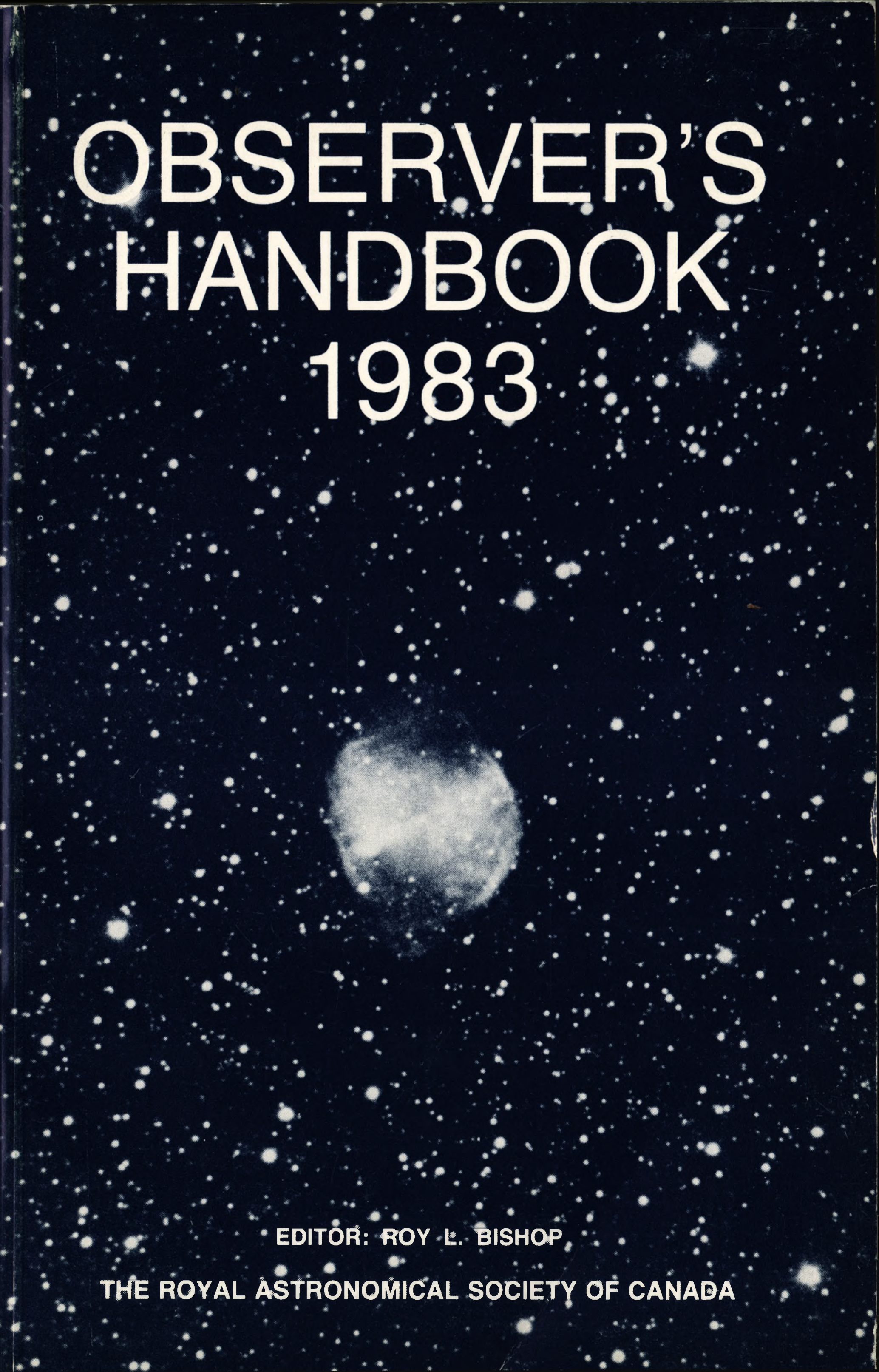
OBSERVER'S HANDBOOK 1983



EDITOR: ROY L. BISHOP

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

CONTRIBUTORS AND ADVISORS

ALAN H. BATTEN, Dominion Astrophysical Observatory, Victoria, BC, Canada V8X 3X3 (The Nearest Stars).

ROY L. BISHOP, Department of Physics, Acadia University, Wolfville, NS, Canada B0P 1X0 (Editor).

TERENCE DICKINSON, R.R. 3, Odessa, ON, Canada K0H 2H0, (The Planets).

DAVID W. DUNHAM, International Occultation Timing Association, P.O. Box 7488, Silver Spring, MD 20907, U.S.A. (Planetary Appulses and Occultations).

ALAN DYER, Queen Elizabeth Planetarium, 10004-104 Ave., Edmonton, AB, Canada T5J 0K1 (Messier Catalogue, Deep-Sky Objects).

MARIE FIDLER, Royal Astronomical Society of Canada, 124 Merton St., Toronto, ON, Canada M4S 2Z2 (Observatories and Planetaria).

VICTOR GAIZAUSKAS, Herzberg Institute of Astrophysics, National Research Council, Ottawa, ON, Canada K1A 0R6 (Solar Activity).

JOHN A. GALT, Dominion Radio Astrophysical Observatory, Penticton, BC, Canada V2A 6K3 (Radio Sources).

IAN HALLIDAY, Herzberg Institute of Astrophysics, National Research Council, Ottawa, ON, Canada K1A 0R6 (Miscellaneous Astronomical Data).

HELEN S. HOGG, David Dunlap Observatory, University of Toronto, Richmond Hill, ON, Canada L4C 4Y6 (Foreword).

YOSHIO KUBO, International Lunar Occultation Centre, Astronomical Division, Hydrographic Department, Tsukiji-5, Chuo-ku, Tokyo, 104 Japan (Total and Grazing Lunar Occultations).

DONALD A. MACRAE, David Dunlap Observatory, University of Toronto, Richmond Hill, ON, Canada L4C 4Y6 (The Brightest Stars).

BARRY F. MADORE, David Dunlap Observatory, University of Toronto, Richmond Hill, ON, Canada L4C 4Y6 (Galaxies).

BRIAN G. MARSDEN, Smithsonian Astrophysical Observatory, Cambridge, MA, U.S.A. 02138 (Comets, Minor Planets).

JANET A. MATTEI, American Association of Variable Star Observers, 187 Concord Ave., Cambridge, MA, U.S.A. 02138 (Variable Stars).

PETER M. MILLMAN, Herzberg Institute of Astrophysics, National Research Council, Ottawa, ON, Canada K1A 0R6 (Meteors, Fireballs and Meteorites).

ANTHONY F. J. MOFFAT, Département de Physique, Université de Montréal, Montréal, PQ, Canada H3C 3J7 (Star Clusters).

JOHN R. PERCY, Erindale College and Department of Astronomy, University of Toronto, Toronto, ON, Canada M5S 1A7 (Sky Month by Month).

RENE RACINE, Director, Canada-France-Hawaii Telescope, P.O. Box 1597, Kamuela, Hawaii, U.S.A. 96743 (Galactic Nebulae).

P. BLYTH ROBERTSON, Earth Physics Branch, Energy, Mines and Resources Canada, Ottawa, ON, Canada K1A 0Y3 (Meteorite Impact Sites).

GORDON E. TAYLOR, H.M. Nautical Almanac Office, Royal Greenwich Observatory, Hailsham, Sussex, England BN27 1RP (Planetary Appulses and Occultations).

JOSEPH F. VEVERKA, Department of Astronomy, Cornell University, Ithaca, NY, U.S.A. 14853 (Planetary Satellites).

CHARLES E. WORLEY, U.S. Naval Observatory, Washington, DC, U.S.A. 20390 (Double Stars).

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OBSERVER'S HANDBOOK 1983

EDITOR
ROY L. BISHOP

SEVENTY-FIFTH YEAR OF PUBLICATION

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THE FIRST OBSERVER'S HANDBOOK OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA, 1907

The first issue of this HANDBOOK appeared under the title "The CANADIAN ASTRONOMICAL HANDBOOK for 1907". In 1911 the name became "THE OBSERVER'S HANDBOOK". The first HANDBOOK was small, consisting of 108 pages 5 by $6\frac{1}{2}$ inches in size. (By comparison the 1983 HANDBOOK has 176 pages, $5\frac{1}{2}$ by $8\frac{1}{2}$ inches.) In the "PREFACE" the distinguished Canadian astronomer, Dr. C. A. Chant, editor of both the HANDBOOK and the Journal of the Royal Astronomical Society of Canada, stated the purpose of the HANDBOOK as follows:

"For a number of years, in several foreign countries astronomical annals, designed chiefly for the use of amateur observers, have been regularly published, and have been very effective in extending the interest in Astronomy. The present HANDBOOK aims to do a similar service for Canada.

"Our country is still young and, as we might expect, the advance of Astronomy has not been so marked as in some other branches of knowledge; and yet in every part of the land are to be found those who have a profound interest in the celestial bodies above and in the natural phenomena about them.

"The Royal Astronomical Society of Canada aims to unite in a common bond of interest all such students of nature. The object of the present work is to furnish, in a form understood by all, concise information regarding the chief astronomical phenomena to be observed in 1907; and it is hoped that the work will find its way into the hands of many who will add their names to the Society's roll of membership. Anyone interested in Astronomy, Astronomical Physics or allied subjects is eligible for membership.

"In preparing the work the Editor has received valued assistance from several members of the Society". Chant then names the contributors.

A few sections in this first HANDBOOK have vanished with the years. There is no longer need to give geographical positions of certain points in Canada such as the Astronomical Station in Calgary which was "1 chain 56 links south of centre line of C.P.R. main line, and 2 chains 49 links north of north-east corner of lot No. 11, in block 69".

Most of the sections in the 1907 HANDBOOK are still appearing in the 1983 edition, though in some cases with altered form or different title. The large section "MONTHLY PREDICTIONS FOR 1907" is now "THE SKY MONTH BY MONTH". In 1907 this section included a transit of Mercury on November 14, partly visible in Canada. Two relatively long articles appear, "OBSERVING THE SUN, MOON AND PLANETS" by Andrew Elvins of Toronto, and "THE STUDY OF VARIABLE STARS" by J. Miller Barr of St. Catherines, Ontario. "RADIANTS OF THE CHIEF METEORIC SHOWERS" are tabulated by W. F. Denning of Bristol, England. Some general Society business is included, "EXTRACTS FROM THE BY-LAWS", and "OFFICERS FOR 1907".

From these early beginnings, with its interest then chiefly in Canada, the Handbook has now evolved to a state useful over much of the North American continent, with important material from eight contributors outside Canada. With a broad and firm base like this, we foresee a long series of OBSERVER'S HANDBOOKS of the Royal Astronomical Society of Canada.

HELEN SAWYER HOGG

EDITOR'S COMMENTS

The appearance of the seventy-fifth edition of an annual publication is a notable event. Except for two years (1909 and 1910), The Royal Astronomical Society of Canada has produced an astronomical handbook for every year since 1907. In her foreword, Helen Hogg refers to some features of the first edition. John Percy, past-editor of the OBSERVER'S HANDBOOK, is preparing an article on the history of the HANDBOOK for the December 1982 issue of the Society's *Journal*.

On behalf of The Royal Astronomical Society of Canada, I wish to thank the several contributors to the 1983 OBSERVER'S HANDBOOK (see the inside front cover). In particular, I wish to welcome Yoshio Kubo (lunar occultations) and Barry Madore (galaxies) as new contributors. They replace Leslie Morrison (Royal Greenwich Observatory) and Sidney van den Bergh (Dominion Astrophysical Observatory), respectively, both of whom have provided valuable service over several years.

Some revisions and additions have been made for 1983. The precession table, a feature of the HANDBOOK for many years, has been reinstated in recognition of its convenience. Precession formulae have been retained for those who prefer computation. Victor Gaizauskas has expanded his section to include the aurora. A simplified, graphical method has been devised for the determination of longitude corrections to moonrise/set times. On David Dunham's suggestion, the number and location of U.S. standard stations for lunar occultations have been revised. The magnitude limit for *total* lunar occultation predictions has been changed from 7.5 to 6.0. A diagram of the main ring features of Saturn has been prepared (data courtesy of the Jet Propulsion Laboratory of the California Institute of Technology). The spacecraft *Voyager 1* and *Voyager 2* have revealed many satellites as worlds in their own right; a pronunciation guide to their names is now included. To facilitate observations of occultations by minor planets, updated predictions may now be obtained by telephone in both Canada and the United States. Peter Millman has expanded the section on meteors. A new section, Interplanetary Dust, has been prepared, including reference to the zodiacal light and the *gegenschein*. At Donald MacRae's request, Robert Garrison (David Dunlap Observatory) has provided revised spectral types for forty stars in the table: The Brightest Stars. Janet Mattei has provided directions for the beginning observer of variable stars. Barry Madore has completely revised the section on galaxies.

In addition to the regular contributors, several other individuals have provided ideas, information, assistance, and/or constructive criticism. In particular I wish to thank Randall Brooks (Halifax, N.S.), Leo Enright (Sharbot Lake, Ont.), David Levy (Tucson, Ariz.), Warren Morrison (Peterborough, Ont.), Kenneth Rose (Bryn Athyn, Pa.), and B. Franklyn Shinn (Nanaimo, B.C.).

As always, the R.A.S.C. is indebted to the Nautical Almanac Office (U.S. Naval Observatory) and its Director, P. K. Seidelmann, for pre-publication material from *The Astronomical Almanac*. Without this support it would not be possible to publish the OBSERVER'S HANDBOOK on time. Also, I wish to acknowledge the invaluable support of Rosemary Freeman, Executive-Secretary of the R.A.S.C. Through its Department of Physics, Acadia University (Wolfville, Nova Scotia) provides substantial direct and indirect support toward the preparation of the HANDBOOK.

Comments and suggestions should be directed to the Editor (address on inside front cover). Good observing *quo ducit Urania*!

ROY L. BISHOP, EDITOR

COVER PHOTOGRAPH

The Dumbbell Nebula in Vulpecula (M27). Photograph by Jack Newton (Victoria Centre, R.A.S.C.). Eighteen minute cold camera exposure on Ektachrome 400 with Mr. Newton's 406 mm, f5 reflector. This "planetary" nebula is set against the rich star fields of the Cygnus arm of our galaxy. It is a shell of gas blown off several thousand years ago by the star at its centre. This star, in the final stages of its life-cycle, is extremely hot ($\sim 10^5$ K). Thus it radiates strongly in the ultraviolet which, in turn, causes the shell of gas to fluoresce. Still expanding, the nebula is now a few light-years in diameter. Here we see material, having been enriched in heavier elements by a stellar nuclear furnace, being returned to the interstellar medium.

REPORTING OF SIGNIFICANT ASTRONOMICAL DISCOVERIES

Professional and amateur astronomers who wish to report a possible discovery (e.g. a new comet, nova, or supernova) should send their report to Dr. Brian Marsden of the International Astronomical Union Central Bureau for Astronomical Telegrams, 60 Garden St., Cambridge, MA 02138, U.S.A. TWX/telex/telegraphic communication is preferred (TWX number: 710-320-6842 ASTROGRAM CAM), although 30 second messages will be recorded by telephone (1-617-864-5758). Messages are accepted at any time. Inexperienced observers are advised to have their observation checked, if at all possible, before contacting the Central Bureau. For an account of the history of the Bureau and its work today, see "Life in the Hot Seat", *Sky and Telescope*, August 1980, p. 92.

AN INVITATION FOR MEMBERSHIP IN THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The history of The Royal Astronomical Society of Canada goes back to the middle of the nineteenth century. The Society was incorporated within the province of Ontario in 1890, received its Royal Charter in 1903, and was federally incorporated in 1968. The National Office of the Society is located at 124 Merton Street, Toronto, Ontario M4S 2Z2, telephone (416) 484 6383. The business office and library are housed there.

The Society is devoted to the advancement of astronomy and allied sciences, and has members in many countries and from all walks of life. Any serious user of this HANDBOOK would benefit from membership. An applicant may affiliate with one of the twenty Centres across Canada, or may join the Society directly as an unattached member. Centres are located in Newfoundland (St. John's), Nova Scotia (Halifax), Quebec (Montreal (2), and Quebec), Ontario (Ottawa, Kingston, Toronto, Hamilton, Niagara Falls, Kitchener-Waterloo, London, Windsor, and Sarnia), Manitoba (Winnipeg), Saskatchewan (Saskatoon), Alberta (Edmonton and Calgary), and British Columbia (Vancouver and Victoria). Contact the National Office for the address of any of the Centres.

Members receive the publications of the Society free of charge: the OBSERVER'S HANDBOOK (published annually in November), and the bimonthly JOURNAL and NATIONAL NEWSLETTER which contain articles on many aspects of astronomy. The membership year begins October 1, and members receive the publications of the Society for the following calendar year. Annual fees are currently $20, and $12.50 for persons under 18 years. Life membership is $300. (To cover higher mailing costs, these fees are to be read as U.S. dollars for members outside of Canada. Also, persons wishing to affiliate with one of the Centres are advised that some Centres levy a small surcharge.)

SUGGESTIONS FOR FURTHER READING

The OBSERVER'S HANDBOOK is an annual guide to astronomical phenomena and data. The following is a brief list of publications which may be useful as an introduction to astronomy, as a companion to the HANDBOOK, or for advanced work. Star atlases are mentioned near the bottom of page 169.

Burnham, Robert. *Burnham's Celestial Handbook, Volumes 1, 2 and 3.* Dover Publications, Inc., New York, 1978. A detailed, well-presented, observer's guide to the universe beyond the solar system.

Hartmann, W. K. *Astronomy: The Cosmic Journey* (Second edition). Wadsworth Publ., Belmont, CA, 1982. An excellent, non-technical, college text.

Hogg, Helen S. *The Stars Belong To Everyone.* Doubleday Canada Ltd., Toronto, 1976. Superb introduction to the sky.

Mayall, R. N., Mayall, M. W., and Wyckoff, J. *The Sky Observer's Guide.* Golden Press, New York, 1977. An excellent, introductory guide to observational astronomy.

Peltier, L. C. *Guideposts To The Stars.* Collier-Macmillan Canada, Ltd., Ontario. Macmillan Publishing Co., New York, 1972. An enjoyable introduction to the stars by a man who loved the night.

Rükl, A. *Moon, Mars and Venus.* Hamlyn Publishing Group Ltd., Toronto and New York, 1976. A compact, detailed, lunar atlas.

Sherrod, P. C. *A Complete Manual of Amateur Astronomy.* Prentice-Hall, New Jersey, 1981. A comprehensive guide to observational astronomy for amateurs.

Sky and Telescope. Sky Publishing Corp., 49 Bay State Road, Cambridge, MA 02238. A monthly magazine containing articles on all aspects of astronomy.

Texereau, J. *How To Make A Telescope.* Doubleday and Co., New York, 1963. The best guide to making a Newtonian telescope.

VISITING HOURS AT SOME CANADIAN OBSERVATORIES AND PLANETARIA

Compiled By Marie Fidler

OBSERVATORIES

Algonquin Radio Observatory, Lake Traverse, Ontario K0A 2L0.
Tours by appointment only. Telephone (613) 735-0141.

Burke-Gaffney Observatory, Saint Mary's University, Halifax, Nova Scotia B3H 3C3.
October-April: Saturday evenings, 7:00 p.m.
May-September: Saturday evenings, 9:00 p.m.
Monday evening or daytime tours by arrangement.
Phone 429-9780, ext. 184.

Canada-France-Hawaii Telescope, Mauna Kea, Hawaii, U.S.A. 96743.
R.A.S.C. members visiting "Big Island" are welcome to day-time visits of the CFHT installations. For appointment please phone (808) 885-7944.

David Dunlap Observatory, Richmond Hill, Ontario L4C 4Y6.
Tuesday mornings throughout the year, 10:00 a.m.
Saturday evenings, April through October, by reservation. Telephone (416) 884-2112.

Dominion Astrophysical Observatory, Victoria, B.C. V8X 3X3.
May-August: Daily, 9:15 a.m.–4:15 p.m.
September-April: Monday to Friday, 9:15 a.m.–4:15 p.m.
Public observing, Saturday evenings, April-October inclusive.

Dominion Radio Astrophysical Observatory, Penticton, B.C. V2A 6K3.
Conducted Tours: Sundays, July and August only, 2:00–5:00 p.m.
Visitors' Centre: Open year round during daylight hours.
Visitors are asked to walk 0.5 km from the road except when Conducted Tours are offered. For information please phone (604) 497-5321.

Hume Cronyn Observatory, The University of Western Ontario, London, Ontario. N6A 5B9.
An active program for individual visitors and groups is maintained through-out the year. For information please phone (519) 679-3184.

National Museum of Science and Technology, 1867 St. Laurent Blvd., Ottawa, Ontario. K1A 0M8.
Evening tours, by appointment only. Telephone (613) 998-9520.
September-June: Group tours: Mon., Tues., Wed., Thurs. Public visits, Fri.
July-August: Public visits: Tues., Wed., Thurs.

Observatoire astronomique du mont Mégantic, Notre-Dame-des-Bois, P.Q. J0B 2E0.
June-September: Daily 2:00 p.m.–sunset.
Public observing, Saturday evening, May-August inclusive, by reservation. Telephone (819) 888-2822.

University of British Columbia Observatory, Vancouver, B.C. V6T 1W5
Public observing, clear Saturday evenings, dark until 11:30 p.m., year round. Tours by appointment; phone (604) 228-2802.

PLANETARIA

Alberta Natural Resources Science Centre, Mobile Planetarium, P.O. Box 3182, Sherwood Park, Alberta T8A 2A6.

This planetarium travels throughout Alberta with public shows given Monday, Tuesday, and Thursday evenings. For locations and times, telephone (403) 427-9490, 9491 or 9492.

Calgary Centennial Planetarium, 701–11 Street S.W., P.O. Box 2100, Calgary, Alberta T2P 2M5.

For program information, telephone (403) 264-4060 or 264-2030.

Doran Planetarium, Laurentian University, Ramsey Lake Road, Sudbury, Ontario P3E 2C6.

Phone (705) 675-1151, ext. 381 for information on group reservations and public shows.

Dow Planetarium, 1000 St. Jacques Street W., Montreal, P.Q. H3C 1G7.

Live shows in French and in English every open day except Monday. Closed 3 weeks in September after Labour Day. For general information telephone (514) 872-4530

The Halifax Planetarium, The Education Section of Nova Scotia Museum, Summer Street, Halifax, N.S. B3H 3A6.

Free public shows take place on some evenings at 8:00 p.m. and group shows can be arranged. For information, telephone (902) 429-4610.

The Lockhart Planetarium, 394 University College, 500 Dysart Road, The University of Manitoba, Winnipeg, Manitoba R3T 2N2.

For group reservations, telephone (204) 474-9785.

H.R. MacMillan Planetarium, 1100 Chestnut Street, Vancouver, B.C. V6J 3J9.

Public shows daily except Monday, 2:30 and 8:00.
Additional shows 1:00 and 4:00 weekends, holidays and summer.
For show information telephone (604) 736-3656.

Manitoba Planetarium, 190 Rupert Avenue at Main Street, Winnipeg, Manitoba R3B 0N2.

For current show times and information, call the recorded message at (204) 943-3142.

McLaughlin Planetarium, 100 Queen's Park, Toronto, Ontario M5S 2C6 (telephone (416) 978-8550).

Tuesday-Friday, 3:00 and 7:45 p.m.
Weekends and holidays, 12:30, 1:45, 3:00 and 7:45 p.m.

Ontario Science Centre, 770 Don Mills Road, Don Mills, Ontario M3C 1T3.

Open daily except Christmas Day from 10:00 a.m. to 6:00 p.m. Telephone (416) 429-4100.

University of Prince Edward Island Planetarium, Charlottetown, P.E.I. C1A 4P3

For show information telephone (902) 892-4121.

Queen Elizabeth Planetarium, Coronation Park, 139 St. & 114 Ave., Edmonton, Alberta T5J 0K1.

Shows for adults and for children are held on most days. A Night Sky programme is held every day at 9:00 p.m. in the summer. Phone 455-0119 for up-to-date programme information and showtimes.

SYMBOLS

D

SUN, MOON, AND PLANETS

☉ The Sun	☾ The Moon generally	♃ Jupiter
● New Moon	☿ Mercury	♄ Saturn
○ Full Moon	♀ Venus	♅ Uranus
☽ First Quarter	⊕ Earth	♆ Neptune
☾ Last Quarter	♂ Mars	♇ Pluto

SIGNS OF THE ZODIAC

♈ Aries . . . . 0°	♌ Leo . . . . 120°	♐ Sagittarius . . . 240°
♉ Taurus . . . . . . 30°	♍ Virgo . . . . . . 150°	♑ Capricornus . . 270°
♊ Gemini . . . . . . 60°	♎ Libra . . . . 180°	♒ Aquarius . . . . 300°
♋ Cancer . . . . . . 90°	♏ Scorpius . . . . 210°	♓ Pisces . . . . 330°

THE GREEK ALPHABET

Α, α	Alpha	Ι, ι	Iota	Ρ, ρ	Rho
Β, β	Beta	Κ, κ	Kappa	Σ, σ	Sigma
Γ, γ	Gamma	Λ, λ	Lambda	Τ, τ	Tau
Δ, δ	Delta	Μ, μ	Mu	Υ, υ	Upsilon
Ε, ε	Epsilon	Ν, ν	Nu	Φ, φ	Phi
Ζ, ζ	Zeta	Ξ, ξ	Xi	Χ, χ	Chi
Η, η	Eta	Ο, ο	Omicron	Ψ, ψ	Psi
Θ, θ, ϑ	Theta	Π, π	Pi	Ω, ω	Omega

CO-ORDINATE SYSTEMS AND TERMINOLOGY

Astronomical positions are usually measured in a system based on the *celestial poles* and *celestial equator*, the intersections of the Earth's rotation axis and equatorial plane, respectively, and the infinite sphere of the sky. *Right ascension* (R.A. or α) is measured in hours (h), minutes (m) and seconds (s) of time, eastward along the celestial equator from the *vernal equinox. Declination* (Dec. or δ) is measured in degrees (°), minutes (′) and seconds (″) of arc, northward (N or +) or southward (S or −) from the celestial equator toward the N or S celestial pole.

Positions can also be measured in a system based on the *ecliptic*, the intersection of the Earth's orbit plane and the infinite sphere of the sky. The Sun appears to move eastward along the ecliptic during the year. *Longitude* is measured eastward along the ecliptic from the vernal equinox; *latitude* is measured at right angles to the ecliptic, northward or southward toward the N or S ecliptic pole. The *vernal equinox* is one of the two intersections of the ecliptic and the celestial equator; it is the one at which the Sun crosses the celestial equator moving from south to north.

Objects are *in conjunction* if they have the same longitude or R.A., and are *in opposition* if they have longitudes or R.A.'s which differ by 180°. If the second object is not specified, it is assumed to be the Sun. For instance, if a planet is "in conjunction", it has the same longitude as the Sun. At *superior conjunction*, the planet is more distant than the Sun; at *inferior conjunction*, it is nearer.

If an object crosses the ecliptic moving northward, it is at the *ascending node* of its orbit; if it crosses the ecliptic moving southward, it is at the *descending node*.

Elongation is the difference in longitude between an object and a second object (usually the Sun). At conjunction, the elongation of a planet is thus zero.

BASIC DATA

PRINCIPAL ELEMENTS OF THE SOLAR SYSTEM

MEAN ORBITAL ELEMENTS

Planet	Mean Distance from Sun A. U.	millions of km	Period of Revolution Sidereal (P)	Synodic	Eccentricity (e)	Inclination (i)	Long. of Node (☊)	Long. of Perihelion (π)	Mean Long. at Epoch (L)
				days		°	°	°	°
Mercury	0.387	57.9	88.0d.	116	.206	7.0	47.9	76.8	222.6
Venus	0.723	108.1	224.7	584	.007	3.4	76.3	131.0	174.3
Earth	1.000	149.5	365.26	...	.017	0.0	0.0	102.3	100.2
Mars	1.524	227.8	687.0	780	.093	1.8	49.2	335.3	258.8
Jupiter	5.203	778.	11.86a	399	.048	1.3	100.0	13.7	259.8
Saturn	9.539	1427.	29.46	378	.056	2.5	113.3	92.3	280.7
Uranus	19.18	2869.	84.01	370	.047	0.8	73.8	170.0	141.3
Neptune	30.06	4497.	164.8	367	.009	1.8	131.3	44.3	216.9
Pluto	39.44	5900.	247.7	367	.250	17.2	109.9	224.2	181.6

These elements, for epoch 1960 Jan. 1.5 E.T., are taken from the *Explanatory Supplement to the American Ephemeris and Nautical Almanac.*

PHYSICAL ELEMENTS

Object	Equat. Diam. km	Oblateness	Mass ⊕ = 1	Density g/cm³	Gravity ⊕ = 1	Esc. Speed km/s	Rotn. Period d	Incl. °	Albedo
☉ Sun	1 392 000	0	332,946	1.41	27.8	616	25–35*		
☾ Moon	3 476	0	0.0123	3.35	0.16	2.3	27.3217	6.7	0.067
☿ Mercury	4 878	0	0.0553	5.43	0.38	4.3	58.65	0.0	0.056
♀ Venus	12 104	0	0.8150	5.24	0.90	10.3	243	~177	0.76
⊕ Earth	12 756	1/298	1.000	5.52	1.00	11.2	0.9973	23.4	0.36
♂ Mars	6 792	1/192	0.1074	3.93	0.38	5.0	1.0260	25.2	0.16
♃ Jupiter	141 700	1/16	317.9	1.36	2.87	63.4	0.410	3.1	0.73
♄ Saturn	120 000	1/9	95.17	0.71	1.32	39.4	0.426	26.7	0.76
♅ Uranus	50 800	1/16	14.56	1.30	0.93	21.5	0.45†	97.9	0.93
♆ Neptune	48 600	1/50	17.24	1.80	1.23	24.2	0.67†	29.6	0.62
♇ Pluto	3 000?	?	0.0015?	0.7?	0.03?		6.3867	118?	0.5?

The table gives the *mean* density, the gravity and escape speed *at the pole* and the inclination of equator *to orbit*. Evidence in 1977 suggests that the equatorial diameter of Uranus may be 55,800 km and that its oblateness may be 1/120.

*depending on latitude

†There is some evidence that the rotation periods of Uranus and Neptune are 1.0 and 0.76 day, respectively; these values are larger than those given in the table.

SATELLITES OF THE SOLAR SYSTEM

By Joseph Veverka

Name	Vis. Mag.	Diam. km	Mean Distance from Planet km/1000	Mean Distance from Planet arc sec	Revolution Period d	Revolution Period h	Revolution Period m	Orbit Incl. °	Discovery
Satellite of the Earth									
Moon	−12.7	3476	384.5	—	27	07	43	18–29	
Satellites of Mars									
I Phobos	11.6	23	9.4	25	0	07	39	1.1	A. Hall, 1877
II Deimos	12.7	13	23.5	63	1	06	18	1.8v	A. Hall, 1877
Satellites of Jupiter									
XVI 1979J3	17.5	(40)	128	42	0	07	04	—	S. Synnott, 1979
XIV Adrastea	18.7	(25)	129	42	0	07	08	—	D. Jewitt, 1979
V Amalthea	14.1	170	180	59	0	11	57	0.4	E. Barnard, 1892
XV 1979J2	16.0	(80)	222	73	0	16	11	—	S. Synnott, 1979
I Io	5.0	3630	422	138	1	18	28	0	Galileo, 1610
II Europa	5.3	3140	671	220	3	13	14	0.5	Galileo, 1610
III Ganymede	4.6	5260	1 070	351	7	03	43	0.2	Galileo, 1610
IV Callisto	5.6	4800	1 885	618	16	16	32	0.2	Galileo, 1610
XIII Leda	20	(10)	11 110	3640	240			26.7	C. Kowal, 1974
VI Himalia	14.7	170	11 470	3760	251			27.6	C. Perrine, 1904
X Lysithea	18.4	(20)	11 710	3840	260			29.0	S. Nicholson, 1938
VII Elara	16.4	80	11 740	3850	260			24.8	C. Perrine, 1905
XII Ananke	18.9	(20)	20 700	6790	617			147	S. Nicholson, 1951
XI Carme	18.0	(30)	22 350	7330	692			164	S. Nicholson, 1938
VIII Pasiphae	17.7	(40)	23 330	7650	735			145	P. Melotte, 1908
IX Sinope	18.3	(30)	23 370	7660	758			153	S. Nicholson, 1914
Satellites of Saturn									
1980S28	(18)	30	137	23	0	14	26	—	1980*
1980S27	(13.5)	100	139	23	0	14	43	—	1980*
1980S26	(14)	90	142	24	0	15	05	—	1980*
1980S1	(14)	190	151	25	0	16	41	—	**
1980S3	(14.5)	120	151	25	0	16	41	—	**
I Mimas	12.9	390	187	30	0	22	37	1.5	W. Herschel, 1789
II Enceladus	11.8	500	238	38	1	08	53	0.0	W. Herschel, 1789
III Tethys	10.3	1060	295	48	1	21	18	1.1	G. Cassini, 1684
1980S13	(18)	25	295	48	1	21	18[a]	—	1980*
1980S25	(18)	25	295	48	1	21	18[b]	—	1980*
IV Dione	10.4	1120	378	61	2	17	41	0.0	G. Cassini, 1684
1980S6	(17.5)	30	378	61	2	17	41[c]	—	1980*

Apparent magnitude and mean distance from planet are at mean opposition distance. The inclination of the orbit is referred to the planet's equator; a value greater than 90° indicates retrograde motion.

Values in brackets are uncertain.

*Observed both from Earth and by Voyager spacecraft. Formal name and priority of discovery is under consideration by the International Astronomical Union.

**Co-orbital satellites. First mistaken for a single object (1966S2) by Fountain and Larson (1978) and probably by Dollfus ("Janus") in 1966.

[a]Librates about trailing (L_5) Lagrangian point of Tethys' orbit.

[b]Librates about leading (L_4) Lagrangian point of Tethys' orbit.

[c]Librates about leading (L_4) Lagrangian point of Dione's orbit with a period of ~790d.

Name	Vis. Mag.	Diam. km	Mean Distance from Planet km/1000	Mean Distance from Planet arc sec	Revolution Period d	h	m	Orbit Incl. °	Discovery
V Rhea	9.7	1530	526	85	4	12	25	0.4	G. Cassini, 1672
VI Titan	8.4	5800[a]	1 221	197	15	22	41	0.3	C. Huygens, 1655
VII Hyperion	14.2	300	1 481	239	21	06	38	0.4	G. Bond, W. Lassell, 1848
VIII Iapetus	11.0v	1460	3 561	575	79	07	56	14.7	G. Cassini, 1671
IX Phoebe	16.5	220	12 960	2096	550	11		150	W. Pickering, 1898
SATELLITES OF URANUS									
V Miranda	16.5	(300)	130	9	1	09	56	3.4	G. Kuiper, 1948
I Ariel	14.4	1400	192	14	2	12	29	0	W. Lassell, 1851
II Umbriel	15.3	1150	267	20	4	03	27	0	W. Lassell, 1851
III Titania	14.0	1650	438	33	8	16	56	0	W. Herschel, 1787
IV Oberon	14.2	1700	587	44	13	11	07	0	W. Herschel, 1787
SATELLITES OF NEPTUNE									
I Triton	13.6	(4400)	354	17	5	21	03	160.0	W. Lassell, 1846
II Nereid	18.7	(300)	5 600	264	365	5		27.6	G. Kuiper, 1949
SATELLITE OF PLUTO									
I Charon	17	(1300)	20.0	0.9	6	09	17	120	J. Christy, 1978

[a]Cloud-top diameter. Solid-body diameter equals 5150 km.

Note: Pronunciations of the names of the planetary satellites are given on p. 103.

TELESCOPE PARAMETERS

(where D = diameter of aperture in millimetres)

Limiting Visual Magnitude $m_l \simeq 2.7 + 5 \log D$, assuming transparent, dark-sky conditions and magnification $\geqslant$ 1D. (See article by R. Sinnott, *Sky and Telescope*, *45*, 401, 1973)

Smallest Resolvable Angle $\theta \simeq 120/D$ seconds of arc. However, atmospheric conditions seldom permit values less than 0.″5.

Useful Magnification Range $\simeq$ 0.2D to 2D. The lower limit may be a little less, but depends upon the maximum diameter of the entrance pupil of the individual observer's eye. Also, 0.2D provides better contrast than a lower value. The upper limit is determined by the wave nature of light and the optical limitations of the eye, although atmospheric turbulence usually limits the maximum magnification to 500x or less. For examination of double stars, magnifications up to 4D are sometimes useful. Note that the reciprocal of the coefficient to D is the diameter (in mm) of the telescope's exit pupil.

Values for some common apertures are:

D (mm)	60	75	100	125	150	200	350	400
m_l	11.6	12.1	12.7	13.2	13.6	14.2	15.4	15.7
θ (″)	2.0	1.6	1.2	1.0	0.80	0.60	0.34	0.30
0.2D	12x	15x	20x	25x	30x	40x	70x	80x
2D	120x	150x	200x	250x	300x	400x	700x	800x

SOME ASTRONOMICAL AND PHYSICAL DATA

D

LENGTH

1 astronomical unit (AU)	= $1.495\,978\,70 \times 10^{11}$ m = 499.004 782 light seconds
1 light year (ly)	= $9.460\,536 \times 10^{15}$ m (based on average Gregorian year)
	= 63 239.8 AU
1 parsec (pc)	= $3.085\,678 \times 10^{16}$ m
	= 206 264.8 AU = 3.261 631 light years
1 mile	≡ 1.609 344 km
1 Angstrom	≡ 0.1 nm

TIME

Day:	Mean sidereal (equinox to equinox)	= 86 164.091 s*
	Mean rotation (fixed star to fixed star)	= 86 164.099 s*
	Mean solar (d)	= 86 400. s*
	(s* = mean solar second, which is now larger than the SI (atomic) second (s) by a few parts in 10^8.)	
Month:	Draconic (node to node)	= 27.212 22 d
	Tropical (equinox to equinox)	= 27.321 58 d
	Sidereal (fixed star to fixed star)	= 27.321 66 d
	Anomalistic (perigee to perigee)	= 27.554 55 d
	Synodic (New Moon to New Moon)	= 29.530 59 d
Year:	Eclipse (lunar node to lunar node)	= 346.6201 d
	Tropical (equinox to equinox)	= 365.2422 d
	Average Gregorian	= 365.2425 d
	Average Julian	= 365.2500 d
	Sidereal (fixed star to fixed star)	= 365.2564 d
	Anomalistic (perihelion to perihelion)	= 365.2596 d

EARTH

Mass = 5.974×10^{24} kg
Radius: Equatorial, a = 6378.140 km; Polar, b = 6356.755 km;
Mean, $\sqrt[3]{a^2b}$ = 6371.004 km
1° of latitude = 111.133 − 0.559 cos 2ϕ km (at latitude ϕ)
1° of longitude = 111.413 cos ϕ − 0.094 cos 3ϕ km
Distance of sea horizon for eye h metres above sea-level = $3.57\sqrt{h}$ km
Standard atmospheric pressure = 101.325 kPa (~1 kg above 1 cm^2)
Speed of sound in standard atmosphere = 331 m s^{-1}
Magnetic field at surface ~5×10^{-5} T
Magnetic poles: 76°N, 101°W; 66°S, 140°E
Surface gravity at latitude 45°, g = 9.806 m s^{-2}
Age ~4.6 Ga
Meteoric flux ~1×10^{-15} kg m^{-2} s^{-1}
Escape speed from Earth = 11.2 km s^{-1}
Solar parallax = 8″.794 148
Constant of aberration = 20″.495 52
Obliquity of ecliptic = 23°.4415 (1983)
Annual general precession = 50″.26; Precession period = 25 800 a
Orbital speed = 29.8 km s^{-1}
Escape speed at 1 AU from Sun = 42.1 km s^{-1}

SUN

Mass = 1.9891×10^{30} kg; Radius = 696 265 km; Eff. temperature = 5770 K
Output: Power = 3.83×10^{26} W; M_{bol} = 4.75
Luminous intensity = 2.84×10^{27} cd; M_V = 4.84
At 1 AU, outside Earth's atmosphere:
Energy flux = 1.36 kW m^{-2}; m_{bol} = −26.82
Illuminance = 1.27×10^5 lx; m_V = −26.74
Solar wind speed near Earth ~450 km s^{-1} (travel time, Sun to Earth ~5 d)
Solar velocity = 19.75 km s^{-1} toward α = 18.07 h, δ = +30° (solar apex)

MILKY WAY GALAXY

Mass $\sim 10^{12}$ solar masses
Centre: $\alpha = 17$ h 42.5 min, $\delta = -28° 59'$ (1950)
Distance to centre ~ 9 kpc, diameter ~ 100 kpc
North pole: $\alpha = 12$ h 49 min, $\delta = 27° 24'$ (1950)
Rotational speed (at Sun) ~ 250 km s^{-1}
Rotational period (at Sun) ~ 220 Ma
Velocity relative to the 3 K background ~ 600 km s^{-1} toward $\alpha \sim 10$ h, $\delta \sim -20°$

MISCELLANEOUS CONSTANTS

Speed of light, $c = 299\,792\,458.$ m s^{-1}
Planck's constant, $h = 6.6262 \times 10^{-34}$ J s
Gravitational constant, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
Elementary charge, $e = 1.6022 \times 10^{-19}$ C
Electron rest mass $= 9.1095 \times 10^{-31}$ kg
Proton rest mass $= 1.6726 \times 10^{-27}$ kg
Avogadro constant, $N_A = 6.022 \times 10^{26}$ kmol^{-1}
Atomic mass unit, $u = 1.6606 \times 10^{-27}$ kg $= N_A{}^{-1} = 931.50$ MeV
Boltzmann constant, $k = 1.381 \times 10^{-23}$ J K^{-1} $= 8.62 \times 10^{-5}$ eV K^{-1} ~ 1 eV/10^4 K
Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Wien's law, $\lambda_m T = 2.898 \times 10^{-3}$ m K (per $d\lambda$)
Hubble constant, $H \sim 50$ to 75 km s^{-1} Mpc^{-1} (depending on method of determination)
Thermochemical calorie (cal) $= 4.184$ J
Electron-volt (eV) $= 1.6022 \times 10^{-19}$ J
1 eV per event $= 23\,060.$ cal mol^{-1}
1 W $= 10^7$ ergs s^{-1}
$\pi = 3.141\,592\,654 \simeq (113 \div 355)^{-1}$
$1'' = 4.8481 \times 10^{-6}$ rad
Number of square degrees on a sphere $= 41\,253.$

MISCELLANEOUS INFORMATION

Relations between sidereal time t, right ascension α, hour angle h, declination δ, azimuth A (measured east of north), altitude a, and latitude ϕ:

$$h = t - \alpha$$
$$\sin a = \sin\delta \sin\phi + \cos h \cos\delta \cos\phi$$
$$\cos\delta \sin h = -\cos a \sin A$$
$$\sin\delta = \sin a \sin\phi + \cos a \cos A \cos\phi$$

Annual precession in $\alpha = 3.0730 + 1.3362 \sin\alpha \tan\delta$ seconds
Annual precession in $\delta = 20''.043 \cos\alpha$
Log of light intensity ratio = 0.4 times magnitude difference
$4\,{}^1H \rightarrow {}^4He + 26.73$ MeV
Stable particles: γ, e^-, e^+, p, $\bar{p}$, neutrinos(?)
Some SI symbols and prefixes:

m	metre	N	newton (kg m s^{-2})	n	nano	10^{-9}
kg	kilogram	J	joule (N m)	μ	micro	10^{-6}
s	second	W	watt (J s^{-1})	m	milli	10^{-3}
min	minute	Pa	pascal (N m^{-2})	c	centi	10^{-2}
h	hour	t	tonne (10^3 kg)	k	kilo	10^3
d	day	Hz	Hertz (s^{-1})	M	mega	10^6
a	year	C	coulomb (A s)	G	giga	10^9

Relation between rest mass (m), linear momentum (p), total energy (E), kinetic energy (KE), and $\gamma = (1 - v^2/c^2)^{-0.5}$:

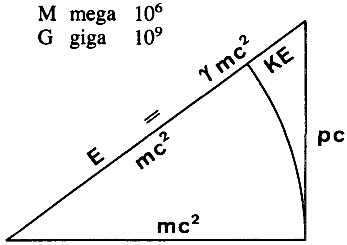


TABLE OF PRECESSION FOR 50 YEARS

If declination is positive, use inner R.A. scale; if declination is *negative*, use *outer* R.A. scale, and *reverse the sign of the precession in declination*

R.A. for Dec. −	R.A. for Dec. +	Prec. in Dec.	Precession in right ascension δ = 85°	80°	75°	70°	60°	50°	40°	30°	20°	10°	0°	Prec. in Dec.	R.A. for Dec. +	R.A. for Dec. −
h m	h m	′	m	m	m	m	m	m	m	m	m	m	m	′	h m	h m
12 00	0 00	+16.7	+ 2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	−16.7	12 00	*24 00*
12 30	0 30	+16.6	4.22	3.39	3.10	2.96	2.81	2.73	2.68	2.64	2.61	2.59	2.56	−16.6	11 30	*23 30*
13 00	1 00	+16.1	5.85	4.20	3.64	3.35	3.06	2.90	2.80	2.73	2.67	2.61	2.56	−16.1	11 00	*23 00*
13 30	1 30	+15.4	7.43	4.98	4.15	3.73	3.30	3.07	2.92	2.81	2.72	2.64	2.56	−15.4	10 30	*22 30*
14 00	2 00	+14.5	8.92	5.72	4.64	4.09	3.53	3.22	3.03	2.88	2.76	2.66	2.56	−14.5	10 00	*22 00*
14 30	2 30	+13.3	10.31	6.41	5.09	4.42	3.73	3.37	3.13	2.95	2.81	2.68	2.56	−13.3	9 30	*21 30*
15 00	3 00	+11.8	11.56	7.03	5.50	4.72	3.92	3.50	3.22	3.02	2.85	2.70	2.56	−11.8	9 00	*21 00*
15 30	3 30	+10.2	12.66	7.57	5.86	4.99	4.09	3.61	3.30	3.07	2.88	2.72	2.56	−10.2	8 30	*20 30*
16 00	4 00	+ 8.4	13.58	8.03	6.16	5.21	4.23	3.71	3.37	3.12	2.91	2.73	2.56	− 8.4	8 00	*20 00*
16 30	4 30	+ 6.4	14.32	8.40	6.40	5.39	4.34	3.79	3.42	3.15	2.94	2.74	2.56	− 6.4	7 30	*19 30*
17 00	5 00	+ 4.3	14.85	8.66	6.57	5.52	4.42	3.84	3.46	3.18	2.95	2.75	2.56	− 4.3	7 00	*19 00*
17 30	5 30	+ 2.2	15.18	8.82	6.68	5.59	4.47	3.88	3.49	3.20	2.96	2.76	2.56	− 2.2	6 30	*18 30*
18 00	6 00	0.0	15.29	8.88	6.72	5.62	4.49	3.89	3.50	3.20	2.97	2.76	2.56	0.0	6 00	*18 00*
0 00	12 00	−16.7	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	+16.7	24 00	*12 00*
0 30	12 30	−16.6	+ 0.90	1.74	2.02	2.16	2.31	2.39	2.44	2.48	2.51	2.54	2.56	+16.6	23 30	*11 30*
1 00	13 00	−16.1	− 0.73	0.93	1.49	1.77	2.06	2.22	2.32	2.39	2.46	2.51	2.56	+16.1	23 00	*11 00*
1 30	13 30	−15.4	− 2.31	+0.14	0.97	1.39	1.82	2.05	2.20	2.31	2.41	2.49	2.56	+15.4	22 30	*10 30*
2 00	14 00	−14.5	− 3.80	−0.60	0.48	1.03	1.60	1.90	2.09	2.24	2.36	2.46	2.56	+14.5	22 00	*10 00*
2 30	14 30	−13.3	− 5.19	−1.28	+0.03	0.70	1.39	1.75	1.99	2.17	2.31	2.44	2.56	+13.3	21 30	*9 30*
3 00	15 00	−11.8	− 6.44	−1.90	−0.38	0.40	1.20	1.62	1.90	2.11	2.27	2.42	2.56	+11.8	21 00	*9 00*
3 30	15 30	−10.2	− 7.54	−2.45	−0.74	+0.13	1.03	1.51	1.82	2.05	2.24	2.41	2.56	+10.2	20 30	*8 30*
4 00	16 00	− 8.4	− 8.46	−2.91	−1.04	−0.09	0.89	1.41	1.75	2.00	2.21	2.39	2.56	+ 8.4	20 00	*8 00*
4 30	16 30	− 6.4	− 9.20	−3.27	−1.28	−0.27	0.78	1.33	1.70	1.97	2.19	2.38	2.56	+ 6.4	19 30	*7 30*
5 00	17 00	− 4.3	− 9.73	−3.54	−1.45	−0.39	0.70	1.28	1.66	1.94	2.17	2.37	2.56	+ 4.3	19 00	*7 00*
5 30	17 30	− 2.2	−10.06	−3.70	−1.56	−0.47	0.65	1.25	1.63	1.92	2.16	2.37	2.56	+ 2.2	18 30	*6 30*
6 00	18 00	0.0	−10.17	−3.75	−1.59	−0.50	0.63	1.23	1.63	1.92	2.16	2.36	2.56	0.0	18 00	*6 00*

To avoid interpolation in this table, which becomes increasingly inaccurate for large |δ|, precession formulae may be used (see p. 13).

TIME

Any recurring event may be used to measure time. The various times commonly used are defined by the daily passages of the Sun or stars caused by the rotation of the Earth on its axis. The more uniform revolution of the Earth about the Sun, causing the return of the seasons, defines *ephemeris time*. Time can also be defined in terms of the vibrations within atoms. Atomic time is maintained in various labs, and an internationally acceptable atomic time scale has now been adopted.

A sundial indicates *apparent solar time*, but this is far from uniform because of the Earth's elliptical orbit and the inclination of the ecliptic. If the real Sun is replaced by a fictitious mean sun moving uniformly in the equator, we have *mean* (solar) *time*. *Apparent time − mean time = equation of time.*

Another useful quantity is the *correction to sundial* (see page 48), which differs from *equation of time* only in its sign. As the name implies, *mean time − apparent time = correction to sundial.*

If instead of the Sun we use other stars, we have *sidereal time*. The sidereal time is zero when the vernal equinox or first point of Aries is on the meridian. As the Earth makes one more rotation with respect to the stars than it does with respect to the Sun during a year, sidereal time gains on mean time $3^m\ 56^s$ per day or 2 hours per month. Right Ascension (R.A.) is measured east from the vernal equinox, so that the R.A. of an object on the meridian is equal to the sidereal time.

Sidereal time is equal to mean solar time plus 12 hours plus the R.A. of the fictitious mean sun, so that by observation of one kind of time we can calculate the other. Sidereal time is useful to an observer for setting his telescope on an object of known right ascension. The *hour angle* of the object is equal to the *sidereal time − right ascension*. There are several ways of calculating sidereal time if you do not have a sidereal clock; an article by Hardie and Krebs, *Sky and Telescope* **41**, 288 (May 1971) provides helpful information. See also the table on p. 16 and diagram on p. 18.

Local mean time varies continuously with longitude. The local mean time of Greenwich, now known as *Universal Time* (UT) is used as a common basis for timekeeping. Navigation and surveying tables are generally prepared in terms of UT.

To avoid the inconveniences to travellers of a changing local time, *standard time* is used. The Earth is divided into 24 zones, each ideally 15 degrees wide, the zero zone being centered on the Greenwich meridian. All clocks within the same zone will read the same time. See map on p. 16.

In Canada and the United States there are 9 standard time zones as follows: Newfoundland (N), $3^h\ 30^m$ slower than Greenwich; 60th meridian or Atlantic (A), 4 hours; 75th meridian or Eastern (E), 5 hours; 90th meridian or Central (C), 6 hours; 105th meridian or Mountain (M), 7 hours; 120th meridian or Pacific (P), 8 hours; 135th meridian or Yukon (Y), 9 hours; 150th meridian or Alaska-Hawaii, 10 hours; and 165th meridian or Bering, 11 hours slower than Greenwich.

The mean solar second, defined as 1/86400 of the mean solar day, has been abandoned as the unit of time because random changes in the Earth's rotation make it variable. The unit of time has been redefined twice within the past decades. In 1956 it was defined in terms of Ephemeris Time (ET) as 1/31,556,925.9747 of the tropical year 1900 at January 0 at 12 hrs. ET. In 1967 it was redefined as 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of cesium 133 atom. *Ephemeris Time* is required in celestial mechanics, while the cesium resonator makes the unit readily available. The difference, ΔT, between UT and ET is measured as a small error in the observed longitude of the Moon, in the sense $\Delta T = ET - UT$. The Moon's position is tabulated in ET, but observed in UT. ΔT was zero near the beginning of the century, but in 1983 will be about 54 seconds.

RADIO TIME SIGNALS

National time services distribute co-ordinated time called UTC, which on January 1, 1972, was adjusted so that the time interval is the atomic second. Atomic time gains on mean solar time at a rate of about a second a year. An approximation to UT1, which is a close approximation to UT, is maintained by stepping the atomic time scale in units of 1 second on June 30 or December 31, when required so that the predicted difference DUT1 = UT1 − UTC does not exceed 0.9 second. The first such "leap second" occurred on June 30, 1972. These changes are coordinated through the Bureau International de l'Heure (BIH), so that most time services are synchronized to the tenth of a millisecond.

Radio time signals readily available in Canada include:

CHU Ottawa, Canada	3330, 7335, 14670 kHz
WWV Fort Collins, Colorado	2.5, 5, 10, 15, 20 MHz
WWVH Kauai, Hawaii	2.5, 5, 10, 15 MHz.

For those without short wave radios, or in areas of poor reception, time service is available from Ottawa by telephone: 613-745-1576 (English) and 613-745-9426 (French).

SIDEREAL TIME 1983

The following is the Greenwich sidereal time (GST) on day 0.0 (0 h UT) of each month:

Jan. 0 $06^h36^m.4$	Apr. 0 $12^h31^m.2$	July 0 $18^h30^m.0$	Oct. 0 $00^h32^m.7$
Feb. 0 08 38.6	May 0 14 29.5	Aug. 0 20 32.2	Nov. 0 02 34.9
Mar. 0 10 29.0	June 0 16 31.7	Sep. 0 22 34.4	Dec. 0 04 33.2

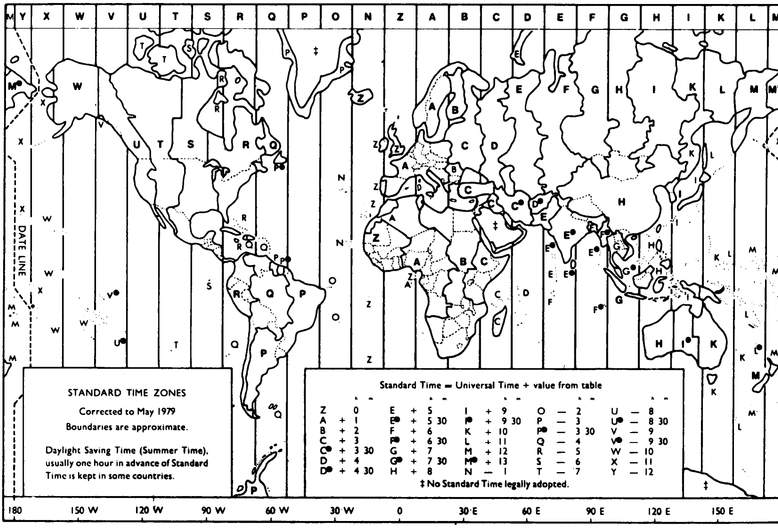
GST at hour t UT on day d of the month

$$= \text{GST at 0 h UT on day 0} + 0^h.0657\, d + 1^h.0027\, t$$

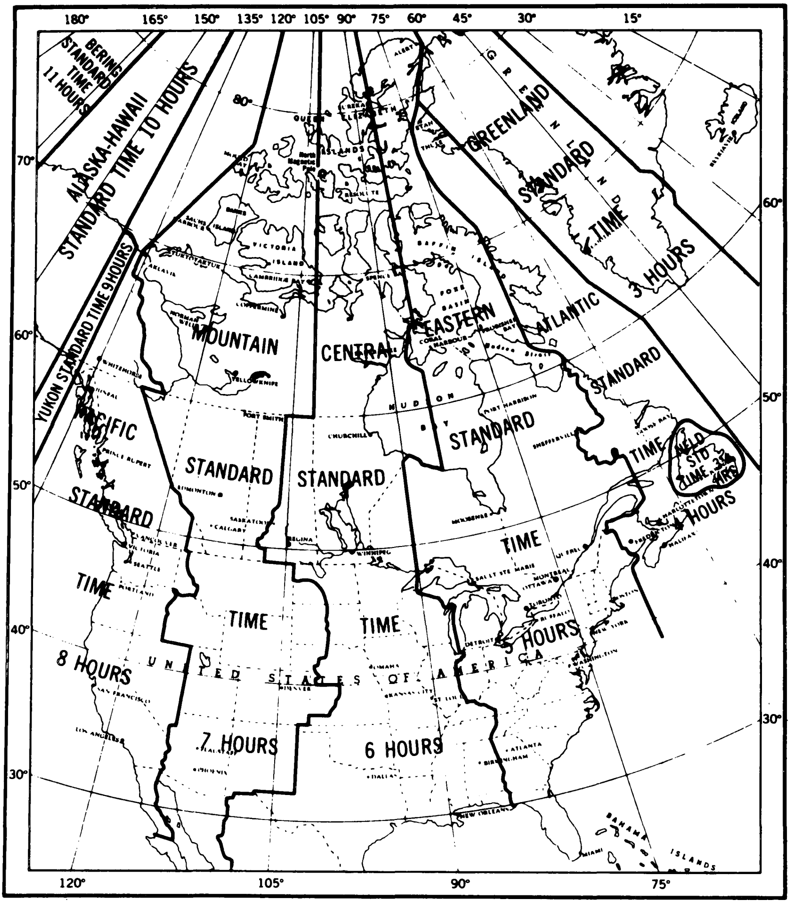
Local sidereal time = GST − west longitude (or + east longitude). (Be sure to convert your time and date to UT to calculate t and d.)

WORLD MAP OF TIME ZONES

Taken from *Astronomical Phenomena for the Year* 1983 (Washington: U.S. Government Printing Office, and London: Her Majesty's Stationery Office)



MAP OF STANDARD TIME ZONES



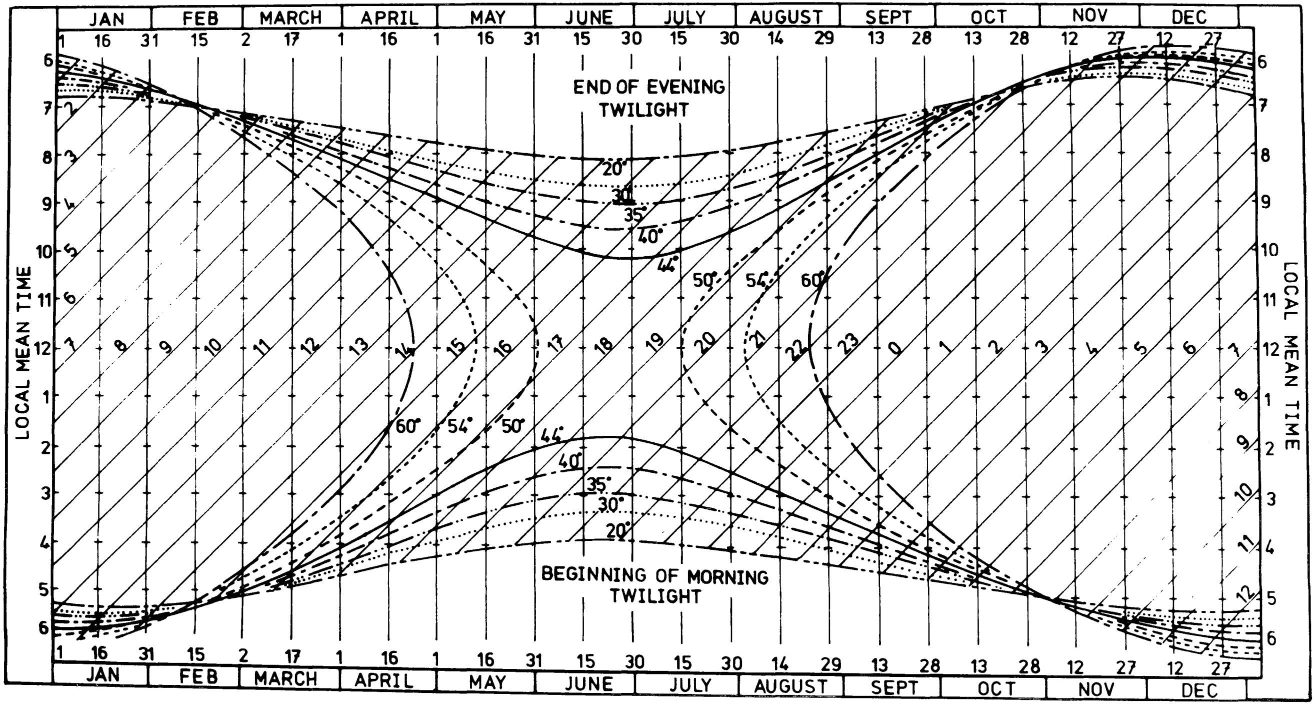
PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA, CANADA, 1973.

The map shows the number of hours by which each time zone is *slower* than Greenwich, that is, the number of hours which must be *added* to the zone's standard time to give Greenwich (Universal) Time.

Note: Since the preparation of the above map, the standard time zones have been changed so that all parts of the Yukon Territory now observe Pacific Standard Time. The Yukon Standard Time Zone still includes a small part of Alaska, as shown on the above map. Also, the part of Texas west of longitude 105° is in the Mountain Time Zone.

ASTRONOMICAL TWILIGHT AND SIDEREAL TIME

The diagram gives (i) the local mean time (L.M.T.) of the beginning and end of astronomical twilight (curved lines) at a given latitude on a given date and (ii) the local sidereal time (L.S.T., diagonal lines) at a given L.M.T. on a given date. The L.S.T. is also the right ascension of an object on the observer's celestial meridian. To use the diagram, draw a line downward from the given date; the line cuts the curved lines at the L.M.T. of beginning and end of twilight, and cuts each diagonal line at the L.M.T. corresponding to the L.S.T. marked on the line. See pages 15 and 56 for definitions of L.M.T., L.S.T. and astronomical twilight.



JULIAN DATE, 1983

The Julian date is commonly used by astronomers to refer to the time of astronomical events, because it avoids some of the annoying complexities of the civil calendar. The Julian day corresponding to a given date is the number of days which have elapsed since January 1, 4713 B.C. For an account of the origin of the Julian system see: "The Julian Period", by C. H. Cleminshaw in the *Griffith Observer*, April 1975; "The Origin of the Julian Day System", by G. Moyer in *Sky and Telescope*, April 1981.

The Julian day commences at noon (12^h) UT. To find the Julian date at any time during 1983, determine the day of the month and time at the Greenwich meridian, convert this to a decimal day, and add it to one of the following numbers according to the month (These numbers are the Julian dates for 0^hUT on the "0th" day of each month.):

Jan. 244 5334.5	Apr. 244 5424.5	July 244 5515.5	Oct. 244 5607.5
Feb. 244 5365.5	May 244 5454.5	Aug. 244 5546.5	Nov. 244 5638.5
Mar. 244 5393.5	June 244 5485.5	Sep. 244 5577.5	Dec. 244 5668.5

e.g. 23:08 EDT on July 22 = 03:08 UT on July 23 = July 23.13 UT = 244 5515.5 + 23.13 = JD 244 5538.63

The Julian dates for 0 UT January 0 for several previous years are 244 0000.5 plus (for years indicated): 951(1971), 1316(1972), 1682(1973), 2047(1974), 2412(1975), 2777(1976), 3143(1977), 3508(1978), 3873(1979), 4238(1980), 4604(1981), 4969(1982), 5334(1983).

ANNIVERSARIES AND FESTIVALS 1983

New Year's Day	Sat.	Jan. 1
Epiphany	Thu.	Jan. 6
Lincoln's Birthday (U.S.)	Sat.	Feb. 12
Ash Wednesday		Feb. 16
Washington's Birthday (U.S.)	Mon.	Feb. 21
St. David (Wales)	Tue.	Mar. 1
St. Patrick (Ireland)	Thu.	Mar. 17
Palm Sunday		Mar. 27
First Day of Passover	Tue.	Mar. 29
Good Friday		Apr. 1
Easter Sunday		Apr. 3
Birthday of Queen Elizabeth II (1926)	Thu.	Apr. 21
St. George (England)	Sat.	Apr. 23
Ascension Day	Thu.	May 12
Shebuoth	Wed.	May 18
Pentecost (Whit Sunday)		May 22
Victoria Day	Mon.	May 23
Trinity Sunday		May 29
Memorial Day (U.S.)	Mon.	May 30
First Day of Ramadan	Sun.	June 12
Canada Day	Fri.	July 1
Independence Day (U.S.)	Mon.	July 4
Civic Holiday	Mon.	Aug. 1
Labour Day	Mon.	Sep. 5
Rosh Hashanah	Thu.	Sep. 8
Yom Kippur	Sat.	Sep. 17
Succoth	Thu.	Sep. 22
Islamic New Year	Sat.	Oct. 8
Thanksgiving (Can.)	Mon.	Oct. 10
Columbus Day (U.S.)	Mon.	Oct. 10
Election Day (U.S.)	Tue.	Nov. 8
Remembrance Day	Fri.	Nov. 11
Veterans' Day (U.S.)	Fri.	Nov. 11
Thanksgiving (U.S.)	Thu.	Nov. 24
First Sunday in Advent		Nov. 27
St. Andrew (Scotland)	Wed.	Nov. 30
Christmas	Sun.	Dec. 25

Note: 1983 and 1984 calendars are on the inside back cover.

THE SKY MONTH BY MONTH

BY JOHN R. PERCY

Introduction—In the monthly descriptions of the sky on the following pages, positions of the Sun and planets are given for 0 h Ephemeris Time, which differs only slightly from Standard Time on the Greenwich meridian. Estimates of altitude are for an observer in latitude 45°N. Unless noted otherwise, the descriptive comments about the planets apply to the middle of the month.

The Sun—The values of the equation of time are for noon U.T. on the first and last days of the month. For times of sunrise and sunset and for changes in the length of the day, see pp. 52–55. See also p. 48.

The Moon—Its phases, perigee and apogee times and distances (rounded to the nearest 100 km), and its conjunctions with the planets are given in the monthly tables. For times of moonrise and moonset, see pp. 60–73.

Age, Elongation and Phase of the Moon—The elongation is the angular distance of the Moon from the Sun in degrees, counted eastward around the sky. Thus, elongations of 0°, 90°, 180°, and 270° correspond to new, first quarter, full, and last quarter moon. For certain purposes the phase of the Moon is more accurately described by elongation than by age in days because the Moon's motion per day is not constant. However, the equivalents in the table below will not be in error by more than half a day.

Elong.	*Age*	*Elong.*	*Age*	*Elong.*	*Age*
0°	$0^{d}.0$	120°	$9^{d}.8$	240°	$19^{d}.7$
30°	2.5	150°	12.3	270°	22.1
60°	4.9	180°	14.8	300°	24.6
90°	7.4	210°	17.2	330°	27.1

The Sun's selenographic colongitude is essentially a convenient way of indicating the position of the sunrise terminator as it moves across the face of the Moon. It provides an accurate method of recording the exact conditions of illumination (angle of illumination), and makes it possible to observe the Moon under exactly the same lighting conditions at a later date. The Sun's selenographic colongitude is numerically equal to the selenographic longitude of the sunrise terminator reckoned eastward from the mean centre of the disk. Its value increases at the rate of nearly 12.2° per day or about ½° per hour; it is approximately 270°, 0°, 90° and 180° at New Moon, First Quarter, Full Moon and Last Quarter respectively. Values of the Sun's selenographic colongitude are given on the following pages for the first day of each month.

Sunrise will occur at a given point *east* of the central meridian of the Moon when the Sun's selenographic colongitude is equal to the eastern selenographic longitude of the point; at a point *west* of the central meridian when the Sun's selenographic colongitude is equal to 360° minus the western selenographic longitude of the point. The longitude of the sunset terminator differs by 180° from that of the sunrise terminator.

Libration is the shifting, or rather apparent shifting, of the visible disk of the Moon. Sometimes the observer sees features farther around the eastern or the western limb (libration in longitude), or the northern or southern limb (libration in latitude). When the libration in longitude is positive, the mean central point of the disk of the Moon is displaced eastward on the celestial sphere, exposing to view a region on the west limb. When the libration in latitude is positive, the mean central point of the disk of the Moon is displaced towards the south, and a region on the north limb is exposed to view.

The dates of the greatest positive and negative values of the libration in longitude and latitude are given in the following pages.

The Moon's Orbit. In 1983, the ascending node of the Moon's orbit regresses from longitude 94° to 75° (Gemini into Taurus).

The Planets—Further information in regard to the planets, including Pluto, is found on pp. 88–103. For the configurations of Jupiter's four Galilean satellites, see the monthly tables. In these diagrams, the central vertical band represents the equatorial diameter of the disk of Jupiter. Time is shown by the vertical scale, each horizontal line denoting 0^h Universal Time. (Be sure to convert to U.T. before using these diagrams.) The relative positions of the satellites at any time with respect to the disk of Jupiter are given by the four labelled curves (I, II, III, IV) (see p. 10 for the key to these Roman numerals). In constructing these diagrams, the positions of the satellites in the direction perpendicular to the equator of Jupiter are necessarily neglected. Note that the orientation is for an inverting telescope. For the various transits, occultations, and eclipses of these satellites, see p. 104.

Minima of Algol—The times of mid-eclipse are given in the monthly tables and are calculated from the ephemeris

$$\text{heliocentric minimum} = 2440953.4657 + 2.8673075\ E$$

and are rounded off to the nearest ten minutes. (The first number in the equation is the Julian date corresponding to 1971 Jan. 1.9657, an Algol minimum. The second number is the period of Algol in days, and E is an integer.)

Occultations of Stars and Planets—For information about occultations of stars and planets visible in North America, see pp. 75–87 and 120.

THE SKY FOR JANUARY 1983

The Sun—During January, the sun's R.A. increases from 18 h 43 m to 20 h 56 m and its Decl. changes from −23°04′ to −17°19′. The equation of time changes from −3 m 24 s to −13 m 25 s. On Jan. 2, the earth is at perihelion, at a distance of 147,094,000 km (91,400,000 mi) from the sun.

The Moon—On Jan. 1.0 U.T., the age of the moon is 16.6 d. The sun's selenographic colongitude is 109.45° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 6 (8°) and minimum (east limb exposed) on Jan. 22 (8°). The libration in latitude is maximum (north limb exposed) on Jan. 20 (7°) and minimum (south limb exposed) on Jan. 5 (7°).

Mercury on the 1st is in R.A. 20 h 08 m, Decl. −21°15′, and on the 15th is in R.A. 19 h 53 m, Decl. −17°59′. Early in the month, it may be seen very low in the south-west at sunset, but thereafter it is too close to the sun to be seen. On Jan. 16, it is in inferior conjunction.

M

Venus on the 1st is in R.A. 19 h 45 m, Decl. −22°33′, and on the 15th it is in R.A. 20 h 58 m, Decl. −18°46′, mag. −3.3, and transits at 13 h 23 m. Toward the end of the month, it may be seen very low in the south-west at sunset.

Mars on the 15th is in R.A. 22 h 02 m, Decl. −13°09′, mag. +1.4, and transits at 14 h 26 m. At sunset, it stands about 25° above the south-western horizon, and sets about 3 hours later. During the month, it moves from Capricorn into Aquarius.

Jupiter on the 15th is in R.A. 16 h 08 m, Decl. −20°06′, mag. −1.4, and transits at 8 h 31 m. It rises about 3½ hours before the sun, and is low in the south-south-east at sunrise. During the month, it moves from Libra through Scorpius, above Antares. Throughout the year, it remains in this part of the ecliptic, far south of the celestial equator. For this reason, it will never appear very high in the northern observer's sky. On the other hand, its motion relative to the bright stars of Scorpius will provide continual interest.

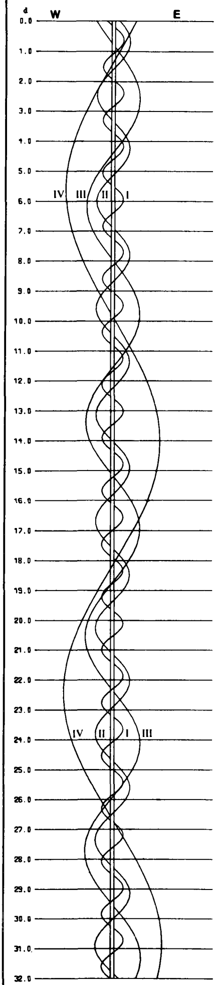
Saturn on the 15th is in R.A. 14 h 09 m, Decl. −10°27′, mag. +0.8, and transits at 6 h 33 m. It rises after midnight, and is west of south by sunrise. Until October, it is in Virgo, a few degrees east of Spica.

Uranus on the 15th is in R.A. 16 h 23 m, Decl. −21°29′, mag. +6.0, and transits at 8 h 47 m. It is in Ophiuchus until early June.

Neptune on the 15th is in R.A. 17 h 50 m, Decl. −22°13′, mag. +7.8, and transits at 10 h 13 m. It is in Sagittarius throughout the year.

1983			JANUARY UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Sat.	1			
Sun.	2	16	Earth at perihelion	
Mon.	3	20	Quadrantid meteor shower	1 50
Tues.	4			
Wed.	5		Mercury at ascending node	22 40
Thur.	6	04 00	☾ Last Quarter	
		18	Mercury stationary	
Fri.	7	10	Mercury 2° N. of Venus	
		12	Saturn 2° S. of Moon	
Sat.	8			19 30
Sun.	9		Mercury at perihelion	
		22	Jupiter 2° S. of Moon	
Mon.	10	07	Uranus 2° S. of Moon	
Tues.	11			16 20
Wed.	12	01	Neptune 0.6° N. of Moon; occultation[1]	
Thur.	13			
Fri.	14	05	Moon at apogee (406,600 km)	13 10
		05 08	● New Moon	
Sat.	15	19	Venus 1.8° N. of Moon	
Sun.	16	03	Mercury in inferior conjunction	
Mon.	17	04	Mars 3° N. of Moon	9 50
Tues.	18	13	Vesta 0.8° S. of Moon; occultation	
Wed.	19			
Thur.	20		Mercury at greatest hel. lat. N.	6 40
Fri.	21			
Sat.	22		Venus at greatest hel. lat. S.	
		05 33	☽ First Quarter	
Sun.	23			3 30
Mon.	24			
Tues.	25			
Wed.	26			0 20
Thur.	27	10	Mercury stationary	
Fri.	28	11	Moon at perigee (357,000 km)	21 10
		22 26	○ Full Moon	
Sat.	29			
Sun.	30			
Mon.	31			18 00

Config. of Jupiter's Satellites



[1]Visible from the central Indian Ocean

THE SKY FOR FEBRUARY 1983

The Sun—During February, the sun's R.A. increases from 20 h 56 m to 22 h 45 m and its Decl. changes from −17°19′ to −7°53′. The equation of time changes from −13 m 34 s to −12 m 40 s, reaching a minimum on Feb. 11.

The Moon—On Feb. 1.0 U.T., the age of the moon is 17.8 d. The sun's selenographic colongitude is 126.32° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 3 (8°) and minimum (east limb exposed) on Feb. 19 (7°). The libration in latitude is maximum (north limb exposed) on Feb. 16 (7°) and minimum (south limb exposed) on Feb. 1 (7°) and Feb. 28 (7°).

Mercury on the 1st is in R.A. 19 h 15 m, Decl. −20°16′, and on the 15th is in R.A. 20 h 12 m, Decl. −20°21′. It reaches greatest elongation west (26°) on Feb. 8, but this is a very unfavourable elongation because of the shallow inclination of the ecliptic to the horizon. Early in the month, it may possibly be seen, with great difficulty, very low in the south-east at sunrise.

