the OBSERVER'S HANDBOOK 1978

seventieth year of publication

the ROYAL ASTRONOMICAL SOCIETY of CANADA

editor: JOHN R. PERCY

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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editor: JOHN R. PERCY

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THE OBSERVER'S HANDBOOK FOR 1978

THE OBSERVER'S HANDBOOK for 1978 is the seventieth edition. It has now grown to 128 pages: the predictions of total and grazing lunar occultations have been considerably expanded to cover the whole of Canada and the U.S., and about a dozen other sections have been extensively revised and/or expanded.

I thank all those who contributed to the preparation of the 1978 edition: those whose names appear explicitly in the various sections, those mentioned below, and especially the editorial assistant, John F. A. Perkins. Among the many people who have given freely of their advice and assistance are: R. C. Brooks (an improved version of the sidereal time diagram), Terry Dickinson (further expansion of the important "Planets" section), Vic Gaizauskas (advice on eclipses and solar phenomena), Ian Halliday (advice on planetary and miscellaneous astronomical data), Janet A. Mattei (predictions of Algol and δ Cephei, as well as other variable star information), P. B. Robertson (revision of the "Impact Craters" section), T. Van Flandern (advice and assistance with the expansion of the occultation predictions) and Joe Veverka (advice on planetary satellite data). I also thank Helen S. Hogg and R. P. Van Zandt for their many comments and suggestions, and Rosemary Freeman and Lloyd Higgs for their assistance and support. Once again, the David Dunlap Observatory and Erindale College, University of Toronto, provided much-appreciated financial, technical and moral support for the HANDBOOK.

My indebtedness to H.M. Nautical Almanac Office, and to the *American Ephemeris*, is even greater than in past years. Leslie Morrison and his colleagues at H.M.N.A.O. provided all of the predictions of total and grazing lunar occultations, well in advance of our publication deadline; Gordon E. Taylor provided the predictions on planetary occultations [I hope that the results of these latter predictions are as exciting as they were in 1977!].

Finally, I must record, with sadness, the death of Dr. John F. Heard in October 1976. He was a major contributor to this HANDBOOK, a leader and counsellor of the R.A.S.C. for forty years, and an outstanding figure in Canadian astronomy.

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 $12.50, and $7.50 for persons under 18 years.

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, 1978

New Year's Day	Sun.	Jan. 1
Epiphany	Fri.	Jan. 6
Septuagesima Sunday		Jan. 22
Quinquagesima (Shrove) Sunday		Feb. 5
Accession of Queen Elizabeth (1952)	Mon.	Feb. 6
Ash Wednesday		Feb. 8
Lincoln's Birthday	Sun.	Feb. 12
Washington's Birthday	Mon.	Feb. 20
St. David	Wed	Mar. 1
St. Patrick	Fri.	Mar. 17
Palm Sunday		Mar. 19
Good Friday		Mar. 24
Easter Sunday		Mar. 26
Birthday of Queen Elizabeth (1926)	Fri.	Apr. 21
First day of Passover	Sat.	Apr. 22
St. George	Sun.	Apr. 23
Rogation Sunday		Apr. 30
Ascension Day	Thur.	May 4
Pentecost (Whit Sunday)		May 14
Trinity Sunday		May 21
Victoria Day	Mon.	May 22
Corpus Christi	Thur.	May 25
Memorial Day	Mon.	May 29
St. John Baptist (Mid-Summer Day)	Sat.	June 24
Canada Day	Sat.	July 1
Independence Day	Tue.	July 4
Birthday of Queen Mother Elizabeth (1900)	Fri.	Aug. 4
Civic Holiday	Mon.	Aug. 7
Labour Day	Mon.	Sept. 4
St. Michael (Michaelmas Day)	Fri.	Sept. 29
Jewish New Year (Rosh Hashanah)	Mon.	Oct. 2
Thanksgiving (Can.)	Mon.	Oct. 9
Columbus Day	Mon.	Oct. 9
Yom Kippur	Wed.	Oct. 11
All Saints' Day	Wed.	Nov. 1
General Election Day	Tue.	Nov. 7
Remembrance Day	Sat.	Nov. 11
Veterans' Day	Sat.	Nov. 11
Thanksgiving (U.S.)	Thur.	Nov. 23
St. Andrew	Thur.	Nov. 30
First Sunday in Advent		Dec. 3
Christmas Day	Mon.	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′sẽr	Cnc	Canc
Canes Venatici, kā′nēz vē-năt′ĭ-sī	CVn	CVen
Canis Major, kā′nĭs mā′jẽr	CMa	CMaj
Canis Minor, kā′nĭs′ mī′nẽr	CMi	CMin
Capricornus, kăp′rĭ-kôr′n*ŭ*s	Cap	Capr
Carina, k*a*-rī′n*a*	Car	Cari
Cassiopeia, kăs′ĭ-ō-pē′y*a*′	Cas	Cas
Centaurus, sĕn-tô′r*ŭ*s	Cen	Cent
Cepheus, sē′fūs	Cep	Ceph
Cetus, sē′t*ŭ*s	Cet	Ceti
Chamaeleon, k*a*-mē′lē-ŭn	Cha	Cham
Circinus, sûr′sĭ-n*ŭ*s	Cir	Circ
Columba, kō-lŭm′b*a*	Col	Colm
Coma Berenices, kō′m*a* bĕr′ē-nī′sēz	Com	Coma
Corona, Australis, kō-rō′n*a* ôs-trā′lĭs	CrA	CorA
Corona Borealis, k*a*-rō n*a* bō′rē-ā′lĭs	CrB	CorB
Corvus, kôr′v*ŭ*s	Crv	Corv
Crater, krā′tẽr	Crt	Crat
Crux, krŭks	Cru	Cruc
Cygnus, sĭg′n*ŭ*s	Cyg	Cygn
Delphinus, dĕl-fī′n*ŭ*s	Del	Dlph
Dorado, dō-rä′dō	Dor	Dora
Draco, drā′kō	Dra	Drac
Equuleus, ē-kwoo′lē-*ŭ*s	Equ	Equl
Eridanus, ē-rĭd′*a*-n*ŭ*s	Eri	Erid
Fornax, fôr′năks	For	Forn
Gemini, jĕm′ĭ-nī	Gem	Gemi
Grus, grŭs	Gru	Grus
Hercules, hûr′kū′lēz	Her	Herc
Horologium, hŏr′ō-lō′jĭ-*ŭ*m	Hor	Horo
Hydra, hī′dr*a*	Hya	Hyda
Hydrus, hī′dr*ŭ*s	Hyi	Hydi
Indus, ĭn′d*ŭ*s	Ind	Indi
Lacerta, l*a*-sûr′t*a*	Lac	Lacr
Leo, lē′ō	Leo	Leon
Leo Minor, lē′ō mī′nẽr	LMi	LMin
Lepus, lē′p*ŭ*s	Lep	Leps
Libra, lī′br*a*	Lib	Libr
Lupus, lū′p*ŭ*s	Lup	Lupi
Lynx, lĭngks	Lyn	Lync
Lyra, lī′r*a*	Lyr	Lyra
Mensa, mĕn′s*a*	Men	Mens
Microscopium, mī′krō-skō′pĭ-*ŭ*m	Mic	Micr
Monoceros, m-ōnŏs′ẽr-*ŏ*s	Mon	Mono
Musca, mŭs′k*a*	Mus	Musc
Norma, nôr′m*a*	Nor	Norm
Octans, ŏk′t*ă*nz	Oct	Octn
Ophiuchus, ŏf′ĭ-ūk*ŭ*s	Oph	Ophi
Orion, ō-rī′*ŏ*n	Ori	Orio
Pavo, Pā′vō	Pav	Pavo
Pegasus, pĕg′*a*-s*ŭ*s	Peg	Pegs
Perseus, pûr′sūs	Per	Pers
Phoenix, fē′nĭks	Phe	Phoe
Pictor, pĭk′tẽr	Pic	Pict
Pisces, pĭs′ēz	Psc	Pisc
Piscis Austrinus, pĭs′ĭs ôs-trī′n*ŭ*s	PsA	PscA
Puppis, pŭp′ĭs	Pup	Pupp
Pyxis, pĭk′sĭs	Pyx	Pyxi
Reticulum, rē-tĭk′ū-l*ŭ*m	Ret	Reti
Sagitta, s*a*-jĭt′*a*	Sge	Sgte
Sagittarius, săj′ĭ-tā′rĭ-*ŭ*s	Sgr	Sgtr
Scorpius, skôr′pĭ-*ŭ*s	Sco	Scor
Sculptor, skŭlp′tẽr	Scl	Scul
Scutum, skū′t*ŭ*m	Sct	Scut
Serpens, sûr′pĕnz	Ser	Serp
Sextans, sĕks′t*ă*nz	Sex	Sext
Taurus, tô′r*ŭ*s	Tau	Taur
Telescopium, tĕl′ē-skō′pĭ-*ŭ*m	Tel	Tele
Triangulum, trī-ăng′gū-l*ŭ*m	Tri	Tria
Triangulum Australe, trī-ăng′gū-l*ŭ*m ôs-trā′lē	Tra	TrAu
Tucana, tū-kā′n*a*	Tuc	Tucn
Ursa Major, ûr′s*a* mā′jẽr	UMa	UMaj
Ursa Minor, ûr′s*a* mi′nẽr	UMi	UMin
Vela, vē′l*a*	Vel	Velr
Virgo, vûr′gō	Vir	Virg
Volans, vō′l*ă*nz	Vol	Voln
Vulpecula, vŭl-pĕk′ū-l*a*	Vul	Vulp

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

PRINCIPAL ELEMENTS OF THE SOLAR SYSTEM

MEAN ORBITAL ELEMENTS

Planet	Mean Distance from Sun (a)		Period of Revolution		Eccen-tri-city	In-clina-tion	Long. of Node	Long. of Peri-helion	Mean Long. at Epoch
	A. U.	millions of km	Sidereal (P)	Syn-odic	(e)	(i)	(☊)	(π)	(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	Ob-late-ness	Mass ⊕ = 1	Den-sity g/cm³	Grav-ity ⊕ = 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	<5,000?	?	<0.1?	6?	0.6?	5?	6.3868	?	?

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

Name	Vis. Mag.	Diam. km	Mean Distance from Planet		Revolution Period			Orbit Incl.	Discovery
			km/1000	arc sec	d	h	m	°	
SATELLITE OF THE EARTH									
Moon	−12.7	3476	384.5		27	07	43	18–29	
SATELLITES OF MARS									
Phobos	11.6	23	9.3	26	0	07	39	1.0	A. Hall, 1877
Deimos	12.7	13	23.5	63	1	06	18	1.3	A. Hall, 1877
SATELLITES OF JUPITER									
V Amalthea	14.0	120	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	3100	671	220	3	13	14	0	Galileo, 1610
III Ganymede	4.6	5270	1,070	351	7	03	43	0	Galileo, 1610
IV Callisto	5.6	4990	1,885	618	16	16	32	0	Galileo, 1610
XIII Leda	20	< 10	11,094	3630	238	17		28.8	C. Kowal, 1974
VI Himalia	14.7	85	11,470	3765	250	14		27.6	C. Perrine, 1904
VII Elara	16.0	40	11,740	3850	259	16		24.8	C. Perrine, 1905
X Lysithea	18.8	< 20	11,850	3888	263	13		29.0	S. Nicholson, 1938
XII Ananke	18.3	< 20	21,200	6958	631	02		147	S. Nicholson, 1951
XI Carme	18.6	< 20	22,560	7404	692	12		164	S. Nicholson, 1938
VIII Pasiphae	18.1	< 20	23,500	7715	738	22		145	P. Melotte, 1908
IX Sinope	18.8	< 20	23,700	7779	758			153	S. Nicholson, 1914
SATELLITES OF SATURN									
Janus	14	(300)	160	26	0	17	59	0.0	A. Dollfus, 1966
Mimas	12.9	(400)	187	30	0	22	37	1.5	W. Herschel, 1798
Enceladus	11.8	(500)	238	38	1	08	53	0.0	W. Herschel, 1789
Tethys	10.3	(950)	295	48	1	21	18	1.1	G. Cassini, 1684
Dione	10.4	1100	378	61	2	17	41	0.0	G. Cassini, 1684
Rhea	9.7	1600	526	85	4	12	25	0.4	G. Cassini, 1672
Titan	8.4	5800	1,221	197	15	22	41	0.3	C. Huygens, 1655
Hyperion	14.2	(320)	1,481	239	21	06	38	0.4	G. Bond, 1848
Iapetus	11.0v	1500	3,561	575	79	07	56	14.7	G. Cassini, 1671
Phoebe	16.5	(200)	12,960	2096	550	11		150	W. Pickering, 1898
SATELLITES OF URANUS									
Miranda	16.5	(400)	128	9	1	09	56	0	G. Kuiper, 1948
Ariel	14.4	(1400)	192	14	2	12	29	0	W. Lassell, 1851
Umbriel	15.3	(1000)	267	20	4	03	38	0	W. Lassell, 1851
Titania	14.0	(1800)	438	33	8	16	56	0	W. Herschel, 1787
Oberon	14.2	(1600)	587	44	13	11	07	0	W. Herschel, 1787
SATELLITES OF NEPTUNE									
Triton	13.6	(4000)	354	17	5	21	03	160.0	W. Lassell, 1846
Nereid	18.7	(600)	5600	264	359	10		27.4	G. Kuiper, 1949

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 = 1.49597870×10^8 km = 9.2956×10^7 mi
1 light-year = 9.461×10^{17} cm = 5.88×10^{12} mi = 0.3068 parsecs
1 parsec = 3.086×10^{18} cm = 1.917×10^{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* = $29^d.5306$
Sidereal month = 27*d* 07*h* 43*m* 12*s* = $27^d.3216$
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* = $346^d.6200$

The Earth

Equatorial radius, a = 6378.140 km = 3963.19 mi: flattening, $c = (a - b)/a = 1/298.257$
Polar radius, b = 6356.755 km = 3949.904 mi
1° of latitude = $111.133 - 0.559 \cos 2\phi$ km = $69.055 - 0.347 \cos 2\phi$ mi (at lat. ϕ)
1° of longitude = $111.413 \cos\phi - 0.094 \cos 3\phi$ km = $69.229 \cos\phi - 0.0584 \cos 3\phi$ mi
Mass of earth = 5.976×10^{24} kgm = 13.17×10^{24} lb
Velocity of escape from $\oplus$ = 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 $\oplus$ = 42.3 km/sec = 26.2 mi/sec

Solar Motion

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

The Galactic System

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

External Galaxies

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

Radiation Constants

Velocity of light, $c = 2.99792458 \times 10^8$ m/s
Frequency, $\nu = c/\lambda$; ν in Hertz (cycles per sec), c in cm/sec, λ in cm
Solar constant = 1.950 gram calories/square cm/minute = 1.36×10^6 cgs units
Light ratio for one magnitude = 2.512 ... ; log ratio = exactly 0.4
Stefan's constant = 5.66956×10^{-5} cgs units

Miscellaneous

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

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

SUN—EPHEMERIS AND CORRECTION TO SUN-DIAL

Date	Apparent R.A. 0h E.T.	Apparent Dec. 0h E.T.	Corr. to Sun-dial 12h E.T.
	h m s	° ′	m s
Jan. 1	18 44 26	−23 02.8	+ 3 30
4	18 57 40	−22 46.7	+ 4 54
7	19 10 50	−22 26.5	+ 6 14
10	19 23 56	−22 02.3	+ 7 29
13	19 36 57	−21 34.2	+ 8 40
16	19 49 53	−21 02.4	+ 9 45
19	20 02 42	−20 27.0	+10 43
22	20 15 24	−19 48.1	+11 35
25	20 28 00	−19 05.9	+12 19
28	20 40 28	−18 20.6	+12 57
31	20 52 49	−17 32.3	+13 27
Feb. 3	21 05 03	−16 41.1	+13 50
6	21 17 10	−15 47.3	+14 06
9	21 29 10	−14 51.1	+14 15
12	21 41 02	−13 52.7	+14 17
15	21 52 48	−12 52.2	+14 11
18	22 04 26	−11 49.8	+13 59
21	22 15 59	−10 45.8	+13 41
24	22 27 25	− 9 40.3	+13 17
27	22 38 46	− 8 33.4	+12 47
Mar. 1	22 46 18	− 7 48.2	+12 25
4	22 57 31	− 6 39.5	+11 48
7	23 08 40	− 5 30.0	+11 07
10	23 19 46	− 4 19.8	+10 23
13	23 30 49	− 3 09.1	+ 9 35
16	23 41 49	− 1 58.1	+ 8 45
19	23 52 46	− 0 47.0	+ 7 53
22	0 03 42	+ 0 24.1	+ 6 59
25	0 14 38	+ 1 35.0	+ 6 04
28	0 25 32	+ 2 45.6	+ 5 09
31	0 36 27	+ 3 55.7	+ 4 15
Apr. 3	0 47 23	+ 5 05.2	+ 3 21
6	0 58 21	+ 6 13.9	+ 2 29
9	1 09 20	+ 7 21.6	+ 1 39
12	1 20 21	+ 8 28.1	+ 0 51
15	1 31 25	+ 9 33.4	+ 0 06
18	1 42 31	+10 37.3	− 0 37
21	1 53 41	+11 39.6	− 1 16
24	2 04 55	+12 40.1	− 1 51
27	2 16 13	+13 38.8	− 2 22
30	2 27 36	+14 35.5	− 2 48
May 3	2 39 03	+15 30.0	− 3 09
6	2 50 36	+16 22.2	− 3 26
9	3 02 14	+17 12.0	− 3 37
12	3 13 57	+17 59.1	− 3 43
15	3 25 44	+18 43.6	− 3 44
18	3 37 37	+19 25.2	− 3 40
21	3 49 35	+20 03.8	− 3 31
24	4 01 37	+20 39.4	− 3 17
27	4 13 44	+21 11.7	− 2 59
30	4 25 56	+21 40.8	− 2 36
June 2	4 38 12	+22 06.5	− 2 10
5	4 50 31	+22 28.7	− 1 40
8	5 02 54	+22 47.4	− 1 06
11	5 15 18	+23 02.5	− 0 31
14	5 27 45	+23 13.9	+ 0 07
17	5 40 13	+23 21.7	+ 0 45
20	5 52 42	+23 25.7	+ 1 24
23	6 05 10	+23 26.0	+ 2 03
26	6 17 38	+23 22.7	+ 2 41
29	6 30 05	+23 15.5	+ 3 18

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 2	6 42 31	+23 04.8	+ 3 54
5	6 54 54	+22 50.4	+ 4 27
8	7 07 14	+22 32.4	+ 4 57
11	7 19 31	+22 10.9	+ 5 23
14	7 31 44	+21 46.0	+ 5 45
17	7 43 52	+21 17.7	+ 6 03
20	7 55 55	+20 46.2	+ 6 16
23	8 07 54	+20 11.6	+ 6 24
26	8 19 47	+19 33.9	+ 6 27
29	8 31 35	+18 53.2	+ 6 24
Aug. 1	8 43 18	+18 09.8	+ 6 17
4	8 54 56	+17 23.7	+ 6 04
7	9 06 28	+16 35.0	+ 5 45
10	9 17 54	+15 44.0	+ 5 21
13	9 29 16	+14 50.7	+ 4 52
16	9 40 32	+13 55.2	+ 4 18
19	9 51 43	+12 57.8	+ 3 39
22	10 02 50	+11 58.6	+ 2 55
25	10 13 53	+10 57.6	+ 2 08
28	10 24 52	+ 9 55.0	+ 1 17
31	10 35 48	+ 8 51.1	+ 0 23
Sept. 3	10 46 41	+ 7 45.8	− 0 34
6	10 57 32	+ 6 39.4	− 1 33
9	11 08 21	+ 5 32.1	− 2 35
12	11 19 08	+ 4 23.9	− 3 38
15	11 29 54	+ 3 15.0	− 4 42
18	11 40 39	+ 2 05.6	− 5 46
21	11 51 24	+ 0 55.8	− 6 50
24	12 02 11	− 0 14.2	− 7 53
27	12 12 58	− 1 24.3	− 8 55
30	12 23 48	− 2 34.4	− 9 55
Oct. 3	12 34 40	− 3 44.2	−10 52
6	12 45 34	− 4 53.7	−11 46
9	12 56 32	− 6 02.6	−12 38
12	13 07 34	− 7 10.8	−13 25
15	13 18 40	− 8 18.1	−14 08
18	13 29 51	− 9 24.3	−14 46
21	13 41 07	−10 29.4	−15 18
24	13 52 30	−11 33.0	−15 44
27	14 03 58	−12 35.1	−16 04
30	14 15 34	−13 35.4	−16 17
Nov. 2	14 27 16	−14 33.9	−16 23
5	14 39 06	−15 30.2	−16 22
8	14 51 03	−16 24.1	−16 14
11	15 03 07	−17 15.6	−15 58
14	15 15 19	−18 04.5	−15 35
17	15 27 38	−18 50.5	−15 04
20	15 40 05	−19 33.4	−14 25
23	15 52 40	−20 13.2	−13 39
26	16 05 21	−20 49.7	−12 46
29	16 18 10	−21 22.7	−11 46
Dec. 2	16 31 05	−21 52.0	−10 39
5	16 44 06	−22 17.6	− 9 28
8	16 57 11	−22 39.3	− 8 11
11	17 10 21	−22 56.9	− 6 50
14	17 23 34	−23 10.5	− 5 26
17	17 36 50	−23 20.0	− 4 00
20	17 50 08	−23 25.2	− 2 31
23	18 03 27	−23 26.2	− 1 02
26	18 16 46	−23 23.0	+ 0 28
29	18 30 05	−23 15.5	+ 1 57

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 is under discussion.

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 1978 will be about 49 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, 20, 25 MHz
WWVH Maui, Hawaii	2.5, 5, 10, 15 MHz.

JULIAN DAY CALENDAR, 1978

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

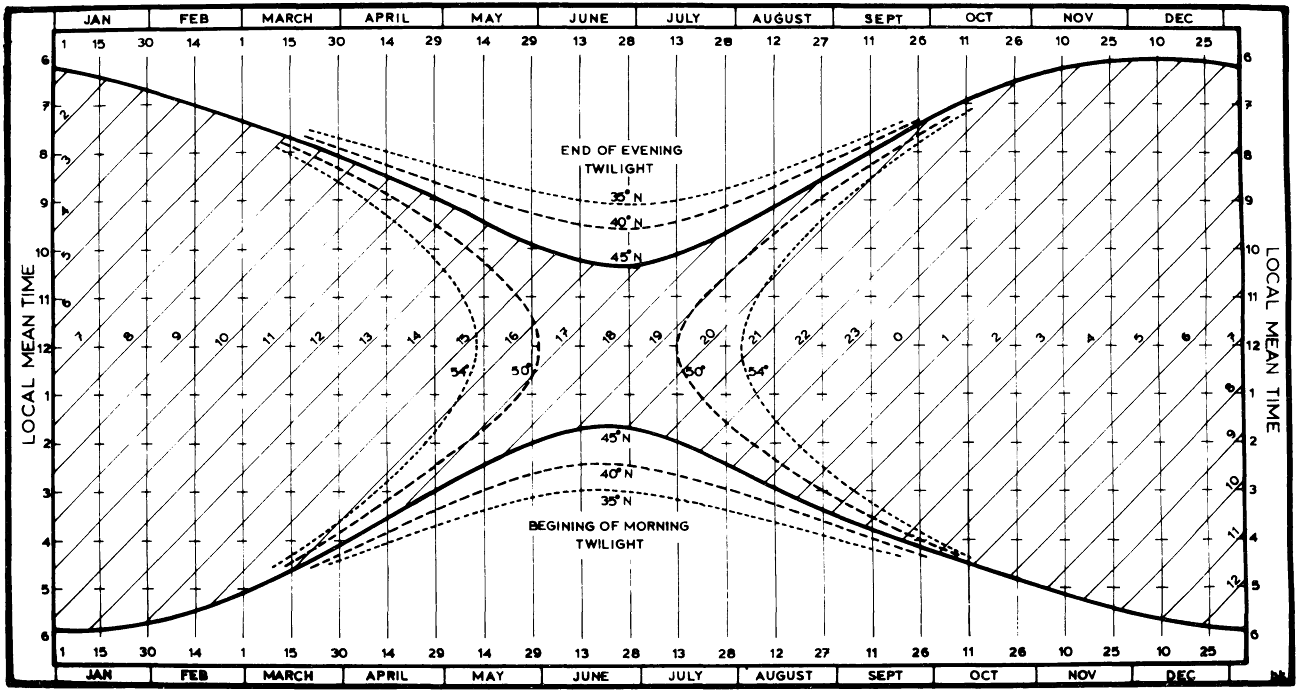
This table lists the Julian Date, and also the Greenwich sidereal time at midnight. The latter quantity is the amount which must be added to the local mean time to give local sidereal time; it increases by 3 m 56 s each day.

The Julian day commences at noon so that J.D. 2443510 = Jan. 1.5 U.T. 1978 = 12^h U.T. Jan. 1, 1978.

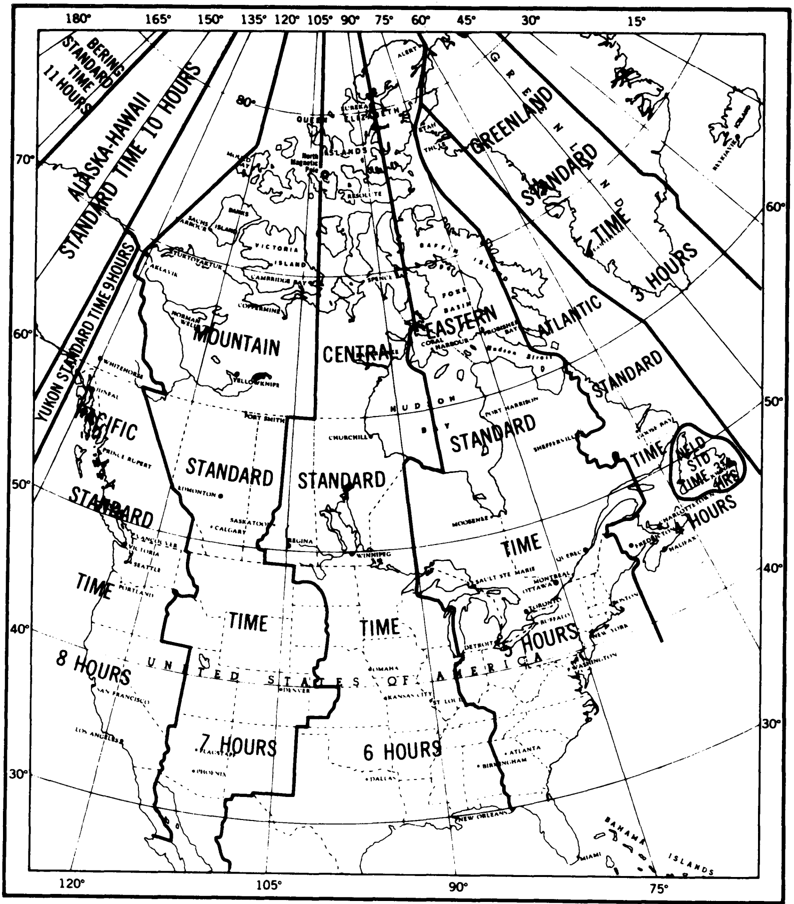
Date 0 h U.T.	JD 2443000+	G.S.T.	Date 0 h G.T.	JD 2443000+	G.S.T.	Date 0 h U.T.	JD 2443000+	G.S.T.
		h m			h m			h m
Jan. 1	509.5	6 41.2	May 1	629.5	14 34.3	Sept. 1	752.5	22 29.2
Feb. 1	540.5	8 43.4	June 1	660.5	16 36.5	Oct. 1	782.5	0 37.5
Mar. 1	568.5	10 33.8	July 1	690.5	18 34.8	Nov. 1	813.5	2 39.7
Apr. 1	599.5	12 36.0	Aug. 1	721.5	20 37.0	Dec. 1	843.5	4 38.0

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).

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

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

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

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

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

The above table gives the local mean time of the beginning of morning twilight, and of the ending of evening twilight, for various latitudes. To obtain the corresponding standard time, the method used is the same as for correcting the sunrise and sunset tables, as described on page 12. The entry —— in the above table indicates that at such dates and latitudes, twilight lasts all night. This table, taken from the American Ephemeris, is computed for *astronomical* twilight, i.e. for the time at which the sun is 108° from the zenith (or 18° below the horizon).

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

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

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

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

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

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

THE PLANETS FOR 1978

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 size we see it to more than ten times its apparent size 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 diameter of Mercury as seen through a telescope are tabulated for the two most

GREATEST ELONGATIONS OF MERCURY IN 1978

Date E.S.T.	Elong.	Mag.	App. Diam.
	°		″
Jan. 11	23 W	0.0	6.6
*Mar. 24	19 E	−0.1	7.3
May 9	26 W	+0.7	8.2
July 21	27 E	+0.6	7.7
*Sept. 4	18 W	+0.1	7.4
Nov. 15	23 E	−0.1	6.4
Dec. 24	22 W	−0.1	6.7

*favourable elongations

TELESCOPIC OBSERVING DATA FOR FAVOURABLE ELONGATIONS

Date	Mag	App. Diam.	Phase (% Ill.)
		″	
Mar. 12	−1.1	5.6	86
17	−0.8	6.2	70
22	−0.2	7.1	50
27	+0.6	8.2	30
Apr. 1	+1.4	9.5	14
Aug. 29	+1.0	8.6	21
Sept. 3	+0.1	7.4	41
8	−0.6	6.4	63
13	−1.0	5.7	81

favourable elongations. Throughout the March elongation Mercury will be within 10° of Venus which should make locating the inner planet especially easy this year.

Mercury's phases have been glimpsed with telescopes of 3-inch aperture or less, but generally a 4-inch or larger telescope is required to distinguish them. In larger instruments under conditions of excellent seeing (usually when Mercury is viewed in the daytime) dusky features have been glimpsed by experienced observers. Recent analysis has shown only a fair correlation between these visually observed features and the surface of the planet as photographed by Mariner 10.

VENUS

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

We now know that Venus is infernally hot over its entire surface, ranging little from a mean of +480° C. The high temperature is due to the dense carbon dioxide atmosphere of Venus which, when combined with small quantities of water vapour and other gases known to be present, has the special property of allowing sunlight to penetrate to the planet's surface but not permitting the resulting heat to escape. In much the same way as the glass cover of a greenhouse keeps plants warm, an atmosphere of carbon dioxide can heat up a planetary surface to a higher temperature than would be achieved by normal sunlight.

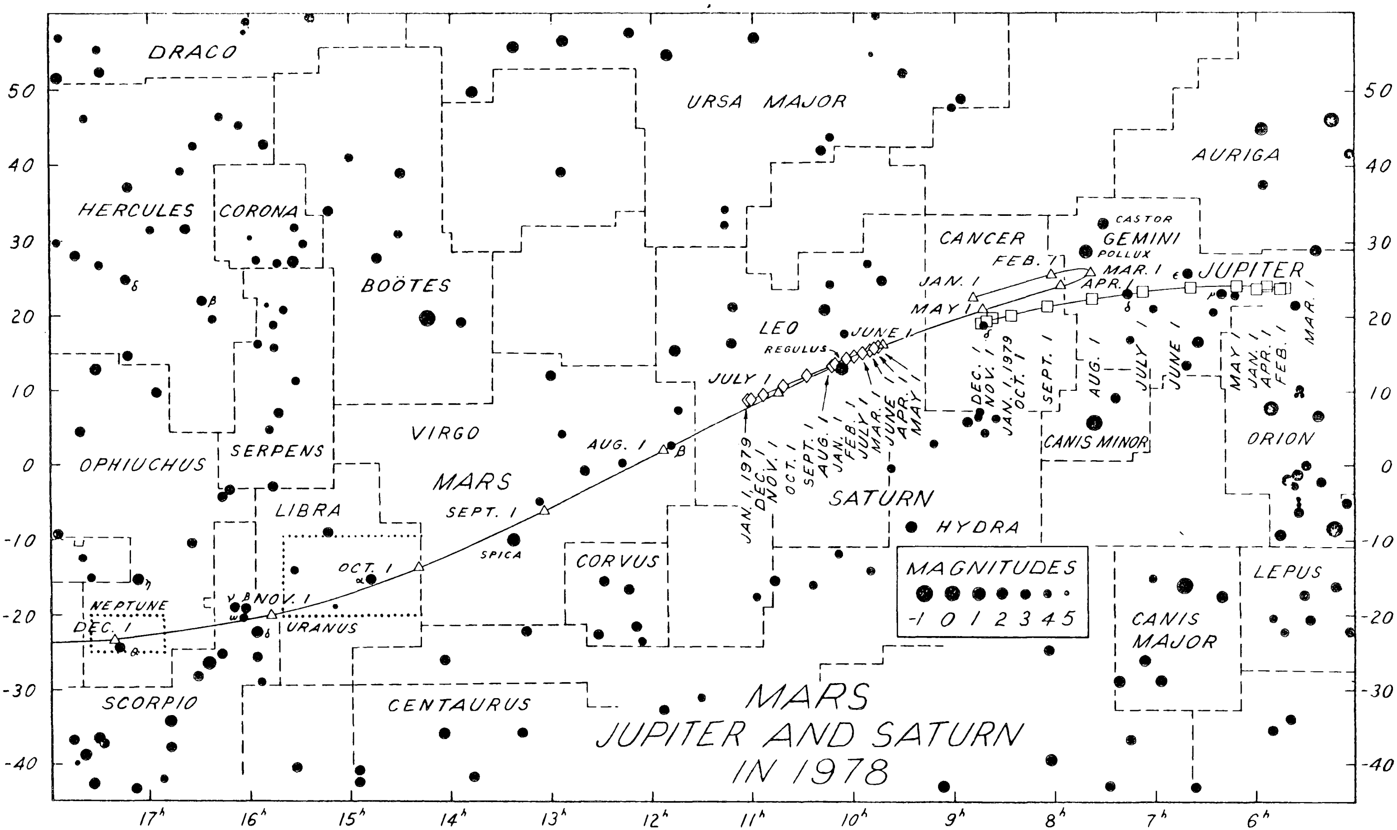
Venus' atmosphere has a thick haze layer extending down from a level about 65 kilometers above the surface. However, the Soviet Venera 9 and 10 spacecraft that landed on Venus in October 1975 and photographed the planet's surface showed that sunlight similar to that received on Earth on a heavily overcast 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 summer of 1978. From March through to early October Venus dominates the evening sky in the west after sunset. For the last few weeks of the year the planet is a prominent object in early morning skies.

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 described as slightly less brilliant than the dazzling white of the rest of the planet.



The Paths of Mars, Jupiter and Saturn: The positions of Mars are shown as triangles, those of Jupiter as squares and those of Saturn as diamonds. The dotted boxes labelled "Uranus" and "Neptune" show the areas covered by the maps of the paths of those two planets.

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.

VENUS—TELESCOPIC OBSERVING DATA 1978

Date	Mag.	App. Diam.	Phase (% Ill.)	Date	Mag.	App. Diam.	Phase (% Ill.)
		″				″	
Apr. 1	−3.4	10.4	96	Oct. 23	−3.9	55.5	8
May 1	−3.4	11.2	91	28	−3.7	59.5	4
June 1	−3.4	12.6	84	Nov. 2	−3.4	61.4	1.3
July 1	−3.5	15.5	74	7	−3.0	62.5	0.3
Aug. 1	−3.7	18.5	63	12	−3.3	61.8	1.1
19	−3.9	22.2	54	17	−3.7	59.7	3.6
Sept. 8	−4.1	28.0	43	22	−4.0	56.4	7
23	−4.2	34.5	33	Dec. 2	−4.3	48.7	16
Oct. 3	−4.3	40.4	26	12	−4.4	41.4	26
13	−4.2	47.6	17	27	−4.4	32.8	37
18	−4.1	51.6	12				

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 have completed their search and although the results are somewhat ambiguous there is no convincing evidence of life processes we are familiar with. However, Viking and its predecessors have shown that water was abundant enough on Mars to leave major structures on the planet resembling riverbeds. Analysis of high resolution Viking photographs of these structures has led most planetary scientists to conclude that they were carved largely during the planet's early history.

The red planet's atmosphere is less than 1% as dense as Earth's and consists of about 96% carbon dioxide, 2.5% nitrogen, 1.5% argon and small amounts of other gases. Winds in the thin atmosphere reach velocities exceeding 300 km/hr 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 complex weather patterns that require further analysis.

As 1978 opens Mars is near opposition and is a brilliant object (magnitude −1) in the constellation Cancer. 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. During February and March it makes particularly striking configurations as it moves among the stars of Gemini. On the evening of June 4 Mars and Saturn are only 0.1 degree apart, close enough for both to be seen in the same telescopic field and a striking naked eye alignment. 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.

Opposition occurs on January 22, a very unfavourable one with the minimum distance between Earth and Mars being 97.7 million km and the apparent diameter less than 15 seconds of arc. For further information see the table on page 82. Throughout the year, 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. Because of its high declination when it is nearest Earth this year, Mars will appear almost overhead for observers in mid-northern latitudes. The main features on the map of Mars on page 82 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 82.

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 48″ at opposition (there is no opposition of Jupiter in 1978) to a minimum of 32″ at conjunction on July 10.

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 1978 opens Jupiter is bright and unmistakable in the early evening sky and is ideally placed for telescopic study having just passed opposition in late 1977. By early June the planet will be lost in the twilight glow in the west after sunset. Shortly before that, on the evening of May 28, Venus and Jupiter will be less than 2 degrees apart forming a striking pair low in the west. In early August Jupiter is visible in the morning sky just before sunrise and by the end of the year the planet is visible all night as a brilliant object—the brightest in the late night sky—located not far from

M44 in Cancer. Despite the fact that it is five times Earth's distance from the sun Jupiter's giant size and reflective clouds make it a celestial beacon that is unmistakable, particularly around opposition.

Opposition occurred December 23, 1977, when Jupiter was 621 million km (4.151 A.U.) from Earth. Minimum possible distance between the two planets is 590 million km.

SATURN

Saturn is the telescopic showpiece of the night sky. The chilling beauty of the small pale orb floating in a field of velvet is something no photographs or description can adequately duplicate. The rings consist of billions of particles which, according to recent photometric, radar and other data, are believed to be approximately fist-sized and made of—or covered by—water ice. This would account for their exceedingly high reflectivity. The reason that "rings" is plural and not singular is that gaps and brightness differences define distinct rings. The most famous gap, called Cassini's Division, was discovered in 1675 and is visible in 3-inch and larger telescopes. More information on the rings and satellites of Saturn is given on page 87.

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 1980 the rings will be seen edge-on and will effectively disappear from view. In apparent width the rings are equal to the equatorial diameter of Jupiter. In 1978 the south side of the rings and the southern hemisphere of Saturn are presented to our view.

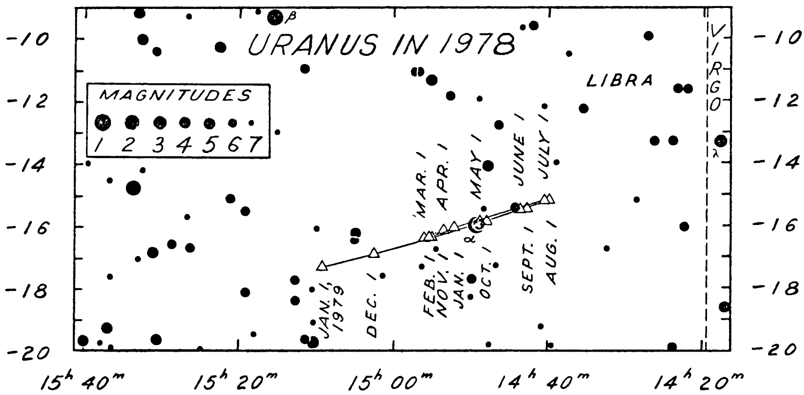
As 1978 opens Saturn's rings are tilted 10.1° with respect to the Earth. This increases to 13.1° in mid-April after which the rings seem to close up, having a tilt of 11.5° by July 1. Saturn will then be too close to the sun for observation until autumn. The rings, with respect to the Earth, will be tipped 5.1° on Nov. 1, and 4.1° Jan. 1, 1979.

