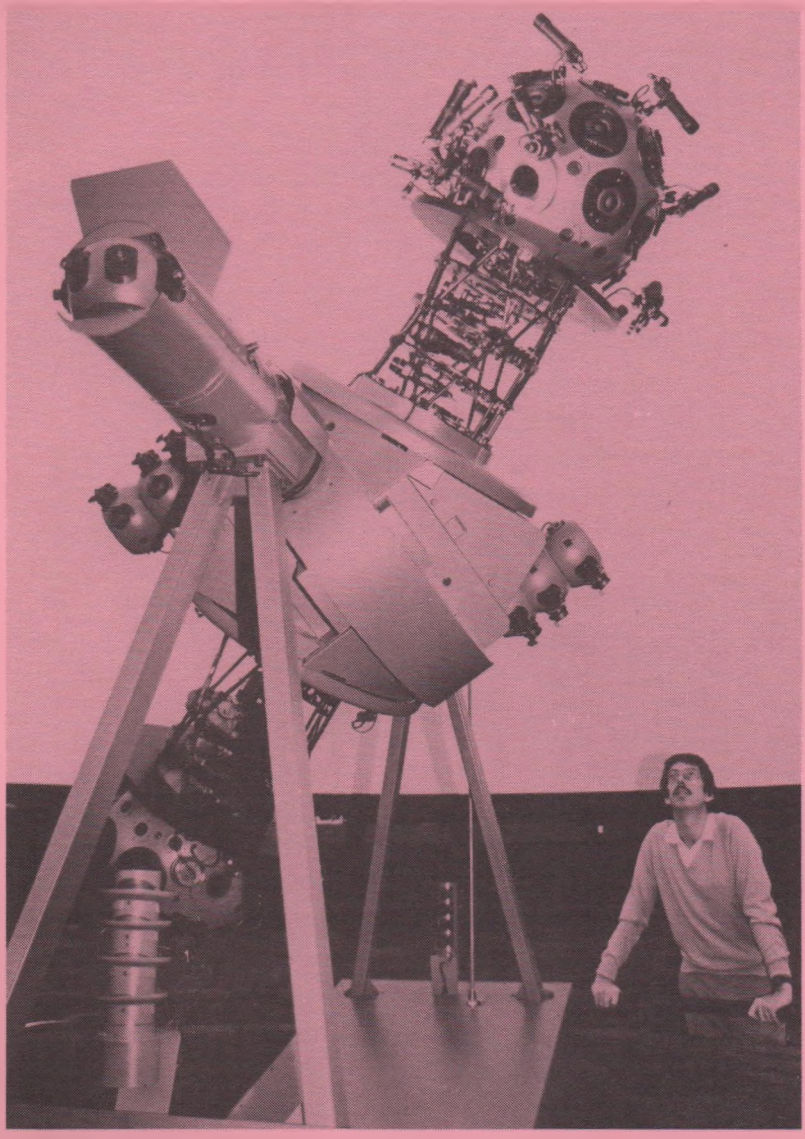
# ASTRONOMICAL HANDBOOK FOR SOUTHERN AFRICA

# 1988



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## MINOR PLANET OCCULTATIONS

A number of A.S.S.A. members and professional observatories form part of a world-wide network which observes the above events. The observations are very useful to astronomers who study the Solar System.

Often an amateur is located on or near an occultation path, and the observation which he or she can make may be of considerable value. The equipment requirements are modest. A 50mm telescope and means to record the times of multiple events will suffice in some instances. The timing equipment can comprise a portable tape recorder and a radio tuned to a continuous time signal such as ZUO or WWV. If a continuous time signal cannot be received reliably, then an assistant can read off time intervals of, say, ten seconds from a quarts watch synchronised with the SABC "six pips" time signal. The commentary of the observer and timekeeper is thus recorded for later analysis.

A list of possible events during 1988 is given below. From time to time instructions will be sent to observers wishing to participate in the programme. These will assist observers to locate and identify the occulted stars.

If you are in touch with one of the A.S.S.A. Centres and would like to participate, then you are invited to contact one of the conveners listed below. If you do not live near a Centre, then please contact M.D. Overbeek, P O Box 212, Edenvale, 1610. Further updated information may also be obtained from him at 011 535447.

| | |
|---|---|
| CAPE TOWN | Cliff Turk, 20 Nerina Avenue, Pinelands, 7405. |
| PIETERMARITZBURG | Mr C S Lake, Budleigh Road, Winterskloof, 3240. |
| BULAWAYO | Arthur G F Morrisby, Dept. of Surveyor General, P O Box 1580, Bulawayo, Zimbabwe. |
| BLOEMFONTEIN | Mr J van Ellinckhuyzen, 30 Mellville Drive, Brandwag, Bloemfontein, 9301. |
| WITWATERSRAND | M D Overbeek, P O Box 212, Edenvale, 1610. |
| HARARE | R W Fleet, P O Box 1335, Harare, Zimbabwe. |
| DURBAN | R K Field, 303 Wakesleigh Road, Bellair, 4094. |
| PRETORIA | Dr J Smit, Dickinsonrylaan 1183, Waverley, 0186. |
| PORT ELIZABETH | V Hirsh, P O Box 13115, Port Elizabeth, 6013. |

### OCCULTATIONS BY MINOR PLANETS

| DATE | SAST | MINOR PLANET | | STAR | MAG | DUR |
|---|---|---|---|---|---|---|
| Jan 2 | 20 37 | 615 | Roswitha | A + 07 0113 | 7.8 | 3.9 |
| Jan 10 | 03 29 | 479 | Caprera | A + 09 1334 | 8.5 | 8.4 |
| Jan 22 | 04 07 | 236 | Honoria | S 160257 | 7.2 | 1.7 |
| Feb 1 | 01 35 | 980 | Anacostia | S 205248 | 7.9 | 4.9 |
| Feb 3 | 00 04 | 241 | Germania | A + 03 1379 | 8.9 | 14.6 |
| Mar 21 | 03 18 | 71 | Niobe | S 202846 | 9.5 | 9.0 |
| Apr 14 | 21 33 | 361 | Bononia | S 182831 | 9.0 | 6.3 |
| Apr 17 | 02 02 | 786 | Bredichina | S 160876 | 9.4 | 14.7 |
| Apr 21 | 20 29 | 139 | Juewa | S 157598 | 8.4 | 18.5 |
| Apr 26 | 02 18 | 105 | Artemis | A + 05 2232 | 8.8 | 11.5 |
| Jun 7 | 19 04 | 152 | Atala | A + 28 0933 | 8.7 | 1.7 |
| Jun 9 | 01 41 | 360 | Carlova | S 141501 | 8.7 | 9.2 |
| Jun 23 | 18 24 | 508 | Princetonia | S 208706 | 9.3 | 11.4 |
| Jun 25 | 02 19 | 115 | Thyra | S 208420 | 8.1 | 7.5 |
| Jun 30 | 05 04 | 48 | Doris | S 161893 | 6.5 | 11.1 |
| Jul 9 | 18 20 | 250 | Bettina | A + 17 1127 | 8.6 | 5.4 |
| Aug 15 | 06 19 | 53 | Kalypso | A + 19 0482 | 9.1 | 3.0 |
| Aug 19 | 22 39 | 735 | Marghanna | S 228290 | 10.0 | 15.3 |
| Aug 24 | 04 57 | 554 | Peraga | A + 25 0452 | 7.2 | 3.9 |
| Aug 31 | 05 20 | 356 | Liguria | A + 30 0629 | 9.2 | 4.9 |
| Sep 19 | 23 14 | 43 | Ariadne | S 185447 | 9.0 | 3.4 |
| Sep 22 | 18 44 | 735 | Marghanna | S 228922 | 8.9 | 4.5 |
| Oct 5 | 02 36 | 202 | Chryseis | A + 15 0728 | 8.7 | 5.1 |
| Oct 25 | 02 35 | 270 | Anahita | A + 05 0022 | 7.2 | 11.7 |
| Oct 30 | 21 35 | 566 | Stereoskopia | A + 09 0234 | 6.3 | 11.8 |
| Nov 11 | 04 23 | 256 | Walpurga | A + 05 1022 | 8.5 | 5.4 |
| Nov 13 | 21 39 | 89 | Julia | S 187992 | 5.5 | 4.7 |
| Nov 18 | 00 44 | 284 | Amalia | A + 18 0482 | 7.5 | 5.4 |
| Dec 8 | 23 49 | 558 | Carmet | A + 13 0806 | 8.5 | 14.6 |
| Dec 25 | 22 47 | 410 | Chloris | S 147128 | 9.1 | 6.6 |

# ASTRONOMICAL HANDBOOK FOR SOUTHERN AFRICA 1988

This booklet is intended both as an introduction to observational astronomy for the interested layman — even if his interest is only a passing one – and as a handbook for the established amateur or professional astronomer.

## FRONT COVER

Forming part of the new facilities of the South African Museum is the second major planetarium in the sub-continent. Beneath the copper-sheathed dome, the auditorium features a precision Minolta M515 Projector that can be raised and lowered under hydraulic control. The projector can show over 8000 stars together with the motions of the sun, moon and planets. It is supported by an array of 21 slides, projectors and special effect devices, which operates under computer control. There is also a very sophisticated audio system. Information on public programmes can be obtained by phoning the South African Museum on (Cape Town) 24-3330

## CONTENTS



NOTE

All times are SAST unless otherwise stated.

This handbook is produced for the Astronomical Society of Southern Africa. The data it contains has been adapted for Southern Africa from data obtained from Royal Greenwich Observatory, Herstmonceux, from the International Lunar Occultation Centre, Tokyo, the British Astronomical Association and the Hydrographer of the South African Navy.

All correspondence concerning this booklet should be addressed to the Handbook Editor, Astronomical Society of Southern Africa, 8 Glebe Road, Rondebosch, 7700 from whom further copies are available at R4.00 per copy.

Although every care has been taken in the compilation of the Handbook, it is sold and distributed on the explicit understanding that neither the Society or its members accepts any responsibility for errors therein.

Dit spyt ons dat as gevolg van beperkte fondse en produksie fasiliteite dit nie moontlik is om die handboek in Afrikaans te laat druk nie.

R F HURLY
Editor

# ASTRONOMY IN SOUTHERN AFRICA

As one of the few parts of the Earth having both access to the rich southern skies and a suitable climate, Southern Africa holds a favoured position in astronomy. Consequently, it has seen the establishment of a number of professional observatories engaged in research while many individuals have become enthusiastic amateur astronomers. Planetaria and visiting nights at observatories convey to the general public much of what goes on in this field.

## Observatories

The South African Astronomical Observatory (SAAO) was established in 1972, as a joint venture between the Council for Scientific and Industrial Research (CSIR) of SA and the Science Research Council of the UK, combining the facilities of the former Royal and Republic Observatories, and is directed by Prof M W Feast. On the closure of the Radcliffe Observatory in 1974, the CSIR acquired the 1.9-m telescope, and moved it to Sutherland in the Karoo, where there are also 1.0-m, 0.75-m and 0.5-m telescopes. The headquarters are in Cape Town, where also a limited amount of observing continues. Research is undertaken in many areas, with considerable effort being put into the study of variable stars, the Galactic Centre, the Magellanic Clouds and sources detected by satellites. These studies involve the use of spectroscopic, photometric and infrared techniques. Besides providing research facilities for its own staff, SAAO observing time is allocated to astronomers from South African universities and elsewhere in the world.

The 0.67-m visual refractor at the former Republic Observatory, Johannesburg is maintained by the National Institute for Telecommunications Research (NITR) of the CSIR. The 0.25-m Franklin-Adams Camera at the Broederstroom Observatory, Hartbeespoort is maintained by the Dept of National Education.

Boyden Observatory, situated at Mazelspoort, 25 km from Bloemfontein, is owned by the Institute and Dept of Astronomy of the University of the Orange Free State, and directed by Prof A H Jarrett. Observing facilities include a 1.52-m and two 0.41-m telescopes, as well as the 0.25-m Metcalf camera, a 0.33-m refractor and a 0.20-m solar installation. The main research areas include flare stars, short period variable stars, and atomic emissions from nebulae, the Sun and interplanetary space.

The Radio Astronomy Observatory at Hartebeesthoek, near Krugersdorp, is operated by the NITR. The director is Dr G D Nicolson. The telescope, a 26-m dish, is used for observations of extragalactic radio objects such as quasars and X-ray sources. The Rhodes University Radio Astronomy Group, led by Prof E E Baart, use this telescope, currently in a survey of the whole southern sky at 13 cm.

In addition to the professional observatories mentioned above, South Africa and Zimbabwe have numerous private observatories, built and operated by amateur astronomers.

## Observatories Open to the Public

SAAO headquarters in Observatory are open to visitors on the second saturday of each month at 20h00. It is not necessary to make a booking, unless there are more than ten persons in a party. Day visits are possible to the SAAO observing site near Sutherland, and enquiries should be made to Sutherland prior to the intended visit.

Visiting nights at Boyden Observatory are generally held around the time of first quarter, and numbers are restricted to 20 persons on each occasion. Enquiries should be made to the Observatory.

## Planetaria

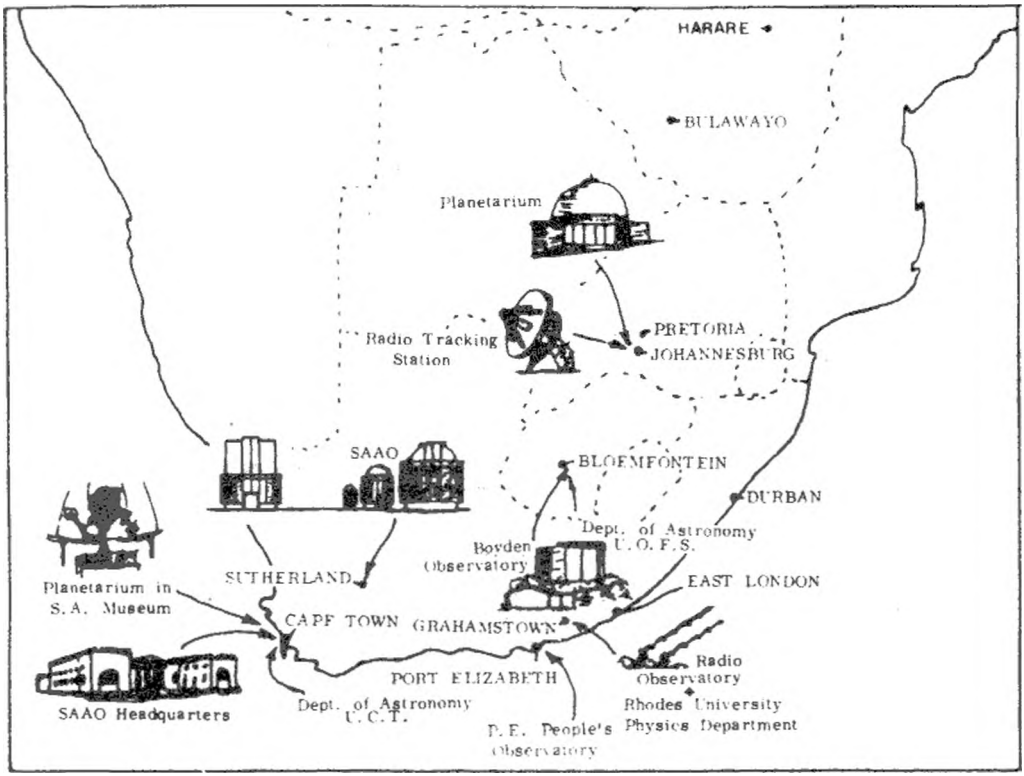
A planetarium is located within the South African Museum in Cape Town. This new planetarium, containing a Minolta Series 4 projector and seating 120, represents one of the most advanced of its kind in the world today.

A planetarium is situated in the grounds of the University of the Witwatersrand in Johannesburg (entrance in Yale Road, alongside M1). It is equipped with a Zeiss projector and seats over 400 persons.

Regular shows are given at both of these planetaria, from whom details may be obtained.

## Universities

Several universities undertake research in astronomy and offer teaching courses. The chair of astronomy at UCT is occupied by Brian Warner, whose department use the SAAO observing facilities at Sutherland. Prof G F R Ellis of the Dept of Applied Mathematics, UCT heads a group carrying out research in theoretical cosmology. The University of OFS has an Institute (created in 1981) and a Dept of Astronomy. Both are incorporated with the Boyden Observatory, and headed by Prof A H Jarrett. The Dept of Physics and Electronics at Rhodes University, under Prof E E Baart, specialises in radio astronomy, and has its own observatory outside Grahamstown. The Dept of Mathematics, Applied Mathematics and Astronomy at UNISA offers a number of courses in astronomy and astrophysics. Prof W F Wargau is the head of Astronomy at UNISA.




## The Astronomical Society of Southern Africa

The Astronomical Society of Southern Africa is a body consisting of both amateur and professional astronomers. Membership is open to all interested persons, regardless of knowledge or experience. In addition to this Handbook, the Society issues the 'Monthly Notes of the Astronomical Society of Southern Africa' (MNASSA). Members also receive the popular monthly magazine 'Sky and Telescope' published in the USA, which provides information on professional and amateur activities, together with news of space research and other related subjects. The Society's annual subscription is R50.00 and there is an entrance fee of R10.00. A prospectus and application form may be obtained from the Honorary Secretary, Astronomical Society of S A, c/o S A Astronomical Observatory, P O Box 9, Observatory 7935, Cape.

## LOCAL CENTRES OF THE SOCIETY

Autonomous local centres of the Society hold regular meetings in Cape Town, Durban, Johannesburg, Bloemfontein, Pietermaritzburg, Pretoria and Harare. Visitors are very welcome at meetings and may, if they wish, join a Centre without becoming a full member of the Society. Centre members do not receive society publications, nor "Sky and Telescope".

CAPE CENTRE (Cape Town): Formal meetings are held on the second Wednesday of the month (except in January and December) when professional and prominent local amateur astronomers present lectures on the latest topics in Astronomy. Informal meetings are held on most other Wednesdays except during January and December. At these informal meetings discussion groups and observing sessions are held. Two or three out-of-town weekend observing sessions are held annually in areas where dark skies are available. The Centre publishes a quarterly journal, the "Cape Observer" which gives information on meetings, current activities and objects to observe. Further information may be obtained from the secretary Mr A D B Cameron, 39 Malleson Road, Mowbray, 7700, telephone 021-6853544. Meetings are held at the S A A O, Observatory Road, Observatory at 20h00.

TRANSVAAL CENTRE (Johannesburg): General meetings are held on the second Wednesday of each month, excluding December, in the Sir Herbert Baker building in the grounds of the former Republic Observatory, 18A Gill Street, Observatory, Johannesburg at 20h00. The meetings consist of lectures, films or observing evenings. There are two small observatories on the site. One contains the Jacobs telescope, a 30cm F8 Newtonian and in the Papadopoulos Dome is housed a combined instrument comprising a 18cm F16 refractor, a 15cm refractor and a 30cm F16 Cassegrain reflector. Informal observing evenings are held every friday night. The Centre publishes a monthly newsletter "Canopus", which carries information on meetings and the Centre's activities. Secretarial address: Mrs H Homer, 20 Selkirk St., Parkview, 2193, telephone 011-6468291.

NATAL CENTRE (Durban): Regular monthly meetings are held at 19h45 on the second Wednesday of each month in St Thomas' Church Hall, Essenwood Road, Berea, Durban. The Centre publishes a monthly magazine "Ndaba" which contains news and views and current information on astronomical and related topics. Secretarial address P O Box 5330, Durban, 4000, telephone 031-(w)842321 (H)255979/823316/844751.

NATAL MIDLANDS CENTRE (Pietermaritzburg): Regular monthly meetings on the third Thursday of each month (except January) at the PMB Music College, Havelock Road at 19h45. Information meetings and membership is available from the secretary Mr J Watson, P O Box 2106, Pietermaritzburg, 3200 or by phoning 0331-33710 or 33646.

BLOEMFONTEIN CENTRE: Meetings are held every fourth Friday of the month. For information contact Mr F C Neser, telephone 051-221142, 108 Japie Neser Road, General de Wet, Bloemfontein, 9301.

PRETORIA CENTRE: Meetings are held on the fourth Wednesday of each month (except December) at 19h00 at the Christian Brothers' College, Silverton Road, where the Centre's observatory containing a 30cm reflecting telescope is situated. For further information contact the secretary Mr N Young at 201 Kritzenger St., Meyers Park, Pretoria, 0184 telephone 012-833765.

HARARE CENTRE: The Centre holds a meeting on the last Wednesday of each month (except December). These are usually held at 17h30 at the Queen Victoria Museum and consist of lectures, films or general discussions. Informal observing sessions are also held at the homes of members. Secretarial address P O Box UA 428, Union Avenue, Harare, Zimbabwe.

## OBSERVING SECTIONS OF THE SOCIETY:

These sections exist to co-ordinate constructive observing programmes. Mention of the type of observations and equipment involved are made in the appropriate parts of this handbook together with the names and addresses of the directors.

# DIARY OF PHENOMENA, CONFIGURATIONS OF SUN, MOON AND PLANETS

| | d | h | |
|---|---|---|---|
| Jan. | 4 | 02 | Earth at perihelion |
| | 4 | 04 | FULL MOON |
| | 7 | 08 | Moon at apogee |
| | 12 | 09 | LAST QUARTER |
| | 12 | 14 | Spica 0°.4 N. of Moon Occ$^{n}$. |
| | 15 | 18 | Mars 5° N. of Moon |
| | 16 | 01 | Antares 0°.3 N. of Moon Occ$^{n}$. |
| | 17 | 06 | Saturn 6° N. of Moon |
| | 17 | 08 | Uranus 5° N. of Moon |
| | 17 | 23 | Neptune 6° N. of Moon |
| | 19 | 07 | NEW MOON |
| | 19 | 23 | Moon at perigee |
| | 20 | 11 | Mercury 2° N. of Moon |
| | 21 | 21 | Venus 0°.07 N. of Moon Occ$^{n}$. |
| | 22 | 00 | Mars 5° N. of Antares |
| | 22 | 08 | Vesta at opposition |
| | 25 | 04 | Jupiter 4° S. of Moon |
| | 26 | 00 | FIRST QUARTER |
| | 26 | 19 | Mercury greatest elong.E.(19°) |
| Feb. | 1 | 12 | Ceres in conjunction with Sun |
| | 1 | 17 | Vesta 0°.2 S. of Moon Occ$^{n}$. |
| | 1 | 18 | Mercury stationary |
| | 2 | 23 | FULL MOON |
| | 3 | 12 | Moon at apogee |
| | 8 | 21 | Spica 0°.7 N. of Moon Occ$^{n}$. |
| | 11 | 01 | LAST QUARTER |
| | 11 | 06 | Mercury in inferior conjunction |
| | 12 | 10 | Antares 0°.5 N. of Moon Occ$^{n}$. |
| | 13 | 03 | Saturn 1°.3 N. of Uranus |
| | 13 | 11 | Mars 5° N. of Moon |
| | 13 | 21 | Saturn 6° N. of Moon |
| | 13 | 21 | Uranus 5° N. of Moon |
| | 14 | 11 | Neptune 6° N. of Moon |
| | 17 | 12 | Moon at perigee |
| | 17 | 18 | NEW MOON |
| | 19 | 01 | Pluto stationary |
| | 20 | 19 | Venus 1°.9 S. of Moon |
| | 21 | 20 | Jupiter 4° S. of Moon |
| | 22 | 23 | Mars 0°.01 N. of Uranus |
| | 23 | 06 | Mercury stationary |
| | 23 | 15 | Mars 1°.3 S. of Saturn |
| | 24 | 14 | FIRST QUARTER |
| | 28 | 14 | Vesta 0°.2 N. of Moon Occ$^{n}$. |
| Mar. | 1 | 14 | Moon at apogee |
| | 3 | 18 | FULL MOON Penumbral Eclipse |
| | 6 | 22 | Venus 2° N. of Jupiter |
| | 7 | 03 | Spica 0°.7 N. of Moon Occ$^{n}$. |
| | 8 | 00 | Mars 1°.4 S. of Neptune |
| | 8 | 08 | Mercury greatest elong.W.(27°) |
| | 10 | 12 | Vesta stationary |
| | 10 | 17 | Antares 0°.6 N. of Moon Occ$^{n}$. |
| | 11 | 13 | LAST QUARTER |
| | 12 | 06 | Uranus 5° N. of Moon |
| | 12 | 08 | Saturn 6° N. of Moon |
| | 12 | 21 | Neptune 6° N. of Moon |
| | 13 | 02 | Mars 5° N. of Moon |
| | 16 | 07 | Mercury 0°.5 N. of Moon Occ$^{n}$. |
| | 16 | 22 | Moon at perigee |
| | 18 | 04 | NEW MOON Eclipse |
| | 20 | 12 | Equinox |
| | 20 | 16 | Jupiter 5° S. of Moon |
| | 21 | 14 | Venus 2° S. of Moon |
| | 25 | 07 | FIRST QUARTER |
| | 26 | 22 | Vesta 0°.5 N. of Moon Occ$^{n}$. |
| | 29 | 02 | Moon at apogee |
| Apr. | 2 | 11 | FULL MOON |
| | 3 | 09 | Spica 0°.7 N. of Moon Occ$^{n}$. |

| | d | h | |
|---|---|---|---|
| Apr. | 3 | 10 | Venus greatest elong.E.(46°) |
| | 4 | 21 | Uranus stationary |
| | 6 | 22 | Antares 0°.5 N. of Moon Occ$^{n}$. |
| | 8 | 12 | Uranus 5° N. of Moon |
| | 8 | 15 | Saturn 6° N. of Moon |
| | 9 | 03 | Neptune 6° N. of Moon |
| | 9 | 21 | LAST QUARTER |
| | 10 | 17 | Mars 3° N. of Moon |
| | 11 | 04 | Saturn stationary |
| | 11 | 14 | Neptune stationary |
| | 14 | 01 | Moon at perigee |
| | 15 | 16 | Venus 10° N. of Aldebaran |
| | 16 | 14 | NEW MOON |
| | 20 | 02 | Venus 1°.0 S. of Moon Occ$^{n}$. |
| | 20 | 17 | Mercury in superior conjunction |
| | 23 | 17 | Vesta 0°.9 N. of Moon Occ$^{n}$. |
| | 24 | 01 | FIRST QUARTER |
| | 25 | 21 | Moon at apogee |
| | 30 | 16 | Spica 0°.7 N. of Moon Occ$^{n}$. |
| May | 1 | 11 | Pluto at opposition |
| | 2 | 02 | FULL MOON |
| | 2 | 23 | Jupiter in conjunction with Sun |
| | 4 | 04 | Antares 0°.4 N. of Moon Occ$^{n}$. |
| | 5 | 17 | Uranus 5° N. of Moon |
| | 5 | 19 | Saturn 6° N. of Moon |
| | 6 | 09 | Neptune 6° N. of Moon |
| | 6 | 22 | Venus greatest brilliancy |
| | 9 | 03 | LAST QUARTER |
| | 9 | 08 | Mars 0°.8 N. of Moon Occ$^{n}$. |
| | 11 | 00 | Moon at perigee |
| | 11 | 08 | Mercury 8° N. of Aldebaran |
| | 16 | 00 | NEW MOON |
| | 17 | 19 | Mercury 3° S. of Moon |
| | 18 | 15 | Venus 1°.2 S. of Moon |
| | 19 | 04 | Mercury greatest elong.E.(22°) |
| | 22 | 15 | Venus stationary |
| | 23 | 14 | Juno in conjunction with Sun |
| | 23 | 16 | Moon at apogee |
| | 23 | 19 | FIRST QUARTER |
| | 28 | 01 | Spica 0°.8 N. of Moon Occ$^{n}$. |
| | 29 | 14 | Pallas stationary |
| | 31 | 12 | Antares 0°.4 N. of Moon Occ$^{n}$. |
| | 31 | 13 | FULL MOON |
| June | 1 | 03 | Mercury stationary |
| | 1 | 23 | Uranus 5° N. of Moon |
| | 2 | 00 | Saturn 6° N. of Moon |
| | 2 | 14 | Neptune 6° N. of Moon |
| | 5 | 02 | Moon at perigee |
| | 6 | 22 | Mars 2° S. of Moon |
| | 7 | 08 | LAST QUARTER |
| | 12 | 05 | Jupiter 6° S. of Moon |
| | 13 | 02 | Venus in inferior conjunction |
| | 13 | 06 | Mercury in inferior conjunction |
| | 14 | 11 | NEW MOON |
| | 19 | 20 | Regulus 1°.2 S. of Moon Occ$^{n}$. |
| | 20 | 06 | Uranus at opposition |
| | 20 | 10 | Moon at apogee |
| | 20 | 11 | Saturn at opposition |
| | 21 | 06 | Solstice |
| | 22 | 12 | FIRST QUARTER |
| | 24 | 10 | Spica 1°.1 N. of Moon Occ$^{n}$. |
| | 25 | 01 | Mercury stationary |
| | 27 | 04 | Saturn 1°.3 N. of Uranus |
| | 27 | 21 | Antares 0°.4 N. of Moon Occ$^{n}$. |
| | 29 | 06 | Saturn 6° N. of Moon |
| | 29 | 06 | Uranus 5° N. of Moon |
| | 29 | 22 | FULL MOON |

