Spring MAR 20/77.
Summer June 21/77.
Autumn Sept 23/77
Winter Dec 21/77.

the OBSERVER'S HANDBOOK 1977

sixty-ninth 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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124 Merton Street, Toronto M4S 2Z2, Canada

editor: JOHN R. PERCY

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THE OBSERVER'S HANDBOOK 1977

THE OBSERVER'S HANDBOOK for 1977 is the sixty-ninth edition. There are some changes and additions: the presentation of the configurations of Jupiter's satellites, and of the sun's selenographic colongitude, is different (see pg. 34); a diagram showing twilight and sidereal time has been added (pg. 12); the section on "Planets" has been rewritten and extended; and some "Suggestions for Further Reading" have been added. The index is now on the last page.

I wish to thank all those who have contributed to the preparation of the 1977 edition: those whose names appear in the various sections, those named below, and especially my editorial assistant, John F. A. Perkins. R. Bishop, L. Bogan and R. C. Brooks contributed the sidereal time diagram and many helpful suggestions. Terence Dickinson generously agreed to rewrite the "Planets" section; John F. Heard has again provided delightful introductions to "The Sky Month by Month". Janet Mattei of the A.A.V.S.O. has provided information on variable stars, including Algol, δ Cephei and R Scuti—our "star for the year" (pg. 103). V. Gaizauskas provided information on sunspots and on the eclipse in February 1979; J. Veverka checked the page of data on planetary satellites. I also thank Rosemary Freeman and Lloyd Higgs for their advice and help, and Carol Percy for assisting with some of the sections. The David Dunlap Observatory and Erindale College, University of Toronto, have once again provided financial, technical and moral support for the HANDBOOK.

Finally, my deep indebtedness to H.M. Nautical Almanac Office (especially G. M. Appleby, A. S. Dennis, Leslie V. Morrison, Gordon E. Taylor and Superintendant Dr. G. A. Wilkins) and to the *American Ephemeris* is gratefully acknowledged.

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.

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

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, 1977

New Year's Day	Sat.	Jan. 1	Pentecost (Whit Sunday)		May 29
Epiphany	Thur.	Jan. 6	Trinity Sunday		June 5
Accession of Queen Elizabeth (1952)	Sun.	Feb. 6	Corpus Christi	Thur.	June 9
Septuagesima Sunday		Feb. 6	St. John Baptist (Mid-Summer Day)	Fri.	June 24
Quinquagesima (Shrove) Sunday		Feb. 20	Dominion Day	Fri.	July 1
Ash Wednesday		Feb. 23	Birthday of Queen Mother Elizabeth (1900)	Thur.	Aug. 4
St. David	Tues.	Mar. 1	Labour Day	Mon.	Sept. 5
St. Patrick	Thur.	Mar. 17	Jewish New Year (Rosh Hashanan)	Tues.	Sept. 13
Palm Sunday		Apr. 3	Yom Kippur	Thur.	Sept. 22
First Day of Passover	Sun.	Apr. 3	St. Michael (Michaelmas Day)	Thur.	Sept. 29
Good Friday		Apr. 8	Thanksgiving	Mon.	Oct. 10
Easter Sunday		Apr. 10	All Saints' Day	Tues.	Nov. 1
Birthday of Queen Elizabeth (1926)	Thur.	Apr. 21	Remembrance Day	Fri.	Nov. 11
St. George	Sat.	Apr. 23	First Sunday in Advent		Nov. 27
Rogation Sunday		May 15	St. Andrew	Wed.	Nov. 30
Ascension Day	Thur.	May 19	Christmas Day	Sun.	Dec. 25
Victoria Day	Mon.	May 23			

All dates are given in terms of the Gregorian calendar. January 14 corresponds to January 1, Julian reckoning.

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* mī′nẽr	UMi	UMin
Vela, vē′l*a*	Vel	Velr
Virgo, vûr′gō	Vir	Virg
Volans, vō′l*ă*nz	Vol	Voln
Vulpecula, vŭl-pĕk′ū-l*a*	Vul	Vulp

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

PRINCIPAL ELEMENTS OF THE SOLAR SYSTEM

MEAN ORBITAL ELEMENTS

Planet	Mean Distance from Sun (a)		Period of Revolution		Eccen-tri-city (e)	In-clina-tion (i)	Long. of Node (☊)	Long. of Peri-helion (π)	Mean Long. at Epoch (L)
	A. U.	millions of km	Sidereal (P)	Syn-odic					
				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	Equa-torial Di-ameter km	Ob-late-ness	Mass ⊕=1	Mean Den-sity water =1	Sur-face Grav-ity ⊕=1	Rotation Period	Incli-nation of Equa-tor to Orbit °	Albedo
☉ Sun	1,392,000	0	332,958	1.41	27.9	25^d–35^d†		
☾ Moon	3,476	0	0.0123	3.36	0.16	$27^d 07^h 43^m$	6.7	0.067
☿ Mercury	4,865	0	0.055	5.46	0.38	$58^d 16^h$	<7	0.056
♀ Venus	12,110	0	0.815	5.23	0.90	243^d(retro.)	~179	0.76
⊕ Earth	12,756	1/298	1.000	5.52	1.00	$23^h 56^m 04^s$	23.4	0.36
♂ Mars	6,788	1/192	0.107	3.93	0.38	24 37 23	24.0	0.16
♃ Jupiter	143,000	1/16	318.0	1.33	2.64	9 50 30	3.1	0.73
♄ Saturn	121,000	1/10	95.2	0.69	1.13	10 14	26.7	0.76
♅ Uranus	47,000	1/16	14.6	1.56	1.07	10 49	97.9	0.93
♆ Neptune	50,900	1/50	17.3	1.54	1.08	16	28.8	0.62
Pluto	5,500?	?	0.11	5?	0.6?	$6^d 9^h 17^m$	?	0.14?

†Depending on latitude. For the physical observations of the sun, p. 60, the sidereal period of rotation is 25.38 m.s.d.

SATELLITES OF THE SOLAR SYSTEM

Name	Vis. Mag.	Diam. km	Mean Distance from Planet km/1000	Mean Distance from Planet arc sec	Revolution Period d	Revolution Period h	Revolution Period m	Orbit Incl. °	Discovery
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	13.0	(200)	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	(150)	11,470	3765	250	14		27.6	C. Perrine, 1904
VII Elara	16.0	(50)	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	12.1	(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 inch = exactly 2.54 centimetres
1 yard = exactly 0.9144 metre
1 mile = exactly 1.609344 kilometres
1 astronomical unit = 1.4960×10^{13} cm = 1.496×10^{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

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

Units of Time

Sidereal day = 23*h* 56*m* 04.09*s* of mean solar time
Mean solar day = 24*h* 03*m* 56.56*s* of mean sidereal time
Synodic month = 29*d* 12*h* 44*m* 03*s* = $29^{d}.5306$
Tropical year (ordinary) = 365*d* 05*h* 48*m* 46*s* = $365^{d}.2422$
Sidereal year = 365*d* 06*h* 09*m* 10*s* = $365^{d}.2564$
Eclipse year = 346*d* 14*h* 52*m* 52*s* = $346^{d}.6200$

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

The Earth

Equatorial radius, a = 6378.164 km = 3963.21 mi: flattening, $c = (a - b)/a$ = 1/298.25
Polar radius, b = 6356.779 km = 3949.92 mi
1° of latitude = 111.133 − 0.559 cos 2ϕ km = 69.055 − 0.347 cos 2ϕ mi (at lat. ϕ)
1° of longitude = 111.413 cos ϕ − 0.094 cos 3ϕ km = 69.229 cos ϕ − 0.0584 cos 3ϕ mi
Mass of earth = 5.976×10^{24} kgm = 13.17×10^{24} lb
Velocity of escape from ⊕ = 11.2 km/sec = 6.94 mi/sec

Earth's Orbital Motion

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

Solar Motion

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

The Galactic System

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

External Galaxies

Red Shift ~ + 75 km/sec/megaparsec ~ 14 miles/sec/million l.y.

Radiation Constants

Velocity of light, $c = 2.997925 \times 10^{10}$ cm/sec = 186,282.1 mi/sec
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 = 3437′.75 = 206,265″
π = 3.141,592,653,6
No. of square degrees in the sky = 41,253
1 gram = 0.03527 oz

SUN—EPHEMERIS AND CORRECTION TO SUN-DIAL

Date	Apparent R.A. 0h E.T.	Apparent Dec. 0h E.T.	Corr. to Sun-dial 12h E.T.
	h m s	° ′	m s
Jan. 1	18 45 31	−23 01.7	+ 3 38
4	18 58 44	−22 45.2	+ 5 01
7	19 11 54	−22 24.7	+ 6 20
10	19 24 59	−22 00.2	+ 7 35
13	19 38 00	−21 31.9	+ 8 45
16	19 50 55	−20 59.7	+ 9 49
19	20 03 43	−20 24.0	+10 47
22	20 16 26	−19 44.8	+11 39
25	20 29 01	−19 02.4	+12 23
28	20 41 29	−18 16.8	+13 00
31	20 53 50	−17 28.2	+13 30
Feb. 3	21 06 03	−16 36.8	+13 52
6	21 18 09	−15 42.9	+14 07
9	21 30 07	−14 46.5	+14 15
12	21 41 59	−13 47.9	+14 16
15	21 53 44	−12 47.2	+14 10
18	22 05 23	−11 44.7	+13 58
21	22 16 55	−10 40.5	+13 40
24	22 28 22	− 9 34.8	+13 15
27	22 39 43	− 8 27.8	+12 46
Mar. 2	22 50 58	− 7 19.8	+12 11
5	23 02 10	− 6 10.7	+11 32
8	23 13 17	− 5 01.0	+10 49
11	23 24 21	− 3 50.6	+10 03
14	23 35 22	− 2 39.8	+ 9 14
17	23 46 21	− 1 28.7	+ 8 23
20	23 57 18	− 0 17.5	+ 7 31
23	0 08 15	+ 0 53.6	+ 6 37
26	0 19 10	+ 2 04.4	+ 5 42
29	0 30 05	+ 3 14.8	+ 4 48
Apr. 1	0 41 00	+ 4 24.7	+ 3 53
4	0 51 56	+ 5 33.8	+ 3 00
7	1 02 54	+ 6 42.1	+ 2 08
10	1 13 53	+ 7 49.3	+ 1 18
13	1 24 55	+ 8 55.4	+ 0 31
16	1 36 00	+10 00.1	− 0 13
19	1 47 09	+11 03.3	− 0 53
22	1 58 21	+12 04.9	− 1 30
25	2 09 37	+13 04.8	− 2 03
28	2 20 57	+14 02.6	− 2 32
May 1	2 32 21	+14 58.4	− 2 57
4	2 43 50	+15 52.0	− 3 16
7	2 55 25	+16 43.1	− 3 31
10	3 07 04	+17 31.8	− 3 40
13	3 18 49	+18 17.9	− 3 44
16	3 30 39	+19 01.2	− 3 43
19	3 42 34	+19 41.6	− 3 36
22	3 54 34	+20 19.0	− 3 25
25	4 06 39	+20 53.2	− 3 09
28	4 18 48	+21 24.2	− 2 49
31	4 31 02	+21 51.9	− 2 25
June 3	4 43 18	+22 16.2	− 1 57
6	4 55 39	+22 36.9	− 1 26
9	5 08 02	+22 54.1	− 0 52
12	5 20 27	+23 07.7	− 0 16
15	5 32 55	+23 17.6	+ 0 22
18	5 45 24	+23 23.8	+ 1 01
21	5 57 53	+23 26.3	+ 1 41
24	6 10 21	+23 25.1	+ 2 20
27	6 22 49	+23 20.2	+ 2 58
30	6 35 15	+23 11.5	+ 3 34

Date	Apparent R.A. 0h E.T.	Apparent Dec. 0h E.T.	Corr. to Sun-dial 12h E.T.
	h m s	° ′	m s
July 3	6 47 40	+22 59.3	+ 4 08
6	7 00 01	+22 43.4	+ 4 39
9	7 12 20	+22 23.9	+ 5 08
12	7 24 35	+22 01.0	+ 5 32
15	7 36 46	+21 34.7	+ 5 53
18	7 48 53	+21 05.0	+ 6 09
21	8 00 54	+20 32.2	+ 6 21
24	8 12 51	+19 56.3	+ 6 27
27	8 24 42	+19 17.3	+ 6 27
30	8 36 28	+18 35.5	+ 6 22
Aug. 2	8 48 08	+17 51.0	+ 6 12
5	8 59 43	+17 03.9	+ 5 56
8	9 11 12	+16 14.2	+ 5 35
11	9 22 37	+15 22.2	+ 5 09
14	9 33 56	+14 28.0	+ 4 38
17	9 45 11	+13 31.7	+ 4 02
20	9 56 21	+12 33.4	+ 3 22
23	10 07 26	+11 33.4	+ 2 37
26	10 18 27	+10 31.8	+ 1 48
29	10 29 25	+ 9 28.7	+ 0 55
Sept. 1	10 40 19	+ 8 24.2	− 0 01
4	10 51 11	+ 7 18.5	− 0 59
7	11 02 01	+ 6 11.7	− 1 59
10	11 12 49	+ 5 03.9	− 3 01
13	11 23 35	+ 3 55.4	− 4 04
16	11 34 21	+ 2 46.3	− 5 08
19	11 45 07	+ 1 36.7	− 6 12
22	11 55 53	+ 0 26.8	− 7 15
25	12 06 40	− 0 43.3	− 8 18
28	12 17 28	− 1 53.4	− 9 20
Oct. 1	12 28 18	− 3 03.4	−10 19
4	12 39 10	− 4 13.1	−11 15
7	12 50 06	− 5 22.3	−12 09
10	13 01 06	− 6 30.9	−12 58
13	13 12 09	− 7 38.8	−13 43
16	13 23 18	− 8 45.7	−14 24
19	13 34 31	− 9 51.5	−14 59
22	13 45 50	−10 56.0	−15 29
25	13 57 15	−11 59.0	−15 53
28	14 08 46	−13 00.4	−16 10
31	14 20 24	−13 59.9	−16 21
Nov. 3	14 32 09	−14 57.5	−16 24
6	14 44 02	−15 52.8	−16 20
9	14 56 02	−16 45.8	−16 08
12	15 08 10	−17 36.2	−15 49
15	15 20 25	−18 23.9	−15 22
18	15 32 48	−19 08.7	−14 47
21	15 45 18	−19 50.4	−14 06
24	15 57 56	−20 28.8	−13 17
27	16 10 40	−21 03.9	−12 21
30	16 23 31	−21 35.3	−11 19
Dec. 3	16 36 28	−22 03.1	−10 11
6	16 49 30	−22 27.0	− 8 57
9	17 02 38	−22 47.1	− 7 38
12	17 15 50	−23 03.1	− 6 15
15	17 29 05	−23 14.9	− 4 50
18	17 42 22	−23 22.6	− 3 22
21	17 55 40	−23 26.1	− 1 53
24	18 08 59	−23 25.4	− 0 23
27	18 22 18	−23 20.4	+ 1 05
30	18 35 35	−23 11.2	+ 2 33

TIME

Any recurring event may be used to measure time. The various times commonly used are defined by the daily passages of the sun or stars caused by the rotation of the earth on its axis. The more uniform revolution of the earth about the sun, causing the return of the seasons, defines ephemeris time. 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 7, 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. 7) to obtain apparent solar time, then adding 12 h and R.A. sun (p. 7). (Note that it is necessary to obtain R.A. of the sun and correction to sundial at the standard time involved.)

Local mean time varies continuously with longitude. The local mean time of Greenwich, now known as *Universal Time* (UT) is used as a common basis for 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 1977 will be about 48 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, 20, 25 MHz
WWVH Maui, Hawaii	2.5, 5, 10, 15 MHz.

JULIAN DAY CALENDAR, 1977

Jan. 1........2443145	May 1.......2443265	Sept. 1.......2443388
Feb. 1........2443176	June 1.......2443296	Oct. 1.......2443418
Mar. 1........2443204	July 1.......2443326	Nov. 1.......2443449
Apr. 1........2443235	Aug. 1.......2443357	Dec. 1.......2443479

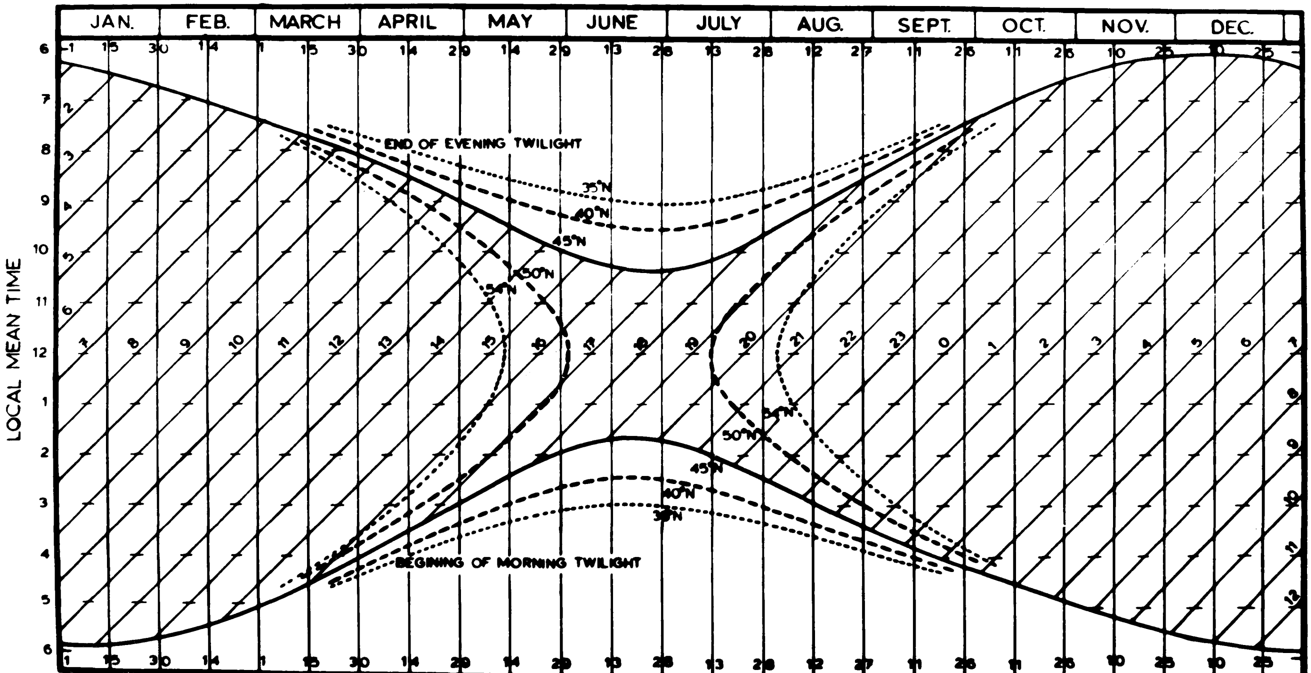
The Julian day commences at noon, so that J.D. 2443145 = Jan. 1.5 U.T. 1977 = 12 hours U.T., Jan. 1, 1977.

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.

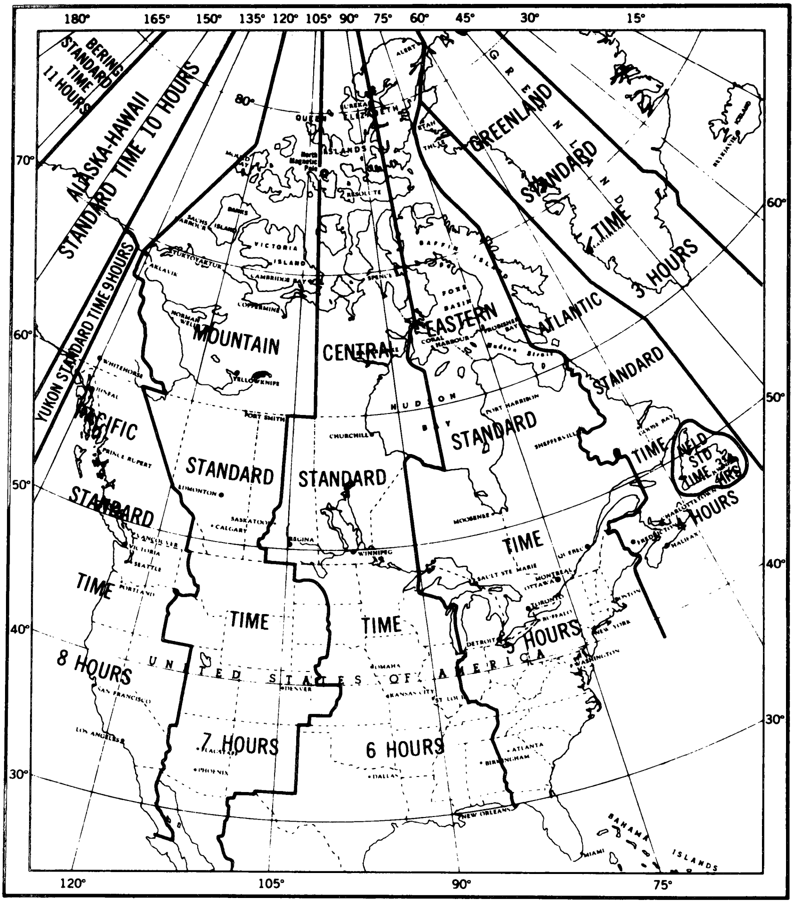
This system was introduced in 1582 by Josephus Justus Scaliger under the name of the Julian period. The Julian period lasts 7980 years, and is the least common multiple of three cycles: the solar cycle of 28 Julian years, the lunar (or Metonic) cycle of 19 Julian years, and the Roman indiction cycle 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

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

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

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

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

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

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

TWILIGHT—BEGINNING OF MORNING AND ENDING OF EVENING

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

The above table gives the local mean time of the beginning of morning twilight, and of the ending of evening twilight, for various latitudes. To obtain the corresponding standard time, the method used is the same as for correcting the sunrise and sunset tables, as described on page 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).

MOONRISE AND MOONSET, 1977; LOCAL MEAN TIME

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

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

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

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

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

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

THE PLANETS FOR 1977

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 with no vast plains or maria which are so conspicuous on the side of the moon that faces the Earth. 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 (area) we see it to more than ten times its apparent size from Earth.

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. The planet'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.

The following table lists the greatest elongations of Mercury in 1977; those marked * are most favourable.

Date E.S.T.	Elong. East	App. Diam.	Vis. Mag.	Date E.S.T.	Elong. West	App. Diam.	Vis.. Mag.
*Apr. 10, 11^h	19°	7″.5	+0.2	Jan. 28, 19^h	25°	6″.8	+0.1
Aug. 8, 15^h	27°	7″.4	+0.6	May 27, 18^h	25°	8″.3	+0.8
Dec. 3, 03^h	21°	6″.5	−0.2	*Sept. 21, 03^h	18°	7″.1	−0.1

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 has the special property of letting the sunlight penetrate to the planet's surface but not letting the heat escape, in much the same way as the glass cover of a greenhouse keeps plants warm.

Venus' atmosphere has a thick cloud 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 the clouds are not opaque. The clouds are believed to consist chiefly of droplets of sulphuric acid. It is these white, reflective clouds that make Venus so brilliant in the night-time sky but also make it a virtually featureless orb when viewed through the telescope.

Venus is the brightest natural celestial object in the night-time 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°. 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 as 1977 opens. Venus dominates the evening sky in the west shortly after sunset. The planet continues to be a prominent evening object until late March. The brilliant planet is in the morning sky from mid-April to the end of the year.

Like Mercury, Venus exhibits phases although they are much easier to distinguish because of Venus' greater size. 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.

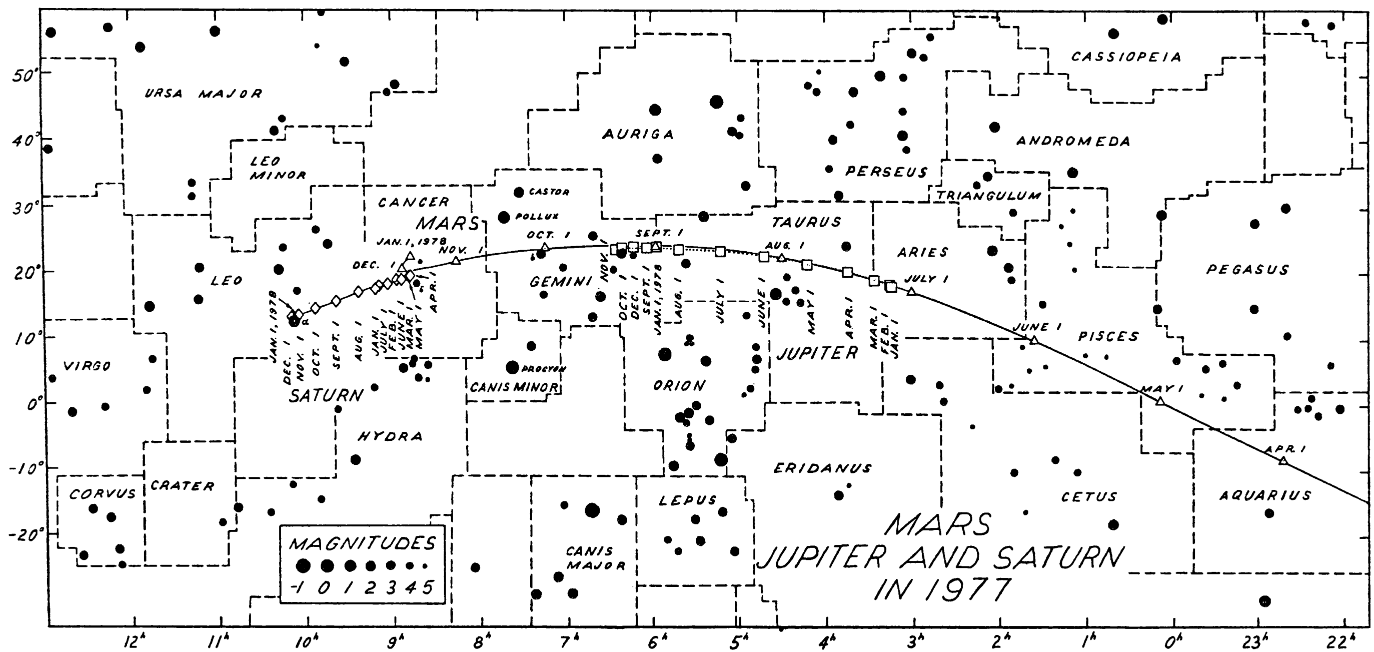
When Venus is less than 10% illuminated the cusps (the points at the ends of the crescent) can sometimes be seen to extend into the night side of the planet. This is an actual observation of solar illumination being scattered by the atmosphere of Venus. When Venus is a thin sliver of a crescent the extended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

MARS

Mars is the planet that has long captivated the imagination of mankind as a possible abode of life. One of the major objectives of the Viking spacecraft which landed on Mars in 1976 was the quest for Martian microorganisms. Viking and its predecessors have shown that water was abundant enough on Mars to leave major structures on the planet resembling riverbeds. Whether water flowed on Mars in the recent past or was limited to the planet's early history is still unresolved. The red planet's atmosphere is less than 1% as dense as Earth's and consists of about 95% carbon dioxide, 3% nitrogen, 2% argon and small amounts of other gases. Winds in the thin atmosphere reach velocities exceeding 300 km per hour and in so doing raise vast amounts of dust that can envelop the planet for weeks at a time. The duststorms occur with seasonal regularity, usually shortly after Mars has passed the perihelion point of its elliptical orbit. (Mars is at perihelion April 3.)

As 1977 opens Mars is hidden within the sun's glow in morning twilight, but by December the red planet will be a prominent object in late night skies. In many ways Mars is the most interesting planet to observe with the unaided eye. It moves rapidly among the stars—its motion can usually be detected after an interval of less than a week—and it varies in brightness over a far greater range than any other planet. Mars may be distinguished by its orange-red colour, a hue that originates with rust-coloured dust that covers much of the planet.

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



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

The next opposition occurs on January 22, 1978, a very unfavourable one with the minimum distance between Earth and Mars being 97.7 million km and the apparent diameter less than 15″. During the last few months of 1977 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 during the last half of this year, Mars will appear almost overhead for observers in mid-northern latitudes. In late autumn the planet will be near enough for telescopic scrutiny. The main features on the map of Mars on page 75 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 75.

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. At best Jupiter has only a small rocky core thousands of miles below the heavily clouded atmosphere.

The windswept cloudy surface of Jupiter is constantly changing. The vast dark belts merge with one another or sometimes fade to insignificance. The bright 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; 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 47″.4 at opposition on December 23 to a minimum of 32″.4 at conjunction on June 4.

The Great Red Spot, a towering vortex whose colour is 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.

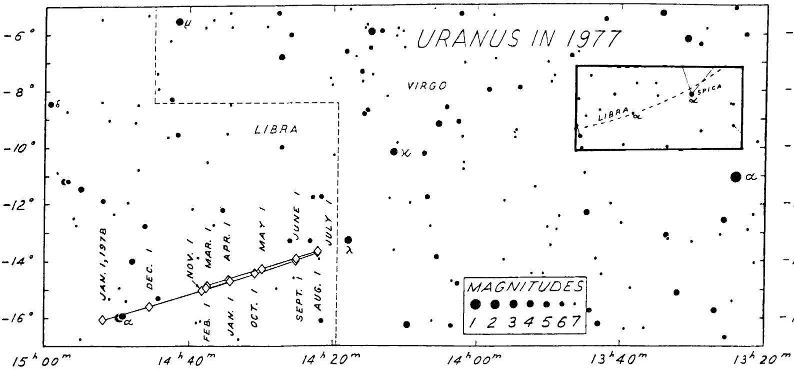
The smallest of telescopes will reveal Jupiter's four large moons, each of which is equal to or larger than Earth's satellite. The moons provide a never-ending fascination for amateur astronomers. Sometimes the satellites are paired on either side of the belted planet; frequently one is missing—either 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 1977 opens Jupiter is bright and unmistakable in the early evening sky and is ideally placed for telescopic study. By early May the planet will be lost in the twilight glow in the west after sunset. In early July it is visible in the morning sky just before sunrise and by the end of the year Jupiter is visible all night as a brilliant object—the brightest in the late night sky—located near the border between Taurus and Gemini. 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.

This year opposition occurs December 23 when Jupiter is 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 85.

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 1977 the south side of the rings and the southern hemisphere of Saturn are presented to our view.

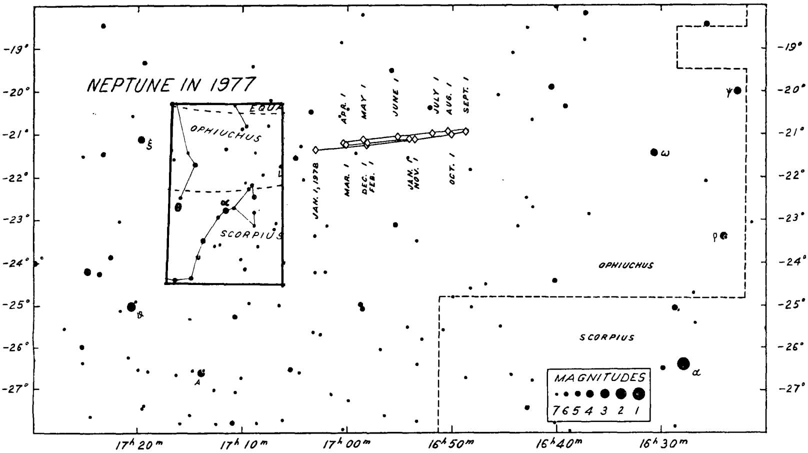
As 1977 opens Saturn's rings are tilted 15.8° with respect to the Earth; by year's end, this figure has decreased to 10.1°.

Opposition is February 2 when Saturn is 1.219 billion km (8.151 A.U.) from Earth, in the constellation Cancer. At that time the rings are 46.″1 in apparent width and the planet is 18.″3 in polar diameter.

URANUS

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

Jupiter, Saturn, Uranus and Neptune are rather similar in the sense that their interiors consist mainly of hydrogen and helium and their atmospheres consist of these same elements and simple compounds of hydrogen. Unlike the three other giant planets, the axis of Uranus is tipped almost parallel to the plane of the solar system. This means that we can view Uranus nearly pole-on at certain points in its 84 year orbit of the sun. The northern hemisphere of Uranus is now directed toward



the Earth and we will be viewing the planet almost directly 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.

Throughout 1977 Uranus is in Libra a few degrees west of Alpha Librae. Uranus is at opposition on April 30 when it is 2.63 billion km (17.56 A.U.) from Earth. At this time its magnitude is +5.7 and its apparent diameter is 3.″9. On March 10 Uranus will occult the star SAO 158687.

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 featureless bluish-green disk. Neptune's large moon Triton can be seen by an experienced observer using a 12-inch telescope. The moon varies from 8″ to 17″ from Neptune during its 5.9 day elliptical orbit. In 1977 Neptune is buried in the Milky Way in Ophiuchus and is not well placed for northern observers. At opposition on June 5 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 the reflectivity of the outermost planet may be much higher than previously thought. If this is true Pluto may prove to be a substantially smaller planet than scientists have guessed. Some current estimates place it as small as Earth's moon. Previous estimates of Pluto's diameter ranged around twice that of our moon. As a result of this discovery some scientists are speculating that Pluto may be more closely related to comets than to the eight major planets of the solar system.

At opposition on April 2 Pluto's astrometric position is R.A. (1950) $13^h13.^m3$ Dec. (1950) +11°16′ and its distance from Earth will be 4.42 billion km (29.54 A.U.). With an apparent magnitude of +14 Pluto is a difficult target in moderate-sized amateur telescopes.

THE SKY MONTH BY MONTH

By John F. Heard

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.

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.

The sun's selenographic colongitude is essentially a convenient way of indicating the position of the sunrise terminator as it moves across the face of the moon. It provides an accurate method of recording the exact conditions of illumination (angle of illumination), and makes it possible to observe the moon under exactly the same lighting conditions at a later date. The sun's selenographic colongitude is numerically equal to the selenographic longitude of the sunrise terminator reckoned eastward from the mean centre of the disk. Its value increases at the rate of nearly 12.2° per day or about ½° per hour; it is approximately 270°, 0°, 90° and 180° at New Moon, First Quarter, Full Moon and Last Quarter respectively. Values of the sun's selenographic colongitude are given on the following pages for the first day of each month.

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

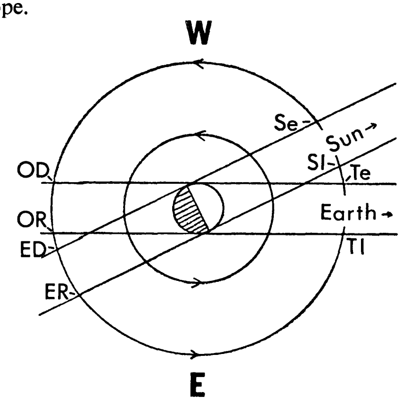
Libration is the shifting, or rather apparent shifting, of the visible disk of the moon. Sometimes the observer sees features farther around the eastern or the western limb (libration in longitude), or the northern or southern limb (libration in latitude). When the libration in longitude is positive,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

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

The Planets—Further information in regard to the planets, including Pluto, is found on pp. 28–33. For the configurations of Jupiter's satellites, see "Astronomical Phenomena Month by Month", and for their eclipses, see p. 79.

