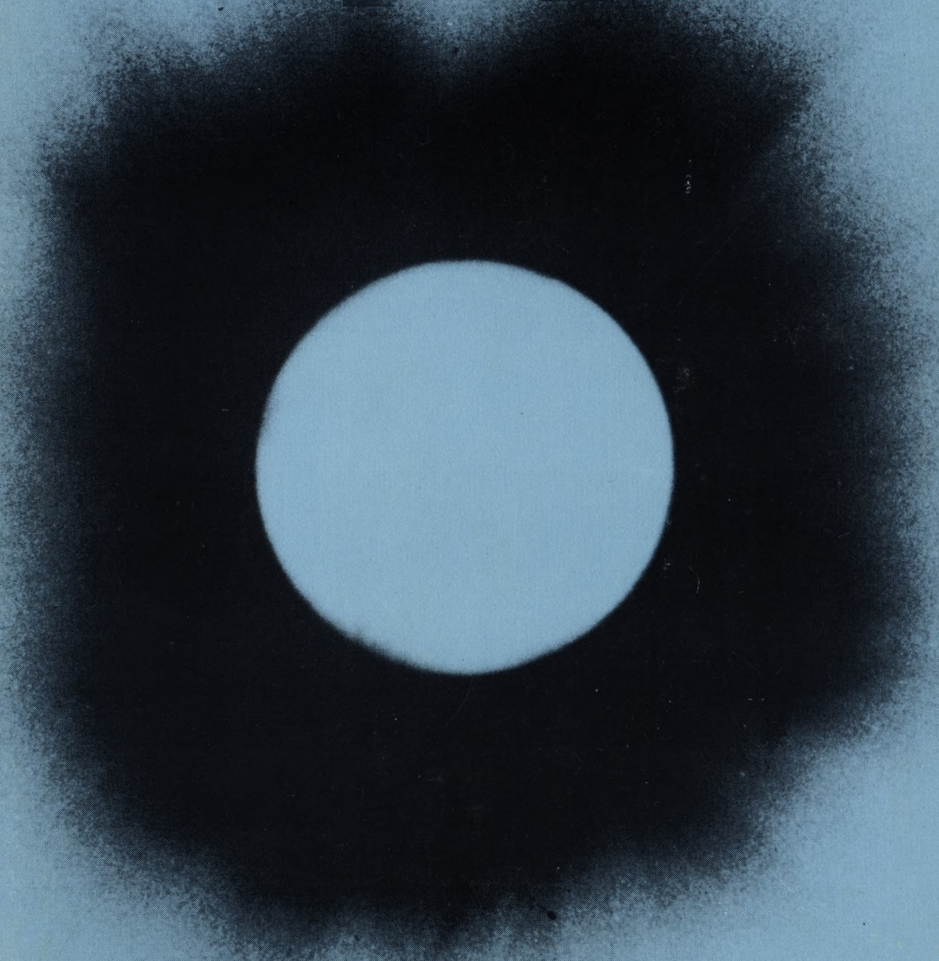
OBSERVER'S HANDBOOK 1980



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ROYAL ASTRONOMICAL SOCIETY OF CANADA

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QUICK INDEX

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 earlier issues of the OBSERVER'S HANDBOOK we gave the details of the establishment and 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. A second Centre was established at Ottawa. Over the years other Centres have been established until the Society now has eighteen from coast to coast in Canada, from St. John's, Newfoundland to Victoria, British Columbia as listed on page 3.

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 as well as to bring information to those members unattached to Centres. 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, as follows, with Toronto, Ontario the site of all the years not listed: 1958 Hamilton, Ontario; 1960 Montreal, Quebec; 1962 Edmonton, Alberta; 1964 Ottawa, Ontario; 1966 Winnipeg, Manitoba; 1967 Montreal, Quebec; 1968 Calgary, Alberta; 1970 Edmonton, Alberta; 1971 Hamilton, Ontario; 1972 Vancouver, British Columbia; 1973 Ottawa, Ontario; 1974 Winnipeg, Manitoba; 1975 Halifax, Nova Scotia; 1976 Calgary, Alberta; 1978 Edmonton, Alberta; 1979 London, Ontario.

In the early decades of the Society when only slow rail travel was available, with the large distances across Canada, such gatherings would have been very difficult. The air age brings the opportunity for members from all Centres to meet together and also enjoy delightful 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 make observations for research in astronomy. Some of the Centres have fine observatories of their own where experienced members devote many hours to research observations on variable stars, nova searches, comet searches, occultation timings, meteor counts and so on. The efforts of the amateur members of the Society really hit the jackpot in 1978 when one member found the first all-Canadian comet and another was the discoverer of Nova Cygni 1978.

HELEN SAWYER HOGG

THE OBSERVER'S HANDBOOK FOR 1980

THE OBSERVER'S HANDBOOK for 1980 is the seventy-second edition. I thank all those who have contributed to its production: those listed on the inside front cover, and also my editorial assistants Tim Pointing and Douglas Welch.

I also thank all those who have sent me corrections to and suggestions about the HANDBOOK. Errors inevitably creep in; if you see one please let me know, obvious though it may be.

Special thanks are due to Dr. Helen Hogg for her interest and her helpful comments, and to Ian McGregor for previewing the 1980 sky for me in the Star Theatre of the McLaughlin Planetarium. I am also grateful to Terence Dickinson for suggesting – and executing – the reorganization of the material on the planets. As always, the members of the R.A.S.C. National Council, the editor Dr. Lloyd Higgs and the executive secretary Rosemary Freeman have given me their cheerful support and assistance. The HANDBOOK also benefits from the direct and indirect support of the David Dunlap Observatory and Erindale College, University of Toronto.

The HANDBOOK is particularly indebted to H.M. Nautical Almanac Office and to the *American Ephemeris* for the generous contribution of essential material. Special thanks go to Leslie V. Morrison and the Occultation Section of H.M.N.A.O. for providing the wealth of material on total and grazing lunar occultations.

I hope that the OBSERVER'S HANDBOOK helps you to find the pleasure and satisfaction which astronomy can provide. Good observing!

JOHN R. PERCY

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 origins of the Society were outlined by Dr. Helen Sawyer Hogg in her article on the inside front cover of the 1979 edition of this HANDBOOK. The subsequent development of the Society is described by Dr. Hogg on the page opposite. The Society was incorporated 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 astronomical library are housed here.

The Society is devoted to the advancement of astronomy and allied sciences, and any serious user of this HANDBOOK would benefit from membership. Applicants may affiliate with one of the eighteen Centres across Canada established in St. John's, Halifax, Quebec, Montreal, Ottawa, Kingston, Toronto, Hamilton, Niagara Falls, London, Windsor, Winnipeg, Saskatoon, Edmonton, Calgary, Vancouver and Victoria, or join the National Society direct, as an unattached member.

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. Membership applies to a given calendar year; new members joining after October 1 will receive membership and publications for the following calendar year. Annual fees are currently $16.00, and $10.00 for persons under eighteen years.

COVER PHOTOGRAPH

The cover of the 1980 OBSERVER'S HANDBOOK shows the total solar eclipse of Feb. 26, 1979. It is a negative print of a photograph by Damien Lemay of Rimouski, Quebec. He used a 300 mm telephoto extended to 600 mm with the aid of a doubler. The original photograph was a 2 second exposure on Ektachrome 200 slide film, and an internegative was made in order to produce a black-and-white print. Special dodging procedures were used to bring out as much detail as possible in the outer corona.

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.

Becvar, A. *Atlas of the Heavens.* Cambridge, Mass.: Sky Publishing Corp., 1962. Useful star charts to magnitude 7.5.

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

Hartmann, W. K. *Astronomy: The Cosmic Journey.* Belmont, Calif.: Wadsworth Publ., 1978. An excellent non-technical college text.

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

Mayall, R. N., Mayall, M. W. and Wyckoff, J. *The Sky Observer's Guide.* New York: Golden Press, 1971. Useful guide to practical astronomy.

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

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

Satterthwaite, G. ed. *Norton's Star Atlas.* Cambridge, Mass.: Sky Publishing Corp., 1973. A classic observing guide.

Sky and Telescope. Sky Publishing Corp., 49-50-51 Bay State Rd., Cambridge, Mass. 02138. A monthly magazine containing articles on all aspects of astronomy.

ANNIVERSARIES AND FESTIVALS, 1980

New Year's Day	Tues.	Jan. 1
Epiphany	Sun.	Jan. 6
Septuagesima Sunday		Feb. 3
Ascension of Queen Elizabeth (1952)	Wed.	Feb. 6
Lincoln's Birthday	Tues.	Feb. 12
Quinquagesima (Shrove) Sunday		Feb. 17
Washington's Birthday	Mon.	Feb. 18
Ash Wednesday		Feb. 20
St. David	Sat.	Mar. 1
St. Patrick	Mon.	Mar. 17
Palm Sunday		Mar. 30
First day of Passover	Tues.	Apr. 1
Good Friday		Apr. 4
Easter Sunday		Apr. 6
Birthday of Queen Elizabeth (1926)	Mon.	Apr. 21
St. George	Wed.	Apr. 23
Rogation Sunday		May 11
Ascension Day	Thur.	May 15
Victoria Day	Mon.	May 19
Pentecost (Whit Sunday)		May 25
Memorial Day	Mon.	May 26
Trinity Sunday		June 1
Corpus Christi	Thur.	June 5
St. John Baptist (Mid-Summer Day)	Tues.	June 24
Canada Day	Tues.	July 1
Independence Day	Fri.	July 4
Birthday of Queen Mother Elizabeth (1900)	Mon.	Aug. 4
Civic Holiday	Mon.	Aug. 4
Labour Day	Mon.	Sept. 1
Jewish New Year (Rosh Hashana)	Thur.	Sept. 11
Yom Kippur	Sat.	Sept. 20
St. Michael (Michaelmas Day)	Mon.	Sept. 29
Thanksgiving (Can.)	Mon.	Oct. 13
Columbus Day	Mon.	Oct. 13
All Saints' Day	Sat.	Nov. 1
General Election Day	Tues.	Nov. 4
Islamic New Year	Sun.	Nov. 9
Remembrance Day	Tues.	Nov. 11
Veterans' Day	Tues.	Nov. 11
Thanksgiving (U.S.)	Thur.	Nov. 27
St. Andrew	Sun.	Nov. 30
First Sunday in Advent		Nov. 30
Christmas Day	Thur.	Dec. 25

All dates are given in terms of the Gregorian calendar. January 14 corresponds to January 1, Julian reckoning. Italicized holidays are celebrated in the U.S. only.

SYMBOLS AND ABBREVIATIONS

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. One hour of time equals 15 degrees.

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.

PRINCIPAL ELEMENTS OF THE SOLAR SYSTEM

MEAN ORBITAL ELEMENTS

Planet	Mean Distance from Sun (a)		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.	11.86y.	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. Vel. 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	0.4101	3.1	0.73
♄ Saturn	120,000	1/10	95.17	0.70	1.32	39.4	0.426	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 velocity *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 †retrograde

SATELLITES OF THE SOLAR SYSTEM

By JOSEPH VEVERKA

Name	Vis. Mag.	Diam. km	Mean Distance from Planet km/1000	arc sec	Revolution Period d	h	m	Orbit Incl. °	Discovery
SATELLITE OF THE EARTH									
Moon	−12.7	3476	384.5	—	27	07	43	18–29	
SATELLITES OF MARS									
I Phobos	11.6	23	9.4	25	0	07	39	1.1	A. Hall, 1877
II Deimos	12.7	13	23.5	63	1	06	18	1.8v	A. Hall, 1877
SATELLITES OF JUPITER									
V Amalthea	14.1	210	180	59	0	11	57	0.4	E. Barnard, 1892
I Io	5.0	3640	422	138	1	18	28	0	Galileo, 1610
II Europa	5.3	3130	671	220	3	13	14	0.5	Galileo, 1610
III Ganymede	4.6	5280	1,070	351	7	03	43	0.2	Galileo, 1610
IV Callisto	5.6	4840	1,885	618	16	16	32	0.2	Galileo, 1610
XIII Leda	20	(10)	11,110	3640	240			26.7	C. Kowal, 1974
VI Himalia	14.7	170	11,470	3760	251			27.6	C. Perrine, 1904
X Lysithea	18.4	(20)	11,710	3840	260			29.0	S. Nicholson, 1938
VII Elara	16.4	80	11,740	3850	260			24.8	C. Perrine, 1905
XII Ananke	18.9	(20)	20,700	6790	617			147	S. Nicholson, 1951
XI Carme	18.0	(30)	22,350	7330	692			164	S. Nicholson, 1938
VIII Pasiphae	17.7	(40)	23,330	7650	735			145	P. Melotte. 1908
IX Sinope	18.3	(30)	23,370	7660	758			153	S. Nicholson, 1914
SATELLITES OF SATURN									
XI	14	(200)	151	25	0	16	40	0.0	J. Fountain, S. Larson, 1978
X Janus	14	(200)	160	26	0	17	59	0.0	A. Dollfus, 1966
I Mimas	12.9	(400)	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	1000	295	48	1	21	18	1.1	G. Cassini, 1684
IV Dione	10.4	1000	378	61	2	17	41	0.0	G. Cassini, 1684
V Rhea	9.7	1600	526	85	4	12	25	0.4	G. Cassini, 1672
VI Titan	8.4	5800	1,221	197	15	22	41	0.3	C. Huyghens, 1655
VII Hyperion	14.2	220	1,481	239	21	06	38	0.4	G. Bond, 1848
VIII Iapetus	11.0v	1450	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)	5600	264	365	5		27.6	G. Kuiper, 1949
SATELLITE OF PLUTO									
I (Charon)	16	(1000)	15.2	(<1)	6.4			(115)	J. Christy, 1978

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.

MISCELLANEOUS ASTRONOMICAL DATA

Units of Length

1 Angstrom unit	$= 10^{-8}$ cm	1 micrometre, μ	$= 10^{-4}$ cm $= 10^4$A.
1 inch	= exactly 2.54 centimetres	1 cm = 10 mm	= 0.39370 ... in
1 yard	= exactly 0.9144 metre	1 m $= 10^2$ cm	= 1.0936 .... yd
1 mile	= exactly 1.609344 kilometres	1 km $= 10^5$ cm	= 0.62137 ... mi

1 astronomical unit $= 1.49597870 \times 10^8$ km $= 9.2956 \times 10^7$ mi
1 light-year $= 9.461 \times 10^{12}$ km $= 5.88 \times 10^{12}$ mi = 0.3068 parsecs
1 parsec $= 3.086 \times 10^{13}$ km $= 1.917 \times 10^{13}$ mi = 3.262 l.y.
1 megaparsec $= 10^6$ parsecs

Units of Time

Sidereal day = 23*h* 56*m* 04.09*s* of mean solar time
Mean solar day = 24*h* 03*m* 56.56*s* of mean sidereal time
Synodic month = 29*d* 12*h* 44*m* 03*s* = 29^d5306 Sidereal month = 27*d* 07*h* 43*m* 12*s* = 27^d3216
Tropical year (ordinary) = 365*d* 05*h* 48*m* 46*s* = 365^d2422
Sidereal year = 365*d* 06*h* 09*m* 10*s* = 365^d2564
Eclipse year = 346*d* 14*h* 52*m* 52*s* = 346^d6200

The Earth

Equatorial radius, a = 6378.140 km = 3963.19 mi: flattening, $c = (a - b)/a = 1/298.257$
Polar radius, b = 6356.755 km = 3949.904 mi
1° of latitude $= 111.133 - 0.559 \cos 2\phi$ km $= 69.055 - 0.347 \cos 2\phi$ mi (at lat. ϕ)
1° of longitude $= 111.413 \cos\phi - 0.094 \cos 3\phi$ km $= 69.229 \cos\phi - 0.0584 \cos 3\phi$ mi
Mass of earth $= 5.976 \times 10^{24}$ kg $= 13.17 \times 10^{24}$ lb
Velocity of escape from ⊕ = 11.2 km/sec = 6.94 mi/sec

Earth's Orbital Motion

Solar parallax = 8″.794 (adopted)
Constant of aberration = 20″.496 (adopted)
Annual general precession = 50″.26; obliquity of ecliptic = 23° 26′ 35′ (1970)
Orbital velocity = 29.8 km/sec = 18.5 mi/sec
Parabolic velocity at ⊕ = 42.3 km/sec = 26.2 mi/sec

Solar Motion

Solar apex, R.A. 18*h* 04*m*, Dec. + 30°; solar velocity = 19.75 km/sec = 12.27 mi/sec

The Galactic System

North pole of galactic plane R.A. 12*h* 49*m*, Dec. + 27.°4 (1950)
Centre of galaxy R.A. 17*h* 42.4*m*, Dec. − 28° 55′ (1950) (zero pt. for new gal. coord.)
Distance to centre ~ 10,000 parsecs; diameter ~ 30,000 parsecs
Rotational velocity (at sun) ~ 250 km/sec
Rotational period (at sun) $\sim 2.46 \times 10^8$ years
Mass $\sim 1.4 \times 10^{11}$ solar masses

External Galaxies

Red Shift = +50−75 km/s/megaparsec (depending on method of determination)

Radiation Constants

Velocity of light, $c = 2.99792458 \times 10^8$ m/s
Frequency, $\nu = c/\lambda$; ν in Hertz (cycles per sec), c in cm/sec, λ in cm
Solar constant = 1.947 cal/cm²/min = 0.1358 W/cm²
Light ratio for one magnitude = 2.512 . . . ; log ratio = exactly 0.4
Stefan's constant $= 5.66956 \times 10^{-5}$ erg/cm²/s/°K⁴

Miscellaneous

Constant of gravitation, $G = 6.6727 \times 10^{-8}$ dyn cm²/g²
Mass of the electron, $m = 9.1096 \times 10^{-28}$ g: mass of the proton $= 1.6727 \times 10^{-24}$ gm
Planck's constant, $h = 6.6262 \times 10^{-27}$ erg sec
Absolute temperature = T° K = T° C + 273° = 5/9 (T° F + 459°)

1 radian	= 57°.2958	π = 3.141,592,653,6
	= 3437′.75	No. of square degrees in the sky = 41,253
	= 206,265″	1 gram = 0.03527 oz

SUN—EPHEMERIS AND CORRECTION TO SUN-DIAL

Date	Apparent R.A. 0h E.T. h	m	s	Apparent Dec. 0h E.T. °	′	Corr. to Sun-dial 12h E.T. m	s
Jan. 1	18	42	17	−23	05.0	+ 3	16
4	18	55	30	−22	49.6	+ 4	40
7	19	08	41	−22	30.1	+ 6	00
10	19	21	48	−22	06.5	+ 7	16
13	19	34	49	−21	39.1	+ 8	28
16	19	47	46	−21	07.9	+ 9	33
19	20	00	36	−20	33.0	+10	33
22	20	13	20	−19	54.7	+11	26
25	20	25	57	−19	13.0	+12	13
28	20	38	27	−18	28.2	+12	51
31	20	50	50	−17	40.3	+13	23
Feb. 3	21	03	04	−16	49.6	+13	47
6	21	15	12	−15	56.3	+14	04
9	21	27	13	−15	00.5	+14	13
12	21	39	06	−14	02.4	+14	16
15	21	50	53	−13	02.2	+14	12
18	22	02	33	−12	00.1	+14	02
21	22	14	07	−10	56.3	+13	45
24	22	25	35	− 9	50.9	+13	22
27	22	36	57	− 8	44.3	+12	54
Mar. 1	22	48	14	− 7	36.4	+12	20
4	22	59	26	− 6	27.6	+11	42
7	23	10	35	− 5	18.0	+11	00
10	23	21	40	− 4	07.7	+10	15
13	23	32	42	− 2	57.0	+ 9	27
16	23	43	41	− 1	45.9	+ 8	36
19	23	54	39	− 0	34.8	+ 7	44
22	0	05	36	+ 0	36.4	+ 6	51
25	0	16	31	+ 1	47.3	+ 5	56
28	0	27	26	+ 2	57.8	+ 5	02
31	0	38	21	+ 4	07.8	+ 4	07
Apr. 3	0	49	17	+ 5	17.1	+ 3	13
6	1	00	14	+ 6	25.6	+ 2	21
9	1	11	13	+ 7	33.1	+ 1	31
12	1	22	15	+ 8	39.5	+ 0	44
15	1	33	19	+ 9	44.5	− 0	01
18	1	44	27	+10	48.2	− 0	43
21	1	55	38	+11	50.2	− 1	21
24	2	06	52	+12	50.4	− 1	55
27	2	18	11	+13	48.8	− 2	25
30	2	29	35	+14	45.1	− 2	51
May 3	2	41	03	+15	39.2	− 3	11
6	2	52	36	+16	31.0	− 3	27
9	3	04	14	+17	20.3	− 3	38
12	3	15	58	+18	07.0	− 3	43
15	3	27	47	+18	51.0	− 3	43
18	3	39	41	+19	32.1	− 3	37
21	3	51	39	+20	10.2	− 3	28
24	4	03	43	+20	45.2	− 3	13
27	4	15	51	+21	17.0	− 2	54
30	4	28	03	+21	45.5	− 2	31
June 2	4	40	19	+22	10.6	− 2	04
5	4	52	38	+22	32.2	− 1	34
8	5	05	01	+22	50.3	− 1	01
11	5	17	26	+23	04.7	− 0	25
14	5	29	53	+23	15.5	+ 0	13
17	5	42	21	+23	22.7	+ 0	52
20	5	54	50	+23	26.1	+ 1	31
23	6	07	19	+23	25.8	+ 2	10
26	6	19	47	+23	21.7	+ 2	48
29	6	32	13	+23	14.0	+ 3	25

Date	Apparent R.A. 0h E.T. h	m	s	Apparent Dec. 0h E.T. °	′	Corr. to Sun-dial 12h E.T. m	s
July 2	6	44	38	+23	02.6	+ 3	59
5	6	57	00	+22	47.6	+ 4	31
8	7	09	19	+22	29.0	+ 5	01
11	7	21	36	+22	06.9	+ 5	26
14	7	33	48	+21	41.4	+ 5	48
17	7	45	55	+21	12.6	+ 6	05
20	7	57	58	+20	40.5	+ 6	18
23	8	09	56	+20	05.4	+ 6	25
26	8	21	48	+19	27.2	+ 6	27
29	8	33	35	+18	46.1	+ 6	23
Aug. 1	8	45	17	+18	02.2	+ 6	14
4	8	56	53	+17	15.7	+ 6	00
7	9	08	24	+16	26.6	+ 5	40
10	9	19	50	+15	35.1	+ 5	15
13	9	31	10	+14	41.5	+ 4	45
16	9	42	26	+13	45.7	+ 4	11
19	9	53	37	+12	47.9	+ 3	31
22	10	04	43	+11	48.3	+ 2	47
25	10	15	45	+10	47.1	+ 1	59
28	10	26	44	+ 9	44.3	+ 1	07
31	10	37	39	+ 8	40.1	+ 0	12
Sept. 3	10	48	31	+ 7	34.7	− 0	46
6	10	59	22	+ 6	28.1	− 1	45
9	11	10	10	+ 5	20.6	− 2	47
12	11	20	57	+ 4	12.3	− 3	49
15	11	31	43	+ 3	03.3	− 4	53
18	11	42	29	+ 1	53.8	− 5	57
21	11	53	15	+ 0	43.9	− 7	01
24	12	04	01	− 0	26.1	− 8	04
27	12	14	49	− 1	36.2	− 9	06
30	12	25	38	− 2	46.3	−10	06
Oct. 3	12	36	30	− 3	56.0	−11	03
6	12	47	25	− 5	05.4	−11	57
9	12	58	24	− 6	14.2	−12	47
12	13	09	27	− 7	22.3	−13	33
15	13	20	34	− 8	29.5	−14	15
18	13	31	46	− 9	35.6	−14	51
21	13	43	04	−10	40.4	−15	23
24	13	54	27	−11	43.8	−15	48
27	14	05	56	−12	45.6	−16	07
30	14	17	33	−13	45.6	−16	19
Nov. 2	14	29	16	−14	43.6	−16	24
5	14	41	07	−15	39.5	−16	22
8	14	53	06	−16	33.1	−16	12
11	15	05	12	−17	24.2	−15	54
14	15	17	25	−18	12.6	−15	29
17	15	29	46	−18	58.1	−14	57
20	15	42	15	−19	40.6	−14	17
23	15	54	50	−20	19.8	−13	30
26	16	07	33	−20	55.6	−12	36
29	16	20	22	−21	28.0	−11	35
Dec. 2	16	33	18	−21	56.7	−10	28
5	16	46	19	−22	21.6	− 9	15
8	16	59	26	−22	42.6	− 7	57
11	17	12	37	−22	59.6	− 6	36
14	17	25	51	−23	12.5	− 5	11
17	17	39	07	−23	21.2	− 3	43
20	17	52	26	−23	25.7	− 2	15
23	18	05	45	−23	26.0	− 0	45
26	18	19	03	−23	22.1	+ 0	44
29	18	32	21	−23	13.9	+ 2	12

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 9), 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 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 the body 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. Your *sidereal time* can be found approximately by (i) first converting your *standard time* to *mean time* by *subtracting* the correction for longitude on p. 14, then (ii) converting to *apparent solar time* by *subtracting* the *correction to sundial* on p. 9, then (iii) adding 12 h and the *right ascension of the sun* on p. 9. Be sure to obtain the correction to sundial and the right ascension of the sun at the standard time involved.

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 time-keeping. 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.

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 1980 will be about 51 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).

JULIAN DAY CALENDAR, 1980

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 Jan. 1, 4713 B.C.

This system was introduced in 1582 by Josephus Justus Scaliger under the name of the Julian period. The Julian period lasts 7980 years, and is the least common multiple of three cycles: the solar cycle of 28 Julian years, the lunar (or Metonic) cycle of 19 Julian years, and the Roman indiction cycle of 15 years. On Jan. 1, 4713 B.C., all three cycles began together. For more information, see "The Julian Period", by C. H. Cleminshaw in the *Griffith Observer*, April 1975

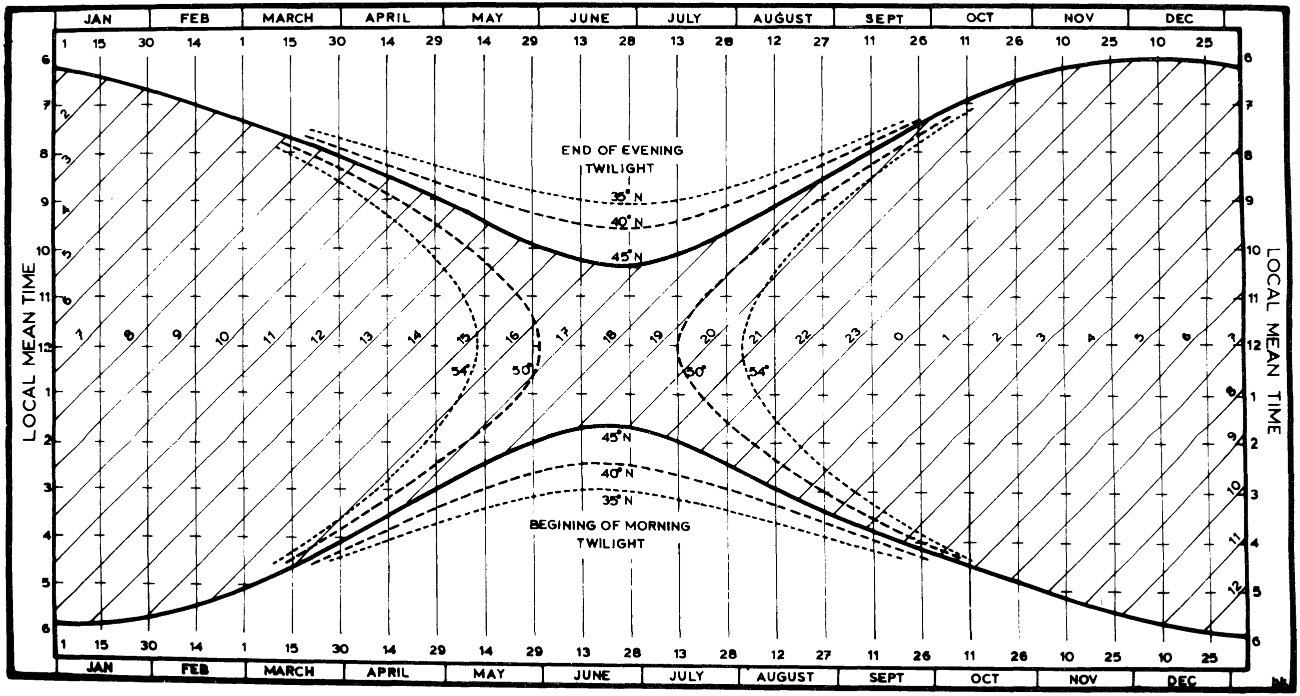
The Julian day commences at noon, so that J.D. 2444240 = Jan. 1.5 U.T. 1980 = 12^h U.T. Jan. 1, 1980.

JULIAN DATES 1980: 2444000 + THE FOLLOWING

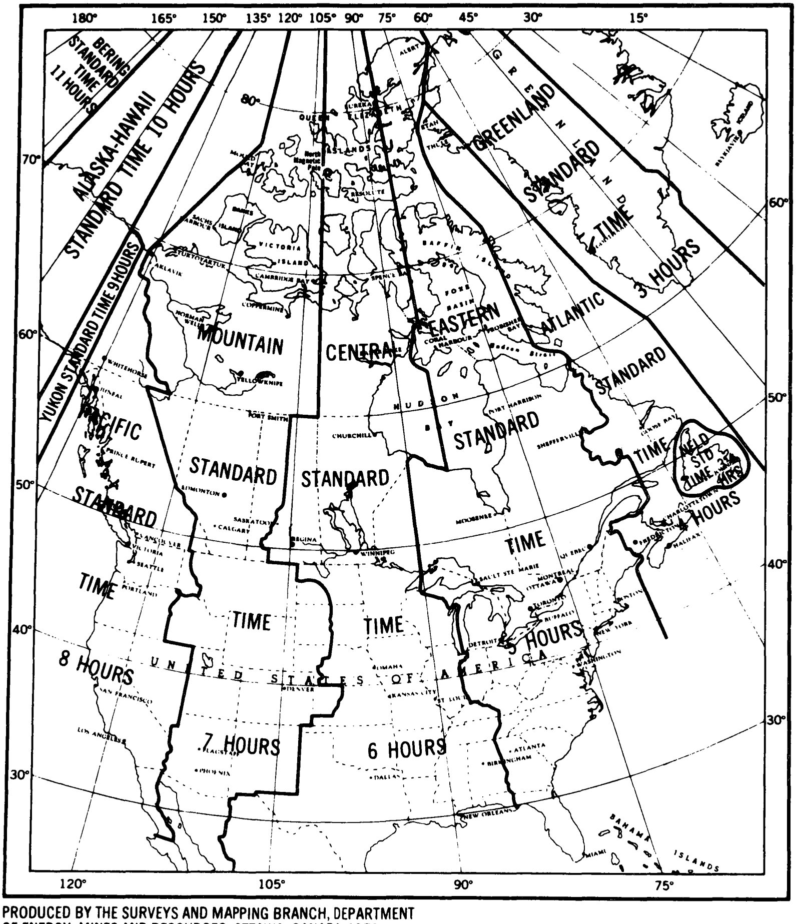
Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	239.5	270.5	299.5	330.5	360.5	391.5	421.5	452.5	483.5	513.5	544.5	574.5
2	240.5	271.5	300.5	331.5	361.5	392.5	422.5	453.5	484.5	514.5	545.5	575.5
3	241.5	272.5	301.5	332.5	362.5	393.5	423.5	454.5	485.5	515.5	546.5	576.5
4	242.5	273.5	302.5	333.5	363.5	394.5	424.5	455.5	486.5	516.5	547.5	577.5
5	243.5	274.5	303.5	334.5	364.5	395.5	425.5	456.5	487.5	517.5	548.5	578.5
6	244.5	275.5	304.5	335.5	365.5	396.5	426.5	457.5	488.5	518.5	549.5	579.5
7	245.5	276.5	305.5	336.5	366.5	397.5	427.5	458.5	489.5	519.5	550.5	580.5
8	246.5	277.5	306.5	337.5	367.5	398.5	428.5	459.5	490.5	520.5	551.5	581.5
9	247.5	278.5	307.5	338.5	368.5	399.5	429.5	460.5	491.5	521.5	552.5	582.5
10	248.5	279.5	308.5	339.5	369.5	400.5	430.5	461.5	492.5	522.5	553.5	583.5
11	249.5	280.5	309.5	340.5	370.5	401.5	431.5	462.5	493.5	523.5	554.5	584.5
12	250.5	281.5	310.5	341.5	371.5	402.5	432.5	463.5	494.5	524.5	555.5	585.5
13	251.5	282.5	311.5	342.5	372.5	403.5	433.5	464.5	495.5	525.5	556.5	586.5
14	252.5	283.5	312.5	343.5	373.5	404.5	434.5	465.5	496.5	526.5	557.5	587.5
15	253.5	284.5	313.5	344.5	374.5	405.5	435.5	466.5	497.5	527.5	558.5	588.5
16	254.5	285.5	314.5	345.5	375.5	406.5	436.5	467.5	498.5	528.5	559.5	589.5
17	255.5	286.5	315.5	346.5	376.5	407.5	437.5	468.5	499.5	529.5	560.5	590.5
18	256.5	287.5	316.5	347.5	377.5	408.5	438.5	469.5	500.5	530.5	561.5	591.5
19	257.5	288.5	317.5	348.5	378.5	409.5	439.5	470.5	501.5	531.5	562.5	592.5
20	258.5	289.5	318.5	349.5	379.5	410.5	440.5	471.5	502.5	532.5	563.5	593.5
21	259.5	290.5	319.5	350.5	380.5	411.5	441.5	472.5	503.5	533.5	564.5	594.5
22	260.5	291.5	320.5	351.5	381.5	412.5	442.5	473.5	504.5	534.5	565.5	595.5
23	261.5	292.5	321.5	352.5	382.5	413.5	443.5	474.5	505.5	535.5	566.5	596.5
24	262.5	293.5	322.5	353.5	383.5	414.5	444.5	475.5	506.5	536.5	567.5	597.5
25	263.5	294.5	323.5	354.5	384.5	415.5	445.5	476.5	507.5	537.5	568.5	598.5
26	264.5	295.5	324.5	355.5	385.5	416.5	446.5	477.5	508.5	538.5	569.5	599.5
27	265.5	296.5	325.5	356.5	386.5	417.5	447.5	478.5	509.5	539.5	570.5	600.5
28	266.5	297.5	326.5	357.5	387.5	418.5	448.5	479.5	510.5	540.5	571.5	601.5
29	267.5	298.5	327.5	358.5	388.5	419.5	449.5	480.5	511.5	541.5	572.5	602.5
30	268.5		328.5	359.5	389.5	420.5	450.5	481.5	512.5	542.5	573.5	603.5
31	269.5		329.5		390.5		451.5	482.5		543.5		604.5

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 10 and 21 for definitions of L.M.T., L.S.T. and astronomical twilight.



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.

TIMES OF RISING AND SETTING OF THE SUN AND MOON

The times of sunrise and sunset for places in latitudes ranging from 30° to 54° are given on pages 15 to 20, and of twilight on page 21. The times of moonrise and moonset for the 5 h meridian are given on pages 22 to 27. The times are given in Local Mean Time, and in the table below are given corrections to change from Local Mean Time to Standard Time for the cities and towns named.

The tabulated values are computed for the sea horizon for the rising and setting of the upper limb of the sun and moon, and are corrected for refraction. Because variations from the sea horizon usually exist on land, the tabulated times can rarely be observed.

The Standard Times for Any Station

To derive the Standard Time of rising and setting phenomena for the places named, from the list below find the approximate latitude of the place and the correction in minutes which follows the name. Then find in the monthly table the Local Mean Time of the phenomenon for the proper latitude on the desired day. Finally apply the correction to get the Standard Time. The correction is the number of minutes of time that the place is west (plus) or east (minus) of the standard meridian. The corrections for places not listed may be obtained by converting the longitude found from an atlas into time (360° = 24 h).

CANADIAN CITIES AND TOWNS						AMERICAN CITIES		
	Lat.	Corr.		Lat.	Corr.		Lat.	Corr.
Athabasca	55°	+33M	Peterborough	44	+13E	Atlanta	34°	+37E
Baker Lake	64	+24C	Port Harrison	59	+13E	Baltimore	39	+06E
Brandon	50	+40C	Prince Albert	53	+63C	Birmingham	33	−13C
Brantford	43	+21E	Prince Rupert	54	+41P	Boston	42	−16E
Calgary	51	+36M	Quebec	47	−15E	Buffalo	43	+15E
Charlottetown	46	+12A	Regina	50	+58C	Chicago	42	−10C
Churchill	59	+17C	St. Catharines	43	+17E	Cincinnati	39	+38E
Cornwall	45	− 1E	St. Hyacinthe	46	−08E	Cleveland	42	+26E
Edmonton	54	+34M	Saint John, N.B.	45	+24A	Dallas	33	+27C
Fredericton	46	+27A	St. John's, Nfld.	48	+01N	Denver	40	00M
Gander	49	+ 8N	Sarnia	43	+29E	Detroit	42	+32E
Glace Bay	46	00A	Saskatoon	52	+67C	Fairbanks	65	−10AL
Goose Bay	53	+ 2A	Sault Ste. Marie	47	+37E	Flagstaff	35	+27M
Granby	45	−09E	Shawinigan	47	−09E	Indianapolis	40	−15C
Guelph	44	+21E	Sherbrooke	45	−12E	Juneau	58	+58P
Halifax	45	+14A	Stratford	43	+24E	Kansas City	39	+18C
Hamilton	43	+20E	Sudbury	47	+24E	Los Angeles	34	−07P
Hull	45	+03E	Sydney	46	+01A	Louisville	38	−17C
Kapuskasing	49	+30E	The Pas	54	+45C	Memphis	35	00C
Kingston	44	+06E	Timmins	48	+26E	Miami	26	+21E
Kitchener	43	+22E	Toronto	44	+18E	Milwaukee	43	−09C
London	43	+25E	Three Rivers	46	−10E	Minneapolis	45	+13C
Medicine Hat	50	+23M	Thunder Bay	48	+57E	New Orleans	30	00C
Moncton	46	+19A	Trail	49	−09P	New York	41	−04E
Montreal	46	−06E	Truro	45	+13A	Omaha	41	+24C
Moosonee	51	+23E	Vancouver	49	+12P	Philadelphia	40	+01E
Moose Jaw	50	+62C	Victoria	48	+13P	Phoenix	33	+28M
Niagara Falls	43	+16E	Whitehorse	61	00Y	Pittsburgh	40	+20E
North Bay	46	+18E	Windsor	42	+32E	St. Louis	39	+01C
Ottawa	45	+03E	Winnipeg	50	+29C	San Francisco	38	+10P
Owen Sound	45	+24E	Yellowknife	62	+38M	Seattle	48	+09P
Penticton	49°	−02P				Washington	39	+08E

Example—Find the time of sunrise at Owen Sound, on February 12.

In the above list Owen Sound is under "45°", and the correction is +24 min. On page 15 the time of sunrise on February 12 for latitude 45° is 7.06; add 24 min. and we get 7.30 (Eastern Standard Time).

	L	Latitude 30° Sunrise	Latitude 30° Sunset	Latitude 35° Sunrise	Latitude 35° Sunset	Latitude 40° Sunrise	Latitude 40° Sunset	Latitude 44° Sunrise	Latitude 44° Sunset	Latitude 46° Sunrise	Latitude 46° Sunset	Latitude 48° Sunrise	Latitude 48° Sunset	Latitude 50° Sunrise	Latitude 50° Sunset	Latitude 54° Sunrise	Latitude 54° Sunset
		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
January	**1**	6 56	17 11	7 08	16 59	7 22	16 45	7 35	16 31	7 42	16 24	7 51	16 16	7 59	16 08	8 19	15 47
	3	6 56	17 12	7 09	17 00	7 22	16 46	7 35	16 33	7 42	16 26	7 50	16 18	7 59	16 10	8 19	15 49
	5	6 57	17 14	7 09	17 02	7 22	16 48	7 35	16 35	7 42	16 28	7 50	16 20	7 58	16 12	8 18	15 52
	7	6 57	17 15	7 09	17 04	7 22	16 50	7 35	16 37	7 42	16 30	7 50	16 22	7 57	16 14	8 17	15 54
	9	6 57	17 17	7 09	17 05	7 22	16 52	7 34	16 39	7 41	16 32	7 49	16 24	7 56	16 17	8 16	15 57
	11	6 57	17 18	7 09	17 07	7 21	16 54	7 34	16 41	7 40	16 34	7 48	16 27	7 55	16 19	8 15	16 00
	13	6 57	17.20	7 08	17 09	7 21	16 56	7 33	16 44	7 40	16 37	7 47	16 29	7 54	16 22	8 14	16 03
	15	6 57	17 22	7 08	17 11	7 20	16 58	7 32	16 46	7 39	16 39	7 46	16 32	7 53	16 25	8 12	16 07
	17	6 57	17 23	7 07	17 13	7 19	17 00	7 31	16 49	7 37	16 42	7 44	16 35	7 51	16 28	8 10	16 10
	19	6 56	17 25	7 07	17 15	7 18	17 03	7 30	16 51	7 36	16 45	7 43	16 38	7 50	16 31	8 08	16 14
	21	6 56	17 27	7 06	17 17	7 17	17 05	7 28	16 54	7 35	16 48	7 41	16 41	7 48	16 34	8 05	16 18
	23	6 55	17 28	7 05	17 19	7 16	17 07	7 27	16 57	7 33	16 51	7 40	16 44	7 46	16 38	8 03	16 21
	25	6 54	17 30	7 04	17 21	7 15	17 10	7 25	16 59	7 31	16 54	7 38	16 47	7 44	16 41	8 00	16 25
	27	6 53	17 32	7 03	17 23	7 14	17 12	7 23	17 02	7 29	16 56	7 35	16 50	7 42	16 44	7 57	16 29
	29	6 52	17 34	7 02	17 25	7 12	17 14	7 22	17 05	7 27	16 59	7 33	16 53	7 39	16 47	7 54	16 33
	31	6 51	17 35	7 00	17 27	7 11	17 17	7 20	17 08	7 25	17 02	7 31	16 57	7 36	16 51	7 51	16 37
February	**2**	6 50	17 37	6 59	17 29	7 09	17 20	7 18	17 10	7 23	17 05	7 28	17 00	7 34	16 54	7 47	16 41
	4	6 49	17 39	6 57	17 31	7 07	17 22	7 16	17 13	7 20	17 08	7 26	17 03	7 31	16 58	7 44	16 45
	6	6 48	17 41	6 56	17 33	7 05	17 24	7 13	17 16	7 18	17 11	7 23	17 06	7 28	17 01	7 40	16 49
	8	6 47	17 42	6 54	17 35	7 03	17 27	7 11	17 19	7 15	17 14	7 20	17 09	7 25	17 04	7 36	16 53
	10	6 45	17 44	6 52	17 37	7 00	17 29	7 08	17 21	7 12	17 17	7 17	17 13	7 21	17 08	7 32	16 57
	12	6 43	17 45	6 50	17 39	6 58	17 31	7 05	17 24	7 09	17 20	7 14	17 16	7 18	17 11	7 28	17 01
	14	6 42	17 47	6 48	17 41	6 56	17 34	7 03	17 27	7 06	17 23	7 10	17 19	7 14	17 15	7 24	17 05
	16	6 40	17 48	6 46	17 43	6 53	17 36	6 59	17 29	7 03	17 26	7 07	17 22	7 11	17 18	7 19	17 09
	18	6 38	17 50	6 44	17 45	6 50	17 38	6 56	17 32	7 00	17 29	7 03	17 25	7 07	17 22	7 15	17 13
	20	6 36	17 52	6 42	17 47	6 47	17 40	6 53	17 35	6 56	17 32	7 00	17 29	7 03	17 25	7 11	17 17
	22	6 34	17 53	6 39	17 48	6 45	17 43	6 50	17 38	6 53	17 35	6 56	17 32	7 00	17 29	7 06	17 21
	24	6 32	17 55	6 37	17 50	6 42	17 45	6 47	17 40	6 50	17 38	6 53	17 35	6 56	17 32	7 02	17 25
	26	6 30	17 56	6 35	17 52	6 39	17 47	6 44	17 43	6 46	17 41	6 49	17 38	6 52	17 36	6 57	17 29
	28	6 28	17 57	6 32	17 54	6 36	17 50	6 40	17 46	6 43	17 44	6 45	17 41	6 48	17 39	6 53	17 33

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

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

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

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

L		Latitude 30° Sunrise	Latitude 30° Sunset	Latitude 35° Sunrise	Latitude 35° Sunset	Latitude 40° Sunrise	Latitude 40° Sunset	Latitude 44° Sunrise	Latitude 44° Sunset	Latitude 46° Sunrise	Latitude 46° Sunset	Latitude 48° Sunrise	Latitude 48° Sunset	Latitude 50° Sunrise	Latitude 50° Sunset	Latitude 54° Sunrise	Latitude 54° Sunset
		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
November	**2**	6 15	17 12	6 22	17 05	6 30	16 56	6 38	16 49	6 42	16 45	6 46	16 40	6 51	16 35	7 03	16 24
	4	6 16	17 10	6 24	17 03	6 33	16 54	6 41	16 46	6 45	16 42	6 50	16 37	6 54	16 32	7 07	16 20
	6	6 18	17 09	6 26	17 01	6 35	16 52	6 43	16 44	6 48	16 39	6 53	16 34	6 58	16 29	7 10	16 16
	8	6 20	17 08	6 28	17 00	6 37	16 50	6 46	16 42	6 51	16 37	6 56	16 31	7 01	16 26	7 14	16 13
	10	6 21	17 07	6 30	16 58	6 39	16 48	6 49	16 39	6 53	16 34	6 59	16 28	7 05	16 23	7 18	16 09
	12	6 23	17 06	6 31	16 57	6 42	16 46	6 51	16 37	6 56	16 32	7 02	16 26	7 08	16 20	7 22	16 05
	14	6 24	17 05	6 33	16 55	6 44	16 45	6 54	16 35	6 59	16 29	7 05	16 23	7 11	16 17	7 26	16 02
	16	6 26	17 04	6 35	16 54	6 46	16 43	6 56	16 33	7 02	16 27	7 08	16 21	7 14	16 15	7 29	15 59
	18	6 28	17 03	6 37	16 53	6 49	16 42	6 59	16 31	7 05	16 25	7 11	16 19	7 18	16 12	7 33	15 57
	20	6 29	17 02	6 39	16 52	6 51	16 40	7 01	16 29	7 07	16 23	7 14	16 17	7 21	16 10	7 37	15 54
	22	6 31	17 02	6 41	16 51	6 53	16 39	7 04	16 28	7 10	16 22	7 17	16 15	7 24	16 08	7 40	15 51
	24	6 33	17 01	6 43	16 50	6 55	16 38	7 06	16 26	7 13	16 20	7 20	16 13	7 27	16 06	7 44	15 49
	26	6 34	17 01	6 45	16 49	6 57	16 37	7 09	16 25	7 15	16 19	7 23	16 11	7 30	16 04	7 47	15 47
	28	6 36	17 00	6 47	16 49	7 00	16 36	7 11	16 24	7 18	16 18	7 25	16 10	7 33	16 03	7 51	15 45
	30	6 37	17 00	6 49	16 49	7 02	16 36	7 14	16 23	7 20	16 17	7 28	16 09	7 36	16 02	7 54	15 43
December	**2**	6 39	17 00	6 50	16 48	7 04	16 36	7 16	16 23	7 23	16 16	7 30	16 08	7 38	16 00	7 57	15 42
	4	6 41	17 00	6 52	16 48	7 06	16 35	7 18	16 22	7 25	16 15	7 33	16 07	7 41	16 00	8 00	15 40
	6	6 42	17 00	6 54	16 48	7 08	16 35	7 20	16 22	7 27	16 15	7 35	16 07	7 43	15 59	8 03	15 39
	8	6 44	17 00	6 55	16 48	7 09	16 35	7 22	16 21	7 29	16 14	7 37	16 06	7 45	15 58	8 05	15 39
	10	6 45	17 01	6 57	16 49	7 11	16 35	7 24	16 21	7 31	16 14	7 39	16 06	7 47	15 58	8 08	15 38
	12	6 46	17 01	6 59	16 49	7 13	16 35	7 26	16 21	7 33	16 14	7 41	16 06	7 49	15 58	8 10	15 38
	14	6 48	17 02	7 00	16 50	7 14	16 36	7 27	16 22	7 34	16 14	7 43	16 06	7 51	15 58	8 12	15 38
	16	6 49	17 02	7 01	16 50	7 15	16 36	7 29	16 23	7 36	16 15	7 44	16 07	7 52	15 58	8 14	15 38
	18	6 50	17 03	7 03	16 51	7 17	16 37	7 30	16 23	7 37	16 16	7 46	16 07	7 54	15 59	8 15	15 39
	20	6 51	17 04	7 04	16 52	7 18	16 38	7 31	16 24	7 39	16 17	7 47	16 08	7 55	16 00	8 16	15 39
	22	6 52	17 05	7 05	16 52	7 19	16 39	7 32	16 25	7 40	16 17	7 48	16 09	7 56	16 01	8 18	15 40
	24	6 53	17 06	7 06	16 54	7 20	16 40	7 33	16 26	7 41	16 18	7 49	16 10	7 57	16 02	8 18	15 41
	26	6 54	17 07	7 06	16 55	7 21	16 41	7 34	16 27	7 41	16 20	7 50	16 12	7 58	16 04	8 19	15 43
	28	6 55	17 09	7 07	16 56	7 21	16 42	7 35	16 29	7 42	16 21	7 50	16 13	7 59	16 05	8 19	15 44
	30	6 56	17 10	7 08	16 58	7 22	16 44	7 35	16 30	7 42	16 23	7 51	16 15	7 59	16 07	8 19	15 46

TWILIGHT—BEGINNING OF MORNING AND ENDING OF EVENING

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

The above table gives the local mean time of the beginning of morning twilight, and of the ending of evening twilight, for various latitudes. To obtain the corresponding standard time, the method used is the same as for correcting the sunrise and sunset tables, as described on page 14. The entry —— in the above table indicates that at such dates and latitudes, twilight lasts all night. This table, taken from the American Ephemeris, is computed for *astronomical* twilight, i.e. for the time at which the sun is 108° from the zenith (or 18° below the horizon).