# DIARY OF PHENOMENA, CONFIGURATIONS OF SUN, MOON AND PLANETS

| | d | h | |
|---|---|---|---|
| June | 29 | 22 | Neptune 6° N. of Moon |
| | 30 | 12 | Neptune at opposition |
| July | 2 | 08 | Moon at perigee |
| | 4 | 10 | Venus stationary |
| | 5 | 09 | Mars 5° S. of Moon |
| | 6 | 02 | Earth at aphelion |
| | 6 | 14 | LAST QUARTER |
| | 6 | 18 | Mercury greatest elong.W.(21°) |
| | 9 | 21 | Jupiter 6° S. of Moon |
| | 11 | 03 | Venus 10° S. of Moon |
| | 12 | 06 | Mercury 7° S. of Moon |
| | 14 | 00 | NEW MOON |
| | 17 | 03 | Regulus 1°.0 S. of Moon Occ$^{n}$. |
| | 18 | 02 | Moon at apogee |
| | 19 | 20 | Venus greatest brilliancy |
| | 22 | 04 | FIRST QUARTER |
| | 25 | 07 | Antares 0°.6 N. of Moon Occ$^{n}$. |
| | 25 | 20 | Pluto stationary |
| | 26 | 13 | Saturn 6° N. of Moon |
| | 26 | 14 | Uranus 5° N. of Moon |
| | 27 | 07 | Neptune 6° N. of Moon |
| | 29 | 05 | FULL MOON |
| | 30 | 10 | Moon at perigee |
| Aug. | 1 | 14 | Ceres stationary |
| | 2 | 13 | Mars 8° S. of Moon |
| | 2 | 18 | Pallas at opposition |
| | 3 | 06 | Mercury in superior conjunction |
| | 4 | 20 | LAST QUARTER |
| | 6 | 10 | Jupiter 6° S. of Moon |
| | 8 | 14 | Venus 9° S. of Moon |
| | 12 | 15 | NEW MOON |
| | 14 | 14 | Moon at apogee |
| | 20 | 18 | FIRST QUARTER |
| | 21 | 16 | Antares 0°.7 N. of Moon Occ$^{n}$. |
| | 22 | 14 | Venus greatest elong.W.(46°) |
| | 22 | 21 | Saturn 6° N. of Moon |
| | 22 | 23 | Uranus 5° N. of Moon |
| | 23 | 16 | Neptune 6° N. of Moon |
| | 27 | 01 | Mars stationary |
| | 27 | 13 | FULL MOON Eclipse |
| | 27 | 19 | Moon at perigee |
| | 30 | 05 | Mars 9° S. of Moon |
| | 30 | 13 | Saturn stationary |
| Sept. | 2 | 10 | Venus 9° S. of Pollux |
| | 2 | 22 | Jupiter 6° S. of Moon |
| | 3 | 06 | LAST QUARTER |
| | 5 | 12 | Uranus stationary |
| | 7 | 01 | Venus 6° S. of Moon |
| | 9 | 15 | Regulus 1°.0 S. of Moon Occ$^{n}$. |
| | 10 | 17 | Moon at apogee |
| | 11 | 07 | NEW MOON Eclipse |
| | 13 | 18 | Mercury 0°.6 N. of Moon Occ$^{n}$. |
| | 16 | 00 | Mercury greatest elong.E.(27°) |
| | 17 | 06 | Ceres at opposition |
| | 17 | 23 | Antares 0°.7 N. of Moon Occ$^{n}$. |
| | 18 | 19 | Neptune stationary |
| | 19 | 05 | FIRST QUARTER |
| | 19 | 05 | Saturn 6° N. of Moon |
| | 19 | 07 | Uranus 5° N. of Moon |
| | 20 | 00 | Neptune 6° N. of Moon |
| | 20 | 18 | Pallas stationary |
| | 21 | 06 | Mercury 1°.3 S. of Spica |
| | 22 | 05 | Mars closest approach |
| | 22 | 21 | Equinox |
| | 24 | 18 | Jupiter stationary |
| | 25 | 06 | Moon at perigee |
| | 25 | 21 | FULL MOON |

| | d | h | |
|---|---|---|---|
| Sept. | 26 | 06 | Mars 7° S. of Moon |
| | 28 | 06 | Mars at opposition |
| | 28 | 23 | Mercury stationary |
| | 30 | 07 | Jupiter 6° S. of Moon |
| Oct. | 2 | 13 | Vesta in conjunction with Sun |
| | 2 | 19 | LAST QUARTER |
| | 4 | 10 | Venus 0°.2 S. of Regulus |
| | 5 | 20 | Mercury 1°.2 S. of Spica |
| | 6 | 22 | Regulus 1°.0 S. of Moon Occ$^{n}$. |
| | 7 | 05 | Venus 0°.6 S. of Moon Occ$^{n}$. |
| | 7 | 22 | Moon at apogee |
| | 11 | 00 | NEW MOON |
| | 11 | 09 | Mercury in inferior conjunction |
| | 15 | 04 | Antares 0°.6 N. of Moon Occ$^{n}$. |
| | 16 | 14 | Saturn 6° N. of Moon |
| | 16 | 14 | Uranus 5° N. of Moon |
| | 17 | 07 | Neptune 6° N. of Moon |
| | 18 | 04 | Saturn 1°.1 N. of Uranus |
| | 18 | 15 | FIRST QUARTER |
| | 19 | 18 | Mercury stationary |
| | 23 | 06 | Mars 5° S. of Moon |
| | 23 | 14 | Moon at perigee |
| | 25 | 07 | FULL MOON |
| | 26 | 23 | Mercury greatest elong.W.(18°) |
| | 27 | 14 | Jupiter 6° S. of Moon |
| | 30 | 16 | Mars Stationary |
| Nov. | 1 | 09 | Mercury 4° N. of Spica |
| | 1 | 12 | LAST QUARTER |
| | 3 | 05 | Regulus 0°.8 S. of Moon Occ$^{n}$. |
| | 4 | 13 | Moon at apogee |
| | 4 | 19 | Pluto in conjunction with Sun |
| | 6 | 17 | Venus 5° N. of Moon |
| | 9 | 16 | NEW MOON |
| | 11 | 10 | Antares 0°.5 N. of Moon Occ$^{n}$. |
| | 12 | 20 | Ceres stationary |
| | 12 | 21 | Uranus 5° N. of Moon |
| | 12 | 23 | Saturn 6° N. of Moon |
| | 13 | 13 | Neptune 5° N. of Moon |
| | 17 | 00 | FIRST QUARTER |
| | 17 | 06 | Venus 4° N. of Spica |
| | 19 | 18 | Mars 3° S. of Moon |
| | 20 | 12 | Moon at perigee |
| | 23 | 05 | Jupiter at opposition |
| | 23 | 18 | FULL MOON |
| | 23 | 19 | Jupiter 6° S. of Moon |
| | 30 | 13 | Regulus 0°.5 S. of Moon Occ$^{n}$. |
| Dec. | 1 | 09 | LAST QUARTER |
| | 1 | 11 | Mercury in superior conjunction |
| | 2 | 08 | Moon at apogee |
| | 7 | 02 | Venus 7° N. of Moon |
| | 9 | 08 | NEW MOON |
| | 10 | 22 | Neptune 5° N. of Moon |
| | 16 | 06 | Moon at perigee |
| | 16 | 08 | FIRST QUARTER |
| | 17 | 18 | Mars 3° S. of Moon |
| | 20 | 11 | Mercury 3° S. of Neptune |
| | 20 | 22 | Jupiter 6° S. of Moon |
| | 21 | 17 | Solstice |
| | 22 | 22 | Uranus in conjunction with Sun |
| | 23 | 07 | FULL MOON |
| | 24 | 20 | Venus 6° N. of Antares |
| | 26 | 14 | Saturn in conjunction with Sun |
| | 27 | 22 | Regulus 0°.2 S. of Moon Occ$^{n}$. |
| | 30 | 06 | Moon at apogee |
| | 31 | 07 | LAST QUARTER |
| | 31 | 11 | Neptune in conjunction with Sun |

## Basic Data

Diameter: 1 392 000 km (1 09 times Earth diameter)

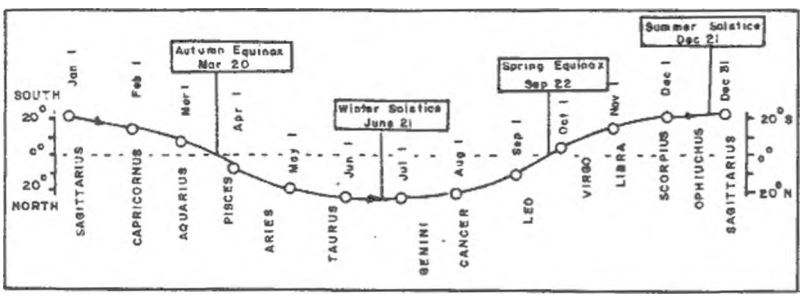
Mass: $1{,}99 \times 10^{30}$kg (330 000 times Earth Mass)

Surface Temperature: Approximately 6 000°C

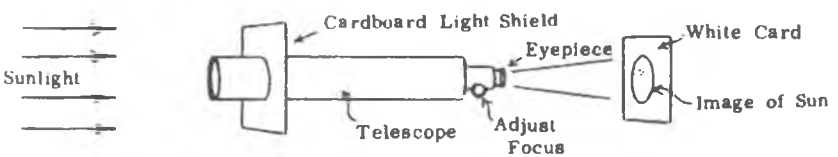
Temperature at centre: Approximately 10 million°C

The sun is our nearest star. It is composed chiefly of hydrogen and is in a gaseous state throughout. So hot and dense is its interior that nuclear reactions occur there - thus producing the energy that is eventually radiated from its surface. At times its surface is disturbed by sunspots (which may persist for some weeks) and flares (short-lived).

The Earth's orbit round the Sun is not quite circular. In 1987 we will be closest to the Sun on January 5 (perihelion - approximate distance 147 million km) and furthest from the Sun on July 4 (aphelion - approximately 152 million km). During the year, the Sun appears to us to make a complete circuit of the sky (i.e. relative to the starry background) as indicated in the diagram.




Permanent damage to the eye can be caused by looking directly at the Sun. The diagram below shows how a small telescope (or half a binocular) may be used to project an image of the solar disc onto a piece of white card. It may also be advisable to stop down the telescope aperture so that the eyepiece is not damaged by the intense light passing through it. Tiny black sunspots are generally visible on the otherwise white solar disc - if monitored over a period of a week or so, the rotation of the Sun should be apparent.




### SUN'S DECLINATION

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 1 | 23°05'S | Apr | 1 | 4°33'N | Jul | 10 | 22°15'N | Oct | 8 | 5°53'S |
| | 11 | 21°57'S | | 11 | 8°19'N | | 20 | 20°40'N | | 18 | 9°37'S |
| | 21 | 20°07'S | | 21 | 11°52'N | | 30 | 18°31'N | | 28 | 13°07'S |
| | 31 | 17°39'S | May | 1 | 15°04'N | Aug | 9 | 15°51'N | Nov | 7 | 16°17'S |
| Feb | 10 | 14°40'S | | 11 | 17°53'N | | 19 | 12°47'N | | 17 | 18°59'S |
| | 20 | 11°17'S | | 21 | 20°11'N | | 29 | 9°22'N | | 27 | 21°08'S |
| Mar | 2 | 7°12'S | | 31 | 21°55'N | Sep | 8 | 5°42'N | Dec | 7 | 22°27'S |
| | 12 | 3°19'S | Jun | 10 | 23°01'N | | 18 | 1°52'N | | 17 | 23°21'S |
| | 22 | 0°38'S | | 21 | 23°27'N | | 28 | 2°01'N | | 22 | 23°27'S |
| | | | | 30 | 23°11'N | | | | | 31 | 23°06'S |

# THE SUN

TIMES OF SUNRISE AND SUNSET FOR THE MAIN CITIES OF SOUTHERN AFRICA

| | | CAPE TOWN | | DURBAN | | BLOEMFONTEIN | | JOHANNESBURG | | HARARE | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | sunrise | sunset | sunrise | sunset | sunrise | sunset | sunrise | sunset | sunrise | sunset |
| Jan | 1 | 05h38m | 20h01m | 04h58m | 19h01m | 05h21m | 19h18m | 05h18m | 19h04m | 05h24m | 18h35m |
| | 11 | 05 46 | 20 02 | 05 06 | 19 02 | 05 29 | 19 18 | 05 25 | 19 05 | 05 29 | 18 37 |
| | 21 | 05 55 | 19 59 | 05 14 | 19 00 | 05 37 | 19 17 | 05 33 | 19 04 | 05 37 | 18 38 |
| Feb | 1 | 06 07 | 19 52 | 05 24 | 18 55 | 05 46 | 19 13 | 05 42 | 19 00 | 05 42 | 18 36 |
| | 11 | 06 17 | 19 44 | 05 32 | 18 48 | 05 54 | 19 06 | 05 49 | 18 55 | 05 47 | 18 32 |
| | 21 | 06 26 | 19 33 | 05 41 | 18 39 | 06 02 | 18 57 | 05 54 | 18 47 | 05 52 | 18 27 |
| Mar | 1 | 06 33 | 19 23 | 05 46 | 18 30 | 06 08 | 18 48 | 06 00 | 18 39 | 05 55 | 18 21 |
| | 11 | 06 41 | 19 11 | 05 53 | 18 19 | 06 13 | 18 38 | 06 04 | 18 29 | 05 57 | 18 15 |
| | 21 | 06 49 | 18 58 | 05 59 | 18 06 | 06 18 | 18 27 | 06 11 | 18 19 | 06 00 | 18 06 |
| Apr | 1 | 06 58 | 18 41 | 06 06 | 17 53 | 06 25 | 18 13 | 06 17 | 18 06 | 06 02 | 17 57 |
| | 11 | 07 04 | 18 30 | 06 11 | 17 43 | 06 30 | 18 03 | 06 21 | 17 56 | 06 04 | 17 50 |
| | 21 | 07 13 | 18 17 | 06 17 | 17 31 | 06 35 | 17 52 | 06 25 | 17 47 | 06 07 | 17 43 |
| May | 1 | 07 20 | 18 06 | 06 24 | 17 22 | 06 42 | 17 44 | 06 31 | 17 38 | 06 10 | 17 37 |
| | 11 | 07 28 | 17 57 | 06 31 | 17 14 | 06 49 | 17 36 | 06 37 | 17 31 | 06 13 | 17 32 |
| | 21 | 07 34 | 17 50 | 06 36 | 17 06 | 06 54 | 17 30 | 06 41 | 17 26 | 06 16 | 17 29 |
| Jun | 1 | 07 43 | 17 45 | 06 43 | 17 04 | 07 01 | 17 27 | 06 47 | 17 23 | 06 20 | 17 28 |
| | 11 | 07 48 | 17 44 | 06 48 | 17 03 | 07 05 | 17 26 | 06 52 | 17 22 | 06 23 | 17 27 |
| | 21 | 07 51 | 17 44 | 06 51 | 17 04 | 07 06 | 17 27 | 06 55 | 17 24 | 06 26 | 17 29 |
| Jul | 1 | 07 53 | 17 48 | 06 53 | 17 07 | 07 10 | 17 30 | 06 57 | 17 27 | 06 27 | 17 32 |
| | 11 | 07 51 | 17 52 | 06 51 | 17 11 | 07 06 | 17 34 | 06 55 | 17 30 | 06 27 | 17 35 |
| | 21 | 07 47 | 17 58 | 06 48 | 17 16 | 07 05 | 17 39 | 06 53 | 17 35 | 06 26 | 17 40 |
| Aug | 1 | 07 39 | 18 06 | 06 42 | 17 22 | 07 00 | 17 45 | 06 48 | 17 41 | 06 23 | 17 42 |
| | 11 | 07 30 | 18 13 | 06 34 | 17 29 | 06 53 | 17 51 | 06 41 | 17 46 | 06 18 | 17 46 |
| | 21 | 07 19 | 18 20 | 06 24 | 17 35 | 06 42 | 17 55 | 06 32 | 17 50 | 06 11 | 17 48 |
| Sep | 1 | 07 06 | 18 27 | 06 12 | 17 40 | 06 31 | 18 01 | 06 21 | 17 54 | 06 04 | 17 49 |
| | 11 | 06 52 | 18 34 | 06 00 | 17 46 | 06 19 | 18 06 | 06 11 | 17 59 | 05 55 | 17 51 |
| | 21 | 06 38 | 18 41 | 05 48 | 17 51 | 06 07 | 18 10 | 05 59 | 18 03 | 05 46 | 17 52 |
| Oct | 1 | 06 25 | 18 48 | 05 37 | 17 57 | 05 57 | 18 16 | 05 50 | 18 08 | 05 39 | 17 54 |
| | 11 | 06 12 | 18 55 | 05 25 | 18 03 | 05 45 | 18 22 | 05 39 | 18 12 | 05 30 | 17 57 |
| | 21 | 05 58 | 19 04 | 05 12 | 18 09 | 05 33 | 18 27 | 05 27 | 18 17 | 05 23 | 17 59 |
| Nov | 1 | 05 46 | 19 13 | 05 02 | 18 17 | 05 24 | 18 35 | 05 19 | 18 24 | 05 16 | 18 03 |
| | 11 | 05 38 | 19 23 | 04 55 | 18 26 | 05 17 | 18 44 | 05 13 | 18 32 | 05 14 | 18 08 |
| | 21 | 05 31 | 19 33 | 04 49 | 18 34 | 05 12 | 18 52 | 05 06 | 18 39 | 05 11 | 18 13 |
| Dec | 1 | 05 29 | 19 43 | 04 48 | 18 42 | 05 11 | 19 00 | 05 07 | 18 46 | 05 12 | 18 19 |
| | 11 | 05 28 | 19 50 | 04 48 | 18 50 | 05 11 | 19 07 | 05 08 | 18 53 | 05 14 | 18 25 |
| | 21 | 05 32 | 19 57 | 04 52 | 18 57 | 05 15 | 19 14 | 05 12 | 19 00 | 05 18 | 18 31 |

ECLIPSES OF THE SUN

**The total eclipse of the Sun on March 18 will be seen from Sumatra, Borneo, the Phillipines and from a line East of Japan and the Aleutians. The annular eclipse on the morning of September 11 will be seen in Southern Africa only as a partial eclipse shortly after sunrise from places East of 25°East.**

# The Moon

## BASIC DATA

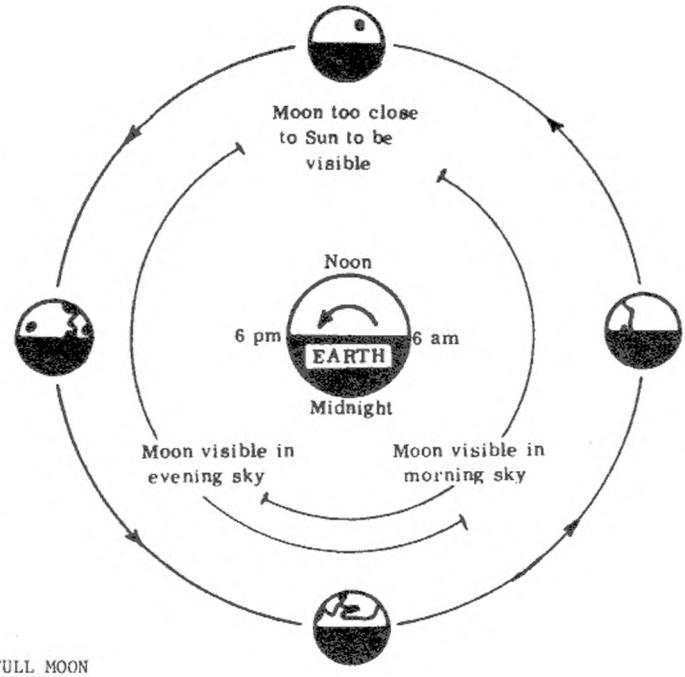
| | |
|---|---|
| Diameter: | 3 480 km (0,27 of Earth) |
| Mass: | 7,35 x $10^{22}$ x kg (1/81 of Earth) |
| Surface Gravity: | 0,16 of Earth |
| Average distance from Earth: | 384 000 km |

## PHASES AND VISIBILITY

### NEW MOON

| | d | h | m | | d | h | m | | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 19 | 07 | 26 | May | 16 | 00 | 11 | Sep | 11 | 06 | 49 |
| Feb | 17 | 17 | 54 | Jun | 14 | 11 | 14 | Oct | 10 | 23 | 49 |
| Mar | 18 | 04 | 02 | Jul | 13 | 23 | 53 | Nov | 9 | 16 | 20 |
| Apr | 16 | 14 | 00 | Aug | 12 | 14 | 31 | Dec | 9 | 07 | 36 |

### SCHEMATIC DIAGRAM OF MOON'S ORBIT




### FIRST QUARTER

| | d | h | m |
|---|---|---|---|
| Jan | 25 | 23 | 53 |
| Feb | 24 | 14 | 15 |
| Mar | 25 | 06 | 41 |
| Apr | 24 | 00 | 32 |
| May | 23 | 18 | 49 |
| Jun | 22 | 12 | 23 |
| Jul | 22 | 04 | 14 |
| Aug | 20 | 17 | 51 |
| Sep | 19 | 05 | 18 |
| Oct | 18 | 15 | 01 |
| Nov | 16 | 33 | 35 |
| Dec | 16 | 07 | 40 |

### LAST QUARTER

| | d | h | m |
|---|---|---|---|
| Jan | 12 | 09 | 04 |
| Feb | 11 | 01 | 01 |
| Mar | 11 | 12 | 56 |
| Apr | 9 | 21 | 21 |
| May | 9 | 03 | 23 |
| Jun | 7 | 08 | 21 |
| Jul | 6 | 13 | 36 |
| Aug | 4 | 26 | 22 |
| Sep | 3 | 05 | 50 |
| Oct | 2 | 18 | 58 |
| Nov | 1 | 12 | 11 |
| Dec | 1 | 08 | 49 |

### FULL MOON

| | d | h | m | | d | h | m | | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 4 | 03 | 40 | May | 2 | 01 | 41 | Aug | 27 | 12 | 56 |
| Feb | 2 | 22 | 51 | May | 31 | 12 | 53 | Sep | 25 | 21 | 07 |
| Mar | 3 | 18 | 01 | Jun | 29 | 21 | 46 | Oct | 25 | 06 | 35 |
| Apr | 1 | 11 | 21 | Jul | 29 | 05 | 25 | Nov | 23 | 17 | 53 |
| | | | | | | | | Dec | 23 | 07 | 29 |

## LUNAR PHENOMENA, 1988

### MOON AT PERIGEE

| | d | h | | d | h | | d | h |
|---|---|---|---|---|---|---|---|---|
| Jan | 19 | 23 | Jun | 5 | 02 | Oct | 23 | 14 |
| Feb | 17 | 12 | Jul | 2 | 08 | Nov | 20 | 12 |
| Mar | 16 | 22 | Jul | 30 | 10 | Dec | 16 | 06 |
| Apr | 14 | 01 | Aug | 27 | 19 | | | |
| May | 11 | 00 | Sep | 25 | 06 | | | |

### MOON AT APOGEE

| | d | h | | d | h | | d | h |
|---|---|---|---|---|---|---|---|---|
| Jan | 7 | 08 | May | 23 | 16 | Oct | 7 | 22 |
| Feb | 3 | 12 | Jun | 20 | 10 | Nov | 4 | 13 |
| Mar | 1 | 14 | Jul | 18 | 02 | Dec | 2 | 08 |
| Mar | 29 | 02 | Aug | 14 | 17 | Dec | 30 | 06 |
| Apr | 25 | 21 | Sep | 10 | 17 | | | |

LUNAR ECLIPSES

There will be a penumbral eclipse of the Moon on March 3. This will start at 17h10 and ends at 18h50, but this is only shortly after sunset in the eastern part of the country so that this event will occur in the twilight.

The partial eclipse of the Moon on August 27 will occur at about 13h00 and so will not be seen from African longitudes.