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. 79) 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 1977

The winter solstice is past and the days are lengthening, the sun rising earlier and setting later. But notice that this lengthening in January is not symmetrical. For example, look at the January sunrise-sunset table for latitude 54 on page 15: sunrise gets earlier during the month by 28 minutes, sunset later by 50 minutes! Now look at February: sunrise gets earlier by 56 minutes, sunset later by 54 minutes. Many people notice this phenomenon and are puzzled by it. The answer lies in the changing values of the correction to the sun-dial (difference between mean time and sun-dial time). See page 9 and notice that correction to the sun-dial is increasing in January for the most part, and decreasing in February; this pushes the noon point of the real sun farther east during January (relative to the noon point of the mean sun, that is) and so defers the rising of the sun as measured in mean time and advances the setting, thus causing the asymmetry we have noted.

The Sun—During January the sun's R.A. increases from 18 h 46 m to 20 h 58 m and its Decl. changes from 23° 02′ S. to 17° 11′ S. The equation of time changes from −3 m 44 s to −13 m 40 s. The earth is in perihelion on the 3rd at a distance of 147,094,000 km (91,400,000 miles) from the sun.

The Moon—On Jan. 1.0, E.S.T., the age of the moon is 11.2^d. The sun's selenographic colongitude is 42.21° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Jan. 22 (6°) and minimum (east limb exposed) on Jan. 8 (5°) The libration in latitude is maximum (north limb exposed) on Jan. 6 (7°) and minimum (south limb exposed) on Jan. 19 (6°).

Mercury on the 1st is in R.A. 19 h 34 m, Decl. 20°27′ S., and on the 15th is in R.A. 18 h 32 m, Decl. 20°02′ S. For a few days before and after the 29th it may be seen very low in the south-east just before sunrise. This greatest western elongation (on the 29th) is, however, a poor one, the planet being only about 12 degrees above the horizon at sunrise.

Venus on the 1st is in R.A. 21 h 55 m, Decl. 14°21′ S., and on the 15th it is in R.A. 22 h 53 m, Decl. 7°53′ S., mag. −4.0, and transits at 15 h 15 m. This month (on the 24th) Venus is at greatest eastern elongation which means that it is well placed for observation being about 33 degrees above the south-western horizon at sunset and setting about four hours later.

Mars on the 15th is in R.A. 18 h 46 m, Decl. 23°46′ S., mag. +1.5, and transits at 11 h 08 m. In the morning sky, it is too close to the sun for easy observation.

Jupiter on the 15th is in R.A. 3 h 16 m, Decl. 17° 10′ N., mag. −2.2, and transits at 19 h 35 m. In Aries, it is well up in the east at sunset. On the 15th it is stationary and resumes eastward motion among the stars.

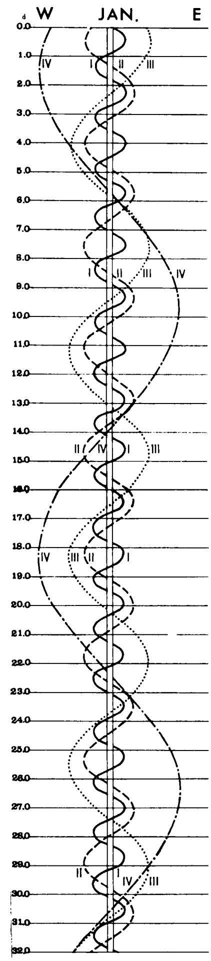
Saturn on the 15th is in R.A. 9 h 11 m, Decl. 17° 14′ N., mag. +0.2, and transits at 1 h 32 m. In Cancer and retrograding, it rises about two hours after sunset.

Uranus on the 15th is in R.A. 14 h 36 m, Decl. 14° 49′ S., and transits at 6 h 57 m.

Neptune on the 15th is in R.A. 16 h 56 m, Decl. 21°09′ S., and transits at 9 h 16 m.

1977	d	h	m	JANUARY E.S.T.	Min. of Algol h m
Sat.	1			Mercury at perihelion	
Sun.	2				
Mon.	3	05		Earth at perihelion	5 50
		08		Quadrantid meteors	
Tues.	4				
Wed.	5	07	10	☺ Full Moon	
Thur.	6	03		Mercury in inferior conjunction	2 40
Fri.	7	19		Saturn 6° N. of Moon	
Sat.	8	21		Vesta at opposition	23 30
Sun.	9				
Mon.	10				
Tues.	11			Mercury at greatest hel. lat. N.	20 20
Wed.	12	07		Mercury 4° N. of Mars	
		14	55	☾ Last Quarter	
Thur.	13	23		Uranus 0.6° S. of Moon. Occ'n.[1]	
Fri.	14				17 10
Sat.	15	15		Jupiter stationary	
Sun.	16	05		Moon at perigee (366, 450 km)	
		07		Neptune 2° S. of Moon	
		23	47	Appulse: SAO 140546 & Juno, (pg. 62)	
Mon.	17	02		Mercury stationary	14 00
		20		Mercury 2° S. of Moon	
Tues.	18	07		Mars 6° S. of Moon	
Wed.	19	09	11	● New Moon	
Thur.	20				10 50
Fri.	21	02	04	Appulse: SAO 176953 & Pallas, (pg. 62)	
		11	52	Appulse: SAO 176943 & Pallas, (pg. 62)	
Sat.	22			Venus at ascending node	
Sun.	23	04		Pluto stationary	7 40
		06		Venus 3° S. of Moon	
Mon.	24	07		Venus greatest elong. E. (47°)	
Tues.	25				
Wed.	26				4 30
Thur.	27	00	11	☽ First Quarter	
Fri.	28	01		Moon at apogee (404,350 km)	
		05		Jupiter 1° N. of Moon	
		19		Mercury greatest elong. W. (25°)	
Sat.	29				1 10
Sun.	30				
Mon.	31				22 00

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



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

THE SKY FOR FEBRUARY 1977

If you are a Venus watcher you may be puzzled to notice (or to read what we say about Venus this month) that although Venus was at greatest eastern elongation in January (on the 24th) it is higher in the south-western sky at sunset in mid-February than it was in mid-January. How can this be since Venus is closing in on the sun? (Want to think about it for a while?) Well, the answer lies mostly in the fact that the ecliptic (which *nearly* represents the path of motion of most planets) at sunset in mid-January makes an angle of about 52 degrees with the horizon, whereas in mid-February it makes an angle of 63 degrees. This greater steepness of the ecliptic in February more than offsets the amount by which Venus has approached the sun.

The Sun—During February the sun's R.A. increases from 20 h 58 m to 22 h 47 m and its Decl. changes from 17° 11′ S. to 7° 43′ S. The equation of time changes from −13 m 40 s to a maximum of −14 m 16 s on the 11th and then to −12 m 32 s at the end of the month.

The Moon—On Feb. 1.0, E.S.T., the age of the moon is 12.6^d. The sun's selenographic colongitude is 59.09° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Feb. 18 (5°) and minimum (east limb exposed) on Feb. 3 (5°). The libration in latitude is maximum (north limb exposed) on Feb. 3 (7°) and minimum (south limb exposed) on Feb. 15 (7°).

Mercury on the 1st is in R.A. 19 h 15 m, Decl. 21° 49′ S., and on the 15th is in R.A. 20 h 34 m, Decl. 20° 07′ S. Except for the first few days of the month (see January) Mercury is too close to the sun for observation.

Venus on the 1st is in R.A. 23 h 54 m, Decl. 0° 29′ N., and on the 15th it is in R.A. 0 h 36 m, Decl. 7° 02′ N., mag. −4.3, and transits at 14 h 56 m. Although closer to the sun than last month, Venus is now even higher in the south-western sky at sunset (about 40 degrees) and sets about four hours later.

Mars on the 15th is in R.A. 20 h 27 m, Decl. 20° 10′ S., mag. +1.5, and transits at 10 h 47 m. It is in the morning sky but still too close to the sun for easy observation.

Jupiter on the 15th is in R.A. 3 h 22 m, Decl. 17° 42′ N., mag. −1.9, and transits at 17 h 39 m. Moving back into Taurus, it is nearing the meridian at sunset and sets soon after midnight.

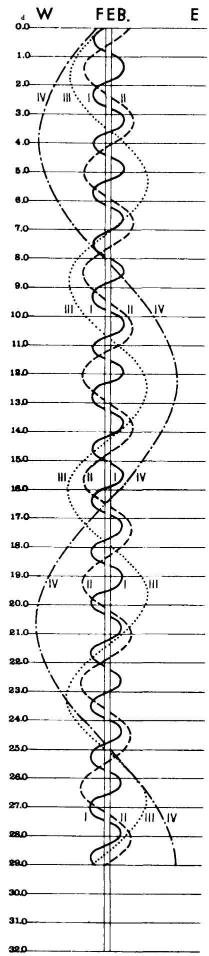
Saturn on the 15th is in R.A. 9 h 01 m, Decl. 18° 00′ N., mag. +0.1, and transits at 23 h 16 m. In Cancer, it rises about at sunset and is visible all night. Opposition is on the 2nd.

Uranus on the 15th is in R.A. 14 h 38 m, Decl. 14° 57′ S., and transits at 4 h 57 m. Note the occultation by the moon on the 10th.

Neptune on the 15th is in R.A. 16 h 59 m, Decl. 21° 13′ S., and transits at 7 h 18 m.

1977				FEBRUARY E.S.T.	Min. of Algol
	d	h	m		h m
Tues.	1				
Wed.	2	05		Saturn at opposition	
Thur.	3	22	56	Full Moon	18 50
		23		Saturn 6° N. of Moon	
Fri.	4			Mercury at descending node	
Sat.	5				
Sun.	6				15 40
Mon.	7				
Tues.	8				
Wed.	9				12 30
Thur.	10	05		Uranus 0.9° S. of Moon. Occ'n.[1]	
		07		Pallas at opposition	
		23	07	Last Quarter	
		23		Moon at perigee (370,250 km)	
Fri.	11	14		Ceres stationary	
Sat.	12	14		Mercury 0.1° S. of Mars	9 20
		15		Neptune 2° S. of Moon.	
Sun.	13				
Mon.	14			Mercury at aphelion	
		17		Uranus stationary	
Tues.	15				6 10
Wed.	16	07		Mars 6° S. of Moon	
		12		Mercury 7° S. of Moon	
Thur.	17	22	37	New Moon	
Fri.	18				3 00
Sat.	19				
Sun.	20				23 50
Mon.	21	12		Venus 3° N. of Moon	
Tues.	22				
Wed.	23				20 40
Thur.	24	17		Jupiter 2° N. of Moon	
		22		Moon at apogee (404,350 km)	
Fri.	25			Venus at perihelion	
		21	50	First Quarter	
Sat.	26	04		Vesta stationary	17 30
Sun.	27				
Mon.	28	21		Venus greatest brilliancy	

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



[1]Visible in parts of N. America.

THE SKY FOR MARCH 1977

A question that we asked (and answered) on last year's March page is perhaps worth repeating and enlarging upon. If March 20 is the time of the equinox (equal day and night) why is it that the sunrise-sunset table shows the day to be longer than 12 hours by about 8 minutes? This means that we have to explain why the sun seems to rise 4 minutes early and set 4 minutes late. Part of the discrepancy lies in the fact that the sunrise-set tables refer to the upper limb of the sun whereas the idealized equinoctial situation refers to the centre of the sun's disk, so this accounts for 15′ both at rise and set. The rest of the discrepancy is attributable to atmospheric refraction which "lifts" the sun by 30′ when it is on the horizon. So we account for a total difference of 45′ between the sunrise or sunset tabulated and sunrise or sunset idealized in the equinoctial situation. Can we equate these 45′ to 4 minutes of time? To answer we must first realize that the 45′ measured perpendicular to the horizon is equivalent along the equator to 45′ times the secant of the latitude—in this case to $45' \sec 45° = 64'$. Now we ask how long does it take for the rotation of the earth to carry a body 64′ along the equator? Well, 1° or 60′ is equivalent to 4 minutes, so the answer is that 64′ is equivalent (to the nearest minute) to 4 minutes—just the discrepancy which we set out to explain.

The Sun—During March the sun's R.A. increases from 22 h 47 m to 0 h 41 m and its Decl. changes from 7° 43′ S. to 4° 25′ N. The equation of time changes from −12 m 21 s to −4 m 08 s. On the 20th at 12 h 43 m E.S.T. the sun crosses the equator on its way north, enters the sign of Aries and spring commences. This is the vernal equinox.

The Moon—On Mar. 1.0, E.S.T., the age of the moon is 11.0^d. The sun's selenographic colongitude is 39.79° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Mar. 16 (5°) and minimum (east limb exposed) on Mar. 2 (6°) and Mar. 30 (7°). The libration in latitude is maximum (north limb exposed) on Mar. 1 (7°) and Mar. 29 (7°) and minimum (south limb exposed) on Mar 14 (7°).

Mercury on the 1st is in R.A. 22 h 03 m, Decl. 14° 16′ S., and on the 15th is in R.A. 23 h 37 m, Decl. 4° 12′ S. It is too close to the sun for observation, superior conjunction being on the 16th.

Venus on the 1st is in R.A. 1 h 08 m, Decl. 12° 33′ N., and on the 15th it is in R.A. 1 h 20 m, Decl. 16° 00′ N., mag. −4.2, and transits at 13 h 47 m. Venus reaches greatest brilliancy at the beginning of the month, but as it approaches the sun it is now perceptibly lower in the sky at sunset and sets within three hours (on the 15th). By the end of the month it is very close to the western horizon at sunset.

Mars on the 15th is in R.A. 21 h 55 m, Decl. 13° 56′ S., mag. +1.4, and transits at 10 h 24 m. It is in the morning sky but still too close to the sun for easy observation.

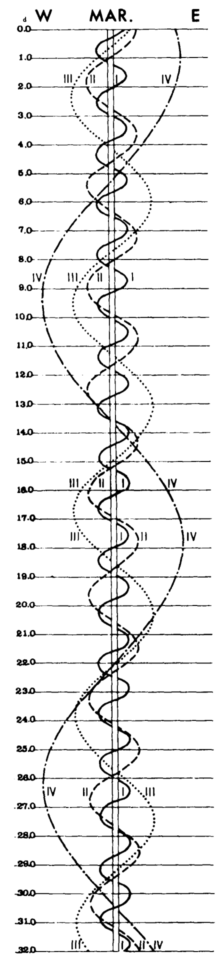
Jupiter on the 15th is in R.A. 3 h 37 m, Decl. 18° 42′ N., mag. −1.7, and transits at 16 h 04 m. In Taurus, it is past the meridian at sunset and sets before midnight.

Saturn on the 15th is in R.A. 8 h 53 m, Decl. 18° 32′ N., mag. +0.2, and transits at 21 h 19 m. In Cancer, it is well up in the east at sunset and sets before dawn.

Uranus on the 15th is in R.A. 14 h 37 m, Decl. 14° 50′ S., and transits at 3 h 05 m.

Neptune on the 15th is in R.A. 17 h 00 m, Decl. 21° 14′ S., and transits at 5 h 29 m.

1977				MARCH E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Tues.	1				14 20	
Wed.	2					
Thur.	3	04		Saturn 6° N. of Moon		
Fri.	4				11 10	
Sat.	5	12	13	☺ Full Moon		
Sun.	6			Mercury at greatest hel. lat. S.		
Mon.	7				8 00	
Tues.	8	18		Moon at perigee (366,450 km)		
Wed.	9	10		Uranus 1° S. of Moon. Occ'n.[1]		
Thur.	10	15	55	Appulse: SAO 158687 & Uranus, (pg. 62)	4 50	
Fri.	11	02		Pallas stationary		
		21		Neptune 3° S. of Moon		
Sat.	12	06	35	☾ Last Quarter		
Sun.	13				1 30	
Mon.	14	14		Venus stationary		
Tues.	15				22 20	
Wed.	16	00		Mercury in superior conjunction		
Thur.	17	07		Mars 6° S. of Moon		
Fri.	18			Venus at greatest hel. lat. N.	19 10	
		06		Neptune stationary		
Sat.	19	13	33	● New Moon		
Sun.	20	12	43	Equinox. Spring begins		
Mon.	21	02		Juno stationary	16 00	
		08		Venus 8° N. of Moon		
Tues.	22					
Wed.	23					
Thur.	24	10		Jupiter 2° N. of Moon	12 50	
		15		Ceres at opposition		
		17		Moon at apogee (405,100 km)		
Fri.	25					
Sat.	26			Mercury at ascending node		
Sun.	27	14		Mercury 8° S. of Venus	9 40	
		17	27	☽ First Quarter		
Mon.	28					
Tues.	29					
Wed.	30			Mercury at perihelion	6 30	
		12		Saturn 6° N. of Moon		
Thur.	31					



[1]Visible in Alaska, N. Pacific.

THE SKY FOR APRIL 1977

Notice that we are having a favourable eastern elongation of Mercury this month. We are saying that Mercury should be easily seen low in the west just after sunset for about half the month, the best time being on the 10th when Mercury is at greatest eastern elongation, and we estimate that it then stands about 17 degrees above the horizon at sunset. Contrast this greatest eastern elongation to the next one, on August 8th, which is called poor and when we estimate that the altitude of Mercury at sunset is only 10 degrees. What is it that makes the difference? We could guess that it has to do with Mercury's orbit being so highly elliptical—perhaps Mercury is near aphelion in April and near perihelion in August; and we might also think of the possible effects of Mercury's relatively high orbital inclination to the ecliptic (7 degrees). But we'd be on the wrong track with these guesses because notice the bracketed figure in the appropriate entries for greatest eastern elongation: 19° in April, 27° in August. These are the actual elongations, i.e. angular distances from sun to Mercury; notice that these figures would seem to predict a more favourable elongation in August than in April! So what, then, *is* the explanation of the favourable elongation of April? It is the steepness of the ecliptic. At latitude 45° on April 10th when the sun is setting the ecliptic makes an angle of about 63 degrees with the horizon; thus most of Mercury's elongation of 19° is translated into altitude. Contrast the situation on August 8th: the ecliptic then makes an angle of only 25 degrees with the horizon; then less than half of Mercury's elongation of 27 degrees is translated into altitude. And so, as a general rule, the greatest eastern elongations of Spring are the most favourable while those of Fall are the least favourable. How would the rule go for the greatest western elongations when Mercury is seen as a morning star?

The Sun—During April the sun's R.A. increases from 0 h 41 m to 2 h 32 m and its Decl. changes from 4° 25′ N. to 14° 58′ N. The equation of time changes from −3 m 50 s to +2 m 51 s, being zero on the 15th.

The Moon—On Apr. 1.0, E.S.T., the age of the moon is 12.4^d. The sun's selenographic colongitude is 57.38° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Apr. 12 (6°) and minimum (east limb exposed) on Apr. 28 (8°). The libration in latitude is maximum (north limb exposed) on Apr. 25 (7°) and minimum (south limb exposed) on Apr. 10 (7°).

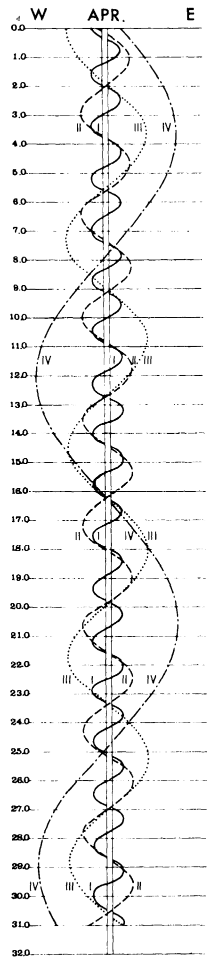
Mercury on the 1st is in R.A. 1 h 36 m, Decl. 11° 17′ N,. and on the 15th is in R.A. 2 h 39 m, Decl. 18° 39′ N. For about the first half of the month mercury should be easily seen low in the west just after sunset; at greatest eastern elongation on the 10th it is about 17 degrees above the western horizon at sunset. However, by the 30th it is in inferior conjunction.

Venus on the 1st is in R.A. 1 h 00 m, Decl. 15° 01′ N., and on the 15th it is in R.A. 0 h 32 m, Decl. 9° 59′ N., mag. −3.6, and transits at 10 h 56 m. At the beginning of the month Venus is very low in the western sky at sunset and difficult to observe. On the 6th it is in inferior conjunction and passes into the morning sky. By mid-month it will be easily seen as a morning star rising about an hour before the sun.

Mars on the 15th is in R.A. 23 h 26 m, Decl. 5° 00′ S., mag. +1.4, and transits at 9 h 53 m. It is in the morning sky but still too close to the sun for easy observation, being only about 10 degrees above the eastern horizon at sunrise.

Jupiter on the 15th is in R.A. 4 h 01 m, Decl. 20° 03′ N., mag. −1.6, and transits at 14 h 24 m. In Taurus, it is well down in the west at sunset and sets about three hours later.

1977				APRIL E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Fri.	1					
Sat.	2	11		Pluto at opposition	3 20	
Sun.	3	23	09	⊕ Full Moon. Eclipse of ☾, pg 61		
Mon.	4			Mars at greatest hel. lat. S.		
Tues.	5	16		Moon at perigee (361,150 km)	0 10	
		17		Uranus 1° S. of Moon. Occ'n.[1]		
Wed.	6	01		Venus in inferior conjunction		
Thur.	7				21 00	
Fri.	8	03		Neptune 3° S. of Moon		
Sat.	9			Mercury at greatest hel. lat. N.		
Sun.	10	11		Mercury greatest elong. E. (19°)	17 50	
		14	15	☾ Last Quarter		
Mon.	11	02		Saturn stationary		
Tues.	12					
Wed.	13				14 40	
Thur.	14					
Fri.	15	07		Mars 4° S. of Moon		
Sat.	16	15		Venus 5° N. of Moon	11 20	
Sun.	17					
Mon.	18	05	35	● New Moon. Eclipse of ⊙, pg. 61		
Tues.	19	11		Mercury 5° N. of Moon	8 10	
Wed.	20	05		Mercury stationary		
Thur.	21	04		Jupiter 3° N. of Moon		
		07		Moon at apogee (406,000 km)		
Fri.	22	04		Lyrid meteors	5 00	
Sat.	23					
Sun.	24	16		Venus stationary		
Mon.	25				1 50	
Tues.	26	09	42	☽ First Quarter		
		20		Saturn 6° N. of Moon		
Wed.	27				22 40	
Thur.	28					
Fri.	29					
Sat.	30			Mars at perihelion	19 30	
		01		Uranus at opposition		
		12		Mercury in inferior conjunction		



[1]Visible in parts of Europe, Central Asia.

Saturn on the 15th is in R.A. 8 h 51 m, Decl. 18° 42′ N., mag. +0.4, and transits at 19 h 15 m. In Cancer, it is approaching the meridian at sunset and sets about two hours after midnight. On the 11th it is stationary and resumes direct, i.e. eastward, motion relative to the stars.

Uranus on the 15th is in R.A. 14 h 33 m, Decl. 14° 30′ S., and transits at 0 h 59 m.

Neptune on the 15th is in R.A. 17 h 00 m, Decl. 21° 11′ S., and transits at 3 h 26 m.

THE SKY FOR MAY ~~1976~~ 1977

Notice that Venus reaches greatest brilliancy "again" on the 11th. Looking back, we see that it was at greatest brilliancy also about March 1—an interval of 72 days. Also notice that on April 6th, just midway between the two greatest brilliancies, Venus is at inferior conjunction. Actually the rule is that greatest brilliancy always occurs 36 days before and 36 days after inferior conjunction. Why 36 days? Well, the brilliancy of Venus is a function both of its apparent size and the proportion of the disk facing us which is illuminated. The time when the two factors add up to greatest brilliancy happens to be 36 days either way from inferior conjunction, and at those times the crescent Venus resembles the moon just two days before first quarter. Venus is then about a magnitude brighter than it is near superior conjunction, that is to say when its disk is fully illuminated.

The Sun—During May the sun's R.A. increases from 2 h 32 m to 4 h 35 m and its Decl. changes from 14° 58′ N. to 22° 00′ N. The equation of time changes from +2m 58 s to a maximum of +3 m 44 s on the 14th and then to +2 m 23 s at the end of the month.

The Moon—On May 1.0, E.S.T., the age of the moon is 12.8^d. The sun's selenographic colongitude is 63.31° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on May 10 (7°) and minimum (east limb exposed) on May 26 (8°). The libration in latitude is maximum (north limb exposed) on May 22 (7°) and minimum (south limb exposed) on May 8 (7°).

Mercury on the 1st is in R.A. 2 h 30 m, Decl. 15° 27′ N., and on the 15th is in R.A. 2 h 14 m, Decl. 10° 28′ N. On the 27th it is in greatest western elongation but at that time stands only about 9 degrees above the eastern horizon at sunrise, so that this is an unfavourable elongation.

Venus on the 1st is in R.A. 0 h 27 m, Decl. 5° 32′ N., and on the 15th it is in R.A. 0 h 50 m, Decl. 5° 11′ N., mag. −4.2, and transits at 9 h 19 m. It is prominent in the eastern sky for about two hours before sunrise; greatest brilliancy occurs again on the 11th. It is in conjunction with Mars on the 13th, Mars being 1.2 degrees north. Note the occultation by the moon on the 14th.

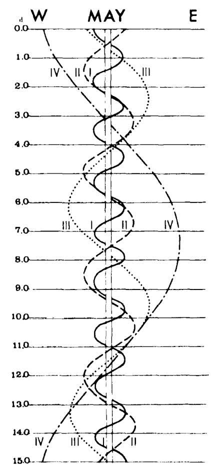
Mars on the 15th is in R.A. 0 h 51 m, Decl. 4° 11′ N., mag. +1.3, and transits at 9 h 20 m. In Pisces, it may be identified low in the eastern sky just before sunrise. (See Venus.)

Jupiter on the 15th is in R.A. 4 h 29 m, Decl. 21° 16′ N., mag. −1.5, and transits at 12 h 57 m. In Taurus, about 5 degrees north of Aldebaran, it is very low in the west at sunset and sets soon thereafter. At the end of the month it is too close to the sun for easy observation.

Saturn on the 15th is in R.A. 8 h 55 m, Decl. 18° 25′ N., mag. +0.6, and transits at 17 h 21 m. In Cancer, it is well past the meridian at sunset and sets at about midnight.

Uranus on the 15th is in R.A. 14 h 28 m, Decl. 14° 07′ S., and transits at 22 h 52 m. Note the occultation by the moon on the 3rd.

Neptune on the 15th is in R.A. 16 h 57 m, Decl. 21° 07′ S., and transits at 1 h 26 m.

1977				MAY E.S.T.	Min. of Algol	Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h m	
Sun.	1					
Mon.	2					
Tues.	3			Mercury at descending node	16 20	
		02		Uranus 1° S. of Moon. Occ'n.[1]		
		08	03	○ Full Moon		
Wed.	4	00		Moon at perigee (357,750 km)		
Thur.	5	05		η Aquarid meteors		
		11		Neptune 3° S. of Moon		
Fri.	6				13 10	
Sat.	7					
Sun.	8					
Mon.	9	23	08	☾ Last Quarter	10 00	
Tues.	10					
Wed.	11	18		Venus greatest brilliancy		
Thur.	12	19		Mercury stationary	6 50	
		23		Juno at opposition		
Fri.	13			Mercury at aphelion		
				Venus at descending node		
		13		Venus 1.3° N. of Mars		
Sat.	14	06		Venus 1° S. of Moon. Occ'n.[1]		
		07		Mars 2° S. of Moon		
Sun.	15				3 30	
Mon.	16	02		Mercury 2° S. of Moon		
Tues.	17	01		Ceres stationary		
		21	51	● New Moon		
Wed.	18	13		Moon at apogee (406,550 km)	0 20	Jupiter being
Thur.	19					near the sun
Fri.	20	08		Jupiter 5° N. of Aldebaran	21 10	configurations
Sat.	21					are not given
Sun.	22					after May 15
Mon.	23				18 00	
Tues.	24	06		Saturn 6° N. of Moon		
Wed.	25	22	20	☽ First Quarter		
Thur.	26				14 50	
Fri.	27	18		Mercury greatest elong. W. (25°)		
Sat.	28					
Sun.	29				11 40	
Mon.	30	11		Uranus 0.9° S. of Moon. Occ'n.[2]		
Tues.	31					

[1]Visible in parts of N. America.
[2]Visible in parts of Asia.

THE SKY FOR JUNE 1977

We are all very much aware of the long duration of sunlight during this month, especially at the time of the summer solstice, the 21st this year. Look it up in the sunrise-sunset table, say for latitude 44 on the 21st. However, we are not so aware of the duration of full moonlight. The June full moon is on the 30th this year; so what could we expect for the duration of full moonlight that night, long or short? The answer is short. Why? Because the full moon is nearly opposite the sun therefore in June must have a very low declination and therefore should behave as to duration of time above the horizon very much as the sun does on December 21st. Confirm this by comparing the duration of full moonlight on June 30th to that of sunlight on December 21st, again using latitude 44. Do the figures bear out our prediction? Using the same kind of reasoning what can we say about the points of rising and setting of the June full moon?

The Sun—During June the sun's R.A. increases from 4 h 35 m to 6 h 39 m and its Decl. changes from 22° 00′ N. to 23° 08′ N. The equation of time changes from +2 m 14 s to −3 m 36 s, being zero on the 13th.

The Moon—On June 1.0, E.S.T., the age of the moon is 14.1^d. The sun's selenographic colongitude is 81.84° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on June 7 (8°) and minimum (east limb exposed) on June 23 (7°) The libration in latitude is maximum (north limb exposed) on June 18 (7°) and minimum (south limb exposed) on June 4 (7°).

Mercury on the 1st is in R.A. 2 h 58 m, Decl. 13° 31′ N., and on the 15th is in R.A. 4 h 22 m, Decl. 20° 12′ N. It is too close to the sun for observation and is in superior conjunction on the 29th.

Venus on the 1st is in R.A. 1 h 38 m, Decl. 7° 59′ N., and on the 15th it is in R.A. 2 h 26 m, Decl. 11° 36′ N., mag. −3.9, and transits at 8 h 54 m. It dominates the eastern sky for about two hours before sunrise. Greatest western elongation is on the 15th. It is in conjunction with Mars (again) on the 3rd, Mars passing 1.2 degrees south.

Mars on the 15th is in R.A. 2 h 18 m, Decl. 12° 47′ N., mag. +1.3, and transits at 8 h 45 m. Moving rapidly through Aries it can easily be found in the eastern sky during the two-to-three hour period before sunrise. (See Venus.)

Jupiter on the 15th is in R.A. 5 h 00 m, Decl. 22° 15′ N., mag. −1.5, and transits at 11 h 25 m. Conjunction being on the 4th, it is too close to the sun for observation early in the month, but by month's end it may be seen in the morning sky, very low in the north-east just before sunrise.

Saturn on the 15th is in R.A. 9 h 05 m, Decl. 17° 44′ N., mag. +0.6, and transits at 15 h 29 m. In Cancer, it is well down in the west at sunset and sets about three hours later.

Uranus on the 15th is in R.A. 14 h 24 m, Decl. 13° 47′ S., and transits at 20 h 47 m. Note the occultation by the moon on the 26th.

Neptune on the 15th is in R.A. 16 h 54 m, Decl. 21° 01′ S., and transits at 23 h 16 m.

1977				JUNE E.S.T.	Min. of Algol	
	d	h	m		h m	
Wed.	1	10		Moon at perigee (357,050 km)	8 30	
		15	31	Full Moon		
		21		Neptune 2° S. of Moon		
Thur.	2			Mercury at greatest hel. lat. S.		
Fri.	3	08		Venus 1.2° S. of Mars		
Sat.	4	05		Jupiter in conjunction with Sun	5 20	
Sun.	5	09		Neptune at opposition		
Mon.	6					
Tues.	7				2 10	
Wed.	8	10	07	Last Quarter		
Thur.	9				22 50	
Fri.	10					
Sat.	11					
Sun.	12	06		Mars 0.1° N. of Moon. Occ'n.[1]	19 40	
		10		Venus 2° S. of Moon		
Mon.	13					Jupiter being
Tues.	14	16		Moon at apogee (406,400 km)		near the sun
Wed.	15	00		Mercury 2° N. of Moon	16 30	configurations
		02		Venus greatest elong. W. (46°)		are not given
Thur.	16	10		Mercury 5° N. of Aldebaran		during June
		13	23	New Moon		
Fri.	17			Venus at aphelion		
Sat.	18				13 20	
Sun.	19					
Mon.	20	02		Mercury 0.1° N. of Jupiter		
		16		Saturn 6° N. of Moon		
Tues.	21			Mercury at ascending node	10 10	
		07	14	Solstice. Summer begins		
Wed.	22					
Thur.	23					
Fri.	24	07	44	First Quarter	7 00	
Sat.	25					
Sun.	26			Mercury at perihelion		
		19		Uranus 1° S. of Moon. Occ'n.[2]		
Mon.	27				3 50	
Tues.	28	16		Pluto stationary		
Wed.	29	06		Neptune 2° S. of Moon		
		19		Moon at perigee (359,150 km)		
		19		Mercury in superior conjunction		
Thur.	30	22	24	Full Moon	0 40	

[1]Visible in parts of S. America, W. Africa.
[2]Visible in parts of N. America, W. Europe, N.W. Africa.

THE SKY FOR JULY 1977

This is the month when the earth is at aphelion (on the 5th), its distance from the sun being 94,505,000 miles compared with 91,400,000 miles at perihelion on January 3rd. Thus it is 3.4% more distant than in January. Since the radiation which we receive from the sun varies inversely as the square of the sun's distance, the radiant energy on July 5th is less than on January 3rd by about 7%. This means that the northern hemisphere's climate is tempered by the earth's changing distance from the sun: summers are made a little cooler, winters a little warmer. The converse is true for the southern hemisphere. However, the fact is that the southern hemisphere's climate is tempered by a still more powerful influence arising from the fact that it is mostly water-covered and thus reacting more extremely to heating and cooling than the northern hemisphere which is more predominantly land-covered. Thus the northern hemisphere in the main still suffers more extremes than the southern, but to a lesser degree than if perihelion and aphelion were reversed.

The Sun—During July the sun's R.A. increases from 6 h 39 m to 8 h 44 m and its Decl. changes from 23° 08′ N. to 18° 06′ N. The equation of time changes from −3 m 48 s to a maximum of −6 m 28 s on the 26th and then to −6 m 19 s at the end of the month. The earth is in aphelion on the 5th at a distance of 152,091,000 km (94,505,000 miles) from the sun.

The Moon—On July 1.0, E.S.T., the age of the moon is 14.4^d. The sun's selenographic colongitude is 88.43° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on July 5 (7°) and minimum (east limb exposed) on July 21 (6°) The libration in latitude is maximum (north limb exposed) on July 15 (7°) and minimum (south limb exposed) on July 1 (7°) and July 29 (7°).