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

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

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

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

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

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

THE SKY MONTH BY MONTH

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. The times of transit at the 75th meridian are given in *local mean time*; to change to Standard Time, see p. 14. 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 E.S.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. 15–20. See also p. 9.

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. 22–27.

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.

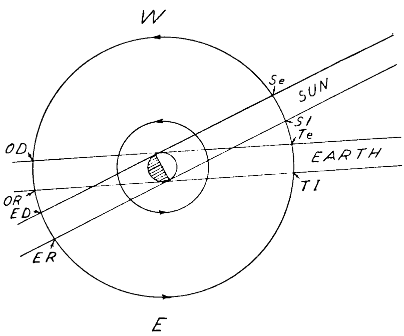
Libration is the shifting, or rather apparent shifting, of the visible disk of the moon. Sometimes the observer sees features farther around the eastern or the western limb (libration in longitude), or the northern or southern limb (libration in latitude). When the libration in longitude is positive, 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 Planets—Further information in regard to the planets, including Pluto, is found on pp. 81–94. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 95.

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.

The motions of the satellites, and the successive phenomena (see p. 95) 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. The sequence of phenomena in the diagram is: transit ingress (TI), transit egress (Te), shadow ingress (SI), shadow egress (Se), occultation disappearance (OD), occultation reappearance (OR), eclipse disappearance (ED) and eclipse reappearance (ER), but this sequence will depend on the actual sun-Jupiter-earth angle.



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. 58–80.

On January 4, there will be an occultation of the star AGK3+13°437 by the asteroid 48 Doris, visible in the eastern parts of Canada and the U.S. Further details are given on page 57. In such an occultation, the star can be thought of as casting a shadow of the asteroid on the surface of the earth. Because the asteroid and the earth are moving, the shadow moves also, just as the shadow of the moon races across the surface of the earth during a total eclipse of the sun.

By measuring the duration of the occultation at various points in and near the shadow path, astronomers can determine the size and shape of the shadow and hence of the asteroid. They can also determine a more accurate position for the star, and a more accurate orbit for the asteroid.

These methods were used successfully in the case of the spectacular occultation of the star κ Gem by the asteroid 433 Eros on January 23–24, 1975, as reported in *Sky and Telescope* **49**, 162, March 1975.

The Sun—During January, the sun's R.A. increases from 18 h 42 m to 20 h 55 m and its Decl. changes from −23°05′ to −17°24′. The equation of time changes from −3 m 22 s to −13 m 25 s. The earth is in perihelion on the 3rd, at a distance of 147,093,000 km (91,399,000 mi) from the sun.

The Moon—On January 1.0 E.S.T., the age of the moon is 12.4 d. The sun's selenographic colongitude is 65.9° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 1 (5°) and Jan. 27 (6°) and minimum (east limb exposed) on Jan. 14 (6°). The libration in latitude is maximum (north limb exposed) on Jan. 26 (7°) and minimum (south limb exposed) on Jan. 13 (7°). There is an occultation of Vesta by the moon on Jan. 24–25. Also, the moon passes through the Hyades on the night of Jan. 26–27, and many occultations can be observed (see "Occultations" section).

Mercury on the 1st is in R.A. 17 h 51 m, Decl. −24°00′, and on the 15th is in R.A. 19 h 27 m, Decl. −23°43′. Early in the month, it may be seen very low in the south-east, just before sunrise. Later in the month, it is too close to the sun to be seen, being in superior conjunction on the 21st.

Venus on the 1st is in R.A. 20 h 58 m, Decl. —19°06′, and on the 15th it is in R.A. 22 h 05 m, Decl. −13°30′, mag. −3.5, and transits at 14 h 31 m. Venus is well placed for viewing throughout 1980. This month, it is well up in the south-west at sunset, and sets about 3 hours later.

Mars on the 15th is in R.A. 11 h 12 m, Decl. +9°05′, mag. −0.2, and transits at 3 h 37 m. In Leo, it rises about 4½ hours after sunset, and is low in the west at sunrise. Mars, Jupiter and Saturn all come to opposition this winter. Watch their motion change from direct (eastward) to retrograde (westward) to direct again. These three planets, along with Regulus and Spica, provide many an interesting configuration during the year.

Jupiter on the 15th is in R.A. 10 h 47 m, Decl. +9°03′, mag. −1.9, and transits at 3 h 12 m. In Leo, it rises about 4 hours after sunset, and is low in the west at sunrise.

Saturn on the 15th is in R.A. 11 h 52 m, Decl. +3°15′, mag. +1.1, and transits at 4 h 17 m. In Virgo, between Regulus and Spica, it rises in mid-evening and is low in the south-west at sunrise.

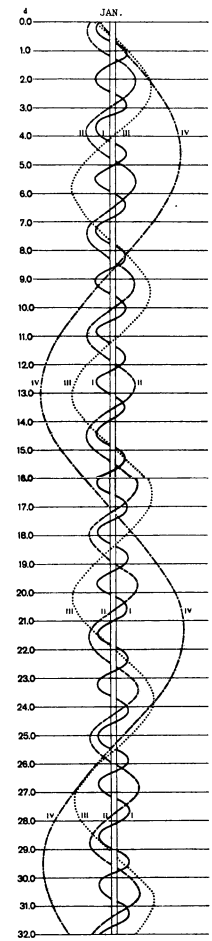
Uranus on the 15th is in R.A. 15 h 29 m, Decl. −18°40′, mag. +5.9, and transits at 7 h 54 m. It is in Libra throughout the year.

Neptune on the 15th is in R.A. 17 h 23 m, Decl. −21°49′, mag. +7.8, and transits at 9 h 47 m. It is in Ophiuchus throughout the year.

1980	d	h	m	JANUARY E.S.T.	Min. of Algol h	m
Tues.	1					
Wed.	2	04	02	Full Moon		
Thur.	3	10		Earth at perihelion	13	20
Fri.	4			Appulse: +13°0437 & Doris, (pg. 57)		
		02		Quadrantid meteors		
Sat.	5					
Sun.	6			Mercury at aphelion	10	10
		02		Regulus 0.6° N. of Moon. Occ'n[1]		
		23		Jupiter 0.3° N. of Moon. Occ'n[2]		
Mon.	7	11		Mars 2° N. of Moon		
		20		Saturn stationary		
Tues.	8	03		Moon at apogee (404, 721 km)		
		09		Saturn 0.2° S. of Moon. Occ'n[3]		
Wed.	9			Occ'n of γ Vir AB	7	00
Thur.	10	06	49	Last Quarter		
Fri.	11					
Sat.	12	23		Juno at opposition	3	50
Sun.	13	01		Uranus 5° S. of Moon		
Mon.	14			Appulse: +0°0181 & Patientia, (pg. 57)		
Tues.	15	04		Neptune 4° S. of Moon	0	40
Wed.	16					
Thur.	17	03		Mars stationary	21	30
		16	19	New Moon		
Fri.	18			Mars at greatest hel. lat. N.		
Sat.	19	21		Moon at perigee (363,254 km)		
Sun.	20	08		Venus 1° S. of Moon. Occ'n[4]	18	20
Mon.	21	04		Mercury in superior conjunction		
Tues.	22					
Wed.	23				15	10
Thur.	24	08	58	First Quarter		
		15		Vesta 0.7° S. of Moon. Occ'n		
Fri.	25					
Sat.	26			Mercury at greatest hel. lat. S.	11	50
Sun.	27	00		Aldebaran 0.3° S. of Moon. Occ'n[5]		
Mon.	28			Appulse: −1°1336 & Daphne, (pg. 57)		
Tues.	29				8	40
Wed.	30					
Thur.	31	04		Pluto stationary		
		21	21	Full Moon		

Configuration of Jupiter's Satellites (Date Markers are U.T.)

← West East →



[1]Visible in S. Pacific, S. America, S. Atlantic.
[2]Visible in S. America, Central Atlantic, W. and S. Africa.
[3]Visible in Japan, N. and Central Pacific, N.W. of S. America.
[4]Visible in N. Atlantic, Europe, N. Africa, W. Asia.
[5]Visible in Central and N. Pacific, N. and Central America.

This year is a leap year, so February has 29 days rather than 28. The extra day is inserted in years which are divisible by 4, but not in century years unless they are divisible by 400. This gives an average calendar year of $365^{d}.2425$ compared with the tropical year of $365^{d}.2422$.

Our calendar has a fascinating history, which can only be touched on here. The ancient Egyptian ceremonial calendar had 365^{d} in the year, but it was supplemented by an accurate natural calendar based on the heliacal ("with the sun") rising of Sirius. The Babylonian calendar was a lunar calendar in which the year sometimes has 12 months, sometimes 13. This calendar still survives in the modern Jewish calendar. The modern Islamic calendar is also a lunar calendar. The Julian calendar introduced a leap year every fourth year. By 1582, however, the difference between $365^{d}.25$ and $365^{d}.2422$ had caused an error of 10 days in the vernal equinox. At that point, the present Gregorian or "New Style" calendar was adopted. The Julian or "Old Style" calendar is still used for religious purposes by some Orthodox religions.

The Sun—During February, the sun's R.A. increases from 20 h 55 m to 22 h 48 m and its Decl. changes from −17°24′ to −7°36′. The equation of time changes from −13 m 34 s to −12 m 29 s. On Feb. 16, there is a total eclipse of the sun, not visible in North America.

The Moon—On February 1.0 E.S.T., the age of the moon is 13.9 d. The sun's selenographic colongitude is 82.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 23 (7°) and minimum (east limb exposed) on Feb. 11 (7°). The libration in latitude is maximum (north limb exposed) on Feb. 22 (7°) and minimum (south limb exposed) on Feb. 10 (7°).

Mercury on the 1st is in R.A. 21 h 27 m, Decl. −16°58′, and on the 15th is in R.A. 22 h 55 m, Decl. −6°48′. Early and late in the month, it is too close to the sun to be seen, but from about the 10th to the 25th, it can be seen low in the west just after sunset. It is at greatest elongation east (18°) on the 19th, at which time it stands about 17° above the horizon. See also "Venus" below.

Venus on the 1st is in R.A. 23 h 22 m, Decl. −5°14′, and on the 15th it is in R.A. 0 h 22 m, Decl. +2°05′, mag. −3.6, and transits at 14 h 45 m. It is well up in the south-west at sunset, and sets about 3½ hours later. Around the 19th, the moon makes a pretty sight with Venus and Mercury in the early evening.

Mars on the 15th is in R.A. 10 h 52 m, Decl. +11°58′, mag. −0.9, and transits at 1 h 15 m. In Leo, it rises about sunset and sets about sunrise. It is in opposition on the 25th, and since it is also in aphelion on the 25th, its nearest approach to earth (on the 26th) is about as large as it can possibly be: 100,000,000 km.

Jupiter on the 15th is in R.A. 10 h 35 m, Decl. +10°18′, mag. −2.0, and transits at 0 h 58 m. In Leo, it rises about sunset and sets about sunrise, being in opposition on the 24th.

Saturn on the 15th is in R.A. 11 h 48 m, Decl. +3°52′, mag. +1.0, and transits at 2 h 11 m. In Virgo, it rises about 3 hours after sunset, and is low in the west at sunrise.

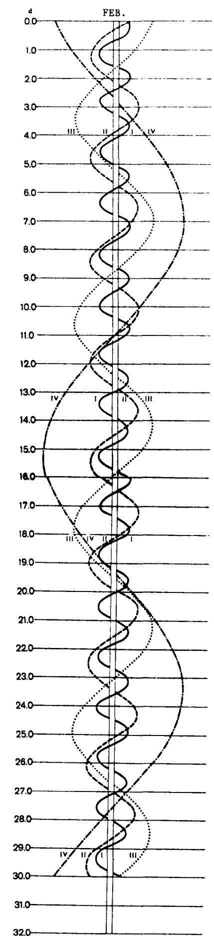
Uranus on the 15th is in R.A. 15 h 33 m, Decl. −18°51′, mag. +5.9, and transits at 5 h 55 m.

Neptune on the 15th is in R.A. 17 h 27 m, Decl. −21°52′, mag. +7.8, and transits at 7 h 49 m.

1980				FEBRUARY E.S.T.	Min. of Algol	
	d	h	m		h	m
Fri.	1				5	30
Sat.	2	10		Regulus 0.5° N. of Moon. Occ'n[1]		
Sun.	3	03		Jupiter 0.5° N. of Moon. Occ'n[2]		
		15		Mars 3° N. of Moon		
Mon.	4	15		Saturn 0.1° S. of Moon. Occ'n[3]	2	20
		21		Moon at apogee (405,605 km)		
Tues.	5					
Wed.	6				23	10
Thur.	8					
Fri.	8					
Sat.	9	02	35	☾ Last Quarter	20	00
		11		Uranus 5° S. of Moon		
Sun.	10					
Mon.	11	15		Neptune 4° S. of Moon		
Tues.	12				16	50
Wed.	13			Appulse: +19°0815 & Winchester, (pg. 57)		
Thur.	14			Mercury at ascending node		
Fri.	15				13	40
Sat.	16	03	51	● New Moon. Eclipse of ☉, pg. 55		
Sun.	17	04		Moon at perigee (358,659 km)		
		09		Mercury 2° N. of Moon		
Mon.	18				10	30
Tues.	19			Mercury at perihelion		
				Venus at ascending node		
		00		Venus 4° N. of Moon		
		07		Mercury greatest elong E. (18°)		
		16		Juno stationary		
Wed.	20					
Thur.	21	09		Vesta 1° N. of Moon. Occ'n	7	20
Fri.	22	19	14	☽ First Quarter		
Sat.	23	06		Aldebaran 0.3° S. of Moon. Occ'n[4]		
Sun.	24	13		Jupiter at opposition	4	10
Mon.	25			Mars at aphelion		
		01		Mars at opposition		
		06		Mercury stationary		
Tues.	26	01		Mars nearest to Earth		
Wed.	27				1	00
Thur.	28					
Fri.	29			Mercury at greatest hel. lat. N.	21	50
		02		Uranus stationary		
		16		Regulus 0.5° N. of Moon. Occ'n[5]		

Configuration of Jupiter's Satellites (Date Markers are U.T.)

← West East →



[1]Visible in Australasia, S. Pacific.
[2]Visible in Central and S. Pacific, S. America, S. Atlantic.
[3]Visible in N.E. Africa, S. Asia, N. Pacific.
[4]Visible in N.E. Africa, S. and Central Asia, N. Pacific.
[5]Visible in S. Atlantic, Africa, Indian Ocean.

This is the month of the vernal equinox. Notice that this happens on March 20 this year. Can you think of a reason why it is "early"? On this day the sun is on the equator and so we say that day and night are equal. Yet if you look at a table of sunrise and sunset for middle latitudes it will appear that the day is about 15 minutes longer than the night. This is partly because sunrise is defined as the moment when the sun's upper limb (rather than its centre) clears the horizon and partly because the refraction of the earth's atmosphere "lifts" the sun a bit. During March, the sunrise and sunset points move northward at the maximum rate. You can easily see this effect by observing the sunrise or sunset point over a period of two or three weeks.

(*Editor's Note*: The item above was written for the March page of the 1976 edition of this HANDBOOK by the late Dr. John F. Heard. If the vernal equinox was "early" in 1976, why is it early again in 1980?)

The Sun—During March, the sun's R.A. increases from 22 h 48 m to 0 h 42 m and its Decl. changes from −7°36′ to +4°31′. The equation of time changes from −12 m 17 s to −4 m 03 s. On the 20th, at 6 h 10 m E.S.T., the sun crosses the equator on its way north, and spring begins in the northern hemisphere.

The Moon—On March 1.0 E.S.T., the age of the moon is 13.4 d. The sun's selenographic colongitude is 75.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Mar. 22 (8°) and minimum (east limb exposed) on Mar. 10 (8°). The libration in latitude is maximum (north limb exposed) on Mar. 20 (7°) and minimum (south limb exposed) on Mar. 8 (7°). On the night of March 1-2, there is a penumbral eclipse of the moon.

Mercury on the 1st is in R.A. 23 h 19 m, Decl. −0°40′, and on the 15th is in R.A. 22 h 37 m, Decl. −6°24′. It is too close to the sun to be seen.

Venus on the 1st is in R.A. 1 h 26 m, Decl. +9°45′, and on the 15th it is in R.A. 2 h 25 m, Decl. +16°13′, mag. −3.8, and transits at 14 h 53 m. It is well up in the west at sunset, and sets about 4 hours later.

Mars on the 15th is in R.A. 10 h 10 m, Decl. +15°29′, mag. −0.7, and transits at 22 h 34 m. In Leo, it is well up in the east at sunset, and sets about an hour before sunrise. In retrograde motion, it passes 3° north of Jupiter on the 2nd, and 4° north of Regulus on the 17th.

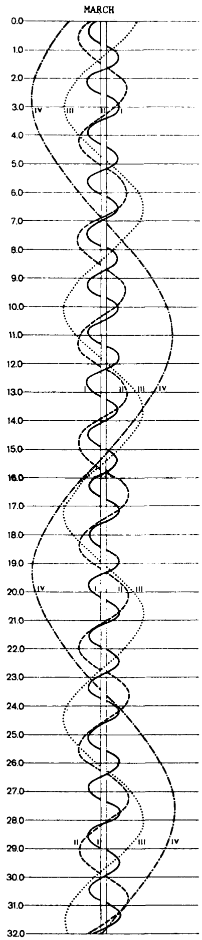
Jupiter on the 15th is in R.A. 10 h 21 m, Decl. +11°41′, mag. −2.0, and transits at 22 h 45 m. In Leo, it is low in the east at sunset, and sets about an hour before sunrise; see also "Mars" above.

Saturn on the 15th is in R.A. 11 h 40 m, Decl. +4°46′, mag. +0.8, and transits at 0 h 09 m. Moving from Virgo into Leo, it rises at about sunset, and sets at about sunrise, being in opposition on the 13th (E.S.T.).

Uranus on the 15th is in R.A. 15 h 33 m, Decl. −18°51′, mag. +5.8, and transits at 4 h 01 m.

Neptune on the 15th is in R.A. 17 h 28 m, Decl. −21°52′, mag. +7.8, and transits at 5 h 56 m.

1980				MARCH E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	← West East →
Sat.	1	03		Mars 4° N. of Moon			
		03		Jupiter 0.9° N. of Moon. Occ'n[1]			
		16	00	☺ Full Moon. Penumbral Eclipse of ☾, pg. 55			
Sun.	2	14		Mars 3° N. of Jupiter			
		19		Saturn 0.2° N. of Moon. Occ'n[2]			
Mon.	3	06		Moon at apogee (406,243 km)	18	40	
Tues.	4			Occ'n of γ Vir AB			
Wed.	5						
Thur.	6	01		Mercury in inferior conjunction	15	20	
Fri.	7	19		Uranus 5° S. of Moon			
Sat.	8						
Sun.	9	18	49	☾ Last Quarter	12	10	
Mon.	10	00		Neptune 3° S. of Moon			
		04		Pallas in conjunction with Sun			
Tues.	11						
Wed.	12				9	00	
Thur.	13	21		Saturn at opposition			
Fri.	14						
Sat.	15	08		Mercury 3° N. of Moon	5	50	
Sun.	16	13	56	☺ New Moon			
		16		Moon at perigee (356,928 km)			
Mon.	17	16		Mars 4° N. of Regulus			
Tues.	18	10		Mercury stationary	2	40	
Wed.	19	01		Ceres 0.2° S. of Moon. Occ'n			
		15		Venus 7° N. of Moon			
Thur.	20	06	10	Equinox. Spring begins.	23	30	
Fri.	21	13		Aldebaran 0.4° S. of Moon. Occ'n[3]			
Sat.	22						
Sun.	23			Mercury at descending node	20	20	
		07	31	☽ First Quarter			
Mon.	24			Venus at perihelion			
		14		Neptune stationary			
Tues.	25						
Wed.	26				17	10	
Thur.	27	18		Mars 4° N. of Moon			
		22		Regulus 0.5° N. of Moon. Occ'n[4]			
Fri.	28	03		Jupiter 1° N. of Moon. Occ'n[5]			
Sat.	29	21		Saturn 0.4° N. of Moon. Occ'n[6]	14	00	
Sun.	30	07		Moon at apogee (406,336 km)			
Mon.	31	10	14	☺ Full Moon			



[1]Visible in S. Pacific, Antarctica, S. of S. America

[2]Visible in N. of S. America, Atlantic, Africa, Indian Ocean

[3]Visible in N. of S. America, Central and N. America, N. Atlantic, N. Africa, Europe, W. Asia.

[4]Visible in Pacific, S. America.

[5]Visible in New Zealand, Antarctica.

[6]Visible in Central and S. America, S. Atlantic, S. Africa.

In many parts of this country, communities change from Standard Time to Daylight Saving Time by adding one hour at midnight on the last Saturday in April, and subtracting it at midnight on the last Saturday in October. Daylight Saving Time makes a great deal of sense, especially in these energy-conscious times. As you can see from the sun tables earlier in this HANDBOOK, the availability of sunlight is more or less symmetrical about noon. Much of urban activity is not. Our waking and working hours are centred in mid-afternoon when the temperature is hottest, and the need for air conditioning is greatest. A rational examination of Daylight Saving Time (see references below) suggests that it should begin about a month earlier than it does (to be more symmetrical about the longest day—which occurs in June), and that Double Daylight Saving Time might be advantageous in June and July.

Two fascinating articles on this topic have recently been published: "On the Management of Daylight Saving Time in Southern Ontario" by Kim and Sandra Innanen, *J. Roy. Astron. Soc. Can.* **72**, 209 (1978), and "Standard and Daylight Saving Time" by Ian R. Bartky and Elizabeth Harrison, *Scientific American* **240**, No. 5, 46 (May 1979).

The Sun—During April, the sun's R.A. increases from 0 h 42 m to 2 h 33 m and its Decl. changes from +4°31′ to +15°03′. The equation of time changes from −3 m 45 s to +2 m to 52 s.

The Moon—On April 1.0 E.S.T., the age of the moon is 15.0 d. The sun's selenographic colongitude is 93.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on April 20 (7°) and minimum (east limb exposed) on April 7 (7°). The libration in latitude is maximum (north limb exposed) on April 17 (7°) and minimum (south limb exposed) on April 4 (7°).

Mercury on the 1st is in R.A. 23 h 02 m, Decl. −7° 46′, and on the 15th is in R.A. 0 h 06 m, Decl. −2°12′. Throughout the month, Mercury appears very low in the east, just before sunrise. Greatest elongation west (28°) occurs on the 2nd, but this is a classic example of an unfavourable greatest elongation.

Venus on the 1st is in R.A. 3 h 37 m, Decl. +22°27′, and on the 15th it is in R.A. 4 h 34 m, Decl. +25°49′, mag. −4.1, and transits at 14 h 59 m. A fine month for Venus watching! Greatest elongation east (46°) occurs on the 5th, and throughout the month, the planet is well up in the west at sunset, and sets about 4 hours later. Early in the month, it passes south of the Pleiades and later passes north of the Hyades, being 9° north of Aldebaran on the 15th. The crescent moon is part of this display around the 18th.

Mars on the 15th is in R.A. 9 h 58 m, Decl. +15°16′, mag. 0.0, and transits at 20 h 22 m. In Leo, it is high in the south-east at sunset, and sets about 2 hours before sunrise. It passes 1.8° north of Regulus on the 29th, in direct motion. The waxing moon joins the display (with Jupiter and Saturn) around the 24th.

Jupiter on the 15th is in R.A. 10 h 12 m, Decl. +12°30′, mag. −1.9, and transits at 20 h 35 m. In Leo, it is well up in the south-east at sunset, and sets about 2 hours before sunrise.

Saturn on the 15th is in R.A. 11 h 32 m, Decl. +5°38′, mag. +0.9, and transits at 21 h 55 m. In Leo, it is well up in the south-east at sunset, and sets before sunrise.

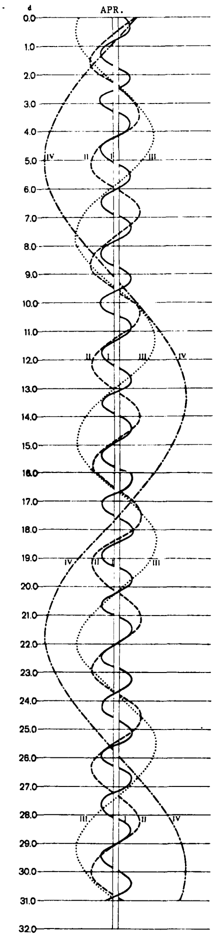
Uranus on the 15th is in R.A. 15 h 30 m, Decl. −18°40′, mag. +5.8, and transits at 1 h 56 m.

Neptune on the 15th is in R.A. 17 h 28 m, Decl. −21°50′, mag. +7.7, and transits at 3 h 54 m.

1980	d	h	m	APRIL E.S.T.	Min. of Algol h	m
Tues.	1				10	50
Wed.	2	12		Mercury greatest elong. W. (28°)		
Thur.	3			Mercury at aphelion		
Fri.	4	00		Uranus 5° S. of Moon	7	40
Sat.	5	10		Venus greatest elong. E. (46°)		
Sun.	6	07		Neptune 3° S. of Moon		
Mon.	7	09		Mars stationary	4	30
Tues.	8	07	06	☾ Last Quarter		
Wed.	9	22		Pluto at opposition		
Thur.	10				1	20
Fri.	11					
Sat.	12				22	00
Sun.	13	04		Mercury 0.02° N. of Moon. Occ'n[1]		
Mon.	14	02		Moon at perigee (358,289 km)		
		22	46	● New Moon		
Tues.	15			Venus at greatest hel. lat. N.	18	50
		02		Venus 9° N. of Aldebaran		
Wed.	16	05		Ceres 1° N. of Moon. Occ'n		
Thur.	17	23		Aldebaran 0.6° S. of Moon. Occ'n[2]		
Fri.	18	04		Venus 9° N. of Moon	15	40
Sat.	19					
Sun.	20					
Mon.	21	21		Lyrid meteors	12	30
		21	59	☽ First Quarter		
Tues.	22			Graze of ZC 1236 ABC		
Wed.	23			Mercury at greatest hel. lat. S.		
Thur.	24	02		Mars 2° N. of Moon	9	20
		04		Regulus 0.3° N. of Moon. Occ'n[3]		
		06		Jupiter 1° N. of Moon. Occ'n[4]		
Fri.	25					
Sat.	26	00		Saturn 0.3° N. of Moon. Occ'n[5]		
		12		Jupiter stationary		
		15		Moon at apogee (405,785 km)		
Sun.	27				6	10
Mon.	28					
Tues.	29	18		Mars 1.8° N. of Regulus		
Wed.	30	02	35	○ Full Moon	3	00

Configuration of Jupiter's Satellites (Date Markers are U.T.)

← West East →



[1]Visible E. of S. America, S. Atlantic, Africa, S. Asia.
[2]Visible in Asia, N. Pacific, N. America.
[3]Visible in S.E. Asia, E. Indies, N.E. Australia, S. Pacific.
[4]Visible in Indian Ocean, S.W. Australia, Antarctica.
[5]Visible in Pacific, S. America.

THE SKY FOR MAY 1980

Much to my surprise, my explanation for the term *Honey Moon* (1979 HANDBOOK, page 50) was picked up by the News Services and distributed quite widely. I tried to make clear that my explanation, based on celestial geometry and atmospheric reddening, was *an* explanation but not *the* explanation!

There are many other effects of atmospheric reddening. The most obvious is the rising or setting sun. When the sunlight passes through a great thickness of atmosphere, most of the blue light is absorbed and scattered away; the red light comes through preferentially. The rising moon, at full phase or a few days past, is another of my favourite astronomical sights. The reddening of stars, when they are seen close to the horizon, is less obvious to the casual observer, but as one who uses telescopes to measure accurate magnitudes and colours of stars, I am well aware of this effect. Finally, the red colour of the moon during a total eclipse of the moon is due to sunlight passing through the earth's atmosphere (and being reddened) and being bent into the earth's shadow.

The Sun—During May, the sun's R.A. increases from 2 h 33 m to 4 h 36 m and its Decl. changes from +15°03′ to +22°03′. The equation of time changes from +3 m 01 s to +2 m 21 s.

The Moon—On May 1.0 E.S.T., the age of the moon is 15.6 d. The sun's selenographic colongitude is 99.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 18 (7°) and minimum (east limb exposed) on May 5 (6°). The libration in latitude is maximum (north limb exposed) on May 14 (7°) and minimum (south limb exposed) on May 1 (7°) and May 28 (7°).

Mercury on the 1st is in R.A. 1 h 44 m, Decl. +8°48′, and on the 15th is in R.A. 3 h 35 m, Decl. +19°43′. Early in the month, it is still *very* low in the east at sunrise, but by the 13th it is in superior conjunction. It emerges rapidly into the evening sky, and by the 31st, it can be seen about 15° above the western horizon at sunset.

Venus on the 1st is in R.A. 5 h 30 m, Decl. +27°34′, and on the 15th it is in R.A. 6 h 04 m, Decl. +27°25′, mag. −4.2, and transits at 14 h 30 m. Passing from Taurus into Gemini, it is still well up in the west at sunset, and sets about 3 hours later. Greatest brilliancy (−4.2) is on the 8th (E.S.T.).

Mars on the 15th is in R.A. 10 h 24 m, Decl. +11°48′, mag. +0.6, and transits at 18 h 50 m. In Leo, it is well up in the south at sunset, and sets about 6 hours later. It passes 0.8° north of Jupiter on the 4th. The moon passes by on the 21st and 22nd.

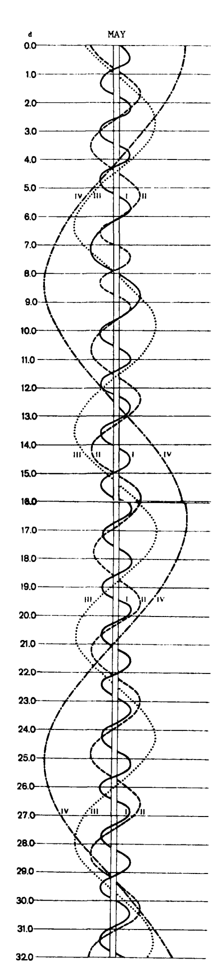
Jupiter. on the 15th is in R.A. 10 h 13m, Decl. +12°19′, mag. −1.7, and transits at 18 h 38 m. In Leo, it is well up in the south at sunset, and sets about 6 hours later; see also "Mars" above.

Saturn on the 15th is in R.A. 11 h 28 m, Decl. +6°00′, mag. +1.1, and transits at 19 h 53 m. In eastern Leo, it is well up in the south at sunset, and sets at about midnight.

Uranus on the 15th is in R.A. 15 h 25 m, Decl. −18°23′, mag. +5.7, and transits at 23 h 49 m. Opposition occurs on the 14th.

Neptune on the 15th is in R.A. 17 h 26 m, Decl. −21°48′, mag. +7.7, and transits at 1 h 54 m.

1980				MAY E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Thur.	1	04		Uranus 5° S. of Moon			
Fri.	2				23	50	
Sat.	3	11		Neptune 3° S. of Moon			
Sun.	4	01		Mars 0.8° N. of Jupiter			
		03		η Aquarid meteors			
Mon.	5				20	40	
Tues.	6						
Wed.	7	15	51	☾ Last Quarter			
Thur.	8	22		Venus greatest brilliancy (−4.2)	17	30	
Fri.	9						
Sat.	10						
Sun.	11	10		Pallas 0.6° N. of Moon. Occ'n	14	10	
Mon.	12			Mercury at ascending node			
		08		Moon at perigee (362,198 km)			
Tues.	13	04		Mercury in superior conjunction			
Wed.	14	00		Uranus at opposition	11	00	
		07	00	● New Moon			
Thur.	15	09		Aldebaran 0.6° S. of Moon. Occ'n[1]			
Fri.	16	23		Venus 8° N. of Moon			
Sat.	17			Mercury at perihelion	7	50	
Sun.	18	01		Ceres in conjunction with sun			
Mon.	19						
Tues.	20				4	40	
Wed.	21	12		Regulus 0.02° S. of Moon. Occ'n[2]			
		14	16	☽ First Quarter			
		15		Jupiter 0.6° N. of Moon. Occ'n[3]			
Thur.	22	01		Mars 0.4° N. of Moon. Occ'n[4]			
Fri.	23	02		Saturn stationary	1	30	
		05		Saturn 0.1° N. of Moon. Occ'n[5]			
Sat.	24	06		Moon at apogee (404,832 km)			
		14		Venus stationary			
				Occ'n of γ Vir AB			
Sun.	25				22	20	
Mon.	26						
Tues.	27			Mercury at greatest hel. lat. N.			
Wed.	28	08		Uranus 5° S. of Moon	19	10	
Thur.	29	16	28	○ Full Moon			
Fri.	30	16		Neptune 3° S. of Moon			
Sat.	31				16	00	



[1]Visible in Central and N. America, Greenland, N. Atlantic, Europe, W. Asia.
[2]Visible in N. Atlantic, S. Iberia, Africa, Indian Ocean.
[3]Visible in S. America, S. Atlantic, S. Africa.
[4]Visible in Australasia, S. Pacific.
[5]Visible in S. Asia, Australasia.

The Sun—During June, the sun's R.A. increases from 4 h 36 m to 6 h 40 m and its Decl. changes from +22°03′ to +23°07′. The equation of time changes from +2 m 12 s to −3 m 39 s. On the 21st, at 0 h 47 m E.S.T., summer begins in the northern hemisphere, as the sun stands over the Tropic of Cancer.

The Moon—On June 1.0 E.S.T., the age of the moon is 17.3 d. The sun's selenographic colongitude is 117.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 14 (6°) and minimum (east limb exposed) on June 1 (5°) and June 27 (5°). The libration in latitude is maximum (north limb exposed) on June 10 (7°) and minimum (south limb exposed) on June 24 (7°). See also "Saturn" below.

Mercury on the 1st is in R.A. 6 h 01 m, Decl. +25°37′, and on the 15th is in R.A. 7 h 21 m, Decl. +23°07′. On the 1st, Mercury is 0.3° north of Venus. At that time, the two planets can be seen low in the west, just after sunset. They are at the foot of Gemini, which is standing upright above the western horizon. Greatest elongation of Mercury (24° E.) occurs on the 14th, at which time the planet stands about 17° above the horizon.

Venus on the 1st is in R.A. 6 h 07 m, Decl. +25°25′, and on the 15th it is in R.A. 5 h 36 m, Decl. +22°14′, mag. −2.6, and transits at 12 h 00 m. The planet can be seen early in the month (see "Mercury" above), but is in inferior conjunction by the 15th.

Mars on the 15th is in R.A. 11 h 12 m, Decl. +6°08′, mag. +1.1, and transits at 17 h 36 m. In Leo, it is high in the south-west at sunset, and sets about 4 hours later. It passes 1.7° south of Saturn on the 25th.

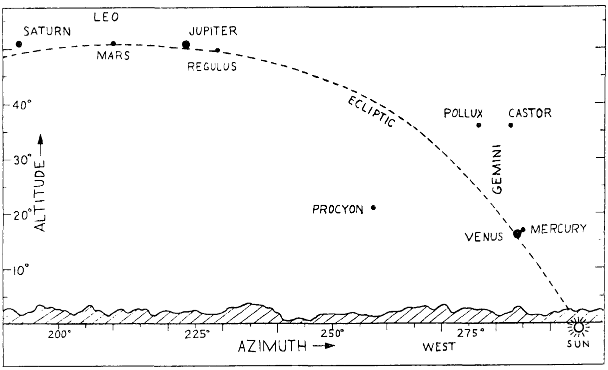
Jupiter on the 15th is in R.A. 10 h 24 m, Decl. +11°11′, mag. −1.5, and transits at 16 h 48 m. In Leo, it is high in the south-west at sunset, and sets about 4 hours later.

Saturn on the 15th is in R.A. 11 h 29 m, Decl. +5°45′, mag. +1.3, and transits at 17 h 53 m. On the eastern boundary of Leo, it is high in the south-west at sunset, and sets about 4½ hours later. See also "Mars" above. Note the occultation of Saturn by the moon on June 19 (see "Occultations" section)..

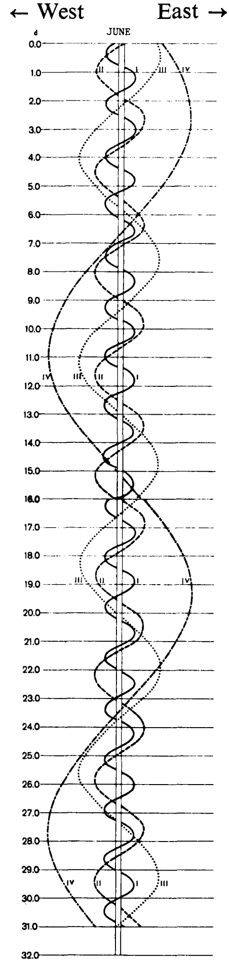
Uranus on the 15th is in R.A. 15 h 20 m, Decl. −18° 05′, mag. +5.8, and transits at 21 h 42 m.

Neptune on the 15th is in R.A. 17 h 22 m, Decl. −21°45′, mag. +7.7, and transits at 23 h 44 m. Opposition occurs on the 11th (E.S.T.).

The diagram below shows the particularly striking appearance of the western sky, just after sunset, at the beginning of June.



1980				JUNE E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Sun.	1	13		Mercury 0.3° N. of Venus			
Mon.	2						
Tues.	3				12	50	
Wed.	4						
Thur.	5	21	53	☾ Last Quarter			
Fri.	6				9	30	
Sat.	7						
Sun.	8	23		Moon at perigee. (367,630 km)			
Mon.	9				6	20	
Tues.	10			Venus at descending node			
Wed.	11	19		Aldebaran 0.7° S. of Moon. Occ'n[1]			
		22		Neptune at opposition			
Thur.	12	15	38	● New Moon	3	10	
Fri.	13						
Sat.	14	09		Mercury greatest elong. E. (24°)			
		15		Mercury 4° N. of Moon			
Sun.	15	02		Venus in inferior conjunction	0	00	
Mon.	16						
Tues.	17	20		Regulus 0.3° S. of Moon. Occ'n[2]	20	50	
Wed.	18	05		Jupiter 0.01° S. of Moon. Occ'n[3]			
Thur.	19			Mercury at descending node			
		09		Mars 2° S. of Moon			
		14		Saturn 0.3° S. of Moon. Occ'n[4]			
Fri.	20	07	32	☽ First Quarter	17	40	
Sat.	21	00	47	Solstice. Summer begins			
		01		Moon at apogee (404,184 km)			
Sun.	22						
Mon.	23	16		Mercury 8° S. of Pollux	14	30	
Tues.	24	14		Uranus 5° S. of Moon			
Wed.	25	08		Mars 1.7° S. of Saturn			
		17		Vesta in conjunction with Sun			
Thur.	26	23		Neptune 3° S. of Moon	11	20	
Fri.	27	15		Mercury stationary			
Sat.	28	04	02	○ Full Moon			
Sun.	29				8	00	
Mon.	30			Mercury at perihelion			



[1]Visible in Central and E. Asia, N. Pacific, N. America.
[2]Visible in N. Pacific, W. of N. America, Central America, N.W. of S. America.
[3]Visible in N.E. Africa, S. Asia, Australasia.
[4]Visible in N. America, N. Atlantic, S.W. Iberia, Africa.

Have you ever tried to rationalize the changing brightnesses of the planets during the year? The brightnesses are listed on these pages each month, and are shown on the graph on page 94.

Neptune and Uranus remain fairly constant in brightness, because their distance from the sun (which provides their light) and the earth (which receives it) does not change very much.

Saturn and Jupiter are noticeably brighter at opposition, because then they are closest to earth. But is this true for Saturn in 1980? Look on page 94 to find out.

In the case of Mars, and particularly Venus and Mercury, there is another consideration. The planet is not always fully illuminated as seen from the earth. And the brightness is not simply proportional to the fraction illuminated: the full moon is 13 times brighter than the first or last quarter moon! Perhaps you can understand now why Venus, for instance, is not brightest when it is nearest the earth at inferior conjunction.

You can estimate the brightness of a planet by comparing it with some of the brightest stars (see table thereof, page 108). It helps if the comparison stars are approximately the same colour as the planet, and at approximately the same altitude.

The Sun—During July, the sun's R.A. increases from 6 h 40 m to 8 h 45 m and its Decl. changes from +23°07′ to +18° 02′. The equation of time changes from −3 m 50 s to −6 m 17 s. On the 5th, the earth is in aphelion, at a distance of 152,100,000 km (94,511,000 mi) from the sun.

The Moon—On July 1.0 E.S.T., the age of the moon is 17.9 d. The sun's selenographic colongitude is 124.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 12 (5°) and minimum (east limb exposed) on July 24 (6°). The libration in latitude is maximum (north limb exposed) on July 7 (7°) and minimum (south limb exposed) on July 22 (7°). On July 27, there is a penumbral eclipse of the moon, not visible in North America. See also "Venus" and "Jupiter" below.

Mercury on the 1st is in R.A. 7 h 45 m, Decl. +18°24′, and on the 15th is in R.A. 7 h 14 m, Decl. +17°24′. Early in the month, it is *very* low in the west, just after sunset. It passes through inferior conjunction on the 11th, and by the end of the month, it can be seen low in the east, just before sunrise. It is still in Gemini, but now Gemini is lying on its side! Greatest elongation west (19°) occurs on the 31st (E.S.T.).

Venus on the 1st is in R.A. 5 h 04 m, Decl. +18°42′, and on the 15th it is in R.A. 5 h 07 m, Decl. +17°50′, mag. −4.2, and transits at 9 h 33 m. It rises about 2 hours before the sun, and at sunrise is low in the east (but higher than Mercury). Greatest brilliancy (−4.2) occurs on the 21st. Note the occultation of Venus by the moon on July 9 (see "Occultations" section).

Mars on the 15th is in R.A. 12 h 09 m, Decl. −0°40′, mag. +1.3, and transits at 16 h 36 m. In Virgo, it is well up in the south-west at sunset, and sets about 3 hours later.

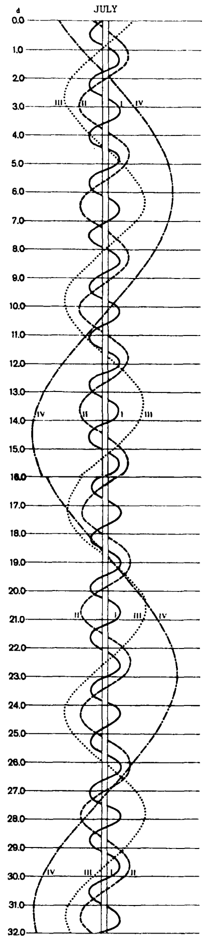
Jupiter on the 15th is in R.A. 10 h 42 m, Decl. +9°24′, mag. −1.4, and transits at 15 h 08 m. In Leo, it is low in the west at sunset, and sets about 2 hours later. Note the occultation of Jupiter by the moon on July 15-16, visible from some parts of N. America (see "Occultations" section).

Saturn on the 15th is in R.A. 11 h 36 m, Decl. +4°56′, mag. +1.4, and transits at 16 h 01 m. Moving from Leo back into Virgo, it is low in the south-west at sunset, and sets about 3 hours later.

Uranus on the 15th is in R.A. 15 h 17 m, Decl. −17° 54′, mag. +5.8, and transits at 19 h 42 m.

Neptune on the 15th is in R.A. 17 h 19 m, Decl. −21°42′, mag. +7.7, and transits at 21 h 43 m.

1980				JULY E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	← West East →
Tues.	1	16		Mercury 10° S. of Pollux			
Wed.	2				4	50	
Thur.	3						
Fri.	4	11		Moon at perigee (369,615 km)			
Sat.	5	02	27	☾ Last Quarter	1	40	
		12		Earth at aphelion			
		23		Pluto stationary			
Sun.	6	12		Venus stationary			
Mon.	7				22	30	
Tues.	8						
Wed.	9	02		Aldebaran 0.6° S. of Moon. Occ'n[1]			
		14		Venus 0.2° S. of Moon. Occ'n[2]			
Thur.	10				19	20	
Fri.	11	14		Mercury in inferior conjunction			
Sat.	12	01	46	☺ New Moon			
Sun.	13				16	10	
Mon.	14						
Tues.	15			Venus at aphelion			
		04		Regulus 0.4° S. of Moon. Occ'n[3]			
		22		Jupiter 0.6° S. of Moon. Occ'n[4]			
Wed.	16				13	00	
Thur.	17	02		Saturn 0.7° S. of Moon. Occ'n[5]			
		23		Mars 4° S. of Moon			
Fri.	18	19		Moon at apogee (404,352 km)			
Sat.	19				9	40	
Sun.	20			Mercury at greatest hel. lat. S.			
		00	51	☽ First Quarter			
Mon.	21	21		Venus greatest brilliancy (−4.2)			
		22		Uranus 5° S. of Moon			
Tues.	22	06		Mercury stationary	6	30	
Wed.	23						
Thur.	24	07		Neptune 3° S. of Moon			
Fri.	25				3	20	
Sat.	26						
Sun.	27	13	54	☺ Full Moon. Penumbral Eclipse of ☾, pg. 55			
Mon.	28	06		S. δ Aquarid meteors	0	10	
Tues.	29						
Wed.	30	10		Uranus stationary	21	00	
		18		Moon at perigee (365,836 km)			
Thur.	31	21		Mercury greatest elong. W. (19°)			



[1]Visible in N. Atlantic, N. Africa, Europe, Asia.
[2]Visible in Pacific, N. and Central America, N. of S. America.
[3]Visible in N. Africa, Europe, Asia, E. Indies.
[4]Visible in N.E. Asia, Arctic, N. Pacific, W. of N. America.
[5]Visible in E. Asia, Arctic, N. Pacific, Alaska.

August and September are rather poor months for planet-viewing this year. Only Venus is well-placed: it is a morning "star", reaching greatest elongation west on Aug. 24. By late fall, there will be an abundance of bright planets in the morning sky: Mercury, Venus, Jupiter and Saturn, with Regulus and Spica thrown in for good measure. But for those of us who organize public star nights, and do "star-gazing" with our classes, the evening sky will be rather dull.

August brings other celestial treats, however. For the observer far from city lights, it is an ideal time to see the Milky Way. The Milky Way is the combined light of millions of faint stars in our disc-shaped galaxy, which we see from within. The centre of our galaxy lies in the direction of the constellation Sagittarius, which is low in the south in the summer evening. Many people recognize the Teapot, a striking star pattern among the stars of Sagittarius. From Sagittarius, the Milky Way extends northward through Aquila, Cygnus and Cassiopeia. Try lying on your back, slowly scanning along the Milky Way with binoculars.

August also brings the Perseid meteor shower, the richest and best-known of the annual showers. This year, it should be especially rewarding because it occurs near new moon, when the sky (at least for the observer away from city lights) is much darker than average.

The Sun—During August, the sun's R.A. increases from 8 h 45 m to 10 h 41 m and its Decl. changes from +18°02′ to +8°18′. The equation of time changes from −6 m 13 s to −0 m 08 s. On Aug. 10, there is an annular eclipse of the sun, the partial phases visible in Mexico and the southern U.S.

The Moon—On August 1.0 E.S.T., the age of the moon is 19.5 d. The sun's selenographic colongitude is 143.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 7 (6°) and minimum (east limb exposed) on Aug. 21 (7°). The libration in latitude is maximum (north limb exposed) on Aug. 4 (7°) and Aug. 31 (7°) and minimum (south limb exposed) on Aug. 18 (7°). On the night of Aug. 25-26, there is a penumbral eclipse of the moon.

Mercury on the 1st is in R.A. 7 h 23 m, Decl. +20°11′, and on the 15th is in R.A. 8 h 53 m, Decl. +18°42′. Early in the month, it can be seen low in the east just before sunrise (see "Mercury" and "Venus" last month), but by the 26th it is in superior conjunction.

Venus on the 1st is in R.A. 5 h 43 m, Decl. +18°42′, and on the 15th it is in R.A. 6 h 29 m, Decl. +19°28′, mag. −4.1, and transits at 8 h 55 m. It is well placed among the "winter six" constellations in the morning sky, rising about 3½ hours before the sun, and standing about 37° above the eastern horizon at sunrise. Greatest elongation west (46°) occurs on the 24th.

Mars on the 15th is in R.A. 13 h 17 m, Decl. −8°19′, mag. +1.4, and transits at 15 h 41 m. In Virgo, it can be seen low in the south-west, just after sunset, but is rather unfavourably situated for northern observers. It passes 2° north of Spica on the 17th.

