TRANSIT OF VENUS, 2012

A transit of Venus over the disk of the Sun will occur on June 5-6. The entire transit will be visible in eastern Asia, eastern Australia, northwestern North America, the Arctic, and the north Pacific Ocean.

The times provided in the following tables are given provisionally in Universal Time, using $\Delta T(A) = +66^{s}.0$. Once the value of ΔT is known, the data on these pages may be expressed in Universal Time as follows:

Define $\delta T = \Delta T - \Delta T(A)$, in units of seconds of time.

Change the times given in provisional Universal Time by subtracting δT.

Apply the correction 0.00417807 δT to the longitudes in such a way that if δT is positive, the longitudes shift to the east.

Leave all other quantities unchanged.

Longitude is positive to the east and negative to the west.

GEOCENTRIC PHASES

		UT	Position Angle P	Venus being in the Zenith in Longitude	Latitude
		d h m s	°	° ′	° ′
Ingress, exterior contact	June	5 22 09 41.8	40.7	−152 34.3	+22 52.0
Ingress, interior contact		5 22 27 29.9	38.2	−157 02.6	+22 51.8
Least angular distance		6 01 29 37.0		+157 13.2	+22 49.5
Egress, interior contact		6 04 31 44.0	292.7	+111 29.0	+22 47.2
Egress, exterior contact		6 04 49 32.1	290.1	+107 00.8	+22 46.9

Least angular distance: $9'\ 14''.4$

The position angle P of the point of contact is reckoned from the north point of the limb of the Sun towards the east as viewed at the geocenter.

The position angle V of the point of contact, reckoned from the vertex of the limb of the Sun towards the east, is found by:

$$V = P - C$$

where C, the parallactic angle, is given by:

$$\tan C = \frac{\cos \phi' \sin h}{\sin \phi' \cos \delta - \cos \phi' \sin \delta \cos h}$$

in which ϕ' is the geocentric latitude of the place, δ is the declination of the Sun, and h is the local hour angle of the Sun; sin C has the same algebraic sign as sin h.

