | 11.9 |
| 2002 May 4 | 19 21.2 | -18 00 | 1.259 | 1.906 | 114 | 11.6 |
| 2002 May 11 | 19 30.9 | -17 22 | 1.178 | 1.881 | 118 | 11.3 |
| 2002 May 18 | 19 39.7 | -16 43 | 1.103 | 1.857 | 123 | 11.1 |
| 2002 May 25 | 19 47.4 | -16 04 | 1.033 | 1.835 | 128 | 10.8 |
| 2002 Jun 1 | 19 53.9 | -15 27 | 0.968 | 1.815 | 133 | 10.6 |
| 2002 Jun 8 | 19 59.1 | -14 54 | 0.910 | 1.797 | 138 | 10.4 |
| 2002 Jun 15 | 20 02.8 | -14 25 | 0.859 | 1.781 | 144 | 10.2 |
| 2002 Jun 22 | 20 05.2 | -14 02 | 0.815 | 1.767 | 149 | 10.0 |
| 2002 Jun 29 | 20 06.2 | -13 47 | 0.778 | 1.755 | 156 | 9.8 |
| 2002 Jul 6 | 20 05.9 | -13 40 | 0.750 | 1.745 | 162 | 9.7 |
| 2002 Jul 13 | 20 04.7 | -13 41 | 0.730 | 1.738 | 168 | 9.6 |
| 2002 Jul 20 | 20 02.9 | -13 50 | 0.720 | 1.733 | 173 | 9.6 |
| 2002 Jul 27 | 20 00.9 | -14 05 | 0.718 | 1.730 | 172 | 9.5 |
| 2002 Aug 3 | 19 59.3 | -14 26 | 0.726 | 1.730 | 167 | 9.6 |
| 2002 Aug 10 | 19 58.6 | -14 48 | 0.742 | 1.732 | 161 | 9.6 |
| 2002 Aug 17 | 19 59.0 | -15 12 | 0.768 | 1.736 | 154 | 9.7 |
| 2002 Aug 24 | 20 00.8 | -15 33 | 0.801 | 1.743 | 148 | 9.8 |
| 2002 Aug 31 | 20 04.2 | -15 50 | 0.842 | 1.753 | 142 | 10.0 |
| 2002 Sep 7 | 20 09.2 | -16 03 | 0.890 | 1.764 | 137 | 10.2 |
| 2002 Sep 14 | 20 15.6 | -16 10 | 0.945 | 1.778 | 131 | 10.4 |
| 2002 Sep 21 | 20 23.3 | -16 10 | 1.006 | 1.794 | 126 | 10.6 |
| 2002 Sep 28 | 20 32.2 | -16 03 | 1.072 | 1.812 | 122 | 10.8 |
| 2002 Oct 5 | 20 42.0 | -15 48 | 1.144 | 1.831 | 117 | 11.0 |
| 2002 Oct 12 | 20 52.7 | -15 27 | 1.221 | 1.853 | 113 | 11.3 |
| 2002 Oct 19 | 21 04.1 | -14 58 | 1.303 | 1.876 | 109 | 11.5 |
| 2002 Oct 26 | 21 15.9 | -14 23 | 1.389 | 1.901 | 105 | 11.8 |
| 2002 Nov 2 | 21 28.1 | -13 42 | 1.479 | 1.927 | 101 | 12.0 |
| 2002 Nov 9 | 21 40.6 | -12 55 | 1.573 | 1.955 | 97 | 12.3 |
| 2002 Nov 16 | 21 53.3 | -12 02 | 1.670 | 1.984 | 93 | 12.6 |
| 2002 Nov 23 | 22 06.1 | -11 05 | 1.770 | 2.014 | 89 | 12.8 |

## Comet P/1992 Q1 (Brewington)

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2002 Jun 15 | 21 12.6 | -35 53 | 2.172 | 2.942 | 131 | 12.9 |
| 2002 Jun 22 | 21 11.5 | -36 17 | 2.062 | 2.893 | 137 | 12.7 |
| 2002 Jun 29 | 21 08.9 | -36 42 | 1.961 | 2.844 | 144 | 12.5 |
| 2002 Jul 6 | 21 04.8 | -37 07 | 1.870 | 2.794 | 150 | 12.3 |
| 2002 Jul 13 | 20 59.3 | -37 28 | 1.790 | 2.745 | 155 | 12.1 |
| 2002 Jul 20 | 20 52.4 | -37 45 | 1.721 | 2.695 | 159 | 12.0 |
| 2002 Jul 27 | 20 44.5 | -37 53 | 1.665 | 2.646 | 161 | 11.8 |
| 2002 Aug 3 | 20 35.8 | -37 51 | 1.621 | 2.596 | 160 | 11.7 |
| 2002 Aug 10 | 20 27.0 | -37 36 | 1.590 | 2.546 | 155 | 11.6 |
| 2002 Aug 17 | 20 18.4 | -37 08 | 1.571 | 2.497 | 150 | 11.5 |
| 2002 Aug 24 | 20 10.7 | -36 27 | 1.563 | 2.448 | 143 | 11.4 |
| 2002 Aug 31 | 20 04.3 | -35 34 | 1.566 | 2.399 | 136 | 11.3 |
| 2002 Sep 7 | 19 59.5 | -34 32 | 1.577 | 2.350 | 129 | 11.2 |
| 2002 Sep 14 | 19 56.6 | -33 21 | 1.596 | 2.301 | 123 | 11.1 |
| 2002 Sep 21 | 19 55.5 | -32 05 | 1.621 | 2.253 | 116 | 11.1 |
| 2002 Sep 28 | 19 56.3 | -30 43 | 1.651 | 2.206 | 110 | 11.0 |
| 2002 Oct 5 | 19 58.9 | -29 19 | 1.683 | 2.159 | 104 | 11.0 |
| 2002 Oct 12 | 20 03.2 | -27 51 | 1.719 | 2.113 | 99 | 10.9 |
| 2002 Oct 19 | 20 09.0 | -26 20 | 1.755 | 2.067 | 93 | 10.9 |
| 2002 Oct 26 | 20 16.3 | -24 47 | 1.791 | 2.023 | 88 | 10.8 |
| 2002 Nov 2 | 20 24.7 | -23 10 | 1.827 | 1.980 | 84 | 10.8 |
| 2002 Nov 9 | 20 34.3 | -21 30 | 1.862 | 1.938 | 79 | 10.7 |
| 2002 Nov 16 | 20 44.9 | -19 46 | 1.896 | 1.897 | 75 | 10.7 |
| 2002 Nov 23 | 20 56.4 | -17 57 | 1.928 | 1.858 | 71 | 10.6 |
| 2002 Nov 30 | 21 08.7 | -16 03 | 1.959 | 1.821 | 67 | 10.6 |
| 2002 Dec 7 | 21 21.8 | -14 04 | 1.988 | 1.786 | 64 | 10.5 |
| 2002 Dec 14 | 21 35.4 | -12 00 | 2.015 | 1.753 | 61 | 10.5 |
| 2002 Dec 21 | 21 49.7 | -09 50 | 2.040 | 1.723 | 57 | 10.4 |
| 2002 Dec 28 | 22 04.5 | -07 35 | 2.064 | 1.695 | 55 | 10.4 |

## Comet 96P/Machholz 1

| Date | R.A. h m | Dec ° ' | Δ AU | R AU | Elg | Mag |
|---|---|---|---|---|---|---|
| 2001 Dec 15 | 18 54.9 | -45 49 | 1.508 | 0.795 | 28 | 12.7 |
| 2001 Dec 22 | 19 12.7 | -43 50 | 1.353 | 0.624 | 25 | 11.2 |
| 2001 Dec 29 | 19 30.4 | -40 19 | 1.163 | 0.430 | 21 | 8.9 |
| 2002 Jan 5 | 19 38.3 | -31 37 | 0.932 | 0.206 | 12 | 4.6 |
| 2002 Jan 12 | 19 04.4 | -12 29 | 0.976 | 0.197 | 12 | 4.5 |
| 2002 Jan 19 | 19 04.4 | -09 31 | 1.231 | 0.422 | 18 | 9.0 |
| 2002 Jan 26 | 19 12.7 | -09 22 | 1.415 | 0.617 | 22 | 11.2 |
| 2002 Feb 2 | 19 21.7 | -09 35 | 1.556 | 0.788 | 25 | 12.7 |

# PART III - APPENDICES

## BRIGHTEST AND NEARER STARS (p. 101)

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. 112). They were ordered by their brightness, alpha being the brightest in most cases.
**Name** Common names for the stars.
**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).

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 then even further subdivided into I, II, III, IV, etc. A discussion of these is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel)
- **G** and early **K** (subclass <5) are yellow (e.g., Capella, the Sun and Arcturus)
- Late **K** (subclass > 5) and **M** stars are the cooler red stars (e.g., Aldebaran, Betelgeuse).

It is interesting trying to see the colour in 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 simply photographed. 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., piggybacked 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.

## NON-STELLAR OBJECTS (p. 102)

The term 'Non-Stellar Object' refers to either clusters of stars, galaxies or nebulae (which include dark, bright and planetary nebulae).

**Clusters of Stars** can be anything from a collection of a few stars, close together (open star clusters), up to the massive collection of millions of stars (globular star clusters). Some globulars are so dense that the central regions, as seen through moderately sized telescopes, remain as cloudy blobs which are unable to be resolved into individual stars. 47 Tucanae is a good example.

**Galaxies** are the largest scale structures in the Universe, consisting of a collection of hundreds of billions of stars. The Milky Way and the two Clouds of Magellan (SMC and LMC) are the brightest examples of galaxies. They are all visible to the unaided eye providing you are under dark skies.

**Nebulae** are enormous clouds of gas that quite often mark the remains of a dead star (e.g., the Crab Nebula) or the birthplace of future stars (e.g., the Orion Nebula). Clouds of gas that do not glow are sometimes visible as shadows against the Milky Way. A good example of these dark nebulae is the Coal Sack which is clearly visible next to the Southern Cross.

The column descriptions are:

**CAT** and **NUM**. Is the catalogue and the number of the object. NGC stands for New General Catalogue and IC, Index Catalogue.

**RA** and **DEC**. This is the position of the object in the sky in Right Ascension and Declination (Epoch 2000.0)

**SIZE**. The object's size expressed in arc minutes.

**CON**. Is the standard three letter abbreviation for the constellation the object is in (see table below).

**TYPE**. Is the broad classification as discussed above.

**MAG**. This is the brightness of the object expressed in magnitude. As these deep sky dwellers are large, compared to the pinpoint stars, the magnitude is expressed as if all the light from the object was compressed into a small 1 arc second square. This raises an interesting point. If the object is bright, it could still be quite faint and hard to locate if it is large. The light is spread out over a larger area and its surface brightness could be low. This is particularly important for galaxies. Therefore, when looking for a new galaxy, check its size before going to the telescope.

