The two total lunar eclipses of 2003

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Abstract: The year 2003 again saw two total lunar eclipses, and visibility was mainly favourable from southern Africa. This article reviews observations of both eclipses and discusses prospects for the two eclipses in 2004. As usual, results are summarised for the size of the umbra, as well as its darkness and colour. The approximately 2% enlargement in the umbra is confirmed for both eclipses. The May eclipse was dark, with grey, brown and dull copper colours evident. The November eclipse was brighter, with yellow and orange predominant.

Circumstances of the eclipses

The contacts of the Moon with the umbral shadow of the Earth are known as the 'circumstances of eclipse'. The circumstances for the two eclipses of 2003, taken from the *Astronomical Handbook for Southern Africa*, are given in Table 1.

Both eclipses were early morning events. On May 16 moonset occurred between 3rd and 4th contacts, and at mid-eclipse the Moon's altitude was only about 12°. As a result only the first half of the eclipse was observable. On November 09 moonset occurred after 4th contact, and at mid-eclipse the Moon was 23° high. Hence the entire eclipse was visible, though the Moon was quite low towards 4th contact.

The circumstances also show the magnitude of the May eclipse to be 1.13 versus 1.02 for the November eclipse. Hence the Moon passed deeper into the umbra in May than November, when the eclipse was only just total. Both eclipses however passed through less dense regions of the umbra, since maximum possible magnitude – when the Moon passes centrally through the umbra – is around 1.8.

Umbral size

It has been known since the early 1700s (for example, see Lahire's *Tabulae astronimicae*, published in 1707) that the umbral shadow is larger than predicted geometrically, due to the effects of the Earth's atmosphere. The degree of enlargement varies from eclipse to eclipse, and can be measured by timing

Table 1. Circumstances of the two total lunar eclipses of 2003

Eclipse event	May 16	November 09
1st contact	02:02.7	23:32.4
2nd contact	03:13.7	01:06.3
Mid-eclipse	03:40.1	01:18.5
Magnitude	1.13	1.02
3rd contact	04:06.4	01:30.7
4th contact	05:17.4	03:04.5
Moonset	04:44	03:21

First contact is the moment when the Moon enters the umbra. Second contact is the start of totality. Magnitude is the amount of the Moon's disk within the umbral shadow, expressed in lunar radii, at maximum eclipse and is greater than 1 for a total eclipse. Third contact is the end of totality, and fourth contact the end of umbral eclipse. Moonset is given for Johannesburg.

Table 2. Determined percent umbral enlargement for the two total lunar eclipses of 2003

Eclipse	Cooper immersions	Cooper emersions	global immersions	global emersions
May 16	2.3	not measured	2.1	1.8
November 09	2.5	2.1	2.2	1.8

the four primary contacts, and the observed entrance and exit of craters into and out of the umbra. The percent enlargement is calculated from observed versus the predicted times.

Timings of the primary contacts, as well as the times of entry and exit of craters to and from the umbra are sent to Byron Soulsby of the Theodore Lunar Observatory in Australia. He has reduced our observations since 1978 for inclusion in his global analyses. Likewise the case for the two most recent eclipses. The entire data set of timings is shown in Appendix 1, and is summarised in Table 2. The results are consistent with a typical umbral enlargement of about 2%.

Darkness

Despite the fact that the Moon passes through the umbral shadow of the Earth, it remains visible due to refraction of light by the atmosphere. The actual visibility of the Moon, or darkness of the shadow, depends on conditions in the Earth's atmosphere at the time of eclipse. Principal determinants of eclipse darkness have been found to be deflagration residues from meteor showers (Link 1969) and aerosols from volcanic eruptions (Keen 1983).

The darkness of an eclipse can be determined by measuring the brightness of the Moon. One method of determining the magnitude of the Moon, m_v, is to diminish its size by looking backwards through binoculars, and comparing the diminished brightness with stars and planets of known brightness. Using this method, known as the Selivanov method or reversed binocular method, the lunar magnitude is given by:

$$m_v = m_{RB} - 0.2 - 5\log M \qquad (1)$$

where M is the magnification of the binoculars. Cooper determined the reversed binocular brightness, m_{RB}, at mid-eclipse for both eclipses (Table 3).

A second method is to determine the lunar appearance at mid-eclipse using the method of Danjon (see, for example, *Sky & Telescope*, 1975 May, p 281). The appearance of the Moon is rated against a set scale which varies from $L=0$ (dark eclipse, Moon almost invisible) to $L=4$ (very light eclipse, details easily visible on eclipsed Moon). From these measurements Keen (private communication) has developed a correlation with the visual lunar magnitude:

$$m_v = 3.99 - 3.13L + 0.364L^2 \qquad (2)$$

Table 3. Eclipse darkness measurements by Cooper

Eclipse	m_{RB}	m_v	L	m_v
May 16	+5.0	–0.2	1.8	–0.5
Nov 09	+1.8	–3.4	3.5	–2.5

The author's results are given in Table 3, which clearly shows that the November 09 eclipse was considerably brighter than the May 16 eclipse, even if the May values are corrected for atmospheric extinction by about 1 mag.

In addition to the author's observations in May, Danjon estimates were made by Mauritz Geyser ($L=1.5$) Neville Young (1.2), Frikkie le Roux (1), Sybil de Clark (1) and Michael Poll (1). The mean $L=1.2$ is consistent with a dark eclipse. Most observers commented on the difficulty in recognising any detail on the eclipsed Moon.