Mercury on the 1st is in R.A. 6 h 45 m, Decl. 24° 25′ N., and on the 15th is in R.A. 8 h 45 m, Decl. 19° 48′ N. It is too close to the sun for easy observation, though technically an evening star all month.

Venus on the 1st is in R.A. 3 h 30 m, Decl. 15° 59′ N., and on the 15th it is in R.A. 4 h 31 m, Decl. 19° 14′ N., mag. −3.7, and transits at 9 h 00 m. Venus is prominent in the eastern sky for about three hours before sunrise. At mid-month it passes about three degrees north of Aldebaran, and at the end of the month it is about a degree and a half south of Jupiter.

Mars on the 15th is in R.A. 3 h 44 m, Decl. 19° 05′ N., mag. +1.2, and transits at 8 h 13 m. Having moved into Taurus, it rises at about midnight. During the latter half of the month it just skirts the northern edge of the Hyades as it moves eastward.

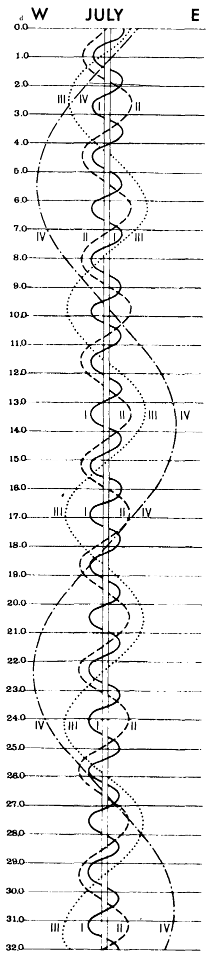
Jupiter on the 15th is in R.A. 5 h 29 m, Decl. 22° 49′ N., mag. −1.5, and transits at 9 h 56 m. In Taurus, it rises about two hours before the sun.

Saturn on the 15th is in R.A. 9 h 18 m, Decl. 16° 46′ N., mag. +0.7, and transits at 13 h 44 m. Moving from Cancer into Leo, it is very low in the west at sunset and sets soon after.

Uranus on the 15th is in R.A. 14 h 22 m, Decl. 13° 40′ S., and transits at 18 h 47 m.

Neptune on the 15th is in R.A. 16 h 51 m, Decl. 20° 57′ S., and transits at 21 h 15 m.

1977				JULY E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Fri.	1						
Sat.	2				21	20	
Sun.	3						
Mon.	4						
Tues.	5	15		Earth at aphelion	18	10	
Wed.	6			Mercury at greatest hel. lat. N.			
Thur.	7	23	39	☾ Last Quarter			
Fri.	8	16	39	Appulse: SAO 99401 & Pallas (pg.62)	15	00	
Sat.	9			Venus at greatest hel. lat. S.			
Sun.	10						
Mon.	11	06		Mars 2° N. of Moon	11	50	
Tues.	12	03		Moon at apogee (405,600 km)			
		04		Venus 1° N. of Moon. Occ'n.[1]			
		15		Juno stationary			
Wed.	13	14		Jupiter 4° N. of Moon			
Thur.	14				8	40	
Fri.	15	14		Venus 3° N. of Aldebaran			
Sat.	16	03	37	● New Moon			
		09		Uranus stationary			
Sun.	17	22		Mercury 6° N. of Moon	5	30	
Mon.	18	04		Saturn 6° N. of Moon			
Tues.	19	20		Mercury 0.4° N. of Saturn			
Wed.	20				2	20	
Thur.	21						
Fri.	22				23	00	
Sat.	23	14	38	☽ First Quarter			
Sun.	24	02		Uranus 1° S. of Moon. Occ'n.[2]			
Mon.	25				19	50	
Tues.	26	14		Neptune 3° S. of Moon			
Wed.	27	21		Moon at perigee (363,450 km)			
		22		Mercury 0.1° S. of Regulus			
Thur.	28				16	40	
Fri.	29	01		δ Aquarid meteors			
Sat.	30			Mercury at descending node			
		01		Venus 1.6° S. of Jupiter			
		05	52	○ Full Moon			
Sun.	31				13	30	



[1]Visible in S. Africa.
[2]Visible in Alaska.

THE SKY FOR AUGUST 1977

Mars, which is now in Taurus, begins this month to rise before midnight and so commands the attention of the average sky gazer. It hasn't been very exciting this year, being between oppositions (the last one in December 1975, the next one in January 1978). On average the interval between oppositions is 780 days which is known as the synodic period. This is about 50 days longer than two years, so that oppositions work their way through the calendar at the average rate of 50 days per opposition and the position of Mars at opposition works its way around the ecliptic at a corresponding rate. When opposition occurs in August or September it is very favourable because Mars is then near its perihelion and so its distance to the earth is close. September 1968 was such an opposition, but the 1978 opposition will be rather poor and the February 25 1980 opposition will be about as unfavourable as an opposition of Mars can be.

The Sun—During August the sun's R.A. increases from 8 h 44 m to 10 h 40 m and its Decl. changes from 18° 06′ N. to 8° 24′ N. The equation of time changes from −6 m 15 s to −0 m 14 s.

The Moon—On Aug. 1.0, E.S.T., the age of the moon is 15.8^d. The sun's selenographic colongitude is 107.23° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Aug. 2 (7°) and Aug. 30 (6°) and minimum (east limb exposed) on Aug. 16 (5°). The libration in latitude is maximum (north limb exposed) on Aug. 12 (7°) and minimum (south limb exposed) on Aug. 25 (7°).

Mercury on the 1st is in R.A. 10 h 26 m, Decl. 9° 31′ N., and on the 15th is in R.A. 11 h 13 m, Decl. 2° 02′ N. It is in greatest eastern elongation on the 8th but poorly placed for easy observation, being only about 10 degrees above the western horizon at sunset. Note the daytime occultation by the moon on the 16th.

Venus on the 1st is in R.A. 5 h 51 m, Decl. 21° 32′ N., and on the 15th it is in R.A. 7 h 00 m, Decl. 21° 35′ N., mag. −3.5, and transits at 9 h 28 m. Though considerably fainter than it was a few months ago, it is better placed for observation, being visible in the east for more than three hours before sunrise.

Mars on the 15th is in R.A. 5 h 13 m, Decl. 22° 45′ N., mag. +1.1, and transits at 7 h 39 m. Moving through Taurus, it rises before midnight and is well up in the east by dawn.

Jupiter on the 15th is in R.A. 5 h 56 m, Decl. 23° 02′ N., mag. −1.7, and transits at 8 h 21 m. Moving from Taurus into Gemini, it rises about four hours before the sun and is well up in the east by sunrise.

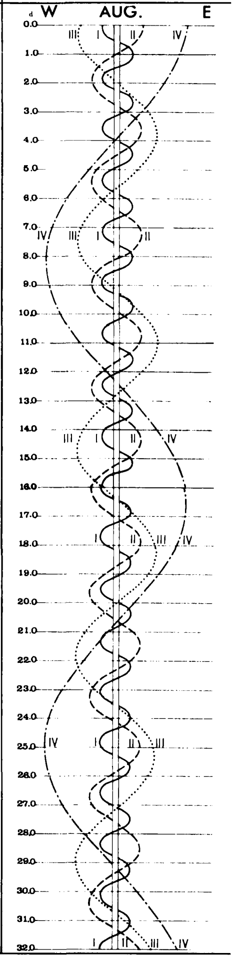
Saturn on the 15th is in R.A. 9 h 33 m, Decl. 15° 35′ N., mag. +0.6, and transits at 11 h 58 m. It is too close to the sun for easy observation, being in conjunction with the sun on the 13th.

Uranus on the 15th is in R.A. 14 h 23 m, Decl. 13° 48′ S., and transits at 16 h 47 m.

Neptune on the 15th is in R.A. 16 h 49 m, Decl. 20° 56′ S., and transits at 19 h 12 m.

1977		AUGUST E.S.T.			Min. of Algol
	d	h	m		h m
Mon.	1	07		Mars 5° N. of Aldebaran	
Tues.	2				
Wed.	3				10.20
Thur.	4				
Fri.	5				
Sat.	6	15	40	☾ Last Quarter	7 10
Sun.	7				
Mon.	8	15		Mercury greatest elong. E. (27°)	
		19		Moon at apogee (404,650 km)	
Tues.	9			Mercury at aphelion	4 00
		06		Mars 4° N. of Moon	
Wed.	10	08		Jupiter 4° N. of Moon	
Thur.	11	09		Venus 4° N. of Moon	
Fri.	12	06		Perseid meteors	0 40
Sat.	13	01		Saturn in conjunction with Sun	
Sun.	14	16	31	● New Moon	21 30
Mon.	15				
Tues.	16	18		Mercury 0.9° S. of Moon. Occ'n.[1]	
Wed.	17				18 20
Thur.	18				
Fri.	19				
Sat.	20	08		Uranus 2° S. of Moon	15 10
Sun.	21	18		Mercury stationary	
		20	04	☽ First Quarter	
Mon.	22	20		Neptune 3° S. of Moon	
Tues.	23	12		Venus 7° S. of Pollux	12 00
Wed.	24	04		Moon at perigee (368,400 km)	
Thur.	25	12		Neptune stationary	
Fri.	26				8 50
Sat.	27				
Sun.	28	15	10	○ Full Moon	
Mon.	29			Mercury at greatest hel. lat. S.	5 40
Tues.	30			Mars at ascending node	
Wed.	31				

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



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

THE SKY FOR SEPTEMBER 1977

There will be a penumbral eclipse of the moon on the night of the 26th–27th. Will it be perceptible by eye? Textbooks say that it will, providing the moon passes within 700 miles of the umbra. Let us see if this September eclipse will be perceptible according to this rule. At the moon's distance the average diameter of the earth's umbral shadow is about 5700 miles, of the penumbral shadow about 10,000 miles; and the moon's diameter is 2160 miles. The Handbook's section on eclipses says that the penumbral magnitude of this eclipse is 0.927, that is to say, at mid-eclipse this fraction of the moon's diameter is within the penumbra. This fraction of 2160 is 2002 miles. The difference between the penumbral radius and the umbral radius is 1/2 (10,000 − 5700) = 2150 miles. Thus the edge of the moon comes within 2150 − 2002 = 148 miles of the umbra. So darkening should be perceptible for about 700 − 148 = 552 miles or a little more than one quarter of the moon's diameter. A sketch would help to follow this reasoning.

The Sun—During September the sun's R.A. increases from 10 h 40 m to 12 h 28 m and its Decl. changes from 8° 24′ N. to 3° 03′ S. The equation of time changes from +0 m 05 s to +10 m 03 s.

The Moon—On Sept. 1.0, E.S.T., the age of the moon is 17.3^d. The sun's selenographic colongitude is 125.84° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Sept. 26 (5°) and minimum (east limb exposed) on Sept. 11 (5°). The libration in latitude is maximum (north limb exposed) on Sept. 8 (7°) and minimum (south limb exposed) on Sept. 21 (7°).

Mercury on the 1st is in R.A. 11 h 04 m, Decl. 1° 14′ N., and on the 15th is in R.A. 10 h 33 m, Decl. 8° 09′ N. On the 5th it is in inferior conjunction, but by the 21st it is at greatest western elongation, standing about 17 degrees above the eastern horizon at sunrise. In fact from about the 15th to the 30th Mercury should be easily found low in the eastern sky just before sunrise.

Venus on the 1st is in R.A. 8 h 25 m, Decl. 19° 06′ N., and on the 15th it is in R.A. 9 h 33 m, Decl. 15° 06′ N., mag. −3.4, and transits at 9 h 59 m. It is visible in the east for about three hours before sunrise. It is less than half a degree south of Saturn on the 18th and about the same amount north of Regulus on the 22nd.

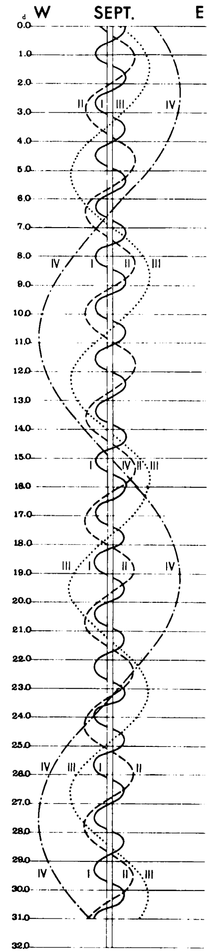
Mars on the 15th is in R.A. 6 h 37 m, Decl. 23° 28′ N, mag. +0.9, and transits at 7 h 01 m. In Gemini, it rises about five hours after sunset and is approaching the meridian at sunrise.

Jupiter on the 15th is in R.A. 6 h 16 m, Decl. 23° 00′ N., mag. −1.8, and transits at 6 h 39 m. In Gemini, it rises before midnight and is nearing the meridian at sunrise.

Saturn on the 15th is in R.A. 9 h 49 m, Decl. 14° 22′ N., mag. +0.8, and transits at 10 h 11 m. In Leo near Regulus, it is now a morning star rising one or two hours before the sun.

Uranus on the 15th is in R.A. 14 h 28 m, Decl. 14° 11′ S., and transits at 14 h 49 m.

Neptune on the 15th is in R.A. 16 h 49 m, Decl. 20° 58′ S., and transits at 17 h 10 m.

1977				SEPTEMBER E.S.T.	Min. of Algol		Configuration of Jupiter's Satellites (Date Markers are U.T.)
	d	h	m		h	m	
Thur.	1				2	20	
Fri.	2						
Sat.	3				23	10	
Sun.	4			Venus at ascending node			
		17		Mars 0.5° N. of Jupiter			
Mon.	5	01		Mercury in inferior conjunction			
		09	33	☾ Last Quarter			
		13		Moon at apogee (404,200 km)			
Tues.	6				20	00	
Wed.	7	02		Jupiter 5° N. of Moon			
		04		Mars 5° N. of Moon			
Thur.	8						
Fri.	9				16	50	
Sat.	10	16		Venus 5° N. of Moon			
Sun.	11	08		Saturn 5° N. of Moon			
Mon.	12				13	40	
Tues.	13	04	23	● New Moon			
		14		Mercury stationary			
Wed.	14						
Thur.	15	03		Vesta in conjunction with Sun	10	30	
Fri.	16	16		Uranus 2° S. of Moon			
Sat.	17			Mercury at ascending node			
Sun.	18	04		Moon at perigee (369,100 km)	7	20	
		08		Venus 0.4° S. of Saturn			
Mon.	19	02		Neptune 3° S. of Moon			
Tues.	20	01	18	☽ First Quarter			
Wed.	21	03		Mercury greatest elong. W. (18°)	4	00	
		22		Venus 0.4° N. of Regulus			
Thur.	22			Mercury at perihelion			
		22	30	Equinox. Autumn begins			
Fri.	23						
Sat.	24				0	50	
Sun.	25						
Mon.	26				21	40	
Tues.	27	03	17	○ Full Moon. Harvest Moon Penumbral Eclipse of ☾, pg. 61			
Wed.	28						
Thur.	29				18	30	
Fri.	30						

THE SKY FOR OCTOBER 1977

October is a good month for star-gazing. It's not too cold, sunset is not too late and there are many interesting constellations to be seen in the evening. Also if you have never been very clear about right ascension and declination, this time of year is a good time to learn, because it is easy at this time to locate the starting point for the equatorial coordinate system, i.e. the vernal equinox or the first point of Aries. Suppose we go out about an hour after sunset. First look to the north-west and locate the big dipper; then follow the pointers at the bowl-end to locate Polaris. In the north-east, across Polaris from the big dipper, is the W-shaped constellation Cassiopeia; and a little to the south and east of Cassiopeia is the Great Square of Pegasus (of which one star, Alpheratz, isn't in Pegasus, but in Andromeda). Let us use the terms preceding and following to designate west and east in the sky, e.g. the preceding end of the W of Cassiopeia, Beta Cassiopeiae, is the star that goes first in the diurnal motion. Conversely the side of the Great Square which is made up of Alpheratz and Gamma Pegasi is known as the following side. Now we are ready to locate the Vernal Equinox. Starting at Polaris we move through the preceding star of the W and along the following side of the Great Square and continue on this line about a Square's length beyond Gamma Pegasi and we arrive pretty close to the Vernal Equinox (or the First Point of Aries—which, by the way, isn't in the constellation Aries any more, but in Pisces). Try this several times during the month and notice how the First Point of Aries is marching westward week by week as we observe it at the same time of night.

We will proceed to the equatorial system of right ascension and declination in this same space on the November page.

The Sun—During October the sun's R.A. increases from 12 h 28 m to 14 h 24 m and its Decl. changes from 3° 03′ S. to 14° 19′ S. The equation of time changes from +10 m 23 s to +16 m 21 s.

The Moon—On Oct. 1.0, E.S.T., the age of the moon is 17.8^{d}. The sun's selenographic colongitude is 131.87° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Oct. 22 (6°) and minimum (east limb exposed) on Oct. 9 (6°). The libration in latitude is maximum (north limb exposed) on Oct. 5 (7°) and minimum (south limb exposed) on Oct. 18 (7°).

Mercury on the 1st is in R.A. 11 h 41 m, Decl. 4° 04′ N., and on the 15th is in R.A. 13 h 11 m, Decl. 6° 12′ S. It is poorly placed for observation, being in superior conjunction on the 18th.

Venus on the 1st is in R.A. 10 h 49 m, Decl. 8° 49′ N., and on the 15th it is in R.A. 11 h 53 m, Decl. 2° 23′ N., mag. −3.4, and transits at 10 h 20 m. It is a morning star, rising in the east about two hours before the sun.

Mars on the 15th is in R.A. 7 h 47 m, Decl. 22° 09′ N., mag. +0.6, and transits at 6 h 12 m. Moving from Gemini into Cancer, it rises well before midnight and is past the meridian by sunset. Watch it line up with Castor and Pollux on or about the 16th.

Jupiter on the 15th is in R.A. 6 h 26 m, Decl. 22° 56′ N., mag. −2.0, and transits at 4 h 51 m. In Gemini, it rises in the evening and is well past the meridian at sunrise. On the 24th it is stationary and begins to retrograde or move westward among the stars.

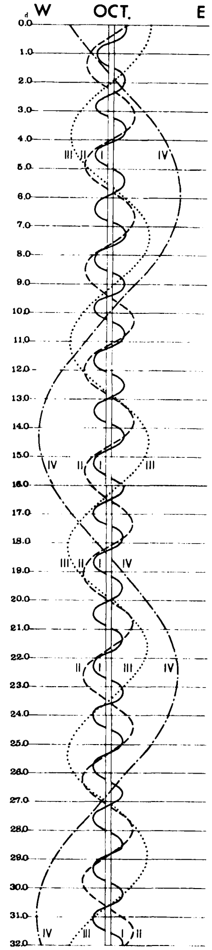
Saturn on the 15th is in R.A. 10 h 01 m, Decl. 13° 21′ N., mag. +0.8, and transits at 8 h 25 m. In Leo near Regulus, it rises about four hours before the sun.

Uranus on the 15th is in R.A. 14 h 34 m, Decl. 14° 42′ S., and transits at 12 h 58 m.

Neptune on the 15th is in R.A. 16 h 52 m, Decl. 21° 03′ S., and transits at 15 h 15 m.

1977				OCTOBER E.S.T.	Min. of Algol
	d	h	m		h m
Sat.	1				
Sun.	2			Mercury at greatest hel. lat. N.	15 20
Mon.	3	05		Occ'n: SAO 98871 by Saturn (pg. 62)	
		09		Moon at apogee (404,650 km)	
Tues.	4	16		Jupiter 5° N. of Moon	
Wed.	5	04	21	☾ Last Quarter	12 10
		22		Mars 6° N. of Moon	
Thur.	6				
Fri.	7			Venus at perihelion	
		07		Pluto in conjunction with Sun	
Sat.	8	23		Saturn 5° N. of Moon	9 00
Sun.	9				
Mon.	10	20		Venus 4° N. of Moon	
Tues.	11				5 40
Wed.	12	15	31	● New Moon. Eclipse of ⊙, pg. 61	
Thur.	13	09		Mars 6° S. of Pollux	
Fri.	14	02		Uranus 2° S. of Moon	2 30
Sat.	15	04		Moon at perigee (364,200 km)	
Sun.	16	09		Neptune 3° S. of Moon	23 20
Mon.	17				
Tues.	18	18		Mercury in superior conjunction	
		20		Pallas in conjunction with Sun	
Wed.	19	07	46	☽ First Quarter	20 10
Thur.	20				
Fri.	21	07		Orionid meteors	
Sat.	22				17 00
Sun.	23				
Mon.	24	06		Jupiter stationary	
Tues.	25				13 50
Wed.	26			Mercury at descending node	
		18	35	○ Full Moon. Hunter's Moon.	
Thur.	27				
Fri.	28				10 40
Sat.	29			Venus at greatest hel. lat. N.	
Sun.	30				
Mon.	31	03		Moon at apogee (405,600 km)	7 30

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



THE SKY FOR NOVEMBER 1977

Some clear evening this month let us locate the First Point of Aries again (see this space for last month): from Polaris through the preceding star of Cassiopeia's W, along the following side of the Great Square and a Square's length farther. Now imagine (or sweep out with your arms) a great circle passing through the east and west points of the horizon and through the First Point of Aries; it should cut the meridian at an altitude of 90 degrees minus your latitude (e.g. 47 degrees if you are at latitude 43). This circle is the celestial equator and it is along this circle that right ascension is measured, (in hours where one hour = 15 degrees) starting at the First Point of Aries and proceeding *eastward* to the hour circle (great circle through the pole of the sky and perpendicular to the equator) which passes through the point in question. Example: Alpheratz is *on* the great circle which we used to find the First Point of Aries, therefore the right ascension of Alpheratz is 0 hours. Declination is defined as the angular distance (in degrees) north or south along the star's hour circle from the equator to the star. Example: a square's length is about 14 degrees; thus Alpheratz as we used it in locating the First Point of Aries is about 28 degrees north of the equator; its declination then is +28° or 28° N. Notice that the stars to the east of the hour circle of the First point of Aries have right ascensions 1, 2, 3 etc. hours; those to the west have right ascensions 23, 22, 21 etc. hours. Identify Altair in the constellation Aquila; can you convince yourself that its right ascension is close to 20 hours and its declination close to +9°? Or Vega, 18½ hours, +40° ?

A few hours of practice with star maps and sky will soon make the equatorial coordinate system meaningful.

The Sun—During November the sun's R.A. increases from 14 h 24 m to 16 h 28 m and its Decl. changes from 14° 19′ S. to 21° 45′ S. The equation of time changes from +16 m 23 s to a maximum of +16 m 24 s on the 3rd and then to +11 m 14 s at the end of the month.

The Moon—On Nov. 1.0, E.S.T., the age of the moon is 19.3^{d}. The sun's selenographic colongitude is 149.58° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Nov. 18 (7°) and minimum (east limb exposed) on Nov. 6 (7°) The libration in latitude is maximum (north limb exposed) on Nov. 1 (7°) and Nov. 29 (7°) and minimum (south limb exposed) on Nov. 14 (7°).

Mercury on the 1st is in R.A. 14 h 56 m, Decl. 17° 25′ S., and on the 15th is in R.A. 16 h 23 m, Decl. 23° 34′ S. Though technically an evening star all month it is too close to the sun for observation.

Venus on the 1st is in R.A. 13 h 11 m, Decl. 5° 50′ S., and on the 15th it is in R.A. 14 h 17 m, Decl. 12° 16′ S., mag. −3.4, and transits at 10 h 42 m. It is a morning star rising in the south-east about an hour before the sun.

Mars on the 15th is in R.A. 8 h 40 m, Decl. 20° 21′ N., mag. +0.2, and transits at 5 h 00 m. In Cancer, it rises about five hours after sunset and is well past the meridian at dawn.

Jupiter on the 15th is in R.A. 6 h 23 m, Decl. 23° 00′ N., mag. −2.2, and transits at 2 h 46 m. In Gemini, it rises about three hours after sunset and is visible during the rest of the night.

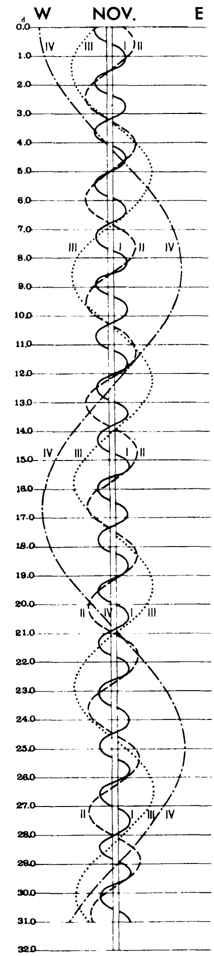
Saturn on the 15th is in R.A. 10 h 10 m, Decl. 12° 40′ N., mag. +0.8, and transits at 6 h 32 m. In Leo near Regulus (passing less than a degree to the north of it on the 3rd) it rises about at midnight and is past the meridian by sunrise.

Uranus on the 15th is in R.A. 14 h 42 m, Decl. 15° 18′ S., and transits at 11 h 03 m.

Neptune on the 15th is in R.A. 16 h 56 m, Decl. 21° 11′ S., and transits at 13 h 17 m.

1977				NOVEMBER E.S.T.	Min. of Algol	
	d	h	m		h	m
Tues.	1	00		Jupiter 5° N. of Moon		
Wed.	2					
Thur.	3	07		Saturn 0.8° N. of Regulus	4	20
		09		Mars 7° N. of Moon		
		15		Venus 4° N. of Spica		
		22	58	☾ Last Quarter		
Fri.	4			Taurid meteors		
		11		Uranus in conjunction with Sun		
Sat.	5			Mercury at aphelion		
		13		Saturn 5° N. of Moon		
Sun.	6				1	00
Mon.	7					
Tues.	8				21	50
Wed.	9	19		Venus 0.1° N. of Moon. Occ'n.[1]		
Thur.	10					
Fri.	11	02	09	● New Moon	18	40
Sat.	12	07		Moon at perigee (359,300 km)		
		19		Neptune 3° S. of Moon		
Sun.	13					
Mon.	14				15	30
Tues.	15	14		Mercury 3° N. of Antares		
Wed.	16	23		Leonid meteors		
Thur.	17	16	52	☽ First Quarter	12	20
Fri.	18					
Sat.	19					
Sun.	20	03		Mercury 4° S. of Neptune	9	10
		05		Venus 0.9° N. of Uranus		
Mon.	21					
Tues.	22					
Wed.	23	00		Ceres in conjunction with Sun	6	00
Thur.	24					
Fri.	25			Mercury at greatest hel. lat. S.		
		12	31	○ Full Moon		
Sat.	26				2	50
Sun.	27	16		Moon at apogee (406,350 km)		
Mon.	28	03		Jupiter 5° N. of Moon	23	40
Tues.	29					
Wed.	30					

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



[1]Visible in parts of Australia, New Zealand, S.E. Asia.

THE SKY FOR DECEMBER 1977

Jupiter reaches opposition this month—on the 22nd. This means that, as seen from earth, Jupiter is opposite to the sun in position. Therefore Jupiter this year will have declination near $23\frac{1}{2}°$ N at opposition since the sun on the 22nd (near the winter solstice) has declination $23\frac{1}{2}°$ S. Also it follows that Jupiter must rise just at sunset and set just at sunrise. Furthermore the times of rising and setting of the planet on December 22nd should be nearly the same as the times of sunrise and sunset on June 22nd. Another thing that happens at and near opposition for any planet is that the planet is retrograding, i.e. moving westward among the stars. Jupiter has been retrograding since October 24 and will continue to retrograde until late February. A planet is said to be stationary when it is changing from direct to retrograde motion or from retrograde to direct. It is easy to understand why Jupiter, for example, must be retrograding at opposition if we sketch the orbits of the earth and Jupiter as circles with radii in the ratio of 1 to 5. Now line earth and Jupiter up with the sun, both planets on the same side; this is the configuration at opposition. Since Jupiter has a period of revolution of nearly 12 years the earth's angular velocity is about 12 times that of Jupiter. Therefore the earth's rapid motion eastward will cause Jupiter to appear to be moving westward (retrograding). On the other hand when the planets are lined up on opposite sides of the sun (conjunction of Jupiter) both the apparent motion of Jupiter arising from the earth's motion and the real motion of Jupiter are eastward and so we have direct motion of Jupiter. Therefore at some point on each side of opposition Jupiter must be stationary. The longer the period of the planet the longer the time between stationary point and opposition. For Mars it is about 39 days, for Jupiter about two months.

The Sun—During December the sun's R.A. increases from 16 h 28 m to 18 h 44 m and its Decl. changes from 21° 45′ S. to 23° 03′ S. The equation of time changes from +10 m 52 s to −3 m 08 s, being zero on the 25th.

The Moon—On Dec. 1.0, E.S.T., the age of the moon is 19.9^{d}. The sun's selenographic colongitude is 154.65° and increases by 12.2° each day thereafter. The libration in longitude is maximum (west limb exposed) on Dec. 16 (8°) and minimum (east limb exposed) on Dec. 5 (8°). The libration in latitude is maximum (north limb exposed) on Dec. 26 (7°) and minimum (south limb exposed) on Dec. 12 (7°).

Mercury on the 1st is in R.A. 17 h 59 m, Decl. 25° 49′ S., and on the 15th is in R.A. 18 h 29 m, Decl. 23° 15′ S. Its greatest eastern elongation on the 3rd is an unfavourable one, Mercury standing only about 10 degrees above the south-western horizon at sunset. By the 21st it is in inferior conjunction.

Venus on the 1st is in R.A. 15 h 36 m, Decl. 18° 24′ S., and on the 15th it is in R.A 16 h 50 m, Decl. 22° 04′ S., mag. −3.4, and transits at 11 h 16 m. Though still a morning star, it is now so close to the sun as to be difficult to observe.

Mars on the 15th is in R.A. 9 h 00 m, Decl. 20° 20′ N., mag. −0.4, and transits at 3 h 24 m. In Cancer and now brightening perceptibly, it rises about five hours after sunset and is well past the meridian at dawn. Anticipating opposition, it is stationary on the 13th and begins to retrograde, or move westward among the stars.

Jupiter on the 15th is in R.A. 6 h 09 m, Decl. 23° 09′ N., mag. −2.3, and transits at 0 h 34 m. In Gemini, it rises about as the sun sets; opposition is on the 22nd.

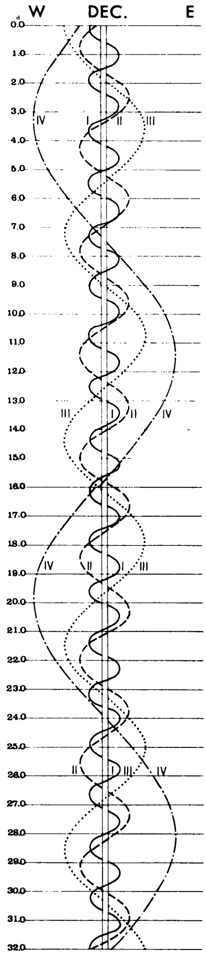
Saturn on the 15th is in R.A. 10 h 12 m, Decl. 12° 33′ N., mag. +0.7, and transits at 4 h 37 m. In Leo near Regulus, it rises late in the evening and is visible the rest of the night. On the 12th it is stationary and begins to retrograde, i.e. move westward among the stars.

Uranus on the 15th is in R.A. 14 h 49 m, Decl. 15° 49′ S., and transits at 9 h 12 m.

Neptune on the 15th is in R.A. 17 h 00 m, Decl. 21° 18′ S., and transits at 11 h 24 m.

1977				DECEMBER E.S.T.	Min. of Algol
	d	h	m		h m
Thur.	1	08		Mars 7° N. of Moon	20 20
		08	09	Appulse: SAO 139709 & Vesta, (pg 62)	
Fri.	2	22		Saturn 5° N. of Moon	
Sat.	3	03		Mercury greatest elong. E. (21°)	
		16	16	☾ Last Quarter	
Sun.	4				17 10
Mon.	5				
Tues.	6				
Wed.	7	21		Neptune in conjunction with Sun	14 00
Thur.	8	05		Uranus 2° S. of Moon	
Fri.	9				
Sat.	10	12	33	● New Moon	10 50
		18		Venus 5° N. of Antares	
		18		Moon at perigee (356,700 km)	
Sun.	11	19		Mercury stationary	
		19		Mercury 6° S. of Moon	
Mon.	12	02		Saturn stationary	
Tues.	13	14		Mars stationary	7 40
		22		Geminid meteors	
Wed.	14			Mercury at ascending node	
Thur.	15	12		Juno in conjunction with Sun	
Fri.	16				4 30
Sat.	17	05	37	☽ First Quarter	
Sun.	18				
Mon.	19			Mercury at perihelion	1 20
Tues.	20				
Wed.	21	09		Mercury in inferior conjunction	22 10
		18	24	Solstice. Winter begins	
Thur.	22	13		Ursid meteors	
		20		Jupiter at opposition	
Fri.	23				
Sat.	24			Venus at descending node	19 00
		16		Moon at apogee (406,500 km)	
Sun.	25	02		Jupiter 5° N. of Moon	
		07	49	○ Full Moon	
Mon.	26				
Tues.	27				15 50
Wed.	28	13		Mars 8° N. of Moon	
Thur.	29			Mercury at greatest hel. lat. N.	
Fri.	30	04		Saturn 5° N. of Moon	12 40
Sat.	31	18		Mercury stationary	

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



SUN—EPHEMERIS FOR PHYSICAL OBSERVATIONS, 1977
For 0 h U.T.

