A note on the remarkable prominence of the 'lumen cinereum', 2009 March 29

'If the student will watch his chance, he will find that some evening he can see with the naked eye, besides the little crescent of light, the dusky figure of the dark side of the Moon filling its horns and extending the arc to the full circle' wrote N. S. Shaler (1841–1906) in 1874. With the benefit of telescopic aid Shaler suggested that the observer will see 'in this earthshine a faint outline of all the great features which come into distincter view when they get the stronger sunlight upon them'.[1]

Many observers will identify with Shaler's description of the earthshine phenomenon. Writing from a 'historical' perspective Joseph Ashbrook noted that '...astronomy books, if they allude to earthshine at all, are apt to attribute its modern explanation to Kepler in 1604'.[2] However Ashbrook goes on to say it was Leonardo da Vinci (1452–1519) who a century before had given the same explanation; unfortunately '...it was forgotten until his manuscripts were published in 1797'. An extract from da Vinci's manuscript reads 'some have believed that the Moon has some light of its own, but this opinion is false, for they have based it upon that glimmer visible in the middle between the horns of the new Moon...this brightness at such a time being derived from our ocean and the other inland seas – for they are at that time illuminated by the sun, which is then on the point of setting, in such a way that the sea then performs the same office for the dark side of the Moon as the Moon when at full does for us when the sun is set'.[3]

Galileo Galilei (1564–1642) gives a long account of earthshine (called 'lumen cinereum' or 'ashen light' of the Moon) in his *Sidereus Nuncius* (1610)[4] where he refutes a number of earlier hypotheses which suggested the phenomenon might be due to the 'intrinsic brightness of the Moon',[5] or that the Sun's rays were powerful enough to 'penetrate the Moon's vast mass'. According to G. F. Chambers (1841–1915), Galileo noticed earthshine was 'stronger during the waning Moon', a point apparently confirmed by Hevelius and others. F. Arago (1786–1853) suggested that the Western [now Eastern] part is better adapted to reflect sunlight than the other hemisphere – a point which led Chambers to suggest this might explain why 'earthshine is more luminous before new Moon than after it'.[6]

W. Derham (1657–1735) used the earthshine phenomenon to note that it is possible to confirm the spherical nature of both the Moon and Venus, even during their crescent phases, because 'the dark part of their globes may be perceived, exhibiting themselves under the appearance of a dull and rusty colour'.[7] During the nineteenth century the celebrated selenographer J. F. J Schmidt (1825–1884) made a 'long series of observational records of earthshine... of which a portion was printed in his 1878 book about the Moon'. In fact his interest in the phenomenon stretched back to his days as an amateur astronomer in the early 1840s. Using small telescopes, his notes contain interesting descriptions of the colour of earthshine (bluish, yellowish grey, reddish brown) and repeated mentions of the 'ashen light [earthshine] being recognised one day after first quarter'.[8]

Like any regular watcher of the skies I have often been struck by the appearance of earthshine when it has been particularly prominent. During the March–April lunations of 2009 I had noticed earthshine appeared quite prominent on a number of occasions. I have often found this seems to be the case in the early spring months.[9] On 2009 March 29 I was using my Miyauchi 20×77 binoculars to observe the narrow lunar crescent, the terminator just clear of the western 'shoreline' of the Mare Crisium. After making a general sketch of the Mare Crisium as part of a planned session to record the appearance of the eastern region of the Mare at sunrise I made special note of the appearance of earthshine around 19:30 UT.

'Sky conditions were particularly good, there was no cloud, temperature dropping, Moon relatively high. I cannot recall ever seeing so many identifiable features on the 'earthshine' portion of the Moon in the past. The Western limb was noticeably brighter (libration favoured this limb). Aristarchus was visible as a diffuse 'starlike' spot. Grimaldi a dark oval nestled in the brighter limb region. I found Plato 'difficult' but on occasion glimpsed. Copernicus and Kepler were light 'splashes' in the dim light, Mare Humorum was quite the darkest of the 'seas'. The Southern highlands and the Western limb had a 'mottled' appearance suggestive of a rough uneven surface. The general impression was of a smoky slate grey hue, the region darkening markedly towards the illuminated crescent; a contrast effect?'

