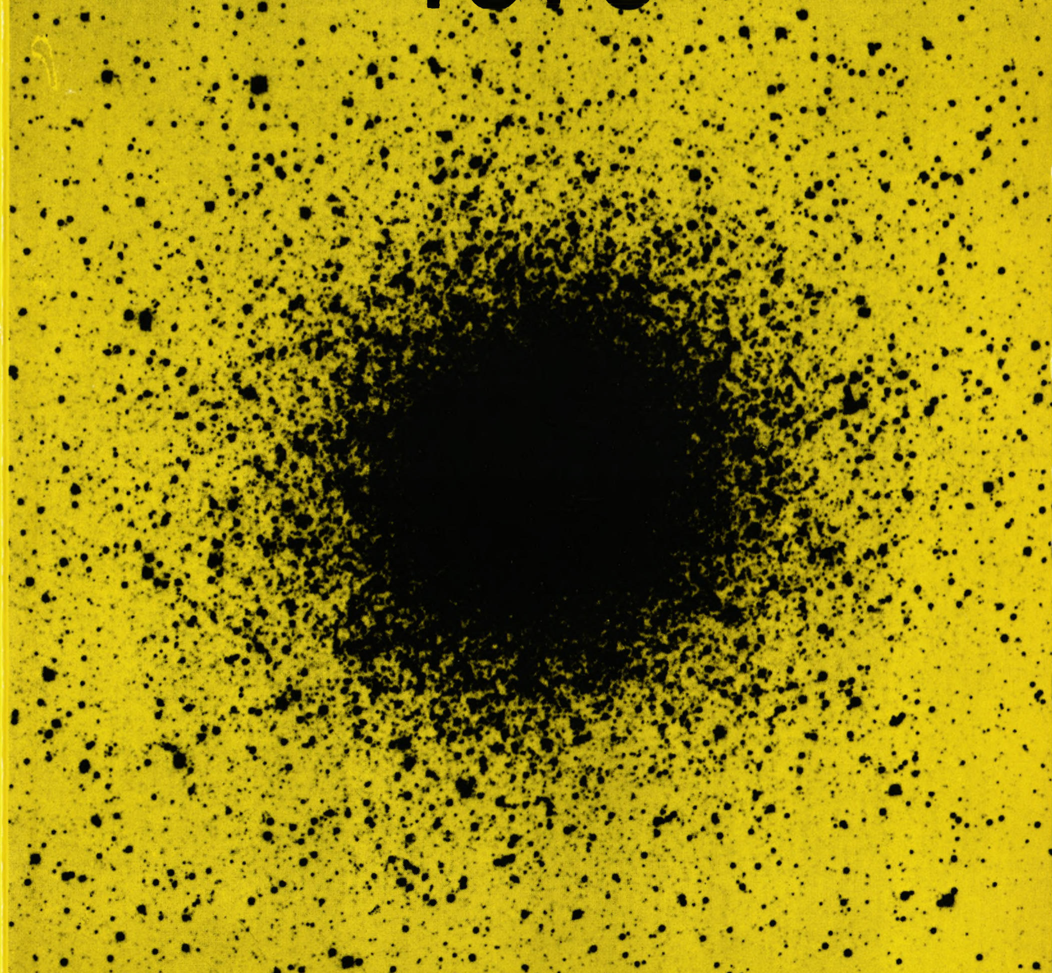
OBSERVER'S HANDBOOK 1979



EDITOR: JOHN R. PERCY

ROYAL ASTRONOMICAL SOCIETY OF CANADA

THE ORIGINS OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

In the mid-nineteenth century, in the bustling Lake Ontario port city of Toronto, there were no professional astronomers. However, many inhabitants of the city were keenly interested in sciences and current developments in them. King's College, which grew into the University of Toronto, had been started in 1842. In 1849 it had 36 undergraduates attending, and had graduated a total of 55 students in the three faculties of arts, law and medicine. The Toronto Magnetic Observatory had been established in 1840. Its early directors and observers were officers and soldiers in garrison. Some of them, such as Captain J. F. Lefroy, contributed much to the cultural life of the city. Out of this body of interest came the Canadian Institute established in 1849 "to promote those pursuits which are calculated to refine and exalt a people".

Besides holding weekly meetings, the Canadian Institute accumulated an outstanding library. There many hours were spent in study by Andrew Elvins who had come to Canada from Cornwall in 1844. In 1860 he moved to Toronto, with a population then of 44,000, and became chief cutter in a well known clothing store on King Street. While the Canadian Institute held discussion meetings of all sciences, Elvins wished to concentrate on astronomy. For this purpose he gathered together a few like-minded friends.

On December 1, 1868 The Toronto Astronomical Club met for the first time, at the Elvins' home, "having for its object the aiding of each other in the pursuit of astronomical knowledge". The thousands of meteor sightings of the Leonid showers made in Toronto in November 1867 and 1868 had doubtless encouraged the project. In May, 1869 the word "Club" was changed to "Society". Written records were kept for the first year, until the secretary moved away. After that, the group met only sporadically, but by the distribution of materials Elvins kept interest alive.

As the century wore on, Elvins, who lived till 1918, acquired more kindred spirits, some of them influential and prominent. As a result, on March 10, 1890 the organization was incorporated as The Astronomical and Astrophysical Society of Toronto. In May, 1900 chiefly through the efforts of one of the important early members George E. Lumsden, the name was changed to The Toronto Astronomical Society. On March 3, 1903 through legal application the name took on its current form, The Royal Astronomical Society of Canada. For many years the Society had its offices and library in the Canadian Institute buildings, and held meetings there.

Early in the 1890's, Dr. Clarence A. Chant of the University of Toronto became deeply interested in the Society. The impetus which he gave to it until his death in 1956 still lingers. During its first fifteen years the Society published annually volumes containing its Transactions and Annual Report. In 1907 Dr. Chant started The Journal of the Royal Astronomical Society of Canada, and this Handbook, called then "The Canadian Astronomical Handbook". It is a remarkable fact that at the time of his death Dr. Chant had been the Editor of both the Journal and the Handbook for exactly 50 years. During this period he received generous assistance from many of the Society's members. At times the Journal was published monthly, but currently it is bi-monthly.

The change of name in 1903 led immediately to the concept that the Society should not be limited to Toronto, but should become national in scope. The second Centre to be established was that of Ottawa in 1906, where the Dominion Observatory was being established. Now the Society has 18 Centres from sea to sea across Canada, as listed elsewhere in this Handbook. The growth in membership to nearly 3000 also shows its flourishing state.

HELEN SAWYER HOGG

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OBSERVER'S HANDBOOK 1979

SEVENTY-FIRST YEAR OF PUBLICATION

EDITOR: JOHN R. PERCY

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QUICK INDEX

THE OBSERVER'S HANDBOOK FOR 1979

THE OBSERVER'S HANDBOOK for 1979 is the seventy-first edition—at 140 pages, the largest edition ever. I thank all those whose names appear explicitly in the various sections, and especially the editor's assistant, Jaymie M. Matthews.

I also wish to thank: R. C. Brooks for the diagram on page 12; Drs. Lorne Avery and Vic Gaizauskas for the material on the 26 February solar eclipse and on sunspots; Terence Dickinson for expanding the "Planets" section and for his advice; Dr. Ian Halliday for looking after the "Miscellaneous Astronomical Data" section; Dr. Helen Hogg for her valuable comments; Janet A. Mattei of the AAVSO for all the data on variable stars; Ian McGregor for previewing the 1979 sky for me in the McLaughlin Planetarium Star Theatre. Many readers provided useful comments and suggestions; I thank them all. The administrative support of the RASC National Council (particularly Dr. Alan Batten, Rosemary Freeman and Dr. Lloyd Higgs) and the financial, technical and moral support of the David Dunlap Observatory and Erindale College, University of Toronto, are much appreciated.

This HANDBOOK is greatly indebted to H.M. Nautical Almanac Office, and to the *American Ephemeris*, for the contribution of essential material. Leslie Morrison and his staff at H.M.N.A.O. have provided all of the predictions of total and grazing lunar occultations, and Gordon E. Taylor has provided the predictions of planetary occultations. To these and all the other contributors, I extend my sincerest thanks.
Good observing!

JOHN R. PERCY

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The history of the Royal Astronomical Society of Canada goes back to the middle of the nineteenth century (see inside front cover). 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; 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, Hamilton, Niagara Falls, London, Windsor, Winnipeg, Saskatoon, Edmonton, Calgary, Vancouver, Victoria and Toronto, 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, which contains 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 18 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.

Abell, G. O. *Realm of the Universe*. Toronto: Holt, Rinehart and Winston, 1976. Standard, non-technical college text.

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

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, 1979

New Year's Day	Mon.	Jan. 1
Epiphany	Sat.	Jan. 6
Accession of Queen Elizabeth (1952)	Tue.	Feb. 6
Septuagesima Sunday		Feb. 11
Lincoln's Birthday	Mon.	Feb. 12
Washington's Birthday	Mon.	Feb. 19
Quinquagesima (Shrove) Sunday		Feb. 25
Ash Wednesday		Feb. 28
St. David	Thur.	Mar. 1
St. Patrick	Sat.	Mar. 17
Palm Sunday		Apr. 8
First day of Passover	Thur.	Apr. 12
Good Friday		Apr. 13
Easter Sunday		Apr. 15
Birthday of Queen Elizabeth (1926)	Sat.	Apr. 21
St. George	Mon.	Apr. 23
Rogation Sunday		May 20
Victoria Day	Mon.	May 21
Ascension Day	Thur.	May 24
Memorial Day	Mon.	May 28
Pentecost (Whit Sunday)		June 3
Trinity Sunday		June 10
Corpus Christi	Thur.	June 14
St. John Baptist (Mid-Summer Day)	Sun.	June 24
Canada Day	Sun.	July 1
Independence Day	Wed.	July 4
Birthday of Queen Mother Elizabeth (1900)	Sat.	Aug. 4
Civic Holiday	Mon.	Aug. 6
Labour Day	Mon.	Sept. 3
Jewish New Year (Rosh Hashanah)	Sat.	Sept. 22
St. Michael (Michaelmas Day)	Sat.	Sept. 29
Yom Kippur	Mon.	Oct. 1
Thanksgiving (Can.)	Mon.	Oct. 8
Columbus Day	Mon.	Oct. 8
All Saints' Day	Thur.	Nov. 1
General Election Day	Tue.	Nov. 6
Remembrance Day	Sun.	Nov. 11
Veterans' Day	Sun.	Nov. 11
Thanksgiving (U.S.)	Thur.	Nov. 22
St. Andrew	Fri.	Nov. 30
First Sunday in Advent		Dec. 2
Christmas Day	Tue.	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.

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

ā fāte; ā chāotic; ă tăp; *ă* fin*ă*l; à àsk; *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.

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 km/1000	Mean Distance from Planet arc sec	Revolution Period d	h	m	Orbit Incl. °	Discovery
SATELLITE OF THE EARTH									
Moon	−12.7	3476	384.5	—	27	07	43	18–29	
SATELLITES OF MARS									
I Phobos	11.6	23	9.4	25	0	07	39	1.1	A. Hall, 1877
II Deimos	12.7	13	23.5	63	1	06	18	1.8v	A. Hall, 1877
SATELLITES OF JUPITER									
V Amalthea	14.1	240	180	59	0	11	57	0.4	E. Barnard, 1892
I Io	5.0	3640	422	138	1	18	28	0	Galileo, 1610
II Europa	5.3	3050	671	220	3	13	14	0.5	Galileo, 1610
III Ganymede	4.6	5270	1,070	351	7	03	43	0.2	Galileo, 1610
IV Callisto	5.6	5000	1,885	618	16	16	32	0.2	Galileo, 1610
XIII Leda	20	(10)	11,110	3640	240			26.7	C. Kowal, 1974
VI Himalia	14.7	170	11,470	3760	251			27.6	C. Perrine, 1904
X Lysithea	18.4	(20)	11,710	3840	260			29.0	S. Nicholson, 1938
VII Elara	16.4	80	11,740	3850	260			24.8	C. Perrine, 1905
XII Ananke	18.9	(20)	20,700	6790	617			147	S. Nicholson, 1951
XI Carme	18.0	(30)	22,350	7330	692			164	S. Nicholson, 1938
VIII Pasiphae	17.7	(40)	23,330	7650	735			145	P. Melotte, 1908
IX Sinope	18.3	(30)	23,370	7660	758			153	S. Nicholson, 1914
SATELLITES OF SATURN									
XI	14	(200)	151	25	0	16	40	0.0	J. Fountain, S. Larson, 1978
X Janus	14	(200)	160	26	0	17	59	0.0	A. Dollfus, 1966
I Mimas	12.9	(400)	187	30	0	22	37	1.5	W. Herschel, 1789
II Enceladus	11.8	(500)	238	38	1	08	53	0.0	W. Herschel, 1789
III Tethys	10.3	1000	295	48	1	21	18	1.1	G. Cassini, 1684
IV Dione	10.4	1000	378	61	2	17	41	0.0	G. Cassini, 1684
V Rhea	9.7	1600	526	85	4	12	25	0.4	G. Cassini, 1672
VI Titan	8.4	5800	1,221	197	15	22	41	0.3	C. Huyghens, 1655
VII Hyperion	14.2	220	1,481	239	21	06	38	0.4	G. Bond, 1848
VIII Iapetus	11.0v	1450	3,561	575	79	07	56	14.7	G. Cassini, 1671
IX Phoebe	16.5	(240)	12,960	2096	550	11		150	W. Pickering, 1898
SATELLITES OF URANUS									
V Miranda	16.5	(300)	130	9	1	09	56	3.4	G. Kuiper, 1948
I Ariel	14.4	(800)	192	14	2	12	29	0	W. Lassell, 1851
II Umbriel	15.3	(550)	267	20	4	03	27	0	W. Lassell, 1851
III Titania	14.0	(1000)	438	33	8	16	56	0	W. Herschel, 1787
IV Oberon	14.2	(900)	587	44	13	11	07	0	W. Herschel, 1787
SATELLITES OF NEPTUNE									
I Triton	13.6	(4400)	354	17	5	21	03	160.0	W. Lassell, 1846
II Nereid	18.7	(300)	5600	264	365	5		27.6	G. Kuiper, 1949
SATELLITE OF PLUTO									
I	(17)	?	(20)	(< 1)	6.4			High	J. Christy, 1978

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

Values in brackets are uncertain.

MISCELLANEOUS ASTRONOMICAL DATA

Units of Length

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

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

Units of Time

Sidereal day = 23*h* 56*m* 04.09*s* of mean solar time
Mean solar day = 24*h* 03*m* 56.56*s* of mean sidereal time
Synodic month = 29*d* 12*h* 44*m* 03*s* = $29^{d}5306$
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 2ϕ km = 69.055 − 0.347 cos 2ϕ mi (at lat. ϕ)
1° of longitude = 111.413 cos ϕ − 0.094 cos 3ϕ km = 69.229 cos ϕ − 0.0584 cos 3ϕ mi
Mass of earth $= 5.976 \times 10^{24}$ kg $= 13.17 \times 10^{24}$ lb
Velocity of escape from ⊕ = 11.2 km/sec = 6.94 mi/sec

Earth's Orbital Motion

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

Solar Motion

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

The Galactic System

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

External Galaxies

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

Radiation Constants

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

Miscellaneous

Constant of gravitation, $G = 6.6727 \times 10^{-8}$ dyn cm²/g²
Mass of the electron, $m = 9.1096 \times 10^{-28}$ g: mass of the proton $= 1.6727 \times 10^{-24}$ gm
Planck's constant, $h = 6.6262 \times 10^{-27}$ erg sec
Absolute temperature = T° K = T° C + 273° = 5/9 (T° F + 459°)
1 radian = 57°.2958 = 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	43	22	−23	03.9	+ 3	24
4	18	56	36	−22	48.1	+ 4	48
7	19	09	46	−22	28.3	+ 6	08
10	19	22	52	−22	04.4	+ 7	23
13	19	35	53	−21	36.7	+ 8	34
16	19	48	49	−21	05.2	+ 9	39
19	20	01	39	−20	30.1	+10	38
22	20	14	22	−19	51.4	+11	30
25	20	26	58	−19	09.5	+12	16
28	20	39	28	−18	24.4	+12	54
31	20	51	50	−17	36.2	+13	26
Feb. 3	21	04	05	−16	45.3	+13	50
6	21	16	12	−15	51.8	+14	06
9	21	28	12	−14	55.8	+14	15
12	21	40	05	−13	57.5	+14	17
15	21	51	50	−12	57.2	+14	12
18	22	03	30	−11	55.0	+14	00
21	22	15	03	−10	51.0	+13	43
24	22	26	30	− 9	45.6	+13	20
27	22	37	52	− 8	38.8	+12	51
Mar. 2	22	49	09	− 7	30.8	+12	18
5	23	00	22	− 6	21.9	+11	40
8	23	11	30	− 5	12.2	+10	57
11	23	22	34	− 4	01.9	+10	12
14	23	33	36	− 2	51.2	+ 9	23
17	23	44	35	− 1	40.2	+ 8	32
20	23	55	32	− 0	29.0	+ 7	40
23	0	06	28	+ 0	42.1	+ 6	46
26	0	17	24	+ 1	53.0	+ 5	52
29	0	28	19	+ 3	03.5	+ 4	57
Apr. 1	0	39	15	+ 4	13.5	+ 4	03
4	0	50	11	+ 5	22.8	+ 3	10
7	1	01	08	+ 6	31.2	+ 2	18
10	1	12	07	+ 7	38.6	+ 1	28
13	1	23	09	+ 8	44.8	+ 0	40
16	1	34	13	+ 9	49.8	− 0	05
19	1	45	20	+10	53.2	− 0	46
22	1	56	32	+11	55.1	− 1	24
25	2	07	47	+12	55.2	− 1	58
28	2	19	07	+13	53.4	− 2	27
May 1	2	30	31	+14	49.6	− 2	52
4	2	42	00	+15	43.5	− 3	12
7	2	53	33	+16	35.1	− 3	27
10	3	05	12	+17	24.2	− 3	37
13	3	16	55	+18	10.7	− 3	43
16	3	28	44	+18	54.4	− 3	42
19	3	40	38	+19	35.3	− 3	37
22	3	52	38	+20	13.1	− 3	27
25	4	04	42	+20	47.9	− 3	12
28	4	16	50	+21	19.4	− 2	52
31	4	29	03	+21	47.7	− 2	28
June 3	4	41	20	+22	12.5	− 2	01
6	4	53	40	+22	33.8	− 1	30
9	5	06	02	+22	51.6	− 0	57
12	5	18	27	+23	05.8	− 0	21
15	5	30	54	+23	16.2	+ 0	16
18	5	43	22	+23	23.1	+ 0	55
21	5	55	51	+23	26.1	+ 1	34
24	6	08	20	+23	25.5	+ 2	13
27	6	20	48	+23	21.2	+ 2	52
30	6	33	15	+23	13.2	+ 3	29

Date	Apparent R.A. 0h E.T.			Apparent Dec. 0h E.T.		Corr. to Sun-dial 12h E.T.	
	h	m	s	°	′	m	s
July 3	6	45	40	+23	01.5	+ 4	03
6	6	58	02	+22	46.2	+ 4	35
9	7	10	21	+22	27.3	+ 5	04
12	7	22	36	+22	04.9	+ 5	29
15	7	34	47	+21	39.2	+ 5	50
18	7	46	54	+21	10.1	+ 6	07
21	7	58	57	+20	37.8	+ 6	19
24	8	10	54	+20	02.3	+ 6	26
27	8	22	47	+19	23.8	+ 6	28
30	8	34	34	+18	42.5	+ 6	24
Aug. 2	8	46	15	+17	58.4	+ 6	15
5	8	57	51	+17	11.7	+ 6	00
8	9	09	21	+16	22.4	+ 5	39
11	9	20	46	+15	30.8	+ 5	14
14	9	32	06	+14	37.0	+ 4	43
17	9	43	21	+13	41.0	+ 4	08
20	9	54	31	+12	43.1	+ 3	28
23	10	05	37	+11	43.4	+ 2	44
26	10	16	40	+10	41.9	+ 1	56
29	10	27	38	+ 9	39.0	+ 1	04
Sept. 1	10	38	33	+ 8	34.7	+ 0	09
4	10	49	25	+ 7	29.2	− 0	49
7	11	00	15	+ 6	22.6	− 1	50
10	11	11	03	+ 5	15.1	− 2	52
13	11	21	49	+ 4	06.7	− 3	55
16	11	32	35	+ 2	57.7	− 4	59
19	11	43	21	+ 1	48.1	− 6	03
22	11	54	07	+ 0	38.2	− 7	06
25	12	04	54	− 0	31.9	− 8	09
28	12	15	42	− 1	42.0	− 9	10
Oct. 1	12	26	32	− 2	52.0	−10	10
4	12	37	24	− 4	01.7	−11	07
7	12	48	19	− 5	11.0	−12	01
10	12	59	17	− 6	19.8	−12	51
13	13	10	20	− 7	27.7	−13	37
16	13	21	28	− 8	34.8	−14	19
19	13	32	40	− 9	40.8	−14	55
22	13	43	59	−10	45.5	−15	25
25	13	55	23	−11	48.8	−15	50
28	14	06	53	−12	50.5	−16	08
31	14	18	30	−13	50.4	−16	20
Nov. 3	14	30	14	−14	48.2	−16	24
6	14	42	05	−15	43.9	−16	22
9	14	54	03	−16	37.3	−16	12
12	15	06	10	−17	28.1	−15	54
15	15	18	24	−18	16.3	−15	28
18	15	30	45	−19	01.6	−14	55
21	15	43	15	−19	43.8	−14	14
24	15	55	51	−20	22.8	−13	26
27	16	08	35	−20	58.4	−12	31
30	16	21	25	−21	30.4	−11	30
Dec. 3	16	34	21	−21	58.8	−10	23
6	16	47	22	−22	23.4	− 9	10
9	17	00	28	−22	44.1	− 7	52
12	17	13	39	−23	00.7	− 6	31
15	17	26	54	−23	13.3	− 5	05
18	17	40	11	−23	21.7	− 3	38
21	17	53	29	−23	25.9	− 2	08
24	18	06	49	−23	25.8	− 0	39
27	18	20	08	−23	21.5	+ 0	51
30	18	33	26	−23	13.0	+ 2	19

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. The atomic second has been defined; atomic time has been 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*. This is the same as *correction to sundial* on page 9, with reversed sign.

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 a 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. Local Sidereal time may be found approximately from Standard or zone time (0 h at midnight) by applying the corrections for longitude (p. 14) and sundial (p. 9) to obtain apparent solar time, then adding 12 h and R.A. sun (p. 9). (Note that it is necessary to obtain R.A. of the sun and correction to sundial at the standard time involved.)

Local sidereal time can also be found by adding the Greenwish sidereal time at midnight (this quantity is tabulated on the next page) to the local mean time. The G.S.T. must be obtained (by interpolation) at the exact date involved.

Local mean time varies continuously with longitude. The local mean time of Greenwich, now known as *Universal Time* (UT) is used as a common basis for timekeeping. Navigation and surveying tables are generally prepared in terms of UT. When great precision is required, UT1 and UT2 are used differing from UT by polar variation and by the combined effects of polar variation and annual fluctuation respectively.

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

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

The mean solar second, defined as 1/86400 of the mean solar day, has been abandoned as the unit of time because random changes in the earth's rotation make it variable. The unit of time has been redefined twice within the past two decades. In 1956 it was defined in terms of Ephemeris Time (ET) as 1/31,556,925.9747 of the tropical year 1900 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 the 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 1979 will be about 50 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. The resulting atomic time gains on mean solar time at a rate of about a second a year. An approximation to UT1 is maintained by stepping the atomic time scale in units of 1 second on June 30 or December 31 when required so that the divergence from mean solar time (DUT1 = UT1 − UTC) does not exceed 0.6 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.

DUT1 is identified each minute on CHU and WWV by a special group of split or double pulses. The number of such marker pulses in a group gives the value of DUT1 in tenths of a second. If the group starts with the first (not zero) second of each minute, DUT1 is positive and mean solar time is ahead of the transmitted time; if with the 9th second DUT1 is negative, and mean solar time is behind.

Radio time signals readily available in Canada include:

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

JULIAN DAY CALENDAR, 1979

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

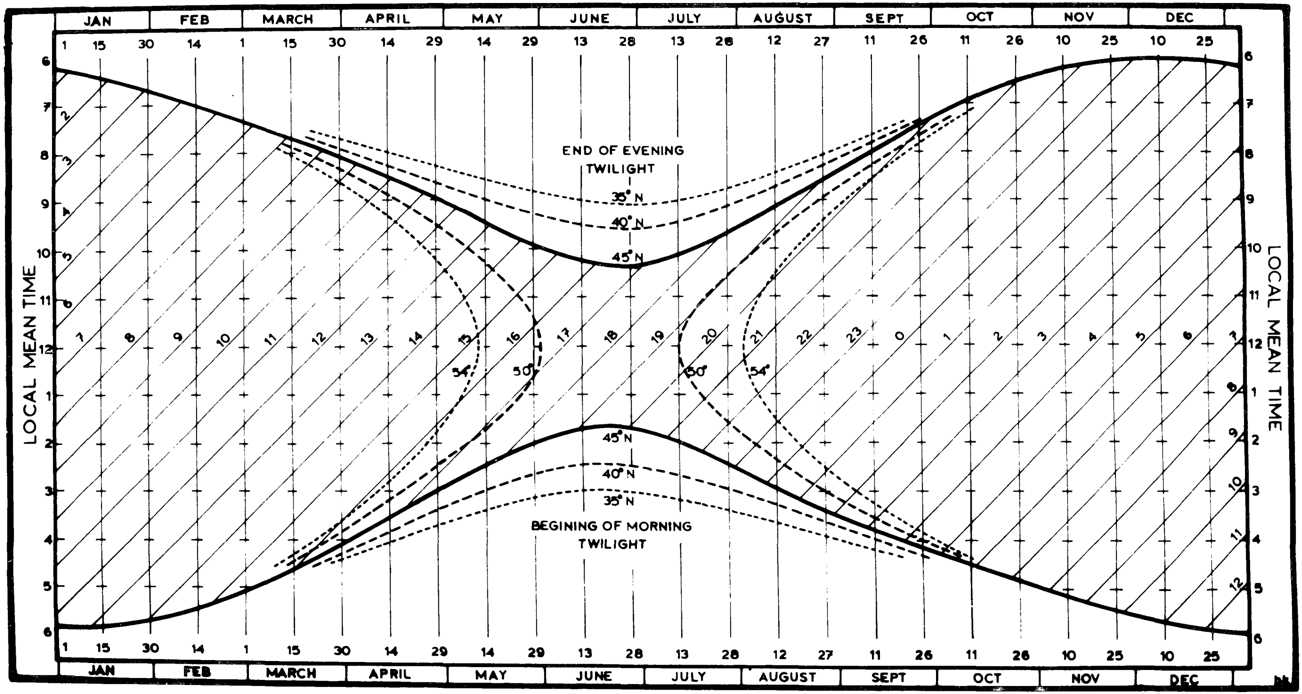
This table lists the Julian Date, and also the Greenwich sidereal time at midnight. The latter quantity is the amount which must be added to the local mean time to give local sidereal time; it increases by 3 m 56 s each day.

The Julian day commences at noon so that J.D. 2443875 = Jan. 1.5 U.T. 1979 = 12^h U.T. Jan. 1, 1979.

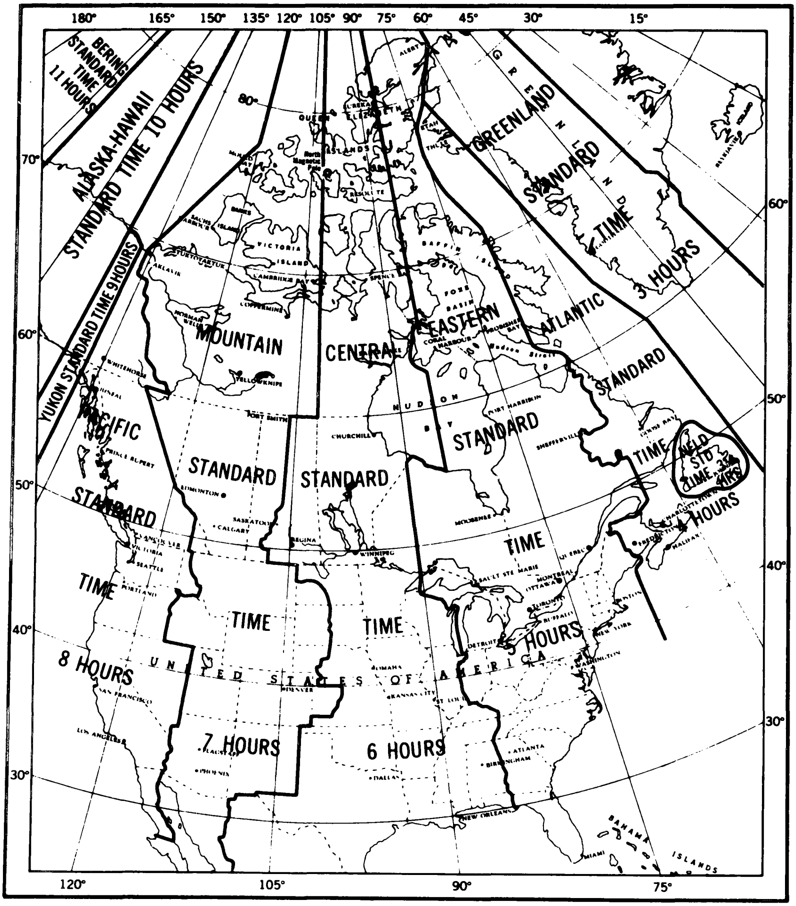
Date 0 h U.T.	J.D. 2440000+	G.S.T.	Date 0 h U.T.	J.D. 2440000+	G.S.T.
		h m			h m
Jan. 1	3874.5	06 40.2	July 1	4055.5	18 33.8
Feb. 1	3905.5	08 42.4	Aug. 1	4086.5	20 36.0
Mar. 1	3933.5	10 32.8	Sept. 1	4117.5	22 38.3
Apr. 1	3964.5	12 35.0	Oct. 1	4147.5	00 36.5
May 1	3994.5	14 33.3	Nov. 1	4178.5	02 38.7
June 1	4025.5	16 35.5	Dec. 1	4208.5	04 37.0

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.

TIMES OF RISING AND SETTING OF THE SUN AND MOON

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

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

The Standard Times for Any Station

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

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

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

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

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

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

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

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

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

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

BEGINNING OF MORNING AND ENDING OF EVENING TWILIGHT

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

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

MOONRISE AND MOONSET, 1979; LOCAL MEAN TIME

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

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

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

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

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

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

THE PLANETS FOR 1979

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 1979

Date E.S.T.	Elong.	Mag.	App. Diam.
	°		″
*Mar. 7	18 E	−0.1	7.3
Apr. 21	27 W	+0.6	8.0
*Jul. 3	26 E	+0.7	7.9
*Aug. 18	19 W	+0.3	7.6
Oct. 29	24 E	+0.1	6.6
*Dec. 7	21 W	−0.3	6.6

*favourable elongations

TELESCOPIC OBSERVING DATA FOR FAVOURABLE ELONGATIONS

Date E.S.T.	Mag.	App. Diam.	Phase % Ill.
		″	
Feb. 25	−1.0	5.4	84
Mar. 2	−0.7	6.3	68
7	−0.1	7.3	46
12	+0.7	8.5	25
Aug. 15	+0.8	8.2	26
20	+0.1	7.2	45
25	−0.6	6.2	65
30	−1.0	5.4	83

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 $+480^\circ$ 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.

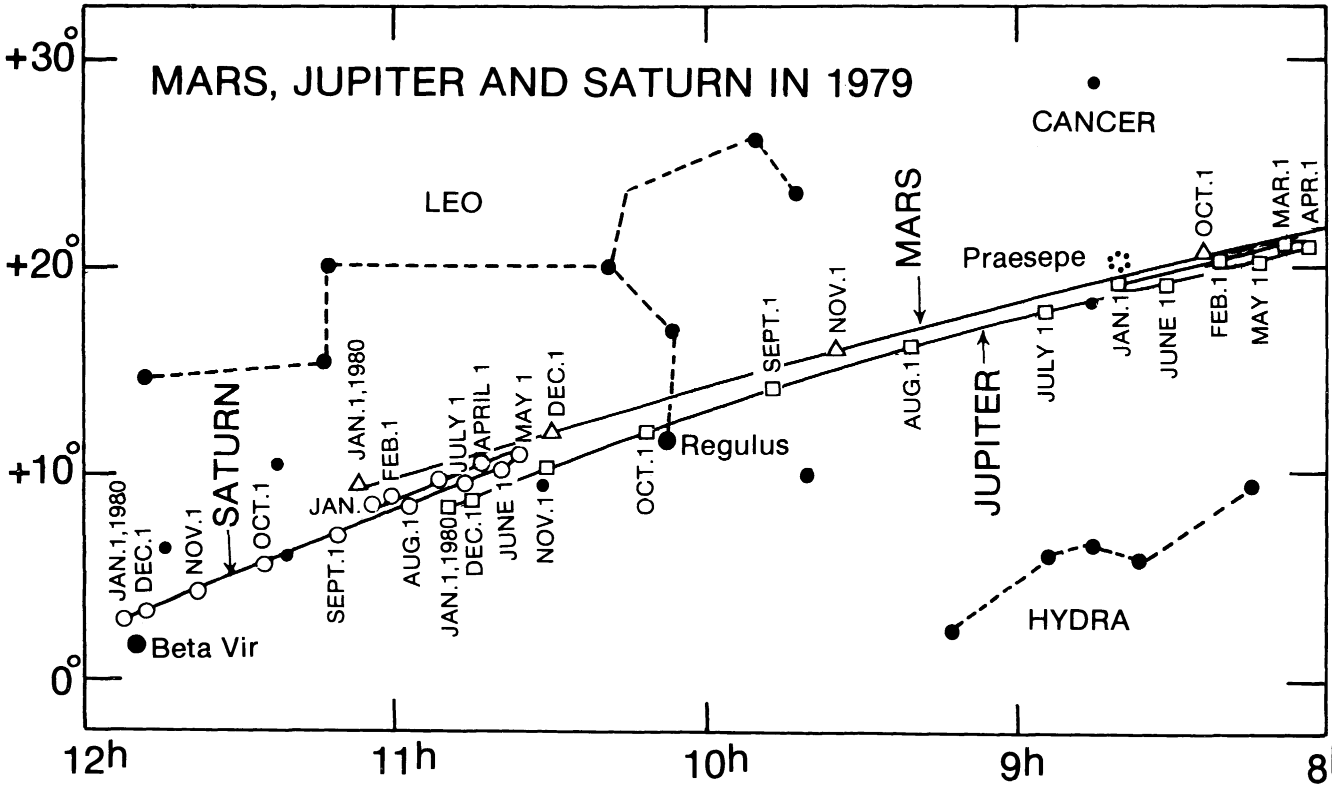
Venus' atmosphere has a surface pressure in excess of 90 times Earth's sea-level atmospheric pressure. A thick haze layer extends down from a level about 65 kilometers above the surface. However, the Soviet Venera 9 and 10 spacecraft that landed on Venus in 1975 and photographed the planet's surface 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.

Venus is the brightest natural celestial object in the nighttime sky apart from the moon and whenever it is visible is readily recognized. Because its orbit is within that of the Earth, Venus is never separated from the sun by an angle greater than 47 degrees. However, this is sufficient for it to be seen in black skies under certain conditions and at these times it is a truly dazzling object. Such circumstances occur during the first few weeks of the year when Venus is brilliant high in the east in the early morning sky. By Christmas Venus will have moved to dominate the evening sky in the west after sunset.

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 markings usually



The Paths of Mars, Jupiter and Saturn: The positions of Mars (after Oct. 1) are shown as triangles, those of Jupiter as squares and those of Saturn as circles.

VENUS—TELESCOPIC OBSERVING DATA 1979

Date	Magnitude	Apparent Diameter	Phase (% illuminated)
		″	
Jan. 1	−4.3	31.0	41
15	−4.1	26.0	48
Feb. 1	−3.9	20.6	57
15	−3.8	19.1	63
Mar. 1	−3.7	17.1	68
Apr. 1	−3.5	14.0	78
May 1	−3.4	12.1	86
June 1	−3.3	10.9	92
July 1	−3.3	10.2	97
Nov. 1	−3.3	10.5	95
Dec. 1	−3.3	11.3	90
31	−3.4	12.4	85

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.

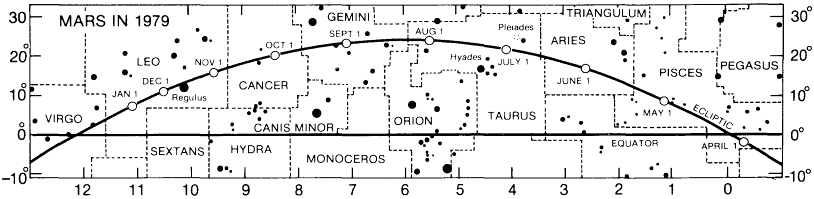
When Venus is less than 10% illuminated the cusps (the points at the ends of the crescent) can sometimes be seen to extend into the night side of the planet. This is an actual observation of solar illumination being scattered by the atmosphere of Venus. When Venus is a thin sliver of a crescent the extended 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 recent Viking observations have revealed more complex weather patterns.



The Path of Mars in 1979.

As 1979 opens Mars is too close to the sun for observation and does not emerge from behind the sun into the morning sky until March. 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 will not be conveniently visible before midnight until the last few weeks of the year when it is in the constellation Leo not far from Jupiter. The two planets will be less than two degrees apart on the night of December 13–14. Mars may be distinguished by its orange-red colour, a hue that originates with rust-coloured dust that covers much of the planet.

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

The next opposition occurs on February 25, 1980, a very unfavourable one with the minimum distance between Earth and Mars being 101 million km and the apparent diameter less than 14 seconds of arc. The distance of Mars from Earth and its apparent diameter are given in the table on page 94. During the last few months of the year—the more favourable period for telescopic study—the north pole of Mars is tipped 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 on page 94 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 on page 94.

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.

The 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 46″ at opposition on January 24 to a minimum of 31″ at conjunction on August 13.

The Great Red Spot, a towering vortex whose colour may possibly be due to organic-like compounds that are constantly spewed from some heated atmospheric source below, is the most conspicuous and longest-lived structure on the visible surface of Jupiter. The spot and the changing cloud structures can be easily observed in small telescopes because the apparent size of the visible surface of Jupiter is far greater than that of any other planet.

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 1979 opens Jupiter is in Cancer, bright and unmistakable in the evening sky and is ideally placed for telescopic study. By early July the planet will be lost in the twilight glow in the west after sunset. In early September Jupiter is visible in the morning sky just before sunrise and by the end of the year the planet is again in the late evening sky having advanced to the constellation Leo. 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.

At opposition on January 24, Jupiter is 643 million km (4.298 A.U.) from Earth. The next opposition will be February 24, 1980. 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. The 17,000 km gap between the planet's surface and the crepe ring contains an exceedingly faint fourth ring. Ring particles could extend well beyond the limits of the visible structure but are likely constrained to the planet's equatorial plane.

In addition to the rings Saturn has a family of at least 10 satellites. Titan, the largest, is easily seen in any telescope as an eighth magnitude object orbiting Saturn in about 16 days. At east and west elongation Titan appears about five ring diameters from the planet. Titan is believed to be unique as the only satellite in the solar system with a substantial atmosphere. Estimates of its density range from 0.1 to equal Earth's although its primary known constituent is methane.

Telescopes over 60 mm aperture should reveal Rhea at 10th magnitude less than two ring-diameters from Saturn. The satellite Iapetus has the peculiar property of being five times brighter at western elongation ($10^{m}1$) than at eastern elongation ($11^{m}9$). One side of the moon has the reflectivity of snow while the other resembles 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. A diagram of seven of the Saturn moons and additional data can be found on page 99.

The disk of Saturn appears about 1/6 the size Jupiter appears through the same telescope with the same magnification. In telescopes less than 4 inches aperture probably no features will ever be seen on the surface of the planet other than the shadow cast by the rings. As the size of the telescope is increased the whitish equatorial region and the darker polar regions become evident. Basically, Saturn has a belt system like Jupiter's but it is much less active and the contrast is reduced. Seldom in telescopes less than 8-inch aperture do more than one or two belts come into view. Very rarely a spot among the Saturnian clouds will appear unexpectedly, but less than a dozen notable spots have been recorded since telescopic observation of Saturn commenced in the 17th century. Saturn, probably more than any other planet can be subjected to very high telescopic powers, probably because of its low surface brightness (due to its great distance from the sun).

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

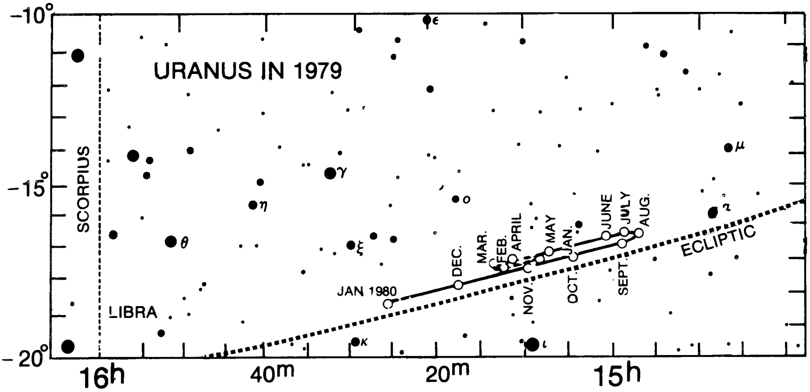
As 1979 opens Saturn's rings are tilted 4.1° with respect to the Earth. This increases to 7.4° in early May after which the rings seem to close up, having a tilt 5.7° by July 15. Saturn will then be too close to the sun for observation until autumn. The rings, with respect to the Earth, will be edge-on the night of October 26–27 and will be invisible in most telescopes. For the rest of the year the sun will be illuminating the side of the rings not visible from Earth (at least at this particular time) and will, therefore, be faint and difficult to distinguish, particularly in small telescopes. Inclination of the rings, with respect to Earth, will be 1.3° on December 1 and 1.7° on January 1, 1980. The ring shadow, a thin, black line near Saturn's equator, will be a distinct feature during this period although by the end of the year it will be very thin.

Opposition is March 1 when Saturn is 1.25 billion km (8.36 A.U.) from Earth, in the constellation Leo. At that time the rings are 45.0″ in apparent width and the planet is 17.9″ in polar diameter. Saturn ranges from magnitude +0.5 in February to +1.4 in late October.

URANUS

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

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



The Path of Uranus in 1979. Positions for first day of each month.

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

These dimensions are markedly different from Saturn's three major rings, each of which is thousands of kilometers wide. Although different in scale, the composition of the Uranian rings should be fundamentally the same as Saturn's—swarms of particles varying from dust-size up to small flying mountains each in its own orbit. The rings are not as dense as Saturn's major ring since the occulted star did not completely disappear during passage behind them. Also, the albedo of the individual particles is believed to be low suggesting a dark substance compared to Saturn's brilliantly reflective ring material. The Uranian rings are invisible by direct observation because of their small dimensions and the enormous distance that separates us from Uranus.

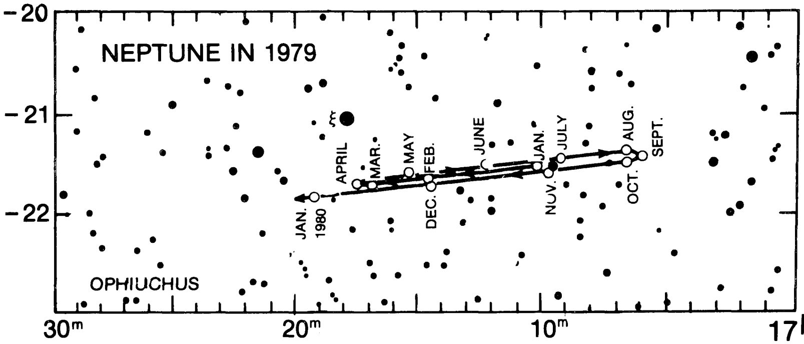
Estimates of the seventh planet's size were refined in 1977 by techniques developed at New Mexico State University. The new diameter estimate of 55,800 km is substantially greater than those of previous studies but similar to some made more than a generation ago by cruder techniques. If the diameter measure is not refined downward Uranus, like Saturn, will prove to have an average density less than that of water.

The long quoted rotation period of Uranus (about 11 hours) now appears to have been in error by a factor of at least 2. A seven month study at Kitt Peak National Observatory (near Tucson, Ariz.) using the 4-meter telescope and its echelle spectrograph indicates a 23 hour rotation period. As with the new Uranus diameter estimate, this figure remains unconfirmed. However, the techniques utilized in both instances were significant advancements over those used in previous work.

Throughout 1979 Uranus is in Libra a few degrees east of Alpha Librae. Uranus is at opposition on May 10 when it is 2.65 billion km (17.67 A.U.) from Earth. At this time its magnitude is +5.7 and its apparent diameter is 3.9 seconds of arc.

NEPTUNE

The discovery of Neptune in 1846, after its existence in the sky had been predicted from independent calculations by Leverrier in France and Adams in England, was



The Path of Neptune in 1979. Positions for first day of each month.

regarded as the crowning achievement of Newton's theory of universal gravitation. Actually Neptune had been seen—but mistaken for a star—several times before its "discovery".

Telescopically the planet appears as a 2.5 second of arc featureless bluish-green disk. Neptune's large moon Triton can be seen by an experienced observer using a 12-inch telescope. Triton is an exceptionally large satellite and may prove to be the solar system's biggest moon. The moon varies from 8 to 17 seconds of arc from Neptune during its 5.9 day orbit.

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

In 1979 Neptune is buried in the Milky Way in Ophiuchus and is not well placed for northern observers. At opposition on June 10 Neptune is magnitude +7.7 and 4.38 billion km (29.27 A.U.) distant from Earth. Around July 1 and Nov. 1, it passes close to the $6^{m}9$ star HD 155469.

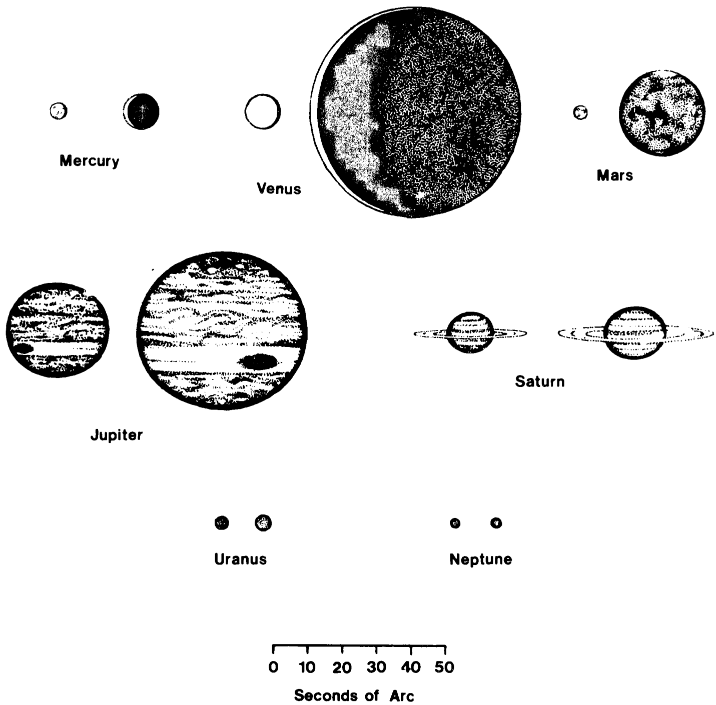
PLUTO

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

The most important advance in our knowledge of Pluto since its discovery came in 1978 as a result of routine examination 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 very 6.3867 days—identical to the planet's rotation period. This means that the moon is visible only from one hemisphere of Pluto. Calculations made some years ago suggest that this is the only stable orbit a satellite could have with Pluto's slow rotation rate. The moon too would likely have one side constantly turned to Pluto. The name Charon has been proposed for the new-found object.