Jupiter on the 15th is in R.A. 11 h 04 m, Decl. +7°04′, mag. −1.2, and transits at 13 h 28 m. Though technically an evening "star", it is too close to the sun to be seen.

Saturn on the 15th is in R.A. 11 h 47 m, Decl. +3°41′, mag. +1.3, and transits at 14 h 10 m. It is very low in the west at sunset.

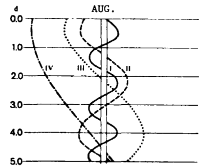
Uranus on the 15th is in R.A. 15 h 17 m, Decl. −17°55′, mag. +5.9 and transits at 17 h 40 m.

Neptune on the 15th is in R.A. 17 h 17 m, Dec. −21°41′, mag. +7.7, and transits at 19 h 39 m.

1980				AUGUST E.S.T.	Min. of Algol	
	d	h	m		h	m
Fri.	1					
Sat.	2				17	50
Sun.	3			Mars at descending node		
		07	00	☾ Last Quarter		
Mon.	4					
Tues.	5	01		Mercury 8° S. of Pollux	14	40
		08		Aldebaran 0.5° S. of Moon. Occ'n[1]		
Wed.	6			Venus at greatest hel. lat. S.		
		21		Venus 0.3° S. of Moon. Occ'n[2]		
Thur.	7					
Fri.	8			Mercury at ascending node	11	20
Sat.	9	05		Mercury 2° N. of Moon		
Sun.	10	14	09	● New Moon. Eclipse of ☉, pg. 55		
Mon.	11	21		Perseid meteors	8	10
Tues.	12					
		16		Jupiter 1° S. of Moon. Occ'n[3]		
Wed.	13	14		Saturn 1° S. of Moon. Occ'n[4]		
Thur.	14				5	00
Fri.	15	13		Moon at apogee (405,245 km)		
		16		Mars 5° S. of Moon		
Sat.	16			Appulse: +0°1581 & Parthenope (pg. 57)		
Sun.	17	20		Mars 2° N. of Spica	1	50
Mon.	18	06		Uranus 5° S. of Moon		
		17	28	☽ First Quarter		
Tues.	19				22	40
Wed.	20	15		Neptune 3° S. of Moon		
Thur.	21					
Fri.	22				19	30
Sat.	23			Mercury at greatest hel. lat. N.		
Sun.	24	14		Venus greatest elong. W. (46°)		
Mon.	25	22	42	○ Full Moon. Penumbral Eclipse of ☾, pg. 55	16	20
Tues.	26	07		Mercury in superior conjunction		
Wed.	27	14		Moon at perigee (360,875 km)		
Thur.	28				13	00
Fri.	29					
Sat.	30					
Sun.	31	22		Neptune stationary	9	50

Configuration of Jupiter's Satellites (Date Markers are U.T.)

← West East →



[1]Visible in N. Pacific, N. America, N. Atlantic, Greenland, W. Europe, N.W. Africa.
[2]Visible in N.E. Africa, Asia, N. Pacific.
[3]Visible in Arctic, Greenland.
[4]Visible in Arctic, Greenland, N.E. of N. America, W. Europe, N.W. Africa.

THE SKY FOR SEPTEMBER 1980

This is a good month to observe the visible effects of the season. Here are some sample projects (suitable also for school classes). (i) Look up the *sunrise and sunset times* in the newspaper, calculate the length of day and night, and tabulate or plot these four quantities for each day in September. When are day and night equal? At the equinox? Are sunrise and sunset symmetrical about noon? (ii) On each clear day in September, observe and sketch the *sunrise or sunset point* as seen from a constant vantage point (with a clear horizon). Can you see the southward motion of the sun? When does the sun rise/set due east/west? (iii) On each clear day in September measure the maximum altitude of the sun. The best way to do this is to measure the minimum length of the shadow of a vertical pole or stick, of known height. The altitude of the sun—its angular distance above the horizon—can then be determined by simple geometry or trigonometry. Alternatively, you can make a simple altitude-measuring device from a protractor. When is the sun at its maximum altitude each day? At noon? In what direction? How does the maximum altitude change during the month?

The Sun—During September, the sun's R.A. increases from 10 h 41 m to 12 h 29 m and its Decl. changes from +8°18′ to −3°10′. The equation of time changes from +0 m 11 s to +10 m 09 s. On Sept. 22, at 16 h 09 m E.S.T., the sun crosses the equator on its way south, and autumn begins in the northern hemisphere.

The Moon—On September 1.0 E.S.T., the age of the moon is 21.0 d. The sun's selenographic colongitude is 161.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 3 (7°) and minimum (east limb exposed) on Sept. 19 (7°). The libration in latitude is maximum (north limb exposed) on Sept. 27 (7°) and minimum (south limb exposed) on Sept. 14 (7°).

Mercury on the 1st is in R.A. 11 h 03 m, Decl. +7°43′, and on the 15th is in R.A. 12 h 30 m, Decl. −3°05′. Though technically an evening "star", it is too close to the sun to be seen.

Venus on the 1st is in R.A. 7 h 38 m, Decl. +19°04′, and on the 15th it is in R.A. 8 h 39 m, Decl. +17°07′, mag. −3.8, and transits at 9 h 02 m. A classic favourable elongation: it rises about 4 hours before the sun, and by sunrise it stands about 40° above the eastern horizon, above Regulus and below Castor and Pollux.

Mars on the 15th is in R.A. 14 h 34 m, Decl. −15°40′, mag. +1.5, and transits at 14 h 56 m. Moving from Virgo into Libra, it is very low in the south-west at sunset and sets about 2 hours later.

Jupiter on the 15th is in R.A. 11 h 29 m, Decl. +4°29′, mag. −1.2, and transits at 11 h 50 m. It is too close to the sun to be seen, conjunction occurring on the 13th.

Saturn on the 15th is in R.A. 12 h 00 m, Decl. +2°13′, mag. +1.2, and transits at 12 h 22 m. It is too close to the sun to be seen, conjunction occurring on the 22nd (E.S.T.).

Uranus on the 15th is in R.A. 15 h 20 m, Decl. −18°08′, mag. +5.9, and transits at 15 h 41 m.

Neptune on the 15th is in R.A. 17 h 17 m, Decl. −21°43′, mag. +7.8, and transits at 17 h 37 m.

1980				SEPTEMBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Mon.	1	13	08	☾ Last Quarter			
		13		Aldebaran 0.5° S. of Moon. Occ'n[1]			
Tues.	2	06		Venus 9° S. of Pollux			
Wed.	3				6	40	
Thur.	4			Appulse: +23°0199 & Diana, (pg. 57)			
Fri.	5	05		Venus 0.04° S. of Moon. Occ'n[2]			
Sat.	6				3	30	
Sun.	7	18		Regulus 0.4° S. of Moon. Occ'n[3]			
Tues.	8						
Wed.	9	05	00	● New Moon	0	20	
		08		Mercury 1.4° S. of Saturn			
Wed.	10						
Thur.	11				21	10	
Fri.	12	04		Moon at apogee (406,237 km)			Jupiter being near the sun, configurations are not given.
Sat.	13	05		Jupiter in conjunction with Sun			
		13		Mars 6° S. of Moon			
Sun.	14	15		Uranus 5° S. of Moon	18	00	
		16		Pallas stationary			
Mon.	15			Appulse: −0°0418 & Hebe, (pg. 57)			
Tues.	16	22		Juno in conjunction with Sun			
		23		Neptune 3° S. of Moon			
Wed.	17	08	54	☽ First Quarter	14	40	
Thur.	18						
Fri.	19						
Sat.	20				11	30	
Sun.	21						
Mon.	22	16	09	Equinox. Autumn begins			
		21		Saturn in conjunction with Sun			
Tues.	23				8	20	
Wed.	24	07	08	○ Full Moon (Harvest Moon)			
		21		Mercury 1.0° N. of Spica			
		22		Moon at perigee (357,439 km)			
Thur.	25						
Fri.	26			Mercury at aphelion	5	10	
Sat.	27						
Sun.	28	20		Aldebaran 0.7° S. of Moon. Occ'n[4]			
Mon.	29				2	00	
Tues.	30	22	18	☾ Last Quarter			

[1]Visible in E. Asia, N. Pacific, N. America.

[2]Visible in Central America, N. of S. America, N. Atlantic, S. Iberia, N. and Central Africa.

[3]Visible in E. Asia, N. Pacific.

[4]Visible in N. Atlantic, N.W. Africa, Europe, N. and Central Asia.

THE SKY FOR OCTOBER 1980

At least three reasonably bright comets will grace our skies this fall. The three "predictable" comets are described on pages 101 and 102. This is the best crop of "predictable" comets for many years. It is also possible that other bright comets, presently (August 1979) undiscovered, may appear in the sky by October 1980. The majority of bright comets are newly-discovered objects.

Comet-hunting is a field in which the amateur astronomer can make an important contribution. All (!) that is needed is a dark sky, a wide-field telescope or binoculars, a knowledge of the sky and lots of patience. It took Rolf Meier of the RASC Ottawa Centre 50 hours of searching to find "his" comet (Comet Meier 1978f) and it took Don Machholz of California 1700 hours to find "his" comet (Comet Machholz 1978l). *Note added in proof*: Meier discovered his second comet in Sept. 1979.

Once a suspicious fuzzy patch is sighted, the observer must be sure that it isn't a known comet, or one of the thousands of nebulae in our galaxy and beyond. If the patch *is* a comet, then the observer should contact the Central Bureau for Astronomical Telegrams at the Smithsonian Astrophysical Observatory (by telegram and/or telephone). The comet can then be confirmed by an independent observer.

The Sun—During October, the sun's R.A. increases from 12 h 29 m to 14 h 25 m and its Decl. changes from −3°10′ to −14°24′. The equation of time changes from +10 m 29 s to +16 m 22 s.

The Moon—On October 1.0 E.S.T., the age of the moon is 21.4 d. The sun's selenographic colongitude is 167.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 1 (8°) and Oct. 29 (8°) and minimum (east limb exposed) on Oct. 17 (7°). The libration in latitude is maximum (north limb exposed) on Oct. 24 (7°) and minimum (south limb exposed) on Oct. 11 (7°).

Mercury on the 1st is in R.A. 13 h 54 m, Decl. −13°40′, and on the 15th is in R.A. 14 h 52 m, Decl. −19°44′. Although greatest elongation east (25°) occurs on the 10th (E.S.T.), this is a very unfavourable elongation; at best, the planet stands 7° above the south-western horizon at sunset.

Venus on the 1st is in R.A. 9 h 51 m, Decl. +13°00′, and on the 15th it is in R.A. 10 h 54 m, Decl. +7°58′, mag. −3.6, and transits at 9 h 19 m. It rises about 3½ hours before the sun, and is well up in the south-east at sunrise. It passes 0.3° south of Regulus on the 4th and 0.5° north of Jupiter on the 30th.

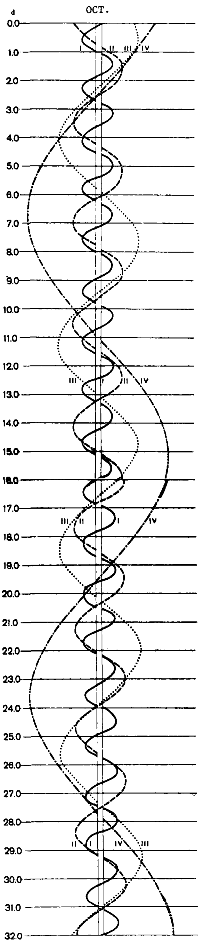
Mars on the 15th is in R.A. 15 h 59 m, Decl. −21°21′, mag. +1.5, and transits at 14 h 23 m. Moving through Libra into Ophiuchus, it is *very* low in the south-west at sunset, and sets less than 2 hours later. On the 2nd, it passes 1.0° south of Uranus, and on the 24th, it passes 4° north of Antares.

Jupiter on the 15th is in R.A. 11 h 53 m, Decl. +1°59′, mag. −1.3, and transits at 10 h 16 m. In Virgo, it rises about 2 hours before the sun, and is low in the east at sunrise (see also "Venus" above).

Saturn on the 15th is in R.A. 12 h 14 m, Decl. +0° 46′, mag. +1.2, and transits at 10 h 38 m. In Virgo, it rises about 1½ hours before the sun, and is low in the east at sunrise.

Uranus on the 15th is in R.A. 15 h 26 m, Decl. −18°30′, mag. +6.0, and transits at 13 h 49 m. Mars passes 1.0° south of Uranus on the 2nd.

Neptune on the 15th is in R.A. 17 h 19 m, Decl. −21°46′, mag. +7.8, and transits at 15 h 41 m.

1980				OCTOBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites) (Date Markers are U.T.)
	d	h	m		h	m	
Wed.	1				22	50	←West East →
Thur.	2	19		Mars 1.0° S. of Uranus			
Fri.	3						
Sat.	4	11		Venus 0.3° S. of Regulus	19	40	
Sun.	5	00		Regulus 0.5° S. of Moon. Occ'n[3]			
		01		Venus 0.8° S. of Moon. Occ'n[2]			
Mon.	6						
Tues.	7	04		Jupiter 2° S. of Moon	16	30	
Wed.	8	21	50	New Moon			
Thur.	9	10		Moon at apogee (406,666 km)			
Fri.	10	23		Mercury 8° S. of Moon	13	10	
		23		Mercury greatest elong. E. (25°)			
Sat.	11						
Sun.	12	00		Uranus 5° S. of Moon			
		13		Mars 6° S. of Moon			
Mon.	13				10	00	
Tues.	14	07		Neptune 3° S. of Moon			
		17		Pluto in conjunction with Sun			
Wed.	15						
Thur.	16			Mercury at greatest hel. lat. S.	6	50	
		22	47	First Quarter			
Fri.	17						
Sat.	18						
Sun.	19	23		Pallas at opposition	3	40	
Mon.	20						
Tues.	21	01		Orionid meteors			
Wed.	22				0	30	
Thur.	23	01		Mercury stationary			
		09		Moon at perigee (356,759 km)			
		15	52	Full Moon (Hunters' Moon)			
Fri.	24	11		Mars 4° N. of Antares	21	20	
Sat.	25						
Sun.	26			Appulse: +1°1310 & Victoria, (pg. 57)			
		06		Aldebaran 0.8° S. of Moon. Occ'n[3]			
Mon.	27				18	10	
Tues.	28						
Wed.	29						
Thur.	30	11	33	Last Quarter	15	00	
		15		Venus 0.5° N. of Jupiter			
Fri.	31						

[1]Visible in Europe, N.W. Africa, Asia, E. Indies.
[2]Visible in Greenland, Arctic, N. and E. Europe, Asia.
[3]Visible in N.E. Asia, N. Pacific, Arctic, N. of N. America, Greenland, N. Atlantic.

The Sun—During November, the sun's R.A. increases from 14 h 25 m to 16 h 29 m and its Decl. changes from −14°24′ to −21°48′. The equation of time changes from +16 m 24 s to +11 m 09 s.

The Moon—On November 1.0 E.S.T., the age of the moon is 22.7 d. The sun's selenographic colongitude is 185.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 26 (7°) and minimum (east limb exposed) on Nov. 14 (7°). The libration in latitude is maximum (north limb exposed) on Nov. 21 (7°) and minimum (south limb exposed) on Nov. 7 (7°).

Mercury on the 1st is in R.A. 14 h 45 m, Decl. −17° 15′, and on the 15th is in R.A. 14 h 12 m, Decl. −10°53′. Inferior conjunction occurs on the 3rd, but by the 19th, the planet is at greatest elongation west (20°), and stands about 17° above the south-eastern horizon (near Spica) at sunrise. Mercury, Venus, Jupiter and Saturn, along with Regulus and Spica, make a pretty sight in the morning sky.

Venus on the 1st is in R.A. 12 h 09 m, Decl. +0°41′, and on the 15th it is in R.A. 13 h 12 m, Decl. −5°43′. mag. −3.5, and transits at 9 h 35 m. It rises about 3 hours before the sun, and is well up in the south-east at sunrise. It passes 0.6° south of Saturn on the 3rd; see also "Mercury" above.

Mars on the 15th is in R.A. 17 h 37 m, Decl. −24°21′, mag. +1.5, and transits at 13 h 59 m. Moving from Ophiuchus into Sagittarius, it continues to be *very* low in the south-west, just after sunset.

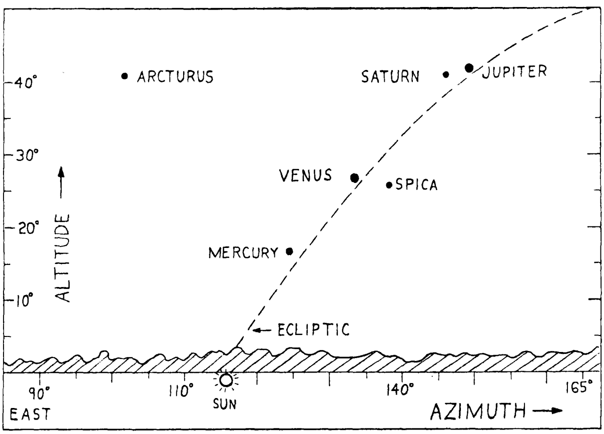
Jupiter on the 15th is in R.A. 12 h 14 m, Decl. −0°20′, mag. −1.4, and transits at 8 h 36 m. In Virgo, midway between Regulus and Spica, it rises about 4 hours before the sun, and is well up in the south-east at sunrise. See also "Mercury" above.

Saturn on the 15th is in R.A. 12 h 27 m, Decl. −0°31′, mag. +1.2, and transits at 8 h 48 m. In Virgo, it rises about 4 hours before the sun, and is well up in the south-east at sunrise. See also "Mercury" and "Venus" above.

Uranus on the 15th is in R.A. 15 h 34 m, Decl. −18°57′, mag. +6.0, and transits at 11 h 55 m.

Neptune on the 15th is in R.A. 17 h 23 m, Dec. −21°51′, mag. +7.8, and transits at 13 h 43 m.

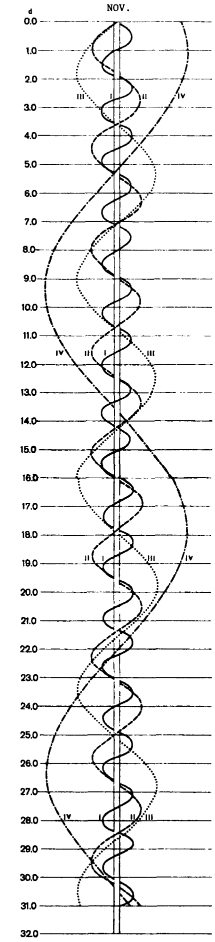
The diagram below shows the particularly striking configuration of the eastern sky around November 19, just before sunrise.



1980				NOVEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Sat.	1	06		Regulus 0.8° S. of Moon. Occ'n[1]		
Sun.	2				11	40
Mon.	3			S. Taurid meteors		
		04		Mercury in inferior conjunction		
		17		Venus 0.6° S. of Saturn		
		20		Jupiter 3° S. of Moon		
Tues.	4			Mercury at ascending node		
		05		Saturn 2° S. of Moon		
		06		Venus 2° S. of Moon		
Wed.	5	12		Moon at apogee (406,422 km)	8	30
Thur.	6					
Fri.	7	15	43	New Moon		
Sat.	8				5	20
Sun.	9			Mercury at perihelion		
Mon.	10			Appulse: SAO 161869 & Bellona, (pg. 57)		
		08		Mars 2° S. of Neptune		
		14		Mars 5° S. of Moon		
		14		Neptune 3° S. of Moon		
Tues.	11	23		Mercury stationary	2	10
Wed.	12					
Thur.	13				23	00
Fri.	14					
Sat.	15	10	47	First Quarter		
Sun.	16	19		Leonid meteors	19	50
Mon.	17	09		Venus 4° N. of Spica		
		20		Uranus in conjunction with Sun		
Tues.	18					
Wed.	19			Mercury at greatest hel. lat. N.	16	40
		14		Mercury greatest elong. W. (20°)		
Thur.	20	20		Moon at perigee (359,259 km)		
Fri.	21					
Sat.	22	01	39	Full Moon	13	30
		17		Aldebaran 0.9° S. of Moon. Occ'n[2]		
Sun.	23					
Mon.	24					
Tues.	25				10	20
Wed.	26			Venus at greatest hel. lat. N.		
Thur.	27	20		Ceres stationary		
Fri.	28	13		Regulus 1° S. of Moon. Occ'n[3]	7	00
Sat.	29	04	59	Last Quarter		
Sun.	30					

Configuration of Jupiter's Satellites (Date Markers are U.T.)

←West East →



[1]Visible in N. America, Arctic, Greenland, N. Atlantic, Europe, N. Africa.
[2]Visible in N. and W. of N. America, Greenland, N. and W. Europe, Arctic, N. Asia.
[3]Visible in N.E. Siberia, Arctic, N. America.

December brings Orion into the evening sky, surrounded by a circle of other bright stars: Aldebaran, Capella, Castor, Pollux, Procyon and Sirius. All but Pollux are double stars, but Castor is triple just to make up for it. Incidentally, you should refer to the "Brightest Stars" section if you want to learn more about your favourite stars.

Aldebaran's companion is very faint, and is 31″ away. Capella on the other hand consists of two stars of comparable brightness, relatively close together. They are too close to be resolved in an ordinary telescope, and they circle each other every 105 days. Castor consists of two stars of comparable brightness, just far enough apart to be resolved in a good amateur telescope. The third component is further away. Procyon and Sirius are both accompanied by white dwarf stars. These are tiny, faint stellar corpses, the end-products of the evolution of stars like the sun. They can usually only be seen in large telescopes—and even then with great difficulty—because they are swamped by the light of their much brighter companions.

The Sun—During December, the sun's R.A. increases from 16 h 29 m to 18 h 46 m and its Decl. changes from −21°48′ to −23°02′. The equation of time changes from +10 m 46 s to −3 m 16 s. On Dec. 21, at 11 h 56 m, winter begins in the northern hemisphere, as the sun stands over the Tropic of Capricorn.

The Moon—On December 1.0 E.S.T., the age of the moon is 22.9 d. The sun's selenographic colongitude is 190.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 24 (6°) and minimum (east limb exposed) on Dec. 12 (6°). The libration in latitude is maximum (north limb exposed) on Dec. 18 (7°) and minimum (south limb exposed) on Dec. 4 (7°) and Dec. 31 (7°).

Mercury on the 1st is in R.A. 15 h 23 m, Decl. −17°06′, and on the 15th is in R.A. 16 h 51 m, Decl. −22°44′. Early in the month, it can be seen low in the south-east, just before sunrise, but by the 31st, it is in superior conjunction. For the first few days in the month, the moon adds to the pretty sight mentioned under "Mercury" last month.

Venus on the 1st is in R.A. 14 h 27 m, Decl. −12°41′, and on the 15th it is in R.A. 15 h 36 m, Decl. −17°49′, mag. −3.4, and transits at 10 h 00 m. It rises about 2½ hours before the sun, and is low in the south-east at sunrise.

Mars on the 15th is in R.A. 19 h 17 m, Decl. −23°24′, mag. +1.4, and transits at 13 h 41 m. In Sagittarius, it is low in the south-west at sunset and sets about 2 hours later.

Jupiter on the 15th is in R.A. 12 h 31 m, Decl. −1°59′, mag. −1.5, and transits at 6 h 55 m. In Virgo, it rises at about midnight, and is high in the south at sunrise.

Saturn on the 15th is in R.A. 12 h 36 m, Decl. −1°22′, mag. +1.1, and transits at 6 h 59 m. In Virgo, it rises at about midnight, and is high in the south at sunrise.

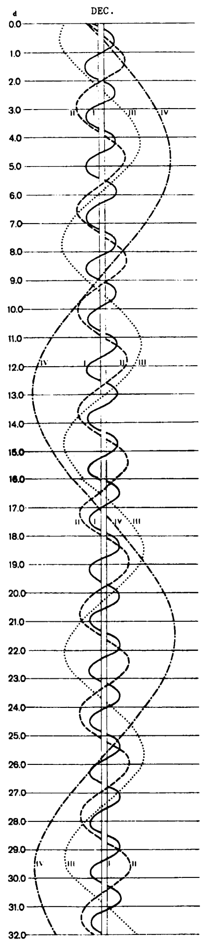
Uranus on the 15th is in R.A. 15 h 41 m, Decl. −19°23′, mag. +6.0, and transits at 10 h 04 m.

Neptune on the 15th is in R.A. 17 h 27 m, Decl. −21°56′, mag. +7.8, and transits at 11 h 50 m.

1980				DECEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Mon.	1	12		Jupiter 3° S. of Moon	3	50
		16		Saturn 2° S. of Moon		
Tues.	2	23		Moon at apogee (405,641 km)		
Wed.	3	09		Mercury 0.9° N. of Uranus		
Thur.	4	16		Venus 4° S. of Moon	0	40
Fri.	5			Appulse: SAO 139356 & Laetitia, (pg. 57)		
		19		Uranus 5° S. of Moon		
Sat.	6				21	30
Sun.	7	09	35	● New Moon		
Mon.	8					
Tues.	9	16		Mars 4° S. of Moon	18	20
Wed.	10					
Thur.	11	08		Mercury 5° N. of Antares		
Fri.	12			Mercury at descending node	15	10
Sat.	13	17		Geminid meteors		
Sun.	14	01		Neptune in conjunction with Sun		
		20	47	☽ First Quarter		
Mon.	15	09		Pallas stationary	12	00
		21		Venus 1° N. of Uranus		
Tues.	16					
Wed.	17					
Thur.	18				8	50
Fri.	19	00		Moon at perigee (364,340 km)		
Sat.	20	03		Aldebaran 0.9° S. of Moon. Occ'n[1]		
Sun.	21	11	56	Solstice: Winter begins	5	40
		13	08	○ Full Moon		
Mon.	22	02		Ursid meteors		
Tues.	23			Mercury at aphelion		
Wed.	24	23		Venus 6° N. of Antares	2	30
Thur.	25	22		Regulus 1° S. of Moon. Occ'n[2]		
Fri.	26				23	20
Sat.	27					
Sun.	28					
Mon.	29	01	32	☾ Last Quarter	20	00
		02		Jupiter 3° S. of Moon		
		03		Saturn 2° S. of Moon		
Tues.	30	18		Moon at apogee (404,749 km)		
		23		Juno 0.4° S. of Moon. Occ'n		
Wed.	31	04		Mercury in superior conjunction		

Configuration of Jupiter's Satellites (Date Markers are U.T.)

← West East →



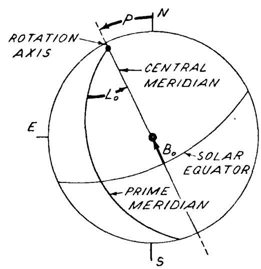
[1]Visible in N.E. Asia, N. of N. America, Arctic, Greenland.
[2]Visible in N. Siberia.

SUN—EPHEMERIS FOR PHYSICAL OBSERVATIONS, 1980

For 0 h U.T.

Date	P	B_0	L_0	Date	P	B_0	L_0
	°	°	°		°	°	°
Jan. 1	+ 2.43	−2.97	305.19	July 4	− 1.27	+3.25	23.51
6	+ 0.01	−3.54	239.34	9	+ 1.00	+3.77	317.33
11	− 2.41	−4.09	173.49	14	+ 3.25	+4.28	251.17
16	− 4.78	−4.61	107.66	19	+ 5.45	+4.75	185.01
21	− 7.09	−5.08	41.82	24	+ 7.60	+5.19	118.85
26	− 9.32	−5.52	335.99	29	+ 9.68	+5.59	52.71
31	−11.46	−5.92	270.16				
				Aug. 3	+11.68	+5.96	346.58
Feb. 5	−13.48	−6.26	204.32	8	+13.58	+6.28	280.47
10	−15.38	−6.56	138.49	13	+15.38	+6.56	214.37
15	−17.16	−6.81	72.65	18	+17.07	+6.80	148.28
20	−18.79	−7.00	6.81	23	+18.64	+6.99	82.20
25	−20.28	−7.14	300.96	28	+20.08	+7.12	16.14
Mar. 1	−21.61	−7.22	235.10	Sept. 2	+21.39	+7.21	310.09
6	−22.79	−7.25	169.23	7	+22.55	+7.25	244.05
11	−23.80	−7.22	103.35	12	+23.58	+7.23	178.03
16	−24.65	−7.14	37.45	17	+24.45	+7.16	112.02
21	−25.33	−7.00	331.54	22	+25.16	+7.04	46.02
26	−25.84	−6.81	265.61	27	+25.71	+6.87	340.03
31	−26.17	−6.57	199.66				
				Oct. 2	+26.08	+6.65	274.04
Apr. 5	−26.31	−6.28	133.68	7	+26.29	+6.37	208.08
10	−26.28	−5.95	67.69	12	+26.31	+6.05	142.12
15	−26.07	−5.57	1.69	17	+26.15	+5.68	76.16
20	−25.67	−5.16	295.66	22	+25.80	+5.27	10.21
25	−25.09	−4.71	229.61	27	+25.25	+4.82	304.27
30	−24.32	−4.22	163.53				
				Nov. 1	+24.51	+4.33	238.34
May 5	−23.38	−3.71	97.44	6	+23.57	+3.81	172.41
10	−22.25	−3.17	31.34	11	+22.43	+3.25	106.49
15	−20.96	−2.61	325.22	16	+21.11	+2.67	40.58
20	−19.50	−2.04	259.08	21	+19.60	+2.07	334.67
25	−17.89	−1.45	192.93	26	+17.91	+1.45	268.76
30	−16.14	−0.85	126.77				
				Dec. 1	+16.05	+0.82	202.87
June 4	−14.26	−0.25	60.60	6	+14.05	+0.18	136.98
9	−12.26	+0.36	354.42	11	+11.92	−0.46	71.10
14	−10.17	+0.96	288.24	16	+ 9.68	−1.09	5.22
19	− 8.01	+1.55	222.06	21	+ 7.35	−1.72	299.35
24	− 5.79	+2.13	155.87	26	+ 4.97	−2.34	233.48
29	− 3.54	+2.70	89.69	31	+ 2.55	−2.94	167.63

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



Carrington's Rotation Numbers—Greenwich Date of Commencement of Synodic Rotations 1980

No.	Commences		No.	Commences		No.	Commences	
1690	Dec.	27.84	1695	May	12.37	1700	Sept.	25.49
1691	Jan.	24.18	1696	June	8.58	1701	Oct.	22.77
1692	Feb.	20.52	1697	July	5.78	1702	Nov.	19.08
1693	Mar.	18.84	1698	Aug.	1.99	1703	Dec.	16.40
1694	Apr.	15.13	1699	Aug.	29.22			

PLANETARY HELIOCENTRIC LONGITUDES 1980

Date U.T.	Planet					
	M	V	E	M	J	S
	°	°	°	°	°	°
Jan. 1.0	242	357	100	132	151	171
Feb. 1.0	339	46	131	145	153	172
Mar. 1.0	141	93	161	158	156	173
Apr. 1.0	251	143	191	171	158	174
May 1.0	347	192	221	185	160	175
June 1.0	160	242	251	199	163	176
July 1.0	259	289	279	213	165	177
Aug. 1.0	6	338	309	228	167	178
Sept. 1.0	178	27	339	244	170	179
Oct. 1.0	270	76	8	260	172	180
Nov. 1.0	27	126	39	278	174	182
Dec. 1.0	190	175	69	295	177	183
Jan. 1.0	282	224	100	315	179	184

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, counterclockwise from the vernal equinox. Knowing the heliocentric longitudes, and the approximate distances of the planets from the sun (page 6), the reader or his students can reconstruct the orientation of the sun and planets on any date.

The heliocentric longitude of Uranus increases from 232° to 236° during the year; that of Neptune increases from 260° to 263°, and that of Pluto increases from 200° to 202°.

ECLIPSES DURING 1980

In 1980 there will be five eclipses, two of the sun and three of the moon. The eclipses of the moon are all penumbral, and in a penumbral eclipse, the moon is only partially shadowed by the earth, and the eclipse is not very conspicuous.

1. *A total eclipse of the sun* on February 16, visible as such along a narrow path through central Africa and Southern Asia. The partial phases are visible throughout most of Africa, the Middle East and Southern Asia.

2. *A penumbral eclipse of the moon* on the night of March 1, the end visible in extreme northeastern North America. Penumbral magnitude* of eclipse: 0.681.
   Middle of eclipse........................March 1 15.45 E.S.T.
   Moon leaves penumbra.......................... 17.47 E.S.T.

3. *A penumbral eclipse of the moon* on July 27, not visible from any part of North America.

4. *An annular eclipse of the sun* on August 10, visible as such along a narrow path through the Pacific Ocean and central South America. The partial phases are visible throughout most of South America, Mexico and part of the southern United States.

5. *A penumbral eclipse of the moon* on the night of August 25–26, visible throughout most of North America. Penumbral magnitude* of eclipse: 0.733
   Moon enters penumbra................August 25 20.41 E.S.T.
   Middle of eclipse................................ 22.30 E.S.T.
   Moon leaves penumbra................August 26 0.20 E.S.T.

*The penumbral magnitude is the fraction of the lunar diameter obscured by the penumbra of the shadow of the Earth at greatest phase, measured along the common diameter.

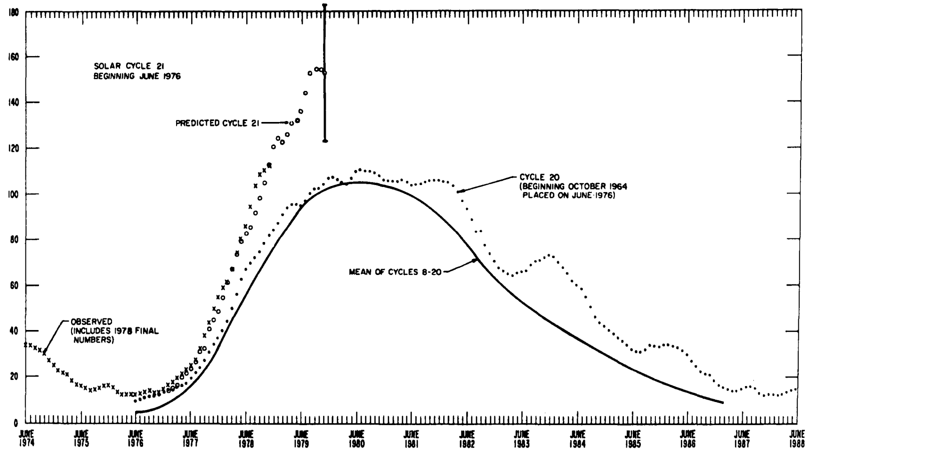
SUNSPOTS

By V. Gaizauskas

The diagram shows the present sunspot cycle (21) compared with the previous cycle (20) and the mean of cycles 8 to 20. This diagram plots the Zurich sunspot numbers which are weighted means from several observatories. The latest studies show that sunspot minimum occurred in June, 1976 and this date has been placed on the date of the previous minimum, October 1964 in order to phase the curves. Another measure of solar activity is the 10 cm radio flux, which has been measured since 1947 by the National Research Council of Canada. The NRC data are internationally recognized for accuracy and self-consistency over a 32 year period. The 10 cm solar radio flux correlates well with sunspot numbers, and reached a minimum in February 1976 (Covington, A. E. 1979, *J. Roy. Astron. Soc. Can.*, **73**, 1).

The general upward trend of solar activity during 1978 was marked by periods of intense activity during the spring and closing months of the year. The greatest outburst of solar microwave emission recorded in the 32-year history of the NRC patrol occurred on 28 April 1978. Activity remained high during the early months of 1979 but tended to subside slightly towards mid-year. Sunspot maximum is expected to occur around September 1979; the most probable value for sunspot maximum is predicted to be 154 ± 29.

The solar radio flux can be detected with amateur radio telescopes.



OBSERVED AND PREDICTED SUNSPOT NUMBERS

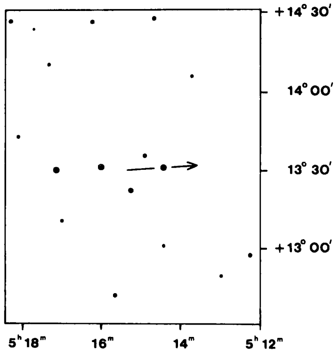
PLANETARY APPULSES AND OCCULTATIONS

A *planetary appulse* is a close approach of a star and a planet, minor planet or satellite, as seen from the earth. At certain locations on the earth, the appulse may be seen as an *occultation*: the nearer object passes directly between the observer and the star. The study of such occultations has been particularly fruitful in recent years: it has provided important information about the sizes and atmospheres of the planets, and it led to the recent discovery of rings about Uranus.

Gordon E. Taylor of H.M. Nautical Almanac Office has issued a list of about 40 predicted occultations of stars by asteroids or planets. The following 8 may be visible from continental North America. The predictions are based on current ephemerides of the asteroids and planets, and on catalogue positions of the stars. Because of uncertainties in these data, improved predictions may be issued nearer to the dates of the events. Δt is the duration in seconds.

Date	Occulting Body		Star		Δm_v	Δt	Possible Area of Visibility
	Name	m_v	Name	m_v			
Jan. 4	48 Doris	11.3	AGK3 + 13°0437	7.4	4.0	15	E. Canada, U.S.
Jan. 14	451 Patientia	11.8	AGK3 + 0°0181	7.8	4.1	17	W. Canada
Aug. 16	11 Parthenope	12.0	AGK3 + 0°1581	9.7	2.4	4	Mexico
Sept. 4	78 Diana	12.5	AGK3 + 23°0199	8.4	4.2	24	Mexico, U.S.
Sept. 15	6 Hebe	9.0	AGK3 − 0°0418	9.7	0.4	19	Canada
Oct. 26	12 Victoria	12.9	AGK3 + 1°1310	9.2	3.7	4	Labrador
Nov. 10	28 Bellona	13.2	SAO 161869	9.0	4.2	4	N.E. U.S.
Dec. 5	39 Laetitia	12.3	SAO 139356	8.0	4.3	5	Canada?

OCCULTATION OF AGK3 +13°437
BY 48 DORIS ON 1980 JAN. 4



Occultation by Asteroid 48 Doris. This occultation may be visible from eastern North America on Jan. 4, 1980. The map at right shows the path of the asteroid (arrow) over the star, which is almost exactly 21^m east of 9 o^2 Ori. Amateur astronomers, particularly those with previous experience of observing lunar occultations, can make a useful contribution by timing both phases of the occultation with stop-watches. Observers should also report their longitude, latitude and height above sea level. If a number of observers with portable equipment are available, they should position themselves on a line at right angles to the expected track and at separations of say 5 to 10 km. Now that there is a possibility that asteroids have satellites, observers at any place where the star is visible around the time of occultation, should be prepared to time any marked changes in brightness of the combined image for short periods within about 10 minutes of the time of the possible occultation by Doris itself.

Possible Occultation by Pluto. Pluto will pass close to an anonymous 12th magnitude star on Apr. 6, 1980 at about $23^{\mathrm{h}}.9$ U.T. Although an occultation is unlikely, it is not impossible. See elsewhere in this HANDBOOK for information on the path of Pluto.

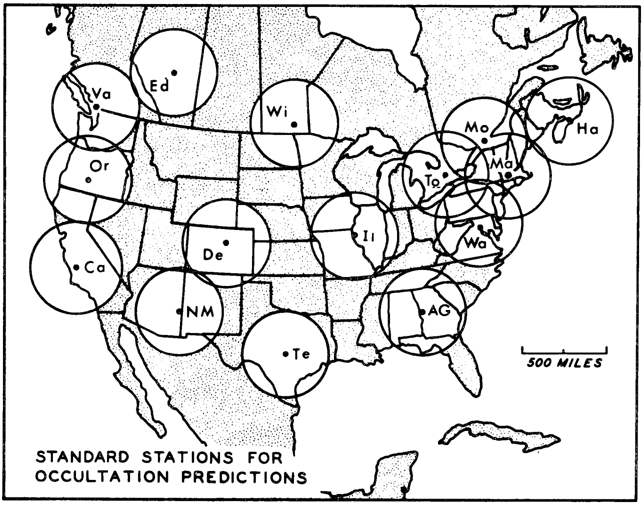
Other Occultations. The following table gives more information on the stars, listed in the above table, which may be occulted in 1980.

Star		m_v	R.A. (1950)		Dec. (1950)	
			h	m	°	′
AGK3	+13°0437	7.4	5	14.4	+13	31
AGK3	+ 0°0181	7.8	1	58.9	+ 0	14
AGK3	+ 0°1581	9.7	12	29.8	+ 0	43
AGK3	+23°0199	8.4	2	25.9	+23	39
AGK3	− 0°0418	9.7	3	56.6	− 0	57
AGK3	+ 1°1310	9.2	10	32.4	+ 1	29
SAO	161869	9.0	18	46.6	−19	04
SAO	139356	8.0	13	26.1	− 4	12

OCCULTATIONS BY THE MOON

PREPARED 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 (see page 73), its magnitude, the phenomenon (1 = disappearance, 2 = reappearance) and the elongation of the moon from the sun in degrees (see page 28). Under each station are given the U.T. of the event, factors *a* and *b* (see below) and the position angle *P* (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 and letters showing the reasons are put in their places: *A*, below or too near the horizon; *G*, near-grazing occultation; *N*, no occultation; *S*, sunlight interferes. Certain other cases where satisfactory observations would be impossible are also omitted.

The terms *a* and *b* are for determining corrections to the times of the phenomena for stations within 300 miles 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. 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 10.*

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 692d (which is α Tau or Aldebaran) on Jan. 27, 1980, 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 U.T. of the ingress ("1") is $6^h\ 22^m.3 - 0^m.8\ (75.72 - 73.60) + 0^m.8\ (45.40 - 45.50 = 6^h\ 20^m.5$. Note that almost the same result is obtained by using Toronto as the standard station.

The elongation of the moon is 123° which means that the moon is about two days past first quarter. Aldebaran therefore disappears at the dark limb of the moon. The position angle of immersion is about 30°.

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, P.O. Box 2987, 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 P 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) Immersion or emersion, (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: H.M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex, England.

