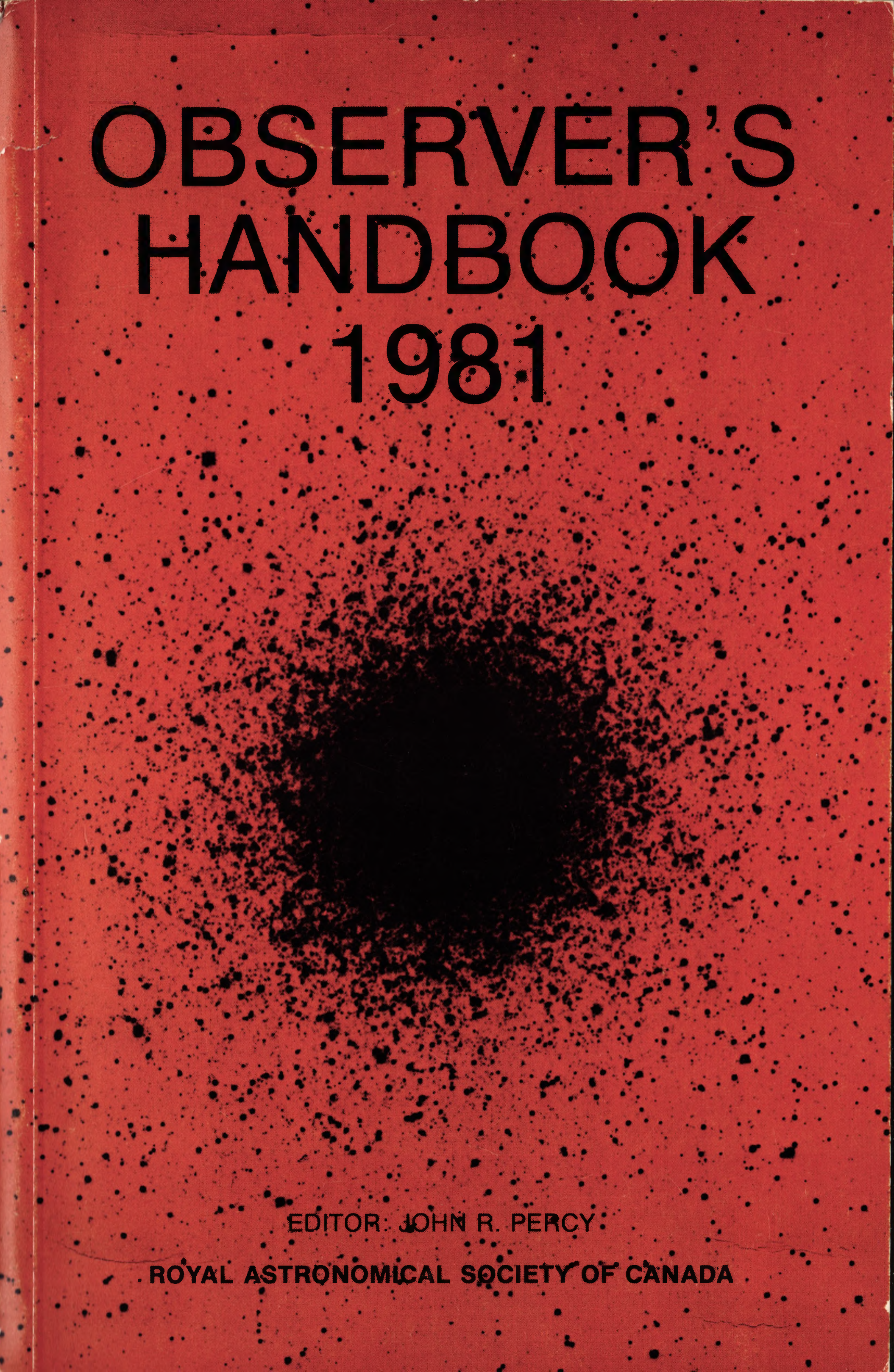
OBSERVER'S HANDBOOK 1981



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ROYAL ASTRONOMICAL SOCIETY OF CANADA

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QUICK INDEX

LOOKING BACKWARD AT THE OBSERVER'S HANDBOOK

The first volume of the OBSERVER'S HANDBOOK was that for 1907. Many of today's users of the HANDBOOK do not have easy access to that first issue so we will describe some of its purposes and contents.

The HANDBOOK was published by the Royal Astronomical Society of Canada just as it is now, but it was titled "The Canadian Astronomical Handbook". The editor was the remarkable Dr. C. A. Chant of the University of Toronto, then President of the Society. For precisely fifty years until his death in 1956, Chant edited both the HANDBOOK and the JOURNAL of the Society.

First printed in 1906, the HANDBOOK consisted of 108 pages and in format was smaller than now, one-half inch narrower and two inches shorter. Chant explains in the Preface that for a number of years astronomical annuals have been published in several foreign countries, designed chiefly for use of amateur observers, "and have been very effective in extending the interest in Astronomy. The present HANDBOOK aims to do a similar service for Canada." Chant further notes that "The Royal Astronomical Society of Canada aims to unite in a common bond of interest all such students of nature," that is, "those who have a profound interest in the celestial bodies above and in the natural phenomena about them." He hopes many "will add their names to the Society's roll of membership. Anyone interested in Astronomy, Astronomical Physics or allied subjects is eligible for membership"—a statement which still holds true.

The first HANDBOOK has basic tables which have appeared in the HANDBOOKS ever since. Sunrise and sunset tables are there, but moonrise and moonset are included in the same table. The values are given for every day of the year for five places in Canada from the Atlantic to the Pacific. "Satellites of the Solar System" was a simpler listing than now. Jupiter had only seven moons, with the last three discoveries still unnamed. Saturn had ten moons, Uranus four, and Neptune one which was nameless. The planet Pluto was unknown.

Readers were encouraged by J. Miller Barr of St. Catharine's, Ontario, to observe variable stars. In fact Barr's section on "The Study of Variable Stars" was so well written and informative that it was republished in its entirety in the April 1907 issue of *Popular Astronomy*, volume XV. The table of "New Stars" was relatively small, with 28 objects from the new star of 134 B.C. in Scorpio to that of 1905 in Aquila. Barr describes the famous "Pilgrim Star" of 1572 as the most striking instance of stellar variation on record. In November 1572 it rivalled Venus in brightness and was distinctly visible in the daytime.

A section entitled "The Most Beautiful Double Stars" lists them under two headings, "I, The Most Luminous Pairs, Diamonds" and "II, The Finest Coloured Pairs, Rubies, Garnets, Sapphires, Topazes, Emeralds". Mizar and Castor were in the first category, γ Andromedae and α Canum Venaticorum in the second.

The star maps were "borrowed from that valuable annual 'Knowledge Diary and Scientific Handbook'." The table of Meteor Showers was supplied by W. F. Denning of Bristol, England, still well known for his meteor studies. Instructions on observing sunspots were included in "Observing the Sun, Moon and Planets" by Andrew Elvins, one of the pioneers who started the Society in Toronto. Elvins also set down some philosophical reflections in a poem whose authorship is not given.

"The Planets
Are planets peopled like the Earth,
And do the people come by birth?
Do they resemble people here,
Or are they only half as queer?
When old do they renew their youth?
Does *falsehood* pass for more than *truth*?"

Dr. Chant earnestly requested that those who use the HANDBOOK send in any suggestions which may come to them regarding methods of improving it. This policy, followed throughout the intervening decades, has led to a greatly improved HANDBOOK. Especially in recent years Editor John Percy has made many agreeable changes and valuable additions.

HELEN SAWYER HOGG

THE OBSERVER'S HANDBOOK FOR 1981

THE OBSERVER'S HANDBOOK for 1981 is the seventy-third edition. On behalf of myself and the Royal Astronomical Society of Canada, I thank all those who have contributed to its production: the contributors listed on the inside front cover, and my editorial assistant Paul Ford.

Special thanks are due to Helen Sawyer Hogg for her unfailing interest and helpful comments. Ian McGregor kindly previewed the 1981 sky for me in the Star Theatre of the McLaughlin Planetarium. Alan Dyer provided the extensive new version of Messier's catalogue, as well as his list of the 110 finest NGC objects. Brian Marsden provided ephemerides of a score of bright asteroids, making the asteroids section considerably more complete and rational. Doug Welch drew the maps of the paths of Uranus, Neptune and Pluto. Terence Dickinson, David Dunham, Ken Hewitt-White and Walter Scott Houston provided valuable advice on a number of points.

As always, the R.A.S.C. National Council, the editor Lloyd Higgs, and the executive secretary Rosemary Freeman have given me their cheerful support and assistance. The HANDBOOK also benefits greatly from the direct and indirect support of the Department of Astronomy and Erindale College, University of Toronto.

The HANDBOOK is particularly indebted to H.M. Nautical Almanac Office (U.K. Science Research Council) and to the Nautical Almanac Office, (U.S. Naval Observatory). I am especially grateful to Leslie Morrison and the Occultation Section of H.M.N.A.O. for providing the wealth of information on total and grazing lunar occultations, and to LeRoy Doggett of the U.S. Naval Observatory for providing proof pages of the *American Ephemeris* in advance of its publication.

I hope the OBSERVER'S HANDBOOK serves you well. If you have comments or suggestions, let me know. Good observing!

JOHN R. PERCY, EDITOR

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 was described by Dr. Hogg in the 1980 edition. 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 great globular cluster 47 Tuc (NGC 104) photographed by W. E. Harris and R. Racine with the University of Toronto 24-inch telescope on Las Campanas in Chile. North is to the right.

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 1981

New Year's Day	Thur.	Jan. 1
Epiphany	Tues.	Jan. 6
Accession of Queen Elizabeth II (1952)	Fri.	Feb. 6
Lincoln's Birthday	Thur.	Feb. 12
Septuagesima Sunday		Feb. 15
Washington's Birthday	Mon.	Feb. 16
St. David	Sun.	Mar. 1
Quinquagesima (Shrove) Sunday		Mar. 1
Ash Wednesday		Mar. 4
St. Patrick	Tues.	Mar. 17
Palm Sunday		Apr. 12
Good Friday		Apr. 17
Easter Sunday		Apr. 19
First Day of Passover	Sun.	Apr. 19
Birthday of Queen Elizabeth II (1926)	Tues.	Apr. 21
St. George	Thur.	Apr. 23
Victoria Day	Mon.	May 18
Rogation Sunday		May 24
Memorial Day	Mon.	May 25
Ascension Day	Thur.	May 28
Pentecost (Whit Sunday)		June 7
Trinity Sunday		June 14
Corpus Christi	Thur.	June 18
St. John Baptist	Wed.	June 24
Canada Day	Wed.	July 1
First Day of Ramadan	Fri.	July 3
Independence Day	Sat.	July 4
Civic Holiday	Mon.	Aug. 3
Labour Day	Mon.	Sept. 7
St. Michael (Michaelmas Day)	Tues.	Sept. 29
Rosh Hashanah	Tues.	Sept. 29
Yom Kippur	Thur.	Oct. 8
Thanksgiving (Can.)	Mon.	Oct. 12
Columbus Day	Mon.	Oct. 12
Islamic New Year	Fri.	Oct. 30
All Saints' Day	Sun.	Nov. 1
Election Day	Tues.	Nov. 3
Remembrance Day	Wed.	Nov. 11
Veterans' Day	Wed.	Nov. 11
Thanksgiving (U.S.)	Thur.	Nov. 26
First Sunday in Advent		Nov. 29
St. Andrew	Mon.	Nov. 30
Christmas	Fri.	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) A. U.	Mean Distance from Sun (a) millions of km	Period of Revolution Sidereal (P)	Period of Revolution Synodic	Eccentricity (e)	Inclination (i)	Long. of Node (☊)	Long. of Perihelion (π)	Mean Long. at Epoch (L)
				days		°	°	°	°
Mercury	0.387	57.9	88.0d.	116	.206	7.0	47.9	76.8	222.6
Venus	0.723	108.1	224.7	584	.007	3.4	76.3	131.0	174.3
Earth	1.000	149.5	365.26	. . .	.017	0.0	0.0	102.3	100.2
Mars	1.524	227.8	687.0	780	.093	1.8	49.2	335.3	258.8
Jupiter	5.203	778.	11.86y.	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		Revolution Period			Orbit Incl. °	Discovery
			km/1000	arc sec	d	h	m		
SATELLITE OF THE EARTH									
Moon	−12.7	3476	384.5	—	27	07	43	18–29	
SATELLITES OF MARS									
I Phobos	11.6	23	9.4	25	0	07	39	1.1	A. Hall, 1877
II Deimos	12.7	13	23.5	63	1	06	18	1.8v	A. Hall, 1877
SATELLITES OF JUPITER									
XIV 1979J1	17.6	(40)	128	42	0	07	04	—	D. Jewitt, 1979
V Amalthea	14.1	170	180	59	0	11	57	0.4	E. Barnard, 1892
XV 1979J2	16.1	(80)	223	73	0	16	16	—	S. Synnott, 1979
I Io	5.0	3630	422	138	1	18	28	0	Galileo, 1610
II Europa	5.3	3140	671	220	3	13	14	0.5	Galileo, 1610
III Ganymede	4.6	5260	1,070	351	7	03	43	0.2	Galileo, 1610
IV Callisto	5.6	4800	1,885	618	16	16	32	0.2	Galileo, 1610
XIII Leda	20	(10)	11,110	3640	240			26.7	C. Kowal, 1974
VI Himalia	14.7	170	11,470	3760	251			27.6	C. Perrine, 1904
X Lysithea	18.4	(20)	11,710	3840	260			29.0	S. Nicholson, 1938
VII Elara	16.4	80	11,740	3850	260			24.8	C. Perrine, 1905
XII Ananke	18.9	(20)	20,700	6790	617			147	S. Nicholson, 1951
XI Carme	18.0	(30)	22,350	7330	692			164	S. Nicholson, 1938
VIII Pasiphae	17.7	(40)	23,330	7650	735			145	P. Melotte, 1908
IX Sinope	18.3	(30)	23,370	7660	758			153	S. Nicholson, 1914
SATELLITES OF SATURN									
XI 1966S2	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	17	1300	20.0	0.8	6	09	17	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.

*Probably the same as 1966 S2.

**At least one other satellite has been reported in the same orbit, near the preceding Lagrangian point. (Disc., B. Smith, 1980).

MISCELLANEOUS ASTRONOMICAL DATA

UNITS OF LENGTH

1 Angstrom unit = 10^{-8} cm
1 inch = exactly 2.54 centimetres
1 yard = exactly 0.9144 metre
1 mile = exactly 1.609344 kilometres
1 astronomical unit = 1.49597870×10^{8} km = 9.2956×10^{7} mi
1 light-year = 9.461×10^{12} km = 5.88×10^{12} mi = 0.3068 parsecs
1 parsec = 3.086×10^{13} km = 1.917×10^{13} mi = 3.262 l.y.
1 megaparsec = 10^{6} parsecs

1 micrometre, μ = 10^{-4} cm = 10^{4}A.
1 cm = 10 mm = 0.39370 . . . in
1 m = 10^{2} cm = 1.0936 . . . . yd
1 km = 10^{5} cm = 0.62137 . . . mi

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* = $29^{d}5306$
Tropical year (ordinary) = 365*d* 05*h* 48*m* 46*s* = $365^{d}2422$
Sidereal year = 365*d* 06*h* 09*m* 10*s* = $365^{d}2564$
Eclipse year = 346*d* 14*h* 52*m* 52*s* = $346^{d}6200$

Sidereal month = 27*d* 07*h* 43*m* 12*s*
= $27^{d}3216$

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 = 5.976×10^{24} kg = 13.17×10^{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) ~ 2.46×10^{8} years
Mass ~ 1.4×10^{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 = 5.66956×10^{-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 = 1.6727×10^{-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
= 3437'.75
= 206,265''

π = 3.141,592,653,6
No. of square degrees in the sky = 41,253
1 gram = 0.03527 oz

SUN—EPHEMERIS AND CORRECTION TO SUN-DIAL

Date	Apparent R.A. 0h E.T.			Apparent Dec. 0h E.T.		Corr. to Sun-dial 12h E.T.	
	h	m	s	°	′	m	s
Jan. 1	18	45	38	−23	01.5	+ 3	38
4	18	58	51	−22	45.0	+ 5	02
7	19	12	01	−22	24.5	+ 6	21
10	19	25	07	−22	00.0	+ 7	37
13	19	38	07	−21	31.6	+ 8	46
16	19	51	02	−20	59.4	+ 9	50
19	20	03	51	−20	23.7	+10	48
22	20	16	32	−19	44.5	+11	39
25	20	29	07	−19	02.0	+12	23
28	20	41	35	−18	16.4	+13	00
31	20	53	56	−17	27.8	+13	30
Feb. 3	21	06	09	−16	36.4	+13	53
6	21	18	16	−15	42.4	+14	08
9	21	30	15	−14	46.0	+14	16
12	21	42	06	−13	47.3	+14	17
15	21	53	51	−12	46.7	+14	11
18	22	05	29	−11	44.1	+13	58
21	22	17	01	−10	39.9	+13	39
24	22	28	27	− 9	34.3	+13	15
27	22	39	48	− 8	27.3	+12	45
Mar. 2	22	51	04	− 7	19.2	+12	12
5	23	02	16	− 6	10.1	+11	32
8	23	13	23	− 5	00.3	+10	50
11	23	24	28	− 3	49.9	+10	04
14	23	35	29	− 2	39.0	+ 9	15
17	23	46	28	− 1	28.0	+ 8	24
20	23	57	25	− 0	16.8	+ 7	30
23	0	08	20	+ 0	54.2	+ 6	36
26	0	19	15	+ 2	05.0	+ 5	42
29	0	30	10	+ 3	15.4	+ 4	47
Apr. 1	0	41	06	+ 4	25.3	+ 3	53
4	0	52	02	+ 5	34.5	+ 3	00
7	1	03	00	+ 6	42.7	+ 2	09
10	1	14	00	+ 7	50.0	+ 1	19
13	1	25	02	+ 8	56.0	+ 0	32
16	1	36	07	+10	00.7	− 0	12
19	1	47	15	+11	03.9	− 0	53
22	1	58	26	+12	05.5	− 1	31
25	2	09	42	+13	05.3	− 2	04
28	2	21	02	+14	03.1	− 2	33
May 1	2	32	27	+14	58.9	− 2	57
4	2	43	57	+15	52.4	− 3	16
7	2	55	32	+16	43.6	− 3	30
10	3	07	11	+17	32.3	− 3	39
13	3	18	56	+18	18.4	− 3	43
16	3	30	46	+19	01.6	− 3	42
19	3	42	40	+19	42.0	− 3	36
22	3	54	40	+20	19.3	− 3	26
25	4	06	45	+20	53.5	− 3	10
28	4	18	54	+21	24.5	− 2	50
31	4	31	07	+21	52.1	− 2	25
June 3	4	43	25	+22	16.4	− 1	57
6	4	55	45	+22	37.1	− 1	25
9	5	08	09	+22	54.3	− 0	51
12	5	20	34	+23	07.9	− 0	15
15	5	33	01	+23	17.7	+ 0	22
18	5	45	29	+23	23.9	+ 1	01
21	5	57	58	+23	26.4	+ 1	40
24	6	10	26	+23	25.1	+ 2	18
27	6	22	54	+23	20.1	+ 2	56
30	6	35	21	+23	11.5	+ 3	33
July 3	6	47	45	+22	59.2	+ 4	08
6	7	00	07	+22	43.3	+ 4	39
9	7	12	26	+22	23.8	+ 5	08
12	7	24	41	+22	00.9	+ 5	32
15	7	36	51	+21	34.5	+ 5	52
18	7	48	57	+21	04.9	+ 6	08
21	8	00	59	+20	32.0	+ 6	19
24	8	12	55	+19	56.1	+ 6	25
27	8	24	46	+19	17.1	+ 6	25
30	8	36	32	+18	35.3	+ 6	21
Aug. 2	8	48	13	+17	50.7	+ 6	11
5	8	59	48	+17	03.5	+ 5	55
8	9	11	18	+16	13.9	+ 5	34
11	9	22	42	+15	21.8	+ 5	08
14	9	34	01	+14	27.6	+ 4	37
17	9	45	15	+13	31.3	+ 4	00
20	9	56	24	+12	33.1	+ 3	19
23	10	07	29	+11	33.1	+ 2	34
26	10	18	31	+10	31.5	+ 1	45
29	10	29	29	+ 9	28.3	+ 0	53
Sept. 1	10	40	24	+ 8	23.7	− 0	02
4	10	51	16	+ 7	18.0	− 1	00
7	11	02	06	+ 6	11.2	− 2	01
10	11	12	53	+ 5	03.5	− 3	03
13	11	23	40	+ 3	55.0	− 4	06
16	11	34	25	+ 2	45.9	− 5	10
19	11	45	11	+ 1	36.3	− 6	14
22	11	55	57	+ 0	26.4	− 7	18
25	12	06	44	− 0	43.7	− 8	20
28	12	17	32	− 1	53.9	− 9	21
Oct. 1	12	28	23	− 3	03.9	−10	20
4	12	39	15	− 4	13.6	−11	16
7	12	50	11	− 5	22.9	−12	10
10	13	01	11	− 6	31.5	−12	59
13	13	12	14	− 7	39.3	−13	45
16	13	23	22	− 8	46.2	−14	26
19	13	34	35	− 9	52.0	−15	01
22	13	45	54	−10	56.4	−15	31
25	13	57	20	−11	59.5	−15	54
28	14	08	51	−13	00.9	−16	11
31	14	20	30	−14	00.4	−16	21
Nov. 3	14	32	15	−14	58.0	−16	24
6	14	44	08	−15	53.3	−16	20
9	14	56	08	−16	46.3	−16	09
12	15	08	15	−17	36.7	−15	50
15	15	20	30	−18	24.3	−15	23
18	15	32	53	−19	09.1	−14	49
21	15	45	23	−19	50.7	−14	07
24	15	58	01	−20	29.1	−13	17
27	16	10	46	−21	04.2	−12	21
30	16	23	38	−21	35.6	−11	18
Dec. 3	16	36	35	−22	03.4	−10	10
6	16	49	37	−22	27.3	− 8	56
9	17	02	45	−22	47.3	− 7	38
12	17	15	56	−23	03.2	− 6	15
15	17	29	10	−23	15.1	− 4	50
18	17	42	27	−23	22.7	− 3	22
21	17	55	46	−23	26.2	− 1	53
24	18	09	06	−23	25.4	− 0	23
27	18	22	25	−23	20.4	+ 1	06
30	18	35	43	−23	11.2	+ 2	34

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. See also the table on p. 11.

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

To avoid the inconveniences to travellers of a changing local time, *standard time* is used. The earth is divided into 24 zones, each ideally 15 degrees wide, the zero zone being centered on the Greenwich meridian. All clocks within the same zone will read the same time. See map on p. 11.

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 1981 will be about 52 seconds.

RADIO TIME SIGNALS

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

Radio time signals readily available in Canada include:

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

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

SIDEREAL TIME 1981

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

Jan. 0 $06^{h}38^{m}.3$	Apr. 0 $12^{h}33^{m}.1$	July 0 $18^{h}31^{m}.9$	Oct. 0 $00^{h}34^{m}.6$
Feb. 0 08 40.5	May 0 14 31.4	Aug. 0 20 34.1	Nov. 0 02 36.8
Mar. 0 10 30.9	June 0 16 33.6	Sept. 0 22 36.3	Dec. 0 04 35.1

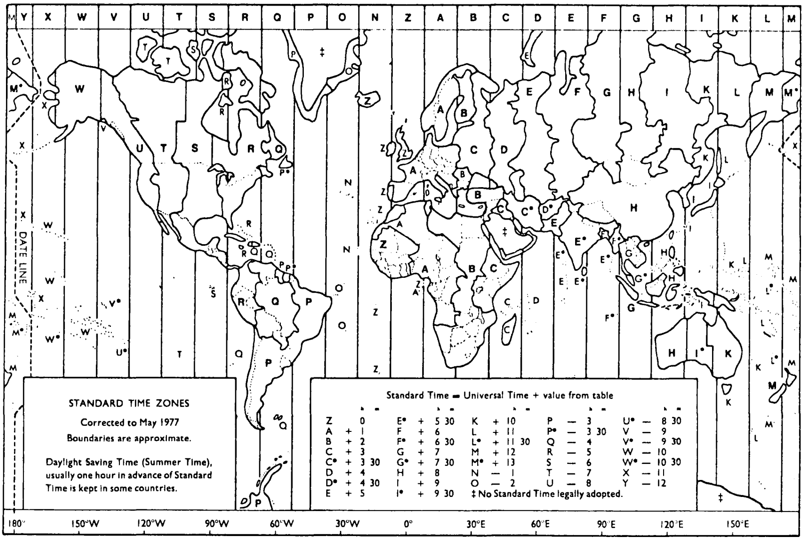
GST at hour t U.T. on day d of the month

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

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

WORLD MAP OF TIME ZONES

Taken from *Astronomical Phenomena for the Year* 1981 (Washington: U.S. Government Printing Office and London: Her Majesty's Stationery Office)



STANDARD TIME ZONES

Corrected to May 1977

Boundaries are approximate.

Daylight Saving Time (Summer Time), usually one hour in advance of Standard Time is kept in some countries.

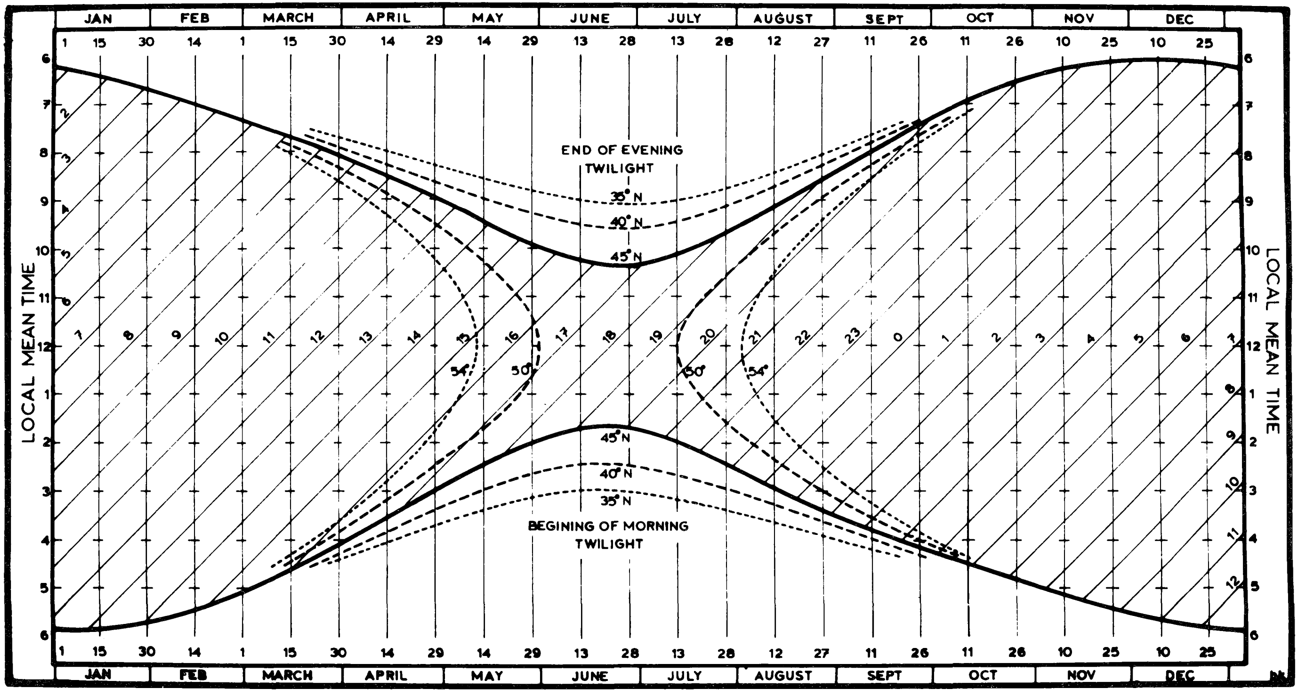
Standard Time = Universal Time + value from table

		h	m			h	m			h	m			h	m			h	m
Z		0		E•	+	5	30	K	+	10		P	−	3		U•	−	8	30
A	+	1		F	+	6		L	+	11		P•	−	3	30	V	−	9	
B	+	2		F•	+	6	30	L•	+	11	30	Q	−	4		V•	−	9	30
C	+	3		G	+	7		M	+	12		R	−	5		W	−	10	
C•	+	3	30	G•	+	7	30	M•	+	13		S	−	6		W•	−	10	30
D	+	4		H	+	8		N	−	1		T	−	7		X	−	11	
D•	+	4	30	I	+	9		O	−	2		U	−	8		Y	−	12	
E	+	5		I•	+	9	30												

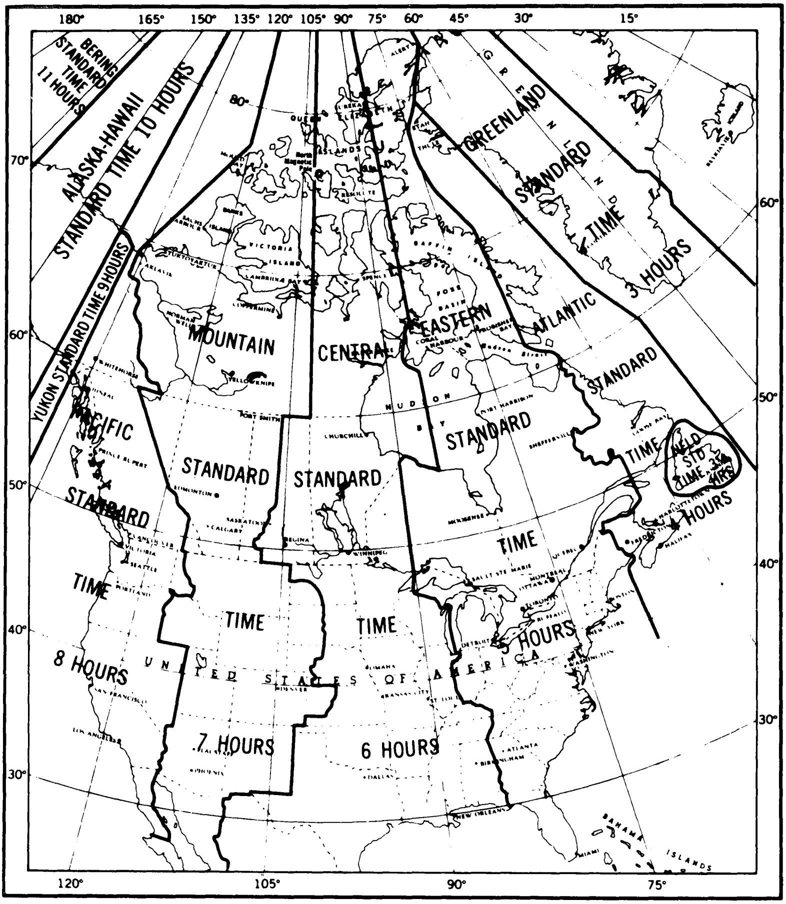
‡ No Standard Time legally adopted.

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).

It is possible to extrapolate these tables northward and southward a few degrees (but not more) without significant loss of accuracy.

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).

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

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

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

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

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

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

TWILIGHT—BEGINNING OF MORNING AND ENDING OF EVENING

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

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).

MOONRISE AND MOONSET, 1981 — LOCAL MEAN TIME

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

The symbols (.. ..) indicate that the phenomenon will occur the next day.

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

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

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

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

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

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 ½° per hour; it is approximately 270°, 0°, 90° and 180° at New Moon, First Quarter, Full Moon and Last Quarter respectively. Values of the sun's selenographic colongitude are given on the following pages for the first day of each month.

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

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

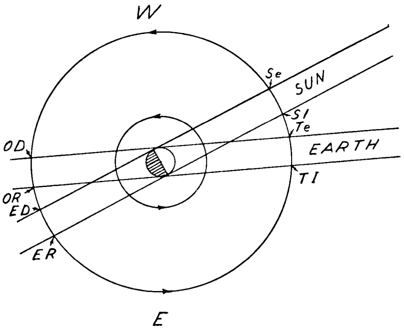
The dates of the greatest positive and negative values of the libration in longitude and latitude are given in the following pages.

The Moon's Orbit. In 1981, the ascending node of the moon's orbit regresses from longitude 132.5° to 114° (Cancer into Gemini).

The Planets—Further information in regard to the planets, including Pluto, is found on pp. 78–91. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 92.

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. 92) 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. 58–77.

THE SKY FOR JANUARY 1981

Observing Meteors. This year, the Quadrantid meteor shower occurs near new moon, and it could well be the most favourable shower of the year. The Perseids, which occurred near new moon in 1980, occur near full moon in 1981.

Two good articles on meteor observing appeared in 1980, both by Mark T. Adams: in *Mercury*, **9**, 31 (March/April 1980) and in *Star and Sky*, **2**, 42 (August 1980). These articles emphasize the enjoyment and simplicity of meteor observing: no elaborate equipment is needed. The following articles are helpful, however; dark-adapted eyes, deck chair or ground sheet, flashlight with red filter, reliable timepiece, short wave radio for monitoring time signals, notebook or tape recorder, and a working knowledge of the constellations.

Good records are essential. Each night's record should include: observer's name and location, date, starting and ending times of observations, record of sky conditions and anything affecting them, and an estimate of the magnitude of the faintest stars visible at the zenith.

Visual observations are particularly useful for monitoring the activity and characteristics of meteor streams, both major and minor, from year to year. Serious meteor observers might wish to join the *American Meteor Society*, c/o Dr. D. Meisel, Dept. of Physics and Astronomy, SUNY, Geneseo, NY 14454, U.S.A.

The Sun—During January, the sun's R.A. increases from 18 h 46 m to 20 h 58 m and its Decl. changes from −23°02′ to −17°11′. The equation of time changes from −3 m 44 s to −13 m 32 s. The earth is at perihelion on Jan. 1 (E.S.T.), at a distance of 147,102,400 km (91,405,000 mi) from the sun.

The Moon—On Jan. 1.0 E.S.T., the age of the moon is 24.2 d. The sun's selenographic colongitude is 212.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 21 (5°) and minimum (east limb exposed) on Jan. 7 (5°). The libration in latitude is maximum (north limb exposed) on Jan. 14 (7°) and minimum (south limb exposed) on Jan. 28 (7°). There is a penumbral eclipse of the moon on the night of Jan. 19–20, visible in North America.

Mercury on the 1st is in R.A. 18 h 48 m, Decl. −24°47′, and on the 15th is in R.A. 20 h 27 m, Decl. −21°16′. Early in the month, it is too close to the sun (superior conjunction having been on Dec. 31), but by the end of the month, it can be seen low in the south-west after sunset (see "February"). On Jan. 23, it is 0.3° S. of Mars.

Venus on the 1st is in R.A. 17 h 04 m, Decl. −21°58′, and on the 15th it is in R.A. 18 h 20 m, Decl. −23°06′, mag. −3.3, and transits at 10 h 44 m. It rises shortly before the sun, and is very low in the south-east just before sunrise. On Jan. 5, it is 0.6° S. of Neptune.

Mars on the 15th is in R.A. 20 h 59 m, Decl. −18°18′, mag. +1.4, and transits at 13 h 20 m. In Capricorn, it is very low in the south-west at sunset, and sets shortly after. See also "Mercury" above.

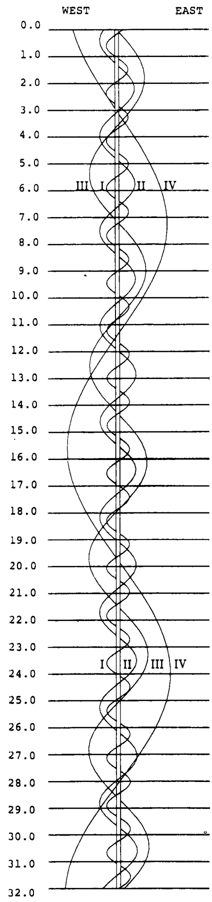
Jupiter on the 15th is in R.A. 12 h 40 m, Decl. −2°48′, mag. −1.7, and transits at 5 h 01 m. In Virgo, it rises shortly before midnight, and is in the south-west at sunrise. In the middle of the month, it passes 1.1° south of Saturn (which is fainter) which in turn is only a fraction of a degree south of the famous double star γ Vir (which is fainter still).

Saturn on the 15th is in R.A. 12 h 40 m, Decl. −1°39′, mag. +1.0, and transits at 5 h 01 m. In Virgo, it rises shortly before midnight, and is in the south-west at sunrise. See also "Jupiter" above.

Uranus on the 15th is in R.A. 15 h 48 m, Decl. −19°44′, mag. +6.0, and transits at 8 h 08 m. It is in Libra until early December.

Neptune on the 15th is in R.A. 17 h 32 m, Dec. −21°59′, mag. +7.8, and transits at 9 h 53 m. It is in Ophiuchus throughout the year. See also "Venus" above. On Jan. 29–30, it passes near 52 Oph.

ASTRONOMICAL PHENOMENA MONTH BY MONTH

1981				JANUARY E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Thur.	1	21		Earth at perihelion	16	50	
Fri.	2	06		Uranus 5°S. of Moon			
Sat.	3	09		Quadrantid Meteors			
Sun.	4	04		Venus 3°S. of Moon	13	40	
		07		Neptune 3° S. of Moon			
Mon.	5	17		Venus 0°6 S. of Neptune			
Tues.	6	02	24	● New Moon			
Wed.	7			Mars at greatest hel. lat. S.	10	30	
		16		Mars 1°6 S. of Moon			
Thur.	8						
Fri.	9						
Sat.	10	17		Ceres at opposition	7	20	
Sun.	11	19		Vesta stationary			
Mon.	12			Mercury at greatest hel. lat. S.			
Tues.	13	05	10	☽ First Quarter	4	10	
Wed.	14	03		Jupiter 1°1 S. of Saturn			
		23		Moon at perigee (369,625 km)			
Thur.	15						
Fri.	16	12		Aldebaran 0°9 S. of Moon. Occ'n[1]	1	00	
Sat.	17						
Sun.	18				21	50	
Mon.	19	15		Saturn stationary			
Tues.	20	02	39	○ Full Moon, Eclipse of ☾, pg. 55			
Wed.	21			Venus at descending node	18	40	
Thur.	22						
Fri.	23	17		Mercury 0°3 S. of Mars			
Sat.	24				15	30	
Sun.	25	05		Jupiter stationary			
		12		Saturn 2° S. of Moon			
		13		Jupiter 3° S. of Moon			
Mon.	26						
Tues.	27	15		Moon at apogee (404, 394 km)	12	20	
		23	19	☾ Last Quarter			
Wed.	28						
Thur.	29	16		Uranus 5°S. of Moon			
Fri.	30				9	10	
Sat.	31			Mercury at ascending node			
		18		Neptune 3° S. of Moon			

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

Observing Asteroids. This is a good month to observe asteroids. Ceres and Vesta are bright and well-placed, and several other asteroids are within the grasp of a small telescope. (See tables and maps in the "Asteroids" section). The bright asteroids can be seen visually, using binoculars or a small telescope. Fainter asteroids can best be seen photographically. The asteroid can be identified by its position on a map, by its absence on a star chart, or by its motion against the background stars.

Many asteroids are irregular in shape. As a result, they vary in brightness as they present varying surface areas to the sun and to the earth. In many cases, the variation in brightness can be detected visually. In other cases, it can only be detected by accurate photoelectric techniques (which are quite within the scope of the serious amateur observer).

Another interesting and useful activity is observing occultations of stars by asteroids. Coordinated observations of this kind can help to determine the shape, size and orbit of the asteroid, and the position and possible duplicity of the star.

Serious asteroid observers may wish to subscribe to *Tonight's Asteroids*, a bimonthly newsletter with interesting facts and high quality tracking charts for currently observable asteroids. This publication is available for a modest price from Jay Gunter, 1411 N. Magnum Street, Durham, North Carolina 27701, U.S.A.

The Sun—During February, the sun's R.A. increases from 20 h 58 m to 22 h 47 m and its Decl. changes from −17°11′ to −7°42′. The equation of time changes from −13 m 40 s to −12 m 32 s. There is an annular eclipse of the sun on Feb. 4.

The Moon—On Feb. 1.0 E.S.T., the age of the moon is 25.5 d. The sun's selenographic colongitude is 229.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 16 (5°) and minimum (east limb exposed) on Feb. 3 (5°). The libration in latitude is maximum (north limb exposed) on Feb. 10 (7°) and minimum (south limb exposed) on Feb. 24 (7°). There is an occultation of Aldebaran by the moon on Feb. 12, visible (in daylight hours) over much of North America. The graze path cuts the continent almost exactly in two.

Mercury on the 1st is in R.A. 22 h 09 m, Decl. −11°16′, and on the 15th is in R.A. 22 h 09 m, Decl. −7°41′. It is at greatest elongation east (18°) on Feb. 1, at which time it is visible low in the south-west just after sunset. By mid-month it is in inferior conjunction, after which it emerges into the dawn sky. By the end of the month it is visible very low in the south-east at sunrise.

Venus on the 1st is in R.A. 19 h 52 m, Decl. −21°25′, and on the 15th it is in R.A. 21 h 05 m, Decl. −17°42′, mag. −3.4, and transits at 11 h 26 m. Early in the month, it can be seen with great difficulty very low in the south-east before sunrise. By the end of the month, it is too close to the sun to be seen.

Mars on the 15th is in R.A. 22 h 34 m, Decl. −10°06′, mag. +1.4, and transits at 12 h 53 m. Early in the month it can be seen with great difficulty very low in the south-west just after sunset. By the end of the month, it is too close to the sun to be seen.

Jupiter on the 15th is in R.A. 12 h 38 m, Decl. −2°27′, mag. −1.9, and transits at 2 h 57 m. In Virgo, it rises about 3 hours after sunset, and is in the south-west at sunrise. Again it passes 1.1° south of Saturn in mid-month, but this time in retrograde motion. Again, γ Vir is part of the scene. (see "January").

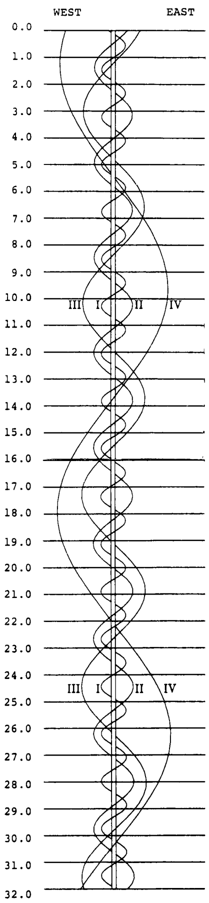
Saturn on the 15th is in R.A. 12 h 38 m, Decl. −1° 16′, mag. +0.8, and transits at 2 h 57 m. In Virgo, it rises about 3 hours after sunset, and is in the south-west at sunrise. See also "Jupiter" above.

Uranus on the 15th is in R.A. 15 h 51 m, Decl. −19°55′, mag. +5.9, and transits at 6 h 10 m.

Neptune on the 15th is in R.A. 17 h 36 m, Decl. 22°01′, mag. +7.8, and transits at 7 h 54 m.

1981				FEBRUARY E.S.T.	Min. of Algol	
	d	h	m		h	m
Sun.	1	20		Mercury at greatest elong. E. (18°)		
		20		Pluto stationary		
Mon.	2			Mars at perihelion	6	00
Tues.	3	12		Venus 1°.6 S. of Moon		
Wed.	4	17	14	● New Moon, Eclipse of ☉, pg. 55		
Thur.	5			Mercury at perihelion	2	40
		15		Mars 0°.6 S. of Moon. Occ'n[1]		
		23		Mercury 4°N. of Moon		
Fri.	6					
Sat.	7	17		Mercury stationary	23	30
Sun.	8	18		Moon at perigee (368,224 km)		
Mon.	9					
Tues.	10	13		Mercury 4° N. of Mars	20	20
Wed.	11	12	49	☽ First Quarter		
Thur.	12	17		Aldebaran 0°.9 S. of Moon. Occ'n[2]		
Fri.	13				17	10
Sat.	14					
Sun.	15			Mercury at greatest hel. lat. N.		
Mon.	16				14	00
Tues.	17	06		Mercury in inferior conjunction		
Wed.	18	17	58	○ Full Moon		
Thur.	19	02		Jupiter 1°.1 S. of Saturn	10	50
Fri.	20					
Sat.	21	18		Vesta at opposition		
		19		Jupiter 3° S. of Moon		
		19		Saturn 2° S. of Moon		
		20		Mercury 5° N. of Venus		
Sun.	22				7	40
Mon.	23					
Tues.	24			Venus at aphelion		
		12		Moon at apogee (404,845 km)		
Wed.	25				4	30
Thur.	26	02		Uranus 5° S. of Moon		
		20	14	☾ Last Quarter		
Fri.	27	02		Ceres stationary		
Sat.	28	00		Juno stationary	1	20
		04		Neptune 2° S. of Moon		

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



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[1] Visible in New Zealand, S. Pacific, Antarctic, S. America.