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

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.

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

The long-standing theory, first proposed in 1936 by R. A. Lyttleton, suggesting that Pluto might be an escaped or ejected satellite of Neptune seems unlikely in view of the new findings. Pluto now appears to be completely different from the other eight planets. Its unique characteristics include its orbit which is relatively highly inclinded and so elliptical that the planet will be closer to the sun than Neptune for 19 years, beginning next year. Just where such a freak fits into the solar system's origin and evolution is unknown. Perhaps Pluto is the largest member of a group of small icy comet-like structures beyond Neptune.

At opposition on April 8 Pluto's astrometric position is R.A. (1950) $13^h31.3^m$ Dec. (1950) $+9°32'$ and its distance from Earth will be 4.38 billion km (29.30 A.U.). With an apparent magnitude of $+14$ Pluto is a difficult target in moderate-sized amateur telescopes.

THE SKY MONTH BY MONTH

Introduction—In the monthly descriptions of the sky on the following pages, positions of the sun and planets are given for 0 h Ephemeris Time, which differs only slightly from Standard Time on the Greenwich meridian. The times of transit at the 75th meridian are given in *local mean time*; to change to Standard Time, see p. 14. Estimates of altitude are for an observer in latitude 45° N. Unless noted otherwise, the descriptive comments about the planets apply to the middle of the month.

The Sun—The values of the equation of time are for noon E.S.T. on the first and last days of the month. For times of sunrise and sunset and for changes in the length of the day, see pp. 15–20. See also p. 9.

The Moon—Its phases, perigee and apogee times and distances, and its conjunctions with the planets are given in the "Astronomical Phenomena Month by Month". For times of moonrise and moonset, see pp. 22–27.

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

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

The sun's selenographic colongitude is essentially a convenient way of indicating the position of the sunrise terminator as it moves across the face of the moon. It provides an accurate method of recording the exact conditions of illumination (angle of illumination), and makes it possible to observe the moon under exactly the same lighting conditions at a later date. The sun's selenographic colongitude is numerically equal to the selenographic longitude of the sunrise terminator reckoned eastward from the mean centre of the disk. Its value increases at the rate of nearly 12.2° per day or about $\frac{1}{2}$° per hour; it is approximately 270°, 0°, 90° and 180° at New Moon, First Quarter, Full Moon and Last Quarter respectively. Values of the sun's selenographic colongitude are given on the following pages for the first day of each month.

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

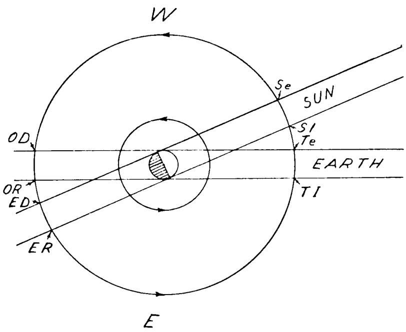
Libration is the shifting, or rather apparent shifting, of the visible disk of the moon. Sometimes the observer sees features farther around the eastern or the western limb (libration in longitude), or the northern or southern limb (libration in latitude). When the libration in longitude is positive,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

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

The Planets—Further information in regard to the planets, including Pluto, is found on pp. 28–37. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 96.

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. 96) 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.

THE SKY FOR JANUARY 1979

The Sun—During January the sun's R.A. increases from 18 h 43 m to 20 h 56 m and its Decl. changes from −23°04′ to −17°20′. The equation of time changes from 3 m 30 s to 13 m 28 s. The earth is in perihelion on the 4th, at a distance of 147,100,000 km (91,404,000 mi) from the sun.

The Moon—On January 1.0 E.S.T., the age of the moon is 2.4 d. The sun's selenographic colongitude is 301.4° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 6 (7°) and minimum (east limb exposed) on Jan. 22 (8°). The libration in latitude is maximum (north limb exposed) on Jan. 10 (7°) and minimum (south limb exposed) on Jan. 24 (7°).

Mercury on the 1st is in R.A. 17 h 13 m, Decl. −21°54′, and on the 15th is in R.A. 18 h 39 m, Decl. −23°51′. At the beginning of the month, it can be seen low in the south-east before sunrise (see diagram), but by the end of the month, it is too close to the sun to be seen.

Venus on the 1st is in R.A. 15 h 32 m, Decl. −15°15′, and on the 15th it is in R.A. 16 h 25 m, Decl. −17°54′, mag. −4.1, and transits at 8 h 50 m. It is at greatest elongation west (47°) on the 18th and dominates the eastern sky just before sunrise. On the 15th, it is 8° N. of Antares, and forms a pretty configuration with that star and with Mercury (see diagram).

Mars on the 15th is in R.A. 19 h 51 m, Decl. −22°01′, mag. +1.4, and transits at 12 h 15 m. It is too close to the sun to be seen, being in conjunction on the 20th.

Jupiter on the 15th is in R.A. 8 h 31 m, Decl. +19°33′, mag. −2.1, and transits at 0 h 55 m. In Cancer, it rises at sunset and sets at sunrise, being at opposition on the 24th.

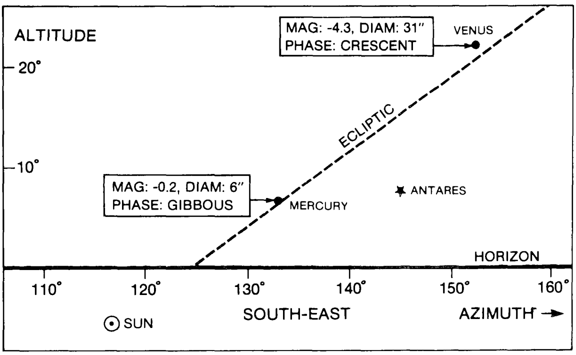
Saturn on the 15th is in R.A. 11 h 02 m, Decl. +8°14′, mag. +0.8, and transits at 3 h 25 m. In Leo, it rises in mid-evening and by sunrise is low in the west.

Uranus on the 15th is in R.A. 15 h 12 m, Decl. −17°29′, mag. +5.9, and transits at 7 h 34 m.

Neptune on the 15th is in R.A. 17 h 14 m, Decl. −21°38′, mag. +7.8, and transits at 9 h 36 m.

Early in the month, the morning sky is particularly impressive, with Mercury, Venus and Antares in the east (see diagram) and Jupiter and Saturn in the west.

The late evening sky is dominated by the "winter six" constellations, with Jupiter and Saturn adding interest in the south-east; in mid-month, the moon joins the display.

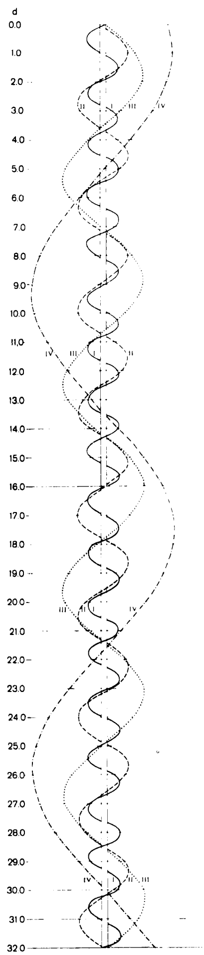


The South-Eastern Sky at Sunrise Early in January.

1979	d	h	m	JANUARY E.S.T.	Min. of Algol h	m
Mon.	1	14		Juno 0°.2 S. of Moon. Occ'n	13	00
Tues.	2					
Wed.	3	20		Quadrantid Meteors		
Thur.	4	17		Earth at perihelion	9	50
Fri.	5	06	15	First Quarter		
Sat.	6					
Sun.	7				6	40
Mon.	8					
Tues.	9			Mercury at descending node		
		13		Aldebaran 0°.5 S. of Moon. Occ'n[1]		
Wed.	10				3	30
Thur.	11					
Fri.	12					
Sat.	13	02	09	Full Moon	0	20
Sun.	14	04		Pallas in conjunction with Sun		
		06		Jupiter 4° N. of Moon		
		22		Moon at apogee (406, 290 km)		
Mon.	15	13		Venus 8° N. of Antares	21	00
Tues.	16					
Wed.	17	11		Saturn 2° N. of Moon		
Thur.	18	01		Venus greatest elong. W. (47°)	17	50
Fri.	19			Mercury at aphelion		
Sat.	20	07		Mars in conjunction with Sun		
Sun.	21			Venus at greatest hel. lat. N	14	40
		06	23	Last Quarter		
Mon.	22	16		Uranus 4° S. of Moon		
Tues.	23					
Wed.	24	10		Jupiter at opposition	11	30
		17		Venus 2° S. of Moon		
		20		Neptune 4° S. of Moon		
Thur.	25					
Fri.	26	13		Venus 1°.9 N. of Neptune		
Sat.	27				8	20
Sun.	28	01	20	New Moon		
		05		Moon at perigee (356, 740 km)		
		13		Pluto stationary		
Mon.	29	21		Juno 0°.4 S. of Moon. Occ'n		
Tues.	30				5	10
Wed.	31					

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

← West East →



[1]Visible in N. and W. Africa, Europe, Asia.

THE SKY FOR FEBRUARY 1979

The Sun—During February the sun's R.A. increases from 20 h 56 m to 22 h 45 m and its Decl. changes from −17°20′ to −7°54′. The equation of time changes from 13 m 36 s to 12 m 38 s. On the 26th, there is an eclipse of the sun, widely visible in North America.

The Moon—On February 1.0 E.S.T., the age of the moon is 3.9 d. The sun's selenographic colongitude is 318.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 3 (7°) and minimum (east limb exposed) on Feb. 19 (8°). The libration in latitude is maximum (north limb exposed) on Feb. 6 (7°) and minimum (south limb exposed) on Feb. 21 (7°).

Mercury on the 1st is in R.A. 20 h 34 m, Decl. −20°46′, and on the 15th is in R.A. 22 h 12 m, Decl. −13°03′. After passing through superior conjunction on the 9th, it moves into the evening sky and by the end of the month, it can be seen very low in the west after sunset.

Venus on the 1st is in R.A. 17 h 40 m, Decl. −20°20′, and on the 15th it is in R.A. 18 h 46 m, Decl. −20°51′, mag. −3.8, and transits at 9 h 09 m. It rises $2\frac{1}{2}$ hours before the sun, and is low in the south-east at sunrise.

Mars on the 15th is in R.A. 21 h 31 m, Decl. −15°53′, mag. +1.3, and transits at 11 h 52 m. It is too close to the sun to be seen.

Jupiter on the 15th is in R.A. 8 h 15 m, Decl. +20°32′, mag. −2.1, and transits at 22 h 32 m. In Cancer, it is low in the east at sunset, and sets shortly before sunrise.
During the early part of the month, the evening sky is impressive, with Jupiter, Saturn and the moon arrayed among the "winter six" constellations.

Saturn on the 15th is in R.A. 10 h 56 m, Decl. +9°02′, mag. +0.6, and transits at 1 h 17 m. In Leo, it rises shortly after sunset and by sunrise is low in the west (see "Jupiter" above).

Uranus on the 15th is in R.A. 15 h 14 m, Decl. −17°40′, mag. +5.9, and transits at 5 h 35 m.

Neptune on the 15th is in R.A. 17 h 18 m, Decl. −21°41′, mag. +7.8, and transits at 7 h 38 m.

On the 26th, there is a total eclipse of the sun, which may be visible in a narrow band which extends from north-west U.S.A. through Winnipeg and Brandon and on to northern Quebec. The eclipse is visible as a partial eclipse over most of the rest of North America (pg. 65).

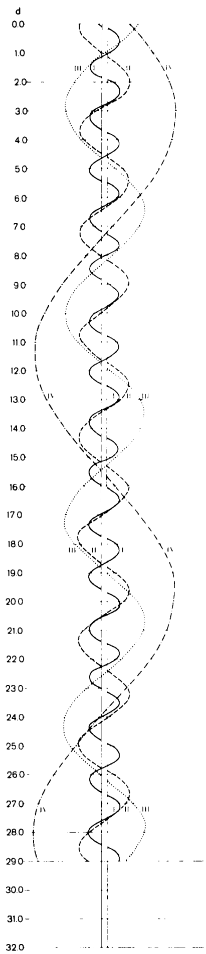
What can the observer expect to see during the total eclipse? It is difficult to describe nature's greatest spectacle in words; Helen Hogg succeeds well in her book *The Stars Belong to Everyone*. The pearly white corona is one of the most beautiful phenomena. The appearance of the corona varies with the phase of the sunspot cycle: near minimum, the corona is quite irregular, with equatorial streamers; near maximum (which is the case in 1979), the corona is larger and more symmetrical.

A total eclipse also provides an opportunity for some daytime stargazing. In late morning on the 26th, the Summer Triangle is almost overhead, Mercury is 14° east of the sun, Venus is 43° west of the sun and Mars is 8° west of the sun. Jupiter and Saturn will not be visible.

1979				FEBRUARY E.S.T.	Min. of Algol	
	d	h	m		h	m
Thur.	1					
Fri.	2				2	00
Sat.	3	19	36	☽ First Quarter		
Sun.	4				22	50
Mon.	5	19		Aldebaran 0°.3 S. of Moon. Occ'n[1]		
Tues.	6					
Wed.	7				19	40
Thur.	8			Mercury at greatest hel. lat. S.		
Fri.	9	01		Mercury in superior conjunction		
Sat.	10	05		Jupiter 4° N. of Moon	16	30
		22		Moon at apogee (406, 410 km)		
Sun.	11	21	39	○ Full Moon		
Mon.	12					
Tues.	13	14		Saturn 3° N. of Moon	13	20
Wed.	14					
Thur.	15					
Fri.	16				10	10
Sat.	17					
Sun.	18	00		Ceres in conjunction with Sun		
Mon.	19	00		Uranus 4° S. of Moon	7	00
		20	17	☾ Last Quarter		
Tues.	20			Mars at greatest hel. lat. S.		
Wed.	21	06		Neptune 4° S. of Moon		
Thur.	22				3	50
Fri.	23	10		Venus 3° S. of Moon		
Sat.	24	08		Uranus stationary		
		17		Vesta in conjunction with Sun		
Sun.	25	17		Moon at perigee (357, 970 km)	0	30
Mon.	26	11	45	● New Moon, Eclipse of ☉ (pg. 65)		
Tues.	27			Mercury at ascending node	21	20
		07		Juno 0°.5 S. of Moon. Occ'n		
		13		Mercury 0°.6 N. of Moon. Occ'n[2]		
		23		Occ'n: SAO 92603 by Egeria		
Wed.	28					

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

← West East →



[1]Visible in Central and N. America, N. Atlantic, N.W. Africa, S.W. Europe.
[2]Visible in S. Pacific, S. America, S. Atlantic.

THE SKY FOR MARCH 1979

The Sun—During March the sun's R.A. increases from 22 h 45 m to 0 h 39 m and its Decl. changes from −7°54′ to +4°13′. The equation of time changes from 12 m 27 s to 4 m 17 s. On the 21st, at 0h 22m E.S.T., the sun crosses the equator on its way north, and spring begins.

The Moon—On March 1.0 E.S.T., the age of the moon is 2.5 d. The sun's selenographic colongitude is 299.0° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Mar. 3 (7°) and minimum (east limb exposed) on Mar. 18 (7°). The libration in latitude is maximum (north limb exposed) on Mar. 5 (7°) and minimum (south limb exposed) on Mar. 20 (7°). There is a partial eclipse of the moon on the night of March 13-14.

Mercury on the 1st is in R.A. 23 h 43 m, Decl. −1°32′, and on the 15th is in R.A. 0 h 26 m, Decl. +6°19′. On the 7th, it is at greatest elongation east (18°), and although the elongation is smaller than average, it is favourable (because of the orientation of the ecliptic to the horizon), and the planet stands about 15° above the horizon at sunset.

Around the 7th, the sky is particularly rewarding after sunset, with the moon and Mercury in the west, the "winter six" constellations in the south and Jupiter and Saturn rising in the east.

Venus on the 1st is in R.A. 19 h 55 m, Decl. −19°37′, and on the 15th it is in R.A. 21 h 02 m, Decl. −16°37′, mag. −3.6, and transits at 9 h 35 m. Although the elongation of Venus is 40°, it is *not* favourable (again, because of the orientation of the ecliptic to the horizon), and the planet rises only 1½ hours before the sun, and is very low in the south-east at sunrise.

Mars on the 15th is in R.A. 22 h 55 m, Decl. −8°04′, mag. +1.4, and transits at 11 h 26 m. Though technically a morning "star", it is too low in the sky to be seen.

Jupiter on the 15th is in R.A. 8 h 06 m, Decl. +21°00′, mag. −2.0, and transits at 20 h 34 m. In Cancer, it is high in the south-east at sunset, and sets before sunrise.

Saturn on the 15th is in R.A. 10 h 47 m, Decl. +9°54′, mag. +0.6, and transits at 23 h 14 m. In Leo, it rises at about sunset and sets at about sunrise, being at opposition on the 1st.

Uranus on the 15th is in R.A. 15 h 14 m, Decl. −17°38′, mag. +5.8, and transits at 3 h 45 m.

Neptune on the 15th is in R.A. 17 h 19 m, Decl. −21°41′, mag. +7.8, and transits at 5 h 49 m.

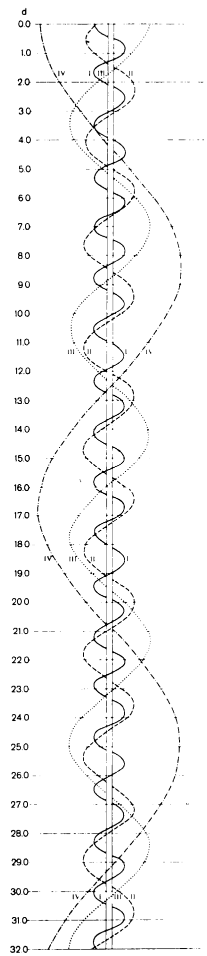
Precession is a slow, conical motion of the rotation axis of the earth (or other spinning body). In the case of the earth, it occurs because the rotation axis is tilted by 23° relative to the perpendicular to the orbit plane of the earth, moon and other planets. The sun and moon exert forces on the earth's equatorial bulge which cause the slow motion of the rotation axis.

There are several noticeable effects of precession. One is the slow motion of the north celestial pole in the sky. Polaris is presently near the north celestial pole; thousands of years from now, the north celestial pole will have moved elsewhere. Since the celestial equator also moves due to precession, its intersection with the ecliptic (the equinoxes) will also move. The vernal equinox was once in the constellation Aries (and is still called the first point in Aries), but it is now in Pisces. Since star positions are measured relative to the celestial equator and vernal equinox, they will gradually change due to the motion of the reference frame. Hence the need for the table on page 106. The solstices, like the equinoxes, have moved due to precession. They are no longer in Cancer and Capricorn, yet we still refer to the Tropics of Cancer and Capricorn. The precession cycle is about 26,000 years long. It is interesting to realize that, in 24,000 years, all the historical terminology will be right again!

1979				MARCH E.S.T.	Min. of Algol	
	d	h	m		h	m
Thur.	1	13		Saturn at opposition		
Fri.	2				18	10
Sat.	3					
Sun.	4			Mercury at perihelion		
Mon.	5	02		Aldebaran 0°.2 S. of Moon. Occ'n[1]	15	00
		11	23	☽ First Quarter		
Tues.	6					
Wed.	7	20		Mercury greatest elong. E. (18°)		
Thur.	8				11	50
Fri.	9	07		Jupiter 5° N. of Moon		
Sat.	10	05		Moon at apogee (405, 900 km)		
Sun.	11				8	40
Mon.	12	16		Saturn 3° N. of Moon		
Tues.	13	16	14	Full Moon. Eclipse of ☾ (pg. 65)		
Wed.	14			Mercury greatest hel. lat. N.	5	30
		10		Mercury stationary		
Thur.	15					
Fri.	16	15		Occ'n: SAO 126160 by Pallas		
Sat.	17				2	20
Sun.	18			Venus in descending node		
				Mars at perihelion		
		06		Uranus 4° S. of Moon		
Mon.	19				23	10
Tues.	20	13		Neptune 4° S. of Moon		
Wed.	21	00	22	Equinox. Spring begins		
		06	22	☾ Last Quarter		
Thur.	22	18		Juno in conjunction with Sun	20	00
Fri.	23	05		Neptune stationary		
Sat.	24	09		Mercury in inferior conjunction		
Sun.	25	04		Venus 2° S. of Moon	16	50
		20		Jupiter stationary		
Mon.	26	01		Moon at perigee (361, 990 km)		
		21		Mars 0°.7 S. of Moon		
Tues.	27	21	59	New Moon		
Wed.	28				13	40
Thur.	29					
Fri.	30					
Sat.	31				10	30

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

← West East →



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

THE SKY FOR APRIL 1979

The Sun—During April the sun's R.A. increases from 0 h 39 m to 2 h 31 m and its Decl. changes from +4°13′ to +14°50′. The equation of time changes from 4 m 00 s to −2 m 46 s.

The Moon—On April 1.0 E.S.T., the age of the moon is 4.1 d. The sun's selenographic colongitude is 316.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Apr. 1 (6°) and Apr. 29 (5°) and minimum (east limb exposed) on Apr. 14 (5°). The libration in latitude is maximum (north limb exposed) on Apr. 2 (7°) and Apr. 29 (7°) and minimum (south limb exposed) on Apr. 16 (7°).

Mercury on the 1st is in R.A. 23 h 48 m, Decl. +0°28′, and on the 15th is in R.A. 23 h 56 m, Decl. −2°12′. Greatest elongation west (27°) occurs on the 21st, but is very unfavourable; the planet is only 9° above the horizon at sunrise (see below). It is 3° N. of Mars on the 1st.

On Apr. 24, there is a total occultation of Mercury by the moon, widely visible across North America.

Venus on the 1st is in R.A. 22 h 22 m, Decl. −10°56′, and on the 15th it is in R.A. 23 h 26 m, Decl. −5°05′, mag. −3.4, and transits at 9 h 56 m. Venus, like Mercury and Mars, is about 30° W. of the sun, but the elongation is very unfavourable: the planet rises only an hour ahead of the sun (see below).

Mars on the 15th is in R.A. 0 h 24 m, Decl. +1°36′, mag. +1.4, and transits at 10 h 53 m. Mars, like Mercury and Venus, is a morning "star", but very unfavourably placed (see below). It is 3° S. of Mercury on the 1st.

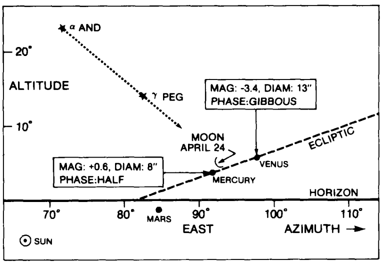
Jupiter on the 15th is in R.A. 8 h 08 m, Decl. +20°54′, mag. −1.8, and transits at 18 h 34 m. In Cancer, it is due south at sunset, and sets at about midnight.

Saturn on the 15th is in R.A. 10 h 40 m, Decl. +10°36′, mag. +0.7, and transits at 21 h 06 m. In Leo, it is well up in the south-east at sunset, and sets shortly before sunrise.

Uranus on the 15th is in R.A. 15 h 11 m, Decl. −17°24′, mag. +5.8, and transits at 1 h 39 m.

Neptune on the 15th is in R.A. 17 h 18 m, Decl. −21°39′, mag. +7.7, and transits at 3 h 47 m.

Mercury, Venus and Mars are together in the morning sky towards the end of the month but, although they are more than 25° W. of the sun, they are very poorly placed for observation. This is because of the shallow slope of the ecliptic with respect to the horizon (see diagram below). On the night of the 23-24th, the moon passes both Mercury and Venus, and an occultation of the former is visible in North America.

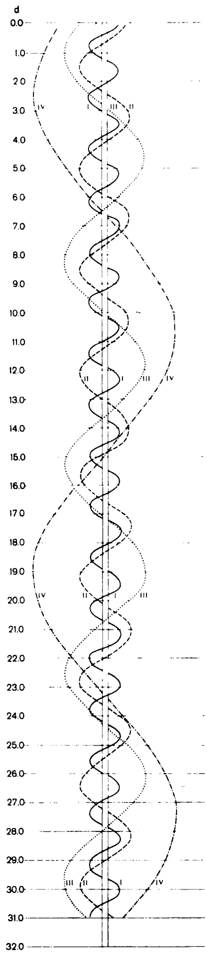


The Eastern Sky at Sunrise around April 24.

1979				APRIL E.S.T.	Min. of Algol	
	d	h	m		h	m
Sun.	1	11		Aldebaran 0°.3 S. of Moon. Occ'n[1]		
		17		Mercury 3° N. of Mars		
Mon.	2					
Tues.	3				7	10
Wed.	4	04	57	☽ First Quarter		
Thur.	5	13		Jupiter 5° N. of Moon		
		20		Mercury stationary		
Fri.	6	22		Moon at apogee (404,940 km)	4	00
Sat.	7			Mercury at descending node		
Sun.	8	02		Pluto at opposition		
		20		Saturn 3° N. of Moon		
Mon.	9				0	50
Tues.	10					
Wed.	11				21	40
Thur.	12	08	15	☺ Full Moon		
Fri.	13					
Sat.	14	10		Uranus 4° S. of Moon	18	30
Sun.	15					
Mon.	16	18		Neptune 4° S. of Moon		
Tues.	17			Mercury at aphelion	15	20
Wed.	18					
Thur.	19	13	30	☾ Last Quarter		
Fri.	20				12	10
Sat.	21	08		Mercury greatest elong. W. (27°)		
Sun.	22			Venus at aphelion		
		16		Lyrid Meteors		
		17		Moon at perigee (367,210 km)		
Mon.	23	22		Venus 0°.3 S. of Moon. Occ'n[2]	9	00
Tues.	24	08		Mercury 1° S. of Moon. Occ'n[3]		
		14		Occ'n: SAO 107061 by Pallas		
		18		Mars 2° N. of Moon		
Wed.	25	06		Juno 0°.7 S. of Moon. Occ'n		
Thur.	26	08	15	● New Moon	5	50
Fri.	27					
Sat.	28	20		Aldebaran 0°.4 S. of Moon. Occ'n[4]		
Sun.	29				2	40
Mon.	30					

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

← West East →



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

THE SKY FOR MAY 1979

The Sun—During May the sun's R.A. increases from 2 h 31 m to 4 h 33 m and its Decl. changes from +14°50′ to +21°56′. The equation of time changes from −2 m 53 s to −2 m 26 s.

The Moon—On May 1.0 E.S.T., the age of the moon is 4.6 d. The sun's selenographic colongitude is 322.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 26 (5°) and minimum (east limb exposed) on May 11 (5°). The libration in latitude is maximum (north limb exposed) on May 26 (7°) and minimum (south limb exposed) on May 13 (7°). Early in the month, it makes a pretty scene with Jupiter, Saturn, Aldebaran and the rest of the "winter six" constellations.

Mercury on the 1st is in R.A. 0 h 59 m, Decl. +3°10′, and on the 15th is in R.A. 2 h 22 m, Decl. +12°08′. Early in the month, it can be seen with very great difficulty, low in the east at sunrise, but by the 29th, it is in superior conjunction. It is 2° S. of Mars on the 5th.

Venus on the 1st is in R.A. 0 h 37 m, Decl. +2°13′, and on the 15th it is in R.A. 1 h 40 m, Decl. +8°35′, mag. −3.3, and transits at 10 h 12 m. Although it is moving closer to the sun, the ecliptic is steepening relative to the horizon, and it still rises about an hour before the sun. On the 20th, it is 1.1° S. of Mars.

Mars on the 15th is in R.A. 1 h 49 m, Decl. +10°30′, mag. +1.5, and transits at 10 h 20 m. Moving from Pisces into Aries, it can be seen very low in the east before sunrise. On the 5th, it is 2° N. of Mercury and on the 20th it is 1.1° N. of Venus.

Jupiter on the 15th is in R.A. 8 h 20 m, Decl. +20°13′, mag. −1.6, and transits at 16 h 49 m. In Cancer, it is high in the south-west at sunset, and sets about 4 hours later.

Saturn on the 15th is in R.A. 10 h 38 m, Decl. +10°43′, mag. +0.9, and transits at 19 h 06 m. In Leo, it is due south at sunset and sets shortly after midnight. On the 9th (E.S.T.) it is stationary; watch its motion relative to Regulus during the month.

Uranus on the 15th is in R.A. 15 h 06 m, Decl. −17°05′, mag. +5.7, and transits at 23 h 32 m. In Libra, it is at opposition on the 10th.

Neptune on the 15th is in R.A. 17 h 16 m, Decl. −21°36′, mag. +7.7, and transits at 1 h 46 m.

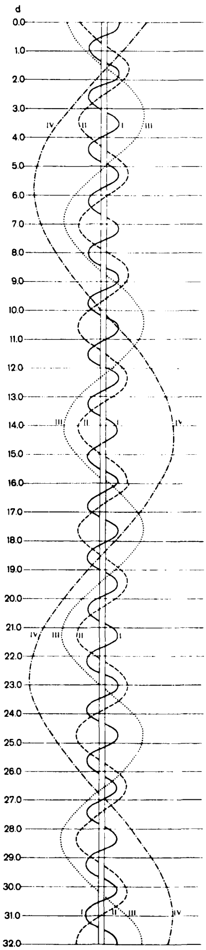
As we pointed out on page 38 of the 1978 HANDBOOK, the moon sweeps out a band in the sky (as seen from the earth) as it moves around its orbit. Anything in this band may be occulted (or eclipsed). This band is not coincident with the ecliptic, or we would have a solar eclipse each month; rather, it is tilted at 5° to the ecliptic. Furthermore, this band is not stationary, but drifts westward along the ecliptic by about 20° each year.

This year, the band passes almost centrally through the Hyades star cluster. This results in a larger-than-average number of occultations, as you can see from the occultations section of this HANDBOOK. The moon takes nearly all night to traverse this loose cluster, and the occultations are quite widely spaced in time. The occultations sometimes include one of Aldebaran, which is not a member of the cluster. Aldebaran is the brightest star which can be occulted by the moon. Observing occultations is an enjoyable and worthwhile activity; why not try it this month?

1979				MAY E.S.T.	Min. of Algol	
	d	h	m		h	m
Tues.	1				23	30
Wed.	2					
Thur.	3	01		Jupiter 4° N. of Moon		
		23	25	☽ First Quarter		
Fri.	4	17		Moon at apogee (404,420 km)	20	10
Sat.	5	03		Mercury 2° S. of Mars		
		17		η Aquarid Meteors		
Sun.	6	02		Saturn 3° N. of Moon		
Mon.	7			Mercury greatest hel. lat. S.	17	00
Tues.	8					
Wed.	9	23		Saturn stationary		
Thur.	10	02		Uranus at opposition	13	50
Fri.	11	16		Uranus 4° S. of Moon		
		21	01	☺ Full Moon		
Sat.	12					
Sun.	13				10	40
Mon.	14			Venus greatest hel. lat. S.		
		00		Neptune 4° S. of Moon		
Tues.	15					
Wed.	16				7	30
Thur.	17					
Fri.	18	04		Moon at perigee (369,740 km)		
		18	57	☾ Last Quarter		
Sat.	19				4	20
Sun.	20	01		Venus 1°.1 S. of Mars		
Mon.	21					
Tues.	22				1	10
Wed.	23	14		Mars 3° N. of Moon		
		17		Juno 1° S. of Moon. Occ'n		
		17		Venus 3° N. of Moon		
Thur.	24				22	00
Fri.	25					
Sat.	26			Mercury at ascending node		
		00	00	● New Moon		
Sun.	27				18	50
Mon.	28					
Tues.	29	18		Mercury in superior conjunction		
Wed.	30	17		Jupiter 4° N. of Moon	15	30
Thur.	31			Mercury at perihelion		

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

← West East →



THE SKY FOR JUNE 1979

The Sun—During June the sun's R.A. increases from 4 h 33 m to 6 h 37 m and its Decl. changes from +21°56′ to +23°10′. The equation of time changes from −2 m 17 s to 3 m 31 s. On June 21st, at 18 h 56 m E.S.T., summer begins.

The Moon—On June 1.0 E.S.T., the age of the moon is 6.2 d. The sun's selenographic colongitude is 341.1° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 21 (5°) and minimum (east limb exposed) on June 7 (6°). The libration in latitude is maximum (north limb exposed) on June 22 (7°) and minimum (south limb exposed) on June 9 (7°).

Mercury on the 1st is in R.A. 4 h 43 m, Decl. +23°10′, and on the 15th is in R.A. 6 h 48 m, Decl. +25°01′. By the end of the month, it can be seen low in the west, just after sunset. Jupiter is also low in the west, and the diagram at the bottom of "The Sky for July" shows their approximate configuration. On the 26th and 27th, the moon moves eastward past Mercury and Jupiter, respectively.

Venus on the 1st is in R.A. 3 h 00 m, Decl. +15°32′, and on the 15th it is in R.A. 4 h 09 m, Decl. +19°58′, mag. −3.3, and transits at 10 h 39 m. Still it rises about an hour before the sun (see comment last month) and can be seen with difficulty low in the east at sunrise.

Mars on the 15th is in R.A. 3 h 19 m, Decl. +17°54′, mag. +1.5, and transits at 9 h 48 m. Moving from Aries into Taurus, it rises about 2 hours before the sun and is low in the east at sunrise.

Jupiter on the 15th is in R.A. 8 h 41 m, Decl. +19°00′, mag. −1.4, and transits at 15 h 08 m. In Cancer, it is low in the west at sunset, and sets about 2½ hours later (see "Mercury" above).

Saturn on the 15th is in R.A. 10 h 42 m, Decl. +10°14′, mag. +1.0, and transits at 17 h 08 m. In Leo, it is well up in the south-west at sunset, and sets at about midnight. At the beginning of the month, the moon makes a pretty scene with Jupiter and Saturn, passing 2° S. of the latter on the 2nd.

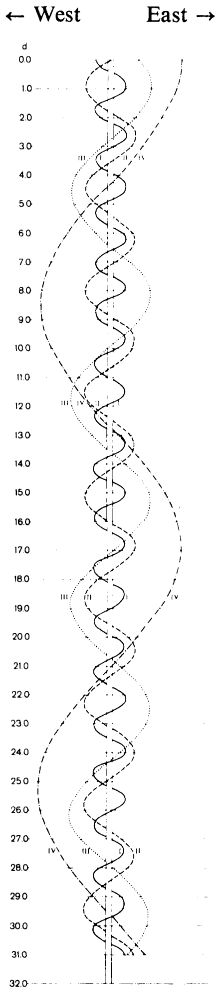
Uranus on the 15th is in R.A. 15 h 01 m, Decl. −16°46′, mag. +5.8, and transits at 21 h 26 m.

Neptune on the 15th is in R.A. 17 h 13 m, Decl. −21°32′, mag. +7.7, and transits at 23 h 37 m. In Ophiuchus, it is at opposition on the 10th.

In the 1978 edition of this HANDBOOK, under "The Sky for September", I repeated the classical explanation for the term *Harvest Moon*. I left it as an exercise for the reader to explain the significance of the term *Hunters' Moon*. I also have an astronomical explanation for the term *Honey Moon*, though I must admit that most people who hear it are a bit skeptical.

It helps if you first read "The Sky for September" in *this* edition of the HANDBOOK. We then note that (i) very many couples marry in May and June and (ii) they usually go on their honeymoon shortly thereafter. Now the sun in June is at its greatest distance north of the celestial equator and the full moon (which is nearly opposite the sun in the sky) is therefore at its greatest distance south of the celestial equator. The full moon in June is therefore seen especially low in the southern sky. Objects seen low in the sky are affected by the reddening properties of the atmosphere. Consequently the full moon in June has a beautiful golden appearance, just like good honey. Do you believe it? Even if not, you will enjoy observing the phenomenon.

1979				JUNE E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Fri.	1	12		Moon at apogee (404,310 km)			
Sat.	2	11		Saturn 2° N. of Moon	12	20	
		17	37	☽ First Quarter			
Sun.	3						
Mon.	4						
Tues.	5				9	10	
Wed.	6						
Thur.	7	23		Uranus 4° S. of Moon			
Fri.	8				6	00	
Sat.	9						
Sun.	10			Mercury greatest hel. lat. N.			
		06	55	○ Full Moon			
		07		Neptune 4° S. of Moon			
		10		Neptune at opposition			
Mon.	11				2	50	
Tues.	12						
Wed.	13	11		Moon at perigee (365,880 km)	23	40	
		23		Pallas stationary			
Thur.	14						
Fri.	15						
Sat.	16				20	30	
Sun.	17	00	01	☾ Last Quarter			
Mon.	18						
Tues.	19	22		Venus 5° N. of Aldebaran	17	20	
Wed.	20						
Thur.	21	11		Mars 5° N. of Moon			
		18	56	Solstice. Summer begins			
Fri.	22	12		Aldebaran 0°.4 S. of Moon. Occ'n[1]	14	10	
		17		Mercury 5° S. of Pollux			
Sat.	23	00		Venus 4° N. of Moon			
Sun.	24	06	58	● New Moon			
Mon.	25				10	50	
Tues.	26	13		Mercury 5° N. of Moon			
Wed.	27	11		Jupiter 3° N. of Moon			
Thur.	28				7	40	
Fri.	29	06		Moon at apogee (405,060 km)			
		22		Saturn 2° N. of Moon			
Sat.	30						



[1]Visible in N. Pacific, N. America, W. Europe.

THE SKY FOR JULY 1979

The Sun—During July the sun's R.A. increases from 6 h 37 m to 8 h 42 m and its Decl. changes from +23°10′ to +18°13′. The equation of time changes from 3 m 43 s to 6 m 21 s. The earth is at aphelion on July 3, at a distance of 152,100,000 km (94,510,000 mi) from the sun.

The Moon—On July 1.0 E.S.T., the age of the moon is 6.7 d. The sun's selenographic colongitude is 347.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 18 (6°) and minimum (east limb exposed) on July 5 (7°). The libration in latitude is maximum (north limb exposed) on July 19 (7°) and minimum (south limb exposed) on July 7 (7°).

Mercury on the 1st is in R.A. 8 h 27 m, Decl. +19°44′, and on the 15th is in R.A. 9 h 03 m, Decl. +14°14′. On the 3rd, it is at greatest elongation east (26°), at which time it stands about 17° above the western horizon at sunset. It makes an interesting configuration with Jupiter and several bright stars (see diagram below). By the end of the month, it is at inferior conjunction.

Venus on the 1st is in R.A. 5 h 31 m, Decl. +22°54′, and on the 15th it is in R.A. 6 h 46 m, Decl. +23°13′, mag. −3.4, and transits at 11 h 18 m. Though technically a morning "star", it is too close to the horizon to be seen.

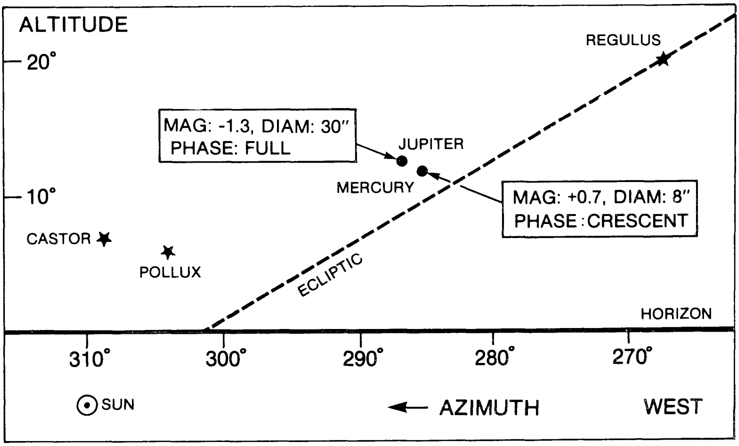
Mars on the 15th is in R.A. 4 h 48 m, Decl. +22°22′, mag. +1.5, and transits at 9 h 18 m. It is moving eastward through Taurus, between the Hyades and Pleiades at the beginning of the month, and 5° N. of Aldebaran on the 10th. It rises about 3 hours before the sun and is well up in the east at sunrise.

Jupiter on the 15th is in R.A. 9 h 05 m, Decl. +17°22′, mag. −1.3, and transits at 13 h 34 m. Early in the month, it can be seen very low in the west after sunset.

Saturn on the 15th is in R.A. 10 h 51 m, Decl. +9°17′, mag. +1.1, and transits at 15 h 19 m. In Leo, it is low in the west at sunset and sets a few hours later.

Uranus on the 15th is in R.A. 14 h 58 m, Decl. −16°36′, mag. +5.8, and transits at 19 h 25 m.

Neptune on the 15th is in R.A. 17 h 09 m, Decl. −21°29′, mag. +7.7, andt ransits at 21 h 36 m.

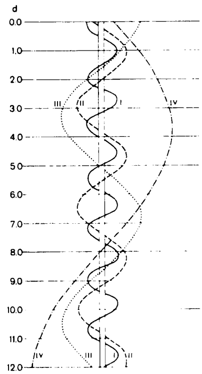


The Western Sky at Sunset in Early July.

1979				JULY E.S.T.	Min. of Algol	
	d	h	m		h	m
Sun.	1				4	30
Mon.	2	10	24	☽ First Quarter		
Tues.	3	17		Earth at aphelion		
		17		Mercury greatest elong. E. (26°)		
Wed.	4			Mercury at descending node	1	20
		04		Pluto stationary		
Thur.	5	06		Uranus 5° S. of Moon		
Fri.	6				22	10
Sat.	7	15		Neptune 4° S. of Moon		
Sun.	8					
Mon.	9	14	59	○ Full Moon	19	00
Tues.	10			Venus at ascending node		
		11		Mars 5° N. of Aldebaran		
Wed.	11	07		Moon at perigee (361,040 km)		
Thur.	12				15	50
Fri.	13					
Sat.	14			Mercury at aphelion		
Sun.	15	15		Occ'n: SAO 77128 by Metis	12	30
Mon.	16	05	59	☾ Last Quarter		
		21		Mercury stationary		
Tues.	17					
Wed.	18			Mars at ascending node	9	20
Thur.	19	18		Aldebaran 0°.3 S. of Moon. Occ'n[1]		
Fri.	20	07		Mars 5° N. of Moon		
Sat.	21				6	10
Sun.	22					
Mon.	23	20	41	● New Moon		
Tues.	24				3	00
Wed.	25					
Thur.	26	10		Uranus stationary	23	50
Fri.	27	00		Moon at apogee (406,040 km)		
		09		Saturn 2° N. of Moon		
Sat.	28					
Sun.	29	13		δ Aquarid Meteors	20	40
Mon.	30					
Tues.	31	12		Mercury in inferior conjunction		

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

← West East →



[1]Visible in S. and E. Asia, N. Pacific.

THE SKY FOR AUGUST 1979

The Sun—During August the sun's R.A. increases from 8 h 42 m to 10 h 39 m and its Decl. changes from +18°13′ to +8°35′. The equation of time changes from 6 m 18 s to 0 m 23 s. On the 22nd, there is an annular eclipse of the sun, not visible in North America.

The Moon—On August 1.0 E.S.T., the age of the moon is 8.1 d. The sun's selenographic colongitude is 6.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 15 (8°) and minimum (east limb exposed) on Aug. 2 (8°) and Aug. 31 (8°). The libration in latitude is maximum (north limb exposed) on Aug. 16 (7°) and minimum (south limb exposed) on Aug. 3 (7°) and Aug. 30 (7°).

Mercury on the 1st is in R.A. 8 h 35 m, Decl. +13°35′, and on the 15th is in R.A. 8 h 24 m, Decl. +17°14′. It is at greatest elongation west (19°) on the 18th (E.S.T.), at which time it stands about 16° above the eastern horizon at sunrise. On the 30th, it passes 0.7° N. of Jupiter at sunrise at which time the planets are about 10° above the eastern horizon (see diagram).

Venus on the 1st is in R.A. 8 h 15 m, Decl. +20°39′, and on the 15th it is in R.A. 9 h 26 m, Decl. +16°22′, mag. −3.5, and transits at 11 h 56 m. It is too close to the sun to be seen, being at superior conjunction on the 25th.

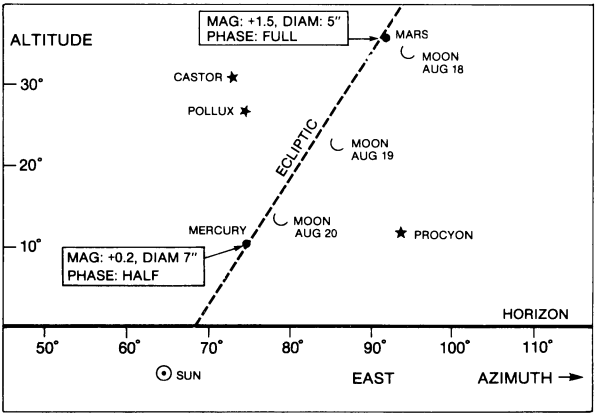
Mars on the 15th is in R.A. 6 h 19 m, Decl. +23°44′, mag. +1.5, and transits at 8 h 47 m. Moving from Taurus into Gemini, it rises about 4 hours before the sun and is well up in the east at sunrise (see diagram).

Jupiter on the 15th is in R.A. 9 h 32 m, Decl. +15°22′, mag. −1.3, and transits at 11 h 59 m. It is too close to the sun to be seen, being in conjunction on the 13th.

Saturn on the 15th is in R.A. 11 h 04 m, Decl. +7°58′, mag. +1.2, and transits at 13 h 30 m. Early in the month, it can be seen with great difficulty, very low in the west after sunset, but by the end of the month it is too close to the sun to be seen.

Uranus on the 15th is in R.A. 14 h 59 m, Decl. −16°38′, mag. +5.9, and transits at 17 h 24 m.

Neptune on the 15th is in R.A. 17 h 07 m, Decl. −21°28′, mag. +7.7, and transits at 19 h 32 m.



The Eastern Sky at Sunrise around August 19.

1979				AUGUST E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Wed.	1	00	57	☽ First Quarter	17	30	
		15		Uranus 5° S. of Moon			
Thur.	2						
Fri.	3			Mercury greatest hel. lat. S.			
Sat.	4	00		Neptune 4° S. of Moon	14	10	
Sun.	5						
Mon.	6						
Tues.	7	22	21	Full Moon	11	00	
Wed.	8	14		Moon at perigee (357,780 km)			
Thur.	9						
Fri.	10	07		Mercury stationary	7	50	
Sat.	11						
Sun.	12			Venus at perihelion			Jupiter being near the sun, configurations are not given.
		18		Perseid Meteors			
Mon.	13	04		Jupiter in conjunction with Sun	4	40	
Tues.	14	14	02	☾ Last Quarter			
Wed.	15	23		Aldebaran 0°.2 S. of Moon. Occ'n[1]			
Thur.	16	20		Pallas at opposition	1	30	
Fri.	17						
Sat.	18	03		Mars 5° N. of Moon	22	20	
		23		Mercury greatest elong. W. (19°)			
Sun.	19	09		Ceres stationary			
Mon.	20	21		Mercury 2° N. of Moon			
Tues.	21				19	10	
Wed.	22			Mercury at ascending node			
		12	10	New Moon. Eclipse of ☉ (pg. 65)			
Thur.	23	02		Moon at apogee (406,550 km)			
Fri.	24				15	50	
Sat.	25	07		Venus in superior conjunction			
Sun.	26						
Mon.	27			Mercury at perihelion	12	40	
Tues.	28	22		Uranus 5° S. of Moon			
Wed.	29						
Thur.	30	06		Mercury 0°.7 N. of Jupiter	9	30	
		10		Neptune stationary			
		13	09	☽ First Quarter			
Fri.	31	08		Neptune 4° S. of Moon			

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

THE SKY FOR SEPTEMBER 1979

The Sun—During September the sun's R.A. increases from 10 h 39 m to 12 h 27 m and its Decl. changes from +8°35′ to −2°52′. The equation of time changes from 0 m 05 s to −9 m 54 s. On Sept. 23 at 10 h 17 m E.S.T., the sun crosses the equator on its way south and autumn begins.