TRANSIT OF VENUS OF 2012 JUNE 5–6

Location	Position		Ingress Exterior Contact		Ingress Interior Contact		Least Angular Distance		Egress Interior Contact		Egress Exterior Contact	
	Latitude	Longitude	UT	*P*	UT	*P*	UT	Separation	UT	*P*	UT	*P*
United States	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Boston, MA	+42 20.0	− 71 05.0	22 03 43.3	41.3	22 21 14.6	38.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Harvard College Obs., Cambridge, MA	+42 22.8	− 71 07.8	22 03 43.4	41.3	22 21 14.7	38.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
New York, NY	+40 44.0	− 74 00.0	22 03 50.9	41.2	22 21 22.1	38.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Black Moshannon Obs., Univ. Park, PA	+40 55.3	− 78 00.2	22 04 00.0	41.2	22 21 30.6	38.7	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
USNO, Washington, DC	+38 55.3	− 77 04.0	22 04 00.2	41.2	22 21 31.2	38.7	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
NRAO, Green Bank, WV	+38 25.8	− 79 50.5	22 04 07.8	41.1	22 21 38.6	38.7	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Morehead Obs., Chapel Hill, NC	+35 54.8	− 79 03.0	22 04 09.7	41.1	22 21 41.1	38.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Fernbank Obs., Atlanta, GA	+33 46.7	− 84 19.1	22 04 28.6	41.0	22 21 59.6	38.5	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Miami, FL	+25 45.0	− 80 15.0	22 04 35.6	40.8	22 22 09.0	38.3	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Univ. of Fl. Radio Obs., Gainesville, FL	+29 31.7	− 83 02.1	22 04 34.3	40.9	22 22 06.4	38.4	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Univ. of Alabama Obs., Tuscaloosa, AL	+33 12.6	− 87 32.5	22 04 39.7	40.9	22 22 10.5	38.5	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Goethe Link Obs., Bloomington, IN	+39 33.0	− 86 23.7	22 04 24.1	41.1	22 21 53.8	38.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Chicago, IL	+41 50.0	− 87 38.0	22 04 24.2	41.2	22 21 53.4	38.7	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Yerkes Obs., Williams Bay, WI	+42 34.2	− 88 33.4	22 04 25.7	41.2	22 21 54.8	38.7	1 26 06.6	9 02.6	.. ..	... .	.. ..	... .
St. Louis, MO	+38 40.0	− 90 15.0	22 04 37.0	41.1	22 22 06.5	38.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Clyde W. Tombaugh Obs., Lawrence, KS	+38 57.6	− 95 15.0	22 04 52.1	41.1	22 22 21.0	38.6	1 25 52.4	9 04.5	.. ..	... .	.. ..	... .
Wyoming Infrared Obs., Laramie, WY	+41 05.9	−105 58.6	22 05 23.2	41.1	22 22 50.8	38.6	1 25 46.4	9 05.2	.. ..	... .	.. ..	... .
Tiara Obs., Colorado Springs, CO	+38 58.2	−105 31.0	22 05 26.8	41.0	22 22 54.7	38.5	1 25 43.2	9 05.8	.. ..	... .	.. ..	... .