[2] Visible in N. America, Greenland, Arctic, N.W. Europe; see "Occultations" section for specific times and circumstances.

THE SKY FOR MARCH 1981

Observing Light Pollution. Light pollution, or "waste lighting" is light which was meant to illuminate streets and buildings but which illuminates the sky instead. It is a hindrance to virtually all astronomical observations, and is a waste of energy as well.

Two interesting articles on light pollution have recently appeared: by Norman Sperling in *Sky and Telescope*, **60**, 17 (July, 1980) and by Leo Henzl in *Star and Sky*, **2**, 58 (August, 1980). Sperling's article reviews the accomplishments of amateur groups in combatting light pollution, and suggests some strategies: "The struggle against light pollution is most successful when the objectors have direct personal access to an influential public official, or, more often, when the objections address economics, conservation, the environment, and realities of crime fighting.... Unfortunately, astronomical points are not well appreciated by public officials unless a major professional observatory is significant to the community's economy or pride." Henzl's article deals with the nature of light pollution, the poor design of street lighting, and some solutions to the problem—reflective shields, fewer lights, and fewer hours of lighting each light.

Light pollution can have its aesthetic pleasures, though. In *Sky and Telescope*, **50**, 155 (Sept., 1975), James Cuffey describes how you can photograph city lights through a transmission diffraction grating using a 35mm camera and colour film. The spectrum of each light is strung out above the light, providing a colourful "second dimension" to the city skyline.

The Sun—During March, the sun's R.A. increases from 22 h 47 m to 0 h 41 m and its Decl. changes from −7°42′ to +4°25′. The equation of time changes from −12 m 20 s to −4 m 7 s. The sun reaches the vernal equinox on Mar. 20, 12 h 03 m E.S.T., and spring begins in the northern hemisphere.

The Moon—On Mar. 1.0 E.S.T., the age of the moon is 23.9 d. The sun's selenographic colongitude is 210.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Mar. 15 (6°) and minimum (east limb exposed) on Mar. 2 (7°) and Mar. 30 (7°). The libration in latitude is maximum (north limb exposed) on Mar. 9 (7°) and minimum (south limb exposed) on Mar. 23 (7°).

Mercury on the 1st is in R.A. 21 h 27 m, Decl. −12°48′, and on the 15th is in R.A. 21 h 57 m, Decl. −13°18′. Throughout the month, it can be seen, with great difficulty, very low in the south-east just before sunrise. Greatest elongation west (28°) occurs on Mar. 15, but despite the greater-than-average elongation, the orientation is very unfavourable for northern observers.

Venus on the 1st is in R.A. 22 h 14 m, Decl. −12°21′, and on the 15th it is in R.A. 23 h 20 m, Decl. −5°55′, mag. −3.4, and transits at 11 h 50 m. It is too close to the sun to be seen.

Mars on the 15th is in R.A. 23 h 55 m, Decl. −1°24′, mag. +1.3, and transits at 12 h 24 m. It is too close to the sun to be seen.

Jupiter on the 15th is in R.A. 12 h 28 m, Decl. −1°18′, mag. −2.0, and transits at 0 h 57 m. In Virgo, it rises shortly before sunset and sets at about sunrise. Jupiter and Saturn are still only a few degrees apart. Opposition occurs on Mar. 26.

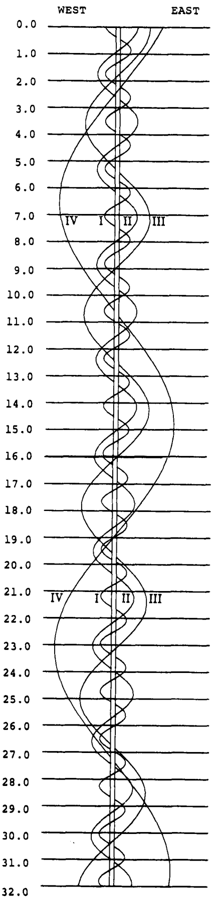
Saturn on the 15th is in R.A. 12 h 31 m, Decl. −0°30′, mag. +0.7, and transits at 1 h 00 m. In Virgo, it rises shortly before sunset and sets at about sunrise. Opposition occurs on Mar. 27. See also "Jupiter" above.

Uranus on the 15th is in R.A. 15 h 52 m, Decl. −19°57′, mag. + 5.9, and transits at 4 h 20 m.

Neptune on the 15th is in R.A. 17 h 38 m, Decl. −22°01′, mag. +7.8, and transits at 6 h 06 m.

1981				MARCH E.S.T.	Min. of Algol	
	d	h	m		h	m
Sun.	1	10		Mercury stationary		
Mon.	2				22	10
Tues.	3					
Wed.	4	09		Mercury 2° N. of Moon		
		21		Uranus stationary		
Thur.	5				19	00
Fri.	6	05	31	● New Moon		
Sat.	7					
Sun.	8	07		Moon at perigee (362,698 km)	15	50
Mon.	9					
Tues.	10			Mercury at descending node		
Wed.	11	23		Aldebaran 1°0 S. of Moon. Occ'n[1]	12	40
Thur.	12	20	50	☽ First Quarter		
Fri.	13					
Sat.	14				9	30
Sun.	15	20		Mercury at greatest elong. W. (28°)		
Mon.	16					
Tues.	17				6	10
Wed.	18			Venus at greatest hel. lat. S.		
Thur.	19					
Fri.	20	10	22	○ Full Moon	3	00
		12	03	Vernal Equinox. Spring begins.		
		20		Jupiter 3° S. of Moon		
		23		Saturn 1°7 S. of Moon		
Sat.	21			Mercury at aphelion		
Sun.	22				23	50
Mon.	23					
Tues.	24	04		Moon at apogee (405,719 km)		
Wed.	25	09		Uranus 5° S. of Moon	20	40
Thur.	26	01		Jupiter at opposition		
Fri.	27	00		Saturn at opposition		
		02		Neptune stationary		
		13		Neptune 2° S. of Moon		
Sat.	28	14	34	☾ Last Quarter	17	30
Sun.	29					
Mon.	30					
Tues.	31				14	20

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



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

THE SKY FOR APRIL 1981

Focus on Virgo. Jupiter and Saturn are in Virgo throughout 1981, and will be joined there by Mars at the end of the year.

Virgo is a constellation which is dominated by its brightest star, namely Spica. There is an easy way to find Spica, starting at the Big Dipper. Follow the arc of the handle of the Big Dipper to the orange star Arcturus ("arc to Arcturus"). Then continue past Arcturus to Spica ("Spike to Spica"). Of course, with so many bright planets in Virgo, it won't be hard to find the constellation. The problem will be keeping track of which planet or star is which. The map in "The Planets" section should help.

Spica is one of the most noteworthy and well-studied stars in the sky. It is actually a pair of stars, of comparable size and brightness, circling each other in a close 4 day orbit. Its distance has been accurately measured using a unique telescope: the *intensity interferometer* developed by Hanbury-Brown and Twiss in Australia. The stars are each about 10 times as massive as the sun, 5 times as large, and 1000 times as luminous. The brighter of the two is slightly variable in brightness, partly because of tidal distortion by its companion, and partly because of an internal pulsational instability.

The Sun—During April, the sun's R.A. increases from 0 h 41 m to 2 h 32 m and its Decl. changes from +4°25′ to +14°59′. The equation of time changes from −3 m 49 s to +2 m 51 s.

The Moon—On Apr. 1.0 E.S.T., the age of the moon is 25.4 d. The sun's selenographic colongitude is 227.9° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Apr. 11 (7°) and minimum (east limb exposed) on Apr. 28 (8°). The libration in latitude is maximum (north limb exposed) on Apr. 6 (7°) and minimum (south limb exposed) on Apr. 19 (7°).

Mercury on the 1st is in R.A. 23 h 20 m, Decl. −6°52′, and on the 15th is in R.A. 0 h 46 m, Decl. +2°48′. Early in the month, it is well west of the sun but unfavourably placed (see "March"). By the end of the month, it is too close to the sun to be seen, superior conjunction being on Apr. 27.

Venus on the 1st is in R.A. 0 h 37 m, Decl. +2°33′, and on the 15th it is in R.A. 1 h 41 m, Decl. +9°24′, mag. −3.5, and transits at 12 h 10 m. It is too close to the sun to be seen, superior conjunction being on April 7.

Mars on the 15th is in R.A. 1 h 23 m, Decl. +8°10′, mag. +1.4, and transits at 11 h 50 m. It is too close to the sun to be seen, conjunction being on Apr. 2.

Jupiter on the 15th is in R.A. 12 h 14 m, Decl. +0°14′, mag. −2.0, and transits at 22 h 36 m. In Virgo, about 2° west of Saturn, it is low in the south-east at sunset, and sets at about sunrise. On Apr. 2-3, it passes near η Vir.

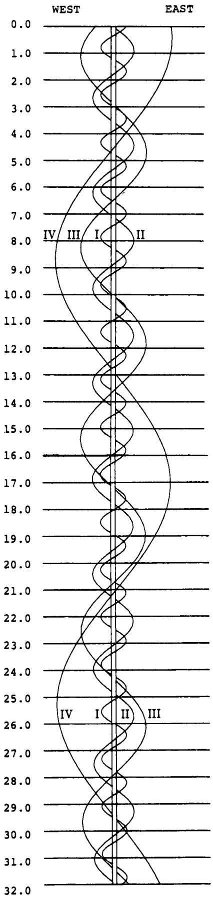
Saturn on the 15th is in R.A. 12 h 23 m, Decl. +0°26′, mag. +0.8, and transits at 22 h 45 m. In Virgo, about 2° east of Jupiter, it is low in the south-east at sunset, and sets at about sunrise. On Apr. 30–May 1, it passes near η Vir.

Uranus on the 15th is in R.A. 15 h 49 m, Decl. −19°48′, mag. +5.8, and transits at 2 h 16 m.

Neptune on the 15th is in R.A. 17 h 37 m, Decl. −21°59′, mag. +7.7, and transits at 4 h 04 m.

1981				APRIL E.S.T.	Min. of Algol	
	d	h	m		h	m
Wed.	1					
Thur.	2	09		Mars in conjunction with Sun		
Fri.	3	01		Mercury 1°1 N. of Moon	11	10
Sat.	4			Occultation by (91) Aegina, pg. 56–7		
		15	19	● New Moon		
Sun.	5	14		Moon at perigee (358,498 km)		
Mon.	6				8	00
Tues.	7	04		Venus in superior conjunction		
Wed.	8					
Thur.	9				4	50
Fri.	10			Mercury at greatest hel. lat. S.		
Sat.	11	06	11	☽ First Quarter		
		09		Vesta stationary		
Sun.	12	19		Pluto at opposition	1	40
Mon.	13					
Tues.	14				22	30
Wed.	15					
Thur.	16	20		Jupiter 3° S. of Moon		
Fri.	17	01		Saturn 1°7 S. of Moon	19	20
Sat.	18					
Sun.	19	02	59	○ Full Moon		
		20		Juno at opposition		
Mon.	20	11		Moon at apogee (406,333 km)	16	00
Tues.	21	14		Uranus 5° S. of Moon		
Wed.	22	03		Lyrid Meteors		
Thur.	23	19		Neptune 2° S. of Moon	12	50
Fri.	24					
Sat.	25					
Sun.	26				9	40
Mon.	27	05	14	☾ Last Quarter		
		11		Mercury in superior conjunction		
Tues.	28					
Wed.	29			Mercury at ascending node	6	30
Thur.	30					

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



THE SKY FOR MAY 1981

Observing the Moon. The moon is certainly the most versatile and dependable subject to observe. Its motion, phases and larger surface features are clearly visible to the unaided eye. The more ambitious observer can watch for *earthshine*, the faint glow seen within the thin crescent moon (sometimes called "the old moon in the new moon's arms").

How close to new moon can the crescent moon be seen? The record seems to be 14 hours. You would need a clear, unobstructed horizon (and binoculars, probably) to break that record.

Another horizon phenomenon is the "moon illusion"—the moon appears larger near the horizon than high in the sky. This appears to be a psychological-physiological effect—and a very striking one indeed.

How much brighter is the full moon than the quarter moon? Not twice as bright, as you might think, but over *ten* times as bright! That isn't an illusion, either. It's due to the microscopic roughness of the moon's surface. The quarter moon is heavily shadowed, even on its apparently illuminated half. The full moon is completely illuminated. The sun shines straight down into all the microscopic crevices. There are no shadows at all.

For more on naked-eye moon watching, see Robert Burnham's article in *Astronomy*, **8**, 46 (June, 1980).

The Sun—During May, the sun's R.A. increases from 2 h 32 m to 4 h 35 m and its Decl. changes from +14°59′ to +22°01′. The equation of time changes from +2 m 58 s to +2 m 23 s.

The Moon—On May 1.0 E.S.T., the age of the moon is 26.0 d. The sun's selenographic colongitude is 233.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 9 (7°) and minimum (east limb exposed) on May 26 (7°). The libration in latitude is maximum (north limb exposed) on May 3 (6°) and May 30 (7°) and minimum (south limb exposed) on May 16 (7°).

Mercury on the 1st is in R.A. 2 h 48 m, Decl. +16°25′, and on the 15th is in R.A. 4 h 42 m, Decl. +24°26′. After about May 10, it can be seen low in the west, below Castor and Pollux, just after sunset. Greatest elongation east (23°) is on May 26, and this elongation is a favourable one for northern observers.

Venus on the 1st is in R.A. 2 h 57 m, Decl. +16°19′, and on the 15th it is in R.A. 4 h 08 m, Decl. +20°58′, mag. −3.4, and transits at 12 h 38 m. Early in the month, it is too close to the sun to be seen, but by the end of the month it can be seen with difficulty, below Mercury in the west, just after sunset.

Mars on the 15th is in R.A. 2 h 49 m, Decl. +16°01′, mag. +1.5, and transits at 11 h 18 m. It is too close to the sun to be easily seen.

Jupiter on the 15th is in R.A. 12 h 05 m, Decl. +1°05′, mag. −1.8, and transits at 20 h 30 m. In Virgo, about 2° west of Saturn, it is east of south at sunset and sets after midnight.

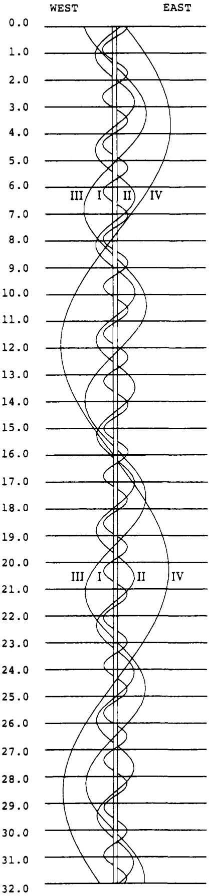
Saturn on the 15th is in R.A. 12 h 16 m, Decl. +1°02′, mag. +1.0, and transits at 20 h 42 m. In Virgo, about 2° east of Jupiter, it is east of south at sunset, and sets after midnight.

Uranus on the 15th is in R.A. 15 h 44 m, Decl. −19°34′, mag. +5.8, and transits at 0 h 13 m. It is at opposition on May 18, 23 h.

Neptune on the 15th is in R.A. 17 h 35 m, Decl. −21°57′, mag. +7.7, and transits at 2 h 04 m. On May 25–26, it passes near 52 Oph.

1981				MAY E.S.T.	Min. of Algol	
	d	h	m		h	m
Fri.	1					
Sat.	2				3	20
Sun.	3	23	19	● New Moon		
Mon.	4			Mercury at perihelion		
		00		Moon at perigee (357,026 km)		
		09		η Aquarid Meteors		
Tues.	5				0	10
Wed.	6					
Thur.	7				21	00
Fri.	8					
Sat.	9					
Sun.	10	17	22	☽ First Quarter	17	50
Mon.	11					
Tues.	12					
Wed.	13	20		Mercury 8° N. of Aldebaran	14	40
		22		Jupiter 3° S. of Moon		
Thur.	14			Occultation by (54) Alexandra, pg. 56–7		
				Mercury at greatest hel. lat. N.		
				Venus at ascending node		
		04		Saturn 1°8 S. of Moon		
Fri.	15					
Sat.	16				11	30
Sun.	17	13		Moon at apogee (406,393 km)		
Mon.	18	17		Uranus 5° S. of Moon		
		19	04	○ Full Moon		
		23		Uranus at opposition		
Tues.	19				8	10
Wed.	20	01		Venus 6° N. of Aldebaran		
		23		Neptune 1°9 S. of Moon		
Thur.	21					
Fri.	22				5	00
Sat.	23					
Sun.	24					
Mon.	25				1	50
Tues.	26	16	00	☾ Last Quarter		
		23		Mercury at greatest elong. E. (23°)		
Wed.	27				22	40
Thur.	28			Jupiter at greatest hel. lat. N.		
		04		Jupiter stationary		
Fri.	29					
Sat.	30				19	30
Sun.	31					

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



THE SKY FOR JUNE 1981

Observing the Sun. The sun provides an unending source of interest for the amateur with a small telescope. But *be careful*! Never look directly at the sun with the unaided eye or with any unfiltered optical instrument. Even filters can be unreliable. Eyepiece filters are extremely hazardous, and are not recommended. Herschel wedges or prisms, in conjunction with eyepiece filters, are acceptable in some cases, but potentially dangerous in others. Full-aperture filters on glass or Mylar are generally regarded as safest, if they are of good quality and are carefully maintained. These filters are placed on the front of the telescope, and reflect away most sunlight *before* it enters the telescope tube.

An alternate approach is to view the sun's image by projecting it onto a screen. This, however, has its dangers: unsupervised bystanders may try to look through the eyepiece; heat may build up inside the telescope and cause permanent damage.

There are many rewarding activities for the careful observer of the sun: counting sunspots, watching, drawing or photographing spots and spot groups, studying solar prominences with a narrow-band filter, or watching for rare "white-light flares" in the vicinity of sunspots.

For more information, see "Exploring the Sun from your Backyard" by Rodger Gordon, *Star and Sky*, **2**, 21 (July, 1980). Serious observers of the sun should join the Solar Division of the American Association of Variable Star Observers, 187 Concord Ave., Cambridge, MA 02138, U.S.A.

The Sun—During June, the sun's R.A. increases from 4 h 35 m to 6 h 39 m and its Decl. changes from +22°01′ to +23°08′. The equation of time changes from +2 m 14 s to −3 m 35 s. The sun reaches the summer solstice on June 21, 06 h 45 m E.S.T., and summer begins in the northern hemisphere.

The Moon—On June 1.0 E.S.T., the age of the moon is 27.6 d. The sun's selenographic colongitude is 252.4° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 7 (7°) and minimum (east limb exposed) on June 22 (6°). The libration in latitude is maximum (north limb exposed) on June 27 (7°) and minimum (south limb exposed) on June 13 (7°).

Mercury on the 1st is in R.A. 6 h 11 m, Decl. +24°40′, and on the 15th is in R.A. 6 h 18 m, Decl. +21°08′. At the beginning of the month, it is well-placed, standing about 16° above the western horizon at sunset. By June 21, it is in inferior conjunction, and is not visible for the rest of the month. On June 9, it is 1.7° south of Venus.

Venus on the 1st is in R.A. 5 h 37 m, Decl. +24°03′, and on the 15th it is in R.A· 6 h 52 m, Decl. +24°05′, mag. −3.3, and transits at 13 h 20 m. Throughout the month, it can be seen low in the west just after sunset. On June 9, it is 1.7° north of Mercury. By month's end, it makes a striking pattern with Castor and Pollux. See also "Jupiter" below.

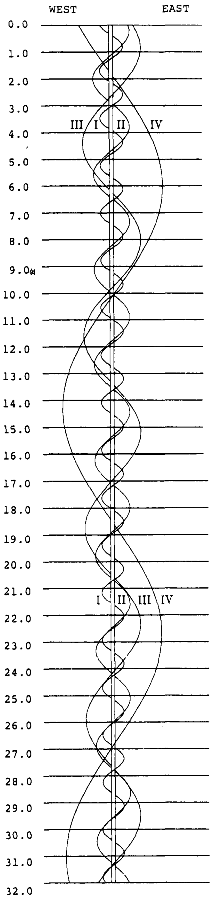
Mars on the 15th is in R.A. 4 h 20 m, Decl. +21°35′, mag. +1.7, and transits at 10 h 47 m. As it gradually moves away from the sun, it becomes more conspicuous in the eastern sky just before sunrise. In Taurus, it passes between the Hyades and Pleiades around June 10, and 6° north of Aldebaran on June 19.

Jupiter on the 15th is in R.A. 12 h 06 m, Decl. +0°52′, mag. −1.7, and transits at 18 h 29 m. In Virgo a few degrees west of Saturn, it is slightly west of the meridian at sunset, and sets about 5 hours later. By the end of the month, Venus, Regulus, Jupiter, Saturn and Spica form a striking configuration across the evening sky.

Saturn on the 15th is in R.A. 12 h 15 m, Decl. +1°02′, mag. +1.1, and transits at 18 h 39 m. In Virgo a few degrees east of Jupiter, it is slightly west of the meridian at sunset, and sets about 5 hours later. See also "Jupiter" above.

Uranus on the 15th is in R.A. 15 h 39 m, Decl. −19°17′, mag. +5.8, and transits at 22 h 02 m. On June 25–26, it passes about 2′ N of 41 Lib.

Neptune on the 15th is in R.A. 17 h 32 m, Decl. −21°55′, mag. +7.7, and transits at 23 h 54 m. It is at opposition on June 14, 11 h.

1981	d	h	m	JUNE E.S.T.	Min. of Algol h	m	Configuration of Jupiter's Satellites (Date Markers are U.T.)
Mon.	1	09		Moon at perigee (358,483 km)			
Tues.	2	06	32	● New Moon	16	20	
Wed.	3			Mars at ascending node			
		08		Venus 4° N. of Moon			
		18		Mercury 3° N. of Moon			
Thur.	4						
Fri.	5			Occultation by (129) Antigone, pg. 56–7	13	10	
		21		Saturn stationary			
Sat.	6			Mercury at descending node			
Sun.	7						
Mon.	8				10	00	
Tues.	9	03		Mercury stationary			
		06		Mercury 1°7 S. of Venus			
		06	33	☽ First Quarter			
Wed.	10	04		Jupiter 3° S. of Moon			
		09		Saturn 2° S. of Moon			
Thur.	11				6	50	
Fri.	12						
Sat.	13	22		Moon at apogee (405,798 km)			
Sun.	14	11		Neptune at opposition	3	30	
		21		Uranus 5° S. of Moon			
Mon.	15						
Tues.	16						
Wed.	17			Mercury at aphelion	0	20	
				Venus at perihelion			
		04		Neptune 1°9 S. of Moon			
		08		Juno stationary			
		10	04	○ Full Moon			
Thur.	18						
Fri.	19	15		Mars 6° N. of Aldebaran	21	10	
Sat.	20						
Sun.	21	06	45	Summer Solstice. Summer begins.			
		20		Mercury in inferior conjunction			
Mon.	22				18	00	
Tues.	23						
Wed.	24	15		Venus 5° S. of Pollux			
		23	25	☾ Last Quarter			
Thur.	25				14	50	
Fri.	26						
Sat.	27						
Sun.	28				11	40	
Mon.	29	14		Moon at perigee (362,350 km)			
Tues.	30	01		Mars 4° N. of Moon			

Early this month the earth is in aphelion; early in January it was at perihelion. The difference in distance from earth to sun between these two extremes is about 5,000,000 km or 3.3 per cent, which makes a difference in radiant heat received by the earth of nearly 7 per cent. Thus for the northern hemisphere the difference tends to warm our winters and cool our summers. However, the preponderance of large land masses in the northern hemisphere works the other way and tends to make our winters colder and summers hotter than those of the southern hemisphere. [by John F. Heard, reprinted from the 1976 HANDBOOK—*Ed.*]

The Sun—During July, the sun's R.A. increases from 6 h 39 m to 8 h 44 m and its Decl. changes from +23°08′ to +18°06′. The equation of time changes from −3 m 47 s to −6 m 17 s. The earth is at aphelion on July 3 at a distance of 152,103,500 km (94,513,000 mi) from the sun. There is a total eclipse of the sun on July 31.

The Moon—On July 1.0 E.S.T., the age of the moon is 28.3 d. The sun's selenographic colongitude is 259.1° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 5 (6°) and minimum (east limb exposed) on July 19 (5°). The libration in latitude is maximum (north limb exposed) on July 24 (7°) and minimum (south limb exposed) on July 10 (7°). There is a partial eclipse of the moon on the night of July 16–17, visible in North America.

Mercury on the 1st is in R.A. 5 h 46 m, Decl. +18°44′, and on the 15th is in R.A. 6 h 08 m, Decl. +20°50′. Throughout the month, it is very low in the east just before sunrise. Greatest elongation west (21°) is on July 14, but this is not a particularly favourable elongation for several reasons: the greatest elongation is less than average, the planet is south of the ecliptic, and the ecliptic is not steeply inclined to the horizon.

Venus on the 1st is in R.A. 8 h 16 m, Decl. +21°21′, and on the 15th it is in R.A. 9 h 25 m, Decl. +16°52′, mag. −3.3, and transits at 13 h 55 m. It can be seen low in the west just after sunset. Moving from Cancer into Leo, it passes through the Praesepe Cluster around July 5–6, and north of Regulus on July 23.

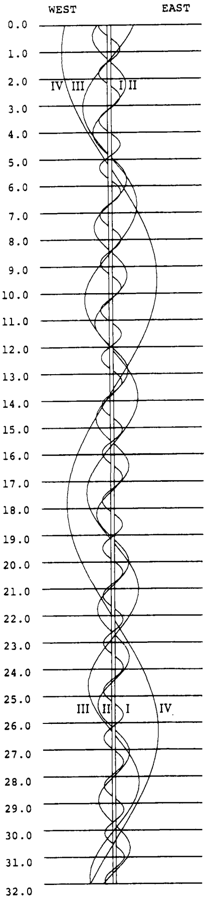
Mars on the 15th is in R.A. 5 h 50 m, Decl. +23°52′, mag. +1.7, and transits at 10 h 18 m. It rises about 2 hours before the sun, and is low in the east at sunrise. Moving from Taurus into Gemini, it makes a pretty picture with the Hyades, the Pleiades, and the several bright stars in this region.

Jupiter on the 15th is in R.A. 12 h 16 m, Decl. −0°19′, mag. −1.5, and transits at 16 h 41 m. In Virgo, it is in the south-west at sunset, and sets about 3 hours later. At the beginning of the month, it is about 2° west of Saturn, but by July 30, it passes 1.2° south of Saturn, moving in direct motion. On July 21–22, it passes close to η Vir.

Saturn on the 15th is in R.A. 12 h 20 m, Decl. +0°27′, mag. +1.2, and transits at 16 h 45 m. In Virgo, it is in the south-west at sunset, and sets about 3 hours later. See also "Jupiter" above.

Uranus on the 15th is in R.A. 15 h 36 m, Decl. −19°06′, mag. +5.8, and transits at 20 h 01 m.

Neptune on the 15th is in R.A. 17 h 29 m, Decl. −21°53′, mag. +7.7, and transits at 21 h 53 m.

1981				JULY E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Wed.	1	14	03	● New Moon	8	30	
Thur.	2						
Fri.	3	08		Venus 1°.3 N. of Moon			
		09		Mercury stationary			
		18		Earth at aphelion			
Sat.	4				5	20	
Sun.	5						
Mon.	6						
Tues.	7			Mercury at greatest hel. lat. S.	2	00	
		15		Jupiter 4° S. of Moon			
		18		Saturn 2° S. of Moon			
Wed.	8			Venus at greatest hel. lat. N.			
		16		Pluto stationary			
		21	39	☽ First Quarter			
Thur.	9				22	50	
Fri.	10						
Sat.	11	13		Moon at apogee (404,838 km)			
Sun.	12	03		Uranus 5° S. of Moon	19	40	
Mon.	13						
Tues.	14	09		Mercury at greatest elong. W. (21°)			
		10		Neptune 2° S. of Moon			
Wed.	15				16	30	
Thur.	16	23	39	○ Full Moon. Eclipse of ☾, pg. 55			
Fri.	17						
Sat.	18				13	20	
Sun.	19						
Mon.	20						
Tues.	21	09		Pallas in conjunction with Sun	10	10	
Wed.	22						
Thur.	23	16		Venus 1°.2 N. of Regulus			
Fri.	24	04	40	☾ Last Quarter	7	00	
Sat.	25						
Sun.	26			Mercury at ascending node			
Mon.	27	04		Moon at perigee (367,265 km)	3	40	
Tues.	28			Jupiter at aphelion			
		12		δ Aquarid Meteors			
		19		Mars 3° N. of Moon			
Wed.	29	14		Mercury 6° S. of Pollux			
Thur.	30	17		Jupiter 1°.2 S. of Saturn	0	30	
		22	52	● New Moon. Eclipse of ⊙, pg. 55.			
Fri.	31			Mercury at perihelion			

THE SKY FOR AUGUST 1981

The Perseid meteor shower occurs on August 12, and for a few days around this date, meteors will be numerous, especially after midnight. The shower meteors will appear to radiate from the constellation Perseus, hence the name of the shower. Unfortunately the moon is close to full at this time, and will certainly reduce the visibility of the meteors.

The Perseids could still provide a pleasant surprise in 1981. Meteor showers are associated with comets. The meteoric particles are the gritty debris left behind when the volatile ices in the comet turn to vapour. The Perseid shower is associated with Comet 1862 III Swift-Tuttle, which was last seen in 1862. According to Brian G. Marsden (pg. 98), this comet will be making its first predicted return to perihelion on Sept. 16, 1981 (give or take two years). As Peter M. Millman therefore points out (pg. 99) "a better than average shower in August is a possibility".

The Sun—During August, the sun's R.A. increases from 8 h 44 m to 10 h 40 m and its Decl. changes from +18°06′ to +8°24′. The equation of time changes from −6 m 14 s to −0 m 13 s.

The Moon—On Aug. 1.0 E.S.T., the age of the moon is 0.6 d. The sun's selenographic colongitude is 278.0° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 2 (5°) and Aug. 29 (5°) and minimum (east limb exposed) on Aug. 15 (5°). The libration in latitude is maximum (north limb exposed) on Aug. 20 (7°) and minimum (south limb exposed) on Aug. 6 (7°).

Mercury on the 1st is in R.A. 8 h 03 m, Decl. +21°26′, and on the 15th is in R.A. 9 h 59 m, Decl. +14° 07′. It is too close to the sun to be easily seen, being in superior conjunction on Aug. 10.

Venus on the 1st is in R.A. 10 h 44 m, Decl. +9°31′, and on the 15th it is in R.A. 11 h 46 m, Decl. +2°34′, mag. −3.4, and transits at 14 h 13 m. It is very low in the west just after sunset. Moving from Leo into Virgo, it passes 2° south of Saturn on Aug. 25, and 0.9° south of Jupiter on Aug. 27.

Mars on the 15th is in R.A. 7 h 20 m, Decl. +22°57′, mag. +1.8, and transits at 9 h 46 m. It rises about 2½ hours before the sun, and—thanks to the steep angle between the ecliptic and the horizon—it is well up in the east at sunrise. Watch its changing position relative to Castor and Pollux during the month. It passes 1.5° S. of ε Gem on Aug. 1–2, 3° N. of ζ Gem on Aug. 8–9, and 1° N. of δ Gem on Aug. 14.

Jupiter on the 15th is in R.A. 12 h 33 m, Decl. −2°18′, mag. −1.3, and transits at 14 h 57 m. In Virgo, it is very low in the south-west at sunset, and sets about 2 hours later. During the month, it gradually moves eastward away from the nearby Saturn. See also "Venus" above.

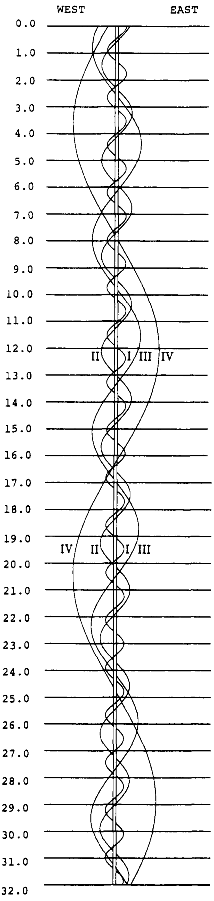
Saturn on the 15th is in R.A. 12 h 29 m, Decl. −0°38′, mag. +1.2, and transits at 14 h 52 m. In Virgo, it is very low in the south-west at sunset, and sets about 2 hours later. See also "Jupiter" and "Venus" above.

Uranus on the 15th is in R.A. 15 h 35 m, Decl. −19°05′, mag. +5.9, and transits at 17 h 58 m.

Neptune on the 15th is in R.A. 17 h 26 m, Decl. −21°53′, mag. +7.7, and transits at 19 h 49 m.

1981				AUGUST E.S.T.	Min. of Algol	
	d	h	m		h	m
Sat.	1				21	20
Sun.	2	08		Venus 2° S. of Moon		
Mon.	3					
Tues.	4	07		Jupiter 4° S. of Moon	18	10
		07		Saturn 3° S. of Moon		
		08		Uranus stationary		
Wed.	5					
Thur.	6					
Fri.	7			Occultation by (18) Melpomene, pg. 56–7	15	00
		14	26	☽ First Quarter		
Sat.	8	07		Moon at apogee (404,227 km)		
		10		Uranus 5° S. of Moon		
Sun.	9					
Mon.	10			Mercury at greatest hel. lat. N.	11	50
		01		Mercury in superior conjunction		
		17		Neptune 2° S. of Moon		
Tues.	11					
Wed.	12	03		Perseid Meteors		
Thur.	13				8	40
Fri.	14					
Sat.	15	11	37	○ Full Moon		
Sun.	16				5	20
Mon.	17					
Tues.	18					
Wed.	19				2	10
Thur.	20					
Fri.	21	16		Moon at perigee (369,652 km)	23	00
Sat.	22	09	16	☾ Last Quarter		
Sun.	23	12		Mars 6° S. of Pollux		
Mon.	24				19	50
Tues.	25	17		Venus 2° S. of Saturn		
Wed.	26	10		Mars 1°.4 N. of Moon		
Thur.	27			Occultation by (105) Artemis, pg. 56-7	16	40
		20		Venus 0°.9 S. of Jupiter		
Fri.	28					
Sat.	29	09	43	● New Moon		
Sun.	30	18		Mercury 4° S. of Moon	13	30
Mon.	31	20		Saturn 3° S. of Moon		

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



THE SKY FOR SEPTEMBER 1981

Notice that the Harvest Moon occurs on September 13. By definition the Harvest Moon is the full moon nearest the autumnal equinox. Around this time, the moon provides an extra measure of light in the early evening, light that was (and is) useful for farmers gathering the harvest.

On the average, the moon rises 50 minutes later from one night to the next, because of its eastward motion around the sky. However, at autumnal equinox, the sun is moving southward at its maximum rate, and the full moon is therefore moving northward at its maximum rate. This northward motion partly counteracts the moon's tendency to rise later from night to night: as a result, the delay in rising may be as little as 20 minutes. Check the tables of moonrise to see that this is so.

Other "moons" have special but less-well-known names. According to Robert Burnham (*Astronomy*, June 1980, pg. 46), "January, for instance, is the Old Moon or the Moon after Yule. February's is the Wolf or the Hunger Moon. March has the Sap or Crow Moon, while April gets the Egg or Grass Moon. The Planting Moon comes in May, and the Rose or Flower Moon in June. July's is called the Thunder or Hay Moon. August has the Grain or Green Corn Moon, while September and October have the Harvest and Hunter's Moons, respectively. The year finishes off with the Frosty or Beaver Moon in November and the Long Night Moon in December."

The Sun—During September, the sun's R.A. increases from 10 h 40 m to 12 h 28 m and its Decl. changes from +8°24′ to −3°04′. The equation of time changes from +0 m 06 s to +10 m 05 s. The sun reaches the autumnal equinox on Sept. 22, 22 h 05 m E.S.T., and autumn begins in the northern hemisphere.

The Moon—On Sept. 1.0 E.S.T., the age of the moon is 2.2 d. The sun's selenographic colongitude is 296.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 24 (5°) and minimum (east limb exposed) on Sept. 11 (6°). The libration in latitude is maximum (north limb exposed) on Sept. 16 (7°) and minimum (south limb exposed) on Sept. 2 (7°) and Sept. 29 (7°).

Mercury on the 1st is in R.A. 11 h 49 m, Decl. +1°25′, and on the 15th is in R.A. 13 h 00m, Decl. −8°10′. Throughout the month, it can be seen with difficulty, low in the west at sunset. Greatest elongation east (26°) is on Sept. 23, but this is a classic unfavourable elongation for northern observers. It passes 4° south of Saturn on Sept. 10, 3° south of Jupiter on Sept. 13, and 0.4° south of Spica on Sept. 20.

Venus on the 1st is in R.A. 12 h 59 m, Decl. −6°11′, and on the 15th it is in R.A. 14 h 00m, Decl. −13°01′, mag. −3.5, and transits at 14 h 25 m. It is low in the south-west at sunset, and sets soon thereafter. Moving from Virgo into Libra, it passes 1.9° north of Spica on Sept. 6.

Mars on the 15th is in R.A. 8 h 43 m, Decl. +19°17′, mag. +1.8, and transits at 9 h 07 m. It rises about 4 hours before the sun, and is well up in the east at sunrise. Moving eastward through Cancer, it passes just north of the Praesepe Cluster around Sept. 13.

Jupiter on the 15th is in R.A. 12 h 55 m, Decl. −4°42′, mag. −1.2, and transits at 13 h 17 m. Early in the month, it can be seen very low in the south-west just after sunset, but by the end of the month, it is too low to be easily seen. It is 3° north of Mercury on Sept. 13.

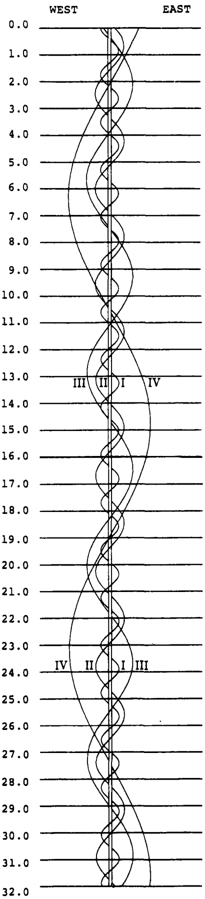
Saturn on the 15th is in R.A. 12 h 41 m, Decl. −2°01′, mag. +1.1, and transits at 13 h 03 m. Early in the month, it can be seen very low in the south-west just after sunset, but by the end of the month, it is too low to be easily seen. It is 4° north of Mercury on Sept. 10.

Uranus on the 15th is in R.A. 15 h 38 m, Decl. −19°15′, mag. +5.9, and transits at 15 h 59 m. On Sept. 12–13, it passes very close to 41 Lib.

Neptune on the 15th is in R.A. 17 h 26 m, Decl. − 21°54′, mag. +7.7, and transits at 17 h 47 m.

1981				SEPTEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Tues.	1	01		Jupiter 4° S. of Moon		
		08		Vesta 0°.2 N. of Moon. Occ'n		
		10		Venus 5° S. of Moon		
Wed.	2			Mercury at descending node	10	20
				Venus at descending node		
Thur.	3	08		Neptune stationary		
Fri.	4	19		Uranus 5° S. of Moon		
Sat.	5	02		Moon at apogee (404,448 km)	7	00
Sun.	6	08	26	☽ First Quarter		
		16		Venus 1°.9 N. of Spica		
Mon.	7	01		Neptune 1°.9 S. of Moon		
Tues.	8				3	50
Wed.	9					
Thur.	10	10		Mercury 4° S. of Saturn		
Fri.	11				0	40
Sat.	12					
Sun.	13			Mercury at aphelion	21	30
		14		Mercury 3° S. of Jupiter		
		22	09	☺ Full Moon, Harvest Moon		
Mon.	14					
Tues.	15	07		Ceres in conjunction with Sun		
Wed.	16	23		Moon at perigee (365,622 km)	18	20
Thur.	17					
Fri.	18					
Sat.	19				15	10
Sun.	20			Occultation by (14) Irene, pg. 56–7		
		14		Mercury 0°.4 S. of Spica		
		14	47	☾ Last Quarter		
Mon.	21					
Tues.	22	22	05	Autumnal Equinox. Fall begins.	12	00
Wed.	23	11		Mercury at greatest elong. E. (26°)		
Thur.	24	00		Mars 0°.04 S. of Moon. Occ'n[1]		
Fri.	25				8	40
Sat.	26					
Sun.	27	23	07	● New Moon		
Mon.	28				5	30
Tues.	29	20		Vesta 0°.4 S. of Moon. Occ'n		
		21		Mercury 9° S. of Moon		
Wed.	30					

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



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[1] Visible in Central and N. Africa, S. Asia, Indonesia, N.W. Australia.

Mars, which is moving into Leo, begins this month to rise about midnight and so commands the attention of the average sky gazer. It hasn't been very exciting this year, being between oppositions (the last one in February 1980, the next one in March 1982). On average the interval between oppositions is 780 days which is known as the synodic period. This is about 50 days longer than two years, so that oppositions work their way through the calendar at the average rate of 50 days per opposition and the position of Mars at opposition works its way around the ecliptic at a corresponding rate. When opposition occurs in August or September it is very favourable because Mars is then near its perihelion and so its distance to the earth is close. September 1968 was such an opposition, but the 1982 opposition will be rather poor and the February 25 1980 opposition was about as unfavourable as an opposition of Mars can be.

The Sun—During October, the sun's R.A. increases from 12 h 28 m to 14 h 24 m and its Decl. changes from −3°04′ to −14°20′. The equation of time changes from +10 m 24 s to +16 m 21 s.

The Moon—On Oct. 1.0 E.S.T., the age of the moon is 2.6 d. The sun's selenographic colongitude is 302.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 21 (7°) and minimum (east limb exposed) on Oct. 9 (7°). The libration in latitude is maximum (north limb exposed) on Oct. 13 (7°) and minimum (south limb exposed) on Oct. 27 (7°).

Mercury on the 1st is in R.A. 13 h 56 m, Decl. −15°29′, and on the 15th is in R.A. 13 h 45 m, Decl. −13°23′. For most of the month, it is too close to the sun to be easily seen, inferior conjunction being on Oct. 18. By the end of the month, however, it is well placed in the morning sky, above Jupiter and Spica, below Saturn, and about 17° above the south-eastern horizon at sunrise.

Venus on the 1st is in R.A. 15 h 12 m, Decl. −19°42′, and on the 15th it is in R.A. 16 h 18 m, Decl. −24°00′, mag. −3.8, and transits at 14 h 45 m. Throughout the month, it is in the south-west at sunset. It passes 2° south of Uranus on Oct. 7, 1.9° north of Antares on Oct. 17, and 5° south of Neptune on Oct. 29.

Mars on the 15th is in R.A. 9 h 57 m, Decl. +14°02′, mag. +1.7, and transits at 8 h 22 m. It rises about 5 hours before the sun, and is near the meridian at sunrise. Moving from Cancer into Leo, it passes 1.1° north of Regulus on Oct. 19.

Jupiter on the 15th is in R.A. 13 h 19 m, Decl. −7°10′, mag. −1.2, and transits at 11 h 43 m. Early in the month, it is too close to the sun to be seen, conjunction being on Oct. 14. By the end of the month, it can be seen very low in the east just before sunrise. See also "Mercury" above.

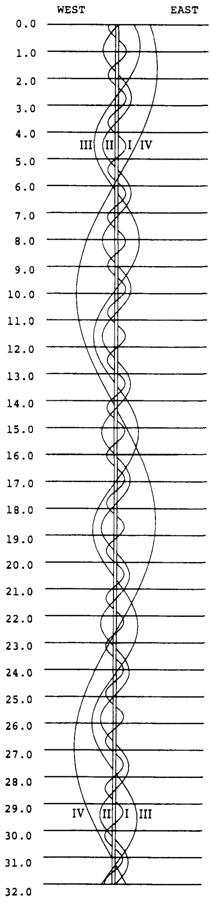
Saturn on the 15th is in R.A. 12 h 55 m, Decl. −3°27′, mag. +1.0, and transits at 11 h 19 m. Early in the month, it is too close to the sun to be seen, conjunction being on Oct. 5. By the end of the month, it can be seen low in the east just before sunrise. See also "Mercury" above.