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 23	249	4.7	1	82	23 54.3	-1.1	+0.7	45	23 43.9	-1.1	+1.5	32	23 34.6	-1.1	+1.8	32
24	4014	7.4	1	93	18 31.2	-0.5	+2.0	56	18 29.2	-0.2	+2.1	47	18 24.5	-0.1	+2.1	46
25	405	4.4	1	98		A			4 48.5	-0.2	-1.8	102	4 50.6	-0.3	-2.1	111
25	498	6.2	1	107	22 07.1	-2.2	-0.2	109		S				S		
26	508	4.3	1	108		N			0 14.2	.	.	128	0 02.5	.	.	128
26	526	6.9	1	110	5 28.2	.	.	12	5 21.8	-0.8	+1.9	19	5 14.8	-0.8	+0.9	33
26	659	6.4	1	121	24 26.2	-1.9	+0.2	83	24 08.8	-1.7	+1.0	72	23 57.2	-1.6	+1.3	72
27	667	5.3	1	122		G				N			2 22.0	.	.	8
27	669	4.0	1	122	2 21.8	-1.6	-2.0	113	2 02.7	-1.9	-1.3	107	1 53.3	-2.1	-1.3	111
27	671	3.6	1	122	2 38.1	.	.	144	2 16.7	.	.	136	2 11.5	.	.	144
27	672d	6.6	1	122	2 35.7	-1.5	-0.3	73	2 19.5	-1.7	+0.2	69	2 08.8	-1.8	+0.4	73
27	677	4.8	1	122	3 29.7	-1.2	-0.7	77	3 15.7	-1.5	-0.4	76	3 07.3	-1.7	-0.4	82
27	680	6.7	1	122	3 36.2	-1.1	-1.2	89	3 22.4	-1.4	-0.9	88	3 15.1	-1.7	-1.0	94
27	685	6.5	1	123	5 09.2	-0.6	-0.7	66	5 01.0	-0.9	-0.7	69	4 56.6	-1.1	-0.8	77
27	692d	1.1	1	123	6 28.8	-0.7	+1.4	23	6 22.3	-0.8	+0.8	32	6 17.0	-0.8	+0.2	45
27	692d	1.1	2	123	6 54.1	+0.8	-3.6	329	6 57.3	+0.4	-3.1	320	7 03.8	+0.1	-2.4	306
28	814d	5.3	1	135	4 30.3	-1.2	-0.8	76	4 16.4	-1.5	-0.6	78	4 08.4	-1.7	-0.7	86
28	943	6.2	1	145	23 19.3	-1.1	+2.2	60	23 13.3	-0.6	+2.7	47	23 05.8	-0.4	+2.6	47
Feb. 3	1547	3.8	1	203	1 38.6	-0.7	+0.1	128	1 32.8	-0.5	+0.4	124	1 30.1	-0.3	+0.2	128
3	1547	3.8	2	203	2 47.3	-1.3	+1.5	266	2 38.1	-0.9	+1.6	267	2 30.7	-0.6	+1.8	261
6	1869d	6.1	2	239		S			10 51.1	.	.	237		N		
22	491	6.2	1	80		A				A			4 23.4	0.0	-1.5	99
23	626	6.4	1	92	2 50.4	-0.6	-1.5	93	2 41.9	-0.9	-1.5	95	2 39.1	-1.1	-1.7	103
23	635	3.9	1	93		A			4 41.8	-0.2	-0.8	71	4 41.8	-0.3	-1.0	80
25	934	6.4	1	118	6 04.3	.	.	161		N				N		
27	1207	5.8	1	142		N			7 58.5	.	.	35	7 52.5	-0.9	-0.2	52
28	1323	6.3	1	153	7 45.1	-0.6	-0.7	60	7 36.7	-0.9	-0.9	70	7 33.1	-1.0	-1.1	81
Mar. 4	1821d	2.9	1	207	5 31.3	-1.6	-0.9	125	5 16.2	-1.3	-0.8	135	5 11.3	-1.0	-1.3	147
4	1821d	2.9	2	207	6 57.5	-1.8	-1.1	292	6 37.8	-2.0	-0.3	281	6 25.3	-2.3	+0.5	269
4	1825	6.1	2	208	8 18.9	-1.2	-2.2	318	8 04.1	-1.4	-1.7	309	7 57.6	-1.7	-1.3	298
5	1921	5.9	2	217	4 03.7	-1.5	+1.1	273	3 51.9	-1.1	+1.6	266	3 42.3	-1.0	+2.3	254
5	1924	5.8	2	218	4 57.3	-2.3	+1.9	252	4 37.4	-2.1	+3.4	239		N		
9	2399	5.0	2	263	7 16.8	-1.4	+0.9	277	7 05.5	-1.1	+1.3	269		A		
22	729	7.2	1	73		N				N			1 12.0	.	.	18
22	741	5.7	1	74		A				A			4 14.9	-0.2	-0.6	65
23	886	7.0	1	86		N			3 33.1	.	.	18	3 21.9	-1.3	+0.7	40
24	1038	6.8	1	98		N				N			3 38.6	.	.	30
25	1158	5.2	1	110	3 37.5	-0.4	-2.5	133	3 30.5	-0.5	-3.0	141	3 33.9	-0.3	-4.0	156
Apr. 4	2223d	4.0	1	222	5 09.6	-1.4	+0.1	117	4 58.3	-0.9	+0.1	127	4 54.0	-0.6	-0.3	139
4	2223d	4.0	2	222	6 33.1	-1.9	-0.2	286	6 15.0	-1.8	+0.5	277	6 03.1	-1.8	+1.1	265
8	2798d	6.3	2	269	6 59.1	-1.0	+1.1	273		A				A		
18	659	6.4	1	40	0 15.3	-0.1	-2.0	113		S				S		
18	667	5.3	1	41		A			1 33.9	-0.4	+0.4	36	1 31.2	-0.5	-0.1	48
18	669	4.0	1	41		A			1 32.6	+0.3	-2.5	131	1 40.2	+0.5	-3.7	147
18	672d	6.6	1	41		A			1 36.2	0.0	-1.2	86	1 38.2	-0.1	-1.4	96
19	814d	5.3	1	54	1 41.1	0.0	-1.5	100	1 38.7	-0.2	-1.7	106	1 40.8	-0.3	-2.0	116
20	985d	6.9	1	67	2 34.8	-0.1	-1.1	82	2 31.4	-0.3	-1.3	88	2 31.7	-0.4	-1.5	98
21	1114	6.8	1	80	3 23.5	-0.1	-1.4	92	3 20.4	-0.3	-1.6	99	3 21.6	-0.4	-1.8	108
21	1124d	6.9	1	80		A				A			4 41.9	+0.1	-1.6	109
23	1360	7.5	1	103	4 12.5	-0.5	-1.2	80	4 04.9	-0.8	-1.4	87	4 02.6	-0.9	-1.5	97
May 3	2448	6.4	2	214	4 31.8	-1.8	+1.3	255	4 15.9	-1.6	+2.0	245	4 01.4	-1.9	+3.2	229
4	2591	6.5	2	227	6 46.6	.	.	213		G				N		
6	2902	6.0	2	251	6 48.7	.	.	335	6 40.8	-0.5	-0.7	328	6 38.2	-0.5	-0.1	316
15	692d	1.1	1	16	12 29.7	-0.2	+1.8	64	12 30.6	+0.1	+1.9	53	12 28.0	+0.2	+1.8	52
15	692d	1.1	2	16	13 30.1	-0.8	+1.4	264	13 24.4	-0.6	+1.2	276	13 19.4	-0.4	+1.1	278

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 17	904	7.1	1	34	0 43.1	-0.1	-0.7	64		S				S		
21	1425	6.9	1	83	3 03.2	-0.9	-0.2	50	2 52.8	-1.1	-0.7	62	2 47.6	-1.2	-0.9	74
21	1427	6.8	1	83	3 36.3	-0.1	-1.4	92	3 32.5	-0.4	-1.6	97	3 33.0	-0.5	-1.7	105
22	1531	5.9	1	94	3 17.9	-0.3	-2.1	128	3 12.1	-0.5	-2.3	135	3 13.8	-0.5	-2.6	145
25	1821d	2.9	1	127	1 34.1	-1.1	-2.3	153	1 23.1	-0.6	-2.8	167	1 29.6	.	.	190
25	1821d	2.9	2	127	2 43.1	-2.0	-0.8	263	2 20.0	-2.6	+0.3	250	1 58.1	.	.	228
25	1825	6.1	1	127	2 50.2	-1.4	-1.8	124	2 34.7	-1.4	-1.8	133	2 30.3	-1.3	-2.0	145
June 16	1260	7.0	1	39	0 38.8	-0.6	-0.2	48		S				S		
16	1262	6.2	1	39	1 02.7	-0.1	-0.9	70		S				S		
19	4006	1.3	1	82	17 23.6	-0.7	+1.5	91	17 20.1	-0.3	+1.6	88	17 16.2	-0.1	+1.3	94
19	4006	1.3	2	82	18 32.3	-1.0	-0.2	310	18 23.7	-0.7	0.0	310	18 19.7	-0.6	+0.3	303
23	2008	6.6	1	119	3 33.3	-0.9	-2.5	146	3 21.0	-1.1	-2.4	150	3 19.5	-1.0	-2.7	158
25	2223d	4.0	1	141	2 44.8	-2.0	-0.5	86	2 24.3	-2.0	-0.1	92	2 12.9	-2.0	-0.1	101
July 21	2072	6.7	1	98	2 12.3	-1.2	-1.2	80	1 57.4	-1.6	-1.0	82	1 49.3	-1.8	-1.0	89
24	2448	6.4	1	133	4 14.1	-1.3	-1.6	108	3 58.7	-1.5	-1.2	103	3 51.3	-1.8	-1.1	105
25	2591	6.5	1	146		A			5 44.1	-1.4	-2.0	125	5 38.6	-1.7	-1.9	124
26	2734d	5.4	1	157	1 27.2	-2.0	+1.7	49	1 10.1	-1.7	+1.9	54		S		
26	2757	5.1	1	159		N			5 49.1	.	.	147	5 40.8	.	.	145
30	3347	6.2	2	211	4 58.1	-1.2	+1.8	214	4 48.1	-1.1	+1.8	222	4 38.2	-1.1	+2.0	222
Aug. 3	364	4.3	2	265	4 43.2	-0.4	+1.2	280		A				A		
4	498	6.2	2	279	6 42.9	-0.8	+1.1	279	6 36.6	-0.6	+0.9	291	6 31.9	-0.4	+0.8	293
4	508	4.3	1	280	7 29.0	-0.8	+1.7	67	7 24.8	-0.4	+2.0	55	7 19.4	-0.2	+2.0	53
4	508	4.3	2	280		S			8 28.7	-1.1	+1.4	262	8 20.4	-0.9	+1.4	265
5	659	6,4	2	292		S			7 48.5	-0.7	+1.1	283	7 43.3	-0.5	+1.0	285
5	661	4.6	2	293		N			7 46.4	+0.4	+3.3	195	7 43.1	+0.4	+3.0	198
5	669	4.0	1	293	8 18.4	-1.1	+1.1	97	8 11.1	-0.6	+1.5	85	8 05.5	-0.4	+1.5	83
5	669	4.0	2	293		S				S			9 08.0	-0.6	+1.9	242
5	671	3.6	1	293	8 26.6	-1.6	0.0	123	8 15.1	-0.9	+0.9	107	8 08.8	-0.7	+1.0	105
5	671	3.6	2	293		S			9 09.4	-0.4	+2.5	218	9 02.7	-0.3	+2.4	221
5	692d	1.1	1	295	12 40.6	-1.9	-0.5	92	12 21.9	-1.8	+0.3	83	12 10.5	-1.8	+0.6	84
5	692d	1.1	2	295	13 57.5	-1.5	+0.1	245	13 41.7	-1.7	+0.3	249	13 30.8	-1.8	+0.7	246
16	1921	5.9	1	56	0 04.9	.	.	186		N				N		
22	2666d	5.0	1	125	1 27.1	-1.9	-0.8	109	1 07.8	-1.8	-0.3	107	0 57.6	-1.8	-0.1	112
24	2981d	5.2	1	151	4 53.1	-0.4	+1.0	24		G				N		
24	2994d	6.1	1	152		N			5 57.6	.	.	148	5 48.1	.	.	141
28	49	6.3	2	207	7 33.9	-0.9	+1.3	210	7 24.3	-1.2	+1.0	225	7 15.1	-1.3	+1.1	228
Sept. 1	608d	6.0	2	261	5 49.2	-1.1	+0.8	290	5 39.4	-1.0	+0.3	306	5 33.7	-0.8	+0.2	309
16	2341	7.2	1	70		N			0 55.9	.	.	170	0 54.2	.	.	174
17	2591	6.5	1	92	22 55.3	-2.0	-0.5	100		S				S		
18	2757	5.1	1	105	24 16.1	-2.0	-1.1	117	23 55.7	-1.9	-0.4	113	23 45.3	-1.9	-0.3	116
19	2760d	6.7	1	105	0 45.6	-1.6	-0.2	68	0 28.9	-1.8	+0.3	62	0 17.3	-2.0	+0.6	64
Oct. 2	1175	5.0	2	283		S			9 46.1	-1.4	+1.8	250	9 34.8	-1.2	+2.1	246
12	2291	5.5	1	39	22 01.4	-1.3	-2.2	132		S				S		
17	2993d	6.6	1	98	24 04.9	-1.5	+0.1	63	23 49.7	-1.6	+0.6	54	23 38.7	-1.7	+1.0	53
17	2994d	6.1	1	98	24 05.8	-1.5	+0.1	63	23 50.7	-1.6	+0.6	53	23 39.7	-1.7	+1.0	53
22	49	6.3	1	153	4 33.4	-2.2	-2.6	120	4 11.4	-1.9	-0.8	99	4 00.9	-2.0	-0.4	96
26	626	6.4	2	209		G			1 54.2	+0.4	+2.9	198	1 51.4	+0.4	+2.7	200
26	667	5.3	2	212	8 48.7	-1.4	+2.7	202	8 37.2	-1.4	+2.3	208	8 24.4	-1.3	+3.2	201
27	832	4.7	2	227		S			10 17.2	-1.6	+1.6	217	10 02.8	.	.	205
28	947d	5.2	2	236	1 47.5	+0.2	+1.6	249		A				A		
Nov. 1	1487d	1.3	1	288	10 36.8	.	.	182		N				N		
1	1487d	1.3	2	288	11 06.2	.	.	222		N				N		
13	2940	7.3	1	67	22 08.1	-0.9	+1.3	25	22 02.9	.	.	5		S		
14	3079	4.2	1	79	22 14.0	-1.4	+0.7	48	22 00.4	-1.4	+1.3	38		S		
14	3086	6.0	1	79	23 28.1	.	.	142	22 58.5	-2.4	-1.2	118	22 46.5	-2.4	-0.8	116

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Nov. 16	3237	4.4	1	93	N				1 23.6	-2.2	-2.2	118	1 14.1	-2.3	-1.7	113
16	3245	6.9	1	93	A				2 50.9	-0.5	-0.1	48	2 47.4	-0.7	+0.1	46
19	106	6.8	1	132	0 39.4	.	.	129	0 14.1	-1.9	+0.3	105	0 02.6	-1.7	+0.6	102
21	405	4.4	1	161	0 38.2	-0.8	+2.0	43	0 34.1	-0.4	+2.4	28	0 27.8	-0.2	+2.5	25
24	913	5.2	2	207	9 32.2	-0.6	-2.4	305	9 21.9	-1.0	-2.1	300	9 18.5	-1.3	-1.7	290
26	1217	6.1	2	233	N				10 12.2	.	.	355	10 17.9	-0.9	-3.7	333
28	1434	5.6	2	255	5 35.7	-0.8	+2.0	255	5 30.7	-0.5	+1.7	262	5 25.2	-0.3	+1.8	259
Dec. 11	3058	5.9	1	50	23 21.2	-0.7	-0.8	71	23 12.8	-0.9	-0.3	57	23 07.6	-1.0	-0.1	55
14	3339	6.7	1	75	N				1 09.9	.	.	130	1 02.5	.	.	126
14	3347	6.2	1	76	A				A				2 24.3	-0.5	0.0	47
16	66	6.8	1	101	0 27.7	-1.6	-0.2	76	0 12.3	-1.5	+0.6	62	0 02.2	-1.5	+1.0	58
16	208	7.0	1	114	24 24.6	.	.	124	23 58.7	-2.1	-0.1	101	23 46.5	-2.0	+0.4	97
17	210d	6.6	1	115	1 20.8	-1.1	+1.2	37	1 12.4	-0.8	+2.1	21	1 03.8	-0.7	+2.5	18
18	346	7.4	1	128	N				0 19.7	.	.	136	0 04.4	.	.	128
24	1259	5.9	2	210	3 06.6	-1.3	-0.1	306	2 54.9	-1.1	-0.4	317	2 49.7	-0.9	-0.2	315
24	1275	5.6	2	212	7 44.1	-0.8	-3.9	339	7 30.7	-1.2	-3.1	331	7 27.0	-1.6	-2.1	318
25	1385	6.5	2	223	N				4 13.0	.	.	207	N			
28	1733	5.2	2	261	S				S				11 53.4	-1.1	-2.4	330

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900 U.T.	a	b	P	Ed EDMONTON, ALTA. W.113°.400, N. 53°.600 U.T.	a	b	P	Va VANCOUVER, B.C. W.123°.100, N. 49°.200 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 10	1921	5.9	2	271	N				N				14 18.6	.	.	1
12	2128	5.8	2	293	12 07.7	.	.	359	12 01.1	-0.1	-1.2	345	12 00.4	-0.4	0.0	319
13	2245	6.4	2	304	11 36.9	-0.7	+0.5	301	A				A			
14	2399	5.0	2	317	S				13 53.9	-0.7	+0.4	309	A			
22	3526d	5.1	1	57	2 28.9	-0.6	-1.3	86	2 13.4	-0.8	-0.5	64	2 05.5	-1.2	-0.2	67
22	3535	5.2	1	58	A				A				4 03.8	-0.4	+0.5	32
23	128	7.3	1	72	A				4 44.8	-0.3	+0.6	26	4 38.4	-0.6	+0.3	38
24	4014	7.4	1	93	18 39.5	+0.2	+2.3	25	A				A			
25	405	4.4	1	98	4 28.6	-0.9	-1.4	90	4 07.9	-1.2	-0.5	75	3 56.7	-1.6	-0.3	82
25	508	4.3	1	108	23 28.0	-1.3	+1.1	85	S				S			
26	526	6.9	1	110	5 10.5	.	.	2	N				G			
26	659	6.4	1	121	23 50.1	-0.6	+2.6	37	S				S			
27	661	4.6	1	121	0 06.9	-1.8	-0.3	124	S				S			
27	669	4.0	1	122	1 20.3	-1.5	+1.0	78	1 07.8	-0.8	+2.0	56	S			
27	671	3.6	1	122	1 23.2	-1.7	+0.3	99	1 05.4	-1.0	+1.5	76	S			
27	672d	6.6	1	122	1 48.9	-1.2	+2.2	41	1 50.2	.	.	4	S			
27	677	4.8	1	122	2 40.4	-1.5	+1.3	55	2 28.7	-0.8	+2.7	30	2 09.2	-0.7	+2.7	34
27	680	6.7	1	122	2 44.2	-1.5	+0.7	68	2 28.2	-1.0	+2.0	46	2 09.4	-0.9	+2.2	49
27	682	6.0	1	122	N				3 06.6	-2.0	-2.0	133	2 54.9	.	.	144
27	685	6.5	1	123	4 31.4	-1.4	+0.2	60	4 12.3	-1.3	+1.5	43	3 52.5	-1.4	+1.6	52
27	692d	1.1	1	123	6 02.3	-1.2	+1.3	31	5 49.7	.	.	15	5 26.1	-1.4	+1.9	36
27	692d	1.1	2	123	6 44.1	-0.4	-3.4	316	6 19.0	.	.	328	6 22.9	-1.4	-2.5	303
28	814d	5.3	1	135	3 38.4	-1.6	+0.9	65	3 22.0	-1.1	+2.2	45	3 01.9	-1.0	+2.3	51
Feb. 3	1547	3.8	2	203	2 32.8	-0.2	+1.1	286	A				A			
6	1875d	6.5	2	240	12 39.8	-1.8	-0.6	248	12 04.5	.	.	233	N			
12	2629d	6.3	2	310	S				S				14 05.5	-1.2	+1.3	264
19	62	7.5	1	38	0 40.2	.	.	133	S				S			
19	76	5.9	1	39	A				3 00.9	-0.4	-1.6	94	3 03.6	-0.7	-2.0	106
22	491	6.2	1	80	4 08.8	-0.6	-1.3	87	3 52.1	-0.9	-0.9	77	3 45.2	-1.3	-1.0	89
22	498	6.2	1	81	5 37.4	0.0	-1.6	97	5 27.6	-0.4	-1.6	92	5 30.1	-0.7	-2.1	109

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900 U.T.	a	b	P	Ed EDMONTON, ALTA. W.113°.400, N. 53°.600 U.T.	a	b	P	Va VANCOUVER, B.C. W.123°.100, N. 49°.200 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Feb. 22	508	4.3	1	81		A				A			7 11.9	-0.1	-1.8	102
23	626	6.4	1	92	2 08.2	-1.5	-0.5	82	1 45.3	-1.3	+0.8	65		S		
23	635	3.9	1	93	4 25.1	-0.8	-0.8	70	4 06.8	-1.1	-0.1	62	3 54.8	-1.5	-0.2	75
23	659	6.4	1	94		A			7 16.8	-0.6	+0.5	29	7 10.9	-0.6	-0.3	52
23	661	4.6	1	94		A			7 23.2	0.0	-2.1	112	7 33.9	0.0	-3.0	134
23	669	4.0	1	95		A				A			8 29.3	-0.2	-0.8	64
23	671	3.6	1	95		A				A			8 28.8	0.0	-1.3	85
24	806	5.1	1	107		A			9 00.6	+0.4	-2.5	135		G		
25	943	6.2	1	118		N				N			6 25.7	-1.7	+1.3	41
25	951	6.8	1	119	7 42.2	-0.1	-1.8	107	7 30.0	-0.5	-2.0	110	7 34.6	-0.6	-2.7	130
27	1207	5.8	1	142	7 30.2	-1.4	-0.3	57	7 05.1	-1.6	0.0	63	6 49.7	-1.8	-0.3	84
28	1323	6.3	1	153	7 04.0	-1.5	-0.9	85	6 36.6	-1.6	-0.4	89	6 22.8	-1.7	-0.6	108
Mar. 4	1821d	2.9	1	207	4 51.9	-0.6	-0.4	143	4 44.3	-0.3	+0.1	139		A		
4	1821d	2.9	2	207	5 57.5	-1.5	+1.4	266	5 44.7	-0.9	+1.8	265	5 26.8	-0.7	+3.0	242
4	1825	6.1	2	208	7 23.2	-1.5	-0.1	291	7 02.6	-1.1	+0.7	286	6 46.3	-1.1	+1.7	265
19	306	6.9	1	34		A				A			3 44.6	-0.2	-3.4	132
20	453	7.3	1	49		A				A			5 06.6	-0.2	-0.7	64
22	741	5.7	1	74	4 03.4	-0.6	-0.6	60	3 48.3	-1.0	-0.3	57	3 39.4	-1.3	-0.5	74
23	886	7.0	1	86	3 02.8	.	.	29	2 46.9	.	.	16		S		
25	1158	5.2	1	110	2 57.0	-1.1	-3.5	150	2 25.3	-1.4	-2.1	142		S		
27	1405	7.0	1	135	9 31.8	+0.4	-2.6	156	9 26.2	+0.2	-3.0	164		N		
27	1413	6.7	1	136		A				A			11 21.5	+0.3	-2.5	154
Apr. 4	2223d	4.0	2	222	5 46.3	-1.1	+1.7	261		A				A		
4	2245	6.4	2	223		N				N			9 53.6	-0.7	-1.2	337
18	677	4.8	1	41	2 06.3	-0.4	-1.4	90		S				S		
18	680	6.7	1	41	2 12.6	-0.3	-1.7	101		S				S		
18	685	6.5	1	42	3 25.5	0.0	-1.1	77	3 18.2	-0.4	-1.2	78		S		
18	692d	1.1	1	43		A			4 23.6	-0.3	-0.4	47	4 23.7	-0.3	-0.8	66
18	692d	1.1	2	43		A			5 06.1	+0.4	-2.0	303	5 16.8	+0.2	-1.6	284
19	829	7.0	1	55	3 32.3	-0.5	-0.3	48	3 19.8	-0.9	-0.3	50		S		
20	985d	6.9	1	67	2 10.0	-0.9	-1.4	96		S				S		
21	1114	6.8	1	80	2 59.3	-0.9	-1.8	110		S				S		
21	1124d	6.9	1	80	4 29.0	-0.3	-1.9	111	4 13.5	-0.7	-2.0	116	4 16.4	-0.8	-2.7	136
23	1360	7.5	1	103	3 33.1	-1.3	-1.4	102		S				S		
May 15	692d	1.1	1	16	12 47.5	+0.6	+2.2	24		N				A		
15	692d	1.1	2	16	13 19.0	-0.3	+0.6	309		N				A		
19	1207	5.8	1	61	4 55.0	+0.6	-2.5	154	4 52.8	+0.5	-3.3	164		N		
20	1336	5.2	1	74		A			6 29.9	0.0	-1.6	96	6 36.8	-0.1	-1.8	109
21	1427	6.8	1	83	3 09.2	-0.9	-1.8	111		S				S		
22	1547	3.8	1	96	5 53.2	-0.1	-2.2	133	5 40.1	-0.4	-2.3	140	5 47.6	-0.3	-2.9	158
June 1	2734d	5.4	2	211		S				S			10 32.1	-1.8	-0.9	310
2	2886	5.1	2	223		S				S			10 27.5	-1.6	+0.7	250
3	3017	5.3	2	235	8 58.0	-1.4	+1.7	212	8 43.7	-1.2	+1.9	218		A		
19	1609	4.7	1	76		A			6 18.2	-0.4	-0.9	51	6 17.8	-0.6	-1.1	66
19	4006	1.3	2	82	18 13.9	-0.2	-0.3	327		A				A		
22	1921	5.9	1	110		A				A			8 02.2	-0.5	-1.9	111
25	2247	5.6	1	143		A			7 26.6	-1.1	-2.4	161	7 28.6	.	.	177
30	2963d	5.5	2	203	6 14.3	.	.	188		A				N		
July 2	3268	5.6	2	230	8 16.8	-1.1	+1.6	219	8 06.2	-0.9	+1.7	229		A		
5	150d	6.2	2	271		S				S			10 02.1	-0.6	+1.5	270
16	4005	-1.3	1	44		G				G			3 17.4	-1.1	-0.9	64
16	4005	-1.3	2	44		G				G			4 02.1	+0.1	-2.8	340
20	1976	6.9	1	88	4 41.8	-0.7	-1.5	81		S				S		
20	1978	6.6	1	89		A			4 55.9	-0.9	-1.6	92	4 52.3	-1.2	-1.5	101
24	2448	6.4	1	133	3 16.3	-1.6	-0.1	101		S				S		

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900 U.T.	a	b	P	Ed EDMONTON, ALTA. W.113°.400, N. 53°.600 U.T.	a	b	P	Va VANCOUVER, B.C. W.123°.100, N. 49°.200 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
July 25	2591	6.5	1	146	5 01.5	-1.6	-0.7	108	4 36.1	-1.4	+0.2	106	S			
26	2757	5.1	1	159	4 58.0	-1.6	-0.5	123	4 35.5	-1.1	+0.4	121	4 24.3	-0.9	+0.1	134
Aug. 4	508	4.3	1	280	7 33.0	+0.2	+2.3	27	A				A			
4	508	4.3	2	280	8 14.3	-0.6	+1.0	295	A				A			
5	661	4.6	2	293	8 01.9	+0.2	+1.9	229	A				A			
5	669	4.0	1	293	8 13.8	+0.1	+1.8	58	A				A			
5	669	4.0	2	293	9 09.0	-0.4	+1.4	271	9 09.8	-0.1	+1.2	289	A			
5	671	3.6	1	293	8 12.3	0.0	+1.6	78	A				A			
5	671	3.6	2	293	9 09.7	-0.2	+1.8	250	9 13.6	0.0	+1.5	267	A			
5	677	4.8	2	294	S				9 51.2	.	.	325	9 43.7	.	.	326
5	678	5.5	2	293	N				9 42.0	+0.6	+3.2	190	9 34.9	+0.8	+3.1	190
5	682	6.0	2	294	S				S				10 19.1	+0.2	+2.2	217
5	685	6.5	2	294	S				S				11 17.1	-0.8	+0.8	297
5	692d	1.1	1	295	11 54.9	-0.9	+2.1	51	11 55.9	-0.1	+3.0	23	11 42.5	+0.1	+3.0	22
5	692d	1.1	2	295	13 03.1	-1.6	+0.3	277	12 38.1	-1.6	-0.1	305	12 23.2	-1.4	+0.2	305
6	814d	5.3	2	306	S				10 10.6	-0.1	+1.5	269	A			
17	2047	6.7	1	69	A				A				4 08.2	-1.2	-0.6	54
20	2396	6.6	1	102	3 23.1	-1.4	-1.0	90	S				S			
24	2994d	6.1	1	152	5 02.9	-1.7	-0.4	103	4 38.7	-1.3	+0.6	93	4 22.7	-1.3	+0.8	98
28	49	6.3	2	207	6 56.1	-1.4	+0.9	260	6 39.9	-1.1	+1.1	279	6 25.5	-0.8	+1.2	279
30	364	4.3	1	238	S				11 27.5	-1.4	+0.1	84	11 11.2	-1.6	+0.6	85
30	364	4.3	2	238	S				S				12 20.3	-1.2	+1.2	226
31	491	6.2	2	251	S				S				12 06.6	-1.6	+0.5	267
Sept. 1	626	6.4	2	263	9 37.7	-1.0	+1.6	248	9 29.0	-0.7	+1.4	270	9 16.5	-0.5	+1.4	270
1	635	3.9	1	264	10 41.2	-1.5	+0.5	94	10 26.2	-0.9	+1.6	71	10 11.4	-0.7	+1.7	71
1	635	3.9	2	264	S				11 36.1	-1.2	+1.2	255	11 19.2	-1.1	+1.5	253
1	692d	1.1	1	268	19 07.1	0.0	-0.5	52	19 02.4	-0.3	-0.6	54	19 02.5	-0.4	-1.0	73
1	692d	1.1	2	268	A				19 50.9	+0.3	-1.9	294	19 59.9	0.0	-1.5	276
3	943	6.2	2	290	N				11 21.2	-0.1	+3.5	207	11 06.4	+0.3	+3.6	203
3	947d	5.2	2	290	S				S				11 56.4	-1.4	-0.2	313
15	2223d	4.0	1	60	A				A				3 12.0	-1.2	-1.4	90
18	2632	7.2	1	95	A				A				4 40.6	-1.4	-0.9	84
21	3091	6.9	1	134	A				A				8 21.9	-0.8	-0.8	71
27	444	6.2	2	219	N				10 33.7	-0.8	+2.0	205	10 16.0	-0.7	+2.6	201
29	741	5.7	2	246	N				10 03.4	-0.7	+2.6	213	9 45.7	-0.4	+2.9	210
Oct. 2	1175	5.0	2	283	9 27.8	-0.7	+1.3	275	9 22.8	-0.4	+0.9	296	9 15.7	-0.2	+0.9	293
16	2717	7.4	1	75	1 55.7	-1.6	-1.8	121	1 26.1	-1.5	-0.7	108	S			
16	2720	6.4	1	75	N				2 39.1	-1.7	-1.9	136	2 29.5	-2.0	-1.7	138
18	3017	5.3	1	100	A				4 45.5	-0.8	-0.3	50	4 37.2	-1.1	+0.1	49
22	49	6.3	1	153	3 35.7	-1.2	+1.1	61	3 25.4	-0.8	+1.7	43	3 10.5	-0.7	+1.9	42
26	635	3.9	1	210	2 59.9	-0.3	+1.0	110	A				A			
26	635	3.9	2	210	3 44.7	0.0	+2.3	217	3 52.7	+0.1	+1.8	236	A			
26	659	6.4	2	212	N				6 18.5	-0.3	+2.4	215	6 05.9	-0.1	+2.4	215
26	667	5.3	2	212	8 12.4	-1.3	+1.2	238	7 56.6	-1.1	+1.0	261	7 40.7	-1.0	+1.3	259
26	677	4.8	2	213	N				8 27.2	.	.	180	G			
27	832	4.7	2	227	9 46.6	-1.5	+1.3	235	9 29.1	-1.2	+1.1	254	9 11.8	-1.1	+1.6	249
27	836	5.5	2	227	10 17.5	-1.4	+2.8	209	10 04.3	-1.2	+1.7	231	9 44.5	-1.0	+2.4	223
Nov. 1	1487d	1.3	1	288	9 44.0	-0.9	-2.1	163	9 31.2	-0.4	+0.1	140	9 28.7	-0.3	-0.6	151
1	1487d	1.3	2	288	10 21.4	-1.0	+4.3	227	10 22.8	-0.4	+2.5	247	10 08.5	0.0	+3.1	233
12	2679	7.4	1	45	A				A				1 21.6	-1.3	-0.8	78
13	2829	6.9	1	56	1 05.3	-1.0	-0.9	75	0 45.2	-1.2	-0.2	58	S			
14	2963d	5.5	1	69	A				2 12.0	-0.4	+0.7	22	2 02.2	-0.7	+1.3	20
16	3237	4.4	1	93	0 37.6	-1.6	+0.3	79	0 17.9	-1.2	+1.1	64	S			
16	3245	6.9	1	93	2 49.2	.	.	353	N				N			
16	3268	5.6	1	95	A				A				6 16.8	-0.6	-0.5	58

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900 U.T.	a	b	P	Ed EDMONTON, ALTA. W.113°.400, N. 53°.600 U.T.	a	b	P	Va VANCOUVER, B.C. W.123°.100, N. 49°.200 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Nov. 18	20	6.8	1	123		A				A			8 55.2	-0.5	-0.8	67
18	106	6.8	1	132	23 49.3	-0.8	+1.5	76		S				S		
19	150d	6.2	1	136	7 42.0	-0.7	-1.6	96	7 24.2	-0.9	-0.7	74	7 16.2	-1.3	-0.5	79
19	165	6.7	1	137		A			9 41.5	-0.2	0.0	37	9 38.4	-0.5	-0.2	50
24	913	5.2	2	207	8 40.9	-1.6	-2.1	310		N			7 54.7	.	.	326
24	940	5.7	2	208		N				G			12 34.9	-0.9	-2.8	314
28	1487d	1.3	1	261		A			18 49.3	+0.1	-2.0	131	18 59.4	+0.1	-2.3	144
28	1487d	1.3	2	261		A			19 42.1	+0.1	-1.4	266	19 48.5	-0.1	-1.3	256
Dec. 10	2797	3.0	1	27		A				A			0 56.5	-1.1	-1.2	89
14	3339	6.7	1	75	0 21.3	-1.6	-0.1	80	0 00.1	-1.2	+0.9	60		S		
14	3347	6.2	1	76	2 26.1	.	.	358		N				N		
15	66	6.8	1	101	23 51.5	-0.7	+2.1	24		S				S		
16	208	7.0	1	114	23 28.5	-0.9	+1.6	65		S				S		
17	346	7.4	1	128	23 40.5	-0.9	+1.4	87		S				S		
18	364	4.3	1	130	3 29.3	-1.8	-0.6	100	3 05.9	-1.2	+0.9	74	2 49.2	-1.2	+1.3	72
19	491	6.2	1	143	2 29.5	-1.5	+0.6	94	2 15.6	-0.8	+1.5	70	2 01.6	-0.6	+1.7	69
19	498	6.2	1	144		N			3 56.0	-1.6	-0.2	112	3 39.5	-1.7	+0.2	112
20	635	3.9	1	156		N			0 36.8	-0.4	+1.0	119	0 29.9	-0.2	+0.8	119
20	667	5.3	1	158	5 06.1	-1.9	-1.7	123	4 37.9	-1.3	+0.5	96	4 22.0	-1.3	+0.8	98
24	1275	5.6	2	212	6 44.3	.	.	345		N				N		
25	1385	6.5	2	223	4 21.5	-0.1	+2.2	247	4 27.8	+0.1	+1.5	267		A		
25	1415d	6.2	2	227	13 02.2	-1.3	-0.8	250	12 35.4	-1.8	+0.3	239		N		
28	1733	5.2	2	261	11 21.2	-1.2	-1.3	321	11 00.4	-1.0	-0.5	316	10 50.3	-1.1	+0.4	296

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72°.500, N. 42°.500 U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77°.000, N. 38°.900 U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85°.000, N. 33°.000 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 13	2245	6.4	2	304		S				S			11 42.3	-2.0	+0.8	271
22	95	7.1	1	82	23 30.9	-1.6	+1.1	50		N				N		
23	249	4.7	1	82	23 41.4	-1.3	+1.1	44	23 30.9	-1.6	+1.1	50		S		
24	4014	7.4	1	93	18 23.4	-0.3	+2.0	53	18 15.4	-0.2	+1.9	57	18 04.7	0.0	+1.5	65
25	405	4.4	1	98	4 54.3	-0.1	-2.1	113	5 03.4	0.0	-3.3	132		N		
26	516	7.3	1	109		N				N			2 01.0	.	.	10
26	526	6.9	1	110	5 19.0	-0.7	+0.8	34	5 14.6	-0.7	+0.1	51	5 09.6	-0.9	-0.6	76
26	659	6.4	1	121	24 08.1	-1.9	+0.7	82	23 56.9	-2.0	+0.6	89	23 36.9	-2.1	+0.5	97
27	667	5.3	1	122	2 26.1	.	.	21	2 08.5	-1.8	+2.3	38	1 41.5	-2.1	+1.7	55
27	669	4.0	1	122	2 10.1	-2.0	-2.2	120	2 10.6	.	.	137		N		
27	672d	6.6	1	122	2 21.4	-1.8	-0.2	79	2 13.7	-2.1	-0.4	90	1 58.5	-2.7	-1.0	106
27	677	4.8	1	122	3 19.3	-1.5	-0.8	86	3 15.4	-1.8	-1.2	98	3 09.0	-2.4	-2.5	121
27	680	6.7	1	122	3 27.4	-1.5	-1.3	98	3 26.1	-1.7	-1.9	111	3 27.8	.	.	141
27	685	6.5	1	123	5 04.3	-0.9	-0.9	78	5 04.1	-1.0	-1.3	92	5 05.3	-1.2	-2.3	117
27	692d	1.1	1	123	6 21.7	-0.6	+0.2	43	6 19.1	-0.6	-0.3	60	6 17.1	-0.8	-0.9	86
27	692d	1.1	2	123	7 05.0	+0.3	-2.4	309	7 13.5	+0.1	-1.8	292	7 21.2	-0.2	-1.0	267
28	814d	5.3	1	135	4 20.3	-1.5	-0.9	88	4 17.3	-1.7	-1.4	101	4 13.8	-2.1	-2.8	127
28	823d	6.6	1	135		N				N			5 48.6	.	.	29
28	829	7.0	1	136		N			7 04.4	-1.4	+1.7	30	6 52.3	-1.1	-0.2	65
28	943	6.2	1	145	23 06.6	-0.7	+2.3	58	22 55.9	-0.6	+2.0	64		S		
Feb. 3	1547	3.8	1	203	1 33.0	-0.5	-0.2	135	1 32.6	-0.5	-1.0	148		G		
3	1547	3.8	2	203	2 33.7	-0.9	+2.0	257	2 21.6	-0.7	+2.8	241		G		
4	1644	4.1	2	214		N				N			3 13.0	-0.6	-1.5	332
5	1749	6.1	2	226		N				N			5 24.7	-0.9	-1.5	329
6	1869d	6.1	2	239	10 51.9	.	.	228		N				N		

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72°.500, N. 42°.500 U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77°.000, N. 38°.900 U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85°.000, N. 33°.000 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Feb. 23	626	6.4	1	92	2 47.8	-0.8	-1.8	104	2 51.6	-0.9	-2.5	120		N		
23	635	3.9	1	93	4 44.8	-0.2	-1.0	78	4 48.0	-0.2	-1.3	92	4 56.1	-0.2	-2.1	119
25	943	6.2	1	118		N				A			7 08.7	-0.5	-0.2	60
27	1207	5.8	1	142	7 58.3	-0.8	+0.1	46	7 56.2	-0.6	-0.5	64	7 56.1	-0.6	-1.1	89
28	1323	6.3	1	153	7 40.6	-0.8	-1.0	76	7 41.1	-0.8	-1.3	89	7 43.2	-0.9	-1.8	113
Mar. 4	1821d	2.9	1	207	5 20.7	-1.3	-1.3	142	5 22.1	-0.8	-2.4	161		N		
4	1821d	2.9	2	207	6 40.9	-2.3	-0.2	275	6 28.2	-2.9	+1.0	257		N		
4	1825	6.1	2	208	8 10.8	-1.6	-1.7	304	8 08.2	-2.0	-1.3	291	7 52.1	-3.1	+0.2	264
5	1921	5.9	2	217	3 47.8	-1.3	+2.1	256	3 30.6	.	.	231		N		
9	2399	5.0	2	263	7 02.6	-1.3	+1.5	262	6 49.8	-1.4	+2.3	244		N		
12	2863	6.1	2	302		N				N			9 57.7	.	.	338
21	692d	1.1	1	70		N				N			16 49.1	.	.	3
21	692d	1.1	2	70		N				N			17 08.7	.	.	324
22	729	7.2	1	73	1 19.8	.	.	19	1 06.4	-1.5	+1.0	43	0 49.9	-1.9	+0.1	69
22	741	5.7	1	74		A				A			4 24.4	0.0	-1.3	100
23	886	7.0	1	86	3 29.2	-1.2	+0.9	35	3 23.2	-1.0	0.0	56	3 17.7	-1.1	-0.8	83
24	1038	6.8	1	98		G			3 37.4	-1.5	+0.4	51	3 26.4	-1.6	-0.7	81
25	1158	5.2	1	110	3 40.5	-0.3	-3.4	151		G				N		
Apr. 4	2223d	4.0	1	222	4 59.5	-0.9	-0.2	133	4 58.4	-0.5	-1.1	151		N		
4	2223d	4.0	2	222	6 15.4	-2.0	+0.6	271	6 02.1	-2.3	+1.5	255		N		
18	659	6.4	1	40	0 19.1	-0.2	-2.7	128	0 32.2	.	.	154		N		
18	667	5.3	1	41	1 33.9	-0.3	0.0	46	1 33.3	-0.3	-0.4	62	1 34.7	-0.3	-0.9	87
18	672d	6.6	1	41		A			1 45.4	+0.1	-1.6	108	1 59.5	+0.4	-3.1	140
19	814d	5.3	1	54	1 44.3	-0.1	-1.9	113	1 51.7	0.0	-2.4	129		N		
19	823d	6.6	1	55		N				A			2 50.3	-0.5	-0.1	61
20	985d	6.9	1	67	2 35.8	-0.2	-1.4	94	2 40.1	-0.2	-1.7	108	2 50.6	-0.1	-2.6	135
21	1114	6.8	1	80	3 25.5	-0.2	-1.6	105	3 31.0	-0.2	-1.9	118	3 43.8	+0.1	-2.8	145
21	1124d	6.9	1	80		A				A			5 03.4	+0.5	-2.3	141
23	1360	7.5	1	103	4 09.9	-0.7	-1.4	93	4 12.3	-0.7	-1.7	105	4 17.8	-0.7	-2.2	128
May 3	2448	6.4	2	214	4 11.1	-2.0	+2.5	237		N				N		
6	2902	6.0	2	251	6 43.0	-0.8	-0.4	319	6 39.6	-0.9	+0.1	305	6 30.3	-0.8	+0.7	283
15	692d	1.1	1	16	12 25.1	0.0	+1.7	60	12 19.4	+0.1	+1.6	63	12 12.6	+0.3	+1.3	70
15	692d	1.1	2	16	13 21.3	-0.6	+1.3	268	13 14.6	-0.4	+1.3	265	13 05.4	-0.1	+1.2	259
17	904	7.1	1	34	0 43.1	-0.2	-0.9	78	0 45.9	-0.2	-1.2	91		S		
18	1060	7.4	1	47		N				N			2 00.1	-1.5	+1.7	35
19	1192	7.4	1	60		N			2 24.3	.	.	34	2 14.3	-1.0	-0.5	71
20	1324	7.2	1	72		N				N			4 11.6	-0.8	+0.5	49
21	1425	6.9	1	83	2 56.2	-1.0	-0.8	68	2 55.2	-1.0	-1.1	82	2 54.7	-1.1	-1.6	106
21	1427	6.8	1	83	3 37.7	-0.3	-1.6	102	3 42.4	-0.3	-1.8	112	3 51.5	-0.3	-2.2	133
22	1531	5.9	1	94	3 19.7	-0.4	-2.4	140	3 27.8	-0.2	-2.9	153		G		
25	1821d	2.9	1	127	1 33.2	.	.	176		N				N		
25	1821d	2.9	2	127	2 21.6	.	.	243		N				N		
25	1825	6.1	1	127	2 41.9	-1.4	-2.0	138	2 44.2	-1.2	-2.6	152		G		
June 19	4006	1.3	1	82	17 16.4	-0.4	+1.1	99	17 11.9	-0.2	+0.6	110		A		
19	4006	1.3	2	82	18 24.0	-0.8	+0.3	300	18 18.7	-0.7	+0.7	287	18 7.9	-0.4	+1.4	265
23	2008	6.6	1	119	3 29.9	-1.0	-2.7	155	3 36.5	-0.9	-3.5	168		N		
25	2223d	4.0	1	141	2 27.2	-2.1	-0.3	96	2 19.0	-2.1	-0.5	108	2 07.4	-1.7	-1.1	132
July 9	4002	-4.1	1	328		N			19 40.5	.	.	21	19 25.0	-1.2	+0.2	59
9	4002	-4.1	2	328		N			20 5.8	.	.	333	20 23.0	-0.3	-1.9	296
21	2072	6.7	1	98	2 02.4	-1.6	-1.1	87	1 58.9	-1.8	-1.2	96	1 50.8	-2.1	-1.5	114
24	2448	6.4	1	133	4 04.4	-1.6	-1.4	108	4 01.7	-1.9	-1.4	114	3 54.2	-2.3	-1.7	126
25	2591	6.5	1	146	5 52.3	-1.6	-2.4	133	5 53.7	-2.0	-2.8	140	5 55.1	.	.	154
26	2734d	5.4	1	157	1 06.7	-1.8	+1.7	60	0 53.2	-1.6	+1.5	72		S		
30	3347	6.2	2	211	4 43.6	-1.2	+2.0	216	4 30.5	-1.1	+2.4	211	4 05.7	-1.0	+3.4	196
Aug. 4	498	6.2	2	279	6 34.3	-0.6	+1.0	284	6 28.5	-0.4	+1.0	280		A		

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72°.500, N. 42°.500				Wa WASHINGTON, D.C. W. 77°.000, N. 38°.900				AG ALABAMA-GEORGIA W. 85°.000, N. 33°.000			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Aug. 4	508	4.3	1	280	7 19.6	-0.5	+1.8	62	7 11.3	-0.4	+1.7	65	6 59.8	-0.2	+1.5	70
4	508	4.3	2	280	8 25.5	-1.0	+1.5	255	8 15.5	-0.9	+1.6	252	8 00.3	-0.6	+1.6	248
5	659	6.4	2	292	7 45.8	-0.6	+1.2	275	7 39.2	-0.4	+1.2	272	7 30.2	-0.1	+1.1	266
5	661	4.6	2	293	7 33.3	.	.	177		N				N		
5	667	5.3	2	293		N				N			8 35.1	.	.	328
5	669	4.0	1	293	8 07.8	-0.7	+1.2	92	8 00.6	-0.6	+1.1	96	7 51.0	-0.4	+0.8	102
5	669	4.0	2	293	9 10.2	-0.7	+2.2	232	8 59.6	-0.5	+2.2	228	8 43.7	-0.2	+2.3	223
5	671	3.6	1	293	8 13.9	-1.1	+0.5	116	8 07.5	-1.1	+0.3	121	7 59.8	-1.0	-0.4	129
5	671	3.6	2	293	9 01.6	-0.3	+3.0	208	8 50.0	0.0	+3.1	203	8 32.5	+0.5	+3.5	195
5	677	4.8	2	294		S				S			9 52.8	-0.8	+1.9	238
5	692d	1.1	1	295	12 23.7	-2.1	-0.1	94	12 14.7	-2.3	-0.3	102	11 57.6	-2.8	-0.8	115
5	692d	1.1	2	295	13 42.0	-1.7	+0.8	239	13 29.6	-1.8	+1.7	227	13 01.2	-1.6	+3.3	210
6	814d	5.3	2	306		S				S			9 20.8	.	.	178
20	2396	6.6	1	102		A				A			4 06.5	-1.5	-2.2	126
20	2399	5.0	1	102		A				A			4 18.8	-0.6	+0.6	47
22	2666d	5.0	1	125	1 11.1	-2.0	-0.5	112	1 03.9	-2.0	-0.6	120	0 53.4	-1.8	-1.4	139
24	2981d	5.2	1	151	4 46.2	-0.4	+1.9	16	4 36.7	-0.9	+1.9	22	4 15.7	-1.6	+2.0	30
28	49	6.3	2	207	7 22.1	-1.1	+1.4	216	7 11.4	-1.2	+1.7	213	6 50.1	-1.2	+2.2	210
Sept. 1	608d	6.0	2	261	5 38.9	-0.9	+0.6	296	5 33.1	-0.6	+0.7	292	5 25.5	-0.3	+0.7	285
1	626	6.4	2	263		S			9 27.0	.	.	183		N		
18	2757	5.1	1	105	23 59.7	-2.1	-0.7	118	23 52.9	-2.2	-0.9	126		S		
19	2760d	6.7	1	105	0 30.1	-1.9	+0.2	68	0 19.8	-2.2	+0.4	73		S		
20	2908	6.9	1	117		N				N			0 29.5	.	.	23
Oct. 2	1175	5.0	2	283	9 41.4	-1.5	+2.4	238	9 25.0	-1.1	+3.4	225	8 53.1	.	.	198
17	2993d	6.6	1	98	23 49.8	-1.7	+0.6	60	23 39.0	-2.0	+0.8	63		S		
17	2994d	6.1	1	98	23 50.8	-1.7	+0.6	59	23 40.0	-2.0	+0.8	63		S		
21	3463	6.4	1	140		N			6 51.9	+0.2	+2.9	4	6 39.2	-0.4	+1.6	23
22	49	6.3	1	153	4 17.2	-2.4	-1.6	112	4 11.6	-3.0	-2.0	118	3 57.0	.	.	125
26	626	6.4	2	209	1 43.7	.	.	184		G				N		
26	667	5.3	2	212	8 28.0	.	.	188		N				N		
27	832	4.7	2	227	10 11.3	.	.	199		N				N		
Nov. 12	2666d	5.0	1	44		N				N			0 18.4	.	.	14
14	3079	4.2	1	79	21 58.3	-1.6	+1.2	44		S				S		
14	3086	6.0	1	79	23 06.1	.	.	129	23 00.1	.	.	134		S		
16	3237	4.4	1	93	1 35.6	.	.	135		G				N		
16	3245	6.9	1	93	2 52.0	-0.6	-0.3	58	2 49.6	-0.9	-0.3	63	2 42.0	-1.4	-0.2	69
18	106	6.8	1	132	24 16.4	-2.4	-0.3	116	24 06.5	-2.5	-0.4	119	23 49.9	.	.	125
21	405	4.4	1	161	0 27.6	-0.5	+2.2	37	0 17.4	-0.5	+2.2	39	0 01.8	-0.3	+2.0	44
24	913	5.2	2	207	9 28.9	-1.1	-1.8	291	9 28.5	-1.4	-1.1	276	9 17.7	-2.0	+0.2	251
26	1217	6.1	2	233	10 27.8	-0.6	-4.0	338	10 35.3	-1.2	-2.6	317	10 33.9	-2.0	-1.3	289
28	1434	5.6	2	255	5 25.5	-0.5	+2.1	251	5 15.7	-0.2	+2.5	239		A		
Dec. 11	3058	5.9	1	50	23 14.9	-1.0	-0.5	66	23 11.4	-1.3	-0.4	69		S		
14	3347	6.2	1	76	2 27.4	-0.4	-0.3	57	2 26.5	-0.6	-0.4	65	2 22.5	-1.1	-0.5	75
15	66	6.8	1	101	24 12.6	-1.7	+0.4	70	24 02.6	-1.9	+0.6	73	23 41.8	-2.1	+0.9	75
16	208	7.0	1	114	23 02.6	-2.7	-0.9	113	24 53.0	-3.0	-1.0	116	23 33.8	.	.	120
17	210d	6.6	1	115	1 07.9	-1.1	+1.7	32	0 56.3	-1.3	+1.8	36	0 34.3	-1.4	+2.0	40
24	1259	5.9	2	210	2 56.4	-1.0	+0.1	305	2 51.3	-0.9	+0.4	296	2 42.8	-0.5	+0.6	284
24	1275	5.6	2	212	7 40.3	-1.5	-2.4	319	7 39.8	-1.9	-1.5	303	7 27.6	-2.4	-0.1	277