Salt Lake City, UT	+40 45.0	−111 55.0	22 05 45.0	41.1	22 23 12.2	38.6	1 25 43.6	9 05.9	.. ..	... .	.. ..	... .
Houston, TX	+29 45.0	− 95 25.0	22 05 15.1	40.8	22 22 45.6	38.3	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
McDonald Obs., Fort Davis, TX	+30 40.3	−104 01.3	22 05 44.5	40.8	22 23 13.9	38.3	1 25 33.8	9 08.3	.. ..	... .	.. ..	... .
NRAO, Socorro, NM	+34 04.7	−107 37.1	22 05 47.9	40.9	22 23 16.4	38.4	1 25 35.2	9 07.6	.. ..	... .	.. ..	... .
Nat. Solar Obs., Sunspot, NM	+32 47.2	−105 49.1	22 05 44.9	40.9	22 23 13.8	38.4	1 25 34.7	9 07.8	.. ..	... .	.. ..	... .
Kitt Peak Nat. Obs., Tucson, AZ	+31 57.8	−111 36.0	22 06 10.1	40.8	22 23 38.7	38.3	1 25 31.2	9 08.8	.. ..	... .	.. ..	... .
USNO, Flagstaff, AZ	+35 11.0	−111 44.4	22 06 00.4	40.9	22 23 28.4	38.4	1 25 35.1	9 07.7	.. ..	... .	.. ..	... .
Big Bear Solar Obs., CA	+34 15.2	−116 54.9	22 06 23.6	40.9	22 23 51.4	38.4	1 25 33.4	9 08.6	.. ..	... .	.. ..	... .
Lick Obs., Mt. Hamilton, CA	+37 20.6	−121 38.2	22 06 31.6	41.0	22 23 58.8	38.5	1 25 38.6	9 08.1	.. ..	... .	.. ..	... .
Griffith Obs., Los Angeles, CA	+34 07.1	−118 17.9	22 06 29.6	40.9	22 23 57.4	38.4	1 25 33.4	9 08.8	.. ..	... .	.. ..	... .
Mt. Wilson Obs., Pasadena, CA	+34 13.0	−118 03.6	22 06 28.3	40.9	22 23 56.1	38.4	1 25 33.4	9 08.8	.. ..	... .	.. ..	... .
Owens Valley Radio Obs., Big Pine, CA	+37 13.9	−118 16.9	22 06 19.1	41.0	22 23 46.4	38.5	1 25 37.6	9 07.8	.. ..	... .	.. ..	... .
Palomar Obs., Palomar Mtn., CA	+33 21.4	−116 51.8	22 06 26.5	40.9	22 23 54.5	38.4	1 25 32.3	9 08.9	.. ..	... .	.. ..	... .
Portland, OR	+45 32.0	−122 40.0	22 06 09.2	41.2	22 23 35.4	38.7	1 25 53.5	9 05.4	.. ..	... .	.. ..	... .
Manastash Ridge Obs., Seattle, WA	+46 57.1	−120 43.4	22 05 58.5	41.2	22 23 24.7	38.7	1 25 55.8	9 04.8	.. ..	... .	.. ..	... .
Fairbanks, AK	+64 50.0	−147 50.0	22 06 16.9	41.7	22 23 42.8	39.2	1 27 00.2	9 00.8	4 31 16.8	291.4	4 48 53.7	289.0
Nome, AK	+64 30.0	−165 30.0	22 06 51.0	41.7	22 24 17.4	39.3	1 27 20.3	9 01.2	4 31 05.5	291.5	4 48 39.8	289.1
Mauna Kea Obs., Honolulu, HI	+19 49.4	−155 28.2	22 10 09.8	40.6	22 27 40.7	38.1	1 26 14.8	9 16.9	4 26 38.5	292.6	4 44 30.7	290.0
Canada												
Algonquin Radio Obs., Ontario	+45 57.3	− 78 04.4	22 03 55.9	41.3	22 21 25.7	38.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Dominion Astro. Obs., Victoria, BC	+48 31.2	−123 25.0	22 06 03.0	41.3	22 23 29.0	38.8	1 26 00.2	9 04.5	.. ..	... .	.. ..	... .
Halifax, Nova Scotia	+44 38.0	− 63 35.0	22 03 28.7	41.4	22 21 00.7	38.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Devon Astro. Obs., Edmonton, Alberta	+53 23.4	−113 45.5	22 05 22.2	41.4	22 22 48.2	38.9	1 26 10.8	9 02.3	.. ..	... .	.. ..	... .