## The Moon


LIBRATIONS

Jan 3, Jan 30, Feb 26
Mar 24, Apr 21, May 18
Jun 14, Jul 11, Aug 7
Sep 3, Oct 1, Oct 28
Nov 24, Dec 21

Jan 26, Feb 23, Mar 23
Apr 20, May 18, Jun 14
Jul 11, Aug 7, Sep 3
Oct 1, Oct 28, Nov 26
Dec 24

Jan 17, Feb 13, Mar 12
Apr 8, May 5, Jun 1
Jun 28, Jul 26, Aug 22
Sep 18, Oct 15, Nov 11
Dec 9

Jan 14, Feb 11, Mar 10
Apr 6, May 3, Jun 1
Jun 28, Jul 26, Aug 21
Sep 19, Oct 15, Nov 11
Dec 8

# TIMES OF MOON RISE AND MOON SET - JOHANNESBURG

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | $17^h09^m$ | $02^h40^m$ | $18^h25^m$ | $04^h06^m$ | $17^h37^m$ | $03^h52^m$ | $17^h34^m$ | $05^h16^m$ | $17^h06^m$ | $05^h51^m$ | $18^h11^m$ | $07^h49^m$ |
| 2 | 18 05 | 03 28 | 19 02 | 05 02 | 18 07 | 04 46 | 15 02 | 05 09 | 17 45 | 06 51 | 19 16 | 08 51 |
| 3 | 18 58 | 04 20 | 19 34 | 05 57 | 18 36 | 05 38 | 18 33 | 07 02 | 18 29 | 07 53 | 20 25 | 09 47 |
| 4 | 19 44 | 05 16 | 20 04 | 06 51 | 19 03 | 06 30 | 19 07 | 08 00 | 19 22 | 08 57 | 21 33 | 10 36 |
| 5 | 20 25 | 06 12 | 20 32 | 07 43 | 19 31 | 07 22 | 19 47 | 09 00 | 20 21 | 10 01 | 22 40 | 11 18 |
| 6 | 21 01 | 07 08 | 20 59 | 08 34 | 19 59 | 08 15 | 20 33 | 10 03 | 21 26 | 10 59 | 23 43 | 11 56 |
| 7 | 21 33 | 08 03 | 21 27 | 09 26 | 20 31 | 09 09 | 21 26 | 11 06 | 22 34 | 11 52 | – | 12 30 |
| 8 | 22 02 | 08 56 | 21 56 | 10 19 | 21 06 | 10 06 | 22 37 | 12 07 | 23 41 | 12 38 | 00 45 | 13 03 |
| 9 | 22 29 | 09 48 | 22 29 | 11 14 | 21 47 | 11 06 | 23 33 | 13 04 | – | 13 18 | 01 47 | 13 36 |
| 10 | 22 57 | 10 39 | 23 06 | 12 13 | 22 35 | 12 09 | – | 13 54 | 00 46 | 13 54 | 02 49 | 14 11 |
| 11 | 23 25 | 11 32 | 23 51 | 13 15 | 23 32 | 13 13 | 00 42 | 14 39 | 01 50 | 14 28 | 03 51 | 14 50 |
| 12 | 23 56 | 12 26 | – | 14 26 | – | 14 14 | 01 49 | 15 18 | 02 52 | 15 01 | 04 55 | 15 33 |
| 13 | – | 13 24 | 00 44 | 15 25 | 00 36 | 15 10 | 02 56 | 15 55 | 03 55 | 15 36 | 05 59 | 16 22 |
| 14 | 00 31 | 14 26 | 01 46 | 16 27 | 01 45 | 16 00 | 04 01 | 16 29 | 04 58 | 16 13 | 07 00 | 17 16 |
| 15 | 01 13 | 15 31 | 02 55 | 17 22 | 02 56 | 16 44 | 05 05 | 18 04 | 06 03 | 16 54 | 07 56 | 18 14 |
| 16 | 02 03 | 16 39 | 04 08 | 18 11 | 04 06 | 17 23 | 06 08 | 18 40 | 07 08 | 17 40 | 08 45 | 19 12 |
| 17 | 03 02 | 17 45 | 05 21 | 18 53 | 05 14 | 17 59 | 07 15 | 18 19 | 08 12 | 18 32 | 09 28 | 20 10 |
| 18 | 04 10 | 18 46 | 06 31 | 19 31 | 06 21 | 18 34 | 08 21 | 19 03 | 09 12 | 19 27 | 10 05 | 21 06 |
| 19 | 05 23 | 19 38 | 07 39 | 20 07 | 07 26 | 19 10 | 09 26 | 19 51 | 10 05 | 20 26 | 10 38 | 21 59 |
| 20 | 06 37 | 20 24 | 08 44 | 20 41 | 08 31 | 19 47 | 10 28 | 20 44 | 10 52 | 21 24 | 11 08 | 22 51 |
| 21 | 07 48 | 21 03 | 09 48 | 21 17 | 09 37 | 20 28 | 11 25 | 21 41 | 11 33 | 22 21 | 11 35 | 23 42 |
| 22 | 08 55 | 21 38 | 10 51 | 21 54 | 10 41 | 21 13 | 12 15 | 22 38 | 12 08 | 23 15 | 12 02 | – |
| 23 | 09 05 | 22 12 | 11 54 | 22 35 | 11 44 | 22 02 | 12 59 | 23 35 | 12 39 | – | 12 30 | 00 34 |
| 24 | 11 01 | 22 45 | 12 56 | 23 21 | 12 42 | 22 56 | 13 36 | – | 13 07 | 00 08 | 13 00 | 01 27 |
| 25 | 12 92 | 23 20 | 13 55 | – | 13 35 | 23 52 | 14 09 | 00 31 | 13 35 | 00 59 | 13 34 | 02 23 |
| 26 | 13 03 | 23 57 | 14 50 | 00 10 | 14 21 | – | 14 39 | 01 24 | 14 03 | 01 51 | 14 13 | 03 23 |
| 27 | 14 04 | – | 15 40 | 01 04 | 15 02 | 00 48 | 15 07 | 02 17 | 14 32 | 02 44 | 15 00 | 04 26 |
| 28 | 15 03 | 00 39 | 16 24 | 02 00 | 15 37 | 01 45 | 15 35 | 03 08 | 15 03 | 03 39 | 15 55 | 05 31 |
| 29 | 16 01 | 01 25 | 17 03 | 02 56 | 16 09 | 02 39 | 16 03 | 04 01 | 15 40 | 04 37 | 16 59 | 06 36 |
| 30 | 16 54 | 02 25 | – | – | 16 38 | 03 32 | 16 33 | 04 55 | 16 22 | 05 39 | 18 08 | 07 36 |
| 31 | 17 42 | 03 09 | – | – | 17 06 | 04 25 | – | – | 17 13 | 06 44 | – | – |

1988

TIMES OF MOON RISE AND MOON SET - JOHANNESBURG

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | 19h19m | 08h29m | 21h31m | 09h03m | 23h35m | 09h26m | - | 09h46m | 00h39m | 11h27m | 00h15m | 11h58m |
| 2 | 20 28 | 09 15 | 22 34 | 09 38 | - | 10 11 | 00 27 | 10 43 | 01 15 | 12 22 | 00 43 | 12 49 |
| 3 | 21 35 | 04 55 | 23 38 | 10 12 | 00 39 | 11 00 | 01 19 | 11 12 | 01 47 | 13 15 | 01 10 | 13 40 |
| 4 | 22 39 | 10 31 | - | 10 49 | 01 39 | 11 54 | 02 03 | 12 39 | 02 15 | 14 06 | 01 38 | 14 32 |
| 5 | 23 41 | 11 04 | 00 41 | 11 30 | 02 34 | 12 51 | 02 42 | 13 35 | 02 43 | 14 57 | 02 07 | 15 26 |
| 6 | - | 11 38 | 01 45 | 12 15 | 03 22 | 13 49 | 03 15 | 14 29 | 03 10 | 15 49 | 02 40 | 16 23 |
| 7 | 00 43 | 12 12 | 02 46 | 13 05 | 04 05 | 14 46 | 03 46 | 15 22 | 03 38 | 16 42 | 03 17 | 17 23 |
| 8 | 01 45 | 12 50 | 03 44 | 13 59 | 04 41 | 15 41 | 04 14 | 16 13 | 04 08 | 17 37 | 04 00 | 18 25 |
| 9 | 02 48 | 13 31 | 04 37 | 14 56 | 05 13 | 16 34 | 04 41 | 17 04 | 04 44 | 18 35 | 04 51 | 19 27 |
| 10 | 03 51 | 14 17 | 05 24 | 15 54 | 05 43 | 17 26 | 05 08 | 17 55 | 05 21 | 19 36 | 05 48 | 20 25 |
| 11 | 04 52 | 15 09 | 06 04 | 16 51 | 06 10 | 18 17 | 05 36 | 18 49 | 06 07 | 20 37 | 06 52 | 21 17 |
| 12 | 05 49 | 16 05 | 06 39 | 17 46 | 06 37 | 19 08 | 06 08 | 19 45 | 06 59 | 21 36 | 07 58 | 22 03 |
| 13 | 06 40 | 17 03 | 07 11 | 18 39 | 07 05 | 20 00 | 06 43 | 20 43 | 07 58 | 22 31 | 09 05 | 22 43 |
| 14 | 07 25 | 18 01 | 07 39 | 19 30 | 07 33 | 20 54 | 07 23 | 21 43 | 09 01 | 23 26 | 10 10 | 23 20 |
| 15 | 08 04 | 18 58 | 08 07 | 20 21 | 08 05 | 21 50 | 08 09 | 22 43 | 10 06 | - | 11 13 | 23 54 |
| 16 | 08 38 | 19 52 | 08 33 | 21 12 | 08 41 | 22 49 | 09 03 | 23 41 | 11 12 | 00 04 | 12 13 | - |
| 17 | 09 09 | 26 44 | 09 01 | 22 04 | 09 23 | 23 49 | 10 03 | - | 12 16 | 00 43 | 13 17 | 00 27 |
| 18 | 09 37 | 21 35 | 09 31 | 22 59 | 10 12 | - | 11 08 | 00 34 | 13 19 | 01 18 | 14 20 | 01 01 |
| 19 | 10 04 | 22 26 | 10 04 | 23 57 | 11 09 | 00 50 | 12 14 | 01 22 | 14 22 | 01 52 | 15 25 | 01 38 |
| 20 | 10 31 | 23 18 | 10 42 | - | 12 12 | 01 48 | 13 20 | 02 05 | 15 26 | 02 26 | 16 31 | 02 19 |
| 21 | 10 59 | - | 11 28 | 00 57 | 13 20 | 02 41 | 14 26 | 02 44 | 16 32 | 03 02 | 17 37 | 03 06 |
| 22 | 11 31 | 00 12 | 12 21 | 02 00 | 14 30 | 03 28 | 15 32 | 03 20 | 17 39 | 03 42 | 18 39 | 03 59 |
| 23 | 12 06 | 01 08 | 13 23 | 03 01 | 15 39 | 04 11 | 16 38 | 03 55 | 18 47 | 04 27 | 19 35 | 04 58 |
| 24 | 12 48 | 02 09 | 14 31 | 05 00 | 16 47 | 04 49 | 17 44 | 04 31 | 19 53 | 05 17 | 20 24 | 05 59 |
| 25 | 13 39 | 03 12 | 15 42 | 04 52 | 17 54 | 05 26 | 18 53 | 05 09 | 20 54 | 06 13 | 21 06 | 07 00 |
| 26 | 14 36 | 04 16 | 16 53 | 05 37 | 19 01 | 06 02 | 20 02 | 05 52 | 21 47 | 07 13 | 21 42 | 07 59 |
| 27 | 15 45 | 05 18 | 18 03 | 06 20 | 20 09 | 06 39 | 21 09 | 06 39 | 22 33 | 08 15 | 22 14 | 08 55 |
| 28 | 16 56 | 06 15 | 19 11 | 06 57 | 21 17 | 07 19 | 22 13 | 07 32 | 23 12 | 09 14 | 22 43 | 09 49 |
| 29 | 18 08 | 07 05 | 20 17 | 07 33 | 22 24 | 08 03 | 23 09 | 08 30 | 23 45 | 10 12 | 23 10 | 10 40 |
| 30 | 19 18 | 07 49 | 21 23 | 05 09 | 23 28 | 08 52 | 23 58 | 09 30 | - | 11 06 | 23 38 | 11 31 |
| 31 | 20 25 | 08 28 | 22 29 | 09 46 | - | - | - | 10 29 | - | - | - | 12 22 |

1988

TIMES OF MOON RISE AND MOON SET CAPE TOWN

FOR PORT ELIZABETH SUBTRACT 28 MINUTES

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | $19^h42^m$ | $09^h28^m$ | $22^h12^m$ | $09^h45^m$ | – | $09^h51^m$ | $00^h31^m$ | $10^h03^m$ | $01^h37^m$ | $11^h51^m$ | $01^h03^m$ | $12^h33^m$ |
| 2 | 20 56 | 10 09 | 23 21 | 10 15 | 00 34 | 10 32 | 01 30 | 11 00 | 02 09 | 12 51 | 01 27 | 13 28 |
| 3 | 22 08 | 10 44 | – | 10 44 | 01 41 | 11 19 | 02 21 | 12 01 | 02 37 | 13 48 | 01 50 | 14 23 |
| 4 | 23 17 | 11 15 | 00 29 | 11 17 | 02 43 | 12 11 | 03 03 | 13 02 | 03 01 | 14 43 | 02 14 | 15 20 |
| 5 | – | 11 44 | 01 37 | 11 53 | 03 37 | 13 09 | 03 38 | 14 01 | 03 25 | 15 38 | 02 39 | 16 18 |
| 6 | 00 24 | 12 13 | 02 45 | 12 35 | 04 24 | 14 09 | 04 08 | 14 59 | 03 48 | 16 34 | 03 07 | 17 19 |
| 7 | 01 31 | 12 43 | 03 49 | 13 23 | 05 03 | 15 09 | 04 34 | 15 55 | 04 12 | 17 31 | 03 40 | 18 23 |
| 8 | 02 38 | 13 16 | 04 48 | 14 16 | 05 36 | 16 08 | 04 58 | 16 51 | 04 38 | 18 30 | 04 20 | 19 27 |
| 9 | 03 45 | 13 53 | 05 40 | 15 15 | 06 05 | 17 06 | 05 21 | 17 46 | 05 08 | 19 32 | 05 08 | 20 30 |
| 10 | 04 51 | 14 36 | 06 24 | 16 15 | 06 30 | 18 01 | 05 45 | 18 42 | 05 44 | 20 36 | 06 06 | 21 27 |
| 11 | 05 55 | 15 26 | 07 02 | 17 16 | 06 54 | 18 57 | 06 09 | 19 40 | 06 26 | 21 40 | 07 11 | 22 17 |
| 12 | 06 52 | 16 22 | 07 33 | 18 15 | 07 16 | 19 52 | 06 36 | 20 40 | 07 16 | 22 39 | 08 20 | 22 59 |
| 13 | 07 42 | 17 22 | 08 01 | 19 11 | 07 40 | 20 48 | 07 07 | 21 42 | 08 15 | 23 33 | 09 31 | 23 35 |
| 14 | 08 25 | 18 23 | 08 25 | 20 07 | 08 05 | 21 46 | 07 44 | 22 45 | 09 20 | – | 10 40 | – |
| 15 | 09 00 | 19 23 | 08 49 | 21 02 | 08 32 | 22 46 | 08 28 | 23 47 | 10 29 | 00 19 | 11 48 | 00 07 |
| 16 | 09 31 | 20 22 | 09 11 | 21 57 | 09 05 | 23 48 | 09 20 | – | 11 39 | 00 59 | 12 54 | 00 36 |
| 17 | 09 57 | 21 18 | 09 35 | 22 54 | 09 43 | – | 10 21 | 00 44 | 12 48 | 01 33 | 14 02 | 01 05 |
| 18 | 10 21 | 22 13 | 10 01 | 23 53 | 10 30 | 00 52 | 11 27 | 01 36 | 13 56 | 02 04 | 15 10 | 01 34 |
| 19 | 10 44 | 23 08 | 10 30 | – | 11 26 | 01 53 | 12 38 | 02 21 | 15 04 | 02 33 | 16 20 | 02 06 |
| 20 | 11 07 | – | 11 05 | 00 54 | 12 30 | 02 51 | 13 49 | 02 59 | 16 13 | 03 03 | 17 30 | 02 43 |
| 21 | 11 32 | 00 04 | 11 47 | 01 58 | 13 41 | 03 41 | 15 00 | 03 33 | 17 24 | 03 34 | 18 39 | 03 27 |
| 22 | 11 59 | 01 02 | 12 38 | 03 03 | 14 55 | 04 25 | 16 11 | 04 04 | 18 36 | 04 09 | 19 42 | 04 17 |
| 23 | 12 31 | 02 03 | 13 40 | 04 05 | 16 09 | 05 03 | 17 22 | 04 34 | 19 48 | 04 49 | 20 38 | 05 15 |
| 24 | 13 09 | 03 07 | 14 50 | 05 02 | 17 23 | 05 36 | 18 34 | 05 05 | 20 56 | 05 36 | 21 24 | 06 18 |
| 25 | 13 57 | 04 14 | 16 05 | 05 51 | 18 36 | 06 08 | 19 47 | 05 38 | 21 57 | 06 31 | 22 03 | 07 22 |
| 26 | 14 55 | 05 20 | 17 22 | 06 33 | 19 48 | 06 38 | 21 01 | 06 16 | 22 49 | 07 31 | 22 35 | 08 24 |
| 27 | 16 03 | 06 22 | 18 37 | 07 09 | 21 01 | 07 10 | 22 11 | 07 00 | 23 32 | 08 35 | 23 03 | 09 25 |
| 28 | 17 17 | 07 16 | 19 50 | 07 42 | 22 14 | 07 45 | 23 16 | 07 50 | – | 09 38 | 23 28 | 10 22 |
| 29 | 18 34 | 08 02 | 21 02 | 08 12 | 23 25 | 08 25 | – | 08 47 | 00 07 | 10 39 | 23 51 | 11 18 |
| 30 | 19 49 | 08 41 | 22 13 | 08 43 | – | 09 11 | 00 12 | 09 48 | 00 37 | 11 37 | – | 12 13 |
| 31 | 21 02 | 09 14 | 23 24 | 09 15 | | | 00 58 | 10 50 | | | 00 15 | 13 08 |

1988

TIMES OF MOON RISE AND MOON SET CAPE TOWN

FOR PORT ELIZABETH SUBTRACT 28 MINUTES

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | 18h11m | 03h00m | 19h24m | 04h25m | 18h30m | 04h17m | 18h12m | 05h57m | 17h34m | 06h43m | 18h28m | 08h52 |
| 2 | 19 09 | 03 46 | 19 57 | 05 25 | 18 57 | 05 15 | 18 37 | 06 54 | 18 08 | 07 46 | 19 34 | 09 54 |
| 3 | 20 01 | 04 37 | 20 27 | 06 24 | 19 21 | 06 12 | 19 03 | 07 52 | 18 49 | 08 53 | 20 45 | 10 48 |
| 4 | 20 45 | 05 34 | 20 52 | 07 21 | 19 44 | 07 08 | 19 33 | 08 54 | 19 39 | 10 00 | 21 58 | 11 33 |
| 5 | 21 23 | 06 33 | 21 16 | 08 18 | 20 08 | 08 04 | 20 09 | 09 57 | 20 38 | 11 04 | 23 09 | 12 11 |
| 6 | 21 56 | 07 32 | 21 40 | 09 13 | 20 32 | 09 01 | 20 52 | 11 03 | 21 45 | 12 02 | – | 12 44 |
| 7 | 22 23 | 08 31 | 22 03 | 10 09 | 21 00 | 09 59 | 21 43 | 12 09 | 22 55 | 12 52 | 00 18 | 13 13 |
| 8 | 22 49 | 09 28 | 22 28 | 11 06 | 21 31 | 11 01 | 22 44 | 13 11 | – | 13 34 | 01 25 | 13 41 |
| 9 | 23 12 | 10 24 | 22 57 | 12 06 | 22 08 | 12 05 | 23 52 | 14 06 | 00 07 | 14 10 | 02 32 | 14 10 |
| 10 | 23 36 | 11 19 | 23 30 | 13 08 | 22 54 | 13 11 | – | 14 54 | 01 17 | 14 41 | 03 38 | 14 41 |
| 11 | – | 12 16 | – | 14 14 | 23 49 | 14 16 | 01 04 | 15 34 | 02 25 | 15 10 | 04 45 | 15 15 |
| 12 | 00 00 | 13 14 | 00 11 | 15 22 | – | 15 17 | 02 17 | 16 09 | 03 33 | 15 39 | 05 53 | 15 54 |
| 13 | 00 27 | 14 16 | 01 01 | 16 29 | 00 53 | 16 11 | 03 28 | 16 40 | 04 41 | 16 08 | 07 00 | 16 41 |
| 14 | 00 58 | 15 23 | 02 02 | 17 30 | 02 05 | 16 58 | 04 38 | 17 09 | 05 49 | 16 41 | 08 03 | 17 33 |
| 15 | 01 35 | 16 32 | 03 13 | 18 22 | 03 20 | 17 37 | 05 48 | 17 39 | 06 58 | 17 17 | 08 59 | 18 32 |
| 16 | 02 21 | 17 42 | 04 30 | 19 06 | 04 36 | 18 11 | 06 58 | 18 10 | 08 08 | 18 00 | 09 47 | 19 33 |
| 17 | 03 19 | 18 49 | 05 48 | 19 44 | 05 49 | 18 42 | 08 08 | 18 45 | 09 14 | 18 49 | 10 27 | 20 33 |
| 18 | 04 27 | 19 47 | 07 04 | 20 17 | 07 01 | 19 12 | 09 19 | 19 24 | 10 15 | 19 45 | 11 00 | 21 33 |
| 19 | 05 44 | 20 36 | 08 17 | 20 47 | 08 12 | 19 42 | 10 27 | 20 10 | 11 08 | 20 44 | 11 29 | 22 30 |
| 20 | 07 02 | 21 16 | 09 27 | 21 16 | 09 22 | 20 15 | 11 31 | 21 01 | 11 53 | 21 45 | 11 55 | 23 26 |
| 21 | 08 18 | 21 50 | 10 36 | 21 47 | 10 32 | 20 51 | 12 28 | 21 58 | 12 30 | 22 45 | 12 19 | – |
| 22 | 09 31 | 22 21 | 11 44 | 22 20 | 11 41 | 21 33 | 13 17 | 22 58 | 13 01 | 23 44 | 12 42 | 00 22 |
| 23 | 10 40 | 22 50 | 12 52 | 22 57 | 12 46 | 22 20 | 13 58 | 23 58 | 13 29 | – | 13 06 | 01 17 |
| 24 | 11 47 | 23 18 | 13 57 | 23 39 | 13 46 | 23 13 | 14 32 | – | 13 53 | 00 41 | 13 32 | 02 15 |
| 25 | 12 52 | 23 48 | 14 58 | – | 14 38 | – | 15 02 | 00 57 | 14 17 | 01 36 | 14 01 | 03 15 |
| 26 | 13 58 | – | 15 54 | 00 28 | 15 23 | 00 10 | 15 28 | 01 55 | 14 40 | 02 32 | 14 36 | 04 19 |
| 27 | 15 02 | 00 21 | 16 43 | 01 21 | 16 00 | 01 09 | 15 52 | 02 51 | 15 05 | 03 29 | 15 19 | 05 26 |
| 28 | 16 05 | 00 59 | 17 24 | 02 19 | 16 32 | 02 08 | 16 15 | 03 47 | 15 33 | 04 29 | 16 12 | 06 34 |
| 29 | 17 04 | 01 43 | 18 00 | 03 17 | 17 00 | 03 07 | 16 39 | 04 44 | 16 05 | 05 31 | 17 16 | 07 39 |
| 30 | 17 57 | 02 32 | | | 17 25 | 04 04 | 17 05 | 05 42 | 16 44 | 06 37 | 18 27 | 08 38 |
| 31 | 18 44 | 03 27 | | | 17 49 | 05 00 | | | 17 31 | 07 45 | | |

# 1988

## TIMES OF MOON RISE AND MOON SET DURBAN

FOR BLOEMFONTEIN ADD 19 MINUTES

| | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | 17h06m | 02h20m | 18h21m | 03h45m | 17h31m | 03h33m | 17h22m | 05h04m | 16h50m | 05h44m | 17h49m | 07h46m |
| 2 | 18 03 | 03 07 | 18 57 | 04 42 | 18 00 | 04 29 | 17 49 | 05 59 | 17 26 | 06 45 | 18 54 | 08 49 |
| 3 | 18 55 | 03 59 | 19 29 | 05 39 | 18 27 | 05 24 | 18 18 | 06 55 | 18 09 | 07 49 | 20 04 | 09 44 |
| 4 | 19 42 | 04 54 | 19 57 | 06 35 | 18 53 | 06 17 | 18 50 | 07 54 | 19 00 | 08 55 | 21 14 | 10 31 |
| 5 | 20 21 | 05 52 | 20 23 | 07 29 | 19 19 | 07 11 | 19 27 | 08 55 | 19 59 | 09 58 | 22 23 | 11 12 |
| 6 | 20 56 | 06 49 | 20 49 | 08 22 | 19 45 | 08 05 | 20 12 | 09 59 | 21 04 | 10 57 | 23 29 | 11 48 |
| 7 | 21 26 | 07 46 | 21 14 | 09 15 | 20 15 | 09 01 | 21 04 | 11 03 | 22 13 | 11 49 | – | 12 20 |
| 8 | 21 54 | 08 41 | 21 42 | 10 10 | 20 48 | 10 00 | 22 05 | 12 05 | 23 22 | 12 33 | 00 33 | 12 51 |
| 9 | 22 20 | 09 34 | 22 13 | 11 07 | 21 27 | 11 02 | 23 12 | 13 01 | – | 13 12 | 01 37 | 13 22 |
| 10 | 22 45 | 10 27 | 22 48 | 12 07 | 22 14 | 12 06 | – | 13 51 | 00 30 | 13 46 | 02 40 | 13 55 |
| 11 | 23 12 | 11 21 | 23 30 | 13 11 | 23 10 | 13 10 | 00 21 | 14 34 | 01 35 | 14 18 | 03 45 | 14 32 |
| 12 | 23 41 | 12 17 | – | 14 17 | – | 14 12 | 01 31 | 15 11 | 02 40 | 14 49 | 04 50 | 15 14 |
| 13 | – | 13 17 | 00 22 | 15 22 | 00 14 | 15 07 | 02 40 | 15 46 | 03 45 | 15 21 | 05 55 | 16 01 |
| 14 | 00 14 | 14 20 | 01 23 | 16 24 | 01 24 | 15 56 | 03 47 | 16 18 | 04 50 | 15 56 | 06 57 | 16 55 |
| 15 | 00 54 | 15 27 | 02 33 | 17 19 | 02 37 | 16 38 | 04 54 | 16 50 | 05 57 | 16 35 | 07 53 | 17 52 |
| 16 | 01 42 | 16 36 | 03 48 | 18 06 | 03 49 | 17 15 | 06 01 | 17 24 | 07 04 | 17 20 | 08 43 | 18 52 |
| 17 | 02 40 | 17 43 | 05 02 | 18 46 | 04 59 | 17 49 | 07 08 | 18 01 | 08 09 | 18 10 | 09 25 | 19 51 |
| 18 | 03 48 | 18 43 | 06 15 | 19 22 | 06 08 | 18 22 | 08 16 | 18 43 | 09 09 | 19 06 | 10 01 | 20 48 |
| 19 | 05 02 | 19 34 | 07 25 | 19 56 | 07 16 | 18 55 | 09 23 | 19 30 | 10 03 | 20 04 | 10 32 | 21 44 |
| 20 | 06 18 | 20 18 | 08 33 | 20 28 | 08 23 | 19 31 | 10 26 | 20 23 | 10 49 | 21 04 | 11 00 | 22 37 |
| 21 | 07 31 | 20 55 | 09 39 | 21 01 | 09 30 | 20 09 | 11 23 | 21 19 | 11 29 | 22 02 | 11 26 | 23 30 |
| 22 | 08 41 | 21 28 | 10 44 | 21 37 | 10 37 | 20 53 | 12 13 | 22 17 | 12 02 | 22 58 | 11 51 | – |
| 23 | 09 47 | 22 00 | 11 49 | 22 16 | 11 41 | 21 41 | 12 55 | 23 16 | 12 32 | 23 53 | 12 17 | 00 23 |
| 24 | 10 51 | 22 31 | 12 52 | 23 00 | 12 40 | 22 34 | 13 32 | – | 12 59 | – | 12 46 | 01 18 |
| 25 | 11 54 | 23 04 | 13 53 | 23 49 | 13 33 | 23 30 | 14 03 | 00 13 | 13 25 | 00 46 | 13 17 | 02 16 |
| 26 | 12 57 | 23 39 | 14 48 | – | 14 19 | – | 14 32 | 01 08 | 13 51 | 01 40 | 13 55 | 03 17 |
| 27 | 13 59 | – | 15 38 | 00 42 | 14 58 | 00 28 | 14 58 | 02 02 | 14 18 | 02 34 | 14 39 | 04 22 |
| 28 | 15 00 | 00 19 | 16 21 | 01 39 | 15 32 | 01 25 | 15 24 | 02 56 | 14 48 | 03 31 | 15 33 | 05 28 |
| 29 | 15 59 | 01 03 | 16 59 | 02 36 | 16 03 | 02 22 | 15 50 | 03 50 | 15 22 | 04 31 | 16 36 | 06 33 |
| 30 | 16 52 | 01 54 | | | 16 30 | 03 17 | 16 19 | 04 46 | 16 03 | 05 34 | 17 46 | 07 33 |
| 31 | 17 40 | 02 48 | | | 16 56 | 04 11 | | | 16 51 | 06 40 | | |

1988

TIMES OF MOON RISE AND MOON SET DURBAN

FOR BLOEMFONTEIN ADD 19 MINUTES

| | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set | Rise | Set |
| 1 | $18^h59^m$ | $08^h25^m$ | $21^h19^m$ | $08^h53^m$ | $23^h30^m$ | $09^h08^m$ | – | $09^h24^m$ | $00^h35^m$ | $11^h08^m$ | $00^h08^m$ | $11^h44^m$ |
| 2 | 20 11 | 09 09 | 22 25 | 09 25 | – | 09 51 | 00 25 | 10 21 | 01 10 | 12 05 | 00 34 | 12 37 |
| 3 | 21 19 | 09 48 | 23 30 | 09 58 | 00 36 | 10 39 | 01 16 | 11 20 | 01 40 | 13 00 | 00 59 | 13 29 |
| 4 | 22 26 | 10 22 | – | 10 33 | 01 37 | 11 32 | 02 00 | 12 20 | 02 07 | 13 53 | 01 25 | 14 23 |
| 5 | 23 30 | 10 53 | 00 36 | 11 11 | 02 32 | 12 29 | 02 38 | 13 17 | 02 33 | 14 46 | 01 53 | 15 19 |
| 6 | = | 11 25 | 01 40 | 11 55 | 03 20 | 13 28 | 03 10 | 14 13 | 02 58 | 15 39 | 02 23 | 16 18 |
| 7 | 00 34 | 11 57 | 02 44 | 12 44 | 04 01 | 14 26 | 03 38 | 15 07 | 03 25 | 16 33 | 02 58 | 17 19 |
| 8 | 01 38 | 12 32 | 03 42 | 13 38 | 04 36 | 15 23 | 04 05 | 16 00 | 03 53 | 17 31 | 03 40 | 18 22 |
| 9 | 02 43 | 13 12 | 04 35 | 14 35 | 05 07 | 16 19 | 04 30 | 16 53 | 04 25 | 18 30 | 04 29 | 19 24 |
| 10 | 03 47 | 13 57 | 05 21 | 15 34 | 05 35 | 17 12 | 04 56 | 17 46 | 05 02 | 19 32 | 05 26 | 20 22 |
| 11 | 04 49 | 14 47 | 06 00 | 16 32 | 06 01 | 18 05 | 05 22 | 18 41 | 05 46 | 20 34 | 06 30 | 21 13 |
| 12 | 05 46 | 15 43 | 06 34 | 17 29 | 06 26 | 18 58 | 05 52 | 19 39 | 06 37 | 21 34 | 07 38 | 21 58 |
| 13 | 06 38 | 16 42 | 07 04 | 18 24 | 06 52 | 19 51 | 06 25 | 20 39 | 07 36 | 22 28 | 08 46 | 22 37 |
| 14 | 07 22 | 17 41 | 07 31 | 19 17 | 07 19 | 20 47 | 07 03 | 21 40 | 08 40 | 23 17 | 09 53 | 23 11 |
| 15 | 08 00 | 18 39 | 07 56 | 20 09 | 07 49 | 21 45 | 07 48 | 22 41 | 09 46 | 23 59 | 10 58 | 23 43 |
| 16 | 08 32 | 19 35 | 08 22 | 21 02 | 08 23 | 22 45 | 08 41 | 23 39 | 10 54 | – | 12 01 | – |
| 17 | 09 01 | 20 30 | 08 47 | 21 56 | 09 03 | 23 47 | 09 41 | – | 12 00 | 00 36 | 13 07 | 00 15 |
| 18 | 09 28 | 21 22 | 09 15 | 22 53 | 09 51 | – | 10 46 | 00 32 | 13 05 | 01 10 | 14 12 | 00 47 |
| 19 | 09 53 | 22 15 | 09 47 | 23 52 | 10 47 | 00 48 | 11 54 | 01 18 | 14 10 | 01 42 | 15 19 | 01 22 |
| 20 | 10 19 | 23 08 | 10 23 | – | 11 51 | 01 45 | 13 03 | 02 00 | 15 16 | 02 14 | 16 26 | 02 01 |
| 21 | 10 45 | – | 11 07 | 00 54 | 12 59 | 02 38 | 14 11 | 02 36 | 16 24 | 02 47 | 17 33 | 02 46 |
| 22 | 11 15 | 00 04 | 11 59 | 01 57 | 14 11 | 03 24 | 15 19 | 03 10 | 17 34 | 03 25 | 18 37 | 03 38 |
| 23 | 11 49 | 01 02 | 13 01 | 02 59 | 15 22 | 04 05 | 16 27 | 03 43 | 18 44 | 04 07 | 19 33 | 04 36 |
| 24 | 12 29 | 02 04 | 14 10 | 03 57 | 16 32 | 04 41 | 17 36 | 04 17 | 19 51 | 04 56 | 20 21 | 05 37 |
| 25 | 13 17 | 03 09 | 15 22 | 04 48 | 17 42 | 05 15 | 18 46 | 04 53 | 20 52 | 05 52 | 21 02 | 06 40 |
| 26 | 14 16 | 04 14 | 16 36 | 05 33 | 18 51 | 05 49 | 19 57 | 05 33 | 21 45 | 06 52 | 21 37 | 07 40 |
| 27 | 15 23 | 05 16 | 17 48 | 06 12 | 20 01 | 06 24 | 21 06 | 06 19 | 22 29 | 07 54 | 22 07 | 08 38 |
| 28 | 16 35 | 06 12 | 18 58 | 06 48 | 21 11 | 07 02 | 22 10 | 07 11 | 23 07 | 08 55 | 22 34 | 09 34 |
| 29 | 17 49 | 07 01 | 20 07 | 07 22 | 22 20 | 07 44 | 23 07 | 08 08 | 23 39 | 09 54 | 23 00 | 10 27 |
| 30 | 19 02 | 07 42 | 21 15 | 07 55 | 23 26 | 08 31 | 23 55 | 09 08 | – | 10 50 | 23 25 | 11 20 |
| 31 | 20 11 | 08 19 | 22 23 | 08 30 | | | – | 10 09 | | | 23 52 | 12 13 |

## COMPUTING SECTION

This newly formed section invites all those interested in Astronomical Computing in any form to share their expertise and any Software they may have with other members in the Society.