Uranus on the 15th is in R.A. 15 h 44 m, Decl. −19°34′, mag. +6.0, and transits at 14 h 07 m. See also "Venus" above.

Neptune on the 15th is in R.A. 17 h 28 m, Decl. −21°57′, mag. +7.8, and transits at 15 h 51 m. See also "Venus" above.

1981	d	h	m	OCTOBER E.S.T.	Min. of Algol h	m
Thur.	1	16		Venus 7° S. of Moon	2	20
Fri.	2	05		Uranus 4° S. of Moon		
		20		Moon at apogee (405,333 km)		
Sat.	3			Mercury at greatest hel. lat. S.	23	10
Sun.	4	09		Neptune 1°7 S. of Moon		
Mon.	5	23		Saturn in conjunction with Sun		
Tues.	6	02	45	☽ First Quarter	20	00
		06		Mercury stationary		
Wed.	7			Occultation by (88) Thisbe, pg. 56–7		
				Venus at aphelion		
		06		Venus 2° S. of Uranus		
Thur.	8					
Fri.	9				16	50
Sat.	10					
Sun.	11					
Mon.	12				13	40
Tues.	13	07	49	○ Full Moon. Hunters' Moon.		
Wed.	14	00		Jupiter in conjuction with Sun		
		21		Moon at perigee (360,481 km)		
Thur.	15				10	20
Fri.	16					
Sat.	17	01		Venus 1°9 N. of Antares		
		13		Pluto in conjunction with Sun		
Sun.	18	06		Mercury in inferior conjunction	7	10
Mon.	19	12		Mars 1°1 N. of Regulus		
		22	40	☾ Last Quarter		
Tues.	20					
Wed.	21	07		Orionid Meteors	4	00
Thur.	22			Mercury at ascending node		
		12		Mars 1°4 S. of Moon		
Fri.	23					
Sat.	24				0	50
Sun.	25	23		Saturn 3° S. of Moon		
Mon.	26	16		Mercury stationary	21	40
Tues.	27			Mercury at perihelion		
		15	13	● New Moon		
Wed.	28					
Thur.	29			Venus at greatest hel. lat. S.	18	30
		15		Uranus 4° S. of Moon		
		20		Venus 5° S. of Neptune		
Fri.	30	11		Moon at apogee (406,288 km)		
Sat.	31	17		Neptune 1°4 S. of Moon		
		22		Venus 6° S. of Moon		

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



THE SKY FOR NOVEMBER 1981

If you are a Venus watcher you may be puzzled to notice (or to read what we say about Venus this month) that although Venus is at greatest eastern elongation this month (on Nov. 10, E.S.T.), it is no higher in the south-western sky at sunset than it has been since mid-year. How can this be since Venus is moving away from the sun? (Want to think about it for a while?) Well, the answer lies mostly in the fact that the ecliptic (which *nearly* represents the path of motion of most planets) makes a much shallower angle with the horizon at early autumn sunset than at early summer sunset. This shallower angle more than makes up for the greater elongation of Venus from the sun.

This same phenomenon is also involved in the explanation of the Harvest Moon, and in the explanation of why some elongations of Mercury (and Venus) are more favourable than others.

The Sun—During November, the sun's R.A. increases from 14 h 24 m to 16 h 28 m and its Decl. changes from −14°20′ to −21°45′. The equation of time changes from +16 m 23 s to +11 m 14 s.

The Moon—On Nov. 1.0 E.S.T., the age of the moon is 4.0 d. The sun's selenographic colongitude is 320.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 18 (8°) and minimum (east limb exposed) on Nov. 6 (8°). The libration in latitude is maximum (north limb exposed) on Nov. 10 (7°) and minimum (south limb exposed) on Nov. 23 (7°).

Mercury on the 1st is in R.A. 13 h 17 m, Decl. −5°58′, and on the 15th is in R.A. 14 h 25 m, Decl. −12°40′. Greatest elongation west (19°) occurs on Nov. 2, and this is a favourable elongation for northern observers: the planet stands about 17° above the south-eastern horizon at sunrise. Jupiter, Saturn and Spica figure prominently in this picture. Mercury is 5° north of Spica on Nov. 2, and 1.2° north of Jupiter on Nov. 5.

Venus on the 1st is in R.A. 17 h 39 m, Decl. −26°40′, and on the 15th it is in R.A. 18 h 43 m, Decl. −26°34′, mag. −4.1, and transits at 15 h 07 m. It can be seen low in the south-west, just after sunset. Greatest elongation east (47°) occurs on Nov. 10, but this is an unfavourable elongation for northern observers, in part because of the shallow angle between the ecliptic and the horizon, and in part because Venus is south of the ecliptic.

Mars on the 15th is in R.A. 11 h 04 m, Decl. +7°51′, mag. +1.5, and transits at 7 h 27 m. It rises after midnight, and is nearly at the meridian by sunrise. Throughout the month, it moves eastward under the lion towards Virgo.

Jupiter on the 15th is in R.A. 13 h 44 m, Decl. −9°35′, mag. −1.2, and transits at 10 h 06 m. In Virgo, it rises about 4 hours after midnight, and is well up in the south-east at sunrise. As the end of the year approaches, Spica, Jupiter, Saturn, Mars and Regulus form a conspicuous parade across the morning sky.

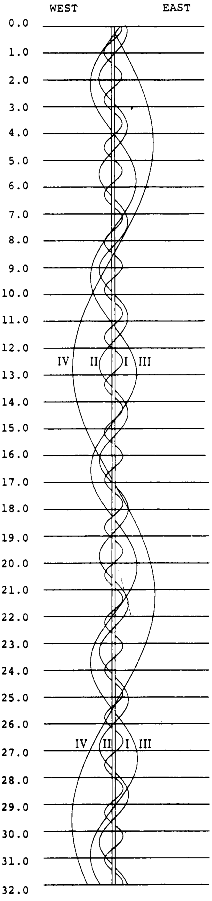
Saturn on the 15th is in R.A. 13 h 08 m, Decl. −4°47′, mag. +1.0, and transits at 9 h 30 m. In Virgo, it rises about 3 hours after midnight, and is well up in the south-east at sunrise. See also "Jupiter" above. On Nov. 16–17, it passes near θ Vir.

Uranus on the 15th is in R.A. 15 h 51 m, Decl. −19°58′, mag. +6.0, and transits at 12 h 13 m. It is in conjunction on Nov. 22, 14 h.

Neptune on the 15th is in R.A. 17 h 32 m, Dec. −22°01′, mag. +7.8, and transits at 13 h 53 m.

1981				NOVEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Sun.	1				15	20
Mon.	2	05		Taurid Meteors		
		20		Mercury 5° N. of Spica		
		23		Mercury at greatest elong. W. (19°)		
Tues.	3					
Wed.	4	20	09	☽ First Quarter	12	10
Thur.	5	19		Mercury 1°2 N. of Jupiter		
Fri.	6			Mercury at greatest hel. lat. N.		
Sat.	7				8	50
Sun.	8					
Mon.	9					
Tues.	10	21		Venus at greatest elong. E. (47°)	5	40
Wed.	11	17	26	○ Full Moon		
Thur.	12	06		Moon at perigee (357,106 km)		
Fri.	13				2	30
Sat.	14	19		Vesta in conjunction with Sun		
Sun.	15				23	20
Mon.	16					
Tues.	17	01		Leonid Meteors		
Wed.	18	09	54	☾ Last Quarter	20	10
Thur.	19	23		Mars 2° S. of Moon		
Fri.	20					
Sat.	21				17	00
Sun.	22	11		Saturn 3° S. of Moon		
		14		Uranus in conjunction with Sun		
		23		Juno in conjunction with Sun		
Mon.	23	08		Jupiter 4° S. of Moon		
Tues.	24				13	50
Wed.	25					
Thur.	26	09	38	● New Moon		
		16		Moon at apogee (406,636 km)		
Fri.	27				10	40
Sat.	28	01		Neptune 1°3 S. of Moon		
Sun.	29			Mercury at descending node		
Mon.	30	15		Venus 3° S. of Moon	7	30

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



THE SKY FOR DECEMBER 1981

Looking Ahead to 1982. Observers who want to know about astronomical phenomena well in advance should obtain the booklet *Astronomical Phenomena for the Year 1982* (or whatever). It is prepared by the Nautical Almanac Office at the U.S. Naval Observatory, and by Her Majesty's Nautical Almanac Office at the Royal Greenwich Observatory in England. It can be obtained from the U.S. Government Printing Office, Washington, or from Her Majesty's Stationery Office, London.

According to this booklet, there will be seven eclipses in 1982, three of the moon (all total) and four of the sun (all partial). Two of the former are visible from North America, but none of the latter. This is the maximum number of eclipses in a year, and it occurs when the "eclipse seasons" are in January and December.

There will be a series of 12 occultations of Neptune by the moon. None of these is visible from North America.

Late in the year, the sun and major planets will gather together in Virgo to produce the notorious "alignment" which you may have read about. The alignment, however, is far from exact, and the combined gravitational and other effects of the assembled planets will be minuscule compared with the normal gravitational and other effects of the sun. Unfortunately, with the major planets so near the sun in the sky, it will be a rather unrewarding time for planet-watchers.

The Sun—During December, the sun's R.A. increases from 16 h 28 m to 18 h 45 m and its Decl. changes from −21°45′ to −23°03′. The equation of time changes from +10 m 51 s to −3 m 09 s. The sun reaches the winter solstice on Dec. 21. 17 h 51 m, E.S.T., and winter begins in the northern hemisphere.

The Moon—On Dec. 1.0 E.S.T., the age of the moon is 4.2 d. The sun's selenographic colongitude is 325.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 16 (8°) and minimum (east limb exposed) on Dec. 4 (8°). The libration in latitude is maximum (north limb exposed) on Dec. 7 (7°) and minimum (south limb exposed) on Dec. 20 (7°).

Mercury on the 1st is in R.A. 16 h 05 m, Decl. −20°58′, and on the 15th is in R.A. 17 h 40 m, Decl. −24°53′. Throughout the month it is too close to the sun to be easily seen, being in superior conjunction on Dec. 10.

Venus on the 1st is in R.A. 19 h 46 m, Decl. −24°12′, and on the 15th it is in R.A. 20 h 26 m, Decl. −20°52′, mag. −4.4, and transits at 14 h 50 m. Throughout the month it can be seen low in the south-west, just after sunset. Greatest brilliancy (−4.4) is on Dec. 16.

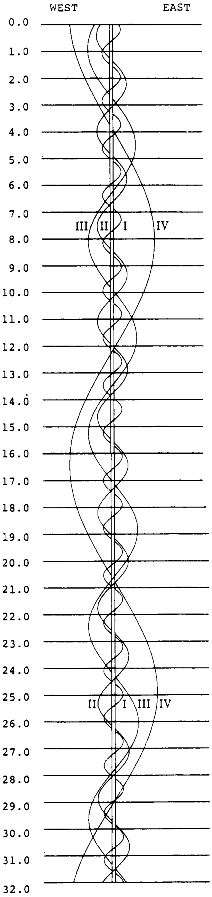
Mars on the 15th is in R.A. 12 h 02 m, Decl. +2°07′, mag. +1.2, and transits at 6 h 26 m. In Virgo, it rises about midnight and is west of the meridian at sunrise.

Jupiter on the 15th is in R.A. 14 h 06 m, Decl. −11°33′, mag. −1.3, and transits at 8 h 30 m. In Virgo, it rises about 3 hours after midnight and is near the meridian by sunrise.

Saturn on the 15th is in R.A. 13 h 19 m, Decl. −5°46′, mag. +1.0, and transits at 7 h 43 m. In Virgo, it rises about 2 hours after midnight, and is on the meridian by sunrise.

Uranus on the 15th is in R.A. 15 h 59 m, Decl. −20°21′, mag. +6.0, and transits at 10 h 22 m.

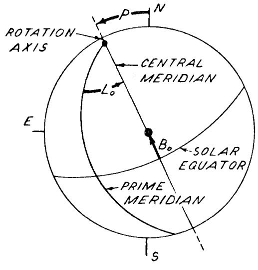
Neptune on the 15th is in R.A. 17 h 36 m, Decl. −22°04′, mag. +7.8, and transits at 11 h 59 m. On Dec. 1, it passes very close to 52 Oph, but it is also very close to the sun at this time, being in conjunction on Dec. 16, at 10 h.

1981				DECEMBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Tues.	1						
Wed.	2						
Thur.	3				4	20	
Fri.	4	11	22	☽ First Quarter			
Sat.	5			Mars at greatest hel. lat. N.			
Sun.	6				1	00	
Mon.	7						
Tues.	8				21	50	
Wed.	9						
Thur.	10			Mercury at aphelion			
		10		Mercury in superior conjunction			
		19		Moon at perigee (356,809 km)			
Fri.	11	03	41	○ Full Moon	18	40	
Sat.	12						
Sun.	13	23		Geminid Meteors			
Mon.	14				15	30	
Tues.	15						
Wed.	16	10		Neptune in conjunction with Sun			
		14		Venus greatest brilliancy (−4.4)			
Thur.	17				12	20	
Fri.	18	00	47	☾ Last Quarter			
		08		Mars 3° S. of Moon			
Sat.	19	22		Saturn 3° S. of Moon			
Sun.	20				9	10	
Mon.	21	01		Jupiter 4° S. of Moon			
		17	51	Winter Solstice. Winter begins.			
Tues.	22	08		Ursid Meteors			
Wed.	23	10		Uranus 4° S. of Moon	6	00	
		18		Moon at apogee (406,376 km)			
Thur.	24			Venus at ascending node			
		11		Vesta 0°.1 S. of Moon. Occ'n			
Fri.	25						
Sat.	26	05	10	● New Moon	2	50	
Sun.	27						
Mon.	28				23	40	
Tues.	29	00		Venus 2° N. of Moon			
Wed.	30			Mercury at greatest hel. lat. S.			
		03		Venus stationary			
Thur.	31						

SUN—EPHEMERIS FOR PHYSICAL OBSERVATIONS 1981
For 0 h U.T.

Date	P	B_0	L_0
	°	°	°
Jan. 1	+ 2.06	−3.06	154.46
6	− 0.36	−3.63	88.61
11	− 2.77	−4.17	22.77
16	− 5.13	−4.68	316.93
21	− 7.43	−5.15	251.09
26	− 9.65	−5.58	185.26
31	−11.77	−5.97	119.42
Feb. 5	−13.78	−6.31	53.59
10	−15.66	−6.60	347.76
15	−17.41	−6.84	281.92
20	−19.02	−7.03	216.08
25	−20.49	−7.16	150.23
Mar. 2	−21.80	−7.23	84.37
7	−22.95	−7.25	18.50
12	−23.94	−7.21	312.61
17	−24.76	−7.12	246.71
22	−25.42	−6.98	180.79
27	−25.90	−6.78	114.86
Apr. 1	−26.20	−6.53	48.90
6	−26.32	−6.24	342.93
11	−26.26	−5.90	276.94
16	−26.02	−5.51	210.92
21	−25.59	−5.09	144.89
26	−24.98	−4.64	78.83
May 1	−24.19	−4.15	12.76
6	−23.22	−3.63	306.67
11	−22.07	−3.09	240.56
16	−20.75	−2.53	174.44
21	−19.27	−1.95	108.30
26	−17.64	−1.36	42.15
31	−15.86	−0.76	335.98
June 5	−13.96	−0.16	269.82
10	−11.95	+0.45	203.64
15	− 9.85	+1.05	137.46
20	− 7.68	+1.64	71.27
25	− 5.45	+2.22	5.08
30	− 3.19	+2.78	298.90
July 5	− 0.92	+3.33	232.72
10	+ 1.34	+3.85	166.55
15	+ 3.58	+4.35	100.38
20	+ 5.78	+4.81	34.22
25	+ 7.92	+5.25	328.07
30	+ 9.99	+5.65	261.93
Aug. 4	+11.97	+6.01	195.81
9	+13.86	+6.33	129.69
14	+15.64	+6.60	63.59
19	+17.31	+6.83	357.50
24	+18.86	+7.01	291.43
29	+20.28	+7.14	225.37
Sept. 3	+21.57	+7.22	159.32
8	+22.72	+7.25	93.29
13	+23.72	+7.23	27.27
18	+24.56	+7.15	321.25
23	+25.25	+7.02	255.26
28	+25.77	+6.84	189.27
Oct. 3	+26.13	+6.61	123.29
8	+26.30	+6.33	57.32
13	+26.30	+6.00	351.36
18	+26.11	+5.63	285.41
23	+25.73	+5.21	219.46
28	+25.15	+4.75	153.52
Nov. 2	+24.38	+4.26	87.59
7	+23.41	+3.73	21.67
12	+22.25	+3.17	315.74
17	+20.89	+2.59	249.83
22	+19.35	+1.98	183.92
27	+17.64	+1.36	118.02
Dec. 2	+15.76	+0.73	52.13
7	+13.74	+0.09	346.24
12	+11.59	−0.55	280.35
17	+ 9.33	−1.19	214.48
22	+ 7.00	−1.82	148.61
27	+ 4.61	−2.43	82.75

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 1981

No.	Commences		No.	Commences		No.	Commences	
1703	Dec.	16.40	1708	May	1.97	1713	Sept.	15.07
1704	Jan.	12.73	1709	May	29.18	1714	Oct.	12.35
1705	Feb.	9.07	1710	June	25.38	1715	Nov.	8.64
1706	Mar.	8.40	1711	July	22.59	1716	Dec.	5.96
1707	Apr.	4.71	1712	Aug.	18.81	1717	Jan.	2.28

PLANETARY HELIOCENTRIC LONGITUDES 1981

Date U.T.	Planet					
	M	V	E	M	J	S
	°	°	°	°	°	°
Jan. 1.0	282	225	100	315	179	184
Feb. 1.0	51	274	132	335	181	185
Mar. 1.0	197	318	160	352	184	186
Apr. 1.0	288	8	190	12	186	187
May 1.0	57	56	221	30	188	188
June 1.0	210	105	250	48	191	189
July 1.0	297	154	279	64	193	190
Aug. 1.0	83	205	309	80	195	191
Sept. 1.0	223	254	338	96	197	192
Oct. 1.0	310	301	8	110	200	193
Nov. 1.0	108	351	38	124	202	194
Dec. 1.0	232	39	69	137	204	195
Jan. 1.0	324	88	100	151	207	196

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 236° to 241° during the year; that of Neptune increases from 263° to 265°, and that of Pluto increases from 202° to 205°.

ECLIPSES DURING 1981

In 1981 there will be four eclipses, two of the sun and two of the moon.

1. *A penumbral eclipse of the moon* on the night of January 19–20, visible in North America and elsewhere. Penumbral magnitude* of the eclipse: 1.039.

   Moon enters penumbra................January 20 00 35.9 E.S.T.
   Middle of eclipse.............................. 02 49.9 E.S.T.
   Moon leaves penumbra.......................... 05 03.9 E.S.T.

2. *An annular eclipse of the sun* on February 4. The path of annularity extends from just south of Australia (passing through Tasmania), just south of New Zealand, and across the South Pacific almost to Chile. The eclipse is visible as a partial eclipse in parts of Australia, New Zealand, Antarctica, South and Central America.

3. *A partial eclipse of the moon* on the night of July 16–17, visible in North America (except certain northern parts) and elsewhere. Magnitude of the eclipse: 0.554.

   Moon enters penumbra....................July 16 21 05.2 E.S.T.
   Moon enters umbra............................ 22 24.8 E.S.T.
   Middle of eclipse.............................. 23 46.8 E.S.T.
   Moon leaves umbra.......................July 17 01 08.9 E.S.T.
   Moon leaves penumbra......................... 02 28.4 E.S.T.

4. *A total eclipse of the sun* on July 31. The path of totality extends from the Black Sea, across the U.S.S.R., north of Japan, and eastward across the North Pacific almost to Hawaii. The eclipse is visible as a partial eclipse in most of Scandinavia, northeastern Europe, most of Asia, the north Pacific, Alaska, British Columbia except the southern portion, most of the Northwest Territories, and the northwestern half of Alberta.

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*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.

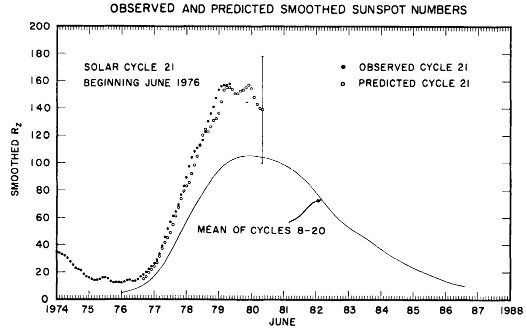
SUNSPOTS

By V. Gaizauskas

The present sunspot cycle (21) is compared with the mean of cycles 8 to 20 in the diagram adapted from "Solar-Geophysical Data" (U.S. Dept. of Commerce, Boulder, Colorado). The data plotted in the graph are monthly smoothed relative sunspot numbers from Zürich. The vertical bar defines the interval in which the most recent value in the graph can be predicted with a confidence of 90%. The predicted maximum value for this cycle has been revised to 159 ± 5, a figure reached already for November 1979.

The general upward trend of solar activity slowed during 1979–80; it is expected to fluctuate around peak levels throughout 1980–81. Another measure of solar activity is the 10 cm microwave flux which has been monitored daily since 1947 by the National Research Council of Canada (Covington, A. E. 1967, *J. Roy. Astron. Soc. Can.*, **61**, 314). The 10 cm flux correlates closely with sunspot number and has the advantage of being reproducible without subjective bias by an observer. These microwave data show that activity experienced a sharp peak in November 1979 and another of almost equal intensity in May 1980.

Amateurs who make sunspot observations may wish to try their hand at detecting white light flares (Pike, R. 1974, *J. Roy. Astron. Soc. Can.*, **68**, 330). 5 or 6 white light flares are estimated to occur each year during a few years around peak sunspot activity. These rare events are visible in the solar photosphere for a few minutes at most and are not to be confused with long-enduring "light-bridges" or bright facular patches adjacent to sunspots. White light flares erupt as one or more intensely bright and compact structures (a few arc-sec or less) during the explosive phase of highly energetic flares. They are most likely to occur in complex, rapidly-evolving sunspot groups with many closely-packed umbrae enclosed by a single penumbra. Forewarning of such energetic events may be given for several hours by a realignment of penumbral filaments or a major increase in penumbral size.



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 75 predicted occultations of stars by asteroids or planets. This list has been augmented and refined by Dr. David W. Dunham. The ones listed below may be visible from North America or are of special interest. 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. In the first table, Δt is the predicted maximum duration in seconds, and Δ m_v is the visual magnitude change at occultation.

Observations of these events are co-ordinated in North America by the International Occultation Timing Association (IOTA). Dr. David W. Dunham of IOTA has published a useful article on "Planetary Occultations of Stars in 1980" in *Sky and Telescope*, January 1980, p. 38, and he expects to publish a similar article on planetary occultations of stars in 1981 in the same magazine in early 1981.

No.	Date	U.T.		Asteroid	m_v	Δm_v	Δt	Path Includes
		h	m					
1	Jan. 26	7	14±2	365 Corbuba	13.3	4.5	14	Hawaii? W. U.S.A.
2	Mar. 19	11	42±2	48 Doris	11.4	2.5	12	N. Cent. U.S.A., Can.
3	Apr. 4	10	06±4	91 Aegina	13.0	4.2	12	U.S.A.—Can. border
4	Apr. 20	3	12±3	36 Atalante	14.2	5.4	6	Maritimes?
5	Apr. 21	6	50±2	1 Ceres	8.4	0.7	46	Hawaii?
6	May 9	8	12±2	56 Melete	14.2	6.0	8	Hawaii?
7	May 10	22	39±2	2 Pallas	8.7	2.2	11	N. Brazil
8	May 13	7	08±2	95 Arethusa	13.5	8.3	4	Hawaii?
9	May 14	7	51±2	54 Alexandra	13.9	4.1	6	N.W. Canada, Alaska
10	May 20	0	20±2	451 Patientia	12.3	2.3	11	Newfoundland
11	June 5	3	16±4	129 Antigone	10.2	3.2v	21	E. Can., N.E. U.S.A.
12	June 13	7	56±10	88 Thisbe	10.2	2.5	26	N. South Amer., Hawaii?
13	July 11	14	57±2	110 Lydia	13.1	3.3	4	Hawaii?
14	Aug. 7	12	06±15	18 Melpomene	8.5	0.5	23	W. U.S.A.
15	Aug. 12	9	17±2	89 Julia	11.8	3.1	4	Alaska
16	Aug. 20	13	26±2	110 Lydia	13.1	4.0	5	Hawaii?
17	Aug. 20	0	15±6	409 Aspasia	11.2	3.0	21	Labrador, Quebec
18	Aug. 27	3	40±8	105 Artemis	11.3	2.7	10	E. Can.? E. U.S.A.?
19	Sept. 20	9	54±6	14 Irene	10.9	2.8	14	W. U.S.A., Hawaii?
20	Sept. 23	6	18±2	39 Laetitia	12.1	5.3	4	Hawaii?
21	Oct. 7	2	01±2	88 Thisbe	11.5	2.7	10	W. North America
22	Nov. 2	6	22±2	88 Thisbe	11.7	5.4	7	Hawaii?
23	Nov. 7	6	34±2	6 Hebe	11.4	2.2	6	Labrador?
24	Nov. 30	14	25±6	471 Papagena	9.7	1.1	13	W. North Am., Hawaii?

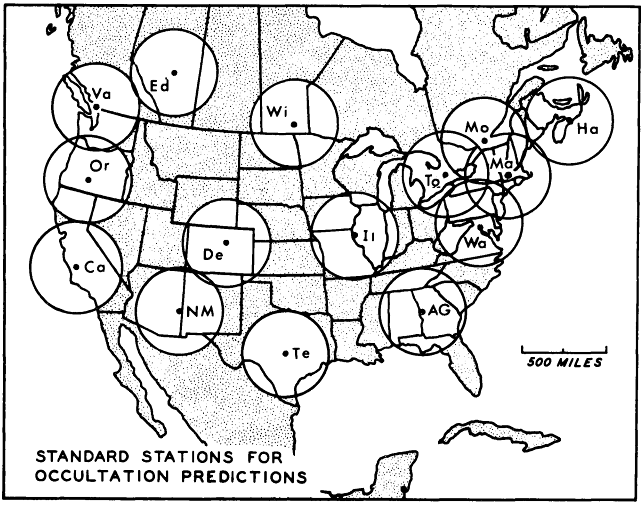
No.	Date	Star		m_v	R.A. (1950)			Dec. (1950)	
					h	m	s	°	′
1	Jan. 26	SAO	111635	8.8	4	07	14	+04	15.0
2	Mar. 19	SAO	118832	9.0	11	21	52	+02	11.6
3	Apr. 4	SAO	158864	8.8	14	49	19	−17	37.4
4	Apr. 20	SAO	205617	8.8	14	27	05	−32	57.2
5	Apr. 21	SAO	60300	8.5	7	40	14	+30	24.9
6	May 9	SAO	97880	8.2	8	28	44	+12	55.2
7	May 10	SAO	131847	6.3	5	08	27	−02	18.8
8	May 13	SAO	95447	5.4	6	12	32	+16	09.6
9	May 14	AGK3	+22°0920	9.8	7	42	54	+22	01.8
10	May 20	AGK3	+29°1008	10.2	8	55	34	+29	58.3
11	June 5	SAO	142674	7.1v	18	47	37	−07	58.0
12	June 13	SAO	186977	7.8	18	30	44	−24	09.7
13	July 11	AGK3	+23°0466	9.9	4	59	59	+23	21.7
14	Aug. 7	SAO	145972	9.0	22	12	31	−08	18.2
15	Aug. 12	SAO	58135	8.8	5	27	38	+36	11.7
16	Aug. 20	SAO	78007	9.1	6	05	06	+24	55.0
17	Aug. 20	SAO	108373	8.3	23	01	42	+12	33.6
18	Aug. 27	SAO	126198	8.7	20	44	11	+09	40.6
19	Sept. 20	SAO	191415	8.2	22	45	24	−21	53.6
20	Sept. 23	SAO	140280	6.8	14	59	24	−08	08.9
21	Oct. 7	SAO	187124	8.9	18	37	54	−20	32.6
22	Nov. 2	SAO	162511	6.3	19	18	41	−19	19.8
23	Nov. 7	SAO	118858	9.3	11	23	38	+07	03.6
24	Nov. 30	AGK3	+20°0540	9.2	5	37	08	+20	26.3

Occultation of σ Sagittarii by Venus on 1981 November 17: Information on this event can be found on page 91.

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 77), 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 444 on Jan. 14, 1981, 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 $23^h\ 54^m.5 - 2^m.4\ (75.72 - 73.60) - 1^m.0\ (45.40 - 45.50) = 23^h\ 49^m.5$. Note that almost the same result is obtained by using Toronto as the standard station.

The elongation of the moon is 111° which means that the moon is about two days past first quarter. The star therefore disappears at the dark limb of the moon. The position angle of immersion is about 114°.

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.

LUNAR OCCULTATIONS 1981

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600				Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500				To TORONTO, ONT. W. 79°.400, N. 43°.700			
					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. 8	3157d	7.1	1	31	A				22 17.5	-1.3	-1.6	102	S			
14	306	6.9	1	98	1 06.5	.	.	357	N				N			
14	444	6.2	1	111	24 25.4	.	.	141	23 54.5	-2.4	-1.0	114	23 42.0	-2.3	-0.5	111
15	453	7.3	1	112	3 28.2	-0.9	-0.4	64	3 17.9	-1.1	-0.1	60	3 10.9	-1.3	0.0	64
15	462	5.9	1	113	5 30.6	-0.1	-1.0	78	5 27.1	-0.4	-1.0	79	5 26.5	-0.5	-1.2	87
18	913	5.2	1	153	4 09.7	-1.7	+0.1	69	3 52.8	-1.7	+0.6	68	3 41.4	-1.8	+0.6	73
18	940	5.7	1	154	G				8 25.8	-1.1	+0.9	32	8 19.4	-0.9	+0.1	48
Feb. 10	405	4.4	1	80	23 10.1	-1.2	+1.4	36	23 00.9	-0.9	+2.4	21	22 50.9	-0.9	+2.7	20
12	692d	1.1	1	106	N				G				21 09.3	.	.	141
12	692d	1.1	2	106	N				G				21 33.3	.	.	182
13	729	7.2	1	109	5 24.9	+0.7	-4.0	151	G				N			
14	862	7.5	1	121	2 20.9	-1.2	-4.0	143	2 02.4	-1.8	-3.6	140	1 59.3	.	.	151
14	863	6.7	1	121	2 37.7	.	.	148	2 20.6	.	.	146	G			
21	1733	5.2	2	207	4 15.4	-1.7	+0.7	277	4 00.6	-1.4	+1.2	271	3 50.0	-1.3	+1.9	260
23	1950	5.8	2	230	7 19.8	-2.6	+0.7	259	6 53.9	.	.	242	N			
26	2291	5.5	2	264	S				S				10 43.0	-2.7	+1.0	244
Mar. 9	364	4.3	1	49	N				22 56.8	.	.	137	S			
11	516	7.3	1	65	N				3 08.4	.	.	7	3 00.9	-0.6	+1.1	26
13	971	7.3	1	103	23 04.6	-1.9	-0.4	101	S				S			
14	995d	4.1	1	104	N				N				3 19.8	.	.	20
15	1135	6.8	1	118	4 44.7	-0.8	-0.8	68	4 35.0	-1.0	-0.9	77	4 30.6	-1.1	-1.1	88
15	1245d	7.5	1	128	23 01.9	-1.6	+1.5	76	S				S			
16	1259	5.9	1	129	3 41.2	-1.6	-0.5	72	3 23.8	-1.8	-0.4	81	3 14.3	-1.9	-0.6	92
17	1385	6.5	1	142	6 11.4	-0.3	-2.1	126	6 05.3	-0.5	-2.3	135	6 07.1	-0.4	-2.7	147
24	2128	5.8	2	222	N				8 16.1	.	.	355	8 16.4	-1.0	-2.2	340
25	2223d	4.0	2	232	4 43.4	-0.9	+0.3	303	4 35.8	-0.7	+0.7	294	A			
28	2633d	4.0	1	267	8 54.1	-2.3	+1.6	54	8 34.5	-1.9	+1.8	61	8 21.1	-1.6	+1.7	72
28	2633d	4.0	2	267	S				9 41.5	-1.5	-0.5	315	9 33.5	-1.5	-0.2	307
Apr. 7	453	7.3	1	31	A				0 13.8	-0.2	-2.0	110	S			
8	618	7.2	1	47	A				A				2 20.5	-0.1	-0.9	77
9	764d	5.0	1	60	0 55.1	-0.8	+0.2	45	0 45.9	-1.0	+0.1	50	0 39.6	-1.2	-0.1	60
10	940	5.7	1	74	2 42.3	0.0	-1.8	112	2 39.7	-0.2	-2.1	119	2 42.8	-0.2	-2.5	131
12	1217	6.1	1	98	1 08.1	-0.6	-3.4	152	0 58.0	.	.	162	N			
13	1345	7.1	1	111	N				2 06.3	.	.	34	1 44.4	-2.6	+1.4	58
15	1562	7.3	1	134	1 20.3	-1.7	-1.1	118	1 03.0	-1.6	-0.9	126	0 56.3	-1.4	-1.3	137
May 9	1186	6.1	1	69	3 10.8	+0.3	-1.6	116	3 11.1	+0.1	-1.9	123	3 15.4	+0.1	-2.2	134
10	1319	7.5	1	81	3 05.8	+0.1	-2.0	130	3 03.9	-0.1	-2.3	139	3 08.3	0.0	-2.8	150
14	1741	7.2	1	127	N				1 24.1	.	.	59	S			
16	1950	5.8	1	150	2 10.3	-1.6	-1.0	124	1 54.7	-1.3	-0.9	135	1 49.9	-1.0	-1.3	148
23	2838	5.6	2	228	S				7 28.8	-2.0	+1.5	224	7 13.7	-2.1	+2.2	218
June 8	1506	7.1	1	75	N				N				3 59.4	-0.8	+0.1	46
9	1603	7.1	1	85	0 48.9	-1.7	-0.9	78	S				S			
12	1923	7.1	1	120	3 21.4	-1.1	-1.8	116	3 07.3	-1.3	-1.8	122	3 02.6	-1.4	-1.8	131
14	2128	5.8	1	142	N				G				2 06.5	.	.	62
15	2247	5.6	1	153	4 35.3	-1.8	-0.7	72	4 15.2	-2.1	-0.3	76	4 02.8	-2.3	-0.2	84
19	2779d	3.9	2	197	2 59.3	-1.2	+0.4	299	A				A			
21	3069	6.2	2	222	S				7 17.[illegible]	-1.6	+1.3	223	7 05.5	-1.7	+1.6	223
22	3190d	3.0	2	232	4 10.7	-0.8	+0.8	295	A				A			
July 7	1684	7.0	1	66	A				2 22.7	-0.4	-1.6	99	2 23.0	-0.5	-1.7	105
19	3171	3.8	1	204	7 26.6	-1.7	-0.4	80	7 10.0	-1.6	+0.3	67	6 59.3	-1.7	+0.6	65

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600				Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500				To TORONTO, ONT. W. 79°.400, N. 43°.700			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				o	h m	m	m	o	h m	m	m	o	h m	m	m	o
July 19	3171	3.8	2	204		S			8 29.0	-1.4	-0.3	249	8 20.7	-1.6	-0.1	252
21	3428d	5.2	2	227	4 02.1	-0.8	+2.4	210		A				A		
28	888	6.0	2	322	7 30.1	-0.1	+0.9	289		A				A		
28	895	5.9	2	322		S				S			8 29.2	+0.2	+1.5	251
Aug. 4	1741	7.2	1	46		A				A			1 28.1	-0.4	-1.4	87
6	1950	5.8	1	69	0 53.7	-0.6	-2.5	149		S				S		
10	2408	6.9	1	113	1 48.9	-1.7	-1.2	102	1 29.9	-1.9	-0.8	102	1 19.8	-2.0	-0.7	107
13	2838	5.6	1	148	3 49.9	-1.9	-1.2	109	3 29.6	-2.0	-0.5	101	3 18.7	-2.1	-0.3	102
13	2851	6.0	1	149		A				A			6 32.3	-0.2	+0.8	27
21	405	4.4	1	252	8 03.5	-1.0	+2.1	35	7 58.3	-0.4	+2.9	16	7 50.9	-0.2	+3.2	11
21	405	4.4	2	252		S			8 49.1	-2.3	-0.4	290	8 36.1	-2.4	-0.4	295
Sept. 6	2361	4.8	1	82		A			1 09.9	-1.4	-1.8	120	1 04.2	-1.6	-1.8	122
9	2779d	3.9	1	116		A			3 28.4	-0.5	+0.6	31	3 23.6	-0.7	+1.0	28
11	3035	6.8	1	139	0 30.0	.	.	17	0 17.5	.	.	11		S		
12	3190d	3.0	1	152	2 51.1	-1.2	+1.1	36	2 40.7	-1.1	+1.9	22	2 30.4	-1.2	+2.3	20
12	3190d	3.0	2	152	3 58.1	-2.0	-0.9	279	3 35.2	-2.4	-1.0	296	3 22.4	-2.6	-0.9	300
17	364	4.3	1	221		N			7 17.2	-2.8	-1.7	122	7 03.6	-2.6	-0.9	117
17	364	4.3	2	221		N			7 55.3	-0.2	+3.8	183	7 47.1	-0.4	+3.4	187
19	650	5.7	2	248	8 19.5	-1.2	+2.3	217	8 09.1	-1.2	+1.8	231	7 59.0	-1.1	+1.9	233
22	1113d	5.2	2	287	7 39.1	-0.4	+2.6	230	7 37.7	-0.3	+2.0	243	7 33.0	-0.1	+1.9	244
25	1493d	6.4	2	325		S			9 02.3	-0.1	+1.3	274		A		
Oct. 8	3113	5.4	1	118	23 13.6	.	.	11		G				S		
10	3271	7.1	1	131		N			1 52.0	.	.	134	1 36.9	.	.	128
10	3288	5.9	1	133		A				A			6 16.2	-0.6	-0.5	64
11	3419d	4.5	1	146	5 40.2	+0.1	+2.0	8		N				N		
11	3425	4.6	1	146	6 16.1	-0.7	-1.1	82	6 07.6	-0.9	-0.6	69	6 03.0	-1.0	-0.4	68
18	894	4.6	2	241	2 30.6	0.0	+1.4	261		A				A		
19	1086	6.5	2	258	9 27.7	-1.8	-1.8	309	9 07.8	-1.9	-1.7	314	8 59.3	-1.9	-1.1	309
20	1205	6.3	2	269	4 45.6	+0.6	+3.6	210	4 53.0	+0.4	+2.3	228		A		
23	1576	5.3	2	307	8 29.5	-0.6	+3.2	238	8 28.0	-0.2	+2.5	245	8 22.7	0.0	+2.7	240
Nov. 3	2929	7.1	1	75	22 22.8	-1.5	+0.4	49		S				S		
5	3069	6.2	1	87	0 22.6	.	.	356		N				N		
7	3356	5.9	1	113		A				A			5 00.5	-1.1	-2.1	106
8	60	7.0	1	137	23 08.9	-1.2	+1.5	63	23 00.2	-0.9	+1.8	53	22 52.2	-0.7	+1.9	52
8	3506	6.3	1	127		A				A			6 28.7	-0.4	-0.3	58
14	881d	5.9	2	213		N				S			11 03.3	-0.4	-3.3	320
17	1322	6.1	2	253	9 36.0	-1.3	-2.5	324	9 19.7	-1.5	-1.9	320	9 13.3	-1.7	-1.2	310
29	2762	6.0	1	34		A			22 06.9	-1.0	-0.6	63		S		
Dec. 5	5	4.7	1	104	21 13.0	.	.	128		S				S		
5	3428d	5.2	1	92	0 25.7	-1.4	-0.3	71	0 11.6	-1.4	+0.5	55	0 02.2	-1.5	+0.8	51
6	25	7.5	1	106	3 40.2	.	.	346		N				N		
8	291	7.1	1	133	2 35.2	-2.1	-1.7	109	2 14.1	-1.9	-0.3	91	2 03.0	-2.0	+0.1	88
8	306	6.9	1	134	5 59.5	-0.4	+0.3	40	5 54.5	-0.6	+0.6	35	5 49.5	-0.8	+0.6	40
16	1504	5.7	2	246	6 38.4	-1.5	+0.5	282	6 25.6	-1.2	+0.8	283	6 17.7	-1.0	+1.1	276
23	2271	4.3	2	327	10 27.4	-1.7	+2.8	243		A				N		
28	2988	6.8	1	26		A			21 53.7	-1.2	-1.2	88		S		

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN..				Ed EDMONTON, ALTA.				Va VANCOUVER, B.C.			
					W. 97.200°, N. 49.900°				W.113.400°, N. 53.600°				W.123.100°, N. 49.200°			
					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. 13	208	7.0	1	87	A				A				7 02.3	-0.4	-2.5	114
15	453	7.3	1	112	2 53.5	-1.0	+1.7	31	N				G			
15	462	5.9	1	113	5 06.8	-1.0	-0.5	68	4 49.4	-1.1	+0.5	51	4 35.1	-1.4	+0.7	58
16	608d	6.0	1	127	N				4 41.7	-1.7	-2.2	126	4 33.5	.	.	139
18	913	5.2	1	153	3 23.6	-1.1	+2.4	43	G				3 06.9	.	.	15
18	940	5.7	1	154	8 00.3	-1.3	+0.6	44	7 40.8	-1.4	+1.4	39	7 21.4	-1.6	+0.9	59
29	2223d	4.0	1	286	12 53.2	-1.7	+0.1	100	12 31.6	-1.1	+0.6	110	12 20.5	-0.7	+0.2	129
29	2223d	4.0	2	286	S				13 50.5	-1.4	-0.1	294	13 35.0	-1.6	+0.7	277
Feb. 1	2633d	4.0	1	321	S				S				15 04.3	-1.0	+0.6	117
9	150d	6.2	1	55	3 10.7	-0.2	+1.5	14	N				3 04.7	.	.	355
10	291	7.1	1	69	3 46.5	-0.5	-2.0	104	3 29.3	-0.9	-1.3	87	3 24.9	-1.3	-1.4	97
11	444	6.2	1	84	A				6 23.4	-0.2	-2.2	110	6 33.5	-0.3	-3.8	134
12	692d	1.1	1	106	20 51.9	-0.5	+1.3	97	20 53.6	0.0	+1.6	79	20 47.7	+0.2	+1.4	79
12	692d	1.1	2	106	21 48.4	-0.4	+2.2	229	21 50.5	-0.2	+1.8	249	21 41.7	0.0	+1.7	250
13	729	7.2	1	109	N				4 33.5	-1.3	-3.7	139	N			
14	862	7.5	1	121	1 11.1	-1.6	0.0	109	S				S			
14	863	6.7	1	121	1 26.6	-1.7	-0.4	115	S				S			
15	1025	7.4	1	134	0 39.0	-1.4	+0.1	121	S				S			
21	1733	5.2	2	207	3 45.2	-0.5	+1.4	276	A				A			
26	2291	5.5	2	264	10 07.6	.	.	232	A				N			
Mar. 1	2704	5.8	2	299	11 51.8	-1.8	+2.5	222	A				N			
11	526	6.9	1	66	A				5 04.0	-0.4	-0.7	58	5 03.1	-0.6	-1.0	75
13	862	7.5	1	94	A				7 57.8	+0.1	-1.6	101	8 06.6	+0.1	-2.0	119
13	863	6.7	1	94	A				8 08.1	+0.2	-1.6	103	8 17.6	+0.2	-2.1	121
14	1025	7.4	1	107	7 53.3	+0.2	-1.7	111	7 47.3	-0.1	-2.0	116	7 56.5	0.0	-2.7	137
15	1135	6.8	1	118	4 00.9	-1.5	-0.6	85	3 35.3	-1.5	+0.3	81	3 19.0	-1.6	+0.2	96
15	1138	7.1	1	118	N				N				4 00.2	-1.8	+2.3	48
16	1259	5.9	1	129	2 41.3	-1.7	+0.6	83	2 21.5	-1.2	+1.6	72	S			
16	1275	5.6	1	131	N				N				7 15.2	.	.	44
17	1385	6.5	1	142	5 39.0	-0.7	-2.9	153	5 15.0	-0.9	-2.9	158	N			
24	2128	5.8	2	222	7 50.6	-0.8	-0.9	329	7 37.2	-0.6	0.0	319	7 29.4	-0.7	+0.6	298
25	2247	5.6	2	234	10 06.7	-1.8	-0.1	274	9 40.0	-1.6	+0.9	264	9 15.4	-2.1	+2.6	239
Apr. 7	462	5.9	1	33	1 56.9	-0.1	-2.5	120	S				S			
8	618	7.2	1	47	2 09.3	-0.5	-0.8	70	S				S			
8	627	6.8	1	48	A				4 32.1	-0.2	-0.7	59	4 33.4	-0.3	-1.1	77
9	787d	7.5	1	62	4 33.2	+0.3	-2.4	131	4 26.0	0.0	-2.8	134	N			
9	800	7.5	1	63	A				A				6 29.1	-0.2	-0.7	59
10	940	5.7	1	74	2 18.3	-0.8	-2.4	126	S				S			
10	971	7.3	1	76	A				6 20.5	-0.1	-1.4	86	6 25.6	-0.2	-1.7	103
11	1109	7.3	1	89	6 36.3	+0.5	-2.4	146	6 33.1	+0.4	-3.2	156	N			
12	1245d	7.5	1	101	6 16.9	-0.9	-0.3	47	5 58.1	-1.2	-0.5	59	5 49.6	-1.3	-0.9	81
12	1259	5.9	1	103	A				A				9 30.5	-0.1	-0.8	60
14	1481	7.4	1	126	8 58.0	-0.1	-1.4	85	8 48.2	-0.4	-1.6	91	8 50.5	-0.6	-1.8	105
May 7	888	6.0	1	43	3 37.0	-0.2	-0.5	51	S				S			
7	895	5.9	1	43	A				4 25.7	-0.1	-1.3	83	4 31.1	-0.1	-1.6	100
9	1186	6.1	1	69	2 59.6	-0.3	-2.5	138	S				N			
9	1202	6.9	1	71	A				6 54.0	.	.	173	N			
10	1319	7.5	1	81	2 47.6	-0.2	-3.3	158	S				N			
10	1327	6.8	1	82	5 05.4	-0.5	-1.3	78	4 50.0	-0.8	-1.4	86	4 47.8	-1.0	-1.6	105
10	1331	5.9-7.5	1	83	6 06.1	-0.1	-1.2	74	5 56.1	-0.5	-1.4	82	5 57.3	-0.6	-1.6	98
10	1335	6.3	1	83	A				6 46.8	-0.3	-1.3	73	6 49.6	-0.4	-1.4	89
12	1562	7.3	1	107	A				8 03.4	-0.3	-1.6	90	8 07.3	-0.4	-1.7	102
14	1758	7.0	1	130	7 22.6	-0.6	-1.8	102	7 02.5	-1.0	-1.7	108	6 59.3	-1.2	-1.7	123
23	2851	6.0	2	229	S				N				9 01.2	-0.7	-0.2	325
June 8	1506	7.1	1	75	3 38.5	-1.3	-0.5	56	S				S			