**DESCRIPTION**. This includes Messier numbers, common names and a general description.

# CONSTELLATIONS - Abbreviations and Culmination at 9pm.

| Name | Genitive | Abr. | Cul. |
|---|---|---|---|
| Andromeda | Andromedae | And | Nov 23 |
| Antlia | Antliae | Ant | Apr 10 |
| Apus | Apodis | Aps | Jul 05 |
| Aquarius | Aquarii | Aqr | Oct 09 |
| Aquila | Aquilae | Aql | Aug 30 |
| Ara | Arae | Ara | Jul 25 |
| Aries | Arietis | Ari | Dec 14 |
| Auriga | Aurigae | Aur | Feb 04 |
| Bootes | Bootis | Boo | Jun 16 |
| Caelum | Caeli | Cae | Jan 15 |
| Camelopardus | Camelopardi | Cam | Feb 06 |
| Cancer | Cancri | Cnc | Mar 16 |
| Canes Venatici | Canum Venaticorum | CVn | May 22 |
| Canis Major | Canis Majoris | CMa | Feb 16 |
| Canis Minor | Canis Minoris | CMi | Feb 28 |
| Capricornus | Capricorni | Cap | Sep 22 |
| Carina | Carinae | Car | Mar 17 |
| Cassiopeia | Cassiopeiae | Cas | Nov 23 |
| Centaurus | Centauri | Cen | May 14 |
| Cepheus | Cephei | Cep | Nov 13 |
| Cetus | Ceti | Cet | Nov 29 |
| Chamaeleon | Chamaeleontis | Cha | Apr 15 |
| Circinus | Circini | Cir | Jun 14 |
| Columba | Columbae | Col | Feb 01 |
| Coma Berenices | Comae Berenices | Com | May 17 |
| Corona Australis | Coronae Australis | CrA | Aug 14 |
| Corona Borealis | Coronae Borealis | CrB | Jul 03 |
| Corvus | Corvi | Crv | May 12 |
| Crater | Crateris | Crt | Apr 26 |
| Crux | Crucis | Cru | May 12 |
| Cygnus | Cygni | Cyg | Sep 13 |
| Delphinus | Delphini | Del | Sep 14 |
| Dorado | Doradus | Dor | Jan 31 |
| Draco | Draconis | Dra | Jul 08 |
| Equuleus | Equulei | Equ | Sep 22 |
| Eridanus | Eridani | Eri | Dec 25 |
| Fornax | Fornacis | For | Dec 17 |
| Gemini | Geminorum | Gem | Feb 19 |
| Grus | Gruis | Gru | Oct 12 |
| Hercules | Herculis | Her | Jul 28 |
| Horologium | Horologii | Hor | Dec 25 |
| Hydra | Hydrae | Hya | Apr 29 |
| Hydrus | Hydri | Hyi | Dec 10 |
| Indus | Indi | Ind | Sep 26 |
| Lacerta | Lacertae | Lac | Oct 12 |
| Leo | Leonis | Leo | Apr 15 |
| Leo Minor | Leonis Minoris | LMi | Apr 09 |
| Lepus | Leporis | Lep | Jan 28 |
| Libra | Librae | Lib | Jun 23 |
| Lupus | Lupi | Lup | Jun 23 |
| Lynx | Lyncis | Lyn | Mar 05 |
| Lyra | Lyrae | Lyr | Aug 18 |
| Mensa | Mensae | Men | Jan 28 |
| Microscopium | Microscopii | Mic | Sep 18 |
| Monoceros | Monocerotis | Mon | Feb 19 |
| Musca | Muscae | Mus | May 14 |
| Norma | Normae | Nor | Jul 03 |
| Octans | Octantis | Oct | Circum |
| Ophiuchus | Ophiuchi | Oph | Jul 26 |
| Orion | Orionis | Ori | Jan 27 |
| Pavo | Pavonis | Pav | Aug 29 |
| Pegasus | Pegasi | Peg | Oct 16 |
| Perseus | Persei | Per | Dec 22 |
| Phoenix | Phoenicis | Phe | Nov 18 |
| Pictor | Pictoris | Pic | Jan 30 |
| Pisces | Piscium | Psc | Nov 11 |
| Piscis Austrinus | Piscis Austrini | PsA | Oct 09 |
| Puppis | Puppis | Pup | Feb 22 |
| Pyxis | Pyxidis | Pyx | Mar 21 |
| Reticulum | Reticuli | Ret | Jan 03 |
| Sagitta | Sagittae | Sge | Aug 30 |
| Sagittarius | Sagittarii | Sgr | Aug 21 |
| Scorpius | Scorpii | Sco | Jul 18 |
| Sculptor | Sculptoris | Scl | Nov 10 |
| Scutum | Scuti | Sct | Aug 15 |
| Serpens | Serpentis | Ser | Jul 21 |
| Sextans | Sextantis | Sex | Apr 08 |
| Taurus | Tauri | Tau | Jan 14 |
| Telescopium | Telescopii | Tel | Aug 24 |
| Triangulum | Trianguli | Tri | Dec 07 |
| Triangulum Australe | Trianguli Australis | TrA | Jul 07 |
| Tucana | Tucanae | Tuc | Nov 01 |
| Ursa Major | Ursae Majoris | UMa | Apr 25 |
| Ursa Minor | Ursae Minoris | UMi | Jun 27 |
| Vela | Velorum | Vel | Mar 30 |
| Virgo | Virginis | Vir | May 26 |
| Volans | Volantis | Vol | Mar 04 |
| Vulpecula | Vulpeculae | Vul | Sep 08 |

## THE BRIGHTEST STARS

See introduction to Part III (p. 100) for more information.

| | Designation | Name | Constellation | R.A. (2000.0) | Dec (2000.0) | Magnitude App. | Magnitude Abs. | Spectral Type | Parallax | Distance ly | Distance pc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | Sun | | | | -26.70 | 4.8 | G2 V | | | |
| 2 | α CMa | Sirius | Canis Major | 06 45.2 | -16 43 | -1.46 | 1.4 | A1 V | 0.375 | 8.7 | 2.67 |
| 3 | α Car | Canopus | Carina | 06 23.9 | -52 42 | -0.72 | -8.5 | F0 Ia | 0.018 | 180 | 55.21 |
| 4 | α Cen | Rigil Kent | Centaurus | 14 39.6 | -60 50 | -0.10 | 4.4 | G2 V | 0.751 | 4.3 | 1.32 |
| 5 | α Boo | Arcturus | Bootes | 14 15.7 | +19 11 | -0.04 | -0.2 | K2 IIIp | 0.090 | 36 | 11.04 |
| 6 | α Lyr | Vega | Lyra | 18 36.9 | +38 47 | 0.03 | 0.5 | A0 V | 0.123 | 26 | 7.98 |
| 7 | α Aur | Capella | Auriga | 05 16.7 | +46 00 | 0.08 | 0.4 | G8 III | 0.073 | 45 | 13.80 |
| 8 | β Ori | Rigel | Orion | 05 14.5 | -08 12 | 0.12 | -7.1 | B8 Ia | 0.004 | 815 | 250.00 |
| 9 | α CMi | Procyon | Canis Minor | 07 39.3 | +05 14 | 0.38 | 2.6 | F5 IV | 0.288 | 11 | 3.37 |
| 10 | α Eri | Achernar | Eridanus | 01 37.7 | -57 14 | 0.46 | -1.6 | B5 IV | 0.023 | 142 | 43.56 |
| 11 | α Ori | Betelgeuse | Orion | 05 55.2 | +07 24 | v0.50 | -5.6 | M2 Iab | 0.005 | 650 | 199.39 |
| 12 | β Cen | Hadar | Centaurus | 14 03.8 | -60 22 | 0.61 | -5.1 | B1 II | 0.008 | 400 | 122.70 |
| 13 | α Aql | Altair | Aquila | 19 50.8 | +08 52 | 0.77 | 2.2 | A7 IV-V | 0.198 | 16 | 4.91 |
| 14 | α Tau | Aldebaran | Taurus | 04 35.9 | +16 31 | 0.85 | -0.3 | K5 III | 0.048 | 68 | 20.86 |
| 15 | α Cru | Acrux | Crux | 12 26.6 | -63 06 | 0.87 | -3.9 | B1 IV | 0.012 | 270 | 82.82 |
| 16 | α Sco | Antares | Scorpius | 16 29.4 | -26 26 | 0.96 | -4.7 | M1 Ib | 0.008 | 400 | 122.70 |
| 17 | α Vir | Spica | Virgo | 13 25.2 | -11 10 | 0.98 | -3.5 | B1 V | 0.012 | 270 | 82.82 |
| 18 | β Gem | Pollux | Gemini | 07 45.3 | +28 02 | 1.14 | 0.2 | K0 III | 0.093 | 35 | 10.74 |
| 19 | α PsA | Fomalhaut | Piscis Austrinus | 22 57.7 | -29 37 | 1.16 | 2.0 | A3 V | 0.144 | 23 | 7.06 |
| 20 | α Cyg | Deneb | Cygnus | 20 41.4 | +45 17 | 1.25 | -7.5 | A2 Ia | 0.002 | 1600 | 490.80 |
| 21 | β Cru | Becrux | Crux | 12 47.7 | -59 41 | 1.25 | -5.0 | B0 III | 0.007 | 460 | 141.10 |
| 22 | α Leo | Regulus | Leo | 10 08.4 | +11 58 | 1.35 | -0.6 | B7 V | 0.039 | 85 | 26.07 |
| 23 | ε CMa | Adhara | Canis Major | 06 58.6 | -28 58 | 1.50 | -4.4 | B2 II | 0.005 | 650 | 199.39 |
| 24 | α Gem | Castor | Gemini | 07 34.6 | +31 53 | 1.58 | 1.2 | AI V | 0.072 | 46 | 14.11 |
| 25 | λ Sco | Shaula | Scorpius | 17 33.6 | -37 06 | 1.63 | -3.0 | B2 1V | 0.010 | 300 | 92.02 |
| 26 | γ Cru | Gacrux | Crux | 12 31.2 | -57 07 | 1.63 | -0.5 | M3 III | 0.015 | 88 | 26.99 |
| 27 | γ Ori | Bellatrix | Orion | 05 25.1 | +06 21 | 1.64 | -3.6 | B2 III | 0.011 | 300 | 92.02 |
| 28 | β Tau | Alnath | Taurus | 05 26.3 | +28 36 | 1.65 | -1.6 | B7 III | 0.018 | 180 | 55.21 |
| 29 | β Car | Miaplacidus | Carina | 09 13.2 | -69 43 | 1.68 | -0.6 | A0 III | 0.031 | 85 | 26.07 |
| 30 | ε Ori | Alnilam | Orion | 05 36.2 | -01 12 | 1.70 | -6.2 | BO Ia | 0.003 | 1206 | 369.94 |