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91°.000, N. 40°.000				Te TEXAS W. 98°.000, N. 31°.000				De DENVER, COLO. W.105°.000, N. 39°.800			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 12	2128	5.8	2	293		S			12 30.4	-1.9	-0.5	299	12 15.7	-1.1	-0.5	313
13	2245	6.4	2	304	11 37.4	-1.3	+0.7	283	11 13.8	-2.0	+2.7	241	11 20.6	-1.0	+1.5	265
22	3526d	5.1	1	57		A				N			2 40.4	-1.4	-2.9	120
23	128	7.3	1	72		A				A			4 50.9	-0.4	-0.8	77
24	4014	7.4	1	93	18 17.4	+0.1	+1.9	47		A				A		
25	398	6.7	1	97		N			3 41.2	.	.	5		N		
25	405	4.4	1	98	4 55.8	-0.6	-3.7	132		N			4 42.8	-1.4	-4.2	132
25	508	4.3	1	108	23 35.5	-2.7	-1.1	123		N				S		
26	526	6.9	1	110	5 02.0	-1.1	+0.2	53	4 55.2	-1.5	-0.8	86	4 43.2	-1.5	+0.6	54
27	667	5.3	1	122	1 50.4	.	.	19	1 12.9	-1.6	+2.4	47		N		
27	669	4.0	1	122	1 30.4	-2.5	-1.1	116		N			0 59.1	-1.9	+0.5	99
27	671	3.6	1	122		N				N			1 09.6	-2.6	-1.1	125
27	672d	6.6	1	122	1 44.1	-2.0	+0.8	77	1 24.2	-2.6	0.0	99	1 18.9	-1.5	+1.7	64
27	677	4.8	1	122	2 46.2	-2.1	-0.3	90	2 36.9	-3.1	-2.0	120	2 16.5	-2.0	+0.8	80
27	680	6.7	1	122	2 56.2	-2.2	-1.0	103	2 59.1	.	.	144	2 24.7	-2.2	+0.2	93
27	685	6.5	1	123	4 45.1	-1.5	-1.1	93	4 50.7	-2.0	-3.5	131	4 19.9	-2.1	-0.7	93
27	692d	1.1	1	123	6 06.8	-1.1	-0.4	66	6 06.4	-1.3	-1.4	100	5 48.6	-1.6	-0.3	72
27	692d	1.1	2	123	7 10.2	-0.3	-1.7	284	7 15.6	-0.9	-0.3	250	7 01.8	-0.9	-1.4	274
28	814d	5.3	1	135	3 49.0	-2.1	-0.8	99	3 47.7	.	.	136	3 18.3	-2.2	+0.1	94
28	823d	6.6	1	135		N			5 15.1	-2.4	+1.6	50		N		
28	829	7.0	1	136	6 46.2	-1.5	+0.9	44	6 35.4	-1.6	-0.6	83	6 22.7	-1.8	+0.7	55
Feb. 3	1547	3.8	2	203	2 18.9	-0.2	+2.1	250		N				A		
5	1749	6.1	2	226	5 02.8	.	.	4	5 16.3	-0.7	-0.6	313	5 01.1	-0.2	-3.2	353
22	491	6.2	1	80	4 29.1	-0.2	-2.3	119		N			4 23.8	-0.7	-3.1	127
22	498	6.2	1	81		A				N			6 01.2	+0.4	-4.0	142
23	626	6.4	1	92	2 31.2	-1.6	-2.5	119		N			2 04.1	-2.3	-1.9	115
23	635	3.9	1	93	4 41.2	-0.6	-1.5	98	4 58.5	-0.3	-3.9	141	4 29.8	-1.1	-1.8	106
25	943	6.2	1	118	7 05.0	-1.0	+0.5	42	7 01.5	-0.8	-0.8	82	6 49.8	-1.2	-0.2	61
25	951	6.8	1	119	8 00.7	+0.3	-2.1	126		N			8 05.0	+0.3	-3.0	144
27	1207	5.8	1	142	7 44.1	-1.0	-0.9	77	7 48.8	-0.9	-1.7	110	7 27.6	-1.4	-1.3	94
28	1323	6.3	1	153	7 25.1	-1.2	-1.6	103	7 35.0	-1.0	-2.6	136	7 06.0	-1.5	-1.9	119
Mar. 4	1821d	2.9	1	207	5 13.4	.	.	183		N				N		
4	1821d	2.9	2	207	5 47.1	.	.	231		N				N		
4	1825	6.1	2	208	7 36.0	-2.4	0.0	274		N			7 00.2	-2.6	+2.2	250
22	741	5.7	1	74	4 15.1	-0.3	-1.1	85	4 26.4	-0.2	-2.0	119	4 08.1	-0.7	-1.4	96
23	886	7.0	1	86	3 06.2	-1.4	-0.2	66	3 02.5	-1.6	-1.3	101	2 43.3	-1.9	-0.2	75
24	1038	6.8	1	98	3 13.9	-1.9	+0.1	63	3 05.0	-2.0	-1.2	100	2 45.5	-2.2	+0.2	75
Apr. 3	2128	5.8	2	212		N			10 32.9	.	.	359		N		
4	2223d	4.0	1	222	4 55.9	+0.5	-2.5	171		N				N		
4	2223d	4.0	2	222	5 32.6	-2.3	+3.6	233		N				N		
4	2245	6.4	2	223		S			11 04.3	-2.0	-2.4	318	10 30.3	-1.4	-2.5	336
18	667	5.3	1	41	1 26.1	-0.7	-0.6	69	1 30.4	-0.7	-1.5	104		S		
18	672d	6.6	1	41	1 42.6	-0.2	-2.1	116		N				S		
18	677	4.8	1	41	2 23.7	0.0	-1.9	116		N			2 22.9	-0.2	-2.7	129
18	680	6.7	1	41	2 32.7	+0.2	-2.4	129		N			2 35.9	+0.2	-4.1	146
18	685	6.5	1	42		A				A			3 39.4	+0.1	-1.7	111
18	692d	1.1	1	43		A				A			4 33.0	+0.2	-0.8	79
19	814d	5.3	1	54	1 47.1	-0.2	-3.4	141		N				S		
19	823d	6.6	1	55	2 47.1	-0.9	+0.5	42	2 43.4	-0.8	-0.7	81	2 33.0	-1.2	0.0	58
19	829	7.0	1	55	3 39.9	-0.2	-0.7	71	3 48.0	-0.1	-1.3	104	3 35.6	-0.5	-1.1	84
20	985d	6.9	1	67	2 32.4	-0.6	-2.1	119	3 01.1	.	.	171	2 22.5	-0.9	-2.9	134
21	1114	6.8	1	80	3 24.5	-0.4	-2.4	130		N			3 18.1	-0.5	-3.6	149
21	1124d	6.9	1	80	4 49.7	+0.1	-2.1	128	5 19.4	.	.	175	4 50.6	0.0	-2.9	146
23	1360	7.5	1	103	3 57.6	-1.1	-2.0	118	4 14.3	-0.6	-3.5	154	3 41.3	-1.3	-2.5	137
May 8	3206	5.2	2	279		S			10 55.4	-1.9	+0.7	275	10 48.3	-1.4	+0.3	298

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91.000°, N. 40.000° U.T.	a	b	P	Te TEXAS W. 98.000°, N. 31.000° U.T.	a	b	P	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 15	692d	1.1	1	16	12 25.2	+0.4	+1.7	50		A				A		
15	692d	1.1	2	16	13 12.3	-0.1	+0.9	281	13 04.1	+0.2	+0.9	266		A		
19	1192	7.4	1	60	2 04.9	-1.4	0.0	57	2 01.4	-1.3	-1.1	94		S		
20	1324	7.2	1	72		N			4 01.0	-0.9	-0.6	76	3 48.8	-1.6	-0.1	58
21	1425	6.9	1	83	2 36.9	-1.4	-1.4	97	2 43.2	-1.3	-2.3	129		S		
21	1427	6.8	1	83	3 33.6	-0.6	-2.1	124	3 53.2	-0.2	-3.2	157	3 23.9	-0.8	-2.7	142
22	1531	5.9	1	94	3 21.7	+0.1	-4.1	173		N				N		
22	1547	3.8	1	96		A				A			6 17.7	+0.1	-2.9	159
25	1825	6.1	1	127	2 29.2	.	.	177		N				N		
June 18	1487d	1.3	1	63		N			1 12.1	.	.	58		N		
18	1487d	1.3	2	63		N			1 54.9	.	.	354		N		
19	4006	1.3	2	82	18 12.9	-0.3	+0.7	291		A				A		
24	2128	5.8	1	131		A			7 36.7	-0.8	-0.3	65		G		
25	2223d	4.0	1	141	1 53.0	-1.5	-0.3	123	1 54.6	-0.6	-2.3	161		S		
25	2245	6.4	1	143		N			7 29.0	-1.2	+0.4	55		N		
July 2	3268	5.6	2	230	8 03.1	-1.0	+3.0	193		N			7 46.2	-1.2	+2.8	203
5	150d	6.2	2	271		S			9 52.5	-1.0	+2.3	217	10 02.6	-1.0	+1.7	243
9	4002	−4.1	1	328	19 21.9	-1.5	+1.6	33	19 6.0	-1.7	-0.2	74	18 58.5	-1.8	+1.5	42
9	4002	−4.1	2	328	20 3.4	-0.3	-3.5	319	20 18.7	-0.9	-1.3	278	19 54.8	-1.0	-2.8	306
16	4005	−1.3	1	44		A				A			3 39.3	-0.3	-0.8	68
16	4005	−1.3	2	44		A			3 47.8	+0.1	-0.9	86	4 23.1	+0.3	-2.4	332
20	1976	6.9	1	88		A			5 11.1	-0.6	-1.8	116	4 50.7	-1.0	-1.6	99
20	1978	6.6	1	89		A				A			5 26.2	-0.7	-1.8	110
24	2448	6.4	1	133	3 32.5	-2.1	-0.9	113	3 28.4	-2.1	-1.8	138	3 05.3	-1.8	-0.5	123
25	2591	6.5	1	146	5 23.5	-2.1	-1.6	126	5 27.1	.	.	150	4 54.6	-2.0	-1.0	125
26	2757	5.1	1	159	5 22.1	.	.	146		N			4 52.5	-1.8	-1.6	145
30	3347	6.2	2	211	4 19.2	-0.8	+2.3	216		A				A		
Aug. 4	508	4.3	1	280	7 11.3	+0.1	+1.9	51		A				A		
4	508	4.3	2	280	8 06.8	-0.6	+1.3	269	7 52.5	-0.2	+1.3	256	8 01.0	-0.2	+1.0	281
5	659	6.4	2	292	7 36.1	-0.2	+0.8	288		A				A		
5	661	4.6	2	293	7 38.1	+0.5	+2.7	201		N				A		
5	669	4.0	1	293	7 57.5	-0.1	+1.4	80		A				A		
5	669	4.0	2	293	8 55.8	-0.3	+1.7	246	8 39.1	+0.1	+1.8	232	8 52.9	-0.1	+1.4	258
5	671	3.6	1	293	7 59.9	-0.2	+1.0	101		A				A		
5	671	3.6	2	293	8 51.7	-0.1	+2.2	225	8 31.9	+0.4	+2.5	208	8 51.4	+0.1	+1.8	238
5	677	4.8	2	294	9 58.9	-0.9	+1.4	262	9 40.6	-0.5	+1.5	249	9 48.2	-0.6	+1.1	277
5	692d	1.1	1	295	11 46.8	-1.7	+1.0	83	11 27.4	-1.9	+0.4	101	11 28.3	-0.9	+1.7	67
5	692d	1.1	2	295	13 06.0	-1.8	+1.4	242	12 36.3	-1.4	+2.7	220	12 42.2	-1.6	+1.3	256
6	814d	5.3	2	306	9 47.9	0.0	+2.4	222	9 25.8	+0.7	+3.2	201	9 48.2	+0.1	+1.8	236
20	2396	6.6	1	102	3 44.7	-1.5	-1.5	107	3 48.0	-2.0	-2.0	125	3 20.5	-2.0	-1.1	106
20	2399	5.0	1	102		N			4 04.1	-1.5	+1.2	44		N		
24	2981d	5.2	1	151		N			3 47.9	-1.9	+3.1	25		N		
24	2994d	6.1	1	152	5 26.3	-2.8	-2.3	132		N			4 51.7	-2.3	-0.6	117
28	49	6.3	2	207	6 54.1	-1.5	+1.4	235	6 28.9	-1.3	+2.0	224	6 33.7	-1.4	+1.4	250
Sept. 1	626	6.4	2	263	9 23.2	-0.8	+2.7	215	8 51.0	+0.1	+4.0	194	9 12.0	-0.7	+2.1	233
1	635	3.9	1	264		S				N			10 24.5	-2.2	-0.3	116
1	635	3.9	2	264		S				N			11 19.3	-0.9	+3.3	206
1	692d	1.1	1	268		A				A			19 15.1	+0.1	-1.0	86
16	2352	6.7	1	71		N			3 08.2	-0.7	+0.6	49		N		
Oct. 2	1175	5.0	2	283	9 15.4	-0.7	+2.3	241	8 47.2	+0.3	+3.9	211	9 08.1	-0.3	+1.8	253
16	2717	7.4	1	75		N				N			2 01.5	-2.5	-2.7	139
18	3017	5.3	1	100		A			5 31.5	.	.	137	5 02.6	-1.2	-1.1	90
19	3167	7.1	1	113		A			6 21.2	-0.8	-0.5	76	6 16.4	-0.4	+0.4	39
21	3463	6.4	1	140		N			6 30.5	-0.2	+2.8	10		N		
22	49	6.3	1	153	3 37.1	-2.0	+0.4	88	3 18.5	-2.4	+0.1	101	3 12.8	-1.4	+1.3	71

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91.000°, N. 40.000° U.T.	a	b	P	Te TEXAS W. 98.000°, N. 31.000° U.T.	a	b	P	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Oct. 26	635	3.9	2	210	N				N				3 22.1	+0.5	+2.7	200
26	667	5.3	2	212	7 57.0	.	.	193	N				7 43.0	-1.0	+2.7	213
27	832	4.7	2	227	N				N				9 07.2	.	.	193
31	1385	6.5	2	277	S				S				11 39.9	-1.7	-1.0	311
Nov. 13	2829	6.9	1	56	1 24.2	-1.3	-1.6	103	1 29.1	-2.1	-2.3	121	1 03.7	-1.7	-0.9	88
14	2963d	5.5	1	69	2 31.3	-0.9	-0.9	80	2 32.5	-1.5	-1.2	97	2 16.9	-1.2	-0.3	64
16	3237	4.4	1	93	0 50.4	-2.5	-0.7	105	0 38.8	.	.	121	0 18.5	-2.1	+0.5	89
16	3245	6.9	1	93	2 36.7	-1.0	+0.6	41	2 21.7	-1.7	+0.7	55	2 23.9	-0.8	+1.9	19
18	106	6.8	1	132	23 42.2	-1.2	+1.0	97	S				S			
20	405	4.4	1	161	24 17.1	+0.1	+2.6	20	23 56.3	+0.1	+2.1	36	24 20.7	+0.6	+3.6	1
24	913	5.2	2	207	9 04.3	-1.9	-0.7	274	8 47.2	-2.3	+1.3	241	8 36.7	-2.0	-0.1	274
26	1217	6.1	2	233	10 11.4	-1.8	-1.9	307	10 04.8	-2.5	0.0	271	9 44.7	-2.0	-1.0	300
Dec. 12	3071	6.5	1	51	A				2 20.3	-0.9	-1.2	94	2 08.8	-0.7	-0.2	58
14	3339	6.7	1	75	0 41.6	-2.8	-2.0	116	N				S			
14	3347	6.2	1	76	2 16.6	-0.8	+0.4	45	2 06.4	-1.4	+0.2	63	2 05.5	-0.7	+1.4	25
14	3355	6.8	1	77	A				4 36.3	-0.4	-0.3	67	4 36.4	-0.1	+0.9	29
15	66	6.8	1	101	23 40.1	-1.4	+1.6	51	S				S			
16	208	7.0	1	114	23 22.8	-1.6	+1.0	89	S				S			
17	210d	6.6	1	115	0 46.5	-0.3	+3.4	7	0 14.9	-0.8	+2.8	23	N			
17	346	7.4	1	128	23 39.0	-1.8	+0.2	116	S				S			
18	364	4.3	1	130	N				N				3 23.1	.	.	128
19	491	6.2	1	143	N				N				2 11.7	-2.0	+0.1	111
24	1259	5.9	2	210	2 41.7	-0.6	-0.1	314	A				A			
24	1275	5.6	2	212	7 11.6	-1.9	-0.8	299	6 57.0	-2.1	+0.9	266	6 46.7	-1.6	-0.2	299
27	1625	5.9	2	249	N				11 14.9	.	.	7	N			
28	1733	5.2	2	261	11 43.6	-1.8	-1.3	304	11 32.4	-3.1	+0.4	267	11 16.0	-2.1	0.0	284

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121.000°, N. 42.500° U.T.	a	b	P	Ca CALIFORNIA W.120.000°, N. 36.000° U.T.	a	b	P	NM N. MEX.-ARIZ. W.109.000°, N. 34.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 12	2128	5.8	2	293	12 00.7	-0.7	+0.3	301	11 15.8	4-.1	1+.0	728	31 21.1	5-.1	5+.0	229
13	2245	6.4	2	304	A				A				11 03.8	-1.4	+3.2	234
14	2399	5.0	2	317	13 40.0	-0.9	+1.1	276	13 33.0	-1.3	+1.5	259	S			
21	3388d	5.6	1	44	3 42.7	-0.3	0.0	50	3 45.0	-0.4	-0.5	72	A			
22	3526d	5.1	1	57	2 11.9	-1.6	-0.9	89	2 23.6	-2.3	-2.5	116	N			
22	3535	5.2	1	58	4 04.1	-0.6	-0.2	57	4 07.9	-0.8	-0.8	80	4 16.4	-0.4	-1.2	93
22	3537	6.8	1	58	G				4 30.4	-0.3	+1.0	31	A			
23	128	7.3	1	72	4 39.9	-0.8	-0.3	62	4 44.8	-0.9	-1.0	85	4 55.4	-0.5	-1.4	97
25	405	4.4	1	98	4 06.3	-2.0	-1.6	107	N				N			
26	526	6.9	1	110	4 21.3	-1.5	+2.0	36	4 13.7	-2.0	+0.9	60	4 34.7	-1.9	0.0	74
27	667	5.3	1	122	N				N				1 10.9	-0.4	+4.3	17
27	669	4.0	1	122	S				S				0 49.5	-2.2	-0.1	112
27	677	4.8	1	122	1 55.3	-1.1	+2.0	56	1 45.3	-1.5	+1.4	75	2 04.5	-2.3	+0.3	94
27	680	6.7	1	122	1 59.1	-1.3	+1.6	69	1 52.1	-1.8	+0.9	88	2 15.9	-2.7	-0.6	109
27	685	6.5	1	123	3 47.5	-1.9	+0.8	75	3 47.1	-2.4	-0.2	97	4 17.2	-2.6	-1.7	113
27	692d	1.1	1	123	5 21.1	-1.8	+0.7	62	5 21.7	-2.2	-0.3	85	5 45.4	-1.8	-1.0	93
27	692d	1.1	2	123	6 38.6	-1.5	-1.3	278	6 45.7	-1.7	-0.3	256	7 02.8	-1.3	-0.4	253
28	814d	5.3	1	135	2 51.7	-1.4	+1.5	73	2 45.7	-1.8	+0.7	93	3 10.1	-2.6	-0.7	112
28	823d	6.6	1	135	N				4 43.5	.	.	16	4 56.0	-2.2	+3.1	36
28	829	7.0	1	136	5 54.8	-1.9	+1.8	47	5 49.8	-2.3	+0.5	72	6 13.7	-2.1	-0.2	78

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121°.000, N. 42°.500 U.T.	a	b	P	Ca CALIFORNIA W.120°.000, N. 36°.000 U.T.	a	b	P	NM N. MEX.-ARIZ. W.109°.000, N. 34°.000 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Feb. 12	2629d	6.3	2	310	13 58.9	-1.5	+1.5	252	13 48.6	-2.0	+2.3	235		S		
13	2791	5.4	2	323		A				A			12 41.5	0.0	-1.0	326
22	491	6.2	1	80	3 58.7	-1.5	-2.3	115		N				N		
22	498	6.2	1	81	5 50.6	-0.3	-4.3	139		N				N		
23	626	6.4	1	92		S				S			2 13.5	.	.	147
23	635	3.9	1	93	4 02.4	-1.7	-1.1	97	4 16.3	-1.9	-2.8	124	4 39.4	-1.1	-3.5	132
23	659	6.4	1	94	7 16.0	-0.5	-0.8	72	7 22.9	-0.4	-1.2	91		A		
25	943	6.2	1	118	6 25.7	-1.7	0.0	66	6 30.3	-1.7	-0.8	87	6 48.0	-1.2	-0.9	84
25	951	6.8	1	119	7 58.0	+0.1	-4.5	156		N				N		
27	1207	5.8	1	142	6 58.4	-1.8	-1.1	102	7 10.4	-1.7	-2.0	121	7 31.1	-1.3	-1.9	115
28	1323	6.3	1	153	6 34.1	-1.8	-1.7	128	6 52.1	-1.5	-3.5	151	7 13.9	-1.3	-3.0	142
Mar. 4	1825	6.1	2	208	6 32.9	-1.8	+3.7	238		N				N		
22	741	5.7	1	74	3 48.2	-1.3	-1.3	95	4 00.8	-1.2	-2.3	118	4 15.4	-0.7	-2.2	118
23	886	7.0	1	86		S				S			2 38.5	-2.1	-0.9	96
24	1038	6.8	1	98		S				S			2 37.5	-2.4	-0.6	97
Apr. 3	2128	5.8	2	212	9 31.9	.	.	0	9 51.8	-1.2	-2.4	338	10 09.5	.	.	352
4	2245	6.4	2	223	10 03.5	-1.3	-1.1	323	10 11.9	-1.8	-1.0	309	10 35.6	-2.0	-1.8	317
17	516	7.3	1	28		S			3 04.5	-0.6	+0.6	41		A		
18	685	6.5	1	42	3 32.7	-0.3	-2.1	115	3 49.8	+0.2	-3.5	142	3 52.6	+0.4	-2.8	138
18	692d	1.1	1	43	4 30.6	-0.2	-1.1	84	4 38.6	0.0	-1.4	102	4 39.5	+0.3	-1.1	99
18	692d	1.1	2	43	5 25.5	+0.2	-1.1	268		A				A		
19	823d	6.6	1	55		S				S			2 30.5	-1.2	-0.7	81
19	829	7.0	1	55	3 21.1	-1.0	-1.2	89	3 31.4	-0.8	-1.7	109	3 41.3	-0.4	-1.5	105
19	836	5.5	1	56		N			4 38.8	-1.2	+1.3	34	4 48.4	.	.	24
21	1124d	6.9	1	80	4 40.2	0.0	-4.4	160		N				N		
23	1360	7.5	1	103		S			3 41.9	.	.	180	3 56.2	-0.6	-4.4	164
May 8	3206	5.2	2	279		A			10 30.8	-0.7	+0.7	286	10 40.1	-1.3	+0.7	283
20	1324	7.2	1	72		S				S			3 46.0	-1.4	-0.9	82
20	1336	5.2	1	74	6 48.8	+0.1	-1.8	119		A				A		
20	1337	5.6	1	74	7 02.9	-0.5	0.0	47		A				A		
21	1427	6.8	1	83		S				G			3 40.5	-0.1	-4.1	167
22	1547	3.8	1	96	6 10.2	+0.3	-4.0	174		N				G		
June 1	2734d	5.4	2	211	10 42.1	-2.1	-0.9	297	10 49.6	-2.3	-0.7	283	11 15.4	-2.0	-0.8	272
2	2886	5.1	2	223	10 25.6	-1.9	+1.0	239	10 19.2	-2.1	+1.7	225	10 37.8	-1.8	+1.9	213
7	49	6.3	2	288	10 35.6	-0.3	+2.6	201		A				N		
18	1487d	1.3	1	63	0 13.4	.	.	57	0 07.4	-2.8	+0.5	83	0 39.0	-3.1	+0.6	72
18	1487d	1.3	2	63	1 01.2	.	.	351	1 24.4	-1.3	-2.9	327	1 41.2	-0.6	-3.6	341
19	1609	4.7	1	76	6 26.8	-0.4	-1.2	78	6 35.0	-0.3	-1.2	90		A		
24	2128	5.8	1	131		N			7 05.5	.	.	53	7 25.0	-1.4	+0.3	54
25	2245	6.4	1	143		N			6 50.0	.	.	42	7 14.5	.	.	42
30	2981d	5.2	2	205		N			10 41.5	-3.0	-2.2	309	11 13.1	-2.1	-1.3	285
July 2	3268	5.6	2	230	7 36.1	-0.9	+2.6	210	7 16.0	.	.	187	7 19.2	.	.	178
3	3421	5.1	2	245		N			10 28.1	-2.5	-0.5	300	10 56.3	-2.6	+0.1	277
5	150d	6.2	2	271	9 53.4	-0.6	+1.5	259	9 43.8	-0.6	+1.6	246	9 48.4	-0.9	+1.9	235
9	4002	-4.1	1	328	18 36.9	-1.6	+3.3	26	18 24.5	-2.0	+1.4	55	18 45.5	-2.0	+0.5	65
9	4002	-4.1	2	328	19 24.0	-1.8	-3.5	315	19 40.7	-1.9	-1.5	286	20 1.8	-1.4	-1.4	282
16	4005	-1.3	1	44	3 26.5	-0.9	-1.1	76	3 35.1	-0.7	-1.3	90	3 43.4	-0.3	-1.1	85
16	4005	-1.3	2	44	4 19.7	0.0	-2.5	328	4 34.7	0.0	-2.1	315	4 37.0	+0.3	-2.0	317
20	1976	6.9	1	88	4 25.9	-1.6	-1.4	102	4 37.7	-1.6	-1.7	113	4 56.1	-1.1	-1.8	111
20	1978	6.6	1	89	5 05.9	-1.2	-1.7	110	5 19.3	-1.2	-2.0	121	5 34.3	-0.8	-2.0	122
24	2448	6.4	1	133		S				S			3 03.6	-1.5	-1.3	142
25	2591	6.5	1	146	4 24.7	-1.4	-0.3	128	4 31.0	-1.5	-1.3	144	4 53.8	-2.1	-1.8	141
26	2757	5.1	1	159	4 28.4	-0.8	-1.0	150		N				N		
Aug. 3	405	4.4	1	269	12 18.2	.	.	359	11 55.6	-0.8	+2.8	26		S		
5	677	4.8	2	294	9 43.3	-0.3	+0.5	301	9 39.1	-0.1	+0.8	283	9 39.9	-0.3	+1.1	268

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121.000, N. 42.500 U.T.	a	b	P	Ca CALIFORNIA W.120.000, N. 36.000 U.T.	a	b	P	NM N. MEX.-ARIZ. W.109.000, N. 34.000 U.T.	a	b	P
				o	h m	m	m	o	h m	m	m	o	h m	m	m	o
Aug. 5	682	6.0	2	294	10 01.6	+0.5	+2.9	198		N				N		
5	685	6.5	2	294	11 12.1	-0.7	+1.1	279	11 04.9	-0.6	+1.3	263	11 09.2	-0.8	+1.7	245
5	692d	1.1	1	295	11 25.0	-0.2	+2.3	43	11 11.7	-0.4	+1.8	59	11 15.4	-0.9	+1.4	77
5	692d	1.1	2	295	12 22.3	-1.3	+0.8	282	12 16.8	-1.1	+1.2	264	12 27.6	-1.3	+1.7	245
17	2043	6.6	1	69		N			4 06.2	-1.5	+0.1	56	4 18.3	-0.7	-0.2	61
17	2047	6.7	1	69	4 15.5	-1.2	-0.8	68	4 22.8	-1.1	-1.1	82	4 34.6	-0.6	-1.1	87
20	2396	6.6	1	102		S				S			3 19.2	-2.3	-1.4	118
24	2994d	6.1	1	152	4 21.3	-1.6	+0.4	108	4 22.1	-1.8	-0.3	123	4 47.3	-2.6	-1.4	131
28	49	6.3	2	207	6 18.9	-0.9	+1.3	267	6 11.0	-0.9	+1.4	254	6 19.8	-1.2	+1.6	242
30	364	4.3	1	238	11 14.1	-2.3	-0.4	107		N				N		
30	364	4.3	2	238	12 10.7	-0.9	+2.6	202		N				N		
31	491	6.2	2	251	12 04.5	-1.6	+1.1	247	11 56.1	-1.5	+2.0	227		S		
Sept. 1	626	6.4	2	263	9 07.5	-0.5	+1.6	256	8 57.0	-0.3	+1.8	241	8 57.1	-0.4	+2.3	223
1	635	3.9	1	264	10 02.8	-0.9	+1.3	87	9 57.3	-1.3	+0.6	105	10 20.0	.	.	134
1	635	3.9	2	264	11 09.8	-1.0	+2.0	235	10 55.6	-0.7	+2.7	216	10 53.1	.	.	185
1	692d	1.1	1	268	19 10.9	-0.3	-1.3	91	19 20.7	0.0	-1.7	110	19 22.7	+0.2	-1.4	107
1	692d	1.1	2	268	20 08.2	0.0	-1.0	260	20 12.3	-0.1	-0.3	241		A		
3	947d	5.2	2	290	11 57.4	-1.2	+0.6	288	11 52.7	-1.1	+1.2	268	12 04.0	-1.4	+1.7	250
15	2223d	4.0	1	60	3 24.2	-1.2	-1.6	101	3 36.3	-1.3	-1.8	113		A		
18	2632	7.2	1	95	4 50.5	-1.6	-1.2	96	5 01.1	-1.8	-1.6	111	5 24.2	-1.7	-2.6	130
20	2935	7.0	1	120		N			7 17.2	-0.3	+1.3	27	7 20.3	-0.4	+0.2	51
21	3091	6.9	1	134	8 30.2	-1.1	-1.2	90	8 41.4	-1.5	-2.0	113		N		
Oct. 2	1175	5.0	2	283	9 09.0	-0.1	+1.2	274	9 00.6	+0.1	+1.4	256	8 56.5	0.0	+2.0	239
4	1415d	6.2	2	307		N			11 56.2	-0.9	-0.9	321	12 09.2	-1.3	-0.4	307
17	2886	5.1	1	88		A			6 03.5	-0.8	-0.9	83		A		
18	3017	5.3	1	100	4 39.8	-1.4	-0.1	64	4 43.1	-1.8	-0.4	80	5 04.1	-1.7	-1.4	101
19	3167	7.1	1	113	6 18.2	.	.	358	6 05.1	-0.7	+1.2	29	6 12.1	-0.8	+0.2	52
22	49	6.3	1	153	2 59.4	-0.8	+1.8	53	2 49.2	-1.0	+1.6	66	2 59.7	-1.5	+1.2	79
26	659	6.4	2	212	5 47.0	+0.4	+3.5	192		N				N		
26	667	5.3	2	212	7 32.4	-1.0	+1.8	241	7 20.0	-0.7	+2.4	222	7 20.9	-0.3	+4.0	196
27	832	4.7	2	227	9 01.1	-1.0	+2.4	227	8 41.2	-0.3	+4.5	198		N		
27	836	5.5	2	227	9 20.9	.	.	186		N				N		
31	1385	6.5	2	277	11 13.2	-1.3	-1.0	323	11 17.5	-1.4	0.0	297	11 35.3	-1.9	0.0	289
Nov. 12	2679	7.4	1	45	1 30.6	-1.6	-1.0	91	1 40.2	-1.8	-1.4	105	2 02.8	-1.6	-2.4	124
13	2829	6.9	1	56		S				S			1 01.3	-2.1	-1.0	97
14	2963d	5.5	1	69	1 57.5	-1.3	+0.8	39	1 54.6	-1.7	+0.5	56	2 12.9	-1.6	-0.3	74
15	3118	6.9	1	82		N			5 13.3	-0.2	+1.2	27	5 15.1	-0.3	+0.2	50
16	3245	6.9	1	93		N			2 04.4	.	.	1	2 09.0	-1.3	+1.9	30
16	3268	5.6	1	95	6 22.9	-0.8	-0.9	80	6 32.1	-1.1	-1.7	103		A		
18	20	6.8	1	123	9 03.2	-0.5	-1.4	91	9 16.2	-0.7	-2.9	121		A		
19	150d	6.2	1	136	7 26.0	-1.8	-1.6	104		N				N		
19	165	6.7	1	137	9 42.5	-0.6	-0.7	73	9 49.8	-0.6	-1.4	97		A		
24	913	5.2	2	207	8 05.2	-1.9	-0.2	293	8 05.6	-1.9	+0.6	270	8 26.0	-2.1	+0.9	256
24	940	5.7	2	208	12 51.9	-1.1	-1.8	291	13 02.3	-1.3	-1.0	271		S		
26	1217	6.1	2	233	9 13.0	-1.7	-0.9	313	9 17.1	-1.8	+0.1	288	9 38.7	-2.2	+0.1	279
28	1487d	1.3	1	261	19 15.1	+0.3	-2.5	155	19 33.6	+0.7	-3.6	175		A		
28	1487d	1.3	2	261	19 55.6	-0.1	-0.7	244	19 57.3	-0.3	+0.6	224		A		
Dec. 10	2797	3.0	1	27	1 08.2	-1.4	-1.6	104	1 22.3	-1.8	-2.5	125		N		
12	3071	6.5	1	51	1 58.9	-0.6	+0.9	29	1 55.4	-1.1	+0.4	49	2 07.2	-1.0	-0.4	70
14	3347	6.2	1	76		N			1 47.8	-0.4	+3.0	8	1 53.8	-1.2	+1.3	37
14	3355	6.8	1	77		N			4 28.2	-0.4	+1.5	23	4 31.5	-0.5	+0.4	46
18	364	4.3	1	130	2 44.5	-1.6	+0.9	89	2 43.1	-2.4	0.0	108		N		
19	491	6.2	1	143	1 52.8	-0.8	+1.4	83	1 46.3	-1.1	+0.8	99	2 04.7	-2.6	-1.0	125
20	667	5.3	1	158	4 23.7	-2.1	-0.5	122		N				N		
24	1275	5.6	2	212	6 23.6	-1.2	-0.7	318	6 25.5	-1.1	+0.3	293	6 39.3	-1.5	+0.6	280
27	1625	5.9	2	249		N			10 39.8	-1.0	-3.2	345	10 57.1	.	.	353
28	1733	5.2	2	261	10 48.5	-1.5	+1.0	276	10 40.0	-2.0	+2.4	251	11 02.5	-2.7	+1.6	258

NAMES OF OCCULTED STARS

The stars which are occulted by the moon 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 American Ephemeris and Nautical Almanac*, Vol. 10, pt. 2 (U.S. Govt. Printing Office; Washington, 1940). The ZC numbers are used in all occultation predictions, and should be used routinely by observers. The symbol "d" means "a double star".

The brighter ZC stars have Greek letter names or Flamsteed numbers; these are given in the following table.

Z.C. No.	Name	Z.C. No.	Name	Z.C. No.	Name	Z.C. No.	Name
62	11 Cet	832	119 Tau	1609	63 χ Leo	2902	57 Sgr
76	14 Cet	836	120 Tau	1644	77 σ Leo	2963	7 σ Cap
150	26 Cet	895	57 Ori	1733	7 Vir	2981	10 π Cap
165	29 Cet	913	64 Ori	1749	10 Vir	2994	12 o Cap
249	106 ν Psc	940	68 Ori	1821	29 γ Vir	3017	15 υ Cap
364	73 ξ^2 Cet	947	71 Ori	1869	46 Vir	3058	19 Cap
405	87 μ Cet	1158	74 Gem	1875	48 Vir	3071	21 Cap
508	5 Tau	1175	81 Gem	1921	65 Vir	3079	23 θ Cap
626	48 Tau	1207	3 Cnc	1924	66 Vir	3206	51 μ Cap
635	54 γ Tau	1259	20 Cnc	1978	88 Vir	3237	33 ι Aqr
659	70 Tau	1262	25 Cnc	2128	13 Lib	3268	42 Aqr
661	71 Tau	1275	31 θ Cnc	2223	38 γ Lib	3347	70 Aqr
667	75 Tau	1323	54 Cnc	2247	44 η Lib	3388	83 Aqr
669	77 θ^1 Tau	1324	52 Cnc	2291	49 Lib	3421	92 χ Aqr
671	78 θ^2 Tau	1336	62 o^1 Cnc	2399	24 Sco	3526	27 Psc
675	80 Tau	1337	63 o^2 Cnc	2448	29 Oph	3535	29 Psc
678	81 Tau	1415	7 Leo	2666	21 Sgr		
682	85 Tau	1434	16 ψ Leo	2734	29 Sgr	4002	Venus
692	87 α Tau	1487	32 α Leo	2757	36 Sgr	4005	Jupiter
806	111 Tau	1531	45 Leo	2797	41 π Sgr	4006	Saturn
814	115 Tau	1547	47 ρ Leo	2886	56 Sgr	4014	Vesta

Editor's Note: Readers who are interested in the scientific value of observations of lunar occultations may wish to read an interesting article by Leslie V. Morrison in the *Monthly Notices of the Royal Astronomical Society* ***187***, 41–82 (1979). The article is entitled "An Analysis of Lunar Occultations in the Years 1943–1974 for Corrections to the Constants in Brown's Theory, the Right Ascension System of the FK4, and Watts' Lunar-Profile Datum"; as the title suggests, the article is a technical one, but the serious amateur may still be interested in reading through it. It is based on approximately 50,000 occultation timings.

Leslie Morrison and his staff at H. M. Nautical Almanac Office prepare all the occultation predictions in this HANDBOOK. In return, we urge readers to take a serious interest in making accurate occultation timings and sending them to H. M. Nautical Almanac Office for analysis.

OCCULTATION LIMITS FOR 1980

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 least10° 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.

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 their latitude and longitude, and details of the event will be supplied (for a nominal fee).

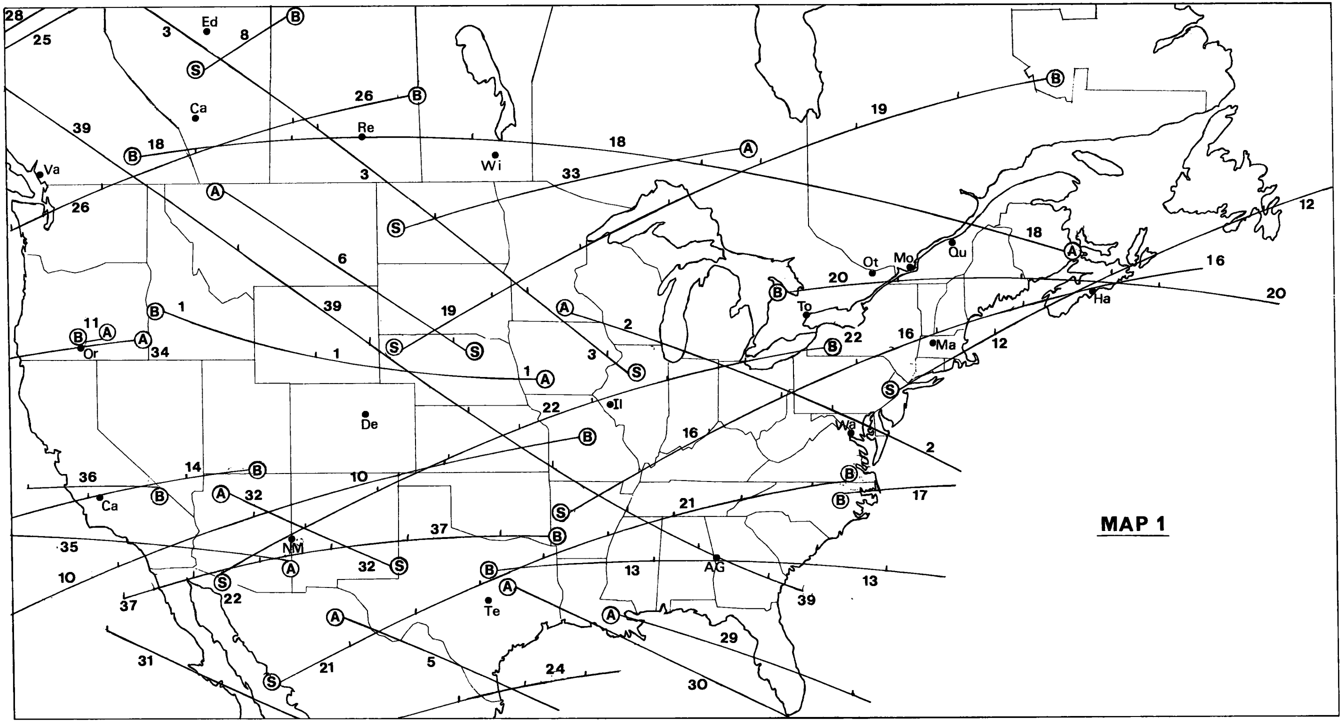
The following table gives, for each track, the date, Zodiacal Catalogue number, magnitude of the star, the time (U.T.) at the beginning of the track in the West, the percent of the Moon sunlit and whether the track is the northern (N) or southern (S) limit of the occultation. An asterisk after the track number refers the reader to the notes following the table; a dagger indicates that the star is a spectroscopic binary.

No.	Date	Z.C.	Mag.	U.T.		%	L	No.	Date	Z.C.	Mag.	U.T.		%	L
				h	m							h	m		
1*	Jan. 9	1821	2.9	17	12	57	N	37	Feb. 23	626	6.4	2	04	52	S
2	11	2008	6.6	8	22	41	S	39	Mar. 8	2280	6.8	10	00	64	S
3	11	2020	6.6	12	12	40	S	40	9	2396	6.6	6	55	55	S
5	13	2245	6.4	10	45	22	S	41	9	2399	5.0	6	19	55	S
6	14	2396	6.6	13	21	13	S	42	11	2710	6.8	10	29	33	S
8	20	3222	7.1	0	36	6	S	43	13	3022	6.9	12	08	14	S
10*	22	3526	5.1	2	28	23	S	44	19	306	6.9	3	58	9	S
11	22	3537	6.8	4	50	24	N	45	21	692	1.1	16	53	33	N
12	22	95	7.1	22	33	32	S	46	22	729	7.2	1	26	36	N
13	25	398	6.7	3	56	57	N	48	23	886	7.0	3	11	47	N
14†	25	405	4.4	4	27	57	S	49	23	904	7.1	7	17	49	N
16†	25	508	4.3	23	46	66	S	50	24	1038	6.8	3	12	58	N
17	26	516	7.3	2	34	67	N	51	25	1158	5.2	2	39	68	S
18	26	526	6.9	4	57	68	N	52	Apr. 6	2497	6.6	6	43	71	S
19†	27	661	4.6	0	11	76	S	54	9	2959	7.2	10	36	38	S
20	27	667	5.3	2	33	77	N	56	17	498	6.2	0	32	6	S
21	27	669	4.0	1	07	77	S	57†	17	508	4.3	1	58	6	S
22†	27	671	3.6	1	09	77	S	58	18	659	6.4	0	39	12	S
24	27	677	4.8	2	52	77	S	59	18	669	4.0	1	43	12	S
25	27	678	5.5	2	17	77	S	60†	18	671	3.6	1	39	12	S
26	27	682	6.0	3	03	77	S	61*	18	672	6.6	2	05	13	S
28	28	806	5.1	1	49	85	S	62	18	677	4.8	2	39	13	S
29	Feb. 8	2072	6.7	6	32	59	S	63	18	680	6.7	2	45	13	S
30	12	2611	6.8	10	47	18	S	64	18	685	6.5	4	03	13	S
31*	12	2629	6.3	13	19	17	S	65*	19	814	5.3	1	55	21	S
32*	13	2798	6.3	13	08	10	S	66*	19	823	6.6	3	02	21	N
33	19	62	7.5	0	50	11	S	67	19	832	4.7	4	13	22	N
34	19	76	5.9	3	28	11	S	68	19	836	5.5	4	46	22	N
35	21	368	6.3	5	12	31	N	69*	22	1236	5.1	1	01	51	N
36	22	491	6.2	4	25	42	S	70	22	1241	6.4	1	58	51	N

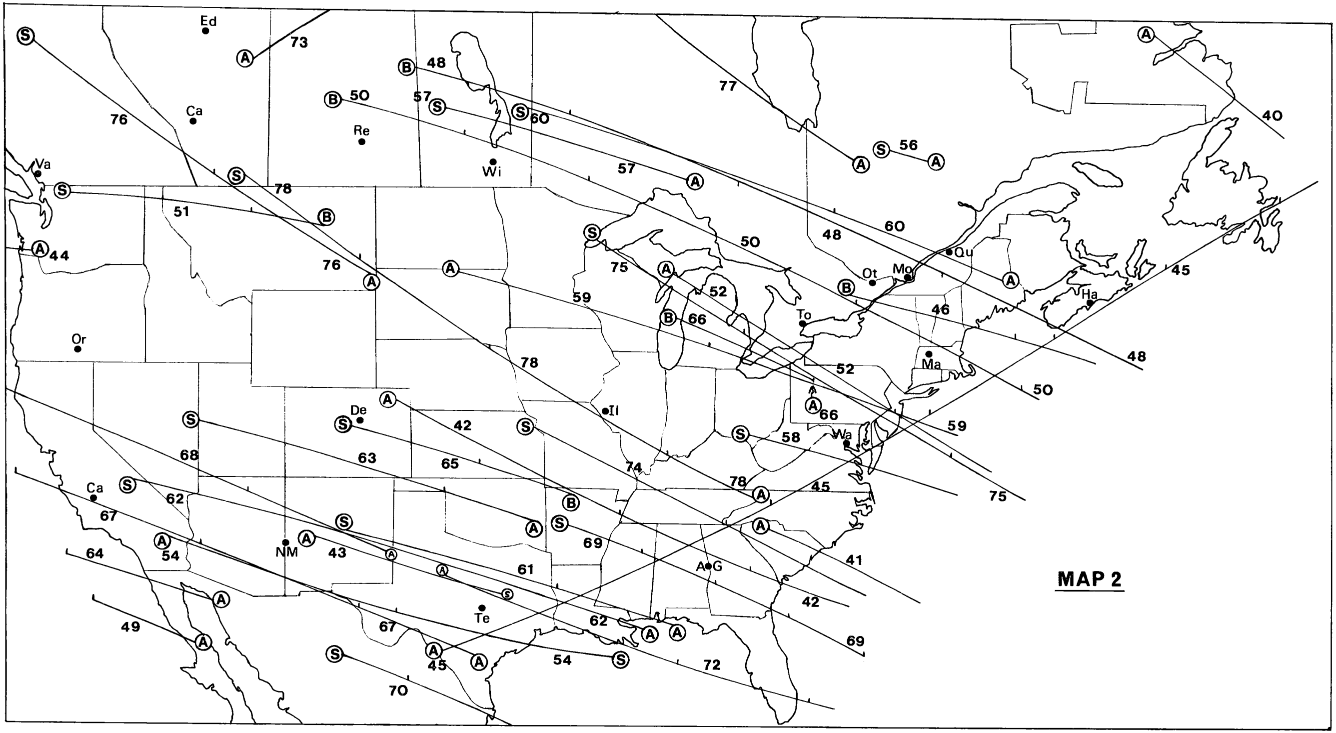
No.	Date	Z.C.	Mag.	U.T.		%	L	No.	Date	Z.C.	Mag.	U.T.		%	L
				h	m							h	m		
72	May 6	2908	6.9	7	22	65	S	131	Sept. 8	1487	1.3	0	40	2	N
73	15	692	1.1	13	11	2	N	134	16	2352	6.7	2	51	34	N
74	18	1060	7.4	2	01	16	N	135	17	2463	6.9	1	29	43	S
75	19	1192	7.4	2	16	25	N	136	18	2632	7.2	5	50	55	S
76	19	1207	5.8	5	04	26	S	138	21	3079	4.2	6	41	84	S
77	20	1323	6.3	4	08	35	S	142	Oct. 2	1151	6.8	4	53	40	N
78	20	1324	7.2	3	49	35	N	143	4	1415	6.2	11	34	19	N
79	21	1425	6.9	2	57	44	N	144	4	1420	6.6	12	37	19	N
80	22	1522	6.8	1	01	53	N	145	5	1501	7.3	7	17	13	N
81†	22	1547	3.8	6	51	55	S	147	16	2717	7.4	2	11	37	S
83*	25	1821	2.9	0	56	80	S	148	16	2720	6.4	3	01	38	S
84	June 3	3017	5.3	7	58	78	S	149	18	3017	5.3	5	39	59	S
86	5	3310	6.4	8	47	58	N	150	26	692	1.1	10	51	91	S
87	6	3449	7.3	8	59	46	N	151	29	1109	7.3	4	16	66	N
88	6	3463	6.4	11	03	45	N	152	29	1135	6.8	8	12	65	N
90	7	49	6.3	10	04	34	S	153	30	1259	5.9	7	51	55	N
93	18	1487	1.3	0	25	27	N	154	31	1385	6.5	10	48	43	N
94	July 2	3268	5.6	7	01	82	S	155	Nov. 1	1481	7.4	8	24	35	N
95	3	3421	5.1	10	00	71	N	156	1	1487	1.3	9	43	34	S
99	9	729	7.2	11	56	9	N	158*	12	2666	5.0	0	09	14	N
100	15	1449	6.7	1	53	8	N	159	12	2679	7.4	2	32	15	S
101†	Aug. 3	405	4.4	12	27	51	N	161	13	2940	7.3	22	09	31	N
103	4	498	6.2	6	27	42	N	164	14	3086	6.0	23	02	41	S
104	4	526	6.9	11	28	39	N	165	16	3237	4.4	0	50	53	S
105	5	659	6.4	7	35	31	N	167	27	1331	5.9	6	12	71	N
106	5	667	5.3	8	16	30	N	168	27	1335	6.3	7	01	71	N
107*	5	672	6.6	8	51	30	N	169	27	1354	7.3	12	55	69	S
108	5	677	4.8	9	35	30	N	171	29	1562	7.3	9	29	51	N
110	5	692	1.1	12	22	29	S	173	Dec. 3	1965	6.5	9	44	16	N
111*	6	823	6.6	10	25	20	N	174	3	1976	6.9	12	43	15	S
112	6	832	4.7	11	34	19	N	175	3	1978	6.6	13	19	15	S
113	6	836	5.5	12	21	19	N	177	10	2797	3.0	1	47	5	S
114	16	1923	7.1	0	30	22	N	178	11	3058	5.9	23	08	18	N
115	17	2035	7.1	2	17	31	N	180	14	3339	6.7	0	32	38	S
116	17	2043	6.6	4	09	32	N	182	16	83	6.9	4	56	62	N
117	20	2390	6.7	2	44	60	S	184	16	208	7.0	23	35	71	S
121	20	2399	5.0	3	20	61	N	185	18	364	4.3	2	50	82	S
123	31	462	5.9	4	47	68	N	186	20	692	1.1	9	20	97	S
124*	Sept. 1	608	6.0	5	19	57	N	189	28	1728	6.9	9	35	58	S
125	1	627	6.8	10	03	55	N	190	28	1733	5.2	10	09	58	S
126*	2	787	7.5	10	40	43	N	191	30	1923	7.1	7	27	40	S
127	3	947	5.2	11	36	33	N	193	31	2035	7.1	9	24	30	S
128	4	1060	7.4	6	13	25	N	194	31	2043	6.6	11	27	29	S
129	4	1084	7.3	10	39	23	N	195	31	2047	6.7	11	54	29	S
130	5	1203	7.1	9	40	16	N								

DOUBLE STAR NOTES 1980

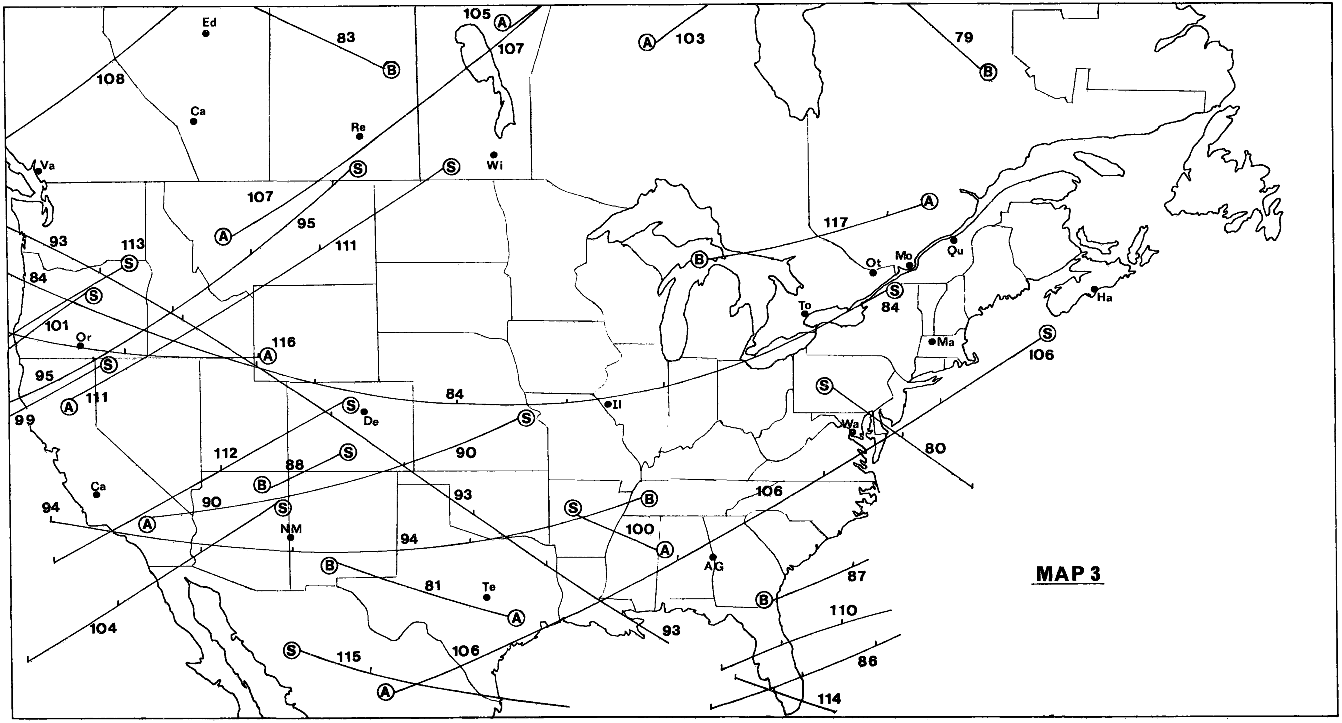
Track No.	Z.C.	
1, 83	1821	is the mean of the binary star Aitken 8630. The components are each of magnitude 3.5; separation 3″.9 in p.a. 297°.
10	3526	is the brighter component of the double star Aitken 17137. The companion is magnitude 10.4; separation 1″.3 in p.a. 298°.
31	2629	is the mean of the double star Aitken 11127. The components are of magnitude 6.9 and 7.3; separation 1″.0 in p.a. 196°.
32	2798	is the mean of the binary star Aitken 12096. The components are of magnitude 7.0 and 7.2; separation 0″.05 in p.a. 170°.
61, 107	672	is the mean of the binary star Aitken 3248. The components are of magnitude 7.0 and 7.7; separation 0″.34 in p.a. 261°.
65	814	is the brightest component of the triple star Aitken 4038. The brighter companion is of magnitude 10.1; separation 10″ in p.a. 306°. The third component is very faint.
66, 111	823	is the brighter component of the double star Aitken 4073. The companion is of magnitude 10″.1; separation 3″.4 in p.a. 133°.
69	1236	is the mean of the brightest two components of the triple system Aitken 6650. These components are of magnitude 5.6 and 6.0; separation 0″.8 in p.a. 277°. The third component is of magnitude 6.2 at a separation from the mean of the other two of 5″ in p.a. 81°.
124	608	is the brighter component of the double star Aitken 2999. The companion is of magnitude 8.8; separation 3″.8 in p.a. 221°.
126	787	is the mean of the double star Aitken 3854. The components are of magnitude 8.0 and 8.5; separation 2″.5 in p.a. 163°.
158	2666	is the mean of the double star Aitken 11325. The components are of magnitude 5.1 and 7.6; separation 1″.8 in p.a. 288°.



