OBSERVER'S HANDBOOK 1982

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OBSERVER'S HANDBOOK 1982

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FRIENDS OF ASTRONOMY

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Way back in 1844 the famous German astronomer, F. W. A. Argelander, compiler of the classic star catalogue the Bonner Durchmusterung, issued in pamphlet form "An Appeal to the Friends of Astronomy". Argelander had concluded that there were far too many objects in the sky for professional astronomers to observe systematically. They needed help from many other people. And he asked the Friends of Astronomy to join in, especially in the observation of variable stars. His plea was echoed in 1882 by E.C. Pickering, Director of the Harvard College Observatory. Pickering anticipated women's lib. He encouraged women to become involved in these pursuits, and women have since made important contributions in this field.

Gathering momentum within the decades, the Friends of Astronomy around the world have formed various amateur societies usually having in their midst some professionals for whom astronomy is a career. On a national basis these societies now number in the dozens. On a local basis, counting astronomy clubs around the world, they number in the hundreds or thousands. The contribution of the Friends of Astronomy has been and continues to be a very major support for the development and understanding of astronomy.

In the 1979 OBSERVER'S HANDBOOK we gave the details of the establishment and the first decades of the Royal Astronomical Society of Canada. In 1906 under the guidance of Dr. Clarence A. Chant, its remarkable mentor for sixty years, the Society ceased to be just a local group at Toronto. Beginning in that year, other Centres have been established until the Society now has nineteen from coast to coast in Canada, from St. John's, Newfoundland to Victoria, British Columbia as listed on page 4.

In 1907 the establishment of the Society's publications, the JOURNAL and the OBSERVER'S HANDBOOK, with Dr. Chant as Editor, began to take the Society around the world. To keep Centres in touch with one another, the NATIONAL NEWSLETTER was started in 1970.

The Society became further established on a national basis in 1958 when, for the first time, the annual meeting and "At Home" were held outside Toronto, at McMaster University, Hamilton, Ontario. Since then the annual meeting and accompanying General Assembly have been held from the Atlantic to the Pacific and in intermediate points. The cities where annual meetings have been held are: Toronto, Ontario, 1891–1957, 1959, 1961, 1963, 1965, 1969, 1977; Hamilton, Ontario, 1958, 1971; Montreal, Quebec, 1960, 1967; Edmonton, Alberta, 1962, 1970, 1978; Ottawa, Ontario, 1964, 1973; Winnipeg, Manitoba, 1966, 1974; Halifax, Nova Scotia 1975, 1980; London, Ontario, 1979; Victoria, British Columbia, 1981. Meetings are planned for Saskatoon, Saskatchewan in 1982, and Quebec City, Quebec, 1983. The air age shrinks distances. Members of the Society from all Centres as well as those unattached can pursue astronomy together and partake of the local sightseeing trips arranged by the host Centre.

The Society has an impressive number of medals and awards to act as incentives and rewards for its most accomplished members. Established in 1905 the Gold Medal goes to a high standing graduate at the University of Toronto. To commemorate the 50-year anniversary of the Society in 1940, a medal in honour of Dr. C. A. Chant was established, to be awarded to an amateur for original investigation. Then in 1959 came the Service Medal for members who have performed outstanding service to the Society. In 1977 the Ken Chilton Prize was established for an amateur astronomer resident in Canada in recognition of a significant piece of astronomical work during the year. In 1978 the Simon Newcomb award was founded for the best essay submitted by a member during the year.

Members of the Society make an enormous contribution to popular interest in astronomy in many ways. For example, they hold star nights with their telescopes available for public viewing, and they are helping to sponsor the new concept of Astronomy Day. In addition, they make observations for research in astronomy, on variable stars, nova searches, comet searches, occultation timings, meteor counts and so on. Some of the Centres have fine observatories of their own. A banner year for the efforts of the amateurs was 1978 when Rolf Meier discovered the first all-Canadian comet and Warren Morrison was the first observer to report Nova Cygni 1978. Three comets now bear the name Meier.

HELEN SAWYER HOGG

EDITOR'S COMMENTS

On behalf of myself and the Royal Astronomical Society of Canada, I thank all those who have contributed to the production of the OBSERVER'S HANDBOOK for 1982. The individuals listed on the inside front cover deserve special mention. Of particular note is the continuing contribution made by Peter M. Millman (Meteors, Fireballs and Meteorites). Dr. Millman's name first appeared in the HANDBOOK 53 years ago, in 1929, and he first provided the article on meteors in 1936. In 1981 he accepted the position of Honorary President of the R.A.S.C.

Special thanks are due to John Percy, Editor of the HANDBOOK for the past eleven years. The R.A.S.C. is in his debt for the standard of excellence which he set. His support and advice were invaluable in the preparation of the 1982 edition; however, the inevitable flaws and errors are solely the responsibility of the new editor.

A few changes and additions have been made for 1982. As an attempt to improve the order, several of the sections have been regrouped. Margin symbols have been added to aid rapid finding of sections. In recognition of increasing wide use of the HANDBOOK, *Universal time* (UT) is used throughout. The section of miscellaneous data has been revised and expanded. This section is now almost entirely based on SI units, and includes two formulae which replace the precession table of previous years. Some information on telescope parameters has been added in the hope that it may serve as a useful reference for users of small telescopes. The latitude range of the rise-set and twilight tables has been expanded to 20°–60° north latitude, and their formats have been standardized. The list of phenomena of Jupiter's Galilean satellites is no longer limited to those visible from North America. An approximate ephemeris for the five brightest satellites of Saturn has been devised. The constellation and star name lists have been revised. A new Moon map has been drawn, together with a key and list of features. Six new maps of the night sky have been prepared.

The HANDBOOK is indebted to H. M. Nautical Almanac Office (U.K. Science Research Council) and to the Nautical Almanac Office (U.S. Naval Observatory). I am particularly grateful to P. K. Seidelmann, Director of the Nautical Almanac Office, U.S. Naval Observatory, for providing proof pages of the *Astronomical Almanac* in advance of its publication, and to Leslie Morrison and the Occultation Section of H.M.N.A.O. for providing the detailed information on total and grazing lunar occultations. Randall Brooks, St. Mary's University, provided the expanded twilight and sidereal time chart, assisted with the table on grazes of double stars, and provided the base map for the path of Pluto. Alan Dyer provided the list of twenty Challenge Objects which have been added to his NGC list.

I wish to acknowledge the efficient support of Rosemary Freeman, the Executive Secretary, and the guidance given by the R.A.S.C. National Council. The HANDBOOK also benefits greatly from the direct and indirect support of the Department of Physics, Acadia University, Wolfville, Nova Scotia.

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

ROY L. BISHOP, EDITOR

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.

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 4960. The business office and library are housed there.

The Society is devoted to the advancement of astronomy and allied sciences, and any serious user of this HANDBOOK would benefit from membership. An applicant may affiliate with one of the nineteen Centres across Canada, or may join the Society directly as an unattached member. Centres are located in St. John's, Halifax, Quebec, Montreal (2), Ottawa, Kingston, Toronto, Hamilton, Niagara Falls, Kitchener-Waterloo, London, Windsor (Ontario), Winnipeg, Saskatoon, Edmonton, Calgary, Vancouver, and Victoria.

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.

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 161.

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*. Wadsworth Publ., Belmont, CA, 1978. 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, 1965. An excellent, introductory guide to observational astronomy.

Mitton, S. ed. *The Cambridge Encyclopaedia of Astronomy*. Prentice-Hall of Canada, Toronto. Crown Publ. Co., New York, 1977. A comprehensive guide to modern 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.

Roth, G. D. *Astronomy: A Handbook*. Springer-Verlag, New York, 1975. A comprehensive, advanced guide to amateur astronomy.

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

Sidgwick, J. B. *Amateur Astronomer's Handbook* (4th edition). Enslow Publishers, New Jersey, 1980. A compendium of information on telescopes, their accessories, and their use.

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

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.

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 8:00 a.m.–8:00 p.m. Contains displays explaining the Observatory's work and other astronomy.
Visitors are asked to walk 1 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) 679-3186.

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.
May-September: Daily 2:00 p.m.–sunset.
Public observing, Saturday evening, May-August inclusive, by reservation. Telephone (819) 888-2822.

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 through Wednesday 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.

Group reservations (maximum 70) can be arranged through the University Liaison Office. Telephone (705) 675-1151, ext. 381. Special theme shows for the general public are presented on Friday and Saturday evenings at certain times during the year; these are announced in advance in the local media. A small admission fee is charged for these theme shows and reservations may be required.

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

For general information telephone (514) 872-4530 (24 hours recorded service).

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

Free public shows take place on some Tuesdays 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 times of public shows and 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.

Shows are presented Tuesday through Sunday and on holiday Mondays. For current show times and information, call the recorded message at (204) 943-3142.
To talk to staff members, call during office hours at 956-2830.
The Copernicus Solar Telescope projects a 130 cm diameter image of the sun every clear day.

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

Tuesday-Sunday, 3:00 and 7:45 p.m.
Weekends and holidays, 12:30, 1:45, 3:00 and 7:45 p.m.
(Theatre closed Mondays, except holidays.)

McMaster University Planetarium, University Information Centre, GH 120, Hamilton, Ontario L8S 4L8.

Group reservations only (maximum 45). Telephone (416) 525-9140, ext. 4721.

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

Opened in July 1981.
For show information telephone (902) 892-4121, ext. 188.

Queen Elizabeth Planetarium, Edmonton, Alberta T5J 0K1.

Winter: Tues.-Fri., 8:00 p.m. Sat., Sun. and holidays 3:00 and 8:00 p.m.
Summer: Daily, 3:00, 8:00 and 9:00 p.m.

SYMBOLS

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		Period of Revolution		Eccentricity (e)	Inclination (i)	Long. of Node (☊)	Long. of Perihelion (π)	Mean Long. at Epoch (L)
	A. U.	millions of km	Sidereal (P)	Synodic					
				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	3.36	0.16	2.3	27.3215	6.7	0.067
☿ Mercury	4,878	0	0.0553	5.44	0.38	4.3	58.67	<7	0.056
♀ Venus	12,104	0	0.8150	5.24	0.90	10.3	243	~179	0.76
⊕ Earth	12,756	1/298	1.000	5.52	1.00	11.2	0.9973	23.4	0.36
♂ Mars	6,794	1/192	0.1074	3.93	0.38	5.0	1.0260	24.0	0.16
♃ Jupiter	142,796	1/16	317.9	1.33	2.87	63.4	0.410	3.1	0.73
♄ Saturn	120,000	1/10	95.17	0.70	1.32	39.4	0.444	26.7	0.76
♅ Uranus	50,800	1/16	14.56	1.28	0.93	21.5	0.45?	97.9	0.93
♆ Neptune	48,600	1/50	17.24	1.75	1.23	24.2	0.67?	28.8	0.62
♇ Pluto	3,000?	?	0.0015?	0.7?	0.03?		6.3868	?	0.5?

The table gives the equatorial diameter and mass of the objects, as recommended by the I.A.U. in 1976, the mean density, the gravity and escape speed *at the pole*, the rotation period, the inclination of equator to orbit, and the albedo. Evidence in 1977 suggests that the equatorial diameter of Uranus may be 55,800 km and that its oblateness may be 1/120. There is also some evidence that the rotation periods of Uranus and Neptune are 1.0 and 0.9 day, respectively; these values are about twice those given in the table.

*depending on latitude

SATELLITES OF THE SOLAR SYSTEM

By Joseph Veverka

Name	Vis. Mag.	Diam. km	Mean Distance from Planet		Revolution Period			Orbit Incl. °	Discovery
			km/1000	arc sec	d	h	m		
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
XI Sinope	18.3	(30)	23,370	7660	758			153	S. Nicholson, 1914
Satellites of Saturn									
1980S28	(18)	(30)	137	23	0	14	26	—	Voyager 1, 1980
1980S27	(13.5)	(220)	139	23	0	14	43	—	Voyager 1, 1980
1980S26	(14)	(200)	142	24	0	15	05	—	Voyager 1, 1980
1980S1	(14)	180	151	25	0	16	41	—	*
1980S3	(14.5)	(140)	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	1050	295	48	1	21	18	1.1	G. Cassini, 1684
1980S6[b]	(17.5)	(40)	378	61	2	17	41[c]	—	P. Laques and J. Lecacheux, 1980
IV Dione	10.4	1120	378	61	2	17	41	0.0	G. Cassini, 1684
Thethys A	(18)	(30)	295	48	1	21	18[d]	—	**
Thethys B	(18)	(30)	295	48	1	21	18[e]	—	**

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.

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

[b]Informally referred to as Dione B.

[c]Librates around the leading (L_4) Lagrangian point with a period of ~790d.

[d]Librates about trailing (L_5) Lagrangian point.

[e]Librates about leading (L_4) Lagrangian point.

**Observed by B. A. Smith, H. Reitsema, C. Veillet and Others.

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	1440	3,561	575	79	07	56	14.7	G. Cassini, 1671
IX Phoebe	16.5	(240)	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	(800)	192	14	2	12	29	0	W. Lassell, 1851
II Umbriel	15.3	(550)	267	20	4	03	27	0	W. Lassell, 1851
III Titania	14.0	(1000)	438	33	8	16	56	0	W. Herschel, 1787
IV Oberon	14.2	(900)	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 5120 km.

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 $\gtrsim$ 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

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)	= 346.6200 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 = $111.133 - 0.559 \cos 2\phi$ km (at latitude ϕ)

1° of longitude = $111.413 \cos \phi - 0.094 \cos 3\phi$ 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

Escape speed from Earth = 11.2 km s^{-1}

Solar parallax = 8″.794 148

Constant of aberration = 20″.495 52

Obliquity of ecliptic = 23°.4416 (1982)

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 $K^{-1} \sim 1$ 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}
$\pi = 3.141\,592\,654 \simeq (113 \div 355)^{-1}$
$1'' = 4.8481 \times 10^{-6}$ rad
Number of square degrees on a sphere = 41 253.

MISCELLANEOUS INFORMATION

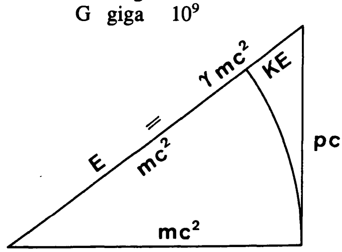
Relations between sidereal time t, right ascension α, hour angle h, declination δ, azimuth A (measured east of north), altitude a, and latitude ϕ:

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

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 $\gamma = (1 - v^2/c^2)^{-0.5}$:



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 46), 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. 14 and diagram on p. 16.

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. 14.

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 1982 will be about 53 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 1982

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

Jan. 0	$06^h37^m.3$	Apr. 0	$12^h32^m.2$	July 0	$18^h30^m.9$	Oct. 0	$00^h33^m.7$
Feb. 0	08 39.5	May 0	14 30.4	Aug. 0	20 33.2	Nov. 0	02 35.9
Mar. 0	10 29.9	June 0	16 32.7	Sep. 0	22 35.4	Dec. 0	04 34.2

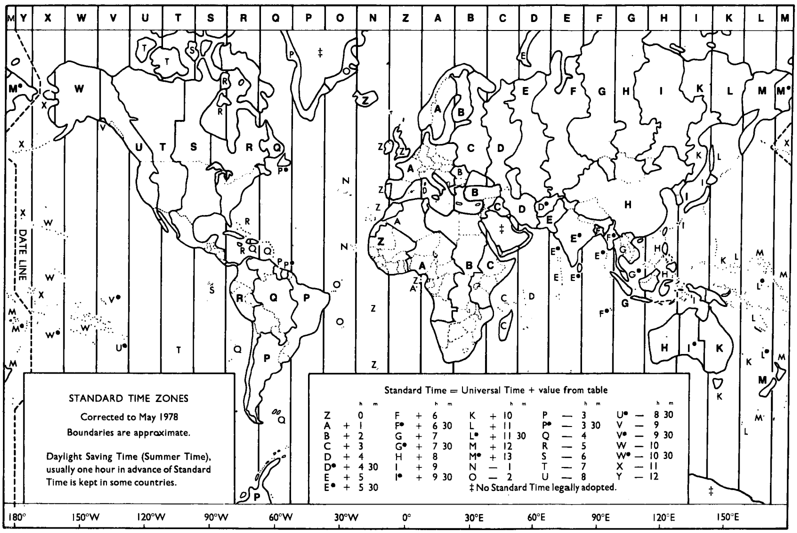
GST at hour t UT on day d of the month

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

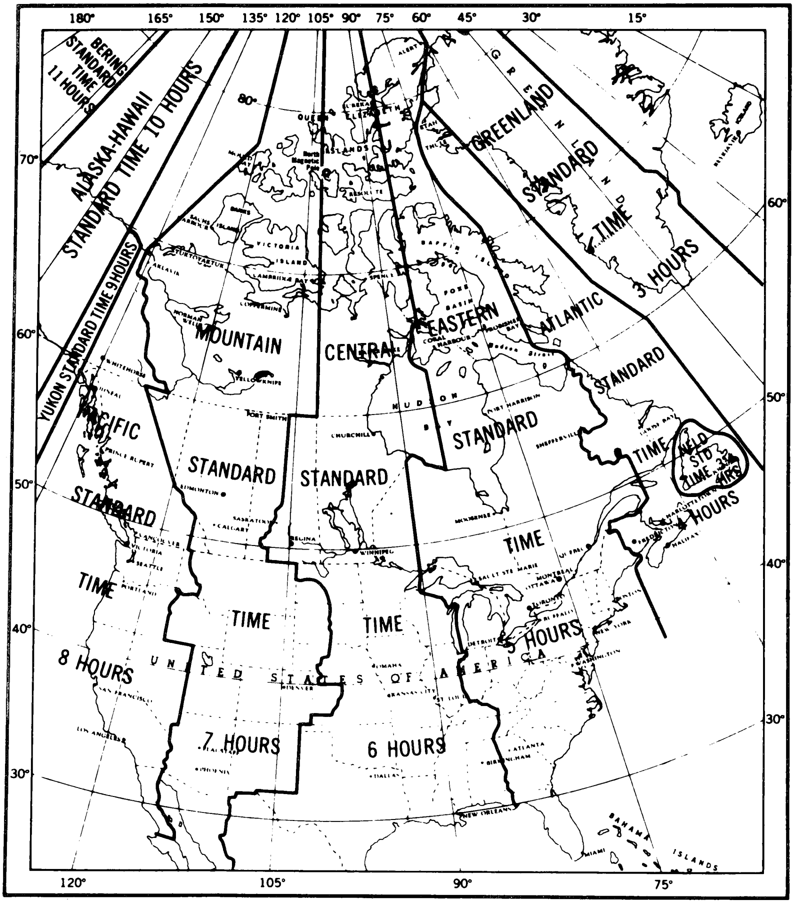
Local sidereal time = GST − west longitude (or + east longitude). (Be sure to convert your time and date to UT to calculate t and d.)

WORLD MAP OF TIME ZONES

Taken from *Astronomical Phenomena for the Year* 1982 (Washington: U.S. Government Printing Office, and London: Her Majesty's Stationery Office)



MAP OF STANDARD TIME ZONES



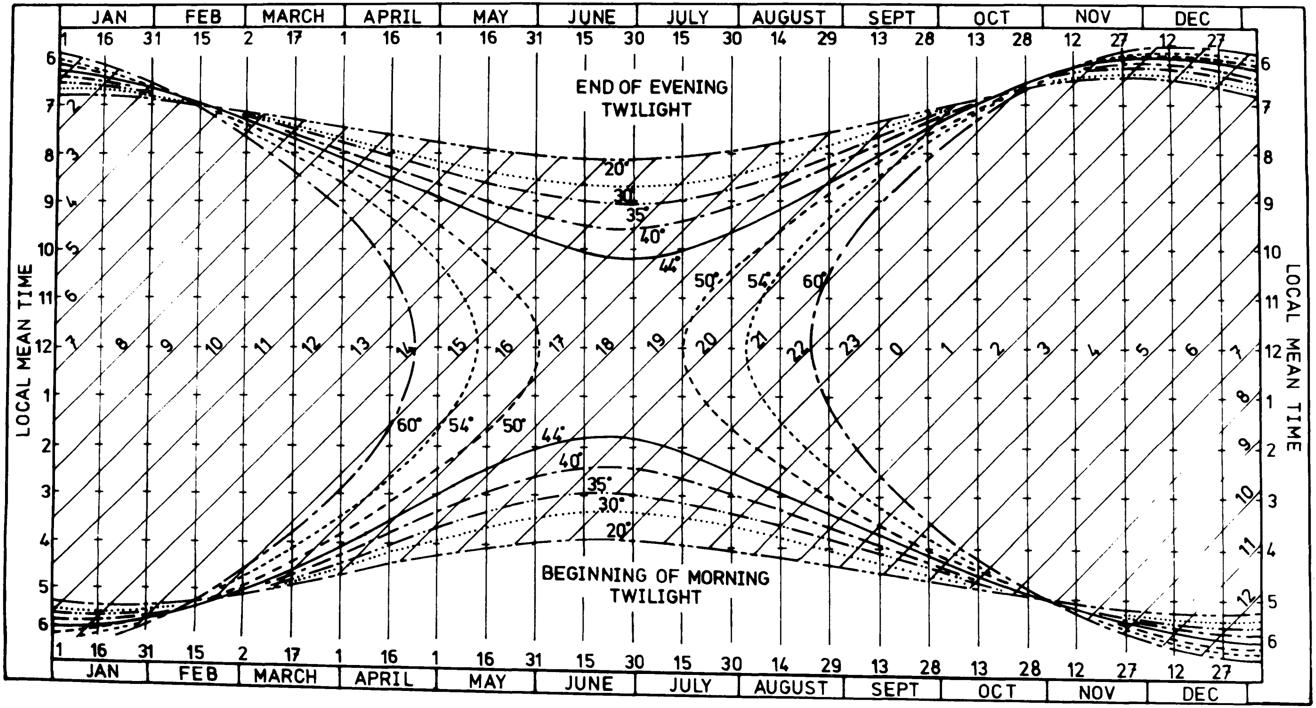
PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA, CANADA, 1973.

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 13 and 52 for definitions of L.M.T., L.S.T. and astronomical twilight.



ANNIVERSARIES AND FESTIVALS 1982

New Year's Day	Fri.	Jan.	1
Epiphany	Wed.	Jan.	6
Septuagesima Sunday		Feb.	7
Lincoln's Birthday (U.S.)	Fri.	Feb.	12
Washington's Birthday (U.S.)	Mon.	Feb.	15
Shrove Sunday		Feb.	21
Ash Wednesday		Feb.	24
St. David (Wales)	Mon.	Mar.	1
St. Patrick (Ireland)	Wed.	Mar.	17
Palm Sunday		Apr.	4
First Day of Passover	Thu.	Apr.	8
Good Friday		Apr.	9
Easter Sunday		Apr.	11
Birthday of Queen Elizabeth II (1926)	Wed.	Apr.	21
St. George (England)	Fri.	Apr.	23
Rogation Sunday		May	16
Ascension Day	Thu.	May	20
Victoria Day	Mon.	May	24
Shebuoth	Fri.	May	28
Pentecost (Whit Sunday)		May	30
Memorial Day (U.S.)	Mon.	May	31
Trinity Sunday		June	6
Corpus Christi	Thu.	June	10
First Day of Ramadan	Wed.	June	23
Canada Day	Thu.	July	1
Independence Day (U.S.)	Sun.	July	4
Civic Holiday	Mon.	Aug.	2
Labour Day	Mon.	Sep.	6
Rosh Hashanah	Sat.	Sep.	18
Yom Kippur	Mon.	Sep.	27
Succoth	Sat.	Oct.	2
Thanksgiving (Can.)	Mon.	Oct.	11
Columbus Day (U.S.)	Mon.	Oct.	11
Islamic New Year	Tue.	Oct.	19
Election Day (U.S.)	Tue.	Nov.	2
Remembrance Day	Thu.	Nov.	11
Veterans' Day (U.S.)	Thu.	Nov.	11
Thanksgiving (U.S.)	Thu.	Nov.	25
First Sunday in Advent		Nov.	28
St. Andrew (Scotland)	Tue.	Nov.	30
Christmas	Sat.	Dec.	25

Note: Julian dates for 1982, and 1982 and 1983 calendars are on the last page and the facing inside back cover.

COVER PHOTOGRAPH

The Great Comet of 1970 (Comet Bennett) against the stars of Pegasus on April 5, 1970, 0748 UT. The comet was 0.8 AU from Earth, of first magnitude, and with a 12° tail. The slight trailing of star images is associated with the comet's motion during the 30 minute exposure. (Acadia University photograph)

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. 48–51. See also p. 46.

The Moon—Its phases, perigee and apogee times and distances, and its conjunctions with the planets are given in the "Astronomical Phenomena Month by Month". For times of moonrise and moonset, see pp. 53–65.

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 $\frac{1}{2}$° 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 1982, the ascending node of the Moon's orbit regresses from longitude 113° to 94° (All within Gemini).

The Planets—Further information in regard to the planets, including Pluto, is found on pp. 86–100. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 101.

In the diagrams of the configurations of Jupiter's four Galilean satellites, 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). 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. 101.

Minima of Algol—The times of mid-eclipse are given in "Astronomical Phenomena Month by Month" and are calculated from the ephemeris

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

and are rounded off to the nearest ten minutes.

Occultations of Stars and Planets—For information about occultations of stars and planets visible in North America, see pp. 67–85.

THE SKY FOR JANUARY 1982

The year 1982 is ultimately defined by the sun's annual circuit around the sky. This circuit is called the ecliptic: the sun's annual path in the sky. The moon and planets move in paths which are close to but not coincident with the ecliptic. They lie (except in the case of Pluto) in a region called the *zodiac*: a band a few degrees wide, centered on the ecliptic.

If the moon and planets moved exactly on the ecliptic,then the following pages of "astronomical phenomena month by month" would be much more interesting. There would be eclipses, occultations and transits galore. As it is, a large fraction of the phenomena are of the form "X is Y° N (or S) of Z".

These phenomena can be understood by considering the *inclination* or angle of the moon's and planets' paths to the ecliptic. The inclination of Mercury's orbit, for instance, is about 7°. A bit of geometry reveals that Mercury can be ±4° from the ecliptic. The inclination of the moon's orbit is 5° and sometimes more. On Sept. 18 therefore, when Mercury is close to its greatest heliocentric latitude south and the moon is at its greatest distance north of the ecliptic, Mercury is a full 10° south of the moon – the width of the bowl of the Big Dipper!

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In future months, we will look at some other effects of the angle of the moon's orbit to the ecliptic.

The Sun—During January, the sun's R.A. increases from 18 h 45 m to 20 h 57 m and its Decl. changes from −23°03′ to −17°15′. The equation of time changes from −3 m 32 s to −13 m 29 s. The earth is at perihelion on Jan. 4, at a distance of 147,099,000 km from the sun. There is a partial eclipse of the sun on Jan. 25, not visible in North America.

The Moon—On January 1.0, the age of the moon in 5.6 d. The sun's selenographic colongitude is 340.0° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 14 (7°) and minimum (east limb exposed) on Jan. 2 (7°) and Jan. 29 (6°). The libration in latitude is maximum (north limb exposed) on Jan. 4 (7°) and Jan 31 (7°) and minimum (south limb exposed) on Jan. 17 (7°). There is a total eclipse of the moon on Jan. 9, not visible in North America.

Mercury on the 1st is in R.A. 19 h 39 m, Decl. −23°41′, and on the 15th is in R.A. 21 h 04 m, Decl. −17°36′. Greatest elongation east occurs on the 16th, but it is only 19°, so the planet can only be seen with difficulty at that time, low in the south-west, just after sunset. By the end of the month, the planet is in inferior conjunction. Mercury is 5° south of Venus on the 9th.

Venus on the 1st is in R.A. 20 h 44 m, Decl. −16°34′, and on the 15th it is in R.A. 20 h 24 m, Decl. −14°10′, mag. −3.5, and transits at 12 h 44 m. Early in the month, it can be seen very low in the south-west at sunset, and it sets about 2 hours later. It moves *rapidly* from the evening sky to the morning sky, passing through inferior conjunction on the 21st. By the end of the month, it can be seen very low in the south-east at sunrise.

Mars on the 15th is in R.A. 12 h 49 m, Decl. −2°31′, mag. +0.6, and transits at 5 h 12 m. In Virgo, near γ Vir, it rises about midnight and is high in the south-west at sunrise.

Jupiter on the 15th is in R.A. 14 h 24 m, Decl. −13°00′, mag. −1.5, and transits at 6 h 46 m. In Libra, it rises in late evening and is due south at sunrise.

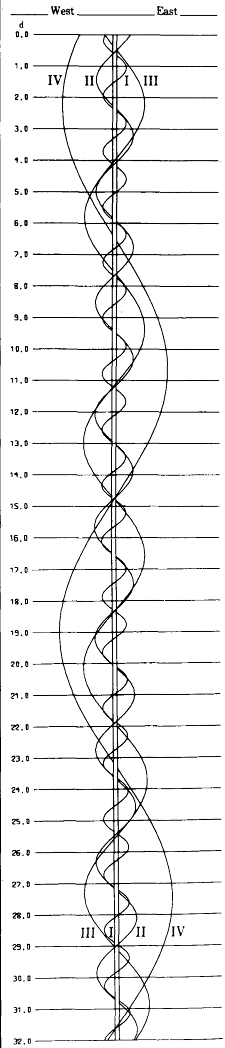
Saturn on the 15th is in R.A. 13 h 25 m, Decl. −6°16′, mag. 0.9, and transits at 5 h 48 m. In Virgo, it rises about midnight, and is well up in the south-west at sunrise. It is 5° north of Spica on the 8th.

Uranus on the 15th is in R.A. 16 h 05 m, Decl. −20°40′, mag. +6.0, and transits at 8 h 28 m. Uranus is in Scorpius until late June. Although it is rather far south of the equator for northern observers, it will be easy and interesting to observe as it moves through the field of ν, β, ω and δ Sco (see map in "Planets" section).

Neptune on the 15th is in R.A. 17 h 41 m, Dec. −22°07′, mag. +7.8, and transits at 10 h 03 m. In late January, it moves from Ophiuchus into Sagittarius, where it remains until early June.

1982	d	h m	JANUARY UNIVERSAL TIME	Min. of Algol h m
Fri.	1			
Sat.	2			
Sun.	3	04 45	☽ First Quarter	22 20
		19	Quadrantid meteors	
Mon.	4	11	Earth at perihelion	
Tues.	5			
Wed.	6			19 00
Thur.	7			
Fri.	8	06	Saturn 5° N. of Spica	
		12	Moon at perigee (359,800 km)	
Sat.	9	14	Mercury 5° S. of Venus	15 50
		19 53	○ Full Moon; eclipse of Moon, p. 66	
Sun.	10			
Mon.	11			
Tues.	12		Mars at aphelion	12 40
Wed.	13			
Thur.	14			
Fri.	15	19	Mars 3° S. of Moon	9 30
Sat.	16	12	Mercury greatest elong. E. (19°)	
		13	Saturn 3° S. of Moon	
		23 58	☾ Last Quarter	
Sun.	17	20	Jupiter 4° S. of Moon	
Mon.	18		Mercury at ascending node	6 20
Tues.	19			
Wed.	20	01	Uranus 4° S. of Moon	
		12	Moon at apogee (405,500 km)	
Thur.	21	10	Venus in inferior conjunction	3 10
		23	Neptune 1.1° S. of Moon; occ'n[1]	
Fri.	22	06	Vesta 0.5° N. of Moon; occ'n	
		18	Mercury stationary	
Sat.	23		Mercury at perihelion	
Sun.	24			0 00
Mon.	25	04 56	● New Moon; eclipse of Sun, p. 66	
Tues.	26			20 50
Wed.	27		Venus at perihelion	
Thur.	28			
Fri.	29			17 40
Sat.	30			
Sun.	31			

Config. of Jupiter's Satellites



[1]Visible only in the Arctic

THE SKY FOR FEBRUARY 1982

As noted last month, the moon's path in the sky is not coincident with the ecliptic; otherwise, we would enjoy two eclipses every month. The moon's path is actually tilted by 5° to the ecliptic, and crosses it at two points: the *ascending node* (moving northward) and the *descending node* (moving southward). Eclipses occur if the sun is near one of the nodes, and if the moon is either full (for a lunar eclipse) or new (for a solar eclipse).

If the moon's path were fixed in space, then the nodes also would be fixed; the sun would cross them at six-month intervals, and eclipse "seasons" would be six months apart. The moon's path is actually *not* fixed in space, due to the complex gravitational pull of the earth, with its equatorial "bulge", and the sun. The nodes slowly "regress" or move westward along the ecliptic, at a rate of about 19° a year, returning to their original position every 18.6 years. As a result, the sun encounters the nodes sooner than if the nodes were fixed; the eclipse "seasons" are ten days short of six months apart.

In 1982, the sun crosses the nodes in mid-January, in early July and in late December. There are consequently three eclipse "seasons" in the calendar year 1982, and there are seven eclipses—the maximum number possible in any calendar year.

The Sun—During February, the sun's R.A. increases from 20 h 57 m to 22 h 46 m and its Decl. changes from −17°15′ to −7°48′. The equation of time changes from −13 m 37 s to −12 m 38 s.

The Moon—On February 1.0, the age of the moon is 6.8 d. The sun's selenographic colongitude is 356.9° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 12 (6°) and minimum (east limb exposed) on Feb. 24 (5°). The libration in latitude is maximum (north limb exposed) on Feb. 27 (7°) and minimum (south limb exposed) on Feb. 13 (7°).

Mercury on the 1st is in R.A. 20 h 54 m, Decl. −13°48′, and on the 15th is in R.A. 20 h 20 m, Decl. −17°26′. The planet is in inferior conjunction on the 1st, but by the end of the month it is at greatest elongation west (a larger-than-average 27°). Unfortunately, because of the orientation of the ecliptic to the horizon, this is a classic unfavourable elongation (for northern observers), and the planet will be very difficult to see.

Venus on the 1st is in R.A. 19 h 44 m, Decl. −13°40′, and on the 15th it is in R.A. 19 h 37 m, Decl. −14°31′, mag. −4.3, and transits at 9 h 57 m. Throughout the month, the planet moves rapidly westward, relative to the sun, but the elongation is an unfavourable one (for the same reasons given above). The planet is therefore seen *very* low in the south-east at sunrise. Greatest brilliancy occurs on the 25th. At this time, the planet—with its conspicuous crescent phase—is an interesting target in a small telescope.

Mars on the 15th is in R.A. 13 h 15 m, Decl. −4°38′, mag. −0.1, and transits at 3 h 35 m. In Virgo, near Spica, it rises in mid-evening and is low in the south-west at sunrise. Mars and Saturn are close; Mars is the brighter (and redder).

Jupiter on the 15th is in R.A. 14 h 33 m, Decl. −13°38′, mag. −1.7, and transits at 4 h 53 m. In Libra, it rises in late evening and is in the south-west at sunrise.

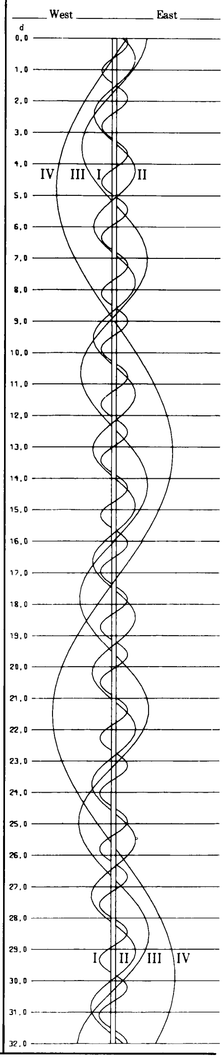
Saturn on the 15th is in R.A. 13 h 26 m, Decl. −6°09′, mag. +0.7, and transits at 3 h 46 m. In Virgo, near Spica, it rises in mid-evening and is low in the south-west at sunrise. See also "Mars" above.

Uranus on the 15th is in R.A. 16 h 10 m, Decl. −20°51′, mag. +5.9, and transits at 6 h 30 m.

Neptune on the 15th is in R.A. 17 h 45 m, Dec. −22°08′, mag. +7.8, and transits at 8 h 05 m.

1982	d	h m	FEBRUARY UNIVERSAL TIME	Min. of Algol h m
Mon.	1	04	Mercury in inferior conjunction	14 30
		05	Saturn stationary	
		14 28	☽ First Quarter	
Tues.	2		Mercury at greatest hel. lat. N.	
Wed.	3			
Thur.	4	16	Pluto stationary	11 20
Fri.	5	14	Moon at perigee (365,100 km)	
Sat.	6			
Sun.	7			8 10
Mon.	8	07 57	○ Full Moon	
Tues.	9			
Wed.	10	14	Venus stationary	5 00
Thur.	11			
Fri.	12	16	Mars 2° S. of Moon	
		22	Saturn 3° S. of Moon	
		22	Mercury stationary	
Sat.	13			1 50
Sun.	14	09	Jupiter 4° S. of Moon	
Mon.	15	20 21	☾ Last Quarter	22 30
Tues.	16	10	Uranus 4° S. of Moon	
Wed.	17	08	Moon at apogee (404,500 km)	
Thur.	18		Venus at greatest hel. lat. N.	19 20
		09	Neptune 1.0° S. of Moon; occ'n[1]	
Fri.	19			
Sat.	20	16	Venus 7° N. of Moon	
Sun.	21	05	Mars stationary	16 10
		15	Mercury 2° N. of Moon	
Mon.	22			
Tues.	23	21 13	● New Moon	
Wed.	24	14	Jupiter stationary	13 00
		23	Pallas stationary	
Thur.	25		Mercury at descending node	
		01	Venus greatest brilliancy (-4.3^m)	
		08	Saturn 5° N. of Spica	
Fri.	26	11	Mercury greatest elong. W. (27°)	
Sat.	27			9 50
Sun.	28			

Config. of Jupiter's Satellites



[1]Visible in S. Greenland, N. Atlantic

THE SKY FOR MARCH 1982

Another consequence of the changing path of the moon in the sky (see last month) is the series of occultations of Neptune by the moon in 1982. If you have a 1981 edition of this HANDBOOK, you will notice that there were no occultations of Neptune in 1981 (but there were several of Aldebaran). The series of occultations of Neptune in 1982 begins on Jan. 21. Subsequent occultations occur at intervals of approximately the moon's *sidereal* period of 27 days, the time it takes the moon to go once around its path relative to the sky. The occultations also show a systematic trend in that the first is visible in the arctic, the last is visible in southerly latitudes.

The explanation can be found by noting the changing positions of Neptune and the moon on the sky. Neptune is situated near the winter solstice, about a degree north of the ecliptic, and moves relatively little during the year. The moon passes Neptune approximately once a sidereal month, moving on a path which varies during the year. In January it passes about a degree north of Neptune, as seen from the centre of the earth. As seen from the arctic, however, the moon is displaced about a degree southward, and an ocultation is visible. By August, the path passes directly over Neptune, as seen from the centre of the earth. The occultation is now visible from equatorial latitudes. By December, the path passes south of Neptune, and the occultation is now visible from southern latitudes.

The Sun—During March, the sun's R.A. increases from 22 h 46 m to 0 h 40 m and its Decl. changes from −7°48′ to +4°20′. The equation of time changes from −12 m 26 s to 4 m 16 s. On March 20, at 22 h 56 m U.T., the sun reaches the vernal equinox, and spring begins in the northern hemisphere.

The Moon—On March 1.0, the age of the moon is 5.1 d. The sun's selenographic colongitude is 337.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on March 11 (5°) and minimum (east limb exposed) on March 23 (6°). The libration in latitude is maximum (north limb exposed) on March 26 (6°) and minimum (south limb exposed) on March 12 (7°).

Mercury on the 1st is in R.A. 21 h 04 m, Decl. −17°19′, and on the 15th is in R.A. 22 h 18 m, Decl. −12°45′. Throughout the month, it can be seen with very great difficulty, very low in the east, just before sunrise (see last month for explanation).

Venus on the 1st is in R.A. 20 h 01 m, Decl. −15°09′, and on the 15th it is in R.A. 20 h 42 m, Decl. −14°39′, mag. −4.2, and transits at 9 h 13 m. Throughout the month, the planet can be seen very low in the south-east at sunrise.

Mars on the 15th is in R.A. 13 h 04 m, Decl. −3°20′, mag. −0.8, and transits at 1 h 35 m. In Virgo, near Spica, it rises about sunset and sets about sunrise, being in opposition on the 31st.

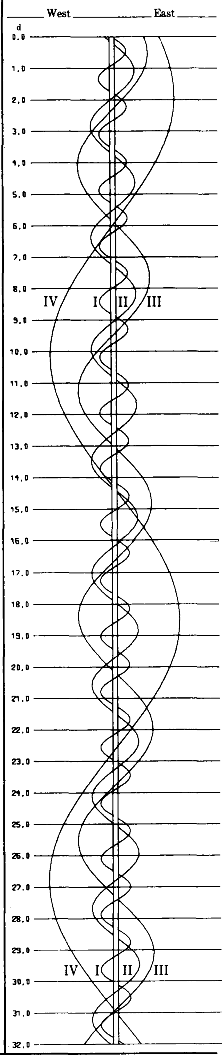
Jupiter on the 15th is in R.A. 14 h 31 m, Decl. −13°25′, mag. −1.9, and transits at 3 h 02 m. In Libra, it rises in mid-evening and is low in the south-west at sunrise.

Saturn on the 15th is in R.A. 13 h 21 m, Decl. −5°34′, mag. +0.6, and transits at 1 h 51 m. In Virgo near Spica, it rises shortly after sunset and is very low in the south-west at sunrise.

Uranus on the 15th is in R.A. 16 h 11 m, Decl. −20°54′, mag. +5.9, and transits at 4 h 41 m.

Neptune on the 15th is in R.A. 17 h 47 m, Dec. −22°07′, mag. +7.8, and transits at 6 h 17 m.

1982			MARCH UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Mon.	1				
Tues.	2	22 15	☽ First Quarter	6 40	
Wed.	3				
Thur.	4	05	Moon at perigee (369,900 km)		
Fri.	5			3 30	
Sat.	6				
Sun.	7				
Mon.	8		Mercury at aphelion	0 20	
Tues.	9	20	Uranus stationary		
		20 45	○ Full Moon		
Wed.	10			21 10	
Thur.	11	22	Mars 2° S. of Moon		
Fri.	12	05	Saturn 3° S. of Moon		
Sat.	13	17	Jupiter 4° S. of Moon	18 00	
Sun.	14				
Mon.	15	19	Uranus 4° S. of Moon		
Tues.	16			14 50	
Wed.	17	05	Moon at apogee (404,300 km)		
		17 15	☾ Last Quarter		
		18	Neptune 0.7° S. of Moon; occ'n[1]		
Thur.	18				
Fri.	19			11 40	
Sat.	20	22 56	Vernal equinox; Spring begins		
Sun.	21	14	Venus 5° N. of Moon		
Mon.	22			8 30	
Tues.	23	09	Ceres stationary		
Wed.	24	01	Mercury 2° N. of Moon		
Thur.	25	10 17	● New Moon	5 20	
Fri.	26				
Sat.	27				
Sun.	28		Mercury at greatest hel. lat. S.	2 00	
Mon.	29	06	Moon at perigee (367,700 km)		
		17	Neptune stationary		
Tues.	30			22 50	
Wed.	31	10	Mars at opposition		



[1]Visible in E. Asia

THE SKY FOR APRIL 1982

Amateur astronomers (as I have said at many times in many places) can make a significant contribution to astronomical research through the study of variable stars. Using visual techniques, with care, they can measure stellar magnitudes to ±0.1, which is more than adequate to discover novae, or to follow the light curves of Mira stars and other large-amplitude variables.