LUNAR OCCULTATIONS 1981

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
				o	h m	m	m	o	h m	m	m	o	h m	m	m	o
June 9	1625	5.9	1	88		A			6 50.1	-0.5	-1.2	60	6 50.3	-0.7	-1.3	75
10	1733	5.2	1	99		A			6 19.9	-0.5	-2.1	127	6 24.1	-0.6	-2.2	140
13	2043	6.6	1	133		A				N			7 12.1	.	.	53
13	2047	6.7	1	133		A			7 37.3	-1.1	-1.2	66	7 29.0	-1.6	-1.0	78
15	2247	5.6	1	153	3 27.8	-1.7	+0.6	93		S				S		
21	3069	6.2	2	222	6 48.6	-1.3	+1.7	233		A				A		
July 19	3171	3.8	1	204	6 39.0	-1.3	+1.5	44	6 26.4	-1.0	+1.9	38		A		
19	3171	3.8	2	204	7 48.0	-1.8	+0.1	281	7 23.5	-1.3	+0.7	294	7 07.9	-1.1	+0.9	289
19	3190d	3.0	1	206		S			10 39.2	-0.8	+0.4	36	10 26.9	-1.1	+1.0	33
19	3190d	3.0	2	206		S				S			11 29.9	-1.8	-1.1	284
25	444	6.2	2	282		S			9 34.2	-0.3	+1.6	260	9 25.2	-0.1	+1.5	260
Aug. 7	2072	6.7	1	82		A			4 22.4	-0.9	-1.6	97		S		
13	2838	5.6	1	148	2 48.8	-1.5	+0.7	95		S				S		
17	3425	4.6	2	200		S				S			12 03.9	-1.3	-0.9	263
Sept. 5	2247	5.6	1	72		A				A			3 39.4	.	.	43
8	2635	5.7	1	105	4 12.0	-1.1	-0.8	65	3 50.6	-1.4	-0.1	53	3 34.3	-1.8	+0.4	58
11	3069	6.2	1	141	6 11.8	-1.7	-1.6	111	5 43.1	-1.5	-0.3	89	5 27.5	-1.7	+0.2	88
17	364	4.3	1	221	6 38.0	-1.0	+1.4	76	6 32.2	-0.5	+1.8	57	6 20.4	-0.3	+1.9	55
17	364	4.3	2	221	7 45.0	-1.0	+1.6	231	7 34.8	-0.9	+1.5	254	7 20.1	-0.7	+1.6	256
18	491	6.2	2	234		N			6 51.3	+0.1	+2.5	199	6 41.8	+0.2	+2.4	201
19	650	5.7	2	248	7 50.1	-0.9	+1.3	267	7 41.3	-0.7	+1.1	291	7 30.9	-0.5	+1.0	293
21	991	6.1	2	276	10 02.0	-0.6	+2.5	227	10 00.7	-0.5	+1.8	251	9 49.3	-0.2	+1.8	250
22	1113d	5.2	2	287	7 41.4	0.0	+1.3	274		A				A		
22	1127	5.9	2	288	9 40.8	-0.1	+3.2	218	9 48.1	-0.1	+2.0	245	9 39.9	+0.2	+1.9	243
Oct. 6	2725d	5.8	1	85		A			2 49.4	-1.5	-1.0	109	2 36.9	-1.8	-0.7	111
10	3271	7.1	1	131	1 04.4	-1.3	+0.9	101		S				S		
10	3288	5.9	1	133	6 06.8	-0.4	+0.7	25		N				N		
11	3425	4.6	1	146	5 47.8	-0.7	+0.9	30		G				N		
11	3428d	5.2	1	146		N			5 46.5	-2.3	-1.4	124	5 27.9	-2.3	-0.5	119
18	915	4.7	2	243		N			6 04.4	.	.	191	5 59.3	+1.1	+3.3	192
19	1077d	**3.7-4.1**	1	257	5 27.6	.	.	156		A				A		
19	1077d	**3.7-4.1**	2	257	5 45.5	.	.	195	6 05.2	+0.5	+2.0	228		A		
Nov. 3	2822	5.6	1	66		A			1 57.3	-1.4	-1.0	95	1 45.9	-1.7	-0.6	94
5	3084	6.8	1	89		A			3 14.4	-1.5	-1.0	98	3 01.4	-1.8	-0.5	95
6	3225d	7.1	1	101	4 43.3	-0.9	-1.0	77	4 26.9	-0.9	-0.2	52	4 16.7	-1.2	+0.3	49
7	3356	5.9	1	113	4 34.3	-1.0	-0.4	66	4 18.6	-0.9	+0.5	40	4 05.6	-1.1	+1.1	37
8	3490	7.1	1	125		N			0 54.5	-1.1	+1.0	115		S		
8	3506	6.3	1	127	6 23.3	-0.3	+1.0	21		N				N		
13	730	5.1	2	200		S			13 22.6	.	.	337	13 37.1	-0.4	-2.5	304
16	1171	6.3	2	239		N			5 48.7	+0.4	+2.7	219	5 42.5	+0.7	+2.5	216
17	1322	6.1	2	253	8 37.3	-1.4	-2.5	339		N				N		
29	2769	6.3	1	35	23 24.7	-1.3	-1.3	95		S				S		
Dec. 2	3049	7.2	1	58		A				A			3 20.7	-0.2	+0.6	25
4	3428d	5.2	1	92	23 51.4	-0.7	+2.0	16		N				N		
5	3438	7.5	1	93		N			0 52.6	-1.7	+0.4	104		N		
5	18	6.0	1	105	23 38.5	.	.	125		S				S		
8	291	7.1	1	133	1 43.3	-1.0	+1.6	51	1 38.8	-0.4	+2.1	28	1 25.6	-0.3	+2.3	24
8	306	6.9	1	134	5 49.9	.	.	353		N				N		
13	1129d	5.3	2	208		N				N			9 56.5	.	.	335
15	1418	5.9	2	236		N				N			14 06.1	-0.2	-3.5	346
16	1504	5.7	2	246	6 10.2	-0.5	+0.6	301	6 06.0	-0.2	+0.1	321		A		
31	3271	7.1	1	51	1 01.6	-0.2	+0.7	23		N				N		

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	°
Jan. 8	3157d	7.1	1	31	22 24.7	-1.6	-2.2	114		S				S		
12	49	6.3	1	72		A				A			3 32.2	-0.4	-0.4	71
14	306	6.9	1	98	0 55.1	.	.	355	0 38.4	-0.6	+3.6	8	0 13.1	-0.9	+3.1	18
15	444	6.2	1	111	0 03.2	.	.	131		G				N		
15	453	7.3	1	112	3 19.9	-1.2	-0.4	70	3 15.8	-1.5	-0.6	81	3 07.1	-2.1	-1.2	99
15	462	5.9	1	113	5 30.9	-0.3	-1.3	89	5 34.6	-0.4	-1.7	103	5 45.7	-0.4	-3.9	135
16	618	7.2	1	127		N			7 21.7	-0.7	+1.6	24	7 13.4	-0.6	0.0	57
18	913	5.2	1	153	3 53.8	-1.9	+0.1	78	3 45.0	-2.1	-0.2	90	3 29.8	-2.5	-0.8	109
18	940	5.7	1	154	8 25.2	-0.8	+0.2	43	8 22.2	-0.7	-0.3	62	8 20.3	-0.8	-1.0	89
Feb. 10	405	4.4	1	80	22 55.8	-1.2	+1.8	34	22 43.2	-1.4	+1.8	40		S		
21	1733	5.2	2	207	3 57.8	-1.6	+1.7	261	3 41.4	-1.7	+3.5	239		N		
23	1950	5.8	2	230	6 46.6	.	.	227		N				N		
26	2291	5.5	2	264		S			10 43.9	.	.	234		N		
Mar. 1	2697	6.5	2	298		N				G			10 21.0	-0.7	-0.5	314
11	516	7.3	1	65		A			2 59.3	-0.4	+0.2	45	2 56.2	-0.5	-0.4	71
14	995d	4.1	1	104		N			3 14.4	-1.9	+1.0	46	2 57.9	-1.9	-0.2	77
15	1135	6.8	1	118	4 39.1	-0.9	-1.1	84	4 39.3	-1.0	-1.4	98	4 41.9	-0.9	-2.2	125
15	1138	7.1	1	118		N			5 19.2	-1.9	+1.4	39	5 05.8	-1.5	-0.5	75
16	1259	5.9	1	129	3 27.6	-1.8	-0.8	89	3 23.1	-1.8	-1.2	104	3 18.4	-1.8	-2.3	132
16	1275	5.6	1	131		N				N			8 10.0	.	.	36
17	1385	6.5	1	142	6 13.0	-0.4	-2.5	140	6 21.8	-0.1	-3.2	157		N		
24	2128	5.8	2	222	8 25.8	.	.	348	8 29.7	-1.4	-2.2	332	8 26.2	-2.1	-1.3	307
25	2223d	4.0	2	232	4 34.4	-0.8	+0.8	287	4 26.6	-0.9	+1.3	270		A		
25	2247	5.6	2	234		S				S			10 38.4	-2.8	+0.1	252
28	2633d	4.0	1	267	8 31.5	-2.0	+1.6	67	8 17.8	-1.7	+1.3	80	8 00.7	-1.1	+0.6	105
28	2633d	4.0	2	267	9 44.9	-1.7	-0.6	310	9 38.2	-1.8	-0.2	299	9 22.3	-1.9	+0.5	278
29	2797	3.0	1	279		N				N			9 40.3	-2.3	+2.4	51
29	2797	3.0	2	279		N				S			10 44.7	-1.8	-1.1	315
Apr. 7	453	7.3	1	31	0 20.6	0.0	-2.5	122	0 33.9	.	.	150		N		
8	618	7.2	1	47		A				A			2 34.2	+0.1	-1.8	116
9	764d	5.0	1	60	0 47.3	-1.0	-0.2	60	0 44.2	-1.1	-0.6	75	0 40.0	-1.3	-1.3	100
10	940	5.7	1	74	2 46.3	0.0	-2.3	127	2 56.3	+0.3	-3.2	147		N		
12	1245d	7.5	1	101		A				A			6 33.1	-0.1	-0.7	78
13	1345	7.1	1	111	2 01.3	.	.	51	1 46.6	-2.5	+0.3	74	1 28.7	-2.4	-0.8	104
15	1562	7.3	1	134	1 08.2	-1.6	-1.4	135	1 08.3	-1.3	-2.4	153		N		
May 9	1186	6.1	1	69	3 16.6	+0.2	-2.0	129	3 25.6	+0.4	-2.4	143		N		
10	1310d	4.2	1	80		N			1 19.1	.	.	38	0 53.7	-2.3	-0.2	81
10	1319	7.5	1	81	3 11.0	+0.1	-2.5	144	3 22.0	+0.4	-3.2	162		N		
14	1741	7.2	1	127	1 22.5	-3.1	+1.3	69	1 07.3	-2.5	+0.3	90		S		
16	1950	5.8	1	150	1 59.4	-1.3	-1.3	141	2 00.3	-0.9	-2.1	159		N		
23	2838	5.6	2	228	7 26.1	-2.1	+1.9	217	7 06.1	.	.	204		N		
June 8	1506	7.1	1	75		A			4 01.9	-0.4	-0.4	59	4 02.5	-0.5	-0.9	82
12	1923	7.1	1	120	3 14.3	-1.3	-1.9	126	3 15.5	-1.4	-2.2	137	3 20.6	-1.0	-3.1	161
14	2128	5.8	1	142	2 28.9	.	.	49	2 07.4	-3.1	+1.0	73	1 43.1	-2.2	0.0	104
15	2247	5.6	1	153	4 18.7	-2.2	-0.4	81	4 10.0	-2.4	-0.5	91	3 54.1	-2.4	-0.8	112
19	2779d	3.9	2	197	2 48.4	-1.0	+0.8	287	2 40.4	-1.0	+1.1	274		A		
21	3069	6.2	2	222	7 15.2	-1.6	+1.6	217	7 00.8	-1.8	+2.2	211	6 27.4	.	.	194
July 7	1684	7.0	1	66	2 28.0	-0.3	-1.6	103	2 32.4	-0.4	-1.7	111	2 39.8	-0.5	-2.0	128
11	2089	6.8	1	111		N			1 49.0	.	.	48		S		
19	3171	3.8	1	204	7 11.3	-1.8	+0.2	74	7 01.5	-2.1	+0.4	76	6 40.4	-2.4	+0.7	80

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS				Wa WASHINGTON, D.C.				AG ALABAMA-GEORGIA			
					W. 72°.500, N. 42°.500				W. 77°.000, N. 38°.900				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	°
July 19	3171	3.8	2	204	8 31.0	-1.3	0.0	241	8 24.2	-1.5	+0.3	239	8 07.4	-1.9	+0.8	236
21	3428d	5.2	2	227	3 50.1	-0.7	+2.6	207		A				N		
25	444	6.2	2	282		S				S			9 01.5	+0.1	+3.4	190
Aug. 4	1741	7.2	1	46		A			1 35.7	-0.3	-1.4	94	1 41.3	-0.5	-1.6	109
6	1950	5.8	1	69	0 52.9	-0.7	-2.8	157	1 00.8	-0.6	-3.5	170		N		
9	2291	5.5	1	103		A				A			4 09.1	-1.2	-0.7	74
10	2408	6.9	1	113	1 34.7	-2.0	-1.0	106	1 28.9	-2.2	-1.0	114	1 18.2	-2.2	-1.5	132
13	2838	5.6	1	148	3 33.8	-2.1	-0.8	107	3 26.3	-2.4	-0.7	111	3 11.1	-2.5	-1.0	123
13	2851	6.0	1	149		A			6 31.1	-0.6	+0.2	46	6 23.0	-1.1	+0.4	51
21	405	4.4	1	252	7 50.8	-0.7	+2.5	27	7 38.4	-0.7	+2.6	29	7 18.4	-0.5	+2.5	32
21	405	4.4	2	252	8 52.1	-2.2	0.0	278	8 41.6	-2.2	+0.4	275	8 21.3	-2.0	+0.7	272
Sept. 6	2361	4.8	1	82	1 17.3	-1.5	-2.0	125	1 17.7	-1.7	-2.2	131	1 16.7	-2.1	-2.8	145
8	2618	6.6	1	104		N				N			1 14.7	.	.	36
8	2635	5.7	1	105		A				A			4 46.0	-1.3	-1.8	112
9	2779d	3.9	1	116	3 27.8	-0.7	+0.3	41	3 22.6	-1.1	+0.4	45	3 08.3	-1.8	+0.7	52
10	3035	6.8	1	139	24 09.6	.	.	21	23 51.3	-1.8	+2.7	33		S		
12	3190d	3.0	1	152	2 36.7	-1.3	+1.7	30	2 23.6	-1.5	+2.0	33	1 58.0	-1.8	+2.1	42
12	3190d	3.0	2	152	3 40.5	-2.4	-0.8	287	3 31.8	-2.5	-0.5	285	3 12.5	-2.6	0.0	280
19	650	5.7	2	248	8 04.3	-1.1	+2.3	220	7 50.8	-0.9	+2.6	215	7 28.6	-0.5	+2.9	209
22	1113d	5.2	2	287	7 31.4	-0.2	+2.3	233	7 22.6	+0.1	+2.5	226	7 10.2	+0.6	+2.7	216
25	1493d	6.4	2	325	8 58.3	-0.1	+1.5	264		A				A		
Oct. 8	3113	5.4	1	118	22 55.3	.	.	12		S				S		
10	3288	5.9	1	133		A			6 21.3	-0.7	-0.9	81	6 19.4	-1.3	-1.1	91
11	3419d	4.5	1	146	5 36.8	+0.3	+2.9	1	5 28.0	-0.1	+2.3	10	5 12.2	-0.6	+2.2	17
11	3425	4.6	1	146	6 10.8	-1.0	-0.9	79	6 08.9	-1.3	-0.9	85	6 02.0	-1.9	-1.0	93
19	1086	6.5	2	258	9 13.9	-2.0	-1.0	301	9 07.2	-2.0	-0.3	289	8 50.3	-1.9	+0.6	273
20	1205	6.3	2	269	4 44.7	+0.7	+2.9	215		A				N		
23	1576	5.3	2	307	8 19.2	-0.1	+3.7	229		N				N		
Nov. 7	3356	5.9	1	113		A			5 20.5	.	.	141		N		
8	60	7.0	1	137	22 55.9	-1.0	+1.7	59	22 45.4	-0.9	+1.7	61		S		
8	3506	6.3	1	127		A			6 32.4	-0.4	-0.8	76	6 32.9	-0.9	-1.1	91
15	1047d	5.2	2	227		N				N			10 39.5	-1.4	-2.9	316
17	1322	6.1	2	253	9 26.5	-1.7	-1.5	309	9 22.2	-2.0	-0.7	294	9 05.8	-2.1	+0.6	270
29	2762	6.0	1	34	22 10.0	-1.1	-0.7	70		S				S		
Dec. 4	3428d	5.2	1	92	24 12.1	-1.6	+0.3	63	24 02.8	-1.8	+0.5	65	23 42.3	-2.2	+1.0	66
6	25	7.5	1	106	3 35.4	.	.	346	3 22.0	0.0	+3.0	3	3 04.8	-0.5	+2.3	16
8	291	7.1	1	133	2 18.1	-2.3	-0.9	102	2 10.2	-2.8	-1.0	108	1 51.9	-3.4	-1.1	112
8	306	6.9	1	134	5 54.0	-0.7	+0.2	46	5 50.2	-0.9	0.0	58	5 42.6	-1.3	-0.3	75
13	1125	6.4	2	207		N				N			10 48.2	-0.6	-2.6	317
13	1129d	5.3	2	208		N			11 03.4	+0.4	-4.0	342	11 18.5	-0.6	-2.1	306
16	1504	5.7	2	246	6 24.2	-1.3	+1.1	272	6 13.7	-1.1	+1.7	259	5 52.8	-0.6	+3.1	234
28	2988	6.8	1	26	21 59.1	-1.3	-1.4	97		S				S		
31	3271	7.1	1	51		A				A			1 13.4	-1.1	-1.2	90

LUNAR OCCULTATIONS 1981

Date		Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS				Te TEXAS				De DENVER, COLO.			
						W. 91.000°, N. 40.000°				W. 98.000°, N. 31.000°				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	49	6.3	1	72	3 29.3	-0.4	+0.3	43	3 24.7	-0.9	-0.2	70	3 22.0	-0.6	+1.0	32
	15	453	7.3	1	112	2 52.7	-1.7	+0.3	69	2 38.0	-2.6	-0.4	92	2 28.3	-1.6	+1.3	55
	15	462	5.9	1	113	5 23.5	-0.9	-1.7	102		N			5 06.4	-1.6	-1.5	101
	16	618	7.2	1	127	7 11.7	-0.9	+1.0	34	7 03.5	-1.0	-0.4	73	6 56.6	-1.2	+0.8	43
	17	764d	5.0	1	140		N			5 54.7	-2.1	+2.5	35		N		
	18	913	5.2	1	153	3 17.2	-1.9	+0.8	81	2 59.3	-2.3	-0.1	106	2 54.2	-1.3	+1.6	70
	18	940	5.7	1	154	8 09.1	-1.1	-0.6	73	8 10.9	-1.1	-1.6	108	7 51.2	-1.5	-0.7	85
	29	2223d	4.0	1	286		S				S			12 41.9	-1.5	-0.6	129
Feb.	9	150d	6.2	1	55		A			3 10.1	-0.5	-0.9	87	3 02.3	-0.6	0.0	53
	12	692d	1.1	1	106	20 49.7	-1.5	-0.4	131		N			20 37.6	-0.4	+0.7	111
	12	692d	1.1	2	106	21 22.5	+0.4	+3.8	192		N			21 23.7	+0.1	+2.5	214
	14	862	7.5	1	121		N				N			1 04.8	.	.	143
	14	895	5.9	1	124		N			8 29.2	.	.	16		N		
	16	1186	6.1	1	149		N			8 51.0	-1.5	+0.4	55		N		
	21	1733	5.2	2	207	3 27.7	-0.8	+3.6	235		N				A		
Mar.	1	2708	5.9	2	299		S				S			12 15.6	-1.3	+0.6	288
	11	516	7.3	1	65	2 51.2	-0.8	+0.2	49	2 47.6	-1.0	-0.7	83	2 37.8	-1.2	+0.3	53
	14	995d	4.1	1	104	2 47.9	-2.1	+1.0	55	2 30.6	-2.4	-0.4	92	2 18.3	-2.1	+1.3	60
	14	1025	7.4	1	107		A				N			8 16.2	+0.6	-2.6	145
	15	1135	6.8	1	118	4 21.2	-1.4	-1.6	110	4 35.0	-0.9	-4.0	151	3 59.7	-1.7	-1.9	122
	15	1138	7.1	1	118	4 54.8	-1.8	+0.3	59	4 46.4	-1.8	-1.1	98	4 27.4	-2.1	0.0	75
	16	1259	5.9	1	129	2 54.9	-2.0	-1.0	113	3 00.3	.	.	154	2 27.1	-2.0	-0.7	119
	16	1275	5.6	1	131		N			7 55.3	-1.1	-0.4	70	7 45.1	-1.8	+0.5	51
	17	1385	6.5	1	142	6 21.5	.	.	186		N				N		
	24	2128	5.8	2	222	8 07.1	-1.5	-1.0	314	7 58.2	-2.4	+0.1	281	7 45.3	-1.5	+0.1	294
	25	2247	5.6	2	234	10 21.9	-2.5	-0.2	262		G			9 42.4	-3.2	+1.9	242
	28	2633d	4.0	2	267	9 16.5	-1.3	+0.6	288	8 57.6	-1.6	+1.5	257		A		
	29	2797	3.0	1	279	9 47.2	.	.	34	9 13.8	-1.2	+1.6	74		A		
	29	2797	3.0	2	279	10 27.8	.	.	333	10 25.4	-1.3	0.0	298	10 18.0	-0.6	-0.2	315
Apr.	8	618	7.2	1	47	2 22.8	-0.2	-1.4	97	2 40.7	+0.2	-3.6	140	2 17.1	-0.6	-1.8	106
	12	1245d	7.5	1	101	6 26.4	-0.4	-0.7	67	6 32.3	-0.3	-1.2	98	6 18.4	-0.7	-1.1	84
	13	1345	7.1	1	111	1 13.5	-2.3	+0.5	85		S				S		
	14	1481	7.4	1	126		A				A			9 12.3	-0.1	-1.5	106
May	7	888	6.0	1	43		A				A			3 43.6	-0.1	-1.0	85
	9	1186	6.1	1	69	3 28.3	+0.6	-3.6	162		N				N		
	10	1327	6.8	1	82	5 19.8	-0.2	-1.2	91	5 31.6	0.0	-1.6	117	5 16.0	-0.4	-1.6	105
	10	1331	5.9-7.5	1	83		A				A			6 18.0	-0.1	-1.4	99
	14	1758	7.0	1	130	7 43.6	-0.4	-1.8	113	7 58.3	-0.4	-2.2	134	7 35.8	-0.8	-2.0	121
	16	1950	5.8	1	150	1 53.3	.	.	186		N				N		
	23	2851	6.0	2	229		S			9 55.6	-2.8	-0.7	290	9 30.9	-2.1	-0.9	313
	25	3113	5.4	2	253	9 49.2	-1.6	+2.4	206		N			9 25.4	-1.6	+2.8	209
	25	3115	6.3	2	253		N			9 53.2	.	.	315		N		
June	5	1123d	7.2	1	36		N			2 05.2	-0.7	-0.2	65		S		
	5	1127	5.9	1	36	2 29.3	-0.2	-0.8	74	2 37.6	0.0	-1.2	104		S		
	8	1506	7.1	1	75	3 52.4	-0.8	-0.9	72	3 56.9	-0.8	-1.4	101	3 38.5	-1.2	-1.2	90
	10	1733	5.2	1	99		A				A			6 52.6	-0.2	-2.3	142
	12	1923	7.1	1	120	2 54.8	-1.1	-2.4	154		N				S		
	13	2035	7.1	1	132		N			5 31.1	.	.	62		G		
	13	2043	6.6	1	133		A			7 58.4	-0.7	-1.0	84	7 45.0	-1.1	-0.6	63
	13	2047	6.7	1	133		A				A			8 02.9	-0.9	-1.3	86

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS				Te TEXAS				De DENVER, COLO.			
					W. 91.000°, N. 40.000°				W. 98.000°, N. 31.000°				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	°
June 15	2247	5.6	1	153	3 37.3	-2.1	-0.1	105	3 29.2	-1.6	-1.2	136	3 12.8	-1.3	-0.2	124
21	3069	6.2	2	222	6 38.1	-1.7	+2.4	216		N			6 14.5	-1.6	+3.3	207
July 4	1345	7.1	1	30		A				A			3 06.8	+0.2	-1.8	129
7	1684	7.0	1	66	2 22.2	-0.8	-1.9	120	2 37.0	-0.6	-2.6	147		S		
19	3171	3.8	1	204	6 34.9	-1.8	+1.2	62	6 10.0	-2.0	+1.2	77	6 11.0	-1.5	+1.7	59
19	3171	3.8	2	204	7 58.8	-2.1	+0.3	258	7 37.7	-2.3	+1.0	247	7 29.3	-2.0	+0.6	270
19	3190d	3.0	1	206		S			11 09.8	-2.4	-2.1	113	10 47.6	-1.6	-0.3	74
25	444	6.2	2	282	9 18.8	-0.5	+2.3	219	8 55.4	0.0	+2.6	206	9 13.0	-0.3	+1.9	233
Aug. 7	2072	6.7	1	82		A				A			4 53.9	-0.7	-1.9	115
9	2291	5.5	1	103	3 58.8	-1.3	-0.1	54	3 49.3	-2.1	-0.5	77	3 32.9	-2.4	+0.3	58
13	2838	5.6	1	148	2 55.0	-2.0	+0.1	108	2 44.2	-1.8	-1.0	133	2 31.2	-1.3	+0.3	116
13	2851	6.0	1	149	6 24.5	.	.	20	6 04.2	-1.6	+1.3	40		N		
17	3419d	4.5	1	200	10 42.2	-0.6	+0.7	37	10 30.9	-1.3	+0.5	56	10 34.1	-0.4	+1.9	15
17	3419d	4.5	2	200		S				S			11 24.3	-1.8	-2.0	288
21	405	4.4	1	252	7 39.3	.	.	358	7 09.7	0.0	+2.9	17		N		
21	405	4.4	2	252	8 08.5	.	.	308	7 55.3	-1.8	+0.2	290		N		
26	1171	6.3	2	319		S			11 09.5	-0.7	+0.5	286	11 02.6	-1.2	-1.3	330
27	1310d	4.2	2	332		S				N			11 53.5	0.0	+1.8	248
Sept. 4	2128	5.8	1	61		N			2 53.5	.	.	31		N		
6	2361	4.8	1	82	0 49.4	-2.0	-1.7	131		S				S		
8	2635	5.7	1	105	4 28.3	-1.2	-1.2	88	4 29.0	-1.9	-1.4	103	4 08.0	-1.7	-0.6	78
9	2779d	3.9	1	116	3 07.2	.	.	25	2 38.4	-2.5	+1.5	48		G		
11	3069	6.2	1	141		N				N			6 13.7	.	.	128
12	3190d	3.0	1	152	2 05.6	-1.4	+2.8	22	1 32.2	-1.5	+2.2	46	1 45.5	-1.3	+3.1	23
12	3190d	3.0	2	152	2 56.0	-2.3	-0.5	304	2 41.3	-2.1	+0.3	285	2 29.7	-1.4	-0.2	309
17	364	4.3	1	221	6 37.1	-2.0	+0.3	106	6 22.0	.	.	122	6 16.0	-1.1	+1.3	86
17	364	4.3	2	221	7 29.8	-0.6	+2.9	197	6 56.6	.	.	180	7 18.5	-0.8	+2.2	220
19	650	5.7	2	248	7 40.3	-0.9	+1.9	238	7 17.2	-0.4	+2.2	224	7 29.2	-0.6	+1.5	254
21	991	6.1	2	276		N				N			9 27.0	.	.	196
22	1113d	5.2	2	287	7 26.6	+0.2	+1.7	246		A				A		
Oct. 6	2725d	5.8	1	85		N				N			3 31.9	.	.	147
10	3271	7.1	1	131	1 09.9	-2.2	-0.3	123		N				S		
10	3288	5.9	1	133	6 08.7	-0.9	-0.2	61	6 01.8	-1.7	-0.3	76	5 54.4	-1.0	+0.7	42
11	3419d	4.5	1	146		N			5 06.4	.	.	346		N		
11	3425	4.6	1	146	5 49.4	-1.4	+0.1	63	5 36.1	-2.1	+0.1	76	5 29.9	-1.3	+1.1	43
19	1086	6.5	2	258	8 40.5	-1.7	-0.4	303	8 27.9	-1.4	+0.6	278	8 17.5	-1.6	-1.1	321
Nov. 3	2822	5.6	1	66		N				N			2 35.1	-2.3	-3.1	133
6	3225d	7.1	1	101	5 06.2	-1.5	-2.8	119		N			4 45.4	-1.6	-1.3	95
7	3356	5.9	1	113	4 51.8	-1.6	-1.8	103	5 01.0	.	.	135	4 27.8	-1.8	-0.4	81
8	3506	6.3	1	127	6 23.6	-0.7	-0.2	61	6 20.2	-1.4	-0.7	83	6 11.7	-0.9	+0.5	45
14	881d	5.9	2	213	11 03.5	-1.1	-1.9	295	11 03.2	-1.8	-0.3	259	10 43.7	-1.7	-1.4	288
15	1047d	5.2	2	227		N			10 20.0	-2.2	-1.7	299		N		
17	1322	6.1	2	253	8 56.0	-1.7	-0.2	295	8 40.0	-1.5	+1.1	265	8 35.4	-1.3	+0.1	299
29	2769	6.3	1	35	23 50.8	-1.8	-2.3	123	24 02.6	.	.	146		S		
Dec. 4	3428d	5.2	1	92	23 40.5	-1.5	+1.6	43		S				S		
6	25	7.5	1	106		N			2 56.9	.	.	351		N		
8	291	7.1	1	133	1 38.9	-1.8	+0.9	79	1 17.6	-2.0	+0.8	90	1 18.4	-1.1	+1.7	60
8	306	6.9	1	134	5 36.2	-1.1	+0.7	46	5 22.1	-1.8	+0.2	70	5 19.6	-1.1	+1.6	32
13	1125	6.4	2	207	10 22.4	-0.4	-4.3	338	10 38.5	-1.5	-1.6	293	10 10.1	-1.4	-2.7	319
13	1129d	5.3	2	208	10 58.2	-0.6	-2.8	321	11 09.1	-1.4	-1.2	283	10 45.3	-1.3	-2.0	304
16	1504	5.7	2	246	6 03.7	-0.6	+1.4	266	5 43.7	+0.1	+2.8	233	5 58.5	-0.2	+1.2	272
31	3271	7.1	1	51	1 03.1	-0.8	-0.3	60	0 58.2	-1.5	-0.4	77	0 50.7	-0.9	+0.6	41

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121.000°, N. 42.500°				Ca CALIFORNIA W.120.000°, N. 36.000°				NM N. MEX.-ARIZ. W.109.000°, N. 34.000°			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				o	h m	m	m	o	h m	m	m	o	h m	m	m	o
Jan. 12	49	6.3	1	72	3 21.9	.	.	354	3 06.0	-0.9	+1.6	28	3 14.6	-1.0	+0.6	49
15	453	7.3	1	112	2 13.5	-0.8	+2.7	25	1 59.2	-1.3	+2.1	46	2 14.0	-2.0	+1.1	67
15	462	5.9	1	113	4 36.3	-1.8	-0.1	80	4 42.3	-2.4	-1.3	105	5 12.3	-2.1	-3.5	126
16	618	7.2	1	127	6 38.1	-1.4	+1.9	32	6 32.4	-1.7	+0.6	59	6 49.4	-1.4	0.0	66
16	627	6.8	1	129	9 39.7	-0.8	+1.1	29	9 37.6	-0.6	0.0	55	9 42.7	-0.3	+0.1	53
17	764d	5.0	1	140		N				N			5 43.5	.	.	15
18	913	5.2	1	153	2 45.5	-0.5	+2.5	45	2 32.2	-0.7	+1.8	65	2 40.9	-1.4	+1.1	84
18	940	5.7	1	154	7 22.6	-1.8	-0.1	82	7 28.3	-2.0	-1.1	104	7 51.2	-1.6	-1.5	107
29	2223d	4.0	1	286	12 23.3	-0.6	-0.7	145	12 32.6	-0.1	-2.3	166	12 43.0	-1.0	-1.7	151
29	2223d	4.0	2	286	13 33.5	-2.2	+1.0	264	13 26.8	-3.1	+2.1	246		S		
Feb. 8	20	6.8	1	42		N			3 52.4	-0.1	+1.2	26		A		
9	150d	6.2	1	55	2 52.5	-0.7	+1.0	32	2 49.5	-1.1	+0.3	56	3 00.5	-0.8	-0.4	71
10	291	7.1	1	69	3 44.3	.	.	131		N				N		
12	692d	1.1	1	106	20 38.7	+0.2	+1.1	91	20 32.5	+0.1	+0.7	106	20 33.3	-0.5	+0.1	123
12	692d	1.1	2	106	21 30.1	+0.1	+1.8	237	21 17.7	+0.3	+2.0	222	21 09.5	+0.4	+2.8	202
14	895	5.9	1	124		N			8 02.8	-1.8	+1.8	35	8 18.1	.	.	25
16	1186	6.1	1	149	8 13.9	-2.4	+1.6	46	8 11.8	-2.1	0.0	72	8 33.5	-1.8	+0.1	63
Mar. 1	2708	5.9	2	299		A				A			12 05.5	-1.4	+1.0	270
11	516	7.3	1	65		S				S			2 32.6	-1.4	-0.3	73
11	526	6.9	1	66	5 12.2	-0.5	-1.5	95	5 24.4	-0.2	-2.3	119		A		
13	862	7.5	1	94	8 21.2	+0.5	-2.6	138		N				A		
13	863	6.7	1	94	8 32.2	+0.6	-2.6	140		N				A		
14	995d	4.1	1	104		S				S			2 04.2	-2.3	+0.5	81
14	1025	7.4	1	107	8 17.6	+0.8	-4.2	161		N				N		
15	1135	6.8	1	118	3 25.2	-2.0	-1.0	119	3 40.8	-2.1	-3.7	147	4 09.1	-1.5	-4.2	151
15	1138	7.1	1	118	3 54.6	-2.1	+0.8	75	3 55.2	-2.3	-0.3	97	4 21.4	-2.2	-0.8	98
16	1259	5.9	1	129		S				S			2 27.3	-2.1	-2.5	143
16	1275	5.6	1	131	7 15.8	-1.9	-0.1	68	7 20.7	-1.8	-0.8	87	7 39.9	-1.4	-0.6	77
24	2128	5.8	2	222	7 25.9	-1.1	+1.0	281	7 18.9	-1.5	+1.7	260	7 35.5	-2.0	+1.0	271
25	2245	6.4	2	234		N			8 15.2	-0.1	-1.7	340	8 19.4	.	.	356
29	2797	3.0	2	279		A				A			10 14.4	-0.8	+0.4	294
Apr. 8	618	7.2	1	47		S				S			2 28.5	-0.5	-3.4	134
8	627	6.8	1	48	4 42.1	-0.2	-1.4	95	4 52.5	+0.1	-1.9	116		A		
10	971	7.3	1	76	6 37.5	0.0	-1.9	118	6 50.7	+0.4	-2.3	136		A		
12	1245d	7.5	1	101	5 59.8	-1.2	-1.3	96	6 10.9	-1.0	-1.7	112	6 23.0	-0.7	-1.5	103
14	1481	7.4	1	126	9 03.7	-0.4	-1.8	114	9 16.4	-0.3	-2.0	125	9 21.5	0.0	-1.7	120
25	2746	5.8	2	248	10 14.9	.	.	341	10 24.1	-1.2	-0.8	319	10 43.0	-1.8	-1.7	324
29	3303	6.2	2	296		A				A			10 52.0	-0.9	+1.9	235
May 7	888	6.0	1	43		S			3 46.1	-0.2	-1.7	111	3 50.2	0.0	-1.4	105
7	895	5.9	1	43	4 42.2	+0.1	-1.8	115	4 54.6	+0.5	-2.2	134		A		
10	1327	6.8	1	82	5 01.4	-0.8	-1.9	117	5 15.6	-0.5	-2.3	132	5 24.5	-0.3	-1.9	123
10	1331	5.9-7.5	1	83	6 09.6	-0.4	-1.7	109	6 21.6	-0.2	-1.9	122	6 26.4	0.0	-1.6	115
10	1335	6.3	1	83	7 00.1	-0.2	-1.5	99	7 10.0	0.0	-1.5	111		A		
12	1562	7.3	1	107	8 19.7	-0.3	-1.7	110	8 31.5	-0.1	-1.8	121		A		
14	1758	7.0	1	130	7 14.6	-1.1	-2.1	132	7 30.6	-1.0	-2.5	143	7 45.0	-0.8	-2.3	135
23	2851	6.0	2	229	9 04.0	-1.2	-0.1	311	9 05.1	-1.6	+0.1	296	9 26.0	-2.2	-0.4	298
25	3115	6.3	2	253		N			9 12.4	.	.	332	9 24.5	.	.	332
26	3256	6.2	2	265	10 11.9	-0.8	-0.2	315	10 11.9	-1.0	+0.4	296	10 26.3	-1.7	+0.3	291
June 8	1506	7.1	1	75		S				S			3 42.1	-1.1	-1.6	108
9	1625	5.9	1	88	7 00.3	-0.5	-1.3	85	7 09.5	-0.4	-1.4	96		A		
10	1733	5.2	1	99	6 41.1	-0.5	-2.5	148	6 59.2	-0.2	-3.0	162	7 06.6	-0.1	-2.8	158
13	2035	7.1	1	132	4 24.5	-2.9	+1.1	72	4 23.0	-2.8	+0.2	89	4 56.7	-3.3	+0.4	73
13	2043	6.6	1	133	7 18.1	-2.1	-0.4	67	7 24.1	-2.0	-0.8	80	7 44.3	-1.3	-0.9	78
13	2047	6.7	1	133	7 39.7	-1.6	-1.2	87	7 49.7	-1.6	-1.4	98	8 07.0	-1.0	-1.5	98
15	2247	5.6	1	153		S				S			3 12.1	-0.9	-1.2	147

LUNAR OCCULTATIONS 1981

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON				Ca CALIFORNIA				NM N. MEX.-ARIZ.			
					W.121.000°, N. 42.500°				W.120.000°, N. 36.000°				W.109.000°, N. 34.000°			
					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	°
June 23	3356	5.9	2	248		S			11 03.1	-1.1	+2.9	197		G		
27	364	4.3	1	301		S			11 54.3	-0.5	+1.9	54		S		
July 4	1345	7.1	1	30		S				S			3 19.5	+0.4	-2.2	147
19	3171	3.8	1	204		A			5 45.3	-1.0	+1.6	70	5 55.4	-1.4	+1.5	70
19	3171	3.8	2	204	7 04.1	-1.4	+1.0	278	6 58.7	-1.5	+1.1	266	7 16.4	-2.0	+1.0	260
19	3190d	3.0	1	206	10 23.4	-1.5	+0.8	48	10 20.2	-1.9	+0.6	63	10 42.1	-2.1	-0.3	83
19	3190d	3.0	2	206	11 39.5	-1.8	-0.6	266	11 43.6	-1.6	0.0	249		S		
25	444	6.2	2	282	9 15.0	0.0	+1.6	249		A			9 01.1	-0.1	+2.0	225
28	915	4.7	2	324	11 58.9	-0.2	+0.9	286	11 52.7	-0.1	+1.0	270		S		
Aug. 7	2072	6.7	1	82	4 32.6	-1.3	-1.8	113	4 46.2	-1.3	-2.0	124	5 02.2	-0.9	-2.1	126
9	2291	5.5	1	103		S				S			3 21.9	-2.7	0.0	75
13	2851	6.0	1	149		N				N			5 54.9	.	.	14
17	3419d	4.5	1	200		N			10 22.1	.	.	354	10 21.5	-0.9	+1.6	28
17	3419d	4.5	2	200		N			10 54.0	.	.	306	11 25.9	-1.8	-1.1	272
17	3425	4.6	2	200	12 09.9	-1.1	-0.2	243	12 09.3	-0.9	+0.7	222		S		
26	1171	6.3	2	319		N				A			11 02.9	-0.6	-0.2	310
27	1310d	4.2	2	332		A				A			11 42.4	+0.4	+2.3	232
Sept. 2	1923	7.1	1	39	3 23.3	-0.5	-1.9	117		A				A		
5	2247	5.6	1	72	3 43.6	-1.5	-0.4	59	3 48.5	-1.6	-0.7	74	4 04.0	-1.0	-0.9	81
8	2635	5.7	1	105	3 36.1	-2.2	+0.3	69	3 37.4	-2.5	0.0	81	4 03.8	-2.2	-0.6	88
9	2779d	3.9	1	116		S				S			2 15.5	.	.	40
9	2802	6.4	1	118	7 03.6	-0.5	+0.4	36	7 03.2	-0.9	0.0	56	7 13.3	-0.8	-0.7	75
10	2938	7.3	1	130		A			8 37.4	-0.9	-0.8	79		A		
11	3069	6.2	1	141	5 31.1	-2.2	-0.1	99	5 36.5	-2.8	-0.9	115		G		
12	3190d	3.0	2	152		S			2 13.5	-0.7	+0.5	294	2 23.6	-1.3	+0.3	293
17	364	4.3	1	221	6 09.1	-0.4	+1.7	66	5 59.6	-0.5	+1.4	79	6 05.1	-1.0	+1.0	94
17	364	4.3	2	221	7 10.7	-0.7	+1.7	244	6 59.5	-0.6	+1.9	230	7 02.2	-0.6	+2.4	212
18	491	6.2	2	234	6 21.6	.	.	178		N				N		
19	650	5.7	2	248	7 24.6	-0.4	+1.1	277	7 17.2	-0.3	+1.3	263	7 18.0	-0.4	+1.6	246
21	991	6.1	2	276	9 36.5	0.0	+2.2	231	9 20.1	+0.5	+3.0	209		N		
22	1127	5.9	2	288	9 25.1	+0.5	+2.4	222		N				N		
24	1395	6.3	2	314	11 47.1	-0.7	-1.0	330	11 49.8	-0.5	+0.1	303	11 56.3	-0.8	+0.5	288
Oct. 6	2725d	5.8	1	85	2 47.6	-2.2	-1.3	122	3 01.9	.	.	139		N		
10	3288	5.9	1	133	5 46.3	.	.	5	5 32.9	-1.2	+1.8	27	5 45.1	-1.5	+0.8	50
10	3303	6.2	1	135	9 02.7	-0.1	+1.1	21	8 58.6	-0.5	+0.3	46		A		
11	3425	4.6	1	146	5 18.0	-0.6	+2.6	10	5 04.0	-1.3	+2.1	29	5 17.0	-1.7	+1.2	50
19	1086	6.5	2	258		N			7 59.4	.	.	333	8 14.9	-1.2	-0.1	302
Nov. 3	2822	5.6	1	66	1 55.5	-2.1	-1.1	106	2 07.1	-2.7	-1.9	122		G		
5	3084	6.8	1	89	3 10.9	-2.5	-1.2	111	3 27.8	.	.	136		N		
6	3225d	7.1	1	101	4 18.2	-1.6	+0.1	65	4 20.6	-2.1	-0.3	82	4 46.5	-2.3	-1.9	108
7	3356	5.9	1	113	4 01.8	-1.5	+0.9	52	3 58.5	-2.0	+0.6	67	4 22.4	-2.4	-0.6	90
8	3506	6.3	1	127	6 03.1	-0.4	+2.2	11	5 52.5	-1.1	+1.4	34	6 04.6	-1.4	+0.4	57
13	730	5.1	2	200	13 51.4	-0.5	-1.6	282		S				S		
14	881d	5.9	2	213	10 09.6	-2.1	-1.5	301	10 17.2	-2.2	-0.3	276	10 41.0	-2.0	-0.3	266
15	1047d	5.2	2	227		N			9 13.4	.	.	338	9 49.2	-2.4	-2.2	313
17	1322	6.1	2	253	8 18.1	-0.9	-0.6	322	8 19.5	-0.8	+0.3	296	8 28.5	-1.1	+0.7	281
Dec. 2	3049	7.2	1	58	3 19.9	-0.6	0.0	47	3 21.8	-1.0	-0.3	66	3 33.4	-0.9	-1.1	87
8	291	7.1	1	133	1 11.4	-0.5	+2.1	38		S			1 04.4	-1.1	+1.6	67
8	306	6.9	1	134	5 19.9	.	.	345	4 55.5	-0.9	+2.6	21	5 05.6	-1.5	+1.4	45
13	1125	6.4	2	207	9 37.2	-1.8	-2.7	323	9 50.7	-2.1	-1.1	295	10 15.2	-1.9	-1.4	293
13	1129d	5.3	2	208	10 15.6	-1.7	-1.6	304	10 24.6	-2.0	-0.6	281	10 47.8	-1.8	-1.0	281
29	3007	7.3	1	28	1 28.1	-1.2	-1.3	91	1 40.1	-1.7	-2.1	113		N		

OCCULTATION LIMITS FOR 1981

The maps show the tracks of stars brighter than $7^{\mathrm{m}}.5$ 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 $5^{\mathrm{m}}.5$ and 2° for those brighter than $3^{\mathrm{m}}.5$). 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 the region of planned observation, and details of the graze path will be supplied (cost $1.50 U.S. per event, or free for IOTA members, see pg. 59).