Venus on the 1st is in R.A. 22 h 21 m, Decl. −11°54′, and on the 15th it is in R.A. 23 h 26 m, Decl. −5°04′, mag. −3.4, and transits at 13 h 49 m. As the month progresses, it moves further up in the south-western sky at sunset, setting about 3 hours later. On Feb. 18, Venus is 0.5° south of Mars. (Note that 0.5° is the apparent diameter of the moon.)

Mars on the 15th is in R.A. 23 h 33 m, Decl. −3°45′, mag. +1.4, and transits at 13 h 54 m. Mars is low in the south-western sky at sunset, setting about 3 hours later; see also "Venus" above. During the month, it moves from Aquarius into Pisces.

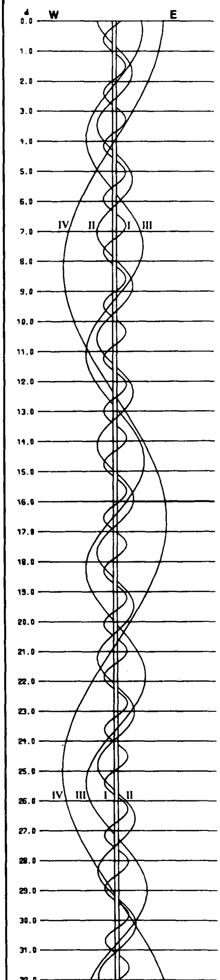
Jupiter on the 15th is in R.A. 16 h 27 m, Decl. −20°52′, mag. −1.6, and transits at 6 h 49 m. It rises after midnight and is due south at sunrise. During the month, it moves from Scorpius into Ophiuchus, passing 5° north of Antares and 0.8° north of Uranus on Feb. 17. This provides an easy way of locating Uranus around that date. A pair of binoculars helps!

Saturn on the 15th is in R.A. 14 h 12 m, Decl. −10°34′, mag. +0.7, and transits at 4 h 34 m. It rises about midnight, and is low in the south-west at sunrise. On Feb. 13, it is stationary, and begins to move westward toward Spica.

Uranus on the 15th is in R.A. 16 h 28 m, Decl. −21°40′, mag. +5.9, and transits at 6 h 49 m. It is 0.8° south of Jupiter on Feb. 17.

Neptune on the 15th is in R.A. 17 h 54 m, Decl. −22°13′, mag. +7.8, and transits at 8 h 15 m.

Northern Chauvinism. Remember that, in this HANDBOOK, the descriptions of the appearance of the sky are for an observer in latitude +45° or thereabouts. The appearance will be quite different for an observer in southern latitudes. An unfavourable elongation of Mercury, for instance, may become favourable. And Orion, as everyone knows, is upside down when viewed from southern latitudes!

1983			FEBRUARY UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Tues.	1				
Wed.	2				
Thur.	3	00	Juno in conjunction	14 50	
		21	Saturn 2° S. of Moon		
Fri.	4	19 17	☾ Last Quarter		
Sat.	5				
Sun.	6	13	Jupiter 1.5° S. of Moon	11 40	
		16	Uranus 2° S. of Moon		
Mon.	7	07	Pluto stationary		
Tues.	8	09	Neptune 0.8° N. of Moon; occultation[1]		
		20	Mercury greatest elong. W. (26°)		
Wed.	9			8 30	
Thur.	10	08	Moon at apogee (406,300 km)		
		15	Mercury 2° N. of Moon		
Fri.	11				
Sat.	12		Mercury at descending node	5 20	
Sun.	13	00 32	● New Moon		
		08	Saturn stationary		
Mon.	14				
Tues.	15	02	Venus 4° N. of Moon	2 10	
		06	Mars 5° N. of Moon		
		15	Uranus 5° N. of Antares		
		19	Vesta 0.3° S. of Moon; occultation		
Wed.	16				
Thur.	17	05	Jupiter 5° N. of Antares	23 00	
		14	Jupiter 0.8° N. of Uranus		
Fri.	18	22	Venus 0.5° S. of Mars		
Sat.	19				
Sun.	20	17 32	☽ First Quarter	19 50	
Mon.	21				
Tues.	22		Mercury at aphelion		
Wed.	23			16 40	
Thur.	24				
Fri.	25	22	Moon at perigee (360,200 km)		
Sat.	26			13 30	
Sun.	27	08 58	○ Full Moon		
Mon.	28				

[1]Visible in the south of S. America

THE SKY FOR MARCH 1983

The Sun—During March, the sun's R.A. increases from 22 h 45 m to 0 h 39 m and its Decl. changes from −7°53′ to +4°14′. The equation of time changes from −12 m 28 s to −4 m 20 s. On Mar. 21, at 4 h 39 m U.T., the sun reaches the vernal equinox, and spring begins in the northern hemisphere.

The Moon—On Mar. 1.0 U.T., the age of the moon is 16.0 d. The sun's selenographic colongitude is 107.03° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Mar. 3 (7°) and Mar. 31 (6°) and minimum (east limb exposed) on Mar. 18 (5°). The libration in latitude is maximum (north limb exposed) on Mar. 15 (7°) and minimum (south limb exposed) on Mar. 28 (7°).

Mercury on the 1st is in R.A. 21 h 33 m, Decl. −16°31′, and on the 15th is in R.A. 23 h 02 m, Decl. −8°30′. It is too close to the sun to be seen.

M

Venus on the 1st is in R.A. 0 h 29 m, Decl. +2°13′, and on the 15th it is in R.A. 1 h 32 m, Decl. +9°21′, mag. −3.4, and transits at 14 h 04 m. It continues to move further up in the south-western sky at sunset, dominating the otherwise-barren region of Pisces. Venus is gradually moving east relative to the sun. The angle of the ecliptic to the horizon is also steepening. The prominence of Venus is due to these two factors (and to its great brilliance, of course).

Mars on the 15th is in R.A. 0 h 51 m, Decl. +5°03′, mag. +1.5, and transits at 13 h 23 m. It is low in the west at sunset, and sets about 2 hours later. It is closing in on the sun, and by next month will be lost in the glow of twilight.

Jupiter on the 15th is in R.A. 16 h 37 m, Decl. −21°10′, mag. −1.8, and transits at 5 h 08 m. It rises before midnight, and is low in the south-western sky by sunrise. On March 28, it is stationary, and begins to move westward.

Saturn on the 15th is in R.A. 14 h 09 m, Decl. −10°13′, mag. +0.5, and transits at 2 h 41 m. It rises in mid-evening, and is very low in the south-west by sunrise.

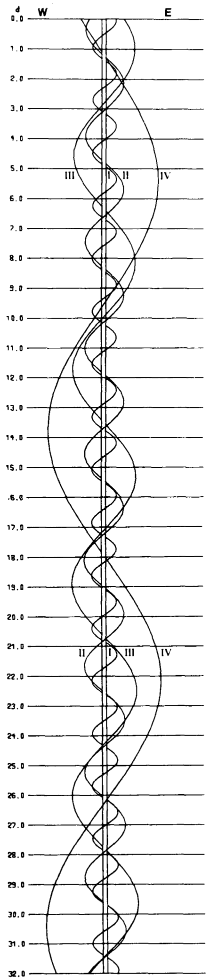
Uranus on the 15th is in R.A. 16 h 30 m, Decl. −21°43′, mag. +5.9, and transits at 5 h 01 m.

Neptune on the 15th is in R.A. 17 h 56 m, Decl. −22°12′, mag. +7.8, and transits at 6 h 27 m.

Occultations of Planets by the Moon. On Apr. 2, Jupiter is occulted by the moon. This event is visible in parts of North America. In 1983, there are 19 occultations of planets by the moon, a rather good crop. All planets except Mars and Pluto will be occulted at some time during 1983. Four of the occultations will be visible from some part of North America.

The series of occultations of Neptune ends on Mar. 7, as the moon's orbit swings south of Neptune (see page 24 of last year's HANDBOOK). A series of occultations of Uranus begins on Oct. 10, the first one being visible from the North Pacific.

1983			MARCH UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Tues.	1			10 10	
Wed.	2				
Thur.	3	06	Saturn 1.7° S. of Moon		
Fri.	4			7 00	
Sat.	5				
Sun.	6	00	Uranus 1.8° S. of Moon		
		03	Jupiter 1.0° S. of Moon; occultation[1]		
		13 16	☾ Last Quarter		
Mon.	7	17	Neptune 1.0° N. of Moon; occultation[2]	3 50	
Tues.	8				
Wed.	9	23	Moon at apogee (405,400 km)		
Thur.	10			0 40	
Fri.	11				
Sat.	12			21 30	
Sun.	13				
Mon.	14	13	Uranus stationary		
		17 43	● New Moon		
Tues.	15		Mercury at greatest hel. lat. S.	18 20	
Wed.	16	02	Vesta 0.3° S. of Moon; occultation		
		06	Mars 5° N. of Moon		
Thur.	17	06	Venus 5° N. of Moon		
Fri.	18			15 10	
Sat.	19		Venus at ascending node		
Sun.	20				
Mon.	21	04 39	Vernal equinox; Spring begins	12 00	
Tues.	22	02 25	☽ First Quarter		
Wed.	23				
Thur.	24			8 50	
Fri.	25	22	Moon at perigee (365,400 km)		
Sat.	26	11	Mercury in superior conjunction		
Sun.	27			5 40	
Mon.	28	01	Jupiter stationary		
		19 27	○ Full Moon		
Tues.	29				
Wed.	30	14	Saturn 1.5° S. of Moon	2 30	
Thur.	31				



[1]Visible in N. and E. Europe, Asia
[2]Visible in Antarctica

THE SKY FOR APRIL 1983

The Sun—During April, the sun's R.A. increases from 0 h 39 m to 2 h 31 m and its Decl. changes from +4°14′ to +14°50′. The equation of time changes from −4 m 02 s to +2 m 45 s.

The Moon—On Apr. 1.0 U.T., the age of the moon is 17.3 d. The sun's selenographic colongitude is 124.58° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Apr. 28 (5°) and minimum (east limb exposed) on Apr. 13 (5°). The libration in latitude is maximum (north limb exposed) on Apr. 11 (7°) and minimum (south limb exposed) on Apr. 24 (7°). On Apr. 2, there is an occultation of Jupiter by the moon, visible from parts of North America.

Mercury on the 1st is in R.A. 1 h 01 m, Decl. +6°07′, and on the 15th is in R.A. 2 h 38 m, Decl. +17°39′. Early in the month, it is too close to the sun to be seen, but by Apr. 21, it reaches greatest elongation east (20°). This is a favourable elongation: the planet stands about 16° above the western horizon at sunset. On Apr. 9, Mercury is 1.4° north of Mars.

Venus on the 1st is in R.A. 2 h 50 m, Decl. +17°02′, and on the 15th it is in R.A. 3 h 58 m, Decl. +21°55′, mag. −3.5, and transits at 14 h 28 m. Moving from Aries into Taurus, it is well up in the west at sunset, and sets about 3 hours later.

Mars on the 15th is in R.A. 2 h 19 m, Decl. +13°46′, mag. +1.6, and transits at 12 h 48 m. Early in the month, it may be seen with difficulty, very low in the west at sunset, but by the end of the month, it is too close to the sun to be seen. See also "Mercury" above.

Jupiter on the 15th is in R.A. 16 h 36 m, Decl. −21°06′, mag. −2.0, and transits at 3 h 05 m. It rises in mid-evening, and is low in the south-west at sunrise. It is occulted by the moon on Apr. 2.

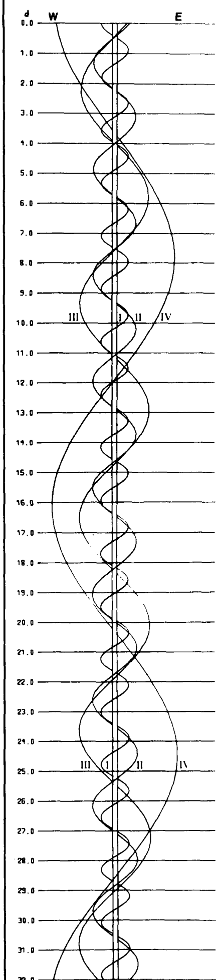
Saturn on the 15th is in R.A. 14 h 02 m, Decl. −9°28′, mag. +0.4, and transits at 0 h 31 m. It rises just after sunset and is setting at sunrise, being in opposition to the sun on Apr. 21.

Uranus on the 15th is in R.A. 16 h 28 m, Decl. −21°39′, mag. +5.8, and transits at 2 h 57 m.

Neptune on the 15th is in R.A. 17 h 56 m, Decl. −22°11′, mag. +7.7, and transits at 4 h 25 m.

Venus Joins the "Winter Six". As the winter constellations appear to gradually swing westward, Venus moves eastward to join them. Venus is now in Taurus, and these, along with the stars of Orion, Auriga, Gemini, Canis Minor and Canis Major, dominate the western sky. In the middle of the month, the crescent moon adds to the beauty of the scene.

In the springtime, sunset rapidly becomes later each evening and the winter constellations slip all too quickly into the dusk. Enjoy them now, before it's too late!

1983			APRIL UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Fri.	1	05	Neptune stationary	23 20	
Sat.	2	09	Uranus 1.6° S. of Moon		
		13	Jupiter 0.6° S. of Moon; occultation[1]		
Sun.	3		Mercury at ascending node		
Mon.	4	01	Neptune 1.3° N. of Moon	20 10	
Tues.	5	08 38	☾ Last Quarter		
Wed.	6	18	Moon at apogee (404,400 km)		
Thur.	7		Mercury at perihelion	16 50	
Fri.	8				
Sat.	9	12	Mercury 1.4° N. of Mars		
Sun.	10	19	Uranus 5° N. of Antares	13 40	
Mon.	11				
Tues.	12				
Wed.	13	07 58	● New Moon	10 30	
Thur.	14	15	Mercury 6° N. of Moon		
		18	Vesta in conjunction		
Fri.	15				
Sat.	16	07	Venus 4° N. of Moon	7 20	
Sun.	17				
Mon.	18		Mercury at greatest hel. lat. N.		
		18	Pluto at opposition		
Tues.	19			4 10	
Wed.	20	08 58	☽ First Quarter		
Thur.	21		Venus at perihelion		
			Mars at ascending node		
		08	Moon at perigee (369,700 km)		
		08	Mercury greatest elong. E. (20°)		
		19	Saturn at opposition		
Fri.	22	13	Venus 7° N. of Aldebaran	1 00	
		22	Lyrid meteor shower		
Sat.	23				
Sun.	24			21 50	
Mon.	25				
Tues.	26	19	Saturn 1.6° S. of Moon		
Wed.	27	06 31	○ Full Moon	18 40	
Thur.	28				
Fri.	29	17	Uranus 1.5° S. of Moon		
		19	Jupiter 0.6° S. of Moon; occultation[2]		
Sat.	30			15 30	

[1]Visible in the N. Pacific, N. and Central America, the north of S. America
[2]Visible in Asia, the E. Indies, and the N. Pacific

THE SKY FOR MAY 1983

The Sun—During May, the sun's R.A. increases from 2 h 31 m to 4 h 33 m and its Decl. changes from +14°50′ to +21°57′. The equation of time changes from +2 m 53 s to +2 m 28 s, reaching a maximum on May 14.

The Moon—On May 1.0 U.T., the age of the moon is 17.7 d. The sun's selenographic colongitude is 130.49° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 24 (5°) and minimum (east limb exposed) on May 10 (6°). The libration in latitude is maximum (north limb exposed) on May 8 (7°) and minimum (south limb exposed) on May 21 (7°).

Mercury on the 1st is in R.A. 3 h 30 m, Decl. +21°29′, and on the 15th is in R.A. 3 h 11 m, Decl. +16°47′. Very early in the month, it may be seen very low in the western sky (near the Pleiades). Binoculars would help. During the rest of the month, it is too close to the sun to be seen. It passes inferior conjunction on May 12.

Venus on the 1st is in R.A. 5 h 18 m, Decl. +25°13′, and on the 15th it is in R.A. 6 h 28 m, Decl. +25°49′, mag. −3.7, and transits at 15 h 00 m. Moving from Taurus into Gemini, it continues to dominate the western sky at sunset. Watch it as it moves past Castor and Pollux; it is 4° south of Pollux on May 31.

Mars on the 15th is in R.A. 3 h 45 m, Decl. +20°06′, mag. +1.6, and transits at 12 h 16 m. It is too close to the sun to be seen.

Jupiter on the 15th is in R.A. 16 h 24 m, Decl. −20°41′, mag. −2.1, and transits at 0 h 55 m. It rises shortly after sunset and is setting at sunrise, being in opposition to the sun on May 27. On May 16, it is 0.8° north of Uranus. This is another excellent opportunity to look for Uranus, especially if you have never done so before. Binoculars would help.

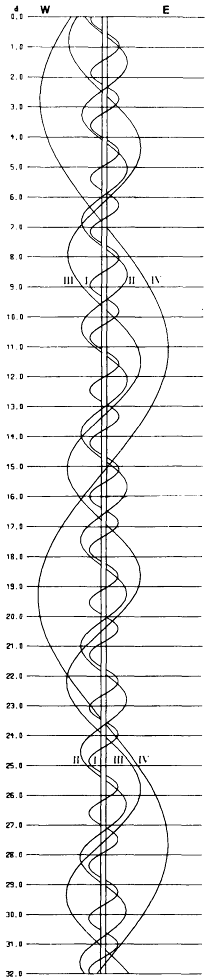
Saturn on the 15th is in R.A. 13 h 53 m, Decl. −8°44′, mag. +0.5, and transits at 22 h 21 m. It rises shortly before sunset and sets before sunrise. In May and June, it continues to move westward, toward Spica. This "retrograde motion" is due to the motion of the earth in its orbit, as it passes between Saturn and the Sun.

Uranus on the 15th is in R.A. 16 h 24 m, Decl. −21°30′, mag. +5.8, and transits at 0 h 55 m. On May 29, it is at opposition, at a distance of 17.933 astronomical units from the earth. It is less than 1° south of Jupiter on May 16.

Neptune on the 15th is in R.A. 17 h 55 m, Decl. −22°10′, mag. +7.7, and transits at 2 h 26 m.

1983			MAY UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Sun.	1	09	Neptune 1.5° N. of Moon	
Mon.	2	04	Mercury stationary	
Tues.	3			12 20
Wed.	4	13	Moon at apogee (404,200 km)	
Thur.	5	01	η Aquarid meteor shower	
		03 43	☾ Last Quarter	
Fri.	6	06	Jupiter 6° N. of Antares	9 10
Sat.	7	21	Pallas stationary	
Sun.	8			
Mon.	9			5 50
Tues.	10			
Wed.	11		Mercury at descending node	
Thur.	12	17	Mercury in inferior conjunction	2 40
		19 25	● New Moon	
Fri.	13		Venus at greatest hel. lat. N.	
Sat.	14			23 30
Sun.	15			
Mon.	16	01	Venus 1.5° N. of Moon	
		13	Jupiter 0.8° N. of Uranus	
		16	Moon at perigee (367,500 km)	
Tues.	17			20 20
Wed.	18			
Thur.	19	14 17	☽ First Quarter	
Fri.	20			17 10
Sat.	21		Mercury at aphelion	
Sun.	22			
Mon.	23	23	Saturn 1.8° S. of Moon	14 00
Tues.	24	23	Mercury stationary	
Wed.	25			
Thur.	26	18 48	○ Full Moon	10 50
		21	Jupiter 0.8° S. of Moon; occultation[1]	
		23	Uranus 1.6° S. of Moon	
Fri.	27	22	Jupiter at opposition	
Sat.	28	16	Neptune 1.6° N. of Moon	
Sun.	29	01	Uranus at opposition	7 40
Mon.	30			
Tues.	31	05	Venus 4° S. of Pollux	

Config. of Jupiter's Satellites



[1]Visible in Europe, N.E. Africa, Asia

THE SKY FOR JUNE 1983

The Sun—During June, the sun's R.A. increases from 4 h 33 m to 6 h 38 m and its Decl. changes from +21°57′ to +23°10′. The equation of time changes from +2 m 19 s to −3 m 29 s. On June 21, at 23 h 09 m U.T., the sun reaches the summer solstice, and summer begins in the northern hemisphere. There is a total eclipse of the sun on June 11, visible along a path stretching from the middle of the Indian Ocean, through Indonesia into the Pacific Ocean.

The Moon—On June 1.0 U.T., the age of the moon is 19.2 d. The sun's selenographic colongitude is 149.04° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 20 (6°) and minimum (east limb exposed) on June 7 (6°). The libration in latitude is maximum (north limb exposed) on June 4 (7°) and minimum (south limb exposed) on June 17 (7°). On June 24–25, there is a partial eclipse of the moon, visible in Australia and in the Americas. On June 9, there is an occultation of Mercury by the moon, visible from parts of North America.

M

Mercury on the 1st is in R.A. 3 h 06 m, Decl. +13°31′, and on the 15th is in R.A. 3 h 57 m, Decl. +17°36′. It reaches greatest elongation west (24°) on June 8, but this is not a favourable elongation. The planet is too low in the sky to be seen with ease.

Venus on the 1st is in R.A. 7 h 48 m, Decl. +23°44′, and on the 15th it is in R.A. 8 h 47 m, Decl. +20°07′, mag. −3.9, and transits at 15 h 16 m. Moving from Gemini into Cancer, it continues to dominate the western sky at sunset. On June 16, it reaches greatest elongation east (45°). Warning: within a few weeks, Venus will no longer be visible! It swings *rapidly* back toward the sun. The increasingly shallow angle of the ecliptic to the horizon does not help matters, either.

Mars on the 15th is in R.A. 5 h 18 m, Decl. +23°37′, mag. +1.7, and transits at 11 h 46 m. It is too close to the sun to be seen, being in conjunction on June 3.

Jupiter on the 15th is in R.A. 16 h 08 m, Decl. −20°04′, mag. −2.1, and transits at 22 h 33 m. It is low in the south-east at sunset, and sets after midnight. Moving westward from Ophiuchus into Scorpius, it passes near β Sco (see map in the "Planets" section).

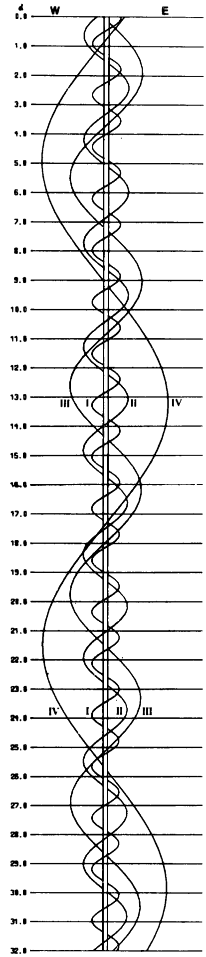
Saturn on the 15th is in R.A. 13 h 48 m, Decl. −8°18′, mag. +0.7, and transits at 20 h 13 m. It is due south at sunset, and sets at about midnight.

Uranus on the 15th is in R.A. 16 h 18 m, Decl. −21°17′, mag. +5.8, and transits at 22 h 44 m. Early in the month, it moves from Ophiuchus into Scorpius.

Neptune on the 15th is in R.A. 17 h 51 m, Decl. −22°10′, mag. +7.7, and transits at 0 h 20 m. On June 19, it is at opposition, at a distance of 29.251 astronomical units from the earth.

1983			JUNE UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Wed.	1	08	Moon at apogee (404,700 km)	4 30
Thur.	2			
Fri.	3	11	Mars in conjunction	
		21 07	☾ Last Quarter	
Sat.	4			1 10
Sun.	5			
Mon.	6			22 00
Tues.	7			
Wed.	8	06	Mercury greatest elong. W. (24°)	
Thur.	9	10	Mercury 0.8° S. of Moon; occultation[1]	18 50
Fri.	10			
Sat.	11		Mercury at greatest hel. lat. S.	
		04 37	● New Moon; eclipse of Sun, pg. 74	
Sun.	12			15 40
Mon.	13	06	Moon at perigee (362,500 km)	
Tues.	14	11	Venus 1.5° S. of Moon	
Wed.	15			12 30
Thur.	16	07	Venus greatest elong. E. (45°)	
Fri.	17	19 46	☽ First Quarter	
Sat.	18			9 20
Sun.	19	17	Neptune at opposition	
Mon.	20	03	Saturn 2° S. of Moon	
Tues.	21	06	Mercury 4° N. of Aldebaran	6 10
		23 09	Summer solstice; summer begins	
Wed.	22	21	Jupiter 1.2° S. of Moon; occultation[2]	
Thur.	23	03	Uranus 1.7° S. of Moon	
Fri.	24	22	Neptune 1.5° N. of Moon	3 00
Sat.	25	08 32	○ Full Moon; eclipse of Moon. pg. 74	
Sun.	26			23 40
Mon.	27			
Tues.	28	06	Ceres stationary	
		23	Moon at apogee (405,700 km)	
Wed.	29			20 30
Thur.	30		Mercury at ascending node	

Config. of Jupiter's Satellites



[1]Visible in eastern N. America, N. Atlantic, Greenland, Arctic, N. Europe and N. Asia
[2]Visible only in the Arctic

THE SKY FOR JULY 1983

The Sun—During July, the sun's R.A. increases from 6 h 38 m to 8 h 42 m and its Decl. changes from +23°10′ to +18°13′. The equation of time changes from −3 m 41 s to −6 m 21 s, reaching a minimum on July 26. On July 6, the earth is at aphelion, at a distance of 152,103,000 km (94,512,000 mi) from the sun.

The Moon—On July 1.0 U.T., the age of the moon is 19.8 d. The sun's selenographic colongitude is 155.68° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 17 (7°) and minimum (east limb exposed) on July 5 (7°). The libration in latitude is maximum (north limb exposed) on July 2 (7°) and July 29 (7°) and minimum (south limb exposed) on July 15 (7°).

Mercury on the 1st is in R.A. 5 h 53 m, Decl. +23°34′, and on the 15th is in R.A. 8 h 03 m, Decl. +22°16′. Throughout the month, it is too close to the sun to be seen, being in superior conjunction on July 9.

Venus on the 1st is in R.A. 9 h 43 m, Decl. +14°41′, and on the 15th it is in R.A. 10 h 19 m, Decl. +9°35′, mag. −4.2, and transits at 14 h 48 m. Early in the month, it is low in the western sky at sunset, but by the end of the month, it is too close to the sun to be seen. On July 9, it passes 0.7° south of Regulus. On July 19, it attains greatest brilliancy ($-4^{\mathrm{m}}.2$). At this time, seen through a small telescope, it would appear as a crescent, about 40 arc seconds in size. See also "Venus" last month.

Mars on the 15th is in R.A. 6 h 46 m, Decl. +23°49′, mag. +1.8, and transits at 11 h 16 m. It is too close to the sun to be seen.

Jupiter on the 15th is in R.A. 15 h 58 m, Decl. −19°41′, mag. −2.0, and transits at 20 h 25 m. It is low in the south at sunset, and sets about 5 hours later. On July 29, it is stationary; thereafter, it resumes its normal eastward motion relative to the background stars.

Saturn on the 15th is in R.A. 13 h 47 m, Decl. −8°24′, mag. +0.9, and transits at 18 h 15 m. At sunset, it is west of south, and it sets about 4 hours later. On July 2, it is stationary; thereafter, it resumes its normal eastward motion relative to the background stars.

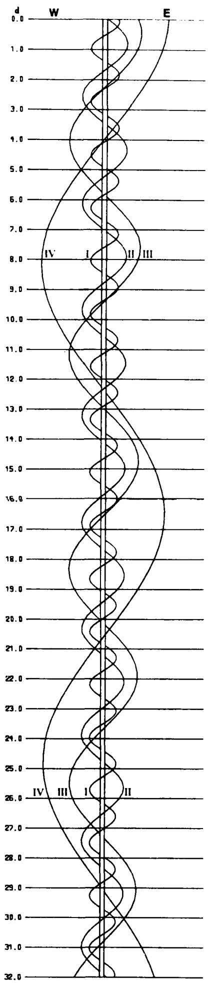
Uranus on the 15th is in R.A. 16 h 14 m, Decl. −21°08′, mag. +5.8, and transits at 20 h 42 m.

Neptune on the 15th is in R.A. 17 h 48 m, Decl. −22°09′, mag. +7.7, and transits at 22 h 15 m.

Angular Distances in the Sky. In "The Sky Month by Month", you will often see reference to angular distances in the sky. For instance, on July 9, Venus passes 0.7° south of Regulus, and on July 13, Venus passes 6° south of the moon. You can visualize these angles more easily if you remember the following. (1) The moon and sun are both 0.5° in diameter. (2) With your arm fully outstretched, your little finger is 1° wide and your fist is 10° wide. (3) The bowl of the Big Dipper is 5° high and 10° wide; the entire Big Dipper is 25° long.

1983			JULY UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Fri.	1			
Sat.	2	13	Saturn stationary	17 20
Sun.	3	12 12	☾ Last Quarter	
Mon.	4		Mercury at perihelion	
Tues.	5			14 10
Wed.	6	10	Earth at aphelion	
Thur.	7			
Fri.	8		Venus at descending node	11 00
		06	Pallas at opposition	
Sat.	9	16	Mercury in superior conjunction	
		23	Venus 0.7° S. of Regulus	
Sun.	10	12 18	🌑 New Moon	
Mon.	11	10	Moon at perigee (358,600 km)	7 50
Tues.	12			
Wed.	13	08	Venus 6° S. of Moon	
Thur.	14	08	Pluto stationary	4 40
Fri.	15		Mercury at greatest hel. lat. N.	
Sat.	16			
Sun.	17	02 50	☽ First Quarter	1 20
		09	Saturn 2° S. of Moon	
Mon.	18			
Tues.	19	15	Venus greatest brilliancy ($-4^{m}.2$)	22 10
		23	Jupiter 1.4° S. of Moon	
Wed.	20	07	Uranus 1.7° S. of Moon	
Thur.	21			
Fri.	22	02	Neptune 1.5° N. of Moon	19 00
Sat.	23			
Sun.	24	23 27	🌕 Full Moon	
Mon.	25			15 50
Tues.	26	07	Moon at apogee (406,300 km)	
Wed.	27			
Thur.	28			12 40
Fri.	29	04	South δ Aquarid meteor shower	
		13	Jupiter stationary	
Sat.	30			
Sun.	31			9 30

Config. of Jupiter's Satellites



THE SKY FOR AUGUST 1983

The Sun—During August, the sun's R.A. increases from 8 h 42 m to 10 h 39 m and its Decl. changes from +18°13′ to +8°34′. The equation of time changes from −6 m 18 s to −0 m 26 s.

The Moon—On August 1.0 U.T., the age of the moon is 21.5 d. The sun's selenographic colongitude is 174.55° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 14 (8°) and minimum (east limb exposed) on Aug. 2 (7°) and Aug. 31 (7°). The libration in latitude is maximum (north limb exposed) on Aug. 25 (7°) and minimum (south limb exposed) on Aug. 11 (7°).

Mercury on the 1st is in R.A. 10 h 07 m, Decl. +12°32′, and on the 15th is in R.A. 11 h 16 m, Decl. +3°25′. Although it reaches greatest elongation east (27°) on Aug. 19, this is an unfavourable elongation. The planet is barely 10° above the horizon at sunset, and could only be seen with great difficulty. On Aug. 1, it passes 0.4° north of Regulus.

Venus on the 1st is in R.A. 10 h 38 m, Decl. +4°20′, and on the 15th it is in R.A. 10 h 25 m, Decl. +2°25′, mag. −3.7, and transits at 12 h 50 m. It is too close to the sun to be seen. On Aug. 25, it is in inferior conjunction.

Mars on the 15th is in R.A. 8 h 13 m, Decl. +20°58′, mag. +1.9, and transits at 10 h 41 m. Throughout the month, it moves rapidly west, relative to the sun. By mid-month, it rises about 2 hours before the sun, and stands about 20° above the eastern horizon at sunrise. It moves from Gemini into Cancer during the month, passing 6° south of Pollux on Aug. 4.

Jupiter on the 15th is in R.A. 15 h 58 m, Decl. −19°50′, mag. −1.8, and transits at 18 h 24 m. It is west of south at sunset, and sets about 4 hours later.

Saturn on the 15th is in R.A. 13 h 52 m, Decl. −9°01′, mag. +0.9, and transits at 16 h 18 m. It is low in the south-west at sunset, and sets about 2½ hours later.

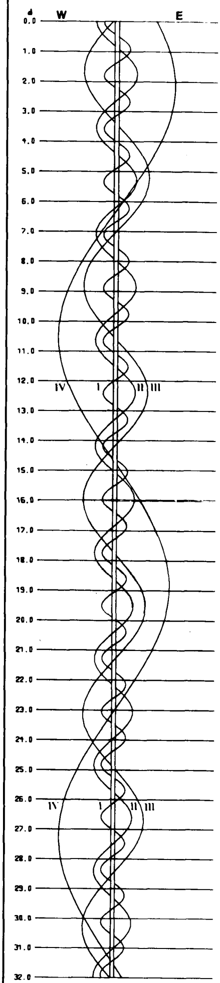
Uranus on the 15th is in R.A. 16 h 13 m, Decl. −21°04′, mag. +5.9, and transits at 18 h 38 m.

Neptune on the 15th is in R.A. 17 h 45 m, Decl. −22°09′, mag. +7.7, and transits at 20 h 11 m.

The Joys of August. August is a good month for stargazing. The nights are warm, but are beginning to get longer. Many observers find themselves cottaging or camping, far from city lights.

One of the treats of August is the Perseid meteor shower. This year, it occurs a few days after new moon, so that by midnight, meteors can be seen against a dark sky. Not completely dark, of course, because the Milky Way stretches across the August sky, arching overhead at midnight. Try scanning along the Milky Way with binoculars, stopping to look at star clouds and star clusters.

Earlier in the evening, the crescent moon is a pretty sight, along with Jupiter and Saturn. Try to find Uranus; it is only a few degrees away from Jupiter (see maps in the "Planets" section).

1983			AUGUST UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Mon.	1	02	Mercury 0.4° N. of Regulus		
		12	Venus stationary		
Tues.	2	00 52	☾ Last Quarter		
Wed.	3			6 20	
Thur.	4	12	Mars 6° S. of Pollux		
Fri.	5				
Sat.	6	06	Mercury 6° N. of Venus	3 10	
Sun.	7		Mercury at descending node		
		12	Mars 1.8° S. of Moon		
Mon.	8	19	Moon at perigee (363,500 km)	23 50	
		19 18	● New Moon		
Tues.	9				
Wed.	10	01	Venus 12°S. of Moon		
		11	Mercury 6° S. of Moon		
Thur.	11			20 40	
Fri.	12		Venus at aphelion		
		19	Perseid meteor shower		
Sat.	13	18	Saturn 1.9° S. of Moon		
Sun.	14	05	Ceres at opposition	17 30	
		08	Uranus stationary		
Mon.	15	12 47	☽ First Quarter		
Tues.	16	06	Jupiter 1.3° S. of Moon		
		13	Uranus 1.6° S. of Moon		
Wed.	17		Mercury at aphelion	14 20	
Thur.	18	07	Neptune 1.5° N. of Moon		
Fri.	19	16	Mercury greatest elong. E. (27°)		
Sat.	20			11 10	
Sun.	21				
Mon.	22	09	Moon at apogee (406,300 km)		
Tues.	23	14 59	○ Full Moon	8 00	
Wed.	24				
Thur.	25	05	Venus in inferior conjunction		
Fri.	26			4 40	
Sat.	27				
Sun.	28				
Mon.	29	20	Pallas stationary	1 30	
Tues.	30				
Wed.	31	11 22	☾ Last Quarter	22 20	

THE SKY FOR SEPTEMBER 1983

The Sun—During September, the sun's R.A. increases from 10 h 39 m to 12 h 27 m and its Decl. changes from +8°34′ to −2°53′. The equation of time changes from −0 m 07 s to +9 m 52 s. On Sept. 23, at 14 h 42 m U.T., the sun reaches the autumnal equinox, and autumn begins in the northern hemisphere.

The Moon—On September 1.0 U.T., the age of the moon is 23.2 d. The sun's selenographic colongitude is 193.20° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 12 (8°) and minimum (east limb exposed) on Sept. 27 (6°). The libration in latitude is maximum (north limb exposed) on Sept. 21 (7°) and minimum (south limb exposed) on Sept. 7 (7°). On Sept. 12, there is an occultation of Jupiter by the moon, visible from parts of North America.

M *Mercury* on the 1st is in R.A. 11 h 56 m, Decl. −3°52′, and on the 15th is in R.A. 11 h 29 m, Decl. −0°21′. Throughout most of the month, it is too close to the sun to be seen (it passes inferior conjunction on Sept. 15), but the situation rapidly improves at the end of the month. At this time, the planet is approaching a favourable greatest elongation west, and stands about 16° above the eastern horizon at sunrise.

Venus on the 1st is in R.A. 9 h 47 m, Decl. +4°27′, and on the 15th it is in R.A. 9 h 33 m, Decl. +7°17′, mag. −4.1, and transits at 9 h 58 m. Early in the month, it is too close to the sun to be seen, but by mid-month, it is well up in the east at sunrise. This elongation west, like that of Mercury discussed above, is extremely favourable, because of the steep angle of the ecliptic to the horizon.

On Sept. 14, Venus passes 9° south of Mars. You might wonder: how can the separation of the planets be as large as 9°, almost the width of the bowl of the Big Dipper? The explanation is as follows. The orbit of Venus is tilted by 3.4° relative to the orbit of the earth. On Sept. 3, Venus is at the extreme southerly position in its orbit ("greatest heliocentric latitude south"). At the same time, Venus is on the near side of the sun, less than 0.4 astronomical units from earth. As a result of these factors, Venus *appears* almost 8° south of the ecliptic.

Mars on the 15th is in R.A. 9 h 34 m, Decl. +15°45′, mag. +2.0, and transits at 9 h 59 m. Moving from Cancer into Leo (near Venus; see "Venus" above), it is well up in the east at sunrise. It passes 0.9° north of Regulus on Sept. 28.

Jupiter on the 15th is in R.A. 16 h 10 m, Decl. −20°29′, mag. −1.6, and transits at 16 h 34 m. It is low in the south-west at sunset, and sets about 3 hours later. On Sept 12, it is occulted by the moon, and on Sept. 24, it passes 0.4° north of Uranus.

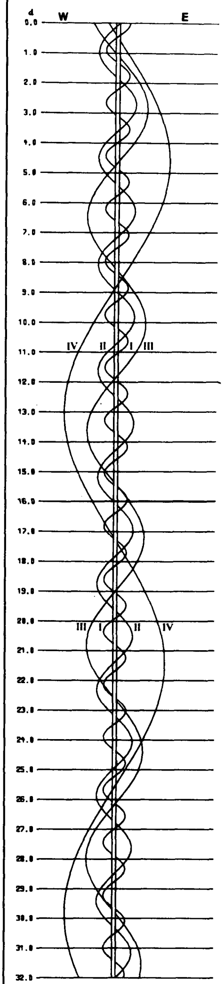
Saturn on the 15th is in R.A. 14 h 02 m, Decl. −10°02′, mag. +0.9, and transits at 14 h 27 m. It is low in the west at sunset, and sets about 2 hours later.

Uranus on the 15th is in R.A. 16 h 14 m, Decl. −21°09′, mag. +5.9, and transits at 16 h 38 m. Late in the month, it moves from Scorpius back into Ophiuchus, where it remains for the rest of the year. It is only 0.4° south of Jupiter on Sept. 24.

Neptune on the 15th is in R.A. 17 h 45 m, Decl. −22°11′, mag. +7.7, and transits at 18 h 08 m.

1983	d	h m	SEPTEMBER UNIVERSAL TIME	Min. of Algol h m
Thur.	1	19	Mercury stationary	
Fri.	2			
Sat.	3		Venus at greatest hel. lat. S.	19 10
Sun.	4			
Mon.	5	02	Mars 3° S. of Moon	
		14	Venus 13° S. of Moon	
Tues.	6	05	Moon at perigee (358,400 km)	16 00
Wed.	7		Mercury at greatest hel. lat. S.	
		02 35	● New Moon	
		20	Mercury 10° S. of Moon	
Thur.	8	12	Neptune stationary	
Fri.	9			12 50
Sat.	10	07	Saturn 1.7° S. of Moon	
Sun.	11			
Mon.	12	18	Jupiter 0.9° S. of Moon; occultation[1]	9 40
		21	Uranus 1.3° S. of Moon	
Tues.	13			
Wed.	14	02 24	☽ First Quarter	
		08	Venus stationary	
		14	Neptune 1.7° N. of Moon	
		19	Venus 9° S. of Mars	
Thur.	15	16	Mercury in inferior conjunction	6 20
Fri.	16			
Sat.	17			
Sun.	18	17	Moon at apogee (405,700 km)	3 10
Mon.	19			
Tues.	20			
Wed.	21			0 00
Thur.	22	06 36	○ Full Moon; Harvest Moon	
Fri.	23	14 42	Autumnal equinox; autumn begins	20 50
Sat.	24	01	Mercury stationary	
		03	Juno stationary	
		22	Jupiter 0.4° N. of Uranus	
Sun.	25			
Mon.	26		Mercury at ascending node	17 40
Tues.	27			
Wed.	28	21	Mars 0.9° N. of Regulus	
Thur.	29	20 05	☾ Last Quarter	14 30
Fri.	30		Mercury at perihelion	

Config. of Jupiter's Satellites



[1]Visible in northeastern N. America, Greenland, N. Atlantic, N. Africa, Europe

THE SKY FOR OCTOBER 1983

The Sun—During October, the sun's R.A. increases from 12 h 27 m to 14 h 22 m and its Decl. changes from −2°53′ to −14°10′. The equation of time changes from +10 m 12 s to +16 m 21 s.

The Moon—On October 1.0 U.T., the age of the moon is 23.9 d. The sun's selenographic colongitude is 199.24° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 10 (7°) and minimum (east limb exposed) on Oct. 24 (5°). The libration in latitude is maximum (north limb exposed) on Oct. 18 (7°) and minimum (south limb exposed) on Oct. 4 (7°).

Mercury on the 1st is in R.A. 11 h 23 m, Decl. +5°15′, and on the 15th is in R.A. 12 h 40 m, Decl. −2°17′. Early in the month, it stands about 16° above the eastern horizon at sunrise. It reaches greatest elongation west (18°) on Oct. 1, and this is a favourable elongation. By the end of the month, it is too close to the sun to be seen; it reaches superior conjunction on Oct. 30.

Venus on the 1st is in R.A. 9 h 52 m, Decl. +8°34′, and on the 15th it is in R.A. 10 h 30 m, Decl. +7°24′, mag. −4.2, and transits at 8 h 58 m. It rises about 3 hours before the sun, and is well up in the south-east at sunrise. In Leo, it passes 4° south of Regulus on Oct. 7, and passes 1.7° south of Mars on Oct. 28. It attains greatest brilliancy ($-4^{m}.3$) on Oct. 1. At this time, it would appear as a crescent in a small telescope. The partial illumination is more than compensated by the small distance of Venus from the earth.

Mars on the 15th is in R.A. 10 h 45 m, Decl. +9°21′, mag. +1.9, and transits at 9 h 13 m. It rises about 3 hours before the sun, and is well up in the south-east at sunrise. In Leo, it passed close to Regulus on Sept. 28, and is in conjunction with Venus on Oct. 28. Of these three objects, Venus is by far the brightest and Mars is by far the reddest.

Incidentally, do you know how to find the autumnal equinox in the sky? It is midway between Regulus and Spica (slightly closer to Spica).

Jupiter on the 15th is in R.A. 16 h 30 m, Decl. −21°22′, mag. −1.4, and transits at 14 h 56 m. It is very low in the south-west at sunset, and sets about 2 hours later.

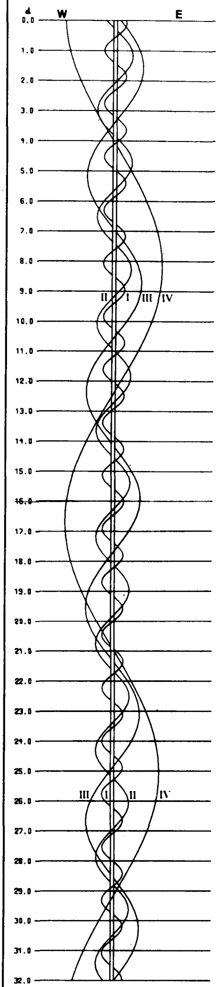
Saturn on the 15th is in R.A. 14 h 15 m, Decl. −11°12′, mag. +0.8, and transits at 12 h 41 m. Early in the month, it may be seen, with very great difficulty, low in the south-west at sunset, but by the end of the month, it is too close to the sun to be seen. It is in conjunction with the sun on Oct. 31.

Uranus on the 15th is in R.A. 16 h 19 m, Decl. −21°21′, mag. +6.0, and transits at 14 h 45 m.

Neptune on the 15th is in R.A. 17 h 46 m, Decl. −22°13′, mag. +7.8, and transits at 16 h 12 m.

1983			OCTOBER UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Sat.	1	07	Venus greatest brilliancy (−4.3)	
		10	Mercury greatest elong. W. (18°)	
Sun.	2			11 20
Mon.	3	07	Venus 9° S. of Moon	
		16	Mars 4° S. of Moon	
Tues.	4	11	Moon at perigee (362,400 km)	
Wed.	5	03	Mercury 4° S. of Moon	8 10
Thur.	6	11 16	● New Moon	
Fri.	7	07	Venus 4° S. of Regulus	
		13	Ceres stationary	
		23	Saturn 1.4° S. of Moon	
Sat.	8			4 50
Sun.	9			
Mon.	10	08	Uranus 1.0° S. of Moon; occultation[1]	
		11	Jupiter 0.4° S. of Moon; occultation[2]	
Tues.	11		Mercury at greatest hel. lat. N.	1 40
		22	Neptune 2° N. of Moon	
Wed.	12			
Thur.	13	01	Jupiter 5° N. of Antares	22 30
		19 42	☽ First Quarter	
Fri.	14			
Sat.	15			
Sun.	16	08	Moon at apogee (404,900 km)	19 20
Mon.	17			
Tues.	18			
Wed.	19			16 10
Thur.	20			
Fri.	21	21 53	○ Full Moon; Hunters' Moon	
		23	Orionid meteor shower	
Sat.	22			13 00
Sun.	23		Mars at greatest hel. lat. N.	
		11	Pluto in conjunction	
Mon.	24	05	Juno at opposition	
Tues.	25	12	Vesta stationary	9 50
Wed.	26			
Thur.	27			
Fri.	28	13	Venus 1.7° S. of Mars	6 30
Sat.	29	03 37	☾ Last Quarter	
Sun.	30		Venus at ascending node	
		17	Mercury in superior conjunction	
Mon.	31	06	Saturn in conjunction	3 20

Config. of Jupiter's Satellites



[1]Visible only in the N. Pacific

[2]Visible in southern Europe, N. Africa, Saudi Arabia, S.E. Asia, the Indian Ocean and the East Indies

THE SKY FOR NOVEMBER 1983

The Sun—During November, the sun's R.A. increases from 14 h 22 m to 16 h 26 m and its Decl. changes from $-14°10'$ to $-21°41'$. The equation of time changes from +16 m 24 s to +11 m 30 s, reaching a maximum on Nov. 3.

The Moon—On November 1.0 U.T., the age of the moon is 25.5 d. The sun's selenographic colongitude is 216.99° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 6 (6°) and minimum (east limb exposed) on Nov. 19 (5°). The libration in latitude is maximum (north limb exposed) on Nov. 14 (7°) and minimum (south limb exposed) on Nov. 1 (7°) and Nov. 28 (7°)

Mercury on the 1st is in R.A. 14 h 26 m, Decl. $-14°10'$, and on the 15th is in R.A. 15 h 54 m, Decl. $-21°33'$. Throughout the month, it is too close to the sun to be seen.

M *Venus* on the 1st is in R.A. 11 h 29 m, Decl. $+3°34'$, and on the 15th it is in R.A. 12 h 24 m, Decl. $-1°02'$, mag. -4.0, and transits at 8 h 50 m. It rises about 4 hours before the sun, and is well up in the south-east at sunrise. During the month, it moves from Leo into Virgo, passing 4° north of Spica on Nov. 29. On Nov. 4, it is at greatest elongation west (47°), and this is a favourable elongation.

Mars on the 15th is in R.A. 11 h 55 m, Decl. $+2°10'$, mag. $+1.8$, and transits at 8 h 20 m. It rises about 5 hours before the sun, and is high up in the south-east at sunrise. During the month, it also moves from Leo into Virgo. It appears to the west of Venus, which is considerably brighter and less red than Mars.

Jupiter on the 15th is in R.A. 16 h 57 m, Decl. $-22°15'$, mag. -1.4, and transits at 13 h 21 m. It is too close to the sun to be seen.

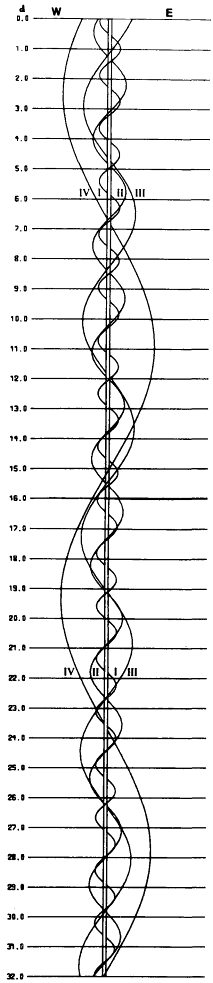
Saturn on the 15th is in R.A. 14 h 29 m, Decl. $-12°25'$, mag. $+0.8$, and transits at 10 h 54 m. It is too close to the sun to be seen.

Uranus on the 15th is in R.A. 16 h 26 m, Decl. $-21°38'$, mag. $+6.0$, and transits at 12 h 50 m.

Neptune on the 15th is in R.A. 17 h 50 m, Decl. $-22°15'$, mag. $+7.8$, and transits at 14 h 14 m.

Observing Variable Stars. This year, in case you have not already noticed, we have made some changes in the "Variable Stars" section of this HANDBOOK. We have replaced the "Star of the Year" feature with a set of simple instructions on variable star observing. These were kindly provided by Janet A. Mattei, of the American Association of Variable Star Observers.

November is a good month for observing variable stars. Three of the most famous variables: Mira (o Ceti), Algol (β Persei) and δ Cephei are well placed for observing. Charts for these stars are included in the "Variable Stars" section of this HANDBOOK. Variable star observing is easy, interesting and worthwhile. Try it – you'll like it!

1983			NOVEMBER UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Tues.	1	03	Moon at perigee (367,800 km)		
		04	Mars 4° S. of Moon		
		06	Venus 5° S. of Moon		
Wed.	2				
Thur.	3		Mercury at descending node	0 10	
		00	South Taurid meteor shower		
Fri.	4	20	Venus greatest elong. W. (47°)		
		22 21	● New Moon		
Sat.	5			21 00	
Sun.	6	20	Uranus 0.7° S. of Moon; occultation[1]		
Mon.	7	07	Jupiter 0.2° N. of Moon; occultation[2]		
Tues.	8	09	Neptune 2° N. of Moon	17 50	
Wed.	9				
Thur.	10				
Fri.	11			14 40	
Sat.	12	15 49	☽ First Quarter		
Sun.	13		Mercury at aphelion		
		03	Moon at apogee (404,400 km)		
Mon.	14			11 30	
Tues.	15				
Wed.	16				
Thur.	17			8 20	
Fri.	18	06	Leonid meteor shower		
Sat.	19				
Sun.	20	04	Mercury 1.8° S. of Uranus	5 10	
		07	Mercury 3° N. of Antares		
		12 29	○ Full Moon		
Mon.	21				
Tues.	22				
Wed.	23			1 50	
Thur.	24				
Fri.	25			22 40	
Sat.	26	02	Moon at perigee (369,800 km)		
		06	Mercury 3° S. of Jupiter		
Sun.	27	10 50	☾ Last Quarter		
Mon.	28			19 30	
Tues.	29	15	Venus 4° N. of Spica		
		15	Mars 4° S. of Moon		
Wed.	30		Mars at aphelion		
		21	Venus 2° S. of Moon		

[1]Visible in the N. Atlantic and northeastern S. America
[2]Visible in E. Africa, the Indian Ocean and Australasia

THE SKY FOR DECEMBER 1983

The Sun—During December, the sun's R.A. increases from 16 h 26 m to 18 h 42 m and its Decl. changes from −21°41′ to −23°05′. The equation of time changes from +11 m 08 s to −2 m 48 s. On Dec. 22, at 10 h 30 m U.T., the sun reaches the winter solstice, and winter begins in the northern hemisphere. On Dec. 4, there is an annular eclipse of the sun, visible as such along a path extending from the middle of the North Atlantic Ocean, through Central Africa.

The Moon—On December 1.0 U.T., the age of the moon is 26.1 d. The sun's selenographic colongitude is 222.08° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 3 (5°) and Dec. 30 (6°) and minimum (east limb exposed) on Dec. 17 (6°). The libration in latitude is maximum (north limb exposed) on Dec. 12 (7°) and minimum (south limb exposed) on Dec. 25 (7°). On Dec. 19–20, there is a penumbral eclipse of the moon, visible in the Americas (among other places). On Dec. 29, there is an occultation of Saturn by the moon, visible from parts of North America.

Mercury on the 1st is in R.A. 17 h 38 m, Decl. −25°41′, and on the 15th is in R.A. 18 h 57 m, Decl. −24°34′. Though technically an evening "star", it remains too low in the sky to be seen. This is due to its extreme southerly declination (25°). Greatest elongation east (21°) occurs on Dec. 13, and inferior conjunction occurs on Dec. 31.

Venus on the 1st is in R.A. 13 h 30 m, Decl. −7°07′, and on the 15th it is in R.A. 14 h 32 m, Decl. −12°27′, mag. −3.7, and transits at 9 h 00 m. It rises about 3 hours before the sun, and stands about 30° above the south-eastern horizon at sunrise. On Dec. 17, it is a scant 0.2° north of Saturn. By the end of the month, it begins to close in on the sun again, and is not so easily seen.

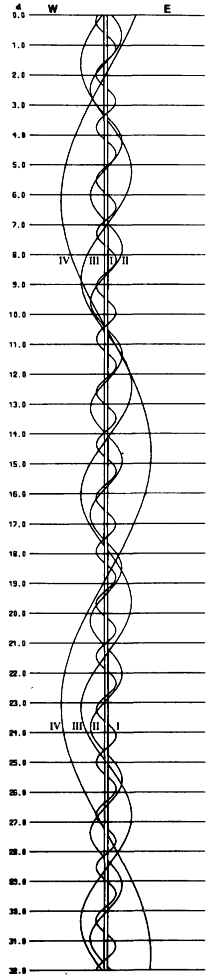
Mars on the 15th is in R.A. 12 h 59 m, Decl. −4°34′, mag. +1.6, and transits at 7 h 26 m. In Virgo, it rises after midnight and is due south at sunrise. It is 4° north of Spica on Dec. 27.

Jupiter on the 15th is in R.A. 17 h 26 m, Decl. −22°52′, mag. −1.3, and transits at 11 h 52 m. It is too close to the sun to be seen, being in conjunction on Dec. 14.

Saturn on the 15th is in R.A. 14 h 42 m, Decl. −13°25′, mag. +0.8, and transits at 9 h 09 m. It has emerged from behind the sun, and is now prominent in the early morning sky. It rises about 3 hours before the sun, and stands almost 30° above the south-eastern horizon at sunrise. It is now in Libra, and passes about 2° north of Zubenelgenubi at the end of the month. Note the occultation of Saturn by the moon on Dec. 29.

Uranus on the 15th is in R.A. 16 h 34 m, Decl. −21°55′, mag. +6.0, and transits at 11 h 00 m. On Dec. 2, it is in conjunction with the sun.

Neptune on the 15th is in R.A. 17 h 54 m, Decl. −22°16′, mag. +7.8, and transits at 12 h 20 m. On Dec. 21, it is in conjunction with the sun.

1983			DECEMBER UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Thur.	1			16 20	
Fri.	2		Venus at perihelion		
		03	Uranus in conjunction		
		04	Saturn 0.9° S. of Moon; occultation[1]		
		23	Juno stationary		
Sat.	3	07	Mercury 4°S. of Neptune		
Sun.	4		Mercury at greatest hel. lat. S.	13 10	
		12 26	● New Moon; eclipse of Sun. pg. 74		
Mon.	5	19	Neptune 2° N. of Moon		
Tues.	6	03	Mercury 0.9° S. of Moon; occultation[2]		
Wed.	7			10 00	
Thur.	8				
Fri.	9				
Sat.	10			6 50	
Sun.	11	01	Moon at apogee (404,700 km)		
Mon.	12	13 09	☽ First Quarter		
Tues.	13	10	Vesta at opposition	3 40	
		21	Mercury greatest elong. E. (21°)		
Wed.	14	13	Jupiter in conjunction		
		18	Geminid meteor shower		
Thur.	15				
Fri.	16			0 30	
Sat.	17	11	Venus 0.2° N. of Saturn		
Sun.	18			21 20	
Mon.	19				
Tues.	20	02 00	○ Full Moon; eclipse of Moon, pg. 74		
Wed.	21	10	Neptune in conjunction	18 10	
		20	Mercury stationary		
Thur.	22	10 30	Winter solstice; winter begins		
		18	Moon at perigee (364,900 km)		
Fri.	23		Mercury at ascending node		
		00	Ursid meteor shower		
Sat.	24		Venus at greatest hel. lat. N.	14 50	
Sun.	25				
Mon.	26	18 52	☾ Last Quarter		
Tues.	27		Mercury at perihelion	11 40	
		08	Mars 4° N. of Spica		
Wed.	28	00	Mars 3° S. of Moon		
Thur.	29	16	Saturn 0.6° S. of Moon; occultation[3]		
Fri.	30	19	Venus 0.7° N. of Moon; occultation[4]	8 30	
Sat.	31	08	Mercury in inferior conjunction		
		18	Uranus 0.4° S. of Moon; occultation[5]		

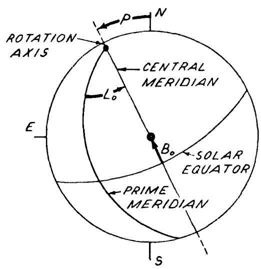
[1]Visible in northeastern Europe, Asia
[2]Visible in E. Asia and the N. Pacific
[3]Visible in the N. Pacific, N. and Central America and northern S. America
[4]Visible in Australasia, the S. Pacific, Antarctica, and southern S. America
[5]Visible only in the N. Pacific

SUN
EPHEMERIS

Date 0^hUT	Apparent 1983 RA	Apparent 1983 Dec	Transit at Greenwich UT	Orientation P	Orientation B_0	Orientation L_0
	h m	° ′	h m s	°	°	°
Jan 1	18 43.5	-23 04	12 03 24	+ 2.3	-3.0	239.3
6	19 05.5	-22 35	12 05 41	- 0.1	-3.6	173.5
11	19 27.3	-21 55	12 07 47	- 2.5	-4.1	107.6
16	19 48.9	-21 05	12 09 40	- 4.9	-4.6	41.8
21	20 10.3	-20 04	12 11 14	- 7.2	-5.1	336.0
26	20 31.3	-18 54	12 12 30	- 9.4	-5.5	270.1
31	20 51.9	-17 36	12 13 25	-11.6	-5.9	204.3
Feb 5	21 12.3	-16 10	12 14 00	-13.6	-6.3	138.5
10	21 32.3	-14 36	12 14 16	-15.5	-6.6	72.6
15	21 52.0	-12 57	12 14 12	-17.2	-6.8	6.8
20	22 11.3	-11 12	12 13 50	-18.9	-7.0	301.0
25	22 30.4	- 9 23	12 13 10	-20.4	-7.2	235.1
Mar 2	22 49.2	- 7 30	12 12 16	-21.7	-7.2	169.2
7	23 07.9	- 5 35	12 11 10	-22.8	-7.2	103.4
12	23 26.3	- 3 38	12 09 55	-23.8	-7.2	37.5
17	23 44.7	- 1 40	12 08 32	-24.7	-7.1	331.6
22	0 02.9	+ 0 19	12 07 04	-25.4	-7.0	265.7
27	0 21.1	+ 2 17	12 05 33	-25.9	-6.8	199.7
Apr 1	0 39.3	+ 4 14	12 04 02	-26.2	-6.6	133.8
6	0 57.6	+ 6 09	12 02 34	-26.3	-6.3	67.8
11	1 15.9	+ 8 01	12 01 11	-26.3	-5.9	1.8
16	1 34.3	+ 9 50	11 59 55	-26.0	-5.6	295.8
21	1 52.9	+11 35	11 58 48	-25.6	-5.1	229.8
26	2 11.7	+13 15	11 57 52	-25.0	-4.7	163.7
May 1	2 30.6	+14 50	11 57 07	-24.3	-4.2	97.7
6	2 49.8	+16 19	11 56 37	-23.3	-3.7	31.6
11	3 09.2	+17 41	11 56 20	-22.2	-3.2	325.5
16	3 28.9	+18 55	11 56 18	-20.9	-2.6	259.3
21	3 48.8	+20 01	11 56 30	-19.4	-2.0	193.2
26	4 08.9	+20 59	11 56 55	-17.8	-1.4	127.0
31	4 29.2	+21 48	11 57 32	-16.0	-0.8	60.9
Jun 5	4 49.7	+22 27	11 58 20	-14.2	-0.2	354.7
10	5 10.3	+22 57	11 59 16	-12.2	+0.4	288.6
15	5 31.0	+23 16	12 00 18	-10.1	+1.0	222.4
20	5 51.8	+23 26	12 01 23	- 7.9	+1.6	156.2
25	6 12.6	+23 25	12 02 27	- 5.7	+2.2	90.0
30	6 33.4	+23 13	12 03 29	- 3.4	+2.7	23.8
Jul 5	6 54.0	+22 52	12 04 25	- 1.1	+3.3	317.6
10	7 14.6	+22 20	12 05 14	+ 1.1	+3.8	251.5
15	7 34.9	+21 39	12 05 52	+ 3.4	+4.3	185.3
20	7 55.1	+20 49	12 06 16	+ 5.6	+4.8	119.1
25	8 15.0	+19 50	12 06 27	+ 7.7	+5.2	53.0
30	8 34.7	+18 42	12 06 23	+ 9.8	+5.6	346.8

Date 0^hUT	Apparent 1983 RA	Dec	Transit at Greenwich UT	Orientation P	B_0	L_0
	h m	° ′	h m s	°	°	°
Aug 4	8 54.1	+17 27	12 06 05	+11.8	+6.0	280.7
9	9 13.3	+16 05	12 05 31	+13.7	+6.3	214.6
14	9 32.2	+14 36	12 04 44	+15.5	+6.6	148.5
19	9 50.9	+13 02	12 03 42	+17.2	+6.8	82.4
24	10 09.4	+11 23	12 02 27	+18.7	+7.0	16.3
29	10 27.7	+ 9 39	12 01 02	+20.2	+7.1	310.3
Sep 3	10 45.9	+ 7 51	11 59 29	+21.4	+7.2	244.2
8	11 04.0	+ 6 00	11 57 49	+22.6	+7.2	178.2
13	11 21.9	+ 4 06	11 56 05	+23.6	+7.2	112.2
18	11 39.9	+ 2 11	11 54 18	+24.5	+7.2	46.1
23	11 57.8	+ 0 14	11 52 31	+25.2	+7.0	340.1
28	12 15.8	- 1 43	11 50 48	+25.7	+6.9	274.2
Oct 3	12 33.9	- 3 39	11 49 10	+26.1	+6.6	208.2
8	12 52.1	- 5 35	11 47 41	+26.3	+6.4	142.2
13	13 10.4	- 7 28	11 46 22	+26.3	+6.0	76.2
18	13 29.0	- 9 20	11 45 16	+26.1	+5.7	10.3
23	13 47.9	-11 07	11 44 24	+25.8	+5.2	304.3
28	14 07.0	-12 51	11 43 50	+25.2	+4.8	238.4
Nov 2	14 26.4	-14 30	11 43 35	+24.5	+4.3	172.5
7	14 46.2	-16 03	11 43 40	+23.5	+3.8	106.5
12	15 06.3	-17 29	11 44 06	+22.4	+3.2	40.6
17	15 26.7	-18 47	11 44 53	+21.0	+2.6	334.7
22	15 47.5	-19 58	11 46 01	+19.5	+2.0	268.8
27	16 08.7	-20 59	11 47 28	+17.8	+1.4	202.9
Dec 2	16 30.1	-21 50	11 49 14	+16.0	+0.8	137.0
7	16 51.9	-22 31	11 51 16	+13.9	+0.2	71.1
12	17 13.8	-23 01	11 53 31	+11.8	-0.5	5.2
17	17 35.9	-23 20	11 55 54	+ 9.6	-1.1	299.4
22	17 58.1	-23 26	11 58 22	+ 7.2	-1.8	233.5
27	18 20.3	-23 22	12 00 51	+ 4.8	-2.4	167.6
32	18 42.4	-23 05	12 03 17	+ 2.4	-3.0	101.8

P is the position angle of the axis of rotation, measured eastward from the north point on the disk. B_0 is the heliographic latitude of the centre of the disk, and L_0 is the heliographic longitude of the centre of the disk, from Carrington's solar meridian, measured in the direction of rotation (see diagram). The rotation period of the Sun depends on latitude. The *sidereal* period of rotation at the equator is 25.38^d.



SUNDIAL CORRECTION

The "Transit at Greenwich" time (pages 46 and 47) may be used to calculate the sundial correction at the observer's position. e.g. To find the correction at Winnipeg on August 16, 1983: At Greenwich the Sun transits at $12^h04^m44^s$ on August 14 and at $12^h03^m42^s$ on August 19. Thus, to the nearest minute, on August 16 at both Greenwich and Winnipeg the Sun will transit at 12^h04^m mean solar time, or 12^h33^m CST, since Winnipeg has a longitude correction of $+29^m$ (See page 52). Thus a 4^m correction must be added to the reading of a simple sundial to obtain mean solar time.

A figure accurate to a second or two can be obtained by interpolating for longitude. The interpolated transit time at Greenwich for August 16 is $12^h04^m19^s$, the daily change in the time being $-12\overset{s}{.}4$. Adjusting this for the longitude of Winnipeg: $12^h04^m19^s - (12\overset{s}{.}4 \times 6^h29^m \div 24^h) = 12^h04^m16^s$. Thus the sundial correction is 4^m16^s. To find the standard time of the Sun's transit to the nearest second or two, the observer's longitude must be known to 10″ or better. e.g. Suppose an observer in Winnipeg is at longitude 97°13′50″ W, or $6^h28^m55^s$ W of Greenwich. The time of transit will be $12^h04^m16^s + 28^m55^s = 12^h33^m11^s$ CST ($13^h33^m11^s$ CDT).

⊙

DATES OF COMMENCEMENT (UT, $L_0 = 0°$) OF NUMBERED SYNODIC ROTATIONS (CARRINGTON'S SERIES)

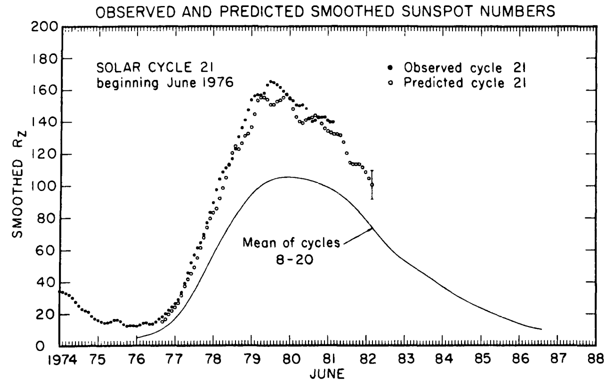
No.	Commences	No.	Commences	No.	Commences
1730	1982 Dec 22.84	1735	May 8.39	1740	Sep 21.50
1731	1983 Jan 19.17	1736	Jun 4.60	1741	Oct 18.78
1732	Feb 15.52	1737	Jul 1.80	1742	Nov 15.08
1733	Mar 14.84	1738	Jul 29.00	1743	Dec 12.40
1734	Apr 11.14	1739	Aug 25.24	1744	1984 Jan 8.73

SOLAR ACTIVITY

SUNSPOTS, FLARES, AND AURORAE

By V. Gaizauskas

The present sunspot cycle (21) is compared with the mean of cycles 8 to 20 in the diagram adapted from "Solar-Geophysical Data" (U.S. Dept. of Commerce, Boulder, Colorado). The data plotted in the graph are monthly smoothed relative sunspot numbers from Zürich. The vertical bar defines the interval in which the most recent value in the graph can be predicted with a confidence of 90%. These *smoothed* data indicate that the maximum of the cycle occurred in the interval December 1979 – January 1980. Another measure of solar activity is the 10 cm microwave flux which has been monitored daily since 1947 by the National Research Council of Canada (Covington, A.E. 1967, *J. Roy. Astron. Soc. Can.*, *61*, 314). The 10 cm flux correlates closely with sunspot number and has the advantage of being reproducible without subjective bias by an observer.



Solar activity was sustained at unexpectedly high levels during 1981 and the early months of 1982. The abatement of activity throughout April and May 1982 seemed to signal the beginning of the long-awaited declining phase. Instead, a spectacular outburst of activity in the early weeks of June 1982 set records for Cycle 21: the largest sunspot group (in fact, the biggest in 25 years); the greatest total emission of X-rays from flares erupting in a single region. Successive eleven-year peaks of sunspot activity follow long-term trends which can in extreme cases result in prolonged periods of very low activity (Eddy, J.A. 1976, *Science*, *192*, 1189; 1977, *Scientific Am.*, *236*, 80). We are at an opposite extreme; Cycle 21 has the second highest peak of this century, exceeded only by Cycle 19 (maximum at 1957.9).

The resurgence of solar activity in mid-1982 means that amateurs who observe sunspots* may still find it worthwhile in 1983 to keep a watch for white light flares (Pike, R. 1974, *J. Roy. Astron. Soc. Can.*, *68*, 330). Five or six white light flares are estimated to occur each year during a few years around peak sunspot activity. These rare events are visible in the solar photosphere for a few minutes at most and are not to be confused with long-enduring "light bridges" or bright facular patches adjacent to sunspots. White light flares erupt as one or more intensely bright and compact structures (a few arc-sec or less) during the explosive phase of highly energetic flares.

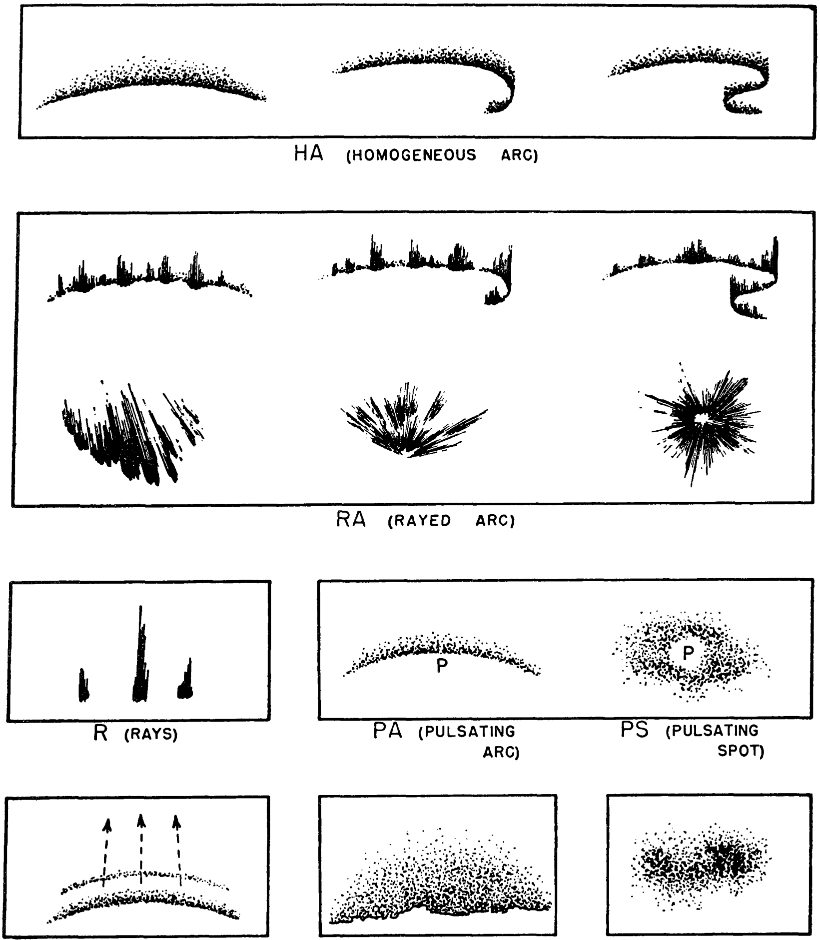
**Editor's Note*: Some of the hazards in viewing the sun and some effective safety precautions are discussed by B. Ralph Chou (*J. Roy. Astron. Soc. Can.*, *75*, 36, 1981; *Sky and Telescope*, *62*, 119, 1981).

They are most likely to occur in complex, rapidly-evolving sunspot groups with many closely-packed umbrae enclosed by a single penumbra. Forewarning of such energetic events may be given for several hours by a realignment of penumbral filaments or a major increase in penumbral size.

The likely occurrence in 1983 of a few episodes of high solar activity holds the promise that some brilliant auroral displays may consequently be observed in the southern, populous parts of Canada. Aurorae ("Northern Lights") are caused by the precipitation into the ionosphere of energetic charged particles from a vast reservoir enveloping Earth, the *magnetosphere*. Seen from above (e.g. from the Canadian ISIS satellites) aurorae are concentrated in elliptical bands called *auroral ovals* that ring Earth's magnetic poles. When the Sun is calm, the ovals shrink to nearly circular rings centred close to the geomagnetic poles. As the Sun grows more active, the ovals advance towards lower latitudes (e.g. in Canada to Churchill, Man. and to Yellowknife, N.W.T.) and become more eccentric with respect to the geomagnetic poles. During periods of very intense solar activity, the ovals shift closer still towards the Equator (e.g. down to the Southern United States for the northern oval). For an observer at the ground, the shifting patterns of the aurora over the night sky reflect the changes in the magnetic and electric fields along the paths of electrons streaming toward Earth.

The magnetospheric reservoir of particles is created by a complicated interaction between Earth's magnetic field and the *solar wind*, a magnetized plasma that flows steadily from the Sun even in the absence of solar activity. When a major solar flare erupts, the normal balance between the solar wind and the magnetosphere can be violently disturbed and can lead to an *auroral sub-storm*. Not every large solar flare will have this effect. Many factors, only partially understood, come into play: the location of the flare in relation to large-scale magnetic structures at the Sun; the state of the interplanetary magnetic field; the transfer of energy from any blast wave accompanying the flare to the magnetosphere; etc.

The atoms and molecules, mostly those of oxygen and nitrogen, that radiate the shimmering light of the aurora are terrestrial in origin. They become luminous at heights between 100 and 400 km through collisions with energetic particles that have leaked out of the magnetosphere during a sub-storm. A faint auroral display may not exceed the brightness threshold of colour perception for the eye; it will be sensed as white. Most aurorae appear green or blue-green with occasional faint patches of pink or red. The green colour is due to excited atoms of oxygen radiating at a wavelength of 558 nm; the blue is produced by ionized nitrogen molecules radiating in a group of spectral bands between 391 and 470 nm. The green and blue emissions are concentrated near an altitude of 100 km. Excited atoms of oxygen also produce a red aurora (630 nm) that originates at greater heights, 300 to 400 km, and is normally faint (because of the low concentration of oxygen at that altitude) unless the influx of particles is very great. Red emission also occurs at lower altitudes, near 100 km, from excited nitrogen molecules radiating in a series of bands between 650 and 680 nm.



Illustrative sketches of standard auroral forms. This simplified classification emphasizes the fundamental features of auroral patterns and minimizes variations which depend on the location of the observer.

TIMES OF SUNRISE AND SUNSET

The tables on pages 53 to 55 give the times of sunrise and sunset at four day intervals for places ranging from 20° to 60° north latitude. "Rise" and "set" correspond to the upper limb of the Sun appearing at the horizon for an observer at sea level. The values are in UT and are for the Greenwich meridian, although for North American observers the stated values may be read as standard time at the standard meridians (60°, 75°, *etc.*) without significant error. The values may be interpolated linearly for both non-tabular latitudes and dates. Also, it is possible to extrapolate the table beyond the 20° and 60° latitude limits a few degrees without significant loss of accuracy.