Recently, two studies have convinced me that visual observers can do even better than this if they average a large number of careful observations to make each magnitude estimate. The *Journal of the British Astronomical Association*, **88**, 397 (1978) reports 5636 observations of ρ Cas by 84 observers over 12 years. The observations are grouped into about 140 30-day averages, each with a precision of $0^m.01$ to $0^m.03$! This is sufficient to follow clearly the semi-regular variations, which have an amplitude of about $0^m.2$ and a time scale of 200 to 400 days. ρ Cas is one of several similar supergiants which I recommended for *photoelectric* observation by amateurs (*Journal of the American Association of Variable Star Observers*, **9**, 64 (1980)). Obviously visual observation is not out of the question.

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The other study is by a large, active group in Europe called GEOS: Groupe: Etude et Observation Stellaire. Using procedures similar to those used for ρ Cas (large numbers of valid observations by careful observers), GEOS has discovered or studied variables with ranges as small as $0^m.15$. This opens up whole new areas of research for visual observers of variable stars.

The Sun—During April, the sun's R.A. increases from 0 h 40 m to 2 h 32 m and its Decl. changes from +4°20′ to +14°55′. The equation of time changes from −3 m 58 s to +2 m 46 s.

The Moon—On April 1.0, the age of the moon is 6.6 d. The sun's selenographic colongitude is 355.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on April 7 (5°) and minimum (east limb exposed) on April 20 (7°). The libration in latitude is maximum (north limb exposed) on April 23 (7°) and minimum (south limb exposed) on April 8 (7°).

Mercury on the 1st is in R.A. 0 h 04 m, Decl. −1°45′, and on the 15th is in R.A. 1 h 46 m, Decl. +10°39′. Throughout most of the month, it is too close to the sun to be seen (superior conjunction occurs on the 11th). By the end of the month, however, it can be seen about 15° above the western horizon at sunset.

Venus on the 1st is in R.A. 21 h 45 m, Decl. −12°01′, and on the 15th it is in R.A. 22 h 42 m, Decl. −8°15′, mag. −3.9, and transits at 9 h 10 m. Greatest elongation west (46°) occurs on the 1st, but this is a classic unfavourable elongation (for northern observers), so even at this time, the planet is only about 17° above the south-eastern horizon at sunrise.

Mars on the 15th is in R.A. 12 h 22 m, Decl. +0°19′, mag. −1.0, and transits at 22 h 46 m. In Virgo, it rises about sunset and sets about sunrise, opposition having occurred on March 31.

Jupiter on the 15th is in R.A. 14 h 20 m, Decl. −12°26′, mag. −2.0, and transits at 0 h 49 m. Moving from Libra back into Virgo, it rises shortly after sunset and is setting at sunrise. Opposition occurs on the 26th.

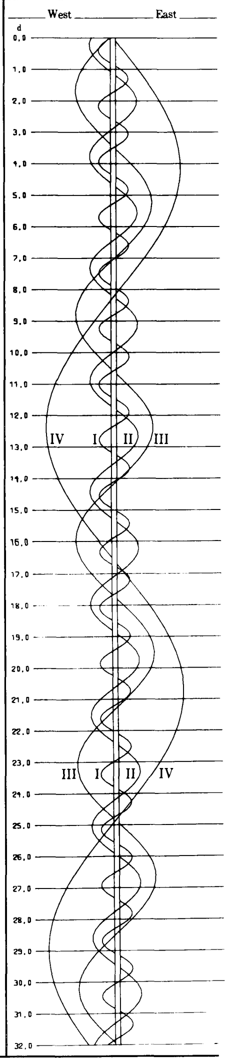
Saturn on the 15th is in R.A. 13 h 12 m, Decl. −4°41′, mag. +0.5, and transits at 23 h 37 m. In Virgo near Spica, it rises at about sunset and sets at about sunrise. Opposition occurs on the 9th.

Uranus on the 15th is in R.A. 16 h 08 m, Decl. −20°48′, mag. +5.8, and transits at 2 h 37 m.

Neptune on the 15th is in R.A. 17 h 47 m, Dec. −22°06′, mag. +7.7, and transits at 4 h 15 m.

1982	d	h m	APRIL UNIVERSAL TIME	Min. of Algol h m
Thur.	1	05 08	☽ First Quarter	
		18	Venus greatest elong. W. (46°)	
		22	Pallas at opposition	
Fri.	2			19 40
Sat.	3			
Sun.	4			
Mon.	5	07	Mars closest approach (95,010,000 km)	16 30
Tues.	6			
Wed.	7	13	Mars 2° S. of Moon	
Thur.	8	10 18	○ Full Moon	13 20
		10	Saturn 2° S. of Moon	
Fri.	9	02	Saturn at opposition	
		21	Jupiter 3° S. of Moon	
Sat.	10			
Sun.	11	18	Mercury in superior conjunction	10 10
Mon.	12	02	Uranus 3° S. of Moon	
Tues.	13			
Wed.	14	00	Moon at apogee (404,700 km)	7 00
		02	Neptune 0.4° S. of Moon; occ'n[1]	
Thur.	15		Venus at descending node	
		21	Pluto at opposition	
Fri.	16		Mercury at ascending node	
		12 42	☾ Last Quarter	
Sat.	17			3 50
Sun.	18			
Mon.	19			
Tues.	20	06	Venus 4° N. of Moon	0 40
Wed.	21		Mercury at perihelion	
Thur.	22	14	Lyrid meteors	21 30
Fri.	23	20 29	● New Moon	
Sat.	24			
Sun.	25	21	Moon at perigee (362,600 km)	18 20
Mon.	26	00	Jupiter at opposition	
Tues.	27			
Wed.	28			15 10
Thur.	29	23	Juno stationary	
Fri.	30	12 07	☽ First Quarter	

Config. of Jupiter's Satellites



[1]Visible in S. Europe, N. and Central Africa, Saudi Arabia

THE SKY FOR MAY 1982

Last month, I discussed one of the areas in which amateur astronomers can make a significant contribution to astronomical research. There is another important contribution which amateurs can make, not directly related to astronomical *research*, and that is in astronomical *education*.

The teaching of astronomy in the schools is spotty, as I have recently pointed out (*Journal of the Royal Astronomical Society of Canada*, **74**, 81 (1980)). In fact, a student can graduate without encountering astronomy at all! Outside of and beyond school, the public may encounter astronomy on TV, in the papers, at planetariums or at observatories. Despite the efforts of astronomy writers, planetariums and observatories, there is still much to be done – and many opportunities – in astronomical education for the public.

Amateur astronomers, individually and in groups, can make a tremendous contribution here. Many already do, and their efforts should be recognized and applauded. Individuals provide instruction for Scout and Guide badges, for schools and camps, and informally in their own back yards. Groups organize astronomy programs, in libraries, for instance, and "star nights" in the parks. Groups with fixed observatories open these to the public on a regular basis.

May is a good month for such programs, since Jupiter and Saturn are well placed for observing. The moon is also well placed around the beginning and end of the month. In recent years, there has been a movement to organize an annual "Astronomy Day" in North America (and elsewhere) sometime in May. Judging by past success, this event deserves to be an annual one.

The Sun—During May, the sun's R.A. increases from 2 h 32 m to 4 h 34 m and its Decl. changes from +14°55′ to +21°59′. The equation of time changes from +2 m 54 s to +2 m 26 s.

The Moon—On May 1.0, the age of the moon is 7.1 d. The sun's selenographic colongitude is 1.1° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 3 (6°) and May 31 (7°) and minimum (east limb exposed) on May 18 (8°). The libration in latitude is maximum (north limb exposed) on May 20 (7°) and minimum (south limb exposed) on May 5 (7°).

Mercury on the 1st is in R.A. 3 h 46 m, Decl. +22°12′, and on the 15th is in R.A. 4 h 48 m, Decl. +24°29′. Greatest elongation east (21°) occurs on the 9th. This elongation is favourable (for northern observers) due to the steep angle of the ecliptic to the horizon; the greatest elongation (21°), however, is considerably less than the maximum possible value (28°). The planet thus appears low in the west at sunset, for the first half of the month. By the end of the month it is in inferior conjunction.

Venus on the 1st is in R.A. 23 h 47 m, Decl. −2°35′, and on the 15th it is in R.A. 0 h 46 m, Decl. +3°02′, mag. −3.6, and transits at 9 h 17 m. It rises about $1\frac{1}{2}$ hours before the sun and is very low in the southeast at sunrise.

Mars on the 15th is in R.A. 12 h 04 m, Decl. +0°56′, mag. −0.4, and transits at 20 h 31 m. In Virgo, it is high in the south-east at sunset, and sets well before sunrise.

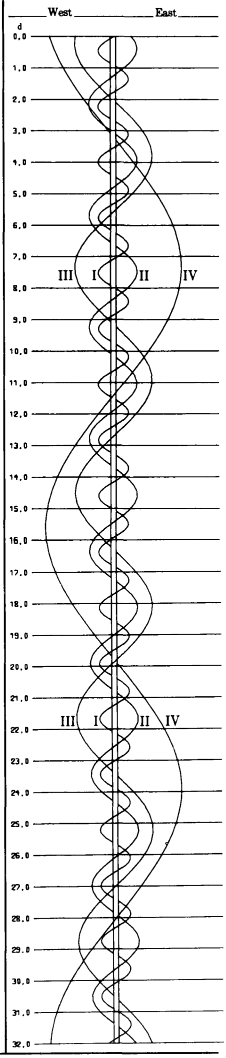
Jupiter on the 15th is in R.A. 14 h 06 m, Decl. −11°13′, mag. −2.0, and transits at 22 h 32 m. In Virgo, it is in the south-east at sunset, and sets about an hour before sunrise.

Saturn on the 15th is in R.A. 13 h 05 m, Decl. −3°58′, mag. +0.7, and transits at 21 h 32 m. In Virgo near Spica, it is well up in the south-east at sunset, and sets an hour or two before sunrise.

Uranus on the 15th is in R.A. 16 h 04 m, Decl. −20°36′, mag. +5.8, and transits at 0 h 34 m. On May 24, it is at opposition, at a distance of 17.867 astronomical units.

Neptune on the 15th is in R.A. 17 h 45 m, Dec. −22°05′, mag. +7.7, and transits at 2 h 15 m.

1982			MAY UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Sat.	1		Mercury at greatest hel. lat. N.	11 50	
Sun.	2				
Mon.	3				
Tues.	4	05	Mars 3° S. of Moon	8 40	
		20	η Aquarid meteors		
Wed.	5	13	Saturn 3° S. of Moon		
Thur.	6	21	Jupiter 4° S. of Moon		
Fri.	7			5 30	
Sat.	8	00 45	☺ Full Moon		
Sun.	9	00	Mercury greatest elong. E. (21°)		
		07	Uranus 3° S. of Moon		
Mon.	10	12	Ceres at opposition	2 20	
		14	Mercury 8° N. of Aldebaran		
Tues.	11	08	Neptune 0.3° S. of Moon; occ'n[1]		
		15	Moon at apogee (405,600 km)		
Wed.	12				
Thur.	13	05	Mars stationary	1 10	
Fri.	14				
Sat.	15			20 00	
Sun.	16	05 11	☾ Last Quarter		
Mon.	17				
Tues.	18			16 50	
Wed.	19		Venus at aphelion		
Thur.	20	02	Venus 3° N. of Moon		
Fri.	21	10	Mercury stationary	13 40	
Sat.	22	00	Pallas stationary		
Sun.	23	04 40	● New Moon		
Mon.	24		Mercury at descending node	10 30	
		03	Moon at perigee (358,700 km)		
		03	Uranus at opposition		
Tues.	25				
Wed.	26				
Thur.	27			7 10	
Fri.	28				
Sat.	29	20 07	☽ First Quarter		
Sun.	30			4 00	
Mon.	31	13	Mars 5° S. of Moon		



[1]Visible in N. and Central S. America

THE SKY FOR JUNE 1982

In February, we discussed the relatively rapid changes in the moon's path in the sky, due to the complex gravitational forces of the earth and sun. These same forces cause *precession*: a slow, conical motion of the rotation axis of the earth.

There are several noticeable effects of precession. One is the slow motion of the celestial poles, which are defined by the rotation axis of the earth. Polaris is presently near the north celestial pole; thousands of years from now, the north celestial pole will have moved elsewhere.

The celestial equator is also defined by the rotation axis of the earth, and will also move; its intersection points with the ecliptic (the equinoxes) will therefore also move. The vernal equinox was once in the constellation Aries (and is still called "the first point of Aries"), but it is now in Pisces. Since star positions are measured relative to the celestial equator and vernal equinox, they will gradually change due to the motion of the reference frame. The solstices, like the equinoxes, have also moved due to precession. They are no longer in Cancer and Capricorn, yet we still refer to the Tropics of Cancer and Capricorn.

The precession cycle is about 26,000 years long. It is interesting to realize that in 24,000 years, all the historical terminology will be right again!

The Sun—During June, the sun's R.A. increases from 4 h 34 m to 6 h 39 m and its Decl. changes from +21°59′ to +23°09′. The equation of time changes from +2 m 17 s to −3 m 33 s. On June 21, at 17 h 23 m U.T., the sun reaches the summer solstice, and summer begins in the northern hemisphere. There is also a partial eclipse of the sun on June 21, not visible in North America.

The Moon—On June 1.0, the age of the moon is 8.8 d. The sun's selenographic colongitude is 19.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 28 (7°) and minimum (east limb exposed) on June 15 (8°). The libration in latitude is maximum (north limb exposed) on June 16 (7°) and minimum (south limb exposed) on June 2 (7°) and June 29 (7°).

Mercury on the 1st is in R.A. 4 h 41 m, Decl. +20°05′, and on the 15th is in R.A. 4 h 22 m, Decl. +17°12′. Early in the month, it is too close to the sun to be seen (inferior conjunction occurs on the 1st). By the end of the month, it can be seen very low in the east at sunrise. Greatest elongation west occurs on the 26th. On the 23rd, it is 1.7° north of Aldebaran.

Venus on the 1st is in R.A. 2 h 00 m, Decl. +9°59′, and on the 15th it is in R.A. 3 h 03 m, Decl. +15°11′, mag. −3.4, and transits at 9 h 31 m. It rises about $1\frac{1}{2}$ hours before the sun, and is very low in the east at sunrise.

Mars on the 15th is in R.A. 12 h 25 m, Decl. −2°31′, mag. +0.2, and transits at 18 h 51 m. In Virgo, it is near the meridian at sunset, and sets about 5 hours later.

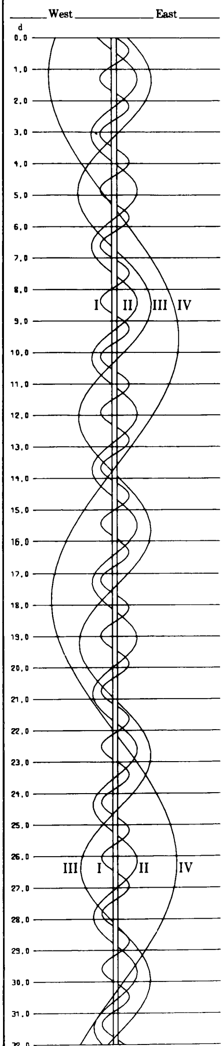
Jupiter on the 15th is in R.A. 13 h 56 m, Decl. −10°29′, mag. −1.9, and transits at 20 h 21 m. In Virgo, it is almost at the meridian at sunset, and it sets shortly after midnight.

Saturn on the 15th is in R.A. 13 h 01 m, Decl. −3°42′, mag. +0.9, and transits at 19 h 26 m. In Virgo near Spica, it is near the meridian at sunset and sets at about midnight.

Uranus on the 15th is in R.A. 15 h 59 m, Decl. −20°21′, mag. +5.8, and transits at 22 h 23 m. From late June to late September, it is in Libra.

Neptune on the 15th is in R.A. 17 h 42 m, Dec. −22°03′, mag. +7.7, and transits at 0 h 10 m. From early June until late November, it is in Ophiuchus. On June 17, it is at opposition, at a distance of 29.256 astronomical units.

1982			JUNE UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Tues.	1	16	Saturn 3° S. of Moon		
		20	Mercury in inferior conjunction		
Wed.	2	21	Jupiter 4° S. of Moon	0 50	
Thur.	3				
Fri.	4		Mercury in aphelion	21 40	
Sat.	5	11	Uranus 3° S. of Moon		
Sun.	6	15 59	○ Full Moon		
Mon.	7	13	Neptune 0.3° S. of Moon; occ'n[1]	18 30	
		23	Moon at apogee (406,200 km)		
Tues.	8				
Wed.	9				
Thur.	10			15 20	
Fri.	11		Venus at greatest hel. lat. S.		
Sat.	12	09	Vesta 0.7° N. of Moon; occ'n		
Sun.	13	21	Mercury stationary	12 10	
Mon.	14	18 06	☾ Last Quarter		
Tues.	15				
Wed.	16			9 00	
Thur.	17	05	Neptune at opposition		
Fri.	18	23	Venus 2° N. of Moon		
Sat.	19	12	Saturn stationary	5 50	
Sun.	20	02	Mercury 1.1° S. of Moon; occ'n[2]		
Mon.	21		Mars at descending node		
		11 52	● New Moon; eclipse of Sun, p. 66		
		12	Moon at perigee (357,300 km)		
		17 23	Summer solstice; summer begins		
Tues.	22			2 30	
Wed.	23	03	Mercury 1.7° N. of Aldebaran		
Thur.	24		Mercury at greatest hel. lat. S.	23 20	
		06	Juno at opposition		
Fri.	25				
Sat.	26	14	Mercury greatest elong. W. (22°)		
Sun.	27			20 10	
Mon.	28	05 56	☽ First Quarter		
		08	Jupiter stationary		
		12	Mars 6° S. of Moon		
		21	Saturn 3° S. of Moon		
Tues.	29	21	Vesta stationary		
Wed.	30	01	Jupiter 4° S. of Moon	17 00	



[1]Visible in S.E. Asia and the Pacific

[2]Visible in N. Asia, the N. of N. America, and the Arctic

THE SKY FOR JULY 1982

One of my major astronomical research interests is the study of small brightness variations in stars. Such variations have often been overlooked or misinterpreted in the past, so I find it an observational challenge to look for them and study them carefully. Also "microvariability" is ubiquitous, and carries much useful information about the stars.

Since microvariability has not been thoroughly explored in many of the brightest stars, I have tended to concentrate my research on naked-eye stars. As a result, I have developed an appreciation of the individual nature of the naked-eye stars. You can do so also, using the information in the table of "The Brightest Stars", and in similar tables and catalogues.

Consider the constellation Cassiopeia, for instance, which is so prominent in July. α Cas (the only reddish star among the conspicuous stars in Cassiopeia) is a suspected variable. β Cas is a microvariable with a period of $2\frac{1}{2}$ hours. γ Cas is a notorious and bizarre variable whose radiation and rotation have produced an outward-flowing disc of gas around its equator. δ Cas is a suspected microvariable – a shallow eclipsing binary? There are numerous variables among the fainter stars in Cassiopeia, including ρ Cas (mentioned in "The Sky for April"), which is one of the most luminous stars known.

The Sun—During July, the sun's R.A. increases from 6 h 39 m to 8 h 43 m and its Decl. changes from +23°09′ to +18°09′. The equation of time changes from −3 m 44 s to −6 m 21 s. The earth is at aphelion on July 4, at a distance of 152,094,000 km from the sun. There is a partial eclipse of the sun on July 20, visible only from the arctic regions of North America.

The Moon—On July 1.0, the age of the moon is 9.5 d. The sun's selenographic colongitude is 26.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 26 (7°) and minimum (east limb exposed) on July 13 (7°). The libration in latitude is maximum (north limb exposed) on July 14 (7°) and minimum (south limb exposed) on July 26 (7°). There is a total eclipse of the moon on the night of July 5–6, visible in North America.

Mercury on the 1st is in R.A. 5 h 06 m, Decl. +20°19′, and on the 15th is in R.A. 6 h 45 m, Decl. +23°21′. Early in the month, it can be seen very low in the east at sunrise, but by the end of the month, it is too close to the sun to be seen: superior conjunction occurs on the 25th.

Venus on the 1st is in R.A. 4 h 20 m, Decl. +19°51′, and on the 15th it is in R.A. 5 h 31 m, Decl. +22°14′, mag. −3.3, and transits at 10 h 01 m. Although the elongation is decreasing somewhat, the angle of the ecliptic to the horizon is increasing (for northern observers), so the planet is actually more visible—low in the east at sunrise—than it was in the spring! It is 4° north of Aldebaran on the 4th.

Mars on the 15th is in R.A. 13 h 11 m, Decl. −8°06′, mag. +0.5, and transits at 17 h 40 m. In Virgo, it is well up in the south-west at sunset, and sets about $3\frac{1}{2}$ hours later. It is 3° south of Saturn on the 10th, and 1.6° north of Spica on the 21st.

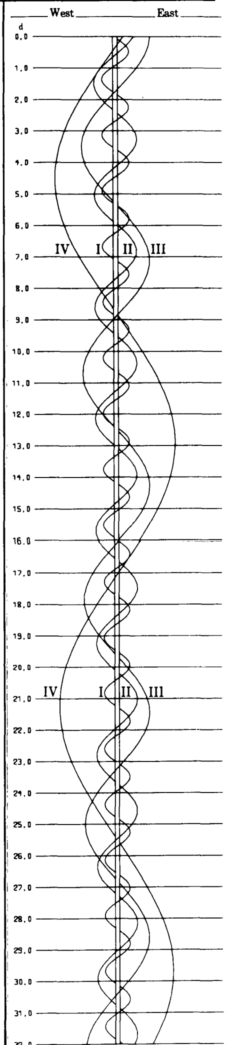
Jupiter on the 15th is in R.A. 13 h 57 m, Decl. −10°41′, mag. −1.7, and transits at 18 h 24 m. In Virgo, it is past the meridian at sunset, and sets before midnight. For the next month or so, Mars, Jupiter, Saturn and Spica are within about 15° of each other on the ecliptic.

Saturn on the 15th is in R.A. 13 h 03 m, Decl. −4°03′, mag. +1.0, and transits at 17 h 30 m. In Virgo near Spica, it is in the south-west at sunset, and it sets about $3\frac{1}{2}$ hours later. It is 3° north of Mars on the 10th.

Uranus on the 15th is in R.A. 15 h 55 m, Decl. −20°11′, mag. +5.8, and transits at 20 h 21 m.

Neptune on the 15th is in R.A. 17 h 38 m, Dec. −22°02′, mag. +7.7, and transits at 22 h 04 m.

1982			JULY UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Thur.	1	04	Ceres 0.2° N. of Moon; occ'n		
Fri.	2	05	Ceres stationary		
		15	Uranus 4° S. of Moon		
Sat.	3			13 50	
Sun.	4	01	Venus 4° N. of Aldebaran		
		13	Earth at aphelion		
		17	Neptune 0.3° S. of Moon; occ'n[1]		
Mon.	5	01	Moon at apogee (406,200 km)		
Tues.	6	07 32	○ Full Moon; eclipse of Moon, p. 66	10 40	
Wed.	7				
Thur.	8				
Fri.	9			7 30	
Sat.	10	00	Mars 3° S. of Saturn		
Sun.	11	16	Pluto stationary		
Mon.	12			4 10	
Tues.	13		Mercury at ascending node		
Wed.	14	03 47	☾ Last Quarter		
Thur.	15			1 00	
Fri.	16				
Sat.	17		Mercury at perihelion	21 50	
Sun.	18	19	Venus 0.6° N. of Moon; occ'n[2]		
Mon.	19	21	Moon at perigee (358,700 km)		
Tues.	20	18 57	● New Moon; eclipse of Sun, p. 66	18 40	
Wed.	21	19	Mars 1.6° N. of Spica		
Thur.	22				
Fri.	23			15 30	
Sat.	24				
Sun.	25	08	Mercury in superior conjunction		
Mon.	26	07	Saturn 3° S. of Moon	12 20	
		22	Mars 6° S. of Moon		
Tues.	27	10	Jupiter 4° S. of Moon		
		18 22	☽ First Quarter		
Wed.	28		Mercury at greatest hel. lat. N.		
		23	S. δ Aquarid meteors		
Thur.	29	21	Uranus 4° S. of Moon	9 10	
Fri.	30				
Sat.	31	23	Neptune 0.4° S. of Moon; occ'n[3]		



[1]Visible in N.E. Africa, S. Asia and the E. Indies
[2]Visible in New Zealand and the S. Pacific
[3]Visible in the N.E. of S. America, the Atlantic, N. and Central Africa

THE SKY FOR AUGUST 1982

In past months, we have talked about sky phenomena which depend on the inclination of the moon's and planets' paths to the ecliptic. There are other sky phenomena which depend on the much larger inclination of the ecliptic to the equator. Experienced sky-watchers are familiar with some of these phenomena: the altitude of the moon at transit, favourable and unfavourable elongations of planets, and so forth.

One of the simplest phenomena is the orientation of the young crescent moon. At this time, the moon is about 60° east of the sun and is easily visible just after sunset. In early spring, the sun is near the vernal equinox: one of the intersection points of the ecliptic and the equator. East of the vernal equinox, the ecliptic moves north of the equator, so that in the spring, the ecliptic makes a steep angle with the western horizon at sunset. The crescent moon is high in the sky, with its cusps nearly horizontal, looking like the disembodied smile of the Cheshire cat. Conversely in the fall at sunset, the crescent moon is low in the sky with its cusps almost vertical.

M

This autumn, we will witness another effect of the ecliptic-equator angle. (This angle, incidentally, is called the *obliquity of the ecliptic*, and is about $23\frac{1}{2}°$.) Between August and December, the elongation of Mars slowly decreases from about 80° east of the sun to about 35° east of the sun. In August, September and October, the elongation is "unfavourable" because of the shallow angle of the ecliptic to the western horizon at sunset. By November and December, the elongation, though smaller, is more favourable, and the planet will still be easily visible.

The Sun—During August, the sun's R.A. increases from 8 h 43 m to 10 h 40 m and its Decl. changes from +18°09′ to +8°29′. The equation of time changes from −6 m 18 s to −0 m 23 s.

The Moon—On August 1.0, the age of the moon is 11.2 d. The sun's selenographic colongitude is 45.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 23 (7°) and minimum (east limb exposed) on Aug. 10 (6°). The libration in latitude is maximum (north limb exposed) on Aug. 10 (7°) and minimum (south limb exposed) on Aug. 22 (7°).

Mercury on the 1st is in R.A. 9 h 15 m, Decl. +17°49′, and on the 15th is in R.A. 10 h 51 m, Decl. +8°09′. Although the planet is approaching greatest elongation east by the end of the month, this is a classic unfavourable elongation (for northern observers), so the planet can only be seen with great difficulty, very low in the west at sunset.

Venus on the 1st is in R.A. 6 h 59 m, Decl. +22°29′, and on the 15th it is in R.A. 8 h 12 m, Decl. +20°22′, mag. −3.3, and transits at 10 h 40 m. The visibility of the planet continuous to improve slightly (see last month). It rises about 2 hours before the sun, and is visible low in the east at sunrise. It is 7° south of Pollux on the 9th.

Mars on the 15th is in R.A. 14 h 16 m, Decl. −14°40′, mag. +0.9, and transits at 16 h 43 m. Moving from Virgo into Libra, it is low in the south-west at sunset and sets about $2\frac{1}{2}$ hours later. It is 2° south of Jupiter on the 10th, with Jupiter being the brighter. By the end of the month, Antares, Mars, Jupiter, Spica and Saturn form an interesting configuration at sunset, stretching across the horizon from south to west.

Jupiter on the 15th is in R.A. 14 h 07 m, Decl. −11°46′, mag. −1.5, and transits at 16 h 33 m. In Virgo, but approaching Libra, it is low in the south-west at sunset, and sets about $2\frac{1}{2}$ hours later. See also "Mars" above.

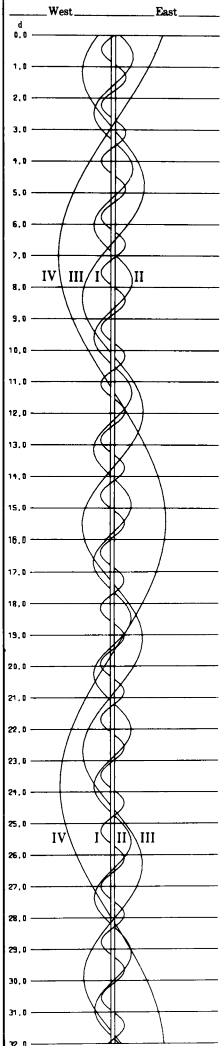
Saturn on the 15th is in R.A. 13 h 10 m, Decl. −4°55′, mag. +1.1, and transits at 15 h 36 m. In Virgo, it is low in the south-west at sunset, and sets about 2 hours later. See also "Mars" above.

Uranus on the 15th is in R.A. 15 h 54 m, Decl. −20°08′, mag. +5.9, and transits at 18 h 19 m.

Neptune on the 15th is in R.A. 17 h 36 m, Dec. −22°02′, mag. +7.7, and transits at 20 h 00 m.

1982			AUGUST UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Sun.	1	10	Moon at apogee (405,600 km)	5 50
Mon.	2			
Tues.	3			
Wed.	4	22 34	Full Moon	2 40
Thur.	5			
Fri.	6		Venus at ascending node	23 30
Sat.	7			
Sun.	8	04	Mercury 1.0° N. of Regulus	
Mon.	9	12	Uranus stationary	20 20
		16	Venus 7° S. of Pollux	
Tues.	10	01	Mars 2° S. of Jupiter	
		11	Vesta at opposition	
Wed.	11			
Thur.	12	11 08	☾ Last Quarter	17 10
		13	Perseid meteors	
Fri.	13			
Sat.	14			
Sun.	15			14 00
Mon.	16			
Tues.	17	02	Moon at perigee (362,500 km)	
		14	Venus 1.4° S. of Moon	
Wed.	18			10 50
Thur.	19	02 45	New Moon	
		19	Juno stationary	
Fri.	20		Mercury at descending node	
		15	Mercury 5° S. of Moon	
Sat.	21			7 30
Sun.	22	20	Saturn 3° S. of Moon	
Mon.	23			
Tues.	24	01	Jupiter 4° S. of Moon	4 20
		15	Mars 6° S. of Moon	
Wed.	25			
Thur.	26	04	Uranus 3° S. of Moon	
		09 49	☽ First Quarter	
Fri.	27		Saturn at greatest hel. lat. N.	1 10
Sat.	28	05	Neptune 0.3° S. of Moon; occ'n[1]	
Sun.	29	00	Moon at apogee (404,700 km)	22 00
Mon.	30		Mercury at aphelion	
Tues.	31			

Config. of Jupiter's Satellites



[1]Visible in Central America and the Pacific

THE SKY FOR SEPTEMBER 1982

Notice how leisurely Venus moves through superior conjunction this fall. It takes four months to move from 15° west of the sun to 15° east! Contrast this with the rapidity with which it moved through inferior conjunction in January. There, it took 17 *days* to move from 15° east to 15° west! Why the great difference? A diagram, and some basic data on orbital elements, may help.

At inferior conjunction, Venus is between the earth and the sun (or more precisely, Venus has the same longitude as the sun). The earth is moving around its orbit at 30 km/s, which causes the sun to appear to move at 30 km/s which, seen at a distance of 1 A.U., corresponds to an apparent eastward *angular* motion of about 1°/day. Venus moves around its orbit at 35 km/s or about 5 km/s relative to the earth. This, seen at a distance of 0.3 A.U. (the distance of Venus from earth at inferior conjunction) corresponds to an apparent *westward* angular motion of about 0.6°/day. Thus the elongation of Venus (relative to the sun) changes at about 1.6°/day as observed.

At superior conjunction, Venus is directly beyond the sun (and again, more precisely, has the same longitude as the sun). Again, the sun has an apparent eastward angular motion of about 1°/day, but now Venus is also moving eastward, at a velocity of 30 km/s + 35 km/s = 65 km/s relative to the earth, seen at a distance of 1.7 A.U. (the distance of Venus from the earth at superior conjunction). This corresponds to an apparent eastward angular velocity of 1.25°/day, or about 0.25°/day relative to the sun. Thus the elongation of Venus (relative to the sun) changes at about 0.25°/day as observed.

The Sun—During September, the sun's R.A. increases from 10 h 40 m to 12 h 28 m and its Decl. changes from +8°29′ to −2°58′. The equation of time changes from −0 m 03 s to +9 m 56 s. On Sept. 23, at 8 h 46 m U.T., the sun reaches the autumnal equinox, and autumn begins in the northern hemisphere.

The Moon—On September 1.0, the age of the moon is 12.9 d. The sun's selenographic colongitude is 63.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 20 (6°) and minimum (east limb exposed) on Sept. 5 (5°). The libration in latitude is maximum (north limb exposed) on Sept. 6 (7°) and minimum (south limb exposed) on Sept. 19 (7°).

Mercury on the 1st is in R.A. 12 h 15 m, Decl. −3°25′, and on the 15th is in R.A. 12 h 55 m, Decl. −9°48′. Greatest elongation east (a near-maximum 27°) occurs on the 6th, but as mentioned last month, this is a very unfavourable elongation because of the shallow angle of the ecliptic to the horizon (for northern observers). The planet is therefore only visible with great difficulty, very low in the west at sunset.

Venus on the 1st is in R.A. 9 h 37 m, Decl. +15°17′, and on the 15th it is in R.A. 10 h 44 m, Decl. +9°30′, mag. −3.4, and transits at 11 h 09 m. Early in the month, it can be seen very low in the east at sunrise, but by the end of the month, it is too close to the sun to be seen. It is 0.7° north of Regulus on the 7th.

Mars on the 15th is in R.A. 15 h 36 m, Decl. −20°36′, mag. +1.0, and transits at 16 h 01 m. Moving from Libra through Scorpius into Ophiuchus, it is low in the south-west at sunset, and sets about 2 hours later. On the 22nd, it is 1.5° south of Uranus.

Jupiter on the 15th is in R.A. 14 h 26 m, Decl. −13°27′, mag. −1.3, and transits at 14 h 49 m. Moving from Virgo into Libra early in the month, it is very low in the south-west at sunset, and it sets an hour or two later.

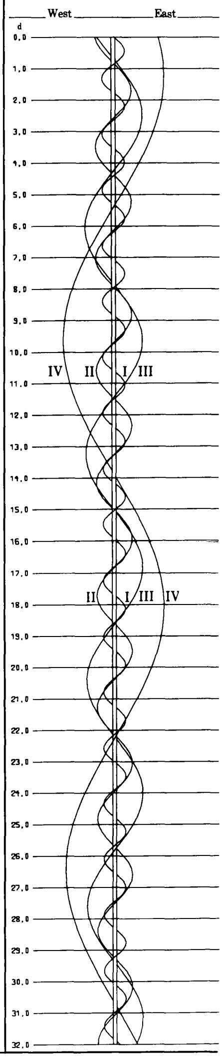
Saturn on the 15th is in R.A. 13 h 22 m, Decl. −6°08′, mag. +1.0, and transits at 13 h 45 m. In Virgo, it may be seen early in the month, very low in the south-west at sunset. It is 5° north of Spica on the 21st.

Uranus on the 15th is in R.A. 15 h 56 m, Decl. −20°16′, mag. +5.9, and transits at 16 h 19 m. In late September, it moves from Libra into Scorpius, where it remains for the rest of the year.

Neptune on the 15th is in R.A. 17 h 35 m, Decl. −22°03′, mag. +7.7, and transits at 17 h 58 m.

1982			SEPTEMBER UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Wed.	1			18 50
Thur.	2			
Fri.	3	12 28	☺ Full Moon	
Sat.	4			15 40
Sun.	5			
Mon.	6	01	Neptune stationary	
		04	Mercury greatest elong. E. (27°)	
Tues.	7	09	Venus 0.7° N. of Regulus	12 30
Wed.	8			
Thur.	9		Venus at perihelion	
Fri.	10	17 19	☾ Last Quarter	9 10
Sat.	11			
Sun.	12			
Mon.	13	18	Moon at perigee (367,500 km)	6 00
Tues.	14			
Wed.	15			
Thur.	16			2 50
Fri.	17	12 09	● New Moon	
Sat.	18	22	Mercury 10° S. of Moon	23 40
Sun.	19	07	Mercury stationary	
		10	Saturn 3° S. of Moon	
Mon.	20		Mercury at greatest hel. lat. S.	
		19	Jupiter 4° S. of Moon	
Tues.	21	04	Saturn 5° N. of Spica	20 30
Wed.	22	13	Mars 1.5° S. of Uranus	
		14	Mars 5° S. of Moon	
		14	Uranus 3° S. of Moon	
Thur.	23	08 46	Autumnal equinox; autumn begins	
		13	Vesta stationary	
Fri.	24	13	Neptune 0.07° S. of Moon; occ'n[1]	17 20
Sat.	25	04 07	☽ First Quarter	
		19	Moon at apogee (404,100 km)	
Sun.	26			
Mon.	27			14 10
Tues.	28			
Wed.	29			
Thur.	30			10 50

Config. of Jupiter's Satellites



[1]Visible in N.W. Australia, the E. Indies and the Indian Ocean

THE SKY FOR OCTOBER 1982

Have you ever looked closely at the changing magnitude of Mercury during the year? The magnitude ranges from −1.7 at brightest to less than +3.2 at faintest, which corresponds to a range of a factor of 100 in brightness! This is much greater than the range in brightness of Venus, despite the fact that the range in *distance* of Venus is much greater than that of Mercury.

The explanation lies in the roughness of the surface of Mercury. At superior conjunction, sunlight shines straight down into the surface irregularities. There are no shadows, and the planet is bright. At greatest elongation, sunlight illuminates the surface from the side. There is extensive shadowing (and only half the disc is illuminated), and the planet is much fainter. A similar effect occurs in the moon for the same reason; the full moon is 13 times brighter than at first or last quarter.

This "phase effect", along with the similar reflecting powers of the surfaces of the moon and Mercury (7 per cent), suggested many years ago that the moon and Mercury were similar. This conclusion was verified in 1974 by the Mariner 10 spacecraft.

The Sun—During October, the sun's R.A. increases from 12 h 28 m to 14 h 23 m and its Decl. changes from −2°58′ to −14°15′. The equation of time changes from +10 m 15 s to +16 m 21 s.

The Moon—On October 1.0, the age of the moon is 13.5 d. The sun's selenographic colongitude is 69.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 17 (5°) and minimum (east limb exposed) on Oct. 2 (5°) and Oct. 29 (6°). The libration in latitude is maximum (north limb exposed) on Oct. 3 (7°) and Oct. 30 (7°) and minimum (south limb exposed) on Oct. 16 (7°).

Mercury on the 1st is in R.A. 12 h 33 m, Decl. −6°29′, and on the 15th is in R.A. 12 h 16 m, Decl. −0°10′. Early in the month, it is too close to the sun to be seen (inferior conjunction occurs on the 2nd). By the 17th, the planet is at greatest elongation west (a near-minimum 18°). However, the orientation of the ecliptic to the horizon is favourable, so the planet should be visible around the 17th, very low in the east at sunrise. On the 29th, it is 4° north of Spica.

Venus on the 1st is in R.A. 11 h 57 m, Decl. +1°51′, and on the 15th it is in R.A. 13 h 02 m, Decl. −5°08′, mag. −3.4, and transits at 11 h 29 m. Throughout the month, it is too close to the sun to be seen.

Mars on the 15th is in R.A. 17 h 05 m, Decl. −24°14′, mag. +1.1, and transits at 15 h 32 m. Moving from Ophiuchus into Sagittarius, it is very low in the south-west at sunset, and sets about 2 hours later. It is 3° north of Antares on the 3rd, and 3° south of Neptune on the 25th.

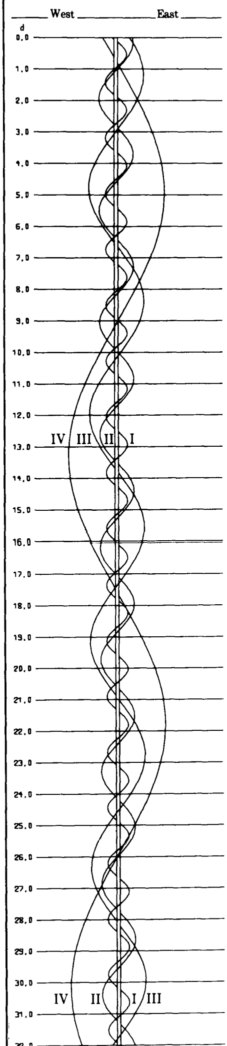
Jupiter on the 15th is in R.A. 14 h 49 m, Decl. −15°20′, mag. −1.3, and transits at 13 h 14 m. In Libra, it may be seen early in the month, with difficulty, low in the south-west at sunset, but by the end of the month it is too close to the sun to be seen.

Saturn on the 15th is in R.A. 13 h 35 m, Decl. −7°28′, mag. +0.9, and transits at 12 h 00 m. It is too close to the sun to be seen: conjunction occurs on the 18th.

Uranus on the 15th is in R.A. 16 h 01 m, Decl. −20°31′, mag. +6.0, and transits at 14 h 26 m.

Neptune on the 15th is in R.A. 17 h 37 m, Decl. −22°06′, mag. +7.8, and transits at 16 h 02 m.

1982			OCTOBER UNIVERSAL TIME	Min. of Algol	Config. of Jupiter's Satellites
	d	h m		h m	
Fri.	1		Venus at greatest hel. lat. N.		
Sat.	2	05	Mercury in inferior conjunction		
Sun.	3	01 08	☺ Full Moon; Harvest Moon	7 40	
		01	Mars 3° N. of Antares		
Mon.	4				
Tues.	5				
Wed.	6			4 30	
Thur.	7				
Fri.	8				
Sat.	9		Mercury at ascending node	1 20	
		01	Moon at perigee (369,900 km)		
		23 26	☾ Last Quarter		
Sun.	10	13	Mercury stationary		
Mon.	11			22 10	
Tues.	12				
Wed.	13		Mercury at perihelion		
Thur.	14			19 00	
Fri.	15	11	Mercury 4° S. of Moon		
Sat.	16				
Sun.	17	00 04	● New Moon	15 50	
		18	Mercury greatest elong. W. (18°)		
Mon.	18	15	Jupiter 3° S. of Moon		
		21	Saturn in conjunction with Sun		
Tues.	19				
Wed.	20	01	Uranus 3° S. of Moon	12 40	
		14	Pluto in conjunction with Sun		
Thur.	21	17	Mars 3° S. of Moon		
		18	Orionid meteors		
		22	Neptune 0.2° N. of Moon; occ'n[1]		
Fri.	22				
Sat.	23	15	Moon at apogee (404,400 km)	9 20	
Sun.	24		Mercury at greatest hel. lat. N.		
Mon.	25	00 08	☽ First Quarter		
		06	Mars 3° S. of Neptune		
Tues.	26			6 10	
Wed.	27				
Thur.	28				
Fri.	29	04	Mercury 4° N. of Spica	3 00	
Sat.	30				
Sun.	31			23 50	



[1]Visible in S. America

THE SKY FOR NOVEMBER 1982

This is the month of "the great alignment". During most of the month, the sun and eight planets are confined to an arc of about 60° on the zodiac. By excluding two or three of the planets, the arc can be reduced to 30° or perhaps even 20°, but the alignment is certainly not exact. From the point of view of the observer, the alignment will be frustrating because the planets will all be close to the sun. Note that the five outer planets come to conjunction between Oct. 18 and Dec. 19. Venus comes to conjunction to Nov. 4. (Mercury *usually* has a conjunction in any two-month period!)

Some years ago, Drs. J. Gribbin and S. Plagemann published a widely-noted book called "The Jupiter Effect", which maintained that "the great alignment" would —through a series of processes not well understood—trigger significant earthquakes. Needless to say, this prediction aroused considerable concern.

Fortunately, the prediction now seems groundless. The direct (tidal) action of the planets on the earth is minuscule compared to the constant tidal action of the sun and moon. Any indirect action works through a series of processes which are individually uncertain and whose additive nature is even more so. In fact, one of the authors
M (Gribbin) has retracted this prediction in print (*Omni*, June 1980) saying "the book has now been proven wrong; the whole basis of the 1982 prediction is gone".