Location	Position		Ingress Exterior Contact		Ingress Interior Contact		Least Angular Distance		Egress Interior Contact		Egress Exterior Contact	
	Latitude	Longitude	UT	*P*	UT	*P*	UT	Separation	UT	*P*	UT	*P*
	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Canada												
Iqaluit, Frobisher Bay, Nunavut	+63 45.0	− 68 30.0	22 03 50.1	41.7	22 21 19.1	39.3	1 27 16.2	8 56.3	.. ..	... .	.. ..	... .
Montreal, Quebec	+45 30.0	− 73 36.0	22 03 46.5	41.3	22 21 17.0	38.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Ottawa River Solar Obs., Ontario	+45 23.2	− 75 53.6	22 03 51.4	41.3	22 21 21.6	38.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Vancouver, British Columbia	+49 13.0	−123 06.0	22 06 00.1	41.3	22 23 26.0	38.8	1 26 01.7	9 04.3	.. ..	... .	.. ..	... .
Winnipeg, Manitoba	+49 53.0	− 97 10.0	22 04 40.7	41.3	22 22 08.0	38.9	1 26 10.3	9 01.7	.. ..	... .	.. ..	... .
Yellowknife, Northwest Territories	+62 30.0	−114 29.0	22 05 10.4	41.6	22 22 36.4	39.2	1 26 37.1	8 59.9	4 32 00.7	291.3	4 49 42.1	288.8
Hamilton, **Bermuda**	+32 18.0	− 64 48.0	22 03 42.8	41.1	22 21 17.1	38.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Nuuk (Godthab), **Greenland**	+64 15.0	− 51 35.0	22 03 37.1	41.8	22 21 07.7	39.4	1 27 43.3	8 55.0	.. ..	... .	.. ..	... .
Puerto Rico												
Arecibo Obs.	+18 20.6	− 66 45.2	22 04 21.0	40.7	22 21 58.7	38.2	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
San Juan	+18 29.0	− 66 08.0	22 04 19.1	40.7	22 21 57.0	38.2	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Kingston, **Jamaica**	+17 58.0	− 76 48.0	22 04 48.9	40.6	22 22 25.0	38.1	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Mexico												
Mexico City	+19 25.0	− 99 10.0	22 06 03.4	40.5	22 23 36.0	38.0	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Monterrey	+25 40.0	−100 20.0	22 05 46.1	40.7	22 23 17.0	38.2	1 25 33.6	9 09.4	.. ..	... .	.. ..	... .
Hermosillo	+29 15.0	−110 59.0	22 06 16.8	40.8	22 23 46.0	38.2	1 25 28.9	9 09.6	.. ..	... .	.. ..	... .
Merida	+20 59.0	− 89 39.0	22 05 21.3	40.6	22 22 54.6	38.1	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Nat. Ast. Obs., Ensenada	+31 02.6	−115 27.8	22 06 28.8	40.8	22 23 57.3	38.3	1 25 29.7	9 09.6	.. ..	... .	.. ..	... .
Nat. Ast. Obs., Tonantzintla	+19 02.0	− 98 18.8	22 06 01.4	40.5	22 23 34.1	38.0	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Guatemala City, **Guatemala**	+14 38.0	− 90 22.0	22 05 47.0	40.4	22 23 22.0	37.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
San Salvador, **El Salvador**	+13 40.0	− 89 10.0	22 05 46.2	40.4	22 23 21.7	37.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Tegucigalpa, **Honduras**	+14 05.0	− 87 14.0	22 05 37.5	40.5	22 23 13.1	37.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Belmopan, **Belize**	+17 13.0	− 88 48.0	22 05 31.4	40.5	22 23 05.9	38.0	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Managua, **Nicaragua**	+12 06.0	− 86 18.0	22 05 41.9	40.4	22 23 18.2	37.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
San Jose, **Costa Rica**	+ 9 59.0	− 84 04.0	22 05 42.5	40.4	22 23 19.9	37.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Panama City, **Panama**	+ 8 57.0	− 79 30.0	22 05 31.3	40.4	22 23 09.7	37.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Colombia												
Nat. Ast. Obs., Bogota	+ 4 35.9	− 74 04.9	22 05 33.2	40.3	22 23 13.9	37.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Bogota	+ 4 38.0	− 74 05.0	22 05 33.1	40.3	22 23 13.8	37.8	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Cartagena	+10 24.0	− 75 33.0	22 05 13.1	40.4	22 22 51.6	37.9	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Cali	+ 3 24.0	− 76 30.0	22 05 46.0	40.3	22 23 26.7	37.7	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Quito Ast. Obs., **Ecuador**	− 0 13.0	− 78 29.9	22 06 09.2	40.2	22 23 50.8	37.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Peru												
Lima	−12 06.0	− 77 03.0	22 07 06.3	39.9	22 24 52.4	37.3	. .. .. .	.. .. .	.. ..	... .	.. ..	... .
Iquitos	− 3 51.0	− 73 13.0	22 06 11.1	40.1	22 23 54.9	37.6	. .. .. .	.. .. .	.. ..	... .	.. ..	... .