The standard time of an event at a particular location must take account of the observer's longitude relative to his or her standard meridian. The table below lists the latitude and the longitude correction (in minutes of time) for a number of cities and towns. e.g. To find the time of sunrise at Toronto on February 19, 1983: The latitude is 44°, and from the table the time of sunrise at 0° longitude is 06:54 UT. Thus at the Eastern time zone (E) meridian (75° west), the time of sunrise will be approximately 06:54 EST. The correction for Toronto is +18 minutes, so sunrise will occur at 07:12 EST on that date. Corrections for places not listed below may be found by converting the difference between the longitude of the place and that of its standard meridian to time (15° = 1 h), the correction being positive if the place is west of its standard meridian, negative if east. Finally, it should be emphasized that the observed time will often differ up to several minutes from the predicted time because of a difference in height between the observer and the actual horizon.

CANADIAN CITIES AND TOWNS						AMERICAN CITIES		
	Lat.	Corr.		Lat.	Corr.		Lat.	Corr.
Baker Lake	64°	+24C	Peterborough	44°	+13E	Atlanta	34°	+37E
Brandon	50	+40C	Prince Albert	53	+63C	Baltimore	39	+06E
Calgary	51	+36M	Prince George	54	+11P	Birmingham	33	−13C
Charlottetown	46	+12A	Prince Rupert	54	+41P	Boston	42	−16E
Chicoutimi	48	−16E	Quebec	47	−15E	Buffalo	43	+15E
Churchill	59	+17C	Regina	50	+58C	Chicago	42	−10C
Corner Brook	49	+22N	Resolute	75	+20C	Cincinnati	39	+38E
Cornwall	45	−01E	Rimouski	48	−26E	Cleveland	42	+26E
Edmonton	54	+34M	St. Catharines	43	+17E	Dallas	33	+27C
Fredericton	46	+27A	St. Hyacinthe	46	−08E	Denver	40	00M
Gander	49	+08N	St. John, N.B.	45	+24A	Fairbanks	65	−10A
Goose Bay	53	+02A	St. John's, Nfld.	48	+01N	Flagstaff	35	+27M
Granby	45	−09E	Sarnia	43	+29E	Indianapolis	40	−15C
Halifax	45	+14A	Saskatoon	52	+67C	Juneau	58	+58P
Hamilton	43	+20E	Sault Ste. Marie	47	+37E	Kansas City	39	+18C
Kapuskasing	49	+30E	Sept Iles	50	−35E	Los Angeles	34	−07P
Kenora	50	+18C	Sherbrooke	45	−12E	Louisville	38	−17C
Kingston	44	+06E	Sudbury	47	+24E	Memphis	35	00C
Kitchener	43	+22E	Sydney	46	+01A	Miami	26	+21E
Lethbridge	50	+31M	The Pas	54	+45C	Milwaukee	43	−09C
London	43	+25E	Thunder Bay	48	+57E	Minneapolis	45	+13C
Medicine Hat	50	+23M	Timmins	48	+26E	New Orleans	30	00C
Moncton	46	+19A	Toronto	44	+18E	New York	41	−04E
Montreal	46	−06E	Trail	49	−09P	Omaha	41	+24C
Moosonee	51	+23E	Trois Rivieres	46	−10E	Philadelphia	40	+01E
Moose Jaw	50	+62C	Vancouver	49	+12P	Phoenix	33	+28M
Niagara Falls	43	+16E	Victoria	48	+13P	Pittsburgh	40	+20E
North Bay	46	+18E	Whitehorse	61	00Y	St. Louis	39	+01C
Ottawa	45	+03E	Windsor, Ont.	42	+32E	San Francisco	38	+10P
Owen Sound	45	+24E	Winnipeg	50	+29C	Seattle	48	+09P
Pangnirtung	66	+23A	Yarmouth	44	+24A	Tucson	32	+24M
Penticton	49	−02P	Yellowknife	62	+38M	Washington	39	+08E

LAT.		+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT		RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	−2	6 34	17 30	6 55	17 09	7 07	16 57	7 21	16 43	7 34	16 30	7 59	16 06	8 19	15 45	9 04	15 01
	2	6 35	17 32	6 56	17 12	7 08	17 00	7 22	16 46	7 35	16 33	7 59	16 09	8 19	15 49	9 02	15 06
	6	6 36	17 35	6 57	17 15	7 09	17 03	7 22	16 49	7 35	16 37	7 58	16 14	8 18	15 54	8 59	15 12
	10	6 37	17 38	6 57	17 18	7 09	17 06	7 22	16 53	7 34	16 41	7 56	16 19	8 15	16 00	8 55	15 20
	14	6 38	17 40	6 57	17 21	7 08	17 10	7 21	16 57	7 32	16 46	7 54	16 24	8 12	16 06	8 50	15 28
	18	6 38	17 43	6 56	17 25	7 07	17 14	7 19	17 02	7 30	16 51	7 51	16 30	8 08	16 13	8 44	15 37
	22	6 38	17 45	6 55	17 28	7 05	17 18	7 17	17 07	7 28	16 56	7 47	16 37	8 03	16 20	8 37	15 47
	26	6 37	17 48	6 54	17 32	7 03	17 22	7 14	17 11	7 24	17 01	7 42	16 43	7 58	16 28	8 29	15 57
	30	6 36	17 50	6 52	17 35	7 01	17 26	7 11	17 16	7 20	17 07	7 37	16 50	7 51	16 36	8 20	16 07
Feb.	3	6 35	17 53	6 50	17 38	6 58	17 30	7 07	17 21	7 16	17 12	7 32	16 57	7 45	16 44	8 11	16 18
	7	6 34	17 55	6 47	17 42	6 55	17 34	7 03	17 26	7 11	17 18	7 25	17 04	7 37	16 52	8 01	16 29
	11	6 32	17 57	6 44	17 45	6 51	17 38	6 59	17 30	7 06	17 23	7 19	17 10	7 29	17 00	7 50	16 39
	15	6 30	17 59	6 41	17 48	6 47	17 42	6 54	17 35	7 00	17 29	7 12	17 17	7 21	17 08	7 40	16 50
	19	6 27	18 01	6 37	17 51	6 42	17 46	6 49	17 40	6 54	17 34	7 04	17 24	7 13	17 16	7 29	17 00
	23	6 25	18 03	6 33	17 54	6 38	17 50	6 43	17 44	6 48	17 40	6 57	17 31	7 04	17 24	7 18	17 10
	27	6 22	18 04	6 29	17 57	6 33	17 53	6 37	17 49	6 41	17 45	6 49	17 38	6 55	17 32	7 06	17 21
Mar.	3	6 19	18 06	6 25	18 00	6 28	17 57	6 31	17 53	6 35	17 50	6 41	17 44	6 45	17 40	6 54	17 31
	7	6 16	18 07	6 20	18 03	6 23	18 00	6 25	17 58	6 28	17 55	6 32	17 51	6 36	17 48	6 43	17 41
	11	6 12	18 08	6 15	18 05	6 17	18 04	6 19	18 02	6 21	18 00	6 24	17 58	6 26	17 55	6 31	17 51
	15	6 09	18 09	6 11	18 08	6 12	18 07	6 13	18 06	6 14	18 05	6 15	18 04	6 16	18 03	6 19	18 01
	19	6 06	18 11	6 06	18 10	6 06	18 10	6 06	18 10	6 06	18 10	6 06	18 10	6 07	18 10	6 07	18 11
	23	6 02	18 12	6 01	18 13	6 00	18 14	6 00	18 14	5 59	18 15	5 58	18 17	5 57	18 18	5 55	18 20
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	31	5 55	18 14	5 51	18 18	5 49	18 20	5 47	18 23	5 44	18 25	5 40	18 29	5 37	18 33	5 30	18 40
Apr.	4	5 52	18 15	5 47	18 20	5 44	18 23	5 40	18 27	5 37	18 30	5 32	18 36	5 27	18 40	5 18	18 50
	8	5 48	18 16	5 42	18 23	5 38	18 26	5 34	18 31	5 30	18 35	5 23	18 42	5 17	18 48	5 06	18 59
	12	5 45	18 17	5 37	18 25	5 33	18 30	5 28	18 35	5 23	18 39	5 15	18 48	5 08	18 55	4 54	19 09
	16	5 42	18 18	5 33	18 27	5 28	18 33	5 22	18 39	5 16	18 44	5 06	18 54	4 58	19 03	4 42	19 19
	20	5 39	18 20	5 29	18 30	5 23	18 36	5 16	18 43	5 10	18 49	4 58	19 01	4 49	19 10	4 31	19 29
	24	5 36	18 21	5 24	18 32	5 18	18 39	5 10	18 47	5 03	18 54	4 51	19 07	4 40	19 18	4 19	19 39
	28	5 33	18 22	5 21	18 35	5 13	18 42	5 05	18 51	4 57	18 59	4 43	19 13	4 31	19 25	4 08	19 49

☉

LAT.		+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT		RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
May	2	5 31	18 24	5 17	18 38	5 09	18 46	5 00	18 55	4 51	19 04	4 36	19 19	4 23	19 32	3 57	19 59
	6	5 28	18 25	5 13	18 40	5 05	18 49	4 55	18 59	4 46	19 08	4 29	19 25	4 15	19 40	3 46	20 09
	10	5 26	18 27	5 10	18 43	5 01	18 52	4 50	19 03	4 41	19 13	4 22	19 31	4 07	19 47	3 36	20 18
	14	5 25	18 28	5 08	18 45	4 58	18 55	4 46	19 07	4 36	19 17	4 16	19 37	4 00	19 54	3 26	20 28
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	22	5 22	18 32	5 03	18 50	4 52	19 01	4 39	19 14	4 28	19 26	4 06	19 48	3 47	20 07	3 08	20 46
	26	5 21	18 33	5 01	18 53	4 50	19 04	4 37	19 18	4 24	19 30	4 02	19 53	3 42	20 13	3 00	20 55
	30	5 20	18 35	5 00	18 55	4 48	19 07	4 34	19 21	4 22	19 34	3 58	19 58	3 37	20 18	2 53	21 03
June	3	5 20	18 36	4 59	18 57	4 47	19 09	4 33	19 24	4 19	19 37	3 55	20 02	3 33	20 23	2 47	21 10
	7	5 20	18 38	4 58	18 59	4 46	19 12	4 31	19 26	4 18	19 40	3 53	20 05	3 30	20 27	2 42	21 16
	11	5 20	18 39	4 58	19 01	4 45	19 14	4 31	19 28	4 17	19 42	3 51	20 08	3 28	20 31	2 39	21 21
	15	5 20	18 40	4 58	19 02	4 45	19 15	4 30	19 30	4 16	19 44	3 50	20 11	3 27	20 34	2 36	21 25
	19	5 21	18 41	4 59	19 04	4 46	19 17	4 31	19 32	4 17	19 46	3 50	20 12	3 27	20 35	2 35	21 27
	23	5 22	18 42	5 00	19 04	4 47	19 17	4 32	19 33	4 17	19 47	3 51	20 13	3 28	20 36	2 36	21 28
	27	5 23	18 43	5 01	19 05	4 48	19 18	4 33	19 33	4 19	19 47	3 52	20 13	3 29	20 36	2 38	21 27
July	1	5 24	18 43	5 02	19 05	4 49	19 18	4 34	19 33	4 21	19 47	3 54	20 13	3 32	20 35	2 41	21 25
	5	5 25	18 44	5 04	19 05	4 51	19 18	4 37	19 32	4 23	19 46	3 57	20 11	3 35	20 33	2 46	21 22
	9	5 27	18 43	5 06	19 04	4 53	19 17	4 39	19 31	4 26	19 44	4 01	20 09	3 39	20 31	2 52	21 17
	13	5 28	18 43	5 08	19 03	4 56	19 15	4 42	19 29	4 29	19 42	4 05	20 06	3 44	20 27	2 59	21 11
	17	5 30	18 42	5 10	19 02	4 58	19 14	4 45	19 27	4 32	19 39	4 09	20 02	3 49	20 22	3 06	21 05
	21	5 31	18 41	5 12	19 00	5 01	19 11	4 48	19 24	4 36	19 36	4 14	19 58	3 55	20 17	3 14	20 57
	25	5 33	18 40	5 14	18 58	5 04	19 09	4 51	19 21	4 40	19 32	4 19	19 53	4 01	20 11	3 23	20 48
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Aug.	2	5 35	18 37	5 19	18 53	5 10	19 02	4 59	19 13	4 48	19 23	4 30	19 42	4 14	19 58	3 41	20 29
	6	5 37	18 35	5 22	18 50	5 13	18 59	5 02	19 09	4 53	19 18	4 35	19 35	4 21	19 50	3 51	20 19
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	14	5 39	18 30	5 26	18 43	5 19	18 50	5 10	18 59	5 02	19 07	4 47	19 21	4 35	19 33	4 10	19 58
	18	5 41	18 27	5 29	18 39	5 22	18 46	5 14	18 53	5 06	19 01	4 53	19 14	4 42	19 25	4 20	19 46
	22	5 42	18 24	5 31	18 35	5 25	18 41	5 18	18 48	5 11	18 54	4 59	19 06	4 49	19 16	4 29	19 35
	26	5 43	18 21	5 33	18 30	5 28	18 36	5 21	18 42	5 15	18 48	5 05	18 58	4 56	19 06	4 39	19 23
	30	5 44	18 18	5 35	18 26	5 31	18 30	5 25	18 36	5 20	18 41	5 11	18 50	5 03	18 57	4 48	19 11

LAT.		+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT		RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Sep.	3	5 45	18 14	5 38	18 21	5 34	18 25	5 29	18 29	5 25	18 34	5 17	18 41	5 10	18 47	4 58	18 59
	7	5 45	18 11	5 40	18 16	5 36	18 19	5 33	18 23	5 29	18 26	5 23	18 32	5 18	18 38	5 07	18 47
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	15	5 47	18 03	5 44	18 06	5 42	18 08	5 40	18 10	5 38	18 12	5 35	18 15	5 32	18 18	5 26	18 23
	19	5 48	18 00	5 46	18 01	5 45	18 02	5 44	18 03	5 43	18 04	5 41	18 06	5 39	18 08	5 36	18 11
	23	5 49	17 56	5 48	17 56	5 48	17 56	5 48	17 57	5 47	17 57	5 47	17 57	5 46	17 58	5 45	17 59
	27	5 50	17 52	5 51	17 51	5 51	17 51	5 52	17 50	5 52	17 49	5 53	17 49	5 53	17 48	5 54	17 47
Oct.	1	5 51	17 49	5 53	17 46	5 54	17 45	5 56	17 43	5 57	17 42	5 59	17 40	6 01	17 38	6 04	17 34
	5	5 52	17 45	5 55	17 41	5 57	17 39	5 59	17 37	6 01	17 35	6 05	17 31	6 08	17 28	6 13	17 22
	9	5 53	17 42	5 58	17 37	6 00	17 34	6 04	17 31	6 06	17 28	6 11	17 23	6 15	17 19	6 23	17 11
	13	5 54	17 39	6 00	17 32	6 04	17 29	6 08	17 25	6 11	17 21	6 18	17 14	6 23	17 09	6 33	16 59
	17	5 55	17 35	6 03	17 28	6 07	17 23	6 12	17 19	6 16	17 14	6 24	17 06	6 30	17 00	6 43	16 47
	21	5 57	17 33	6 05	17 24	6 10	17 19	6 16	17 13	6 21	17 08	6 30	16 58	6 38	16 51	6 53	16 36
	25	5 58	17 30	6 08	17 20	6 14	17 14	6 20	17 07	6 26	17 01	6 37	16 51	6 46	16 42	7 03	16 25
	29	6 00	17 27	6 11	17 16	6 18	17 09	6 25	17 02	6 32	16 55	6 44	16 43	6 53	16 33	7 13	16 14
Nov.	2	6 02	17 25	6 14	17 13	6 21	17 05	6 29	16 57	6 37	16 50	6 50	16 36	7 01	16 25	7 23	16 03
	6	6 04	17 23	6 17	17 10	6 25	17 02	6 34	16 53	6 42	16 45	6 57	16 30	7 09	16 17	7 33	15 53
	10	6 06	17 22	6 20	17 07	6 29	16 58	6 39	16 49	6 48	16 40	7 04	16 24	7 17	16 10	7 44	15 43
	14	6 08	17 21	6 24	17 05	6 33	16 56	6 43	16 45	6 53	16 35	7 10	16 18	7 25	16 03	7 54	15 34
	18	6 10	17 20	6 27	17 03	6 37	16 53	6 48	16 42	6 58	16 32	7 17	16 13	7 32	15 57	8 04	15 26
	22	6 13	17 19	6 30	17 01	6 41	16 51	6 52	16 39	7 03	16 28	7 23	16 09	7 40	15 52	8 14	15 18
	26	6 15	17 19	6 34	17 00	6 44	16 50	6 57	16 37	7 08	16 26	7 29	16 05	7 47	15 47	8 23	15 11
	30	6 18	17 19	6 37	17 00	6 48	16 49	7 01	16 36	7 13	16 24	7 35	16 02	7 53	15 44	8 32	15 05
Dec.	4	6 20	17 20	6 40	17 00	6 52	16 48	7 05	16 35	7 17	16 23	7 40	16 00	7 59	15 41	8 40	15 00
	8	6 23	17 21	6 43	17 00	6 55	16 48	7 09	16 35	7 21	16 22	7 45	15 59	8 05	15 39	8 47	14 56
	12	6 25	17 22	6 46	17 01	6 58	16 49	7 12	16 35	7 25	16 22	7 49	15 58	8 09	15 38	8 53	14 54
	16	6 27	17 23	6 49	17 02	7 01	16 50	7 15	16 36	7 28	16 23	7 52	15 58	8 13	15 38	8 58	14 53
	20	6 30	17 25	6 51	17 04	7 03	16 51	7 17	16 37	7 31	16 24	7 55	16 00	8 16	15 39	9 01	14 54
	24	6 32	17 27	6 53	17 06	7 05	16 53	7 19	16 39	7 33	16 26	7 57	16 02	8 18	15 41	9 03	14 56
	28	6 33	17 29	6 55	17 08	7 07	16 56	7 21	16 42	7 34	16 29	7 58	16 04	8 19	15 44	9 04	14 59
	32	6 35	17 32	6 56	17 11	7 08	16 59	7 22	16 45	7 35	16 32	7 59	16 08	8 19	15 48	9 03	15 04

TWILIGHT

This table gives the beginning of morning and ending of evening astronomical twilight (Sun 18° below the horizon) in UT at the Greenwich meridian. For observers in North America, the times may be treated in the same way as those of sunrise and sunset (see p. 52).

LAT.	+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
M-E	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.	MORN.	EVE.
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan. 0	5 15	18 50	5 30	18 35	5 36	18 29	5 44	18 21	5 50	18 15	6 00	18 06	6 06	18 00	6 18	17 48
10	5 19	18 55	5 32	18 42	5 39	18 36	5 45	18 30	5 51	18 24	5 59	18 16	6 05	18 10	6 15	18 00
20	5 21	19 01	5 32	18 50	5 38	18 44	5 43	18 39	5 48	18 35	5 54	18 28	5 59	18 24	6 06	18 16
30	5 20	19 06	5 30	18 57	5 34	18 53	5 38	18 49	5 41	18 47	5 45	18 42	5 48	18 39	5 52	18 36
Feb. 9	5 18	19 11	5 24	19 05	5 27	19 02	5 29	19 00	5 31	18 58	5 32	18 57	5 33	18 56	5 33	18 57
19	5 13	19 15	5 17	19 11	5 18	19 11	5 18	19 10	5 18	19 11	5 16	19 12	5 14	19 15	5 09	19 20
Mar. 1	5 07	19 18	5 07	19 18	5 06	19 19	5 05	19 21	5 03	19 23	4 57	19 29	4 53	19 34	4 42	19 45
11	4 59	19 21	4 56	19 25	4 53	19 28	4 49	19 32	4 45	19 37	4 36	19 46	4 28	19 54	4 10	20 12
21	4 51	19 24	4 44	19 31	4 39	19 37	4 32	19 43	4 26	19 50	4 13	20 04	4 01	20 16	3 35	20 42
31	4 41	19 28	4 31	19 38	4 24	19 46	4 14	19 55	4 05	20 05	3 47	20 23	3 31	20 40	2 55	21 17
Apr. 10	4 32	19 31	4 18	19 46	4 08	19 56	3 56	20 08	3 44	20 20	3 21	20 44	2 59	21 07	2 06	22 02
20	4 23	19 36	4 05	19 54	3 53	20 06	3 38	20 22	3 22	20 37	2 52	21 08	2 23	21 38	0 51	23 20
30	4 14	19 41	3 52	20 03	3 38	20 18	3 20	20 36	3 01	20 55	2 23	21 34	1 41	22 18	.. ..	.. ..
May 10	4 07	19 46	3 41	20 12	3 24	20 29	3 03	20 51	2 40	21 14	1 51	22 05	0 39	23 24	.. ..	.. ..
20	4 01	19 52	3 32	20 21	3 13	20 40	2 48	21 06	2 21	21 33	1 16	22 40	.. ..	.. ..	.. ..	.. ..
30	3 58	19 57	3 26	20 29	3 05	20 51	2 37	21 19	2 05	21 51	0 29	23 33	.. ..	.. ..	.. ..	.. ..
June 9	3 56	20 02	3 23	20 36	3 00	20 59	2 30	21 29	1 53	22 06	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
19	3 57	20 05	3 22	20 40	2 59	21 04	2 27	21 35	1 49	22 13	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
29	3 59	20 07	3 25	20 41	3 02	21 05	2 31	21 36	1 53	22 13	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
July 9	4 03	20 07	3 30	20 39	3 08	21 01	2 39	21 31	2 05	22 05	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
19	4 08	20 04	3 38	20 34	3 17	20 55	2 51	21 21	2 21	21 51	1 00	23 08	.. ..	.. ..	.. ..	.. ..
29	4 14	19 59	3 46	20 26	3 28	20 44	3 04	21 08	2 38	21 33	1 41	22 29	.. ..	.. ..	.. ..	.. ..
Aug. 8	4 19	19 52	3 55	20 16	3 39	20 32	3 19	20 52	2 57	21 13	2 13	21 56	1 17	22 49	.. ..	.. ..
18	4 24	19 44	4 03	20 04	3 50	20 17	3 33	20 34	3 15	20 52	2 40	21 25	2 04	22 01	.. ..	.. ..
28	4 28	19 35	4 11	19 51	4 00	20 02	3 46	20 15	3 32	20 29	3 05	20 56	2 38	21 22	1 26	22 30
Sep. 7	4 31	19 25	4 18	19 37	4 10	19 46	3 59	19 57	3 48	20 07	3 26	20 28	3 06	20 48	2 20	21 32
17	4 34	19 15	4 25	19 24	4 18	19 30	4 10	19 38	4 02	19 46	3 46	20 02	3 31	20 16	2 59	20 48
27	4 37	19 05	4 31	19 11	4 27	19 15	4 21	19 20	4 15	19 26	4 04	19 37	3 53	19 48	3 30	20 10
Oct. 7	4 39	18 57	4 37	18 58	4 35	19 01	4 32	19 04	4 28	19 07	4 20	19 14	4 13	19 21	3 58	19 36
17	4 42	18 49	4 43	18 48	4 43	18 48	4 42	18 49	4 40	18 50	4 36	18 54	4 32	18 57	4 23	19 06
27	4 45	18 43	4 49	18 38	4 51	18 37	4 52	18 36	4 52	18 35	4 52	18 35	4 50	18 36	4 47	18 40
Nov. 6	4 48	18 39	4 56	18 31	4 59	18 28	5 02	18 25	5 04	18 23	5 06	18 20	5 08	18 19	5 09	18 18
16	4 53	18 36	5 03	18 26	5 07	18 22	5 12	18 17	5 15	18 14	5 20	18 09	5 24	18 05	5 29	18 00
26	4 58	18 36	5 10	18 24	5 16	18 19	5 21	18 13	5 26	18 08	5 33	18 01	5 38	17 56	5 47	17 47
Dec. 6	5 03	18 38	5 17	18 25	5 23	18 18	5 30	18 11	5 36	18 06	5 44	17 57	5 51	17 51	6 01	17 40
16	5 09	18 42	5 23	18 28	5 30	18 21	5 37	18 13	5 43	18 07	5 53	17 58	6 00	17 51	6 12	17 39
26	5 14	18 47	5 28	18 33	5 35	18 25	5 43	18 18	5 49	18 12	5 58	18 02	6 05	17 55	6 18	17 43
Jan. 5	5 18	18 52	5 32	18 39	5 38	18 32	5 44	18 25	5 50	18 20	6 00	18 10	6 06	18 04	6 18	17 52

MOON

KEY TO THE MAP OF THE MOON

CRATERS

21—Albategnius
22—Alphonsus
23—Arago
24—Archimedes
25—Aristarchus
26—Aristillus
27—Aristoteles
28—Arzachel
29—Atlas
31—Autolycus
32—Bessel
33—Bullialdus
34—Cassini
35—Catharina
36—Clavius
37—Cleomedes
38—Cook
39—Copernicus
41—Cyrillus
42—Delambre
43—Endymion
44—Eratosthenes
45—Eudoxus
46—Fracastorius
47—Furnerius
48—Gassendi
49—Grimaldi
51—Halley
52—Hercules
53—Herschel
54—Hevelius
55—Hipparchus
56—Julius Caesar
57—Kepler
58—Langrenus
59—Lansberg
61—Longomontanus
62—Macrobius
63—Maginus
64—Manilius
65—Maskelyne
66—Maurolycus
67—Mersenius
68—Newcomb
69—Petavius
71—Piccolomini
72—Plato
73—Plinius
74—Posidonius
75—Ptolemaeus
76—Reinhold
77—Ross
78—Schickard
79—Schiller
81—Snellius
82—Stevinus
83—Taruntius
84—Theophilus
85—Timocharis
86—Tycho
87—Wilhelm

MOUNTAINS

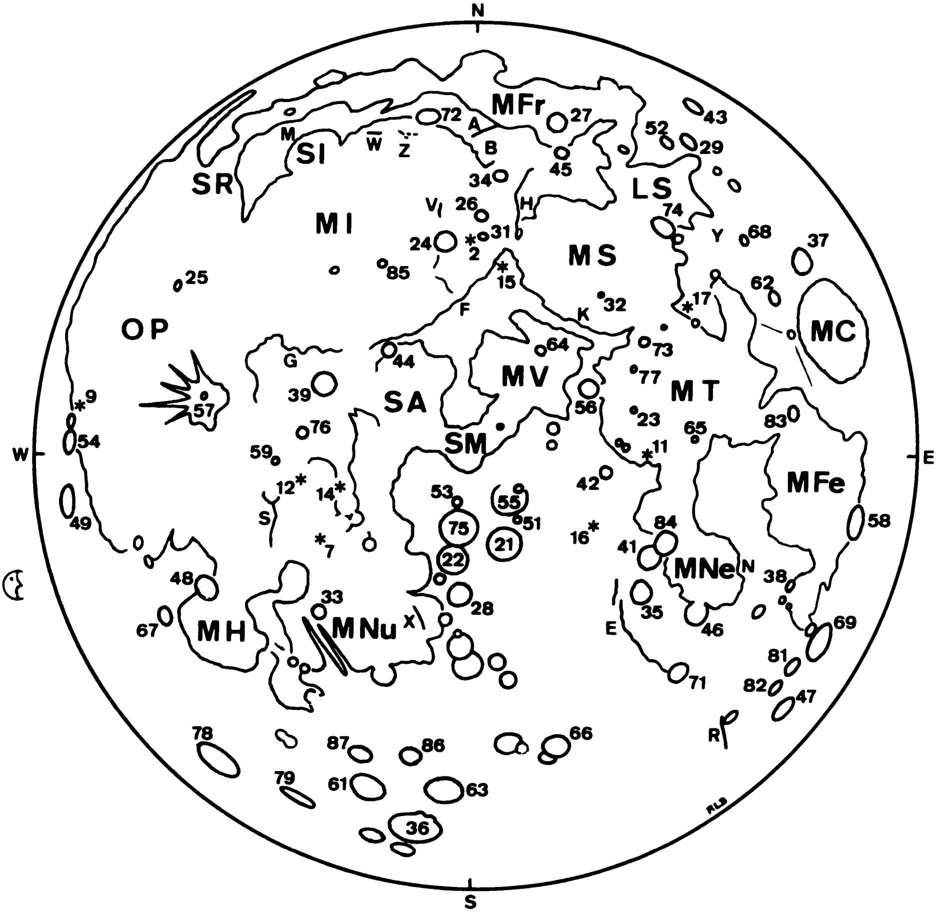
A —Alpine Valley
B —Alps Mts.
E —Altai Mts.
F —Apennine Mts.
G —Carpathian Mts.
H —Caucasus Mts.
K —Haemus Mts.
M—Jura Mts.
N —Pyrenees Mts.
R —Rheita Valley
S —Riphaeus Mts.
V —Spitzbergen
W—Straight Range
X —Straight Wall
Y —Taurus Mts.
Z —Teneriffe Mts.

MARIA

LS —Lacus Somniorum (Lake of Dreams)
MC —Mare Crisium (Sea of Crises)
MFe —Mare Fecunditatis (Sea of Fertility)
MFr —Mare Frigoris (Sea of Cold)
MH —Mare Humorum (Sea of Moisture)
MI —Mare Imbrium (Sea of Rains)
MNe—Mare Nectaris (Sea of Nectar)
MNu—Mare Nubium (Sea of Clouds)
MS —Mare Serenitatis (Sea of Serenity)
MT —Mare Tranquillitatis (Sea of Tranquillity)
MV —Mare Vaporum (Sea of Vapors)
OP —Oceanus Procellarum (Ocean of Storms)
SA —Sinus Aestuum (Seething Bay)
SI —Sinus Iridum (Bay of Rainbows)
SM —Sinus Medii (Central Bay)
SR —Sinus Roris (Bay of Dew)

LUNAR PROBES

2—Luna 2, First to reach Moon (1959·9·13)
7—Ranger 7, First close pictures (1964·7·31)
9—Luna 9, First soft landing (1966·2·3)
11—Apollo 11, First men on Moon (1969·7·20)
12—Apollo 12 (1969·11·19)
14—Apollo 14 (1971·2·5)
15—Apollo 15 (1971·7·30)
16—Apollo 16 (1972·4·21)
17—Apollo 17 (1972·12·11)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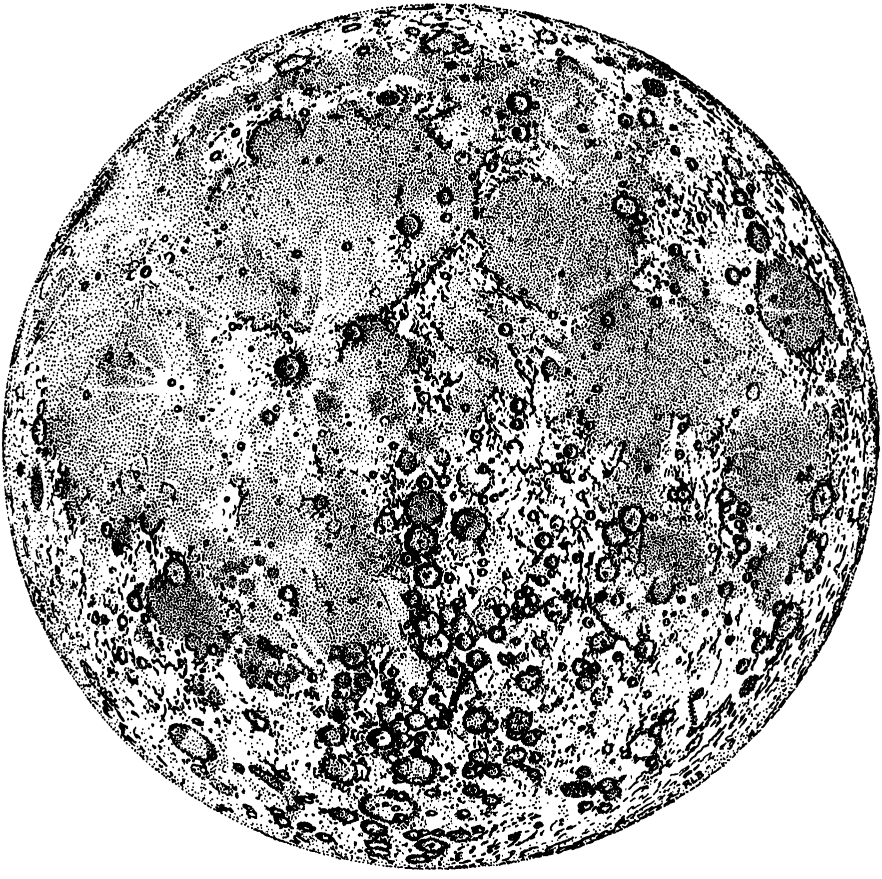
MAP OF



THE MOON

FULL MOON DATES

(UT)

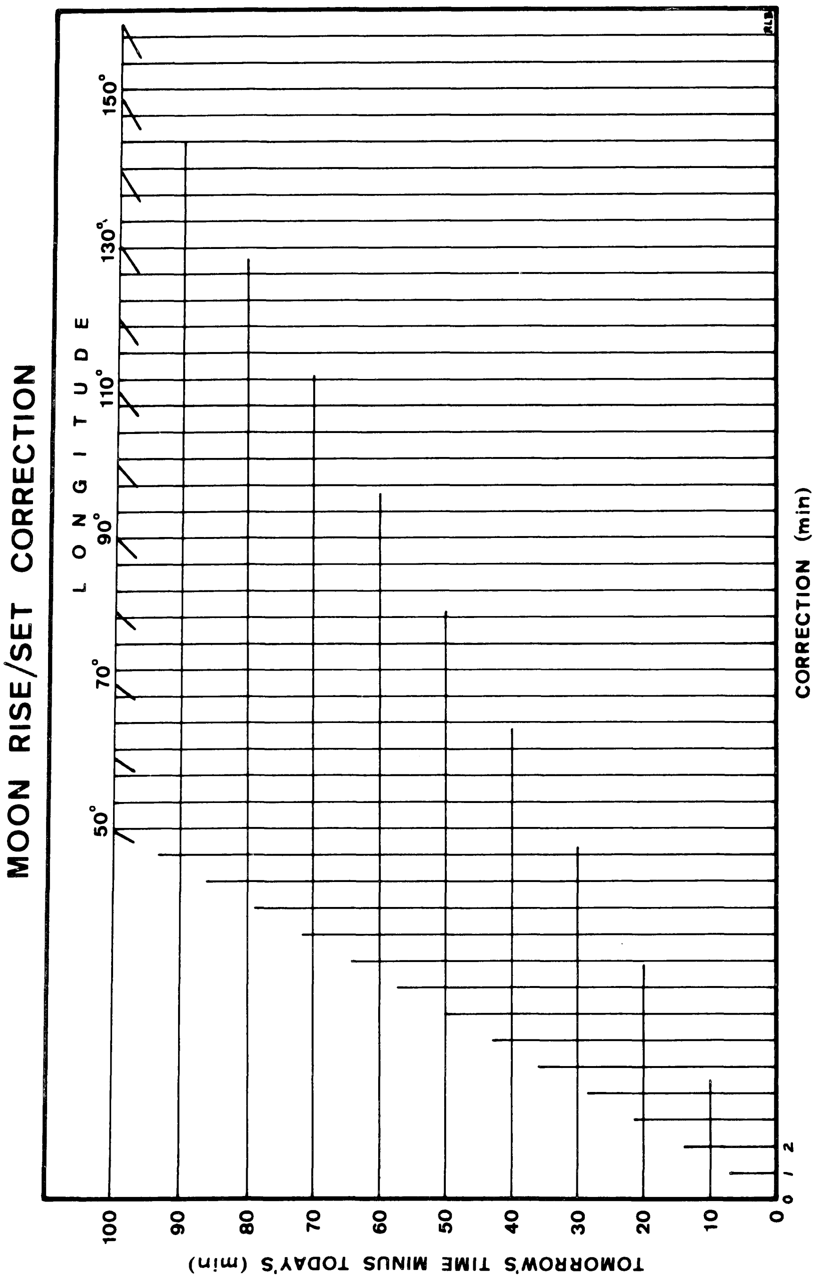
1983		1984	
Jan. 28	Jul. 24	Jan. 18	Jul. 13
Feb. 27	Aug. 23	Feb. 17	Aug. 11
Mar. 28	Sep. 22	Mar. 17	Sep. 10
Apr. 27	Oct. 21	Apr. 15	Oct. 9
May 26	Nov. 20	May 15	Nov. 8
Jun. 25	Dec. 20	Jun. 13	Dec. 8

TIMES OF MOONRISE AND MOONSET

The tables on pages 62 to 73 give the times of moonrise and moonset for each day of the year for places ranging from 20° to 60° north latitude. The tables may be interpolated linearly for non-tabular latitudes, and can be extrapolated beyond the 20° and 60° latitude limits a few degrees without significant loss of accuracy. "Rise" and "set" correspond to the upper limb of the Moon appearing at the horizon for an observer at sea level. The times are in UT and are for the Greenwich meridian. Because of the relatively rapid eastward motion of the Moon, unlike the sunrise and sunset tables, the times *cannot* be read directly as standard times at the various standard meridians in North America. The table must be interpolated according to the observer's longitude. Also, the observer's longitude correction relative to his standard meridian must, of course, be applied (see p. 52). The graph on the opposite page enables the sum of these two corrections to be determined easily in one step. However, the graph must be set for your longitude.

To prepare the Moon Rise/Set Correction graph, first locate your longitude on the longitude scale. Using a straight-edge, draw a line from the origin (0,0 point) to your position on the longitude scale (a *red* pen is recommended to make this line stand out). Next, the CORRECTION axis must be labeled. As a guide, the first three divisions have been tentatively labeled 0, 1, 2; *but*, to these numbers must be added your longitude correction relative to your standard meridian (p. 52). e.g. For Toronto the correction is +18 minutes, thus an observer in Toronto would label this axis: 18, 19, 20, 21, ... 62, 63. An observer in Rimouski (longitude correction: −26) would label the axis: −26, −25, −24, ... 18, 19.

The graph is now ready for use on any day from your position. From the table obtain tomorrow's time and today's time for the event (moonrise, or moonset), enter the difference on the ordinate, and run horizontally across to meet the diagonal line. The correction, to the nearest minute, can then be read directly below off the abscissa. This correction is applied to "today's time" in the table. (Note that, due to a difference in height between the observer and the actual horizon, the observed time may differ by up to several minutes from the predicted time.)


MOON RISE/SET CORRECTION
LONGITUDE
50°
70°
90°
110°
130°
150°
CORRECTION (min)
0
1
2
TOMORROW'S TIME MINUS TODAY'S (min)
0
10
20
30
40
50
60
70
80
90
100
RLB

LAT.		+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT		RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	1	19 57	8 30	19 39	8 51	19 28	9 02	19 15	9 16	19 03	9 28	18 42	9 51	18 24	10 10	17 45	10 50
	2	21 02	9 25	20 48	9 41	20 39	9 50	20 30	10 01	20 21	10 11	20 05	10 29	19 51	10 44	19 24	11 13
	3	22 04	10 13	21 54	10 25	21 49	10 31	21 42	10 39	21 37	10 46	21 26	10 58	21 17	11 09	21 00	11 29
	4	23 02	10 56	22 57	11 03	22 55	11 07	22 52	11 11	22 49	11 15	22 44	11 23	22 40	11 29	22 32	11 40
	5	23 57	11 36	23 57	11 38	23 58	11 39	23 58	11 40	23 58	11 42	23 58	11 44	23 59	11 45	23 59	11 49
☾	6	.. ..	12 14	.. ..	12 11	.. ..	12 10	.. ..	12 08	.. ..	12 06	.. ..	12 03	.. ..	12 01	.. ..	11 57
	7	0 50	12 51	0 55	12 44	0 58	12 40	1 02	12 35	1 05	12 31	1 10	12 23	1 15	12 17	1 24	12 05
	8	1 43	13 29	1 52	13 17	1 58	13 11	2 04	13 03	2 10	12 56	2 21	12 44	2 30	12 34	2 47	12 14
	9	2 35	14 08	2 49	13 52	2 57	13 44	3 06	13 33	3 14	13 24	3 30	13 07	3 43	12 53	4 09	12 26
	10	3 27	14 49	3 44	14 31	3 55	14 20	4 06	14 07	4 17	13 56	4 37	13 35	4 54	13 17	5 29	12 41
	11	4 19	15 33	4 40	15 12	4 51	15 00	5 05	14 46	5 18	14 33	5 41	14 09	6 02	13 48	6 45	13 04
	12	5 11	16 20	5 33	15 58	5 46	15 45	6 01	15 30	6 15	15 16	6 41	14 49	7 03	14 26	7 53	13 37
	13	6 01	17 10	6 24	16 47	6 37	16 34	6 53	16 19	7 07	16 04	7 34	15 38	7 57	15 15	8 48	14 24
●	14	6 49	18 00	7 11	17 39	7 24	17 27	7 39	17 12	7 53	16 59	8 18	16 34	8 40	16 12	9 28	15 25
	15	7 35	18 52	7 55	18 33	8 07	18 22	8 20	18 09	8 33	17 57	8 55	17 35	9 15	17 16	9 56	16 36
	16	8 17	19 43	8 34	19 27	8 45	19 18	8 56	19 07	9 06	18 58	9 26	18 40	9 42	18 24	10 14	17 53
	17	8 57	20 34	9 11	20 22	9 19	20 15	9 28	20 07	9 36	19 59	9 51	19 46	10 03	19 35	10 28	19 12
	18	9 34	21 25	9 44	21 17	9 50	21 12	9 56	21 07	10 02	21 02	10 12	20 53	10 21	20 46	10 38	20 32
	19	10 10	22 15	10 16	22 11	10 19	22 09	10 23	22 07	10 26	22 05	10 32	22 01	10 37	21 58	10 46	21 52
	20	10 46	23 06	10 47	23 07	10 47	23 08	10 48	23 08	10 49	23 09	10 50	23 10	10 51	23 11	10 53	23 13
	21	11 22	23 59	11 18	.. ..	11 16	.. ..	11 14	.. ..	11 12	.. ..	11 09	.. ..	11 06	.. ..	11 01	.. ..
☽	22	12 00	.. ..	11 52	0 05	11 47	0 08	11 42	0 12	11 38	0 15	11 29	0 21	11 23	0 27	11 09	0 37
	23	12 41	0 54	12 29	1 05	12 22	1 11	12 14	1 18	12 06	1 24	11 53	1 36	11 42	1 45	11 20	2 04
	24	13 28	1 53	13 11	2 08	13 01	2 17	12 50	2 27	12 40	2 36	12 22	2 53	12 06	3 07	11 36	3 36
	25	14 20	2 55	14 00	3 14	13 48	3 25	13 34	3 38	13 22	3 50	12 59	4 12	12 40	4 30	11 59	5 09
	26	15 19	4 00	14 57	4 22	14 44	4 35	14 28	4 49	14 14	5 03	13 48	5 29	13 26	5 51	12 38	6 38
	27	16 24	5 06	16 01	5 28	15 48	5 42	15 33	5 57	15 18	6 11	14 52	6 38	14 29	7 01	13 39	7 52
○	28	17 32	6 09	17 11	6 30	16 59	6 43	16 45	6 57	16 32	7 11	16 08	7 36	15 48	7 57	15 04	8 42
	29	18 39	7 07	18 23	7 26	18 13	7 36	18 02	7 49	17 51	8 00	17 32	8 20	17 16	8 38	16 43	9 13
	30	19 45	8 00	19 33	8 14	19 26	8 22	19 18	8 31	19 10	8 40	18 57	8 55	18 46	9 08	18 24	9 33
	31	20 47	8 47	20 40	8 56	20 36	9 02	20 32	9 08	20 27	9 13	20 20	9 23	20 14	9 31	20 02	9 46

LAT.	+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Feb. 1	21 46	9 30	21 44	9 34	21 43	9 36	21 42	9 39	21 41	9 42	21 39	9 46	21 38	9 49	21 35	9 56
2	22 42	10 10	22 45	10 09	22 47	10 09	22 49	10 08	22 51	10 08	22 55	10 07	22 58	10 06	23 04	10 05
3	23 36	10 49	23 44	10 43	23 49	10 40	23 54	10 36	23 59	10 33	.. ..	10 27	.. ..	10 22	.. ..	10 13
☾ 4	.. ..	11 27	.. ..	11 17	.. ..	11 11	.. ..	11 05	.. ..	10 59	0 08	10 48	0 15	10 39	0 30	10 22
5	0 29	12 06	0 42	11 52	0 49	11 44	0 57	11 35	1 05	11 26	1 19	11 11	1 31	10 58	1 54	10 33
6	1 22	12 47	1 39	12 30	1 48	12 19	1 59	12 08	2 09	11 57	2 28	11 37	2 44	11 21	3 16	10 47
7	2 15	13 31	2 34	13 10	2 46	12 59	2 59	12 45	3 11	12 32	3 34	12 09	3 53	11 49	4 34	11 07
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	19	16 46	5 02	16 34	5 13	16 26	5 19	16 18	5 26	16 10	5 32	15 56	5 44	15 45	5 54	15 23	6 14
○	20	17 30	5 58	17 12	6 14	17 02	6 23	16 51	6 33	16 40	6 43	16 21	7 01	16 05	7 15	15 33	7 46
	21	18 18	6 58	17 57	7 18	17 45	7 30	17 31	7 43	17 17	7 55	16 53	8 18	16 33	8 38	15 49	9 20
	22	19 12	8 00	18 49	8 23	18 35	8 36	18 19	8 52	18 04	9 07	17 36	9 34	17 11	9 58	16 18	10 51
	23	20 12	9 02	19 47	9 27	19 33	9 41	19 16	9 58	19 01	10 13	18 31	10 43	18 05	11 08	17 07	12 07
	24	21 15	10 02	20 51	10 26	20 38	10 40	20 22	10 56	20 07	11 11	19 40	11 40	19 15	12 04	18 22	12 59
	25	22 18	10 58	21 58	11 19	21 47	11 32	21 33	11 46	21 20	12 00	20 57	12 24	20 37	12 45	19 54	13 29
	26	23 21	11 49	23 06	12 06	22 56	12 16	22 46	12 28	22 36	12 39	22 19	12 58	22 04	13 14	21 33	13 47
☾	27	.. ..	12 35	.. ..	12 48	.. ..	12 55	23 58	13 03	23 52	13 11	23 40	13 25	23 31	13 36	23 12	13 58
	28	0 22	13 17	0 12	13 25	0 05	13 29	.. ..	13 34	.. ..	13 38	.. ..	13 46	.. ..	13 53	.. ..	14 05
	29	1 21	13 57	1 16	13 59	1 13	14 01	1 10	14 02	1 06	14 03	1 01	14 06	0 56	14 08	0 47	14 11
	30	2 19	14 36	2 19	14 33	2 19	14 31	2 19	14 29	2 20	14 27	2 20	14 24	2 20	14 22	2 21	14 17

LAT.	+20°		+30°		+35°		+40°		+44°		+50°		+54°		+60°	
EVENT	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET	RISE	SET
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Dec. 1	3 16	15 15	3 22	15 07	3 25	15 02	3 29	14 57	3 32	14 52	3 39	14 43	3 44	14 36	3 54	14 23
2	4 13	15 56	4 24	15 43	4 31	15 35	4 38	15 27	4 45	15 19	4 57	15 04	5 07	14 53	5 28	14 30
3	5 11	16 39	5 27	16 22	5 36	16 11	5 47	16 00	5 57	15 49	6 15	15 29	6 30	15 13	7 01	14 40
● 4	6 10	17 26	6 30	17 05	6 41	16 52	6 55	16 38	7 08	16 25	7 31	16 00	7 51	15 39	8 34	14 55
5	7 08	18 16	7 31	17 52	7 44	17 38	8 00	17 22	8 14	17 07	8 42	16 39	9 06	16 14	9 59	15 20
6	8 04	19 08	8 28	18 43	8 43	18 29	8 59	18 12	9 15	17 56	9 44	17 27	10 11	17 01	11 10	16 01
7	8 57	20 01	9 21	19 38	9 35	19 24	9 52	19 07	10 07	18 52	10 36	18 23	11 02	17 58	11 59	17 01
8	9 45	20 55	10 08	20 33	10 21	20 21	10 37	20 06	10 51	19 52	11 17	19 26	11 40	19 04	12 30	18 15
9	10 30	21 48	10 49	21 29	11 01	21 18	11 14	21 06	11 26	20 54	11 49	20 33	12 08	20 14	12 48	19 36
10	11 10	22 39	11 26	22 24	11 35	22 15	11 46	22 06	11 56	21 57	12 14	21 40	12 29	21 26	12 59	20 58
11	11 46	23 28	11 59	23 18	12 06	23 12	12 14	23 05	12 21	22 59	12 34	22 47	12 45	22 38	13 06	22 19
☽ 12	12 21	.. ..	12 29	.. ..	12 34	.. ..	12 39	.. ..	12 43	.. ..	12 52	23 54	12 59	23 49	13 12	23 38
13	12 54	0 17	12 58	0 11	13 00	0 08	13 02	0 04	13 04	0 00	13 08	.. ..	13 11	.. ..	13 16	.. ..
14	13 28	1 06	13 27	1 05	13 26	1 04	13 25	1 03	13 25	1 03	13 23	1 01	13 23	1 00	13 21	0 58
15	14 02	1 56	13 56	2 00	13 53	2 02	13 49	2 04	13 46	2 06	13 40	2 10	13 35	2 13	13 25	2 19
16	14 39	2 48	14 29	2 56	14 23	3 01	14 16	3 07	14 10	3 12	13 58	3 21	13 49	3 29	13 31	3 44
17	15 20	3 43	15 05	3 56	14 56	4 04	14 46	4 13	14 37	4 21	14 21	4 36	14 07	4 48	13 40	5 13
18	16 07	4 41	15 47	4 59	15 36	5 10	15 23	5 22	15 11	5 33	14 49	5 53	14 31	6 11	13 53	6 47
19	16 59	5 43	16 36	6 05	16 23	6 17	16 08	6 32	15 53	6 46	15 27	7 11	15 04	7 34	14 15	8 22
○ 20	17 58	6 47	17 33	7 11	17 19	7 25	17 02	7 41	16 47	7 57	16 18	8 26	15 52	8 51	14 55	9 48
21	19 02	7 50	18 38	8 14	18 23	8 29	18 07	8 45	17 52	9 01	17 23	9 30	16 58	9 55	16 01	10 53
22	20 07	8 50	19 46	9 12	19 33	9 25	19 19	9 41	19 05	9 55	18 40	10 21	18 18	10 43	17 31	11 32
23	21 13	9 44	20 56	10 03	20 45	10 14	20 34	10 27	20 23	10 38	20 03	11 00	19 47	11 17	19 12	11 54
24	22 16	10 33	22 04	10 47	21 57	10 56	21 48	11 05	21 41	11 14	21 27	11 29	21 16	11 42	20 54	12 07
25	23 16	11 17	23 09	11 26	23 05	11 32	23 01	11 38	22 57	11 43	22 50	11 53	22 44	12 01	22 32	12 16
☾ 26	.. ..	11 58	.. ..	12 02	.. ..	12 04	.. ..	12 06	.. ..	12 09	.. ..	12 13	.. ..	12 16	.. ..	12 22
27	0 14	12 37	0 13	12 35	0 12	12 35	0 11	12 34	0 11	12 33	0 09	12 31	0 08	12 30	0 06	12 28
28	1 11	13 15	1 15	13 09	1 17	13 05	1 20	13 01	1 23	12 57	1 27	12 50	1 31	12 44	1 38	12 33
29	2 07	13 55	2 17	13 43	2 22	13 36	2 28	13 29	2 34	13 22	2 44	13 10	2 53	12 59	3 10	12 40
30	3 04	14 36	3 18	14 20	3 26	14 11	3 36	14 00	3 45	13 50	4 01	13 33	4 14	13 18	4 42	12 48
31	4 01	15 21	4 19	15 01	4 30	14 49	4 43	14 35	4 55	14 23	5 16	14 00	5 34	13 41	6 13	13 01

ECLIPSES DURING 1983

In 1983 there will be four eclipses, two of the Sun (one total and one annular) and two of the Moon (one partial and one penumbral).

1. *June 11: Total Eclipse of the Sun*
   This is entirely an Eastern Hemisphere event. Also, the path of totality remains south of the equator. It begins in the Indian Ocean, crosses Java, Celebes, New Guinea, and ends in the South Pacific Ocean near the New Hebrides. The path of totality is in contact with Earth from 3^h11^m to 6^h14^m UT on June 11.

2. *June 25: Partial Eclipse of the Moon*
   This is generally visible from the Pacific, South America, and North America except the northern part. Also, the end of the umbral phase will not be visible from the northeastern part of either North America or South America. Magnitude of eclipse* = 0.339

Moon enters penumbra	05^h	43.0^m	UT
Moon enters umbra	07	14.4	
Middle of eclipse	08	22.3	
Moon leaves umbra	09	30.1	
Moon leaves penumbra	11	01.6	

3. *December 4: Annular Eclipse of the Sun*
   The path of annularity is confined to the North Atlantic Ocean and central Africa near the equator. A partial eclipse is visible from nearly all of Africa, much of Europe and the Near East, northeastern South America, and the Atlantic Provinces of Canada. In the latter case the Sun rises partially eclipsed, but this lasts only a few minutes. The path of annularity is in contact with Earth from 10^h47^m to 14^h13^m UT.

4. *December 19/20: Penumbral eclipse of the Moon*
   This is generally visible from North America and Europe, and much of Africa and South America. Penumbral magnitude of the eclipse* = 0.914

Moon enters penumbra	23^h	45.9^m	UT
Middle of eclipse	01	49.0	
Moon leaves penumbra	03	52.3	

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*The magnitude of a partial or total lunar eclipse is the fraction of the lunar diameter within the umbra of Earth's shadow at greatest obscuration, measured along the common diameter. Hence the magnitude $\geqq 1$ for a total lunar eclipse. For a penumbral lunar eclipse, the magnitude is the fraction of the lunar diameter within the penumbra at greatest obscuration.

OCCULTATIONS BY THE MOON

PREDICTIONS BY THE
INTERNATIONAL LUNAR OCCULTATION CENTRE
TOKYO, JAPAN

The Moon often passes between Earth and a star, an event called an occultation. During an occultation a star suddenly disappears as the east limb of the Moon crosses the line between the star and observer. The star reappears from behind the west limb some time later. Because the Moon moves through an angle about equal to its own diameter every hour, the longest time for an occultation is about an hour. The time is shorter if the occultation is not central. Occultations are equivalent to total solar eclipses, except they are eclipses of stars other than the Sun.

Since observing occultations is rather easy, provided the weather is suitable and equipment is available, amateur astronomers are encouraged to try this activity. The slow, majestic drift of the Moon in its orbit is an interesting part of such observations, and the disappearance or reappearance of a star at the Moon's limb is a remarkable sight, particularly when it occurs as a *graze* near the Moon's northern or southern edge. In the latter case the star may disappear and reappear several times in succession as mountains and valleys in the Moon's polar regions pass by it. On rarer occasions the moon occults a planet. A memorable event observed by the editor a few years ago was a graze involving Saturn. At one point only a portion of Saturn's rings were visible over a lunar valley, resembling a pale rainbow above that stark landscape.

Lunar occultation and graze observations are used to refine our knowledge of the Moon's orbit and the shape of the lunar profile. These observations complement those made by other techniques, such as laser-ranging and photographs. Improved knowledge of the lunar profile is useful in determinations of the Sun's diameter from solar eclipse records. Occultation observations are also useful for detecting double stars and measuring their separations. Binaries with separations as small as 0.″01 have been discovered visually during grazes. Doubles with separations in this range are useful for filling the gap between doubles which can be directly resolved visually and those whose duplicity has been discovered spectroscopically.

Analysis of lunar occultation observations is currently being done at the U.S. Naval Observatory and the International Lunar Occultation Centre (ILOC). The latter organization is the world clearing house for such observations. Readers who are interested in pursuing a systematic program of lunar occultation observations should write to the ILOC (address on the inside front cover under "Kubo") for their booklet: *Guide to Lunar Occultation Observations*.

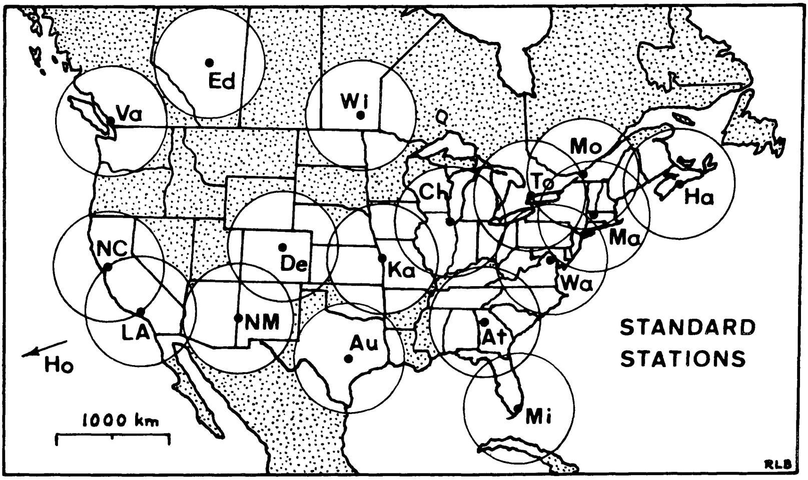
Observers in North America should also contact the International Occultation Timing Association (IOTA), P.O. Box 596, Tinley Park, IL 60477, U.S.A. IOTA provides predictions and coordination services for occultation observers. Detailed predictions for any grazing occultation are available ($1.50 U.S. each); instructions concerning the use of predictions are also available ($2.50 U.S.). Annual membership in IOTA is $11.00 U.S. in North America, $16.00 U.S. overseas. Membership includes free graze predictions, descriptive materials, and a subscription to *Occultation Newsletter* (available separately for $5.50 U.S.).

The main information required in a lunar occultation observation is the time of the event and the observer's location. Supplementary information includes the seeing conditions, size of telescope used, method used, estimate of accuracy, etc. The timing should be as precise as possible, preferably to 0.5s or better. (A shortwave radio time signal and cassette tape recorder provide a simple, permanent time record). The observer's latitude, longitude, and altitude should be known to the nearest second of arc and 20 metres respectively. These can be determined from a suitable topographical map. For Canada these are available from the Canada Map Office, 615 Booth Street, Ottawa, ON K1A 0E9. In the United States east of the Mississippi write to: U.S. Geological Survey, 1200 S. Eads St., Arlington, VA 22202; west of the Mississippi the address is: U.S. Geological Survey, Denver Federal Centre, Bldg. 41, Denver, CO 80225.

The following pages give tables of predictions, and a table and maps of northern or southern limits for many cases where grazing occultations may be seen.

1. TOTAL OCCULTATION PREDICTIONS

The total occultation predictions are for the 18 standard stations identified on the map below; the coordinates of these stations are given in the table headings. The tables are generally limited to stars of magnitude 6.0 or brighter. More detailed lists, including over 100 events with stars as faint as $8^{m}.1$, are also available. These can be obtained for any location in North America from Walter V. Morgan, 10961 Morgan Territory Rd., Livermore, CA 94550, U.S.A., provided that accurate geographical coordinates and a long, stamped, self-addressed envelope are provided.



The first five columns in the tables give for each occultation the date, the Zodiacal Catalogue number of the star, its magnitude, the phenomenon (DD or DB = disappearance at dark limb or bright limb, respectively; RD or RB = reappearance at dark limb or bright limb, respectively), and the elongation of the Moon from the Sun in degrees (see page 20). Under each station are given the universal time of the event, factors *a* and *b* (see below), and the position angle (from the north point, eastward around the Moon's limb to the point of occurrence of the phenomenon). In certain cases, predictions have been omitted due to the Moon being too near or below the horizon, no occultation, interference of sunlight, or other difficulties. If *a* and *b* are insignificant, they are omitted.

The terms *a* and *b* are for determining corrections to the times of the phenomena for stations within 500 km of the standard stations. Thus if λ_o, ϕ_o, be the longitude and latitude of the standard station and λ, ϕ, the longitude and latitude of the observer, then for the observer we have: UT of phenomenon = UT of phenomenon at the standard station + $a(\lambda - \lambda_o) + b(\phi - \phi_o)$ where $\lambda - \lambda_o$ and $\phi - \phi_o$ are expressed in degrees and *a* and *b* are in minutes of time per degree. Due regard must be paid to the algebraic signs of the terms. Also, to convert UT to the standard time of the observer, see page 15.

As an example, consider the occultation of ZC 1702 on April 24, 1983 as seen from Ottawa. For Ottawa, $\lambda = 75.72°$ and $\phi = 45.40°$. The nearest standard station is Montreal, for which $\lambda_o = 73.60°$ and $\phi_o = 45.50°$. Therefore, the UT of the disappearance at the dark limb ("DD") is $4^h30^m.6 - 2^m.4(75.72 - 73.60) + 0^m.0(45.40 - 45.50) = 4^h25^m.5$. Note that almost the same result is obtained by using Toronto as the standard station. The elongation of the Moon is 140° which means that the Moon is in the waxing gibbous phase (between first quarter and full). The position angle of disappearance is about 65°.

DATE	ZC	MAG	PH	ELG	Ha HALIFAX, NS W 63°6, N 44°6 UT	a	b	PA	Mo MONTREAL, PQ W 73°6, N 45°5 UT	a	b	PA	To TORONTO, ON W 79°4, N 43°7 UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Jan 5	1773	5.1	RD	258	5 8.1	-0.5	-0.4	321	5 4.2	-0.3	-0.3	322				
Feb 8	2589	4.8	RD	310	10 41.9	-1.4	0.7	284	10 30.4	-1.1	1.2	275				
21	639	6.0	DD	95	2 34.6	-0.8	-1.4	91	2 24.2	-1.1	-1.3	92	2 19.7	-1.3	-1.5	99
21	654	6.0	DD	96	4 42.1	-0.2	-0.7	65	4 38.9	-0.4	-0.8	70	4 38.2	-0.5	-1.0	80
21	668	3.6	DD	97									6 13.2	0.1	-0.9	77
22	817	4.8	DD	110	6 23.0	-0.3	0.2	37	6 19.6	-0.4	-0.2	48	6 18.1	-0.4	-0.5	60
Mar 22	916	4.3	DD	90	2 54.3	-1.2	0.5	41	2 42.3	-1.3	0.2	51	2 34.8	-1.4	-0.2	63
22	929	5.8	DD	91	5 3.9	0.0	-0.7	66	5 2.3	-0.2	-1.0	75	5 3.2	-0.2	-1.2	85
Apr 1	2209	5.9	RD	222	3 26.3			225								
1	2213	5.9	RD	223	4 49.9	-0.7	-0.5	325	4 43.4	-0.6	0.0	313	4 39.3	-0.6	0.4	300
1	2218	5.6	RD	224	6 14.1	-0.8	-1.2	334	6 4.8	-0.9	-0.5	321	5 59.8	-1.0	-0.1	308
19	1050	5.8	DD	74	2 50.4	-0.1	-1.4	95	2 47.1	-0.3	-1.6	104	2 48.5	-0.3	-1.9	115
24	1702	4.2	DD	140					4 30.6	-2.4	0.0	65	4 18.1	-2.1	-0.4	83
29	2302	2.9	DB	204	6 33.5	-1.4	-1.3	143	6 19.8	-1.0	-1.2	153	6 17.5	-0.5	-1.7	166
29	2302	2.9	RD	205	7 42.7	-1.8	-0.6	257	7 22.5	-2.2	-0.0	252	7 7.9	-2.7	0.8	241
29	2303	5.1	RD	205	7 43.0	-1.8	-0.7	258	7 23.0	-2.2	-0.1	253	7 8.6	-2.7	0.7	242
May 2	2719	5.8	RD	239	6 40.7	-1.5	0.2	300	6 27.9	-1.2	0.7	292				
3	2864	4.7	RD	249	5 39.1			201								
24	2022	5.5	DD	150	7 0.0	-0.5	-1.7	107	6 51.8	-0.8	-1.7	106	6 49.6	-1.0	-1.7	110
28	2523	4.9	RD	197	6 44.2	-1.9	-0.9	281	6 24.7	-1.9	-0.4	281	6 13.6	-2.0	0.0	275
30	2809	4.9	RD	219	4 10.0	-2.0	2.5	224								
Jun 9	MERC	0.7	DB	335	8 31.0	0.2	1.8	53								
9	MERC	0.7	RD	336	9 28.6	-0.2	1.6	259	9 28.4	-0.1	1.5	268	9 25.9	0.1	1.3	270
22	2209	5.9	DD	143	3 51.7	-2.0	-0.2	58	3 29.8	-2.3	-0.0	67	3 15.9	-2.4	0.0	78
29	3164	4.7	RD	224	7 33.8	-2.4	-0.4	281	7 8.9	-2.4	-0.1	295	6 55.2	-2.3	0.1	297
Jul 6	454	5.8	RD	304	7 37.3	-0.0	2.1	219	7 39.1	0.1	1.9	228				
9	MARS	1.8	DB	350	19 58.5	-1.1	-0.2	54	19 46.8	-1.2	-0.4	64	19 40.4	-1.3	-0.6	76
9	MARS	1.8	RD	351	20 45.0	0.2	-2.5	316	20 43.2	-0.2	-2.3	306	20 45.1	-0.5	-1.9	294
10	MERC	-1.8	DB	2	12 29.9	-1.4	0.1	126	12 19.7	-0.8	0.9	111	12 14.3	-0.5	1.0	109
10	MERC	-1.8	RB	2	13 29.8	-0.8	3.3	225	13 25.2	-0.6	2.5	239	13 17.7	-0.4	2.4	240
20	2303	5.1	DD	126	3 17.7	-1.4	-1.7	121	3 1.2	-1.6	-1.4	121	2 54.1	-1.7	-1.3	126
20	2302	2.9	DD	126	3 17.8	-1.4	-1.7	122	3 1.3	-1.6	-1.4	122	2 54.3	-1.7	-1.3	127
20	2302	2.9	RB	127	4 29.2	-0.8	-1.4	266	4 17.9	-1.2	-1.3	271	4 12.3	-1.5	-1.2	269
Aug 14	2022	5.5	DD	72	1 37.3			43	1 29.5			42	1 21.6			53
18	2523	4.9	DD	118	0 7.0	-2.3	0.7	59								
19	2672	2.9	DD	131	2 22.3	-2.2	-1.7	133	2 0.1	-2.0	-0.9	128	1 50.1	-2.0	-0.8	131
19	2672	2.9	RB	131	3 21.2	-0.9	0.1	222	3 9.3	-1.5	-0.0	232	2 59.6	-1.8	0.3	232
22	3089	5.3	DD	164	5 31.9	-1.4	-0.7	77	5 16.9	-1.5	-0.0	62	5 7.6	-1.6	0.3	58
26	18	6.0	RD	208	3 28.0	-1.1	1.9	230	3 19.5	-0.9	1.9	238	3 11.1	-0.8	2.0	239
Sep 1	766	6.0	RD	279	4 48.1	0.2	1.7	240								
19	3164	4.7	DD	144	1 6.5	-1.4	1.6	31	0 54.2	-1.4	2.2	22	0 41.6	-1.5	2.5	23
19	3175	4.8	DD	146	5 6.9	-0.5	0.1	41	5 2.8	-0.3	0.9	22	4 58.9	-0.3	1.4	16
25	322	5.7	RD	212	1 17.2	-0.3	1.7	252								
25	327	4.5	RD	212	2 17.2	-0.8	1.6	262	2 11.7	-0.6	1.5	273	2 6.3	-0.4	1.4	275
25	354	5.5	RD	216									10 23.4	-1.5	-1.6	276
27	593	5.8	RD	238									5 31.6			170
30	1070	5.2	RD	277	9 16.8			195	9 13.5	-0.8	3.7	214	9 2.9	-0.5	3.8	212
Oct 25	700	5.7	RD	219					3 37.8			173	3 37.2			184
Nov 6	URAN	6.0	DD	24	20 34.3	-1.1	-0.4	53	20 20.5	-1.7	-0.0	50	20 9.7	-2.1	0.1	56
15	5	4.7	DD	125	21 21.7	-0.7	2.5	23								
16	18	6.0	DD	127	0 50.6	-2.6	-0.3	97	0 28.8	-1.9	0.9	77	0 16.2	-1.8	1.3	72
18	249	4.7	DD	150	0 45.6	-1.5	1.4	65	0 34.7	-1.0	1.9	49	0 25.8	-0.8	2.1	44
23	936	5.9	RD	212	0 27.9	-0.5	0.5	305	0 22.5			327				
27	1544	5.7	RD	270	10 13.7	-2.2	0.5	262	9 52.5	-2.2	1.7	250	9 34.0			231
Dec 9	3158	5.8	DD	63	24 15.1	-1.3	-2.0	103	24 0.7	-1.3	-1.1	84	23 54.2	-1.5	-0.8	80
24	1484	3.6	RD	235	4 13.6	-1.0	-1.5	336	4 2.5			347	4 0.8	-0.8	-1.7	342

DATE	ZC	MAG	PH	ELG	Wi WINNIPEG, MB W 97°2, N 49°9 UT	a	b	PA	Ed EDMONTON, AB W 113°4, N 53°6 UT	a	b	PA	Va VANCOUVER, BC W 123°1, N 49°2 UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Jan 4	1702	4.2	RD	251					14 30.1	-0.6	-2.0	329	14 30.3	-1.1	-1.6	310
Feb 5	2213	5.9	RD	278	11 41.3			232								
6	2353	4.6	RD	290					13 46.3	-1.2	0.1	300	13 32.3	-1.3	0.7	283
21	639	6.0	DD	94	1 48.5	-1.5	0.1	74	1 29.6	-1.1	1.4	51				
21	654	6.0	DD	96	4 19.9	-0.9	-0.7	70	4 1.0	-1.2	0.1	59	3 47.7	-1.5	0.1	71
21	668	3.6	DD	97	6 4.5	-0.4	-1.0	74	5 51.7	-0.7	-0.9	71	5 47.9	-1.0	-1.2	88
22	817	4.8	DD	110	6 4.0	-0.8	-0.5	59	5 47.0	-1.1	-0.1	58	5 36.4	-1.4	-0.4	75
Mar 21	766	6.0	DD	78									4 18.1			358
22	916	4.3	DD	90	2 9.8	-1.6	0.9	51								
22	929	5.8	DD	91	4 47.9	-0.7	-1.3	87	4 29.8	-1.0	-1.1	88	4 24.6	-1.3	-1.5	107
Apr 16	577	6.0	DD	35	2 24.3	-0.2	-1.3	84								
19	1050	5.8	DD	73	2 26.4	-0.8	-1.9	116								
24	1702	4.2	DD	140	3 42.6	-1.7	0.0	96	3 20.3	-1.2	0.5	103				
29	2303	5.1	DD	204	6 7.9			190								
29	2302	2.9	DD	204	6 10.4			194								
29	2302	2.9	RD	204	6 24.1			215								
29	2303	5.1	RD	204	6 26.5			219								
May 23	1921	5.9	DD	139									10 13.6			180
24	2022	5.5	DD	149	6 19.0	-1.3	-1.3	115	5 54.9	-1.1	-0.8	127	5 48.5	-0.9	-1.0	146
24	2033	4.3	DD	151									10 18.2			182
28	2523	4.9	RD	197	5 45.3	-1.5	1.0	268								
Jun 29	3164	4.7	RD	223	6 28.5	-1.0	0.6	312								
Jul 9	MARS	1.8	DB	350	19 12.3	-1.6	0.3	67	18 50.9	-1.4	1.5	55	18 31.0	-1.4	1.4	67
9	MARS	1.8	RD	351	20 19.7	-1.0	-2.0	296	19 54.1	-1.3	-1.7	301	19 44.9	-1.7	-0.7	284
10	MERC	-1.8	DD	2	12 20.9	0.2	1.7	77	12 34.1	0.6	1.9	55				
10	MERC	-1.8	RB	2	13 22.6	-0.3	1.5	274	13 23.8	-0.1	1.1	298	13 19.3	0.1	0.8	299
20	2302	2.9	DD	126	2 21.8	-1.2	-0.5	134	2 5.4	-0.6	-0.2	147	2 6.6			176
20	2302	2.9	RB	126	3 37.3	-1.8	-0.5	270	3 8.8	-1.7	0.6	259	2 42.8			234
Aug 13	1921	5.9	DD	61									4 51.3	-0.4	-1.8	120
14	2033	4.3	DD	73					4 7.3	-0.7	-1.7	114	4 7.0	-0.9	-1.7	121
16	2275	5.9	DD	98					4 20.1	-1.1	-1.6	138	4 15.2	-1.3	-1.6	145
19	2672	2.9	DD	130	1 21.6	-1.1	0.2	133								
19	2672	2.9	RB	131	2 28.2	-1.9	0.8	240	2 3.4	-1.7	1.7	232				
22	3089	5.3	DD	164	4 46.2	-1.4	1.3	33	4 31.0	-1.3	1.9	22	4 8.2	-1.4	2.4	31
Sep 1	792	5.1	RD	282	9 25.3			189	9 38.2	0.0	2.2	224	9 29.7	0.2	2.0	227
16	2809	4.9	DD	114									6 38.1	-0.9	-0.8	65
24	249	4.7	RD	205					11 40.6	-0.7	0.8	210	11 28.0	-0.8	1.5	205
27	593	5.8	RD	238	5 54.3	-0.1	2.2	220	6 0.4	0.0	1.9	240	5 53.1	0.2	1.7	243
30	1070	5.2	RD	277	9 7.1	-0.6	1.8	253	9 5.2	-0.4	1.3	277	8 56.9	-0.2	1.2	277
30	1092	5.8	RD	279									13 25.9	-1.3	2.7	226
Oct 11	2434	5.6	DD	58	0 33.4	-1.2	-0.6	55								
16	3130	5.5	DD	114	1 34.1	-2.0	0.2	101	1 10.4	-1.3	1.1	91				
25	700	5.7	RD	219	3 57.8	0.0	2.1	226	4 5.9	0.1	1.7	245				
29	1308	4.7	RD	271	6 10.4	0.6	2.5	226	6 25.6	0.5	1.5	253				
Nov 1	1702	4.2	RD	315					12 32.8	-0.6	1.2	281	12 21.5	-0.4	1.7	264
6	URAN	6.0	DD	24	19 32.5	-2.2	0.7	63	19 6.1	-1.5	1.2	78				
14	3343	5.8	DD	107	5 44.6			145	5 3.9	-1.4	-1.3	91	4 53.0	-1.8	-0.7	87
14	3349	4.2	DD	107					6 30.0	-0.4	-0.4	49	6 26.1	-0.7	-0.2	50
16	18	6.0	DD	127	0 4.0	-0.9	1.9	47	0 0.5	-0.5	2.1	35				
18	249	4.7	DD	150	0 31.9	-0.1	2.5	15	0 44.5			349				
27	1544	5.7	RD	269	9 23.8	-1.1	2.2	252	9 18.6	-0.5	1.7	266	9 6.9	-0.2	2.1	254
Dec 1	2022	5.5	RD	323	13 2.3	0.2	-2.0	357								
6	2750	2.1	DD	28	22 23.7			168	21 40.0	-1.6	-0.7	140	21 27.4	-1.5	-0.7	147
6	2750	2.1	RB	28	22 32.0			180	22 28.5	-1.1	0.1	215	22 13.0	-1.7	0.9	213
9	3158	5.8	DD	62	23 29.4	-1.2	0.4	45								
13	3536	4.7	DD	98					5 52.3	-0.7	-1.1	74	5 48.3	-1.1	-1.0	78
16	322	5.7	DD	129	1 19.7	-1.8	0.7	97	1 4.3	-0.8	1.7	71	0 49.5	-0.6	1.8	67
16	327	4.5	DD	130	2 30.8	-2.0	0.2	94	2 10.5	-1.0	1.5	65	1 53.8	-0.8	1.8	60
16	354	5.5	DD	134					10 9.8			8	10 1.7	-0.5	0.4	33
29	SATU	0.8	DB	306									14 40.2	-1.8	1.3	80
29	SATU	0.8	RD	306									15 36.3	-0.5	-1.2	342