On the same evening earthshine made a similar impression on Richard Baum and Tony Bills. Using 15×70 binoculars under 'excellent conditions with a clear blue sky', Richard was 'struck by the larger than normal amount of detail visible on the earthlit side'. Tony found the earthshine 'a striking feature... even the pattern of the maria on the dark side was apparent'.[10]

In addition to his own observing notes Richard provided the following extract from Alexander von Humboldt's (1769–1859) *Cosmos, a Sketch of a Physical Description of the Universe*. Describing earthshine Humboldt notes, 'Lambert made the remarkable observation (14th February 1774) of a change of the ash-coloured moonlight into an olive green colour, bordering upon yellow. The Moon which then stood vertically over the Atlantic Ocean, received upon its night side the green terrestrial light, which is reflected towards her when the sky is clear, by the forest districts of South America'. Humboldt adds a footnote in which he postulates, 'It is not therefore impossible, notwithstanding the surprise which such a result may excite on first view, that one day meteorologists will derive valuable ideas as to the mean state of the diaphanity of our atmosphere in the hemispheres which successively contribute to the production of the ashy light'.[11]

Earthshine on 2009 December 9 observed by David Gray at 07:40 UT with 20×100 binoculars. Digital image of the bright side, superimposed on a stock image of the dark side and colourised to match the visual impression.

Further according to Humboldt, citing Beer & Maedler, '...after the new Moon it stands during the evening in the west, it can only receive the reflection in less quantities from the narrower American Continent, and principally from the wide ocean'.[12]

The foregoing suggests the state of the Earth's atmosphere has some bearing on the appearance of the earthshine portion of the lunar surface. The NOAA weather archive for North America on 2009 March 29 indicates that heavy snowfalls prevailed over much of the Eastern and Western states. Might it have been these heavy snow-laden clouds which had some effect on the intensity of sunlight reflected towards the Moon, perhaps contributing to the prominence of earthshine visible in the UK evening sky?

However it is not only from the Earth that the phenomenon of earthshine can be readily seen and make a striking impression. Visual observations made by crew members of both *Apollo 10* and *Apollo 12* record the phenomenon being visible whilst in orbit around the Moon. As Stafford, Cernan & Young reported

from *Apollo 10* 'On several revolutions we were able to observe the lunar surface lighted by earth shine'. Once their eyes had become dark adapted and the spacecraft was out of direct solar illumination they perceived a 'bluish white' tone to the lunar surface where 'peaks on the lunar horizon were clearly visible'. The astronauts had no difficulty 'in recognising major features' and observed a 'surprising amount of textural detail within the craters. Rays and halos were clearly visible'.[13] *Apollo 12* crew members Bean, Conrad & Gordon recorded that earthshine was an 'especially impressive sight'. Further noting that the Moon was 'fairly easy to see in earthshine', being 'quite beautiful and soft looking... with a greenish tinge, making it look gray-green'.[14] Perhaps the astronauts were seeing something of the 'green terrestrial light' alluded to by Humboldt.

I was favoured with a prominent display of earthshine whilst in Turkey in 2006, three days after the total solar eclipse of March 29 that year. Taking an evening walk I noted earthshine comprised a 'rather strange light'. There was a distinct 'coppery' hue to the un-illuminated portion of the Moon, with the Western limb a lighter shade of 'greyish copper – the whole appeared very warm in tone'. Surface features within the earth-lit part of the disk appeared less prominent than they sometimes do from the UK, and I wondered if the reduced prominence and coppery hue was due to dust suspended in the atmosphere. Both Derham and Schmidt suggest a 'rusty' or 'reddish brown' colouration being observed, yet earthshine generally appears to my eyes as a light smoky grey colour; perhaps others observers perceive things differently. I would be interested to know if any other observers have noted unusual colouration to the earthshine.

