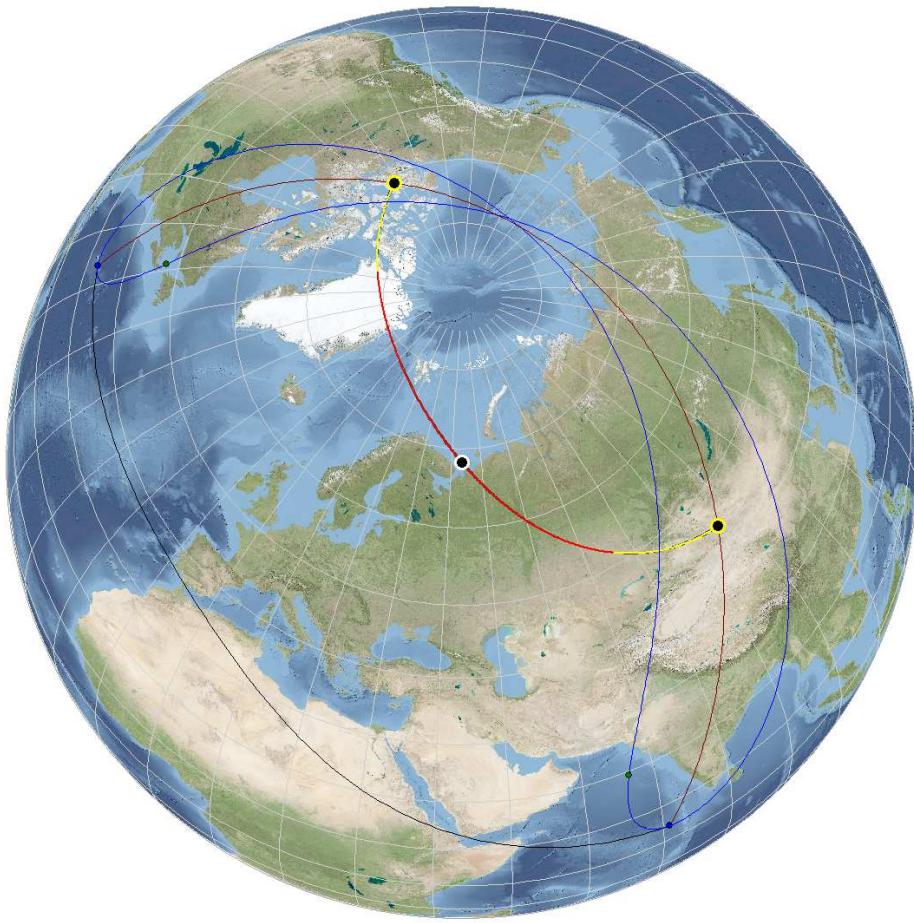


# Hybrid (annular–total) Solar Eclipse

## 1645 August 21



View centered at longitude 43.69° / latitude 68.21° Orthographic representation  
Win\_Eclipsemaps graphics state Psi 0.0° Phi 0.0° Chi 0.0° Globe size 525 pixels

9<sup>th</sup> eclipse of 71 eclipses belonging to Saros series 139

Difference between Terrestrial Time and Universal Time	$\Delta T$	55.40 secs
Minimum distance of the shadow axis from the Earth center	$\gamma$	0.87100 $r_E$
Lunation number (according to Jean Meeus [a])	$k$	-4383

### Geocentric position, apparent motion and size of Sun and Moon

Instant of greatest eclipse	1645–08–21	11:33:22.33	JD 2322116.981520	UT
	1645–08–21	11:34:17.73	JD 2322116.982161	TT
Geocentric conjunction in Right Ascension	1645–08–21	11:08:21.83	JD 2322116.964142	UT
	1645–08–21	11:09:17.23	JD 2322116.964783	TT
Right Ascension of Sun	$10^h 02^m 50.63^s$	Hourly motion	$00^h 00^m 09.26^s$	
Right Ascension of Moon	$10^h 03^m 42.96^s$	Hourly motion	$00^h 02^m 14.75^s$	
Declination of Sun	$11^\circ 59' 58.6''$	Hourly motion	$-00^\circ 00' 50.3''$	
Declination of Moon	$12^\circ 48' 37.4''$	Hourly motion	$-00^\circ 08' 54.6''$	
Equatorial horizontal parallax of Sun	$00^\circ 00' 08.7''$	Semidiameter	$00^\circ 15' 49.8''$	
Equatorial horizontal parallax of Moon	$00^\circ 57' 53.5''$	Semidiameter	$00^\circ 15' 46.6''$	