					Ma MASSACHUSETTS W 72°5, N 42°5					Wa WASHINGTON, DC W 77°0, N 38°9					Ch CHICAGO, IL W 87°7, N 41°9				
DATE	ZC	MAG	PH	ELG	UT		a	b	PA	UT		a	b	PA	UT		a	b	PA
				°	h	m	m/°	m/°	°	h	m	m/°	m/°	°	h	m	m/°	m/°	°
Jan 5	1773	5.1	RD	258	5	4.9	-0.3	0.0	311										
Feb 5	2213	5.9	RD	278											11	53.5			226
8	2589	4.8	RD	310	10	28.0	-1.3	1.3	269	10	16.6	-1.4	1.8	254					
18	249	4.7	DD	57						1	10.1			343					
21	639	6.0	DD	95	2	29.9	-1.1	-1.7	102	2	32.4	-1.2	-2.6	119	2	9.9	-1.7	-1.7	106
21	654	6.0	DD	96	4	41.9	-0.3	-1.0	78	4	44.8	-0.3	-1.3	93	4	35.9	-0.6	-1.3	91
21	668	3.6	DD	97											6	15.4	0.0	-1.2	89
22	817	4.8	DD	110	6	20.9	-0.3	-0.4	56	6	21.8	-0.2	-0.7	72	6	15.8	-0.5	-0.8	74
Mar 19	593	5.8	DD	63						23	50.4	-1.4	3.7	14					
21	752	4.7	DD	77						2	38.2			15	2	28.8			9
22	916	4.3	DD	90	2	43.8	-1.2	-0.2	60	2	40.0	-1.2	-0.7	77	2	23.3	-1.6	-0.4	76
22	929	5.8	DD	91	5	5.4	-0.1	-1.0	81	5	9.2	0.0	-1.2	94	5	3.6	-0.3	-1.4	99
Apr 1	2213	5.9	RD	223	4	43.9	-0.8	0.1	306	4	38.9	-0.9	0.6	290					
1	2218	5.6	RD	224	6	7.2	-1.1	-0.5	315	6	2.8	-1.3	0.0	300	5	51.1	-1.0	0.5	292
2	2353	4.6	RD	235						4	48.3			6					
2	JUPI	-1.9	DB	239											13	43.1			36
16	577	6.0	DD	35											2	35.0	0.2	-1.5	101
19	1050	5.8	DD	74	2	52.3	-0.2	-1.7	110	2	58.3	-0.1	-2.0	125	2	49.6	-0.3	-2.4	130
24	1702	4.2	DD	140	4	33.6	-2.2	-0.3	72	4	26.0	-2.0	-0.8	90	4	2.5	-1.9	-0.7	102
29	2302	2.9	DB	204	6	25.1	-1.1	-1.6	157	6	29.4			176					
29	2302	2.9	RD	205	7	24.9	-2.4	0.1	247	7	9.9			232					
29	2303	5.1	RD	205	7	25.5	-2.4	0.1	249	7	11.0			234					
May 2	2719	5.8	RD	239	6	27.2	-1.3	0.7	288	6	18.3	-1.4	1.0	276					
20	1544	5.7	DD	96	0	30.3	-3.1	1.4	60										
24	2022	5.5	DD	150	6	57.8	-0.8	-1.7	110	7	0.1	-0.9	-1.8	116	6	43.2	-1.2	-1.7	117
28	2523	4.9	RD	197	6	28.0	-2.1	-0.4	277	6	18.8	-2.3	0.0	269	5	55.8	-2.1	0.6	265
Jun 9	MERC	0.7	RD	336	9	24.1	0.0	1.5	263	9	19.2	0.1	1.4	261					
22	2209	5.9	DD	143	3	32.6	-2.4	-0.1	71	3	22.2	-2.5	-0.2	84	2	56.6	-2.2	0.1	94
29	3164	4.7	RD	223	7	11.9	-2.5	-0.1	288	7	0.3	-2.5	0.2	286	6	37.8	-1.8	0.4	297
Jul 6	454	5.8	RD	304	7	33.3	0.1	1.9	223										
9	MARS	1.8	DB	350	19	49.7	-1.1	-0.6	72	19	47.4	-1.2	-1.0	88	19	30.0	-1.5	-0.9	88
9	MARS	1.8	RD	351	20	49.8	-0.2	-2.0	298	20	54.6	-0.5	-1.5	283	20	42.6	-0.9	-1.5	280
10	MERC	-1.8	DB	2	12	18.6	-1.0	0.4	121	12	13.2	-1.0	0.1	126	12	9.4	-0.2	1.0	103
10	MERC	-1.8	RB	2	13	17.6	-0.5	3.0	228	13	5.3	-0.1	3.2	221	13	11.2	-0.2	2.1	245
20	2303	5.1	DD	126	3	7.4	-1.7	-1.6	125	3	5.4	-1.8	-1.7	132	2	42.2	-1.7	-1.2	135
20	2302	2.9	DD	126	3	7.6	-1.7	-1.6	125	3	5.7	-1.8	-1.7	133	2	42.6	-1.6	-1.3	136
20	2302	2.9	RB	127	4	23.0	-1.2	-1.2	266	4	21.1	-1.5	-1.0	261	4	0.3	-1.9	-0.8	265
Aug 14	2022	5.5	DD	72	1	30.6			52	1	26.8	-1.3	-0.5	64					
19	2672	2.9	DD	131	2	5.8	-2.2	-1.3	133	2	0.8	-2.3	-1.6	140	1	36.3	-1.6	-0.8	139
19	2672	2.9	RB	131	3	10.6	-1.4	0.3	226	3	1.3	-1.8	0.9	221	2	41.8	-2.2	0.9	230
22	3089	5.3	DD	164	5	18.9	-1.7	-0.1	69	5	10.8	-2.0	0.1	70	4	52.1	-1.8	0.9	52
26	18	6.0	RD	208	3	14.6	-0.9	2.0	234	3	3.2	-0.8	2.1	231	3	2.1	-0.5	2.0	239
Sep 19	3164	4.7	DD	144	0	49.2	-1.5	2.2	28	0	33.5	-1.7	2.4	33	0	24.2	-1.5	2.8	27
19	3175	4.8	DD	146	5	1.0	-0.6	0.7	33	4	55.0	-0.8	0.9	34	4	54.7	0.3	2.7	2
25	327	4.5	RD	212	2	7.8	-0.6	1.5	268	2	0.5	-0.4	1.4	266	2	1.9	-0.1	1.2	278
25	354	5.5	RD	216											10	12.2	-1.9	-1.4	275
27	593	5.8	RD	238											5	32.4	0.6	3.4	188
30	1070	5.2	RD	277	8	58.0			190						8	53.3	-0.3	3.3	216
Oct 11	2434	5.6	DD	58											0	49.6	-1.0	-0.9	72
16	3130	5.5	DD	115											2	3.6			130
25	700	5.7	RD	219											3	36.8	0.5	2.9	197
Nov 6	URAN	6.0	DD	24	20	22.7	-1.7	-0.1	56	20	14.6	-2.1	-0.1	65	19	50.5	-2.4	0.3	66
16	18	6.0	DD	127	0	28.6	-2.2	0.7	84	0	15.5	-2.3	0.9	83	0	0.2	-1.5	1.7	64
18	249	4.7	DD	150	0	30.3	-1.2	1.8	55	0	18.4	-1.1	1.9	55	0	16.2	-0.5	2.2	37
23	936	5.9	RD	212	0	23.4	-0.4	0.1	314										
27	1544	5.7	RD	269	9	48.0			236										
Dec 9	3158	5.8	DD	62	24	6.0	-1.5	-1.4	94	24	3.3	-1.9	-1.4	97	23	41.8	-1.7	-0.2	71
24	1484	3.6	RD	235	4	7.9	-0.8	-1.0	330	4	6.9	-0.7	-0.4	317	3	57.3	-0.7	-1.6	342

DATE	ZC	MAG	PH	ELG	Mi MIAMI, FL W 80°3, N 25°8 UT	a	b	PA	At ATLANTA, GA W 84°3, N 33°8 UT	a	b	PA	Au AUSTIN, TX W 97°8, N 30°2 UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Jan 3	1544	5.7	RD	231	3 37.7	-0.5	-0.3	304								
27	1050	5.8	DD	155	3 41.3	-2.5	0.4	83	3 41.8	-2.0	2.2	51	3 9.7	-1.6	2.0	57
Feb 18	249	4.7	DD	57	0 38.1	-1.2	0.8	51	0 45.9	-0.7	2.5	15				
21	654	6.0	DD	96	5 17.8			161	4 51.4	-0.2	-2.2	118	5 5.7			163
21	668	3.6	DD	97					6 25.8	0.3	-1.5	111	6 40.6			147
22	792	5.1	DD	108	2 29.3	-2.2	0.7	63	2 34.5	-2.1	3.3	27	1 56.9	-2.0	2.6	40
22	817	4.8	DD	110	6 35.2	0.2	-1.5	114	6 25.0	-0.2	-1.1	94	6 27.6	-0.2	-2.1	122
Mar 21	752	4.7	DD	77	2 24.0	-1.2	-0.4	78	2 18.8	-1.5	0.6	52	1 54.6	-2.0	0.1	73
21	766	6.0	DD	78	4 39.2	-0.3	0.0	64	4 39.4	-0.7	0.7	39	4 29.3	-0.8	-0.3	71
22	916	4.3	DD	90	2 54.1	-0.8	-2.2	125	2 35.4	-1.4	-1.3	100	2 20.1	-1.9	-2.4	124
22	929	5.8	DD	92	5 30.6	0.6	-2.2	138	5 16.7	0.1	-1.7	117	5 28.5	0.6	-3.8	153
Apr 1	2213	5.9	RD	223	4 12.5			227	4 26.5	-1.1	1.5	262				
1	2218	5.6	DD	223									5 0.6			196
1	2218	5.6	RD	224	5 49.3	-2.7	1.7	254	5 50.3	-1.7	0.8	274	5 14.3			220
2	2353	4.6	RD	235	5 5.2	-0.5	-0.3	304	5 0.6	0.0	-0.7	325				
2	JUPI	-1.9	DB	239	13 52.7	-0.7	-0.9	89	13 44.8	-0.6	-0.4	64	13 32.5	-1.4	-0.1	63
2	JUPI	-1.9	RD	239									14 36.2	-1.4	-2.4	313
8	3175	4.8	RD	303	9 46.4	-1.3	2.2	230	9 57.3	-1.0	1.8	248				
19	1050	5.8	DD	74					3 12.6	0.5	-3.6	155				
24	1702	4.2	DD	140	4 36.4	-1.6	-1.8	127	4 17.1	-1.8	-1.3	115	4 1.8	-1.2	-2.3	150
May 2	2719	5.8	RD	238	5 52.9	-2.3	2.5	235	6 1.6	-1.4	1.6	254				
18	1308	4.7	DD	71	4 26.5			27					4 5.7	-1.3	0.2	59
20	1544	5.7	DD	95	0 20.7	-1.9	-1.8	130								
24	2022	5.5	DD	150	7 23.1	-1.0	-2.3	143	7 1.9	-1.1	-1.9	128	6 52.3	-1.3	-2.3	146
28	2523	4.9	RD	197	5 59.7	-3.8	2.1	235	5 57.9	-2.8	1.0	252				
Jun 1	3089	5.3	RD	243									9 47.4	-2.8	0.2	280
13	1092	5.8	DD	26	1 12.7			31								
22	2209	5.9	DD	143	3 22.0	-2.5	-1.1	116	3 5.9	-2.4	-0.5	105	2 42.2	-1.4	-1.1	136
29	3164	4.7	RD	223	6 44.5	-2.6	1.0	261	6 40.8	-2.2	0.6	280	6 13.1	-1.4	1.0	272
29	3175	4.8	RD	225									10 39.5	-3.8	-1.6	291
Jul 8	766	6.0	RD	331									10 39.7	-0.1	0.7	279
9	MARS	1.8	DB	350	20 7.3	-0.6	-2.8	137	19 45.5	-1.3	-1.8	112	19 35.5	-1.5	-3.7	141
9	MARS	1.8	RD	351	21 1.3	-1.4	0.4	238	20 54.9	-1.1	-0.7	259	20 31.4	-2.4	1.6	227
10	MERC	-1.8	DB	2					12 7.1	-0.9	-0.4	132				
10	MERC	-1.8	RB	2					12 50.2	0.5	3.3	214	12 47.3	0.6	2.3	224
20	2303	5.1	DD	126	3 32.1	-1.8	-4.1	167	3 1.5	-1.8	-2.1	147	2 54.4			181
20	2302	2.9	DD	126	3 33.2			168	3 2.0	-1.8	-2.2	148	2 56.0			183
20	2302	2.9	RB	127	4 17.0			226	4 12.0	-2.0	-0.3	251	3 31.1			227
Aug 14	2022	5.5	DD	72	1 33.2	-1.4	-1.1	96	1 19.4	-1.7	-0.8	81				
19	2672	2.9	DD	130					1 56.0			159				
19	2672	2.9	RB	131					2 37.0			208				
22	3089	5.3	DD	164	5 3.2	-3.2	-0.4	94	4 53.2	-2.4	0.5	70	4 16.5	-2.5	1.3	65
26	18	6.0	RD	208	2 30.3	-0.6	2.8	205	2 47.4	-0.6	2.2	225				
28	249	4.7	RD	231	3 43.2	-0.9	0.1	293								
Sep 18	3164	4.7	DD	144	23 58.8	-1.8	1.8	62	24 8.7	-1.7	2.4	44				
19	3175	4.8	DD	146	4 40.7	-2.0	0.6	61	4 42.1	-1.2	1.3	34	4 19.0	-1.1	2.8	16
25	327	4.5	RD	212	1 41.2	0.0	1.5	243	1 52.0	-0.1	1.3	262				
25	354	5.5	RD	216	10 19.6	-1.3	2.1	210	10 22.3	-1.6	0.2	243	9 54.8	-2.2	0.6	247
27	614	5.7	RD	241									11 15.1	-2.6	-0.3	269
Oct 3	1484	3.6	RD	317	9 7.8			346								
11	2434	5.6	DD	59	1 16.7	-1.2	-1.6	115	1 1.2	-1.1	-1.1	91	0 44.9	-1.9	-0.9	90
27	1030	3.2	RD	246	7 18.0	-2.4	-0.7	298								
28	1170	3.7	RD	259	6 38.6	-1.4	-0.3	299								
Nov 6	URAN	6.0	DD	24	20 11.3	-2.5	-0.6	94	19 58.1	-2.5	-0.1	79	19 23.8	-2.4	-0.2	103
7	2513	4.3	DD	38	23 40.6	0.1	1.8	32								
12	3089	5.3	DD	85	3 41.6	-0.1	0.4	51	3 49.9	0.7	1.9	14	3 54.0			353
15	18	6.0	DD	126	23 59.7	-3.8	-0.5	110	23 53.9	-2.1	1.3	81				
17	249	4.7	DD	149	23 51.9	-1.3	1.4	75	24 1.4	-0.8	2.0	54				
29	1773	5.1	RD	296	10 31.3	-1.1	-1.5	324	10 12.3	-0.4	-2.8	352	10 10.4	-0.6	-1.0	323
Dec 9	3158	5.8	DD	62					23 53.6	-2.5	-1.1	97				
10	3164	4.7	DD	63	1 48.6	-0.6	0.1	60	1 52.0	0.0	1.1	27	1 47.4	0.3	2.4	11
24	1484	3.6	RD	235	4 2.1	-0.4	0.8	273	4 3.6	-0.4	0.0	304				
29	SATU	0.8	DB	307	16 23.6	-2.4	0.5	63					15 32.6	-3.2	0.2	79
29	SATU	0.8	RD	307	17 12.4	-1.2	-3.6	346					16 37.1	-1.2	-2.9	343

					Ka KANSAS CITY, MO W 94°5, N 39°0				De DENVER, CO W 105°0, N 39°8				NM NEW MEXICO, AZ W 109°0, N 34°0			
DATE	ZC	MAG	PH	ELG	UT	a	b	PA	UT	a	b	PA	UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Jan 27	1050	5.8	DD	155	3 46.9			9					3 9.1	-0.4	4.4	25
Feb 21	639	6.0	DD	94	2 2.1	-2.2	-2.2	115	1 36.5	-2.4	-0.8	102	1 33.9	-3.4	-2.5	123
21	654	6.0	DD	96	4 35.5	-0.8	-1.8	106	4 23.2	-1.3	-1.9	107	4 34.4	-1.3	-4.6	137
21	668	3.6	DD	97	6 19.2	0.0	-1.6	104	6 16.1	-0.3	-2.0	111	6 31.3	0.2	-4.1	142
22	792	5.1	DD	107									1 58.9			360
22	817	4.8	DD	110	6 15.2	-0.6	-1.2	90	6 6.7	-0.9	-1.4	97	6 13.6	-0.8	-2.3	121
28	1702	4.2	RD	196									11 12.6	0.0	-3.2	354
Mar 21	752	4.7	DD	77	2 7.5	-1.8	1.7	36	1 50.2	-1.8	2.3	34				
21	766	6.0	DD	78	4 34.4	-1.2	1.2	32	4 22.5	-1.3	0.7	43	4 16.8	-1.2	-0.3	69
22	916	4.3	DD	90	2 13.7	-1.8	-0.7	89	1 53.3	-2.0	-0.3	89	1 48.7	-2.4	-1.2	110
22	929	5.8	DD	91	5 6.3	-0.3	-1.9	114	5 0.4	-0.5	-2.3	124	5 18.0			157
Apr 1	2218	5.6	RD	223	5 41.5	-1.1	1.1	273								
2	JUPI	-1.9	DB	239	13 38.3	-0.7	0.8	38	13 31.1			24	13 14.6	-2.1	0.9	49
2	JUPI	-1.9	RD	239	14 15.6	-1.7	-3.6	338	13 49.6			358	14 5.8	-2.0	-3.3	335
16	577	6.0	DD	35	2 41.8	0.3	-2.1	118	2 42.0	0.1	-2.7	125				
19	1050	5.8	DD	74	2 56.6	0.0	-3.7	152	2 56.3			174				
24	1702	4.2	DD	140	3 52.7	-1.7	-1.0	120	3 35.6	-1.4	-1.1	134	3 40.6	-1.0	-2.4	159
May 18	1308	4.7	DD	71					4 2.1			29	3 49.0	-1.6	-0.3	70
24	2022	5.5	DD	150	6 39.2	-1.4	-1.7	127	6 23.0	-1.4	-1.7	137	6 29.1	-1.2	-2.3	154
28	2523	4.9	RD	197	5 37.8	-2.3	1.5	250	5 14.5	-2.5	2.9	232				
Jun 1	3089	5.3	RD	243	9 55.4	-2.7	-0.4	297	9 29.9	-2.0	-0.1	305	9 21.4	-1.9	0.3	291
3	3343	5.8	RD	266									11 32.1	-1.6	2.4	212
22	2209	5.9	DD	143	2 42.8	-1.8	-0.1	110								
29	3164	4.7	RD	223	6 25.2	-1.4	0.7	291	6 13.9	-0.9	0.9	289	6 4.7	-0.8	1.1	274
29	3175	4.8	DD	225	10 13.4			341								
Jul 9	MARS	1.8	DB	350	19 22.0	-1.7	-1.2	103	19 1.3	-2.0	-0.9	104	19 1.6	-2.3	-2.4	128
9	MARS	1.8	RD	351	20 38.3	-1.4	-0.8	264	20 21.0	-1.8	-0.3	258	20 10.0	-2.4	1.5	232
10	MERC	-1.8	DB	2	12 5.9	0.0	0.9	102								
10	MERC	-1.8	RB	2	13 4.8	0.0	1.9	246	13 6.9	0.1	1.5	260	12 59.4	0.4	1.5	251
20	2302	2.9	DD	126	2 36.1	-1.4	-1.5	149	2 24.1	-0.6	-1.9	166				
20	2303	5.1	DD	126	2 35.6	-1.4	-1.5	148								
20	2302	2.9	RB	126	3 47.4	-2.4	-0.2	256	3 19.6	-3.0	0.9	245				
Aug 14	2033	4.3	DD	74					4 38.3	-0.5	-2.0	130	4 48.1	-0.6	-2.2	141
16	2275	5.9	DD	98					5 2.0	-1.5	-3.3	162				
19	2672	2.9	DD	130	1 29.9	-1.1	-1.5	154	1 25.1			174				
19	2672	2.9	RB	131	2 20.7	-2.8	2.0	221	1 48.9			206				
22	3089	5.3	DD	164	4 36.0	-2.0	1.3	51	4 16.9	-1.9	1.9	44	3 57.9	-2.0	1.9	55
Sep 19	3175	4.8	DD	146	4 48.9			352								
25	354	5.5	RD	216	10 1.3	-2.3	-0.9	272	9 30.4			297	9 25.0	-3.3	-0.7	281
27	593	5.8	RD	238	5 26.7	0.5	3.0	193	5 32.1	0.2	2.3	212	5 20.1	0.5	2.4	204
27	614	5.7	RD	240	11 10.2	-2.8	-3.4	305					10 36.9			304
30	1070	5.2	RD	277	8 43.1	0.0	3.1	215	8 44.6	-0.1	2.1	234	8 31.9	0.3	2.4	222
Oct 11	2434	5.6	DD	58	0 43.6	-1.4	-0.7	74								
16	3130	5.5	DD	114	1 43.8	-3.4	-1.2	123	1 14.1	-2.3	0.2	110	1 4.3	-2.4	-0.3	121
25	700	5.7	RD	219	3 32.4	0.5	2.6	201	3 38.8	0.4	2.0	217				
Nov 6	URAN	6.0	DD	24	19 32.7	-2.5	0.3	80	19 9.1	-2.0	0.5	93	19 0.2	-1.7	0.0	112
14	3349	4.2	DD	108					6 49.8	-0.9	-2.1	103	7 2.4			129
15	18	6.0	DD	126	23 45.9	-1.2	1.8	62								
18	249	4.7	DD	149	0 6.5	-0.4	2.3	34	0 6.1	-0.1	2.4	23				
22	839	5.3	RD	205									12 41.8	-0.5	-2.5	307
29	1773	5.1	RD	296	9 47.8			22	9 43.9			20	10 0.9	-0.3	-1.3	334
Dec 1	2022	5.5	RD	323					13 7.9	-0.7	-0.2	310	13 3.7	-1.0	0.5	286
9	3158	5.8	DD	62	23 29.5	-1.9	0.2	67								
16	322	5.7	DD	129					0 56.9	-2.2	0.6	106	0 45.4	-2.4	0.1	113
16	327	4.5	DD	130					2 11.1	-3.0	-0.1	107	2 0.5			117
24	1484	3.6	RD	235	3 57.0	-0.5	-1.1	335								
29	SATU	0.8	DB	306					15 14.8	-3.3	1.0	68	15 0.2	-2.6	0.1	93
29	SATU	0.8	RD	306					16 3.8	-0.4	-2.8	356	16 14.0	-1.3	-2.1	334

					LA LOS ANGELES, CA W 118°3, N 34°1				NC N. CALIFORNIA W 122°0, N 38°0				Ho HONOLULU, HI W 157°9, N 21°3			
DATE	ZC	MAG	PH	ELG	UT	a	b	PA	UT	a	b	PA	UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Jan 4	1702	4.2	RD	251					14 48.9	-1.6	-1.4	290				
22	322	5.7	DD	92									9 57.2	-0.5	1.3	36
24	577	6.0	DD	116									6 54.3	-2.1	1.9	46
26	916	4.3	DD	145									11 23.2	-2.0	1.1	53
26	929	5.8	DD	147									13 47.8	-0.5	0.0	67
Feb 6	2353	4.6	RD	290	13 27.4	-2.8	1.5	254	13 23.6	-2.3	1.4	259				
8	2630	5.1	RD	313									15 33.1	-0.9	0.3	283
21	654	6.0	DD	96	4 17.9			137	3 57.6	-2.2	-1.9	113				
21	668	3.6	DD	97	6 35.9			163	6 12.6	-0.7	-3.7	133				
22	817	4.8	DD	110	6 4.6	-1.1	-2.9	129	5 50.3	-1.5	-2.0	114				
25	1308	4.7	DD	150									6 20.9	-1.5	3.4	46
28	1702	4.2	RD	196	11 8.7	-0.7	-2.5	335	10 56.4	-0.7	-2.5	338				
Mar 2	1950	5.8	RD	223									13 3.9	-2.9	-0.4	280
5	2322	4.3	RD	260									16 7.3	-3.2	-0.2	273
21	766	6.0	DD	78	4 3.8	-1.6	-0.3	75	3 57.5	-1.7	0.2	62				
21	792	5.1	DD	81									9 16.3	-0.2	-1.0	101
22	929	5.8	DD	91					4 57.2			156				
Apr 2	JUPI	-1.9	DB	239	12 50.9	-3.0	1.1	53	12 45.1			45	11 25.9	-0.1	-1.9	156
2	JUPI	-1.9	RD	239	13 46.6	-2.0	-3.1	337	13 27.0			349	12 29.4	-3.0	1.2	257
16	593	5.8	DD	37									6 14.5	0.0	-1.8	118
18	916	4.3	DD	64									8 58.2			175
19	1070	5.2	DD	76									6 51.3	-2.0	0.3	69
24	1702	4.2	DD	140	3 34.0	-0.3	-3.8	178	3 20.1	-0.7	-2.3	164				
29	2322	4.3	RD	205									8 44.1	-0.9	-0.2	295
May 1	2602	5.5	RD	230									11 9.6	-1.4	-0.2	294
1	2607	5.9	RD	230									11 52.4	-1.9	-0.3	292
18	1308	4.7	DD	71	3 34.0	-1.6	-0.8	86								
21	1702	4.2	DD	114									11 21.0	-0.4	-1.3	113
24	2022	5.5	DD	149	6 20.7	-0.5	-3.0	173	6 8.3	-0.5	-2.5	171				
30	2861	5.7	RD	224									15 8.6	-2.1	0.9	235
Jun 1	3089	5.3	RD	243	9 6.4	-1.3	0.6	288	9 4.4	-1.0	0.6	295				
1	3106	5.4	RD	244									12 40.5	-2.3	-0.4	294
3	3343	5.8	RD	265	11 17.6	-1.6	2.3	221	11 20.4	-1.5	2.0	229				
3	3349	4.2	RD	266									11 44.0	-0.7	1.2	257
16	1544	5.7	DD	70									7 22.9	-1.3	-0.5	82
22	2213	5.9	DD	143	3 33.5	-3.1	2.1	68								
23	2376	4.6	DD	158					10 44.8			161				
Jul 2	5	4.7	RD	258									11 32.8	-1.0	0.5	280
2	18	6.0	RD	260									15 16.4	-1.5	2.7	208
9	MARS	1.8	DB	350	18 38.4	-2.6	-1.7	124	18 26.0	-2.2	-0.3	106	17 21.2	-1.2	-0.2	114
9	MARS	1.8	RD	350	19 47.8	-2.4	2.2	229	19 45.6	-2.1	1.1	245	18 14.9	-0.3	2.6	219
19	2209	5.9	DD	118									10 8.9	-1.2	-1.0	95
Aug 1	322	5.7	RD	264									13 36.1	-1.9	1.4	252
1	327	4.5	RD	265									14 57.9	-2.3	1.5	245
3	577	6.0	RD	288									12 49.5	0.6	2.9	194
13	1921	5.9	DD	61					5 13.1	-0.4	-2.0	135				
14	2033	4.3	DD	74	4 40.9	-0.9	-2.2	141	4 29.0	-1.0	-2.1	135				
16	2275	5.9	DD	98	5 3.3			180	4 41.5	-1.5	-3.1	165				
19	2719	5.8	DD	134									10 42.7	-1.5	-0.5	83
20	2861	5.7	DD	145									9 27.0	-3.1	-0.8	99
22	3089	5.3	DD	164	3 41.1	-1.6	2.0	58	3 43.5	-1.5	2.2	52				
29	404	5.2	RD	247									12 59.9	-3.8	-0.6	287
Sep 1	792	5.1	RD	281					9 3.6	0.8	2.8	199				
14	2513	4.3	DD	92	5 53.9	-1.4	-2.1	124	5 41.5	-1.3	-1.7	110	4 49.4	-2.6	-2.1	137
14	2523	4.9	DD	93									8 13.0	-0.9	0.3	61
16	2809	4.9	DD	114	6 59.9	-1.5	-1.6	103	6 49.5	-1.4	-1.1	88	5 30.5	-3.1	0.0	95
24	249	4.7	RD	205									9 46.6	-0.4	3.4	191
29	936	5.9	RD	266									12 49.7	-1.1	1.2	254
30	1070	5.2	RD	277	8 34.9	0.3	1.8	236	8 42.0	0.1	1.5	251				
Oct 10	2307	4.1	DD	48					3 18.9			161				
16	3164	4.7	DD	118									9 29.5	-2.7	-1.9	108

					LA LOS ANGELES, CA W 118°.3, N 34°.1				NC N. CALIFORNIA W 122°.0, N 38°.0				Ho HONOLULU, HI W 157°.9, N 21°.3			
DATE	ZC	MAG	PH	ELG	UT	a	b	PA	UT	a	b	PA	UT	a	b	PA
				°	h m	m/°	m/°	°	h m	m/°	m/°	°	h m	m/°	m/°	°
Nov 6	URAN	6.0	DD	23	18 47.5	-1.0	-0.3	128	18 43.6	-0.9	0.1	124				
14	3349	4.2	DD	108	6 44.4	-1.8	-2.1	105	6 32.9	-1.4	-1.0	83	5 12.3	-2.5	1.6	57
14	3343	5.8	DD	107					5 19.7			135				
14	3343	5.8	RD	107					5 34.3			156				
22	839	5.3	RD	205	12 34.5	-1.0	-2.1	297	12 20.9	-1.1	-2.9	310	11 13.1	-2.4	1.2	250
23	1030	3.2	RD	220									14 59.3	-2.5	0.5	250
24	1170	3.7	RD	232					14 14.5	-0.5	-3.1	327	13 6.1	-2.6	3.4	226
28	1689	5.5	RD	285									14 57.5	-1.5	-1.0	308
Dec 1	2022	5.5	RD	323	12 56.0	-0.7	1.0	275								
13	3536	4.7	DD	98					6 20.0			139	4 37.1	-4.0	0.0	93
13	3536	4.7	RD	98					6 30.1			155				
16	327	4.5	DD	130	1 36.4	-1.8	1.0	93	1 35.8	-1.3	1.5	79				
16	354	5.5	DD	134	10 9.1	-0.2	-1.0	86	10 4.5	-0.4	-0.7	73				
18	628	4.8	DD	160									13 54.7	-1.3	1.8	33
21	1117	5.1	RD	200									14 18.1	-1.2	-2.1	308
29	SATU	0.8	DB	306	14 39.8	-1.8	-0.1	112	14 33.6	-1.6	0.2	108				
29	SATU	0.8	RD	306	16 0.6	-1.5	-1.3	318	15 50.5	-1.3	-1.1	320				
31	URAN	6.0	RD	331									17 36.6	-1.4	0.0	288

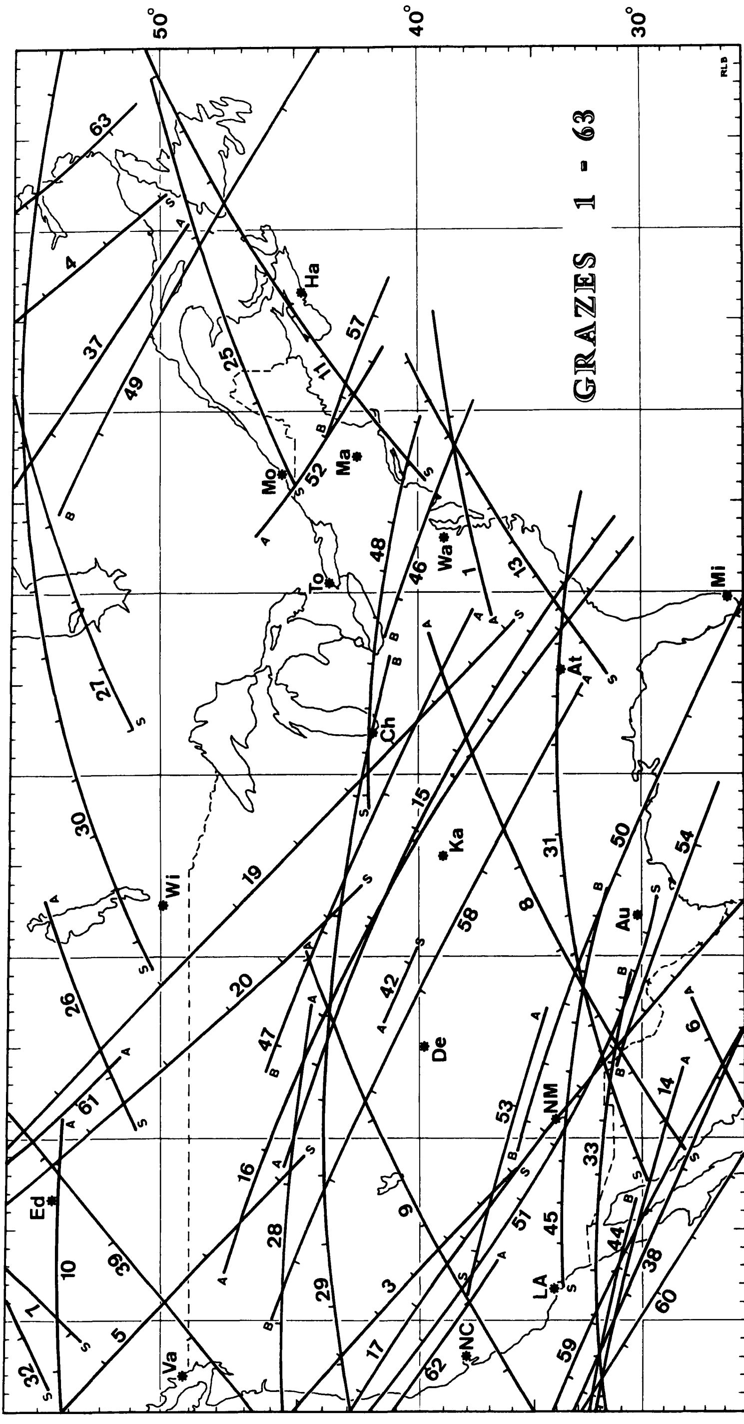
2. GRAZE PREDICTIONS

The table on the next page lists lunar graze predictions for much of North America for 1983. The events are limited to stars of magnitude 7.5 or brighter 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 (5° in the case of stars brighter than $5^{m}.5$ and 2° for those brighter than $3^{m}.5$). For each is given: the Zodiacal Catalogue number and magnitude of the star, the time of the beginning of each graze track (the west end of the track), the percent of the Moon sunlit (a minus sign indicates a waning Moon), and whether the track is the northern (N) or southern (S) limit of the occultation.

The maps show the predicted graze tracks. Each track is keyed by a number to the table. Several tracks begin and/or end with a letter *A*, *B*, or *S* indicated. *A* denotes that the Moon is at a low altitude, *B* that the bright limb interferes, and *S* that daylight interferes. The tick marks along the tracks indicate multiples of 5 minutes of every hour. e.g. If the time for the west end of a track is $3^h16^m11^s$, the tick marks proceeding eastward correspond to $3^h20^m00^s$, $3^h25^m00^s$, *etc.* Also, the tick marks are located on the side of each line that the star is occulted.

To avoid clutter, only international boundaries have been indicated on the maps. With the aid of a scale or divider, the latitude-longitude grid can be used to transfer any graze track to a detailed map of the observer's area. Also, as mentioned on page 75, detailed predictions for any graze are available from the International Occultation Timing Association.

No	ZC	m_v	UT at Start of Track in West	h	m	s	%	L
1	1544	5.7	Jan. 3	3	16	11	-81	N
3	1923	7.1	6	13	34	8	-45	S
4	2020	6.6	7	10	57	45	-36	S
5	2259	6.7	9	14	13	23	-18	S
6	3228	6.5	17	1	37	21	7	S
7	3349	4.2	18	0	39	29	12	S
8	3480	7.3	19	1	16	37	20	S
9	3484	6.8	19	2	26	17	20	S
10	306	6.9	22	6	38	45	50	S
11	398	6.7	22	22	32	26	58	S
13	523	6.5	23	23	30	8	69	S
14	577	6.0	24	8	24	47	72	N
15	1976	6.9	Feb. 3	7	47	29	-64	S
16	1978	6.6	3	8	17	2	-64	S
17	2097	7.1	4	10	59	2	-53	S
19	2213	5.9	5	11	13	10	-43	S
20	2218	5.6	5	12	35	46	-42	S
25	5	4.7	15	22	36	24	8	S
26	18	6.0	16	1	8	10	8	S
27	368	6.3	18	23	44	59	31	S
28	393	6.8	19	5	6	4	33	S
29	504	7.3	20	3	55	42	43	S
30	629	7.5	21	0	42	5	53	S
31	639	6.0	21	1	46	16	54	S
32	643	6.7	21	2	10	24	54	S
33	654	6.0	21	4	23	5	55	S
37	817	4.8	22	6	28	39	66	N
38	828	6.5	22	7	58	59	67	N
39	946	3.2	22	22	36	40	75	S
42	3106	5.4	Mar.11	12	43	54	- 9	S
44	617	6.6	20	4	36	11	29	S
45	755	6.3	21	2	29	4	39	S
46	752	4.7	21	2	42	49	39	N
47	766	6.0	21	4	38	36	39	N
48	907	6.9	22	0	48	19	49	S
49	916	4.3	22	2	55	28	50	N
50	923	6.9	22	3	57	0	50	N
51	2659	6.4	Apr. 4	11	1	36	-58	S
52	2792	6.8	5	8	45	12	-50	S
53	577	6.0	16	2	57	55	9	S
54	725	6.9	17	2	35	53	16	N
57	865	6.1	18	0	12	20	24	N
58	887	7.0	18	3	31	7	25	N
59	1052	6.8	19	3	56	29	36	N
60	1200	6.9	20	5	18	7	48	N
61	1222	7.2	20	8	2	28	49	N
62	1221	6.2	20	8	13	6	49	N
63	1462	7.4	22	5	9	21	70	N
66	1178	6.2	May 17	6	37	54	24	N
67	1308	4.7	18	3	44	12	33	N
68	1544	5.7	20	0	47	22	55	N
70	1773	5.1	22	1	47	54	77	N
71	3089	5.3	June 1	9	24	24	-73	N
72	3214	6.6	2	8	50	32	-64	N
75	1514	6.1	16	2	47	43	31	N
77	1647	6.7	17	5	9	11	43	N
78	1659	6.8	17	7	30	20	44	N
79	1755	6.8	18	4	2	22	54	N
80	1856	6.6	19	1	22	16	64	N
81	3536	4.7	July 2	9	33	51	-60	N
84	766	6.0	8	10	34	33	- 6	N
85	1725	7.5	15	4	17	17	29	N
86	1950	5.8	Jul.17	2	41	7	50	N
90	303	6.6	Aug. 1	10	5	9	-56	N
91	308	6.7	1	10	56	44	-56	N
93	527	6.3	3	6	56	2	-36	N
96	859	6.5	5	9	27	59	-16	N
97	865	6.1	5	10	6	36	-16	N
101	2022	5.5	14	1	24	34	34	N
102	2032	7.3	14	4	11	40	36	N
104	249	4.7	28	3	27	34	-81	N
105	784	6.2	Sep. 1	7	43	21	-40	N
106	954	6.1	2	7	42	21	-29	N
108	2491	6.7	14	2	20	54	50	S
109	2507	6.7	14	4	46	43	51	N
112	2652	6.4	15	5	13	52	60	S
113	2780	6.9	16	1	2	59	69	N
115	2809	4.9	16	7	39	52	70	S
116	614	5.7	27	9	38	25	-75	N
118	898	6.0	29	6	24	24	-56	N
119	936	5.9	29	13	31	46	-53	N
120	1058	7.0	30	6	6	52	-45	N
122	1208	6.4	Oct. 1	6	57	22	-33	N
123	1239	6.4	1	12	20	37	-30	N
124	1484	3.6	3	8	54	33	-13	N
125	1499	7.3	3	11	54	49	-12	N
126	2033	4.3	8	0	8	43	3	N
128	2296	7.1	10	1	38	32	15	N
131	2879	6.6	14	1	49	6	52	N
132	3130	5.5	16	1	30	15	71	S
133	3349	4.2	17	21	11	41	85	N
134	882	5.0	26	9	31	21	-79	N
135	1015	6.4	27	4	13	56	-71	N
136	1023	6.5	27	5	2	58	-71	N
137	1030	3.2	27	6	29	36	-70	N
138	1058	7.0	27	13	19	7	-68	S
140	1157	6.0	28	4	17	24	-60	N
141	1168	6.8	28	6	0	46	-59	N
142	1170	3.7	28	6	3	35	-59	N
143	1180	7.1	28	8	15	16	-58	N
144	1195	6.7	28	12	12	59	-57	S
145	1334	7.0	29	11	17	9	-46	N
148	1586	7.5	31	12	48	54	-23	N
150	1702	4.2	Nov. 1	12	8	50	-14	S
151	2657	6.7	8	22	56	27	17	S
152	3227	6.4	13	6	18	32	55	S
153	3336	7.2	14	2	33	11	63	S
154	3343	5.8	14	5	21	20	64	S
155	3349	4.2	14	7	1	4	64	S
159	1393	6.7	26	3	54	0	-64	N
160	1535	7.1	27	7	36	47	-51	S
161	1544	5.7	27	8	58	26	-50	S
162	1647	6.7	28	7	6	51	-40	S
163	1659	6.8	28	9	11	9	-39	S
165	1773	5.1	29	9	40	9	-28	N
166	2016	6.5	Dec. 1	11	32	59	-10	S
167	3160	7.0	9	23	53	15	26	S
168	3158	5.8	10	0	23	31	26	S
170	3408	7.0	12	1	42	3	45	S
171	3536	4.7	13	6	22	1	56	S
172	322	5.7	16	0	52	43	82	S
173	327	4.5	16	1	50	30	82	S
174	1484	3.6	24	3	43	40	-78	N
177	1985	7.0	28	10	52	38	-31	S


GRAZES 1 - 63
50°
40°
30°
60°
80°
100°
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Ha
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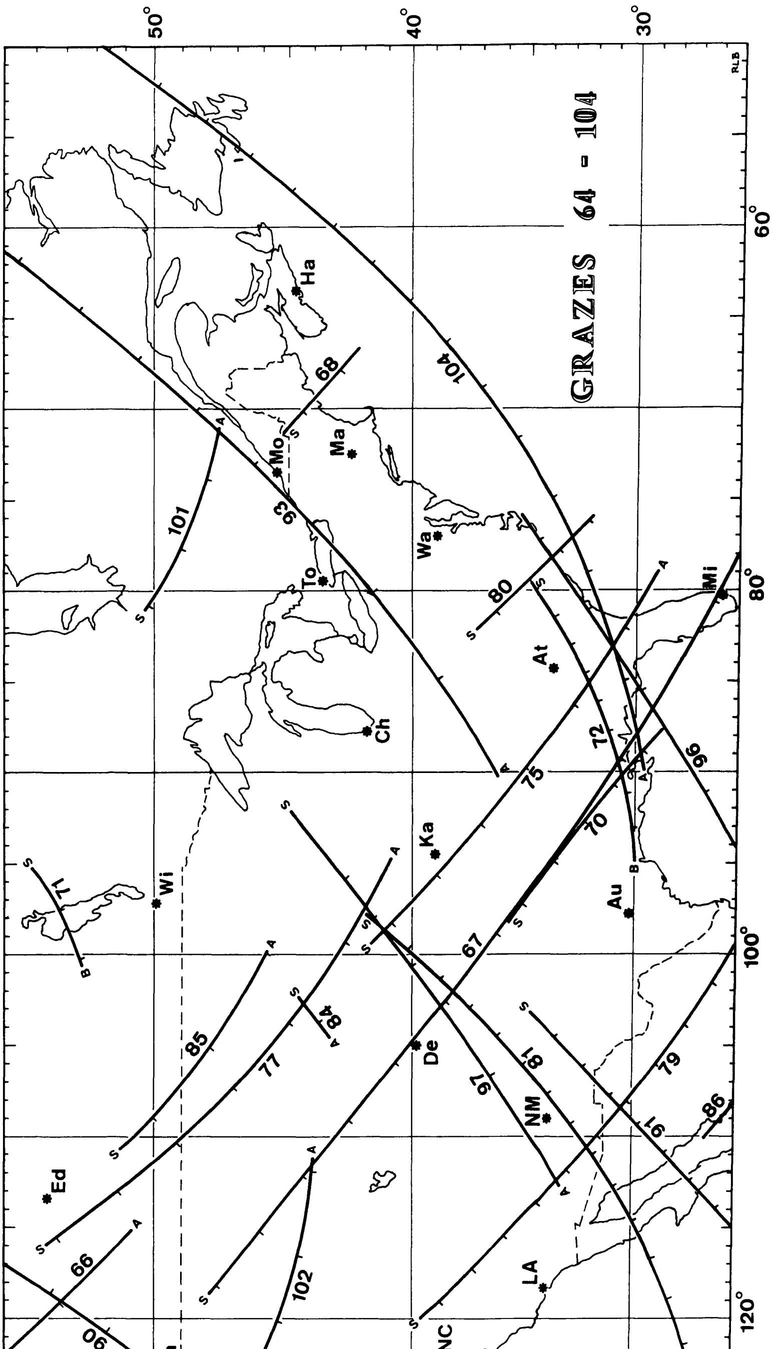
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30°
60°
80°
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120°
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104
68
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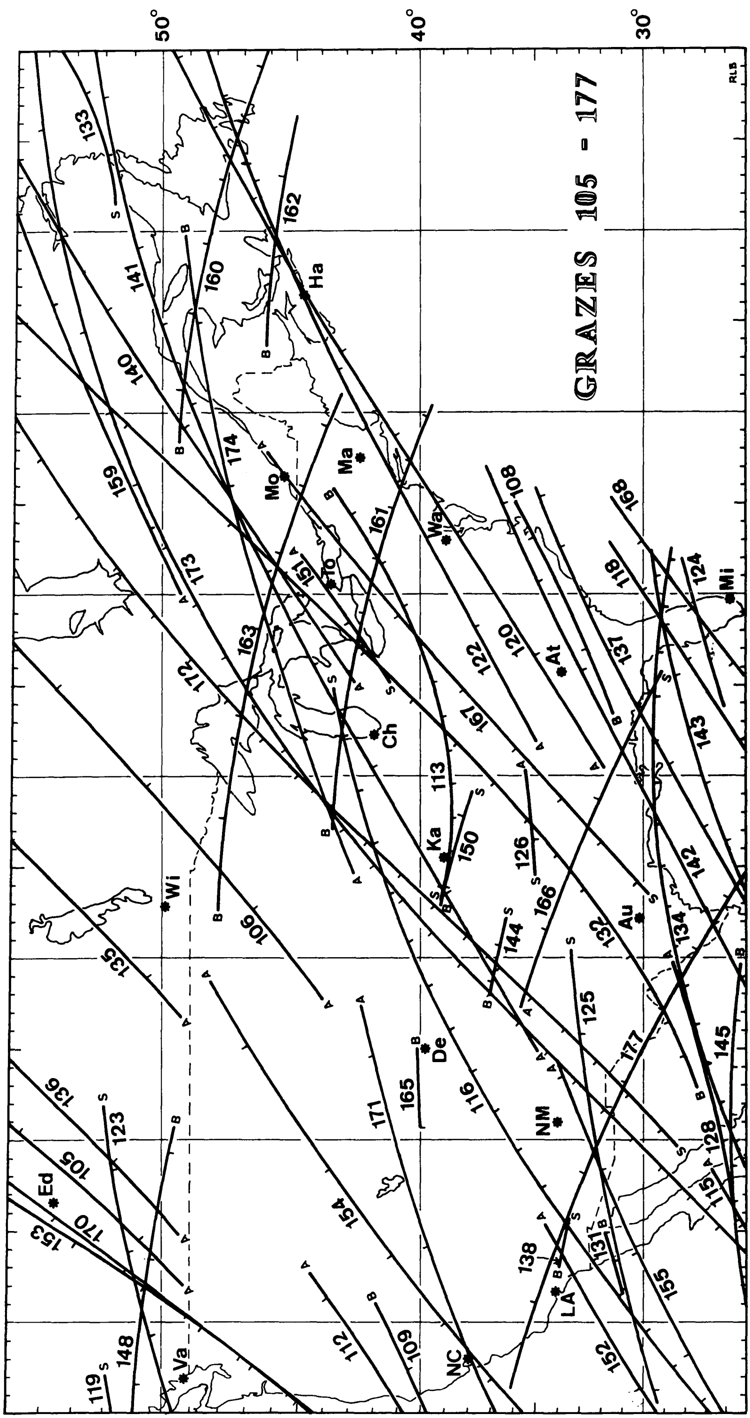
102
90
78


GRAZES 105 - 177
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40°
30°
60°
80°
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Va
NC
LA
RLB

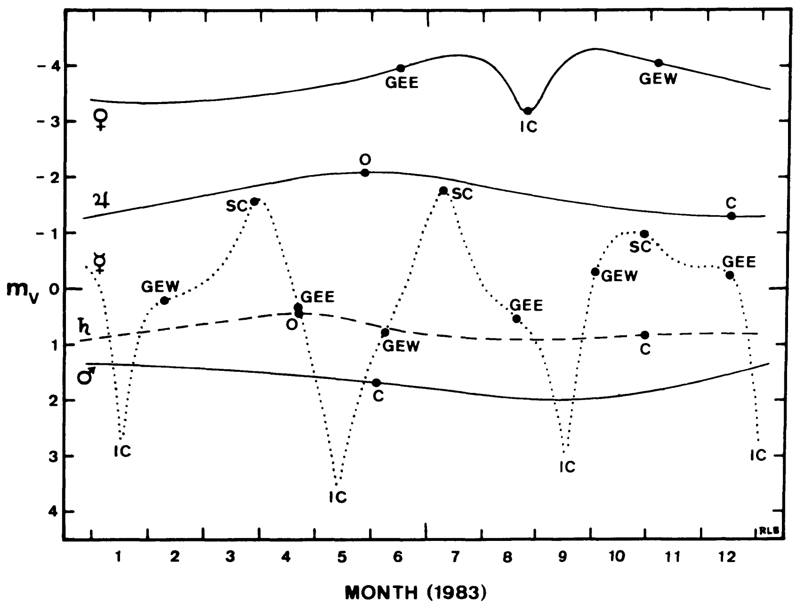
PLANETS, SATELLITES, AND ASTEROIDS

PLANETARY HELIOCENTRIC LONGITUDES 1983

Date UT	Planet M	V	E	M	J	S
Jan. 1.0	23°	313°	100°	342°	235°	208°
Feb. 1.0	191	2	132	2	237	209
Mar. 1.0	274	47	160	19	239	209
Apr. 1.0	35	97	191	37	242	210
May 1.0	194	146	220	54	244	211
June 1.0	285	196	250	71	246	212
July 1.0	53	244	279	86	249	213
Aug. 1.0	208	293	308	101	251	214
Sep. 1.0	298	342	338	116	254	215
Oct. 1.0	78	30	7	129	256	216
Nov. 1.0	221	80	38	143	258	217
Dec. 1.0	307	128	68	156	261	218
Jan. 1.0	103	179	100	170	263	219

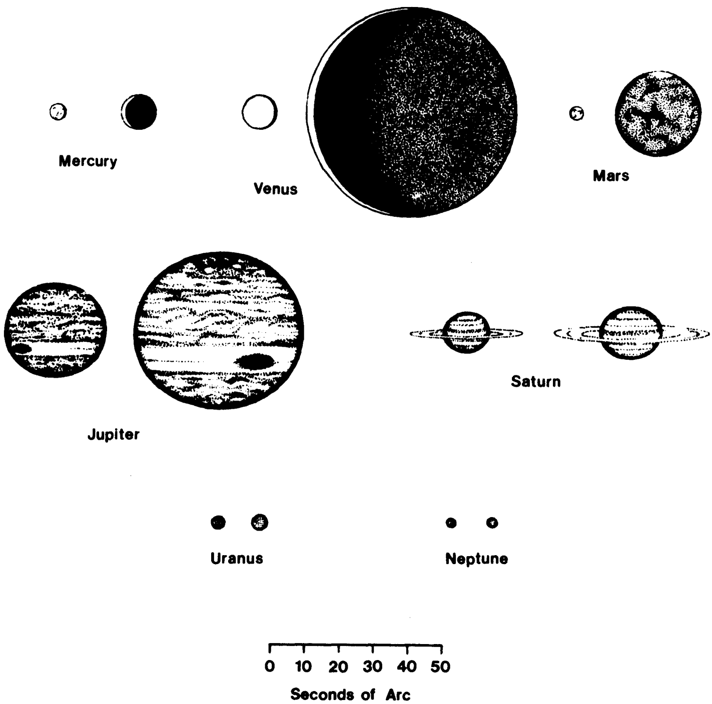
The heliocentric longitude is the angle between the vernal equinox and the planet, as seen from the Sun. It is measured in the ecliptic plane, in the direction of the orbital motion of the planets (counterclockwise as viewed from the north side of the ecliptic plane). Knowing the heliocentric longitudes, and the approximate distances of the planets from the Sun (page 9), the reader can construct the orientation of the Sun and planets on any date.

The heliocentric longitude of Uranus increases from 245° to 250° during the year; that of Neptune from 267° to 269°, and that of Pluto from 207° to 210°.



The magnitudes of the five, classical (naked eye) planets in 1983. Oppositions (O), conjunctions (C), inferior and superior conjunctions (IC, SC), and greatest elongations east and west (GEE, GEW) are indicated. (For planetary symbols see page 8.)

PLANETS: APPARENT SIZES



The apparent maximum and minimum observable size of seven planets is illustrated along with characteristic telescopic appearance. The large satellites of Jupiter (not shown) appear smaller than Neptune.

Note: Pronunciations of the names of the planets are given on p. 103.

THE PLANETS FOR 1983

BY TERENCE DICKINSON

MERCURY

At just over one-third Earth's distance from the Sun, Mercury is the solar system's innermost planet and the only one known to be almost entirely without an atmosphere. Mercury is a small world only 6% as large as the Earth by volume—barely larger than our moon.

Until the advent of interplanetary probes, virtually nothing was known about the surface of Mercury. Only the vaguest smudges have been seen through Earth-based telescopes. In 1974 the U.S. spacecraft Mariner 10 photographed one hemisphere of Mercury revealing it to be extremely heavily cratered, in many respects identical in appearance to the far side of Earth's moon. There is no interplanetary mission planned to photograph the other hemisphere.

Mercury's orbit is the most elliptical of any planet except Pluto's. Once each orbit Mercury approaches to within 0.31 A.U. of the Sun and then half an orbit (44 days) later it is out to 0.47 A.U. This amounts to a 24 million km range in distance from the Sun, making the Sun in Mercury's sky vary from about four times the area we see it to more than ten times its apparent area from Earth. Mercury's sidereal rotation period of 59 days combines with the 88 day orbital period of the planet to produce a solar day (one sunrise to the next) of 176 days—the longest of any planet.

Of the five planets visible to the unaided eye Mercury is by far the most difficult to observe and is seldom conveniently located for either unaided eye or telescopic observation. The problem for observers is Mercury's tight orbit which constrains the planet to a small zone on either side of the Sun as viewed from Earth. When Mercury is east of the Sun we may see it as an evening star low in the west just after sunset. When it is west of the Sun we might view Mercury as a morning star in the east before sunrise. But due to celestial geometry involving the tilt of the Earth's axis and Mercury's orbit we get much better views of Mercury at certain times of the year.

The best time to see the planet in the evening is in the spring, and in the morning in the fall (from the northern hemisphere). Binoculars are of great assistance in searching for the planet about 40 minutes to an hour after sunset or before sunrise during the periods when it is visible. Mercury generally appears about the same colour and brightness as the planet Saturn.

Telescopic observers will find the rapidly changing phases of Mercury of interest. The planet appears to zip from gibbous to crescent phase in about three weeks during each of its elongations. In the table below data concerning the six greatest elongations of Mercury during 1983 are presented.

GREATEST ELONGATIONS OF MERCURY IN 1983

Date, UT	Elongation	Magnitude	Apparent Diameter
Feb 8	26° W	+0.2	6″.8
Apr 21	20 E	+0.3	7.7
Jun 8	24 W	+0.7	8.2
Aug 19	27 E	+0.5	7.2
Oct 1	18 W	-0.2	7.1
Dec 13	21 E	-0.2	6.5

MERCURY
TELESCOPIC OBSERVING DATA FOR
FAVOURABLE EASTERN (EVENING) ELONGATION 1983

Date 0h UT	Magnitude	Apparent Diameter	% of Disk Illuminated	Distance From Sun	RA	Dec
Apr 10	-0.9	5″.9	78	15°	2^h06^m	+14°09′
Apr 14	-0.5	6.4	64	18	2 32	17 02
Apr 18	0.0	7.1	50	19	2 54	19 15
Apr 22	+0.5	7.9	36	20	3 12	20 45
Apr 26	+1.0	8.8	25	19	3 24	21 31
Apr 30	+1.5	9.8	15	16	3 30	21 34

Mercury's phases have been glimpsed with telescopes of 75 mm aperture or less, but generally a 100 mm or larger telescope is required to distinguish them. In larger instruments under conditions of excellent seeing (usually when Mercury is viewed in the daytime) dusky features have been glimpsed by experienced observers. Recent analysis has shown only a fair correlation between these visually observed features and the surface of the planet as photographed by Mariner 10.

VENUS

Venus is the only planet in the solar system that closely resembles Earth in size and mass. It also comes nearer to the Earth than any other planet, at times approaching as close as 41 million km. Despite the fundamental similarity, Earth and Venus differ greatly according to findings of recent spacecraft missions to the planet.

We now know that Venus is infernally hot over its entire surface, ranging little from a mean of +455°C. The high temperature is due to the dense carbon dioxide atmosphere of Venus which, when combined with small quantities of water vapour and other gases known to be present, has the special property of allowing sunlight to penetrate to the planet's surface but not permitting the resulting heat to escape. In much the same way as the glass cover of a greenhouse keeps plants warm, an atmosphere of carbon dioxide can heat up a planetary surface to a higher temperature than would be achieved by normal sunlight.

Venus' atmosphere has a surface pressure 91 times Earth's sea-level atmospheric pressure. A haze layer extends down from about 65 km above the surface to about 50 km, where a dense two- to three-km-thick cloud deck occurs. The haze continues to within about 30 km from the surface where the atmosphere clears. The Soviet Venera 9 and 10 spacecraft which landed on Venus in 1975 and photographed the planet's surface showed that sunlight similar to that received on Earth on a heavily overcast day does penetrate down to the surface. The clouds and haze that cloak the planet, consisting chiefly of droplets of sulphuric acid, are highly reflective, making Venus brilliant in the nighttime sky. However, telescopically, the planet is virtually a featureless orb.

In 1978 Soviet and American landing devices detected what appears to be evidence of periods of continuous lightning in the atmosphere and of a glow at night near Venus' surface. The source of the glow and the mechanism that produces the lightning in Venus' atmosphere are unknown. Recent findings also show that below the clouds Venus' atmosphere is remarkably uniform in temperature and pressure at all latitudes and in both day and night hemispheres. Winds at the surface range from 2 to 10 km/h.

VENUS NEAR INFERIOR CONJUNCTION 1983

Date 0h UT	Magnitude	Apparent Diameter	% of Disk Illuminated	Distance From Sun	RA	Dec
May 31	-3.8	20″.0	58	45° E	$7^h 43^m$	23° 56′
Jun 20	-4.0	24.8	47	45	9 06	18 32
Jul 5	-4.1	30.2	38	44	9 55	13 13
Jul 15	-4.2	35.1	30	41	10 19	9 35
Jul 25	-4.2	41.1	22	36	10 34	6 14
Jul 30	-4.1	45.7	17	33	10 37	4 49
Aug 4	-4.0	48.2	13	29	10 37	3 40
Aug 9	-3.9	51.5	8.7	24	10 34	2 51
Aug 14	-3.7	54.9	4.9	18	10 27	2 27
Aug 19	-3.4	57.3	2.4	12	10 17	2 30
Aug 24	-3.2	58.4	1.2	8 E	10 05	3 00
Aug 29	-3.3	58.1	1.7	10 W	9 53	3 50
Sep 3	-3.6	56.6	3.7	16	9 43	4 53
Sep 8	-3.8	54.0	7.0	22	9 36	5 58
Sep 18	-4.2	46.9	16	32	9 34	7 44
Oct 3	-4.3	37.4	29	41	9 57	8 31
Oct 18	-4.2	30.3	40	45	10 40	6 54
Nov 7	-4.0	23.9	52	47	11 52	1 43

Based on extensive radar data returned from the Pioneer Orbiter, nearly the entire planet has been mapped. Sixty percent of Venus' surface is relatively flat, rolling plains varying in height by only about 1 km between high and low points. Only 16 percent of the surface could be described as lowlands (perhaps comparable to ocean basis on Earth). Only eight percent is true highland, ranging to a maximum altitude of 10.6 km above the rolling plains. Venus' crust appears to be thicker than Earth's—thick enough to choke off plate tectonics. Apparently, Venus' crust is one huge tectonic plate. There is no evidence of features like Earth's midocean ridges.

Despite the differences between Venus and Earth, there is growing evidence from analysis of the Pioneer readings that about four billion years ago, Venus probably had a global ocean of water almost identical to Earth's for several hundred million years. At that time the Sun was only two-thirds of its present brightness, but as solar radiation slowly increased toward present levels, the Venus ocean was doomed. Evaporation fuelled a massive buildup of atmospheric carbon dioxide, which ultimately led to the greenhouse situation seen today.

Venus is the brightest natural celestial object in the nighttime sky apart from the Moon and whenever it is visible is readily recognized. Because its orbit is within that of the Earth, Venus is never separated from the Sun by an angle greater than 47 degrees. However, this is more than sufficient for the dazzling object to dominate the morning or evening sky.

Like Mercury, Venus exhibits phases although they are much easier to distinguish because of Venus' greater size. When it is far from us (near the other side of its orbit) we see the planet nearly fully illuminated, but because of its distance it appears small—about 10 seconds of arc in diameter. As Venus moves closer to Earth the phase decreases (we see less of the illuminated portion of the planet) but the diameter increases until it is a thin slice nearly a minute of arc in diameter. It takes Venus several months to run through from one of these extremes to the other compared to just a few weeks for Mercury.

As 1983 opens, Venus is visible very low in the west just after sunset. Within a few weeks it moves away from the Sun and to a more favourable declination, becoming a prominent evening object for the next six months. Throughout this period the planet is approaching Earth, its distance decreasing from 1.64 AU on

January 1 to 0.287 AU at inferior conjunction on August 25. The corresponding increase in apparent diameter ranges from 10″.2 on January 1 to 13″.2 on April 1, and 58″.9 at inferior conjunction. On those same dates the portion of the disk of Venus illuminated by sunlight is 97%, 81%, and 1.0% respectively. Other values for the months around inferior conjunction are given in the table.

When Venus is about a 20% crescent even rigidly-held, good quality binoculars can be used to distinguish that the planet is not spherical or a point source. A 60 mm refractor should be capable of revealing all but the gibbous and full phases of Venus. Experienced observers prefer to observe Venus during the daytime, and indeed the planet is bright enough to be seen with the unaided eye if one knows where to look.

Venus appears to most observers to be featureless no matter what type of telescope is used or what the planet's phase. However, over the past century some observers using medium or large size telescopes have reported dusky, patchy markings usually described as slightly less brilliant than the dazzling white of the rest of the planet. We now know that there are many subtle variations in the intensity of the clouds of Venus as photographed in ultraviolet by spacecraft and Earth-based telescopes. But when the ultraviolet photos are compared to drawings of the patchy markings seen by visual observers the correlation is fair at best.

When Venus is less than 10% illuminated the cusps (the points at the ends of the crescent) can sometimes be seen to extend into the night side of the planet. This is an actual observation of solar illumination being scattered by the atmosphere of Venus. When Venus is a thin sliver of a crescent the extended cusps may be seen to ring the entire planet.

MARS

Mars is the planet that has long captivated the imagination of mankind as a possible abode of life. One of the major objectives of the Viking spacecraft which landed on Mars in 1976 was the quest for Martian microorganisms. The Viking biology experiments completed the search in 1977 and, although the results are somewhat ambiguous, there is no convincing evidence of life we are familiar with.

The landscapes photographed by the Viking landers were basically desert vistas strewn with rocks ranging up to several metres wide. Judging by their texture and colour, and chemistry analysis by Viking, the rocks are fragments of lava flows. The soil composition resembles that of basaltic lavas on the Earth and Moon. About 1% of the soil is water, chemically bound in the crystal structure of the rock and soil particles. Some planetary scientists speculate that water in the form of permafrost exists a few metres below the surface. However, Viking and its predecessors have shown that water was once abundant enough on Mars to leave major structures on the planet resembling riverbeds. Analysis of high resolution Viking Orbiter photographs of these structures has led most investigators to conclude that they were likely carved during the planet's early history.

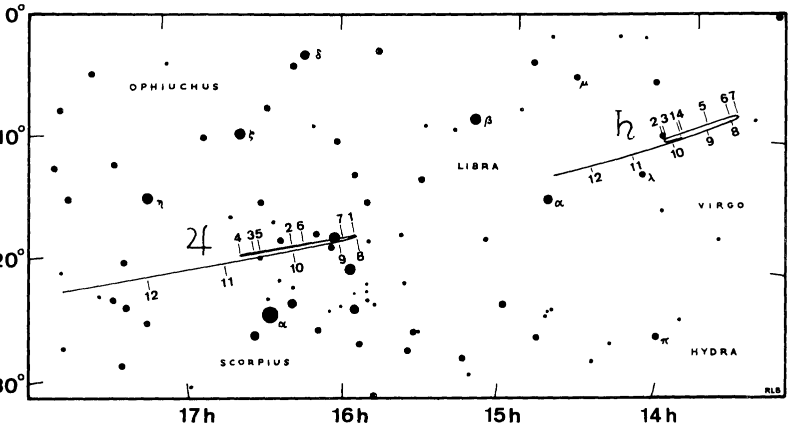
The red planet's thin atmosphere has an average surface pressure only 0.7% of Earth's and consists of 95% carbon dioxide, 2.7% nitrogen, 1.6% argon, 0.6% carbon monoxide, 0.15% oxygen and 0.03% water vapour. Winds in the Martian atmosphere reach velocities exceeding 300 km/h and in so doing raise vast amounts of dust that can envelop the planet for weeks at a time. The dust storms were thought to occur with seasonal regularity shortly after Mars passed the perihelion point of its elliptical orbit, but the Viking observations revealed more complex weather patterns.

In many ways Mars is the most interesting planet to observe with the unaided eye. It moves rapidly among the stars—its motion can usually be detected after an interval of less than a week—and it varies in brightness over a far greater range than any other planet. Mars may be distinguished by its orange-red colour, a hue that originates with rust-coloured dust that covers much of the planet.

Telescopically Mars is usually a disappointingly small featureless ochre disk except within a few months of opposition when its distance from the Earth is then near minimum. If Mars is at perihelion at these times the separation can be as little as 56 million km. Such close approaches occur at intervals of 15 to 17 years; the most recent was in 1971. At a perihelion opposition the telescopic disk of Mars is 25 seconds of arc in diameter and much detail on the planet can be distinguished with telescopes of 100 mm aperture or greater. At oppositions other than when Mars is at perihelion, the disk is correspondingly smaller.

Throughout 1983 Mars will be swinging around the far side of its orbit for Earth-bound observers and, consequently, appears relatively faint (below magnitude +1.3) and remains within 75° of the Sun. It is in Capricornus, low in the southwest evening sky at the beginning of the year. Moving through Aquarius and Pisces, it becomes lost in the solar glare by spring. (On the evening of February 18, Mars will be only half a degree north of Venus, the pair being low in the west just after sunset.) Conjunction is on June 3. Mars reappears in the morning sky in Gemini in August. Moving through Cancer and Leo, it is in Virgo at the end of the year. The right ascension of Mars at the beginning of each month is (month, h, min): J2119, F2252, M0012, A0139, M0305, J0436, J0605, A0735, S0858, O1013, N1124, D1229, J1334. These figures can be used in conjunction with the star charts in the back of this book to locate the approximate position of Mars at any time during the year (Its path lies near the ecliptic.).

This year is very unfavourable for observing the red planet. The diameter of Mars varies from 4″.6 to 3″.7 and back to only 5″.8 at the end of the year, its angular surface area remaining less than 16% of its value at the unfavourable opposition of 1982. However, the next opposition (1984) will be better than any since 1973, with Mars attaining an apparent diameter of 17″.6.



The paths of Jupiter and Saturn during 1983. Their positions are marked for the first day of each month, where 1 = January, 2 = February, etc. Jupiter is at opposition on May 27 at magnitude −2.1. Saturn is at opposition on April 21 at magnitude +0.4. The path of Uranus (see page 99) is north of Antares and just below Jupiter's path, while that of Neptune (see page 101) is east of Jupiter's, at the left edge of the chart. (To avoid clutter, the paths of Uranus and Neptune are not shown on the chart.) On February 17 and again on May 16 Jupiter passes 0.8° north of Uranus. On September 24 Jupiter passes only 0.4° north of Uranus.

JUPITER

Jupiter, the solar system's largest planet, is a colossal ball of hydrogen and helium without any solid surface comparable to land masses on Earth. In many respects Jupiter is more like a star than a planet. Jupiter likely has a small rocky core encased in a thick mantle of metallic hydrogen which is enveloped by a massive atmospheric cloak topped by a quilt of multi-coloured clouds.

The windswept visible surface of Jupiter is constantly changing. Vast dark belts merge with one another or sometimes fade to insignificance. Brighter zones—actually smeared bands of ammonia clouds—vary in intensity and frequently are carved up with dark rifts or loops called festoons. The equatorial region of Jupiter's clouds rotates five minutes faster than the rest of the planet: 9 hours 50 minutes compared to 9 hours 55 minutes. This means constant interaction as one region slips by the other at about 400 km/h. It also means that there are basically two rotational systems from the viewpoint of week-to-week telescopic observation.

In the table below the two quantities L(1) and Δ can be used to calculate the longitude of the central meridian of the illuminated disk of Jupiter. System I is the most rapidly rotating region between the middle of the North Equatorial Belt and the middle of the South Equatorial Belt. System II applies to the rest of the planet. For a given date and time (U.T.) of observation, the central meridian longitude is equal to L(1) for the month in question plus Δ times the number of complete days elapsed since 0 h U.T. on the first of the month plus either 36.58° (for system I) or 36.26° (for system II) times the number of hours elapsed since 0 h U.T. The result will usually exceed 360°; if so, divide the result by 360 and then multiply the decimal portion of the quotient by 360°. This procedure, which is accurate to 1°, is readily computed using a modest calculator.

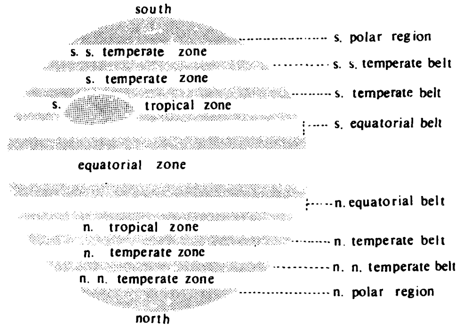
Jupiter's rapid rotation also makes the great globe markedly oval so that it appears about 7% "squashed" at the poles. Jupiter's apparent equatorial diameter ranges from 45″ at opposition on May 27 to a minimum of 31″ at conjunction on December 14.

JUPITER: EPHEMERIS FOR PHYSICAL OBSERVATIONS 1983

Date U.T.	Vis. Mag.	App. Equat. Diam.	System I		System II	
			L(1)	Δ	L(1)	Δ
Jan 1.0	-1.3	32″.2	133°.6	157°.80	328°.6	150°.17
Feb 1.0	-1.5	34.4	345.3	157.87	303.8	150.23
Mar 1.0	-1.7	37.3	85.6	157.94	190.4	150.31
Apr 1.0	-1.9	41.0	301.7	158.01	170.0	150.38
May 1.0	-2.0	44.2	1.9	158.03	1.3	150.40
Jun 1.0	-2.1	45.4	221.0	157.98	343.8	150.35
Jul 1.0	-2.0	43.8	280.3	157.87	174.2	150.24
Aug 1.0	-1.9	40.5	134.3	157.77	151.7	150.14
Sep 1.0	-1.7	37.0	345.1	157.70	126.0	150.07
Oct 1.0	-1.5	34.2	36.1	157.67	308.1	150.04
Nov 1.0	-1.4	32.3	243.7	157.66	279.2	150.03
Dec 1.0	-1.3	31.4	293.5	157.68	100.1	150.05
Jan 1.0	-1.3	31.6				

JUPITER'S BELTS AND ZONES

Viewed through a telescope of 150 mm aperture or greater, Jupiter exhibits a variety of changing detail and colour in its cloudy atmosphere. Some features are of long duration, others are short-lived. The standard nomenclature of the belts and zones is given in the figure.



The Great Red Spot, a towering vortex whose colour may possibly be due to organic-like compounds that are constantly spewed from some heated atmospheric source below, is a conspicuous and longest-lived structure on the visible surface of Jupiter. The spot and the changing cloud structures can be easily observed in small telescopes because the apparent size of the visible surface of Jupiter is far greater than that of any other planet. Occasionally (as in 1981 and 1982) the Red Spot loses its prominence, becoming difficult to detect in smaller telescopes, only to return to its normal state a year or two later.

Two Voyager spacecraft swung through the Jovian system in 1979 and transmitted to Earth superbly detailed photographs of the planet and its five inner moons. Among the most surprising finds was a ring of dust-size particles around the giant planet's equator. The ring apparently extends from the Jovian clouds out to 59 000 km.

The smallest of telescopes will reveal Jupiter's four large moons, each of which is equal to or larger than Earth's satellite. The moons provide a never-ending fascination for amateur astronomers. Sometimes the satellites are paired on either side of the belted planet; frequently one is missing—either behind Jupiter or in the planet's shadow. Even more interesting are the occasions when one of the moons casts its shadow on the disk of the planet. The tiny black shadow of one of the moons can be particularly evident if it is cast on one of the bright zones of Jupiter. According to some observers this phenomenon is evident in a good 60 mm refractor. Both the satellite positions and the times of their interaction with the Jovian disk are given elsewhere in the HANDBOOK. Jupiter's other satellites are photographic objects for large instruments.

As 1983 opens, Jupiter, in Libra, is the most prominent object in the morning sky. By March it becomes visible in the late evening sky and is ideally placed for telescopic viewing for the next six months. Despite the fact that it is five times Earth's distance from the Sun, Jupiter's giant size and reflective clouds make it a celestial beacon which is unmistakable, particularly around opposition.

Opposition this year occurs on May 27, when the giant planet is 649 million km (4.34 A.U.) from Earth. Minimum possible distance between the two planets is 590 million km.

SATURN

Saturn is the telescopic showpiece of the night sky. The chilling beauty of the small pale orb floating in a field of velvet is something no photographs or descriptions can adequately duplicate. According to recent Voyager spacecraft findings, the rings consist of billions of particles that range in size from microscopic specks to flying mountains kilometres across. The reason "rings" is plural and not singular is that gaps and brightness differences define hundreds of distinct rings. However, from Earth only the three most prominent components—known simply as rings A, B, and C—can be distinguished. (See the diagram on p. 98.)

The outer ring A has an external diameter of 273 000 km and is 15 000 km wide. Separating ring A from the 26 000-km-wide ring B is a 4000 km gap known as Cassini's Division. The gap was discovered in 1675 and is visible when the ring system is well inclined to our view from Earth in good-quality telescopes of 60 mm aperture. The Voyager spacecraft revealed Cassini's Division as a region less densely populated with ring particles than adjacent rings A and B. Ring B, the brightest, overpowers ring C to such an extent that ring C is seen only with difficulty in small telescopes. Ring C, also known as the crepe ring, extends 17 000 km toward Saturn from the inner edge of ring B. Other ring structures beyond these three are not visible in amateur telescopes.