The Moon—On September 1.0 E.S.T., the age of the moon is 9.5 d. The sun's selenographic colongitude is 25.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 12 (8°) and minimum (east limb exposed) on Sept. 27 (7°). The libration in latitude is maximum (north limb exposed) on Sept. 12 (7°) and minimum (south limb exposed) on Sept. 27 (7°). There is a total eclipse of the moon on the night of Sept. 5-6, visible in parts of North America.

Mercury on the 1st is in R.A. 9 h 57 m, Decl. +14°09′, and on the 15th is in R.A. 11 h 37 m, Decl. +4°07′. It is too close to the sun to be seen, being at superior conjunction on the 13th.

Venus on the 1st is in R.A. 10 h 47 m, Decl. +9°13′, and on the 15th it is in R.A. 11 h 52 m, Decl. +2°23′, mag. −3.4, and transits at 12 h 19 m. It is too close to the sun to be seen.

Mars on the 15th is in R.A. 7 h 44 m, Decl. +22°07′, mag. +1.5, and transits at 8 h 10 m. Moving from Gemini into Cancer, it rises about 5 hours before the sun, and is high in the south-east at sunrise. On the 5th, it is 1° N. of δ Gem and on the 14th is 6° S. of Pollux. Watch Mars relative to Castor and Pollux; its motion is easy to see.

Jupiter on the 15th is in R.A. 9 h 58 m, Decl. +13°12′, mag. −1.3, and transits at 10 h 23 m. In Leo, it rises 3 hours before the sun and is well up in the east at sunrise (owing to the favourable orientation of the ecliptic relative to the horizon). On the 26th, it passes 0.3° N. of Regulus.

Saturn on the 15th is in R.A. 11 h 18 m, Decl. +6°29′, mag. +1.2, and transits at 11 h 42 m. It is too close to the sun to be seen, being in conjunction on the 10th.

Uranus on the 15th is in R.A. 15 h 02 m, Decl. −16°54′, mag. +5.9, and transits at 15 h 26 m.

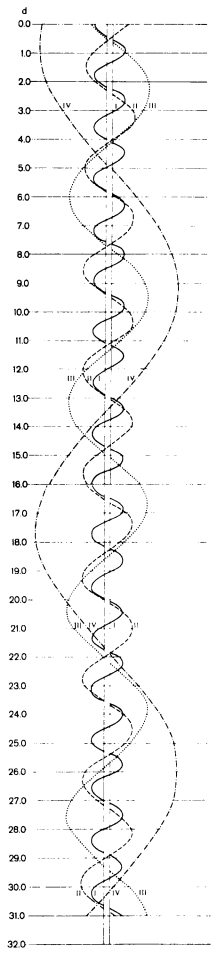
Neptune on the 15th is in R.A. 17 h 07 m, Decl. −21°30′, mag. +7.8, and transits at 17 h 30 m.

[The following item is based on one prepared by the late Dr. John F. Heard for the 1976 HANDBOOK, page 52—*Ed.*]

I wonder how many astronomy enthusiasts ever rationalize the position and phase of the moon. Take this month, for example. We see from the preceding page that new moon was on Aug. 22 and first quarter on Aug. 30. Therefore on Sept. 1 the moon is 8½ days old and about a day past first quarter. Where will we expect to see it that evening as the sun sets? Well, for one thing it will be near the ecliptic (the moon's orbit plane is tilted only about 5 degrees to the earth's orbit plane or ecliptic) and somewhat more than 90 degrees east of the sun, so about an hour east of the meridian. Will it be high or low in altitude? Well, since it is somewhat more than 90 degrees along (or nearly along) the ecliptic eastward of the sun, it must have declination about the same as the sun will have in three month's time, namely about Dec. 1, therefore nearly as far south as it ever is, i.e. about 23 degrees south. And this means its altitude as it approaches the meridian is very low, say in the neighbourhood of 20 degrees for those of us near latitude 44° N. This kind of mental gymnastics can deceive us by as much as the 5 degrees by which the moon's orbit is inclined to the earth's orbit, and in fact it did so in our example because the moon is almost exactly 5 degrees north of the ecliptic on the 1st so a more accurate altitude for the moon at sunset is 25 degrees.

1979				SEPTEMBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Sat.	1						
Sun.	2	06		Mercury 1°.2 N. of Regulus	6	20	
Mon.	3			Venus greatest hel. lat. N.			
Tues.	4						
Wed.	5				3	10	
Thur.	6			Mercury greatest hel. lat. N.			
		00		Moon at perigee (357,090 km)			
		05	59	○ Full Moon. Eclipse of ☾ (pg. 65)			
Fri.	7						
Sat.	8				0	00	
Sun.	9						
Mon.	10	09		Saturn in conjunction with Sun	20	50	
Tues.	11						
Wed.	12	06		Aldebaran 0°.2 S. of Moon. Occ'n[1]			
Thur.	13	00		Mercury in superior conjunction	17	30	
		01		☾ Last Quarter			
Fri.	14	18		Mars 6° S. of Pollux			
Sat.	15	22		Mars 5° N. of Moon			
Sun.	16	20		Vesta stationary	14	20	
Mon.	17						
Tues.	18	17		Jupiter 2° N. of Moon			
Wed.	19	05		Moon at apogee (406,400 km)	11	10	
Thur.	20						
Fri.	21	04	47	● New Moon			
Sat.	22				8	00	
Sun.	23	10	17	Equinox. Autumn begins			
Mon.	24						
Tues.	25	06		Uranus 5° S. of Moon	4	50	
Wed.	26	08		Jupiter 0°.3 N. of Regulus			
		00		Occ'n: SAO 114497 by Juno			
Thur.	27	15		Neptune 4° S. of Moon			
Fri.	28	23		☽ First Quarter	1	40	
Sat.	29						
Sun.	30			Mercury at descending node	22	30	

← West East →



[1]Visible in Central Pacific, N. and Central America, N. Atlantic, N.W. Africa.

THE SKY FOR OCTOBER 1979

The Sun—During October the sun's R.A. increases from 12 h 27 m to 14 h 22 m and its Decl. changes from $-2°52'$ to $-14°10'$. The equation of time changes from -10 m 14 s to -16 m 20 s.

The Moon—On October 1.0 E.S.T., the age of the moon is 9.8 d. The sun's selenographic colongitude is 31.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 10 (8°) and minimum (east limb exposed) on Oct. 25 (6°). The libration in latitude is maximum (north limb exposed) on Oct. 9 (7°) and minimum (south limb exposed) on Oct. 24 (7°).

Mercury on the 1st is in R.A. 13 h 16 m, Decl. $-8°07'$, and on the 15th is in R.A. 14 h 33 m, Decl. $-16°53'$. By the end of the month, it is at greatest elongation east (24°), but this elongation is very unfavourable, the planet standing only 7° above the western horizon at sunset.

Venus on the 1st is in R.A. 13 h 04 m, Decl. $-5°44'$, and on the 15th it is in R.A. 14 h 10 m, Decl. $-12°27'$, mag. -3.4, and transits at 12 h 39 m. Venus, which was unfavourably placed in the morning sky until August, is now unfavourably placed in the evening sky. Although technically an evening "star", 10° to 18° E. of the sun, it is too close to the horizon to be seen.

Mars on the 15th is in R.A. 8 h 58 m, Decl. $+18°32'$, mag. $+1.3$, and transits at 7 h 25 m. Moving from Cancer into Leo (and passing between Praesepe and δ Cnc on the 7th), it rises at midnight and is almost due south at sunrise.

Jupiter on the 15th is in R.A. 10 h 21 m, Decl. $+11°12'$, mag. -1.4, and transits at 8 h 47 m. In Leo, it rises about 5 hours before the sun, and is high in the south-east at sunrise.

Saturn on the 15th is in R.A. 11 h 32 m, Decl. $+5°06'$, mag. $+1.3$, and transits at 9 h 58 m. Moving from Leo into Virgo, it rises about 3 hours before the sun, and is low in the south-east at sunrise. By the end of October, the rings of Saturn will be seen edge-on, and will effectively disappear from view.

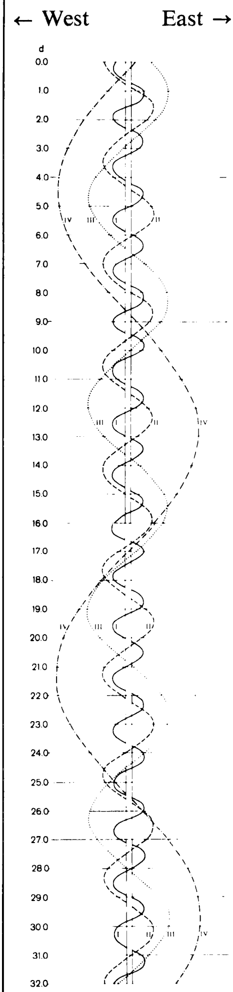
Uranus on the 15th is in R.A. 15 h 08 m, Decl. $-17°19'$, mag. $+6.0$, and transits at 13 h 34 m.

Neptune on the 15th is in R.A. 17 h 10 m, Decl. $-21°34'$, mag. $+7.8$, and transits at 15 h 35 m.

Autumn brings some excellent opportunities to observe the asteroids. Ceres spends the autumn in Cetus (see map on page 102) and passes only a degree away from θ and η Cet; it is a 7th magnitude object at the time. Juno makes a close approach to the variable star S Mon on Sept. 21-22 (see map on page 102) and moves through Canis Minor in October; it passes within a degree of Procyon on the 31st. Vesta, at 6th magnitude, is the brightest of the asteroids in 1979; it should be easy to identify in binoculars, using the stars in Cetus as a reference frame (see map on page 102). Pallas comes to opposition early in 1980, and is never brighter than 9th magnitude.

1979				OCTOBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Mon.	1					
Tues.	2	07		Mercury 1°.9 N. of Spica		
Wed.	3				19	10
Thur.	4	10		Pallas stationary		
		10		Moon at perigee (359,290 km)		
Fri.	5	02		Venus 3° N. of Spica		
		14	35	Full Moon, Harvest Moon		
Sat.	6	01		Ceres at opposition	16	00
		18		Occ'n: SAO 98024 by Mars		
Sun.	7					
Mon.	8					
Tues.	9	15		Aldebaran 0°.3 S. of Moon. Occ'n[1]	12	50
Wed.	10			Mercury at aphelion		
Thur.	11					
Fri.	12	16	24	Last Quarter	9	40
		21		Pluto in conjunction with Sun		
Sat.	13					
Sun.	14	15		Mars 4° N. of Moon		
Mon.	15				6	30
Tues.	16	10		Jupiter 1° N. of Moon		
		15		Moon at apogee (405,600 km)		
Wed.	17					
Thur.	18	00		Saturn 0°.7 N. of Moon. Occ'n[2]	3	20
Fri.	19					
Sat.	20	21	23	New Moon		
Sun.	21	19		Mercury 3° S. of Uranus	0	10
		19		Orionid Meteors		
Mon.	22	03		Venus 5° S. of Moon		
		15		Uranus 5° S. of Moon		
		17		Mercury 8° S. of Moon		
Tues.	23				21	00
Wed.	24	22		Neptune 4° S. of Moon		
Thur.	25					
Fri.	26				17	40
Sat.	27	11		Venus 0°.2 S. of Uranus		
Sun.	28	08	06	First Quarter		
Mon.	29			Venus at descending node	14	30
		11		Mercury greatest elong. E. (24°)		
Tues.	30			Mercury greatest hel. lat. S.		
Wed.	31					

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



[1]Visible in N.E. Africa, S. and E. Asia.
[2]Visible in S. Africa, Indian Ocean, Antarctica.

THE SKY FOR NOVEMBER 1979

The Sun—During November the sun's R.A. increases from 14 h 22 m to 16 h 26 m and its Decl. changes from $-14°10'$ to $-21°40'$. The equation of time changes from -16 m 22 s to -11 m 25 s.

The Moon—On November 1.0 E.S.T., the age of the moon is 11.1 d. The sun's selenographic colongitude is 49.0° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 7 (7°) and minimum (east limb exposed) on Nov. 20 (5°). The libration in latitude is maximum (north limb exposed) on Nov. 5 (7°) and minimum (south limb exposed) on Nov. 20 (6°).

Mercury on the 1st is in R.A. 15 h 55 m, Decl. $-23°19'$, and on the 15th is in R.A. 16 h 05 m, Decl. $-22°01'$. 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 low in the south-east just before sunrise. On the 8th it is 2° S. of Venus; this may aid in locating it, even though both planets will be very low in the sky.

Venus on the 1st is in R.A. 15 h 33 m, Decl. $-19°16'$, and on the 15th it is in R.A. 16 h 46 m, Decl. $-23°03'$, mag. -3.3, and transits at 13 h 13 m. It can be seen very low in the south-west, just after sunset. On the 8th it is 2° N. of Mercury and on the 11th it is 4° N. of Antares.

Mars on the 15th is in R.A. 10 h 02 m, Decl. $+14°02'$, mag. $+1.0$, and transits at 6 h 27 m. In Leo, it rises at about midnight and is past south by sunrise. On the 17th, it is $1\frac{1}{2}°$ N. of Regulus; watch the motion of Mars, relative to Regulus, during the month.

Jupiter on the 15th is in R.A. 10 h 39 m, Decl. $+9°35'$, mag. -1.6, and transits at 7 h 03 m. In Leo, it rises at about midnight and is due south by sunrise.

Saturn on the 15th is in R.A. 11 h 43 m, Decl. $+3°57'$, mag. $+1.3$, and transits at 8 h 07 m. In Virgo, it rises about 5 hours before the sun and is high in the southern sky at sunrise.

Uranus on the 15th is in R.A. 15 h 16 m, Decl. $-17°50'$, mag. $+6.0$, and transits at 11 h 39 m.

Neptune on the 15th is in R.A. 17 h 13 m, Decl. $-21°39'$, mag. $+7.8$, and transits at 13 h 37 m.

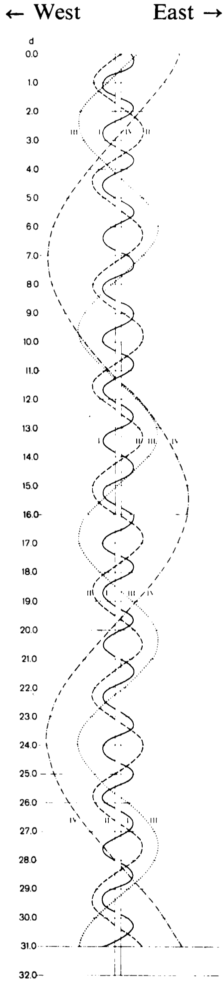
The word *planet* is derived from a Greek word meaning *wanderer*, and refers to the fact that the planets appear to move relative to the background stars. The motion is complex: the planets generally move eastward, but periodically stop and move westward, stop again and then resume their eastward motion. This motion is due to the combined motion of the earth and the planet. It took thousands of years for observers to understand these motions, but when they did, they accomplished a major revolution in our understanding of the universe.

Observing the motion of a planet is fun, and makes a good project for a student of any age. The motion is easiest to see if it is rapid (as it is with the nearby planets) and if it occurs in the vicinity of a convenient reference star. There are several suitable stars near the ecliptic: Regulus, Spica, Antares, Aldebaran, Castor and Pollux. The last two are particularly convenient, because the planet makes a dog-leg with these two stars, and the observer can watch the dog-leg change. Regulus is also useful because it is so close to the ecliptic.

Late in the summer, you may have seen Mars as it moved south of Castor and Pollux. This month, it moves past Regulus, as Jupiter did in September. On the 17th, Mars is less than 2° north of Regulus, and its motion should be easily visible.

1979				NOVEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Thur.	1	15		Moon at perigee (363,960 km)	11	20
Fri.	2					
Sat.	3	07		Vesta at opposition		
Sun.	4			Taurid Meteors	8	40
		00	47	Full Moon, Hunters' Moon		
Mon.	5					
Tues.	6	01		Aldebaran 0°.4 S. of Moon. Occ'n[1]		
Wed.	7				5	00
Thur.	8	15		Mercury 2° S. of Venus		
Fri.	9	13		Mercury stationary		
Sat.	10				1	50
Sun.	11	09		Venus 4° N. of Antares		
		11	24	Last Quarter		
Mon.	12	05		Mars 3° N. of Moon	22	40
		10		Regulus 1° N. of Moon. Occ'n[2]		
Tues.	13	02		Jupiter 0°.8 N. of Moon. Occ'n[3]		
		09		Moon at apogee (404,610 km)		
Wed.	14	02		Uranus in conjunction with Sun		
		13		Saturn 0°.3 N. of Moon. Occ'n[4]		
Thur.	15					
Fri.	16				19	30
Sat.	17	11		Leonid Meteors		
		12		Mars 1°.6 N. of Regulus		
Sun.	18			Mercury at ascending node	16	20
Mon.	19	13	04	New Moon		
		23		Mercury in inferior conjunction		
Tues.	20	00		Venus 2° S. of Neptune		
Wed.	21	06		Neptune 4° S. of Moon	13	00
		09		Venus 6° S. of Moon		
Thur.	22					
Fri.	23			Mercury at perihelion		
Sat.	24	21		Mercury 1°.7 N. of Uranus	9	50
Sun.	25					
Mon.	26	16	09	First Quarter		
Tues.	27				6	40
Wed.	28	19		Moon at perigee (369,280 km)		
Thur.	29	05		Mercury stationary		
Fri.	30	00		Juno stationary	3	30

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



[1]Visible in N. and Central America, N. Atlantic, Europe, N. Africa.
[2]Visible in New Zealand, Antarctica.
[3]Visible in S. America, S. Atlantic, S. Africa, Antarctica.
[4]Visible in S. Pacific, S. America.

THE SKY FOR DECEMBER 1979

The Sun—During December the sun's R.A. increases from 16 h 26 m to 18 h 42 m and its Decl. changes from −21°40′ to −23°05′. The equation of time changes from −11 m 04 s to 2 m 53 s. On Dec. 22, at 6 h 10 m E.S.T., winter begins.

The Moon—On December 1.0 E.S.T., the age of the moon is 11.4 d. The sun's selenographic colongitude is 54.1° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 5 (6°) and minimum (east limb exposed) on Dec. 17 (5°). The libration in latitude is maximum (north limb exposed) on Dec. 3 (7°) and Dec. 30 (7°) and minimum (south limb exposed) on Dec. 17 (7°).

Mercury on the 1st is in R.A. 15 h 12 m, Decl. −15°12′, and on the 15th is in R.A. 16 h 06 m, Decl. −19°18′. It is well placed for observation all month; it is at greatest elongation west (21°) on the 7th, at which time it stands about 16° above the south-eastern horizon at sunrise. It is 6° N. of Antares on the 18th.

Venus on the 1st is in R.A. 18 h 13 m, Decl. −24°42′, and on the 15th it is in R.A. 19 h 29 m, Decl. −23°32′, mag. −3.4, and transits at 13 h 58 m. It is rapidly becoming easier to see, as the angle between the ecliptic and the horizon increases. It is low in the south-west at sunset, and sets about 2 hours later.

Mars on the 15th is in R.A. 10 h 49 m, Decl. +10°20′, mag. +0.5, and transits at 5 h 16 m. In Leo, it rises in late evening, and is high in the south-west at sunrise. It is 1.7° N. of Jupiter on the 13th. Saturn is only 15° further east, and the moon joins the array on the 11-13th. A pretty picture!

Jupiter on the 15th is in R.A. 10 h 48 m, Decl. +8°47′, mag. −1.8, and transits at 5 h 14 m. In Leo, it rises in late evening and is high in the south-west at sunrise (see "Mars" above).

Saturn on the 15th is in R.A. 11 h 51 m, Decl. +3°17′, mag. +1.2, and transits at 6 h 17 m. In Virgo, it rises before midnight and is high in the south at sunrise. On the 9th it is 1.5° N. of β Vir.

Uranus on the 15th is in R.A. 15 h 23 m, Decl. −18°17′, mag. +6.0, and transits at 9 h 49 m.

Neptune on the 15th is in R.A. 17 h 18 m, Decl. −21°45′, mag. +7.8, and transits at 11 h 43 m.

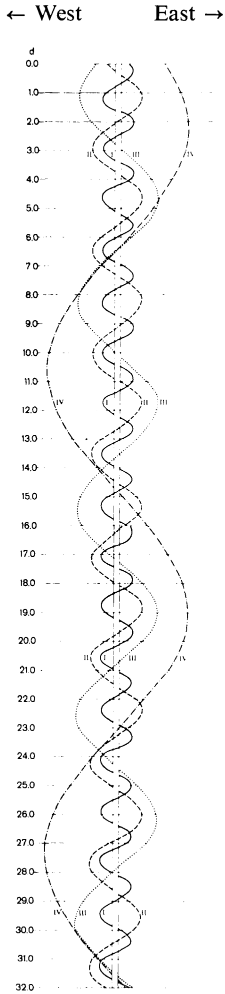
As the year draws to a close, it would be appropriate to remember that wonderful poem by Walt Whitman, which so well sums up the spirit of this HANDBOOK: it's fine to hear about astronomy and read about astronomy, but nothing can replace the enjoyment of actually *seeing* astronomy. I often think of this poem (a trifle uncomfortably) toward the end of one of my lectures.

When I Heard the Learn'd Astronomer

When I heard the learn'd astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture-room,
How soon unaccountable I became tired and sick,
Till rising and gliding out I wander'd off by myself,
In the mystical moist night-air, and from time to time,
Look'd up in perfect silence at the stars.

WALT WHITMAN

1979				DECEMBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Sat.	1	07		Ceres stationary			
Sun.	2						
Mon.	3			Mercury greatest hel. lat. N.	0	20	
				Venus at aphelion			
		11		Aldebaran 0°.5 S. of Moon. Occ'n[1]			
		13	08	Full Moon			
Tues.	4	19		Mercury 2° N. of Uranus			
Wed.	5				21	10	
Thur.	6						
Fri.	7	11		Mercury greatest elong. W. (21°)			
Sat.	8				18	00	
Sun.	9	18		Regulus 0°.8 N. of Moon. Occ'n[2]			
Mon.	10	13		Mars 2° N. of Moon			
		15		Jupiter 0°.4 N. of Moon. Occ'n[3]			
Tues.	11	03		Occ'n: SAO 80950 by Metis	14	50	
		04		Occ'n: SAO 115946 by Juno			
		06		Moon at apogee (404,530 km)			
		08	59	Last Quarter			
Wed.	12	00		Saturn 0°.01 S. of Moon. Occ'n[4]			
		15		Neptune in conjunction with Sun			
Thur.	13	12		Mars 1°.7 N. of Jupiter			
Fri.	14	10		Geminid Meteors	11	40	
Sat.	15						
Sun.	16	13		Uranus 5° S. of Moon			
Mon.	17	15		Mercury 4° S. of Moon	8	30	
Tues.	18	17		Mercury 6° N. of Antares			
Wed.	19	03	23	New Moon			
Thur.	20				5	10	
Fri.	21	12		Venus 5° S. of Moon			
Sat.	22	06	10	Solstice. Winter begins			
Sun.	23	01		Ursid Meteors	2	00	
		11		Moon at perigee (368,800 km)			
Mon.	24	00		Vesta stationary			
Tues.	25			Venus greatest hel. lat. S.	22	50	
Wed.	26			Mercury at descending node			
		00	11	First Quarter			
Thur.	27	00		Jupiter stationary			
		02		Mercury 1°.4 S. of Neptune			
Fri.	28				19	40	
Sat.	29						
Sun.	30	19		Aldebaran 0°.4 S. of Moon. Occ'n[5]			
Mon.	31				16	30	

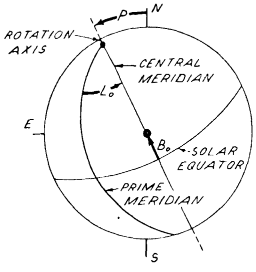


[1]Visible in Asia, N. Pacific, Alaska. [2]Visible in S. Africa, S. Indian Ocean, Antarctica. [3]Visible in E. Indies, Australia, New Zealand. [4]Visible in N. Atlantic, Africa. [5]Visible in Central and N. America, Europe, N. Africa, Asia Minor.

SUN—EPHEMERIS FOR PHYSICAL OBSERVATIONS, 1979
For 0 h U.T.

Date	P	B_0	L_0	Date	P	B_0	L_0
	°	°	°		°	°	°
Jan. 1	+ 2.31	−3.00	82.76	July 5	− 1.15	+3.28	161.06
6	− 0.12	−3.57	16.91	10	+ 1.11	+3.80	94.89
11	− 2.53	−4.12	311.06	15	+ 3.36	+4.30	28.72
16	− 4.89	−4.63	245.22	20	+ 5.56	+4.77	322.56
21	− 7.20	−5.11	179.39	25	+ 7.71	+5.21	256.41
26	− 9.43	−5.54	113.55	30	+ 9.78	+5.61	190.27
31	−11.56	−5.94	47.72				
				Aug. 4	+11.78	+5.97	124.14
Feb. 5	−13.58	−6.28	341.89	9	+13.67	+6.30	58.02
10	−15.48	−6.58	276.06	14	+15.47	+6.58	351.92
15	−17.24	−6.82	210.22	19	+17.15	+6.81	285.83
20	−18.87	−7.01	144.38	24	+18.71	+6.99	219.76
25	−20.35	−7.15	78.53	29	+20.15	+7.13	153.70
Mar. 2	−21.68	−7.23	12.67	Sept. 3	+21.45	+7.22	87.65
7	−22.84	−7.25	306.80	8	+22.61	+7.25	21.61
12	−23.85	−7.22	240.92	13	+23.62	+7.23	315.58
17	−24.69	−7.13	175.01	18	+24.48	+7.16	249.57
22	−25.36	−6.99	109.10	23	+25.19	+7.04	183.58
27	−25.86	−6.80	43.17	28	+25.73	+6.86	117.59
Apr. 1	−26.18	−6.56	337.22	Oct. 3	+26.10	+6.63	51.61
6	−26.32	−6.27	271.25	8	+26.29	+6.36	345.63
11	−26.28	−5.93	205.25	13	+26.31	+6.04	279.67
16	−26.05	−5.55	139.24	18	+26.14	+5.67	213.72
21	−25.65	−5.13	73.21	23	+25.77	+5.25	147.77
26	−25.06	−4.68	7.16	28	+25.22	+4.80	81.83
May 1	−24.28	−4.20	301.09	Nov. 2	+24.47	+4.31	15.90
6	−23.33	−3.68	235.00	7	+23.52	+3.78	309.97
11	−22.19	−3.14	168.89	12	+22.38	+3.23	244.05
16	−20.89	−2.58	102.77	17	+21.04	+2.64	178.13
21	−19.43	−2.01	36.63	22	+19.52	+2.04	112.23
26	−17.81	−1.42	330.48	27	+17.82	+1.42	46.33
31	−16.05	−0.82	264.32				
				Dec. 2	+15.96	+0.79	340.43
June 5	−14.16	−0.22	198.15	7	+13.95	+0.15	274.54
10	−12.16	+0.39	131.97	12	+11.82	−0.49	208.65
15	−10.07	+0.99	65.79	17	+ 9.57	−1.13	142.78
20	− 7.90	+1.58	359.61	22	+ 7.24	−1.76	76.91
25	− 5.68	+2.16	293.42	27	+ 4.85	−2.37	11.05
30	− 3.42	+2.73	227.24				

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 1979

No.	Commences		No.	Commences		No.	Commences	
1676	Dec.	10.95	1681	Apr.	26.54	1686	Sept.	9.64
1677	Jan.	7.28	1682	May	23.77	1687	Oct.	6.91
1678	Feb.	3.62	1683	June	19.97	1688	Nov.	3.21
1679	Mar.	2.96	1684	July	17.17	1689	Nov.	30.51
1680	Mar.	30.27	1685	Aug.	13.39	1690	Dec.	27.84

ECLIPSES DURING 1979

In 1979, there will be four eclipses, two of the sun and two of the moon.

1. *A total eclipse of the sun* on February 26. The path of totality passes through north-western U.S., Manitoba, northern Quebec and Baffin Island. The eclipse is visible as a partial one over most of the rest of North America. See following pages for more information about this eclipse.

2. *A partial eclipse of the moon* on the night of March 13, the end visible in north-eastern North America.

Moon enters penumbra	March 13	13.11 E.S.T.
Moon enters umbra		14.29 E.S.T.
Middle of eclipse		16.08 E.S.T.
Moon leaves umbra		17.47 E.S.T.
Moon leaves penumbra		19.05 E.S.T.

Magnitude of eclipse 0.858.

3. *An annular eclipse of the sun* on August 22, visible in the south Atlantic and Pacific Oceans, southern South America and part of Antarctica.

4. *A total eclipse of the moon* on the night of September 5–6, the beginning visible in North America except the north-eastern part, the end visible in the western half of North America.

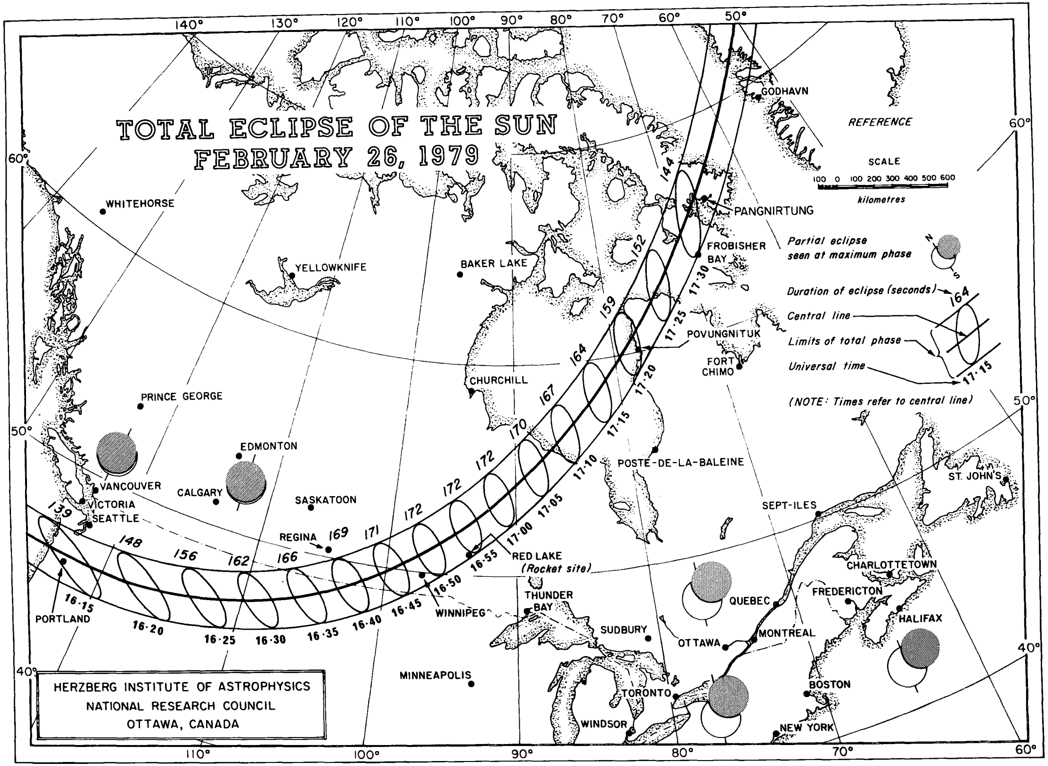
Moon enters penumbra	September 6	3.20 E.S.T.
Moon enters umbra		4.18 E.S.T.
Total eclipse begins		5.31 E.S.T.
Middle of eclipse		5.54 E.S.T.
Total eclipse ends		6.17 E.S.T.
Moon leaves umbra		7.30 E.S.T.
Moon leaves penumbra		8.28 E.S.T.

Magnitude of eclipse 1.099.

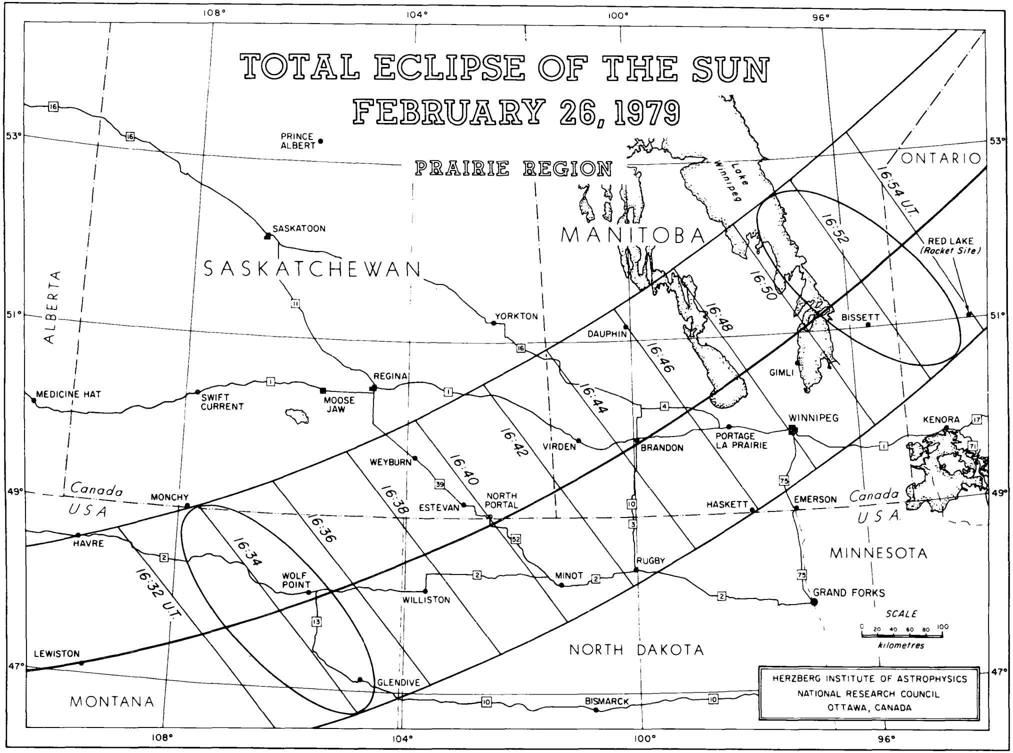
THE TOTAL SOLAR ECLIPSE OF 26 FEBRUARY 1979

This is the last total solar eclipse visible in North America between now and the end of the century. Predictions of the local circumstances for 70 cities in Canada and the U.S.A. appear in the *J. Roy. Ast. Soc. Canada*, **72**, 149 (1978). The maps on the following pages were prepared by Drs. Lorne Avery and Vic Gaizauskas of the Herzberg Institute of Astrophysics, National Research Council, from data published in Circular No. 157 of the U.S. Naval Observatory; the maps were drawn by Joan Ricketts.

Other useful maps and information have been produced by the Manitoba Planetarium, 190 Rupert Ave., Winnipeg, Man. R3B 0N2; the Canadian co-ordinator for professional observations of the eclipse is Dr. John B. Rice, Brandon University, Brandon, Man. R7A 6A9.



The ellipses indicate the instantaneous shape and orientation of the moon's shadow on the earth at the times marked adjacent to the path of totality. The durations and times refer to the total phase when the eclipse is observed on the central line. A partial eclipse of the sun is predicted for all locations in North America outside the path of totality. The N-S markers on the sketches of the partial phases for 5 cities define the direction towards the zenith at the moment of maximum obscuration.



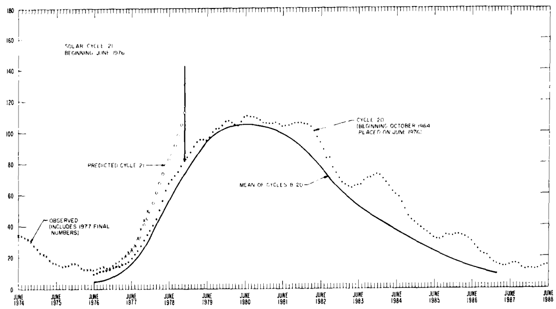
All points along the straight lines transverse to the path experience mid-totality at the indicated times. The duration of the total phase reaches a maximum on the central line and drops off to zero at the northern and southern limits of the path. The numbered lines are the major highways in Canada and the U.S.A. which intersect the path of totality.

SUNSPOTS

The diagram shows the present sunspot cycle (21) compared with the previous cycle (20) and the mean of cycles 8 to 20. This diagram plots the Zurich sunspot numbers which are weighted means from several observatories. The latest studies show that sunspot minimum occured in June, 1976 and this date has been placed on the date of the previous minimum, October 1964 in order to phase the curves. Solar activity rose steadily through 1977, then surged upwards sharply in the early months of 1978. The consensus predicted value for the maximum sunspot member is 150 with a 90% confidence interval of 49. Maximum is expected to occur around October 1979.

Another measure of solar activity is the 10 cm radio flux, which has been measured since 1947 by the National Research Council of Canada. This measure has many advantages over the sun-spot numbers: it is accurate, objective and absolute. The NRC data are internationally recognized for accuracy and self-consistency over a 30-year period. The 10 cm solar radio flux correlates well with sun-spot numbers, and reached a minimum in February 1976.

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



Sunspot Numbers in the Previous and Present Cycles. (from *Solar-Geophysical Data*, NOAA, Boulder, Colo., U.S.A.)

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.

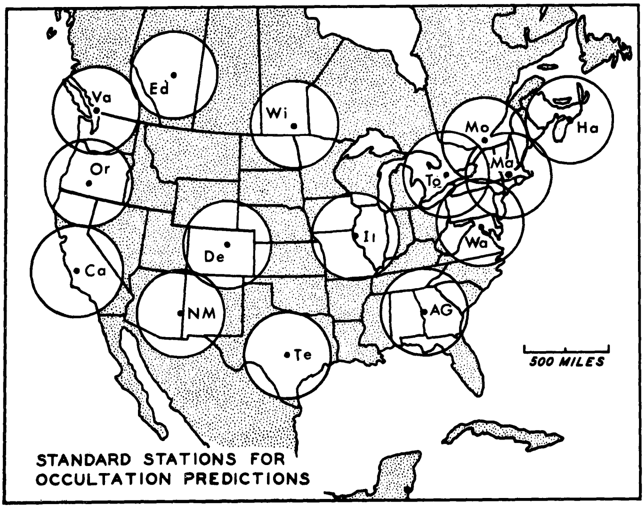
According to Gordon E. Taylor of H. M. Nautical Almanac Office, the following occultations will occur in 1979. For the minor planets the predictions are based on current ephemerides of these bodies and catalogue positions of the stars. Because of uncertainty in these ephemerides and positions, improved predictions may be issued nearer the date of the events.

Date E.S.T.	Planet			Star			Area of Visibility
	Name	Vis. Mag.	Phot. Mag.	S.A.O.	Vis. Mag.	Phot. Mag.	
Feb. 27, 23^h	Egeria	—	—	92603	8.9	9.7	N. America
Mar. 16, 15^h	Pallas	10.5	11.2	126160	9.0	11.0	E. Indies
Apr. 24, 14^h	Pallas	10.4	11.0	107061	6.9	7.2	China
July 15, 15^h	Metis	—	—	77128	8.5	10.1	S. E. Australia
Sept. 27, 0^h	Juno	9.2	10.0	114497	8.6	8.1	Brazil
Oct. 6, 18^h	Mars	1.4	2.1	98024	6.3	6.6	U.S.S.R.
Dec. 11, 3^h	Metis	—	—	80950	6.8	6.4	N. of S. America
Dec. 11, 4^h	Juno	8.2	9.0	115946	8.9	9.2	N. America

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^m5 at the dark limb of the moon.



The first five columns in the tables give for each occultation the date, ZC number of the star (see page 73), its magnitude, the phenomenon (1 = disappearance, 2 = reappearance) and the elongation of the moon from the sun in degrees (see page 36). 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 Aldebaran (ZC 692) on June 22, 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 $17^h\ 00^m.2 - 1^m.7\ (75.72 - 73.60) - 0^m.5\ (45.40 - 45.50) = 16^h\ 56^m.6$. Note that almost the same result is obtained by using Toronto as the standard station.

The elongation of the moon is 339° which means that the moon is about 2 days before new. Aldebaran therefore disappears at the bright edge of the moon and reappears at the dark edge. The position angle of immersion is close to 90° and the position angle of emersion is close to 270°; the occultation is therefore almost central, and lasts well over an hour.

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

The following information should be recorded. (1) Description of the star (catalogue number), (2) Date, (3) Derived time of the occultation, (4) Longitude and latitude to nearest second of arc, height above sea level to the nearest 20 metres. [These data can be scaled from a 7.5- or 15-minute U.S. Geological Survey map. Observers east of the Mississippi River should write to U.S. Geological Survey, 1200 S. Eads St., Arlington, Va. 22202; west of the Mississippi the address is U.S. Geological Survey, Denver Federal Center, Bldg. 41, Denver, Colo. 80225. Topographic maps for Canada are available from Map Distribution Office, Department of Mines and Technical Surveys, 615 Booth St., Ottawa K1A 0E9], (5) Seeing conditions, (6) Stellar magnitude (7) Immersion or emersion, (8) At dark or light limb; presence or absence of earthshine, (9) Method used, (10) Estimate of accuracy, (11) Anomalous appearance: gradual disappearance, pausing on the limb. All occultation data should be sent to the world clearing house for occultation data: H.M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex England.

