TOTAL SOLAR ECLIPSE OF 2006, MARCH 29[•]

I. UMBRAL PATH AND VISIBILITY

On Wednesday, 2006 March 29, a total eclipse of the Sun will be visible from within a narrow corridor which traverses half the Earth. The path of the Moon's umbral shadow begins in Brazil and extends across the Atlantic, northern Africa, and central Asia, where it will end at sunset in northern Mongolia (Fig. 1). A partial eclipse will be seen within the much broader path of the Moon's penumbral shadow, which includes the northern two thirds of Africa, Europe, and central Asia.

The central eclipse track begins in eastern Brazil, where the Moon’s umbral shadow first touches down on Earth at 08:36 UT (Fig. 1). Along the sunrise terminator, the duration is 1m53s from the center of the 129km wide path. Travelling over 9 km/s, the umbra quickly leaves Brazil and races across the Atlantic Ocean (with no landfall) for the next half hour. After crossing the equator, the Moon’s shadow enters the Gulf of Guinea and encounters the coast of Ghana at 09:08UT. The Sun stands 44° above the eastern horizon during the 3m24s total phase. The path width has expanded to 184km while the shadow’s ground speed has decreased to 0.958km/s. Located about 50km south of the central line, Accra, Ghana’s capital city, can expect a total eclipse lasting 2m58s (09:11UT). Then the umbra enters Togo at 09:14 UT. The capital city Lome lies just outside the southern limit so its inhabitants will only witness a grazing partial eclipse. Two minutes later, the leading edge of the umbra will reach Benin whose capital Porto-Novo experiences a deep partial eclipse of magnitude 0.985.

Continuing northeast, the shadow's axis enters Nigeria at 09:21 UT. The central duration has increased to 3m40 s, the Sun's altitude is 52°, the path of totality is 188 km wide and the velocity is 0.818 km/s. Because Lagos is situated about 120 km outside the umbra's southern limit, its population will witness a partial eclipse of magnitude 0.968. The umbra's axis takes about 16min to cross western Nigeria before entering Niger at 09:37 UT. The central duration is 3min54s as the umbra's velocity continues to decrease (0.734 km/s). During the next hour, the shadow traverses some of the most remote and desolate deserts on the planet. When the umbra reaches northern Niger (10:05 UT), it briefly enters extreme northwestern Chad before crossing into southern Libya.

The instant of **greatest eclipse** occurs at 10:11:18 UT, when the axis of the Moon's shadow passes closest to the center of Earth (gamma = +0.384). Totality reaches its maximum duration of 4min7s, the Sun's altitude is 67°, the path width is 184km and the umbra's velocity is 0.697 km/s (Fig. 2). Continuing on a northeastern course, the umbra crosses central Libya and reaches the Mediterranean coast at 10:40 UT. Northwestern Egypt also lies within the umbral path where the central duration is 3min58s.

[•] This text was adapted from: **Total Solar Eclipse of 2006 March 29** (authors: F. Espenak and J. Anderson) by Georgeta Maris, Senior researcher, Solar group, Astronomical Institute of the Romanian Academy.