Opposition is February 16 when Saturn is 1.233 billion km (8.22 A.U.) from Earth, in the constellation Leo. At that time the rings are 45.6″ in apparent width and the planet is 18.1″in polar diameter. Saturn ranges from magnitude +0.3 in February to +1.1 throughout autumn.

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



The Path of Uranus: See caption on page 30 for more information.

system. This means that we can view Uranus nearly pole-on at certain points in its 84 year orbit of the sun. The northern hemisphere of Uranus is now directed toward the Earth and we will be viewing the planet almost exactly toward its north pole in 1985. Uranus has five satellites, all smaller than Earth's moon, none of which can be detected in small or moderate sized telescopes.

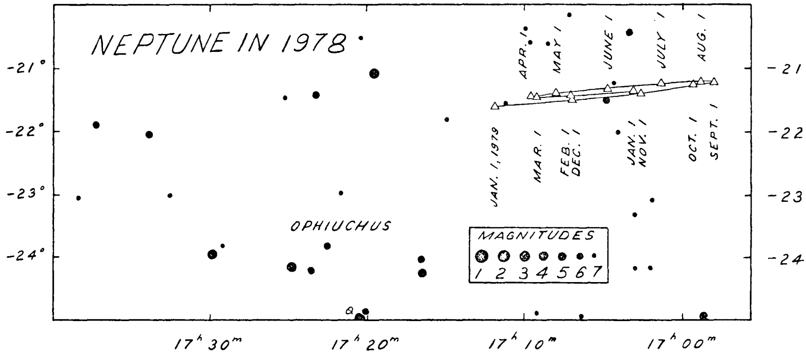
The 1977 discovery of at least five rings encircling Uranus is regarded as one of the major planetary finds in recent years. Their detection emerged during a relatively routine occultation observation from an airborne observatory—an experiment initially intended to provide a more accurate measure of the diameter of Uranus. Refinement of the observations made over the Indian Ocean and by several ground-based teams indicates that the five rings are relatively evenly spaced from 16,000 to 26,000 km above the cloudy surface of Uranus. The outer ring is about 100 km wide while the others are between 5 and 10 km across.

These dimensions are markedly different from Saturn's three major rings, each of which is thousands of kilometres wide. Although different in scale, the composition of the Uranian rings is probably much 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. 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. If confirmed 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 158-inch 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 1978 Uranus is in Libra, near Alpha Librae (see p. 44). Uranus is at opposition on May 5 when it is 2.64 billion km (17.61 A.U.) from Earth. At this time its magnitude is +5.7 and its apparent diameter is 3.9 seconds of arc.



The Path of Neptune: See caption on page 30 for more information.

NEPTUNE

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

Telescopically the planet appears as a 2.5 second of arc featureless bluish-green disk. Neptune's large moon Triton can be seen by an experienced observer using a 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 durings 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 1978 Neptune is buried in the Milky Way in Ophiuchus and is not well placed for northern observers. At opposition on June 8 Neptune is magnitude +7.7 and 4.38 billion km (29.27 A.U.) distant from Earth.

PLUTO

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

In 1976, in the first successful attempt to investigate Pluto's surface composition, a team of astronomers from the University of Hawaii detected frozen methane on the planet. This is the first direct evidence that the temperature was below −225°C when the planet formed. Because Pluto is so distant and cold the methane may have remained undisturbed and frozen since the creation of the solar system. If most of the surface of Pluto is covered with methane ice as these new observations imply, the reflectivity of the outermost planet is likely much higher than previously thought. If this is true Pluto may prove to be a substantially smaller planet than scientists have guessed—perhaps as small as Earth's moon. Previous estimates of Pluto's diameter ranged around twice that of our moon.

At opposition on April 5 Pluto's astrometric position is R.A. (1950) $13^h22.3^m$ Dec. (1950) +10°25′ and its distance from Earth will be 4.41 billion km (29.42 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.

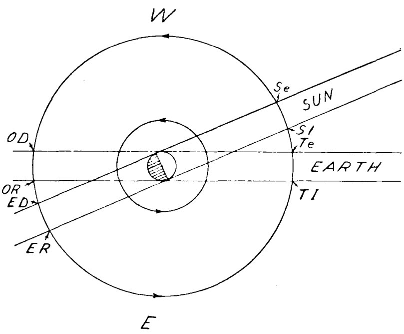
Libration is the shifting, or rather apparent shifting, of the visible disk of the moon. Sometimes the observer sees features farther around the eastern or the western limb (libration in longitude), or the northern or southern limb (libration in latitude). When the libration in longitude is positive, 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. 28–35. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 87.

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. 87) 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 1978

On January 19, the first of a series of about a dozen occultations of Aldebaran by the moon takes place. Last year it was Uranus which underwent a series of occultations. Why?

As seen from the earth, the moon sweeps out a band in the sky 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) but is tilted by 5°. Furthermore, this band is not stationary, but drifts westward along the ecliptic by about 20° each year. An object (such as Uranus) which was in this band in 1977—and would be occulted—may not be in this band in 1978. [See "The Sky for May" for further discussion].

The westward drift of the moon's orbit is called "the regression of the nodes", the nodes being the intersection points of the moon's orbit and the ecliptic. The ascending node, at which the moon crosses the ecliptic from S. to N., moves from longitude 190.5° to 171.0° in 1978; the descending node is 180° different. The sun is in these parts of the ecliptic in early spring and early fall; eclipses may therefore occur around these times.

The Sun—During January the sun's R.A. increases from 18 h 44 m to 20 h 57 m and its Decl. changes from −23°03′ to −17°16′. The equation of time changes from −3 m 36 s to −13 m 29 s. The earth is in perihelion on Jan. 1, at a distance of 147,100,000 km (91,405,000 mi) from the sun.

The Moon—On Jan. 1.0 E.S.T., the age of the moon is 21.5 d. The sun's selenographic colongitude is 171.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 14 (8°) and minimum (east limb exposed) on Jan. 2 (7°) and Jan. 30 (6°). The libration in latitude is maximum (north limb exposed) on Jan. 22 (7°) and minimum (south limb exposed) on Jan .8 (6°).

Mercury on the 1st is in R.A. 17 h 22 m, Decl. −20°10′, and on the 15th is in R.A. 18 h 06 m, Decl. −22°23′. For a few days around the 11th, it may be seen low in the south-east before sunrise. At greatest elongation west, the planet is about 14° above the horizon at sunrise.

Venus on the 1st is in R.A. 18 h 22 m, Decl. −23°38′, and on the 15th it is in R.A. 19 h 39 m, Decl. −22°19′, mag. −3.5, and transits at 12 h 03 m. It is too close to the sun for observation, being in superior conjunction on Jan. 22.

Mars on the 15th is in R.A. 8 h 31 m, Decl. +23°20′, mag. −1.0, and transits at 0 h 54 m. In Cancer, it rises at about sunset and is visible all night, opposition being on the 21st (E.S.T.).

Jupiter on the 15th is in R.A. 5 h 52 m, Decl. +23°14′, mag. −2.3, and transits at 22 h 11 m. Moving from Gemini into Taurus, it is well up in the east at sunset and sets before dawn. [It was in opposition on 22 Dec. 1977.]

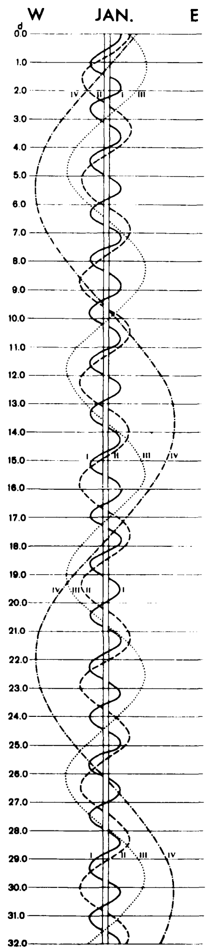
Saturn on the 15th is in R.A. 10 h 09 m, Decl. +13°02′, mag. +0.5, and transits at 2 h 31 m. In Leo, it rises about 3 hours after sunset and is low in the west at sunrise. On the 20th it is 1.1° N of Regulus.

Uranus on the 15th is in R.A. 14 h 54 m, Decl. −16°12′, mag. +5.9, and transits at 7 h 16 m.

Neptune on the 15th is in R.A. 17 h 05 m, Decl. −21°24′, mag. +7.8, and transits at 9 h 26 m.

1978				JANUARY E.S.T.	Min. of Algol
	d	h	m		h m
Sun.	1	18		Earth at perihelion	
Mon.	2	07	07	Last Quarter	9 20
Tues.	3	14		Quadrantid Meteors	
Wed.	4	17		Uranus 3° S. of Moon	
Thur.	5				6 10
Fri.	6	21		Neptune 3° S. of Moon	
Sat.	7	08		Mercury 3° S. of Moon	
Sun.	8	07		Moon at perigee (357,450 km)	3 00
		23	00	New Moon	
Mon.	9				
Tues.	10				23 50
Wed.	11	04		Mercury greatest elong. W. (23°)	
Thur.	12				
Fri.	13				20 40
Sat.	14				
Sun.	15	22	03	First Quarter	
Mon.	16				17 30
Tues.	17				
Wed.	18	16		Occ'n: SAO 159344 by Vesta	
		22		Mars nearest to Earth	
Thur.	19	14		Aldebaran 1° S. of Moon. Occ'n[1]	14 20
Fri.	20	07		Saturn 1.1° N. of Regulus	
		21		Moon at apogee (406,100 km)	
Sat.	21	02		Jupiter 5° N. of Moon	
		19		Mars at opposition	
Sun.	22			Mercury at descending node	11 10
		00		Venus in superior conjunction	
Mon.	23				
Tues.	24	01		Mars 9° N. of Moon	
		02	55	Full Moon	
Wed.	25	21		Pluto stationary	8 00
Thur.	26	07		Saturn 5° N. of Moon	
Fri.	27				
Sat.	28			Venus at aphelion	4 50
Sun.	29				
Mon.	30				
Tues.	31	18	51	Last Quarter	1 40

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



[1]Visible in Greenland.

THE SKY FOR FEBRUARY 1978

Have you noticed that the moon appears larger when it is near the horizon than when it is high in the sky? This well-known effect, called the "Moon Illusion", is discussed in *Scientific American* ***207***, No. 1, 120 (1962) and in *Mercury* ***5***, No. 2, 20 (1976).

You can verify that this is an illusion by measuring the apparent diameter of the moon. Take a small coin of diameter d, and place it at the *minimum* distance D from your eye, at which it will exactly cover the disc of the moon. The apparent diameter of the moon is then $(57d/D)^\circ$. Try this on a night near full moon, once when the moon is near the horizon, once when it is high in the sky.

The moon's apparent diameter actually varies during the *month* because of its varying distance from the earth; this effect is about 10 per cent. See if you can detect this effect by doing the coin experiment once near perigee (see opposite page) and once near apogee.

The Sun—During February the sun's R.A. increases from 20 h 57 m to 22 h 46 m and its Decl. changes from −17°16′ to −7°48′. The equation of time changes from −13 m 38 s to −12 m 34 s, reaching a maximum of −14 m 17 s on Feb. 11.

The Moon—On Feb. 1.0 E.S.T., the age of the moon is 23.0 d. The sun's selenographic colongitude is 188.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 11 (7°) and minimum (east limb exposed) on Feb. 26 (5°). The libration in latitude is maximum (north limb exposed) on Feb. 18 (7°) and minimum (south limb exposed) on Feb. 4 (7°).

Mercury on the 1st is in R.A. 19 h 46 m, Decl. −22°22′, and on the 15th is in R.A. 21 h 19 m, Decl. −17°49′. Early in the month it may be seen very low in the south-east before sunrise, but by the end of the month it is too close to the sun for observation, superior conjunction being on the 26th (E.S.T.).

Venus on the 1st is in R.A. 21 h 08 m, Decl. −17°48′, and on the 15th it is in R.A. 22 h 17 m, Decl. −12°14′, mag. −3.4, and transits at 12 h 39 m. It is too close to the sun for observation.

Mars on the 15th is in R.A. 7 h 46 m, Decl. +25°26′, mag. −0.6, and transits at 22 h 02 m. Moving from Cancer into Gemini it is about 30° above the eastern horizon at sunset and sets shortly before sunrise. It forms a pretty conjunction with Castor and Pollux.

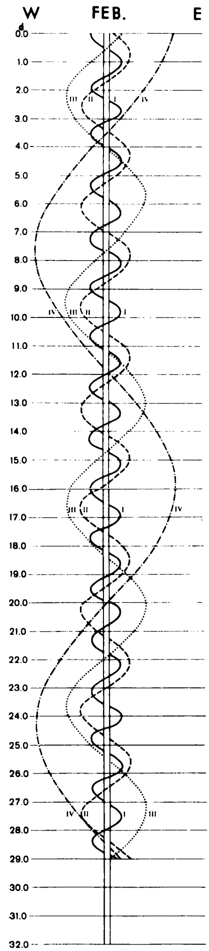
Jupiter on the 15th is in R.A. 5 h 43 m, Decl. +23°16′, mag. −2.1, and transits at 20 h 00 m. In Taurus, it is high in the east at sunset and sets about 4 hours before sunrise. On Feb. 19 (E.S.T.) it is stationary and resumes direct motion.

Saturn on the 15th is in R.A. 10 h 00 m, Decl. +13°53′, mag. +0.3, and transits at 0 h 20 m. It rises at about sunset and is above the horizon all night, being at opposition on the 15th, in the constellation Leo.

Uranus on the 15th is in R.A. 14 h 56 m, Decl. −16°22′, mag. +5.8, and transits at 5 h 16 m.

Neptune on the 15th is in R.A. 17 h 08 m, Decl. −21°28′, mag. +7.8, and transits at 7 h 28 m.

1978				FEBRUARY E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Wed.	1			Mercury at aphelion		
		01		Uranus 3° S. of Moon		
Thur.	2				22 30	
Fri.	3	07		Neptune 3° S. of Moon		
Sat.	4					
Sun.	5	16		Moon at perigee (361,350 km)	19 20	
Mon.	6					
Tues.	7	09	54	New Moon		
Wed.	8				16 10	
Thur.	9					
Fri.	10					
Sat.	11				12 50	
Sun.	12					
Mon.	13					
Tues.	14	17	11	First Quarter	9 40	
Wed.	15	21		Aldebaran 0.9° S. of Moon. Occ'n[1]		
		23		Saturn at opposition		
Thur.	16					
Fri.	17	01		Mars 3° S. of Pollux	6 30	
		06		Jupiter 5° N. of Moon		
		13		Moon at apogee (405,150 km)		
Sat.	18					
Sun.	19			Venus at greatest hel. lat. S.		
		12		Uranus stationary		
		15		Mars 9° N. of Moon		
		21		Jupiter stationary		
Mon.	20				3 20	
Tues.	21			Mercury at greatest hel. lat. S.		
Wed.	22	09		Saturn 5° N. of Moon		
		20	26	Full Moon		
Thur.	23				0 10	
Fri.	24					
Sat.	25				21 00	
Sun.	26	22		Mercury in superior conjunction		
Mon.	27					
Tues.	28	07		Uranus 3° S. of Moon	17 50	



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

THE SKY FOR MARCH 1978

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

The Sun—During March the sun's R.A. increases from 22 h 46 m to 0 h 40 m and its Decl. changes from −7°48′ to +4°19′. The equation of time changes from −12 m 23 s to −4 m 11 s. On March 20, at 18 h 34 m 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 21.6 d. The sun's selenographic colongitude is 169.2° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on March 11 (5°) and minimum (east (limb exposed) on March 24 (5°). The libration in latitude is maximum (north limb exposed) on March 17 (7°) and minimum (south limb exposed) on March 4 (7°) and March 31 (7°).

Mercury on the 1st is in R.A. 22 h 55 m, Decl. −8°45′, and on the 15th is in R.A. 0 h 30 m, Decl. +3°42′. Early in the month, it is too close to the sun to be seen, but by March 24 it is at greatest elongation east (19°), at which time it stands about 16° above the horizon at sunset.

Venus on the 1st is in R.A. 23 h 22 m, Decl. −5°35′, and on the 15th it is in R.A. 0 h 26 m, Decl. +1°33′, mag. −3.4 and transits at 12 h 58 m. It can be seen very low in the south-west after sunset.

Mars on the 15th is in R.A. 7 h 43 m, Decl. +24°41′, mag. +0.1, and transits at 20 h 10 m. Moving from Gemini back into Cancer (it was stationary on the 2nd), it is high in the south-east at sunset and sets a few hours before sunrise.

Jupiter on the 15th is in R.A. 5 h 47 m, Decl. +23°21′, mag. −1.9, and transits at 18 h 14 m. In Taurus, it is on the meridian at sunset and sets shortly after midnight.

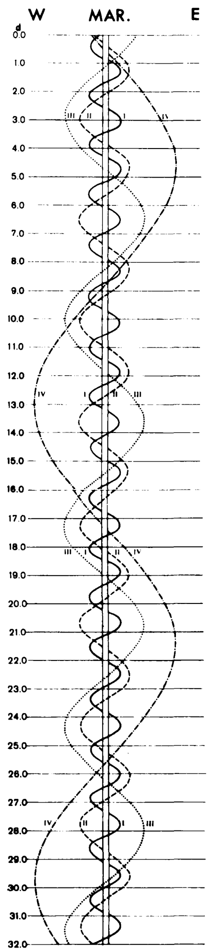
Saturn on the 15th is in R.A. 9 h 52 m, Decl. +14°38′, mag. +0.4, and transits at 22 h 18 m. In Leo, it is well up in the east at sunset and sets before sunrise.

Uranus on the 15th is in R.A. 14 h 55 m, Decl. −16°17′, mag. +5.8, and transits at 3 h 25 m.

Neptune on the 15th is in R.A. 17 h 10 m, Decl. −21°28′, mag. +7.8, and transits at 5 h 39 m.

1978				MARCH E.S.T.	Min. of Algol
	d	h	m		h m
Wed.	1				
Thur.	2			Mars at greatest hel. lat. N.	
		03	34	☾ Last Quarter	
		15		Neptune 4° S. of Moon	
		16		Mars stationary	
Fri.	3				14 40
Sat.	4				
Sun.	5	12		Moon at perigee (366,850 km)	
Mon.	6				11 30
Tues.	7				
Wed.	8	21	36	● New Moon	
Thur.	9	20		Venus 2° S. of Moon	8 20
Fri.	10				
Sat.	11				
Sun.	12			Mercury at ascending node	5 10
		17		Mercury 1.3° N. of Venus	
Mon.	13				
Tues.	14				
Wed.	15	05		Aldebaran 0.8° S. of Moon. Occ'n[1]	2 00
Thur.	16	13	21	☽ First Quarter	
		16		Jupiter 5° N. of Moon	
Fri.	17			Mercury at perihelion	22 50
		00		Mars 4° S. of Pollux	
		09		Moon at apogee (404,450 km)	
Sat.	18				
Sun.	19	01		Mars 8° N. of Moon	
Mon.	20	17		Neptune stationary	19 30
		18	34	Equinox. Spring begins	
Tues.	21	14		Saturn 5° N. of Moon	
Wed.	22	07		Occ'n: SAO 160266 by Vesta	
Thur.	23				16 20
Fri.	24	11	20	○ Full Moon; eclipse of ☾, p. 64	
		12		Mercury greatest elong. E. (19°)	
Sat.	25				
Sun.	26				13 10
Mon.	27			Mercury at greatest hel. lat. N.	
		12		Uranus 3° S. of Moon	
Tues.	28	14		Mercury 4° N. of Venus	
Wed.	29	20		Neptune 4° S. of Moon	10 00
Thur.	30				
Fri.	31	00		Moon at perigee (369,950 km)	
		10	11	☾ Last Quarter	

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



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

THE SKY FOR APRIL 1978

Have you ever seen Uranus? This would be a good month to try. At the end of April, Uranus is approaching opposition, and is technically bright enough ($5^{m}.7$) to be seen with the unaided eye against a clear, dark sky. In binoculars or a small telescope, it will be an easy target.

On April 27, Uranus is only 5′ north of the double star α Librae (Zubenelgenubi for the *cognoscenti*). The primary, α^2 Lib, is $2^{m}.8$, and the secondary, α^1 Lib, is $5^{m}.2$, about 4′ north and west. For a few days around the 27th, Uranus, α^2 Lib and α^1 Lib will provide a fascinating sight as the planet moves westward past the two fixed stars.

The Sun—During April the sun's R.A. increases from 0 h 40 m to 2 h 31 m and its Decl. changes from +4°19′ to +14°54′. The equation of time changes from −3 m 53 s to +2 m 50 s, being zero on April 15.

The Moon—On April 1.0 E.S.T., the age of the moon is 23.1 d. The sun's selenographic colongitude is 186.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on April 7 (5°) and minimum (east limb exposed) on April 20 (6°). The libration in latitude is maximum (north limb exposed) on April 13 (7°) and minimum (south limb exposed) on April 27 (7°).

Mercury on the 1st is in R.A. 1 h 32 m, Decl. +13°07′, and on the 15th is in R.A. 1 h 08 m, Decl. +8°46′. At the beginning of the month, Mercury is still visible very low in the west after sunset, but by April 11 it is in inferior conjunction. Later in the month it is still too close to the sun to be easily visible.

Venus on the 1st is in R.A. 1 h 44 m, Decl. +10°02′, and on the 15th it is in R.A. 2 h 50 m, Decl. +16°14′, mag. −3.3, and transits at 13 h 19 m. It is well up in the west at sunset and sets about two hours later.

Mars on the 15th is in R.A. 8 h 17 m, Decl. +22°10′, mag. +0.8, and transits at 18 h 44 m. In Cancer, it is on the meridian at sunset and sets shortly after midnight.

Jupiter on the 15th is in R.A. 6 h 02 m, Decl. +23°27′, mag. −1.7, and transits at 16 h 28 m. Moving from Taurus into Gemini, it is high in the south-west at sunset and sets about 5 hours later.

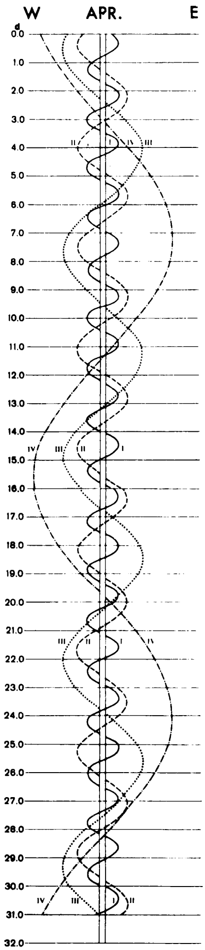
Saturn on the 15th is in R.A. 9 h 46 m, Decl. +15°03′, mag. +0.5, and transits at 20 h 11 m. In Leo, it is high in the south-east at sunset and sets about 2½ hours before sunrise. On the 25th it is stationary and resumes direct motion with respect to the background stars.

Uranus on the 15th is in R.A. 14 h 52 m, Decl. −16°00′, mag. +5.7, and transits at 1 h 19 m.

Neptune on the 15th is in R.A. 17 h 09 m, Decl. −21°26′, mag. +7.7, and transits at 3 h 36 m.

1978				APRIL E.S.T.	Min. of Algol
	d	h	m		h m
Sat.	1	09		Mercury stationary	6 50
Sun.	2				
Mon.	3				
Tues.	4				3 40
Wed.	5	06		Pluto at opposition	
Thur.	6				
Fri.	7	10	15	● New Moon; eclipse of ☉, p. 64	0 30
Sat.	8	22		Venus 3° N. of Moon	
Sun.	9			Mars at aphelion	21 20
Mon.	10			Jupiter at ascending node	
Tues.	11	12		Mercury in inferior conjunction	
		13		Aldebaran 0.8° S. of Moon. Occ'n[1]	
Wed.	12				18 10
Thur.	13	06		Jupiter 5° N. of Moon	
Fri.	14	05		Moon at apogee (404,450 km)	
Sat.	15	03		Pallas stationary	15 00
		08	56	☽ First Quarter	
Sun.	16			Venus at ascending node	
		02		Mars 7° N. of Moon	
Mon.	17	21		Saturn 5° N. of Moon	
Tues.	18				11 50
Wed.	19				
Thur.	20			Mercury at descending node	
Fri.	21				8 40
Sat.	22	10		Lyrid Meteors	
		23	11	○ Full Moon	
Sun.	23	18		Uranus 3° S. of Moon	
		19		Vesta stationary	
		21		Mercury stationary	
Mon.	24				5.20
Tues.	25	14		Saturn stationary	
Wed.	26	02		Neptune 3° S. of Moon	
		03		Moon at perigee (365,950 km)	
Thur.	27				2 10
Fri.	28				
Sat.	29	16	02	☾ Last Quarter	23 00
Sun.	30			Mercury at aphelion	

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



[1]Visible in N. America, Europe, Asia Minor.

THE SKY FOR MAY 1978

From time to time you will see such statements as "Aldebaran 0.9° S of moon; occultation" in the pages opposite. This statement means that, as seen from the *centre* of the earth, Aldebaran is 0.9° south of the *centre* of the moon. Since the moon's disc is only 0.25° in radius, an occultation would not be seen from the *centre* of the earth.

Because of the effect of parallax, however, the *centre* of the moon's disc is displaced about 1° south or north when viewed from the north or south pole of the earth, respectively. Also, because of the 0.25° radius of the moon's disc, Aldebaran could be as much as 1.25° north or south of the moon, and an occultation could be seen somewhere on the earth. Thus, the "band" referred to in "The Sky for January" is 2.5° wide.

When the occulted object is south of the moon, the occultation is generally visible in the northern hemisphere, and *vice versa.* Check the opposite pages and verify that this is so.

The Sun—During May the sun's R.A. increases from 2 h 31 m to 4 h 34 m and its Decl. changes from +14°54′ to +21°58′. The equation of time changes from +2 m 57 s to +2 m 26 s, reaching a maximum of +3 m 44 s on May 14.

The Moon—On May 1.0 E.S.T., the age of the moon is 23.6 d. The sun's selenographic colongitude is 192.7° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 3 (5°) and May 30 (6°) and minimum (east limb exposed) on May 18 (7°). The libration in latitude is maximum (north limb exposed) on May 11 (7°) and minimum (south limb exposed) on May 24 (7°).

Mercury on the 1st is in R.A. 1 h 03 m, Decl. +4°12′, and on the 15th is in R.A. 1 h 50 m, Decl. +7°56′. On May 9, Mercury is at greatest elongation west (26°) but because of the unfavourable orientation of the ecliptic, the planet is only 11° above the horizon at sunrise at this time.

Venus on the 1st is in R.A. 4 h 10 m, Decl. +21°40′, and on the 15th it is in R.A. 5 h 22 m, Decl. +24°23′, mag. −3.4, and transits at 13 h 54 m. At sunset it is about 26° above the western horizon and sets about 2½ hours later. On the 5th it is 6° N. of Aldebaran and on the 28th it is 1.6° N. of Jupiter.

Mars on the 15th is in R.A. 9 h 10 m, Decl. +18°10′, mag. +1.2, and transits at 17 h 38 m. Moving from Cancer into Leo, it is past the meridian at sunset and sets about 5½ hours later.

Jupiter on the 15th is in R.A. 6 h 25 m, Decl. +23°23′, mag. −1.5, and transits at 14 h 53 m. In Gemini, it is about 35° above the western horizon at sunset and sets about 3 hours later. On May 28 (E.S.T.) it is 1.6° S. of Venus.

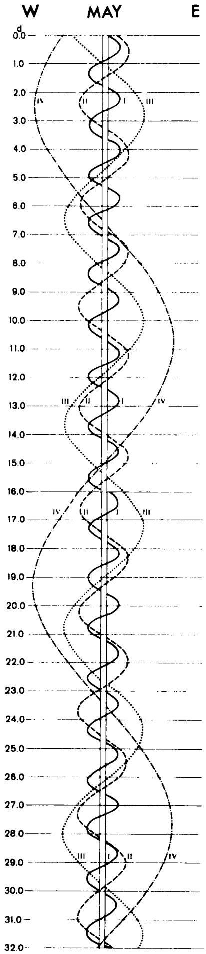
Saturn on the 15th is in R.A. 9 h 47 m, Decl. +14°56′, mag. +0.7, and transits at 18 h 14 m. In Leo, it is past the meridian at sunset and sets at about midnight.

Uranus on the 15th is in R.A. 14 h 47 m, Decl. −15°39′, mag. +5.7, and transits at 23 h 12 m. It is at opposition on May 5.

Neptune on the 15th is in R.A. 17 h 07 m, Decl. −21°22′, mag. +7.7, and transits at 1 h 36 m.

1978	d	h	m	MAY E.S.T.	Min. of Algol h m
Mon.	1				
Tues.	2				19 50
Wed.	3				
Thur.	4	21		Mercury 2° S. of Moon	
Fri.	5	01		Uranus at opposition	16 40
		11		η Aquarid meteors	
		16		Venus 6° N. of Aldebaran	
Sat.	6	23	47	New Moon	
Sun.	7				
Mon.	8	21		Aldebaran 0.9° S. of Moon. Occ'n.[1]	13 30
Tues.	9	06		Venus 6° N. of Moon	
		10		Mercury greatest elong. W. (26°)	
Wed.	10				
Thur.	11	00		Jupiter 5° N. of Moon	10 20
		23		Moon at apogee (405,200 km)	
Fri.	12				
Sat.	13				
Sun.	14	10		Mars 6° N. of Moon	7 10
Mon.	15	02	39	First Quarter	
		06		Saturn 5° N. of Moon	
Tues.	16				
Wed.	17				4 00
Thur.	18				
Fri.	19				
Sat.	20			Mercury at greatest hel. lat. S.	0 50
				Venus at perihelion	
		12		Ceres stationary	
Sun.	21	02		Uranus 3° S. of Moon	
Mon.	22	08	17	Full Moon	21 30
Tues.	23	10		Neptune 3° S. of Moon	
Wed.	24	00		Moon at perigee (360,950 km)	
Thur.	25				18 20
Fri.	26				
Sat.	27				
Sun.	28	21		Venus 1.6° N. of Jupiter	15 10
		22	30	Last Quarter	
Mon.	29	00		Occ'n: SAO 85009 by Pallas	
Tues.	30				
Wed.	31				12 00

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



[1]Visible in Central and E. Asia, N. America.

THE SKY FOR JUNE 1978

In the evening sky in June, the four bright planets Venus, Mars, Jupiter and Saturn are gathered together along the ecliptic, stretching from Gemini (low in the west) eastward to Leo. Jupiter is in Gemini, and has moved into the western twilight by month's end. Venus begins in Gemini but moves eastward into Cancer, fast enough to keep ahead of the sun; it therefore remains visible throughout the month. Mars and Saturn are together in Leo: Mars is 0.1° S. of Saturn on the 4th (E.S.T.) and is 0.8° N. of Regulus on the 12th. From June 8 to 13, the moon also joins the array, being at first quarter on the 13th.

Some fears have recently been expressed in the popular literature about the possible tidal effects of the planets when they are all on the same side of the earth. It must be remembered, though, that the combined tidal effect of the planets is thousands of times smaller than that of the much more massive sun, and the much closer moon.

The Sun—During June the sun's R.A. increases from 4 h 34 m to 6 h 38 m and its Decl. changes from +21°58′ to +23°09′. The equation of time changes from +2 m 17 s to −3 m 33 s, being zero on June 13. On June 21, at 13 h 10 m E.S.T., summer begins.

The Moon—On June 1.0 E.S.T., the age of the moon is 25.0 d. The sun's selenographic colongitude is 211.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 27 (7°) and minimum (east limb exposed) on June 15 (8°). The libration in latitude is maximum (north limb exposed) on June 7 (7°) and minimum (south limb exposed) on June 20 (7°).

Mercury on the 1st is in R.A. 3 h 32 m, Decl. +17°38′, and on the 15th is in R.A. 5 h 34 m, Decl. +24°19′. Mercury is too close to the sun to be easily visible this month; it is in superior conjunction on the 14th.

Venus on the 1st is in R.A. 6 h 52 m, Decl. +24°38′, and on the 15th it is in R.A. 8 h 04 m, Decl. +22°21′, mag. −3.5, and transits at 14 h 33 m. It is about 26° above the western horizon at sunset and sets about 2½ hours later. During the month it moves south of Castor and Pollux.

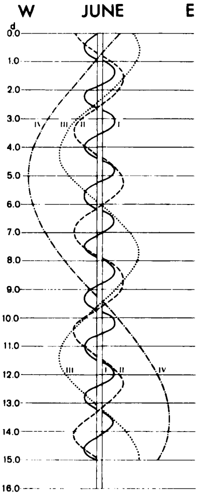
Mars on the 15th is in R.A. 10 h 12 m, Decl. +12°26′, mag. +1.5, and transits at 16 h 38 m. In Leo, it is well up in the south-west at sunset and sets about 4 hours later. It is 0.1° S. of Saturn on the 4th (E.S.T.) and 0.8° N. of Regulus on the 12th.

Jupiter on the 15th is in R.A. 6 h 53 m, Decl. +22°59′, mag. −1.4, and transits at 13 h 19 m. In Gemini, it is very low in the west at sunset and sets about 1½ hours later.

Saturn on the 15th is in R.A. 9 h 54 m, Decl. +14°18′, mag. +0.8, and transits at 16 h 19 m. In Leo, it is high in the south-west at sunset and sets about 4 hours later. On the 4th it is 0.1° N. of Mars.

Uranus on the 15th is in R.A. 14 h 42 m, Decl. −15°19′, mag. +5.8, and transits at 21 h 06 m.

Neptune on the 15th is in R.A. 17 h 03 m, Decl. −21°18′, mag. +7.7, and transits at 23 h 27 m. It is at opposition on June 7 (E.S.T.).

1978				JUNE E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Thur.	1	08		Juno stationary		
Fri.	2					
Sat.	3				8 50	
Sun.	4	18		Pallas at opposition		
		19		Vesta at opposition		
		19		Mars 0.1° S. of Saturn		
Mon.	5	14	01	● New Moon		
Tues.	6				5 40	
Wed.	7	19		Jupiter 5° N. of Moon		
		21		Neptune at opposition		
Thur.	8			Mercury at ascending node		
		13		Moon at apogee (406,150 km)		
		18		Venus 7° N. of Moon		
Fri.	9				2 30	
Sat.	10	19		Venus 5° S. of Pollux		
Sun.	11			Venus at greatest hel. lat. N.	23 20	
		16		Saturn 5° N. of Moon		
		22		Mars 4° N. of Moon		
Mon.	12	12		Mars 0.8° N. of Regulus		
Tues.	13			Mercury at perihelion		
		17	44	☽ First Quarter		
Wed.	14	07		Mercury in superior conjunction	20 10	
Thur.	15					
Fri.	16					
Sat.	17	11		Uranus 3° S. of Moon	16 50	
Sun.	18					
Mon.	19	10		Vesta 0.9° N. of Moon. Occ'n		Jupiter
		19		Neptune 3° S. of Moon		near
Tues.	20	15	30	○ Full Moon	13 40	sun;
Wed.	21	07		Moon at perigee (357,650 km)		configurations
		13	10	Solstice. Summer begins		not given
Thur.	22					
Fri.	23			Mercury at greatest hel. lat. N.	10 30	
Sat.	24	03		Mercury 1.8° N. of Jupiter		
Sun.	25					
Mon.	26				7 20	
Tues.	27	06	44	☾ Last Quarter		
Wed.	28					
Thur.	29	05		Mercury 5° S. of Pollux	4 10	
Fri.	30					

THE SKY FOR JULY 1978

If you were successful in locating Uranus in April, perhaps you would like to try to locate an asteroid (or two, or three, or four) this month. The four asteroids Ceres, Juno, Pallas and Vesta all come to opposition in June or July this year. [Actually, these are not the four *largest* asteroids (see "Asteroids", page 88) nor are they necessarily the *brightest* (this depends on the size and also on the Earth-asteroid-sun distances at opposition) nor the most easily observed (this depends also on the R.A. and Dec. at opposition). Nevertheless, maps are provided for these four asteroids, as they have been for many years.]

Vesta is undoubtedly the best one to locate first, since it is $5^{m}.5$ at brightest: visible to the unaided eye if the sky is clear and dark. Binoculars or a small telescope would certainly help. Use the "key" map on page 89 to locate the general area of sky, then use the more detailed map on page 89 to locate the asteroid. During late June and July, the asteroid weaves in and out of a line of three bright stars. Once you have located the asteroid, you can follow its motion from night to night.

The Sun—During July the sun's R.A. increases from 6 h 38 m to 8 h 43 m and its Decl. changes from +23°09′ to +18°10′. The equation of time changes from −3 m 44 s to −6 m 19 s, reaching a maximum of −6 m 27 s on July 26. The earth is in aphelion on July 4 (E.S.T.) at a distance of 152,100,000 km (94,509,000 mi) from the sun.

The Moon—On July 1.0 E.S.T., the age of the moon is 25.4 d. The sun's selenographic colongitude is 217.9° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 25 (8°) and minimum (east limb exposed) on July 13 (8°). The libration in latitude is maximum (north limb exposed) on July 4 (7°) and July 31 (7°) and minimum (south limb exposed) on July 18 (7°).

Mercury on the 1st is in R.A. 7 h 56 m, Decl. +22°39′, and on the 15th is in R.A. 9 h 22 m, Decl. +15°48′. Throughout the month Mercury can be seen very low in the west after sunset. Greatest elongation east (27°) occurs on the 21st, but this is not a particularly favourable one; the planet stands about 14° above the horizon at sunset.

Venus on the 1st is in R.A. 9 h 21 m, Decl. +17°24′, and on the 15th it is in R.A. 10 h 23 m, Decl. +11°34′, mag. −3.6, and transits at 14 h 53 m. Although it is becoming brighter and moving further east of the sun, it is becoming less favourably placed for northern observers, and is quite low in the south-west at sunset. It passes 0.1° N. of Saturn on the 10th and 1.1° N. of Regulus the next day.

Mars on the 15th is in R.A. 11 h 16 m, Decl. +5°36′, mag. +1.7, and transits at 15 h 44 m. Moving from Leo into Virgo, it is low in the south-west at sunset and sets about 2½ hours later.

Jupiter on the 15th is in R.A. 7 h 22 m, Decl. +22°16′, mag. −1.4, and transits at 11 h 49 m. It is too close to the sun for observation, being in conjunction on the 10th.

Saturn on the 15th is in R.A. 10 h 05 m, Decl. +13°17′, mag. +0.9, and transits at 14 h 32 m. In Leo, it is low in the west at sunset and sets about 2 hours later. On the 10th it is 0.1° S. of Venus and on the 19th it is 1.0° N. of Regulus.

Uranus on the 15th is in R.A. 14 h 40 m, Decl. −15°11′, mag. +5.8, and transits at 19 h 06 m.

Neptune on the 15th is in R.A. 17 h 00 m, Decl. −21°14′, mag. +7.7, and transits at 21 h 26 m.