This is not to say that controversial books should not be published. "The Jupiter Effect" certainly stirred a great deal of thought about solar-planetary relationships. Unfortunately, the average reader was probably not able to assess the likelihood of the Gribbin-Plagemann hypothesis. The average non-reader heard only the sensationalized and simplified account in the mass media.

The Sun—During November, the sun's R.A. increases from 14 h 23 m to 16 h 27 m and its Decl. changes from −14°15′ to −21°43′. The equation of time changes from +16 m 23 s to +11 m 24 s.

The Moon—On November 1.0, the age of the moon is 15.0 d. The sun's selenographic colongitude is 87.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 12 (6°) and minimum (east limb exposed) on Nov. 26 (7°). The libration in latitude is maximum (north limb exposed) on Nov. 26 (7°) and minimum (south limb exposed) on Nov. 12 (7°). On Nov. 19, there is an occultation of Mars by the moon, visible in North America along a track which extends through Halifax and the south-east and south U.S.A (see "Lunar Occultations" section for further details).

Mercury on the 1st is in R.A. 13 h 41 m, Decl. −8°44′, and on the 15th is in R.A. 15 h 08 m, Decl. −17°26′. Early in the month, it may be seen with difficulty, very low in the east at sunrise, but by the 19th, it is in superior conjunction. On the 1st, it is 0.7° south of Saturn (which is the fainter of the two).

Venus on the 1st is in R.A. 14 h 22 m, Decl. −13°08′, and on the 15th it is in R.A. 15 h 31 m, Decl. −18°36′, mag. −3.5, and transits at 11 h 57 m. Throughout the month, it is too close to the sun to be seen: superior conjunction occurs on the 4th.

Mars on the 15th is in R.A. 18 h 46 m, Decl. −24°24′, mag. +1.2, and transits at 15 h 11 m. In Sagittarius, it is low in the south south-west at sunset, and sets about $2\frac{1}{2}$ hours later.

Jupiter on the 15th is in R.A. 15 h 16 m, Decl. −17°15′, mag. −1.2, and transits at 11 h 39 m. It is too close to the sun to be seen: conjunction occurs on the 13th.

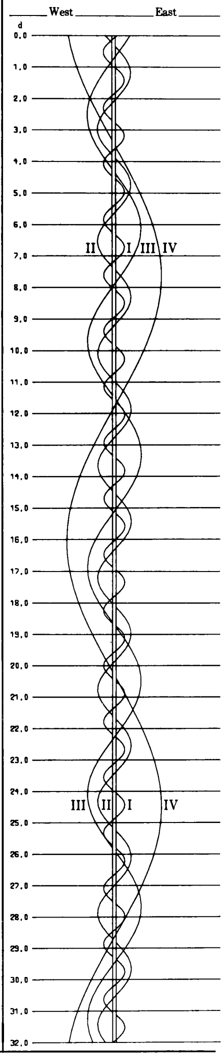
Saturn on the 15th is in R.A. 13 h 49 m, Decl. −8°47′, mag. +0.9, and transits at 10 h 12 m. During the month, as it moves away from the sun, it becomes progressively more visible, low in the east just before sunrise. See also "Mercury" above.

Uranus on the 15th is in R.A. 16 h 09 m, Decl. −20°51′, mag. +6.0, and transits at 12 h 32 m. On Nov. 27, it is in conjunction with the sun.

Neptune on the 15th is in R.A. 17 h 41 m, Decl. −22°09′, mag. +7.8, and transits at 14 h 03 m. In late November, it returns to Sagittarius, where it remains for the rest of the year.

1982			NOVEMBER UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Mon.	1	06	Mercury 0.7° S. of Saturn	
		12 57	○ Full Moon; Hunters' Moon	
Tues.	2	18	S. Taurid meteors	
Wed.	3			20 40
Thur.	4	02	Venus in superior conjunction	
		10	Moon at perigee (365,500 km)	
Fri.	5			
Sat.	6			17 30
Sun.	7			
Mon.	8	06 38	☾ Last Quarter	
Tues.	9			14 20
Wed.	10			
Thur.	11			
Fri.	12			11 10
Sat.	13	14	Jupiter in conjunction with Sun	
		15	Saturn 3° S. of Moon	
Sun.	14			
Mon.	15	15 10	● New Moon	7 50
Tues.	16		Mercury at descending node	
Wed.	17	12	Leonid meteors	
Thur.	18	08	Neptune 0.4° N. of Moon; occ'n[1]	4 40
Fri.	19	18	Mercury in superior conjunction	
		21	Mars 0.5° S. of Moon; occ'n[2]	
Sat.	20	11	Moon at apogee (405,400 km)	
Sun.	21			1 30
Mon.	22			
Tues.	23	20 05	☽ First Quarter	22 20
Wed.	24			
Thur.	25		Mars at greatest hel. lat. S.	
Fri.	26		Mercury at aphelion	19 10
			Venus at descending node	
		03	Pallas in conjunction with Sun	
Sat.	27	11	Uranus in conjunction with Sun	
Sun.	28			
Mon.	29			16 00
Tues.	30			

Config. of Jupiter's Satellites



[1]Visible in S.E. Australia and New Zealand

[2]Visible in N. and Central America, N. of S. America, and in the N. Pacific

THE SKY FOR DECEMBER 1982

The tables of "Astronomical Phenomena Month by Month" give the dates and times at which the moon is at apogee and perigee, as well as the apogee and perigee distances. Have you ever looked closely at these figures?

To begin with, you may notice that, whereas the apogee distance is approximately constant from orbit to orbit, the perigee distance varies considerably. Furthermore, the apogee-to-apogee (or perigee-to-perigee) period is not constant, but varies by a day or more on either side of the mean sidereal period. Nor is the motion symmetric: the apogee-to-perigee interval is not necessarily equal to the perigee-to-agogee interval. These are further examples of the complex motions of the moon.

With care, you can *measure* the changing distance of the moon from the earth. Take a coin and carefully measure its diameter (d). Hold the coin so that it exactly covers the disc of the moon and carefully measure the distance (D) from your eye to the coin in the same units. The distance of the moon is then 3476 D/d kilometres. See how close you can come to the apogee and perigee distances given in the tables opposite.

M

The Sun—During December, the sun's R.A. increases from 16 h 27 m to 18 h 43 m and its Decl. changes from −21°43′ to −23°04′. The equation of time changes from +11 m 02 s to −2 m 56 s. On Dec. 22, at 4 h 39 m U.T., the sun reaches the winter solstice, and winter begins in the northern hemisphere. On Dec. 15, there is a partial eclipse of the sun, not visible in North America.

The Moon—On December 1.0, the age of the moon is 15.4 d. The sun's selenographic colongitude is 92.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 9 (7°) and minimum (east limb exposed) on Dec. 25 (8°). The libration in latitude is maximum (north limb exposed) on Dec. 24 (7°) and minimum (south limb exposed) on Dec. 9 (7°). On the night of Dec. 29–30, there is a total eclipse of the moon, visible in North America.

Mercury on the 1st is in R.A. 16 h 53 m, Decl. −24°01′, and on the 15th is in R.A. 18 h 28 m, Decl. −25°32′. Early in the month, it is too close to the sun to be seen, but by the end of the month it is at greatest elongation east (20°) and can be seen very low in the south-west at sunset. Mercury and Venus are close throughout the month, with Venus (as always) being the brighter.

Venus on the 1st is in R.A. 16 h 55 m, Decl. −22°48′, and on the 15th it is in R.A. 18 h 12 m, Decl. −24°09′, mag. −3.4, and transits at 12 h 39 m. Early in the month, it is too close to the sun to be seen, but by the end of the month it can be seen with difficulty, very low in the south-west at sunset (see also "Mercury" above).

Mars on the 15th is in R.A. 20 h 25 m, Decl. −20°34′, mag. +1.3, and transits at 14 h 52 m. Moving from Sagittarius into Capricornus, it is low in the south south-west at sunset, and sets about 3 hours later.

Jupiter on the 15th is in R.A. 15 h 43 m, Decl. −18°51′, mag. −1.3, and transits at 10 h 08 m. It is in Libra, approaching Scorpius and the conspicuous grouping of ν, β, ω and δ Sco. Late in the month, it can be seen very low in the south-east at sunrise.

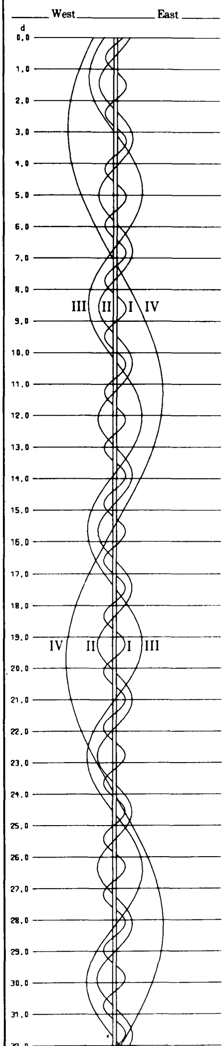
Saturn on the 15th is in R.A. 14 h 01 m, Decl. −9°49′, mag. +0.9, and transits at 8 h 26 m. In Virgo, it rises about 4 hous before the sun, and is well up in the south-east at sunrise.

Uranus on the 15th is in R.A. 16 h 16 m, Decl. −21°11′, mag. +6.0, and transits at 10 h 41 m.

Neptune on the 15th is in R.A. 17 h 45 m, Decl. −22°11′, mag. +7.8, and transits at 12 h 10 m. On Dec. 19, it is in conjunction with the sun.

1982			DECEMBER UNIVERSAL TIME	Min. of Algol
	d	h m		h m
Wed.	1	00 21	Full Moon	
Thur.	2	11	Moon at perigee (360,200 km)	12 50
Fri.	3			
Sat.	4			
Sun.	5			9 40
Mon.	6			
Tues.	7	15 53	Last Quarter	
Wed.	8	13	Mercury 3° S. of Neptune	6 30
Thur.	9			
Fri.	10			
Sat.	11	02	Saturn 3° S. of Moon	3 20
Sun.	12			
Mon.	13	05	Jupiter 2° S. of Moon	
		22	Uranus 2° S. of Moon	
Tues.	14	10	Geminid meteors	0 00
Wed.	15	09 18	New Moon; eclipse of Sun, p. 66	
Thur.	16			20 50
Fri.	17		Mercury at greatest hel. lat. S.	
Sat.	18	02	Moon at apogee (406,300 km)	
Sun.	19	00	Neptune in conjunction with Sun	17 40
		01	Mars 1.6° N. of Moon	
Mon.	20			
Tues.	21		Mars at perihelion	
Wed.	22	04 39	Winter solstice; winter begins	14 30
		19	Ursid meteors	
Thur.	23	14 17	First Quarter	
Fri.	24			
Sat.	25			11 20
Sun.	26			
Mon.	27			
Tues.	28			8 10
Wed.	29	23	Ceres in conjunction with Sun	
Thur.	30		Venus at aphelion	
		11 33	Full Moon; eclipse of Moon, p. 66	
		19	Mercury greatest elong. E. (20°)	
		22	Moon at perigee (356,900 km)	
Fri.	31			5 00

Config. of Jupiter's Satellites

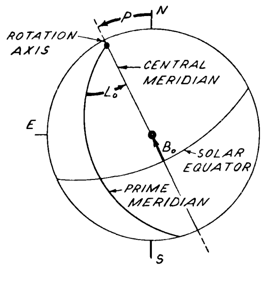


SUN
EPHEMERIS

Date		Apparent, 0^h UT R.A.		Dec.		Transit at Greenwich (UT)			Orientation at 0^h UT P	B_0	L_0
		h	m	°	′	h	m	s	°	°	°
Jan.	1	18	44.6	−23	03	12	03	32	+ 2.2	−3.0	16.9
	6	19	06.6	−22	34	12	05	49	− 0.2	−3.6	311.0
	11	19	28.4	−21	53	12	07	54	− 2.6	−4.1	245.2
	16	19	50.0	−21	02	12	09	44	− 5.0	−4.6	179.4
	21	20	11.3	−20	01	12	11	18	− 7.3	−5.1	113.5
	26	20	32.3	−18	51	12	12	33	− 9.5	−5.6	47.7
	31	20	52.9	−17	32	12	13	28	−11.7	−6.0	341.9
Feb.	5	21	13.3	−16	05	12	14	02	−13.7	−6.3	276.0
	10	21	33.2	−14	31	12	14	16	−15.6	−6.6	210.2
	15	21	52.9	−12	52	12	14	10	−17.3	−6.8	144.4
	20	22	12.2	−11	07	12	13	47	−19.0	−7.0	78.5
	25	22	31.3	− 9	18	12	13	08	−20.4	−7.2	12.7
Mar.	2	22	50.2	− 7	25	12	12	14	−21.7	−7.2	306.8
	7	23	08.8	− 5	29	12	11	07	−22.9	−7.2	240.9
	12	23	27.2	− 3	32	12	09	51	−23.9	−7.2	175.0
	17	23	45.6	− 1	34	12	08	27	−24.7	−7.1	109.1
	22	0	03.8	+ 0	25	12	06	59	−25.4	−7.0	43.2
	27	0	22.0	+ 2	23	12	05	28	−25.9	−6.8	337.3
Apr.	1	0	40.2	+ 4	20	12	03	58	−26.2	−6.5	271.4
	6	0	58.5	+ 6	15	12	02	30	−26.3	−6.2	205.4
	11	1	16.8	+ 8	07	12	01	07	−26.3	−5.9	139.4
	16	1	35.2	+ 9	56	11	59	51	−26.0	−5.5	73.4
	21	1	53.8	+11	40	11	58	44	−25.6	−5.1	7.3
	26	2	12.6	+13	20	11	57	49	−25.0	−4.7	301.3
May	1	2	31.5	+14	55	11	57	06	−24.2	−4.2	235.2
	6	2	50.7	+16	23	11	56	36	−23.3	−3.7	169.1
	11	3	10.1	+17	44	11	56	19	−22.1	−3.1	103.0
	16	3	29.8	+18	58	11	56	18	−20.8	−2.6	36.9
	21	3	49.7	+20	04	11	56	30	−19.3	−2.0	330.8
	26	4	09.8	+21	02	11	56	57	−17.7	−1.4	264.6
	31	4	30.2	+21	50	11	57	34	−16.0	−0.8	198.4
June	5	4	50.7	+22	29	11	58	22	−14.0	−0.2	132.3
	10	5	11.3	+22	58	11	59	18	−12.0	+0.4	66.1
	15	5	32.0	+23	17	12	00	20	−10.0	+1.0	359.9
	20	5	52.8	+23	26	12	01	25	− 7.8	+1.6	293.7
	25	6	13.6	+23	24	12	02	31	− 5.6	+2.2	227.6
	30	6	34.4	+23	12	12	03	32	− 3.3	+2.8	161.4
July	5	6	55.0	+22	50	12	04	28	− 1.0	+3.3	95.2
	10	7	15.5	+22	18	12	05	15	+ 1.2	+3.8	29.0
	15	7	35.9	+21	37	12	05	52	+ 3.5	+4.3	322.8
	20	7	56.0	+20	46	12	06	17	+ 5.7	+4.8	256.7
	25	8	16.0	+19	46	12	06	28	+ 7.8	+5.2	190.5
	30	8	35.6	+18	39	12	06	23	+ 9.9	+5.6	124.4

Date	Apparent, 0h UT R.A.		Dec.		Transit at Greenwich (UT)			Orientation at 0h UT P	B_0	L_0
	h	m	°	′	h	m	s	°	°	°
Aug. 4	8	55.0	+17	23	12	06	04	+11.9	+6.0	58.3
9	9	14.2	+16	01	12	05	29	+13.8	+6.3	352.1
14	9	33.1	+14	32	12	04	40	+15.6	+6.6	286.0
19	9	51.8	+12	57	12	03	38	+17.2	+6.8	220.0
24	10	10.3	+11	18	12	02	24	+18.8	+7.0	153.9
29	10	28.6	+ 9	33	12	00	59	+20.2	+7.1	87.8
Sep. 3	10	46.8	+ 7	45	11	59	25	+21.5	+7.2	21.8
8	11	04.8	+ 5	54	11	57	44	+22.7	+7.2	315.7
13	11	22.8	+ 4	01	11	55	59	+23.7	+7.2	249.7
18	11	40.7	+ 2	05	11	54	13	+24.5	+7.2	183.7
23	11	58.7	+ 0	09	11	52	27	+25.2	+7.0	117.7
28	12	16.7	− 1	48	11	50	44	+25.8	+6.8	51.7
Oct. 3	12	34.7	− 3	45	11	49	07	+26.1	+6.6	345.7
8	12	52.9	− 5	40	11	47	37	+26.3	+6.4	279.8
13	13	11.3	− 7	34	11	46	19	+26.3	+6.0	213.8
18	13	29.9	− 9	25	11	45	13	+26.1	+5.6	147.8
23	13	48.8	−11	13	11	44	23	+25.8	+5.2	81.9
28	14	07.9	−12	56	11	43	50	+25.2	+4.8	16.0
Nov. 2	14	27.4	−14	34	11	43	36	+24.4	+4.3	310.0
7	14	47.1	−16	07	11	43	41	+23.5	+3.8	244.1
12	15	07.3	−17	33	11	44	08	+22.3	+3.2	178.2
17	15	27.7	−18	51	11	44	56	+21.0	+2.6	112.3
22	15	48.6	−20	01	11	46	06	+19.4	+2.0	46.4
27	16	09.7	−21	02	11	47	34	+17.7	+1.4	340.5
Dec. 2	16	31.2	−21	52	11	49	20	+15.9	+0.8	274.6
7	16	52.9	−22	33	11	51	22	+13.8	+0.1	208.7
12	17	14.8	−23	02	11	53	37	+11.7	−0.5	142.8
17	17	37.0	−23	20	11	56	01	+ 9.4	−1.2	76.9
22	17	59.1	−23	26	11	58	30	+ 7.1	−1.8	11.0
27	18	21.3	−23	21	12	00	59	+ 4.7	−2.4	305.2
32	18	43.5	−23	04	12	03	24	+ 2.3	−3.0	239.3

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 25.38d.



SUNDIAL CORRECTION

The "Transit at Greenwich" time (pages 44 and 45) may be used to calculate the sundial correction at the observer's position. e.g. To find the correction at Winnipeg on August 16, 1982: At Greenwich the Sun transits at $12^h04^m40^s$ on August 14 and at $12^h03^m38^s$ 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 48). 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 $12^h04^m15^s$, the daily change in the time being $-12^s.4$. Adjusting this for the longitude of Winnipeg: $12^h04^m15^s - (12^s.4 \times 6^h29^m \div 24^h) = 12^h04^m12^s$. Thus the sundial correction is 4^m12^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 $12^h04^m12^s + 28^m55^s = 12^h33^m07^s$ CST ($13^h33^m07^s$ CDT).

⊙

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

No.	Commences		No.	Commences		No.	Commences	
1717	Jan.	2.28	1722	May	18.79	1727	Oct.	1.92
1718	Jan.	29.62	1723	June	14.99	1728	Oct.	29.21
1719	Feb.	25.96	1724	July	12.19	1729	Nov.	25.52
1720	Mar.	25.28	1725	Aug.	8.41	1730	Dec.	22.84
1721	Apr.	21.56	1726	Sep.	4.65			

SUNSPOTS

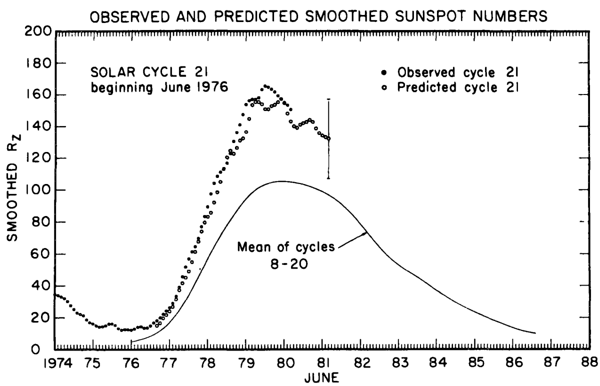
By V. Gaizauskas

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.

Solar activity was sustained at high levels during 1980 except for a short-lived dip in mid-summer. Although activity may briefly surge to very high levels, as in April 1981, it is expected to decline steadily throughout 1981–82. 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. These microwave data show that April 1981 was one of the most intensively active periods of Cycle 21. 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).

Amateurs who make sunspot observations* may wish to try their hand at detecting 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. 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.

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



TIMES OF SUNRISE AND SUNSET

The tables on pages 49 to 51 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, 1982: 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 03	15 01
	2	6 35	17 33	6 56	17 12	7 08	17 00	7 22	16 46	7 35	16 33	7 59	16 10	8 19	15 49	9 02	15 06
	6	6 37	17 35	6 57	17 15	7 09	17 03	7 22	16 50	7 35	16 37	7 58	16 14	8 18	15 54	8 59	15 13
	10	6 37	17 38	6 57	17 18	7 09	17 07	7 22	16 54	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 58	7 32	16 46	7 54	16 25	8 12	16 07	8 50	15 29
	18	6 38	17 43	6 56	17 25	7 07	17 14	7 19	17 02	7 30	16 51	7 51	16 31	8 08	16 13	8 43	15 38
	22	6 38	17 46	6 55	17 28	7 05	17 18	7 17	17 07	7 27	16 56	7 47	16 37	8 03	16 21	8 36	15 48
	26	6 37	17 48	6 54	17 32	7 03	17 22	7 14	17 12	7 24	17 02	7 42	16 44	7 57	16 28	8 28	15 58
	30	6 36	17 51	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 19	16 08
Feb.	3	6 35	17 53	6 49	17 39	6 58	17 30	7 07	17 21	7 16	17 13	7 31	16 57	7 44	16 44	8 10	16 19
	7	6 33	17 55	6 47	17 42	6 54	17 34	7 03	17 26	7 11	17 18	7 25	17 04	7 37	16 52	8 00	16 29
	11	6 32	17 57	6 44	17 45	6 51	17 38	6 58	17 31	7 06	17 24	7 18	17 11	7 29	17 00	7 50	16 40
	15	6 29	17 59	6 40	17 48	6 46	17 42	6 53	17 35	7 00	17 29	7 11	17 18	7 21	17 08	7 39	16 50
	19	6 27	18 01	6 37	17 52	6 42	17 46	6 48	17 40	6 54	17 35	7 04	17 25	7 12	17 17	7 28	17 01
	23	6 24	18 03	6 33	17 55	6 37	17 50	6 43	17 45	6 48	17 40	6 56	17 31	7 03	17 25	7 17	17 11
	27	6 22	18 04	6 29	17 57	6 33	17 54	6 37	17 49	6 41	17 45	6 48	17 38	6 54	17 32	7 05	17 21
Mar.	3	6 19	18 06	6 24	18 00	6 27	17 57	6 31	17 54	6 34	17 50	6 40	17 45	6 45	17 40	6 54	17 31
	7	6 15	18 07	6 20	18 03	6 22	18 01	6 25	17 58	6 27	17 56	6 32	17 51	6 35	17 48	6 42	17 42
	11	6 12	18 08	6 15	18 06	6 17	18 04	6 19	18 02	6 20	18 01	6 23	17 58	6 26	17 56	6 30	17 51
	15	6 09	18 10	6 10	18 08	6 11	18 07	6 12	18 06	6 13	18 06	6 15	18 04	6 16	18 03	6 18	18 01
	19	6 05	18 11	6 06	18 11	6 06	18 11	6 06	18 11	6 06	18 11	6 06	18 11	6 06	18 11	6 06	18 11
	23	6 02	18 12	6 01	18 13	6 00	18 14	5 59	18 15	5 59	18 16	5 57	18 17	5 56	18 18	5 54	18 21
	27	5 58	18 13	5 56	18 15	5 55	18 17	5 53	18 19	5 51	18 20	5 49	18 23	5 46	18 26	5 42	18 31
	31	5 55	18 14	5 51	18 18	5 49	18 20	5 46	18 23	5 44	18 25	5 40	18 30	5 36	18 33	5 30	18 40
Apr.	4	5 51	18 15	5 46	18 20	5 43	18 23	5 40	18 27	5 37	18 30	5 31	18 36	5 27	18 41	5 17	18 50
	8	5 48	18 16	5 42	18 23	5 38	18 27	5 34	18 31	5 30	18 35	5 23	18 42	5 17	18 48	5 05	19 00
	12	5 45	18 17	5 37	18 25	5 33	18 30	5 27	18 35	5 23	18 40	5 14	18 48	5 07	18 56	4 54	19 10
	16	5 42	18 18	5 33	18 28	5 27	18 33	5 21	18 39	5 16	18 45	5 06	18 55	4 58	19 03	4 42	19 20
	20	5 39	18 20	5 28	18 30	5 22	18 36	5 16	18 43	5 09	18 49	4 58	19 01	4 49	19 11	4 30	19 30
	24	5 36	18 21	5 24	18 33	5 18	18 39	5 10	18 47	5 03	18 54	4 50	19 07	4 40	19 18	4 19	19 40
	28	5 33	18 22	5 20	18 35	5 13	18 43	5 04	18 51	4 57	18 59	4 43	19 13	4 31	19 25	4 07	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 30	18 24	5 17	18 38	5 09	18 46	4 59	18 55	4 51	19 04	4 35	19 20	4 22	19 33	3 56	19 59
	6	5 28	18 25	5 13	18 40	5 05	18 49	4 55	18 59	4 45	19 09	4 29	19 26	4 14	19 40	3 46	20 09
	10	5 26	18 27	5 10	18 43	5 01	18 52	4 50	19 03	4 40	19 13	4 22	19 32	4 07	19 47	3 35	20 19
	14	5 24	18 28	5 07	18 45	4 58	18 56	4 46	19 07	4 36	19 18	4 16	19 37	4 00	19 54	3 26	20 29
	18	5 23	18 30	5 05	18 48	4 55	18 59	4 42	19 11	4 31	19 22	4 11	19 43	3 53	20 01	3 16	20 38
	22	5 22	18 32	5 03	18 50	4 52	19 02	4 39	19 14	4 27	19 26	4 06	19 48	3 47	20 07	3 08	20 47
	26	5 21	18 33	5 01	18 53	4 50	19 04	4 37	19 18	4 24	19 30	4 01	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 21	19 34	3 58	19 58	3 37	20 19	2 53	21 03
June	3	5 20	18 36	4 59	18 57	4 47	19 10	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 52	20 05	3 30	20 28	2 42	21 16
	11	5 20	18 39	4 58	19 01	4 45	19 14	4 31	19 29	4 17	19 42	3 51	20 08	3 28	20 31	2 38	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 36	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 35	19 33	4 21	19 47	3 55	20 13	3 32	20 35	2 42	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 30	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 07	21 04
	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 15	20 56
	25	5 33	18 40	5 14	18 58	5 04	19 09	4 52	19 21	4 40	19 32	4 19	19 53	4 01	20 11	3 24	20 48
	29	5 34	18 39	5 17	18 56	5 07	19 06	4 55	19 17	4 44	19 28	4 24	19 48	4 08	20 04	3 33	20 39
Aug.	2	5 36	18 37	5 19	18 53	5 10	19 02	4 59	19 13	4 49	19 23	4 30	19 42	4 14	19 57	3 42	20 29
	6	5 37	18 35	5 22	18 50	5 13	18 58	5 03	19 09	4 53	19 18	4 36	19 35	4 21	19 49	3 51	20 19
	10	5 38	18 32	5 24	18 46	5 16	18 54	5 06	19 04	4 58	19 12	4 42	19 28	4 28	19 41	4 01	20 08
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	22	5 42	18 24	5 31	18 34	5 25	18 40	5 18	18 47	5 11	18 54	4 59	19 05	4 49	19 15	4 30	19 34
	26	5 43	18 21	5 33	18 30	5 28	18 35	5 22	18 41	5 16	18 47	5 05	18 57	4 57	19 06	4 40	19 23
	30	5 44	18 17	5 36	18 25	5 31	18 30	5 25	18 35	5 20	18 40	5 11	18 49	5 04	18 56	4 49	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 33	5 17	18 41	5 11	18 47	4 59	18 59
	7	5 46	18 10	5 40	18 16	5 37	18 19	5 33	18 23	5 29	18 26	5 23	18 32	5 18	18 37	5 08	18 47
	11	5 46	18 07	5 42	18 11	5 40	18 13	5 37	18 16	5 34	18 19	5 29	18 23	5 25	18 27	5 17	18 35
	15	5 47	18 03	5 44	18 06	5 42	18 08	5 40	18 09	5 39	18 11	5 35	18 14	5 32	18 17	5 27	18 22
	19	5 48	17 59	5 46	18 01	5 45	18 02	5 44	18 03	5 43	18 04	5 41	18 06	5 39	18 07	5 36	18 10
	23	5 49	17 56	5 49	17 56	5 48	17 56	5 48	17 56	5 48	17 56	5 47	17 57	5 47	17 57	5 46	17 58
	27	5 50	17 52	5 51	17 51	5 51	17 50	5 52	17 50	5 52	17 49	5 53	17 48	5 54	17 47	5 55	17 46
Oct.	1	5 51	17 48	5 53	17 46	5 54	17 45	5 56	17 43	5 57	17 42	5 59	17 39	6 01	17 37	6 04	17 34
	5	5 52	17 45	5 55	17 41	5 57	17 39	6 00	17 37	6 02	17 34	6 05	17 31	6 08	17 28	6 14	17 22
	9	5 53	17 42	5 58	17 36	6 01	17 34	6 04	17 30	6 07	17 27	6 12	17 22	6 16	17 18	6 24	17 10
	13	5 54	17 38	6 00	17 32	6 04	17 28	6 08	17 24	6 12	17 20	6 18	17 14	6 23	17 08	6 33	16 58
	17	5 55	17 35	6 03	17 28	6 07	17 23	6 12	17 18	6 16	17 14	6 24	17 06	6 31	16 59	6 43	16 46
	21	5 57	17 32	6 06	17 23	6 11	17 18	6 16	17 12	6 22	17 07	6 31	16 58	6 38	16 50	6 53	16 35
	25	5 58	17 30	6 08	17 19	6 14	17 14	6 21	17 07	6 27	17 01	6 37	16 50	6 46	16 41	7 03	16 24
	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 54	16 33	7 14	16 13
Nov.	2	6 02	17 25	6 14	17 13	6 22	17 05	6 30	16 57	6 37	16 49	6 51	16 36	7 02	16 25	7 24	16 02
	6	6 04	17 23	6 17	17 10	6 25	17 02	6 34	16 53	6 42	16 44	6 57	16 29	7 10	16 17	7 34	15 52
	10	6 06	17 22	6 21	17 07	6 29	16 58	6 39	16 48	6 48	16 40	7 04	16 23	7 17	16 10	7 44	15 43
	14	6 08	17 21	6 24	17 05	6 33	16 55	6 44	16 45	6 53	16 35	7 11	16 18	7 25	16 03	7 55	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 33	15 57	8 05	15 25
	22	6 13	17 19	6 31	17 01	6 41	16 51	6 53	16 39	7 03	16 28	7 23	16 08	7 40	15 52	8 14	15 17
	26	6 15	17 19	6 34	17 00	6 45	16 50	6 57	16 37	7 08	16 26	7 29	16 05	7 47	15 47	8 24	15 10
	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 43	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 40	8 40	15 00
	8	6 23	17 21	6 43	17 00	6 55	16 48	7 09	16 35	7 22	16 22	7 45	15 59	8 05	15 38	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 10	15 38	8 53	14 54
	16	6 28	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 52	7 18	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 54	7 20	16 39	7 33	16 26	7 57	16 02	8 18	15 41	9 03	14 56
	28	6 34	17 29	6 55	17 08	7 07	16 56	7 21	16 42	7 34	16 29	7 58	16 05	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. 48).

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

MOON

TIMES OF MOONRISE AND MOONSET

The tables on pages 54 to 65 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. However, for North American observers, an approximate time (generally within ±10 min) may be obtained simply by adding 15 min to the stated time, plus the usual correction for the observer's position relative to his standard meridian.

e.g. To find the time of moonrise at Montreal (latitude 46°) on August 3, 1982: The approximate prediction is 18:54 (the tabular value interpolated for latitude 46°) + 15 min − 06 min (see p. 48) = 19:03 EST (or 20:03 EDT). For a better value, Montreal's longitude (4h 54 min, or 73.5° W) must be used. The tabular values interpolated for latitude +46° for August 3 and the following day are 18:54 and 19:32. Interpolating for longitude: (19:32 − 18:54) × 73.5 ÷ 360 = 8 min. Thus the time will be 18:54 + 08 − 06 = 18:56 EST. However, due to a difference in height between the observer and the actual horizon, the observed time may differ by several minutes from the predicted time.

NAMES OF OCCULTED STARS

The stars which are occulted by the Moon (see pages 67 to 85) are stars which lie along the zodiac; hence they are known by their number in the "Zodiacal Catalogue" (ZC) compiled by James Robertson and published in the *Astronomical Papers Prepared for the Use of the America Ephemeris and Nautical Almanac*, Vol. 10, pt.2 (U.S. Government Printing Office, Washington, 1940). The ZC numbers are used in all occultation predictions, and should be used routinely by observers.

The brighter ZC stars have Greek letter names (a system devised by Bayer in 1603) or Flamsteed numbers (from Flamsteed's *Historia Coelestis Britannica* of 1725); these are given in the following table.

ZC	Name	ZC	Name	ZC	Name	ZC	Name
5	33 Psc	942	6 Gem	1370	80 Cnc	2714	26 Sgr
118	20 Cet	946	η Gem	1383	83 Cnc	2725	28 Sgr
150	26 Cet	976	μ Gem	1418	8 Leo	2836	49 Sgr
364	ξ^2 Cet	984	14 Gem	1504	37 Leo	2961	4 Cap
401	85 Ari	1047	36 Gem	1576	53 Leo	3031	17 Cap
405	μ Cet	1110	δ Gem	1702	ν Vir	3078	η Cap
648	δ Tau	1118	58 Gem	1950	80 Vir	3090	26 Cap
650	63 Tau	1129	63 Gem	1978	88 Vir	3092	27 Cap
653	64 Tau	1221	9 Cnc	2128	13 Lib	3175	κ Cap
658	68 Tau	1277	η Cnc	2196	30 Lib	3228	29 Aqr
730	97 Tau	1282	35 Cnc	2247	η Lib	3304	56 Aqr
765	106 Tau	1292	38 Cnc	2271	θ Lib	3356	74 Aqr
769	107 Tau	1295	39 Cnc	2361	χ Oph	3358	75 Aqr
817	o Tau	1296	40 Cnc	2498	ξ Oph	3428	ψ^3 Aqr
847	ζ Tau	1299	ϵ Cnc	2692	24 Sgr	3536	30 Psc
911	141 Ori	1302	42 Cnc	2694	25 Sgr	4004	Mars

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

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

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

ECLIPSES DURING 1982

In 1982 there will be seven eclipses, four of the Sun and three of the Moon. Two of these, the total lunar eclipses of July 6 and December 30, are of special interest to observers in North America. Such an eclipse was last visible from the central and western portions of North America in 1979; however, it has been seven years since observers in eastern North America have been treated to the ethereal beauty of a total lunar eclipse. For a description of several visual and photographic observations that can be made of a lunar eclipse, see *Sky and Telescope*, May 1975, pages 280–283.

1. *January 9: Total Eclipse of the Moon*
   This is generally visible from the Eastern Hemisphere and Arctic regions, although the beginning of the umbral phase is visible from extreme northwestern North America, and the end from extreme northeastern North America. Magnitude of eclipse* = 1.337

Moon enters penumbra	17^h	14.8^m	UT
Moon enters umbra	18	13.6	
Total eclipse begins	19	16.6	
Middle of eclipse	19	55.8	
Total eclipse ends	20	35.0	
Moon leaves umbra	21	38.1	
Moon leaves penumbra	22	36.9	

2. *January 25: Partial Eclipse of the Sun*
   Visible from New Zealand and Antarctica.
3. *June 21: Partial Eclipse of the Sun*
   Visible from southern Africa.
4. *July 6: Total Eclipse of the Moon*
   Visible in North America, except the Arctic regions. Also, the last portion of totality is not visible from extreme northeastern North America. Visible also from South America, Antarctica, and the Pacific Ocean. Magnitude of eclipse* = 1.722

Moon enters penumbra	04^h	22.2^m	UT
Moon enters umbra	05	32.8	
Total eclipse begins	06	37.7	
Middle of eclipse	07	30.9	
Total eclipse ends	08	24.1	
Moon leaves umbra	09	29.0	
Moon leaves penumbra	10	39.6	

5. *July 20: Partial Eclipse of the Sun*
   Visible from western Europe, Greenland, the Arctic islands, and northeastern Asia.
6. *December 15: Partial Eclipse of the Sun*
   Visible from Europe, northeastern Africa, and western Asia.
7. *December 30: Total Eclipse of the Moon*
   Visible from North America and several other areas, including the Arctic regions and the Pacific. Magnitude of eclipse* = 1.188

Moon enters penumbra	08^h	51.9^m	UT
Moon enters umbra	09	50.4	
Total eclipse begins	10	58.2	
Middle of eclipse	11	28.7	
Total eclipse ends	11	59.3	
Moon leaves umbra	13	07.0	
Moon leaves penumbra	14	05.5	

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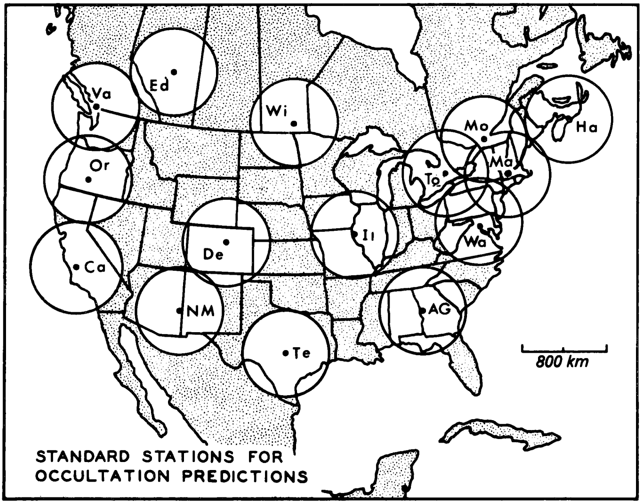
*The magnitude of a partial or total lunar eclipse is the fraction of the lunar diameter within the umbra of Earth's shadow at greatest phase, measured along the common diameter.

OCCULTATIONS BY THE MOON

PREDICTIONS BY H.M. NAUTICAL ALMANAC OFFICE, ROYAL GREENWICH OBSERVATORY, HERSTMONCEUX CASTLE, ENGLAND

The Moon often passes between the Earth and a star; the phenomenon is 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 can be shorter if the occultation is not central. Occultations are equivalent to total solar eclipses, except that they are total eclipses of stars other than the Sun. The following pages give tables of predictions, and tables and maps of northern or southern limits for many cases where grazing occultations may be seen. The predictions are for the 15 standard stations identified on the map below; the coordinates of these stations are given in the table headings. The predictions are generally limited to stars brighter than $7^{m}.5$ at the dark limb of the Moon.



The first five columns in the tables give for each occultation the date, ZC number of the star ("d" means a double star; and note page 53), its magnitude, the phenomenon (D = disappearance, R = reappearance) and the elongation of the Moon from the sun in degrees (see page 18). Under each station are given the U.T. of the event, factors *a* and *b* (see below) and the position angle *PA* (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.

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_0, ϕ_0, 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 U.T. of phenomenon = U.T. of phenomenon at the standard station $+ a(\lambda - \lambda_0) + b(\phi + \phi_0)$ where $\lambda - \lambda_0$ and $\phi - \phi_0$ are expressed in degrees and *a* and *b* are in minutes of time per degree. This formula must be evaluated with due regard for the algebraic signs of the terms. *Note that all predictions are given in U.T.; to convert to Standard Time or Daylight Saving Time, see page 13.*

An observer located between two standard stations can often make more accurate predictions by replacing *a* and *b* of the *nearer* station by a' and b', which are found as follows. First compute the interpolation factor $q = (\phi - \phi_{01})/2(\phi_{02} - \phi_{01})$, where ϕ_{01} and ϕ_{02} are the latitudes of the nearer and further standard station, respectively. Then $a' = a_1 + q(a_2 - a_1)$ and $b' = b_1 + q(b_2 - b_1)$, where a_1, b_1 and a_2, b_2 are the *a* and *b* values at the nearer and further standard station, respectively. These a' and b' factors can then be used just as *a* and *b*, to find the correction to the time given for the *nearer* standard station.

As an example, consider the occultation of ZC 208 on January 31, 1982 as seen from Ottawa. For Ottawa, $\lambda = 75.72°$ and $\phi = 45.40°$. The nearest standard station is Montreal, for which $\lambda_0 = 73.60°$ and $\phi_0 = 45.50°$. Therefore, the UT of the disappearance ("D") is $1^h41^m.1 - 0^m.6(75.72 - 73.60) - 0^m.2(45.40 - 45.50) = 1^h39^m.8$. Note that almost the same result is obtained by using Toronto as the standard station.

The elongation of the Moon is 70° which means that the Moon is approaching first quarter. The star therefore disappears at the dark limb of the Moon. The position angle of immersion is about 54°.

The International Occultation Timing Association (IOTA), P.O. Box 596, Tinley Park, Ill. 60477, U.S.A. provides valuable information, prediction and co-ordination services for occultation observers. Detailed predictions of the limit of any occultation are available (currently for $1.50 U.S., each); papers describing the use of these predictions can also be obtained (currently for $2.00 U.S.). Annual membership in IOTA currently costs $7.00 U.S. in North America, $9.00 U.S. overseas. Included are free graze predictions, descriptive materials and a subscription to *Occultation Newsletter* (available separately for $4.00 U.S.), which contains prediction maps, finder charts, observations of planetary and asteroidal occultations, lists of close double stars discovered during occultations, as well as articles and information on all aspects of occultations. Predictions of total occultations, for any location in North America, can be obtained from Walter V. Morgan, 10961 Morgan Territory Rd., Livermore, Calif. 94550, U.S.A., provided that accurate geographical co-ordinates and a long, stamped, self-addressed envelope are provided.

Since observing occultations is rather easy, provided the weather is good and the equipment is available, timing occultations should be part of any amateur's observing program. The method of timing is as follows: Using as large a telescope as is available with a medium power eyepiece, the observer starts a stopwatch at the time of immersion or emersion. The watch is stopped again on a time signal from the WWV or CHU station. The elapsed time is read from the stopwatch and is then subtracted from the standard time signal to obtain the time of occultation. All times should be recorded to 0.1 second and all timing errors should be held to within 0.5 second if possible. The position angle of the point of contact on the Moon's disk reckoned from the north point towards the east may also be estimated.

The following information should be recorded. (1) Description of the star (catalogue number), (2) Date, (3) Derived time of the occultation, (4) Longitude and latitude to nearest second of arc, height above sea level to the nearest 20 metres. [These data can be scaled from a 7.5- or 15-minute U.S. Geological Survey map. Observers east of the Mississippi River should 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 Center, Bldg. 41, Denver, Colo. 80225. Topographic maps for Canada are available from Map Distribution Office, Department of Mines and Technical Surveys, 615 Booth St., Ottawa K1A 0E9], (5) Seeing conditions, (6) Stellar magnitude, (7) Disappearance or reappearance, (8) At dark or light limb; presence or absence of earthshine, (9) Method used, (10) Estimate of accuracy, (11) Anomalous appearance: gradual disappearance, pausing on the limb. All occultation data should be sent to the world clearing house for occultation data: The International Occultation Centre, Astronomical Division, Hydrographic Department, Tsukiji-5, Chuo-ku, Tokyo, 104 Japan.