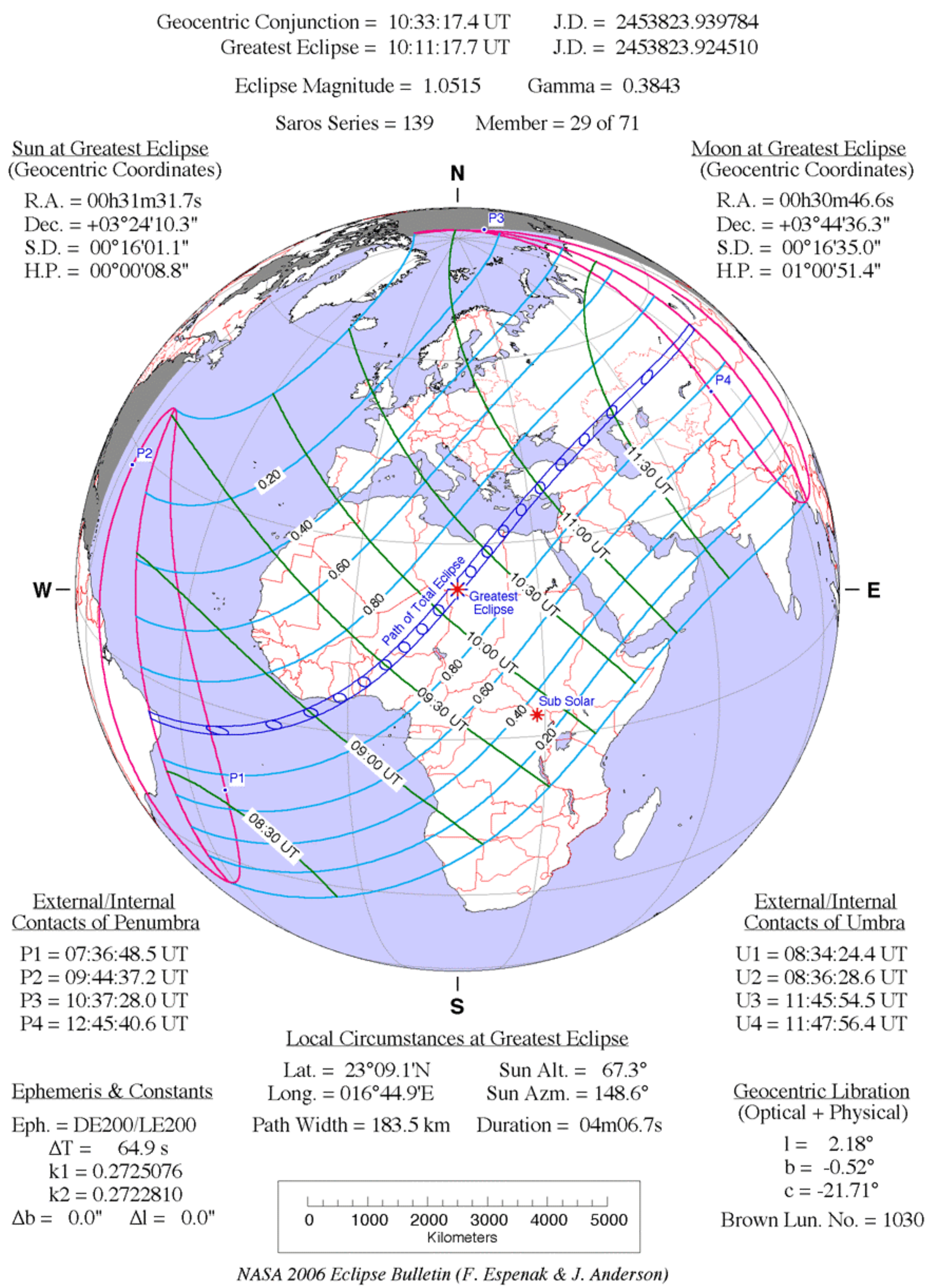

Fig. 1 – The path of total solar eclipse of March 29, 2006

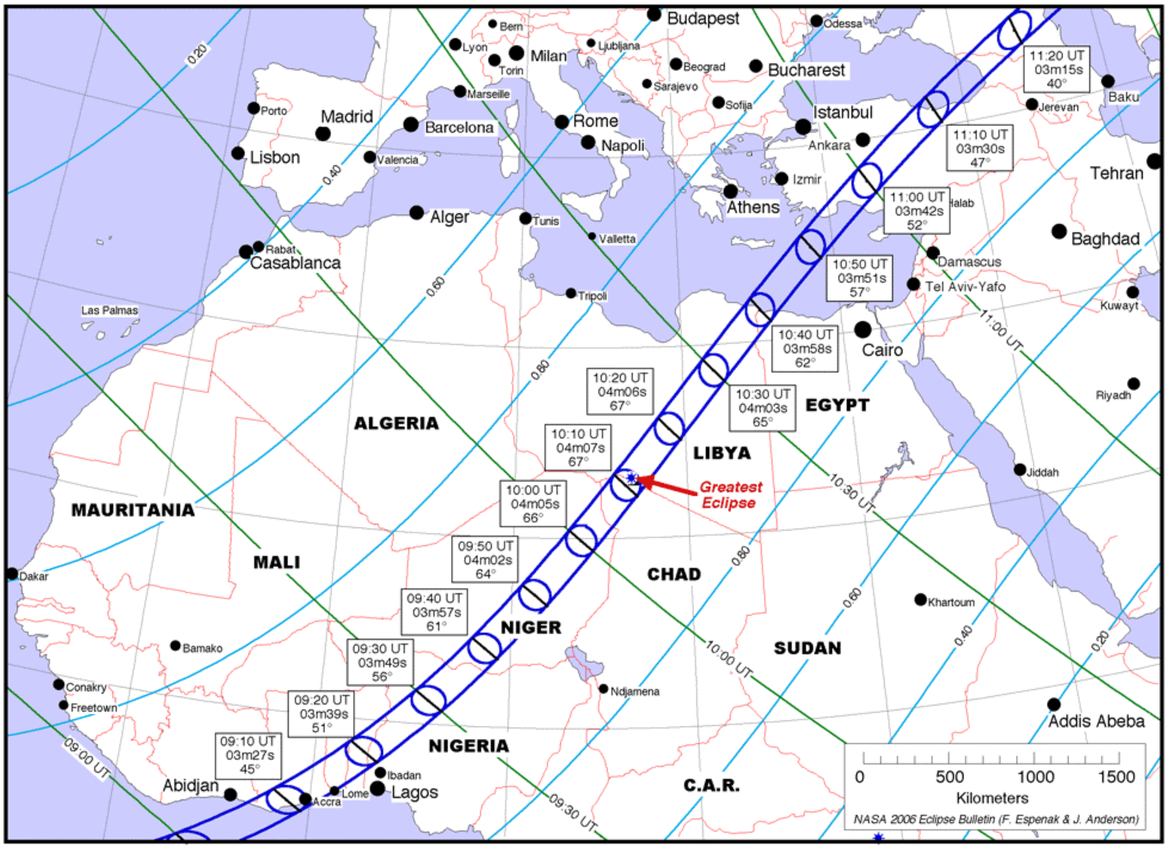

Fig.2 – The March 29, 2006 total solar eclipse path through Africa.
The place of greatest eclipse is marked.