In addition to the rings, Saturn has a family of at least twenty satellites. Titan, the largest, is easily seen in any telescope as an eighth-magnitude object orbiting Saturn in about 16 days. At east and west elongation Titan appears about five ring diameters from the planet. Titan is the only satellite in the solar system with a substantial atmosphere, now known to be primarily nitrogen and 4.6 times as massive as Earth's, with a surface pressure of 1.6 Earth atmospheres.

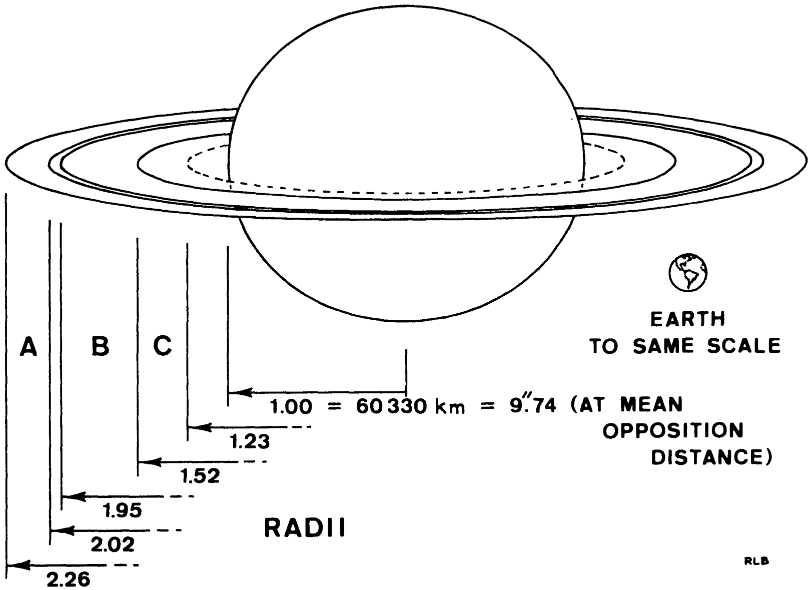
Telescopes over 60 mm aperture should reveal Rhea at 10th magnitude less than two ring-diameters from Saturn. The satellite Iapetus has the peculiar property of being five times brighter at western elongation ($10^{m}.1$) than at eastern elongation ($11^{m}.9$). One side of the moon has the reflectivity of snow while the other resembles dark rock. The reason for this is unknown. When brightest, Iapetus is located about 12 ring-diameters west of its parent planet. Of the remaining moons Tethys and Dione may be glimpsed in a 150 mm telescope but the others require larger apertures or photographic techniques. (See page 115 for an ephemeris for the five brightest satellites of Saturn.)

The disk of Saturn appears about 1/6 the size Jupiter appears through the same telescope with the same magnification. In telescopes less than 100 mm aperture probably no features will ever be seen on the surface of the planet other than the shadow cast by the rings. As the size of the telescope is increased the pale equatorial region and the darker polar regions become evident. Basically, Saturn has a belt system like Jupiter's but it is much less active and the contrast is reduced. Seldom in telescopes less than 200 mm aperture do more than one or two belts come into view. In 1980, the planet's rotation period was established at 10 hours, 40 minutes, four per cent longer than previous estimates. Very rarely a spot among the Saturnian clouds will appear unexpectedly, but less than a dozen notable spots have been recorded since telescopic observation of Saturn commenced in the 17th century.

From year to year the rings of Saturn take on different appearances. The planet's orbit is an immense 29.5 year circuit about the sun, so in the course of an observing season the planet moves relatively little in its orbit (and thus appears to remain in about the same general area of the sky) and maintains an essentially static orientation toward Earth. In 1973 the rings were presented to their fullest extent (27°) as viewed from Earth, with the southern face being visible. In apparent width the rings are equal to the equatorial diameter of Jupiter.

SATURN

MAIN RING FEATURES VISIBLE FROM EARTH



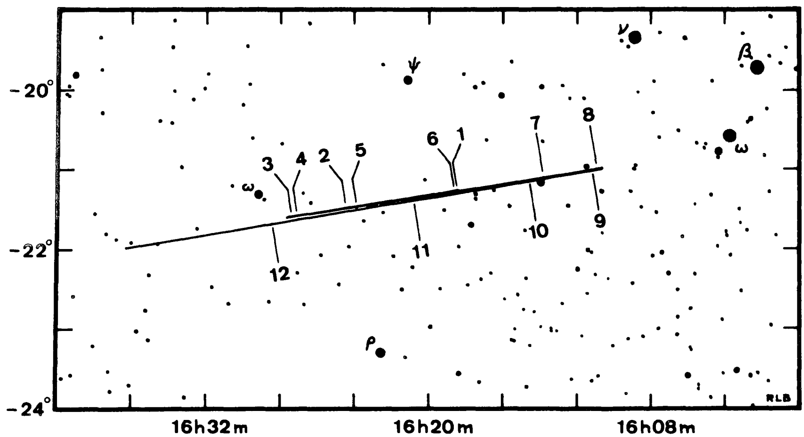
P As 1983 opens, the rings are tilted 16.7° with respect to Earth, with the northern face being visible. The tilt remains near this value until April when it decreases slightly, reaching 14.6° in June. From then until October, when Saturn is too close to the Sun for observation, the ring inclination slowly increases to near 17°. By December 31, when Saturn is visible in the morning sky, the rings have opened to 20.4°.

Saturn is in Virgo and rises about 2 a.m. as 1983 begins. Opposition is on April 21, when the planet is 1.31 billion km (8.77 AU) from Earth. At that time Saturn is 19″.0 in equatorial diameter and the rings are 42″.8 in width. By the end of 1983, Saturn has slipped into Libra, where it will remain for most of the following two years.

URANUS

Although Uranus can be seen with the unaided eye under a clear, dark sky it was apparently unknown until 1781 when it was accidentally discovered by William Herschel with a 150 mm reflecting telescope. It can be easily seen with binoculars, and a telescope will reveal its small, greenish, featureless disk.

Jupiter, Saturn, Uranus and Neptune are rather similar in the sense that their interiors consist mainly of hydrogen and helium and their atmospheres consist of these same elements and simple compounds of hydrogen. Unlike the three other giant planets, the axis of Uranus is tipped almost parallel to the plane of the solar system. This means that we can view Uranus nearly pole-on at certain points in its 84 year orbit of the Sun. The northern hemisphere of Uranus is now directed toward the Earth and we will be viewing the planet almost exactly toward its north pole in 1985. Uranus has five satellites, all smaller than Earth's moon, none of which can be detected in small or moderate sized telescopes.



The path of Uranus at the Ophiuchus-Scorpius border, 1983. Its position is marked for the first day of each month, where 1 = January, 2 = February, etc. The faintest stars shown are of magnitude 9. The magnitude of Uranus is about 6. The coordinates are for 1950.

The 1977 discovery of at least five rings encircling Uranus is regarded as one of the major planetary finds in recent years. Their detection emerged during a relatively routine occultation observation from an airborne observatory—an experiment initially intended to provide a more accurate measure of the diameter of Uranus. Refinement of the observations and results from another occultation in 1978 indicates there is evidence for eight (possibly nine) rings relatively evenly spaced from 16 000 to 24 000 km above the cloudy surface of Uranus. The outer ring is about 100 km wide but curiously eccentric. The others are estimated to be between 5 and 10 km across.

These dimensions are markedly different from Saturn's three major rings, each of which is thousands of kilometres wide. The rings are not as dense as Saturn's major ring since the occulted star did not completely disappear during passage behind them. Also, the albedo of the individual particles is believed to be low suggesting a dark substance compared to Saturn's brilliantly reflective ring material. The Uranian rings are invisible by direct visual observation because of their small dimensions and the enormous distance that separates us from Uranus.

Estimates of Uranus' diameter made over the last half century range from 46 000 to 56 000 km depending on the technique employed. Some recent work supports the high end of this range. If this proves to be correct then Uranus, like Saturn, has an average density less than that of water. The long-quoted rotation period of Uranus (about 11 hours) has come into question recently and may be in error by a factor of at least 2, since several recent studies have yielded values in the 12 to 24 hour range. Uranus' nearly pole-on aspect in recent years is the primary impediment to obtaining an accurate value for the planet's spin.

Uranus is near the Scorpius/Ophiuchus border during 1983, close to Omega Ophiuchi. Opposition is on May 29, when the planet is 2.68 billion km (17.93 AU) from Earth. At this time its magnitude is +5.8 and its apparent diameter is 3.8 seconds of arc.

NEPTUNE

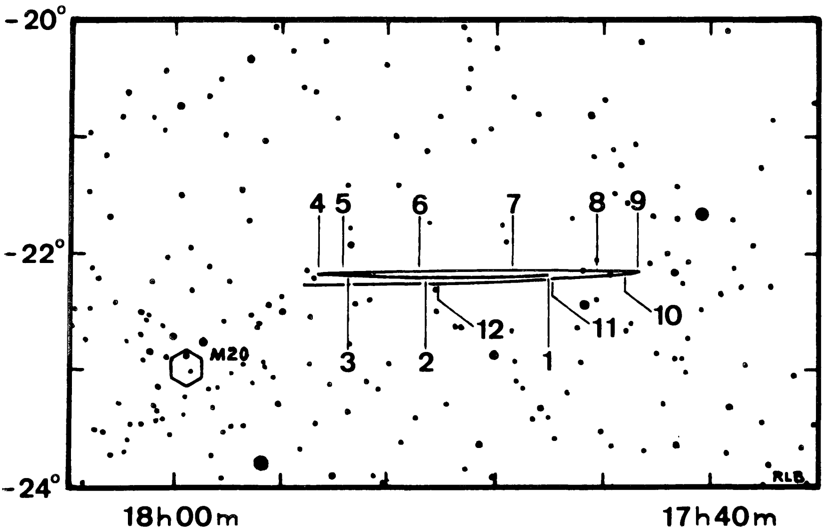
The discovery of Neptune in 1846, after its existence in the sky had been predicted from independent calculations by Leverrier in France and Adams in England, was regarded as the crowning achievement of Newton's theory of universal gravitation. Actually Neptune had been seen—but mistaken for a star—several times before its "discovery".

Telescopically the planet appears as a 2.5 second of arc, featureless, bluish-green disk. Neptune's large moon Triton can be seen by an experienced observer using a 300 mm telescope. Recent measurements using NASA's Infrared Facility on Mauna Kea (Hawaii) show Triton and Pluto to have many common characteristics. Triton is likely smaller than Earth's moon, thus effectively eliminating the possibility that Triton is the largest moon in the solar system. Triton varies from 8 to 17 seconds of arc from Neptune during its 5.9 day orbit. A third moon of Neptune was tentatively identified in 1981. This object will probably prove to be one of a large number of smaller as-yet-undetected bodies in orbit around the planet.

Since the discovery of Uranus' rings in 1977, numerous searches for a Neptunian ring system have failed to reveal one. However, recent analysis of decade-old records of an occultation by Neptune suggests there may indeed be a tenuous ring about 3000 to 7000 km above the planet's equator. Other occultation records are being scanned to confirm the suspected dimming of starlight near Neptune. Neptune's diameter was determined with high precision from occultation observations in 1969.

Uncertainties in the rotation period of Neptune may have narrowed in 1981 with the results from over 300 infrared observations of the planet made with a 1.3-metre telescope at Kitt Peak. Astronomers Michael Belton, Lloyd Wallace and Sethanne Howard conclude that Neptune's rotation period is 18.2 hours, with an uncertainty of plus or minus 24 minutes.

In 1983 Neptune is buried in the Milky Way in western Sagittarius and is not well placed for northern observers. At opposition on June 19 Neptune is magnitude +7.7 and 4.38 billion km (29.25 AU) distant from Earth.



The path of Neptune in western Sagittarius, 1983. Its position is marked for the first day of each month, where 1 = January, 2 = February, etc. The faintest stars shown are of 9th magnitude, somewhat dimmer than 7.7 magnitude Neptune. The bright (5th magnitude) star northwest of the path is 58 Ophiuchi. Southeast of the path is the Trifid Nebula (M20). The coordinates are for 1950.

PLUTO

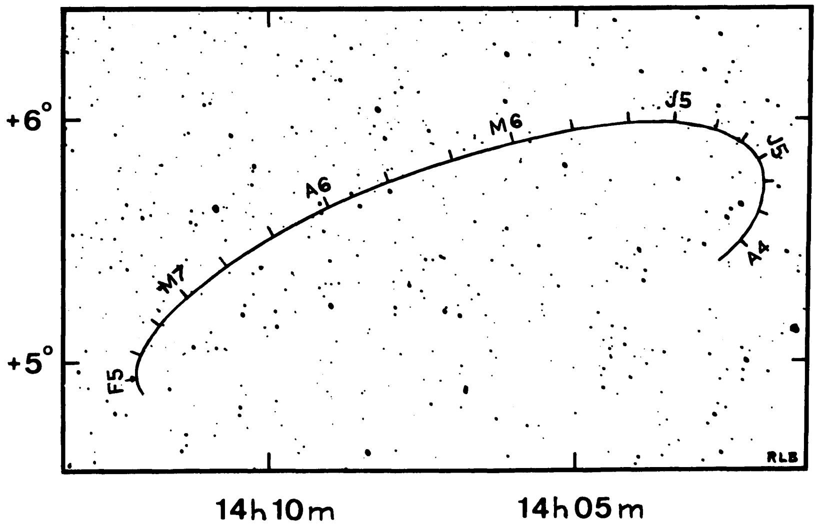
Pluto, the most distant known planet, was discovered at the Lowell Observatory in 1930 as a result of an extensive search started two decades earlier by Percival Lowell. The faint star-like image was first detected by Clyde Tombaugh by comparing photographs taken on different dates.

The most important advance in our knowledge of Pluto since its discovery came in 1978 as a result of routine examinations of photographs of the planet taken at the U.S. Naval Observatory, Flagstaff, Arizona. James W. Christy detected an elongation of Pluto's image on some of the photos which has been confirmed as a large satellite revolving once every 6.3867 days—identical to the planet's rotation period. This means that the moon is visible only from one hemisphere of Pluto. Calculations made some years ago suggest that this is the only stable orbit a satellite could have with Pluto's slow rotation rate. The moon too would likely have one side constantly turned to Pluto. The name Charon has been proposed for the new-found object.

Recent speckle-interferometry observations by D. Bonneau and R. Foy using the Canada-France-Hawaii Telescope reveal Pluto and Charon as a unique double planet, 4000 and 2000 km in diameter respectively, orbiting 22 000 km apart. This amounts to an apparent separation of 1.02 seconds of arc at Pluto's present distance. The derived mass for Pluto is one-quarter the mass of Earth's moon. Charon is about one-tenth as massive. The albedo of both objects is about 20%. These values yield a density of 0.5 that of water, definitely indicating Pluto and Charon are fluffy balls of ice, most likely water, methane, and ammonia. This conclusion is supported by recent observations of a tenuous methane atmosphere on Pluto. However, since Pluto's surface gravity is too feeble to retain a primordial methane atmosphere it is possible that as the planet nears perihelion, the Sun is evaporating its frosty surface.

Besides being the solar system's smallest planet, Pluto is different from the other eight in almost every respect. Its unique characteristics include its orbit which is relatively higher inclined and so elliptical that the planet will be closer to the Sun than Neptune from 1980 to 1999. Just where such a freak fits into the solar system's origin and evolution is unknown. Perhaps Pluto is the largest member of a group of small, icy, comet-like structures beyond Neptune.

At opposition on April 18, Pluto's astrometric position is R.A. (1950) $14^h\ 07^m.8$, Dec. (1950) $+5°\ 46'$ and its distance from Earth will be 4.33 billion km (28.93 A.U.). With an apparent magnitude of +13.7, Pluto is a difficult target in moderate-sized amateur telescopes.



P *The path of Pluto in eastern Virgo, 1983. Its position is marked at 10-day intervals, beginning at February 5 (F5). The faintest stars shown are of magnitude 14. The bright star at the right edge of the chart is of 6th magnitude and lies about 3.4 degrees north of the star τ Virginis. Pluto reaches opposition on April 18 at magnitude 13.7. The chart is based on Vehrenberg's* Atlas Stellarum *(1950.0).*

PRONUNCIATION OF PLANET NAMES

Mercury	mûr'kyoo-rē
Venus	vē'nŭs
Earth	ûrth
Mars	mȧrs
Jupiter	jo͞o'pĭ-tẽr
Saturn	sȧt'ûrn
Uranus	yoor'ȧ-nŭs
Neptune	nĕp'to͞on
Pluto	plo͞o'tō

PRONUNCIATION OF SATELLITE NAMES

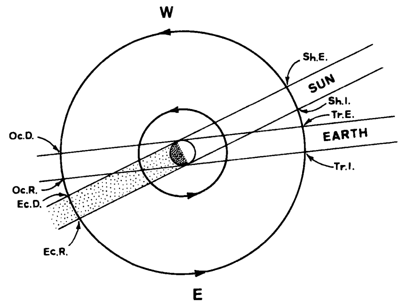
Adrastea	ȧ-drăs'tē-ȧ	Europa	yoo-rō'pȧ	Nereid	nẽr'ē-ĭd
Amalthea	ăm''l-thē'ȧ	Ganymede	găn'ĕ-mēd'	Oberon	ō'bȧ-rŏn'
Ananke	ȧ'năn-kē	Himalia	hĭm'ȧ-lĭ-ȧ	Pasiphae	pȧ-sĭf'ȧ ē'
Ariel	âr'ē-ĕl	Hyperion	hī-pẽr'ĭ-ĕn	Phobos	fō'bŏs
Callisto	kȧ-lĭs'tō	Iapetus	ī-ăp'ŭ-tŭs	Phoebe	fē'bē
Carme	kȧr'mē	Io	ī'ō	Rhea	rē'ȧ
Charon	kâr'ĕn	Leda	lē'dȧ	Sinope	sĭ-nō'pē
Deimos	dī'mŏs	Lysithea	lĭs'ĭ-thē'-ȧ	Tethys	tē'thĭs
Dione	dī-ŏ'nē	Mimas	mī'măs	Titan	tī't'n
Elara	ē'lȧr-ȧ	Miranda	mĭ-răn'dȧ	Titania	tī-tā'nē-ȧ
Enceladus	ĕn-sĕl'ȧ-dŭs	Moon	mo͞on	Triton	trī't'n
				Umbriel	ŭm'brē-ĕl'

ā dāte; ă tăp; â câre; ȧ ȧsk; ē wē; ĕ mĕt; ẽ makẽr; ī īce; ĭ bĭt; ō gō; ŏ hŏt; ô ôrb; oo book; o͞o mo͞on; ū ūnite; ŭ ŭp; û ûrn.

PHENOMENA OF THE GALILEAN SATELLITES

The following tables give the various transits, occultations, and eclipses of the four great satellites of Jupiter. All such phenomena are given except when Jupiter is within a few weeks of conjunction (December 14 in 1983). Since the phenomena are not instantaneous but require up to several minutes, the predicted times are for the middle of each event. The abbreviations are: I = Io, II = Europa, III = Ganymede, IV = Callisto; Ec = eclipse, Oc = occultation, Tr = transit of the satellite, Sh = transit of the shadow, I = ingress, E = egress, D = disappearance, R = reappearance.

The general motions of the satellites, and the successive phenomena are shown in the diagram at right. Satellites move from east to west across the face of the planet, and from west to east behind it. Before opposition, shadows fall to the west, and after opposition, to the east (as in the diagram). The sequence of phenomena in the diagram, beginning at the lower right, is: transit ingress (Tr.I.), transit egress (Tr.E.), shadow ingress (Sh.I.), shadow egress (Sh.E.), occultation disappearance (Oc.D.), occultation reappearance (Oc.R.), eclipse disappearance (Ec.D.) and eclipse reappearance (Ec.R.), but this sequence will depend on the actual Sun-Jupiter-Earth angle.



Over half the phenomena listed will not be visible from any one locality because they occur when Jupiter is below the horizon or when daylight interferes. To determine which phenomena are visible from a given locality (latitude ϕ) on a certain date, note the local time that Jupiter transits and its declination δ (see The Sky Month By Month section). Jupiter will be above the horizon for a time of $(1/15)\cos^{-1}(-\tan\phi\tan\delta)$ hours on either side of the time of transit. A second time interval corresponding to nighttime can be determined from the Twilight table. The region of overlap of these two time intervals will correspond to Jupiter being both above the horizon and in a dark sky. Those phenomena in the table which fall within this time "window" will be visible.

In practice, the observer usually knows when Jupiter will be conveniently placed in the night sky, and the table can simply be scanned to select those events which occur near these times. For example, an active observer in Victoria, British Columbia, on June 6 would know that Jupiter is well placed in the late evening sky. If he planned to observe from 10 pm to 2 am PDT (7 h behind UT), he could scan the table for events in the interval June 7, 5 h to 9 h UT. He would find two events, at 1019 and 0134 PDT, both involving the satellite Ganymede.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JANUARY

d	h	m	Phenomenon
0	2	45	I. Ec.D.
	5	41	I. Oc.R.
	15	09	III. Ec.D.
	17	20	III. Ec.R.
	18	14	III. Oc.D.
	20	30	III. Oc.R.
	23	53	I. Sh.I.
1	0	39	I. Tr.I.
	2	03	I. Sh.E.
	2	49	I. Tr.E.
	11	26	II. Sh.I.
	12	59	II. Tr.I.
	13	46	II. Sh.E.
	15	20	II. Tr.E.
	21	14	I. Ec.D.
2	0	11	I. Oc.R.
	18	22	I. Sh.I.
	19	09	I. Tr.I.
	20	31	I. Sh.E.
	21	19	I. Tr.E.
3	5	32	II. Ec.D.
	9	32	II. Oc.R.
	15	42	I. Ec.D.
	18	41	I. Oc.R.
4	5	08	III. Sh.I.
	7	18	III. Sh.E.
	8	26	III. Tr.I.
	10	39	III. Tr.E.
	12	50	I. Sh.I.
	13	39	I. Tr.I.
	15	00	I. Sh.E.
	15	49	I. Tr.E.
5	0	43	II. Sh.I.
	2	22	II. Tr.I.
	3	03	II. Sh.E.
	4	43	II. Tr.E.
	10	11	I. Ec.D.
	13	11	I. Oc.R.
6	7	19	I. Sh.I.
	8	09	I. Tr.I.
	9	28	I. Sh.E.
	10	19	I. Tr.E.
	18	50	II. Ec.D.
	22	56	II. Oc.R.
7	4	39	I. Ec.D.
	7	40	I. Oc.R.
	19	07	III. Ec.D.
	21	18	III. Ec.R.
	22	36	III. Oc.D.
8	0	50	III. Oc.R.
8	1	47	I. Sh.I.
	2	39	I. Tr.I.
	3	56	I. Sh.E.
	4	48	I. Tr.E.
	14	00	II. Sh.I.
	15	45	II. Tr.I.
	16	20	II. Sh.E.
	18	05	II. Tr.E.
	23	07	I. Ec.D.
9	2	10	I. Oc.R.
	20	15	I. Sh.I.
	21	08	I. Tr.I.
	22	25	I. Sh.E.
	23	18	I. Tr.E.
10	8	07	II. Ec.D.
	12	18	II. Oc.R.
	17	36	I. Ec.D.
	20	40	I. Oc.R.
11	9	06	III. Sh.I.
	11	16	III. Sh.E.
	12	47	III. Tr.I.
	14	44	I. Sh.I.
	14	59	III. Tr.E.
	15	38	I. Tr.I.
	16	53	I. Sh.E.
	17	48	I. Tr.E.
12	3	17	II. Sh.I.
	5	07	II. Tr.I.
	5	37	II. Sh.E.
	7	27	II. Tr.E.
	12	04	I. Ec.D.
	15	09	I. Oc.R.
13	9	12	I. Sh.I.
	10	08	I. Tr.I.
	11	21	I. Sh.E.
	12	17	I. Tr.E.
	21	25	II. Ec.D.
14	1	41	II. Oc.R.
	6	32	I. Ec.D.
	9	39	I. Oc.R.
	23	04	III. Ec.D.
15	1	16	III. Ec.R.
	2	55	III. Oc.D.
	3	41	I. Sh.I.
	4	37	I. Tr.I.
	5	09	III. Oc.R.
	5	50	I. Sh.E.
	6	47	I. Tr.E.
	16	34	II. Sh.I.
	18	29	II. Tr.I.
	18	54	II. Sh.E.
15	20	49	II. Tr.E.
16	1	01	I. Ec.D.
	4	08	I. Oc.R.
	22	09	I. Sh.I.
	23	07	I. Tr.I.
17	0	18	I. Sh.E.
	1	17	I. Tr.E.
	10	42	II. Ec.D.
	15	04	II. Oc.R.
	19	29	I. Ec.D.
	22	38	I. Oc.R.
18	13	04	III. Sh.I.
	15	14	III. Sh.E.
	16	37	I. Sh.I.
	17	05	III. Tr.I.
	17	37	I. Tr.I.
	18	47	I. Sh.E.
	19	17	III. Tr.E.
	19	46	I. Tr.E.
19	5	51	II. Sh.I.
	7	51	II. Tr.I.
	8	11	II. Sh.E.
	10	11	II. Tr.E.
	13	57	I. Ec.D.
	17	07	I. Oc.R.
20	11	06	I. Sh.I.
	12	06	I. Tr.I.
	13	15	I. Sh.E.
	14	16	I. Tr.E.
21	0	00	II. Ec.D.
	4	26	II. Oc.R.
	8	26	I. Ec.D.
	11	37	I. Oc.R.
22	3	02	III. Ec.D.
	5	14	III. Ec.R.
	5	34	I. Sh.I.
	6	36	I. Tr.I.
	7	13	III. Oc.D.
	7	43	I. Sh.E.
	8	45	I. Tr.E.
	9	26	III. Oc.R.
	19	08	II. Sh.I.
	21	12	II. Tr.I.
	21	28	II. Sh.E.
	23	32	II. Tr.E.
23	2	54	I. Ec.D.
	6	06	I. Oc.R.
24	0	03	I. Sh.I.
	1	05	I. Tr.I.
24	2	12	I. Sh.E.
	3	15	I. Tr.E.
	13	17	II. Ec.D.
	17	48	II. Oc.R.
	21	22	I. Ec.D.
25	0	36	I. Oc.R.
	17	01	III. Sh.I.
	18	31	I. Sh.I.
	19	11	III. Sh.E.
	19	35	I. Tr.I.
	20	40	I. Sh.E.
	21	21	III. Tr.I.
	21	44	I. Tr.E.
	23	32	III. Tr.E.
26	8	25	II. Sh.I.
	10	34	II. Tr.I.
	10	45	II. Sh.E.
	12	53	II. Tr.E.
	15	50	I. Ec.D.
	19	05	I. Oc.R.
27	12	59	I. Sh.I.
	14	04	I. Tr.I.
	15	08	I. Sh.E.
	16	13	I. Tr.E.
28	2	35	II. Ec.D.
	7	10	II. Oc.R.
	10	19	I. Ec.D.
	13	34	I. Oc.R.
29	6	59	III. Ec.D.
	7	28	I. Sh.I.
	8	33	I. Tr.I.
	9	12	III. Ec.R.
	9	37	I. Sh.E.
	10	43	I. Tr.E.
	11	28	III. Oc.D.
	13	40	III. Oc.R.
	21	42	II. Sh.I.
	23	54	II. Tr.I.
30	0	02	II. Sh.E.
	2	13	II. Tr.E.
	4	47	I. Ec.D.
	8	03	I. Oc.R.
31	1	56	I. Sh.I.
	3	03	I. Tr.I.
	4	05	I. Sh.E.
	5	12	I. Tr.E.
	15	52	II. Ec.D.
	20	31	II. Oc.R.
	23	15	I. Ec.D.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

FEBRUARY

d	h	m	Phenomenon
1	2	32	I. Oc.R.
	20	24	I. Sh.I.
	20	59	III. Sh.I.
	21	32	I. Tr.I.
	22	34	I. Sh.E.
	23	09	III. Sh.E.
	23	41	I. Tr.E.
2	1	35	III. Tr.I.
	3	44	III. Tr.E.
	10	59	II. Sh.I.
	13	15	II. Tr.I.
	13	19	II. Sh.E.
	15	33	II. Tr.E.
	17	44	I. Ec.D.
	21	01	I. Oc.R.
3	14	53	I. Sh.I.
	16	01	I. Tr.I.
	17	02	I. Sh.E.
	18	10	I. Tr.E.
4	5	10	II. Ec.D.
	9	52	II. Oc.R.
	12	12	I. Ec.D.
	15	31	I. Oc.R.
5	9	21	I. Sh.I.
	10	30	I. Tr.I.
	10	57	III. Ec.D.
	11	30	I. Sh.E.
	12	39	I. Tr.E.
	13	10	III. Ec.R.
	15	40	III. Oc.D.
	17	51	III. Oc.R.
6	0	16	II. Sh.I.
	2	34	II. Tr.I.
	2	35	II. Sh.E.
	4	53	II. Tr.E.
	6	40	I. Ec.D.
	10	00	I. Oc.R.
7	3	49	I. Sh.I.
	4	59	I. Tr.I.
	5	59	I. Sh.E.
	7	09	I. Tr.E.
	18	27	II. Ec.D.
	20	49	II. Ec.R.
	20	52	II. Oc.D.
	23	12	II. Oc.R.
8	1	08	I. Ec.D.
8	4	28	I. Oc.R.
	22	18	I. Sh.I.
	23	28	I. Tr.I.
9	0	27	I. Sh.E.
	0	56	III. Sh.I.
	1	38	I. Tr.E.
	3	07	III. Sh.E.
	5	45	III. Tr.I.
	7	54	III. Tr.E.
	13	33	II. Sh.I.
	15	52	II. Sh.E.
	15	54	II. Tr.I.
	18	12	II. Tr.E.
	19	37	I. Ec.D.
	22	57	I. Oc.R.
10	16	46	I. Sh.I.
	17	57	I. Tr.I.
	18	55	I. Sh.E.
	20	07	I. Tr.E.
11	7	45	II. Ec.D.
	10	07	II. Ec.R.
	10	13	II. Oc.D.
	12	33	II. Oc.R.
	14	05	I. Ec.D.
	17	26	I. Oc.R.
12	11	15	I. Sh.I.
	12	26	I. Tr.I.
	13	24	I. Sh.E.
	14	36	I. Tr.E.
	14	54	III. Ec.D.
	17	07	III. Ec.R.
	19	48	III. Oc.D.
	21	58	III. Oc.R.
13	2	49	II. Sh.I.
	5	09	II. Sh.E.
	5	13	II. Tr.I.
	7	31	II. Tr.E.
	8	33	I. Ec.D.
	11	55	I. Oc.R.
14	5	43	I. Sh.I.
	6	55	I. Tr.I.
	7	52	I. Sh.E.
	9	04	I. Tr.E.
	21	03	II. Ec.D.
	23	25	II. Ec.R.
	23	32	II. Oc.D.
15	1	53	II. Oc.R.
	3	01	I. Ec.D.
	6	24	I. Oc.R.
16	0	11	I. Sh.I.
	1	24	I. Tr.I.
	2	20	I. Sh.E.
	3	33	I. Tr.E.
	4	54	III. Sh.I.
	7	05	III. Sh.E.
	9	53	III. Tr.I.
	12	01	III. Tr.E.
	16	06	II. Sh.I.
	18	25	II. Sh.E.
	18	31	II. Tr.I.
	20	49	II. Tr.E.
	21	30	I. Ec.D.
17	0	52	I. Oc.R.
	18	40	I. Sh.I.
	19	53	I. Tr.I.
	20	49	I. Sh.E.
	22	02	I. Tr.E.
18	10	21	II. Ec.D.
	12	43	II. Ec.R.
	12	52	II. Oc.D.
	15	13	II. Oc.R.
	15	58	I. Ec.D.
	19	21	I. Oc.R.
19	13	08	I. Sh.I.
	14	22	I. Tr.I.
	15	17	I. Sh.E.
	16	31	I. Tr.E.
	18	51	III. Ec.D.
	21	04	III. Ec.R.
	23	53	III. Oc.D.
20	2	02	III. Oc.R.
	5	23	II. Sh.I.
	7	42	II. Sh.E.
	7	50	II. Tr.I.
	10	07	II. Tr.E.
	10	26	I. Ec.D.
	13	50	I. Oc.R.
21	7	36	I. Sh.I.
	8	50	I. Tr.I.
	9	46	I. Sh.E.
	10	59	I. Tr.E.
	23	38	II. Ec.D.
22	2	00	II. Ec.R.
	2	11	II. Oc.D.
	4	31	II. Oc.R.
	4	54	I. Ec.D.
	8	18	I. Oc.R.
23	2	05	I. Sh.I.
	3	19	I. Tr.I.
	4	14	I. Sh.E.
	5	28	I. Tr.E.
	8	52	III. Sh.I.
	11	03	III. Sh.E.
	13	57	III. Tr.I.
	16	04	III. Tr.E.
	18	39	II. Sh.I.
	20	59	II. Sh.E.
	21	07	II. Tr.I.
	23	22	I. Ec.D.
	23	25	II. Tr.E.
24	2	47	I. Oc.R.
	20	33	I. Sh.I.
	21	47	I. Tr.I.
	22	42	I. Sh.E.
	23	57	I. Tr.E.
25	12	56	II. Ec.D.
	15	18	II. Ec.R.
	15	30	II. Oc.D.
	17	50	II. Oc.R.
	17	51	I. Ec.D.
	21	15	I. Oc.R.
26	15	01	I. Sh.I.
	16	16	I. Tr.I.
	17	11	I. Sh.E.
	18	25	I. Tr.E.
	22	48	III. Ec.D.
27	1	01	III. Ec.R.
	3	54	III. Oc.D.
	6	03	III. Oc.R.
	7	56	II. Sh.I.
	10	15	II. Sh. E.
	10	24	II. Tr.I.
	12	19	I. Ec.D.
	12	42	II. Tr.E.
	15	43	I. Oc.R.
28	9	30	I. Sh.I.
	10	44	I. Tr.I.
	11	39	I. Sh.E.
	12	54	I. Tr.E.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

MARCH

d	h	m	
1	2	13	II. Ec.D.
	4	35	II. Ec.R.
	4	48	II. Oc.D.
	6	47	I. Ec.D.
	7	08	II. Oc.R.
	10	11	I. Oc.R.
2	3	58	I. Sh.I.
	5	13	I. Tr.I.
	6	07	I. Sh.E.
	7	22	I. Tr.E.
	12	50	III. Sh.I.
	15	01	III. Sh.E.
	17	57	III. Tr.I.
	20	03	III. Tr.E.
	21	12	II. Sh.I.
	23	32	II. Sh.E.
	23	41	II. Tr.I.
3	1	15	I. Ec.D.
	1	58	II. Tr.E.
	4	40	I. Oc.R.
	22	26	I. Sh.I.
	23	41	I. Tr.I.
4	0	36	I. Sh.E.
	1	50	I. Tr.E.
	15	32	II. Ec.D.
	17	54	II. Ec.R.
	18	06	II. Oc.D.
	19	44	I. Ec.D.
	20	26	II. Oc.R.
	23	08	I. Oc.R.
5	16	55	I. Sh.I.
	18	10	I. Tr.I.
	19	04	I. Sh.E.
	20	19	I. Tr.E.
6	2	45	III. Ec.D.
	4	59	III. Ec.R.
	7	51	III. Oc.D.
	9	59	III. Oc.R.
	10	29	II. Sh.I.
	12	48	II. Sh.E.
	12	57	II. Tr.I.
	14	12	I. Ec.D.
	15	14	II. Tr.E.
	17	36	I. Oc.R.
7	11	23	I. Sh.I.
	12	38	I. Tr.I.
	13	32	I. Sh.E.
	14	47	I. Tr.E.
8	4	49	II. Ec.D.
	7	11	II. Ec.R.
	7	23	II. Oc.D.
	8	40	I. Ec.D.
	9	43	II. Oc.R.

d	h	m	
8	12	04	I. Oc.R.
9	5	52	I. Sh.I.
	7	06	I. Tr.I.
	8	01	I. Sh.E.
	9	15	I. Tr.E.
	16	47	III. Sh.I.
	18	59	III. Sh.E.
	21	52	III. Tr.I.
	23	45	II. Sh.I.
	23	57	III. Tr.E.
10	2	05	II. Sh.E.
	2	13	II. Tr.I.
	3	08	I. Ec.D.
	4	30	II. Tr.E.
	6	32	I. Oc.R.
11	0	20	I. Sh.I.
	1	34	I. Tr.I.
	2	29	I. Sh.E.
	3	43	I. Tr.E.
	18	07	II. Ec.D.
	20	29	II. Ec.R.
	20	40	II. Oc.D.
	21	36	I. Ec.D.
	23	00	II. Oc.R.
12	1	00	I. Oc.R.
	18	48	I. Sh.I.
	20	02	I. Tr.I.
	20	58	I. Sh.E.
	22	11	I. Tr.E.
13	6	43	III. Ec.D.
	8	57	III. Ec.R.
	11	45	III. Oc.D.
	13	02	II. Sh.I.
	13	52	III. Oc.R.
	15	21	II. Sh.E.
	15	28	II. Tr.I.
	16	05	I. Ec.D.
	17	44	II. Tr.E.
	19	28	I. Oc.R.
14	13	17	I. Sh.I.
	14	30	I. Tr.I.
	15	26	I. Sh.E.
	16	39	I. Tr.E.
15	7	25	II. Ec.D.
	9	47	II. Ec.R.
	9	56	II. Oc.D.
	10	33	I. Ec.D.
	12	15	II. Oc.R.
	13	55	I. Oc.R.
16	7	45	I. Sh.I.
	8	58	I. Tr.I.
	9	54	I. Sh.E.

d	h	m	
16	11	07	I. Tr.E.
	20	44	III. Sh.I.
	22	57	III. Sh.E.
17	1	43	III. Tr.I.
	2	18	II. Sh.I.
	3	48	III. Tr.E.
	4	38	II. Sh.E.
	4	42	II. Tr.I.
	5	01	I. Ec.D.
	6	59	II. Tr.E.
	8	23	I. Oc.R.
18	2	13	I. Sh.I.
	3	26	I. Tr.I.
	4	23	I. Sh.E.
	5	35	I. Tr.E.
	20	43	II. Ec.D.
	23	05	II. Ec.R.
	23	12	II. Oc.D.
	23	29	I. Ec.D.
19	1	31	II. Oc.R.
	2	51	I. Oc.R.
	20	42	I. Sh.I.
	21	53	I. Tr.I.
	22	51	I. Sh.E.
20	0	03	I. Tr.E.
	10	40	III. Ec.D.
	12	55	III. Ec.R.
	15	34	III. Oc.D.
	15	35	II. Sh.I.
	17	40	III. Oc.R.
	17	54	II. Sh.E.
	17	56	II. Tr.I.
	17	58	I. ECD.
	20	13	II. Tr.E.
	21	18	I. Oc.R.
21	15	10	I. Sh.I.
	16	21	I. Tr.I.
	17	20	I. Sh.E.
	18	30	I. Tr.E.
22	10	00	II. Ec.D.
	12	22	II. Ec.R.
	12	26	I. Ec.D.
	12	27	II. Oc.D.
	14	46	II. Oc.R.
	15	46	I. Oc.R.
23	9	39	I. Sh.I.
	10	49	I. Tr.I.
	11	48	I. Sh.E.
	12	58	I. Tr.E.
24	0	42	III. Sh.I.
	2	55	III. Sh.E.
	4	51	II. Sh.I.

d	h	m	
24	5	30	III. Tr.I.
	6	54	I. Ec.D.
	7	10	II. Tr.I.
	7	10	II. Sh.E.
	7	34	III. Tr.E.
	9	26	II. Tr.E.
	10	13	I. Oc.R.
25	4	07	I. Sh.I.
	5	16	I. Tr.I.
	6	16	I. Sh.E.
	7	25	I. Tr.E.
	23	19	II. Ec.D.
26	1	22	I. Ec.D.
	1	41	II. Ec.R.
	1	42	II. Oc.D.
	4	01	II. Oc.R.
	4	41	I. Oc.R.
	22	35	I. Sh.I.
	23	44	I. Tr.I.
27	0	45	I. Sh.E.
	1	53	I. Tr.E.
	14	37	III. Ec.D.
	16	53	III. Ec.R.
	18	07	II. Sh.I.
	19	18	III. Oc.D.
	19	51	I. Ec.D.
	20	23	II. Tr.I.
	20	27	II. Sh.E.
	21	24	III. Oc.R.
	22	39	II. Tr.E.
	23	08	I. Oc.R.
28	17	04	I. Sh.I.
	18	11	I. Tr.I.
	19	13	I. Sh.E.
	20	20	I. Tr.E.
29	12	36	II. Ec.D.
	14	19	I. Ec.D.
	17	14	II. Oc.R.
	17	35	I. Oc.R.
30	11	32	I. Sh.I.
	12	39	I. Tr.I.
	13	42	I. Sh.E.
	14	48	I. Tr.E.
31	4	39	III. Sh.I.
	6	53	III. Sh.E.
	7	24	II. Sh.I.
	8	47	I. Ec.D.
	9	13	III. Tr.I.
	9	35	II. Tr.I.
	9	43	II. Sh.E.
	11	15	III. Tr.E.
	11	51	II. Tr.E.
	12	02	I. Oc.R.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

APRIL

d	h	m	
1	6	00	I. Sh.I.
	7	06	I. Tr.I.
	8	10	I. Sh.E.
	9	15	I. Tr.E.
2	1	54	II. Ec.D.
	3	15	I. Ec.D.
	6	28	II. Oc.R.
	6	29	I. Oc.R.
3	0	29	I. Sh.I.
	1	33	I. Tr.I.
	2	38	I. Sh.E.
	3	42	I. Tr.E.
	18	34	III. Ec.D.
	20	40	II. Sh.I.
	20	50	III. Ec.R.
	21	43	I. Ec.D.
	22	47	II. Tr.I.
	22	58	III. Oc.D.
	23	00	II. Sh.E.
4	0	56	I. Oc.R.
	1	02	III. Oc.R.
	1	03	II. Tr.E.
	18	57	I. Sh.I.
	20	00	I. Tr.I.
	21	07	I. Sh.E.
	22	09	I. Tr.E.
5	15	12	II. Ec.D.
	16	12	I. Ec.D.
	19	23	I. Oc.R.
	19	40	II. Oc.R.
6	13	26	I. Sh.I.
	14	27	I. Tr.I.
	15	35	I. Sh.E.
	16	37	I. Tr.E.
7	8	37	III. Sh.I.
	9	56	II. Sh.I.
	10	40	I. Ec.D.
	10	51	III. Sh.E.
	11	58	II. Tr.I.
	12	16	II. Sh.E.
	12	51	III. Tr.I.
	13	50	I. Oc.R.
	14	14	II. Tr.E.
	14	53	III. Tr.E.
8	7	54	I. Sh.I.
	8	54	I. Tr.I.
	10	04	I. Sh.E.
8	11	04	I. Tr.E.
9	4	30	II. Ec.D.
	5	08	I. Ec.D.
	8	17	I. Oc.R.
	8	53	II. Oc.R.
10	2	22	I. Sh.I.
	3	21	I. Tr.I.
	4	32	I. Sh.E.
	5	31	I. Tr.E.
	22	31	III. Ec.D.
	23	13	II. Sh.I.
	23	37	I. Ec.D.
11	0	48	III. Ec.R.
	1	09	II. Tr.I.
	1	33	II. Sh.E.
	2	33	III. Oc.D.
	2	44	I. Oc.R.
	3	25	II. Tr.E.
	4	36	III. Oc.R.
	20	51	I. Sh.I.
	21	48	I. Tr.I.
	23	01	I. Sh.E.
	23	58	I. Tr.E.
12	17	48	II. Ec.D.
	18	05	I. Ec.D.
	21	11	I. Oc.R.
	22	04	II. Oc.R.
13	15	19	I. Sh.I.
	16	15	I. Tr.I.
	17	29	I. Sh.E.
	18	25	I. Tr.E.
14	12	29	II. Sh.I.
	12	33	I. Ec.D.
	12	35	III. Sh.I.
	14	19	II. Tr.I.
	14	49	II. Sh.E.
	14	50	III. Sh.E.
	15	37	I. Oc.R.
	16	24	III. Tr.I.
	16	35	II. Tr.E.
	18	26	III. Tr.E.
15	9	47	I. Sh.I.
	10	42	I. Tr.I.
	11	58	I. Sh.E.
	12	51	I. Tr.E.
16	7	01	I. Ec.D.
16	7	07	II. Ec.D.
	10	04	I. Oc.R.
	11	16	II. Oc.R.
17	4	16	I. Sh.I.
	5	09	I. Tr.I.
	6	26	I. Sh.E.
	7	18	I. Tr.E.
18	1	30	I. Ec.D.
	1	46	II. Sh.I.
	2	28	III. Ec.D.
	3	29	II. Tr.I.
	4	06	II. Sh.E.
	4	30	I. Oc.R.
	4	45	III. Ec.R.
	5	45	II. Tr.E.
	6	03	III. Oc.D.
	8	07	III. Oc.R.
	22	44	I. Sh.I.
	23	35	I. Tr.I.
19	0	54	I. Sh.E.
	1	45	I. Tr.E.
	19	58	I. Ec.D.
	20	24	II. Ec.D.
	22	57	I. Oc.R.
20	0	26	II. Oc.R.
	17	13	I. Sh.I.
	18	02	I. Tr.I.
	19	23	I. Sh.E.
	20	11	I. Tr.E.
21	14	26	I. Ec.D.
	15	02	II. Sh.I.
	16	33	III. Sh.I.
	16	38	II. Tr.I.
	17	23	II. Sh.E.
	17	23	I. Oc.R.
	18	48	III. Sh.E.
	18	54	II. Tr.E.
	19	54	III. Tr.I.
	21	55	III. Tr.E.
22	11	41	I. Sh.I.
	12	29	I. Tr.I.
	13	51	I. Sh.E.
	14	38	I. Tr.E.
23	8	54	I. Ec.D.
	9	43	II. Ec.D.
	11	50	I. Oc.R.
	13	37	II. Oc.R.
24	6	10	I. Sh.I.
	6	55	I. Tr.I.
	8	20	I. Sh.E.
	9	05	I. Tr.E.
25	3	23	I. Ec.D.
	4	19	II. Sh.I.
	5	47	II. Tr.I.
	6	16	I. Oc.R.
	6	26	III. Ec.D.
	6	39	II. Sh.E.
	8	03	II. Tr.E.
	8	43	III. Ec.R.
	9	30	III. Oc.D.
	11	33	III. Oc.R.
26	0	38	I. Sh.I.
	1	22	I. Tr.I.
	2	48	I. Sh.E.
	3	31	I. Tr.E.
	21	51	I. Ec.D.
	23	00	II. Ec.D.
27	0	42	I. Oc.R.
	2	46	II. Oc.R.
	19	07	I. Sh.I.
	19	48	I. Tr.I.
	21	17	I. Sh.E.
	21	57	I. Tr.E.
28	16	19	I. Ec.D.
	17	35	II. Sh.I.
	18	56	II. Tr.I.
	19	09	I. Oc.R.
	19	56	II. Sh.E.
	20	31	III. Sh.I.
	21	12	II. Tr. E.
	22	47	III. Sh.E.
	23	19	III. Tr.I.
29	1	20	III. Tr.E.
	13	35	I. Sh.I.
	14	14	I. Tr.I.
	15	45	I. Sh.E.
	16	24	I. Tr.E.
30	10	48	I. Ec.D.
	12	19	II. Ec.D.
	13	35	I. Oc.R.
	15	56	II. Oc.R.

P

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

MAY

d	h	m	Phenomenon
1	8	03	I. Sh.I.
	8	41	I. Tr.I.
	10	14	I. Sh.E.
	10	50	I. Tr.E.
2	5	16	I. Ec.D.
	6	52	II. Sh.I.
	8	01	I. Oc.R.
	8	04	II. Tr.I.
	9	12	II. Sh.E.
	10	20	II. Tr.E.
	10	24	III. Ec.D.
	12	42	III. Ec.R.
	12	54	III. Oc.D.
	14	57	III. Oc.R.
3	2	32	I. Sh.I.
	3	07	I. Tr.I.
	4	42	I. Sh.E.
	5	16	I. Tr.E.
	23	44	I. Ec.D.
4	1	37	II. Ec.D.
	2	27	I. Oc.R.
	5	05	II. Oc.R.
	21	00	I. Sh.I.
	21	33	I. Tr.I.
	23	11	I. Sh.E.
	23	43	I. Tr.E.
5	18	13	I. Ec.D.
	20	08	II. Sh.I.
	20	53	I. Oc.R.
	21	11	II. Tr.I.
	22	29	II. Sh.E.
	23	28	II. Tr.E.
6	0	28	III. Sh.I.
	2	40	III. Tr.I.
	2	45	III. Sh.E.
	4	42	III. Tr.E.
	15	29	I. Sh.I.
	15	59	I. Tr.I.
	17	39	I. Sh.E.
	18	09	I. Tr.E.
7	12	41	I. Ec.D.
	14	55	II. Ec.D.
	15	19	I. Oc.R.
	18	14	II. Oc.R.
8	9	57	I. Sh.I.
	10	26	I. Tr.I.
	12	08	I. Sh.E.
8	12	35	I. Tr.E.
9	7	09	I. Ec.D.
	9	25	II. Sh.I.
	9	45	I. Oc.R.
	10	19	II. Tr.I.
	11	46	II. Sh.E.
	12	35	II. Tr.E.
	14	22	III. Ec.D.
	18	18	III. Oc.R.
10	4	26	I. Sh.I.
	4	52	I. Tr.I.
	6	37	I. Sh.E.
	7	01	I. Tr.E.
11	1	38	I. Ec.D.
	4	11	I. Oc.R.
	4	13	II. Ec.D.
	7	22	II. Oc.R.
	22	54	I. Sh.I.
	23	18	I. Tr.I.
12	1	05	I. Sh.E.
	1	27	I. Tr.E.
	20	06	I. Ec.D.
	22	37	I. Oc.R.
	22	41	II. Sh.I.
	23	26	II. Tr.I.
13	1	03	II. Sh.E.
	1	43	II. Tr.E.
	4	26	III. Sh.I.
	5	59	III. Tr.I.
	6	44	III. Sh.E.
	8	01	III. Tr.E.
	17	23	I. Sh.I.
	17	44	I. Tr.I.
	19	34	I. Sh.E.
	19	53	I. Tr.E.
14	14	35	I. Ec.D.
	17	03	I. Oc.R.
	17	31	II. Ec.D.
	20	31	II. Oc.R.
15	11	51	I. Sh.I.
	12	10	I. Tr.I.
	14	02	I. Sh.E.
	14	20	I. Tr.E.
16	9	03	I. Ec.D.
	11	29	I. Oc.R.
	11	58	II. Sh.I.
16	12	33	II. Tr.I.
	14	20	II. Sh.E.
	14	50	II. Tr.E.
	18	20	III. Ec.D.
	21	36	III. Oc.R.
17	6	20	I. Sh.I.
	6	36	I. Tr.I.
	8	31	I. Sh.E.
	8	46	I. Tr.E.
18	3	31	I. Ec.D.
	5	55	I. Oc.R.
	6	49	II. Ec.D.
	9	38	II. Oc.R.
19	0	49	I. Sh.I.
	1	02	I. Tr.I.
	2	59	I. Sh.E.
	3	12	I. Tr.E.
	22	00	I. Ec.D.
20	0	21	I. Oc.R.
	1	15	II. Sh.I.
	1	40	II. Tr.I.
	3	36	II. Sh.E.
	3	57	II. Tr.E.
	8	24	III. Sh.I.
	9	16	III. Tr.I.
	10	43	III. Sh.E.
	11	19	III. Tr.E.
	19	17	I. Sh.I.
	19	28	I. Tr.I.
	21	28	I. Sh.E.
	21	38	I. Tr.E.
21	16	28	I. Ec.D.
	18	47	I. Oc.R.
	20	08	II. Ec.D.
	22	46	II. Oc.R.
22	13	46	I. Sh.I.
	13	54	I. Tr.I.
	15	57	I. Sh.E.
	16	04	I. Tr.E.
23	10	57	I. Ec.D.
	13	13	I. Oc.R.
	14	32	II. Sh.I.
	14	46	II. Tr.I.
	16	53	II. Sh.E.
	17	04	II. Tr.E.
	22	17	III. Ec.D.
24	0	53	III. Oc.R.
	8	14	I. Sh.I.
	8	20	I. Tr.I.
	10	25	I. Sh.E.
	10	30	I. Tr.E.
25	5	25	I. Ec.D.
	7	39	I. Oc.R.
	9	26	II. Ec.D.
	11	54	II. Oc.R.
26	2	43	I. Sh.I.
	2	46	I. Tr.I.
	4	54	I. Sh.E.
	4	56	I. Tr.E.
	23	54	I. Ec.D.
27	2	05	I. Oc.R.
	3	49	II. Sh.I.
	3	53	II. Tr.I.
	6	10	II. Sh.E.
	6	10	II. Tr.E.
	12	23	III. Sh.I.
	12	33	III. Tr.I.
	14	37	III. Tr.E.
	14	42	III. Sh.E.
	21	11	I. Sh.I.
	21	12	I. Tr I.
	23	22	I. Tr.E.
	23	22	I. Sh.E.
28	18	21	I. Oc.D.
	20	32	I. Ec.R.
	22	43	II. Oc.D.
29	1	07	II. Ec.R.
	15	38	I. Tr.I.
	15	40	I. Sh.I.
	17	48	I. Tr.E.
	17	51	I. Sh.E.
30	12	47	I. Oc.D.
	15	01	I. Ec.R.
	17	00	II. Tr.I.
	17	06	II. Sh.I.
	19	17	II. Tr.E.
	19	27	II. Sh.E.
31	2	03	III. Oc.D.
	4	36	III. Ec.R.
	10	04	I. Tr.I.
	10	09	I. Sh.I.
	12	14	I. Tr.E.
	12	20	I. Sh.E.

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JUNE

d	h	m	Phenomenon
1	7	13	I. Oc.D.
	9	29	I. Ec.R.
	11	51	II. Oc.D.
	14	25	II. Ec.R.
2	4	30	I. Tr.I.
	4	37	I. Sh.I.
	6	40	I. Tr.E.
	6	48	I. Sh.E.
3	1	39	I. Oc.D.
	3	58	I. Ec.R.
	6	06	II. Tr.I.
	6	23	II. Sh.I.
	8	24	II. Tr.E.
	8	45	II. Sh.E.
	15	49	III. Tr.I.
	16	22	III. Sh.I.
	17	55	III. Tr.E.
	18	41	III. Sh.E.
	22	56	I. Tr.I.
	23	06	I. Sh.I.
4	1	06	I. Tr.E.
	1	17	I. Sh.E.
	20	05	I. Oc.D.
	22	26	I. Ec.R.
5	0	59	II. Oc.D.
	3	44	II. Ec.R.
	17	22	I. Tr.I.
	17	35	I. Sh.I.
	19	32	I. Tr.E.
	19	45	I. Sh.E.
6	14	31	I. Oc.D.
	16	55	I. Ec.R.
	19	13	II. Tr.I.
	19	40	II. Sh.I.
	21	31	II. Tr.E.
	22	02	II. Sh.E.
7	5	19	III. Oc.D.
	8	34	III. Ec.R.
	11	48	I. Tr.I.
	12	03	I. Sh.I.
	13	58	I. Tr.E.
	14	14	I. Sh.E.
8	8	57	I. Oc.D.
	11	23	I. Ec.R.
	14	06	II. Oc.D.
	17	02	II. Ec.R.
9	6	14	I. Tr.I.
	6	32	I. Sh.I.
	8	24	I. Tr.E.
	8	43	I. Sh.E.
10	3	23	I. Oc.D.
	5	52	I. Ec.R.
	8	20	II. Tr.I.
	8	57	II. Sh.I.
	10	39	II. Tr.E.
	11	19	II. Sh.E.
	19	06	III. Tr.I.
	20	21	III. Sh.I.
	21	13	III. Tr.E.
	22	41	III. Sh.E.
11	0	40	I. Tr.I.
	1	00	I. Sh.I.
	2	50	I. Tr.E.
	3	11	I. Sh.E.
	21	49	I. Oc.D.
12	0	21	I. Ec.R.
	3	14	II. Oc.D.
	6	20	II. Ec.R.
	19	07	I. Tr.I.
	19	29	I. Sh.I.
	21	17	I. Tr.E.
	21	40	I. Sh.E.
13	16	15	I. Oc.D.
	18	49	I. Ec.R.
	21	28	II. Tr.I.
	22	14	II. Sh.I.
	23	46	II. Tr.E.
14	0	36	II. Sh.E.
	8	37	III. Oc.D.
	12	33	III. Ec.R.
	13	33	I. Tr.I.
	13	58	I. Sh.I.
	15	43	I. Tr.E.
	16	09	I. Sh.E.
15	10	41	I. Oc.D.
	13	18	I. Ec.R.
	16	22	II. Oc.D.
	19	38	II. Ec.R.
16	7	59	I. Tr.I.
	8	26	I. Sh.I.
	10	09	I. Tr.E.
	10	37	I. Sh.E.
17	5	07	I. Oc.D.
	7	46	I. Ec.R.
	10	35	II. Tr.I.
	11	31	II. Sh.I.
	12	54	II. Tr.E.
	13	53	II. Sh.E.
	22	24	III. Tr.I.
18	0	19	III. Sh.I.
	0	34	III. Tr.E.
	2	26	I. Tr.I.
	2	40	III. Sh.E.
	2	55	I. Sh.I.
	4	35	I. Tr.E.
	5	06	I. Sh.E.
	23	34	I. Oc.D.
19	2	15	I. Ec.R.
	5	31	II. Oc.D.
	8	57	II. Ec.R.
	20	52	I. Tr.I.
	21	24	I. Sh.I.
	23	02	I. Tr.E.
	23	35	I. Sh.E.
20	18	00	I. Oc.D.
	20	43	I. Ec.R.
	23	43	II. Tr.I.
21	0	49	II. Sh.I.
	2	03	II. Tr.E.
	3	11	II. Sh.E.
	11	57	III. Oc.D.
	14	09	III. Oc.R.
	14	11	III. Ec.D.
	15	18	I. Tr.I.
	15	52	I. Sh.I.
	16	33	III. Ec.R.
	17	28	I. Tr.E.
	18	03	I. Sh.E.
22	12	26	I. Oc.D.
	15	12	I. Ec.R.
	18	40	II. Oc.D.
	22	15	II. Ec.R.
23	9	45	I. Tr.I.
	10	21	I. Sh.I.
	11	55	I. Tr.E.
	12	32	I. Sh.E.
24	6	53	I. Oc.D.
	9	41	I. Ec.R.
24	12	52	II. Tr.I.
	14	06	II. Sh.I.
	15	11	II. Tr.E.
	16	28	II. Sh.E.
25	1	45	III. Tr.I.
	3	56	III. Tr.E.
	4	11	I. Tr.I.
	4	18	III. Sh.I.
	4	50	I. Sh.I.
	6	21	I. Tr.E.
	6	39	III. Sh.E.
	7	01	I. Sh.E.
26	1	19	I. Oc.D.
	4	09	I. Ec.R.
	7	49	II. Oc.D.
	11	34	II. Ec.R.
	22	38	I. Tr.I.
	23	19	I. Sh.I.
27	0	48	I. Tr.E.
	1	29	I. Sh.E.
	19	46	I. Oc.D.
	22	38	I. Ec.R.
28	2	00	II. Tr.I.
	3	24	II. Sh.I.
	4	20	II. Tr.E.
	5	46	II. Sh.E.
	15	19	III. Oc.D.
	17	04	I. Tr.I.
	17	34	III. Oc.R.
	17	47	I. Sh.I.
	18	10	III. Ec.D.
	19	14	I. Tr.E.
	19	58	I. Sh.E.
	20	33	III. Ec.R.
29	14	12	I. Oc.D.
	17	07	I. Ec.R.
	20	59	II. Oc.D.
30	0	52	II. Ec.R.
	11	31	I. Tr.I.
	12	16	I. Sh.I.
	13	41	I. Tr.E.
	14	27	I. Sh.E.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JULY

d	h	m	Phenomenon
1	8	39	I. Oc.D.
	11	35	I. Ec.R.
	15	10	II. Tr.I.
	16	41	II. Sh.I.
	17	30	II. Tr.E.
	19	03	II. Sh.E.
2	5	09	III. Tr.I.
	5	58	I. Tr.I.
	6	45	I. Sh.I.
	7	23	III. Tr.E.
	8	08	I. Tr.E.
	8	16	III. Sh.I.
	8	55	I. Sh.E.
	10	38	III. Sh.E.
3	3	05	I. Oc.D.
	6	04	I. Ec.R.
	10	09	II. Oc.D.
	14	10	II. Ec.R.
4	0	25	I. Tr.I.
	1	13	I. Sh.I.
	2	35	I. Tr.E.
	3	24	I. Sh.E.
	21	32	I. Oc.D.
5	0	33	I. Ec.R.
	4	19	II. Tr.I.
	5	50	II. Sh.I.
	6	40	II. Tr.E.
	8	21	II. Sh.E.
	18	46	III. Oc.D.
	18	52	I. Tr.I.
	19	42	I. Sh.I.
	21	01	I. Tr.E.
	21	02	III. Oc.R.
	21	53	I. Sh.E.
	22	09	III. Ec.D.
6	0	32	III. Ec.R.
	15	59	I. Oc.D.
	19	01	I. Ec.R.
	23	19	II. Oc.D.
7	3	28	II. Ec.R.
	13	19	I. Tr.I.
	14	11	I. Sh.I.
	15	28	I. Tr.E.
	16	21	I. Sh.E.
8	10	26	I. Oc.D.
	13	30	I. Ec.R.
	17	30	II. Tr.I.
	19	16	II. Sh.I.
	19	50	II. Tr.E.
	21	38	II. Sh.E.
9	7	45	I. Tr.I.
	8	37	III. Tr.I.
	8	40	I. Sh.I.
	9	55	I. Tr.E.
	10	50	I. Sh.E.
	10	53	III. Tr.E.
	12	15	III. Sh.I.
	14	38	III. Sh.E.
10	4	53	I. Oc.D.
	7	59	I. Ec.R.
	12	31	II. Oc.D.
	16	47	II. Ec.R.
11	2	13	I. Tr.I.
	3	08	I. Sh.I.
	4	22	I. Tr.E.
	5	19	I. Sh.E.
	23	20	I. Oc.D.
12	2	27	I. Ec.R.
	6	40	II. Tr.I.
	8	34	II. Sh.I.
	9	01	II. Tr.E.
	10	56	II. Sh.E.
	20	40	I. Tr.I.
	21	37	I. Sh.I.
	22	15	III. Oc.D.
	22	50	I. Tr.E.
	23	47	I. Sh.E.
13	0	34	III. Oc.R.
	2	07	III. Ec.D.
	4	32	III. Ec.R.
	17	47	I. Oc.D.
	20	56	I. Ec.R.
14	1	42	II. Oc.D.
	6	05	II. Ec.R.
	15	07	I. Tr.I.
	16	06	I. Sh.I.
	17	17	I. Tr.E.
	18	16	I. Sh.E.
15	12	14	I. Oc.D.
	15	25	I. Ec.R.
	19	52	II. Tr.I.
	21	52	II. Sh.I.
	22	13	II. Tr.E.
16	0	14	II. Sh.E.
	9	34	I. Tr.I.
	10	35	I. Sh.I.
	11	44	I. Tr.E.
	12	10	III. Tr.I.
	12	45	I. Sh.E.
	14	28	III. Tr.E.
16	16	15	III. Sh.I.
	18	38	III. Sh.E.
17	6	41	I. Oc.D.
	9	53	I. Ec.R.
	14	54	II. Oc.D.
	19	23	II. Ec.R.
18	4	02	I. Tr.I.
	5	03	I. Sh.I.
	6	11	I. Tr.E.
	7	14	I. Sh.E.
19	1	08	I. Oc.D.
	4	22	I. Ec.R.
	9	04	II. Tr.I.
	11	09	II. Sh.I.
	11	25	II. Tr.E.
	13	32	II. Sh.E.
	22	29	I. Tr.I.
	23	32	I. Sh.I.
20	0	39	I. Tr.E.
	1	42	I. Sh.E.
	1	49	III. Oc.D.
	4	10	III. Oc.R.
	6	06	III. Ec.D.
	8	31	III. Ec.R.
	19	36	I. Oc.D.
	22	51	I. Ec.R.
21	4	07	II. Oc.D.
	8	41	II. Ec.R.
	16	56	I. Tr.I.
	18	01	I. Sh.I.
	19	06	I. Tr.E.
	20	11	I. Sh.E.
22	14	03	I. Oc.D.
	17	20	I. Ec.R.
	22	16	II. Tr.I.
23	0	27	II. Sh.I.
	0	38	II. Tr.E.
	2	50	II. Sh.E.
	11	24	I. Tr.I.
	12	30	I. Sh.I.
	13	34	I. Tr.E.
	14	40	I. Sh.E.
	15	47	III. Tr.I.
	18	07	III. Tr.E.
	20	14	III. Sh.I.
	22	38	III. Sh.E.
24	8	31	I. Oc.D.
	11	48	I. Ec.R.
	17	20	II. Oc.D.
24	21	59	II. Ec.R.
25	5	52	I. Tr.I.
	6	58	I. Sh.I.
	8	01	I. Tr.E.
	9	08	I. Sh.E
26	2	58	I. Oc.D.
	6	17	I. Ec.R.
	11	29	II. Tr.I.
	13	45	II. Sh.I.
	13	51	II. Tr.E.
	16	08	II. Sh.E.
27	0	19	I. Tr.I.
	1	27	I. Sh.I.
	2	29	I. Tr.E.
	3	37	I. Sh.E.
	5	28	III. Oc.D.
	7	51	III. Oc.R.
	10	05	III. Ec.D.
	12	31	III. Ec.R.
	21	26	I. Oc.D.
28	0	46	I. Ec.R.
	6	34	II. Oc.D.
	11	17	II. Ec.R.
	18	47	I. Tr.I.
	19	56	I. Sh.I.
	20	57	I. Tr.E.
	22	06	I. Sh.E.
29	15	53	I. Oc.D.
	19	15	I. Ec.R.
30	0	43	II. Tr.I.
	3	03	II. Sh.I.
	3	05	II. Tr.E.
	5	26	II. Sh.E.
	13	15	I. Tr.I.
	14	25	I. Sh.I.
	15	25	I. Tr.E.
	16	35	I. Sh.E.
	19	28	III. Tr.I.
	21	50	III. Tr.E.
31	0	14	III. Sh.I.
	2	38	III. Sh.E.
	10	21	I. Oc.D.
	13	43	I. Ec.R.
	19	48	II. Oc.D.
	22	12	II. Oc.R.
	22	12	II. Ec.D.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

AUGUST

d	h	m	
1	0	36	II. Ec.R.
	7	43	I. Tr.I.
	8	53	I. Sh.I.
	9	52	I. Tr.E.
	11	03	I. Sh.E.
2	4	49	I. Oc.D.
	8	12	I. Ec.R.
	13	57	II. Tr.I.
	16	20	II. Tr.E.
	16	21	II. Sh.I.
	18	44	II. Sh.E.
3	2	11	I. Tr.I.
	3	22	I. Sh.I.
	4	20	I. Tr.E.
	5	32	I. Sh.E.
	9	11	III. Oc.D.
	11	36	III. Oc.R.
	14	04	III. Ec.D.
	16	31	III. Ec.R.
	23	17	I. Oc.D.
4	2	41	I. Ec.R.
	9	03	II. Oc.D.
	11	27	II. Oc.R.
	11	30	II. Ec.D.
	13	54	II. Ec.R.
	20	39	I. Tr.I.
	21	51	I. Sh.I.
	22	48	I. Tr.E.
5	0	01	I. Sh.E.
	17	45	I. Oc.D.
	21	10	I. Ec.R.
6	3	12	II. Tr.I.
	5	35	II. Tr.E.
	5	39	II. Sh.I.
	8	02	II. Sh.E.
	15	07	I. Tr.I.
	16	20	I. Sh.I.
	17	16	I. Tr.E.
	18	30	I. Sh.E.
	23	14	III. Tr.I.
7	1	37	III. Tr.E.
	4	13	III. Sh.I.
	6	37	III. Sh.E.
	12	13	I. Oc.D.
	15	39	I. Ec.R.
	22	18	II. Oc.D.
8	0	43	II. Oc.R.
	0	48	II. Ec.D.
	3	12	II. Ec.R.
	9	35	I. Tr.I.
	10	48	I. Sh.I.
	11	45	I. Tr.E.
	12	58	I. Sh.E.
9	6	41	I. Oc.D.
	10	07	I. Ec.R.
	16	27	II. Tr.I.
	18	50	II. Tr.E.
	18	57	II. Sh.I.
	21	20	II. Sh.E.
10	4	03	I. Tr.I.
	5	17	I. Sh.I.
	6	13	I. Tr.E.
	7	27	I. Sh.E.
	12	59	III. Oc.D.
	15	26	III. Oc.R.
	18	04	III. Ec.D.
	20	31	III. Ec.R.
11	1	09	I. Oc.D.
	4	36	I. Ec.R.
	11	34	II. Oc.D.
	13	58	II. Oc.R.
	14	06	II. Ec.D.
	16	30	II. Ec.R.
	22	31	I. Tr.I.
	23	46	I. Sh.I.
12	0	41	I. Tr.E.
	1	56	I. Sh.E.
	19	38	I. Oc.D.
	23	05	I. Ec.R.
13	5	44	II. Tr.I.
	8	07	II. Tr.E.
	8	16	II. Sh.I.
	10	38	II. Sh.E.
	17	00	I. Tr.I.
	18	15	I. Sh.I.
	19	09	I. Tr.E.
	20	25	I. Sh.E.
14	3	04	III. Tr.I.
	5	29	III. Tr.E.
	8	12	III. Sh.I.
	10	37	III. Sh.E.
	14	06	I. Oc.D.
	17	34	I. Ec.R.
15	0	50	II. Oc.D.
	3	15	II. Oc.R.
	3	24	II. Ec.D.
	5	48	II. Ec.R.
	11	28	I. Tr.I.
	12	43	I. Sh.I.
	13	38	I. Tr.E.
	14	53	I. Sh.E.
16	8	34	I. Oc.D.
	12	02	I. Ec.R.
	19	00	II. Tr.I.
	21	23	II. Tr.E.
	21	34	II. Sh.I.
16	23	57	II. Sh.E.
17	5	56	I. Tr.I.
	7	12	I. Sh.I.
	8	06	I. Tr.E.
	9	22	I. Sh.E.
	16	52	III. Oc.D.
	19	20	III. Oc.R.
	22	03	III. Ec.D.
18	0	31	III. Ec.R.
	3	03	I. Oc.D.
	6	31	I. Ec.R.
	14	07	II. Oc.D.
	16	32	II. Oc.R.
	16	42	II. Ec.D.
	19	06	II. Ec.R.
19	0	25	I. Tr.I.
	1	41	I. Sh.I.
	2	35	I. Tr.E.
	3	51	I. Sh.E.
	21	31	I. Oc.D.
20	1	00	I. Ec.R.
	8	17	II. Tr.I.
	10	41	II. Tr.E.
	10	52	II. Sh.I.
	13	15	II. Sh.E.
	18	54	I. Tr.I.
	20	10	I. Sh.I.
	21	03	I. Tr.E.
	22	20	I. Sh.E.
21	6	58	III. Tr.I.
	9	25	III. Tr.E.
	12	11	III. Sh.I.
	14	37	III. Sh.E.
	16	00	I. Oc.D.
	19	29	I. Ec.R.
22	3	25	II. Oc.D.
	5	50	II. Oc.R.
	6	00	II. Ec.D.
	8	24	II. Ec.R.
	13	22	I. Tr.I.
	14	38	I. Sh.I.
	15	32	I. Tr.E.
	16	48	I. Sh.E.
23	10	29	I. Oc.D.
	13	58	I. Ec.R.
	21	35	II. Tr.I.
	23	59	II. Tr.E.
24	0	10	II. Sh.I.
	2	33	II. Sh.E.
	7	51	I. Tr.I.
	9	07	I. Sh.I.
	10	01	I. Tr.E.
24	11	17	I. Sh.E.
	20	49	III. Oc.D.
	23	19	III. Oc.R.
25	2	03	III. Ec.D.
	4	32	III. Ec.R.
	4	57	I. Oc.D.
	8	27	I. Ec.R.
	16	42	II. Oc.D.
	19	07	II. Oc.R.
	19	18	II. Ec.D.
	21	42	II. Ec.R.
26	2	20	I. Tr.I.
	3	36	I. Sh.I.
	4	30	I. Tr.E.
	5	46	I. Sh.E.
	23	26	I. Oc.D.
27	2	55	I. Ec.R.
	10	53	II. Tr.I.
	13	17	II. Tr.E.
	13	29	II. Sh.I.
	15	52	II. Sh.E.
	20	48	I. Tr.I.
	22	05	I. Sh.I.
	22	58	I. Tr.E.
28	0	15	I. Sh.E.
	10	57	III. Tr.I.
	13	25	III. Tr.E.
	16	10	III. Sh.I.
	17	55	I. Oc.D.
	18	37	III. Sh.E.
	21	24	I. Ec.R.
29	6	01	II. Oc.D.
	8	26	II. Oc.R.
	8	36	II. Ec.D.
	11	00	II. Ec.R.
	15	17	I. Tr.I.
	16	33	I. Sh.I.
	17	27	I. Tr.E.
	18	43	I. Sh.E.
30	12	24	I. Oc.D.
	15	53	I. Ec.R.
31	0	12	II. Tr.I.
	2	36	II. Tr.E.
	2	47	II. Sh.I.
	5	10	II. Sh.E.
	9	46	I. Tr.I.
	11	02	I. Sh.I.
	11	56	I. Tr.E.
	13	12	I. Sh.E.