In more recent years climatologists have used the phenomenon of earthshine to measure albedo fluctuations in the earth's atmosphere, which is 'closely related to cloud cover and the concentration of airborne particles'. Orbiting satellites have limited coverage and are difficult to maintain over extended periods; however measurement of earthshine carried out at the Big Bear Solar Observatory for a period of two years in the late 1990s put the Earth's albedo at 0.297. 'This means that nearly a third of the sunlight that impinges on Earth is reflected into space'. Comparing observations with those in the mid 1990s hinted at a '2.5% decrease in albedo' in a five year period. A drop in the Earth's reflectivity over that time scale, 'during which the Sun's activity had climbed from a minimum to a peak', lent support to the theory that the 11-year solar cycle directly affects the Earth's climate. Further 'scientists believe a drop of just 1% could play a role in global warming'.[15] Perhaps then Humboldt's suggestion that one day 'meteorologists will derive valuable ideas as to the mean state of the diaphanity of our atmosphere' has come to fruition some 150 years later.

Earthshine is a phenomenon which is generally taken for granted, and remarked little in the astronomical literature of the past or the present. Personally I have only ever observed earthshine with any marked 'colouration'on one occasion; it seems it would be worth noting any unusual colour effects which might be seen. Similarly, telescopically, it would be interesting to note how long earthshine remains visible as the Moon's phase increases. Furthermore, something I have never seen documented is the earliest appearance of earthshine as the Moon wanes. Positive results in this regard might suggest that Arago's theory that the Western [Eastern] part is better adapted to reflect sunlight than the other hemisphere might have a basis in reality. The appearance of earthshine over the long term could have a part to play in understanding the mechanisms which drive our climate and which would ultimately affect our everyday lives.

There appears to be opportunity for the amateur with even the most basic observing aid to monitor the relative brightness of lunar features whilst situated in the portion of the Moon illuminated by earthshine. In doing so it might be possible to shed some light on the observations of William Herschel (1738–1822) and others, who at times remarked on the peculiar brilliance of certain lunar features when observing the earthlit portion of the Moon, comparing their appearance to that of erupting volcanoes.[16]

On a clear crisp evening the wonderful appearance of the faintly illuminated lunar globe nestled in the brightly illuminated horned crescent never fails to make an impression. Unfortunately such appearances are often regarded as commonplace – perhaps our efforts to understand our own planet might be better served by making a detailed long term record of such observations.

In closing I extend special thanks to Richard Baum who supplied a great deal of the reference material I have used whilst compiling this short note.

Nigel Longshaw

Notes & references

1 Shaler N. S., 'The Moon', *Atlantic Monthly*, **34**, 270–278 (1874 September)

2 Ashbrook J., 'The Astronomical Scrapbook', *Skywatchers, Pioneers and Seekers in Astronomy*, Cambridge University Press, 1984, pp.196–200

3 American Museum of Natural History, online reference 'Leonardo's Codex Leicester, A Masterpiece of Science', printed material dated 2003

4 Galileo Galilei, *Sidereus Nuncius* or *The Sidereal Messenger*, tr. Albert Van Helden, Univ. of Chicago Press, 1989, pp.53–57

5 Fontana noted 'earthshine' on several of his observations of the Moon published in 1646. Typically he says the '...part of the Moon not illuminated by the sun nevertheless displays its own secondary light, although subdued...' From *New observations of heavenly and earthly objects by Francesco Fontana*, Naples 1646, tr. Sally Beaumont & Peter Fay, privately published.