Passing directly between Crete and Cyprus, the track reaches the southern coast of Turkey at 10:54 UT. Antalya lies 50 km northwest of the central line; here the total eclipse lasts 3 min 11 s, while observers on the central line an additional 35s of totality. Konya is 25km from path center and experiences a 3min3 s total phase beginning at 10:58 UT. Crossing mountainous regions of central Turkey, the Moon's shadow intersects the path of the 1999 Aug 11 total eclipse. A quarter of a million people in Sivas have the opportunity of witnessing a second total eclipse from their homes in less than five years. At 11:10 UT, the shadow axis reaches the Black Sea along the northern coast of Turkey (Fig. 3). The central duration is 3min30s, the Sun's altitude is 47°, the path width is 165 km and the umbra's velocity is 0.996 km/s. Six minutes later, the umbra encounters the western shore of Georgia. Moving inland, the track crosses the Caucasus Mountains, which form the highest mountain chain of Europe. Georgia's capital, Tbilisi, is outside the path and experiences a magnitude 0.949 partial eclipse at 11:19 UT. As the shadow proceeds into Russia, it engulfs the northern end of the Caspian Sea and crosses into Kazakhstan. At 11:30 UT, the late afternoon Sun's altitude is 32°, the central line duration is 2min57s and the umbral velocity is 1.508 km/s and increasing.

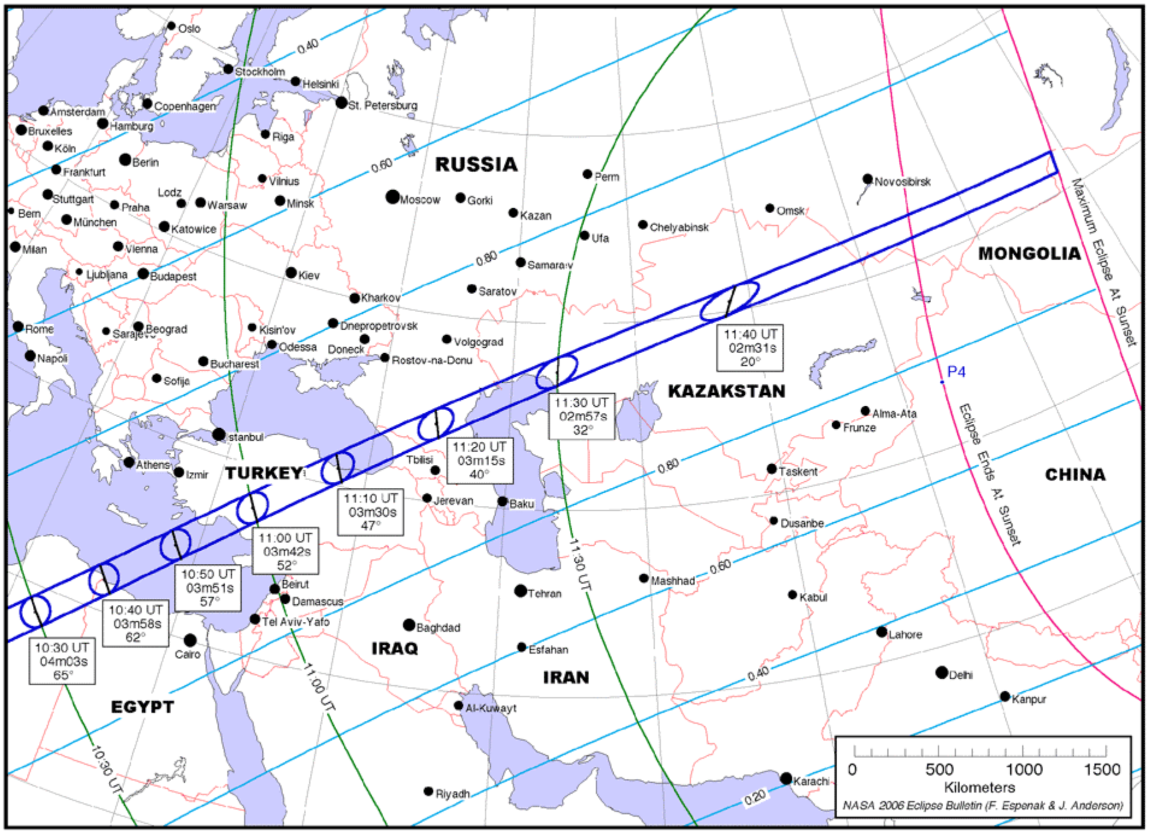

Fig.3 – The March 29, 2006 total solar eclipse path through Asia.

In the remaining 17min, the shadow rapidly accelerates across central Asia while the duration dwindles. It traverses northern Kazakhstan and briefly re-enters Russia before lifting off Earth's surface at sunset along Mongolia's northern border at 11:48 UT.

Over the course of 3h12min, the Moon's umbra travels along a path approximately 14,500 km long and covers 0.41% of Earth's surface area.