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SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

SEPTEMBER

d	h	m	
1	0	49	III. Oc.D.
	3	21	III. Oc.R.
	6	02	III. Ec.D.
	6	53	I. Oc.D.
	8	31	III. Ec.R.
	10	22	I. Ec.R.
	19	19	II. Oc.D.
	21	45	II. Oc.R.
	21	53	II. Ec.D.
2	0	18	II. Ec.R.
	4	15	I. Tr.I.
	5	31	I. Sh.I.
	6	25	I. Tr.E.
	7	41	I. Sh.E.
3	1	22	I. Oc.D.
	4	51	I. Ec.R.
	13	31	II. Tr.I.
	15	56	II. Tr.E.
	16	06	II. Sh.I.
	18	29	II. Sh.E.
	22	44	I. Tr.I.
4	0	00	I. Sh.I.
	0	54	I. Tr.E.
	2	10	I. Sh.E.
	15	00	III. Tr.I.
	17	30	III. Tr.E.
	19	51	I. Oc.D.
	20	10	III. Sh.I.
	22	38	III. Sh.E.
	23	20	I. Ec.R.
5	8	38	II. Oc.D.
	11	04	II. Oc.R.
	11	11	II. Ec.D.
	13	36	II. Ec.R.
	17	13	I. Tr.I.
	18	28	I. Sh.I.
	19	23	I. Tr.E.
	20	38	I. Sh.E.
6	14	20	I. Oc.D.
	17	48	I. Ec.R.
7	2	51	II. Tr.I.
	5	15	II. Tr.E.
	5	24	II. Sh.I.
	7	47	II. Sh.E.
	11	42	I. Tr.I.
	12	57	I. Sh.I.
	13	53	I. Tr.E.
	15	07	I. Sh.E.
8	4	53	III. Oc.D.
	7	26	III. Oc.R.
8	8	49	I. Oc.D.
	10	01	III. Ec.D.
	12	17	I. Ec.R.
	12	31	III. Ec.R.
	21	58	II. Oc.D.
9	0	23	II. Oc.R.
	0	29	II. Ec.D.
	2	53	II. Ec.R.
	6	12	I. Tr.I.
	7	26	I. Sh.I.
	8	22	I. Tr.E.
	9	36	I. Sh.E.
10	3	19	I. Oc.D.
	6	46	I. Ec.R.
	16	11	II. Tr.I.
	18	36	II. Tr.E.
	18	42	II. Sh.I.
	21	06	II. Sh.E.
11	0	41	I. Tr.I.
	1	54	I. Sh.I.
	2	51	I. Tr.E.
	4	05	I. Sh.E.
	19	06	III. Tr.I.
	21	37	III. Tr.E.
	21	48	I. Oc.D.
12	0	09	III. Sh.I.
	1	15	I. Ec.R.
	2	38	III. Sh.E.
	11	18	II. Oc.D.
	13	43	II. Oc.R.
	13	47	II. Ec.D.
	16	11	II. Ec.R.
	19	10	I. Tr.I.
	20	23	I. Sh.I.
	21	20	I. Tr.E.
	22	33	I. Sh.E.
13	16	17	I. Oc.D.
	19	44	I. Ec.R.
14	5	31	II. Tr.I.
	7	56	II. Tr.E.
	8	01	II. Sh.I.
	10	25	II. Sh.E.
	13	39	I. Tr.I.
	14	52	I. Sh.I.
	15	50	I. Tr.E.
	17	02	I. Sh.E.
15	9	01	III. Oc.D.
	10	47	I. Oc.D.
	11	35	III. Oc.R.
	14	00	III. Ec.D.
15	14	12	I. Ec.R.
	16	31	III. Ec.R.
16	0	38	II. Oc.D.
	3	04	II. Oc.R.
	3	04	II. Ec.D.
	5	29	II. Ec.R.
	8	09	I. Tr.I.
	9	21	I. Sh.I.
	10	19	I. Tr.E.
	11	31	I. Sh.E.
17	5	16	I. Oc.D.
	8	41	I. Ec.R.
	18	53	II. Tr.I.
	21	18	II. Tr.E.
	21	20	II. Sh.I.
	23	44	II. Sh.E.
18	2	38	I. Tr.I.
	3	49	I. Sh.I.
	4	48	I. Tr.E.
	6	00	I. Sh.E.
	23	16	III. Tr.I.
	23	46	I. Oc.D.
19	1	48	III. Tr.E.
	3	10	I. Ec.R.
	4	09	III. Sh.I.
	6	38	III. Sh.E.
	13	58	II. Oc.D.
	18	47	II. Ec.R.
	21	08	I. Tr.I.
	22	18	I. Sh.I.
	23	18	I. Tr.E.
20	0	28	I. Sh.E.
	18	15	I. Oc.D.
	21	39	I. Ec.R.
21	8	14	II. Tr.I.
	10	38	II. Sh.I.
	10	39	II. Tr.E.
	13	02	II. Sh.E.
	15	37	I. Tr.I.
	16	47	I. Sh.I.
	17	47	I. Tr.E.
	18	57	I. Sh.E.
22	12	45	I. Oc.D.
	13	13	III. Oc.D.
	15	47	III. Oc.R.
	16	08	I. Ec.R.
	17	59	III. Ec.D.
	20	31	III. Ec.R.
23	3	19	II. Oc.D.
23	8	04	II. Ec.R.
	10	07	I. Tr.I.
	11	15	I. Sh.I.
	12	17	I. Tr.E.
	13	26	I. Sh.E.
24	7	14	I. Oc.D.
	10	37	I. Ec.R.
	21	36	II. Tr.I.
	23	57	II. Sh.I.
25	0	02	II. Tr.E.
	2	21	II. Sh.E.
	4	36	I. Tr.I.
	5	44	I. Sh.I.
	6	47	I. Tr.E.
	7	54	I. Sh.E.
26	1	44	I. Oc.D.
	3	28	III. Tr.I.
	5	05	I. Ec.R.
	6	02	III. Tr.E.
	8	07	III. Sh.I.
	10	38	III. Sh.E.
	16	41	II. Oc.D.
	21	22	II. Ec.R.
	23	06	I. Tr.I.
27	0	13	I. Sh.I.
	1	16	I. Tr.E.
	2	23	I. Sh.E.
	20	14	I. Oc.D.
	23	34	I. Ec.R.
28	10	58	II. Tr.I.
	13	15	II. Sh.I.
	13	24	II. Tr.E.
	15	40	II. Sh.E.
	17	35	I. Tr.I.
	18	42	I. Sh.I.
	19	46	I. Tr.E.
	20	52	I. Sh.E.
29	14	44	I. Oc.D.
	17	27	III. Oc.D.
	18	03	I. Ec.R.
	20	03	III. Oc.R.
	21	59	III. Ec.D.
30	0	32	III. Ec.R.
	6	02	II. Oc.D.
	10	39	II. Ec.R.
	12	05	I. Tr.I.
	13	10	I. Sh.I.
	14	16	I. Tr.E.
	15	21	I. Sh.E.

SATELLITES OF JUPITER, 1983

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

OCTOBER

d	h	m	
1	9	13	I. Oc.D.
	12	32	I. Ec.R.
2	0	21	II. Tr.I.
	2	34	II. Sh.I.
	2	47	II. Tr.E.
	4	59	II. Sh.E.
	6	35	I. Tr.I.
	7	39	I. Sh.I.
	8	45	I. Tr.E.
	9	49	I. Sh.E.
3	3	43	I. Oc.D.
	7	01	I. Ec.R.
	7	43	III. Tr.I.
	10	18	III. Tr.E.
	12	06	III. Sh.I.
	14	38	III. Sh.E.
	19	24	II. Oc.D.
	23	57	II. Ec.R.
4	1	04	I. Tr.I.
	2	08	I. Sh.I.
	3	15	I. Tr.E.
	4	18	I. Sh.E.
	22	13	I. Oc.D.
5	1	30	I. Ec.R.
	13	43	II. Tr.I.
	15	52	II. Sh.I.
	16	10	II. Tr.E.
	18	17	II. Sh.E.
	19	34	I. Tr.I.
	20	36	I. Sh.I.
	21	45	I. Tr.E.
	22	47	I. Sh.E.
6	16	43	I. Oc.D.
	19	58	I. Ec.R.
	21	44	III. Oc.D.
7	0	21	III. Oc.R.
	1	59	III. Ec.D.
	4	32	III. Ec.R.
	8	46	II. Oc.D.
	13	15	II. Ec.R.
	14	04	I. Tr.I.
	15	05	I. Sh.I.
	16	15	I. Tr.E.
	17	15	I. Sh.E.
8	11	13	I. Oc.D.
	14	27	I. Ec.R.
9	3	07	II. Tr.I.
9	5	11	II. Sh.I.
	5	34	II. Tr.E.
	7	37	II. Sh.E.
	8	34	I. Tr.I.
	9	34	I. Sh.I.
	10	45	I. Tr.E.
	11	44	I. Sh.E.
10	5	43	I. Oc.D.
	8	56	I. Ec.R.
	12	01	III. Tr.I.
	14	37	III. Tr.E.
	16	05	III. Sh.I.
	18	38	III. Sh.E.
	22	08	II. Oc.D.
11	2	32	II. Ec.R.
	3	04	I. Tr.I.
	4	02	I. Sh.I.
	5	14	I. Tr.E.
	6	13	I. Sh.E.
12	0	13	I. Oc.D.
	3	25	I. Ec.R.
	16	30	II. Tr.I.
	18	30	II. Sh.I.
	18	57	II. Tr.E.
	20	55	II. Sh.E.
	21	33	I. Tr.I.
	22	31	I. Sh.I.
	23	44	I. Tr.E.
13	0	42	I. Sh.E.
	18	43	I. Oc.D.
	21	54	I. Ec.R.
14	2	04	III. Oc.D.
	4	42	III. Oc.R.
	5	58	III. Ec.D.
	8	33	III. Ec.R.
	11	31	II. Oc.D.
	15	50	II. Ec.R.
	16	03	I. Tr.I.
	17	00	I. Sh.I.
	18	14	I. Tr.E.
	19	10	I. Sh.E.
15	13	13	I. Oc.D.
	16	22	I. Ec.R.
16	5	54	II. Tr.I.
	7	49	II. Sh.I.
	8	21	II. Tr.E.
	10	14	II. Sh.E.
	10	33	I. Tr.I.
16	11	28	I. Sh.I.
	12	44	I. Tr.E.
	13	39	I. Sh.E.
17	7	43	I. Oc.D.
	10	51	I. Ec.R.
	16	21	III. Tr.I.
	18	58	III. Tr.E.
	20	04	III. Sh.I.
	22	38	III. Sh.E.
18	0	53	II. Oc.D.
	5	03	I. Tr.I.
	5	07	II. Ec.R.
	5	57	I. Sh.I.
	7	14	I. Tr.E.
	8	08	I. Sh.E.
19	2	13	I. Oc.D.
	5	20	I. Ec.R.
	19	18	II. Tr.I.
	21	07	II. Sh.I.
	21	45	II. Tr.E.
	23	33	II. Sh.E.
	23	33	I. Tr.I.
20	0	25	I. Sh.I.
	1	44	I. Tr.E.
	2	36	I. Sh.E.
	20	44	I. Oc.D.
	23	49	I. Ec.R.
21	6	25	III. Oc.D.
	9	04	III. Oc.R.
	9	57	III. Ec.D.
	12	33	III. Ec.R.
	14	16	II. Oc.D.
	18	03	I. Tr.I.
	18	24	II. Ec.R.
	18	54	I. Sh.I.
	20	14	I. Tr.E.
	21	05	I. Sh.E.
22	15	14	I. Oc.D.
	18	18	I. Ec.R.
23	8	43	II. Tr.I.
	10	26	II. Sh.I.
	11	10	II. Tr.E.
	12	33	I. Tr.I.
	12	52	II. Sh.E.
	13	23	I. Sh.I.
	14	44	I. Tr.E.
	15	34	I. Sh.E.
24	9	44	I. Oc.D.
	12	46	I. Ec.R.
	20	44	III. Tr.I.
	23	21	III. Tr.E.
25	0	04	III. Sh.I.
	2	38	III. Sh.E.
	3	39	II. Oc.D.
	7	03	I. Tr.I.
	7	42	II. Ec.R.
	7	51	I. Sh.I.
	9	14	I. Tr.E.
	10	02	I. Sh.E.
26	4	14	I. Oc.D.
	7	15	I. Ec.R.
	22	07	II. Tr.I.
	23	44	II. Sh.I.
27	0	35	II. Tr.E.
	1	33	I. Tr.I.
	2	11	II. Sh.E.
	2	20	I. Sh.I.
	3	45	I. Tr.E.
	4	31	I. Sh.E.
	22	45	I. Oc.D.
28	1	44	I. Ec.R.
	10	48	III. Oc.D.
	13	28	III. Oc.R.
	13	56	III. Ec.D.
	16	32	III. Ec.R.
	17	02	II. Oc.D.
	20	03	I. Tr.I.
	20	48	I. Sh.I.
	20	59	II. Ec.R.
	22	15	I. Tr.E.
	23	00	I. Sh.E.
29	17	15	I. Oc.D.
	20	13	I. Ec.R.
30	11	32	II. Tr.I.
	13	03	II. Sh.I.
	14	00	II. Tr.E.
	14	33	I. Tr.I.
	15	17	I. Sh.I.
	15	30	II. Sh.E.
	16	45	I. Tr.E.
	17	28	I. Sh.E.
31	11	45	I. Oc.D.
	14	42	I. Ec.R.

SATURN

EPHEMERIS FOR THE BRIGHTER SATELLITES

The table below may be used to determine the orbital position of each of the five brightest satellites of Saturn at any time in 1983. The northern side of the rings and orbital planes of the five satellites now face Earth, being tilted approximately 16° from edge-on during the part of the year when Saturn is conveniently placed in the night sky (The orbit of Iapetus deviates most from this figure since it is itself tilted 15° to the ring plane). Hence the satellites pass (east to west) in front of and south of the centre of Saturn, and (west to east) behind and north of the centre of Saturn.

For each satellite, the table gives the visual magnitude, orbital period,* distance from the centre of Saturn in units of the radius of Saturn's rings (the outer radius of ring A), and time of the first eastern elongation in each month. For example, to find the position of Rhea on May 19, 1983 at 22 h EDT (May 20, 2 h UT): The first eastern elongation in May occurs on May 2 at 10.0 h. May 20, 2 h is 17.667 d or 3.911 periods later. Thus Rhea will be 0.911 × 360° = 328° from eastern elongation. Hence it will be behind Saturn, 3.9 × cos 328° = 3.3 ring radii east of the centre of Saturn, and somewhat north.

**Note*: Sidereal periods rather than synodic periods are listed since, due to Earth's orbital motion, the sidereal period yields less error in predictions during the months near opposition. Predictions based on this table are accurate to within a couple of degrees.

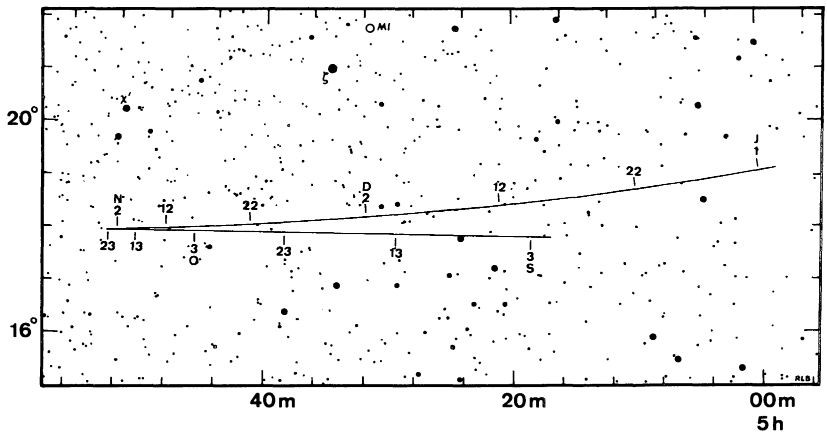
	Tethys	Dione	Rhea	Titan	Iapetus
m_v	10.3	10.4	9.7	8.4	~11
P	1.888^d	2.737^d	4.517^d	15.945^d	79.331^d
r	2.2	2.8	3.9	9.0	26.1
Jan.	$1^d 11^h.8$	$0^d 10^h.8$	$0^d 11^h.5$	$15^d 02^h.6$	
Feb.	2 14.1	2 07.2	1 02.8	16 00.7	$11^d 11^h.2$
Mar.	1 00.4	1 16.0	4 17.6	3 23.1	
Apr.	2 02.3	3 11.9	5 08.0	4 18.7	30 21.9
May	2 07.0	3 14.0	2 10.0	6 13.8	
June	1 11.7	2 16.3	3 00.4	7 09.4	
July	1 16.6	2 18.8	4 15.2	9 06.4	18 16.8
Aug.	2 19.0	1 21.5	5 06.4	10 05.0	
Sep.	2 00.2	1 00.5	1 09.6	11 04.9	
Oct.	2 05.6	1 03.6	3 01.5	13 05.8	7 10.8
Nov.	1 10.9	3 00.5	3 17.6	14 07.0	
Dec.	1 16.3	3 03.7	5 09.6	16 07.9	27 19.3

EPHEMERIDES FOR THE BRIGHTEST ASTEROIDS 1983

PROVIDED BY BRIAN G. MARSDEN

The following are the ephemerides for the brightest asteroids in 1983: those asteroids which will be brighter than photographic magnitude 11.0 and more than 90° from the Sun. The tables give the number and name of the asteroid, the date at 0^h E.T. (which differs only slightly from U.T.), the right ascension and declination for the epoch 1950 (for convenience in plotting on commonly-used star charts) and the *photographic* magnitude (which is normally about $0^m\!.7$ *fainter* than the visual magnitude). These data were derived from current osculating elements, and were generously calculated and provided by Dr. Brian G. Marsden of the Smithsonian Astrophysical Observatory.

Maps are provided for two of the brighter asteroids in 1983, Juno and Vesta. The maps are based on the *A.A.V.S.O. Variable Star Atlas* and show the predicted paths of the asteroids during a four month interval around opposition. The coordinates are for 1950. Readers can make maps for other asteroids by using the ephemerides and an appropriate star atlas.



The path of Vesta near the Taurus-Orion border, 1983. Its position is marked at 10-day intervals, beginning with September 3, where S = September, O = October, etc. The faintest stars shown are of magnitude 9. During September Vesta is about 9th magnitude, but brightens to 7.2 when near opposition in mid-December and 1.6 AU from Earth. Near the top edge of the chart is the Crab Nebula (M1).

(1) Ceres

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
May 26	$22^{h}03^{m}.1$	$-21^\circ 03'$	9.0
June 5	22 09.1	-21 18	
15	22 13.1	-21 46	8.8
25	22 15.0	-22 28	
July 5	22 14.6	-23 22	8.5
15	22 11.8	-24 26	
25	22 06.6	-25 36	8.2
Aug. 4	21 59.6	-26 47	
14	21 51.2	-27 50	8.0
24	21 42.4	-28 41	
Sept. 3	21 34.2	-29 15	8.2
13	21 27.3	-29 30	
23	21 22.5	-29 27	8.5
Oct. 3	21 20.1	-29 07	
13	21 20.3	-28 35	8.8
23	21 22.8	-27 51	
Nov. 2	21 27.5	-26 58	9.1
12	21 34.0	-25 58	

(2) Pallas

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Apr. 16	$19^{h}13^{m}.9$	$+15^\circ 02'$	10.6
26	19 17.3	+16 40	
May 6	19 18.8	+18 14	10.5
16	19 18.1	+19 42	
26	19 15.4	+20 57	10.3
June 5	19 10.7	+21 56	
15	19 04.3	+22 34	10.2
25	18 56.6	+22 45	
July 5	18 48.4	+22 29	10.1
15	18 40.2	+21 45	
25	18 32.8	+20 35	10.2
Aug. 4	18 26.8	+19 03	
14	18 22.5	+17 16	10.3
24	18 20.3	+15 20	
Sept. 3	18 20.1	+13 20	10.5
13	18 21.9	+11 21	
23	18 25.6	+ 9 27	10.7
Oct. 3	18 31.0	+ 7 40	

(3) Juno

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
July 25	$1^{h}37^{m}.9$	$+ 7^\circ 47'$	10.1
Aug. 4	1 50.5	+ 7 51	
14	2 01.7	+ 7 35	9.7
24	2 11.2	+ 6 58	
Sept. 3	2 18.5	+ 5 58	9.2
13	2 23.2	+ 4 33	
23	2 25.1	+ 2 45	8.7
Oct. 3	2 24.0	+ 0 40	
13	2 20.1	- 1 35	8.3
23	2 14.2	- 3 44	
Nov. 2	2 07.6	- 5 34	8.3
12	2 01.5	- 6 52	
22	1 57.1	- 7 32	8.6
Dec. 2	1 55.4	- 7 34	
12	1 56.6	- 7 03	9.0
22	2 00.9	- 6 03	

(4) Vesta

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Sept.23	$5^{h}38^{m}.5$	$+18^\circ 01'$	8.7
Oct. 3	5 45.7	+18 01	
13	5 50.5	+17 59	8.4
23	5 52.7	+17 58	
Nov. 2	5 51.9	+17 59	8.0
12	5 48.0	+18 02	
22	5 41.2	+18 09	7.7
Dec. 2	5 31.8	+18 19	
12	5 21.0	+18 31	7.2
22	5 09.9	+18 47	

(5) Astraea

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 6	$11^{h}00^{m}.3$	$+ 6^\circ 12'$	10.9
16	11 03.9	+ 6 23	
26	11 04.3	+ 6 58	10.5
Feb. 5	11 01.6	+ 7 56	
15	10 56.2	+ 9 11	10.1
25	10 48.9	+10 37	
Mar. 7	10 41.0	+12 00	9.9
17	10 34.0	+13 11	
27	10 28.9	+14 03	10.4
Apr. 6	10 26.6	+14 31	
16	10 27.2	+14 36	10.9
26	10 30.8	+14 20	

(6) Hebe

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Apr. 16	$18^{h}06^{m}.7$	$- 6^\circ 03'$	10.9
26	18 09.0	- 5 17	
May 6	18 08.8	- 4 34	10.5
16	18 05.9	- 3 57	
26	18 00.3	- 3 31	10.1
June 5	17 52.5	- 3 21	
15	17 43.1	- 3 29	9.8
25	17 33.2	- 3 58	
July 5	17 23.7	- 4 46	9.9
15	17 15.9	- 5 50	
25	17 10.3	- 7 08	10.1
Aug. 4	17 07.6	- 8 33	
14	17 07.9	-10 03	10.4
24	17 11.0	-11 33	
Sept. 3	17 16.9	-13 01	10.6
13	17 25.3	-14 25	

(7) Iris

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
May 6	$17^{h}59^{m}.2$	$-24^\circ 02'$	10.9
16	17 54.6	-23 47	
26	17 47.3	-23 30	10.5
June 5	17 38.0	-23 09	
15	17 27.5	-22 44	9.8
25	17 16.9	-22 17	
July 5	17 07.3	-21 49	10.4
15	16 59.6	-21 24	
25	16 54.5	-21 03	10.7
Aug. 4	16 52.3	-20 48	
14	16 52.9	-20 39	11.0
24	16 56.2	-20 37	

(8) Flora

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Apr. 16	$15^h08^m.7$	$-8°20'$	10.7
26	14 59.6	− 7 34	
May 6	14 49.4	− 6 52	10.5
16	14 39.2	− 6 19	
26	14 30.1	− 5 59	10.8
June 5	14 23.1	− 5 55	

(10) Hygiea

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Mar. 7	$13^h52^m.4$	$-17°09'$	10.8
17	13 49.6	−17 09	
27	13 44.6	−16 53	10.4
Apr. 6	13 38.0	−16 24	
16	13 30.4	−15 43	10.0
26	13 22.9	−14 54	
May 6	13 16.1	−14 04	10.3
16	13 11.0	−13 19	
26	13 08.0	−12 42	10.6
June 5	13 07.3	−12 18	
15	13 08.9	−12 07	10.9
25	13 12.7	−12 09	

(15) Eunomia

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 26	$12^h19^m.0$	$-15°39'$	11.0
Feb. 5	12 17.4	−16 27	
15	12 13.6	−16 58	10.8
25	12 07.6	−17 12	
Mar. 7	11 59.9	−17 05	10.5
17	11 51.1	−16 38	
27	11 42.1	−15 55	10.4
Apr. 6	11 33.8	−15 00	
16	11 27.0	−14 00	10.7
26	11 22.2	−13 01	
May 6	11 19.6	−12 09	10.9
16	11 19.2	−11 27	

(18) Melpomene

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Mar. 7	$10^h48^m.1$	$+11°06'$	11.0
17	10 39.3	+12 31	

(20) Massalia

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Sept. 3	$1^h54^m.6$	$+12°02'$	10.8
13	1 53.6	+11 54	
23	1 49.7	+11 30	10.4
Oct. 3	1 43.1	+10 50	
13	1 34.6	+ 9 57	9.8
23	1 25.2	+ 8 58	
Nov. 2	1 16.2	+ 8 01	10.0
12	1 09.0	+ 7 13	
22	1 04.4	+ 6 41	10.3
Dec. 2	1 02.9	+ 6 29	
12	1 04.5	+ 6 36	10.7
22	1 09.1	+ 7 02	

(29) Amphitrite

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Dec. 12	$8^h58^m.7$	$+25°25'$	10.8
22	8 56.5	+25 49	

(39) Laetitia

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Nov. 22	$5^h11^m.5$	$+6°41'$	10.8
Dec. 2	5 03.0	+ 6 19	
12	4 53.8	+ 6 12	10.7
22	4 45.2	+ 6 21	

(40) Harmonia

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
July 5	$19^h54^m.5$	$-23°00'$	10.8
15	19 44.5	−23 52	
25	19 34.0	−24 38	10.7
Aug. 4	19 24.5	−25 16	

(44) Nysa

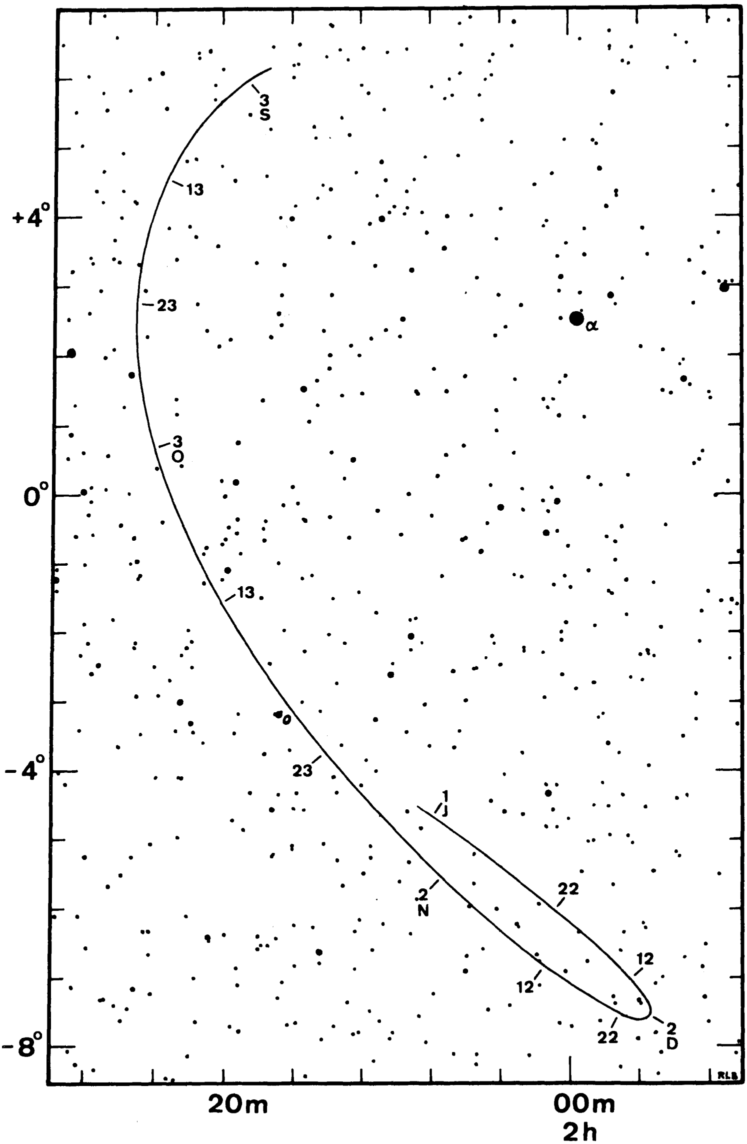
Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 13	$2^h25^m.8$	$+7°54'$	10.7
23	2 17.3	+ 6 58	
Nov. 2	2 07.8	+ 6 03	10.4
12	1 58.7	+ 5 19	
22	1 51.2	+ 4 50	10.7
Dec. 2	1 46.2	+ 4 42	

(68) Leto

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 13	$1^h52^m.0$	$+6°30'$	10.9
23	1 42.5	+ 6 19	
Nov. 2	1 33.4	+ 6 14	11.0
12	1 25.8	+ 6 17	

(80) Sappho

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 13	$2^h20^m.6$	$+17°24'$	10.7
23	2 13.1	+15 28	
Nov. 2	2 05.0	+13 25	10.4
12	1 58.0	+11 29	



The path of Juno in Cetus, 1983. Its position is marked at 10-day intervals, beginning with September 3, where S = September, O = October, etc. The faintest stars shown are of magnitude 9. Juno reaches magnitude 8.3 when near opposition in late October and 1.05 AU from Earth. On October 19 Juno passes within 0.2° of Mira (omicron Ceti), the famous variable star.

PLANETARY APPULSES AND OCCULTATIONS

A *planetary appulse* is a close approach of a star and a planet, minor planet (asteroid), or satellite (moon) as seen from Earth. At certain locations on Earth, the appulse may be seen as an *occultation*, a "solar eclipse", but of a star other than our Sun. Carefully executed observations of such events can provide valuable information on the position, size, and shape of the occulting body, plus the presence of possible satellites and/or atmosphere surrounding the body. In the case of asteroids, information of this sort is not currently obtainable in any other way. Only within the past decade have computers and careful astrometric measurements been combined to make possible the prediction of many such events per year several months in advance. Much of this progress is due to Gordon E. Taylor of the Royal Greenwich Observatory, a contributor to this *Handbook* for many years. It was one of his predictions that led to the discovery of the rings of Uranus in 1977 (See *Sky and Telescope*, June 1977, p. 412).

Mr. Taylor has issued a list of 80 predicted possible occultations of stars by asteroids for 1983. Eleven of these may be visible from North America (including Hawaii). Two additional predictions (on June 10 and September 1) have been taken from a list by Wasserman, Bowell, and Millis of Lowell Observatory (*Astronomical Journal*, *86*, 1974, December 1981). These predictions are listed on the next page. In the first table, the month (M), day (D), hour, and minute range of each event are given along with data on the occulted star. In the second table, Δm_v is the change in visual magnitude which will accompany the occultation, and Δt is the predicted maximum duration in seconds.

Improved predictions may be available closer to the time of the various events. Within a few days of each event, observers may obtain recorded telephone messages at 312-259-2376 (Chicago, Ill.). Observers of events which may cross parts of Canada (May 29, June 10, August 21, September 1, September 11, and November 12) should call 613-996-9345 (Dr. Ian Halliday, Herzberg Institute of Astrophysics, Ottawa, Ont.) to obtain possible last-minute updates. This Ottawa service will first be available in late 1982 for event numbers 16 and 18, page 117, 1982 OBSERVER'S HANDBOOK. Also, arrangements have been made to broadcast hourly updates on WWV for the unusual May 29 occultation by Pallas.

Serious observers of occultations pay careful attention to: the determination of their geographical latitude, longitude, and altitude (which should be known to the nearest second of arc and 20 m, respectively); identification of the star; accurate timing of the events (a shortwave radio time signal and cassette tape recorder are recommended); and the provision of two or more independent observers a kilometre or more apart for both confirmation and improved "resolution" of the eclipse shadow. Also, photoelectric recordings are very desirable when possible.

Observations of these events are coordinated in North America by the International Occultation Timing Association (IOTA). Dr. Dunham of the IOTA intends to publish an article on planetary occultations for 1983 in the December 1982 or January 1983 issue of *Sky and Telescope*. (See page 75 of this *Handbook* for more information on the IOTA.) Observations of planetary occultations, including negative observations, should be sent to H. M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex BN27 1RP, England (the world clearing house for such observations), and to Dr. Dunham at P.O. Box 7488, Silver Spring, Md 20907, U.S.A. for publication by the IOTA. (Note that observations of lunar occultations should be sent to Japan. See Page 75.)

No.	Time (UT) M D h min	Star Name	m_v	α (1950)	δ
1	2 21 11 23±7	AGK3 + 5°1549	10.0	$10^h 38^m 47^s$	+ 5°16′55″
2	4 21 5 16±6	AGK3 +10°1124	8.8	8 38 59	+ 9 55 25
3	5 14 11 05±4	SAO 159459	7.2	15 42 10	-10 52 50
4	5 29 4 57±3	1 Vulpeculae	4.7	19 15 30	+21 21 27
5	6 10 8 50±6?	AGK3 + 4°60	10.9	0 31 29	+ 4 36 17
6	6 15 9 24±7	SAO 210241	8.3	18 29 16	-30 58 25
7	6 28 12 45±1	SAO 185215	9.1	17 15 20	-22 09 13
8	8 15 10 59±9	SAO 163239	9.1	20 04 02	-17 49 52
9	8 21 5 38±9	AGK3 +23°0050	8.3	0 30 48	+23 37 00
10	9 1 0 43±8?	SAO 208888	8.7	17 26 59	-30 13 11
11	9 11 7 46±3	14 Piscium	5.6	23 33 19	- 1 20 15
12.	11 12 13 20±1	AGK3 - 0°1793	8.6	12 58 30	- 1 02 25
13	12 30 14 09±9	AGK3 +19°0418	10.0	5 03 13	+19 04 25

No.	Asteroid Name	Asteroid m_v	Occult. Δm_v	Occult. Δt	Possible Area of Visibility*
1	59 Elpis	11.9	2.1	12	Pacific (Hawaii?), Japan
2	71 Niobe	11.8	3.1	10	E. Pacific (California?)
3	521 Brixia	13.6	6.4	6	western U.S.A., N. Pacific
4	2 Pallas	9.6	4.9	46	southern(?) U.S.A.
5	3 Juno	10.8	0.7	8	central U.S.A., Great Lakes
6	83 Beatrix	11.6	3.4	12	U.S.A., Hawaii
7	7 Iris	9.6	1.0	17	N. Pacific (Hawaii?), China
8	65 Cybele	11.7	2.7	25	N. Pacific (Hawaii?), Indonesia
9	372 Palma	12.0	3.7	17	north-east N. America
10	120 Lachesis	13.8	5.1	17	southern U.S.A. to eastern Canada
11	51 Nemausa	10.8	5.2	12	east and south N. America
12	52 Europa	12.4	3.8	7	southern Canada
13	4 Vesta	6.8	0.1	49	Hawaii?, Japan, S. and E. Asia

*These predicted areas of visibility are uncertain. Substantial improvements in the expected occultation path are often possible a few days before an event when the star and the asteroid can be photographed on the same astrographic plate. See the preceding page for directions to obtain updates.

METEORS, COMETS, AND DUST

METEORS, FIREBALLS, AND METEORITES

BY PETER M. MILLMAN

Meteoroids are small solid particles moving in orbits about the Sun. On entering the Earth's atmosphere they become luminous and appear as meteors or fireballs, and in rare cases, if large enough to avoid complete fragmentation and vaporization, they may fall to the Earth as meteorites.

Meteors are visible on any night of the year. At certain times of the year the Earth encounters larger numbers of meteoroids all moving together along the same orbit. Such a group is known as a meteor stream and the visible phenomenon is called a meteor shower. The orbits followed by these meteor streams are very similar to those of short-period comets, and in many cases can be identified with the orbits of specific comets.

The radiant is the position among the stars from which the meteors of a given shower seem to radiate. This is an effect of perspective commonly observed for any group of parallel lines. Some showers, notably the Quadrantids, Perseids, and Geminids, are very regular in their return each year and do not vary greatly in the numbers of meteors seen at the time of maximum. Other showers, like the Leonids, are very unpredictable and may arrive in great numbers or fail to appear at all in any given year. The δ Aquarids and the Taurids are spread out over a fairly extended period of time without a sharp maximum.

For more information concerning meteor showers, see the paper by A. F. Cook in "Evolutionary and Physical Properties of Meteoroids", NASA SP-319, pp. 183–191, 1973.

The light of meteors is produced by a mixture of atoms and molecules, originating from both the meteoroid and the Earth's atmosphere. i.e. The light of a meteor is primarily from a glowing gas, and not from the solid meteoroid itself. The collision, at a very high speed, of the material from the meteoroid with the Earth's atmosphere

MAJOR VISUAL METEOR SHOWERS FOR 1983

	Shower Maximum			Radiant				Single Observer Hourly Rate	Speed	Normal Duration to ¼ Strength of Max.
				Position at Max.		Daily Motion				
Shower	Date	U.T.	Moon	R.A.	Dec.	R.A.	Dec.			
		h		h m	°	m	°		km/s	days
Quadrantids	Jan. 3	20	LQ	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	22	FQ	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 5	01	LQ	22 24	00	+3.6	+0.4	20	65	3
S. δ Aquarids	July 29	04	LQ	22 36	−17	+3.4	+0.17	20	41	7
Perseids	Aug. 12	19	FQ	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	23	FM	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 3	00	NM	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 18	06	FM	10 08	+22	+2.8	−0.42	15	71	—
Geminids	Dec. 14	18	FQ	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 23	00	FM	14 28	+76	—	—	15	34	2
	(1984)									
Quadrantids	Jan. 4	02	NM	15 28	+50	—	—	40	41	1.1

excites the involved atoms and molecules to shine, each with its own characteristic wavelength (colour). In addition to the light of oxygen and nitrogen, prominent in the luminosity of meteors, we find the orange-yellow of sodium, the brilliant green of magnesium, and various other wavelengths of light produced by iron, calcium, and some dozen, less-common elements. For a general survey of the light of meteors see *Smithsonian Contributions to Astrophysics*, 7, p. 119–127, 1963.

An observer located away from city lights, and with perfect sky conditions on a moonless night, will see an overall average of seven sporadic meteors per hour apart from the shower meteors. These have been included in the hourly rates listed in the table. Slight haze or nearby lighting will greatly reduce the number of meteors seen. More meteors appear in the early morning hours than in the evening, and more during the last half of the year than during the first half.

When a meteor has a luminosity greater than the brightest stars and planets it is generally termed a fireball. The visible trails of most meteors occur high in the atmosphere from 60 to 110 kilometres altitude. Only the rare, very bright fireballs survive down to the lower levels of Earth's atmosphere, and, in general, these are not associated with meteor showers. The occurrence of such an object should be reported immediately to the nearest astronomical group or other organization concerned with the collection of such information. Where no local organization exists, reports should be sent to Meteor Centre, Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa, Ontario, K1A 0R6. If sounds are heard accompanying a bright fireball there is a possibility that a meteorite may have fallen. Astronomers must rely on observations made by the general public to track down such an object.

For 1983 the comet associated with the Perseid meteor shower, 1862 III Swift-Tuttle, may be in the inner part of the solar system and a better than average shower in August is a possibility. The two showers associated with Halley's Comet, due in 1986, are the η Aquarids and the Orionids and these showers should be given priority in meteor observations for the next few years.

A SELECTION OF MINOR VISUAL METEOR SHOWERS

Shower	Dates	Date of Max.	Speed
			km/s
δ Leonids	Feb. 5–Mar. 19	Feb. 26	23
σ Leonids	Mar. 21–May 13	Apr. 17	20
τ Herculids	May 19–June 14	June 3	15
N. δ Aquarids	July 14–Aug. 25	Aug. 12	42
α Capricornids	July 15–Aug. 10	July 30	23
S. ι Aquarids	July 15–Aug. 25	Aug. 5	34
N. ι Aquarids	July 15–Sept. 20	Aug. 20	31
κ Cygnids	Aug. 9–Oct. 6	Aug. 18	25
S. Piscids	Aug. 31–Nov. 2	Sept. 20	26
N. Piscids	Sept. 25–Oct. 19	Oct. 12	29
N. Taurids	Sept. 19–Dec. 1	Nov. 13	29
Annual Andromedids	Sept. 25–Nov. 12	Oct. 3	18–23
Coma Berenicids	Dec. 12–Jan. 23	—	65

NORTH AMERICAN METEORITE IMPACT SITES

BY P. BLYTH ROBERTSON

The search for ancient terrestrial meteorite craters, and investigations in the related fields of shock metamorphism and cratering mechanics, have been carried out on a continuing basis since approximately 1950, although a few structures were investigated earlier. In Canada, this research is undertaken largely at the Earth Physics Branch, Dept. Energy, Mines and Resources, and in the United States at the facilities of NASA and the U.S. Geological Survey. Particular aspects of these studies are also carried out at various universities in both countries, and the information in the following table is a compilation from all these sources.

Of the thirty-seven confirmed North American impact structures, which account for about 40% of the world's recognized total, meteorite fragments are preserved at only three. In large impacts, where craters greater than approximately 1.5 km in diameter are created, extreme shock pressures and temperatures vapourize or melt the meteorite which subsequently becomes thoroughly mixed with the melted target rocks and is no longer recognizable in its original form, but chemical traces have been recognized. These larger hypervelocity impact craters are therefore identified by the presence of shock metamorphic effects, the characteristic suite of deformation in the target rocks produced by shock pressures exceeding approximately 7 GPa (1 GPa = 10 kilobars).

In addition to the sites whose impact origin is confirmed by identification of diagnostic shock features, there are approximately twenty structures in Canada and the United States for which an impact origin seems highly probable, but where distinctive evidence of shock metamorphism has not been found.

No new sites were recognized in the past year, but ages for several structures have been refined or modified by 40Ar–39Ar radiometric dating. In the table, sites accessible by road or boat are marked "A" or "B" respectively and those sites where data have been obtained through diamond-drilling or geophysical surveys are signified by "D" and "G", respectively.

Name	Lat. °	′	Long. °	′	Diam. (km)	Age ($\times 10^6$ a)	Surface Expression	Visible Geologic Features			
Barringer, Meteor Crater, Ariz.	35	02	111	01	1.2	.05	rimmed polygonal crater	fragments of meteorite, highly shocked sandstone	A	D	G
Bee Bluff, Texas	29	02	099	51	2.4	40±10	shallow circ. depress'n.; rim remnants	breccia	A		
Brent, Ont.	46	05	078	29	3.8	450±30	sediment-filled shallow depression	fracturing	A	D	G
Carswell, Sask.	58	27	109	30	37	485±50	discontinuous circular ridge	shatter cones, breccia			G
Charlevoix, Que.	47	32	070	18	46	360±25	semi-circular trough, central elevation	breccia, shatter cones, impact melt	A		G
Clearwater Lake East, Que.	56	05	074	07	22	290±20	circular lake	sedimentary float		D	G
Clearwater Lake West, Que.	56	13	074	30	32	290±20	island ring in circular lake	impact melt		D	G
Crooked Creek, Missouri	37	50	091	23	5.6	320±80	oval area of disturbed rocks, shallow marginal depression	breccia, shatter cones	A		
Decaturville, Missouri	37	54	092	43	6	<300	slight oval depression	breccia, shatter cones	A	D	
Deep Bay, Sask.	56	24	102	59	12	100±50	circular bay	sedimentary float		D	G
Flynn Creek, Tenn.	36	16	085	37	3.8	360±20	sediment-filled shallow depression with slight central elevation	breccia, shatter cones, disturbed rocks	A	D	G
Gow Lake, Sask.	56	27	104	29	5	<250	lake and central island	breccia			G
Haviland, Kansas	37	35	099	10	0.0011	<0.001	excavated depression	fragments of meteorite	A		
Haughton, NWT	75	22	089	40	20	<20	shallow circular depression	shatter cones, breccia			G
Holleford, Ont.	44	28	076	38	2	550±100	sediment-filled shallow depression	sedimentary fill	A	D	G
Ile Rouleau, Que.	50	41	073	53	4	<300	island is central uplift of submerged structure	shatter cones, breccia dikes			
Kentland, Ind.	40	45	087	24	13	300	central uplift exposed in quarries, rest buried	breccia, shatter cones, disturbed rocks	A		
Lac Couture, Que.	60	08	075	18	8	430	circular lake	breccia float			
Lac la Moinerie, Que.	57	26	066	36	8	400	lake-filled, partly circular	breccia float			G
Lake St. Martin, Man.	51	47	098	33	23	225±40	none, buried and eroded	impact melt	A	D	G
Lake Wanapitei, Ont.	46	44	080	44	8.5	37±2	lake-filled, partly circular	breccia float	A		G
Manicouagan, Que.	51	23	068	42	100	210±4	circumferal lake, central elevation	impact melt, breccia	B		G
Manson, Iowa	42	35	094	31	32	<100	none, central elevation buried to 30 m	none	A	D	G
Middlesboro, Ky.	36	37	083	44	6	300	circular depression	disturbed rocks	A		
Mistastin Lake, Labr.	55	53	063	18	28	38±4	elliptical lake and central island	breccia, impact melt			
New Quebec Crater, Que.	61	17	073	40	3.2	<5	rimmed, circular lake	raised rim			G
Nicholson Lake, NWT	62	40	102	41	12.5	<400	irregular lake with islands	breccia			G
Odessa, Tex.	31	48	102	30	0.17	0.03	sediment-filled depression with very slight rim, 4 others buried and smaller	fragments of meteorite	A	D	G
Pilot Lake, NWT	60	17	111	01	6	440	circular lake	fracturing, breccia float			
Redwing Creek, N. Dak.	47	40	102	30	9	200	none, buried	none	A	D	G
Serpent Mound, Ohio	39	02	083	24	6.4	300	circular area of disturbed rock, slight central elevation	breccia, shatter cones	A		G
Sierra Madera, Tex.	30	36	102	55	13	100	central hills, annular depression, outer ring of hills	breccia, shatter cones	A	D	G
Slate Islands, Ont.	48	40	087	00	30	350	islands are central uplift of submerged structure	shatter cones, breccia dikes	B		G
Steen River, Alta.	59	31	117	38	25	95±7	none, buried to 200 metres	none		D	G
Sudbury, Ont.	46	36	081	11	140	1840±150	elliptical basin	breccia, impact melt, shatter cones	A	D	G
Wells Creek, Tenn.	36	23	087	40	14	200±100	basin with cenral hill, inner and outer annular, valleys and ridges	breccia, shatter cones	A	D	G
West Hawk Lake, Man.	49	46	095	11	2.7	100±50	circular lake	none	A	D	G

COMETS IN 1983

BY BRIAN G. MARSDEN

The following periodic comets are expected at perihelion during 1983:

Comet	Perihelion Date	Perihelion Dist.	Period
		A.U.	a
Pons-Winnecke	Apr. 7	1.25	6.4
Arend	May 22	1.86	8.0
du Toit-Neujmin-Delporte	June 1	1.71	6.4
Tempel 2	June 1	1.38	5.3
Oterma	June 18	5.47	19.4
Tempel 1	July 9	1.49	5.5
Kopff	Aug. 10	1.58	6.4
Harrington-Abell	Dec. 1	1.79	7.6
Johnson	Dec. 3	2.30	6.9

The returns of P/Tempel 1 and P/Kopff are very favourable, and ephemerides are given below. P/Tempel 2 will also be moderately easy to observe; P/Pons-Winnecke and P/Johnson somewhat less so. P/Oterma used to be observable all around its orbit, but no observations have been possible since a close approach to Jupiter caused a substantial change in the orbit around 1962; the comet may be detectable at magnitude 21 in 1983. P/du Toit-Neujmin-Delporte and P/Harrington-Abell are never particularly bright objects, but these comets are also well placed for observation this year. The return of P/Arend is most unfavourable.

As P/Halley approaches its perihelion passage on 1986 Feb. 9 several astronomers are making attempts to recover it. It is possible that this famous comet will be detected during the latter part of this year, when it will be 8.2 AU from the Sun. Nevertheless, P/Halley will still then be considerably fainter than any comet ever observed before, and it would not be surprising if it is not recovered before late 1984.

COMET TEMPEL 1

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
May 6	$12^h33^m.3$	$+13°15'$	11.5
16	12 31.6	+10 50	
26	12 34.2	+ 7 49	11.3
June 5	12 41.0	+ 4 21	
15	12 51.8	+ 0 34	11.3
25	13 06.1	- 3 25	
July 5	13 23.5	- 7 29	11.4

COMET KOPFF

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Apr. 16	$15^h46^m.5$	$-10°50'$	11.4
26	15 46.3	-10 18	
May 6	15 43.4	- 9 46	10.6
16	15 38.3	- 9 20	
26	15 32.2	- 9 08	10.0
June 5	15 26.7	- 9 18	
15	15 23.3	- 9 53	9.7
25	15 23.3	-10 53	
July 5	15 27.3	-12 17	9.5
15	15 35.7	-13 57	
25	15 48.3	-15 49	9.6
Aug. 4	16 04.8	-17 44	
14	16 24.7	-19 35	9.8
24	16 47.4	-21 16	
Sept. 3	17 12.5	-22 40	10.2
13	17 39.3	-23 45	
23	18 07.3	-24 25	10.7
Oct. 3	18 35.8	-24 41	
13	19 04.4	-24 33	11.3

INTERPLANETARY DUST

Outside of the astronomical community it is not generally realized that the inner solar system contains a vast cloud of dust. The particles in this cloud are concentrated near the plane of the ecliptic and toward the Sun, their spatial particle density in the ecliptic falling off somewhat more rapidly than the reciprocal of their distance from the Sun. Measurements from spacecraft indicate that the cloud extends well beyond the orbit of Mars, but that it is negligible in the vicinity of Jupiter's orbit and beyond. Aside from this overall structure, the cloud is quite uniform both spatially and temporally.

The particles composing the cloud have a continuum of sizes, from pebble-sized clumps down to specks with diameters comparable to the wavelength of visible light and smaller. The smaller particles are the more numerous, although the mass distribution appears to peak near 10^{-8} kg, corresponding to a particle diameter of a few tenths of a millimetre. The total mass of the cloud is small, amounting to perhaps 10^{-14} of the mass of the solar system. It is as if the moons of Mars had been pulverized and spread throughout the inner solar system.

Like the planetary system, the interplanetary dust cloud is not static. Its particles generally move in orbits about the Sun. In addition, the particles undergo continual fragmentation due to collisions, sputtering associated with bombardment by the solar wind, electrostatic bursting, and sublimation. This progression toward smaller and smaller sizes is of crucial significance for the cloud, since particles with diameters appreciably less than a tenth of a millimetre have a sufficiently large surface-to-volume ratio that the pressure of the Sun's radiation has a significant effect upon their motion. Their orbits become non-Keplerian and many particles are lost as they spiral inward toward the Sun (the Poynting-Robertson effect). For the smallest particles, radiation pressure and interactions with the solar wind dominate, with the result that these particles are blown out of the solar system. The estimated mean life of a cloud particle is about 10^5 years. Since this is much less than the age of the solar system, it is obvious that the cloud must be in a dynamic equilibrium. Part of the tail of a bright comet is due to significant quantities of dust ejected from its nucleus, and it is generally assumed that comets provide the main supply of new dust to the cloud. Since comet nuclei are believed to consist of the undifferentiated matter from which the solar system formed, the dust of the interplanetary cloud is most likely composed of this same low-density, fragile, primitive material.

To an observer on Earth the most noticeable aspect of the dust cloud is meteors – larger particles of the cloud which encounter Earth and vaporize in its upper atmosphere. In addition, sunlight scattered by the dust cloud appears as a faint glow in the vicinity of the ecliptic. This glow is brightest toward the Sun, is due primarily to particles having diameters between a few micrometres and a millimetre, and is referred to as the *zodiacal light*. A slight brightening in the sky opposite the Sun, called the *Gegenschein* (German for "counter-glow"), is due to a phase effect (analogous to the full moon), and also possibly to a concentration of dust at the L3 Lagrangian point of the Earth-Sun system. As astronomical objects, the zodiacal light and Gegenschein are unusual in that they can be seen only with the unaided eye. Both are invisible in binoculars or a telescope.

The Zodiacal Light

Nearly a millenium ago the Persian astronomer-poet Omar Khayyam referred to the zodiacal light in the second quatrain of his *Rubaiyat*. As translated by the poet Edward FitzGerald, we have the haunting lines: "Dreaming when Dawn's Left Hand was in the Sky", and "Before the phantom of False morning died".

When conditions are favorable, the zodiacal light is indeed a mysterious and beautiful sight. It is best seen after the end of evening twilight and before the beginning of morning twilight (see page 56). Because the zodiacal light is brightest nearest the Sun, it is best seen when the ecliptic is at a steep angle relative to the horizon. In the tropics this is always the case and the short duration of twilight is an added advantage. At mid-northern latitudes the optimum geometry occurs in the evening western sky in February and March, and in the morning eastern sky in October. The zodiacal light appears as a huge, softly radiant pyramid of white light with its base near the horizon and its axis centered on the zodiac. In its brightest parts it exceeds the luminance of the central Milky Way.

Despite its brightness, many people have not seen the zodiacal light. As mentioned above, certain times of night and times of year are more favorable than others. In addition, moonlight, haze, or light pollution rule out any chance of seeing this phenomenon. Even with a dark, transparent sky the inexperienced observer may confuse the zodiacal light with twilight and thus ignore it, or he may not notice it because he is expecting a much smaller object.

The Gegenschein

Photometric measurements indicate that the zodiacal light extends all around the zodiac with a shallow minimum in brightness some 120° to 150° from the Sun; nevertheless, this "zodiacal band" or "light bridge" is exceedingly faint and hence rarely visible. However, the slight brightening in the vicinity of the anti-solar point can be seen under the right conditions.

The Gegenschein is very faint. The slightest haze, moonlight, bright nearby stars, planets, or light pollution will hide it completely. Most observers, including experienced ones, have not seen it. It is a ghostly apparition best seen near midnight and, in mid-northern latitudes, in the fall or winter when the anti-solar point is nearest the zenith. To avoid interference from bright stars or the Milky Way, observations should be restricted to the periods late September to early November, and late January to early February when the Gegenschein is in Pisces and Cancer respectively. It appears as a faint yet distinct, somewhat elliptical glow perhaps 10° in diameter. The luminance of the Gegenschein is about 10^{-4} cd/m^2, some ten orders of magnitude dimmer than the brightest light the human eye can tolerate.

STARS

CONSTELLATIONS

Nominative & Pronunciation	Genitive	Abbr.	Meaning
Andromeda, ăn-drŏm'ē-dȧ	Andromedae	And	Daughter of Cassiopeia
Antlia, ănt'lĭ-ȧ	Antliae	Ant	The Air Pump
Apus, ā'pŭs	Apodis	Aps	Bird of Paradise
Aquarius, ȧ-kwâr'ĭ-ŭs	Aquarii	Aqr	The Water-bearer
Aquila, ăk'wĭ-lȧ	Aquilae	Aql	The Eagle
Ara, ā'rȧ	Arae	Ara	The Altar
Aries, ā'rĭ-ēz	Arietis	Ari	The Ram
Auriga, ô-rī'gȧ	Aurigae	Aur	The Charioteer
Bootes, bō-ō'tēz	Bootis	Boo	The Herdsman
Caelum, sē'lŭm	Caeli	Cae	The Chisel
Camelopardalis kȧ-mĕl'ō-pȧr'dȧ-lĭs	Camelopardalis	Cam	The Giraffe
Cancer, kăn'sẽr	Cancri	Cnc	The Crab
Canes Venatici kā'nēz vē-năt'ĭ-sī	Canum Venaticorum	CVn	The Hunting Dogs
Canis Major, kā'nĭs mā'jẽr	Canis Majoris	CMa	The Big Dog
Canis Minor, kā'nĭs mī'nẽr	Canis Minoris	CMi	The Little Dog
Capricornus, kăp'rĭ-kôr'nŭs	Capricorni	Cap	The Horned Goat
Carina, kȧ-rī'nȧ	Carinae	Car	The Keel
Cassiopeia, kăs'ĭ-ō-pē'yȧ	Cassiopeiae	Cas	The Queen
Centaurus, sĕn-tô'rŭs	Centauri	Cen	The Centaur
Cepheus, sē'fŭs	Cephei	Cep	The King
Cetus, sē'tŭs	Ceti	Cet	The Whale
Chamaeleon, kȧ-mē'lē-ŭn	Chamaeleontis	Cha	The Chameleon
Circinus, sûr'sĭ-nŭs	Circini	Cir	The Compasses
Columba, kō-lŭm'bȧ	Columbae	Col	The Dove
Coma Berenices kō'mȧ bĕr'ē-nī'sēz	Comae Berenices	Com	Berenice's Hair
Corona Australis kō-rō'nȧ ôs-trā'lĭs	Coronae Australis	CrA	The Southern Crown
Corona Borealis kō-rō'nȧ bō'rē-ā'lĭs	Coronae Borealis	CrB	The Northern Crown
Corvus, kôr'vŭs	Corvi	Crv	The Crow
Crater, krā'tẽr	Crateris	Crt	The Cup
Crux, krŭks	Crucis	Cru	The Cross
Cygnus, sĭg'nŭs	Cygni	Cyg	The Swan
Delphinus, dĕl-fī'nŭs	Delphini	Del	The Dolphin
Dorado, dō-rȧ'dō	Doradus	Dor	The Goldfish
Draco, drā'kō	Draconis	Dra	The Dragon
Equuleus, ē-kwo͞o'lē-ŭs	Equulei	Equ	The Little Horse
Eridanus, ē-rĭd'ȧ-nŭs	Eridani	Eri	A River
Fornax, fôr'năks	Fornacis	For	The Furnace
Gemini, jĕm'ĭ-nī	Geminorum	Gem	The Twins
Grus, grŭs	Gruis	Gru	The Crane (bird)
Hercules, hûr'kū-lēz	Herculis	Her	The Son of Zeus
Horologium, hŏr'ō-lō'jĭ-ŭm	Horologii	Hor	The Clock
Hydra, hī'drȧ	Hydrae	Hya	The Water Snake (♀)
Hydrus, hī'drŭs	Hydri	Hyi	The Water Snake (♂)

Nominative & Pronunciation	Genitive	Abbr.	Meaning
Indus, ĭn'dŭs	Indi	Ind	The Indian
Lacerta, lȧ-sûr'tȧ	Lacertae	Lac	The Lizard
Leo, lē'ō	Leonis	Leo	The Lion
Leo Minor, lē'ō mī'nẽr	Leonis Minoris	LMi	The Little Lion
Lepus, lē'pŭs	Leporis	Lep	The Hare
Libra, lī'brȧ	Librae	Lib	The Balance
Lupus, lū'pŭs	Lupi	Lup	The Wolf
Lynx, lĭnks	Lyncis	Lyn	The Lynx
Lyra, lī'rȧ	Lyrae	Lyr	The Lyre
Mensa, mĕn'sȧ	Mensae	Men	Table Mountain
Microscopium mī'krō-skō'pĭ-ŭm	Microscopii	Mic	The Microscope
Monoceros, mō-nŏs'ẽr-ŏs	Monocerotis	Mon	The Unicorn
Musca, mŭs'kȧ	Muscae	Mus	The Fly
Norma, nôr'mȧ	Normae	Nor	The Square
Octans, ŏk'tănz	Octantis	Oct	The Octant
Ophiuchus, ŏf'ĭ-ū'kŭs	Ophiuchi	Oph	The Serpent-bearer
Orion, ō-rī'ŏn	Orionis	Ori	The Hunter
Pavo, pā'vō	Pavonis	Pav	The Peacock
Pegasus, pĕg'ȧ-sŭs	Pegasi	Peg	The Winged Horse
Perseus, pûr'sūs	Persei	Per	Rescuer of Andromeda
Phoenix, fē'nĭks	Phoenicis	Phe	The Phoenix
Pictor, pĭk'tẽr	Pictoris	Pic	The Painter
Pisces, pĭs'ēz	Piscium	Psc	The Fishes
Piscis Austrinus pĭs'ĭs ôs-trī'nŭs	Piscis Austrini	PsA	The Southern Fish
Puppis, pŭp'ĭs	Puppis	Pup	The Stern
Pyxis, pĭk'sĭs	Pyxidis	Pyx	The Compass
Reticulum, rē-tĭk'ū-lŭm	Reticuli	Ret	The Reticle
Sagitta, sȧ-jĭt'ȧ	Sagittae	Sge	The Arrow
Sagittarius, săj'ĭ-tā'rĭ-ŭs	Sagittarii	Sgr	The Archer
Scorpius, skôr'pĭ-ŭs	Scorpii	Sco	The Scorpion
Sculptor, skŭlp'tẽr	Sculptoris	Scl	The Sculptor
Scutum, skū'tŭm	Scuti	Sct	The Shield
Serpens, sûr'pĕnz	Serpentis	Ser	The Serpent
Sextans, sĕks'tănz	Sextantis	Sex	The Sextant
Taurus, tô'rŭs	Tauri	Tau	The Bull
Telescopium tĕl'ē-skō'pĭ-ŭm	Telescopii	Tel	The Telescope
Triangulum, trī-ăng'gū-lŭm	Trianguli	Tri	The Triangle
Triangulum Australe trī-ăng'gū-lŭm ôs-trā'lē	Trianguli Australis	TrA	The Southern Triangle
Tucana, tū-kā'nȧ	Tucanae	Tuc	The Toucan
Ursa Major, ûr'sȧ mā'jẽr	Ursae Majoris	UMa	The Great Bear
Ursa Minor, ûr'sȧ mī'nẽr	Ursae Minoris	UMi	The Little Bear
Vela, vē'lȧ	Velorum	Vel	The Sails
Virgo, vûr'gō	Virginis	Vir	The Maiden
Volans, vō'lănz	Volantis	Vol	The Flying Fish
Vulpecula, vŭl-pĕk'ū-lȧ	Vulpeculae	Vul	The Fox

ā dāte; ă tăp; â câre; ȧ ȧsk; ē wē; ĕ mĕt; ẽ makẽr; ī īce; ĭ bĭt; ō gō; ŏ hŏt; ô ôrb; o͞o mo͞on; ū ūnite; ŭ ŭp; û ûrn.

FINDING LIST OF SOME NAMED STARS

Name	Con.	R.A.	Name	Con.	R.A.
Acamar, ā'kȧ-mȧr	θ Eri	02	Gienah, jē'nȧ	γ Crv	12
Achernar, ā'kēr-nȧr	α Eri	01	Hadar, hăd'ȧr	β Cen	14
Acrux, ā'krŭks	α Cru	12	Hamal, hăm'ăl	α Ari	02
Adara, ȧ-dā'rȧ	ε CMa	06	Kaus Australis,	ε Sgr	18
Al Na'ir, ăl-nâr'	α Gru	22	kôs ôs-trā'lĭs		
Albireo, ăl-bĭr'ē-ō	β Cyg	19	Kochab, kō'kăb	β UMi	14
Alcor, ăl-kôr'	80 UMa	13	Markab, mȧr'kăb	α Peg	23
Alcyone, ăl-sī'ō-nē	η Tau	03	Megrez, mē'grĕz	δ UMa	12
Aldebaran,	α Tau	04	Menkar, mĕn'kȧr	α Cet	03
ăl-dĕb'ȧ-rȧn			Menkent, mĕn'kĕnt	θ Cen	14
Alderamin,	α Cep	21	Merak, mē'răk	β UMa	11
ăl-dĕr'ȧ-mĭn			Merope, mĕr'ō-pē	23 Tau	03
Algeiba, ăl-jē'bȧ	γ Leo	10	Miaplacidus,	β Car	09
Algenib, ăl-jē'nĭb	γ Peg	00	mī'ȧ-plăs'ĭ-dŭs		
Algol, ăl'gŏl	β Per	03	Mintaka, mĭn-tȧ'kȧ	δ Ori	05
Alioth, ăl'ĭ-ŏth	ε UMa	12	Mira, mī'rȧ	o Cet	02
Alkaid, ăl-kād'	η UMa	13	Mirach, mī'răk	β And	01
Almach, ăl'măk	γ And	02	Mirfak, mĭr'făk	α Per	03
Alnilam, ăl-nī'lăm	ε Ori	05	Mizar, mī'zȧr	ζ UMa	13
Alphard, ăl'fȧrd	α Hya	09	Nunki, nŭn'kē	σ Sgr	18
Alphecca, ăl-fĕk'ȧ	α CrB	15	Peacock, pē'kŏk'	α Pav	20
Alpheratz, ăl-fē'răts	α And	00	Phecda, fĕk'dȧ	γ UMa	11
Altair, ăl-târ'	α Aql	19	Polaris, pō-lâr'ĭs	α UMi	02
Ankaa, ăn'kȧ	α Phe	00	Pollux, pŏl'ŭks	β Gem	07
Antares, ăn-tā'rēs	α Sco	16	Procyon, prō'sĭ-ŏn	α CMi	07
Arcturus, ȧrk-tū'rŭs	α Boo	14	Pulcherrima,	ε Boo	14
Atria, ā'trĭ-ȧ	α TrA	16	pŭl-kĕr'ĭmȧ		
Avior, ă-vĭ-ôr'	ε Car	08	Ras-Algethi,	α Her	17
Bellatrix, bĕ-lā'trĭks	γ Ori	05	rȧs'ăl-jē'thē		
Betelgeuse, bĕt'ĕl-jūz	α Ori	05	Rasalhague,	α Oph	17
			rȧs'ăl-hā'gwē		
Canopus, kȧ-nō'pŭs	αCar	06	Regulus, rĕg'ū-lŭs	α Leo	10
Capella, kȧ-pĕl'ȧ	α Aur	05	Rigel, rī'jĕl	β Ori	05
Caph, kăf	β Cas	00	Rigil Kentaurus,	α Cen	14
Castor, kȧs'tēr	α Gem	07	rī'jĭl kĕn-tô'rŭs		
Cor Caroli, kôr kăr'ŏ-lī	α CVn	12	Sabik, sā'bĭk	η Oph	17
Deneb, dĕn'ĕb	α Cyg	20	Scheat, shē'ăt	β Peg	23
Denebola, dĕ-nĕb'ō-lȧ	β Leo	11	Schedar, shĕd'ȧr	α Cas	00
Diphda, dĭf'dȧ	β Cet	00	Shaula, shô'lȧ	λ Sco	17
Dubhe, dŭb'ē	α UMa	11	Sirius, sĭr'ĭ-ŭs	α CMa	06
Elnath, ĕl'năth	β Tau	05	Spica, spī'kȧ	α Vir	13
Eltanin, ĕl-tā'nĭn	γ Dra	17	Suhail, sŭ-hāl'	λ Vel	09
Enif, ĕn'ĭf	ε Peg	21	Thuban, thōō'bȧn	α Dra	14
Fomalhaut, fō'măl-ôt	α PsA	22	Vega, vē'gȧ	α Lyr	18
Gacrux, gȧ'krŭks	γ Cru	12	Zubenelgenubi,	α Lib	14
Gemma, jĕm'ȧ	α CrB	15	zōō-bĕn'ĕl-jĕ-nū'bē		

Key to pronunciation on p. 130.

THE BRIGHTEST STARS

By Donald A. MacRae

The 286 stars brighter than apparent magnitude 3.55.

Star. If the star is a visual double the letter *A* indicates that the data are for the brighter component. The brightness and separation of the second component *B* are given in the last column. Sometimes the double is too close to be conveniently resolved and the data refer to the combined light, *AB*; in interpreting such data the magnitudes of the two components must be considered.

Visual Magnitude (*V*). These magnitudes are based on *photoelectric observations*, with a few exceptions, which have been adjusted to match the yellow colour-sensitivity of the eye. The photometric system is that of Johnson and Morgan in *Ap. J.*, vol. 117, p. 313, 1953. It is as likely as not that the true magnitude is within 0.03 mag. of the quoted figure, on the average. Variable stars are indicated with a "v". The type of variability, range, *R*, in magnitudes, and period in days are given.

Colour index ($B-V$). The blue magnitude, *B*, is the brightness of a star as observed photoelectrically through a blue filter. The difference $B-V$ is therefore a measure of the colour of a star. The table reveals a close relation between $B-V$ and spectral type. Some of the stars are slightly reddened by interstellar dust. The probable error of a value of $B-V$ is only 0.01 or 0.02 mag.

Type. The customary spectral (temperature) classification is given first. The Roman numerals are indicators of *luminosity class*. They are to be interpreted as follows: Ia—most luminous supergiants; Ib—less luminous supergiants; II—bright giants; III—normal giants; IV—subgiants; V—main sequence stars. Intermediate classes are sometimes used, e.g. Iab. Approximate absolute magnitudes can be assigned to the various spectral and luminosity class combinations. Other symbols used in this column are: p—a peculiarity; e—emission lines; v—the spectrum is variable; m—lines due to metallic elements are abnormally strong; f—the O-type spectrum has several broad emission lines; n or nn—unusually wide or diffuse lines. A composite spectrum, e.g. M1 Ib+B, shows up when a star is composed of two nearly equal but unresolved components. The table now includes accurate spectral and luminosity classes for all stars in the southern sky. These were provided by Dr. Robert Garrison of the David Dunlap Observatory. All other types were very kindly provided especially for this table by Dr. W. W. Morgan, Yerkes Observatory.

Parallax (π). From "General Catalogue of Trigonometric Stellar Parallaxes" by Louise F. Jenkins, Yale Univ. Obs., 1952.

Absolute visual magnitude (M_V), and *distance in light-years* (D). If π is greater than 0.030″ the distance corresponds to this trigonometric parallax and the absolute magnitude was computed from the formula $M_V = V + 5 + 5 \log \pi$. Otherwise a generally more accurate absolute magnitude was obtained from the luminosity class. In this case the formula was used to *compute* π and the distance corresponds to this "spectroscopic" parallax. The formula is an expression of the inverse square law for decrease in light intensity with increasing distance. The effect of absorption of light by interstellar dust was neglected, except for three stars, ζ Per, σ Sco and ζ Oph, which are significantly reddened and would therefore be about a magnitude brighter if they were in the clear.

Annual proper motion (μ), and *radial velocity* (R). From "General Catalogue of Stellar Radial Velocities" by R. E. Wilson, Carnegie Inst. Pub. 601, 1953. The information on radial velocities was brought up-to-date in 1975 by Dr. C. T. Bolton of the Dunlap Observatory. Italics indicate an average value of a variable radial velocity.

The star names are given for all the officially designated navigation stars and a few others. Throughout the table, a *colon* (:) indicates an uncertainty.