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Location	Position		Ingress Exterior Contact		Ingress Interior Contact		Least Angular Distance		Egress Interior Contact		Egress Exterior Contact	
	Latitude	Longitude	UT	*P*	UT	*P*	UT	Separation	UT	*P*	UT	*P*
Venezuela	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Cagigal Obs., Caracas	+10 30.4	− 66 55.7	22 04 49.2	40.5	22 22 29.4	38.0	. .. .. .	.. .. .	.. ..	. . . .	.. ..	. . . .
Caracas	+10 35.0	− 66 56.0	22 04 49.0	40.5	22 22 29.1	38.0	. .. .. .	.. .. .	.. ..	. . . .	.. ..	. . . .
New Zealand												
Auckland Obs.	−36 54.4	+174 46.7	22 15 37.2	39.6	22 33 31.1	36.9	1 29 10.2	9 33.6	4 25 21.9	294.2	4 43 22.5	291.5
Carter Obs., Black Birch Sta., Blenheim	−41 44.9	+173 48.2	22 15 45.2	39.6	22 33 41.0	36.9	1 29 22.6	9 34.3	4 25 32.7	294.2	4 43 34.4	291.5
Christchurch	−43 33.0	+172 40.0	22 15 48.8	39.5	22 33 45.4	36.9	1 29 29.3	9 34.5	4 25 38.7	294.2	4 43 40.6	291.6
Mt. John Univ. Obs., South Canterbury	−43 59.2	+170 27.9	22 15 53.1	39.6	22 33 50.1	36.9	1 29 36.4	9 34.5	4 25 43.6	294.3	4 43 45.0	291.6
Wellington	−41 17.0	+174 47.0	22 15 42.7	39.6	22 33 38.2	36.9	1 29 18.9	9 34.3	4 25 30.2	294.2	4 43 32.0	291.5
Australia												
Anglo-Aust. Obs., Coonabarabran	−31 16.6	+149 04.0	22 16 05.9	40.0	22 34 01.5	37.3	1 30 28.9	9 30.7	4 26 29.9	294.1	4 44 20.3	291.5
Aust. Tel. Nat. Facility	−30 18.9	+149 33.7	22 16 03.8	40.0	22 33 59.0	37.4	1 30 26.2	9 30.5	4 26 27.8	294.1	4 44 18.0	291.5
Aust. Nat. Radio Ast. Obs., Parkes	−33 00.0	+148 15.7	22 16 09.0	40.0	22 34 05.3	37.3	1 30 33.3	9 31.0	4 26 33.5	294.2	4 44 24.4	291.5
Brisbane	−27 30.0	+153 00.0	22 15 55.6	40.0	22 33 49.3	37.4	1 30 10.7	9 30.2	4 26 14.4	294.1	4 44 04.6	291.4
Darwin	−12 23.0	+130 44.0	22 15 14.2	40.6	22 33 06.8	38.0	1 31 21.2	9 23.4	4 28 16.9	293.7	4 45 54.2	291.1
Melbourne	−37 45.0	+144 58.0	22 16 15.9	39.9	22 34 14.3	37.2	1 30 48.1	9 31.7	4 26 48.6	294.2	4 44 40.4	291.6
Mt. Stromlo Obs., Weston Creek	−35 19.2	+149 00.5	22 16 11.6	39.9	22 34 08.6	37.2	1 30 32.8	9 31.6	4 26 31.6	294.2	4 44 23.6	291.5
Perth	−31 58.0	+115 49.0	. .. .. .	.. .	. .. .. .	.. .	1 32 18.3	9 26.9	4 29 10.1	294.1	4 46 52.5	291.4
Sydney	−33 55.0	+151 10.0	22 16 08.4	39.9	22 34 04.5	37.3	1 30 24.1	9 31.5	4 26 22.9	294.2	4 44 14.9	291.5
Alice Springs	−23 42.0	+133 52.0	22 15 51.2	40.3	22 33 47.0	37.7	1 31 18.0	9 27.1	4 27 43.1	294.0	4 45 25.9	291.4
Papeete, **Tahiti**	−17 32.0	−149 34.0	22 12 42.0	39.7	22 30 25.3	37.0	1 26 46.9	9 29.1	.. ..	. . . .	.. ..	. . . .
Pago Pago, **Samoa**	−14 16.0	−170 43.0	22 13 52.8	39.9	22 31 36.4	37.3	1 27 38.2	9 28.7	4 24 56.0	293.6	4 42 54.8	291.0
Port Moresby, **Papua New Guinea**	− 9 30.0	+147 07.0	22 15 05.3	40.5	22 32 53.6	37.9	1 30 13.4	9 24.6	4 26 56.8	293.7	4 44 38.0	291.1
Suva (Viti Levu), **Fiji**	−18 08.0	+178 25.0	22 14 41.5	40.0	22 32 27.8	37.3	1 28 22.6	9 29.5	4 25 05.0	293.8	4 43 01.0	291.1
Majuro, **Marshall Islands**	+ 7 05.0	+171 08.0	22 13 11.0	40.6	22 30 49.3	38.0	1 28 14.5	9 21.2	4 26 09.9	293.2	4 43 54.2	290.6
Japan												
Nat. Ast. Obs., Tokyo	+35 40.3	+139 32.5	22 10 54.3	41.6	22 28 30.1	39.1	1 29 40.4	9 08.1	4 30 01.1	292.4	4 47 27.6	289.9
Kyoto Univ. Ast. Obs.	+35 01.7	+135 47.2	22 10 57.8	41.6	22 28 34.4	39.2	1 29 53.9	9 07.9	4 30 14.9	292.4	4 47 40.5	289.9
Nobeyama Solar Radio Obs., Nagano-ken	+35 56.3	+138 28.8	22 10 52.4	41.6	22 28 28.3	39.1	1 29 43.4	9 07.9	4 30 06.8	292.4	4 47 32.9	289.9
Norikura Solar Obs., Nagano	+36 06.8	+137 33.3	22 10 51.1	41.6	22 28 27.1	39.2	1 29 46.2	9 07.7	4 30 11.5	292.4	4 47 37.4	289.9
Osaka	+34 40.0	+135 30.0	22 11 00.1	41.6	22 28 36.8	39.2	1 29 55.4	9 08.0	4 30 14.8	292.4	4 47 40.3	289.9
Tokyo Hydorgraphic Obs.	+35 39.7	+139 46.2	22 10 54.4	41.6	22 28 30.1	39.1	1 29 39.6	9 08.1	4 30 00.1	292.4	4 47 26.6	289.9
Sapporo	+43 05.0	+141 21.0	22 10 04.2	41.7	22 27 38.0	39.3	1 29 22.9	9 05.8	4 30 26.5	292.2	4 47 52.6	289.7
Philippines												
Manila Obs.	+14 38.2	+121 04.6	22 12 52.0	41.4	22 30 37.6	38.9	1 31 21.8	9 12.9	4 30 22.9	293.0	4 47 48.7	290.4
Manilla	+14 37.0	+120 58.0	22 12 52.0	41.4	22 30 37.6	38.9	1 31 22.2	9 12.9	4 30 23.5	293.0	4 47 49.3	290.4
Indonesia												
Jakarta (Java)	− 6 08.0	+106 45.0	. .. .. .	.. .	. .. .. .	.. .	1 32 37.2	9 17.6	4 30 58.7	293.4	4 48 28.3	290.9