II. SKY DURING TOTALITY

During the total solar eclipse of March 29, 2006, the Sun will be in southern Pisces. Three naked-eye planets and a number of bright stars will be above the horizon within the total eclipse path. Fig. 4 depicts the appearance of the sky during totality as seen from the central line at 10:30 UT. This corresponds to central Libya, south of Jalu.

The most conspicuous planet visible during totality will be Venus (m_v=–4.2) located 47° west of the Sun in Capricornus. Mercury (m_v = +1.0) is also west of the Sun at an elongation of 25°, however, it will prove more challenging to detect because it is five magnitudes (~100 times) fainter than Venus. Mars (m_v = +1.3) lies 73° east of the Sun and is slightly fainter than Mercury. Although no bright stars will be close to the Sun during the eclipse, a number of them will be above the horizon and may become visible during the eerie twilight of totality. Deneb (m_v = +1.25), Altair (m_v = +0.76), and Vega (m_v = +0.03) are 65°, 71°, and 87° northwest of the Sun, respectively. Betelgeuse (m_v =

+0.45), Rigel (m_v = +0.18), Aldebaran (m_v = +0.87), and Capella (m_v = +0.08) are to the northeast at distances of 80°, 71°, 61°, and 75°, respectively. Finally, Fomalhaut (m_v = +1.17) is 40° southwest of the Sun. Star visibility requires a very dark and cloud free sky during totality.

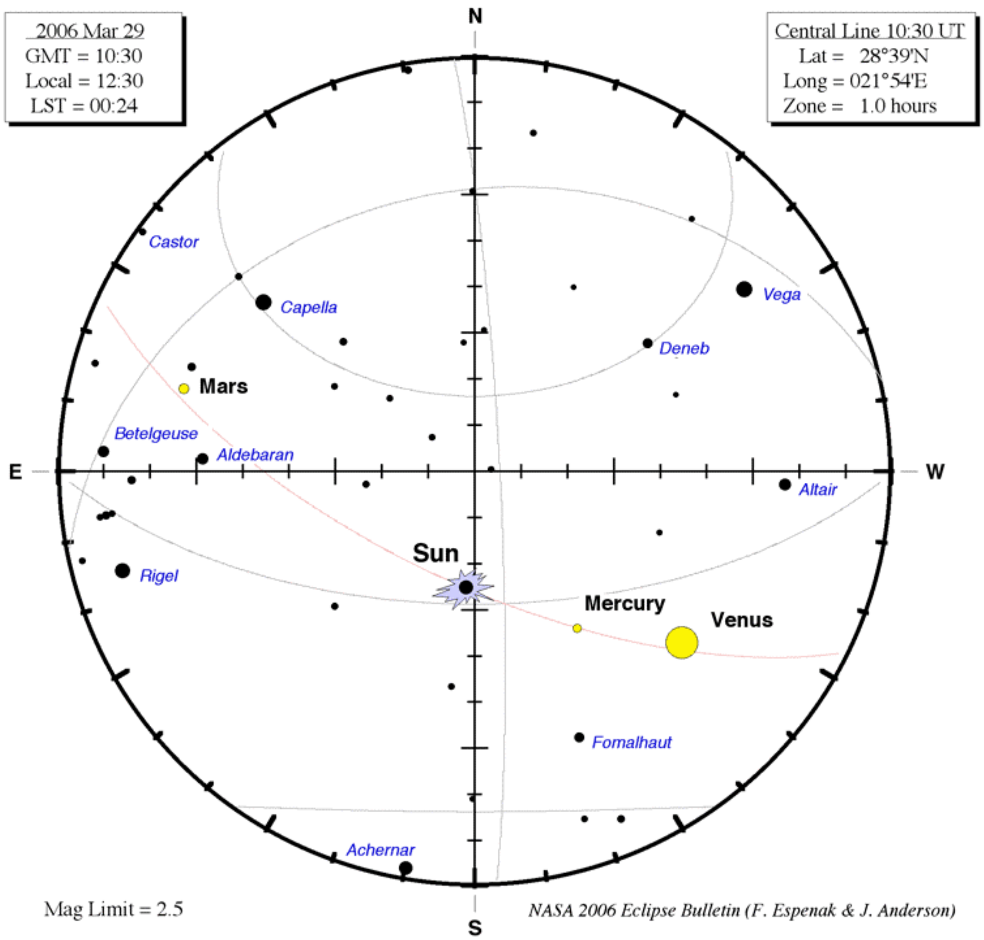

Fig. 4 – The sky during totality as seen from the central line at 10:30 UT

III. SAROS SERIES 139

The 29 March 2006 eclipse belongs to 139 Saros series (Table 1).

The duration of Saros Series no. 139 is of 1262.1 years and it comprises 71 eclipses. First eclipse of this series happened at May 17, 1501 and the last one will be at July 3, 2763. The Saros summary shows that it contains: 16 partial, 43 total and 12 hybrid eclipses. Any annular eclipse is not present in Saros 139 series, only 12 hybrid eclipses (anular/total).