Date		P	B_0	L_0	Date		P	B_0	L_0
		°	°	°			°	°	°
Jan.	1	+ 2.07	−3.06	357.89	July	5	− 0.93	+3.33	76.16
	6	− 0.35	−3.63	292.04		10	+ 1.34	+3.85	9.98
	11	− 2.76	−4.17	226.19		15	+ 3.58	+4.35	303.82
	16	− 5.12	−4.68	160.35		20	+ 5.78	+4.82	237.66
	21	− 7.43	−5.15	94.52		25	+ 7.92	+5.25	171.51
	26	− 9.64	−5.59	28.69		30	+ 9.98	+5.65	105.37
	31	−11.76	−5.97	322.86	Aug.	4	+11.97	+6.01	39.24
Feb.	5	−13.77	−6.31	257.02		9	+13.86	+6.33	333.13
	10	−15.66	−6.60	191.19		14	+15.64	+6.60	267.03
	15	−17.41	−6.84	125.35		19	+17.31	+6.83	200.94
	20	−19.02	−7.03	59.51		24	+18.86	+7.01	134.87
	25	−20.49	−7.16	353.66		29	+20.28	+7.14	68.81
Mar.	2	−21.80	−7.23	287.80	Sept.	3	+21.57	+7.22	2.76
	7	−22.95	−7.25	221.92		8	+22.72	+7.25	296.72
	12	−23.94	−7.21	156.04		13	+23.72	+7.23	230.70
	17	−24.77	−7.12	90.14		18	+24.56	+7.15	164.69
	22	−25.42	−6.97	24.22		23	+25.25	+7.02	98.69
	27	−25.90	−6.78	318.29		28	+25.78	+6.84	32.70
Apr.	1	−26.20	−6.53	252.33	Oct.	3	+26.13	+6.61	326.72
	6	−26.33	−6.23	186.36		8	+26.31	+6.33	260.75
	11	−26.27	−5.89	120.36		13	+26.30	+6.00	194.80
	16	−26.03	−5.51	54.35		18	+26.11	+5.62	128.84
	21	−25.60	−5.09	348.32		23	+25.73	+5.21	62.90
	26	−24.99	−4.63	282.26		28	+25.16	+4.75	356.96
May	1	−24.20	−4.14	216.19	Nov.	2	+24.39	+4.25	291.02
	6	−23.23	−3.63	150.10		7	+23.42	+3.73	225.10
	11	−22.08	−3.09	83.99		12	+22.25	+3.17	159.18
	16	−20.76	−2.53	17.87		17	+20.90	+2.58	93.26
	21	−19.28	−1.95	311.73		22	+19.36	+1.98	27.35
	26	−17.64	−1.36	245.58		27	+17.65	+1.36	321.45
	31	−15.87	−0.76	179.42	Dec.	2	+15.77	+0.73	255.55
June	5	−13.97	−0.15	113.24		7	+13.75	+0.09	189.67
	10	−11.96	+0.45	47.07		12	+11.60	−0.55	123.78
	15	− 9.86	+1.05	340.89		17	+ 9.34	−1.19	57.91
	20	− 7.69	+1.64	274.70		22	+ 7.01	−1.82	352.04
	25	− 5.46	+2.22	208.52		27	+ 4.62	−2.43	286.18
	30	− 3.20	+2.79	142.34		32	+ 2.19	−3.03	220.32

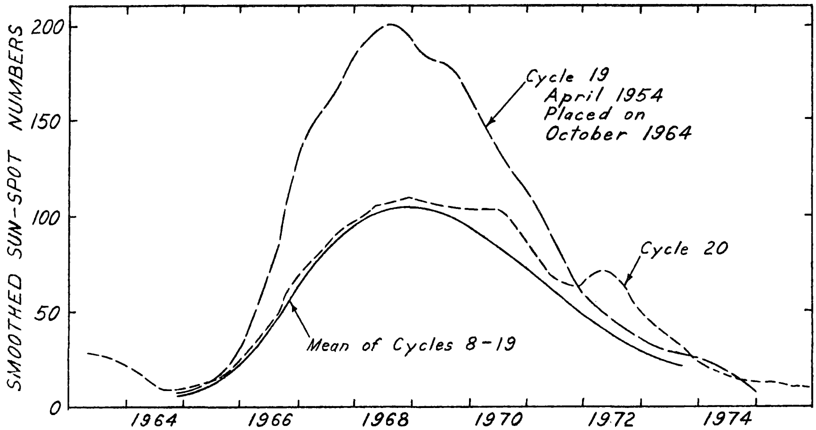
P—is the position angle of the axis of rotation, measured eastward from the north point on the disk, B_0 is the heliographic latitude of the centre of the disk, and L_0 is the heliographic longitude of the centre of the disk, from Carrington's solar meridian, measured in the direction of rotation.

CARRINGTON'S ROTATION NUMBERS—GREENWICH DATE OF COMMENCEMENT OF SYNODIC ROTATION, 1977

No.	Commences		No.	Commences		No.	Commences	
1650	Dec.	31.84	1655	May	17.35	1660	Sept.	30.48
1651	Jan.	28.18	1656	June	13.56	1661	Oct.	27.77
1652	Feb.	24.52	1657	July	10.75	1662	Nov.	24.08
1653	Mar.	23.84	1658	Aug.	6.97	1663	Dec.	21.40
1654	Apr.	20.12	1659	Sept.	3.21			

SUN-SPOTS

The diagram compares the sun-spot activity for cycles 19 and 20 (immediately past), with the mean of that for cycles 8 to 19. A protracted minimum in sun-spot activity has extended throughout 1975 into 1976. Early sightings of sun-spots belonging to the new cycle 21 were made by Gillespie (Kitt Peak) on 22 August 1973 at solar latitude 45° S and by Waldmeier (Zurich) on 15 November 1974 at solar latitude 36° N.



ECLIPSES DURING 1977

In 1977 there will be four eclipses, two of the sun and two of the moon.

1. *A partial eclipse of the moon* on the night of April 3–4, visible in North America except the extreme northwestern part.

Moon enters penumbra	Apr. 3	21.05 E.S.T.
Moon enters umbra		22.30 E.S.T.
Middle of eclipse		23.18 E.S.T.
Moon leaves umbra	Apr. 4	0.06 E.S.T.
Moon leaves penumbra		1.32 E.S.T.

Magnitude of eclipse 0.198

2. *An annular eclipse of the sun* on April 18 visible as an annular eclipse in a narrow path across the eastern part of the South Atlantic Ocean, across southern Africa and the western part of the Indian Ocean, visible as a partial eclipse in the southern parts of Africa and Asia and in the South Atlantic Ocean and the Indian Ocean.

3. *A penumbral eclipse of the moon* on the night of September 26–27, visible in North America except the north-eastern part.

Moon enters penumbra	Sept. 27	1.18 E.S.T.
Middle of eclipse		3.29 E.S.T.
Moon leaves penumbra		5.40 E.S.T.

Penumbral magnitude of eclipse 0.927

4. *A total eclipse of the sun* on October 12, the path of totality being almost entirely in the Pacific Ocean, except that it traverses Colombia just as the sun is setting. All of North America except the northern parts of Canada will experience a partial eclipse, the middle of the eclipse occurring about at mid-day on the west coast and in the late afternoon on the east coast.

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).

PLANETARY APPULSES AND OCCULTATIONS

A planetary appulse is a close approach of a star and a solar system object, as seen from the earth. According to Gordon E. Taylor, of H. M. Nautical Almanac Office, the following appulses will occur in 1977, and may be of interest to observers. The geocentric separation, in declination, is given in the sense planet *minus* star. The horizontal parallax is the angle subtended at the planet by the earth's equatorial radius. Times are given in U.T.; to get E.S.T., subtract 5 hours.

Planet	Date	U.T. of conjunction	Star Name or SAO No.	Vis. Mag.	Geocentric Separation	Horizontal Parallax
		h m			″	″
Saturn	Oct. 3	10 28	98871	8.3	−2.5	0.9
Uranus	Mar. 10	20 55	158687	8.8	−0.7	0.5
Pallas	Jan. 21	07 04	176953	9.4	+0.2	6.6
Pallas	Jan. 21	16 52	176943	9.4	+0.6	6.6
Pallas	July 8	21 39	99401	8.3	−0.9	3.1
Juno	Jan. 17	04 47	140546	9.1	+5.8	2.5
Vesta	Dec. 1	13 09	139709	8.8	+7.2	3.0

The following appulses give rise to observable occultations: that of SAO 98871 by Saturn and its rings, visible in North America; that of SAO 158687 by Uranus, visible in western Australia, Indonesia, parts of Asia and Africa; that of SAO 176943 by Pallas, visible in Australia and New Zealand, and that of SAO 99401 by Pallas, visible in South America. The visibility of the occultation of SAO 98871 by Saturn and its rings (outer edge) is as follows:

By	At	Disappearance			Reappearance		
		U.T.	P	Alt.	U.T.	P	Alt.
		h m	°	°	h m	°	°
Saturn	Texas	low			10 50	307	22
	Toronto	09 52	90	25	sun		
Rings	Texas	low			not vis.		
	Toronto	09 34	97	21	sun		

In the table, P is the position angle on the planet, alt is the altitude of the planet.

OCCULTATIONS BY THE MOON

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. This is referred to as immersion (I). The reappearance from behind the west limb of the moon is called emersion (E). 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 elongation of the moon is its angular distance 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. When elongation is less than 180°, a star will disappear at the dark limb and reappear at the bright limb. If the elongation is greater than 180° the reverse is true.

As in the case of eclipses, the times of immersion and emersion and the duration of the occultation are different for different places on the earth's surface. The tables given below, are adapted from data supplied by the British Nautical Almanac Office and give the times of immersion or emersion or both for occultations visible from six stations distributed across Canada. Stars of magnitude 7.5 or brighter are included as well as daytime occultations of very bright stars and planets. Since an occultation at the bright limb of the moon is difficult to observe the predictions are limited to phenomena occurring at the dark limb.

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 neighbouring station then for the neighbouring station we have: Standard Time of phenomenon = Standard Time 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. The quantity P is the position angle of the point of contact on the moon's disk reckoned from the north point towards the east.

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 a 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 included: (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 100 feet, (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.

The co-ordinates of the standard stations are given in the tables.

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	HALIFAX W. 63°6, N. 44°6 A.S.T.	a	b	P	MONTREAL W. 73°6, N. 45°5 E.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Jan. 3	764d	5.0	I	154	2 56.3	−0.5	−1.9	107	1 48.5	−0.7	−2.1	113
21	3248	6.6	I	30	Low				17 55.1	−1.0	−1.9	102
22	3366d	6.6	I	41	17 52.4	−0.6	+1.1	27	Sun			
23	3508	5.8	I	54	19 59.1	−0.8	−1.7	96	18 48.0	−1.1	−1.2	87
27	445	7.3	I	99	21 20.0	−1.5	−0.5	73	20 03.5	−1.7	+0.1	69
28	577	6.0	I	111	23 45.7	—	—	19	22 31.4	—	—	25
30	832	4.7	I	132	21 37.9	−1.9	−2.1	127	20 16.3	−2.0	−1.4	123
30	836	5.5	I	133	22 37.7	−1.4	−3.2	139	21 18.7	−1.8	−3.1	139
Feb. 7	1807	5.9	E	232	23 27.1	−0.3	−0.7	331	Low			
9	1945	5.4	E	245	0 10.6	+0.2	2.1	351	Low			
10	4007	5.7	E	261	6 27.0	−1.8	−0.6	277	5 08.7	−1.8	0.0	272
25	648	3.9	I	90	21 58.1	−0.7	−2.4	118	20 46.8	−1.1	−2.6	121
25	653	4.8	I	91	22 52.3	+0.3	−4.5	152	21 50.6	—	—	163
25	658d	4.2	I	91	No occ.				Graze			
26	764d	5.0	I	100	18 13.3	—	—	22	No occ.			
26	787d	7.5	I	102	23 49.2	−0.7	−0.9	70	22 40.3	−0.9	−1.0	77
28	934	6.4	I	114	1 22.2	−0.3	−1.1	76	0 16.9	−0.5	−1.3	83
Mar. 1	1073	6.0	I	125	1 38.9	—	—	173	No. occ.			
2	1309	5.7	I	148	22 17.1	−2.5	+1.7	60	20 55.4	−2.1	+1.7	68
2/3	1318	5.7	I	149	0 41.1	−1.2	−1.6	110	23 26.7	−1.4	−1.6	119
9	2053	4.6	E	229	3 28.2	−0.8	−2.2	345	2 17.9	−0.9	−1.3	333
11	2331	6.4	E	255	2 05.9	−0.9	+0.7	288	Low			
14	2826	4.0	I	297	5 58.6	−1.5	+0.7	102	4 46.5	−1.1	+0.9	104
27	1011	7.4	I	92	20 55.7	−1.6	−0.7	79	19 37.8	−1.8	−0.6	85
28/9	1145	6.7	I	105	0 29.4	−0.2	−1.7	109	23 24.8	−0.4	−1.9	116
28/9	1147	5.1	I	105	0 37.7	−0.6	−0.7	61	23 30.0	−0.8	−0.9	69
29	1256	7.1	I	116	22 44.0	−1.7	−0.6	73	21 25.8	−1.8	−0.6	83
30	1359	5.1	I	127	18 59.3	−1.1	−2.9	162	Sun			
31	1384	7.4	I	130	1 55.3	−0.4	−1.5	97	0 49.0	−0.6	−1.6	103
Apr. 8	2436d	6.3	E	238	2 04.7	−1.8	+1.6	240	0 49.6	−1.6	+2.2	231
10	2764	6.3	E	265	2 38.0	−1.5	+2.9	212	Low			
22	823d	6.6	I	51	21 00.2	−0.7	0.0	47	19 51.7	−0.9	−0.3	56
22	829	7.0	I	51	Low				21 00.2	−0.3	−1.0	73
23	970	6.5	I	62	21 48.9	−0.2	−1.4	91	20 44.1	−0.5	−1.6	98
23	975d	6.8	I	63	22 34.4	+0.3	−1.9	121	21 34.4	+0.1	−2.2	128
24	1096	5.3	I	74	23 01.8	+0.8	−3.5	166	Graze			
29	1564d	6.6	I	123	No. occ.				1 06.3	—	—	33
May 24	1397d	5.5	I	78	22 32.9	+0.1	−2.7	157	21 31.0	+0.1	−3.1	165
June 24	1807	5.9	I	97	22 01.0	−1.1	−1.2	85	20 47.3	−1.4	−1.1	89
24	1817	6.9	I	98	Low				22 21.8	−0.8	−1.4	91
25	1945	5.4	I	110	23 13.4	−0.9	−0.9	73	22 01.5	−1.3	−0.8	73
July 3	3169	6.2	E	221	23 59.0	−1.1	+1.9	230	22 51.2	−0.8	+2.0	233
25	2313	7.0	I	119	22 18.8	−1.4	−1.0	96	21 02.7	−1.6	−0.6	94
25	2316	6.4	I	119	23 16.6	−1.2	−1.5	109	22 02.4	−1.4	−1.2	104
26	2463	6.9	I	133	22 29.3	−1.6	−0.5	82	21 12.5	−1.7	0.0	79
29	2826	4.0	I	162	1 49.8	−1.2	−1.0	91	0 36.0	−1.4	−0.5	79
Aug. 1	3269	4.3	I	203	2 58.5	−2.4	−1.6	114	1 35.8	−2.0	−0.2	96
1	3269	4.3	E	203	3 47.5	−0.4	+1.9	195	2 41.5	−1.0	+1.1	213
2/3	3520	6.0	E	226	0 03.4	−0.2	+3.5	186	23 02.8	−0.4	+2.8	199
16	4001	0.9	I	24	Low				18 59.3	−0.2	−1.7	105
23	2571	6.9	I	115	21 54.5	−1.7	−1.4	117	20 36.1	−1.8	−0.8	109
23	2573	7.3	I	115	22 31.5	—	—	20	No occ.			
24	2731	6.5	I	128	19 41.9	−1.7	+1.1	60	Sun			
24	2745d	6.9	I	129	22 06.3	−1.8	−0.7	98	20 48.2	−1.8	−0.1	90
24	2755	6.6	I	129	No occ.				22 51.3	—	—	149
31/1	184	6.2	E	219	1 03.2	−2.2	+0.1	289	23 40.5	—	—	310
Sept. 6	814d	5.3	E	276	4 28.4	−1.5	+1.5	258	3 16.0	−1.2	+1.3	268
7	944	5.7	E	286	2 31.6	−0.7	+0.5	300	1 25.4	−0.6	+0.1	314
17	2218	5.6	I	57	Low				18 44.9	−1.4	−2.8	154
19	2531	7.3	I	85	Low				21 00.6	−0.2	+0.8	27

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	HALIFAX W. 63°6, N. 44°6 A.S.T.	a	b	P	MONTREAL W. 73°6, N. 45°5 E.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Sept. 20	2687	6.9v	I	97	19 22.3	—	—	146	Sun			
21	2871d	7.1	I	112	Low				22 32.6	−1.0	−0.8	76
24	3269	4.3	I	149	18 50.8	−1.0	+1.6	71	Sun			
24	3285	6.1	I	150	23 11.4	−2.0	−0.6	94	21 52.0	−1.8	+0.3	80
28	257	4.5	I	199	23 49.9	−1.3	+1.9	51	22 41.5	−0.8	+2.5	37
28/9	257	4.5	E	199	1 09.8	−2.0	+0.5	261	23 50.5	−2.0	+0.5	275
30	384	5.7	E	211	2 29.6	−1.9	+0.5	255	1 10.6	−2.0	+0.5	267
Oct. 6	1147	5.1	E	277	0 47.0	0.0	+1.3	270	Low			
17	2649d	6.6	I	67	19 59.0	−0.6	0.0	45	18 53.2	−0.6	+0.7	31
19	2968d	6.2	I	95	Low				21 59.1	+0.1	+1.4	17
19	2969	3.2	I	95	Low				22 03.6	0.0	+1.0	22
21	3233	7.2	I	119	20 01.3	−2.1	−0.1	98	18 42.0	−1.8	+0.7	85
21	3247	7.0	I	120	23 18.8	−1.5	−1.8	104	22 02.1	−1.6	−0.9	89
Nov. 1/2	1106d	3.6	I	247	0 08.9	−0.5	+1.6	86	23 07.0	−0.2	+1.8	77
2	1106d	3.6	E	247	1 21.0	−1.2	+1.0	280	0 11.9	−0.8	+0.9	288
3	1234	6.1	E	258	3 20.5	−1.6	−1.1	316	2 05.1	−1.3	−0.9	321
4	1341d	4.3	I	269	1 18.4	−0.5	+0.7	115	0 15.8	−0.2	+0.9	107
4	1341d	4.3	E	269	2 25.5	−0.9	+1.5	269	1 19.6	−0.6	+1.3	274
13	2571	6.9	I	34	17 50.7	−1.9	−3.4	147	Sun			
13	2573	7.3	I	34	17 56.9	−0.6	−0.3	53	Sun			
16	3070	6.6	I	77	Low				20 30.7	−1.1	−1.3	92
19	3459	6.6	I	113	17 36.0	−1.0	+2.3	35	Sun			
19	3474	6.0	I	114	20 55.5	−1.3	+1.0	44	19 44.9	−1.0	+1.9	28
21	184	6.2	I	138	23 17.0	−1.5	+0.3	58	22 02.9	−1.4	+1.1	47
23	404	5.2	I	159	No occ.				17 34.1	—	—	142
27	814d	5.3	E	195	4 19.4	−1.4	−0.4	248	3 03.0	−1.8	+0.1	244
27	934	6.4	E	205	23 45.3	−1.8	−0.4	301	22 27.6	−1.6	−0.6	313
28	944	5.7	E	206	2 15.9	−2.1	+0.7	252	0 56.1	−2.0	+1.1	254
28	970	6.5	E	207	Sun				5 38.7	−0.9	−1.3	268
Dec. 2	1410d	5.3	E	250	Graze				0 58.8	—	—	210
5	1735	6.4	E	286	3 26.8	−0.7	+0.2	304	2 21.7	−0.4	+0.4	302
13	2995	6.2	I	43	17 22.8	−1.8	−1.5	109	Sun			
15	3285	6.1	I	70	17 55.9	—	—	6	No occ.			
15	3294	6.9	I	70	19 30.7	—	—	140	18 01.8	−2.3	−1.6	112
15	3308	6.2	I	72	Low				20 58.5	−0.4	−0.1	49
16	3416	5.6	I	82	17 24.2	—	—	122	Sun			
19	257	4.5	I	118	19 55.1	—	—	11	No occ.			
20	384	5.7	I	130	21 35.7	−1.7	+1.2	52	20 21.5	−1.4	+2.1	39
23	650	5.7	I	154	3 11.3	−0.1	−3.1	134	2 05.8	−0.4	−3.7	140
27/8	1271	5.9	E	209	0 40.0	—	—	349	23 22.1	—	—	352
31	1599	5.0	E	244	No occ.				4 05.4	—	—	9

LUNAR OCCULTATIONS VISIBLE AT TORONTO AND WINNIPEG, 1977

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	TORONTO W. 79°4, N. 43°7 E.S.T.	a	b	P	WINNIPEG W. 97°2, N. 49°9 C.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Jan. 3	764d	5.0	I	154	1 48.0	−0.8	−2.5	124	0 13.0	−1.5	−1.7	114
21	3248	6.6	I	30	17 52.3	−1.2	−1.9	103	No occ.			
23	3508	5.8	I	54	18 42.8	−1.4	−1.2	88	No occ.			
27	445	7.3	I	99	19 52.5	−2.0	+0.2	72	18 30.3	−1.3	+2.2	40
28	577	6.0	I	111	22 18.3	−1.7	+1.5	38	No occ.			
29	590	6.3	I	112	No occ.				1 04.1	−0.4	−0.9	67
30	832	4.7	I	132	20 06.7	−2.2	−1.6	129	18 35.3	−1.3	+1.0	97
30	836	5.5	I	133	21 14.3	—	—	150	19 27.5	−1.6	−0.1	116
31	871	6.9	I	135	No occ.				2 49.6	—	—	22
Feb. 1	1106d	3.6	I	156	No occ.				19 16.6	−1.1	−0.6	141
2	1147	5.1	I	159	No occ.				4 16.5	−0.1	−1.9	114
10	Uran.	5.7	E	261	4 57.1	−2.0	+0.5	262	3 31.9	−1.5	+1.4	256

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	TORONTO W. 79°.4, N. 43°.7 E.S.T.	a	b	P	WINNIPEG W. 97°.2, N. 49°.9 C.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
25	648	3.9	I	90	20 45.2	−1.3	−3.3	132	19 01.3	−1.8	−1.2	110
25	653	4.8	I	91	No occ.				20 09.4	—	—	153
25	658d	4.2	I	91	22 26.7	−1.4	+1.2	34	21 10.8	—	—	16
26	787d	7.5	I	102	22 36.4	−1.1	−1.2	87	21 06.4	−1.6	−0.5	79
27/8	934	6.4	I	114	0 15.9	−0.6	−1.5	93	22 50.6	−1.2	−1.3	93
Feb. 28	944	5.7	I	115	2 01.8	+0.2	−1.7	112	0 49.3	−0.3	−2.0	114
Mar. 2	1309	5.7	I	148	20 41.2	−1.9	+1.3	79	19 27.1	−1.1	+2.7	59
2	1318	5.7	I	149	23 21.8	−1.4	−1.9	130	21 47.6	−1.4	−1.0	128
3	1332	5.7	I	151	No occ.				3 13.0	−1.1	−0.2	47
9	2053	4.6	E	229	2 13.9	−1.1	−0.8	321	0 56.2	−0.6	0.0	315
14	2826	4.0	I	297	4 39.2	−0.9	+0.8	110	No occ.			
14	2826	4.0	E	297	5 45.1	−1.5	+1.7	239	No occ.			
27	1011	7.4	I	92	19 27.9	−2.0	−0.7	95	No occ.			
28	1145	6.7	I	105	23 26.1	−0.4	−2.2	125	22 00.0	−0.9	−2.2	128
28	1147	5.1	I	105	23 26.8	−0.9	−1.1	80	21 59.1	−1.4	−0.9	84
29	1256	7.1	I	116	21 16.2	−1.9	−0.7	94	19 41.8	−1.7	+0.3	91
30/1	1384	7.4	I	130	0 48.2	−0.7	−1.8	111	23 21.0	−1.1	−1.6	117
Apr. 8	2436d	6.3	E	238	0 34.3	—	—	215	No occ.			
22	823d	6.6	I	51	19 46.9	−1.0	−0.7	67	No occ.			
22	829	7.0	I	51	21 00.4	−0.3	−1.2	82	No occ.			
23	970	6.5	I	62	20 44.2	−0.6	−1.8	107	No occ.			
23	975d	6.8	I	63	21 39.3	+0.1	−2.6	139	20 20.3	−0.4	−2.9	140
24	1104	6.8	I	75	23 23.5	+0.3	−2.0	128	22 11.3	−0.1	−2.3	130
26	1332	5.7	I	97	22 32.9	−1.8	+0.2	51	20 59.3	−2.0	+0.2	61
28/9	1564d	6.6	I	123	0 58.9	−1.1	0.0	50	23 32.5	−1.7	−0.1	55
May 14	Venus	−4.3	I	321	No occ.				3 55.4	—	—	153
14	Venus	−4.3	E	321	No occ.				4 02.4	—	—	167
21	1073	6.0	I	45	No occ.				21 39.7	+0.2	−1.9	123
22	1183	7.2	I	55	22 02.8	+0.4	−2.4	147	No occ.			
24	1397d	5.5	I	78	21 39.3	—	—	181	No occ.			
June 4	2826	4.0	I	216	3 57.0	−1.8	−0.6	93	2 28.0	−1.5	+0.5	73
21	1489	6.8	I	61	No occ.				22 00.5	0.0	−2.4	151
24	1807	5.9	I	97	20 40.5	−1.6	−1.1	97	No occ.			
24	1817	6.9	I	98	22 19.3	−1.0	−1.4	95	No occ.			
25	1945	5.4	I	110	21 54.7	−1.6	−0.8	79	No occ.			
27	2209	5.9	I	137	21 08.6	—	—	31	No occ.			
July 22	1911	7.1	I	80	21 36.0	−0.8	−0.8	67	No occ.			
24	2170	6.8	I	106	22 55.0	−1.1	−1.9	125	21 23.8	−1.3	−1.2	113
25	2313	7.0	I	119	20 53.8	−1.8	−0.5	98	No occ.			
25	2316	6.4	I	119	21 55.7	−1.6	−1.0	106	No occ.			
25	2331	6.4	I	121	No occ.				22 56.6	−1.2	−1.3	111
26	2463	6.9	I	133	21 02.0	−1.8	+0.2	83	No occ.			
28/9	2826	4.0	I	162	0 28.2	−1.6	−0.3	78	23 03.0	−1.4	+0.7	56
Aug. 1	3269	4.3	I	203	1 24.0	−2.0	+0.2	93	0 00.8	−1.2	+1.3	67
1	3269	4.3	E	203	2 33.3	−1.2	+1.2	216	1 14.8	−1.4	+0.9	248
2	3520	6.0	E	226	22 55.8	−0.3	+2.9	198	No occ.			
16	Merc.	0.9	I	24	19 01.0	−0.3	−1.7	109	17 40.2	−0.8	−1.7	107
16	Merc.	0.9	E	24	No occ.				18 46.7	−0.4	−1.9	294
23	2571	6.9	I	115	20 26.8	−1.9	−0.7	111	No occ.			
24	2745d	6.9	I	129	20 37.7	−1.8	+0.1	91	No occ.			
24	2755	6.6	I	129	22 42.0	—	—	145	20 57.7	−1.7	−0.3	114
24	2764	6.3	I	130	No occ.				22 42.3	−1.6	−1.1	109
31	184	6.2	E	219	23 28.2	—	—	316	No occ.			
Sept. 6	814d	5.3	E	276	3 07.0	−1.0	+1.4	268	1 59.0	−0.7	+0.7	301
7	944	5.7	E	286	1 22.4	−0.4	0.0	315	No occ.			
7	970	6.5	E	288	No occ.				4 11.7	−1.0	+0.9	288
18	2391	7.1	I	72	No occ.				20 11.9	−1.3	−1.9	130
19	2531	7.3	I	85	20 57.4	−0.3	+1.2	26	No occ.			
21	2871d	7.1	I	112	22 27.7	−1.2	−0.6	75	21 06.2	−1.1	+0.4	45
23	3146	6.5	I	137	No occ.				19 08.7	−1.4	0.0	133
24	3163	7.3	I	139	1 59.4	−0.2	+0.4	35	No occ.			
24	3285	6.1	I	150	21 40.5	−1.8	+0.7	77	20 22.4	−1.1	+1.6	53
25	3308	6.2	I	152	No occ.				1 13.6	−1.3	−1.4	96
28	257	4.5	I	199	22 32.7	−0.6	+2.6	34	No occ.			
28	257	4.5	E	199	23 38.1	−1.9	+0.6	278	No occ.			

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	TORONTO W. 79°4, N. 43°7				WINNIPEG W. 97°2, N. 49°9			
					E.S.T.	a	b	P	C.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Sept.29/0	384	5.7	E	211	0 58.1	−1.9	+0.7	269	23 26.7	—	—	312
Oct. 2	650	5.7	E	235	No occ.				4 26.2	−1.6	+1.5	232
7	1281	6.4	E	291	5 15.9	−1.5	+0.8	277	3 59.9	−0.8	+0.5	299
16	2497d	6.6	I	54	No occ.				19 08.4	−1.2	−1.7	118
17	2649d	6.6	I	67	18 47.5	−0.8	+1.0	29	No occ.			
17	2658	5.8v	I	68	20 20.3	−0.8	−0.8	76	19 01.3	−1.0	0.0	47
18	2826	4.0	I	81	No occ.				19 12.9	−1.9	−1.4	124
19	2968d	6.2	I	95	21 56.7	0.0	+1.7	15	No occ.			
19	2969	3.2	I	95	22 01.2	−0.1	+1.3	20	No occ.			
19	2969	3.2	E	95	22 42.7	−1.3	−2.7	303	No occ.			
21	3233	7.2	I	119	18 30.4	−1.7	+1.0	84	No occ.			
21	3247	7.0	I	120	21 53.6	−1.8	−0.6	87	20 26.7	−1.3	+0.8	54
22	3367	6.4	I	132	No occ.				18 19.0	−1.4	+0.5	124
31	878	5.5	E	227	No occ.				4 25.6	—	—	202
Nov. 1	1106d	3.6	I	247	23 03.4	0.0	+1.7	77	No occ.			
1/2	1106d	3.6	E	247	0 06.0	−0.6	+0.9	286	23 00.6	−0.4	0.0	320
3	1234	6.1	E	258	1 59.0	−1.2	−0.5	315	No occ.			
4	1341d	4.3	E	269	1 14.5	−0.4	+1.4	270	No occ.			
16	3070	6.6	I	77	20 26.2	−1.3	−1.2	91	19 00.8	−1.2	+0.1	58
19	3474	6.0	I	114	19 35.1	−1.0	+2.3	24	No occ.			
21	184	6.2	I	138	21 52.0	−1.5	+1.5	46	20 52.7	—	—	356
23	404	5.2	I	159	17 28.4	—	—	140	No occ.			
27	814d	5.3	E	195	2 50.7	−2.1	+1.1	234	1 21.7	−1.8	+0.8	254
27	934	6.4	E	205	22 19.5	−1.5	−0.4	311	No occ.			
27/8	944	5.7	E	206	0 42.5	−1.9	+1.7	249	23 23.7	−1.2	+1.1	276
28	970	6.5	E	207	5 34.6	−1.2	−0.9	257	4 03.7	−1.6	−0.6	261
29	1106d	3.6	I	220	No occ.				7 02.6	−0.9	−1.3	83
30	1309	5.7	E	239	No occ.				23 38.8	0.0	+4.4	219
Dec. 2	1410d	5.3	E	250	No occ.				0 04.8	−0.2	+2.6	243
4	1637	6.0	E	276	No occ.				5 53.9	−1.1	−1.0	318
14	3169	6.2	I	59	No occ.				20 33.0	−0.5	−0.7	64
15	3294	6.9	I	70	17 50.8	−2.4	−1.1	108	No occ.			
15	3308	6.2	I	72	20 55.8	−0.6	0.0	50	19 52.7	0.0	+2.3	6
15	3311	7.0	I	72	21 33.9	−0.4	−0.4	59	20 26.9	−0.4	+1.0	22
17	32	7.3	I	97	No occ.				22 03.6	−1.2	−2.0	103
18	153	6.2	I	109	No occ.				22 05.6	—	—	138
20	384	5.7	I	130	20 09.4	−1.3	+2.4	39	No occ.			
22	523	6.5	I	144	No occ.				2 42.4	−0.6	−0.7	63
23	650	5.7	I	154	2 12.9	—	—	158	0 27.4	−1.5	−3.1	132
27	1271	5.9	E	209	23 21.0	—	—	339	No occ.			
31	1599	5.0	E	244	4 11.6	−0.8	−3.0	345	2 42.7	−0.6	−2.3	346

LUNAR OCCULTATIONS VISIBLE AT EDMONTON AND VANCOUVER, 1977

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	EDMONTON W. 113°4, N. 53°6				VANCOUVER W. 123°1, N. 49°2			
					M.S.T.	a	b	P	P.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Jan. 1	610d	6.2	I	141	17 47.9	−1.3	−0.1	137	Sun			
2	658d	4.2	I	145	4 02.9	0.0	−1.7	101	3 11.7	0.0	−2.2	118
2	764d	5.0	I	154	22 43.3	−1.6	−0.5	103	21 28.8	−1.8	−0.6	115
12	1886	5.7	E	266	6 32.0	−0.8	−1.5	337	5 27.8	−1.1	−0.9	317
12	1887	6.4	E	267	7 07.4	—	—	220	No occ.			
28	469	7.3	I	102	1 22.1	−0.3	−0.2	39	0 20.9	−0.4	−0.7	60
28	590	6.3	I	112	23 50.1	−0.8	−0.8	66	22 44.9	−1.1	−1.1	84
29	600	6.8	I	113	No occ.				1 13.3	−0.7	+0.2	37
30	836	5.5	I	133	18 09.2	−0.9	+1.3	95	Sun			
31	871	6.9	I	135	1 30.4	−1.4	+0.9	35	0 16.8	−1.4	−0.3	62
31	886	7.0	I	137	Low				3 22.4	−0.3	−0.7	55
Feb. 1	1029	5.1	I	148	3 47.4	−0.3	−1.3	75	2 49.9	−0.4	−1.5	91
1	1106d	3.6	I	156	18 04.7	−0.5	+0.8	119	Sun			
2	1147	5.1	I	159	3 04.3	−0.5	−2.0	120	2 09.5	−0.5	−2.5	139
20	53	6.9	I	36	Low				19 40.6	—	—	141