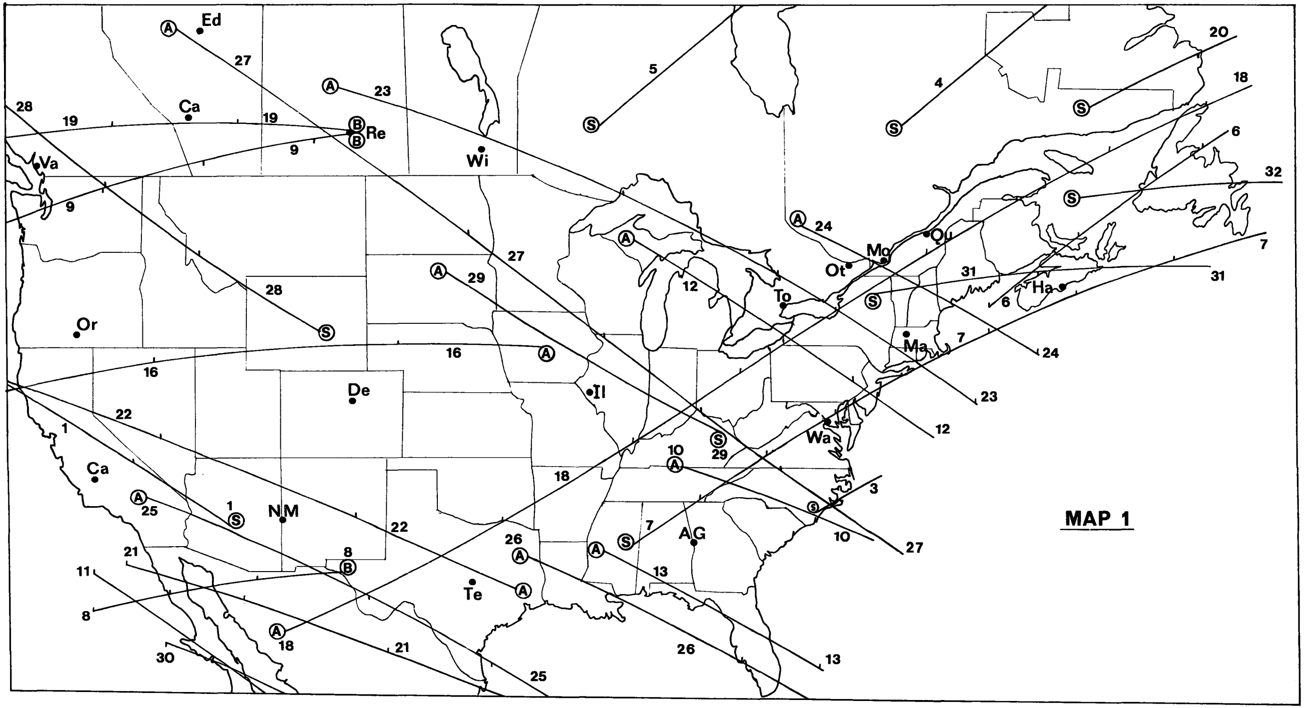
The following table gives, for each track, the date, Zodiacal Catalogue number, magnitude of the star, the time (U.T.) at the beginning of the track in the West, the percent of the Moon sunlit and whether the track is the northern (N) or southern (S) limit of the occultation. An asterisk after the track 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. 1	2158	7.3	13	37	20	S	37	Mar. 14	991	6.1	2	44	63	N
3*	8	3157	7.1	22	46	8	S	38†*	14	995	4.1	3	12	63	N
4	10	3434	7.4	21	49	23	S	39	15	1127	5.9	3	4	73	N
5*	10	3446	7.2	22	57	23	S	40	16	1259	5.9	3	57	82	N
6	11	25	7.5	21	39	33	S	41	16	1259	5.9	2	32	82	S
7	14	444	6.2	23	37	68	S	42*	16	1275	5.6	7	25	83	N
8	15	462	5.9	5	11	70	S	44	25	2247	5.6	8	50	79	S
9*	16	608	6.0	4	43	80	S	45	26	2391	7.1	12	51	70	S
10	28	2089	6.8	7	14	47	S	48*	Apr. 1	3217	7.2	11	2	14	S
11*	29	2223	4.0	13	0	36	S	49	7	453	7.3	0	38	8	S
12	30	2341	7.2	9	58	28	S	50	7	462	5.9	2	18	8	S
13	31	2463	6.9	10	13	20	S	51	8	618	7.2	2	37	16	S
16	Feb. 10	291	7.1	3	54	33	S	53*	9	787	7.5	4	44	27	S
18	12	692	1.1	20	43	64	S	55	10	940	5.7	2	35	37	S
19	13	729	7.2	4	35	67	S	58	12	1217	6.1	0	56	58	S
20	13	836	5.5	21	34	75	S	59*	12	1245	7.5	6	25	60	N
21	14	888	6.0	7	7	78	N	61	13	1345	7.1	1	50	68	N
22†	14	895	5.9	8	10	78	N	62	25	2739	6.7	9	26	68	S
23	23	1950	5.8	6	2	82	S	63	27	3026	7.3	11	13	48	S
24	25	2158	7.3	6	3	65	S	68	May 9	1193	5.4	5	8	33	N
25	25	2167	7.5	8	8	64	S	69	9	1202	6.9	7	1	34	S
26	26	2280	6.8	7	25	55	S	70	10	1310	4.2	1	11	42	N
27	26	2291	5.5	9	34	54	S	71*	10	1321	6.7	3	59	43	N
28	28	2556	7.1	12	56	34	S	72	23	2838	5.6	6	25	83	S
29	Mar. 1	2704	5.8	11	23	26	S	73*	25	3113	5.4	8	40	64	S
30	2	2859	6.7	12	5	17	S	74	25	3115	6.3	10	1	64	N
31	9	364	4.3	23	9	18	S	75	27	3392	7.1	9	50	43	S
32	10	491	6.2	22	39	27	S	77*	June 5	1123	7.2	2	18	10	N
33	11	516	7.3	3	15	29	N	78	5	1138	7.1	4	17	10	S
35	12	667	5.3	1	5	40	S	79	6	1259	5.9	1	27	17	S

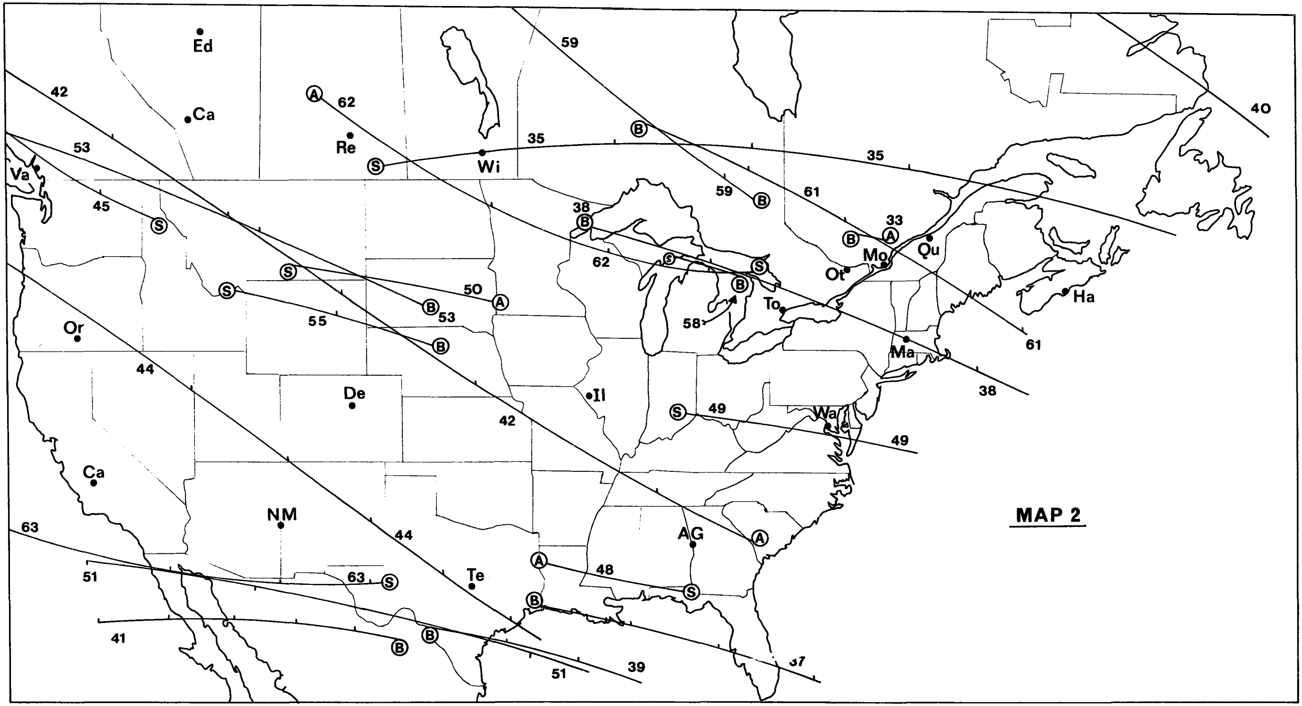
No.	Date	Z.C.	Mag.	U.T.		%	L
				h	m		
80	June 7	1387	6.8	2	0	26	N
82	8	1506	7.1	3	48	37	N
84	10	1709	6.7	0	29	56	N
85	10	1733	5.2	7	37	58	S
87	26	208	7.0	8	36	36	N
88*	29	636	6.9	10	36	7	N
89	29	650	5.7	11	54	7	N
90	July 6	1576	5.3	3	23	22	N
92	11	2089	6.8	1	49	68	N
95	24	291	7.1	6	0	52	N
96	25	453	7.3	11	43	38	N
98	Aug. 8	2167	7.5	2	38	52	N
99	9	2291	5.5	3	31	62	N
100†	21	405	4.4	7	17	65	N
102	25	1031	7.0	10	35	20	N
103	26	1171	6.3	10	47	12	N
104	Sept. 4	2128	5.8	2	33	26	N
106	8	2614	6.2	0	31	62	N
107	8	2618	6.6	1	10	63	N
108	9	2779	3.9	2	27	72	N
109	19	653	4.8	7	47	68	N
110*	19	684	6.2	12	19	66	N
111	20	796	6.8	5	53	58	N
114*	21	989	6.6	9	23	45	N
115	24	1395	6.3	11	31	15	N
117	Oct. 5	2580	6.6	4	31	37	S
118	Oct. 6	2725	5.8	3	34	46	S
119*	8	3113	5.4	23	3	74	N
120	10	3288	5.9	6	19	85	N
122	18	935	6.9	9	11	71	N
123*	18	969	7.1	14	5	69	N
124	19	1086	6.5	7	48	60	N
126	21	1343	6.6	5	15	39	N
127	Nov. 3	2822	5.6	2	41	30	S
128	5	3084	6.8	3	37	49	S
129	5	3197	6.5	22	42	58	S
130*	6	3225	7.1	5	6	60	S
131*	7	3356	5.9	4	54	70	S
132	15	1057	5.2	8	57	84	N
133	17	1287	6.7	2	40	67	N
137	17	1322	6.1	8	0	64	N
138	17	1340	6.6	12	13	63	S
139	17	1343	6.6	12	36	63	S
141	18	1459	7.5	14	5	51	S
142	19	1576	5.3	14	50	41	S
143	20	1669	6.7	9	25	33	N
144	30	2769	6.3	0	15	9	S
146	Dec. 5	3438	7.5	0	58	53	S
147†	5	5	4.7	21	36	62	S
148	5	18	6.0	23	40	63	S
151	18	1725	7.5	5	26	50	N

DOUBLE STAR NOTES 1981

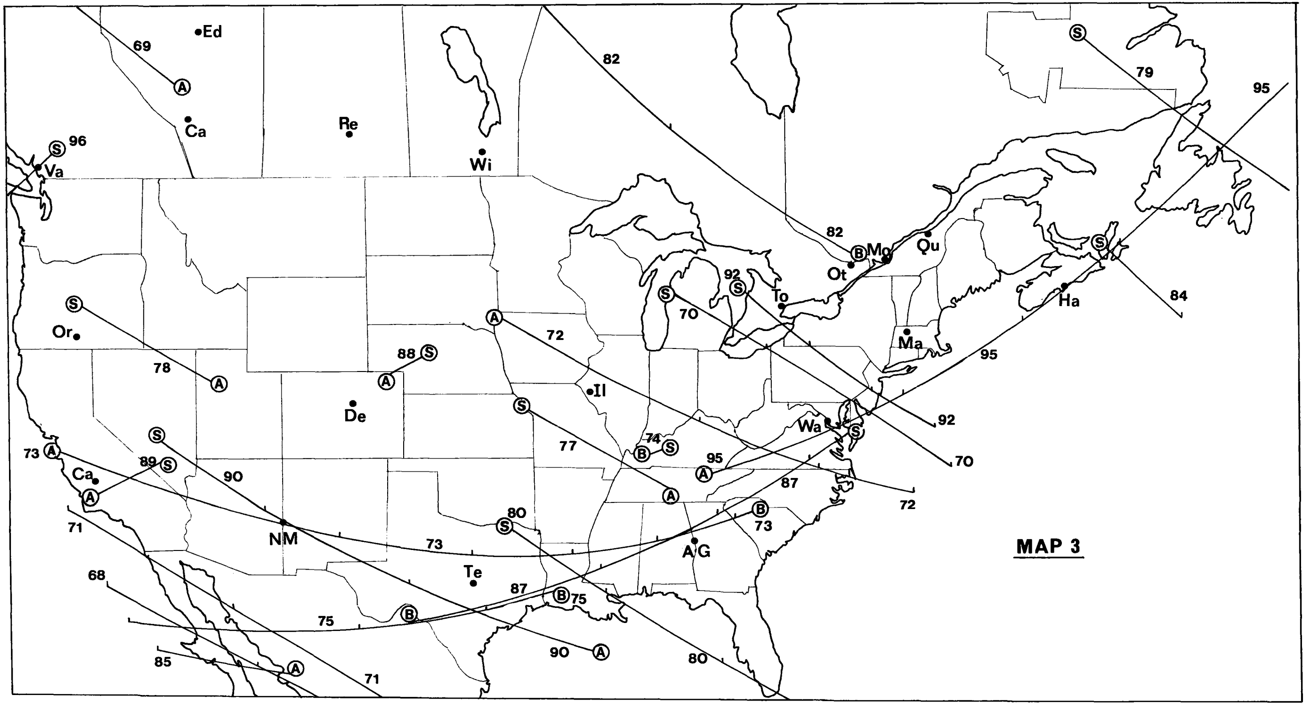
Track No.	Z.C.	
3	3157	is the brighter component of the double star Aitken 15080. The companion is of magnitude 10.5; separation 0″.8 in pa. 31°.
5	3446	is the brighter component of the double star Aitken 16725. The companion is of magnitude 8.2; separation 3″.6 in pa. 165°.
9	608	is the brighter component of the double star Aitken 2999. The companion is of magnitude 8.8; separation 3″.8 in pa. 221°.
11	2223	is 38γ Lib, G8 III-IV, the brightest component of the triple star Aitken 9704. The brighter companion is of magnitude 4.2; separation 0″.1 in pa. 285°. The third component is of magnitude 11.2 at a wide separation.
38	995	is the mean of the triple star Aitken 5103. The brightest component 18ν Gem, B7 IV e, is a 9.6 year spectroscopic binary, combined magnitude 4.0. The second component is of magnitude 8.5 at a wide separation. The third component is of magnitude 8.8; separation 0″.2 in pa. 300°.
42	1275	is 31 θ Cnc, gM1, a double star with both components of magnitude 6.4; separation at least 0″.1.
48	3217	is the brighter component of the double star Aitken 15489. The companion is of magnitude 10.9; separation 17″.6 in pa. 324°.
53	787	is the mean of the double star Aitken 3854. The components are of magnitude 8.0 and 8.5; separation 2″.5 in pa. 163°.
59	1245	is the brighter component of the double star Aitken 6696. The companion is of magnitude 10.5; separation 4″.0 in pa. 340°.
71	1321	is the mean of the double star Aitken 7039. The components are both of magnitude 7.5; separation 0″.3 in pa. 31°.
73, 119	3113	is 30 Cap, B8, a double star with both components of magnitude 6.1; separation at least 0″.1.
77	1123	is the brighter component of the double star Aitken 6060. The companion is of magnitude 8.3; separation 6″.4 in pa 44°.
88	636	is 55 Tau, the mean of the binary star Aitken 3135. The components are of magnitude 7.2 and 8.2; separation 0″.3 in pa. 88°.
100	405	is 87 μ Cet, FO IV, a spectroscopic binary with combined magnitude 4.4.
110	684	is the mean of the double star Aitken 3297. The components are of magnitude 7.0 and 7.1; separation 3″.0 in pa. 277°.
114	989	is the brighter component of the double star Aitken 5080. The companion is of magnitude 8.0 at a wide separation.
123	969	is the brightest component of the quadruple star Aitken 4962. The companions are of magnitude 7.7, 8.9 and 10.8. All the components are at a wide separation.
130	3225	is the brighter component of the double star Aitken 15546. The companion is of magnitude 10.6; separation 9″.1 in pa. 271°.
131	3356	is 74 Aqr, B9, a double star with both components of magnitude 6.7; separation at least 0″.2.
147	5	is 33 Psc, K1, a spectroscopic binary with combined magnitude 4.7.



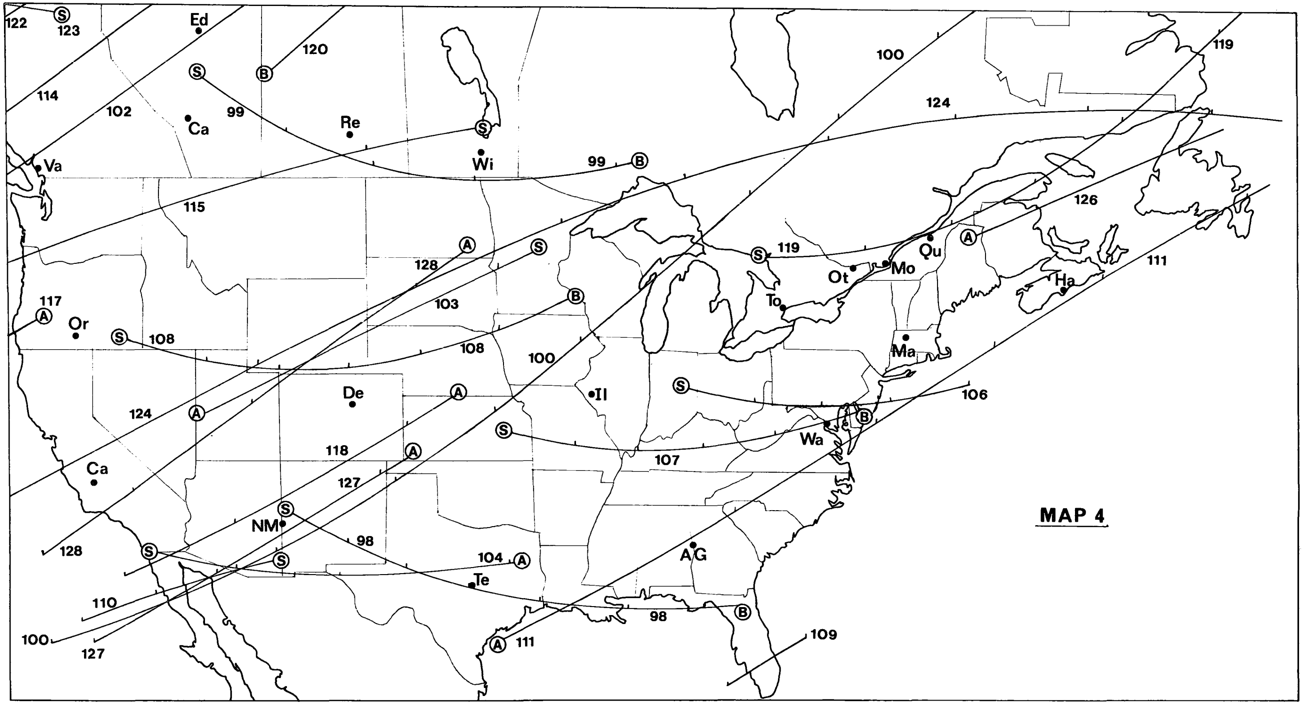
Map 1: Tracks 1 to 32; Grazes Jan. 1 to Mar. 10, 1981



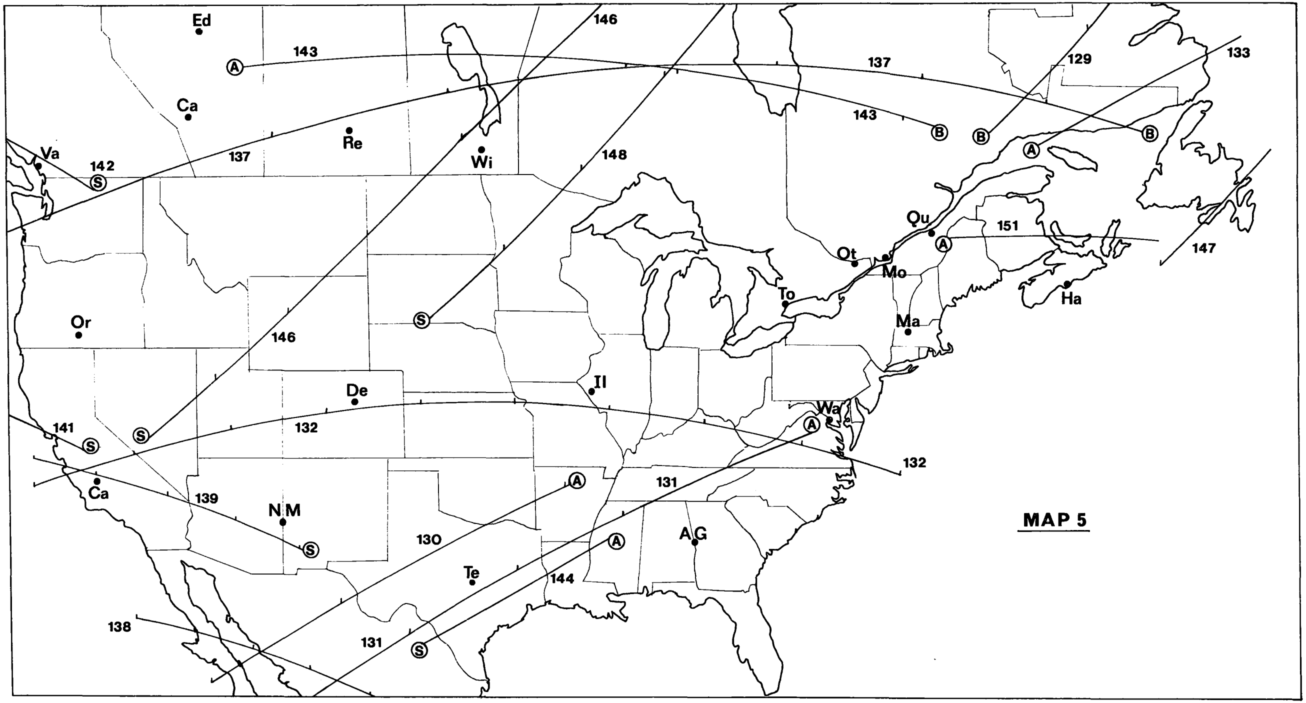
Map 2: Tracks 33 to 63; Grazes Mar. 11 to Apr. 27, 1981.



Map 3: Tracks 68 to 96; Grazes May 9 to July 25, 1981.



Map 4: Tracks 98 to 128; Grazes Aug. 8 to Nov. 5, 1981.



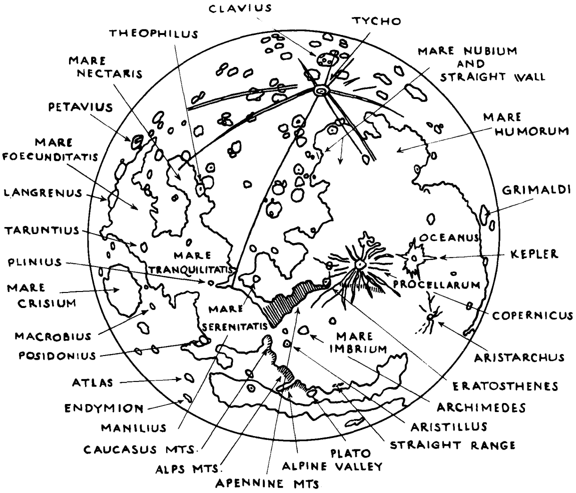
Map 5: *Tracks 129 to 151; Grazes Nov. 5 to Dec. 18, 1981.*

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
5	33 Psc	940	68 Ori	1493	34 Leo	2779	39 o Sgr
150	26 Cet	989	15 Gem	1504	37 Leo	2797	41 π Sgr
364	73 ξ^2 Cet	991	16 Gem	1576	53 Leo	2838	50 Sgr
405	87 μ Cet	995	18 ν Gem	1733	7 Vir	3069	20 Cap
636	55 Tau	1047	36 Gem	1950	80 Vir	3113	30 Cap
650	63 Tau	1077	43 ζ Gem	2128	13 Lib	3115	31 Cap
653	64 Tau	1113	56 Gem	2223	38 γ Lib	3171	40 γ Cap
667	75 Tau	1127	61 Gem	2247	44 η Lib	3190	49 δ Cap
692	87 α Tau	1129	63 Gem	2271	46 θ Lib	3256	39 Aqr
730	97 ι Tau	1171	79 Gem	2291	49 Lib	3288	50 Aqr
764	104 Tau	1193	85 Gem	2361	7 χ Oph	3356	74 Aqr
863	127 Tau	1259	20 Cnc	2633	13 μ Sgr	3419	91 ψ^1 Aqr
894	54 χ^2 Ori	1275	31 θ Cnc	2635	14 Sgr	3425	93 ψ^2 Aqr
895	57 Ori	1310	47 δ Cnc	2725	28 Sgr	3428	95 ψ^3 Aqr
913	64 Ori	1345	68 Cnc	2739	31 Sgr		
915	62 χ^2 Ori	1418	8 Leo	2746	33 Sgr		



MAP OF THE MOON: SOUTH IS AT THE TOP

THE PLANETS FOR 1981

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 1981

Date E.S.T.	Elong.	Mag.	App. Diam.
	°		″
Feb. 1	18E	−0.3	6.8
Mar. 15	28W	+0.4	7.2
*May 26	23E	+0.6	8.0
July 14	21W	+0.5	7.7
Sept. 23	26E	+0.3	6.8
*Nov. 2	19W	−0.3	6.7

*favourable elongations

MERCURY: TELESCOPIC OBSERVING DATA FOR FAVOURABLE EASTERN ELONGATIONS 1981

Date 19h EST	Magnitude	Apparent Diameter	Phase % illuminated	R.A.	Dec.
		″		h m	° ′
Jan. 21	−0.9	5.5	88	21 15	−17 40
25	−0.8	5.6	79	21 39	−15 10
29	−0.6	6.4	66	20 01	−12 32
Feb. 2	−0.2	7.2	49	22 16	−10 05
6	+0.4	8.1	30	22 24	−8 12
May 13	−0.5	6.1	71	4 34	+24 08
17	−0.1	6.6	60	5 03	+25 08
21	+0.2	7.2	49	5 28	+25 33
25	+0.6	7.9	40	4 49	+25 29
29	+0.9	8.6	31	6 01	+25 10

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. The Soviet and

VENUS: TELESCOPIC OBSERVING DATA 1981

Date	Magnitude	Apparent Diameter	Phase (% illuminated)
		″	
Jan. 1	−3.4	11.1	92
Feb. 1	−3.3	10.4	96
June 1	−3.3	10.2	97
July 1	−3.3	10.9	92
Aug. 1	−3.4	12.2	85
Sept. 1	−3.5	14.2	77
Oct. 1	−3.7	17.2	67
Nov. 1	−3.9	22.5	54
Dec. 1	−4.3	32.2	38
Dec. 10	−4.4	37.1	32
Dec. 20	−4.4	43.1	23
Dec. 30	−4.3	51.1	14

American landing devices detected what 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.

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

Venus is the brightest natural celestial object in the nighttime sky apart from the moon and whenever it is visible is readily recognized. Because its orbit is within that of the Earth, Venus is never separated from the sun by an angle greater than 47 degrees. However, this is 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 January in the eastern morning sky and, for the last half of the year, in the west during the early evening.

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.

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 observers the correlation is fair at best.

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

MARS

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

The landscapes photographed by the Viking landers were basically desert vistas strewn with rocks ranging up to several 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.

In January Mars is low in the west after sunset and poorly placed for telescopic observation. From February to June it is too close to the sun for convenient viewing, and although it climbs higher in the morning sky as the last half of the year progresses, the planet is not well placed for telescopic scrutiny.

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

Telescopically Mars is usually a disappointingly small featureless ochre disk except within a few months of opposition when its distance from the Earth is then near minimum. If Mars is at perihelion at these times the separation can be as little as 56 million km. Such close approaches occur at intervals of 15 to 17 years; the most

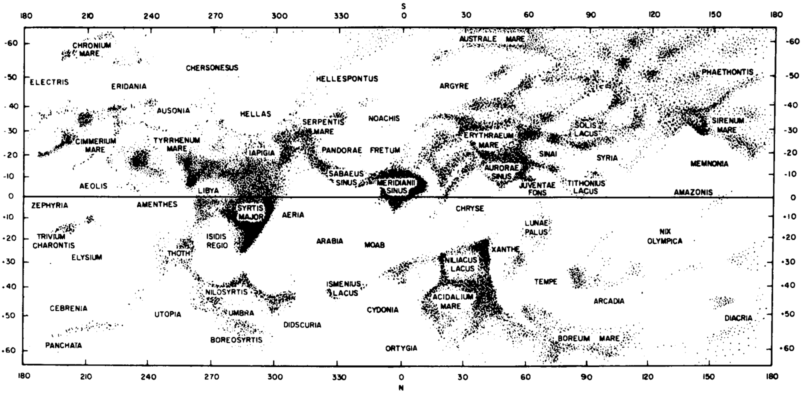
MARS: EPHEMERIS FOR PHYSICAL OBSERVATIONS 1981

Date U.T.	Dist. A.U.	Vis. Mag.	App. Diam.	% Ill.	Pos. Ang.	Incl.	$L(1)$	Δ
			″		°	°	°	°
July 1.0	2.411	+1.7	3.88	99	329	−2	131.45	9.72
Aug. 1.0	2.347	+1.8	3.99	97	339	+7	190.17	9.71
Sept. 1.0	2.233	+1.8	4.19	96	351	+14	249.10	9.72
Oct. 1.0	2.071	+1.7	4.52	94	2	+20	317.52	9.72
Oct. 15.0	1.977	+1.7	4.73	93	8	+22	181.41	9.72
Nov. 1.0	1.849	+1.6	5.06	92	14	+24	16.24	9.70
Nov. 15.0	1.733	+1.5	5.40	92	19	+24	240.44	9.67
Dec. 1.0	1.590	+1.3	5.88	91	23	+24	85.69	9.63
Dec. 15.0	1.457	+1.1	6.43	90	27	+24	310.88	9.57
Jan. 1.0	1.291	+0.9	7.25	90	30	+23	148.23	—

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. There is no opposition of Mars in 1981.

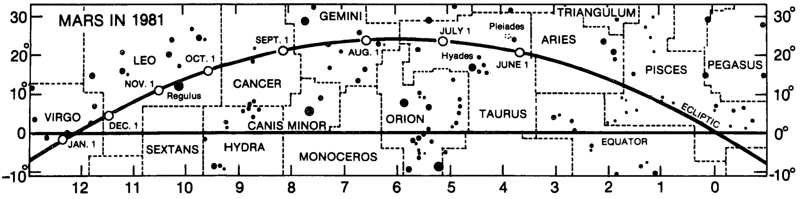
For selected dates when Mars is favourably placed, the table above gives the distance from the earth, the magnitude, apparent diameter, fraction of the disk illuminated, position angle of the rotation axis (measured from the north through the east), inclination of the rotation axis to the plane of the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

MAP OF MARS



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

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 on pg. 82.



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.

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

JUPITER: EPHEMERIS FOR PHYSICAL OBSERVATIONS 1981

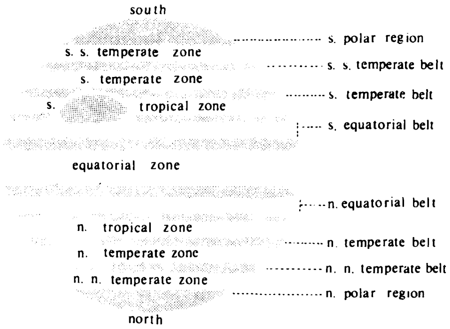
Date U.T.	Vis. Mag.	App. Equat. Diam.	System I L(1)	System I Δ	System II L(1)	System II Δ
		″	°	°	°	°
Jan. 1.0	−1.6	36.9	122.5	157.95	127.4	150.30
Feb. 1.0	−1.8	40.5	338.9	158.00	107.2	150.40
Mar. 1.0	−2.0	43.2	83.2	158.05	357.9	150.40
Apr. 1.0	−2.0	44.2	302.3	157.95	340.4	150.35
May 1.0	−1.9	42.5	1.4	157.85	170.7	150.25
June 1.0	−1.7	39.2	215.2	157.75	147.9	150.15
July 1.0	−1.6	35.9	268.1	157.70	332.0	150.10
Aug. 1.0	−1.4	33.2	116.9	157.65	304.2	150.05
Sept. 1.0	−1.3	31.4	324.7	157.65	275.5	150.05
Oct. 1.0	−1.2	30.6	14.8	157.70	96.7	150.05
Nov. 1.0	−1.2	30.7	223.1	157.75	68.5	150.10
Dec. 1.0	−1.3	31.8	275.2	157.80	251.7	150.15
Jan. 1.0	−1.4	33.9	127.1	157.85	226.9	150.25

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.

Jupiter's rapid rotation also makes the great globe markedly oval so that it appears about 7% "squashed" at the poles. Jupiter's apparent equatorial diameter ranges from 44″ at opposition on March 27 to a minimum of 31″ at conjunction on October 14.

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.



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 1981 opens Jupiter is in Virgo, flanked by Saturn, which has conjunctions with Jupiter on January 14, February 19, and July 30. Jupiter is by far the brighter of the two planets and is ideally placed for telescopic study for the first half of the year. 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.

Opposition this year occurs on March 27 when the giant planet is 666 million km (4.44 A.U.) from Earth. Minimum possible distance between the two planets is 590 million km.

SATURN

Saturn is the telescopic showpiece of the night sky. The chilling beauty of the small pale orb floating in a field of velvet is something no photographs or 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.

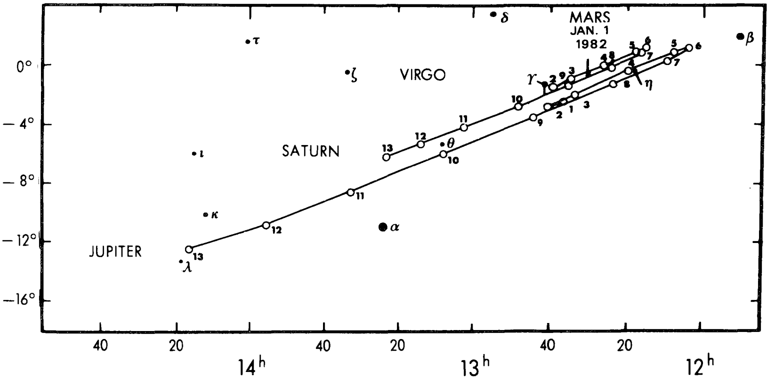
The outer ring A has an external diameter of 274,000 km and is 16,000 km wide. Separating ring A from the 26,000 km-wide ring B is a 3,000 km gap known as Cassini's Division which appears to be virtually free of ring particles. The gap was discovered in 1675 and is visible in good quality telescopes 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.

Pioneer 11, which hurtled by Saturn in 1979, detected particles both inside and outside the three rings visible from Earth as well as in the gaps between them. The content, extent, and structure of the rings are being dramatically refined by examination of data returned from the Voyager 1 spacecraft, which is nearing Saturn as the HANDBOOK goes to press.

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 ($10^{\mathrm{m}}.1$) than at eastern elongation ($11^{\mathrm{m}}.9$). One side of the moon has the reflectivity of snow while the other resembles dark rock. The reason for this is unknown. When brightest, Iapetus is located about 12 ring-diameters west of its parent planet. Of the remaining moons Tethys and Dione may be glimpsed in a 15 cm telescope but the others require larger apertures or photographic techniques.

The disk of Saturn appears about 1/6 the size Jupiter appears through the same telescope with the same magnification. In telescopes less than 4 inches aperture



The Paths of Jupiter and Saturn in 1981. The positions are marked for the first day of each month: (1) January, (2) February, etc.

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. In 1980, the planet's rotation period was established at 10 hours, 40 minutes, four per cent longer than previous estimates. Very rarely a spot among the Saturnian clouds will appear unexpectedly, but less than a dozen notable spots have been recorded since telescopic observation of Saturn commenced in the 17th century.

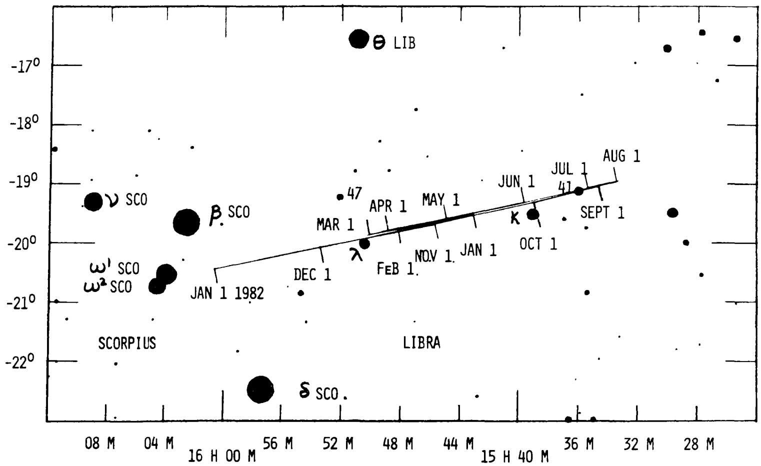
From year to year the rings of Saturn take on different appearances. The planet's orbit is an immense 29.5 year circuit about the sun, so in the course of an observing season the planet moves relatively little in its orbit (and thus appears to remain in about the same general area of the sky) and maintains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

As 1981 opens, the rings are tilted 7.3° with respect to Earth with the northern face being visible. This value remains essentially constant through January, then decreases to 6.5° by March 1, 5.4° by April 1, and 4.4° by May 1. From then until September, when Saturn is too close for observation, the ring inclination slowly increases back to about 7°. By December 31, when Saturn is well up in the morning sky, the rings have opened to 12.2°.

Both Saturn and Jupiter are in Virgo and rise at about midnight as 1981 begins. Both planets remain in Virgo all year and are in conjunction on January 14, February 19, and July 30. Saturn opposition is March 27, when the planet is 1.28 billion km (8.53 AU) from Earth. At that time the planet is 19.5″ in equatorial diameter and the rings are 43.8″ in width.

URANUS

Although Uranus can be seen with the unaided eye under a clear, dark sky it was apparently unknown until 1781 when it was accidentally discovered by William Herschel with a 6-inch reflecting telescope. It can be easily seen with binoculars and a telescope will reveal its small greenish featureless disk.



The Path of Uranus in 1981. Positions for first day of each month. The faintest stars are about magnitude 8.

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 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.