Date		Z.C. No.	Mag	P	Elgn of Moon	Ha HALIFAX, N.S. 44°600 N, 63°600 W U.T.	a	b	PA	Mo MONTREAL, P.Q. 45°500 N, 73°600 W U.T.	a	b	PA	To TORONTO, ONT. 43°700 N, 79°400 W U.T.	a	b	PA
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan	2	3529	6.8	D	75									2 54.9	-0.9	-2.5	111
	4	364	4.3	D	112	22 53.7	-2.2	0.0	101	22 36.0	-1.5	+1.0	83	22 25.5	-1.3	+1.3	79
	6	650	5.7	D	140					22 32.4			145				
	6	653	4.8	D	140	23 15.0	-0.1	+3.6	13								
	7	684d	6.2	D	142	4 5.7	-1.4	+0.6	50	3 52.5	-1.4	+1.1	45	3 41.9	-1.5	+1.2	50
	18	2128	5.8	R	286									10 41.4			3
	20	2361	4.8	R	308	10 0.4	-0.7	-0.1	316	9 53.9	-0.6	+0.4	305				
	21	2498	4.5	D	320					11 32.2	-1.1	+0.6	115	11 26.2	-0.7	+0.3	126
	29	60	7.0	D	56	22 21.9	-1.3	-0.3	70								
	31	208	7.0	D	70	1 46.7	-0.4	-0.4	60	1 41.1	-0.6	-0.2	54	1 37.1	-0.8	-0.1	57
Feb	3	609	7.5	D	109	1 30.3	-1.5	+0.1	65	1 15.6	-1.5	+0.8	57	1 5.0	-1.6	+1.0	59
	4	796	6.8	D	126					7 17.0	+0.3	-2.2	127	7 23.7	+0.5	-3.0	141
	4	798	6.4	D	126					7 27.1	-0.1	-0.9	76	7 28.6	-0.1	-1.1	86
	5	969d	7.1	D	139	6 44.1	-0.2	-1.5	99	6 39.6	-0.4	-1.7	107	6 40.4	-0.5	-2.0	117
	5	1086	6.5	D	150	23 33.3	-1.6	-0.8	133	23 19.4	-1.1	+0.3	119	23 12.7	-1.0	+0.4	118
	13	1965	6.5	R	242	6 20.2	0.0	-2.8	357	6 16.0	-0.4	-1.6	343	6 15.3	-0.6	-0.8	328
	28	306	6.9	D	53									2 8.3	-0.3	-0.5	62
Mar	2	726	6.8	D	92	23 48.3	-1.7	-1.3	105	23 29.3	-1.9	-0.5	97				
	3	730	5.1	D	93	1 16.4	-1.2	-1.6	103	1 1.6	-1.5	-1.3	101	0 54.7	-1.8	-1.4	107
	3	881d	5.9	D	105	23 20.8	-1.9	-0.2	94								
	4	1047d	5.2	D	119	24 11.7	-1.8	+0.8	73	23 55.5	-1.6	+1.4	67	23 43.9	-1.5	+1.4	71
	5	1054d	6.8	D	120	2 4.6	-1.4	-1.4	107	1 48.0	-1.6	-1.1	108	1 40.1	-1.8	-1.3	116
	6	1191	7.0	D	132	0 52.0	-2.0	+2.1	53	0 36.3	-1.6	+2.6	50	0 23.1	-1.4	+2.3	57
	6	1322	6.1	D	145	22 51.9	-1.2	-0.2	128								
	16	2401	5.6	R	257									10 15.2	-2.4	+0.4	257
	28	398	6.7	D	36									1 18.6	-0.3	-0.1	50
	30	697	7.2	D	63	1 33.6	-0.5	-0.4	58	1 27.0	-0.7	-0.5	62	1 23.3	-0.9	-0.6	71
Apr	1	1021	6.3	D	89	1 49.5			30	1 32.0	-1.8	+1.3	42	1 19.8	-1.8	+0.7	55
	2	1174d	7.5	D	104	4 24.3	-0.4	-1.2	84	4 18.3	-0.6	-1.4	92	4 17.3	-0.7	-1.6	103
	2	1282	6.6	D	114	23 16.4	-1.4	-3.4	157								
	3	1292	6.7	D	115	1 41.1			44	1 17.6	-2.3	+1.7	56	1 2.4	-2.1	+1.1	69
	3	1293	6.7	D	115	1 34.7	-1.6	-1.1	102	1 17.7	-1.7	-0.9	109	1 9.9	-1.7	-1.2	119
	3	1294d	6.9	D	115	1 37.6	-1.6	-1.0	98	1 20.4	-1.7	-0.8	105	1 12.1	-1.7	-1.0	115
	3	1297	6.8	D	116	2 2.6	-1.0	-2.3	135	1 50.0	-1.1	-2.6	144	1 49.6	-0.9	-3.8	159
	3	1298d	6.5	D	116	1 55.9	-2.1	+0.3	65	1 35.8	-2.0	+0.3	74	1 23.9	-2.0	+0.1	85
	3	1299	6.3	D	116	1 54.9	-1.6	-0.9	92	1 37.8	-1.7	-0.8	100	1 29.3	-1.7	-0.9	110
	3	1302	6.7	D	116	2 20.5			35	1 54.9	-2.4	+1.6	53	1 39.6	-2.2	+0.9	68
	3	1303	6.8	D	116	2 12.8	-1.7	-0.4	76	1 54.6	-1.8	-0.3	85	1 44.8	-1.8	-0.5	96
	3	1312	6.8	D	117	5 5.8			178								
	3	1322	6.1	D	118					6 52.5	-0.1	-1.3	87	6 54.4	-0.1	-1.4	95
	4	1418	5.9	D	128	1 44.5	-1.4	-1.8	131	1 29.3	-1.4	-1.8	139	1 25.3	-1.3	-2.5	151
	12	2331	6.4	R	224	4 3.8	-1.6	+1.9	255								
	14	2595d	5.7	R	248					8 8.5	-1.8	+0.6	275	7 56.6	-1.8	+1.0	267
	27	790d	6.9	D	45	0 49.6	+0.2	-2.3	127	0 48.8	+0.1	-2.9	136	0 56.9			155
	27	793d	6.2	D	45	1 31.0	+0.5	-2.3	132	1 33.4	+0.5	-3.0	142	1 47.1			170
	27	793d	6.2	R	45									1 54.4			185
	28	984	6.6	D	59					2 54.6	+0.2	-1.8	121	2 59.7	+0.3	-2.2	132
	28	1110d	3.5	D	71	23 16.9	-1.5	-0.7	86								
	29	1110d	3.5	R	71	0 25.3	-0.8	-1.8	293	0 14.2	-1.2	-1.5	285				
	29	1125	6.4	D	73	2 30.1	0.0	-1.9	122	2 28.1	-0.1	-2.2	132	2 32.4	0.0	-2.8	145
	29	1129d	5.3	D	73	2 55.9	+0.3	-2.1	135	2 56.6	+0.3	-2.6	145	3 4.5	+0.7	-3.7	162
	29	1143	6.8	D	74									4 45.1	+0.3	-1.6	116
	30	1261	7.2	D	85	1 19.2	-0.6	-2.3	131	1 10.7	-0.7	-2.6	142	1 12.6	-0.5	-3.6	157
May	2	1504	5.7	D	111	1 4.3	-0.2	-3.8	171	1 6.5			200				
	2	1504	5.7	R	111					1 14.5			212				
	14	2961	6.0	D	249	5 58.2			12								
	14	2961	6.0	R	249	6 19.9			340								
	27	1216	7.3	D	54	0 32.7	-0.3	-1.7	110								
	28	1370	6.8	D	69					3 35.9	+0.2	-1.7	124	3 40.2	+0.2	-1.9	132
Jun	2	1923	7.1	D	130	3 21.0	-1.0	-2.2	147	3 9.7	-0.9	-2.3	158	3 10.1	-0.5	-2.8	171

Date	Z.C. No.	Mag	P	Elgn of Moon	Ha HALIFAX, N.S. 44°600 N, 63°600 W U.T.	a	b	PA	Mo MONTREAL, P.Q. 45°500 N, 73°600 W U.T.	a	b	PA	To TORONTO, ONT. 43°700 N, 79°400 W U.T.	a	b	PA
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
June 10	2921	6.1	R	219	5 30.5	-1.9	+1.1	252	5 14.1	-1.6	+1.5	250	5 2.0	-1.5	+1.9	243
10	2928	6.5	R	219					6 50.8	-2.0	+0.4	271	6 38.5	-1.9	+0.8	269
15	18	6.0	R	276	6 10.1	-0.6	+1.2	286								
July 9	3150	6.5	D	211	4 46.2			152					4 27.7			162
9	3150	6.5	R	211	5 2.8			175	4 55.2			186	4 35.4			173
15	364	4.3	D	284	6 29.2	-0.8	+0.9	113	6 25.1	-0.3	+1.2	103				
15	364	4.3	R	284	7 9.4	0.0	+2.7	194	7 11.2	-0.1	+2.3	207	7 6.9	0.0	+2.3	209
17	648	3.9	D	311	7 32.1	-0.1	+1.4	80	7 33.5	+0.1	+1.5	70				
17	648	3.9	R	311					8 27.5	-0.1	+1.6	251	8 24.3	0.0	+1.5	253
17	653	4.8	R	311									8 41.1	+0.3	+2.2	212
17	658d	4.2	D	312									8 45.7	+0.3	+2.2	31
30	2313	7.0	D	115					3 31.7	-1.3	-1.0	74	3 25.1	-1.6	-0.9	77
30	2316	6.4	D	116									4 36.0	-1.0	-1.1	76
Aug 1	2567	7.1	D	138									5 24.3	-1.6	-1.9	121
2	2706	5.8	D	148	2 54.8	-2.0	-0.2	80	2 34.6	-2.0	+0.3	79	2 21.7	-2.1	+0.6	84
27	2394	6.5	D	96									2 51.0	-1.4	-1.8	116
30	2921	6.1	D	138	23 41.8	-1.7	+1.2	77								
31	2928	6.5	D	139	1 23.2	-1.9	+0.8	58	1 5.1	-1.9	+1.3	55	0 51.5	-1.9	+1.5	59
Sept 11	847	3.0	R	274	4 19.8	+0.1	+1.4	259								
23	2457	6.3	D	74	22 54.1			39								
29	3150	6.5	D	130					2 19.7	-2.8	-1.3	121	2 5.7	-2.7	-0.7	117
Oct 5	401	6.3	R	207									10 1.9	-0.8	+2.5	194
9	976d	3.2	R	257	3 26.6	-0.2	+0.8	293								
11	1277	5.5	R	285	6 13.6			203	6 22.3	+0.4	+2.7	225	6 20.3	+0.5	+2.5	226
22	2689	6.8	D	66					23 53.0	-1.5	-1.2	95	23 45.6	-1.8	-1.0	94
23	2692	5.7	D	66					0 17.7	-1.2	-1.0	80	0 11.8	-1.4	-0.8	78
23	2694	6.4	D	66									0 44.6	-1.9	-2.4	129
23	2836	5.6	D	77	24 20.8	-1.6	-1.7	109	24 2.6	-1.8	-1.0	96	23 53.3	-2.0	-0.8	94
26	3090	6.9	D	99	1 25.4	-1.0	-0.1	53	1 15.5	-1.0	+0.5	38	1 8.0	-1.1	+0.9	33
26	3092	6.2	D	99					1 25.5			139	1 10.4			129
27	3228d	6.5	D	111	3 37.4			130	3 16.0	-1.7	-1.8	104	3 8.2	-1.9	-1.4	99
28	3358	7.2	D	123									5 29.3	+0.4	+2.4	4
28	3480	7.3	D	133	24 18.4	-1.7	+1.0	70	24 4.2	-1.4	+1.5	58	23 53.7	-1.3	+1.7	55
29	3484	6.8	D	134	1 59.6			116	1 33.5	-2.2	+0.2	93	1 20.5	-2.1	+0.6	88
29	3490	7.1	D	135	3 59.0	-0.9	+0.2	49	3 50.8	-0.8	+0.9	32	3 44.0	-0.8	+1.3	28
Nov 5	911	6.3	R	226	1 27.2	-0.3	+0.7	295	1 25.0	-0.2	+0.3	311				
5	942	6.3	R	228	6 18.5	-2.0	-0.8	300	5 57.4	-2.1	-1.5	316	5 47.5	-2.1	-1.4	317
5	946d	3.2	D	228					6 34.8			154	6 25.9			156
5	946d	3.2	R	228					6 56.7			188	6 43.3			184
6	1118	6.0	R	243					10 5.3	-1.6	-1.2	290	9 57.1	-1.8	-0.6	282
19	4004	1.2	D	45	22 27.9			357								
19	4004	1.2	R	45	22 36.7			345								
21	3031	5.9	D	67	22 0.2			12								
22	3046	7.1	D	68					0 31.3	-0.8	-0.2	52	0 26.6	-0.9	+0.1	48
22	3050	7.3	D	68									1 18.6	-0.8	-0.4	59
24	3304	6.4	D	90	1 54.4	-0.2	+0.7	28	1 54.8	+0.2	+2.0	6	1 52.6			0
24	3413d	6.4	D	101	23 46.3			356								
25	3438	7.5	D	103					4 18.4	+0.2	+1.8	10	4 16.1	+0.1	+1.8	10
25	3536	4.7	D	113	23 1.3	-0.7	+2.3	14	23 1.8			350				
26	5	4.7	D	114	1 6.0	-1.5	+0.3	63	0 52.3	-1.3	+1.1	47	0 42.4	-1.3	+1.4	42
26	18	6.0	D	115					4 17.0	-1.6	-3.1	116	4 12.3	-1.9	-3.0	115
29	401	6.3	D	153	4 9.4	-2.0	-2.1	112	3 47.9	-2.0	-0.6	95	3 36.7	-2.1	-0.2	92
Dec 6	1479	6.3	R	252	9 50.8	-1.5	-1.1	296	9 33.7	-1.7	-0.4	287	9 23.7	-1.8	+0.2	276
8	1702	4.2	D	277	5 32.6			184								
8	1702	4.2	R	277	5 51.1			220								
20	3243	7.4	D	58	21 32.9	-0.3	+2.0	10								
25	208	7.0	D	107	2 50.0	-1.2	-1.7	96	2 35.6	-1.4	-0.9	83	2 27.9	-1.7	-0.6	82
25	210d	6.6	D	107	4 8.2	-0.2	+3.0	3	4 12.5			343	4 2.4			354
25	210d	6.6	R	107					4 23.3			324				
27	454	5.8	D	132	1 7.8	-0.9	+2.5	23	1 5.8			359	1 0.0			351
27	475	7.4	D	135	7 3.4	+0.1	-1.9	109	7 1.1	-0.2	-2.2	112	7 4.3	-0.3	-2.9	124
27	590	6.3	D	145	23 18.2	+0.1	+3.4	11								

Date		Z.C. No.	Mag	P	Elgn of Moon	Wi WINNIPEG, MAN. 49°900 N, 97°200 W U.T.	a	b	PA	Ed EDMONTON, ALTA. 53°600 N, 113°400 W U.T.	a	b	PA	Va VANCOUVER, B.C. 49°200 N, 123°100 W U.T.	a	b	PA
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan	2	3529	6.8	D	75	2 28.4	-1.0	-0.7	72	2 11.8	-0.9	+0.4	45	1 59.1	-1.1	+0.9	43
	5	405	4.4	D	117	7 39.0	-0.2	-1.5	91	7 27.5	-0.6	-1.2	81	7 26.2	-0.9	-1.5	95
	6	516	7.3	D	128	3 10.3	-2.0	-1.2	114	2 43.6	-1.3	+0.8	85	2 27.1	-1.2	+1.2	84
	7	684d	6.2	D	142	3 38.5			3								
	7	730	5.1	D	146									11 42.5			5
	18	2128	5.8	R	286	10 30.0	+0.1	-1.7	351								
	28	3356	5.9	D	33	0 43.4			349								
	31	208	7.0	D	70	1 26.5	-0.6	+1.5	20								
Feb	1	364	4.3	D	86					6 44.3			140				
	3	609	7.5	D	109	0 55.7	-0.6	+3.1	19								
	3	653	4.8	D	113					8 51.9	-0.8	+1.5	16	8 43.9	-0.6	-0.1	45
	4	796	6.8	D	126	7 7.6	-0.2	-3.1	136	6 48.7	-0.8	-2.9	132				
	4	798	6.4	D	126	7 15.2	-0.6	-1.2	83	6 58.8	-0.9	-1.0	81	6 53.3	-1.2	-1.2	98
	5	935	6.9	D	137	1 14.9	-1.5	-0.2	122								
	5	969d	7.1	D	139	6 14.8	-1.0	-1.7	112	5 50.3	-1.3	-1.0	106	5 41.3	-1.6	-1.4	121
	6	1129d	5.3	D	153									7 19.5	-1.9	+2.6	39
	17	2456	6.2	R	289					12 30.9	-0.9	+0.5	303				
	28	306	6.9	D	53	1 58.5	-0.6	+0.3	39	1 51.3	-0.6	+1.6	16				
Mar	2	609	7.5	D	83									7 36.6	-0.1	-0.9	69
	4	935	6.9	D	110					9 26.6	+0.3	-1.7	114	9 38.4	+0.4	-2.3	134
	5	1054d	6.8	D	120	1 8.1	-1.4	+0.6	92								
	5	1086	6.5	D	123	8 33.8	0.0	-1.5	100	8 25.4	-0.3	-1.8	106	8 30.9	-0.3	-2.2	126
	12	1950	5.8	R	214									13 17.7	-1.0	-1.7	298
	15	2271	4.3	D	246					9 5.5			29				
	15	2271	4.3	R	246					9 12.8			17	9 25.4	-0.2	-0.5	333
	16	2401	5.6	R	257	9 42.6	-2.0	+1.6	247								
	30	710	7.1	D	64	3 40.6	-0.5	-0.7	64	3 27.5	-0.8	-0.5	61	3 21.2	-1.1	-0.8	78
	30	718	6.1	D	65	5 3.0	0.0	-1.1	81	4 56.3	-0.3	-1.3	83	4 59.3	-0.4	-1.7	101
	30	726	6.8	D	65					5 56.8	+0.1	-1.7	102	6 6.4	+0.1	-2.3	123
	31	881d	5.9	D	78	5 45.9	0.0	-1.4	93	5 38.3	-0.3	-1.6	98	5 43.3	-0.4	-2.1	117
Apr	1	1047d	5.2	D	92	6 43.5	-0.3	-0.6	53	6 33.1	-0.6	-0.8	61	6 31.0	-0.7	-1.1	82
	1	1054d	6.8	D	93					7 53.2	0.0	-1.4	87	7 59.4	-0.1	-1.6	103
	2	1174d	7.5	D	104	3 51.9	-1.1	-1.4	105	3 27.6	-1.3	-0.9	105	3 19.0	-1.5	-1.4	124
	2	1191	7.0	D	105									7 39.1	-1.6	+0.7	38
	3	1322	6.1	D	118	6 39.1	-0.5	-1.6	102	6 21.9	-0.8	-1.6	110	6 21.6	-0.9	-2.1	131
	3	1340	6.6	D	120					9 52.7	+0.1	-1.6	106	10 1.0	+0.1	-1.8	119
	3	1343	6.6	D	120									10 31.6	+0.4	-2.0	144
	4	1459	7.5	D	133									11 19.4	+0.3	-2.0	140
	5	1576	5.3	D	146					11 15.4	+0.2	-2.2	157	11 28.6	+0.4	-2.8	172
	26	648	3.9	D	32					3 18.7	+0.1	-2.1	116	3 32.3	+0.3	-4.0	144
	26	658d	4.2	D	33									4 24.0	-0.1	-0.9	72
	27	808	6.8	D	46	3 37.3	-0.2	-0.8	63								
	27	826	6.8	D	47					5 25.5	+0.2	-1.2	86	5 33.1	+0.2	-1.6	104
	28	984	6.6	D	59	2 46.3	-0.1	-2.6	134								
	29	1129d	5.3	D	73	2 48.9			170								
	29	1143	6.8	D	74	4 36.8	0.0	-1.9	121	4 26.2	-0.3	-2.2	129	4 35.6	-0.1	-3.4	154
	30	1282	6.6	D	88	5 44.5	0.0	-1.9	123	5 35.1	-0.2	-2.2	132	5 44.4	0.0	-3.0	155
	30	1293	6.7	D	89					7 28.0	-0.1	-1.3	80	7 32.5	-0.2	-1.5	95
	30	1294d	6.9	D	89					7 30.9	-0.2	-1.3	75	7 34.9	-0.2	-1.4	91
	30	1297	6.8	D	89					7 42.2	+0.1	-1.7	114	7 51.4	+0.1	-1.9	128
	30	1298d	6.5	D	89									7 51.6	-0.6	-0.7	54
	30	1299	6.3	D	89					7 44.4	-0.1	-1.2	69	7 48.3	-0.2	-1.3	85
	30	1303	6.8	D	89					8 1.0	-0.3	-0.8	50	8 2.6	-0.3	-1.0	69
May	1	1418	5.9	D	102					7 39.9	-0.2	-1.7	104	7 45.5	-0.3	-1.9	118
	11	2557	6.2	R	218	8 32.2			344	8 16.7	-0.6	-0.3	332	8 9.8	-0.8	+0.3	312
	12	2706	5.8	R	228	8 30.5	-1.7	+0.8	262								
	27	1242	6.8	D	56	4 22.8	-0.1	-1.2	77								
	28	1370	6.8	D	69	3 27.5	-0.1	-2.2	139								
	28	1383	6.6	D	70					6 15.7	0.0	-1.6	101	6 22.5	-0.1	-1.7	114
	29	1504	5.7	D	84					7 14.1	+0.1	-1.8	127	7 23.5	+0.1	-2.0	138

Date	Z.C. No.	Mag	P	Elgn of Moon	Wi WINNIPEG, MAN. 49°900 N, 97°200 W U.T.	a	b	PA	Ed EDMONTON, ALTA. 53°600 N, 113°400 W U.T.	a	b	PA	Va VANCOUVER, B.C. 49°200 N, 123°100 W U.T.	a	b	PA
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jun 2	1950	5.8	D	133									9 15.0	-0.6	-1.9	114
Jul 11	3413d	6.4	R	236									8 55.4	-1.2	+0.9	297
12	3536	4.7	R	247	8 56.9			308								
12	5	4.7	R	248									10 41.9	-1.9	+0.6	294
13	118	4.9	R	260									10 1.9	-0.6	+2.1	216
17	653	4.8	R	311	8 56.7	+0.2	+1.6	237								
27	1978	6.6	D	82					4 50.9	-0.6	-2.2	152	4 55.1	-0.6	-2.5	162
29	2196	6.7	D	105	4 57.5	-1.0	-1.5	87	4 33.4	-1.4	-1.1	87				
30	2316	6.4	D	116	4 7.3	-1.6	-0.6	65								
Aug 1	2567	7.1	D	138	4 45.7	-1.7	-0.8	106	4 18.0	-1.5	+0.1	106				
2	2714	6.1	D	148	4 36.8			163	4 12.8			165				
14	760d	6.5	R	294	9 32.4	-0.3	+1.7	253	9 34.2	-0.1	+1.4	273	9 27.9	+0.1	+1.2	274
16	1110d	3.5	D	323									11 55.6	0.0	+1.2	93
27	2394	6.5	D	96	2 15.2	-1.6	-1.0	107								
Sept 10	736	6.2	R	265									11 25.7	-0.2	+3.5	198
28	3031	5.9	D	121									5 46.9			135
29	3150	6.5	D	130	1 31.5	-1.5	+0.9	95								
30	3304	6.4	D	144					7 55.7	-1.2	-1.1	86	7 46.8	-1.5	-0.7	84
Oct 5	401	6.3	R	207	9 51.4	-1.2	+0.6	232	9 31.9	-1.4	+0.3	257	9 15.3	-1.5	+0.8	257
6	523	6.5	R	220	10 2.7	-1.5	+0.1	253	9 38.0	-1.6	0.0	279	9 20.9	-1.7	+0.4	279
7	658d	4.2	R	231					4 31.9	+0.5	+2.1	202				
8	851	6.3	R	248					11 26.9	-1.5	0.0	280	11 11.2	-1.5	+0.6	274
10	1167	6.3	R	274					11 2.1			343	10 55.9	-1.5	-1.3	329
11	1295	6.5	D	287									9 4.2			174
11	1295	6.5	R	287					9 25.5			206	9 13.7			195
23	2694	6.4	D	66	0 3.2	-1.8	-0.8	106								
26	3092	6.2	D	99	0 25.0	-1.8	+0.4	98								
27	3228d	6.5	D	111	2 35.5	-1.5	+0.3	63	2 16.3	-1.2	+1.1	45	1 58.0	-1.3	+1.6	43
27	3243	7.4	D	112					6 4.6	-1.2	-1.4	93	5 56.8	-1.6	-1.0	91
28	3480	7.3	D	133	23 48.7	-0.7	+2.1	39								
29	3484	6.8	D	134	1 0.9	-1.1	+1.6	63	0 53.2	-0.7	+1.9	53				
Nov 4	765	5.3	R	214	4 49.1	-0.1	+2.5	213	4 55.5	-0.1	+1.9	238	4 47.7	+0.1	+1.7	240
5	928	6.0	R	227	4 25.9	+0.3	+2.4	215	4 37.4	+0.2	+1.7	239				
5	946d	3.2	D	228	5 54.3	-0.8	+1.0	102	5 51.5	-0.2	+1.6	79	5 43.7	0.0	+1.5	78
5	946d	3.2	R	228	6 54.2	-0.7	+2.0	237	6 50.6	-0.5	+1.5	262	6 39.8	-0.3	+1.5	262
5	976d	3.2	D	230					9 50.1			153				
5	976d	3.2	R	230					10 15.8			195				
6	1118	6.0	R	243	9 23.4	-1.5	-0.7	304	8 54.8			334	8 46.0	-1.4	-0.9	324
22	3046	7.1	D	68	0 21.2			2								
22	3050	7.3	D	68	1 8.5	-0.3	+0.9	18								
23	3175	4.8	D	79					0 47.0	-2.2	-0.5	123				
25	3458	6.5	D	105									7 30.8	-0.4	-0.3	51
26	5	4.7	D	114	0 40.1	-0.2	+2.7	2								
26	18	6.0	D	115	3 36.4	-1.4	0.0	68	3 18.9	-1.0	+1.0	41	3 3.2	-1.0	+1.6	36
26	118	4.9	D	125	23 34.0			129								
29	401	6.3	D	153	3 14.8	-1.0	+1.6	53	3 10.4	-0.4	+2.2	27	2 57.5	-0.2	+2.4	22
Dec 6	1479	6.3	R	252	8 59.5	-1.2	+0.5	288	8 46.4	-0.7	+0.5	299	8 36.9	-0.5	+0.9	288
10	1950	5.8	D	304									12 37.4			206
10	1950	5.8	R	304					13 15.6	-1.3	+1.7	261	12 40.8			212
20	3150	6.5	D	50									2 45.5	+0.2	+1.2	13
25	208	7.0	D	107	2 4.4	-1.1	+1.1	43	1 57.8	-0.4	+2.3	12	1 43.9	-0.1	+2.8	5
26	368d	6.3	D	123					9 23.4	-0.2	-1.0	70	9 26.3	-0.3	-1.4	86
27	464	6.4	D	133	2 58.8			131	2 26.7	-1.3	+0.9	92	2 10.0	-1.1	+1.3	88
27	475	7.4	D	135	6 37.8	-1.0	-1.7	99	6 14.8	-1.2	-0.5	81	6 2.9	-1.6	-0.4	88
28	610d	6.2	D	146	2 8.5	-1.7	+0.2	111	1 53.5	-0.7	+1.5	83	1 40.8	-0.5	+1.5	80
28	639	6.0	D	149									8 41.9	-1.2	+3.2	14
29	765	5.3	D	160	1 18.7			144	1 5.3	-0.4	+1.2	108	0 57.5	-0.2	+1.1	105

Date	Z.C. No.	Mag	P	Elgn of Moon	Ma MASSACHUSETTS 42°500 N, 72°500 W U.T.	a	b	PA	Wa WASHINGTON, D.C. 38°900 N, 77°000 W U.T.	a	b	PA	AG ALABAMA-GEORGIA 33°000 N, 85°000 W U.T.	a	b	PA
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan 1	3392	7.1	D	62	1 22.4			346	1 11.2	+0.4	+2.8	4	0 58.1	-0.2	+2.0	17
1	3392	7.1	R	62	1 35.9			322								
3	106	6.8	D	88									3 56.1			338
3	106	6.8	R	88									4 0.3			330
4	364	4.3	D	112	22 35.1	-1.8	+0.7	92	22 24.1	-1.8	+0.8	93				
6	653	4.8	D	140	23 9.2			1	22 56.7	+0.6	+4.0	7				
7	684d	6.2	D	142	3 51.5	-1.6	+0.7	57	3 41.9	-1.8	+0.5	68	3 23.8	-2.2	+0.2	82
18	2128	5.8	R	286					10 55.0	-0.4	-2.5	348	10 56.8	-1.4	-1.0	315
20	2361	4.8	R	308	9 53.4	-0.8	+0.4	299	9 47.4	-0.8	+0.9	283				
21	2498	4.5	D	320	11 32.1	-1.1	+0.3	120	11 27.8	-0.7	-0.3	135	11 34.3			174
21	2498	4.5	R	320									12 8.4			225
28	3356	5.9	D	33									0 34.5	-0.6	-0.6	74
31	208	7.0	D	70	1 42.7	-0.7	-0.4	64	1 41.1	-0.9	-0.7	75	1 36.6	-1.5	-1.1	90
31	210d	6.6	D	71									3 8.0			344
31	210d	6.6	R	71									3 16.0			329
Feb 3	609	7.5	D	109	1 15.7	-1.7	+0.4	68	1 6.3	-2.0	+0.3	77	0 47.7	-2.4	+0.1	88
4	769	6.6	D	123					2 4.1			18	1 32.6	-1.7	+2.5	40
4	790d	6.9	D	125									6 19.3	-1.2	+0.7	46
4	793d	6.2	D	126									7 4.2	-0.8	+0.4	49
4	796	6.8	D	126	7 23.5	+0.5	-2.5	137								
4	798	6.4	D	126	7 30.1	0.0	-1.0	83	7 34.3	+0.1	-1.2	97	7 44.5	+0.2	-2.0	124
5	969d	7.1	D	139	6 45.3	-0.3	-1.8	114	6 51.7	-0.2	-2.4	130				
5	1086	6.5	D	150	23 20.8	-1.4	-0.4	131	23 16.6	-1.6	-1.1	140				
6	1125	6.4	D	153									7 55.5	-2.0	+1.3	43
6	1129d	5.3	D	153									8 14.9	-1.3	+0.1	58
13	1965	6.5	R	242	6 20.6	-0.6	-1.2	333	6 20.2	-0.9	-0.5	315	6 12.4	-1.1	+0.5	287
28	306	6.9	D	53					2 12.2	-0.2	-0.9	78	2 16.7	-0.4	-1.6	102
Mar 2	726	6.8	D	92	23 34.0	-2.1	-1.2	109	23 29.3	-2.5	-2.0	121				
3	730	5.1	D	93	1 8.2	-1.5	-1.9	112	1 9.5	-1.8	-3.2	129				
3	736	6.2	D	93									3 10.4	-1.7	+1.7	36
4	1047d	5.2	D	119	23 53.9	-1.8	+0.9	78	23 42.9	-1.8	+0.7	88				
5	1054d	6.8	D	120	1 54.0	-1.7	-1.7	119	1 53.8	-1.8	-2.7	135				
6	1191	7.0	D	132	0 31.5	-1.7	+1.8	63	0 18.1	-1.7	+1.3	76				
15	2271	4.3	D	246									9 24.4			57
15	2271	4.3	R	246									10 14.0			354
16	2401	5.6	R	257					10 19.0	-2.8	+0.6	250				
28	393	6.8	D	35									0 21.2	-0.8	+2.7	14
28	398	6.7	D	36									1 23.2	-0.3	-1.0	90
30	697	7.2	D	63	1 29.5	-0.7	-0.7	71	1 29.3	-0.8	-1.0	85	1 30.9	-0.9	-1.9	111
31	847	3.0	D	76					1 39.2	-1.7	+1.4	37	1 22.4	-1.8	+0.1	68
31	847	3.0	R	76					2 20.9	-0.1	-3.3	321	2 30.8	-0.8	-1.7	288
Apr 1	1021	6.3	D	89	1 31.4	-1.7	+0.5	54	1 22.8	-1.8	-0.1	71	1 10.5	-2.0	-0.9	97
2	1174d	7.5	D	104	4 23.1	-0.5	-1.4	98	4 26.5	-0.5	-1.7	112	4 35.5	-0.3	-2.6	139
3	1292	6.7	D	115	1 16.5	-2.3	+0.9	68	1 4.6	-2.2	+0.2	85	0 48.3	-2.2	-0.7	111
3	1293	6.7	D	115	1 23.0	-1.7	-1.4	117	1 21.6	-1.6	-2.1	134	1 31.3			174
3	1294d	6.9	D	115	1 25.3	-1.7	-1.2	113	1 23.1	-1.7	-1.9	129	1 28.3			166
3	1295	6.5	D	115									1 9.9	-2.9	+2.9	53
3	1296	6.5	D	115									1 9.2	-2.7	+1.9	62
3	1297	6.8	D	116	2 0.1	-0.8	-3.4	155								
3	1298d	6.5	D	116	1 37.7	-2.0	-0.1	83	1 29.9	-2.0	-0.6	99	1 19.7	-2.1	-1.6	126
3	1299	6.3	D	116	1 42.4	-1.7	-1.1	108	1 39.7	-1.7	-1.7	124	1 41.5	-1.4	-3.9	156
3	1302	6.7	D	116	1 54.1	-2.3	+0.7	65	1 42.9	-2.2	0.0	83	1 27.9	-2.2	-0.9	111
3	1303	6.8	D	116	1 58.2	-1.8	-0.7	93	1 53.2	-1.8	-1.1	109	1 48.4	-1.8	-2.4	138
3	1305	7.0	D	116									2 16.0	-3.1	+1.9	57
3	1322	6.1	D	118	6 56.3	0.0	-1.2	91	7 1.0	0.0	-1.4	102	7 10.2	+0.1	-1.7	123
4	1418	5.9	D	128	1 37.1	-1.3	-2.5	148	1 44.7			172				
14	2595d	5.7	R	248	8 8.9	-2.0	+0.6	271	7 56.4	-2.2	+1.1	260	7 26.0	-2.9	+3.1	230
15	2754	5.9	R	259									9 14.6	-2.3	+0.9	265
27	790d	6.9	D	45	0 58.4	+0.5	-3.9	149								
27	793d	6.2	D	45	1 43.4			157								
28	984	6.6	D	59	2 59.8	+0.4	-1.9	127	3 9.9	+0.6	-2.6	145				
29	1110d	3.5	R	71	0 19.6	-1.2	-1.2	278	0 16.4	-1.7	-0.6	262				
29	1125	6.4	D	73	2 35.1	+0.1	-2.4	138	2 46.5	+0.6	-3.5	159				
29	1129d	5.3	D	73	3 4.4	+0.5	-2.9	153								
30	1261	7.2	D	85	1 19.9	-0.5	-3.1	150	1 34.7			178				
May 10	2425	5.9	R	206									6 24.9	-1.0	-2.3	339

Date	Z.C. No.	Mag	P	Elgn of Moon	Ma MASSACHUSETTS 42°500 N, 72°500 W U.T.	a	b	PA	Wa WASHINGTON, D.C. 38°900 N, 77°000 W U.T.	a	b	PA	AG ALABAMA-GEORGIA 33°000 N, 85°000 W U.T.	a	b	PA
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 11	2557	6.2	R	218									9 25.3	-2.5	-1.8	309
12	2706	5.8	R	228									8 43.5	-2.8	+1.3	238
14	2961	6.0	R	249	6 17.9	-0.6	-0.3	320	6 15.0	-0.7	+0.2	305				
28	1370	6.8	D	69	3 40.9	+0.3	-1.7	128	3 48.8	+0.3	-1.9	139	4 6.2	+0.7	-2.9	166
Jun 2	1923	7.1	D	130	3 17.9	-0.8	-2.6	162	3 26.3			180				
9	2793	6.5	R	208					4 0.8			340	4 2.2	-0.7	-0.1	307
10	2921	6.1	R	219	5 11.3	-1.8	+1.6	245	4 56.5	-1.8	+2.2	234				
10	2928	6.5	R	219	6 51.7	-2.1	+0.5	267	6 39.6	-2.2	+0.8	262	6 15.1	-2.2	+1.6	247
Jul 12	3536	4.7	R	247									9 15.3	-2.2	+1.1	252
15	364	4.3	D	284	6 22.2	-0.4	+1.0	110								
15	364	4.3	R	284	7 4.0	0.0	+2.5	200	6 55.2	+0.2	+2.6	196				
17	648	3.9	D	311	7 29.1	+0.1	+1.4	76								
17	648	3.9	R	311	8 22.8	-0.1	+1.6	245	8 16.9	0.0	+1.6	243				
17	653	4.8	R	311					8 28.7	+0.5	+2.7	197				
17	658d	4.2	D	312	8 42.0	0.0	+2.1	41	8 35.2	+0.1	+1.9	44				
17	658d	4.2	R	312									9 16.7	-0.4	+1.0	271
26	1856d	6.6	D	69									2 56.5	-0.9	-0.4	67
30	2313	7.0	D	115	3 36.2	-1.3	-1.1	79	3 33.5	-1.6	-1.0	85	3 24.8	-2.1	-1.1	97
30	2316	6.4	D	116					4 43.8	-1.0	-1.2	86	4 41.6	-1.4	-1.2	94
Aug 1	2557	6.2	D	137									3 5.2			43
1	2567	7.1	D	138					5 39.4	-1.9	-2.7	135	5 39.1			145
2	2706	5.8	D	148	2 36.1	-2.2	+0.2	83	2 24.8	-2.3	+0.3	90	2 5.2	-2.1	+0.1	107
14	760d	6.5	R	294					9 13.8	+0.1	+3.3	200	8 56.6	+0.6	+3.5	194
15	928	6.0	R	308									10 2.7	-1.3	-0.1	301
23	1923	7.1	D	49									1 59.8	-0.4	-1.9	126
27	2394	6.5	D	96					3 3.8	-1.4	-2.2	126	3 4.4	-1.9	-2.5	136
31	2928	6.5	D	139	1 3.4	-2.0	+1.3	60	0 49.3	-2.1	+1.4	67				
Sept 1	3078	4.9	D	152					7 14.8	-0.4	+0.2	45	7 8.9	-0.8	+0.3	50
22	2210	6.8	D	52									0 26.7			41
29	3150	6.5	D	130	2 29.2			134	2 21.5			137	2 6.5			146
29	3150	6.5	R	130									2 25.5			169
Oct 1	3428d	5.2	D	156									8 41.7	-0.3	+0.5	44
11	1277	5.5	R	285	6 12.2	+0.9	+3.9	209								
22	2689	6.8	D	66	23 58.7	-1.6	-1.4	101	23 55.7	-1.9	-1.4	104	23 45.8	-2.5	-1.3	110
23	2692	5.7	D	66	0 22.3	-1.3	-1.1	86	0 20.0	-1.6	-1.1	89	0 11.0	-2.2	-0.9	94
23	2694	6.4	D	66					1 5.1			151				
23	2836	5.6	D	77	24 8.1	-1.9	-1.3	103	24 3.1	-2.3	-1.2	105	23 49.2	-2.9	-1.1	110
26	3090	6.9	D	99	1 15.3	-1.2	+0.4	46	1 7.3	-1.5	+0.7	47	0 47.9	-2.0	+1.2	49
27	3228d	6.5	D	111	3 24.8	-2.2	-2.8	118	3 24.1			123	3 16.6			129
28	3358	7.2	D	123	5 26.3	0.0	+1.1	21	5 22.2	-0.2	+0.9	29	5 13.7	-0.6	+0.9	37
28	3480	7.3	D	133	24 1.3	-1.5	+1.5	63	23 48.9	-1.5	+1.6	64	23 27.9	-1.3	+1.6	69
29	3484	6.8	D	134	1 36.2	-2.6	-0.2	102	1 24.5	-2.8	0.0	102	1 1.6	-2.7	+0.3	103
29	3490	7.1	D	135	3 49.4	-1.0	+0.7	42	3 41.4	-1.3	+0.9	44	3 23.3	-1.6	+1.3	45
Nov 5	942	6.3	R	228	6 2.4	-1.9	-0.5	301	5 54.9	-1.8	0.0	293	5 40.1	-1.5	+0.4	284
6	1118	6.0	R	243	10 10.2	-1.7	-0.9	281	10 3.4	-2.0	-0.1	266	9 41.1	-2.3	+1.7	241
19	4004	1.2	D	45									21 41.1			13
19	4004	1.2	R	45									22 16.2			335
22	3046	7.1	D	68	0 33.2	-0.9	-0.4	60	0 29.6	-1.2	-0.2	62	0 18.6	-1.7	+0.1	65
22	3050	7.3	D	68					1 23.6	-1.0	-0.8	75	1 17.9	-1.5	-0.6	78
24	3304	6.4	D	90	1 50.1	-0.3	+1.3	20	1 43.8	-0.5	+1.3	24	1 29.5	-0.9	+1.7	26
25	3438	7.5	D	103	4 14.5	-0.1	+0.9	25	4 10.7	-0.3	+0.7	33	4 2.7	-0.7	+0.7	43
25	3536	4.7	D	113	22 51.3	-0.3	+3.2	2	22 38.1	-0.4	+3.4	3				
26	5	4.7	D	114	0 50.9	-1.6	+0.9	54	0 39.7	-1.7	+1.2	55	0 17.1	-1.8	+1.6	54
29	401	6.3	D	153	3 53.1	-2.4	-1.4	108	3 46.9	-3.1	-2.0	116	3 31.8			125
Dec 3	1036	6.5	R	208									2 24.6			334
6	1479	6.3	D	252									8 30.2			190
6	1479	6.3	R	252	9 36.7	-1.9	-0.2	279	9 26.3	-2.3	+0.8	261	8 45.6			212
7	1598	6.4	R	265									8 12.6	-1.1	-1.8	332
21	3265	6.6	D	60					1 28.6	0.0	+1.1	24	1 21.4	-0.4	+1.0	33
25	208	7.0	D	107	2 40.7	-1.6	-1.5	95	2 38.2	-2.2	-1.9	104	2 30.0			117
25	210d	6.6	D	107	4 0.2	-0.4	+2.3	10	3 51.4	-0.7	+1.5	24	3 36.8	-1.1	+1.2	39
27	454	5.8	D	132	0 55.4	-0.6	+3.1	15	0 41.9	-0.6	+3.0	18	0 20.1	-0.5	+3.0	20
27	475	7.4	D	135	7 8.7	0.0	-2.9	125								
27	590	6.3	D	145	23 14.4			356	23 3.2			0				
28	639	6.0	D	149									9 7.1	-0.4	-0.1	61