Location	Position Latitude	Position Longitude	Ingress Exterior Contact UT	Ingress Exterior Contact *P*	Ingress Interior Contact UT	Ingress Interior Contact *P*	Least Angular Distance UT	Least Angular Distance Separation	Egress Interior Contact UT	Egress Interior Contact *P*	Egress Exterior Contact UT	Egress Exterior Contact *P*
	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Indonesia												
Bosscha Obs., Jakarta	− 6 49.5	+107 37.0	. .. .. .	.. .	. .. .. .	.. .	1 32 35.3	9 17.9	4 30 51.4	293.5	4 48 21.4	290.9
Bangkok, **Thailand**	+13 44.0	+100 30.0	. .. .. .	.. .	. .. .. .	.. .	1 32 25.4	9 09.8	4 32 28.5	292.9	4 49 51.2	290.3
Korea, Rep of												
Korea Ast. Obs., Taejeon	+36 23.9	+127 22.3	22 10 43.3	41.7	22 28 21.0	39.3	1 30 17.9	9 06.5	4 30 59.3	292.4	4 48 22.8	289.9
Seoul	+37 30.0	+127 00.0	22 10 35.6	41.8	22 28 13.1	39.3	1 30 16.7	9 06.1	4 31 05.0	292.3	4 48 28.4	289.9
China, People's Republic of												
Purple Mountain Obs., Nanjing	+32 04.0	+118 49.3	22 11 01.1	41.8	22 28 41.6	39.3	1 30 53.3	9 06.7	4 31 28.3	292.5	4 48 50.5	290.0
Yunnan Obs., Kunming	+25 01.5	+102 47.3	. .. .. .	.. .	22 28 55.5	39.3	1 31 54.3	9 06.6	4 32 40.5	292.6	4 50 01.2	290.1
Beijing	+39 55.0	+116 26.0	22 10 06.3	41.9	22 27 44.9	39.4	1 30 40.6	9 04.0	4 32 03.7	292.2	4 49 24.9	289.8
Wuhan	+30 35.0	+114 19.0	22 11 02.7	41.8	22 28 44.5	39.3	1 31 09.9	9 06.6	4 31 48.3	292.5	4 49 10.0	290.0
Victoria, Hong Kong	+22 16.0	+114 13.0	22 11 54.2	41.6	22 29 38.6	39.1	1 31 29.2	9 09.2	4 31 25.8	292.7	4 48 48.6	290.2
Harbin	+45 50.0	+126 40.0	22 09 39.4	41.9	22 27 14.9	39.4	1 29 59.4	9 03.5	4 31 36.3	292.1	4 48 59.2	289.6
Taipei Obs., **Taiwan**	+25 04.7	+121 31.6	22 11 49.7	41.6	22 29 31.8	39.1	1 31 00.2	9 09.4	4 30 51.9	292.7	4 48 15.7	290.2
Ulaanbaatar, **Mongolia**	+47 54.0	+106 52.0	22 08 58.5	42.1	22 26 36.3	39.6	1 30 39.6	9 00.7	4 33 07.6	292.0	4 50 27.7	289.5
Hanoi, **Vietnam**	+21 01.0	+105 52.0	. .. .. .	.. .	22 29 28.4	39.2	1 31 55.9	9 08.3	4 32 12.6	292.7	4 49 34.4	290.2
Yangon, **Myanmar**	+16 47.0	+ 96 10.0	. .. .. .	.. .	. .. .. .	.. .	1 32 29.3	9 08.1	4 33 02.6	292.7	4 50 24.2	290.2
Kuala Lumpur, **Malaysia**	+ 3 08.0	+101 42.0	. .. .. .	.. .	. .. .. .	.. .	1 32 40.5	9 13.6	4 31 54.9	293.2	4 49 20.6	290.6
India												
Mumbai	+18 56.0	+ 72 51.0	. .. .. .	.. .	. .. .. .	.. .	1 32 59.0	9 03.8	4 35 23.6	292.4	4 52 44.5	290.0
New Delhi	+28 37.0	+ 77 13.0	. .. .. .	.. .	. .. .. .	.. .	1 32 28.1	9 01.7	4 35 10.4	292.2	4 52 29.8	289.8
Calcutta	+22 30.0	+ 88 20.0	. .. .. .	.. .	. .. .. .	.. .	1 32 30.9	9 05.1	4 34 01.0	292.5	4 51 21.1	290.0
Vainu Bappu Obs., Tamil Nadu	+12 34.6	+ 78 49.6	. .. .. .	.. .	. .. .. .	.. .	1 33 08.2	9 06.7	4 34 39.8	292.7	4 52 01.8	290.2
Colombo, **Sri Lanka**	+ 6 55.0	+ 79 52.0	. .. .. .	.. .	. .. .. .	.. .	1 33 17.7	9 08.7	4 34 22.3	292.8	4 51 45.7	290.3
Riyadh, **Saudi Arabia**	+24 39.0	+ 46 46.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 24.8	292.0	4 54 48.4	289.5
Tehran, **Iran**	+35 40.0	+ 51 26.0	. .. .. .	.. .	. .. .. .	.. .	1 32 07.4	8 57.1	4 37 02.8	291.8	4 54 24.3	289.4
Amman, **Jordan**	+31 57.0	+ 35 56.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 51.9	291.7	4 55 16.9	289.3
F. & G. Wise Obs., Tel Aviv, **Israel**	+30 35.8	+ 34 45.8	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 56.1	291.7	4 55 21.6	289.3
Tashkent Obs., Tashkent, **Uzbekistan**	+41 19.5	+ 69 17.6	. .. .. .	.. .	. .. .. .	.. .	1 31 49.6	8 57.8	4 35 49.8	291.8	4 53 09.0	289.4
Qaraghandy (Karaganda), **Kazakstan**	+49 53.0	+ 73 07.0	. .. .. .	.. .	. .. .. .	.. .	1 31 14.5	8 56.6	4 35 28.7	291.7	4 52 48.1	289.3
Baku, **Azerbaijan**	+40 22.0	+ 49 53.0	. .. .. .	.. .	. .. .. .	.. .	1 31 49.5	8 56.0	4 37 01.9	291.7	4 54 23.5	289.3
Kabul, **Afghanistan**	+34 30.0	+ 69 10.0	. .. .. .	.. .	. .. .. .	.. .	1 32 14.2	8 59.2	4 35 52.2	292.0	4 53 11.6	289.6
Egypt												
Kottamia Obs., Kottamia	+29 55.9	+ 31 49.5	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 03.1	291.7	4 55 29.4	289.3