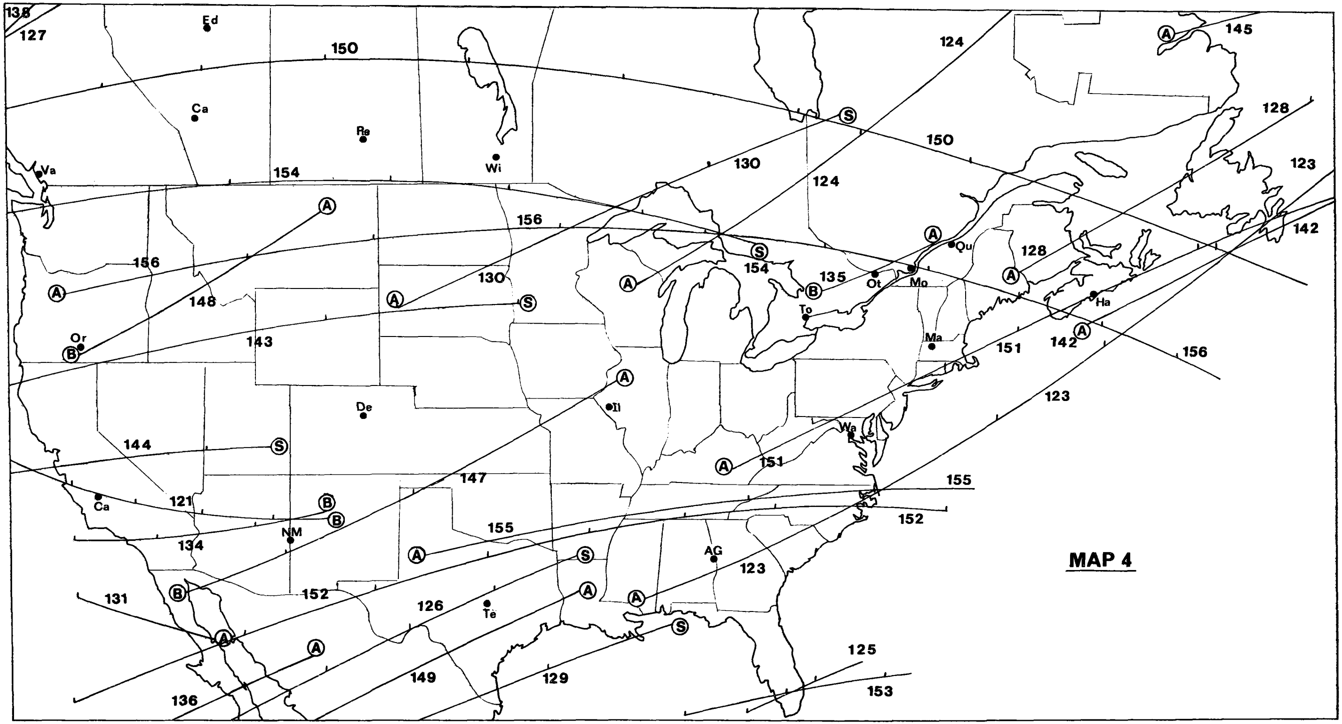
Map 1: Tracks 1 to 39; Grazes Jan. 1 to Mar. 8, 1980.



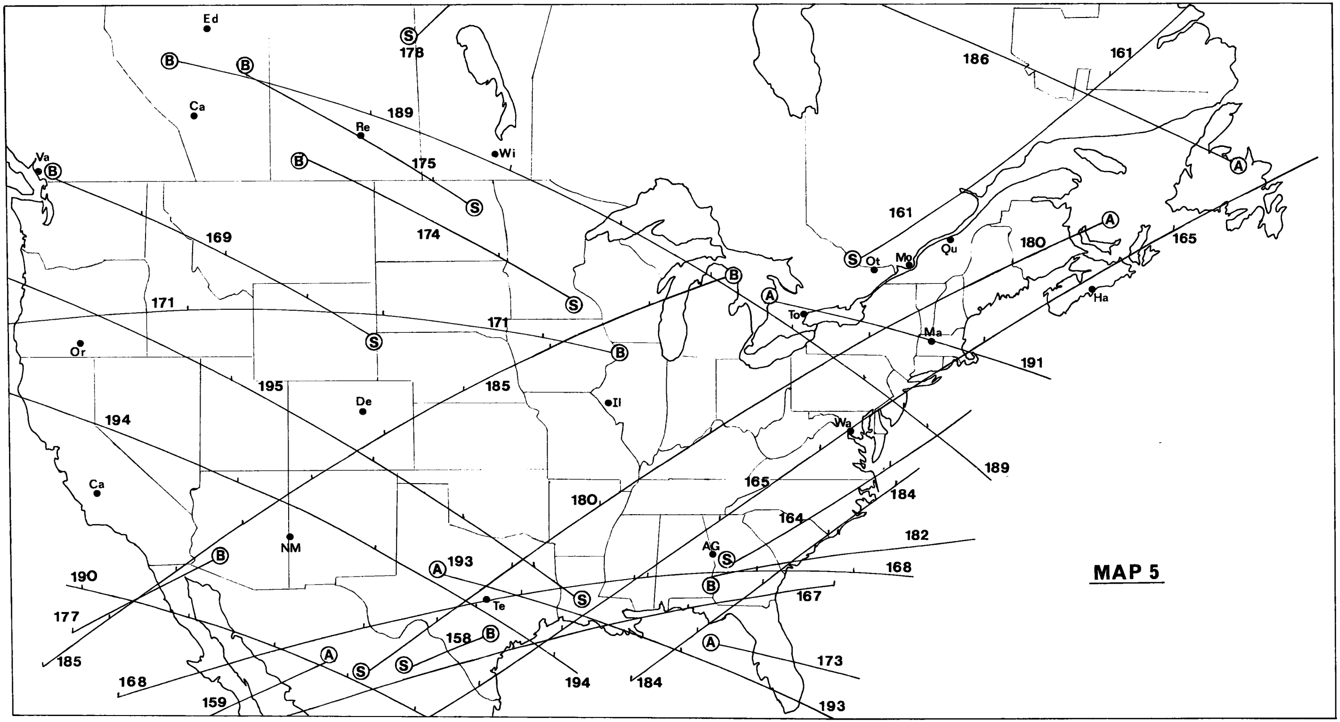
Map 2: Tracks 40 to 78; Grazes Mar. 9 to May 20, 1980.



Map 3: Tracks 79 to 117; Grazes May 21 to Aug. 20, 1980.



Map 4: Tracks 121 to 156; Grazes Aug. 20 to Nov. 1, 1980.



Map 5: Tracks 158 to 195; Grazes Nov. 12 to Dec. 31, 1980.

THE PLANETS FOR 1980

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 the visual magnitude, phase and apparent

GREATEST ELONGATIONS OF MERCURY IN 1980

Date E.S.T.	Elong.	Mag.	App. Diam.
ʹ	°		ʺ
*Feb. 19	18E	−0.1	7.3
Apr. 2	28W	0.6	8.0
*June 14	24E	0.7	7.9
July 31	19W	0.3	7.6
Oct. 10	25E	0.1	6.6
*Nov. 19	20W	−0.3	6.6

*favourable elongations

MERCURY: TELESCOPIC OBSERVING DATA FOR FAVOURABLE ELONGATIONS 1980

Date 19h EST	Magnitude	Apparent Diameter	Phase (% illuminated)	R.A.	Dec.
		″		h m	° ′
May 25	−1.0	5.6	82	5 13	+24 55
May 30	−0.4	6.1	69	5 53	25 36
June 4	+0.1	6.7	58	6 28	25 22
June 9	+0.4	7.4	47	6 57	24 27
June 14	+0.8	8.2	37	7 21	23 07
June 19	+1.1	9.1	28	7 37	21 34
Nov. 11	+0.6	8.3	26	14 10	−11 00
16	−0.1	7.2	49	14 17	11 11
21	−0.4	6.3	68	14 35	12 50
26	−0.5	5.7	80	15 00	15 09

diameter of Mercury as seen through a telescope are tabulated for two of the most favourable elongations.

Mercury's phases have been glimpsed with telescopes of 3-inch aperture or less, but generally a 4-inch 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 +480° 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 in excess of 90 times Earth's sea-level atmospheric pressure. A thick haze layer extends down from a level about 65 kilometers above the surface. However, the Soviet Venera 9 and 10 spacecraft that 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, proving that previously predicted layers of opaque clouds do not exist. The cloud-like haze that cloaks the planet, believed to consist chiefly of droplets of sulphuric acid, is highly reflective making Venus brilliant in the nighttime sky. However, telescopically the planet is virtually a featureless orb.

Results from the U.S. Pioneer and Soviet Venera robot explorations of Venus in 1978 added substantially to our knowledge of the veiled planet. A vast 5 km deep, 1500 km long rift valley, the largest canyon yet found in the solar system, was mapped by the Pioneer Orbiter. The Soviet and American landing devices detected what

VENUS NEAR INFERIOR CONJUNCTION 1980

Date 19h EST	Mag.	App. Diam.	Phase % ill.	Ang. Dist. from Sun	R.A.	Dec.
		″		°	h m	° ′
Apr. 5	−4.0	23.7	51	46E	5 57	+23 51
20	−4.1	28.4	42	45	4 56	26 44
May 5	−4.2	35.3	30	42	5 44	27 41
15	−4.2	41.3	22	36	6 05	27 21
20	−4.1	44.8	17	31	6 10	26 56
25	−4.0	48.4	12	23	6 11	26 21
30	−3.8	52.0	8	18	6 08	25 35
June 4	−3.5	55.1	4	14	6 00	24 38
9	−3.1	57.3	1.0	9	5 49	23 30
14	−2.6	58.1	0.0	1.6E	5 36	22 14
19	−3.1	57.4	0.9	8W	5 23	20 57
24	−3.5	55.4	3	13	5 13	19 47
29	−3.8	52.3	7	17	5 05	18 51
July 4	−4.0	48.8	12	23	5 02	18 13
9	−4.1	45.2	16	30	5 02	17 54
14	−4.2	41.7	21	35	5 07	17 50
24	−4.2	35.6	30	42	5 24	18 14
Aug. 8	−4.1	28.8	41	44	6 08	19 13
23	−4.0	24.0	50	46W	7 04	19 30

appears to be evidence of periods of virtually continuous lightning in the atmosphere and of a continuous glow at night near Venus' surface. "Chemical fires" due to reactions of various compounds in the super-heated atmosphere close to, or on, Venus' surface have been cited as a possible source for the glow. The Pioneer Orbiter's infrared radiometer found both a depression in the clouds at the north pole, and an actual 1100 km hole where there were few or no clouds. This finding strongly suggests a downflow of atmosphere at the pole. New probe 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.

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 sufficient for it to be seen in black skies under certain conditions and at these times it is a truly dazzling object. Such circumstances occur during the spring of 1980 when Venus is brilliant high in the west shortly after sunset. In June Venus reaches inferior conjunction and quickly moves to dominate the morning sky for the remainder of the year.

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 1980 opens Venus is an 85% illuminated disk 12.5″ in apparent diameter. On February 1 these quantities are 77% and 14.5″; by March 1, 67% and 17.3″. The table supplies more information for the period around inferior conjunction. By October 1

Venus is again a distant gibbous orb 68% illuminated and 16.9″ in apparent diameter. At the end of the year the phase is 92% with an 11.1″ apparent diameter.

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 was used or what the planet's phase. However, over the past century some observers using medium or large size telescopes have reported dusky, patchy marking 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 Earth-based telescopes and by the cameras of Mariner 10 as it swung by the planet in February 1974. But when the ultraviolet photos are compared to drawings of the patchy markings seen by visual obseivers 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 meters 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 meters 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 per hour 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.

As 1980 opens Mars is a brilliant object low in the east soon after dusk. Nearing opposition in February Mars is high in the sky and unmistable throughout the first third of the year. 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 and Jupiter are at opposition within 12 hours of each other this year and will be a striking pair in Leo for several months. The two planets will be less than three degrees apart on the evening of March 2 and even closer on May 3. Mars may be distinguished by its orange-red colour, a hue that originates with rust-coloured dust that covers much of the planet.

Telescopically Mars is usually a disappointingly small featureless ochre disk except within a few months of opposition when its distance from the Earth is then near minimum. If Mars is at perihelion at these times the separation can be as little as 56 million km. Such close approaches occur at intervals of 15 to 17 years; the most recent was in 1971. At a perihelion opposition the telescopic disk of Mars is 25 seconds of arc in diameter and much detail on the planet can be distinguished with telescopes of 4-inch aperture or greater. At oppositions other than when Mars is at perihelion the disk is correspondingly smaller.

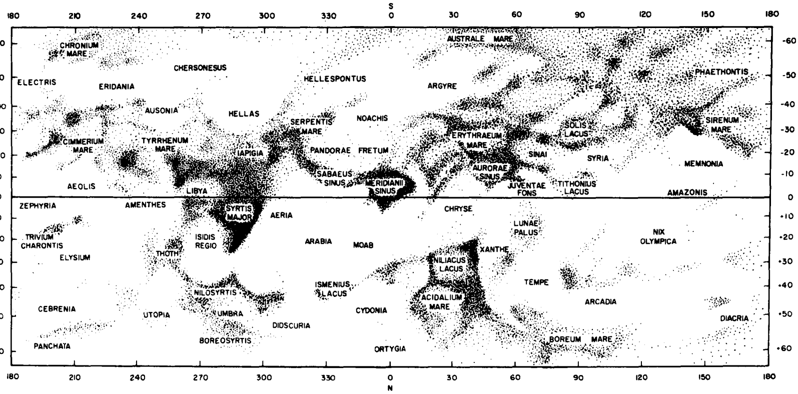
The opposition on February 25 is relatively unfavourable because the minimum distance between Earth and Mars is 101 million km or 1.8 times the favourable opposition separation. The planet's maximum apparent diameter of 13.8 seconds of arc is the smallest opposition diameter since 1948. However, this is somewhat offset by the planet's high altitude this year for northern hemisphere observers. The distance of Mars from Earth, its apparent diameter and other useful data are given in the table below.

For the first day of each month when Mars is favourably placed, the table gives the distance from the earth, the magnitude, apparent diameter, fraction of the disc 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°. This formula replaces the tables given in past years; it is accurate to better than 1°. The value of *L* can then be compared with the map below.

Date U.T.	Dist. A.U.	Vis. Mag.	App. Diam.	Ill. %	Pos. Ang.	Incl.	*L(1)*	Δ
			″		°	°	°	°
Jan. 1.0	0.967	+0.2	9.7	92	19	23	351.93	9.22
11.0	0.886	−0.1	10.6	94	19	23	259.69	9.09
21.0	0.813	−0.3	11.5	95	19	22	168.71	8.96
31.0	0.752	−0.6	12.5	97	19	22	79.10	8.82
Feb. 10.0	0.707	−0.8	13.2	99	17	21	350.81	8.72
20.0	0.682	−1.0	13.7	100	15	21	263.54	8.68
Mar. 1.0	0.679	−0.9	13.8	100	13	21	176.64	8.73
11.0	0.698	−0.8	13.4	99	11	20	89.36	8.83
21.0	0.737	−0.6	12.7	97	9	20	1.10	8.96
Apr. 1.0	0.798	−0.3	11.7	95	8	20	262.47	9.23
May 1.0	1.020	+0.4	9.2	91	10	22	345.74	9.50
June 1.0	1.275	+0.8	7.4	89	16	24	51.31	9.67
July 1.0	1.507	+1.2	6.2	89	24	26	121.50	9.75
Aug. 1.0	1.716	+1.4	5.5	91	32	25	179.26	9.78
Sept. 1.0	1.888	+1.5	5.0	92	38	20	235.94	9.78
Oct. 1.0	2.020	+1.5	4.6	94	38	14	302.43	9.77
Nov. 1.0	2.125	+1.5	4.4	96	33	5	359.34	9.78
Dec. 1.0	2.203	+1.4	4.3	97	23	−5	65.64	9.83
Jan. 1.0	2.268	+1.4	4.1	98	8	−15	120.75	—

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 4-inch 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

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/hr. 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(l) 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(l) 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° and is readily computed using a modest calculator, replaces the tables given in previous editions of the HANDBOOK.

Date U.T.	Vis. Mag.	App. Equat. Diam.	System I		System II	
			L(1)	Δ	L(1)	Δ
		″	°	°	°	°
Jan. 1.0	−1.9	40.8	322.9	158.00	240.3	150.40
Feb. 1.0	−2.0	43.9	181.2	158.05	222.1	150.40
Mar. 1.0	−2.1	44.7	84.2	157.95	263.8	150.35
Apr. 1.0	−2.0	42.7	301.3	157.85	244.4	150.25
May 1.0	−1.8	39.5	357.1	157.75	71.3	150.15
June 1.0	−1.6	36.0	207.6	157.70	45.3	150.10
July 1.0	−1.4	33.4	258.6	157.65	227.4	150.05
Aug. 1.0	−1.3	31.5	106.4	157.65	198.7	150.05
Sept. 1.0	−1.2	30.7	314.1	157.70	169.9	150.05
Oct. 1.0	−1.2	30.8	4.8	157.75	351.7	150.10
Nov. 1.0	−1.3	31.8	214.6	157.80	325.0	150.15
Dec. 1.0	−1.4	33.9	268.5	157.85	150.0	150.25
Jan. 1.0	−1.6	36.9	—	157.95		150.30

Jupiter's rapid rotation also makes the great globe markedly oval so that it appears about 7% "squashed" at the poles. Jupiter's apparent equatorial diameter ranges from 45″ at opposition on February 24 to a minimum of 31″ at conjunction on September 13.

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 the most 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.

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 outer 1000 km of the ring is its brightest zone but its proximity to the planet makes recent claims of its detection from Earth some years ago controversial.

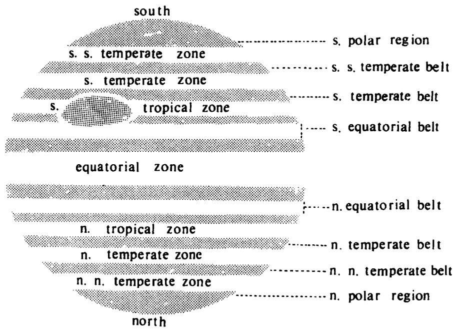
The smallest of telescopes will reveal Jupiter's four large moons, each of which is equal to or larger than Earth's satellite. The moons provide a never-ending fascination for amateur astronomers. Sometimes the satellites are paired on either side of the belted planet; frequently one is missing—either 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 1980 opens Jupiter is in Leo, bright and unmistakable in the late evening sky and ideally placed for telescopic study. By early August the planet will be lost in the twilight glow in the west after sunset. In early October Jupiter is visible in the morning sky just before sunrise. By the end of the year the planet is seen low in the east shortly after midnight. 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 that is unmistakable, particularly around opposition. With Mars and Saturn nearby in the late winter and early spring sky this year, skywatchers are treated to a planetary parade for several months.

At opposition on February 24, Jupiter is 659 million km (4.404 A.U.) from Earth. The next opposition will be March 26, 1981. Minimum possible distance between the two planets is 590 million km.

JUPITER'S BELTS AND ZONES

Viewed through a telescope of 6-inch 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.



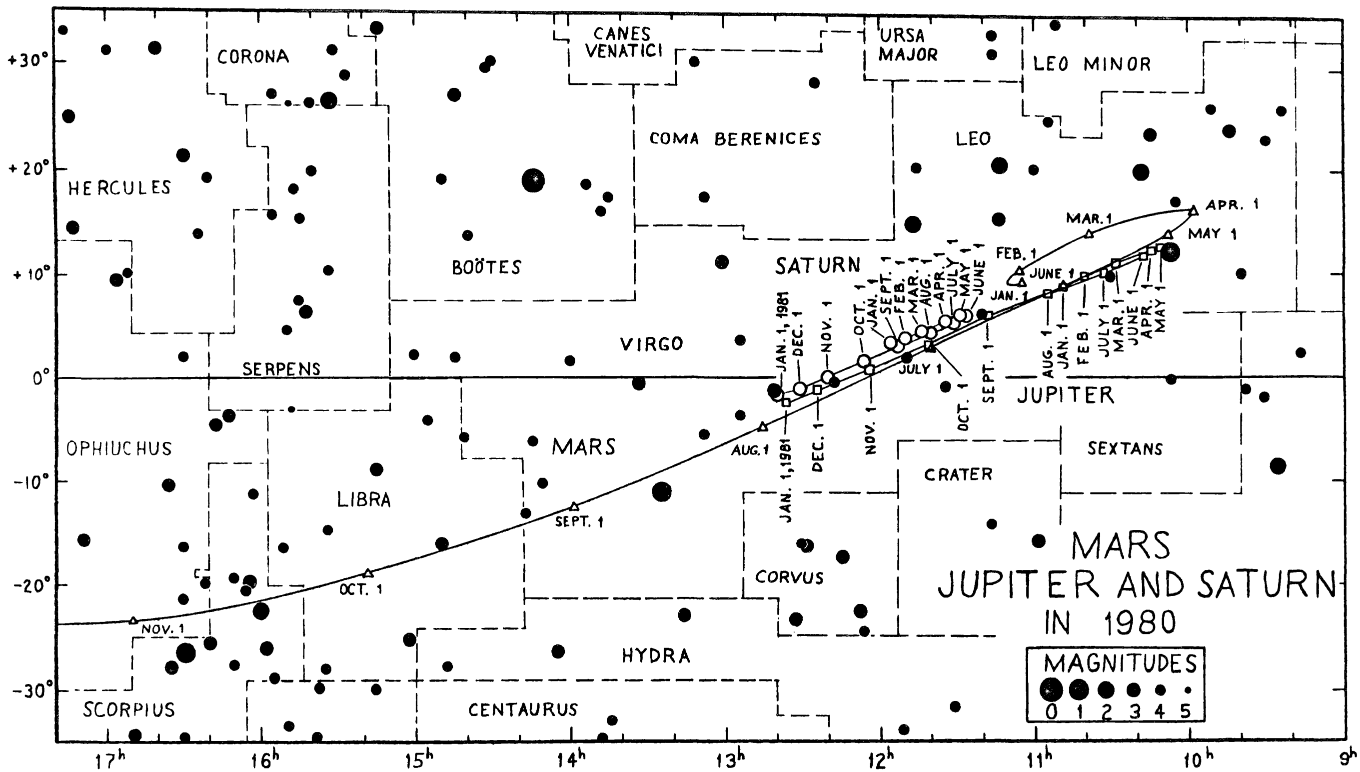
SATURN

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 description can adequately duplicate. The rings consist of billions of particles which, according to recent photometric, radar and other data, are believed to be approximately fist-sized and made-of—or covered by—water ice. This would account for their exceedingly high reflectivity. The reason that "rings" is plural and not singular is that gaps and brightness differences define distinct rings.

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 3,000 km gap known as Cassini's Division which appears to be virtually free of ring particles. The gap was discovered in 1675 and is visible in good quality telescopes of 60 mm aperture when the ring system is well inclined to our view from Earth. Ring B, the brightest, overpowers ring C to such an extent that it 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. The 17,000 km gap between the planet's surface and the crepe ring contains an exceedingly faint fourth ring. Ring particles could extend well beyond the limits of the visible structure but are likely constrained to the planet's equatorial plane.

In addition to the rings Saturn has a family of at least 10 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 believed to be unique as the only satellite in the solar system with a substantial atmosphere. Estimates of its density range from 0.1 to equal Earth's although its primary known constituent is methane.

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



The Paths of Mars, Jupiter and Saturn: The positions of Mars are shown as triangles, those of Jupiter as squares and those of Saturn as circles.

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 15 cm telescope but the others require larger apertures or photographic techniques. Additional data can be found on page 97.

The disk of Saturn appears about 1/6 the size Jupiter appears through the same telescope with the same magnification. In telescopes less than 4 inches 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 whitish 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 8-inch aperture do more than one or two belts come into view. 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. Saturn, probably more than any other planet can be subjected to very high telescopic powers, probably because of its low surface brightness (due to its great distance from the sun).

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.

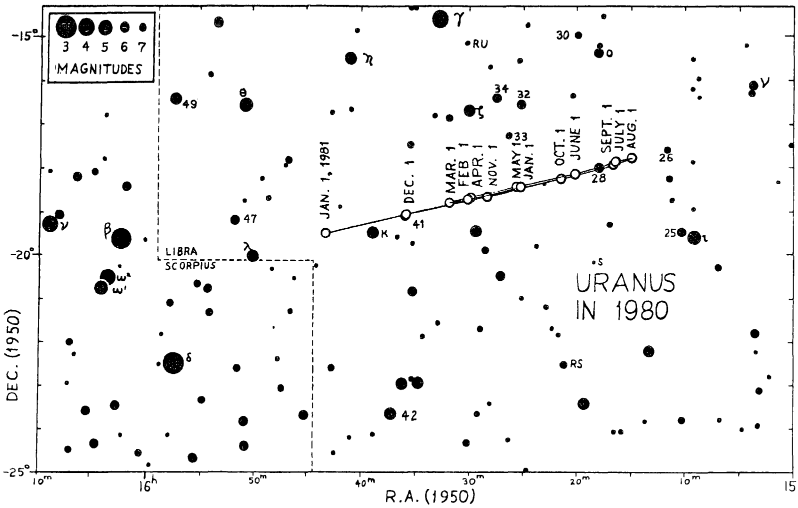
As 1980 opens Saturn's rings are tilted 1.7° with respect to the Earth and 1.0° in the *opposite* sense with respect to the sun. This means the side of the rings visible from Earth at this time (the north face) is unilluminated by the sun and is virtually invisible. In most telescopes Saturn will be without rings. This situation persists until the rings are edge-on to the sun at approximately 19:30 EST March 2, at which time the rings are 0.35° inclined to Earth. Subsequently the rings will be visible in some telescopes as a thin bright line as their inclination decreases to become edge-on to Earth at approximately 10:30 EST March 12. Again the rings become invisible as sun and Earth are on opposite sides. The inclination to Earth increases to 1.6° in mid-May and then slowly decreases to the final edge-on presentation to Earth at about 22:30 EST July 22. Once again the rings orient to face both Earth and sun. Saturn will be too close to the sun for observation from mid-August until late October when it will be visible in the morning sky. Inclination of the rings, with respect to Earth, will be 5.4° on November 1 and 7.3° on January 1, 1981. For the next seven years the inclination will increase as the rings' southern face opens to our inspection.

Opposition is March 14 when Saturn is 1.26 billion km (8.45 A.U.) from Earth, in the constellation Leo. At that time the rings are 44.4″ in apparent width (although they are invisible as mentioned above) and the planet is 17.7″ in polar diameter. Saturn ranges from magnitude +0.8 in March to +1.4 in August.

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 6-inch reflecting telescope. It can be easily seen with binoculars and a telescope will reveal its small greenish featureless disk.

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



The Path of Uranus in 1980. Positions for first day of each month.

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.

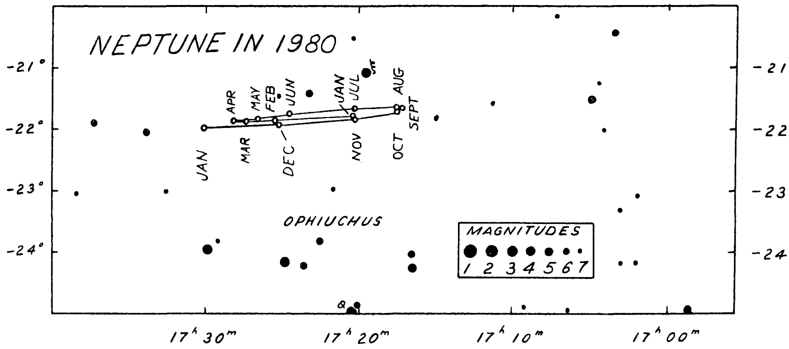
These dimensions are markedly different from Saturn's three major rings, each of which is thousands of kilometers wide. Although different in scale, the composition of the Uranian rings should be fundamentally the same as Saturn's—swarms of particles varying from dust-size up to small flying mountains each in its own orbit. 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. A Kitt Peak National Observatory study in 1977 yielded a 23-hour period while researchers elsewhere have obtained other figures in the 12 to 24 hours range.

Throughout 1980 Uranus is in Libra near the Scorpius-Libra boundary. Uranus is at opposition on May 14 when it is 2.65 billion km (17.74 A.U.) from Earth. At this time its magnitude is +5.8 and its apparent diameter is 3.9 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



The Path of Neptune in 1980. Positions for first day of each month.

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 12-inch 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.

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 1979 Neptune is buried in the Milky Way in Ophiuchus and is not well placed for northern observers. At opposition on June 12 Neptune is magnitude +7.7 and 4.38 billion km (29.26 A.U.) distant from Earth.

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.

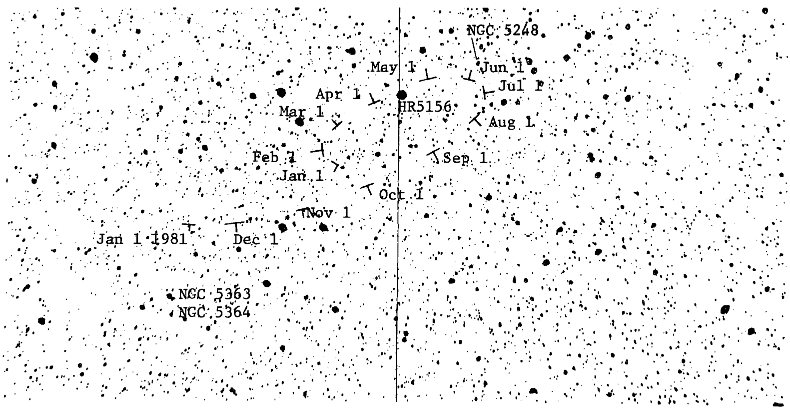
The most important advance in our knowledge of Pluto since its discovery came in 1978 as a result of routine examinations of photographs of the planet taken at the U.S. Naval Observatory, Flagstaff, Arizona, James W. Christy detected an elongation of Pluto's image on some of the photos which has been interpreted as a satellite at an approximate distance of 17,000 km 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.

From the distance and orbital period of Charon, Pluto's mass is estimated to be about one-eighth of the moon's, making it the least massive planet in the solar system. It is also the smallest. Assuming an albedo of 0.5, Pluto's diameter is a mere 3000 km. These figures yield a density of 0.7 that of water. Thus, Pluto is likely a ball of ice with water, methane and ammonia the major constituents. This conclusion is supported by observations in 1976, by a team of astronomers at the University of Hawaii, that revealed frozen methane on much of Pluto's surface.

Based on the satellite's distance, brightness and revolution period the Naval Observatory astronomers derived a mass ratio of 12 to one for the Pluto-Charon system. Charon is therefore so massive in comparison to Pluto that the two are, in effect, a unique double planet system. No other planet and moon approach this ratio. The Earth-moon system, for comparison, has an 81 to one ratio of masses. Charon's diameter is roughly estimated at 1200 km. Its orbital inclination, which is assumed to coincide with Pluto's axial inclination, is about 105° with respect to the sky.

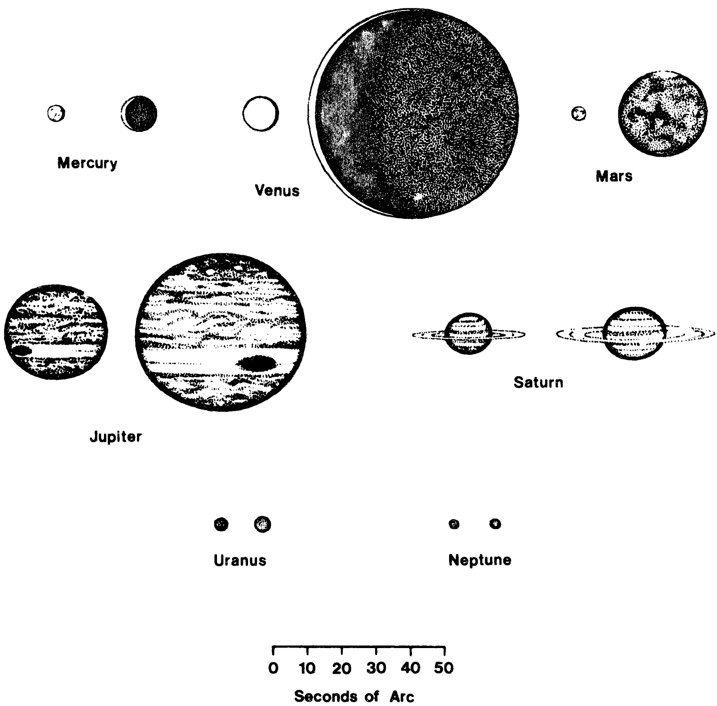
The long-standing theory, first proposed in 1936 by R. A. Lyttleton, suggesting that Pluto might be an escaped or ejected satellite of Neptune seems unlikely in view of the new findings. Pluto now appears to be completely different from the other eight planets. Its unique characteristics include its orbit which is relatively higher inclined and so elliptical that the planet will be closer to the sun than Neptune for 19 years, beginning this year. 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 ice comet-like structures beyond Neptune.

At opposition on April 10 Pluto's astrometric position is R.A. (1950) $13^h40.5^m$ Dec. (1950) +8°37′ and its distance from Earth will be 4.37 billion km (29.20 A.U.). With an apparent magnitude of +13.7 Pluto is a difficult target in moderate-sized amateur telescopes.

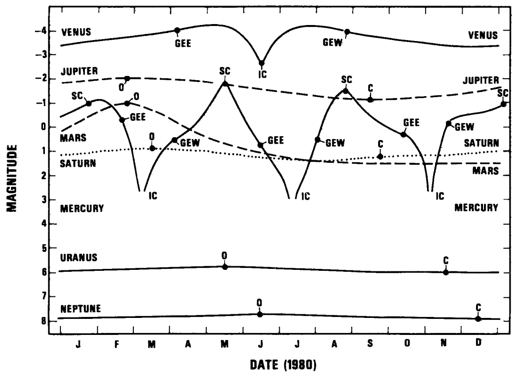


The Path of Pluto in 1980: The star HR 5156 has R.A. (1950) $13^h\ 39^m\ 45^s$, Dec. (1950) +8°39′ and m_v 5^m88. Diagram adapted from Vehrenberg's Sternatlas.

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.



The magnitudes of the planets in 1980. Conjunctions, oppositions and greatest elongations are indicated.

JUPITER—PHENOMENA OF THE BRIGHTEST SATELLITES 1980

Times and dates given are E.S.T. The phenomena are given for latitude 44° N., for Jupiter at least one hour above the horizon, and the sun at least one hour below the horizon, as seen from most of North America. See also pgs. 28–29.

The symbols are as follows: E—eclipse, O—occultation, T—transit, S—shadow, D—disappearance, R—reappearance, I—ingress, e—egress. 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. Thus eclipse phenomena occur on the east side from February 24 until September 13, and on the west otherwise.

JANUARY

d	h m	Sat.	Phen.
1	2 15	II	OR
	6 36	I	SI
	7 40	I	TI
	8 53	I	Se
2	3 43	I	ED
	7 04	I	OR
	17 31	II	TI
	18 16	II	Se
	20 22	II	Te
3	1 05	I	SI
	2 07	I	TI
	3 21	I	Se
	4 22	I	Te
	19 27	III	Se
	20 09	III	TI
	22 11	I	ED
	23 35	III	Te
4	1 31	I	OR
	19 33	I	SI
	20 34	I	TI
	21 49	I	Se
	22 49	I	Te
5	16 40	I	ED
	19 58	I	OR
6	4 40	II	SI
	6 42	II	TI
	7 33	II	Se
	9 34	II	Te
	17 16	I	Te
7	5 51	III	ED
	9 26	III	ER
	23 48	II	ED
8	3 45	IV	SI
	4 38	II	OR
	8 14	IV	Se
	8 30	I	SI
	9 28	I	TI
	17 02	IV	Te
9	5 36	I	ED
	8 52	I	OR
	17 58	II	SI
	19 54	II	TI
	20 51	II	Se
	22 46	II	Te
10	2 58	I	SI
	3 55	I	TI
	5 14	I	Se
	6 10	I	Te
	19 51	III	SI
	23 24	III	Se
	23 43	III	TI
11	0 05	I	ED
	3 09	III	Te
	3 19	I	OR
	17 48	II	OR
	21 26	I	SI
	22 21	I	TI
	23 42	I	Se
12	0 37	I	Te
	18 33	I	ED
	21 46	I	OR
13	7 15	II	SI
	9 05	II	TI
	16 48	I	TI
	18 11	I	Se
	19 03	I	Te
14	16 56	III	OR
15	2 22	II	ED
	6 58	II	OR
16	7 30	I	ED
	16 57	IV	ER
	20 33	II	SI
	20 57	IV	OD
	22 16	II	TI
	23 26	II	Se
17	0 46	IV	OR
	1 08	II	Te
	4 51	I	SI
	5 41	I	TI
	7 07	I	Se
	7 57	I	Te
	23 49	III	SI
18	1 58	I	ED
	3 12	III	TI
	3 22	III	Se
	5 06	I	OR
	6 38	III	Te
	20 08	II	OR
	23 19	I	SI
19	0 08	I	TI
	1 36	I	Se
	2 23	I	Te
	20 27	I	ED
	23 32	I	OR
20	17 48	I	SI
	18 34	I	TI
	20 04	I	Se
	20 50	I	Te
21	17 59	I	OR
	20 23	III	OR
22	4 57	II	ED
	9 17	II	OR
23	9 23	I	ED
	23 08	II	SI
24	0 35	II	TI
	2 02	II	Se
	3 28	II	Te
	6 44	I	SI
	7 27	I	TI
	9 01	I	Se
	21 42	IV	SI
25	2 08	IV	Se
	3 46	III	SI
	3 52	I	ED
	4 27	IV	TI
	6 37	III	TI
	6 51	I	OR
	7 19	III	Se
	8 18	IV	Te
	18 14	II	ED
	22 26	II	OR
26	1 13	I	SI
	1 53	I	TI
	3 29	I	Se
	4 09	I	Te
	22 20	I	ED
27	1 18	I	OR
	19 41	I	SI
	20 19	I	TI
	21 57	I	Se
	22 35	I	Te
28	17 46	III	ED
	19 44	I	OR
28	23 47	III	OR
29	7 31	II	ED
	17 01	I	Te
31	1 43	II	SI
	2 53	II	TI
	4 38	II	Se
	5 46	II	Te
	8 38	I	SI
	9 12	I	TI

FEBRUARY

d	h m	Sat.	Phen.
1	5 46	I	ED
	7 44	III	SI
	8 36	I	OR
	20 48	II	ED
2	0 42	II	OR
	3 06	I	SI
	3 38	I	TI
	5 22	I	Se
	5 53	I	Te
	6 30	IV	ED
3	0 14	I	ED
	3 03	I	OR
	17 55	II	Se
	18 55	II	Te
	21 34	I	SI
	22 04	I	TI
	23 51	I	Se
4	0 19	I	Te
	18 43	I	ED
	21 29	I	OR
	21 44	III	ED
5	3 08	III	OR
	18 19	I	Se
	18 45	I	Te
7	4 19	II	SI
	5 10	II	TI
	7 14	II	Se
	8 03	II	Te
8	7 40	I	ED
	23 22	II	ED
9	2 56	II	OR
	5 00	I	SI
	5 22	I	TI
	7 16	I	Se
	7 37	I	Te
10	2 08	I	ED
	4 47	I	OR
	17 36	II	SI
	18 17	II	TI
	19 00	IV	TI
	20 03	IV	Se
	20 31	II	Se
	21 11	II	Te
	22 52	IV	Te
	23 28	I	SI
	23 48	I	TI
11	1 44	I	Se
	2 03	I	Te
	20 37	I	ED
	23 13	I	OR
12	1 43	III	ED
	6 26	III	OR
	17 56	I	SI
	18 14	I	TI
	20 13	I	Se
12	20 29	I	Te
13	17 39	I	OR
14	6 55	II	SI
	7 25	II	TI
15	19 12	III	Se
	20 01	III	Te
16	1 56	II	ED
	5 10	II	OR
	6 53	I	SI
	7 05	I	TI
17	4 02	I	ED
	6 31	I	OR
	20 12	II	SI
	20 33	II	TI
	23 08	II	Se
	23 27	II	Te
18	1 22	I	SI
	1 31	I	TI
	3 38	I	Se
	3 47	I	Te
	22 31	I	ED
19	0 32	IV	ED
	0 57	I	OR
	5 41	III	ED
	5 52	IV	OR
	18 17	II	OR
	19 50	I	SI
	19 57	I	TI
	22 06	I	Se
	22 13	I	Te
20	19 23	I	OR
22	19 38	III	SI
	19 50	III	TI
	23 11	III	Se
	23 18	III	Te
23	4 30	II	ED
	7 23	II	OR
	8 47	I	SI
	8 49	I	TI
24	5 57	I	ED
	8 15	I	OR
	22 48	II	TI
	22 49	II	SI
25	1 42	II	Te
	1 44	II	Se
	3 15	I	TI
	3 15	I	SI
	5 30	I	Te
	5 31	I	Se
26	0 23	I	OD
	2 43	I	ER
	17 41	II	OD
	20 37	II	ER
	21 41	I	TI
	21 44	I	SI
	23 56	I	Te
27	0 00	I	Se
	18 49	I	OD
	21 12	I	ER
28	18 22	I	Te
	18 28	I	Se
29	23 06	III	TI
	23 37	III	SI

MARCH

d	h	m	Sat.	Phen.
1	2	33	III	Te
	3	09	III	Se
	6	48	II	OD
2	7	41	I	OD
3	1	03	II	TI
	1	25	II	SI
	3	57	II	Te
	4	21	II	Se
	4	58	I	TI
	5	09	I	SI
	7	14	I	Te
	7	25	I	Se
4	2	07	I	OD
	4	38	I	ER
	19	54	II	OD
	23	11	II	ER
	23	24	I	TI
	23	38	I	SI
5	1	40	I	Te
	1	54	I	Se
	20	33	I	OD
	23	06	I	ER
6	18	06	I	SI
	20	06	I	Te
	20	22	I	Se
	22	47	IV	ER
8	2	22	III	TI
	3	35	III	SI
	5	50	III	Te
	7	07	III	Se
10	3	19	II	TI
	4	02	II	SI
	6	13	II	Te
	6	42	I	TI
	6	57	II	Se
	7	03	I	SI
11	3	52	I	OD
	6	32	I	ER
	21	09	III	ER
	22	08	II	OD
12	1	08	I	TI
	1	32	I	SI
	1	45	II	ER
	3	24	I	Te
	3	48	I	Se
	22	18	I	OD
13	1	01	I	ER
	17	21	II	SI
	19	22	II	Te
	19	34	I	TI
	20	00	I	SI
	20	16	II	Se
	21	50	I	Te
	22	16	I	Se
14	19	30	I	ER
	23	23	IV	TI
15	3	26	IV	Te
	3	39	IV	SI
	5	40	III	TI
	7	34	III	SI
17	5	36	II	TI
	6	39	II	SI
18	5	37	I	OD
	19	23	III	OD
19	0	24	II	OD
	1	08	III	ER
	2	53	I	TI
	3	26	I	SI
	4	19	II	ER
	5	09	I	Te
	5	42	I	Se
20	0	03	I	OD
	2	56	I	ER
	18	45	II	TI
	19	58	II	SI
	21	19	I	TI
	21	40	II	Te
	21	55	I	SI
20	22	53	II	Se
	23	35	I	Te
21	0	10	I	Se
	18	29	I	OD
	21	25	I	ER
22	18	39	I	Se
23	6	26	IV	OD
25	22	46	III	OD
26	2	40	II	OD
	4	39	I	TI
	5	07	III	ER
	5	20	I	SI
27	1	49	I	OD
	4	51	I	ER
	21	05	II	TI
	22	35	II	SI
	23	05	I	TI
	23	49	I	SI
28	0	00	II	Te
	1	21	I	Te
	1	30	II	Se
	2	04	I	Se
	20	16	I	OD
	23	19	I	ER
29	19	01	III	Se
	19	47	I	Te
	20	10	II	ER
	20	33	I	Se
31	21	40	IV	SI

APRIL

d	h	m	Sat.	Phen.
1	1	47	IV	Se
2	2	13	III	OD
	4	59	II	OD
	6	25	I	TI
3	3	36	I	OD
	23	27	II	TI
4	0	52	I	TI
	1	12	II	SI
	1	43	I	SI
	2	21	II	Te
	3	07	I	Te
	3	58	I	Se
	4	07	II	Se
	22	03	I	OD
5	1	14	I	ER
	19	19	I	TI
	19	23	III	Te
	19	30	III	SI
	20	12	I	SI
	21	34	I	Te
	22	27	I	Se
	22	44	II	ER
	22	59	III	Se
6	19	43	I	ER
8	21	31	IV	OD
9	1	42	IV	OR
	5	43	III	OD
10	5	24	I	OD
11	1	50	II	TI
	2	40	I	TI
	3	38	I	SI
	3	50	II	SI
	4	45	II	Te
	4	55	I	Te
	23	52	I	OD
12	3	10	I	ER
	19	26	III	TI
	20	31	II	OD
	21	07	I	TI
	22	06	I	SI
	22	57	III	Te
	23	22	I	Te
	23	30	III	SI
13	0	21	I	Se
	1	18	II	ER
	2	58	III	Se
	21	38	I	ER
14	20	02	II	Se
17	19	42	IV	Se
18	4	16	II	TI
	4	29	I	TI
19	1	41	I	OD
	5	05	I	ER
	22	55	II	OD
	22	57	I	TI
	23	03	III	TI
20	0	01	I	SI
	1	12	I	Te
	2	16	I	Se
	2	34	III	Te
	3	29	III	SI
	3	53	II	ER
	20	09	I	OD
	23	34	I	ER
21	19	39	I	Te
	19	46	II	SI
	20	25	II	Te
	20	44	I	Se
	22	40	II	Se
23	21	02	III	ER
26	0	45	IV	ED
	3	32	I	OD
	4	41	IV	ER
27	0	47	I	TI
	1	21	II	OD
	1	56	I	SI
	2	45	III	TI
	3	02	I	Te
	4	10	I	Se
	22	00	I	OD
28	1	29	I	ER
	19	15	I	TI
	20	00	II	TI
	20	24	I	SI
	21	30	I	Te
	22	23	II	SI
	22	39	I	Se
	22	54	II	Te
29	1	17	II	Se
	19	58	I	ER
30	19	45	II	ER
	20	14	III	OR
	21	32	III	ED