## THE NEARER STARS

| No | Star Name | | Constellation | R.A. 2000 hh mm.m | Dec ° ' | Magnitude Apparent | Magnitude Absolute | Spect Type | Parallax ' " | Proper Motion | Distance ly | Distance pc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sun | | | | | -26.70 | 4.80 | G2 | | | | |
| 2 | Proxima Centauri | | Centaurus | 14 29.7 | -62 41 | 11.09 | 15.50 | M5 | 0.772 | 3"82 | 4.23 | 1.30 |
| 3 | Alpha Centauri | A | Centaurus | 14 39.6 | -60 50 | 0.01 | 4.40 | G2 | 0.750 | 3"70 | 4.35 | 1.33 |
| | | B | | | | 1.34 | 5.70 | K0 | | | | |
| 4 | Barnard's Star | | Ophiuchus | 17 57.8 | +04 42 | 9.55 | 13.20 | M4 | 0.545 | 10"37 | 5.98 | 1.83 |
| 5 | Wolf 359 | | Leo | 10 56.5 | +07 01 | 13.45 | 16.60 | M6 | 0.418 | 4"69 | 7.80 | 2.39 |
| 6 | Lalande 21185 | | Ursa Major | 11 03.4 | +35 58 | 7.47 | 10.50 | M2 | 0.395 | 4"82 | 8.23 | 2.52 |
| 7 | UV Ceti (L726-8) | A | Cetus | 01 39.0 | -17 57 | 12.41 | 15.30 | M6 | 0.381 | 3"37 | 8.57 | 2.63 |
| | | B | | | | 13.20 | 16.10 | M6 | | | | |
| 8 | Sirius | A | Canis Major | 06 45.2 | -16 43 | -1.43 | 1.50 | A1 | 0.380 | 1"33 | 8.57 | 2.63 |
| | | B | | | | 8.40 | 11.30 | DA2 | | | | |
| 9 | Ross 154 | | Sagittarius | 18 49.8 | -23 50 | 10.47 | 13.10 | M4 | 0.341 | 0"72 | 9.56 | 2.93 |
| 10 | Ross 248 | | Andromeda | 23 41.9 | +44 11 | 12.29 | 14.80 | M6 | 0.316 | 1"63 | 10.33 | 3.17 |
| 11 | Epsilon Eridani | | Eridanus | 03 32.9 | -09 28 | 3.73 | 6.20 | K2 | 0.306 | 0"98 | 10.67 | 3.27 |
| 12 | Ross 128 | | Virgo | 11 47.8 | +00 48 | 11.12 | 13.50 | M4 | 0.301 | 1"35 | 10.83 | 3.32 |
| 13 | L 789-6 | ABC | Aquarius | 22 38.5 | -15 18 | 12.33 | 14.70 | M5 | 0.294 | 3"26 | 11.08 | 3.40 |
| 14 | BD +43°44 | A | Andromeda | 00 18.4 | +44 01 | 8.08 | 10.40 | M1 | 0.290 | 2"91 | 11.27 | 3.46 |
| | (Groombridge 34) | B | | | | 11.07 | 13.40 | M4 | | | | |
| 15 | Epsilon Indi | | Indus | 22 03.4 | -56 47 | 4.68 | 7.00 | K5 | 0.289 | 4"71 | 11.29 | 3.46 |
| 16 | 61 Cygni | A | Cygnus | 21 06.9 | +38 45 | 5.22 | 7.50 | K5 | 0.289 | 5"23 | 11.30 | 3.47 |
| | | B | | | | 6.03 | 8.30 | K7 | | | | |
| 17 | BD +59°1915 | A | Draco | 18 42.9 | +59 38 | 8.90 | 11.20 | M3 | 0.286 | 2"27 | 11.40 | 3.50 |
| | | B | | | | 9.68 | 12.00 | M4 | | | | |
| 18 | Tau Ceti | | Cetus | 01 44.1 | -15 56 | 3.50 | 5.80 | G8 | 0.286 | 1"92 | 11.40 | 3.50 |
| 19 | Procyon | A | Canis Minor | 07 39.3 | +05 14 | 0.38 | 2.70 | F5 | 0.286 | 1"24 | 11.41 | 3.50 |
| | | B | | | | 10.70 | 13.00 | F5 | | | | |
| 20 | Lacaille 9352 | | Piscis Austrinus | 23 05.9 | -35 51 | 7.34 | 9.60 | M2 | 0.284 | 6"90 | 11.47 | 3.52 |
| 21 | GJ 1111 | | Cancer | 08 29.8 | +26 47 | 14.79 | 17.00 | M7 | 0.276 | 1"29 | 11.83 | 3.63 |
| 22 | GJ 1061 | | Horologium | 03 36.0 | -44 31 | 13.03 | 15.20 | M6 | 0.270 | 0"84 | 12.06 | 3.70 |
| 23 | YZ Ceti (L725-32) | | Cetus | 01 12.5 | -17 00 | 12.05 | 14.20 | M5 | 0.267 | 1"35 | 12.20 | 3.74 |
| 24 | Luyten (BD + 5°1668) | | Canis Minor | 07 27.4 | +05 14 | 9.86 | 12.00 | M4 | 0.264 | 3"76 | 12.34 | 3.79 |
| 25 | Lacaille 8760 | | Microscopium | 21 17.3 | -38 52 | 6.67 | 8.70 | M0 | 0.259 | 3"45 | 12.61 | 3.87 |
| 26 | Kapteyn's Star | | Pictor | 05 11.6 | -45 01 | 8.84 | 10.90 | M0 | 0.258 | 8"65 | 12.63 | 3.87 |

# NON-STELLAR OBJECTS (Epoch 2000.0)

See introduction to Part III (p. 100) for more information.

| CAT | NUM | R.A. | DEC | SIZE | CON | TYPE | MAG | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| NGC | 55 | 00 14.9 | -39° 11' | 30'x6.3' | Scl | Spiral galaxy | 8.1 | A bright galaxy in the Sculptor Group |
| NGC | 104 | 00 24.1 | -72° 05' | 30.9' | Tuc | Globular cluster | 3.8 | 47 Tucanae, one of the finest globulars |
| NGC | 224 | 00 42.7 | +41° 16' | 185'x75' | And | Spiral galaxy | 3.4 | M31, The 'Andromeda Galaxy' |
| NGC | 253 | 00 47.6 | -25° 17' | 30'x6.9' | Scl | Spiral galaxy | 7.6 | 'Silver Coin' galaxy. Large, bright edge-on spiral |
| | SMC | 00 52.7 | -72° 30' | 5°x4° | Tuc | Galaxy | 2.3 | Small Magellanic Cloud. Visible to unaided eye from dark sky |
| | Pleiades | 03 47.0 | +24° 07' | 2° | Tau | Open cluster | 1.2 | M45 or 'Seven Sisters'. Naked eye cluster, the brighter stars mag. 2 |
| | Hyades | 04 27.0 | +16° 00' | 6° | Tau | Open cluster | 0.5 | A naked eye, 'V' shaped cluster. 28 stars, the brighter mag. 3 and 4 |
| | LMC | 05 23.6 | -69° 45' | 9°x10° | Dor | Galaxy | 0.1 | Large Magellanic Cloud. Visible to unaided eye from dark sky |
| NGC | 1976 | 05 35.4 | -05° 27' | 65'x60' | Ori | Gaseous nebula | 4.0 | M42, 'Orion Nebula', emission and reflection nebula |
| NGC | 2070 | 05 38.6 | -69° 05' | 30'x20' | Dor | Emission nebula | 8.3 | 30 Doradus, 'Tarantula Nebula', bright complex looped structure |
| NGC | 2169 | 06 08.4 | +13° 57' | 6' | Ori | Open cluster | 5.9 | Rich loose cluster, 30 stars magnitude 7 and fainter |
| NGC | 2168 | 06 08.9 | +24° 20' | 28' | Gem | Open cluster | 5.3 | M35, 200 stars, magnitude range 9 to 16, no central concentration |
| NGC | 2244 | 06 32.4 | -04° 52' | 23' | Mon | Open cluster | 4.8 | Rich cluster of 100 stars, with nebulosity (Rosette Nebula) |
| NGC | 2264 | 06 41.1 | +09° 53' | 20' | Mon | Open cluster | 3.9 | 40 stars, large brightness range, involved in nebulosity (Cone Nebula) |
| NGC | 2287 | 06 47.0 | -20° 44' | 38' | CMa | Open cluster | 4.5 | M41, 80 stars 7th magnitude and fainter with 6.9 mag. red star near centre |
| NGC | 2301 | 06 51.8 | +00° 28' | 12' | Mon | Open cluster | 6.0 | Rich cluster, 80 stars, large magnitude range, central concentration |
| NGC | 2362 | 07 18.8 | -24° 57' | 8' | CMa | Open cluster | 4.1 | 60 stars, large brightness range (4th mag. down), concentrated centre |
| NGC | 2422 | 07 36.6 | -14° 30' | 29' | Pup | Open cluster | 4.4 | M47, large coarse cluster with 30 bright and faint stars |
| NGC | 2437 | 07 41.8 | -14° 49' | 27' | Pup | Open cluster | 6.1 | M46, rich open cluster, 100 stars, planetary nebula NGC2438 in same field |
| NGC | 2447 | 07 44.6 | -23° 52' | 22' | Pup | Open cluster | 6.2 | M93, 80 stars magnitude 8 to 13 with strong central concentration |
| NGC | 2451 | 07 45.4 | -37° 58' | 45' | Pup | Open cluster | 2.8 | Rich in stars with slight central concentration |
| NGC | 2477 | 07 52.3 | -38° 33' | 27' | Pup | Open cluster | 5.8 | 160 stars around 10 - 12th magnitude, strong central concentration |
| NGC | 2516 | 07 58.3 | -60° 52' | 29' | Car | Open cluster | 3.8 | 80 stars 6th magnitude and fainter, strong central concentration |
| NGC | 2547 | 08 10.7 | -49° 16' | 74' | Vel | Open cluster | 4.7 | Rich in stars with strong central concentration. Brightest stars mag. 6 |
| NGC | 2548 | 08 13.8 | -05° 48' | 54' | Hya | Open cluster | 5.8 | M48, Large cluster of 80 stars 8 to 13th magnitude, central concentration |
| NGC | 2632 | 08 40.1 | +19° 59' | 95' | Cnc | Open cluster | 3.1 | M44, 'Praesepe' or 'Beehive Cluster', very large cluster, 50 stars |
| IC | 2391 | 08 40.2 | -53° 04' | 50' | Vel | Open cluster | 2.5 | Moderately rich in bright (about mag. 3) and faint stars |
| IC | 2395 | 08 41.1 | -48° 12' | 7' | Vel | Open cluster | 4.6 | 40 stars 6th magnitude and fainter |
| NGC | 2808 | 09 12.0 | -64° 52' | 13.8' | Car | Globular cluster | 6.1 | Large and rich, compressed centre, stars 13 to 15th magnitude |
| NGC | 3114 | 10 02.7 | -60° 07' | 35' | Car | Open cluster | 4.2 | Rich cluster, stars 9 to 14th magnitude, slight central concentration |
| NGC | 3132 | 10 07.1 | -40° 26' | 30" | Vel | Planetary nebula | 9.7 | The 'Eight Burst Nebula', ring and disk, 10th magnitude central star |
| IC | 2602 | 10 43.2 | -64° 24' | 50' | Car | Open cluster | 1.9 | Rich in stars, strong central concentration, brightest stars mag. 3 |
| NGC | 3372 | 10 43.8 | -59° 52' | | Car | Emission nebula | | The 'Eta Carinae Nebula', very bright, prominent dark lanes |
| NGC | 3532 | 11 06.4 | -58° 40' | 55' | Car | Open cluster | 3.0 | Rich and large, slight central concentration, 150 stars 7 to 12th magnitude |
| NGC | 3766 | 11 36.1 | -61° 37' | 12' | Cen | Open cluster | 5.3 | Rich cluster, 100 stars magnitude range 7 to 12th |
| NGC | 4755 | 12 53.6 | -60° 20' | 10' | Cru | Open cluster | 4.2 | The 'Jewel Box', rich in stars, large brightness range |
| NGC | 4945 | 13 05.4 | -49° 28' | 23'x5.9' | Cen | Spiral galaxy | 9.0 | Large edge on spiral, good field, another small galaxy in same field |
| NGC | 5128 | 13 25.5 | -43° 01' | 31'x23' | Cen | Galaxy | 6.7 | 'Centaurus A', bright sphere crossed by dark lane, radio source |
| NGC | 5139 | 13 26.8 | -47° 29' | 36' | Cen | Globular cluster | 3.5 | Omega Centauri, perhaps the finest example of a globular cluster |
| NGC | 5272 | 13 42.2 | +28° 23' | 16.2' | CVn | Globular cluster | 5.9 | M3, large bright globular, brightens suddenly towards the middle |
| NGC | 5281 | 13 46.6 | -62° 54' | 5' | Cen | Open cluster | 5.9 | 40 stars, moderately rich in bright and faint stars, magnitudes 6 to 12 |
| NGC | 5617 | 14 29.8 | -60° 43' | 10' | Cen | Open cluster | 6.3 | 80 stars, large brightness range, strong central concentration |
| NGC | 5904 | 15 18.6 | +02° 05' | 17.4' | Ser | Globular cluster | 5.7 | M5, bright, large very compressed in middle, slightly oval in shape |
| NGC | 6025 | 16 03.7 | -60° 30' | 12' | TrA | Open cluster | 5.1 | 60 stars, large brightness range, slight central concentration |
| NGC | 6067 | 16 13.2 | -54° 13' | 12' | Nor | Open cluster | 5.6 | 100 stars, large brightness range, strong central concentration |
| NGC | 6087 | 16 18.9 | -57° 54' | 12.5' | Nor | Open cluster | 5.4 | 40 stars, moderate brightness range, slight central concentration |
| NGC | 6121 | 16 23.6 | -26° 32' | 26.3' | Sco | Globular cluster | 5.8 | M4, conspicuous globular near Antares |
| NGC | 6124 | 16 25.6 | -40° 40' | 29' | Sco | Open cluster | 5.8 | 100 stars, large brightness range, strong central concentration |
| NGC | 6193 | 16 41.3 | -48° 46' | 14' | Ara | Open cluster | 5.2 | Few stars, large brightness range, slight central concentration |
| NGC | 6205 | 16 41.7 | +36° 28' | 16.6' | Her | Globular cluster | 5.7 | M13, the 'Great Hercules Cluster', showpiece of northern skies |
| NGC | 6231 | 16 54.0 | -41° 48' | 14' | Sco | Open cluster | 2.6 | A few stars with strong central concentration. Brightest stars mag. 5 |
| NGC | 6405 | 17 40.1 | -32° 13' | 33' | Sco | Open cluster | 4.2 | M6, the 'Butterfly Cluster', 80 stars, large brightness range |
| NGC | 6397 | 17 40.7 | -53° 40' | 25.7' | Ara | Globular cluster | 5.8 | Loose, scattered structure, possibly the nearest of the globulars |
| NGC | 6475 | 17 53.9 | -34° 49' | 80' | Sco | Open cluster | 3.2 | M7, 80 stars brighter than 10th magnitude, large brightness range |
| NGC | 6494 | 17 56.8 | -19° 01' | 27' | Sgr | Open cluster | 5.5 | M23, 150 stars, moderate brightness range, lies in good star field |
| NGC | 6514 | 18 02.3 | -23° 02' | 20' | Sgr | Gaseous nebula | 5.0 | M20, 'Trifid Nebula', emission and reflection nebulosity cut by dark lanes |
| NGC | 6523 | 18 03.8 | -24° 23' | 45'x30' | Sgr | Emission nebula | 5.0 | M8, 'Lagoon', densest section known as the 'Hourglass', dark lane |
| NGC | 6611 | 18 18.8 | -13° 47' | 21' | Ser | Open cluster | 6.0 | M16, 100 bright and faint stars, involved in the 'Eagle Nebula' |
| IC | 4725 | 18 31.6 | -19° 15' | 32' | Sgr | Open cluster | 4.6 | M25, 30 stars loosely scattered |
| NGC | 6656 | 18 36.4 | -23° 54' | 24' | Sgr | Globular cluster | 5.1 | M22. Fine globular, only Omega Centauri and 47 Tucanae are brighter |
| NGC | 6705 | 18 51.1 | -06° 16' | 13' | Sct | Open cluster | 5.8 | M11, the 'Wild Duck Cluster', rich and compact open cluster |
| NGC | 7009 | 21 04.2 | -11° 22' | 25" | Aqr | Planetary nebula | 8.5 | The 'Saturn Nebula', ring structure in a larger and fainter halo |
| NGC | 7078 | 21 30.0 | +12° 10' | 12.3' | Peg | Globular cluster | 6.0 | M15, bright, irregularly round, well resolved into faint stars |
| NGC | 7293 | 22 29.6 | -20° 48' | 12' | Aqr | Planetary nebula | 7.3 | The 'Helix Nebula', ring structure involved in larger and fainter disk |