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Location	Position Latitude	Position Longitude	Ingress Exterior Contact UT	Ingress Exterior Contact *P*	Ingress Interior Contact UT	Ingress Interior Contact *P*	Least Angular Distance UT	Least Angular Distance Separation	Egress Interior Contact UT	Egress Interior Contact *P*	Egress Exterior Contact UT	Egress Exterior Contact *P*
	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Egypt												
Cairo	+30 03.0	+ 31 15.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 04.1	291.7	4 55 30.5	289.3
Algeria												
Alger Obs., Univ. of Alger	+36 48.1	+ 3 02.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 09.5	291.3	4 55 43.3	288.9
Algiers	+36 50.0	+ 3 00.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 09.4	291.3	4 55 43.2	288.9
Khartoum, **Sudan**	+15 33.0	+ 32 32.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 03.9	292.0	4 55 32.9	289.6
Nairobi, **Kenya**	− 1 17.0	+ 36 50.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 24.8	292.5	4 54 57.4	290.0
Addis Ababa, **Ethiopia**	+ 9 03.0	+ 38 42.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 40.4	292.2	4 55 09.3	289.8
Dar es Salaam, **Tanzania**	− 6 51.0	+ 39 18.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 01.5	292.7	4 54 35.3	290.2
N′Djamena, **Chad**	+12 10.0	+ 14 59.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 25.9	291.9	4 56 01.5	289.5
Sanaa, **Yemen**	+15 24.0	+ 44 14.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 29.8	292.2	4 54 55.7	289.7
Lusaka, **Zambia**	−15 26.0	+ 28 20.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 36 58.0	292.8	4 54 38.2	290.3
Antananarivo (Tananarive), **Madagascar**	−18 52.0	+ 47 30.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 35 49.4	293.1	4 53 26.0	290.6
Univ. of Ankara, **Turkey**	+39 50.6	+ 32 46.8	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 45.7	291.5	4 55 10.7	289.1
National Obs. of Athens, **Greece**	+37 58.4	+ 23 43.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 03.1	291.5	4 55 30.6	289.1
Barcelona, **Spain**	+41 25.0	+ 2 10.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 58.1	291.2	4 55 31.2	288.9
United Kingdom												
Univ. of London Obs.	+51 36.8	− 0 14.4	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 24.3	291.1	4 54 56.3	288.7
Taunton, England	+51 01.3	− 3 06.3	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 23.7	291.1	4 54 56.5	288.7
Armagh Obs., Northern Ireland	+54 21.2	− 6 38.9	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 07.5	291.1	4 54 40.5	288.7
Cambridge Univ. Observatories	+52 12.8	+ 0 05.6	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 22.4	291.1	4 54 54.2	288.7
Univ. of Glasgow Obs., Scotland	+55 54.1	− 4 18.3	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 04.1	291.1	4 54 36.3	288.7
Univ. of St. Andrews Obs., Scotland	+56 20.2	− 2 48.9	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 03.8	291.1	4 54 35.6	288.7
Dunsink Obs., Dublin **Ireland**	+53 23.3	− 6 20.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 11.5	291.1	4 54 44.6	288.7
France												
Paris Obs.	+48 50.2	+ 2 20.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 36.1	291.2	4 55 07.8	288.8
Pic du Midi Obs.	+42 56.2	+ 0 08.7	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 52.5	291.2	4 55 25.9	288.8
Lyon	+45 46.0	+ 4 50.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 47.6	291.2	4 55 19.1	288.8
Strasbourg Obs.	+48 35.0	+ 7 46.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 39.6	291.2	4 55 10.0	288.8
Marseilles	+43 18.0	+ 5 22.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 55.1	291.2	4 55 27.0	288.9
Germany												
Archenhold Obs., Berlin	+52 29.2	+ 13 28.7	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 25.9	291.2	4 54 54.4	288.8
Hamburg Obs.	+53 28.9	+ 10 14.5	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 22.1	291.2	4 54 51.3	288.8
Max Planck Inst. for Radio Ast., Effelsberg	+50 31.6	+ 6 53.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 32.5	291.2	4 55 02.9	288.8
Italy												
Bologna Univ. Obs.	+44 15.5	+ 11 20.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 53.9	291.3	4 55 23.9	288.9