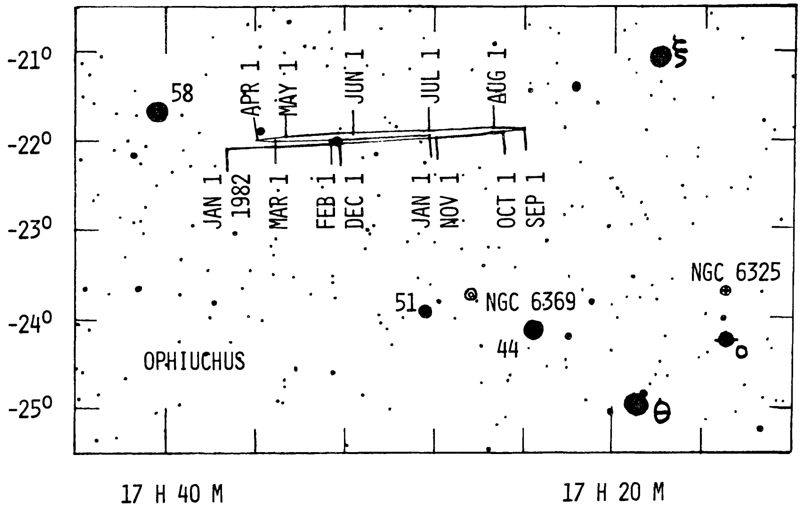
These dimensions are markedly different from Saturn's three major rings, each of which is thousands of kilometers wide. Although different in scale, the composition of the Uranian rings should be fundamentally the same as Saturn's—swarms of particles varying from dust-size up to small flying mountains 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.

Uranus is in Libra for most of 1981, opposition being on May 19 when the planet is 2.66 billion km (17.80 AU) 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 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".



The Path of Neptune in 1981. Positions for first day of each month. The faintest stars are about magnitude 10.

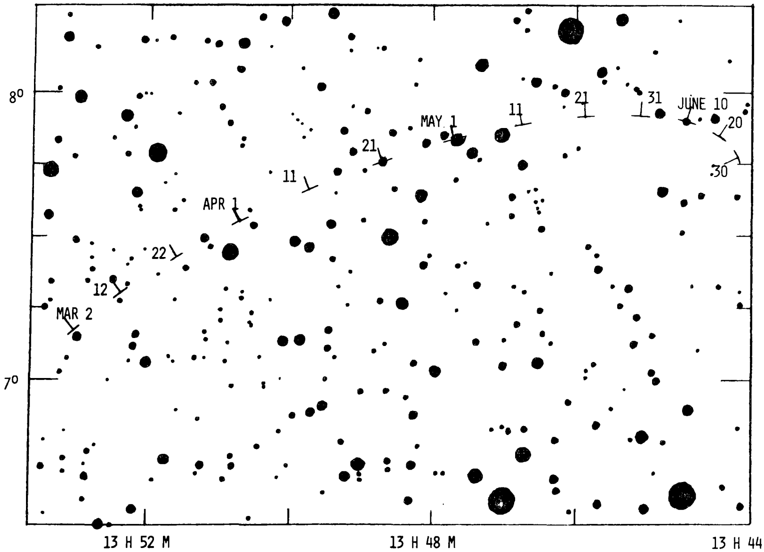
Telescopically the planet appears as a 2.5 second of arc featureless bluish-green disk. Neptune's large moon Triton can be seen by an experienced observer using a 12-inch telescope. Triton is an exceptionally large satellite and may prove to be the solar system's biggest moon. The moon varies from 8 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 1981 Neptune is buried in the Milky Way in Ophiuchus and is not well placed for northern observers. At opposition on June 14 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.



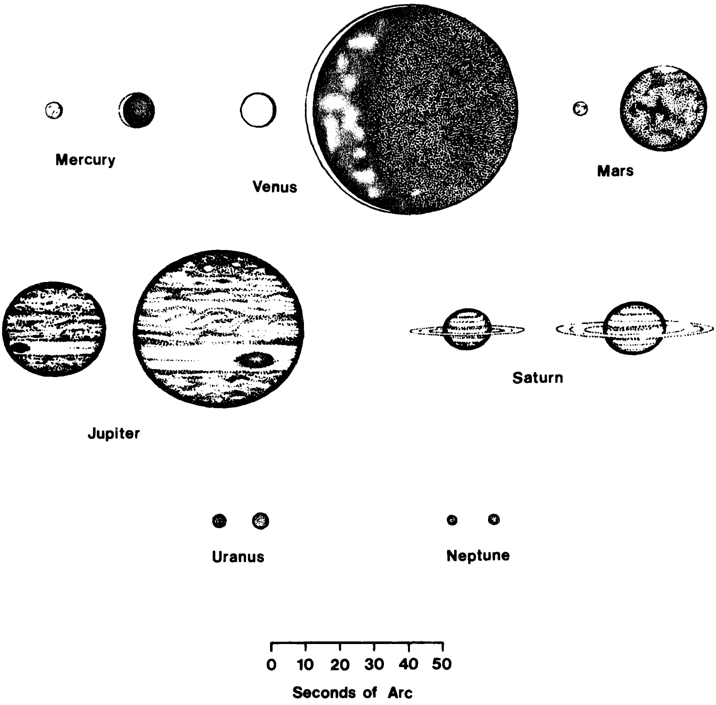
The Path of Pluto in 1981. The faintest stars are about magnitude 12–13. The co-ordinates are for 1950.

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 that revealed frozen methane on much of Pluto's surface, as well as by 1978 speckle interferometry work with the Hale 200″ telescope suggesting a 3300 km diameter for Pluto.

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

PLANETS: APPARENT SIZES

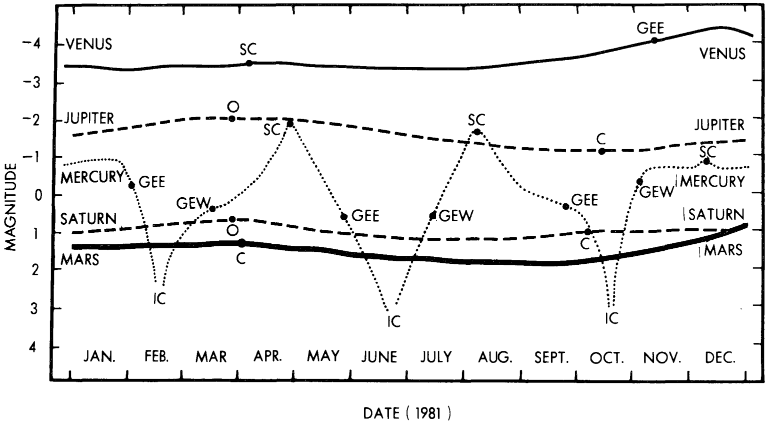


The apparent maximum and minimum observable size of seven planets is illustrated along with characteristic telescopic appearance. The large satellites of Jupiter (not shown) appear smaller than Neptune.

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.

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 from 1980 to 1999. Just where such a freak fits into the solar system's origin and evolution is unknown. Perhaps Pluto is the largest member of a group of small ice comet-like structures beyond Neptune.

At opposition on April 13, Pluto's astrometric position is R.A. (1950) $13^{h}\ 49^{m}.5$, Dec. (1950) $+7^\circ\ 41'$ and its distance from Earth will be 4.36 billion km (29.10 A.U.). With an apparent magnitude of +13.7, Pluto is a difficult target in moderate-sized amateur telescopes.



The magnitudes of the planets in 1981. Conjunctions, oppositions and greatest elongations are indicated.

OCCULTATION OF σ SAGITTARII BY VENUS

Occultation of σ Sagittarii by Venus on 1981 November 17: σ Sgr is a B3 star with a visual magnitude of 2.1. At the time of the occultation, Venus will be 47° from the sun, have an angular diameter of 28″ and a magnitude of −4.1. It will be 46% illuminated, the position angle of the mid-point of the illuminated limb being 268°. Thus the disappearance will occur at the dark limb and the reappearance at the bright limb.

The area of visibility will be Newfoundland (very low), Central and South America and the Caribbean, Africa, Europe and S.W. Asia. However only in eastern Europe and S.W. Asia will the event occur after sunset.

The times of disappearance and reappearance, as seen from the western hemisphere, are as follows:

Place	Disappearance Nov. 17				Reappearance Nov. 17			
			Altitude				Altitude	
	U.T.	P.A.	Star	Sun	U.T.	P.A.	Star	Sun
	h m	°	°	°	h m	°	°	°
Bermuda	15 23.6	58	7	38	15 34.1	290	9	38
Caracas	15 22.1	76	18	58	15 33.6	273	20	59
Cerro Tololo	15 23.0	117	31	71	15 32.8	232	34	73
Buenos Aires	15 23.8	117	43	74	15 33.6	231	45	74
Rio de Janeiro	15 23.8	101	54	79	15 35.0	247	57	76

JUPITER—PHENOMENA OF THE BRIGHTEST SATELLITES 1981

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 March 26 until October 14, and on the west otherwise.

JANUARY

d	h	m	Sat.	Phen.
2	8	10	IV	ED
	8	45	IV	ER
3	2	45	III	SI
	5	49	III	Se
	7	50	III	TI
	9	32	I	SI
4	6	41	I	ED
5	4	01	I	SI
	5	14	I	TI
	6	14	I	Se
	7	26	I	Te
6	1	09	I	ED
	4	36	I	OR
	6	03	II	SI
	8	29	II	TI
	8	46	II	Se
	23	42	I	TI
7	0	33	III	OR
	0	43	I	Se
	1	54	I	Te
8	1	00	II	ED
	6	12	II	OR
10	0	22	II	Te
	6	42	III	SI
	9	45	III	Se
11	8	34	I	ED
12	5	54	I	SI
	7	06	I	TI
	8	08	I	Se
	9	18	I	Te
13	3	02	I	ED
	6	27	I	OR
	8	36	II	SI
	23	44	III	ER
14	0	22	I	SI
	1	34	I	TI
	1	37	III	OD
	2	36	I	Se
	3	46	I	Te
	4	23	III	OR
15	0	55	I	OR
	3	36	II	ED
	8	43	II	OR
17	0	14	II	TI
	0	35	II	Se
	2	51	II	Te
19	7	47	I	SI
	8	57	I	TI
20	4	55	I	ED
	8	17	I	OR
21	0	36	III	ED
	2	16	I	SI
	3	25	I	TI
	3	40	III	ER
	4	29	I	Se
	5	24	III	OD
	5	36	I	Te
	8	08	III	OR
	23	24	I	ED
22	2	45	I	OR
	6	11	II	ED
	22	58	I	Se
23	0	04	I	Te
24	0	26	II	SI
	2	41	II	TI
	3	08	II	Se
	5	19	II	Te
26	0	25	II	OR
	9	41	I	SI
27	6	48	I	ED
28	4	09	I	SI
	4	34	III	ED
	5	14	I	TI
	6	22	I	Se
	7	26	I	Te
	7	37	III	ER
	9	06	III	OD
29	1	17	I	ED
	4	34	I	OR
	8	46	II	ED
	22	37	I	SI
	23	42	I	TI
30	0	51	I	Se
	1	53	I	Te
	23	01	I	OR
31	2	59	II	SI
	5	07	II	TI
	5	42	II	Se
	7	44	II	Te
	22	58	III	TI

FEBRUARY

d	h	m	Sat.	Phen.
1	1	38	III	Te
	22	04	II	ED
2	2	50	II	OR
3	8	41	I	ED
4	6	02	I	SI
	7	03	I	TI
	8	16	I	Se
	8	31	III	ED
	9	14	I	Te
5	3	10	I	ED
	6	22	I	OR
6	0	31	I	SI
	1	30	I	TI
	2	44	I	Se
	3	41	I	Te
	21	38	I	ED
7	0	49	I	OR
	5	33	II	SI
	7	30	II	TI
	8	15	II	Se
	22	08	I	Te
	22	33	III	SI
8	1	33	III	Se
	2	34	III	TI
	5	12	III	Te
9	0	39	II	ED
	5	13	II	OR
10	21	32	II	Se
	23	17	II	Te
11	7	56	I	SI
	8	50	I	TI
12	5	03	I	ED
	8	09	I	OR
13	2	24	I	SI
	3	17	I	TI
	4	37	I	Se
	5	28	I	Te
	23	31	I	ED
14	2	36	I	OR
	8	06	II	SI
	21	43	I	TI
14	23	06	I	Se
	23	55	I	Te
15	2	30	III	SI
	5	30	III	Se
	6	04	III	TI
	8	42	III	Te
	21	02	I	OR
16	3	14	II	ED
	7	34	II	OR
17	21	23	II	SI
	23	00	II	TI
18	0	06	II	Se
	1	37	II	Te
	22	24	III	OR
19	6	56	I	ED
	20	43	II	OR
20	4	17	I	SI
	5	03	I	TI
	6	31	I	Se
	7	14	I	Te
21	1	25	I	ED
	4	21	I	OR
	22	46	I	SI
	23	29	I	TI
22	0	59	I	Se
	1	41	I	Te
	6	28	III	SI
	22	48	I	OR
23	5	49	II	ED
24	23	57	II	SI
25	1	19	II	TI
	2	40	II	Se
	3	56	II	Te
	20	24	III	ED
26	1	48	III	OR
	8	50	I	ED
	23	01	II	OR
27	6	11	I	SI
	6	48	I	TI
	8	24	I	Se
	9	00	I	Te
28	3	18	I	ED
	6	07	I	OR

MARCH

d	h	m	Sat.	Phen.
1	0	39	I	SI
	1	14	I	TI
	2	53	I	Se
	3	26	I	Te
	21	46	I	ED
2	0	33	I	OR
	8	23	II	ED
	19	41	I	TI
	21	21	I	Se
	21	52	I	Te
4	2	32	II	SI
	3	36	II	TI
	5	15	II	Se
	6	13	II	Te
5	0	23	III	ED
	5	10	III	OR
	21	41	II	ED
6	1	18	II	OR
	8	04	I	SI
	8	33	I	TI
7	5	12	I	ED
7	7	51	I	OR
8	2	33	I	SI
	2	59	I	TI
	4	46	I	Se
	5	10	I	Te
	23	40	I	ED
9*	21	01	I	SI
	21	25	I	TI
	23	15	I	Se
	23	36	I	Te
10	20	43	I	OR
11	5	06	II	SI
	5	51	II	TI
	7	49	II	Se
	8	29	II	Te
12	4	21	III	ED
	8	29	III	OR
13	0	16	II	ED
	3	33	II	OR
14	7	05	I	ED
	21	07	II	Se
	21	37	II	Te
15	4	26	I	SI
	4	43	I	TI
	6	40	I	Se
	6	54	I	Te
	19	30	III	TI
	21	19	III	Se
	22	08	III	Te
16	1	34	I	ED
	4	01	I	OR
	22	55	I	SI
	23	09	I	TI
17	1	08	I	Se
	1	20	I	Te
	20	02	I	ED
	22	27	I	OR
18	7	42	II	SI
	8	06	II	TI
	19	37	I	Se
	19	46	I	Te
19	8	19	III	ED
20	2	50	II	ED
	5	47	II	OR
21	20	59	II	SI
	21	13	II	TI
	23	42	II	Se
	23	52	II	Te
22†	6	20	I	SI
	6	26	I	TI
	8	34	I	Se
	22	20	III	SI
	22	45	III	TI
23	1	16	III	Se
	1	26	III	Te
	3	28	I	ED
	5	45	I	OR
	18	54	II	OR
24	0	49	I	SI
	0	52	I	TI
	3	02	I	Se
	3	04	I	Te
	21	56	I	ED
25	0	11	I	OR
	19	17	I	SI
	19	18	I	TI
	21	30	I	Te
	21	31	I	Se

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*Add Mar. 9 2^{h}17^{m} I OR

†Add Mar. 22 8^{h}38^{m} I Te

d	h	m	Sat.	Phen.
26	18	39	I	ER
27	5	23	II	OD
	8	07	II	ER
28	23	28	II	TI
	23	35	II	SI
29	2	07	II	Te
	2	18	II	Se
	8	10	I	TI
	8	14	I	SI
30	2	01	III	TI
	2	19	III	SI
	4	43	III	Te
	5	14	III	Se
	5	17	I	OD
	7	36	I	ER
	18	30	II	OD
	21	24	II	ER
31	2	36	I	TI
	2	43	I	SI
	4	48	I	Te
	4	56	I	Se
	23	43	I	OD

APRIL

d	h	m	Sat.	Phen.
1	2	04	I	ER
	21	02	I	TI
	21	11	I	SI
	23	14	I	Te
	23	24	I	Se
2	19	11	III	ER
	20	33	I	ER
3	7	37	II	OD
5	1	43	II	TI
	2	11	II	SI
	4	22	II	Te
	4	53	II	Se
6	5	17	III	TI
	6	17	III	SI
	7	01	I	OD
	20	44	II	OD
	23	59	II	ER
7	4	20	I	TI
	4	37	I	SI
	6	32	I	Te
	6	50	I	Se
8	1	27	I	OD
	3	59	I	ER
	22	46	I	TI
	23	05	I	SI
9	0	58	I	Te
	1	18	I	Se
	19	53	I	OD
	22	27	I	ER
	23	09	III	ER
10	19	24	I	Te
	19	47	I	Se
12	3	58	II	TI
	4	47	II	SI
	6	39	II	Te
13	22	59	II	OD
14	2	33	II	ER
	6	04	I	TI
	6	31	I	SI
15	3	11	I	OD
	5	53	I	ER
	19	47	II	Te
	20	47	II	Se
16	0	31	I	TI
	1	00	I	SI
	2	43	I	Te
	3	12	I	Se
	21	38	I	OD
	22	12	III	OD
17	0	22	I	ER
	3	07	III	ER
	18	57	I	TI
17	19	28	I	SI
	21	09	I	Te
	21	41	I	Se
18	18	51	I	ER
19	6	16	II	TI
21	1	15	II	OD
	5	07	II	ER
22	4	57	I	OD
	19	24	II	TI
	20	41	II	SI
	22	05	II	Te
	23	23	II	Se
23	2	16	I	TI
	2	54	I	SI
	4	28	I	Te
	5	06	I	Se
	23	23	I	OD
24	1	34	III	OD
	2	17	I	ER
	20	42	I	TI
	21	22	I	SI
	22	55	I	Te
	23	35	I	Se
25	20	45	I	ER
27	21	04	III	Se
28	3	33	II	OD
29	21	44	II	TI
	23	18	II	SI
30	0	25	II	Te
	1	59	II	Se
	4	02	I	TI
	4	48	I	SI

MAY

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

JUNE

d	h	m	Sat.	Phen.
1	0	13	I	TI
	1	24	I	SI
	1	46	II	Se
	2	25	I	Te
	3	35	I	Se
	21	23	I	OD
2	0	49	I	ER
	19	52	I	SI
	20	33	II	ER
	20	53	I	Te
	22	03	I	Se
5	23	06	III	OD
6	2	06	III	OR
7	23	12	II	TI
8	1	44	II	SI
	1	55	II	Te
	2	05	I	TI
	3	18	I	SI
	23	16	I	OD
9	2	44	I	ER
	20	34	I	TI
	20	53	III	Se
	21	47	I	SI
	22	46	I	Te
	23	07	II	ER
	23	58	I	Se
10	21	13	I	ER
13	2	58	III	OD
15	1	46	II	TI
16	1	09	I	OD
	19	53	III	Te
	20	32	II	OD
	22	06	III	SI
	22	27	I	TI
	23	41	I	SI
17	0	39	I	Te
	0	51	III	Se
	1	42	II	ER
	1	52	I	Se
17	19	38	I	OD
	23	08	I	ER
18	20	18	II	Se
	20	21	I	Se
23	20	52	III	TI
	23	06	II	OD
	23	51	III	Te
24	0	21	I	TI
	1	36	I	SI
	2	06	III	SI
	2	33	I	Te
	21	33	I	OD
25	1	03	I	ER
	20	05	I	SI
	20	17	II	SI
	20	24	II	Te
	21	02	I	Te
	22	16	I	Se
	22	56	II	Se
26	19	32	I	ER

JULY

d	h	m	Sat.	Phen.
1	0	53	III	TI
	1	42	II	OD
	23	29	I	OD
2	20	20	II	TI
	20	45	I	TI
	21	59	I	SI
	22	55	II	SI
	22	57	I	Te
	23	03	II	Te
3	0	10	I	Se
	1	33	II	Se
	21	27	I	ER
4	20	06	III	ED
	20	07	II	ER
	22	52	III	ER
9	1	26	I	OD
	22	41	I	TI
	23	01	II	TI
	23	54	I	SI
10	0	54	I	Te
	19	55	I	OD
	23	23	I	ER
11	19	02	III	OD
	19	23	I	Te
	20	33	I	Se
	22	04	III	OR
	22	42	II	ER
12	0	06	III	ED
17	0	38	I	TI
	21	53	I	OD
18	19	08	I	TI
	20	17	I	SI
	20	18	II	OD
	21	20	I	Te
	22	28	I	Se
	23	12	III	OD
19	19	47	I	ER
20	20	07	II	Se
22	20	44	III	Se
24	23	51	I	OD
25	21	05	I	TI
	22	12	I	SI
	22	59	II	OD
	23	18	I	Te
26	0	23	I	Se
	21	42	I	ER
27	20	07	II	SI
	20	33	II	Te
	22	44	II	Se
29	20	29	III	Te
	22	02	III	SI

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*Add May 24 1^h04^m I OD

AUGUST

d	h	m	Sat.	Phen.
1	23	04	I	TI
2	0	06	I	SI
	20	20	I	OD
	23	37	I	ER
3	19	46	I	Te
	20	36	II	TI
	20	46	I	Se
	22	44	II	SI
	23	19	II	Te
5	19	42	II	ER
	21	46	III	TI
9	22	20	I	OD

Jupiter being near the sun, phenomena are not given between Aug. 9 and Nov. 15

NOVEMBER

d	h	m	Sat.	Phen.
15	7	31	I	ED
16	4	39	I	SI
	5	11	I	TI
16	6	50	I	Se
	7	23	I	Te
17	4	43	I	OR
18	4	35	III	OR
20	7	52	II	ED
22	5	28	II	Se
	6	43	II	Te
23	6	33	I	SI
	7	11	I	TI
	8	44	I	Se
24	6	43	I	OR
25	6	11	III	ER
	6	26	III	OD
	8	56	III	OR
29	5	31	II	SI
	6	58	II	TI
	8	01	II	Se
	9	28	II	Te
30	8	27	I	SI
	9	11	I	TI

DECEMBER

d	h	m	Sat.	Phen.
1	3	50	II	OR
	5	46	I	ED
1	8	42	I	OR
2	5	06	I	Se
2	5	52	I	Te
	7	40	III	ED
6	8	04	II	SI
	9	43	II	TI
8	6	37	II	OR
	7	39	I	ED
9	4	49	I	SI
	5	41	I	TI
	7	00	I	Se
	7	51	I	Te
10	5	10	I	OR
13	4	01	III	Se
	5	20	III	TI
	7	41	III	Te
15	4	57	II	ED
	9	23	II	OR
	9	32	I	ED
16	6	43	I	SI
	7	40	I	TI
	8	53	I	Se
	9	50	I	Te
17	4	00	I	ED
	4	16	II	Te
	7	08	I	OR
18	3	21	I	Se
	4	19	I	Te
20	5	33	III	SI
	7	58	III	Se
	9	38	III	TI
22	7	32	II	ED
23	8	36	I	SI
	9	38	I	TI
24	4	31	II	TI
	4	57	II	Se
	5	53	I	ED
	6	57	II	Te
	9	05	I	OR
25	3	05	I	SI
	4	07	I	TI
	5	15	I	Se
	6	17	I	Te
27	9	31	III	SI
31	4	02	III	OD
	5	01	II	SI
	6	17	III	OR
	7	12	II	TI
	7	29	II	Se
	7	46	I	ED
	9	37	II	Te

ELONGATIONS OF SATURN'S SATELLITES 1981

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

JANUARY

d	h	Sat.	Elong.
2	06.5	Ti	W
2	16.2	Rh	E
7	04.7	Rh	E
10	10.9	Ti	E
11	17.1	Rh	E
11	18.0	Ia	W
16	05.5	Rh	E
18	05.4	Ti	W
20	18.0	Rh	E
25	06.4	Rh	E
26	09.6	Ti	E
29	18.8	Rh	E

FEBRUARY

d	h	Sat.	Elong.
3	03.8	Ti	W
3	07.1	Rh	E
7	19.5	Rh	E
11	07.8	Ti	E
12	07.9	Rh	E
16	20.2	Rh	E
19	01.9	Ti	W
21	08.6	Rh	E
21	15.3	Ia	E
25	20.9	Rh	E
27	05.8	Ti	E

MARCH

d	h	Sat.	Elong.
2	09.3	Rh	E
6	21.6	Rh	E
6	23.6	Ti	W
11	09.9	Rh	E
15	03.5	Ti	E
15	22.3	Rh	E
20	10.6	Rh	E
22	21.1	Ti	W
24	22.9	Rh	E
29	11.2	Rh	E
31	01.0	Ti	E
31	07.0	Ia	W

APRIL

d	h	Sat.	Elong.
2	23.6	Rh	E
7	11.9	Rh	E
7	18.6	Ti	W
12	00.2	Rh	E
15	22.7	Ti	E
16	12.6	Rh	E
21	00.9	Rh	E
23	16.2	Ti	W
25	13.3	Rh	E
30	01.6	Rh	E

MAY

d	h	Sat.	Elong.
1	20.5	Ti	E
4	14.0	Rh	E
9	02.3	Rh	E
9	14.1	Ti	W
10	19.6	Ia	E
13	14.7	Rh	E
17	18.5	Ti	E
18	03.1	Rh	E
22	15.5	Rh	E
25	12.3	Ti	W
27	03.9	Rh	E
31	16.3	Rh	E

JUNE

d	h	Sat.	Elong.
2	17.0	Ti	E
5	04.7	Rh	E
9	17.2	Rh	E
10	10.9	Ti	W
14	05.6	Rh	E
17	23.4	Ia	W
18	15.8	Ti	E
18	18.1	Rh	E
23	06.5	Rh	E
26	10.0	Ti	W
27	19.0	Rh	E

JULY

d	h	Sat.	Elong.
2	07.5	Rh	E
4	15.0	Ti	E
6	20.0	Rh	E
11	08.5	Rh	E
12	09.4	Ti	W
15	21.0	Rh	E
20	09.5	Rh	E
20	14.6	Ti	E
24	22.0	Rh	E
28	09.2	Ti	W
29	10.5	Rh	E
29	13.1	Ia	E

AUGUST

d	h	Sat.	Elong.
2	23.0	Rh	E
5	14.5	Ti	E
7	11.6	Rh	E
12	00.1	Rh	E
13	09.3	Ti	W
16	12.7	Rh	E
21	01.2	Rh	E
21	14.6	Ti	E
25	13.8	Rh	E
29	09.7	Ti	W
30	02.3	Rh	E

Elongations are not given between Sept. 2 and Nov. 9, Saturn being near the sun

NOVEMBER

d	h	Sat.	Elong.
10	11.4	Rh	E
15	00.0	Rh	E
17	12.7	Ti	W
19	12.5	Rh	E
24	01.1	Rh	E
25	17.1	Ti	E
27	02.0	Ia	W
28	13.6	Rh	E

DECEMBER

d	h	Sat.	Elong.
3	02.1	Rh	E
3	13.0	Ti	W
7	14.7	Rh	E
11	17.2	Ti	E
12	03.2	Rh	E
16	15.7	Rh	E
19	13.0	Ti	W
21	04.2	Rh	E
25	16.7	Rh	E
27	16.9	Ti	E
30	05.2	Rh	E

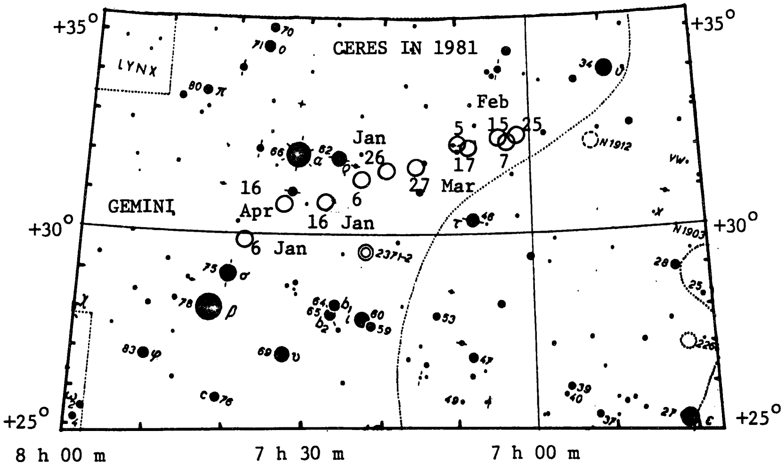
EPHEMERIDES FOR THE BRIGHTEST ASTEROIDS 1981

PROVIDED BY BRIAN G. MARSDEN

The following are the ephemerides for the brightest asteroids in 1981: those asteroids which will be brighter than photographic magnitude 11.0 and more than 90° from the sun. The tables give the number and name of the asteroid, the date at 0^h E.T. (which differs only slightly from U.T.), the right ascension and declination for the epoch 1950 (for convenience in plotting on commonly-used star charts) and the *photographic* magnitude (which is normally about $0^{\mathrm{m}}.7$ *fainter* than the visual magnitude). These data were derived from current osculating elements, and were generously calculated and provided by Dr. Brian G. Marsden of the Smithsonian Astrophysical Observatory.

Note that both Ceres and Vesta are bright and well-placed for northern observers in 1981. Ceres comes to opposition between Castor and Pollux on January 10. Vesta comes to opposition near γ Leo on February 21, Pallas does not come to opposition in 1981, and Juno is very faint. Maps, based on the *Atlas Coeli*, are provided for Ceres and Vesta. The 1980 edition of this HANDBOOK contains maps for Ceres, Pallas and Vesta in late 1980. Readers can make maps for the other asteroids by using the ephemerides and such star atlases as the *S.A.O.* and the *Atlas Coeli.*

It is evident from these ephemerides that many asteroids can rival or even exceed Ceres, Pallas, Juno and Vesta in brightness.



The position of Ceres in 1981, plotted at ten-day intervals on the Atlas Coeli. Coordinates are for 1950. The curved dotted lines are contours of the Milky Way.

(1) CERES

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 6	7^{h} $38^{m}.1$	+29° 55′	
16	7 27.9	+30 54	7.3
26	7 18.0	+31 39	
Feb. 5	7 09.8	+32 09	7.6
15	7 04.2	+32 24	
25	7 01.8	+32 27	7.9
Mar. 7	7 02.7	+32 20	
17	7 06.7	+32 05	8.2
27	7 13.4	+31 44	
Apr. 6	7 22.6	+31 18	8.5
16	7 33.7	+30 45	

(3) JUNO

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Apr. 6	14^{h} $17^{m}.0$	−01° 38′	10.8
16	14 09.5	−00 24	
26	14 01.6	+00 42	10.8
May 6	13 54.0	+01 36	

(4) VESTA

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 6	10^{h} $55^{m}.3$	+13° 28′	
16	10 55.6	+14 16	7.6
26	10 52.9	+15 22	
Feb. 5	10 47.4	+16 41	7.2
15	10 39.5	+18 08	
25	10 30.1	+19 30	6.9
Mar. 7	10 20.5	+20 40	
17	10 12.1	+21 28	7.2
27	10 05.9	+21 53	
Apr. 6	10 02.7	+21 54	7.6
16	10 02.5	+21 35	
26	10 05.3	+20 58	7.9
May 6	10 10.7	+20 06	
16	10 18.4	+19 01	8.2
26	10 28.1	+17 45	

(6) HEBE

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 6	3^{h} $22^{m}.6$	−2° 36′	
16	3 26.6	−0 22	9.8
26	3 33.3	+1 55	
Feb. 5	3 42.3	+4 09	10.2
15	3 53.3	+6 18	

(8) FLORA

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 3	5^{h} $53^{m}.1$	+17° 05′	10.3
13	6 04.5	+17 00	
23	6 12.9	+16 55	10.0
Nov. 2	6 17.7	+16 54	
12	6 18.6	+16 59	9.6
22	6 15.2	+17 14	
Dec. 2	6 07.9	+17 39	9.2
12	5 57.7	+18 14	
22	5 46.2	+18 54	8.9

(9) METIS

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
May 16	16^{h} $59^{m}.3$	−22° 38′	10.8
26	16 49.6	−22 43	
June 5	16 38.9	−22 44	10.3
15	16 28.4	−22 42	
25	16 19.4	−22 39	10.8
July 5	16 12.5	−22 37	

(11) PARTHENOPE

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
June 5	20^{h} $11^{m}.2$	−17° 06′	10.8
15	20 09.9	−17 23	
25	20 05.6	−17 53	10.4
July 5	19 58.6	−18 34	
15	19 49.8	−19 24	9.8
25	19 40.5	−20 15	
Aug. 4	19 32.0	−21 03	10.2
14	19 25.5	−21 45	
24	19 22.0	−22 18	10.6
Sept. 3	19 21.8	−22 41	
13	19 24.9	−22 55	11.0
23	19 31.0	−22 59	

(15) EUNOMIA

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Oct. 3	5^{h} $36^{m}.6$	+35° 38′	9.8
13	5 45.0	+35 57	
23	5 49.9	+36 10	9.5
Nov. 2	5 50.9	+36 16	
12	5 47.8	+36 12	9.1
22	5 40.8	+35 54	
Dec. 2	5 30.8	+35 17	8.8
12	5 19.4	+34 19	
22	5 08.3	+33 05	8.8

(16) PSYCHE

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 16	4^{h} $26^{m}.5$	+17° 43′	10.9
26	4 26.3	+17 59	

(18) MELPOMENE

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
June 5	21^{h} $52^{m}.9$	−5° 43′	11.0
15	22 02.4	−5 07	
25	22 09.9	−4 47	10.6
July 5	22 15.2	−4 48	
15	22 17.7	−5 16	10.0
25	22 17.4	−6 13	
Aug. 4	22 14.2	−7 41	9.4
14	22 08.6	−9 36	
24	22 01.5	−11 48	8.7
Sept. 3	21 54.2	−14 03	
13	21 48.4	−16 05	9.3
23	21 45.3	−17 42	
Oct. 3	21 45.7	−18 50	9.7
13	21 49.8	−19 25	
23	21 57.4	−19 31	10.1
Nov. 2	22 08.0	−19 10	
12	22 21.2	−18 24	10.4
22	22 36.4	−17 17	

(20) MASSALIA

Date 0^{h} E.T.	R.A. (1950)	Dec. (1950)	Mag.
Jan. 6	11^{h} $06^{m}.6$	+4° 43′	
16	11 08.5	+4 29	10.3
26	11 07.2	+4 36	
Feb. 5	11 02.6	+5 04	9.9
15	10 55.4	+5 49	
25	10 46.5	+6 46	9.5
Mar. 7	10 37.2	+7 45	
17	10 29.0	+8 38	9.9
27	10 22.9	+9 19	
Apr. 6	10 19.7	+9 43	10.4
16	10 19.5	+9 50	
26	10 22.2	+9 39	10.8
May 6	10 27.4	+9 14	

Date 0^h E.T.	(21) LUTETIA		
	R.A. (1950)	Dec. (1950)	Mag.
Sept. 13	0^h 45^m.7	−1° 16′	10.8
23	0 37.8	−2 08	
Oct. 3	0 29.0	−2 58	10.5
13	0 20.5	−3 37	
23	0 13.9	−3 58	11.0
Nov. 2	0 09.7	−3 58	

Date 0^h E.T.	(22) KALLIOPE		
	R.A. (1950)	Dec. (1950)	Mag.
Nov. 12	4^h 40^m.3	+21° 06′	10.9
22	4 31.0	+21 42	
Dec. 2	4 20.6	+22 15	10.4
12	4 10.4	+22 45	
22	4 01.6	+23 13	11.0

Date 0^h E.T.	(23) THALIA		
	R.A. (1950)	Dec. (1950)	Mag.
Jan. 6	5^h 26^m.1	+31° 32′	
16	5 18.6	+32 04	10.6
26	5 15.1	+32 26	
Feb. 5	5 15.8	+32 41	11.0
15	5 20.8	+32 52	

Date 0^h E.T.	(29) AMPHITRITE		
	R.A. (1950)	Dec. (1950)	Mag.
Apr. 26	16^h 01^m.7	−28° 38′	11.0
May 6	15 53.2	−28 40	
16	15 43.2	−28 29	10.7
26	15 32.9	−28 06	
June 5	15 23.4	−27 35	10.9
15	15 15.7	−27 00	

Date 0^h E.T.	(44) NYSA		
	R.A. (1950)	Dec. (1950)	Mag.
Feb. 5	12^h 08^m.4	+2° 25′	10.7
15	12 06.0	+3 12	
25	12 00.7	+4 16	10.4
Mar. 7	11 53.2	+5 30	
17	11 44.5	+6 45	10.0
27	11 36.0	+7 52	
Apr. 6	11 28.9	+8 41	10.6
16	11 24.2	+9 08	

Date 0^h E.T.	(88) THISBE		
	R.A. (1950)	Dec. (1950)	Mag.
June 25	18^h 20^m.3	−23° 46′	10.5
July 5	18 11.0	−23 23	
15	18 02.6	−22 57	11.0
25	17 56.4	−22 33	

Date 0^h E.T.	(97) KLOTHO		
	R.A. (1950)	Dec. (1950)	Mag.
Jan. 16	8^h 15^m.8	+5° 48′	10.9
26	8 07.1	+7 18	

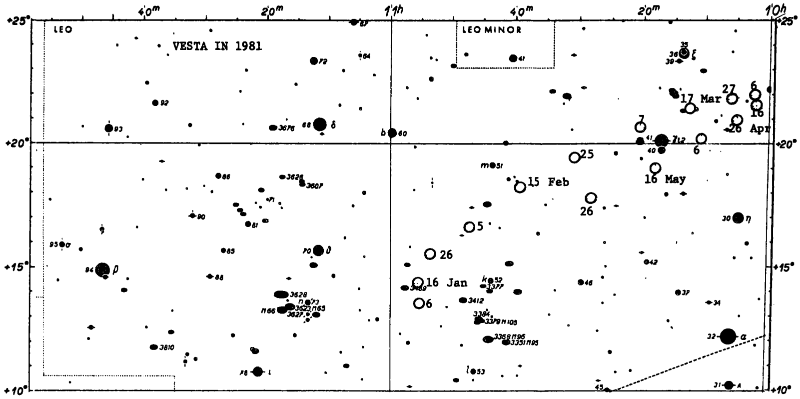
Date 0^h E.T.	(129) ANTIGONE		
	R.A. (1950)	Dec. (1950)	Mag.
May 16	18^h 52^m.8	−7° 57′	11.0
26	18 51.7	−7 49	
June 5	18 47.7	−7 58	10.6
15	18 41.4	−8 24	
25	18 33.6	−9 09	10.4
July 5	18 25.4	−10 10	
15	18 17.8	−11 22	10.6
25	18 12.0	−12 42	
Aug. 4	18 08.7	−14 03	11.0
14	18 08.1	−15 21	

Date 0^h E.T.	(135) HERTHA		
	R.A. (1950)	Dec. (1950)	Mag.
July 15	20^h 57^m.7	−20° 28′	10.8
25	20 50.1	−20 48	
Aug. 4	20 41.1	−21 07	10.4
14	20 32.5	−21 18	
24	20 25.8	−21 18	10.9
Sept. 3	20 22.3	−21 07	

Date 0^h E.T.	(192) NAUSIKAA		
	R.A. (1950)	Dec. (1950)	Mag.
June 25	20^h 11^m.0	−30° 16′	10.9
July 5	20 02.7	−30 41	
15	19 52.0	−30 58	10.4
25	19 40.2	−30 59	
Aug. 4	19 29.1	−30 42	10.6
14	19 20.4	−30 08	
24	19 15.3	−29 20	10.8
Sept. 3	19 14.1	−28 24	

Date 0^h E.T.	(349) DEMBOWSKA		
	R.A. (1950)	Dec. (1950)	Mag.
Aug. 4	21^h 58^m.4	−25° 33′	10.9
14	21 49.9	−26 13	
24	21 40.9	−26 40	10.9
Sept. 3	21 32.6	−26 52	

Date 0^h E.T.	(471) PAPAGENA		
	R.A. (1950)	Dec. (1950)	Mag.
Nov. 12	5^h 50^m.6	+18° 23′	10.8
22	5 44.6	+19 27	
Dec. 2	5 35.8	+20 36	10.5
12	5 25.4	+21 48	
22	5 14.8	+22 57	10.5



The position of Vesta in 1981, plotted at ten-day intervals on the Atlas Coeli. Coordinates are for 1950. The elliptical symbols are galaxies, with their NGC or Messier numbers indicated.

COMETS IN 1981

By Brian G. Marsden

The following periodic comets are expected at perihelion during 1981:

Comet	Perihelion Date	Perihelion Dist.	Period
		A.U.	Yr.
Reinmuth 2	Jan. 29	1.95	6.7
Borrelly	Feb. 20	1.32	6.8
Schwassmann-Wachmann 2	Mar. 17	2.14	6.5
West-Kohoutek-Ikemura	Apr. 12	1.40	6.1
Kohoutek	Apr. 17	1.57	6.2
Finlay	June 20	1.10	7.0
Swift-Tuttle	Sept. 16	0.96	125
Longmore	Oct. 21	2.40	7.0
Gale	Oct. 27	1.20	11.1
Slaughter-Burnham	Nov. 16	2.54	11.6
Gehrels 2	Nov. 18	2.36	8.0
Swift-Gehrels	Nov. 27	1.36	9.3
Kearns-Kwee	Nov. 30	2.22	9.0

The returns of Comets Reinmuth 2, Finlay and Gale are rather unfavourable. Comets Swift-Gehrels and Kearns-Kwee will be favourably placed for observation and could attain total magnitude 12–13. Comets West-Kohoutek-Ikemura, Kohoutek and Longmore are making their first predicted returns to perihelion. Comet Swift-Tuttle, which is associated with the Perseid meteor stream, is also making its first predicted return; although nominally due at perhelion on the date stated, there is an uncertainty of ± 2 years; if this comet were to come to perihelion during June-

October it could attain naked-eye brightness. Comets Tuttle and Stephan-Oterma, bright objects at the end of 1980, will be likewise early in 1981, and the ephemeris for the latter comet continues as follows:

Date	R.A. (1950.0)	Dec. (1950.0)	Mag.
Jan. 1	$5^{\mathrm{h}}32^{\mathrm{m}}.4$	+35°33′	
6	5 33.9	+37 29	10.3
11	5 36.2	+39 09	
16	5 39.4	+40 33	10.7
21	5 43.6	+41 41	
26	5 48.8	+42 36	11.1

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.