Date		Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan.	1	3189	7.0	1	43	23 18.3	-0.6	-0.8	72	23 11.2	-0.7	-0.4	60	23 07.0	-0.9	-0.2	59
	6	219	5.1	1	97	3 17.0	-0.5	+0.1	45	3 10.7	-0.8	+0.5	40	3 05.1	-0.9	+0.4	45
	6	327	4.5	1	107	21 37.3	-2.0	+0.4	103	S				S			
	7	362	6.5	1	111	A				A				6 21.7	-0.2	-0.7	67
	8	464	6.4	1	121	2 49.9	-1.3	+1.2	38	2 37.5	-1.4	+2.0	31	2 25.6	-1.5	+2.0	35
	10	741	5.7	1	145	4 35.8	-1.4	-1.0	86	4 19.5	-1.7	-0.7	86	4 10.2	-1.9	-0.7	93
	17	1567	6.3	2	224	8 23.7	-1.8	-1.1	285	8 03.5	-2.1	-0.3	275	7 50.3	-2.4	+0.6	263
	19	1770	5.9	2	246	N				7 11.8	.	.	9	7 18.0	-0.5	-2.4	346
	20	1891d	4.4	1	258	10 04.8	-1.6	-1.3	127	9 48.9	-1.4	-1.2	137	9 44.1	-1.1	-1.6	149
	20	1891d	4.4	2	258	S				11 07.4	-1.9	-0.7	275	10 55.9	-2.3	0.0	264
	23	2247	5.6	2	294	S				10 33.3	-1.6	+0.9	269	10 22.0	-1.6	+1.4	258
	24	2399	5.0	2	307	10 36.9	-1.1	+0.1	301	10 26.9	-0.9	+0.6	294	10 20.5	-0.9	+0.8	283
	31	3430d	5.7	1	38	A				0 04.6	-0.7	-2.0	106	0 03.7	-0.9	-2.1	109
Feb.	3	298	7.2	1	78	N				0 22.3	.	.	141	G			
	3	308	6.7	1	79	2 50.5	-0.1	-3.0	126	2 44.8	-0.5	-3.1	124	2 47.8	-0.7	-4.4	135
	5	692d	1.1	1	113	23 22.0	-1.7	+1.9	52	23 09.1	-1.3	+2.7	41	22 57.3	-1.1	+2.8	41
	5	692d	1.1	2	113	24 40.3	-2.0	-1.2	286	24 18.0	-2.2	-1.1	294	24 06.6	-2.3	-0.7	292
	8	970	6.5	1	137	1 22.0	-2.0	-3.1	141	0 58.6	-2.1	-1.9	134	0 49.5	-2.3	-2.2	139
	8	1003d	7.2	1	139	7 42.6	-0.1	-0.9	68	7 39.4	-0.3	-1.1	75	7 39.3	-0.4	-1.3	85
	16	1849	6.2	2	227	N				N				7 11.3	.	.	5
	16	1850	6.5	2	227	8 47.2	.	.	233	N				N			
Mar.	3	393	6.8	1	60	A				2 26.6	-0.3	-0.5	60	2 25.9	-0.4	-0.7	68
	4	516	7.3	1	72	A				3 03.9	-0.4	-0.4	55	3 02.0	-0.5	-0.6	64
	4	635	3.9	1	83	23 37.0	-1.7	-2.0	113	23 17.0	-2.0	-1.3	107	S			
	5	659	6.4	1	84	2 55.0	-0.5	-0.9	73	2 48.3	-0.7	-1.0	77	2 45.5	-0.9	-1.2	85
	5	669	4.0	1	85	A				4 16.4	-0.1	-1.2	82	4 17.6	-0.2	-1.4	91
	5	671	3.6	1	85	A				4 19.4	0.0	-1.7	103	4 22.5	0.0	-2.0	113
	5	672d	6.6	1	85	A				A				4 38.9	-0.5	+0.1	44
	7	944	5.7	1	108	A				5 48.9	-0.9	+0.8	34	5 43.7	-0.8	-0.1	49
	7	1057	6.9	1	118	24 20.0	-2.2	+1.5	60	24 00.7	-1.9	+2.1	58	23 46.2	-1.8	+2.0	64
	8	1176	7.4	1	129	24 06.6	-1.9	-0.8	117	23 47.5	-1.8	-0.2	114	S			
	9	1190d	7.1	1	130	5 22.4	-0.5	-1.9	109	5 14.4	-0.7	-2.1	116	5 13.8	-0.8	-2.4	126
	9	1197	6.0	1	131	7 02.6	+0.2	-2.0	124	7 02.1	+0.1	-2.2	131	7 06.7	+0.1	-2.6	141
	11	1409	5.1	1	153	6 29.3	-0.4	-2.5	141	6 22.7	-0.5	-2.9	150	6 26.3	-0.2	-3.6	163
	20	2441	6.5	2	258	S				9 21.1	-1.8	+0.2	277	9 10.1	-1.8	+0.6	270
	21	2578	6.4	2	270	N				8 01.9	.	.	345	8 03.1	-0.4	-0.7	328
	30	322	5.7	1	26	A				A				0 21.4	-0.2	-2.4	117
Apr.	3	878	5.5	1	75	0 31.0	-1.1	-1.5	97	0 17.1	-1.4	-1.4	101	0 11.1	-1.6	-1.7	109
	4	1029	5.1	1	88	2 13.8	-0.7	-1.7	102	2 04.2	-0.9	-1.9	109	2 02.0	-1.1	-2.2	119
	5	1141	5.6	1	98	1 38.6	.	.	38	1 15.5	-2.4	+1.4	50	1 00.0	-2.3	+0.8	63
	5	1246	6.6	1	109	23 20.5	.	.	36	S				S			
	9	1567	6.3	1	143	2 59.7	-1.4	-1.9	133	2 44.5	-1.3	-2.0	143	2 41.6	-1.1	-2.7	157
	15	2247	5.6	2	214	5 59.1	-2.0	+0.4	264	5 39.9	-1.9	+1.1	255	5 25.4	-2.1	+2.0	242
	16	2399	5.0	2	227	7 08.1	-1.6	-0.7	306	6 52.1	-1.5	-0.2	300	6 43.6	-1.5	+0.2	292
	19	2865	5.9	2	265	7 35.4	-1.4	+1.2	258	7 24.2	-1.1	+1.5	255	A			
	24	4001	0.6	1	334	11 05.5	-1.1	+1.3	93	10 57.9	-0.7	+1.6	86	10 51.7	-0.5	+1.5	87
	24	4001	0.6	2	334	12 12.9	-1.0	+2.3	219	12 05.2	-0.9	+2.1	229	11 56.6	-0.8	+2.2	230
	29	685	6.5	1	32	A				0 49.6	-0.2	-0.9	74	0 50.2	-0.3	-1.1	83
	29	692d	1.1	1	33	A				A				1 59.8	-0.2	+0.1	43
May	1	970	6.5	1	56	1 16.0	+0.1	-2.4	131	1 13.8	-0.1	-2.9	139	1 19.7	+0.1	-3.9	153
	4	1328	7.0	1	90	1 41.7	-0.9	-1.8	108	1 29.4	-1.2	-1.9	116	1 26.1	-1.2	-2.2	127
	8	1730d	6.5	1	134	0 29.1	.	.	181	N				N			
	9	1850	6.5	1	147	5 26.1	-0.7	-2.7	156	5 16.2	-0.7	-2.8	162	5 18.3	.	.	175
	16	2814	5.0	2	234	4 56.8	-1.3	+1.8	241	A				A			
	20	3412	4.4	1	289	S				8 02.9	-0.6	+1.8	64	A			

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 20	3412	4.4	2	289	S				S				9 00.5	-0.9	+1.5	256
29	1057	6.9	1	37	A				A				1 43.5	+0.1	-1.6	106
June 2	1497	7.5	1	81	2 22.2	-0.5	-1.6	97	2 13.9	-0.8	-1.7	104	2 12.1	-0.9	-1.9	112
5	1808	7.0	1	116	A				5 26.0	-0.5	-1.2	74	5 24.6	-0.7	-1.2	79
6	1920	6.7	1	127	4 15.7	-1.0	-1.7	105	4 02.9	-1.3	-1.6	108	3 57.9	-1.4	-1.6	115
7	2022	5.5	1	137	0 34.2	-2.5	+1.3	68	S				S			
7	2032	7.3	1	139	4 34.5	-1.3	-0.8	69	4 18.9	-1.7	-0.6	72	4 09.3	-1.9	-0.5	80
7	2033	4.3	1	139	5 02.4	-0.9	-2.5	149	4 50.1	-1.1	-2.4	150	4 48.2	-1.1	-2.6	157
9	2291	5.5	1	164	4 56.3	-1.6	-1.3	114	4 39.0	-1.7	-0.9	116	4 30.9	-1.7	-0.9	122
17	3514	6.1	2	271	S				7 29.7	-0.8	+1.7	250	7 22.2	-0.7	+1.7	249
22	692d	1.1	1	339	17 16.6	-1.4	-0.9	86	17 00.2	-1.7	-0.5	84	16 50.5	-1.9	-0.4	89
22	692d	1.1	2	339	18 30.9	-1.0	-1.1	262	18 18.8	-1.3	-0.9	261	18 11.8	-1.5	-0.4	254
29	1467	7.3	1	51	A				A				2 13.2	-0.3	-1.4	87
July 3	1866d	5.9	1	94	0 39.7	.	.	53	S				S			
18	462	5.9	2	292	6 59.4	-0.2	+2.2	226	7 00.3	0.0	+1.9	235	6 57.1	+0.1	+1.8	235
30	1828	6.6	1	63	0 34.4	.	.	181	S				N			
Aug. 1	2056	7.4	1	87	1 57.2	-0.9	-2.0	120	1 45.5	-1.1	-1.9	120	1 41.7	-1.3	-1.9	125
4	2441	6.5	1	123	0 58.5	-1.9	+0.1	72	S				S			
6	2773d	6.1	1	150	2 16.8	-1.8	+0.2	79	2 00.0	-1.7	+0.7	78	1 49.0	-1.6	+0.8	82
6	2774	6.3	1	150	2 28.3	-1.6	+0.9	47	2 12.5	-1.7	+1.4	44	1 59.6	-1.8	+1.6	49
6	2791	5.4	1	151	5 09.9	-1.6	-2.0	124	4 52.1	-1.7	-1.3	112	4 43.9	-1.8	-1.0	111
11	12	6.3	2	221	3 43.3	.	.	174	3 44.5	-0.3	+3.1	189	3 37.0	-0.3	+3.3	187
11	13	6.3	2	221	4 12.0	-0.6	+2.7	196	4 08.5	-0.6	+2.4	206	4 01.1	-0.5	+2.5	206
28	2020	6.6	1	56	A				0 55.5	-0.7	-0.1	47	0 51.0	-1.0	-0.3	53
28	2022	5.5	1	56	A				A				1 16.9	-0.8	-2.7	149
29	2245	6.4	1	79	23 47.4	.	.	40	S				S			
31	2399	5.0	1	92	A				2 05.5	-1.2	-1.4	101	2 00.4	-1.4	-1.3	102
Sept. 1	2531	7.3	1	104	1 49.0	-1.2	-0.8	76	1 34.8	-1.5	-0.4	70	1 25.8	-1.8	-0.1	72
2	2699	7.2	1	117	1 38.7	-1.4	+0.2	51	1 24.4	-1.6	+0.8	45	1 12.9	-1.8	+1.0	47
3	2863	6.1	1	130	2 00.0	.	.	151	1 34.7	-2.0	-1.3	137	1 25.5	-1.9	-1.2	140
4	3005	6.2	1	144	0 29.4	-1.5	+1.6	43	0 16.6	-1.4	+2.0	40	S			
4	3019	5.9	1	145	3 33.8	-0.4	+1.9	14	N				N			
9	249	4.7	2	217	6 57.0	-0.5	+3.3	189	6 51.6	-1.0	+2.2	208	6 42.0	-1.0	+2.2	211
11	491	6.2	2	242	2 41.8	-0.1	+1.4	267	A				A			
11	498	6.2	2	242	4 07.1	-0.4	+2.0	236	4 05.8	-0.2	+1.8	246	4 01.8	-0.1	+1.7	247
11	508	4.3	1	243	4 58.1	-1.3	+0.8	108	4 49.4	-0.7	+1.3	95	4 43.6	-0.5	+1.3	94
11	508	4.3	2	243	5 53.3	-0.6	+2.7	212	5 49.2	-0.6	+2.2	226	5 42.1	-0.5	+2.2	228
12	659	6.4	2	256	5 49.0	.	.	328	N				N			
12	661	4.6	2	256	6 22.3	-0.8	+2.3	230	6 17.1	-0.6	+2.0	242	6 10.3	-0.5	+1.9	244
12	669	4.0	1	256	6 38.8	-1.0	+2.1	57	6 33.5	-0.5	+2.5	44	6 26.7	-0.3	+2.5	42
12	669	4.0	2	256	7 52.7	-1.8	+0.6	271	7 36.2	-1.6	+0.6	284	7 26.1	-1.5	+0.7	286
12	671	3.6	1	256	6 36.7	-1.2	+1.5	78	6 28.6	-0.7	+1.9	66	6 21.6	-0.5	+1.9	64
12	671	3.6	2	256	7 53.6	-1.6	+1.4	250	7 40.2	-1.4	+1.3	262	7 30.4	-1.2	+1.3	264
12	677	4.8	2	257	S				8 39.4	.	.	314	8 27.7	.	.	315
12	682	6.0	2	257	S				9 20.4	-1.2	+3.0	211	9 08.2	-1.0	+3.2	210
12	692d	1.1	1	258	11 43.0	.	.	14	G				11 13.7	.	.	17
12	692d	1.1	2	258	12 10.3	.	.	332	G				11 51.9	.	.	323
13	806	5.1	2	269	8 38.0	-1.3	+2.7	223	8 28.3	-1.1	+2.2	236	8 18.5	-0.9	+2.3	236
14	934	6.4	2	279	5 00.7	-0.5	+0.1	313	A				A			
14	944	5.7	2	280	6 45.8	-0.4	+2.5	233	6 44.9	-0.2	+2.0	244	6 40.7	0.0	+1.9	245
16	1198	6.2	2	303	7 30.7	-0.2	+2.2	243	7 31.7	0.0	+1.8	253	7 29.0	+0.2	+1.7	253
16	1210	5.9	2	304	S				9 04.7	-0.6	+2.3	245	8 58.0	-0.3	+2.3	244
26	2352	6.7	1	61	A				23 54.5	-1.2	-1.0	79	23 48.6	-1.4	-0.9	81
29	2794	6.7	1	97	22 46.4	.	.	15	S				S			
30	2814	5.0	1	99	A				3 03.0	-0.9	-1.2	87	2 58.9	-1.1	-1.0	86

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Mo MONTREAL, Q.P. W. 73°.600, N. 45°.500 U.T.	a	b	P	To TORONTO, ONT. W. 79°.400, N. 43°.700 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Sept. 30	2816	6.8	1	99		A				A			3 17.8	-0.9	-0.7	72
Oct. 3	3253	5.4	1	139	0 31.4	-1.9	+0.1	108	0 14.7	-1.5	+0.7	99	0 05.0	-1.4	+0.8	100
3	3255	7.4	1	139	1 43.7	-1.2	+1.2	38	1 33.7	-1.0	+1.9	25	1 23.9	-1.1	+2.2	23
3	3388d	5.6	1	152	22 26.5	-0.8	+0.1	130		S				S		
9	608d	6.0	2	225	8 36.4	-1.6	+0.4	244	8 20.0	-1.7	+0.5	251	8 08.7	-1.8	+0.8	249
12	1040d	6.2	2	260	5 14.0	-0.8	+0.8	289	5 07.9	-0.6	+0.6	301	5 04.0	-0.4	+0.5	301
14	1284	6.3	2	284	8 57.6	-1.5	+2.5	242	8 46.7	-1.1	+2.3	248	8 36.8	-0.8	+2.5	243
24	2441	6.5	1	42	22 07.1	-0.7	+0.7	35		S				S		
27	2763	6.7	1	68		A				A			1 24.5	-0.7	-0.6	64
28	3036	7.0	1	93	21 51.1	-2.1	-0.5	121		S				S		
29	3196	6.1	1	107	24 21.4	-1.3	+0.7	48	24 09.8	-1.2	+1.3	35	23 59.9	-1.3	+1.7	33
Nov. 1	3514	6.1	1	136	5 59.1	-0.4	-0.5	64	5 53.6	-0.6	-0.2	55	5 49.8	-0.8	-0.1	57
3	249	4.7	1	163		N				G			3 24.3	.	.	137
6	661	4.6	2	202	0 48.0	+0.7	+3.9	189	0 55.2	+0.3	+2.6	207	0 52.8	+0.4	+2.5	208
6	669	4.0	1	202	1 14.8	-0.5	+1.4	86	1 12.6	-0.2	+1.6	76	1 09.2	0.0	+1.5	74
6	669	4.0	2	202	2 17.9	-0.7	+1.9	242	2 13.3	-0.5	+1.7	254	2 07.7	-0.4	+1.6	255
6	671	3.6	1	202	1 18.9	-0.8	+0.9	108	1 14.3	-0.3	+1.2	96	1 10.6	-0.2	+1.2	95
6	671	3.6	2	202	2 12.4	-0.4	+2.5	220	2 10.7	-0.3	+2.1	233	2 05.5	-0.2	+2.0	235
6	677	4.8	2	203	3 27.0	-1.3	+1.2	262	3 15.6	-1.1	+1.1	274	3 07.5	-1.0	+1.1	276
6	692d	1.1	1	204	5 20.5	-1.7	+0.9	73	5 05.9	-1.4	+1.6	63	4 55.2	-1.3	+1.7	62
6	692d	1.1	2	204	6 40.8	-1.8	-0.1	262	6 22.6	-1.8	+0.1	270	6 11.4	-1.9	+0.4	268
7	806	5.1	2	215		N			1 32.2	+0.6	+3.0	203	1 30.5	+0.6	+2.8	204
7	814d	5.3	2	216	3 10.8	-1.4	+0.2	300	2 57.2	-1.4	-0.6	318	2 50.5	-1.3	-0.7	321
10	1238	6.1	2	252	5 20.9	-0.9	+1.6	264	5 15.1	-0.6	+1.4	273	5 10.0	-0.4	+1.4	271
16	1869d	6.1	2	320	9 00.9	-0.4	+0.3	303		A				A		
16	1875d	6.5	2	320		S				S			10 50.1	-0.7	+0.2	303
23	2863	6.1	1	50	22 04.0	-0.9	0.0	49	21 54.4	-1.0	+0.7	36		S		
24	3011	7.0	1	63		G			23 39.0	-1.9	-2.2	122	23 30.8	-2.1	-1.8	119
25	3152	6.8	1	75	21 17.8	-1.7	+0.6	67		S				S		
27	3313	6.8	1	90	2 07.3	-0.1	+1.3	19	2 11.2	.	.	354	2 08.6	.	.	350
28	36	7.2	1	115	22 14.5	.	.	131	21 54.0	-1.5	+0.6	113		S		
30	192	5.3	1	130	1 36.8	-2.0	-0.6	96	1 17.8	-1.8	+0.5	81	1 06.5	-1.7	+0.8	78
Dec. 7	1207	5.8	2	222	10 14.9	-0.5	-3.1	326	10 05.2	-0.9	-2.7	317	10 02.9	-1.3	-2.1	305
8	1323	6.3	2	234	9 35.3	-1.1	-2.6	319	9 20.0	-1.5	-2.0	311	9 13.5	-1.8	-1.4	300
13	1821d	2.9	2	288	7 13.9	-0.5	-0.2	317		A				A		
13	1825	6.1	2	288	8 18.1	-0.5	-1.6	340	8 12.2	-0.4	-1.1	334	8 11.1	-0.4	-0.5	323
22	3108	5.5	1	45	21 30.9	-1.0	+0.2	47		S				S		
23	3262	7.1	1	58	21 32.3	-2.2	-1.3	110		S				S		
23	3267	7.2	1	59	23 37.7	.	.	138	23 14.6	-1.9	-1.9	112	23 06.2	-2.1	-1.5	109
25	12	6.3	1	86	24 03.3	-1.4	-0.4	76	23 48.9	-1.4	+0.3	62	23 39.4	-1.5	+0.7	59
26	13	6.3	1	86	0 22.6	-1.2	-0.2	67	0 10.0	-1.3	+0.5	54	0 01.2	-1.4	+0.8	52
26	15	7.3	1	86	0 55.0	-0.7	+0.8	35	0 49.2	-0.6	+1.7	19	0 42.2	-0.6	+2.0	17
26	128	7.3	1	98	21 44.9	-1.2	+1.8	42		S				S		
28	303	6.6	1	115		A			6 02.9	.	.	359	5 54.5	-0.5	+1.9	16
28	405	4.4	1	124	21 21.9	-1.1	+1.4	83		S				S		
30	692d	1.1	1	150	22 14.7	-0.1	+2.9	29	22 20.3	.	.	9	22 17.7	.	.	4
30	692d	1.1	2	150	23 02.4	-1.6	+0.2	299	22 46.4	.	.	320	22 38.3	.	.	325

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
Jan.	4	3496	7.2	1	71		N			1 24.6	-2.0	-1.9	122	1 10.2	-2.5	-1.5	121
	4	3505	5.6	1	72		N			3 21.3	-1.2	-2.1	111	3 16.5	-1.8	-2.4	117
	6	212d	7.3	1	96	0 52.1	.	.	133	0 17.3	-1.5	+0.7	97		S		
	6	219	5.1	1	97	3 00.0	.	.	3		N				N		
	7	362	6.5	1	111	6 10.9	-0.6	-0.3	52	5 58.5	-0.9	+0.5	38	5 46.4	-1.2	+0.4	50
	10	741	5.7	1	145	3 38.8	-1.6	+1.1	68	3 24.2	-1.0	+2.4	47	3 05.0	-0.8	+2.4	51
	11	878	5.5	1	156	2 41.7	-1.6	-0.2	121	2 24.2	-0.9	+1.3	98	2 11.3	-0.6	+1.2	101
	17	1567	6.3	2	224	7 21.4	-1.5	+1.3	266	7 07.1	-0.9	+1.5	270	6 51.1	-0.6	+2.3	254
	19	1770	5.9	2	246	6 56.4	.	.	359		N				A		
	20	1891d	4.4	1	258	9 20.6	-0.6	-1.0	154	9 10.1	-0.3	-0.8	158		N		
	20	1891d	4.4	2	258	10 21.0	-1.9	+1.3	256	10 00.3	-1.4	+2.2	249		N		
	31	3437	6.7	1	39	1 00.9	-0.2	+1.0	21		N				N		
Feb.	3	308	6.7	1	79	2 11.3	-1.3	-1.6	101	1 45.3	-1.4	-0.2	79		S		
	3	322	5.7	1	80	5 03.1	-0.2	-2.4	116	4 47.6	-0.7	-2.0	104	4 49.4	-1.1	-2.8	119
	3	327	4.5	1	80		A			5 40.6	-0.4	-1.0	68	5 40.1	-0.7	-1.2	82
	7	878	5.5	1	129		A			10 16.2	-0.3	-0.7	51	10 17.1	-0.3	-1.0	70
	8	970	6.5	1	137	0 18.8	-1.1	+1.0	104		S				S		
	8	975d	6.8	1	137		N			1 10.5	-1.3	-0.6	141		S		
	8	1003d	7.2	1	139	7 18.7	-1.0	-1.3	84	6 55.8	-1.3	-0.9	85	6 45.8	-1.6	-1.1	102
	14	1660d	6.2	2	207	12 19.1	-0.7	-1.7	279	11 57.8	-1.2	-1.3	273	11 47.6	-1.9	-0.5	255
	14	1663	5.2	2	207		S			12 43.9	-1.0	-1.4	265	12 36.2	-1.7	-0.6	249
	16	1849	6.2	2	227	6 50.2	.	.	2	6 40.3	.	.	2	6 46.2	-0.2	-0.6	331
Mar.	3	393	6.8	1	60	2 12.3	-0.8	-0.1	51	1 58.8	-1.0	+0.8	36		S		
	3	398	6.7	1	60	3 37.0	-0.2	-2.1	110	3 21.9	-0.7	-1.8	100	3 22.7	-1.1	-2.5	116
	3	401	6.3	1	60	3 50.4	-0.3	-1.0	72	3 39.7	-0.6	-0.8	65	3 35.9	-0.9	-0.9	78
	4	516	7.3	1	72	2 46.2	-1.0	0.0	50	2 30.5	-1.1	+1.1	36		S		
	4	526	6.9	1	74		A			5 29.5	-0.4	-1.1	73	5 30.8	-0.6	-1.5	89
	5	659	6.4	1	84	2 19.4	-1.4	-0.4	71	1 56.9	-1.4	+0.8	58		S		
	5	669	4.0	1	85	4 00.0	-0.8	-1.3	84	3 40.0	-1.2	-0.8	78	3 30.5	-1.5	-0.9	92
	5	671	3.6	1	85	4 03.8	-0.7	-1.9	105	3 42.7	-1.1	-1.5	99	3 37.4	-1.5	-2.0	114
	5	672d	6.6	1	85	4 27.5	-1.0	+0.6	36	4 12.8	-1.2	+1.4	29	3 55.7	-1.5	+0.7	50
	5	677	4.8	1	85	5 16.8	-0.8	+0.6	32	5 04.4	-1.1	+1.0	30	4 51.3	-1.3	+0.2	52
	5	680	6.7	1	85	5 16.7	-0.6	-0.3	48	5 03.8	-0.9	0.0	46	4 54.7	-1.2	-0.4	65
	5	682	6.0	1	86	5 45.5	+0.1	-2.4	123	5 34.2	-0.4	-2.6	123	5 45.6	.	.	149
	5	685	6.5	1	86		N				N			6 42.2	-1.0	+0.9	30
	6	806	5.1	1	97	6 01.0	-0.5	-1.0	69	5 46.4	-0.9	-0.9	70	5 41.3	-1.1	-1.2	87
	6	820	6.0	1	98		A			7 36.6	-0.1	-1.8	101	7 44.1	-0.1	-2.2	118
	7	944	5.7	1	108	5 24.8	-1.3	+0.1	48	5 02.6	-1.5	+0.7	48	4 45.0	-1.8	+0.2	69
	7	970	6.5	1	110		A			8 49.6	-0.4	-0.6	47	8 49.2	-0.4	-1.0	67
	7	975d	6.8	1	110		A			9 21.1	+0.1	-1.5	89	9 28.8	+0.1	-1.7	104
	8	1091	6.7	1	121	8 52.0	+0.2	-1.7	111	8 45.6	-0.1	-2.1	115	8 54.1	-0.1	-2.5	133
	9	1190d	7.1	1	130	4 40.6	-1.3	-2.0	126	4 11.7	-1.4	-1.2	125	4 04.1	-1.6	-2.2	144
	9	1197	6.0	1	131	6 47.0	-0.4	-2.9	144	6 27.2	-0.7	-3.2	150		N		
	11	1409	5.1	1	153	5 56.8	.	.	171	5 35.1	.	.	180		N		
	20	2441	6.5	2	258	8 49.9	-1.1	+1.2	267		A				A		
Apr.	1	608d	6.0	1	53	3 37.3	-0.1	-1.3	86	3 26.7	-0.5	-1.4	84	3 27.1	-0.8	-1.7	100
	4	1029	5.1	1	88	1 26.2	-1.6	-1.4	111		S				S		
	5	1176	7.4	1	102		A				A			8 49.0	-0.4	-0.7	56
	9	1567	6.3	1	143	2 09.3	-1.0	-1.7	154		S				S		
	16	2399	5.0	2	227	6 26.9	-0.8	+0.8	288		A				A		
	18	2715	6.5	2	253	9 30.3	-1.4	+1.2	250		A				A		
	24	4001	0.6	2	334	11 59.1	-0.4	+1.9	247		A				A		
	29	692d	1.1	1	33	1 52.9	-0.6	+0.2	38	1 40.8	-1.0	+0.5	36	1 30.3	-1.2	-0.1	58
	29	692d	1.1	2	33	2 31.8	+0.3	-2.7	316	2 23.0	-0.1	-3.0	315	2 31.3	-0.5	-2.2	293
May	1	1003d	7.2	1	58		A			5 57.1	+0.1	-1.3	79	6 03.5	0.0	-1.5	94

Date		Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900 U.T.	a	b	P	Ed EDMONTON, ALTA. W.113°.400, N. 53°.600 U.T.	a	b	P	Va VANCOUVER, B.C. W.123°.100, N. 49°.200 U.T.	a	b	P
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May	7	1657	6.7	1	125	8 04.4	-0.3	-1.7	99	7 50.0	-0.7	-1.8	102	7 50.1	-0.9	-1.8	114
	7	1660d	6.2	1	126	A				8 42.7	-0.2	-2.3	142	8 50.6	-0.3	-2.6	154
	7	1663	5.2	1	126	A				A				9 39.8	0.0	-3.0	167
June	4	1712	3.8	1	104	N				N				4 29.1	-2.5	+0.5	62
	5	1808	7.0	1	116	4 58.0	-1.4	-1.1	79	S				S			
	6	1920	6.7	1	127	3 23.3	-1.4	-0.9	120	S				S			
	7	2032	7.3	1	139	3 33.2	-1.8	+0.2	85	S				S			
	7	2033	4.3	1	139	4 15.9	-0.9	-2.0	161	3 59.6	.	.	176	N			
	9	2291	5.5	1	164	4 02.3	-1.2	-0.1	125	S				S			
	12	2791	5.4	2	205	S				9 18.5	-1.4	+0.1	261	9 02.7	-1.5	+0.7	256
	22	692d	1.1	1	339	16 22.7	-1.4	+1.4	61	16 12.0	-0.8	+2.6	37	15 53.8	-0.6	+2.6	40
	22	692d	1.1	2	339	17 39.6	-1.7	-0.6	276	17 09.9	-1.7	-0.6	297	16 54.2	-1.7	+0.1	291
July	1	1678	5.8	1	74	4 13.6	-0.4	-1.9	109	S				S			
	2	1770	5.9	1	84	3 37.5	-0.7	-2.3	141	S				S			
	2	1772	4.0	1	84	4 10.5	-0.8	-1.5	87	S				S			
	6	2247	5.6	1	133	A				A				7 39.3	-1.2	-1.6	119
	7	2399	5.0	1	146	A				A				8 21.1	-1.0	+0.4	36
	12	3196	6.1	2	215	S				S				10 00.5	-1.5	+0.6	255
	19	608d	6.0	2	305	9 03.4	.	.	323	N				N			
	30	1849	6.2	1	66	A				A				4 57.9	-0.5	-2.5	148
Aug.	5	2611	6.8	1	137	4 01.0	.	.	154	S				N			
	6	2791	5.4	1	151	4 11.3	-1.5	+0.2	95	3 51.2	-1.2	+0.8	92	S			
	6	2814	5.0	1	153	A				A				8 30.9	-1.1	-0.4	68
	10	3432	6.3	2	210	9 29.7	-1.6	-0.6	276	8 57.2	-2.1	-0.9	308	8 39.7	.	.	310
	12	192	5.3	2	238	S				S				11 21.2	-1.1	+1.5	225
Sept.	2	2715	6.5	1	119	4 47.7	-1.0	-0.5	61	4 29.4	-1.2	+0.2	46	4 14.1	-1.6	+0.7	50
	2	2718	6.7	1	119	5 22.1	-0.9	-0.9	75	5 03.3	-1.1	-0.3	60	4 50.9	-1.5	+0.2	62
	2	2724	6.6	1	119	N				A				6 00.3	-1.8	-2.0	138
	9	249	4.7	2	217	6 34.5	-1.0	+1.6	244	6 26.4	-0.7	+1.5	262	6 13.9	-0.5	+1.5	261
	10	405	4.4	1	232	10 00.5	.	.	137	9 25.5	-1.4	+0.5	101	9 08.7	-1.4	+0.8	101
	10	405	4.4	2	232	10 28.9	.	.	181	10 26.5	-0.9	+1.8	217	10 08.8	-0.9	+2.2	216
	11	508	4.3	1	243	4 49.4	0.0	+1.6	71	A				A			
	11	508	4.3	2	243	5 47.0	-0.3	+1.7	255	5 50.4	0.0	+1.5	269	A			
	12	661	4.6	2	256	6 14.1	-0.2	+1.4	271	A				A			
	12	671	3.6	1	256	6 32.1	+0.1	+2.5	33	6 51.5	.	.	359	A			
	12	671	3.6	2	256	7 18.3	-0.9	+0.8	297	7 04.1	.	.	334	A			
	12	675d	5.7	2	257	7 57.5	-0.4	+2.5	223	8 00.2	-0.2	+1.9	244	7 50.6	0.0	+1.8	244
	12	678	5.5	2	257	8 16.1	-0.5	+2.3	228	8 16.3	-0.4	+1.9	249	8 05.9	-0.1	+1.8	249
	12	682	6.0	2	257	9 03.2	-1.0	+1.8	246	8 55.5	-0.7	+1.5	268	8 43.2	-0.5	+1.5	267
	12	699	5.8	2	259	S				S				12 00.5	-1.1	+2.5	221
	13	806	5.1	2	269	8 16.1	-0.6	+1.5	267	8 13.4	-0.3	+1.2	288	8 06.0	-0.1	+1.1	287
	13	820	6.0	2	270	N				9 51.3	-0.3	+2.8	218	9 37.7	0.0	+2.8	216
	14	944	5.7	2	280	6 50.9	+0.1	+1.3	272	A				A			
	14	970	6.5	2	282	N				10 01.5	-0.1	+3.1	217	9 49.2	+0.3	+3.1	213
	16	1210	5.9	2	304	9 05.2	-0.1	+1.4	273	A				A			
	26	2223d	4.0	1	50	A				1 52.6	-1.0	-0.8	59	S			
	30	2814	5.0	1	99	2 33.8	-1.3	-0.1	60	2 13.7	-1.3	+0.6	47	S			
	30	2816	6.8	1	99	2 59.0	-1.0	+0.2	43	2 45.2	.	.	22	S			
	30	2825	6.4	1	100	N				4 32.0	.	.	150	4 23.3	.	.	150
Oct.	2	3134	6.9	1	128	A				6 59.6	-1.1	-1.5	103	6 52.8	-1.5	-1.2	103
	8	462	5.9	2	211	7 20.8	-1.0	+2.0	222	7 11.7	-0.9	+1.6	245	6 56.5	-0.7	+1.7	245
	9	608d	6.0	2	225	7 42.6	-1.6	+0.4	283	7 18.7	-1.6	-0.3	314	7 05.2	-1.3	-0.1	314
	9	626	6.4	2	227	S				12 00.1	-1.3	0.0	250	11 44.4	-1.5	+0.9	239
	9	635	3.9	1	227	S				13 03.6	-1.1	-0.7	79	12 54.3	-1.5	-0.8	92
	14	1284	6.3	2	284	8 38.3	-0.4	+1.5	272	8 39.2	-0.1	+1.1	291	A			

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97.200°, N. 49.900° U.T.	a	b	P	Ed EDMONTON, ALTA. W.113.400°, N. 53.600° U.T.	a	b	P	Va VANCOUVER, B.C. W.123.100°, N. 49.200° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Oct. 26	2611	6.8	1	57		A				A			2 14.1	-1.5	-1.5	116
27	2763	6.7	1	68	1 10.1	-0.7	+0.5	31		N				S		
27	2773d	6.1	1	69		A			2 45.5	-0.5	+0.1	33	2 37.1	-0.9	+0.6	33
29	3064	6.0	1	95	2 30.5	-2.0	-1.8	124	1 59.3	-1.5	-0.1	101	1 43.3	-1.7	+0.3	102
Nov. 1	3514	6.1	1	136	5 40.5	-0.5	+1.5	18		N				N		
1	3537	6.8	1	139		N				A			9 56.2	.	.	141
3	249	4.7	1	163	2 48.9	-1.2	+1.1	89	2 40.3	-0.6	+1.6	72	2 28.3	-0.4	+1.7	72
6	669	4.0	2	202	2 11.6	-0.1	+1.2	282		A				A		
6	671	3.6	2	202	2 14.0	0.0	+1.5	261		A				A		
6	677	4.8	2	203	2 56.7	-0.8	+0.3	314		N				N		
6	678	5.5	2	203		N			2 55.7	+0.4	+2.3	210		A		
6	692d	1.1	1	204	4 56.8	-0.2	+3.2	24		N				N		
6	692d	1.1	2	204	5 40.4	-1.7	-0.4	306		N				N		
10	1238	6.1	2	252	5 12.2	-0.1	+0.7	301		A				A		
23	2724	6.6	1	39		A				A			1 07.9	-0.7	+0.5	32
25	3036	7.0	1	66		A				A			4 08.4	-1.0	-1.4	95
26	3307	4.9	1	89	22 51.5	-1.9	-0.3	129		S				S		
27	3325	6.7	1	92	4 25.8	-0.5	-0.3	53	4 17.8	-0.4	+0.6	26	4 08.9	-0.7	+1.0	27
30	192	5.3	1	130	0 52.7	-0.9	+1.8	47	0 50.4	-0.4	+2.3	27	0 37.2	-0.2	+2.4	27
Dec. 1	368d	6.3	1	148		A			10 09.7	-0.5	+0.1	37	10 04.7	-0.7	-0.2	53
7	1207	5.8	2	222	9 24.9	-1.5	-1.8	312	8 55.4	-1.4	-1.5	323	8 45.5	-1.4	-0.4	307
8	1323	6.3	2	234	8 37.1	-1.5	-0.9	312	8 13.2	-1.1	-0.9	326	8 04.8	-1.0	0.0	312
10	1550d	5.8	2	258		S			13 40.1	-1.5	-0.9	284	13 24.3	-2.1	+0.4	263
22	2979	7.1	1	34		A				A			1 34.5	0.0	+1.2	16
25	3422	6.7	1	74	1 27.2	.	.	132	0 51.0	-1.6	-0.3	96		S		
25	12	6.3	1	86	23 26.6	-0.8	+2.0	24		N				N		
25	13	6.3	1	86	23 52.7	-0.5	+2.4	11		N				N		
26	36	7.2	1	88	5 09.7	-0.8	-4.4	134	4 44.5	-1.0	-1.8	103	4 40.6	-1.6	-2.0	110
27	192	5.3	1	103		A				A			8 15.1	-0.3	-0.7	65
29	453	7.3	1	129	8 55.2	0.0	-1.6	97	8 45.5	-0.4	-1.6	91	8 48.0	-0.7	-2.1	108

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72.500°, N. 42.500° U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77.000°, N. 38.900° U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85.000°, N. 33.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 1	3188	5.4	1	43		N				N			23 32.6	+0.2	+3.2	6
1	3189	7.0	1	43	23 13.4	-0.8	-0.6	70	23 11.2	-1.1	-0.6	75		S		
6	219	5.1	1	97	3 10.8	-0.8	+0.1	52	3 06.8	-1.0	-0.2	63	2 58.4	-1.6	-0.5	79
7	352	7.3	1	110		N			5 11.1	-0.8	+2.7	15	4 55.9	-1.0	+0.7	46
7	362	6.5	1	111		A				A			6 32.5	-0.1	-1.6	105
8	464	6.4	1	121	2 34.3	-1.6	+1.3	44	2 22.3	-1.9	+1.1	54	1 59.6	-2.3	+1.0	67
9	618	7.2	1	135		N			7 44.5	.	.	11	7 29.4	-0.8	+0.2	53
10	741	5.7	1	145	4 24.1	-1.8	-1.1	96	4 20.6	-2.0	-1.7	109	4 17.1	.	.	136
17	1567	6.3	2	224	8 06.5	-2.4	-0.1	268	7 52.1	-3.1	+1.5	249		N		
19	1770	5.9	2	246	7 24.8	-0.4	-3.2	352	7 29.2	-1.1	-1.6	330	7 24.3	-1.4	-0.3	300
20	1891d	4.4	1	258	9 54.6	-1.4	-1.6	142	9 56.1	-1.0	-2.5	160		N		
20	1891d	4.4	2	258	11 11.6	-2.1	-0.6	270	11 01.5	-2.8	+0.3	255		N		
23	2245	6.4	2	294		N				N			9 10.9	+0.6	-3.0	352
23	2247	5.6	2	294	10 32.3	-1.8	+1.0	263	10 18.5	-2.1	+1.9	246		N		
24	2399	5.0	2	307	10 26.3	-1.1	+0.6	288	10 18.6	-1.1	+1.0	274	10 00.9	-1.2	+2.0	245
31	3430d	5.7	1	38	0 12.3	-0.7	-2.8	121	0 21.7	.	.	141		N		
31	3437	6.7	1	39		A				A			1 09.2	-0.5	-1.0	90
Feb. 3	308	6.7	1	79	2 57.1	.	.	144		N				N		
5	692d	1.1	1	113	23 03.4	-1.5	+2.2	52	22 49.0	-1.5	+2.0	59	22 26.1	-1.3	+1.8	67
5	692d	1.1	2	113	24 23.0	-2.3	-0.6	282	24 13.5	-2.4	+0.1	273	23 51.6	-2.2	+1.0	261

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72.500°, N. 42.500° U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77.000°, N. 38.900° U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85.000°, N. 33.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Feb. 8	970	6.5	1	137	1 09.9	.	.	151		N				N		
8	1003d	7.2	1	139	7 43.1	-0.2	-1.1	81	7 46.4	-0.2	-1.4	94	7 54.0	-0.2	-1.9	118
16	1849	6.2	2	227		N			7 29.1	-0.7	-2.9	347	7 30.7	-1.6	-1.3	314
22	2658	5.4-6.2	2	302		N				S			11 36.1	-1.3	-0.6	311
23	2828	6.0	2	316		S				S			11 06.7	-1.1	+1.2	263
Mar. 3	393	6.8	1	60	2 28.7	-0.2	-0.7	69	2 30.7	-0.3	-1.0	83	2 36.0	-0.4	-1.7	107
4	516	7.3	1	72	3 05.7	-0.3	-0.6	64	3 06.6	-0.4	-0.9	78	3 09.8	-0.5	-1.5	102
4	635	3.9	1	83	23 24.3	-2.1	-2.2	119	23 23.9	.	.	135		N		
5	659	6.4	1	84	2 52.3	-0.7	-1.2	85	2 54.1	-0.7	-1.6	99	2 59.9	-0.8	-2.8	126
5	667	5.3	1	85		N				N			4 42.2	-1.1	+2.0	27
5	669	4.0	1	85	4 20.2	-0.1	-1.3	89	4 25.0	0.0	-1.6	103	4 36.9	+0.1	-2.6	131
5	671	3.6	1	85	4 24.5	+0.1	-1.8	111	4 32.7	+0.2	-2.4	127		N		
5	672d	6.6	1	85		A			4 40.5	-0.3	-0.3	59	4 41.7	-0.3	-0.9	84
7	934	6.4	1	108		N				N			3 50.4	-2.0	+0.6	58
7	944	5.7	1	108	5 48.5	-0.6	+0.1	45	5 46.7	-0.5	-0.5	62	5 46.9	-0.6	-1.1	88
7	1057	6.9	1	118	23 57.8	-2.1	+1.4	69	23 43.8	-2.1	+1.0	81		S		
8	1072	6.2	1	119		N				N			4 10.1	-2.5	+0.9	57
8	1176	7.4	1	129	23 51.0	-1.9	-0.9	125	23 46.9	-2.1	-1.9	140		N		
9	1190d	7.1	1	130	5 21.6	-0.6	-2.2	122	5 27.7	-0.5	-2.7	137	5 49.1	.	.	177
9	1197	6.0	1	131	7 08.8	+0.2	-2.3	137	7 19.2	+0.4	-2.9	151		N		
11	1409	5.1	1	153	6 32.2	-0.3	-3.2	156	6 46.4	.	.	179		N		
20	2441	6.5	2	258	9 22.5	-1.9	+0.2	273	9 11.7	-2.1	+0.7	262	8 45.0	-2.6	+2.3	236
21	2578	6.4	2	270	8 06.9	-0.4	-1.2	334	8 06.7	-0.7	-0.3	316	7 59.8	-0.8	+0.4	290
22	2764	6.3	2	284		N				S			10 19.4	-1.5	-0.3	304
Apr. 2	741	5.7	1	64		N			2 17.3	-1.1	+0.9	37	2 08.0	-1.1	-0.3	68
3	878	5.5	1	75	0 23.6	-1.4	-1.8	109	0 24.9	-1.5	-2.6	125		G		
4	1029	5.1	1	88	2 11.1	-0.8	-2.1	116	2 16.0	-0.8	-2.7	132		G		
5	1141	5.6	1	98	1 15.1	-2.3	+0.6	61	1 03.9	-2.3	-0.1	79	0 47.4	-2.5	-1.0	105
9	1567	6.3	1	143	2 52.7	-1.2	-2.5	151	3 00.0	.	.	172		N		
10	1678	5.8	1	154		N				N			3 12.1	-3.5	+2.0	68
15	2245	6.4	2	213		N				N			4 24.2	-0.2	-1.5	335
15	2247	5.6	2	214	5 38.4	-2.2	+1.4	249	5 19.1	.	.	227		N		
16	2399	5.0	2	227	6 54.3	-1.6	-0.2	296	6 46.4	-1.8	+0.2	284	6 27.5	-2.0	+1.2	260
18	2715	6.5	2	253		S				S			9 25.6	.	.	215
19	2865	5.9	2	265	7 20.8	-1.2	+1.6	250	7 09.1	-1.2	+2.0	239		A		
20	3019	5.9	2	280		S			9 19.3	.	.	187		N		
24	4001	0.6	1	334	10 54.3	-0.8	+1.4	92	10 46.5	-0.6	+1.2	97	10 37.3	-0.3	+0.6	109
24	4001	0.6	2	334	11 59.6	-0.9	+2.3	223	11 47.4	-0.7	+2.4	219	11 27.6	-0.4	+2.7	210
29	685	6.5	1	32	0 52.7	-0.1	-1.0	81	0 56.5	-0.1	-1.3	95	1 05.6	0.0	-2.1	121
29	692d	1.1	1	33		A			2 00.6	0.0	-0.2	56	2 03.7	0.0	-0.7	81
30	814d	5.3	1	44		N				N			0 48.0	-1.4	+0.6	49
May 1	970	6.5	1	56	1 22.9	+0.2	-3.3	148		N				N		
4	1328	7.0	1	90	1 36.7	-1.1	-2.1	122	1 40.4	-1.0	-2.6	137	1 56.4	.	.	174
9	1849	6.2	1	146		N				N			4 16.6	.	.	61
9	1850	6.5	1	147	5 26.2	-0.6	-3.4	169		G				N		
20	3412	4.4	1	289	7 58.5	-0.7	+1.7	69	7 49.9	-0.5	+1.5	75		A		
20	3412	4.4	2	289		S			8 55.1	-1.0	+1.7	247	8 38.0	-0.7	+1.9	236
29	1057	6.9	1	37		A				A			2 04.7	+0.4	-2.3	139
June 1	1399	6.9	1	71		N				N			3 39.0	-0.9	+0.1	56
2	1497	7.5	1	81	2 20.1	-0.7	-1.8	108	2 23.5	-0.8	-2.0	119	2 30.9	-0.7	-2.7	142

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72.500°, N. 42.500° U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77.000°, N. 38.900° U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85.000°, N. 33.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
June 4	1712	3.8	1	104		N				N			5 37.6	-0.7	-0.2	61
5	1808	7.0	1	116	5 30.2	-0.5	-1.2	80	5 32.3	-0.6	-1.3	88	5 34.6	-0.9	-1.5	103
6	1920	6.7	1	127	4 09.2	-1.3	-1.7	112	4 09.5	-1.4	-1.8	122	4 10.0	-1.5	-2.4	141
7	2032	7.3	1	139	4 22.8	-1.7	-0.7	77	4 17.2	-1.9	-0.8	87	4 05.9	-2.2	-1.1	107
7	2033	4.3	1	139	4 58.9	-1.1	-2.8	156	5 05.5	.	.	169		N		
9	2291	5.5	1	164	4 44.0	-1.7	-1.1	120	4 40.3	-1.8	-1.3	130	4 36.3	-1.6	-2.3	152
12	2791	5.4	2	205		S				S			9 41.7	.	.	187
16	3379	6.4	2	259		S				S			8 40.2	-2.0	+0.3	287
17	3514	6.1	2	271	7 25.5	-0.9	+1.7	245	7 15.5	-0.7	+1.8	240	6 59.6	-0.5	+2.0	230
22	692d	1.1	1	339	17 04.2	-1.8	-0.9	94	16 59.6	-2.1	-1.4	106	16 52.5	-2.9	-3.2	129
22	692d	1.1	2	339	18 22.3	-1.4	-0.5	252	18 15.7	-1.7	+0.4	238	17 51.1	-2.1	+3.2	210
29	1467	7.3	1	51		A			2 20.2	-0.1	-1.4	95	2 27.8	-0.2	-1.6	112
July 6	2223d	4.0	1	131		N				N			3 41.4	.	.	52
18	462	5.9	2	292	6 54.4	0.0	+2.0	229		A				A		
19	608d	6.0	2	305		S				S			8 56.8	-0.4	+1.2	265
31	1941	4.8	1	75	0 58.6	.	.	38	0 46.2	-2.2	+0.2	58		S		
Aug. 1	2056	7.4	1	87	1 52.5	-1.1	-2.0	125	1 54.5	-1.3	-2.2	133	1 58.1	-1.4	-2.9	151
4	2441	6.5	1	123	0 40.1	-2.0	+0.4	80		S				S		
5	2596	7.3	1	137		N				N			2 09.3	.	.	34
6	2773d	6.1	1	150	2 00.1	-1.8	+0.6	82	1 49.8	-1.8	+0.6	90	1 33.2	-1.6	+0.3	107
6	2774	6.3	1	150	2 10.4	-1.8	+1.3	50	1 57.2	-2.0	+1.3	59	1 34.4	-1.8	+1.1	77
6	2791	5.4	1	151	4 58.2	-1.9	-1.6	120	4 55.2	-2.2	-1.8	125	4 47.3	-2.7	-2.4	136
10	3432	6.3	2	210		S				S			9 44.4	-1.0	+1.4	214
11	12	6.3	2	221	3 33.9	.	.	176		N				N		
11	13	6.3	2	221	4 01.4	-0.5	+2.7	199	3 48.7	-0.4	+3.3	191		N		
28	2020	6.6	1	56	0 57.1	-0.7	-0.4	56	0 55.5	-0.9	-0.6	65	0 50.6	-1.4	-0.9	82
31	2399	5.0	1	92	2 11.3	-1.2	-1.6	107	2 11.0	-1.5	-1.6	112	2 07.4	-2.0	-1.9	123
Sept. 1	2531	7.3	1	104	1 37.8	-1.6	-0.5	76	1 31.4	-1.9	-0.4	81	1 16.4	-2.4	-0.4	93
2	2699	7.2	1	117	1 24.1	-1.7	+0.6	51	1 13.2	-2.0	+0.8	58	0 50.7	-2.3	+0.8	72
2	2715	6.5	1	119		A				A			5 17.8	-1.4	-1.7	111
3	2863	6.1	1	130	1 42.6	.	.	148		G				N		
4	3005	6.2	1	144	0 12.5	-1.5	+1.9	46		S				S		
4	3019	5.9	1	145	3 25.8	.	.	5	3 12.2	.	.	13	2 46.0	-1.6	+2.6	25
9	249	4.7	2	217	6 45.1	-0.7	+2.9	197	6 31.0	-0.5	+3.4	192	6 06.2	-0.1	+4.2	185
10	401	6.3	2	232		N				N			9 49.6	.	.	320
11	498	6.2	2	242	4 00.6	-0.2	+1.8	240	3 53.5	0.0	+1.8	236		A		
11	508	4.3	1	243	4 46.9	-0.9	+1.0	103	4 40.0	-0.7	+0.8	107	4 31.4	-0.5	+0.3	115
11	508	4.3	2	243	5 42.8	-0.5	+2.5	218	5 31.7	-0.3	+2.6	214	5 14.9	+0.1	+2.7	207
12	659	6.4	2	256		N			5 29.7	.	.	331	5 26.5	-1.1	-0.8	314
12	661	4.6	2	256	6 11.6	-0.6	+2.2	234	6 01.6	-0.4	+2.2	230	5 47.0	0.0	+2.2	224
12	669	4.0	1	256	6 27.2	-0.6	+2.2	53	6 16.8	-0.5	+2.1	57	6 02.2	-0.3	+1.7	63
12	669	4.0	2	256	7 35.9	-1.6	+0.8	274	7 25.5	-1.5	+1.1	269	7 08.3	-1.1	+1.3	263
12	671	3.6	1	256	6 24.2	-0.9	+1.7	74	6 14.8	-0.8	+1.5	77	6 01.5	-0.5	+1.3	83
12	671	3.6	2	256	7 37.6	-1.4	+1.5	253	7 26.0	-1.2	+1.7	249	7 07.4	-0.8	+1.9	243
12	677	4.8	2	257	8 46.2	-2.4	-0.9	298	8 37.7	-2.3	-0.2	290	8 19.6	-2.0	+0.4	281
12	682	6.0	2	257	9 10.0	.	.	194		G				N		
12	685	6.5	2	258		S				S			10 25.8	-2.4	+0.6	261
12	692d	1.1	1	258	11 20.2	-1.7	+3.0	28	11 03.3	-1.9	+2.1	43	10 36.5	-2.2	+1.6	60
12	692d	1.1	2	258	12 09.0	-1.6	-3.7	315	12 11.6	-1.9	-2.2	297	12 03.5	-2.4	-0.8	275
13	806	5.1	2	269	8 22.2	-1.0	+2.7	225	8 07.9	-0.7	+3.1	218	7 45.3	0.0	+3.6	207