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	EDMONTON W. 113°.4, N. 53°.6				VANCOUVER W. 123°.1, N. 49°.2			
					M.S.T.	a	b	P	P.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Feb. 21	180d	5.6	I	47	20 37.0	−0.3	−4.0	133	No occ.			
21	181d	6.5	I	47	20 37.6	−0.3	−3.9	133	No occ.			
24	527d	6.3	I	81	No occ.				20 48.0	−1.4	+1.7	28
25	653	4.8	I	91	18 27.8	−1.8	−1.9	129	Sun			
25	658d	4.2	I	91	No occ.				18 23.2	—	—	26
25	684d	6.2	I	93	No occ.				23 26.1	—	—	20
26	787d	7.5	I	102	19 40.3	−1.6	+0.6	71	Sun			
27	934	6.4	I	114	21 25.0	−1.4	−0.7	93	20 13.4	−1.7	−1.0	109
27	944	5.7	I	115	23 34.0	−0.7	−2.1	118	22 38.1	−0.7	−3.0	139
28	970	6.5	I	116	Low				2 07.5	+0.1	−1.7	106
Mar. 2	1318	5.7	I	149	20 25.1	−1.1	−0.1	124	19 16.3	−1.1	−0.8	142
3	1332	5.7	I	151	1 51.3	−1.4	−0.5	59	0 40.8	−1.5	−0.8	82
24	620	6.3	I	61	21 46.3	−0.6	−0.3	44	20 42.3	−0.7	−0.8	64
27	1029	5.1	I	94	No occ.				19 41.1	−2.2	+1.6	49
28	1145	6.7	I	105	20 35.3	−1.2	−1.9	132	19 35.0	−1.1	−3.5	156
28	1147	5.1	I	105	20 32.3	−1.5	−0.4	87	19 18.8	−1.7	−0.6	106
30	1384	7.4	I	130	21 56.9	−1.2	−1.3	124	20 52.2	−1.1	−1.9	145
31	1397d	5.5	I	132	2 53.2	−0.1	−1.7	100	1 58.9	−0.3	−1.8	111
Apr. 6	2159	5.3	E	213	Sun				3 53.9	−1.4	−0.8	274
7	2316	6.4	E	227	Sun				4 22.4	−1.4	−1.8	331
24	1104	6.8	I	75	20 57.5	−0.4	−2.6	137	20 07.7	−0.1	−4.1	163
25	1237	6.4	I	87	23 46.1	−0.7	−0.5	45	22 42.8	−0.8	−1.0	66
28	1564d	6.6	I	123	22 03.0	−1.8	0.0	68	20 46.3	−1.8	−0.2	91
May 7	2731	6.5	E	236	Sun				2 26.6	−1.4	+0.2	299
20	944	5.7	I	34	Low				20 34.4	0.0	−1.3	84
23	1318	5.7	I	68	22 57.3	−0.2	−1.1	62	21 59.6	−0.4	−1.3	77
29	1886	5.7	I	132	Low				0 43.6	−0.7	−2.8	165
31	2159	5.3	I	159	1 19.3	−1.1	−1.1	102	0 11.9	−1.4	−0.9	108
June 3/4	2826	4.0	I	216	1 09.4	−1.2	+1.1	66	23 52.4	−1.1	+1.4	73
4	2826	4.0	E	216	2 17.8	−1.4	+0.3	276	1 02.0	−1.4	+0.7	272
27	2232	7.2	I	139	23 41.1	−1.2	−1.4	133	22 34.9	−1.3	−1.4	141
July 6	3474	6.0	E	248	Sun				1 39.6	−0.9	+1.8	241
23	2053	4.6	I	94	Low				21 35.4	−1.0	−2.1	141
25	2331	6.4	I	121	21 32.0	−1.3	−0.7	104	Sun			
25	2345	6.9	I	122	Low				23 16.3	—	—	158
26	2497d	6.6	I	135	Graze				22 48.9	—	—	18
26/7	2497d	6.6	E	135	0 15.2	—	—	346	Graze			
28	2826	4.0	I	162	21 45.3	−1.2	+1.3	48	20 26.7	−1.2	+1.6	56
31	3269	4.3	I	203	22 50.6	−0.8	+1.8	56	21 35.7	−0.6	+1.8	60
31	3269	4.3	E	203	23 57.1	−1.2	+1.1	264	22 40.8	−1.0	+1.4	262
Aug. 5	257	4.5	I	253	3 50.5	−1.4	+0.9	86	2 32.0	−1.3	+1.3	85
5	257	4.5	E	253	Sun				3 46.4	−1.2	+1.9	228
10	878	5.5	E	307	2 38.1	+0.6	+2.8	210	Low			
11	1029	5.1	E	319	Sun				3 34.0	−0.9	−1.2	336
16	Merc.	0.9	I	24	16 18.4	−1.1	−1.5	113	15 13.8	−1.2	−1.6	128
16	Merc.	0.9	E	24	17 30.3	−0.8	−1.8	292	16 28.1	−1.2	−1.4	280
23	2596	7.3	I	117	Low				22 15.1	—	—	9
24	2764	6.3	I	130	21 15.8	−1.4	0.0	95	20 00.6	−1.5	+0.3	99
Sept. 6	814d	5.3	E	276	0 49.7	—	—	333	Low			
7	970	6.5	E	288	3 00.3	−0.7	+0.4	311	1 52.3	−0.5	+0.5	307
8	1106d	3.6	I	300	Sun				4 06.2	−0.6	+1.8	78
10	1341d	4.3	I	323	4 49.6	−0.2	+1.8	81	Low			
10	1341d	4.3	E	323	Sun				4 40.7	−0.4	+0.9	292
21	2871d	7.1	I	112	19 51.4	−1.1	+1.3	26	Sun			
23/4	3169	6.2	I	140	0 28.0	−1.5	−2.2	118	23 19.9	−2.1	−2.0	119
24	3285	6.1	I	150	19 14.5	−0.7	+2.0	42	Sun			
24	3308	6.2	I	152	23 49.7	−1.3	−0.1	71	22 35.5	−1.5	+0.4	70
Oct. 1	523	6.5	E	225	Sun				4 48.2	−1.6	−0.5	261
2	650	5.7	E	235	3 06.4	−1.4	+1.2	251	1 46.7	−1.2	+1.8	246
7	1281	6.4	E	291	2 51.2	−0.5	+0.2	317	1 46.3	−0.2	+0.4	308
Oct. 18	2826	4.0	I	81	17 43.3	−1.5	−0.1	107	Sun			
21	3247	7.0	I	120	19 12.6	−1.0	+1.6	34	17 54.8	−1.0	+2.1	35
21	3269	4.3	I	122	23 38.1	−1.4	−2.4	117	22 32.4	−2.0	−2.5	120
23	3520	6.0	I	146	21 59.8	−2.0	−0.7	114	20 41.1	−2.1	−0.1	112
31	878	5.5	E	227	3 10.7	−1.5	+2.7	222	1 40.7	—	—	203

Date	Z.C. No.	Mag.	I or E	Elong. of Moon	EDMONTON W. 113°.4, N. 53°.6 M.S.T.	a	b	P	VANCOUVER W. 123°.1, N. 49°.2 P.S.T.	a	b	P
				°	h m	m	m	°	h m	m	m	°
Nov. 3	1237	6.4	E	259	0 33.8	—	—	209	No occ.			
13	2596	7.3	I	37	Low				17 27.0	−0.7	−0.1	44
16	3070	6.6	I	77	17 44.7	−1.0	+0.9	36	Sun			
17	3233	7.2	I	92	Low				22 38.7	−0.9	−2.5	114
19	3500	7.3	I	116	23 38.5	−1.2	−2.7	116	22 37.5	—	—	127
22	214	6.4	I	141	Low				2 40.0	−0.4	−0.8	67
26	814d	5.3	E	195	23 59.0	−1.4	+0.9	270	22 40.9	−1.2	+1.4	263
27	944	5.7	E	206	22 11.1	−0.8	+0.8	296	21 00.4	−0.6	+1.0	292
28	970	6.5	E	207	2 36.3	−1.6	+0.1	266	1 16.9	−1.8	+1.3	251
28	1073	6.0	E	216	21 04.7	—	—	204	Low			
29	1106d	3.6	I	220	5 40.7	−1.2	−1.1	88	4 33.2	−1.5	−1.4	107
29	1106d	3.6	E	220	6 51.9	−0.6	−2.1	298	5 52.3	−1.1	−1.6	280
30	1309	5.7	E	239	22 50.0	+0.1	+2.3	244	Low			
Dec. 1	1341d	4.3	I	243	7 14.5	−1.1	−1.4	99	6 09.3	−1.3	−1.6	117
4	1635	5.4	E	275	No occ.				2 06.1	−0.3	−1.5	343
4	1637	6.0	E	276	4 35.1	−0.9	−0.2	314	3 25.6	−0.9	+0.5	295
14	3169	6.2	I	59	19 22.8	−0.6	0.0	40	18 15.2	−0.8	+0.4	42
16	3459	6.6	I	86	22 23.6	−0.3	+0.9	20	21 16.3	−0.6	+0.7	31
17	24	6.9	I	96	18 42.7	−2.0	−0.6	111	17 23.9	−2.1	0.0	109
17	32	7.3	I	97	20 37.9	−1.3	−0.5	79	19 24.6	−1.7	−0.1	82
18	153	6.2	I	109	20 24.4	−1.8	−0.8	101	19 08.0	−2.1	−0.4	103
22	523	6.5	I	144	1 26.8	−1.0	−0.4	58	0 17.7	−1.3	−0.6	74
22	650	5.7	I	154	22 52.3	−1.7	−1.1	114	21 38.8	−2.1	−1.3	125
28	1309	5.7	E	212	6 41.3	−1.2	−0.6	235	No occ.			
29	1410d	5.3	E	223	7 02.7	−1.0	−1.2	253	5 50.3	—	—	228
31	1599	5.0	E	244	1 26.2	−0.4	−2.2	350	0 26.1	−0.6	−0.5	325

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
153	73 Psc	1029	26 Gem	1518	43 Leo	2826	44 ρ Sgr
180	86 ζ Psc	1096	51 Gem	1564	34 Sex	2969	9 β Cap
184	88 Psc	1106	54 λ Gem	1565	35 Sex	3070	8 Aqr
257	110 o Psc	1145	67 Gem	1599	58 Leo	3187	47 Cap
384	31 Ari	1147	68 Gem	1635	75 Leo	3247	36 Aqr
404	38 Ari	1271	29 Cnc	1637	76 Leo	3269	43 θ Aqr
648	61 δ Tau	1309	45 Cnc	1807	25 Vir	3459	11 Psc
650	63 Tau	1318	50 Cnc	1945	76 Vir	3467	13 Psc
653	64 Tau	1332	60 Cnc	2053	100 λ Vir	3474	14 Psc
658	68 Tau	1341	65 α Cnc	2117	8 Lib	3508	21 Psc
764	104 Tau	1359	76 κ Cnc	2118	9 α Lib	4001	Mercury
814	115 Tau	1397	2 ω Leo	2159	21 ν Lib	4002	Venus
832	119 Tau	1410	6 Leo	2209	32 Lib	4007	Uranus
836	120 Tau	1468	29 π Leo	2218	35 ζ Lib		
878	130 Tau	1489	16 Sex	2658	Y Sgr		

GRAZING OCCULTATIONS OVER CANADA DURING 1977

H.M. Nautical Almanac Office
Herstmonceux Castle, Hailsham, Sussex, England

The maps show the tracks of stars brighter than $7^{m}.5$ which will graze the limb of the Moon when it is at a favourable elongation from the Sun and at least 10° above the observer's horizon (5° in the case of stars brighter than $5^{m}.5$ and 2° for those brighter than $3^{m}.5$). Each track starts in the West at some arbitrary 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 of time which, when added to the time at the beginning of the track, give the approximate time of the graze at places along the tracks.

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. Observers situated near to any of these tracks who are interested 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 approximate latitude and longitude, and details of the event will be supplied. A nominal fee is charged for this service.

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

The numbering of the graze tracks differs slightly from that in previous years; there is no longer a continuous sequence. This arises from the method of preparing and editing the maps. It is easier and safer to preserve the original computer sequential numbering, even when certain tracks are later eliminated.

No.	Date	Z.C.	Mag.	U.T.	%	L	No.	Date	Z.C.	Mag.	U.T.	%	L
				h m							h m		
1	Jan. 12	1887	6.4	13 48	52	S	21	Mar. 27	886	7.0	4 04	44	N
2	14	2117	5.3	8 23	32	S	22	28	1029	5.1	3 59	54	N
3*	14	2118	2.9	8 32	32	S	23	29	1147	5.1	4 42	64	N
4*	16	2436	6.3	10 50	12	N	24	Apr. 9	2611	6.8	8 44	64	S
5*	22	3366	6.6	22 09	13	N	26	13	3187	6.2	8 39	22	N
6	23	3502	7.4	22 12	20	S	27*	23	823	6.6	1 01	19	N
7	27	340	7.1	4 52	50	N	28	23	836	5.5	3 07	19	N
8	29	577	6.0	2 36	68	N	29	25	1106	3.6	4 54	37	N
9	29	600	6.8	9 24	70	N	30	27	1332	5.7	3 19	57	N
10	Feb. 8	1807	5.9	3 08	81	N	31	May 29	1886	5.7	9 09	84	S
11*	15	2871	7.1	11 28	8	N	32†	June 5	2969	3.2	9 49	82	N
12	25	527	6.3	5 03	42	N	33	21	1384	7.4	4 08	18	S
13*	26	658	4.2	2 43	51	N	34	22	1489	6.8	4 28	26	S
14*	26	684	6.2	7 33	53	N	35	July 6	3467	6.5	8 26	68	N
15*	26	764	5.0	22 26	59	N	36	9	301	6.8	12 16	37	N
16	Mar. 13	2685	7.0	13 27	36	N	37	11	523	6.5	11 17	20	S
17*	15	2968	6.2	11 38	17	N	40	Aug. 10	878	5.5	9 15	19	S
18†	15	2969	3.2	11 44	17	N	41	12	1147	5.1	11 28	6	S
19	22	252	7.4	3 00	6	N	42	Sept. 4	523	6.5	2 42	65	N
20*	25	610	6.2	2 41	25	N	43*	6	814	5.3	7 38	44	N

No.	Date	Z.C.	Mag.	U.T.	%	L	No.	Date	Z.C.	Mag.	U.T.	%	L
				h m							h m		
44	Sept. 6	829	7.0	9 38	43	N	66*	Nov. 6	1565	6.3	8 42	29	N
45*	7	944	5.7	6 11	35	N	67	8	1787	6.0	10 11	11	S
46	8	1091	6.7	9 16	25	N	69	14	2755	6.6	22 32	17	S
47	9	1212	7.1	9 39	17	N	70	14	2764	6.3	23 59	18	S
48	10	1332	5.7	11 11	10	S	72	Dec. 2	1429	6.8	11 03	65	S
50†	18	2218	5.6	0 09	23	S	73	3	1518	6.3	6 47	56	N
52†	Oct. 2	650	5.7	10 16	78	S	74	4	1624	6.8	8 12	46	N
54	19	2826	4.0	1 35	43	S	75	4	1635	5.4	9 50	45	N
55	22	3269	4.3	6 52	77	S	76*	13	2871	7.1	1 31	8	N
56*	22	3362	5.9	23 22	83	S	78	15	3294	6.9	23 38	34	S
57	31	878	5.5	10 25	84	S	79	16	3308	6.2	2 11	35	N
58	Nov. 2	1106	3.6	4 47	69	N	81	18	24	6.9	1 36	56	S
59	2	1145	6.7	13 36	67	S	82	18	32	7.3	4 23	57	S
61	3	1234	6.1	6 23	60	N	83	19	153	6.2	3 28	66	S
62	3	1237	6.4	8 12	59	S	84	20	257	4.5	0 32	74	N
63	3	1256	7.1	12 54	57	S	85	21	384	5.7	1 39	83	N
64	5	1457	6.7	10 36	38	S	86	31	1599	5.0	8 17	71	N
65	5	1468	4.9	12 08	38	N							

NOTES ON DOUBLE STARS

Track 3: ZC 2118 is the mean of a close double star. The components are of $3^{m}.4$ and $3^{m}.8$ at a minimum separation of $0''.01$.

Track 4: ZC 2436 is the brighter component of the double star Aitken 10266. The companion is $8^{m}.3$; separation $4''.7$ in p.a. 231°.

Track 5: ZC 3366 is the brighter component of the double star Aitken 16392. The companion is 10th magnitude; separation $10''.4$ in p.a. 117°.

Tracks 11, 76: ZC 2871 is the brighter component of the double star Aitken 12728. The companion is $7^{m}.6$; separation $10''.2$ in p.a. 236°.

Track 13: ZC 658 is the brightest component of the triple star Aitken 3206. The brighter companion is $7^{m}.5$ with separation $1''.5$ in p.a. 342°. The second companion is $8^{m}.7$ and is separated from the primary by more than 1′ in p.a. 232°.

Track 14: ZC 684 is the mean of the double star Aitken 3297. The components are $7^{m}.0$ and $7^{m}.1$ with separation 3″ in p.a. 277°.

Track 15: ZC 764 is the mean of the close double star Aitken 3701. The components are both $6^{m}.0$; separation $0''.1$ at an uncertain p.a.

Track 17: ZC 2968 is the brighter component of the double star Aitken 13717. The companion is 10th magnitude; separation $0''.8$ in p.a. 84°.

Track 20: ZC 610 is the brighter component of the double star Aitken 3006. The companion is $9^{m}.3$; separation $4''.4$ in p.a. 326°.

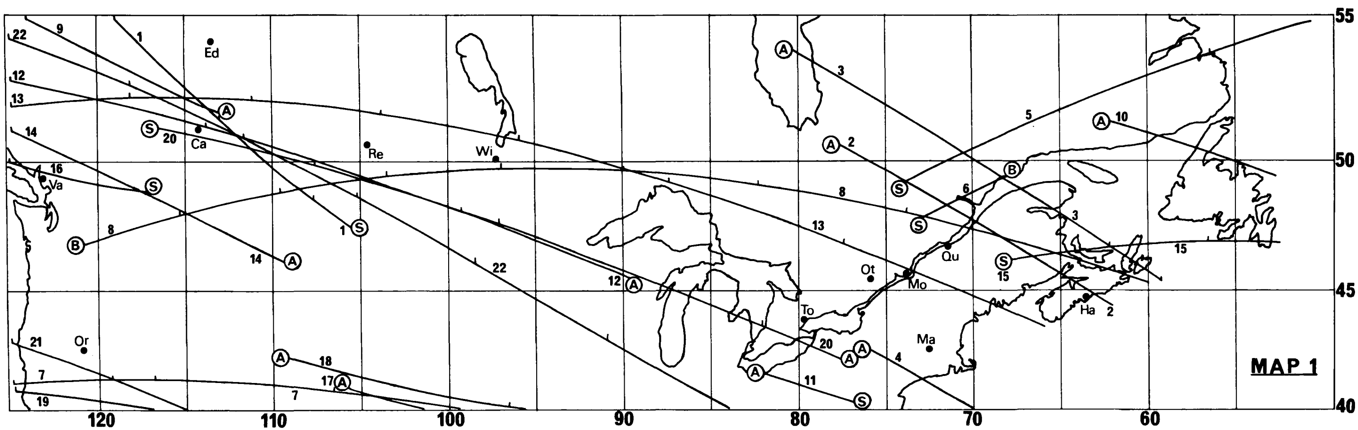
Track 27: ZC 823 is the brighter component of the double star Aitken 4073. The companion is 10th magnitude; separation $3''.4$ in p.a. 133°.

Track 43: ZC 814 is the brightest component of the triple star Aitken 4038. The brighter companion is 10th magnitude; separation 10″ in p.a. 306°.

Track 45: 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 56: 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 66: ZC 1565 is the brightest component of the triple star Aitken 7902. The brighter companion is $7^{m}.4$; separation $6''.8$ in p.a. 240°.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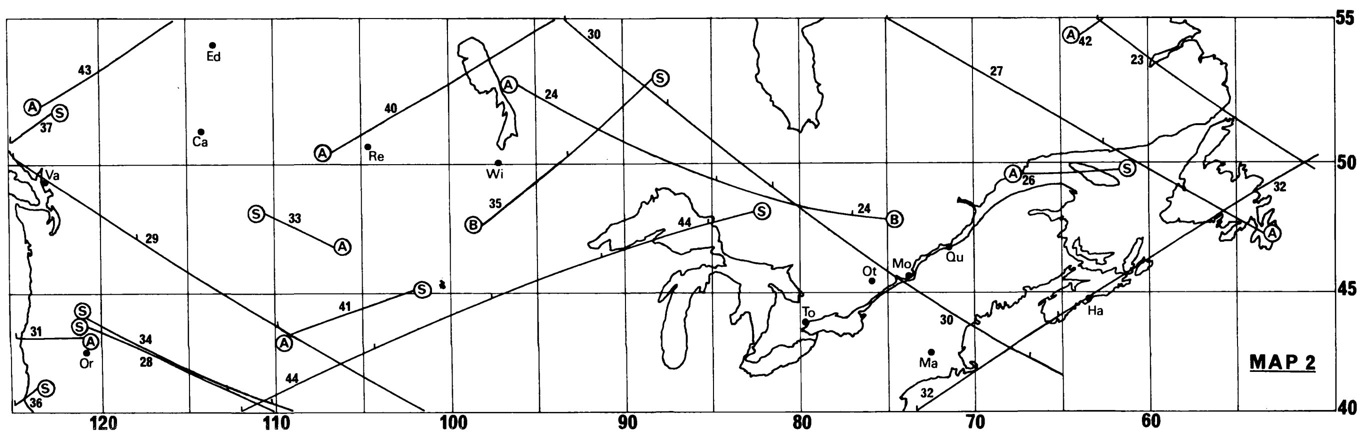
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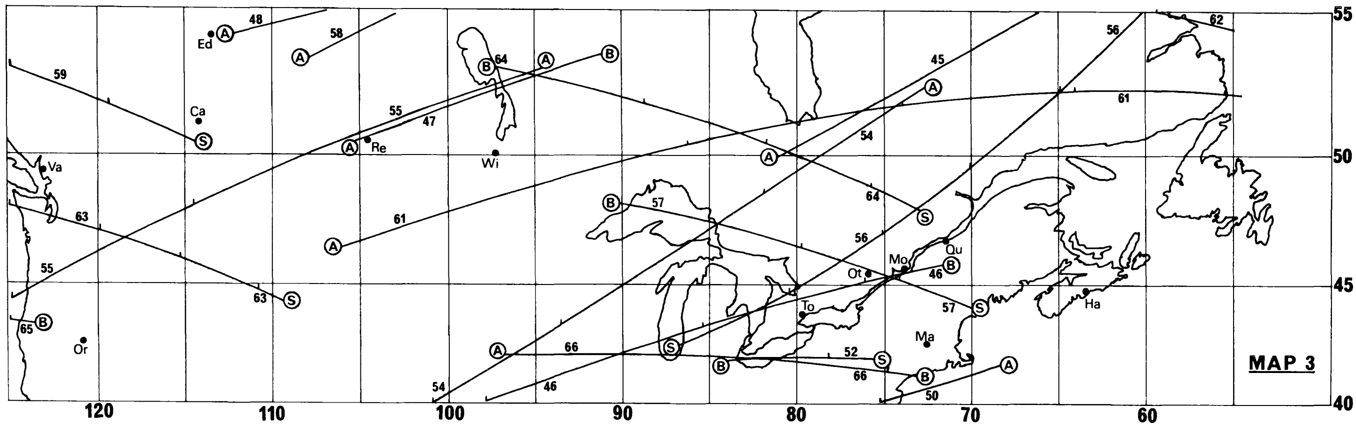
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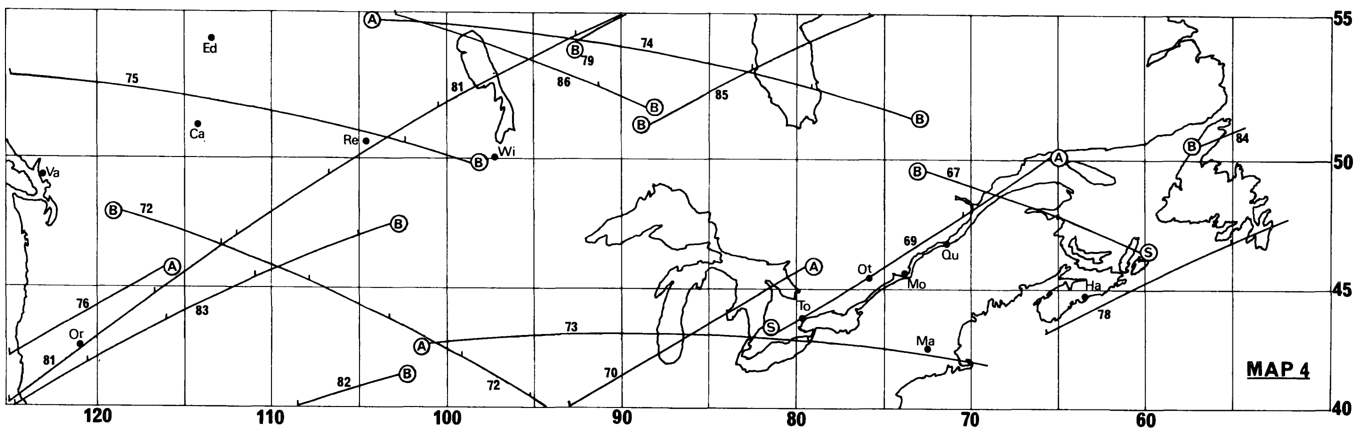
MAP 4
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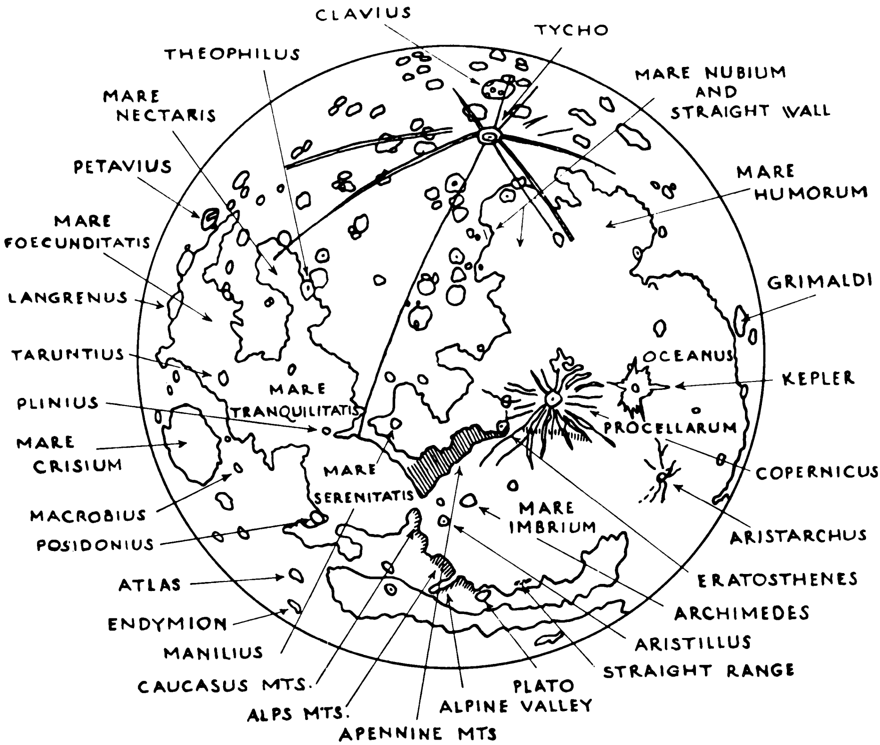
MAP OF THE MOON



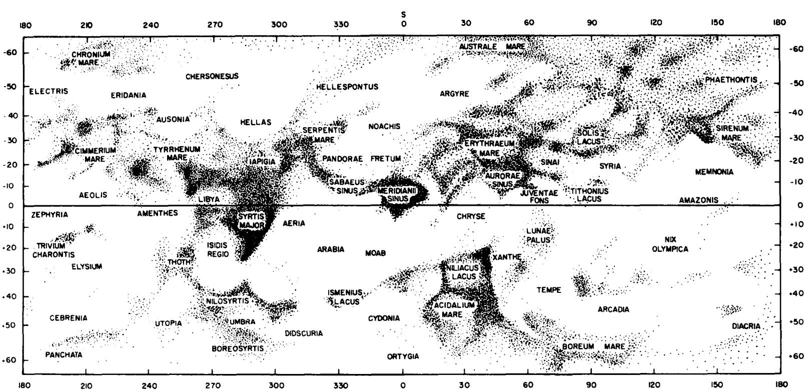
South appears at the top.

MARS—LONGITUDE OF THE CENTRAL MERIDIAN

The following table lists the longitude of the central meridian of the geometric disk of Mars for each date at 0 hours U.T. (19 hours E.S.T. on the preceding date). To obtain the longitude of the central meridian for other times, add 14.6° for each hour elapsed since 0 hours U.T.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°
1	328.39	29.73	82.38	147.43	205.16	264.85	335.84	39.70	118.19
2	318.43	19.78	72.51	137.64	195.45	255.19	326.24	30.22	108.94
3	308.48	9.84	62.64	127.86	185.73	245.53	316.64	20.74	99.71
4	298.53	359.90	52.77	118.08	176.02	235.87	307.05	11.26	90.48
5	288.57	349.96	42.91	108.30	166.31	226.22	297.45	1.79	81.27
6	278.62	340.02	33.04	98.52	156.61	216.57	287.86	352.33	72.07
7	268.66	330.08	23.18	88.75	146.90	206.91	278.27	342.87	62.88
8	258.70	320.15	13.33	78.97	137.20	197.26	268.69	333.42	53.70
9	248.75	310.21	3.47	69.20	127.50	187.62	259.11	323.98	44.54
10	238.79	300.28	353.62	59.44	117.80	177.97	249.53	314.54	35.39
11	228.83	290.35	343.78	49.67	108.10	168.32	239.95	305.11	26.25
12	218.87	280.42	333.93	39.91	98.40	158.68	230.38	295.68	17.12
13	208.91	270.50	324.09	30.15	88.71	149.04	220.81	286.27	8.01
14	198.95	260.57	314.25	20.39	79.01	139.40	211.24	276.86	358.91
15	188.99	250.65	304.41	10.64	69.32	129.76	201.68	267.45	349.82
16	179.04	240.73	294.58	0.89	59.64	120.13	192.12	258.06	340.75
17	169.08	230.82	284.75	351.14	49.95	110.50	182.56	248.67	331.69
18	159.12	220.90	274.92	341.39	40.26	100.86	173.01	239.29	322.64
19	149.16	210.99	265.10	331.65	30.58	91.23	163.46	229.92	313.61
20	139.20	201.08	255.28	321.90	20.90	81.61	153.91	220.56	304.59
21	129.25	191.18	245.46	312.16	11.22	71.98	144.37	211.21	295.58
22	119.29	181.27	235.64	302.42	1.54	62.36	134.83	201.86	286.58
23	109.34	171.37	225.83	292.69	351.86	52.74	125.30	192.53	277.60
24	99.38	161.47	216.02	282.95	342.19	43.12	115.77	183.20	268.64
25	89.43	151.58	206.21	273.22	332.51	33.50	106.25	173.88	259.68
26	79.47	141.68	196.41	263.49	322.84	23.89	96.73	164.58	250.74
27	69.52	131.79	186.61	253.77	313.17	14.27	87.21	155.28	241.81
28	59.57	121.91	176.81	244.04	303.51	4.66	77.70	145.99	232.90
29	49.62	112.02	167.02	234.32	293.84	355.05	68.19	136.71	224.00
30	39.68	102.14	157.22	224.60	284.17	345.45	58.69	127.44	215.11
31		92.26		214.88	274.51		49.19		206.23

MAP OF MARS



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

ASTEROIDS—EPHEMERIDES AT OPPOSITION, 1977

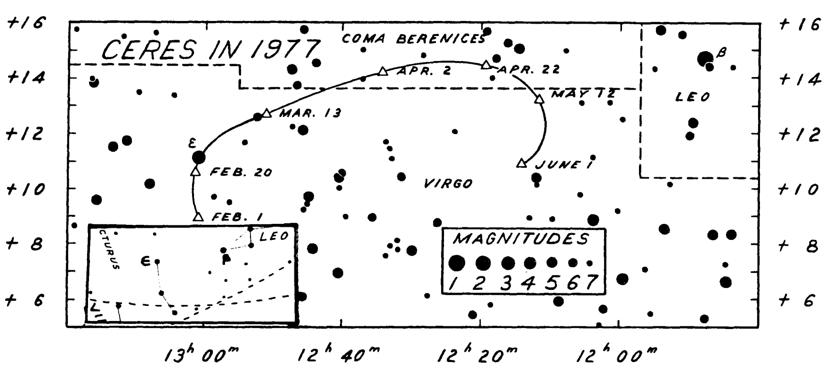
All four major asteroids come to opposition in 1977. The following table gives the date (U.T.) of opposition, the constellation, visual magnitude, right ascension and declination (astrometric, 1950 co-ordinates), and the distance from earth, in astronomical units.

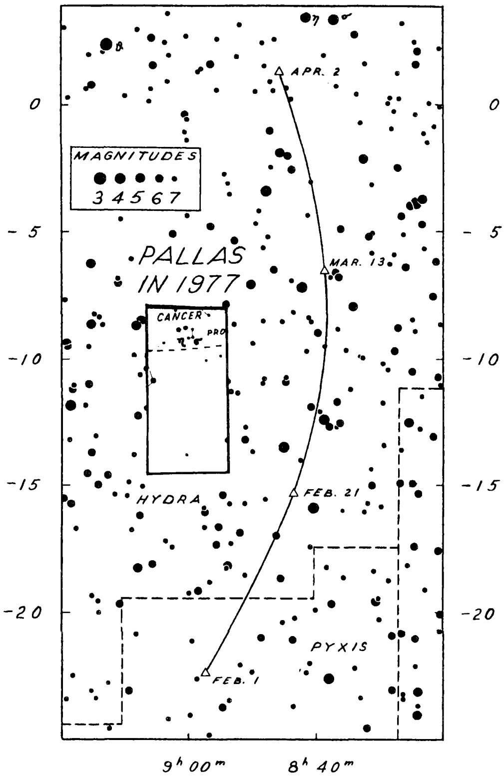
Asteroid	At Opposition					
	Date	Const.	Vis. Mag.	R.A.	Dec.	Dist. from ⊕
Ceres	Mar. 24	Com-Vir	6.5	12^h41^m	+13°46′	1.61
Pallas	Feb. 10	Pyx	6.7	8^h49^m	−19°27′	1.26
Juno	May 13	Ser	10.1	15^h35^m	− 2°23′	2.37
Vesta	Jan. 9	Gem	6.6	7^h20^m	+23°10′	1.55

Ceres and Vesta will be well-placed for observation, Pallas is rather far south at opposition but will move rapidly northward thereafter (see map), and Juno will be fainter than tenth magnitude even at opposition.

The following tables list the 1950 co-ordinates (for convenience in plotting on the *Atlas Coeli*) and the visual magnitudes of Ceres, Pallas and Vesta 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 three asteroids. They are keyed to the star maps in the back of this Handbook via the small inserts.