Location	Position		Ingress Exterior Contact		Ingress Interior Contact		Least Angular Distance		Egress Interior Contact		Egress Exterior Contact	
	Latitude	Longitude	UT	*P*	UT	*P*	UT	Separation	UT	*P*	UT	*P*
	° ′	° ′	h m s	°	h m s	°	h m s	′ ″	h m s	°	h m s	°
Italy												
Rome Obs.	+41 55.3	+ 12 27.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 00.4	291.3	4 55 30.4	288.9
Palermo Univ. Ast. Obs., Sicily	+38 06.7	+ 13 21.5	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 38 09.6	291.4	4 55 40.0	289.0
Warsaw Univ. Ast. Obs. **Poland**	+52 05.4	+ 21 25.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 24.1	291.2	4 54 50.9	288.9
Norway												
Skibotn Ast. Obs., Skibotn	+69 20.9	+ 20 21.9	22 04 35.4	42.2	22 22 10.1	39.8	1 29 29.4	8 52.8	4 36 06.3	291.1	4 53 33.4	288.7
Oslo	+59 56.0	+ 10 45.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 36 54.7	291.1	4 54 23.3	288.7
Longyearbyen (Svalbard)	+78 12.0	+ 15 40.0	22 04 42.1	42.1	22 22 14.1	39.8	1.28 56.6	8 53.4	4 35 17.1	291.1	4 52 45.2	288.7
Univ. of Helsinki Obs., **Finland**	+60 09.7	+ 24 57.3	. .. .. .	.. .	. .. .. .	.. .	1 30 07.0	8 52.8	4 36 48.6	291.2	4 54 14.7	288.8
Sweden												
Lund Obs., Lund	+55 41.9	+ 13 11.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 13.1	291.2	4 54 41.5	288.8
Stockholm	+59 20.0	+ 18 05.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 36 56.2	291.2	4 54 23.5	288.8
Russia												
Irkutsk Ast. Obs., Irkutsk	+52 16.7	+104 20.7	22 08 26.9	42.1	22 26 03.9	39.7	1 30 30.2	8 59.5	4 33 26.1	291.8	4 50 46.3	289.4
Pulkovo Obs., St. Petersburg	+59 46.4	+ 30 19.6	. .. .. .	.. .	. .. .. .	.. .	1 30 15.2	8 53.0	4 36 45.5	291.2	4 54 10.6	288.8
Moscow	+55 45.0	+ 37 42.0	. .. .. .	.. .	. .. .. .	.. .	1 30 39.0	8 53.4	4 36 51.3	291.3	4 54 15.0	288.9
Murmansk	+68 59.0	+ 33 08.0	22 04 55.9	42.2	22 22 31.0	39.8	1 29 42.4	8 53.0	4 36 00.5	291.2	4 53 26.0	288.8
Tomsk Univ. Obs.	+56 28.1	+ 84 56.8	22 07 23.0	42.2	22 25 00.7	39.8	1 30 39.8	8 56.8	4 34 42.0	291.6	4 52 01.9	289.2
Tiksi	+71 40.0	+128 45.0	22 06 52.2	42.1	22 24 22.8	39.7	1 28 57.7	8 57.4	4 33 02.7	291.5	4 50 27.9	289.1
Magadan	+59 38.0	+150 50.0	22 08 10.0	41.9	22 25 39.9	39.4	1 28 38.0	9 01.5	4 31 21.0	291.8	4 48 48.1	289.3
Vladivostok	+43 09.0	+131 53.0	22 10 01.2	41.8	22 27 36.5	39.3	1 29 50.7	9 04.9	4 31 04.4	292.2	4 48 28.4	289.7
Urania Obs., Budapest, **Hungary**	+47 29.1	+ 19 03.8	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 41.6	291.3	4 55 09.2	288.9
Bucharest Ast. Obs., **Romania**	+44 24.8	+ 26 05.8	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 44.6	291.4	4 55 10.8	289.0
Prague, **Czech Rep.**	+50 04.6	+ 14 23.7	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 34.6	291.2	4 55 03.2	288.8
Austria												
Univ. of Graz Obs.	+47 04.7	+ 15 27.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 44.6	291.3	4 55 13.1	288.9
Urania Obs., Vienna	+48 12.7	+ 16 23.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 40.5	291.3	4 55 08.7	288.9
Copenhagen Univ. Obs., **Norway**	+55 41.2	+ 12 34.6	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 13.2	291.2	4 54 41.7	288.8
Leiden Obs., **Netherlands**	+52 09.3	+ 4 29.1	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 25.5	291.1	4 54 56.2	288.8
Royal Obs., Brussels, **Belgium**	+50 47.9	+ 4 21.5	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 30.4	291.2	4 55 01.4	288.8
Zimmerwald Obs., Berne, **Switzerland**	+46 52.6	+ 7 27.9	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 45.2	291.2	4 55 15.9	288.8
Sarajevo, **Bosnia**	+43 52.0	+ 18 26.0	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 53.0	291.3	4 55 21.1	288.9
Kiev Univ. Obs., **Ukraine**	+50 27.2	+ 30 29.9	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 20.5	291.3	4 54 45.4	288.9
Vilnius Ast. Obs., **Lithuania**	+54 41.0	+ 25 17.2	. .. .. .	.. .	. .. .. .	.. .	. .. .. .	.. .. .	4 37 11.1	291.2	4 54 37.1	288.9
Reykjavik, **Iceland**	+64 09.0	− 21 58.0	22 03 37.9	42.0	22 21 11.3	39.6	. .. .. .	.. .. .	4 36 06.5	291.0	4 53 40.6	288.6

Dot leaders indicate the phenomenon occurs below the horizon.