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

MAJOR VISUAL METEOR SHOWERS FOR 1981

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. 3	09	NM	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	03	FM	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 4	09	NM	22 24	00	+3.6	+0.4	20	65	3
S. δ Aquarids	July 28	12	NM	22 36	−17	+3.4	+0.17	20	41	7
Perseids	Aug. 12	03	FM	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	07	LQ	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 2	05	FQ	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 17	01	LQ	10 08	+22	+2.8	−0.42	15	71	—
Geminids	Dec. 13	23	FM	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 22	08	NM	14 28	+76	—	—	15	34	2
Quadrantids	(1982) Jan. 3	15	FQ	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
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-eight 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 (× 10⁶ 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
Bee Bluff, Texas	29 02	099 51	2.4	40 ± 10	shallow circ. depress'n.; rim remnants	breccia A
Brent, Ont.	46 05	078 29	3.8	450 ± 30	sediment-filled shallow depression	fracturing A D G
Carswell, Sask.	58 27	109 30	37	485 ± 50	discontinuous circular ridge	shatter cones, breccia G
Charlevoix, Que.	47 32	070 18	46	360 ± 25	semi-circular trough, central elevation	breccia, shatter cones, impact melt A G
Clearwater Lake East, Que.	56 05	074 07	22	290 ± 20	circular lake	sedimentary float D G
Clearwater Lake West, Que.	56 13	074 30	32	290 ± 20	island ring in circular lake	impact melt D G
Crooked Creek, Missouri	37 50	091 23	5.6	320 ± 80	oval area of disturbed rocks, shallow marginal depression	breccia, shatter cones A
Decaturville, Missouri	37 54	092 43	6	< 300	slight oval depression	breccia, shatter cones A D
Deep Bay, Sask.	56 24	102 59	12	100 ± 50	circular bay	sedimentary float D G
Flynn Creek, Tenn.	36 16	085 37	3.8	360 ± 20	sediment-filled shallow depression with slight central elevation	breccia, shatter cones, disturbed rocks A D G
Gow Lake, Sask.	56 27	104 29	5	< 200	lake and central island	breccia G
Haviland, Kansas	37 37	099 05	0.0011	< 0.001	excavated depression	fragments of "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* mi′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.	Name	Con.	R.A.
Acamar, ā'k*a*-mär	θ Eri	02	Gienah, jē'n*a*	γ Crv	12
Achernar, ā'kēr-när	α Eri	01	Hadar, hăd'är	β Cen	14
Acrux, ā'krŭks	α Cru	12	Hamal, hăm'ăl	α Ari	02
Adhara, *a*-dā'r*a*	ε CMa	06	Kaus Australis,		
Al Na'ir, ăl-nâr'	α Gru	22	kôs ôs-trā'lĭs	ε Sgr	18
Albireo, ăl-bĭr'ē-ō	β Cyg	19	Kochab, kō'kăb	β UMi	14
Alcyone, ăl-sī'ō-nē	η Tau	03	Markab, mär'kăb	α Peg	23
Aldebaran, ăl-dĕb'*a*-r*a*n	α Tau	04	Megrez, mē'grĕz	δ UMa	12
Alderamin, ăl-dĕr'*a*-mĭn	α Cep	21	Menkar, mĕn'kär	α Cet	03
Algenib, ăl-jē'nĭb	γ Peg	00	Menkent, mĕn'kĕnt	θ Cen	14
Algol, ăl'gŏl	β Per	03	Merak, mē'răk	β UMa	11
Alioth, ăl'ĭ-ŏth	ε UMa	12	Miaplacidus,		
Alkaid, ăl-kād'	η UMa	13	mī'*a*-plăs'ĭ-d*u*s	β Car	09
Almach, ăl'măk	γ And	02	Mira, mī'r*a*	o Cet	02
Alnilam, ăl-nī'lăm	ε Ori	05	Mirach, mī'răk	β And	01
Alphard, ăl'färd	α Hya	09	Mirfak, mĭr'făk	α Per	03
Alphecca, ăl-fĕk'*a*	α CrB	15	Mizar, mī'zär	ζ UMa	13
Alpheratz, ăl-fē'răts	α And	00	Nunki, nŭn'kē	σ Sgr	18
Altair, ăl-târ'	α Aql	19	Peacock	α Pav	20
Ankaa	α Phe	00	Phecda, fĕk'd*a*	γ UMa	11
Antares, ăn-tā'rēs	α Sco	16	Polaris	α UMi	01
Arcturus, ärk-tū'r*ŭ*s	α Boo	14	Pollux, pŏl'*ŭ*ks	β Gem	07
Atria, ā'trĭ-*a*	α TrA	16	Procyon, prō'sĭ-ŏn	α CMi	07
Avior, ă-vĭ-ôr'	ε Car	08	Ras-Algethi, rås'*ă*l-jē'the	α Her	17
Bellatrix, bĕ-lā'trĭks	γ Ori	05	Rasalhague, rås'*ă*l-hā'gwē	α Oph	17
Betelgeuse, bĕt'*e*l-juz	α Ori	05	Regulus, rĕg'u-l*ŭ*s	α Leo	10
Canopus, k*a*-nō'p*ŭ*s	α Car	06	Rigel, rī'j*e*l	β Ori	05
Capella, k*a*-pĕl'*a*	α Aur	05	Rigil Kentaurus		
Caph, kăf	β Cas	00	rī'jĭl kĕn-tô'r*ŭ*s	α Cen	14
Castor, kås'tĕr	α Gem	07	Sabik, sā'bĭk	η Oph	17
Deneb, dĕn'ĕb	α Cyg	20	Scheat, shē'ăt	β Peg	23
Denebola, dĕ-nĕb'ō-l*a*	β Leo	11	Schedar, shĕd'*a*r	α Cas	00
Diphda, dĭf'd*a*	β Cet	00	Shaula, shô'l*a*	λ Sco	17
Dubhe, dŭb'ē	α UMa	11	Sirius, sĭr'ĭ-*ŭ*s	α CMa	06
Elnath, ĕl'năth	β Tau	05	Spica, spī'k*a*	α Vir	13
Eltanin, ĕl-tā'nĭn	γ Dra	17	Suhail, sŭ-hāl'	λ Vel	09
Enif, ĕn'ĭf	ε Peg	21	Vega, vē'g*a*	α Lyr	18
Fomalhaut, fō'm*ă*l-ôt	α PsA	22	Zubenelgenubi,		
Gacrux, gä'krŭks	γ Cru	12	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.

	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* $0^{\mathrm{m}}.08$, 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* $0.08{:}^{\mathrm{m}}$ 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	$B\,5.4^{\mathrm{m}}$ $C\,6.2^{\mathrm{m}}$ 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., $R\,0.11^{\mathrm{m}}$ 4.0^{d}, $B\,8.9^{\mathrm{m}}$ 18″	*Polaris*
o Cet *A*	18.3	−03 04	2.0v		M5.5e–M9e	0.013	−0.5	103	0.232	+63.8	LP, R 2.0–10.1, 332^{d}, $B\,10^{\mathrm{m}}$ 1″	*Mira*
γ Cet *AB*	42.2	+03 10	3.48	+0.11	A2 V	0.048	+2.0	68	0.203	−05.1	$A\,3.57^{\mathrm{m}}$ $B\,6.23^{\mathrm{m}}$ 3″	
θ Eri *AB*	57.5	−40 23	2.92	+0.13	A3 III	0.028	+1.7	65	0.061	*+11.9*	$A\,3.25^{\mathrm{m}}$ $B\,4.36^{\mathrm{m}}$ 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	$B\,9.36^{\mathrm{m}}$ 13″	
ε Per *A*	56.5	+39 57	2.88	−0.17	B0.5 V	−.001	−3.7	680	0.036	*−01*	$B\,7.99^{\mathrm{m}}$ 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	$B\,12^{\mathrm{m}}$ 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, $B\,13^{\mathrm{m}}$ 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* 8.66^m 1980.0: 10.0″, P.A. 46°	***Sirius***
α Pic	48.2	−61 55	3.27	+0.21	A7 Vn		+2.1	57	0.272	+20.6		
τ Pup	49.5	−50 36	2.92	+1.21	*K0 III*		+0.1	124	0.079	*+36.4*		
ε CMa *A*	57.8	−28 57	1.48:	−0.18:	B2 II		−5.1	680	0.004	+27.4	*B* 7.5^m 8″	***Adhara***
o^2 CMa	07 02.2	−23 48	3.02	−0.09	B3 Ia		−7.1	3400	0.000	+48.4		
δ CMa	07.6	−26 22	1.85	+0.65	F8 Ia	−.018	−7.1	2100	0.005	+34.3		
L_2 Pup	12.9	−44.37			(gM5e)	0.016	−3.1	650	0.342	+53.0	LP, *R* 3.4–6.2, 141^d	
π Pup	16.5	−37 04	2.70:	+1.63:	(gK4)	0.023	−0.3	140	0.008	+15.8		
η CMa	23.3	−29 15	2.46	−0.08	B5 Ia		−7.1	2700	0.008	+41.1		
β CMi	26.2	+08 20	2.91	−0.09	B7 V	0.020	−1.1	210	0.065	+22		
σ Pup *A*	28.6	−43 15	3.24	+1.49	K5 III	0.013	−0.4	180	0.195	*+88.1*	*B* 9.4^m 22″	
α Gem *A*	33.3	+31 56	1.97	+0.00:	A1 V	0.072	+1.3	45	0.199	+06.0	2″, *B–V*+0.02, *C* $9.08v^m$ 73″	***Castor***
α Gem *B*	33.3	+31 56	2.95	+0.07:	A5m	0.072	+2.3	45	0.199	*−01.2*		
α CMi *A*	38.2	+05 17	0.37	+0.41	F5 IV–V	0.288	+2.7	11.3	1.250	*−03.2*	*B* 10.7^m 4″	***Procyon***
β Gem	44.1	+28 05	1.16	+1.02	K0 III	0.093	+1.0	35	0.625	+03.3		***Pollux***
ξ Pup	48.4	−24 50	3.34	+1.23	G3 Ib	−.003	−4.6	1240	0.005	*+02.7*		
χ Car	56.2	−52 56	3.48	−0.18	B3 IVp		−2.1	430	0.039	+19.1		
ζ Pup	08 02.9	−39.57	2.23	−0.26	O5f		−7.1	2400	0.033	−24		
ρ Pup	06.7	−24 15	2.80v	+0.42	F6 IIp	0.031	+0.3:	105:	0.098	+46.6	Var. *R* 2.72–2.87, 0.14^d	
γ Vel *A*	08.9	−47 18	1.83	−0.26	WC8		−4.1	520	0.011	+35	*B* 4.31^m 41″	
ε Car	22.1	−59 26	1.90:	+1.30:	K3: III+B2:v		−3.1:	340	0.030	+11.5		***Avior***
o UMa *A*	28.6	+60 47	3.37	+0.83	G5 III	0.004	+0.1	150	0.171	+19.8	*B* 15^m 7″	
δ Vel *AB*	44.2	−54 38	1.95	+0.05	A2 V	0.043	+0.2	76	0.086	+02.2	*A* 2.0^m *B* 5.1^m 3″ *CD* 10^m 69″	
ε Hya *ABC*	45.7	+06 30	3.39	+0.68	G0 comp.	0.010	+0.6	140	0.198	*+36.4*	*A* 3.7^m *B* 5.2^m 0.2″ 15^y, *C* 6.8^m 3″ *D* 12^m 20″	
ζ Hya	54.3	+06 02	3.11	+1.00	K0 II–III	0.029	−1.1	220	0.101	+22.8		
ι UMa *A*	57.9	+48 07	3.12	+0.19	A7 V	0.066	+2.2	49	0.505	+12.2	*BC* 10.8^m 4″	

Star	R.A. 1980	Dec.	*V*	*B–V*	Type		π	M_V	D	μ	R		
	h m	° ′					″		l.y.	″	km/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* 14^{m} 5″	
ε Leo	44.7	+23 51	2.99	+0.81	G0	II	0.002	−2.1	340	0.048	+05.0		
l Car	44.7	−62 26	4.1		G8	Ia	0.019	−5.5	2700	0.016	*+04.0*	Cep. max. 3.4^{m} min. 4.8^{m}, 35.52^{d}	
υ Car *AB*	46.6	−64 59	2.95	+0.26	A8	Ib	0.020	−2.1	340	0.012	+13.6	*A* 3.02^{m} *B* 6.03^{m} 5″	
α Leo *A*	10 07.3	+12 04	1.36	−0.11	B7	V	0.039	−0.7	84	0.248	+03.5	*B* 8.1^{m} 177″	***Regulus***
ω Car	13.2	−69 56	3.33	−0.08	B8	III		−1.5	300	0.029	*+04*		
ζ Leo	15.7	+23 31	3.46	+0.30	F0	III	0.009	+0.5	130	0.023	−15.0		
λ UMa	15.9	+43 01	3.45	+0.03	A2	IV	−.010	+0.1	150	0.170	+18.3		
q Car	16.4	−61 14	3.41v	+1.55	K3	Ib–II	0.018	−4.6	1300	0.023	+08.6	Var. *R* 3.38–3.44	
γ Leo *AB*	18.8	+19 57	1.99	+1.13	K0	IIIp	0.019	+0.1	90	0.350	−36.6	*A* 2.29^{m} *B* 3.54^{m} 4″	
μ UMa	21.1	+41 36	3.05	+1.55	M0	III	0.031	+0.5	105	0.086	*−20.5*		
p Car	31.4	−61 35	3.30v	−0.11	B4	Vne		−2.3	430	0.021	+26.0	Var. *R* 3.22–3.39	
θ Car	42.2	−64 17	2.74	−0.22	B0.5	Vp		−4.0	710	0.018	+24		
μ Vel *AB*	45.9	−49 19	2.67	+0.89	*G5*	*III*		+0.1	108	0.085	+06.9	*A* 2.7^{m} *B* 7.2^{m} 1″	
ν Hya	48.6	−16 05	3.12	+1.25	K3	III	0.022	−0.2	150	0.221	−01.0		
β UMa	11 00.6	+56 30	2.37	−0.03	A1	V	0.042	+0.5	78	0.087	−12.0		***Merak***
α UMa *AB*	02.5	+61 52	1.81	+1.06	K0	III	0.031	−0.7	105	0.138	−08.9	*A* 1.88^{m} *B* 4.82^{m} 1″	***Dubhe***
ψ UMa	08.6	+44 36	3.00	+1.14	K1	III		+0.0	130	0.072	−03.8		
δ Leo	13.0	+20 38	2.57	+0.13	A4	V	0.040	+0.6	82	0.201	−20.6		
θ Leo	13.2	+15 33	3.34	0.00	A2	V	0.019	+1.1	90	0.104	+07.8		
λ Cen	34.9	−62 54	3.15	−0.05	B9	III		−2.1	370	0.039	*−01*		
β Leo	48.0	+14 41	2.14	+0.09	A3	V	0.076	+1.5	43	0.511	−01		***Denebola***

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/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* 0.7^{m} *B* 3.9^{m} 1″, β CMa var.	***Hadar***
π Hya	05.3	−26 35	3.25	+1.13	K2 III	0.039	+1.2	84	0.156	+27.2		
θ Cen	05.5	−36 17	2.04	+1.03	K0 III–IV	0.059	+0.9	55	0.738	+01.3		*Menkent*
α Boo	14.8	+19 17	−0.06	+1.23	K2 IIIp	0.090	−0.3	36	2.284	−05.2		***Arcturus***
γ Boo	31.3	+38 24	3.05	+0.19	A7 III	0.016	+0.2	118	0.186	−35.5		
η Cen	34.2	−42 04	2.39v	−0.21	B1.5 V:ne		−3.0	390	0.049	−00.2	Var, R 2.33–2.45	
α Cen *A*	38.4	−60 46	0.01	+0.68	G2 V	.751	+4.39	4.3	3.676	−24.6	22″	***Rigil Kentaurus***
α Cen *B*	38.4	−60 46	1.40:	+0.73:	K4 V		+5.8	4.3		−20.7		
α Lup	40.7	−47 19	2.32v	−0.22	B1 V		−3.3	430	0.033	*+07.3*	β CMa var., 0.26^{d}	
α Cir *AB*	40.9	−64 53	3.18	+0.25	A8 p	0.049	+1.6	66	0.308	+07.4	Strontium star. *A* 3.19^{m} *B* 8.61^{m} 16″	
ε Boo *AB*	44.1	+27 09	2.37	+0.96	K1: III:+A	0.013	+0.0	103	0.051	−16.5	*A* 2.47^{m} *B* 5.04^{m} 3″	
α Lib *A*	49.8	−15 54	2.76	+0.15	A3m	0.049	+1.2	66	0.130	−10	*B* 5.15^{m} 231″	*Zubenelgenubi*
β UMi	50.8	+74 14	2.07	+1.47	K4 III	0.031	−0.5	105	0.033	+16.9		*Kochab*
β Lup	57.3	−43 03	2.69	−0.23	B2 IV		−3.4	540	0.066	−00.3		
κ Cen	57.8	−42 01	3.15	−0.21	B2 V		−2.7	470	0.033	+09.1		
β Boo	15 01.2	+40 28	3.48	+0.95	G8 III	0.022	+0.3	140	0.059	−19.9		
σ Lib	02.9	−25 12	3.31	+1.65	M4 III	0.056	+2.0:	58:	0.089	−04.3		
ζ Lup *A*	10.8	−52 01	3.42	+0.90:	*K0 III*	0.036	+1.2	90	0.135	−09.7	*B* 7.8^{m} 71″	
δ Boo *A*	14.7	+33 24	3.47	+0.95	G8 III	0.028	+0.3	140	0.148	−12.2	*B* 7.84^{m} 105″	
β Lib	15.9	−09 18	2.61	−0.11	B8 V	−.012	−0.6	140	0.101	−35.2		
γ TrA	17.1	−68 36	2.89	+0.01	A0 IV	0.005	+0.2	113	0.067	−06	Europium star	
δ Lup	20.1	−40 34	3.21v	−0.23	B2 IV		−3.4	680	0.032	+02	β CMa var., 0.165^{d}	
γ UMi	20.8	+71 54	3.04	+0.06	A3 II–III	−.005	−1.5	270	0.026	*−03.9*		
ι Dra	24.5	+59 02	3.28	+1.18	K2 III	0.032	+0.8	102	0.012	−11.0		
γ Lup *AB*	33.8	−41 06	2.80	−0.22	B2 Vn		−2.7	570	0.037	*+06*	*A* 3.5^{m} *B* 3.7^{m} 1″	
α CrB	33.8	+26 47	2.23v	−0.02	A0 V	0.043	+0.4	76	0.154	*+01.7*	Ecl. R 0.11^{m}, 17.4^{d}	*Alphecca*
α Ser	43.3	+06 29	2.65	+1.17	K2 III	0.046	+1.0	71	0.139	+02.9		
β TrA	53.4	−63 22	2.84	+0.28:	F0 IV	0.078	+2.3	42	0.448	−00.3		
π Sco	57.6	−26 04	2.92	−0.19	B1 V	0.005	−3.3	570	0.034	*−03*		
η Lup *AB*	58.8	−38 21	3.40	−0.23	B2 V		−2.7	570	0.042	+07	*A* 3.47^{m} *B* 7.70^{m} 15″	
δ Sco	59.2	−22 34	2.34	−0.13	B0 V		−4.0	590	0.032	−14		*Dschubba*

Star	R.A. 1980	Dec.	*V*	*B–V*	Type		π	M_V	D	μ	R	
	h m	° ′					″		l.y.	″	km/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., 0.20^{d}	
β Oph	42.5	+04 35	2.77	+1.16	K2	III	0.023	−0.1	124	0.160	−12.0		
μ Her *A*	45.7	+27 45	3.42	+0.75	G5	IV	0.108	+3.6	30	0.811	−15.6	*BC* 9.78^{m} 33″	
ι^1 Sco	46.2	−40 06	3.02	+0.49	F2	Ia	0.013	−7.1	3400	0.004	*−27.6*		
G Sco	48.4	−37 02	3.21	+1.18	K2	III	0.032	+0.7	102	0.064	+24.7		
γ Dra	56.1	+51 29	2.21	+1.52	K5	III	0.017	−0.4	108	0.026	−27.6		*Eltanin*
ν Oph	58.0	−09 47	3.32	+1.00	G9	III	0.015	+0.2	140	0.118	+12.4		
γ Sgr	18 04.5	−30 26	2.97	+1.00	*K0*	*III*	0.018	+0.1	124	0.200	*+22.1*		
η Sgr *A*	16.3	−36 47	3.12	+1.55	M3.5	III	0.038	+1.1:	86:	0.218	+00.5	*B* 10^{m} 4″	
δ Sgr	19.7	−29 50	2.71	+1.39	K2	III	0.039	+0.7	84	0.050	−20.0		
η Ser	20.2	−02 54	3.23	+0.94	K0	III–IV	0.054	+1.9	60	0.894	+08.9		
ε Sgr	22.9	−34 24	1.81	−0.02	B9.5	III	0.015	−1.1	124	0.135	−11		*Kaus Australis*
λ Sgr	26.7	−25 27	2.80	+1.05	*K2*	*III*	0.046	+1.1	71	0.194	−43.3		
α Lyr	36.2	+38 46	0.04	0.00	A0	V	0.123	+0.5	26.5	0.345	−13.9		***Vega***
φ Sgr	44.4	−27 01	3.20	−0.11	*B8*	*III*		−3.1	590	0.052	+21.5		
β Lyr *A*	49.4	+33 21	3.38v	−0.05:	Bpe		−.011	−4.6	1300	0.007	*−17.8*	Ecl. *R* 3.38–4.36, 12.9^{d}, *B* 7.8^{m} 46″	
σ Sgr	54.0	−26 19	2.12:	−0.21	B2	V		−2.7	300	0.059	−11		***Nunki***
ξ^2 Sgr	56.5	−21 07	3.51	+1.18:	K1	III	0.006	+0.0	160	0.035	−19.9		
γ Lyr	58.2	+32 40	3.25	−0.05	B9	III	0.011	−2.1	370	0.007	−21.5		
ζ Sgr *AB*	19 01.3	−29 54	2.61	+0.08	*A2*	*IV*	0.020	+0.1	140	0.020	+22	*A* 3.3^{m} *B* 3.5^{m} < 1″	
ζ Aql *A*	04.5	+13 50	2.99	+0.01	A0	V:nn	0.036	+0.8	90	0.101	−26.3	*B* 12^{m} 5″	
λ Aql	05.2	−04 55	3.44	−0.10	B9:	V:n	0.025	−0.1	160	0.092	−14		
τ Sgr	05.7	−27 42	3.30	+1.18	K1	III	0.038	+1.2	86	0.261	*+45.4*		
π Sgr *ABC*	08.6	−21 03	2.89	+0.35	F2	II–III	0.016	−0.7	250	0.040	−09.8	*A* 3.7^{m} *B* 3.8^{m} *C* 6.0^{m} < 1″	
δ Dra	12.5	+67 38	3.06	+1.00	G9	III	0.028	+0.2	124	0.130	+24.8		
δ Aql	24.5	+03 04	3.38	+0.31	F0	IV	0.062	+2.3	53	0.267	*−29.9*		
β Cyg *A*	29.9	+27 55	3.07	+1.12	K3	II:+B:	0.004	−2.4	410	0.009	−24.0	*B* 5.11^{m} 35″	*Albireo*
δ Cyg *AB*	44.3	+45 05	2.87	−0.03	B9.5	III	0.021	−1.7	270	0.060	−21	*A* 2.91^{m} *B* 6.44^{m} 2″	
γ Aql	45.3	+10 33	2.72	+1.52	K3	II	0.006	−2.4	340	0.012	−02.1		
α Aql	49.8	+08 49	0.77	+0.22	A7	IV–V	0.198	+2.2	16.5	0.658	−26.3		***Altair***

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

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 1981.0; 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		Dec. 1980.0		Magnitudes			P.A. 1981.0	Sep. 1981.0	P (app.) years
			h	m	°	′	comb.	A	B	°	″	
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	280	1.7	720
33	Ori	4123	05	30.2	+03	16	5.7	6.0	7.3	27	1.8	—
ΟΣ	156	5447	06	46.3	+18	13	6.1	6.8	7.0	241	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	256	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	164	1.1	500
Σ	2054	10052	16	23.6	+61	44	5.6	6.0	7.2	355	1.1	—
ε^1	Lyr†	11635	18	43.7	+39	38	5.1	5.4	6.5	355	2.7	1200
ε^2	Lyr†	11635	18	43.7	+39	38	4.4	5.1	5.3	83	2.3	600
π	Aql	12962	19	47.7	+11	45	5.6	6.0	6.8	110	1.4	—
ΟΣ	500	16877	23	36.5	+44	20	5.9	6.4	7.1	355	0.5	—
η	Cas	671	00	47.7	+57	44	3.5*	3.5	7.2	308	12.0	480
Σ	186	1538	01	54.8	+01	45	6.0	6.8	6.8	55	1.4	170
γ	And AB	1630	02	02.4	+42	16	2.1*	2.1	5.1	64	9.8	—
γ	And BC	1630	02	02.4	+42	16	5.1	5.5	6.3	108	0.6	61
ΟΣ	65	2799	03	49.2	+25	32	5.2	5.8	6.2	208	0.6	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	46	10.0	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	92	2.3	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	273	0.8	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	80	5.9	1150
σ^2	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	2	3.3	1100
γ	Leo	7724	10	18.9	+19	57	1.8	2.1	3.4	123	4.3	620
ξ	UMa	8119	11	17.1	+31	39	3.8	4.3	4.8	102	2.8	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	296	3.8	170
ζ	Boo	9343	14	40.1	+13	49	3.8	4.5	4.5	305	1.1	125
ξ	Boo	9413	14	50.4	+19	12	4.5	4.7	6.8	332	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	135	1.3	35
τ	Oph	11005	18	01.9	−08	11	4.7	5.2	5.9	278	1.8	280
70	Oph	11046	18	04.5	+02	32	4.0	4.2	6.0	317	2.3	88
δ	Cyg	12880	19	44.4	+45	04	2.9*	2.9	6.3	233	2.4	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	138	0.8	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	299	1.8	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	224	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	311	1.6	350

*There is a marked colour difference between the components.

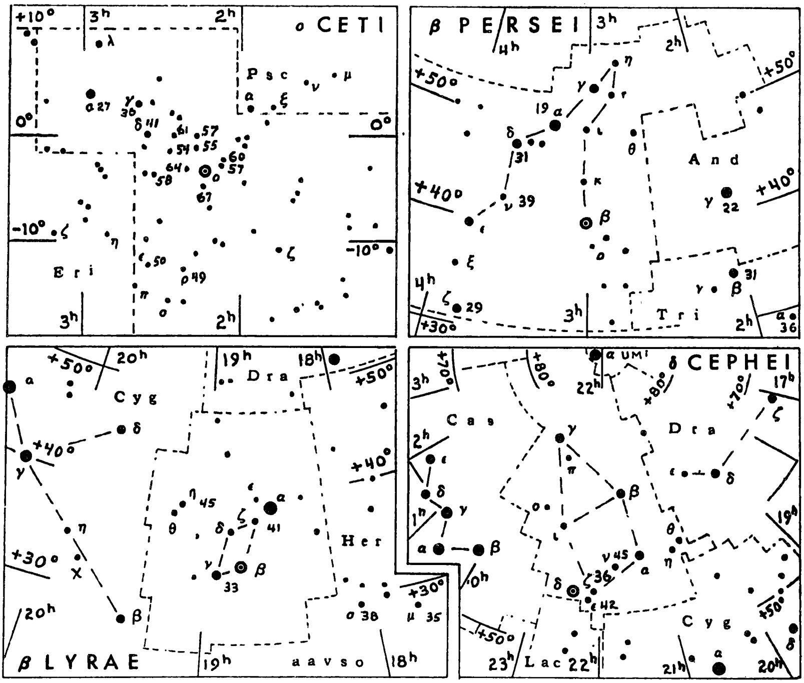
†The separation of the two pairs of ε Lyr is 208″.

VARIABLE STARS

By Janet Mattei

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

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 1980, International Supplement.*



LONG-PERIOD VARIABLE STARS

Variable	Max. m_v	Per d	Epoch 1981	Variable	Max. m_v	Per d	Epoch 1981
001755 T Cas	7.8	445	—	142539 V Boo	7.9	258	June 26
001838 R And	7.0	409	June 30	143227 R Boo	7.2	223	May 15
021143 W And	7.4	397	Apr. 8	151731 S CrB	7.3	361	Jan. 1
0214*03* o Cet	3.4	332	Aug. 6	154639 V CrB	7.5	358	Sept. 2
0228*13* U Cet	7.5	235	Apr. 22	154615 R Ser	6.9	357	July 19
023133 R Tri	6.2	266	Mar. 16	160625 RU Her	8.0	484	Oct. 14
043065 T Cam	8.0	374	Nov. 21	162119 U Her	7.5	406	—
0455*14* R Lep	6.8	432	Mar. 23	1621*12* V Oph	7.5	298	June 27
050953 R Aur	7.7	459	Nov. 9	163266 R Dra	7.6	245	June 24
054920 U Ori	6.3	372	Oct. 7	164715 S Her	7.6	307	May 27
0617*02* V Mon	7.0	335	Jan. 17	1702*15* R Oph	7.9	302	Jan. 6
065355 R Lyn	7.9	379	June 25	171723 RS Her	7.9	219	May 26
070122aR Gem	7.1	370	Aug. 7	180531 T Her	8.0	165	Feb. 1
070310 R CMi	8.0	338	Apr. 14	181136 W Lyr	7.9	196	Mar. 9
072708 S CMi	7.5	332	Nov. 3	183308 X Oph	6.8	334	May 24
081112 R Cnc	6.8	362	Dec. 19	190108 R Aql	6.1	300	Jan. 1
081617 V Cnc	7.9	272	Aug. 26	1910*17* T Sgr	8.0	392	Oct. 23
084803 S Hya	7.8	257	Aug. 8	1910*19* R Sgr	7.3	269	Mar. 27
0850*08* T Hya	7.8	288	Feb. 3	193449 R Cyg	7.5	426	—
093934 R LMi	7.1	372	Apr. 16	194048 RT Cyg	7.3	190	June 21
094211 R Leo	5.8	313	June 25	194632 χ Cyg	5.2	407	—
103769 R UMa	7.5	302	Mar. 31	201647 U Cyg	7.2	465	—
1214*18* R Crv	7.5	317	Mar. 14	2044*05* T Aqr	7.7	202	June 10
122001 SS Vir	6.8	355	Feb. 21	210868 T Cep	6.0	390	Dec. 24
123160 T UMa	7.7	257	Sept. 3	213753 RU Cyg	8.0	234	May 4
123307 R Vir	6.9	146	Mar. 29	230110 R Peg	7.8	378	Apr. 2
123961 S UMa	7.8	226	Feb. 14	230759 V Cas	7.9	228	Aug. 14
131546 V CVn	6.8	192	Apr. 17	231508 S Peg	8.0	319	Mar. 9
1327*06* S Vir	7.0	378	Mar. 13	2338*15* R Aqr	6.5	387	Mar. 27
134440 R CVn	7.7	328	Oct. 12	235350 R Cas	7.0	431	Nov. 4
142584 R Cam	7.9	270	June 15	2357*15* W Cet	7.6	351	Jan. 1

OTHER TYPES OF VARIABLE STARS

Variable		Max. m_v	Min. m_v	Type	Sp. Cl.	Period d	Epoch 1981 E.S.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 1.72*
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. 3.19*
060822	η Gem	3.1	3.9	Semi R	M3	233.4	—
061907	T Mon	5.6	6.6	δ Cep	F7–K1	27.0205	Jan. 16.82
065820	ζ Gem	3.6	4.2	δ Cep	F7–G3	10.15082	Jan. 3.34
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. 13.41*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.566867	Jan. 1.17
194700	η Aql	3.5	4.3	δ Cep	F6–G4	7.176641	Jan. 5.80
222557	δ Cep	3.5	4.4	δ Cep	F5–G2	5.366341	Jan. 3.22

*Minimum.

BRIEF DESCRIPTION OF VARIABLE TYPES

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

I. *Pulsating Variables*

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

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

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

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

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

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

II. *Eruptive Variables*

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

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

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

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

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

III. *Eclipsing Binaries*

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

IV. *Rotating Variables*

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

INTRODUCING SS CYGNI

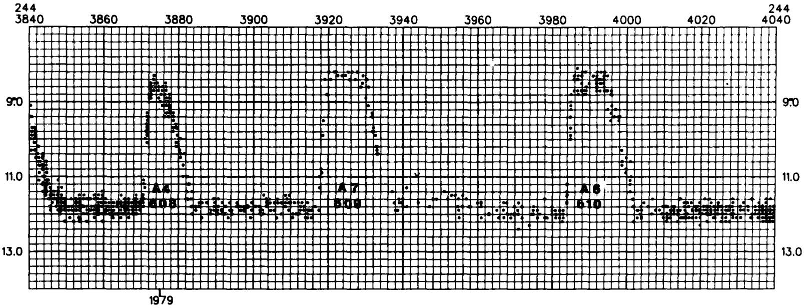
Each year, in co-operation with the AAVSO, we introduce one or two new variables to our readers. Recent editions of this HANDBOOK, for instance, have featured the Orion variables, CY Aqr, Mira, Z UMa, R Sct and R CrB.

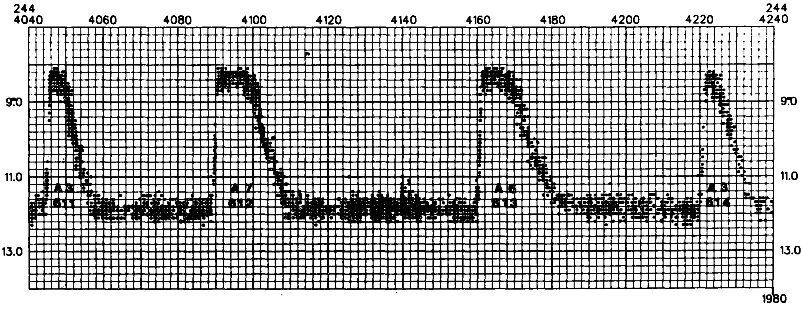
This year, we introduce SS Cygni. To many variable star observers, it needs no introduction, as it is one of the most famous variables in the sky. It is an eruptive variable of the *U Geminorum* type (see opposite). Every few weeks, on the average, it brightens from magnitude 12 to magnitude 8. At minimum, it can be observed with a small telescope. At maximum, it can be observed with binoculars.

Visual observations of SS Cyg have always been worthwhile, but are particularly important now that SS Cyg has been found (from satellite observations) to be an ultraviolet and X-ray emitter. The satellite users depend on visual observers to tell them when the star is bright and active, and therefore worthy of further observation by satellite. The AAVSO particularly needs observations in the first half of the year.

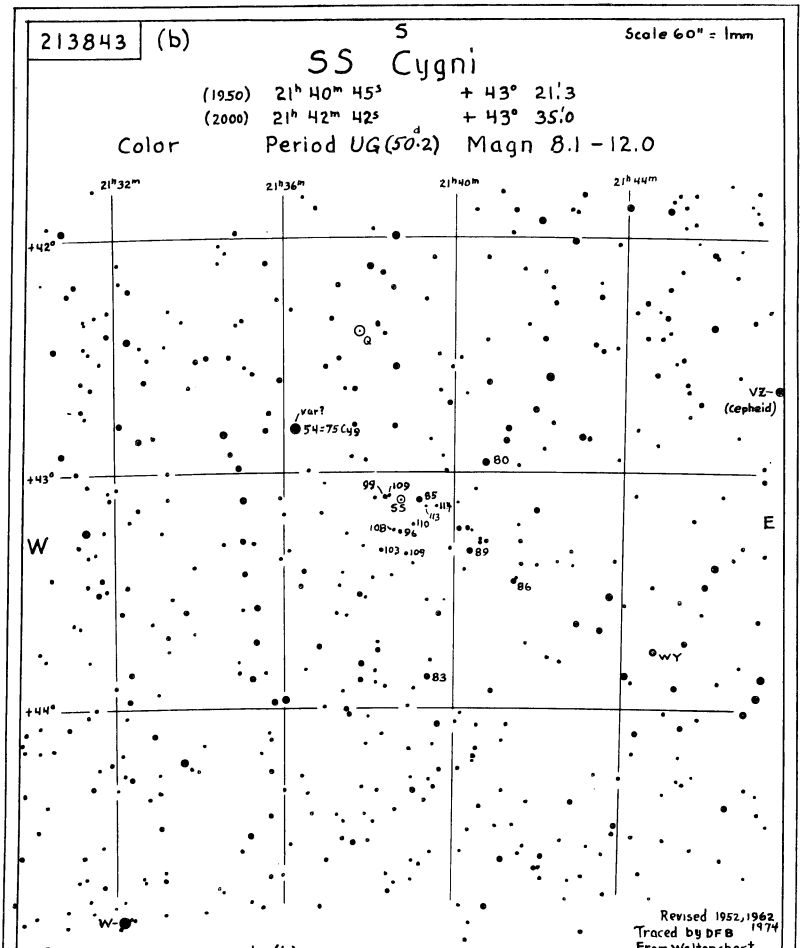
The recent light curve of SS Cyg is shown below, partly to illustrate the typical behaviour of the star, and partly to show off the AAVSO's new computer-plotted light curves. All future AAVSO data will be published in this format. Each dot represents one observation. The outbursts are numbered consecutively since the discovery in 1896, and they are typed according to shape.

For more information on the classification of the outbursts, please see the Variable Star Notes in the *JRASC*.





AAVSO FINDING CHART FOR SS CYGNI



The chart above was provided by the American Association of Variable Star Observers. SS Cygni is the circled dot. The numbers beside certain stars are the visual magnitudes with the decimal point removed. Charts for SS Cygni showing fainter stars are available from the AAVSO.

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				π	*D*	Sp.	μ	*W*	*V*	*Mv*
	α		δ								
	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
o^2 Eri A	4	14	−07	41	.205	15.9	K1e	4.08	104	4.43	5.99
B							*wd*A			9.53	11.09
C							M4e			11.17	12.73
BD+20°2465*	10	19	+19	58	.202	16.1	M4e	0.49	16	9.43	10.96
BD+44°2051A	11	05	+43	36	.199	16.4	M2e	4.40	132	8.77	10.26
B							M8e			(14.5)	(16.0)
Altair	19	49	+08	49	.196	16.6		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		Type	Size	S	m	Dist.	Remarks
			h m	° ′		′	mag. sq″	*	10^3 l.y.	
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.

THE MESSIER CATALOGUE

Compiled By Alan Dyer

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

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

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

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

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
				h m °			
82	UMa	3034	G-Pec*	9 54.4 +69 47	8.8	the "exploding" galaxy	
97	UMa	3587	PN*	11 13.7 +55 08	12.0	Owl Nebula	
101	UMa	5457	G-Sc*	14 02.5 +54 27	9.6	large, faint face-on spiral	
108	UMa	3556	G-Sc	11 10.5 +55 47	10.7	nearly edge-on; near M97	
109	UMa	3992	G-Sb	11 56.6 +53 29	10.8	barred spiral; near γ UMa	
65	Leo	3623	G-Sb	11 17.8 +13 13	9.3	bright elongated spiral	
66	Leo	3627	G-Sb	11 19.1 +13 07	8.4	M65 in same field	
95	Leo	3351	G-SBb	10 42.8 +11 49	10.4	bright barred spiral	
96	Leo	3368	G-Sbp	10 45.6 +11 56	9.1	M95 in same field	
105	Leo	3379	G-E1	10 46.8 +12 42	9.2	very near M95 and M96	
53	Com	5024	GC	13 12.0 +18 17	7.6	15 cm scope needed to resolve	
64	Com	4826	G-Sb*	12 55.7 +21 48	8.8	Black Eye Galaxy	
85	Com	4382	G-SO	12 24.3 +18 18	9.3	bright elliptical shape	
88	Com	4501	G-Sb	12 30.9 +14 32	10.2	bright multiple-arm spiral	
91	Com	4548	G-SBb	12 34.4 +14 36	10.8	not the same as M58	
98	Com	4192	G-Sb	12 12.7 +15 01	10.7	nearly edge-on spiral	
99	Com	4254	G-Sc	12 17.8 +14 32	10.1	nearly face-on spiral	
100	Com	4321	G-Sc	12 21.9 +15 56	10.6	face-on spiral; star-like nuc.	
49	Vir	4472	G-E4*	12 28.8 +08 07	8.6	very bright elliptical	
58	Vir	4579	G-SB	12 36.7 +11 56	9.2	bright barred spiral	
59	Vir	4621	G-E3	12 41.0 +11 47	9.6	bright elliptical near M58	
60	Vir	4649	G-E1	12 42.6 +11 41	8.9	bright elliptical near M59	
61	Vir	4303	G-Sc	12 20.8 +04 36	10.1	face-on barred spiral	
84	Vir	4374	G-E1	12 24.1 +13 00	9.3	bright elliptical	
86	Vir	4406	G-E3	12 25.1 +13 03	9.7	M84 in same field	
87	Vir	4486	G-E1	12 29.7 +12 30	9.2	nearly spherical galaxy	
89	Vir	4552	G-E0	12 34.6 +12 40	9.5	resembles M87; smaller	
90	Vir	4569	G-Sb	12 35.8 +13 16	10.0	bright spiral; near M89	
104	Vir	4594	G-Sb*	12 38.8 −11 31	8.7	Sombrero Galaxy	
3	CVn	5272	GC*	13 41.3 +28 29	6.4	contains many variables	
51	CVn	5194	G-Sc*	13 29.0 +47 18	8.1	Whirlpool Galaxy	
63	CVn	5055	G-Sb*	13 14.8 +42 08	9.5	Sunflower Galaxy	
94	CVn	4736	G-Sbp*	12 50.1 +41 14	7.9	very bright and comet-like	
106	CVn	4258	G-Sbp*	12 18.0 +47 25	8.6	large, bright spiral	
68	Hya	4590	GC	12 38.3 −26 38	8.2	15 cm scope needed to resolve	
83	Hya	5236	G-Sc*	13 35.9 −29 46	10.1	very faint and diffuse	
102	Dra	5866	G-E6p	15 05.9 +55 50	10.8	small edge-on galaxy	
5	Ser	5904	GC*	15 17.5 +02 11	6.2	one of the finest globulars	
The Summer Sky							
13	Her	6205	GC*	16 41.0 +36 30	5.7	spectacular globular cl.	
92	Her	6341	GC*	17 16.5 +43 10	6.1	9°NE. of M13; bright	
9	Oph	6333	GC	17 18.1 −18 30	7.3	smallest of Oph. globulars	
10	Oph	6254	GC*	16 56.0 −04 05	6.7	rich cl.; M12 3.4° away	
12	Oph	6218	GC*	16 46.1 −01 55	6.6	loose globular	
14	Oph	6402	GC	17 36.5 −03 14	7.7	20 cm scope needed to resolve	
19	Oph	6273	GC	17 01.3 −26 14	6.6	oblate globular	
62	Oph	6266	GC	16 59.9 −30 05	6.6	unsymmetrical; in rich field	
107	Oph	6171	GC	16 31.3 −13 02	9.2	small, faint globular	
4	Sco	6121	GC*	16 22.4 −26 27	6.4	bright globular near Antares	
6	Sco	6405	OC*	17 38.9 −32 11	5.3	best at low magnification	
7	Sco	6475	OC*	17 52.6 −34 48	3.2	excellent in binoculars	
80	Sco	6093	GC	16 15.8 −22 56	7.7	very compressed globular	
16	Ser	6611	EN*	18 17.8 −13 48	—	Star-Queen Neb. w/ open cl.	
8	Sgr	6523	EN*	18 02.4 −24 23	—	Lagoon Neb. w/cl. NGC 6530	
17	Sgr	6618	EN*	18 19.7 −16 12	—	Swan or Omega Nebula	
18	Sgr	6613	OC	18 18.8 −17 09	7.5	sparse cluster; 1°S. of M17	
20	Sgr	6514	EN*	18 01.2 −23 02	—	Trifid Nebula	
21	Sgr	6531	OC	18 03.4 −22 30	6.5	0.7°SW. of M20	
22	Sgr	6656	GC*	18 35.2 −23 55	5.9	low altitude dims beauty	
23	Sgr	6494	OC*	17 55.7 −19 00	6.9	bright, loose cluster	
24	Sgr	—	—	18 17 −18 27	4.6	Milky Way patch; binoc. obj.	
25	Sgr	I4725	OC*	18 30.5 −19 16	6.5	bright but sparse cluster	
28	Sgr	6626	GC	18 23.2 −24 52	7.3	compact globular near M22	

M	Con	NGC	Type	R.A. (1980) Dec.	m_v	Remarks	Seen
				h m ° ′			
54	Sgr	6715	GC	18 53.8 −30 30	8.7p	not easily resolved	
55	Sgr	6809	GC*	19 38.7 −31 00	7.1p	bright, loose globular	
69	Sgr	6637	GC	18 30.1 −32 23	8.9	small, poor globular	
70	Sgr	6681	GC	18 42.0 −32 18	9.6	small globular; 2°E. of M69	
75	Sgr	6864	GC	20 04.9 −21 59	8.0	small, remote globular	
11	Sct	6705	OC*	18 50.0 −06 18	6.3	superb open cluster	
26	Sct	6694	OC	18 44.1 −09 25	9.3	bright, coarse cluster	
56	Lyr	6779	GC	19 15.8 +30 08	8.2	within rich field	
57	Lyr	6720	PN*	18 52.9 +33 01	9.3	Ring Nebula	
71	Sge	6838	GC	19 52.8 +18 44	9.0	loose globular cl.	
27	Vul	6853	PN*	19 58.8 +22 40	7.6	Dumbbell Nebula	
29	Cyg	6913	OC	20 23.3 +38 27	7.1	small, poor open cl.	
39	Cyg	7092	OC	21 31.5 +48 21	5.2	very sparse cluster	
The Autumn Sky							
2	Aqr	7089	GC*	21 32.4 −00 54	6.3	20 cm scope needed to resolve	
72	Aqr	6981	GC	20 52.3 −12 39	9.8	near NGC 7009 (Saturn Neb.)	
73	Aqr	6994	OC	20 57.8 −12 44	11.0	group of 4 stars only	
15	Peg	7078	GC*	21 29.1 +12 05	6.0	rich, compact globular	
30	Cap	7099	GC	21 39.2 −23 15	8.4	noticeable elliptical shape	
52	Cas	7654	OC	23 23.3 +61 29	7.3	young, rich cluster	
103	Cas	581	OC	01 31.9 +60 35	7.4	3 NGC clusters nearby	
31	And	224	G-Sb*	00 41.6 +41 09	4.8	Andromeda Gal.; large	
32	And	221	G-E2*	00 41.6 +40 45	8.7	companion gal. to M31	
110	And	205	G-E6*	00 39.1 +41 35	9.4	companion gal. to M31	
33	Tri	598	G-Sc*	01 32.8 +30 33	6.7	large, diffuse spiral	
74	Psc	628	G-Sc	01 35.6 +15 41	10.2	faint, elusive spiral	
77	Cet	1068	G-Sbp	02 41.6 +00 04	8.9	Seyfert gal.; star-like nuc.	
34	Per	1039	OC	02 40.7 +42 43	5.5	best at very low mag.	
76	Per	650	PN*	01 40.9 +51 28	12.2	Little Dumbbell Neb.	