Date	CERES			PALLAS			VESTA		
(0^h U.T.)	R.A. h m	Dec. ° ′	Mag.	R.A. h m	Dec. ° ′	Mag.	R.A. h m	Dec. ° ′	Mag.
Jan. 1	12 39.8	+ 8 31	7.3	9 13.3	−26 09	7.0	7 28.8	+22 29	6.6
11	12 48.3	+ 8 26	7.1	9 09.9	−25 51	6.9	7 17.9	+23 20	6.6
21	12 55.0	+ 8 35	7.0	9 04.2	−24 41	6.8	7 07.0	+24 07	6.5
31	12 59.3	+ 9 01	6.9	8 56.9	−22 32	6.7	6 57.5	+24 45	6.6
Feb. 10	13 01.1	+ 9 42	6.8	8 49.4	−19 27	6.7	6 50.5	+25 16	6.6
20	13 00.2	+10 35	6.7	8 42.9	−15 35	6.8	6 46.7	+25 38	6.7
Mar. 2	12 56.6	+11 37	6.6	8 38.7	−11 15	6.8	6 46.2	+25 53	6.9
12	12 50.6	+12 40	6.5	8 37.4	− 6 50	6.9	6 49.0	+26 01	7.0
22	12 42.8	+13 36	6.5	8 39.1	− 2 37	7.0	6 54.6	+26 04	7.1
Apr. 1	12 34.2	+14 17	6.6	8 43.9	+ 1 09	7.1	7 02.8	+26 01	7.2
11	12 25.9	+14 38	6.6	8 51.3	+ 4 21	7.2	7 13.1	+25 51	7.3
21	12 18.8	+14 36	6.7	9 01.0	+ 6 59	7.4	7 25.2	+25 34	7.4
May 1	12 13.7	+14 11	6.8	9 12.6	+ 9 02	7.5	7 38.7	+25 11	7.5
11	12 10.9	+13 26	6.9	9 25.6	+10 35	7.8	7 53.4	+24 39	7.6




MAGNITUDES
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PALLAS
IN 1977
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HYDRA
PYXIS
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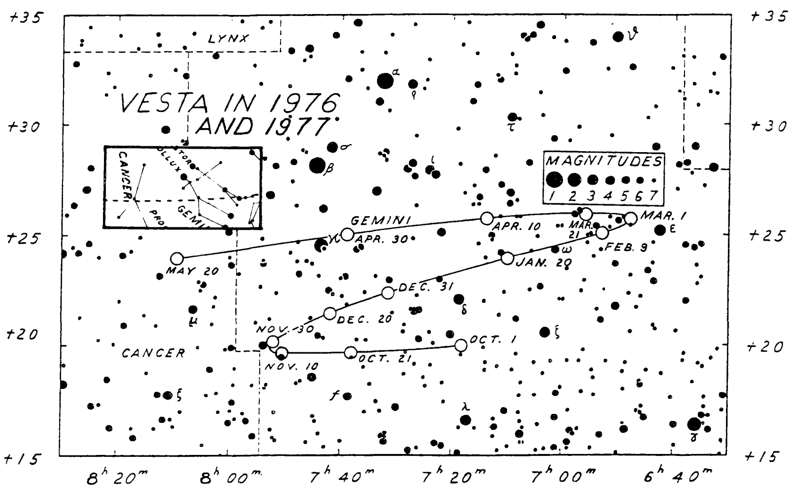
LYNX
VESTA IN 1976
AND 1977
MAGNITUDES
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GEMINI
CANCER
MAY 20
APR. 30
APR. 10
MAR. 21
MAR. 1
FEB. 9
JAN. 20
DEC. 31
DEC. 20
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OCT. 21
OCT. 1
+35
+30
+25
+20
+15
8h 20m
8h 00m
7h 40m
7h 20m
7h 00m
6h 40m

JUPITER—LONGITUDE OF CENTRAL MERIDIAN

The table lists the longitude of the central meridian of the illuminated disk of Jupiter at 0^h U.T. daily during the period when the planet is favourably placed. Longitude increases hourly by 36.58° in System I (which applies to regions between the middle of the North Equatorial Belt and the middle of the South Equatorial Belt) and by 36.26° in System II (which applies to the rest of the planet). The longitude of the Great Red Spot is variable with respect to neighbouring features.

SYSTEM I

Day (0^h U.T.)	Jan.	Feb.	Mar.	Apr.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°
1	332.8	185.1	281.3	129.1	76.2	285.8	137.4	193.4	49.6	109.9
2	130.7	342.8	79.0	286.7	233.9	83.6	295.3	351.3	207.5	268.0
3	288.5	140.6	236.7	84.4	31.6	241.4	93.1	149.2	5.5	66.0
4	86.4	298.3	34.4	242.0	189.3	39.1	250.9	307.1	163.5	224.1
5	244.3	96.1	192.1	39.7	347.0	196.9	48.8	105.0	321.5	22.1
6	42.1	253.8	349.8	197.3	144.7	354.7	206.6	262.9	119.5	180.1
7	200.0	51.6	147.4	355.0	302.4	152.4	4.4	60.8	277.5	338.2
8	357.8	209.3	305.1	152.6	100.1	310.2	162.3	218.7	75.5	136.2
9	155.7	7.1	102.8	310.3	257.9	108.0	320.1	16.7	233.5	294.3
10	313.5	164.8	260.5	107.9	55.6	265.8	118.0	174.6	31.5	92.3
11	111.4	322.5	58.1	265.6	213.3	63.5	275.8	332.5	189.5	250.3
12	269.2	120.3	215.8	63.2	11.0	221.3	73.7	130.4	347.5	48.4
13	67.0	278.0	13.5	220.9	168.7	19.1	231.5	288.4	145.5	206.4
14	224.8	75.7	171.2	18.5	326.5	176.9	29.4	86.3	303.5	4.5
15	22.7	233.4	328.8	176.2	124.2	334.7	187.2	244.2	101.5	162.5
16	180.5	31.2	126.5	333.8	281.9	132.5	345.1	42.2	259.5	320.5
17	338.3	188.9	284.2	131.5	79.7	290.3	143.0	200.1	57.6	118.6
18	136.1	346.6	81.8	289.1	237.4	88.1	300.8	358.1	215.6	276.6
19	293.9	144.3	239.5	86.8	35.1	245.9	98.7	156.0	13.6	74.7
20	91.7	302.0	37.2	244.4	192.9	43.7	256.6	314.0	171.6	232.7
21	249.5	99.7	194.8	42.1	350.6	201.5	54.5	111.9	329.6	30.7
22	47.3	257.4	352.5	199.7	148.3	359.3	212.3	269.9	127.7	188.8
23	205.1	55.1	150.2	357.3	306.1	157.1	10.2	67.8	285.7	346.8
24	2.9	212.8	307.8	155.0	103.8	314.9	168.1	225.8	83.7	144.8
25	160.7	10.5	105.5	312.6	261.6	112.7	326.0	23.8	241.7	302.9
26	318.5	168.2	263.1	110.3	59.3	270.5	123.9	181.7	39.8	100.9
27	116.2	325.9	60.8	267.9	217.1	68.3	281.8	339.7	197.8	258.9
28	274.0	123.6	218.4	65.6	14.8	226.1	79.7	137.7	355.8	56.9
29	71.8		16.1	223.2	172.6	24.0	237.6	295.6	153.9	215.0
30	229.6		173.8	20.9	330.3	181.8	35.5	93.6	311.9	13.0
31	27.3		331.4		128.1	339.6		251.6		171.0

SYSTEM II

Day (0^h U.T.)	Jan.	Feb.	Mar.	Apr.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°
1	325.0	300.8	183.4	154.7	127.5	100.6	75.6	262.6	242.3	73.8
2	115.3	91.0	333.5	304.7	277.6	250.7	225.8	52.9	32.7	224.2
3	265.5	241.1	123.6	94.7	67.6	40.9	16.0	203.2	183.0	14.6
4	55.8	31.2	273.6	244.7	217.7	191.0	166.2	353.5	333.4	165.0
5	206.0	181.3	63.7	34.8	7.8	341.1	316.4	143.8	123.7	315.4
6	356.2	331.4	213.7	184.8	157.9	131.3	106.7	294.0	274.1	105.8
7	146.5	121.6	3.8	334.8	307.9	281.4	256.9	84.3	64.5	256.2
8	296.7	271.7	153.8	124.8	98.0	71.6	47.1	234.6	214.8	46.6
9	86.9	61.8	303.9	274.9	248.1	221.7	197.3	24.9	5.2	197.0
10	237.1	211.9	93.9	64.9	38.2	11.8	347.5	175.2	155.6	347.4
11	27.3	2.0	244.0	214.9	188.3	162.0	137.7	325.5	305.9	137.9
12	177.5	152.1	34.0	4.9	338.4	312.1	287.9	115.8	96.3	288.3
13	327.7	302.2	184.1	154.9	128.5	102.3	78.2	266.1	246.7	78.7
14	117.9	92.3	334.1	304.9	278.6	252.5	228.4	56.4	37.1	229.1
15	268.1	242.4	124.1	95.0	68.7	42.6	18.6	206.7	187.4	19.5
16	58.3	32.5	274.2	245.0	218.8	192.8	168.9	357.0	337.8	169.9
17	208.5	182.6	64.2	35.0	8.9	342.9	319.1	147.3	128.2	320.3
18	358.7	332.6	214.3	185.0	159.0	133.1	109.3	297.6	278.6	110.7
19	148.8	122.7	4.3	335.0	309.1	283.3	259.6	88.0	69.0	261.1
20	299.0	272.8	154.3	125.1	99.2	73.4	49.8	238.3	219.4	51.5
21	89.2	62.9	304.4	275.1	249.3	223.6	200.1	28.6	9.8	202.0
22	239.4	213.0	94.4	65.1	39.4	13.8	350.3	178.9	160.2	352.4
23	29.5	3.0	244.4	215.1	189.5	164.0	140.6	329.2	310.6	142.8
24	179.7	153.1	34.5	5.1	339.6	314.1	290.8	119.6	101.0	293.2
25	329.8	303.2	184.5	155.1	129.7	104.3	81.1	269.9	251.4	83.6
26	120.0	93.2	334.5	305.2	279.9	254.5	231.3	60.2	41.8	234.0
27	270.1	243.3	124.5	95.2	70.0	44.7	21.6	210.6	192.2	24.4
28	60.3	33.4	274.6	245.2	220.1	194.9	171.8	0.9	342.6	174.8
29	210.4		64.6	35.2	10.2	345.1	322.1	151.3	133.0	325.1
30	0.6		214.6	185.2	160.3	135.2	112.4	301.6	283.4	115.5
31	150.7		4.7		310.5	285.4		92.0		265.9

JUPITER—PHENOMENA OF THE BRIGHTEST SATELLITES 1977

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. 34–35.

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 west side until December 23, and on the east thereafter.

JANUARY

d	h	m	Sat.	Phen.
1	2	57	II	OD
	16	57	I	ER
2	1	22	III	TI
	3	31	III	Te
	22	03	II	TI
3	0	07	II	SI
	0	34	II	Te
	2	38	II	Se
4	20	50	II	ER
5	2	40	I	OD
	17	29	III	OR
	19	37	III	ED
	21	53	III	ER
	23	48	I	TI
6	0	52	I	SI
	1	58	I	Te
	3	02	I	Se
	21	08	I	OD
7	0	24	I	ER
	18	16	I	TI
	19	21	I	SI
	20	25	I	Te
	21	31	I	Se
8	18	53	I	ER
10	0	28	II	TI
	2	44	II	SI
	2	59	II	Te
11	18	34	II	OD
	23	28	II	ER
12	18	54	III	OD
	21	09	III	OR
	23	38	III	ED
13	1	38	I	TI
	1	54	III	ER
	2	48	I	SI
	3	48	I	Te
	18	33	II	Se
	22	58	I	OD
14	2	19	I	ER
	20	06	I	TI
	21	17	I	SI
	22	16	I	Te
	23	27	I	Se
15	17	26	I	OD
	20	48	I	ER
16	17	56	I	Se
17	2	56	II	TI
18	21	02	II	OD
19	2	06	II	ER
	22	37	III	OD
20	0	54	III	OR
	3	30	I	TI
	3	40	III	ED
	18	39	II	SI
	18	42	II	Te
	21	09	II	Se
21	0	49	I	OD
	21	58	I	TI
	23	13	I	SI
22	0	08	I	Te
	1	22	I	Se
	19	17	I	OD
	22	43	I	ER
23	17	33	III	SI
	17	41	I	SI
	18	36	I	Te
23	19	48	III	Se
	19	51	I	Se
24	17	12	I	ER
25	23	33	II	OD
26	2	08	II	OR
	2	10	II	ED
27	2	25	III	OD
	18	41	II	TI
	21	13	II	Te
	21	16	II	SI
	23	45	II	Se
28	2	42	I	OD
	23	51	I	TI
29	1	08	I	SI
	2	01	I	Te
	18	03	II	ER
	21	10	I	OD
30	0	39	I	ER
	18	19	I	TI
	18	34	III	Te
	19	37	I	SI
	20	29	I	Te
	21	34	III	SI
	21	47	I	Se
	23	50	III	Se
31	19	08	I	ER

FEBRUARY

d	h	m	Sat.	Phen.
2	2	07	II	OD
3	21	15	II	TI
	23	46	II	Te
	23	52	II	SI
4	2	21	II	Se
5	1	45	I	TI
	18	00	II	OR
	18	07	II	ED
	20	41	II	ER
	23	04	I	OD
6	2	34	I	ER
	20	11	III	TI
	20	14	I	TI
	21	33	I	SI
	22	24	I	Te
	22	32	III	Te
	23	43	I	Se
7	1	36	III	SI
	17	33	I	OD
	21	03	I	ER
8	18	12	I	Se
10	18	03	III	ER
	23	50	II	TI
11	2	21	II	Te
12	18	01	II	OD
	20	38	II	OR
	20	45	II	ED
	23	20	II	ER
13	0	59	I	OD
	22	09	I	TI
	23	29	I	SI
14	0	11	III	TI
	0	20	I	Te
	1	39	I	Se
	18	16	II	Se
	19	28	I	OD
	22	58	I	ER
15	17	58	I	SI
15	18	49	I	Te
	20	08	I	Se
17	19	45	III	ED
	22	05	III	ER
19	20	41	II	OD
	23	18	II	OR
	23	23	II	ED
21	0	06	I	TI
	1	25	I	SI
	18	18	II	Te
	18	23	II	SI
	20	52	II	Se
	21	25	I	OD
22	0	54	I	ER
	18	35	I	TI
	19	53	I	SI
	20	46	I	Te
	22	04	I	Se
23	19	23	I	ER
24	18	25	III	OD
	20	52	III	OR
	23	46	III	ED
26	23	22	II	OD
28	18	26	II	TI
	20	58	II	Te
	20	59	II	SI
	23	22	I	OD
	23	28	II	Se

MARCH

d	h	m	Sat.	Phen.
1	20	33	I	TI
	21	49	I	SI
	22	44	I	Te
2	0	00	I	Se
	17	51	I	OD
	17	57	II	ER
	21	18	I	ER
3	18	29	I	Se
	22	35	III	OD
4	1	03	III	OR
7	20	01	III	Se
	21	07	II	TI
	23	35	II	SI
	23	39	II	Te
8	22	31	I	TI
	23	45	I	SI
9	0	43	I	Te
	19	50	I	OD
	20	36	II	ER
	23	13	I	ER
10	18	14	I	SI
	19	12	I	Te
	20	25	I	Se
14	19	20	III	Te
	21	44	III	SI
	23	50	II	TI
15	0	03	III	Se
16	0	31	I	TI
	18	14	II	OD
	21	49	I	OD
	23	15	II	ER
17	19	01	I	TI
	20	10	I	SI
	21	12	I	Te
	22	21	I	Se
18	19	37	I	ER
21	21	10	III	TI
	23	39	III	Te
23	21	02	II	OD
	23	48	I	OD
24	21	01	I	TI
	22	06	I	SI
	23	12	I	Te
25	18	14	III	ER
	18	18	I	OD
	18	28	II	TE
	20	33	II	Se
	21	32	I	ER
26	18	46	I	Se
30	23	50	II	OD
31	23	01	I	TI

APRIL

d	h	m	Sat.	Phen.
1	18	42	II	TI
	19	52	III	ED
	20	18	I	OD
	20	40	II	SI
	21	14	II	Te
	22	16	III	ER
	23	09	II	Se
	23	27	I	ER
2	18	30	I	SI
	19	43	I	Te
	20	42	I	Se
8	20	10	III	OD
	21	28	II	TI
	22	18	I	OD
	22	42	III	OR
	23	15	II	SI
9	19	32	I	TI
	20	26	I	SI
	21	45	I	Te
	22	37	I	Se
10	19	51	I	ER
	20	30	II	ER
16	21	34	I	TI
	22	21	I	SI
17	18	49	I	OD
	18	56	II	OD
	21	46	I	ER
18	19	02	I	Se
19	20	14	III	Se

Jupiter being near the sun, phenomena are not given between Apr. 19 and July 5

JULY

d	h	m	Sat.	Phen.
5	5	04	II	OR
8	5	32	I	ED
9	2	52	I	SI
	3	27	I	TI
	5	04	I	Se
	5	39	I	Te
10	2	48	I	OR
11	3	54	III	ED
12	4	02	II	ED
16	4	47	I	SI
	5	28	I	TI
17	4	49	I	OR

d	h	m	Sat.	Phen.
18	2	10	I	Te
19	6	38	II	ED
21	2	18	II	TI
	3	21	II	Se
	4	53	II	Te
22	3	39	III	Te
23	6	41	I	SI
24	3	48	I	ED
	6	49	I	OR
25	1	58	I	TI
	3	21	I	Se
	4	10	I	Te
28	3	22	II	SI
	5	05	II	TI
	5	57	II	Se
29	1	52	III	SI
	4	29	III	Se
	5	21	III	TI
30	2	54	II	OR
31	5	42	I	ED

AUGUST

d	h	m	Sat.	Phen.
1	3	04	I	SI
	3	58	I	TI
	5	15	I	Se
	6	10	I	Te
2	3	19	I	OR
4	5	58	II	SI
5	5	51	III	SI
6	1	07	II	ED
	5	40	II	OR
8	4	58	I	SI
	5	57	I	TI
	7	09	I	Se
9	2	05	I	ED
	2	41	III	OR
	5	19	I	OR
10	1	38	I	Se
	2	39	I	Te
13	3	42	II	ED
15	2	38	II	Te
	6	52	I	SI
16	2	31	III	ER
	3	58	I	ED
	4	14	III	OD
	7	01	III	OR
	7	18	I	OR
17	1	20	I	SI
	2	25	I	TI
	3	31	I	Se
	4	37	I	Te
18	1	47	I	OR
20	6	17	II	ED
22	0	27	II	SI
	2	46	II	TI
	3	03	II	Se
	5	23	II	Te
23	3	50	III	ED
	5	52	I	ED
	6	32	III	ER
24	0	29	II	OR
	3	14	I	SI
	4	23	I	TI
	5	25	I	Se
	6	34	I	Te
25	0	21	I	ED
	3	45	I	OR
	23	53	I	Se
26	1	04	I	Te
27	1	21	III	Te
29	3	03	II	SI
	5	30	II	TI
	5	39	II	Se
31	3	11	II	OR
	5	08	I	SI
	6	20	I	TI
	7	19	I	Se

SEPTEMBER

d	h	m	Sat.	Phen.
1	2	15	I	ED
	5	43	I	OR
	23	36	I	SI
2	0	49	I	TI
	1	47	I	Se
	3	00	I	Te
3	0	12	I	OR
	0	28	III	Se
	2	47	III	TI
	5	34	III	Te
5	5	40	II	SI
7	0	44	II	ED
	5	51	II	OR
	7	01	I	SI
8	4	08	I	ED
	7	40	I	OR
9	0	11	II	Te
	1	30	I	SI
	2	45	I	TI
	3	40	I	Se
	4	56	I	Te
10	1	46	III	SI
	2	09	I	OR
	4	28	III	Se
	6	56	III	TI
	23	25	I	Te
13	23	53	III	OR
14	3	18	II	ED
	5	52	II	ER
	5	54	II	OD
15	6	02	I	ED
16	0	11	II	Se
	0	13	II	TI
	2	51	II	Te
	3	23	I	SI
	4	40	I	TI
	5	34	I	Se
	6	52	I	Te
17	0	31	I	ED
	4	05	I	OR
	5	46	III	SI
	23	09	I	TI
18	0	02	I	Se
	1	20	I	Te
20	22	31	III	ER
21	1	07	III	OD
	3	58	III	OR
	5	52	II	ED
23	0	10	II	SI
	2	47	II	Se
	2	52	II	TI
	5	17	I	SI
	5	30	II	Te
	6	35	I	TI
	7	27	I	Se
24	2	25	I	ED
	5	59	I	OR
	23	45	I	SI
25	0	22	II	OR
	1	03	I	TI
	1	56	I	Se
	3	14	I	Te
26	0	28	I	OR
27	23	45	III	ED
28	2	31	III	ER
	5	07	III	OD
	7	59	III	OR
30	2	47	II	SI
	5	24	II	Se
	5	28	II	TI
	7	10	I	SI

OCTOBER

d	h	m	Sat.	Phen.
1	4	18	I	ED
	7	53	I	OR
	21	52	III	Te
2	0	17	II	ER
	0	21	II	OD
	1	38	I	SI
	2	56	I	TI
	2	56	II	OR
	3	49	I	Se
	5	07	I	Te
	22	47	I	ED
3	2	22	I	OR
	22	17	I	Se
	23	35	I	Te
5	3	44	III	ED
	6	31	III	ER
7	5	23	II	SI
	8	01	II	Se
	8	03	II	TI
8	6	12	I	ED
	22	55	III	TI
9	0	17	II	ED
	1	46	III	Te
	2	51	II	ER
	2	52	II	OD
	3	32	I	SI
	4	48	I	TI
	5	27	II	OR
	5	42	I	Se
	6	59	I	Te
10	0	41	I	ED
	4	14	I	OR
	21	18	II	TI
	21	18	II	Se
	22	00	I	SI
	23	16	I	TI
	23	57	II	Te
11	0	11	I	Se
	1	27	I	Te
	22	42	I	OR
12	7	44	III	ED
14	7	59	II	SI
15	8	06	I	ED
	11	38	I	OR
	21	40	III	SI
16	0	26	III	Se
	2	44	III	TI
	2	51	II	ED
	5	25	I	SI
	5	35	III	Te
	6	39	I	TI
	7	36	I	Se
	7	56	II	OR
	8	50	I	Te
17	2	35	I	ED
	6	05	I	OR
	21	17	II	SI
	23	50	II	TI
	23	53	I	SI
	23	55	II	Se
18	1	07	I	TI
	2	04	I	Se
	2	28	II	Te
	3	18	I	Te
	21	03	I	ED
19	0	33	I	OR
	21	09	II	OR
	21	45	I	Te
23	1	38	III	SI
	4	26	III	Se
	5	24	II	ED
	6	28	III	TI
	7	18	I	SI
24	4	29	I	ED
	7	56	I	OR
	23	53	II	SI
25	1	47	I	SI
	2	18	II	TI
	2	32	II	Se
	2	56	I	TI
	3	58	I	Se
	4	57	II	Te
	5	08	I	Te
	22	57	I	ED
26	2	23	I	OR
	20	15	I	SI
	20	25	III	OD
	21	23	I	TI
	22	26	I	Se
	23	19	III	OR
	23	34	II	OR
	23	35	I	Te
27	20	50	I	OR
30	5	37	III	SI
	7	58	II	ED
	8	26	III	Se
31	6	23	I	ED

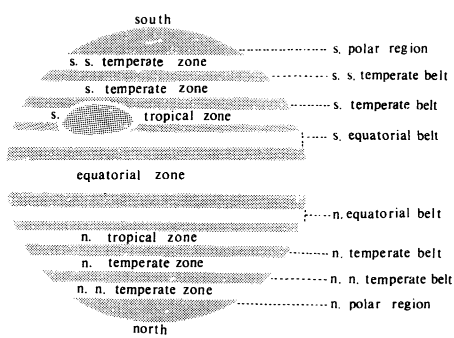
NOVEMBER

d	h	m	Sat.	Phen.
1	2	30	II	SI
	3	40	I	SI
	4	45	I	TI
	4	45	II	TI
	5	09	II	Se
	5	51	I	Se
	6	56	I	Te
	7	24	II	Te
2	0	51	I	ED
	4	12	I	OR
	21	15	II	ED
	22	08	I	SI
	22	31	III	ER
	23	12	I	TI
3	0	02	III	OD
	0	19	I	Se
	1	23	I	Te
	1	58	II	OR
	2	56	III	OR
	22	39	I	OR
4	19	50	I	Te
	20	37	II	Te
7	8	17	I	ED
8	5	06	II	SI
	5	33	I	SI
	6	32	I	TI
	7	09	II	TI
	7	45	I	Se
	7	46	II	Se
9	2	45	I	ED
	6	00	I	OR
	23	39	III	ED
	23	48	II	ED
10	0	01	I	SI
	0	59	I	TI
	2	13	I	Se
	2	31	III	ER
	3	10	I	Te
	3	35	III	OD
	4	18	II	OR
	6	29	III	OR
	21	14	I	ED
11	0	26	I	OR
	19	25	I	TI
	20	20	II	TI
	20	41	I	Se
	21	05	II	Se
	21	37	I	Te
	23	00	II	Te
13	20	06	III	Te
15	7	26	I	SI
	7	43	II	SI
	8	18	I	TI
16	4	40	I	ED
	7	46	I	OR
17	1	55	I	SI
	2	22	II	ED
	2	45	I	TI
	3	39	III	ED
	4	07	I	Se
	4	56	I	Te
	6	32	III	ER

d	h m	Sat.	Phen.
17	6 37	II	OR
	7 04	III	OD
	23 08	I	ED
18	2 13	I	OR
	20 23	I	SI
	21 02	II	SI
	21 11	I	TI
	22 35	I	Se
	22 41	II	TI
	23 23	I	Te
	23 42	II	Se
19	1 21	II	Te
	20 39	I	OR
20	19 46	II	OR
	20 25	III	Se
	20 39	III	TI
	23 32	III	Te
23	6 34	I	ED
24	3 48	I	SI
	4 30	I	TI
	4 56	II	ED
	6 00	I	Se
	6 42	I	Te
	7 38	III	ED
	8 54	II	OR
25	1 02	I	ED
	3 58	I	OR
	22 17	I	SI
	22 56	I	TI
	23 39	II	SI
26	0 29	I	Se
	1 00	II	TI
	1 08	I	Te
	2 19	II	Se
	3 40	II	Te
	19 31	I	ED
	22 25	I	OR
27	18 13	II	ED
	18 57	I	Se
	19 34	I	Te
	21 31	III	SI
	22 02	II	OR
28	0 01	III	TI
	0 25	III	Se
28	2 54	III	Te
30	8 28	I	ED
DECEMBER			
d	h m	Sat.	Phen.
1	5 42	I	SI
	6 14	I	TI
	7 30	II	ED
	7 54	I	Se
	8 26	I	Te
2	2 57	I	ED
	5 43	I	OR
3	0 10	I	SI
	0 40	I	TI
	2 15	II	SI
	2 23	I	Se
	2 52	I	Te
	3 17	II	TI
	4 56	II	Se
	5 57	II	Te
	21 25	I	ED
4	0 09	I	OR
	18 39	I	SI
	19 06	I	TI
	20 47	II	ED
	20 51	I	Se
	21 18	I	Te
5	0 17	II	OR
	1 30	III	SI
	3 19	III	TI
	4 25	III	Se
	6 13	III	Te
	18 35	I	OR
6	18 15	II	Se
	19 04	II	Te
8	7 36	I	SI
	7 58	I	TI
	20 01	III	OR
9	4 51	I	ED
	7 27	I	OR
10	2 04	I	SI
	2 23	I	TI
	4 17	I	Se
	4 36	I	Te
10	4 52	II	SI
	5 32	II	TI
	7 33	II	Se
	8 13	II	Te
	23 20	I	ED
11	1 53	I	OR
	20 32	I	SI
	20 49	I	TI
	22 45	I	Se
	23 02	I	Te
	23 21	II	ED
12	2 30	II	OR
	5 29	III	SI
	6 36	III	TI
	8 25	III	Se
	17 49	I	ED
	20 19	I	OR
13	17 14	I	Se
	17 28	I	Te
	18 11	II	SI
	18 40	II	TI
	20 52	II	Se
	21 20	II	Te
15	19 37	III	ED
	23 16	III	OR
16	6 46	I	ED
	9 11	I	OR
17	3 58	I	SI
	4 07	I	TI
	6 11	I	Se
	6 19	I	Te
	7 30	II	SI
	7 47	II	TI
18	1 15	I	ED
	3 37	I	OR
	22 26	I	SI
	22 32	I	TI
19	0 39	I	Se
	0 45	I	Te
	1 56	II	ED
	4 43	II	OR
	19 43	I	ED
	22 03	I	OR
20	16 55	I	SI
20	16 58	I	TI
	19 08	I	Se
	19 11	I	Te
	20 48	II	SI
	20 54	II	TI
	23 29	II	Se
	23 35	II	Te
22	17 49	II	OR
	23 36	III	OD
23	2 34	III	ER
	8 40	I	OD
24	5 50	I	TI
	5 52	I	SI
	8 03	I	Te
	8 05	I	Se
25	3 06	I	OD
	5 24	I	ER
26	0 16	I	TI
	0 21	I	SI
	2 28	I	Te
	2 34	I	Se
	4 20	II	OD
	7 07	II	ER
	21 32	I	OD
	23 53	I	ER
27	18 42	I	TI
	18 49	I	SI
	20 54	I	Te
	21 02	I	Se
	23 09	II	TI
	23 25	II	SI
28	1 49	II	Te
	2 06	II	Se
	18 22	I	ER
29	17 27	II	OD
	20 24	II	ER
30	2 51	III	OD
	6 34	III	ER
31	7 33	I	TI
	7 46	I	SI
32	4 50	I	OD
	7 19	I	ER

JUPITER'S BELTS AND ZONES

Viewed through a telescope of 6-inch aperture or greater, Jupiter exhibits a variety of changing detail and colour in its cloudy atmosphere. Some features are of long duration, others are short-lived. The standard nomenclature of the belts and zones is given in the figure.



COMETS IN 1977

By Brian G. Marsden

The following periodic comets are expected at perihelion during 1977:

Comet	Perihelion Date	Perihelion Distance	Period
van Houten	Jan. 1	3.98 A.U.	16.1 yr
Johnson	Jan. 8	2.20	6.8
du Toit-Neujmin-Delporte	Jan. 31	1.68	6.3
Faye	Feb. 27	1.61	7.4
Kopff	Mar. 7	1.57	6.4
Grigg-Skjellerup	Apr. 11	0.99	5.1
Encke	Aug. 16	0.34	3.3

Comet van Houten, discovered in the course of the Palomar-Leiden asteroid survey in 1960, has a very uncertain orbit, and its predicted perihelion date could be in error by as much as three months. Comets Johnson, Faye and Kopff were recovered early in 1976, but none of them is expected to become a bright object. Comet du Toit-Neujmin-Delporte, lost from its discovery in 1941 until 1970, is very badly placed at this return and will certainly not be observed.

Comet Grigg-Skjellerup, discovered by Grigg in 1902 and by Skjellerup in 1922, has been observed at all its subsequent returns. In 1977 it makes an unusually close approach to the earth, passing only 0.18 A.U. away on April 2. This comet can be expected to attain magnitude 9–10 for a short while—as it did in 1947, when it passed only 0.16 A.U. from the earth.

Comet Encke will be too close to the sun and very badly placed for observation at this perihelion passage, although it was in fact under observation at *aphelion* in 1972 and 1975.

Comet Grigg-Skjellerup

Date	R.A. (1950)	Dec. (1950)	Mag.
Feb. 26	$10^h25^m.9$	−62°08′	12.3
Mar. 8	11 24.7	−71 15	
18	15 12.0	−77 04	10.6
28	18 52.6	−60 44	
Apr. 7	19 52.9	−32 20	9.8
17	20 18.1	− 8 11	
27	20 32.4	+ 7 24	10.9
May 7	20 41.2	+17 14	
17	20 45.5	+23 47	12.3

Comet Encke

Date	R.A. (1950)	Dec. (1950)	Mag.
July 6	$4^h49^m.1$	+28°52′	12.1
16	5 47.0	+29 26	
26	6 56.5	+27 57	9.8
Aug. 5	8 16.2	+23 11	
15	9 42.0	+14 12	8.5
25	11 04.9	+ 2 37	
Sept. 4	12 20.2	− 8 12	10.0
14	13 30.8	−16 52	
24	14 36.2	−22 55	13.0

Any other bright comets that may appear during 1977 will be completely unexpected.

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.

METEOR SHOWERS FOR 1977

Shower	Shower Maximum			Radiant				Single Observer Hourly Rate	Velocity	Normal Duration to 1/4 strength of Max.
	Date	E.S.T.	Moon	Position at Max. R.A.	Position at Max. Dec.	Daily Motion R.A.	Daily Motion Dec.			
		h		h m	°	m	°		km/sec	days
Quadrantids	Jan. 3	08	F.M.	15 28	+50	—	—	40	41	1.1
Lyrids	Apr. 22	04	N.M.	18 16	+34	+4.4	0.0	15	48	2
η Aquarids	May 5	05	F.M.	22 24	00	+3.6	+0.4	20	64	3
δ Aquarids	July 29	01	F.M.	22 36	−17	+3.4	+0.17	20	40	—
Perseids	Aug. 12	06	N.M.	03 04	+58	+5.4	+0.12	50	60	4.6
Orionids	Oct. 21	07	F.Q.	06 20	+15	+4.9	+0.13	25	66	2
Taurids	Nov. 4	—	L.Q.	03 32	+14	+2.7	+0.13	15	28	—
Leonids	Nov. 16	23	F.Q.	10 08	+22	+2.8	−0.42	15	72	—
Geminids	Dec. 13	22	F.Q.	07 32	+32	+4.2	−0.07	50	35	2.6
Ursids	Dec. 22	13	F.M.	14 28	+76	—	—	15	34	2
Quadrantids	(1978) Jan. 3	14	L.Q.	15 28	+50	—	—	40	41	1.1

CANADIAN 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 since 1951 at the Earth Physics Branch (formerly Dominion Observatory) Department of Energy, Mines and Resources. Approximately 40 percent of the craters recognized in the world have been discovered in Canada. At large impact sites (greater than approximately 1500 m diameter) original meteoritic material is not recognizable. Extreme shock pressures and temperatures at impact vapourize or melt the meteorite and it becomes intimately mixed and disseminated in the melted target rocks. 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 75 kilobars. The twenty-three "confirmed" structures in the Table contain definitive evidence of shock metamorphism, and are listed in order of their discovery. The latter three of these features were recognized during 1974. The "possible" sites represent only a few of those under consideration but where definitive shock metamorphic effects have not been found. Craters where data have been obtained through diamond-drilling or geophysical surveys are marked "D" and "G", respectively, and "A" signifies those sites accessible by road. "Float" includes boulders and pebbles in glacial deposits.