1978				JULY E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Sat.	1	11		Pluto stationary		
Sun.	2	10		Aldebaran 0.8° S. of Moon. Occ'n[1]	1 00	
Mon.	3					
Tues.	4	19		Earth at aphelion	21 50	
Wed.	5	04	50	● New Moon		
		19		Moon at apogee (406,600 km)		
Thur.	6					
Fri.	7	09		Mercury 5° N. of Moon	18 30	
Sat.	8					
Sun.	9	00		Venus 4° N. of Moon		
		03		Saturn 4° N. of Moon		
		06		Ceres at opposition		
Mon.	10	06		Jupiter in conjunction with Sun	15 20	
		07		Venus 0.1° N. of Saturn		
		11		Mars 2° N. of Moon		
Tues.	11	03		Venus 1.1° N. of Regulus		
Wed.	12					
Thur.	13	05	49	☽ First Quarter	12 10	Jupiter
Fri.	14	19		Uranus 3° S. of Moon		near sun;
Sat.	15					configurations
Sun.	16				9 00	not given
Mon.	17			Mercury at descending node		
		05		Neptune 3° S. of Moon		
Tues.	18					
Wed.	19	01		Vesta stationary	5 50	
		01		Saturn 1.0° N. of Regulus		
		16		Moon at perigee (357,050 km)		
		18		Occ'n: SAO 144070 by Juno		
		22	05	○ Full Moon		
Thur.	20					
Fri.	21	09		Uranus stationary		
		19		Mercury greatest elong. E. (27°)		
Sat.	22				2 40	
Sun.	23					
Mon.	24	13		Juno at opposition	23 30	
Tues.	25					
Wed.	26	17	31	☾ Last Quarter		
Thur.	27			Mercury at aphelion	20 10	
		21		Mercury 3° S. of Regulus		
Fri.	28					
Sat.	29	7		δ Aquarid meteors		
		15		Aldebaran 0.7° S. of Moon. Occ'n[2]		
Sun.	30				17 00	
Mon.	31	17		Mercury 5° S. of Saturn		

[1]Visible in N. America, N.W. Europe.
[2]Visible in Central and E. Asia, N. America.

THE SKY FOR AUGUST 1978

In previous editions of this HANDBOOK (e.g. 1977, page 42), we have often discussed (and explained) "favourable and unfavourable elongations of Mercury". This month we have a very unfavourable elongation of *Venus*: although it is 46° E. of the sun on the 29th, it is nevertheless very low in the south-western sky, as seen by northern observers. The explanation is similar to that for Mercury.

The explanation is the shallow angle between the ecliptic and the western horizon, as seen in the evening in the autumn by northern observers. An equivalent explanation is the low declination of Venus, relative to that of the sun, during this period. Other things being equal, objects at lower declinations are more difficult for northern observers to see.

Mars too is 40° to 50° E. of the sun during this period and, for the same reason, is very low in the sky. In fact, for several weeks in autumn, Mars is barely 10° above the south-western horizon at sunset.

The Sun—During August the sun's R.A. increases from 8 h 43 m to 10 h 39 m and its Decl. changes from +18°10′ to +8°29′. The equation of time changes from −6 m 16 s to −0 m 19 s.

The Moon—On Aug. 1.0 E.S.T., the age of the moon is 26.8 d. The sun's selenographic colongitude is 236.8° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 23 (7°) and minimum (east limb exposed) on Aug. 10 (7°). The libration in latitude is maximum (north limb exposed) on Aug. 27 (7°) and minimum (south limb exposed) on Aug. 14 (7°).

Mercury on the 1st is in R.A. 10 h 13 m, Decl. +7°51′, and on the 15th is in R.A. 9 h 57 m, Decl. +7°24′. It is too close to the sun for observation, being in inferior conjunction on the 18th.

Venus on the 1st is in R.A. 11 h 32 m, Decl. +3°26′, and on the 15th it is in R.A. 12 h 26 m, Decl. −3°34′, mag. −3.8, and transits at 14 h 53 m. Although it reaches greatest elongation east on the 29th, it is even less favourably placed than last month, being only about 18° above the horizon at sunset. On the night of the 7th, both Venus and Mars are occulted by the moon (see opposite page).

Mars on the 15th is in R.A. 12 h 25 m, Decl. −2°17′, mag. +1.7, and transits at 14 h 51 m. In Virgo, it is very low in the south-west at sunset and sets about 2 hours later. It is 1.2° N. of Venus on the 14th.

Jupiter on the 15th is in R.A. 7 h 51 m, Decl. +21°13′, mag. −1.4, and transits at 10 h 17 m. In Gemini, it is about 22° above the eastern horizon at sunrise.

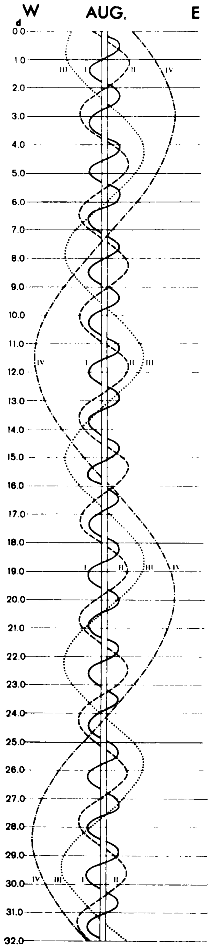
Saturn on the 15th is in R.A. 10 h 20 m, Decl. +11°58′, mag. +0.9, and transits at 12 h 45 m. It is too close to the sun for observation, being in conjunction on the 27th.

Uranus on the 15th is in R.A. 14 h 41 m, Decl. −15°16′, mag. +5.9, and transits at 17 h 05 m.

Neptune on the 15th is in R.A. 16 h 58 m, Decl. −21°13′, mag. +7.7, and transits at 19 h 22 m.

1978				AUGUST E.S.T.	Min. of Algol
	d	h	m		h m
Tues.	1	06		Occ'n: SAO 119114 by Mars	
		22		Moon at apogee (406,450 km)	
Wed.	2	09		Jupiter 5° N. of Moon	13 50
		10		Pallas stationary	
Thur.	3	20	01	New Moon	
		22		Mercury stationary	
Fri.	4	00		Mercury 5° S. of Saturn	
Sat.	5	14		Mercury 2° S. of Moon	10 40
		15		Saturn 4° N. of Moon	
Sun.	6			Venus at descending node	
Mon.	7	09		Jupiter 7° S. of Pollux	
		20		Venus 0.4° S. of Moon. Occ'n[1]	
Tues.	8	01		Mars 0.004° N. of Moon. Occ'n[2]	7 30
Wed.	9				
Thur.	10	17		Mercury 5° S. of Regulus	
Fri.	11	02		Uranus 3° S. of Moon	4 20
		15	06	First Quarter	
Sat.	12	12		Perseid meteors	
Sun.	13	13		Neptune 4° S. of Moon	
Mon.	14	10		Venus 1.2° S. of Mars	1 10
Tues.	15				
Wed.	16			Mercury at greatest hel. lat. S.	21 50
Thur.	17	01		Moon at perigee (359,250 km)	
Fri.	18	05	14	Full Moon	
		15		Mercury in inferior conjunction	
Sat.	19				18 40
Sun.	20				
Mon.	21				
Tues.	22				15 30
Wed.	23				
Thur.	24				
Fri.	25	07	18	Last Quarter	12 20
		22		Aldebaran 0.5° S. of Moon. Occ'n[3]	
Sat.	26				
Sun.	27	10		Saturn in conjunction with Sun	
		16		Mercury stationary	
Mon.	28	00		Neptune stationary	9 10
Tues.	29	08		Moon at apogee (405,600 km)	
		15		Venus greatest elong. E. (46°)	
		16		Ceres stationary	
Wed.	30	03		Jupiter 5° N. of Moon	
Thur.	31	04		Venus 0.3° S. of Spica	6 00

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



[1]Visible in E. Asia, N. Pacific, Central America.
[2]Visible in S.E. Asia, East Indies, N.E. Australia.
[3]Visible in N. and W. Africa, Europe, Central Asia.

THE SKY FOR SEPTEMBER 1978

Notice that the Harvest Moon occurs on September 16. By definition the Harvest Moon is the full moon nearest the autumnal equinox. Around this time, the moon provides an extra measure of light in the early evening, light that was (and is) useful for farmers gathering the harvest.

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

I leave it as an "exercise for the reader" to explain the astronomical and cultural significance of the Hunters' Moon on October 16.

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°29′ to −2°58′. The equation of time changes from 0 m 00 s to +9 m 59 s. On Sept. 23 at 04 h 26 m E.S.T., the sun crosses the equator on its way south, and autumn begins.

The Moon—On Sept. 1.0 E.S.T., the age of the moon is 28.2 d. The sun's selenographic colongitude is 255.5° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 20 (6°) and minimum (east limb exposed) on Sept. 7 (6°). The libration in latitude is maximum (north limb exposed) on Sept. 23 (7°) and minimum (south limb exposed) on Sept. 10 (7°).

Mercury on the 1st is in R.A. 9 h 33 m, Decl. +13°27′, and on the 15th is in R.A. 10 h 43 m, Decl. +9°55′. On the 4th, it is at greatest elongation west (18°), at which time it can be seen about 16° above the eastern horizon at sunrise, but by the end of the month it is in superior conjunction.

Venus on the 1st is in R.A. 13 h 26 m, Decl. −11°40′, and on the 15th it is in R.A. 14 h 12 m, Decl. −17°29′, mag. −4.2, and transits at 14 h 37 m. At sunset, it is visible low in the south-west and sets about 1½ hours later.

Mars on the 15th is in R.A. 13 h 39 m, Decl. −10°18′, mag. +1.8, and transits at 14 h 04 m. In Virgo, it is only about 12° above the south-western horizon at sunset. It is 2° N. of Spica on the 8th.

Jupiter on the 15th is in R.A. 8 h 16 m, Decl. +20°01′, mag. −1.5, and transits at 8 h 40 m. Now in Cancer, it rises about 4½ hours before the sun and is high in the south-east at sunrise.

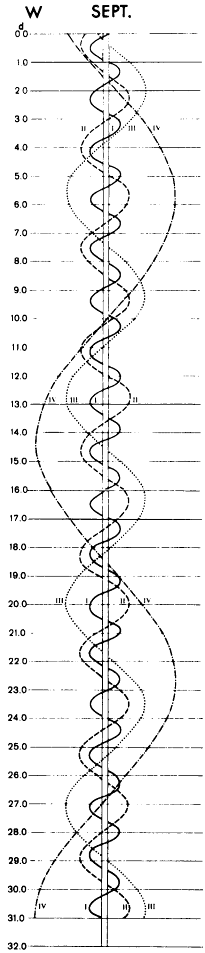
Saturn on the 15th is in R.A. 10 h 34 m, Decl. +10°35′, mag. +1.0, and transits at 10 h 58 m. Still in Leo, it is now in the morning sky, very low in the east at sunrise. On the 13th it is 0.1° S. of Mercury.

Uranus on the 15th is in R.A. 14 h 45 m, Decl. −15°35′, mag. +5.9, and transits at 15 h 07 m.

Neptune on the 15th is in R.A. 16 h 58 m, Decl. −21°15′, mag. +7.8, and transits at 17 h 20 m.

1978				SEPTEMBER E.S.T.	Min. of Algol
	d	h	m		h m
Fri.	1	00		Mercury 2° N. of Moon	
Sat.	2	11	09	● New Moon	
Sun.	3				2 50
Mon.	4			Mercury at ascending node	
		16		Mercury greatest elong. W. (18°)	
Tues.	5	16		Mars 2° S. of Moon	23 30
Wed.	6	05		Venus 6° S. of Moon	
Thur.	7	09		Uranus 4° S. of Moon	
Fri.	8	16		Mars 2° N. of Spica	20 20
Sat.	9			Mercury at perihelion	
				Venus at aphelion	
		03		Mercury 0.5° N. of Regulus	
		19		Neptune 4° S. of Moon	
		22	20	☽ First Quarter	
Sun.	10				
Mon.	11				17 10
Tues.	12	09		Juno stationary	
Wed.	13	10		Mercury 0.1° N. of Saturn	
Thur.	14	05		Moon at perigee (363,650 km)	14 00
Fri.	15				
Sat.	16			Mars at descending node	
		14	01	○ Full Moon, Harvest Moon, Eclipse of ☾, p. 64	
Sun.	17				10 50
Mon.	18				
Tues.	19			Mercury at greatest hel. lat. N.	
Wed.	20				7 40
Thur.	21				
Fri.	22	06		Aldebaran 0.4° S. of Moon. Occ'n[1]	
Sat.	23	04	26	Equinox. Autumn begins	4 30
Sun.	24	00	07	☾ Last Quarter	
Mon.	25				
Tues.	26	01		Moon at apogee (404,700 km)	1 10
		21		Jupiter 5° N. of Moon	
Wed.	27	19		Venus 6° S. of Uranus	
Thur.	28				22 00
Fri.	29	18		Saturn 3° N. of Moon	
Sat.	30	10		Mercury in superior conjunction	

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



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

THE SKY FOR OCTOBER 1978

The Summer Triangle, with Vega to the west, Deneb to the east, and Altair to the south, is high overhead in the early evening—as indeed it has been for several weeks and will be for several weeks more. Although the constellations march across the sky from east to west as the seasons progress, this effect is counterbalanced in the autumn by the advance of sunset time. As a result, the sky at twilight looks much the same for many weeks. This is a great convenience for observers—both amateur and professional—who are interested in objects in this part of the sky. [Incidentally, you can see this effect on the diagram on page 12: note that the twilight curves and the sidereal time lines are almost parallel in September and October.]

Perhaps this explains why the Summer Triangle is firmly imprinted on the minds of observers but (for the opposite reason) Leo, Virgo and Boötes slip away so quickly in the spring.

The Sun—During October the sun's R.A. increases from 12 h 27 m to 14 h 23 m and its Decl. changes from $-2°58'$ to $-14°15'$. The equation of time changes from $+10$ m 18 s to $+16$ m 21 s.

The Moon—On Oct. 1.0 E.S.T., the age of the moon is 28.5 d. The sun's selenographic colongitude is 261.6° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 17 (5°) and minimum (east limb exposed) on Oct. 3 (5°) and Oct. 30 (5°). The libration in latitude is maximum (north limb exposed) on Oct. 21 (7°) and minimum (south limb exposed) on Oct. 7 (7°).

Mercury on the 1st is in R.A. 12 h 30 m, Decl. $-1°54'$, and on the 15th is in R.A. 13 h 56 m, Decl. $-12°06'$. Throughout the month, it is very poorly placed for observation.

Venus on the 1st is in R.A. 14 h 54 m, Decl. $-22°33'$, and on the 15th it is in R.A. 15 h 13 m, Decl. $-24°51'$, mag. -4.2, and transits at 13 h 38 m. Early in the month, it is visible very low in the south-west at sunset. It is at greatest brilliancy on the 3rd.

Mars on the 15th is in R.A. 14 h 59 m, Decl. $-17°16'$, mag. $+1.7$, and transits at 13 h 25 m. In Libra, it is only about 10° above the south-western horizon at sunset.

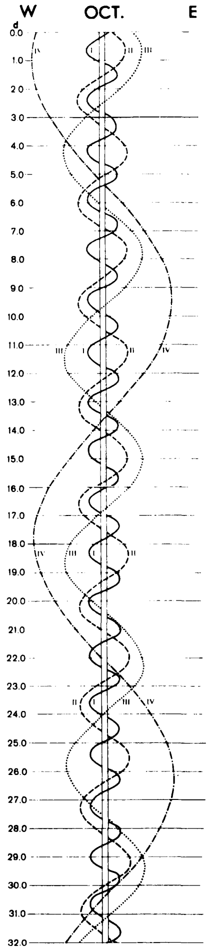
Jupiter on the 15th is in R.A. 8 h 35 m, Decl. $+19°01'$, mag. -1.7, and transits at 7 h 01 m. In Cancer, it rises at about midnight and is near the meridian at sunrise.

Saturn on the 15th is in R.A. 10 h 48 m, Decl. $+9°20'$, mag. $+1.1$, and transits at 9 h 13 m. In Leo, it rises about $3\frac{1}{2}$ hours before the sun and is well up in the east at sunrise.

Uranus on the 15th is in R.A. 14 h 51 m, Decl. $-16°04'$, mag. $+6.0$, and transits at 13 h 16 m.

Neptune on the 15th is in R.A. 17 h 00 m, Decl. $-21°19'$, mag. $+7.8$, and transits at 15 h 25 m.

1978				OCTOBER E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites) (Date Markers are U.T.)
	d	h	m		h m	
Sun.	1				18 50	
Mon.	2			Venus at greatest hel. lat. S.		
		01	41	New Moon; eclipse of ⊙, p. 64		
Tues.	3	17		Venus greatest brilliancy $(-4^{m}.3)$		
Wed.	4	09		Mars 4° S. of Moon	15 40	
		17		Uranus 4° S. of Moon		
		23		Venus 10° S. of Moon		
Thur.	5					
Fri.	6					
Sat.	7	01		Neptune 4° S. of Moon	12 30	
Sun.	8					
Mon.	9	04	38	First Quarter		
Tues.	10	01		Pluto in conjunction with Sun	9 20	
Wed.	11	11		Moon at perigee (368,800 km)		
		21		Mars 0.6° S. of Uranus		
Thur.	12					
Fri.	13			Mercury at descending node	6 10	
Sat.	14					
Sun.	15					
Mon.	16	01	09	Full Moon, Hunters' Moon	3 00	
Tues.	17	20		Venus stationary		
Wed.	18				23 40	
Thur.	19	15		Aldebaran 0.5° S. of Moon. Occ'n[1]		
Fri.	20	03		Venus 7° S. of Mars		
Sat.	21	13		Orionid meteors	20 30	
Sun.	22					
Mon.	23			Mercury at aphelion		
		19	34	Last Quarter		
		20		Moon at apogee (404,300 km)		
Tues.	24	12		Jupiter 4° N. of Moon	17 20	
		13		Mercury 1.7° S. of Uranus		
Wed.	25	25				
Thur.	26	23		Mercury 5° N. of Venus		
Fri.	27	08		Saturn 3° N. of Moon	14 10	
Sat.	28					
Sun.	29					
Mon.	30				11 00	
Tues.	31	00		Occ'n: SAO 122731 by Pallas		
		15	06	New Moon		



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

THE SKY FOR NOVEMBER 1978

Algol, or β Persei, has fascinated observers for centuries. Every 2.9 days, this star fades in brightness by $1^{m}.2$ in a few hours, then returns to normal. The cause of this behaviour is an eclipse. Algol consists of two stars in mutual orbit: a smaller, hotter, brighter component, and a larger, cooler, fainter one. When the larger component passes in front of the smaller one, the primary eclipse occurs.

The times of mid-eclipse are given in the pages opposite. You should start watching a few hours earlier (therefore choose an eclipse which occurs in late evening, if you can). The chart on page 108 shows the star, along with some comparison stars of known constant brightness. The text above the chart gives brief instructions on how to measure the changing brightness of the star.

Amateur observers can make useful contributions to astronomy by observing the times of mid-eclipse of eclipsing stars. If you are interested, you should contact the A.A.V.S.O.; see page 108 for further information.

The Sun—During November the sun's R.A. increases from 14 h 23 m to 16 h 27 m and its Decl. changes from −14°15′ to −21°43′. The equation of time changes from +16 m 22 s to +11 m 19 s, reaching a maximum of +16 m 24 s on Nov. 3.

The Moon—On Nov. 1.0 E.S.T., the age of the moon is 0.4 d. The sun's selenographic colongitude is 279.3° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 13 (5°) and minimum (east limb exposed) on Nov. 27 (6°). The libration in latitude is maximum (north limb exposed) on Nov. 17 (7°) and minimum (south limb exposed) on Nov. 4 (7°).

Mercury on the 1st is in R.A. 15 h 36 m, Decl. −21°23′, and on the 15th is in R.A. 16 h 52 m, Decl. −25°12′. It is at greatest elongation east (23°) on the 15th, but this is an unfavourable elongation; the planet stands only 10° above the horizon at sunset.

Venus on the 1st is in R.A. 14 h 59 m, Decl. −23°14′, and on the 15th it is in R.A. 14 h 30 m, Decl. −18°02′, mag. −3.5, and transits at 10 h 52 m. During the month, it moves rapidly through inferior conjunction (on the 7th) into the morning sky. By the end of the month, it rises about 2½ hours before the sun and stands about 25° above the south-eastern horizon at sunrise.

Mars on the 15th is in R.A. 16 h 30 m, Decl. −22°27′, mag. +1.6, and transits at 12 h 55 m. Moving through Scorpius to Ophiuchus, it is only 7° above the south-western horizon at sunset.

Jupiter on the 15th is in R.A. 8 h 46 m, Decl. +18°28′, mag. −1.9, and transits at 5 h 09 m. In Cancer, it rises about 2 hours before midnight and is past the meridian at sunrise. On Nov. 25 (E.S.T.) it is stationary and begins retrograde motion.

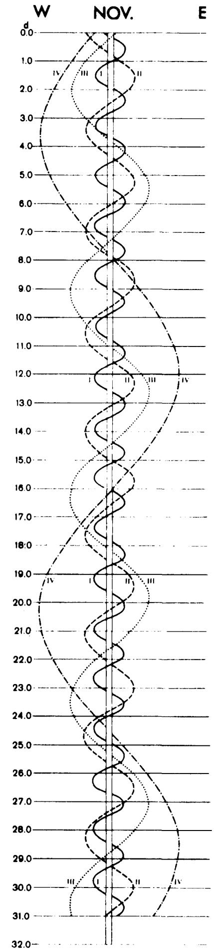
Saturn on the 15th is in R.A. 10 h 58 m, Decl. +8°23′, mag. +1.1, and transits at 7 h 21 m. In Leo, it rises at about midnight and is on the meridian at sunrise.

Uranus on the 15th is in R.A. 14 h 59 m, Decl. −16°37′, mag. +6.0, and transits at 11 h 21 m.

Neptune on the 15th is in R.A. 17 h 04 m, Decl. −21°26′, mag. +7.8, and transits at 13 h 27 m.

1978				NOVEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Wed.	1					
Thur.	2	00		Mercury 7° S. of Moon	7	50
		04		Mars 5° S. of Moon		
Fri.	3	09		Neptune 4° S. of Moon		
Sat.	4			Taurid meteors		
Sun.	5				4	40
		03		Mercury 1.9° S. of Mars		
		07		Moon at perigee (369,000 km)		
Mon.	6					
Tues.	7	11	18	First Quarter		
		16		Venus in inferior conjunction		
Wed.	8				1	30
Thur.	9	07		Uranus in conjunction with Sun		
		10		Occ'n: SAO 187470 by Vesta		
Fri.	10	01		Mercury 2° N. of Antares	22	10
Sat.	11					
Sun.	12			Mercury at greatest hel. lat. S.		
Mon.	13				19	00
Tues.	14	01		Mars 4° N. of Antares		
		15	00	Full Moon		
Wed.	15	21		Mercury greatest elong. E. (23°)		
Thur.	16	00		Aldebaran 0.6° S. of Moon. Occ'n[1]	15	50
Fri.	17	5		Leonid meteors		
		18		Mercury 4° S. of Neptune		
Sat.	18					
Sun.	19				12	40
Mon.	20	17		Moon at apogee (404,750 km)		
Tues.	21	00		Jupiter 4° N. of Moon		
Wed.	22	16	24	Last Quarter	9	30
Thur.	23	20		Saturn 3° N. of Moon		
Fri.	24					
Sat.	25	19		Mercury stationary	6	20
		22		Jupiter stationary		
Sun.	26	02		Mars 2° S. of Neptune		
		11		Venus stationary		
Mon.	27			Venus at ascending node		
		22		Venus 3° S. of Moon		
Tues.	28	16		Uranus 4° S. of Moon	3	10
Wed.	29	14		Mercury 0.1° N. of Mars		
Thur.	30	03	19	New Moon		

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



[1]Visible in N. America, Europe, N. Africa.

THE SKY FOR DECEMBER 1978

In "The Sky for November", we discussed the brightness variations in Algol. Similar variations—clearly visible to the unaided eye—occur in several of the brightest stars [see "The Brightest Stars", p. 96]. Nevertheless, from antiquity to about A.D. 1600, Western observers regarded the stars as fixed and unchanging. The recognition of brightness variations in some stars was really the beginning of true astrophysics.

The experienced eye can measure the brightness of a star to within $0^{m}.1$ or $0^{m}.2$ under ideal conditions. [Use the chart on page 108 to measure the brightness of Algol *outside* eclipse and compare your result with the correct answer: $2^{m}.1$.] The experienced eye can therefore measure brightness *changes* of $0^{m}.5$ with relative ease.

The eye can also perceive the colours of stars; the colours, when corrected for the effects of the earth's atmosphere, are a measure of the temperature of a star. [Scan the bright stars of the constellations Cassiopeia, Orion and Ursa Major; which star in each constellation is a different colour from the rest?]

The Sun—During December the sun's R.A. increases from 16 h 27 m to 18 h 43 m and its Decl. changes from −21°43′ to −23°04′. The equation of time changes from +10 m 57 s to −3 m 01 s, being zero on Dec. 25. On Dec. 22, at 0 h 21 m, winter begins.

The Moon—On Dec. 1.0 E.S.T., the age of the moon is 0.9 d. The sun's selenographic colongitude is 284.4° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 9 (6°) and minimum (east limb exposed) on Dec. 25 (7°). The libration in latitude is maximum (north limb exposed) on Dec. 14 (7°) and minimum (south limb exposed) on Dec. 1 (6°) and Dec. 28 (7°).

Mercury on the 1st is in R.A. 17 h 14 m, Decl. −23°17′, and on the 15th is in R.A. 16 h 16 m, Decl. −18°24′. Early in the month, it is too close to the sun for observation, but by the 24th it is at greatest elongation west (22°) at which time it stands about 14° above the horizon at sunrise.

Venus on the 1st is in R.A. 14 h 21 m, Decl. −13°18′, and on the 15th it is in R.A. 14 h 42 m, Decl. −12°51′, mag. −4.4, and transits at 9 h 08 m. At mid-month, it is at greatest brilliancy again, rising about 3½ hours before the sun, and standing about 28° above the horizon at sunrise. On the 26th, Venus is occulted by the moon (see opposite page).

Mars on the 15th is in R.A. 18 h 08 m, Decl. −24°15′, mag. +1.5, and transits at 12 h 34 m. It is too low in the sky for easy observation.

Jupiter on the 15th is in R.A. 8 h 44 m, Decl. +18°40′, mag. −2.1, and transits at 3 h 10 m. In Cancer, it rises about 3 hours after sunset and is about 30° above the western horizon at sunrise.

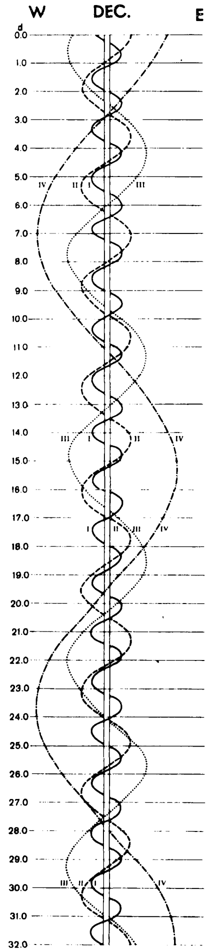
Saturn on the 15th is in R.A. 11 h 03 m, Decl. +8°00′, mag. +1.0, and transits at 5 h 28 m. In Leo, it rises before midnight and is past the meridian at sunrise. On the 25th it is stationary and commences retrograde motion with respect to the background stars.

Uranus on the 15th is in R.A. 15 h 06 m, Decl. −17°06′, mag. +5.9, and transits at 9 h 31 m.

Neptune on the 15th is in R.A. 17 h 09 m, Decl. −21°32′, mag. +7.8, and transits at 11 h 33 m.

1978				DECEMBER E.S.T.	Min. of Algol
	d	h	m		h m
Fri.	1			Mercury at ascending node	0 00
Sat.	2	11		Moon at perigee (363,700 km)	
Sun.	3				20 50
Mon.	4	10		Juno 0.4° N. of Moon. Occ'n	
Tues.	5	16		Mercury in inferior conjunction	
Wed.	6			Mercury at perihelion	17 40
		19	34	☽ First Quarter	
Thur.	7				
Fri.	8				
Sat.	9				14 20
Sun.	10	06		Neptune in conjunction with Sun	
Mon.	11				
Tues.	12				11 10
Wed.	13	07		Aldebaran 0.6° S. of Moon. Occ'n[1]	
Thur.	14	00		Venus greatest brilliancy $(-4^{m}.4)$	
		04		Geminid meteors	
		07	31	○ Full Moon	
Fri.	15	11		Mercury stationary	8 00
Sat.	16			Mercury at greatest hel. lat. N.	
Sun.	17				
Mon.	18	05		Jupiter 4° N. of Moon	4 50
		11		Moon at apogee (405,650 km)	
Tues.	19				
Wed.	20				
Thur.	21	06		Saturn 3° N. of Moon	1 40
Fri.	22	00	21	Solstice. Winter begins	
		01		Mercury 7° N. of Antares	
		12	41	☾ Last Quarter	
		19		Ursid meteors	
Sat.	23				22 30
Sun.	24	10		Venus 3° N. of Uranus	
		16		Mercury greatest elong. W. (22°)	
Mon.	25	16		Saturn stationary	
Tues.	26	05		Uranus 4° S. of Moon	19 20
		08		Venus 0.8° S. of Moon. Occ'n[2]	
Wed.	27				
Thur.	28	01		Mercury 3° S. of Moon	
		08		Neptune 4° S. of Moon	
Fri.	29	14	36	● New Moon	16 10
Sat.	30	17		Moon at perigee (358,850 km)	
Sun.	31			Venus at perihelion	
		14		Mercury 0.3° S. of Neptune	

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



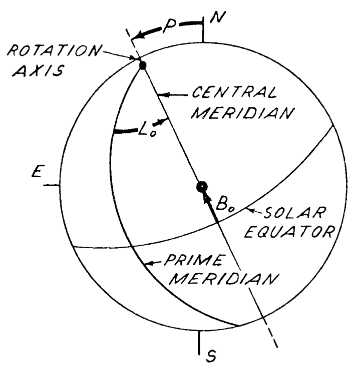
[1]Visible in Asia, N. America.

[2]Visible in N. America, W. Europe, N.W. Africa.

SUN—EPHEMERIS FOR PHYSICAL OBSERVATIONS, 1978
For 0 h U.T.

Date	P	B_0	L_0	Date	P	B_0	L_0
	°	°	°		°	°	°
Jan. 1	+ 2.19	−3.03	220.32	July 4	− 1.50	+3.20	311.84
6	− 0.23	−3.60	154.47	9	+ 0.77	+3.73	245.67
11	− 2.64	−4.15	88.63	14	+ 3.02	+4.23	179.50
16	− 5.01	−4.66	22.79	19	+ 5.23	+4.70	113.34
21	− 7.31	−5.13	316.95	24	+ 7.39	+5.15	47.18
26	− 9.54	−5.57	251.12	29	+ 9.47	+5.55	341.04
31	−11.66	−5.96	185.29	Aug. 3	+11.48	+5.92	274.91
Feb. 5	−13.67	−6.30	119.45	8	+13.40	+6.25	208.80
10	−15.57	−6.59	53.62	13	+15.21	+6.54	142.69
15	−17.33	−6.83	347.79	18	+16.91	+6.78	76.60
20	−18.95	−7.02	281.94	23	+18.49	+6.97	10.52
25	−20.42	−7.15	216.09	28	+19.94	+7.11	304.46
Mar. 1	−21.48	−7.22	163.40	Sept. 2	+21.26	+7.21	238.41
6	−22.68	−7.25	97.53	7	+22.44	+7.25	172.37
11	−23.71	−7.23	31.65	12	+23.48	+7.24	106.35
16	−24.58	−7.15	325.76	17	+24.37	+7.17	40.34
21	−25.27	−7.02	259.84	22	+25.09	+7.06	334.33
26	−25.79	−6.83	193.91	27	+25.66	+6.89	268.34
31	−26.14	−6.60	127.96	Oct. 2	+26.06	+6.67	202.36
Apr. 5	−26.31	−6.31	61.99	7	+26.28	+6.40	136.39
10	−26.30	−5.98	356.01	12	+26.32	+6.09	70.43
15	−26.10	−5.61	290.00	17	+26.18	+5.72	4.47
20	−25.72	−5.20	223.97	22	+25.84	+5.32	298.52
25	−25.16	−4.75	157.92	27	+25.32	+4.87	232.58
30	−24.41	−4.27	91.85	Nov. 1	+24.59	+4.38	166.65
May 5	−23.48	−3.76	25.76	6	+23.67	+3.86	100.72
10	−22.38	−3.22	319.66	11	+22.56	+3.31	34.80
15	−21.10	−2.67	253.54	16	+21.25	+2.73	328.88
20	−19.66	−2.09	187.41	21	+19.76	+2.13	262.97
25	−18.06	−1.51	121.26	26	+18.09	+1.52	197.07
30	−16.33	−0.91	55.10	Dec. 1	+16.25	+0.89	131.17
June 4	−14.46	−0.31	348.93	6	+14.26	+0.25	65.28
9	−12.47	+0.30	282.76	11	+12.14	−0.39	359.40
14	−10.39	+0.90	216.58	16	+ 9.92	−1.03	293.52
19	− 8.24	+1.49	150.39	21	+ 7.60	−1.66	227.65
24	− 6.02	+2.08	84.20	26	+ 5.22	−2.28	161.78
29	− 3.77	+2.64	18.02	31	+ 2.80	−2.88	95.93

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 1978

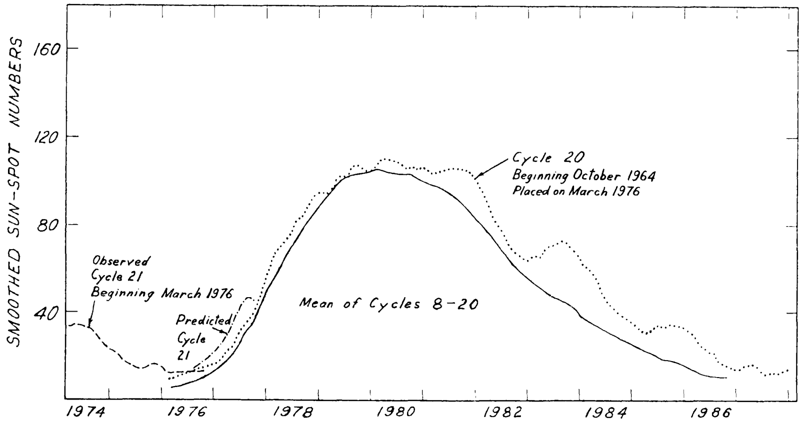
No.	Commences		No.	Commences		No.	Commences	
1663	Dec.	21.40	1668	May	6.95	1673	Sept.	20.06
1664	Jan.	17.73	1669	June	3.16	1674	Oct.	17.34
1665	Feb.	14.07	1670	June	30.36	1675	Nov.	13.64
1666	Mar.	13.40	1671	July	27.57	1676	Dec.	10.95
1667	Apr.	9.70	1672	Aug.	23.80			

SUN-SPOTS

The diagram shows the present sun-spot cycle (21) compared with the previous cycle (20) and with the mean of cycles 8 to 20. This diagram plots the Zurich sun-spot numbers, which are weighted means from several observatories. Sun-spot minimum occurred in March 1976, and this date has been placed on the date of the previous minimum, October 1964, in order to phase the curves.

Another measure of solar activity is the 10 cm radio flux, which has been measured since 1947 by Covington at 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.



THE TOTAL SOLAR ECLIPSE OF 26 FEBRUARY 1979

Only one total solar eclipse is visible in North America between now and the end of this century. It occurs on 26 February 1979. The eclipse shadow will travel from the Pacific Ocean across the extreme north-western corner of the U.S.A. It will cross the Pacific coast at 16:14 UT and enter Canada south of Regina at about 16:35 UT. It will pass through Brandon and Winnipeg, Manitoba, then move northward across Hudson's Bay. At Brandon, the duration of totality will be 168 seconds, just one second short of the maximum duration for this eclipse. Further information appears in the *Journal of the R.A.S.C.* **70**, 135 (1976).

ECLIPSES DURING 1978

In 1978, there will be four eclipses, two of the sun and two of the moon. Throughout most of North America, none of these is visible. However, a total eclipse of the sun will be visible in parts of western Canada and the U.S. in February of 1979

1. *A total eclipse of the moon* on the night of March 23–24, visible in the extreme north-western part of North America.

Moon enters penumbra	March 24	8.28 E.S.T.
Moon enters umbra		9.33 E.S.T.
Middle of eclipse		10.37 E.S.T.

Magnitude of eclipse 1.457

2. *A partial eclipse of the sun* on April 7, visible in the south Atlantic Ocean, in the extreme southern portions of South America and Africa, and in parts of Antarctica.

3. *A total eclipse of the moon* on September 16 generally visible in Australia, Asia, Africa and Europe, but not at all in North America.

4. *A partial eclipse of the sun* on October 2, visible from Scandinavia on the west to Siberia and China on the east.

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. According to Gordon E. Taylor, of H.M. Nautical Almanac Office, the following occultations will occur during 1978. Only the second occultation by Pallas, and that by Juno are likely to be detected by visual observers. Because of uncertainty in the positions of the stars and in the ephemerides of the minor planets, improved predictions will be issued nearer the date of the events. No occultations of radio sources by planets are predicted for 1978.

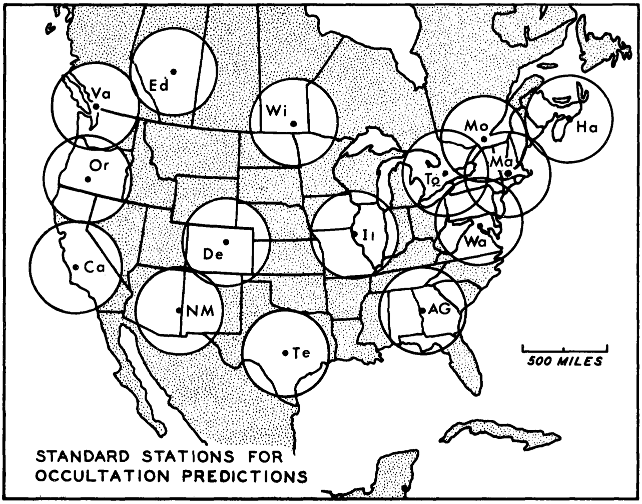
[*Editor's Note:* Mr. Taylor's prediction of the occultation of SAO 158687 by Uranus on Mar. 10, 1977, led to the discovery of rings around Uranus (*Sky and Telescope* **53,** 412 (1977).]

Date E.S.T.	Planet			Star			Area of Visibility
	Name	Vis. Mag.	Phot. Mag.	S.A.O.	Vis. Mag.	Phot. Mag.	
Jan. 18, 16^h	Vesta	7.7	8.5	159344	8.8	10.0	W. Australia
Mar. 22, 7^h	Vesta	7.0	7.7	160266	9.2	10.7	Canada
May 29, 0^h	Pallas	9.2	9.8	85009	10.6	10.6	Bermuda, U.S.
July 19, 18^h	Juno	9.3	10.1	144070	7.1	7.1	Asia, N.W. Africa
Aug. 1, 6^h	Mars	1.7	2.4	119114	7.1	7.5	S.E. Asia
Oct. 31, 0^h	Pallas	10.4	11.0	122731	8.0	8.4	Siberia, N. Pacific
Nov. 9, 10^h	Vesta	7.9	8.6	187470	8.9	9.1	N.E. Africa, Asia Minor

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 $7^{\rm m}.5$ at the dark limb of the moon.