NUMERICAL LISTING OF MESSIER OBJECTS

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

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

THE FINEST N.G.C. OBJECTS

COMPILED BY ALAN DYER

The New General Catalogue of deep-sky objects was originally published by J. L. E. Dreyer in 1888. Supplementary Index Catalogues were published in 1895 and 1908. Together, they contain descriptions and positions of 14,755 galaxies, clusters and nebulae. Many of these are well within the reach of amateur telescopes. Indeed, the brightness and size of many NGC objects rival those of the better known deep-sky targets of the Messier Catalogue (almost all of which are also in the NGC catalogue). However, most NGC objects are more challenging to locate and observe than the Messiers. The following is a listing of 110 of the finest NGC objects. Objects are grouped within their respective constellations, with the constellations listed roughly in order of right ascension, commencing with the autumn *evening* sky.

A telescope of at least 15 cm aperture will likely be required to locate all these objects. The Skalnate Pleso *Atlas of the Heavens* or the sets of index card finder charts called *AstroCards* will be indispensible in locating these and many other deep-sky objects. All 110 objects are plotted on the Skalnate Pleso *Atlas*, with the exception of NGC 3432 in Leo Minor and NGC 4388 in Virgo which are plotted but not labelled on the *Atlas* charts. Use of a nebular filter is also recommended for observing the planetary and emission nebula on the list.

Abbreviations used: OC = open cluster, GC = globular cluster, PN = planetary nebula, EN = emission nebula, RN = reflection nebula, E/RN = combination emission and reflection nebula, SNR = supernova remnant, G = galaxy (the Hubble classification is also listed with each galaxy). Coordinates are for Epoch 1950. Magnitudes are visual; exceptions are marked with a "p" indicating a photographic magnitude. Sizes of each object are in minutes of arc, with the exception of planetary nebulae which are given in seconds of arc. The number of stars (*) and, where space permits, the Shapley classification is also given for star clusters in the Remarks column. Most data are from the Skalnate Pleso *Atlas* Catalogue, occasionally from other sources.

No.	NGC	Con	Type	R.A. (1950) Dec.				m_v	Size	Remarks
The Autumn Sky										
				h	m	°	′			
1	7009	Aqr	PN	21	01.4	−11	34	9.1	44″ × 26″	Saturn Nebula; bright oval planetary
2	7293	Aqr	PN	22	27.0	−21	06	6.5	900″ × 720″	Helix Nebula; very large and diffuse
3	7331	Peg	G-Sb	22	34.8	+34	10	9.7	10.0 × 2.3	large, very bright spiral galaxy
4	7789	Cas	OC	23	54.5	+56	26	9.6	30	200*; faint but very rich cluster
5	185	Cas	G-EO	00	36.1	+48	04	11.7	2.2 × 2.2	companion to M31; quite bright
6	281	Cas	EN	00	50.4	+56	19	—	23 × 27	large, faint nebulosity near γ Cas.
7	457	Cas	OC	01	15.9	+58	04	7.5	10	100*; Type e—intermediate rich
8	663	Cas	OC	01	42.6	+61	01	7.1	11	80*; NGC 654 and 659 nearby
9	7662	And	PN	23	23.5	+42	14	9.2	32″ × 28″	star-like at low mag.; annular, bluish
10	891	And	G-Sb	02	19.3	+42	07	10.9p	11.8 × 1.1	faint, classic edge-on with dust lane
11	253	Scl	G-Scp	00	45.1	−25	34	8.9	24.6 × 4.5	very large and bright but at low alt.
12	772	Ari	G-Sb	01	56.6	+18	46	10.9	5.0 × 3.0	diffuse spiral galaxy
13	936	Cet	G-SBa	02	25.1	−01	22	10.7	3.3 × 2.5	near M77; NGC 941 in same field
14a	869	Per	OC	02	17.0	+56	54	4.4	36	Double Cluster; superb!
14b	884	Per	OC	02	17.0	+56	54	4.7	36	Double Cluster; superb!
15	1023	Per	G-E7p	02	37.2	+38	52	10.5p	4.0 × 1.2	bright, lens-shaped galaxy; near M34
16	1491	Per	EN	03	59.5	+51	10	—	3 × 3	small, fairly bright emission nebula
17	1501	Cam	PN	04	02.6	+60	47	12.0	56″ × 58″	faint, distinctive oval; darker centre
18	1232	Eri	G-Sc	03	07.5	−20	46	10.7	7.0 × 5.5	fairly bright, large face-on spiral
19	1300	Eri	G-SBb	03	17.5	−19	35	11.3	5.7 × 3.5	large barred spiral near NGC 1232
20	1535	Eri	PN	04	12.1	−12	52	10.4	20″ × 17″	blue-grey disk

No.	NGC	Con	Type	R.A. (1950) Dec.				m_v	Size	Remarks
				h	m	°	′			
The Winter Sky										
21	1907	Aur	OC	05	24.7	+35	17	9.9	5	40*; nice contrast with nearby M38
22	1931	Aur	EN	05	28.1	+34	13	—	3 × 3	haze surrounding 4 stars
23	1788	Ori	E/RN	05	04.5	−03	24	—	8 × 5	fairly bright emission/reflection neb.
24	1973+	Ori	E/RN	05	32.9	−04	48	—	40 × 25	near M42 and M43; often neglected
25	2022	Ori	PN	05	39.3	+09	03	12.4	28″ × 27″	small, faint but distinct; annular
26	2194	Ori	OC	06	11.0	+12	50	9.2	8	100*; Type e; faint but rich
27	2158	Gem	OC	06	04.3	+24	06	12.5	4	40*; same field as M35; nice contrast
28	2392	Gem	PN	07	26.2	+21	01	8.3	47″ × 43″	Clown-Face Nebula; very bright
29	2244	Mon	OC	06	29.7	+04	54	6.2	40	16*; in centre of Rosette Nebula
30	2261	Mon	E/RN	06	36.4	+08	46	var.	5 × 3	Hubble's Variable Nebula
31	2359	CMa	EN	07	15.4	−13	07	—	8 × 6	10 stars in bright circular nebulosity
32	2438	Pup	PN	07	39.6	−14	36	11.8	68″	within M46 open cluster
33	2440	Pup	PN	07	39.9	−18	05	10.3	54″ × 20″	irregular appearance
34	2539	Pup	OC	08	08.4	−12	41	8.2	21	150*; Type f—fairly rich
35	2403	Cam	G-Sc	07	32.0	+65	43	8.9	17 × 10	bright, very large; visible in binocs.
36	2655	Cam	G-S	08	49.4	+78	25	10.7	5.0 × 2.4	star-like nucleus
The Spring Sky										
37	2683	Lyn	G-Sb	08	49.6	+33	38	9.6	8.0 × 1.3	nearly edge-on spiral; very bright
38	2841	UMa	G-Sb	09	18.6	+51	12	9.3	6.4 × 2.4	classic elongated spiral; very bright
39	2985	UMa	G-Sb	09	46.0	+72	31	10.6	5.5 × 5.0	near M81 and M82
40	3077	UMa	G-E2p	09	59.4	+68	58	10.9	2.3 × 1.9	small elliptical; companion to M81/82
41	3079	UMa	G-Sb	09	58.6	+55	57	11.2	8.0 × 1.0	edge-on spiral, NGC 2950 nearby
42	3184	UMa	G-Sc	10	15.2	+41	40	9.6	5.6 × 5.6	large, diffuse face-on spiral
43	3675	UMa	G-Sb	11	23.5	+43	52	10.6	4.0 × 1.7	elongated spiral; same field as 56 UMa
44	3877	UMa	G-Sb	11	43.5	+47	46	10.9	4.4 × 0.8	edge-on; same field as Chi UMa
45	3941	UMa	G-Sa	11	50.3	+37	16	9.8	1.8 × 1.2	small, bright elliptical shape
46	4026	UMa	G-E8	11	56.9	+51	12	10.7	3.6 × 0.7	lens-shaped edge-on; near γ UMa
47	4088	UMa	G-Sc	12	03.0	+50	49	10.9	4.5 × 1.4	nearly edge-on; 4085 in same field
48	4111	UMa	G-S0	12	04.5	+43	21	9.7	3.3 × 0.6	bright lens-shaped edge-on spiral
49	4157	UMa	G-Sb	12	08.6	+50	46	11.9	6.5 × 0.8	edge-on, a thin sliver; 4026+4088 nearby
50	4605	UMa	G-Scp	12	37.8	+61	53	9.6	5.0 × 1.2	bright, distinct edge-on spiral
51	3115	Sex	G-E6	10	02.8	−07	28	9.3	4.0 × 1.2	"Spindle Galaxy"; bright, elongated
52	3242	Hya	PN	10	22.4	−18	23	9.1	40″ × 35″	"Ghost of Jupiter" planetary
53	3344	LMi	G-Sc	10	40.7	+25	11	10.4	7.6 × 6.2	diffuse face-on spiral
54	3432	LMi	G-Sc	10	49.7	+36	54	11.4	5.8 × 0.8	nearly edge-on; faint flat streak
55	2903	Leo	G-Sb	09	29.3	+21	44	9.1	11.0 × 4.6	very bright, large elongated spiral
56	3384	Leo	G-E7	10	45.7	+12	54	10.2	4.4 × 1.4	same field as M105 and NGC 3389
57	3521	Leo	G-Sc	11	03.2	+00	14	9.5	7.0 × 4.0	very bright, large spiral
58	3607	Leo	G-E1	11	14.3	+18	20	9.6	1.7 × 1.5	NGC 3605 and 3608 in same field
59	3628	Leo	G-Sb	11	17.7	+13	53	10.9	12.0 × 1.5	large edge-on; same field as M65/M66
60	4214	CVn	G-Irr	12	30.1	+36	36	10.3	6.6 × 5.8	large irregular galaxy
61	4244	CVn	G-S	12	15.0	+38	05	11.9	14.5 × 1.0	large, distinct edge-on spiral
62	4449	CVn	G-Irr	12	25.8	+44	22	9.2	4.1 × 3.4	bright rectangular shape
63	4490	CVn	G-Sc	12	28.3	+41	55	9.7	5.6 × 2.1	bright spiral; 4485 in same field
64	4631	CVn	G-Sc	12	39.8	+32	49	9.3	12.6 × 1.4	very large, bright edge-on; no dust lane
65	4656	CVn	G-Sc	12	41.6	+32	26	11.2	19.5 × 2.0	same field as 4631; fainter, smaller
66	5005	CVn	G-Sb	13	08.5	+37	19	9.8	4.4 × 1.7	bright elongated spiral; near α CVn
67	5033	CVn	G-Sb	13	11.2	+36	51	10.3	9.9 × 4.8	large, bright spiral near NGC 5005
68	4274	Com	G-Sb	12	17.4	+29	53	10.8	6.7 × 1.3	NGC 4278 in same field
69	4494	Com	G-E1	12	28.9	+26	03	9.6	1.3 × 1.2	small, bright elliptical
70	4414	Com	G-Sc	12	24.0	+31	30	9.7	3.2 × 1.5	bright spiral; star-like nucleus
71	4559	Com	G-Sc	12	33.5	+28	14	10.6	11.0 × 4.5	large spiral; coarse structure
72	4565	Com	G-Sb	12	33.9	+26	16	10.2	14.4 × 1.2	superb edge-on spiral with dust lane
73	4725	Com	G-Sb	12	48.1	+25	46	8.9	10.0 × 5.5	very bright, large spiral
74	4631	Crv	PN	12	21.9	−18	29	11.4	18″	$12\overset{m}{.}8$ central star

No.	NGC	Con	Type	R.A. (1950) Dec.		m_v	Size	Remarks
75	4216	Vir	G-Sb	12 13.4	+13 25	10.4	7.4 × 0.9	nearly edge-on; two others in field
76	4388	Vir	G-Sb	12 23.3	+12 56	11.7p	5.0 × 0.9	edge-on; near M84 and M86
77	4438	Vir	G-S	12 25.3	+13 17	10.8	8.0 × 3.0	paired with NGC a4435
78	4473	Vir	G-E4	12 27.3	+13 42	10.1	1.6 × 0.9	NGC 4477 in same field
79	4517	Vir	G-Sc	12 29.0	+00 21	12.0	8.9 × 0.8	faint edge-on spiral
80	4526	Vir	G-E7	12 31.6	+07 58	10.9	3.3 × 1.0	between two $7^{m}0$ stars
81	4535	Vir	G-Sc	12 31.8	+08 28	10.4p	6.0 × 4.0	near M49
82	4697	Vir	G-E4	12 46.0	−05 32	9.6	2.2 × 1.4	small, bright elliptical
83	4699	Vir	G-Sa	12 46.5	−08 24	9.3	3.0 × 2.0	small, bright elliptical shape
84	4762	Vir	G-Sa	12 50.4	+11 31	11.0	3.7 × 0.4	flattest galaxy; 4754 in same field
85	5746	Vir	G-Sb	14 42.3	+02 10	10.1	6.3 × 0.8	fine edge-on spiral near 109 Virginis
86	5907	Dra	G-Sb	15 14.6	+56 31	11.3	11.1 × 0.7	fine edge-on spiral with dust lane
87	6503	Dra	G-Sb	16 49.9	+70 10	9.6	4.5 × 1.0	bright spiral
88	6543	Dra	PN	17 58.8	+66 38	8.7	22″	luminous blue-green disk
The Summer Sky								
89	6207	Her	G-Sc	16 41.3	+36 56	11.3	2.0 × 1.1	same field as M13 cluster
90	6210	Her	PN	16 42.5	+23 53	9.2	20″ × 13″	very star-like blue planetary
91	6369	Oph	PN	17 26.3	−23 44	9.9	28″	greenish, annular, and circular
92	6572	Oph	PN	18 09.7	+06 50	8.9	16″ × 13″	tiny oval; bright blue
93	6633	Oph	OC	18 25.1	+06 32	4.9	20	wide-field cluster; IC4756 nearby
94	6712	Sct	GC	18 50.3	−08 47	8.9	2.1	small globular near M26
95	6819	Cyg	OC	19 39.6	+40 06	10.1	6	150*; faint but rich cluster
96	6826	Cyg	PN	19 43.4	+50 24	9.4	27″ × 24″	Blinking Planetary Nebula
97	6960	Cyg	SNR	20 43.6	+30 32	—	70 × 6	Veil Nebula (west component)
98	6992–5	Cyg	SNR	20 54.3	+31 30	—	78 × 8	Veil Nebula (east component)
99	7000	Cyg	EN	20 57.0	+44 08	—	120 × 100	North America Neb.; binoc. obj.
100	7027	Cyg	EN	21 05.1	+42 02	10.4	18″ × 11″	very star-like H II region
101	6445	Sgr	PN	17 47.8	−20 00	11.8	38″ × 29″	small, bright and annular; near M23
102	6818	Sgr	PN	19 41.1	−14 17	9.9	22″ × 15″	"Little Gem"; annular; 6822 nearby
103	6802	Vul	OC	19 28.4	+20 10	11.0	3.5	60*; small, faint but rich
104	6940	Vul	OC	20 32.5	+28 08	8.2	20	100*; Type e; rich cluster
105	6939	Cep	OC	20 30.4	+60 28	10.0	5	80*; very rich; 6946 in same field
106	9646	Cep	G-Sc	20 33.9	+59 58	9.7p	9.0 × 7.5	faint, diffuse face-on spiral
107	7129	Cep	RN	21 42.0	+65 52	—	7 × 7	fairly bright; several stars involved
108	40	Cep	PN	00 10.2	+72 15	10.5	60″ × 38″	fairly large; $11^{m}5$ central star
109	7209	Lac	OC	22 03.2	+46 15	7.6	20	50*; Type d; within Milky Way
110	7243	Lac	OC	22 13.2	+49 38	7.4	20	40*; Type d; within Milky Way

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) δ		Remarks
	h m	° ′	
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.*)

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 of thousands of stars, sometimes barely distinguishable from random fluctuations of the general field; they are concentrated toward the Galactic disk and generally contain stars of chemical abundance like the sun. They range in age from very young to very old.

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

The first table includes all well-defined Galactic open clusters with diameters greater than 40′ and/or integrated magnitudes brighter than 5.0, as well as the richest clusters and some of special interest. The apparent integrated photographic magnitude is from Collinder, the angular diameter is generally from Trumpler, and the photographic magnitude of the fifth-brightest star, m(5) is from Shapley, except where in italics which are new data. The distance is mainly from Becker and Fenkart (*Astr. Astrophys. Suppl.* **4**, 241 (1971)). The earliest spectral type of cluster stars, Sp, is a measure of the age as follows: expressed in millions of years, 05 = 2, B0 = 8, B5 = 70, A0 = 400, A5 = 1000, F0 = 3000 and F5 = 10000.

The second table includes all globular clusters with a total apparent photographic magnitude brighter than about 7.6. 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(25) refers to the mean blue magnitude of the 25 brightest stars excluding the 5 brightest, which are liable to fluctuate more. The number of variables known in the cluster is also given.

OPEN CLUSTERS

NGC or other†	R.A. 1980		Dec. 1980		Int. m_{pg}	Diam. ′	m(5)	Dist. 1000 l.y.	Sp	Remarks
	h	m	°							
188	00	42.0	+85	14	9.3	14	14.6	5.0	F2	oldest known
752	01	56.6	+37	35	6.6	45	9.6	1.2	A5	
869	02	17.6	+57	04	4.3	30	9.5	7.0	B1	h Per
884	02	21.0	+57	02	4.4	30	9.5	8.1	B0	χ Per, M supergiants
Perseus	03	21	+48	32	2.3	240	5	0.6	B1	moving cl.; α Per
Pleiades	03	45.9	+24	04	1.6	120	4.2	0.41	B6	M45, best known
Hyades	04	19	+15	35	0.8	400	*1.5*	0.13	A2	moving cl.**, in Taurus
1912	05	27.3	+35	49	7.0	18	9.7	4.6	B5	M38
1976/80	05	34.4	−05	24	2.5	50	*5.5*	1.3	O5	Trapezium, very young
2099	05	51.1	+32	32	6.2	24	9.7	4.2	B8	M37

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

NGC or other	R.A. 1980 h	m	Dec. 1980 °	′	Int. m_{pg}	Diam. ′	m(5)	Dist. 1000 l.y.	Sp	Remarks
2168	06	07.6	+24	21	5.6	29	9.0	2.8	B5	M35
2232	06	25.5	−04	44	4.1	*20*	*7*	1.6	B1	
2244	06	31.3	+04	53	5.2	27	*8.0*	5.3	O5	Rosette, very young
2264	06	39.9	+09	54	4.1	30	*8.0*	2.4	O8	S Mon
2287	06	46.2	−20	43	5.0	32	*8.8*	2.2	B4	M41
2362	07	18.0	−24	54	3.8	7	9.4	5.4	O9	τ CMa
2422	07	34.7	−14	27	4.3	30	9.8	1.6	B3	
2437	07	40.9	−14	46	6.6	27	10.8	5.4	B8	M46
2451	07	44.7	−37	55	3.7	37	6	1.0	B5	
2516	07	58.0	−60	51	3.3	50	10.1	1.2	B8	
2546	08	11.8	−37	35	5.0	45	7	2.7	B0	
2632	08	39.0	+20	04	3.9	90	7.5	0.52	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	O3	η Car and Nebula
3532	11	05.5	−58	33	3.4	55	8.1	1.4	B8	
3766	11	35.2	−61	30	4.4	12	8.1	5.8	B1	
Coma	12	24.1	+26	13	2.9	300	5.5	0.3	A1	Very sparse 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	06	7.1	4.5	11.7	10.3	B1	Cepheids CEa, CEb and CF Cas

GLOBULAR CLUSTERS

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

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

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

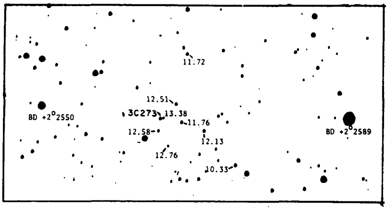
NGC or name	M	α 1980 δ		Type	m_{pg}	Dimensions	Distance millions of l.y.
		h m	° ′			′ ′	
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		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		m_{pg}	$(m-M)_{pg}$	M_{pg}	Type	Dist. thous. of l.y.
		h m	° ′					
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.

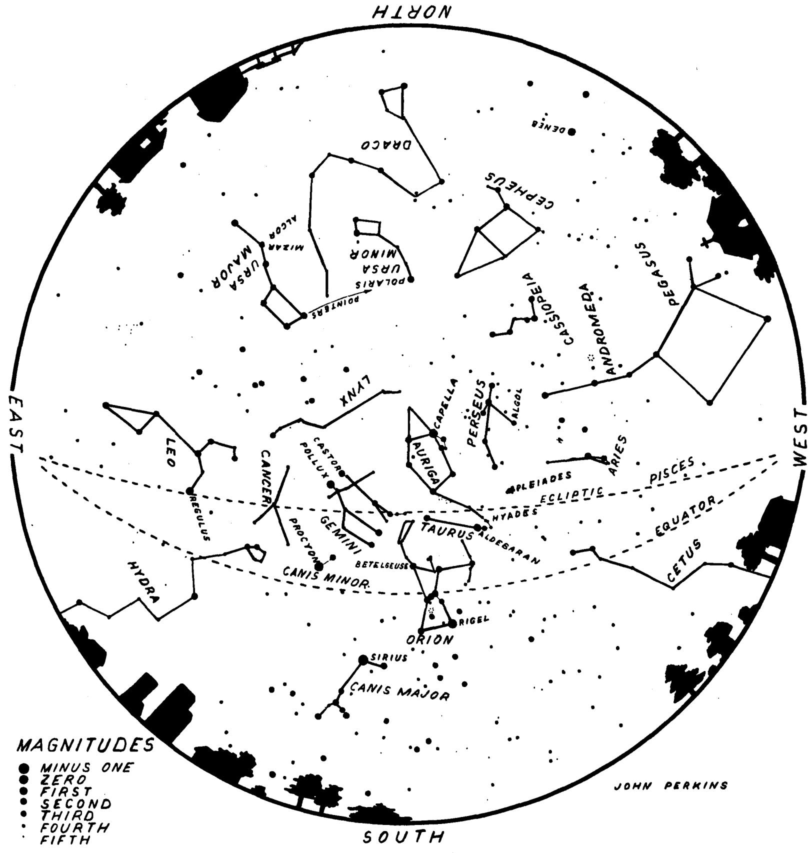


Name	Type	R.A. 1950	Dec.	Mag.
		h m	° ′	
NGC 1275	Seyfert?	3 16.5	+41 20	11–13
3C 120	Seyfert	4 30.5	+05 15	14–16
OJ 287	BL Lac	8 52.0	+20 18	12–16
NGC 4151	Seyfert	12 08.0	+39 41	10–12
3C 273	Quasar	12 26.6	+02 20	12–13
3C 345	Quasar	16 41.3	+39 54	14–17
Mkn. 509	Seyfert	20 41.5	−10 54	12–13
BL Lac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

THE NIGHT SKY

LATITUDE 45°N

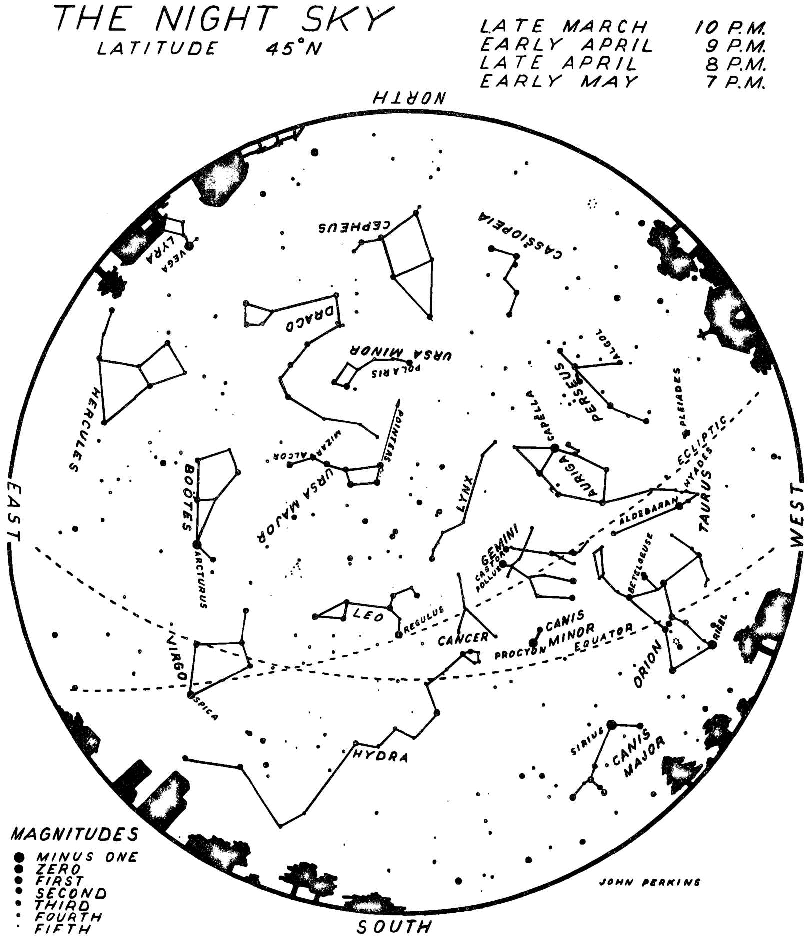
LATE JANUARY 10 P.M.
EARLY FEBRUARY 9 P.M.
LATE FEBRUARY 8 P.M.
EARLY MARCH 7 P.M.



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*.



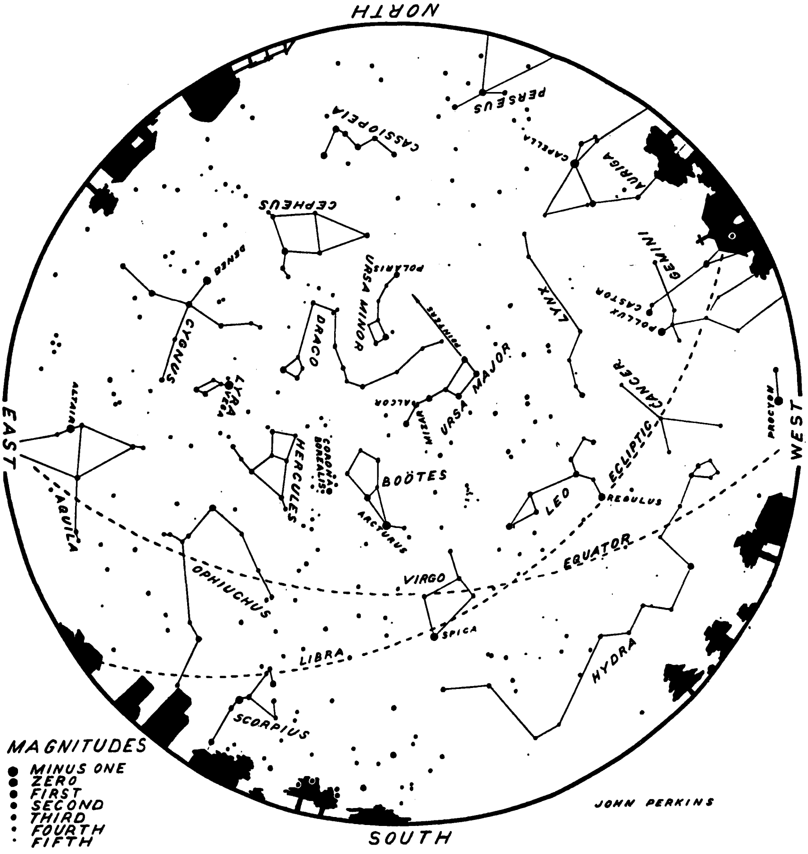
The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late December at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees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

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 NIGHT SKY
LATITUDE 45°N

LATE MAY 10 P.M.
EARLY JUNE 9 P.M.
LATE JUNE 8 P.M.
EARLY JULY 7 P.M.



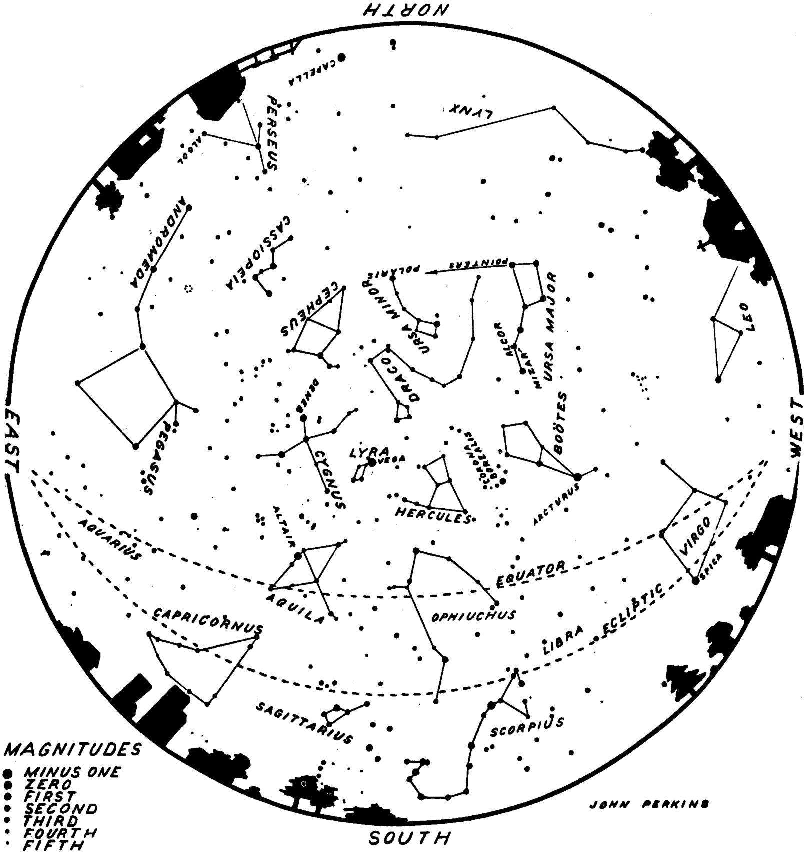
The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late February at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees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

LATE JULY 10 P.M.
EARLY AUGUST 9 P.M.
LATE AUGUST 8 P.M.
EARLY SEPTEMBER 7 P.M.



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.

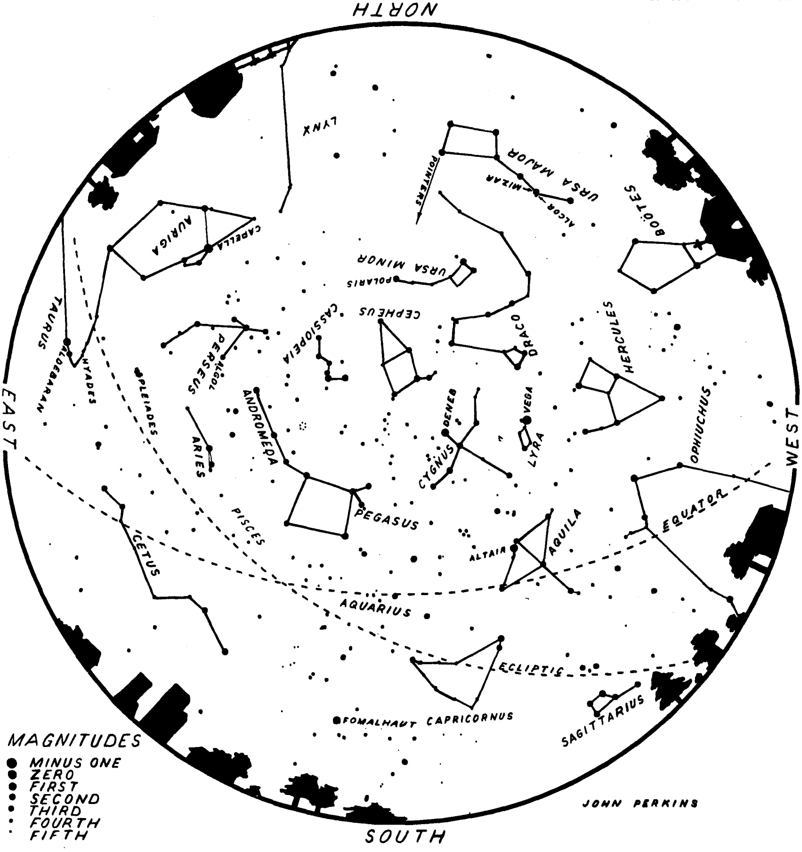
The centre of the map is the *zenith*, the point directly overhead; the circumference of the map is the *horizon*. To identify the stars, hold the map in front of you so that the part of the horizon which you are facing (north, for instance) is downward.

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 NIGHT SKY

LATITUDE 45°N

LATE SEPTEMBER 10 P.M.
EARLY OCTOBER 9 P.M.
LATE OCTOBER 8 P.M.
EARLY NOVEMBER 7 P.M.

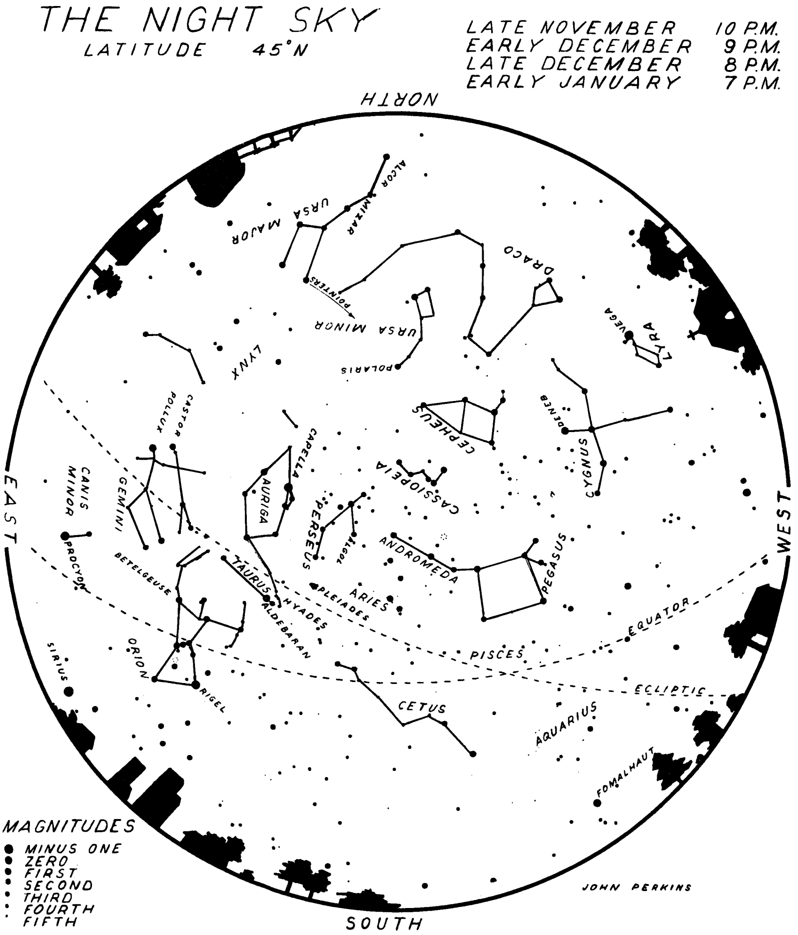


JOHN PERKINS

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.

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.

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.

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

Observatoire astronomique du mont Mégantic, Notre-Dame-des-Bois, P.Q. J0B 2E0.
May-September: Daily 2:00 p.m.–sunset.
Public observing, Saturday evening, May-August inclusive, by reservation. Telephone (514) 343-6718.

PLANETARIUMS

Calgary Centennial Planetarium, Mewata Park, P.O. Box 2100, Calgary, Alberta T2P 2M5.
For program information, telephone (403) 264-4060 or 264-2030.

Dow Planetarium, 1000 St. Jacques Street W., Montreal, P.Q. H3C 1G7.
For general information telephone (514) 872-4210 (24 hours recorded service).

The Halifax Planetarium, The Education Section of Nova Scotia Museum, Summer Street, Halifax, N.S. B3H 3A6.
Free public shows take place on most Tuesdays at 8:00 p.m. and group shows can be arranged. For information, telephone (902) 429-4610.

The Lockhart Planetarium, 394 University College, 500 Dysart Road, The University of Manitoba, Winnipeg, Manitoba R3T 2N2.
For times of public shows and for group reservations, telephone (204) 474-9785.

H.R. MacMillan Planetarium, 1100 Chestnut Street, Vancouver, B.C. V6J 3J9.
Public shows daily except Monday, 2:30 and 8:00.
Additional shows 1:00 and 4:00 weekends, holidays and summer.
For show information telephone (604) 736-3656.

Manitoba Planetarium, 190 Rupert Avenue at Main Street, Winnipeg, Manitoba R3B 0N2.
Shows are presented Tuesday through Sunday and on holiday and summer 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 7:45 p.m.
Weekends and holidays, 12:30, 1:45, 3:00 and 7:45 p.m. (Theatre closed Mondays, except holidays.)

McMaster University Planetarium, University Information Centre, GH 120, Hamilton, Ontario L8S 4L8.
Group reservations only (maximum 45). Telephone (416) 525-9140, ext. 4721.

Ontario Science Centre, 770 Don Mills Road, Don Mills, Ontario M3C 1T3.
Open daily except Christmas Day from 10:00 a.m. to 6:00 p.m. Telephone (416) 429-4100.

Provincial Museum of Alberta, Mobile Planetarium, 12845-102 Avenue, Edmonton, Alberta T5N 0M6.
This planetarium travels throughout Alberta with public shows given Monday through Wednesday evenings. For locations and times telephone (403) 427-1730.

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.

INDEX

JULIAN DAY CALENDAR, 1981

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. 2444606 = Jan. 1.5 U.T. 1981 = 12^h U.T. Jan. 1, 1981.

JULIAN DATES 1981: 2444000 +

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	605.5	636.5	664.5	695.5	725.5	756.5	786.5	817.5	848.5	878.5	909.5	939.5
2	606.5	637.5	665.5	696.5	726.5	757.5	787.5	818.5	849.5	879.5	910.5	940.5
3	607.5	638.5	666.5	697.5	727.5	758.5	788.5	819.5	850.5	880.5	911.5	941.5
4	608.5	639.5	667.5	698.5	728.5	759.5	789.5	820.5	851.5	881.5	912.5	942.5
5	609.5	640.5	668.5	699.5	729.5	760.5	790.5	821.5	852.5	882.5	913.5	943.5
6	610.5	641.5	669.5	700.5	730.5	761.5	791.5	822.5	853.5	883.5	914.5	944.5
7	611.5	642.5	670.5	701.5	731.5	762.5	792.5	823.5	854.5	884.5	915.5	945.5
8	612.5	643.5	671.5	702.5	732.5	763.5	793.5	824.5	855.5	885.5	916.5	946.5
9	613.5	644.5	672.5	703.5	733.5	764.5	794.5	825.5	856.5	886.5	917.5	947.5
10	614.5	645.5	673.5	704.5	734.5	765.5	795.5	826.5	857.5	887.5	918.5	948.5
11	615.5	646.5	674.5	705.5	735.5	766.5	796.5	827.5	858.5	888.5	919.5	949.5
12	616.5	647.5	675.5	706.5	736.5	767.5	797.5	828.5	859.5	889.5	920.5	950.5
13	617.5	648.5	676.5	707.5	737.5	768.5	798.5	829.5	860.5	890.5	921.5	951.5
14	618.5	649.5	677.5	708.5	738.5	769.5	799.5	830.5	861.5	891.5	922.5	952.5
15	619.5	650.5	678.5	709.5	739.5	770.5	800.5	831.5	862.5	892.5	923.5	953.5
16	620.5	651.5	679.5	710.5	740.5	771.5	801.5	832.5	863.5	893.5	924.5	954.5
17	621.5	652.5	680.5	711.5	741.5	772.5	802.5	833.5	864.5	894.5	925.5	955.5
18	622.5	653.5	681.5	712.5	742.5	773.5	803.5	834.5	865.5	895.5	926.5	956.5
19	623.5	654.5	682.5	713.5	743.5	774.5	804.5	835.5	866.5	896.5	927.5	957.5
20	624.5	655.5	683.5	714.5	744.5	775.5	805.5	836.5	867.5	897.5	928.5	958.5
21	625.5	656.5	684.5	715.5	745.5	776.5	806.5	837.5	868.5	898.5	929.5	959.5
22	626.5	657.5	685.5	716.5	746.5	777.5	807.5	838.5	869.5	899.5	930.5	960.5
23	627.5	658.5	686.5	717.5	747.5	778.5	808.5	839.5	870.5	900.5	931.5	961.5
24	628.5	659.5	687.5	718.5	748.5	779.5	809.5	840.5	871.5	901.5	932.5	962.5
25	629.5	660.5	688.5	719.5	749.5	780.5	810.5	841.5	872.5	902.5	933.5	963.5
26	630.5	661.5	689.5	720.5	750.5	781.5	811.5	842.5	873.5	903.5	934.5	964.5
27	631.5	662.5	690.5	721.5	751.5	782.5	812.5	843.5	874.5	904.5	935.5	965.5
28	632.5	663.5	691.5	722.5	752.5	783.5	813.5	844.5	875.5	905.5	936.5	966.5
29	633.5		692.5	723.5	753.5	784.5	814.5	845.5	876.5	906.5	927.5	967.5
30	634.5		693.5	724.5	754.5	785.5	815.5	846.5	877.5	907.5	938.5	968.5
31	635.5		694.5		755.5		816.5	847.5		908.5		969.5

PHASES OF THE MOON 1982, U.T.

Lunation	New Moon				First Quarter				Full Moon				Last Quarter			
		d	h	m		d	h	m		d	h	m		d	h	m
730					Jan.	3	04	45	Jan.	9	19	53	Jan.	16	23	58
731	Jan.	25	04	56	Feb.	1	14	28	Feb.	8	07	57	Feb.	15	20	21
732	Feb.	23	21	13	Mar.	2	22	15	Mar.	9	20	45	Mar.	17	17	15
733	Mar.	25	10	17	Apr.	1	05	08	Apr.	8	10	18	Apr.	16	12	42
734	Apr.	23	20	29	Apr.	30	12	07	May	8	00	45	May	16	05	11
735	May	23	04	40	May	29	20	07	June	6	15	59	June	14	18	06
736	June	21	11	52	June	28	05	56	July	6	07	32	July	14	03	47
737	July	20	18	57	July	27	18	22	Aug.	4	22	34	Aug.	12	11	08
738	Aug.	19	02	45	Aug.	26	09	49	Sept.	3	12	28	Sept.	10	17	19
739	Sept.	17	12	09	Sept.	25	04	07	Oct.	3	01	08	Oct.	9	23	26
740	Oct.	17	00	04	Oct.	25	00	08	Nov.	1	12	57	Nov.	8	06	38
741	Nov.	15	15	10	Nov.	23	20	05	Dec.	1	00	21	Dec.	7	15	53
742	Dec.	15	09	18	Dec.	23	14	17	Dec.	30	11	33				

To change these times to other zone times, see pp. 10, 11, 13.

CALENDAR 1981

January

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

February

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

March

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

April

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

May

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

June

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

July

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

August

S	M	T	W	T	F	S
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16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

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

October

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

November

S	M	T	W	T	F	S
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15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

December

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

CALENDAR 1982

January

S	M	T	W	T	F	S
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3	4	5	6	7	8	9
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17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

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

March

S	M	T	W	T	F	S
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21	22	23	24	25	26	27
28	29	30	31			

April

S	M	T	W	T	F	S
				1	2	3
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18	19	20	21	22	23	24
25	26	27	28	29	30	

May

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

June

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

July

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

August

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

September

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

October

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

November

S	M	T	W	T	F	S
	1	2	3	4	5	6
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14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

December

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