Name	Lat.	Long.	Diam. (km)	Age ($\times 10^6$ years)	Surface Expression	Visible Geologic Features	
A Confirmed sites							
New Quebec Crater, Que.	61°17′	73°40′	3	<1	rimmed circular lake	raised rim	G
Brent, Ont.	46°05′	78°29′	4	450±40	sediment-filled shallow depression	fracturing	A D G
Manicouagan, Que.	51°23′	68°42′	65	210±4	circumferal lake, central elevation	impact melt	G*
Clearwater Lake West, Que.	56°13′	74′30′	25	285±30	island ring in circular lake	impact melt	D G
Clearwater Lake East, Que.	56°05′	74°07′	14.5	285±30	circular lake	sedimentary float	D G
Holleford, Ont.	44°28′	76°38′	2	550±50	sediment-filled shallow depression	sedimentary fill	A D G
Deep Bay, Sask.	56°24′	102°59′	9	100±50	circular bay	sedimentary float	D G
Carswell, Sask.	58°27′	109°30′	30	485±50	discontinuous circular ridge	weak shatter cones and breccia	G
Lac Couture, Que.	60°08′	75°18′	10	350±50	circular lake	breccia float	
West Hawk Lake, Man.	49°46′	95°11′	3	150±50	circular lake	none	A D G
Pilot Lake, N.W.T.	60°17′	111°01′	5	300±150	circular lake	fracturing, breccia float	
Nicholson Lake, N.W.T.	62°40′	102°41′	12.5	300±150	irregular lake with islands	breccia	G
Steen River, Alta.	59°31′	117°38′	13.5	95±7	none, buried to 200 metres	none	D G
Sudbury, Ont.	46°36′	81°11′	100	1700±200	elliptical basin	breccia, impact melt, shatter cones	A D G
Charlevoix, Que.	47°32′	70°18′	35	350±25	semi-circular trough, central elevation	breccia float, shatter cones, impact melt	A G
Lake Mistastin, Labr.	55°53′	63°18′	20	40±3	elliptical lake and central island	breccia, impact melt	
Lake St. Martin, Man.	51°47′	98°33′	24	225±25	none, buried and eroded	impact melt	A D G
Lake Wanapitei, Ont.	46°44′	80°44′	8.5	37±2	lake-filled, partly circular	breccia float	A G
Gow Lake, Sask.	56°27′	104°29′	5	>150	lake and central island	breccia	G
Lac La Moinerie, Que.	57°26′	66°36′	8	400±50	lake-filled, partly circular	breccia float	
Haughton Dome, N.W.T.	75°22′	89°40′	18	<400	shallow, ringed depression	shatter cones, breccia	
Slate Islands, Ont.	48°40′	87°00′	13	<1100	islands are central uplift of submerged structure	shatter cones, breccia dikes	*
Ile Rouleau (L. Mistassini) Que.	50°41′	73°53′	4	<1000	island is central uplift of submerged structure.	shatter cones, breccia dikes	
B Possible sites							
Skeleton Lake, Ont.	45°15′	79°26′	4		lake-filled partly circular	breccia, sedimentary float	A G
Kakiattukallak Lake, Que.	57°42′	71°40′	6		circular lake	breccia float	
Meen Lake, N.W.T.	64°58′	87°41′	4		circular lake	breccia	
Charron Lake, Man.	52°44′	95°15′	5		circular lake	?	
Eagle Butte, Alta.	49°42′	110°30′	10		slight, buried and eroded	disturbed beds	A D
McIntosh Bay, Ont.	52°35′	94°05′	5		circular lake	?	
Poplar Bay (L. DuBonnet), Man.	50°23′	95°48′	3.5		circular lake	?	A G
Viewfield, Sask.	49°33′	103°04′	2.5		completely buried circular depression	?	A D G

*readily accessible by boat

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. 81).

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, 1977 (E.S.T.)

JANUARY

d	h	Sat.	Elong.
2	07.8	Ti	E
3	21.6	Rh	E
8	10.0	Rh	E
9	23.7	Ti	W
12	22.3	Rh	E
17	10.6	Rh	E
18	05.4	Ti	E
21	22.9	Rh	E
25	21.2	Ti	W
26	11.3	Rh	E
30	23.6	Rh	E

FEBRUARY

d	h	Sat.	Elong.
2	00.2	Ia	W
3	02.8	Ti	E
4	11.9	Rh	E
9	00.2	Rh	E
10	18.6	Ti	W
13	12.5	Rh	E
18	00.8	Rh	E
19	00.3	Ti	E
22	13.2	Rh	E
26	16.1	Ti	W
27	01.5	Rh	E

MARCH

d	h	Sat.	Elong.
3	13.8	Rh	E
6	21.9	Ti	E
8	02.2	Rh	E
12	14.5	Rh	E
13	22.1	Ia	E
14	13.9	Ti	W
17	02.9	Rh	E
21	15.3	Rh	E
22	19.8	Ti	E
26	03.7	Rh	E
30	12.1	Ti	W
30	16.1	Rh	E

APRIL

d	h	Sat.	Elong.
4	04.5	Rh	E
7	18.2	Ti	E
8	16.9	Rh	E
13	05.3	Rh	E
15	10.7	Ti	W
17	17.8	Rh	E
21	15.8	Ia	W
22	06.2	Rh	E
23	17.1	Ti	E
26	18.7	Rh	E

MAY

d	h	Sat.	Elong.
1	07.1	Rh	E
1	09.8	Ti	W
5	19.6	Rh	E
9	16.4	Ti	E
10	08.1	Rh	E
14	20.6	Rh	E
17	09.3	Ti	W
19	09.1	Rh	E
23	21.7	Rh	E
25	16.2	Ti	E
28	10.2	Rh	E

JUNE

d	h	Sat.	Elong.
1	14.5	Ia	E
1	22.7	Rh	E
2	09.2	Ti	W
6	11.3	Rh	E
10	16.3	Ti	E
10	23.8	Rh	E
15	12.4	Rh	E
18	09.4	Ti	W
20	00.9	Rh	E
24	13.5	Rh	E
26	16.6	Ti	E
29	02.1	Rh	E

JULY

d	h	Sat.	Elong.
3	14.6	Rh	E
4	09.9	Ti	W
8	03.2	Rh	E

Saturn being near the sun, elongations are not given between July 8 and Sept. 18.

SEPTEMBER

d	h	Sat.	Elong.
18	12.5	Rh	E
22	13.2	Ti	W
23	01.0	Rh	E
27	13.6	Rh	E
30	14.4	Ia	W
30	20.4	Ti	E

OCTOBER

d	h	Sat.	Elong.
2	02.1	Rh	E
6	14.7	Rh	E
8	13.6	Ti	W
11	03.2	Rh	E
15	15.7	Rh	E
16	20.6	Ti	E
20	04.3	Rh	E
24	13.7	Ti	W
24	16.8	Rh	E
29	05.3	Rh	E

NOVEMBER

d	h	Sat.	Elong.
1	20.5	Ti	E
2	17.8	Rh	E
7	06.3	Rh	E
9	13.4	Ti	W
11	02.5	Ia	E
11	18.7	Rh	E
16	07.2	Rh	E
17	20.0	Ti	E
20	19.7	Rh	E
25	08.1	Rh	E
25	12.8	Ti	W
29	20.6	Rh	E

DECEMBER

d	h	Sat.	Elong.
3	19.2	Ti	E
4	09.0	Rh	E
8	21.4	Rh	E
11	11.7	Ti	W
13	09.8	Rh	E
17	22.3	Rh	E
19	17.8	Ti	E
19	19.1	Ia	W
22	10.6	Rh	E
26	23.0	Rh	E
27	10.1	Ti	W
31	11.4	Rh	E

TABLE OF PRECESSION FOR 50 YEARS

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

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

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'kẽr-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, râs'*ă*l-jē'the	α Her	17
Bellatrix, bĕ-lā'trĭks	γ Ori	05	Rasalhague, râs'*ă*l-hā'gwē	α Oph	17
Betelgeuse, bĕt'*e*l-juz	α Ori	05	Regulus, rĕg'u-l*ŭ*s	α Leo	10
Canopus, k*a*-nō'p*ŭ*s	α Car	06	Rigel, rī'j*e*l	β Ori	05
Capella, k*a*-pĕl'*a*	α Aur	05	Rigil Kentaurus		
Caph, kăf	β Cas	00	rī'jĭl kĕn-tô'r*ŭ*s	α Cen	14
Castor, kås'tẽr	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 0ᵐ08, 0.10ᵈ	*Caph*
γ Peg	12.2	+15 04	2.84v	−0.23	B2	IV	−.004	−3.4	570	0.010	+04.1	β CMa type, R in V 2.83–2.85, 0.15ᵈ	
β Hyi	24.6	−77 22	2.78	+0.62	G1	IV	0.153	+3.7	21	2.255	+22.8		γ Peg = *Algenib*
α Phe	25.3	−42 25	2.39	+1.08	*K0*	*III*	0.035	+0.1	93	0.442	*+74.6*		*Ankaa*
δ And *A*	38.2	+30 45	3.25:	+1.26	K3	III	0.024	−0.2	160	0.161	−07.3	*B* 12ᵐ 28″	
α Cas	39.4	+56 25	2.22	+1.18	K0	II–III	0.009	−1.1	150	0.058	−03.8	Var.?	*Schedar*
β Cet	42.6	−18 06	2.02	+1.03	K1	III	0.057	+0.8	57	0.234	+13.1		*Diphda*
η Cas *A*	47.9	+57 42	3.47	+0.56	G0	V	0.182	+4.8	18	1.221	+09.4	*B* 7.26ᵐ 12″	
γ Cas *A*	55.5	+60 36	2.5v	−0.16v	B0	IV:pe	0.034	−0.3:	96:	0.026	−06.8	Var. *B* 8.18ᵐ 2″	
β Phe *AB*	01 05.1	−46 50	3.30	+0.88	*G8*	*III*	0.017	+0.3	190	0.035	−01.1	*A* 4.1ᵐ *B* 4.1ᵐ 1″	
η Cet	07.6	−10 17	3.44	+1.16	K3	III	0.032	+1.0	102	0.250	+11.5		
β And	08.6	+35 31	2.02	+1.57	M0	III	0.043	+0.2	76	0.211	+00.3		*Mirach*
δ Cas	24.4	+60 08	2.67	+0.13	A5	V	0.029	+2.1	43	0.301	+06.7	Ecl.? R 0.08:ᵐ 759ᵈ	*Ruchbah*
γ Phe	27.5	−43 25	3.40	+1.56	K5	IIb–III	−.003	−4.6	1300	0.209	*+25.7*		
α Eri	37.0	−57 20	0.51	−0.16	B3	Vp	0.023	−2.3	118	0.098	+19		***Achernar***
τ Cet	43.2	−16 03	3.50	+0.72	G8	Vp	0.275	+5.70	12	1.921	−16.2		

Star	R.A. 1980	Dec.	V	B–V	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/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*
o Cet *A*	18.3	−03 04	2.0v		M5.5e–M9e	0.013	−0.5	103	0.232	+63.8	LP, *R* 2.0–10.1, 332^d, *B* 10^m 1″	*Mira*
γ Cet *AB*	42.2	+03 10	3.48	+0.11	A2 V	0.048	+2.0	68	0.203	−05.1	*A* 3.57^m *B* 6.23^m 3″	
θ Eri *AB*	57.5	−40 23	2.92	+0.13	A3 III	0.028	+1.7	65	0.061	*+11.9*	*A* 3.25^m *B* 4.36^m 8″	*Acamar*
α Cet	03 01.2	+04 00	2.54	+1.63	M2 III	0.003	−0.5	130	0.075	−25.9		*Menkar*
γ Per	03.3	+53 25	2.91:	+0.72:	G8 III: +A3	0.011	+0.3	113	0.004	*+02.5*		
ρ Per	03.7	+38 45	3.5v		M4 II–III	0.008	−1.0	260	0.172	+28.2	Irr. *R* 3.2–3.8	
β Per	06.6	+40 52	2.06v	−0.07	B8 V	0.031	−0.5	105	0.006	*+06.0*	Ecl. *R* 2.06–3.28, 2.87^d	*Algol*
α Per	22.9	+49 47	1.80	+0.48	F5 Ib	0.029	−4.4	570	0.035	−02.4		*Mirfak*
δ Per	41.5	+47 44	3.03	−0.14	B5 III	0.007	−3.3	590	0.046	+02.8		
η Tau	46.3	+24 03	2.86	−0.09	B7 III	0.005	−3.2	541	0.050	+10.1	in Pleiades	*Alcyone*
γ Hyi	47.5	−74 18	3.30	+1.61	M2 III	−.001	−1.5	300	0.125	+16.0		
ζ Per *A*	52.7	+31 50	2.83	+0.13	B1 Ib	0.007	−6.1	1000	0.015	+20.6	*B* 9.36^m 13″	
ε Per *A*	56.5	+39 57	2.88	−0.17	B0.5 V	−.001	−3.7	680	0.036	*−01*	*B* 7.99^m 9″	
γ Eri	57.1	−13 34	2.96	+1.58	M0 III	0.003	−0.5	160	0.126	+61.7		
α Ret *A*	04 14.1	−62 32	3.33	+0.91	G9 III	0.008	−2.1	390	0.064	+35.6	*B* 12^m 49″	
ε Tau	27.5	+19 08	3.54	+1.02	K0 III	0.018	+0.1	160	0.118	+38.6		
$θ^2$ Tau	27.5	+15 49	3.42	+0.17	A7 III	0.025	+0.2	140	0.108	*+39.5*		
α Dor	33.5	−55 05	3.28	−0.08	A0 IIIp	0.011	−1.2	260	0.051	+25.6	Silicon star	
α Tau *A*	34.8	+16 28	0.86v	+1.52	K5 III	0.048	−0.7	68	0.202	+54.1	Irr.? *R* 0.78–0.93, *B* 13^m 31″	***Aldebaran***
$π^3$ Ori	48.3	+06 56	3.17	+0.45	F6 V	0.125	+3.65	26	0.468	+24.3		
ι Aur	55.7	+33 08	2.68:	+1.49	K3 II	0.015	−2.4	330	0.021	+17.5		

Star	R.A. 1980	Dec.	*V*	*B–V*	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/sec	
ε Aur	05 00.5	+43 48	3.0v	+0.50:	F0 Iap	0.004	−7.1	3400	0.008	*−01.4*	Ecl. *R* 0.81^m 9886^d
ε Lep	04.6	−22 24	3.21	+1.46	*K5 III*	0.006	−0.4	170	0.077	+01.0	
η Aur	05.1	+41 13	3.17	−0.18	B3 V	0.013	−2.1	370	0.077	+07.4	
β Eri	06.9	−05 06	2.79	+0.13	A3 III	0.042	+0.9	78	0.122	−08	
μ Lep	12.1	−16 13	3.29	−0.09	*B9 IIIp*	0.018	−2.1	390	0.049	+27.7	Manganese star
β Ori *A*	13.6	−08 13	0.14v	−0.04	B8 Ia	−.003	−7.1	900	0.001	*+20.7*	Irr.? *R* 0.08–0.20, *B* 6.65^m 9″ ***Rigel***
α Aur	15.2	+45 59	0.05	+0.80	G8 III: +F	0.073	−0.6	45	0.435	*+30.2*	***Capella***
η Ori *AB*	23.5	−02 24	3.32v	−0.18	B0.5 V	0.004	−3.7	940	0.008	*+19.8*	Ecl. *R* 3.32–3.50, 8.0^d, *A* 3.59^m *B* 4.98^m 1″
γ Ori	24.0	+06 20	1.64	−0.23	B2 III	0.026	−4.2	470	0.015	+18.2	*Bellatrix*
β Tau	25.0	+28 36	1.65	−0.13	B7 III	0.018	−3.2	300	0.178	+08.0	*Elnath*
β Lep *A*	27.4	−20 47	2.81	+0.82	G5 III	0.014	+0.1	113	0.090	−13.5	*B* 9.4^m 3″
δ Ori *A*	31.0	−00 19	2.20v	−0.20	O9.5 II	0.004	−6.1	1500	0.002	*+22.0*	Ecl. *R* 2.20–2.35 5.7^d, B 6.74^m 53″
α Lep	31.8	−17 51	2.58	+0.22	F0 Ib	0.002	−4.6	900	0.006	+24.7	
λ Ori *AB*	34.1	+09 55	3.40	−0.18	O8	0.006	−5.1	1800	0.006	+33.5	*A* 3.56^m *B* 5.54^m 4″ *C* 10.92^m 29″
ι Ori *AB*	34.5	−05 56	2.76	−0.24	O9 III	0.021	−6.1	2000	0.005	*+27.6*	*A* 2.78^m *B* 7.31^m 11″
ε Ori	35.2	−01 13	1.70	−0.19	B0 Ia	−.007	−6.8	1600	0.000	+26.1	*Alnilam*
ζ Tau	36.5	+21 08	3.07:	−0.13:	B2 III:p	−.002	−4.2	940	0.023	*+22.8*	Shell star
α Col *A*	39.0	−34 05	2.64	−0.11	*B8 Ve*	−.005	−0.6	140	0.026	+35	*B* 12^m 12″ *Phact*
ζ Ori *AB*	39.7	−01 57	1.79	−0.22	O9.5 Ib	0.022	−6.6	1600	0.004	+18.1	*A* 1.91^m *B* 4.05^m 3″ *Alnitak*
κ Ori	46.8	−09 41	2.06	−0.17	B0.5 Ia	0.009	−6.9	2100	0.004	+20.6	
β Col	50.2	−35 47	3.12	+1.16	K2 III	0.023	+0.0	140	0.402	+89.4	
α Ori	54.0	+07 24	0.41v	+1.87:	M2 Iab	0.005	−5.6	520	0.028	*+21.0*	Irr.? *R* 0.06:–0.75:^{m} ***Betelgeuse***
β Aur	58.0	+44 57	1.86	+0.06	A2 V	0.037	−0.3	88	0.051	*−18.2*	*Menkalinan*
θ Aur *AB*	58.4	+37 13	2.65v	−0.07	B9.5pv	0.018	+0.1	108	0.097	+29.3	Silicon star *A* 2.67^m *B* 7.14^m 3″, var., 1.4^d
η Gem *A*	06 13.7	+22 31	3.33v	+1.58	M3 III	0.013	−0.6	200	0.066	*+19.0*	*R* 0.27^m, *B* 6.70^m 1″
ζ CMa	19.6	−30 03	3.04	−0.18	B2.5 V	−.003	−2.4	390	0.004	*+32.2*	
μ Gem	21.7	+22 32	2.92v	+1.63	M3 III	0.021	−0.6	160	0.129	+54.8	*R* 0.14^m
β CMa	21.8	−17 56	1.96v	−0.24	B1 II–III	0.014	−4.8	750	0.004	*+33.7*	β CMa type variable, 0.25^d
α Car	23.5	−52 41	−0.72	+0.16	F0 Ib–II	0.018	−3.1	98	0.025	+20.5	***Canopus***
γ Gem	36.6	+16 25	1.93	0.00	A0 IV	0.031	−0.6	105	0.066	*−12.5*	*Alhena*

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
ν Pup	06 37.1	−43 11	3.19	−0.10	*B7 III*		−3.2	620	0.010	+28.2		
ε Gem	42.7	+25 09	3.00	+1.39	G8 Ib	0.009	−4.6	1080	0.016	+09.9		
ξ Gem	44.2	+12 55	3.38	+0.43	F5 IV	0.051	+1.9	64	0.224	+25.3		
α CMa *A*	44.2	−16 42	−1.47	+0.01	A1 V	0.375	+1.45	8.7	1.324	*−07.6*	*B* 8.66^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***
σ² CMa	07 02.2	−23 48	3.02	−0.09	B3 Ia		−7.1	3400	0.000	+48.4		
δ CMa	07.6	−26 22	1.85	+0.65	F8 Ia	−.018	−7.1	2100	0.005	+34.3		
L_2 Pup	12.9	−44.37			(gM5e)	0.016	−3.1	650	0.342	+53.0	LP, *R* 3.4–6.2, 141^d	
π Pup	16.5	−37 04	2.70:	+1.63:	(gK4)	0.023	−0.3	140	0.008	+15.8		
η CMa	23.3	−29 15	2.46	−0.08	B5 Ia		−7.1	2700	0.008	+41.1		
β CMi	26.2	+08 20	2.91	−0.09	B7 V	0.020	−1.1	210	0.065	+22		
σ Pup *A*	28.6	−43 15	3.24	+1.49	K5 III	0.013	−0.4	180	0.195	*+88.1*	*B* 9.4^m 22″	
α Gem *A*	33.3	+31 56	1.97	+0.00:	A1 V	0.072	+1.3	45	0.199	+06.0	} 2″, *B–V* +0.02, *C* 9.08v^m 73″	***Castor***
α Gem *B*	33.3	+31 56	2.95	+0.07:	A5m	0.072	+2.3	45	0.199	*−01.2*	}	
α CMi *A*	38.2	+05 17	0.37	+0.41	F5 IV–V	0.288	+2.7	11.3	1.250	*−03.2*	*B* 10.7^m 4″	***Procyon***
β Gem	44.1	+28 05	1.16	+1.02	K0 III	0.093	+1.0	35	0.625	+03.3		***Pollux***
ξ Pup	48.4	−24 50	3.34	+1.23	G3 Ib	−.003	−4.6	1240	0.005	*+02.7*		
χ Car	56.2	−52 56	3.48	−0.18	B3 IVp		−2.1	430	0.039	+19.1		
ζ Pup	08 02.9	−39.57	2.23	−0.26	O5f		−7.1	2400	0.033	−24		
ρ Pup	06.7	−24 15	2.80v	+0.42	F6 IIp	0.031	+0.3:	105:	0.098	+46.6	Var. *R* 2.72–2.87, 0.14^d	
γ Vel *A*	08.9	−47 18	1.83	−0.26	WC8		−4.1	520	0.011	+35	*B* 4.31^m 41″	
ε Car	22.1	−59 26	1.90:	+1.30:	K3: III+B2:v		−3.1:	340	0.030	+11.5		***Avior***
ο UMa *A*	28.6	+60 47	3.37	+0.83	G5 III	0.004	+0.1	150	0.171	+19.8	*B* 15^m 7″	
δ Vel *AB*	44.2	−54 38	1.95	+0.05	A2 V	0.043	+0.2	76	0.086	+02.2	*A* 2.0^m *B* 5.1^m 3″ *CD* 10^m 69″	
ε Hya *ABC*	45.7	+06 30	3.39	+0.68	G0 comp.	0.010	+0.6	140	0.198	*+36.4*	*A* 3.7^m *B* 5.2^m 0.2″ 15^y, *C* 6.8^m 3″ *D* 12^m 20″	
ζ Hya	54.3	+06 02	3.11	+1.00	K0 II–III	0.029	−1.1	220	0.101	+22.8		
ι UMa *A*	57.9	+48 07	3.12	+0.19	A7 V	0.066	+2.2	49	0.505	+12.2	*BC* 10.8^m 4″	

Star	R.A. 1980	Dec.	V	$B–V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
λ Vel	09 07.3	−43 21	2.24	+1.64:	K4 Ib–IIa	0.015	−4.6	750	0.026	+18.4		*Suhail*
a Car	10.5	−58 52	3.43	−0.17	B2 IV–V		−2.9	590	0.028	*+23.3*		
β Car	13.0	−69 38	1.67	+0.01	A1 III	0.038	−0.4	86	0.183	−05		*Miaplacidus*
ι Car	16.6	−59 11	2.25	+0.17	A9 Ib		−4.6	750	0.019	+13.3		
α Lyn	19.9	+34 29	3.17	+1.54	M0 III	0.021	−0.5	180	0.217	+37.6		
κ Vel	21.5	−54 56	2.49	−0.20	B2 IV–V	0.007	−3.4	470	0.012	*+21.9*		
α Hya	26.6	−08 35	1.98	+1.44	K4 III	0.017	−0.3	94	0.034	−04.3		*Alphard*
N Vel	30.6	−56 57	3.19	+1.56	K5 III	0.015	−0.4	170	0.036	−13.9		
θ UMa *A*	31.5	+51 46	3.12	+0.46	F6 IV	0.052	+1.8	63	1.094	+15.4	$B\ 14^{m}\ 5''$	
ε Leo	44.7	+23 51	2.99	+0.81	G0 II	0.002	−2.1	340	0.048	+05.0		
l Car	44.7	−62 26	4.1		G8 Ia	0.019	−5.5	2700	0.016	*+04.0*	Cep. max. 3.4^{m} min. 4.8^{m}, 35.52^{d}	
υ Car *AB*	46.6	−64 59	2.95	+0.26	A8 Ib	0.020	−2.1	340	0.012	+13.6	$A\ 3.02^{m}\ B\ 6.03^{m}\ 5''$	
α Leo *A*	10 07.3	+12 04	1.36	−0.11	B7 V	0.039	−0.7	84	0.248	+03.5	$B\ 8.1^{m}\ 177''$	***Regulus***
ω Car	13.2	−69 56	3.33	−0.08	B8 III		−1.5	300	0.029	*+04*		
ζ Leo	15.7	+23 31	3.46	+0.30	F0 III	0.009	+0.5	130	0.023	−15.0		
λ UMa	15.9	+43 01	3.45	+0.03	A2 IV	−.010	+0.1	150	0.170	+18.3		
q Car	16.4	−61 14	3.41v	+1.55	K3 Ib–II	0.018	−4.6	1300	0.023	+08.6	Var. *R* 3.38–3.44	
γ Leo *AB*	18.8	+19 57	1.99	+1.13	K0 IIIp	0.019	+0.1	90	0.350	−36.6	$A\ 2.29^{m}\ B\ 3.54^{m}\ 4''$	
μ UMa	21.1	+41 36	3.05	+1.55	M0 III	0.031	+0.5	105	0.086	*−20.5*		
p Car	31.4	−61 35	3.30v	−0.11	B4 Vne		−2.3	430	0.021	+26.0	Var. *R* 3.22–3.39	
θ Car	42.2	−64 17	2.74	−0.22	B0.5 Vp		−4.0	710	0.018	+24		
μ Vel *AB*	45.9	−49 19	2.67	+0.89	*G5 III*		+0.1	108	0.085	+06.9	$A\ 2.7^{m}\ B\ 7.2^{m}\ 1''$	
ν Hya	48.6	−16 05	3.12	+1.25	K3 III	0.022	−0.2	150	0.221	−01.0		
β UMa	11 00.6	+56 30	2.37	−0.03	A1 V	0.042	+0.5	78	0.087	−12.0		*Merak*
α UMa *AB*	02.5	+61 52	1.81	+1.06	K0 III	0.031	−0.7	105	0.138	−08.9	$A\ 1.88^{m}\ B\ 4.82^{m}\ 1''$	*Dubhe*
ψ UMa	08.6	+44 36	3.00	+1.14	K1 III		+0.0	130	0.072	−03.8		
δ Leo	13.0	+20 38	2.57	+0.13	A4 V	0.040	+0.6	82	0.201	−20.6		
θ Leo	13.2	+15 33	3.34	0.00	A2 V	0.019	+1.1	90	0.104	+07.8		
λ Cen	34.9	−62 54	3.15	−0.05	B9 III		−2.1	370	0.039	*−01*		
β Leo	48.0	+14 41	2.14	+0.09	A3 V	0.076	+1.5	43	0.511	−01		*Denebola*

Star	R.A. 1980	Dec.	V	B–V	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
γ UMa	11 52.7	+53 49	2.44	0.00	A0 V	0.020	+0.2	90	0.094	−12.9		*Phecda*
δ Cen	12 07.3	−50 36	2.59v	−0.11:	B2 IVne		−2.7	370	0.042	+09	Var. *R* 2.56–2.62	
ε Crv	09.1	−22 30	3.00	+1.33	K3 III		−0.2	140	0.069	+04.9		
δ Cru	14.1	−58 38	2.81v	−0.23	B2 IV		−3.4	570	0.041	+26.4	Var *R* 2.78–2.84	
δ UMa	14.4	+57 09	3.30	+0.07	A3 V	0.052	+1.9	63	0.106	−12.9		*Megrez*
γ Crv	14.8	−17 25	2.59	−0.10	B8 III		−3.1	450	0.163	−04.2		*Gienah*
α Cru *A*	25.4	−62 59	1.39	−0.25	B0.5 IV		−3.9	370	0.042	−*11.2*	} 5″, *C* 4.90m 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* 8.26m 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* 2.9m *B* 2.9m 2″	
γ Vir *AB*	40.6	−01 20	2.76	+0.34	F0 V	0.101	+3.5	32	0.567	−19.7	*A* 3.50m *B* 3.52m 4″	
β Mus *AB*	45.0	−68 00	3.06	−0.17:	B2 V		−2.1	470	0.041	+42	*A* 3.7m *B* 4.0m 1″	
β Cru	46.6	−59 35	1.28v	−0.25	B0.5 III		−4.6	490	0.049	+20.0	β CMa var., 0.25d:	***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* 5.61m 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* 3.94m 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, 4.0d, 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., 0.17d	
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		
μ¹ Sco	50.5	−38 01	2.99v	−0.20	B1.5 V		−3.0	520	0.033	*−25*	Ecl. *R* 2.99–3.09, 1.4^{d}	
κ Oph	56.8	+09 25	3.18	+1.15	K2 III	0.026	−0.1	150	0.293	−55.6		
ζ Ara	56.9	−55 57	3.12	+1.61	K4 III	0.036	+0.9	90	0.042	−06.0		
ζ Dra	17 08.7	+65 44	3.20	−0.12	B6 III	0.017	−3.2	620	0.026	−14.1		
η Oph *AB*	09.3	−15 42	2.43	+0.06	A2.5 V	0.047	+1.4	69	0.097	−00.9	*A* 3.0^{m} *B* 3.4^{m} 1″	*Sabik*
η Sco	10.7	−43 13	3.33	+0.38	*F2 III*	0.063	+2.3	52	0.293	−28.4		
α Her *AB*	13.8	+14 24	3.10v	+1.41	M5 II	−.007	−2.3	410	0.032	−33.1	*A* 3.2^{m} ± 0.3 *B* 5.4^{m} 5″	*Ras-Algethi*
δ Her	14.2	+24 51	3.14	+0.09	A3 IV	0.034	+0.8	96	0.164	−41		
π Her	14.3	+36 49	3.13	+1.43	K3 II	0.020	−2.4	410	0.029	−25.7		
θ Oph	20.8	−24 59	3.29v	−0.22	B2 IV		−3.4	710	0.025	*−03.6*	β CMa var., 0.14^{d}	
β Ara	23.6	−55 31	2.90:	+1.45:	K1.5 Ib	0.026	−4.6	1030	0.035	−00.4		
γ Ara *A*	23.8	−56 22	3.32	−0.16:	B1 Ib		−3.3	680	0.017	−04	*B* 10^{m} 18″	
υ Sco	29.4	−37 16	2.71	−0.22	B2 IV		−3.4	540	0.039	*+07*		
β Dra *A*	29.9	+52 20	2.77	+0.96	G2 II	0.009	−2.1	310	0.019	−20.0	*B* 11.49^{m} 4″	
α Ara	30.3	−49 52	2.95	−0.18:	B2.5 V		−2.4	390	0.083	*−02*		
λ Sco	32.3	−37 05	1.60v	−0.24	B1 V		−3.3	310	0.031	00	β CMa var., 0.21^{d}	*Shaula*
α Oph	34.0	+12 35	2.09	+0.16	A5 III	0.056	+0.8	58	0.260	+12.7		*Rasalhague*
θ Sco	35.9	−42 59	1.86	+0.39	*F0 Ib*	0.020	−4.6	650	0.012	+01.4		

Star	R.A. 1980	Dec.	*V*	*B–V*	Type	π	M_V	D	μ	R	
	h m	° ′				″		l.y.	″	km/sec	
κ Sco	17 41.1	−39 01	2.39v	−0.21	B1.5 III		−3.4	470	0.031	*−10*	β CMa var., 0.20^d
β Oph	42.5	+04 35	2.77	+1.16	K2 III	0.023	−0.1	124	0.160	−12.0	
μ Her *A*	45.7	+27 45	3.42	+0.75	G5 IV	0.108	+3.6	30	0.811	−15.6	*BC* 9.78^m 33″
ι^1 Sco	46.2	−40 06	3.02	+0.49	F2 Ia	0.013	−7.1	3400	0.004	*−27.6*	
G Sco	48.4	−37 02	3.21	+1.18	K2 III	0.032	+0.7	102	0.064	+24.7	
γ Dra	56.1	+51 29	2.21	+1.52	K5 III	0.017	−0.4	108	0.026	−27.6	*Eltanin*
ν Oph	58.0	−09 47	3.32	+1.00	G9 III	0.015	+0.2	140	0.118	+12.4	
γ Sgr	18 04.5	−30 26	2.97	+1.00	*K0 III*	0.018	+0.1	124	0.200	*+22.1*	
η Sgr *A*	16.3	−36 47	3.12	+1.55	M3.5 III	0.038	+1.1:	86:	0.218	+00.5	*B* 10^m 4″
δ Sgr	19.7	−29 50	2.71	+1.39	K2 III	0.039	+0.7	84	0.050	−20.0	
η Ser	20.2	−02 54	3.23	+0.94	K0 III–IV	0.054	+1.9	60	0.894	+08.9	
ε Sgr	22.9	−34 24	1.81	−0.02	B9.5 III	0.015	−1.1	124	0.135	−11	*Kaus Australis*
λ Sgr	26.7	−25 27	2.80	+1.05	*K2 III*	0.046	+1.1	71	0.194	−43.3	
α Lyr	36.2	+38 46	0.04	0.00	A0 V	0.123	+0.5	26.5	0.345	−13.9	*Vega*
ϕ Sgr	44.4	−27 01	3.20	−0.11	*B8 III*		−3.1	590	0.052	+21.5	
β Lyr *A*	49.4	+33 21	3.38v	−0.05:	Bpe	−.011	−4.6	1300	0.007	*−17.8*	Ecl. *R* 3.38–4.36, 12.9^d, *B* 7.8^m 46″
σ Sgr	54.0	−26 19	2.12:	−0.21	B2 V		−2.7	300	0.059	−11	*Nunki*
ξ^2 Sgr	56.5	−21 07	3.51	+1.18:	K1 III	0.006	+0.0	160	0.035	−19.9	
γ Lyr	58.2	+32 40	3.25	−0.05	B9 III	0.011	−2.1	370	0.007	−21.5	
ζ Sgr *AB*	19 01.3	−29 54	2.61	+0.08	*A2 IV*	0.020	+0.1	140	0.020	+22	*A* 3.3^m *B* 3.5^m < 1″
ζ Aql *A*	04.5	+13 50	2.99	+0.01	A0 V:nn	0.036	+0.8	90	0.101	−26.3	*B* 12^m 5″
λ Aql	05.2	−04 55	3.44	−0.10	B9: V:n	0.025	−0.1	160	0.092	−14	
τ Sgr	05.7	−27 42	3.30	+1.18	K1 III	0.038	+1.2	86	0.261	*+45.4*	
π Sgr *ABC*	08.6	−21 03	2.89	+0.35	F2 II–III	0.016	−0.7	250	0.040	−09.8	*A* 3.7^m *B* 3.8^m *C* 6.0^m < 1″
δ Dra	12.5	+67 38	3.06	+1.00	G9 III	0.028	+0.2	124	0.130	+24.8	
δ Aql	24.5	+03 04	3.38	+0.31	F0 IV	0.062	+2.3	53	0.267	*−29.9*	
β Cyg *A*	29.9	+27 55	3.07	+1.12	K3 II:+B:	0.004	−2.4	410	0.009	−24.0	*B* 5.11^m 35″ *Albireo*
δ Cyg *AB*	44.3	+45 05	2.87	−0.03	B9.5 III	0.021	−1.7	270	0.060	−21	*A* 2.91^m *B* 6.44^m 2″
γ Aql	45.3	+10 33	2.72	+1.52	K3 II	0.006	−2.4	340	0.012	−02.1	
α Aql	49.8	+08 49	0.77	+0.22	A7 IV–V	0.198	+2.2	16.5	0.658	−26.3	*Altair*