# RISE/SET TIME CORRECTIONS FOR OTHER LOCATIONS

This page is designed to help people, who live outside of Perth (Lat. 31° 57' S, Long. 115° 51' E), to convert the rise/set times in this publication, to the corresponding 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 Perth, subtract or add respectively 4 minutes to both the rise and set times.** Examples of corrections for various towns/cities are given in table 1.
2. An adjustment for the difference in latitude, which also requires the declination for the object of interest. Table 2 presents these corrections (south latitudes are negative). NB. **for rise times you add these values, for set - subtract**. For your specific latitude it is normally sufficient to interpolate these figures.

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 Jan 16 for Kalgoorlie (30° 45'S, 121° 28'E)

| | Rise | Set |
|---|---|---|
| From page 72 the rise/set values are:- | 5:26 | 19:26 |
| Adjust for longitude (115.85 - 121.47) x 4 | - :22 | - :22 |
| (or see table 1 opposite. The value is negative due to Kalgoorlie being east of Perth.) | | |
| Adjust for latitude & declination of Sun (table 2). | +:04 | - :04 |
| (Dec. = -21° 01' see page 71) | | |
| Rise/Set times for Kalgoorlie are :- | 5:08 | 19:00 |

TABLE 1

**LONGITUDE ADJUSTS FOR SOME TOWNS/CITIES FROM PERTH**

| Location | Latitude (° 'S) | Longitude (° 'E) | Change in Longitude (decimal °) | correction (mins.) |
|---|---|---|---|---|
| **W.A.** | | | | |
| Albany | 35 01 | 117 53 | -2.0 | -8 |
| Bickley Observatory | 32 01 | 116 08 | -0.3 | -1 |
| Bridgetown | 33 58 | 116 08 | -0.3 | -1 |
| Broome | 17 58 | 122 14 | -6.4 | -26 |
| Bunbury | 33 20 | 115 38 | 0.2 | 1 |
| Carnarvon | 24 53 | 113 40 | 2.2 | 9 |
| Denmark | 34 58 | 117 21 | -1.5 | -6 |
| Derby | 17 19 | 123 38 | -7.8 | -31 |
| Esperance | 33 52 | 121 54 | -6.1 | -24 |
| Eucla | 31 41 | 128 53 | -13.0 | -52 |
| Fitzroy Crossing | 18 11 | 125 36 | -9.8 | -39 |
| Geraldton | 28 46 | 114 37 | 1.2 | 5 |
| Giles Met. Stn | 25 02 | 128 18 | -12.5 | -50 |
| Kalgoorlie | 30 45 | 121 28 | -5.6 | -22 |
| Kellerberrin | 31 38 | 117 43 | -1.9 | -7 |
| Lake Grace | 33 06 | 118 28 | -2.6 | -10 |
| Marble Bar | 21 10 | 119 45 | -3.9 | -16 |
| Meekatharra | 26 36 | 118 28 | -2.6 | -10 |
| Mount Barker | 34 38 | 117 40 | -1.8 | -7 |
| Mount Magnet | 28 04 | 117 51 | -2.0 | -8 |
| Mount Newman | 23 19 | 119 45 | -3.9 | -16 |
| Mount Tom Price | 22 41 | 117 47 | -1.9 | -8 |
| Norseman | 32 12 | 121 47 | -5.9 | -24 |
| Northam | 31 39 | 116 40 | -0.8 | -3 |
| Onslow | 21 38 | 115 07 | 0.7 | 3 |
| Pemberton | 34 27 | 116 02 | -0.2 | -1 |
| Port Hedland | 20 18 | 118 35 | -2.7 | -11 |
| Rawlinna | 31 01 | 125 20 | -9.5 | -38 |
| Southern Cross | 31 14 | 119 19 | -3.5 | -14 |
| Wagin | 33 19 | 117 20 | -1.5 | -6 |
| Wiluna | 26 35 | 120 14 | -4.4 | -18 |
| Wyndham | 15 28 | 128 06 | -12.3 | -49 |
| Yampi Sound | 16 08 | 123 36 | -7.8 | -31 |
| **OTHER AUSTRALIAN CITIES** | | | | |
| Adelaide | 34 58 | 138 38 | -22.8 | -91 |
| Brisbane | 27 30 | 153 01 | -37.2 | -149 |
| Darwin | 12 21 | 130 55 | -15.1 | -60 |
| Hobart | 42 48 | 147 13 | -31.4 | -125 |
| Melbourne | 37 50 | 145 00 | -29.2 | -117 |
| Sydney | 33 54 | 151 15 | -35.4 | -142 |

## TABLE 2 - RISE/SET CORRECTIONS FOR LATITUDE/DECLINATION FROM PERTH

**Declination**

| South Latitude (negative) | 30° | 25° | 20° | 15° | 10° | 5° | 0° | -5° | -10° | -15° | -20° | -25° | -30° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -12 | -56 | -45 | -35 | -25 | -17 | -8 | 0 | 8 | 17 | 25 | 35 | 45 | 56 |
| -14 | -51 | -41 | -32 | -23 | -15 | -8 | 0 | 8 | 15 | 23 | 32 | 41 | 51 |
| -16 | -46 | -37 | -29 | -21 | -14 | -7 | 0 | 7 | 14 | 21 | 29 | 37 | 46 |
| -18 | -41 | -33 | -25 | -19 | -12 | -6 | 0 | 6 | 12 | 19 | 25 | 33 | 41 |
| -20 | -36 | -29 | -22 | -16 | -11 | -5 | 0 | 5 | 11 | 16 | 22 | 29 | 36 |
| -22 | -30 | -24 | -19 | -14 | -9 | -4 | 0 | 4 | 9 | 14 | 19 | 24 | 30 |
| -24 | -25 | -20 | -15 | -11 | -7 | -4 | 0 | 4 | 7 | 11 | 15 | 20 | 25 |
| -26 | -19 | -15 | -12 | -8 | -6 | -3 | 0 | 3 | 6 | 8 | 12 | 15 | 19 |
| -28 | -13 | -10 | -8 | -6 | -4 | -2 | 0 | 2 | 4 | 6 | 8 | 10 | 13 |
| -30 | -7 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 7 |
| -32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -34 | 7 | 6 | 4 | 3 | 2 | 1 | 0 | -1 | -2 | -3 | -4 | -6 | -7 |
| -36 | 15 | 12 | 9 | 6 | 4 | 2 | 0 | -2 | -4 | -6 | -9 | -12 | -15 |
| -38 | 23 | 18 | 14 | 10 | 6 | 3 | 0 | -3 | -6 | -10 | -14 | -18 | -23 |
| -40 | 31 | 25 | 19 | 13 | 9 | 4 | 0 | -4 | -9 | -13 | -19 | -25 | -31 |
| -42 | 41 | 32 | 24 | 17 | 11 | 6 | 0 | -6 | -11 | -17 | -24 | -32 | -41 |
| -44 | 51 | 39 | 30 | 22 | 14 | 7 | 0 | -7 | -14 | -22 | -30 | -39 | -51 |

# JULIAN DATE — 2002

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 8 hrs from WAST, 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 0hrs 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 21:00 WAST on July 17th. Subtract 8 hours to get UT.

21 - 8 = 13:00 hrs UT

From the table the JD for July is 2452455.5
Add the day of month, 17 gives us 2452472.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 21:00hr 17 July 2002 WAST is 2452473.042

| JULIAN DATE at 0hrs UT | |
|---|---|
| Month | Julian Date |
| Jan 0 | 2452274.5 |
| Feb 0 | 2452305.5 |
| Mar 0 | 2452333.5 |
| Apr 0 | 2452364.5 |
| May 0 | 2452394.5 |
| Jun 0 | 2452425.5 |
| Jul 0 | 2452455.5 |
| Aug 0 | 2452486.5 |
| Sep 0 | 2452517.5 |
| Oct 0 | 2452547.5 |
| Nov 0 | 2452578.5 |
| Dec 0 | 2452608.5 |

| 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 — 2002

Greenwich mean sidereal time at 0hrs UT

| | | | | | |
|---|---|---|---|---|---|
| Jan | 0 | 6.6327 | Jul | 0 | 18.5262 |
| Feb | 0 | 8.6697 | Aug | 0 | 20.5632 |
| Mar | 0 | 10.5096 | Sep | 0 | 22.6002 |
| Apr | 0 | 12.5466 | Oct | 0 | 0.5715 |
| May | 0 | 14.5179 | Nov | 0 | 2.6085 |
| Jun | 0 | 16.5549 | Dec | 0 | 4.5798 |

You can use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to U.T. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day $d$ of month at hour $t$ U.T.