MAY

d	h	m	Sat.	Phen.
1	1	01	III	ER
3	22	14	IV	TI
4	2	32	IV	Te
	2	39	I	TI
	3	49	II	OD
	3	50	I	SI
	23	52	I	OD
5	3	24	I	ER
	21	07	I	TI
	22	19	I	SI
	22	31	II	TI
	23	22	I	Te
6	0	33	I	Se
	1	01	II	SI
	1	26	II	Te
	3	54	II	Se
	21	53	I	ER
7	20	30	III	OD
	22	19	II	ER
8	0	03	III	OR
	1	33	III	ED
12	1	45	I	OD
	22	38	IV	ER
	23	00	I	TI
13	0	13	I	SI
	1	05	II	TI
	1	15	I	Te
	2	28	I	Se
	20	14	I	OD
	23	48	I	ER
14	19	35	II	OD
	19	43	I	Te
	20	57	I	Se
15	0	23	III	OD
	0	54	II	ER
16	19	50	II	Se
18	22	51	III	Se
20	0	54	I	TI
	2	08	I	SI
	3	08	I	Te
	20	01	IV	Te
	22	09	I	OD
21	1	43	I	ER
	20	37	I	SI
	21	37	I	Te
	22	09	II	OD
	22	51	I	Se
22	20	12	I	ER
23	19	54	II	Te
	22	27	II	Se
25	21	46	III	Te
	23	25	III	SI
26	2	49	III	Se
27	2	48	I	TI
28	0	04	I	OD
	21	17	I	TI
	22	32	I	SI
	23	32	I	Te
29	0	27	IV	OD
	0	44	II	OD
	0	46	I	Se
	22	07	I	ER
30	22	12	II	SI
	22	33	II	Te
31	1	04	II	Se

JUNE

d	h	m	Sat.	Phen.
1	22	18	III	TI
2	1	49	III	Te
4	2	01	I	OD
	23	13	I	TI
5	0	26	I	SI
	1	28	I	Te
	20	30	I	OD
	20	57	III	ER
6	0	02	I	ER
	19	57	I	Te
	21	10	I	Se
	21	47	IV	SI
	22	19	II	TI
7	0	49	II	SI
	1	13	II	Te
	1	28	IV	Se
8	21	56	II	ER
12	1	10	I	TI
	20	07	III	OR
	21	30	III	ED
	22	27	I	OD
13	0	56	III	ER
	20	50	I	SI
	21	54	I	Te
	23	04	I	Se
14	1	01	II	TI
	20	26	I	ER
	23	28	IV	OR
16	0	31	II	ER
19	20	45	III	OD
20	0	18	III	OR
	0	25	I	OD
	21	36	I	TI
	22	45	I	SI
	23	52	I	Te
21	0	59	I	Se
	22	21	I	ER
22	22	01	II	OD
24	19	59	II	Te
	22	13	II	Se
27	0	59	III	OD

d	h m	Sat.	Phen.
27	23 35	I	TI
28	0 39	I	SI
	20 54	I	OD
29	0 16	I	ER
	20 20	I	Te
	21 23	I	Se
30	0 44	II	OD
	22 44	III	Se

JULY

d	h m	Sat.	Phen.
1	21 58	II	SI
	22 44	II	Te
5	22 53	I	OD
6	20 03	I	TI
	21 03	I	SI
	22 19	I	Te
	23 18	I	Se
7	20 40	I	ER
	22 48	III	Te
	23 21	III	SI
8	22 36	II	TI
10	21 36	II	ER
13	22 02	I	TI
	22 57	I	SI
14	22 34	I	ER
	23 36	III	TI

Jupiter being near the sun, phenomena are not given between July 14 and Oct. 18

OCTOBER

d	h m	Sat.	Phen.
18	7 08	II	ED
19	5 52	IV	Te
	7 10	I	SI
	7 44	I	TI
20	4 27	I	ED
	4 44	II	Se
	5 54	II	Te
	7 16	I	OR
21	4 30	I	Te
27	4 33	II	SI
27	5 55	II	TI
	6 20	I	ED
	7 07	III	OR
	7 17	II	Se
	7 36	IV	ED
	8 39	II	Te
28	4 15	I	TI
	5 48	I	Se
	6 30	I	Te
29	3 45	I	OR

NOVEMBER

d	h m	Sat.	Phen.
3	5 02	III	ED
	7 06	II	SI
	8 13	I	ED
	8 15	III	ER
	8 16	III	OD
	8 40	II	TI
4	5 26	I	SI
	6 14	I	TI
	7 42	I	Se
	8 30	I	Te
11	7 20	I	SI
	8 14	I	TI
12	4 14	II	ED
	4 35	I	ED
	7 42	I	OR
	8 54	II	OR
13	3 31	IV	ER
	4 04	I	Se
	4 58	I	Te
14	3 27	II	Te
	5 51	III	Te
19	6 28	I	ED
	6 50	II	ED
20	3 42	I	SI
	4 42	I	TI
	5 57	I	Se
	6 56	I	Te
21	2 56	III	SI
	3 28	II	TI
	4 09	I	OR
	4 12	II	Se
	6 05	III	Se
21	6 09	II	Te
	7 04	III	TI
26	8 21	I	ED
27	5 36	I	SI
	6 40	I	TI
	7 51	I	Se
	8 54	I	Te
28	2 49	I	ED
	4 02	II	SI
	6 06	I	OR
	6 09	II	TI
	6 44	II	Se
	6 54	III	SI
	8 49	II	Te
29	2 19	I	Se
	3 23	I	Te
30	3 45	II	OR

DECEMBER

d	h m	Sat.	Phen.
2	4 27	III	OR
4	7 29	I	SI
	8 37	I	TI
5	4 42	I	ED
	6 35	II	SI
	8 02	I	OR
	8 49	II	TI
	9 17	II	Se
6	1 58	I	SI
	3 06	I	TI
	4 13	I	Se
	5 20	I	Te
7	2 31	I	OR
	6 27	II	OR
8	4 06	IV	SI
	5 47	IV	Se
9	4 00	III	ER
	5 37	III	OD
	8 35	III	OR
11	9 23	I	SI
12	9 08	II	SI
13	3 51	I	SI
	5 02	I	TI
	6 06	I	Se
	7 16	I	Te
14	3 55	II	ED
	4 27	I	OR
	9 07	II	OR
15	1 45	I	Te
16	3 24	II	Te
	4 48	III	ED
	7 56	III	ER
19	8 27	I	ED
20	2 40	III	Te
	5 45	I	SI
	6 58	I	TI
	7 59	I	Se
	9 11	I	Te
21	2 56	I	ED
	6 21	I	OR
	6 31	II	ED
22	1 26	I	TI
	2 28	I	Se
	3 39	I	Te
23	3 22	II	TI
	3 39	II	Se
	6 00	II	Te
	8 45	III	ED
25	1 04	II	OR
27	1 50	III	Se
	3 51	III	TI
	6 40	III	Te
	7 38	I	SI
	8 52	I	TI
28	4 48	I	ED
	8 15	I	OR
	9 06	II	ED
29	2 07	I	SI
	3 21	I	TI
	4 21	I	Se
	5 33	I	Te
30	2 43	I	OR
	3 30	II	SI
	5 56	II	TI
	6 11	II	Se
	8 34	II	Te

SATURN'S RINGS AND SATELLITES, 1980

In 1980, the earth will pass through the ring plane of Saturn (see pg. 88). As the major satellites of Saturn orbit very nearly in the same plane, their apparent orbits are nearly straight lines. For this reason, our usual diagram of the apparent orbits is not given.

When the apparent orbits are seen edge-on, mutual eclipses and occultations of the satellites may occur. Predictions of these are given by Aksnes and Franklin (*Icarus* **34**, 194, 1978); most of these can be seen only in a large telescope. A copy of these predictions can be obtained by writing to the editor of this HANDBOOK.

The table below lists eclipses of the brighter satellites by the shadow of ring A. The EVENT column lists the number of the satellite involved, and whether the event is a disappearance (D) or reappearance (R). The last column gives the location of the satellite east (E) or west (W) of the planet, in seconds of arc.

Date	E.S.T.	Event	Dist.	Date	E.S.T.	Event	Dist.	Date	E.S.T.	Event	Dist.
	h m				h m				h m		
Jan. 5	7 38	3D	23W	Jan. 26	3 48	3D	13W	Feb. 16	1 59	3D	13E
7	5 01	3D	23W	26	7 54	3R	13W	16	3 02	3R	19E
9	2 25	3D	22W	28	5 16	3R	14E	17	23 38	3D	15E
10	23 50	3D	22W	30	2 39	3R	14E	18	0 25	3R	19E
11	4 55	3R	9E	Feb. 1	0 01	3R	15E	19	21 17	3D	17E
13	2 18	3R	10E	2	22 23	3R	15E	19	21 47	3R	20E
14	23 40	3R	10E	12	8 16	3R	18E	27	1 43	4R	11E
22	8 42	3D	16W	14	4 20	3D	10E	Mar. 18	2 56	5D	14W
24	6 14	3D	15W	14	5 39	3R	18E	22	22 38	5R	22E

ELONGATIONS OF SATURN'S SATELLITES 1980.

Times given are E.S.T. To convert to other times, see pp. 10–11.

JANUARY

d	h	Sat.	Elong.
1	00.1	Ti	W
2	14.8	Rh	E
7	03.2	Rh	E
9	05.2	Ti	E
11	15.6	Rh	E
16	04.0	Rh	E
16	22.7	Ti	W
19	08.8	Ia	E
20	16.4	Rh	E
25	03.6	Ti	E
25	04.8	Rh	E
29	17.1	Rh	E

FEBRUARY

d	h	Sat.	Elong.
1	20.9	Ti	W
3	05.5	Rh	E
7	17.9	Rh	E
10	01.7	Ti	E
12	06.2	Rh	E
16	18.6	Rh	E
17	18.7	Ti	W
21	06.9	Rh	E
25	19.2	Rh	E
25	23.4	Ti	E
26	05.4	Ia	W

MARCH

d	h	Sat.	Elong.
1	07.5	Rh	E
4	16.3	Ti	W
5	19.9	Rh	E
10	08.2	Rh	E
12	21.0	Ti	E
14	20.5	Rh	E
19	08.9	Rh	W
20	13.8	Ti	W
23	21.2	Rh	E
28	09.5	Rh	E
28	18.6	Ti	E

APRIL

d	h	Sat.	Elong.
1	21.8	Rh	E
5	11.4	Ti	W
6	10.2	Rh	E
6	14.8	Ia	E
10	22.5	Rh	E
13	16.3	Ti	E
15	10.9	Rh	E
19	23.2	Rh	E
21	09.2	Ti	W
24	11.6	Rh	E
29	00.0	Rh	E
29	14.3	Ti	E

MAY

d	h	Sat.	Elong.
3	12.4	Rh	E
7	07.3	Ti	W
8	00.8	Rh	E
12	13.2	Rh	E
14	13.6	Ia	W
15	12.6	Ti	E
17	01.6	Rh	E
21	14.0	Rh	E
23	05.8	Ti	W
26	02.4	Rh	E
30	14.9	Rh	E
31	11.3	Ti	E

JUNE

d	h	Sat.	Elong.
4	03.3	Rh	E
8	04.7	Ti	W
8	15.8	Rh	E
13	04.2	Rh	E
16	10.4	Ti	E
17	16.7	Rh	E
22	05.2	Rh	E
24	04.0	Ti	W
24	18.7	Ia	E
26	17.7	Rh	E

JULY

d	h	Sat.	Elong.
1	06.2	Rh	E
2	09.9	Ti	E
5	18.7	Rh	E
10	03.8	Ti	W
10	07.2	Rh	E
14	19.8	Rh	E
18	09.8	Ti	E
19	08.3	Rh	E
23	20.8	Rh	E
26	03.8	Ti	W
28	09.4	Rh	E

AUGUST

d	h	Sat.	Elong.
1	21.9	Rh	E
2	17.6	Ia	W
3	09.8	Ti	E
6	10.5	Rh	E
10	23.0	Rh	E
11	04.0	Ti	W
15	11.6	Rh	E

Elongations are not given between Aug. 19 and Oct. 27, Saturn being near the sun

OCTOBER

d	h	Sat.	Elong.
30	06.9	Ti	W
31	09.2	Rh	E

NOVEMBER

d	h	Sat.	Elong.
4	21.7	Rh	E
7	12.3	Ti	E
9	10.3	Rh	E
13	22.8	Rh	E
15	07.2	Ti	W
18	11.3	Rh	E
22	23.9	Rh	E
23	12.4	Ti	E
27	12.4	Rh	E

DECEMBER

d	h	Sat.	Elong.
1	07.3	Ti	W
2	00.9	Rh	E
4	03.0	Ia	E
6	13.4	Rh	E
9	12.3	Ti	E
11	01.9	Rh	E
15	14.4	Rh	E
17	07.1	Ti	W
20	02.9	Rh	E
24	15.3	Rh	E
25	11.8	Ti	E
29	03.8	Rh	E

ASTEROIDS—EPHEMERIDES NEAR OPPOSITION 1980

The asteroids Pallas and Juno come to opposition in 1980. Ceres and Vesta came to opposition in late 1979 and are visible in early 1980. The following table gives the radiometric diameter, rotation period, orbital period, eccentricity and inclination for each of the four major asteroids, together with the date (U.T.), constellation, visual magnitude, right ascension and declination (astrometric, 1950 co-ordinates) and distance from earth at opposition.

		Period				At Opposition					
Asteroid	Diam.	Rot.	Orb.	e	i	Date	Const.	Vis. Mag.	R.A. (1950)	Dec. (1950)	d(⊕)
	km	h	yr.		°	U.T.			h m	° ′	a.u.
1 Ceres	1000	9.1	4.6	0.08	11	*	Gem	6.6	7 43.0	+29 21	1.65
2 Pallas	530	10.0	4.6	0.24	35	Oct. 20	Cet	7.8	2 26.8	−20 33	1.74
3 Juno	240	7.2	4.4	0.26	13	Jan. 13	CMi	7.7	7 21.4	+ 1 55	1.22
4 Vesta	530	10.7	3.6	0.09	7	*	Leo	6.8	10 54.1	+13 12	1.79

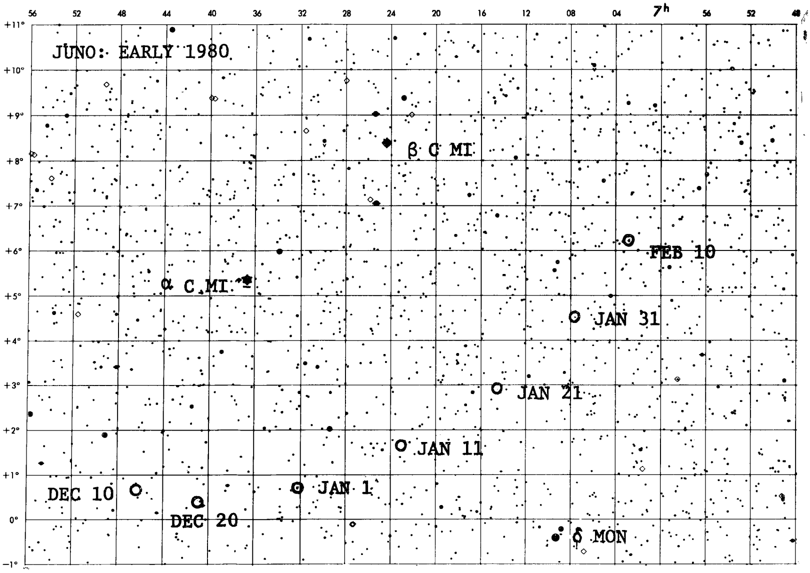
*Data given for Jan. 1, 1981; no opposition in 1980.

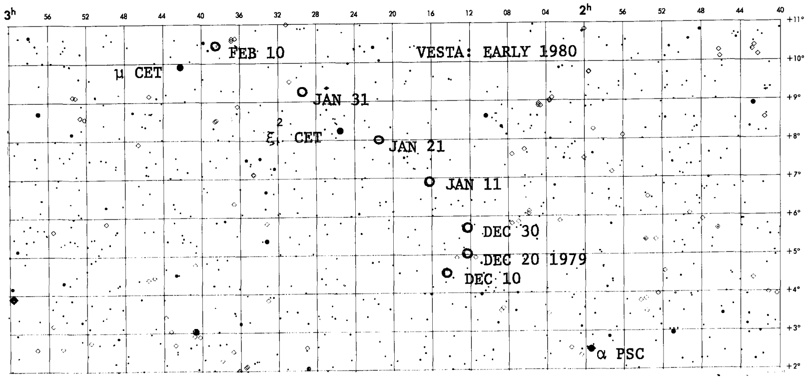
The following tables list the 1950 co-ordinates (for convenience in plotting on commonly-used star charts) and the visual magnitudes of the four asteroids on selected dates (at 0^h U.T.) near opposition. The maps, which are based on the *Smithsonian Astrophysical Observatory Star Atlas*, show the positions of the four asteroids. The 1979 edition of this HANDBOOK shows the positions of three of the asteroids in late 1979.

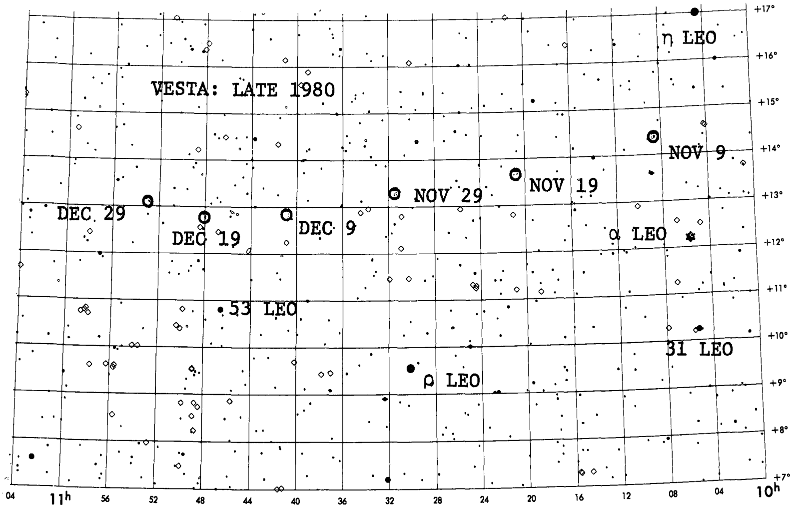
Ceres in late 1980 is in the field of β Gem (Pollux). Pallas is not well placed for northern observers. Juno in early 1980 is still in the field of α C Mi (Procyon). Vesta in late 1980 is in the field of α Leo (Regulus).

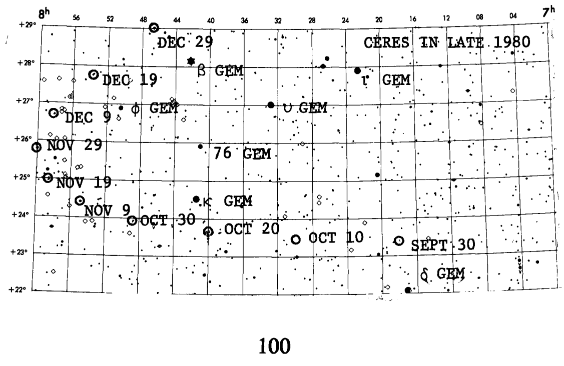
Date 0h U.T.	CERES R.A.	CERES Dec.	CERES Mag.	JUNO R.A.	JUNO Dec.	JUNO Mag.	VESTA R.A.	VESTA Dec.	VESTA Mag.
	h m	° ′		h m	° ′		h m	° ′	
Jan. 1	0 46.0	−4 37	7.9	7 32.2	+00 48	7.7	2 12.8	+05 57	7.1
11	0 52.8	−3 10	8.0	7 23.3	+01 40	7.7	2 16.1	+06 55	7.2
21	1 01.2	−1 37	8.1	7 14.7	+02 57	7.8	2 21.7	+08 02	7.4
31	1 10.8	−0 01	8.1	7 07.6	+04 31	7.9	2 29.3	+09 15	7.5
Feb. 10	1 21.5	+1 37	8.2	7 03.0	+06 13	8.0	2 38.6	+10 31	7.6
20	1 33.1	+3 17	8.2	7 01.5	+07 54	8.2	2 49.4	+11 49	7.7
Mar. 1	1 45.5	+4 56	8.3	7 03.0	+09 28	8.3	3 01.5	+13 07	7.8
11	1 58.6	+6 35	8.3	7 07.5	+10 52	8.5	3 14.7	+14 24	7.9
21	2 12.4	+8 13	8.4	7 14.5	+12 02	8.7	3 28.9	+15 39	8.0
31	2 26.7	+9 48	8.4	7 23.7	+12 59	8.9	3 44.0	+16 50	8.1

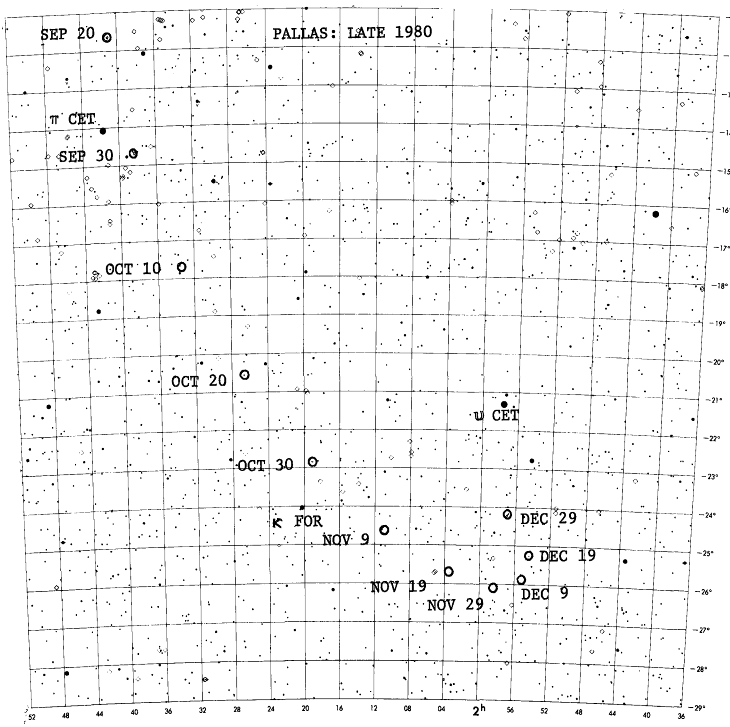
Date 0h U.T.	CERES R.A.	CERES Dec.	CERES Mag.	PALLAS R.A.	PALLAS Dec.	PALLAS Mag.	VESTA R.A.	VESTA Dec.	VESTA Mag.
	h m	° ′		h m	° ′		h m	° ′	
Sept. 20	7 05.0	+23 18	7.8	2 41.0	−11 38	8.0	8 54.1	+18 34	8.1
30	7 18.0	+23 24	7.7	2 38.6	−14 41	8.0	9 10.4	+17 42	8.0
Oct. 10	7 29.8	+23 31	7.6	2 33.7	−17 43	7.9	9 26.2	+16 50	7.9
20	7 40.0	+23 42	7.4	2 26.9	−20 31	7.8	9 41.2	+15 57	7.7
30	7 48.5	+23 58	7.2	2 19.0	−22 52	7.8	9 55.4	+15 08	7.6
Nov. 9	7 54.8	+24 24	7.1	2 10.9	−24 37	7.8	10 08.7	+14 22	7.5
19	7 58.8	+25 00	7.0	2 03.6	−25 41	7.8	10 20.7	+13 43	7.3
29	7 59.9	+25 47	6.8	1 58.2	−26 05	7.9	10 31.5	+13 13	7.2
Dec. 9	7 58.1	+26 45	6.7	1 55.1	−25 54	7.9	10 40.7	+12 55	7.0
19	7 53.2	+27 51	6.6	1 54.6	−25 13	8.0	10 48.0	+12 51	6.9
29	7 45.7	+29 01	6.6	1 56.9	−24 09	8.1	10 53.1	+13 04	6.8




VESTA: EARLY 1980
FEB 10
JAN 31
JAN 21
JAN 11
DEC 30
DEC 20 1979
DEC 10
μ CET
ξ CET
α PSC


VESTA: LATE 1980
η LEO
NOV 9
NOV 19
NOV 29
DEC 9
DEC 19
DEC 29
α LEO
53 LEO
31 LEO
ρ LEO


CERES IN LATE 1980
DEC 29
DEC 19
DEC 9
NOV 29
NOV 19
NOV 9
OCT 30
OCT 20
OCT 10
SEPT 30
β GEM
ι GEM
φ GEM
υ GEM
76 GEM
κ GEM
δ GEM



COMETS IN 1980

BY BRIAN G. MARSDEN

The following periodic comets are expected at perihelion during 1980:

Comet	Perihelion		Period
	Date	Dist.	
		A.U.	yr.
Honda-Mrkos-Pajdušáková	Apr. 11	0.58	5.3
Wirtanen	May 22	1.26	5.9
de Vico-Swift	July 13	2.19	7.4
Forbes	Sept. 25	1.48	6.3
Reinmuth 1	Oct. 29	1.98	7.6
Brooks 2	Nov. 25	1.85	6.9
Stephan-Oterma	Dec. 5	1.57	38
Encke	Dec. 6	0.34	3.3
Tuttle	Dec. 14	1.01	14
Harrington	Dec. 24	1.60	6.9

The returns of Comets Honda-Mrkos-Padjušáková, Wirtanen, de Vico-Swift and Harrington are very unfavourable, and observations are unlikely. Comets Forbes and Brooks 2 are making rather favourable returns and could attain total magnitudes of 12–13; Comet Reinmuth 1 will be fainter. Comet Stephan-Oterma, discovered in 1867 and rediscovered in 1942, will be making its first predicted return; this comet, as well as Comets Encke and Tuttle, are all expected to become particularly bright objects in 1980. Ephemerides (based in part on predicted orbital elements by D. K. Yeomans) are given below.

EPHEMERIDES OF BRIGHT COMETS IN 1980

Date	COMET ENCKE			COMET STEPHAN-OTERMA			COMET TUTTLE		
	R.A. (1950.0)	Dec. (1950.0)	Mag.	R.A. (1950.0)	Dec. (1950.0)	Mag.	R.A. (1950.0)	Dec. (1950.0)	Mag.
	h m	° ′		h m	° ′		h m	° ′	
Oct. 18	7 06.9	+59 51	9.3	—	—	—	—	—	—
23	9 14.7	+60 14		—	—	—	—	—	—
28	11 22.0	+51 21	7.7	—	—	—	—	—	—
Nov. 2	12 40.9	+36 25		—	—	—	—	—	—
7	13 25.5	+21 56	7.2	5 19.4	+ 8 46	10.4	10 06.9	+37 12	9.8
12	13 53.3	+10 29		5 23.0	+10 34		10 15.8	+30 22	
17	14 13.0	+ 1 50	7.1	5 26.0	+12 36	10.1	10 24.1	+22 01	8.9
22	14 29.3	− 4 54		5 28.3	+14 53		10 32.1	+11 59	
27	14 45.7	−10 29	7.3	5 29.9	+17 22	9.9	10 40.1	+ 0 20	8.3
Dec. 2	15 05.6	−15 23		5 30.8	+20 01		10 48.3	−12 22	
7	15 31.6	−19 42	7.8	5 31.3	+22 46	9.8	10 56.9	−25 07	8.1
12	—	—	—	5 31.4	+25 34		11 06.2	−36 52	
17	—	—	—	5 31.3	+28 18	9.9	11 16.6	−47 01	8.4
22	—	—	—	5 31.4	+30 55		11 28.4	−55 24	
27	—	—	—	5 31.6	+33 21	10.0	11 42.3	−62 14	8.9

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, 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.

Major Visual Meteor Showers for 1980

Shower	Shower Maximum			Radiant				Single Observer Hourly Rate	Velocity	Normal Duration to ¼ strength of Max.
				Position at Max.		Daily Motion				
	Date	E.S.T.	Moon	R.A.	Dec.	R.A.	Dec.			
		h		h m	°	m	°		km/sec	days
Quadrantids	Jan. 4	02	FM	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 21	21	FQ	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 4	03	LQ	22 24	00	+3.6	+0.4	20	65	3
S. δ Aquarids	July 28	06	FM	22 36	−17	+3.4	+0.17	20	41	7
Perseids	Aug. 11	21	NM	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	01	FM	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 3	—	LQ	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 16	19	FQ	10 08	+22	+2.8	−0.42	15	71	—
Geminids	Dec. 13	17	FQ	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 22	02	FM	14 28	+76	—	—	15	34	2
	(1981)									
Quadrantids	Jan. 3	08	NM	15 28	+50	—	—	40	41	1.1

A Selection of Minor Visual Meteor Showers

Shower	Dates	Date of Max.	Velocity
			km/sec
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
χ Scorpiids	May 27–June 20	June 5	21
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-six confirmed North American impact structures, which account for almost half 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. 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). The Holyrood structure, in fact, comprises four sites at the surface where definitive shock features have been recognized, but the circular crater outline is not evident.

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 ($\times 10^6$ yr)	Surface Expression	Visible Geologic Features
Barringer, Meteor Crater, Ariz.	35 02	111 01	1.2	.05	rimmed polygonal crater	fragments of "Canyon Diablo" meteorite, highly shocked sandstone, disturbed rocks A D G
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 "Brenham" 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
Holyrood, Nfld.	47 20	053 12	2	500	4 localities of shocked rock	shatter cones, breccia A
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 shallow depression with very slight rim, 4 others buried and smaller	fragments of "Odessa" 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 and surrounding depression	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 central 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

TABLE OF PRECESSION FOR 50 YEARS

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

R.A. for Dec.−	R.A. for Dec.+	Prec. in Dec.	Precession in right ascension											Prec. in Dec.	R.A. for Dec.+	R.A. for Dec.−
			δ=85°	80°	75°	70°	60°	50°	40°	30°	20°	10°	0°			
h m	h m	′	m	m	m	m	m	m	m	m	m	m	m	′	h m	*h m*
12 00	0 00	+16.7	+ 2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	−16.7	12 00	*24 00*
12 30	0 30	+16.6	4.22	3.38	3.10	2.96	2.81	2.73	2.68	2.64	2.61	2.59	2.56	−16.6	11 30	*23 30*
13 00	1 00	+16.1	5.85	4.19	3.64	3.36	3.06	2.90	2.80	2.73	2.67	2.61	2.56	−16.1	11 00	*23 00*
13 30	1 30	+15.4	7.43	4.98	4.15	3.73	3.30	3.07	2.92	2.81	2.72	2.64	2.56	−15.4	10 30	*22 30*
14 00	2 00	+14.5	8.92	5.72	4.64	4.09	3.52	3.22	3.03	2.88	2.76	2.66	2.56	−14.5	10 00	*22 00*
14 30	2 30	+13.2	10.31	6.40	5.09	4.42	3.73	3.37	3.13	2.95	2.81	2.68	2.56	−13.2	9 30	*21 30*
15 00	3 00	+11.8	11.56	7.02	5.50	4.73	3.92	3.50	3.22	3.02	2.85	2.70	2.56	−11.8	9 00	*21 00*
15 30	3 30	+10.2	12.66	7.57	5.86	4.99	4.09	3.61	3.30	3.07	2.88	2.72	2.56	−10.2	8 30	*20 30*
16 00	4 00	+ 8.3	13.58	8.03	6.16	5.21	4.23	3.71	3.37	3.12	2.91	2.73	2.56	− 8.3	8 00	*20 00*
16 30	4 30	+ 6.4	14.32	8.40	6.40	5.39	4.34	3.79	3.42	3.16	2.93	2.74	2.56	− 6.4	7 30	*19 30*
17 00	5 00	+ 4.3	14.85	8.66	6.58	5.52	4.42	3.84	3.46	3.18	2.95	2.75	2.56	− 4.3	7 00	*19 00*
17 30	5 30	+ 2.2	15.18	8 82	6.68	5.60	4.47	3.88	3.49	3.20	2.96	2.75	2.56	− 2.2	6 30	*18 30*
18 00	6 00	0.0	15.29	8.88	6.72	5.62	4.49	3.89	3.50	3.20	2.97	2.76	2.56	0.0	6 00	*18 00*
0 00	12 00	−16.7	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	+16.7	24 00	*12 00*
0 30	12 30	−16.6	+ 0.90	1.82	2.02	2.16	2.31	2.39	2.44	2.48	2.51	2.53	2.56	+16.6	23 30	*11 30*
1 00	13 00	−16.1	− 0.73	0.93	1.48	1.77	2.06	2.22	2.32	2.39	2.45	2.51	2.56	+16.1	23 00	*11 00*
1 30	13 30	−15.4	− 2.31	+0.14	0.97	1.39	1.82	2.05	2.20	2.31	2.40	2.49	2.56	+15 4	22 30	*10 30*
2 00	14 00	−14.5	− 3.80	−0.60	0.46	1.03	1.60	1.90	2.09	2.24	2.36	2.46	2.56	+14.5	22 00	*10 00*
2 30	14 30	−13 2	− 5.19	−1.28	+0.03	0.70	1.39	1.75	1.99	2.17	2.31	2.44	2.56	+13 2	21 30	*9 30*
3 00	15 00	−11 8	− 6.44	−1.90	−0.38	0.40	1.20	1.62	1.90	2.11	2.27	2.42	2.56	+11.8	21 00	*9 00*
3 30	15 30	−10.2	− 7.54	−2.45	−0.74	+0.13	1.03	1.51	1.81	2.05	2.24	2.40	2.56	+10.2	20 30	*8 30*
4 00	16 00	− 8.3	− 8.46	−2.91	−1.04	−0.09	0.89	1.41	1.75	2.00	2.21	2.39	2.56	+ 8.3	20 00	*8 00*
4 30	16 30	− 6.4	− 9.20	−3.27	−1.28	−0.27	0.78	1.33	1.70	1.97	2.19	2.38	2.56	+ 6.4	19 30	*7 30*
5 00	17 00	− 4.3	− 9.73	−3.54	−1.45	−0.40	0.70	1.28	1.66	1.94	2.17	2.37	2.56	+ 4.3	19 00	*7 00*
5 30	17 30	− 2.2	−10.06	−3.70	−1.56	−0.47	0.65	1.25	1.63	1.92	2.16	2.37	2.56	+ 2.2	18 30	*6 30*
6 00	18 00	0.0	−10.17	−3.75	−1.60	−0.50	0.63	1.23	1.62	1.92	2.16	2.36	2.56	0.0	18 00	*6 00*

THE CONSTELLATIONS

Latin Names with Pronunciations and Abbreviations

Andromeda, ăn-drŏm′ē-d*a*	And	Andr
Antlia, ănt′lĭ-*a*	Ant	Antl
Apus, ā′p*ŭ*s	Aps	Apus
Aquarius, *a*-kwâr′ĭ-*ŭ*s	Aqr	Aqar
Aquila, ăk′wĭ-l*a*	Aql	Aqil
Ara, ā′r*a*	Ara	Arae
Aries, ā′rĭ-ēz	Ari	Arie
Auriga, ô-rī′g*a*	Aur	Auri
Boötes, bō-ō′tēz	Boo	Boot
Caelum, sē′l*ŭ*m	Cae	Cael
Camelopardalis, k*a*-mĕl′ō-pär′d*a*-lĭs	Cam	Caml
Cancer, kăn′sẽr	Cnc	Canc
Canes Venatici, kā′nēz vē-năt′ĭ-sī	CVn	CVen
Canis Major, kā′nĭs mā′jẽr	CMa	CMaj
Canis Minor, kā′nĭs′ mī′nẽr	CMi	CMin
Capricornus, kăp′rĭ-kôr′n*ŭ*s	Cap	Capr
Carina, k*a*-rī′n*a*	Car	Cari
Cassiopeia, kăs′ĭ-ō-pē′y*a*′	Cas	Cas
Centaurus, sĕn-tô′r*ŭ*s	Cen	Cent
Cepheus, sē′fūs	Cep	Ceph
Cetus, sē′t*ŭ*s	Cet	Ceti
Chamaeleon, k*a*-mē′lē-ŭn	Cha	Cham
Circinus, sûr′sĭ-n*ŭ*s	Cir	Circ
Columba, kō-lŭm′b*a*	Col	Colm
Coma Berenices, kō′m*a* bĕr′ē-nī′sēz	Com	Coma
Corona, Australis, kō-rō′n*a* ôs-trā′lĭs	CrA	CorA
Corona Borealis, k*a*-rō n*a* bō′rē-ā′lĭs	CrB	CorB
Corvus, kôr′v*ŭ*s	Crv	Corv
Crater, krā′tẽr	Crt	Crat
Crux, krŭks	Cru	Cruc
Cygnus, sĭg′n*ŭ*s	Cyg	Cygn
Delphinus, dĕl-fī′n*ŭ*s	Del	Dlph
Dorado, dō-rä′dō	Dor	Dora
Draco, drā′kō	Dra	Drac
Equuleus, ē-kwoo′lē-*ŭ*s	Equ	Equl
Eridanus, ē-rĭd′*a*-n*ŭ*s	Eri	Erid
Fornax, fôr′năks	For	Forn
Gemini, jĕm′ĭ-nī	Gem	Gemi
Grus, grŭs	Gru	Grus
Hercules, hûr′kū′lēz	Her	Herc
Horologium, hŏr′ō-lō′jĭ-*ŭ*m	Hor	Horo
Hydra, hī′dr*a*	Hya	Hyda
Hydrus, hī′dr*ŭ*s	Hyi	Hydi
Indus, ĭn′d*ŭ*s	Ind	Indi
Lacerta, l*a*-sûr′t*a*	Lac	Lacr
Leo, lē′ō	Leo	Leon
Leo Minor, lē′ō mī′nẽr	LMi	LMin
Lepus, lē′p*ŭ*s	Lep	Leps
Libra, lī′br*a*	Lib	Libr
Lupus, lū′p*ŭ*s	Lup	Lupi
Lynx, lĭngks	Lyn	Lync
Lyra, lī′r*a*	Lyr	Lyra
Mensa, mĕn′s*a*	Men	Mens
Microscopium, mī′krō-skō′pĭ-*ŭ*m	Mic	Micr
Monoceros, m-ōnŏs′ẽr-*ŏ*s	Mon	Mono
Musca, mŭs′k*a*	Mus	Musc
Norma, nôr′m*a*	Nor	Norm
Octans, ŏk′t*ă*nz	Oct	Octn
Ophiuchus, ŏf′ĭ-ūk*ŭ*s	Oph	Ophi
Orion, ō-rī′*ŏ*n	Ori	Orio
Pavo, Pā′vō	Pav	Pavo
Pegasus, pĕg′*a*-s*ŭ*s	Peg	Pegs
Perseus, pûr′sūs	Per	Pers
Phoenix, fē′nĭks	Phe	Phoe
Pictor, pĭk′tẽr	Pic	Pict
Pisces, pĭs′ēz	Psc	Pisc
Piscis Austrinus, pĭs′ĭs ôs-trī′n*ŭ*s	PsA	PscA
Puppis, pŭp′ĭs	Pup	Pupp
Pyxis, pĭk′sĭs	Pyx	Pyxi
Reticulum, rē-tĭk′ū-l*ŭ*m	Ret	Reti
Sagitta, s*a*-jĭt′*a*	Sge	Sgte
Sagittarius, săj′ĭ-tā′rĭ-*ŭ*s	Sgr	Sgtr
Scorpius, skôr′pĭ-*ŭ*s	Sco	Scor
Sculptor, skŭlp′tẽr	Scl	Scul
Scutum, skū′t*ŭ*m	Sct	Scut
Serpens, sûr′pĕnz	Ser	Serp
Sextans, sĕks′t*ă*nz	Sex	Sext
Taurus, tô′r*ŭ*s	Tau	Taur
Telescopium, tĕl′ē-skō′pĭ-*ŭ*m	Tel	Tele
Triangulum, trī-ăng′gū-l*ŭ*m	Tri	Tria
Triangulum Australe, trī-ăng′gū-l*ŭ*m ôs-trā′lē	Tra	TrAu
Tucana, tū-kā′n*a*	Tuc	Tucn
Ursa Major, ûr′s*a* mā′jẽr	UMa	UMaj
Ursa Minor, ûr′s*a* mī′nẽr	UMi	UMin
Vela, vē′l*a*	Vel	Velr
Virgo, vûr′gō	Vir	Virg
Volans, vō′l*ă*nz	Vol	Voln
Vulpecula, vŭl-pĕk′ū-l*a*	Vul	Vulp

ā fāte; ā chāotic; ă tăp; *ă* fin*ă*l; ȧ ȧsk; *a* ide*a*; â câre; ä älms; au aught; ē bē; e crēate; ĕ ĕnd; *ĕ* ang*ĕ*l; ẽ makẽr; ī tīme; ĭ bĭt; *ĭ* an*ĭ*mal; ō nōte; ō anatōmy; ŏ hŏt; *ŏ* *ŏ*ccur; ô ôrb; ōō mōōn; oo book; ou out; ū tūbe; ū unite; ŭ sŭn; *ŭ* s*ŭ*bmit; û hûrl.

FINDING LIST OF NAMED STARS

Name	Con.	R.A.
Acamar, ā′k*a*-mär	θ Eri	02
Achernar, ā′kĕr-när	α Eri	01
Acrux, ā′krŭks	α Cru	12
Adhara, *a*-dā′r*a*	ε CMa	06
Al Na'ir, ăl-nâr′	α Gru	22
Albireo, ăl-bĭr′ē-ō	β Cyg	19
Alcyone, ăl-sī′ō-nē	η Tau	03
Aldebaran, ăl-dĕb′*a*-r*a*n	α Tau	04
Alderamin, ăl-dĕr′*a*-mĭn	α Cep	21
Algenib, ăl-jē′nĭb	γ Peg	00
Algol, ăl′gŏl	β Per	03
Alioth, ăl′ĭ-ŏth	ε UMa	12
Alkaid, ăl-kād′	η UMa	13
Almach, ăl′măk	γ And	02
Alnilam, ăl-nī′lăm	ε Ori	05
Alphard, ăl′fărd	α Hya	09
Alphecca, ăl-fĕk′*a*	α CrB	15
Alpheratz, ăl-fē′răts	α And	00
Altair, ăl-târ′	α Aql	19
Ankaa	α Phe	00
Antares, ăn-tā′rēs	α Sco	16
Arcturus, ärk-tū′r*ŭ*s	α Boo	14
Atria, ā′trĭ-*a*	α TrA	16
Avior, ă-vĭ-ôr′	ε Car	08
Bellatrix, bĕ-lā′trĭks	γ Ori	05
Betelgeuse, bĕt′*e*l-juz	α Ori	05
Canopus, k*a*-nō′p*ŭ*s	α Car	06
Capella, k*a*-pĕl′*a*	α Aur	05
Caph, kăf	β Cas	00
Castor, kås′tĕr	α Gem	07
Deneb, dĕn′ĕb	α Cyg	20
Denebola, dĕ-nĕb′ō-l*a*	β Leo	11
Diphda, dĭf′d*a*	β Cet	00
Dubhe, dŭb′ē	α UMa	11
Elnath, ĕl′năth	β Tau	05
Eltanin, ĕl-tā′nĭn	γ Dra	17
Enif, ĕn′ĭf	ε Peg	21
Fomalhaut, fō′m*ă*l-ôt	α PsA	22
Gacrux, gä′krŭks	γ Cru	12
Gienah, jē′n*a*	γ Crv	12
Hadar, hăd′är	β Cen	14
Hamal, hăm′ăl	α Ari	02
Kaus Australis, kôs ôs-trā′lĭs	ε Sgr	18
Kochab, kō′kăb	β UMi	14
Markab, mär′kăb	α Peg	23
Megrez, mē′grĕz	δ UMa	12
Menkar, mĕn′kär	α Cet	03
Menkent, mĕn′kĕnt	θ Cen	14
Merak, mē′răk	β UMa	11
Miaplacidus, mī′*a*-plăs′ĭ-d*u*s	β Car	09
Mira, mī′r*a*	o Cet	02
Mirach, mī′răk	β And	01
Mirfak, mĭr′făk	α Per	03
Mizar, mī′zär	ζ UMa	13
Nunki, nŭn′kē	σ Sgr	18
Peacock	α Pav	20
Phecda, fĕk′d*a*	γ UMa	11
Polaris	α UMi	01
Pollux, pŏl′*ŭ*ks	β Gem	07
Procyon, prō′sĭ-ŏn	α CMi	07
Ras-Algethi, rås′*ă*l-jē′the	α Her	17
Rasalhague, rås′*ă*l-hā′gwē	α Oph	17
Regulus, rĕg′u-l*ŭ*s	α Leo	10
Rigel, rī′j*e*l	β Ori	05
Rigil Kentaurus rī′jĭl kĕn-tô′r*ŭ*s	α Cen	14
Sabik, sā′bĭk	η Oph	17
Scheat, shē′ăt	β Peg	23
Schedar, shĕd′*a*r	α Cas	00
Shaula, shô′l*a*	λ Sco	17
Sirius, sĭr′ĭ-*ŭ*s	α CMa	06
Spica, spī′k*a*	α Vir	13
Suhail, sŭ-hāl′	λ Vel	09
Vega, vē′g*a*	α Lyr	18
Zubenelgenubi, zōō-bĕn′ĕl-jĕ-nū′bē	α Lib	14

Pronunciations are generally as given by G. A. Davis, *Popular Astronomy*, **52**, 8 (1944). Key to pronunciation on p. 106.

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.