Star	R.A. 1980	Dec.	V	$B-V$	Type	π	M_V	D	μ	R		
	h m	° ′				″		l.y.	″	km/sec		
θ Aql	20 10.3	−00 52	3.24	−0.07	B9.5 III	0.008	−1.7	330	0.034	*−27.3*		
β Cap *A*	19.9	−14 51	3.06	+0.76	comp.	0.005	+0.1	130	0.039	−18.9	Type gK0: + late B; *B* 5.97^m 205″	
γ Cyg	21.5	+40 11	2.22	+0.66	F8 Ib	−.006	−4.6	750	0.001	−07.5		
α Pav	24.1	−56 48	1.95	−0.20	B2.5 V		−2.9	310	0.087	*+02.0*		*Peacock*
α Ind	36.2	−47 21	3.11	+1.00	*K0 III*	0.039	+1.1	84	0.082	−01.1		
α Cyg	40.7	+45 12	1.26	+0.09	A2 Ia	−.013	−7.1	1600	0.003	*−04.6*		***Deneb***
β Pav	43.2	−66 17	3.45	+0.16	A7 III	0.026	−0.1	160	0.046	+09.8		
η Cep	44.9	+61 45	3.41	+0.92	K0 IV	0.071	+2.7	46	0.825	−87.3		
ε Cyg	45.4	+33 53	2.46	+1.03	K0 III	0.044	+0.7	74	0.481	*−10.3*		
ζ Cyg	21 12.1	+30 08	3.19	+1.00	G8 II	0.021	−2.2	390	0.056	+17.4		
α Cep	18.2	+62 31	2.44	+0.24	A7 IV–V	0.063	+1.4	52	0.156	−10		*Alderamin*
β Cep	28.4	+70 28	3.15v	−0.22v	B2 III	0.005	−4.2	980	0.014	*−03.1*	β CMa *R* 3.14–3.16, 0.19^d	
β Aqr	30.5	−05 40	2.86	+0.82	G0 Ib	0.000	−4.6	1030	0.017	+06.5		
ε Peg *A*	43.2	+09 48	2.38	+1.55	K2 Ib	−.005	−4.6	780	0.025	+04.7	*B* 11^m 82″	*Enif*
δ Cap	45.9	−16 13	2.92v	+0.29	A6m	0.065	+2.0	50	0.392	*−00.2*	Var. *R* 2.88–2.95	
γ Gru	52.7	−37 27	3.00	−0.10	B8 III	0.008	−3.1	540	0.102	−02.1		
α Aqr	22 04.7	−00 25	2.93	+0.96	G2 Ib	0.003	−4.6	1080	0.016	+07.5		
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 1977.0; 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. 1977.0 °	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	283	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	249	1.1	400
35	Com	8695	12	52.3	+21	21	5.1*	5.2	7.4	160	1.0	500
Σ	2054	10052	16	23.6	+61	44	5.6	6.0	7.2	355	1.1	—
ε¹	Lyr†	11635	18	43.7	+39	38	5.1	5.4	6.5	356	2.7	1200
ε²	Lyr†	11635	18	43.7	+39	38	4.4	5.1	5.3	85	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	305	11.8	480
Σ	186	1538	01	54.8	+01	45	6.0	6.8	6.8	52	1.3	160
γ	And AB	1630	02	02.4	+42	16	2.1*	2.1	5.1	64	9.8	—
γ	And BC	1630	02	02.4	+42	16	5.1	5.5	6.3	109	0.5	61
OΣ	65	2799	03	49.2	+25	32	5.2	5.8	6.2	207	0.7	62
α	CMa	5423	06	44.3	−16	40	−1.4	−1.4	8.5	55	10.9	50
α	Gem	6175	07	33.3	+31	55	1.6	2.0	2.8	104	2.0	420
ζ	Cnc AB	6650	08	11.1	+17	43	5.0	5.6	5.9	298	0.9	60
ζ	Cnc AC	6650	08	11.1	+17	43	5.2	5.4	7.3	82	5.9	1150
σ²	UMa	7203	09	08.6	+67	13	4.8*	4.8	8.2	5	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	111	3.1	60
γ	Vir	8630	12	40.7	−01	21	2.8	3.5	3.5	299	4.1	170
ζ	Boo	9343	14	40.1	+13	49	3.8	4.5	4.5	306	1.1	125
ξ	Boo	9413	14	50.4	+19	12	4.5	4.7	6.8	335	7.2	150
ζ	Her	10157	16	40.6	+31	38	2.8	2.9	5.5	165	1.2	35
τ	Oph	11005	18	01.9	−08	11	4.7	5.2	5.9	276	1.9	280
70	Oph	11046	18	04.5	+02	32	4.0	4.2	6.0	351	1.9	88
δ	Cyg	12880	19	44.4	+45	04	2.9*	2.9	6.3	235	2.3	830
4	Aqr	14360	20	50.4	−05	53	6.0	6.4	7.2	14	0.8	150
τ	Cyg	14787	21	13.9	+37	57	3.7	3.8	6.4	159	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	232	1.8	850
Σ	3050	17149	23	58.5	+33	37	5.8	6.5	6.7	305	1.5	350

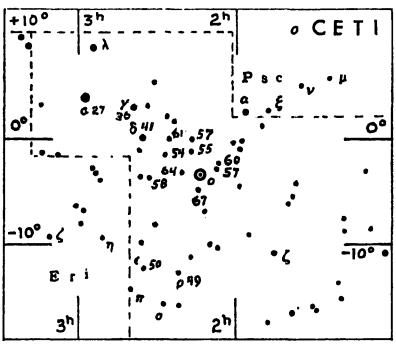
*There is a marked colour difference between the components.
†The separation of the two pairs of ε Lyr is 208″.

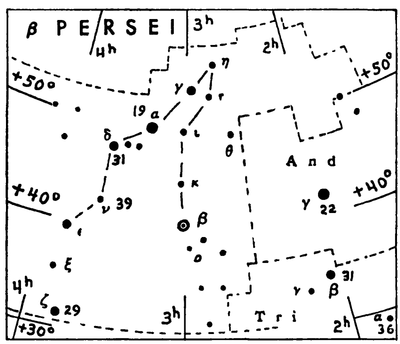
VARIABLE STARS

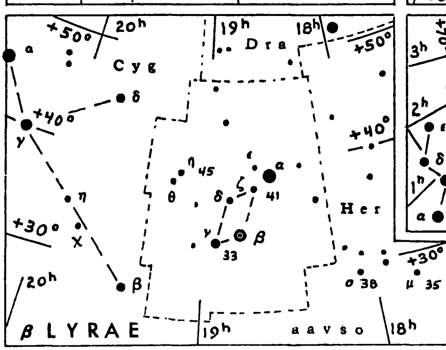
By Janet Mattei

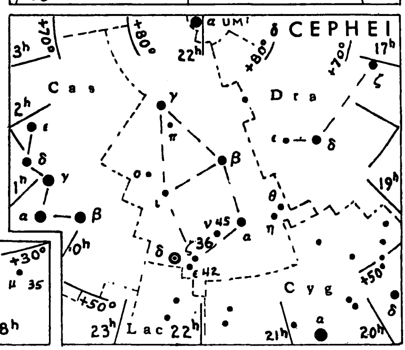
The systematic observation of variable stars is an area in which an amateur can make a valuable contribution to astronomy. For beginning observers, maps of the fields of four bright variable stars are given below. In each case, the magnitudes (with decimal point omitted) of several suitable comparison 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 1976, International Supplement.*









LONG-PERIOD VARIABLE STARS

Variable	Max. m	Per d	Epoch 1977	Variable	Max. m	Per d	Epoch 1977
001755 T Cas	7.8	445	Apr. 26	142539 V Boo	7.9	258	Apr. 2
001838 R And	7.0	409	—	143227 R Boo	7.2	223	Feb. 10
021143 W And	7.4	397	—	151731 S CrB	7.3	361	Jan. 14
0214*03* o Cet	3.4	332	Dec. 14	154639 V CrB	7.5	358	Oct. 18
0228*13* U Cet	7.5	235	June 17	154615 R Ser	6.9	357	Aug. 17
023133 R Tri	6.2	266	July 20	160625 RU Her	8.0	484	Nov. 21
043065 T Cam	8.0	374	Nov. 20	162119 U Her	7.5	406	July 29
0455*14* R Lep	6.8	432	Sept. 2	1621*12* V Oph	7.5	298	May 25
050953 R Aur	7.7	459	—	163266 R Dra	7.6	245	May 31
054920 U Ori	6.3	372	Sept. 8	164715 S Her	7.6	307	Mar. 9
0617*02* V Mon	7.0	335	Apr. 28	1702*15* R Oph	7.9	302	Sept. 1
065355 R Lyn	7.9	379	May 8	171723 RS Her	7.9	219	Mar. 16
070122aR Gem	7.1	370	July 10	180531 T Her	8.0	165	Jan. 7
070310 R CMi	8.0	338	Aug. 8	181136 W Lyr	7.9	196	May 29
072708 S CMi	7.5	332	Mar. 30	183308 X Oph	6.8	334	Oct. 31
081112 R Cnc	6.8	362	Dec. 24	190108 R Aql	6.1	300	Jan. 20
081617 V Cnc	7.9	272	Mar. 7	1910*17* T Sgr	8.0	392	July 3
084803 S Hya	7.8	257	Apr. 1	1910*19* R Sgr	7.3	269	Aug. 3
0850*08* T Hya	7.8	288	Feb. 4	193449 R Cyg	7.5	426	July 5
093934 R LMi	7.1	372	Mar. 4	194048 RT Cyg	7.3	190	Apr. 20
094211 R Leo	5.8	313	Apr. 1	194632 χ Cyg	5.2	407	Aug. 15
103769 R UMa	7.5	302	Feb. 19	201647 U Cyg	7.2	465	Jan. 24
1214*18* R Crv	7.5	317	Sept. 29	2044*05* T Aqr	7.7	202	Jan. 15
122001 SS Vir	6.8	355	Jan. 8	210868 T Cep	6.0	390	Sept. 3
123160 T UMa	7.7	257	May 27	213753 RU Cyg	8.0	234	July 14
123307 R Vir	6.9	146	Apr. 3	230110 R Peg	7.8	378	Mar. 17
123961 S UMa	7.8	226	May 31	230759 V Cas	7.9	228	Mar. 7
131546 V CVn	6.8	192	Feb. 14	231508 S Peg	8.0	319	Sept. 14
1327*06* S Vir	77.0	378	Jan. 24	2338*15* R Aqr	6.5	387	Jan. 12
134440 R CVn	.7	328	Apr. 22	235350 R Cas	7.0	431	Feb. 3
142584 R Cam	7.9	270	Jan. 13	2357*15* W Cet	7.6	351	Feb. 25

OTHER TYPES OF VARIABLE STARS

Variable		Max. m	Min. m	Type	Sp. Cl.	Period d	Epoch 1977 E.S.T.
005381	U Cep	6.7	9.8	Ecl.	B8+gG2	2.49302	Jan. 1.77*
025838	ρ Per	3.3	4.0	Semi R	M4	33–55, 1100	—
030140	β Per	2.1	3.3	Ecl.	B8+G	2.86731	—
035512	λ Tau	3.5	4.0	Ecl.	B3	3.952952	Jan. 1.60*
060822	η Gem	3.1	3.9	Semi R	M3	233.4	—
061907	T Mon	6.4	8.0	δ Cep	F7–K1	27.0205	Jan. 18.71
065820	ζ Gem	4.4	5.2	δ Cep	F7–G3	10.15082	Jan. 2.63
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	12.931163	Jan. 12.39*
192242	RR Lyr	6.9	8.0	RR Lyr	A2–F1	0.5668223	Jan. 1.38
194700	η Aql	4.1	5.2	δ Cep	F6–G4	7.176641	Jan. 2.76
222557	δ Cep	4.1	5.2	δ Cep	F5–G2	5.366341	—

*Minimum.

BRIEF DESCRIPTION OF VARIABLE TYPES

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

I. *Pulsating Variables*

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

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

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

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

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

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

II. *Eruptive Variables*

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

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

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

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

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

III. *Eclipsing Binaries*

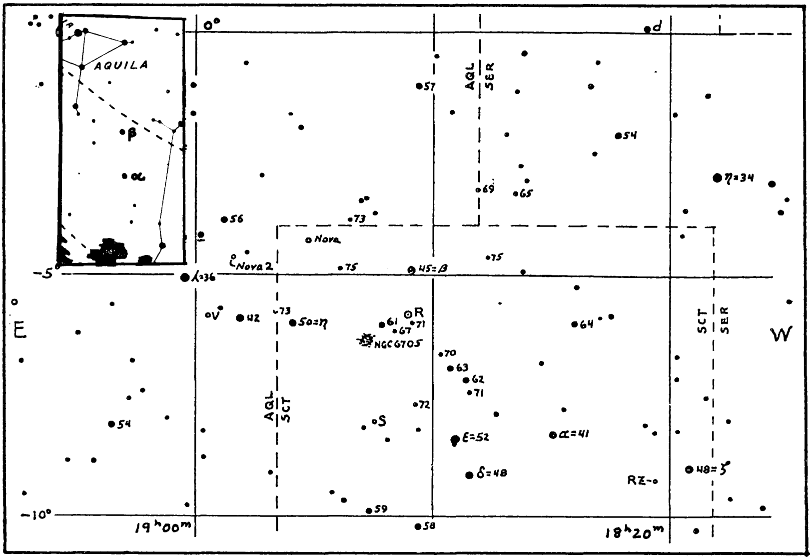
Binary systems of stars with the orbital plane lying close to the line of sight of the observer. The components periodically eclipse each other, causing variations in the apparent brightness of the system, as is seen and recorded by the observer. The period of the eclipses coincides with the period of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

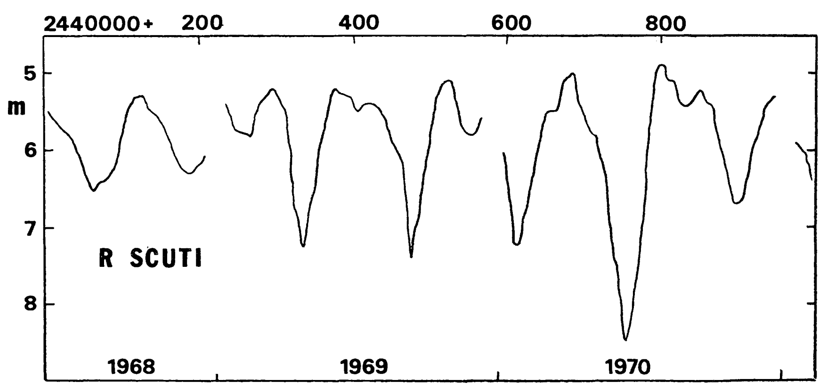
Editor's Note: In cooperation with the A.A.V.S.O., we plan to introduce one or two new variables to our readers each year. This year, we introduce R Scuti, an RV Tauri type star; this star is an easy one to observe with binoculars.

The numbers beside the stars on the finding chart are the magnitudes, with the decimal points removed. The coordinate grid is for 1900. The inset is a key to the star maps in the back of this HANDBOOK.

The light curve shows typical RV Tauri type behaviour: great irregularity, but with a tendency toward alternating deep and shallow minima.

The 1976 HANDBOOK contained a finding chart and light curve for R CrB.





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.

THE NEAREST STARS

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.

NGC	M	Con	α 1980 δ h m	° ′	Type	Size ′	S mag. sq″	m *	Dist. 10^3 l.y.	Remarks
650/1	76	Per	01 40.9	+51 28	Pl	1.5	20	17	15	
IC348		Per	03 43.2	+32 07	Ref	3	21	8	0.5	Nebulous cluster
1435		Tau	03 46.3	+24 01	Ref	15	20	4	0.4	Merope nebula
1535		Eri	04 13.3	−12 48	Pl	0.5	17	12		
1952	1	Tau	05 33.3	+22 05	SN	5	19	16v	4	"Crab" + pulsar
1976	42	Ori	05 34.3	−05 25	HII	30	18	4	1.5	Orion nebula
1999		Ori	05 35.5	−06 45	PrS	1		10v	1.5	
ζ Ori		Ori	05 39.8	−01 57	Comp	2°			1.5	Incl. "Horsehead"
2068	78	Ori	05 45.8	+00 02	Ref	5	20		1.5	
IC443		Gem	06 16.4	+22 36	SN	40			2	
2244		Mon	06 31.3	+04 53	HII	50	21	7	3	Rosette neb.
2247		Mon	06 32.1	+10 20	PrS	2	20	9	3	
2261		Mon	06 38.0	+08 44	PrS	2		12v	4	Hubble's var. neb.
2392		Gem	07 28.0	+20 57	Pl	0.3	18	10	10	Clown face neb.
3587	97	UMa	11 13.6	+55 08	Pl	3	21	13	12	Owl nebula
ρOph		Oph	16 24.4	−23 24	Comp	4°			0.5	Bright + dark neb.
θOph		Oph	17 20.7	−24 59	Comp	5°				Incl. "S" neb.
6514	20	Sgr	18 01.2	−23 02	HII	15	19		3.5	Trifid nebula
6523	8	Sgr	18 02.4	−24 23	HII	40	18		4.5	Lagoon nebula
6543		Dra	17 58.6	+66 37	Pl	0.4	15	11	3.5	
6611	16	Ser	18 17.8	−13 48	HII	15	19	10	6	
6618	17	Sgr	18 19.7	−16 12	HII	20	19		3	Horseshoe neb.
6720	57	Lyr	18 52.9	+33 01	Pl	1.2	18	15	5	Ring nebula
6826		Cyg	19 44.4	+50 28	Pl	0.7	16	10	3.5	
6853	27	Vul	19 58.6	+22 40	Pl	7	20	13	3.5	Dumb-bell neb.
6888		Cyg	20 11.6	+38 21	HII	15				
γCyg		Cyg	20 21.5	+40 12	Comp	6°				HII + dark neb.
6960/95		Cyg	20 44.8	+30 38	SN	150			2.5	Cygnus loop
7000		Cyg	20 58.2	+44 14	HII	100	22		3.5	N. America neb.
7009		Aqr	21 03.0	−11 28	Pl	0.5	16	12	3	Saturn nebula
7023		Cep	21 01.4	+68 05	Ref	5	21	7	1.3	
7027		Cyg	21 06.4	+42 09	Pl	0.2	15	13		
7129		Cep	21 42.5	+65 00	Ref	3	21	10	2.5	Small cluster
7293		Aqr	22 28.5	−20 54	Pl	13	22	13		Helix nebula
7662		And	23 25.0	+42 25	Pl	0.3	16	12	4	

MESSIER'S CATALOGUE OF DIFFUSE OBJECTS

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

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

†Index Catalogue Number.

STAR CLUSTERS

By T. Schmidt-Kaler

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

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

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

Open Clusters

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

***Basic for distance determination.**

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

Globular Clusters

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

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

EXTERNAL GALAXIES

BY S. VAN DEN BERGH

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

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

THE BRIGHTEST GALAXIES

NGC or name	M	α 1980 δ h m	° ′	Type	m_{pg}	Dimensions ′ ′	Distance millions of l.y.
55		00 14.0	−39 20	Sc or Ir	7.9	30×5	7.5
205		00 39.2	+41 35	E6p	8.89	12×6	2.1
221	32	00 41.6	+40 46	E2	9.06	3.4×2.9	2.1
224	31	00 41.6	+41 10	Sb I–II	4.33	163×42	2.1
247		00 46.1	−20 51	S IV	9.47	21×8.4	7.5
253		00 46.6	−25 24	Sep	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 h m	δ ° ′	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

MAXIMA OF DELTA CEPHEI

A finding chart for this famous pulsating variable is given on p. 100. The magnitudes (minus decimal point) of non-variable comparison stars are marked; the magnitude of δ Cep can be estimated relative to these. Observation of this star, or of Algol, is a good introduction to serious variable star observing, and is a good project for the amateur or student.

Times given are E.S.T., rounded off to the nearest 10 minutes, and are based on the ephemeris J.D. (max) = 2436075.445 + 5.366341 E.

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

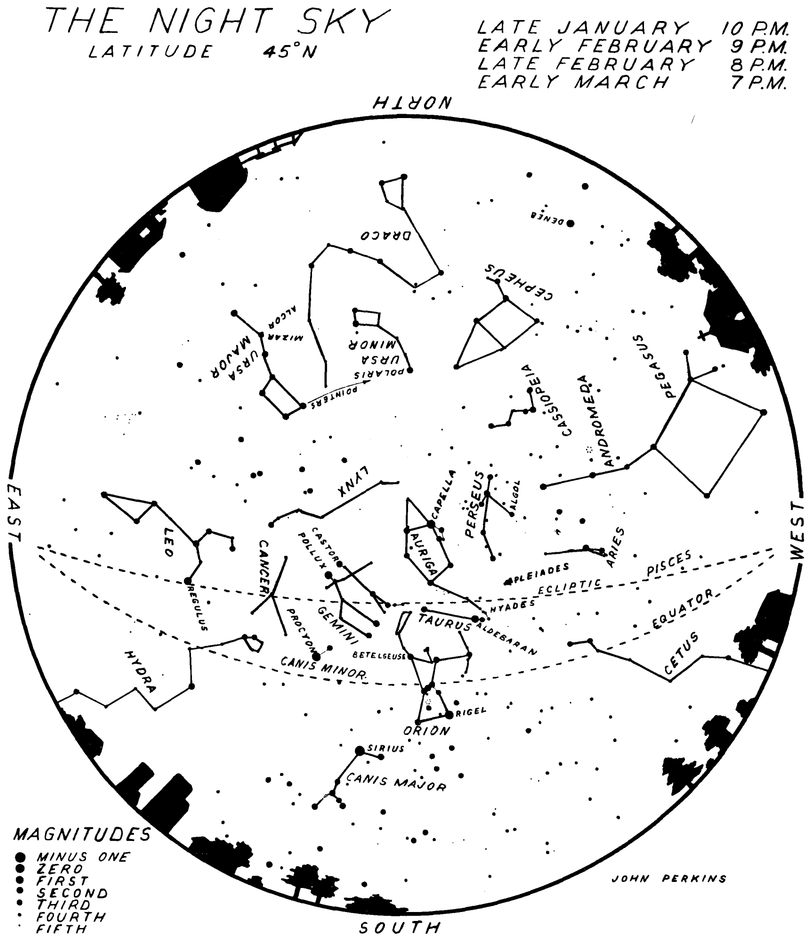
RADIO SOURCES

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.

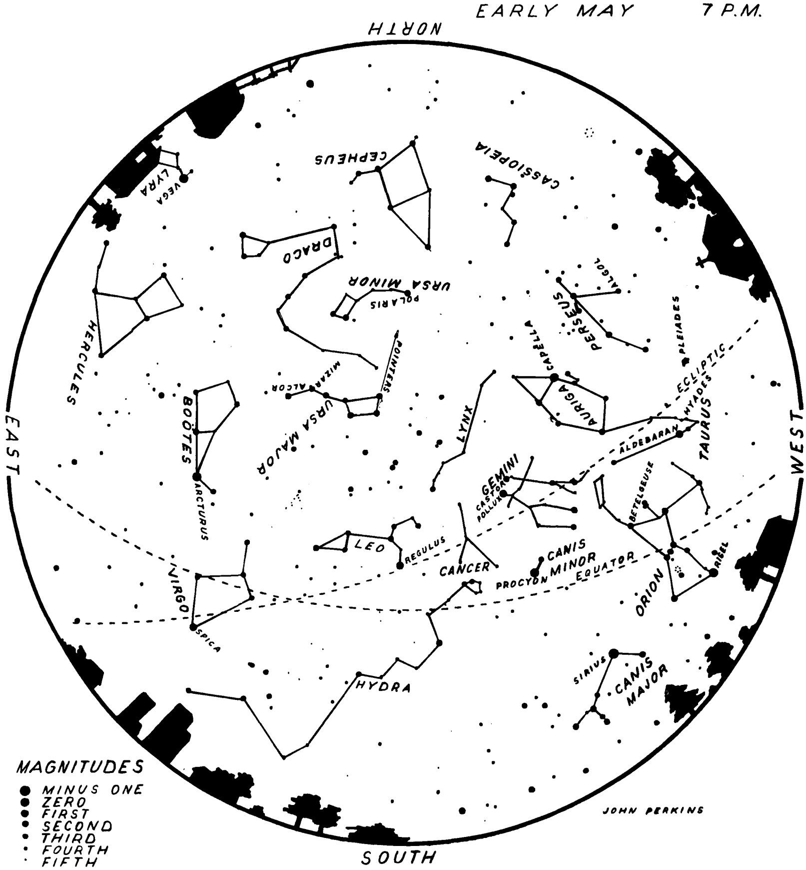
The centre of the map is the *zenith*, the point directly overhead; the circumference of the map is the *horizon*. To identify the stars, hold the map in front of you so that the part of the horizon which you are facing (north, for instance) is downward.

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 NIGHT SKY

LATITUDE 45°N

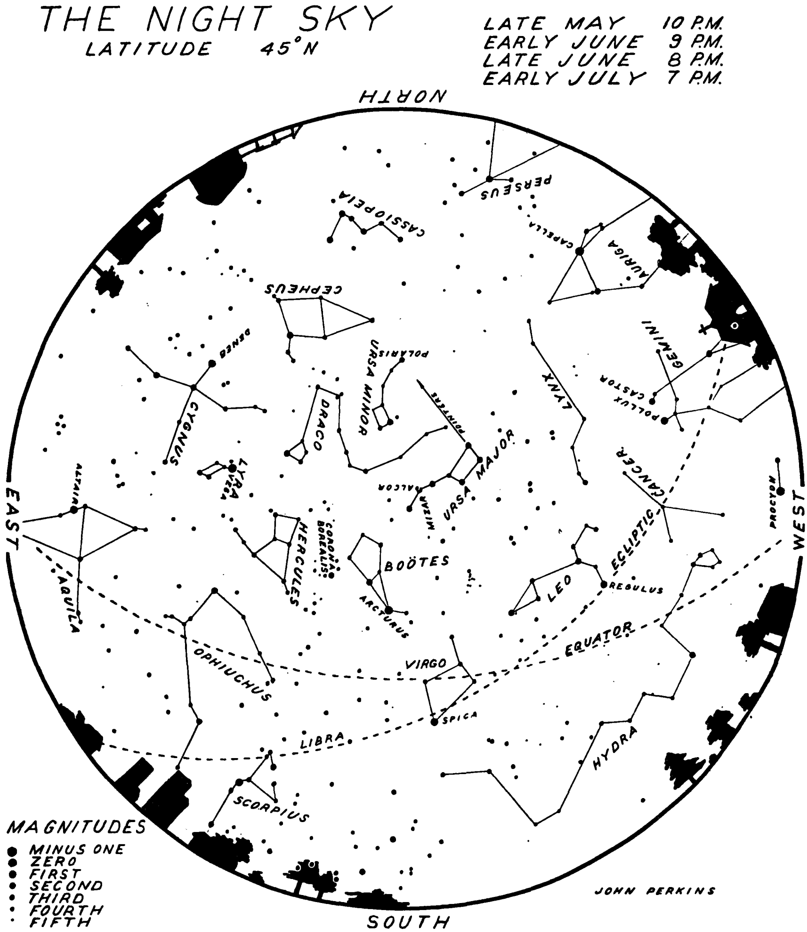
LATE MARCH 10 P.M.
EARLY APRIL 9 P.M.
LATE APRIL 8 P.M.
EARLY MAY 7 P.M.



The above map represents the evening sky on the dates and times shown. For earlier (or later) dates, add (or subtract) two hours per month. For instance, the map represents the early morning sky in late 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.

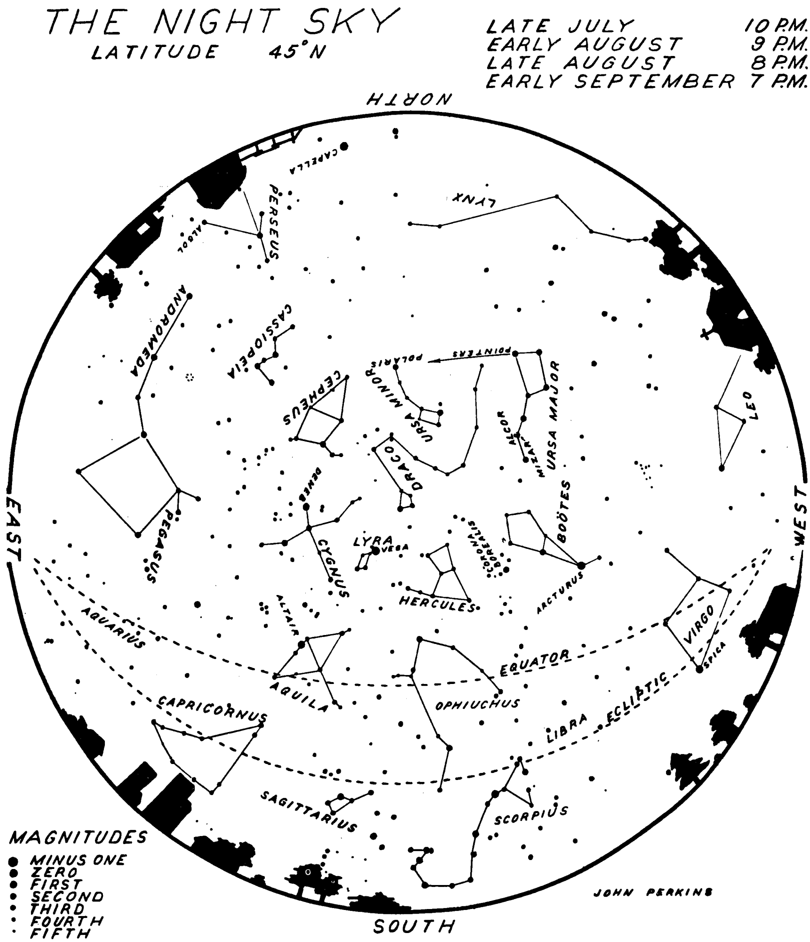
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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.

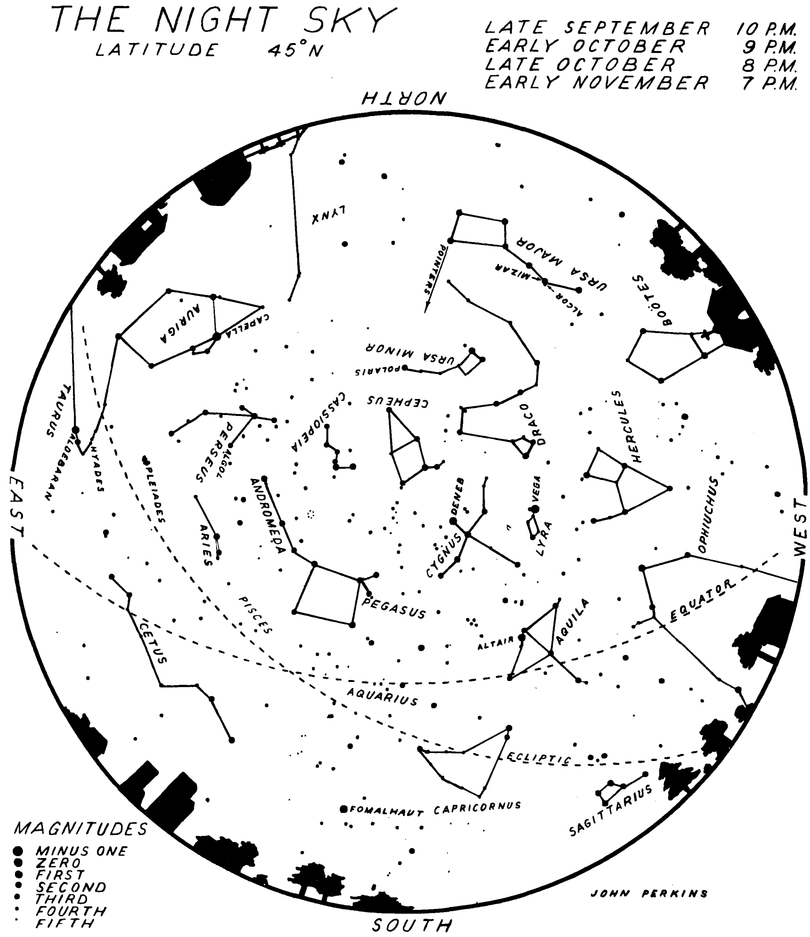
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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.

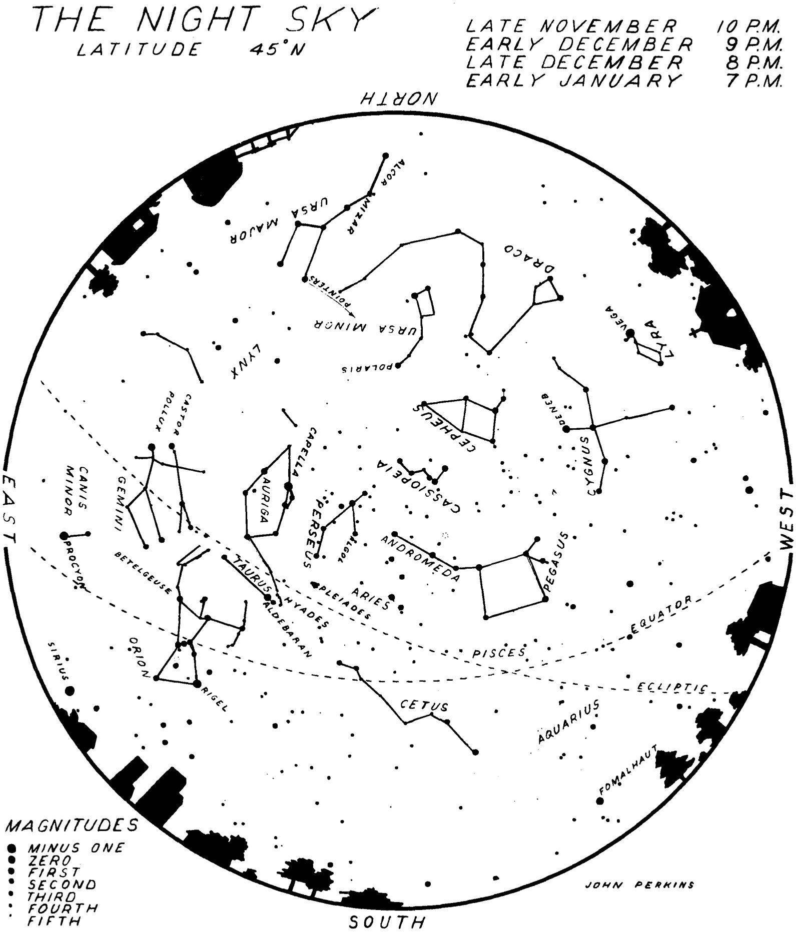
The north celestial *pole* is near the star Polaris. The celestial *equator* is also marked. The sun, moon and planets are always found near the *ecliptic*.



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*.

CALENDAR 1977

January

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

February

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

March

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

April

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

May

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

June

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

July

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

August

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

September

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

October

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

November

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

December

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

CALENDAR 1978

January

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

February

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

March

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

April

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

May

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

June

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

July

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

August

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

September

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

October

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

November

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

December

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