The objectives of The Computing section were outlined in M.N.A.S.S.A. Vol 46 Nos. 5 & 6 June 1987 page 66. Please refer to this write up for detailed information.

Persons interested in the activities of the Computing Section are urged to contact the Director of the Societies Computing Section Mr Tony Hilton, P O Box 68846, Bryanston, 2021. Phone (w) 011-4032422.

Mr Hilton is in the process of compiling a comprehensive DATA BASE of all interested person's, equipment, available software etc. This report will be available to all interested persons in the first quarter of 1988. If you wish to become a subscriber to this DATA BASE list please contact Mr Hilton for the relevant questionnair.

Furthermore, if you are embarking on any Computer Projects, Mr Hilton would like to hear from you, and would make himself or any other competent individuals available to supply expert advice or additional information where necessary.

## SOLAR SECTION

The work undertaken by this section covers a broad range of techniques to observe activity on the sun's disk. Members of the section note their observations on appropriate forms, which are then forwarded to various organisations in the United States of America, the United Kingdom, the Federal Republic of Germany and South Africa. The results we provide are further reduced by these organisations and incorporated with the information provided by other world-wide groups of Solar Observers, such as ours. The data produced is then fed to over 450 scientific institutions all over the world, where it is used by a very wide range of scientific disciplines.

Observational techniques employed include the visual observation of the sun's disk (using suitable filters or by projecting the image onto an appropriate screen) to determine sun spots and active areas, the monitoring of solar flares by very low frequency radio waves and monitoring changes in the earth's magnetic field caused by solar activity. Other activities such as photographing and the drawing of visible solar features are also undertaken.

A weekly update of solar activity is broadcast country wide on Sunday mornings at 10h00 and again on Monday evenings at 20h30 by the Amateur Radio League, enabling amateur astronomers and amateur radio enthusiasts alike to keep abreast of the latest developments as well as with all other interesting solar information. Short lectures are also given at this time.

Towards the end of 1986, the Sun entered the new 11 year Solar cycle and this cycle is characterised by a steady climb over approximately 4½ years, followed by a slower decline to minimum lasting approximately 6½ years. 1988, will therefore experience a marked increase in Solar activity and provide the observer with much to look at.

A word of caution - NEVER observe the sun directly without adequate filtration as permanent eye damage can occur, and do not use the screw-in filters provided with some commercial telescopes, as they are inclined to shatter!

Large instruments are not a pre-requisite! Any telescope from 50mm, reflector or refractor can be used and provides an ideal opportunity for owners of small instruments to contribute immediately to Science. If one has no filter, then the only safe method is to project the image on to a white card. Image quality will be enhanced if the card is kept in the shade, or enclosed in a screen. Details of suitable filters are best sought from experienced solar observers or from the Director of the Solar Section.

Persons interested in observing the sun, or requiring information are invited to contact The Director of the Solar Section, Jim Knight, at Mars Street, Atlasville, Boksburg, 1459 or at 011-9731380.

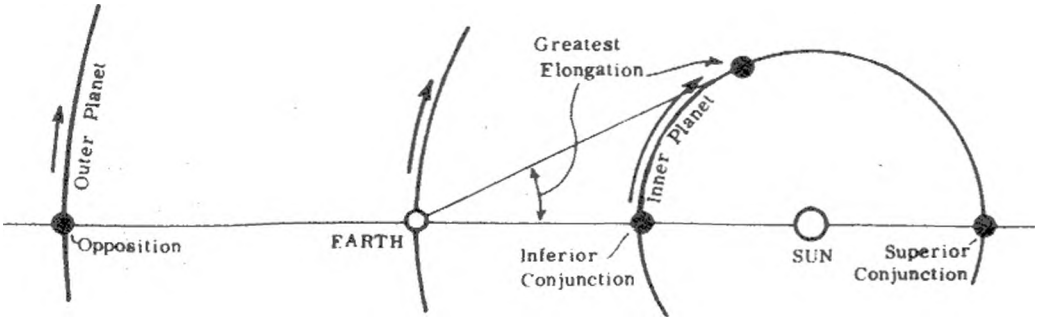
# THE PLANETS

BASIC DATA

| | Dist from Sun $10^6$ km | Period of Revolution years | Mass (Earth = 1) | Diameter $10^3$ km | Rotation Period | Inclination of Equator to Orbit |
|---|---|---|---|---|---|---|
| Mercury | 58 | 0,24 | 0,056 | 4,98 | 59d | ? |
| Venus | 108 | 0,62 | 0,817 | 12,4 | 244 | ? |
| Earth | 150 | 1,00 | 1,000 | 12,8 | $23^h56^m$ | 23°27' |
| Mars | 228 | 1,88 | 0,108 | 6,76 | 24 37 | 23 59 |
| Jupiter | 778 | 11,9 | 318,0 | 142,7 | 09 51 | 03 04 |
| Saturn | 1 426 | 29,5 | 95,2 | 120,8 | 10 14 | 26 44 |
| Uranus | 2 868 | 84,0 | 14,6 | 47,1 | 10 49 | 27 53 |
| Neptune | 4 494 | 164,8 | 17,3 | 44,6 | 14 ? | 28 48 |
| Pluto | 5 896 | 247,6 | 0,9? | ? | 6d? | ? |

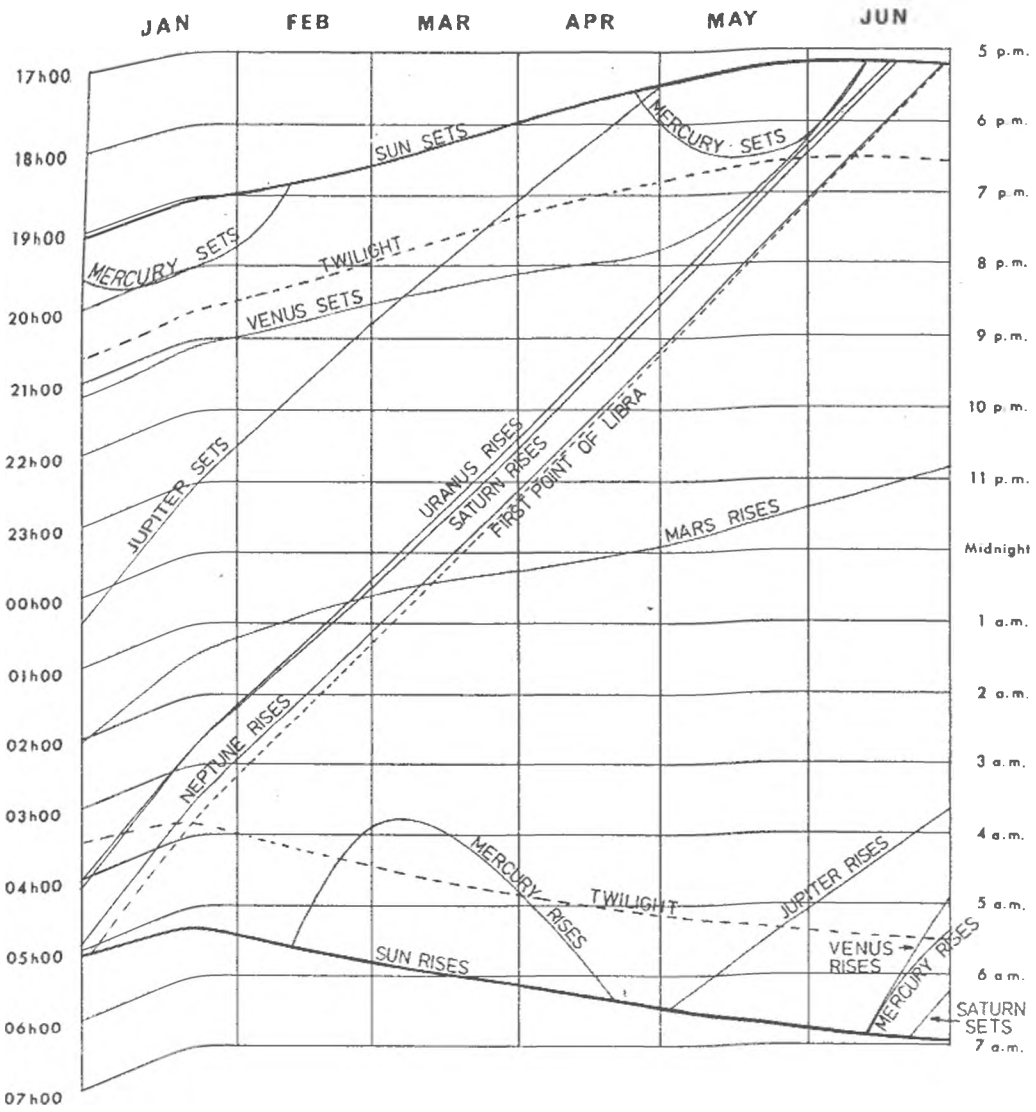
GENERAL

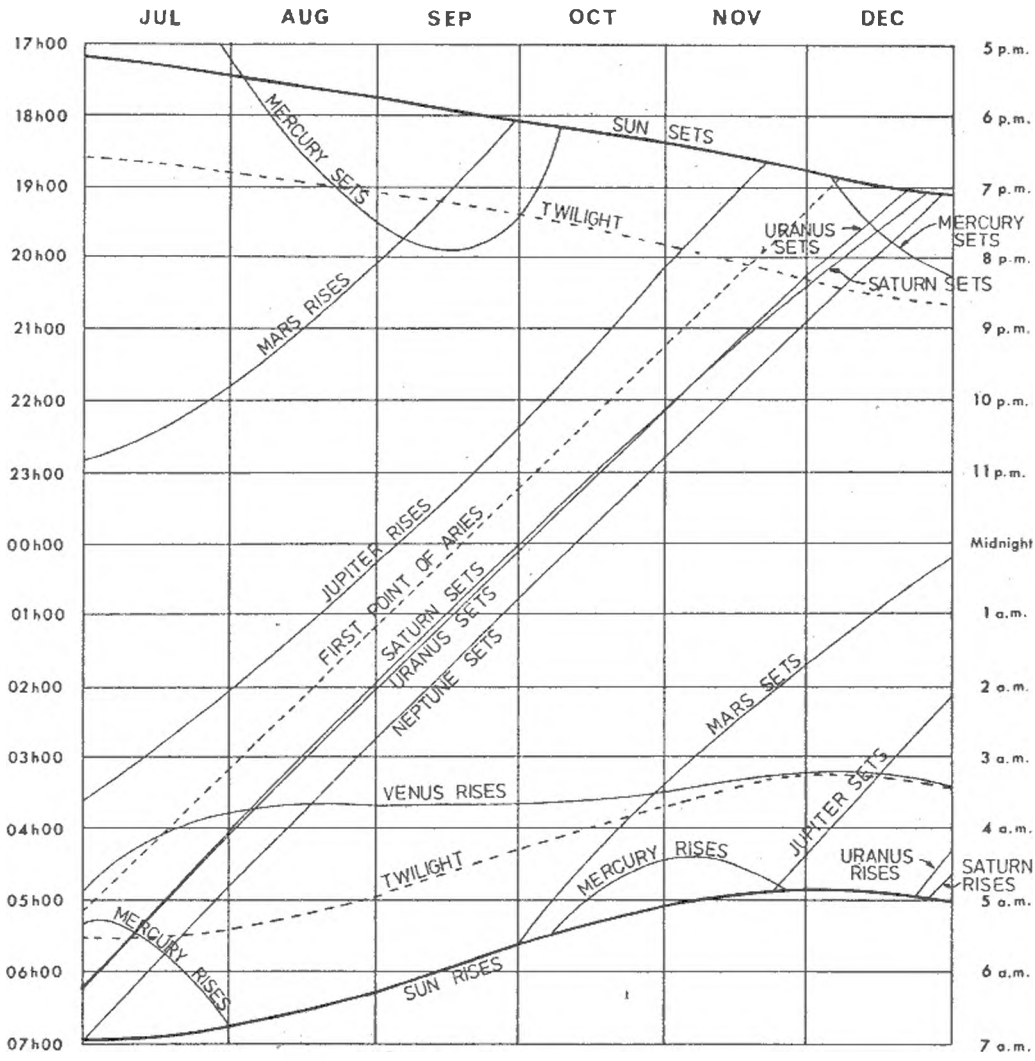
Apart from Uranus, Neptune and Pluto, the planets of our solar system are amongst the brightest objects in the night sky. Unlike the distant stars, their relative positions do not remain fixed, but continually change as, like the Earth, they orbit around the Sun. Their apparent movements against the starry background are complicated as they result from a combination of their own motion and the Earth's motion. Their brightnesses also vary considerably, as both their distances from the Earth and the visible portions of their sunlit hemispheres change. Since the period of a planet increases with increasing distance from the Sun, so we find that the inner planets - Mercury and Venus - appear to "overtake" the Earth in their orbits, while the Earth in turn "overtakes" the outer planets - Mars, Jupiter and Saturn. The terms given in astronomy to the various Sun-Earth-Planet configurations are illustrated in the accompanying diagram. Dates of such configurations occuring in 1986 are listed chronologically in the Diary (pages 4 and 5) and are also mentioned in the text below.



## TIMES OF RISING AND SETTING

The times of rising and setting given by the diagram are accurate for position 30° East, 30° South and approximately correct for other places in Southern Africa. Strictly speaking, corrections for latitude and longitude should be applied, but the latitude correction is in general sufficiently small to be ignored and in no case will exceed 15 minutes. Longitude corrections are given on page 44.




JUL
AUG
SEP
OCT
NOV
DEC
17h00
18h00
19h00
20h00
21h00
22h00
23h00
00h00
01h00
02h00
03h00
04h00
05h00
06h00
07h00
5 p.m.
6 p.m.
7 p.m.
8 p.m.
9 p.m.
10 p.m.
11 p.m.
Midnight
1 a.m.
2 a.m.
3 a.m.
4 a.m.
5 a.m.
6 a.m.
7 a.m.
MERCURY SETS
SUN SETS
TWILIGHT
URANUS SETS
MERCURY SETS
SATURN SETS
MARS RISES
JUPITER RISES
FIRST POINT OF ARIES
SATURN SETS
URANUS SETS
NEPTUNE SETS
MARS SETS
VENUS RISES
JUPITER SETS
TWILIGHT
MERCURY RISES
URANUS RISES
SATURN RISES
MERCURY RISES
SUN RISES

# The Planets

## OBSERVING THE PLANETS

To the naked eye, planets appear as virtually pinpoint sources of light. However, their disks can be readily resolved with the aid of a small telescope. Even so, their angular diameters are of the order of 10 seconds of arc - roughly 1/200 of the Moon's angular diameter - so it is not always possible to distinguish details on their disks. The disks of Mercury and Venus are only seen fully illuminated when they are furthest from us - as they draw closer, their disks grow larger but the phase changes to a crescent as we see more of their dark hemispheres. In contrast, the disks of the outer planets are always seen fully or near fully illuminated.

### Mercury

Mercury is visible in the morning skies from about February 17 to April 12, from June 22 to July 26, and from October 18 to November 15. It will be best seen in mid-March in Capricornus. In the evening sky it will be seen from about January 8 to February 5, from April 28 to June 3, from August 12 to October 4 and from December 18 to December 31. Best time in the evening sky will be in mid-September in Virgo.

| | | d | h | | | d | h | | | d | h | | d | h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Superior Conjunction | | | | | Apr | 20 | 15 | | Aug. | 3 | 04 | Dec | 1 | 11 |
| Greatest Elongation East | Jan | 26 | 19 | (19°) | May | 19 | 04 | (22°) | Sep | 16 | 00 | (22°) | | |
| Stationary | Feb | 1 | 18 | | Jun | 1 | 03 | | Sep | 28 | 23 | | | |
| Inferior conjunction | Feb | 11 | 06 | | Jun | 13 | 06 | | Oct | 11 | 09 | | | |
| Stationary | Feb | 23 | 06 | | Jun | 25 | 01 | | Oct | 19 | 18 | | | |
| Greatest Elongation West | Mar | 8 | 08 | | Jul | 6 | 18 | (21°) | Oct | 26 | 23 | (18°) | | |

### Venus

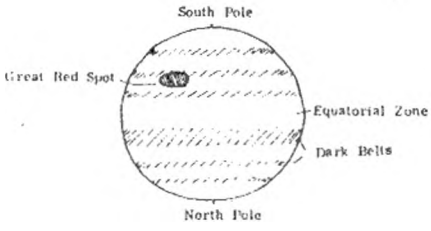
Venus will be seen in the evening sky from the beginning of the year until early June. It will be seen in the morning sky from the last week in June until the end of the year.

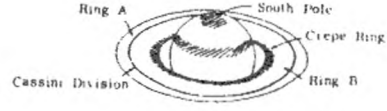
### Mars

Mars rises after mid-night in Libra at the beginning of the year. It gradually moves westwards among the stars passing into Scorpius in mid-January, into Ophiuchus a week later, into Sagittarius in mid-February, Capricornus in second week of April, Aquarius in Mid-May, and into Pisces in early July, into Cetus in late July and back into Pisces at the end of September. Its brightness varies from +1.6 early in January to -2.8 at opposition on September 28, and faces to -0.1 at the end of the year.

### Jupiter

Jupiter is visible in the evening sky in Pisces from the beginning of the year. It moves into Aries in mid-May and into Tautus in mid-June. It remains in that constellation for the rest of the year. Its magnitude varies from -2.5 in January to -2.0 in mid-year and then brightens to -2.9 at opposition on November 23 before fading to -2.7 at the end of the year.

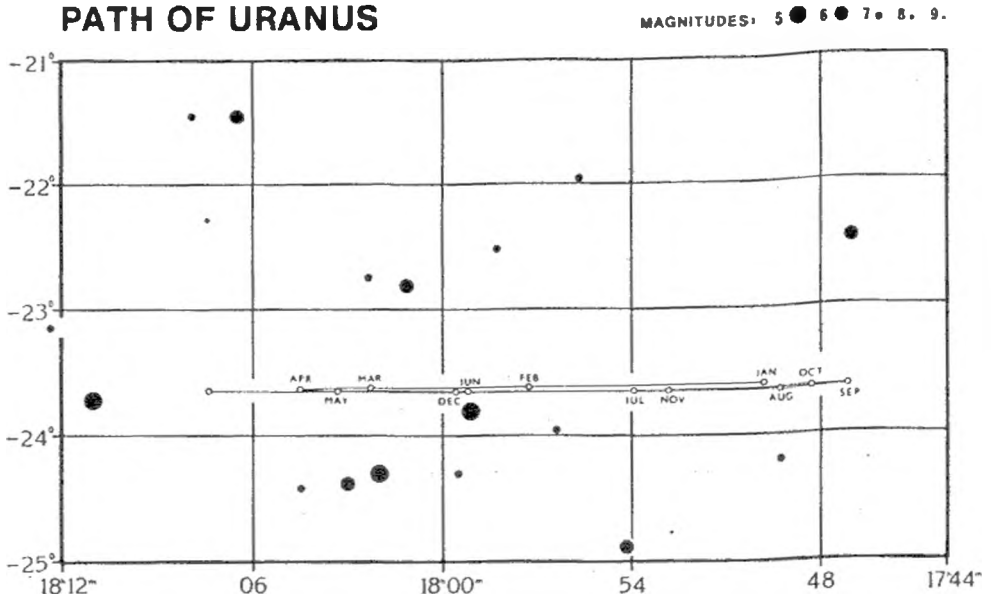



### Saturn

Saturn will be seen just before morning twilight from the second week in January in Sagittarius. It will remain in that constellation all year. Its magnitude will vary from +0.5 on January 1 to 0.6 a month later and then brighten to 0.0 on June 20 when it is at opposition. It will then fade to +0.6 at the end of October and brighten again to 0.5 in first week of December before being lost in the evening twilight.

Uranus is in Sagittarius. At opposition on June 20 its magnitude will be 5· and its apparent diameter 3".9.

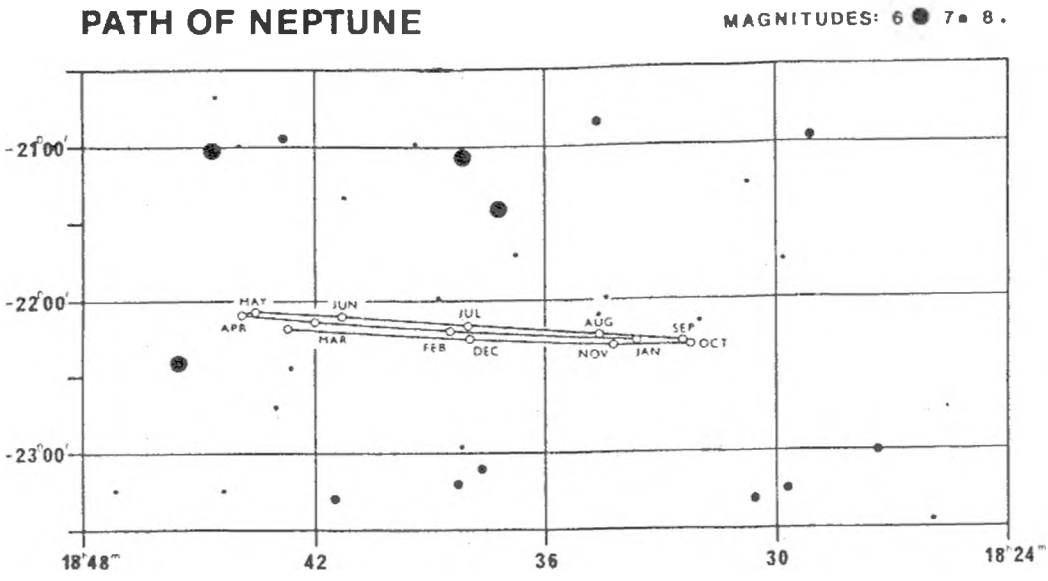



| | R.A. h m | Dec |
|---|---|---|
| Jan 1 | 17.50 | -23°35' |
| 16 | 17.54 | -23°36' |
| Feb 1 | 17.57 | -23°37' |
| 15 | 18.00 | -23°37' |
| Mar 1 | 18.02 | -23°37' |
| 16 | 18.04 | -23°38' |
| Apr 1 | 18.05 | -23°38' |
| 16 | 18.04 | -23°38' |
| May 1 | 18.03 | -23°38' |
| 16 | 18.02 | -23°39' |
| Jun 1 | 17.59 | -23°39' |
| 16 | 17.57 | -23°39' |
| Jul 1 | 17.54 | -23°39' |
| 15 | 17.52 | -23°39' |
| Aug 1 | 17.49 | -23°38' |
| 16 | 17.48 | -23°38' |
| Sep 1 | 17.47 | -23°38' |
| 16 | 17.47 | -23°38' |
| Oct 1 | 17.48 | -23°38' |
| 16 | 17.50 | -23°38' |
| Nov 1 | 17.53 | -23°39' |
| 16 | 17.56 | -23°39' |
| Dec 1 | 18.00 | -23°39' |

## Uranus

Uranus will be near Saturn all year. To assist in finding the fainter planet the time that Saturn is ahead of Uranus is tabulated below so that by setting on Saturn and waiting the correct time one can fine Uranus. The negative sign denotes that Uranus is ahead of Saturn. Uranus is at all times South of Saturn by the number of degrees and minutes stated.

| | R.A. m s | Dec |
|---|---|---|
| Jan 1 | 9.31 | 1°20' |
| 15 | 6. 4 | 1°18' |
| Feb 1 | 2.17 | 1°17' |
| 15 | -0.26 | 1°17' |
| Mar 1 | -2.55 | 1°18' |
| 15 | -4.52 | 1°20' |
| Apr 1 | -6.17 | 1°22' |
| 15 | -6.36 | 1°22' |
| May 1 | -6.17 | 1°22' |
| 15 | -5.23 | 1°23' |
| Jun 1 | -3.33 | 1°22' |
| 15 | -1.42 | 1°21' |
| Jul 1 | 0.40 | 1°20' |
| 15 | 2.26 | 1°20' |
| Aug 1 | 4.01 | 1°17' |
| 15 | 4.44 | 1°16' |
| Sep 1 | 4.41 | 1°13' |
| 15 | 3.57 | 1°11' |
| Oct 1 | 2.22 | 1°07' |
| 15 | 23 | 1°04' |
| Nov 1 | -2.37 | 1°02' |
| 15 | -5.29 | 0°59' |
| Dec 1 | -9.06 | 0°59' |




## Neptune

After mid-January Neptune will be observable in the morning sky in Sagittarius and it will remain there all year. At magnitude 7.9 it will be difficult to identify as its diamter is only 1.1". On January 20 the planet was at RA 18h37m, Dec -22°13'; on April 11 Neptune was stationary at 18h44m -22°04'; on July 2 Neptune will be at 18h38m -22°10'; on September 19 18h32m -22°17'; on December 1 18h38m -22°15'. Interpolation between these values will be sufficiently accurate to locate the planet.