= GMST at 0h 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 21:00 hours Perth time (WAST) on 17th July 2002.

21:00 WAST = 13:00 UT

GMST for July 0 is 18.5262 hours.

GMST = 18.5262 + (0.06571 x 17) + (1.00274 x 13) = 32.6789

Perth's longitude is 115.85° which is 7.7233 hrs so

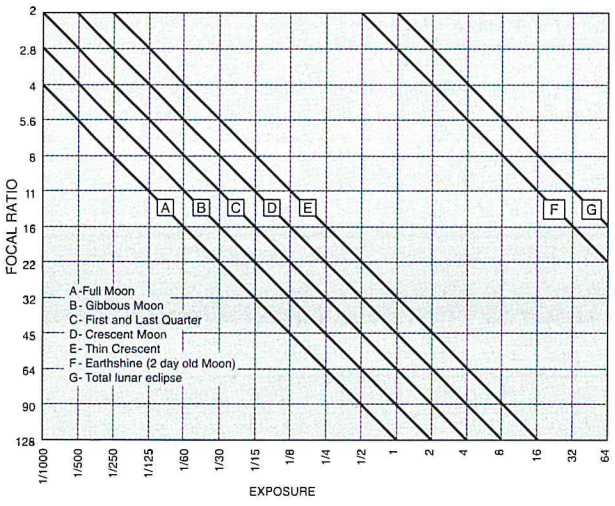
LMST = 32.6789 + 7.7233 = 40.4022

Subtract from or add to this multiples of 24 until it is in the range of 0 to 24

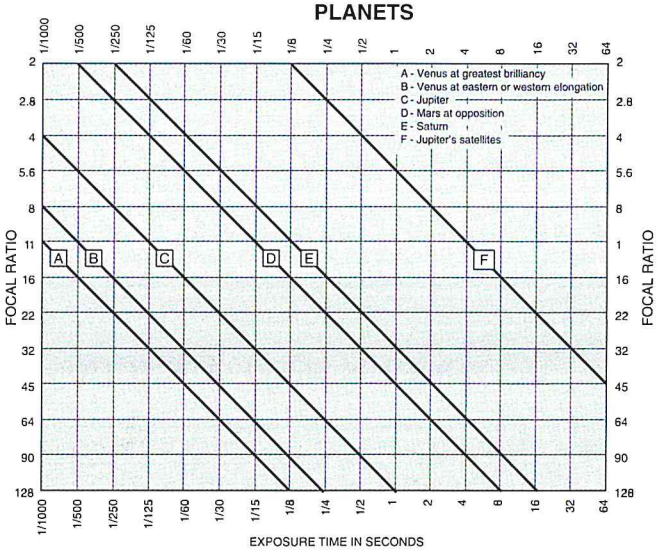
40.4022 - 24 = 16.4022 hrs or 16h 24m 8s

# 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 |
|---|---|---|---|
| 32 ISO | 4 | 200 ISO | 2 |
| 64 ISO | 2 | 400 ISO | 4 |

*For ISO values other than 100 the above factors should be applied to the exposure time.*

# 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)

## WESTERN AUSTRALIA

### PERTH OBSERVATORY

Situated in the Darling Ranges, 40km inland from the West Coast, Perth Observatory is well located to conduct astronomical research as well as educational activities for the public of WA. As part of the Observatory public education program, several telescopes with mirrors ranging from 10" to 16" are used to delight night visitors with the splendour of the rich southern skies. Observatory astronomers also take telescopes to conduct Astronomy Field Nights at various locations, and are in great demand for astronomy talks. A portable display is often used at public libraries and schools. A museum, displaying instruments from the old Observatory (founded in 1896), paintings and current photographs has been established. A well equipped shop sells all sorts of astronomical memorabilia.

Hours: 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.

Costs: All services attract charges, contact the observatory for details.
Phone: (08) 9293-8255 (3 lines)
Fax: (08) 9293-8138 Info Line: (08) 9293-8109
Web: www.wa.gov.au/perthobs
Email: perthobs@iinet.net.au

### PINGELLY HEIGHTS OBSERVATORY (ASTRO VENTURES)

The observatory is just one and a half hours drive from the Perth Metropolitan area. Follow the Brookton Highway from Kelmscott to Brookton then turn South for Pingelly. 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. For prices, further information and ticket reservations:

Contact: Susie or Trevor on (08) 9887 0088 or write to:
Address: ASTRO VENTURES, PO Box 512, Pingelly, WA 6308
Web: http://www.westnet.com.au/astroventures

### SOUTHERN CROSS COSMOS CENTRE

The Southern Cross Cosmos Centre is a commercial observatory situated about an hours drive North of Perth, and is co-sited with the Australian International Gravitational Observatory, a research establishment run by the University of Western Australia. The SCCC has seven telescopes including West Australia's biggest, the 25 inch Obsession. The other instruments include two 8 inch Schmidt Cassegrains, two 12 inch LX200 computer controlled SC's, a 14 inch Celestron SC and a 16 inch Meade newtonian. Binoculars will be available for patrons to use plus live video of the Moon and planets when appropriate.

The observatory is open each Friday and Saturday from October to April, (inclusive) with the evenings running from 7:30pm to 10:00pm. Other evenings are available on request but minimum charges apply. Bookings are essential and can be made by contacting ASTRO NIGHTS

Phone: (08) 9246-5782 or
Email: sccc@bigpond.net.au.

## NEW SOUTH WALES & ACT

**THE UNIVERSITY OF NSW OBSERVATORY (SYDNEY)** is open to the general public most Friday nights for viewing sessions. The nights also include regular astronomy talks and a visit to the university's Mini-Planetarium. Bookings are also available for school groups on other nights; group discounts apply. Holiday programs are also organised. For those who are keen, it is possible to join SUNS, the 'Science at UNSW' society. Activities are suitable for all ages. For further information and bookings:

Contact: Outreach Manager (02) 9385-6100
Web: www.scitech.unsw.edu.au Follow links to Outreach Centre

**THE AUSTRALIA TELESCOPE - NARRABRI ARRAY** 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. The Tidbinbilla Tracking Station and Parkes Radio Telescope are also equipped to form part of the long baseline array. Also on the ATNF site at Narrabri is the Sydney University Stellar Interferometer (SUSI) which is described in the display at the visitor's centre. From the visitor's centre there are great views of the dishes and an excellent display and video tape presentation.

Hours: 8am to 4pm daily (not staffed weekends, exc school holidays).
Cost: No charge for the centre. Bookings appreciated for groups.
Contact: Tim Kennedy (02) 6790-4070.
Email: tkennedy@atnf.csiro.au
Web: wwwnar.atnf.csiro.au

**GROVE CREEK OBSERVATORY** This observatory is located 60km south of Bathurst. The facility caters for amateur astronomers and groups who are looking for very dark skies and excellent seeing conditions. The facility boasts a Celestron C-14, two 12.5" Newtonians and a Meade 10" LX-200 which include full astrophotography and CCD equipment. Grove Creek Observatory has modern on-site accommodation, sleeping up to 10 people with full facilities available.

cost: $120 per person/per night all inclusive (conditions apply).
contact: Steven Williams on (02) 6368-8611 or (02) 9438-1757
Email: info@gco.org.au
Web: www.gco.org.au

**DARBY FALLS OBSERVATORY** The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. It offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments. They have 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

**GILGANDRA OBSERVATORY** The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It has operated since 1975 providing a 12.5" $f/6$ newtonian reflector for the public to view the heavens. Guided tours of the night sky are held each night except Sundays (during school holidays it is also open Sunday nights and during the day, noon till 4pm). It pays to book ahead to avoid disappointment.

Times: 7pm to 10pm (daylight saving 8:30pm to 10pm)
Cost: Adults $8, pensioners $6, children $5, family $20.
Contact: (02) 6847-2646 fax:(02) 6847-2845
Email: mail@gilobs.com.au
Web: www.gilobs.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 3 x 300 mm Schmidt Cassegrain telescopes and 2 pairs of 30 x 70 binoculars. At this dark site, you will have the opportunity to scan the Milky Way through these binoculars or tour the skies with the computerised telescopes. Slides of the Universe, displays, videos and a well stocked gift shop are available.

Cost: Adults $13.50; family of four $38.50 concession, school groups, tour groups and interested amateur astronomers.
Address: 13L Camp Rd. P.O.Box 308 Dubbo NSW 2830.
Email: dubbobs@hwy.com.au
Hours. Open daily (except Christmas) from 10 a.m. until late. Bookings essential for night sessions.
Contact: Peter Neilson (manager) (02) 6885-3022 Fax (02) 6885-3012
Web: www.hwy.com.au/~dubbobs/

**GREEN POINT OBSERVATORY** The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two observatory buildings house a 41cm reflector and a 35cm C14 SCT. The Society also has a 15cm $f/12$ refractor and several smaller telescopes. Visitors are most welcome. The observatory is open on every Thursday night. The society also runs regular open nights which are very popular with the general public. In 2002, open nights are tentatively scheduled for First Quarter Moon weekends in August. Contact the SAS for details.

**PORT MACQUARIE OBSERVATORY** is operated by the Port Macquarie Astronomical Association. It is open to the public on Wednesday & Sunday evenings at 7.30 pm (8.15pm, daylight savings). Lectures are given on the Solar System and Universe plus viewing of celestial objects. Special opening nights can be arranged for organised groups. The Observatory is situated in Rotary Park which is opposite Town Beach, Port Macquarie. They own two Celestron telescopes.

Address: Port Macquarie Astronomical Association Inc, P. O. Box 1453, Port Macquarie NSW 2444
Contact: Jim Daniel (02) 6583-1933 or Peter Hall (02) 6586-1095
Email: jaidanl@bigpond.com.au

**THE CANBERRA SPACE DOME & OBSERVATORY** The Canberra Space Dome (Planetarium) is a virtual reality star theatre that uses special effects to take you on a cosmic adventure through the Universe. Experience perfect night sky simulations, interplanetary space flight, and discover the mysteries of the night sky. Shows are tailored to educate and entertain. The Observatory features research-grade telescopes under domes and is one of the finest public observatories in Australia. Sessions are conducted by professional astronomers and explainers.

Address: Hawdon Place (off Antill St) Dickson, ACT
Open: Tue - Sat evenings (phone for times) Bookings essential.
Cost: per facility: $8.50-adult, $6.00-child/student/senior, $24.00-family (2 adults + 2 children, extra child $4 each)
Contact: Phone: (02) 6248-5333 Fax: (02) 6249-7238
Email: planetarium@ctuc.asn.au
Web: www.ctuc.asn.au/planetarium/

**KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE** Located on the border of the Central Coast, Lower Hunter and Wyong, the centre is no more than 2 hours from most Sydney and Newcastle suburbs. Koolang's 0.5 metre and other telescopes are in operation 7 days and nights a week. Bookings are essential. Over 10,000 students have visited the observatory during the last 6 years and Koolang staff have developed curriculum and theme based presentations to cover all school years from infants through to year 12. Support material is available.

Hours: 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; concession $4; children $3; 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: michael@koolang.com.au
Web: www.koolang.com.au

**NEPEAN OBSERVATORY** is on the Werrington North campus of the University of Western Sydney Nepean, near Penrith. The main telescope is a 24 inch (600 mm) used for both public viewing and research. The Observatory is open every Friday night (except between Christmas and New Year) for star gazing, astronomy talks and slide shows. Sessions commence at 7pm (7.30pm during daylight saving). Group bookings taken for other nights.