The first five columns in the tables give for each occultation the date, ZC number of the star (see page 73), its magnitude, the phenomenon (1 = disappearance, 2 = reappearance) and the elongation of the moon from the sun in degrees (see page 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.

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	Ma MASSACHUSETTS W. 72°.500, N. 42°.500 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	°	h m	m	m	°
Jan. 6	2361	4.8	2	321	10 40.2	.	.	218		N				N				N		
11	3233	7.2	1	38		A			23 35.2	-0.1	+1.3	21	23 41.0	.	.	2	23 37.8	+0.3	+2.9	4
12	3367	6.4	1	51	22 25.5	-0.9	+0.1	52	22 15.6	-1.2	+0.5	49	22 16.3	-1.0	+0.8	39		S		
13	3380	6.2	1	52		A				G			0 35.8	-1.0	-3.0	121	0 34.4	-1.4	-3.3	124
14	3520	6.0	1	65	1 34.4	-0.3	+0.1	44	1 30.7	-0.5	+0.1	48	1 30.9	-0.5	+0.4	37	1 27.0	-0.6	+0.4	40
15	215	6.7	1	87	21 56.7	-2.4	-0.6	103		S				S				S		
19	609	7.5	1	124		G			5 57.8	-1.0	+0.8	36	6 00.8	.	.	21	5 51.4	-1.2	+0.8	38
22	1029	5.1	1	158		N			8 36.1	-0.9	+0.2	46	8 36.4	.	.	35	8 29.2	-1.1	-0.1	52
26	1468	4.9	2	203	10 11.1	-0.6	-1.7	285	10 07.5	-1.0	-1.4	273	10 01.9	-1.0	-1.6	278	9 57.8	-1.3	-1.2	269
27	1565d	6.3	2	214	6 21.2	.	.	228		N				N				N		
Feb. 3	2448	6.4	2	302	9 13.2	-1.3	+1.7	250		A				A				A		
17	814d	5.3	1	115	3 11.2	.	.	34	2 52.1	-1.9	+0.7	53	2 53.3	-2.0	+1.6	41	2 39.3	-2.1	+1.1	52
18	944	5.7	1	125	0 55.6	-2.1	+0.6	74	0 35.2	-2.1	+0.7	82	0 35.9	-2.0	+1.2	72	0 22.4	-1.9	+1.3	76
18	970	6.5	1	127	5 29.0	-0.9	-0.4	56	5 21.8	-1.0	-0.8	72	5 18.5	-1.1	-0.6	64	5 12.8	-1.3	-0.8	75
18	975d	6.8	1	127	6 07.3	-0.2	-1.4	91	6 08.0	-0.4	-1.7	104	6 02.5	-0.5	-1.6	98	6 02.6	-0.6	-1.9	107
19	1091	6.7	1	138		N			5 47.9	.	.	36		N			5 34.0	.	.	44
24	1652	5.5	2	197	10 11.9	-0.5	-1.4	269	10 09.0	-0.8	-1.2	261	10 04.2	-0.8	-1.4	266	10 00.9	-1.1	-1.1	259
27	1973	6.2	2	231	3 58.8	-1.2	+2.1	252	3 42.1	-1.3	+3.9	229		A				A		
Mar. 4	2731	6.5	2	299		S				S				S			10 33.2	-1.3	+1.2	263
13	376	7.0	1	49	0 25.7	-0.4	-0.9	74	0 22.8	-0.7	-1.2	84	0 18.9	-0.7	-0.9	74	0 15.8	-1.0	-1.0	81
15	627	6.8	1	72	1 19.5	-0.7	-1.6	95	1 16.3	-0.9	-2.0	107	1 09.9	-1.0	-1.6	98	1 06.7	-1.2	-1.9	106
15	636d	6.9	1	73		N			3 10.2	-0.7	+0.6	36	3 12.5	.	.	22	3 05.3	-0.9	+0.5	39
20	1281	6.4	1	129	5 49.1	-0.1	-2.2	131	5 52.8	-0.2	-2.6	144	5 44.9	-0.3	-2.5	138	5 48.1	-0.2	-2.9	149
23	1599	5.0	1	164	5 04.2	-1.8	-0.8	87	4 49.8	-1.9	-0.9	103	4 45.3	-1.8	-0.7	97	4 36.0	-1.8	-0.8	109
27	2060	6.3	2	212	2 15.0	0.0	-1.2	340		A				A				A		
31	2680	5.8	2	268		S			8 53.7	-1.5	+0.4	288	8 53.3	-1.4	+0.4	293	8 44.8	-1.3	+0.6	286
Apr. 10	454	5.8	1	29		A				A			0 37.2	+0.1	-2.0	113	0 41.5	0.0	-2.5	123
11	692d	1.1	1	49		N				N			17 00.4	.	.	140	16 50.8	-1.9	-1.0	138
11	692d	1.1	2	49		N				N			17 35.2	.	.	194	17 26.4	.	.	196
12	729	7.2	1	53		A			2 04.6	-0.4	-0.3	55	2 03.4	-0.5	-0.1	46	2 00.8	-0.6	-0.4	58
15	1106d	3.6	1	85	0 25.4	-1.4	-1.4	99	0 15.1	-1.6	-1.7	113	0 08.6	-1.7	-1.3	106	0 01.2	-1.8	-1.6	115
16	1234	6.1	1	97	2 43.2	-1.0	-1.2	82	2 36.4	-1.2	-1.5	96	2 30.9	-1.2	-1.3	90	2 25.8	-1.4	-1.5	101
19	1565d	6.3	1	133	6 27.6	-0.2	-1.8	113	6 29.1	-0.4	-1.9	121	6 22.9	-0.4	-1.9	116	6 23.6	-0.5	-2.0	122
May 16	1518	6.3	1	101		A			5 01.1	-0.2	-1.6	102	4 56.1	-0.3	-1.6	98	4 57.2	-0.4	-1.7	104
20	1973	6.2	1	150	6 29.4	-0.6	-1.2	83	6 24.8	-1.0	-1.2	87	6 20.2	-1.0	-1.1	82	6 15.8	-1.2	-1.1	86
25	2731	6.5	2	218	5 51.1	-1.6	-0.9	319	5 39.0	-1.4	-0.3	311	5 36.5	-1.2	-0.4	318	5 30.3	-1.1	-0.1	310
29	3334	6.3	2	272	6 48.9	-0.8	+2.5	210	6 37.5	-0.6	+2.7	207	6 44.3	-0.6	+2.4	214		A		
June 10	1271	5.9	1	47		N				A				A			2 20.9	-0.6	0.0	46
12	1478	7.2	1	70		A				A			3 09.9	0.0	-2.0	125	3 13.3	-0.1	-2.1	132
23	2986	6.4	2	214	6 19.3	-1.6	+0.6	246	6 03.0	-1.7	+1.0	247	6 04.0	-1.6	+0.9	253	5 53.3	-1.5	+1.1	251
24	3131	5.5	2	227	3 33.0	-0.9	+2.8	203		A				A				A		
July 17	2396	6.6	1	136	1 33.5	-2.0	+0.8	53	1 13.2	-2.1	+1.0	63		S				S		
27	362	6.5	2	272	5 40.4	-0.1	+2.5	215	5 35.3	+0.1	+2.3	217	5 42.0	0.0	+2.2	224		A		
Aug. 12	2196	6.7	1	91	1 55.1	-1.0	-1.8	115	1 48.5	-1.3	-1.7	117	1 42.3	-1.3	-1.5	111	1 37.0	-1.5	-1.5	114
13	2341	7.2	1	104	0 59.8	-1.6	-1.0	97	0 46.5	-1.8	-0.7	101	0 42.6	-1.7	-0.6	96		S		
15	2658	5.4-6.2	1	131	1 53.7	-1.4	+1.3	32	1 36.6	-1.8	+1.7	34	1 40.4	.	.	25	1 26.2	.	.	31
16	2828	6.0	1	145	0 15.5	-1.5	+0.2	116		S				S				S		
17	3015d	5.3	1	162		A				A				A			7 45.2	-0.6	-0.4	62
29	1106d	3.6	1	311		N				N			7 37.0	-0.7	-1.2	153		A		
29	1106d	3.6	2	311		N				N			8 04.3	+0.7	+4.2	207	8 01.3	+0.8	+4.0	206
Sept. 8	2291	5.5	1	73	23 31.8	-1.4	-0.8	80		S				S				S		
10	2441	6.5	1	86	0 36.5	-1.2	-0.6	68	0 25.2	-1.6	-0.3	68	0 22.9	-1.5	-0.2	62	0 13.7	-1.7	0.0	65
11	2596	7.3	1	100	2 02.4	-1.4	-1.8	118	1 52.6	-1.7	-1.6	115	1 46.6	-1.5	-1.3	108	1 39.3	-1.7	-1.1	108
11	2764	6.3	1	113	24 16.9	-1.8	-0.2	91	24 00.5	-1.9	+0.1	92	23 59.2	-1.7	+0.3	87		S		
13	2922	7.4	1	127	0 55.9	-1.8	-0.1	93	0 39.2	-1.9	+0.3	92	0 38.4	-1.7	+0.4	87	0 27.6	-1.7	+0.6	89
13	3066	6.0	1	140	23 23.0	-1.5	-0.6	137		S				S				S		
22	635	3.9	2	244	2 51.5	+0.1	+2.0	236		A				A				A		
22	659	6.4	2	246	6 00.2	-0.9	+2.5	227	5 47.9	-0.7	+2.4	231	5 53.9	-0.8	+2.1	240	5 46.2	-0.6	+2.1	241
22	667	5.3	2	246	8 02.4	-2.2	-0.4	286	7 43.7	-2.1	0.0	286	7 40.7	-2.1	-0.5	298	7 29.2	-2.0	-0.3	298
22	669	4.0	2	246		N				N			6 41.6	.	.	137	6 30.9	-2.1	-1.0	135
22	669	4.0	1	246		N				N			7 19.8	.	.	195	7 09.7	.	.	196
22	677	4.8	2	247		S			8 59.4	-1.7	+2.5	222	9 03.7	-1.7	+1.7	233	8 50.6	-1.6	+2.1	231
22	692d	1.1	1	248	11 40.2	-1.3	-0.9	81	11 28.8	-1.7	-1.0	90	11 24.6	-1.6	-0.6	81	11 15.5	-1.9	-0.6	87
22	692d	1.1	2	248	12 53.8	-0.7	-1.5	273	12 48.1	-1.1	-1.0	262	12 43.4	-1.1	-1.3	270	12 38.2	-1.4	-0.9	262
24	944	5.7	2	270		S				S				S			9 36.8	-2.2	-1.7	315
Oct. 6	2396	6.6	1	55	22 16.1	-1.5	-1.5	116		S				S				S		
6	2399	5.0	1	55	22 35.4	-0.9	+0.5	38		S				S				S		
10	2889	7.1	1	96		A			2 27.0	-0.8	-0.3	59	2 25.5	-0.7	-0.1	50	2 20.9	-0.9	+0.1	49
10	3015d	5.3	1	108	23 13.9	.	.	12	22 58.5	.	.	9		N				G		
12	3188	5.4	1	124		N				N			4 17.1	-2.0	-3.3	129	4 10.6	-2.2	-3.0	126
13	3334	6.3	1	137	4 52.4	-0.8	-0.4	63	4 44.7	-1.1	-0.1	60	4 43.7	-0.9	+0.1	50	4 37.5	-1.1	+0.4	49
20	741	5.7	2	226	6 12.8	-2.0	+0.1	281	5 54.9	-1.9	+0.4	282	5 53.5	-1.8	0.0	293	5 42.9	-1.7	+0.2	293
21	878	5.5	2	237	4 57.0	-1.2	+1.2	272	4 44.8	-0.9	+1.2	274	4 47.1	-0.9	+1.0	283	4 40.3	-0.8	+1.0	283
22	1029	5.1	2	249	7 21.9	-1.9	+0.1	285	7 05.1	-1.7	+0.6	282	7 04.6	-1.6	+0.2	292	6 55.1	-1.4	+0.5	290
Nov. 7	2986	6.4	1	79	0 48.4	-1.1	-1.2	90	0 39.5	-1.4	-0.8	85	0 35.8	-1.2	-0.6	77	0 29.0	-1.4	-0.4	75

Date	Z.C. No.	Mag.	P.	El. of Moon	Ha HALIFAX, N.S. W. 63°.600, N. 44°.600 U.T.	a	b	P	Ma MASSACHUSETTS W. 72°.500, N. 42°.500 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	°	h m	m	m	°
Nov. 7	3131	5.5	1	92	23 43.1	-1.8	-0.6	90	23 27.2	-1.9	0.0	85	23 25.4	-1.7	+0.2	78	23 14.6	-1.8	+0.5	76
9	3280	7.4	1	105	0 41.8	-0.9	+1.2	30	0 30.4	-0.9	+1.8	23	0 35.7	-0.5	+2.4	12	0 28.1	.	.	7
10	3431	6.6	1	120	4 11.5	-0.1	+2.1	11	4 05.5	-0.2	+2.3	11	N				G			
10	4	6.3	1	130	23 05.7	.	.	5	22 57.1	.	.	354	N				N			
16	692d	1.1	1	194	4 00.9	-2.1	-0.4	112	3 42.9	-2.0	+0.1	110	3 42.1	-1.7	+0.6	99	3 31.6	-1.5	+0.8	99
16	692d	1.1	2	194	5 12.0	-1.7	+2.1	225	4 52.7	-1.5	+2.5	224	4 57.4	-1.6	+1.8	235	4 45.2	-1.4	+2.1	234
17	806	5.1	2	205	2 23.0	-0.2	+3.7	207	2 14.9	0.0	+3.2	212	2 23.6	-0.2	+2.7	223	2 18.0	-0.1	+2.6	224
18	944	5.7	2	216	1 41.9	-0.5	+1.0	286	1 36.3	-0.3	+0.9	289	1 38.4	-0.3	+0.7	298	1 35.6	-0.2	+0.6	299
18	970	6.5	2	217	5 43.0	-1.7	+3.1	224	5 22.4	-1.3	+3.7	219	5 30.2	-1.4	+2.6	232	5 18.0	-1.1	+2.8	229
20	1197	6.0	2	239	2 44.9	-0.1	+1.9	251	A				A				A			
26	1850	6.5	2	308	8 48.9	-0.3	-1.0	334	8 47.1	-0.3	-0.3	319	8 45.4	-0.2	-0.7	330	A			
Dec. 2	2787	6.4	1	34	A				22 50.8	-1.2	-2.0	116	22 44.2	-1.1	-1.6	107	22 40.1	-1.3	-1.5	105
4	3083d	7.3	1	61	22 34.5	-1.1	0.0	57	22 23.6	-1.3	+0.4	52	22 23.7	-1.1	+0.6	44	22 15.6	-1.2	+0.9	41
9	109	6.5	1	115	3 38.5	-0.6	+1.6	21	3 29.3	-0.8	+1.6	24	3 35.1	-0.4	+3.0	8	3 27.0	-0.6	+2.8	11
9	237	7.1	1	126	23 30.4	-1.2	+2.0	42	23 16.0	-1.0	+2.4	35	23 22.6	-0.7	+2.6	26	23 13.8	-0.6	+2.9	23
10	269d	7.3	1	129	A				6 42.6	-0.3	-1.0	79	6 39.5	-0.3	-0.8	70	6 38.7	-0.5	-0.9	76
10	362	6.5	1	138	22 56.2	-1.2	+1.6	69	22 43.1	-0.9	+1.8	64	22 47.9	-0.8	+2.0	57	22 40.3	-0.6	+2.0	55
25	2033	4.3	2	300	8 10.3	-0.7	+0.9	284	A				A				A			
26	4002	-4.4	1	315	11 32.6	-1.6	+0.3	106	11 19.9	-1.1	+0.1	122	11 19.4	-1.1	+0.4	115	11 13.3	-0.8	+0.1	126
26	4002	-4.4	2	315	12 56.2	-1.8	-0.5	294	12 40.1	-1.9	+0.2	281	12 38.8	-1.7	+0.2	286	12 28.2	-1.7	+0.7	276

Date	Z.C. No.	Mag.	P.	El. of Moon	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	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
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 1	1708	6.2	2	256	8 50.3	.	.	354	8 55.0	-1.4	-1.3	318	8 38.1	-0.8	-1.7	336	8 37.8	-1.4	-0.1	296
11	3233	7.2	1	38	23 30.3	-0.4	+0.9	30	23 21.0	-0.8	+0.8	42	23 29.6	.	.	2	S			
12	3247	7.0	1	39	A				A				N				1 53.1	-0.2	+1.0	34
13	3380	6.2	1	52	N				N				0 26.3	-2.3	-3.7	126	N			
14	3520	6.0	1	65	1 28.0	-0.7	-0.1	59	1 21.8	-1.2	-0.4	73	1 15.8	-1.0	+0.6	45	1 02.8	-1.7	+0.2	67
16	226d	6.6	1	89	G				0 58.0	-1.3	+3.2	21	N				0 37.0	.	.	5
16	247	6.7	1	90	N				A				N				5 20.8	-0.7	+0.8	43
19	609	7.5	1	124	5 52.3	-1.0	0.0	55	5 46.3	-1.2	-0.8	81	5 35.4	-1.4	0.0	60	5 29.2	-1.8	-1.2	95
22	1029	5.1	1	158	8 33.1	-0.8	-0.5	64	8 31.4	-0.9	-1.1	90	8 18.0	-1.2	-0.8	77	8 21.0	-1.2	-1.8	111
26	1468	4.9	2	203	10 06.5	-1.4	-0.9	261	9 46.8	.	.	222	9 38.2	-2.7	+0.5	242	N			
Feb. 17	814d	5.3	1	115	2 41.5	-2.1	+0.1	69	2 24.6	-2.5	-0.6	93	2 10.5	-2.3	+0.8	69	1 50.4	-2.8	-0.4	100
18	944	5.7	1	125	0 23.4	-2.2	+0.4	93	0 04.4	-2.3	-0.2	110	S				S			
18	970	6.5	1	127	5 20.5	-1.1	-1.1	87	5 20.0	-1.2	-1.9	112	5 00.2	-1.6	-1.3	96	5 06.7	-1.6	-3.0	133
18	975d	6.8	1	127	6 13.1	-0.3	-2.0	117	6 26.0	-0.1	-3.3	146	6 03.2	-0.7	-2.6	129	N			
19	1091	6.7	1	138	5 36.1	-1.8	+0.1	60	5 24.1	-1.9	-0.9	90	5 07.9	-2.2	-0.1	74	4 59.3	-2.3	-1.5	110
19	1106d	3.6	1	139	A				A				8 55.3	-0.2	-1.3	90	9 07.8	-0.1	-1.8	119
20	1197	6.0	1	148	N				1 52.5	.	.	42	N				1 21.1	-1.3	+3.3	50
24	1652	5.5	2	197	10 08.0	-1.2	-0.7	250	N				9 43.4	.	.	235	N			
Mar. 1	2271	4.3	1	260	S				S				11 39.6	-2.1	0.0	83	11 25.4	-2.2	-0.5	108
4	2731	6.5	2	299	10 30.6	-1.5	+1.3	254	10 08.4	-1.5	+2.2	232	10 14.1	-1.1	+1.7	247	A			
12	258	6.6	1	37	A				1 28.7	-0.3	-0.8	80	1 22.7	-0.5	-0.2	57	1 23.6	-0.8	-1.1	90
13	376	7.0	1	49	0 24.1	-0.9	-1.6	97	0 28.5	-1.2	-3.0	123	S				S			
15	627	6.8	1	72	1 20.3	-1.0	-2.7	123	N				0 58.4	-1.7	-2.8	124	N			
15	636d	6.9	1	73	3 06.5	-0.7	-0.1	55	3 03.9	-0.8	-0.8	81	2 54.1	-1.1	-0.3	63	2 53.1	-1.3	-1.3	97
15	650	5.7	1	74	N				N				N				5 05.3	-0.9	+1.4	34
20	1271	5.9	1	128	N				1 43.4	-3.0	+1.8	67	G				S			
20	1281	6.4	1	129	6 03.2	+0.1	-3.4	160	N				G				N			
21	1381	6.3	1	139	N				1 32.1	-2.7	+2.1	68	G				S			
23	1599	5.0	1	164	4 45.4	-1.8	-1.3	117	4 41.7	-1.5	-2.3	145	4 19.8	-1.6	-1.3	132	4 34.9	.	.	180
31	2680	5.8	2	268	8 45.0	-1.5	+0.7	278	8 27.5	-1.5	+1.3	258	8 28.3	-1.0	+1.1	271	8 07.7	-1.1	+2.0	239
31	2686d	5.2	2	268	N				N				N				8 37.7	-0.4	-0.8	319
Apr. 2	2995	6.2	2	295	S				9 58.3	-1.3	+1.6	245	10 02.3	-1.0	+1.4	259	A			
3	3146	6.5	2	308	S				10 17.0	-0.8	+0.2	298	A				A			
11	692d	1.1	1	49	N				N				16 35.2	-1.2	-0.4	134	N			
11	692d	1.1	2	49	N				N				17 12.2	+0.2	+3.9	200	N			
12	729	7.2	1	53	2 04.7	-0.4	-0.7	70	2 07.2	-0.4	-1.3	95	1 55.6	-0.8	-1.0	79	2 02.5	-0.8	-2.0	113
14	1003d	7.2	1	75	N				3 02.6	.	.	32	N				2 34.1	-2.1	+0.2	66
14	1011	7.4	1	76	N				N				N				4 53.9	.	.	36
15	1106d	3.6	1	85	0 14.9	-1.7	-2.4	129	0 24.6	.	.	166	S				N			
16	1234	6.1	1	97	2 36.8	-1.2	-1.8	110	2 40.0	-1.1	-2.7	136	2 15.0	-1.6	-2.0	123	2 34.2	.	.	167
19	1565d	6.3	1	133	6 34.6	-0.4	-2.1	130	6 45.1	-0.4	-2.7	150	6 24.2	-0.7	-2.4	139	6 47.8	0.0	-4.3	174
27	2640d	6.1	2	238	N				N				N				8 30.5	.	.	344
28	2826	4.0	1	253	S				S				S				10 41.4	-2.4	0.0	100
May 11	944	5.7	1	44	2 06.4	-0.7	+0.6	40	2 02.9	-0.5	-0.5	71	1 56.1	-0.9	-0.2	56	1 56.6	-0.8	-1.1	91
16	1518	6.3	1	101	5 06.1	-0.2	-1.7	111	5 14.6	-0.3	-2.0	128	4 57.9	-0.6	-1.9	118	5 13.5	-0.5	-2.6	144
20	1973	6.2	1	150	6 24.3	-1.2	-1.2	95	6 21.3	-1.5	-1.4	109	6 03.0	-1.7	-1.1	99	6 01.9	-1.9	-1.6	123
25	2731	6.5	2	218	5 33.3	-1.4	0.0	300	5 20.7	-1.3	+0.6	281	5 18.0	-0.9	+0.5	293	5 04.7	-0.9	+1.1	265
28	3208	6.5	2	261	S				9 03.5	-1.8	+1.1	258	9 00.2	-1.5	+0.9	276	8 40.4	-1.3	+1.3	258
June 10	1271	5.9	1	47	A				2 24.9	-0.3	-0.9	82	2 15.8	-0.7	-0.8	71	2 21.4	-0.6	-1.4	100
11	1381	6.3	1	58	A				3 15.4	-0.3	-0.8	77	3 07.6	-0.7	-0.6	63	3 11.3	-0.6	-1.2	93

Date	Z.C. No.	Mag.	P.	El. of Moon	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	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
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°	h m	m	m	°
June 12	1478	7.2	1	70	3 23.8	+0.1	-2.2	140	3 39.8	+0.2	-3.1	162	3 20.2	-0.2	-2.6	147	N			
14	1692d	6.8	1	92	N				N				N				3 17.8	-2.6	+0.3	65
22	2826	4.0	2	199	N				3 17.3	-0.6	-0.4	311	A				A			
23	2986	6.4	2	214	5 51.4	-1.7	+1.3	242	5 28.7	-1.6	+1.9	229	5 31.8	-1.3	+1.5	245	5 05.2	-1.3	+2.5	219
July 2	667	5.3	2	327	S				9 49.4	+0.4	+2.6	212	S				A			
14	1997	6.8	1	98	A				4 22.8	-0.8	-0.8	78	4 13.1	-1.1	-0.3	59	4 09.1	-1.5	-0.8	84
18	2578	6.4	1	153	N				7 30.1	.	.	19	N				N			
25	109	6.5	2	250	S				8 34.8	-1.5	+2.0	229	8 37.2	-1.5	+1.4	253	8 12.9	-1.2	+1.8	241
Aug. 12	2196	6.7	1	91	1 48.3	-1.5	-1.8	123	1 46.6	-1.8	-2.3	138	S				S			
12	2208	7.4	1	92	A				A				N				4 13.0	-1.0	+0.7	48
13	2341	7.2	1	104	0 40.5	-2.0	-0.8	109	S				S				S			
15	2658	5.4-6.2	1	131	1 22.0	-2.1	+1.6	45	0 55.8	-2.2	+1.4	63	S				S			
15	2680	5.8	1	133	5 57.8	-0.6	-0.4	64	5 53.9	-1.0	-0.4	71	5 47.8	-0.8	+0.3	46	5 38.0	-1.5	+0.1	63
15	2685	7.0	1	133	A				6 29.4	-1.4	-2.0	120	6 11.5	-1.2	-1.1	93	6 12.5	-1.8	-1.5	110
16	2826	4.0	1	145	0 05.1	.	.	22	S				S				S			
17	3015d	5.3	1	162	7 49.6	-0.8	-0.7	78	7 46.1	-1.2	-0.8	86	7 36.5	-1.0	-0.1	59	7 28.2	-1.6	-0.1	74
Sept. 10	2441	6.5	1	86	0 18.4	-1.9	-0.2	75	S				S				S			
11	2596	7.3	1	100	1 50.3	-1.9	-1.7	120	1 43.5	-2.5	-2.1	131	1 20.7	-2.0	-0.8	111	1 15.0	-2.4	-1.7	133
11	2764	6.3	1	113	23 51.2	-2.0	+0.2	99	S				S				S			
13	2922	7.4	1	127	0 29.6	-1.9	+0.3	98	S				S				S			
22	659	6.4	2	246	5 36.6	-0.4	+2.5	226	5 19.9	0.0	+2.6	219	5 34.1	-0.2	+1.9	244	5 16.5	+0.2	+2.0	228
22	667	5.3	2	246	7 33.4	-2.0	+0.5	279	7 14.2	-1.7	+0.9	271	7 07.5	-1.7	-0.1	301	6 54.1	-1.2	+0.7	282
22	669	4.0	1	246	N				N				6 12.7	-1.4	-0.3	130	N			
22	669	4.0	2	246	N				N				6 52.9	0.0	+3.9	200	N			
22	677	4.8	2	247	8 41.3	-1.4	+3.6	211	8 06.9	.	.	193	8 25.3	-1.3	+2.4	231	7 52.4	-0.5	+3.5	209
22	685	6.5	2	247	S				N				10 29.9	-1.8	+2.6	220	N			
22	692d	1.1	1	248	11 24.8	-2.0	-1.4	103	11 19.2	-2.6	-3.0	127	10 53.2	-2.3	-0.5	97	10 46.3	.	.	129
22	692d	1.1	2	248	12 44.4	-1.5	-0.2	247	12 25.3	-2.2	+2.1	220	12 20.0	-2.0	+0.3	247	11 49.0	.	.	209
23	806	5.1	2	259	S				N				9 55.8	-1.6	+2.7	228	9 11.4	.	.	193
23	814d	5.3	2	259	N				S				N				11 26.3	.	.	330
24	944	5.7	2	270	9 47.2	-2.3	-0.6	294	9 29.2	-2.1	+0.5	278	9 16.7	-2.0	-0.8	309	9 04.7	-1.5	+0.5	283
26	1197	6.0	2	292	S				S				S				10 50.7	-1.4	+1.6	257
28	1409	5.1	2	314	G				9 42.1	-0.8	-1.2	326	N				A			
Oct. 9	2731	6.5	1	83	A				2 52.6	-1.4	-1.7	112	2 35.7	-1.3	-0.9	86	2 33.8	-1.9	-1.2	102
10	2889	7.1	1	96	2 23.6	-1.1	-0.2	64	2 13.8	-1.6	-0.1	70	2 07.1	-1.3	+0.6	45	1 49.7	-2.0	+0.7	61
12	3188	5.4	1	124	N				N				3 51.6	-2.6	-2.0	119	N			
12	3205	6.8	1	125	A				A				A				7 29.7	-1.0	-1.9	110
12	3208	6.5	1	126	A				A				A				7 47.5	-0.4	-0.3	68
13	3322d	6.4	1	136	N				N				1 11.7	.	.	137	N			
13	3334	6.3	1	137	4 39.6	-1.3	-0.1	66	4 26.9	-1.9	+0.1	72	4 21.1	-1.3	+1.0	45	4 00.6	-2.0	+1.0	59
20	741	5.7	2	226	5 44.5	-1.7	+0.8	275	5 26.2	-1.3	+1.2	266	5 23.6	-1.4	+0.4	295	5 09.9	-0.9	+0.9	276
21	878	5.5	2	237	4 36.5	-0.7	+1.3	268	4 24.4	-0.3	+1.4	260	4 30.1	-0.4	+0.9	285	A			
22	1029	5.1	2	249	6 55.0	-1.5	+1.0	273	6 37.1	-1.1	+1.5	261	6 38.4	-1.0	+0.7	287	6 24.1	-0.5	+1.2	267
Nov. 5	2680	5.8	1	52	A				1 00.2	-0.7	-0.2	62	0 58.6	-0.3	+0.8	32	0 48.4	-1.1	+0.4	53
5	2685	7.0	1	53	A				A				1 16.4	-0.9	-1.0	84	1 17.8	-1.5	-1.2	101
7	2986	6.4	1	79	0 35.5	-1.7	-0.8	89	0 24.1	-2.3	-0.7	95	0 10.6	-1.8	+0.2	71	S			
7	3131	5.5	1	92	23 17.8	-2.1	+0.1	88	22 58.3	-2.4	+0.3	93	S				S			
8	3155	6.8	1	94	A				N				3 55.9	-1.4	-2.1	112	N			
8	3280	7.4	1	105	24 18.8	-1.2	+2.0	27	23 55.5	-1.5	+2.3	32	24 11.5	.	.	356	S			
10	3431	6.6	1	120	3 56.6	-0.6	+1.7	21	3 40.5	-1.1	+1.6	32	N				3 23.0	-0.9	+2.9	16
10	4	6.3	1	130	22 41.1	.	.	2	S				N				S			
16	692d	1.1	1	194	3 34.0	-2.1	-0.2	117	3 20.0	-2.2	-1.0	128	3 13.0	-1.1	+1.1	96	2 59.4	-1.1	+0.2	114
16	692d	1.1	2	194	4 36.0	-1.3	+3.3	214	4 06.5	-0.4	+4.4	201	4 22.3	-1.1	+2.2	234	3 53.4	-0.4	+3.0	215
17	806	5.1	2	205	2 03.4	+0.4	+3.6	204	1 45.1	.	.	188	2 09.9	+0.2	+2.3	226	A			
17	814d	5.3	2	205	3 37.3	.	.	334	3 31.6	-1.9	-1.2	314	N				3 09.3	.	.	336
18	944	5.7	2	216	1 32.3	-0.1	+0.9	284	A				A				A			
18	970	6.5	2	217	5 02.0	.	.	204	N				4 57.4	-0.6	+2.9	226	4 22.1	.	.	191
23	1549	5.2	2	275	S				S				11 42.1	-1.9	-0.9	300	11 26.1	-2.8	+1.1	262
Dec. 2	2787	6.4	1	34	22 52.0	-1.5	-2.2	122	S				S				S			
5	3109	6.5	1	63	A				A				A				2 48.3	-0.8	-0.5	76
5	3112	6.2	1	63	A				A				A				3 29.1	-1.1	-2.5	121
5	3238	7.0	1	75	N				N				23 42.7	.	.	134	N			
8	4	6.3	1	104	A				A				5 59.0	-0.3	-0.2	56	6 00.0	-0.7	-0.9	85
9	109	6.5	1	115	3 20.1	-1.1	+1.3	35	3 02.6	-1.6	+1.2	47	3 08.8	-0.7	+3.1	12	2 38.5	-1.5	+2.2	35
9	237	7.1	1	126	23 03.0	-0.9	+2.4	38	S				S				S			
10	269d	7.3	1	129	6 45.3	-0.4	-1.3	92	6 52.0	-0.6	-2.5	117	6 34.9	-0.9	-1.2	89	6 45.4	-1.4	-3.6	127
10	362	6.5	1	138	22 32.8	-0.8	+1.8	67	S				S				S			
19	1409	5.1	2	233	S				S				11 48.3	-2.2	-0.3	255	N			
26	4002	-4.4	1	315	11 16.1	-0.8	-0.5	137	11 22.8	.	.	176	11 08.8	-0.1	-1.0	153	N			
26	4002	-4.4	2	315	12 29.2	-2.1	+0.8	267	11 57.6	.	.	229	12 02.8	-1.8	+2.1	249	N			

Date	Z.C. No.	Mag.	P.	El. of Moon	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P	NM N. MEX.-ARIZ. W.109.000°, N. 34.000° U.T.	a	b	P	Ca CALIFORNIA W.120.000°, N. 36.000° U.T.	a	b	P	Or OREGON W.121.000°, N. 42.500° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 1	1708	6.2	2	256	8 27.2	-0.7	-0.7	321	8 25.7	-0.9	+0.1	298	8 18.8	-0.5	+0.2	300	8 17.6	-0.3	-0.5	323
12	3247	7.0	1	39	N				1 57.9	+0.3	+3.3	4	N				N			
14	3520	6.0	1	65	1 00.7	-1.1	+1.7	29	S				S				N			
16	238	6.7	1	89	N				N				N				1 43.6	-3.0	-1.7	119
16	247	6.7	1	90	N				5 15.0	-1.0	+1.5	31	5 07.8	-1.1	+3.0	17	N			
19	609	7.5	1	124	5 11.6	-1.9	+0.3	65	5 03.6	-2.3	-0.5	86	4 37.0	-2.4	+0.6	75	4 41.8	-2.0	+1.6	52
22	1029	5.1	1	158	7 57.7	-1.7	-1.1	92	7 59.4	-1.7	-1.9	114	7 34.4	-2.1	-1.8	117	7 24.6	-2.1	-0.6	96
Feb. 5	2826	4.0	1	333	S				S				14 13.0	-0.8	+1.2	84	S			
17	814d	5.3	1	115	1 39.1	-2.1	+1.6	66	1 22.9	-2.2	+1.0	83	S				S			
18	970	6.5	1	127	4 34.7	-2.1	-1.3	107	4 37.3	-2.2	-2.7	131	4 06.4	-2.5	-1.9	126	3 57.6	-2.2	-0.3	102
18	975d	6.8	1	127	5 52.1	-1.0	-3.8	146	N				N				5 20.4	.	.	148
19	1091	6.7	1	138	4 35.9	-2.4	0.0	87	4 28.8	-2.5	-0.9	108	4 00.7	-2.3	-0.2	104	4 01.5	-2.0	+1.0	82
19	1106d	3.6	1	139	8 50.6	-0.5	-1.7	104	8 59.5	-0.4	-2.1	123	8 48.8	-0.7	-2.5	130	8 33.6	-1.0	-2.0	113
20	1234	6.1	1	151	10 35.7	-0.3	-1.2	86	10 42.3	-0.2	-1.4	103	10 35.1	-0.5	-1.7	109	10 24.1	-0.7	-1.5	95
Mar. 1	2271	4.3	1	260	11 10.5	-1.9	+0.4	95	11 02.3	-1.8	-0.1	113	10 45.9	-1.2	0.0	121	10 46.7	-1.2	+0.6	105
1	2271	4.3	2	260	12 31.5	-1.9	-0.7	294	12 26.1	-2.3	-0.2	279	12 02.3	-2.0	+0.4	273	12 02.2	-1.6	+0.2	287
3	2578	6.4	2	287	N				S				13 30.0	-1.3	-1.4	325	N			
15	636d	6.9	1	73	2 35.3	-1.6	-0.3	71	2 32.2	-1.9	-1.0	92	S				S			
15	650	5.7	1	74	N				4 58.0	-1.2	+1.4	35	4 45.4	-1.6	+1.4	38	N			
18	1073	6.0	1	109	A				A				A				9 21.7	+0.2	-1.8	119
20	1309	5.7	1	131	A				A				A				10 40.7	+0.3	-2.5	149
21	1410d	5.3	1	143	A				N				N				10 52.1	.	.	179
23	1599	5.0	1	164	4 01.0	-1.1	-1.7	150	G				N				3 41.6	-0.8	-1.4	153
Apr. 11	692d	1.1	1	49	16 25.5	-0.3	+0.6	116	16 22.9	-0.4	-0.3	130	A				A			
11	692d	1.1	2	49	17 13.4	+0.1	+2.6	219	16 58.5	+0.6	+3.1	205	17 08.4	+0.4	+2.1	224	17 21.4	+0.2	+1.8	241
12	741	5.7	1	54	A				A				5 29.3	+0.2	-1.8	116	5 18.5	-0.1	-1.5	99
13	878	5.5	1	65	5 15.8	-0.1	-1.0	78	5 21.9	-0.1	-1.3	97	5 16.8	-0.4	-1.5	102	5 07.2	-0.6	-1.3	86
14	1003d	7.2	1	75	2 27.8	.	.	35	S				S				S			
14	1011	7.4	1	76	N				4 40.8	-1.7	+1.2	44	4 21.9	-2.0	+0.6	54	N			
17	1364	6.5	1	111	8 11.2	-0.3	-0.7	66	8 15.1	-0.3	-1.0	84	8 07.9	-0.6	-1.2	88	8 00.0	-0.8	-1.0	74
18	1465	6.3	1	122	8 07.6	-0.5	-1.3	89	8 13.8	-0.5	-1.5	104	8 03.2	-0.9	-1.7	109	7 51.9	-1.0	-1.5	97
18	1468	4.9	1	122	A				A				9 19.9	-0.2	-1.9	122	9 07.8	-0.4	-1.8	111
19	1565d	6.3	1	133	6 14.2	-0.7	-2.9	156	6 36.2	.	.	187	N				5 56.0	.	.	176
27	2640d	6.1	2	238	N				8 15.5	.	.	342	8 10.2	-0.1	-1.4	332	N			
27	2658	5.4-6.2	2	239	S				S				11 43.1	-2.2	-0.4	289	11 37.7	-1.9	-0.6	303
28	2826	4.0	1	253	10 30.6	-1.8	+0.8	80	10 18.9	-1.9	+0.6	93	10 02.5	-1.4	+0.9	92	10 08.3	-1.3	+1.3	79
28	2826	4.0	2	253	S				11 40.7	-2.2	+0.7	253	11 19.4	-1.9	+0.9	259	11 22.7	-1.7	+0.7	271
May 10	814d	5.3	1	34	N				A				3 32.3	-1.0	+0.7	42	N			
11	970	6.5	1	46	A				A				A				5 18.0	-0.3	-0.3	52
12	1091	6.7	1	57	N				A				5 50.4	-0.6	+0.6	44	N			
13	1212	7.1	1	68	A				A				A				6 36.1	+0.1	-1.6	108
14	1320	6.8	1	79	6 01.7	.	.	178	N				N				N			
16	1518	6.3	1	101	4 47.1	-0.9	-2.2	131	4 58.3	-0.7	-2.9	150	4 44.0	-0.7	-3.5	162	4 24.0	-1.1	-2.5	145
17	1635	5.4	1	114	A								8 48.2	.	.	185	8 24.6	-0.2	-2.9	160
19	1865	7.2	1	138	8 53.9	-0.5	-1.5	99	9 00.4	-0.7	-1.6	111	8 47.7	-1.1	-1.6	109	8 37.0	-1.1	-1.4	98
20	1973	6.2	1	150	5 38.0	-1.9	-0.9	111	5 36.9	-1.8	-1.4	128	5 16.0	-1.5	-1.3	138	5 08.8	-1.5	-0.5	123
25	2764	6.3	2	221	S				10 36.4	-2.0	+0.3	251	10 14.2	-2.1	+0.5	260	10 14.5	-1.8	+0.2	272
28	3208	6.5	2	261	8 42.5	-1.0	+1.0	278	8 32.4	-0.8	+1.2	265	A				A			
June 11	1381	6.3	1	58	S				2 57.8	-1.1	-1.4	98	S				S			
12	1478	7.2	1	70	3 17.9	-0.1	-3.4	164	N				N				S			
18	2193	6.1	1	145	8 43.9	-1.1	-2.9	150	G				8 35.1	-1.5	-3.2	155	8 17.6	-1.4	-2.0	137
23	2986	6.4	2	214	5 16.0	-0.9	+1.8	239	A				A				A			
23	3015d	5.3	2	216	S				11 05.0	-1.9	-0.2	261	10 40.9	-2.3	-0.3	278	10 35.2	-2.2	-0.8	295
July 2	692d	1.1	1	329	N				N				N				13 01.0	-1.1	-0.2	134
2	692d	1.1	2	329	N				N				N				13 37.0	+0.3	+3.8	200
14	1997	6.8	1	98	3 52.5	-1.9	-0.2	66	3 47.0	-2.1	-0.6	83	S				S			
16	2271	4.3	1	125	A				7 45.0	-1.2	-2.7	142	7 25.6	-1.5	-2.0	129	7 12.7	-1.3	-1.6	114
24	4	6.3	2	238	S				N				11 33.3	-1.2	+2.3	209	S			
25	109	6.5	2	250	8 17.6	-1.2	+1.3	267	8 05.4	-1.0	+1.4	258	7 59.5	-0.6	+1.2	270	8 06.2	-0.6	+1.1	284
29	692d	1.1	1	302	21 26.7	+0.3	-1.9	118	21 42.1	+0.7	-3.0	144	21 42.8	+0.7	-4.0	151	21 23.6	0.0	-2.4	124
29	692d	1.1	2	302	A				A				22 12.1	-0.7	+1.6	208	22 14.2	-0.3	-0.3	234
Aug. 10	1962	5.2	1	68	3 47.4	-0.7	-1.7	108	3 54.4	-0.9	-1.9	120	3 38.7	-1.3	-1.8	118	3 26.7	-1.3	-1.5	106
11	2088	6.2	1	81	A				A				5 40.8	-0.7	-0.9	79	5 35.0	-0.7	-0.7	63
12	2208	7.4	1	92	N				4 05.2	.	.	28	N				N			
15	2680	5.8	1	133	5 34.4	-1.1	+1.3	31	5 22.1	-1.7	+1.0	45	5 05.6	-1.9	+2.1	32	N			
15	2685	7.0	1	133	5 52.7	-1.5	-0.5	81	5 48.9	-1.9	-0.6	91	5 26.3	-2.1	+0.1	81	5 25.6	-1.8	+0.3	67
15	2687	6.5-7.3	1	133	6 22.2	-2.2	-2.7	137	N				5 56.5	-2.4	-2.0	133	5 45.4	-1.9	-0.9	116
17	3015d	5.3	1	162	7 21.1	-1.2	+0.8	42	7 11.2	-1.6	+0.8	53	6 56.5	-1.5	+1.7	35	7 08.5	.	.	12
22	219	5.1	2	232	N				N								11 51.5	.	.	182
24	464	6.4	2	256	S				11 01.9	-1.8	+1.9	236	10 46.2	-1.6	+1.4	255	10 51.9	-1.7	+0.9	274
Sept. 8	2180	7.0	1	62	A				A				4 00.3	-0.7	+0.6	45	N			
14	3109	6.5	1	144	8 10.7	.	.	144	N				7 44.8	-2.7	-2.8	126	7 31.5	-1.8	-1.1	101
22	659	6.4	2	246	5 32.4	0.0	+1.5	255	A				A				A			
22	667	5.3	2	246	6 42.8	.	.	329	6 42.9	-1.1	-0.3	307	N				N			
22	669	4.0	1	246	6 00.3	-0.5	+0.7	113	5 56.3	-0.5	-0.1	126	A				A			