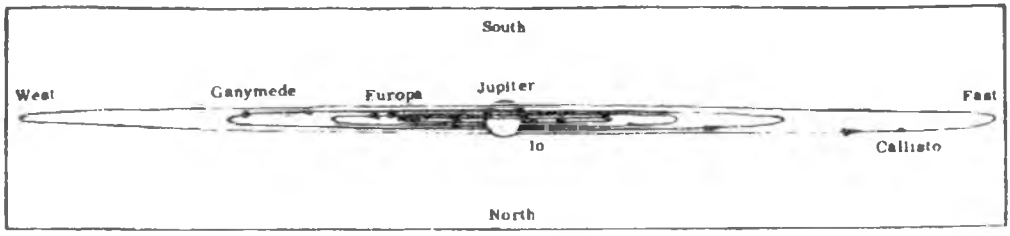
## Pluto

Pluto at magnitude 13.7 is too faint for all but the larger telescopes. It is in the constellation of Sagittarius, about 2° north of M22.

# THE MOONS OF JUPITER AND SATURN

## MOONS OF JUPITER

One of the most popular sights for an observer with a small telescope is Jupiter and its Moons. Four of the fifteen - Io, Europa, Ganymede and Callisto - are generally clearly visible - they would just be visible to the naked eye were it not for the glare from the mother planet. As the diagram below indicates, the system is seen almost edge-on so




the moons always lie close to a straight line extending from the planet's equator. As they orbit, so they appear to oscillate from one side to the other, alternately passing in front and behind the planet. This motion is represented in the diagrams on page 26 which cover the period when Jupiter is clearly visible in the evening sky. The horizontal lines show their relative configurations at 2am each day.

When the moons pass in front and behind the planet, transits, occultations and eclipses occur. Details of such phenomena occurring between the end of astronomical twilight and just after midnight (and when the planet is above the horizon in Southern Africa) are given in the table below.

### Explanation of Table

- Date and predicted times are given; these are for mid-phenomean and are not instantaneous.
- The moon concerned are I - Io, II - Europa, III - Ganymede and IV - Callisto.
- Phenomena - the abbreviations used are: D - Disappearance; Ec - Eclipse: the satellite passes through the shadow of Jupiter; R - Reappearance; Oc - Occultation: the satellite is obscured by the disc of Jupiter; I - Ingress; Sh - Shadow Transit: the shadow of the satellite transits the disc; E - Egress; Tr - Transit: the satellite crosses the disc of Jupiter.

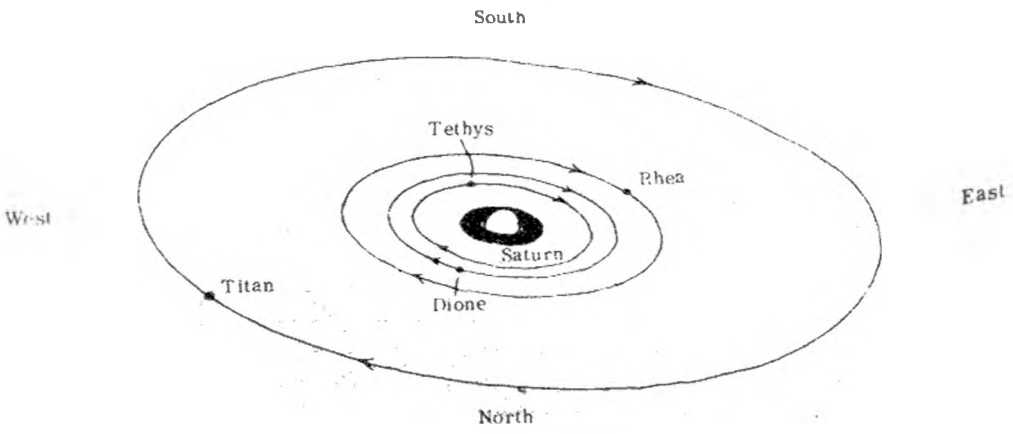
| d | h | m | | d | h | m | | d | h | m | | d | h | m | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan 2 | 0 | 03 | III Oc D | Jan30 | 21 | 43 | III Ec D | Jul 7 | 6 | 07 | I Tr I | Aug16 | 4 | 16 | II Oc R |
| 5 | 20 | 11 | II Tr I | | 22 | 15 | II Sh E | 8 | 5 | 28 | I Oc R | 17 | 2 | 03 | II Tr E |
| | 21 | 55 | III Sh E | Feb 6 | 20 | 04 | II Tr I | 15 | 4 | 09 | I Ec D | 24 | 1 | 55 | II Sh E |
| | 22 | 34 | II Tr E | | 20 | 32 | III Oc D | 16 | 4 | 44 | I Tr E | | 2 | 02 | I Sh E |
| 6 | 20 | 19 | I Tr I | 7 | 20 | 31 | I Sh E | 21 | 5 | 13 | III Oc R | | 2 | 28 | II Tr I |
| | 21 | 39 | I Sh I | 14 | 20 | 18 | I Sh E | | 5 | 27 | II Ec D | | 3 | 22 | I Tr E |
| | 22 | 29 | I Tr E | | 21 | 18 | I Tr E | 23 | 3 | 23 | I Sh I | | 4 | 41 | II Tr E |
| | 23 | 49 | I Sh E | 15 | 19 | 58 | II Oc R | | 4 | 33 | I Tr I | 26 | 1 | 59 | III Oc R |
| 7 | 21 | 06 | I Ec R | | 19 | 58 | II Ec D | | 4 | 34 | II Tr E | 31 | 1 | 48 | I Sh I |
| 12 | 20 | 41 | III Tr E | 17 | 19 | 56 | III Sh I | | 5 | 31 | I Sh E | | 2 | 17 | II Sh I |
| | 22 | 46 | II Tr I | 21 | 21 | 07 | I Tr I | 24 | 3 | 56 | I Oc R | | 3 | 08 | I Tr I |
| 13 | 22 | 14 | I Tr I | 22 | 20 | 20 | II Oc D | 28 | 4 | 26 | III Ec R | | 3 | 56 | I Sh E |
| 14 | 20 | 02 | II Ec D | 29 | 20 | 20 | I Oc D | 30 | 4 | 45 | II Sh E | | 4 | 32 | II Sh E |
| | 22 | 22 | II Ec R | Mar 1 | 19 | 50 | I Tr E | | 5 | 04 | II Tr I | | 5 | 05 | II Tr I |
| | 23 | 01 | I Ec R | | 20 | 48 | I Sh E | | 5 | 16 | I Sh I | | 5 | 16 | I Tr E |
| 15 | 20 | 14 | I Sh E | 2 | 20 | 05 | II Tr E | 31 | 5 | 54 | I Oc R | Sep 1 | 2 | 34 | I Oc R |
| 19 | 22 | 12 | III Tr I | 6 | 20 | 07 | III Ec R | Aug 1 | 3 | 08 | I Tr E | 2 | 1 | 49 | II Oc R |
| 21 | 21 | 26 | I Oc D | 8 | 17 | 39 | I Tr I | 6 | 5 | 07 | II Sh I | 7 | 3 | 41 | I Sh I |
| | 22 | 21 | II Oc R | 9 | 19 | 54 | I Ec R | 7 | 4 | 21 | I Ec D | | 4 | 54 | II Sh I |
| | 22 | 41 | II Ec D | Jun28 | 4 | 58 | II Sh E | 8 | 2 | 56 | I Tr I | | 5 | 01 | I Tr I |
| 22 | 20 | 51 | I Tr E | 29 | 5 | 52 | I Ec D | | 3 | 47 | III Tr E | 8 | 0 | 55 | I Ec D |
| | 22 | 10 | I Sh E | 30 | 5 | 21 | I Sh E | | 4 | 25 | II Oc R | | 4 | 27 | I Oc R |
| 28 | 22 | 37 | II Oc D | | 6 | 17 | I Tr E | | 5 | 04 | I Tr E | 9 | 1 | 36 | I Tr E |
| 29 | 20 | 38 | I Tr I | Jul 3 | 6 | 26 | III Tr E | 15 | 2 | 26 | II Ec D | | 1 | 42 | II Ec R |
| | 21 | 56 | I Sh I | 5 | 5 | 20 | II Sh I | | 2 | 31 | III Sh E | | 2 | 06 | II Oc D |
| 30 | 21 | 20 | I Ec R | 7 | 5 | 06 | I Sh I | | 3 | 32 | I Sh I | | 2 | 22 | III Ec D |

| d | h | m | | | | d | h | m | | | | d | h | m | | | | d | h | m | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 9 | 4 | 20 | II | Oc | R | Oct 15 | 4 | 54 | I | Ec | D | Nov 9 | 2 | 34 | III | Sh | E | Dec 5 | 0 | 58 | II | Tr | I |
| | 4 | 29 | III | Ec | R | 16 | 2 | 05 | I | Sh | I | | 3 | 52 | III | Tr | E | | 1 | 33 | II | Sh | I |
| 15 | 2 | 49 | I | Ec | D | | 3 | 00 | I | Tr | I | | 21 | 05 | I | Tr | I | | 3 | 12 | II | Tr | E |
| 16 | 1 | 20 | I | Tr | I | | 4 | 14 | I | Sh | E | | 22 | 54 | I | Sh | E | | 3 | 52 | II | Sh | E |
| | 1 | 59 | II | Ec | D | | 23 | 23 | I | Ec | D | | 23 | 14 | I | Tr | E | 9 | 1 | 19 | I | Oc | D |
| | 2 | 11 | I | Sh | E | 17 | 2 | 27 | I | Oc | R | 10 | 4 | 24 | II | Sh | I | | 3 | 54 | I | Ec | R |
| | 3 | 27 | I | Tr | E | | 22 | 43 | I | Sh | E | 11 | 22 | 36 | II | Ec | D | | 22 | 26 | I | Tr | I |
| | 4 | 16 | II | Ec | R | | 23 | 34 | I | Tr | E | 12 | 1 | 27 | II | Oc | R | | 22 | 51 | I | Sh | I |
| | 4 | 35 | II | Oc | D | 18 | 01 | 33 | II | Ec | D | 13 | 20 | 29 | II | Tr | E | 10 | 0 | 35 | I | Tr | E |
| 17 | 0 | 46 | I | Oc | R | 19 | 22 | 18 | II | Tr | I | 16 | 1 | 30 | I | Ec | D | | 1 | 01 | I | Sh | E |
| 18 | 1 | 41 | II | Tr | E | | 22 | 52 | II | Sh | E | | 3 | 51 | I | Oc | R | | 19 | 45 | I | Oc | D |
| 20 | 1 | 41 | III | Tr | I | 20 | 0 | 31 | II | Tr | E | | 22 | 38 | I | Sh | I | | 22 | 22 | I | Ec | R |
| | 3 | 30 | III | Tr | E | 22 | 2 | 24 | III | Ec | D | | 22 | 49 | I | Tr | I | 12 | 3 | 13 | II | Tr | I |
| 23 | 1 | 56 | I | Sh | I | | 4 | 33 | III | Ec | R | 17 | 0 | 48 | I | Sh | E | 13 | 21 | 16 | II | Oc | D |
| | 3 | 10 | I | Tr | I | 23 | 3 | 59 | I | Sh | I | | 0 | 57 | I | Tr | E | 14 | 0 | 37 | II | Ec | R |
| | 4 | 05 | I | Sh | E | | 4 | 45 | I | Tr | I | | 22 | 17 | I | Oc | R | | 20 | 18 | III | Tr | E |
| | 4 | 33 | II | Ec | D | 24 | 01 | 18 | I | Ec | D | 19 | 1 | 11 | II | Ec | D | | 20 | 26 | III | Sh | I |
| | 5 | 17 | I | Tr | E | | 4 | 13 | I | Oc | R | | 3 | 40 | II | Oc | R | | 22 | 38 | III | Sh | E |
| 24 | 2 | 36 | I | Oc | R | | 22 | 27 | I | Sh | I | | 20 | 49 | III | Oc | R | 15 | 19 | 47 | II | Sh | E |
| | 23 | 45 | I | Tr | E | | 23 | 11 | I | Tr | I | 20 | 20 | 20 | II | Sh | I | 16 | 3 | 04 | I | Oc | D |
| 25 | 1 | 42 | II | Sh | E | 25 | 0 | 37 | I | Sh | E | | 20 | 30 | II | Tr | I | 17 | 0 | 10 | I | Tr | I |
| | 1 | 57 | II | Tr | I | | 1 | 19 | I | Tr | E | | 22 | 38 | II | Sh | E | | 0 | 46 | I | Sh | I |
| | 4 | 09 | II | Tr | E | | 4 | 08 | II | Ec | D | | 22 | 43 | II | Tr | E | | 2 | 20 | I | Tr | E |
| 27 | 0 | 25 | III | Sh | I | | 22 | 39 | I | Oc | R | 23 | 3 | 25 | I | Ec | D | | 2 | 56 | I | Sh | E |
| | 2 | 31 | III | Sh | E | | 23 | 11 | II | Sh | I | 24 | 0 | 32 | I | Tr | I | 18 | 0 | 18 | I | Ec | R |
| | 5 | 23 | III | Tr | I | 27 | 0 | 37 | II | Tr | I | | 0 | 33 | I | Sh | I | | 20 | 46 | I | Tr | E |
| Oct 1 | 1 | 06 | I | Ec | D | | 1 | 29 | II | Sh | E | | 2 | 41 | I | Tr | E | | 21 | 25 | I | Sh | E |
| | 4 | 25 | I | Oc | R | | 2 | 49 | II | Tr | E | | 2 | 43 | I | Sh | E | 20 | 23 | 33 | II | Oc | D |
| | 23 | 26 | I | Tr | I | 31 | 3 | 12 | I | Ec | D | | 21 | 51 | I | Oc | D | 21 | 3 | 15 | II | Ec | R |
| 2 | 0 | 27 | I | Sh | E | Nov 1 | 0 | 21 | I | Sh | I | 25 | 0 | 04 | I | Ec | R | | 21 | 39 | III | Tr | I |
| | 1 | 33 | I | Tr | E | | 0 | 56 | I | Tr | I | | 21 | 07 | I | Tr | E | | 23 | 41 | III | Tr | E |
| | 2 | 03 | II | Sh | I | | 2 | 31 | I | Sh | E | | 21 | 11 | I | Sh | E | 22 | 0 | 27 | III | Sh | I |
| | 4 | 19 | II | Sh | E | | 3 | 04 | I | Tr | E | 26 | 3 | 40 | II | Oc | D | 22 | 2 | 40 | III | Sh | E |
| | 4 | 23 | II | Tr | I | | 21 | 41 | I | Ec | D | | 22 | 11 | III | Oc | D | | 20 | 05 | II | Sh | I |
| 4 | 0 | 52 | II | Oc | R | | 22 | 32 | III | Sh | E | 27 | 0 | 38 | III | Ec | R | | 20 | 54 | II | Tr | E |
| | 4 | 24 | III | Sh | I | | 22 | 47 | III | Tr | I | 27 | 22 | 44 | II | Tr | I | | 22 | 24 | II | Sh | E |
| 7 | 22 | 50 | III | Oc | D | 2 | 0 | 23 | I | Oc | R | | 22 | 57 | II | Sh | I | 24 | 1 | 56 | I | Tr | I |
| 8 | 0 | 38 | III | Oc | R | | 0 | 34 | III | Tr | E | 28 | 0 | 57 | II | Tr | E | | 2 | 41 | I | Sh | I |
| | 3 | 00 | I | Ec | D | | 21 | 30 | I | Tr | E | 28 | 1 | 15 | II | Sh | E | | 23 | 16 | I | Oc | D |
| 9 | 0 | 12 | I | Sh | I | 3 | 1 | 48 | II | Sh | I | Dec 1 | 2 | 16 | I | Tr | I | 25 | 2 | 13 | I | Ec | R |
| | 1 | 13 | I | Tr | I | | 2 | 53 | II | Tr | I | | 2 | 28 | I | Sh | I | | 20 | 23 | I | Tr | I |
| | 2 | 20 | I | Sh | E | | 4 | 06 | II | Sh | E | | 4 | 24 | I | Tr | E | | 21 | 10 | I | Sh | I |
| | 3 | 21 | I | Tr | E | 4 | 23 | 13 | II | Oc | R | | 23 | 35 | I | Oc | D | | 22 | 32 | I | Tr | E |
| | 4 | 40 | II | Sh | I | 8 | 2 | 15 | I | Sh | I | 2 | 1 | 59 | I | Ec | R | | 23 | 20 | I | Sh | E |
| 10 | 22 | 59 | II | Ec | D | | 2 | 40 | I | Tr | I | | 20 | 41 | I | Tr | I | 26 | 20 | 42 | I | Ec | R |
| | 3 | 13 | II | Oc | R | | 4 | 25 | I | Sh | E | | 20 | 56 | I | Sh | I | 28 | 1 | 51 | II | Oc | D |
| 14 | 22 | 23 | III | Ec | R | | 23 | 35 | I | Ec | D | | 22 | 50 | I | Tr | E | 29 | 1 | 04 | III | Tr | I |
| 15 | 0 | 32 | III | Ec | R | 9 | 0 | 24 | III | Sh | I | | 23 | 06 | I | Sh | E | | 20 | 58 | II | Tr | I |
| | 2 | 21 | III | Oc | D | | 2 | 04 | I | Oc | R | 3 | 20 | 27 | I | Ec | R | | 22 | 41 | II | Sh | I |
| | 4 | 09 | III | Oc | R | | 2 | 07 | III | Sh | E | 4 | 1 | 26 | I | Oc | D | | 23 | 14 | II | Tr | E |
| | | | | | | | | | | | | | | | | | | 30 | 1 | 00 | II | Sh | E |

# THE MOONS OF JUPITER AND SATURN

## SATURN'S MOONS

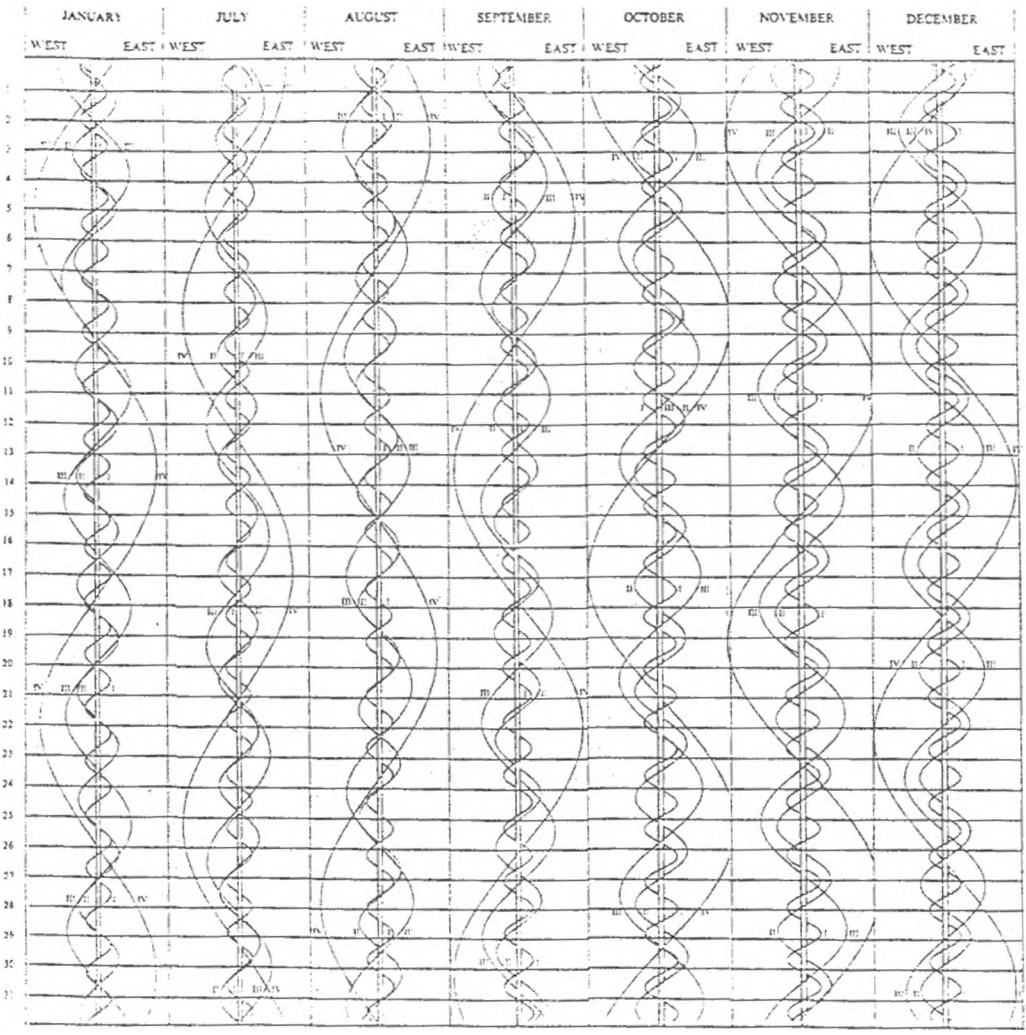
Saturn's moons are considerably fainter than the four Galilean moons of Jupiter. The diagram shows the orbits of four of Saturn's ten moons. The easiest to find is Titan (magnitude 8,5), according to the diagram and the information in the table below.




TITAN 1988

| Eastern Elongation | | Inferior Conjunction | | Western Elongation | | Superior Conjunction | |
|---|---|---|---|---|---|---|---|
| SAST | | SAST | | SAST | | SAST | |
| | | | | Jan 1 | 11.1 | Jan 5 | 12.5 |
| Jan 9 | 08.0 | Jan 13 | 06.8 | 17 | 11.9 | 21 | 13.2 |
| 25 | 08.6 | 29 | 07.6 | Feb 2 | 12.6 | Feb 6 | 13.7 |
| Feb 10 | 09.0 | Feb 14 | 08.1 | 18 | 13.0 | 22 | 13.9 |
| 26 | 09.1 | Mar 1 | 08.2 | Mar 5 | 13.0 | Mar 9 | 13.7 |
| Mar 13 | 08.8 | 17 | 07.8 | 21 | 12.6 | 25 | 13.0 |
| 29 | 08.1 | Apr 2 | 05.0 | Apr 6 | 11.6 | Apr 10 | 12.0 |
| Apr 14 | 06.9 | 18 | 03.7 | 22 | 10.2 | 26 | 10.4 |
| 30 | 05.2 | May 4 | 03.9 | May 8 | 08.3 | May 12 | 08.4 |
| May 16 | 03.3 | 19 | 25.6 | 24 | 05.9 | 28 | 06.1 |
| Jun 0 | 00.7 | Jun 4 | 23.1 | Jun 9 | 03.3 | Jun 13 | 03.5 |
| 16 | 22.1 | 20 | 20.4 | 25 | 00.6 | 29 | 00.9 |
| Jul 2 | 19.5 | Jul 6 | 17.7 | Jul 10 | 21.8 | Jul 14 | 22.3 |
| 18 | 17.3 | 22 | 15.2 | 26 | 19.4 | 30 | 20.0 |
| Aug 3 | 14.9 | Aug 7 | 13.0 | Aug 11 | 17.3 | Aug 15 | 18.1 |
| 19 | 13.0 | 23 | 11.3 | 27 | 15.7 | 31 | 16.6 |
| Sep 4 | 11.7 | Sep 8 | 10.8 | Sep 12 | 14.6 | Sep 16 | 15.6 |
| 20 | 10.8 | 27 | 09.3 | 28 | 14.0 | Oct 2 | 15.1 |
| Oct 6 | 10.4 | Oct 10 | 09.0 | Oct 14 | 13.8 | 18 | 15.0 |
| 22 | 10.3 | 26 | 09.2 | 30 | 14.1 | Nov 3 | 15.2 |
| Nov 7 | 10.6 | Nov 11 | 09.7 | Nov 15 | 14.7 | 19 | 15.8 |
| 23 | 11.9 | 27 | 10.4 | Dec 1 | 15.6 | Dec 5 | 16.5 |
| Dec 9 | 11.9 | Dec 13 | 11.4 | 17 | 16.6 | 21 | 17.3 |
| 25 | 12.7 | 29 | 12.4 | | | | |

## CHANGING CONFIGURATIONS OF JUPITER'S MOONS




The four bright moons of Jupiter always appear close to a straight line passing through the planets since, as shown in the drawing at the top, their orbits are seen nearby edge on. The main part of the diagram then shows how their positions along such a straight line change during the seven months when Jupiter is prominent. For each month, time increases downward; the disk of Jupiter is stretched to make the central column and horizontal lines, representing 2 am (0 hrs Universal time), are shown for every day of the month. The wavy lines show how the Moons appear to oscillate from each side of the planet to the other.

# COMETS AND METEORS

## COMETS

About a dozen comets are observed each year. Of these, five or six are new discoveries while the others have been observed during their previous returns around our Sun.
Comets are divided into two groups, depending on the length of their periods around the Sun: Short-period comets, which on the average have a 7 year period, an orbital inclination of about 13 degrees, small orbital eccentricities (between 0.2 and 0.9) and usually travel in a direction motion.
Long-period comets, i.e. those of a period greater than 200 years, have random orbital inclinations, about 0.9999 eccentricity and random motion.
A typical comet consists of a very small solid nucleous surrounded by a large envelope of gas and dust called the coma and in some instances they might develop two kinds of tail, dust and gas tails. As a comet approaches or moves away from the Sun its visual appearance changes drastically. Observers with modest equipment such as a good pair of binoculars (for bright comets) or a refractor with an objective not less than 7,5cm can contribute with valuable information, by reporting on their visual appearance. Another area in need of observers, is that of regularly and systemetrically conducting visual searches for new comets, namely in the southern celestial hemisphere: this activity is also well within the scope of the equipment mentioned. Occasionally, very bright comets are discovered with the naked eye.
Interested members are asked to contact the Director of the Comet & Meteor Section, Mr. Jose' Campos, 19 Fiskaal Place, Woodhaven, Durban, 4001.

PREDICTED PERIHELION PASSAGES OF COMETS, 1988

| Periodic comet | Perihelion date | Revolution period years | Perihelion distance au | Mag |
|---|---|---|---|---|
| Reinmuth 1 | May 9 | 7.3 | 1.98 | 18 |
| Finlay | June 6 | 7.0 | 1.10 | 16 |
| Tempel 2 | Sep 16 | 5.3 | 1.38 | 16 |
| Longmore | Oct 11 | 7.0 | 2.40 | 18 |
| Du Toit | Dec 26 | 14.7 | 1.27 | 20 |

## METEORS

Orbiting in the interplanetary space, METEOROIDS (usually about the size of a grain of sand), sometimes collide with the Earth's atmosphere and due to the direction of the Earth's motion around the Sun, these collisions are generally seen in greater numbers after local midnight, than in the early evening.
As the meteoroid enters the upper Earth's atmosphere, its rapid motion will heat it to incandescence by friction with the atmosphere's gaseous molecules, causing them to be ionized resulting in an emission of light; this is then called a METEOR (popularly known as a "shooting star") and they are disintergrated completely, long before they reach the ground. There are two types of meteors, the sporadic ones and the showers; the direction in the sky where the shower appears to come from, is called the Radiant. Some showers are known to be caused by the debris of a comet; when our planet intersects a comet's orbit, such a shower may take place.
A table of predicted meteor showers is given on the next page.
Occasionally an extremely bright meteor, i.e. those of visual magnitude greater than Venus (-4.0 mag.), is seen travelling across the sky and it may break up or even explode during its flight; such a very bright meteor is called a fireball and somet it may produce debris that reach the ground becoming then known as METEORITES and their masses can range from a few grams, up to several tons.
Interested persons are urged to contact the Director of Comet and Meteor Section, Mr. J. Campos, 19 Friskaal Place, Woodhaven, Durban 4001. In the event of bright fireballs, please phone 031-423684 at any time.