During the November eclipse, maria were easily visible to the naked eye, and most prominent craters could be recognised in a small telescope. Additional Danjon values were received from Wolf Lange ($L=3$), Rodney Tudhope (2.5), Andrew Helsdon (3), Charlie Fleming (3), and from Mike Begbie (2) in Harare, as well as Wolfgang Vollmann in Austria (3) and Willian Souza in Brazil (3.5). The mean $L=2.9$ is consistent with a bright eclipse.

Colour

Apart from darkness of the umbra, there was a distinct difference in colouration between the two eclipses. During the May 16 eclipse, the author recorded (at mid-eclipse): "southern region very dark grey, almost black, central region dull copper-orange, region from Aristarchus to Sinus Iridum whitish to pale yellow. Umbra definitely very dark towards centre with brightish outer rim." Anton Nel wrote: "During totality, I had to look very carefully to see the eastern limb. I reckon that this eclipse was substantially darker than the 2001 eclipse. The Moon took on a dark brown colour and very little red or gold visible. The features (craters and maria) also disappeared…"

During the November 09 eclipse, the author recorded: "naked eye southern limb bright yellowish-white, remainder orange. In 5-inch rich-field refractor bright yellow with light orange northern limb and bright white southern limb. In 8-inch Newtonian southern limb definitely grey-blue, remainder orange."

Prospects for 2004

2004 sees two total lunar eclipses. In both cases the umbral magnitude is 1.31, so that the Moon passes deeper into the umbra than the two 2003 eclipses. The first occurs on May 04, and the entire eclipse is visible from southern Africa. Mid-eclipse is at 20:31 (UT). The second eclipse is on October 28, with mid-eclipse at 03:04, so that only the first parts of the eclipse will be visible (moonset around 03:25 for Johannesburg). I hope the above discussion will motivate others to observe these beautiful events and submit their data for analysis of umbral size, colour and darkness.

References

Link, F. (1969) Eclipse Phenomena in Astronomy, p.112.

Keen, R. (1983) Volcanic aerosols and lunar eclipses. Science, 222, 1011-1013.

Appendix 1 Contact and crater timings

Total lunar eclipse 2003 May 16

Tim Cooper	T1	T2
Primary contacts	02:01:50	03:13:30
Schickard	02:05:50	02:07:36
Grimaldi	02:07:55	02:10:04
Gassendi	02:11:12	02:12:10
Capuanus	02:13:54	02:14:20
Bullialdus	02:17:42	02:18:24
Tycho	02:18:05	02:19:30
Pitatus	02:19:04	02:20:25
Kepler	02:19:15	02:20:15
Aristarchus	02:27:24	02:28:24
Copernicus	02:28:04	02:30:00
Eratosthenes	02:34:12	02:34:38
Timocharis	02:39:54	02:41:04
Theophilus	02:40:34	02:41:54
Archimedes	02:44:54	02:46:30
Goclenius	02:48:15	02:49:15
Langrenus	02:52:40	02:54:50
Plato	02:55:25	02:57:25
Proclus	02:58:36	02:59:02
Hercules	03:06:04	03:06:44

Young team*	T1	T2	T3
Primary contacts	02:04:15	03:16:22	04:06:30
Grimaldi	02:08:30		
Tycho	02:18:30		
Kepler	02:21:15		
Aristarchus	02:28:00		
Copernicus	02:29:00		
Pytheas	02:34:30		
Stevinus	02:43:00		
Montes Haemus	02:47:19		
Plinius	02:50:04	02:50:06	
Vitruvius	02:54:26		
Marsh of Sleep	02:54:48		
Taruntius	02:54:50	02:55:26	
Plato	02:55:58	02:57:28	
Mare Crisium	02:59:45	03:04:38	
Hercules	03:07:02		
Zeno	03:10:08	03:11:19	
Endymion	03:11:08	03:12:06	

*Neville Young, Frikkie le Roux, Sybil de Clark, Mauritz Geyser, Tony Viljoen

Total lunar eclipse 2003 November 9

Tim Cooper	T1	T2	T3	T4
Primary contacts	23:30:44	01:05:00	01:31:39	too low
Grimaldi	23:43:57	23:48:16	01:49:49	01:51:29
Schickard	00:21:29		01:38:37	01:40:59
Gassendi		00:03:29		
Ramsden			01:52:39	01:53:09
Campanus	00:14:49	00:15:59		
Capuanus	00:19:51	00:21:29		
Mercator	00:16:09	00:16:55		
Kepler	23:46:24	23:47:04	02:07:24	02:07:57
Aristarchus	23:38:19	23:39:13	02:09:02	02:09:43
Bullialdus	00:10:49	00:11:48	02:03:29	02:04:29
Pitatus	00:20:35	00:23:05	02:03:14	02:05:44
Tycho	00:32:24	00:36:14*	01:56:59	01:59:24
Copernicus	23:53:24	23:55:29	02:16:21	02:18:25
Archimedes	23:54:44	23:55:39		
Manilius	00:06:39	00:07:09		
Menelaus	00:09:49	00:10:29		
Plato	23:48:49	23:50:34	02:32:09	02:33:51
Eudoxus	00:00:06	00:01:08		
Aristoteles	23:58:16	23:59:53		
Proclus	00:23:19	00:24:04		

* T2 for Tycho is uncertain due to cloud interference

In addition, Mike Begbie provided mid-feature times of immersion for Plato (23:50:34), Pytheus (23:51:31) and Copernicus (23:55:18).