Date	Z.C. No.	Mag.	P.	El. of Moon	De DENVER, COLO. W.105.000°, N. 39.800° U.T.	a	b	P	NM N. MEX.-ARIZ. W.109.000°, N. 34.000° U.T.	a	b	P	Ca CALIFORNIA W.120.000°, N. 36.000° U.T.	a	b	P	Or OREGON W.121.000°, N. 42.500° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Sept. 22	669	4.0	2	246	6 51.2	-0.1	+2.6	219	6 35.4	+0.4	+3.1	206	6 43.4	+0.2	+2.2	225	6 56.4	0.0	+1.9	242
22	671	3.6	1	246	6 16.4	.	.	150	N				A				A			
22	671	3.6	2	246	6 33.8	.	.	182	N				6 31.7	+0.8	+3.7	194	6 50.8	+0.3	+2.4	218
22	677	4.8	2	247	8 09.2	-0.9	+1.9	245	7 54.0	-0.6	+2.2	234	7 51.8	-0.5	+1.7	251	8 01.3	-0.6	+1.4	268
22	685	6.5	2	247	10 05.3	-1.6	+2.3	232	9 43.7	-1.2	+3.3	216	9 36.4	-1.1	+2.2	236	9 47.5	-1.2	+1.6	255
22	692d	1.1	1	248	10 21.5	-2.1	+0.6	88	10 10.3	-2.5	0.0	103	9 49.7	-1.6	+1.2	84	9 58.5	-1.2	+1.9	65
22	692d	1.1	2	248	11 50.7	-2.2	+0.8	249	11 33.3	-2.2	+2.2	230	11 14.2	-2.0	+1.6	247	11 19.6	-2.0	+0.7	268
23	806	5.1	2	259	9 35.3	-1.2	+2.2	240	9 16.8	-0.8	+2.8	226	9 13.5	-0.6	+2.0	245	9 24.1	-0.8	+1.5	263
24	944	5.7	2	270	8 50.9	.	.	328	8 50.3	-1.2	-0.3	307	8 32.9	.	.	339	N			
26	1197	6.0	2	292	10 50.7	-1.2	+0.5	291	10 41.9	-0.9	+1.0	274	10 35.3	-0.6	+0.6	288	10 36.8	-0.7	0.0	311
Oct. 8	2573	7.3	1	71	A				N				4 01.2	.	.	149	3 41.9	-1.6	-2.0	124
9	2731	6.5	1	83	2 15.5	-1.6	-0.3	74	2 09.8	-2.1	-0.3	84	S				S			
9	2745d	6.9	1	84	A				4 50.9	.	.	144	4 24.4	-1.9	-1.8	116	4 13.3	-1.5	-1.2	98
10	2889	7.1	1	96	1 47.7	-1.5	+1.7	31	1 31.2	-2.0	+1.6	44	S				S			
12	3188	5.4	1	124	3 18.0	-2.2	-0.2	98	3 10.0	-2.7	-0.5	108	2 44.6	-2.0	+0.6	92	2 48.2	-1.6	+1.0	78
12	3205	6.8	1	125	7 13.8	-0.8	-0.6	71	7 14.2	-1.1	-0.9	85	6 59.9	-1.3	-0.1	66	6 59.7	-0.9	+0.4	46
12	3208	6.5	1	126	7 47.0	-0.2	+0.8	30	7 42.5	-0.5	+0.4	47	7 38.6	-0.4	+1.4	26	N			
13	3334	6.3	1	137	4 03.4	-1.1	+2.1	25	3 46.3	-1.5	+2.0	36	3 38.1	-0.9	+3.2	14	N			
20	741	5.7	2	226	5 06.6	-1.1	-0.4	314	5 03.3	-0.7	+0.2	299	A				N			
22	1029	5.1	2	249	6 26.9	-0.6	+0.4	300	6 21.9	-0.3	+0.6	286	A				A			
Nov. 5	2685	7.0	1	53	1 01.1	-1.3	-0.4	71	0 57.9	-1.7	-0.5	81	S				S			
5	2687	6.5-7.3	1	53	1 23.9	-1.8	-2.1	125	1 30.8	.	.	141	S				S			
7	3008	6.9	1	81	4 40.9	-0.6	-0.8	76	4 43.1	-0.9	-1.0	90	4 30.3	-1.1	-0.4	70	4 28.2	-0.8	0.0	51
7	3015d	5.3	1	81	A				A				5 33.1	-0.6	-0.3	64	5 32.1	-0.3	+0.2	43
8	3155	6.8	1	94	3 34.2	-1.7	-1.0	93	3 32.9	-2.3	-1.4	105	3 07.1	-2.1	-0.1	83	3 06.2	-1.7	+0.3	67
16	692d	1.1	1	194	3 02.8	-0.4	+1.4	82	2 54.1	-0.3	+1.0	92	2 55.4	+0.1	+1.3	78	3 05.6	+0.1	+1.8	63
16	692d	1.1	2	194	4 09.1	-0.8	+1.8	249	3 55.6	-0.5	+2.0	238	3 54.9	-0.3	+1.5	255	4 03.8	-0.4	+1.3	271
18	970	6.5	2	217	4 51.0	-0.3	+2.2	240	4 37.3	+0.1	+2.5	226	4 42.8	+0.2	+1.8	244	4 53.4	0.0	+1.5	262
23	1549	5.2	2	275	11 16.1	-1.7	+0.2	287	11 04.1	-1.9	+1.4	263	10 49.5	-1.3	+1.5	265	10 55.1	-1.1	+0.7	288
24	1660d	6.2	2	287	N				S				S				13 38.5	.	.	7
Dec. 5	3109	6.5	1	63	2 43.0	-0.5	+0.4	40	2 38.3	-0.9	+0.3	54	2 30.0	-0.8	+1.2	32	2 42.1	.	.	2
5	3112	6.2	1	63	3 09.9	-0.8	-0.8	79	3 11.6	-1.2	-1.1	93	2 56.3	-1.3	-0.3	72	2 54.3	-1.0	+0.1	54
5	3119	6.7	1	64	A				A				4 07.3	-0.8	-0.4	67	4 05.7	-0.5	+0.1	46
6	3270	6.1	1	77	A				5 02.3	-0.3	+0.3	48	4 59.8	-0.3	+1.2	28	N			
8	4	6.3	1	104	5 51.9	-0.7	+0.2	50	5 48.7	-1.0	-0.2	67	5 36.7	-1.2	+0.5	51	5 41.6	-0.7	+1.4	27
9	109	6.5	1	115	N				2 37.1	.	.	0	N				N			
10	269d	7.3	1	129	6 18.3	-1.5	-0.9	85	6 18.8	-2.0	-1.7	104	5 53.2	-2.2	-0.4	86	5 51.4	-1.7	+0.4	65
13	692d	1.1	1	167	A				A				13 16.0	+0.4	-2.2	126	13 03.9	+0.1	-1.7	107
13	692d	1.1	2	167	A				A				A				13 57.9	+0.1	-0.7	250
19	1409	5.1	2	233	11 05.5	.	.	226	N				N				N			
22	1716	6.4	2	267	12 43.4	-3.3	+1.6	246	N				N				G			
26	4002	-4.4	1	315	11 13.9	.	.	180	N				N				N			
26	4002	-4.4	2	315	11 36.3	.	.	220	N				N				N			

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97.200°, N. 49.900° U.T.	a	b	P	Ed EDMONTON, ALTA. W.113.400°, N. 53.600° U.T.	a	b	P	Va VANCOUVER, B.C. W.123.100°, N. 49.200° U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Jan. 12	3380	6.2	1	52	23 59.9	-1.3	-0.7	81	S				S			
16	235d	6.9	1	89	N				1 31.2	-2.2	-1.7	123	S			
16	238	6.7	1	89	2 25.6	-1.8	-2.6	118	1 52.3	-1.6	-0.3	91	1 35.3	-1.9	+0.2	93
16	258	6.6	1	91	A				A				7 25.1	-0.3	-2.2	108
17	376	7.0	1	103	A				7 40.2	.	.	144	N			
19	609	7.5	1	124	5 37.1	.	.	18	N				4 54.9	.	.	22
19	627	6.8	1	126	A				10 07.3	+0.6	-3.4	147	N			
20	729	7.2	1	133	0 21.0	-1.4	+0.4	118	S				S			
21	878	5.5	1	146	N				4 54.1	.	.	160	N			
22	1029	5.1	1	158	8 04.8	-1.6	+0.1	53	7 39.1	-1.7	+0.7	55	7 19.5	-1.9	+0.3	75
26	1468	4.9	2	203	9 23.6	-1.8	-0.4	262	8 54.0	-1.8	+0.8	255	8 22.9	.	.	222
27	1565d	6.3	2	214	N				5 19.8	.	.	219	N			
Feb. 14	454	5.8	1	83	A				6 50.6	+0.1	-2.4	119	7 05.6	+0.3	-4.4	145
16	729	7.2	1	107	A				A				9 28.5	-0.2	-0.7	59
17	814d	5.3	1	115	2 19.0	.	.	26	N				G			
18	970	6.5	1	127	4 42.4	-1.7	-0.1	71	4 16.1	-1.7	+0.9	65	3 55.6	-1.8	+0.8	80
18	975d	6.8	1	127	5 35.9	-1.1	-1.7	106	5 09.2	-1.4	-1.1	104	4 59.5	-1.7	-1.5	121
19	1091	6.7	1	138	5 02.7	.	.	40	4 38.7	.	.	34	4 08.5	-1.7	+2.3	58
19	1106d	3.6	1	139	8 40.5	-0.5	-1.2	75	8 23.8	-0.9	-1.2	81	8 19.8	-1.1	-1.5	99
20	1234	6.1	1	151	10 27.5	-0.3	-0.8	57	10 15.4	-0.7	-1.1	65	10 13.0	-0.9	-1.3	83
21	1341d	4.3	1	162	9 47.9	0.0	-2.9	158	9 36.4	0.0	-3.6	169	N			
24	1652	5.5	2	197	9 29.4	-1.7	-0.5	254	8 58.0	-2.1	+1.0	241	N			
Mar. 1	2271	4.3	1	260	11 30.6	-1.8	+0.6	68	11 07.4	-1.4	+1.1	75	10 49.9	-1.1	+1.1	92
1	2271	4.3	2	260	12 34.3	-1.4	-1.2	316	12 11.0	-1.1	-0.4	313	12 00.1	-1.2	+0.1	298
12	258	6.6	1	37	1 23.8	-0.6	+1.7	17	N				S			

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97.200°, N. 49.900°				Ed EDMONTON, ALTA. W.113.400°, N. 53.600°				Va VANCOUVER, B.C. W.123.100°, N. 49.200°			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Mar. 15	636d	6.9	1	73	2 50.9	-1.4	+1.8	27	2 37.6	.	.	12		S		
15	667	5.3	1	75		A			6 48.3	+0.1	-1.6	96	6 57.1	+0.1	-2.0	113
17	938d	7.2	1	97		A			8 25.3	+0.2	-1.7	103	8 34.9	+0.1	-2.0	119
18	1073	6.0	1	109		A			9 02.1	+0.1	-1.6	93	9 09.7	0.0	-1.8	107
20	1281	6.4	1	129	5 21.6	-0.6	-3.1	154	4 58.7	-0.7	-3.4	161		N		
20	1309	5.7	1	131		A			10 15.5	+0.1	-2.0	124	10 25.4	+0.1	-2.2	136
21	1410d	5.3	1	143		A			10 19.1	0.0	-2.3	144	10 30.4	+0.1	-2.8	159
23	1599	5.0	1	164	4 04.3	-1.4	0.0	111	3 46.2	-1.0	+0.6	111	3 36.3	-0.8	+0.1	129
Apr. 11	692d	1.1	1	49	16 38.2	-0.4	+1.3	100	16 41.7	+0.1	+1.6	82	16 36.9	+0.3	+1.4	83
11	692d	1.1	2	49	17 38.9	-0.4	+2.2	237	17 41.6	-0.2	+1.8	256	17 33.3	+0.1	+1.7	255
12	741	5.7	1	54		A			5 05.3	-0.2	-1.1	67	5 08.5	-0.3	-1.3	84
13	878	5.5	1	65	5 10.7	-0.3	-0.3	44	5 01.5	-0.6	-0.5	49	4 58.2	-0.8	-1.0	70
17	1364	6.5	1	111		N			8 01.1	.	.	33	7 51.9	-1.0	-0.8	61
18	1465	6.3	1	122	7 59.1	-0.4	-1.1	64	7 44.3	-0.9	-1.2	69	7 40.2	-1.1	-1.3	86
18	1468	4.9	1	122		A			8 51.7	-0.3	-1.6	89	8 55.2	-0.5	-1.7	101
19	1565d	6.3	1	133	5 57.9	-0.9	-1.9	126	5 35.0	-1.0	-1.6	134	5 33.7	-0.9	-2.3	156
27	2658	5.4-6.2	2	239		S				S			11 29.9	-1.5	-0.7	317
28	2826	4.0	1	253		S			10 33.2	-1.2	+1.3	59	10 15.2	-1.1	+1.5	68
28	2826	4.0	2	253		S				S			11 23.6	-1.4	+0.6	282
May 9	692d	1.1	1	22	2 54.0	+0.6	-2.3	135	2 51.9	+0.3	-2.9	138		N		
9	692d	1.1	2	22		A			3 29.6	-0.2	-0.2	219		N		
11	961	6.2	1	45		A			4 04.8	+0.5	-3.5	158		N		
11	970	6.5	1	46		N				N			5 17.5	.	.	30
13	1212	7.1	1	68		A			6 18.8	0.0	-1.5	85	6 25.1	-0.1	-1.6	97
14	1320	6.8	1	79	5 29.5	+0.2	-2.3	141	5 21.2	-0.1	-2.6	147	5 34.9	+0.3	-3.8	170
16	1518	6.3	1	101	4 34.9	-0.9	-1.7	106	4 12.1	-1.1	-1.5	114		S		
17	1624	6.8	1	113	6 27.3	-0.3	-2.5	151	6 11.8	-0.5	-2.5	157	6 22.0	.	.	180
17	1635	5.4	1	114		A			7 59.6	-0.2	-2.2	137	8 06.6	-0.4	-2.4	147
19	1865	7.2	1	138		A			8 29.2	-0.8	-1.3	78	8 25.7	-1.1	-1.2	88
20	1973	6.2	1	150	5 44.7	-1.6	-0.6	86	5 18.4	-1.5	0.0	93	5 04.2	-1.4	0.0	111
25	2764	6.3	2	221		S				S			10 12.2	-1.5	+0.2	283
June 18	2193	6.1	1	145		A			8 07.0	-1.0	-1.6	120	8 03.1	-1.2	-1.5	125
23	2986	6.4	2	214	5 39.0	-0.9	+1.4	260		S				S		
23	3015d	5.3	2	216		S				S			10 23.9	.	.	316
July 2	692d	1.1	1	329	13 35.4	.	.	143	13 14.4	-0.8	+1.1	111	13 03.2	-0.5	+1.0	112
July 2	692d	1.1	2	329	14 07.1	.	.	192	14 12.5	-0.5	+2.6	225	13 57.4	-0.2	+2.6	223
16	2271	4.3	1	125		A				A			7 00.7	-1.2	-1.3	103
25	109	6.5	2	250	8 39.4	-1.4	+1.0	279	8 23.5	-1.0	+0.9	301	8 11.4	-0.7	+0.9	300
29	692d	1.1	1	302	21 09.2	+0.2	-1.3	86	21 03.6	-0.2	-1.5	88	21 08.7	-0.3	-1.9	105
29	692d	1.1	2	302		A			22 03.8	+0.1	-1.4	268	22 09.1	-0.2	-1.0	251
Aug. 15	2685	7.0	1	133	5 56.7	-1.0	-0.6	67	5 38.6	-1.1	0.0	52	5 24.9	-1.5	+0.5	55
15	2687	6.5-7.3	1	133	6 14.4	-1.3	-1.7	118	5 48.8	-1.3	-0.8	101	5 37.3	-1.6	-0.4	104
17	3015d	5.3	1	162	7 35.1	-0.5	+0.8	24		N				N		
22	219	5.1	2	232		S				S			12 07.9	-1.1	+1.7	213
24	464	6.4	2	256		S				S			10 52.0	-1.8	+0.2	295
Sept. 14	3109	6.5	1	144	7 53.1	-1.0	-1.9	108	7 31.8	-1.0	-0.8	82	7 23.1	-1.4	-0.5	82
14	3112	6.2	1	144		N			8 15.9	-1.4	-2.6	126	8 10.8	-2.0	-2.6	128
20	401	6.3	2	222		N			5 38.0	.	.	181	5 27.2	.	.	179
22	659	6.4	2	246	5 48.9	-0.3	+1.5	269	5 50.9	-0.1	+1.3	287		A		
22	661	4.6	2	246		N			5 49.7	+0.7	+3.2	193		A		
22	669	4.0	1	246	6 15.0	-0.5	+1.4	97	6 16.7	0.0	+1.7	79		A		
22	669	4.0	2	246	7 18.2	-0.6	+2.2	237	7 18.1	-0.3	+1.8	257	7 08.3	-0.1	+1.7	256
22	671	3.6	1	246	6 22.6	-0.9	+0.7	122	6 19.1	-0.2	+1.4	100		A		
22	671	3.6	2	246	7 10.0	-0.2	+3.0	212	7 15.8	-0.2	+2.2	235	7 06.0	+0.1	+2.1	234
22	677	4.8	2	247	8 34.7	-1.3	+1.3	263	8 21.5	-0.9	+1.1	286	8 08.6	-0.7	+1.2	285
22	685	6.5	2	247	10 33.2	-1.7	+0.7	257	10 11.0	-1.4	+0.7	278	9 54.0	-1.2	+1.1	274
22	692d	1.1	1	248	10 45.4	-1.6	+1.2	62	10 31.4	-1.0	+2.6	40	10 11.4	-0.8	+2.6	45
22	692d	1.1	2	248	12 04.6	-1.7	-1.0	280	11 33.2	-1.7	-0.9	298	11 17.8	-1.8	-0.1	290
23	806	5.1	2	259	10 02.9	-1.5	+1.1	264	9 45.7	-1.1	+0.9	285	9 31.3	-0.9	+1.2	281
23	820	6.0	2	260		S			11 49.1	-1.2	+2.4	225	11 25.6	-0.9	+3.4	215
26	1197	6.0	2	292	10 59.1	-1.3	-1.1	325		N			10 29.1	.	.	346
Oct. 8	2573	7.3	1	71		A				A			3 27.9	-1.3	-1.4	108
9	2731	6.5	1	83	2 22.5	-1.0	-0.4	60	2 04.9	-1.1	+0.3	43		S		
9	2745d	6.9	1	84		A				A			4 04.0	-1.2	-0.8	83
10	2889	7.1	1	96	2 14.4	.	.	6		N				N		
12	3188	5.4	1	124	3 31.0	-1.6	-0.2	85	3 09.3	-1.3	+0.8	66	2 52.4	-1.3	+1.2	67
12	3205	6.8	1	125		A			7 09.7	-0.2	+0.8	20	7 02.6	-0.4	+1.0	23
13	3322d	6.4	1	136	1 01.9	-1.3	+0.9	106		S				S		
13	3334	6.3	1	137	4 31.2	.	.	5		N				N		
19	608d	6.0	2	215		N			6 34.7	-0.1	+3.3	202	6 20.0	+0.1	+3.3	200
21	878	5.5	2	237	4 32.7	-0.6	0.0	320		N				N		
22	1029	5.1	2	249	6 32.5	-1.3	-1.2	330		N				N		
24	1271	5.9	2	273	11 05.6	.	.	226	10 54.9	-1.0	+2.6	242	10 33.4	-0.6	+3.6	226
Nov. 5	2685	7.0	1	53	1 04.2	-0.7	-0.5	56	0 50.7	-0.9	+0.2	36		S		
5	2687	6.5-7.3	1	53		A			0 53.7	-1.2	-0.8	90		S		

Date	Z.C. No.	Mag.	P.	El. of Moon	Wi WINNIPEG, MAN. W. 97°.200, N. 49°.900				Ed EDMONTON, ALTA. W.113°.400, N. 53°.600				Va VANCOUVER, B.C. W.123°.100, N. 49°.200			
					U.T.	a	b	P	U.T.	a	b	P	U.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°	h m	m	m	°
Nov. 7	2986	6.4	1	79	0 05.5	-1.3	+0.7	48		S				S		
7	3008	6.9	1	81		A				A			4 28.5	-0.4	+0.5	30
8	3155	6.8	1	94	3 35.9	-1.0	-0.8	75	3 18.5	-1.0	+0.1	52	3 06.2	-1.3	+0.6	51
16	692d	1.1	1	194	3 23.7	-0.5	+1.9	68	3 27.6	0.0	+2.3	47	3 19.0	+0.2	+2.1	48
16	692d	1.1	2	194	4 32.6	-1.1	+1.3	266	4 22.2	-0.8	+1.1	288	4 10.9	-0.5	+1.1	288
17	806	5.1	2	205	2 29.7	0.0	+1.7	254		A				A		
17	820	6.0	2	206		N			3 58.6	+0.5	+3.4	201	3 49.8	+0.8	+3.4	198
18	970	6.5	2	217	5 14.7	-0.7	+1.7	261	5 11.0	-0.4	+1.3	281	5 02.4	-0.2	+1.3	279
23	1549	5.2	2	275	11 22.0	-1.1	-1.3	325	11 02.3	-0.8	-0.8	328	10 55.6	-0.8	+0.1	310
Dec. 2	2794	6.7	1	34	23 18.9	.	.	154		S				S		
5	3112	6.2	1	63		A			3 00.5	-0.4	+0.2	32	2 54.4	-0.6	+0.5	33
5	3119	6.7	1	64		A				A			4 07.8	-0.1	+0.9	21
5	3238	7.0	1	75	23 18.8	-1.7	0.0	96		S				S		
8	4	6.3	1	104	6 02.1	-0.2	+1.7	13		N				N		
10	269d	7.3	1	129	6 22.3	-0.9	-0.2	55	6 08.3	-0.9	+0.9	35	5 53.4	-1.2	+1.1	42
13	692d	1.1	1	167		A			12 48.4	-0.1	-1.2	74	12 53.3	-0.1	-1.5	90
13	692d	1.1	2	167		A			13 43.0	+0.3	-1.5	281	13 51.5	+0.1	-1.2	265
17	1197	6.0	2	212	12 23.3	-1.3	-0.4	236	11 57.3	-1.9	+0.9	227		N		
19	1409	5.1	2	233	11 29.6	-1.7	-0.9	274	11 00.6	-1.7	+0.2	269	10 38.4	-2.0	+1.9	247
22	1716	6.4	2	267	13 01.4	-1.6	-0.8	284	12 34.0	-1.6	+0.3	276	12 12.9	-1.9	+1.8	252
26	4002	-4.4	1	315	11 05.6	-0.3	+0.5	127		A				A		
26	4002	-4.4	2	315	12 10.4	-1.0	+1.3	272		A				A		

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
50	44 Psc	806	111 Tau	1549	48 Leo	2399	24 Sco
215	96 Psc	814	115 Tau	1565	35 Sex	2448	29 Oph
219	98 μ Psc	820	117 Tau	1599	58 Leo	2826	44 ρ^1 Sgr
362	25 Ari	878	130 Tau	1635	75 Leo	2828	45 ρ^2 Sgr
401	85 Cet	1003	21 Gem	1652	79 Leo	3008	τ^1 Cap
635	54 γ Tau	1029	26 Gem	1660	83 Leo	3015	τ^2 Cap
636	55 Tau	1106	54 λ Gem	1962	82 Vir	3131	18 Aqr
650	63 Tau	1197	1 Cnc	2033	98 κ Vir	3188	48 λ Cap
659	70 Tau	1271	29 Cnc	2060	2 Lib	3247	36 Aqr
661	71 Tau	1341	65 α Cnc	2193	29 o^1 Lib	3334	67 Aqr
667	75 Tau	1409	5 ξ Leo	2196	30 o^2 Lib	4002	Venus
669	77 θ^1 Tau	1410	6 Leo	2271	46 θ Lib		
671	78 θ^2 Tau	1468	29 π Leo	2291	49 Lib		
692	87 α Tau	1518	43 Leo	2361	7 χ Oph		

OCCULTATION LIMITS FOR 1978

The maps show the tracks of stars brighter than $7^{\rm m}.5$ which will graze the limb of the Moon when it is at a favourable elongation from the Sun and at least 10° above the observer's horizon (5° in the case of stars brighter than $5^{\rm m}.5$ and 2° for those brighter than $3^{\rm m}.5$). Each track starts in the West at the time given in the tables and ends beyond the area of interest, except where the letters *A*, *B* or *S* are given. *A* denotes that the Moon is at a low altitude, *B* that the bright limb interferes, and *S* that daylight interferes. The tick marks along the tracks denote 10 minute intervals which, when added to the time at the beginning of the track, give the time of the graze at places along the tracks.

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

Observers positioned on or very near one of these tracks will probably see the star disappear and reappear several times at the edge of features on the limb of the Moon. The recorded times of these events (to a precision of a second, if possible) are very valuable in the study of the shape and motion of the Moon currently being investigated at the Royal Greenwich Observatory and the U.S. Naval Observatory. Interested observers situated near to any of these tracks should write to Dr. David W. Dunham, IOTA, 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	1708	6.2	7 59	62	N	30	Mar. 31	2685	7.0	8 17	51	S
2	2	1814	7.0	7 56	51	N	31	31	2687	6.5	9 03	51	S
3	6	2390	6.7	14 40	9	N	33*	Apr. 2	3015	5.3	13 08	27	S
4	11	3233	7.2	23 41	11	N	35	11	692	1.1	16 36	18	S
5	12	3247	7.0	2 05	12	N	36	12	729	7.2	2 10	20	N
5a*	12	3362	5.9	21 34	18	N	36a	13	878	5.5	5 20	29	N
5b	12	3367	6.4	22 32	19	N	37*	14	1003	7.2	2 32	37	N
6	13	3380	6.2	0 28	19	S	38	14	1011	7.4	4 31	38	N
7	13	3385	6.6	1 11	20	S	39	17	1364	6.5	8 06	68	N
8	14	3520	6.0	1 36	29	N	40	May 9	692	1.1	3 14	4	S
9*	16	226	6.6	1 34	49	N	41	10	806	5.1	2 23	8	S
10*	16	235	6.9	1 30	50	S	42	11	934	6.4	0 39	14	N
11	16	238	6.7	1 55	50	S	42a*	11	938	7.2	0 49	14	S
12	16	247	6.7	5 23	51	N	43*	11	944	5.7	2 07	14	N
14	17	355	7.5	3 25	60	N	44	11	961	6.2	4 21	15	S
16	31	2036	6.9	10 27	55	S	45	12	1091	6.7	5 58	23	N
18*	Feb. 4	2649	6.6	14 13	12	N	47	17	1624	6.8	7 02	70	S
19	10	3459	6.6	0 26	8	N	48	17	1635	5.4	8 55	71	S
20	14	437	7.4	3 19	43	N	51	June 12	1478	7.2	4 01	33	S
20a	15	667	5.3	21 36	61	S	52*	14	1692	6.8	3 13	52	N
20b	17	806	5.1	0 30	71	S	56	July 2	677	4.8	10 44	8	S
21*	17	814	5.3	2 05	71	N	57	2	692	1.1	13 08	7	S
22	Mar. 3	2573	7.3	11 13	35	S	58	14	1996	6.9	3 45	57	N
24*	4	2745	6.9	11 26	25	S	60	16	2271	4.3	8 08	79	S
25	4	2755	6.6	12 56	24	S	60a	27	360	6.8	5 11	47	N
25a	12	258	6.6	1 33	11	N	61	29	618	7.2	7 10	27	N
26	14	504	7.3	2 57	27	N	62	29	627	6.8	9 54	26	N
27*	15	636	6.9	2 40	36	N	63*	29	636	6.9	11 26	26	N
28†	15	650	5.7	4 58	36	N	64	29	692	1.1	21 58	23	S
29	20	1271	5.9	1 38	81	N	65	31	896	7.4	9 13	12	S

No.	Date	Z.C.	Mag.	U.T.	%	L	No.	Date	Z.C.	Mag.	U.T.	%	L
				h m							h m		
67	Aug. 23	327	4.5	6 23	73	S	94	Oct. 24	1271	5.9	10 58	47	S
68	24	454	5.8	8 00	63	N	94a	25	1381	6.3	11 42	38	S
69	26	729	7.2	8 38	42	N	94b	Nov. 4	2658	5.4	21 20	19	N
70*	28	1003	7.2	9 33	24	N	95	5	2687	6.5	1 36	20	S
71	28	1011	7.4	11 34	24	N	96	5	2699	7.2	3 02	21	S
72	31	1344	6.8	9 47	5	N	97	5	2846	6.9	23 42	29	S
73	Sept. 11	2596	7.3	2 12	59	S	100	8	3155	6.8	3 57	54	S
73a	12	2787	6.4	3 27	71	S	101	16	692	1.1	3 23	98	S
74	22	667	5.3	6 22	70	N	102	21	1328	7.0	6 12	66	N
75	22	692	1.1	10 45	68	S	103	21	1344	6.8	10 19	64	S
76*	23	814	5.3	10 17	59	N	105	26	1850	6.5	8 28	19	N
78*	24	944	5.7	8 23	50	N	106*	26	1855	7.1	10 05	18	S
79*	26	1190	7.1	8 34	31	N	107	26	1874	7.5	13 44	17	N
80	26	1197	6.0	10 20	31	N	107a	28	2097	7.1	10 45	5	N
81†	28	1409	5.1	9 20	15	N	108	Dec. 5	3112	6.2	3 47	28	S
84	Oct. 6	2399	5.0	22 37	22	N	109	5	3238	7.0	23 43	37	S
85	8	2573	7.3	4 14	34	S	109a	7	3505	5.6	20 19	58	S
86	9	2731	6.5	3 25	45	S	110	8	4	6.3	6 03	62	N
87*	9	2745	6.9	4 52	46	S	112†	19	1409	5.1	10 25	80	S
88*	10	3015	5.3	23 00	66	N	113	22	1716	6.4	11 40	52	S
89	Oct. 12	3188	5.4	3 34	78	S	114	23	1808	7.0	8 43	43	N
90	20	741	5.7	4 47	85	N	115*	23	1830	6.8	14 38	41	S
91	21	878	5.5	4 18	77	N	116	24	1920	6.7	7 31	34	N
92	22	1011	7.4	3 06	69	N	117	24	1947	7.1	13 41	32	S
93	22	1029	5.1	6 07	68	N	118	26	2180	7.0	11 01	15	S

NOTES ON DOUBLE STARS 1978

Track 5a: ZC 3362 is the mean of the double star Aitken 16365. The components are $6^m.1$ and $8^m.1$; separation $0''.3$ in p.a. 309°.

Track 9: ZC 226 is the brighter component of the double star Aitken 1214. The companion is $10^m.7$; separation $4''.1$ in p.a. 77°.

Track 10: ZC 235 is the mean of the double star Aitken 1254. The components are both $7^m.7$; separation $1''.6$ in p.a. 50°.

Track 18: ZC 2649 is the brighter component of the double star Aitken 11232. The companion is $9^m.6$; separation $54''.3$ in p.a. 12°.

Tracks 21, 76: ZC 814 is the brightest component of the triple star Aitken 4038. The brighter companion is 10th magnitude; separation 10″ in p.a. 306°.

Tracks 24, 87: ZC 2745 is the brighter component of the double star Aitken 11776. The companion is $11^m.8$; separation $18''.5$ in p.a. 40°.

Tracks 27, 63: ZC 636 is the mean of the double star Aitken 3135. The components are $7^m.0$ and $8^m.9$; separation $0''.46$ in p.a. 75°.

Tracks 33, 88: ZC 3015 is the mean of the double star Aitken 14099. The components are $5^m.8$ and $6^m.3$ separation $0''.2$ in p.a. 115°.

Tracks 37, 70: ZC 1003 is the brighter component of the double star Aitken 5166. The companion is $8^m.1$; separation $20''.0$ in p.a. 210°.

Track 42a: ZC 938 is the brighter component of the double star Aitken 4789. The companion is $8^m.7$; separation $2''.1$ in p.a. 155°.

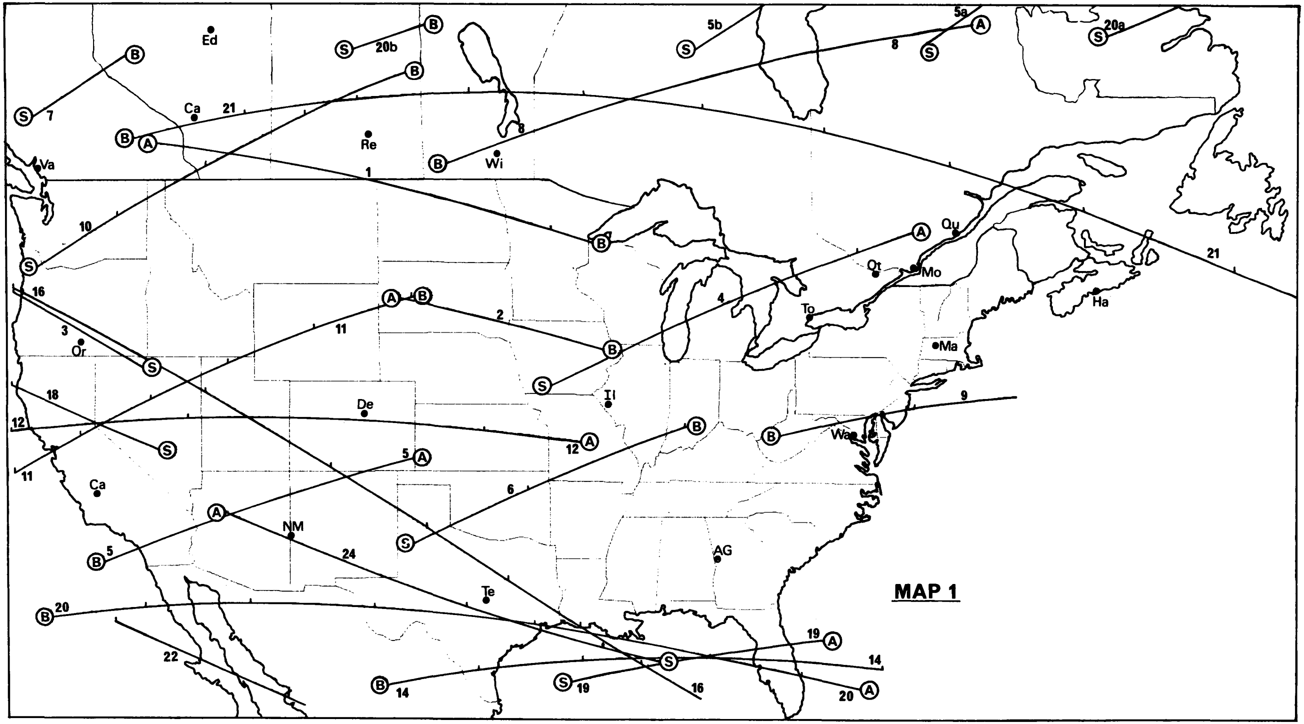
Tracks 43, 78: ZC 944 is the mean of a double star not listed by Aitken. The components are both $6^m.2$; separation $0''.3$ in p.a. 137°.

