Unusual shadow bands observed at the 2010 July 11 total solar eclipse

I observed this year's eclipse from the south Pacific atoll of Hao.[1] My main objective was to obtain a high quality, high definition video of the event using a Megrez 72 telescope and a Canon EOS 550D DSLR working in 1920×1080 video mode at 25 frames per second. In the event we had variable amounts of thin cloud covering the Sun at second and third contact, but this led to a very unusual phenomenon that I had not previously experienced.

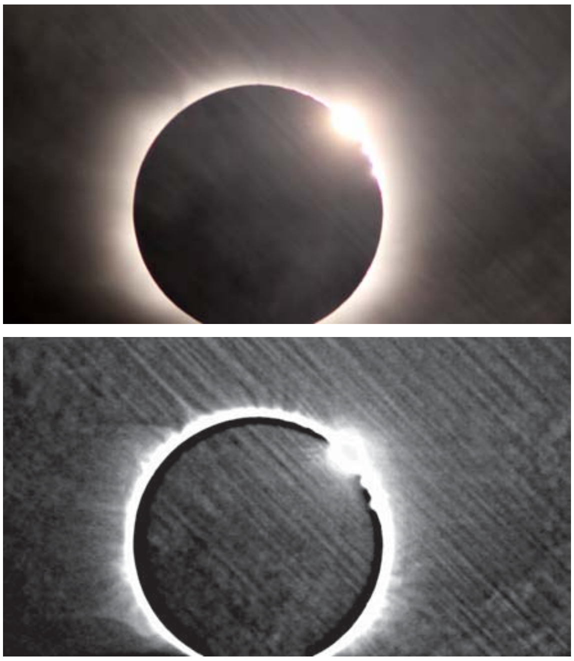


Figure 1. HD video frame around 4s before second contact at 18:41:23.2s ±1s UTC. *Top*, raw colour frame; *bottom*, wavelet processed and stretched.

Shadow bands can occasionally be seen as faint, rippling waves on the ground just before 2nd and just after 3rd contact. They are a subtle effect, probably due to a scintillation phenomenon caused by turbulence in the low atmosphere.[2] Strong bands on the ground were observed during this eclipse from Anaa atoll, 470km to the west of Hao,[3] but I did not see these myself since I was observing from an area covered with scrubby vegetation. However immediately after the event when reviewing my video, I noticed strange moving bands in front of the Sun around the time of second contact. I initially put this down to some artefact of the imaging system but later on eclipse day I mentioned the effect to John Mason and it turned out that he had also caught these bands on stills taken with a shorter focal length EOS 450D system. It looked as if the phenomenon was real. This was confirmed when I returned from my trip to see a wide field image on NASA's Astronomy Picture of the Day,[4] also taken from Hao, which showed the same thing.

Still frames from my video show the effect very clearly from around 6s to 2s before second contact. The effect is present, though more muted, at third contact. In both cases the bands are parallel to the bright slit of the remaining photosphere (see Figures). My processed video at second contact is available online.[5] There has been a considerable online debate about whether existing theories can account for bands projected onto clouds several hundred metres above the ground surface, and John Mason and I are currently working on a detailed analysis of this event. If any other observers recorded similar bands on Hao or anywhere else at this (or indeed any other) eclipse we would be pleased to hear from you.

Nick James *(ndj@nickdjames.com)*

1 James N. D. & Mason J., *J. Brit. Astron. Assoc.*, **120**(4), 204 (2010 August)
2 Codona J. L., *Astron. Astrophys.*, **164**, 415–427 (1986) [Available through ADS]
3 McGee H., *J. Brit. Astron. Assoc.*, **120**(4), 203
4 **http://apod.nasa.gov/apod/ap100724.html**
5 **http://www.youtube.com/watch?v=DLhD81ZeSkE**

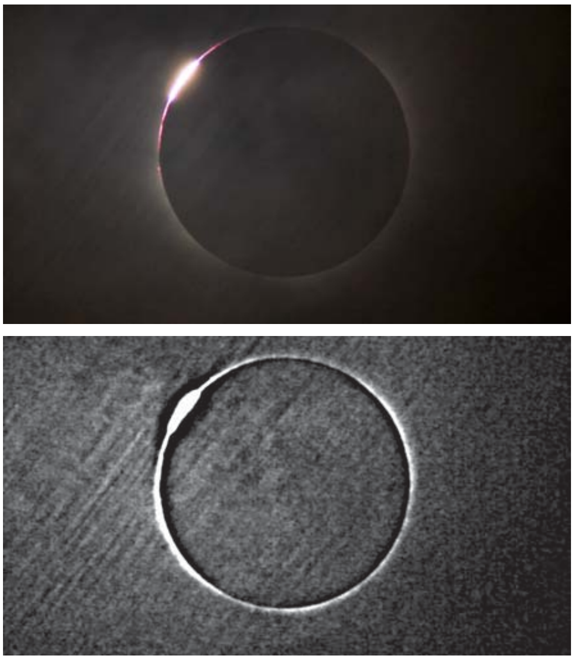


Figure 2. HD video frame around 2s after third contact at 18:45:02.1s ±1s UTC. *Top*, raw colour frame; *bottom*, wavelet processed and stretched.