Date	Z.C. No.	Mag.	P.	El. of Moon	Ma MASSACHUSETTS W. 72.500°, N. 42.500° U.T.	a	b	P	Wa WASHINGTON, D.C. W. 77.000°, N. 38.900° U.T.	a	b	P	AG ALABAMA-GEORGIA W. 85.000°, N. 33.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Sept. 13	814d	5.3	2	270		N				N			9 36.9	.	.	316
14	944	5.7	2	280	6 38.8	-0.1	+2.2	235	6 30.7	+0.1	+2.3	230		A		
16	1198	6.2	2	303	7 25.9	+0.1	+2.0	244		A				A		
16	1210	5.9	2	304	8 57.7	-0.5	+2.8	234	8 45.6	-0.1	+3.3	223	8 24.9	.	.	201
26	2352	6.7	1	61	23 58.9	-1.2	-1.1	85	23 56.8	-1.5	-1.1	91		S		
30	2814	5.0	1	99	3 07.9	-1.0	-1.3	96	3 07.5	-1.3	-1.4	100	3 03.4	-1.9	-1.5	107
30	2816	6.8	1	99		A			3 24.2	-1.0	-1.0	86	3 20.2	-1.5	-1.0	93
Oct. 2	3120	7.0	1	127	5 28.0	+0.2	+1.7	14	5 23.1	-0.1	+1.2	23	5 13.7	-0.6	+1.1	34
2	3253	5.4	1	139	24 14.6	-1.7	+0.5	105	24 05.6	-1.6	+0.3	111	23 52.9	-1.4	-0.4	125
3	3255	7.4	1	139	1 29.6	-1.2	+1.7	33	1 17.1	-1.4	+1.9	37	0 53.8	-1.5	+2.0	44
9	608d	6.0	2	225	8 19.8	-1.8	+0.9	241	8 07.2	-1.8	+1.6	232	7 41.0	-1.5	+2.6	219
10	741	5.7	2	236		N				N			3 58.9	.	.	324
12	1040d	6.2	2	260	5 06.4	-0.5	+0.8	291	5 01.6	-0.3	+0.8	285		A		
14	1284	6.3	2	284	8 40.0	-1.1	+3.0	235	8 23.1	-0.6	+4.4	220		N		
27	2758	7.0	1	68	0 55.0	0.0	+1.4	22	0 49.7	-0.4	+1.1	29	0 37.7	-1.0	+1.1	38
27	2763	6.7	1	68		A			1 29.7	-0.8	-0.8	78	1 25.9	-1.3	-0.8	85
29	3196	6.1	1	107	24 07.5	-1.4	+1.2	42	23 56.1	-1.6	+1.4	46	23 33.2	-1.8	+1.6	52
Nov. 1	3514	6.1	1	136	5 55.3	-0.7	-0.5	66	5 53.5	-0.9	-0.6	74	5 48.1	-1.5	-0.8	86
6	661	4.6	2	202	0 46.2	+0.6	+3.2	196	0 37.3	+1.0	+3.9	187		N		
6	669	4.0	1	202	1 08.4	-0.2	+1.4	82	1 02.7	-0.1	+1.2	86		A		
6	669	4.0	2	202	2 08.7	-0.5	+1.8	246	2 00.4	-0.3	+1.8	243	1 48.7	0.0	+1.8	237
6	671	3.6	1	202	1 11.4	-0.4	+1.0	104	1 06.4	-0.3	+0.8	108		A		
6	671	3.6	2	202	2 04.4	-0.2	+2.3	225	1 55.5	0.0	+2.3	221	1 42.6	+0.3	+2.4	213
6	677	4.8	2	203	3 13.3	-1.1	+1.3	266	3 03.9	-1.0	+1.4	262	2 49.5	-0.6	+1.4	256
6	692d	1.1	1	204	5 03.4	-1.6	+1.2	72	4 51.7	-1.6	+1.2	78	4 32.3	-1.5	+1.0	86
6	692d	1.1	2	204	6 23.9	-1.9	+0.4	259	6 12.6	-1.9	+1.0	251	5 49.4	-1.7	+1.8	240
7	806	5.1	2	215	1 20.4	.	.	186		N				N		
7	814d	5.3	2	216	2 59.1	-1.2	+0.1	305	2 53.5	-0.9	+0.3	299	2 45.2	-0.5	+0.5	291
10	1238	6.1	2	252	5 11.3	-0.5	+1.6	263	5 03.4	-0.3	+1.7	255	4 52.0	+0.1	+1.9	243
16	1875d	6.5	2	320		S				S			10 36.7	-0.9	+1.6	262
23	2863	6.1	1	50	21 53.9	-1.2	+0.5	45		S				S		
24	3011	7.0	1	63	23 49.7	.	.	137	23 51.9	.	.	147		N		
27	3313	6.8	1	90	2 02.8	-0.2	+1.8	15	1 55.5	-0.5	+1.5	22	1 41.0	-1.0	+1.5	30
28	36	7.2	1	115	21 55.0	-1.9	0.0	122		S				S		
30	192	5.3	1	130	1 19.0	-2.1	+0.1	90	1 08.7	-2.3	+0.2	93	0 48.4	-2.4	+0.3	97
Dec. 7	1207	5.8	2	222	10 13.8	-1.0	-2.4	309	10 15.6	-1.5	-1.8	294	10 07.6	-2.3	-0.5	267
8	1323	6.3	2	234	9 27.4	-1.7	-1.8	303	9 24.0	-2.1	-1.0	288	9 05.6	-2.8	+0.7	260
10	1531	5.9	2	256		N			8 25.4	.	.	354	8 30.4	-1.7	-1.5	318
10	1547	3.8	1	257		N				N			11 39.3	.	.	52
13	1821d	2.9	2	288	7 10.1	-0.3	+0.2	305		A				A		
13	1825	6.1	2	288	8 15.2	-0.6	-0.6	323	8 13.6	-0.6	-0.1	307	8 06.9	-0.5	+0.7	283
23	3267	7.2	1	59	23 24.2	-2.5	-3.2	127	23 25.1	.	.	137		N		
25	12	6.3	1	86	23 49.9	-1.6	+0.1	71	23 41.3	-1.9	+0.2	75	23 22.1	-2.3	+0.5	78
25	13	6.3	1	86	24 10.5	-1.5	+0.2	63	24 02.3	-1.7	+0.3	67	23 43.9	-2.2	+0.6	72
26	15	7.3	1	86	0 45.8	-0.9	+1.2	32	0 37.0	-1.1	+1.2	38	0 18.6	-1.5	+1.4	44
28	303	6.6	1	115	5 55.7	-0.4	+1.4	21	5 50.4	-0.5	+0.6	39	5 44.5	-0.7	-0.1	62
30	692d	1.1	1	150	22 09.5	+0.3	+3.1	22	22 00.4	+0.3	+2.7	28	21 48.6	+0.4	+2.2	36
30	692d	1.1	2	150	22 49.1	-1.4	0.0	305	22 42.9	-1.1	+0.2	300	22 33.8	-0.7	+0.4	293

Date		Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91°.000, N. 40°.000				Te TEXAS W. 98°.000, N. 31°.000				De DENVER, COLO. W.105°.000, N. 39°.800			
						U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
					°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan.	6	219	5.1	1	97	2 49.9	-1.4	+0.6	51	2 34.4	-2.1	+0.1	74	2 29.7	-1.4	+1.7	38
	6	237	7.1	1	99		A			6 33.6	-0.3	-0.6	77	6 28.9	-0.5	+0.2	46
	7	352	7.3	1	110	5 01.5	.	.	10	4 37.5	-1.6	+0.8	52	4 47.0	.	.	4
	7	360	6.8	1	111		N			6 29.5	-1.0	+2.6	20		N		
	7	362	6.5	1	111	6 21.2	-0.5	-1.1	83	6 32.2	-0.6	-2.5	120	6 11.4	-1.0	-1.1	86
	8	464	6.4	1	121	1 59.6	-1.5	+2.4	37	1 28.5	-1.9	+1.8	58	1 42.5	-0.7	+3.9	18
	9	618	7.2	1	135	7 29.0	-1.3	+1.8	27	7 16.0	-1.3	-0.2	70	7 09.3	-1.5	+1.2	40
	10	741	5.7	1	145	3 47.9	-2.4	-0.7	103	3 44.5	.	.	138	3 15.9	-2.1	+0.5	94
	17	1567	6.3	2	224	7 10.5	.	.	227		N				N		
	18	1678	5.8	2	235		N			8 12.4	-1.2	-2.5	335		N		
	19	1770	5.9	2	246	7 14.1	-0.9	-0.7	318	7 07.2	-1.1	+0.6	282	7 03.9	-0.6	-0.1	308
	19	1772	4.0	1	246		N			6 41.1	-1.1	+2.5	66		N		
	19	1772	4.0	2	246		N			7 31.2	-0.6	-2.4	341		N		
	20	1891d	4.4	1	258	9 48.2	.	.	189		N				N		
	20	1891d	4.4	2	258	10 15.7	.	.	226		N				N		
	23	2247	5.6	2	294	9 52.9	.	.	223		N				N		
	30	3430d	5.7	1	38	23 57.8	-1.5	-2.2	112		N				S		
	31	3437	6.7	1	39	1 01.3	-0.5	-0.3	61	1 01.0	-1.0	-0.9	87	0 51.7	-0.8	+0.2	51
Feb.	5	692d	1.1	1	113	22 36.5	-0.7	+2.9	39	22 09.6	-0.6	+2.1	56	22 32.6	+0.3	+3.9	17
	5	692d	1.1	2	113	23 41.5	-2.2	-0.1	291	23 23.1	-1.8	+0.9	270	23 11.8	-2.1	-0.9	312
	8	970	6.5	1	137	0 31.2	.	.	148		N				S		
	8	1003d	7.2	1	139	7 38.7	-0.6	-1.7	104	7 55.2	-0.3	-3.0	140	7 27.6	-1.0	-2.2	118
	14	1660d	6.2	2	207		S				S			12 25.3	-1.4	-0.9	254
	14	1663	5.2	2	207		S				S			13 08.4	-1.0	-0.6	245
	16	1849	6.2	2	227	7 13.7	-1.0	-1.4	327	7 09.7	-1.7	0.0	290	6 59.6	-0.9	-0.3	311
	21	2508	6.3	2	290		N				S			12 43.4	.	.	347
	22	2658	5.4-6.2	2	302	11 25.2	-0.6	-0.9	327	11 21.5	-1.0	+0.2	292		A		
Mar.	3	393	6.8	1	60	2 23.0	-0.7	-1.0	83	2 32.0	-0.9	-2.6	120	2 09.7	-1.2	-0.9	85
	3	401	6.3	1	60		A				A			4 01.8	-0.3	-1.9	108
	4	516	7.3	1	72	2 56.8	-0.9	-0.9	81	3 03.6	-1.0	-2.3	116	2 41.2	-1.4	-0.9	85
	5	659	6.4	1	84	2 37.9	-1.3	-1.6	102	2 53.9	.	.	147	2 15.2	-2.0	-1.5	105
	5	667	5.3	1	85		N			4 26.2	-1.2	+0.5	52		G		
	5	669	4.0	1	85	4 19.9	-0.4	-2.0	110		G			4 11.2	-0.9	-2.5	121
	5	671	3.6	1	85	4 30.9	-0.1	-3.2	136		N			4 30.1	.	.	155
	5	672d	6.6	1	85	4 33.6	-0.6	-0.6	67	4 37.7	-0.7	-1.4	101	4 21.6	-1.1	-0.7	76
	5	677	4.8	1	85	5 21.0	-0.4	-0.5	62	5 26.2	-0.3	-1.2	96	5 13.7	-0.7	-0.8	74
	5	680	6.7	1	85	5 25.0	-0.2	-0.8	74	5 33.9	-0.1	-1.6	107	5 19.4	-0.6	-1.1	85
	6	806	5.1	1	97	6 14.1	-0.1	-1.2	89	6 27.8	+0.1	-2.0	122	6 10.3	-0.5	-1.6	102
	7	934	6.4	1	108	3 48.0	.	.	30	3 20.5	-2.5	+0.1	77	3 12.0	-2.5	+2.3	45
	7	944	5.7	1	108	5 35.8	-0.9	-0.8	74	5 40.2	-0.9	-1.7	107	5 19.8	-1.4	-1.1	87
	8	1072	6.2	1	119		G			3 35.3	-2.7	+0.2	79	3 26.8	-2.7	+2.6	48
	9	1190d	7.1	1	130	5 15.3	-0.7	-3.8	153		N				G		
	9	1197	6.0	1	131	7 21.6	.	.	170		N				N		
	16	1937d	6.1	2	209		N			8 16.6	.	.	351		N		
	20	2441	6.5	2	258	8 45.2	-1.8	+1.6	250		N			8 20.6	-1.7	+3.1	228
	22	2764	6.3	2	284	10 09.7	-0.8	-0.6	320	10 03.2	-1.0	+0.4	288		A		
	30	327	4.5	1	26	1 05.8	-0.3	-1.3	93	1 23.0	-0.2	-3.8	136		S		
Apr.	1	608d	6.0	1	53		A				A			3 53.8	0.0	-2.3	121
	2	741	5.7	1	64	2 01.1	-1.4	+0.6	47	1 52.0	-1.6	-0.7	85		S		
	4	1029	5.1	1	88	1 58.7	-1.2	-3.6	143		N			1 40.6	.	.	158
	8	1474	7.1	1	133		N			5 10.8	-3.3	+0.7	67		G		
	10	1678	5.8	1	154		G			2 35.2	-2.1	+0.6	96	2 34.3	-1.9	+2.5	68
	15	2245	6.4	2	213	4 08.4	.	.	4	4 21.7	-0.3	-0.3	309		A		
	16	2399	5.0	2	227	6 24.8	-1.4	+1.0	272	5 58.2	-2.0	+3.0	231	6 07.4	-1.1	+1.7	255
	18	2715	6.5	2	253	9 27.1	-2.0	+1.7	233		N			8 59.2	-1.9	+2.8	220

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91.000°, N. 40.000° U.T.	a	b	P	Te TEXAS W. 98.000°, N. 31.000° U.T.	a	b	P	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Apr. 24	4001	0.6	1	334	10 43.0	-0.1	+1.3	91		A				A		
24	4001	0.6	2	334	11 41.7	-0.4	+2.2	229	11 18.8	-0.1	+2.6	209	11 37.8	-0.1	+2.0	232
29	692d	1.1	1	33	1 58.3	-0.3	-0.6	66	2 04.7	-0.2	-1.3	99	1 52.4	-0.6	-0.9	77
29	692d	1.1	2	33	2 50.4	+0.4	-1.6	290	3 01.8	0.0	-0.6	258	2 53.0	0.0	-1.4	278
May 7	1657	6.7	1	125		A				A			8 20.0	-0.4	-1.9	118
9	1849	6.2	1	146		G			3 33.8	-2.7	+0.1	95	3 21.9	-2.5	+1.3	78
16	2828	6.0	2	235		N			6 00.3	+0.3	-2.1	334		N		
20	3412	4.4	2	289	8 46.3	-0.5	+1.6	251		A				A		
29	1057	6.9	1	37		S			2 19.2	.	.	170		S		
June 1	1399	6.9	1	71	3 36.9	.	.	34	3 26.6	-1.2	-0.8	80	3 11.0	-1.8	-0.3	64
2	1497	7.5	1	81	2 07.9	-1.1	-2.3	133	2 30.1	-0.2	-4.4	171		S		
4	1712	3.8	1	104	5 35.1	.	.	36	5 25.3	-1.3	-0.7	78	5 10.0	-2.0	-0.1	60
5	1808	7.0	1	116	5 18.3	-1.2	-1.4	92	5 23.2	-1.4	-1.8	116	4 58.2	-1.7	-1.4	104
6	1920	6.7	1	127	3 46.2	-1.6	-1.8	132	3 58.1	-1.0	-3.5	166	3 26.2	-1.2	-2.0	151
7	2032	7.3	1	139	3 47.2	-2.1	-0.5	99	3 40.3	-2.0	-1.4	128	3 19.4	-1.8	-0.4	116
7	2033	4.3	1	139	4 50.9	.	.	184		N				N		
9	2291	5.5	1	164	4 15.7	-1.4	-1.1	140		N			4 01.4	-0.5	-1.8	160
12	2791	5.4	2	205		S			9 28.6	.	.	203	9 28.6	-1.7	+0.6	236
16	3379	6.4	2	259	8 27.1	.	.	316	8 18.1	-1.3	+0.3	290	8 07.5	.	.	327
22	692d	1.1	1	339	16 27.4	-2.3	-0.2	96	16 16.9	-3.3	-2.1	125	15 57.9	-1.9	+0.9	84
22	692d	1.1	2	339	17 50.6	-2.0	+0.8	241	17 17.4	-1.9	+4.0	207	17 22.4	-2.0	+1.1	247
29	1467	7.3	1	51	2 14.3	-0.5	-1.6	102	2 27.5	-0.4	-2.1	128		S		
July 1	1678	5.8	1	74		A				A			4 30.3	-0.5	-2.1	128
2	1770	5.9	1	84	4 06.4	-0.4	-2.9	157		N			4 00.7	-0.4	-3.6	169
2	1772	4.0	1	84	4 30.2	-0.5	-1.6	101	4 41.7	-0.6	-1.9	122	4 19.8	-1.0	-1.7	107
6	2223d	4.0	1	131		N			3 01.1	-2.9	+0.8	74	2 52.3	-2.9	+1.9	57
7	2399	5.0	1	146		A				A			8 38.8	-0.7	-0.7	70
12	3196	6.1	2	215		S				N			10 20.1	-1.2	+1.1	219
19	608d	6.0	2	305	9 01.7	-0.4	+0.9	287		A				A		
Aug. 6	2791	5.4	1	151	4 24.2	-2.1	-0.6	112	4 17.5	-2.4	-1.7	135	3 56.9	-1.8	0.0	112
6	2814	5.0	1	153		A				N			8 59.9	-1.1	-1.5	105
10	3432	6.3	2	210	9 41.8	-1.4	+0.2	243	9 24.8	-1.6	+1.2	228	9 17.8	-1.9	+0.2	261
28	2022	5.5	1	56	1 17.5	-1.0	-3.3	160		N				S		
31	2399	5.0	1	92	1 45.5	-1.9	-1.1	107	1 43.0	-2.3	-1.7	128		S		
Sept. 2	2715	6.5	1	119	5 01.3	-1.2	-0.9	86	4 59.8	-1.9	-1.2	102	4 41.4	-1.6	-0.3	75
2	2718	6.7	1	119	5 39.6	-1.1	-1.5	102	5 44.8	-1.8	-2.0	120	5 21.5	-1.5	-0.9	89
3	2863	6.1	1	130	1 11.4	.	.	154		N				N		
4	3019	5.9	1	145		N			2 17.5	-1.8	+3.2	26		N		
9	249	4.7	2	217	6 22.5	-0.9	+2.2	217	5 54.3	-0.5	+2.9	202	6 09.7	-0.8	+1.9	232
11	508	4.3	1	243	4 35.4	-0.1	+1.2	92		A				A		
11	508	4.3	2	243	5 30.4	-0.2	+2.0	232	5 11.6	+0.2	+2.2	216	5 29.0	0.0	+1.7	242
12	661	4.6	2	256	5 59.9	-0.2	+1.7	247		A				A		
12	669	4.0	1	256	6 16.1	0.0	+2.4	38	5 57.8	+0.1	+1.8	55	6 19.7	+0.5	+2.9	22
12	669	4.0	2	256	7 08.5	-1.1	+0.7	290	6 54.8	-0.6	+0.9	273	6 54.8	-0.8	0.0	308
12	671	3.6	1	256	6 10.5	-0.2	+1.9	61	5 55.6	0.0	+1.3	76	6 10.9	+0.2	+2.0	49
12	671	3.6	2	256	7 13.3	-0.9	+1.3	267	6 56.0	-0.4	+1.5	252	7 03.5	-0.5	+1.0	281
12	675d	5.7	2	257		N				N			7 28.9	+0.2	+3.1	204
12	677	4.8	2	257	8 03.7	.	.	320	7 55.8	-1.6	0.0	294		N		
12	678	5.5	2	257	7 45.6	.	.	184		N			7 47.6	0.0	+2.9	210
12	682	6.0	2	257	8 46.1	-0.7	+3.2	212	8 08.1	.	.	183	8 36.0	-0.6	+2.3	229

Date	Z.C. No.	Mag.	P.	El. of Moon	Il ILLINOIS W. 91.000°, N. 40.000° U.T.	a	b	P	Te TEXAS W. 98.000°, N. 31.000° U.T.	a	b	P	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Sept. 12	685	6.5	2	258	10 11.6	-2.4	-0.6	291	9 54.4	-2.2	+0.7	269	9 37.8	-2.5	-1.4	312
12	692d	1.1	1	258	10 42.9	-1.3	+3.7	26	10 07.3	-1.7	+2.2	53	10 33.0	.	.	1
12	692d	1.1	2	258	11 38.3	-2.5	-2.6	307	11 31.1	-2.7	-0.2	276	10 56.1	.	.	328
13	806	5.1	2	269	8 02.0	-0.5	+2.1	238	7 39.2	+0.1	+2.6	219	7 56.3	-0.2	+1.7	251
16	1210	5.9	2	304	8 48.5	+0.1	+2.1	241		A				A		
24	1994d	6.5	1	27		A			1 05.5	-0.6	-0.9	82		S		
26	2223d	4.0	1	50		A				A			2 14.3	-0.9	-1.2	86
30	2814	5.0	1	99	2 46.1	-1.6	-0.6	83	2 38.4	-2.3	-0.8	98	2 21.2	-1.9	+0.1	73
30	2816	6.8	1	99	3 07.1	-1.3	-0.4	69	2 58.8	-2.0	-0.4	84	2 45.9	-1.7	+0.4	58
Oct. 2	3120	7.0	1	127		N			5 02.8	-0.5	+2.4	18		N		
3	3255	7.4	1	139	1 02.0	-1.1	+2.7	23		S				S		
8	462	5.9	2	211		N				N			6 48.7	-0.5	+3.2	202
9	608d	6.0	2	225	7 44.4	-1.7	+1.3	249	7 17.7	-1.3	+2.2	231	7 22.3	-1.4	+1.2	264
9	626	6.4	2	227		S				N			11 49.7	.	.	185
14	1284	6.3	2	284	8 21.1	-0.2	+2.6	236		N			8 19.6	+0.1	+2.0	247
27	2758	7.0	1	68		N			0 17.8	-1.6	+2.3	29		N		
27	2763	6.7	1	68	1 15.0	-1.2	-0.2	61	1 06.2	-1.9	-0.2	76	0 55.7	-1.6	+0.6	49
27	2773d	6.1	1	69		A			3 12.4	-1.2	-1.5	105	2 55.9	-1.0	-0.6	73
27	2774	6.3	1	69		A			3 14.3	-0.8	-0.5	74	3 09.1	-0.4	+0.4	40
29	3196	6.1	1	107	23 37.2	-1.4	+2.2	31		S				S		
Nov. 1	3514	6.1	1	136	5 38.4	-1.2	+0.2	57	5 27.0	-1.9	0.0	76	5 21.1	-1.2	+1.1	40
3	249	4.7	1	163	2 54.4	-2.6	-0.8	124		N			2 28.9	-1.3	+0.8	102
6	669	4.0	2	202	1 59.4	-0.1	+1.4	258		A				A		
6	671	3.6	2	202	1 57.8	+0.1	+1.8	237		A				A		
6	677	4.8	2	203	2 54.1	-0.6	+1.0	280	2 41.6	-0.2	+1.1	265	2 47.4	-0.3	+0.6	294
6	692d	1.1	1	204	4 35.7	-0.9	+1.9	60	4 14.5	-0.8	+1.4	75	4 27.2	-0.3	+2.3	44
6	692d	1.1	2	204	5 47.9	-1.7	+0.9	268	5 25.9	-1.4	+1.5	250	5 25.7	-1.4	+0.7	284
7	814d	5.3	2	216	2 40.6	.	.	327		A				N		
10	1238	6.1	2	252	5 03.0	0.0	+1.2	270		A				A		
16	1875d	6.5	2	320	10 41.0	-0.5	+0.9	284		A				A		
23	2718	6.7	1	38		N			1 08.3	.	.	12		N		
23	2724	6.6	1	39		A				A			1 23.7	-0.8	-0.7	73
27	3313	6.8	1	90		N			1 25.5	-0.6	+3.1	12		N		
27	3325	6.7	1	92	4 36.8	-0.7	-1.2	88	4 44.7	-1.5	-2.5	117	4 24.4	-1.1	-0.6	75
30	192	5.3	1	130	0 43.7	-1.5	+1.3	72	0 21.8	-1.5	+1.1	84	0 26.9	-0.9	+1.8	58
Dec. 1	368d	6.3	1	148		A				A			10 19.4	-0.2	-0.9	81
7	1207	5.8	2	222	9 49.2	-2.0	-1.0	284	9 31.1	-3.0	+1.5	246	9 19.0	-2.2	+0.1	275
8	1323	6.3	2	234	8 52.8	-2.2	0.0	280	8 26.9	-2.4	+2.5	243	8 25.0	-1.7	+0.7	276
10	1531	5.9	2	256	8 07.1	.	.	348	8 12.5	-1.3	-0.5	305	7 53.9	-0.9	-2.8	345
10	1547	3.8	1	257		N			10 49.7	-2.9	+0.6	88	10 44.9	.	.	59
10	1547	3.8	2	257		N			12 14.2	-1.6	-2.8	326	11 36.6	.	.	349
23	3134	6.9	1	47		A			2 16.8	-0.2	+0.5	44		N		
25	3432	6.3	1	75		N			4 16.7	+0.3	+3.4	4		N		
25	12	6.3	1	86	23 17.5	-1.6	+1.4	53		S				S		
25	13	6.3	1	86	23 40.6	-1.5	+1.4	46		S				S		
26	15	7.3	1	86	0 26.1	-0.5	+2.9	10		S				N		
28	303	6.6	1	115	5 42.4	-0.8	+0.9	34	5 31.7	-1.3	0.0	67	5 29.2	-1.0	+1.5	30
29	453	7.3	1	129		A				N			9 20.0	+0.4	-4.5	145
30	692d	1.1	2	150		G			22 27.2	-0.3	0.0	303		N		

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
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 6	219	5.1	1	97	2 22.4	.	.	0	2 01.1	-1.2	+2.6	28	2 14.4	-1.8	+1.4	51
6	237	7.1	1	99	6 19.6	-0.8	+0.9	34	6 17.6	-1.0	0.0	59	6 27.1	-0.7	-0.3	68
7	352	7.3	1	110		N			4 15.7	.	.	9	4 24.0	-1.6	+2.1	33
7	362	6.5	1	111	5 49.0	-1.5	-0.4	73	5 55.9	-1.8	-1.3	97	6 15.7	-1.2	-2.0	108
8	464	6.4	1	121		N				S			1 19.4	-1.0	+3.0	32
9	618	7.2	1	135	6 47.2	-1.7	+2.6	30	6 38.8	-2.1	+0.9	58	6 59.0	-1.8	+0.2	64
10	741	5.7	1	145	2 53.1	-1.2	+1.8	71	2 45.1	-1.5	+1.1	90	3 05.8	-2.5	-0.2	109
11	878	5.5	1	156	2 07.3	-1.0	+0.3	121	2 15.2	.	.	155		N		
17	1567	6.3	2	224	6 29.8	.	.	218		N				N		
18	1678	5.8	2	235		N			7 41.4	-0.6	-1.8	337	7 53.9	-0.9	-2.1	335
19	1770	5.9	2	246		A				A			7 00.0	-0.6	+0.6	286
19	1772	4.0	1	246		N				A			6 40.0	-0.6	+3.2	57
19	1772	4.0	2	246		N				A			7 19.1	-0.3	-2.5	346
21	2016	6.5	2	271	12 36.8	.	.	357	12 53.3	-1.1	-1.9	334	13 09.0	-0.8	-3.3	348
Feb. 3	327	4.5	1	80	5 51.9	-0.6	-2.0	105	6 10.6	-0.3	-4.4	138		A		
5	692d	1.1	1	113		N			22 26.9	.	.	3	22 13.9	+0.1	+2.9	33
5	692d	1.1	2	113		N			22 46.4	.	.	327	23 06.2	-1.6	+0.1	296
7	878	5.5	1	129	10 25.1	-0.1	-1.2	85	10 33.5	+0.1	-1.4	100		A		
8	1003d	7.2	1	139	7 00.3	-1.6	-2.2	123	7 22.0	-1.2	-4.3	149	7 40.0	-0.7	-3.6	144
14	1660d	6.2	2	207	11 53.0	.	.	239		N			12 18.5	.	.	229
14	1663	5.2	2	207	12 41.7	.	.	232		N				G		
16	1849	6.2	2	227	6 48.2	-0.5	+0.1	308	6 46.3	-0.7	+0.6	286	6 55.1	-1.1	+0.4	288
21	2508	6.3	2	290	12 31.1	-0.4	-0.9	331	12 35.8	-0.9	-0.4	312	12 49.6	-1.3	-1.0	319
Mar. 3	393	6.8	1	60		S				S			2 11.7	-1.6	-1.8	105
3	401	6.3	1	60	3 46.6	-1.0	-1.7	101	4 03.1	-0.8	-3.5	130	4 15.8	-0.1	-3.9	137
4	516	7.3	1	72		S				S			2 42.3	-1.7	-1.7	106
4	526	6.9	1	74	5 43.3	-0.4	-2.0	110	6 00.1	0.0	-3.4	137		A		
5	659	6.4	1	84		S				S			2 19.5	-2.4	-3.4	130
5	667	5.3	1	85		N			3 54.9	-2.0	+1.5	44	4 12.5	-1.6	+0.9	48
5	669	4.0	1	85	3 43.8	-1.7	-2.2	115	4 08.3	.	.	149	4 30.6	.	.	156
5	671	3.6	1	85	4 02.1	.	.	147		N				N		
5	672d	6.6	1	85	3 57.9	-1.6	-0.3	73	4 04.2	-1.8	-1.2	95	4 23.1	-1.2	-1.4	98
5	677	4.8	1	85	4 55.7	-1.3	-0.6	74	5 03.3	-1.2	-1.3	95	5 16.7	-0.7	-1.3	95
5	680	6.7	1	85	5 02.1	-1.2	-1.1	85	5 12.5	-1.1	-1.8	106	5 25.1	-0.6	-1.7	106
5	685	6.5	1	86	6 42.4	-0.7	-0.2	54	6 46.1	-0.5	-0.7	75	6 51.3	-0.2	-0.5	72
5	692d	1.1	1	87		N			8 08.1	-0.8	+2.0	23		A		
6	806	5.1	1	97	5 53.7	-1.0	-1.8	106	6 09.1	-0.7	-2.7	127	6 19.9	-0.3	-2.3	124
6	820	6.0	1	98	8 00.6	+0.2	-2.8	137	8 26.4	.	.	174		A		
6	820	6.0	2	98		N			8 35.3	.	.	191		A		
7	934	6.4	1	108	2 44.9	.	.	31	2 28.5	-2.3	+1.9	61	2 53.2	-2.6	+0.9	70
7	944	5.7	1	108	4 50.5	-1.9	-0.7	89	5 00.2	-1.9	-1.7	110	5 22.3	-1.4	-1.8	109
7	970	6.5	1	110	8 57.0	-0.3	-1.1	82	9 05.2	-0.1	-1.3	97		A		
8	1072	6.2	1	119	2 58.1	.	.	37	2 41.8	-2.2	+1.9	66	3 06.4	-2.7	+1.0	74
8	1091	6.7	1	121	9 12.5	+0.3	-3.1	150		G				A		
16	1937d	6.1	2	209	7 30.7	-0.1	-2.8	352	7 43.7	-1.0	-1.4	327	7 58.4	-0.9	-2.4	339
Apr. 1	608d	6.0	1	53	3 42.8	-0.6	-2.6	123	4 09.0	.	.	161	4 13.5	.	.	157
5	1176	7.4	1	102	8 55.1	-0.2	-0.9	70		A				A		
8	1474	7.1	1	133	4 13.2	-2.8	+2.5	60	4 06.3	-2.6	+0.7	86	4 37.0	-3.1	+0.6	77
10	1678	5.8	1	154		S				S			2 18.6	-1.4	+0.9	95
29	692d	1.1	1	33	1 36.0	-1.2	-0.8	78	1 44.4	-1.1	-1.5	99	1 56.4	-0.6	-1.4	98
29	692d	1.1	2	33	2 44.5	-0.6	-1.4	274	2 52.0	-0.7	-0.7	255	2 58.6	-0.3	-0.7	258
May 2	1116	7.4	1	70		N			6 08.8	-0.9	+0.5	46		A		
7	1657	6.7	1	125	8 05.1	-0.8	-2.1	123	8 20.0	-0.7	-2.3	135	8 30.2	-0.4	-2.2	132
7	1660d	6.2	1	126	9 10.4	-0.1	-3.3	167		N				N		
9	1849	6.2	1	146		S				S			3 08.7	-2.0	+0.2	103

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121°.000, N. 42°.500 U.T.	a	b	P	Ca CALIFORNIA W.120°.000, N. 36°.000 U.T.	a	b	P	NM N. MEX.-ARIZ. W.109°.000, N. 34°.000 U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
May 15	2687	6.5-7.3	2	224		N			11 07.0	.	.	334		S		
29	1072	6.2	1	38	4 34.5	-0.1	-1.2	85		A				A		
June 1	1399	6.9	1	71		S				S			3 08.0	-1.7	-1.0	87
4	1712	3.8	1	104	4 33.7	-2.4	-0.3	77	4 39.8	-2.3	-0.9	92	5 05.0	-1.9	-0.8	82
5	1808	7.0	1	116	4 26.1	-1.8	-1.2	117	4 37.3	-1.8	-1.8	130	5 00.5	-1.7	-1.8	120
6	1920	6.7	1	127		S				N			3 40.0	.	.	180
7	2032	7.3	1	139		S				S			3 17.2	-1.5	-1.2	137
12	2791	5.4	2	205	9 01.2	-1.8	+0.9	246	8 55.8	-2.1	+1.5	232	9 15.7	-2.0	+1.4	224
14	3100	6.4	2	233		N			10 05.9	.	.	317	10 38.0	-2.8	-1.0	297
16	3379	6.4	2	259		N				A			8 08.1	-0.7	+0.1	302
22	692d	1.1	1	339	15 39.9	-0.9	+2.0	60	15 29.7	-1.2	+1.4	78	15 45.9	-2.1	+0.5	98
22	692d	1.1	2	339	16 54.7	-1.8	+0.8	269	16 48.8	-1.7	+1.5	249	17 05.2	-1.9	+2.2	231
29	1474	7.1	1	52	4 56.9	+0.1	-2.5	147	5 14.5	+0.4	-3.1	164		A		
July 1	1678	5.8	1	74		S			4 30.6	-0.7	-2.7	148	4 41.9	-0.4	-2.5	143
2	1772	4.0	1	84	3 54.8	-1.5	-1.7	116	4 08.4	-1.4	-2.1	127	4 26.3	-1.1	-2.0	121
6	2223d	4.0	1	131		S				S			2 33.9	-2.4	+0.9	82
6	2247	5.6	1	133	7 54.0	-1.3	-2.0	131	8 10.9	-1.5	-2.9	148		A		
7	2399	5.0	1	146	8 22.6	-1.2	-0.1	54	8 25.5	-1.4	-0.4	70	8 39.8	-1.0	-0.8	81
12	3196	6.1	2	215	9 58.9	-1.6	+0.9	242	9 53.3	-1.7	+1.4	228	10 06.7	-1.2	+1.9	208
30	1849	6.2	1	66	5 17.1	-0.4	-3.1	162		N				N		
Aug. 6	2791	5.4	1	151	3 34.4	-1.1	+0.5	114	3 34.7	-1.1	-0.3	129	3 51.4	-1.7	-0.6	127
6	2814	5.0	1	153	8 37.2	-1.4	-0.7	82	8 44.3	-1.7	-1.1	98	9 04.7	-1.5	-2.0	118
10	3432	6.3	2	210	8 45.5	-2.1	+0.1	288	8 45.6	-2.1	+0.5	271	9 07.3	-2.0	+0.7	252
12	192	5.3	2	238	11 10.7	-0.9	+2.4	205	10 49.9	.	.	178		N		
17	878	5.5	2	301	12 11.8	-0.4	+2.5	231	11 53.0	+0.1	+3.6	207		N		
Sept. 2	2715	6.5	1	119	4 13.4	-1.9	+0.5	63	4 12.7	-2.2	+0.3	76	4 36.1	-2.0	-0.4	85
2	2718	6.7	1	119	4 53.7	-1.8	0.0	74	4 56.6	-2.1	-0.3	87	5 20.1	-1.9	-1.0	99
2	2733	6.4	1	120	7 51.2	-0.7	-0.7	69	7 57.3	-0.9	-1.0	86		A		
4	3019	5.9	1	145		N				S			2 09.1	.	.	14
9	249	4.7	2	217	6 04.2	-0.5	+1.6	250	5 53.6	-0.4	+1.8	237	5 55.2	-0.6	+2.1	224
10	405	4.4	1	232	9 10.0	-2.2	-0.5	123		N				N		
10	405	4.4	2	232	9 51.4	-0.3	+3.8	191		N				N		
12	669	4.0	2	256		N				A			6 50.8	-0.5	+0.4	294
12	671	3.6	2	256		A				A			6 56.0	-0.3	+1.1	271
12	675d	5.7	2	257	7 37.6	+0.1	+2.1	229	7 22.8	+0.4	+2.5	211	7 09.7	.	.	184
12	678	5.5	2	257	7 53.4	0.0	+2.0	234	7 39.4	+0.2	+2.4	217	7 29.9	+0.6	+3.8	194
12	682	6.0	2	257	8 33.3	-0.4	+1.7	252	8 21.9	-0.2	+2.0	236	8 20.0	-0.2	+2.6	218
12	685	6.5	2	258		N				G			9 32.4	-2.0	-0.1	295
12	692d	1.1	1	258		N				N			10 02.9	-0.6	+3.7	26
12	692d	1.1	2	258		N				N			10 59.0	-2.9	-1.2	301
12	699	5.8	2	259	11 37.8	.	.	187		N				N		
13	806	5.1	2	269	7 58.3	0.0	+1.2	271		A			7 45.8	0.0	+1.8	241
13	820	6.0	2	270	9 12.3	.	.	184		N				N		
26	2223d	4.0	1	50		S			1 59.5	-1.7	-1.0	91	2 17.4	-1.2	-1.3	97
30	2814	5.0	1	99		S				S			2 12.0	-2.3	+0.1	84
30	2816	6.8	1	99	2 19.8	-1.8	+1.4	45	2 13.7	-2.2	+1.1	60	2 35.9	-2.1	+0.4	68
30	2833	7.0	1	101	6 22.8	-0.3	+0.4	36	6 22.3	-0.7	-0.1	57		A		
Oct. 2	3134	6.9	1	128	7 08.9	-2.3	-2.9	128		N				N		
2	3142	6.8	1	129	8 34.1	+0.4	+2.4	8	8 26.2	-0.4	+0.6	38	8 29.8	-0.3	-0.1	58
8	462	5.9	2	211	6 45.2	-0.6	+2.1	230	6 30.8	-0.4	+2.6	213	6 26.4	.	.	186
9	608d	6.0	2	225	7 05.0	-1.1	+0.7	290	7 00.2	-0.9	+1.1	272	7 09.3	-1.2	+1.5	253
9	626	6.4	2	227	11 37.0	-1.5	+2.5	213		N				N		
9	635	3.9	1	227	13 07.0	-1.7	-2.1	116		S				N		
26	2611	6.8	1	57	2 30.0	-1.8	-2.3	133		G				N		
27	2773d	6.1	1	69	2 36.9	-1.3	+0.2	51	2 37.9	-1.6	-0.1	67	2 55.2	-1.4	-0.7	83

Date	Z.C. No.	Mag.	P.	El. of Moon	Or OREGON W.121.000°, N. 42.500° U.T.	a	b	P	Ca CALIFORNIA W.120.000°, N. 36.000° U.T.	a	b	P	NM N. MEX.-ARIZ. W.109.000°, N. 34.000° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Oct. 27	2774	6.3	1	69	N				2 56.1	-0.9	+1.4	31	3 04.7	-0.9	+0.2	52
29	3064	6.0	1	95	1 47.2	-2.1	-0.3	115	1 56.3	.	.	136	N			
31	3379	6.4	1	124	N				8 17.2	.	.	357	8 12.0	-0.1	+1.3	26
Nov. 1	3514	6.1	1	136	5 12.4	-0.3	+3.3	4	4 56.5	-1.2	+2.1	28	5 09.0	-1.6	+1.1	51
3	249	4.7	1	163	2 18.8	-0.5	+1.4	84	2 11.5	-0.6	+1.0	97	2 20.3	-1.3	+0.3	113
6	692d	1.1	1	204	4 36.9	+0.6	+3.6	13	4 18.1	+0.2	+2.3	36	4 13.9	-0.2	+1.9	55
6	692d	1.1	2	204	5 05.1	-1.4	-0.6	317	5 05.7	-0.9	+0.5	292	5 15.7	-1.2	+1.0	272
23	2724	6.6	1	39	1 08.2	-1.0	+0.1	51	S				1 24.5	-1.1	-0.8	84
25	3036	7.0	1	66	4 22.8	-1.3	-2.4	118	N				N			
26	3186	6.7	1	79	N				N				5 15.2	+0.1	+1.5	21
27	3325	6.7	1	92	4 06.0	-1.1	+0.5	48	4 05.5	-1.6	+0.1	67	4 23.4	-1.5	-0.9	88
Dec. 1	368d	6.3	1	148	10 09.6	-0.7	-0.8	75	10 17.6	-0.7	-1.5	98	10 25.5	-0.2	-1.5	103
7	1207	5.8	2	222	8 48.6	-1.7	+0.4	283	8 44.9	-1.8	+1.3	261	9 05.6	-2.4	+1.4	253
8	1323	6.3	2	234	8 04.7	-1.1	+0.7	288	7 59.3	-1.1	+1.4	266	8 11.0	-1.6	+1.8	255
8	1336	5.2	2	235	N				11 49.3	.	.	348	12 06.1	.	.	2
10	1531	5.9	2	256	N				7 49.7	-0.6	-1.2	330	7 59.0	-0.8	-0.7	317
10	1547	3.8	1	257	10 18.9	-1.6	+3.3	59	10 06.3	-1.5	+1.4	87	10 24.1	-2.2	+1.0	88
10	1547	3.8	2	257	11 10.7	-1.1	-2.8	341	11 24.5	-1.7	-1.3	315	11 47.6	-1.8	-2.1	320
10	1550d	5.8	2	258	13 23.0	.	.	241	N				S			
22	2979	7.1	1	34	1 30.9	-0.6	+0.3	41	1 31.3	-0.9	-0.1	61	1 41.5	-0.8	-0.7	80
23	3134	6.9	1	47	N				N				2 19.1	+0.2	+2.2	14
28	303	6.6	1	115	5 25.2	.	.	354	5 04.6	-1.3	+2.0	31	5 17.6	-1.5	+0.9	49
29	453	7.3	1	129	9 08.5	-0.4	-4.4	139	N				N			

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
12	4 Cet	678	81 Tau	1550	49 Leo	2033	98 κ Vir
13	5 Cet	682	85 Tau	1567	37 Sex	2223	38 γ Lib
212	95 Psc	692	87 α Tau	1657	82 Leo	2247	44 η Lib
219	98 μ Psc	699	89 Tau	1660	83 Leo	2291	49 Lib
249	106 ν Psc	806	111 Tau	1678	89 Leo	2399	24 Sco
322	64 Cet	814	115 Tau	1712	5 β Vir	2814	43 δ Sgr
327	65 ξ^1 Cet	820	117 Tau	1770	13 Vir	2828	45 Sgr
362	25 Ari	878	130 Tau	1772	15 η Vir	3108	29 Cap
401	85 Cet	1003	21 Gem	1821	29 γ Vir	3188	48 λ Cap
405	87 μ Cet	1029	26 Gem	1849	38 Vir	3189	50 Cap
626	48 Tau	1197	1 Cnc	1866	44 κ Vir	3253	38 Aqr
635	54 γ Tau	1207	3 Cnc	1869	46 Vir	3262	40 Aqr
659	70 Tau	1210	5 Cnc	1875	48 Vir	3307	57 σ Aqr
661	71 Tau	1323	54 Cnc	1937	72 Vir	3388	83 Aqr
667	75 Tau	1336	62 o^1 Cnc	1941	74 Vir	3412	90 φ Aqr
669	77 θ^1 Tau	1409	5 ξ Leo	2020	94 Vir	3505	20 Psc
671	78 θ^2 Tau	1531	45 Leo	2022	95 Vir	3514	24 Psc
675	80 Tau	1547	47 ρ Leo	2032	97 Vir	4001	Mercury

OCCULTATION LIMITS FOR 1979

The maps show the tracks of stars brighter than 7^m5 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^m5 and 2° for those brighter than 3^m5). 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, 4032 N. Ashland Ave., Chicago, Ill. 60613, U.S.A., at least two months before the event, giving their latitude and longitude, and details of the event will be supplied (for a nominal fee).