Track 52: ZC 1692 is the brighter component of the double star Aitken 8261. The companion is $11^m.5$; separation $0''.9$ in p.a. 140°.

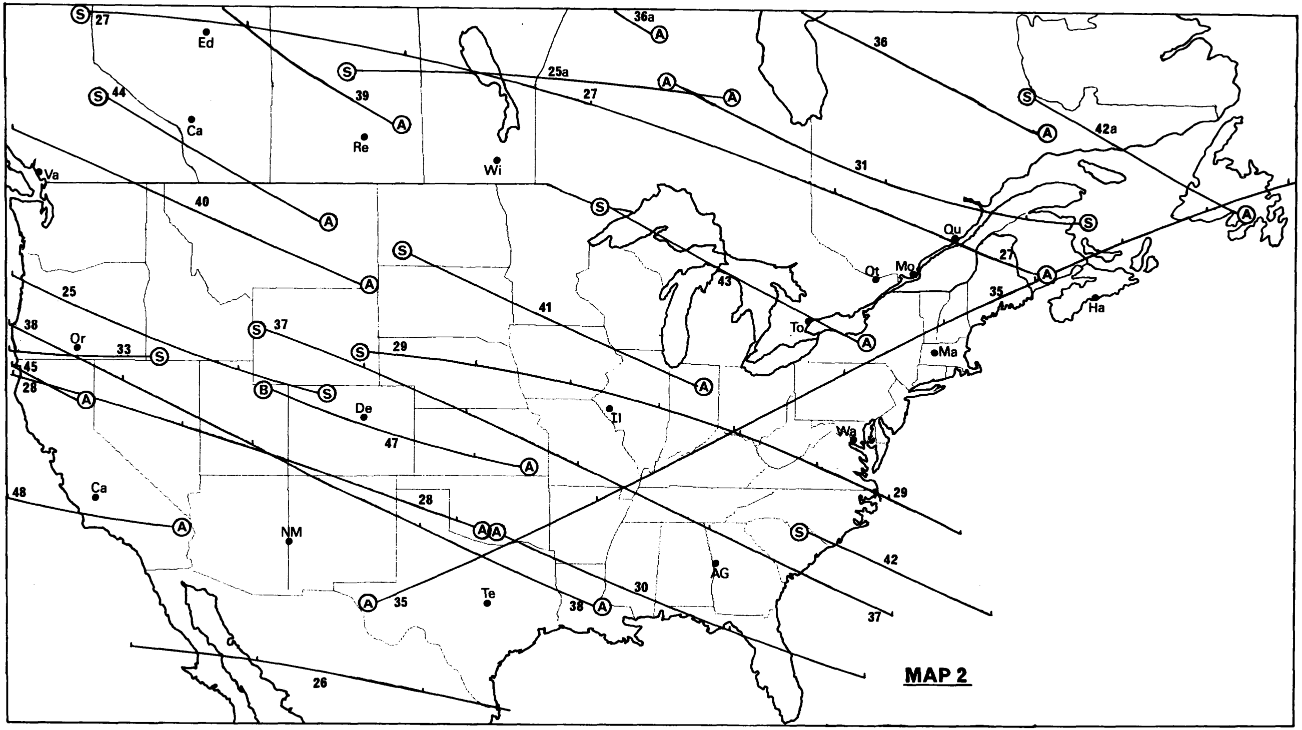
Track 79: ZC 1190 is the brighter component of the double star Aitken 6440. The companion is $11^m.1$; separation $15''.9$ in p.a. 20°.

Track 106: ZC 1855 is the brighter component of the double star Aitken 8707. The companion is $8^m.6$; separation $5''.7$ in p.a. 148°.

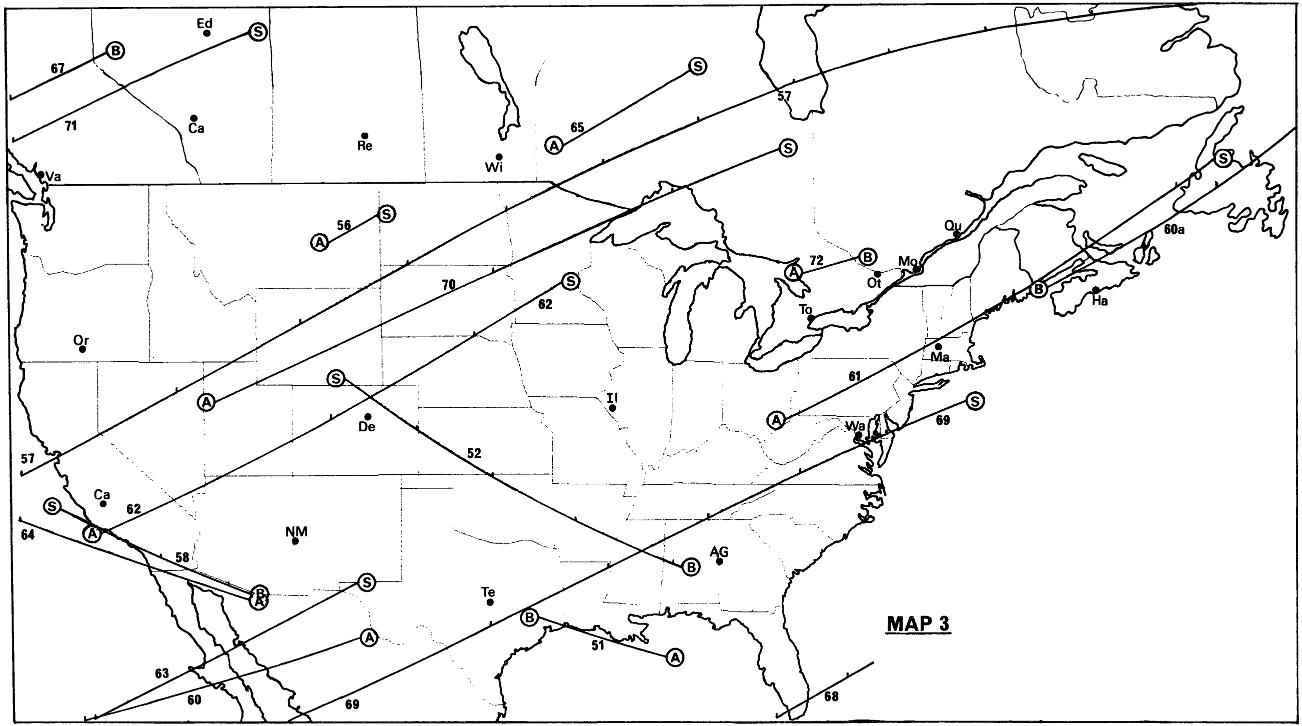
Track 115: ZC 1830 is the brighter component of the double star Aitken 8657. The companion is $8^m.3$; separation $15''.9$ in p.a. 349°.



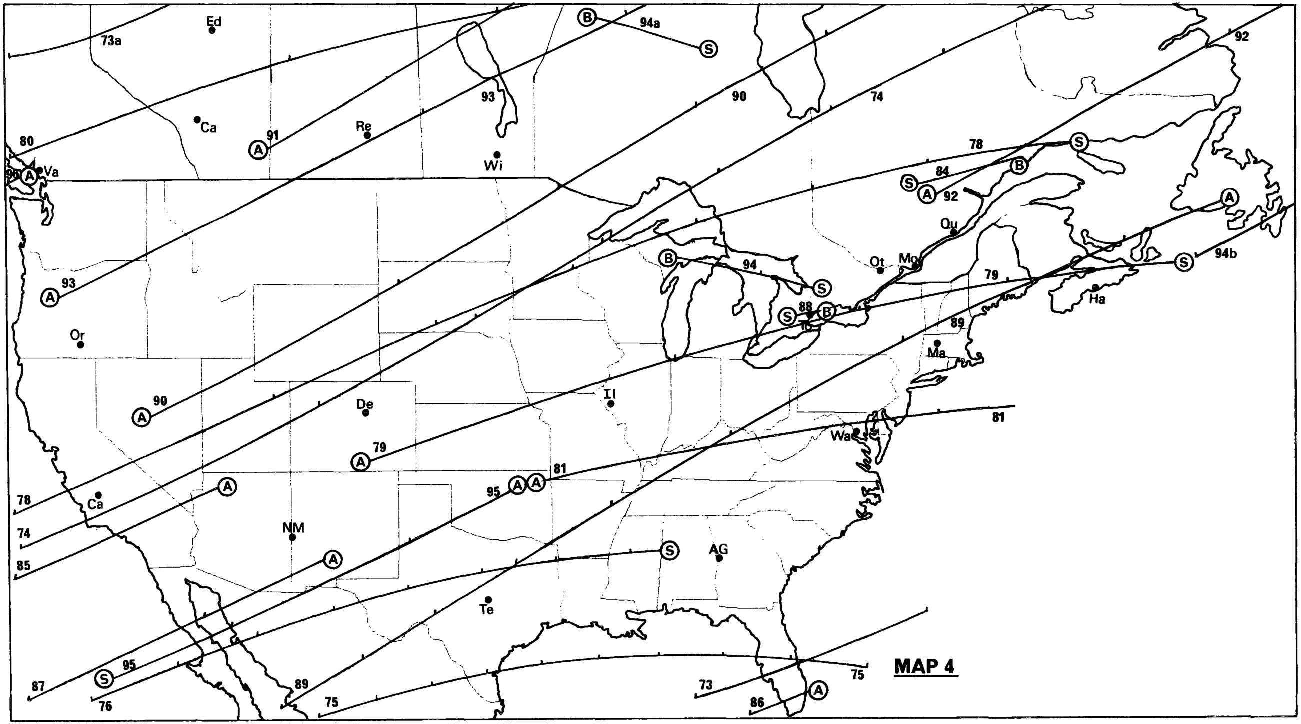
Map 1: Tracks 1 to 24; January 1 to March 4.



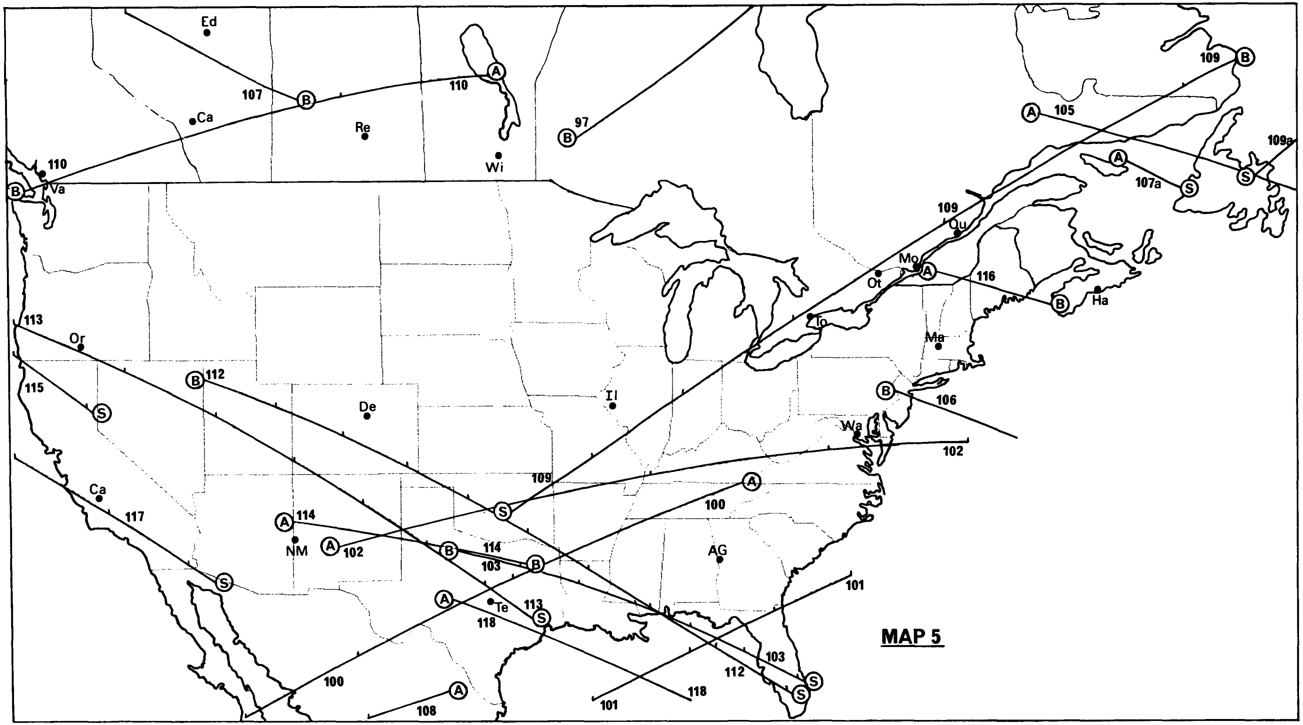
Map 2: Tracks 25 to 48; March 4 to May 17.



Map 3: Tracks 51 to 72; June 12 to August 31.

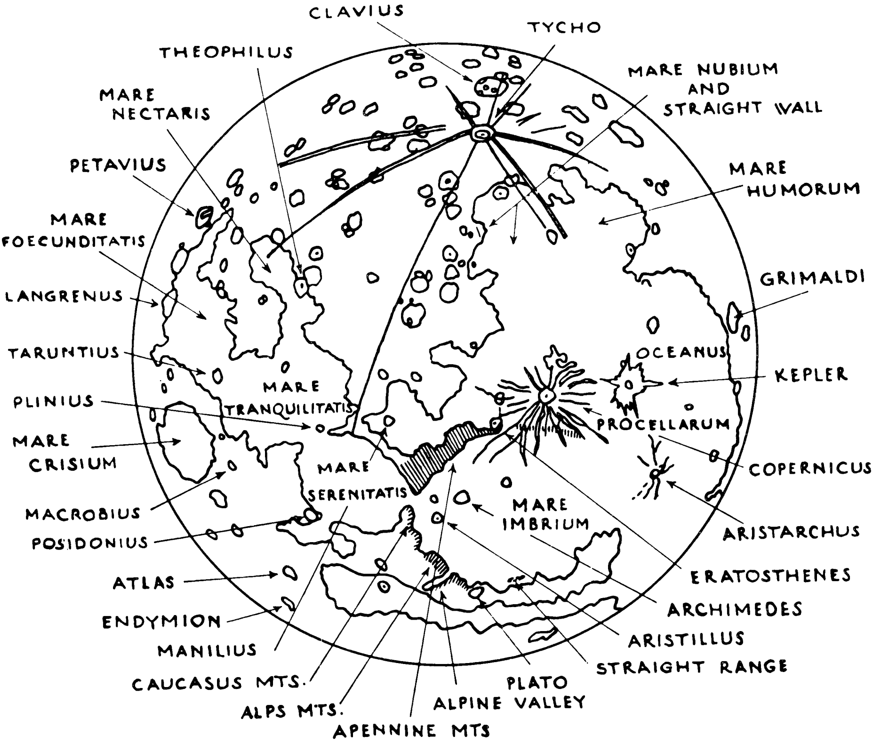


Map 4: Tracks 73 to 96; September 11 to November 5.



Map 5: Tracks 97 to 118; November 5 to December 31.

MAP OF THE MOON



South appears at the top.

PLANETARY HELIOCENTRIC LONGITUDES 1978

Date (0 h E.T.)	Mercury	Venus	Earth	Mars	Jupiter	Saturn
	°	°	°	°	°	°
Jan. 1	149	268	100	112	92	145
Feb. 1	255	317	132	126	94	147
Mar. 1	346	2	160	139	97	148
Apr. 1	159	51	191	152	99	149
May 1	258	100	220	165	102	150
June 1	5	150	250	179	105	151
July 1	173	199	279	192	107	152
Aug. 1	269	248	308	207	110	153
Sept. 1	26	297	338	222	112	154
Oct. 1	188	345	7	237	115	155
Nov. 1	281	34	38	253	117	156
Dec. 1	43	82	68	270	120	157
Jan. 1	203	133	100	288	122	158

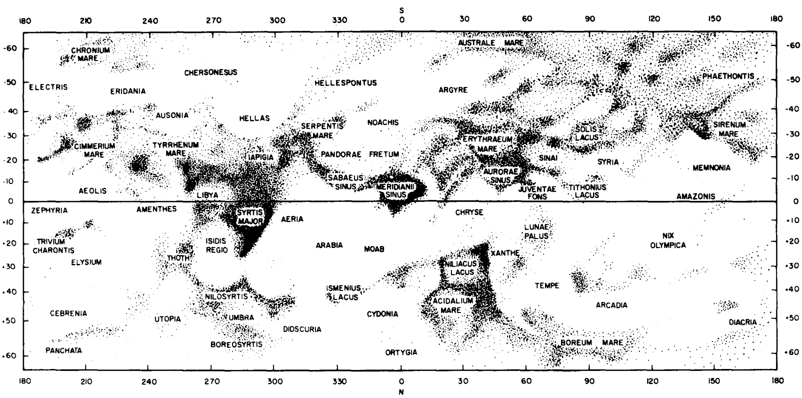
The heliocentric longitude of Uranus increases from 223° to 228° during the year; that of Neptune increases from 256° to 258°, and that of Pluto increases from 195° to 197°.

MARS—EPHEMERIS FOR PHYSICAL OBSERVATIONS

For the first day of each month and for other dates near opposition, the table gives the distance from the earth *r*, the magnitude *m*, apparent diameter *d*, fraction *f* of the disc illuminated, position angle *P* of the rotation axis (measured from the north through the east), inclination *i* 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 315.5° − (10 × 9.78°) + (2 × 14.6°) = 246.9°. 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.	*r*	*m*	*d*	*f*	*P*	*i*	*L(1)*	Δ
	A.U.		″		°	°	°	°/d
Jan. 1.0	0.68	−0.8	13.6	0.98	357	+15	197.4	8.76
11.0	0.66	−1.0	14.2	0.99	355	+14	—	—
21.0	0.65	−1.1	14.3	1.00	353	+12	—	—
Feb. 1.0	0.67	−1.0	13.9	0.99	350	+11	285.7	8.93
11.0	0.71	−0.7	13.2	0.98	348	+10	—	—
Mar. 1.0	0.83	−0.2	11.4	0.95	347	+9	35.8	9.25
Apr. 1.0	1.09	+0.5	8.6	0.91	349	+12	108.9	9.48
May 1.0	1.37	+1.0	6.9	0.90	356	+16	184.7	9.61
June 1.0	1.64	+1.4	5.7	0.91	6	+21	246.8	9.71
July 1.0	1.87	+1.6	5.0	0.92	16	+25	315.5	9.78
Aug. 1.0	2.07	+1.7	4.5	0.94	26	+26	12.4	9.81
Sept. 1.0	2.21	+1.8	4.2	0.96	34	+24	68.3	9.81
Oct. 1.0	2.31	+1.7	4.0	0.97	38	+18	134.1	9.79
Nov. 1.0	2.38	+1.7	3.9	0.99	37	+11	190.7	9.78
Dec. 1.0	2.40	+1.5	3.9	0.99	30	+1	257.4	9.80

MAP OF MARS



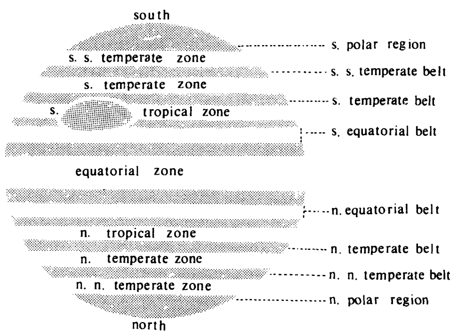
Latitude is plotted on the vertical axis (south at the top); longitude is plotted on the horizontal axis

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.	Mag.	Equat. Diam.	System I		System II	
			L(1)	Δ	*L(1)*	Δ
		″	°	°	°	°
Jan. 1	−2.3	47.2	329.0	157.90	56.3	150.35
Feb. 1	−2.2	44.7	185.7	157.85	36.4	150.20
Mar. 1	−2.0	41.1	285.1	157.75	282.3	150.10
Apr. 1	−1.7	37.2	135.1	157.70	255.8	150.05
May 1	−1.6	34.4	185.6	157.65	77.4	150.05
June 1	−1.4	32.5	33.0	157.65	48.2	150.05
July 1	−1.4	31.7	82.7	157.70	229.1	150.05
Aug. 1	−1.4	31.9	290.9	157.70	200.7	150.10
Sept. 1	−1.5	33.0	140.5	157.85	173.8	150.20
Oct. 1	−1.6	35.1	194.3	157.90	358.6	150.25
Nov. 1	−1.8	38.2	48.0	157.95	335.8	150.30
Dec. 1	−2.0	41.9	106.2	158.00	165.1	150.40

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.



JUPITER—PHENOMENA OF THE BRIGHTEST SATELLITES 1978

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. 36–37.

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 July 10, and on the west thereafter.

JANUARY

d	h	m	Sat.	Phen.
1	4	50	I	OD
	7	19	I	ER
2	1	59	I	TI
	2	15	I	SI
	4	12	I	Te
	4	28	I	Se
	6	33	II	OD
	17	28	III	SI
	19	16	III	Te
	20	27	III	Se
	23	16	I	OD
3	1	48	I	ER
	20	25	I	TI
	20	43	I	SI
	22	38	I	Te
	22	57	I	Se
4	1	24	II	TI
	2	02	II	SI
	4	04	II	Te
	4	43	II	Se
	17	42	I	OD
	20	17	I	ER
5	17	04	I	Te
	17	25	I	Se
	19	40	II	OD
	23	00	II	ER
6	6	08	III	OD
7	17	12	II	Te
	18	02	II	Se
8	6	34	I	OD
9	3	43	I	TI
	4	09	I	SI
	5	56	I	Te
	6	23	I	Se
	19	39	III	TI
	21	28	III	SI
	22	34	III	Te
10	0	27	III	Se
	1	00	I	OD
	3	43	I	ER
	22	09	I	TI
	22	38	I	SI
11	0	22	I	Te
	0	51	I	Se
	3	40	II	TI
	4	40	II	SI
	6	20	II	Te
	7	21	II	Se
	19	27	I	OD
	22	12	I	ER
12	17	07	I	SI
	18	48	I	Te
	19	20	I	Se
	21	55	II	OD
13	1	35	II	ER
14	16	49	II	TI
	17	59	II	SI
	19	29	II	Te
	20	39	II	Se
16	5	28	I	TI
	6	04	I	SI
	7	41	I	Te
	22	58	III	TI
17	1	27	III	SI
	1	54	III	Te
	2	45	I	OD
17	4	27	III	Se
	5	38	I	ER
	23	55	I	TI
18	0	33	I	SI
	2	07	I	Te
	2	46	I	Se
	5	58	II	TI
	7	17	II	SI
	21	12	I	OD
19	0	07	I	ER
	18	21	I	TI
	19	01	I	SI
	20	34	I	Te
	21	15	I	Se
20	0	11	II	OD
	4	11	II	ER
	18	36	I	ER
	18	39	III	ER
21	19	08	II	TI
	20	36	II	SI
	21	48	II	Te
	23	16	II	Se
23	07	14	I	TI
	17	29	II	ER
24	2	22	III	TI
	4	32	I	OD
	5	17	III	Te
	5	27	III	SI
25	1	41	I	TI
	2	27	I	SI
	3	53	I	Te
	4	41	I	Se
	22	58	I	OD
26	2	02	I	ER
	20	07	I	TI
	20	56	I	SI
	22	20	I	Te
	23	09	I	Se
27	2	29	II	OD
	6	47	II	ER
	17	25	I	OD
	19	11	III	OR
	19	37	III	ED
	20	31	I	ER
	22	39	III	ER
28	17	38	I	Se
	21	28	II	TI
	23	13	II	SI
29	0	08	II	Se
	1	53	II	Se
30	20	05	II	ER
31	5	49	III	TI
	6	19	I	OD

FEBRUARY

d	h	m	Sat.	Phen.
1	3	28	I	TI
	4	22	I	SI
	5	40	I	Te
	6	36	I	Se
2	0	46	I	OD
	3	57	I	ER
	21	55	I	TI
	22	51	I	SI
3	0	07	I	Te
	1	04	I	Se
3	4	50	II	OD
	17	29	IV	SE
	19	13	I	OD
	19	44	III	OD
	22	26	I	ER
	22	41	III	OR
	23	37	III	ED
4	2	40	III	ER
	17	20	I	SI
	18	35	I	Te
	19	33	I	Se
	23	51	II	TI
5	1	50	II	SI
	2	31	II	Te
	4	30	II	Se
6	18	01	II	OD
	22	41	II	ER
8	5	16	I	TI
	6	17	I	SI
	17	49	II	Se
9	2	35	I	OD
	5	53	I	ER
	23	44	I	TI
10	0	46	I	SI
	1	56	I	Te
	2	59	I	Se
	21	02	I	OD
	23	18	III	OD
11	0	21	I	ER
	2	16	III	OR
	3	37	III	ED
	18	11	I	TI
	19	15	I	SI
	20	24	I	Te
	21	28	I	Se
	23	49	IV	ED
12	0	53	IV	ER
	2	16	II	TI
	4	27	II	SI
	4	55	II	Te
	18	50	I	ER
13	20	25	II	OD
14	1	18	II	ER
	17	28	III	SI
	20	31	III	Se
15	17	46	II	SI
	18	09	II	Te
	20	26	II	Se
16	4	25	I	OD
17	1	34	I	TI
	2	41	I	SI
	3	46	I	Te
	4	55	I	Se
	22	52	I	OD
18	2	17	I	ER
	2	57	III	OD
	20	01	I	TI
	21	10	I	SI
	22	14	I	Te
	23	23	I	Se
19	4	44	II	TI
	20	46	I	ER
20	17	52	I	Se
	22	52	II	OD
21	3	55	II	ER
	19	39	III	Te
21	21	28	III	SI
22	0	32	III	Se
	17	58	II	TI
	20	23	II	SI
	20	37	II	Te
	23	02	II	Se
24	3	25	I	TI
	4	36	I	SI
25	0	44	I	OD
	4	12	I	ER
	21	53	I	TI
	23	05	I	SI
26	0	05	I	Te
	1	19	I	Se
	19	12	I	OD
	22	41	I	ER
27	18	33	I	Te
	19	48	I	Se
28	1	21	II	OD
	19	16	IV	ER
	20	28	III	TI
	23	27	III	Te

MARCH

d	h	m	Sat.	Phen.
1	1	29	III	SI
	4	33	III	Se
	20	29	II	TI
	23	00	II	SI
	23	08	II	Te
2	1	39	II	Se
3	19	51	II	ER
4	2	36	I	OD
	18	45	III	ER
	23	45	I	TI
5	1	01	I	SI
	1	58	I	Te
	3	14	I	Se
	21	05	I	OD
6	0	36	I	ER
	18	14	I	TI
	19	29	I	SI
	20	27	I	Te
	21	43	I	Se
7	3	53	II	OD
	19	05	I	ER
8	0	19	III	TI
	3	19	III	Te
	23	02	II	TI
9	1	36	II	SI
	1	41	II	Te
	4	16	II	Se
	4	19	IV	SI
10	22	28	II	ER
11	19	39	III	ED
	22	47	III	ER
12	1	39	I	TI
	2	56	I	SI
	3	52	I	Te
	22	59	I	OD
13	2	32	I	ER
	20	08	I	TI
	21	25	I	SI
	22	21	I	Te
	23	38	I	Se
14	21	00	I	ER

d	h	m	Sat.	Phen.
15	18	07	I	Se
16	1	37	II	TI
17	0	04	IV	OD
	0	16	IV	OR
	19	45	II	OD
18	1	05	II	ER
	18	24	III	OD
	21	26	III	OR
	23	39	III	ED
19	2	48	III	ER
	3	34	I	TI
	20	10	II	Se
20	0	54	I	OD
	22	03	I	TI
	23	20	I	SI
21	0	16	I	Te
	1	34	I	Se
	19	23	I	OD
	22	56	I	ER
22	18	45	I	Te
	20	03	I	Se
25	22	18	IV	SI
	22	26	III	OD
26	0	27	IV	Se
	1	30	III	OR
	20	08	II	SI
	20	12	II	Te
	22	47	II	Se
27	2	50	I	OD
	23	59	I	TI
28	1	16	I	SI
	2	13	I	Te
	21	19	I	OD
29	0	51	I	ER
	18	28	I	TI
	19	44	I	SI
	20	37	III	Se
	20	42	I	Te
	21	59	I	Se
30	19	20	I	ER

APRIL

d	h	m	Sat.	Phen.
1	1	02	II	OD
2	2	31	III	OD
	19	13	IV	OR
	20	13	II	TI
	22	44	II	SI
	22	51	II	Te
3	1	23	II	Se
4	1	56	I	TI
	19	39	II	ER
	23	16	I	OD
5	2	46	I	ER
	19	31	III	Te
	20	25	I	TI
	21	31	III	SI
	21	40	I	SI
	22	39	I	Te
	23	54	I	Se
6	0	39	III	Se
	21	15	I	ER
9	22	54	II	TI
10	1	20	II	SI
	1	32	II	Te
11	18	42	IV	Se
	22	17	II	ER
12	1	14	I	OD
	20	40	III	TI
	22	23	I	TI
	23	35	I	SI
	23	44	III	Te
13	0	38	I	Te
	1	31	III	SI
	1	50	I	Se
	19	44	I	OD
	23	10	I	ER
14	19	07	I	Te
14	20	19	I	Se
16	18	52	III	ER
17	1	36	II	TI
18	19	49	II	OD
19	0	55	II	ER
	23	44	IV	ED
20	0	22	I	TI
	0	54	III	TI
	1	31	I	SI
	19	53	II	Se
	21	42	I	OD
21	1	05	I	ER
	18	52	I	TI
	20	00	I	SI
	21	06	I	Te
	22	14	I	Se
22	19	34	I	ER
23	19	40	III	ED
	22	53	III	ER
25	22	34	II	OD
27	19	49	II	SI
	20	20	II	Te
	22	28	II	Se
	23	41	I	OD
28	0	32	IV	TI
	20	51	I	TI
	21	55	I	SI
	23	06	I	Te
29	0	10	I	Se
	21	29	I	ER
30	19	28	III	OD
	22	37	III	OR
	23	40	III	ED

MAY

d	h	m	Sat.	Phen.
3	1	21	II	OD
4	20	26	II	TI
	22	24	II	SI
	23	05	II	Te
5	1	04	II	Se
	22	51	I	TI
	23	50	I	SI
6	1	06	I	Te
	19	30	II	ER
	20	11	I	OD
	20	26	IV	ER
	23	24	I	ER
7	19	37	I	Te
	20	35	I	Se
	23	48	III	OD
11	20	45	III	Se
	23	12	II	TI
13	0	52	I	TI
	22	08	II	ER
	22	11	I	OD
14	1	19	I	ER
	19	22	I	TI
	20	15	I	SI
	20	20	IV	TI
	21	37	I	Te
	22	30	I	Se
	22	38	IV	Te
15	19	47	I	ER
18	21	23	III	Te
	21	32	III	SI
20	20	23	II	OD
21	0	12	I	OD
	21	23	I	TI
	22	10	I	SI
	23	39	I	Te
22	19	32	II	Se
	21	42	I	ER
25	22	38	III	TI
27	23	13	II	OD
28	23	24	I	TI
29	0	05	I	SI
	20	42	I	OD
29	20	48	II	Te
	22	07	II	Se
	23	37	I	ER
30	20	11	I	Te
	20	50	I	Se
31	22	18	IV	SI

Jupiter being near the sun, phenomena are not given between May 31 and Aug. 12

AUGUST

d	h	m	Sat.	Phen.
12	5	20	I	ED
13	2	39	I	SI
	3	04	III	Te
	3	12	I	TI
	4	55	I	Se
	5	29	I	Te
14	2	38	I	OR
	5	27	II	ED
15	5	52	IV	ED
16	3	40	II	Te
20	4	04	III	TI
	4	33	I	SI
	4	48	III	Se
	5	12	I	TI
	6	49	I	Se
21	4	38	I	OR
23	2	19	II	SI
	3	42	II	TI
	5	03	II	Se
	6	27	II	Te
24	2	52	IV	Te
27	5	24	III	SI
	6	27	I	SI
	7	12	I	TI
28	3	36	I	ED
	6	38	I	OR
29	3	12	I	Se
	3	59	I	Te
30	4	53	II	SI
	6	28	II	TI
31	2	09	III	OR

SEPTEMBER

d	h	m	Sat.	Phen.
1	3	42	IV	ER
	4	26	II	OR
4	5	29	I	ED
5	2	50	I	SI
	3	42	I	TI
	5	06	I	Se
	5	59	I	Te
6	3	08	I	OR
	7	27	II	SI
7	2	49	III	ER
	3	02	III	OD
	6	31	III	OR
8	2	33	II	ED
	7	13	II	OR
10	1	23	II	Te
11	7	23	I	ED
12	4	44	I	SI
	5	41	I	TI
	7	00	I	Se
13	1	51	I	ED
	5	06	I	OR
14	1	28	I	Se
	2	27	I	Te
	3	22	III	ED
	6	49	III	ER
	7	21	III	OD
15	5	08	II	ED
17	1	20	II	TI
	2	04	II	Se
	4	08	II	Te
18	0	57	III	Te
	3	38	IV	OD
19	6	37	I	SI
	7	40	I	TI
20	3	45	I	ED
	7	05	I	OR
21	1	06	I	SI
	2	09	I	TI
	3	22	I	Se
	4	25	I	Te
	7	20	III	ED
22	1	34	I	OR
	7	44	II	ED
24	1	54	II	SI
	4	04	II	TI
	4	39	II	Se
	6	52	II	Te
25	0	44	III	Se
	1	44	III	TI
	5	14	III	Te
26	2	04	II	OR
	4	13	IV	SI
27	5	38	I	ED
28	3	00	I	SI
	4	07	I	TI
	5	15	I	Se
	6	23	I	Te
29	3	32	I	OR
30	0	52	I	Te

OCTOBER

d	h	m	Sat.	Phen.
1	4	28	II	SI
	6	46	II	TI
2	1	17	III	SI
	4	43	III	Se
	5	57	III	TI
3	4	46	II	OR
4	7	31	I	ED
5	3	29	IV	OR
	4	53	I	SI
	6	03	I	TI
	7	09	I	Se
6	2	00	I	ED
	5	29	I	OR
7	0	33	I	TI
	1	37	I	Se
	2	48	I	Te
	23	58	I	OR
8	7	03	II	SI
9	5	15	III	SI
10	2	11	II	ED
	7	27	II	OR
12	1	36	II	Te
	6	47	I	SI
	8	00	I	TI
13	0	13	III	OD
	2	16	IV	Se
	3	47	III	OR
	3	53	I	ED
	7	25	I	OR
14	1	15	I	SI
	2	28	I	TI
	3	31	I	Se
	4	44	I	Te
15	1	54	I	OR
17	4	46	II	ED
19	1	26	II	TI
	1	42	II	Se
	4	15	II	Te
20	2	42	III	ER
	4	18	III	OD
	5	47	I	ED
	7	52	III	OR
	23	24	II	OR
21	3	09	I	SI
	4	23	I	TI
	5	24	I	Se

d	h	m	Sat.	Phen.
22	0	15	I	ED
	3	49	I	OR
	23	52	I	Se
23	1	08	I	Te
24	7	21	II	ED
26	1	30	II	SI
	4	03	II	TI
	4	18	II	Se
	6	53	II	Te
27	3	10	III	ED
	6	40	III	ER
	7	40	I	ED
	8	20	III	OD
28	1	59	II	OR
	5	02	I	SI
	6	17	I	TI
	7	17	I	Se
	8	33	I	Te
29	2	08	I	ED
	5	43	I	OR
	23	30	I	SI
30	0	46	I	TI
	1	46	I	Se
	3	01	I	Te
	3	56	IV	TI
	8	28	IV	Te
31	0	12	I	OR
	1	50	III	Te

NOVEMBER

d	h	m	Sat.	Phen.
2	4	05	II	SI
	6	39	II	TI
	6	53	II	Se
3	7	09	III	ED
	23	12	II	ED
4	4	33	II	OR
	6	55	I	SI
	8	10	I	TI
5	4	02	I	ED
	7	37	I	OR
	22	47	II	Te
6	1	24	I	SI
	2	39	I	TI
	3	39	I	Se
	4	54	I	Te
	22	30	I	ED
	23	50	IV	ED
7	0	36	III	Se
	2	05	I	OR
	2	13	III	TI
	4	05	IV	ER
	5	46	III	Te
	22	07	I	Se
9	6	41	II	SI
11	1	46	II	ED
	7	04	II	OR
	8	49	I	SI
12	5	55	I	ED
	22	29	II	TI
	22	47	II	Se
13	1	20	II	Te
	3	17	I	SI

d	h	m	Sat.	Phen.
13	4	30	I	TI
	5	32	I	Se
	6	46	I	Te
14	0	24	I	ED
	1	05	III	SI
	3	57	I	OR
	4	34	III	Se
	6	04	III	TI
	21	45	I	SI
	22	58	I	TI
15	0	00	I	Se
	1	13	I	Te
	22	25	I	OR
16	2	03	IV	Te
17	23	37	III	OR
18	4	20	II	ED
19	7	49	I	ED
	22	34	II	SI
20	0	59	II	TI
	1	23	II	Se
	3	50	II	Te
	5	10	I	SI
	6	21	I	TI
	7	25	I	Se
	8	36	I	Te
21	2	17	I	ED
	5	03	III	SI
	5	48	I	OR
	22	47	II	OR
	23	38	I	SI
22	0	48	I	TI
	1	54	I	Se
	3	04	I	Te
23	0	15	I	OR
	21	31	I	Te
	22	09	IV	ER
24	4	56	IV	OD
	22	36	III	ER
	23	46	III	OD
25	3	22	III	OR
	6	54	II	ED
27	1	09	II	SI
	3	27	II	TI
	3	59	II	Se
	6	19	II	Te
	7	03	I	SI
	8	10	I	TI
28	4	11	I	ED
	7	38	I	OR
	9	01	III	SI
29	1	12	II	OR
	1	31	I	SI
	2	37	I	TI
	3	47	I	Se
	4	53	I	Te
	22	39	I	ED
30	2	05	I	OR
	21	05	I	TI
	22	15	I	Se
	23	20	I	Te

DECEMBER

d	h	m	Sat.	Phen.
1	20	32	I	OR
	23	02	III	ED
2	2	34	III	ER
	3	25	III	OD
	4	03	IV	SI
	7	01	III	OR
	8	24	IV	Se
4	3	45	II	SI
	5	53	II	TI
	6	35	II	Se
	8	45	II	Te
	8	56	I	SI
5	6	05	I	ED
	20	44	III	Te
	22	44	II	ED
6	3	25	I	SI
	3	35	II	OR
	4	25	I	TI
	5	40	I	Se
	6	41	I	Te
7	0	33	I	ED
	3	53	I	OR
	21	53	I	SI
	21	57	II	Te
	22	52	I	TI
8	0	08	I	Se
	1	08	I	Te
	22	20	I	OR
9	3	00	III	ED
	6	33	III	ER
	7	00	III	OD
10	21	00	IV	OD
11	1	39	IV	OR
	6	21	II	SI
	8	17	II	TI
	9	11	II	Se
12	7	58	I	ED
	20	29	III	Se
	20	43	III	TI
13	0	17	III	Te
	1	18	II	ED
	5	18	I	SI
	5	56	II	OR
	6	12	I	TI
	7	33	I	Se
	8	28	I	Te
14	2	27	I	ED
	5	41	I	OR
	19	38	II	SI
	21	27	II	TI
	22	29	II	Se
	23	46	I	SI
15	0	20	II	Te
	0	39	I	TI
	2	02	I	Se
	2	55	I	Te
	20	55	I	ED
16	0	07	I	OR
	6	58	III	ED
	20	30	I	Se
	21	21	I	Te

d	h	m	Sat.	Phen
18	8	56	II	SI
	22	00	IV	SI
19	2	26	IV	Se
	5	36	IV	TI
	20	55	III	SI
20	0	10	III	TI
	0	27	III	Se
	3	45	III	Te
	3	51	II	ED
	7	11	I	SI
	7	58	I	TI
	8	15	II	OR
	9	27	I	Se
21	4	21	I	ED
	7	27	I	OR
	22	14	II	SI
	23	48	II	TI
22	1	06	II	Se
	1	39	I	SI
	2	25	I	TI
	2	41	II	Te
	3	55	I	Se
	4	41	I	Te
	22	49	I	ED
23	1	54	I	OR
	20	08	I	SI
	20	51	I	TI
	21	23	II	OR
	22	23	I	Se
	23	07	I	Te
24	20	20	I	OR
27	0	53	III	SI
	3	34	III	TI
	4	25	III	Se
	5	50	IV	ED
	6	25	II	ED
	7	09	III	Te
	9	04	I	SI
28	6	15	I	ED
	9	12	I	OR
29	0	50	II	SI
	2	07	II	TI
	3	33	I	SI
	3	42	II	Se
	4	10	I	TI
	5	00	II	Te
	5	48	I	Se
	6	26	I	Te
30	0	43	I	ED
	3	39	I	OR
	19	42	II	ED
	20	56	III	OR
	22	01	I	SI
	22	36	I	TI
	23	39	II	OR
31	0	17	I	Se
	0	52	I	Te
	19	12	I	ED
	22	05	I	OR

SATURN AND ITS SATELLITES

By Terence Dickinson

Saturn, with its system of rings, is a unique sight through a telescope. There are three rings. The outer ring A has an outer diameter 169,000 miles. It is separated from the middle ring B by Cassini's gap, which has an outer diameter 149,000 miles, and an inner diameter 145,000 miles. The inner ring C, also known as the dusky or crape ring, has an outer diameter 112,000 miles and an inner diameter 93,000 miles. Evidence for a fourth, innermost ring has been found; this ring is very faint.