All eclipses in the series occur at the Moon's ascending node and the Moon moves southward with each member in the family, i.e., gamma decreases and takes on negative values south of the Earth's center. Saros 139 is a middle-aged series which began with a small partial eclipse at high northern latitudes on 1501 May 17. After seven partial eclipses each of increasing magnitude, the first umbral eclipse occurred on 1627 August 11. This event was the first hybrid or annular-total class of eclipses. The nature of such an eclipse changes from total to annular or vice versa along different portions of the track. The dual nature arises from the curvature of Earth's surface, which brings the middle part of the path into the umbra (total eclipse) while other, more distant segments remain within the antumbral shadow (annular eclipse). Quite remarkably, the first dozen central eclipses of Saros 139 were all hybrid with the duration of totality increasing during each successive event. The first purely total eclipse of the series occurred on 1843 December 21 and had a maximum duration of 1 min 43 s. Throughout the 19th and 20th centuries, Saros 139 continued to produce total eclipses with increasing durations. The last two members of the series were in 1970 and 1988. The trend culminates with the 39th member of the series on 2186 July 16. This remarkable eclipse will produce a total phase lasting as much as 7min29s. This is very close to a total eclipse's theoretical maximum duration of 7min32s. Long total eclipses from the series will occur throughout the 23rd century with gradually decreasing durations. By the eclipse of 2294 September 20, the duration will slip below 5min. The last central eclipse occurs on 2601 March 26 and has duration of just 36s. The final nine eclipses are all partial events visible from the southern Hemisphere. Saros series 139 ends with the partial eclipse of 2763 July 03.

Table 1. Solar Eclipses of Saros Series 139

Date	**Type**	**Gamma**	**Mag./ Width (km)**	**Center Duration**
1501 May 17	Pb	1.500	0.091	
1519 May 28	P	1.418	0.235	
1537 Jun 07	P	1.337	0.380	
1555 Jun 19	P	1.254	0.530	
1573 Jun 29	P	1.172	0.678	
1591 Jul 20	P	1.091	0.826	
1609 Jul 30	P	1.014	0.966	
1627 Aug 11	H	0.940	2	00m01s
1645 Aug 21	H	0.871	28	00m16s
1663 Sep 01	H	0.807	38	00m29s
1681 Sep 12	H	0.750	43	00m40s
1699 Sep 23	H	0.700	46	00m49s
1717 Oct 04	H	0.656	47	00m56s
1735 Oct 16	H	0.620	48	01m02s
1753 Oct 26	H	0.591	49	01m08s
1771 Nov 06	H	0.567	50	01m13s
1789 Nov 17	H	0.550	52	01m19s
1807 Nov 29	H	0.538	55	01m26s
1825 Dec 09	H	0.530	60	01m34s
1843 Dec 21	T	0.523	66	01m43s
1861 Dec 31	T	0.519	74	01m55s
1880 Jan 11	T	0.514	84	02m07s
1898 Jan 22	T	0.508	96	02m21s
1916 Feb 03	T	0.499	108	02m36s
1934 Feb 14	T	0.487	123	02m52s
1952 Feb 25	T	0.470	138	03m09s
1970 Mar 07	T	0.447	153	03m28s

1988 Mar 18	T	0.419	169	03m46s
2006 Mar 29	**T**	**0.384**	**183**	**04m07s**
2024 Apr 08	T	0.343	197	04m28s
2042 Apr 20	T	0.296	210	04m51s
2060 Apr 30	T	0.242	222	05m15s
2078 May 11	T	0.184	232	05m40s
2096 May 22	T	0.120	241	06m06s
2114 Jun 03	T	0.053	248	06m32s
2132 Jun 13	Tm	-0.018	255	06m55s
2150 Jun 25	T	-0.091	260	07m14s
2168 Jul 05	T	-0.166	264	07m26s
2186 Jul 16	T	-0.239	267	07m29s
2204 Jul 27	T	-0.313	269	07m22s
2222 Aug 08	T	-0.383	270	07m06s
2240 Aug 18	T	-0.452	270	06m40s
2258 Aug 29	T	-0.516	269	06m09s
2276 Sep 09	T	-0.575	266	05m33s
2294 Sep 20	T	-0.630	263	04m57s
2312 Oct 01	T	-0.678	257	04m20s
2330 Oct 13	T	-0.720	251	03m46s
2348 Oct 23	T	-0.756	242	03m14s
2366 Nov 03	T	-0.786	231	02m47s
2384 Nov 14	T	-0.810	217	02m22s
2402 Nov 25	T	-0.829	202	02m02s
2420 Dec 05	T	-0.843	185	01m45s
2438 Dec 17	T	-0.853	167	01m30s
2456 Dec 27	T	-0.861	150	01m19s
2475 Jan 08	T	-0.867	136	01m10s
2493 Jan 18	T	-0.874	123	01m02s
2511 Jan 30	T	-0.881	114	00m57s
2529 Feb 10	T	-0.890	108	00m53s
2547 Feb 21	T	-0.904	106	00m50s
2565 Mar 03	T	-0.921	106	00m46s
2583 Mar 15	T	-0.945	115	00m42s
2601 Mar 26	T	-0.973	141	00m36s
2619 Apr 06	P	-1.010	0.978	
2637 Apr 17	P	-1.052	0.901	
2655 Apr 28	P	-1.102	0.810	
2673 May 08	P	-1.157	0.709	
2691 May 20	P	-1.220	0.593	
2709 May 31	P	-1.286	0.471	
2727 Jun 11	P	-1.358	0.339	
2745 Jun 22	P	-1.434	0.201	
2763 Jul 03	Pe	-1.512	0.058	

The table notations are: P – Partial; Pb – Partial Eclipse (Saros series Begins); Pe – Partial Eclipse (Saros series Ends); T – Total; Tm – Middle Eclipse of Saros series; H – Hybrid (Annular/Total). Note that Mag./Width column gives either the eclipse magnitude (for partial eclipses) or the umbral path width in kilometers (for total and annular eclipses).