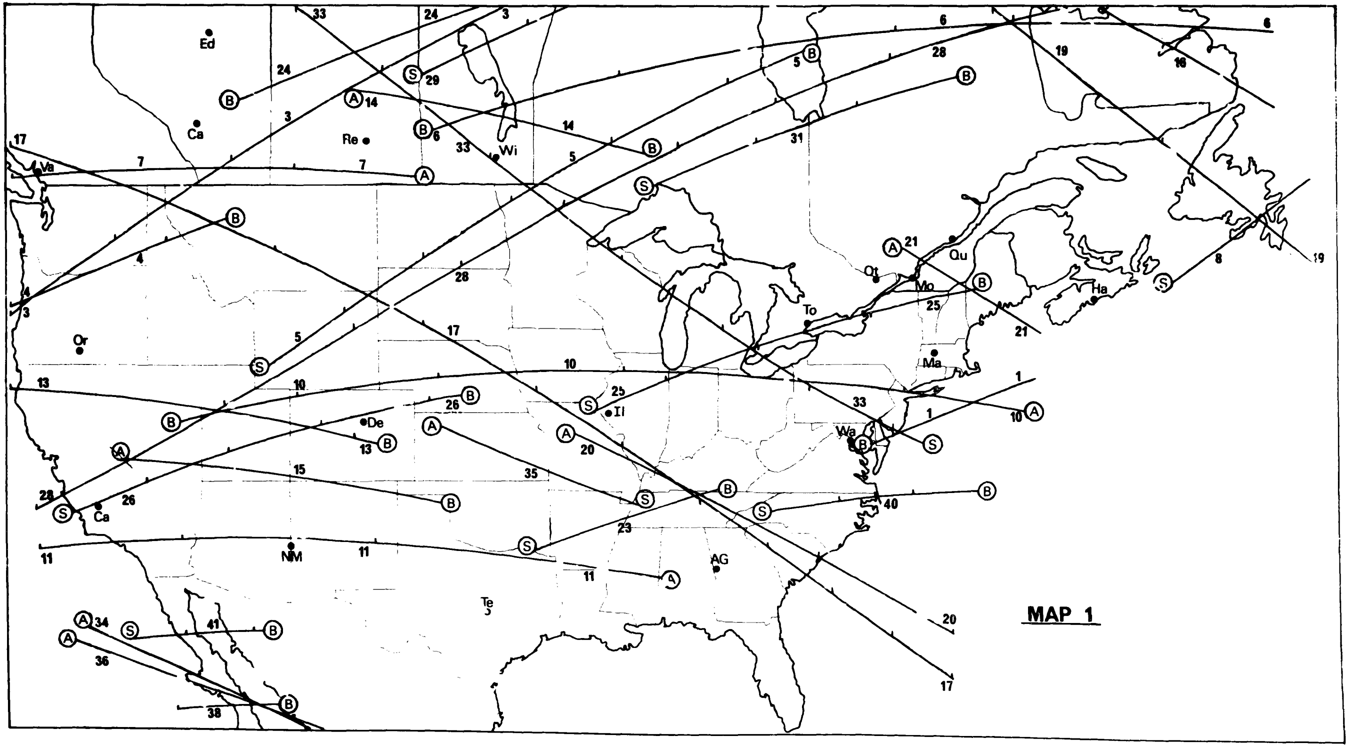
The following table gives, for each track, the date, Zodiacal Catalogue number, magnitude of the star, the time (U.T.) at the beginning of the track in the West, the percent of the Moon sunlit and whether the track is the northern (N) or southern (S) limit of the occultation. An asterisk after the track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

No.	Date	Z.C.	Mag.	U.T.	%	L	No.	Date	Z.C.	Mag.	U.T.	%	L
				h m							h m		
1	Jan 1	3188	5.4	23 54	14	N	41	Mar. 5	659	6.4	2 25	45	S
3	4	3496	7.2	1 25	34	S	42†	5	661	4.6	2 33	45	S
4	4	3505	5.6	3 36	35	S	43	5	667	5.3	4 14	46	N
5*	6	212	7.3	0 36	56	S	44*	5	672	6.6	4 41	46	N
6	6	219	5.1	3 10	57	N	45	5	677	4.8	5 27	46	N
7	6	237	7.1	6 37	58	N	46	5	685	6.5	6 54	47	N
8	6	322	5.7	21 03	65	S	47	5	692	1.1	8 17	47	N
10	7	352	7.3	4 46	68	N	48	7	934	6.4	3 12	66	N
11	7	360	6.8	6 21	68	N	49	7	944	5.7	5 43	66	N
13	18	1678	5.8	7 17	78	N	50	7	951	6.8	6 32	66	N
14	19	1770	5.9	6 42	70	N	51	19	2291	5.5	6 51	71	S
15†	19	1772	4.0	6 58	70	N	52	20	2441	6.5	7 59	60	S
16	20	1874	7.5	6 41	61	S	54	21	2596	7.3	9 56	48	S
17*	20	1891	4.4	9 24	60	S	55	22	2758	7.0	9 13	38	S
19	22	2110	6.4	9 14	40	S	56	22	2774	6.3	11 34	37	S
20	23	2247	5.6	9 37	29	S	58	30	322	5.7	0 44	5	S
21	24	2396	6.6	9 55	19	S	59	30	327	4.5	1 34	5	S
23*	31	3430	5.7	0 17	11	S	60	31	464	6.4	3 26	12	N
24	31	3437	6.7	1 11	11	N	63	Apr. 2	741	5.7	2 03	29	N
25	Feb. 3	298	7.2	0 00	40	S	65	5	1141	5.6	1 11	58	N
26	3	308	6.7	2 02	41	S	66	5	1246	6.6	23 31	66	N
28	5	692	1.1	22 36	70	N	67	16	2399	5.0	5 32	84	S
29	6	699	5.8	0 16	71	S	69	18	2715	6.5	8 29	64	S
31	6	820	6.0	23 33	79	S	70	18	2718	6.7	9 04	64	S
33	19	2208	7.4	10 18	55	S	72	20	3019	5.9	8 54	41	S
34	20	2352	6.7	9 57	44	S	73	20	3029	6.9	10 44	40	S
35	23	2833	7.0	11 59	13	S	77	29	682	6.0	0 16	8	S
36	23	2846	6.9	12 56	13	S	78	29	685	6.5	1 31	8	S
38	Mar. 3	393	6.8	2 35	25	S	79	29	692	1.1	2 06	8	N
40	4	635	3.9	23 36	44	S	82*	30	814	5.3	1 05	14	N

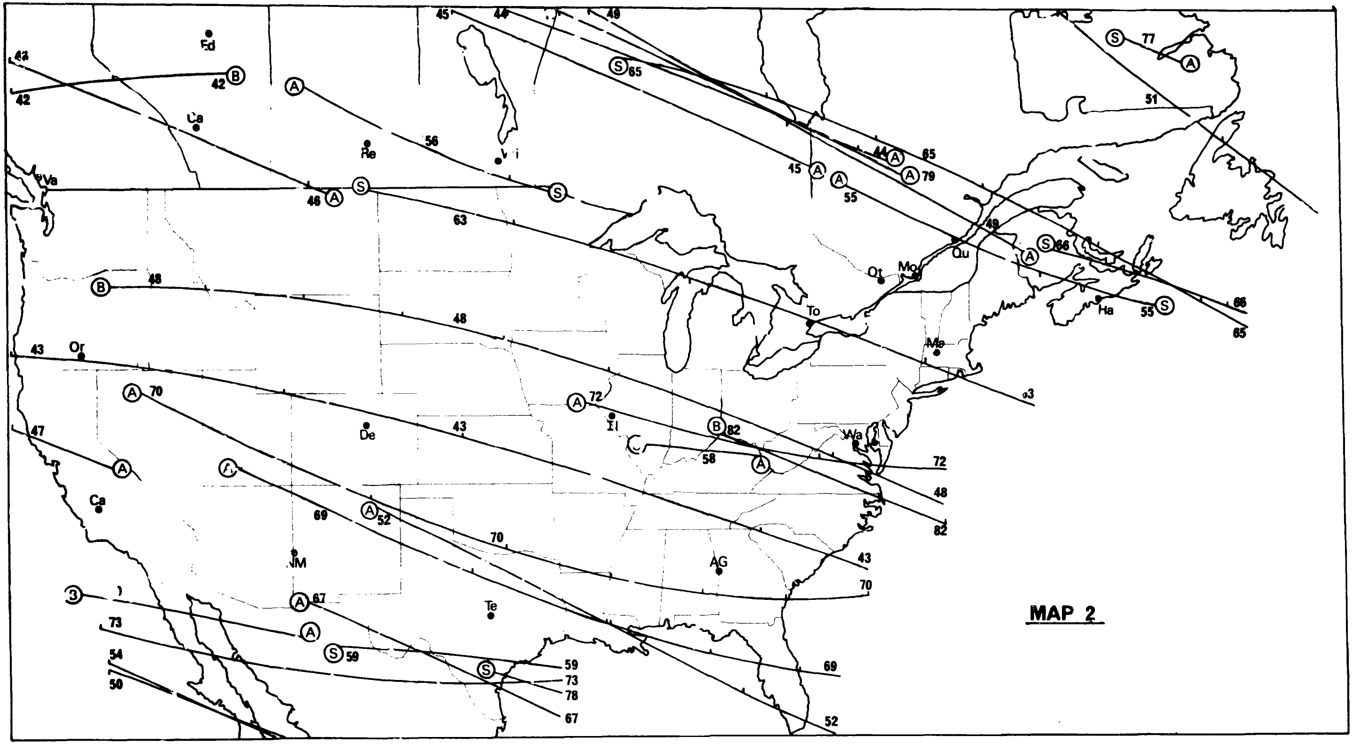
No.	Date	Z.C.	Mag.	U.T.	%	L	No.	Date	Z.C.	Mag.	U.T.	%	L
				h m							h m		
83	Apr. 30	820	6.0	1 15	14	S	151	Sept. 30	2825	6.4	4 35	59	S
85*	May 1	975	6.8	2 03	23	S	152*	Oct. 9	608	6.0	6 54	85	N
86	2	1116	7.4	6 15	33	N	153	10	741	5.7	3 47	78	N
89	7	1663	5.2	10 08	80	S	154*	12	1040	6.2	4 52	58	N
91*	17	2997	7.1	11 23	66	S	156	15	1405	7.0	11 32	27	N
93	19	3286	7.3	10 10	44	S	157	15	1413	6.7	13 44	26	N
95	29	1057	6.9	2 26	10	S	158*	19	1821	2.9	14 49	2	N
96	30	1176	7.4	1 30	17	S	159	24	2441	6.5	22 13	13	N
97	31	1284	6.3	1 24	24	N	160	26	2611	6.8	2 59	23	S
99	June 1	1399	6.9	3 23	34	N	161	27	2758	7.0	0 31	32	N
101	3	1600	5.1	2 32	52	N	162	27	2763	6.7	1 04	32	N
102	4	1712	3.8	4 49	63	N	164	29	3064	6.0	2 08	54	S
103	20	393	6.8	10 44	16	N	165	30	3196	6.1	0 01	65	N
104	22	692	1.1	16 22	3	S	167	Nov. 6	692	1.1	4 47	95	N
107	July 2	1770	5.9	4 31	45	S	169	9	1158	5.2	14 39	71	N
109	4	1985	7.0	2 23	64	N	171	10	1258	6.7	10 28	63	S
110*	4	1994	6.5	4 50	65	N	172	11	1360	7.5	7 04	54	N
111*	6	2223	4.0	3 14	83	N	173	12	1448	6.7	4 48	46	N
112	6	2247	5.6	8 42	84	S	174	23	2718	6.7	1 06	11	N
120	31	1941	4.8	0 57	37	N	175	23	2863	6.1	22 05	18	N
121	Aug. 13	303	6.6	6 48	67	N	176	24	3011	7.0	23 36	28	S
123	13	322	5.7	10 50	65	N	177	25	3036	7.0	4 44	30	S
124	20	1247	6.8	11 07	5	N	178	26	3307	4.9	23 07	50	S
125	26	1802	7.1	1 30	9	N	180†	27	3325	6.7	5 02	52	S
126	28	2016	6.5	0 20	22	S	181	30	192	5.3	1 11	83	S
127	28	2020	6.6	0 57	22	N	182	Dec. 8	1336	5.2	11 15	78	N
128	28	2022	5.5	1 49	23	S	183	9	1427	6.8	7 27	71	N
129	29	2245	6.4	23 53	41	N	184	9	1439	5.9	12 08	70	S
131	Sept. 3	2865	5.9	1 30	83	N	185	10	1531	5.9	7 31	62	N
132	11	526	6.9	9 11	71	N	186†	10	1547	3.8	10 41	61	N
134	12	659	6.4	5 12	62	N	187†	10	1550	5.8	12 38	60	S
136	12	669	4.0	6 37	61	N	188	12	1732	7.0	8 44	43	S
137†	12	671	3.6	6 53	61	N	189	13	1825	6.1	7 50	34	N
138*	12	672	6.6	6 36	61	N	190	14	1933	7.0	8 04	25	S
139	12	677	4.8	7 22	61	N	191	14	1941	4.8	9 42	24	S
140	12	680	6.7	7 32	61	N	192	16	2167	7.5	10 21	9	N
141	12	685	6.5	8 53	60	N	195	22	3108	5.5	21 36	15	N
142	12	692	1.1	10 10	60	N	197	23	3267	7.2	23 18	25	S
143*	13	814	5.3	8 37	50	N	198	25	3422	6.7	1 07	36	S
144	13	829	7.0	11 26	49	N	199	25	3432	6.3	4 29	37	N
145	14	934	6.4	4 49	42	N	202	26	15	7.3	1 18	47	N
146	14	951	6.8	6 42	41	N	203	26	36	7.2	5 03	49	S
147	18	1439	5.9	12 39	8	N	204	30	692	1.1	22 16	94	N
149	29	2794	6.7	22 50	57	N							

NOTES ON DOUBLE STARS 1979

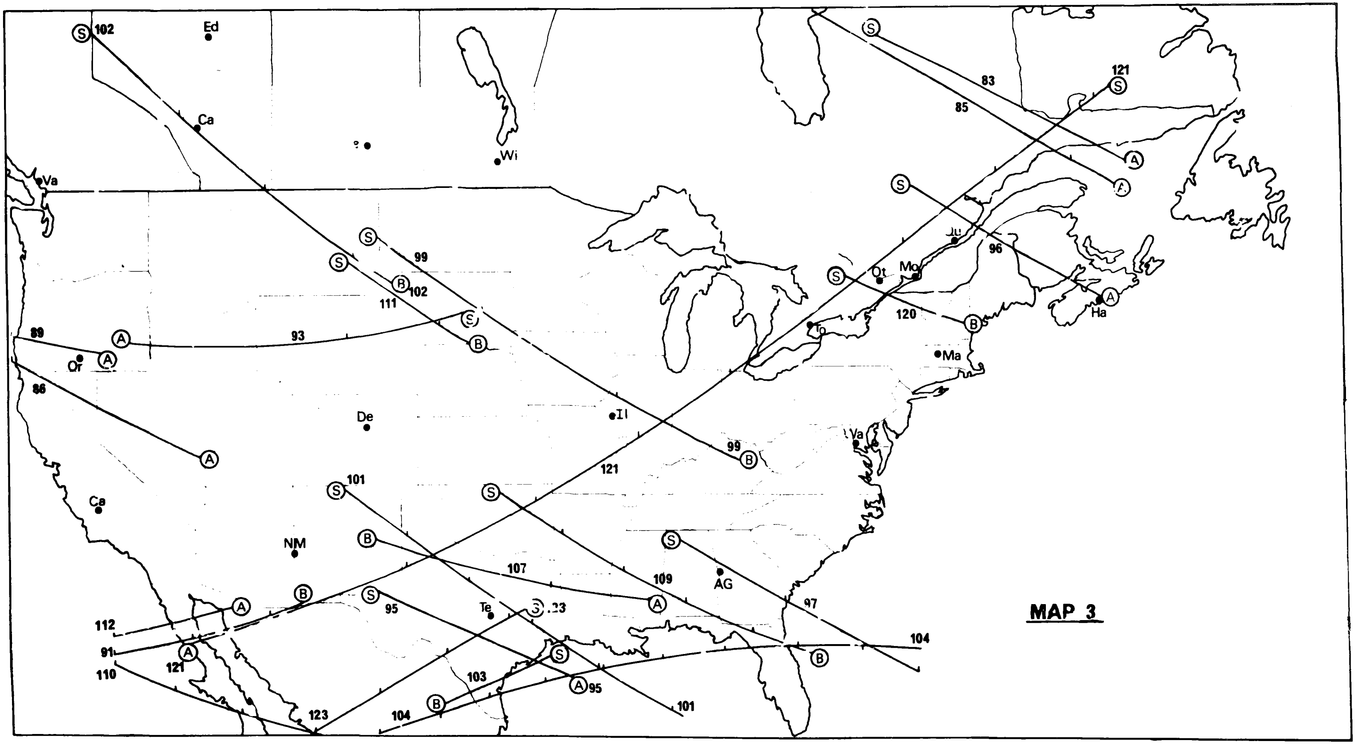
Track No.	Z.C.	
5	212	is the mean of the binary star Aitken 1158. The components are of magnitude 7.6 and 7.9; separation 0″.4 in p.a. 156°.
17	1891	is the brightest component of the triple star Aitken 8801. The brighter companion, of magnitude 9.4 has separation 7″.1 in p.a. 343°. The fainter companion is at a wide separation.
23	3430	is the brighter component of the double star Aitken 16676. The companion, of magnitude 10.6, has separation 10″.8 in p.a. 19°.
44, 138	672	is the mean of the binary star Aitken 3248. The components are of magnitude 7.0 and 7.7; separation 0″.3 in p.a. 262°.
82, 143	814	is the brightest component of the triple star Aitken 4038. The brighter companion, of magnitude 10.1, has separation 10″ in p.a. 306°. The faint companion is of magnitude 12.
85	975	is the mean of the double star Aitken 4991. The components are of magnitude 7.2 and 8.2.
91	2997	is the mean of the close double star Aitken 13961. The components are each of magnitude 7.9.
110	1994	is the brighter component of the double star Aitken 9053. The companion is of magnitude 7.7, separation 3″.4 in p.a. 96°.
111	2223	is the brightest component of the triple star Aitken 9704. The brighter companion is of magnitude 4.2 at a close separation. The second companion is 11th magnitude at a wide separation.
152	608	is the brighter component of the double star Aitken 2999. The companion is of magnitude 8.8, separation 3″.8 in p.a. 221°.
154	1040	is the mean of the binary star Aitken 5447. The components are of magnitude 6.8 and 7.0; separation 0″.5 in p.a. 242°.
158	1821	is the mean of the binary star Aitken 8630. The components are each of magnitude 3.5; separation 3″.9 in p.a. 297°.



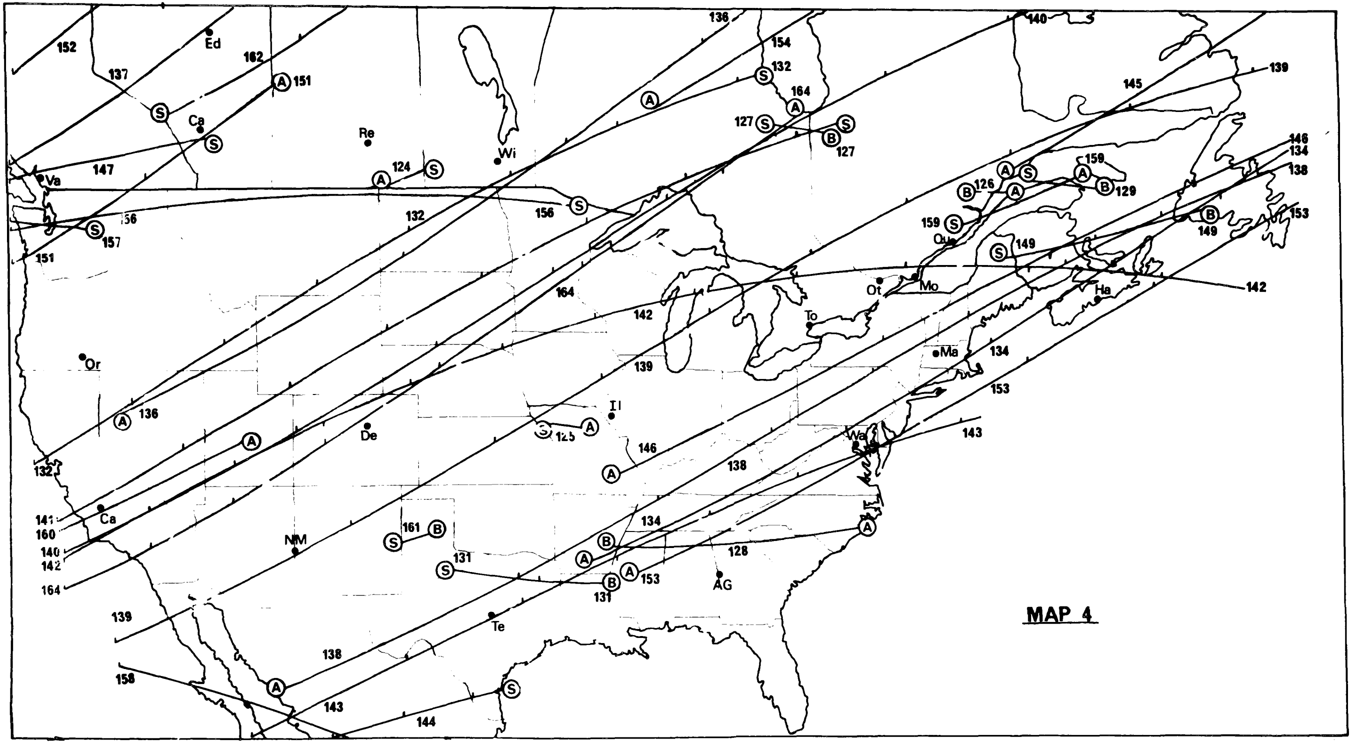
Map 1: Tracks 1 to 41; Grazes Jan. 1 to Mar. 5.



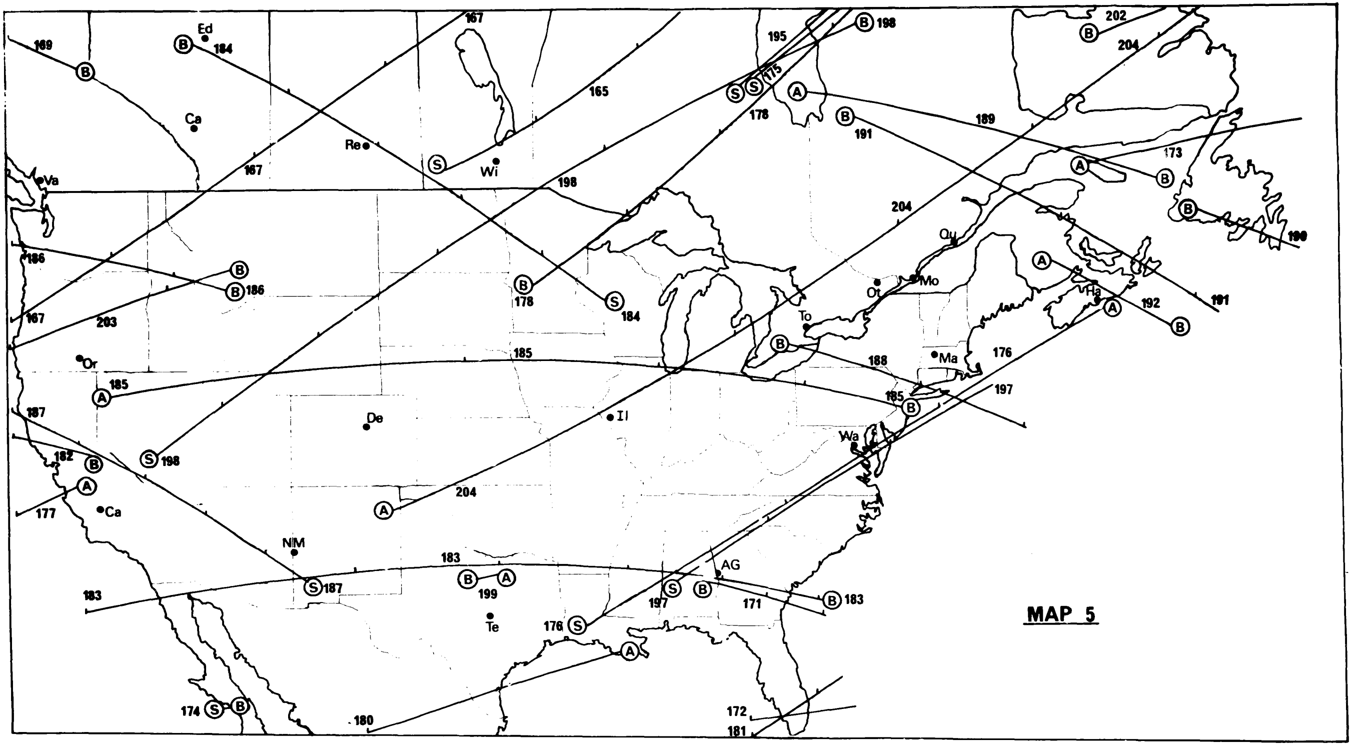
Map 2: Tracks 42 to 82; Grazes Mar. 5 to Apr. 30.



Map 3: Tracks 83 to 123; Grazes Apr. 30 to Aug. 13.

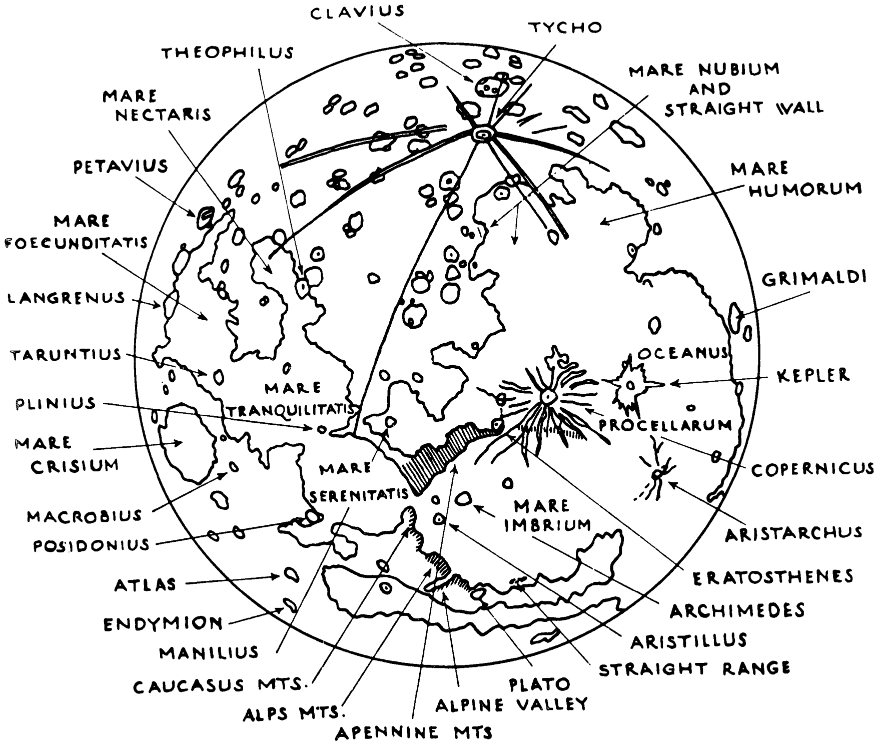


Map 4: Tracks 124 to 164; Grazes Aug. 20 to Oct. 29.



Map 5: Tracks 165 to 204; Grazes Oct. 30 to Dec. 30.

MAP OF THE MOON



South appears at the top.

PLANETARY HELIOCENTRIC LONGITUDES 1979

Date U.T.	Planet					
	M	V	E	M	J	S
	°	°	°	°	°	°
Jan. 1.0	203	133	100	288	122	158
Feb. 1.0	293	183	132	307	125	160
Mar. 1.0	56	228	160	323	127	161
Apr. 1.0	209	277	191	344	129	162
May 1.0	296	325	220	3	132	163
June 1.0	81	15	250	22	134	164
July 1.0	219	62	279	40	137	165
Aug. 1.0	309	112	308	57	139	166
Sept. 1.0	106	162	338	74	141	167
Oct. 1.0	231	211	7	89	144	168
Nov. 1.0	323	260	38	104	146	169
Dec. 1.0	124	308	68	118	149	170
Jan. 1.0	242	357	100	132	151	171

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, counter-clockwise 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.

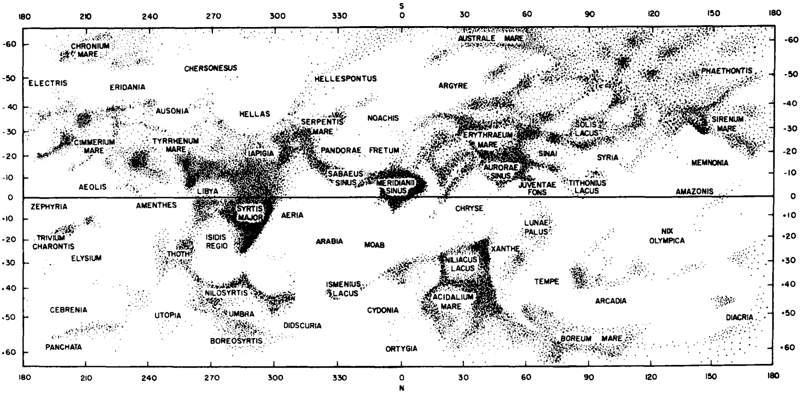
The heliocentric longitude of Uranus increases from 228° to 232° during the year; that of Neptune increases from 258° to 260°, and that of Pluto increases from 197° to 200°.

MARS—EPHEMERIS FOR PHYSICAL OBSERVATIONS

For the first day of each month when Mars is favourably placed, the table gives the distance from the earth, the magnitude, apparent diameter, fraction of the disc illuminated, position angle of the rotation axis (measured from the north through the east), inclination of the rotation axis to the plane of the sky (positive if the north pole is tipped toward the earth) and two quantities *L(1)* and Δ which can be used to calculate the longitude *L* of the central meridian of the geometric disc. To calculate *L*, note the date and time of the observation, and then convert them to U.T. (see section on *Time*). Take *L(1)* for the first day of the month, and from it *subtract* Δ times the number of full days elapsed since the first day of the month. To the result, *add* 14.6° for each hour elapsed since 0 h U.T. If the result is less than 0°, *add* 360°; if the result is greater than 360°, *subtract* 360°. For example, on July 10 at 21 h E.S.T. = July 11 at 2 h U.T., *L* is 323.36° − (10 × 9.73° + (2 × 14.6°) = 255.3°. This formula replaces the tables given in past years; it is accurate to better than 1°. The value of *L* can then be compared with the map below.

Date U.T.	Dist. A.U.	Mag.	App. Diam.	Ill. %	Pos. Ang.	Incl.	*L(1)*	Δ
			″		°	°	°	°
Mar. 1.0	2.35	+1.4	3.98	1.00	348	−23	90.53	9.97
Apr. 1.0	2.32	+1.4	4.03	0.99	335	−25	141.56	9.95
May 1.0	2.28	+1.4	4.10	0.98	326	−23	203.12	9.87
June 1.0	2.23	+1.5	4.20	0.97	322	−16	257.06	9.79
July 1.0	2.16	+1.5	4.34	0.96	324	−8	323.36	9.73
Aug. 1.0	2.06	+1.5	4.55	0.94	332	+1	21.71	9.70
Sept. 1.0	1.91	+1.5	4.89	0.93	342	+9	81.06	9.68
Oct. 1.0	1.73	+1.4	5.41	0.91	353	+16	150.62	9.66
Nov. 1.0	1.50	+1.2	6.25	0.90	4	+21	211.29	9.58
Dec. 1.0	1.24	+0.8	7.55	0.90	13	+23	283.78	9.41
Jan. 1.0	0.97	+0.2	9.68	0.92	19	+23	351.93	

MAP OF MARS



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

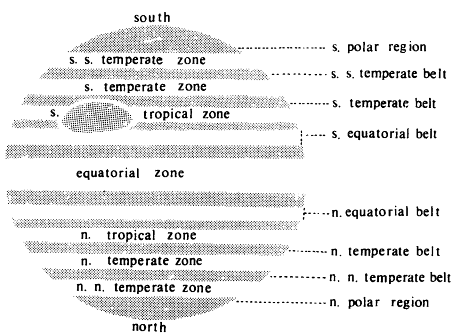
JUPITER—EPHEMERIS FOR PHYSICAL OBSERVATIONS

The table gives the magnitude and the apparent equatorial diameter of Jupiter, along with two quantities *L(1)* and Δ which can be used to calculate the longitude of the central meridian of the illuminated disc of the planet. System I applies to regions 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 longitude is equal to *L(1)* for the month in question *plus* Δ times the number of complete days elapsed since 0 h U.T. on the first of the month *plus* either 36.58° (for system I) *or* 36.26° (for system II) times the number of hours elapsed since 0 h U.T. The result will usually exceed 360°; if so, divide the result by 360° and then multiply the *decimal* portion of the quotient by 360°. This procedure, which is accurate to 1°, replaces the tables given in previous editions of this HANDBOOK.

Date 0 h U.T.	Vis. Mag.	Equat. Diam.	System I		System II	
			L(1)	Δ	*L(1)*	Δ
		″	°	°	°	°
Jan. 1	−2.1	45.0	324.5	158.05	146.9	150.40
Feb. 1	−2.1	45.8	183.6	157.95	129.4	150.35
Mar. 1	−2.1	43.9	286.7	157.85	18.9	150.25
Apr. 1	−1.9	40.2	140.2	157.75	355.9	150.10
May 1	−1.7	36.7	192.9	157.70	179.7	150.05
June 1	−1.5	33.7	41.4	157.65	151.7	150.05
July 1	−1.3	32.0	91.4	157.65	332.8	150.05
Aug. 1	−1.3	31.1	299.0	157.70	303.8	150.05
Sept. 1	−1.3	31.2	147.2	157.75	275.6	150.10
Oct. 1	−1.4	32.2	199.2	157.80	98.6	150.15
Nov. 1	−1.5	34.2	50.7	157.85	73.6	150.25
Dec. 1	−1.7	37.2	106.7	157.95	260.6	150.30
Jan. 1	−1.9	40.8				

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.



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 Central North America. See also pgs. 38–39.

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 until August 13, and on the west thereafter.

JANUARY

d	h	m	Sat.	Phen.
1	18	45	I	Se
	19	18	I	Te
3	4	51	III	SI
	6	55	III	TI
	8	24	III	Se
	8	59	II	ED
4	8	09	I	ED
	20	22	IV	TI
	20	29	IV	Se
5	1	00	IV	Te
	3	26	II	SI
	4	24	II	TI
	5	26	I	SI
	5	54	I	TI
	6	19	II	Se
	7	17	II	Te
	7	42	I	Se
	8	10	I	Te
6	2	37	I	ED
	5	23	I	OR
	18	55	III	ED
	22	16	II	ED
	23	54	I	SI
7	0	16	III	OR
	0	20	I	TI
	1	54	II	OR
	2	10	I	Se
	2	36	I	Te
	21	06	I	ED
	23	49	I	OR
8	18	23	I	SI
	18	46	I	TI
	19	38	II	Se
	20	26	II	Te
	20	39	I	Se
	21	02	I	Te
9	18	15	I	OR
10	8	49	III	SI
12	6	03	II	SI
	6	40	II	TI
	7	20	I	SI
	7	37	I	TI
	8	56	II	Se
	9	33	II	Te
	9	36	I	Se
	23	50	IV	ED
13	4	32	I	ED
	7	07	I	OR
	7	07	IV	OR
	22	54	III	ED
14	0	49	II	ED
	1	48	I	SI
	2	03	I	TI
	3	32	III	OR
	4	04	I	Se
	4	07	II	OR
	4	19	I	Te
	23	00	I	ED
15	1	33	I	OR
	19	22	II	SI
	19	48	II	TI
	20	16	I	SI
	20	29	I	TI
	22	15	II	Se
	22	33	I	Se
	22	41	II	Te
15	22	45	I	Te
16	17	29	I	ED
	19	59	I	OR
17	17	11	I	Te
	17	14	II	OR
19	8	40	II	SI
	8	55	II	TI
	9	13	I	SI
	9	21	I	TI
20	6	26	I	ED
	8	51	I	OR
21	2	52	III	ED
	3	23	II	ED
	3	42	I	SI
	3	47	I	TI
	5	58	I	Se
	6	03	I	Te
	6	20	II	OR
	6	48	III	OR
22	0	55	I	ED
	3	17	I	OR
	21	59	II	SI
	22	03	II	TI
	22	10	I	SI
	22	12	I	TI
23	0	26	I	Se
	0	29	I	Te
	0	52	II	Se
	0	56	II	Te
	19	24	I	ED
	21	43	I	OR
24	18	54	I	Te
	18	55	I	Se
	19	27	II	ER
	20	19	III	Te
	20	21	III	Se
27	8	16	I	OD
28	5	30	I	TI
	5	36	I	SI
	5	45	II	OD
	6	27	III	OD
	7	46	I	Te
	7	52	I	Se
	8	44	II	ER
29	2	42	I	OD
	5	08	I	ER
	22	28	IV	ER
	23	56	I	TI
30	0	04	I	SI
	0	18	II	TI
	0	36	II	SI
	2	12	I	Te
	2	20	I	Se
	3	11	II	Te
	3	29	II	Se
	21	08	I	OD
	23	37	I	ER
31	18	22	I	TI
	18	33	I	SI
	18	52	II	OD
	20	00	III	TI
	20	38	I	Te
	20	45	III	SI
	20	49	I	Se
	22	01	II	ER
	23	34	III	Te

FEBRUARY

d	h	m	Sat.	Phen.
1	0	20	III	Se
	18	05	I	ER
4	7	14	I	TI
	7	30	I	SI
	7	58	II	OD
5	4	26	I	OD
	7	03	I	ER
6	1	40	I	TI
	1	58	I	SI
	2	34	II	TI
	3	13	II	SI
	3	56	I	Te
	4	14	I	Se
	5	27	II	Te
	6	06	II	Se
	22	53	I	OD
7	0	45	IV	TI
	1	32	I	ER
	3	56	IV	SI
	5	21	IV	Te
	8	34	IV	Se
	20	06	I	TI
	20	27	I	SI
	21	05	II	OD
	22	22	I	Te
	22	43	I	Se
	23	16	III	TI
8	0	36	II	ER
	0	44	III	SI
	2	51	III	Te
	4	19	III	Se
	17	19	I	OD
	20	00	I	ER
9	18	35	II	Te
	19	24	II	Se
11	18	26	III	ER
12	6	11	I	OD
13	3	24	I	TI
	3	52	I	SI
	4	51	II	TI
	5	40	I	Te
	5	50	II	SI
	6	09	I	Se
	7	44	II	Te
14	0	38	I	OD
	3	26	I	ER
	21	50	I	TI
	22	21	I	SI
	23	20	II	OD
15	0	06	I	Te
	0	37	I	Se
	2	35	III	TI
	3	10	II	ER
	4	43	III	SI
	6	09	III	Te
	6	48	IV	OD
	19	04	I	OD
	21	55	I	ER
16	17	59	II	TI
	18	32	I	Te
	19	06	I	Se
	19	08	II	SI
	20	52	II	Te
	22	01	II	Se
18	22	26	III	ER
20	5	09	I	TI
20	5	47	I	SI
	7	09	II	TI
	7	25	I	Te
21	2	23	I	OD
	5	21	I	ER
	23	35	I	TI
22	0	15	I	SI
	1	36	II	OD
	1	51	I	Te
	2	32	I	Se
	5	45	II	ER
	5	57	III	TI
	20	50	I	OD
	23	50	I	ER
23	18	02	I	TI
	18	44	I	SI
	19	55	IV	Te
	20	18	I	Te
	20	18	II	TI
	21	00	I	Se
	21	46	II	SI
	21	56	IV	SI
	23	11	II	Te
24	0	39	II	Se
	2	36	IV	Se
	18	19	I	ER
25	19	02	II	ER
	19	47	III	OD
26	2	27	III	ER
27	6	55	I	TI
28	4	10	I	OD

MARCH

d	h	m	Sat.	Phen.
1	1	22	I	TI
	2	10	I	SI
	3	38	I	Te
	3	54	II	OD
	4	26	I	Se
	22	36	I	OD
2	1	45	I	ER
	19	49	I	TI
	20	39	I	SI
	22	04	I	Te
	22	39	II	TI
	22	55	I	Se
3	0	23	II	SI
	1	32	II	Te
	3	16	II	Se
	20	14	I	ER
	21	40	IV	OD
4	2	15	IV	OR
	5	57	IV	ED
	21	37	II	ER
	23	14	III	OD
5	6	26	III	ER
7	5	57	I	OD
8	3	09	I	TI
	4	04	I	SI
	5	25	I	Te
	6	15	II	OD
	6	20	I	Se
	20	16	III	Se
9	0	24	I	OD
	3	40	I	ER
	21	36	I	TI

d	h	m	Sat.	Phen.
9	22	33	I	SI
	23	52	I	Te
10	0	49	I	Se
	1	03	II	TI
	3	00	II	SI
	3	55	II	Te
	5	53	II	Se
	18	52	I	OD
	22	09	I	ER
11	18	19	I	Te
	19	18	I	Se
	19	26	II	OD
12	0	12	II	ER
	2	46	III	OD
	20	39	IV	Se
13	19	12	II	Se
15	4	58	I	TI
	5	59	I	SI
	20	00	III	Te
	20	40	III	SI
16	0	16	III	Se
	2	14	I	OD
	5	36	I	ER
	23	25	I	TI
17	0	28	I	SI
	1	41	I	Te
	2	44	I	Se
	3	28	II	TI
	5	38	II	SI
	20	41	I	OD
18	0	05	I	ER
	18	57	I	SI
	20	08	I	Te
	21	12	I	Se
	21	49	II	OD
19	2	47	II	ER
	18	33	I	ER
20	18	57	II	SI
	19	34	II	Te
	21	49	II	Se
21	0	00	IV	ED
	4	45	IV	ER
22	20	07	III	TI
	23	40	III	Te
23	0	40	III	SI
	4	04	I	OD
	4	16	III	Se
24	1	15	I	TI
	2	23	I	SI
	3	31	I	Te
	4	38	I	Se
	22	32	I	OD
25	2	00	I	ER
	19	43	I	TI
	20	51	I	SI
	21	58	I	Te
	23	07	I	Se
26	0	15	II	OD
	5	23	II	ER
	18	25	III	ER
	20	29	I	ER
27	19	11	II	TI
	21	34	II	SI
	22	03	II	Te
28	0	26	II	Se
	22	57	IV	TI
29	3	30	IV	Te
	18	41	II	ER
	23	51	III	TI
30	3	24	III	Te
	4	40	III	SI
31	3	07	I	TI
	4	17	I	SI

APRIL

d	h	m	Sat.	Phen.
1	0	24	I	OD
	3	55	I	ER
	21	34	I	TI
	22	46	I	SI
	23	50	I	Te
2	1	02	I	Se
	2	44	II	OD
	18	48	III	ED
	18	52	I	OD
	22	24	I	ER
	22	26	III	ER
3	19	31	I	Se
	21	43	II	TI
4	0	11	II	SI
	0	34	II	Te
	3	03	II	Se
5	21	16	II	ER
6	3	39	III	TI
	22	50	IV	ER
8	2	16	I	OD
	23	27	I	TI
9	0	41	I	SI
	1	43	I	Te
	2	57	I	Se
	20	45	I	OD
	21	18	III	OR
	22	48	III	ED
10	0	19	I	ER
	2	26	III	ER
	19	10	I	SI
	20	11	I	Te
	21	26	I	Se
11	0	16	II	TI
	2	49	II	SI
	3	07	II	Te
12	23	52	II	ER
14	18	58	II	Se
	20	45	IV	Te
15	4	00	IV	SI
16	1	21	I	TI
	2	36	I	SI
	3	36	I	Te
	21	38	III	OD
	22	39	I	OD
17	1	14	III	OR
	2	14	I	ER
	2	48	III	ED
	19	50	I	TI
	21	05	I	SI
	22	05	I	Te
	23	21	I	Se
18	2	51	II	TI
	20	43	I	ER
19	21	04	II	OD
20	2	28	II	ER
	20	14	III	Se
21	18	44	II	SI
	19	00	II	Te
	21	35	II	Se
22	23	54	IV	OD
23	3	16	I	TI
24	0	34	I	OD
	1	37	III	OD
	21	44	I	TI
	23	00	I	SI
25	0	00	I	Te
	1	16	I	Se
	19	03	I	OD
	22	38	I	ER
26	19	45	I	Se
	23	41	II	OD
27	19	04	III	Te
	20	38	III	SI
28	0	14	III	Se
	21	21	II	SI
	21	38	II	Te
29	0	12	II	Se

MAY

d	h	m	Sat.	Phen.
1	2	30	I	OD
	22	02	IV	SI
	23	40	I	TI
2	0	55	I	SI
	1	56	I	Te
	2	48	IV	Se
	21	00	I	OD
3	0	34	I	ER
	19	24	I	SI
	20	25	I	Te
	21	40	I	Se
4	2	19	II	OD
	19	35	III	TI
	23	09	III	Te
5	0	38	III	SI
	21	27	II	TI
	23	57	II	SI
6	0	17	II	Te
	2	48	II	Se
7	20	59	II	ER
9	1	37	I	TI
	22	57	I	OD
	23	06	IV	OR
10	2	29	I	ER
	20	06	I	TI
	21	19	I	SI
	22	22	I	Te
	23	35	I	Se
11	20	58	I	ER
	23	44	III	TI
13	0	09	II	TI
14	23	36	II	ER
15	22	25	III	ER
17	0	55	I	OD
	22	04	I	TI
	23	14	I	SI
18	0	20	I	Te
	1	31	I	Se
	19	24	I	OD
	20	50	IV	Se
	22	52	I	ER
19	19	59	I	Se
21	21	01	II	OD
22	21	47	III	OR
	22	47	III	ED
23	21	19	II	Se
25	0	02	I	TI
	1	09	I	SI
	21	23	I	OD
26	0	47	I	ER
	19	38	I	SI
	20	49	I	Te
	21	55	I	Se
27	0	15	IV	ED
	19	16	I	ER
28	23	45	II	OD
29	22	25	III	OD
30	21	04	II	SI
	21	47	II	Te
	23	55	II	Se

JUNE

d	h	m	Sat.	Phen.
1	23	22	I	OD
2	20	14	III	Se
	20	31	I	TI
	21	33	I	SI
	22	48	I	Te
	23	50	I	Se
3	21	11	I	ER
4	0	34	IV	TI
6	21	42	II	TI
	23	40	II	SI
7	0	32	II	Te
8	20	44	II	ER
9	20	19	III	Te
	20	36	III	SI
	22	31	I	TI
	23	28	I	SI
10	0	13	III	Se
	19	52	I	OD
	23	06	I	ER
11	20	14	I	Se
12	23	09	IV	ER
14	0	28	II	TI
15	23	21	II	ER
16	21	04	III	TI
17	21	52	I	OD
18	19	51	I	SI
	21	18	I	Te
	22	09	I	Se
24	23	52	I	OD

Jupiter being near the sun, phenomena are not given between June 24 and Sept. 9

SEPTEMBER

d	h	m	Sat.	Phen.
9	7	38	II	OR
13	7	32	IV	Te
15	7	44	I	SI
16	6	24	II	ED
	6	47	I	OR
17	4	31	I	Se
	5	05	I	Te
18	3	47	II	Se
	4	23	III	SI
	6	44	III	TI
23	6	51	I	ED
24	4	06	I	SI
	4	46	I	TI
	6	25	I	Se
	7	05	I	Te
25	3	31	II	SI
	4	16	I	OR
	4	51	II	TI
	6	21	II	Se
	7	41	II	Te
27	2	42	II	OR
29	5	01	III	OR
30	3	45	IV	Te

OCTOBER

d	h	m	Sat.	Phen.
1	6	00	I	SI
	6	46	I	TI
2	3	12	I	ED
	6	05	II	SI
	6	15	I	OR
	7	36	II	TI
3	2	47	I	Se
	3	34	I	Te
4	5	30	II	OR
6	2	21	III	ED
8	5	16	IV	ER
	7	54	I	SI
9	5	05	I	ED
10	2	23	I	SI
	3	16	I	TI
	4	41	I	Se
	5	34	I	Te
11	2	44	I	OR
	3	31	II	ED
13	2	33	II	Te
	6	19	III	ED
16	6	59	I	ED
17	3	47	III	Te
	4	17	I	SI
	5	14	I	TI
	6	35	I	Se
	7	32	I	Te
18	4	42	I	OR
	6	07	II	ED
19	2	02	I	Te

d	h	m	Sat.	Phen.
20	2	26	II	TI
	3	18	II	Se
	5	16	II	Te
24	3	51	III	Se
	4	28	III	TI
	6	11	I	SI
	7	13	I	TI
	8	03	III	Te
	8	28	I	Se
25	3	20	I	ED
	4	42	IV	OD
	6	40	I	OR
26	1	42	I	TI
	2	57	I	Se
	3	59	I	Te
27	1	09	I	OR
	3	02	II	SI
	5	08	II	TI
	5	52	II	Se
	7	58	II	Te
29	3	08	II	OR
31	4	13	III	SI
	7	49	III	Se
	8	04	I	SI
	8	43	III	TI

NOVEMBER

d	h	m	Sat.	Phen.
1	5	13	I	ED
	8	37	I	OR
2	2	33	I	SI
	3	40	I	TI
	3	58	IV	SI
	4	50	I	Se
	5	57	I	Te
	8	38	IV	Se
3	3	06	I	OR
	5	35	II	SI
	7	49	II	TI
	8	25	II	Se
4	2	25	III	OR
5	5	50	II	OR
7	8	11	III	SI
8	7	06	I	ED
9	4	26	I	SI
	5	36	I	TI
	6	43	I	Se
	7	53	I	Te
10	1	34	I	ED
	5	02	I	OR
	8	09	II	SI
11	1	12	I	Se
11	1	48	III	ER
	2	22	I	Te
	2	59	III	OD
	4	25	IV	OR
	6	34	III	OR
12	3	11	II	ED
	8	30	II	OR
14	0	16	II	Se
	2	38	II	Te
15	8	59	I	ED
16	6	20	I	SI
	7	32	I	TI
	8	37	I	Se
17	3	27	I	ED
	6	57	I	OR
18	0	48	I	SI
	2	01	I	TI
	2	07	III	ED
	3	05	I	Se
	4	17	I	Te
	5	45	III	ER
	7	05	III	OD
19	1	26	I	OR
	2	32	IV	Se
	5	46	II	ED
20	23	59	II	SI
21	2	25	II	TI
	2	50	II	Se
	5	16	II	Te
22	0	38	III	Te
23	0	27	II	OR
	8	13	I	SI
24	5	20	I	ED
	8	52	I	OR
25	2	42	I	SI
	3	55	I	TI
	4	58	I	Se
	6	05	III	ED
	6	11	I	Te
	23	49	I	ED
26	3	20	I	OR
	8	21	II	ED
	23	27	I	Se
27	0	40	I	Te
	6	30	IV	ED
28	2	33	II	SI
	5	01	II	TI
	5	24	II	Se
	7	52	II	Te
	23	40	III	Se
29	1	09	III	TI
	4	39	III	Te
30	5	03	II	OR

DECEMBER

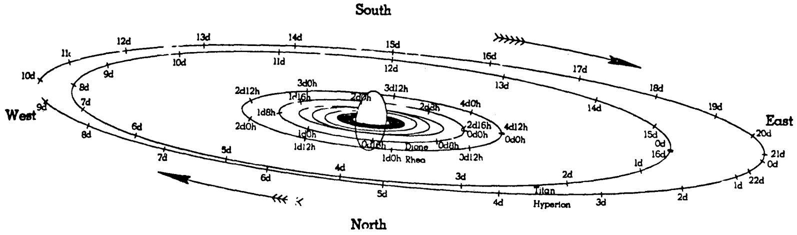
d	h	m	Sat.	Phen.
1	7	14	I	ED
2	4	35	I	SI
	5	49	I	TI
	6	52	I	Se
	8	05	I	Te
3	1	42	I	ED
	5	14	I	OR
	23	03	I	SI
4	0	17	I	TI
	1	20	I	Se
	2	33	I	Te
	23	42	I	OR
5	5	07	II	SI
	7	35	II	TI
	7	58	II	Se
6	0	03	III	SI
	3	37	III	Se
	3	37	IV	TI
	5	06	III	TI
	7	45	IV	Te
	8	35	III	Te
7	0	14	II	ED
	5	36	II	OR
8	9	07	I	ED
	23	42	II	Te
9	6	28	I	SI
	7	42	I	TI
	8	45	I	Se
10	3	35	I	ED
	7	06	I	OR
11	0	57	I	SI
	2	10	I	TI
	3	13	I	Se
	4	25	I	Te
12	1	34	I	OR
	7	41	II	SI
	22	53	I	Te
13	4	00	III	SI
	7	34	III	Se
	8	58	III	TI
14	0	29	IV	ED
	2	48	II	ED
	5	04	IV	ER
	8	07	II	OR
15	23	22	II	TI
	23	49	II	Se
16	2	13	II	Te
	8	22	I	SI
16	9	33	I	TI
	22	53	III	OD
17	2	24	III	OR
	5	28	I	ED
	8	58	I	OR
18	2	50	I	SI
	4	01	I	TI
	5	06	I	Se
	6	16	I	Te
	23	56	I	ED
19	3	25	I	OR
	22	29	I	TI
	23	35	I	Se
20	0	44	I	Te
	7	58	III	SI
21	5	23	II	ED
22	23	32	II	SI
23	0	52	IV	Te
	1	51	II	TI
	2	24	II	Se
	4	42	II	Te
	21	56	III	ED
24	1	32	III	ER
	2	39	III	OD
	6	09	III	OR
	7	21	I	ED
	23	50	II	OR
25	4	43	I	SI
	5	51	I	TI
	6	59	I	Se
	8	06	I	Te
26	1	50	I	ED
	5	15	I	OR
	23	11	I	SI
27	0	18	I	TI
	1	28	I	Se
	2	34	I	Te
	23	43	I	OR
28	7	57	II	ED
30	2	06	II	SI
	4	18	II	TI
	4	58	II	Se
	7	09	II	Te
	23	00	IV	ER
31	1	54	III	ED
	5	12	IV	OD
	5	29	III	ER
	6	20	III	OD
	9	06	IV	OR
	9	15	I	ED

SATURN'S RINGS AND SATELLITES

The diagram below, which is taken from the *American Ephemeris and Nautical Almanac*, shows the apparent orbits of satellites I to VII of Saturn at the date of opposition. At other dates, the inclination of the orbits (which is the same as that of the rings, except for Iapetus) is slightly different; see the description of Saturn in the section on "The Planets" for further details. On the orbits of satellites IV–VII, there are markers which show the days elapsed since greatest elongation east. The dates of greatest elongation east are given for V (Rhea) and VI (Titan) in the table below. The dates of the first greatest elongation east in 1979 are Jan. 2, 2^h8, E.S.T. for Dione and Jan. 2, 5^h6 for Hyperion. The greatest elongation east then recurs at intervals of the mean synodic period.