## PREDICTED METEOR SHOWERS 1988

| Predicted Limits | Shower | Radiant R.A. (1950) | Radiant Dec | Transit of Radiant SAST | Transit of Radiant Alt | Date at Maximum | Zenithal Hourly Rate | Recommended time of Watch Beginning SAST | Recommended time of Watch Beginning Alt | Recommended time of Watch Ending : SAST | Recommended time of Watch Ending : Alt | Conditions at Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb 6-15 | Theta Centaurids | 14h20m | -44° | 05h05 | 76° | Feb 8 | ? | 01h00 | 40° | 04h00 | 70° | Unfavourable |
| Mar 13-18 | Corona Australids | 16h20 | -48 | 04h43 | 72 | Mar 16 | 5 | 01h00 | 44 | 04h30 | 71 | Favourable |
| Apr 19-24 | April Lyrids | 18h08 | +32 | 04h06 | 28 | Apr 22 | 15 | 03h00 | 26 | 05h00 | 26 | Favourable |
| May 1-12 | Eta Aquarids | 22h24 | 00 | 07h30 | 60 | May 5 | 30 | 04h00 | 31 | 05h00 | 43 | Unfavourable |
| Apr 20-Jul 30 | Sco-SGR System | 18h00 | -30 | 00h29 | 90 | Jun 14 | ? | 21h00 | 45 | 04h00 | 44 | Good |
| Jun 10-21 | June Lyrids | 18h32 | +35 | 00h53 | 25 | Jun 16 | 8 | 23h30 | 22 | 01h30 | 24 | Good |
| Jun 17-26 | Ophiuchids | 17h20 | -20 | 23h22 | 80 | Jun 20 | 10 | 19h00 | 30 | 02h00 | 53 | Good |
| Jun 26-29 | Cetids (New) | 02h00 | -15 | 07h35 | 75 | Jun 28 | ? | 03h00 | 25 | 05h20 | 56 | Unfavourable |
| Jul 10-Aug 5 | Capricornids | 21h00 | -15 | 00h47 | 75 | Jul 26 | 8 | 20h30 | 30 | 05h15 | 25 | Unfavourable |
| Jul 15- | N Delta Aquarids | 22h36 | (- 5 | | | Aug 12 | (10 | | | | | |
| Aug 15 | S Delta Aquarids | 22h36 | (-17 | 02h07 | 77 | Jul 29 | (40 | 22h00 | 33 | 05h00 | 47 | Unfavourable |
| Jul 15-Aug 20 | Pisces Australids | 22h40 | -30 | 02h03 | 89 | Jul 31 | 12 | 21h30 | 32 | 05h00 | 51 | Unfavourable |
| Jul 15-Aug 25 | Alpha Capricornids | 20h36 | -10 | 23h48 | 70 | Aug 2 | 10 | 20h00 | 33 | 04h00 | 29 | Poor |
| Jul 15- | N Iota Aquarids | (21h48 | (- 6 | | | Aug 10 | 10 | | | | | |
| Aug 24 | S Iota Aquarids | (22h13 | (-15 | 01h33 | 75 | Aug 6 | 12 | 22h00 | 40 | 04h00 | 52 | Favourable |
| Oct 16-31 | Orionids | 06h24 | +15 | 04h23 | 45 | Oct 21 | 20 | 02h00 | 33 | 03h20 | 42 | Favourable |
| Oct 10- | S Taurids | (03h44 | (+14 | | | (Nov 6 | ( 5 | | | | | |
| Dec 5 | N Taurids | (03h44 | (+22 | 00h26 | 38 | (Nov 10 | (10 | 23h30 | 36 | 01h00 | 37 | Good |
| Nov 14-20 | Leonids | 10h08 | +22 | 06h21 | 38 | Nov 17 | 10 | 03h00 | 18 | 03h30 | 23 | Poor |
| Dec 3- 5 | Phoenicids | 01h00 | -55 | 20h03 | 65 | Dec 4 | 5 | 20h30 | 64 | 01h00 | 33 | Favourable |
| Dec 7-15 | Geminids | 07h28 | +32 | 01h55 | 28 | Dec 14 | 55 | 23h30 | 19 | 03h00 | 26 | Favourable |
| Dec 5-Jan 7 | Velaids | 09h56 | -51 | 03h25 | 69 | Dec 29 | 15? | 00h30 | 51 | 03h30 | 69 | Unfavourable |

NOTE: The times and altitudes (in degrees) given, are for an observer stationed at E 30.5 S 29.5 (Durban). The Cetids are uncertain and confirmation on this Shower is requested.

## CONSTELLATIONS

Apart from our Sun all the stars that we see are so incredibly distant that, despite their high speed velocities, their apparent positions change by only minute amounts each year. Consequently the patterns that they form appear unchanged. The Greeks and other ancient civilisations identified these patters, or constellations, with various mythological characters and creatures, and most of the names they gave are still used today.

In all there are 88 constellations, roughtly one half of which would be above the horizon at any one time. Some contain distinctive patterns of bright stars and are relatively easy to find; others are difficult to locate, even with suitable maps. The Southern Cross and Centaurus, Orion and Taurus, Scorpius and Sagittarius, are featured later in this section. Detailed information on other constellations is beyond the scope of this handbook and interested observers are advised to obtain a suitable star atlas.

## STAR NAMES

Within each constellation, the brightest star is generally labelled a(Alpha), the next B(Beta) and so on through the Greek alphabet. Most of the brightest stars also have their own names - usually of arabic origin. For example, $\alpha$ Canis Majoris, otherwise known Sirius, is the brightest star in the constellation Canis Major.

## STELLAR MAGNITUDES

The apparent brightness of a star - which depends both on its true luminosity and its distance - is indicated by its magnitude. Equal intervals of magnitude represent equal ratios in light intensity. A star of magnitude 1.0 (typical of the brightest stars in the night sky) would be exactly one hundred times more luminous than a star of magnitude 6,0 (about the limit of visibility to the naked eye). The maps in this section show stars down to magnitude 4,5.

## STELLAR DISTANCES

Distances are often expressed in units of light years - the distance light would travel in a year (equal to $9{,}5 \times 10^{12}$km).

## DOUBLE STARS

It now appears that single stars such as our Sun are the exception, the majority of stars being double or multiple - two or more suns in orbit around one another.

## STAR CLUSTERS

These are two completely different sorts. Galactic clusters, having of the order of 100 stars, are found close to the plane of the Milky Way. The ones we can see are relatively nearby. Globular clusters are much larger and far more distant. They contain of the order of 100 000 stars each and are seen above and below the Milky Way on that side of the sky towards the centre of our galaxy. So great is their distance that small telescopes fail to resolve individual stars - instead they appear as fuzzy balls.

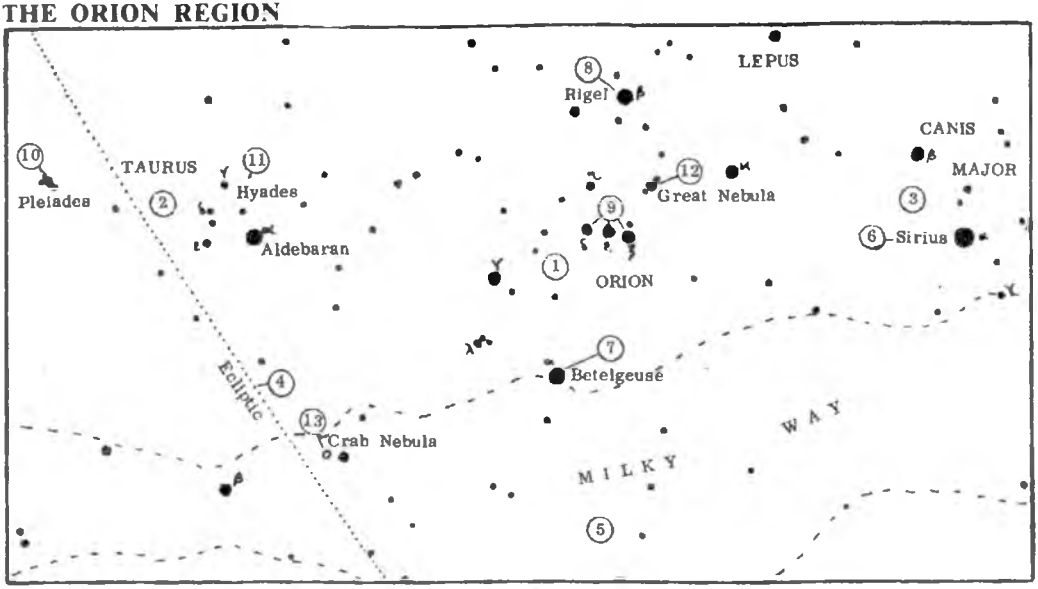
## NEBULAE

Possibly one third of the matter in our region of the Galaxy is in the form of gas and dust (the remainder being contained in stars, plus a tiny amount in planets). Condensations of this material are called nebulae, some of which are illuminated by nearby stars while others are dark. They are usually referred to by their numbers in Messier's catalogue (M) or the New General Catalogue (NGC).

## THREE POPULAR REGIONS

The dominating constellation of the summer skies is Orion, that of the winter skies is Scorpius, while the Southern Cross is conspicuous for most of the year. The regions around these constellations are also rich in interesting objects - visible either to the naked eye, or with the aid of binoculars or a small telescope - and are featured in the maps and text below. It may be necessary to rotate the maps to match the orientation of the constellations in the sky.

## THE ORION REGION




(1) The constellation of Orion. The figure of the legendary hunter of Greek mythology is unfortunately upside down when seen from Southern Africa. The faint stars by λ represent the head, α and γ the shoulders, δ - ε - ζ the belt, and β and κ the legs. Orion forms part of the "great hunting scene" in which he faces the onslaught of (2) Taurus, the bull. Only the forepart of the bull is depicted and, like Orion, it is upside down. α and ε are the eyes, γ the nose. Orion is accompanied by (3) Canis major, the large dog, and the small dog (off map) while Lepus, the hare, crouches at his feet.

(4) A section of the Ecliptic - a line encircling the entire sky and representing the plane of the Earth's orbit. As the Earth revolves around the Sun, the Sun appears to move along the ecliptic through the constellations of the Zodiac, of which Taurus is one.

(5) A portion of the Milky Way (looking out towards the edge of our Galaxy).

(6) Sirius - the brightest star in the night sky. It is somewhat brighter than our Sun and relatively close by - at a distance of 9 light years. It is a double star but the companion is a white dwarf (only slightly larger than the Earth, and with a mass comparable to our Sun ) and is only visible through a large telescope.

(7) Betelgeuse - most famous of the red giant stars. Its diameter is of the order of the size of the Earth's orbit and its luminosity is nearly 10 000 times that of our Sun. Its red colour should be obvious to the eye. It is 520 light years distant.

(8) Rigel, despite being physically smaller than Betelgeuse, is more luminous (higher surface temperature - bluish colour) and more distant.

(9) The stars in Orion's belt are distant hot blue stars.

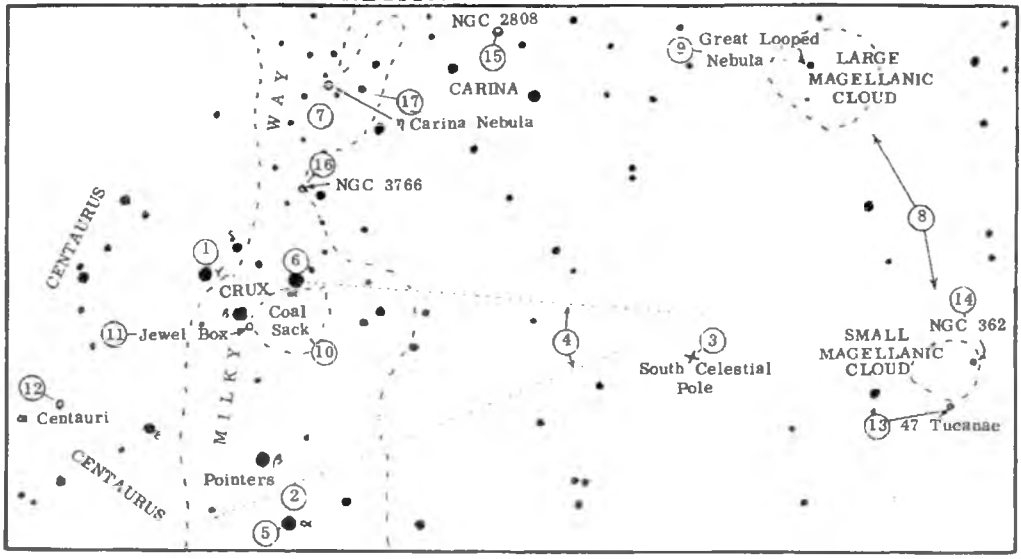
(10) The Pleiades or Seven Sisters form the best known nearby star cluster. Six or seven stars are visible to the naked eye, binoculars or a small telescope show more.

(11) The Hyades is another nearby galactic cluster, but Aldebaran is not a member (it lies closer to us).

(12) The Great Nebula in Orion, just visible to the naked eye, shows up as a fan shaped mass of luminous gas through binoculars or a telescope. A telescope will also show a tiny "Trapezium" of four stars in the centre.

(13) The Crab Nebula, the remnant of a supernova recorded by the Chinese in 1054, requires a moderate sized telescope for observation. In its heart is located the extraodinary pulsar which emits a double flash of light 30 times every second. The current belief is that it is a rapidly rotating neutron star - a star with the mass of our sun but with a diameter of only 10 km.

## THE SOUTHERN CROSS REGION




(1) Crux, the Southern Cross, is one of the most compact patterns of bright stars to be found in the sky. It lies on the border of that region of the sky which never sets as seen from Southern Africa.

(2) The two "Pointer" stars lie close to the Cross. (A similar pattern to the Southern Cross - called the False Cross - lies just outside and above the map, but has no accompanying pointer stars).

(3) The South Celestial Pole: This is one of two opposite points in space towards which the Earth's axis of rotation is directed. As the Earth rotates so the sky appears to pivot about this point. It always lies above the south point on the horizon, elevated by an angle equal to the observer's southern latitude. (The north celestial pole lies below the northern horizon and can never be seen from the Earth's southern hemisphere)

(4) The intersection of a line extended through the major axis of the Cross and the perpendicular bisector to the Pointers indicates the approximate position of the South Celestial Pole.

(5) α Centauri has the distinction of being the closest star to our solar system - at a distance of approximately 40 million million km or 4,3 light years. A small telescope readily shows that it is a double star - the two components take 80 years to revolve about one another. A much fainter third star also belongs to the system.

(6) α Crucis can also be resolved as a double star by a small telescope (separation 5 sec of arc).

(7) The region indicated is one of the brightest sections of the entire Milky Way.

(8) The Large and Small Magellanic Clouds are the nearest of the external galaxies (see also next section). They can be seen with the naked eye provided the sky is reasonably dark.

(9) The Great Looped Nebula - possibly the remnant of a supernova explosion - in the Large Magellanic Cloud. (Naked eye or binoculars).

(10) The "Coal Sack" - a dark mass of gas and dust obscuring a part of the Milky Way. (Naked eye or binoculars).

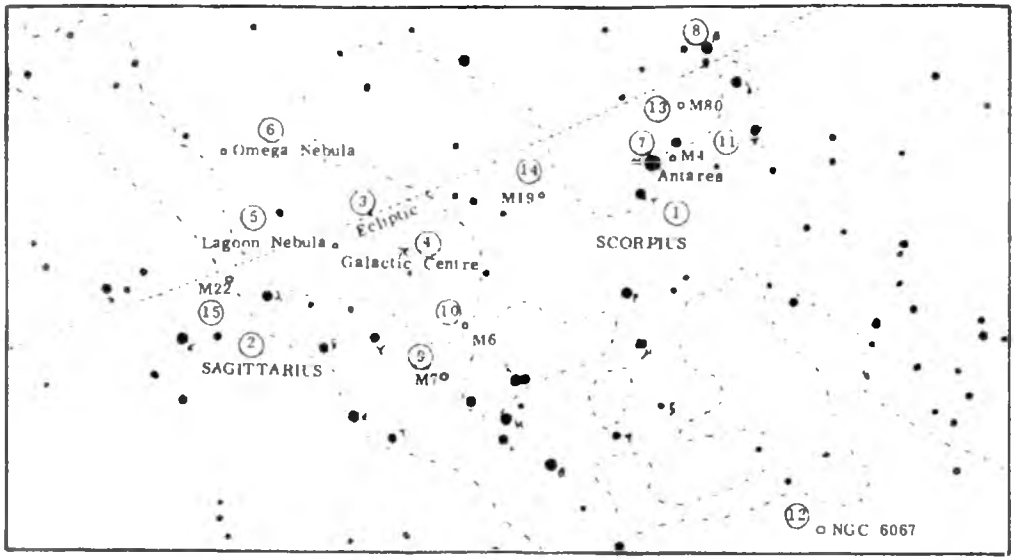
(11) Herschel's "Jewel Box" - a galactic cluster containing stars of different colours. (Small telescope or binoculars).

(12) ω Centauri and (13) 47 Tucanae are perhaps the best known globular clusters. Binoculars will show their fuzzy appearance. (14) NGC 362 and (15) NGC 2808 are fainter globular clusters.

(16) NGC 3760 - a fine galactic cluster. (Binoculars or small telescope).

(17) The η Carinae nebula - site of a slow supernova that brightened to magnitude -0,8 in 1843 and is now of magnitude 6,4.

## THE SCORPIUS REGION




(1) The constellation of Scorpius. The creature is depicted with α in the centre of the body and β and π the claws. The distinctive tail ε — ζ — η curls round to the sting λ

(2) Sagittarius - the figure of the centaur archer is very difficult to make out.

(3) A section of the Ecliptic. Like Taurus, Scorpius and Sagittarius are constellations of the Zodiac.

(4) The direction of the centre of our Galaxy - the Milky Way is that part of our Galaxy visible to us. Unfortunately the central nucleus is obscured by foreground gaseous and dusty matter - both dark and luminous - hence the irregular shape of the Milky Way in this region. Luminous nebulae include (5) the Lagoon nebula and (6) the Omega nebula. These are best seen with the aid of binoculars.

(7) Antares - a distant red giant, several hundred times the diameter of our Sun - is so named because its red colour rivals that of the planet Mars.

(8) δ Scorpii can be resolved as a double star (separation 16 sec of arc) with a small telescope. In fact the brighter component is in itself a triple star, and the fainter component a double star!

This region includes a number of galactic clusters including (9) M7, (10) M8, (11) M4 and (12) NGC 6067. (Use binoculars or a small telescope).

Further from the plane of the Milky Way are some globular clusters (13) M80 (14) M19 and (15) M22.

## VARIABLE STAR OBSERVING

The latest (1985) edition of the "General Catalogue of Variable Stars" lists more than 28 000 stars. Professional observatories cannot possibly monitor all of these, and this makes the observation of variable stars a field in which amateurs can make a real contribution to astronomical knowledge.

Of these 28 000 stars at least 2 000 are suitable for visual monitoring in the southern hemisphere. However, the number of active observers in this part of the world remains woefully small, and less than 400 variables are at present being observed from South Africa.

The Variable Star Section of the A.S.S.A. exists for the purpose of encouraging observers and of acting as a medium communication. The Section disseminates incoming information amongst observers, and will forward (on request) the observations of individuals to various variable star bodies. These include the American Association of the Variable Star Observers (AAVSO) and the Variable Star Section of the Royal Astronomical Society of New Zealand. These bodies combine the South African light estimates with those from other parts of the world. The resulting "light curves" and tables are made available to a large number of professional observatories where astronomers are interested in investigating certain of the stars more fully.

In recent years amateur observers have played an invaluable part by alerting the operators of orbiting satellite observatories whenever outburst occurred of certain eruptive variables.

Visual estimates of magnitude are made by comparing the variable with two or more comparison stars, respectively brighter and fainter than the unknown variable. Suitable comparison stars are shown on special charts, which have been prepared for each variable, mainly by the two variable star organisations mentioned above. The use of these charts is essential for accurate, standardized observations and intending new observers are therefore advised to obtain the necessary data by contacting the Director of the Variable Star Section, Mr. J. Hers, P.O. Box 48, Sedgefield, 6573, Telephone (04455) 736. They will then be sent charts of a few easy objects and data on stars which may be observed with the equipment at their disposal.

Prospective observers should, when writing, give brief details of their equipment. Larger, more powerful telescopes will naturally greatly increase the number of stars which may be measured, but many variables are bright enough to be observed through most of their cycles with quite modest equipment, e.g. binoculars. Some stars, such as 07104 L2 Puppis, are so bright that they may be observed without optical aid whatever.

Variable stars are designated in two ways. The first of these, the Harvard designation, consists of six figures which give the position for 1900; the first four figures give hours and minutes of R.A., the last two give the declination in degrees, underlined for southern declinations. The second name consists of one or two letters (or letter V plus a number and the name of constellation.

Variables can be divided into three main classes : pulsating, eruptive and eclipsing binary stars.

Most suitable for beginners are the long period variables (or Mira variables, named after the typical representative Mira = o Ceti) which belongs to the class of pulsating stars. They are giant stars which vary through a range of brightness of 2,5 to 5 magnitudes or more, and which have well defined periodicities, ranging from 80 to 1000 days. In most cases one observation per observer every 10 days will suffice.

Typical examples include :

| | | | Approximate magnitude range |
|---|---|---|---|
| 021403 | o | Ceti Mira | 2. 0-10.1 |
| 092962 | R | Carinae | 3. 9-10.0 |
| 100661 | S | Carinae | 4. 5-9.9 |

Among the eruptive variables, two groups are of special importance:

U Geminorum type. These are dwarf novae which have long periods of apparent quiescence at minimum, with sudden rises to maximum. A typical representative in the southern hemisphere is 040971 VW Hydri.

R. Coronae Borealis type. These are high luminosity variables with slow, non-periodic drops in brightness. A typical representative is 191033 RY sagittarii.

Eclipsing Binary Stars have orbital planes which lie close to the line of sight of the observer. The two components periodically eclipse each other, thus causing variations in the apparent brightness of the system. Periods are generally short, of the order of hours, so that observational programmes need very careful planning. Monitoring these interesting stars is therefore for experienced observers only.

## NOVA SEARCHING

On rare occasions a star may undergo a nova outburst, its light increasing tremendously. The result is that a "new" star appears where previously no star was visible to the naked eye, or even with a small telescope. The light of the nova may fluctuate for a time, then gradually fades over a period of days, weeks or months.

Even observers having no telescopes can perform a useful task in keeping a watch for such novae in an allocated area of the sky. A good knowledge of the constellations is a recommendation, since part of the procedure is to scan the whole sky for bright novae before the more detailed search in the allocated area is begun. However, anyone can be given training in star recognition.

# ORDINARY OCCULTATIONS

This Section and that following concern a specialised branch of observational astronomy in which both professional and amateur participate. The tables of predictions must necessarily occupy a number of pages as this handbook is the sole published source for Southern Africa.

An occultation occurs when the disk of the Moon moves in front of a star. Timings of occultations, to a precision of one-tenth of a second if possible are very valuable for studies of the Moon's shape and motion. Since only very modest equipment is required, amateurs can make important contributions in this field. Persons interested in making and reporting occultation observations are urged to contact the Director of the Society's Occultation Section, Mr A G F Morrisby, (c/o Dept of Surveyor General, P O Box 1580, Bulawayo, Zimbabwe).

Predictions of occultations of all stars brighter than magnitude 7,5 supplied by Hydrographic Dept, Tokyo are given below. The main set of tables give predictions for three stations, namely,

| | Longitude | Latitude |
|---|---|---|
| Cape Town | - 18°.475 | - 33°.933 |
| Johannesburg | - 28°.075 | - 26°.182 |
| Harare | - 31°.100 | - 17°.700 |

This does not restrict its use to observers to those centres. The approximate time of an occultation at a place $\lambda$ degrees west and $\phi$ degrees north of one of the standard stations given above may be found from:

$$\text{Approximate time} = \text{predicted time} + a.\Delta\lambda + b.\Delta\phi$$

where a and b, in minutes of time, are given in the tables. Alternatively, rough times for intermediate stations can usually be estimated direct from the tables.

Occulted stars have been identified by their Z.C. numbers, that is their numbers in the "Catalogue of 3539 Zodiacal Stars for the Equinox 1950.0" by James Robertson (U S Naval Observatory, 1939).

Note: That the times of these occultations are given in U.T.

Explanations of Abbreviations used in Tables

Z.C. - the number of the star in the Zodiacal Catalogue. An "m" following the number indicates the star is not single.

Mag. - the visual magnitude
Ph - the Phase: D = Disappearance, R = Reappearance
h.m. - the time of the occultation in U T
a,b - parameters in minutes for predicting times other than at standard stations (explained above in text)
P.A. - The Position Angle on the Moon's limb measured eastward from the north point