6 Chambers G. F., *A Handbook of Descriptive and Practical Astronomy*, 4th edn, Clarendon Press, 1889, vol.1 p.135

7 Derham W., *Astro-Theology: Or a demonstration of the being and attributes of God from a survey of the heavens*, London, 1715, vol.5 ch.1, p.107

8 *op. cit.*, ref. 2

9 'Like a gold ring snapped in two and shaven off at the ends it was so narrow', was how Dorothy Wordsworth described the appearance of a young Moon hanging over Silver How on the evening of 1802 March 5. She added 'within the ring lay the circle of the round Moon, as distinctly to be seen as ever the enlightened Moon is'. *Journals of Dorothy Wordsworth*, 2nd edn., ed. M. Moorman, Oxford University Press, 1981, pp.97–99

10 Tony Bills of Harrogate used modest equipment to observe the three day Moon on 2009 March 29. Observing at the same time from the Isle of Wight Ian Morrison also noted the prominence of earthshine. *Popular Astronomy*, **56**(3), 37 (2009)

11 Humboldt A. von, *Cosmos, a sketch of a physical description of the universe*, London: Henry G. Bohn, 1852, vol. 4 p.481

12 Cited from Beer & Maedler, *Der Mond* Section 106, p.152.

13 NASA SP-232, *Analysis of Apollo 10 photography and visual observations*, NASA, Washington DC, 1971, p.3

14 NASA SP-235, *Apollo 12 preliminary science report*, NASA, Washington DC, 1970, p.30

15 'Physics news', **http://physicsworld.com/cws/article/news/2687**

16 Herschel, W., 'An Account of Three Volcanoes in the Moon', *Phil. Trans. Roy. Soc.*, Vol. 77, 1787, p.229–232. Herschel gives an account of three regions of the Moon observed over two nights in 1787 April and claimed that the brilliance of at least one of these spots was evidence that a volcanic eruption was taking place on the Moon. Backed up by his high standing in astronomical circles, Herschel's account brought about a flurry of observational activity, however by May the following year Joseph J. de Lalande (1732–1807) wrote to Herschel explaining that '...many astronomers... are inclined to believe that Mount Aristarchus... might very well reflect the light of the Earth in such a manner as to produce this bright appearance across the pale light of the Moon'. 'Herschel acquiesced to this embarrassingly mundane explanation' wrote Sheehan & Dobbins in *Epic Moon*, however it is perhaps worth considering that Herschel made his observations of this feature, which in his own words showed 'an actual eruption of fire, or luminous matter', at a time when earthshine often appears to be at its most prominent, during the months of March and April.

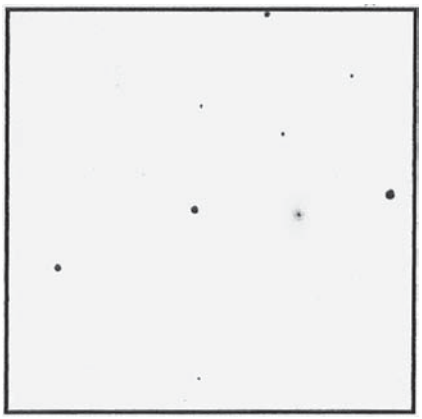
NGC 40 – an intriguing planetary nebula in Cepheus

Planetary nebulae are the death throes of stars not massive enough to become supernovae. Our Sun is expected to become such a 'celestial butterfly' in around 4 billion years when, after several billion years on the Main Sequence, it finally runs out of fuel and shines as a planetary for just a few thousand years.

Planetary nebulae come in all shapes and sizes. Some of the variation is undoubtedly due to line of sight effects – are we observing the dying star towards its equator, its pole or some position in between. However, there is still disagreement concerning exactly how planetaries are formed and what shapes can be expected. Indeed the situation is more complicated than it was a decade or so ago, with some astronomers now suggesting that a double-star is necessary for their formation.