Iapetus is most conspicuous at greatest elongation west, at which time it is about 12 ring-diameters west of the planet.

SATURN'S RINGS AND SATELLITES



Elongated in the ratio of two to one in the direction of their minor axes.

	Name	Mean Synodic Period d	h		Name	Mean Synodic Period d	h
X	Janus	0	18.0	V	Rhea	4	12.5
I	Mimas	0	22.6	VI	Titan	15	23.3
II	Enceladus	1	08.9	VII	Hyperion	21	07.6
III	Tethys	1	21.3	VIII	Iapetus	79	22.1
IV	Dione	2	17.7	IX	Phœbe	523	15.6

ELONGATION OF SATURN'S SATELLITES, 1979 (E.S.T.)

JANUARY

d	h	Sat.	Elong.
1	13.2	Rh	E
6	01.6	Rh	E
6	23.0	Ti	E
10	13.9	Rh	E
14	15.7	Ti	W
15	02.3	Rh	E
19	14.7	Rh	E
22	21.2	Ti	E
23	02.0	Ia	W
24	03.0	Rh	E
28	15.4	Rh	E
30	13.6	Ti	W

FEBRUARY

d	h	Sat.	Elong.
2	03.7	Rh	E
6	16.1	Rh	E
7	19.0	Ti	E
11	04.4	Rh	E
15	11.3	Ti	W
15	16.7	Rh	E
20	05.1	Rh	E
23	16.6	Ti	E
24	17.4	Rh	E

MARCH

d	h	Sat.	Elong.
1	05.7	Rh	E
3	08.8	Ti	W
4	10.4	Ia	E
5	18.0	Rh	E
10	06.4	Rh	E
11	14.1	Ti	E
14	18.7	Rh	E
19	06.3	Ti	W
19	07.0	Rh	E
23	19.4	Rh	E
27	11.7	Ti	E
28	07.7	Rh	E

APRIL

d	h	Sat.	Elong.
1	20.0	Rh	E
4	04.0	Ti	W
6	08.4	Rh	E
10	20.8	Rh	E
11	07.2	Ia	W
12	09.6	Ti	E
15	09.1	Rh	E
19	21.5	Rh	E
20	02.0	Ti	W
24	09.9	Rh	E
28	07.8	Ti	E
28	22.3	Rh	E

MAY

d	h	Sat.	Elong.
3	10.7	Rh	E
6	00.4	Ti	W
7	23.1	Rh	E
12	11.6	Rh	E
14	06.4	Ti	E
17	00.0	Rh	E
21	12.5	Rh	E
21	23.2	Ti	W
22	02.2	Ia	E
26	00.9	Rh	E
30	05.4	Ti	E
30	13.4	Rh	E

JUNE

d	h	Sat.	Elong.
4	01.9	Rh	E
6	22.5	Ti	W
8	14.4	Rh	E
13	02.9	Rh	E
15	04.9	Ti	E
17	15.4	Rh	E
22	03.9	Rh	E
22	22.1	Ti	W
26	16.4	Rh	E
29	22.5	Ia	W

JULY

d	h	Sat.	Elong.
1	04.6	Ti	E
1	04.9	Rh	E
5	17.4	Rh	E
8	22.0	Ti	W
10	06.0	Rh	E
14	18.5	Rh	E
17	04.7	Ti	E
19	07.1	Rh	E
23	19.6	Rh	E
24	22.3	Ti	W
28	08.2	Rh	E

AUGUST

d	h	Sat.	Elong.
1	20.7	Rh	E
2	05.0	Ti	E

Elongations are not given between Aug. 2 and Oct. 16, Saturn being near the sun.

OCTOBER

d	h	Sat.	Elong.
17	18.4	Rh	E
21	07.3	Ti	E
22	06.9	Rh	E
26	19.5	Rh	E
29	01.5	Ti	W
31	05.6	Ia	E
31	08.0	Rh	E

NOVEMBER

d	h	Sat.	Elong.
4	20.5	Rh	E
6	07.5	Ti	E
9	09.1	Rh	E
13	21.6	Rh	E
14	01.6	Ti	W
18	10.1	Rh	E
22	07.5	Ti	E
22	22.6	Rh	E
27	11.1	Rh	E
30	01.5	Ti	W

DECEMBER

d	h	Sat.	Elong.
1	23.6	Rh	E
6	12.1	Rh	E
8	07.1	Ti	E
9	04.1	Ia	W
11	00.6	Rh	E
15	13.0	Rh	E
16	01.0	Ti	W
20	01.5	Rh	E
24	06.4	Ti	E
24	13.9	Rh	E
29	02.4	Rh	E
32	00.1	Ti	W

ASTEROIDS—EPHEMERIDES NEAR OPPOSITION 1979

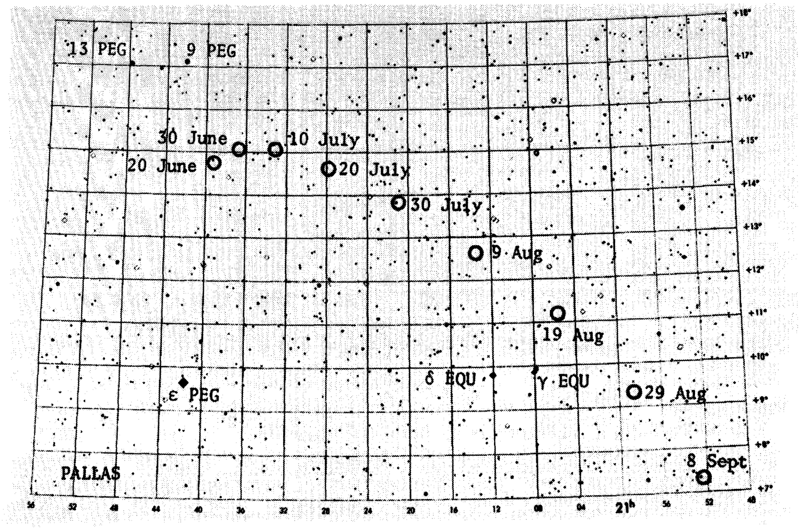
The asteroids Ceres, Pallas and Vesta come to opposition in 1979. The following table gives the radiometric diameter, rotation period, orbital period, eccentricity and inclination for each asteroid, together with the date (U.T.), constellation, visual magnitude, right ascension and declination (astrometric,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

Asteroid	Diam.	Period Rot.	Period Orb.	e	i	At opposition Date	Const.	Vis. Mag.	R.A. 1950	Dec. 1950	Dist
	km	hr	yr		°	U.T.			h m	° ′	A.U.
1 Ceres	1000	9.1	4.6	0.08	11	Oct. 6	Cet	7.2	01 07.4	−08 57	1.95
2 Pallas	530	10.0	4.6	0.24	35	Aug. 17	Equ	9.1	21 07.3	+11 27	2.45
3 Juno	240	7.2	4.4	0.26	13	*	CMi	7.7	7 32.2	+00 48	1.22
4 Vesta	530	10.7	3.6	0.09	7	Nov. 3	Cet	6.5	2 43.9	+04 52	1.55

*Information for Jan. 1, 1980; opposition occurs in early 1980

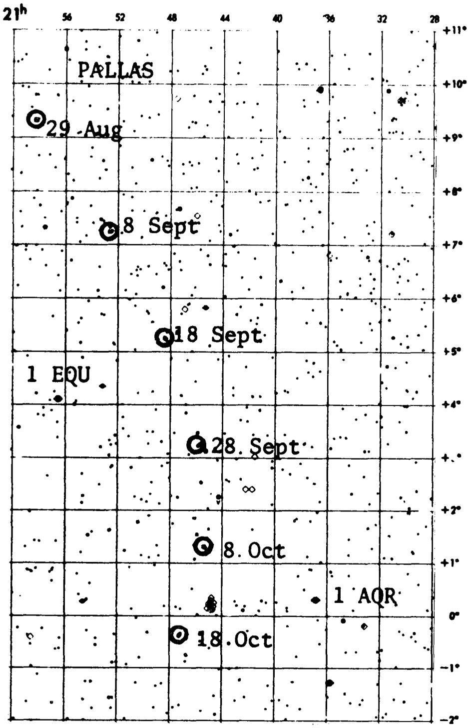
The following tables list the 1950 co-ordinates (for convenience in plotting on the *Atlas Coeli*) and the visual magnitudes of the four asteroids on selected dates (at 0 h U.T.) near opposition. The maps, which are suitable for binocular or telescopic observers, show the positions of the four asteroids. These maps are adapted from the S.A.O. Star Charts; the open symbols are non-stellar objects.

Date 0^h U.T.	CERES R.A.	CERES Dec.	CERES Mag.	JUNO R.A.	JUNO Dec.	JUNO Mag.	VESTA R.A.	VESTA Dec.	VESTA Mag.
	h m	° ′		h m	° ′		h m	° ′	
Sept. 1	1 29.4	−06 00	7.3	5 59.7	+11 56	8.7	3 09.6	+08 26	7.0
11	1 25.5	−06 51	7.3	6 19.1	+11 05	8.6	3 12.6	+08 10	6.9
21	1 19.4	−07 44	7.3	6 37.3	+10 02	8.5	3 12.9	+07 43	6.8
Oct. 1	1 11.8	−08 34	7.3	6 54.0	+08 51	8.4	3 10.3	+07 08	6.7
11	1 03.3	−09 15	7.2	7 09.1	+07 33	8.3	3 04.8	+06 27	6.6
21	0 54.9	−09 41	7.2	7 22.0	+06 11	8.2	2 56.9	+05 44	6.6
31	0 47.4	−09 49	7.3	7 32.7	+04 48	8.1	2 47.4	+05 04	6.5
Nov. 10	0 41.5	−09 38	7.3	7 40.7	+03 28	8.0	2 37.3	+04 33	6.5
20	0 37.7	−09 09	7.4	7 45.7	+02 17	7.9	2 27.9	+04 15	6.6
30	0 36.2	−08 23	7.4	7 47.5	+01 18	7.9	2 20.1	+04 14	6.6
Dec. 10	0 37.0	−07 24	7.5	7 45.9	+00 39	7.8	2 14.8	+04 29	6.7
20	0 39.9	−06 13	7.7	7 41.1	+00 26	7.8	2 12.3	+05 01	6.9
30	0 44.8	−04 54	7.9	7 33.8	+00 41	7.7	2 12.5	+05 46	7.1

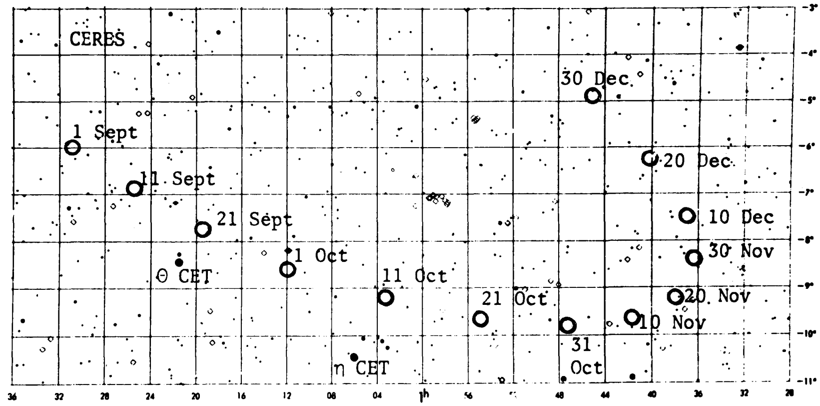


Path of Pallas, June to Sept., 1979.

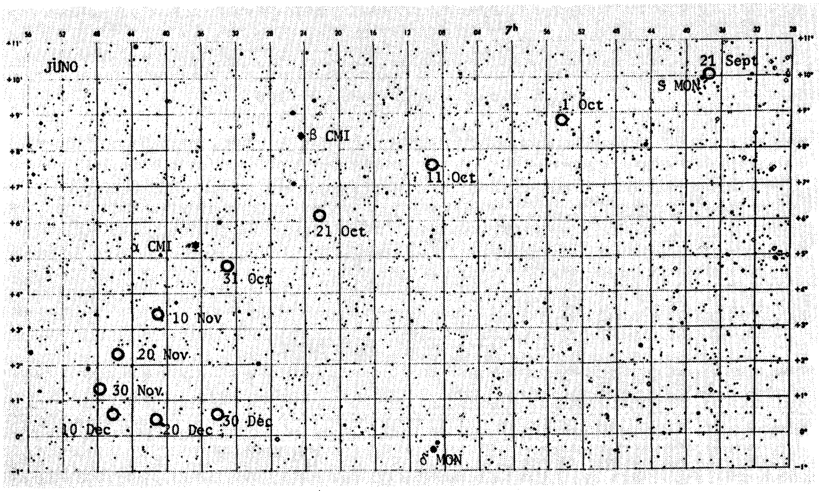
Date 0h U.T.	PALLAS		
	R.A.	Dec.	Mag.
	h m	° ′	
June 20	21 39.2	+14 48	9.5
30	21 37.1	+15 04	9.4
July 10	21 33.3	+15 02	9.3
20	21 27.8	+14 38	9.2
30	21 21.0	+13 51	9.2
Aug. 9	21 13.5	+12 40	9.1
19	21 05.8	+11 07	9.1
29	20 58.6	+09 18	9.1
Sept. 8	20 52.6	+07 17	9.1
18	20 48.3	+05 13	9.2
28	20 45.9	+03 12	9.2
Oct. 8	20 45.6	+01 18	9.3
18	20 47.3	−00 23	9.4



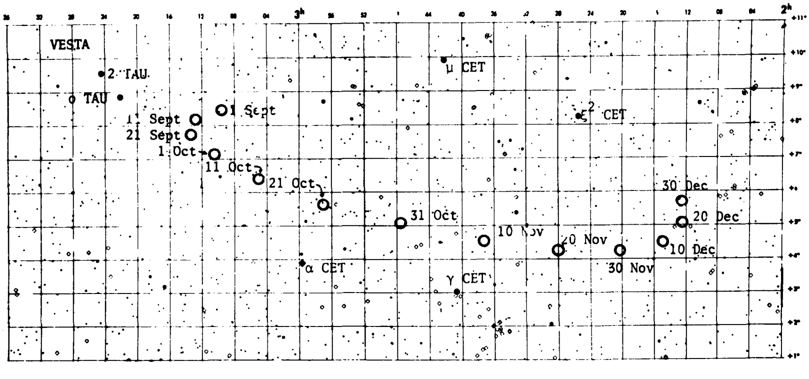
Path of Pallas, Aug. to Oct., 1979.



Path of Ceres, Sept. to Dec., 1979.



Path of Juno, Sept. to Dec., 1979.



Path of Vesta, Sept. to Dec., 1979.

COMETS IN 1979

BY BRIAN G. MARSDEN

The following periodic comets are expected at perihelion during 1979:

Comet	Perihelion Date	Perihelion Dist.	Period
		A.U.	yr.
Shajn-Schaldach	Jan. 9	2.22	7.3
Giacobini-Zinner	Feb. 12	1.00	6.5
Holmes	Feb. 22	2.16	7.1
Schwassmann-Wachmann 3	July 27	0.91	5.3

Comets Shajn-Schaldach and Giacobini-Zinner were recovered during the first half of 1978, but neither is expected to become a bright object. Comet Holmes, lost from 1906 to 1964, experienced spectacular outbursts in brightness during its discovery apparition of 1892–93, but a recurrence is unlikely. Comet Schwassmann-Wachmann 3 is an intrinsically faint comet observed only at the time of its close approach to the earth in 1930; the 1979 return is the most favorable since then, and there is a reasonable chance that the comet can be recovered.

METEORS, FIREBALLS AND METEORITES

BY PETER M. MILLMAN

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

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

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

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

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

When a meteor has a luminosity greater than the brightest stars and planets it is generally termed a fireball. The appearance of any very bright fireball should be reported immediately to the nearest astronomical group or other organization concerned with the collection of such information. Where no local organization exists, reports should be sent to Meteor Centre, Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa, Ontario, K1A 0R6. If sounds are heard accompanying a bright fireball there is a possibility that a meteorite may have fallen. Astronomers must rely on observations made by the general public to track down such an object.

Major Visual Meteor Showers for 1978

Shower	Shower Maximum			Radiant				Single Observer Hourly Rate	Velocity	Normal Duration to 1/4 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	20	FQ	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	16	LQ	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 5	17	FQ	22 24	00	+3.6	+0.4	20	64	3
S. δ Aquarids	July 29	13	FQ	22 36	−17	+3.4	+0.17	20	40	—
Perseids	Aug. 12	18	LQ	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	19	NM	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 4	—	FM	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 17	11	NM	10 08	+22	+2.8	−0.42	15	72	—
Geminids	Dec. 14	10	LQ	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 23	01	FQ	14 28	+76	—	—	15	34	2
Quadrantids	Jan. 4 (1979)	02	FM	15 28	+50	—	—	40	41	1.1

A Selection of Minor Visual Meteor Showers

Shower	Dates	Date of Max.	Velocity
			km/sec
δ Leonids	Feb. 5–Mar. 19	Feb. 26	23
σ Leonids	Mar. 21–May 13	Apr. 17	20
τ Herculids	May 19–June 14	June 3	15
χ Scorpiids	May 27–June 20	June 5	21
N. δ Aquarids	July 14–Aug. 25	Aug. 12	42
α Capricornids	July 15–Aug. 10	July 30	23
S. ι Aquarids	July 15-Aug. 25	Aug. 5	34
N. ι Aquarids	July 15–Sept. 20	Aug. 20	31
κ Cygnids	Aug. 9–Oct. 6	Aug. 18	25
S. Piscids	Aug. 31–Nov. 2	Sept. 20	26
N. Piscids	Sept. 25–Oct. 19	Oct. 12	29
N. Taurids	Sept. 19–Dec. 1	Nov. 13	29
Annual Andromedids	Sept. 25–Nov. 12	Oct. 3	18–23
Coma Berenicids	Dec. 12–Jan. 23	—	65

NORTH AMERICAN METEORITE IMPACT SITES

By P. Blyth Robertson

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

Of the thirty-six confirmed North American impact structures, which account for almost half of the world's recognized total, meteorite fragments are preserved at only three. In large impacts, where craters greater than approximately 1.5 km in diameter are created, extreme shock pressures and temperatures vapourize or melt the meteorite which subsequently becomes thoroughly mixed with the melted target rocks and is no longer recognizable in its original form. These larger hypervelocity impact craters are therefore identified by the presence of shock metamorphic effects, the characteristic suite of deformation in the target rocks produced by shock pressures exceeding approximately 7 GPa (1 GPa = 10 kilobars). The Conception Bay structure, in fact, comprises four sites at the surface where definitive shock features have been recognized, but the circular crater outline is not evident.

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

In the table, sites accessible by road or boat are marked "A" or "B" respectively and those sites where data have been obtained through diamond-drilling or geophysical surveys are signified by "D" and "G", respectively.

Name	Lat. ° ′	Long. ° ′	Diam. (km)	Age ($\times 10^6$ yr)	Surface Expression	Visible Geologic Features	
Barringer, Meteor Crater, Ariz.	35 02	111 01	1.2	.05	rimmed polygonal crater	fragments of "Canyon Diablo" meteorite, highly shocked sandstone, disturbed rocks	A D G
Brent, Ont.	46 05	078 29	3.8	450 ± 30	sediment-filled shallow depression	fracturing	A D G
Carswell, Sask.	58 27	109 30	37	485 ± 50	discontinuous circular ridge	shatter cones, breccia	G
Charlevoix, Que.	47 32	070 18	46	360 ± 25	semi-circular trough, central elevation	breccia, shatter cones, impact melt	A G
Clearwater Lake East, Que.	56 05	074 07	22	290 ± 20	circular lake	sedimentary float	D G
Clearwater Lake West, Que.	56 13	074 30	32	290 ± 20	island ring in circular lake	impact melt	D G
Conception Bay, Nfld.	47 20	053 12	2	500	4 localities of shocked rock	shatter cones, breccia	A
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
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 δ=85°	80°	75°	70°	60°	50°	40°	30°	20°	10°	0°	Prec. in Dec.	R.A. for Dec.+	R.A. for Dec.−
h m	h m		m	m	m	m	m	m	m	m	m	m	m		h m	h m
12 00	0 00	+16.7	+ 2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	+2.56	−16.7	12 00	*24 00*
12 30	0 30	+16.6	4.22	3.38	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*

FINDING LIST OF NAMED STARS

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

Pronunciations are generally as given by G. A. Davis, *Popular Astronomy*, **52,** 8 (1944). Key to pronunciation on p. 5.

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* $0^m.08$, 0.10^d	*Caph*
γ Peg	12.2	+15 04	2.84v	−0.23	B2	IV	−.004	−3.4	570	0.010	+04.1	β CMa type, *R* in *V* 2.83–2.85, 0.15^d	
β Hyi	24.6	−77 22	2.78	+0.62	G1	IV	0.153	+3.7	21	2.255	+22.8		γ Peg = *Algenib*
α Phe	25.3	−42 25	2.39	+1.08	*K0*	*III*	0.035	+0.1	93	0.442	+*74.6*		*Ankaa*
δ And *A*	38.2	+30 45	3.25:	+1.26	K3	III	0.024	−0.2	160	0.161	−07.3	*B* 12^m 28″	
α Cas	39.4	+56 25	2.22	+1.18	K0	II–III	0.009	−1.1	150	0.058	−03.8	Var.?	*Schedar*
β Cet	42.6	−18 06	2.02	+1.03	K1	III	0.057	+0.8	57	0.234	+13.1		*Diphda*
η Cas *A*	47.9	+57 42	3.47	+0.56	G0	V	0.182	+4.8	18	1.221	+09.4	*B* 7.26^m 12″	
γ Cas *A*	55.5	+60 36	2.5v	−0.16v	B0	IV:pe	0.034	−0.3:	96:	0.026	−06.8	Var. *B* 8.18^m 2″	
β Phe *AB*	01 05.1	−46 50	3.30	+0.88	*G8*	*III*	0.017	+0.3	190	0.035	−01.1	*A* 4.1^m *B* 4.1^m 1″	
η Cet	07.6	−10 17	3.44	+1.16	K3	III	0.032	+1.0	102	0.250	+11.5		
β And	08.6	+35 31	2.02	+1.57	M0	III	0.043	+0.2	76	0.211	+00.3		*Mirach*
δ Cas	24.4	+60 08	2.67	+0.13	A5	V	0.029	+2.1	43	0.301	+06.7	Ecl.? *R* $0.08:^m$ 759^d	*Ruchbah*
γ Phe	27.5	−43 25	3.40	+1.56	K5	IIb–III	−.003	−4.6	1300	0.209	+*25.7*		
α Eri	37.0	−57 20	0.51	−0.16	B3	Vp	0.023	−2.3	118	0.098	+19		***Achernar***
τ Cet	43.2	−16 03	3.50	+0.72	G8	Vp	0.275	+5.70	12	1.921	−16.2		

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
α Tri	01 52.0	+29 29	3.42	+0.50	F6 IV	0.050	+2.0	65	0.230	*−12.6*		
ε Cas	52.9	+63 34	3.37	−0.15	B3 IV:p	0.007	−2.7	520	0.038	−08.1		
β Ari	53.6	+20 43	2.65	+0.14	A5 V	0.063	+1.7	52	0.147	*−04.0*		*Sheratan*
α Hyi	58.1	−61 40	2.84	+0.28	F0 V		+2.9	31	0.265	+07		
γ And *A*	02 02.7	+42 14	2.14:	+1.16:	K3 II	0.005	−2.4	260	0.068	−11.7	*B* 5.4$^\mathrm{m}$ *C* 6.2$^\mathrm{m}$ *A–BC* 10″ *B–C* 0.5″	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$^\mathrm{d}$, *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$^\mathrm{d}$, *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$^\mathrm{d}$	*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		
θ² Tau	27.5	+15 49	3.42	+0.17	A7 III	0.025	+0.2	140	0.108	*+39.5*		
α Dor	33.5	−55 05	3.28	−0.08	A0 IIIp	0.011	−1.2	260	0.051	+25.6	Silicon star	
α Tau *A*	34.8	+16 28	0.86v	+1.52	K5 III	0.048	−0.7	68	0.202	+54.1	Irr.? *R* 0.78–0.93, *B* 13$^\mathrm{m}$ 31″	***Aldebaran***
π³ Ori	48.3	+06 56	3.17	+0.45	F6 V	0.125	+3.65	26	0.468	+24.3		
ι Aur	55.7	+33 08	2.68:	+1.49	K3 II	0.015	−2.4	330	0.021	+17.5		

Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/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 1976: 11″, p.a. 57°	***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	} 18″	***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		
μ¹ Sco	50.5	−38 01	2.99v	−0.20	B1.5 V		−3.0	520	0.033	*−25*	Ecl. *R* 2.99–3.09, 1.4^d	
κ Oph	56.8	+09 25	3.18	+1.15	K2 III	0.026	−0.1	150	0.293	−55.6		
ζ Ara	56.9	−55 57	3.12	+1.61	K4 III	0.036	+0.9	90	0.042	−06.0		
ζ Dra	17 08.7	+65 44	3.20	−0.12	B6 III	0.017	−3.2	620	0.026	−14.1		
η Oph *AB*	09.3	−15 42	2.43	+0.06	A2.5 V	0.047	+1.4	69	0.097	−00.9	*A* 3.0^m *B* 3.4^m 1″	*Sabik*
η Sco	10.7	−43 13	3.33	+0.38	*F2 III*	0.063	+2.3	52	0.293	−28.4		
α Her *AB*	13.8	+14 24	3.10v	+1.41	M5 II	−.007	−2.3	410	0.032	−33.1	*A* 3.2^m ± 0.3 *B* 5.4^m 5″	*Ras-Algethi*
δ Her	14.2	+24 51	3.14	+0.09	A3 IV	0.034	+0.8	96	0.164	−41		
π Her	14.3	+36 49	3.13	+1.43	K3 II	0.020	−2.4	410	0.029	−25.7		
θ Oph	20.8	−24 59	3.29v	−0.22	B2 IV		−3.4	710	0.025	*−03.6*	β CMa var., 0.14^d	
β Ara	23.6	−55 31	2.90:	+1.45:	K1.5 Ib	0.026	−4.6	1030	0.035	−00.4		
γ Ara *A*	23.8	−56 22	3.32	−0.16:	B1 Ib		−3.3	680	0.017	−04	*B* 10^m 18″	
υ Sco	29.4	−37 16	2.71	−0.22	B2 IV		−3.4	540	0.039	*+07*		
β Dra *A*	29.9	+52 20	2.77	+0.96	G2 II	0.009	−2.1	310	0.019	−20.0	*B* 11.49^m 4″	
α Ara	30.3	−49 52	2.95	−0.18:	B2.5 V		−2.4	390	0.083	*−02*		
λ Sco	32.3	−37 05	1.60v	−0.24	B1 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^m 205″	
γ Cyg	21.5	+40 11	2.22	+0.66	F8 Ib	−.006	−4.6	750	0.001	−07.5		
α Pav	24.1	−56 48	1.95	−0.20	B2.5 V		−2.9	310	0.087	*+02.0*		*Peacock*
α Ind	36.2	−47 21	3.11	+1.00	*K0 III*	0.039	+1.1	84	0.082	−01.1		
α Cyg	40.7	+45 12	1.26	+0.09	A2 Ia	−.013	−7.1	1600	0.003	*−04.6*		***Deneb***
β Pav	43.2	−66 17	3.45	+0.16	A7 III	0.026	−0.1	160	0.046	+09.8		
η Cep	44.9	+61 45	3.41	+0.92	K0 IV	0.071	+2.7	46	0.825	−87.3		
ε Cyg	45.4	+33 53	2.46	+1.03	K0 III	0.044	+0.7	74	0.481	*−10.3*		
ζ Cyg	21 12.1	+30 08	3.19	+1.00	G8 II	0.021	−2.2	390	0.056	+17.4		
α Cep	18.2	+62 31	2.44	+0.24	A7 IV–V	0.063	+1.4	52	0.156	−10		*Alderamin*
β Cep	28.4	+70 28	3.15v	−0.22v	B2 III	0.005	−4.2	980	0.014	*−03.1*	β CMa *R* 3.14–3.16, 0.19^d	
β Aqr	30.5	−05 40	2.86	+0.82	G0 Ib	0.000	−4.6	1030	0.017	+06.5		
ε Peg *A*	43.2	+09 48	2.38	+1.55	K2 Ib	−.005	−4.6	780	0.025	+04.7	*B* 11^m 82″	*Enif*
δ Cap	45.9	−16 13	2.92v	+0.29	A6m	0.065	+2.0	50	0.392	*−00.2*	Var. *R* 2.88–2.95	
γ Gru	52.7	−37 27	3.00	−0.10	B8 III	0.008	−3.1	540	0.102	−02.1		
α Aqr	22 04.7	−00 25	2.93	+0.96	G2 Ib	0.003	−4.6	1080	0.016	+07.5		*Al Na'ir*
α Gru	06.9	−47 04	1.76	−0.14	B7 IV	0.051	+0.3:	64:	0.194	+11.8		
ζ Cep	10.1	+58 06	3.36	+1.59	K1 Ib	0.019	−4.6	1240	0.015	*−18.4*		
α Tuc	17.1	−60 21	2.87	+1.40	K4 III	0.019	+1.5	62	0.079	*+42.2*		
δ Cep *A*	28.5	+58 19	3.96v	+0.66v	F5–G2 Ib	0.005	−4.0	1300	0.012	*−16.8*	Cep. *R* 3.51–4.42, 5.4^d, *B* 6.19^m 41″	
ζ Peg	40.5	+10 44	3.40	−0.08:	B8 V	−.004	−0.6	210	0.077	+07		
β Gru	41.5	−46 59	2.17v	+1.59	M5 III	0.003	−2.5	280	0.134	+01.6	Var. *R* 2.11–2.23	
η Peg	42.1	+30 07	2.95	+0.85	G8 II: + F?	−.002	−2.2	360	0.027	*+04.3*		
δ Aqr	53.6	−15 56	3.28	+0.08	A3 V	0.039	+1.2	84	0.047	+18.0		
α PsA	56.5	−29 44	1.15	+0.10	A3 V	0.144	+2.0	22.6	0.367	+06.5		***Fomalhaut***
β Peg	23 02.8	+27 58	2.5 v	+1.67	M2 II–III	0.015	−1.5	210	0.234	+08.7	Var. *R* 2.4–2.7	*Scheat*
α Peg	03.8	+15 05	2.50	−0.03	B9.5 III	0.030	−0.1	109	0.071	−03.5		*Markab*
γ Cep	38.5	+77 30	3.20	+1.02	K1 IV	0.064	+2.2	51	0.168	−42.4		

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 1979.0; 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. 1979.0	Sep. 1979.0	P (app.)
			h	m	°	′	comb.	A	B	°	″	years
λ	Cas	434	00	30.7	+54	26	4.9	5.5	5.8	182	0.6	640
α	Psc	1615	02	01.0	+02	40	4.0	4.3	5.3	282	1.7	720
33	Ori	4123	05	30.2	+03	16	5.7	6.0	7.3	27	1.8	—
OΣ	156	5447	06	46.3	+18	13	6.1	6.8	7.0	243	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	252	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	162	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	356	2.7	1200
ε^2	Lyr[†]	11635	18	43.7	+39	38	4.4	5.1	5.3	84	2.3	600
π	Aql	12962	19	47.7	+11	45	5.6	6.0	6.8	110	1.4	—
OΣ	500	16877	23	36.5	+44	20	5.9	6.4	7.1	355	0.5	—
η	Cas	671	00	47.7	+57	44	3.5*	3.5	7.2	306	11.9	480
Σ	186	1538	01	54.8	+01	45	6.0	6.8	6.8	53	1.2	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	109	0.6	61
OΣ	65	2799	03	49.2	+25	32	5.2	5.8	6.2	207	0.6	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	51	10.5	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	98	2.2	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	286	0.8	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	81	5.9	1150
σ^2	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	3	3.2	1100
γ	Leo	7724	10	18.9	+19	57	1.8	2.1	3.4	123	4.3	620
ξ	UMa	8119	11	17.1	+31	39	3.8	4.3	4.8	107	3.0	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	298	4.0	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	334	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	150	1.2	35
τ	Oph	11005	18	01.9	−08	11	4.7	5.2	5.9	277	1.9	280
70	Oph	11046	18	04.5	+02	32	4.0	4.2	6.0	333	2.1	88
δ	Cyg	12880	19	44.4	+45	04	2.9*	2.9	6.3	234	2.3	830
4	Aqr	14360	20	50.4	−05	53	6.0	6.4	7.2	9	1.0	150
τ	Cyg	14787	21	13.9	+37	57	3.7	3.8	6.4	150	0.9	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	297	1.8	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	228	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	308	1.5	350

*There is a marked colour difference between the components.

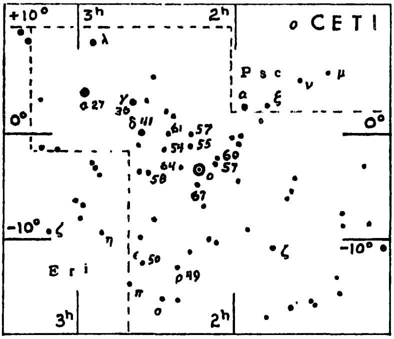
†The separation of the two pairs of ε Lyr is 208″.

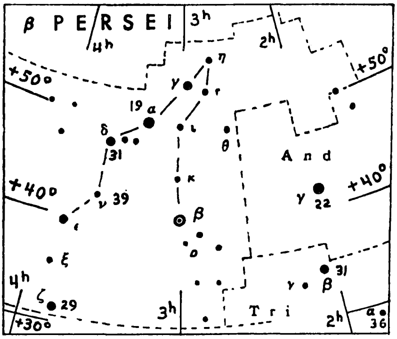
VARIABLE STARS

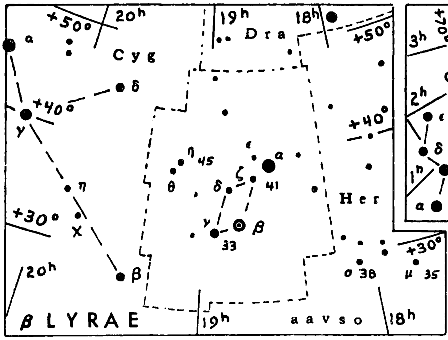
By Janet Mattei

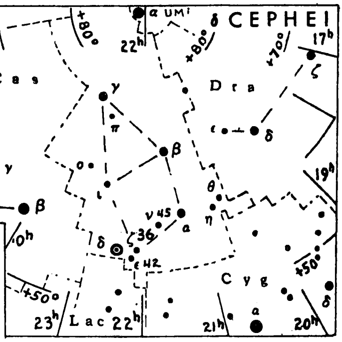
The systematic observation of variable stars is an area in which an amateur can make a valuable contribution to astronomy. For beginning observers, maps of the fields of four bright variable stars are given below. In each case, the magnitudes (with decimal point omitted) of several suitable comparison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

In the tables the first column, the Harvard designation of the star, gives the 1900 position: the first four figures give the hours and minutes of R.A., the last two figures give the Dec. in degrees, italicised for southern declinations. The column headed *Max.* gives the mean maximum magnitude. The *Period* is in days. The *Epoch* gives the predicted date of the *earliest* maximum occurring this year; by adding the period to this epoch other dates of maximum may be found. The list of long-period variables has been prepared by the American Association of Variable Star Observers and includes the variables with maxima brighter than mag. 8.0, and north of Dec. −20°. These variables may reach maximum two or three weeks before or after the listed epoch and may remain at maximum for several weeks. The second table contains stars which are representative of other types of variable. The data are taken from the third edition and the *Second Supplement* of the third edition of "*The General Catalogue of Variable Stars*" by Kukarkin and Parenago and for the eclipsing binaries and RR Lyrae variables from *Rocznik Astronomiczny Obserwatorium Krakowskiego 1978*, *International Supplement.*









LONG-PERIOD VARIABLE STARS

Variable	Max. m	Per d	Epoch 1979	Variable	Max. m	Per d	Epoch 1979
001755 T Cas	7.8	445	Oct. 7	142539 V Boo	7.9	258	May 23
001838 R And	7.0	409	Mar. 13	143227 R Boo	7.2	223	July 16
021143 W And	7.4	397	Feb. 3	151731 S CrB	7.3	361	Jan. 6
0214*03* o Cet	3.4	332	Sept. 24	154639 V CrB	7.5	358	Sept. 26
0228*13* U Cet	7.5	235	May 22	154615 R Ser	6.9	357	July 30
023133 R Tri	6.2	266	Jan. 4	160625 RU Her	8.0	484	Feb. 27
043065 T Cam	8.0	374	Nov. 5	162119 U Her	7.5	406	Oct. 23
0455*14* R Lep	6.8	432	—	1621*12* V Oph	7.5	298	Jan. 15
050953 R Aur	7.7	459	May 16	163266 R Dra	7.6	245	June 3
054920 U Ori	6.3	372	Sept. 29	164715 S Her	7.6	307	Sept. 20
0617*02* V Mon	7.0	335	Feb. 20	1702*15* R Oph	7.9	302	May 8
065355 R Lyn	7.9	379	June 9	171723 RS Her	7.9	219	Jan. 6
070122aR Gem	7.1	370	July 20	180531 T Her	8.0	165	Apr. 10
070310 R CMi	8.0	338	June 16	181136 W Lyr	7.9	196	Jan. 7
072708 S CMi	7.5	332	Feb. 2	183308 X Oph	6.8	334	Aug. 4
081112 R Cnc	6.8	362	Jan. 6	190108 R Aql	6.1	300	June 18
081617 V Cnc	7.9	272	May 30	1910*17* T Sgr	8.0	392	Sept. 3
084803 S Hya	7.8	257	May 15	1910*19* R Sgr	7.3	269	Jan. 21
0850*08* T Hya	7.8	288	July 20	193449 R Cyg	7.5	426	Nov. 2
093934 R LMi	7.1	372	Apr. 5	194048 RT Cyg	7.3	190	May 19
094211 R Leo	5.8	313	Oct. 27	194632 χ Cyg	5.2	407	Nov. 21
103769 R UMa	7.5	302	Aug. 9	201647 U Cyg	7.2	465	Aug. 6
1214*18* R Crv	7.5	317	June 29	2044*05* T Aqr	7.7	202	Mar. 31
122001 SS Vir	6.8	355	Feb. 5	210868 T Cep	6.0	390	Oct. 7
123160 T UMa	7.7	257	July 14	213753 RU Cyg	8.0	234	June 19
123307 R Vir	6.9	146	Apr. 9	230110 R Peg	7.8	378	Mar. 25
123961 S UMa	7.8	226	Apr. 9	230759 V Cas	7.9	228	Jan. 21
131546 V CVn	6.8	192	Mar. 9	231508 S Peg	8.0	319	June 7
1327*06* S Vir	7.0	378	Feb. 10	2338*15* R Aqr	6.5	387	Feb. 27
134440 R CVn	7.7	328	Feb. 9	235350 R Cas	7.0	431	June 11
142584 R Cam	7.9	270	Mar. 30	2357*15* W Cet	7.6	351	Jan. 29

OTHER TYPES OF VARIABLE STARS

Variable		Max. m	Min. m	Type	Sp. Cl.	Period d	Epoch 1979 E.S.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 2.24*
025838	ρ Per	3.3	4.0	Semi R	M4	33–55, 1100	—
030140	β Per	2.1	3.3	Ecl.	B8+G	2.86731	—
035512	λ Tau	3.5	4.0	Ecl.	B3	3.952952	Jan. 2.89*
060822	η Gem	3.1	3.9	Semi R	M3	233.4	—
061907	T Mon	6.4	8.0	δ Cep	F7–K1	27.0205	Jan. 18.27
065820	ζ Gem	4.4	5.2	δ Cep	F7–G3	10.15082	Jan. 3.49
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	6.3	8.6	RVTau	G0e-K0p	144	—
184633	β Lyr	3.4	4.3	Ecl.	B8	12.9350	Jan. 7.10*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.5668158	Jan. 1.40
194700	η Aql	4.1	5.2	δ Cep	F6–G4	7.176641	Jan. 4.78
222557	δ Cep	4.1	5.2	δ Cep	F5–G2	5.366341	—

***Minimum.**

BRIEF DESCRIPTION OF VARIABLE TYPES

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

I. *Pulsating Variables*

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

RR Lyrae Type: Pulsating, giant variables with periods ranging from $0^d\!.05$ to $1^d\!.2$ and amplitude of light variation between 1 and 2^m. They are usually of A spectral class. Typical representative: RR Lyrae.

RV Tauri Type: Supergiant variables with light curves of alternating deep and shallow minima. The periods, defined as the interval between two deep minima, range from 30 to 150 days. The amplitude of light variations goes up to 3^m. Many show long term variations of 500 to 9000 days in their mean magnitude. Generally the spectral classes range from G to K. Typical representative: R Scuti.

Long period—Mira Ceti variables: Giant variables that vary with amplitudes from 2.5 to 5^m and larger with well defined periodicity, ranging from 80 to 1000 days. They show characteristic emission spectra of late spectral classes of Me, Ce and Se. Typical representative: *o* Ceti (Mira).