NGC 7293 – The Helix nebula

Lying in a watery region of the sky along with Pisces (the Fishes), Cetus (the Whale) and Capricornus (the Sea Goat), Aquarius (the Water Carrier) is an ancient constellation. Unfortunately it is not particularly conspicuous, and the two brightest stars are only magnitudes 2.9 and 3. This combined with its low declination from the UK means that the constellation is all but invisible from many city locations here. However, as with many constellations, the brightness of its major stars is no guide to the deep sky treasures within and Aquarius holds many gems. The globular clusters M2 and M72 are popular targets, as is the planetary nebula NGC 7009, commonly known as the Saturn Nebula because of its likeness to Saturn through a small telescope. There is even a scattering of 12th magnitude galaxies for owners of larger telescopes. The real gem in Aquarius though is NGC 7293, the Helix nebula. At a distance of around 600 light years the Helix is the closest planetary nebula to us and covers an area on the sky over half that of the full Moon, which equates to a true diameter of around 1.5 light years.

Discovered from Gottingen, Germany in 1823 by Karl Ludwig Harding using a 4-inch (100mm) refractor, many people find it surprising that such a large object could have escaped the scrutiny of William and John Herschel. The most likely explanation is that because of its large size and low surface brightness (it has a visual magnitude of 7.3 spread out over 12×10 arcmin) it would have been almost invisible in the narrow field eyepieces used by these early observers in their large reflectors. Visually the Helix is much easier to see in small wide field instruments

Paul Downing

Andy Wilson

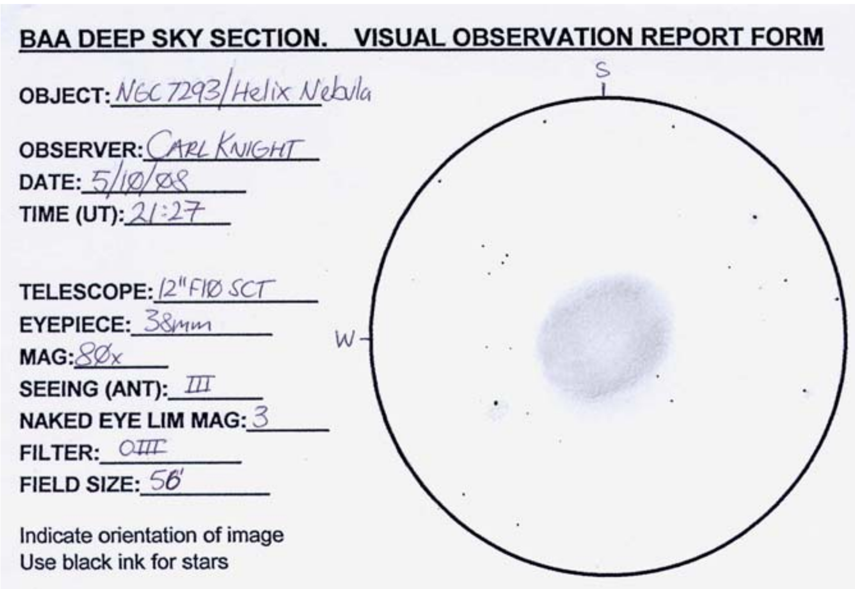
Mike Glenny

that concentrate its light than in larger apertures – although large aperture short focal length reflectors with modern wide field eyepieces can provide stunning views.

It lies in a relatively barren part of the sky at RA 22h 29m 38s and Dec −20° 50' 11" (2000.0), and while users of computer controlled telescopes will have no trouble locating it, star hoppers may well find the lack of bright stars causes problems unless they are observing from a dark location (some observers claim it is a naked eye object from a very dark site). One of the best ways of locating it, particularly if you are using binoculars and know you are in the right area, is to scan slowly from side to side until you see a ghostly patch of haze slightly brighter than the background sky pass through the field. The Director has observed the Helix visually through a variety of instruments, from 10×50 binoculars to a 25-inch telescope, and has found that its appearance changes markedly depending upon the aperture used. Small binoculars and telescopes around 10cm aperture will show a hazy circular patch with no indication of annularity, while 25cm and upwards begin to show the shape familiar in popular images, particularly if used with a wide field eyepiece and OIII filter.