# LUNAR OCCULTATIONS

| DATE M | D | SC | MAG | PH | ELG ° | CAPE TOWN E 18.5 S 33.9 TIME H M | A m | B m | P ° | JOHANNESBURG E 28.1 S 26.2 TIME H M | A m | B m | P ° | HARARE E 31.0 S 17.8 TIME H M | A m | B m | P ° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 1 | 1888 | 6.2 | DD | 145 | 01 50.4 | -0.2 | -1.5 | 104 | 01 45.7 | -0.9 | -0.7 | 78 | | | | |
| Jan | 11 | 3367 | 6.4 | DD | 264 | | | | | 20 07.3 | | | 331 | | | | |
| Jan | 11 | 3367 | 6.4 | RD | 264 | | | | | 20 12.9 | | | 321 | | | | |
| Jan | 16 | 490 | 5.7 | RD | 326 | 21 13.3 | -2.2 | 0.8 | 249 | 21 42.4 | -2.3 | 1.0 | 258 | 21 54.5 | -2.3 | 0.2 | 278 |
| Jan | 23 | 1383 | 6.6 | DD | 54 | 4 55.9 | -0.7 | -0.5 | 135 | 5 06.0 | -1.2 | 0.9 | 93 | | | | |
| Jan | 24 | 1487 | 1.3 | DB | 69 | 7 23.1 | 0.4 | -2.1 | 172 | | | | | | | | |
| Jan | 25 | 1660 | 6.2 | SS | 90 | 23 31.5 | -1,0 | -1,2 | 84 | | | | | | | | |
| Jan | 26 | 1663 | 5.2 | DD | 90 | 0 25.7 | -2.0 | -0.7 | 73 | | | | | | | | |
| Jan | 26 | 1660 | 6.2 | RD | 90 | 0 27.9 | -0.6 | -2.8 | 344 | | | | | | | | |
| Jan | 26 | 1663 | 5.2 | RD | 91 | 1 11.3 | -0.0 | -3.4 | 2 | | | | | | | | |
| Jan | 27 | 1754 | 6.9 | DD | 103 | | | | | | | | | 2 18.2 | -1.2 | -2.7 | 152 |
| Jan | 28 | 1949 | 5.8 | DD | 125 | 23 47.9 | | | 38 | | | | | | | | |
| Feb | 11 | | 7.1 | DD | 280 | 21 14.1 | | | 4 | | | | | | | | |
| Feb | 21 | 1547 | 3.9 | DD | 47 | 2 39.7 | -09 | -1.6 | 153 | 2 45.9 | -1.9 | -0.2 | 111 | 3 0.0 | | | 69 |
| Feb | 21 | 1547 | 3.9 | RD | 47 | | | | | | | | | 3 36.2 | | | 14 |
| Feb | 21 | 1550 | 5.8 | DD | 48 | | | | | 4 52.6 | -0.3 | -1.2 | 148 | 4 47.8 | -0.7 | -0.3 | 116 |
| Feb | 24 | 1822 | 7.2 | DD | 85 | 3 15.0 | -3.6 | 0.4 | 84 | | | | | | | | |
| Feb | 24 | 1913 | 7.1 | DD | 94 | 22 40.3 | -0.7 | -0.8 | 71 | | | | | | | | |
| Feb | 25 | 1919 | 7.1 | DD | 95 | | | | | 0 41.5 | -1.0 | -2.3 | 140 | 0 28.6 | -1.7 | -1.6 | 116 |
| Feb | 27 | 2134 | 6.1 | DD | 118 | 1 44.4 | | | 39 | | | | | | | | |
| Feb | 27 | 2134 | 6.1 | RD | 118 | 1 54.6 | | | 23 | | | | | | | | |
| Feb | 28 | 2263 | 4.8 | DD | 130 | | | | | | | | | 3 17.8 | -0.1 | -3.9 | 164 |
| Feb | 28 | 2268 | 4.8 | DD | 130 | 4 16.0 | -2.4 | -0.4 | 81 | | | | | | | | |
| Feb | 28 | 2287 | 3.0 | DD | 132 | | | | | 8 45.3 | -2.4 | -2.4 | 145 | 8 41.6 | -2.0 | -0.4 | 113 |
| Feb | 28 | 2287 | 3.0 | RD | 133 | | | | | 9 35.5 | -0.2 | 3.5 | 223 | 9 55.0 | -0.5 | 1.3 | 253 |
| Feb | 29 | 2405 | 6.4 | DD | 140 | | | | | 1 45.3 | 0.2 | -2.3 | 141 | 1 30.7 | -0.3 | -1.3 | 113 |
| Mar | 01 | 2545 | 6.4 | DD | 151 | 2 01.3 | -0.1 | -1.1 | 91 | 2 02.8 | -1.3 | 0.6 | 51 | | | | |
| Mar | 02 | 2721 | 3.3 | DD | 162 | 3 02.8 | -0.3 | -0.7 | 75 | | | | | | | | |
| Mar | 09 | 267 | 7.3 | DD | 249 | | | | | 18 58.1 | | | 351 | | | | |
| Mar | 15 | 1169 | 5.4 | RD | 327 | | | | | 19 13.0 | -2.2 | -2.4 | 329 | | | | |
| Mar | 20 | 1600 | 5.1 | DD | 26 | 0 42.2 | -0.6 | -2.3 | 345 | | | | | | | | |
| Mar | 20 | 1692 | 6.8 | DD | 37 | 21 01.1 | -1.1 | -1.9 | 117 | 21 05.0 | 7.4 | -0.9 | 88 | | | | |
| Mar | 21 | 1779 | 6.7 | DD | 50 | 21 50.9 | -0.6 | -2.4 | 148 | 21 43.8 | -1.5 | -1.8 | 119 | 21 37.2 | -2.4 | -0.9 | 95 |
| Mar | 22 | 1884 | 5.3 | DD | 63 | 23 10.4 | -0.7 | -2.5 | 148 | 23 05.6 | -1.9 | -1.7 | 114 | 23 03.9 | -3.6 | -0.2 | 84 |
| Mar | 23 | 1884 | 5.3 | RD | 63 | | | | | | | | | 0 00.7 | 0.6 | -4.4 | 5 |
| Mar | 25 | 2108 | 6.4 | DD | 89 | 3 58.9 | -1.8 | -2.2 | 140 | 4 11.9 | -2.7 | -0.1 | 103 | 4 29.1 | -3.2 | 2.7 | 65 |
| Mar | 25 | 2109 | 6.1 | DD | 89 | 4 54.1 | -1.8 | -2.3 | 146 | 5 04.4 | -2.2 | -0.3 | 111 | 5 14.8 | -2.2 | 1.3 | 79 |
| Mar | 26 | 2220 | 7.0 | DD | 99 | | | | | 1 26.5 | -0.7 | -3.1 | 151 | 1 10.2 | -1.7 | -1.7 | 120 |
| Mar | 28 | 2505 | 5.4 | DD | 120 | | | | | 1 12.1 | -0.2 | -2.4 | 135 | 0 59.1 | -0.9 | -1.1 | 104 |
| Apr | 09 | 810 | 1.8 | DB | 268 | | | | | 18 05.5 | | | 161 | 17 54.8 | -1.9 | -1.0 | 125 |
| Apr | 09 | 810 | 1.8 | RD | 269 | | | | | 18 41.1 | | | 211 | 19 08.9 | -2.1 | 1.3 | 250 |
| Apr | 18 | 1853 | 4.9 | DD | 31 | | | | | | | | | 22 42.7 | -1.5 | -2.6 | 148 |
| Apr | 20 | 1970 | 6.2 | DD | 46 | | | | | | | | | 4 30.1 | -1.1 | -1.9 | 148 |
| Apr | 23 | 2449 | 7.5 | DD | 89 | 22 07.3 | -0.8 | -0.1 | 57 | | | | | | | | |
| Apr | 24 | 2470 | 6.1 | DD | 91 | 3 19.2 | -2.5 | -0.5 | 95 | 3 50.4 | -2.7 | 1.9 | 63 | 4 30.6 | | | 18 |
| Apr | 24 | 2474 | 6.6 | DD | 92 | 4 25.3 | -2.5 | 0.0 | 96 | 4 54.6 | -2.2 | 1.5 | 72 | 5 19.2 | -1.3 | 3.2 | 42 |
| Apr | 24 | 2601 | 6.7 | DD | 100 | 23 34.8 | 0.9 | -3.6 | 156 | 23 15.1 | -0.3 | -1.5 | 111 | 23 09.2 | -1.0 | -0.3 | 90 |
| Apr | 25 | 2621 | 7.4 | DD | 102 | 2 25.2 | -1.7 | -1.4 | 102 | 2 44.5 | -2.8 | 0.9 | 67 | 3 18.0 | | | 21 |
| Apr | 25 | 2634 | 7.4 | DD | 103 | 5 58.7 | -1.8 | 2.2 | 55 | | | | | | | | |
| Apr | 26 | 2781 | 7.4 | DD | 112 | 1 29.4 | -1.3 | -0.1 | 64 | | | | | | | | |
| Apr | 26 | 2804 | 5.9 | DD | 114 | 6 23.7 | -2.3 | 0.8 | 80 | | | | | | | | |
| Apr | 28 | 3069 | 6.2 | DD | 135 | 2 37.8 | -0.4 | -2.7 | 135 | 2 33.1 | -1.1 | -0.6 | 82 | 2 38.5 | -1.5 | 1.1 | 50 |
| Apr | 29 | 3206 | 5.2 | DD | 146 | 2 45.1 | -0.1 | -2.3 | 146 | 2 39.2 | -0.6 | -0.4 | 77 | 2 43.9 | -0.9 | 1.1 | 46 |
| Apr | 29 | 3206 | 5.2 | RD | 146 | 3 28.3 | -0.8 | 1.8 | 201 | | | | | | | | |
| May | 12 | 1531 | 5.9 | RD | 318 | | | | | 17 48.4 | -1.1 | -2.7 | 160 | | | | |

| DATE | | ZC | MAG | PH | ELG | CAPE TOWN E 18.5 S 33.9 | | | | JOHANNESBURG E 28.1 S 26.2 | | | | HARARE E 31.0 S 17.8 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TIME | A | B | P | TIME | A | B | P | TIME | A | B | P |
| M | D | | | | ° | H M | m | m | ° | H M | m | m | ° | H M | m | m | ° |
| May | 12 | 1531 | 5.9 | RD | 318 | | | | | 19 10.5 | -2.9 | -0.7 | 285 | 19 7.6 | -2.1 | -1.8 | 312 |
| May | 18 | 2039 | 5.6 | DD | 26 | 1 21.0 | -2.4 | 1.4 | 82 | | | | | | | | |
| May | 18 | 2045 | 6.4 | DD | 26 | 2 43.2 | -1.4 | -0.6 | 128 | 2 55.5 | -1.0 | 0.5 | 102 | 3 06.4 | -0.6 | 1.6 | 71 |
| May | 18 | 2051 | 5.7 | DD | 27 | 3 43.5 | -1.0 | -0.3 | 128 | 3 51.7 | -0.6 | 0.4 | 107 | 3 58.7 | -0.1 | 1.1 | 79 |
| May | 18 | 2134 | 6.1 | DD | 35 | 19 54.4 | -0.7 | -1.6 | 107 | 20 01.1 | -2.8 | 0.4 | 65 | | | | |
| May | 18 | 2134 | 6.1 | RD | 35 | | | | | 20 42.7 | 0.9 | -4.5 | 360 | | | | |
| May | 19 | 2268 | 4.8 | DD | 48 | 22 47.6 | -0.5 | -3.5 | 156 | 22 41.0 | -2.0 | -1.6 | 113 | 22 42.5 | -3.4 | 0.3 | 80 |
| May | 19 | 2273 | 5.9 | DD | 48 | 23 07.0 | -1.7 | -1.6 | 113 | 23 26.9 | -3.5 | 1.1 | 71 | | | | |
| May | 20 | 2298 | 5.1 | DD | 51 | 5 22.1 | | | 169 | 5 21.0 | -1.4 | -1.3 | 142 | 5 18.8 | -0.7 | -0.2 | 113 |
| May | 20 | 2404 | 6.9 | DD | 58 | 19 49.6 | 0.3 | -1.7 | 126 | 19 38.5 | -0.3 | -1.0 | 93 | 19 37.1 | -1.1 | 0.4 | 62 |
| May | 20 | 2409 | 6.9 | DD | 58 | 20 43.1 | -1.3 | 0.1 | 56 | | | | | | | | |
| May | 21 | 2449 | 7.5 | DD | 63 | 6 55.6 | 0.2 | 2.3 | 50 | | | | | | | | |
| May | 21 | 2545 | 6.4 | DD | 69 | | | | | 21 01.9 | 1.0 | -3.7 | 159 | 20 41.0 | 0.0 | -1.5 | 121 |
| May | 21 | 2554 | 4.4 | DD | 70 | 22 59.8 | -0.3 | -2.9 | 139 | 22 53.2 | -1.5 | -1.1 | 98 | 22 56.6 | -2.6 | 0.8 | 64 |
| May | 22 | 2721 | 3.3 | DD | 81 | | | | | 22 51.5 | -0.4 | -2.7 | 131 | 22 39.6 | -1.1 | -0.9 | 97 |
| May | 23 | 2735 | 7.2 | DD | 82 | 1 29.9 | -1.8 | -2.5 | 121 | 1 40.8 | -2.6 | -0.3 | 88 | 1 54.4 | -2.9 | 1.6 | 57 |
| May | 23 | 2740 | 6.3 | DD | 83 | 2 35.3 | -2.4 | -1.2 | 104 | 2 58.4 | -2.7 | 0.5 | 80 | 3 16.9 | -2.4 | 2.0 | 54 |
| May | 23 | 2750 | 2.1 | DD | 84 | 4 31.2 | -1.9 | 1.7 | 60 | 5 02.5 | -1.3 | 2.3 | 50 | 5 27.1 | -0.3 | 3.1 | 27 |
| May | 23 | 2750 | 2.1 | RD | 84 | 5 53.2 | -1.7 | 1.2 | 262 | 6 16.3 | -1.4 | 1.0 | 267 | 6 25.1 | -1.8 | -0.1 | 287 |
| May | 26 | 3167 | 7.1 | DD | 115 | 2 04.5 | -1.0 | -2.0 | 106 | 2 08.4 | -1.5 | -0.2 | 76 | 2 17.8 | -1.6 | 1.4 | 47 |
| May | 26 | 3177 | 6.0 | DD | 117 | | | | | | | | | 6 00.5 | | | 115 |
| Jun | 03 | 810 | 1.8 | DB | 220 | 12 56.4 | -2.3 | -0.7 | 106 | 12 56.4 | -2.6 | 0.0 | 93 | 13 07.2 | -2.9 | 0.8 | 73 |
| Jun | 03 | 810 | 1.8 | RD | 220 | 14 24.1 | -2.3 | 0.7 | 250 | 14 24.1 | -2.2 | 0.5 | 271 | 14 30.6 | -1.9 | -0.5 | 295 |
| Jun | 07 | 1395 | 6.3 | RD | 276 | 19 39.8 | -1.0 | -0.3 | 309 | | | | | | | | |
| Jun | 08 | 1487 | 1.3 | DB | 287 | 16 08.1 | -1.0 | -2.8 | 165 | 15 01.8 | -1.7 | -2.1 | 137 | 14 52.2 | -2.4 | -1.5 | 116 |
| Jun | 08 | 1487 | 1.3 | RD | 288 | 16 13.5 | -2.9 | -0.5 | 265 | 16 31.8 | -2.3 | -1.3 | 300 | 16 23.0 | -1.8 | -2.3 | 325 |
| Jun | 16 | 2366 | 1.2 | DD | 29 | 21 36.4 | -3.2 | 1.5 | 55 | | | | | | | | |
| Jun | 16 | 2366 | 1.2 | RB | 29 | 22 29.2 | -0.9 | -4.7 | 340 | | | | | | | | |
| Jun | 16 | 2373 | 6.2 | DD | 29 | 23 01.0 | -3.6 | 3.8 | 44 | | | | | | | | |
| Jun | 17 | 2404 | 6.9 | DD | 32 | 5 51.7 | 0.0 | 0.9 | 93 | | | | | | | | |
| Jun | 17 | 2512 | 7.4 | DD | 39 | 20 53.5 | -1.0 | -1.4 | 100 | 21 06.7 | -2.7 | 1.0 | 57 | | | | |
| Jun | 21 | 2988 | 6.8 | DD | 74 | 1 25.8 | -1.9 | 0.8 | 58 | 1 56.3 | -1.9 | 2.2 | 40 | | | | |
| Jun | 22 | 3255 | 7.4 | DD | 95 | | | | | 23 29.3 | | | 145 | 23 09.2 | -0.6 | -0.7 | 91 |
| Jul | 07 | 1652 | 5.5 | DD | 286 | | | | | 19 40.2 | -0.4 | -2.4 | 165 | | | | |
| Jul | 07 | 1652 | 5.5 | RD | 287 | | | | | 20 39.1 | -1.1 | 1.2 | 268 | 20 42.4 | -0.7 | -0.6 | 302 |
| Jul | 11 | 2051 | 5.7 | RD | 334 | | | | | 18 12.6 | -1.2 | -3.0 | 332 | | | | |
| Jul | 16 | 2750 | 2.1 | DD | 30 | 17 28.4 | 1.1 | -2.7 | 145 | 17 09.4 | 0.2 | -1.1 | 103 | 17 04.2 | -0.2 | -0.1 | 73 |
| Jul | 16 | 2750 | 2.1 | RB | 31 | 18 00.6 | -0.9 | 0.9 | 216 | 18 06.8 | -0.5 | -0.6 | 260 | 18 00.3 | -0.1 | -1.3 | 291 |
| Jul | 16 | 2781 | 7.4 | DD | 33 | 22 03.0 | -1.8 | -2.4 | 119 | 22 14.1 | -2.5 | -0.3 | 87 | 22 27.1 | -2.7 | 1.5 | 37 |
| Jul | 17 | 2809 | 4.9 | DD | 35 | 4 12.0 | -1.1 | 1.0 | 95 | 4 27.1 | -0.6 | 0.8 | 93 | 4 35.2 | -0.2 | 0.9 | 76 |
| Jul | 17 | 2921 | 6.1 | DD | 43 | 20 47.0 | -1.3 | 1.1 | 38 | | | | | | | | |
| Jul | 17 | 2928 | 6.5 | DD | 43 | 22 05.5 | -1.7 | 2.0 | 32 | | | | | | | | |
| Jul | 18 | 2964 | 6.6 | DD | 47 | 7 02.6 | 0.2 | 1.5 | 57 | | | | | | | | |
| Jul | 19 | 3086 | 6.0 | DD | 56 | 2 32.1 | -2.9 | -0.3 | 100 | 3 00.0 | -2.9 | 0.1 | 98 | 3 12.1 | -2.2 | 0.9 | 81 |
| Jul | 19 | 3086 | 6.0 | RD | 57 | 3 27.6 | -0.2 | 3.3 | 190 | 3 53.0 | 0.2 | 3.2 | 189 | | | | |
| Jul | 20 | 3238 | 7.0 | DD | 69 | 6 22.4 | -0.9 | 1.6 | 64 | | | | | | | | |
| Jul | 21 | 3362 | 5.9 | DD | 78 | 3 15.9 | -3.1 | -0.7 | 97 | 3 44.9 | -3.7 | -0.4 | 100 | 3 56.4 | -2.9 | 0.7 | 82 |
| Jul | 21 | 3362 | 5.9 | RD | 79 | 4 07.2 | 0.0 | 3.3 | 180 | 4 32.1 | 0.4 | 3.7 | 175 | 4 59.9 | -0.3 | 3.0 | 191 |
| Jul | 23 | 89 | 6.5 | DD | 102 | 5 46.0 | -1.7 | 1.2 | 54 | 6 14.1 | -1.9 | 1.5 | 57 | | | | |
| Jul | 26 | 490 | 5.7 | DD | 138 | 3 37.4 | 0.3 | 1.0 | 24 | 3 44.5 | 0.4 | 1.8 | 17 | | | | |
| Aug | 05 | 1809 | 6.9 | DD | 283 | 21 38.0 | | | 186 | | | | | | | | |
| Aug | 10 | 2268 | 4.8 | DD | 332 | 2 04.0 | 0.3 | 1.0 | 270 | | | | | | | | |
| Aug | 10 | 2366 | 1.2 | DB | 337 | 13 56.5 | 0.1 | -1.2 | 97 | 13 54.0 | -0.9 | 0.1 | 61 | | | | |
| Aug | 10 | 2366 | 1.2 | RB | 338 | 14 54.6 | 0.0 | -1.7 | 299 | 14 35.2 | 0.7 | -3.0 | 338 | | | | |
| Aug | 15 | 3026 | 7.3 | DD | 27 | 2 05.1 | -1.4 | 1.5 | 68 | 2 28.4 | -1.0 | 1.4 | 69 | 2 43.4 | -0.6 | 1.6 | 55 |

| DATE | | ZC | MAG | PH | ELG | CAPE TOWN E 18.5 S 33.9 | | | | JOHANNESBURG E 28.1 S 26.2 | | | | HARARE E 31.0 S 17.8 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | D | | | | ° | TIME H | M | A m | B m | P ° | TIME H | M | A m | B m | P ° | TIME H | M | A m | B m | P ° |
| Aug | 16 | 3186 | 6.7 | DD | 39 | 5 | 32.9 | -0.2 | 1.8 | 48 | 5 | 46.5 | 0.1 | 1.7 | 43 | | | | | |
| Aug | 18 | 29 | 7.2 | DD | 70 | 23 | 41.8 | -0.4 | 1.3 | 24 | | | | | | | | | | |
| Aug | 19 | 51 | 7.2 | DD | 73 | 6 | 26.5 | -1.1 | 1.8 | 50 | | | | | | | | | | |
| Aug | 19 | 163 | 7.2 | DD | 80 | | | | | | | | | | | 22 | 12.6 | -0.6 | -0.6 | 88 |
| Aug | 21 | 329 | 7.1 | DD | 96 | 5 | 05.5 | -1.9 | 0.8 | 60 | 5 | 33.1 | -2.1 | 1.3 | 60 | | | | | |
| Aug | 22 | 448 | 7.1 | DD | 105 | | | | | | | | | | | 0 | 16.4 | 0.2 | 1.0 | 37 |
| Aug | 23 | 603 | 7.5 | DD | 118 | | | | | | | | | | | 1 | 29.8 | | | 150 |
| Aug | 24 | 788 | 6.9 | DD | 134 | 6 | 15.0 | -1.3 | 0.8 | 40 | | | | | | | | | | |
| Aug | 24 | 810 | 1.8 | DD | 137 | 11 | 18.2 | -1.0 | 0.7 | 104 | 11 | 37.1 | -1.3 | 1.6 | 68 | | | | | |
| Sep | 04 | 2084 | 6.5 | RD | 289 | 19 | 47.9 | -1.5 | 0.1 | 293 | 19 | 57.6 | -1.4 | -1.2 | 319 | | | | | |
| Sep | 07 | 2470 | 6.1 | RD | 322 | 19 | 34.9 | -2.4 | -0.7 | 263 | 20 | 01.1 | -2.6 | -0.2 | 285 | 19 | 58.6 | -3.7 | -3.2 | 319 |
| Sep | 13 | 3362 | 5.9 | DD | 28 | 20 | 44.4 | -1.0 | 0.4 | 52 | 20 | 57.6 | -1.1 | 1.4 | 36 | | | | | |
| Sep | 13 | 3367 | 6.4 | DD | 29 | 21 | 51.3 | -1.9 | -0.6 | 85 | 22 | 09.7 | -2.3 | 0.2 | 76 | 22 | 22.3 | -2.0 | 1.2 | 57 |
| Sep | 13 | 3367 | 6.4 | RD | 29 | 22 | 52.6 | -0.8 | 2.2 | 195 | 23 | 18.5 | -0.9 | 2.4 | 201 | | | | | |
| Sep | 17 | 266 | 5.7 | DD | 64 | 1 | 48.8 | -1.5 | 0.6 | 56 | 2 | 11.8 | -2.0 | 1.0 | 58 | 2 | 28.6 | -1.9 | 1.6 | 45 |
| Sep | 17 | 267 | 7.3 | DD | 65 | 1 | 58.4 | -1.4 | 0.8 | 50 | 2 | 21.9 | -1.8 | 1.2 | 52 | 2 | 40.2 | -1.7 | 1.9 | 39 |
| Sep | 20 | 731 | 5.9 | DD | 101 | 2 | 17.4 | | | 157 | 2 | 16.4 | | | 143 | 2 | 03.7 | -2.5 | -1.5 | 113 |
| Sep | 20 | 731 | 5.9 | RD | 101 | 2 | 25.4 | | | 171 | | | | | | | | | | |
| Sep | 22 | 1067 | 7.2 | DD | 128 | 4 | 42.9 | -1.3 | -0.5 | 70 | 4 | 58.1 | -2.0 | 0.5 | 58 | | | | | |
| Oct | 03 | 2298 | 5.1 | RD | 282 | 20 | 50.8 | 0.2 | 2.8 | 228 | 21 | 05.6 | 0.3 | 1.8 | 241 | | | | | |
| Oct | 05 | 2554 | 4.4 | RD | 303 | | | | | | | | | | | 18 | 19.0 | -2.8 | 0.2 | 273 |
| Oct | 13 | 177 | 7.1 | DD | 32 | 20 | 33.8 | | | 143 | 20 | 25.3 | -2.2 | -2.2 | 110 | 20 | 21.8 | -1.4 | -0.2 | 81 |
| Oct | 15 | 337 | 5.7 | DD | 46 | 0 | 29.8 | -0.9 | 1.2 | 31 | 0 | 52.0 | -1.4 | 1.7 | 32 | 1 | 14.3 | -1.1 | 2.9 | 15 |
| Oct | 15 | 341 | 6.8 | DD | 46 | 0 | 46.6 | -2.6 | -0.6 | 98 | 1 | 10.5 | -3.0 | -0.2 | 99 | 1 | 20.1 | -2.7 | 0.5 | 82 |
| Oct | 16 | 490 | 5.7 | DD | 59 | 2 | 10.5 | -2.0 | 0.2 | 75 | 2 | 35.6 | -2.3 | 0.8 | 71 | 2 | 51.8 | -2.3 | 1.5 | 54 |
| Oct | 17 | 673 | 6.6 | DD | 71 | 2 | 07.4 | -2.6 | -1.4 | 116 | 2 | 25.2 | -2.9 | -0.8 | 110 | 2 | 29.7 | -2.9 | -0.1 | 92 |
| Oct | 19 | 1013 | 6.9 | DD | 96 | | | | | | | | | | | 1 | 36.7 | -2.7 | -2.9 | 140 |
| Oct | 22 | 1395 | 6.3 | DD | 137 | 4 | 17.6 | -1.2 | -1.3 | 93 | 4 | 45.6 | -2.0 | -0.3 | 74 | | | | | |
| Oct | 31 | 2366 | 1.2 | DB | 258 | 11 | 01.3 | -0.6 | -2.1 | 125 | 11 | 01.1 | -1.8 | -0.7 | 87 | 11 | 17.1 | | | 41 |
| Oct | 31 | 2366 | 1.2 | RD | 259 | 12 | 17.6 | -1.9 | -1.0 | 274 | 12 | 21.3 | -1.6 | -2.6 | 313 | 11 | 47.2 | | | 2 |
| Nov | 01 | 2537 | 7.4 | DD | 274 | | | | | | 20 | 59.7 | | | 3 | | | | | |
| Nov | 03 | 2834 | 5.0 | RD | 295 | | | | | | 19 | 15.5 | -1.7 | 1.2 | 260 | 19 | 27.3 | -2.1 | 0.2 | 279 |
| Nov | 03 | 2835 | 7.1 | DD | 295 | | | | | | | | | | | 18 | 46.4 | | | 360 |
| Nov | 12 | 569 | 5.4 | DD | 39 | 22 | 08.5 | | | 129 | 22 | 16.7 | -3.3 | -2.5 | 124 | 22 | 12.1 | -2.5 | -0.8 | 100 |
| Nov | 12 | 569 | 5.4 | RD | 39 | 22 | 40.7 | | | 185 | | | | | | | | | | |
| Nov | 14 | 768 | 7.0 | DD | 54 | 3 | 58.8 | -2.0 | 0.8 | 79 | 4 | 30.1 | -2.4 | 2.3 | 49 | | | | | |
| Nov | 14 | 771 | 6.1 | DD | 55 | 4 | 43.0 | -1.1 | -0.2 | 130 | | | | | | | | | | |
| Nov | 16 | 1089 | 6.8 | DD | 78 | 0 | 43.9 | | | 19 | | | | | | | | | | |
| Nov | 16 | 1094 | 6.9 | DD | 78 | | | | | | | | | | | 1 | 33.1 | -2.6 | -3.2 | 151 |
| Nov | 18 | 1362 | 7.4 | DD | 106 | | | | | | | | | | | 4 | 44.0 | -2.4 | -1.5 | 126 |
| Nov | 19 | 1466 | 5.2 | DD | 119 | 4 | 49.2 | -1.5 | -2.1 | 142 | 4 | 53.8 | -2.4 | -1.3 | 114 | 4 | 55.2 | -3.7 | -0.2 | 87 |
| Nov | 29 | 2657 | 6.7 | DD | 254 | 20 | 40.6 | | | 15 | | | | | | | | | | |
| Nov | 30 | 2811 | 6.2 | DD | 264 | 20 | 30.9 | | | 354 | | | | | | | | | | |
| Nov | 30 | 2811 | 6.2 | RD | 265 | 20 | 46.9 | | | 323 | | | | | | | | | | |
| Dec | 12 | 1013 | 6.9 | DD | 45 | | | | | | 21 | 26.5 | -0.8 | -0.3 | 71 | 21 | 30.6 | -0.7 | 0.9 | 50 |
| Dec | 13 | 1157 | 6.0 | DD | 59 | | | | | | | | | | | 21 | 47.2 | -1.5 | -2.1 | 134 |
| Dec | 14 | 1168 | 6.8 | DD | 60 | 00 | 10.6 | -1.7 | -1.5 | 118 | 0 | 19.0 | -2.2 | -1.0 | 104 | 0 | 20.8 | -2.6 | -0.1 | 83 |
| Dec | 14 | 1170 | 3.7 | DD | 60 | | | | | | 0 | 41.4 | -2.6 | 0.6 | 62 | | | | | |
| Dec | 14 | 1295 | 6.5 | DD | 73 | | | | | | 23 | 59.8 | -1.7 | -2.4 | 144 | 23 | 47.7 | -1.8 | -1.7 | 122 |
| Dec | 14 | 1296 | 6.5 | DD | 73 | | | | | | 24 | 07.7 | -1.7 | -2.7 | 152 | 23 | 53.7 | -1.8 | -1.9 | 129 |
| Dec | 15 | 1305 | 7.0 | DD | 73 | | | | | | 1 | 03.9 | -1.9 | -2.0 | 137 | 00 | 55.6 | -2.3 | -1.4 | 116 |
| Dec | 16 | 1415 | 6.2 | | | | | | | | | | | | | 2 | 50.7 | -1.7 | -2.4 | 149 |
| Dec | 16 | 1420 | 6.6 | DD | 88 | 4 | 01.0 | -1.5 | -1.7 | 142 | 4 | 10.8 | -2.6 | -0.7 | 108 | 4 | 21.7 | -4.9 | 1.5 | 73 |
| Dec | 17 | 1525 | 5.9 | DD | 101 | | | | | | 3 | 50.4 | -1.8 | -1.9 | 137 | 3 | 43.3 | -2.7 | -1.3 | 112 |
| Dec | 20 | 1809 | 6.9 | DD | 140 | | | | | | | | | | | 4 | 04.6 | -0.6 | -2.9 | 159 |
| Dec | 20 | 1815 | 4.8 | DD | 140 | 4 | 55.0 | -2.3 | -1.0 | 86 | | | | | | | | | | |
| Dec | 31 | 3308 | 6.2 | RD | 277 | 21 | 54.2 | -0.1 | 1.5 | 231 | | | | | | | | | | |

# GRAZING OCCULTATIONS

When a star moves tangentially to the limb of the Moon, and is occulted for a very short period only - a few minutes, or even seconds - a grazing occultation is said to occur. Because the limb, as seen from the Earth, is in fact the outline of numerous mountains and valleys, there may be several disappearances and reappearances, which are not only fascinating to observe, but which may be accurately timed to yield valuable data on the relative positions of star and Moon as well as on the shape of the Moon. Some of these data cannot readily be obtained in any other way.

The maps on the following pages have been prepared by Hydrographic Dept, Tokyo to show the tracks of stars brighter than 7.5 magnitude which will graze the limb of the Moon when it is at a favourable elongation from the Sun and at least 10° above the observer's horizon (2° in the case of bright stars). Each track starts in the West at some arbitrary time given in the key and ends beyond the area of interest, except where the letters "A", "B" or "S" are given. "A" denotes that the Moon is at a low altitude, "B" that the bright limb interferes, and "S" that sunlight interferes. The tick marks along the tracks denote 5 minute intervals (at whole minutes), give the approximate time of the graze at places along the tracks.