IV. WEATHER PROSPECTS FOR THE ECLIPSE

The eclipse path begins in the tropical climate of northeastern Brazil, south of the Intertropical Convergence Zone (ITCZ) where the southeast trade winds bring a generous humidity onto the land. The ITCZ is a cloudy, unstable and wet region where winds from the southern and Northern Hemispheres converge, forming the Earth's “weather equator”.

Leaving Brazil, the shadow path curves slowly northward across the Atlantic and then turns more sharply as it reaches the African coast, crossing to the north side of the ITCZ in northern Nigeria and into a sharply drier climate controlled by winds from the Sahara Desert. **Maximum eclipse** is attained over the desert before the path moves across the Mediterranean coast and into the influence of the mobile highs and lows of the middle latitudes. Leaving Turkey, the shadow moves gradually back into winter as it crosses the Black Sea and Georgia and then heads into Kazakhstan. The Siberian anticyclone, which is a large and semi-permanent high-pressure system, traps winter over the middle of Asia well past March and temperatures fall steadily as the track moves through Kazakhstan. The eclipse comes to its sunset termination in the center of the Siberian anticyclone in Mongolia where the cold temperatures bring a frequency of sunny skies that rivals

Cloudiness varies in concert with the diverse weather zones. Along the ITCZ, skies have a high frequency of heavy cloudiness as the wind flow from the two hemispheres converges and forces the tropical air to rise, a surefire recipe for cloud and rain.

Over northern Nigeria, the winds flowing into the ITCZ originate over the Sahara Desert and have no moisture to contribute to cloud building. There is an abrupt change to a sunny climate in this area, but the winds are laden with desert dust and sand, which puts a reddish haze into the sky. **Eclipse maximum** is reached over the Sahara, just inside Libya, where the frequency of sunny skies is the highest in the world.

Pressing northward, the shadow crosses the Mediterranean coast and enters the mid-latitudes, where weather comes from a never-ending procession of high and low pressure systems - the signature of springtime in the Northern Hemisphere. During March and April, low-pressure systems form preferentially on the east side of the Atlas Mountains in Algeria and travel eastward along the coast of North Africa - either just inland or a short distance offshore. On the north side of the Mediterranean, Turkey and Greece have their own set of Mediterranean lows in spring. The Ionic Sea southwest of the Greek mainland tends to be a holding zone for lows that comes from the west and northwest. After regrouping in this area, the lows continue their journey into Asia, heading either northeastward into the Black Sea or eastward to Cyprus and beyond. Both tracks will plague the eclipse path, either along the Black Sea coasts, or near Antalya in southern Turkey. European lows also have influence in the area, especially the farther north one goes along the eclipse path, and so there is a steady increase in cloudiness from Mediterranean Turkey to Georgia's Black Sea coast. The cloud cover is encouraged by the rough terrain throughout this region, which causes airmasses to rise and condense.

The high levels of cloudiness continue through the Russian Caucasus and western Kazakhstan, but once over the Ural Mountains and onto the steppes of central Asia, the Moon's shadow begins to encounter the sunnier skies and colder temperatures brought by the Siberian anticyclone.

This eclipse samples a large section of global weather and culture, with attractions to please just about everyone. No region is without its problems, but weather prospects are good-to-excellent across most of the path, save for a portion from northern Turkey to western Kazakhstan. Egypt, Libya, and Mediterranean Turkey offer a combination of the best weather prospects and the easiest travel arrangements, but western Africa has some tempting locations, especially in northern Nigeria and southern Niger.

V. ECLIPSE PHOTOGRAPHY

All phenomena described in the 4th paragraph can be recorded on a photographic layer, starting with the first contact and continuing with the following: the development of the partial eclipse, the second contact, the total eclipse, the third contact and finally the partial eclipse, from the second part of the development up to the fourth contact. The diamond ring, Baily's beads, chromosphere, and most important, the solar corona, and prominences can be shot at this time. We can also record on film both the shadow bands that appear on the surface of the Earth before total eclipse, and the light crescents projected on soil before the second contact and after the third contact, as well as the Moon shadow, before and after total eclipse.

Sun's eclipse will be safely shot if all the **eye protection precautions** are followed. To photograph the eclipse any type of camera with manual controls can be used. The objective or zoom lens must be chosen so as to project on film the greatest possible image of the Sun. The image size on a 35 mm film frame can be approximately computed by: **I(mm)=f(mm)/109**, where I–diameter of the solar disk on film and f–focal length of the camera's objective (Table 2).