Saturn exhibits a system of belts and zones with names and appearances similar to those of Jupiter (see diagram pg. 83).

Titan, the largest and brightest of Saturn's moons is seen easily in a 2-inch or larger telescope. At elongation Titan appears about 5 ring-diameters from Saturn. The satellite orbits Saturn in about 16 days and at magnitude 8.4* dominates the field around the ringed planet.

Rhea is considerably fainter than Titan at magnitude 9.8 and a good quality 3-inch telescope may be required to detect it. At elongation Rhea is about 2 ring-diameters from the centre of Saturn.

Iapetus is unique among the satellites of the solar system in that it is five times brighter at western elongation (mag. 10.1) than at eastern elongation (mag. 11.9). When brightest, Iapetus is located about 12 ring-diameters west of its parent planet.

Of the remaining moons only Dione and Tethys are seen in "amateur"-sized telescopes.

*Magnitudes given are at mean opposition.

ELONGATIONS OF SATURN'S SATELLITES, 1978 (E.S.T.)

JANUARY

d	h	Sat.	Elong.
4	16.0	Ti	E
4	23.7	Rh	E
9	12.1	Rh	E
12	08.1	Ti	W
14	00.4	Rh	E
18	12.8	Rh	E
20	13.8	Ti	E
23	01.1	Rh	E
27	13.4	Rh	E
28	05.8	Ti	W
29	04.5	Ia	E

FEBRUARY

d	h	Sat.	Elong.
1	01.8	Rh	E
5	11.4	Ti	E
5	14.1	Rh	E
10	02.4	Rh	E
13	03.3	Ti	W
14	14.7	Rh	E
19	03.0	Rh	E
21	08.9	Ti	E
23	15.4	Rh	E
28	03.7	Rh	E

MARCH

d	h	Sat.	Elong.
1	00.8	Ti	W
4	16.0	Rh	E
8	03.3	Ia	W
9	04.3	Rh	E
9	06.4	Ti	E
13	16.7	Rh	E
16	22.3	Ti	W
18	05.0	Rh	E
22	17.4	Rh	E
25	04.2	Ti	E
27	05.7	Rh	E
31	18.1	Rh	E

APRIL

d	h	Sat.	Elong.
1	20.2	Ti	W
5	06.5	Rh	E
9	18.9	Rh	E
10	02.3	Ti	E
14	07.3	Rh	E
17	11.3	Ia	E
17	18.5	Ti	W
18	19.7	Rh	E
23	08.1	Rh	E
26	00.8	Ti	E
27	20.5	Rh	E

MAY

d	h	Sat.	Elong.
2	09.0	Rh	E
3	17.2	Ti	W
6	21.4	Rh	E
11	09.9	Rh	E
11	23.7	Ti	E
15	22.4	Rh	E
19	16.4	Ti	W
20	10.8	Rh	E
24	23.3	Rh	E
26	06.0	Ia	W
27	23.1	Ti	E
29	11.8	Rh	E

JUNE

d	h	Sat.	Elong.
3	00.3	Rh	E
4	16.0	Ti	W
7	12.8	Rh	E
12	01.4	Rh	E
12	22.9	Ti	E
16	13.9	Rh	E
20	15.9	Ti	W
21	02.4	Rh	E
25	15.0	Rh	E
28	23.1	Ti	E
30	03.5	Rh	E

JULY

d	h	Sat.	Elong.
4	16.1	Rh	E
6	16.1	Ti	W
6	16.8	Ia	E
9	04.6	Rh	E
13	17.2	Rh	E
14	23.3	Ti	E
18	05.7	Rh	E
22	16.6	Ti	W
22	18.3	Rh	E

Elongations are not given between July 22 and October 3, Saturn being near the sun.

OCTOBER

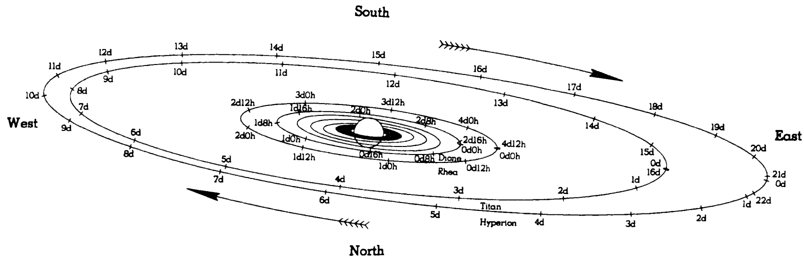
d	h	Sat.	Elong.
3	02.0	Ti	E
3	03.5	Rh	E
7	16.0	Rh	E
10	19.5	Ti	W
12	04.6	Rh	E
16	17.1	Rh	E
19	02.3	Ti	E
21	05.6	Rh	E
25	18.2	Rh	E
26	19.8	Ti	W
30	06.7	Rh	E

NOVEMBER

d	h	Sat.	Elong.
3	19.2	Rh	E
4	02.3	Ti	E
4	10.6	Ia	W
8	07.7	Rh	E
11	19.7	Ti	W
12	20.2	Rh	E
17	08.7	Rh	E
20	02.1	Ti	E
21	21.2	Rh	E
26	09.7	Rh	E
27	19.3	Ti	W
30	22.2	Rh	E

DECEMBER

d	h	Sat.	Elong.
5	10.6	Rh	E
6	01.5	Ti	E
9	23.1	Rh	E
13	18.6	Ti	W
14	11.5	Rh	E
15	20.7	Ia	E
18	23.9	Rh	E
22	00.5	Ti	E
23	12.4	Rh	E
28	00.8	Rh	E
29	17.4	Ti	W



APPARENT ORBITS OF SATELLITES I-VII, AT DATE OF OPPOSITION, FEBRUARY 16

	Name	Mean Synodic Period		Name	Mean Synodic Period
		d h			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

The diagram above, which is taken from *The Astronomical Ephemeris*, shows the apparent orbits of satellites I-VII of Saturn, at the date of opposition. At other dates, the inclination of the orbits is slightly different (see page 33). 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 on page 87. The dates of the first greatest elongation east in 1978 are Jan. 3, $0^{h}.3$ E.S.T. for Dione and Jan. 5, $10^{h}.9$ E.S.T. 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.

ASTEROIDS—EPHEMERIDES AT OPPOSITION, 1978

The asteroids Ceres, Pallas, Juno and Vesta all come to opposition in 1978—within an interval of less than two months! 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 earth, at opposition.

Asteroid	Diam.	Period		e	i	At Opposition					
		Rot.	Orb.			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	July 9	Sgr	7.0	19 16	−29 38	1.89
2 Pallas	530	10.0	4.6	0.24	35	June 4	Her	8.8	17 13	+25 48	2.35
3 Juno	240	7.2	4.4	0.26	13	July 24	Aql	9.2	20 00	−04 53	1.83
4 Vesta	530	10.7	3.6	0.09	7	June 5	Oph	5.5	16 52	−15 44	1.14

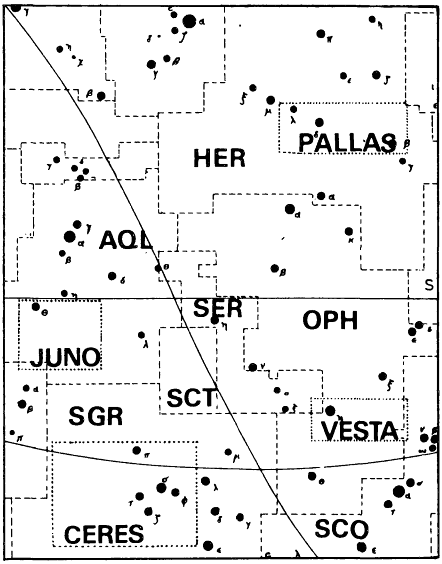
The following table lists the 1950 co-ordinates (for convenience in plotting on the *Atlas Coeli*) and the visual magnitudes of the four asteroids on selected dates (at 0 h U.T.) near opposition. The maps, which are suitable for binocular or telescopic observers, show the positions of the four asteroids.

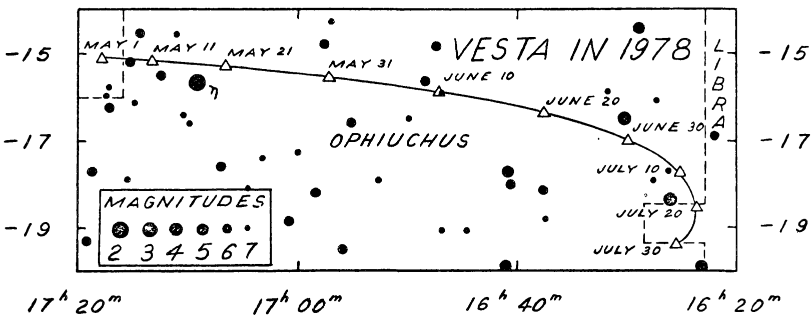
Note that, although Ceres, Pallas, Juno and Vesta were the first four asteroids to be discovered, they are not the four largest: at least half a dozen asteroids are probably larger than Juno.

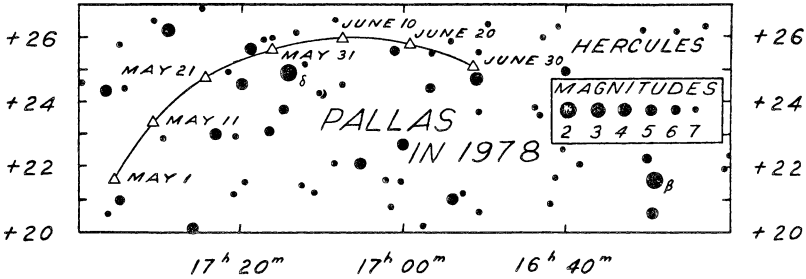
Date 0 h U.T.	CERES			PALLAS			JUNO		
	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.
	h m	° ′		h m	° ′		h m	° ′	
May 1	19 40.0	−24 21	7.5	17 35.5	+21 40	8.8	20 18.1	−06 27	10.2
11	19 43.7	−24 49	7.4	17 30.7	+23 23	8.8	20 23.3	−05 38	10.0
21	19 44.9	−25 26	7.3	17 24.1	+24 43	8.8	20 26.7	−04 55	9.9
31	19 43.5	−26 11	7.2	17 16.1	+25 36	8.8	20 28.1	−04 18	9.7
June 10	19 39.4	−27 03	7.2	17 07.6	+25 57	8.9	20 27.3	−03 52	9.6
20	19 32.9	−27 59	7.1	16 59.2	+25 46	8.9	20 24.3	−03 38	9.5
30	19 24.6	−28 53	7.1	16 51.8	+25 05	9.0	20 19.2	−03 40	9.4
July 10	19 15.1	−29 43	7.0	16 46.0	+23 58	9.0	20 12.2	−03 58	9.3
20	19 05.5	−30 23	7.1	16 42.1	+22 31	9.1	20 03.9	−04 34	9.2
30	18 56.9	−30 52	7.2	16 40.2	+20 50	9.2	19 55.2	−05 25	9.1
Aug. 9	18 50.2	−31 09	7.3	16 40.5	+18 59	9.3	19 46.8	−06 28	9.2
19	18 45.9	−31 17	7.4	16 42.8	+17 05	9.4	19 39.8	−07 39	9.2
29	18 44.3	−31 18	7.5	16 46.9	+15 11	9.5	19 34.7	−08 52	9.2

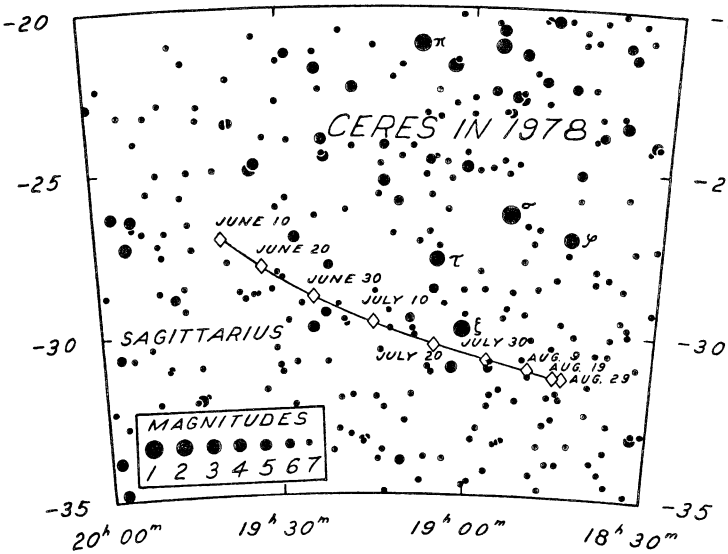
Date 0 h U.T.	VESTA		
	R.A.	Dec.	Mag.
	h m	° ′	
May 1	17 17.8	−15 08	5.7
11	17 13.7	−15 11	5.7
21	17 06.6	−15 19	5.6
31	16 57.3	−15 34	5.6
June 10	16 47.1	−15 56	5.5
20	16 37.6	−16 25	5.6
30	16 29.9	−17 02	5.7
July 10	16 25.2	−17 45	5.8
20	16 23.7	−18 32	5.9
30	16 25.6	−19 24	6.0
Aug. 9	16 30.7	−20 18	6.1
19	16 38.6	−21 12	6.3
29	16 49.0	−22 04	6.5

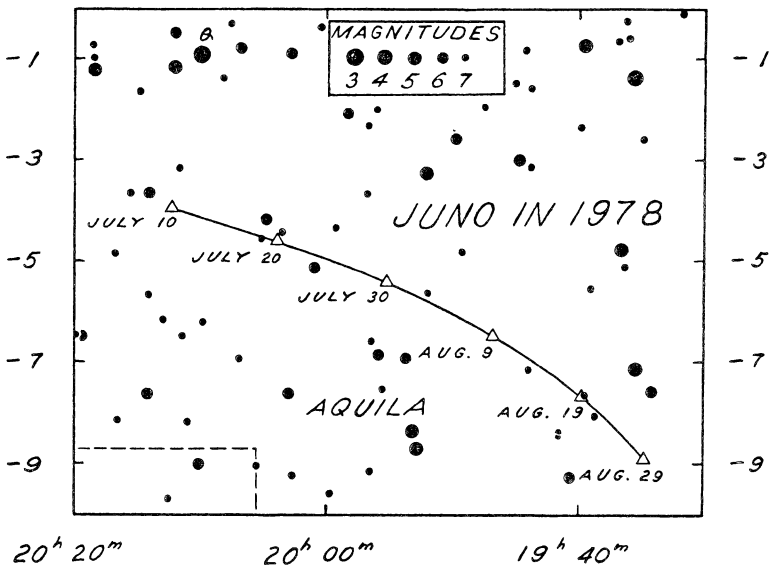
The key map at right shows the areas covered by the four other maps.






PALLAS IN 1978
HERCULES
MAGNITUDES
2 3 4 5 6 7
MAY 1
MAY 11
MAY 21
MAY 31
JUNE 10
JUNE 20
JUNE 30
+26
+24
+22
+20
17h 20m
17h 00m
16h 40m


CERES IN 1978
SAGITTARIUS
MAGNITUDES
1 2 3 4 5 6 7
JUNE 10
JUNE 20
JUNE 30
JULY 10
JULY 20
JULY 30
AUG. 9
AUG. 19
AUG. 29
-20
-25
-30
-35
20h 00m
19h 30m
19h 00m
18h 30m


JUNO IN 1978
AQUILA
MAGNITUDES
3 4 5 6 7
JULY 10
JULY 20
JULY 30
AUG. 9
AUG. 19
AUG. 29
-1
-3
-5
-7
-9
20h 20m
20h 00m
19h 40m

COMETS IN 1978

BY BRIAN G. MARSDEN

The following periodic comets are expected at perihelion during 1978:

Comet	Perihelion Date	Perihelion Dist.	Period	Comet	Perihelion Date	Perihelion Dist.	Period
		A.U.	yr.			A.U.	yr.
Tempel 1	Jan. 11	1.50	5.5	Ashbrook-Jackson	Aug. 19	2.28	7.4
Arend-Rigaux	Feb. 2	1.44	6.8	Tsuchinshan 2	Sept. 20	1.78	6.8
Tempel 2	Feb. 20	1.37	5.3	Comas Solá	Sept. 24	1.87	8.9
Wolf-Harrington	Mar. 15	1.61	6.5	Clark	Nov. 26	1.56	5.5
Whipple	Mar. 27	2.47	7.4	Van Biesbroeck	Dec. 3	2.40	12.4
Tsuchinshan 1	May 7	1.50	6.7	Jackson-Neujmin	Dec. 25	1.43	8.4
Kojima	May 24	2.40	7.9	Tuttle-Giacobini-Kresák	Dec. 25	1.12	5.6
Daniel	July 8	1.66	7.1				

Comets Tempel 1, Tempel 2, Wolf-Harrington, Whipple and Ashbrook-Jackson were recovered early in 1977, but neither these nor any of the other comets listed above is expected to become a bright object. Comet Tuttle-Giacobini-Kresák experienced two outbursts in 1973, one of them bringing the comet to naked-eye brightness, but the 1978 return is not a particularly favourable one, and a recurrence is highly unlikely. As in 1971, the return of P/Daniel this year is highly unfavourable, and this comet will certainly escape detection entirely.

Comets Kojima and Clark are of interest because they are making their first predicted returns this year. The orbit of the former comet has been changed rather substantially as the result of a close approach to Jupiter, and with its increased perihelion distance this comet will always be very faint in the future.

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.

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	14	L.Q.	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	10	F.M.	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 5	11	N.M.	22 24	00	+3.6	+0.4	20	64	3
S. δ Aquarids	July 29	7	L.Q.	22 36	−17	+3.4	+0.17	20	40	—
Perseids	Aug. 12	12	F.Q.	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	13	L.Q.	06 20	+15	+4.9	+0.13	25	66	2
S. Taurids	Nov. 4	—	F.Q.	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 17	5	F.M.	10 08	+22	+2.8	−0.42	15	72	—
Geminids	Dec. 14	4	F.M.	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 22	19	L.Q.	14 28	+76	—	—	15	34	2
Quadrantids	Jan. 3 (1979)	20	F.Q.	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

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.

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) .

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	4	450±30	sediment-filled shallow depression	fracturing A D G
Carswell, Sask.	58 27	109 30	30	485±50	discontinuous circular ridge	shatter cones, breccia G
Charlevoix, Que.	47 32	070 18	50	360±25	semi-circular trough, central elevation	breccia, shatter cones, impact melt A G
Clearwater Lake East, Que.	56 05	074 07	23	290±20	circular lake	sedimentary float D G
Clearwater Lake West, Que.	56 13	074 30	35	290±20	island ring in circular lake	impact melt D G
Crooked Creek, Missouri	37 50	091 23	5	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	3.6	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 Dome, NWT	75 22	089 40	30	< 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	6	300	central uplift exposed in quarries, rest buried	breccia, shatter cones, disturbed rocks A
Lac Couture, Que.	60 08	075 18	10	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	40	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	75	210±4	circumferal lake, central elevation	impact melt, breccia B G
Manson, Iowa	42 35	094 31	30	< 70	none, central elevation buried to 30 m	none A D G
Middlesboro, Ky.	36 37	083 44	7	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	5	< 300	circular lake	fracturing, breccia float
Redwing Creek, N. Dak.	47 40	102 30	9	200	none, buried	none
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	100+	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.	Name	Con.	R.A.
Acamar, ā'k*a*-mär	θ Eri	02	Gienah, jē'n*a*	γ Crv	12
Achernar, ā'kĕr-när	α Eri	01	Hadar, hăd'är	β Cen	14
Acrux, ā'krŭks	α Cru	12	Hamal, hăm'ăl	α Ari	02
Adhara, *a*-dā'r*a*	ε CMa	06	Kaus Australis,		
Al Na'ir, ăl-nâr'	α Gru	22	kôs ôs-trā'lĭs	ε Sgr	18
Albireo, ăl-bĭr'ē-ō	β Cyg	19	Kochab, kō'kăb	β UMi	14
Alcyone, ăl-sī'ō-nē	η Tau	03	Markab, mär'kăb	α Peg	23
Aldebaran, ăl-dĕb'*a*-r*a*n	α Tau	04	Megrez, mē'grĕz	δ UMa	12
Alderamin, ăl-dĕr'*a*-mĭn	α Cep	21	Menkar, mĕn'kär	α Cet	03
Algenib, ăl-jē'nĭb	γ Peg	00	Menkent, mĕn'kĕnt	θ Cen	14
Algol, ăl'gŏl	β Per	03	Merak, mē'răk	β UMa	10
Alioth, ăl'ĭ-ŏth	ε UMa	12	Miaplacidus,		
Alkaid, ăl-kād'	η UMa	13	mī'*a*-plăs'ĭ-d*u*s	β Car	09
Almach, ăl'măk	γ And	02	Mira, mī'r*a*	o Cet	02
Alnilam, ăl-nī'lăm	ε Ori	05	Mirach, mī'răk	β And	01
Alphard, ăl'färd	α Hya	09	Mirfak, mĭr'făk	α Per	03
Alphecca, ăl-fĕk'*a*	α CrB	15	Mizar, mī'zär	ζ UMa	13
Alpheratz, ăl-fē'răts	α And	00	Nunki, nŭn'kē	σ Sgr	18
Altair, ăl-târ'	α Aql	19	Peacock	α Pav	20
Ankaa	α Phe	00	Phecda, fĕk'd*a*	γ UMa	11
Antares, ăn-tā'rēs	α Sco	16	Polaris	α UMi	01
Arcturus, ärk-tū'r*ŭ*s	α Boo	14	Pollux, pŏl'*ŭ*ks	β Gem	07
Atria, ā'trĭ-*a*	α TrA	16	Procyon, prō'sĭ-ŏn	α CMi	07
Avior, ă-vĭ-ôr'	ε Car	08	Ras-Algethi, ràs'*ă*l-jē'the	α Her	17
Bellatrix, bĕ-lā'trĭks	γ Ori	05	Rasalhague, ràs'*ă*l-hā'gwē	α Oph	17
Betelgeuse, bĕt'*e*l-juz	α Ori	05	Regulus, rĕg'u-l*ŭ*s	α Leo	10
Canopus, k*a*-nō'p*ŭ*s	α Car	06	Rigel, rī'j*e*l	β Ori	05
Capella, k*a*-pĕl'*a*	α Aur	05	Rigil Kentaurus		
Caph, kăf	β Cas	00	rī'jĭl kĕn-tô'r*ŭ*s	α Cen	14
Castor, kàs'tĕr	α Gem	07	Sabik, sā'bĭk	η Oph	17
Deneb, dĕn'ĕb	α Cyg	20	Scheat, shē'ăt	β Peg	23
Denebola, dĕ-nĕb'ō-l*a*	β Leo	11	Schedar, shĕd'*a*r	α Cas	00
Diphda, dĭf'd*a*	β Cet	00	Shaula, shô'l*a*	λ Sco	17
Dubhe, dŭb'ē	α UMa	11	Sirius, sĭr'ĭ-*ŭ*s	α CMa	06
Elnath, ĕl'năth	β Tau	05	Spica, spī'k*a*	α Vir	13
Eltanin, ĕl-tā'nĭn	γ Dra	17	Suhail, sŭ-hāl'	λ Vel	09
Enif, ĕn'ĭf	ε Peg	21	Vega, vē'g*a*	α Lyr	18
Fomalhaut, fō'm*ă*l-ôt	α PsA	22	Zubenelgenubi,		
Gacrux, gä'krŭks	γ Cru	12	zōō-bĕn'ĕl-jĕ-nū'bē	α Lib	14

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

Star	Right Ascension	Declination	Visual Magnitude	Colour Index	Spectral Classification		Parallax	Absolute Magnitude	Distance light-years	Proper Motion	Radial Velocity		
Star	R.A. 1980	Dec.	*V*	*B–V*	Type		π	M_V	D	μ	R		
	h m	° ′					″		l.y.	″	km/sec		
Sun			-26.73	+0.63	G2	V		+4.84					***Sun***
α And	00 07.3	+28 58	2.06	−0.08	B9p		0.024	−0.1	90	0.209	*−11.7*	Manganese star	*Alpheratz*
β Cas	08.1	+59 02	2.26v	+0.34	F2	IV	0.072	+1.6	45	0.555	+11.8	Var. *R* 0^m08, 0.10[d]	*Caph*
γ Peg	12.2	+15 04	2.84v	−0.23	B2	IV	−.004	−3.4	570	0.010	+04.1	β CMa type, *R* in *V* 2.83–2.85, 0.15[d]	
β Hyi	24.6	−77 22	2.78	+0.62	G1	IV	0.153	+3.7	21	2.255	+22.8		γ Peg = *Algenib*
α Phe	25.3	−42 25	2.39	+1.08	*K0*	*III*	0.035	+0.1	93	0.442	*+74.6*		*Ankaa*
δ And *A*	38.2	+30 45	3.25:	+1.26	K3	III	0.024	−0.2	160	0.161	−07.3	*B* 12^m 28″	
α Cas	39.4	+56 25	2.22	+1.18	K0	II–III	0.009	−1.1	150	0.058	−03.8	Var.?	*Schedar*
β Cet	42.6	−18 06	2.02	+1.03	K1	III	0.057	+0.8	57	0.234	+13.1		*Diphda*
η Cas *A*	47.9	+57 42	3.47	+0.56	G0	V	0.182	+4.8	18	1.221	+09.4	*B* 7.26^m 12″	
γ Cas *A*	55.5	+60 36	2.5v	−0.16v	B0	IV:pe	0.034	−0.3:	96:	0.026	−06.8	Var. *B* 8.18^m 2″	
β Phe *AB*	01 05.1	−46 50	3.30	+0.88	*G8*	*III*	0.017	+0.3	190	0.035	−01.1	*A* 4.1^m *B* 4.1^m 1″	
η Cet	07.6	−10 17	3.44	+1.16	K3	III	0.032	+1.0	102	0.250	+11.5		
β And	08.6	+35 31	2.02	+1.57	M0	III	0.043	+0.2	76	0.211	+00.3		*Mirach*
δ Cas	24.4	+60 08	2.67	+0.13	A5	V	0.029	+2.1	43	0.301	+06.7	Ecl.? *R* 0.08:^{m} 759[d]	*Ruchbah*
γ Phe	27.5	−43 25	3.40	+1.56	K5	IIb–III	−.003	−4.6	1300	0.209	*+25.7*		
α Eri	37.0	−57 20	0.51	−0.16	B3	Vp	0.023	−2.3	118	0.098	+19		***Achernar***
τ Cet	43.2	−16 03	3.50	+0.72	G8	Vp	0.275	+5.70	12	1.921	−16.2		

Star	R.A. 1980	Dec.	V	$B-V$	Type		π	M_V	D	μ	R		
	h m	° ′					″		l.y.	″	km/sec		
α Tri	01 52.0	+29 29	3.42	+0.50	F6	IV	0.050	+2.0	65	0.230	*−12.6*		
ε Cas	52.9	+63 34	3.37	−0.15	B3	IV:p	0.007	−2.7	520	0.038	−08.1		
β Ari	53.6	+20 43	2.65	+0.14	A5	V	0.063	+1.7	52	0.147	*−04.0*		*Sheratan*
α Hyi	58.1	−61 40	2.84	+0.28	F0	V		+2.9	31	0.265	+07		
γ And *A*	02 02.7	+42 14	2.14:	+1.16:	K3	II	0.005	−2.4	260	0.068	−11.7	*B* 5.4^{m} *C* 6.2^{m} *A–BC* 10″ *B–C* 0.5″ 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^{m} 4.0^{d}, *B* 8.9^{m} 18″	*Polaris*
ο Cet *A*	18.3	−03 04	2.0v		M5.5e–M9e		0.013	−0.5	103	0.232	+63.8	LP, *R* 2.0–10.1, 332^{d}, *B* 10^{m} 1″	*Mira*
γ Cet *AB*	42.2	+03 10	3.48	+0.11	A2	V	0.048	+2.0	68	0.203	−05.1	*A* 3.57^{m} *B* 6.23^{m} 3″	
θ Eri *AB*	57.5	−40 23	2.92	+0.13	A3	III	0.028	+1.7	65	0.061	*+11.9*	*A* 3.25^{m} *B* 4.36^{m} 8″	*Acamar*
α Cet	03 01.2	+04 00	2.54	+1.63	M2	III	0.003	−0.5	130	0.075	−25.9		*Menkar*
γ Per	03.3	+53 25	2.91:	+0.72:	G8 III: +A3:		0.011	+0.3	113	0.004	*+02.5*		
ρ Per	03.7	+38 45	3.5v		M4	II–III	0.008	−1.0	260	0.172	+28.2	Irr. *R* 3.2–3.8	
β Per	06.6	+40 52	2.06v	−0.07	B8	V	0.031	−0.5	105	0.006	*+06.0*	Ecl. *R* 2.06–3.28, 2.87^{d}	*Algol*
α Per	22.9	+49 47	1.80	+0.48	F5	Ib	0.029	−4.4	570	0.035	−02.4		*Mirfak*
δ Per	41.5	+47 44	3.03	−0.14	B5	III	0.007	−3.3	590	0.046	+02.8		
η Tau	46.3	+24 03	2.86	−0.09	B7	III	0.005	−3.2	541	0.050	+10.1	in Pleiades	*Alcyone*
γ Hyi	47.5	−74 18	3.30	+1.61	M2	III	−.001	−1.5	300	0.125	+16.0		
ζ Per *A*	52.7	+31 50	2.83	+0.13	B1	Ib	0.007	−6.1	1000	0.015	+20.6	*B* 9.36^{m} 13″	
ε Per *A*	56.5	+39 57	2.88	−0.17	B0.5	V	−.001	−3.7	680	0.036	*−01*	*B* 7.99^{m} 9″	
γ Eri	57.1	−13 34	2.96	+1.58	M0	III	0.003	−0.5	160	0.126	+61.7		
α Ret *A*	04 14.1	−62 32	3.33	+0.91	G9	III	0.008	−2.1	390	0.064	+35.6	*B* 12^{m} 49″	
ε Tau	27.5	+19 08	3.54	+1.02	K0	III	0.018	+0.1	160	0.118	+38.6		
θ² Tau	27.5	+15 49	3.42	+0.17	A7	III	0.025	+0.2	140	0.108	*+39.5*		
α Dor	33.5	−55 05	3.28	−0.08	A0	IIIp	0.011	−1.2	260	0.051	+25.6	Silicon star	
α Tau *A*	34.8	+16 28	0.86v	+1.52	K5	III	0.048	−0.7	68	0.202	+54.1	Irr.? *R* 0.78–0.93, *B* 13^{m} 31″	***Aldebaran***
π³ Ori	48.3	+06 56	3.17	+0.45	F6	V	0.125	+3.65	26	0.468	+24.3		
ι Aur	55.7	+33 08	2.68:	+1.49	K3	II	0.015	−2.4	330	0.021	+17.5		

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

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

Star	R.A. 1980	Dec.	*V*	*B–V*	Type		π	M_V	D	μ	R		
	h m	° ′					″		l.y.	″	km/sec		
β Cen *AB*	14 02.4	−60 16	0.63v	−0.23:	B1	III	0.016	−5.2	490	0.035	*−12*	*A* 0.7^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:	K1	V		+5.8	4.3		−20.7		
α Lup	40.7	−47 19	2.32v	−0.22	B1	V		−3.3	430	0.033	*+07.3*	β CMa var., 0.26^d	
α Cir *AB*	40.9	−64 53	3.18	+0.25	A8	p	0.049	+1.6	66	0.308	+07.4	Strontium star. *A* 3.19^m *B* 8.61^m 16″	
ε Boo *AB*	44.1	+27 09	2.37	+0.96	K1:	III:+A	0.013	+0.0	103	0.051	−16.5	*A* 2.47^m *B* 5.04^m 3″	
α Lib *A*	49.8	−15 54	2.76	+0.15	A3m		0.049	+1.2	66	0.130	−10	*B* 5.15^m 231″	*Zubenelgenubi*
β UMi	50.8	+74 14	2.07	+1.47	K4	III	0.031	−0.5	105	0.033	+16.9		*Kochab*
β Lup	57.3	−43 03	2.69	−0.23	B2	IV		−3.4	540	0.066	−00.3		
κ Cen	57.8	−42 01	3.15	−0.21	B2	V		−2.7	470	0.033	+09.1		
β Boo	15 01.2	+40 28	3.48	+0.95	G8	III	0.022	+0.3	140	0.059	−19.9		
σ Lib	02.9	−25 12	3.31	+1.65	M4	III	0.056	+2.0:	58:	0.089	−04.3		
ζ Lup *A*	10.8	−52 01	3.42	+0.90:	*K0*	*III*	0.036	+1.2	90	0.135	−09.7	*B* 7.8^m 71″	
δ Boo *A*	14.7	+33 24	3.47	+0.95	G8	III	0.028	+0.3	140	0.148	−12.2	*B* 7.84^m 105″	
β Lib	15.9	−09 18	2.61	−0.11	B8	V	−.012	−0.6	140	0.101	−35.2		
γ TrA	17.1	−68 36	2.89	+0.01	A0	IV	0.005	+0.2	113	0.067	−06	Europium star	
δ Lup	20.1	−40 34	3.21v	−0.23	B2	IV		−3.4	680	0.032	+02	β CMa var., 0.165^d	
γ UMi	20.8	+71 54	3.04	+0.06	A3	II–III	−.005	−1.5	270	0.026	*−03.9*		
ι Dra	24.5	+59 02	3.28	+1.18	K2	III	0.032	+0.8	102	0.012	−11.0		
γ Lup *AB*	33.8	−41 06	2.80	−0.22	B2	Vn		−2.7	570	0.037	*+06*	*A* 3.5^m *B* 3.7^m 1″	
α CrB	33.8	+26 47	2.23v	−0.02	A0	V	0.043	+0.4	76	0.154	*+01.7*	Ecl. *R* 0.11^m, 17.4^d	*Alphecca*
α Ser	43.3	+06 29	2.65	+1.17	K2	III	0.046	+1.0	71	0.139	+02.9		
β TrA	53.4	−63 22	2.84	+0.28:	F0	IV	0.078	+2.3	42	0.448	−00.3		
π Sco	57.6	−26 04	2.92	−0.19	B1	V	0.005	−3.3	570	0.034	*−03*		
η Lup *AB*	58.8	−38 21	3.40	−0.23	B2	V		−2.7	570	0.042	+07	*A* 3.47^m *B* 7.70^m 15″	
δ Sco	59.2	−22 34	2.34	−0.13	B0	V		−4.0	590	0.032	−14		*Dschubba*

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

Star	R.A. 1980	Dec.	*V*	*B–V*	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/sec	
κ Sco	17 41.1	−39 01	2.39v	−0.21	B1.5 III		−3.4	470	0.031	*−10*	β CMa var., 0.20ᵈ
β Oph	42.5	+04 35	2.77	+1.16	K2 III	0.023	−0.1	124	0.160	−12.0	
μ Her *A*	45.7	+27 45	3.42	+0.75	G5 IV	0.108	+3.6	30	0.811	−15.6	*BC* 9.78ᵐ 33″
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* 10ᵐ 4″
δ Sgr	19.7	−29 50	2.71	+1.39	K2 III	0.039	+0.7	84	0.050	−20.0	
η Ser	20.2	−02 54	3.23	+0.94	K0 III–IV	0.054	+1.9	60	0.894	+08.9	
ε Sgr	22.9	−34 24	1.81	−0.02	B9.5 III	0.015	−1.1	124	0.135	−11	*Kaus Australis*
λ Sgr	26.7	−25 27	2.80	+1.05	*K2 III*	0.046	+1.1	71	0.194	−43.3	
α Lyr	36.2	+38 46	0.04	0.00	A0 V	0.123	+0.5	26.5	0.345	−13.9	***Vega***
φ Sgr	44.4	−27 01	3.20	−0.11	*B8 III*		−3.1	590	0.052	+21.5	
β Lyr *A*	49.4	+33 21	3.38v	−0.05:	Bpe	−.011	−4.6	1300	0.007	*−17.8*	Ecl. *R* 3.38–4.36, 12.9ᵈ, *B* 7.8ᵐ 46″
σ Sgr	54.0	−26 19	2.12:	−0.21	B2 V		−2.7	300	0.059	−11	*Nunki*
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* 3.3ᵐ *B* 3.5ᵐ < 1″
ζ Aql *A*	04.5	+13 50	2.99	+0.01	A0 V:nn	0.036	+0.8	90	0.101	−26.3	*B* 12ᵐ 5″
λ Aql	05.2	−04 55	3.44	−0.10	B9: V:n	0.025	−0.1	160	0.092	−14	
τ Sgr	05.7	−27 42	3.30	+1.18	K1 III	0.038	+1.2	86	0.261	*+45.4*	
π Sgr *ABC*	08.6	−21 03	2.89	+0.35	F2 II–III	0.016	−0.7	250	0.040	−09.8	*A* 3.7ᵐ *B* 3.8ᵐ *C* 6.0ᵐ < 1″
δ Dra	12.5	+67 38	3.06	+1.00	G9 III	0.028	+0.2	124	0.130	+24.8	
δ Aql	24.5	+03 04	3.38	+0.31	F0 IV	0.062	+2.3	53	0.267	*−29.9*	
β Cyg *A*	29.9	+27 55	3.07	+1.12	K3 II:+B:	0.004	−2.4	410	0.009	−24.0	*B* 5.11ᵐ 35″ *Albireo*
δ Cyg *AB*	44.3	+45 05	2.87	−0.03	B9.5 III	0.021	−1.7	270	0.060	−21	*A* 2.91ᵐ *B* 6.44ᵐ 2″
γ Aql	45.3	+10 33	2.72	+1.52	K3 II	0.006	−2.4	340	0.012	−02.1	
α Aql	49.8	+08 49	0.77	+0.22	A7 IV–V	0.198	+2.2	16.5	0.658	−26.3	***Altair***

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

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 1978.0; and the period, if known.