Cost: Adults $8.80, child/concession $4.40, family $19.80
Contact: (02) 9678-7524
Email: r.mccourt@uws.edu.au
Web: www.uws.edu.au/astronomy/observatory/observatory.html

**PARKES RADIO TELESCOPE** is located on the western plains of NSW, 20 km 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, its visitor's centre has doubled in size, upgraded its displays, beautified its grounds and added a 3-D audio visual 'The Sun what a Star' to compliment the flag-ship presentation 'The Invisible Universe'. There is also a freely available public picnic area, with a large shelter and gas barbecue facility. Souvenirs and educational material are available (including mail order).

Hours: 8:30am to 4:30pm - daily except Christmas & Boxing Day.
Cost: Admission to the visitor's centre is free. A modest charge is made for the audio visual presentations.
Contact: (02) 6861-1777
Email: rtwardy@atnf.csiro.au
Web: www.parkes.atnf.csiro.au/visitors_centre/

**BIG BADJA OBSERVATORY (NUMERALLA)** Situated on a dark site 20 km east of Cooma, the 3.4m domed observatory houses a 25cm Meade SC telescope on a Losmandy mount. Objectives include developing CCD imaging skills and expanding community awareness about current astronomical events. Instruction is freely offered in the use of telescopes and accessories. Small groups are welcome by appointment and asked to make a donation direct to the Fred Hollows Foundation. Open most suitable evenings throughout the year.

Contact: Robert McDonald (02) 6453-3221

**WOLLONGONG SCIENCE CENTRE AND PLANETARIUM** Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive indoor and outdoor hands-on exhibition areas, demonstration theatre, and a gift & resource shop, retailing astronomical materials as well as general science items. The BHP Star Theatre seats 70 and has a state of the art Zeiss ZKP3 star projector. The Duke Energy Observatory houses a computer controlled DFM telescope under a large dome which is used for solar as well as stellar observations.

Cost: Child $5.50, concession $7, adult $9
Hours: 10am to 4pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Address: Science Centre, Squires Way, Wollongong NSW 2522
Contact: (02) 4286-5000, fax: (02) 4283-6665
Web: www.uow.edu.au/science_centre

**KINGS TABLELAND OBSERVATORY (BLUE MOUNTAINS)** The observatory is located at Wentworth Falls. It is at an altitude of 930 metres which makes it a high and dark site, while still close to Sydney. The facility is open to any interested people or groups. Two modern telescopes are available for use; both housed in a 4.5 metre dome. The observatory also conducts classes for the Nepean Community College which includes: workshops on the night sky, use of star charts, astrophotography and instructions on the use of telescopes. There is also a flat screen planetarium.

Hours: Flexible to meet demand.
Contact: Roger North, Sybil Barber (02) 4757-2954
Email: north.barber@bigpond.com

**CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)** is located 40km SW of Canberra (Tourist Drive 5). Tidbinbilla is a major link in NASA's Deep Space Network, playing an essential role in communicating with NASA's interplanetary robotic spacecraft. The Complex sends and receives radio signals from distant spacecraft as they explore the bodies in our Solar System: the planets and their moons, asteroids, comets and the Sun. The centrepiece of the Complex is the 70 metre antenna, the largest steerable antenna in the Southern Hemisphere. The visitor centre incorporates audio and visual displays, interactive exhibits, models and images from the spacecraft.

Hours: 9am to 5pm, 7 days per week (8pm daylight saving time).
Cost: There is no charge for the Space Centre.
Contact: (02) 6201-7880
Email: cdscc-prc@anbe.cdscc.nasa.gov
Web: www.cdscc.nasa.gov/

**BOWEN MOUNTAIN 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 welcome. Contact Adrian Saw (02) 4572-1568

**MACQUARIE UNIVERSITY OBSERVATORY** is located on the Macquarie University Campus at North Ryde, open to the public several nights a week. With a range of telescopes for use by visitors, the observatory offers great views of the heavens. Intending visitors should ring the observatory for further information on times and charges.

Contact: (02) 9850-8914
Web: www.southernskies.com.au/macu.htm

**MAGELLAN OBSERVATORY** is situated on 120 acres at Lake Bathurst in the Southern Tablelands of NSW, 30km south of Goulburn. This well equipped observatory has accommodation and a variety of telescopes which includes a computerised 46cm New Generation Telescope (NGT18) housed in a 4.5m dome. An astrophotography rig is also available for hire. Accommodation is a two bedroom house, a short walk from the observatory. For those travelling by train, your hosts Zane & Fiona Hammond will even pick you up from Goulburn station.

Address: Lot 48 Covan Creek Rd Lake Bathurst 2580 (02) 4849-4489
Email: magellan@goulburn.net.au
Web: www.goulburn.net.au/~magellan

**SETTLERS FLAT LODGE - COUNTRY RETREAT WITH OBSERVATORY** is a four star guesthouse 14km east of Braidwood. It features seven ensuited rooms, tennis court, full size billiard table and an observatory facility. Instruments include Celestron C14 and C8 telescopes, plus an 8" *f*/7 Dobsonian. Prices for accommodation include dinner, bed & breakfast, with sky tour (please enquire). Bookings essential. The observatory and sky tour costs $5 ($10 including a light supper).

Address: 112 Charleys Forest Road, Mongarlowe Via Braidwood
Contact: Carolyn or Noel Matthews (02) 4842-8085 fax (02) 4842-8003
Email: settlers@sci.net.au
Web: www.settlersflat.com.au

**SYDNEY OBSERVATORY** is in a park just a short walk from the historic Rocks district of Sydney, near the southern end of the Harbour Bridge. Since the Powerhouse Museum took over the observatory, it has had a renewed interest in public education. The centre offers a more hands–on approach for visitors, with a number of displays and films on astronomy. On weekends, visitors are invited to observe the Sun - safely (weather permitting). Night time tours include observations of the Moon and planets through the observatory's historic and modern telescopes. There is also an exhibition called 'By the light of the Southern Stars'.

Hours: 10am to 5pm, except Christmas Day. Night sessions are held every night of the week. Bookings required for evening tours.
Cost: Evening sessions - $10 adults, $5 students or concession and $25 for families. There is no charge for daytime visits.
Contact: (02) 9217-0485
Web: www.phm.gov.au/observe/

**MT. STROMLO OBSERVATORY** is the oldest fully operational research observatory in Australia, and the closest active optical observatory to a capital city anywhere in the world. The observatory is operated by the ANU, and, together with the university's dark sky observatory at Siding Spring, near Coonabarabran, is an international leader in optical astronomy. Mt Stromlo Observatory Visitors' Centre (formerly called Stromlo Exploratory) is full of exciting interactive exhibits to make astronomy come alive for all ages. A heliostat allows visitors to safely view sunspots on the Sun's surface, and displays include a chunk of the Henbury meteorite. Professional astronomers and explainers conduct hourly slide shows and tours of the massive 74" reflector. Other telescopes date back to 1868 and include the 50" (the former Great Melbourne Telescope), 30" Reynolds and Yale-Columbia refractor. Astronomers also run regular public observing nights (phone for details). School or special interest groups of 10 or more can visit at night by appointment. Star Wares is a well stocked astronomy-related gift shop. Red Belly Black Cafe, winner of Best Tourism Restaurant 2001, offers Canberra's best settings for breakfasts, lunches, and special functions.Visitors can stroll amongst heritage buildings and enjoy stunning panoramic views from the sundial garden and outdoor BBQ area. To assist its astronomy education programs and develop new exhibits, Stromlo maintains a tax-deductible 'Adopt-a-Star' program.

Address: 15 min from Canberra City, Mt Stromlo Rd, via Cotter Rd, Weston Creek, ACT
Hours: Open every day (except Christmas) 9:30am-4:30pm.
Cost: Different tour packages, $6-$12 adult, $5-10 concession, $3.50-$7 child, $15-$25 family.
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

**SKYWATCH OBSERVATORY AND ASTRO GOLF** This public observatory is in Coonabarabran, which is also the home of the Siding Spring Observatory. It is located along Timor Rd, 2km west of the clock tower. During the day the large exhibition is open featuring hands on activities, a theatrette, puzzles, computers and a display of pictures and information boards. At night time there is guided telescope viewing. There is also Astro Golf, a popular 18 hole mini golf course. A great family activity, open day and night. Light refreshments are available.

Hours: 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. Open every day except Christmas day.

Cost: Adult $12.10 child/pensioner $7.15 family $33.00
Contact: Karl Rafferty (02) 6842-3303 fax: (02) 6842-2978
Email: astro@skywatch.cx
Web: www.skywatch.cx

**SIDING SPRING OBSERVATORY** The Warrumbungle National Park indeed makes a magnificent setting for this world class observatory. It is situated 25 kilometres west of Coonabarabran. The most prominent feature is the tall white dome of the Anglo-Australian Telescope (AAT). The 3.9 metre instrument is still the 'flag-ship' for optical astronomy in this country. Siding Spring Mountain is also home for a number of other telescopes such as the Australian National University's (ANU) 0.4m, 0.6m, 1.0m and the 2.2m Advanced Technology Telescope (ATT). The 1.2m Schmidt Camera is also located on the mountain. For the public there is a viewing gallery for the AAT. The visitor's centre or 'Siding Spring Exploratory' consists of the 'Exploring the Universe' exhibition.

Hours: 9:30am to 4:00pm daily except Christmas Day.
Cost: $5.50 adults, $3.50 children/concession and $13.50 family. Special tours can be arranged for buses or school groups. During NSW school holidays a 1.5 hour tour is available, conducted by an astronomer. They run daily, ring for details. Cost is $9 seniors/children, $11 adult, $27 family.
Contact: (02) 6842-6211.
email juls@mso.anu.edu.com.au
Web: www.aao.gov.au/

## QUEENSLAND

**GREAT BARRIER REEF OBSERVATORY**, situated on Hamilton Island, 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 (07) 4946-8686
Email: star@whitsunday.net.au

**THE SIR THOMAS BRISBANE PLANETARIUM** This world class planetarium is located in the beautiful surrounds of the Mt. Coot-tha Botanic Gardens in Brisbane. Regular programmes are presented, lasting about 45 minutes. The 'Cosmic Skydome' has an artificial sky projected onto the interior surface of a 12.5m dome. The foyer and gallery areas contain an interesting collection of displays and artifacts related to astronomy. The planetarium also has an observatory with a 15cm refractor and a 41cm reflector. Observatory sessions must be pre-booked.

Public shows are 3:30pm & 7:30pm, Wednesday to Friday (also 1:30pm during Qld school holidays). Weekend shows are 1:30pm, 3:30pm and 7:30pm on Saturday and 1:30pm and 3:30pm on Sunday. Visitors are requested to arrive at least 15 minutes before the starting time and bookings are advisable. Not recommended for children under 6. School shows Wed-Fri on a booking basis only.

Skydome $10 adult, $6 child (under 15), $8.50 for concessions, $28 for a family pass, group rates apply.
Observatory: $10 adult, $6 child (under 15)
Bookings: (07) 3403-2578

**SPRINGBROOK MOUNTAIN OBSERVATORY** Springbrook National Park is world heritage listed and is only a 45 minute drive from Surfers Paradise. It is a perfect setting for Springbrook Observatory which is open to the general public by appointment, astronomical groups, and researchers. This facility has a C14, C11, 4.5" refractor, and CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing. Next to the observatory is a fully licensed restaurant.