Star	Right Ascension R.A. 1980 h m	Declination Dec. ° ′	Visual Magnitude V	Colour Index $B-V$	Spectral Classification Type		Parallax π ″	Absolute Magnitude M_V	Distance light-years D l.y.	Proper Motion μ ″	Radial Velocity R km/s		
Sun			-26.73	+0.63	G2	V		+4.84					***Sun***
α And	00 07.3	+28 58	2.06	−0.08	B9p		0.024	−0.1	90	0.209	*−11.7*	Manganese star	*Alpheratz*
β Cas	08.1	+59 02	2.26v	+0.34	F2	IV	0.072	+1.6	45	0.555	+11.8	Var. *R* $0^m.08$, 0.10^d	*Caph*
γ Peg	12.2	+15 04	2.84v	−0.23	B2	IV	−.004	−3.4	570	0.010	+04.1	β CMa type, *R* in *V* 2.83–2.85, 0.15^d	γ Peg = *Algenib*
β Hyi	24.6	−77 22	2.78	+0.62	G1	IV	0.153	+3.7	21	2.255	+22.8		
α Phe	25.3	−42 25	2.39	+1.08	K0	IIIb	0.035	+0.1	93	0.442	*+74.6*		*Ankaa*
δ And *A*	38.2	+30 45	3.25:	+1.26	K3	III	0.024	−0.2	160	0.161	−07.3	*B* 12^m 28″	
α Cas	39.4	+56 25	2.22	+1.18	K0	II–III	0.009	−1.1	150	0.058	−03.8	Var.?	*Schedar*
β Cet	42.6	−18 06	2.02	+1.03	K1	III	0.057	+0.8	57	0.234	+13.1		*Diphda*
η Cas *A*	47.9	+57 42	3.47	+0.56	G0	V	0.182	+4.8	18	1.221	+09.4	*B* 7.26^m 12″	
γ Cas *A*	55.5	+60 36	2.5v	−0.16v	B0	IV:pe	0.034	−0.3:	96:	0.026	−06.8	Var. *B* 8.18^m 2″	
β Phe *AB*	01 05.1	−46 50	3.30	+0.88	G8	III	0.017	+0.3	190	0.035	−01.1	*A* 4.1^m *B* 4.1^m 1″	
η Cet	07.6	−10 17	3.44	+1.16	K3	III	0.032	+1.0	102	0.250	+11.5		
β And	08.6	+35 31	2.02	+1.57	M0	III	0.043	+0.2	76	0.211	+00.3		*Mirach*
δ Cas	24.4	+60 08	2.67	+0.13	A5	V	0.029	+2.1	43	0.301	+06.7	Ecl.? *R* $0.08{:}^m$ 759^d	*Ruchbah*
γ Phe	27.5	−43 25	3.40	+1.56	K5	IIb–III	−.003	−4.6	1300	0.209	*+25.7*		
α Eri	37.0	−57 20	0.51	−0.16	B3	Vp	0.023	−2.3	118	0.098	+19		***Achernar***
τ Cet	43.2	−16 03	3.50	+0.72	G8	Vp	0.275	+5.70	12	1.921	−16.2		

Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
α Tri	01 52.0	+29 29	3.42	+0.50	F6 IV	0.050	+2.0	65	0.230	*−12.6*		
ε Cas	52.9	+63 34	3.37	−0.15	B3 IV:p	0.007	−2.7	520	0.038	−08.1		
β Ari	53.6	+20 43	2.65	+0.14	A5 V	0.063	+1.7	52	0.147	*−04.0*		*Sheratan*
α Hyi	58.1	−61 40	2.84	+0.28	F0 V		+2.9	31	0.265	+07		
γ And *A*	02 02.7	+42 14	2.14:	+1.16:	K3 II	0.005	−2.4	260	0.068	−11.7	*B* 5.4ᵐ *C* 6.2ᵐ *A–BC* 10″ *B–C* 0.6″	γ And = *Almach*
α Ari	06.1	+23 22	2.00	+1.15	K2 III	0.043	+0.2	76	0.241	−14.3		*Hamal*
β Tri	08.4	+34 54	3.00	+0.13	A5 III	0.012	−0.1	140	0.156	*+15.2*		
α UMi *A*	12.5	+89 11	1.99v	+0.60v	F8 Ib	0.003	−4.6	680	0.046	*−17.4*	Cep., *R* 0.11ᵐ 4.0ᵈ, *B* 8.9ᵐ 18″	*Polaris*
o Cet *A*	18.3	−03 04	2.0v		M5.5e–M9e	0.013	−0.5	103	0.232	+63.8	LP, *R* 2.0–10.1, 332ᵈ, *B* 10ᵐ 1″	*Mira*
γ Cet *AB*	42.2	+03 10	3.48	+0.11	A2 V	0.048	+2.0	68	0.203	−05.1	*A* 3.57ᵐ *B* 6.23ᵐ 3″	
θ Eri *AB*	57.5	−40 23	2.92	+0.13	A3 III	0.028	+1.7	65	0.061	*+11.9*	*A* 3.25ᵐ *B* 4.36ᵐ 8″	*Acamar*
α Cet	03 01.2	+04 00	2.54	+1.63	M2 III	0.003	−0.5	130	0.075	−25.9		*Menkar*
γ Per	03.3	+53 25	2.91:	+0.72:	G8III + A5V	0.011	+0.3	113	0.004	*+02.5*		
ρ Per	03.7	+38 45	3.5v		M4 II–III	0.008	−1.0	260	0.172	+28.2	Irr. *R* 3.2–3.8	
β Per	06.6	+40 52	2.06v	−0.07	B8 V	0.031	−0.5	105	0.006	*+06.0*	Ecl. *R* 2.06–3.28, 2.87ᵈ	*Algol*
α Per	22.9	+49 47	1.80	+0.48	F5 Ib	0.029	−4.4	570	0.035	−02.4		*Mirfak*
δ Per	41.5	+47 44	3.03	−0.14	B5 III	0.007	−3.3	590	0.046	+02.8		
η Tau	46.3	+24 03	2.86	−0.09	B7 III	0.005	−3.2	541	0.050	+10.1	in Pleiades	*Alcyone*
γ Hyi	47.5	−74 18	3.30	+1.61	M2 III	−.001	−1.5	300	0.125	+16.0		
ζ Per *A*	52.7	+31 50	2.83	+0.13	B1 Ib	0.007	−6.1	1000	0.015	+20.6	*B* 9.36ᵐ 13″	
ε Per *A*	56.5	+39 57	2.88	−0.17	B0.5 V	−.001	−3.7	680	0.036	*−01*	*B* 7.99ᵐ 9″	
γ Eri	57.1	−13 34	2.96	+1.58	M0 III	0.003	−0.5	160	0.126	+61.7		
α Ret *A*	04 14.1	−62 32	3.33	+0.91	G9 III	0.008	−2.1	390	0.064	+35.6	*B* 12ᵐ 49″	
ε Tau	27.5	+19 08	3.54	+1.02	K0 III	0.018	+0.1	160	0.118	+38.6		
$θ^2$ Tau	27.5	+15 49	3.42	+0.17	A7 III	0.025	+0.2	140	0.108	*+39.5*		
α Dor	33.5	−55 05	3.28	−0.08	A0 IIIp	0.011	−1.2	260	0.051	+25.6	Silicon star	
α Tau *A*	34.8	+16 28	0.86v	+1.52	K5 III	0.048	−0.7	68	0.202	+54.1	Irr.? *R* 0.78–0.93, *B* 13ᵐ 31″	***Aldebaran***
$π^3$ Ori	48.3	+06 56	3.17	+0.45	F6 V	0.125	+3.65	26	0.468	+24.3		
ι Aur	55.7	+33 08	2.68:	+1.49	K3 II	0.015	−2.4	330	0.021	+17.5		

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/s	
ε Aur	05 00.5	+43 48	3.0v	+0.50:	F0 Iap	0.004	−7.1	3400	0.008	*−01.4*	Ecl. R 0.81^m 9886^d
ε Lep	04.6	−22 24	3.21	+1.46	K5 III	0.006	−0.4	170	0.077	+01.0	
η Aur	05.1	+41 13	3.17	−0.18	B3 V	0.013	−2.1	370	0.077	+07.4	
β Eri	06.9	−05 06	2.79	+0.13	A3 III	0.042	+0.9	78	0.122	−08	
μ Lep	12.1	−16 13	3.29	−0.09	B9 IIIp	0.018	−2.1	390	0.049	+27.7	Manganese star
β Ori *A*	13.6	−08 13	0.14v	−0.04	B8 Ia	−.003	−7.1	900	0.001	*+20.7*	Irr. ? R 0.08–0.20, B 6.65^m 9″ ***Rigel***
α Aur	15.2	+45 59	0.05	+0.80	G8 III: +F	0.073	−0.6	45	0.435	*+30.2*	***Capella***
η Ori *AB*	23.5	−02 24	3.32v	−0.18	B0.5 V	0.004	−3.7	940	0.008	*+19.8*	Ecl. R 3.32–3.50, 8.0^d, A 3.59^m B 4.98^m 1″
γ Ori	24.0	+06 20	1.64	−0.23	B2 III	0.026	−4.2	470	0.015	+18.2	*Bellatrix*
β Tau	25.0	+28 36	1.65	−0.13	B7 III	0.018	−3.2	300	0.178	+08.0	*Elnath*
β Lep *A*	27.4	−20 47	2.81	+0.82	G5 III	0.014	+0.1	113	0.090	−13.5	B 9.4^m 3″
δ Ori *A*	31.0	−00 19	2.20v	−0.20	O9.5 II	0.004	−6.1	1500	0.002	*+22.0*	Ecl. R 2.20–2.35 5.7^d, B 6.74^m 53″
α Lep	31.8	−17 51	2.58	+0.22	F0 Ib	0.002	−4.6	900	0.006	+24.7	
λ Ori *AB*	34.1	+09 55	3.40	−0.18	O8 III	0.006	−5.1	1800	0.006	+33.5	A 3.56^m B 5.54^m 4″ C 10.92^m 29″
ι Ori *AB*	34.5	−05 56	2.76	−0.24	O9 III	0.021	−6.1	2000	0.005	*+27.6*	A 2.78^m B 7.31^m 11″
ε Ori	35.2	−01 13	1.70	−0.19	B0 Ia	−.007	−6.8	1600	0.000	+26.1	*Alnilam*
ζ Tau	36.5	+21 08	3.07:	−0.13:	B2 III:p	−.002	−4.2	940	0.023	*+22.8*	Shell star
α Col *A*	39.0	−34 05	2.64	−0.11	B7 IV	−.005	−0.6	140	0.026	+35	B 12^m 12″ *Phact*
ζ Ori *AB*	39.7	−01 57	1.79	−0.22	O9.5 Ib	0.022	−6.6	1600	0.004	+18.1	A 1.91^m B 4.05^m 3″ *Alnitak*
κ Ori	46.8	−09 41	2.06	−0.17	B0.5 Ia	0.009	−6.9	2100	0.004	+20.6	
β Col	50.2	−35 47	3.12	+1.16	K1.5 III	0.023	+0.0	140	0.402	+89.4	
α Ori	54.0	+07 24	0.41v	+1.87:	M2 Iab	0.005	−5.6	520	0.028	*+21.0*	Irr. ? R 0.06:–0.75:^{m} ***Betelgeuse***
β Aur	58.0	+44 57	1.86	+0.06	A2 V	0.037	−0.3	88	0.051	*−18.2*	*Menkalinan*
θ Aur *AB*	58.4	+37 13	2.65v	−0.07	B9.5pv	0.018	+0.1	108	0.097	+29.3	Silicon star A 2.67^m B 7.14^m 3″, var., 1.4^d
η Gem *A*	06 13.7	+22 31	3.33v	+1.58	M3 III	0.013	−0.6	200	0.066	*+19.0*	R 0.27^m, B 6.70^m 1″
ζ CMa	19.6	−30 03	3.04	−0.18	B2.5 V	−.003	−2.4	390	0.004	*+32.2*	
μ Gem	21.7	+22 32	2.92v	+1.63	M3 III	0.021	−0.6	160	0.129	+54.8	R 0.14^m
β CMa	21.8	−17 56	1.96v	−0.24	B1 II–III	0.014	−4.8	750	0.004	*+33.7*	β CMa type variable, 0.25^d
α Car	23.5	−52 41	−0.72	+0.16	F0 Ib–II	0.018	−3.1	98	0.025	+20.5	***Canopus***
γ Gem	36.6	+16 25	1.93	0.00	A0 IV	0.031	−0.6	105	0.066	*−12.5*	*Alhena*

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
ν Pup	06 37.1	−43 11	3.19	−0.10	B8 III		−3.2	620	0.010	+28.2		
ε Gem	42.7	+25 09	3.00	+1.39	G8 Ib	0.009	−4.6	1080	0.016	+09.9		
ξ Gem	44.2	+12 55	3.38	+0.43	F5 IV	0.051	+1.9	64	0.224	+25.3		
α CMa *A*	44.2	−16 42	−1.47	+0.01	A1 V	0.375	+1.45	8.7	1.324	*−07.6*	*B* 8.66^m 1980.0: 10.0″, P.A. 46°	***Sirius***
α Pic	48.2	−61 55	3.27	+0.21	A7 Vn		+2.1	57	0.272	+20.6		
τ Pup	49.5	−50 36	2.92	+1.21	K1 III		+0.1	124	0.079	*+36.4*		
ε CMa *A*	57.8	−28 57	1.48:	−0.18:	B2 II		−5.1	680	0.004	+27.4	*B* 7.5^m 8″	***Adhara***
o^2 CMa	07 02.2	−23 48	3.02	−0.09	B3 Ia		−7.1	3400	0.000	+48.4		
δ CMa	07.6	−26 22	1.85	+0.65	F8 Ia	−.018	−7.1	2100	0.005	+34.3		
L_2 Pup	12.9	−44.37			M5e–M6e	0.016	−3.1	650	0.342	+53.0	LP, *R* 3.4–6.2, 141^d	
π Pup	16.5	−37 04	2.70:	+1.63:	K3 Ib	0.023	−0.3	140	0.008	+15.8		
η CMa	23.3	−29 15	2.46	−0.08	B5 Ia		−7.1	2700	0.008	+41.1		
β CMi	26.2	+08 20	2.91	−0.09	B7 V	0.020	−1.1	210	0.065	+22		
σ Pup *A*	28.6	−43 15	3.24	+1.49	K5 III	0.013	−0.4	180	0.195	*+88.1*	*B* 9.4^m 22″	
α Gem *A*	33.3	+31 56	1.97	+0.00:	A1 V	0.072	+1.3	45	0.199	+06.0	2″, *B–V*+0.02, *C* 9.08v^m 73″	***Castor***
α Gem *B*	33.3	+31 56	2.95	+0.07:	A5m	0.072	+2.3	45	0.199	*−01.2*		
α CMi *A*	38.2	+05 17	0.37	+0.41	F5 IV–V	0.288	+2.7	11.3	1.250	*−03.2*	*B* 10.7^m 4″	***Procyon***
β Gem	44.1	+28 05	1.16	+1.02	K0 III	0.093	+1.0	35	0.625	+03.3		***Pollux***
ξ Pup	48.4	−24 50	3.34	+1.23	G3 Ib	−.003	−4.6	1240	0.005	*+02.7*		
χ Car	56.2	−52 56	3.48	−0.18	B3 IVp		−2.1	430	0.039	+19.1		
ζ Pup	08 02.9	−39.57	2.23	−0.26	O5 Iaf		−7.1	2400	0.033	−24		
ρ Pup	06.7	−24 15	2.80v	+0.42	F6 IIp	0.031	+0.3:	105:	0.098	+46.6	Var. *R* 2.72–2.87, 0.14^d	
γ Vel *A*	08.9	−47 18	1.83	−0.26	WC8		−4.1	520	0.011	+35	*B* 4.31^m 41″	
ε Car	22.1	−59 26	1.90:	+1.30:	K3:III+B2:V		−3.1:	340	0.030	+11.5		***Avior***
o UMa *A*	28.6	+60 47	3.37	+0.83	G5 III	0.004	+0.1	150	0.171	+19.8	*B* 15^m 7″	
δ Vel *AB*	44.2	−54 38	1.95	+0.05	A2 V	0.043	+0.2	76	0.086	+02.2	*A* 2.0^m *B* 5.1^m 3″ *CD* 10^m 69″	
ε Hya *ABC*	45.7	+06 30	3.39	+0.68	G0:IV comp.	0.010	+0.6	140	0.198	*+36.4*	*A*3.7^m*B*5.2^{m}0.2″15^y,*C*6.8^{m}3″*D*12^{m}20″	
ζ Hya	54.3	+06 02	3.11	+1.00	K0 II–III	0.029	−1.1	220	0.101	+22.8		
ι UMa *A*	57.9	+48 07	3.12	+0.19	A7 V	0.066	+2.2	49	0.505	+12.2	*BC* 10.8^m 4″	

Star	R.A. 1980	Dec.	V	B–V	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
λ Vel	09 07.3	−43 21	2.24	+1.64:	K4 Ib–IIa	0.015	−4.6	750	0.026	+18.4		Suhail
a Car	10.5	−58 52	3.43	−0.17	B2 IV–V		−2.9	590	0.028	+*23.3*		
β Car	13.0	−69 38	1.67	+0.01	A1 III	0.038	−0.4	86	0.183	−05		Miaplacidus
ι Car	16.6	−59 11	2.25	+0.17	A9 Ib		−4.6	750	0.019	+13.3		
α Lyn	19.9	+34 29	3.17	+1.54	M0 III	0.021	−0.5	180	0.217	+37.6		
κ Vel	21.5	−54 56	2.49	−0.20	B2 IV–V	0.007	−3.4	470	0.012	+*21.9*		
α Hya	26.6	−08 35	1.98	+1.44	K4 III	0.017	−0.3	94	0.034	−04.3		Alphard
N Vel.	30.6	−56 57	3.19	+1.56	K5 III	0.015	−0.4	170	0.036	−13.9		
θ UMa *A*	31.5	+51 46	3.12	+0.46	F6 IV	0.052	+1.8	63	1.094	+15.4	*B* 14^m 5″	
ε Leo	44.7	+23 51	2.99	+0.81	G0 II	0.002	−2.1	340	0.048	+05.0		
l Car	44.7	−62 26	4.1		G8 Ia	0.019	−5.5	2700	0.016	+*04.0*	Cep. max. 3.4^m min. 4.8^m, 35.52^d	
υ Car *AB*	46.6	−64 59	2.95	+0.26	A8 Ib	0.020	−2.1	340	0.012	+13.6	*A* 3.02^m *B* 6.03^m 5″	
α Leo *A*	10 07.3	+12 04	1.36	−0.11	B7 V	0.039	−0.7	84	0.248	+03.5	*B* 8.1^m 177″	Regulus
ω Car	13.2	−69 56	3.33	−0.08	B8 III		−1.5	300	0.029	+*04*		
ζ Leo	15.7	+23 31	3.46	+0.30	F0 III	0.009	+0.5	130	0.023	−15.0		
λ UMa	15.9	+43 01	3.45	+0.03	A2 IV	−.010	+0.1	150	0.170	+18.3		
q Car	16.4	−61 14	3.41v	+1.55	K3 Ib–II	0.018	−4.6	1300	0.023	+08.6	Var. *R* 3.38–3.44	
γ Leo *AB*	18.8	+19 57	1.99	+1.13	K0 IIIp	0.019	+0.1	90	0.350	−36.6	*A* 2.29^m *B* 3.54^m 4″	
μ UMa	21.1	+41 36	3.05	+1.55	M0 III	0.031	+0.5	105	0.086	−*20.5*		
p Car	31.4	−61 35	3.30v	−0.11	B4 Vne		−2.3	430	0.021	+26.0	Var. *R* 3.22–3.39	
θ Car	42.2	−64 17	2.74	−0.22	B0.5 Vp		−4.0	710	0.018	+24		
μ Vel *AB*	45.9	−49 19	2.67	+0.89	G5 IIIa		+0.1	108	0.085	+06.9	*A* 2.7^m *B* 7.2^m 1″	
ν Hya	48.6	−16 05	3.12	+1.25	K3 III	0.022	−0.2	150	0.221	−01.0		
β UMa	11 00.6	+56 30	2.37	−0.03	A1 V	0.042	+0.5	78	0.087	−12.0		Merak
α UMa *AB*	02.5	+61 52	1.81	+1.06	K0 III	0.031	−0.7	105	0.138	−08.9	*A* 1.88^m *B* 4.82^m 1″	Dubhe
ψ UMa	08.6	+44 36	3.00	+1.14	K1 III		+0.0	130	0.072	−03.8		
δ Leo	13.0	+20 38	2.57	+0.13	A4 V	0.040	+0.6	82	0.201	−20.6		
θ Leo	13.2	+15 33	3.34	0.00	A2 V	0.019	+1.1	90	0.104	+07.8		
λ Cen	34.9	−62 54	3.15	−0.05	B9 III		−2.1	370	0.039	−*01*		
β Leo	48.0	+14 41	2.14	+0.09	A3 V	0.076	+1.5	43	0.511	−01		Denebola

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/s	
γ UMa	11 52.7	+53 49	2.44	0.00	A0 V	0.020	+0.2	90	0.094	−12.9	*Phecda*
δ Cen	12 07.3	−50 36	2.59v	−0.11:	B2 IVne		−2.7	370	0.042	+09	Var. *R* 2.56–2.62
ε Crv	09.1	−22 30	3.00	+1.33	K3 III		−0.2	140	0.069	+04.9	
δ Cru	14.1	−58 38	2.81v	−0.23	B2 IV		−3.4	570	0.041	+26.4	Var *R* 2.78–2.84
δ UMa	14.4	+57 09	3.30	+0.07	A3 V	0.052	+1.9	63	0.106	−12.9	*Megrez*
γ Crv	14.8	−17 25	2.59	−0.10	B8 III		−3.1	450	0.163	−04.2	*Gienah*
α Cru *A*	25.4	−62 59	1.39	−0.25	B0.5 IV		−3.9	370	0.042	*−11.2*	5″, *C* 4.90^m 89″
α Cru *B*	25.4	−62 59	1.86	−0.25	B1 V		−3.4	370	0.042	*−00.6*	***Acrux***
δ Crv *A*	28.8	−16 24	2.97	−0.04	B9.5 V	0.018	+0.1	124	0.255	+09	*B* 8.26^m 24″
γ Cru	30.1	−57 00	1.69	+1.55	M4 III		−2.5	220	0.274	+21.3	*Gacrux*
β Crv	33.3	−23 17	2.66	+0.89	G5 III	0.027	+0.1	108	0.059	−07.7	
α Mus	36.0	−69 01	2.70v	−0.20	B2 IV–V		−2.9	430	0.037	*+10*	Var. *R* 2.66–2.73
γ Cen *AB*	40.5	−48 51	2.17	+0.00	A0 IV	0.006	−0.5	160	0.197	−07.5	*A* 2.9^m *B* 2.9^m 2″
γ Vir *AB*	40.6	−01 20	2.76	+0.34	F0 V	0.101	+3.5	32	0.567	−19.7	*A* 3.50^m *B* 3.52^m 4″
β Mus *AB*	45.0	−68 00	3.06	−0.17:	B2 V		−2.1	470	0.041	+42	*A* 3.7^m *B* 4.0^m 1″
β Cru	46.6	−59 35	1.28v	−0.25	B0.5 III		−4.6	490	0.049	+20.0	β CMa var., 0.25^d: ***Beta Crucis***
ε UMa	53.2	+56 04	1.79v	−0.03	A0pv	0.008	+0.2	68	0.113	−09.3	Chromium-europium star *Alioth*
α CVn *A*	55.1	+38 26	2.90v	−0.10	B9.5pv	0.023	+0.1	118	0.238	*−03.3*	Silicon-europium star. *B* 5.61^m 20″ *Cor Caroli*
ε Vir	13 01.2	+11 05	2.83	+0.93	G9 II–III	0.036	+0.6	90	0.274	−14.0	
γ Hya	17.8	−23 04	2.98	+0.92	G8 III	0.021	+0.3	113	0.086	−05.4	
ι Cen	19.5	−36 36	2.76	+0.05	A2 V	0.046	+1.1	71	0.351	+00.1	
ζ UMa *A*	23.1	+55 02	2.26	+0.02	A2 V	0.037	+0.1	88	0.127	*−05.6*	*B* 3.94^m 14″ (Alcor, 708″) *Mizar*
α Vir	24.1	−11 03	0.91v	−0.24	B1 V	0.021	−3.3	220	0.054	*+01.0*	Ecl. *R* 0.91–1.01, 4.0^d, β CMa var., ***Spica***
ζ Vir	33.7	−00 30	3.37	+0.10	A3 Vn	0.035	+1.1	93	0.287	−13.2	
ε Cen	38.6	−53 22	2.33v	−0.23	B1 III		−3.9	570	0.033	+05.6	β CMa var., 0.17^d
η UMa	46.8	+49 25	1.87	−0.20	B3 V	0.004	−2.1	210	0.123	−10.9	*Alkaid*
ν Cen	48.3	−41 35	3.42	−0.22	B2 IV		−3.4	750	0.037	*+09.0*	
μ Cen	48.4	−42 23	3.12v	−0.13:	B2 V:pne		−2.7	470	0.032	+12.6	Var. *R* 3.08–3.17
η Boo	53.8	+18 30	2.69	+0.59	G0 IV	0.102	+2.7	32	0.370	*+01.0*	
ζ Cen	54.3	−47 12	2.56	−0.23:	B2.5 IV		−3.4	520	0.076	*+06.5*	

Star	R.A. 1980	Dec.	*V*	*B–V*	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
β Cen *AB*	14 02.4	−60 16	0.63v	−0.23:	B1 III	0.016	−5.2	490	0.035	*−12*	*A* 0.7^m *B* 3.9^m 1″, β CMa var.	***Hadar***
π Hya	05.3	−26 35	3.25	+1.13	K2 III	0.039	+1.2	84	0.156	+27.2		
θ Cen	05.5	−36 17	2.04	+1.03	K0 IIIb	0.059	+0.9	55	0.738	+01.3		*Menkent*
α Boo	14.8	+19 17	−0.06	+1.23	K2 IIIp	0.090	−0.3	36	2.284	−05.2		***Arcturus***
γ Boo	31.3	+38 24	3.05	+0.19	A7 III	0.016	+0.2	118	0.186	−35.5		
η Cen	34.2	−42 04	2.39v	−0.21	B1.5 V:ne		−3.0	390	0.049	−00.2	Var, *R* 2.33–2.45	
α Cen *A*	38.4	−60 46	0.01	+0.68	G2 V	.751	+4.39	4.3	3.676	−24.6	22″	***Rigil Kentaurus***
α Cen *B*	38.4	−60 46	1.40:	+0.73:	K4 V		+5.8	4.3		−20.7		
α Lup	40.7	−47 19	2.32v	−0.22	B1 V		−3.3	430	0.033	*+07.3*	β CMa var., 0.26^d	
α Cir *AB*	40.9	−64 53	3.18	+0.25	A8p	0.049	+1.6	66	0.308	+07.4	Strontium star. *A* 3.19^m *B* 8.61^m 16″	
ε Boo *AB*	44.1	+27 09	2.37	+0.96	K1: III:+A	0.013	+0.0	103	0.051	−16.5	*A* 2.47^m *B* 5.04^m 3″	
α Lib *A*	49.8	−15 54	2.76	+0.15	A3m	0.049	+1.2	66	0.130	−10	*B* 5.15^m 231″	*Zubenelgenubi*
β UMi	50.8	+74 14	2.07	+1.47	K4 III	0.031	−0.5	105	0.033	+16.9		*Kochab*
β Lup	57.3	−43 03	2.69	−0.23	B2 IV		−3.4	540	0.066	−00.3		
κ Cen	57.8	−42 01	3.15	−0.21	B2 V		−2.7	470	0.033	+09.1		
β Boo	15 01.2	+40 28	3.48	+0.95	G8 III	0.022	+0.3	140	0.059	−19.9		
σ Lib	02.9	−25 12	3.31	+1.65	M4 III	0.056	+2.0:	58:	0.089	−04.3		
ζ Lup *A*	10.8	−52 01	3.42	+0.90:	G8 III	0.036	+1.2	90	0.135	−09.7	*B* 7.8^m 71″	
δ Boo *A*	14.7	+33 24	3.47	+0.95	G8 III	0.028	+0.3	140	0.148	−12.2	*B* 7.84^m 105″	
β Lib	15.9	−09 18	2.61	−0.11	B8 V	−.012	−0.6	140	0.101	−35.2		
γ TrA	17.1	−68 36	2.89	+0.01	A0 IV	0.005	+0.2	113	0.067	−06	Europium star	
δ Lup	20.1	−40 34	3.21v	−0.23	B2 IV		−3.4	680	0.032	+02	β CMa var., 0.165^d	
γ UMi	20.8	+71 54	3.04	+0.06	A3 II–III	−.005	−1.5	270	0.026	*−03.9*		
ι Dra	24.5	+59 02	3.28	+1.18	K2 III	0.032	+0.8	102	0.012	−11.0		
γ Lup *AB*	33.8	−41 06	2.80	−0.22	B2 Vn		−2.7	570	0.037	*+06*	*A* 3.5^m *B* 3.7^m 1″	
α CrB	33.8	+26 47	2.23v	−0.02	A0 V	0.043	+0.4	76	0.154	*+01.7*	Ecl. *R* 0.11^m, 17.4^d	*Alphecca*
α Ser	43.3	+06 29	2.65	+1.17	K2 III	0.046	+1.0	71	0.139	+02.9		
β TrA	53.4	−63 22	2.84	+0.28:	F0 IV	0.078	+2.3	42	0.448	−00.3		
π Sco	57.6	−26 04	2.92	−0.19	B1 V	0.005	−3.3	570	0.034	*−03*		
η Lup *AB*	58.8	−38 21	3.40	−0.23	B2.5 IV		−2.7	570	0.042	+07	*A* 3.47^m *B* 7.70^m 15″	
δ Sco	59.2	−22 34	2.34	−0.13	B0 V		−4.0	590	0.032	−14		*Dschubba*

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Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
β Sco *AB*	16 04.3	−19 45	2.65	−0.09	B0.5 V	0.004	−3.7	650	0.027	*−01.0*	*A* 2.78^{m} *B* 5.04^{m} 1″, *C* 4.93^{m} 14″	
δ Oph	13.3	−03 37	2.72	+1.59	M1 III	0.029	−0.5	140	0.156	−19.9		
ε Oph	17.2	−04 39	3.22	+0.97	G9 III	0.036	+1.0	90	0.089	−10.3		
σ Sco *A*	20.0	−25 32	2.86v	+0.14	B1 III		−4.4	570	0.030	*+02.5*	β CMa *R* 2.82–2.90, 0.25^{d}, *B* 8.49^{m} 20″	
η Dra *A*	23.7	+61 33	2.71	+0.92	G8 III	0.043	+0.9	76	0.062	−14.3	*B* 8.7^{m} 6″	
α Sco *A*	28.2	−26 23	0.92v	+1.84	M1.5Iab +B2.5V	0.019	−5.1	520	0.029	−03.2	*A* 0.86^{m}–1.02^{m} *B* 5.07^{m} 3″	***Antares***
β Her	29.3	+21 32	2.78	+0.92	G8 III	0.017	+0.3	103	0.105	*−25.5*		
τ Sco	34.6	−28 10	2.85	−0.25	B0 V		−4.0	750	0.030	−00.7		
ζ Oph	36.1	−10 31	2.57	+0.00	O9.5 V	−.007	−4.3	520	0.022	*−19*		
ζ Her *AB*	40.6	+31 38	2.81	+0.64	G0 IV	0.110	+3.1	30	0.608	*−69.9*	*A* 2.91^{m} *B* 5.46^{m} 1″	
η Her	42.2	+38 58	3.46	+0.92	G7 III–IV	0.053	+2.1	62	0.097	+08.3		
α TrA	46.5	−68 60	1.93	+1.43	K2 Ib	0.024	−0.1	82	0.044	−03.6		***Atria***
ε Sco	48.8	−34 16	2.28	+1.16	K2 IIIb	0.049	+0.7	66	0.664	−02.5		
μ^{1} Sco	50.5	−38 01	2.99v	−0.20	B1.5 IV+B		−3.0	520	0.033	*−25*	Ecl. *R* 2.99–3.09, 1.4^{d}	
κ Oph	56.8	+09 25	3.18	+1.15	K2 III	0.026	−0.1	150	0.293	−55.6		
ζ Ara	56.9	−55 57	3.12	+1.61	K4 III	0.036	+0.9	90	0.042	−06.0		
ζ Dra	17 08.7	+65 44	3.20	−0.12	B6 III	0.017	−3.2	620	0.026	−14.1		
η Oph *AB*	09.3	−15 42	2.43	+0.06	A2.5 V	0.047	+1.4	69	0.097	−00.9	*A* 3.0^{m} *B* 3.4^{m} 1″	***Sabik***
η Sco	10.7	−43 13	3.33	+0.38	F2 III	0.063	+2.3	52	0.293	−28.4		
α Her *AB*	13.8	+14 24	3.10v	+1.41	M5 II	−.007	−2.3	410	0.032	−33.1	*A* 3.2^{m} ± 0.3 *B* 5.4^{m} 5″	***Ras-Algethi***
δ Her	14.2	+24 51	3.14	+0.09	A3 IV	0.034	+0.8	96	0.164	−41		
π Her	14.3	+36 49	3.13	+1.43	K3 II	0.020	−2.4	410	0.029	−25.7		
θ Oph	20.8	−24 59	3.29v	−0.22	B2 IV		−3.4	710	0.025	*−03.6*	β CMa var., 0.14^{d}	
β Ara	23.6	−55 31	2.90:	+1.45:	K1.5 Ib	0.026	−4.6	1030	0.035	−00.4		
γ Ara *A*	23.8	−56 22	3.32	−0.16:	B1 Ib		−3.3	680	0.017	−04	*B* 10^{m} 18″	
υ Sco	29.4	−37 16	2.71	−0.22	B2 IV		−3.4	540	0.039	*+07*		
β Dra *A*	29.9	+52 20	2.77	+0.96	G2 II	0.009	−2.1	310	0.019	−20.0	*B* 11.49^{m} 4″	
α Ara	30.3	−49 52	2.95	−0.18:	B2.5 V		−2.4	390	0.083	*−02*		
λ Sco	32.3	−37 05	1.60v	−0.24	B1.5 IV		−3.3	310	0.031	00	β CMa var., 0.21^{d}	***Shaula***
α Oph	34.0	+12 35	2.09	+0.16	A5 III	0.056	+0.8	58	0.260	+12.7		***Rasalhague***
θ Sco	35.9	−42 59	1.86	+0.39	F0 II	0.020	−4.6	650	0.012	+01.4		

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/s	
κ Sco	17 41.1	−39 01	2.39v	−0.21	B1.5 III		−3.4	470	0.031	*−10*	β CMa var., 0.20^d
β Oph	42.5	+04 35	2.77	+1.16	K2 III	0.023	−0.1	124	0.160	−12.0	
μ Her *A*	45.7	+27 45	3.42	+0.75	G5 IV	0.108	+3.6	30	0.811	−15.6	*BC* 9.78^m 33″
ι¹ Sco	46.2	−40 06	3.02	+0.49	F2 Ia	0.013	−7.1	3400	0.004	*−27.6*	
G Sco	48.4	−37 02	3.21	+1.18	K2 III	0.032	+0.7	102	0.064	+24.7	
γ Dra	56.1	+51 29	2.21	+1.52	K5 III	0.017	−0.4	108	0.026	−27.6	*Eltanin*
ν Oph	58.0	−09 47	3.32	+1.00	G9 III	0.015	+0.2	140	0.118	+12.4	
γ Sgr	18 04.5	−30 26	2.97	+1.00	K0 III	0.018	+0.1	124	0.200	*+22.1*	
η Sgr *A*	16.3	−36 47	3.12	+1.55	M3 III	0.038	+1.1:	86:	0.218	+00.5	*B* 10^m 4″
δ Sgr	19.7	−29 50	2.71	+1.39	K2.5 IIIa	0.039	+0.7	84	0.050	−20.0	
η Ser	20.2	−02 54	3.23	+0.94	K0 III–IV	0.054	+1.9	60	0.894	+08.9	
ε Sgr	22.9	−34 24	1.81	−0.02	B9.5 III	0.015	−1.1	124	0.135	−11	*Kaus Australis*
λ Sgr	26.7	−25 27	2.80	+1.05	K1 III	0.046	+1.1	71	0.194	−43.3	
α Lyr	36.2	+38 46	0.04	0.00	A0 V	0.123	+0.5	26.5	0.345	−13.9	***Vega***
φ Sgr	44.4	−27 01	3.20	−0.11	B8.5 II–III		−3.1	590	0.052	+21.5	
β Lyr *A*	49.4	+33 21	3.38v	−0.05:	B5pe shell+A	−.011	−4.6	1300	0.007	*−17.8*	Ecl. *R* 3.38–4.36, 12.9^d, *B* 7.8^m 46″
σ Sgr	54.0	−26 19	2.12:	−0.21	B2.5 V		−2.7	300	0.059	−11	*Nunki*
ξ² Sgr	56.5	−21 07	3.51	+1.18:	K1 III	0.006	+0.0	160	0.035	−19.9	
γ Lyr	58.2	+32 40	3.25	−0.05	B9 III	0.011	−2.1	370	0.007	−21.5	
ζ Sgr *AB*	19 01.3	−29 54	2.61	+0.08	A3 IV	0.020	+0.1	140	0.020	+22	*A* 3.3^m *B* 3.5^m < 1″
ζ Aql *A*	04.5	+13 50	2.99	+0.01	A0 V:nn	0.036	+0.8	90	0.101	−26.3	*B* 12^m 5″
λ Aql	05.2	−04 55	3.44	−0.10	B9 V:n	0.025	−0.1	160	0.092	−14	
τ Sgr	05.7	−27 42	3.30	+1.18	K1.5 III	0.038	+1.2	86	0.261	*+45.4*	
π Sgr *ABC*	08.6	−21 03	2.89	+0.35	F2 II–III	0.016	−0.7	250	0.040	−09.8	*A* 3.7^m *B* 3.8^m *C* 6.0^m < 1″
δ Dra	12.5	+67 38	3.06	+1.00	G9 III	0.028	+0.2	124	0.130	+24.8	
δ Aql	24.5	+03 04	3.38	+0.31	F0 IV	0.062	+2.3	53	0.267	*−29.9*	
β Cyg *A*	29.9	+27 55	3.07	+1.12	K3 II:+B:	0.004	−2.4	410	0.009	−24.0	*B* 5.11^m 35″ *Albireo*
δ Cyg *AB*	44.3	+45 05	2.87	−0.03	B9.5 III	0.021	−1.7	270	0.060	−21	*A* 2.91^m *B* 6.44^m 2″
γ Aql	45.3	+10 33	2.72	+1.52	K3 II	0.006	−2.4	340	0.012	−02.1	
α Aql	49.8	+08 49	0.77	+0.22	A7 IV–V	0.198	+2.2	16.5	0.658	−26.3	***Altair***

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/s		
θ Aql	20 10.3	−00 52	3.24	−0.07	B9.5 III	0.008	−1.7	330	0.034	*−27.3*		
β Cap *A*	19.9	−14 51	3.06	+0.76	K2III+A5:V	0.005	+0.1	130	0.039	−18.9	Type gK0: + late B; *B* 5.97^m 205″	
γ Cyg	21.5	+40 11	2.22	+0.66	F8 Ib	−.006	−4.6	750	0.001	−07.5		
α Pav	24.1	−56 48	1.95	−0.20	B2.5 V		−2.9	310	0.087	*+02.0*		*Peacock*
α Ind	36.2	−47 21	3.11	+1.00	K0 III CN-1	0.039	+1.1	84	0.082	−01.1		
α Cyg	40.7	+45 12	1.26	+0.09	A2 Ia	−.013	−7.1	1600	0.003	*−04.6*		***Deneb***
β Pav	43.2	−66 17	3.45	+0.16	A7 III	0.026	−0.1	160	0.046	+09.8		
η Cep	44.9	+61 45	3.41	+0.92	K0 IV	0.071	+2.7	46	0.825	−87.3		
ε Cyg	45.4	+33 53	2.46	+1.03	K0 III	0.044	+0.7	74	0.481	*−10.3*		
ζ Cyg	21 12.1	+30 08	3.19	+1.00	G8 II	0.021	−2.2	390	0.056	+17.4		
α Cep	18.2	+62 31	2.44	+0.24	A7 IV–V	0.063	+1.4	52	0.156	−10		*Alderamin*
β Cep	28.4	+70 28	3.15v	−0.22v	B2 III	0.005	−4.2	980	0.014	*−03.1*	β CMa *R* 3.14–3.16, 0.19^d	
β Aqr	30.5	−05 40	2.86	+0.82	G0 Ib	0.000	−4.6	1030	0.017	+06.5		
ε Peg *A*	43.2	+09 48	2.38	+1.55	K2 Ib	−.005	−4.6	780	0.025	+04.7	*B* 11^m 82″	*Enif*
δ Cap	45.9	−16 13	2.92v	+0.29	A6m	0.065	+2.0	50	0.392	*−00.2*	Var. *R* 2.88–2.95	
γ Gru	52.7	−37 27	3.00	−0.10	B8 III	0.008	−3.1	540	0.102	−02.1		
α Aqr	22 04.7	−00 25	2.93	+0.96	G2 Ib	0.003	−4.6	1080	0.016	+07.5		
α Gru	06.9	−47 04	1.76	−0.14	B7 IV	0.051	+0.3:	64:	0.194	+11.8		*Al Na'ir*
ζ Cep	10.1	+58 06	3.36	+1.59	K1 Ib	0.019	−4.6	1240	0.015	*−18.4*		
α Tuc	17.1	−60 21	2.87	+1.40	K4 III	0.019	+1.5	62	0.079	*+42.2*		
δ Cep *A*	28.5	+58 19	3.96v	+0.66v	F5–G2 Ib	0.005	−4.0	1300	0.012	*−16.8*	Cep. *R* 3.51–4.42, 5.4^d, *B* 6.19^m 41″	
ζ Peg	40.5	+10 44	3.40	−0.08:	B8 V	−.004	−0.6	210	0.077	+07		
β Gru	41.5	−46 59	2.17v	+1.59	M5 III	0.003	−2.5	280	0.134	+01.6	Var. *R* 2.11–2.23	
η Peg	42.1	+30 07	2.95	+0.85	G8 II: + F?	−.002	−2.2	360	0.027	*+04.3*		
δ Aqr	53.6	−15 56	3.28	+0.08	A3 V	0.039	+1.2	84	0.047	+18.0		
α PsA	56.5	−29 44	1.15	+0.10	A3 V	0.144	+2.0	22.6	0.367	+06.5		***Fomalhaut***
β Peg	23 02.8	+27 58	2.5 v	+1.67	M2 II–III	0.015	−1.5	210	0.234	+08.7	Var. *R* 2.4–2.7	*Scheat*
α Peg	03.8	+15 05	2.50	−0.03	B9.5 III	0.030	−0.1	109	0.071	−03.5		*Markab*
γ Cep	38.5	+77 30	3.20	+1.02	K1 IV	0.064	+2.2	51	0.168	−42.4		

THE NEAREST STARS

By Alan H. Batten

The accompanying table lists all the stars known to be within a distance of just over 5 parsecs (or 17 light-years) from the Sun. The table is based on the list published by Prof. P. van de Kamp in the 1971 edition of *Annual Reviews of Astronomy and Astrophysics*, but has been further revised at his suggestion. There are five systems in this Table not listed by van de Kamp: two (L725-32 and B.D. 44°2051) have been included for several years now, the other three (G51-15, G208-44 and 45, and G9-38A and B) are all objects for which parallaxes have recently been determined with the 155 cm astrometric reflector of the U.S. Naval Observatory in Flagstaff, Arizona. One disadvantage of updating the list in this way is that it loses some of the homogeneity of van de Kamp's original. As more refined values of the parallaxes become available, the order of some of the stars in the list is likely to be changed, and some now included may be excluded. In particular, the last system in the list, G9-38, is just beyond the limit of 17 light-years. It has been included because it is an interesting system and an example of some of the surprises that may still be in store for us as faint nearby stars are examined with the powerful astrometric reflector. Moreover, its right to inclusion is no more in doubt than those of some other systems, notably Stein 2051 and B.D. 44°2051, above it in the list. Readers who have earlier issues of the HANDBOOK will notice that some stars are now designated by their numbers in familiar catalogues such as the B.D. instead of by older and little used designations. There should be no difficulty in identifying the stars under their new names.

Successive columns of the table give the name of each star, its position for 1980, its annual parallax π, its distance in light years, its spectral type, its proper motion in seconds of arc per year (that is its apparent motion across the sky—nearby stars usually have large proper motions), its total space velocity W in km/s when known, its apparent magnitude V, and its absolute visual magnitude M_v. Spectral types have not yet been determined for the newest stars in the list: all of those stars are very red and they will probably be found to be of type M. Luminosity classes have not been given because all the stars are dwarfs or fainter. An *e* after the spectral type indicates that emission lines are visible in the spectrum; the prefix *wd* indicates a white dwarf or analogous object. Apparent magnitudes given to two decimals are photoelectric V magnitudes. Those given to one decimal are the best available visual magnitudes. The magnitudes of stars known to be variable are bracketed. A major change from earlier versions of the table is the substitution of the stars' absolute visual magnitudes for their luminosities relative to the Sun. To convert the new quantities to the old, one would have to take into account the bolometric corrections—poorly determined for very red stars—and convert the magnitudes to intensity ratios. The brightest star in the list, Sirius A, is about 23 times the Sun's luminosity, and the faintest, Wolf 359, is about 50,000 times less luminous than the Sun. Data like proper motion and space velocity are not given separately for the components of multiple systems, unless each component has a somewhat different motion. The space velocities and many of the magnitudes have been taken from Gliese's *Catalogue of Nearby Stars*, and differ somewhat from the figures published in earlier years.

Measuring the distances of stars is one of the most difficult and important jobs of an observational astronomer. As the Earth travels around the Sun each year, the positions of the nearer stars, against the background of the more distant ones, changes very slightly. This change is called *annual parallax*, and even for the nearest star to the Sun it is less than the apparent size of a penny at about 4 km distance. Ultimately all our knowledge of distances in the universe depends on our being able to measure these tiny apparent displacements accurately, for a relatively small sample of nearby stars. A graphic way of conveying the immense distances of stars is to express them in *light-years*. One light-year, about ten million million km, is the distance light travels in one year. The more useful technical unit is a *parsec*—the distance at which a star would have an annual parallax of one second of arc. One parsec is equal to about 3.26 light years. The distance of a star in parsecs is simply the reciprocal of its annual parallax expressed (as in the table) in seconds of arc.

The list contains 68 stars. Of these, 34 are single (including the Sun, whose planets are not counted); 28 are found in 14 double systems (including the pair G208-44 and 45), and 6 are found in 2 triple systems. In addition, there is some evidence for unseen companions, that might be intermediate in mass between stars and planets, associated with seven of these stars. Not all astronomers are agreed, however, on the strength of this evidence. Note how nearly all the stars in the list are very faint cool stars of low mass. Highly luminous stars are very rare, and no giants or very hot massive stars are to be found in the solar neighbourhood.

Name	1980 α		1980 δ		π	D	Sp.	μ	W	V	M_v
	h	m	°	′	″	l.y.		″	km/s		
Sun							G2			−26.72	+4.85
α Cen A	14	38	−60	46	0.760	4.3	G2	3.68	32	−0.01	4.39
B							K4			1.33	5.73
C	14	28	−62	36			M5e	3.85	29	11.05	15.45
Barnard's*	17	56	+04	36	.552	5.9	M5	10.61	140	9.54	13.25
Wolf 359	10	56	+07	10	.431	7.6	M8e	4.71	54	13.53	16.70
BD+36°2147*	11	03	+36	07	.402	8.1	M2e	4.78	102	7.50	10.52
Sirius A	6	44	−16	42	.377	8.6	A1	1.33	19	−1.46	1.42
B							*wd*A			8.7	11.6
Luy 726−8A	1	37	−18	04	.365	8.9	M5e	3.36	52	12.5	15.3
B							M5e		54	(13.0)	(15.8)
Ross 154	18	49	−23	50	.345	9.4	M5e	0.72	11	10.6	13.3
Ross 248	23	40	+44	04	.317	10.3	M6e	1.58	84	12.29	14.80
ε Eri	3	32	−09	32	.305	10.7	K2e	0.98	23	3.73	6.15
Luy 789−6	22	38	−15	28	.302	10.8	M7e	3.26	79	12.18	14.58
Ross 128	11	47	+00	58	.301	10.8	M5	1.37	25	11.10	13.49
61 Cyg A	21	06	+38	38	.292	11.2	K5e	5.22	105	5.22	7.55
B*							K7e			6.03	8.36
ε Ind	22	03	−56	52	.291	11.2	K8e	4.69	86	4.68	7.00
Procyon A	7	39	+05	17	.287	11.4	F5	1.25	21	0.37	2.66
B							*wd*F			10.7	12.99
Σ 2398 A	18	42	+59	36	.284	11.5	M4	2.28	39	8.90	11.17
B							M5			9.69	11.96
BD+43°44A	0	18	+43	54	.282	11.6	M1e	2.89	50	8.07	10.32
B							M6e		53	11.04	13.29
CD−36°15693	23	05	−35	59	.279	11.7	M2e	6.90	118	7.36	9.59
τ Ceti	1	43	−16	03	.273	11.9	G8p	1.92	36	3.50	5.68
G51−15	8	29	+26	51	.273	12.0		0.42		14.81	16.99
BD+5°1668*	7	27	+05	27	.266	12.2	M5	3.73	71	9.82	11.94
Luy 725−32	1	11	−17	06	.262	12.5	M5e	1.31	52	11.6	13.7
CD−39°14192	21	16	−38	58	.260	12.6	M0e	3.46	67	6.67	8.75
Kapteyn's	5	11	−44	59	.256	12.7	M0	8.89	293	8.81	10.85
Krüger 60A	22	27	+57	36	.254	12.8	M3	0.86	30	9.85	11.87
B							M4.5e			(11.3)	(13.3)
Ross 614A	6	28	−02	48	.249	13.1	M7e	0.99	30	11.07	13.05
B										14.8	16.8
BD−12°4523	16	30	−12	36	.249	13.1	M5	1.18	26	10.12	12.10
van Maanen's	0	48	+05	19	.234	13.9	*wd*G	2.95	59	12.37	14.22
Wolf 424A	12	33	+09	09	.229	14.2	M6e	1.75	37	13.16	14.96
B							M6e			13.4	15.2
G158−27	0	06	−07	38	.226	14.4		2.06		13.73	15.50
CD−37°15492	0	04	−37	27	.225	14.5	M4	6.08	130	8.63	10.39
BD+50°1725	10	10	+49	33	.217	15.0	K7e	1.45	40	6.59	8.27
CD−46°11540	17	28	−46	53	.216	15.1	M4	1.13		9.36	11.03
CD−49°13515	21	32	−49	11	.214	15.2	M1	0.81	20	8.67	10.32
CD−44°11909*	17	37	−44	17	.213	15.3	M5	1.16		11.2	12.8
G208−44	19	53	+44	21	.213	15.3		0.75		13.41	15.05
Luy 1159−16	1	59	+13	00	.212	15.4	M8e	2.08		12.27	13.90
BD+15°2620	13	44	+15	01	.208	15.7	M4e	2.30	56	8.50	10.09
G208−45	19	53	+44	21	.207	15.8	M5	0.63		13.99	15.57
BD+68°946	17	37	+68	22	.207	15.8	M4	1.33	36	9.15	10.73
Luy 145−141	11	44	−64	42	.206	15.9	*wd*	2.68		11.44	13.01
BD−15°6290	22	52	−14	22	.206	15.9	M5	1.16	28	10.17	11.74
o^2 Eri A	4	14	−07	41	.205	15.9	K1e	4.08	104	4.43	5.99
B							*wd*A			9.53	11.09
C							M4e			11.17	12.73
BD+20°2465*	10	19	+19	58	.202	16.1	M4e	0.49	16	9.43	10.96
BD+44°2051A	11	05	+43	36	.199	16.4	M2e	4.40	132	8.77	10.26
B							M8e			(14.5)	(16.0)
Altair*	19	49	+08	49	.196	16.6	A7	0.66	31	0.76	2.22
70 Oph A	18	05	+02	31	.195	16.7	K0e	1.13	28	4.22	5.67
B							K5e			6.0	7.5
AC+79°3888	11	46	+78	47	.194	16.8	M4	0.89	121	10.9	12.3
BD+43°4305*	22	46	+44	14	.193	16.9	M5e	0.83	20	10.2	11.6
Stein 2051A	4	30	+58	57	.192	17.0	M4	2.37		11.09	12.51
B							*wd*			12.44	13.86
G9−38A	8	57	+19	51	.190	17.2		0.89		14.06	15.45
B								0.79		14.92	16.31

*Suspected unseen companion.

DOUBLE AND MULTIPLE STARS

By Charles E. Worley

Many stars can be separated into two or more components by use of a telescope. The larger the aperture of the telescope, the closer the stars which can be separated under good seeing conditions. With telescopes of moderate size and good optical quality, and for stars which are not unduly faint or of large magnitude difference, the minimum angular separation in seconds of arc is given by 120/D, where D is the diameter of the telescope's objective in millimetres.

The following lists contain some interesting examples of double stars. The first list presents pairs whose orbital motions are very slow. Consequently, their angular separations remain relatively fixed and these pairs are suitable for testing the performance of small telescopes. In the second list are pairs of more general interest, including a number of binaries of short period for which the position angles and separations are changing rapidly.

In both lists the columns give, successively: the star designation in two forms; its right ascension and declination for 1980; the combined visual magnitude of the pair and the individual magnitudes; the apparent separation and position angle for 1983.0; and the period, if known. (The position angle is the angular direction of the fainter star from the brighter, measured counterclockwise from north.)

Many of the components are themselves very close visual or spectroscopic binaries. (Other double stars appear in the tables of Nearest Stars and Brightest Stars. For more information about observing these stars, see the articles by: J. Ashbrook in *Sky and Telescope*, **60**, 379 (1980); J. Meeus in *Sky and Telescope*, **41**, 21 and 89 (1971); and by C. E. Worley in *Sky and Telescope*, **22**, 73, 140 and 261 (1961). The latter two articles have been reprinted by Sky Publishing Corp., 49 Bay State Road, Cambridge, Mass. 02238 under the titles *Some Bright Visual Binary Stars* and *Visual Observing of Double Stars*, each $1.95 U.S.—Ed.)

Star		A.D.S.	R.A. 1980.0 h	m	Dec. 1980.0 °	′	Magnitudes comb.	A	B	P.A. 1983.0 °	Sep. 1983.0 ″	P (app.) years
λ	Cas	434	00	30.7	+54	26	4.9	5.5	5.8	184	0.6	640
α	Psc	1615	02	01.0	+02	40	4.0	4.3	5.3	279	1.7	720
33	Ori	4123	05	30.2	+03	16	5.7	6.0	7.3	27	1.8	—
OΣ	156	5447	06	46.3	+18	13	6.1	6.8	7.0	239	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	259	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	166	1.1	500
Σ	2054	10052	16	23.6	+61	44	5.6	6.0	7.2	355	1.1	—
ϵ^1	Lyr†	11635	18	43.7	+39	38	5.1	5.4	6.5	355	2.7	1200
ϵ^2	Lyr†	11635	18	43.7	+39	38	4.4	5.1	5.3	83	2.3	600
π	Aql	12962	19	47.7	+11	45	5.6	6.0	6.8	110	1.4	—
61	Cyg	14636	21	05.5	+38	34	4.8	5.2	6.0	146	29.4	722
OΣ	500	16877	23	36.5	+44	20	5.9	6.4	7.1	355	0.5	—
η	Cas	671	00	47.7	+57	44	3.5*	3.5	7.2	309	12.1	480
Σ	186	1538	01	54.8	+01	45	6.0	6.8	6.8	55	1.4	170
γ	And AB	1630	02	02.4	+42	16	2.1*	2.1	5.1	64	9.8	—
γ	And BC	1630	02	02.4	+42	16	5.1	5.5	6.3	108	0.6	61
OΣ	65	2799	03	49.2	+25	32	5.2	5.8	6.2	208	0.6	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	41	9.2	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	87	2.4	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	257	0.7	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	80	5.9	1150
σ^2	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	1	3.3	1100
γ	Leo	7724	10	18.9	+19	57	1.8	2.1	3.4	123	4.3	620
ξ	UMa	8119	11	17.1	+31	39	3.8	4.3	4.8	97	2.6	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	294	3.7	170
ζ	Boo	9343	14	40.1	+13	49	3.8	4.5	4.5	304	1.1	125
ξ	Boo	9413	14	50.4	+19	12	4.5	4.7	6.8	331	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	122	1.4	35
τ	Oph	11005	18	01.9	−08	11	4.7	5.2	5.9	278	1.8	280
70	Oph	11046	18	04.5	+02	32	4.0	4.2	6.0	302	2.3	88
δ	Cyg	12880	19	44.4	+45	04	2.9*	2.9	6.3	232	2.4	830
4	Aqr	14360	20	50.4	−05	53	6.0	6.4	7.2	11	0.9	150
τ	Cyg	14787	21	13.9	+37	57	3.7	3.8	6.4	123	0.7	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	300	1.7	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	220	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	313	1.6	350

*There is a marked colour difference between the components.

†The separation of the two pairs of ϵ Lyr is 208″.

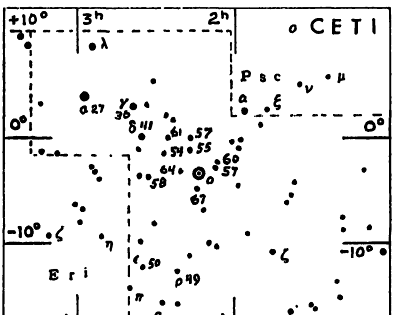
VARIABLE STARS

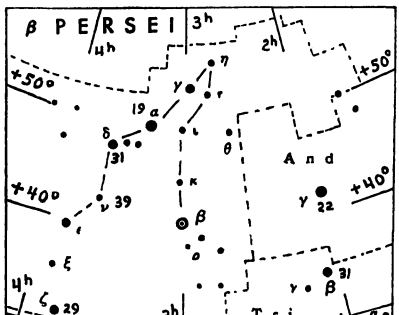
By Janet Mattei

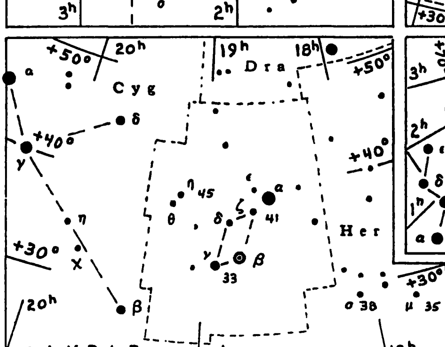
Variable stars provide information about many stellar properties. Depending upon their type, variables can tell the mass, radius, temperature, luminosity, internal and external structure, composition, and the evolution of stars. The systematic observation of variable stars is an area in which an amateur astronomer can make a significant contribution to astronomy. For a beginning observer, maps of an interesting variable, Z Ursae Majoris, and the steps involved in observing variable stars are summarized on pages 149–151. Additional maps of four other bright variables of different types are given below.

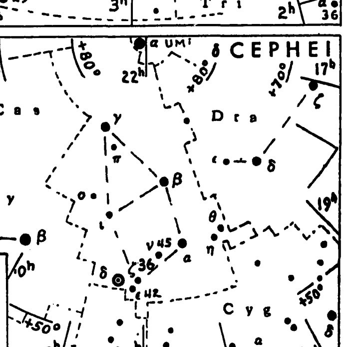
On the next page are two tables. The first is a list of long-period variables and has been prepared by the American Association of Variable Star Observers. It includes variables with maxima brighter than magnitude 8.0, and north of declination −20°. The second table contains stars which are representative of other types of variables.

In the tables the first column, the Harvard designation of the star, gives the 1900 position: the first four figures give the hours and minutes of R.A., the last two figures give the Dec. in degrees, italicised for southern declinations. The column headed *Max.* gives the mean maximum magnitude. The *Period* is in days. The *Epoch* gives the predicted date of the *earliest* maximum occurring this year; by adding the period to this epoch other dates of maximum may be found. The long-period variables may reach maximum two or three weeks before or after the listed epoch and may remain at maximum for several weeks. The data in the second table are taken from the third edition and the *Second Supplement* of the third edition of "*The General Catalogue of Variable Stars*" by Kukarkin and Parenago and for the eclipsing binaries and RR Lyrae variables from *Rocznik Astronomiczny Obserwatorium Krakowskiego 1982, International Supplement.*









LONG-PERIOD VARIABLE STARS

Variable	Max. m_v	Per d	Epoch 1983	Variable	Max. m_v	Per d	Epoch 1983
001755 T Cas	7.8	445	June 24	142539 V Boo	7.9	258	Aug. 7
001838 R And	7.0	409	Oct. 17	143227 R Boo	7.2	223	Mar. 12
021143 W And	7.4	397	June 18	151731 S CrB	7.3	361	Jan. 1
0214*03* o Cet	3.4	332	June 13	154639 V CrB	7.5	358	Aug. 12
0228*13* U Cet	7.5	235	Mar. 31	154615 R Ser	6.9	357	July 4
023133 R Tri	6.2	266	June 4	160625 RU Her	8.0	484	Feb. 18
043065 T Cam	8.0	374	Dec. 4	162119 U Her	7.5	406	Feb. 28
0455*14* R Lep	6.8	432	July 30	1621*12* V Oph	7.5	298	Feb. 16
050953 R Aur	7.7	459	Feb. 28	163266 R Dra	7.6	245	July 3
054920 U Ori	6.3	372	Oct. 25	164715 S Her	7.6	307	Jan. 21
0617*02* V Mon	7.0	335	Nov. 1	1702*15* R Oph	7.9	302	July 3
065355 R Lyn	7.9	379	Aug. 1	171723 RS Her	7.9	219	Mar. 15
070122aR Gem	7.1	370	Aug. 15	180531 T Her	8.0	165	May 15
070310 R CMi	8.0	338	Feb. 23	181136 W Lyr	7.9	196	May 20
072708 S CMi	7.5	332	Sept. 3	183308 X Oph	6.8	334	Mar. 14
081112 R Cnc	6.8	362	Dec. 5	190108 R Aql	6.1	300	Apr. 25
081617 V Cnc	7.9	272	Feb. 16	1910*17* T Sgr	8.0	392	Dec. 3
084803 S Hya	7.8	257	Aug. 31	1910*19* R Sgr	7.3	269	June 17
0850*08* T Hya	7.8	288	June 27	193449 R Cyg	7.5	426	Apr. 21
093934 R LMi	7.1	372	May 17	194048 RT Cyg	7.3	190	Jan. 15
094211 R Leo	5.8	313	Mar. 21	194632 χ Cyg	5.2	407	Apr. 14
103769 R UMa	7.5	302	Sept. 17	201647 U Cyg	7.2	465	May 29
1214*18* R Crv	7.5	317	Oct. 21	2044*05* T Aqr	7.7	202	Feb. 6
122001 SS Vir	6.8	355	Feb. 3	210868 T Cep	6.0	390	Jan. 21
123160 T UMa	7.7	257	Feb. 6	213753 RU Cyg	8.0	234	Mar. 12
123307 R Vir	6.9	146	Mar. 26	230110 R Peg	7.8	378	Apr. 11
123961 S UMa	7.8	226	Aug. 4	230759 V Cas	7.9	228	June 29
131546 V CVn	6.8	192	May 14	231508 S Peg	8.0	319	Oct. 22
1327*06* S Vir	7.0	378	Apr. 9	2338*15* R Aqr	6.5	387	Apr. 15
134440 R CVn	7.7	328	Aug. 2	235350 R Cas	7.0	431	—
142584 R Cam	7.9	270	Aug. 21	2357*15* W Cet	7.6	351	Nov. 28

OTHER TYPES OF VARIABLE STARS

Variable		Max. m_v	Min. m_v	Type	Sp. Cl.	Period d	Epoch 1983 U.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 2.39*
025838	ρ Per	3.3	4.0	Semi R	M4	33–55, 1100	—
030140	β Per	2.1	3.3	Ecl.	B8+G	2.86731	—
035512	λ Tau	3.5	4.0	Ecl.	B3	3.952952	Jan. 4.69*
060822	η Gem	3.1	3.9	Semi R	M3	233.4	—
061907	T Mon	5.6	6.6	δ Cep	F7–K1	27.0205	Jan. 16.58
065820	ζ Gem	3.6	4.2	δ Cep	F7–G3	10.15082	Jan. 4.41
154428	R Cr B	5.8	14.8	R Cr B	cFpep		—
171014	α Her	3.0	4.0	Semi R	M5	50–130, 6 yrs.	—
1842*05*	R Sct	5.0	7.0	RVTau	G0e-K0p	144	—
184633	β Lyr	3.4	4.3	Ecl.	B8	12.93538	Jan. 7.89*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.566867	Jan. 1.50
194700	η Aql	3.5	4.3	δ Cep	F6–G4	7.176641	Jan. 8.02
222557	δ Cep	3.5	4.4	δ Cep	F5–G2	5.366341	Jan. 3.25

*Minimum.

BRIEF DESCRIPTION OF VARIABLE TYPES

Variable stars are divided into four main classes: Pulsating and eruptive variables where variability is intrinsic due to physical changes in the star or stellar system; eclipsing binary and rotating stars where variability is extrinsic due to an eclipse of one star by another or the effect of stellar rotation. A brief and general description about the major types in each class is given below.

I. *Pulsating Variables*

Cepheids: Variables that pulsate with periods from 1 to 70 days. They have high luminosity and the amplitude of light variation ranges from 0.1 to 2 magnitudes. The prototypes of the group are located in open clusters and obey the well known period-luminosity relation. They are of F spectral class at maximum and G to K at minimum. The later the spectral class of a Cepheid the longer is its period. Typical representative: δ Cephei.

RR Lyrae Type: Pulsating, giant variables with periods ranging from 0.05 to 1.2 days with amplitude of light variation between 1 and 2 magnitudes. They are usually of A spectral class. Typical representative: RR Lyrae.

RV Tauri Type: Supergiant variables with characteristic light curve of alternating deep and shallow minima. The periods, defined as the interval between two deep minima, range from 30 to 150 days. The amplitude of light variation may be as much as 3 magnitudes. Many show long term cyclic variation of 500 to 9000 days. Generally the spectral classes range from G to K. Typical representative: R Scuti.

Long period—Mira Ceti variables: Giant variables that vary with amplitudes from 2.5 to 5 magnitudes or more. They have well defined periodicity, ranging from 80 to 1000 days. They show characteristic emission spectra of late spectral classes of M, C, and S. Typical representative: o Ceti (Mira).

Semiregular Variables: Giants and supergiants showing appreciable periodicity accompanied by intervals of irregularities of light variation.The periods range from 30 to 1000 days with amplitudes not more than 1 to 2 magnitudes in general. Typical representative: R Ursae Minoris.

Irregular Variables: Stars that at times show only a trace of periodicity or none at all. Typical representative: RX Leporis.

II. *Eruptive Variables*

Novae: Close binary systems consisting of a normal star and a white dwarf that increase 7 to 16 magnitudes in brightness in a matter of 1 to several hundreds of days. After the outburst, the star fades slowly until the initial brightness is reached in several years or decades. Near maximum brightness, the spectrum is generally similar to A or F giants. Typical representative: CP Puppis (Nova 1942).

Supernovae: Brightness increases 20 or more magnitudes due to a gigantic stellar explosion. The general appearance of the light curve is similar to novae. Typical representative: CM Tauri (Supernova of A.D. 1054 and the central star of the Crab Nebula).

R Coronae Borealis Type: Highly luminous variables that have non-periodic drops in brightness from 1 to 9 magnitudes, due to the formation of "carbon soot" in the stars' atmosphere. The duration of minima varies from a few months to years. Members of this group have F to K and R spectral class. Typical representative: R Coronae Borealis.

U Geminorum Type: Dwarf novae that have long intervals of quiescence at minimum with sudden rises to maximum. Depending upon the star, the amplitude of eruptions range from 2 to 6 magnitudes, and the duration between outbursts ten to thousands of days. Most of these stars are spectroscopic binaries with periods of few hours. Typical representative: SS Cygni.

Z Camelopardalis Type: Variables similar to U Gem stars in their physical and spectroscopic properties. They show cyclic variations interrupted by intervals of constant brightness (stillstands) lasting for several cycles, approximately one third of the way from maximum to minimum. Typical representative: Z Camelopardalis.

III. *Eclipsing Binaries*

Binary system of stars with the orbital plane lying near the line of sight of the observer. The components periodically eclipse each other, causing decrease in light in the apparent brightness of the system, as is seen and recorded by the observer. The period of the eclipses coincides with the period of the orbital motion of the components. Typical representative: β Persei (Algol).

IV. *Rotating Variables*

Rapidly rotating stars, usually close binary systems, which undergo small amplitude changes in light that may be due to dark or bright spots on their stellar surface. Eclipses may also be present in such systems. Typical representative: R Canum Venaticorum.

OBSERVING VARIABLE STARS

This year, instead of introducing a "star of the year" to our readers, we will summarize the steps involved in observing variable stars.

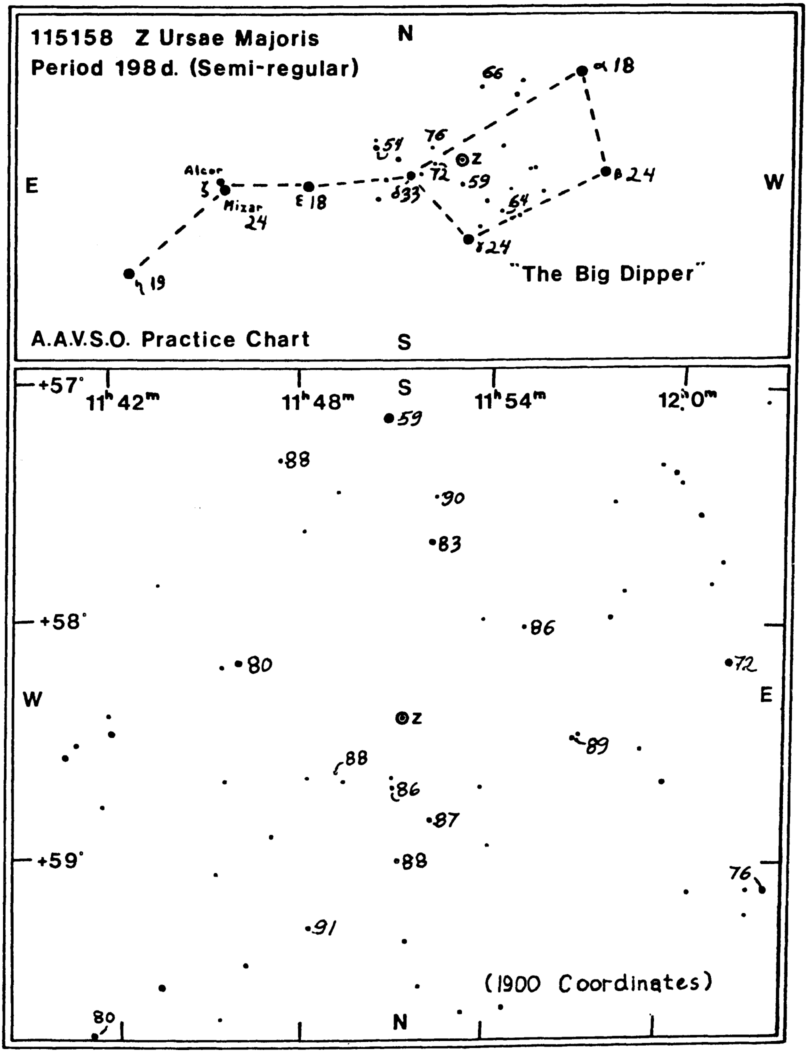
The first step is to acquaint oneself with the sky and the constellations. For this a good atlas is necessary (see page 169). Next obtain an instrument – a telescope or even a good pair of binoculars – for observing. The most popular telescope used by variable star observers is a short focus (f/5 to f/8) Newtonian reflector with an aperture of 150 mm or more. The next step is to obtain suitable star finding charts. The AAVSO supplies charts for all the variables in its observing program. The last and very important step is perseverance and determination to succeed, as locating and observing variable stars is a learned skill.

Before attempting to locate a variable star, the observer should know the angular diameter of each of the eyepieces in order to tell how much of the star charts will be covered. To determine this, point the telescope at a star near the celestial equator, not far from the meridian, then note the number of seconds or minutes required for the star to cross the field diameter. Finally multiply either number by 15 to obtain the width of the field in seconds or minutes of arc, respectively. This procedure should also be carried out for the telescope's finder.

The interesting, northern circumpolar, semiregular variable *Z Ursae Majoris* is particularly well suited for the beginning observer with a small telescope or binoculars. Its proximity to several bright "key" stars makes it very easy to identify and to observe. (This variable was introduced to our readers in the 1978 *Observer's Handbook*.) Below are two finder charts of different scales for Z UMa. The top chart covering the whole Big Dipper region should be used in locating the approximate position of Z UMA with the naked eye. The bottom chart covering the close vicinity of the variable should be used for telescopic observing. Notice the orientation of the two charts. South is up in the lower chart, since when observing through a Newtonian telescope star fields are seen upside down. The stars are represented with different size dots, indicating their relative brightness. The numbers next to some stars (comparison stars) are magnitudes. The decimal point is omitted in order not to confuse it with a star image. The number – 115158 – on the upper left-hand corner of the chart is the Harvard designation of Z UMa.

Find the Big Dipper in the northern sky and identify the stars in it with the naked eye. Find the 3.3 magnitude star Delta Ursae Majoris and aim your telescope to it. Center it in your finder and finally in the eyepiece of your telescope. Now move the telescope from one distinctive group of stars to another (star hopping); find formations like squares, triangles, etc., and point your way to the variable which is shown on the chart as ⊙. Next allow the stars to drift from east to west across the field of the eyepiece, thereby establishing the cardinal directions. This is important in order to orient your chart.

Once in the field of Z UMa bring the variable and the various comparison stars successively to the center of your field and get a mental image of their brightness. Select two comparison stars, one brighter and one fainter than Z UMa. Let us assume that the brightness of Z UMa is somewhere between 8.0 and 8.3 magnitudes. You will then be using the 8.0 and 8.3 comparison stars. First bring the 8.0 comparison star to the center of the field and glance at it quickly. Repeat with Z UMa and then with the 8.3 comparison star. If the brightness of the variable is closer to that of 8.0, but not as bright, report it as 8.1. If it is closer to 8.3, but not as faint, report it as 8.2. Record the night of your observation in double date, for example April 13–14, 1981 Monday. Record observing conditions, especially the transparency, the cloud cover,



the presence of moonlight, as well as any changes in these conditions. For each Observation enter the Harvard designation and the name of the variable, the time to the minute and the kind of time (Eastern Standard, Universal, etc.,), the magnitude estimate, and the comparison stars used.

An AAVSO observing report form with an observation of Z UMa made on April 13–14, 1981 at 9:30 PM Eastern Standard Time is shown below. The date of the observation has been converted to Julian Date. This is particularly convenient in graphing light curves. For variables such as Z UMa which do not vary rapidly, reporting the time to a tenth of a day is sufficient.

The AAVSO welcomes carefully made observations of variable stars from observers worldwide. Further information, charts, Julian Date calendars, decimal of the day tables, and observing report forms may be obtained from the AAVSO at 187 Concord Avenue, Cambridge, Massachusetts, 02138, U.S.A.

VARIABLE STAR OBSERVATIONS
For
THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

Report No. . 1 . Sheet .1. of . 1 .
For Month of . April . . . 19 81
Observer . . J. Doe. . . . .
Street . Starlane Drive . . . .
City . Moonlight . State Vermont Zip . . .
Time Used, G.M.A.T., or. . . . E.S.T. . . .
Instrument . . 2 1/4 refractor . . . . .

DO NOT WRITE HERE
Recd. . . . .
Pltd. . . . .
Ackd. . . . .
Posted. . . . .
Ledgd . . . .

DESIGNATION	VARIABLE	JUL.DAY&DEC.	MAGN.	DESIGNATION	VARIABLE	JUL.DAY&DEC.	MAGN.
115158	Z UMa	2444708.6	8.1				
TOTAL NUMBER OF STARS OBSERVED				TOTAL NUMBER OBSERVATIONS			

Observations should be sent to Headquarters, 187 Concord Avenue, Cambridge, Mass. 02138, as soon as possible, after the first of each month.

STAR CLUSTERS

By Anthony Moffat

The study of star clusters is crucial for the understanding of stellar structure and evolution. It is generally believed that the stars seen in a given cluster formed nearly simultaneously from the same parent cloud of gas and dust; thus, the basic factor which distinguishes one star from another is the quantity of matter each contains. Comparing one cluster with another, it is essentially only the age and the chemical composition of their stars that differ. But what makes one cluster *appear* different from another in the sky is mainly the degree of concentration and regularity, the spread in magnitude and colour of the member stars, all of which vary mainly with age, and the total number of stars. Extremely young clusters are often irregular in shape with clumps of newly formed stars, pervaded by lanes of obscuring dust and bright nebulosity, while the oldest clusters, if they were fortunate enough not to have already dissipated or been torn apart by external forces, tend to be symmetric in shape, with only the slower-burning, low-mass stars left for us to appreciate; the massive stars will have spent their nuclear fuel and passed to the degenerate graveyard of white dwarfs, neutron stars, or black holes depending on their original mass.

The star clusters in the lists below were selected as the most conspicuous. Two types can be recognized: open and globular. Open clusters often appear as irregular aggregates of tens to thousands of stars, sometimes barely distinguishable from random fluctuations of the general field; they are concentrated toward the Galactic disk and generally contain stars of chemical abundance like the Sun. They range in age from very young to very old.

Globular clusters on the other hand are highly symmetric, extremely old agglomerations of up to several million stars, distributed throughout the Galactic halo but concentrated toward the centre of the Galaxy. Compared to the Sun, they tend to be much less abundant in elements heavier than hydrogen and helium.

The first table includes all well-defined Galactic open clusters with diameters greater than 40′ and/or integrated magnitudes brighter than 5.0, as well as the richest clusters and some of special interest. The apparent integrated photographic magnitude is from Collinder, the angular diameter is generally from Trumpler, and the photographic magnitude of the fifth-brightest star, m_5, is from Shapley, except where in italics, which are new data. The distance is mainly from Becker and Fenkart (*Astr. Astrophys. Suppl.* **4**, 241 (1971)). The earliest spectral type of cluster stars, Sp, is a measure of the age as follows: expressed in millions of years, 05 = 2, B0 = 8, B5 = 70, A0 = 400, A5 = 1000, F0 = 3000 and F5 = 10000.

The second table includes all globular clusters with a total apparent photographic magnitude brighter than about 7.5. The data are taken from a compilation by Arp (*Galactic Structure*, ed. Blaauw and Schmidt, U. Chicago 1965), supplemented by H. S. Hogg's Bibliography (*Publ. David Dunlap Obs.* **2**, No. 12, 1963). The apparent diameter given contains 90% of the stars, except values in italics which are from miscellaneous sources. The concentration class is such that I is the most compact, XII is least. The integrated spectral type varies mainly with the abundances, and m(25) refers to the mean blue magnitude of the 25 brightest stars excluding the 5 brightest, which are liable to fluctuate more. The number of variables known in the cluster is also given.

Open Clusters

NGC or other†	R.A. 1980 h m	Dec. 1980 ° ′	Int. m_{pg}	Diam. ′	m_5	Dist. 1000 l.y.	Sp	Remarks
188	00 42.0	+85 14	9.3	14	14.6	5.0	F2	Oldest known
752	01 56.6	+37 35	6.6	45	9.6	1.2	A5	
869	02 17.6	+57 04	4.3	30	9.5	7.0	B1	h Per
884	02 21.0	+57 02	4.4	30	9.5	8.1	B0	χ Per, M supergiants
Perseus	03 21	+48 32	2.3	240	5	0.6	B1	Moving cl.; α Per
Pleiades	03 45.9	+24 04	1.6	120	4.2	0.41	B6	M45, best known
Hyades	04 19	+15 35	0.8	400	*1.5*	0.13	A2	Moving cl.**, in Taurus
1912	05 27.3	+35 49	7.0	18	9.7	4.6	B5	M38
1976/80	05 34.4	−05 24	2.5	50	*5.5*	1.3	O5	Trapezium, very young
2099	05 51.1	+32 32	6.2	24	9.7	4.2	B8	M37
2168	06 07.6	+24 21	5.6	29	9.0	2.8	B5	M35
2232	06 25.5	−04 44	4.1	*20*	*7*	1.6	B1	
2244	06 31.3	+04 53	5.2	27	*8.0*	5.3	O5	Rosette, very young
2264	06 39.9	+09 54	4.1	30	*8.0*	2.4	O8	S Mon
2287	06 46.2	−20 43	5.0	32	*8.8*	2.2	B4	M41
2362	07 18.0	−24 54	3.8	7	9.4	5.4	O9	τ CMa
2422	07 34.7	−14 27	4.3	30	9.8	1.6	B3	
2437	07 40.9	−14 46	6.6	27	10.8	5.4	B8	M46
2451	07 44.7	−37 55	3.7	37	6	1.0	B5	
2516	07 58.0	−60 51	3.3	50	10.1	1.2	B8	
2546	08 11.8	−37 35	5.0	45	7	2.7	B0	
2632	08 39.0	+20 04	3.9	90	7.5	0.59	A0	Praesepe, M44
IC2391	08 39.7	−52 59	2.6	45	3.5	0.5	B4	
IC2395	08 40.4	−48 07	4.6	20	10.1	2.9	B2	
2682	08 49.3	+11 54	7.4	18	10.8	2.7	F2	M67, very old
3114	10 02.0	−60 01	4.5	37	7	2.8	B5	
IC2602	10 42.6	−64 17	1.6	65	6	0.5	B1	θ Car
Tr 16	10 44.4	−59 36	6.7	10	10	9.6	O3	η Car and Nebula
3532	11 05.5	−58 33	3.4	55	8.1	1.4	B8	
3766	11 35.2	−61 30	4.4	12	8.1	5.8	B1	
Coma	12 24.1	+26 13	2.9	300	5.5	0.3	A1	Very sparse
4755	12 52.4	−60 13	5.2	12	7	6.8	B3	κ Cru, "jewel box"
6067	16 11.7	−54 10	6.5	16	10.9	4.7	B3	G, K supergiants
6231	16 52.6	−41 46	8.5	16	7.5	5.8	O9	O supergiants, WR stars
Tr 24	16 55.6	−40 38	8.5	60	*7.3*	5.2	O5	
6405	17 38.8	−32 12	4.6	26	8.3	1.5	B4	M6
IC4665	17 45.7	+05 44	5.4	50	7	1.1	B8	
6475	17 52.6	−34 48	3.3	50	7.4	0.8	B5	M7
6494	17 55.7	−19 01	5.9	27	10.2	1.4	B8	M23
6523	18 01.9	−24 23	5.2	45	*7*	5.1	O5	M8, Lagoon Neb.
6611	18 17.8	−13 48	6.6	8	10.6	5.5	O7	M16, nebula
IC4725	18 30.5	−19 16	6.2	35	9.3	2.0	B3	M25, Cepheid U Sgr
IC4756	18 38.3	+05 26	5.4	50	8.5	1.4	A3	
6705	18 50.0	−06 18	6.8	12.5	12	5.6	B8	M11, very rich
Mel 227	20 08.2	−79 23	5.2	60	*9*	0.8	B9	
IC1396	21 38.3	+57 25	5.1	60	*8.5*	2.3	O6	Tr 37
7790	23 57.4	+61 06	7.1	4.5	11.7	10.3	B1	Cepheids CEa, CEb and CF Cas

†IC = Index Catalogue; Tr = Trumpler; Mel = Melotte.
**basic for distance determination.