Star	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/sec		
Sun			-26.73	+0.63	G2	V		+4.84					***Sun***
α And	00 07.3	+28 58	2.06	−0.08	B9p		0.024	−0.1	90	0.209	−*11.7*	Manganese star	*Alpheratz*
β Cas	08.1	+59 02	2.26v	+0.34	F2	IV	0.072	+1.6	45	0.555	+11.8	Var. *R* $0^m.08$, 0.10^d	*Caph*
γ Peg	12.2	+15 04	2.84v	−0.23	B2	IV	−.004	−3.4	570	0.010	+04.1	β CMa type, *R* in *V* 2.83–2.85, 0.15^d	
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* 12^m 28″	
α Cas	39.4	+56 25	2.22	+1.18	K0	II–III	0.009	−1.1	150	0.058	−03.8	Var.?	*Schedar*
β Cet	42.6	−18 06	2.02	+1.03	K1	III	0.057	+0.8	57	0.234	+13.1		*Diphda*
η Cas *A*	47.9	+57 42	3.47	+0.56	G0	V	0.182	+4.8	18	1.221	+09.4	*B* 7.26^m 12″	
γ Cas *A*	55.5	+60 36	2.5v	−0.16v	B0	IV:pe	0.034	−0.3:	96:	0.026	−06.8	Var. *B* 8.18^m 2″	
β Phe *AB*	01 05.1	−46 50	3.30	+0.88	*G8*	*III*	0.017	+0.3	190	0.035	−01.1	*A* 4.1^m *B* 4.1^m 1″	
η Cet	07.6	−10 17	3.44	+1.16	K3	III	0.032	+1.0	102	0.250	+11.5		
β And	08.6	+35 31	2.02	+1.57	M0	III	0.043	+0.2	76	0.211	+00.3		*Mirach*
δ Cas	24.4	+60 08	2.67	+0.13	A5	V	0.029	+2.1	43	0.301	+06.7	Ecl.? *R* 0.08:^{m} 759^d	*Ruchbah*
γ Phe	27.5	−43 25	3.40	+1.56	K5	IIb–III	−.003	−4.6	1300	0.209	+*25.7*		
α Eri	37.0	−57 20	0.51	−0.16	B3	Vp	0.023	−2.3	118	0.098	+19		***Achernar***
τ Cet	43.2	−16 03	3.50	+0.72	G8	Vp	0.275	+5.70	12	1.921	−16.2		

Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
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*
ο 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		
θ^{2} Tau	27.5	+15 49	3.42	+0.17	A7 III	0.025	+0.2	140	0.108	*+39.5*		
α Dor	33.5	−55 05	3.28	−0.08	A0 IIIp	0.011	−1.2	260	0.051	+25.6	Silicon star	
α Tau *A*	34.8	+16 28	0.86v	+1.52	K5 III	0.048	−0.7	68	0.202	+54.1	Irr.? *R* 0.78–0.93, *B* 13^{m} 31″	***Aldebaran***
π^{3} Ori	48.3	+06 56	3.17	+0.45	F6 V	0.125	+3.65	26	0.468	+24.3		
ι Aur	55.7	+33 08	2.68:	+1.49	K3 II	0.015	−2.4	330	0.021	+17.5		

Star	R.A. 1980	Dec.	V	B–V	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/sec	
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/sec		
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* 8.66ᵐ 1980.0: 10.3″, P.A. 49°	***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* 7.5ᵐ 8″	***Adhara***
o² 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, 141ᵈ	
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* 9.4ᵐ 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* 9.08vᵐ 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* 10.7ᵐ 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, 0.14ᵈ	
γ Vel *A*	08.9	−47 18	1.83	−0.26	WC8		−4.1	520	0.011	+35	*B* 4.31ᵐ 41″	
ε Car	22.1	−59 26	1.90:	+1.30:	K3:III+B2:v		−3.1:	340	0.030	+11.5		***Avior***
o UMa *A*	28.6	+60 47	3.37	+0.83	G5 III	0.004	+0.1	150	0.171	+19.8	*B* 15ᵐ 7″	
δ Vel *AB*	44.2	−54 38	1.95	+0.05	A2 V	0.043	+0.2	76	0.086	+02.2	*A* 2.0ᵐ *B* 5.1ᵐ 3″ *CD* 10ᵐ 69″	
ε Hya *ABC*	45.7	+06 30	3.39	+0.68	G0 comp.	0.010	+0.6	140	0.198	*+36.4*	*A* 3.7ᵐ *B* 5.2ᵐ 0.2″ 15ʸ, *C* 6.8ᵐ 3″ *D* 12ᵐ 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* 10.8ᵐ 4″	

Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
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/sec		
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″	*Acrux*
α Cru *B*	25.4	−62 59	1.86	−0.25	B1 V		−3.4	370	0.042	*−00.6*		
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/sec		
β Cen *AB*	14 02.4	−60 16	0.63v	−0.23:	B1	III	0.016	−5.2	490	0.035	*−12*	*A* 0.7ᵐ *B* 3.9ᵐ 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., 0.26ᵈ	
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* 3.19ᵐ *B* 8.61ᵐ 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* 2.47ᵐ *B* 5.04ᵐ 3″	
α Lib *A*	49.8	−15 54	2.76	+0.15	A3m		0.049	+1.2	66	0.130	−10	*B* 5.15ᵐ 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* 7.8ᵐ 71″	
δ Boo *A*	14.7	+33 24	3.47	+0.95	G8	III	0.028	+0.3	140	0.148	−12.2	*B* 7.84ᵐ 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., 0.165ᵈ	
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* 3.5ᵐ *B* 3.7ᵐ 1″	
α CrB	33.8	+26 47	2.23v	−0.02	A0	V	0.043	+0.4	76	0.154	*+01.7*	Ecl. *R* 0.11ᵐ, 17.4ᵈ	*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* 3.47ᵐ *B* 7.70ᵐ 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/sec		
β Sco *AB*	16 04.3	−19 45	2.65	−0.09	B0.5 V	0.004	−3.7	650	0.027	*−01.0*	*A* 2.78^m *B* 5.04^m 1″, *C* 4.93^m 14″	
δ Oph	13.3	−03 37	2.72	+1.59	M1 III	0.029	−0.5	140	0.156	−19.9		
ε Oph	17.2	−04 39	3.22	+0.97	G9 III	0.036	+1.0	90	0.089	−10.3		
σ Sco *A*	20.0	−25 32	2.86v	+0.14	B1 III		−4.4	570	0.030	*+02.5*	β CMa *R* 2.82–2.90, 0.25^d, *B* 8.49^m 20″	
η Dra *A*	23.7	+61 33	2.71	+0.92	G8 III	0.043	+0.9	76	0.062	−14.3	*B* 8.7^m 6″	
α Sco *A*	28.2	−26 23	0.92v	+1.84	M1 Ib+B	0.019	−5.1	520	0.029	−03.2	*A* 0.86^m–1.02^m *B* 5.07^m 3″	***Antares***
β Her	29.3	+21 32	2.78	+0.92	G8 III	0.017	+0.3	103	0.105	*−25.5*		
τ Sco	34.6	−28 10	2.85	−0.25	B0 V		−4.0	750	0.030	−00.7		
ζ Oph	36.1	−10 31	2.57	+0.00	O9.5 V	−.007	−4.3	520	0.022	*−19*		
ζ Her *AB*	40.6	+31 38	2.81	+0.64	G0 IV	0.110	+3.1	30	0.608	*−69.9*	*A* 2.91^m *B* 5.46^m 1″	
η Her	42.2	+38 58	3.46	+0.92	G7 III–IV	0.053	+2.1	62	0.097	+08.3		
α TrA	46.5	−68 60	1.93	+1.43	K2 Ib	0.024	−0.1	82	0.044	−03.6		*Atria*
ε Sco	48.8	−34 16	2.28	+1.16	K2.5 III	0.049	+0.7	66	0.664	−02.5		
μ^1 Sco	50.5	−38 01	2.99v	−0.20	B1.5 V		−3.0	520	0.033	*−25*	Ecl. *R* 2.99–3.09, 1.4^d	
κ Oph	56.8	+09 25	3.18	+1.15	K2 III	0.026	−0.1	150	0.293	−55.6		
ζ Ara	56.9	−55 57	3.12	+1.61	K4 III	0.036	+0.9	90	0.042	−06.0		
ζ Dra	17 08.7	+65 44	3.20	−0.12	B6 III	0.017	−3.2	620	0.026	−14.1		
η Oph *AB*	09.3	−15 42	2.43	+0.06	A2.5 V	0.047	+1.4	69	0.097	−00.9	*A* 3.0^m *B* 3.4^m 1″	*Sabik*
η Sco	10.7	−43 13	3.33	+0.38	*F2 III*	0.063	+2.3	52	0.293	−28.4		
α Her *AB*	13.8	+14 24	3.10v	+1.41	M5 II	−.007	−2.3	410	0.032	−33.1	*A* $3.2^m \pm 0.3$ *B* 5.4^m 5″	*Ras-Algethi*
δ Her	14.2	+24 51	3.14	+0.09	A3 IV	0.034	+0.8	96	0.164	−41		
π Her	14.3	+36 49	3.13	+1.43	K3 II	0.020	−2.4	410	0.029	−25.7		
θ Oph	20.8	−24 59	3.29v	−0.22	B2 IV		−3.4	710	0.025	*−03.6*	β CMa var., 0.14^d	
β Ara	23.6	−55 31	2.90:	+1.45:	K1.5 Ib	0.026	−4.6	1030	0.035	−00.4		
γ Ara *A*	23.8	−56 22	3.32	−0.16:	B1 Ib		−3.3	680	0.017	−04	*B* 10^m 18″	
υ Sco	29.4	−37 16	2.71	−0.22	B2 IV		−3.4	540	0.039	*+07*		
β Dra *A*	29.9	+52 20	2.77	+0.96	G2 II	0.009	−2.1	310	0.019	−20.0	*B* 11.49^m 4″	
α Ara	30.3	−49 52	2.95	−0.18:	B2.5 V		−2.4	390	0.083	*−02*		
λ Sco	32.3	−37 05	1.60v	−0.24	B1 V		−3.3	310	0.031	00	β CMa var., 0.21^d	*Shaula*
α Oph	34.0	+12 35	2.09	+0.16	A5 III	0.056	+0.8	58	0.260	+12.7		*Rasalhague*
θ Sco	35.9	−42 59	1.86	+0.39	*F0 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/sec		
κ Sco	17 41.1	−39 01	2.39v	−0.21	B1.5	III		−3.4	470	0.031	*−10*	β CMa var., 0.20ᵈ	
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* 9.78ᵐ 33″	
ι¹ Sco	46.2	−40 06	3.02	+0.49	F2	Ia	0.013	−7.1	3400	0.004	*−27.6*		
G Sco	48.4	−37 02	3.21	+1.18	K2	III	0.032	+0.7	102	0.064	+24.7		
γ Dra	56.1	+51 29	2.21	+1.52	K5	III	0.017	−0.4	108	0.026	−27.6		*Eltanin*
ν Oph	58.0	−09 47	3.32	+1.00	G9	III	0.015	+0.2	140	0.118	+12.4		
γ Sgr	18 04.5	−30 26	2.97	+1.00	*K0*	*III*	0.018	+0.1	124	0.200	*+22.1*		
η Sgr *A*	16.3	−36 47	3.12	+1.55	M3.5	III	0.038	+1.1:	86:	0.218	+00.5	*B* 10ᵐ 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, 12.9ᵈ, *B* 7.8ᵐ 46″	
σ Sgr	54.0	−26 19	2.12:	−0.21	B2	V		−2.7	300	0.059	−11		*Nunki*
ξ² Sgr	56.5	−21 07	3.51	+1.18:	K1	III	0.006	+0.0	160	0.035	−19.9		
γ Lyr	58.2	+32 40	3.25	−0.05	B9	III	0.011	−2.1	370	0.007	−21.5		
ζ Sgr *AB*	19 01.3	−29 54	2.61	+0.08	*A2*	*IV*	0.020	+0.1	140	0.020	+22	*A* 3.3ᵐ *B* 3.5ᵐ < 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* 12ᵐ 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* 3.7ᵐ *B* 3.8ᵐ *C* 6.0ᵐ < 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* 5.11ᵐ 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* 2.91ᵐ *B* 6.44ᵐ 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/sec		
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* 5.97ᵐ 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, 0.19ᵈ	
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* 11ᵐ 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, 5.4ᵈ, *B* 6.19ᵐ 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		

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 average optical quality, and for stars which are not unduly faint or of large magnitude difference, the minimum angular separation is given by 4.6/D, where D is the diameter of the telescope's objective in inches.

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 1980.0; and the period, if known.

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. 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. 02138 under the title *Visual Observing of Double Stars—Ed.*)

Star		A.D.S.	R.A. 1980.0 h	m	Dec. 1980.0 °	′	Magnitudes comb.	A	B	P.A. 1980.0 °	Sep. ″	P (app.) years
λ	Cas	434	00	30.7	+54	26	4.9	5.5	5.8	183	0.6	640
α	Psc	1615	02	01.0	+02	40	4.0	4.3	5.3	281	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	242	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	254	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	163	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	84	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	307	12.0	480
Σ	186	1538	01	54.8	+01	45	6.0	6.8	6.8	54	1.3	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	207	0.6	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	49	10.3	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	95	2.2	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	280	0.8	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	81	5.9	1150
σ^2	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	3	3.2	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	105	2.9	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	297	3.9	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	333	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	142	1.3	35
τ	Oph	11005	18	01.9	−08	11	4.7	5.2	5.9	277	1.9	280
70	Oph	11046	18	04.5	+02	32	4.0	4.2	6.0	324	2.2	88
δ	Cyg	12880	19	44.4	+45	04	2.9*	2.9	6.3	233	2.3	830
4	Aqr	14360	20	50.4	−05	53	6.0	6.4	7.2	10	1.0	150
τ	Cyg	14787	21	13.9	+37	57	3.7	3.8	6.4	144	0.8	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	298	1.8	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	226	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	309	1.5	350

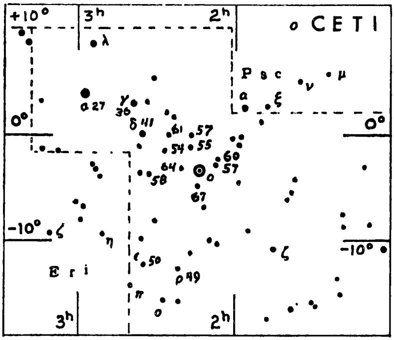
*There is a marked colour difference between the components.
†The separation of the two pairs of ε Lyr is 208″.

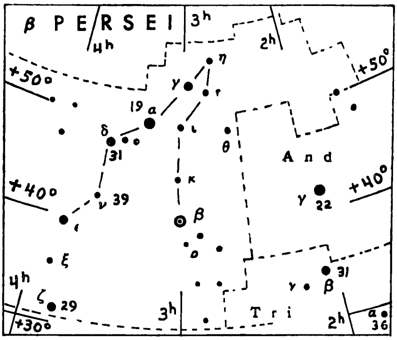
VARIABLE STARS

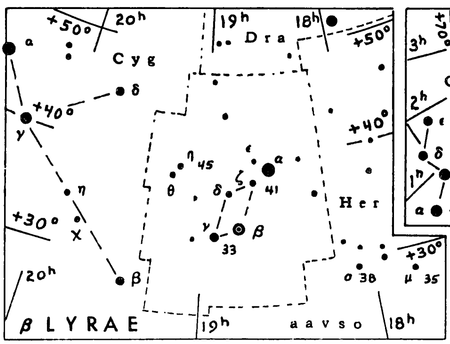
By Janet Mattei

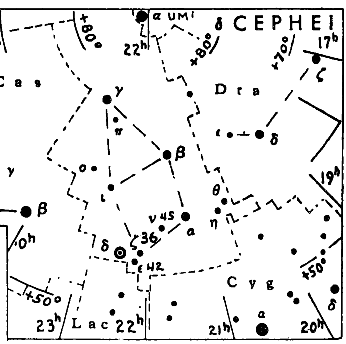
The systematic observation of variable stars is an area in which an amateur can make a valuable contribution to astronomy. For beginning observers, maps of the fields of four bright variable stars are given below. In each case, the magnitudes (with decimal point omitted) of several suitable comparison 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.

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 1979, International Supplement.*









LONG-PERIOD VARIABLE STARS

Variable	Max. m_v	Per d	Epoch 1980	Variable	Max. m_v	Per d	Epoch 1980
001755 T Cas	7.8	445	Dec. 26	142539 V Boo	7.9	258	Feb. 5
001838 R And	7.0	409	May 16	143227 R Boo	7.2	223	Feb. 24
021143 W And	7.4	397	Mar. 6	151731 S CrB	7.3	361	Jan. 1
0214*03* o Cet	3.4	332	Sept. 22	154639 V CrB	7.5	358	Aug. 29
0228*13* U Cet	7.5	235	Jan. 11	154615 R Ser	6.9	357	July 21
023133 R Tri	6.2	266	June 18	160625 RU Her	8.0	484	June 19
043065 T Cam	8.0	374	Nov. 22	162119 U Her	7.5	406	Dec. 1
0455*14* R Lep	6.8	432	Jan. 15	1621*12* V Oph	7.5	298	Sept. 1
050953 R Aur	7.7	459	Aug. 15	163266 R Dra	7.6	245	Feb. 12
054920 U Ori	6.3	372	Oct. 1	164715 S Her	7.6	307	July 14
0617*02* V Mon	7.0	335	Feb. 4	1702*15* R Oph	7.9	302	Mar. 5
065355 R Lyn	7.9	379	June 8	171723 RS Her	7.9	219	Mar. 27
070122aR Gem	7.1	370	Aug. 5	180531 T Her	8.0	165	Mar. 9
070310 R CMi	8.0	338	May 20	181136 W Lyr	7.9	196	Feb. 4
072708 S CMi	7.5	332	Nov. 23	183308 X Oph	6.8	334	June 29
081112 R Cnc	6.8	362	Dec. 21	190108 R Aql	6.1	300	Mar. 28
081617 V Cnc	7.9	272	Feb. 26	1910*17* T Sgr	8.0	392	Oct. 2
084803 S Hya	7.8	257	Feb. 2	1910*19* R Sgr	7.3	269	July 13
0850*08* T Hya	7.8	288	May 9	193449 R Cyg	7.5	426	Dec. 28
093934 R LMi	7.1	372	Apr. 13	194048 RT Cyg	7.3	190	June 2
094211 R Leo	5.8	313	Aug. 13	194632 χ Cyg	5.2	407	Dec. 31
103769 R UMa	7.5	302	June 4	201647 U Cyg	7.2	465	Nov. 17
1214*18* R Crv	7.5	317	May 9	2044*05* T Aqr	7.7	202	May 5
122001 SS Vir	6.8	355	Jan. 26	210868 T Cep	6.0	390	Nov. 6
123160 T UMa	7.7	257	Mar. 23	213753 RU Cyg	8.0	234	Feb. 8
123307 R Vir	6.9	146	Jan. 26	230110 R Peg	7.8	378	Mar. 20
123961 S UMa	7.8	226	July 6	230759 V Cas	7.9	228	Apr. 26
131546 V CVn	6.8	192	Mar. 26	231508 S Peg	8.0	319	Apr. 23
1327*06* S Vir	7.0	378	Feb. 25	2338*15* R Aqr	6.5	387	Feb. 27
134440 R CVn	7.7	328	Jan. 4	235350 R Cas	7.0	431	Aug. 11
142584 R Cam	7.9	270	Sept. 12	2357*15* W Cet	7.6	351	Jan. 16

OTHER TYPES OF VARIABLE STARS

Variable		Max. m_v	Min. m_v	Type	Sp. Cl.	Period d	Epoch 1980 E.S.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 1.24*
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. 1.56*
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. 4.53
065820	ζ Gem	3.6	4.2	δ Cep	F7–G3	10.15082	Jan. 3.92
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	12.935306	Jan. 4.29*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.566867	Jan. 1.54
194700	η Aql	3.5	4.3	δ Cep	F6–G4	7.176641	Jan. 5.79
222557	δ Cep	3.5	4.4	δ Cep	F5–G2	5.366341	Jan. 4.30

*Minimum.

BRIEF DESCRIPTION OF VARIABLE TYPES

Variables can be divided into three main classes; pulsating, eruptive and eclipsing binary stars as recommended by Commission 27 of the International Astronomical Union at its 12th General Assembly in Hamburg in 1964. A very brief and general description about the major types of variables in each class is given below.

I. *Pulsating Variables*

Cepheids: Variables that pulsate periodically with periods 1 to 70 days. They have high luminosity with amplitudes of light variations ranging from 0.1 to 2^m. Some of the group are located in open clusters, and they obey the well known period-luminosity relation. They are of F spectral class at maximum and G–K at minimum. The later their spectral class the greater is the period of light variation. Typical representative: δ Cephei.

RR Lyrae Type: Pulsating, giant variables with periods ranging from 0^d05 to 1^d2 and amplitude of light variation between 1 and 2^m. They are usually of A spectral class. Typical representative: RR Lyrae.

RV Tauri Type: Supergiant variables with light curves 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 variations goes up to 3^m. Many show long term variations of 500 to 9000 days in their mean magnitude. 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^m and larger with well defined periodicity, ranging from 80 to 1000 days. They show characteristic emission spectra of late spectral classes of Me, Ce and Se. 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 exceeding 1 to 2^m, in general. Typical representative: R Ursae Minoris.

Irregular Variables: Stars that show no periodicity or only a trace of it at times. Typical representative: ω Canis Majoris.

II. *Eruptive Variables*

Novae: Hot, dwarf stars with sudden increase in brightness, from 7 to 16^m in amplitude, in a matter of 1 to several to hundreds of days. After the outburst the brightness decreases slowly until its initial brightness is reached in several years or decades. Near the maximum brightness, spectra similar to A or F giants are usually observed. Typical representative: CP Puppis (Nova 1942).

Supernovae: Novae in a much larger scale, with sudden increase in brightness up to 20^m or more. The general appearance of their light curve is similar to novae. Typical representative: CM Tauri (central star of the Crab Nebula).

R Coronae Borealis Type: High luminosity variables with slow, non-periodic drops in brightness of amplitudes from about 1 to 9^m. The duration of minima varies from some dozen to several hundreds of days. Members of this type are of F to K and R spectral class. Typical representative: R Coronae Borealis.

U Geminorum Type: Dwarf novae that have long intervals of apparent quiesence at minimum with sudden rises to maximum. The range of outburst is from 2 to 6^m in light variations and ten to thousands of days between outbursts depending upon the star. It is a well established fact that most of the members are spectroscopic binaries with periods in order of hours. Typical representative: SS Cygni.

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

III. *Eclipsing Binaries*

Binary systems of stars with the orbital plane lying close to the line of sight of the observer. The components periodically eclipse each other, causing variations 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).

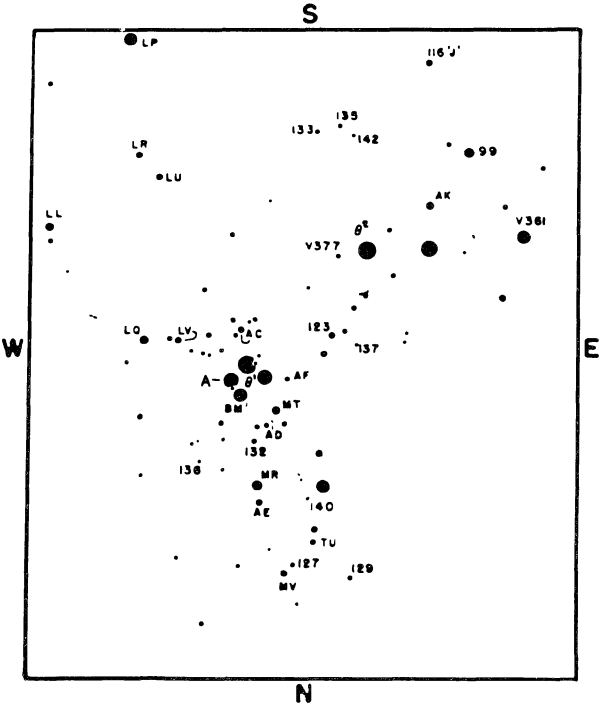
INTRODUCING THE ORION VARIABLES

Each year, we introduce one or two new variables to our readers. Recent editions of this HANDBOOK, for instance, have featured CY Aqr, Mira, Z UMa, R Sct and R CrB.

This year, we focus on the region of the Trapezium, a group of hot young stars at the core of the great Orion Nebula. Dozens of variables—mostly irregular *nebular variables*—are found in this region. Most amateurs and students have looked at or photographed the Trapezium region; why not make some variable star measurements there as well?

On the chart below, variables are designated by letters or V numbers (BM or V377, for instance; the full name of BM is BM Orionis). Non-variable comparison stars are marked by numbers which are their apparent visual magnitudes with the decimals removed. You can estimate the magnitude of a variable by comparing it with the comparison stars, preferably two or more. This can be done visually, or from photographs, but keep in mind that the magnitudes used on this chart are visual magnitudes, which match the sensitivity of the eye. You should record the date and time of the observation to a thousandth of a day. Since some nebular variables change in less than an hour, it may be useful to make observations as frequently as every 15 minutes. For further instruction in variable star observing, contact the AAVSO.

Though most of the variables on the chart are nebular variables—young stars in transition from birth to stability—there are two notable exceptions, both in the Trapezium. They are BM Orionis and θ^1 Orionis A, and they are both eclipsing variables, with periods of $6^{\rm d}.470525$ and $65^{\rm d}.432$ respectively. Their first minima in 1980 are on Jan. 6.01 E.S.T. and Jan. 18.24 E.S.T. respectively. During eclipse, the stars decrease in brightness by a magnitude for several hours.



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/sec, 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 3.27 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	Mv
	h	m	°	′	″	l.y.		″	km/sec		
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
o² 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		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.

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.

NGC	M	Con	α 1980 δ h m	° ′	Type	Size ′	S mag. sq″	m *	Dist. 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	
ζ Ori		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 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.

MESSIER'S CATALOGUE OF DIFFUSE OBJECTS

This table lists the 110 objects ascribed to Messier's catalogue. The columns contain: Messier's number (M), the number of Dreyer's New General Catalogue (NGC), the constellation, the 1980 position, the integrated visual magnitude (m_v), and the class of object. OC means open cluster, GC, globular cluster, PN, planetary nebula, DN, diffuse nebula, and G, galaxy. The type of galaxy is also indicated, as explained in the table of external galaxies. An asterisk indicates that additional information about the object may be found elsewhere in the *Handbook*, in the appropriate table. See also *Editor's Note* opposite.

M	NGC	Con	α 1980	δ	m_v	Type	M	NGC	Con	α 1980	δ	m_v	Type
1	1952	Tau	5 33.3	+22 01	11.3	DN*	56	6779	Lyr	19 15.8	+30 08	8.33	GC
2	7089	Aqr	21 32.4	−00 54	6.27	GC*	57	6720	Lyr	18 52.9	+33 01	9.0	PN*
3	5272	CVn	13 41.3	+28 29	6.22	GC*	58	4579	Vir	12 36.7	+11 56	9.9	G-SBb
4	6121	Sco	16 22.4	−26 27	6.07	GC*	59	4621	Vir	12 41.0	+11 47	10.3	G-E
5	5904	Ser	15 17.5	+02 11	5.99	GC*	60	4649	Vir	12 42.6	+11 41	9.3	G-E
6	6405	Sco	17 38.9	−32 11	6	OC*	61	4303	Vir	12 20.8	+04 36	9.7	G-Sc
7	6475	Sco	17 52.6	−34 48	5	OC*	62	6266	Sco	16 59.9	−30 05	7.2	GC
8	6523	Sgr	18 02.4	−24 23		DN*	63	5055	CVn	13 14.8	+42 08	8.8	G-Sb*
9	6333	Oph	17 18.1	−18 30	7.58	GC	64	4826	Com	12 55.7	+21 48	8.7	G-Sb*
10	6254	Oph	16 56.0	−04 05	6.40	GC*	65	3623	Leo	11 17.8	+13 13	9.6	G-Sa
11	6705	Sct	18 50.0	−06 18	7	OC*	66	3627	Leo	11 19.1	+13 07	9.2	G-Sb
12	6218	Oph	16 46.1	−01 55	6.74	GC*	67	2682	Cnc	8 50.0	+11 54	7	OC*
13	6205	Her	16 41.0	+36 30	5.78	GC*	68	4590	Hya	12 38.3	−26 38	8.04	GC
14	6402	Oph	17 36.5	−03 14	7.82	GC	69	6637	Sgr	18 30.1	−32 23	7.7	GC
15	7078	Peg	21 29.1	+12 05	6.29	GC*	70	6681	Sgr	18 42.0	−32 18	8.2	GC
16	6611	Ser	18 17.8	−13 48	7	OC*	71	6838	Sge	19 52.8	+18 44	6.9	GC
17	6618	Sgr	18 19.7	−16 12	7	DN*	72	6981	Aqr	20 52.3	−12 39	9.15	GC
18	6613	Sgr	18 18.8	−17 09	7	OC	73	6994	Aqr	20 57.8	−12 44		OC
19	6273	Oph	17 01.3	−26 14	6.94	GC	74	628	Psc	1 35.6	+15 41	9.5	G-Sc
20	6514	Sgr	18 01.2	−23 02		DN*	75	6864	Sgr	20 04.9	−21 59	8.31	GC
21	6531	Sgr	18 03.4	−22 30	7	OC	76	650	Per	1 40.9	+51 28	11.4	PN*
22	6656	Sgr	18 35.2	−23 55	5.22	GC*	77	1068	Cet	2 41.6	−00 04	9.1	G-Sb
23	6494	Sgr	17 55.7	−19 00	6	OC*	78	2068	Ori	5 45.8	+00 02		DN
24	6603	Sgr	18 17.3	−18 27	6	OC	79	1904	Lep	5 23.3	−24 32	7.3	GC
25	4725†	Sgr	18 30.5	−19 16	6	OC*	80	6093	Sco	16 15.8	−22 56	7.17	GC
26	6694	Sct	18 44.1	−09 25	9	OC	81	3031	UMa	9 54.2	+69 09	6.9	G-Sb*
27	6853	Vul	19 58.8	+22 40	8.2	PN*	82	3034	UMa	9 54.4	+69 47	8.7	G-Irr*
28	6626	Sgr	18 23.2	−24 52	7.07	GC	83	5236	Hya	13 35.9	−29 46	7.5	G-Sc*
29	6913	Cyg	20 23.3	+38 27	8	OC	84	4374	Vir	12 24.1	+13 00	9.8	G-E
30	7099	Cap	21 39.2	−23 15	7.63	GC	85	4382	Com	12 24.3	+18 18	9.5	G-S0
31	224	And	0 41.6	+41 09	3.7	G-Sb*	86	4406	Vir	12 25.1	+13 03	9.8	G-E
32	221	And	0 41.6	+40 45	8.5	G-E*	87	4486	Vir	12 29.7	+12 30	9.3	G-Ep
33	598	Tri	1 32.8	+30 33	5.9	G-Sc*	88	4501	Com	12 30.9	+14 32	9.7	G-Sb
34	1039	Per	2 40.7	+42 43	6	OC	89	4552	Vir	12 34.6	+12 40	10.3	G-E
35	2168	Gem	6 07.6	+24 21	6	OC*	90	4569	Vir	12 35.8	13 16	9.7	G-Sb
36	1960	Aur	5 35.0	+34 05	6	OC	91	4548	Com	12 34.4	+14 36	10.8	G-SBb
37	2099	Aur	5 51.5	+32 33	6	OC*	92	6341	Her	17 16.5	+43 10	6.33	GC*
38	1912	Aur	5 27.3	+35 48	6	OC	93	2447	Pup	7 43.6	−23 49	6	OC
39	7092	Cyg	21 31.5	+48 21	6	OC	94	4736	CVn	12 50.1	+41 14	8.1	G-Sb*
40	—	UMa	12 34.4	+58 20	9.0	2 stars	95	3351	Leo	10 42.8	+11 49	9.9	G-SBb
41	2287	CMa	6 46.2	−20 43	6	OC*	96	3368	Leo	10 45.6	+11 56	9.4	G-Sa
42	1976	Ori	5 34.4	−05 24		DN*	97	3587	UMa	11 13.7	+55 08	11.1	PN*
43	1982	Ori	5 34.6	−05 18		DN	98	4192	Com	12 12.7	+15 01	10.4	G-Sb
44	2632	Cnc	8 38.8	+20 04	4	OC*	99	4254	Com	12 17.8	+14 32	9.9	G-Sc
45	—	Tau	3 46.3	+24 03	2	OC*	100	4321	Com	12 21.9	+15 56	9.6	G-Sc
46	2437	Pup	7 40.9	−14 46	7	OC*	101	5457	UMa	14 02.5	+54 27	8.1	G-Sc*
47	2422	Pup	7 35.6	−14 27	5	OC	102	5866	Dra	15 05.9	+55 50	10.8	G-E6p
48	2548	Hya	8 12.5	−05 43	6	OC	103	581	Cas	1 31.9	+60 35	7	OC
49	4472	Vir	12 28.8	+08 07	8.9	G-E*	104	4594	Vir	12 38.8	−11 31	8.7	G-Sb*
50	2323	Mon	7 02.0	−08 19	7	OC	105	3379	Leo	10 46.8	+12 42	9.2	G-E1
51	5194	CVn	13 29.0	+47 18	8.4	G-Sc*	106	4258	CVn	12 18.0	+47 25	8.6	GSbp*
52	7654	Cas	23 23.3	+61 29	7	OC	107	6171	Oph	16 31.3	−13 02	9.2	GC
53	5024	Com	13 12.0	+18 17	7.70	GC	108	3556	UMa	11 10.5	+55 47	10.7	G-Sc
54	6715	Sgr	18 53.8	−30 30	7.7	GC	109	3992	UMa	11 56.6	+53 29	10.8	G-SBb
55	6809	Sgr	19 38.7	−31 00	6.09	GC*	110	205	And	00 39.1	+41 35	9.4	G-E6*

†Index Catalogue Number

STAR CLUSTERS

BY ANTHONY MOFFAT AND THEODOR SCHMIDT-KALER

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 extremely 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 to 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 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′ 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_{pg*} 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, Spe*, 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 7.6. 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_{b25*} 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_{pg}*	Dist. 1000 l.y.	Sp. e*	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	
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_{pg}*	Dist. 1000 l.y.	Sp. e*	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	B3	
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	0.52	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	O5	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 cl.
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 cl.
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	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_b 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.

EXTERNAL GALAXIES

By S. van den Bergh

Among the hundreds of thousands 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 Brightest Galaxies

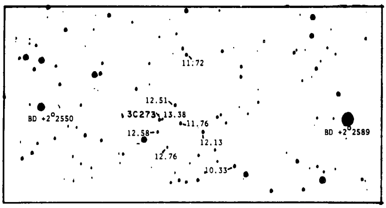
NGC or name	M	α 1980	δ	Type	m_{pg}	Dimensions	Distance millions of l.y.
		h m	° ′			′ ′	
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		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	Ir IV–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	Ir V	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 finding charts for four of these objects. A chart for 3C273, the brightest quasar, is at right. North is at the top.



Name	Type	R.A. 1950 h m	Dec. ° ′	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

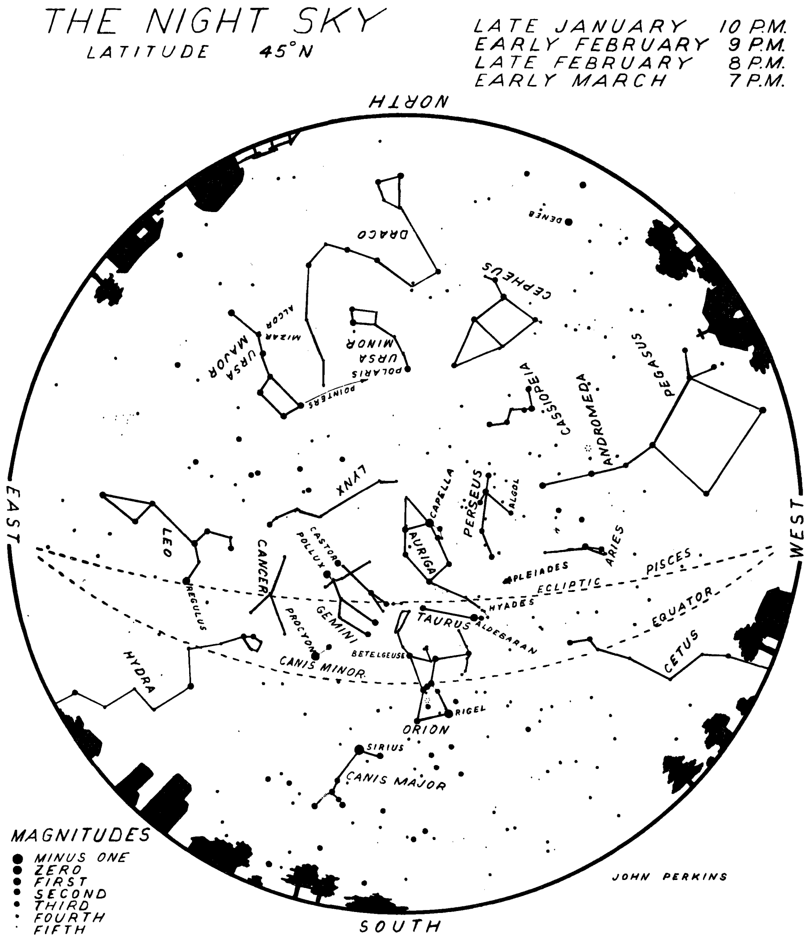
RADIO SOURCES

By John Galt

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

Name	α (1980) h m	δ ° ′	Remarks
Tycho's s'nova	00 24.6	+64 01	Remnant of supernova of 1572
Andromeda gal.	00 41.5	+41 09	Closest normal spiral galaxy
IC 1795, W3	02 23.9	+62 01	Multiple HII region, OH emission
Algol	03 06.6	+40 52	Star emits high freq. radio waves
NGC 1275, 3C 84	03 18.5	+41 26	Seyfert galaxy, radio variable
CP 0328	03 31.3	+54 29	Pulsar, period = 0.7145 sec., 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
3C 353	17 19.5	−00 58	Double source, probably galaxy
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
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

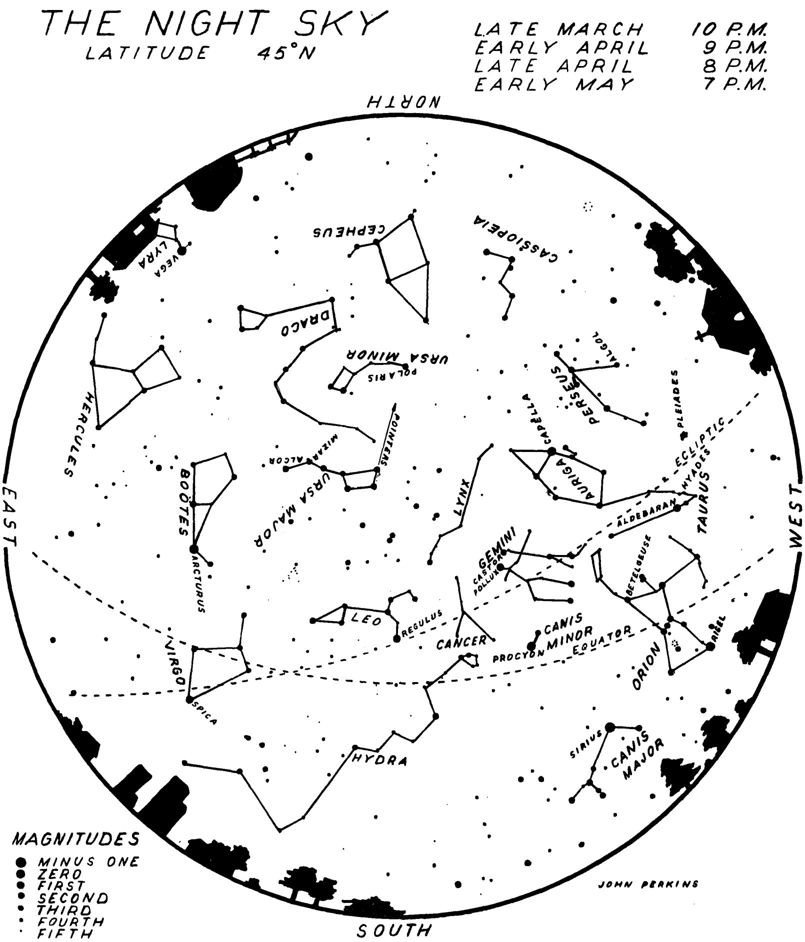
Sources marked * could be detected with amateur radio telescopes. (For more information about amateur radio astronomy, see *Astronomy*, **5**, no. 12, 50 (1977), a series of articles in *J. Roy. Ast. Soc. Canada*, **72**, L5, L22, L38 . . . (1978) and a series of articles in *Sky and Telescope*, **55**, 385 and 475 and **56**, 28 and 114 (1978)—*Ed.*)



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late October at 4 a.m. The map is drawn for latitude 45° N. but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late December at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

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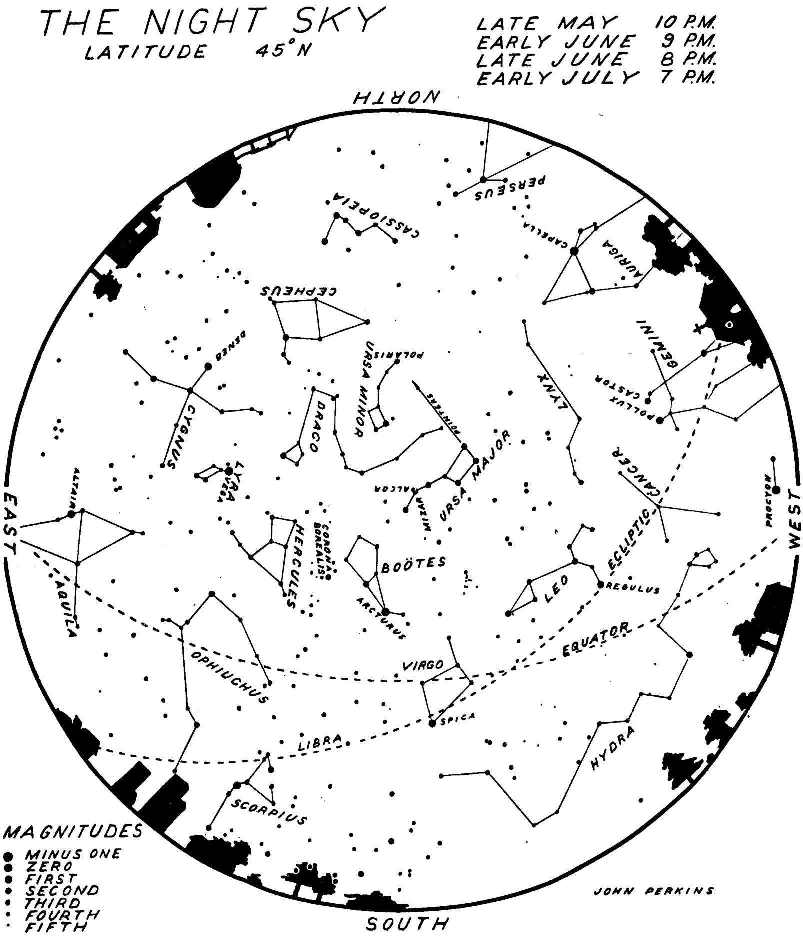
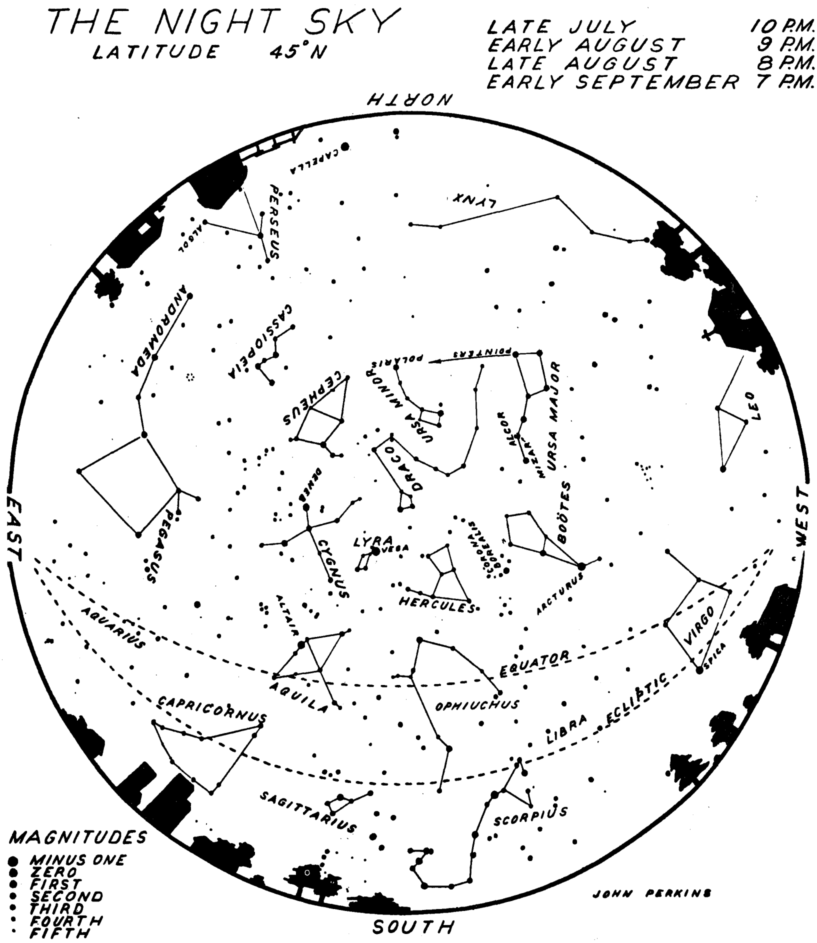


The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late February at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

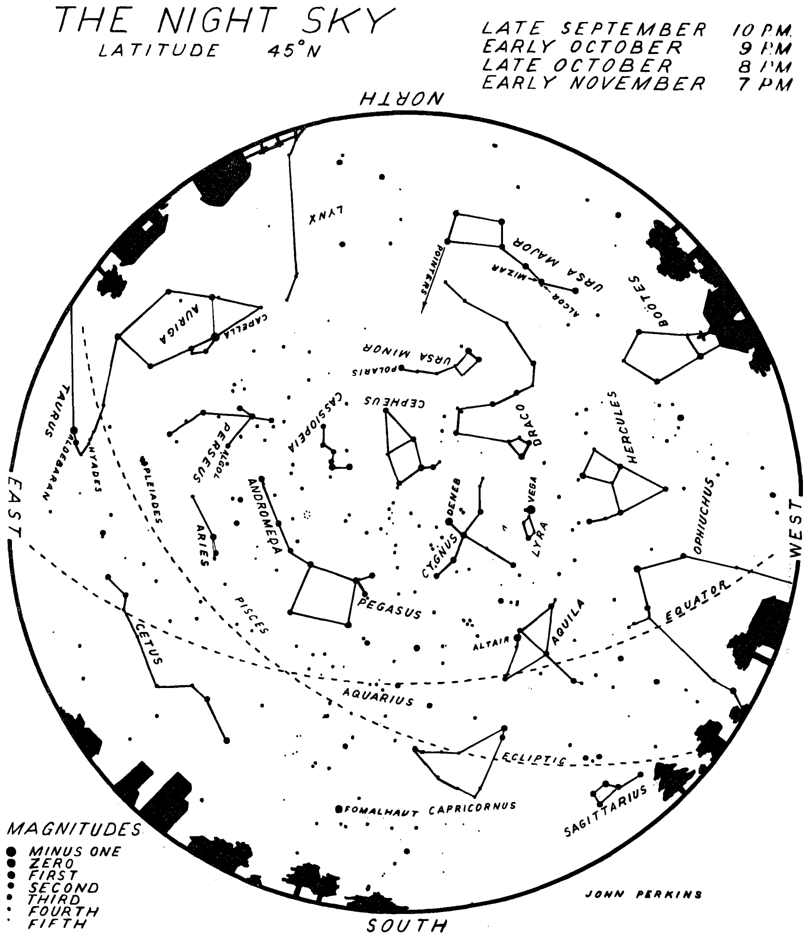
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late April at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

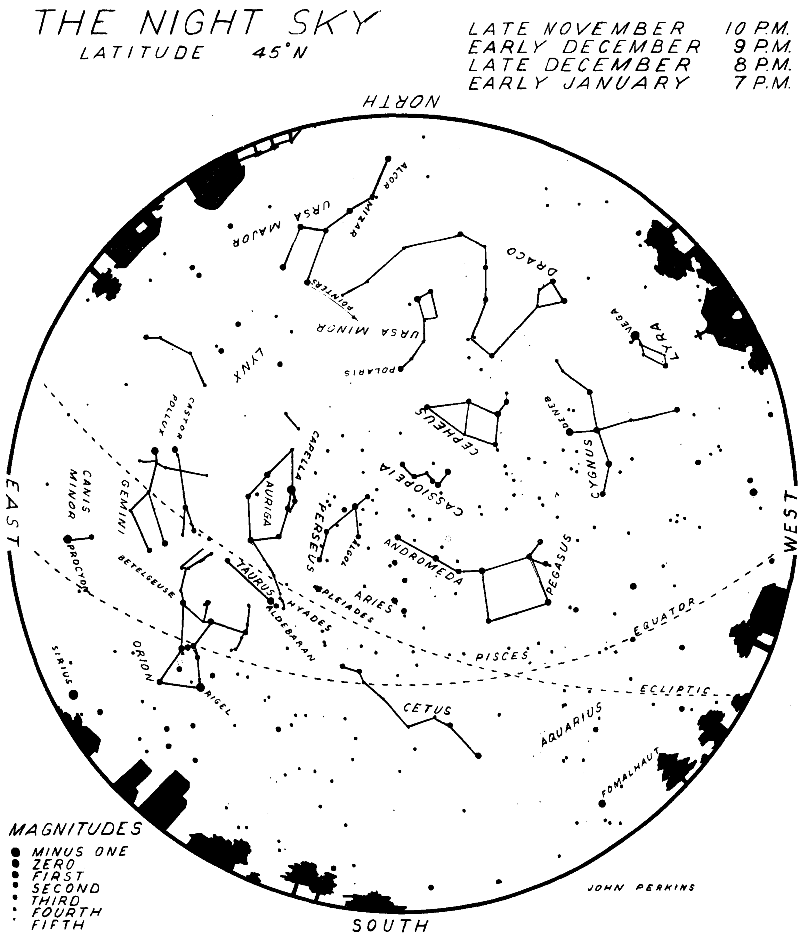
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late June at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late August at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

The centre of the map is the *zenith*, the point directly overhead; the circumference of the map 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 (north, for instance) is downward.

The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.

VISITING HOURS AT SOME CANADIAN OBSERVATORIES

COMPILED BY MARIE FIDLER

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.

Hume Cronyn Observatory, The University of Western Ontario, London, Ontario N6A 5B9.
An active program for individual visitors and groups is maintained throughout the year. For information, phone (519) 679-3186.

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.
Sunday, July and August only, 2:00–5:00 p.m.

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.

PLANETARIUMS

Calgary Centennial Planetarium, Mewata Park, P.O. Box 2100, Calgary, Alberta T2P 2M5.
For program information, telephone (403)264-4060.

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.

Dow Planetarium, 1000 St. Jacques Street W., Montreal, P.Q. H3C 1G7.
For general information telephone 872-4210. 24 hours recorded service telephone 872-4530.

H.R. MacMillan Planetarium, 1100 Chestnut Street, Vancouver, B.C. V6J 3J9.
Public shows daily except Mondays, 2:30 and 8:00 p.m.
For show information, telephone (604)736-3656. To contact staff, telephone (604)736-4431.

Manitoba Planetarium, 190 Rupert Avenue at Main Street, Winnipeg, Manitoba R3B 0N2.
Shows are presented Tuesdays through Sundays and 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 52-inch diameter image of the sun every clear day.

McLaughlin Planetarium, 100 Queen's Park, Toronto, Ontario M5S 2C6 (telephone (416)978-8550).
Tues.-Sun., 3:00 and 7:30 p.m.
Weekends and holidays, 12:30, 1:45, 3:00 and 7:30 p.m. (Theatre closed Mondays, except holidays.)

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McMaster University Planetarium, School of Adult Education, GH-122, Hamilton, Ontario L8S 4L8.
Group reservations only. Telephone (416)525-9140, ext. 4691.

Ontario Science Centre, 770 Don Mills Road, Don Mills, Ontario M3C 1T3.
Open daily except Christmas Day.

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.

Seneca College Planetarium, 1750 Finch Ave. East, Willowdale, Ont. M2N 5T7.
Group reservations only.

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April

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July

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August

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September

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October

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December

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