Contact: Andre Clayden (07) 5533-5200, fax (07) 5533-5457
Email: springbrook@iprimus.com.au
Web: www.maguires.com/astronomy

**OUTBACK QUEENSLAND SKYWATCH** This public observatory is in Charleville on Cunnamulla Road, near the airport. It is expected that by November 2002 it should become the 'Charleville Cosmos Centre'. They have a telescope garden and 'Galactic Theatre'. Booking is essential.

Contact: Visitor Information Centre (07) 4654-3057
Address: PO Box 63, Charleville QLD 4470
Email: murweh@growzone.com.au

## SOUTH AUSTRALIA

**UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM** The planetarium was originally installed to teach surveying to students at the university. It is now available to the public. There is a regular show on the 1st Saturday of each month at 3pm. Other sessions are available for groups via bookings.

Address: University of SA, Mowson Lakes Campus (08) 8302-3138
Web: www.unisa.edu.au/planetarium/

**INTERNATIONAL CANGAROO PROJECT, WOOMERA** In 2002 the second 10 metre telescope will be installed at G Range Woomera. The telescopes are used for high energy astrophysical studies of pulsars, supernovae, gamma ray bursts and black holes. It is a joint Japan-Australia university project. Although the telescope is inside the Woomera Security Area, afternoon site visits can be arranged for small groups about a week either side of New Moon, by applying in advance, giving names and addresses. This information is needed to gain access to the range. There is a display in the Woomera Heritage Centre. An idea of the activities, including a picture gallery, is available on the web site. The telescope will be open to visitors at the time of the 2002 solar eclipse. A small charge may be made to cover costs.

Contact: Dr John Patterson (08) 8222-4038 or (08) 8396-1004 (AH)
Fax (08) 8673-7033 mobile 0417 805 547.
Email: jpatters@physics.adelaide.edu.au.
Web: www.physics.adelaide.edu.au/astrophysics/cangaroo.html

## TASMANIA

**LAUNCESTON PLANETARIUM** is in the Queen Victoria Museum, Wellington St. Show Times: Tuesday to Friday 3:00pm, Saturday 2:00pm and 3:00pm. During government school holidays, shows run Monday to Saturday 2:00pm and 3:00pm. Group bookings by arrangement.

Cost: $2.20 Children (under 15), $3.30 adults and $7.70 family (children under 5 years old are not admitted)
Contact: (03) 6323-3777
Web: www.vision.net.au/~peter/AST/launplan/launplan.htm

## VICTORIA

**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. In addition, there is a 360 mm Schmidt-Cassegrain, two portable Dobsonians - a 315 mm and a 250 mm. A computer-enhanced, disabled-access 406 Cassegrain is due for commissioning in December 2001. The observatory is open most Friday and some Saturday nights. Daytime tours can also be arranged.

Contact: (03) 5332-7526
Email: bas@cbl.com.au
Web: www.looksgood.com.au/astronomy.

**MELBOURNE OBSERVATORY** The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. On Wednesdays at 2pm an historical presentation is made 'Stars, Cows and Spiderwebs'. 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 on the Observatory site.

Bookings: Visitor Centre, Observatory Gate (03) 9252-2300
Web: www.rbgmelb.org.au

**MELBOURNE PLANETARIUM** is Australia's first digital planetarium, at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages including those for amateur astronomers and tertiary students. It is open 7 days a week from 10am. Bookings are essential.

Contact: (03) 9392-4800
Web: www.museum.vic.gov.au/planetarium

# ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following lists astronomy courses, events, magazines and radio programs known to the authors for 2002. 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. The Internet also should not be overlooked as a valuable source of information.

**INTERNATIONAL DARKSKY ASSOCIATION (AUS/NZ)**

Contact: Reg R. Wilson FIES (Director, Australian Representative)
+61 (02) 9488-7078 (phone and fax)
32 Carina Road, Turramurra, NSW 2074
Email: regrw@acay.com.au

**FUNDING FOR ASTRONOMICAL RESEARCH** The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateur astronomers and students. Funds are made available annually and disbursed with advice from a research committee appointed with the approval of CSIRO Australia. An amount of $6,000 has been made available for grants in 2002. Application forms and further information concerning eligibility of applicants and obligations of successful applicants are available from:

The General Secretary, Astronomical Association of Queensland, PO Box 6101, St. Lucia Qld 4067.

**NACAA 2002** The National Australian Convention of Amateur Astronomers is a biennial meeting normally held over Easter. The last convention in 2000 was held in Perth. The 2002 gathering will be in Adelaide, hosted by the Astronomical Society of South Australia. Contact the society (next section) for details.

Web: www.assa.org.au/nacaa2002

## GENERAL 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.

Cost: $10 for 10 - subscriptions payable to the ASNSW.
Contact: Greg Bryant (as per 'Comet Tales' below)

**COMET TALES** This quarterly publication for amateur astronomers covers a variety of topics. It has a strong focus on providing the latest information on comets. Deep-sky and planetary observing, monthly sky highlights, and astronomy news (particularly Australian professional research and amateur star parties) are broadly covered. The publication has expanded significantly since its first issue in 1995.

Cost $14 for one year (payable to Greg Bryant, credit card accepted)
Address: 2/100-104 Kissing Point Rd, Dundas NSW 2117
Email: gchbryant@hotmail.com
Web: gchbryant.tripod.com

**PERIHELION** A bulletin for comet observers. This newsletter, published by David Seargent, is specifically designed for the Australian observer. It is only for newly discovered comets of 11th magnitude or brighter and visible from Australia. David is an author and contributor to Sky & Space magazine.

Cost: $12 (for 4 issues per year), $15 includes special mail notices for new discoveries (cheques payable to Karagi Publication).
Address: PO Box 204, The Entrance NSW 2261

**SKY & SPACE MAGAZINE** This astronomy and space exploration magazine is produced for Australia and New Zealand. This full-colour magazine is bi-monthly and available through newsagencies or by subscription. Sky & Space also produce a magazine called 'Southern Astronomy'. It is a no frills magazine designed specifically for amateur astronomers. It is available only by subscription.

Contact: (02) 9369-3344, fax (02) 9369-3366.
Address: Sky & Space Publishing, PO Box 1690, Bondi Junction NSW 1355

## WESTERN AUSTRALIA

**BROOME - ASTRO TOURS OF THE KIMBERLEY** Two hour Night Sky Tour Show, 4 nights a week, Monday, Wednesday, Friday and Saturday; April through December. Astro Tours is available for schools, conferences, private bookings, community groups, clubs, outdoor restaurants. Functions and special events Tuesdays and Thursdays in Broome and from January through March in southern Western Australia.

**Outback Stargazing Adventures** Exotic stargazing locations, good food, comfy swags, class telescopes and a Kimberley bush guide combine to make these remote area adventure tours an unforgettable experience. Limited availability on these very special and exclusive 4WD expeditions. For further information contact Greg Quicke:

Phone: 0500 831 111 (a local call unless you hear the pips)
Fax: (08) 9193-5362
Address: PO Box 2537, Broome, 6725
Email: mail@astrotours.net
Web: www.astrotours.net

### ASTRO GUIDES

**Sky Tours and Star Parties, Beginners courses, Packages for Schools**

Astro Guides provides Educational and Special Events for newcomers to Astronomy.

- Regular courses for beginners are conducted in Perth Metro Area
- Viewing Nights for schools, groups, and parties using first class telescopes, at your venue or ours. Viewing is accompanied by a talk on Astronomy and information about the objects being viewed.
- Packages for schools including a 114 mm telescope, instruction for teachers and a viewing night for students and parents are available
- Build a home for your telescope in the backyard

Country: All services available outside the metro area by arrangement
Contact: Keith Galbraith phone/fax (08) 9307 1353

## NEW SOUTH WALES & ACT

**ASTROFEST (COONABARABRAN)** has been held annually for a number of years. Activities include: observing, lectures, tour of Siding Spring Observatory and Skywatch Observatory, the Bart Bok annual lecture, Science in the Pub (subject to availability) and the Siding Spring Open day (check before to confirm). This jam-packed weekend will be held in November 2002, hosted by the Warrumbungle Mountain Motel

Contact: Mark Boyd (02) 6842-1832.
email: warrumbunglelodge@bigpond.com.au

**SOUTH PACIFIC STAR PARTY** is 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 from all over Australia and overseas. The 2002 SPSP will be held from 15-17 March. Contact the ASNSW for details.

## QUEENSLAND

**ASTROFEST** The Queensland Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours drive northwest of Brisbane. It has a dark sky with superb living conditions and a Celestron-14 telescope (the Stewart Observatory). The event is held over six nights. Activities include: presentations from guest professional astronomers, awards in amateur astronomy, swap & sell, barbecue, catered smorgasboard, slide shows and light sports. The event usually attracts over 100 people. The Astrofest is to be held over the week of the 5th to 11th of August 2002.

Contact: Glenn Lang 0418 169 547
Email: info@aaq.org.au
Web: queenslandastrofest.homestead.com/qldastrofest.html

**STARGAZERS WEEK 2002** O'Reilly's Rainforest Guesthouses will run its annual Stargazers Week from 14th to 18th July. Guests will be treated to spectacular dark skies with telescopic views of winter Milky Way objects, instructional programmes, solar observing and slide shows combined with O'Reillys fine fare and friendly staff.

Contact: Tony Surma (07) 3274 5073.
Web: members.optushome.com.au/firstlight/stargazers/stargazers.htm

## VICTORIA

**VASTROC** Victorian Amateur Astronomical Society's Conventions (VASTROC's) are held every second year (alternating years with NACAA Conventions). Activities include keynote speakers, workshops, poster displays, forums, observing, social gatherings at lunch/tea breaks and the convention dinner. The 2001 VASTROC was held by the Astronomical Society of Victoria. The host society for the 2003 VASTROC is yet to be announced.

**AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)** The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. Using this callsign, Russell Ward has been conducting an amateur radio net for hams and shortwave listeners on the subject of astronomy since August 1989. The net commences each Friday evening at 8pm WAST on 3.543 MHz (LSB). New stations and shortwave listeners are most welcome.

# ASTRONOMICAL SOCIETIES

The following is a list of the amateur societies in Australia. A common philosophy within these organisations is the emphasis they place on public education. Enquires from anyone with an interest in astronomy are most welcome. Where given, annual fees are subject to change. The authors of this publication are keen to keep the information in this section 'evergreen'. It would be appreciated if any significant change occurs (especially new organisations) that the society contact Quasar Publishing (p. 2). The deadline for Astronomy 2003 is July 1, 2002.

Please note that a number of the societies now have Internet homepages. These can be excellent sources of information such as latest astronomical discoveries, society events and connections to other astronomy sites on the Web. Links to the society homepages can be found on the Quasar homepage (www.quasarastronomy.com.au).

## WESTERN AUSTRALIA

**ASTRONOMICAL SOCIETY OF WA** meets at 8pm on the second Monday of every month at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como. The Society conducts regular 'Astro-camps' at remote locations with good accommodation and very dark skies. It also promotes public awareness of astronomy by holding regular viewing nights for the public, and by providing speakers to schools, clubs and community groups. The Society owns a wealth of astronomical apparatus for use by members. They also publish a bi-monthly journal "The Sidereal Times".

Address: P.O. Box 421 Subiaco WA 6008
Contact: (08) 9299 6347
E-mail: aswa@cleo.murdoch.edu.au
Web: http://cleo.murdoch.edu.au/gen/aswa/

**ASTRONOMICAL GROUP OF WESTERN AUSTRALIA (AGWA)** was formed to provide activity and networking for amateur astronomers and people interested in the wonders of the night sky, with or without their own telescopes. Activities throughout the year include: Field trips, seminars by noted astronomers, workshops and special events and an Annual Astro-Fest. The group meets at 7pm on the first Tuesday of every month at 159A Scarborough Beach Rd, Mt Hawthorn. Everybody is welcome to attend the meetings. AGWA is proudly sponsored by Binocular, Telescope And Optical World.

