

THE INFERIOR CONJUNCTIONS OF VENUS, 1960 TO 2023

J. MEEUS

In the 1956 volume of this *Journal*, M. B. B. Heath published the lists of oppositions of the planets Mars to Neptune taking place in the period 1956–2000. In the case of Venus, we may consider the inferior conjunction as the most important geocentric phase, because the planet is then nearest to the Earth, and moreover moving rapidly from the evening towards the morning sky. We have calculated all inferior conjunctions of Venus in the period 1960–2023. Our results are given in the table below.

The times are given to the nearest hour Ephemeris Time. Since the difference between E.T. and U.T. will be less than 3 minutes in the considered period, the instant may be regarded as expressed in Universal Time as well. Besides the instant, the geocentric latitude of Venus at the time of conjunction is given; the sign + (or –) indicates that Venus is north (or south) of the ecliptic. Because the path of Venus, at the time of inferior conjunction, is nearly parallel to the ecliptic, the planet's geocentric latitude is approximately equal to its least distance to the *centre* of the Sun.

When, as in 1967 August and in 1969 April, Venus passed more than seven degrees north or south of the Sun, observers were able to keep the planet under uninterrupted watch as it moved from the evening into the morning sky. On 1959 September 1, at 8^h U.T., only two hours after the inferior conjunction, the author could see the planet with his 15 cm refractor; the line joining the cusps of Venus' very thin crescent was nearly east-west instead of north-south.

	h	°	'		h	°	'		
1961 April	10	24	+7	08	1993 April	1	13	+7	52
1962 Nov.	12	20	–4	04	1994 Nov.	2	23	–5	24
1964 June	19	23	–1	49	1996 June	10	16	–0	30
1966 Jan.	26	9	+6	55	1998 Jan.	16	11	+5	49
1967 Aug.	29	22	–8	30	1999 Aug.	20	12	–8	07
1969 April	8	15	+7	20	2001 March	30	4	+8	01
1970 Nov.	10	9	–4	25	2002 Oct.	31	12	–5	42
1972 June	17	15	–1	29	2004 June	8	9	–0	11
1974 Jan.	23	21	+6	40	2006 Jan.	13	24	+5	30
1975 Aug.	27	13	–8	26	2007 Aug.	18	4	–7	59
1977 April	6	6	+7	31	2009 March	27	19	+8	10
1978 Nov.	7	22	–4	45	2010 Oct.	29	1	–5	59
1980 June	15	7	–1	10	2012 June	6	1	+0	09
1982 Jan.	21	10	+6	24	2014 Jan.	11	12	+5	11
1983 Aug.	25	5	–8	20	2015 Aug.	15	19	–7	51
1985 April	3	22	+7	42	2017 March	25	10	+8	18
1986 Nov.	5	10	–5	05	2018 Oct.	26	14	–6	15
1988 June	12	24	–0	50	2020 June	3	18	+0	29
1990 Jan.	18	23	+6	07	2022 Jan.	9	1	+4	51
1991 Aug.	22	20	–8	14	2023 Aug.	13	11	–7	41

Method of Computing. Strictly speaking, the times given in the table are those of the geocentric conjunctions in longitude, not those of the least distance of the centres of Venus and the Sun. The angular distances are the differences of the latitudes at the instants of conjunction; they differ very little from the least distances between the centres.

The values for the period 1961–1970 have been deduced from the *Astronomical Ephemeris*. For the years 1972–1999, the calculations were performed with the Tables of Herget^{1,2}. For the years after A.D. 2000, we used our own solar tables³ and the Tables of Venus of H. P. Bhatt⁴.

Since the times were required only to the nearest hour, and the latitudes to the nearest minute of arc, we have in our calculations neglected the latitude of the Sun (which never exceeds $1''.1$), the corrections for aberration (which are nearly equal for Venus and the Sun when these bodies are in conjunction), and the correction for light-time.

The geocentric latitude β of Venus, at the time of inferior conjunction, was calculated by

$$\tan \beta = \frac{r \sin b}{R - r \cos b}$$

where R is the Sun's radius vector, or the distance Sun–Earth in astronomical units; r is Venus' radius vector, or the distance Sun–Venus, and b is the heliocentric latitude of Venus.

Other Phenomena. Approximate times of Venus' greatest brilliancy may be obtained by adding or subtracting 36 days from the instants of the inferior conjunctions.

To obtain the approximate times of greatest elongations east (evening visibility), subtract 71 days from the times of inferior conjunctions; for the greatest elongations west (morning visibility), add 71 days instead. It may be noted that a list of all greatest elongations in the period 1956–2000 has been published in 1956 in this *Journal*⁵.