Being the closest planetary nebula to us it is not surprising that the Helix has been much scrutinised by professional astronomers. The Hubble Space Telescope, the Canada-France-Hawaii Telescope and the Spitzer Space Telescope have all returned stunning images. One of the most reproduced images which shows the complete nebula appeared as Astronomy Picture of the Day on 2003 May 10 and can be seen at **http://apod.nasa.gov/apod/ap030510.html**. On the inside rim of the expanding nebula the radial features known as cometary globules can just be glimpsed. These are huge condensations of molecular gas – the head of each containing more mass than the Earth – embedded in the ionised nebula and driven outwards by the stellar wind from the evolving central star. This star is extremely hot, around 120,000K, and shines at mag 13.5. How and why cometary globules form like this is still being debated but it is likely they are common in all planetary nebulae and are a result of hot fast gas from the central star colliding with cooler material released from the star during its earlier red giant stage. They can be seen clearly in the Hubble Space Telescope image at **http://antwrp.gsfc.nasa.gov/apod/ap080413.html.**

Because of its low altitude and low surface brightness the Helix is a challenging target for UK observers and most of the recent images received by the Section have been taken from abroad – either by members with observatories outside the UK, on holiday with portable equipment, or using remotely operated telescopes. The



BAA DEEP SKY SECTION. VISUAL OBSERVATION REPORT FORM

OBJECT: NGC 7293/Helix Nebula

OBSERVER: CARL KNIGHT

DATE: 5/10/08

TIME (UT): 21:27

TELESCOPE: 12" F10 SCT

EYEPIECE: 38mm

MAG: 80x

SEEING (ANT): III

NAKED EYE LIM MAG: 3

FILTER: OIII

FIELD SIZE: 56'

Indicate orientation of image

Use black ink for stars

Radio Astronomy Group

The solar outburst of 2010 August 1

At about 9am BST on Sunday August 1 Brian Coleman (Redenham Observatory, Hants.) was checking the 3.4GHz amateur radio equipment he uses for making contacts by bouncing signals off the Moon. When he pointed the system at the Sun to check the calibration he found nearly 10 times the anticipated level of noise power. Brian used the BAA RAG Discussion Group (**http://tech.groups.yahoo.com/group/baa-rag**) to ask if anyone knew what was happening and it was quickly established that a C3.4 solar flare had just occurred.

This relatively modest flare event also appears to have been connected to a large filament eruption, resulting in a coronal mass ejection (CME) in the direction of the Earth. Several members observed the effect of the increased electromagnetic radiation hitting the earth's ionosphere a few minutes after the flare event, followed by the start of disturbances in the magnetosphere some 60 hours later as the plasma cloud released by the CME reached the Earth.

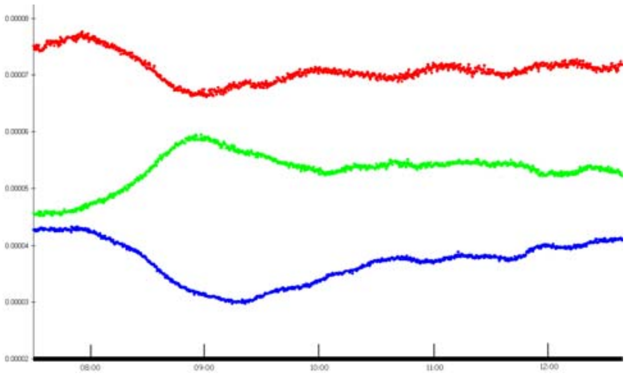


Figure 1. Received signal levels on 2010 Aug 1. ***Mark Edwards, Coventry, UK***

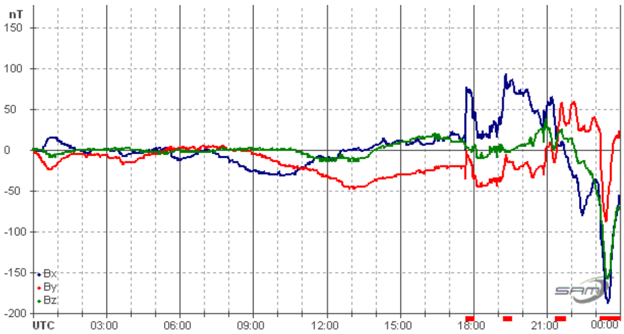


Figure 2. 'Fluxgate' magnetometer results on 2010 Aug 3. ***Roger Blackwell, Isle of Mull, UK***

Impact on the ionosphere

Figure 1 shows the results of the increased ionisation levels in the D layer of the ionosphere caused by the UV and X-ray emissions from the flare event. The received signal levels from Skelton (UK, 22.1 kHz – red trace) and Rosnay (France, 21.75 kHz – blue trace) declined, whilst the signal from Anthorn (UK, 19.6kHz – green trace) increased. The direction of the change in received signal level is determined by the phase relationship between the version of the transmitted signal reflected from the ionosphere (the 'sky wave') and the version of the signal received directly from the transmitter (the 'ground wave'). If the two versions are in phase, an increase in the sky wave leads to an increase in the received signal level. If the sky wave is out of phase with the ground wave, an increase in its level leads to a diminishing of the received signal. The observed signal thus depends upon the height of the D layer and the geographical location of the receiver, but when monitoring for Sudden Ionospheric Disturbances (SIDs) we are only interested in the timings of the start of the event, the time to reach the maximum deviation, and the time for the received radio signal to return to its normal level.