General circumstances of the eclipse (UT)					
Point	Event description	Date	Time	Longitude 1)	Latitude 2)
TP1	(Partial) <b>eclipse begins</b>	1645–08–21	09:13:34.4	-61°18.4'	47°43.5'
TP4	(Partial) <b>eclipse ends</b>	1645–08–21	13:53:27.7	66°29.6'	19°12.7'
TPS1	First extreme point on the southern penumbral limit	1645–08–21	09:44:24.3	-63°25.8'	33°03.9'
TPS2	Last extreme point on the southern penumbral limit	1645–08–21	13:22:31.1	70°53.8'	04°14.2'
TU1	Umbral eclipse begins	1645–08–21	10:40:28.1	-108°50.0'	71°27.2'
TU2	Complete umbral eclipse begins	1645–08–21	10:40:00.0	-108°16.8'	71°17.5'
TU3	Complete umbral eclipse ends	1645–08–21	12:27:05.9	96°01.9'	44°48.8'
TU4	Umbral eclipse ends	1645–08–21	12:26:31.9	96°16.8'	45°03.7'
TUN1	First extreme point on the northern umbral limit	1645–08–21	10:40:01.4	-108°15.3'	71°16.8'
TUS1	First extreme point on the southern umbral limit	1645–08–21	10:40:26.7	-108°51.5'	71°27.9'
TUN2	Last extreme point on the northern umbral limit	1645–08–21	12:27:04.1	96°01.8'	44°47.7'
TUN2	Last extreme point on the southern umbral limit	1645–08–21	12:26:33.7	96°16.8'	45°04.7'
TC1	Begin of central eclipse (annular)	1645–08–21	10:40:14.0	-108°33.3'	71°22.3'
TC2	End of central eclipse (annular)	1645–08–21	12:26:48.9	96°09.3'	44°56.2'
TG0	Greatest eclipse (total)	1645–08–21	11:33:22.3	43°41.5'	68°12.6'

<sup>1)</sup> Longitudes are measured positively eastwards from the Greenwich meridian

<sup>2)</sup> Latitudes are measured positively in the northern hemisphere

## General circumstances of the eclipse (TT)

Point	Event description	Date	Time	Ephemeris Longitude <sup>1)</sup>	Latitude <sup>2)</sup>
TP1	(Partial) <b>eclipse begins</b>	1645–08–21	09:14:29.8	-61°32.3'	47°43.5'
TP4	(Partial) <b>eclipse ends</b>	1645–08–21	13:54:23.1	66°15.7'	19°12.7'
TPS1	First extreme point on the southern penumbral limit	1645–08–21	09:45:19.7	-63°39.7'	33°03.9'
TPS2	Last extreme point on the southern penumbral limit	1645–08–21	13:23:26.5	70°39.9'	04°14.2'
TU1	Umbral eclipse begins	1645–08–21	10:41:23.5	-109°03.9'	71°27.2'
TU2	Complete umbral eclipse begins	1645–08–21	10:40:55.4	-108°30.6'	71°17.5'
TU3	Complete umbral eclipse ends	1645–08–21	12:28:01.3	95°48.0'	44°48.8'
TU4	Umbral eclipse ends	1645–08–21	12:27:27.3	96°02.9'	45°03.7'
TUN1	First extreme point on the northern umbral limit	1645–08–21	10:40:56.8	-108°29.1'	71°16.8'
TUS1	First extreme point on the southern umbral limit	1645–08–21	10:41:22.1	-109°05.4'	71°27.9'
TUN2	Last extreme point on the northern umbral limit	1645–08–21	12:27:59.5	95°48.0'	44°47.7'
TUN2	Last extreme point on the southern umbral limit	1645–08–21	12:27:29.1	96°02.9'	45°04.7'
TC1	Begin of central eclipse (annular)	1645–08–21	10:41:09.4	-108°47.2'	71°22.3'
TC2	End of central eclipse (annular)	1645–08–21	12:27:44.3	95°55.4'	44°56.2'
TG0	Greatest eclipse (total)	1645–08–21	11:34:17.7	43°27.6'	68°12.6'