The tracks as shown on the maps are approximate only. Since the observer's location is very critical, successful observations call for very accurate predictions. Such predictions, which include graphical representations of the probable profile of the Moon, are computed annually for a number of centres in Southern Africa. By plotting the predicted graze track on a reliable survey map (e.g. South African 1:50 000 series) it is usually possible to select a convenient site from where the graze may be observed. Ideally a team of observers would be stationed at intervals along a line running at right angles to the graze track - say, along a main road - each with his own telescope and timing equipment. Each observer will see a different sequence of events, the combined results forming an accurate picture of the limb of the Moon.

The equipment needed is similar to that used for ordinary (or "total") occultations, but must, of course, be portable. A 75 mm refractor is ideal for average events, but instruments with a larger aperture have often shown their superiority under difficult conditions. Timing is best carried out with a portable tape recorder and radio receiver tuned to ZUO or other time signal station.

It will be seen from the maps that many grazing occultations occur in regions which are rather far removed from the main cities, and which cannot easily be reached by teams of observers from one of the ASSA centres. It is worth remembering, however, that a team of many observers, while ideal, is by no means essential; that a single good observer is worth more than many unsuccessful ones, and that one good observation is worth infinitely more than no observation at all.

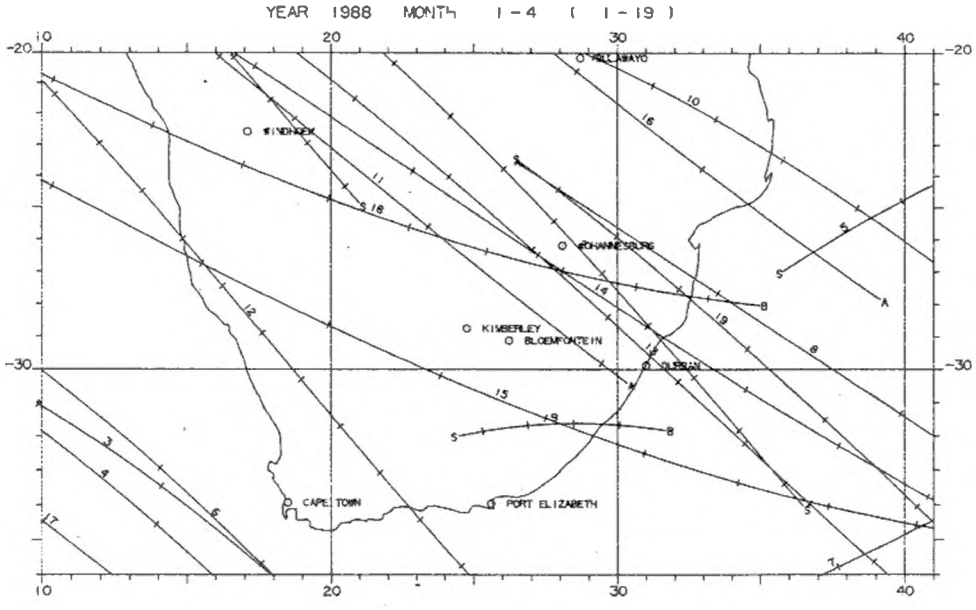
Interested observers - especially those living in the more distant regions - who wish to be informed of favourable grazes occurring in their neighbourhood, are therefore invited to contact the co-ordinator for grazing occultations:
M.D. Overbeek, P.O. Box 212, Edenvale, 1610. Tel: (011) 535 447.

EXPLANATION OF COLUMN HEADINGS IN TABLES:

| | | |
|---|---|---|
| SEQ | : | Sequential number in the year. The same number is attached to the corresponding track on the map. |
| NZC NO | : | Zodiacal Catalogue number of the star. |
| MAG | : | Magnitude of the star. |
| MON, DAY, H, M, S | : | Month, day, hour, minute and second in UT for the west end of the track. |
| SUNLIT (%) | : | Percent of the Moon sunlit (a minus sign indicates a waning Moon). |
| Limit | : | Whether the track is the north (N) or the south (S) limits of the occultation. |
| | | (A) denotes that the Moon is at a low altitude. |
| | | (B) denotes that the star is occultated at bright limb. |
| | | S) denotes that the daylight interferes. |

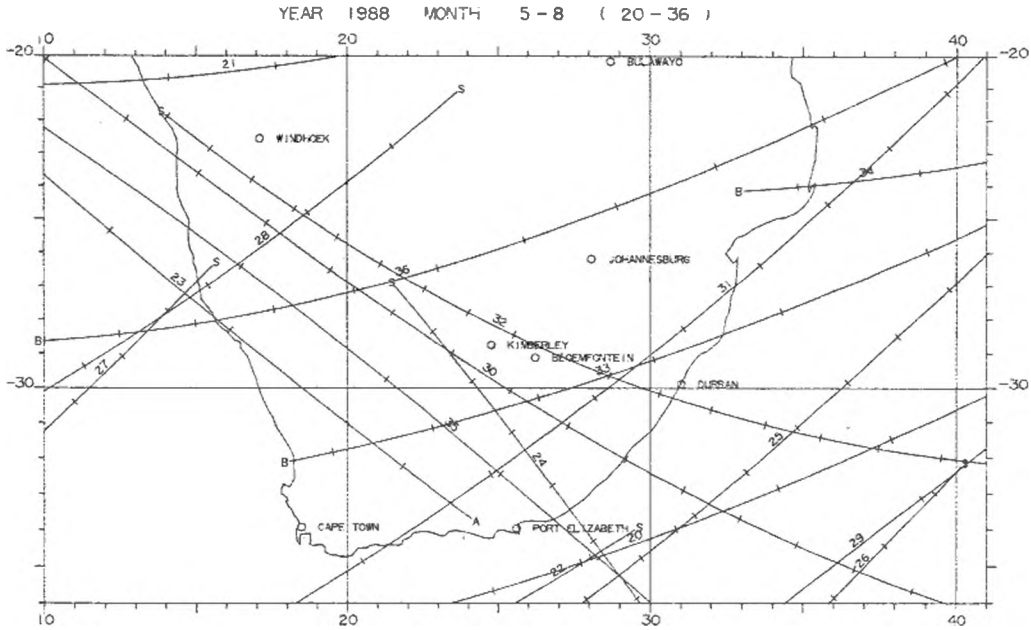
The map gives the graze tracks or the limits of occultations. Along each track on the map, tick marks are given for the points corresponding to the multiples of five minutes of every hour, while the prediction for the west end of each track is shown on the computer list, e.g. if the time for the west end of a track is 5h 43m 21s, the tick marks proceeding eastward correspond to 5h 45m 00s, 5h 50m 00s, 5h 55m 00s etc.

# GRAZING OCCULTATIONS



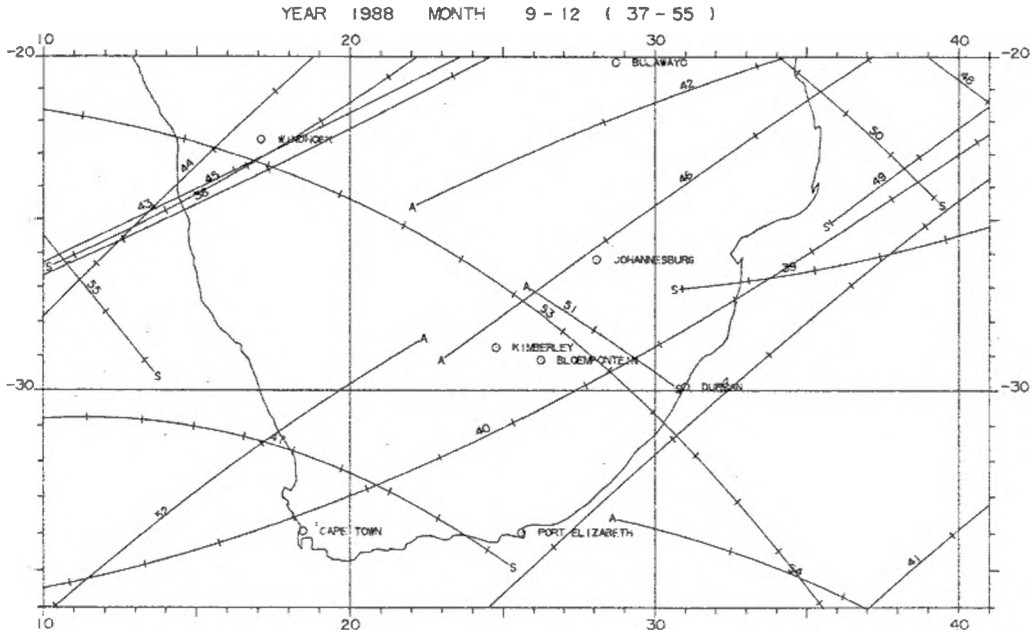

| SEQ | NZC NO | MAG | MON | DAY | SAST H | M | S | SUNLIT(%) | LIMIT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1887 | 6.44 | 1 | 12 | 5 | 14 | 31.94 | -51.37 | S | ( ) | (S) |
| 2 | 1992 | 7.22 | 1 | 13 | 3 | 24 | 5.40 | -41.74 | S | ( ) | (S) |
| 3 | 2099 | 7.00 | 1 | 14 | 2 | 31 | 54.44 | -32.05 | S | (A) | ( ) |
| 4 | 2237 | 5.06 | 1 | 15 | 3 | 36 | 21.78 | -22.02 | S | ( ) | ( ) |
| 5 | 3307 | 4.89 | 1 | 21 | 18 | 45 | 10.07 | 8.70 | S | (S) | ( ) |
| 6 | 2183 | 5.71 | 2 | 11 | 1 | 45 | 22.52 | -49.04 | S | ( ) | ( ) |
| 7 | 2366 | 1.22 | 2 | 12 | 11 | 4 | 17.62 | -35.66 | N | ( ) | ( ) |
| 8 | 2660 | 6.07 | 2 | 14 | 2 | 56 | 29.37 | -17.84 | S | (A) | ( ) |
| 9 | 788 | 6.89 | 2 | 25 | 19 | 27 | 21.19 | 62.12 | S | (S) | (B) |
| 10 | 948 | 4.45 | 2 | 26 | 20 | 54 | 17.22 | 71.60 | N | ( ) | ( ) |
| 11 | 1103 | 5.87 | 2 | 25 | 0 | 19 | 45.11 | 80.60 | N | ( ) | (A) |
| 12 | 1925 | 1.21 | 3 | 7 | 1 | 13 | 31.78 | -89.88 | N | ( ) | ( ) |
| 13 | 2273 | 5.93 | 3 | 10 | 0 | 42 | 21.80 | -65.23 | S | ( ) | ( ) |
| 14 | 2586 | 5.95 | 3 | 12 | 2 | 14 | 28.65 | -43.08 | S | ( ) | ( ) |
| 15 | 2784 | 3.42 | 3 | 13 | 4 | 9 | 40.71 | -31.33 | S | ( ) | ( ) |
| 16 | 1181 | 6.82 | 3 | 26 | 22 | 48 | 55.95 | 65.21 | N | ( ) | (A) |
| 17 | 2536 | 7.41 | 4 | 8 | 0 | 34 | 56.64 | -69.49 | S | ( ) | ( ) |
| 18 | 2727 | 7.24 | 4 | 9 | 3 | 9 | 25.32 | -57.78 | S | ( ) | (B) |
| 19 | 1119 | 5.71 | 4 | 22 | 18 | 16 | 37.54 | 37.73 | N | (S) | ( ) |

# GRAZING OCCULTATIONS




| SEQ | NZC NO | MAG | MON | DAY | H | M | S | SUNLIT(%) | LIMIT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 2366 | 1.22 | 5 | 4 | 5 | 7 | 20.96 | -94.89 | N | ( ) | ( ) |
| 21 | 3295 | 7.02 | 5 | 10 | 4 | 10 | 6.05 | -37.47 | N | ( ) | ( ) |
| 22 | 3431 | 6.60 | 5 | 11 | 6 | 10 | 7.40 | -26.09 | N | ( ) | (S) |
| 23 | 1206 | 5.88 | 5 | 20 | 20 | 1 | 38.78 | 22.80 | N | ( ) | (A) |
| 24 | 1609 | 4.66 | 5 | 24 | 18 | 0 | 13.49 | 59.19 | N | (S) | ( ) |
| 25 | 3113 | 5.39 | 6 | 5 | 4 | 49 | 29.54 | -73.76 | N | ( ) | ( ) |
| 26 | 3262 | 7.06 | 6 | 6 | 5 | 34 | 25.77 | -62.71 | N | ( ) | (S) |
| 27 | 3267 | 7.21 | 6 | 6 | 6 | 56 | 43.35 | -62.02 | N | ( ) | (S) |
| 28 | 244 | 6.93 | 6 | 10 | 6 | 13 | 35.89 | -18.85 | N | ( ) | (S) |
| 29 | 810 | 1.78 | 6 | 14 | 7 | 48 | 4.74 | -0.25 | S | ( ) | ( ) |
| 30 | 2366 | 1.22 | 8 | 27 | 19 | 49 | 48.18 | 94.51 | N | ( ) | ( ) |
| 31 | 197 | 7.04 | 7 | 7 | 3 | 42 | 49.06 | -42.69 | N | ( ) | ( ) |
| 32 | 2157 | 6.11 | 7 | 23 | 19 | 4 | 40.74 | 66.27 | N | (S) | ( ) |
| 33 | 2312 | 5.64 | 7 | 24 | 23 | 27 | 43.47 | 76.87 | S | (B) | ( ) |
| 34 | 2109 | 6.11 | 8 | 19 | 20 | 2 | 35.87 | 40.18 | S | (B) | ( ) |
| 35 | 2366 | 1.22 | 8 | 21 | 14 | 0 | 35.43 | 59.48 | N | ( ) | ( ) |
| 36 | 2397 | 6.54 | 8 | 21 | 21 | 28 | 36.48 | 61.66 | S | (B) | ( ) |

# GRAZING OCCULTATIONS




| SEQ | NZC NO | MAG | MON | DAY | H | M | S | SUNLIT(Z) | LIMIT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | 674 | 6.64 | 9 | 3 | 3 | 22 | 45.89 | -50.52 | N | ( ) | ( ) |
| 38 | 2354 | 7.34 | 9 | 17 | 22 | 1 | 52.85 | 35.77 | S | ( ) | ( ) |
| 39 | 2645 | 6.04 | 9 | 19 | 18 | 14 | 46.86 | 55.83 | S | (S) | ( ) |
| 40 | 2660 | 6.07 | 9 | 19 | 20 | 13 | 11.48 | 56.63 | S | ( ) | ( ) |
| 41 | 2852 | 7.36 | 9 | 21 | 0 | 27 | 17.28 | 68.78 | S | ( ) | ( ) |
| 42 | 1206 | 5.88 | 10 | 4 | 3 | 21 | 4.01 | -36.22 | N | (A) | ( ) |
| 43 | 2312 | 5.64 | 10 | 14 | 20 | 40 | 1.64 | 13.65 | S | ( ) | ( ) |
| 44 | 3084 | 6.78 | 10 | 19 | 22 | 50 | 13.79 | 64.37 | S | ( ) | ( ) |
| 45 | 3353 | 3.84 | 10 | 21 | 19 | 38 | 54.41 | 83.98 | S | (S) | ( ) |
| 46 | 850 | 6.00 | 10 | 28 | 23 | 46 | 25.45 | -82.18 | N | (A) | ( ) |
| 47 | 1169 | 5.40 | 10 | 31 | 4 | 21 | 13.01 | -62.60 | S | ( ) | (S) |
| 48 | 2366 | 1.22 | 11 | 11 | 8 | 26 | 53.08 | 3.33 | N | ( ) | ( ) |
| 49 | 2723 | 6.70 | 11 | 13 | 18 | 24 | 57.48 | 16.92 | s | (S) | ( ) |
| 50 | 1735 | 6.45 | 12 | 3 | 3 | 43 | 8.27 | -33.07 | S | ( ) | (S) |
| 51 | 2157 | 6.11 | 12 | 7 | 4 | 18 | 40.81 | - 4.78 | S | (A) | (S) |
| 52 | 2864 | 4.66 | 12 | 11 | 21 | 9 | 55.77 | 7.48 | S | ( ) | (A) |
| 53 | 1600 | 5.08 | 12 | 29 | 1 | 13 | 19.84 | -69.94 | S | ( ) | ( ) |
| 54 | 1592 | 6.83 | 12 | 30 | 0 | 1 | 18.56 | -61.56 | S | (A) | ( ) |
| 55 | 1792 | 7.14 | 12 | 31 | 5 | 26 | 48.69 | -50.38 | S | ( ) | (S) |

# TIME SYSTEMS

This section is intended to serve established amateurs and profession astronomers - i.e. those having some knowledge of time and coordinate systems. Space in the booklet does not permit full explanation, which in any case would appear complicated to the layman.

## TIME SIGNALS FROM RADIO STATION ZUO

Radio signals of mean solar time are generated by the Precise Physical Measurements Division of the National Physical Research Laboratory in Pretoria. They are broadcast by the Post Office, the 2.5 and 5 MHz signals from Olifantsfontein, and the 100 MHz signals from Johannesburg.

| Carrier Frequency | Radiated Power | Time of Transmission |
|---|---|---|
| 2,5 MHz | 4 Kw | 2000 - 0600 SAST |
| 5 MHz | 4 Kw | Continuous |

The signals consist of one pulse per second, each pulse consisting of 5 cycles of 1000 Hz tone. The first pulse in every minute is lengthened to 500 milliseconds. Morse code announcements are made during the minute preceding every fifth minute. They consist of the call sign ZUO (repeated 3 times) and the Universal Time (formerly known as Greenwich Mean Time) at the next minute. (A special coding indicating UT1 minus UTC is also indicated in the first 15 seconds of the minute by slightly lengthened second pulses.)

## SOUTH AFRICAN STANDARD TIME

South African Standard Time (as in everyday use) is mean solar time on the 30° East meridian (which runs east of Johannesburg and just west of Durban) and is exactly 2 hours ahead of Universal Time.

## TIME OF SUN'S TRANSIT OVER 30° MERIDIAN

The table below gives the SAST when the Sun transits the 30° meridian - and a sundial on that meridian reads noon.

| | | h | m | s |
|---|---|---|---|---|
| Jan | 1 | 12 | 03 | 14 |
| | 11 | 12 | 07 | 38 |
| | 21 | 12 | 11 | 08 |
| | 31 | 12 | 13 | 22 |
| Feb | 10 | 12 | 14 | 14 |
| | 20 | 12 | 13 | 50 |
| Mar | 2 | 12 | 12 | 07 |
| | 12 | 12 | 09 | 43 |
| | 22 | 12 | 06 | 51 |
| Apr | 1 | 12 | 03 | 49 |
| | 11 | 12 | 00 | 59 |
| | 21 | 11 | 58 | 38 |
| May | 1 | 11 | 57 | 03 |
| May | 11 | 11 | 56 | 20 |
| | 21 | 11 | 56 | 34 |
| | 31 | 11 | 57 | 39 |
| Jun | 10 | 11 | 59 | 25 |
| | 20 | 12 | 01 | 33 |
| | 30 | 12 | 03 | 39 |
| Jul | 10 | 12 | 05 | 21 |
| | 20 | 12 | 06 | 20 |
| | 30 | 12 | 06 | 23 |
| Aug | 9 | 12 | 05 | 26 |
| | 19 | 12 | 03 | 32 |
| | 29 | 12 | 00 | 50 |
| Sep | 8 | 11 | 57 | 35 |
| Sep | 18 | 11 | 54 | 04 |
| | 28 | 11 | 50 | 34 |
| Oct | 8 | 11 | 47 | 29 |
| | 18 | 11 | 45 | 08 |
| | 28 | 11 | 43 | 47 |
| Nov | 7 | 11 | 43 | 42 |
| | 17 | 11 | 45 | 02 |
| | 27 | 11 | 47 | 42 |
| Dec | 7 | 11 | 51 | 34 |
| | 17 | 11 | 56 | 14 |
| | 27 | 12 | 01 | 11 |
| | 31 | 12 | 03 | 07 |

## SIDEREAL TIME ON THE 30° MERIDIAN

| | At 0 hrs SAST | At 21 hrs SAST | | At 0 hrs SAST | At 21 hrs SAST | | At 0 hrs SAST | At 21 hrs SAST |
|---|---|---|---|---|---|---|---|---|
| | h m | h m | | h m | h m | | h m | h m |
| Jan 1 | 6 39 | 3 43 | May 11 | 15 16 | 12 19 | Sep 18 | 23 48 | 20 52 |
| 11 | 7 18 | 4 22 | 21 | 15 55 | 12 59 | 28 | 0 28 | 21 31 |
| 21 | 7 58 | 5 02 | 31 | 16 34 | 13 38 | Oct 8 | 1 07 | 22 11 |
| 31 | 8 37 | 5 41 | Jun 10 | 17 14 | 14 17 | 18 | 1 46 | 22 50 |
| Feb 10 | 9 17 | 6 20 | 20 | 17 53 | 14 57 | 28 | 2 26 | 23 29 |
| 20 | 9 56 | 7 00 | 30 | 18 33 | 15 36 | Nov 7 | 3 05 | 0 09 |
| Mar 2 | 10 40 | 7 43 | Jul 10 | 19 12 | 16 16 | 17 | 3 45 | 0 48 |
| 12 | 11 19 | 8 22 | 20 | 19 52 | 16 55 | 27 | 4 24 | 1 28 |
| 22 | 11 59 | 9 02 | 30 | 20 31 | 17 35 | Dec 7 | 5 04 | 2 07 |
| Apr 1 | 12 38 | 9 41 | Aug 9 | 21 10 | 18 14 | 17 | 5 43 | 2 47 |
| 11 | 13 17 | 10 21 | 19 | 21 50 | 18 53 | 27 | 6 22 | 3 26 |
| 21 | 13 57 | 11 00 | 29 | 22 29 | 19 33 | 31 | 6 38 | 3 42 |
| May 1 | 14 36 | 11 40 | Sep 8 | 23 09 | 20 12 | | | |

## CORRECTION FOR PLACES NOT ON THE 30° MERIDIAN

Approximate longitude corrections from the 30° East Meridian are provided below. To find time of Sun's transit over local meridian, apply the longitude corrections to the data in the table on page 43.

To find the sidereal times at SAST 0 hrs and SAST 21 hrs apply the corrections with the sign reversed to the data in the table.

| | | | | | |
|---|---|---|---|---|---|
| Bloemfontein | +15$^m$ | East London | + 8$^m$ | Port Elizabeth | +18$^m$ |
| Bulawayo | + 6$^m$ | Grahamstown | +14$^m$ | Pretoria | + 7$^m$ |
| Cape Town | +46$^m$ | Johannesburg | + 8$^m$ | Harare | - 4$^m$ |
| Durban | - 4$^m$ | Kimberley | +21$^m$ | Windhoek | +52$^m$ |

## TELESCOPE SETTING

When a telescope equipped with setting circles is aimed on the meridian, its R.A. circle should read the sidereal time. Thus one can calculate the sidereal time and then set the circle, but it is usually simpler to aim the telescope at one of the well known stars given below and then to adjust the R.A. circle.

## A LIST OF BRIGHT STARS FOR CHECKING TELESCOPE CIRCLES

| Star | R.A. | Dec | Mag. | Sp. | Star | R.A. | Dec. | Mag. | Sp. |
|---|---|---|---|---|---|---|---|---|---|
| Achernar | 1$^h$37$^m$,3 | -57°18' | 0,6 | B5 | Procyon | 7$^h$38$^m$,7 | + 5°15' | 0,5 | F5 |
| Aldebaran | 4 35,3 | +16 29 | 1,1 | K5 | Regulus | 10 07,8 | +12 01 | 1,3 | B8 |
| Rigel | 5 14,0 | - 8 13 | 0,3 | B8 | Spica | 13 24,6 | -11,06 | 1,2 | B2 |
| Betelgeuse | 5 54,5 | + 7 24 | 0,4 | M0 | Arcturus | 14 15,1 | +19,15 | 0,2 | K0 |
| Canopus | 6 23,7 | -52,41 | -0,9 | F0 | Antares | 16 28,7 | -26,24 | 1,2 | M1 |
| Sirius | 6 44,6 | -16,42 | -1,6 | A0 | Altair | 19 50,2 | + 8,50 | 0,9 | A5 |

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| | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 | 2447 |
| 1 | 162 | 193 | 222 | 253 | 283 | 314 | 344 | 375 | 406 | 436 | 467 | 497 |
| 2 | 163 | 194 | 223 | 254 | 284 | 315 | 345 | 376 | 407 | 437 | 468 | 498 |
| 3 | 164 | 195 | 224 | 255 | 285 | 316 | 346 | 377 | 408 | 438 | 469 | 499 |
| 4 | 165 | 196 | 225 | 256 | 286 | 317 | 347 | 378 | 409 | 439 | 470 | 500 |
| 5 | 166 | 197 | 226 | 257 | 287 | 318 | 348 | 379 | 410 | 440 | 471 | 501 |
| 6 | 167 | 198 | 227 | 258 | 288 | 319 | 349 | 380 | 411 | 441 | 472 | 502 |
| 7 | 168 | 199 | 228 | 259 | 289 | 320 | 350 | 381 | 412 | 442 | 473 | 503 |
| 8 | 169 | 200 | 229 | 260 | 290 | 321 | 351 | 382 | 413 | 443 | 474 | 504 |
| 9 | 170 | 201 | 230 | 261 | 291 | 322 | 352 | 383 | 414 | 444 | 475 | 505 |
| 10 | 171 | 202 | 231 | 262 | 292 | 323 | 353 | 384 | 415 | 445 | 476 | 506 |
| 11 | 172 | 203 | 232 | 263 | 293 | 324 | 354 | 385 | 416 | 446 | 477 | 507 |
| 12 | 173 | 204 | 233 | 264 | 294 | 325 | 355 | 386 | 417 | 447 | 478 | 508 |
| 13 | 174 | 205 | 234 | 265 | 295 | 326 | 356 | 387 | 418 | 448 | 479 | 509 |
| 14 | 175 | 206 | 235 | 266 | 296 | 327 | 357 | 388 | 419 | 449 | 480 | 510 |
| 15 | 176 | 207 | 236 | 267 | 297 | 328 | 358 | 389 | 420 | 450 | 481 | 511 |
| 16 | 177 | 208 | 237 | 268 | 298 | 329 | 359 | 390 | 421 | 451 | 482 | 512 |
| 17 | 178 | 209 | 238 | 269 | 299 | 330 | 360 | 391 | 422 | 452 | 483 | 513 |
| 18 | 179 | 210 | 239 | 270 | 300 | 331 | 361 | 392 | 423 | 453 | 484 | 514 |
| 19 | 180 | 211 | 240 | 271 | 301 | 332 | 362 | 393 | 424 | 454 | 485 | 515 |
| 20 | 181 | 212 | 241 | 272 | 302 | 333 | 363 | 394 | 425 | 455 | 486 | 516 |
| 21 | 182 | 213 | 242 | 273 | 303 | 334 | 364 | 395 | 426 | 456 | 487 | 517 |
| 22 | 183 | 214 | 243 | 274 | 304 | 335 | 365 | 396 | 427 | 457 | 488 | 518 |
| 23 | 184 | 215 | 244 | 275 | 305 | 336 | 366 | 397 | 428 | 458 | 489 | 519 |
| 24 | 185 | 216 | 245 | 276 | 306 | 337 | 367 | 398 | 429 | 459 | 490 | 520 |
| 25 | 186 | 217 | 246 | 277 | 307 | 338 | 368 | 399 | 430 | 460 | 491 | 521 |
| 26 | 187 | 218 | 247 | 278 | 308 | 339 | 369 | 400 | 431 | 461 | 492 | 522 |
| 27 | 188 | 219 | 248 | 279 | 309 | 340 | 370 | 401 | 432 | 462 | 493 | 523 |
| 28 | 189 | 220 | 249 | 280 | 310 | 341 | 371 | 402 | 433 | 463 | 494 | 524 |
| 29 | 190 | 221 | 250 | 281 | 311 | 342 | 372 | 403 | 434 | 464 | 495 | 525 |
| 30 | 191 | | 251 | 282 | 312 | 343 | 373 | 404 | 435 | 465 | 496 | 526 |
| 31 | 192 | | 252 | | 313 | | 374 | 405 | | 466 | | 527 |

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