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

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

II. *Eruptive Variables*

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

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

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

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

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

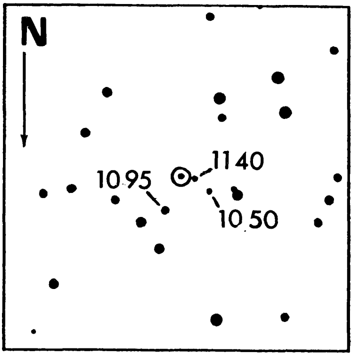
III. *Eclipsing Binaries*

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

Each year, in co-operation with the AAVSO, we introduce a new variable to our readers; the 1976, 1977 and 1978 HANDBOOKS introduced R CrB, R Sct and Z UMa respectively. This year, we introduce two new variables.

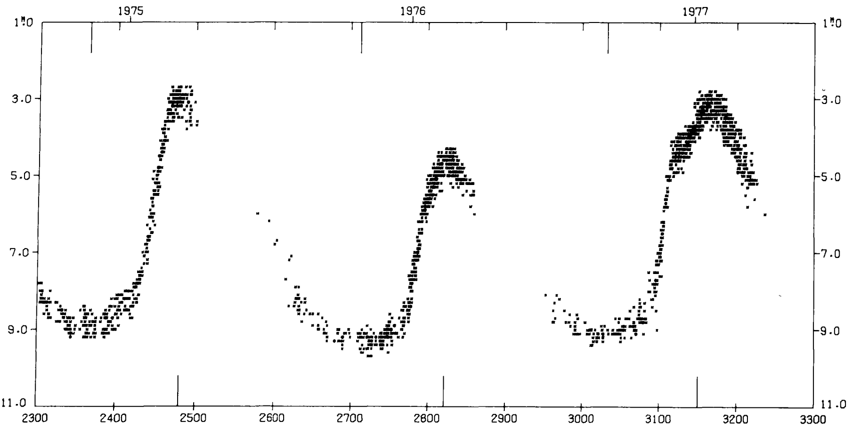
The first is CY Aqr, a dwarf Cepheid pulsating variable. It has a period of only 0.061 day. It rises from $11^{m}3$ to $10^{m}5$ in only ten minutes, then fades more slowly. Its variations can be studied visually with a telescope of moderate aperture, and several cycles can be recorded in a single night. The observer can plot up a light curve right at the telescope, and see the results almost immediately. The study of this star is a good project for an amateur or student.

The star is located at R. A. 22^{h} $35^{m}2$, Dec. +01° 16′ (1950). Plot this position on the *Atlas Eclipticalis* or other suitable star atlas, and use the finding chart to locate the variable.



Finding Chart—CY Aquarii.

The second variable is hardly new; it is o Ceti (or *Mira*), the prototype of all pulsating variables! It was discovered in 1596, and has a period of 332 days and an average range of from $3^{m}4$ to $9^{m}3$. When it is near maximum, it is observable with a small telescope, binoculars or even the unaided eye. Early evening and predawn observations at the beginning and at the end of its visibility season are of particular importance. A finding chart is located on page 116. As shown in the following light curve, its maximum brightness is quite variable; this is the reason for calling attention to it now.



AAVSO Light Curve of Mira: 1975–1977.

THE NEAREST STARS

By Alan H. Batten

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

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

Measuring the distances of stars is one of the most difficult and important jobs of an observational astronomer. As the earth travels around the sun each year, the positions of the nearer stars, against the background of the more distant ones, changes very slightly. This change is called *annual parallax*, and even for the nearest star to the sun it is less than the apparent size of a penny at about 4 km distance. Ultimately all our knowledge of distances in the universe depends on our being able to measure these tiny apparent displacements accurately, for a relatively small sample of nearby stars. A graphic way of conveying the immense distances of stars is to express them in *light-years*. One light-year, about ten million million km, is the distance light travels in one year. The more useful technical unit is a *parsec*—the distance at which a star would have an annual parallax of one second of arc. One parsec is equal to about 3.27 light years. The distance of a star in parsecs is simply the reciprocal of its annual parallax expressed (as in the table) in seconds of arc.

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

Name	1980 α		1980 δ		π	D	Sp.	μ	W	V	Mv
	h	m	°	′	″	l.y.		″	km/sec		
Sun							G2			−26.72	+4.85
α Cen A	14	38	−60	46	0.760	4.3	G2	3.68	32	−0.01	4.39
B							K4			1.33	5.73
C	14	28	−62	36			M5e	3.85	29	11.05	15.45
Barnard's*	17	56	+04	36	.552	5.9	M5	10.61	108	9.54	13.25
Wolf 359	10	56	+07	10	.431	7.6	M8e	4.71	54	13.53	16.70
BD+36°2147*	11	03	+36	07	.402	8.1	M2e	4.78	102	7.50	10.52
Sirius A	6	44	−16	42	.377	8.6	A1	1.33	19	−1.46	1.42
B							*wd*A			8.7	11.6
Luy.726–8A	1	37	−18	04	.365	8.9	M5e	3.36	52	12.5	15.3
B							M5e		54	(13.0)	(15.8)
Ross 154	18	49	−23	50	.345	9.4	M5e	0.72	11	10.6	13.3
Ross 248	23	40	+44	04	.317	10.3	M6e	1.58	84	12.29	14.80
ε Eri	3	32	−09	32	.305	10.7	K2e	0.98	23	3.73	6.15
Luy 789–6	22	38	−15	28	.302	10.8	M7e	3.26	79	12.18	14.58
Ross 128	11	47	+00	58	.301	10.8	M5	1.37	25	11.10	13.49
61 Cyg A	21	06	+38	38	.292	11.2	K5e	5.22	105	5.22	7.55
B*							K7e			6.03	8.36
ε Ind	22	03	−56	52	.291	11.2	K8e	4.69	86	4.68	7.00
Procyon A	7	39	+05	17	.287	11.4	F5	1.25	21	0.37	2.66
B							*wd*F			10.7	12.99
Σ 2398 A	18	42	+59	36	.284	11.5	M4	2.28	39	8.90	11.17
B							M5			9.69	11.96
BD+43°44A	0	18	+43	54	.282	11.6	M1e	2.89	50	8.07	10.32
B							M6e		53	11.04	13.29
CD−36°15693	23	05	−35	59	.279	11.7	M2e	6.90	118	7.36	9.59
τ Ceti	1	43	−16	03	.273	11.9	G8p	1.92	36	3.50	5.68
G51–15	8	29	+26	51	.273	12.0		0.42		14.81	16.99
BD+5°1668*	7	27	+05	27	.266	12.2	M5	3.73	71	9.82	11.94
Luy 725–32	1	11	−17	06	.262	12.5	M5e	1.31	52	11.6	13.7
CD−39°14192	21	16	−38	58	.260	12.6	M0e	3.46	67	6.67	8.75
Kapteyn's	5	11	−44	59	.256	12.7	M0	8.89	293	8.81	10.85
Krüger 60A	22	27	+57	36	.254	12.8	M3	0.86	30	9.85	11.87
B							M4.5e			(11.3)	(13.3)
Ross 614A	6	28	−02	48	.249	13.1	M7e	0.99	30	11.07	13.05
B										14.8	16.8
BD−12°4523	16	30	−12	36	.249	13.1	M5	1.18	26	10.12	12.10
van Maanen's	0	48	+05	19	.234	13.9	*wd*G	2.95	59	12.37	14.22
Wolf 424A	12	33	+09	09	.229	14.2	M6e	1.75	37	13.16	14.96
B							M6e			13.4	15.2
G158–27	0	06	−07	38	.226	14.4		2.06		13.73	15.50
CD−37°15492	0	04	−37	27	.225	14.5	M4	6.08	130	8.63	10.39
BD+50°1725	10	10	+49	33	.217	15.0	K7e	1.45	40	6.59	8.27
CD−46°11540	17	28	−46	53	.216	15.1	M4	1.13		9.36	11.03
CD−49°13515	21	32	−49	11	.214	15.2	M1	0.81	20	8.67	10.32
CD−44°11909*	17	37	−44	17	.213	15.3	M5	1.16		11.2	12.8
G208–44	19	53	+44	21	.213	15.3		0.75		13.41	15.05
Luy 1159–16	1	59	+13	00	.212	15.4	M8e	2.08		12.27	13.90
BD+15°2620	13	44	+15	01	.208	15.7	M4e	2.30	56	8.50	10.09
G208–45	19	53	+44	21	.207	15.8	M5	0.63		13.99	15.57
BD+68°946	17	37	+68	22	.207	15.8	M4	1.33	36	9.15	10.73
Luy 145–141	11	44	−64	42	.206	15.9	*wd*	2.68		11.44	13.01
BD−15°6290	22	52	−14	22	.206	15.9	M5	1.16	28	10.17	11.74
o² Eri A	4	14	−07	41	.205	15.9	K1e	4.08	104	4.43	5.99
B							*wd*A			9.53	11.09
C							M4e			11.17	12.73
BD+20°2465*	10	19	+19	58	.202	16.1	M4e	0.49	16	9.43	10.96
BD+44°2051A	11	05	+43	36	.199	16.4	M2e	4.40	132	8.77	10.26
B							M8e			(14.5)	(16.0)
Altair	19	49	+08	49	.196	16.6		0.66	31	0.76	2.22
70 Oph A	18	05	+02	31	.195	16.7	K0e	1.13	28	4.22	5.67
B							K5e			6.0	7.5
AC+79°3888	11	46	+78	47	.194	16.8	M4	0.89	121	10.9	12.3
BD+43°4305*	22	46	+44	14	.193	16.9	M5e	0.83	20	10.2	11.6
Stein 2051A	4	30	+58	57	.192	17.0	M4	2.37		11.09	12.51
B							*wd*			12.44	13.86
G9–38A	8	57	+19	51	.190	17.2		0.89		14.06	15.45
B								0.79		14.92	16.31

*Suspected unseen companion.

GALACTIC NEBULAE

BY RENÉ RACINE

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

NGC	M	Con	α 1980 δ		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	

MESSIER'S CATALOGUE OF DIFFUSE OBJECTS

This table lists the 103 objects in Messier's original catalogue. The columns contain: Messier's number (M), the number in Dreyer's New General Catalogue (NGC), the constellation, the 1970 position, the integrated visual magnitude (m_v), and the class of object. OC means open cluster, GC, globular cluster, PN, planetary nebula, DN, diffuse nebula, and G, galaxy. The type of galaxy is also indicated, as explained in the table of external galaxies. An asterisk indicates that additional information about the object may be found elsewhere in the *Handbook*, in the appropriate table.

M	NGC	Con	α 1980	δ	m_v	Type
1	1952	Tau	5 33.3	+22 01	11.3	DN*
2	7089	Aqr	21 32.4	−00 54	6.27	GC*
3	5272	CVn	13 41.3	+28 29	6.22	GC*
4	6121	Sco	16 22.4	−26 27	6.07	GC*
5	5904	Ser	15 17.5	+02 11	5.99	GC*
6	6405	Sco	17 38.9	−32 11	6	OC*
7	6475	Sco	17 52.6	−34 48	5	OC*
8	6523	Sgr	18 02.4	−24 23		DN*
9	6333	Oph	17 18.1	−18 30	7.58	GC
10	6254	Oph	16 56.0	−04 05	6.40	GC*
11	6705	Sct	18 50.0	−06 18	7	OC*
12	6218	Oph	16 46.1	−01 55	6.74	GC*
13	6205	Her	16 41.0	+36 30	5.78	GC*
14	6402	Oph	17 36.5	−03 14	7.82	GC
15	7078	Peg	21 29.1	+12 05	6.29	GC*
16	6611	Ser	18 17.8	−13 48	7	OC*
17	6618	Sgr	18 19.7	−16 12	7	DN*
18	6613	Sgr	18 18.8	−17 09	7	OC
19	6273	Oph	17 01.3	−26 14	6.94	GC
20	6514	Sgr	18 01.2	−23 02		DN*
21	6531	Sgr	18 03.4	−22 30	7	OC
22	6656	Sgr	18 35.2	−23 55	5.22	GC*
23	6494	Sgr	17 55.7	−19 00	6	OC*
24	6603	Sgr	18 17.3	−18 27	6	OC
25	4725†	Sgr	18 30.5	−19 16	6	OC*
26	6694	Sct	18 44.1	−09 25	9	OC
27	6853	Vul	19 58.8	+22 40	8.2	PN*
28	6626	Sgr	18 23.2	−24 52	7.07	GC
29	6913	Cyg	20 23.3	+38 27	8	OC
30	7099	Cap	21 39.2	−23 15	7.63	GC
31	224	And	0 41.6	+41 09	3.7	G-Sb*
32	221	And	0 41.6	+40 45	8.5	G-E*
33	598	Tri	1 32.8	+30 33	5.9	G-Sc*
34	1039	Per	2 40.7	+42 43	6	OC
35	2168	Gem	6 07.6	+24 21	6	OC*
36	1960	Aur	5 35.0	+34 05	6	OC
37	2099	Aur	5 51.5	+32 33	6	OC*
38	1912	Aur	5 27.3	+35 48	6	OC
39	7092	Cyg	21 31.5	+48 21	6	OC
40	—	UMa	—	—		2 stars
41	2287	CMa	6 46.2	−20 43	6	OC*
42	1976	Ori	5 34.4	−05 24		DN*
43	1982	Ori	5 34.6	−05 18		DN
44	2632	Cnc	8 38.8	+20 04	4	OC*
45	—	Tau	3 46.3	+24 03	2	OC*
46	2437	Pup	7 40.9	−14 46	7	OC*
47	2422	Pup	7 35.6	−14 27	5	OC
48	2548	Hya	8 12.5	−05 43	6	OC
49	4472	Vir	12 28.8	+08 07	8.9	G-E*
50	2323	Mon	7 02.0	−08 19	7	OC
51	5194	CVn	13 29.0	+47 18	8.4	G-Sc*
52	7654	Cas	23 23.3	+61 29	7	OC
53	5024	Com	13 12.0	+18 17	7.70	GC
54	6715	Sgr	18 53.8	−30 30	7.7	GC
55	6809	Sgr	19 38.7	−31 00	6.09	GC*
56	6779	Lyr	19 15.8	+30 08	8.33	GC
57	6720	Lyr	18 52.9	+33 01	9.0	PN*
58	4579	Vir	12 36.7	+11 56	9.9	G-SBb
59	4621	Vir	12 41.0	+11 47	10.3	G-E
60	4649	Vir	12 42.6	+11 41	9.3	G-E
61	4303	Vir	12 20.8	+04 36	9.7	G-Sc
62	6266	Sco	16 59.9	−30 05	7.2	GC
63	5055	CVn	13 14.8	+42 08	8.8	G-Sb*
64	4826	Com	12 55.7	+21 48	8.7	G-Sb*
65	3623	Leo	11 17.8	+13 13	9.6	G-Sa
66	3627	Leo	11 19.1	+13 07	9.2	G-Sb
67	2682	Cnc	8 50.0	+11 54	7	OC*
68	4590	Hya	12 38.3	−26 38	8.04	GC
69	6637	Sgr	18 30.1	−32 23	7.7	GC
70	6681	Sgr	18 42.0	−32 18	8.2	GC
71	6838	Sge	19 52.8	+18 44	6.9	GC
72	6981	Aqr	20 52.3	−12 39	9.15	GC
73	6994	Aqr	20 57.8	−12 44		OC
74	628	Psc	1 35.6	+15 41	9.5	G-Sc
75	6864	Sgr	20 04.9	−21 59	8.31	GC
76	650	Per	1 40.9	+51 28	11.4	PN*
77	1068	Cet	2 41.6	−00 04	9.1	G-Sb
78	2068	Ori	5 45.8	+00 02		DN
79	1904	Lep	5 23.3	−24 32	7.3	GC
80	6093	Sco	16 15.8	−22 56	7.17	GC
81	3031	UMa	9 54.2	+69 09	6.9	G-Sb*
82	3034	UMa	9 54.4	+69 47	8.7	G-Irr*
83	5236	Hya	13 35.9	−29 46	7.5	G-Sc*
84	4374	Vir	12 24.1	+13 00	9.8	G-E
85	4382	Com	12 24.3	+18 18	9.5	G-SO
86	4406	Vir	12 25.1	+13 03	9.8	G-E
87	4486	Vir	12 29.7	+12 30	9.3	G-Ep
88	4501	Com	12 30.9	+14 32	9.7	G-Sb
89	4552	Vir	12 34.6	+12 40	10.3	G-E
90	4569	Vir	12 35.8	+13 16	9.7	G-Sb
91	—	—	—	—		M58?
92	6341	Her	17 16.5	+43 10	6.33	GC*
93	2447	Pup	7 43.6	−23 49	6	OC
94	4736	CVn	12 50.1	+41 14	8.1	G-Sb*
95	3351	Leo	10 42.8	+11 49	9.9	G-SBb
96	3368	Leo	10 45.6	+11 56	9.4	G-Sa
97	3587	UMa	11 13.7	+55 08	11.1	PN*
98	4192	Com	12 12.7	+15 01	10.4	G-Sb
99	4254	Com	12 17.8	+14 32	9.9	G-Sc
100	4321	Com	12 21.9	+15 56	9.6	G-Sc
101	5457	UMa	14 02.5	+54 27	8.1	G-Sc*
102	—	—	—	—		M101?
103	581	Cas	1 31.9	+60 35	7	OC

†Index Catalogue Number.

STAR CLUSTERS

By T. Schmidt-Kaler

The star clusters for this list have been selected to include those most conspicuous. Two types of clusters can be recognized: open (or galactic), and globular. Globulars appear as highly symmetrical agglomerations of very large numbers of stars, distributed throughout the galactic halo but concentrated toward the centre of the Galaxy. Their colour-magnitude diagrams are typical for the old stellar population II. Open clusters appear usually as irregular aggregates of stars, sometimes barely distinguished from random fluctuations of the general field. They are concentrated to the galactic disk, with colour-magnitude diagrams typical for the stellar population I of the normal stars of the solar neighbourhood.

The first table includes all well-defined open clusters with diameters greater than 40′ or integrated magnitudes brighter than 5.0, as well as the richest clusters and some of special interest. *NGC* indicates the serial number of the cluster in Dreyer's *New General Catalogue of Clusters and Nebulae*, *M*, its number in Messier's catalogue, α and δ denote right ascension and declination, *P*, the apparent integrated photographic magnitude according to Collinder (1931), *D*, the apparent diameter in minutes of arc according to Trumpler (1930) when possible, in one case from Collinder; *m*, the photographic magnitude of the fifth-brightest star according to Shapley (1933) when possible or from new data, in italics; *r*, the distance of the cluster in kpcs (1 kpc = 3263 light-years), usually as given by Becker and Fenkart (1971); Sp, the earliest spectral type of cluster stars as a mean determined from three colour photometry and directly from the stellar spectra. The spectral type indicates the age of the cluster, expressed in millions of years, thus: O5 = 2, B0 = 8, B5 = 70, A0 = 400, A5 = 1000, F0 = 3000 and F5 = 10000.

The second table includes all globular clusters with a total apparent photographic magnitude brighter than 7.6. The first three columns are as in the first table, followed by *B*, the total photographic magnitude; *D*, the apparent diameter in minutes of arc containing 90 per cent of the stars, and in italics, total diameters from miscellaneous sources; *Sp*, the integrated spectral type; *m*, the mean blue magnitude of the 25 brightest stars (excluding the five brightest); *N*, the number of known variables; *r*, the distance in kpcs (absolute magnitude of RR Lyrae variables taken as M_B = +0.5); *V*, the radial velocity in km/sec. The data are taken from a compilation by Arp (1965); in case no data were available there, various other sources have been used, especially H. S. Hogg's Bibliography (1963).

Open Clusters

NGC	α 1980 δ							
	h m	° ′	P	D	m	r	Sp	Remarks
188	00 42.0	+85 14	9.3	14	14.6	1.55	F2	oldest known
752	01 56.6	+37 35	6.6	45	9.6	0.38	A5	
869	02 17.6	+57 04	4.3	30	9.5	2.15	B1	h Per
884	02 21.0	+57 02	4.4	30	9.5	2.48	B0	χ Per, M supergiants
Perseus	03 21	+48 32	2.3	240	5	0.17	B1	moving cl., α Per
Pleiades	03 45.9	+24 04	1.6	120	4.2	0.125	B6	M45, best known
Hyades	04 19	+15 35	0.8	400	*1.5*	0.040	A2	moving cl. in Tau*
1912	05 27.3	+35 49	7.0	18	9.7	1.41	B5	
1976/80	05 34.4	−05 24	2.5	50	*5.5*	0.41	O5	Trapezium, very young
2099	05 51.1	+32 32	6.2	24	9.7	1.28	B8	M37
2168	06 07.6	+24 21	5.6	29	9.0	0.87	B5	M35
2232	06 25.5	−04 44	4.1	*20*	7	0.49	B3	
2244	06 31.3	+04 53	5.2	27	*8.0*	1.62	O5	Rosette, very young
2264	06 39.9	+09 54	4.1	30	*8.0*	0.72	O8	S Mon
2287	06 46.2	−20 43	5.0	32	*8.8*	0.66	B4	M41
2362	07 18.0	−24 54	3.8	7	9.4	1.64	O9	τ CMa
2422	07 34.7	−14 27	4.3	30	9.8	0.48	B3	

*Basic for distance determination.

NGC	α 1980 δ		P	D	m	r	Sp	Remarks
	h m	° ′						
2437	07 40.9	−14 46	6.6	27	10.8	1.66	B8	M46
2451	07 44.7	−37 55	3.7	37	6	0.30	B5	
2516	07 58.0	−60 51	3.3	50	10.1	0.37	B8	
2546	08 11.8	−37 35	5.0	45	7	0.84	B0	
2632	08 39.0	+20 04	3.9	90	7.5	0.158	A0	Praesepe, M44
IC2391	08 39.7	−52 59	2.6	45	3.5	0.15	B4	
IC2395	08 40.4	−48 07	4.6	20	10.1	0.90	B2	
2682	08 49.3	+11 54	7.4	18	10.8	0.83	F2	M67, old cl.
3114	10 02.0	−60 01	4.5	37	7	0.85	B5	
IC2602	10 42.6	−64 17	1.6	65	6	0.15	B1	θ Car
Tr 16	10 44.4	−59 36	6.7	10	10	2.95	O5	η Car and Nebula
3532	11 05.5	−58 33	3.4	55	8.1	0.42	B8	
3766	11 35.2	−61 30	4.4	12	8.1	1.79	B1	
Coma	12 24.1	+26 13	2.9	300	5.5	0.08	A1	Very sparse cl.
4755	12 52.4	−60 13	5.2	12	7	2.10	B3	κ Cru, "jewel box"
6067	16 11.7	−54 10	6.5	16	10.9	1.45	B3	G and K supergiants
6231	16 52.6	−41 46	8.5	16	7.5	1.77	O9	O supergiants, WR-stars
Tr 24	16 55.6	−40 38	8.5	60	*7.3*	1.60	O5	
6405	17 38.8	−32 12	4.6	26	8.3	0.45	B4	M6
IC4665	17 45.7	+05 44	5.4	50	7	0.33	B8	
6475	17 52.6	−34 48	3.3	50	7.4	0.23	B5	M7
6494	17 55.7	−19 01	5.9	27	10.2	0.44	B8	M23
6523	18 01.9	−24 23	5.2	45	*7*	1.56	O5	M8, Lagoon neb. and very young cl. NGC6530
6611	18 17.8	−13 48	6.6	8	10.6	1.69	O7	M16, nebula
IC4725	18 30.5	−19 16	6.2	35	9.3	0.60	B3	M25, Cepheid, U Sgr
IC4756	18 38.3	+05 26	5.4	50	8.5	0.44	A3	
6705	18 50.0	−06 18	6.8	12.5	12	1.70	B8	M11, very rich cl.
Mel 227	20 08.2	−79 23	5.2	60	*9*	0.24	B9	
IC1396	21 38.3	+57 25	5.1	60	*8.5*	0.71	O6	Tr 37
7790	23 57.4	+61	7.1	4.5	11.7	3.16	B1	Cepheids: CEa, CEb, CF Cas

Globular Clusters

NGC	M	α 1980 δ		B	D	Sp	m	N	r	V
		h m	° ′							
104	47 Tuc	00 23.1	−72 11	4.35	*44*	G3	13.54	11	5	−24
*1851		05 13.3	−40 02	7.72:	*11.5*	F7		3	14.0	+309
2808		09 11.5	−64 42	7.4	*18.8*	F8	15.09	4	9.1	+101
5139	ω Cen	13 25.6	−47 12	4.5	*65.4*	F7	13.01	165	5.2	+230
5272	3	13 41.3	+28 29	6.86	9.3	F7	14.35	189	10.6	−153
5904	5	15 17.5	+02 10	6.69	10.7	F6	14.07	97	8.1	+49
6121	4	16 22.4	−26 28	7.05	22.6	*G0*	13.21	43	4.3	+65
6205	13	16 41.0	+36 30	6.43	12.9	F6	13.85	10	6.3	−241
6218	12	16 46.1	−01 55	7.58	21.5	F8	14.07	1	7.4	−16
6254	10	16 56.0	−04 05	7.26	16.2	G1	14.17	3	6.2	+71
*6341	92	17 16.5	+43 10	6.94	12.3	F1	13.96	16	7.9	−118
6397		17 39.2	−53 40	6.9	*19*	F5	12.71	3	2.9	+11
6541		18 06.5	−43 45	7.5	*23.2*	F6	13.45	1	4.0	−148
6656	22	18 35.1	−23 56	6.15	26.2	F7	13.73	24	3.0	−144
6723		18 58.3	−36 39	7.37	11.7	G4	14.32	19	7.4	−3
6752		19 09.1	−60 01	6.8	*41.9*	F6	13.36	1	5.3	−39
6809	55	19 38.8	−30 59	6.72	21.1	F5	13.68	6	6.0	+170
*7078	15	21 29.1	+12 05	6.96	9.4	F2	14.44	103	10.5	−107
7089	2	21 32.4	−00 55	6.94	6.8	F4	14.77	22	12.3	−5

*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

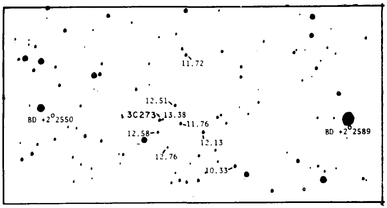
NGC or name	M	α 1980 δ h m	° ′	Type	m_{pg}	Dimensions ′ ′	Distance millions of l.y.
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		00 46.6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

The Nearest Galaxies

Name	NGC	α 1980 δ h m	° ′	m_{pg}	$(m - M)_{pg}$	M_{pg}	Type	Dist. thous. of l.y.
M31	224	00 41.6	+41 10	4.33	24.65	−20.3	Sb I–II	2,100
Galaxy		—	—	—	—	?	Sb or Sc	—
M33	598	01 32.8	+30 33	6.19	24.70	−18.5	Sc II–III	2,400
LMC		05 23.7	−69 46	0.86	18.65	−17.8	Ir or SBc III–IV	160
SMC		00 52.0	−72 56	2.86	19.05	−16.2	Ir IV or IV–V	190
NGC	205	00 39.2	+41 35	8.89	24.65	−15.8	E6p	2,100
M32	221	00 41.6	+40 46	9.06	24.65	−15.6	E2	2,100
NGC	6822	19 43.8	−14 49	9.21	24.55	−15.3	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

VARIABLE GALAXIES

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



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

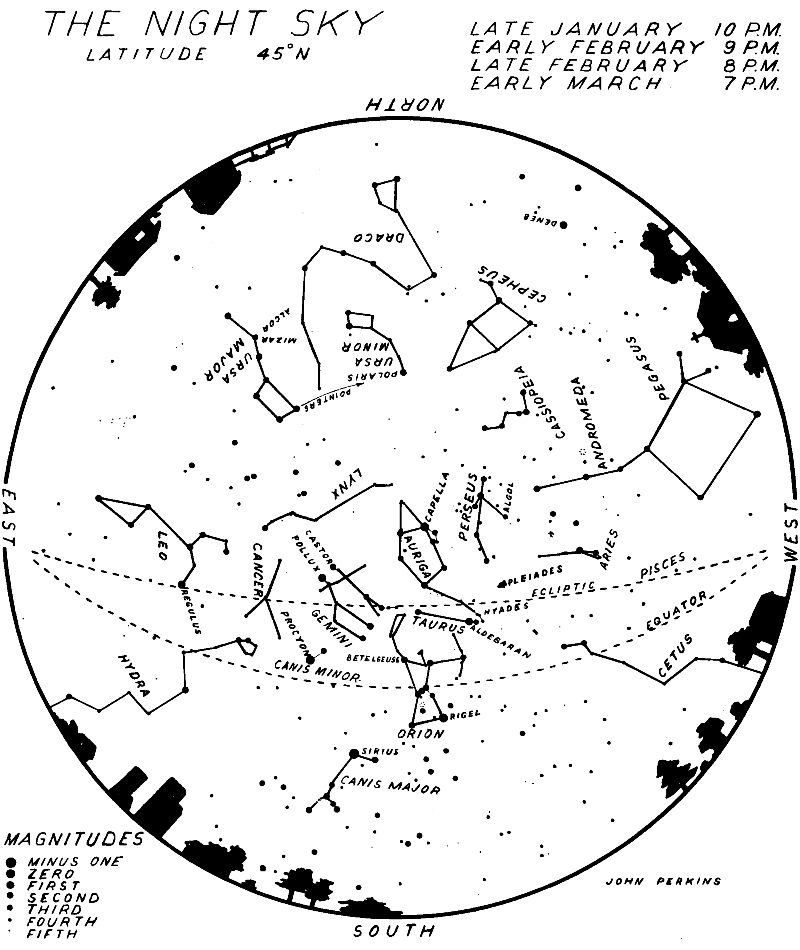
RADIO SOURCES

By John Galt

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

Name	α (1980) h m	δ ° ′	Remarks
Tycho's s'nova	00 24.6	+64 01	Remnant of supernova of 1572
Andromeda gal.	00 41.5	+41 09	Closest normal spiral galaxy
IC 1795, W3	02 23.9	+62 01	Multiple HII region, OH emission
Algol	03 06.6	+40 52	Star emits high freq. radio waves
NGC 1275, 3C 84	03 18.5	+41 26	Seyfert galaxy, radio variable
CP 0328	03 31.3	+54 29	Pulsar, period = 0.7145 sec., H abs'n.
Crab neb, M1*	05 33.2	+22 00	Remnant of supernova of 1054
NP 0532	05 33.2	+22 00	Radio, optical & X-ray pulsar
V 371 Orionis	05 32.7	+01 54	Red dwarf, radio & optical flare star
Orion neb, M42	05 34.3	−05 24	HII region, OH emission, IR source
IC 443	06 16.1	+22 36	Supernova remnant (date unknown)
Rosette neb	06 30.9	+04 53	HII region
YV CMa	07 22.2	−20 42	Optical var. IR source, OH, H_2O emission
3C 273	12 28.0	+02 10	Nearest, strongest quasar
Virgo A, M87*	12 29.8	+12 30	EO galaxy with jet
Centaurus A	13 24.2	−42 55	NGC 5128 peculiar galaxy
3C 295	14 10.7	+52 18	21st mag. galaxy, 4,500,000,000 light years
OQ 172	14 44.3	+10 04	Quasar, very large redshift Z = 3.53
Scorpio X-1	16 18.8	−15 35	X-ray, radio optical variable
3C 353	17 19.5	−00 58	Double source, probably galaxy
Kepler's s'nova	17 27.6	−21 16	Remnant of supernova of 1604
Galactic nucleus	17 44.3	−28 56	Complex region OH, NH_3 em., H_2CO abs'n.
Omega neb, M17	18 19.3	−16 10	HII region, double structure
CP 1919	19 20.8	+21 50	First pulsar discovered, P = 1.337 sec.
Cygnus A*	19 58.7	+40 41	Strong radio galaxy, double source
Cygnus X	20 21.9	+40 19	Complex region
NML Cygnus	20 45.8	+40 02	Infrared source, OH emission
Cygnus loop	20 51.4	+29 36	S'nova remnant (Network nebula)
N. America	20 54.4	+43 59	Radio shape resembles photographs
BL Lac	22 01.9	+42 11	Radio and optical variable
3C 446	22 24.7	−05 04	Quasar, optical mag. & spectrum var.
Cassiopeia A*	23 22.5	+58 42	Strongest source, s'nova remnant
Sun*			Continuous emission & bursts
Moon			Thermal source only
Jupiter*			Radio bursts controlled by Io

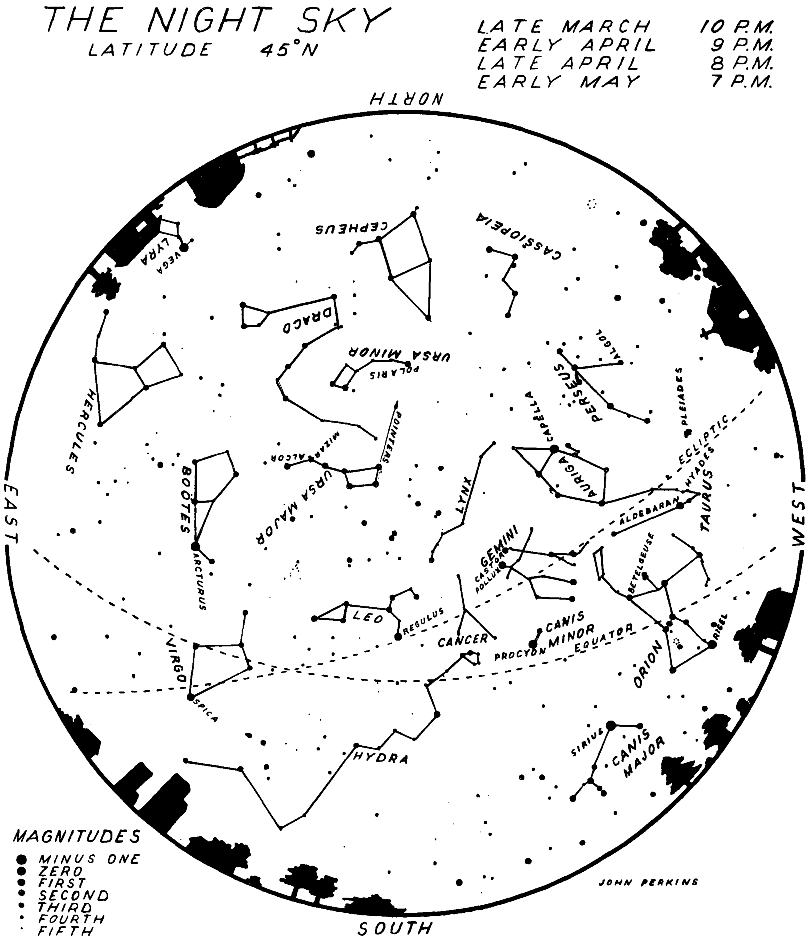
Sources marked * could be detected with amateur radio telescopes. (For more information about amateur radio astronomy, see *Astronomy*, **5**, no. 12, 50 (1977), a series of articles in *J. Roy. Ast. Soc. Canada*, **72**, L5, L22, L38 . . . (1978) and a series of articles in *Sky and Telescope*, **55**,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



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

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

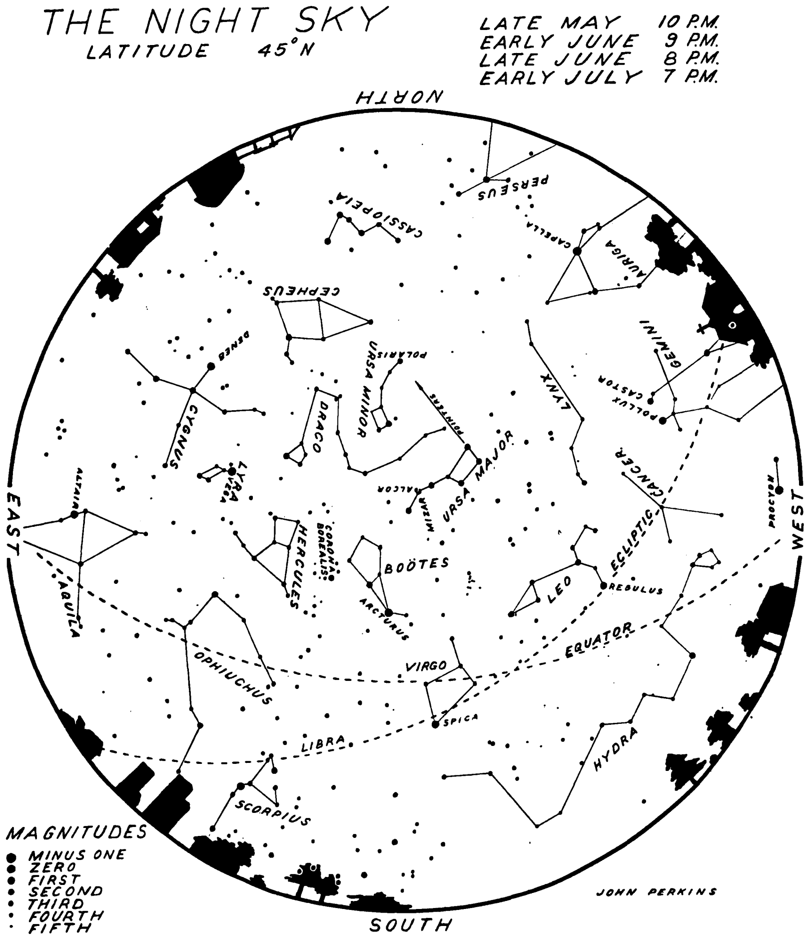
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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

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

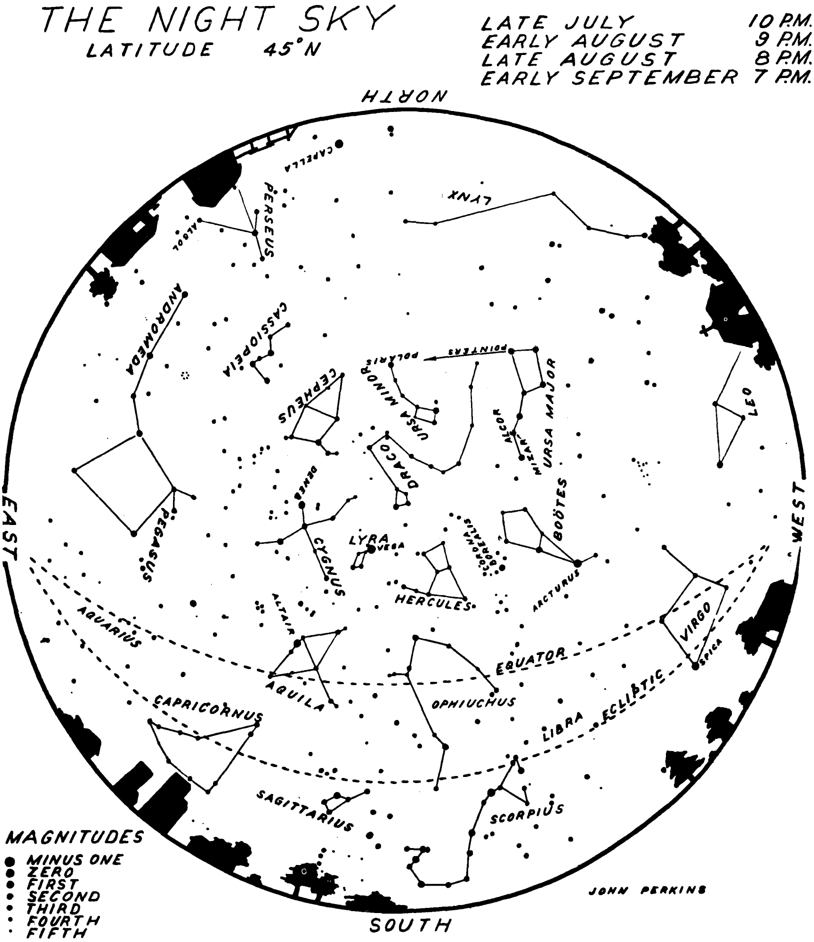
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic.*



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 February at 4 a.m. The map is drawn for latitude 45° N, but is useful for latitudes several degrees north or south of this.

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

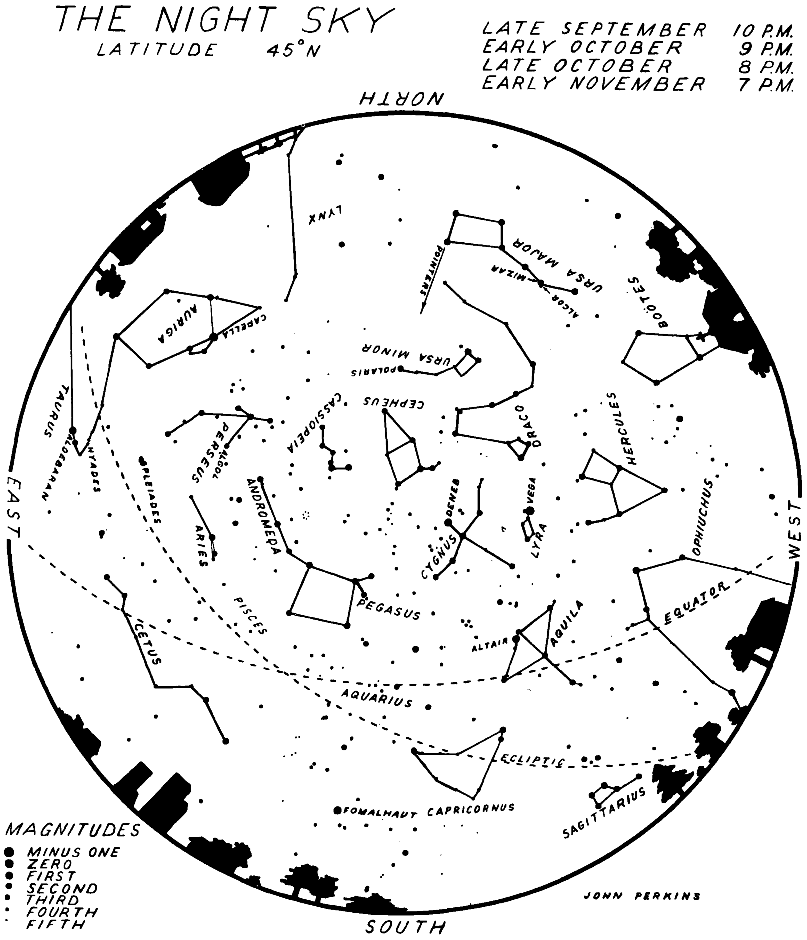
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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

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

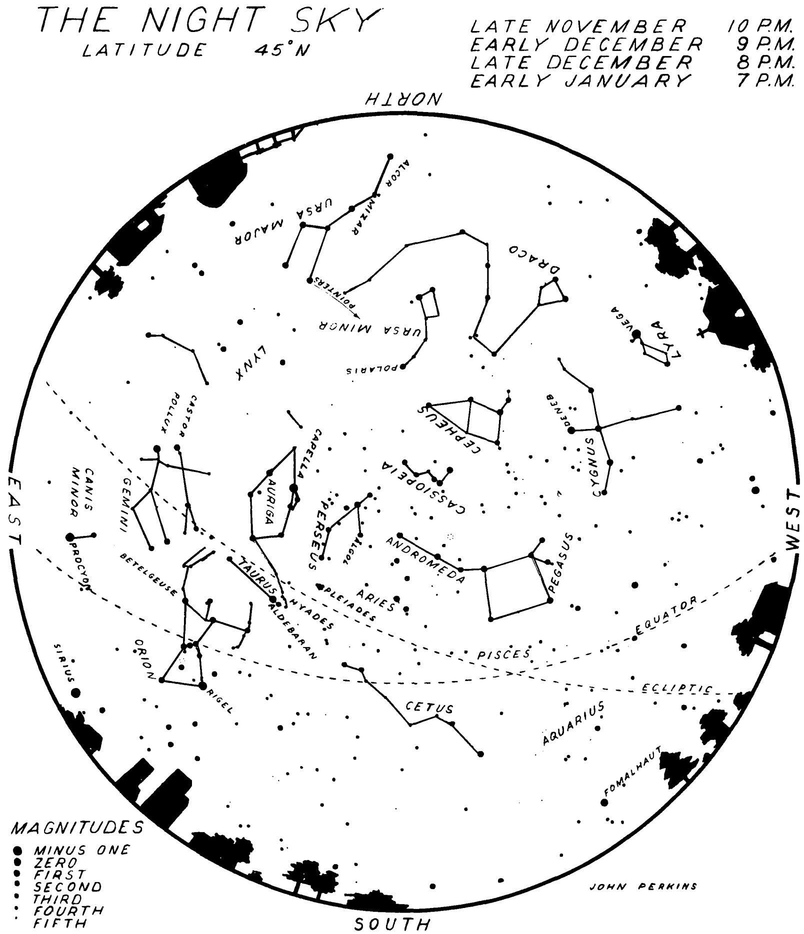
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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

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

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



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

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

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

VISITING HOURS AT SOME CANADIAN OBSERVATORIES

COMPILED BY MARIE FIDLER

Burke-Gaffney Observatory, Saint Mary's University, Halifax, Nova Scotia B3H 3C3.
October-April: Saturday evenings 7:00 p.m.
May-September: Saturday evenings 9:00 p.m.

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

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

Dominion Radio Astrophysical Observatory, Penticton, B.C. V2A 6K3
Sunday, July and August only (2:00–5:00 p.m.).

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

PLANETARIUMS

The Calgary Centennial Planetarium, Mewata Park, Calgary, Alberta T2P 2M5.
Winter: Mon., Wed., Fri., 7:30 p.m.; Sat.-Sun., 2:30 and 7:30 p.m.
(Closed Christmas Day, New Year's Day and Good Friday.)
Summer: Daily except Tues., 2:15, 3:30, 7:15, 8:30 p.m.

Doran Planetarium, Laurentian University, Ramsey Lake Road, Sudbury, Ontario T3E 2C6. Shows by reservation only.

Dow Planetarium, 1000 ouest St. Jacques Street, Montreal, P.Q. H3C 1G7 (Phone 872-3455).
Tues.-Sun. 11:30 a.m., 4:30, 7:30 and 10:45 p.m.
Theatre closed Mondays and Holidays.

The Lockhart Planetarium, 394 University College, 500 Dysart Road, The University of Manitoba, Winnipeg., Man. R3T 2N2.
Telephone 474–9785 for times of public shows and for group reservations.

H.R. MacMillan Planetarium, 1100 Chestnut Street, Vancouver, B.C. V6J 3J9.
Public shows daily except Mondays, 2:30 and 8:00 p.m.

Manitoba Planetarium, 190 Rupert Ave. and Main St., Winnipeg, Manitoba R3B 0N2.
Shows are presented several times each day, except Mondays. Monday programs are presented during July and August and on holidays. For current show times and information, call the Manitoba Planetarium recorded message at (204) 943–3142. Planetarium staff can be reached at 956–2830. The Copernicus Solar Telescope projects a 52-inch diameter image of the sun every clear day.

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McLaughlin Planetarium, 100 Queen's Park, Toronto, Ontario M5S 2C6 (Phone 978–8550).
Tues.-Sun. 1:30, 3:00 and 7:30 p.m.
Holidays 1:30, 3:00 and 4:15 p.m. Theatre closed Mondays, except holidays.

McMaster University, School and Adult Education, GH-122, Hamilton, Ontario L8S 4L8. Group reservations only. Phone 525–9140, ext. 4691.

Ontario Science Centre, 770 Don Mills Road, Don Mills, Ontario M3C 1T3.
Shows continuous every day except Christmas Day.

Queen Elizabeth Planetarium, Edmonton, Alberta T5J 0K1.
Winter: Tues.-Fri. 8:00 p.m.; Sat., Sun. and holidays 3:00 and 8:00 p.m.
Summer: Daily: 3:00, 8:00 and 9:00 p.m.

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

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