Date		Z.C. No.	Mag	P	Elgn of Moon	Il ILLINOIS 40°000 N, 91°000 W				Te TEXAS 31°000 N, 98°000 W				De DENVER, COLO. 39°800 N, 105°000 W			
						U.T.	a	b	PA	U.T.	a	b	PA	U.T.	a	b	PA
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan	1	3392	7.1	D	62					0 54.4			351				
	2	3529	6.8	D	75	2 50.5	-1.6	-2.8	115					2 26.0	-1.9	-1.1	93
	5	398	6.7	D	116					7 4.3	-0.8	+3.0	12				
	5	405	4.4	D	117									8 1.8			140
	7	684d	6.2	D	142	3 18.6	-1.6	+1.5	54	2 54.7	-2.0	+1.0	74	2 59.6	-1.0	+2.5	37
	7	718	6.1	D	145					9 44.1	-0.5	+0.1	57	9 43.7	-1.0	+1.3	28
	14	1702	4.2	D	240					8 43.7	-2.7	+2.0	73				
	14	1702	4.2	R	240					9 40.7	-0.8	-3.5	349				
	18	2128	5.8	R	286	10 43.9	-0.8	-0.9	326	10 39.0	-1.4	+0.3	288	10 33.0	-0.7	0.0	306
	19	2247	5.6	R	298					12 29.3	-1.2	-1.3	322	12 12.8	-0.4	-1.4	337
	21	2498	4.5	R	320	12 14.3	-2.0	+2.4	242								
	28	3356	5.9	D	33	0 30.4	-0.4	+0.2	44								
	31	208	7.0	D	70	1 25.2	-1.3	+0.1	60	1 14.7	-2.1	-0.3	82	1 6.5	-1.3	+1.1	44
	31	210d	6.6	D	71					2 54.4			350				
Feb	3	609	7.5	D	109	0 41.6	-1.6	+1.4	59								
	4	769	6.6	D	123					1 9.2	-1.0	+3.3	29				
	4	790d	6.9	D	125	6 23.5			12	6 0.9	-1.5	+0.1	65	5 57.1	-1.7	+2.1	32
	4	793d	6.2	D	126	7 4.7	-1.5	+2.2	23	6 51.7	-1.1	-0.3	70	6 44.7	-1.5	+0.9	42
	4	798	6.4	D	126	7 31.9	-0.2	-1.6	107	7 54.7			155	7 27.3	-0.5	-2.3	121
	5	969d	7.1	D	139	6 44.4	-0.4	-3.5	144					6 43.9			174
	5	969d	7.1	R	139									6 53.2			189
	6	1125	6.4	D	153					7 31.1	-1.8	-0.1	74	7 21.4	-2.3	+1.5	47
	6	1129d	5.3	D	153	8 9.7	-2.0	+1.5	39	7 57.8	-1.5	-0.7	84	7 43.7	-1.8	+0.2	63
	13	1965	6.5	R	242	6 9.5	-0.6	+0.1	304	5 59.1	-0.7	+1.3	266				
	17	2456	6.2	R	289									12 36.3	-1.8	+0.3	286
	19	2725d	5.8	R	311					11 45.7	-0.5	-0.7	317				
	28	306	6.9	D	53	2 5.3	-0.7	-0.8	75	2 11.0	-1.1	-2.1	109	1 53.0	-1.1	-0.5	71
Mar	3	730	5.1	D	93	0 36.6	-2.4	-1.6	116								
	3	736	6.2	D	93					2 43.9	-2.0	+1.3	50				
	5	1054d	6.8	D	120	1 22.9	-2.1	-1.8	130								
	5	1086	6.5	D	123									8 51.9	+0.2	-2.0	130
	6	1216	7.3	D	134					6 1.7			31				
	15	2271	4.3	D	246	9 22.8			39	8 42.1	-2.1	+0.7	93	8 38.7	-1.9	+1.7	78
	15	2271	4.3	R	246	9 43.5			12	10 3.3	-1.5	-1.6	323	9 42.6	-0.8	-1.4	334
	16	2401	5.6	R	257	9 37.0			228								
	28	398	6.7	D	36	1 15.4	-0.5	-0.5	67	1 19.5	-0.7	-1.5	101				
	28	401	6.3	D	36	1 41.6	-0.5	+0.8	31	1 35.9	-0.6	-0.3	68				
	30	697	7.2	D	63	1 14.1	-1.3	-1.0	88	1 20.0	-1.5	-3.0	127				
	30	710	7.1	D	64	3 52.0	-0.2	-1.1	88	4 5.7	+0.1	-2.3	126	3 47.8	-0.5	-1.5	100
	30	718	6.1	D	65									5 18.2	+0.2	-1.8	116
	31	847	3.0	D	76	1 16.2	-1.8	+1.4	43	0 56.6	-2.2	0.0	80				
	31	847	3.0	R	76	2 10.3	-0.9	-2.9	310	2 17.5	-1.6	-0.9	271	1 53.0	-1.6	-2.3	301
	31	881d	5.9	D	78									6 4.0	+0.3	-2.1	128
Apr	1	1021	6.3	D	89	0 56.1	-2.0	+0.3	75								
	1	1047d	5.2	D	92									6 50.0	-0.2	-1.1	86
	2	1174d	7.5	D	104	4 15.9	-0.7	-2.2	126	4 46.5			182	4 4.8	-0.9	-3.2	145
	2	1174d	7.5	R	104					5 2.3			207				
	2	1191	7.0	D	105									7 57.0	-1.0	+0.6	40
	3	1294d	6.9	D	115	0 56.4	-1.8	-1.7	135								
	3	1298d	6.5	D	116	1 1.2	-1.9	-0.2	104								
	3	1299	6.3	D	116	1 13.1	-1.8	-1.5	130								
	3	1302	6.7	D	116	1 12.9	-2.0	+0.3	90								
	3	1303	6.8	D	116	1 25.6	-1.9	-0.9	117	1 31.4			160				
	3	1305	7.0	D	116					1 37.6	-2.5	+0.9	80				
	3	1322	6.1	D	118	6 58.0	-0.2	-1.7	114	7 15.0	+0.1	-2.4	145	6 54.0	-0.4	-2.2	132
	14	2595d	5.7	R	248	7 29.9	-1.9	+2.2	244								
	15	2754	5.9	R	259	9 8.8	-1.7	+0.9	275	8 44.2	-2.0	+1.9	245				
	27	808	6.8	D	46									3 46.6	-0.1	-1.3	96
	28	984	6.6	D	59	3 19.6			173								
	29	1128d	6.9	D	73					2 41.7	-1.9	+0.3	62	2 38.0			30
	29	1143	6.8	D	74	4 55.6	+0.4	-2.1	137					5 2.5	+0.7	-3.4	160
	30	1282	6.6	D	88	6 2.3	+0.3	-1.9	136	6 29.4			176	6 7.6	+0.4	-2.7	154
May	10	2425	5.9	R	206	6 5.2			351	6 11.3	-1.4	-0.6	310	5 59.2	-0.6	-0.6	323
	11	2557	6.2	R	218	8 58.5	-2.0	-1.8	325	8 55.1	-2.5	-1.0	300	8 33.0	-1.7	-0.7	313
	12	2706	5.8	R	228	8 35.1	-2.4	+0.9	250	7 58.3			218	8 1.9	-2.3	+2.1	237
	25	905	6.7	D	27	1 54.5	0.0	-1.1	90	2 7.7	+0.3	-1.8	124				
	27	1242	6.8	D	56									4 35.0	0.0	-1.4	103
	28	1370	6.8	D	69	3 50.5	+0.3	-2.5	153					3 59.6			184

Date	Z.C. No.	Mag	P	Elgn of Moon	Il ILLINOIS 40°000 N, 91°000 W U.T.	a	b	PA	Te TEXAS 31°000 N, 98°000 W U.T.	a	b	PA	De DENVER, COLO. 39°800 N, 105°000 W U.T.	a	b	PA
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 29	1485	7.2	D	81					3 20.8			42				
Jun 10	2928	6.5	R	219	6 13.7	-1.7	+1.4	258	5 44.9	-1.9	+2.5	230				
14	3458	6.5	R	266					9 59.8	-2.0	+1.1	266	9 54.6	-1.6	+0.6	291
Jul 11	3413d	6.4	R	236					9 22.8	-2.2	+1.4	241	9 17.7	-2.1	+0.9	267
12	3536	4.7	R	247	9 7.8	-2.3	+0.6	276	8 45.0	-2.0	+1.1	266	8 38.6	-1.8	+0.5	294
13	118	4.9	R	260									9 45.9			177
17	658d	4.2	D	312	8 42.2	+0.5	+2.2	26								
17	658d	4.2	R	312	9 19.9	-0.5	+0.6	295								
26	1856d	6.6	D	69	2 48.6			49	2 42.2	-1.5	-0.9	84				
27	1976	6.9	D	82									4 52.4	-0.6	-2.9	162
29	2196	6.7	D	105					5 27.2	-1.2	-1.9	119	5 3.2	-1.4	-1.5	102
30	2313	7.0	D	115	3 5.6	-2.2	-0.6	87	2 55.6	-2.5	-1.0	110				
30	2316	6.4	D	116	4 24.8	-1.6	-0.9	80	4 20.2	-2.2	-1.1	98	3 57.3	-2.3	-0.5	84
Aug 1	2557	6.2	D	137					2 18.4	-3.1	+1.6	66				
1	2567	7.1	D	138	5 9.2	-2.1	-1.7	121	5 10.5	-2.7	-2.6	140	4 38.8	-2.2	-1.0	121
2	2706	5.8	D	148	1 56.6	-1.7	+0.7	98								
12	464	6.4	R	268	10 1.4	-2.4	0.0	288	9 42.5	-1.9	+0.7	275				
14	760d	6.5	R	294	9 15.5	-0.1	+2.1	226	8 56.3	+0.3	+2.3	212	9 14.1	0.0	+1.7	242
14	765	5.3	R	294					10 5.8	-2.0	-0.9	310				
15	928	6.0	R	308					9 46.7	-1.5	-1.4	322				
23	1923	7.1	D	49	1 43.7	-0.7	-1.8	115	1 55.8	-0.8	-2.1	134				
27	2394	6.5	D	96	2 39.0	-1.8	-1.7	119	2 42.0	-2.3	-2.4	139	2 11.6	-2.0	-1.2	123
Sept 1	3078	4.9	D	152	7 12.0	0.0	+1.6	16	6 56.1	-0.9	+1.3	33				
21	2097	7.1	D	42									1 30.9	-1.0	-2.2	137
29	3150	6.5	D	130	1 37.5	-2.3	0.0	113	1 25.1			134				
Oct 1	3428d	5.2	D	156	8 49.3	+0.3	+2.4	6	8 34.5	-0.5	+1.1	34				
5	401	6.3	R	207	9 41.5	-0.6	+3.8	186					9 28.5	-1.1	+2.2	207
6	523	6.5	R	220	10 3.5	-1.4	+1.8	215	9 26.2			182	9 42.2	-1.6	+1.5	230
8	851	6.3	R	248									11 30.4	-1.8	+1.9	230
10	1167	6.3	R	274					11 26.8	-2.0	+1.9	243	11 23.7	-1.7	+0.5	278
22	2692	5.7	D	66	23 54.1	-2.0	-0.3	77								
23	2694	6.4	D	66	0 28.1	-2.3	-1.9	125	0 30.6			144				
26	3090	6.9	D	99	0 48.3	-1.4	+1.9	26	0 17.2	-2.2	+2.1	40				
26	3092	6.2	D	99	0 40.1	-2.9	-0.9	119	0 31.2			140				
27	3228d	6.5	D	111	2 47.3	-2.3	-0.5	89	2 32.8	-3.2	-0.6	99	2 16.6	-2.1	+0.7	70
28	3358	7.2	D	123	5 24.9			356	5 2.8	-0.5	+2.0	19				
29	3484	6.8	D	134	0 55.0	-1.7	+1.2	81	0 32.7	-1.6	+1.0	92	0 35.4	-1.1	+1.6	72
29	3490	7.1	D	135	3 28.3	-0.7	+2.2	16	3 0.7	-1.2	+2.4	26				
Nov 4	765	5.3	R	214									4 23.3	+0.6	+3.1	196
5	928	6.0	R	227									4 3.8	+1.1	+3.2	195
5	942	6.3	R	228	5 27.7			325	5 22.2	-1.2	0.0	299				
5	946d	3.2	D	228	6 3.7			150					5 40.1	-1.0	+0.3	120
5	946d	3.2	R	228	6 25.3			187					6 26.5	-0.1	+2.8	216
6	1118	6.0	R	243	9 35.3	-1.9	+0.5	268	9 10.0	-1.8	+2.3	236	9 10.3	-1.6	+0.7	273
19	2641	7.4	D	35					0 13.4	-1.4	-0.8	82				
19	4004	1.2	D	45					20 53.3			22				
19	4004	1.2	R	45					21 33.9			340				
22	3046	7.1	D	68	0 12.7	-1.2	+0.8	39								
22	3050	7.3	D	68	1 8.5	-1.1	+0.1	52	0 56.4	-1.9	+0.3	63	0 52.3	-1.2	+1.2	31
24	3304	6.4	D	90					1 17.3			0				
25	3438	7.5	D	103	4 9.6	+0.1	+2.4	7	3 50.4	-0.8	+1.6	28				
25	5	4.7	D	114	24 21.4	-1.2	+2.1	31	23 52.7	-1.3	+2.3	40	24 8.4	-0.6	+2.9	12
26	18	6.0	D	115	3 55.6	-2.6	-2.1	108					3 22.4	-2.2	+0.1	81
27	150d	6.2	D	129					7 50.1			345				
27	150d	6.2	R	129					8 2.1			323				
29	401	6.3	D	153	3 11.8	-2.0	+0.7	84	2 51.1	-2.4	+0.5	96	2 49.7	-1.2	+1.6	63
Dec 4	1221	6.2	R	225					9 11.1			352				
6	1479	6.3	R	252	8 58.4	-1.8	+1.8	254					8 37.7	-1.1	+2.2	250
7	1598	6.4	R	265					8 2.2	-0.9	-1.0	322				
21	3265	6.6	D	60	1 41.6			340	1 14.5	-0.1	+2.3	14				
21	3265	6.6	R	60	1 52.0			324								
25	208	7.0	D	107	2 7.2	-2.0	+0.1	77	1 49.5	-3.0	-0.1	91	1 41.1	-1.6	+1.4	55
25	210d	6.6	D	107	3 46.8	-0.1	+3.8	0	3 18.4	-1.1	+2.1	27				
27	454	5.8	D	132					0 15.2			352				
28	610d	6.2	D	146									1 55.6			133
28	639	6.0	D	149	9 4.3	-0.7	+0.4	41	9 0.6	-0.7	-0.6	79	8 52.1	-1.0	+0.2	52
28	654	6.0	D	150									11 6.5			12
29	817d	4.8	D	164					10 55.4	-0.6	+0.1	56	10 53.9	-1.2	+1.4	29

Date		Z.C. No.	Mag	P	Elgn of Moon	Or OREGON 42°500 N, 121°000 W				Ca CALIFORNIA 36°000 N, 120°000 W				NM N. MEX.-ARIZ. 34°000 N, 109°000 W			
						U.T.	a	b	PA	U.T.	a	b	PA	U.T.	a	b	PA
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan	2	3529	6.8	D	75	1 57.1	-1.6	+0.6	61	1 56.6	-2.2	+0.1	79	2 25.4	-2.8	-1.9	107
	5	405	4.4	D	117	7 43.2	-0.9	-3.4	125								
	6	516	7.3	D	128	2 24.4	-1.8	+0.5	103	2 29.2			131				
	7	684d	6.2	D	142					2 39.0	-0.3	+3.0	25	2 42.2	-1.1	+2.1	49
	7	718	6.1	D	145	9 29.1	-1.3	+1.3	32	9 26.5	-1.1	+0.1	58	9 37.1	-0.8	0.0	57
	7	730	5.1	D	146	11 35.9	-0.5	+0.3	40	11 36.7	-0.3	-0.3	62				
	14	1702	4.2	D	240					8 13.8	-1.1	+2.3	71	8 25.2	-1.8	+2.1	73
	14	1702	4.2	R	240					9 6.5	-0.9	-2.1	338	9 21.6	-1.0	-2.7	342
	18	2128	5.8	R	286									10 27.5	-1.0	+0.7	282
	19	2247	5.6	R	298	12 4.8	-0.3	-0.3	321	12 5.9	-0.7	+0.1	302	12 15.2	-0.9	-0.5	312
	29	3506	6.3	D	46					3 34.2			359				
Feb	3	648	3.9	D	113	8 29.0	-0.9	+1.1	30	8 27.0	-0.7	0.0	56	8 32.8	-0.4	+0.1	53
	3	653	4.8	D	113	8 47.3	-0.4	-0.6	65	8 52.7	-0.3	-1.0	85				
	4	790d	6.9	D	125	5 37.5			18	5 23.5	-2.0	+1.4	51	5 42.9	-1.9	+0.6	59
	4	793d	6.2	D	126	6 22.5	-1.7	+1.7	38	6 18.1	-1.8	+0.4	65	6 36.5	-1.5	0.0	68
	4	798	6.4	D	126	7 7.7	-1.2	-2.4	121	7 34.2			160	7 45.5			156
	5	969d	7.1	D	139	6 5.7			160								
	6	1125	6.4	D	153	6 50.5	-2.1	+2.0	50	6 45.3	-2.2	+0.5	76	7 8.9	-2.1	+0.1	76
	6	1129d	5.3	D	153	7 13.9	-2.0	+0.7	67	7 15.0	-2.1	-0.3	90	7 37.6	-1.8	-0.6	88
	17	2456	6.2	R	289	12 13.7	-1.3	+1.2	272	12 5.8	-1.8	+1.8	255	12 24.8	-2.2	+1.0	267
	28	306	6.9	D	53									1 51.9	-1.5	-1.0	90
Mar	3	736	6.2	D	93									2 27.8	-1.9	+2.6	34
	3	760d	6.5	D	96					7 49.4	-1.3	+2.2	23				
	5	1086	6.5	D	123	8 47.7	+0.1	-2.8	143	9 11.0			174	9 7.6	+0.8	-3.1	156
	6	1216	7.3	D	134					5 5.6			44	5 32.2			41
	15	2271	4.3	D	246					8 16.7	-0.6	+0.5	112	8 25.8	-1.3	+0.6	102
	15	2271	4.3	R	246	9 28.7	-0.7	-0.2	316	9 30.1	-1.1	+0.1	300	9 44.1	-1.3	-0.7	312
	30	710	7.1	D	64	3 31.1	-1.1	-1.5	100	3 45.5	-0.9	-2.8	125	3 57.3	-0.3	-2.5	125
	30	718	6.1	D	65	5 13.5	-0.1	-2.4	122	5 35.0			157				
	30	726	6.8	D	65	6 24.7	+0.9	-4.0	150								
	31	847	3.0	R	76									1 54.8	-2.0	-0.9	277
	31	881d	5.9	D	78	6 0.4	+0.1	-3.0	139					6 23.2			162
Apr	1	1047d	5.2	D	92	6 41.0	-0.5	-1.4	97	6 51.5	-0.3	-1.7	113	6 56.6	-0.1	-1.4	105
	1	1054d	6.8	D	93	8 10.2	+0.2	-1.7	116	8 21.6	+0.4	-1.9	131				
	2	1174d	7.5	D	104	3 37.6	-1.4	-3.7	151								
	2	1191	7.0	D	105	7 41.6	-1.0	-0.4	59	7 46.3	-0.8	-0.8	77	7 54.7	-0.5	-0.4	67
	3	1322	6.1	D	118	6 39.4	-0.6	-2.8	147	7 1.9	+0.4	-4.4	170	7 7.5	0.0	-2.9	154
	3	1340	6.6	D	120	10 12.5	+0.3	-1.8	128								
	27	808	6.8	D	46	3 38.7	-0.5	-1.6	104	3 51.4	-0.1	-2.2	125	3 55.4	+0.1	-1.8	118
	28	1001	7.2	D	61					5 31.7	-0.8	+0.3	48				
	30	1282	6.6	D	88	6 8.1			178								
	30	1292	6.7	D	89	7 46.0	-0.8	0.0	48	7 48.7	-0.4	-0.5	66				
	30	1293	6.7	D	89	7 42.7	-0.1	-1.5	104	7 52.5	+0.1	-1.5	116				
	30	1294d	6.9	D	89	7 44.8	-0.1	-1.4	100	7 54.1	+0.1	-1.5	112				
	30	1297	6.8	D	89	8 4.0	+0.3	-2.0	138								
	30	1298d	6.5	D	89	7 57.4	-0.3	-0.8	67	8 3.1	-0.1	-0.9	81				
	30	1299	6.3	D	89	7 57.4	0.0	-1.3	95	8 5.9	+0.1	-1.3	106				
	30	1302	6.7	D	89	8 13.0	-0.7	+0.2	43	8 14.6	-0.3	-0.4	62				
	30	1303	6.8	D	89	8 10.0	-0.1	-1.0	80								
May	1	1418	5.9	D	102	7 58.6	-0.1	-1.9	127	8 11.6	+0.1	-2.1	139				
	10	2425	5.9	R	206					5 48.4	-0.7	+0.5	290	5 57.4	-1.0	0.0	301
	11	2557	6.2	R	218	8 10.0	-1.2	+0.3	301	8 9.2	-1.6	+0.4	288	8 28.5	-2.0	-0.3	297
	12	2706	5.8	D	228									7 15.3			181
	12	2706	5.8	R	228									7 28.7			201
	27	1242	6.8	D	56	4 28.2	-0.3	-1.7	115	4 40.4	-0.1	-2.0	129	4 43.7	+0.1	-1.6	120
	28	1383	6.6	D	70	6 34.1	+0.1	-1.7	122	6 45.4	+0.3	-1.8	134				
	29	1485	7.2	D	81									2 48.1	-2.9	+0.6	65
	29	1504	5.7	D	84	7 37.0	+0.3	-2.1	147								
Jun	2	1950	5.8	D	133	9 29.2	-0.6	-2.0	122	9 43.1	-0.5	-2.1	133				
	14	3458	6.5	R	266	9 37.5	-0.7	+0.5	304	9 33.9	-0.8	+0.8	287	9 44.1	-1.4	+0.9	280

Date		Z.C. No.	Mag	P	Elgn of Moon	Or OREGON 42°500 N, 121°000 W				Ca CALIFORNIA 36°000 N, 120°000 W				NM N. MEX.-ARIZ. 34°000 N, 109°000 W			
						U.T.	a	b	PA	U.T.	a	b	PA	U.T.	a	b	PA
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jul	11	3413d	6.4	R	236	8 51.8	-1.4	+1.0	285	8 46.3	-1.5	+1.1	272	9 3.4	-2.0	+1.2	260
	12	3536	4.7	R	247	8 16.9			316	8 16.7	-0.9	+0.5	295	8 28.4	-1.5	+0.8	284
	12	5	4.7	R	248	10 41.3	-2.0	+0.8	278	10 37.2	-2.0	+1.1	264	10 57.4	-2.0	+1.3	245
	13	118	4.9	R	260	9 47.7	-0.5	+2.5	205	9 30.0	-0.3	+3.2	189				
	18	847	3.0	D	328					12 21.1	+0.2	+1.7	55				
	27	1976	6.9	D	82	4 34.2	-0.7	-2.8	166	4 57.3			184	5 10.7			183
	27	1978	6.6	D	82	5 15.3	-0.5	-3.3	175								
	29	2196	6.7	D	105	4 32.6	-1.9	-1.1	105	4 42.8	-2.0	-1.5	114	5 6.3	-1.6	-1.7	113
	30	2316	6.4	D	116									3 51.0	-2.5	-0.7	98
	30	2331	6.4	D	117	6 59.2	-1.1	+0.1	46	7 1.5	-1.3	-0.4	64				
Aug	1	2567	7.1	D	138	4 6.0	-1.6	-0.3	126	4 11.8	-1.7	-1.1	139	4 36.6	-2.3	-1.5	134
	12	464	6.4	R	268									9 19.2			313
	13	620	6.3	R	282					12 4.8	-1.1	+1.8	241				
	14	760d	6.5	R	294									9 4.9	+0.2	+1.7	234
	16	1110d	3.5	D	323	11 49.0	-0.2	+0.7	110	11 47.0	-0.5	-0.2	131				
	16	1110d	3.5	R	323	12 39.5	0.0	+1.9	241	12 25.2	+0.4	+2.6	219				
	29	2682	7.0	D	119					7 22.8	-0.2	+1.2	30				
	31	2961	6.0	D	142					9 30.5	-0.3	+0.4	41				
Sept	1	3078	4.9	D	152									7 3.3			349
	1	3078	4.9	R	152									7 21.9			325
	21	2097	7.1	D	42									1 40.8	-1.1	-2.7	150
	30	3304	6.4	D	144	7 57.8	-2.2	-1.6	105								
Oct	1	3428d	5.2	D	156									8 37.9	+0.4	+3.4	0
	5	401	6.3	R	207	9 11.5	-1.5	+1.3	238	9 1.9	-1.3	+2.1	220	9 8.5	-0.7	+3.4	192
	6	523	6.5	R	220	9 19.5	-1.7	+1.0	258	9 12.6	-1.5	+1.6	240	9 25.0	-1.4	+2.3	217
	8	851	6.3	R	248	11 8.1	-1.5	+1.3	252	10 58.4	-1.4	+2.2	230	11 8.0	-1.4	+3.8	207
	10	1167	6.3	R	274	11 1.3	-1.3	+0.2	299	10 59.2	-1.2	+0.8	276	11 12.1	-1.5	+1.2	260
	21	2432d	6.8	D	45					2 44.7	-1.4	-2.1	124				
	27	3228d	6.5	D	111	1 50.1	-1.6	+1.6	53	1 41.6	-1.9	+1.5	64	2 3.0	-2.4	+0.8	76
	27	3243	7.4	D	112	6 11.1	-2.4	-2.3	114								
	29	3490	7.1	D	135									3 3.8			350
Nov	4	765	5.3	R	214	4 35.2	+0.3	+1.9	226	4 21.7	+0.5	+2.2	209	4 6.2			178
	5	946d	3.2	D	228	5 34.8	-0.1	+1.1	93	5 29.1	-0.3	+0.6	109	5 36.3	-1.3	-0.7	134
	5	946d	3.2	R	228	6 29.5	-0.2	+1.7	245	6 17.2	+0.1	+2.1	227	6 9.3	+0.6	+3.5	201
	5	983	6.0	R	231					11 40.3	-2.3	-3.5	321	12 8.3	-1.7	-2.9	313
	6	1118	6.0	R	243	8 49.7	-1.2	+0.3	295	8 46.7	-1.1	+0.9	274	8 58.0	-1.4	+1.4	256
	19	4004	1.2	D	45					19 52.3			43	20 22.5			26
	19	4004	1.2	R	45					20 43.9			334	20 57.4			346
	22	3050	7.3	D	68									0 39.0	-1.7	+1.4	39
	25	3438	7.5	D	103									3 59.0			344
	25	3458	6.5	D	105	7 35.6	-0.6	-0.8	74	7 44.3	-0.8	-1.7	99				
	26	18	6.0	D	115	2 55.6	-1.5	+1.5	50	2 48.1	-1.9	+1.3	63	3 12.1	-2.8	0.0	88
	29	401	6.3	D	153	2 42.7	-0.4	+2.2	37	2 29.7	-0.6	+1.9	50	2 35.7	-1.2	+1.5	69
Dec	6	1479	6.3	R	252	8 30.1	-0.5	+1.5	265	8 18.0	-0.3	+2.6	239	8 15.0			217
	7	1598	6.4	R	265									7 50.0	-0.7	-2.0	341
	20	3150	6.5	D	50	2 41.2	-0.5	+0.4	38	2 40.9	-0.9	0.0	58	2 51.6	-0.9	-0.8	80
	25	208	7.0	D	107	1 27.5	-0.7	+2.4	24					1 25.8	-1.9	+1.5	61
	25	210d	6.6	D	107									3 24.2			345
	26	368d	6.3	D	123	9 38.5	-0.2	-2.2	111								
	27	464	6.4	D	133	2 6.1	-1.7	+0.6	105	2 10.3			133				
	27	475	7.4	D	135	6 14.4	-2.4	-2.3	116								
	28	610d	6.2	D	146	1 32.9	-0.7	+1.2	94	1 28.0	-1.1	+0.5	111				
	28	639	6.0	D	149	8 33.8	-1.4	+0.8	46	8 33.3	-1.5	-0.1	71	8 48.7	-1.1	-0.5	75
	28	654	6.0	D	150	10 55.0	-1.0	+1.6	24	10 51.4	-0.8	+0.2	52	10 57.8	-0.5	+0.3	48
	29	817d	4.8	D	164	10 36.2	-1.4	+0.9	39	10 35.3	-1.2	-0.1	64	10 47.2	-0.9	0.0	60

OCCULTATION LIMITS FOR 1982

The maps show the tracks of stars brighter than $7^{m}.5$ 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 $3^{m}.5$). Each track starts in the West at the time given in the tables and ends beyond the area of interest, except where the letters *A*, *B* or *S* are given. *A* denotes that the Moon is at a low altitude, *B* that the bright limb interferes, and *S* that daylight interferes. The tick marks along the tracks denote 10 minute intervals which, when added to the time at the beginning of the track, give the time of the graze at places along the tracks. The tick marks are located on the side of each line that the star is occulted.

In the case of a near-grazing occultation, where no **a** or **b** factors are given in the table of predictions but the limit line is shown on the map, the time of central occultation can be estimated as the time on the limit line closest to the observer's location. To see a near-graze disappearance, the observer should start watching about a half hour earlier. After timing the disappearance, he can predict the time of reappearance approximately by adding the difference *central occultation time* minus *the observed time of disappearance* to the central time.

Observers positioned on or very near one of these tracks will probably see the star disappear and reappear several times at the edge of features on the limb of the Moon. The recorded times of these events (to a precision of a second, if possible) are very valuable in the study of the shape and motion of the Moon currently being investigated at the Royal Greenwich Observatory and the U.S. Naval Observatory. Interested observers situated near to any of these tracks should write to Dr. David W. Dunham, IOTA, P.O. Box 596, Tinley Park, Ill. 60477, U.S.A., at least two months before the event, giving the region of planned observation, and details of the graze path will be supplied (cost $1.50 U.S. per event, or free for IOTA members, see pg. 68).

The following table gives, for each track the Zodiacal Catalogue number and magnitude of the star, the time (U.T.) at the beginning of the track in the West, the percent of the Moon sunlit, and whether the track is the northern (N) or southern (S) limit of the occultation. An asterisk after the track number indicates that the star is double; information on these stars is given in the second table.

No.	Z.C.	m_v	UT at Start of Track in West	h m	%	L
1	3529	6.8	Jan. 2	2 34	38	S
2	3536	4.7	2	3 29	38	S
5	1923	7.1	16	12 44	54	S
6	2361	4.8	20	9 6	19	S
7	2498	4.5	21	11 40	12	S
8*	2509	6.0	21	13 56	11	S
9	3358	7.2	28	0 28	8	S
10	3490	7.1	28	22 59	14	S
13	346	7.4	Feb. 1	2 56	45	S
14	364	4.3	1	6 49	47	S
15	453	7.3	1	22 35	55	S
16	462	5.9	2	0 27	56	S
18	620	6.3	3	4 29	68	N
19	648	3.9	3	8 37	70	N
20	653	4.8	3	9 1	70	N
23	2446	7.2	17	9 54	34	S
25	2588	6.9	18	14 7	24	S
26	291	7.1	27	23 11	19	S
28	726	6.8	Mar. 2	23 46	52	S
29	730	5.1	3	0 45	53	S
30	736	6.2	3	3 31	53	N
31*	760	6.5	3	7 54	55	N
33	905	6.7	4	5 4	65	N
34	2401	5.6	16	9 1	61	S
35	2529	6.6	17	10 46	51	S
36	2661	7.1	18	8 35	42	S
37	2675	7.1	18	11 27	41	S
38	3078	4.9	21	11 22	15	S
39*	684	6.2	29	23 58	27	S
40	697	7.2	30	1 36	27	S
41	710	7.1	Mar.30	4 0	28	S
44	837	6.1	30	23 50	38	S
45	847	3.0	31	1 57	38	N
46	1021	6.3	Apr. 1	1 50	50	N
47*	1174	7.5	2	3 45	62	S
48	1191	7.0	2	7 40	64	N
50	1418	5.9	4	1 23	81	S
51*	2595	5.7	14	6 53	69	S
52*	2597	7.0	14	7 44	69	S
53	2604	6.6	14	7 17	69	S
54	2608	6.9	14	7 53	68	S
59	648	3.9	26	3 45	8	S
60	653	4.8	26	4 4	8	S
61*	790	6.9	27	1 5	15	S
62*	793	6.2	27	1 42	15	S
64*	976	3.2	28	1 53	25	N
65	984	6.6	28	3 4	25	S
66	1001	7.2	28	5 35	26	N
67*	1110	3.5	28	22 57	34	S
68*	1128	6.9	29	2 42	36	N
69	1277	5.5	30	4 25	48	N
70	1287	6.7	30	7 17	49	S
71	1292	6.7	30	7 43	49	N
72	1302	6.7	30	8 12	49	N
73*	1392	7.1	May 1	1 34	58	N
74	1402	7.5	1	3 50	59	N
75	2706	5.8	12	7 17	83	S
78	1078	5.9	26	2 41	13	N
79	1224	5.4	27	2 6	21	N
80	1485	7.2	29	3 3	43	N

No.	Z.C.	m_v	UT at Start of Track in West			%	L
				h	m		
81	1702	4.2	May 31	0	27	64	N
82	1725	7.5	31	6	38	66	N
83	3078	4.9	Jun.11	11	21	80	N
84	3458	6.5	14	9	44	53	N
88	3536	4.7	Jul.12	8	5	69	N
89*	658	4.2	17	9	7	16	N
90*	663	6.9	17	9	31	16	N
91	847	3.0	18	13	5	7	N
92*	1856	6.6	26	2	45	33	N
93	2072	6.7	28	0	59	52	N
94	2180	7.0	29	0	20	62	N
95	2425	5.9	31	0	46	79	N
96	464	6.4	Aug.12	8	48	52	N
98*	610	6.2	13	9	28	40	N
99	765	5.3	14	9	38	29	N
100	928	6.0	15	9	33	19	N
101*	946	3.2	15	11	43	18	N
102*	976	3.2	15	15	25	17	N
104	581	6.9	Sep. 9	9	35	66	N
109	1215	6.8	13	12	32	21	N
111	2210	6.8	22	0	29	20	N
112	2457	6.3	23	23	1	37	N
113	3031	5.9	28	5	55	76	S
115*	843	7.2	Oct. 8	8	46	69	N
116*	976	3.2	9	3	17	61	N
117	1014	6.8	9	8	10	58	N
118	1036	6.5	9	12	53	57	N
120	1167	6.3	10	10	36	46	N
121*	1304	6.6	11	9	34	35	N
122	1315	6.9	11	11	21	34	N

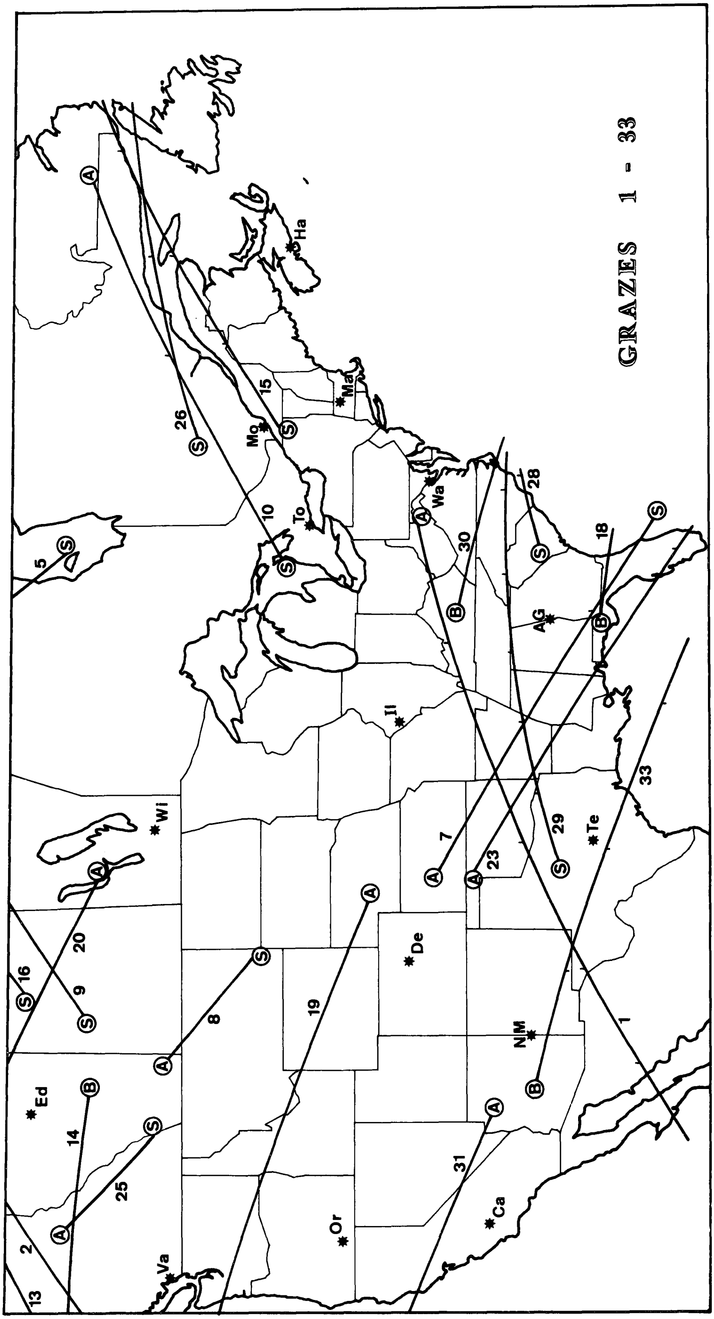
No.	Z.C.	m_v	UT at Start of Track in West			%	L
				h	m		
123	1659	6.8	Oct.14	8	52	9	N
125	2694	6.4	23	0	48	30	S
128	2857	6.7	24	5	9	40	S
129	3090	6.9	26	0	44	58	N
130	3092	6.2	26	0	35	58	S
131*	3228	6.5	27	3	14	68	S
132	3243	7.4	27	6	21	69	S
134*	976	3.2	Nov. 5	11	12	82	S
135	983	6.0	5	10	58	81	N
136	1118	6.0	6	8	26	72	N
137*	1144	6.6	6	12	55	71	N
138	1253	7.4	7	6	31	62	N
139	1269	7.0	7	10	38	61	S
140*	1392	7.1	8	9	34	50	S
141	1514	6.1	9	8	48	39	N
142	1535	7.1	9	12	13	37	N
143	1647	6.7	10	12	57	27	N
144	1755	6.8	11	12	48	18	N
145*	1856	6.6	12	11	2	11	S
148	3175	4.8	23	0	51	41	S
151	18	6.0	26	3	41	71	S
152	118	4.9	26	23	31	79	S
153	1224	5.4	Dec. 4	10	22	85	S
154	1479	6.3	6	8	27	65	S
155	1485	7.2	6	10	18	64	S
157	1598	6.4	7	7	33	54	N
158	1612	7.3	7	12	4	52	S
159	1725	7.5	8	11	8	41	S
160	1950	5.8	10	12	35	21	S
161	3009	7.1	19	0	55	11	S
162	208	7.0	25	2	25	65	S

*DOUBLE STAR GRAZES

Track No.	Z.C.	Aitken	Companion m	Sep.	PA
8	2509	10522	11.5	4″.3	144°
31	760	3672	7.6	0.9	314
39	684	3297	7.1	3.4	276
47	1174	6347	8.0	--	--
51	2595	10983*	12.5	8.2	236
52	2597	10991	**	--	--
61	790	3866	9.5	2.7	234
62	793	3894	10.2	9.1	204
64	976	4990*	9.8	122.5	141
67	1110	5983	8.1	6.8	211
68	1128	6087	10.	(35.)	276
73	1392	7341	8.5	--	--
89	658	3206	8.3	1.5	325

Track No.	Z.C.	Aitken	Companion m	Sep.	PA
90	663	3226	9.3	18″.8	58°
92	1856	8708	7.5	0.8	79
98	610	3006	9.2	4.4	326
101	946	4841	8.8	1.3	278
102	976	4990*	9.8	122.5	141
115	843	4200	7.8	3.6	262
116	976	4990*	9.8	122.5	141
121	1304	6930	9.0	0.5	105
131	3228	15562	7.2	(3.9)	244
134	976	4990*	9.8	122.5	141
137	1144	6160	8.5	11.5	178
140	1392	7341	8.5	--	--
145	1856	8708	7.5	0.8	79

*Triple system
**Companion is variable (m = 8.8 - 13.5)