Table 2. Field of view and size of Sun's image
for various photographic focal lengths (on 35 mm film)

Focal Length	Field of View	Size of Sun	Focal Length	Field of View	Size of Sun
28 mm	$49^o \times 74^o$	0.2 mm	500 mm	$2.7^o \times 4.1^o$	4.6 mm
35 mm	$39^o \times 59^o$	0.3 mm	1000 mm	$1.4^o \times 2.1^o$	9.2 mm
50 mm	$27^o \times 40^o$	0.5 mm	1500 mm	$0.9^o \times 1.4^o$	13.8 mm
105	$13^o \times 19^o$	1.0 mm	2000 mm	$0.7^o \times 1.0^o$	18.4 mm
200	$7^o \times 10^o$	1.8 mm	2500 mm	$0.6^o \times 0.8^o$	22.9 mm
400	$3.4^o \times 5.1^o$	3.7 mm	–	–	–

The most convenient teleobjective to photograph the eclipse has a 500 mm focal length, providing a 4.6 mm (more precisely 4.59 mm) solar image that makes possible capture of the solar corona during the total phase to four solar radius. Zoom lens may increase the focal length up to about 2,000 mm or grater. In the table below the dimensions of sight range and diameter of the Sun's image on a film of 35 mm are presented. To obtain an image of the solar corona at the totality phase, telescope's focal length should not be greater than 1,500 mm for 35 mm cameras, while very extended corona structures images may be obtained with objectives of less than 1,000 mm focal length.

To avoid eye damage that may be caused by strong solar radiation we must use a Mylar filter in front of camera's objective or a special glass filter. It is worth mentioning that these are meant to attenuate solar radiation (in visible or infrared range) for 100,000 times, and to allow the right timeframe to expose to partial eclipse phases. We must pay attention on the fact that in all localities on Romanian territory, displayed sideways from the stripe of total eclipse visibility, eclipse will be partial, despite the fact that at the maximum phase only a small fraction of the Sun's surface will be visible (between 1% and 6%).

Camera stability may be ensured by mounting it on a tripod, and exposure switching is better made through a distance control. In case the 36 frames of the film are finished just in the proximity of the eclipse's maximum phase, it is recommended not to change the film from camera but use another identical camera already having a film inside.

Picking the film depends on the type of the studied eclipse (partial, annular, total). A low or mid sensitive film (50–100 ISO) is recommended, as sunlight is strong enough in partial eclipse phases. Previous to the eclipse, it is useful that experiments on choosing exposure time should be made. Black-and-white emulsions grant a variety of rapid films, written down as ISO (ex-ASA). Fine-grained films are preferable as they can reproduce the every little details of solar phenomena. Colour negative films and slide films (with ”chrome“ suffix in their names) could be also used.

The most important thing to be noted is that **during the totality phase, all the filters in front of the photographic objectives must be pulled out.** The corona has a surface shining one million times smaller than the one of the photosphere, so that its photograph must be taken without filters. Furthermore, there is no danger for the eye by watching totally eclipsed Sun with the naked eye. To take pictures of the corona, with a view to making its structures as much real as possible, is very difficult, as the internal corona is more shining than the external one and cannot work with one exposure time. The best method is to choose a diaphragm and to use many exposure times (from 1/1000 s to 1 s) during the totality. It is recommended that one should choose and repeat an appropriate cycle of exposures before the eclipse, because, taking into account the emotion of the moment, little time remains for decision making during the short interval of totality!

Exposure times for various combinations of film speeds (ISO), apertures (f/number) and solar features (chromosphere, prominences, internal, middle corona and extended corona) are presented in the table below. We choose the ISO film speed from the upper part of the first column, and then we go right to design the aperture or f/number for the chosen ISO. Going down on the fixed column, we can find exposure times for the phenomena we want to take picture of. The found value will be orientatively used as basis for taking pictures of the phenomena listed in the first column. For example, in order to take pictures of the prominences on 100 ISO film at diaphragm 11, the table recommends a 1/500-exposure time. The exposure time can be computed by using ”***Q***“ factor – *brightness exponent* – in the table, according to the formula: $t=f^2/(I\times 2^Q)$, where t – exposure time in seconds, f – f/diaphragm or focal ratio, I – film speed in ISO. All the data in Table 3 refer to a clear sky and medium shines. Exposure can be modified according to sky conditions and fluctuating nature of the aimed solar phenomenon. The exposures for partial phases are also good for annular eclipses. We note that ***Baily's Beads*** are extremely bright and change rapidly. The exposure recommended for the ***Diamond Ring*** effect is the same as that recommended for Corona – 0.2 $R_{\odot}$ (see Table 3)

Another interesting way to take pictures of the eclipse is to record all its phases on a single film. A fixed camera able to make multiple exposures could do this. As the Sun moves with 15º/h on the sky, it will move slowly and will be the sight field of any camera with an ordinary objective and normal focal length. If the camera is oriented in such a way so that the Sun can move lengthways the diagonal of a frame, 3 hours will take over the Sun to cross the field of a 50 mm lens. The orientation of the camera might be practised by repeated experiments, long before the eclipse. Sun will be positioned along the Eastern edge of the viewfinder (left, in the Northern Hemisphere) before the eclipse begins. Exposures will be carried out every 5 minutes throughout the eclipse. The camera must be rigid during the eclipse, well fixed on a wall or support, a simple tripod bring easily moved by the wind. The final photo will consist of a succession of ”Suns“, each showing various phases of the eclipse.