Similar results were obtained by Martyn Kinder, John Cook, Karl–Heinz Gansel and Paul Hyde. This particular event was unusual in that the time taken to reach maximum deviation from the normal level was in excess of 40 minutes, compared to the 4 to 6 minutes for a typical SID event. The reason for this is not known. In each case the observed deviation was relatively small and observations at more than one frequency were needed to confirm that ionospheric variations were responsible for the changes.

Impact on the magnetosphere

Figure 2 is the chart for Aug 3 from Roger Blackwell's three-axis 'Fluxgate' magnetometer at Willowbank Observatory on the Isle of Mull. No significant changes were seen between the flare event on Aug 1 until 17:43UT on Aug 3 when there was a sharp increase of about +80 nT in Bx, followed by continuing fluctuations in all three axes starting about an hour later. Maximum deviations were about +90 to –80nT for Bx, +55 to –45nT for By and +35 to –70nT for Bz for the period ending 23:59 UT.

Figure 3 shows the results from Martyn Kinder's magnetometer. This uses a 'magnetoresistive' type sensor which measures differential rather than absolute changes in the magnetic field, so the results are not directly

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orientation of the various images is a function of the optical system used to capture them. They are shown here as submitted to the Section.

Paul Downing's image was shot from his observatory in southern Spain (see *JBAA* **117**(6), 2007 for details of the observatory) using a Takahashi FSQ 106 f/5 refractor and SBIG ST8-XE CCD. It comprises 60min L and 30min each RGB. Tremendous detail is visible, including an external loop of material that is part of the nebula's outer envelope.

Remote imaging via the internet is becoming increasingly popular, allowing observers cost effective access to first class equipment in prime dark site locations, and Andy Wilson's photograph, another LRGB shot (32min L, 2min each RGB), was obtained in this way using a Takahashi Epsilon 250 mounted on a Paramount ME plus SBIG ST-10XME from Global Rent a Scope, New Mexico.

Mike Glenny observes from Andoversford, Gloucester (latitude 52°N) and his photograph of the Helix shows just what can be achieved from UK skies with relatively simple equipment. Taken through an 8-inch (203mm) LX90 and Canon 20Da DSLR combination fitted with a UHC filter, the 35×180s image shows a great deal of fine structure in the nebula.

Nebula filters are probably essential for visual observers trying to see detail in the Helix from the UK. Carl Knight is a skilled observer and his drawing was made from Sawston, Cambridgeshire using a 300mm f/10 Schmidt–Cassegrain at ×80 giving a field diameter of 56 arcmin. When the observation was made the naked eye limiting magnitude was 6 overhead but only around 3 in the vicinity of the nebula, and Carl reported that without the filter only the merest hint of the nebula could be glimpsed, confirming the power of these filters to cut through the ever pervasive sky glow near the horizon. In his sketch the nebula was drawn through an OIII filter, but the star field was sketched without.

During October the Helix will be culminating at around 21:00UT so will be ideally placed at a convenient time for UK observers. The Section would be delighted to receive any observations of it that you make.

Stewart L. Moore, *Director, Deep Sky Section* on one axis, to be supplemented by later disturbances on the second axis.

As can be seen, the disturbances in the magnetosphere continued into Aug 4 and there were several reports of increased auroral activity in the popular press.

Proposed observation programme

By combining the ionospheric and magnetic field observations we can see that the first impact on the Earth's magnetosphere of the plasma cloud released at 07:55 UT on Aug 1 was at 17:43 on Aug 3, almost precisely 60 hours later. This compares to a figure of 56 hours for average CME transit times, but higher energy flares are sometimes associated with much shorter transits, perhaps only 32 hours. BAA RAG is proposing to make such comparisons the subject of a study over the coming solar cycle and we welcome all observations, both from those with VLF receivers and those with magnetometers. If you are interested in participating please contact the coordinator at the address below.

A more detailed version of this report can be found in the Resources section of the BAA RAG website at **http://www.britastro.org/radio/,** and includes additional observations by Brian Coleman, John Cook, Karl–Heinz Gansel and Paul Hyde.

Paul Hyde, *Coordinator, Radio Astronomy Group. [g4csd@yahoo.co.uk]*

Figure 3. ***(left)*** **'Magnetoresistive' magnetometer results on 2010 Aug 3 & 4.** ***Martyn Kinder, Haslington, UK***