Many of the components are themselves very close visual or spectroscopic binaries. (Other double stars appear in the table of The Brightest Stars and of The Nearest Stars.)

Star		A.D.S.	R.A. 1980.0 h	m	Dec. °	′	Magnitudes comb.	A	B	P.A. 1978.0 °	Sep. ″	P (app.) 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	1.8	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	244	0.5	1100
Σ	1338	7307	09	19.7	+38	17	5.8	6.5	6.7	251	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	161	1.0	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	54	1.4	170
γ	And AB	1630	02	02.4	+42	16	2.1*	2.1	5.1	64	9.8	—
γ	And BC	1630	02	02.4	+42	16	5.1	5.5	6.3	108	0.6	61
OΣ	65	2799	03	49.2	+25	32	5.2	5.8	6.2	207	0.6	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	53	10.8	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	101	2.1	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	292	0.9	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	82	5.9	1150
σ^2	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	4	3.1	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	109	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	157	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	341	2.0	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	15	0.7	150
τ	Cyg	14787	21	13.9	+37	57	3.7	3.8	6.4	154	0.9	50
μ	Cyg	15270	21	43.2	+28	39	4.5	4.8	6.1	296	1.8	500
ζ	Aqr	15971	22	27.8	−00	08	3.6	4.3	4.5	230	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	306	1.5	350

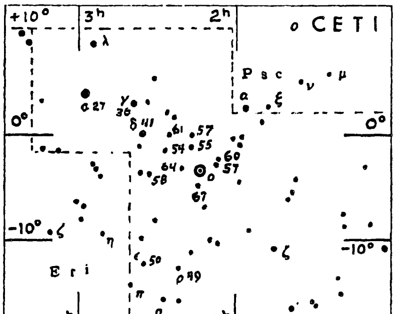
*There is a marked colour difference between the components.
†The separation of the two pairs of ε Lyr is 208″.

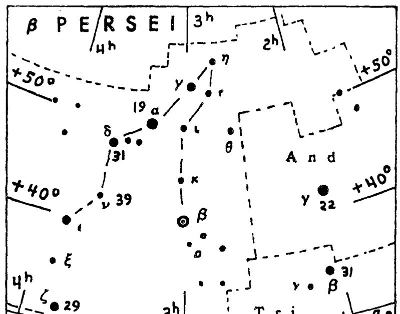
VARIABLE STARS

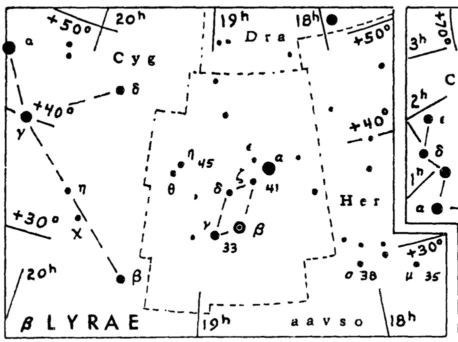
By Janet Mattei

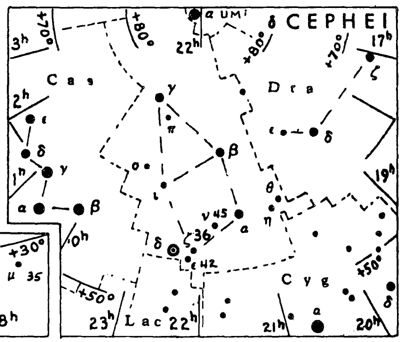
The systematic observation of variable stars is an area in which an amateur can make a valuable contribution to astronomy. For beginning observers, maps of the fields of four bright variable stars are given below. In each case, the magnitudes (with decimal point omitted) of several suitable comparison 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 1977*, *International Supplement*.









LONG-PERIOD VARIABLE STARS

Variable	Max. m	Per d	Epoch 1978	Variable	Max. m	Per d	Epoch 1978
001755 T Cas	7.8	445	July 19	142539 V Boo	7.9	258	Aug. 30
001838 R And	7.0	409	Jan. 29	143227 R Boo	7.2	223	Apr. 29
021143 W And	7.4	397	Jan. 1	151731 S CrB	7.3	361	Jan. 12
0214*03* o Cet	3.4	332	Oct. 31	154639 V CrB	7.5	358	Sept. 28
0228*13* U Cet	7.5	235	Feb. 6	154615 R Ser	6.9	357	Aug. 5
023133 R Tri	6.2	266	Apr. 12	160625 RU Her	8.0	484	—
043065 T Cam	8.0	374	Nov. 22	162119 U Her	7.5	406	Sept. 18
0455*14* R Lep	6.8	432	Nov. 9	1621*12* V Oph	7.5	298	Mar. 22
050953 R Aur	7.7	459	Feb. 13	163266 R Dra	7.6	245	Jan. 31
054920 U Ori	6.3	372	Sept. 16	164715 S Her	7.6	307	Jan. 9
0617*02* V Mon	7.0	335	Mar. 20	1702*15* R Oph	7.9	302	July 1
065355 R Lyn	7.9	379	May 25	171723 RS Her	7.9	219	May 28
070122aR Gem	7.1	370	Aug. 8	180531 T Her	8.0	165	May 16
070310 R CMi	8.0	338	July 14	181136 W Lyr	7.9	196	June 22
072708 S CMi	7.5	332	Feb. 26	183308 X Oph	6.8	334	Sept. 23
081112 R Cnc	6.8	362	Dec. 23	190108 R Aql	6.1	300	Aug. 29
081617 V Cnc	7.9	272	Sept. 5	1910*17* T Sgr	8.0	392	July 28
084803 S Hya	7.8	257	Aug. 31	1910*19* R Sgr	7.3	269	Apr. 29
0850*08* T Hya	7.8	288	Sept. 6	193449 R Cyg	7.5	426	Aug. 19
093934 R LMi	7.1	372	Mar. 22	194048 RT Cyg	7.3	190	May 6
094211 R Leo	5.8	313	Feb. 1	194632 χ Cyg	5.2	407	Sept. 28
103769 R UMa	7.5	302	Oct. 17	201647 U Cyg	7.2	465	May 3
1214*18* R Crv	7.5	317	Aug. 16	2044*05* T Aqr	7.7	202	Feb. 13
122001 SS Vir	6.8	355	Feb. 6	210868 T Cep	6.0	390	Sept. 18
123160 T UMa	7.7	257	Feb. 11	213753 RU Cyg	8.0	234	Mar. 11
123307 R Vir	6.9	146	Jan. 27	230110 R Peg	7.8	378	Mar. 12
123961 S UMa	7.8	226	Jan. 11	230759 V Cas	7.9	228	June 7
131546 V CVn	6.8	192	Feb. 24	231508 S Peg	8.0	319	July 24
1327*06* S Vir	7.0	378	Jan. 31	2338*15* R Aqr	6.5	387	Feb. 3
134440 R CVn	7.7	328	Mar. 21	235350 R Cas	7.0	431	Apr. 4
142584 R Cam	7.9	270	July 2	2357*15* W Cet	7.6	351	Feb. 16

OTHER TYPES OF VARIABLE STARS

Variable	Max. m	Min. m	Type	Sp. Cl.	Period d	Epoch 1978 E.S.T.
005381 U Cep	6.7	9.8	Ecl.	B8+gG2	2.49307	Jan. 3.26*
025838 ρ Per	3.3	4.0	Semi R	M4	33–55, 1100	—
030140 β Per	2.1	3.3	Ecl.	B8+G	2.86731	—
035512 λ Tau	3.5	4.0	Ecl.	B3	3.952952	Jan. 4.22*
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. 4.98
065820 ζ Gem	4.4	5.2	δ Cep	F7–G3	10.15082	Jan. 3.06
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. 9.91*
192242 RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.5668158	Jan. 1.37
194700 η Aql	4.1	5.2	δ Cep	F6–G4	7.176641	Jan. 3.77
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 $0\overset{d}{.}05$ to $1\overset{d}{.}2$ 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.

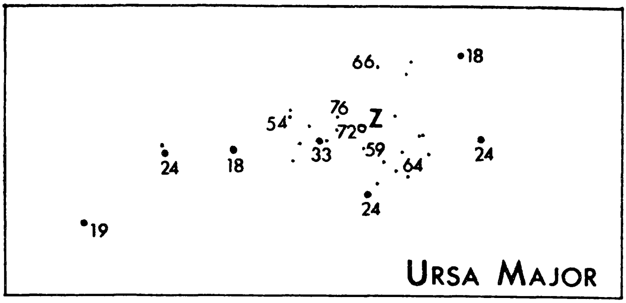
Z Camelopardalis Type: Variables similar to U Gem stars in their physical and spectroscopic properties. They show cyclical variations with intervals of constant brightness for several cycles, approximately one third of the way from maximum to minimum. Typical representative: Z Camelopardalis.

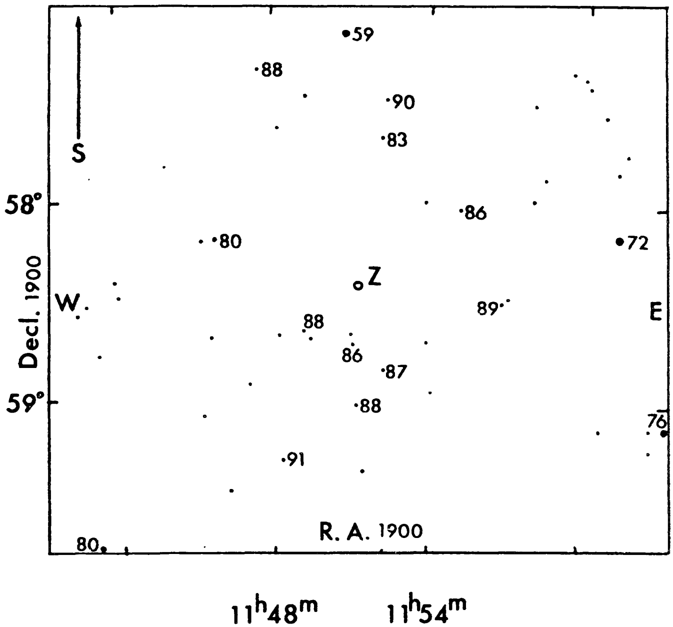
III. *Eclipsing Binaries*

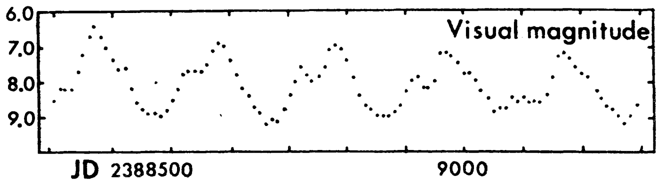
Binary systems of stars with the orbital plane lying close to the line of sight of the observer. The components periodically eclipse each other, causing variations in the apparent brightness of the system, as is seen and recorded by the observer. The period of the eclipses coincides with the period of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

Each year, in cooperation with the A.A.V.S.O., we introduce a new variable to our readers. This year's star is Z UMa, an interesting semiregular variable. It is bright, and very easy to observe with binoculars or small telescopes. On the finding charts below, the numbers beside the stars are the magnitudes, with the decimal points removed. The light curve below is a computer-plotted graph of 10-day mean values of observations from 1963 to 1966 (JD 2438300 to 2439300).

The 1976 and 1977 HANDBOOKS featured the stars R CrB and R Sct, respectively.







THE NEAREST STARS

By Alan H. Batten

The accompanying table is similar to one that has been published in the HANDBOOK for several years. Like its predecessors, it is based on the work of Professor van de Kamp who has studied many of the nearest stars and published a revised list of them in 1969 in the *Publications of the Astronomical Society of the Pacific*. Since that list was published, four new stars have been found to have parallaxes of about 0$''$.190 or greater and are therefore within the distance limit of about seventeen light years (or just over five parsecs) which has been arbitrarily set as the limit for this table. One of them, G158–27, has been included in the HANDBOOK since 1972; the other two, L725–32 and B.D. 44° 2051, appear for the first time in the 1976 HANDBOOK. New determinations of the parallaxes of some of the stars in this list have also been published in the last few years. They have not been used because van de Kamp's discussion made use of all the data available for each star, and the inclusion of new data from single observatories for just a few stars would destroy the homogeneity of his list. The reader should remember, however, that new results may affect the order of stars in the list, and that the parallaxes of the new stars included will be relatively uncertain until more observations are available. The latest determination of the parallax of Stein 2051A and B is 0$''$.179 and if this value is confirmed the stars should be dropped from the list.

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 directions of the nearer stars seem to change very slightly compared with those of more distant background stars. This change is called *annual parallax*; even for the nearest star it is less than one second of arc—the angle subtended by a penny about 2.5 miles away. That explains the difficulty of the task, and why results from different observatories are often slightly different. Parallax measurements are important because all our knowledge of the luminosities of stars, and hence of the structures of both the stars and the Galaxy, depends on the relatively few stellar distances that can be directly and accurately measured. The distances are so vast that new units are needed to describe them. Often we talk of *light-years*—the distance (nearly ten million million km or six million million miles) that light travels in a year—but in their own calculations astronomers use *parsecs*. One parsec is the distance of a star that has an annual parallax of one second of arc, and is equal to about 3.26 light years. The distance in parsecs is the reciprocal of the parallax expressed (as in the table) in seconds of arc.

The table gives the name and position of each star, the annual parallax π, the distance D in light-years, the spectral type, the proper motion μ in seconds of arc per year (that is the apparent motion of the star across the sky each year—nearby stars usually have large proper motions), the total space velocity W in km/sec (if known), the visual apparent magnitude and the luminosity in visible light in terms of that of the sun. In column 6, *wd* stands for white dwarf, and *e* indicates the presence of emission lines in the spectrum. Very few stars in our neighbourhood are brighter than the sun, and there are no very luminous or very hot stars at all. Most stars in this part of the galaxy are small, cool, and insignificant objects; we shall probably never be sure we have found them all.

The newest list contains 63 stars, including the Sun, thirty-one of which are single. There are eleven double-star systems and two triple systems. Earlier lists have emphasized the unseen companions believed to be associated with seven of the stars or systems. Recent work has called the reality of some of these into question—especially that of the supposed planetary companion of Barnard's star. The suspected companions are still indicated by asterisks in the table, but the evidence for several of them is no longer as clear as it appeared to be some years ago.

Name	1980 α	1980 δ	π	D	Sp.	μ	W	m	L
	h m	° ′	″	l.y.		″	km/sec		
Sun					G2			−26.8	1.0
α Cen A	14 38	−60 46	0.760	4.3	G2	3.68	32	0.1	1.3
B					K5			1.5	0.36
C	14 28	−62 36			M5*e*			11.0	0.00006
Barnard's*	17 56	+04 36	.552	5.9	M5	10.30	140	9.5	0.00044
Wolf 359	10 56	+07 10	.431	7.6	M6*e*	4.84	55	13.5	0.00002
Lal. 21185*	11 03	+36 07	.402	8.1	M2	4.78	103	7.5	0.0052
Sirius A	6 44	−16 42	.377	8.6	A1	1.32	18	−1.5	23.
B					*wd*			7.2	0.008
Luy. 726–8A	1 37	−18 04	.365	8.9	M6*e*	3.35	52	12.5	0.00006
B					M6*e*			13.0	0.00004
Ross 154	18 49	−23 50	.345	9.4	M5*e*	0.74	12	10.6	0.0004
Ross 248	23 40	+44 04	.317	10.3	M6*e*	1.82	86	12.2	0.00011
ε Eri	03 32	−09 32	.305	10.7	K2	0.97	22	3.7	0.30
Luy. 789–6	22 38	−15 28	.302	10.8	M6	3.27	79	12.2	0.00012
Ross 128	11 47	+00 58	.301	10.8	M5	1.40	26	11.1	0.00033
61 Cyg A	21 06	+38 38	.292	11.2	K5	5.22	106	5.2	0.083
B*					K7			6.0	0.040
ε Ind	22 03	−56 52	.291	11.2	K5	4.67	86	4.7	0.13
Procyon A	07 39	+05 17	.287	11.4	F5	1.25	21	0.3	7.6
B					*wd*			10.8	0.0005
Σ 2398 A	18 42	+59 36	.284	11.5	M3.5	2.29	39	8.9	0.0028
B					M4			9.7	0.0013
Groom. 34 A	00 18	+43 54	.282	11.6	M1	2.91	52	8.1	0.0058
B					M6			11.0	0.00040
Lacaille 9352	23 05	−35 59	.279	11.7	M2	6.87	117	7.4	0.012
τ Ceti	01 43	−16 03	.273	11.9	G8	1.92	37	3.5	0.44
BD+5°1668*	07 27	+05 27	.266	12.2	M4	3.73	71	9.8	0.0014
L725–32	01 11	−17 06	.262	12.4	M5*e*	1.31		11.5	0.0003
Lacaille 8760	21 16	−38 58	.260	12.5	M1	3.46	67	6.7	0.025
Kapteyn's	05 11	−44 59	.256	12.7	M0	8.79	292	8.8	0.0040
Kruger 60 A	22 27	+57 36	.254	12.8	M4	0.87	31	9.7	0.0017
B					M6			11.2	0.00044
Ross 614 A	06 28	−02 48	.249	13.1	M5*e*	0.97	30	11.3	0.0004
B					?			14.8	0.00002
BD−12°4523	16 30	−12 36	.249	13.1	M5	1.18	38	10.0	0.0013
van Maanen's	00 48	+05 19	.234	13.9	*wd*F	2.98	270	12.4	0.00017
Wolf 424 A	12 33	+09 09	.229	14.2	M6*e*	1.87	39	12.6	0.00014
B					M6*e*			12.6	0.00014
CD−37°15492	00 04	−37 27	.225	14.5	M3	6.09	130	8.6	0.0058
G158 27	00 06	−07 38	.224	14.6		2.1		13.8	0.00005
Groom. 1618	10 10	+49 33	.217	15.0	M0	1.45	40	6.6	0.040
CD−46°11540	17 28	−46 53	.216	15.1	M4	1.15		9.4	0.0030
CD−49°13515	21 32	−49 11	.214	15.2	M3	0.78		8.7	0.0058
CD−44°11909	17 37	−44 17	.213	15.3	M5	1.14		11.2	0.00063
Luy. 1159–16	01 59	+13 00	.212	15.4	(M7)	2.08		12.3	0.00023
Lal. 25372	13 44	+15 01	.208	15.7	M3.5	2.30	55	8.5	0.0076
AOe 17415–6*	17 37	+68 22	.207	15.7	M3.5	1.31	34	9.1	0.0044
CC 658	11 44	−64 42	.206	15.8	*wd*	2.69		11.0	0.0008
Ross 780	22 52	−14 22	.206	15.8	M5	1.17	28	10.2	0.0016
o^2 Eri A	04 14	−07 41	.205	15.9	K0	4.08	104	4.4	0.33
B					*wd*A			9.9	0.0027
C					M4*e*			11.2	0.00063
BD+20°2465*	10 19	+19 58	.202	16.1	M4.5	0.49	15	9.4	0.0036
BD+44°2051	11 05	+43 36	.199	16.4	M2*e*	4.40		8.8	0.0063
Altair	19 49	+08 49	.196	16.6	A7	0.66	31	0.8	10.
70 Oph A	18 05	+02 31	.195	16.7	K1	1.13	29	4.2	0.44
B					K6			6.0	0.083
AC+79°3888	11 46	+78 47	.194	16.8	M4	0.87	121	11.0	0.0009
BD+43°4305*	22 46	+44 14	.193	16.9	M5*e*	0.84	21	10.1	0.0021
Stein 2051 A	04 30	+58 57	.192	17.0	(M5)	2.37		11.1	0.0008
B					*wd*			12.4	0.0003

*Star may have an unseen component.

GALACTIC NEBULAE

BY RENÉ RACINE

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

			α 1980 δ				S		Dist.	
NGC	M	Con	h m	° ′	Type	Size ′	mag. sq″	m *	10^3 l.y.	Remarks
650/1	76	Per	01 40.9	+51 28	Pl	1.5	20	17	15	
IC348		Per	03 43.2	+32 07	Ref	3	21	8	0.5	Nebulous cluster
1435		Tau	03 46.3	+24 01	Ref	15	20	4	0.4	Merope nebula
1535		Eri	04 13.3	−12 48	Pl	0.5	17	12		
1952	1	Tau	05 33.3	+22 05	SN	5	19	16v	4	"Crab" + pulsar
1976	42	Ori	05 34.3	−05 25	HII	30	18	4	1.5	Orion nebula
1999		Ori	05 35.5	−06 45	PrS	1		10v	1.5	
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 h m	δ ° ′	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 h m	° ′	P	D	m	r	Sp	Remarks
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 h m	° ′	B	D	Sp	m	N	r	V
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 h m	δ ° ′	Type	m_{pg}	Dimensions ′ ′	Distance millions of l.y.
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		00 46.6	−25 24	Scp	7.0:	22×4.6	7.5
SMC		00 52.0	−72 56	Ir IV or IV–V	2.86	216×216	0.2
300		00 54.0	−37 48	Sc III–IV	8.66	22×16.5	7.5
598	33	01 32.8	+30 33	Sc II–III	6.19	61×42	2.4
Fornax		02 38.7	−34 36	dE	9.1:	50×35	0.4
LMC		05 23.7	−69 46	Ir or Sc III–IV	0.86	432×432	0.2
2403		07 34.9	+65 39	Sc III	8.80	22×12	6.5
2903		09 31.0	+21 36	Sb I–II	9.48	16×6.8	19.0
3031	81	09 53.9	+69 09	Sb I–II	7.85	25×12	6.5
3034	82	09 54.4	+69 47	Scp:	9.20	10×1.5	6.5
4258		12 18.0	+47 25	Sbp	8.90	19×7	14.0
4472	49	12 28.8	+08 06	E4	9.33	9.8×6.6	37.0
4594	104	12 38.8	−11 31	Sb	9.18	7.9×4.7	37.0
4736	94	12 50.0	+41 13	Sbp II:	8.91	13×12	14.0
4826	64	12 55.8	+21 48	?	9.27	10×3.8	12.0:
4945		13 04.1	−49 22	Sb III	8.0	20×4	—
5055	63	13 14.8	+42 08	Sb II	9.26	8.0×3.0	14.0
5128		13 24.2	−42 54	E0p	7.87	23×20	—
5194	51	13 29.0	+47 18	Sc I	8.88	11×6.5	14.0
5236	83	13 36.0	−29 46	Sc I–II	7.0:	13×12	8.0:
5457	101	14 02.4	+54 26	Sc I	8.20	23×21	14.0
6822		19 43.8	−14 49	Ir IV–V	9.21	20×10	1.7

THE NEAREST GALAXIES

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

MAXIMA OF DELTA CEPHEI

Date	Time	Date	Time	Date	Time	Date	Time
	h m		h m		h m		h m
Jan. 4	11 40	Apr. 5	17 10	July 5	22 30	Oct. 5	4 00
9	20 30	11	1 50	11	7 20	10	12 50
15	5 10	16	10 40	16	16 10	15	21 40
20	14 00	21	19 30	22	1 00	21	6 30
25	22 50	27	4 20	27	9 50	26	15 10
31	7 40						
		May 2	13 00	Aug. 1	18 30	Nov. 1	0 00
Feb. 5	16 20	7	21 50	7	3 20	6	8 50
11	1 10	13	6 40	12	12 10	11	17 40
16	10 00	18	15 30	17	21 00	17	2 20
21	18 50	24	0 10	23	5 40	22	11 10
27	3 30	29	9 00	28	14 30	27	20 00
Mar. 4	12 20	June 3	17 50	Sept. 2	23 20	Dec. 3	4 50
9	21 10	9	2 40	8	8 10	8	13 30
15	6 00	14	11 20	13	16 50	13	22 20
20	14 40	19	20 10	19	1 40	19	7 10
25	23 30	25	5 00	24	10 30	24	16 00
31	8 20	30	13 50	29	19 20	30	0 40

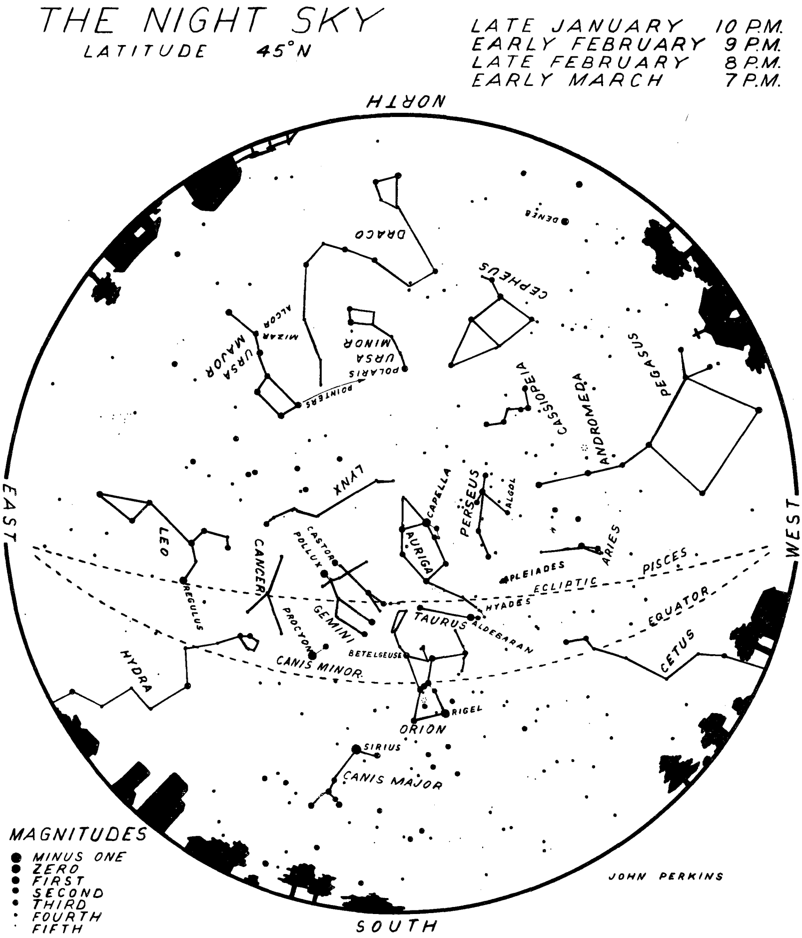
RADIO SOURCES

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
PKS 0237-23	02 39.1	−23 14	Quasar with large red shift Z = 2.2
NGC 1275, 3C 84	03 18.5	+41 26	Seyfert galaxy, radio variable
Fornax A	03 21.6	−37 15	10th mag. SO galaxy
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
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
W 49	19 09.4	+09 05	HII region s'nova remnant, OH emission
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
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

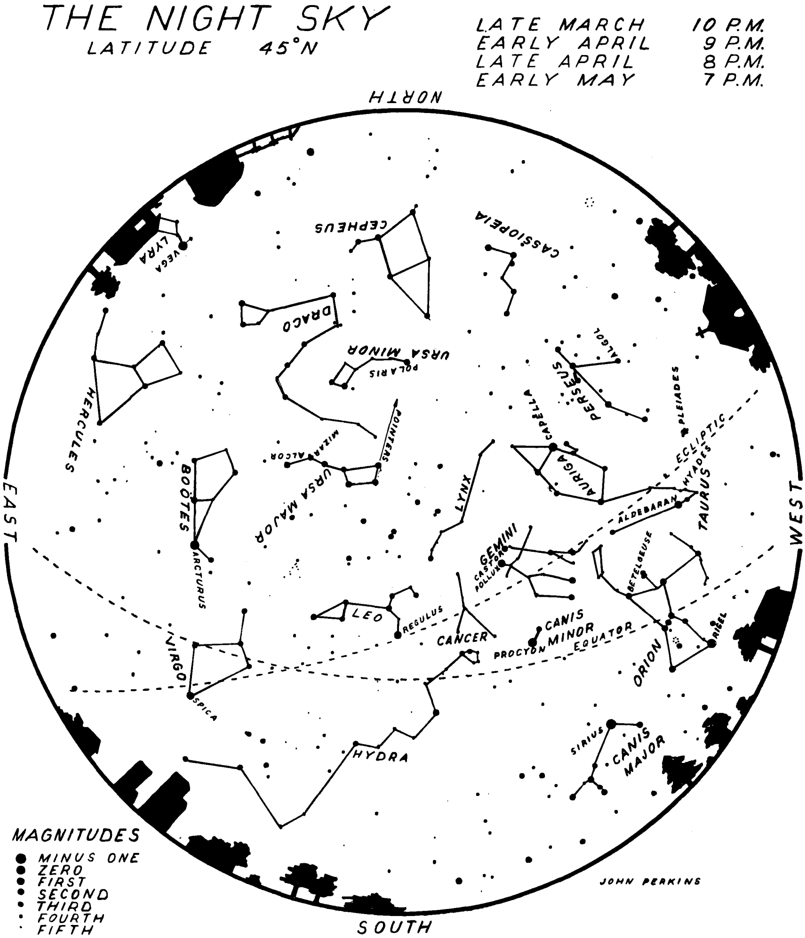
*Could be detected with amateur radio telescopes.



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.

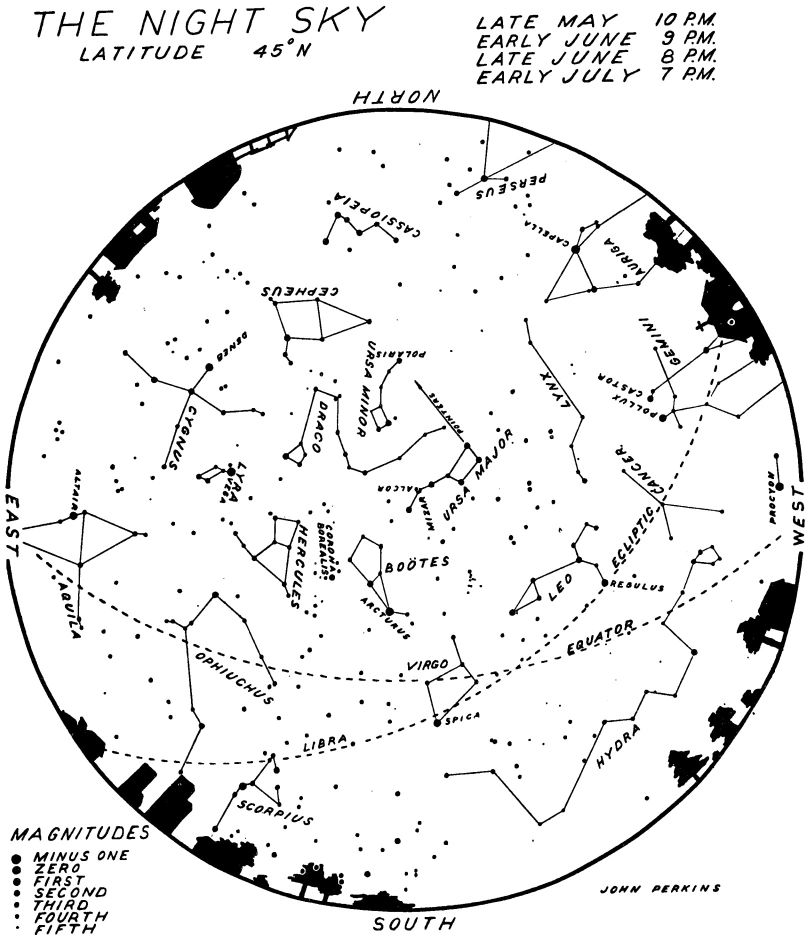
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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.

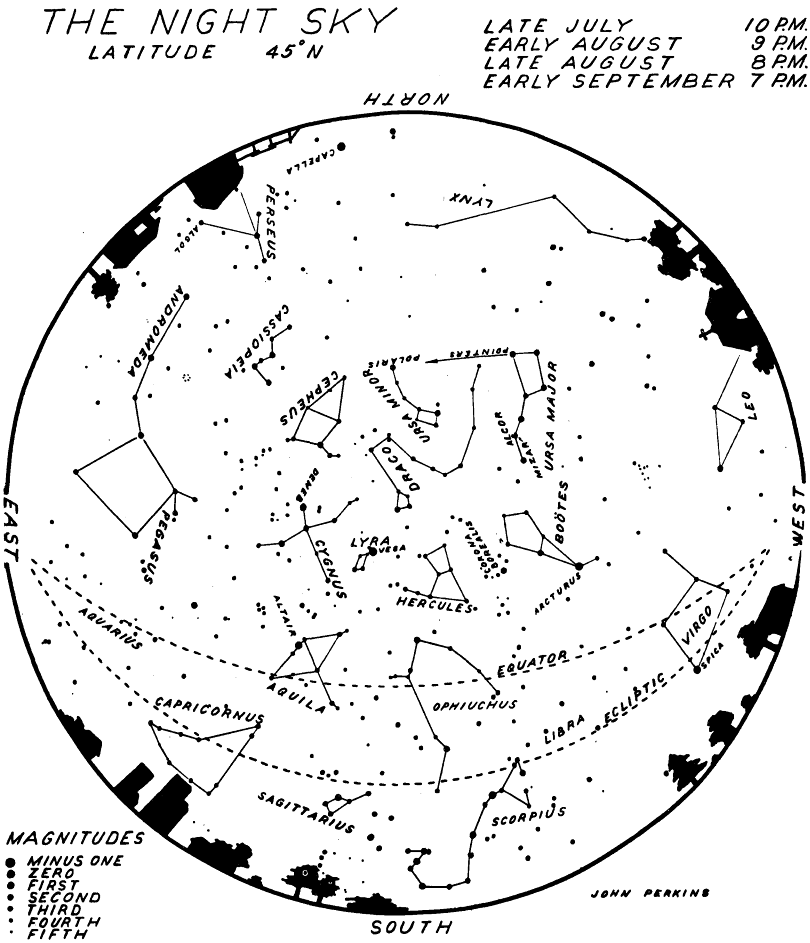
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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.

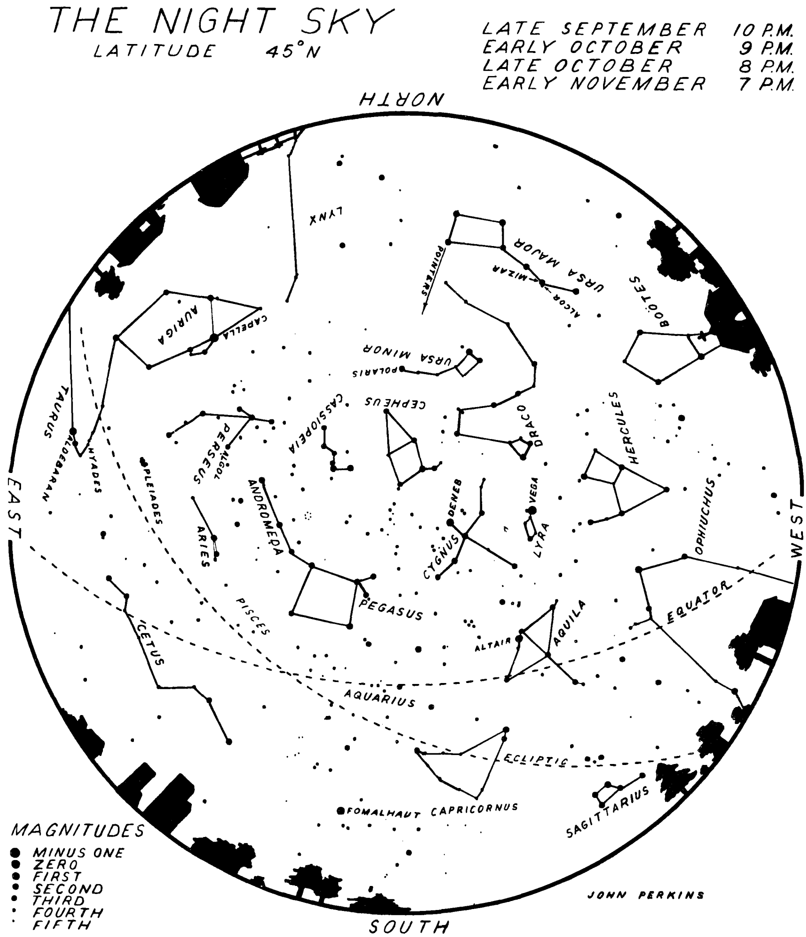
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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.

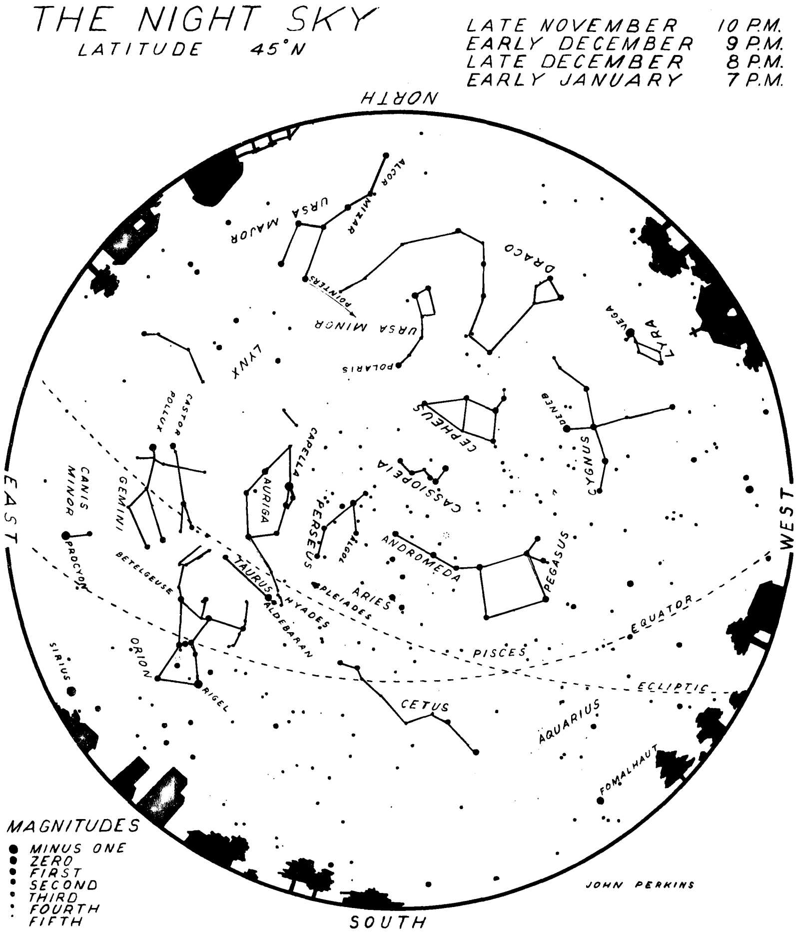
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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 LITCHINSKY

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.

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.
Additional shows at 4:00 and 9:30 p.m. on weekends and holidays.
Children's shows at 1:00 p.m. on weekends and school holidays.

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.

cont'd. on pg. 128

McLaughlin Planetarium, 100 Queen's Park, Toronto, Ont. M5S 2C6.
Tues.-Sun. 1:30 (except weekdays in winter season), 3:00 and 7:30 p.m. Holidays 1:30 and 3:00 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.

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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CALENDAR 1978

January

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CALENDAR 1979

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