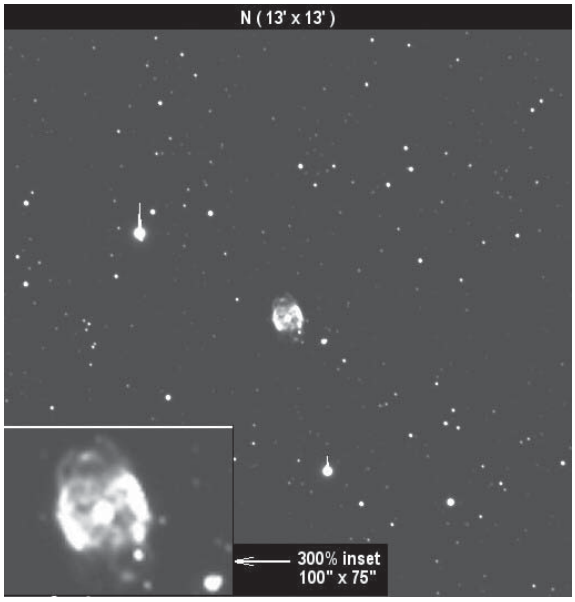
The traditional shape of a planetary nebula is a bright nebulous ring surrounding a central star. Common examples are M57, the Ring Nebula in Lyra and NGC 7293, the Helix Nebula in Aquarius. One that is less well observed is NGC 40 in Cepheus. It was discovered by William Herschel in 1788 and lies at RA 00h 13m 01s and Dec +72° 31' 19" (2000.0), which puts it 5.5° SSE of mag 3.3 Gamma, the star forming the roof top of the house-shaped constellation that is Cepheus. Slightly elliptical in shape with a size of 38×35 arcseconds, it has a quoted visual magnitude of between 10 and 12 depending upon the reference – although most sources tend towards the fainter magnitude. It lies at a distance of around 3,500 light years.

Bob Garner



David Wagstaff

A telescope in the 25cm class with a magnification of around ×100 will be needed to show much detail under typical UK skies, although it can be spotted with smaller instruments. David Wagstaff, observing from Birmingham with a 15cm f/6 reflector, found it small, round and grey in colour. At a power of ×137 he found the 11.6 mag central star obvious with the nebula less so, but definitely seen. Prolonged study hinted at structure in the nebula but at the limit of detection. David's sketch is shown below. The field size is 17.5×17.5 arcsec.



Martin Mobberley

OIII filters are almost magical on many planetaries, increasing contrast and frequently showing extra detail in the ionised gas that forms the nebula, albeit at the expense of dimming or even extinguishing the central star. However, on NGC 40 the OIII filter is a great disappointment and the no extra detail or contrast is gained. This is surprising as the central star has a temperature of 60,000K which should excite the nebula much more than it does. This suggests there is obscuring material between the star and the nebula which is presumably why the OIII filter has little effect. The Director finds that a UHC filter, with its wider bandpass, is the filter of choice on NGC 40. It increases the annular effect, while still showing the central star, and allowing high powers to be used. As magnification is increased, assuming the aperture of the telescope is sufficient to take this extra power, mottling becomes apparent in the halo on the eastern and western edges. This can lead to some interesting images where, if the central star becomes bloated, it can almost join this bright halo material making the planetary look as if it has a bright bar running across it.

Two images of NGC 40 by Bob Garner (Greenford, Middlesex) and Martin Mobberley (Cockfield, Suffolk) are shown here. Bob's was taken through his 35cm f/4.6 Newtonian on an AWR guided Fullerscope Mark IV mount with SBIG-2000XM CCD. Exposures were L 6×5min, R 9×5min, G 2×5min and B 2×5min. The image was processed in *Astroart4* and *Photoshop*. Although the image scale is such that the nebula appears very small, the main features are still seen, along with hints of outer wisps of nebulous material first seen by Heber Curtis in 1918.

This outer wispy material is clearer in Martin's image, particularly in the inset 300% view. Martin used a 35cm Celestron Schmidt–Cassegrain mounted on a Paramount ME and coupled to a SBIG ST9XE CCD camera. The field size in the main image is 13×13 arcmin. Exposure was 120s. The central star, which appears to be almost touching the bright patches in the outer nebula, certainly gives the impression of a bar. Is it this which caused William Herschel to suggest that the central star was either double or elongated when he studied this intriguing object in the 18th century?

Stewart L. Moore, *Director, Deep Sky Section*