Address: 159A Scarborough Beach Rd Mount Hawthorn WA 6016
Contact: (08) 9201-0895

**MURDOCH ASTRONOMICAL SOCIETY** is an active body based at Murdoch University. Membership is open to the general public and no extensive knowledge of astronomy is required, only an interest and lots of enthusiasm. Meetings are conducted each month at the University and usually consist of informal talks, occasional guest speakers, slide shows and observation reports. A small library is available for loans to members. There is deep sky viewing away from the lights of Perth every new moon and activities at the Murdoch Observatory during the warmer months. Other activities include: star parties with the Astronomical Society of the South West, an annual public viewing night around February and viewing nights on request from school and other community groups. The society owns a 44cm, a 20cm and a 15cm Newtonian telescope for members use.

Address: c/- Murdoch Uni. Physics $ Energy Studies, Murdoch WA 6150
Contact: Graham Clements (08) 9227 0923 ( after 12)

**ASTRONOMICAL SOCIETY OF THE SOUTH WEST (Inc)**
Membership is open to anyone interested in basic astronomy. Observing nights at their observatory south of Bunbury on the two Fridays before the new moon. There is an active junior group which meets twice monthly. Astronomy camps in good cottage accommodation are held during the year at dark sky sites. Other observing at nearby dark sky sites occurs on an informal basis. A six evenings astronomy course for beginners is conducted each year in March/April. Nights for the general public are held during school holidays on three occasions through the year. Community groups are welcome to book for special nights.

Address : PO Box 1100, Bunbury, WA 6231 Phone: (08) 9721 1586
Email : dodong@gateway.net.au

## NEW SOUTH WALES & ACT

**Astronomical Society Of Coonabarabran** meets 3rd Thursday each month at 7:30pm at Coonabarabran High School. Paul Cass (02) 6842-2994

**Astronomical Society Of The Hunter** meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday of each month at 7:30pm. Col Maybury (02) 4937-4664

**Astronomical Society Of NSW** meets twice monthly at the CSIRO, Div of Radio Physics, Pembroke Rd. (cnr. Vimera Rd), Marsfield. Max Gardner (02) 9337-3371

**Newcastle Astronomical Society** meets on the last Friday of each month (except December), at the University of Newcastle, Lecture Theatre GP, 1st flr Linguistics Building at 7:30pm. Contact Alan Meehan (02) 4929-6600 or George Barnes (02) 4967-1057

**Canberra Astronomical Society** meets on the 3rd Thursday of every month (except July and December) starting at 8:00pm at the Duffield Building, Mt Stromlo. Contact John Howard (02) 6248-0552

**British Astronomical Association - NSW Branch** meets at Sydney Observatory on the 3rd Wednesday each month, at 7:30pm. Contact Elizabeth Cocking (02) 9398-9705

**Shoalhaven Astronomers** meet at the library, Falls Creek Public School 3rd Friday each month at 7:30pm. Jack Apfelbaum (02) 4423-2255

**Hawkesbury Astronomical Association** meets once a month on the 2nd Wednesday, commencing 7:45pm, in the Tebbutt Rooms at the Windsor Library, Dight St. Windsor. Contact Adrian Saw (02) 4572-1568

**Illawarra Astronomical Society** meets at the Wollongong Science Centre and Planetarium, Fairy Meadow, on the 2nd Tuesday each month at 8:00pm. Contact Dave Wheeler (02) 4226-3584

**Macarthur Astronomical Society** meets 3rd Monday of the month at 7.30pm at the University of Western Sydney - Macarthur, Building 22, Room 5. Contact Ian Cook (02) 4627-1424

**Northern Sydney Astronomical Society** meets at the Sports Pavilion, St. Ignatius College, Lane Cove on the 3rd Tuesday each month at 7:30pm. Contact Ron Washington (02) 9949-3544

**Port Macquarie Astronomical Association** meets at the Port Macquarie Observatory (in Rotary Park, opposite Town Beach) on the last Monday of each month at 6.30pm. Contact Jim Daniel (02) 6583-1933

**Sutherland Astronomical Society** operates from Green Point Observatory near Sutherland. They meet every Thursday at 8:00pm. Contact the secretary (02) 9589-1014.

**Western Sydney Amateur Astronomy Group** meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus. Contact Peter Nakitch (02) 9835-1824 or Brett White (02) 9623-2496

**Wollongong Amateur Astronomy Club** meets on the 1st Thursday each month, at 7:30pm, at the Unanderra Community Centre, Princess Highway, Unanderra. Contact Andrew Wood (02) 4272-4505

**University Of New England And Northern Tablelands Astronomical Society** (UNENTAS) meets once per month (except December and January) at 6:30pm AEST on Thursday evenings at the Kirby Observatory. Contact (02) 6771-1123

## QUEENSLAND

**Astronomical Association Of Queensland** meets on the afternoon of the 2nd Saturday each month at 2.30pm in the lecture theatre of the Sir Thomas Brisbane Planetarium, Mt Coot-tha Botanic Gardens. Contact Bill Oliver (07) 3391-4587

**Tropical Stargazers** (formerly Astronomy 20 South) This Hamilton Island based group meets on the 4th Wednesday each month. Contact Ray Johnston (07) 4946-8686

**Bundaberg Astronomical Society** meets at Alloway Observatory every Friday at 7:30pm. Contact Bill Fielding, Don Gray or Peter Rehbein (07) 4159-7232

**Bundy Skywatchers** (Bundaberg) meets every Friday with three nights a month being field nights. Contact Karlene Galway (07) 4159-9674

**Brisbane Astronomical Society** meets on the 2nd Friday each month at 7:30pm at Kelvin Grove State High School Library. Contact David Durham (07) 3321-8511

**Cairns Astronomy Group** meets from June to November at Bob's place, 18 Yurongi St, Caravonica Qld 4878 Contact Bob Dollery (07) 4058-1180

**Redlands Astronomical Society** meets at Ormiston College, Ormiston (27km SE of Brisbane) twice a month on the 2nd and last Tuesdays. Contact Ross Spence (07) 3822-5545

**South East Queensland Astronomical Society** meets on the 3rd Monday of the month at Kedron High School, from February to November. Contacts Graham Long (07) 3205-4541 or David Larkin (07) 3844-7904

**Southern Astronomical Society** meets at Ormeau State School on Saturdays, at 7pm. Contact Kevin Dixon (07) 5537-3852

**Sun Coast Astronomical Society** meets on the 3rd Friday each month at 7pm at the Beerwah Field Study Centre, Roys Road, Beerwah. Contact Terry O'Keefe (07) 5491-5257 or Glen Lang (07) 5496-0310

**Townsville Astronomy Group** observe on the 1st Saturday closest to New Moon at Alligator Creek (20km south of Townsville) or at Kelso Dam. Contact Richard Free (07) 4789-2214

SOUTH AUSTRALIA

**Astronomical Society Of S.A.** meets on the 1st Wednesday each month (except Jan.) at the University of Adelaide, North Terrace Campus. Contact (08) 8338-1231

## TASMANIA

**Astronomical Society Of Tasmania** meets at the Hutchins School, Sandy Bay, on the last Tuesday each month except Dec.ember. The September meeting is held at Launceston Planetarium. Contact (03) 6244-3476, Karenne Barnes (Launceston) (03) 6344-7100 or Peter Sayers (Devonport) (03) 6424-2588

## VICTORIA

**Astronomical Society Of Victoria** has general meetings at 8pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. Contact Linda Mockridge (Public Relations Officer) (03) 9888-7130

**Astronomical Society of East Gippsland** meet at 10 Waterholes Rd, Bairnsdale Vic 3875. Contact Mike Finn (03) 5156-0676

**Astronomical Society Of Melbourne** has regular club nights. Contact Chris Ellis 0412 318 125

**Ballarat Astronomical Society** has a general meeting on the 2nd Friday each month and various activities are available on the other Friday evenings. Contact (03) 5332-7526

**Astronomical Society Of Albury Wodonga** meets on the first Wednesday each month (except January) at Victory Primary School, Drages Road, Wodonga at 8pm. Contact John Hills (02) 6024-7255

**Astronomical Society Of Geelong** meets every Friday from about 8:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong. Contact Frank Baker 0407 345 070

**Latrobe Valley Astronomical Society** meets each month (except December and January). Contact Rob Read (03) 5176-1560

**Oasis Stargazers Club Mildura** conduct regular viewing nights which are open to the public and once a month have a public activity night. Contact Kerry Needs (03) 5021-1330 or David Martin (03) 5023-3931

**Astronomical Society Of Frankston** meets on the 3rd Wednesday each month (except Dec.) at 8pm, at The Peninsula School, Wooralla Drive, Mt. Eliza. Contact Peter Skilton 0419 253 252

**Bendigo District Astronomical Society** meets at the BRiT (3rd Floor of McCrae St Campus) at 7:30pm on the 4th Wednesday of each month (excluding December). Contact Neil Linton (03) 5448-8352

## NORTHERN TERRITORY

**Alice Springs Astronomical Society** meets on the 2nd Monday each month at the Motor Registry Office, METEL Centre. Contact Annette Green (08) 8952-9817

**Darwin Astronomy Group** has monthly viewing nights during the dry season. Contact Phillip Smith (08) 8945-9450

# GLOSSARY

*Albedo* The ratio 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 invisible companion.

*Almanac* A set of tables giving positions of Sun, Moon & 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***.

*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 stars* Stars which never set. To determine which stars are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** a star 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 a ***superior planet*** 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.

*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. If the eccentricity equals zero, you have a circle.

*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. 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 March 21st, and autumnal or fall equinox about September 22nd (northern hemisphere seasons).

*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 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 2.52. 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). The faintest visible to the unaided are 6 (in 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 association 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°).

*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 23hrs56m4s 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 this continuous spectrum, a star normally shows a distinctive set of dark and light 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* A time system measured on the Meridian of Greenwich, it is 8 hours less than Western Australian Standard Time (***WAST***).

*WAST* Western Australian 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 a radiant 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 |

**INDEX** Entries which refer to diagrams or tables are in **bold** type.

There is no one who has not gazed on the beauty of the night sky and wondered:

What is that bright star ?
Why do some "stars" move from night to night ?
Which planet is that ?

This book is for you. No knowledge of Astronomy is needed to enjoy this publication. Not even a telescope! Five of the planets are easily visible to the unaided eye, just look up!

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- A comprehensive guide to the Total Solar Eclipse, visible from South Australia, in December 2002.
- Diagrams explaining the spectacular and rare gathering of the naked eye planets in the evening sky in May.
- Realistic views of the sky, easily identifying the planets from the stars
- Guide to the best times to observe the planets
- When to see Shooting Stars (Meteor showers)
- Easy to read monthly rise/set charts
- Public observatories in Australia
- Amateur astronomical societies
- Comets
- and much more ...

"Whether you are a casual skywatcher - or an experienced telescope user trying to glimpse an elusive little moon of Saturn - this book is for you! It's packed with information on the Sun, Moon, planets and other Solar System objects for the whole year. You will also find plenty of tips on observing, and explanations of many of the terms used in astronomy. I recommend this yearbook to everyone!"

*Martin George*
*Launceston Planetarium*

Quasar Publishing has been producing yearbooks since 1991 and ASTRONOMY 2002 continues with the high standard established over the years. The authors have had many years experience in observational astronomy, astronomical publications, public education and the amateur astronomical community.

QUASAR PUBLISHING

ISBN 0-9585906-7-2

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ESTIMATING ANGLES IN THE SKY. When held 0.5m(20 inches) from the eye, each division on this scale corresponds to 1° of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°