GRAZES 1 - 33
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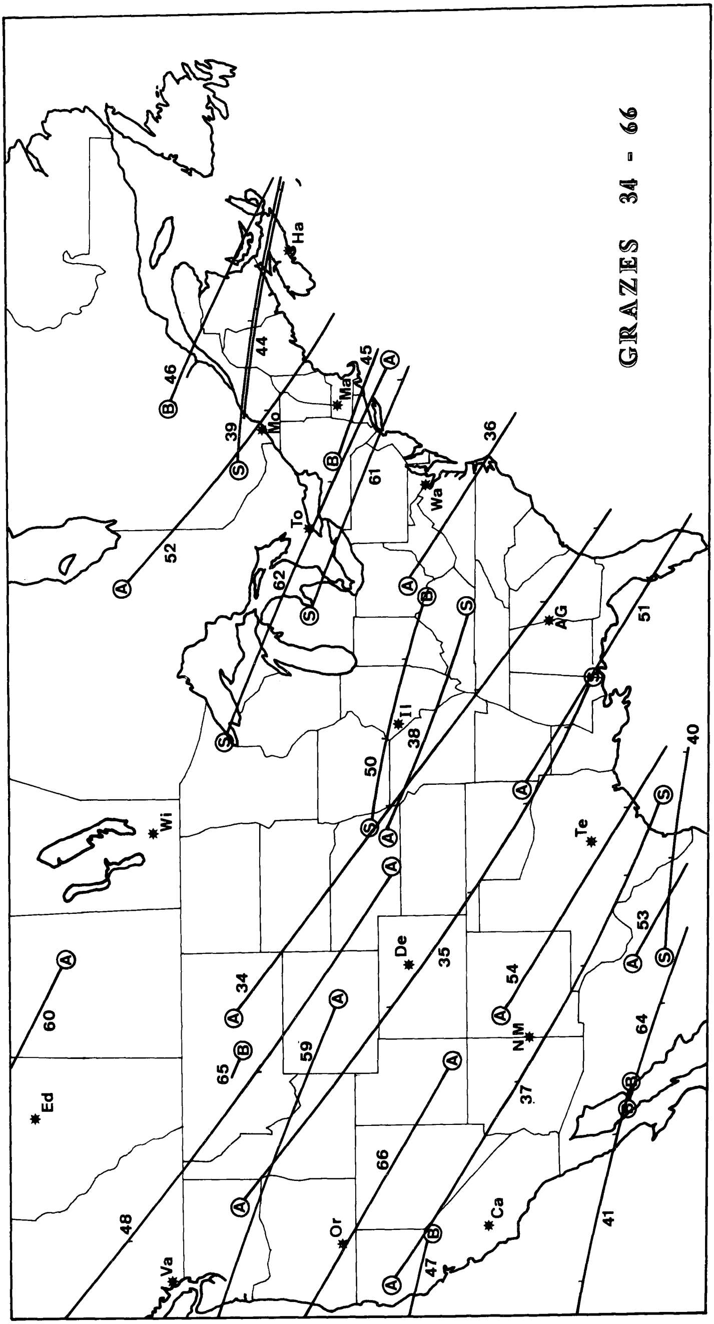
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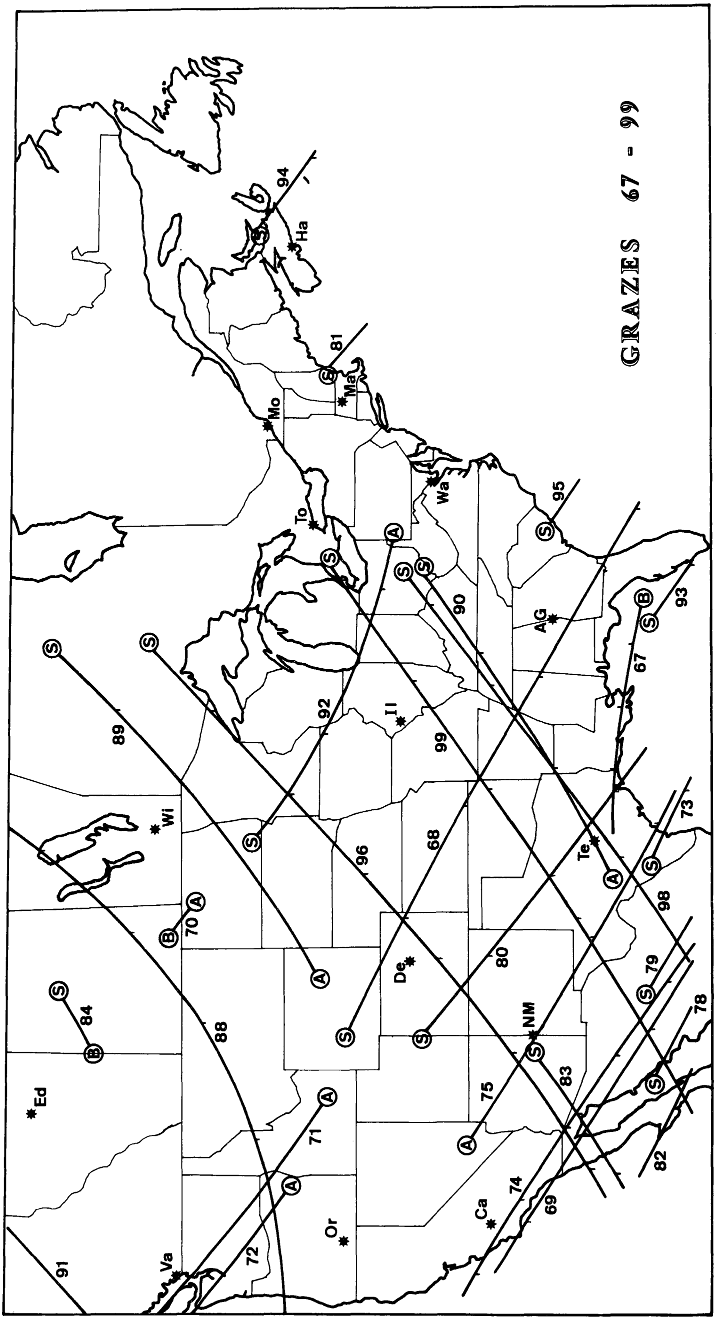
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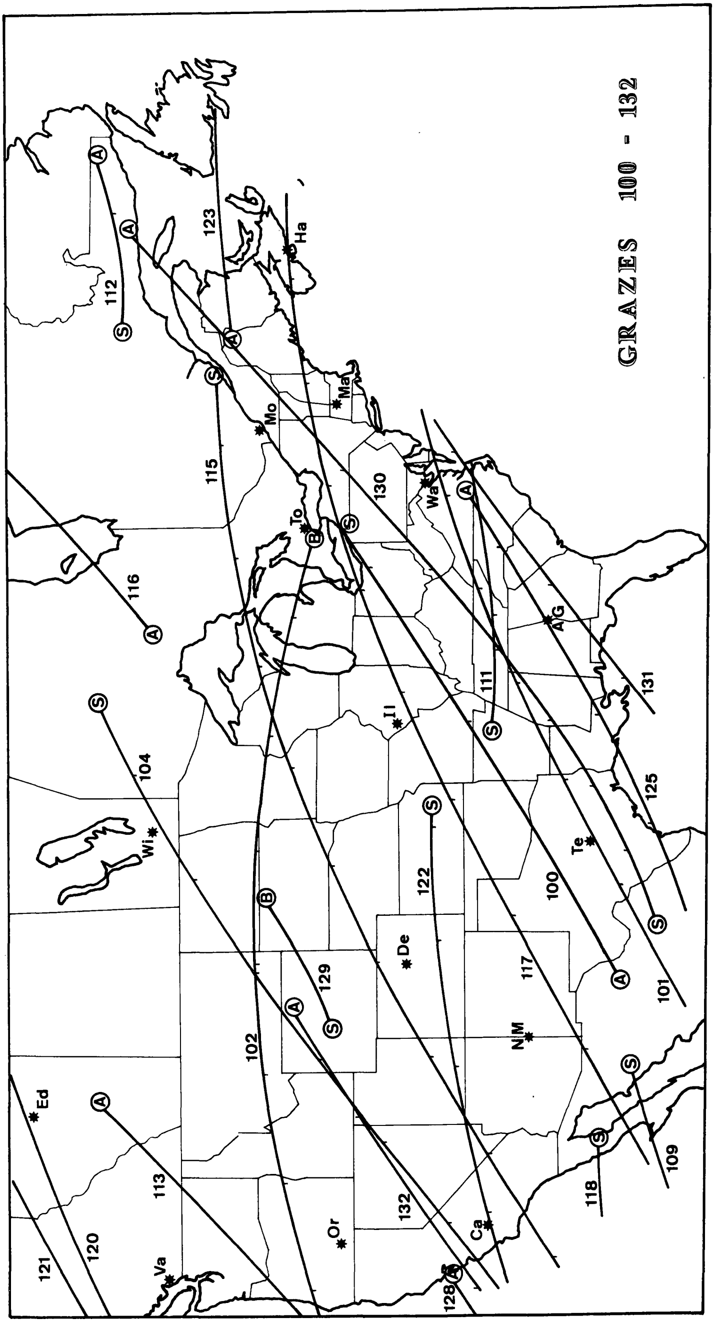
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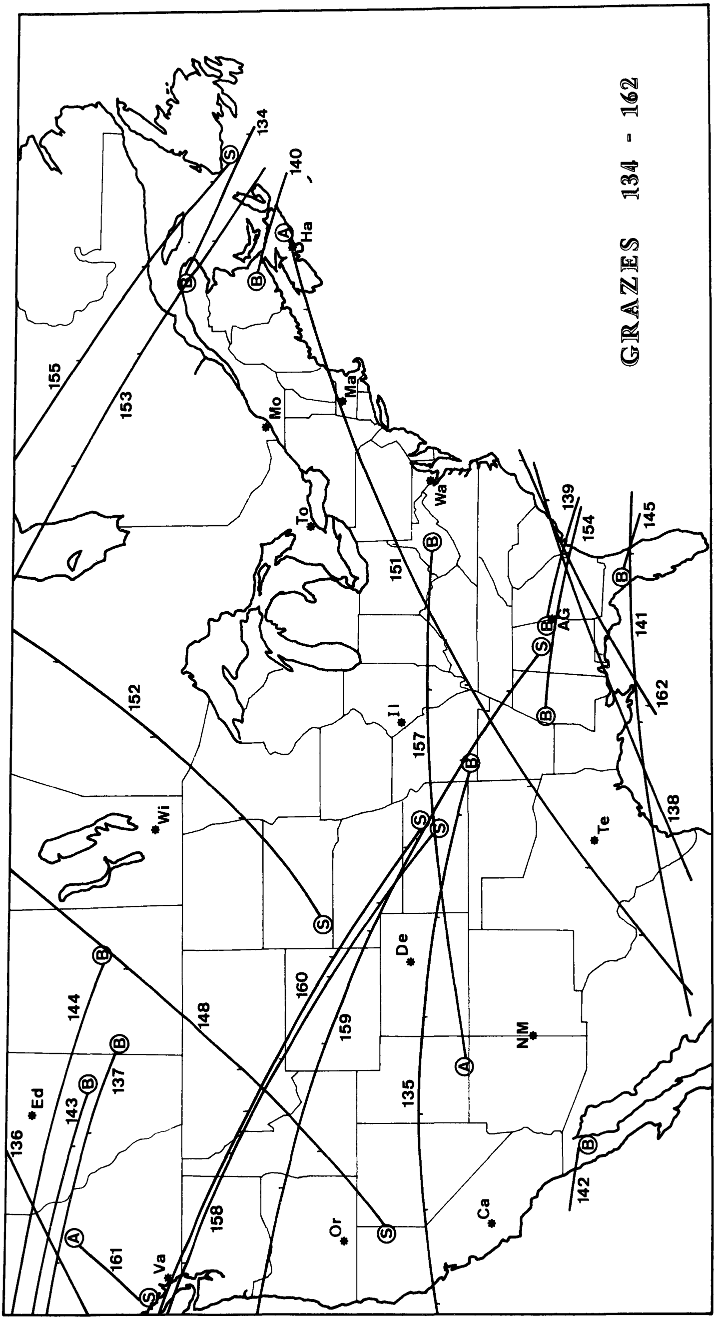
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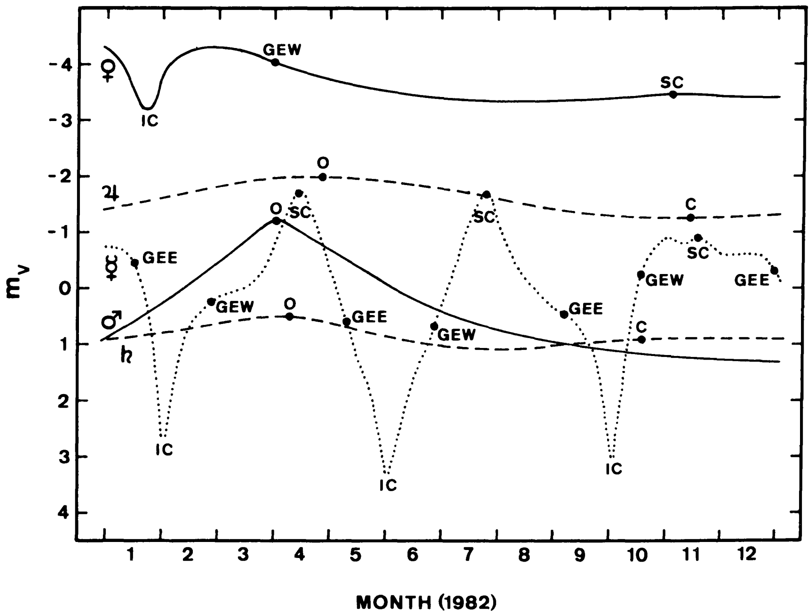
PLANETS

PLANETARY HELIOCENTRIC LONGITUDES 1982

Date UT	Planet					
	M	V	E	M	J	S
Jan. 1.0	324°	88°	100°	151°	207°	196°
Feb. 1.0	131	138	132	164	209	197
Mar. 1.0	238	184	160	177	211	198
Apr. 1.0	332	234	191	191	214	199
May 1.0	137	281	220	204	216	200
June 1.0	249	330	250	219	218	201
July 1.0	344	18	279	234	220	202
Aug. 1.0	157	68	308	250	223	203
Sep. 1.0	260	118	338	268	225	204
Oct. 1.0	3	166	7	285	228	205
Nov. 1.0	175	216	38	304	230	206
Dec. 1.0	268	264	68	323	232	207
Jan. 1.0	23	313	100	342	235	208

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 8), the reader can construct the orientation of the Sun and planets on any date.

The heliocentric longitude of Uranus increases from 241° to 245° during the year; that of Neptune from 265° to 267°, and that of Pluto from 205° to 207°.



The magnitudes of the planets in 1982. Conjunctions, oppositions, and greatest elongations are indicated.

THE PLANETS FOR 1982

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 seven greatest elongations of Mercury during 1982 are presented.

GREATEST ELONGATIONS OF MERCURY IN 1982

Date UT	Elongation	Magnitude	Apparent Diameter
	°		″
Jan. 16	19E	−0.3	6.9
Feb. 26	27W	+0.3	6.9
*May 9	21E	+0.6	7.9
Jun. 26	22W	+0.6	8.0
Sept. 6	27E	+0.4	7.0
*Oct. 17	18W	−0.2	6.8
Dec. 30	20E	−0.3	6.7

*favourable elongations for midnorthern latitudes

MERCURY: TELESCOPIC OBSERVING DATA FOR FAVOURABLE EASTERN (EVENING) ELONGATIONS 1982

Date 0 h UT		Magnitude	Apparent Diameter	Phase % Illuminated	R.A.		Dec.	
			″		h	m	°	′
Jan.	7	−0.7	5.6	85	20	19	−21	31
Jan.	11	−0.6	6.0	76	20	43	−19	39
Jan.	15	−0.5	6.6	63	21	04	−17	36
Jan.	19	−0.1	7.4	46	21	18	−15	35
Jan.	23	+0.5	8.3	27	21	23	−14	01
Apr.	25	−0.9	5.8	80	3	04	+18	52
Apr.	29	−0.5	6.2	67	3	32	+21	15
May	3	−0.1	6.8	55	3	58	+22	58
May	7	+0.4	7.5	43	4	20	+24	03
May	11	+0.8	8.4	32	4	36	+24	32
May	15	+1.2	9.3	22	4	48	+24	29

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 1982

Date 0 h UT		Magnitude	Apparent Diameter	Phase % Illuminated	R.A.		Dec.	
			″		h	m	°	′
Jan.	3	−4.2	54.3	10.4	20	43	−16	08
	7	−4.0	57.3	7.0	20	39	−15	20
	11	−3.8	59.9	4.1	20	32	−14	41
	15	−3.5	61.8	1.9	20	24	−14	10
	19	−3.2	62.7	0.7	20	14	−13	49
	23	−3.2	62.6	0.7	20	03	−13	37
	27	−3.5	61.4	1.9	19	53	−13	34
	31	−3.7	59.3	4.1	19	45	−13	38
Feb.	4	−4.0	56.6	7.0	19	39	−13	49
	8	−4.1	53.6	10.4	19	36	−14	03
	12	−4.2	50.3	14.0	19	36	−14	19
	20	−4.3	44.1	21.3	19	43	−14	50
	28	−4.3	38.7	28.1	19	58	−15	08
Mar.	12	−4.2	32.3	37.1	20	32	−14	53
	24	−4.1	27.4	44.7	21	15	−13	32
Apr.	9	−3.9	22.8	53.2	22	17	−10	01
May	3	−3.7	18.2	63.8	23	56	− 1	49

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.

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 1982 opens, Venus is a slim 12% crescent with a large apparent diameter of 53″. Other data for the months around inferior conjunction on January 21 are supplied in the table. From mid-February to September Venus remains in the early morning sky. Telescopically, the planet shrinks from a hairline 63″ crescent at inferior conjunction to a 75% gibbous phase, 14.5″ in diameter, on June 4. In that interval its distance from Earth increases from 0.27 to 1.16 A.U. Until superior conjunction on November 4, the separation continues to increase with a corresponding decrease in apparent diameter. After superior conjunction the cycle is reversed.

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.

Mars is well placed for observation in Virgo from January to August. Reaching opposition on March 31, Mars will be a brilliant −1.2 magnitude, about midway between Jupiter and Saturn in brightness. By late August Mars will be down to magnitude +1.0, and for the rest of the year it will remain below this level as we recede from the red planet.

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

MARS: EPHEMERIS FOR PHYSICAL OBSERVATIONS 1982

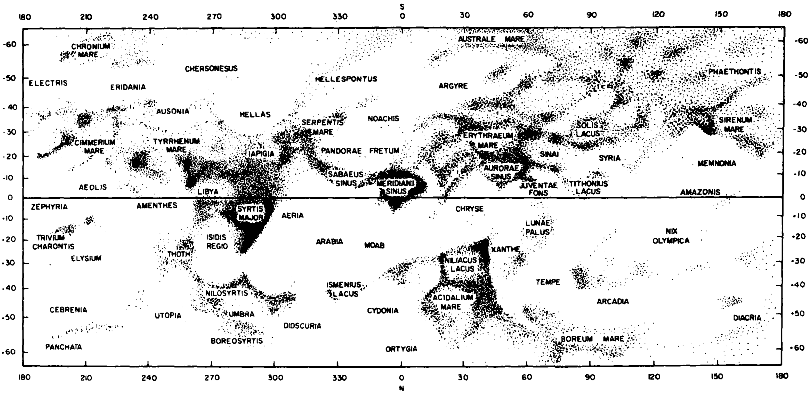
Date UT		Dist. AU	Vis. Mag.	App. Diam.	Ill. %	Pos. Ang.	Incl.	L(1)	Δ
				″		°	°	°	°
Jan.	1.0	1.291	+0.9	7.3	90	30	23	148.23	9.42
Feb.	2.0	0.981	+0.2	9.5	92	34	21	206.70	9.25
	12.0	0.892	0.0	10.5	94	34	21	114.24	9.14
	22.0	0.811	−0.3	11.5	95	34	20	22.88	9.01
Mar.	4.0	0.742	−0.6	12.6	97	34	20	292.78	8.88
	14.0	0.688	−0.8	13.6	98	33	21	203.97	8.77
	24.0	0.651	−1.1	14.4	100	32	21	116.27	8.72
	28.0	0.642	−1.1	14.6	100	32	22	81.41	8.70
Apr.	1.0	0.637	−1.2	14.7	100	31	22	46.61	8.70
	5.0	0.635	−1.2	14.7	100	31	22	11.82	8.71
	9.0	0.637	−1.1	14.7	100	30	23	336.99	8.73
	13.0	0.641	−1.1	14.6	99	30	23	302.07	8.80
	23.0	0.666	−0.9	14.0	98	28	24	214.12	8.92
May	3.0	0.707	−0.7	13.2	96	27	24	124.89	9.07
	13.0	0.759	−0.4	12.3	93	27	25	34.21	9.21
	23.0	0.820	−0.2	11.4	92	28	25	302.14	9.33
June	2.0	0.885	0.0	10.6	90	28	25	208.86	9.51
July	2.0	1.092	+0.4	8.6	88	33	25	283.70	9.66
Aug.	1.0	1.290	+0.8	7.3	87	37	22	353.82	9.73
Sep.	2.0	1.479	+1.0	6.3	88	39	16	42.51	9.75
Oct.	2.0	1.636	+1.1	5.7	90	35	8	109.98	9.77
Nov.	1.0	1.776	+1.2	5.3	92	26	− 2	176.86	9.81
Dec.	1.0	1.905	+1.3	4.9	93	13	−12	242.53	9.88
Jan.	2.0	2.038	+1.3	4.6	95	358	−20	286.39	—

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. This year's opposition is more favourable than the past two, with Mars attaining an apparent diameter of 14.74 seconds of arc on April 5, the date of closest approach to Earth.

For selected dates when Mars is favourably placed, the table above gives the distance from the Earth, the magnitude, apparent diameter, fraction of the disk illuminated, position angle of the rotation axis (measured from the north through the east), inclination of the rotation axis to the plane of the sky (positive if the north pole is tipped toward the Earth) and two quantities *L(1)* and Δ which can be used to calculate the longitude *L* of the central meridian of the geometric disc. To calculate *L,* note the date and time of the observation, and then convert them to U.T. (see section on *Time*). Take *L(1)* for the first date in the table preceding the date of observation, and from it *subtract* Δ times the number of full days elapsed since the first date in the table preceding the date of observation. To the result, *add* 14.6° for each hour elapsed since 0 h U.T. If the result is less than 0°, *add* 360°; if the result is greater than 360°, *subtract* 360°. The answer is accurate to better than 1°. The value of *L* can then be compared with the map on pg. 92.

During opposition period the north pole of Mars is tipped strongly toward the Earth and the north polar cap should be the most prominent feature visible in small telescopes. The main features on the map of Mars can be seen with a good 100 mm telescope when the planet is within 1 A.U. of the Earth. The features of the map can be correlated to the planet's rotation by use of the table.

MAP OF MARS



Latitude is plotted on the vertical axis (south at the top); longitude is plotted on the horizontal axis

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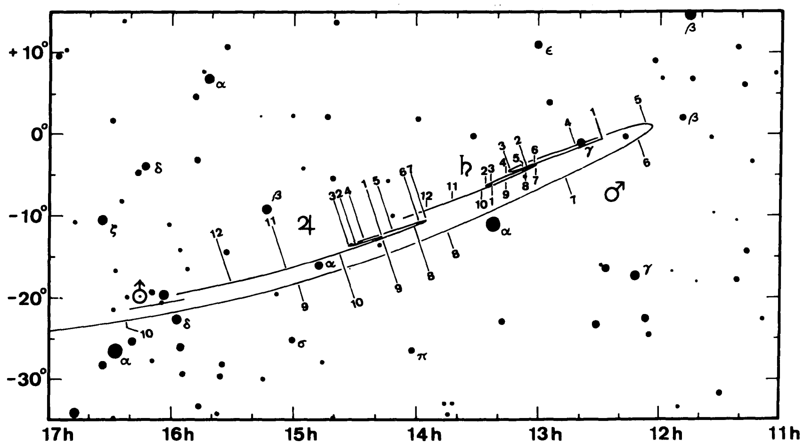


The paths of Mars, Jupiter, Saturn, and Uranus in the Virgo-Libra-Scorpius region during 1982. (A larger map for Uranus appears on p. 96). The positions are marked for the first day of each month, where 1 = January, 2 = February, etc. On October 13 the path of Mars moves off the diagram; however, from then until the end of the year, Mars is difficult to observe since its angular diameter is less than 6" and, for observers in mid-northern latitutdes, Mars is located low in the southwestern evening sky.

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.

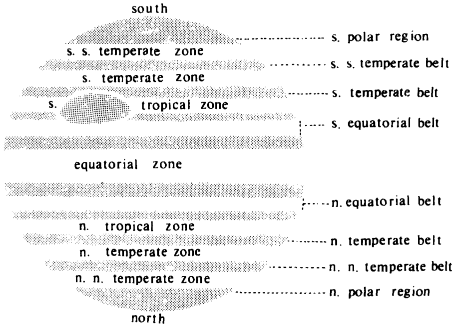
Jupiter's rapid rotation also makes the great globe markedly oval so that it appears about 7% "squashed" at the poles. Jupiter's apparent equatorial diameter ranges from 44″ at opposition on April 26 to a minimum of 31″ at conjunction on November 13.

JUPITER: EPHEMERIS FOR PHYSICAL OBSERVATIONS 1982

Date U.T.	Vis. Mag.	App. Equat. Diam.	System I		System II	
			L(1)	Δ	L(1)	Δ
		″	°	°	°	°
Jan 1.0	−1.4	33.9	127.0	157.87	226.9	150.24
Feb 1.0	−1.6	37.1	341.0	157.95	204.4	150.31
Mar 1.0	−1.8	40.3	83.5	158.01	93.3	150.38
Apr 1.0	−2.0	43.4	301.8	158.03	75.0	150.40
May 1.0	−2.0	44.4	2.8	157.98	267.1	150.35
Jun 1.0	−1.9	42.8	220.0	157.87	247.8	150.23
Jul 1.0	−1.8	39.6	275.9	157.77	74.8	150.14
Aug 1.0	−1.6	36.2	126.7	157.70	49.1	150.07
Sep 1.0	−1.4	33.5	335.5	157.67	21.3	150.04
Oct 1.0	−1.3	31.7	25.6	157.67	202.6	150.04
Nov 1.0	−1.2	30.9	233.3	157.68	173.7	150.06
Dec 1.0	−1.3	31.0	283.8	157.73	355.4	150.10
Jan 1.0	−1.3	32.2				

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) 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 1982 opens, Jupiter is in the morning sky in Virgo, just east of Saturn and Mars. Jupiter is the brightest member of this planet cluster and is ideally placed for telescopic study from February through July. 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 April 26, when the giant planet is 663 million km (4.43 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.

The outer ring A has an external diameter of 274 000 km and is 16 000 km wide. Separating ring A from the 26 000-km-wide ring B is a 3000 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 16 000 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 a dozen 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.

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 the Earth. In 1973 the rings were presented to their fullest extent (27°) as viewed from the Earth. In apparent width the rings are equal to the equatorial diameter of Jupiter.

As 1982 opens, the rings are tilted 12.3° with respect to Earth, with the northern face being visible. The tilt remains near this value until March when it decreases slightly, reaching 9.7° in June. From then until September, when Saturn is too close to the Sun for observation, the ring inclination slowly increases to near 12°. By December 31, when Saturn is well up in the morning sky, the rings have opened to 16.7°.

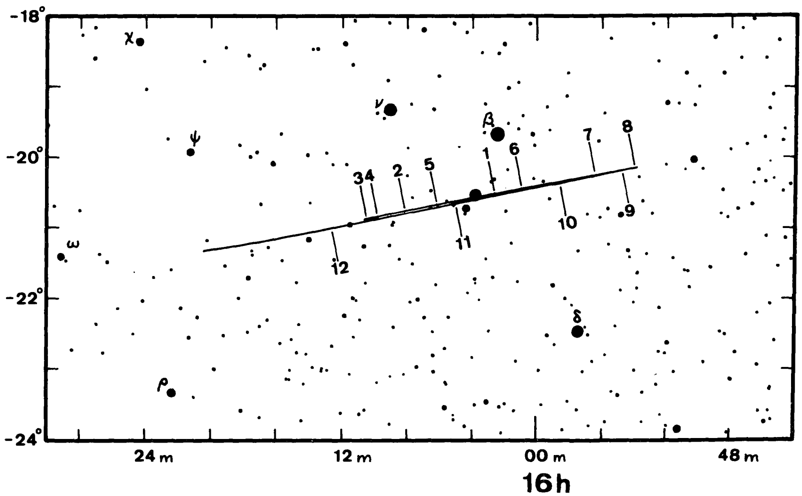
Saturn is in Virgo and rises about 1 a.m. as 1982 begins. The planet remains in Virgo all year and is in opposition April 9, when the planet is 1.30 billion km (8.67 A.U.) from Earth. At that time Saturn is 19″.2 in equatorial diameter, and the rings are 43″.3 in width.

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.

P



The path of Uranus in western Scorpius, 1982. 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 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 is in Scorpius this year, opposition being on May 24 when the planet is 2.67 billion km (17.87 A.U.) from Earth. At this time its magnitude is +5.8 and its apparent diameter is 3.8 seconds of arc.

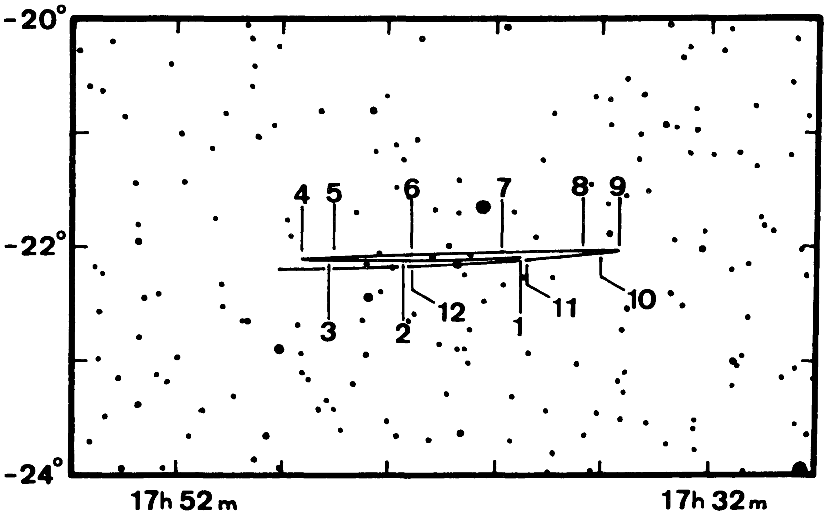
NEPTUNE

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. Triton is an exceptionally large satellite and may prove to be the solar system's biggest moon. The moon 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.

No surface features have ever been distinctly seen on Neptune's visible surface. The planet's rotation period, determined spectroscopically, was tentatively revised upward to 22 hours in 1977. Neptune's diameter is known with high precision due to analysis of a series of observations of a rare occultation in 1969.

In 1981 Neptune is buried in the Milky Way on the Sagittarius/Ophiuchus border and is not well placed for northern observers. At opposition on June 17 Neptune is magnitude +7.7 and 4.38 billion km (29.26 A.U.) distant from Earth.



The path of Neptune at the Ophiuchus-Scorpius border, 1982. 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 north of the path is 58 Ophiuchi.

PLUTO

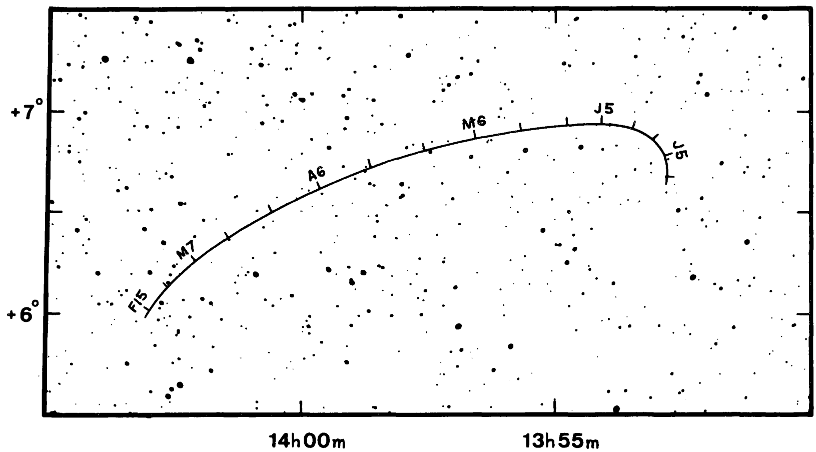
Pluto, the most distant known planet, was discovered at the Lowell Observatory in 1930 as a result of an extensive search started two decades earlier by Percival Lowell. The faint star-like image was first detected by Clyde Tombaugh by comparing photographs taken on different dates.

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.

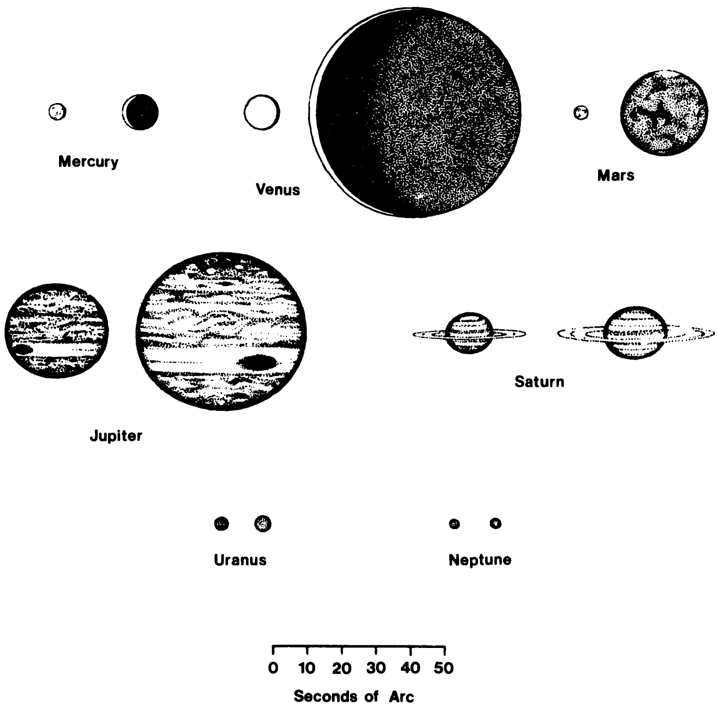
Besides being the solar system's smallest planet, Pluto is different from the other eight in almost every respect. Its unique characteristics include its orbit which is relatively higher inclined and so elliptical that the planet will be closer to the Sun than Neptune from 1980 to 1999. Just where such 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 15, Pluto's astrometric position is R.A. (1950) $13^h\ 58^m.7$, Dec. (1950) +6° 44′ and its distance from Earth will be 4.34 billion km (29.01 A.U.). With an apparent magnitude of +13.7, Pluto is a difficult target in moderate-sized amateur telescopes.



The path of Pluto in eastern Virgo, 1982. Its position is marked at 10-day intervals, beginning at February 15 (F15). The brightest stars shown are approximately 8th magnitude and the chart limit is 14. Pluto reaches opposition on April 15 at magnitude 13.7. The chart is based on Vehrenberg's Atlas Stellarum *(1950.0).*

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.

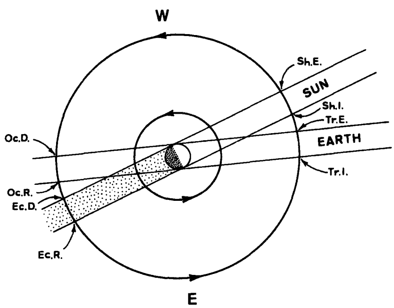
P

JUPITER

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 (November 13 in 1982). 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 May 7 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 May 8, 5 h to 9 h UT. He would find two events, at 0027 and 0100 PDT, both involving the satellite Europa.

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JANUARY

d	h	m	
0	4	31	III. Ec.D.
	6	56	III. Ec.R.
	9	02	III. Oc.D.
	10	01	II. Sh.I.
	11	17	III. Oc.R.
	12	12	II. Tr.I.
	12	29	II. Sh.E.
	12	46	I. Ec.D.
	14	37	II. Tr.E.
	16	02	I. Oc.R.
1	9	58	I. Sh.I.
	11	05	I. Tr.I.
	12	08	I. Sh.E.
	13	14	I. Tr.E.
2	4	25	II. Ec.D.
	7	14	I. Ec.D.
	9	12	II. Oc.R.
	10	31	I. Oc.R.
3	4	27	I. Sh.I.
	5	34	I. Tr.I.
	6	37	I. Sh.E.
	7	43	I. Tr.E.
	18	28	III. Sh.I.
	20	51	III. Sh.E.
	23	08	III. Tr.I.
	23	17	II. Sh.I.
4	1	20	III. Tr.E.
	1	32	II. Tr.I.
	1	43	I. Ec.D.
	1	46	II. Sh.E.
	3	56	II. Tr.E.
	5	00	I. Oc.R.
	22	55	I. Sh.I.
5	0	03	I. Tr.I.
	1	05	I. Sh.E.
	2	13	I. Tr.E.
	17	44	II. Ec.D.
	20	11	I. Ec.D.
	22	33	II. Oc.R.
	23	29	I. Oc.R.
6	17	23	I. Sh.I.
	18	32	I. Tr.I.
	19	34	I. Sh.E.
	20	42	I. Tr.E.
7	8	28	III. Ec.D.
	10	53	III. Ec.R.
	12	34	II. Sh.I.
	13	13	III. Oc.D.
	14	39	I. Ec.D.
	14	51	II. Tr.I.
	15	02	II. Sh.E.
	15	26	III. Oc.R.
	17	15	II. Tr.E.

d	h	m	
7	17	58	I. Oc.R.
8	11	52	I. Sh.I.
	13	01	I. Tr.I.
	14	02	I. Sh.E.
	15	11	I. Tr.E.
9	7	01	II. Ec.D.
	9	07	I. Ec.D.
	11	53	II. Oc.R.
	12	26	I. Oc.R.
10	6	20	I. Sh.I.
	7	31	I. Tr.I.
	8	30	I. Sh.E.
	9	40	I. Tr.E.
	22	27	III. Sh.I.
11	0	49	III. Sh.E.
	1	50	II. Sh.I.
	3	19	III. Tr.I.
	3	36	I. Ec.D.
	4	10	II. Tr.I.
	4	18	II. Sh.E.
	5	28	III. Tr.E.
	6	34	II. Tr.E.
	6	55	I. Oc.R.
12	0	49	I. Sh.I.
	1	59	I. Tr.I.
	2	59	I. Sh.E.
	4	09	I. Tr.E.
	20	19	II. Ec.D.
	22	04	I. Ec.D.
13	1	14	II. Oc.R.
	1	24	I. Oc.R.
	19	17	I. Sh.I.
	20	28	I. Tr.I.
	21	27	I. Sh.E.
	22	37	I. Tr.E.
14	12	25	III. Ec.D.
	14	49	III. Ec.R.
	15	07	II. Sh.I.
	16	32	I. Ec.D.
	17	21	III. Oc.D.
	17	29	II. Tr.I.
	17	34	II. Sh.E.
	19	31	III. Oc.R.
	19	52	II. Tr.E.
	19	53	I. Oc.R.
15	13	45	I. Sh.I.
	14	57	I. Tr.I.
	15	55	I. Sh.E.
	17	06	I. Tr.E.
16	9	37	II. Ec.D.
	11	00	I. Ec.D.

d	h	m	
16	14	21	I. Oc.R.
	14	33	II. Oc.R.
17	8	14	I. Sh.I.
	9	26	I. Tr.I.
	10	24	I. Sh.E.
	11	35	I. Tr.E.
18	2	25	III. Sh.I.
	4	23	II. Sh.I.
	4	46	III. Sh.E.
	5	28	I. Ec.D.
	6	47	II. Tr.I.
	6	51	II. Sh.E.
	7	26	III. Tr.I.
	8	50	I. Oc.R.
	9	10	II. Tr.E.
	9	32	III. Tr.E.
19	2	42	I. Sh.I.
	3	55	I. Tr.I.
	4	52	I. Sh.E.
	6	04	I. Tr.E.
	22	55	II. Ec.D.
	23	57	I. Ec.D.
20	1	26	II. Ec.R.
	1	27	II. Oc.D.
	3	18	I. Oc.R.
	3	52	II. Oc.R.
	21	11	I. Sh.I.
	22	24	I. Tr.I.
	23	20	I. Sh.E.
21	0	32	I. Tr.E.
	16	22	III. Ec.D.
	17	39	II. Sh.I.
	18	25	I. Ec.D.
	18	45	III. Ec.R.
	20	05	II. Tr.I.
	20	07	II. Sh.E.
	21	26	III. Oc.D.
	21	47	I. Oc.R.
	22	27	II. Tr.E.
	23	32	III. Oc.R.
22	15	39	I. Sh.I.
	16	52	I. Tr.I.
	17	49	I. Sh.E.
	19	01	I. Tr.E.
23	12	13	II. Ec.D.
	12	53	I. Ec.D.
	14	44	II. Ec.R.
	14	46	II. Oc.D.
	16	15	I. Oc.R.
	17	11	II. Oc.R.
24	10	07	I. Sh.I.
	11	21	I. Tr.I.

d	h	m	
24	12	17	I. Sh.E.
	13	30	I. Tr.E.
25	6	23	III. Sh.I.
	6	56	II. Sh.I.
	7	21	I. Ec.D.
	8	44	III. Sh.E.
	9	22	II. Tr.I.
	9	23	II. Sh.E.
	10	44	I. Oc.R.
	11	30	III. Tr.I.
	11	44	II. Tr.E.
	13	32	III. Tr.E.
26	4	36	I. Sh.I.
	5	49	I. Tr.I.
	6	45	I. Sh.E.
	7	58	I. Tr.E.
27	1	31	II. Ec.D.
	1	49	I. Ec.D.
	4	02	II. Ec.R.
	4	05	II. Oc.D.
	5	12	I. Oc.R.
	6	29	II. Oc.R.
	23	04	I. Sh.I.
28	0	18	I. Tr.I.
	1	14	I. Sh.E.
	2	27	I. Tr.E.
	20	12	II. Sh.I.
	20	17	I. Ec.D.
	20	19	III. Ec.D.
	22	39	II. Tr.I.
	22	39	II. Sh.E.
	22	41	III. Ec.R.
	23	40	I. Oc.R.
29	1	01	II. Tr.E.
	1	27	III. Oc.D.
	3	30	III. Oc.R.
	17	32	I. Sh.I.
	18	46	I. Tr.I.
	19	42	I. Sh.E.
	20	55	I. Tr.E.
30	14	46	I. Ec.D.
	14	48	II. Ec.D.
	17	19	II. Ec.R.
	17	23	II. Oc.D.
	18	08	I. Oc.R.
	19	47	II. Oc.R.
31	12	01	I. Sh.I.
	13	15	I. Tr.I.
	14	11	I. Sh.E.
	15	23	I. Tr.E.

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

FEBRUARY

d	h	m	
1	9	14	I. Ec.D.
	9	28	II. Sh.I.
	10	20	III. Sh.I.
	11	56	II. Sh.E.
	11	56	II. Tr.I.
	12	37	I. Oc.R.
	12	41	III. Sh.E.
	14	17	II. Tr.E.
	15	29	III. Tr.I.
	17	29	III. Tr.E.
2	6	29	I. Sh.I.
	7	43	I. Tr.I.
	8	39	I. Sh.E.
	9	51	I. Tr.E.
3	3	42	I. Ec.D.
	4	07	II. Ec.D.
	6	37	II. Ec.R.
	6	41	II. Oc.D.
	7	05	I. Oc.R.
	9	04	II. Oc.R.
4	0	57	I. Sh.I.
	2	11	I. Tr.I.
	3	07	I. Sh.E.
	4	20	I. Tr.E.
	22	10	I. Ec.D.
	22	45	II. Sh.I.
5	0	16	III. Ec.D.
	1	12	II. Tr.I.
	1	12	II. Sh.E.
	1	33	I. Oc.R.
	2	38	III. Ec.R.
	3	32	II. Tr.E.
	5	24	III. Oc.D.
	7	24	III. Oc.R.
	19	26	I. Sh.I.
	20	39	I. Tr.I.
	21	36	I. Sh.E.
	22	48	I. Tr.E.
6	16	38	I. Ec.D.
	17	24	II. Ec.D.
	19	54	II. Ec.R.
	19	58	II. Oc.D.
	20	01	I. Oc.R.
	22	21	II. Oc.R.
7	13	54	I. Sh.I.
	15	08	I. Tr.I.
	16	04	I. Sh.E.

d	h	m	
7	17	16	I. Tr.E.
8	11	07	I. Ec.D.
	12	01	II. Sh.I.
	14	18	III. Sh.I.
	14	27	II. Tr.I.
	14	28	II. Sh.E.
	14	28	I. Oc.R.
	16	37	III. Sh.E.
	16	47	II. Tr.E.
	19	24	III. Tr.I.
	21	20	III. Tr.E.
9	8	22	I. Sh.I.
	9	36	I. Tr.I.
	10	32	I. Sh.E.
	11	44	I. Tr.E.
10	5	35	I. Ec.D.
	6	42	II. Ec.D.
	8	56	I. Oc.R.
	9	13	II. Ec.R.
	9	15	II. Oc.D.
	11	37	II. Oc.R.
11	2	51	I. Sh.I.
	4	04	I. Tr.I.
	5	01	I. Sh.E.
	6	12	I. Tr.E.
12	0	03	I. Ec.D.
	1	17	II. Sh.I.
	3	24	I. Oc.R.
	3	42	II. Tr.I.
	3	44	II. Sh.E.
	4	14	III. Ec.D.
	6	02	II. Tr.E.
	6	35	III. Ec.R.
	9	17	III. Oc.D.
	11	14	III. Oc.R.
	21	19	I. Sh.I.
	22	31	I. Tr.I.
	23	29	I. Sh.E.
13	0	40	I. Tr.E.
	18	31	I. Ec.D.
	20	00	II. Ec.D.
	21	52	I. Oc.R.
	22	30	II. Ec.R.
	22	30	II. Oc.D.
14	0	52	II. Oc.R.
	15	48	I. Sh.I.

d	h	m	
14	16	59	I. Tr.I.
	17	57	I. Sh.E.
	19	07	I. Tr.E.
15	12	59	I. Ec.D.
	14	34	II. Sh.I.
	16	19	I. Oc.R.
	16	56	II. Tr.I.
	17	00	II. Sh.E.
	18	15	III. Sh.I.
	19	16	II. Tr.E.
	20	34	III. Sh.E.
	23	15	III. Tr.I.
16	1	08	III. Tr.E.
	10	16	I. Sh.I.
	11	27	I. Tr.I.
	12	26	I. Sh.E.
	13	35	I. Tr.E.
17	7	28	I. Ec.D.
	9	18	II. Ec.D.
	10	47	I. Oc.R.
	14	08	II. Oc.R.
18	4	44	I. Sh.I.
	5	55	I. Tr.I.
	6	54	I. Sh.E.
	8	03	I. Tr.E.
19	1	56	I. Ec.D.
	3	50	II. Sh.I.
	5	14	I. Oc.R.
	6	10	II. Tr.I.
	6	17	II. Sh.E.
	8	12	III. Ec.D.
	8	29	II. Tr.E.
	10	32	III. Ec.R.
	13	05	III. Oc.D.
	15	00	III. Oc.R.
	23	13	I. Sh.I.
20	0	22	I. Tr.I.
	1	22	I. Sh.E.
	2	30	I. Tr.E.
	20	24	I. Ec.D.
	22	36	II. Ec.D.
	23	42	I. Oc.R.
21	3	22	II. Oc.R.
	17	41	I. Sh.I.
	18	50	I. Tr.I.
	19	51	I. Sh.E.

d	h	m	
21	20	58	I. Tr.E.
22	14	52	I. Ec.D.
	17	06	II. Sh.I.
	18	09	I. Oc.R.
	19	23	II. Tr.I.
	19	33	II. Sh.E.
	21	42	II. Tr.E.
	22	13	III. Sh.I.
23	0	31	III. Sh.E.
	3	01	III. Tr.I.
	4	51	III. Tr.E.
	12	09	I. Sh.I.
	13	17	I. Tr.I.
	14	19	I. Sh.E.
	15	25	I. Tr.E.
24	9	21	I. Ec.D.
	11	54	II. Ec.D.
	12	36	I. Oc.R.
	16	36	II. Oc.R.
25	6	38	I. Sh.I.
	7	45	I. Tr.I.
	8	48	I. Sh.E.
	9	53	I. Tr.E.
26	3	49	I. Ec.D.
	6	23	II. Sh.I.
	7	03	I. Oc.R.
	8	36	II. Tr.I.
	8	49	II. Sh.E.
	10	55	II. Tr.E.
	12	09	III. Ec.D.
	14	29	III. Ec.R.
	16	49	III. Oc.D.
	18	40	III. Oc.R.
27	1	06	I. Sh.I.
	2	12	I. Tr.I.
	3	16	I. Sh.E.
	4	20	I. Tr.E.
	22	17	I. Ec.D.
28	1	11	II. Ec.D.
	1	31	I. Oc.R.
	5	49	II. Oc.R.
	19	34	I. Sh.I.
	20	40	I. Tr.I.
	21	44	I. Sh.E.
	22	47	I. Tr.E.