For the approximate times of superior conjunctions, take the instants midway between two consecutive inferior conjunctions.

Periodicity. The well-known periodicity of 8 years may be seen in the list. Since 8 sidereal revolutions of the Earth are approximately equal to 13 revolutions of Venus, the two planets are again in nearly the same points of their orbit after a period of 8 years. In such a period, there are five (13 minus 8) inferior conjunctions of Venus.

The synodic period of Venus is 583.92 days. Hence, five synodic revolutions is 2 919.6 days, which is 2.4 days shorter than eight julian years (2 922.0 days).

Hence, after a period of eight years, the same geocentric phenomena of Venus occur again but $2\frac{1}{2}$ days earlier. For example:

	1961			1969		
		d	h		d	h
greatest elongation east	Jan.	29	07	Jan.	26	22
greatest brilliancy	March	5	17	March	3	10
stationary	March	19	18	March	17	07
inferior conjunction	April	10	24	April	8	15
stationary	April	29	17	April	27	07
greatest brilliancy	May	16	20	May	14	09
greatest elongation west	June	20	02	June	17	17

After every period of eight years, at the inferior conjunction, the path of Venus relative to the Sun is slightly displaced. This may be seen, for example, from the following series; for each inferior conjunction, Venus' geocentric latitude is given:

	h	°	'
1911 September 15	12	—8	42
1919 September 13	3	—8	43
1927 September 10	18	—8	43
1935 September 8	9	—8	42
1943 September 6	0	—8	40
1951 September 3	15	—8	38
1959 September 1	6	—8	34
1967 August 29	22	—8	30
etc.			

Greatest latitude. At its inferior conjunctions, Venus is nearer to the Earth than to the Sun. Consequently, at these epochs the planet's geocentric latitude is greater than its heliocentric latitude, approximately in the ratio 13 : 5.

Presently (1970), the longitude of Venus' ascending node, referred to the mean equinox of date, is $76^{\circ} 25'$. The orbit's inclination on the plane of the ecliptic is $3^{\circ} 23' 40''$. Consequently, Venus reaches its greatest latitudes north and south in longitudes $166^{\circ} 25'$ and $346^{\circ} 25'$, respectively. The Earth reaches these longitudes on March 7 and September 9. The corresponding values of r , R and b are given below.

l	$166^{\circ} 25'$	$346^{\circ} 25'$
date	March 7	September 9
r	0.7193	0.7273
R	0.9925	1.0071
b	$+3^{\circ} 23' 40''$	$-3^{\circ} 23' 40''$
β	$+8^{\circ} 49'$	$-8^{\circ} 43'$

Consequently, Venus' geocentric latitude has its greatest northern value ($+8^{\circ} 49'$) at an inferior conjunction occurring about March 7. The greatest southern latitudes ($-8^{\circ} 43'$) take place at inferior conjunctions about September 9.

In the 20th century, the greatest geocentric latitudes of Venus took place on 1919 September 13 and 1927 September 10, when in both cases it was $-8^{\circ} 43'$, in exact agreement with the value quoted above. Venus will reach no greater

geocentric latitude (at inferior conjunction) until the second half of the 21st century:

	h	°	'
2065 March 11	2	+8	47
2073 March 8	17	+8	49
2081 March 6	7	+8	50
2089 March 3	21	+8	50
2097 March 1	12	+8	49

When the inferior conjunction takes place near the longitudes $76^{\circ} 25'$ or $256^{\circ} 25'$ (about December 8 or June 7), there occurs a transit of the planet across the solar disk, for example on 2004 June 8 and 2012 June 6. Furthermore, we have the following rules:

<i>Inferior conjunction occurring in the period</i>	<i>Latitude of Venus</i>	<i>Latitude of Venus at inf. conj. 8 years later</i>
Dec. 8 – March 7	north	decreasing
March 7 – June 7	north	increasing
June 7 – Sept. 9	south	decreasing
Sept. 9 – Dec. 8	south	increasing

References

- 1 Herget, Paul, *Astron. Papers American Ephemeris*, **XIV**, Washington, 1953.
- 2 Herget, Paul, *ibid.*, **XV**, part III, Washington, 1955.
- 3 Meeus, Jean, *Tables of Moon and Sun*, Kessel-Lo, 1962.
- 4 Bhatt, Harihar P., *Tables of Venus*, Ahmedabad, 1957.
- 5 Heath, M. B. B., *J. Brit. astr. Ass.*, **66**, 139 (1956).