<sup>1)</sup> Longitudes are measured positively eastwards from the Greenwich meridian

<sup>2)</sup> Latitudes are measured positively in the northern hemisphere

## Ephemeris of Sun and Moon, and Besselian elements in polynomial form

Instant of greatest eclipse 1645–08–21 11:34:17.73 JD 2322116.982161 TT

Nearest integer hour ( $H_0$ ) 12

		$V_0$	$V_1$	$V_2$	$V_3$
$RA_S$	hrs Apparent right ascension of Sun	1.50727476E+02	3.85798722E-02	-1.65079365E-06	-2.46913636E-09
$DE_S$	° Apparent declination of Sun	1.19936108E+01	-1.39878722E-02	-2.77460317E-06	2.46913583E-09
$R_S$	AU Radius vector Earth–Sun	1.01030658E+00	-9.46333333E-06	-4.12698412E-09	2.64399250E-21
$RA_M$	hrs Apparent right ascension of Moon	1.51169428E+02	5.60983328E-01	-5.73847619E-04	3.28395061E-07
$DE_M$	° Apparent declination of Moon	1.51169428E+02	5.60983328E-01	-5.73847619E-04	3.28395061E-07
$R_M$	AU Radius vector Earth–Moon	2.53233798E-03	1.10006022E-06	3.50569458E-09	-1.98061841E-11
x	$r_E$ x-position of the shadow axis <sup>1)</sup>	4.47978277E-01	5.29975309E-01	-5.59104340E-05	-7.46657619E-06
y	$r_E$ x-position of the shadow axis <sup>1)</sup>	7.82960476E-01	-1.39069394E-01	-1.03766411E-04	1.90849290E-06
d	° Declination <sup>2)</sup>	1.19917177E+01	-1.36516291E-02	-2.51752885E-06	-2.14602139E-09
M	° Ephemeris hour angle <sup>2)</sup>	-6.30804541E-01	1.50037981E+01	1.44594490E-06	-1.61125406E-08
$L_1$	$r_E$ Radius of the penumbral cone <sup>2)</sup>	5.47370009E-01	1.12267801E-04	-1.13295626E-05	3.72525361E-09
$L_2$	$r_E$ Radius of the umbral cone <sup>2)</sup>	1.20675259E-03	1.11708565E-04	-1.12731381E-05	3.70670082E-09
$\tan(f_1)$	of the penumbral vertex angle	4.62808808E-03	4.80901651E-08	-4.57528970E-10	1.52966396E-13
$\tan(f_2)$	of the umbral vertex angle	4.60503934E-03	4.78506569E-08	-4.55250294E-10	1.52204659E-13

Values of the above elements at a given time are computed from  $V = V_0 + V_1 * t + V_2 * t^2 + V_3 * t^3$ , where  $t = t - H_0$  (hrs)

$\tan f_1$	Tangent of the penumbral vertex angle at greatest eclipse	0.00462807	$k_1$	0.2725076 (Penumbra) <sup>3)</sup>
$\tan f_2$	Tangent of the umbral vertex angle at greatest eclipse	0.00460502	$k_2$	0.2722810 (Umbra) <sup>3)</sup>
$\mu'$	°/h Hourly variation of M at greatest eclipse	15.00379589		
$d'$	°/h Hourly variation of d at greatest eclipse	-0.01364786		

<sup>1)</sup> on the fundamental Plane. ( $r_E$  = Equatorial Earth radii)

<sup>2)</sup> of the point on the celestial sphere toward which the axis of the shadow is directed

<sup>3)</sup> Adopted mean lunar radius