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

MARCH

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

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

APRIL

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

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

MAY

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

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JUNE

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

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

JULY

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

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SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

AUGUST

d	h	m	Phenomenon
1	12	41	II. Tr.I.
	15	10	II. Tr.E.
	15	18	II. Sh.I.
	17	41	II. Sh.E.
	17	45	I. Tr.I.
	19	00	I. Sh.I.
	19	54	I. Tr.E.
	21	08	I. Sh.E.
2	14	54	I. Oc.D.
	18	21	I. Ec.R.
	22	22	III. Oc.D.
3	0	50	III. Oc.R.
	3	37	III. Ec.D.
	5	48	III. Ec.R.
	7	40	II. Oc.D.
	10	08	II. Oc.R.
	10	12	II. Ec.D.
	12	14	I. Tr.I.
	12	35	II. Ec.R.
	13	29	I. Sh.I.
	14	23	I. Tr.E.
	15	37	I. Sh.E.
4	9	23	I. Oc.D.
	12	50	I. Ec.R.
5	2	02	II. Tr.I.
	4	31	II. Tr.E.
	4	37	II. Sh.I.
	6	43	I. Tr.I.
	7	00	II. Sh.E.
	7	57	I. Sh.I.
	8	52	I. Tr.E.
	10	05	I. Sh.E.
6	3	52	I. Oc.D.
	7	19	I. Ec.R.
	12	29	III. Tr.I.
	14	55	III. Tr.E.
	17	41	III. Sh.I.
	19	49	III. Sh.E.
	20	58	II. Oc.D.
	23	27	II. Oc.R.
	23	29	II. Ec.D.
7	1	12	I. Tr.I.
	1	52	II. Ec.R.
	2	26	I. Sh.I.
	3	21	I. Tr.E.
	4	34	I. Sh.E.
	22	21	I. Oc.D.
8	1	47	I. Ec.R.
	15	22	II. Tr.I.
	17	51	II. Tr.E.
	17	55	II. Sh.I.

d	h	m	Phenomenon
8	19	41	I. Tr.I.
	20	18	II. Sh.E.
	20	55	I. Sh.I.
	21	51	I. Tr.E.
	23	03	I. Sh.E.
9	16	51	I. Oc.D.
	20	16	I. Ec.R.
10	2	28	III. Oc.D.
	4	56	III. Oc.R.
	7	36	III. Ec.D.
	9	46	III. Ec.R.
	10	18	II. Oc.D.
	12	47	II. Oc.R.
	12	47	II. Ec.D.
	14	10	I. Tr.I.
	15	10	II. Ec.R.
	15	23	I. Sh.I.
	16	20	I. Tr.E.
	17	31	I. Sh.E.
11	11	20	I. Oc.D.
	14	45	I. Ec.R.
12	4	43	II. Tr.I.
	7	12	II. Tr.E.
	7	15	II. Sh.I.
	8	40	I. Tr.I.
	9	38	II. Sh.E.
	9	52	I. Sh.I.
	10	49	I. Tr.E.
	12	00	I. Sh.E.
13	5	49	I. Oc.D.
	9	14	I. Ec.R.
	16	37	III. Tr.I.
	19	03	III. Tr.E.
	21	40	III. Sh.I.
	23	37	II. Oc.D.
	23	48	III. Sh.E.
14	3	09	I. Tr.I.
	4	21	I. Sh.I.
	4	27	II. Ec.R.
	5	18	I. Tr.E.
	6	29	I. Sh.E.
15	0	19	I. Oc.D.
	3	43	I. Ec.R.
	18	03	II. Tr.I.
	20	33	II. Tr.E.
	20	33	II. Sh.I.
	21	38	I. Tr.I.
	22	49	I. Sh.I.
	22	56	II. Sh.E.
	23	47	I. Tr.E.

d	h	m	Phenomenon
16	0	57	I. Sh.E.
	18	48	I. Oc.D.
	22	11	I. Ec.R.
17	6	36	III. Oc.D.
	9	05	III. Oc.R.
	11	35	III. Ec.D.
	12	57	II. Oc.D.
	13	46	III. Ec.R.
	16	07	I. Tr.I.
	17	18	I. Sh.I.
	17	44	II. Ec.R.
	18	17	I. Tr.E.
	19	26	I. Sh.E.
18	13	18	I. Oc.D.
	16	40	I. Ec.R.
19	7	25	II. Tr.I.
	9	52	II. Sh.I.
	9	55	II. Tr.E.
	10	37	I. Tr.I.
	11	47	I. Sh.I.
	12	15	II. Sh.E.
	12	46	I. Tr.E.
	13	55	I. Sh.E.
20	7	47	I. Oc.D.
	11	09	I. Ec.R.
	20	46	III. Tr.I.
	23	13	III. Tr.E.
21	1	39	III. Sh.I.
	2	18	II. Oc.D.
	3	47	III. Sh.E.
	5	06	I. Tr.I.
	6	15	I. Sh.I.
	7	01	II. Ec.R.
	7	16	I. Tr.E.
	8	23	I. Sh.E.
22	2	17	I. Oc.D.
	5	38	I. Ec.R.
	20	47	II. Tr.I.
	23	11	II. Sh.I.
	23	16	II. Tr.E.
	23	35	I. Tr.I.
23	0	44	I. Sh.I.
	1	33	II. Sh.E.
	1	45	I. Tr.E.
	2	52	I. Sh.E.
	20	47	I. Oc.D.
24	0	07	I. Ec.R.
	10	49	III. Oc.D.
	13	18	III. Oc.R.
	15	35	III. Ec.D.

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

SATELLITES OF JUPITER, 1982

UNIVERSAL TIME OF GEOCENTRIC PHENOMENA

SEPTEMBER

d	h	m	Phenomenon
1	17	15	I. Oc.D.
	20	31	I. Ec.R.
2	12	55	II. Tr.I.
	14	33	I. Tr.I.
	15	08	II. Sh.I.
	15	24	II. Tr.E.
	15	36	I. Sh.I.
	16	43	I. Tr.E.
	17	30	II. Sh.E.
	17	44	I. Sh.E.
3	11	45	I. Oc.D.
	14	59	I. Ec.R.
4	5	15	III. Tr.I.
	7	42	III. Tr.E.
	7	42	II. Oc.D.
	9	03	I. Tr.I.
	9	36	III. Sh.I.
	10	04	I. Sh.I.
	11	12	I. Tr.E.
	11	44	III. Sh.E.
	12	10	II. Ec.R.
	12	13	I. Sh.E.
5	6	15	I. Oc.D.
	9	28	I. Ec.R.
6	2	18	II. Tr.I.
	3	32	I. Tr.I.
	4	26	II. Sh.I.
	4	33	I. Sh.I.
	4	47	II. Tr.E.
	5	42	I. Tr.E.
	6	41	I. Sh.E.
	6	49	II. Sh.E.
7	0	45	I. Oc.D.
	3	57	I. Ec.R.
	19	22	III. Oc.D.
	21	04	II. Oc.D.
	21	51	III. Oc.R.
	22	02	I. Tr.I.
	23	01	I. Sh.I.
	23	34	III. Ec.D.
8	0	12	I. Tr.E.
	1	10	I. Sh.E.
	1	27	II. Ec.R.
	1	44	III. Ec.R.
	19	15	I. Oc.D.
	22	26	I. Ec.R.

d	h	m	Phenomenon
9	15	42	II. Tr.I.
	16	32	I. Tr.I.
	17	30	I. Sh.I.
	17	45	II. Sh.I.
	18	11	II. Tr.E.
	18	42	I. Tr.E.
	19	39	I. Sh.E.
	20	08	II. Sh.E.
10	13	45	I. Oc.D.
	16	55	I. Ec.R.
11	9	33	III. Tr.I.
	10	26	II. Oc.D.
	11	02	I. Tr.I.
	11	59	I. Sh.I.
	12	00	III. Tr.E.
	13	11	I. Tr.E.
	13	35	III. Sh.I.
	14	07	I. Sh.E.
	14	44	II. Ec.R.
	15	43	III. Sh.E.
12	8	15	I. Oc.D.
	11	23	I. Ec.R.
13	5	06	II. Tr.I.
	5	31	I. Tr.I.
	6	27	I. Sh.I.
	7	03	II. Sh.I.
	7	34	II. Tr.E.
	7	41	I. Tr.E.
	8	36	I. Sh.E.
	9	26	II. Sh.E.
14	2	45	I. Oc.D.
	5	52	I. Ec.R.
	23	41	III. Oc.D.
	23	48	II. Oc.D.
15	0	01	I. Tr.I.
	0	56	I. Sh.I.
	2	10	III. Oc.R.
	2	11	I. Tr.E.
	3	04	I. Sh.E.
	3	33	III. Ec.D.
	4	01	II. Ec.R.
	5	43	III. Ec.R.
	21	15	I. Oc.D.
16	0	21	I. Ec.R.
	18	30	II. Tr.I.
	18	31	I. Tr.I.

d	h	m	Phenomenon
16	19	25	I. Sh.I.
	20	23	II. Sh.I.
	20	41	I. Tr.E.
	20	59	II. Tr.E.
	21	33	I. Sh.E.
	22	45	II. Sh.E.
17	15	45	I. Oc.D.
	18	50	I. Ec.R.
18	13	01	I. Tr.I.
	13	10	II. Oc.D.
	13	53	I. Sh.I.
	13	53	III. Tr.I.
	15	11	I. Tr.E.
	16	02	I. Sh.E.
	16	20	III. Tr.E.
	17	19	II. Ec.R.
	17	34	III. Sh.I.
	19	42	III. Sh.E.
19	10	15	I. Oc.D.
	13	18	I. Ec.R.
20	7	31	I. Tr.I.
	7	54	II. Tr.I.
	8	22	I. Sh.I.
	9	41	I. Tr.E.
	9	41	II. Sh.I.
	10	23	II. Tr.E.
	10	30	I. Sh.E.
	12	03	II. Sh.E.
21	4	46	I. Oc.D.
	7	47	I. Ec.R.
22	2	01	I. Tr.I.
	2	33	II. Oc.D.
	2	50	I. Sh.I.
	4	02	III. Oc.D.
	4	11	I. Tr.E.
	4	59	I. Sh.E.
	6	31	III. Oc.R.
	6	36	II. Ec.R.
	7	32	III. Ec.D.
	9	42	III. Ec.R.
	23	16	I. Oc.D.
23	2	16	I. Ec.R.
	20	31	I. Tr.I.
	21	19	I. Sh.I.
	21	19	II. Tr.I.
	22	41	I. Tr.E.

d	h	m	Phenomenon
23	23	00	II. Sh.I.
	23	28	I. Sh.E.
	23	48	II. Tr.E.
24	1	23	II. Sh.E.
	17	46	I. Oc.D.
	20	45	I. Ec.R.
25	15	01	I. Tr.I.
	15	47	I. Sh.I.
	15	56	II. Oc.D.
	17	11	I. Tr.E.
	17	56	I. Sh.E.
	18	15	III. Tr.I.
	19	53	II. Ec.R.
	20	42	III. Tr.E
	21	33	III. Sh.I.
	23	41	III. Sh.E.
26	12	16	I. Oc.D.
	15	13	I. Ec.R.
27	9	31	I. Tr.I.
	10	16	I. Sh.I.
	10	43	II. Tr.I.
	11	41	I. Tr.E.
	12	18	II. Sh.I.
	12	25	I. Sh.E.
	13	12	II. Tr.E.
	14	41	II. Sh.E.
28	6	46	I. Oc.D.
	9	42	I. Ec.R.
29	4	01	I. Tr.I.
	4	45	I. Sh.I.
	5	19	II. Oc.D.
	6	11	I. Tr.E.
	6	53	I. Sh.E.
	8	26	III. Oc.D.
	9	10	II. Ec.R.
	10	53	III. Oc.R.
	11	31	III. Ec.D.
	13	40	III. Ec.R.
30	1	17	I. Oc.D.
	4	11	I. Ec.R.
	22	31	I. Tr.I.
	23	13	I. Sh.I.

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 1982. The northern side of the rings and orbital planes of four of the five satellites now face Earth, being tilted approximately 11° from edge-on during the part of the year when Saturn is conveniently placed in the night sky (The exception is the orbit of Iapetus which 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 17, 1982 at 22 h EDT (May 18, 2 h UT): The first eastern elongation in May occurs on May 1 at 8.3 h. May 18, 2 h is 16.738 d or 3.705 periods later. Thus Rhea will be 0.705 × 360° = 254° from eastern elongation. Hence it will be behind Saturn, 3.9 × cos 254° = 1.1 ring radii west 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.

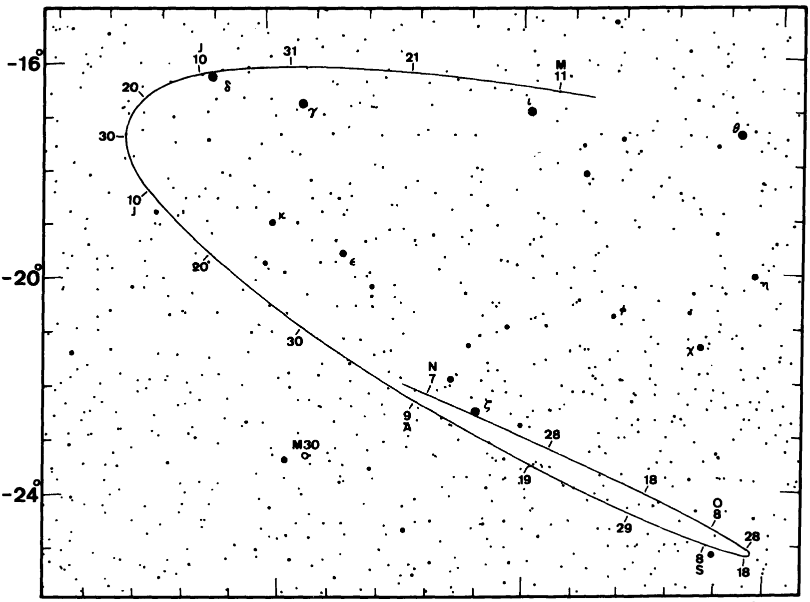
	Tethys	Dione	Rhea	Titan	Iapetus
m_v	10.3	10.4	9.7	8.4	~11
P	1.888^d	2.737^d	4.517^d	15.945^d	79.331^d
r	2.2	2.8	3.9	9.0	26.2
Jan.	$2^d02^h.1$	$1^d08^h.5$	$3^d22^h.6$	$12^d21^h.3$	$8^d00^h.5$
Feb.	1 07.0	3 04.8	4 13.7	13 18.8	
Mar.	1 14.5	2 13.5	3 16.0	1 16.9	27 22.3
Apr.	2 16.4	1 15.7	4 06.3	2 12.3	
May	2 21.1	1 17.9	1 08.3	4 07.5	
June	2 01.9	3 13.9	1 22.8	5 03.6	14 07.3
July	2 06.9	3 16.5	3 13.8	7 01.1	
Aug.	1 12.0	2 19.3	4 05.2	8 00.2	
Sep.	2 14.6	1 22.4	4 21.0	9 00.4	2 14.0
Oct.	2 19.9	2 01.5	2 00.4	11 01.3	
Nov.	2 01.3	1 04.7	2 16.4	12 02.4	23 00.1
Dec.	2 06.6	1 07.8	4 08.3	14 03.0	

EPHEMERIDES FOR THE BRIGHTEST ASTEROIDS 1982

PROVIDED BY BRIAN G. MARSDEN

The following are the ephemerides for the brightest asteroids in 1982: 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 the two brightest asteroids in 1982, Ceres 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 six 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 in eastern Capricornus, 1982. Its position is marked at 10-day intervals, beginning with May 11, where M = May, J = June, etc. The faintest stars shown are of magnitude 9. Vesta reaches magnitude 6.7 when near opposition early in August and 1.24 A.U. from Earth, but fades to 8th magnitude by late October.

(1) CERES

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Feb. 20	$15^{h}31^{m}.3$	− 9°35′	8.5
Mar. 2	15 37.8	− 9 47	
12	15 42.0	− 9 51	8.3
22	15 43.7	− 9 48	
Apr. 1	15 42.7	− 9 40	8.0
11	15 39.0	− 9 29	
21	15 32.8	− 9 17	7.6
May 1	15 24.8	− 9 07	
11	15 15.7	− 9 02	7.4
21	15 06.5	− 9 04	
31	14 58.3	− 9 15	7.7
June 10	14 51.8	− 9 37	
20	14 47.6	−10 09	8.1
30	14 45.8	−10 51	
July 10	14 46.4	−11 41	8.4
20	14 49.4	−12 38	
30	14 54.5	−13 40	8.7
Aug. 9	15 01.4	−14 45	

(2) PALLAS

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 11	$13^{h}04^{m}.0$	− 7°24′	9.1
21	13 14.1	− 6 12	
31	13 22.1	− 4 30	8.8
Feb. 10	13 27.6	− 2 16	
20	13 30.5	+ 0 30	8.5
Mar. 2	13 30.5	+ 3 44	
12	13 27.7	+ 7 18	8.3
22	13 22.6	+10 57	
Apr. 1	13 15.7	+14 26	8.2
11	13 08.3	+17 26	
21	13 01.2	+19 49	8.5
May 1	12 55.6	+21 28	
11	12 51.9	+22 27	8.9
21	12 50.5	+22 50	
31	12 51.4	+22 44	9.3
June 10	12 54.5	+22 15	
20	12 59.6	+21 29	9.7

(3) JUNO

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
May 31	$18^{h}26^{m}.5$	− 5°14′	11.0
June 10	18 19.4	− 4 55	
20	18 11.1	− 4 48	10.7
30	18 02.3	− 4 54	
July 10	17 53.9	− 5 14	10.8
20	17 46.5	− 5 45	
30	17 40.8	− 6 27	11.0

(4) VESTA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
May 11	$21^{h}17^{m}.3$	−16°39′	8.0
21	21 28.8	−16 19	
31	21 38.2	−16 11	7.7
June 10	21 45.3	−16 18	
20	21 49.7	−16 41	7.4
30	21 51.2	−17 24	
July 10	21 49.6	−18 24	7.0
20	21 44.9	−19 39	
30	21 37.7	−21 02	6.7
Aug. 9	21 28.8	−22 24	
19	21 19.4	−23 35	6.7
29	21 11.1	−24 29	
Sept. 8	21 04.8	−25 01	7.1
18	21 01.5	−25 13	
28	21 01.3	−25 06	7.6
Oct. 8	21 04.2	−24 43	
18	21 09.9	−24 06	8.0
28	21 17.9	−23 17	
Nov. 7	21 27.8	−22 18	8.3

(6) HEBE

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 31	$12^{h}29^{m}.6$	+ 7°20′	11.0
Feb. 10	12 28.3	+ 8 38	
20	12 24.5	+10 11	10.7
Mar. 2	12 18.5	+11 52	
12	12 10.9	+13 33	10.5
22	12 02.4	+15 05	
Apr. 1	11 53.9	+16 21	10.6
11	11 46.5	+17 15	
21	11 40.7	+17 46	10.9

(7) IRIS

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 31	$12^{h}25^{m}.7$	−10°41′	10.8
Feb. 10	12 23.7	−10 55	
20	12 19.0	−10 48	10.5
Mar. 2	12 12.1	−10 21	
12	12 03.5	− 9 36	10.3
22	11 54.1	− 8 36	
Apr. 1	11 45.0	− 7 28	10.3
11	11 37.2	− 6 19	
21	11 31.4	− 5 17	10.7
May 1	11 27.9	− 4 26	

(8) FLORA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 1	$5^{h}35^{m}.2$	+19°38′	
11	5 26.8	+20 22	9.4
21	5 22.0	+21 06	
31	5 21.1	+21 49	10.0
Feb. 10	5 24.1	+22 30	
20	5 30.6	+23 08	10.5
Mar. 2	5 40.0	+23 41	
12	5 51.9	+24 08	10.9

(9) METIS

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
July 30	$1^{h}05^{m}.5$	− 0°53′	10.9
Aug. 9	1 10.6	− 0 47	
19	1 13.2	− 0 56	10.5
29	1 13.0	− 1 20	
Sept. 8	1 09.8	− 1 58	10.0
18	1 03.8	− 2 44	
28	0 55.5	− 3 35	9.6
Oct. 8	0 46.0	− 4 20	
18	0 36.6	− 4 51	9.7
28	0 28.6	− 5 04	
Nov. 7	0 23.1	− 4 55	10.0
17	0 20.6	− 4 24	
27	0 21.2	− 3 33	10.4
Dec. 7	0 24.8	− 2 25	
17	0 31.1	− 1 04	10.7
27	0 39.8	+ 0 30	

(10) HYGIEA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 31	$8^{h}04^{m}.7$	+18°30′	11.0
Feb. 10	7 56.8	+18 46	

(11) PARTHENOPE

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Dec. 17	$5^{h}21^{m}.8$	+18°03′	10.8
27	5 11.5	+18 10	

(12) VICTORIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Sept. 8	$0^{h}30^{m}.0$	+17°38′	10.7
18	0 22.7	+16 36	
28	0 14.3	+15 05	10.5
Oct. 8	0 06.3	+13 16	
18	0 00.1	+11 24	10.8

(14) IRENE

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Nov. 27	$3^h53^m.0$	+13°57′	10.8
Dec. 7	3 43.0	+13 58	

(15) EUNOMIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 1	$4^h59^m.1$	+31°40′	
11	4 53.2	+30 15	9.3
21	4 50.7	+28 56	
31	4 51.8	+27 47	9.7
Feb. 10	4 56.1	+26 49	
20	5 03.0	+26 02	10.1
Mar. 2	5 12.3	+25 23	
12	5 23.5	+24 50	10.5

(19) FORTUNA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Sept. 8	$1^h34^m.0$	+10°59′	10.8
18	1 31.3	+10 37	
28	1 25.8	+ 9 56	10.4
Oct. 8	1 18.2	+ 9 01	
18	1 09.7	+ 7 57	10.0
28	1 01.9	+ 6 57	
Nov. 7	0 56.0	+ 6 08	10.5
17	0 52.9	+ 5 37	
27	0 53.0	+ 5 27	11.0

(20) MASSALIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
June 20	$18^h34^m.2$	−22°11′	10.9
30	18 23.8	−22 17	
July 10	18 13.7	−22 22	11.0

(29) AMPHITRITE

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
July 30	$23^h39^m.7$	− 5°33′	10.9
Aug. 9	23 36.7	− 5 38	
19	23 31.2	− 5 54	10.5
29	23 23.5	− 6 20	
Sept. 8	23 14.5	− 6 51	9.9
18	23 05.1	− 7 20	
28	22 56.4	− 7 43	10.4
Oct. 8	22 49.6	− 7 54	
18	22 45.3	− 7 53	10.7
28	22 43.8	− 7 37	

(30) URANIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Nov. 27	$4^h44^m.7$	+25°41′	10.7
Dec. 7	4 33.6	+25 13	
17	4 23.4	+24 39	10.9
27	4 15.6	+24 05	

(39) LAETITIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
July 10	$20^h39^m.5$	− 8°26′	10.8
20	20 32.6	− 9 14	
30	20 24.6	−10 15	10.5
Aug. 9	20 16.6	−11 25	
19	20 09.7	−12 38	10.7
29	20 04.6	−13 48	
Sept. 8	20 01.9	−14 51	11.0

(40) HARMONIA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Feb. 20	$10^h37^m.1$	+15°30′	11.0
Mar. 2	10 27.1	+16 38	

(42) ISIS

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
May 31	$18^h12^m.9$	−22°39′	10.9
June 10	18 05.4	−23 40	
20	17 55.7	−24 44	10.1
30	17 45.2	−25 47	
July 10	17 35.8	−26 45	10.6
20	17 29.0	−27 35	
30	17 25.8	−28 17	10.9

(324) BAMBERGA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
June 20	$20^h24^m.5$	−31°53′	11.0
30	20 18.5	−32 05	
July 10	20 09.3	−32 10	10.4
20	19 57.9	−32 00	
30	19 45.9	−31 30	10.3
Aug. 9	19 34.9	−30 40	
19	19 26.6	−29 33	10.5
29	19 22.0	−28 14	
Sept. 8	19 21.5	−26 48	10.7
18	19 24.9	−25 20	
28	19 32.0	−23 50	11.0

(349) DEMBOWSKA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Nov. 27	$4^h37^m.8$	+29°55′	10.8
Dec. 7	4 27.4	+29 59	
17	4 17.7	+29 52	10.9
27	4 09.7	+29 39	

(354) ELEONORA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 11	$9^h22^m.1$	+ 9°09′	10.9
21	9 16.2	+10 47	
31	9 08.6	+12 41	10.4
Feb. 10	9 00.5	+14 43	
20	8 52.9	+16 42	10.7
Mar. 2	8 47.0	+18 29	
12	8 43.5	+19 59	11.0

(471) PAPAGENA

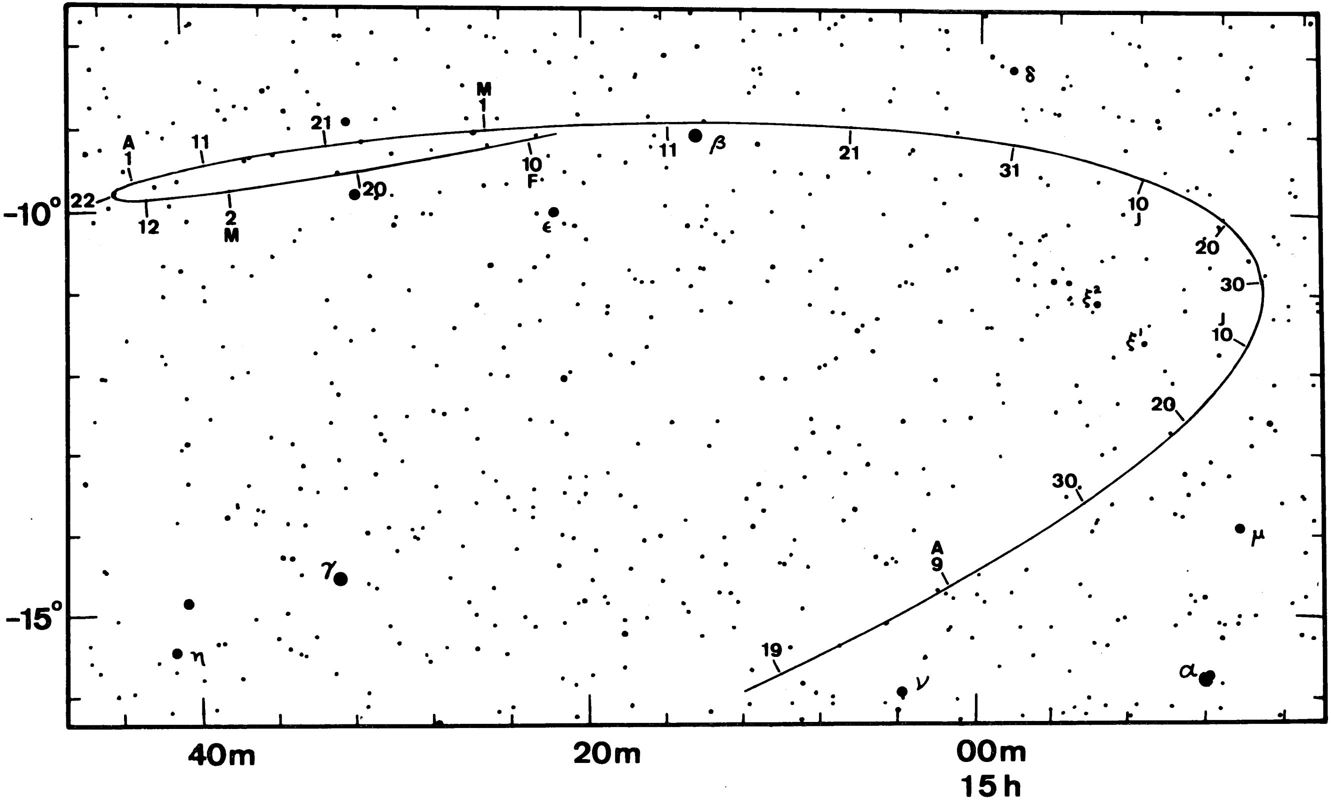
Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 1	$5^h05^m.4$	+24°02′	
11	4 58.5	+25 00	11.0

(532) HERCULINA

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Jan. 31	$8^h46^m.5$	+28°11′	10.8
Feb. 10	8 37.2	+29 51	

(679) PAX

Date 0h E.T.	R.A.(1950)	Dec.(1950)	Mag.
Aug. 19	$23^h14^m.9$	−38°28′	11.0
29	23 11.3	−42 06	
Sept. 8	23 05.7	−45 00	11.0



The path of Ceres in Libra, 1982. Its position is marked at 10-day intervals, beginning with February 10, where F = February, M = March, etc. The faintest stars shown are of magnitude 9. Ceres reaches magnitude 7.4 when near opposition early in May and 1.69 A.U. from Earth, but fades to 9th magnitude by late August.

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 61 predicted possible occultations of stars by asteroids for 1982. This list has been augmented and refined by Dr. David W. Dunham of the International Occultation Timing Association. The 18 events listed below may be visible from North America (including Hawaii). Improved predictions may be issued a few days prior to each event. 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 maximum duration in seconds.

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 1982 in the December 1981 or January 1982 issue of *Sky and Telescope*. (See page 68 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 68.)

No.	Time (UT) M D h min	Star Name	m_v	α (1950)	δ
1	1 21 15 59±4	SAO 158136	9.3	$13^h43^m47^s$	−10°42′37″
2	1 24 8 39±8	AGK3 +26°0972	10.6	8 54 32	+26 49 00
3	2 8 0 29±7	AGK3 +45°0730	10.0	7 59 23	+45 07 52
4	3 20 7 41±9	AGK3 +42°0834	9.6	7 36 58	+42 55 22
5	3 23 5 40±1	AGK3 + 6°0848	10.0	6 58 10	+ 6 43 23
6	7 7 7 21±5	SAO 139812	8.2	14 13 41	− 5 14 37
7	7 18 10 17±8	SAO 187802	9.3	19 09 00	−20 19 50
8	8 11 3 01±1	SAO 139729	8.2	14 04 26	− 7 54 41
9	8 29 8 04±7	SAO 127592	8.8	22 30 19	+ 6 19 36
10	9 15 11 08±1	SAO 96932	8.5	7 28 02	+17 50 28
11	9 17 3 16±8	SAO 92517	9.2	1 33 27	+10 49 48
12	10 7 5 16±9	SAO 110631	9.2	2 34 37	+ 4 03 17
13	10 31 13 16±2	SAO 98369	9.4	9 06 03	+18 20 25
14	11 14 9 46±9	AGK3 +24°0312	9.8	3 37 14	+25 01 16
15	11 15 11 49±8	SAO 55791	8.7	2 40 57	+39 13 11
16	11 22 3 39±5	SAO 76017	7.8	3 35 08	+29 55 38
17	12 13 3 00±5	SAO 93544	8.8	3 37 27	+14 01 36
18	12 21 5 52±3	SAO 110157	9.4	1 49 13	+ 6 52 48

No.	Asteroid Name	Asteroid m_v	Occult. Δm_v	Occult. Δt	Possible Area of Visibility
1	37 Fides	12.5	3.3	7	Japan, Pacific
2	532 Herculina	9.2	0.3	18	Northern S. America, Cent. Am., U.S.A.
3	344 Desiderata	13.3	3.4	10	Mediterranean, Caribbean
4	344 Desiderata	13.7	4.1	18	N. & W. Canada, N.W. U.S.A.*
5	386 Siegena	12.7	2.8	13	N. Mexico, S.E. U.S.A.
6	56 Melete	12.2	4.0	18	E. Pacific, N.W. Mexico
7	44 Nysa	10.8	1.7	5	Cent. Am., Mexico?, N. Australia
8	334 Chicago	14.1	5.9	8	S. America
9	57 Mnemosyne	11.4	2.7	9	Caribbean, S. Mexico, N. Zealand
10	52 Europa	12.0	3.2	9	N.W. U.S.A., S. Cent. Canada
11	19 Fortuna	9.9	1.0	58	E. Canada, W. U.S.A.
12	481 Emita	12.0	2.7	14	Shetland Is., S.E. Canada, N.W. U.S.A.
13	21 Lutetia	12.6	3.3	7	Hawaii?, Baja California
14	690 Wratislavia	11.4	1.8	14	Bermuda, S. U.S.A., E. Australia
15	375 Ursula	12.2	3.3	14	N. Mexico, Okinawa, S.E. Asia
16	93 Minerva	12.0	4.1	12	N. Europe, Canada
17	14 Irene	10.4	1.8	14	Northern S. America
18	481 Emita	12.7	3.2	16	W. U.S.A., E. Canada

*Updated predictions indicate that this event will miss Earth.

METEORS AND COMETS

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 large 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.

An observer located away from city lights and with perfect sky conditions 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 appearance of any very bright fireball 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,

MAJOR VISUAL METEOR SHOWERS FOR 1982

	Shower Maximum			Radiant						
				Position at Max.		Daily Motion		Single Observer Hourly		Normal Duration to ¼ Strength
Shower	Date	U.T.	Moon	R.A.	Dec.	R.A.	Dec.	Rate	Speed	of Max.
		h		h m	°	m	°		km/s	days
Quadrantids	Jan. 3	19	FQ	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	14	NM	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 4	20	FM	22 24	00	+3.6	+0.4	20	65	3
S. δ Aquarids	July 28	23	FQ	22 36	−17	+3.4	+0.17	20	41	7
Perseids	Aug. 12	13	LQ	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	18	FQ	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 2	18	FM	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 17	12	NM	10 08	+22	+2.8	−0.42	15	71	—
Geminids	Dec. 14	10	NM	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 22	19	FQ	14 28	+76	—	—	15	34	2
	(1983)									
Quadrantids	Jan. 4	01	LQ	15 28	+50	—	—	40	41	1.1

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 the years near 1980 the comet associated with the Perseid meteor shower, 1862 III Swift-Tuttle, is estimated to be in the inner part of the solar system and a better than average shower in August is a possibility.

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.

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	<200	lake and central island	breccia			G
Haviland, Kansas	37	37	099	05	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	420	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	70	210±4	circumferal lake, central elevation	impact melt, breccia	B		G
Manson, Iowa	42	35	094	31	32	<70	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	<450	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	<300	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 1982

BY BRIAN G. MARSDEN

The following periodic comets are expected at perihelion during 1982:

Comet	Perihelion Date	Perihelion Dist.	Period
		A.U.	a
Grigg-Skjellerup	May 15	0.99	5.1
Perrine-Mrkos	May 16	1.30	6.8
Väisälä 1	July 30	1.80	10.9
d'Arrest	Sept. 14	1.29	6.4
Tempel-Swift	Oct. 22	1.60	6.4
Churyumov-Gerasimenko	Nov. 12	1.31	6.6
Gunn	Nov. 26	2.46	6.8
Neujmin 3	Dec. 6	2.06	10.9

The returns of P/Grigg-Skjellerup, P/d'Arrest and P/Churyumov-Gerasimenko are favourable, and ephemerides are given below. P/Perrine-Mrkos and P/Tempel-Swift have not been observed at recent returns, and their recovery in 1982 is questionable. P/Väisälä 1 and P/Neujmin 3 are rather unfavourably placed at perihelion passage, but observations should be possible earlier in the year. P/Gunn is observable all around its orbit.

COMET GRIGG-SKJELLERUP

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
May 11	$8^h26^m.1$	+13°42′	11.4
16	8 52.3	+18 11	
21	9 22.8	+22 56	11.2
26	9 58.0	+27 39	
31	10 37.9	+31 58	11.2
June 5	11 21.6	+35 27	
10	12 07.0	+37 46	11.5
15	12 51.6	+38 50	

COMET D'ARREST

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
July 30	$15^h57^m.5$	+ 5°30′	10.9
Aug. 9	16 09.7	− 0 02	
19	16 27.2	− 6 00	10.6
29	16 50.1	−12 10	
Sept. 8	17 18.5	−18 09	10.5
18	17 52.2	−23 35	
28	18 30.7	−28 05	10.7
Oct. 8	19 12.7	−31 20	

COMET CHURYUMOV-GERASIMENKO

Date 0h E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 18	$5^h09^m.7$	+19°44′	10.3
28	5 38.8	+22 53	
Nov. 7	6 06.3	+26 11	9.8
17	6 30.5	+29 31	
27	6 49.8	+32 42	9.8
Dec. 7	7 02.9	+35 33	
17	7 09.6	+37 50	10.1
27	7 11.3	+39 22	

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'sēr	Cancri	Cnc	The Crab
Canes Venatici kā'nēz vē-năt'ĭ-sī	Canum Venaticorum	CVn	The Hunting Dogs
Canis Major, kā'nĭs mā'jēr	Canis Majoris	CMa	The Big Dog
Canis Minor, kā'nĭs mī'nēr	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'tēr	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-kwōō'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	01
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'ō-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, tho͞o'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	zo͞o-bĕn'ĕl-jĕ-nū'bē		

Key to pronunciation on p. 123.

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 most stars in the southern sky. These were provided by Dr. Robert Garrison of the Dunlap Observatory. A few types in italics and parentheses remain poorly defined. Types in parentheses are less accurately defined (g—giant, d—dwarf, c—exceptionally high luminosity). 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.

	Right Ascension	Declination	Visual Magnitude	Colour Index	Spectral Classification		Parallax	Absolute Magnitude	Distance light-years	Proper Motion	Radial Velocity		
Star	R.A. 1980	Dec.	V	$B–V$	Type		π	M_V	D	μ	R		
	h m	° ′					″		l.y.	″	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* 0ᵐ.08, 0.10ᵈ	*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, 0.15ᵈ	
β Hyi	24.6	−77 22	2.78	+0.62	G1	IV	0.153	+3.7	21	2.255	+22.8		γ Peg = *Algenib*
α Phe	25.3	−42 25	2.39	+1.08	*K0*	*III*	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* 12ᵐ 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* 7.26ᵐ 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* 8.18ᵐ 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* 4.1ᵐ *B* 4.1ᵐ 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 759ᵈ	*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	$B\,5.4^{m}$ $C\,6.2^{m}$ 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., $R\,0.11^{m}$ 4.0^{d}, $B\,8.9^{m}$ 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, 332^{d}, $B\,10^{m}$ 1″	*Mira*
γ Cet *AB*	42.2	+03 10	3.48	+0.11	A2 V	0.048	+2.0	68	0.203	−05.1	$A\,3.57^{m}$ $B\,6.23^{m}$ 3″	
θ Eri *AB*	57.5	−40 23	2.92	+0.13	A3 III	0.028	+1.7	65	0.061	*+11.9*	$A\,3.25^{m}$ $B\,4.36^{m}$ 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:	G8 III: +A3:	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, 2.87^{d}	*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	$B\,9.36^{m}$ 13″	
ε Per *A*	56.5	+39 57	2.88	−0.17	B0.5 V	−.001	−3.7	680	0.036	*−01*	$B\,7.99^{m}$ 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	$B\,12^{m}$ 49″	
ε Tau	27.5	+19 08	3.54	+1.02	K0 III	0.018	+0.1	160	0.118	+38.6		
θ² 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, $B\,13^{m}$ 31″	***Aldebaran***
π³ 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	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	*B8 Ve*	−.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	K2 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	*B7 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	*K0 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			(gM5e)	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:	(gK4)	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	O5f		−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*
ο 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 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* 14ᵐ 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. 3.4ᵐ min. 4.8ᵐ, 35.52ᵈ	
υ Car *AB*	46.6	−64 59	2.95	+0.26	A8	Ib	0.020	−2.1	340	0.012	+13.6	*A* 3.02ᵐ *B* 6.03ᵐ 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* 8.1ᵐ 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* 2.29ᵐ *B* 3.54ᵐ 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*	*III*		+0.1	108	0.085	+06.9	*A* 2.7ᵐ *B* 7.2ᵐ 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* 1.88ᵐ *B* 4.82ᵐ 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:n	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 III–IV	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	A8 p	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:	*K0 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 V		−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*

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* 2.78ᵐ *B* 5.04ᵐ 1″, *C* 4.93ᵐ 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, 0.25ᵈ, *B* 8.49ᵐ 20″	
η Dra *A*	23.7	+61 33	2.71	+0.92	G8 III	0.043	+0.9	76	0.062	−14.3	*B* 8.7ᵐ 6″	
α Sco *A*	28.2	−26 23	0.92v	+1.84	M1 Ib+B	0.019	−5.1	520	0.029	−03.2	*A* 0.86ᵐ–1.02ᵐ *B* 5.07ᵐ 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* 2.91ᵐ *B* 5.46ᵐ 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	K2.5 III	0.049	+0.7	66	0.664	−02.5		
μ¹ Sco	50.5	−38 01	2.99v	−0.20	B1.5 V		−3.0	520	0.033	*−25*	Ecl. *R* 2.99–3.09, 1.4ᵈ	
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* 3.0ᵐ *B* 3.4ᵐ 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* 3.2ᵐ ± 0.3 *B* 5.4ᵐ 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., 0.14ᵈ	
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* 10ᵐ 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* 11.49ᵐ 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 V		−3.3	310	0.031	00	β CMa var., 0.21ᵈ	*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 Ib*	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″	
ι^1 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	M3.5 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 III	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	*K2 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 III*		−3.1	590	0.052	+21.5		
β Lyr *A*	49.4	+33 21	3.38v	−0.05:	Bpe	−.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 V		−2.7	300	0.059	−11		*Nunki*
ξ^2 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	*A2 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 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	comp.	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*	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 1982.0; 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 articles have been reprinted by Sky Publishing Corp., 49-50-51 Bay State Road, Cambridge, Mass. 02238 under the title *Visual Observing of Double Stars*, $1.95 U.S.—Ed.)

Star		A.D.S.	R.A. 1980.0 h	m	Dec. 1980.0 °	′	Magnitudes comb.	A	B	P.A. 1982.0 °	Sep. 1982.0 ″	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	280	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	240	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	257	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	165	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	—
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	308	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	44	9.6	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	89	2.4	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	265	0.8	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	100	2.7	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	295	3.7	170
ζ	Boo	9343	14	40.1	+13	49	3.8	4.5	4.5	305	1.1	125
ξ	Boo	9413	14	50.4	+19	12	4.5	4.7	6.8	332	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	128	1.3	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	310	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	131	0.7	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	299	1.8	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	222	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	312	1.6	350

*There is a marked colour difference between the components.