Table 3. Solar eclipse exposure guide

ISO		**f/Number**								
25		1.4	2	2.8	4	5.6	8	11	16	22
50		2	2.8	4	5.6	8	11	16	22	34
100		2.8	4	5.6	8	11	16	22	34	44
200		4	5.6	8	11	16	22	34	44	64
400		5.6	8	11	16	22	34	44	64	84
800		8	11	16	22	34	44	64	84	128
1600		11	16	22	34	44	64	84	128	176
Phenomenon	**Q**	**Shutter Speed**								
Partial Eclipse (4)	11	-	-	-	1/400	/20	1/1000	1/500	1/250	1/125
Partial Eclipse (5)	8	1/4000	1/200	1/100	1/500	/25	1/125	1/60	1/30	1/15
Baily's Beads	11	-	-	-	1/400	/20	1/1000	1/500	1/250	1/125
Cromosphere	10	-	-	1/400	1/200	/10	1/500	1/250	1/125	1/60
Prominences	9	-	1/400	1/200	1/100	/50	1/250	1/125	1/60	1/30
Corona – 0.1 $R_\odot$	7	1/2000	1/100	1/500	1/250	/12	1/60	1/30	1/15	1/8
Corona – 0.2 $R_\odot$	5	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
Corona – 0.5 $R_\odot$	3	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec
Corona – 1.0 $R_\odot$	1	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec
Corona – 2.0 $R_\odot$	0	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15sec
Corona – 4.0 $R_\odot$	-1	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15sec	30sec
Corona – 8.0 $R_\odot$	-3	1/2	1 sec	2 sec	4 sec	3 sec	15 sec	30 sec	1 min	2 min

(4) – neutral filters with density 4; (5)– neutral filter with density 5; $R_\odot$ – solar disk radius

Pictures of solar eclipses could be taken in a plane, or on a boat. It is more difficult to make recommendations for these situations, especially due to the lack of fix platforms. This imposes certain limits for the focal length of the objective and exposure times. Telescopes of 1000 mm or more focal length might not be used, because their small fields of view requires that the boat should be stable during the totality phase, which is of course difficult even for a calm sea. An objective of 500 mm focal distance may be recommended, as being the superior limit of the admitted focal length. Film choice depends on both the atmosphere and sea status. During a calm day, 100 ISO could be tried.

Planets, stars and other astral bodies visible on the sky during the totality phase of the solar eclipse can also be photographed. A regular objective might be used (35–50 mm) but the exposure time might be prolonged up to 10–20 s with the view of obtaining the solar corona, shining stars and planets. Previous to the eclipse, it is recommended that experimental exposures should be made during Full Moon nights, in order to find the correct exposure time so that the stars and the Sun not to be moved due to Earth's rotation.

VI. VIDEO AND CCD IMAGING OF SOLAR ECLIPSES

Total solar eclipses, precisely their phases and associated phenomena can be video recorded. Video camera technology has changed during the last decade. Video camera now uses CCD (Charge Coupled Devices) or MOS (Metal Oxide Semiconductor) system replacing the older video tube sensors. The new ones have two major advantages: greater sensitivity and cannot be damaged by intense sunlight. In this sense, we remind here that *Apollo 12* stopped its broadcasting on the Moon as an astronaut accidentally pointed the video camera at the Sun and ”fried“ its tube. A significant advantage of video recording is the miniaturization of electronic device both the video camera and camcorder are placed in a single portable, compact and easy-handling ”unit“. Electronic recording of the images allows the observers to almost simultaneously watch the film, while camera keeps taking pictures. An audio recording channel could be simultaneously for time signals. Most camcorders are provided with a zoom lens of 6:1 or 8:1; some new patterns have even 12:1. In order to find out solar image's dimension, the focal length and the size of the CCD or MOS have to be known. The Table 4 presents image's sizes for various focal lengths.

Table 4. Solar image's sizes on CCD, for various focal lengths.

Focal Length (mm)	Image Size of the Sun (½" CCD)	Image Size of the Sun (2/3" CCD)	Focal Length (mm)	Image Size of the Sun (½" CCD)	Image Size of the Sun (2/3" CCD)
50	20	17	200	80	68
60	24	20	250	100	85
70	28	24	300	120	102
80	32	27	350	140	119
100	40	34	400	160	136
150	60	51	500	200	170

It is absolutely necessary that special filters should be used in front of camera's lens during the partial phases. They could be either glass-made, provided with a film thin layer of metalled with chrome (solar image is orange), or Mylar-made, using a film thin layer with aluminium (solar image is light blue).

During the totality phase, the filter will be removed, when the diamond ring is formed. However, due to camcorder's high sensitivity, a neutral film of 0.9 might be used to ”view“ either the internal corona's fine structure or prominences.

Certain camcorders have manual control of the exposures, which is very useful to differentiate exposures for internal and external corona. In order to succeed thoroughly in experiments with video camera, repetitions during Full Moon nights are required, to be able to choose the most appropriate exposures for taking pictures of the solar corona during the totality phase.

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