GLOBULAR CLUSTERS

NGC	M or other	R.A. 1980 h m	Dec. 1980 ° ′	Int. m_{pg}	Diam. ′	Conc.	Int. Sp. T.	m(25)	No. Var.	Dist. 1000 l.y.
104	47 Tuc	00 23.1	−72 11	4.35	*44*	III	G3	13.54	11	16
1851*		05 13.3	−40 02	7.72	*11.5*	II	F7		3	46
2808		09 11.5	−64 42	7.4	*18.8*	I	F8	15.09	4	30
5139	ω Cen	13 25.6	−47 12	4.5	*65.4*	VIII	F7	13.01	165	17
5272	3	13 41.3	+28 29	6.86	9.3	VI	F7	14.35	189	35
5904	5	15 17.5	+02 10	6.69	10.7	V	F6	14.07	97	26
6121	4	16 22.4	−26 28	7.05	22.6	IX	*G0*	13.21	43	14
6205	13	16 41.0	+36 30	6.43	12.9	V	F6	13.85	10	21
6218	12	16 46.1	−01 55	7.58	21.5	IX	F8	14.07	1	24
6254	10	16 56.0	−04 05	7.26	16.2	VII	G1	14.17	3	20
6341*	92	17 16.5	+43 10	6.94	12.3	IV	F1	13.96	16	26
6397		17 39.2	−53 40	6.9	*19*	IX	F5	12.71	3	9
6541		18 06.5	−43 45	7.5	*23.2*	III	F6	13.45	1	13
6656	22	18 35.1	−23 56	6.15	26.2	VII	F7	13.73	24	10
6723		18 58.3	−36 39	7.37	11.7	VII	G4	14.32	19	24
6752		19 09.1	−60 01	6.8	*41.9*	VI	F6	13.36	1	17
6809	55	19 38.8	−30 59	6.72	21.1	XI	F5	13.68	6	20
7078*	15	21 29.1	+12 05	6.96	9.4	IV	F2	14.44	103	34
7089	2	21 32.4	−00 55	6.94	6.8	II	F4	14.77	22	40

*Compact X-ray sources were discovered in these clusters in 1975.

NEBULAE

GALACTIC NEBULAE

By René Racine

The following objects were selected from the brightest and largest of the various classes to illustrate the different types of interactions between stars and interstellar matter in our galaxy. *Emission regions* (HII) are excited by the strong ultraviolet flux of young, hot stars and are characterized by the lines of hydrogen in their spectra. *Reflection nebulae* (Ref) result from the diffusion of starlight by clouds of interstellar dust. At certain stages of their evolution stars become unstable and explode, shedding their outer layers into what becomes a *planetary nebula* (Pl) or a *supernova remnant* (SN). Protostellar nebulae (PrS) are objects still poorly understood; they are somewhat similar to the reflection nebulae, but their associated stars, often variable, are very luminous infrared stars which may be in the earliest stages of stellar evolution. Also included in the selection are four *extended complexes* (Compl) of special interest for their rich population of dark and bright nebulosities of various types. In the table S is the optical surface brightness in magnitude per square second of arc of representative regions of the nebula, and m* is the magnitude of the associated star.

			α 1980	δ			S		Dist.	
NGC	M	Con	h m	° ′	Type	Size ′	mag. sq″	m *	10^3 l.y.	Remarks
650/1	76	Per	01 40.9	+51 28	Pl	1.5	20	17	15	
IC348		Per	03 43.2	+32 07	Ref	3	21	8	0.5	Nebulous cluster
1435		Tau	03 46.3	+24 01	Ref	15	20	4	0.4	Merope nebula
1535		Eri	04 13.3	−12 48	Pl	0.5	17	12		
1952	1	Tau	05 33.3	+22 05	SN	5	19	16v	4	"Crab" + pulsar
1976	42	Ori	05 34.3	−05 25	HII	30	18	4	1.5	Orion nebula
1999		Ori	05 35.5	−06 45	PrS	1		10v	1.5	
ζOri		Ori	05 39.8	−01 57	Comp	2°			1.5	Incl. "Horsehead"
2068	78	Ori	05 45.8	+00 02	Ref	5	20		1.5	
IC443		Gem	06 16.4	+22 36	SN	40			2	
2244		Mon	06 31.3	+04 53	HII	50	21	7	3	Rosette neb.
2247		Mon	06 32.1	+10 20	PrS	2	20	9	3	
2261		Mon	06 38.0	+08 44	PrS	2		12v	4	Hubble's var. neb.
2392		Gem	07 28.0	+20 57	Pl	0.3	18	10	10	Clown face neb.
3587	97	UMa	11 13.6	+55 08	Pl	3	21	13	12	Owl nebula
ρOph		Oph	16 24.4	−23 24	Comp	4°			0.5	Bright + dark neb.
θOph		Oph	17 20.7	−24 59	Comp	5°				Incl. "S" neb.
6514	20	Sgr	18 01.2	−23 02	HII	15	19		3.5	Trifid nebula
6523	8	Sgr	18 02.4	−24 23	HII	40	18		4.5	Lagoon nebula
6543		Dra	17 58.6	+66 37	Pl	0.4	15	11	3.5	
6611	16	Ser	18 17.8	−13 48	HII	15	19	10	6	
6618	17	Sgr	18 19.7	−16 12	HII	20	19		3	Horseshoe neb.
6720	57	Lyr	18 52.9	+33 01	Pl	1.2	18	15	5	Ring nebula
6826		Cyg	19 44.4	+50 28	Pl	0.7	16	10	3.5	
6853	27	Vul	19 58.6	+22 40	Pl	7	20	13	3.5	Dumb-bell neb.
6888		Cyg	20 11.6	+38 21	HII	15				
γCyg		Cyg	20 21.5	+40 12	Comp	6°				HII + dark neb.
6960/95		Cyg	20 44.8	+30 38	SN	150			2.5	Cygnus loop
7000		Cyg	20 58.2	+44 14	HII	100	22		3.5	N. America neb.
7009		Aqr	21 03.0	−11 28	Pl	0.5	16	12	3	Saturn nebula
7023		Cep	21 01.4	+68 05	Ref	5	21	7	1.3	
7027		Cyg	21 06.4	+42 09	Pl	0.2	15	13		
7129		Cep	21 42.5	+65 00	Ref	3	21	10	2.5	Small cluster
7293		Aqr	22 28.5	−20 54	Pl	13	22	13		Helix nebula
7662		And	23 25.0	+42 25	Pl	0.3	16	12	4	

THE MESSIER CATALOGUE

By Alan Dyer

The Messier Catalogue, with its modern additions, represents a listing of many of the brightest and best deep-sky wonders. The following table lists the Messier objects by season for the *evening observer*, grouping the objects within their respective constellations, with the constellations themselves listed roughly in order of increasing right ascension, i.e., constellations further to the east and which rise later in the night are further down the list.

The columns contain: Messier's number (M); the constellation; the object's New General Catalogue (NGC) number; the type of object (OC = open cluster, GC = globular cluster, PN = planetary nebula, EN = emission nebula, RN = reflection nebula, SNR = supernova remnant, G = galaxy (with the type of galaxy also listed); the 1980 co-ordinates; the visual magnitude (unless marked with a "p" which indicates a photographic magnitude). The "Remarks" column contains comments on the object's appearance and observability. The final column, marked "Seen", is for the observer to use in checking off those objects which he or she has located. An asterisk in the "Type" column indicates that additional information about the object may be found elsewhere in the HANDBOOK, in the appropriate table. Most data are from the Skalnate Pleso *Atlas of the Heavens* catalogue; occasionally from other sources.

All these objects can be seen in a small telescope (60 mm refractor, for instance), with M74 and M83 generally considered to be the most difficult. The most southerly M-objects are M6 and M7 in Scorpius, with M54, M55, M69, and M70 in Sagittarius almost as far south. Notice how different classes of objects dominate the skies of the various seasons: open clusters dominate the winter sky; galaxies by the hundreds abound in the spring sky; the summer sky contains many globular clusters and nebulae; while the autumn sky is a mixture of clusters and galaxies. This effect is due to the presence (or absence) of the Milky Way in any particular season, and whether or not we are looking toward the centre of the Galaxy (as in summer) or away from the centre (as in winter).

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
The Winter Sky				h m ° ′			
1	Tau	1952	SNR*	5 33.3 +22 01	8.4	Crab Neb.; supernova remnant	
45	Tau	—	OC*	3 46.3 +24 03	1.4	Pleiades; RFT object	
36	Aur	1960	OC	5 35.0 +34 05	6.3	best at low magnification	
37	Aur	2099	OC*	5 51.5 +32 33	6.2	finest of 3 Aur. clusters	
38	Aur	1912	OC	5 27.3 +35 48	7.4	large, scattered group	
42	Ori	1976	EN*	5 34.4 −05 24	—	Orion Nebula	
43	Ori	1982	EN	5 34.6 −05 18	—	detached part of Orion Neb.	
78	Ori	2068	RN	5 45.8 +00 02	—	featureless reflection neb.	
79	Lep	1904	GC	5 23.3 −24 32	8.4	20 cm scope needed to resolve	
35	Gem	2168	OC*	6 07.6 +24 21	5.3	superb open cluster	
41	CMa	2287	OC*	6 46.2 −20 43	5.0	4°S. of Sirius; use low mag.	
50	Mon	2323	OC	7 02.0 −08 19	6.9	between Sirius and Procyon	
46	Pup	2437	OC*	7 40.9 −14 46	6.0	rich cl.; contains PN NGC 2438	
47	Pup	2422	OC	7 35.6 −14 27	4.5	coarse cl.; 1.5°W. of M46	
93	Pup	2447	OC	7 43.6 −23 49	6.0	smaller, brighter than M46	
48	Hya	2548	OC	8 12.5 −05 43	5.3	former "lost" Messier object	
The Spring Sky							
44	Cnc	2632	OC*	8 38.8 +20 04	3.7	Beehive Cl.; RFT object	
67	Cnc	2682	OC*	8 50.0 +11 54	6.1	"ancient" star cluster	
40	UMa	—	—	12 34.4 +58 20	9.0	two stars; sep. 50″	
81	UMa	3031	G-Sb*	9 54.2 +69 09	7.9	very bright spiral	
82	UMa	3034	G-Pec*	9 54.4 +69 47	8.8	the "exploding" galaxy	
97	UMa	3587	PN*	11 13.7 +55 08	12.0	Owl Nebula	

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
101	UMa	5457	G-Sc*	14 02.5 +54 27	9.6	large, faint, face-on spiral	
108	UMa	3556	G-Sc	11 10.5 +55 47	10.7	nearly edge-on; near M97	
109	UMa	3992	G-Sb	11 56.6 +53 29	10.8	barred spiral; near γ UMa	
65	Leo	3623	G-Sb	11 17.8 +13 13	9.3	bright elongated spiral	
66	Leo	3627	G-Sb	11 19.1 +13 07	8.4	M65 in same field	
95	Leo	3351	G-SBb	10 42.8 +11 49	10.4	bright barred spiral	
96	Leo	3368	G-Sbp	10 45.6 +11 56	9.1	M95 in same field	
105	Leo	3379	G-E1	10 46.8 +12 42	9.2	very near M95 and M96	
53	Com	5024	GC	13 12.0 +18 17	7.6	15 cm scope needed to resolve	
64	Com	4826	G-Sb*	12 55.7 +21 48	8.8	Black Eye Galaxy	
85	Com	4382	G-SO	12 24.3 +18 18	9.3	bright elliptical shape	
88	Com	4501	G-Sb	12 30.9 +14 32	10.2	bright multiple-arm spiral	
91	Com	4548	G-SBb	12 34.4 +14 36	10.8	not the same as M58	
98	Com	4192	G-Sb	12 12.7 +15 01	10.7	nearly edge-on spiral	
99	Com	4254	G-Sc	12 17.8 +14 32	10.1	nearly face-on spiral	
100	Com	4321	G-Sc	12 21.9 +15 56	10.6	face-on spiral; star-like nuc.	
49	Vir	4472	G-E4*	12 28.8 +08 07	8.6	very bright elliptical	
58	Vir	4579	G-SB	12 36.7 +11 56	9.2	bright barred spiral	
59	Vir	4621	G-E3	12 41.0 +11 47	9.6	bright elliptical near M58	
60	Vir	4649	G-E1	12 42.6 +11 41	8.9	bright elliptical near M59	
61	Vir	4303	G-Sc	12 20.8 +04 36	10.1	face-on barred spiral	
84	Vir	4374	G-E1	12 24.1 +13 00	9.3	bright elliptical	
86	Vir	4406	G-E3	12 25.1 +13 03	9.7	M84 in same field	
87	Vir	4486	G-E1	12 29.7 +12 30	9.2	nearly spherical galaxy	
89	Vir	4552	G-E0	12 34.6 +12 40	9.5	resembles M87; smaller	
90	Vir	4569	G-Sb	12 35.8 +13 16	10.0	bright spiral; near M89	
104	Vir	4594	G-Sb*	12 38.8 −11 31	8.7	Sombrero Galaxy	
3	CVn	5272	GC*	13 41.3 +28 29	6.4	contains many variables	
51	CVn	5194	G-Sc*	13 29.0 +47 18	8.1	Whirlpool Galaxy	
63	CVn	5055	G-Sb*	13 14.8 +42 08	9.5	Sunflower Galaxy	
94	CVn	4736	G-Sbp*	12 50.1 +41 14	7.9	very bright and comet-like	
106	CVn	4258	G-Sbp*	12 18.0 +47 25	8.6	large, bright spiral	
68	Hya	4590	GC	12 38.3 −26 38	8.2	15 cm scope needed to resolve	
83	Hya	5236	G-Sc*	13 35.9 −29 46	10.1	very faint and diffuse	
102	Dra	5866	G-E6p	15 05.9 +55 50	10.8	small, edge-on galaxy	
5	Ser	5904	GC*	15 17.5 +02 11	6.2	one of the finest globulars	
The Summer Sky							
13	Her	6205	GC*	16 41.0 +36 30	5.7	spectacular globular cl.	
92	Her	6341	GC*	17 16.5 +43 10	6.1	9°NE. of M13; bright	
9	Oph	6333	GC	17 18.1 −18 30	7.3	smallest of Oph. globulars	
10	Oph	6254	GC*	16 56.0 −04 05	6.7	rich cl.; M12 3.4° away	
12	Oph	6218	GC*	16 46.1 −01 55	6.6	loose globular	
14	Oph	6402	GC	17 36.5 −03 14	7.7	20 cm scope needed to resolve	
19	Oph	6273	GC	17 01.3 −26 14	6.6	oblate globular	
62	Oph	6266	GC	16 59.9 −30 05	6.6	unsymmetrical; in rich field	
107	Oph	6171	GC	16 31.3 −13 02	9.2	small, faint globular	
4	Sco	6121	GC*	16 22.4 −26 27	6.4	bright globular near Antares	
6	Sco	6405	OC*	17 38.9 −32 11	5.3	best at low magnification	
7	Sco	6475	OC*	17 52.6 −34 48	3.2	excellent in binoculars	
80	Sco	6093	GC	16 15.8 −22 56	7.7	very compressed globular	
16	Ser	6611	EN*	18 17.8 −13 48	—	Star-Queen Neb. w/ open cl.	
8	Sgr	6523	EN*	18 02.4 −24 23	—	Lagoon Neb. w/cl. NGC 6530	
17	Sgr	6618	EN*	18 19.7 −16 12	—	Swan or Omega Nebula	
18	Sgr	6613	OC	18 18.8 −17 09	7.5	sparse cluster; 1°S. of M17	
20	Sgr	6514	EN*	18 01.2 −23 02	—	Trifid Nebula	
21	Sgr	6531	OC	18 03.4 −22 30	6.5	0.7°NE. of M20	
22	Sgr	6656	GC*	18 35.2 −23 55	5.9	low altitude dims beauty	
23	Sgr	6494	OC*	17 55.7 −19 00	6.9	bright, loose cluster	
24	Sgr	—	—	18 17 −18 27	4.6	Milky Way patch; binoc. obj.	
25	Sgr	I4725	OC*	18 30.5 −19 16	6.5	bright but sparse cluster	
28	Sgr	6626	GC	18 23.2 −24 52	7.3	compact globular near M22	
54	Sgr	6715	GC	18 53.8 −30 30	8.7p	not easily resolved	

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
55	Sgr	6809	GC*	19 38.7 −31 00	7.1p	bright, loose globular	
69	Sgr	6637	GC	18 30.1 −32 23	8.9	small, poor globular	
70	Sgr	6681	GC	18 42.0 −32 18	9.6	small globular; 2°E. of M69	
75	Sgr	6864	GC	20 04.9 −21 59	8.0	small, remote globular	
11	Sct	6705	OC*	18 50.0 −06 18	6.3	superb open cluster	
26	Sct	6694	OC	18 44.1 −09 25	9.3	bright, coarse cluster	
56	Lyr	6779	GC	19 15.8 +30 08	8.2	within rich field	
57	Lyr	6720	PN*	18 52.9 +33 01	9.3	Ring Nebula	
71	Sge	6838	GC	19 52.8 +18 44	9.0	loose globular cl.	
27	Vul	6853	PN*	19 58.8 +22 40	7.6	Dumbbell Nebula	
29	Cyg	6913	OC	20 23.3 +38 27	7.1	small, poor open cl.	
39	Cyg	7092	OC	21 31.5 +48 21	5.2	very sparse cluster	
The Autumn Sky							
2	Aqr	7089	GC*	21 32.4 −00 54	6.3	20 cm scope needed to resolve	
72	Aqr	6981	GC	20 52.3 −12 39	9.8	near NGC 7009 (Saturn Neb.)	
73	Aqr	6994	OC	20 57.8 −12 44	11.0	group of 4 stars only	
15	Peg	7078	GC*	21 29.1 +12 05	6.0	rich, compact globular	
30	Cap	7099	GC	21 39.2 −23 15	8.4	noticeable elliptical shape	
52	Cas	7654	OC	23 23.3 +61 29	7.3	young, rich cluster	
103	Cas	581	OC	01 31.9 +60 35	7.4	3 NGC clusters nearby	
31	And	224	G-Sb*	00 41.6 +41 09	4.8	Andromeda Gal.; large	
32	And	221	G-E2*	00 41.6 +40 45	8.7	companion gal. to M31	
110	And	205	G-E6*	00 39.1 +41 35	9.4	companion gal. to M31	
33	Tri	598	G-Sc*	01 32.8 +30 33	6.7	large, diffuse spiral	
74	Psc	628	G-Sc	01 35.6 +15 41	10.2	faint, elusive spiral	
77	Cet	1068	G-Sbp	02 41.6 +00 04	8.9	Seyfert gal.; star-like nuc.	
34	Per	1039	OC	02 40.7 +42 43	5.5	best at very low mag.	
76	Per	650	PN*	01 40.9 +51 28	12.2	Little Dumbbell Neb.	

NUMERICAL LISTING OF MESSIER OBJECTS

M	Sky	Con	M	Sky	Con	M	Sky	Con	M	Sky	Con	M	Sky	Con
1	Wi	Tau	23	Su	Sgr	45	Wi	Tau	67	Sp	Cnc	89	Sp	Vir
2	Au	Aqr	24	Su	Sgr	46	Wi	Pup	68	Sp	Hya	90	Sp	Vir
3	Sp	CVn	25	Su	Sgr	47	Wi	Pup	69	Su	Sgr	91	Sp	Com
4	Su	Sco	26	Su	Sct	48	Wi	Hya	70	Su	Sgr	92	Su	Her
5	Sp	Ser	27	Su	Vul	49	Sp	Vir	71	Su	Sge	93	Wi	Pup
6	Su	Sco	28	Su	Sgr	50	Wi	Mon	72	Au	Aqr	94	Sp	CVn
7	Su	Sco	29	Su	Cyg	51	Sp	CVn	73	Au	Aqr	95	Sp	Leo
8	Su	Sgr	30	Au	Cap	52	Au	Cas	74	Au	Psc	96	Sp	Leo
9	Su	Oph	31	Au	And	53	Sp	Com	75	Su	Sgr	97	Sp	UMa
10	Su	Oph	32	Au	And	54	Su	Sgr	76	Au	Per	98	Sp	Com
11	Su	Sct	33	Au	Tri	55	Su	Sgr	77	Au	Cet	99	Sp	Com
12	Su	Oph	34	Au	Per	56	Su	Lyr	78	Wi	Ori	100	Sp	Com
13	Su	Her	35	Wi	Gem	57	Su	Lyr	79	Wi	Lep	101	Sp	UMa
14	Su	Oph	36	Wi	Aur	58	Sp	Vir	80	Su	Sco	102	Sp	Dra
15	Au	Peg	37	Wi	Aur	59	Sp	Vir	81	Sp	UMa	103	Au	Cas
16	Su	Ser	38	Wi	Aur	60	Sp	Vir	82	Sp	UMa	104	Sp	Vir
17	Su	Sgr	39	Su	Cyg	61	Sp	Vir	83	Sp	Hya	105	Sp	Leo
18	Su	Sgr	40	Sp	UMa	62	Su	Oph	84	Sp	Vir	106	Sp	CVn
19	Su	Oph	41	Wi	CMa	63	Sp	CVn	85	Sp	Com	107	Su	Oph
20	Su	Sgr	42	Wi	Ori	64	Sp	Com	86	Sp	Vir	108	Sp	UMa
21	Su	Sgr	43	Wi	Ori	65	Sp	Leo	87	Sp	Vir	109	Sp	UMa
22	Su	Sgr	44	Sp	Cnc	66	Sp	Leo	88	Sp	Com	110	Au	And

The abbreviations are: Wi, winter; Sp, spring; Su, summer; Au, autumn.

Footnote to Messier Catalogue: The identifications of M91 and M102 are controversial; some believe that these two objects are duplicate observations of M58 and M101 respectively. Also, objects M104 to M110 are not always included in the standard version of the Messier Catalogue. Like many other objects in the catalogue, they were discovered by Mechain and reported to Messier for verification and inclusion in the catalogue.

THE FINEST N.G.C. OBJECTS + 20

BY ALAN DYER

The New General Catalogue of deep-sky objects was originally published by J. L. E. Dreyer in 1888. Supplementary Index Catalogues were published in 1895 and 1908. Together, they contain descriptions and positions of 13,226 galaxies, clusters and nebulae. Many of these are well within reach of amateur telescopes. Indeed, the brightness and size of many NGC objects rival those of the better known deep-sky targets of the Messier Catalogue (almost all of which are also in the NGC catalogue). However, most NGC objects are more challenging to locate and observe than the Messiers.

The first four sections of the following list contain 110 of the finest NGC objects that are visible from mid-northern latitudes. The arrangement is similar to that used in the preceding Messier Catalogue. A telescope of at least 15 cm aperture will likely be required to locate all these objects. The last section is for those wishing to begin to extend their deep-sky observing program beyond the basic catalogue of Charles Messier or the brightest objects of the New General Catalogue. It is a selected list of 20 "challenging" objects, and is arranged in order of right ascension.

The *Wil Tirion Sky Atlas 2000.0*, the sets of index card finder charts called *AstroCards*, or the *AAVSO Variable Star Atlas* will be indispensible in locating the objects on this list. For more information about them, and many other deep-sky objects, see *Burnham's Celestial Handbook* (Vol. 1, 2, 3), and the *Webb Society Deep-Sky Observer's Handbooks*.

Abbreviations used: OC = open cluster, GC = globular cluster, PN = planetary nebula, EN = emission nebula, RN = reflection nebula, E/RN = combination emission and reflection nebula, DN = dark nebula, SNR = supernova remnant, G = galaxy (the Hubble classification is also listed with each galaxy). Magnitudes are visual; exceptions are marked with a "p" indicating a photographic magnitude. Sizes of each object are in minutes of arc, with the exception of planetary nebulae which are given in seconds of arc. The number of stars (*) and, where space permits, the Shapley classification is also given for star clusters in the Remarks column.

No.	NGC	Con	Type	R.A. (1950)	Dec.	m_v	Size	Remarks
The Autumn Sky				h m	° ′			
1	7009	Aqr	PN	21 01.4	−11 34	9.1	44″ × 26″	Saturn Nebula; bright oval planetary
2	7293	Aqr	PN	22 27.0	−21 06	6.5	900″ × 720″	Helix Nebula; very large and diffuse
3	7331	Peg	G-Sb	22 34.8	+34 10	9.7	10.0 × 2.3	large, very bright spiral galaxy
4	7789	Cas	OC	23 54.5	+56 26	9.6	30	200*; faint but very rich cluster
5	185	Cas	G-EO	00 36.1	+48 04	11.7	2.2 × 2.2	companion to M31; quite bright
6	281	Cas	EN	00 50.4	+56 19	—	22 × 27	large, faint nebulosity near γ Cas.
7	457	Cas	OC	01 15.9	+58 04	7.5	10	100*; Type e—intermediate rich
8	663	Cas	OC	01 42.6	+61 01	7.1	11	80*; NGC 654 and 659 nearby
9	7662	And	PN	23 23.5	+42 14	9.2	32″ × 28″	star-like at low mag.; annular, bluish
10	891	And	G-Sb	02 19.3	+42 07	10.9p	11.8 × 1.1	faint, classic edge-on with dust lane
11	253	Scl	G-Scp	00 45.1	−25 34	8.9	24.6 × 4.5	very large and bright but at low alt.
12	772	Ari	G-Sb	01 56.6	+18 46	10.9	5.0 × 3.0	diffuse spiral galaxy
13	936	Cet	G-SBa	02 25.1	−01 22	10.7	3.3 × 2.5	near M77; NGC 941 in same field
14a	869	Per	OC	02 15.5	+56 55	4.4	36	Double Cluster; superb!
14b	884	Per	OC	02 18.9	+56 53	4.7	36	Double Cluster; superb!
15	1023	Per	G-E7p	02 37.2	+38 52	10.5p	4.0 × 1.2	bright, lens-shaped galaxy; near M34
16	1491	Per	EN	03 59.5	+51 10	—	3 × 3	small, fairly bright emission nebula
17	1501	Cam	PN	04 02.6	+60 47	12.0	56″ × 58″	faint, distinctive oval; darker centre
18	1232	Eri	G-Sc	03 07.5	−20 46	10.7	7.0 × 5.5	fairly bright, large face-on spiral
19	1300	Eri	G-SBb	03 17.5	−19 35	11.3	5.7 × 3.5	large barred spiral near NGC 1232
20	1535	Eri	PN	04 12.1	−12 52	10.4	20″ × 17″	blue-grey disk

No.	NGC	Con	Type	R.A. (1950)	Dec.	m_v	Size	Remarks
The Winter Sky				h m	° ′			
21	1907	Aur	OC	05 24.7	+35 17	9.9	5	40*; nice contrast with nearby M38
22	1931	Aur	EN	05 28.1	+34 13	—	3 × 3	haze surrounding 4 stars
23	1788	Ori	E/RN	05 04.5	−03 24	—	8 × 5	fairly bright but diffuse E/R neb.
24	1973+	Ori	E/RN	05 32.9	−04 48	—	40 × 25	near M42 and M43; often neglected
25	2022	Ori	PN	05 39.3	+09 03	12.4	28″ × 27″	small, faint but distinct; annular
26	2194	Ori	OC	06 11.0	+12 50	9.2	8	100*; Type e; faint but rich
27	2158	Gem	OC	06 04.3	+24 06	12.5	4	40*; same field as M35; nice contrast
28	2392	Gem	PN	07 26.2	+21 01	8.3	47″ × 43″	Clown-Face Nebula; very bright
29	2244	Mon	OC	06 29.7	+04 54	6.2	40	16*; in centre of Rosette Nebula
30	2261	Mon	E/RN	06 36.4	+08 46	var.	5 × 3	Hubble's Variable Nebula
31	2359	CMa	EN	07 15.4	−13 07	—	8 × 6	fairly bright; NGC's 2360 & 2362 nearby
32	2438	Pup	PN	07 39.6	−14 36	11.8	68″	within M46 open cluster
33	2440	Pup	PN	07 39.9	−18 05	10.3	54″ × 20″	almost starlike; irregular at high mag.
34	2539	Pup	OC	08 08.4	−12 41	8.2	21	150*; Type f—fairly rich
35	2403	Cam	G-Sc	07 32.0	+65 43	8.9	17 × 10	bright, very large; visible in binocs.
36	2655	Cam	G-S	08 49.4	+78 25	10.7	5.0 × 2.4	bright ellipse w/ star-like nucleus
The Spring Sky								
37	2683	Lyn	G-Sb	08 49.6	+33 38	9.6	8.0 × 1.3	nearly edge-on spiral; very bright
38	2841	UMa	G-Sb	09 18.6	+51 12	9.3	6.4 × 2.4	classic elongated spiral; very bright
39	2985	UMa	G-Sb	09 46.0	+72 31	10.6	5.5 × 5.0	near M81 and M82
40	3077	UMa	G-E2p	09 59.4	+68 58	10.9	2.3 × 1.9	small elliptical; companion to M81/82
41	3079	UMa	G-Sb	09 58.6	+55 57	11.2	8.0 × 1.0	edge-on spiral, NGC 2950 nearby
42	3184	UMa	G-Sc	10 15.2	+41 40	9.6	5.6 × 5.6	large, diffuse face-on spiral
43	3675	UMa	G-Sb	11 23.5	+43 52	10.6	4.0 × 1.7	elongated spiral; same field as 56 UMa
44	3877	UMa	G-Sb	11 43.5	+47 46	10.9	4.4 × 0.8	edge-on; same field as Chi UMa
45	3941	UMa	G-Sa	11 50.3	+37 16	9.8	1.8 × 1.2	small, bright, elliptical shape
46	4026	UMa	G-E8	11 56.9	+51 12	10.7	3.6 × 0.7	lens-shaped edge-on; near γ UMa
47	4088	UMa	G-Sc	12 03.0	+50 49	10.9	4.5 × 1.4	nearly edge-on; 4085 in same field
48	4111	UMa	G-S0	12 04.5	+43 21	9.7	3.3 × 0.6	bright, lens-shaped, edge-on spiral
49	4157	UMa	G-Sb	12 08.6	+50 46	11.9	6.5 × 0.8	edge-on, a thin sliver; 4026+4088 nearby
50	4605	UMa	G-Scp	12 37.8	+61 53	9.6	5.0 × 1.2	bright, distinct, edge-on spiral
51	3115	Sex	G-E6	10 02.8	−07 28	9.3	4.0 × 1.2	"Spindle Galaxy"; bright, elongated
52	3242	Hya	PN	10 22.4	−18 23	9.1	40″ × 35″	"Ghost of Jupiter" planetary
53	3344	LMi	G-Sc	10 40.7	+25 11	10.4	7.6 × 6.2	diffuse, face-on spiral
54	3432	LMi	G-Sc	10 49.7	+36 54	11.4	5.8 × 0.8	nearly edge-on; faint flat streak
55	2903	Leo	G-Sb	09 29.3	+21 44	9.1	11.0 × 4.6	very bright, large elongated spiral
56	3384	Leo	G-E7	10 45.7	+12 54	10.2	4.4 × 1.4	same field as M105 and NGC 3389
57	3521	Leo	G-Sc	11 03.2	+00 14	9.5	7.0 × 4.0	very bright, large spiral
58	3607	Leo	G-E1	11 14.3	+18 20	9.6	1.7 × 1.5	NGC 3605 and 3608 in same field
59	3628	Leo	G-Sb	11 17.7	+13 53	10.9	12.0 × 1.5	large, edge-on; same field as M65/M66
60	4214	CVn	G-irr	12 13.1	+36 36	10.3	6.6 × 5.8	large irregular galaxy
61	4244	CVn	G-S	12 15.0	+38 05	11.9	14.5 × 1.0	large, distinct, edge-on spiral
62	4449	CVn	G-irr	12 25.8	+44 22	9.2	4.1 × 3.4	bright rectangular shape
63	4490	CVn	G-Sc	12 28.3	+41 55	9.7	5.6 × 2.1	bright spiral; 4485 in same field
64	4631	CVn	G-Sc	12 39.8	+32 49	9.3	12.6 × 1.4	very large, bright, edge-on; no dust lane
65	4656	CVn	G-Sc	12 41.6	+32 26	11.2	19.5 × 2.0	same field as 4631; fainter, smaller
66	5005	CVn	G-Sb	13 08.5	+37 19	9.8	4.4 × 1.7	bright elongated spiral; near α CVn
67	5033	CVn	G-Sb	13 11.2	+36 51	10.3	9.9 × 4.8	large, bright spiral near NGC 5005
68	4274	Com	G-Sb	12 17.4	+29 53	10.8	6.7 × 1.3	NGC 4278 in same field
69	4494	Com	G-E1	12 28.9	+26 03	9.6	1.3 × 1.2	small, bright elliptical
70	4414	Com	G-Sc	12 24.0	+31 30	9.7	3.2 × 1.5	bright spiral; star-like nucleus
71	4559	Com	G-Sc	12 33.5	+28 14	10.6	11.0 × 4.5	large spiral; coarse structure
72	4565	Com	G-Sb	12 33.9	+26 16	10.2	14.4 × 1.2	superb edge-on spiral with dust lane
73	4725	Com	G-Sb	12 48.1	+25 46	8.9	10.0 × 5.5	very bright, large spiral
74	4361	Crv	PN	12 21.9	−18 29	11.4	18″	$12^m.8$ central star

No.	NGC	Con	Type	R.A. (1950)	Dec.	m_v	Size	Remarks
75	4216	Vir	G-Sb	12 13.4	+13 25	10.4	7.4 × 0.9	nearly edge-on; two others in field
76	4388	Vir	G-Sb	12 23.3	+12 56	11.7p	5.0 × 0.9	edge-on; near M84 and M86
77	4438	Vir	G-S	12 25.3	+13 17	10.8	8.0 × 3.0	paired with NGC 4435
78	4473	Vir	G-E4	12 27.3	+13 42	10.1	1.6 × 0.9	NGC 4477 in same field
79	4517	Vir	G-Sc	12 29.0	+00 21	12.0	8.9 × 0.8	faint edge-on spiral
80	4526	Vir	G-E7	12 31.6	+07 58	10.9	3.3 × 1.0	between two 7^{m}0 stars
81	4535	Vir	G-Sc	12 31.8	+08 28	10.4p	6.0 × 4.0	near M49
82	4697	Vir	G-E4	12 46.0	−05 32	9.6	2.2 × 1.4	small, bright elliptical
83	4699	Vir	G-Sa	12 46.5	−08 24	9.3	3.0 × 2.0	small, bright elliptical shape
84	4762	Vir	G-Sa	12 50.4	+11 31	11.0	3.7 × 0.4	flattest galaxy; 4754 in same field
85	5746	Vir	G-Sb	14 42.3	+02 10	10.1	6.3 × 0.8	fine, edge-on spiral near 109 Virginis
86	5907	Dra	G-Sb	15 14.6	+56 31	11.3	11.1 × 0.7	fine, edge-on spiral with dust lane
87	6503	Dra	G-Sb	16 49.9	+70 10	9.6	4.5 × 1.0	bright spiral
88	6543	Dra	PN	17 58.8	+66 38	8.7	22″	luminous blue-green disk

The Summer Sky

No.	NGC	Con	Type	R.A. (1950)	Dec.	m_v	Size	Remarks
89	6207	Her	G-Sc	16 41.3	+36 56	11.3	2.0 × 1.1	same field as M13 cluster
90	6210	Her	PN	16 42.5	+23 53	9.2	20″ × 13″	very star-like blue planetary
91	6369	Oph	PN	17 26.3	−23 44	9.9	28″	greenish, annular, and circular
92	6572	Oph	PN	18 09.7	+06 50	8.9	16″ × 13″	tiny oval; bright blue
93	6633	Oph	OC	18 25.1	+06 32	4.9	20	wide-field cluster; IC4756 nearby
94	6712	Sct	GC	18 50.3	−08 47	8.9	2.1	small globular near M26
95	6819	Cyg	OC	19 39.6	+40 06	10.1	6	150*; faint but rich cluster
96	6826	Cyg	PN	19 43.4	+50 24	9.4	27″ × 24″	Blinking Planetary Nebula
97	6960	Cyg	SNR	20 43.6	+30 32	—	70 × 6	Veil Nebula (west component)
98	6992–5	Cyg	SNR	20 54.3	+31 30	—	78 × 8	Veil Nebula (east component)
99	7000	Cyg	EN	20 57.0	+44 08	—	120 × 100	North America Neb.; binoc. obj.
100	7027	Cyg	EN	21 05.1	+42 02	10.4	18″ × 11″	very star-like H II region
101	6445	Sgr	PN	17 47.8	−20 00	11.8	38″ × 29″	small, bright and annular; near M23
102	6818	Sgr	PN	19 41.1	−14 17	9.9	22″ × 15″	“Little Gem”; annular; 6822 nearby
103	6802	Vul	OC	19 28.4	+20 10	11.0	3.5	60*; small, faint but rich
104	6940	Vul	OC	20 32.5	+28 08	8.2	20	100*; Type e; rich cluster
105	6939	Cep	OC	20 30.4	+60 28	10.0	5	80*; very rich; 6946 in same field
106	6946	Cep	G-Sc	20 33.9	+59 58	9.7p	9.0 × 7.5	faint, diffuse, face-on spiral
107	7129	Cep	RN	21 42.0	+65 52	—	7 × 7	small faint RN; several stars inv.
108	40	Cep	PN	00 10.2	+72 15	10.5	60″ × 38″	small circular glow; 11^{m}5 central star
109	7209	Lac	OC	22 03.2	+46 15	7.6	20	50*; Type d; within Milky Way
110	7243	Lac	OC	22 13.2	+49 38	7.4	20	40*; Type d; within Milky Way

Challenge Objects

No.	NGC	Con	Type	R.A. (1950)	Dec.	m_v	Size	Remarks
1	246	Cet	PN	00 44.6	−12 09	8.5	240″ × 210″	large and diffuse; deceptively difficult
2	1275	Per	G	03 16.4	+41 20	12.7	0.7 × 0.6	small and faint; exploding gal.; Perseus A
3	1432/35	Tau	RN	03 43.3	+23 42	—	30 × 30	Pleiades nebl'y; brightest around Merope
4	1499	Per	EN	04 00.1	+36 17	—	145 × 40	California Neb.; very large and faint
5	IC434/35/ B33/2023	Ori	E/R/DN	05 38.6	−02 26	—	60/3/10	complex of nebl'y S. of zeta Ori., B33 is famous dark Horsehead Neb.; difficult
6	IC431/32/ NGC 2024	Ori	E/RN	05 39.4	−01 52	—	4/6/30	complex of nebl'y N. of zeta Ori., NGC2024 is easy but masked by glow from zeta.
7	IC 443	Gem	SNR	06 13.9	+22 48	—	27 × 5	v. faint supernova remnant NE. of η Gem.
8	J 900	Gem	PN	06 23.0	+17 49	12.2	12″ × 10″	bright but starlike; oval at high mag.
9	2237/46	Mon	EN	06 29.6	+04 40	—	60	Rosette Neb.; very large; incl. NGC2244
10	2419	Lyn	GC	07 34.8	+39 00	11.5	1.7	most distant known Milky Way GC (2×10^5 l.y.)
11	5897	Lib	GC	15 14.5	−20 50	10.9	7.3	large, but faint and loose globular cl.
12	B 72	Oph	DN	17 21.0	−23 35	—	30	Barnard's dark S-Nebula; RFT needed
13	6781	Aql	PN	19 16.0	+06 26	11.8	106″	pale version of M97; large, fairly bright
14	6791	Lyr	OC	19 19.0	+37 40	11	13	large, faint but very rich cl.; 100+*
15	M1-92	Cyg	RN	19 34.3	+29 27	11	0.2 × 0.1	Footprint Neb.; bright but starlike; double
16	6822	Sgr	G-irr	19 42.1	−14 53	11.0	16.2 × 11.2	Barnard's Gal.; member Local Grp.; faint
17	6888	Cyg	SNR?	20 10.7	+38 16	—	18 × 12	Crescent Neb.; small faint arc near γ Cyg.
18	IC 5146	Cyg	RN	21 51.3	+47 02	—	12 × 12	Cocoon Neb.; faint; at end of long dark neb.
19	7317–20	Peg	G's	22 33.7	+33 42	14–15	—	Stephan's Quintet; ½°SSW. of NGC 7331
20	7635	Cas	EN	23 18.5	+60 54	—	4 × 3	Bubble Neb.; v. faint; ½°SW. of M52

GALAXIES

By Barry F. Madore

External galaxies are generally of such low surface brightness that they often prove disappointing objects for the amateur observer. However it must be remembered that many of these galaxies were discovered with very small telescopes and that the enjoyment of their discovery can be recaptured. In addition the central concentration of light varies from galaxy to galaxy making a visual classification of the types possible at the telescope. Indeed the type of galaxy as listed in the first table is in part based on the fraction of light coming from the central bulge of the galaxy as compared to the contribution from a disk component. Disk galaxies with dominant bulges are classified as Sa; as the nuclear contribution declines, types of Sb, Sc, and Sd are assigned until the nucleus is absent at type Sm. Often the disks of these galaxies show spiral symmetry, the coherence and strength of which is denoted by Roman numerals I through V, smaller numbers indicating well-formed global spiral patterns. Those spirals with central bars are designated SB while those with only a hint of a disk embedded in the bulge are called Sϕ. A separate class of galaxies which possess no disk component are called ellipticals and can only be further classified numerically by their apparent flattening: Eϕ being apparently round, E7 being the most flattened.

The following table presents the 40 brightest galaxies taken from the Revised Shapley-Ames Catalog. As well as their designations, positions, and types, the table lists the total blue magnitudes, major and minor axis lengths (to the nearest minute of arc), one modern estimate of their distances in thousands of parsecs, and finally their radial velocities corrected for the motion of our Sun about the galactic centre.

THE 40 OPTICALLY BRIGHTEST SHAPLEY-AMES GALAXIES

NGC/IC (Other)	α/δ (1983)	Type	B_T ma × mi	Distance Corrected Radial Vel.
55	$00^h14^m04^s$ $-39°17.1'$	Sc	8.22 mag 25 × 3 arc min	3 100 kpc +115 km/s
205	00 39 27 +41 35.7	S∅/E5pec	8.83 8 × 3	730 +49
221 M32	00 41 49 +40 46.3	E2	9.01 3 × 3	730 +86
224 M31	00 41 49 +41 10.5	Sb I–II	4.38 160 × 40	730 −10
247	00 46 19 −20 51.2	Sc III–IV	9.51 18 × 5	3 100 +604
253	00 46 46 −25 23.0	Sc	8.13 22 × 6	4 200 +504
SMC	00 52 10 −72 55.3	Im IV–V	2.79 216 × 216	78 +359
300	00 54.05 −37 46.7	Sc III	8.70 20 × 10	2 400 +625
598 M33	01 32 55 +30 34.0	Sc II–III	6.26 60 × 40	900 +506
628 M74	01 35 49 +15 41.6	Sc I	9.77 8 × 8	17 000 +507
1068 M77	02 41 49 −00 05.2	Sb II	9.55 3 × 2	25 000 +510
1291	03 16 42 −41 11.3	SBa	9.42 5 × 2	15 000 +512
1313	03 18 04 −66 33.6	SBc III–IV	9.37 5 × 3	5 200 +261
1316 Fornax A	03 22 03 −37 16.1	Sa (pec)	9.60 4 × 3	30 000 +1713
LMC	05 23 45 −69 46.3	SBm III	0.63 432 × 432	57 +34
2403	07 35 13 +65 38.2	Sc III	8.89 16 × 10	3 600 +299
2903	09 31 02 +21 34.4	Sc I–III	9.50 11 × 5	9 400 +472
3031 M81	09 54 11 +69 08.9	Sb I–II	7.86 16 × 10	3 600 +124
3034 M82	09 54 24 +69 45.5	Amor- phous	9.28 7 × 2	3 600 +409
3521	11 04 57 +00 03.5	Sb II–III	9.64 7 × 2	13 000 +627

NGC/IC (Other)	α/δ (1983)	Type	B_T ma × mi	Distance Corrected Radial Vel.
3627 M66	11 19 22 +13 05.0	Sb II	9.74 8 × 3	12 000 +593
4258 M106	12 18 07 +47 24.1	Sb II	8.95 20 × 6	10 000 +520
4449	12 27 24 +44 11.4	Sm IV	9.85 5 × 3	5 000 +250
4472 M49	12 28 55 +08 05.8	E1/Sϕ	9.32 5 × 4	22 000 +822
4486 M87	12 29 58 +12 29.2	Eϕ	9.62 3 × 3	22 000 +1136
4594 M104	12 39 07 −11 31.8	Sa/b	9.28 7 × 2	17 000 +873
4631	12 41 18 +32 38.0	Sc	9.84 12 × 1	12 000 +606
4649 M60	12 42 49 +11 38.7	Sϕ	9.83 4 × 3	22 000 +1142
4736 M94	12 50 06 +41 12.9	Sab	8.92 5 × 4	6 900 +345
4826 M64	12 55 55 +21 46.5	Sab II	9.37 8 × 4	7 000 +350
4945	13 04 28 −49 22.5	Sc	9.60 12 × 2	7 000 +275
5055 M63	13 15 04 +42 07.4	Sbc II–III	9.33 8 × 3	11 000 +550
5128 Cen A	13 24 29 −42 35.7	Sϕ (pec)	7.89 10 × 3	6 900 +251
5194 M51	13 29 10 +47 17.2	Sbc I–II	8.57 12 × 6	11 000 +541
5236 M83	13 36 02 −29 46.8	SBc II	8.51 10 × 8	6 900 +275
5457 M101	14 02 39 +54 26.4	Sc I	8.18 22 × 22	7 600 +372
6744	19 08 09 −63 53.0	Sbc II	9.24 9 × 9	13 000 +663
6822	19 43 59 −14 50.8	Im IV–V	9.35 20 × 10	680 +15
6946	20 34 30 +60 05.9	Sc II	9.68 13 × 9	6 700 +336
7793	23 56 57 −32 41.1	Sd IV	9.65 6 × 4	4 200 +241

The following table contains the positions and catalogue designations of all those galaxies known to have proper names which usually honour the discoverer (Object McLeish), identify the constellation in which the galaxy is found (Fornax A) or describe the galaxy in some easily remembered way (Whirlpool galaxy).

GALAXIES WITH PROPER NAMES

Name/Other	α/δ (1950)	Name/Other	α/δ (1950)
Andromeda Galaxy = M31 = NGC 224	$00^h40^m\!.0$ +41°00′	Holmberg III	$09^h09^m\!.6$ +74°26′
Andromeda I	00 43.0 +37 44	Holmberg IV = DDO 185	13 52.8 +54 09
Andromeda II	01 13.5 +33 09	Holmberg V	13 38.8 +54 35
Andromeda III	00 32.6 +36 14	Holmberg VI = NGC 1325 A	03 22.6 −21 31
Andromeda IV	00 39.8 +40 18	Holmberg VII = DDO 137	12 33.2 +06 35
Antennae = NGC 4038/39	11 59.3 −18 35	Holmberg VIII = DDO 166	13 11.0 +36 29
Barnard's Galaxy = NGC 6822	19 42.1 −14 53	Holmberg IX = DDO 66	09 53.5 +69 17
BL Lac	22 01.9 +42 11	Hydra A	09 15.7 −11 53
Capricorn Dwarf = Pal 13	21 44.0 −21 29	Keenan's System = NGC 5216/18 = Arp 104	13 31.1 +62 52
Caraffe Galaxy	04 26.6 −48 01	Large Magellanic Cloud	05 24.0 −69 48
Carina Dwarf	06 45.1 −51 00	Leo I = Harrington-Wilson #1 = Regulus Dwarf = DDO 74	10 05.8 +12 33
Cartwheel Galaxy	00 35.0 −34 01	Leo II = Harrington-Wilson #2 = Leo B = DDO 93	11 10.8 +22 26
Centaurus A = NGC 5128 = Arp 153	13 22.5 −42 46	Leo A = Leo III = DDO 69	09 56.5 +30 59
Circinus Galaxy	14 09.3 −65 06	Lindsay-Shapley Ring	06 44.4 −74 11
Copeland Septet = NGC 3745/54 = Arp 370	11 35.1 +22 18	McLeish's Object	20 05.0 −66 22
Cygnus A	19 57.7 +40 36	Maffei I	02 32.6 +59 26
Draco Dwarf = DDO 208	17 19.2 +57 58	Maffei II	02 38.1 +59 23
Fath 703	15 11.0 −15 17	Mayall's Object = Arp 148 = VV32	11 01.1 +41 07
Fornax A = NGC 1316	03 20.8 −37 23	Mice = NGC 4676 = Arp 242	12 44.7 +30 54
Fornax Dwarf	02 37.8 −34 44	Pegasus Dwarf = DDO 216	23 26.0 +14 28
Fourçade-Figueroa Object	13 32.4 −33 38	Perseus A = NGC 1275	03 16.5 +41 20
GR8 (Gibson Reaves) = DDO 155	12 56.2 +14 29	Pinwheel Galaxy = M101 = NGC 5457	14 01.5 +54 36
Hardcastle Nebula	13 10.2 −32 26	Regulus Dwarf = Leo I = DDO 74	10 05.8 +12 33
Hercules A	16 48.7 +05 06	Reticulum Dwarf	04 35.4 −58 56
Holmberg I = DDO 63	09 36.0 +71 25	Reinmuth 80 = NGC 4517 A	00 57.6 −33 58
Holmberg II = DDO 50 = Arp 268	08 13.7 +70 52	Seashell Galaxy	13 44.5 −30 10

Name/Other	α/δ (1950)	Name/Other	α/δ (1950)
Serpens Dwarf	$15^h13^m.5$ +00°03′	Triangulum Galaxy = M33 = NGC 598	$01^h31^m.0$ +30°24′
Seyfert's Sextet = NGC 6027 A–D	15 57.0 +20 54	Ursa Minor Dwarf = DDO 199	15 08.2 +67 23
Sextans A = DDO 75	10 08.6 −04 28	Virgo A = M87 = NGC 4486 = Arp 152	12 28.3 +12 40
Sextans B = DDO 70	09 57.4 +05 34	Whirlpool Galaxy = M51 = NGC 5194	13 27.8 +47 27
Sextans C	10 03.0 +00 19	Wild's Triplet = Arp 248	11 44.2 −03 33
Small Magellanic Cloud	00 51.0 −73 06	Wolf-Lundmark-Melotte = DDO 221	23 59.4 −15 44
Sombrero Galaxy = M104 = NGC 4594	12 37.6 −11 21	Zwicky No. 2 = DDO 105	11 55.9 +38 21
Spindle Galaxy = NGC 3115	10 02.8 −07 28	Zwicky's Triplet = Arp 103	16 48.0 +45 33
Stephans Quintet = NGC 7317-20 = Arp 319	22 33.7 +33 42		

The nearest galaxies listed below form what is known as our Local Group of galaxies. Many of the distances are still quite uncertain.

THE NEAR-BY GALAXIES: OUR LOCAL GROUP

Name	α (1983.0)	δ	B_T	Type	Distance (kpc)
M31 = NGC 224	$00^h41^m.8$	+41°11′	4.38	Sb I–II	670
Galaxy	—	—	—	Sb/c	—
M33 = NGC 598	01 32.9	+30 34	6.26	Sc II–III	550
LMC	05 23.8	−69 46	0.63	SBm III	50
SMC	00 52.2	−72 55	2.79	Im IV–V	60
NGC 6822	19 44.0	−14 51	9.35	Im IV–V	520
IC 1613	01 03.9	+02 02	10.00	Im V	740
NGC 205	00 39.5	+41 36	8.83	SØ/E5 pec	670
M32 = NGC 221	00 41.8	+40 46	9.01	E2	670
NGC 185	00 38.0	+48 15	10.13	dE3 pec	670
NGC 147	00 32.3	+48 25	10.36	dE5	670
Fornax	02 39.2	−34 36	9.1	dE	130
Sculptor	00 59.0	−33 47	10.5	dE	85
Leo I	10 07.6	+12 24	11.27	dE	230
Leo II	11 12.6	+22 15	12.85	dE	230
Draco	17 19.8	+57 56	—	dE	80
Ursa Minor	15 08.6	+67 16	—	dE	75
Carina	06 47.2	−50 59	—	dE	170
And I	00 44.6	+37 57	13.5	dE	670
And II	01 15.5	+33 21	13.5	dE	670
And III	00 34.5	+36 25	13.5	dE	670
LGS 3	01 02.9	+21 48	—	?	670

RADIO SOURCES

BY JOHN GALT

Although several thousand radio sources have been catalogued, most of them are observable only with the largest radio telescopes. This list contains the few strong sources which could be detected with amateur radio telescopes as well as representative examples of astronomical objects which emit radio waves.

Name	α (1980) h	m	δ °	′	Remarks
Tycho's s'nova	00	24.6	+64	01	Remnant of supernova of 1572
Andromeda gal.	00	41.5	+41	09	Closest normal spiral galaxy
IC 1795, W3	02	23.9	+62	01	Multiple HII region, OH emission
Algol	03	06.6	+40	52	Star emits high freq. radio waves
NGC 1275, 3C 84	03	18.5	+41	26	Seyfert galaxy, radio variable
CP 0328	03	31.3	+54	29	Pulsar, period = 0.7145 s, H abs'n.
Crab neb, M1*	05	33.2	+22	00	Remnant of supernova of 1054
NP 0532	05	33.2	+22	00	Radio, optical & X-ray pulsar
V 371 Orionis	05	32.7	+01	54	Red dwarf, radio & optical flare star
Orion neb, M42	05	34.3	−05	24	HII region, OH emission, IR source
IC 443	06	16.1	+22	36	Supernova remnant (date unknown)
Rosette neb	06	30.9	+04	53	HII region
YV CMa	07	22.2	−20	42	Optical var. IR source, OH, H_2O emission
3C 273	12	28.0	+02	10	Nearest, strongest quasar
Virgo A, M87*	12	29.8	+12	30	EO galaxy with jet
Centaurus A	13	24.2	−42	55	NGC 5128 peculiar galaxy
3C 295	14	10.7	+52	18	21st mag, galaxy, 4.5 × 10^9 light years
OQ 172	14	44.3	+10	04	Quasar, very large redshift z = 3.53
Scorpio X-1	16	18.8	−15	35	X-ray, radio, and optical variable
Kepler's s'nova	17	27.6	−21	16	Remnant of supernova of 1604
Galactic nucleus	17	44.3	−28	56	Complex region OH, NH_3 em., H_2CO abs'n.
Omega neb, M17	18	19.3	−16	10	HII region, double structure
SS433	19	10.9	+04	56	Star with high velocity jets
CP 1919	19	20.8	+21	50	First pulsar discovered, P = 1.337 s
Cygnus A*	19	58.7	+40	41	Strong radio galaxy, double source
Cygnus X	20	21.9	+40	19	Complex region
NML Cygnus	20	45.8	+40	02	Infrared source, OH emission
Cygnus loop	20	51.4	+29	36	S'nova remnant (Network nebula)
N. America	20	54.4	+43	59	Radio shape resembles photographs
BL Lac	22	01.9	+42	11	Radio and optical variable
3C 446	22	24.7	−05	04	Quasar, optical mag. & spectrum var.
Cassiopeia A*	23	22.5	+58	42	Strongest source, s'nova remnant
Sun*					Continuous emission & bursts
Moon					Thermal source only
Jupiter*					Radio bursts controlled by Io

Source marked * could be detected with amateur radio telescopes. Radio maps of the broad structure of the sky can be found in *Sky and Telescope*, 1982, March, p. 230. (For more information about amateur radio astronomy, see *Astronomy*, **5**, no. 12, 50 (1977), a series of articles in *J. Roy. Ast. Soc. Canada*, **72**, L5, L22, L38 . . . (1978) and a series of articles in *Sky and Telescope*, **55**, 385 and 475 and **56**, 28 and 114 (1978)—*Ed.*)

OBSERVING NOTES

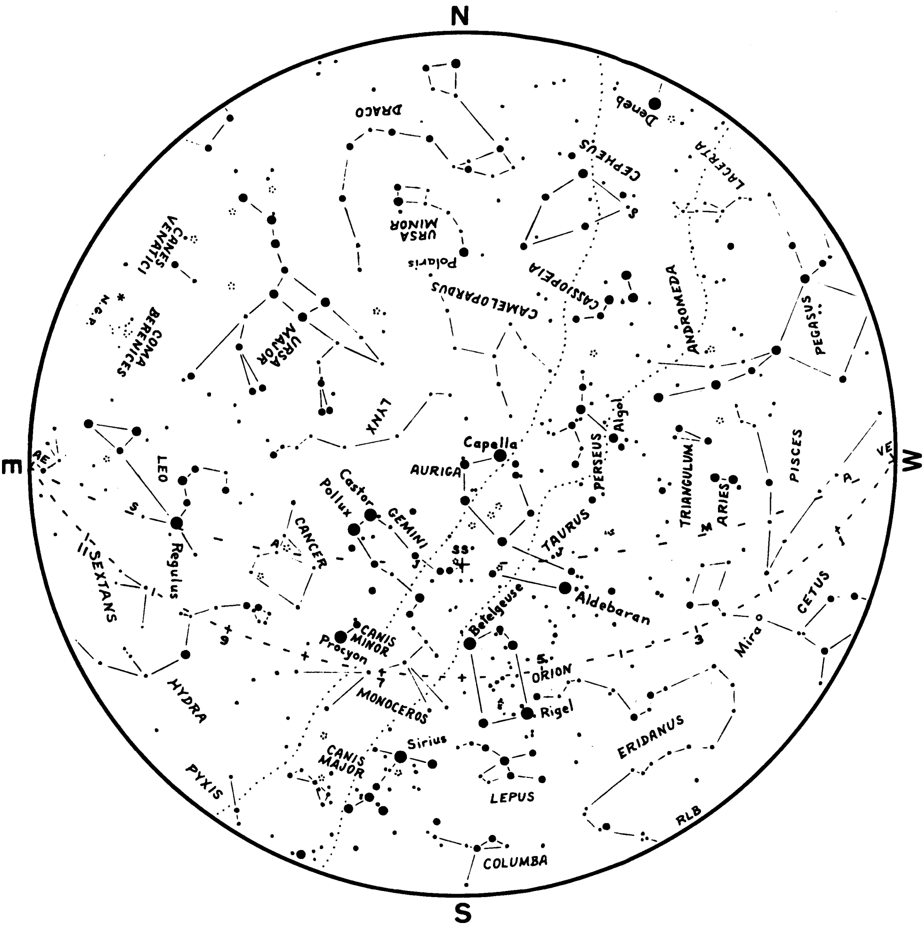
MAPS OF THE NIGHT SKY

The maps on the next six pages depict the night sky as it appears at various times of the year. The maps are drawn for latitude 45° N, but are useful for latitudes several degrees north or south of this. Because the aspect of the night sky changes continuously with both longitude and time, while time zones change discontinuously with both longitude and time of year, it is not possible to state simply when, in general, a particular observer will find that his or her sky fits exactly one of the six maps. The month indicated on each map is the time of year when the map will match the "late evening" sky. On any particular night, successive maps will represent the sky as it appears every four hours later. For example, at 2 or 3 am on a March night, the May map should be used. Just after dinner on a January night, the November map will be appropriate.

The maps show stars down to a magnitude of 4.5 or 5, i.e. those which are readily apparent to the unaided eye on a reasonably dark night. The center of each map is the zenith, the point directly overhead; the circumference is the horizon. To identify the stars, hold the map in front of you so that the part of the horizon which you are facing (west, for instance) is downward. (The four letters around the periphery of each map indicate compass directions.) Stars forming the usual constellation patterns are linked by straight lines, constellation names being given in upper case letters. The names in lower case are those of first magnitude stars, except Algol and Mira which are famous variable stars, and Polaris which is near the north celestial pole. Small clusters of dots indicate the positions of bright star clusters, nebulae, or galaxies. Although a few of these are just visible to the naked eye, and most can be located in binoculars, a telescope is needed for good views of these objects.

The pair of wavy, dotted lines indicates roughly the borders of the Milky Way, while small asterisks locate the directions of the galactic center (G.C.), north galactic pole (N.G.P.) and south galactic pole (S.G.P.). Two dashed lines appear on each map. The one with more dashes is the celestial equator. Tick marks along this indicate hours of right ascension, the odd hours being labeled. The line with fewer dashes is the ecliptic, the apparent annual path of the Sun across the heavens. Letters along this line indicate the approximate position of the Sun at the beginning of each month. Also located along the ecliptic are the vernal equinox (VE), summer solstice (SS), autumnal equinox (AE), and winter solstice (WS). The Moon and the other eight planets are found near the ecliptic, but since their motions are not related in a simple way to our year, it is not feasible to show them on a general set of star maps.

Star maps providing more detail than possible in the six, all-sky maps presented here are available. For example: *Norton's Star Atlas* (8700 stars to magnitude 6.3); *Tirion's Sky Atlas 2000.0* (43 000 stars to magnitude 8.0); *AAVSO Variable Star Atlas* (260 000 stars to magnitude 9.5) (Sky Publishing Corporation, 49 Bay State Road, Cambridge, MA 02238). Norton's is a classic and should be in the library of anyone who has a keen interest in the night sky. Both Tirion's atlas and the AAVSO atlas will be invaluable to the advanced observer. For information on the mythology of the night sky, *Star Names, Their Lore and Meaning* by R. H. Allen is a standard reference (Dover Publications, Inc., 180 Varick St., New York, NY 10014).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CASSIOPEIA
ANDROMEDA
PEGASUS
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Capella
AURIGA
PERSEUS
Algol
TRIANGULUM
ARIES
PISCES
LEO
Regulus
Castor
Pollux
GEMINI
CANCER
TAURUS
Aldebaran
SEXTANS
Betelgeuse
CANIS MINOR
Procyon
ORION
Rigel
Mira
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Sirius
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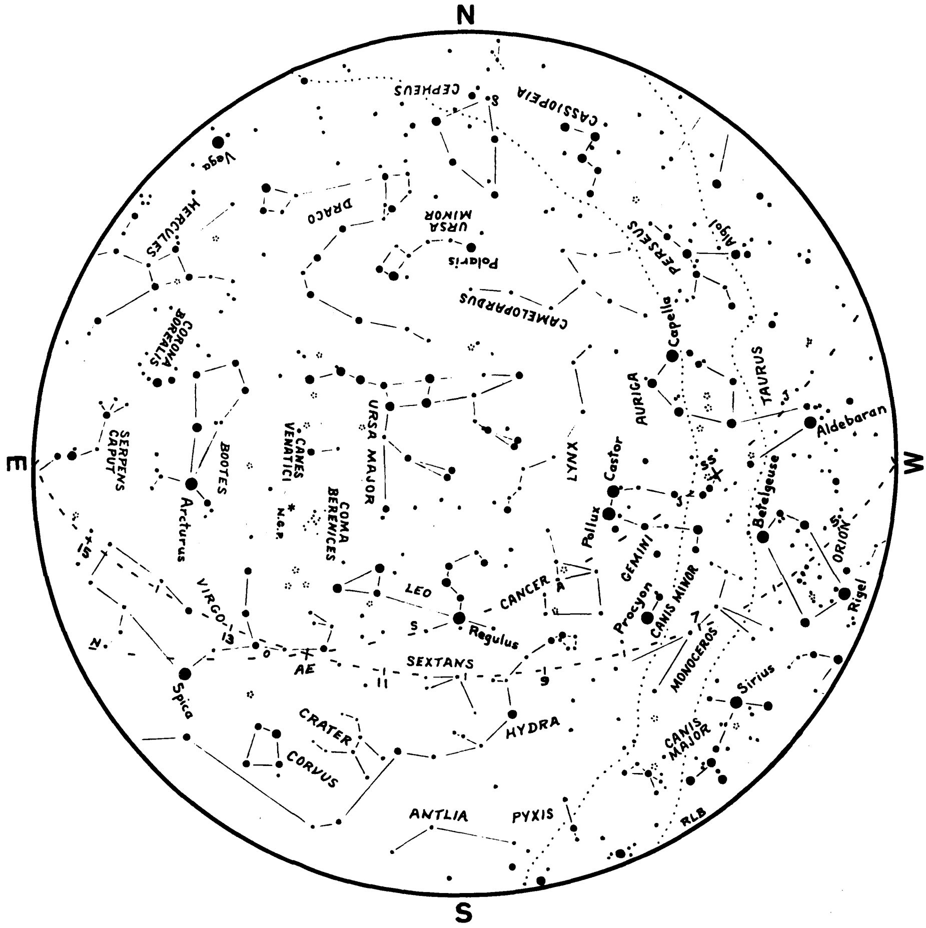
LEPUS
ERIDANUS
PYXIS
COLUMBA
RLB

JANUARY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VIRGO
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Rigel
Regulus
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CANIS MAJOR
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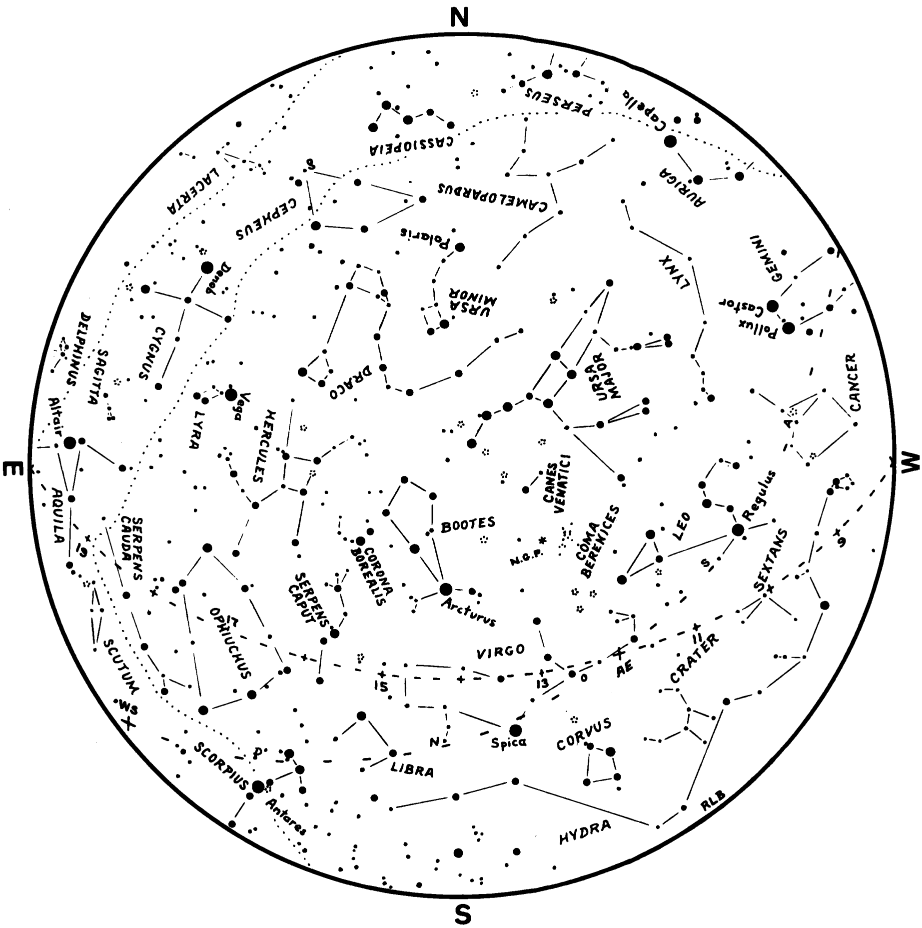
PYXIS
RLB

MARCH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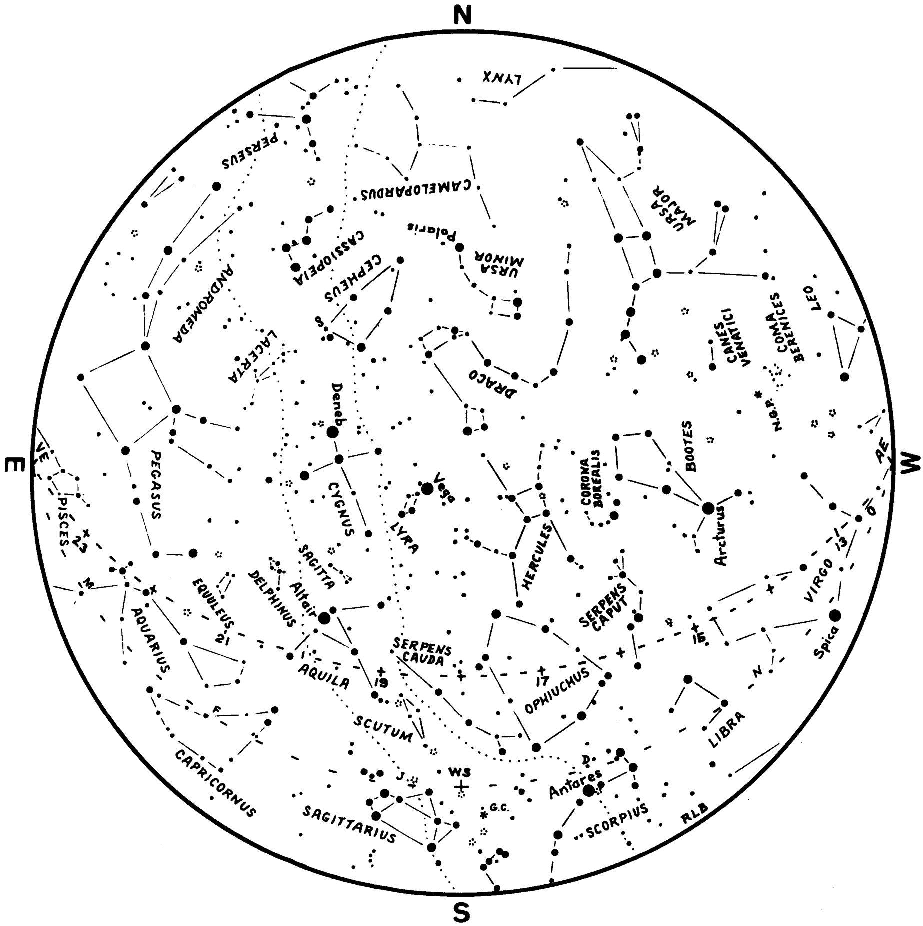
HYDRA
RLB

MAY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Spica
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Antares
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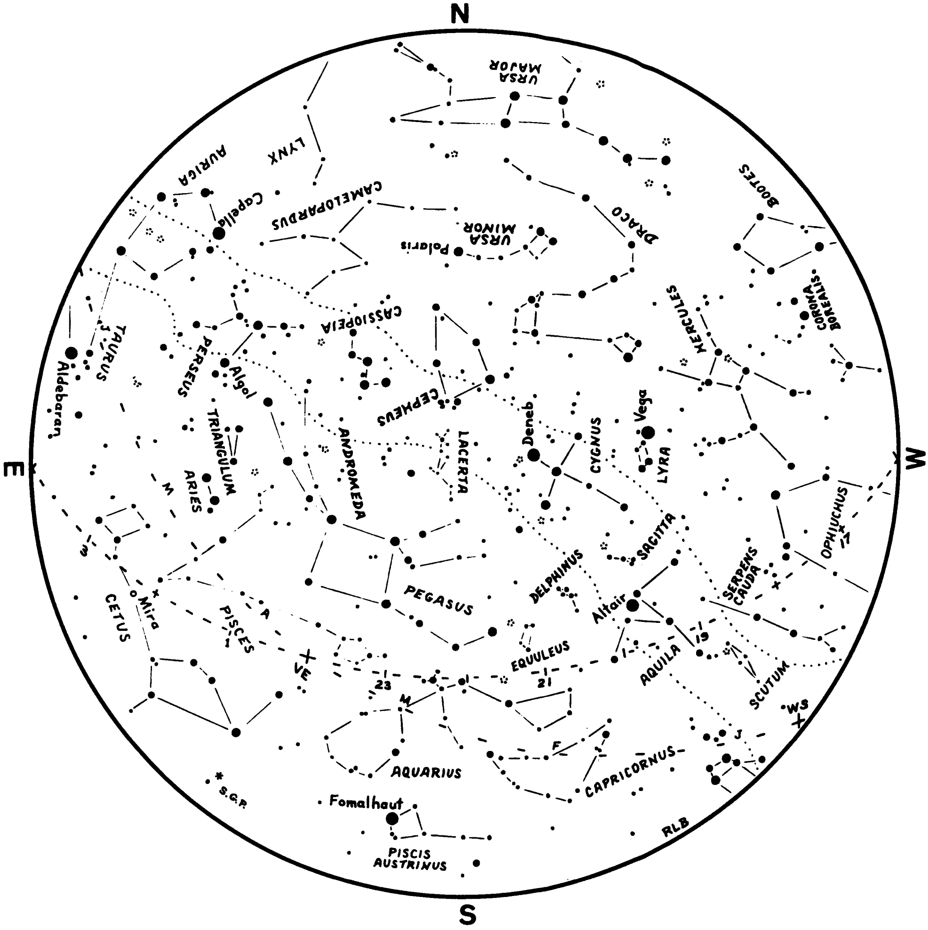
G.C.
SCORPIUS
RLB
VE
AE

JULY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CETUS
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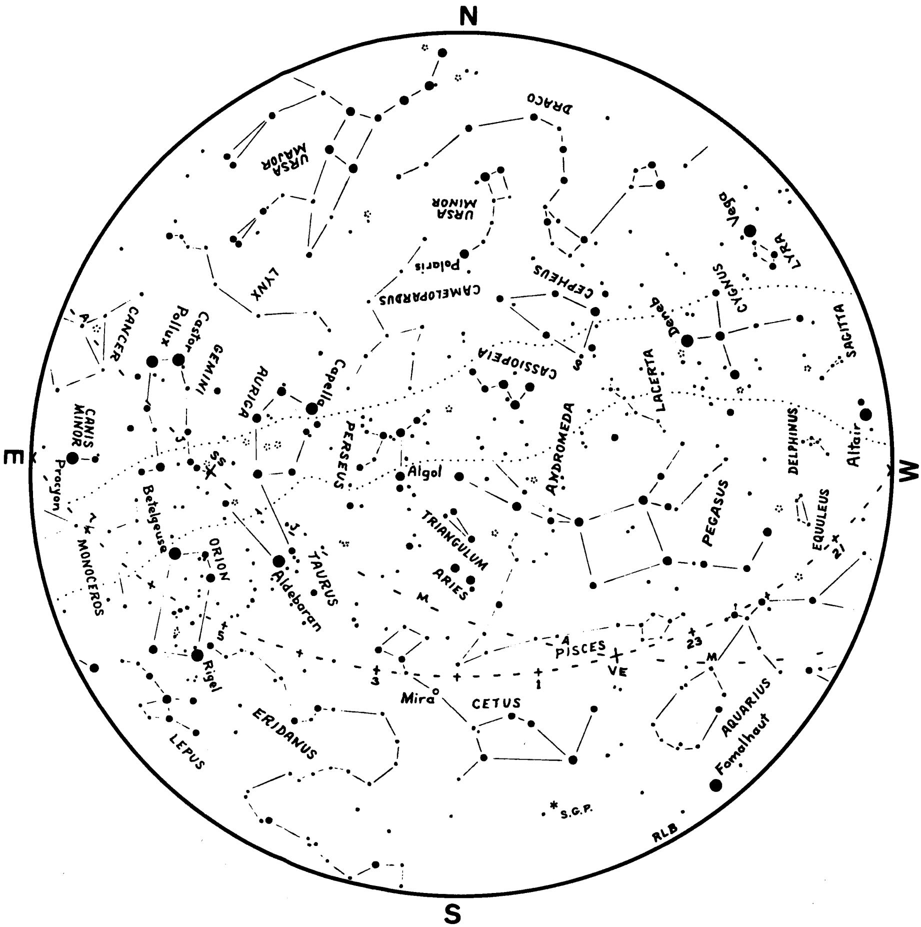
CAPRICORNUS
S.G.P.
Fomalhaut
PISCIS AUSTRINUS
RLB

SEPTEMBER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Rigel
PISCES
VE
CETUS
Mira
AQUARIUS
Fomalhaut
ERIDANUS
LEPUS
S.G.P.
RLB

NOVEMBER

KEY TO LEFT-HAND MARGIN SYMBOLS

D BASIC DATA

t TIME

M THE SKY MONTH BY MONTH

⊙ SUN

☾ MOON

P PLANETS, SATELLITES, AND ASTEROIDS

╲ METEORS, COMETS, AND DUST

✸ STARS

⁘ NEBULAE

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CALENDAR 1983

January

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February

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