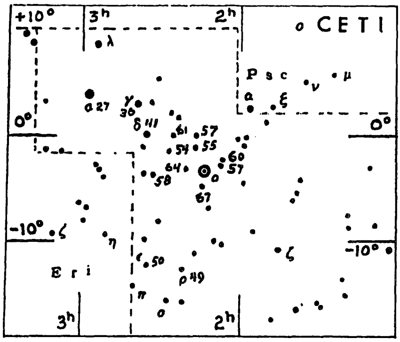
†The separation of the two pairs of ε Lyr is 208″.

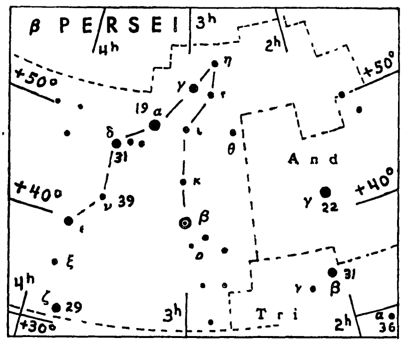
VARIABLE STARS

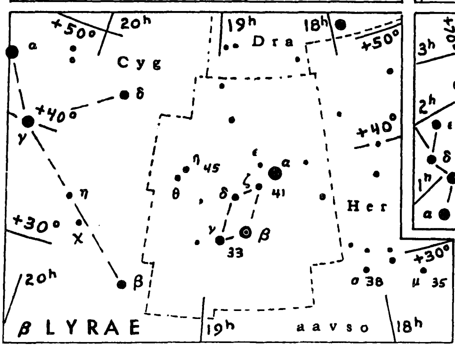
By Janet Mattei

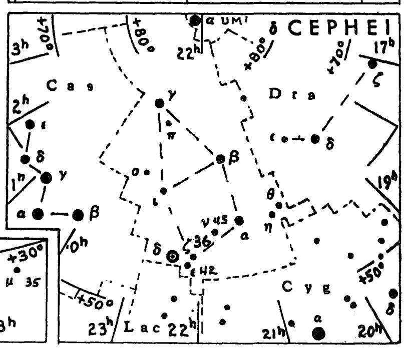
The systematic observation of variable stars is an area in which an amateur can make a valuable contribution to astronomy. For beginning observers, maps of the fields of four bright variable stars are given below. In each case, the magnitudes (with decimal point omitted) of several suitable comparison stars are given. Using two comparison stars, one brighter, one fainter than the variable, estimate the brightness of the variable in terms of these two stars. Record also the date and time of observation. When a number of observations have been made, a graph of magnitude versus date may be plotted. The shape of this "light curve" depends on the type of variable. Further information about variable star observing may be obtained from the American Association of Variable Star Observers, 187 Concord Ave., Cambridge, Mass. 02138, U.S.A.

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 list of long-period variables has been prepared by the American Association of Variable Star Observers and includes the variables with maxima brighter than mag. 8.0, and north of Dec. −20°. These variables may reach maximum two or three weeks before or after the listed epoch and may remain at maximum for several weeks. The second table contains stars which are representative of other types of variable. The data 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 1981, International Supplement.*









LONG-PERIOD VARIABLE STARS

Variable	Max. m_v	Per d	Epoch 1982	Variable	Max. m_v	Per d	Epoch 1982
001755 T Cas	7.8	445	Mar. 16	142539 V Boo	7.9	258	Feb. 28
001838 R And	7.0	409	Sept. 2	143227 R Boo	7.2	223	Aug. 6
021143 W And	7.4	397	May 9	151731 S CrB	7.3	361	Dec. 26
0214*03* o Cet	3.4	332	July 16	154639 V CrB	7.5	358	Aug. 19
0228*13* U Cet	7.5	235	Aug. 8	154615 R Ser	6.9	357	July 10
023133 R Tri	6.2	266	Sept. 14	160625 RU Her	8.0	484	—
043065 T Cam	8.0	374	Nov. 26	162119 U Her	7.5	406	Jan. 18
0455*14* R Lep	6.8	432	May 24	1621*12* V Oph	7.5	298	Apr. 21
050953 R Aur	7.7	459	—	163266 R Dra	7.6	245	Feb. 25
054920 U Ori	6.3	372	Oct. 19	164715 S Her	7.6	307	Mar. 20
0617*02* V Mon	7.0	335	Nov. 29	1702*15* R Oph	7.9	302	Sept. 2
065355 R Lyn	7.9	379	July 16	171723 RS Her	7.9	219	Jan. 1
070122aR Gem	7.1	370	Aug. 10	180531 T Her	8.0	165	Jan. 3
070310 R CMi	8.0	338	Mar. 17	181136 W Lyr	7.9	196	Apr. 8
072708 S CMi	7.5	332	Oct. 15	183308 X Oph	6.8	334	Apr. 10
081112 R Cnc	6.8	362	Dec. 17	190108 R Aql	6.1	300	July 22
081617 V Cnc	7.9	272	May 20	1910*17* T Sgr	8.0	392	Nov. 19
084803 S Hya	7.8	257	Mar. 29	1910*19* R Sgr	7.3	269	Sept. 14
0850*08* T Hya	7.8	288	Sept. 11	193449 R Cyg	7.5	426	Mar. 17
093934 R LMi	7.1	372	Apr. 23	194048 RT Cyg	7.3	190	Jan. 1
094211 R Leo	5.8	313	May 3	194632 χ Cyg	5.2	407	Feb. 13
103769 R UMa	7.5	302	Jan. 24	201647 U Cyg	7.2	465	Feb. 21
1214*18* R Crv	7.5	317	Jan. 28	2044*05* T Aqr	7.7	202	Jan. 1
122001 SS Vir	6.8	355	Feb. 14	210868 T Cep	6.0	390	Jan. 1
123160 T UMa	7.7	257	May 19	213753 RU Cyg	8.0	234	Aug. 19
123307 R Vir	6.9	146	Jan. 13	230110 R Peg	7.8	378	Mar. 29
123961 S UMa	7.8	226	Sep. 3	230759 V Cas	7.9	228	Mar. 31
131546 V CVn	6.8	192	May 7	231508 S Peg	8.0	319	Jan. 23
1327*06* S Vir	7.0	378	Mar. 24	2338*15* R Aqr	6.5	387	Mar. 28
134440 R CVn	7.7	328	Sept. 13	235350 R Cas	7.0	431	Dec. 21
142584 R Cam	7.9	270	Mar. 1	2357*15* W Cet	7.6	351	Dec. 3

OTHER TYPES OF VARIABLE STARS

Variable		Max. m_v	Min. m_v	Type	Sp. Cl.	Period d	Epoch 1982 U.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 3.41*
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. 2.07*
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. 3.30
065820	ζ Gem	3.6	4.2	δ Cep	F7–G3	10.15082	Jan. 3.98
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. 10.75*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.566867	Jan. 1.44
194700	η Aql	3.5	4.3	δ Cep	F6–G4	7.176641	Jan. 7.02
222557	δ Cep	3.5	4.4	δ Cep	F5–G2	5.366341	Jan. 3.34

*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.

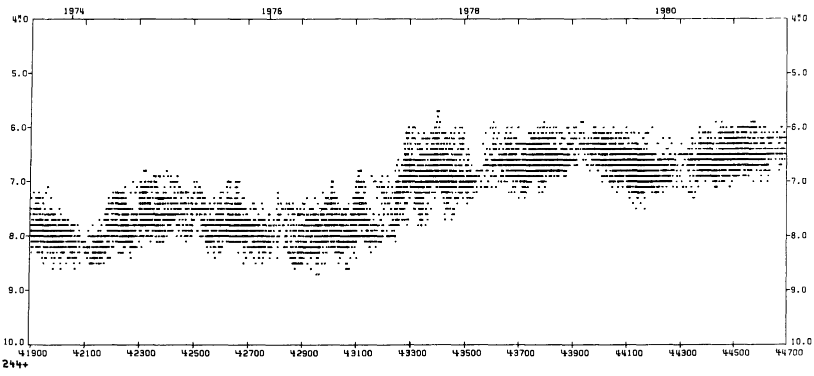
STAR OF THE YEAR: THE SYMBIOTIC STAR, CH CYGNI

Each year, in co-operation with the AAVSO, we introduce one or two new variables to our readers. Recent editions of this HANDBOOK, for instance, have featured SS Cyg, the Orion variables, CY Aqr, Mira, Z UMa, R Sct and R CrB. This year's "Star of the Year" is CH Cyg. Janet Mattei, Director of the AAVSO, sends the following credentials.

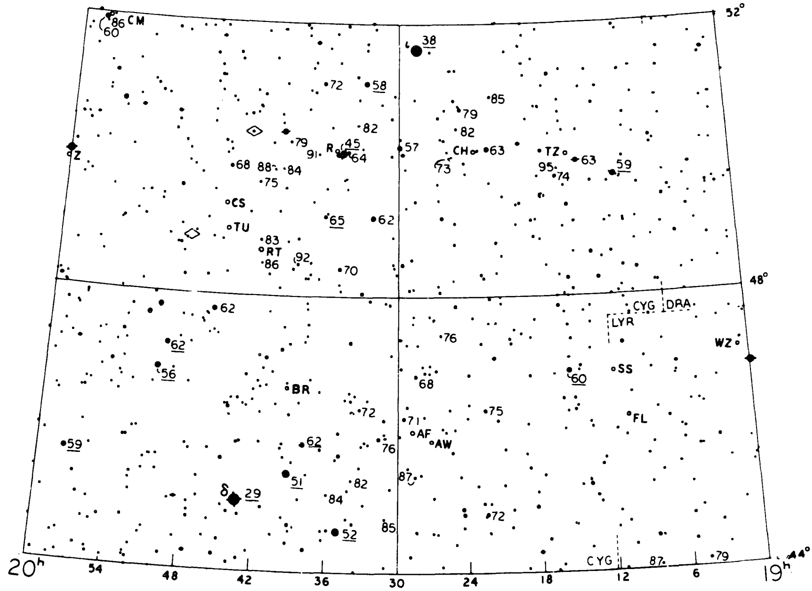
"CH Cygni is an interesting, bright, circumpolar variable, well suited for observing with binoculars or small telescopes. It had been classified as a semiregular variable. However, spectroscopic observations in 1967 and later indicated that the system is made up of an M6 type giant and a hot, blue component embedded in an excited nebulosity. Consequently, CH Cygni has been reclassified as a symbiotic star.

CH Cygni varies between 6.3 and 8.4 mean visual magnitude, and it has short (~100 d) and long (~700+ d) period light variations superimposed in its light curve. This variable has been unusually bright since 1977. The AAVSO computerized light curve of individual observations from August 1973 to March 1981 is shown below.

CH Cygni is strongly recommended to observers with photoelectric photometers. The amplitude of its variation increases as one goes to decreasing wavelengths. The light fluctuations are most significant in the U band. The star varies as much as $0^{m}.7$ within minutes. At times, the oscillations in the U gradually diminish and completely disappear and the three-colour UBV photometric data closely resemble those of an M6 giant. This behavior, observed between 1970 and 1973, has been interpreted as a total eclipse of the blue component by the M6 giant. A five year period has been suggested for the eclipses, with the duration of the total eclipse lasting over two years. If these values are correct, the system should be undergoing another eclipse at this time. UBV photometry will be most crucial to confirm the eclipses. In the visual domain, due to the overwhelming brightness of the M star, the eclipses are not detected. However, visual observations are necessary to continue to determine its long term behavior."



1921+50 CH CYG



The chart above is taken from the new AAVSO Variable Star Atlas, prepared by Charles C. Scovil and published by Sky Publishing Corporation, Cambridge, Mass. CH Cygni is at about decl. +50°, R.A. 19^h25^m. The numbers are magnitudes of the comparison stars, with decimal points omitted. Co-ordinates are for epoch 1950.

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 stars differ from one another only in 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 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

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

NGC or other	R.A. 1980 h m	Dec. 1980 ° ′	Int. m_{pg}	Diam. ′	m_5	Dist. 1000 l.y.	Sp	Remarks
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

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	

***Footnote to Messier Catalogue, opposite page*:** 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 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, 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 of course 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	PN*	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	
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	

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
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	
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	

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
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	Sco	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.

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 Skalnate Pleso *Atlas of the Heavens*, 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 shape at HP
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								
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								
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 34	+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°SSW. of M52

GALAXIES

By S. van den Bergh

Among the billions of systems far beyond our own Galaxy relatively few are readily seen in small telescopes. The first list contains the brightest galaxies. The first four columns give the catalogue numbers and position. In the column *Type*, *E* indicates elliptical, *I*, irregular, and *Sa*, *Sb*, *Sc*, spiral galaxies in which the arms are more open going from *a* to *c*. Roman numerals I, II, III, IV, and V refer to supergiant, bright giant, giant, subgiant, and dwarf galaxies respectively; *p* means "peculiar". The remaining columns give the apparent photographic magnitude, the angular dimensions and the distance in millions of light-years.

The second list contains the nearest galaxies and includes the photographic distance modulus $(m - M)_{pg}$, and the absolute photographic magnitude, M_{pg}.

THE OPTICALLY BRIGHTEST GALAXIES

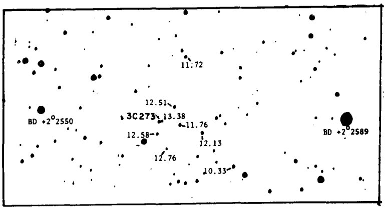
NGC or name	M	α 1980 h m	δ ° ′	Type	m_{pg}	Dimensions ′ ′	Distance Millions of l.y.
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		00 46.6	−25 24	Scp	7.0:	22×4.6	7.5
SMC		00 52.0	−72 56	Ir IV or IV–V	2.86	216×216	0.2
300		00 54.0	−37 48	Sc III–IV	8.66	22×16.5	7.5
598	33	01 32.8	+30 33	Sc II–III	6.19	61×42	2.4
Fornax		02 38.7	−34 36	dE	9.1:	50×35	0.4
LMC		05 23.7	−69 46	Ir or Sc III–IV	0.86	432×432	0.2
2403		07 34.9	+65 39	Sc III	8.80	22×12	6.5
2903		09 31.0	+21 36	Sb I–II	9.48	16×6.8	19.0
3031	81	09 53.9	+69 09	Sb I–II	7.85	25×12	6.5
3034	82	09 54.4	+69 47	Scp:	9.20	10×1.5	6.5
4258		12 18.0	+47 25	Sbp	8.90	19×7	14.0
4472	49	12 28.8	+08 06	E4	9.33	9.8×6.6	37.0
4594	104	12 38.8	−11 31	Sb	9.18	7.9×4.7	37.0
4736	94	12 50.0	+41 13	Sbp II:	8.91	13×12	14.0
4826	64	12 55.8	+21 48	?	9.27	10×3.8	12.0:
4945		13 04.1	−49 22	Sb III	8.0	20×4	—
5055	63	13 14.8	+42 08	Sb II	9.26	8.0×3.0	14.0
5128		13 24.2	−42 54	E0p	7.87	23×20	—
5194	51	13 29.0	+47 18	Sc I	8.88	11×6.5	14.0
5236	83	13 36.0	−29 46	Sc I–II	7.0:	13×12	8.0:
5457	101	14 02.4	+54 26	Sc I	8.20	23×21	14.0
6822		19 43.8	−14 49	Ir IV–V	9.21	20×10	1.7

THE NEAREST GALAXIES

Name	NGC	α 1980 δ h m	° ′	m_{pg}	$(m-M)_{pg}$	M_{pg}	Type	Dist. thous. of l.y.
M31	224	00 41.6	+41 10	4.33	24.65	−20.3	Sb I–II	2,100
Galaxy	—	—	—	—	—	?	Sb or Sc	—
M33	598	01 32.8	+30 33	6.19	24.70	−18.5	Sc II–III	2,400
LMC		05 23.7	−69 46	0.86	18.65	−17.8	Ir or SBc III–IV	160
SMC		00 52.0	−72 56	2.86	19.05	−16.2	Ir IV or IV–V	190
NGC	205	00 39.2	+41 35	8.89	24.65	−15.8	E6p	2,100
M32	221	00 41.6	+40 46	9.06	24.65	−15.6	E2	2,100
NGC	6822	19 43.8	−14 49	9.21	24.55	−15.3	IrIV–V	1,700
NGC	185	00 37.8	+48 14	10.29	24.65	−14.4	E0	2,100
IC1613		01 04.0	+02 01	10.00	24.40	−14.4	IrV	2,400
NGC	147	00 32.0	+48 14	10.57	24.65	−14.1	dE4	2,100
Fornax		02 38.7	−34 36	9.1:	20.6:	−12:	dE	430
And I		00 44.4	+37 56	13.5:	24.65	−11:	dE	2,100
And II		01 15.3	+33 20	13.5:	24.65	−11:	dE	2,100
And III		00 34.3	+36 24	13.5:	24.65	−11:	dE	2,100
Leo I		10 07.4	+12 24	11.27	21.8:	−10:	dE	750:
Sculptor		00 58.9	−33 49	10.5	19.70	−9.2:	dE	280:
Leo II		11 12.4	+22 16	12.85	21.8:	−9:	dE	750:
Draco		17 19.8	+57 56	—	19.50	?	dE	260
Ursa Minor		15 08.5	+67 11	—	19.40	?	dE	250
Carina		06 47.2	−50 59	—	21.8:	?	dE	550
LGS3		01 02.8	+21 47	?	?	?	?	2,100:

VARIABLE GALAXIES

Some peculiar galaxies (Seyfert galaxies, BL Lacertae objects and quasars) have bright, star-like nuclei which vary in brightness by up to several magnitudes on a time scale of months to years. These variations can be studied by amateurs and students, especially using photographic techniques. The following table lists the brightest variable galaxies. For more information, see *Sky and Telescope* **55**, 372 (1978), which gives finder charts and comparison stars for the four brightest Seyfert galaxies (indicated with asterisks below). A chart for 3C273, the brightest quasar, is at right. North is at the top.



Name	Type	R.A. 1950 Dec. h m	° ′	Mag.
NGC 1275*	Seyfert?	3 16.5	+41 20	11–13
3C 120	Seyfert	4 30.5	+05 15	14–16
OJ 287	BL Lac	8 52.0	+20 18	12–16
NGC 4151*	Seyfert	12 08.0	+39 41	10–12
3C 273	Quasar	12 26.6	+02 20	12–13
3C 345	Quasar	16 41.3	+39 54	14–17
Mkn. 509*	Seyfert	20 41.5	−10 54	12–13
BL Lac	BL Lac	22 00.7	+42 02	14–17
NGC 7469*	Seyfert	23 00.7	+08 36	12–13

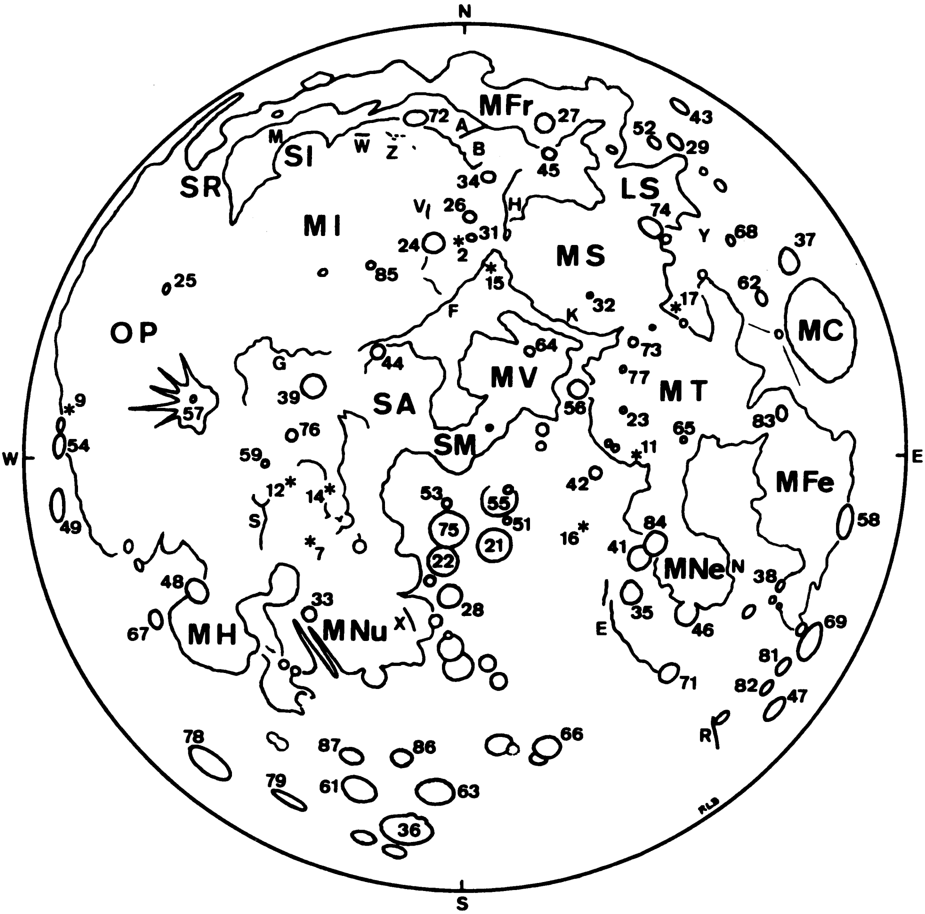
RADIO SOURCES

By John Galt

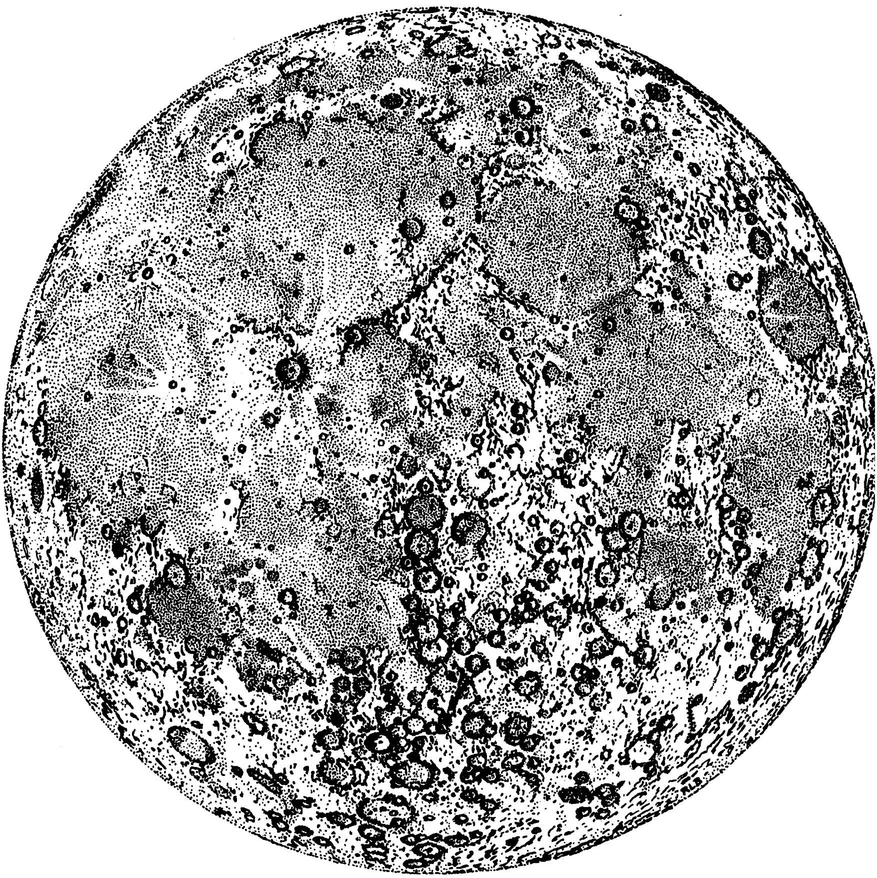
Although several thousand radio sources have been catalogued, most of them are observable only with the largest radio telescopes. This list contains the few strong sources which could be detected with amateur radio telescopes as well as representative examples of astronomical objects which emit radio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

Name	α (1980) δ h	m	°	′	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, 4,500,000,000 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 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 sec.
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. (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.*)



MAP OF



THE 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)

NOTES

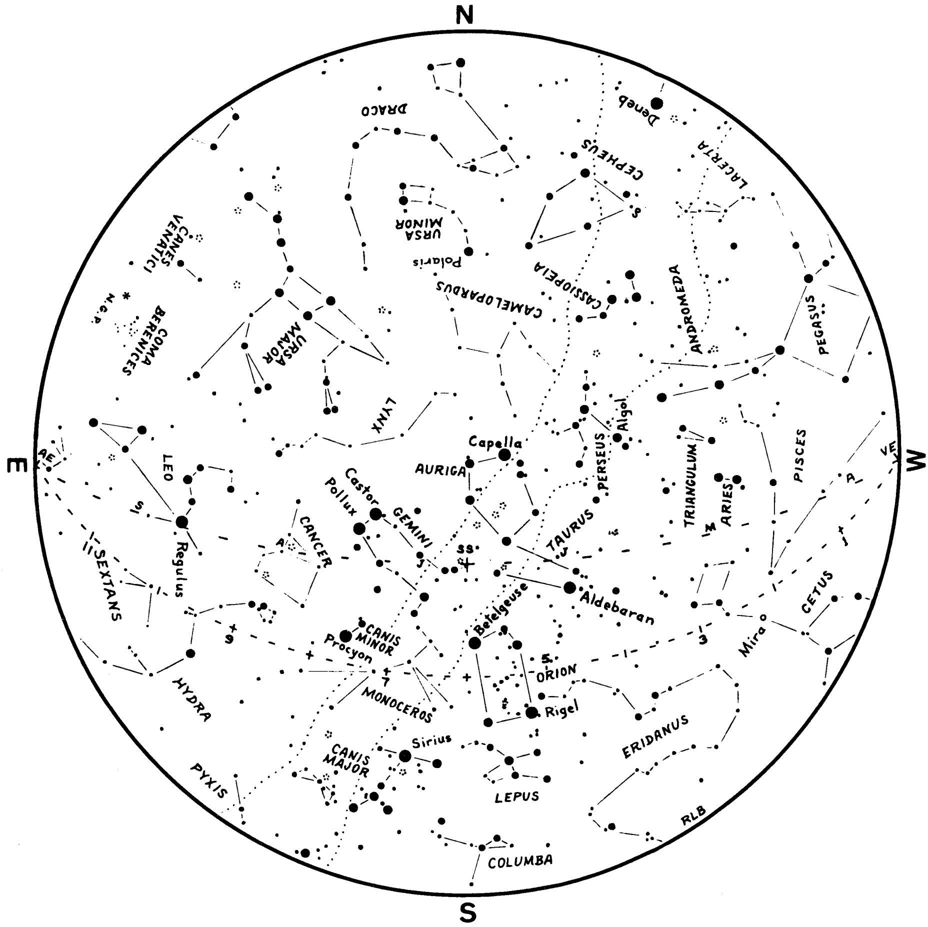
MAPS OF THE NIGHT SKY

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.

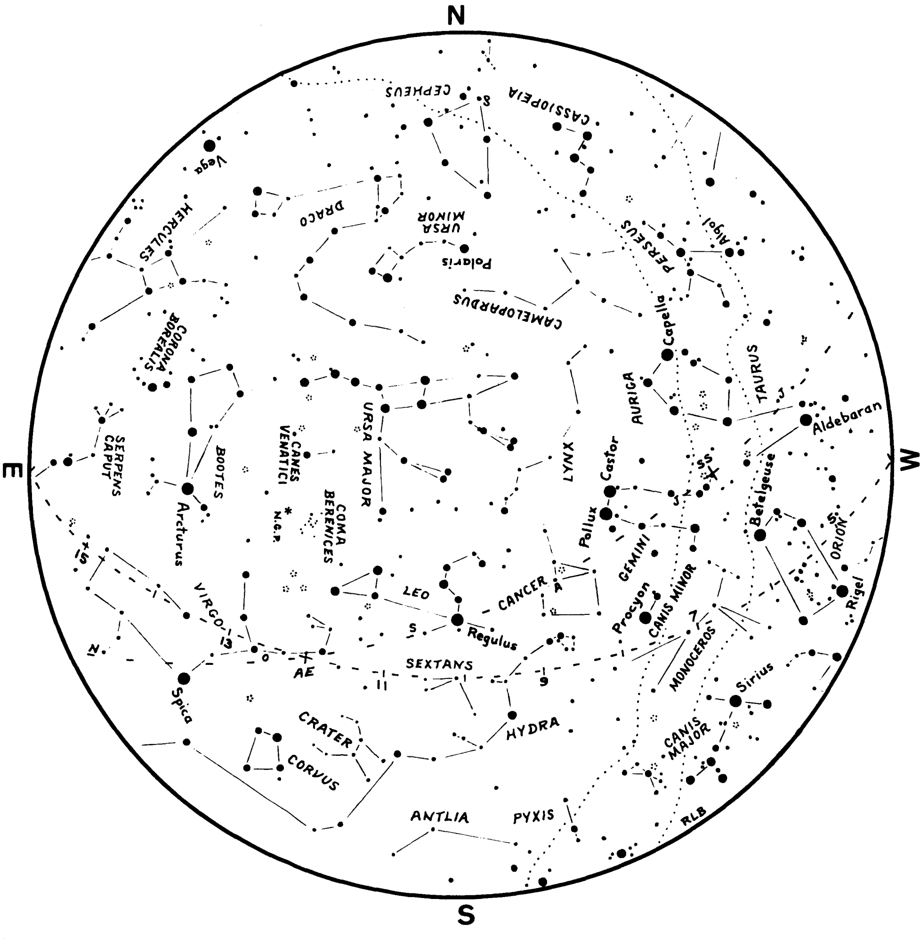
The maps show stars down to a magnitude of 4.5 or 5, i.e. those which are readily apparent to the unaided eye on a reasonably dark night. The center of each map is the zenith, the point directly overhead; the circumference is the horizon. To identify the stars, hold the map in front of you so that the 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); *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. 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, N.Y.).


N
S
E
W
DRACO
URSA MINOR
Polaris
CEPHEUS
Deneb
LACERTA
CASSIOPEIA
CAMELOPARDUS
ANDROMEDA
PEGASUS
CANES VENATICI
N.G.P.
COMA BERENICES
URSA MAJOR
LYNX
Capella
AURIGA
PERSEUS
Algol
TRIANGULUM
ARIES
PISCES
LEO
Regulus
Castor
Pollux
GEMINI
CANCER
TAURUS
Aldebaran
SEXTANS
Betelgeuse
CANIS MINOR
Procyon
MONOCEROS
ORION
Rigel
CETUS
Mira
HYDRA
ERIDANUS
Sirius
CANIS MAJOR
LEPUS
PYXIS
COLUMBA
RLB

JANUARY


N
S
E
W
CEPHEUS
CASSIOPEIA
Vega
HERCULES
DRACO
URSA MINOR
Polaris
PERSEUS
Algol
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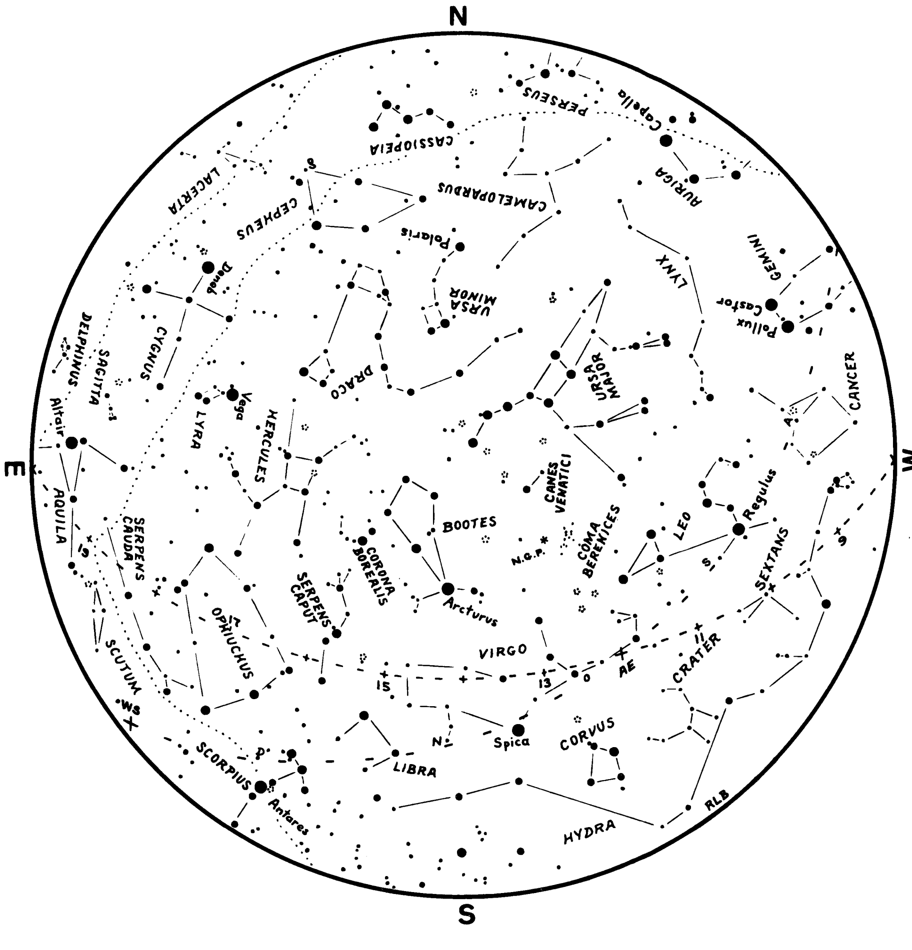
CORONA BOREALIS
Capella
TAURUS
AURIGA
Aldebaran
SERPENS CAPUT
BOOTES
CANES VENATICI
URSA MAJOR
LYNX
Castor
Arcturus
COMA BERENICES
N.G.P.
Pollux
GEMINI
Betelgeuse
ORION
Rigel
VIRGO
LEO
CANCER
Procyon
CANIS MINOR
Regulus
MONOCEROS
SEXTANS
AE
Spica
Sirius
CRATER
CORVUS
HYDRA
CANIS MAJOR
ANTLIA
PYXIS
RLB

MARCH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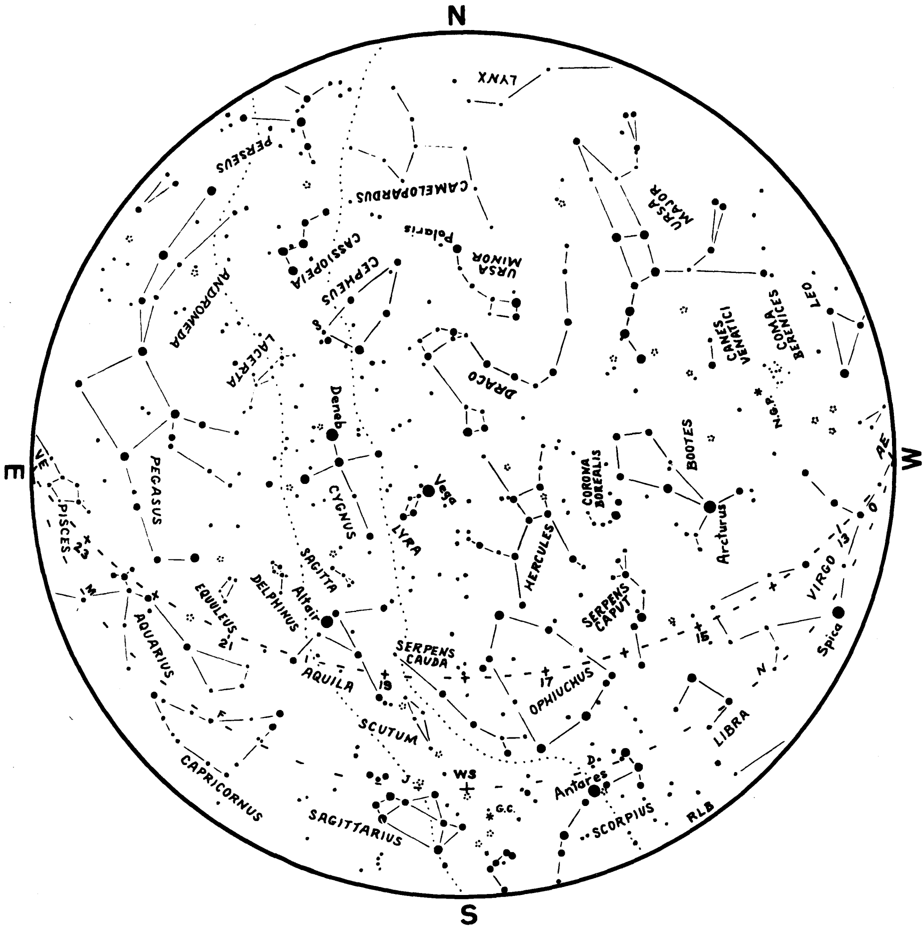
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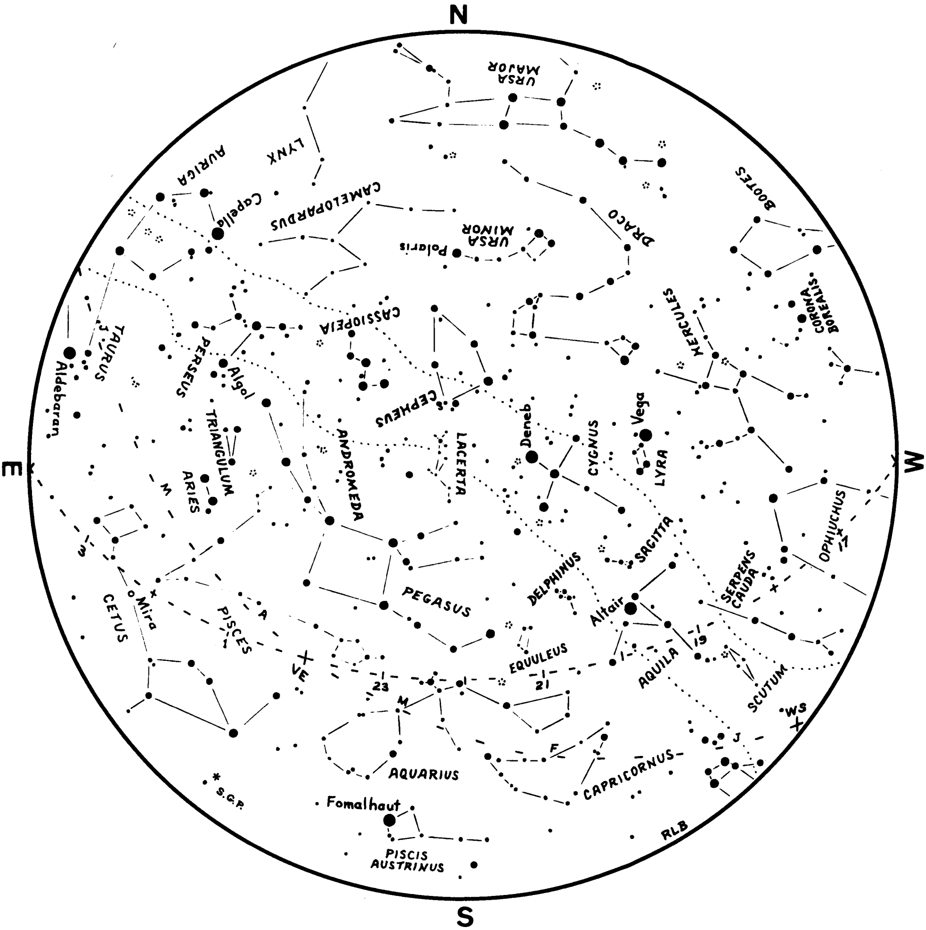
JULY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ARIES
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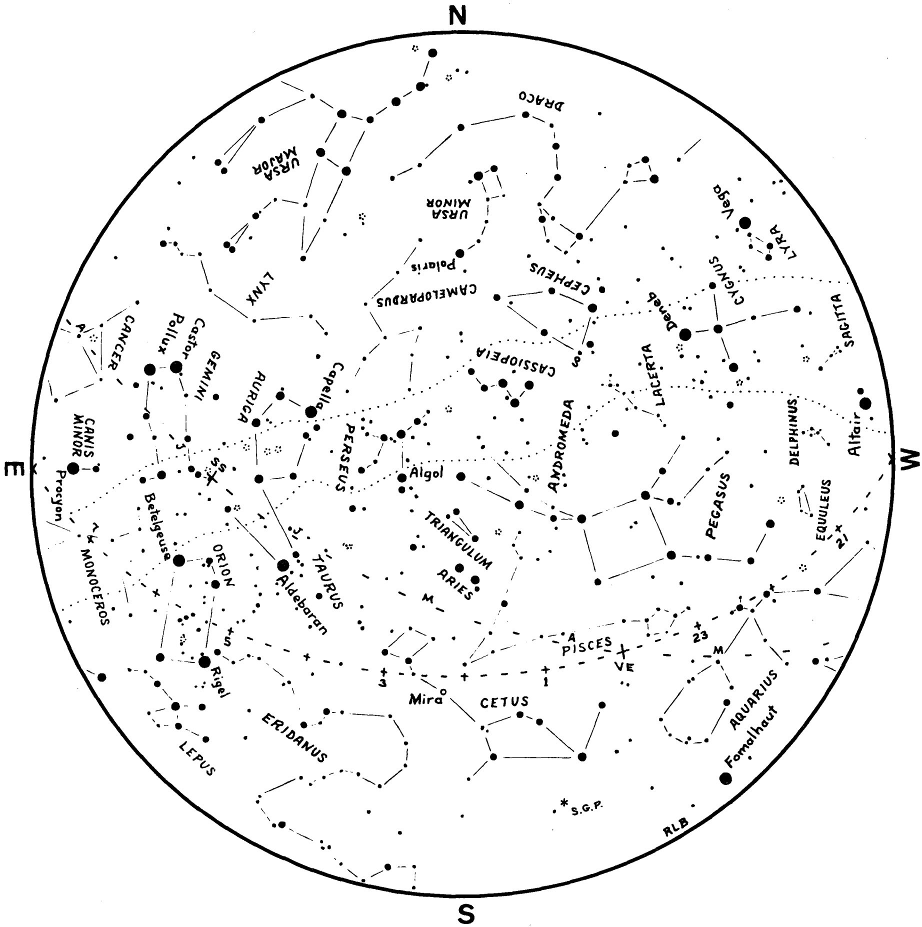
S.G.P.
Fomalhaut
PISCIS AUSTRINUS
RLB

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

NOVEMBER

JULIAN DATE, 1982

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 1982, 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:

Jan.	244 4969.5	Apr.	244 5059.5	July	244 5150.5	Oct.	244 5242.5
Feb.	244 5000.5	May	244 5089.5	Aug.	244 5181.5	Nov.	244 5273.5
Mar.	244 5028.5	June	244 5120.5	Sep.	244 5212.5	Dec.	244 5303.5

e.g. 23:08 EDT on July 22 = 03:08 UT on July 23 = July 23.13 UT = 244 5150.5 + 23.13 = JD 244 5173.63

INDEX

CALENDAR 1982

January

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

S	M	T	W	T	F	S
	1	2	3	4	5	6
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21	22	23	24	25	26	27
28						

March

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21	22	23	24	25	26	27
28	29	30	31			

April

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May

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23	24	25	26	27	28	29
30	31					

June

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20	21	22	23	24	25	26
27	28	29	30			

July

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4	5	6	7	8	9	10
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18	19	20	21	22	23	24
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August

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September

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26	27	28	29	30		

October

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November

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28	29	30				

December

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19	20	21	22	23	24	25
26	27	28	29	30	31	

CALENDAR 1983

January

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February

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March

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27	28	29	30	31		

April

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May

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June

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July

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August

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September

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October

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